Adverse Effects of Domestic Livestock Grazing on the Archaeological Resources of Capitol Reef National Park, Utah

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Abstract. The effect of livestock grazing on archaeological resources in Capitol Reef National Park was evaluated by examining 8 existing prehistoric sites and by establishing 13 experimental artifact plots. Five of the prehistoric sites were rock-shelters, first recorded in 1958. Qualitative reassessments of these sites in 1985 revealed substantial effects of cattle and human vandalism. The effects of grazing were quantitatively assessed by establishing 12 2- × 2-m plots and 1 1- × 1-m control plot with manufactured stone flakes, tools, and ceramic fragments. Experimental plots were established in fall 1985 and monitored after a 10-month period. Factors monitored included differential breakage and damage, visibility, and displacement. Both lithic and ceramic artifacts are damaged by livestock activity, but ceramic artifacts are more severely affected.

Key words: Animal trampling, archaeological remains, Capital Reef National Park, ceramic artifacts, grazing.

Archaeologists have long been aware of the effects of wild and domestic herd animals on the material remains that constitute the prehistoric record. Accounts of animals trampling archaeological remains include McBurney's (1960) description of postdepositional wear on lower Paleolithic and Acheulian artifacts at Sidi Zin (northern Tunisia) caused by herds of large mammals around a water hole. Lynch (1974) described the stone tools of the Chuqui complex from northern Chile that were typically found along deeply furrowed trails used by shod pack animals, cattle, and iron-tired wagons. One of the best known instances of detrimental effects of livestock on archaeological sites concerns the spectacular early hominid locality, Olduvai Gorge, in east Africa (Johanson and Edey 1981). Fossilized human teeth and cranial fragments of a 1.5–1.85-million-year-old *Homo habilis* ("Olduvai George") were trampled by Masai cattle the night before they were to have been excavated.

Gifford (1981) discussed the dramatic changes that have occurred in paleontology as a result of taphonomic studies conducted by German researchers in the early 1900's. Efremov (1940, 1953) formalized a number of natural processes responsible for burial and postdepositional changes in fossil remains. Paleontologists began to use taphonomic processes in studies that emphasized the dynamic aspects of prehistoric animal populations and biological communities. Archaeologists also now realize that explanations of past human behavior cannot proceed without consideration of the natural processes that alter prehistoric remains during and following their deposition.

Some of the taphonomic processes studied to date include physico-chemical weathering, hydrodynamic sorting, aeolian modification, cryoturbation, solifluction, bioturbation (including trampling by wild and domestic animals and humans), and animal gnawing and consumption (e.g., Stockton 1973; Behrensmeyer 1976; Gifford and Behrensmeyer 1977; Gifford 1978, 1980, 1981; Moeyersons 1978; Wood and Johnson 1978; Flenniken and Haggarty 1979; Binford 1981; Brain 1981; Wildesen 1982; Nash and Petraglia 1984; Simms 1984; Gifford-Gonzalez et al. 1985; Sala 1986; Pintar 1987; Schiffer 1987; Pryor 1988; Wandsnider 1989; Hartley 1991; Nielsen 1991). These natural processes operate singly or in combination to modify the composition, condition, and distribution of archaeological and ecological remains.

This study was done to evaluate the effects of livestock grazing and associated human activities on the archaeological resources in Capitol Reef National Park, southeastern Utah. Initially, our investigations were conducted in response to Public Law 97-341 that required cooperative, systematic studies of the effects of livestock grazing on federal lands.

Before this investigation, studies of the effects of livestock on archaeological remains were limited (e.g., Naval Weapons Center 1981; Van Vuren 1982; J. Roney, Bureau of Land Management, Nevada State Office, Reno, unpublished study). Our study of the harmful effects of grazing on archaeological remains in Capitol Reef National Park, Utah, involved two primary field endeavors: an examination of select archaeological sites (recorded) within the park to assess effects from livestock activities; and the establishment of experimental artifact plots to assess current livestock effects. More detailed results have been published elsewhere (Osborn et al. 1987).

Methods

Fieldwork included reconnaissance of select recorded archaeological sites, creation of experimental artifact plots, and later monitoring of the artifact experiments. Eight archaeological sites (six rock-shelters and two lithic scatters) were examined, and the artifact experiments were established between 23 September 1985 and 3 October 1985. The artifact plots were monitored from 21 June through 24 June 1986.

Park personnel provided information and suggestions concerning current livestock grazing activities. We decided to monitor livestock disturbance over a greater area of the park—particularly in four grazing allotments (Waterpocket, Sandy III, Hartnet, and Cathedral) scheduled for grazing during winter (1985–86).

Twelve experimental plots and one control plot were placed along a 96-km north–south axis that crosscut 5 of 18 grazing allotments within the park (Fig. 1). Eight plots were established near vegetation exclosures; these exclosures were fenced, ungrazed vegetative plots established by park personnel. Plots were established from 15 m (unit A) to more than 400 m (unit I) from vegetation exclosures. Four plots (units F, G, H, and K) were not associated with any of the vegetation exclosures. A control plot was established within a vegetation exclosure. Several plots were established in locations analogous to known archaeological sites in the park (e.g., unit F) or they were set up near rock-shelters (unit G near 42GA651) and artifact scatters (e.g., units H and K). Two of the units were located close to water sources. Unit H lay 50 m north of the Fremont River near its confluence with Deep Creek. Unit K was placed less than 40 m from Ackland Spring.

Plots were placed on relatively flat ground. Each 2- × 2-m experimental plot was established using portable meter-grid frames subdivided into 100 10- × 10-cm cells. Plots consisted of four conjoined 1- × 1-m quads aligned with magnetic north using Brunton field compasses. The four outermost corners were marked using 8-inch steel nails or spikes. Nylon twine outlined the unit to align the 1- × 1-m grid frames. Crew members did not disturb the original ground surface of the plots at this time. Azimuths and distances from plots to nearby landmarks or permanent features were made using Brunton compasses and steel tapes.

The original assemblage consisted of 980 artifacts including 572 (58%) flakes, 17 (2%) tools, and 391 (40%) ceramic vessel fragments. The stone flakes and tools were produced at the Midwest Archaeological Center (National Park Service) laboratory from obsidian obtained from Glass Buttes, Oregon. Soft hammer percussion and pressure flaking were used to produce flakes of varying sizes. Ten unglazed, commercially produced clay flower pots provided potsherds. Plot designation and plot specimen number were placed on all artifacts with india ink, correction fluid, and clear nail polish. All experimental artifacts were traced on metric graph paper and were weighed to the nearest 0.01 g. These tracings and weights were later used to assess artifact attrition and breakage.

Experimental artifacts were then placed in the extreme northwest corners of specified 10- × 10-cm cells (Fig. 2). Twenty cells (20%) within each 1- × 1-m quad were selected using computer-generated random numbers with replacement. The numbering sequence for the 100 10- × 10-cm cells is illustrated in Fig. 3. All duplicate numbers were ignored, and only one artifact

was placed in a designated cell. Catalog numbers for artifacts in each cell were recorded on grid plots for each of the 49 squares. All experimental units were located on 15-min topographical maps, and the position and vegetative context of each unit was described in detail. A photographic

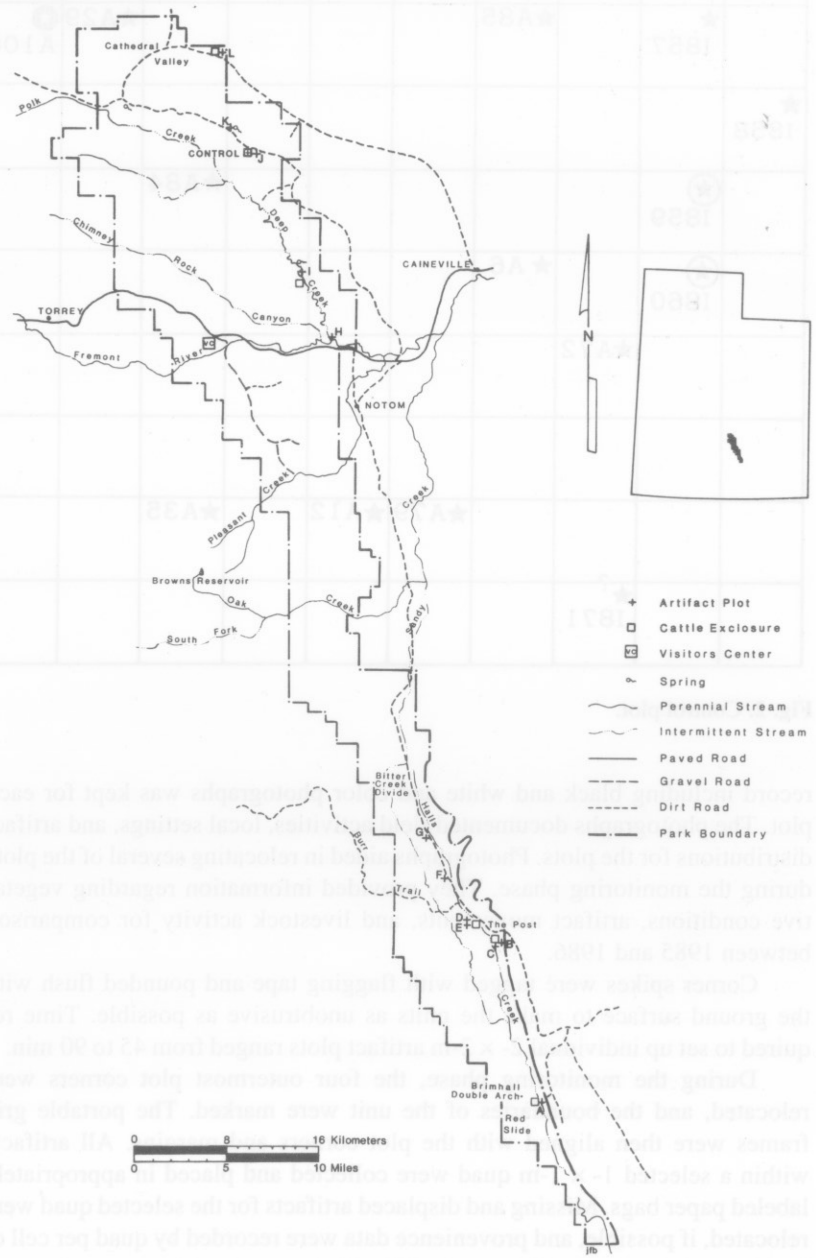

Fig. 1. Capitol Reef National Park with locations of artifact plots and cattle exclosures.

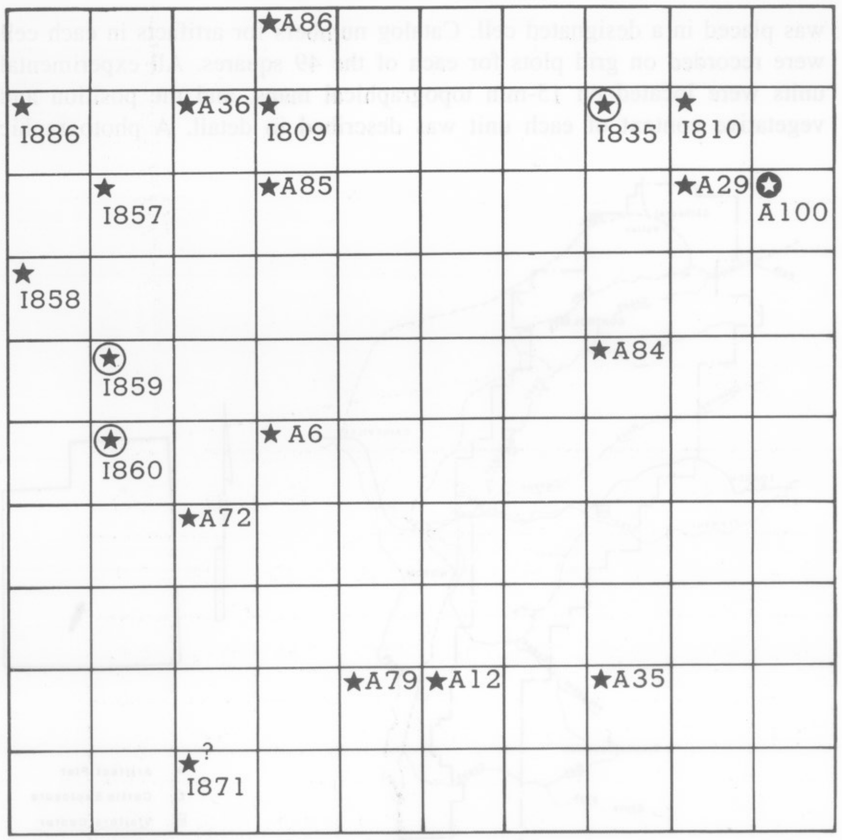

Fig. 2. Control plot.

record including black and white and color photographs was kept for each plot. The photographs documented field activities, local settings, and artifact distributions for the plots. Photographs aided in relocating several of the plots during the monitoring phase. They provided information regarding vegetative conditions, artifact movements, and livestock activity for comparison between 1985 and 1986.

Corner spikes were tagged with flagging tape and pounded flush with the ground surface to make the units as unobtrusive as possible. Time required to set up individual 2- × 2-m artifact plots ranged from 45 to 90 min.

During the monitoring phase, the four outermost plot corners were relocated, and the boundaries of the unit were marked. The portable grid frames were then aligned with the plot corners and margins. All artifacts within a selected 1- × 1-m quad were collected and placed in appropriately labeled paper bags. Missing and displaced artifacts for the selected quad were relocated, if possible, and provenience data were recorded by quad per cell or by triangulation from plot corners (Fig. 4). No probing or excavation was

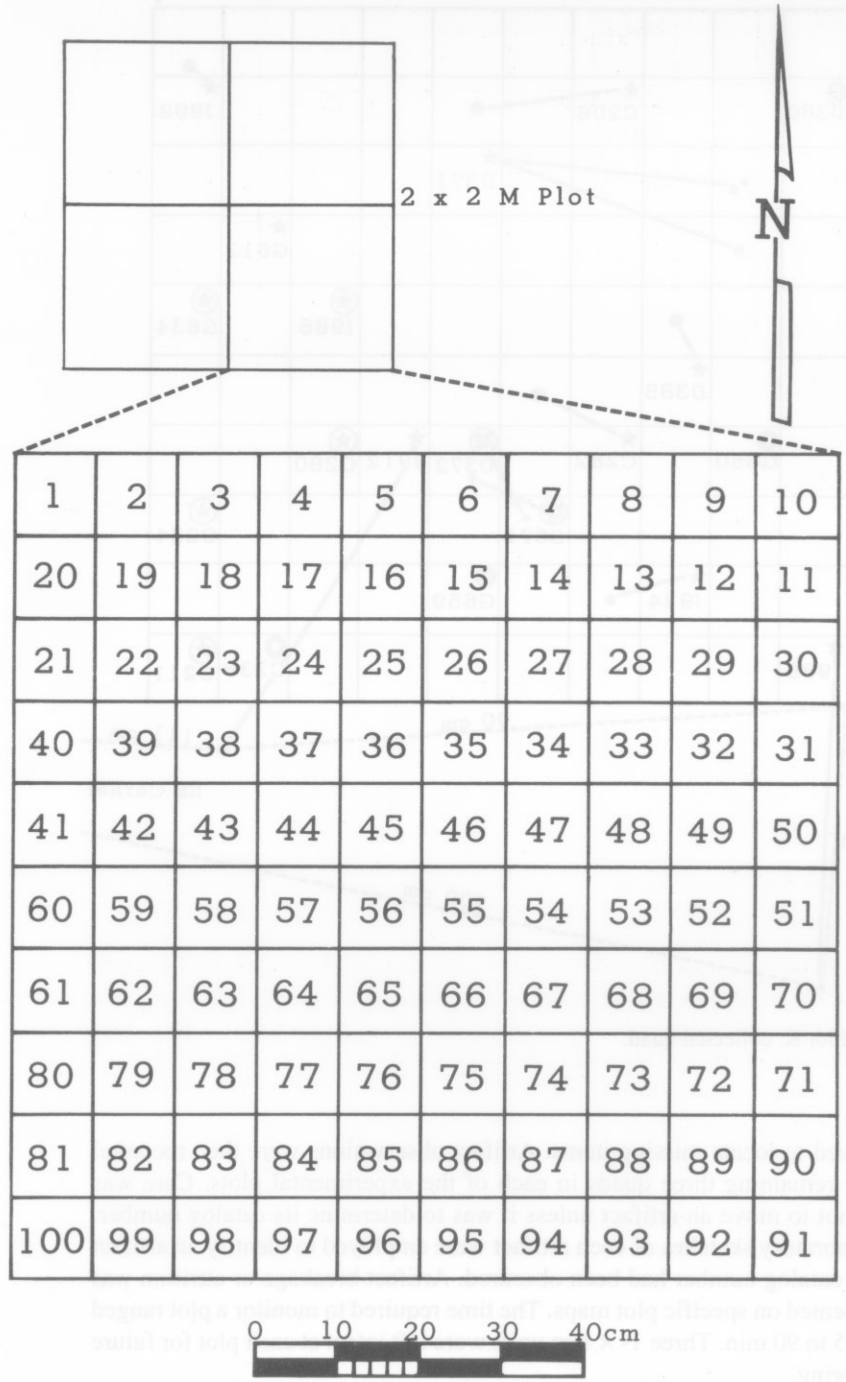

Fig. 3. Artifact plot numbering, scale, and orientation.

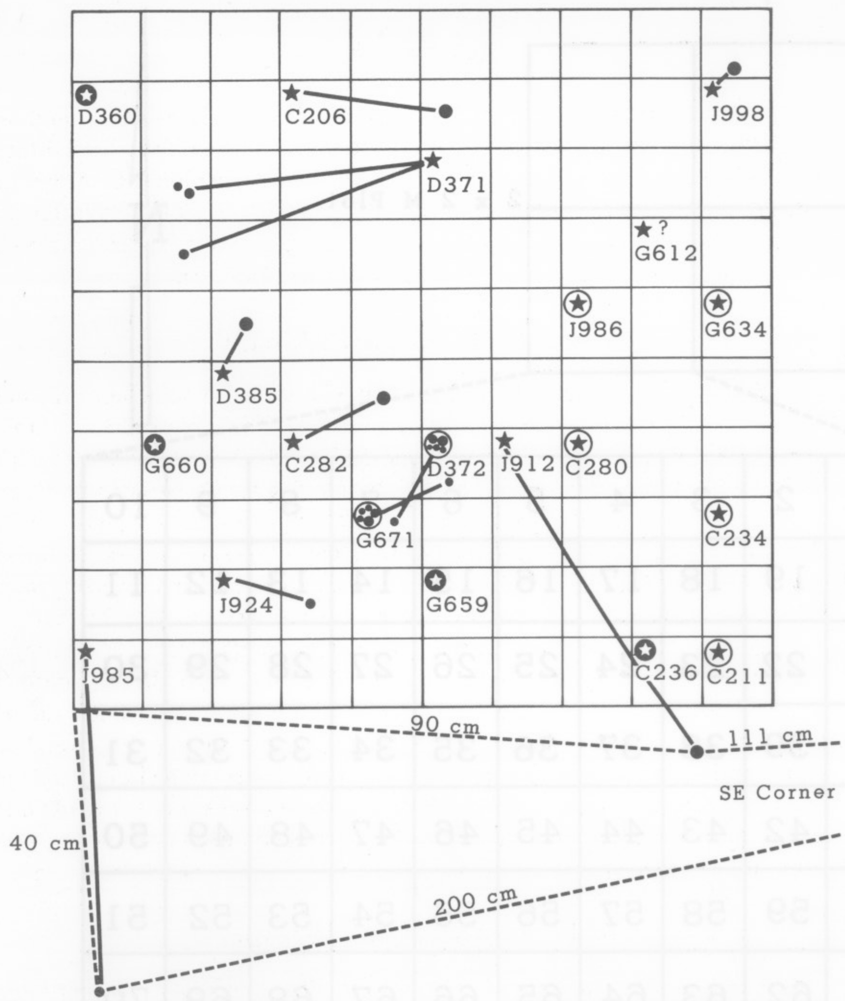

Fig. 4. Plot K, collected quad.

employed to locate missing items. Artifact observations were then recorded for the remaining three quads in each of the experimental plots. Care was taken not to move an artifact unless it was to determine its catalog number. The laboratory sketches of each artifact were employed to identify an artifact whose catalog number had been obscured. Artifact breakage or attrition was documented on specific plot maps. The time required to monitor a plot ranged from 45 to 90 min. Three 1- × 1-m units were left intact at each plot for future monitoring.

Results

The analysis focused on the observable effects of livestock trampling artifacts at both the individual plot level and the total assemblage level. More specifically, the study examined differential postdepositional breakage or edge damage, differential visibility, and differential horizontal displacement (Figs. 5–7; Table 1). Analysis made use of field observations concerning both collected and noncollected experimental artifacts (Table 2).

Differential Artifact Visibility

Sixteen percent (162/980) of the original artifact assemblage was not visible. Artifacts that were not visible included 116 flakes (72%), 3 lithic tools (2%), and 43 ceramic fragments (26%); 116/572 (2%) flakes; 3/17 (18%) lithic tools; and 43/391 (11%) ceramic fragments. Missing debitage weights ranged from 0.1 to 37.1 g; their mean weight was 2.17 g (SD = 4.90). Most (79%) of the missing debitage weighed 2.0 grams or less. A linear regression revealed that the disappearance of debitage varied inversely with mean debitage weight per plot ($r = -0.3815$; $R = 0.1455$; df = 9; $P > 0.10$).

Forty-three potsherds were not visible in the plots. These sherds represented 11% of the original 391 placed in the plots and 27% of the artifacts that were not visible. Mean weight per size class for these "invisible" sherds equaled 1.67 g (range = 0.1–11.1; SD = 2.64). Thirty-three (75%) weighed less than 2 g. This conforms to previous observations regarding lithic debitage weight per size class and visibility. Based on these observations, we find that sherds are more likely to be damaged but less likely to disappear compared with lithic debitage and small tools.

Differential Artifact Breakage

Intact artifacts numbered 763 (93%). Fifty-five (7%) artifacts were broken or modified. Eleven lithic and 44 ceramic items were broken. Eleven pieces of debitage exhibited edge damage or were fragmented. These modified debitage pieces represent 2% of the original debitage sample or 2% of the visible debitage. None of the 14 visible lithic tools were modified (i.e., no edge damage or breakage).

The observed pattern of artifact breakage indicates that lithic debitage and potsherds are affected differently by domestic livestock trampling. A chi-square test revealed that lithic artifacts and potsherds exhibited different degrees of damage (two-tailed test; df = 1; $P \leq 0.001$). The chi-square value equaled 82.40, and the critical value equaled 10.83. In the trampled plots, fewer lithic items (debitage and tools) and more potsherds were damaged or broken than were expected.

Two forms of ceramic breakage were noted. Sherds exhibited either snap fractures or laminar exfoliation. Several sherds reflected evidence for

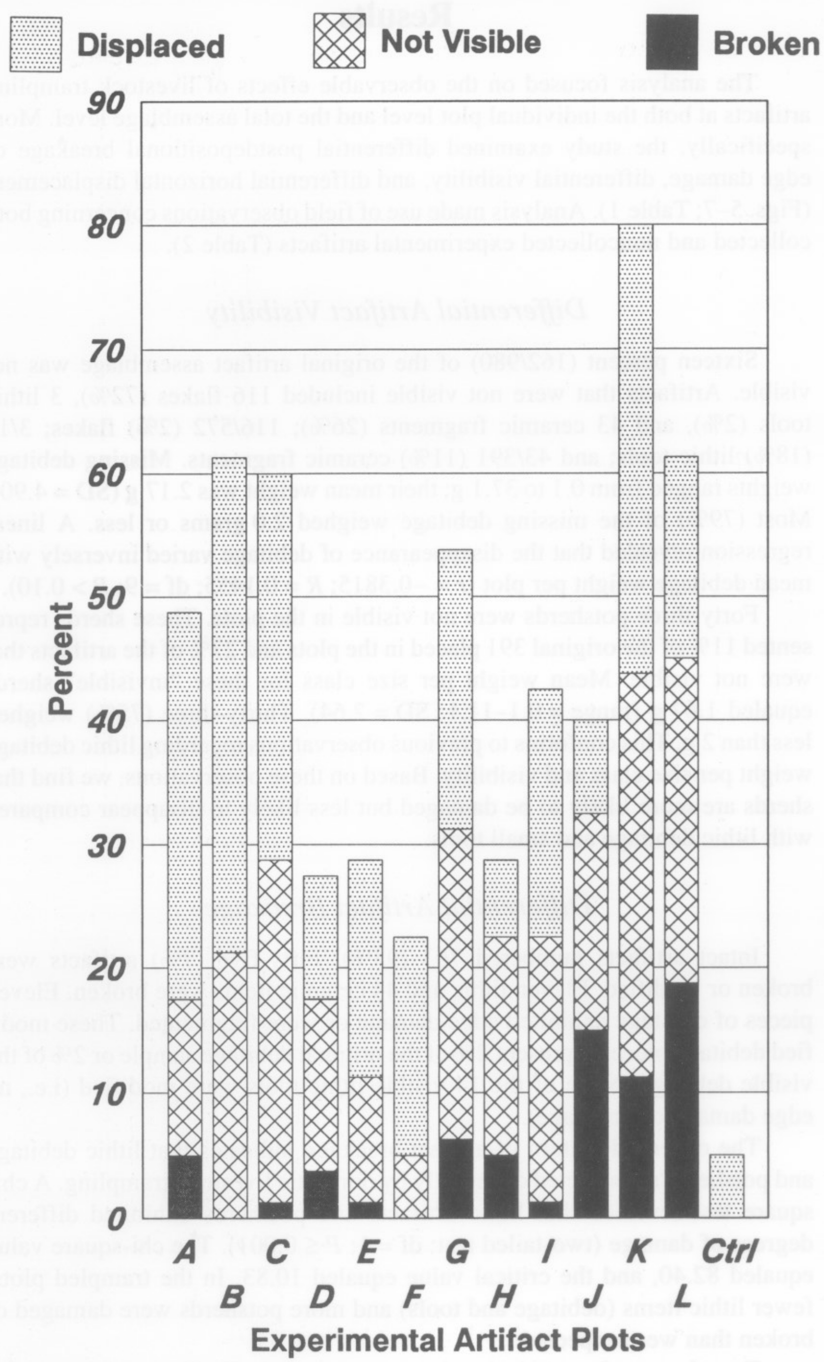

Fig. 5. Lithic and ceramic experimental artifacts—postdepositional changes.

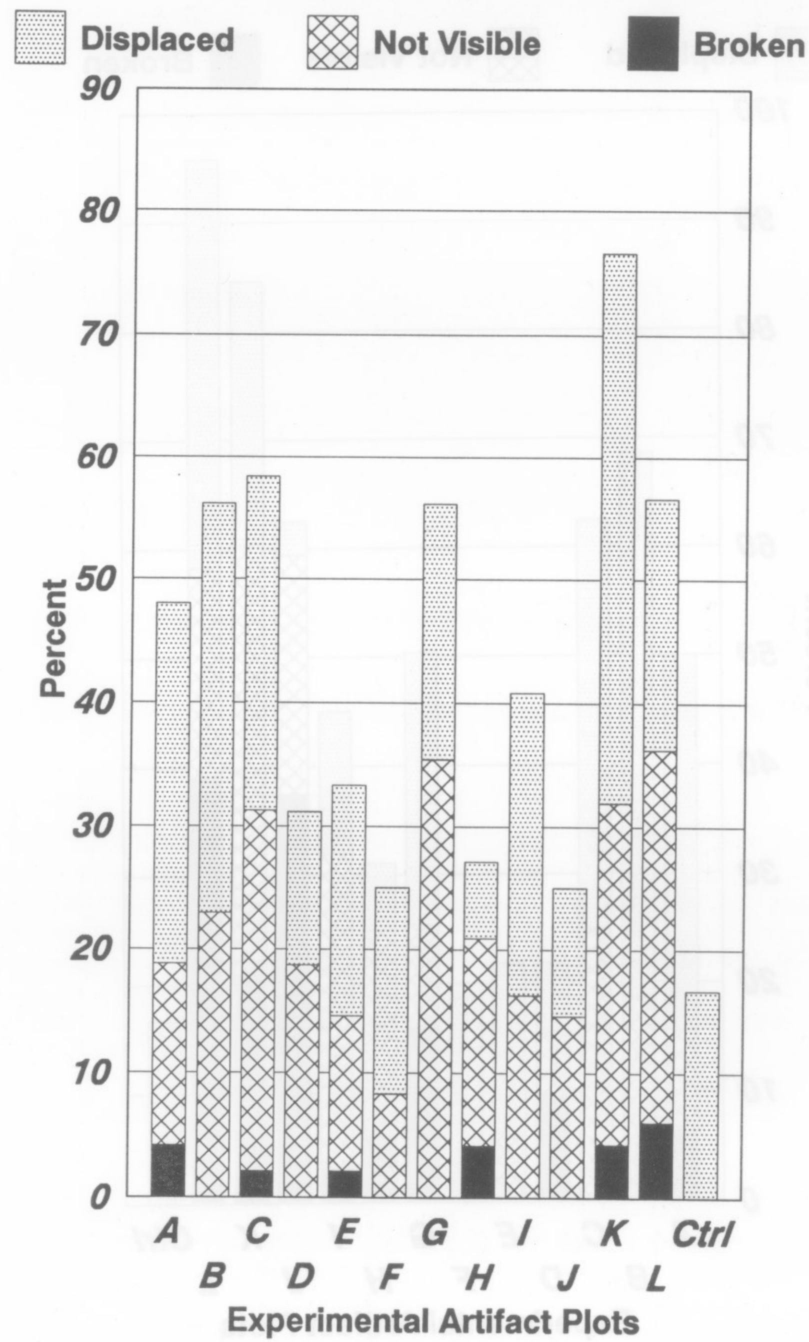

Fig. 6. Lithic experimental artifacts—postdepositional changes.

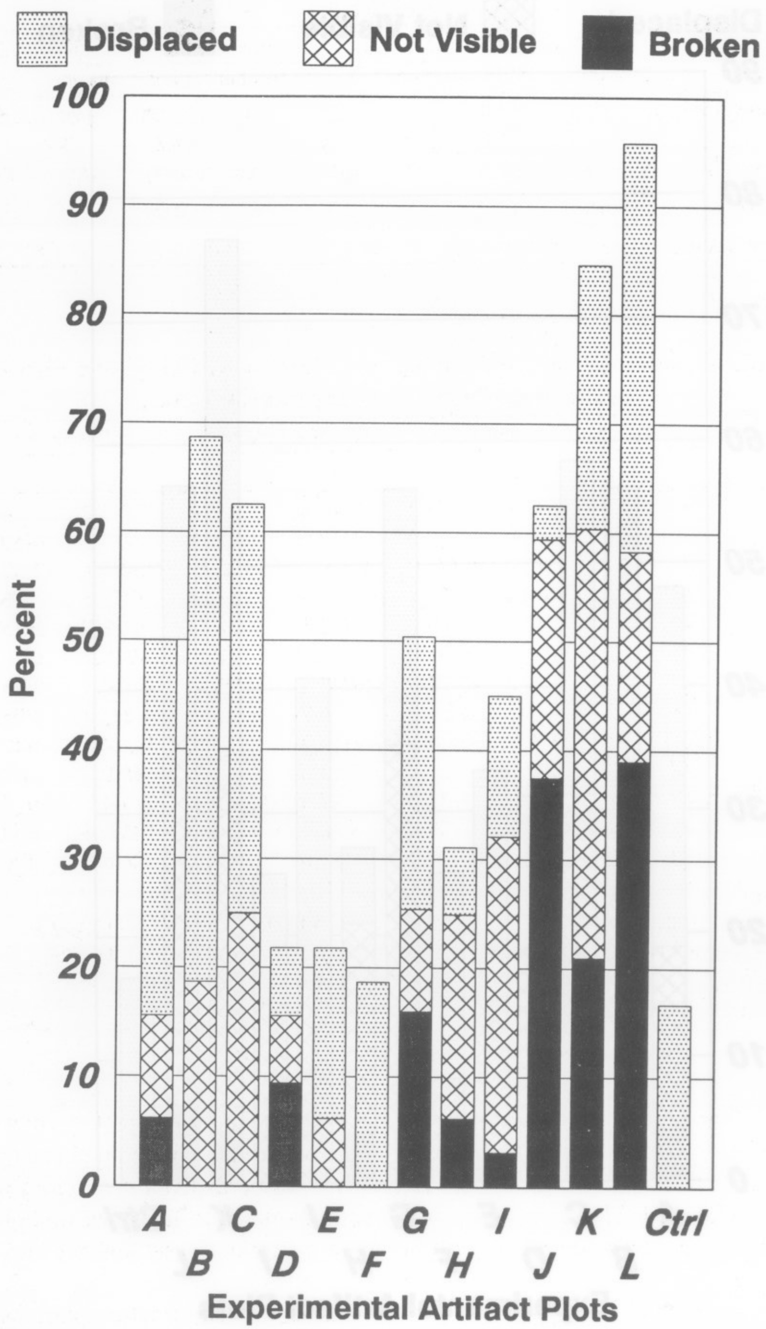

Fig. 7. Ceramic experimental artifacts—postdepositional changes.

Table 1. General experimental artifact summary for Capitol Reef National Park, Utah.

	Total		Modified		Not visible		Displaced	
Artifact	number	(%)	number	(%)	number	(%)	number	(%)
Lithic debitage	572	(58.4)	11	(20)	116	(71.6)	129	(56.1)
Lithic tools	17	(1.7)	0	(0)	3	(1.8)	0	(0)
Ceramics	391	(39.9)	44	(80)	43	(26.5)	101	(43.9)
Total	980	(100)	55	(100)	162	(100)	230	(100)
Total artifacts (%)	100		5.6		16.5		23.5	

Table 2. Summary data for artifact modification, visibility, and displacement in the Capitol Reef experimental plots.

	Total		Modified		Not visible		Displaced	
Plot	L	C	L	C	L	C	L	C
A	48	32	2/4.2[a]	2/6.2	7/14.6	3/9.4	14/29.2	11/34.4
B	48	32	0/0.0	0/0.0	11/22.9	6/18.7	16/33.3	16/50.0
C	48	32	1/2.1	0/0.0	14/29.2	8/25.0	13/27.1	12/37.5
D	48	32	0/0.0	3/9.4	9/18.7	2/6.20	6/12.5	2/6.20
E	48	32	1/2.1	0/0.0	6/12.5	2/6.20	9/18.7	5/15.6
F	48	32	0/0.0	0/0.0	4/8.30	0/0.00	8/16.7	6/18.7
G	48	32	0/0.0	5/16	17/35.4	3/9.40	10/20.8	8/25.0
H	48	32	2/4.2	2/6.2	8/16.7	6/18.7	3/6.20	2/06.2
I	49	31	0/0.0	1/3.1	8/16.3	9/29.0	12/24.5	4/12.9
J	48	32	0/0.0	12/37.5	7/14.6	7/21.9	5/10.4	1/3.10
K	47	33	2/4.3	7/21	13/27.6	13/39.4	21/44.7	8/24.2
L	49	31	3/6.1	12/39	15/30.1	6/19.3	10/20.4	3/37.5
Control	12	8	0/0.0	0/0.0	0/0.0	0/0.0	2/16.7	0/0.0
Total[b]								
Lithics	589/60		11/1.9		119/20.2		129/21.9	
Ceramics	391/40		44/11.25		43/11.0		101/25.8	

[a] Artifact count/%.
[b] Count/% of original.

both snap fractures and exfoliation. Initially, the exfoliation breakage pattern was thought to be related to extreme diurnal or seasonal temperature changes. This seems less likely, however, because no potsherds from the control plot had exfoliated. This form of breakage can be related to livestock trampling and perhaps to the uniformity of the modern clay pot paste and the lack of temper.

Another idea regarding the exfoliation versus snap fracture patterns of ceramics relates to sherd size. Because all sherds were of the same relative thickness, sherd weight could be used as a measure of sherd size relative to surface area. Perhaps the exfoliation pattern might be related in a regular, direct way to sherd size relative to surface area. Mean sherd weights for each breakage pattern group were calculated. A t-test was performed to test the hypothesis that these two forms of breakage were related to sherd size relative to surface area. Six sherds that exhibited two or more forms of breakage or damage were excluded from this analysis.

Mean weight relative to size for the exfoliated sherds ($n = 18$) equals 5.16 g (range = 0.1–22.0; SD = 5.89). Mean weight relative to size for snap fracture sherds ($n = 20$) equals 7.82 g (range = 0.1–22.0; SD = 6.99). The t value equals −1.14766 (two-tailed test; df = 36; $P \geq 0.20$); therefore, there was no difference between the mean sherd weights relative to sizes for these two breakage classes. Exfoliation does not seem to occur as a function of increased sherd size.

Nielsen's (1991) study of human trampling and surface archaeological remains revealed that potsherd fracture rates decreased as sherd size decreased. Smaller sherds were stronger. Trampled ceramic assemblages are then expected to exhibit a unimodal size distribution once such a size to strength threshold is reached. Nielsen (1991) does not include the effects of large animal trampling in his investigations. Such modal size categories, however, would vary as a function of foot loading weights of tramplers including humans, wild ungulates, and domesticated livestock.

Differential Artifact Displacement

Observations from this first monitoring phase were also utilized to evaluate the relation between artifact weight relative to size and to displacement. Displaced artifacts were separated into two classes: displaced out of cell (DOC) and displaced out of quad (DOQ). Moves that ranged from 2 to 14 cm were classed as DOC. Moves ranging from 15 to 141 cm were classified as DOQ. Artifact plot diagrams were used to make the final classification (i.e., DOC versus DOQ).

We evaluated initial field observations, which suggested that larger lithic artifacts tend to be displaced over greater distances than either small debitage or ceramic fragments. Displaced artifacts were grouped into minimal (DOC) and maximal (DOQ) categories according to experimental plot and quads. Mean lithic artifact weights for material displaced out of cell equaled 8.74 g versus 19.72 g for lithic materials displaced out of quad (Table 3). Mean ceramic weights equaled 5.75 g for DOC and 6.16 g for DOQ. Ceramic materials did not seem to reflect the same relation between weight relative to size and degree of horizontal displacement.

Two t-tests were conducted to assess differences between mean artifact weight relative to size and degree of horizontal displacement. No significant differences were detected for mean lithic debitage or sherd weight relative to size between minimal (DOC) and maximal (DOQ) degrees of horizontal displacement (Table 4).

Table 3. Summary statistics for lithic and ceramic artifacts and degree of horizontal displacement (DOC vs. DOQ).

	Minimal (DOC)	Maximal (DOQ)
Lithic artifacts		
Mean weight (g)	8.74	19.72
SD	18.66	21.56
Number	120.00	17.00
Ceramic artifacts		
Mean weight (g)	5.75	6.16
SD	6.38	6.25
Number	90.00	14.00

Table 4. *T*-test results for difference of mean artifact weight/size for minimal and maximal horizontal displacement. Neither was significant.

Artifact type	t-value	DF	P
Lithic	0.1495	135	>0.20
Ceramic	0.2239	102	>0.20

Villa and Courtin (1983) found that artifact weight was not a good predictor of horizontal displacement. Nielsen (1991) observed that denser artifacts exhibited smaller displacement distances if artifact size and shape were held constant. Larger, bulkier items were more apt to be displaced if they consisted of low density materials. Flat artifacts were less likely to be displaced by trampling and scuffling.

Discussion

Our purpose was to monitor the effects of livestock and related human activities on archaeological resources within Capitol Reef National Park. The major factors monitored were differential modification (breakage or edge damage), differential visibility, and differential degree of displacement.

First, 55 (6%) artifacts were broken. Included were 11 (20%) lithic and 44 (80%) ceramic items constituting 2 and 11% of their respective raw material categories. Second, 162 (17%) of the artifacts were not visible during this first monitoring phase—119 (73%) lithic and 43 (26%) ceramic or 20% and 11% of their raw material categories. Third, 230 (23%) artifacts were displaced by livestock. Fifty-six percent were lithic items, and 44% were ceramic. They constituted 22 and 26% of their respective raw material categories.

Livestock grazed in the park for approximately 6 months (November to April). Cattle affected 10 (83%) of the 12 original experimental plots. The degree of effect is a direct reflection of grazing intensity and dependence on limited water sources in this cold desert environment. Future investigations of livestock grazing effects on archaeological remains should include models that incorporate precipitation, growing season, forage production, grazing intensity, and water resources. We hoped models would allow us to predict variable livestock effects in different environmental situations.

We expect, given our preliminary results, that artifact breakage will continue to reduce lithic and ceramic items into smaller and smaller fragments. Lithic debitage and potsherd breakage would decrease as object weight relative to size approached a mean of 2 g. Greater percentages of these smaller fragments would undergo repeated cycles of burial and exposure as a function of trampling. Horizontal displacement of lithic and ceramic artifacts would apparently continue throughout the grazing period(s) independent of artifact weight relative to size.

Future studies should consider livestock trampling and patterns of artifact attrition and breakage. Knudson (1979) has observed marked edge damage on historic bottle and window glass at the Homestead Site in Washington County, Colorado. These pseudo-tools were referred to by Knudson (1979:280) as bovifacts. Finally, our preliminary results suggest several items for consideration in future archaeological studies in the Southwest and elsewhere. First, ceramic remains or potsherds seem to undergo more severe adverse effects from livestock trampling than do lithic remains (i.e., chipped stone tools and debitage). Plog (1980:1) also points out that 75% of the ceramic variation in the American Southwest is based on design elements and design layouts. He also states that the distinction between the Wingate and the Tularosa design styles (ca. A.D. 1000–1300) is a function of sherd size due to design spacing and configuration. Archaeologists might experience greater difficulties in recognizing meaningful stylistic variation in prehistoric ceramics in regions where livestock grazing and associated trampling has occurred. Such difficulty in ceramic classification would, in this case, be a function of ceramic breakage and sherd size.

Second, archaeologists must consider the adverse effects of livestock on lithic artifacts. A number of flakes were broken by livestock trampling. Debitage breakage is significant to lithic analyses designed to delineate functional site types or other forms of site taxonomies. For example, Sullivan and Rosen (1985) utilize hierarchical cluster analysis in order to define four technological groupings of prehistoric debitage from archaeological sites in east-central Arizona. Two of these archaeological assemblages groups (Groups I and II) are defined statistically on the basis of differential percentages of cores, complete flakes, and incomplete flakes and flake fragments. Sullivan and Rosen (1985:763) did rule out domestic livestock trampling, but archaeologists must also consider the effects of wild ungulates (e.g., mule deer [*Odocoileus hemionus*], pronghorn antelope [*Antilocapra americana*], elk [*Cervus elaphus*], bighorn sheep [*Ovis canadensis*], and bison [*Bison bison*]) on artifact assemblages in western North America.

Archaeologists have made tremendous progress in the last decade in their continuing efforts to understand the dynamic aspects of past human behavior. Like paleontologists, we have become more aware of the range of taphonomic processes that have transformed and altered the content and spatial distribution of material remains during and following their deposition. Systematic studies of human and livestock trampling and effects on artifactual remains are essential in our investigations of the dynamic natural and behavioral processes that produced the archaeological record.

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