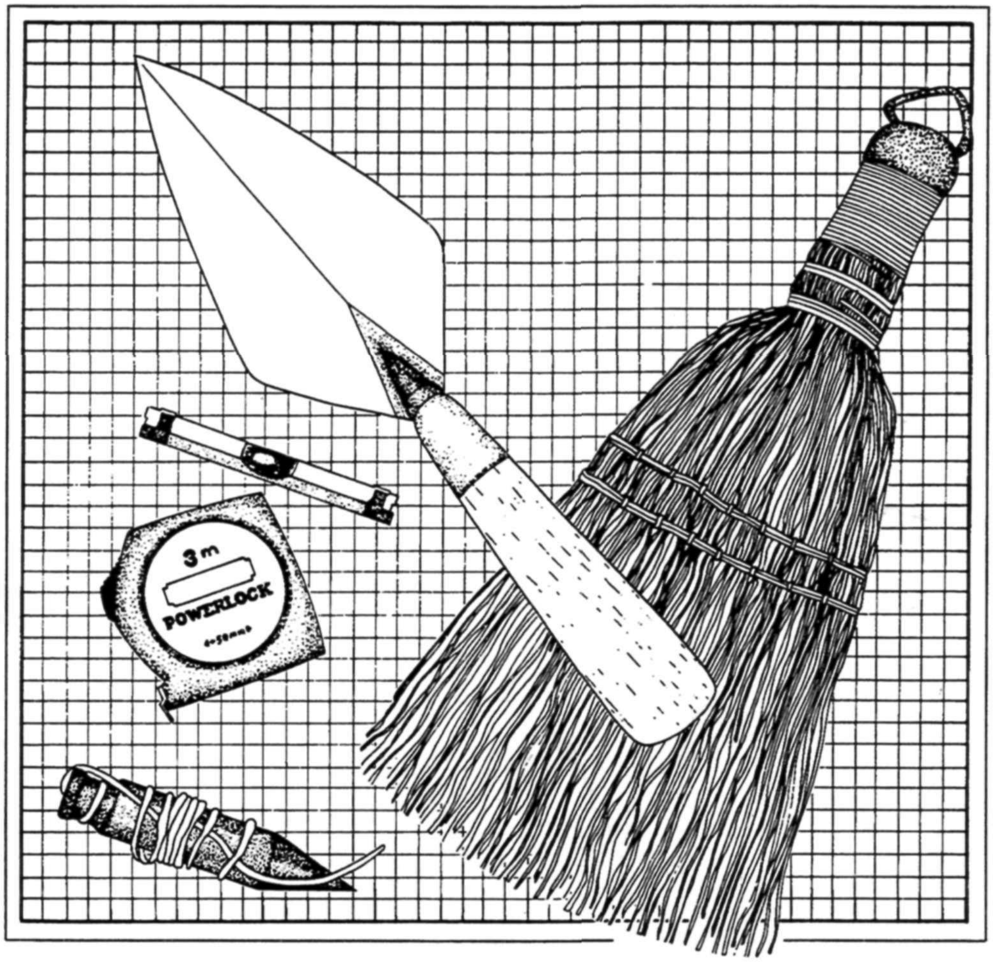
Formation Processes in Curecanti Archeology: The Elk Creek Site



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FORMATION PROCESSES IN CURECANTI ARCHEOLOGY: THE ELK CREEK SITE

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ABSTRACT

Mitigative archeological investigations were conducted in 1983 at the southern end of the important Elk Creek site, 5GN204/205, within Curecanti National Recreation Area prior to construction of a park apartment complex. That portion of the site extended onto a rocky promontory overlooking Blue Mesa Lake. Archeological activities undertaken at the site in 1982 focused upon the western half of the promontory (Jones 1986), while the eastern half of the point was investigated the following year. During the 1983 research, two small chipped-stone concentrations and an isolated projectile point were identified and collected. Stylistic comparisons of several diagnostic artifacts collected in 1983 suggest that an Early or Middle Archaic component was represented.

The 1983 work at Elk Creek provided an opportunity to investigate the role of natural erosion in the formation of the Curecanti archeological record. A statistical analysis performed during the project confirmed an initial field impression that the artifacts within one of the chipped-stone concentrations were roughly size-sorted in the direction of the ground surface slope. Based in part upon an analysis of local weather and physical environmental data, that size distribution of artifacts is believed to relate to a postdepositional restructuring of the material by precipitation runoff in combination with deflation of the deposit by strong western and southwestern winds. The study suggests that ongoing erosion by water and wind operating under the particular environmental conditions of the site area may dramatically affect contextual information given the passage of sufficient time, an issue of importance to archeological research elsewhere within Curecanti and other parks in semiarid settings.

ACKNOWLEDGEMENTS

I greatly appreciate the opportunity to design and direct this project that was provided by Bruce Jones, Bob Nickel, and F.A. Calabrese. The staff at Curecanti was extremely helpful both in support of the initial fieldwork and later in providing access to wind data tapes from the Blue Mesa Lake weather station. Special thanks are due the enthusiastic and persevering individuals on the 1983 field crew, including Janet Matel, Barry Brenton, Amy Orenstein, Eric Manhart, and Doug Johnson.

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INTRODUCTION

> Disturbed sites would provide opportunity for studying the effects of natural processes on spatial information. Once these effects are understood, it may be possible to translate the results of disturbance into meaningful statements about the past. With this research, a small disturbed site often dismissed by contract archaeologists becomes the source of valuable information.
>
> Stiger 1986:359

Project Background

The 1983 archeological research conducted by the Midwest Archeological Center (MWAC, or the Center) in the Elk Creek Development at Curecanti occurred atop the eastern half of a rocky promontory which overlooks Blue Mesa Lake to the south and Haystack Gulch to the east (Figures 1–3). The promontory lay at the southern end of the Elk Creek site, 5GN204/205, the important multicomponent prehistoric site which formed the foundation for the Curecanti Archeological District nomination to the National Register of Historic Places in 1982. The 1983 Center research at Elk Creek was necessitated by the construction of an employee housing complex on the point, and represented the second and final phase of archeological mitigation efforts begun at the site in 1982 (Jones 1986). The Elk Creek site covers an area of approximately 30 ac (12 ha), of which about 3/4 ac (3,000 sq m) was addressed in the 1983 research. The site area is illustrated on the Carpenter Ridge Quadrangle of the U.S. Geological Survey 7.5 minute topographic map series.

The top of the promontory ranged in elevation between approximately 7,600 and 7,630 ft (2,316–2,325 m), approximately 250 ft (76 m) above the former channel of the Gunnison River. A sparse sagebrush community was supported atop the promontory, the eastern half of which sloped downward to the northeast into Haystack Gulch. That area has been classified as stony rock land and is characterized by numerous bedrock exposures and shallow soils containing much loose rock (Hunter and Spears 1975:31). The bedrock atop the point consists of Precambrian Black Canyon Schist, although 5GN204/205 also extends to the north across areas underlain by the Oligocene West Elk Breccia and the Upper Jurassic Junction Creek Sandstone (Hedlund and Olson 1973). Several of the surface exposures of Junction Creek quartzite at Elk Creek appear to have been quarried prehistorically. A number of such quartzite sources along this section of the Gunnison River Valley were in fact heavily exploited in the past and undoubtedly served in part to attract prehistoric populations to the present area of the park.

Previous Archeological Investigations

The complex of cultural deposits now identified as 5GN204/205 was initially recorded during an archeological survey of Curecanti conducted by the University of Colorado in 1976 (Stiger 1977, 1980). At that time, the remains were recorded as two separate lithic scatters which were assigned individual site designations. Two years later, a program of archeological test excavation was undertaken at these sites by the University of Colorado in conjunction with expansion of the Elk Creek Development at the park (Euler and Stiger 1981). Those investigations suggested that aboriginal materials probably lay along the entire length of this ridge prior to modern construction in the area, prompting a redefinition of the remains as a single site.

The 1978 archeological program at 5GN204/205 involved testing at a number of locations across the site and resulted in several significant discoveries. A probable fire hearth exposed in association with a concentration of chipped-stone debris was subsequently radiocarbon dated to 9800 ± 830 B.P. Those materials were interpreted as the remains of a possible Paleoindian lithic workshop. A complex of features believed to represent the remains of a burned Archaic habitation structure was identified elsewhere at the site. The complex included a basin-shaped soil stain approximately 3.5 m across and 16 cm deep which was found to contain a number of ground-stone fragments, charcoal, and a large quantity of burned clay which still retained log impressions. Charcoal samples from the basin were subsequently radiocarbon dated to 4430 ± 300 B.P., 4270 ± 90 B.P., and 4560 ± 80 B.P. Rare midden deposits were also identified in still another area of the site where testing revealed deposits containing faunal remains, ground-stone tools, chipped-stone artifacts, and charcoal.

The Midwest Archeological Center conducted additional investigations at 5GN204/205 during the 1980 field season at Curecanti (Jones 1982). That project resulted in the documentation of a possible stone hunting blind at the site, documentation of the on-site quarrying of quartzite outcrops, recovery of additional faunal samples from the midden deposits, and production of a transit map illustrating the extent of surface archeological remains to assist the park in preservation of the site.

Finally, Center crews returned to the site in 1982 and 1983 to mitigate the anticipated impact of park housing construction on the overlook at the southern end of the site (Figures 2 and 4). Surface material on the overlook was found to be sparse, and only two small lithic concentrations were identified there in 1982, one of which was investigated that year (Jones 1986). The second concentration was investigated in the spring of 1983 and is reported here together with a third small chipped-stone concentration and an isolated projectile point. Also in 1982, systematic shovel testing was conducted across the western half of the promontory, resulting in the identification of a small isolated charcoal stain at a depth of 10 cm below the ground surface (Feature 1). The stain was found to contain a single charred animal bone fragment and has been interpreted as a probable hearth location.

Problem Statement

Two anthropological problem domains were addressed during the 1983 field investigations at 5GN204/205 and the subsequent artifact and data analyses. The first concerned site function and the nature of prehistoric adaptations along the Gunnison River and its tributaries. As discussed above, the diverse range of archeological features and materials previously investigated at the site suggested that it had been utilized for purposes which included a game observation overlook, a habitation site, a lithic quarry, and a lithic tool production/maintenance station. The radiocarbon dating of feature materials suggested that Paleoindian and Early/Middle Archaic components were represented at the site.

Two chipped-stone concentrations and an isolated projectile point were studied and collected during the 1983 field season at Elk Creek. Subsequent analytical emphasis was placed upon the larger of those two concentrations, which was well defined and spatially distinct from other cultural deposits within the site. The dating associations which have been made for several diagnostic artifacts recovered from this lithic concentration are temporally broad but essentially contemporaneous. As a consequence, the assumption has been made that the lithic concentration represented a single depositional episode of relatively short duration.

The second problem domain addressed by the 1983 research was prompted by field observations which suggested that the largest artifact concentration within the project area had been heavily disturbed by natural erosion and that the artifacts were roughly size-sorted in the direction of the ground surfaçe slope. It was subsequently learned that selected local environmental data were available from the nearby Blue Mesa Lake weather station which might be brought to bear in a study concerned with the effects of natural erosion upon archeological deposits. The project therefore represented an opportunity to investigate the possible restructuring of a cultural deposit under the influence of such natural agents as wind, precipitation runoff, and temperature fluctuation. It was believed that such a study would be applicable beyond site-specific results to future archeological research elsewhere within Curecanti and to other parks in semiarid settings.

The vegetative cover within Curecanti today is generally sparse and soil formation appears to have been slow, conditions which have probably prevailed in this region for a considerable length of time. Archeological materials in much of the park often appear to have lain exposed on the ground surface for extended time periods and have thus been subjected to ongoing surface formation/deformation processes under the influence of various natural agents. For example, the radiocarbon dating of two fill components within a single slab-lined hearth exposed at 5GN222 a distance of 1.1 mi (1.75 km) to the northeast of Elk Creek suggested that the feature may have been exposed at the ground surface for 1,200 years between use episodes (Jones 1986).

Paleoclimatic reconstruction is typically of interest to archeologists from the perspective of past cultural adaptation to those conditions. However, climatic change may also affect the manner and intensity with which various natural processes in turn affect archeological deposits. Within the Upper Gunnison Basin, paleoenvironmental research has suggested that present vegetative communities and, by extension, the climatic conditions which affect the distribution of those communities, have remained relatively stable over the past 4,000 to 6,000 years. For example, pollen analysis performed on lacustrine sediments collected at an elevation of 9,000 ft (2,800 m) in the Upper Alkali Creek Basin to the northeast and upvalley from Curecanti suggested that a major climatic change from warm moist to warm dry conditions occurred at approximately 4000 B.P. (Markgraf and Scott 1981). That change was believed responsible for a shift in vegetation in the Alkali Creek area from a montane pine forest to the sagebrush community which grows there today.

Based upon analysis of pollen and macrofloral samples collected within Curecanti itself, Scott (1986) has suggested that the major vegetative patterns in the park have remained largely unchanged over the past 6,000 years (no samples older than 6,000 years have yet been collected). In particular, most of the Curecanti area appears to have supported a sagebrush community throughout that time period. Additional pollen analysis of soil cores from two springs near the park has provided a similar picture regarding the predominance of sagebrush (Scott 1986). However, the spring data also suggested that slightly warmer and/or drier conditions prevailed between about 3000 and 2000 B.P., with an attendant shift upward in the lower limit of pine growth at higher elevations outside the park. Most recently, the combined results of analyses performed on macrofloral and faunal remains recovered from several hearths at 5GN191 within the park are interpreted as evidence that the area supported a mosaic of forest and open parkland as late as 5900–5700 B.P. (Jones 1992).

The lithic concentration at Elk Creek studied here for evidence of restructuring by natural erosion is believed to date to the Early or Middle Archaic periods. Restructuring processes may thus have operated on those site materials over a period of 3,000 to 8,000 years. Given the climatic reconstruction outlined above, environmental conditions during much of that period are here assumed to have been generally similar to those of today.

Our understanding of past human activity at any archeological site is derived from the contextual relationships of features and artifacts/ecofacts as well as from the actual physical remains themselves. The restructuring of an archeological deposit through natural erosion therefore results in the degradation and loss of scientific information. In order to determine a level or scale of interpretation that is appropriate in a particular setting, the depositional and erosional contexts of that location must first be clearly understood. The specific contextual questions posed with regard to the main lithic concentration within the 1983 project area at 5GN204/205 included the following:

1. Can the initial field impression of artifactual size-sorting be substantiated analytically?

2. If substantiated, to what extent has the deposit been affected by post-depositional processes?

3. Which natural processes appear to have most affected that artifactual distribution?

4. What may be learned from this study regarding the role of natural processes in shaping/reshaping the archeological record of the Curecanti area?

Assessment of the condition or spatial integrity of an archeological deposit is also essential to the process of determining the eligibility of that resource for nomination to the National Register of Historic Places. This study thus has additional relevance for cultural resources management as related to compliance with the National Historic Preservation Act, the implementing regulations for that act (36 CFR Part 800), and National Park Service historic preservation policies outlined in NPS-28.

Field Methodology

The 1982–1983 program of archeological mitigation at the southern end of 5GN204/205 involved systematic shovel testing to identify subsurface remains and limited excavation at three locations on the promontory (Figure 4). In 1982, mitigative activities included the excavation of shovel tests at two-meter intervals across the western half of the promontory, the excavation of a lithic concentration in the northwestern corner of the construction zone, the excavation of a probable subsurface hearth (Feature 1) identified in a shovel test, and a survey of the eastern half of the zone which resulted in the identification of an additional lithic concentration (Jones 1986). That latter concentration was scheduled for investigation the following year.

The 1983 Center research occurred on the eastern half of the promontory on which the housing complex was to be built, an area of approximately 3,000 sq m. Investigations began there on May 25th and concluded on June 7th. The initial activity at the site in 1983 involved the excavation of two-meter-interval shovel tests across the project area, resulting in the identification of an isolated projectile point on the ground surface at Positive Shovel Test 1 and a very small cluster of quartzite flaking debris at and around Positive Shovel Test 2 (designated Lithic Concentration 2). All of the chipped stone recovered from the latter concentration lay on the ground surface. No subsurface remains were identified in any of the shovel tests excavated across the eastern half of the promontory.

A block excavation was also opened atop the lithic concentration identified in 1982 which lay roughly midway north-south along the promontory (designated Lithic Concentration 1). A 2-m grid was established over the concentration and aligned on magnetic north. The location of the grid was determined relative to a permanent benchmark near the southern tip of the promontory and other landmarks in the vicinity. Twenty-nine squares were ultimately opened within the grid using a combination of three excavation/collection strategies. Grid squares X1 through X9 were excavated to bedrock in arbitrary 10-cm levels below the highest corner in each unit. Surface artifact collections were made within five other grid squares (X12, X13, X27, X28, and X29) followed by the skim-shovel excavation of unit fill. Finally, artifacts were collected at and immediately below the ground surface within fifteen additional grid units (X10, X11, X14-X26). All excavated fill was screened through ¼-in hardware cloth.

The positions of selected individual artifacts were also recorded when those artifacts were exposed *in situ* within the uphill portion of Lithic Concentration 1. The piece-plotted artifacts included those 3 cm or larger in maximum dimension and those believed to be temporally diagnostic. The positions of the artifacts were measured from the northwest and southwest corners of the grid squares. The downhill section of the concentration consisted of artifacts distributed along a shallow wash. None of the latter artifacts were piece-plotted.

Stratigraphy

The downward slope of the ground surface within the 1983 research area increased to the northeast toward the edge of the promontory, with soil depth decreasing in the same direction. The soil accumulation across Lithic Concentration 1 was typical for that area and ranged from 30 cm within the uphill or southwestern portion of the deposit to less than 5 cm at the downhill northeastern end. The ground surface at the concentration had a deflated appearance. Accumulations of coarse gravel lay on the exposed surface immediately underlain by finer sediments. Gravel and rock inclusions in the soil then became more numerous with depth toward bedrock. The soil in the project area was a brown sandy loam which became tighter and darker in color with increased depth.

Within the extreme uphill section of the lithic concentration, three distinct soil strata extended to a maximum depth of 30 cm atop a layer of coarse gravel and a rough jumble of broken bedrock (see X13 vertical profile in Figure 5). Chipped-stone artifacts were contained within the upper two soil layers in that area. The third soil stratum was encountered at a depth of 20–25 cm and extended laterally into X8, X9, X12, X13, and X27. It contained scattered fragments of charcoal but was devoid of other clearly cultural material.

A short distance downhill in X7, the soil depth was approximately 20 cm but was still differentiated into three layers (Figure 5). Finally, a single 5-cm-thick layer of soil lay directly atop weathered bedrock along the northern edge of X3. Artifacts lay in direct contact with bedrock in the latter area.

Dating the Aboriginal Occupations

Five hafted bifaces were recovered within Lithic Concentration 1, and they provide the only means to address the dating of that feature. Four of those artifacts are medium sized, stemmed, and shouldered with a triangular blade, but differ from each other in details of their shoulders, stems, and bases. A gray and white quartzite biface recovered from the 10–20 cm level in the southeast corner of X9 has a contracting stem and a concave base (Figure 6a, Field Catalog No. 5038). The extreme tip of this point and part of its base are missing. The midsection of a chert projectile point exhibits a similar shoulder and stem configuration but is slightly thicker in cross section than the above artifact (Figure 6b, Field Catalog No. 5004). It was recovered from the 10–20 cm level in X2 and may display evidence of heat alteration in the form of a color change from white to pink at the base. In contrast, a white agate point fragment recovered from the southeastern portion of X28 has more pronounced shoulders than the bifaces described above, less tapering in the stem, and appears to have had a bifurcated base (Figure 6c, Field Catalog No. 5064). The tip and part of the base are now broken.

In the Rocky Mountains and the adjacent Great Plains of Wyoming and Montana, stemmed projectile points with an indented or bifurcated base are typically believed to date to the Middle Archaic Period. However, stylistically similar points assigned to the Pinto series in the Eastern Great Basin are believed to date somewhat earlier, between 6300 B.C. and 4200 B.C. (Holmer 1986:97–99). Consistent with the dating of the Pinto series, points of a similar style were recovered from an Early Archaic context dated 5500–5000 B.C. at the Yarmony site in north central Colorado (Metcalf and Black 1988). Within the Colorado Front Range, stemmed indented-base points have been dated from roughly 4000 to 2000 B.C. during both the Early and Middle Archaic Periods (Benedict 1990:26–27).

The fourth stemmed point recovered from Lithic Concentration 1 is complete and manufactured from milky agate with orange staining. One side of the stem of the artifact is straight, while the other side is irregular concave. The basal edge is also irregular in form. This point was exposed at a depth of 1 cm below the ground surface within X3 (Figure 6d, Feature 1, Field Catalog No. 5008).

A fifth projectile point was recovered immediately beneath the ground surface in X9 (Figure 6e, Feature 2, Field Catalog No. 5039). This medium-sized quartzite point is distinguished from the other four bifaces recovered from Lithic Concentration 1 by its overall triangular shape. Only the extreme tip of the point is missing. However, from a dating perspective, this artifact is somewhat problematical because of ambiguity in its form. Specifically, it is unclear as to whether slight hafting notches are present high on the sides of the projectile. This artifact compares most favorably with the Pinto shoulderless type believed to date between 6300 B.C. and 4200 B.C. in the Eastern Great Basin (Holmer 1978:Figure 10g-i, 1986:97–99; Jennings 1978:Figure 51k,l). It also appears stylistically similar to certain points associated with the San Jose complex in the northern section of the Southwest, which dates between approximately 3000 B.C. and 1800 B.C. (Bryan and Toulouse 1943:Plate XIX; Irwin-Williams 1979:39–40). In conclusion, then, these artifacts from Lithic Concentration 1 together suggest that this feature may be associated with an Early or Middle Archaic component at 5GN204/205.

One additional hafted biface fragment was recovered at 5GN204/205 in 1983. This large corner-notched quartzite artifact lay on the ground surface at Positive Shovel Test 1, a distance of 35 m from Lithic Concentration 1 (Figure 6f, Field Catalog No. 5066). It exhibits a short expanding stem and a slightly convex basal edge. While the upper half of the blade is missing, the extant blade edges are nearly parallel to each other and 34 mm apart. The single intact barb extends toward the base. Similar artifacts recovered elsewhere in the mountains of Colorado and in the Eastern Great Basin may date from the Early Archaic Period into the Late Prehistoric or Historic Periods (Black 1986:140–141; Holmer 1978:Figure 7; 1986:101–104; Irwin-Williams and Irwin 1966:71–72; Reed and Scott 1982:381).

CHIPPED-STONE ARTIFACTS

Lithic Concentration 1

Chipped-stone artifacts recovered from Lithic Concentration 1 included seventeen tools and tool fragments subsequently refitted to fifteen complete and partial tools, and 120 fragments of debitage. The predominant raw material type represented in the collection is quartzite, accounting for three-fourths of the tool fragments (n=13) and all but a single piece of debitage. Tools of agate (n=2), chert (n=1), and jasper (n=1) are also represented, and one fragment of chert shatter was recovered. Much of the quartzite was undoubtedly quarried in the immediate vicinity of the site, while the non-quartzitic raw materials were probably obtained from more distant sources.

Five projectile points are included in the assemblage, two of quartzite, two of agate, and one of chert (Figure 6 a–e), which suggests that hafted tool production or maintenance was performed in this area. Four of the points are triangular-bladed, stemmed, and shouldered, and are stylistically similar. The fifth point is triangular in overall shape. All are finely flaked. Individual descriptions of these artifacts and dating associations are provided elsewhere in this report. To reiterate in part, however, the chert point fragment exhibits a pinkish hue at its base which is believed to reflect heat alteration of the raw material. A markedly heat-altered blocky chert fragment recovered from the concentration exhibits a dark red color, crazing, and potlid fracturing. The latter two artifacts suggest that a deliberate attempt may have been made to modify the functional or flaking qualities of this particular raw material type through heating. While heat treatment of chert may have occurred elsewhere at the site, no burned features were identified in immediate spatial association with Lithic Concentration 1.

Three additional finely flaked implements are represented in the collection, all of quartzite. Subsequent to breakage of one of those tools, an attempt appears to have been made to rework one of the fragments into another tool, possibly a graver. This was accomplished through the unifacial retouch of a section of the broken edge.

While the final stages of chipped-stone tool manufacture or repair may have occurred in the area of Lithic Concentration 1, no pressure flakes were recovered. As will be discussed later, however, this concentration is believed to have been restructured through the displacement of artifacts by erosion, with the smallest artifacts displaced the farthest distance in a downhill direction. As a consequence, it is possible that artifacts as small as pressure flakes which may originally have been present were subsequently removed from the site during that process. A few such artifacts may also have been lost during the archeological recovery process through the screening of excavated fill. No particular significance is therefore attached to the absence of such materials in the collection.

Four roughly shaped medium- and large-sized quartzite tools/incipient tools are also represented. The extant fragment of one of these tools exhibits light edge wear indicative of use.

Two possible unifacial quartzite notches are also included in the collection, as well as one utilized jasper flake.

Four white quartzite resharpening flakes are included in the collection which exhibit wear along the remnant tool edge between what is now the resharpening flake platform and the flake exterior. Two instances of this wear are light and two are heavy. Based upon their general appearance, all of these resharpening flakes could conceivably have originated from modification of a single medium- to large-sized implement. They suggest that at least one such tool was reworked in the vicinity of Lithic Concentration 1. However, none of the flakes were refitted to any of the white quartzite tools in the collection. In addition to resharpening flakes, the chipped-stone debitage from Lithic Concentration 1 includes sixteen quartzite resharpening/thinning flakes (no apparent wear along the remnant tool edge), 99 quartzite waste flakes and shatter fragments, and the one blocky chert fragment.

No flakes of non-quartzitic raw materials were recovered at Lithic Concentration 1, suggesting that tool production focused upon the use of quartzite. Quartzite occurs naturally in the vicinity of the site, and several quartzite outcrops across 5GN204/205 appear to have been quarried prehistorically (Jones 1986:5). Based upon geographical proximity, it seems likely that much of the chipped quartzite in the concentration was obtained from this local source. The rough texture of the cortex on several artifacts is also consistent with acquisition from an exposed weathered outcrop.

In summary, the assemblage is believed to reflect chipped-stone tool production and maintenance activities in the vicinity of Lithic Concentration 1. These activities appear to have included the reduction of quartzite, a raw material which was probably obtained on-site, and the tooling/retooling of hafted projectiles of quartzite, chert, and agate.

Positive Shovel Test 1

A large corner-notched point fragment was recovered from the ground surface immediately north of a sizeable rock outcrop within the 1983 project area and about 35 m north of Lithic Concentration 1 (Figure 4). A description of that point and dating associations are provided elsewhere in this report. No additional cultural material was observed on the ground surface in that area, and none was found during subsurface shovel testing immediately beneath and around the point.

Positive Shovel Test 2, Lithic Concentration 2

A light scatter of chipped stone was observed across the northern end of the 1983 project area. The only material actually collected from that area was a small cluster of quartzite flaking debris at and around Positive Shovel Test 2 (Figure 4). Fourteen quartzite fragments were recovered from the ground surface over an area nearly 2.5 m in diameter at Positive Shovel Test

2; the shovel test itself yielded only a single surface artifact. No subsurface artifacts or features were exposed in any shovel tests in that area. Most of the artifacts collected from the area of Positive Shovel Test 2 are composed of a poorly silicified red and white quartzite, and the concentration appears to represent the results of rind removal to access better quality material on the interior of a weathered quartzite fragment.

General Surface Collection

A single additional bifacially flaked quartzite tool was collected from the ground surface within the project area. The surface of the artifact exhibits an overall smoothed appearance.

ARTIFACT DISTRIBUTION WITHIN LITHIC CONCENTRATION 1

Introduction

In brief review, the 1983 Center research area within the Elk Creek Development at Curecanti included most of the eastern half of a rocky promontory overlooking Blue Mesa Lake. A sparse sagebrush community grew atop the promontory in relatively shallow soil around several bedrock exposures. The ground surface within the project area sloped increasingly downward to the northeast toward the edge of the promontory, and soil depth decreased in the same direction. Lithic Concentration 1 was identified roughly midway along the length of the promontory on the eastern side (Figure 4). Most of the chipped stone within that concentration lay in an area roughly 10 m in diameter, while a number of additional artifacts were found along a rill which extended downslope a distance of nearly 12 m from that upper area. Field observations suggested that the concentration had been heavily disturbed by natural erosion and that the artifacts were roughly size-sorted in the direction of the slope.

The ground surface elevation across the uphill or southwestern half of the concentration decreased by a total of 43 cm to the northeast, amounting to approximately 2° of slope (Figure 7). A 1.05 m decrease in elevation along the rill represented approximately 5° of slope. Soil accumulation across the concentration ranged from 30 cm within the upper portion of the deposit to less than 5 cm at the lower end. Within the upper half of the concentration, chipped-stone artifacts were vertically distributed from the ground surface to a depth which ranged from 20–25 cm uphill to 5 cm downhill. Soil was extremely thin along the rill, where artifacts were recovered at and immediately beneath the ground surface.

Because of the shallow nature of this entire cultural deposit, a detailed analysis of the vertical distribution of artifacts was believed to be inappropriate. A cursory review of the limited data which were collected in that regard revealed no evidence of vertical size-sorting of the artifacts. The impact of natural erosion upon the horizontal distribution of artifacts was therefore the focus of this study.

Selected literature concerned with the archeological effects of natural erosion was reviewed during the present study in order to identify the most relevant artifactual attributes for investigation and to define those structural artifact patterns believed to result from the operation of erosional processes. A detailed discussion of a portion of that literature is included in Appendix A. That information was then evaluated together with local weather and physical environmental data to develop an interpretive framework specific to Lithic Concentration 1.

The literature review suggested that three primary artifactual attributes, size, shape, and density, affect the movements of artifacts under the influence of erosion. The movement which occurs is then typically different for the various erosional processes, with the result that a deposit may be restructured along several different lines depending upon the assemblage composition and physical setting. The Curecanti study involved an investigation of the role of artifact size in artifact movement, with control for the density of the raw material type. The attribute of artifact shape was not investigated during the present project.

Studies by Rick (1976) and Frostick and Reid (1983) have suggested that artifacts dropped or dislodged on a slope will travel downhill under the omnipresent influence of gravity, with large heavy artifacts typically traveling longer distances than small light artifacts. Several factors which may operate to either moderate or facilitate that artifact movement include the density of vegetation on the slope, soil compaction, and the amount of precipitation received in the area. Critically, however, it has been suggested that the slope of the ground surface upon which artifacts are deposited must be moderately steep in order for that displacement to occur. In view of those studies, the shallow surface slopes at Lithic Concentration 1 in Curecanti would preclude gravity as the primary determinant of artifact movement there, and the Curecanti dataset was thus not expected to exhibit the size-sorted pattern of artifact distribution which would develop under the influence of gravity. Indeed, the actual artifact size distribution within Lithic Concentration 1 was found to be the reverse of the above pattern. Nevertheless, gravity is believed to have affected the directions of artifact movement in combination with other erosional agents, as explained below.

Wind and water are capable of actively dislodging and transporting archeological materials. In marked contrast to the movement believed to result under the influence of gravity, the smallest artifacts in an assemblage are the most susceptible to displacement by wind and water. For example, precipitation which falls across a site will generally drain in the direction of the ground surface slope (under the influence of gravity). Some of the artifacts exposed on the surface may be transported by that runoff, with the smallest artifacts generally traveling the farthest distances in a downhill direction. The latter process may then result in a size-sorted assemblage on a slope which is reverse in pattern to that which may develop under the influence of gravity. The movement of wind across a site may result in a similar size redistribution of artifacts, but one which occurs in the direction that the wind is blowing. As with movement under the influence of gravity, the effects of precipitation and wind may be modified by such environmental factors as the amount of vegetation growing on a site and the nature of the sediment substrate.

Experimental research by Wandsnider (1989) suggested that the nature of the substrate at a site may significantly affect the extent to which artifacts are displaced by natural erosional agents (Appendix A). The least amount of artifact movement was observed by Wandsnider in contexts of intermediate substrate compaction. While the soil in the area of Lithic Concentration 1 at Curecanti was relatively loose and sandy at the ground surface, it increased in compaction with depth. The substrate in the study area is therefore here considered to be intermediate in compaction and may have had little facilitating or moderating effect upon artifact movement. In contrast, the sparse vegetation at the site has undoubtedly served to facilitate the displacement of artifacts by wind, water, and other agents of erosion.

Finally, several freeze-thaw processes may also serve to separate the fine- and coarse-textured materials in a deposit. Different freeze-thaw processes produce particular size-graded distributions, certain of which are opposite in pattern to each other.

Curecanti Wind Data

Several lines of evidence suggest that wind may have contributed significantly to artifact displacement at Lithic Concentration 1. For instance, the site is exposed atop a promontory which is not sheltered by adjacent landforms. Further, concentrations of coarse gravel and small rocks lying on the exposed ground surface of the site were immediately underlain by finer sediments. Such coarse surface materials are referred to as lag deposits and are formed when the smaller particles in a sediment matrix are blown away (Bagnold 1954:93; Wood and Johnson 1978:358). Lag deposits then typically serve to stabilize or protect the ground surface against further wind erosion until wind velocity increases sufficiently to displace those coarse particles.

Local wind data collected at the Blue Mesa Lake weather station between 1989 and 1991 provide an indication of the strength of wind in the Curecanti area and the directions from which the strongest winds blow. In general, the station data indicate that wind velocity and direction may vary widely during any given day. For the purpose of assessing the potential role of wind in artifact movement at 5GN204/205, the present study analyzed two selected portions of that data: the maximum recorded wind velocity for each day, and the wind direction at the time of maximum daily velocity. The resulting dataset consisted of wind velocity data for 919 days within the three-year period (84 percent) and wind direction data for 656 days (60 percent). Statistics by month and year were then compiled from the daily readings.

According to that analysis, spring is the windiest season of the year at the weather station. During the months of April, May, and June for the three-year period, the average daily maximum wind velocity exceeded 30 mph and individual gusts up to 70 mph were recorded (Figure 8). Conversely, wind appears to blow the least during the late fall and early winter when the average maximum velocity diminishes to the teens. Further, the daily maximum velocity winds blow most frequently from the west and next most frequently from the southwest. Together, the winds from those two directions account for 75 percent of the three-year dataset (Figure 9) and predominate in every season of the year.

Maximum velocity winds from the different directions may be ranked on the basis of both frequency of occurrence and strength (Table 1). While maximum winds blowing from the south, southeast, north, and northwest were all strong and averaged between 20 and 30 mph, they occurred infrequently (less than 5 percent of the time). East and northeast wind maximums occurred with slightly greater frequency but were extremely low in velocity (10 mph). In contrast, west and southwest wind maximums ranked high in both frequency of occurrence and velocity. Of the latter two, west wind maximums were recorded 3½ times more frequently during the sample weather period than were southwest maximums. Winds from the west and southwest therefore appear to possess the greatest potential for inducing artifact movement in the project portion of Elk Creek, with the west wind contribution to that movement undoubtedly the greater of the two.

The high frequency of west wind maximums throughout the year may in part represent a meteorological effect produced by air movement around the large-scale topographic features of the region. The Blue Mesa Lake weather station is located on the same exposed ridgetop as the archeological site, and lies along the main stem of the Gunnison River. From the area of Cimarron, Colorado, to the upper end of Blue Mesa Lake, the Gunnison Basin trends in a direction nearly straight east-west. The West Elk Mountains lie to the immediate north of Curecanti and the San Juans lie to the south, ranges rising to heights of 13,000–14,000 ft (4,000+ m). Together, these features may serve to funnel the incoming winds with a western component (from the southwest, west, or northwest) in an upvalley direction. While documentation of this funneling effect is lacking in this particular instance, large topographic features elsewhere in western Colorado are believed to have similar widespread meteorological effects upon both surface winds and winds aloft (Nolan Doesken, Climate Division, Colorado State University, personal communication 1992). If the Blue Mesa Lake wind patterns relate in large part to regional topographic features which are relatively old in geologic terms, these general wind patterns may also have been operative in the relatively recent past.

Within Curecanti itself, seasonal wind patterns may vary along tributary drainages to the Gunnison which run in directions other than east–west, with implications for the directions of artifact movement under the influence of wind in those settings. However, no data have yet been collected which bear upon that issue.

Curecanti Precipitation and Temperature Data

The distribution of many artifacts along a rill within Lithic Concentration 1 is a clear indication that precipitation runoff has also affected the archeological deposit. While the amount of precipitation received in this area is typically low, there is very little vegetation to reduce both the initial impact of the precipitation as it strikes the ground surface and the subsequent water runoff (e.g., Turnbaugh 1978:597). The amount of precipitation received at the Blue Mesa Lake weather station varies seasonally, with an average annual total of 10 in (Figure 10). Under the present climatic regime, the highest monthly totals typically occur during July and August. Precipitation decreases during the fall and then increases slightly again during December and January. The least amount of precipitation is typically recorded during the spring, the windiest season.

A general appreciation for seasonal temperature extremes at the Blue Mesa Lake weather station may be gained from a review of data collected there during 1989 and 1990. During that period, the average minimum January temperature was -1.0 degree Fahrenheit, while the average maximum July temperature was 82.7 degrees Fahrenheit (data on file, Climate Division, Colorado State University, Fort Collins). Site disturbance through the seasonal freeze-thaw process is therefore clearly a possibility, although freeze-thaw cycles in the ground do not always occur in direct and immediate response to temperature changes in the air (Washburn 1980:71–73). In general, certain freeze-thaw processes serve to separate the fine- and coarse-textured materials in a deposit. For instance, frost heaving and frost creep operating in combination may result in the upward migration of the largest inclusions in a deposit followed by the downslope displacement of those same materials. In contrast, solifluction appears to result in a faster rate of downhill movement for small inclusions than for large ones. As described by Benedict (1970, 1976, 1990) for the Colorado Front Range, abundant soil moisture during the fall at the initiation of the annual freeze-thaw cycle is critical to the effective operation of these processes, particularly solifluction (Appendix A). However, small rocks on the ground surface may be displaced by short-term freeze-thaw cycles during either the spring or fall, presumably if sufficient moisture is present. As is indicated in Figure 10, precipitation amounts recorded during these seasons at Blue Mesa Lake are typically low. An average monthly precipitation of 1 inch or less falls from September through February, and approximately 1/2 inch falls per month from March through May. No known supplementary sources of moisture such as a spring are present on or adjacent to the Elk Creek site today. The shallow depth to bedrock at the site may also serve to inhibit the effectiveness of freeze-thaw action.

Analytical Methodology

The distribution of artifacts across Lithic Concentration 1 was investigated relative to the size of those materials. The specific size-related attribute used for this purpose was termed maximum dimension and was defined as the distance between those two points on an artifact which are the farthest apart. Maximum dimension measurements were recorded to the nearest whole millimeter for each artifact recovered at the concentration. However, since the assemblage was composed almost entirely of quartzite artifacts, only the quartzite was included in this study in order to control for the density of the raw material.

As was described in the previous section on field methodology, the deposit at Lithic Concentration 1 was excavated in 2-m squares within a grid aligned on magnetic north. As a consequence, the direction of the ground surface slope relative to the grid was downhill from the southwest to northeast corners of each square. While lithics 3 cm or larger in maximum dimension were generally piece-plotted as they were exposed in the excavation, the horizontal provenience associated with most of the material collected in the study area was simply a 2-m square. For the purposes of this distributional study, the general 2-m grid provenience for all quartzite artifacts was used rather than the limited piece-plotted data in order to increase the sample size and provide for the widest possible future application of these analytical methods at other sites. The grid squares were then grouped into tiers from 1 to 15 based upon their relative positions on the slope, Tier 1 encompassing the artifacts which lay the farthest downhill and Tier 15 encompassing the artifacts the farthest uphill (Figure 7). Squares included within the same tier lay at the same approximate elevation along the slope.

However, it must be understood that a slight mismatch was thus created between field and analytical methods. Because each tier consisted of squares in contact with each other only at the corners, adjacent tiers were interfingered with each other. As a consequence, for example, an artifact recovered from the extreme northeast corner of X1 (Slope Tier 10) was actually positioned slightly farther downslope than an artifact from the extreme southwest corner of X2 (Slope Tier 9). This system of tiers therefore only approximated the original slope positions of the artifacts.

The artifact sample consisted of 132 quartzite tools, tool fragments, and debitage. Of the twenty-nine 2-m squares excavated at the site, eight squares that were located either on the perimeter of the concentration or in the lower half yielded only a single quartzite artifact apiece. No quartzite artifacts were recovered from X28 near the center of the upper half of the concentration. Twenty-four quartzite artifacts were recovered from X8, the most from any square. With regard to the composition of the tiers, six tiers in the lower half of the concentration consisted of a single 2-m square each and a seventh tier consisted of two squares. Within the upper section of the concentration, the tiers included between 1 and 4 squares.

Finally, a bias in artifact sizes was undoubtedly introduced into the collection by the process of on-site screening of excavated fill through ¼-in hardware cloth. The sizes of quartzite artifacts recovered from Lithic Concentration 1 are indicated in Figure 11. Those data suggest that the lower end of the artifact size distribution may have been truncated by screening, with artifact sizes smaller than 10 to 15 mm in maximum dimension underrepresented in the collection. Data are thus not available on the physical positions of the smallest artifacts which may have been present at the site. However, as mentioned previously, it is also highly possible that small artifacts which may originally have been present were displaced from the immediate area of Lithic Concentration 1 by erosion.

Results and Conclusions

The size distribution of quartzite artifacts within Lithic Concentration 1 was explored from several perspectives. First, the upper and lower sections of the deposit, possessing slightly different topographic characteristics, are reflected in the percentage distributions of small and large artifacts by slope tier (Figure 12). Small artifacts were defined as those less than 2 cm in maximum dimension, while large artifacts included those 2 cm or larger. Most of the artifacts within the concentration lay within the upper half (Tiers 8–15), where the ground surface slope was approximately 2°. Both small and large artifacts were well represented in that upper section. Small artifacts predominated in the lower section along the wash (Tiers 1-7) where the surface slope approximated 5°.

However, upon recombination of the artifact size data for the entire collection, a linear trend in the data emerges which crosscuts those topographic differences. That trend may be seen in Figure 13, a histogram in which the maximum dimension data for all quartzite artifacts within each tier have been averaged. A scatter plot of average maximum dimension by 2-m square is presented in Figure 14 and also illustrates the linear nature of those data. Indeed, a linear correlation analysis has suggested that a strong relationship existed between quartzite artifact size and relative position on the slope which accounts for 65 percent of the variation in the data (Table 2). Further, because the linear trend in artifact size extends throughout the dataset, the entire deposit appears to have been affected by the restructuring process. Based upon diagnostic artifact comparisons, Lithic Concentration 1 is believed to date to the Early or Middle Archaic periods, thus providing a time span of 3,000 up to 8,000 years during which that restructuring may have taken place. These analyses confirm the initial field impression of a rough size-sorting of artifacts in the direction of the ground surface slope. An explanation for that distribution may now be considered.

The presence of artifacts along a rill in the lower section of the concentration indicated that the deposit had been significantly affected by precipitation runoff. That suggestion is supported by the overall pattern of artifact distribution in which the average size of artifacts decreased down the slope. The lag deposits observed at the site suggest that wind deflation of fine sediments had also occurred. As was discussed previously, relatively strong winds blowing from the west and secondarily from the southwest have the greatest potential for inducing the movement of artifacts exposed on the ground surface in the study portion of Elk Creek. The artifact size distribution across Lithic Concentration 1 was generally consistent with a pattern which would develop as a result of erosion by wind blowing from those directions. To further investigate the role of high-velocity winds specifically from the west, a second linear correlation analysis was performed in which a different set of tiers was constructed from squares adjacent to each other on the north and south. The tiers then progressed from 1 on the east to 8 on the west. The resulting correlation coefficient of +.75 was significant at the .01 level but accounted for less variation in the data than did the previously discussed tier organization, which was more directly related to the ground surface slope.

While strong west winds at Elk Creek may thus have contributed to the restructuring process over time, they do not seem to have been the primary agent responsible for the distribution within the archeological deposit. Precipitation draining in the direction of the slope clearly played an important role in the process, the effects of which may have been augmented by strong southwestern winds blowing in the same approximate direction. While the structure of the deposit may actually be referable in whole or in part to a different natural or cultural process which was not investigated, wind and water-related erosion operating in combination provide the best explanation that is consistent with the data. However, the relative importance of each of these factors is not completely understood.

Because of low soil moisture levels at Elk Creek during critical seasonal transitions, freeze-thaw processes probably had a minimal impact upon this distribution of artifacts. The freeze-thaw processes most likely to have affected this particular deposit include frost heaving and possibly frost creep. In combination, they would have operated to displace the largest artifacts upward within the deposit and downslope. As mentioned previously, the artifacts within this concentration were not found to be vertically size-sorted within the deposit. Further, the horizontal artifact size distribution was opposite to that which would develop under the influence of those processes.

In summary, the size-sorted artifact distribution within Lithic Concentration 1 is believed to reflect the results of an extensive spatial reordering of that deposit by natural erosion. The specific erosional processes which appear to have played the most important roles in that restructuring include precipitation runoff and displacement by wind. In this particular instance, the entire assemblage appears to have been affected. The dating associations which have been made for the collection suggest that this redistribution may have occurred gradually over a period of several thousand years.

Under this particular set of environmental conditions, it is clear that ongoing erosion by wind and water may ultimately result in the loss of cultural contextual information within an archeological deposit. Lithic Concentration 1 lay on a slope ranging between 2° and 5°, raising the possibility that other sites with minimal slope and in otherwise similar environmental settings may be significantly reordered given elapse of sufficient time. With regard to the environmental setting represented in this particular instance, the two primary erosional processes identified above were both operative in the same approximate direction. Such a thorough restructuring may have been possible *only* because of the combined effects of the two. These and other questions regarding the role of natural processes in the formation of the Curecanti archeological record may be addressed through future studies in the park.

SUMMARY AND CONCLUSIONS

Mitigative archeological investigations were conducted in 1982 and 1983 at the southern end of 5GN204/205 prior to park housing construction atop a rocky promontory overlooking Blue Mesa Lake. Archeological activities undertaken at the site in 1982 focused upon the western half of the promontory (Jones 1986), while the eastern half of the point was investigated the following year.

Archeological remains identified on the promontory included several small chipped-stone concentrations within an overall low-density scatter and a single subsurface charcoal stain interpreted as a possible hearth location. A diverse range of archeological features and materials identified elsewhere at 5GN204/205 suggested that the site was utilized prehistorically for purposes which included a game observation overlook, a habitation site, and a lithic quarry and reduction area. The results of an analysis of chipped stone collected in 1983 within two lithic concentrations at the site are consistent with earlier interpretations of site function, specifically providing additional evidence of chipped-stone tool production and maintenance activities. Those activities involved the reduction of quartzite that was probably obtained in the immediate vicinity of the site, and the tooling/retooling of hafted projectiles of quartzite, chert, and agate. The radiocarbon dating of feature material collected during previous investigations suggested that Paleoindian and Early/Middle Archaic components were represented at the site. Stylistic comparisons of several diagnostic artifacts collected in 1983 similarly suggest that an Early or Middle Archaic component is represented on the promontory.

In addition, the 1983 work at Elk Creek provided an opportunity to investigate the role of natural erosion in the formation/deformation of the Curecanti archeological record. A statistical analysis performed during the project has confirmed an initial field impression that the artifacts within a chipped-stone concentration on the promontory were roughly size-sorted in the direction of the ground surface slope. That size distribution of artifacts is believed to relate to a postdepositional restructuring of the material by precipitation runoff in combination with deflation of the deposit by strong western and southwestern winds. The study therefore suggested that ongoing erosion by wind and water runoff operating under the particular environmental conditions of the site area may dramatically affect cultural contextual information given the passage of sufficient time, an issue of importance to archeological research elsewhere within Curecanti and other parks in semiarid settings.

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Table 1. Ranking of maximum velocity winds from different directions on the basis of frequency and strength.

	FREQUENCY			VELOCITY	
Rank	Direction	N	%	Direction	Avg (mph)
1	W	386	59	S	30
2	SW	110	17	W and SW	28
3	E	62	9	NW	27
4	NE	36	5	SE	23
5	S	29	4	N	20
6	NW	15	2	E and NE	10
7	N	11	2		
8	SE	7	1		

Table 2. Calculation of Pearson's product moment correlation coefficient (r) and coefficient of determination (r^2) between quartzite artifact mean maximum dimension (MMD) recorded in mm and slope tier for 2-m squares, Area 831, 5GN204/205.

2-m Square	Slope Tier X	MMD Y	XY	X^2	Y^2
1	10	27.2	272.0	100	739.84
2	9	22.0	198.0	81	484.00
3	8	23.4	187.2	64	547.56
4	9	25.5	229.5	81	650.25
5	10	25.0	250.0	100	625.00
6	10	33.0	330.0	100	1089.00
7	11	32.2	354.2	121	1036.84
8	12	28.5	342.0	144	812.25
9	14	38.7	541.8	196	1497.69
10	8	22.0	176.0	64	484.00
11	10	28.0	280.0	100	784.00
12	12	31.3	375.6	144	979.69
13	13	28.3	367.9	169	800.89
14	14	33.0	462.0	196	1089.00
15	15	56.0	840.0	225	3136.00
16	11	17.0	187.0	121	289.00
17	9	42.0	378.0	81	1764.00
18	8	26.0	208.0	64	676.00
19	7	25.0	175.0	49	625.00
20	5	17.0	85.0	25	289.00
21	6	22.0	132.0	36	484.00
22	3	15.5	46.5	9	240.25
23	4	17.4	69.6	16	302.76
24	2	16.0	32.0	4	256.00
25	1	11.0	11.0	1	121.00
26	2	13.5	27.0	4	182.25
27	13	37.5	487.5	169	1406.25
29	11	31.8	349.8	121	1011.24
Totals	247	745.8	7394.6	2585	22402.76

$$r = \frac{N\Sigma XY - \Sigma X \Sigma Y}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$$

$$r = \frac{(28)(7394.6)-(247)(745.8)}{\sqrt{[28(2585)-(247)^2][28(22402.76)-(745.8)^2]}}$$

$r = +.80$ $r^2 = .65$

H_0 : Population correlation coefficient (p) = 0
H_1 : p = 0
Criterion of significance for two-tailed test = .01
Degrees of freedom = N-2 = 26
t = .479
Since .80 > .479, null hypothesis is rejected.

Reference: Welkowitz et al. 1971.

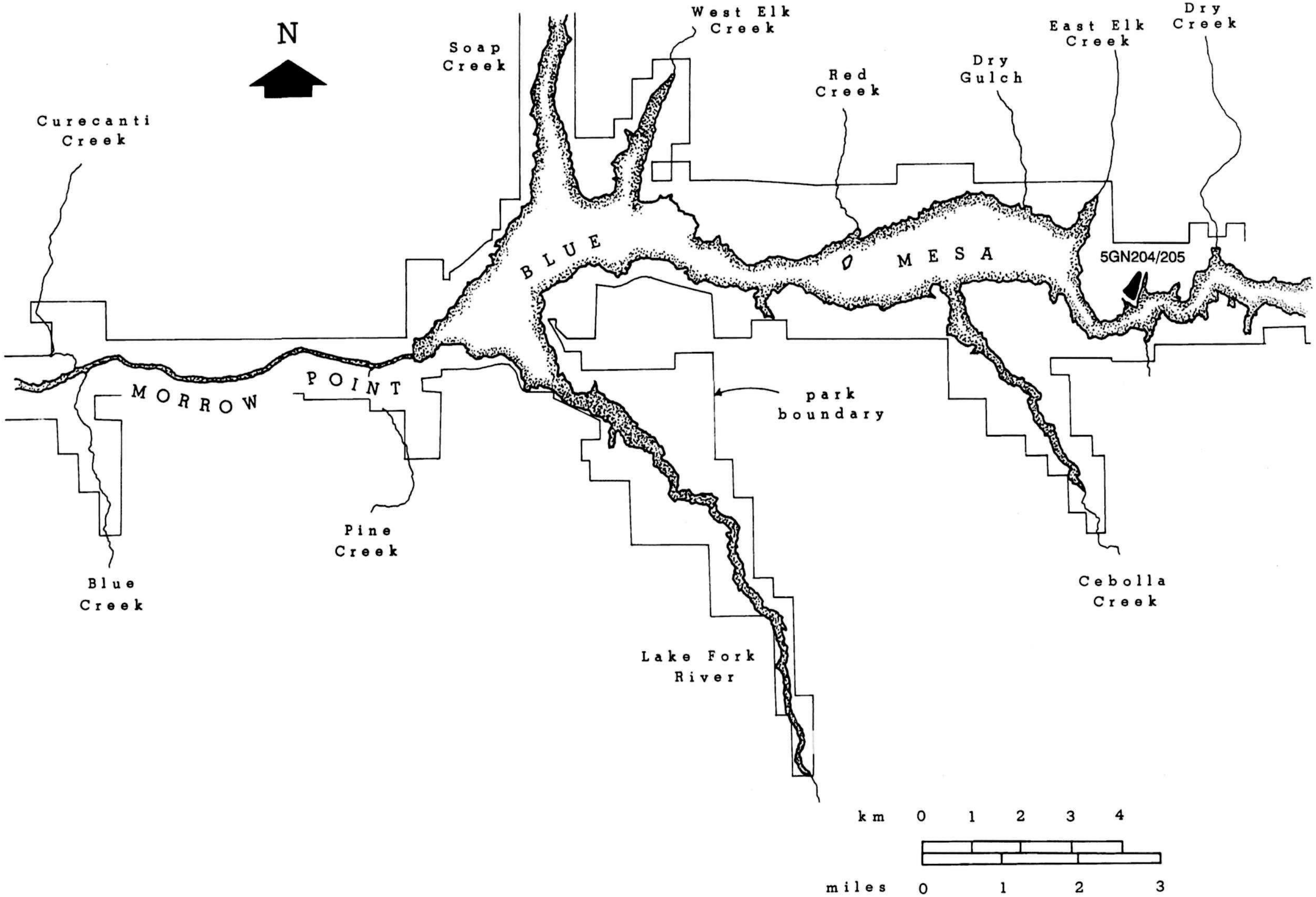

Figure 1. Location of site 5GN204/205 within Curecanti National Recreation Area, Colorado.

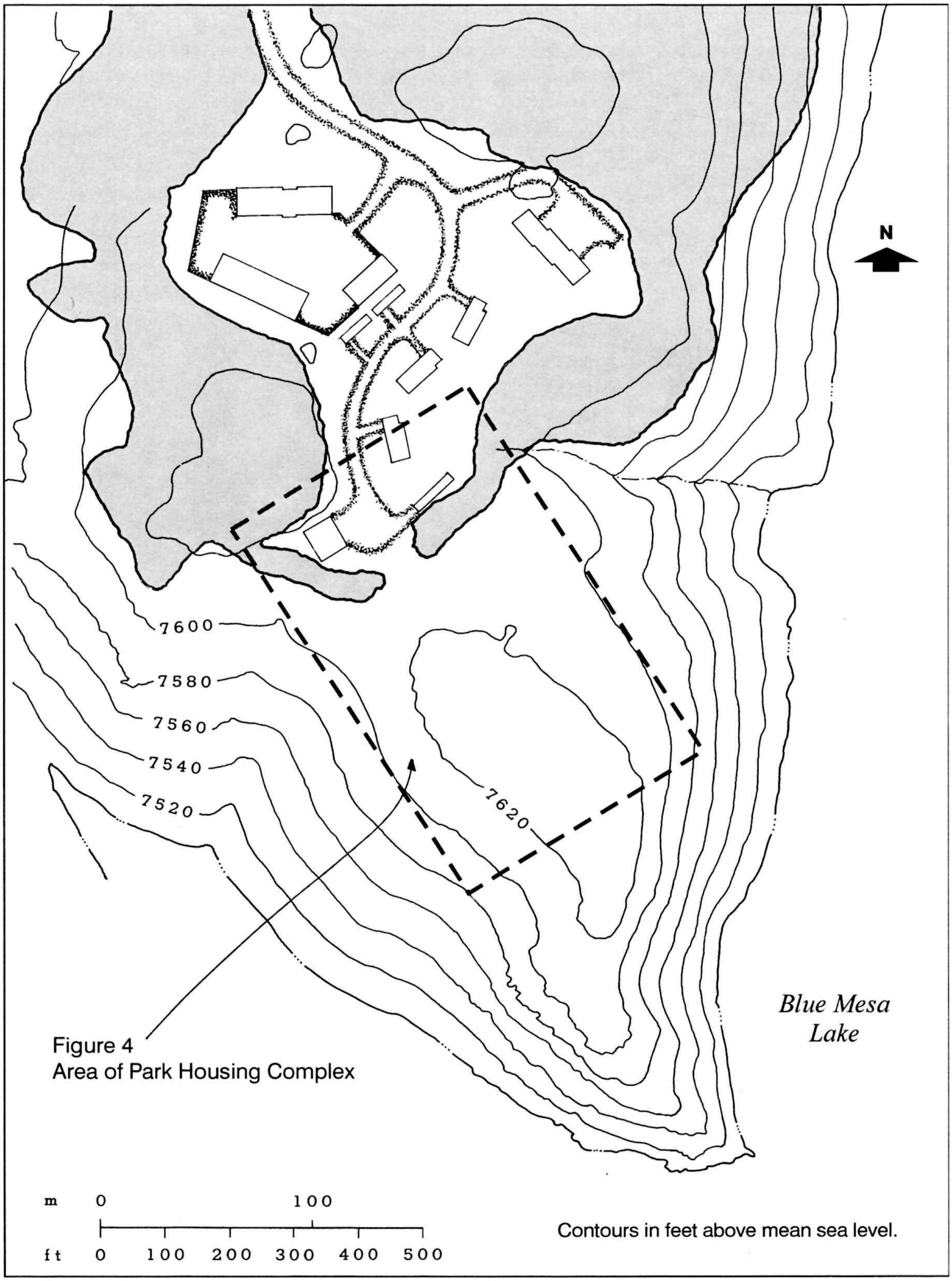

Figure 2. Southern limits of 5GN204/205 relative to park development. Shaded area indicates densest surface material.

Figure 3. View north across excavations at Lithic Concentration 1, 5GN204/205. Previously existing park buildings may be seen in the background.

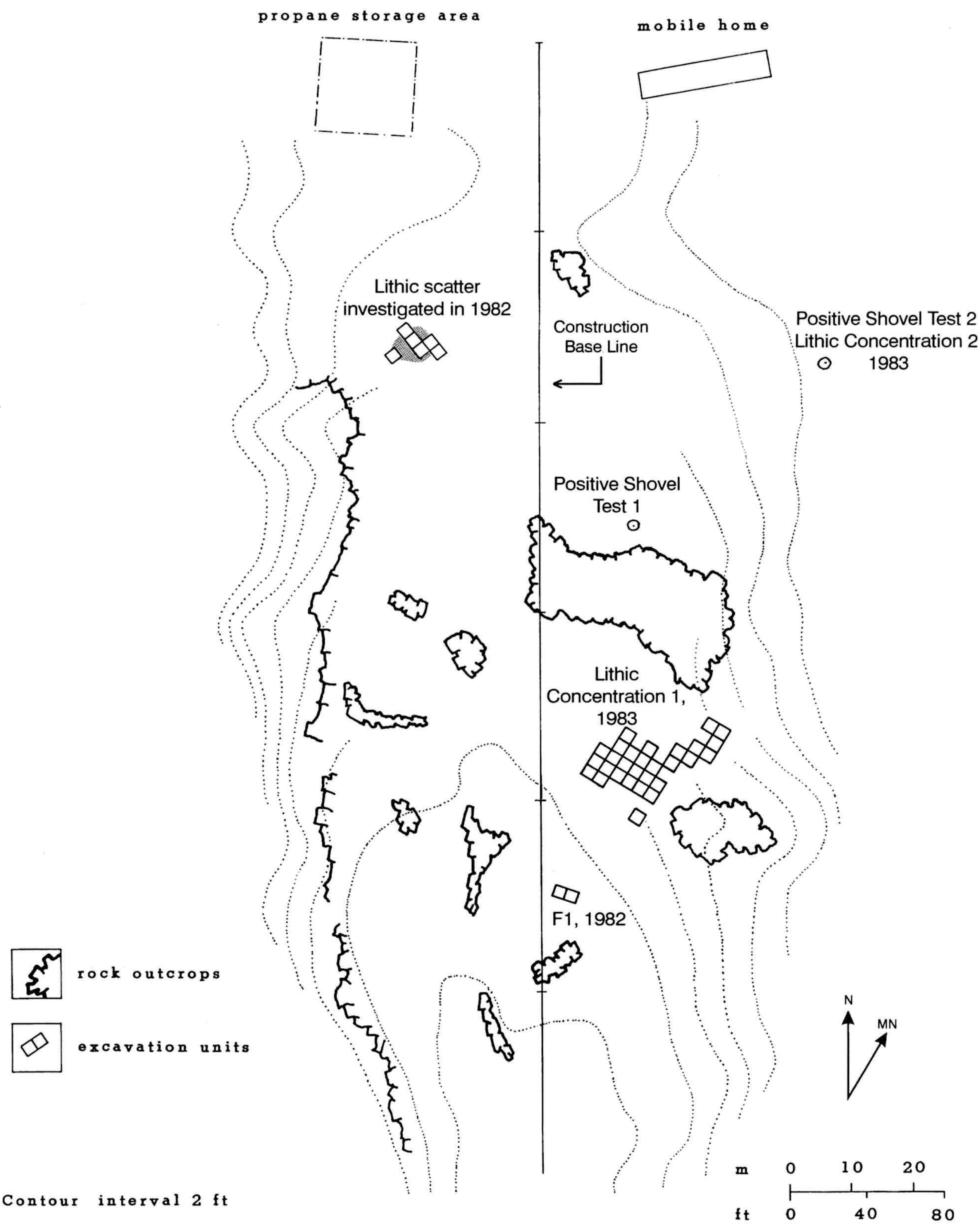

Figure 4. Detail of 1982 and 1983 investigations at 5GN204/205.

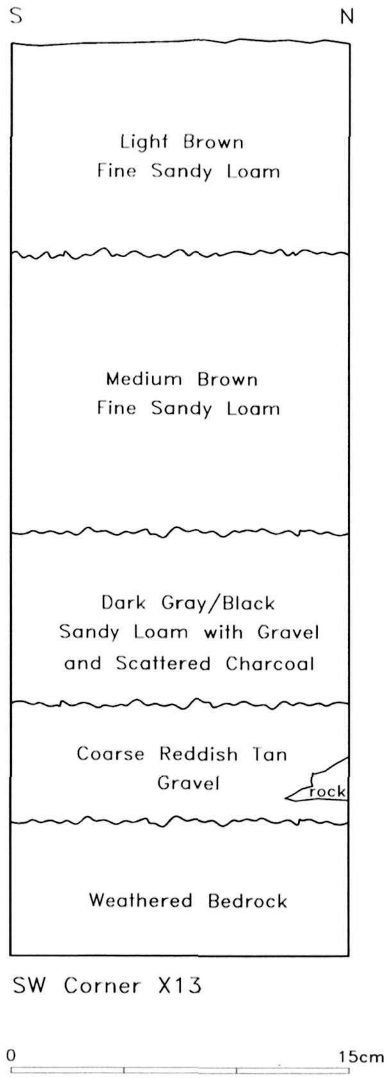

Figure 5. Vertical profiles illustrating the changes in stratigraphy across Lithic Concentration 1, Area 831, 5GN204/205.

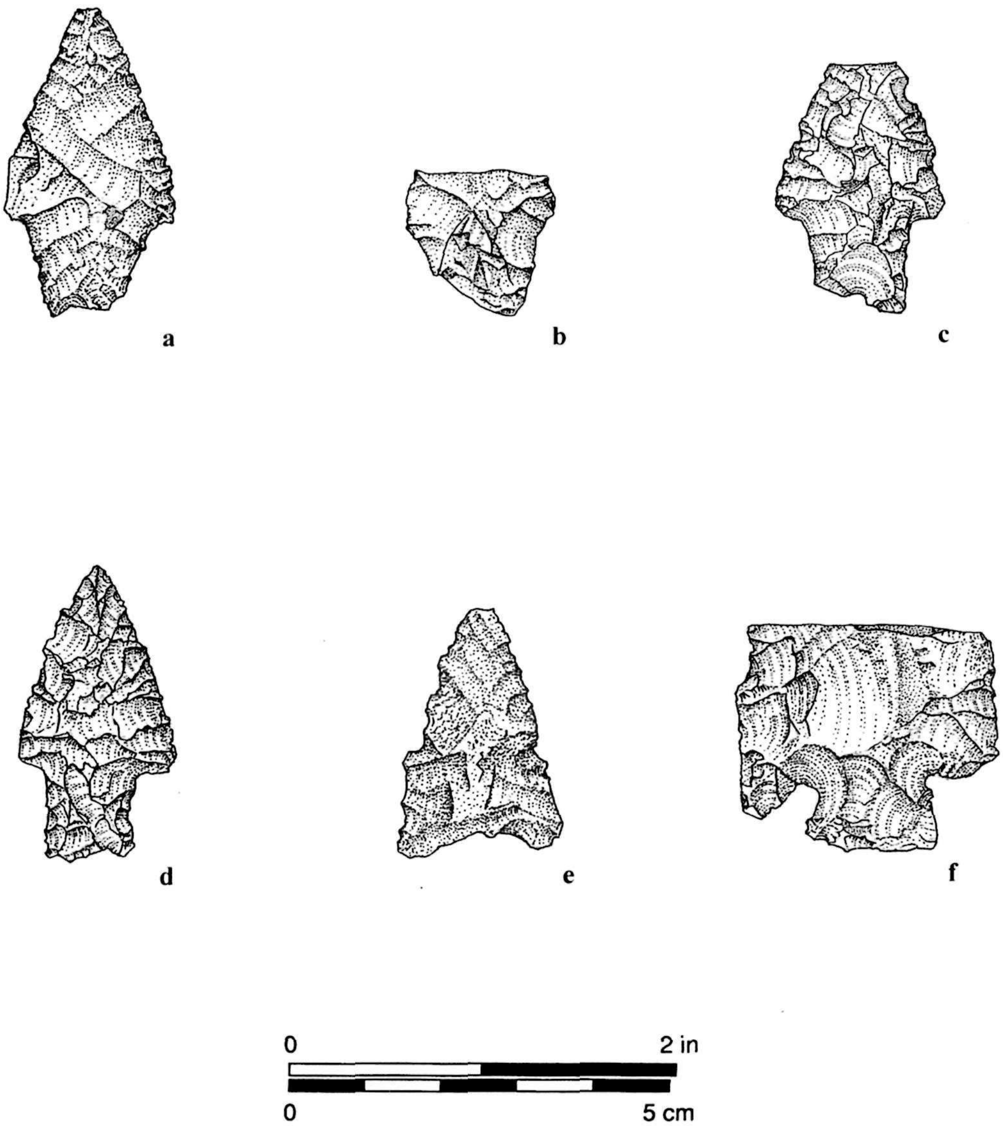

Figure 6. Hafted bifaces recovered at Lithic Concentration 1 and an isolated projectile point, 5GN204/205: (a) gray and white quartzite biface, Field Cat. No. 5038; (b) chert projectile point midsection, Field Cat. No. 5004; (c) white agate point fragment, Field Cat. No. 5064; (d) complete, stemmed point made from milky agate with orange staining, Field Cat. No. 5008; (e) quartzite point, Field Cat. No. 5039; (f) large corner-notched quartzite hafted biface fragment, Field Cat. No. 5066, from the ground surface at Positive Shovel Test 1.

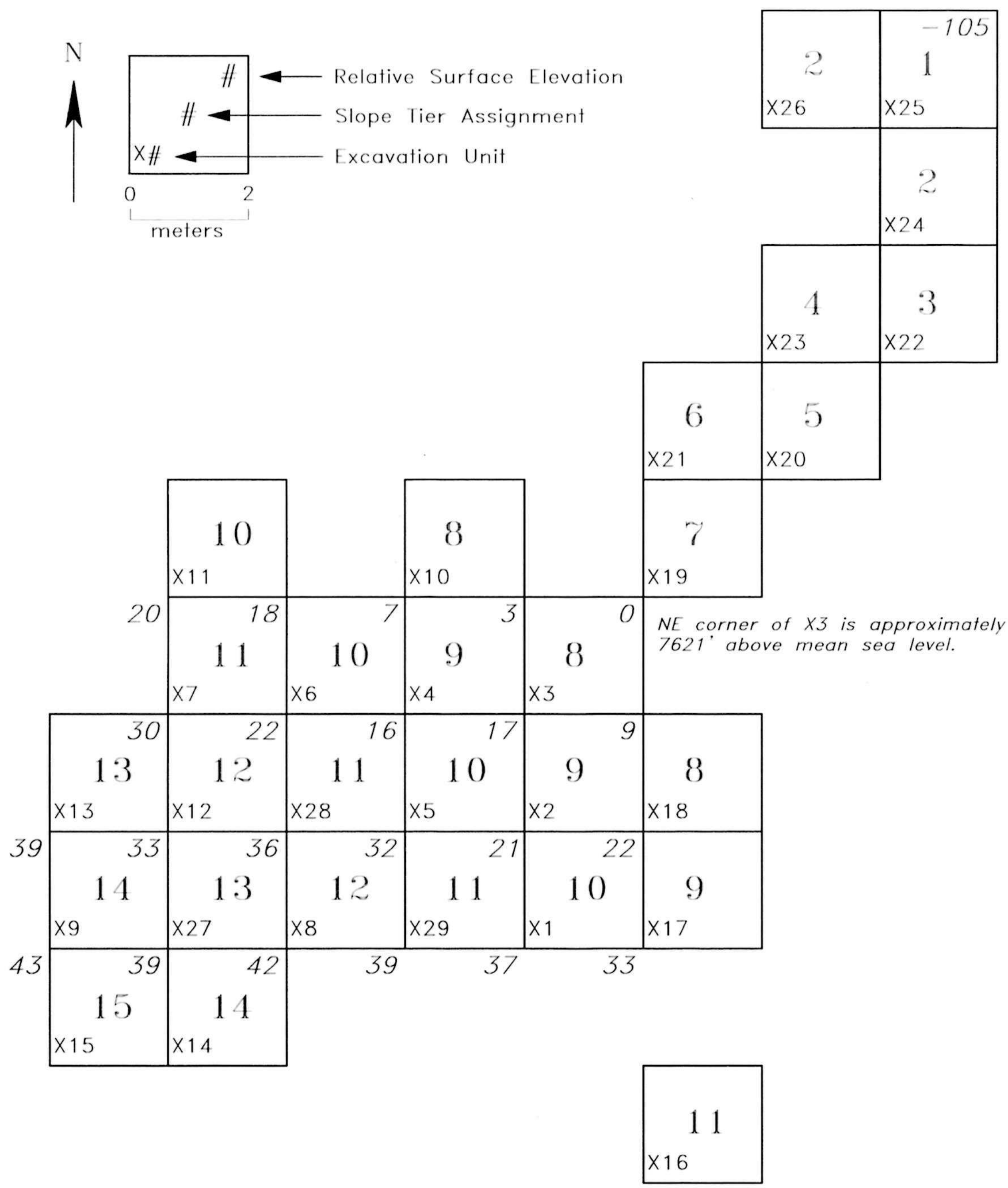

Figure 7. Relative surface elevations and slope tier assignments across Lithic Concentration 1, Area 831, 5GN204/205.

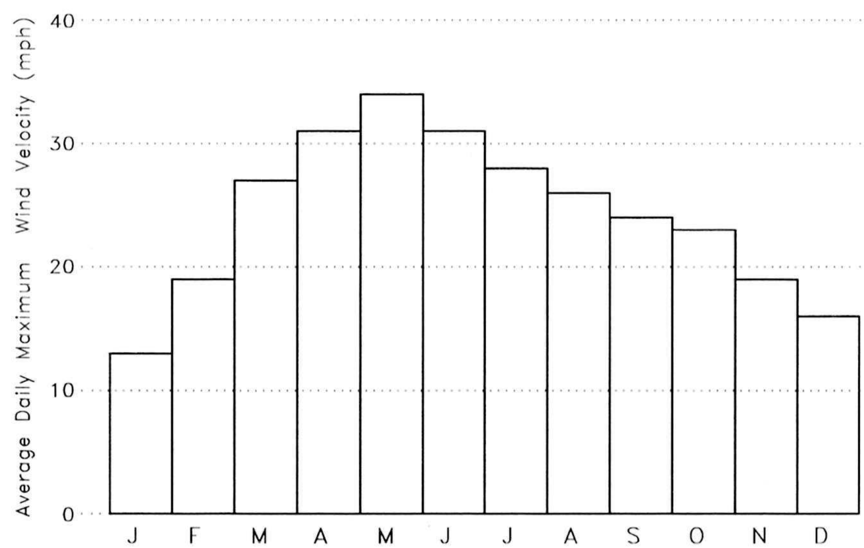

Figure 8. Monthly average of maximum daily wind velocity recorded at the Blue Mesa Lake weather station, Colorado, between 1989 and 1991.

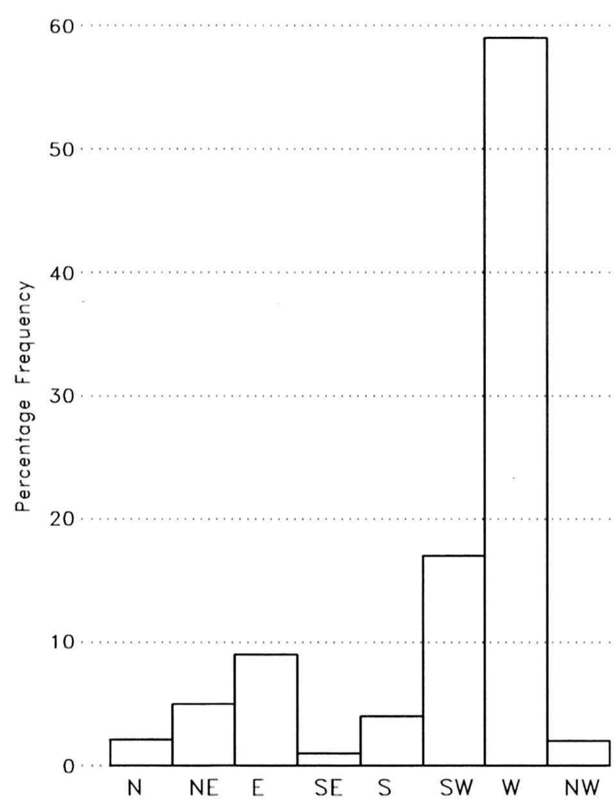

Figure 9. Frequency of maximum velocity winds by direction, 1989-1991, Blue Mesa Lake weather station, Colorado.

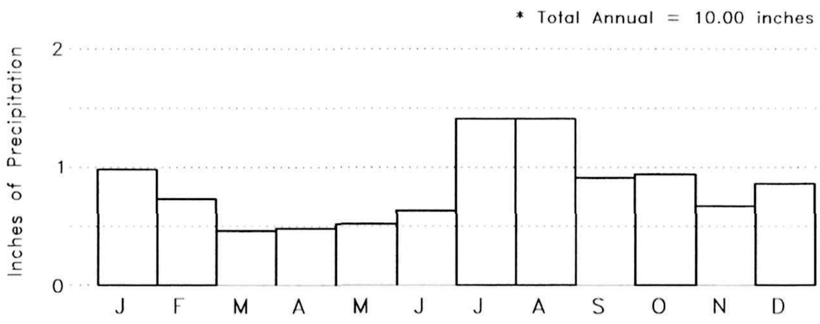

Figure 10. Average monthly precipitation received at the Blue Mesa Lake weather station, Colorado, between 1967 and 1990 (data on file, Climate Division, Colorado State University, Fort Collins).

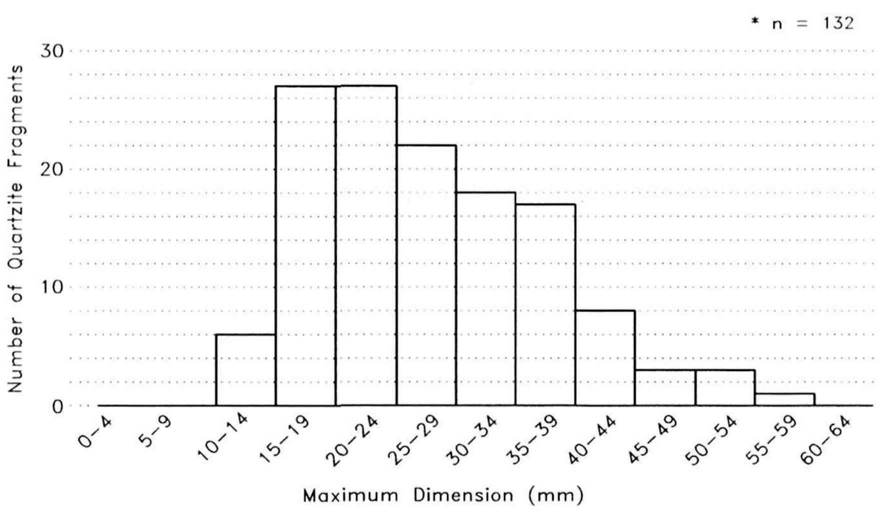

Figure 11. Size of quartzite artifacts recovered from Lithic Concentration 1, Area 831, 5GN204/205.

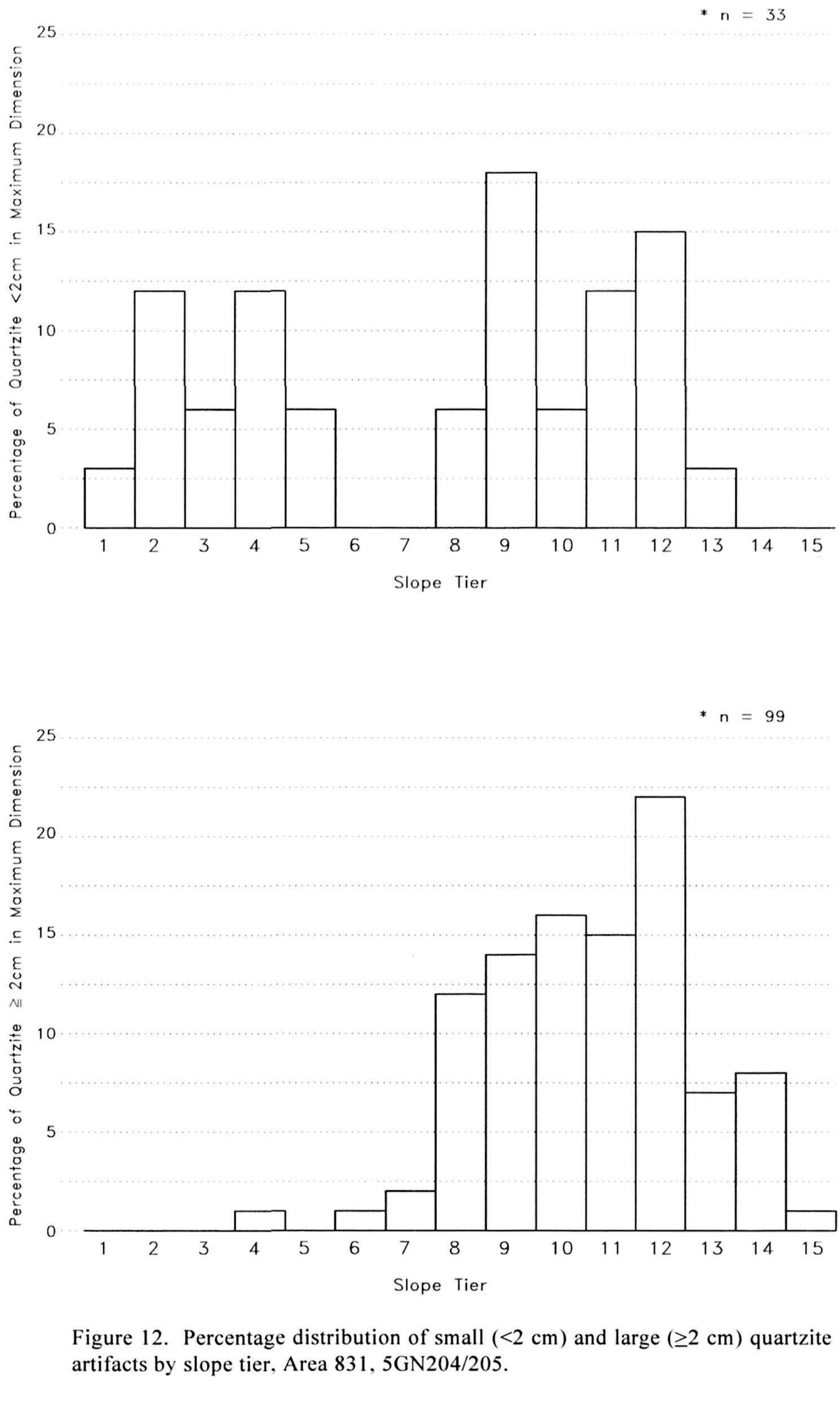

Figure 12. Percentage distribution of small (<2 cm) and large (≥2 cm) quartzite artifacts by slope tier, Area 831, 5GN204/205.

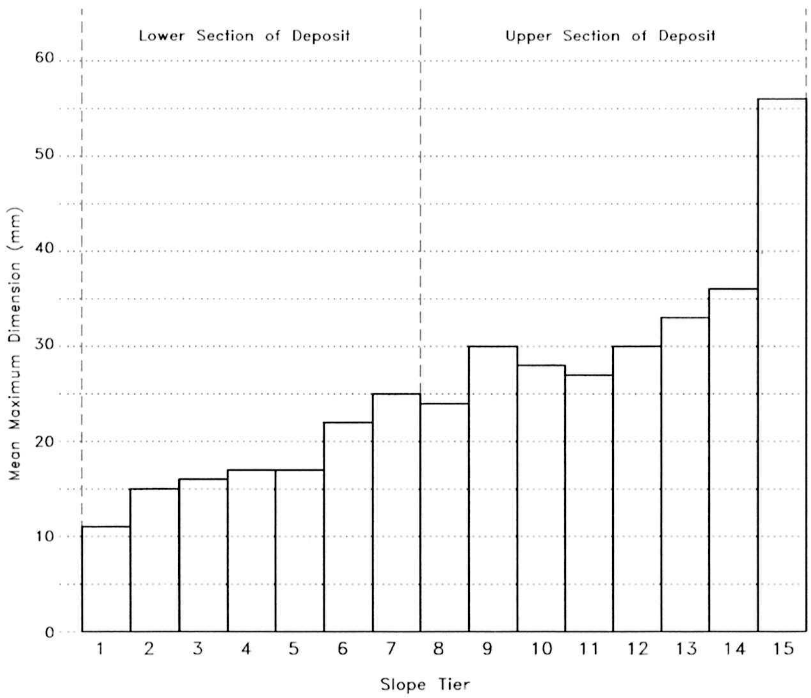

Figure 13. Average size of quartzite artifacts for each slope tier, Area 831, 5GN204/205.

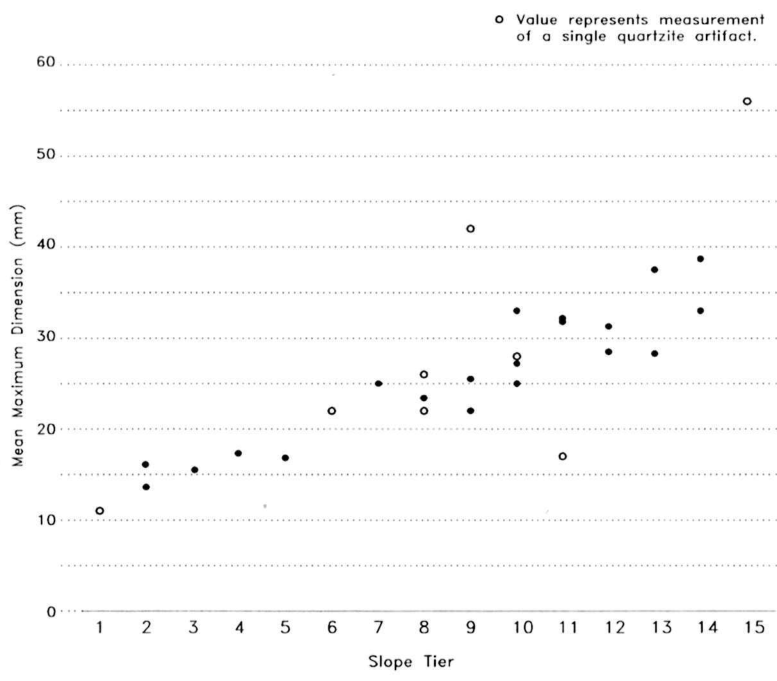

Figure 14. Scatter plot of quartzite artifact mean maximum dimensions and slope tier for 2-m squares, Area 831, 5GN204/205.

APPENDIX A

REVIEW OF SELECTED LITERATURE ON THE ARCHEOLOGICAL EFFECTS OF NATURAL EROSION

An extensive body of literature concerned with the operation and effects of natural erosional processes has been generated within such diverse fields as paleontology, engineering, and agriculture. While much of that literature is relevant to archeological research, many studies have also been undertaken by archeologists which specifically address problems defined within the discipline. Some of the latter studies have been experimental in nature, while others have involved the application of experimentally derived conclusions to the interpretation of actual archeological deposits. Still, many basic questions remain to be answered because of the overall need for additional research along these lines coupled with the situational nature of erosion in every setting. While the discussion of selected studies presented in this appendix may appear to characterize these processes in simplistic terms, natural erosion is typically complex and may involve the interaction of numerous factors which have changed in relative importance through time. This review is generally confined to information deemed most relevant to the present study.

Rick (1976) has addressed the downslope displacement of artifacts under the influence of gravity, suggesting that gravity was the primary factor responsible for the artifactual distributions observed on the slopes below a Peruvian rockshelter. Those slopes were relatively steep and ranged in angle up to about 44°. Rick found that the heavier denser artifacts at the site had been displaced further downhill than the lighter artifacts. With regard specifically to the lithic artifacts, he determined that the heaviest artifacts had ceased downhill movement and were thus deposited/redeposited when the angle of the slope was about 16°–17°, referred to as the critical angle for that material at that particular site. Because vegetation growing on the slopes would have served to inhibit some of that downhill movement, the density of plant growth was believed to have affected the magnitude of the critical angle. Rick ultimately concluded that any given slope must be steeper than a certain critical angle in order for an object to travel downhill after it is dropped or dislodged. For slopes with a gradient equal to or greater than the critical angle, the average weight of artifacts may be expected to correlate with the slope. In contrast, Rick suggested that horizontal artifact distributions on lesser slopes may predominately reflect the operation of cultural rather than natural processes.

Wandsnider (1989) has conducted experimental research on the movement of modern artifact collections under the influence of several natural processes. That research began with a year and a half of field observation at experimental artifact stations established in a stabilized dune setting in west-central New Mexico. A computer simulation of the model developed from those observations was then conducted in order to study the longer-term effects of natural processes on the archeological record. In this case, artifact movement data were generated for 50 years of simulated time.

During the initial field component of Wandsnider's research, artifact size was found to contribute significantly to differential artifact movement when the experimental station was located on a moderate or steep slope with a consolidated substrate, i.e., the station was underlain by relatively compact sediments. Further, the results of her computer simulation suggested that the largest artifacts in an assemblage tend to disperse the greatest distance from the point of introduction at a site with a consolidated substrate, even in the absence of a surface slope (variation in degree of slope was not investigated during the simulation). Under those particular conditions, any original spatial associations between large and small artifacts may become lost during the subsequent size redistribution of the material. Thus, in general, Wandsnider's research suggested that the nature of the substrate at a site may greatly affect the structuring of the artifact assemblage by either facilitating or moderating the effects of wind, water, gravity, and other impinging factors. The least amount of artifact displacement typically occurred during this study in contexts of intermediate substrate compaction, resulting in artifact movement on a scale of 1 to 2 sq m. In contexts of either consolidated or unconsolidated substrates, the scale of spatial restructuring ranged between 5 and 10 sq m. While artifacts within the simulated assemblage continued to move relative to each other through time, the general movement of the assemblage as a whole ceased after 10 to 14 years, a phenomenon which has been reported elsewhere and is discussed further below. Wandsnider also found that the density of vegetation growing on a site affected artifact movement, the degree of effect varying in part with the coming and going of the growing season.

Experimental research has also been conducted by Simms (1984) to study the effects of slope and wind upon artifact movements in sand dune settings. According to Simms, wind deflation of sand dunes may result in the vertical displacement of artifacts at a site. As a consequence, artifacts originally deposited in a stratigraphic sequence may subsequently become mixed or combined, thereby limiting the interpretive potential of those materials.

Artifacts may also move horizontally in dunal settings. In a study designed principally to investigate the latter kind of movement, Simms established four experimental plots of modern artifacts in the Sevier Desert in western Utah on sand dunes which had been stabilized to varying degrees by surface accumulations of calcium carbonate. Those plots were located on slopes which ranged between 6° and 17°. The positions of the artifacts were then remeasured approximately six months after the plots were established. The results suggested that artifact movement in dunal settings will be affected by the following factors: (1) artifact size and shape; (2) direction of prevailing winds versus direction of other seasonal winds; (3) nature of the ground surface, especially the presence of carbonate crusts; and (4) slope and aspect of the exposure.

Unfortunately, much of the artifact movement recorded by Simms occurred in a direction which coincided with both the ground surface slope and either the prevailing or a seasonal wind. As a consequence, the individual contributions of slope and wind to artifact movement could not be determined. However, two of the experimental artifacts were found to have moved downslope and into the wind, similar to artifact behavior previously reported by Beckett (1980). Simms also suggested that seasonal precipitation in the study area served to temporarily inhibit artifact movement through increased adherence between the artifacts and the moist ground.

A fifteen-year field experiment in downslope surface movement was conducted by Caine (1981), who introduced several sets of marked stones on four Tasmanian sites with surface slopes ranging between 1° and 12°. The results of the study suggested that the stones underwent an initial period of rapid downslope movement, referred to as a settling period. Gradually, the stones became incorporated into the natural surfaces of those sites and their movement rates slowed. While the settling periods for the experimental materials at the Tasmanian sites lasted for approximately one year, Caine suggested that the length of time necessary for this transition will be different at every site. Shorter settling periods should occur where the natural long-term surface movement rates are relatively rapid.

Frostick and Reid (1983) conducted a study concerned with the downslope movement of paleontological and archeological materials of various shapes and sizes under the influence of gravity. During the study, vertebrate fossils, artifacts, and natural basalt cobbles were collected, marked, and reintroduced on a moderately steep slope of approximately 30° in a badland setting in Kenya. The positions of the experimental objects were then rechecked after one and two years, and a few object positions were recorded after a third year. Frostick and Reid concluded that large spherical and rod-shaped objects may be expected to move rapidly down a steep slope in an unvegetated arid environment. Objects with a blade or disc shape and small light objects will move at slower rates. In addition, the experimental cobbles which fell into shallow chutes and rills that carried rainwater runoff from the Kenyan site exhibited the highest rates of movement during the study. The large objects within the runoff features were ultimately displaced when they were undermined through the removal of the small underlying particles. However, Frostick and Reid suggested that runoff appears to be incapable of displacing objects larger than 8 mm in size on slopes of less than about 10°. No evidence was observed during the three years of this study for a settling period similar to that reported by Caine (1981).

During an experimental project conducted in a South African coastal dune setting, Lancaster (1986) observed that small artifacts were particularly subject to displacement during wind erosion. Lancaster found that a direct relationship ensued between flake size and displacement by wind for those artifacts which were positioned on the windward side of a sand dune undergoing active deflation. In a separate study, Nicholson (1983) concluded that microdebitage less than 2 mm in size is generally a poor indicator of archeological site location because of its susceptibility to displacement by eolian erosional processes, dispersing downwind from the larger material. Wandsnider's experimental research also confirmed that high velocity winds are capable of displacing artifacts, particularly those less than about 2 cm in size (Wandsnider 1989:52). She found that artifacts on a loose sandy substrate were the most susceptible to such displacement, although artifacts on consolidated substrates also exhibited considerable movement during her study. Artifacts on substrates of intermediate compaction were the least likely to be affected by wind.

Isaac (1967) documented the movements of experimental artifacts subjected to flowing water under flash flood conditions. Those movements were found to include the settling and burial of artifacts in stream bottom sediments, the horizontal rotation of artifacts relative to the direction of the current, the washing of artifacts into clusters, and dispersal downstream of the smaller flakes. The size of artifacts which may be displaced by running water is believed to be largely a function of water velocity (Schiffer 1987:268). At a South African site with an overall surface slope less than 5°, Butzer (1982:101–102) observed that rainwater runoff had concentrated artifacts into clusters based upon microtopographic variations across the site. The edges of the artifacts at the latter site also exhibited abrasion, and the smaller pieces of debitage had been completely washed away. Turnbaugh (1978:597) observed that water currents may sort artifacts according to size, shape, and relative density of material, or may align artifacts along the flow. Wandsnider's research has suggested that artifact movement will vary according to substrate compaction when rainfall amounts are high (Wandsnider 1989:52). Specifically, horizontal artifact movements will be greatest where sediments are relatively compact and least where sediments are loose.

The size-sorting effects of freeze-thaw processes have been addressed by Benedict during research conducted in alpine settings along the Colorado Front Range (e.g., Benedict 1970, 1976, 1990). In general, certain of those processes serve to separate the fine- and coarse-textured materials in a deposit. For example, the coarse inclusions in a deposit may be displaced upward toward the ground surface by the process of frost heaving, which involves the formation of ice layers within the soil. That heaving or expansion of the soil usually occurs at right angles to the ground surface. During a subsequent thaw, the soil will typically settle in a vertical direction. For deposits on a slope, repeated freeze-thaw cycles may then result in the gradual horizontal displacement of the largest materials in a downhill direction, a process known as frost creep. The settling component of this process also occasionally occurs in a nonvertical direction, resulting in the upslope displacement of inclusions referred to as retrograde movement. Frost heaving has its greatest effect under conditions of moisture saturation coupled with a slow deep freezing of soil which contains much fine-textured material, i.e., silt and clay. The presence of bedrock at a relatively shallow depth (0.5–1.0 m) may lessen the effect of these freeze-thaw processes because of the reduced amount of soil within which ice may form.

In the Front Range, Benedict determined that moisture availability at the beginning of the annual freeze-thaw cycle during the fall is of critical importance to the rates of movement exhibited by materials under the influence of frost heaving and other such processes. That moisture may be supplied by any combination of sources but most typically includes fall precipitation and meltwater from perennial snowbanks. All sizes of rock debris may be displaced during the annual cycle when soil moisture content is high. Small stones on the ground surface may also be affected by the shorter term, shallow freeze-thaw cycles which occur during both the spring and the fall.

Freeze-thaw processes may also create symmetrical patterns of coarse and fine materials across an expansive area. Such patterns include sorted circles, polygons, and nets which may elongate into steps and stripes with increased gradient. Goldthwait (1976) has related the size of the individual cells within such patterns to the mean maximum size of the rock fragments present in an area. Cell sizes may range from 5 cm in diameter to more than 100 m across. Unit size has also been associated with the process of feature origin (e.g., needle ice may produce only small forms of patterned ground) and with climatic conditions. With regard to the latter, short-term freeze-thaw cycles and shallow freezing tend to produce small forms, while annual freeze-thaw cycles accompanied by deep freezing tend to produce large forms (Washburn 1980).

Ultimately, it appears that frost creep may result in the formation of stone-banked lobes and terraces on a slope when the fast-moving large rock within such features as sorted stripes slows and spreads in an area of reduced gradient. In general, such stone-banked lobes and terraces were found to have developed in the Front Range on relatively steep upper slopes which averaged 16°–17° and were generally devoid of vegetation.

In contrast, the freeze-thaw process of solifluction involves the slow flowing of moisture-saturated sediment in areas with increased vegetation, and appears to result in a faster rate of downhill movement for fine particles than for coarse materials. It may also serve to obliterate any vertical size sorting which was previously introduced into the deposit by frost heaving. In the Front Range, solifluction has typically occurred on lower gentler slopes which average about 10°. Abundant moisture availability during the fall is particularly critical to the operation of this process.

While solifluction and frost creep have been defined as separate and distinct processes, they have frequently operated in combination during the past to produce many of the individual landforms found in the Front Range today. Their relative intensity and importance in reshaping the landscape has changed through time with fluctuating climatic conditions, in large part because of the greater dependence of solifluction upon moisture for its operation. Solifluction has decreased in overall importance since the Late Wisconsin Glaciation, while periods of significant frost creep activity have occurred as recently as 1,000 years ago. However, Benedict has indicated that "neither process is particularly effective today, except in specialized microenvironments that are saturated with meltwater in the autumn" (Benedict 1970:166).

In summary, Benedict has identified the availability of abundant moisture at the initiation of the freeze-thaw cycle as the key factor required for the effective operation of all of these processes in the Colorado Front Range. The sources of moisture typically include precipitation received at that time of year and meltwater from perennial snowbanks. The rates of downhill sediment movement under the influence of these processes are therefore dependent primarily upon timely moisture availability, generally in the fall, and secondarily upon the degree of ground surface slope. Of course, the amount of seasonal moisture may vary through time with climatic change. The maximum modern rates of downhill movement measured by Benedict at experimental sites in the Front Range ranged from 0.4 cm to 4.3 cm per year. The process of frost heaving and downslope movement affected sediments to a depth of 50–75 cm.

In a broad-ranging overview of disturbance processes which may affect archeological deposits, Wood and Johnson (1978) described another possible freeze-thaw process to result in a similar vertical size sorting of sediment inclusions. However, sorting by frost action is believed to develop through the downward migration of fine particles as freezing proceeds deeper into the ground, rather than through the upward displacement of coarse materials. Wood and Johnson also discussed the formation of stone pavements in periglacial regions thought to result largely from the combined effects of frost heaving/vertical frost sorting and wind/water erosion of fine particles at the ground surface. Stone pavements consist of a mosaic of stones across the ground surface oriented with flat surfaces facing upward. The effects of frost heaving upon the orientation of objects in the ground and the extent to which orientation will then affect the vertical displacement of objects have been investigated by Johnson and Hansen (1974) and Johnson et al. (1977). Finally, during field experiments conducted by Bowers et al. (1983) in arctic and subarctic environments in Alaska, many experimental artifacts were observed to have moved upslope. It was suggested that those movements may have related to the formation and collapse of needle ice, perhaps in combination with the factors of sun and wind which could have affected the direction of ice crystal collapse. Since needle ice may form only at and immediately beneath the ground surface, its displacement effects will also be limited to artifacts included within those zones.

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