

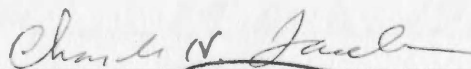
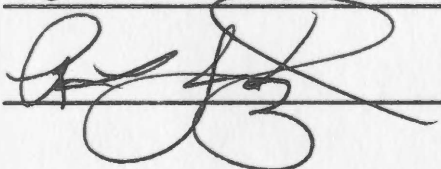
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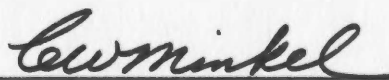
I am submitting herewith a thesis written by William B. Turner entitled "Surface Artifact Assemblage Variability: A Consideration of the Natural Factors Influencing Artifact Recovery." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.


Walter E. Klippel, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:


Vice Provost
and Dean of The Graduate Office

SURFACE ARTIFACT ASSEMBLAGE VARIABILITY:
A CONSIDERATION OF THE NATURAL FACTORS
INFLUENCING ARTIFACT RECOVERY

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

William B. Turner
August 1986

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responsible for the excellent quality work performed at 40MU409 during times when I was unable to be present. I thank him because he accepted this responsibility as much out of friendship as for any other reason.

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ABSTRACT

The purpose of this research was to examine the effects of naturally occurring variables on surface artifact recovery. This was accomplished by isolating and reviewing pertinent variables, which are rainfall and soil factors. Information from this review was incorporated into an experiment designed to measure the effects of rainfall on artifact exposure and recovery. The results from the surface recovery experiment were used to form baseline data that allowed meaningful interpretation of three additional plowzone data recovery exercises. These were (1) artifact detection by shovel test, (2) prediction of surface density from plowzone excavation data, and (3) reliability of surface collections as indicators of plowzone assemblage content.

Results of repeated collections following precipitation ranging from no rain to more than 11 cm demonstrated drastic increases in artifact densities, yet a recovery threshold was recognized past which more rainfall produced few additional artifacts. Small plowzone shovel tests (25 cm²) proved to be fairly good detectors of surface scatters as sparse as .10 artifacts/m², and increasing test size to 50 cm² allowed detection of scatters as sparse as .04/m². Results of least squares model regression revealed that the relationship between the artifact density/m² for a 5 m² surface collection and the artifact density/liter excavated beneath it is a strong one. However, this relationship weakens with a decrease in excavated volume to a point where densities from a 25 cm² test demonstrate very little association

with surface density. Comparative analysis showed artifact size to be the primary difference between surface and plowzone assemblages. In instances where artifact type is size-dependent, assessments of total plowzone assemblages based on surface samples could be incorrect. It is stressed that integration of the surface recovery information produced by this study, with plowzone recovery techniques such as shovel-testing, will alleviate the problem of incompatibility of results derived from surface and subsurface data recovery techniques prevalent in regional archaeological survey.

PREFACE

During the 1978 and 1979 field seasons, work was conducted on three archaeological sites (40MU86, 40MU110, and 40MU409) by personnel from The University of Tennessee, Knoxville as part of the Tennessee Valley Authority's Columbia Archaeological Project under the direction of Walter E. Klippel as principal investigator (contract TV-49244A). Work was conducted under authority of the National Historic Preservation Act (16USC470H) as implemented by 36 C.F.R. VIII 800.

The project area encompasses nearly 32,000 acres within the Central Duck River Drainage in portions of Maury and Marshall Counties, Tennessee. The transitional zone between the Inner and Outer portions of the Nashville Basin bisects the project area in a North-South direction. Because geologic characteristics, as well as closely related floral and faunal ones, differ greatly between basin subdivisions, proposed research was designed to explore variation in human adaptive response to the two areas. Due to the vastness of the area, it was clear that archaeological survey would have to provide a large part of the data used in such regional comparison. To further focus the investigations, two archaeological research districts were chosen as contrastive sets. The Cannon Bend District was selected to represent the Outer Nashville Basin, and the Cheek Bend District chosen to represent the Inner Nashville Basin.

Results of survey in the two districts was designed to be used to predict contents of two additional districts, Vaughan and Tugus Bends, representing outer and inner portions of the basin respectively. The

work conducted at 40MU86, 110, and 409 was specifically designed to ensure that data derived from analysis of these surveys reflected actual similarities or differences between districts. Experiments conducted at the three sites examined the effects of rainfall on artifact recovery rates, and how these can affect assessments of plowzone artifact densities. Knowledge of how to control these biases was important in planning survey of the original contrastive districts (ie., Cheek and Cannon), but will be especially important in subsequent survey in the additional districts (Vaughan and Tugas), and in subsequent comparative analyses.

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CHAPTER I

INTRODUCTION

In recent years, archaeologists have recognized the value of surface remains as more than indicators of where to excavate (see Lewarch and O'Brian 1981b and references contained therein). Investigations have demonstrated that excavated data are not necessarily derived from a pristine record of prehistoric activity simply because they are recovered from a buried context (e.g. Cahen 1976; Cahen and Moeyersons 1977; Schiffer 1972, 1975; Binford 1977, 1981; Wood and Johnson 1978; Matthews 1965; Wildeson 1973; Ascher 1968; Gifford 1978; Stockton 1973; Hofman 1986). Efforts must be made to understand postdepositional factors that affect the archaeological record. All sites were at one time exposed on the surface, which leads some investigators to posit that a similar approach be utilized in studying archaeological surface material (Talmage and Chesler 1977; Todd and Hofman 1980).

Studies have been conducted to help understand the complexities of surface patterning (e.g., Binford 1972; Reid et al. 1975; Healan 1972; Redman and Watson 1970; Chomko 1974; Sterud et al. 1978; Hofman 1982; Hoffman 1982) and the mechanical and natural processes that contribute to it (e.g., Ford and Rollingson 1972; Medford 1972; Roper 1976; Rudolph 1977; Rick 1976; Lewarch 1979; Francis 1978; Lightfoot 1978; Ammerman 1985). Likewise, advances have been made toward understanding problems caused by variability in sampling design,

surveyor/collector bias, and survey intensity (cf. Judge et al. 1975; Plog 1976; Plog et al. 1978). Forays into the effects of surface visibility on artifact collection contents have dealt primarily with discussion of differences between samples obtained from vegetated versus plowed surfaces (House and Schiffer 1975; Baker 1978; Stoutamire 1975), although some have dealt with how surface preparation influences artifact recovery (Baker 1980). The present study investigates the effects that natural factors have on artifact recovery from surface sites. These natural factors are rainfall, soil type, and soil conditions.

The influence that rainfall has on surface artifact exposure has long been realized by both collectors and professionals (e.g. House and Schiffer 1975; Roper 1979; Davis 1981; Jermann 1978, 1981; Odell 1985; represent just a few examples). Some investigators have only intimated that rainfall affects collection contents (Riordon 1982; Lewarch 1979; Lewarch and O'Brian 1981b), while others have demonstrated that it, in fact, does (Hirth 1978; Ammerman and Feldman 1978; Baden 1982). For example, Hirth (1978) chronicled artifact densities in identical localities before and subsequent to rainfall and discerned that artifact densities were greatly increased following rainfall. Soil factors are equally important because they affect rainfall-induced erosion and artifact exposure rates.

In regional archaeological surveys conducted in the Eastern United States, there are usually two survey strategies employed, one for exposed areas and another for vegetated ones (Schiffer et al.

1978). Exposed or plowed areas are usually subjected to surface collecting, while data collection from vegetated surfaces requires the creation of "artificial" exposures, usually by shovel testing. This two-strategy approach frequently ends with another phenomenon prevalent in the Eastern United States: the two-result survey. Results from the different strategies are generally incompatible because the relationship between the techniques employed to produce them has never been established. The importance of being able to use results produced by surface collection and shovel testing in an integrated manner for regional survey evaluations increases with the amount of vegetated area. In many parts of the Southeast, such as the Central Nashville Basin of Tennessee where this study was conducted, as much as 50% or more of the terrain is vegetated (Figure 1.1).

This study endeavors to show how results from the two survey approaches can be melded into a more coherent whole by sequentially:

- 1) Recognizing the pertinent variables that affect the recovery of surface artifacts. Certain factors are controllable, while others are not. Rainfall and soil conditions are not controllable, but can be monitored.
- 2) Designing and completing an experiment that measures the effects of rainfall on artifact recovery rates.
- 3) Utilizing data from the surface recovery experiment as a basis for interpreting a shovel testing study designed to establish the surface density necessary for artifact detection in a small plowzone excavation. This

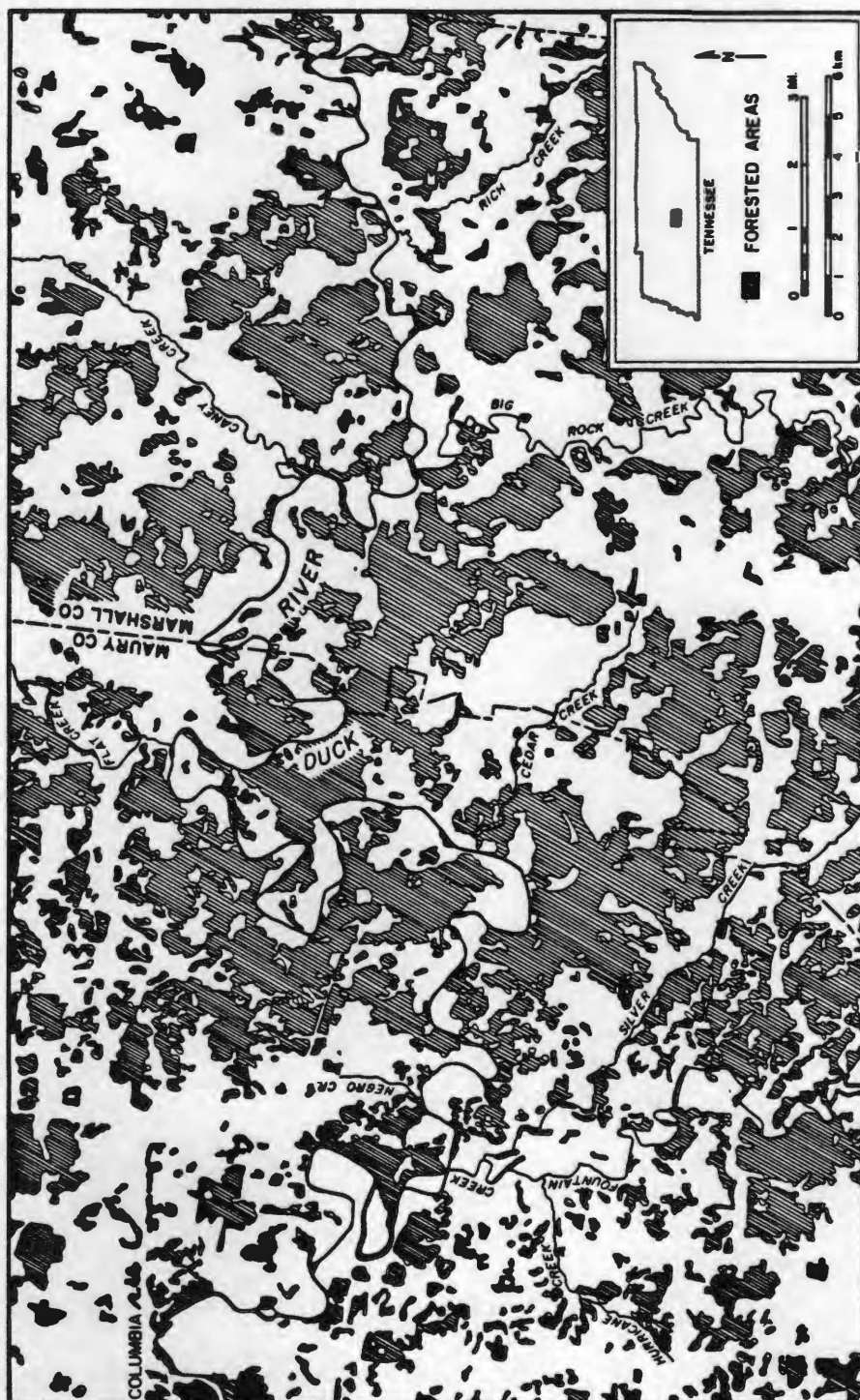


Figure 1.1. Forested areas in the study locality.

establishes that only sites above a certain density threshold will be located using the shovel-test technique.

- 4) Examining the relationship of surface artifacts/m² to plowzone artifact densities/liter using plowzone excavation squares of various sizes. This was done to establish a minimum unit size below which surface densities could not be predicted with reasonable certainty.
- 5) Comparing surface and plowzone artifact assemblages to determine the reliability of surface samples as indicators of total plowzone content.

Each of these steps is intended to form part of a research approach designed to help ensure the recovery of comparable data. This is a basic effort, yet such an approach is deemed essential to the acquisition of data usable for regional, intersite, or intrasite analysis.

CHAPTER II

MATERIALS AND METHODS

Sample Derivation

Data were collected from three sites, 40MU86, 40MU110 and 40MU409, to examine the relationship between surface and plowzone lithic assemblage density and composition. All three sites are located in the Central Duck River drainage but occur in differing physiographic settings (Figure 2.1). Because of this variability, pertinent physical features as well as data collection procedures implemented will be described separately for each site.

The discussion will also proceed chronologically to better illustrate how findings and realized shortcomings from the separate projects were utilized in the planning and implementation of data collection techniques for successive efforts. An attempt was made to standardize data collection procedures in each project in order to prevent sample bias and permit conscious manipulation of controllable variables. A more detailed account of variable control will be presented with site discussions.

40MU86

The Pilkinton site (40MU86) was the first area examined and the present fieldwork was begun and completed in the summer of 1979. The site is located on a level-topped T_2 terrace of Fountain Creek, the largest Duck River tributary in this eastern portion of the Central Nashville Basin (Figure 2.1). Surface sediments in the examined area

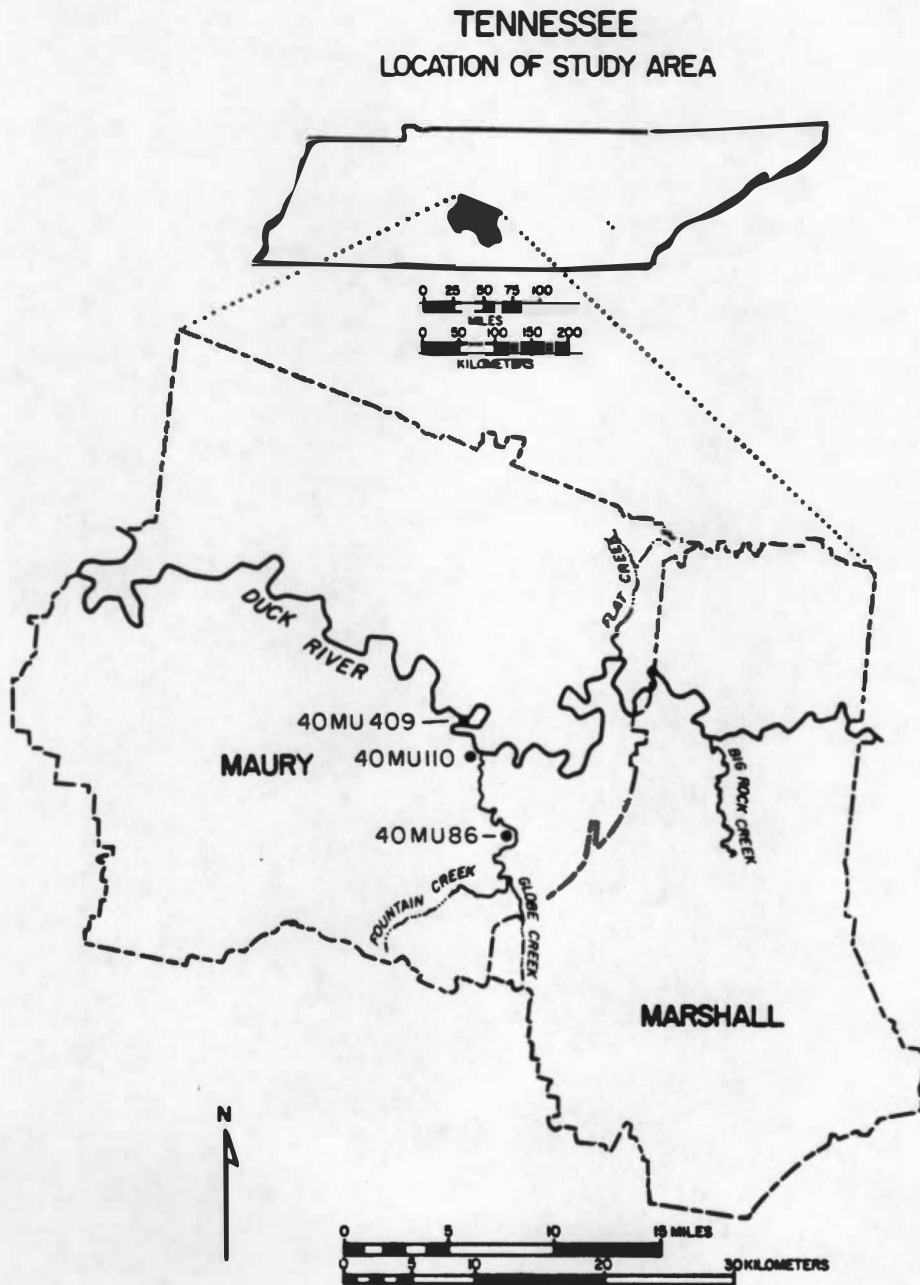


Figure 2.1. Location of the three sites utilized in the plowzone study.

are listed by Harmon et al. (1959) as Armour silt loam occurring on slopes between 0 and 5%. Topographic variation at Pilkinton is abbreviated, with slopes along the terrace in the 40MU86 site vicinity registering within the lower limits of this range (see Figure 2.2).

Initial fieldwork at 40MU86 was begun in 1972 by Dickson, who made a surface collection of the site during the reconnaissance survey for the Tennessee Valley Authority Columbia Reservoir (Dickson 1976). Although Dickson recommended that the site be extensively excavated (Dickson 1976:615), no information was provided regarding surficial distribution of artifacts. Consequently, field procedures were directed at recovering this information. In concert with this planned research, the Pilkinton site offered an ideal opportunity for structuring recovery techniques to study the relationship between surface and plowzone artifacts under controlled conditions.

The entire site area was in pasture, which necessitated surface preparation prior to inspection. Four shovel tests were excavated at intervals along the terrace crest to establish plowzone thickness and determine a safe plowing depth that would not extend into undisturbed deposits. The site was then plowed, disked, and the entire area of over 30,000 m² gridded into 10 meter units. A rectangle of 18 contiguous 10 meter units was isolated and designated as a control block to be subjected to intensive recollection.

The control block was selected without prior knowledge of surface artifact distribution and was located upon a level area in close proximity to Fountain Creek, the nearest water source. As initially

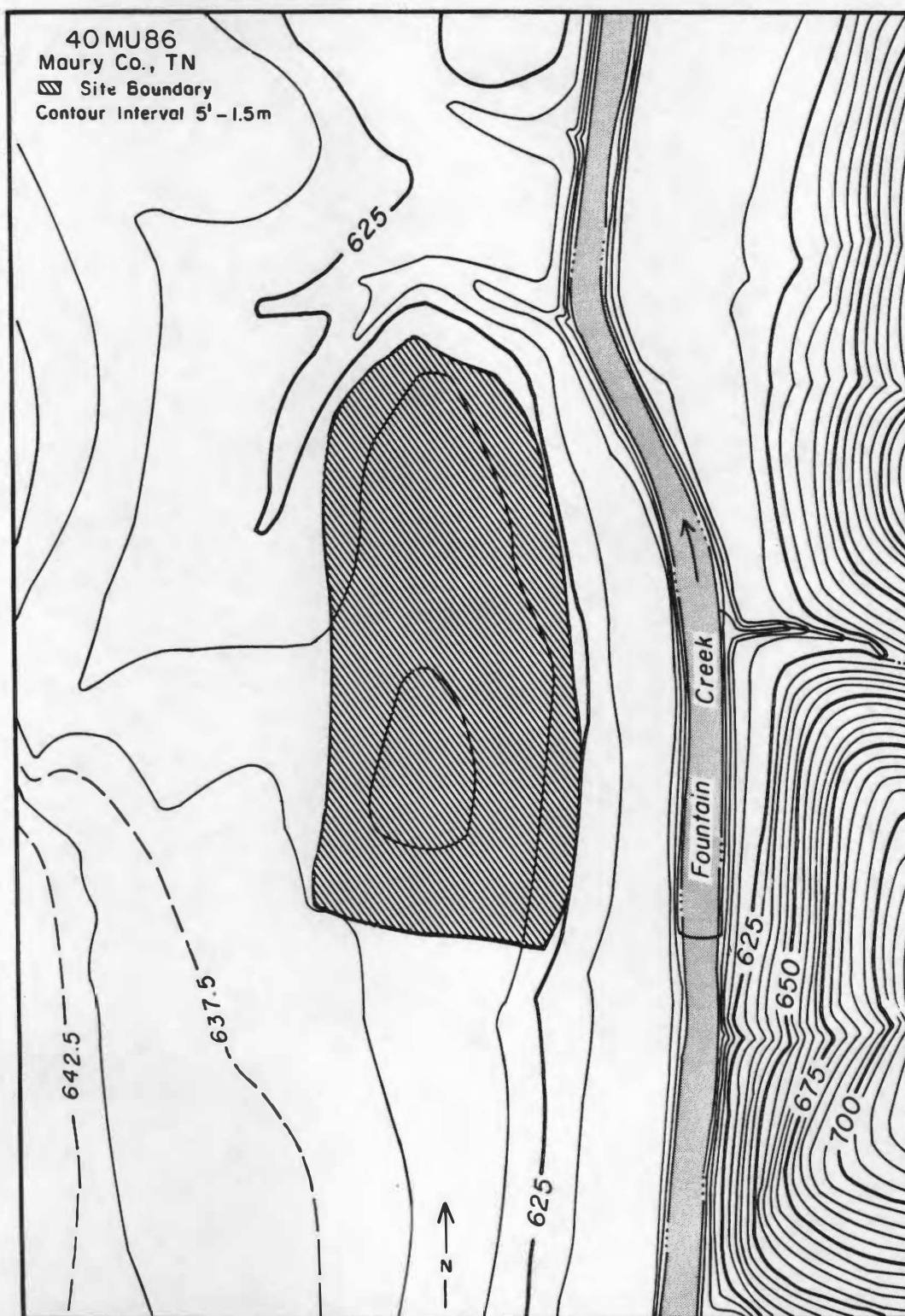


Figure 2.2. Horizontal extent and topographic features of the Pilkinton site, 40MU86.

conceived, each collection was to follow an even increment of precipitation provided by a sprinkler system powered by a three-inch trashpump placed downslope and adjacent to Fountain Creek. Considerable distance and excessive lift requirements prevented adequate pressure for even coverage by the sprinklers when they were tested. As an alternative, rain gauges were placed in both the control block and along the grid baseline to monitor normal rainfall. Gauges were elevated by strapping them to grid stakes to prevent rainsplash entry.

Four intensive recollections of the control block were made to examine how the amount of precipitation would affect the number of artifacts recovered and collection content. All collections were made by a three-person crew. Interval spacing of surveyors was one meter. No time limit was imposed on unit collections to help ensure that workers recovered all cultural material larger than .635 cm (.25 inch). Surface visibility was excellent during each of the four collections, with five percent or less obstructive cover estimated to be present. To test for size variation between the four collections, all lithic specimens recovered in the control block were subjected to four measurements: length, width, thickness, and weight. Linear measurements were recorded to the nearest mm and weights to the nearest .5 gr.

Control block collections were made subsequent to (1) disking (no rainfall), (2) 2.22 cm (.88 inch) of rain, (3) an additional 4.13 cm (1.63 inches) of rainfall, and finally (4) an additional 4.76 cm (1.88

inches) of rain (total 11.11 cm or 4.38 inches). This approach allowed the sequent collections from the control block to be examined individually and in combination. The remainder of the site, outside the control block, was collected twice: first after the initial rainfall (2.22 cm) and again after 11.11 cm of rain. The second site-wide collection was conducted to make recovery of cultural material comparable between the control block and the rest of the site. Collection techniques were the same as those used in the control block.

Following the intensive, controlled surface collection at 40MU86, eight transects of 10 m² units (N = 93 units) were chosen traversing the North-South and East-West axes of the site (Figure 2.3). The two North-South transects were intuitively placed to sample areas of suspected high and low artifact density. East-West transects were systematically spaced at 50 meter intervals, beginning with the southernmost line of complete surface squares. As established, the transects provide information on artifact density changes both parallel and perpendicular to Fountain Creek. Each 10 meter unit within the transects was divided into 100 consecutively numbered one meter squares. A single one meter square was randomly selected from each 10 meter unit and a 30 cm² test, approximately the width of a standard square shovel blade, was then excavated in the square's southwest corner. Each test was excavated in 10 centimeter levels to the bottom of the plowzone and screened through .635 cm mesh. The use of arbitrary levels was designed to (1) detect possible vertical size

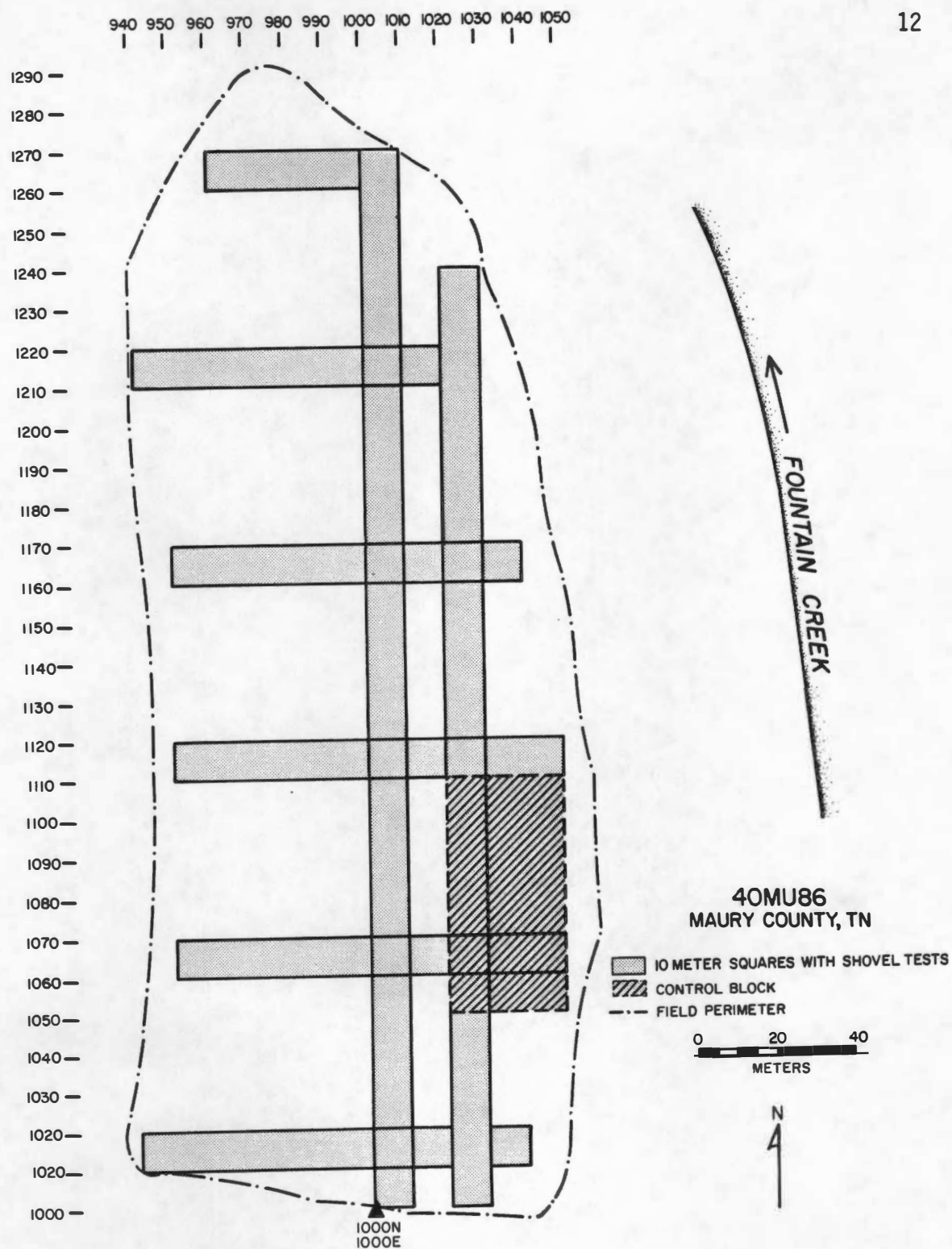


Figure 2.3. Orientation of shovel-test transects and location of the control block at site 40MU86.

sorting in the plowzone and (2) allow comparison of standard unit volume across the site. The use of .635 cm (.25 inch) screen was implemented to keep shovel-test and surface-collection data comparable.

Surface lithic counts per 10 meter square were compared to lithic counts from the first two 10 cm levels of the shovel tests using simple linear regression. A cutoff point at 20 centimeters was chosen because it closely approximates the average depth of the plowzone across the site. In all cases two complete 10 centimeter levels were excavated. Measurements of lithic material recovered from shovel tests were taken employing the same techniques used for measuring the control block surface collection. Mean dimensions of the lithics from level one and two in the two N-S transects were compared. The measured lithics represent 66% of the total lithics from all shovel tests.

The Harris Plantation Site 40MU110

This site is a large, multicomponent lithic scatter located on a relatively level plateau lying immediately south and west of the confluence of Fountain Creek with the Duck River (Figure 2.1). Areas of artifact distribution cover nearly all level agricultural land north of the Harris Plantation house, an area in excess of 85,000 m². In spite of its considerable areal extent (Figure 2.4), soil associations at 40MU110 are of a single series, reported by Harmon et al. (1959) as Etowah silt loam. Constituents of the Etowah soil series present at Harris Plantation, considered very similar to the

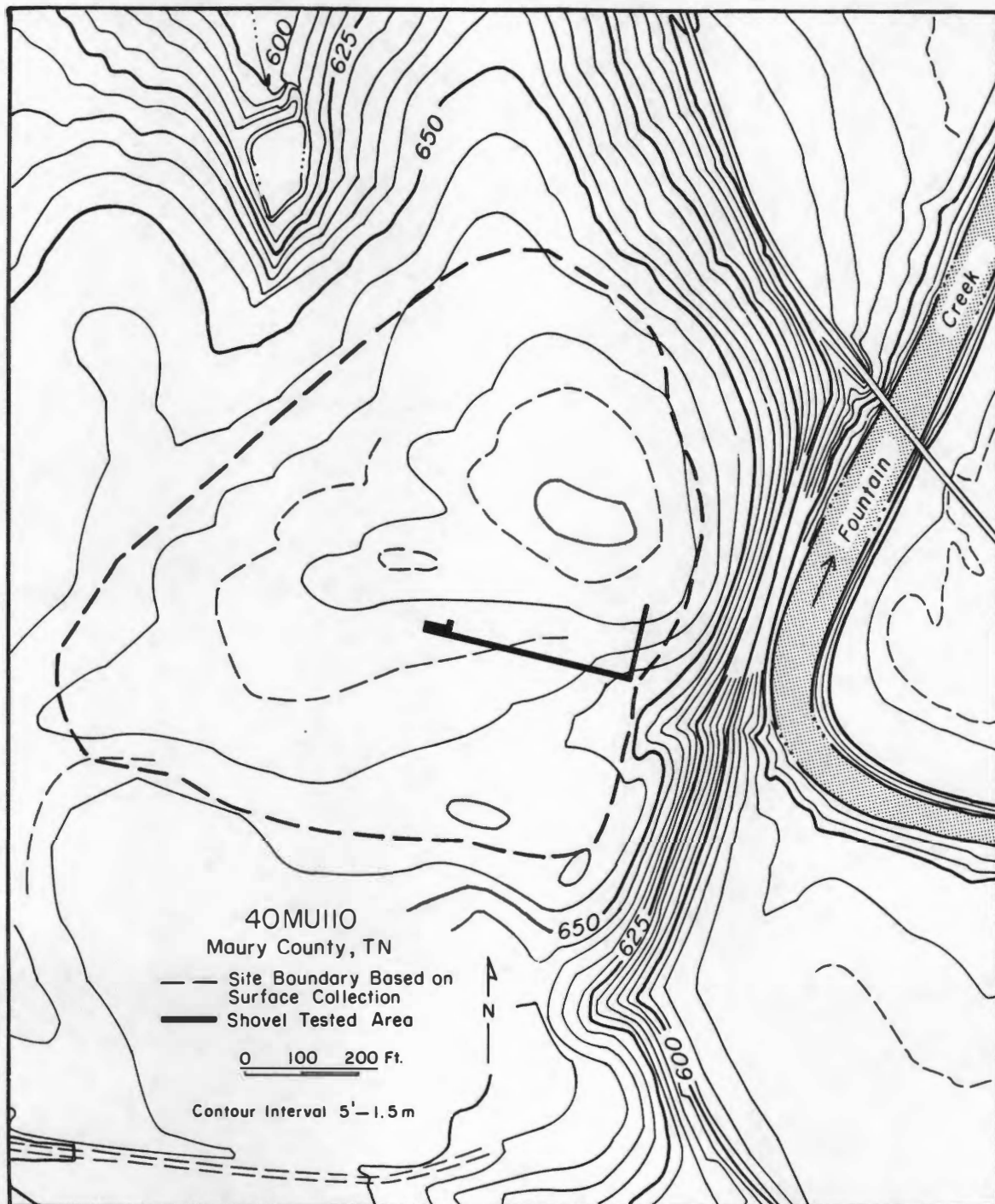


Figure 2.4. Site boundaries, topographic variation, and shovel-test transect locations at site 40MU110.

Armour series sediments at 40MU86, also exhibit 5% or less slope and are derived from the same parent materials (Harmon et al. 1959:31). The importance of sediment properties will be discussed extensively in a later section.

Prehistoric components at 40MU110 were first reported by Dickson (1976) when a minute portion of this expansive scatter was detected in a small field and farm road at the southeastern site perimeter. Following extensive re-survey of the area in 1979 by the University of Tennessee Department of Anthropology, the remaining majority was defined and has been assigned the same site designation. During this most recent work, another program of controlled, intensive surface collection and associated shovel testing was conducted with the resultant data planned for use in examining artifact density thresholds necessary for detection with shovel tests. Before work at 40MU110 began, the entire area had been plowed, disked, and planted in soybeans. Equipment used by the leasee was comparable to that used at Pilkinton (40MU86).

Following agricultural preparation and preceding archaeological work, in excess of 12 cm (nearly five inches) of rain fell as a result of summer convective thunderstorms. This precipitation occurred over such a short interval that soybeans were only 10 cm high and presented no surface visibility hinderance. They were, however, large enough to sustain trampling damage, influencing the placement of surface units receiving shovel tests and hence increased localized collection activity. An agricultural mishap, representing either planting

failure or an area of overfertilization, afforded an opportune transect location which was totally without vegetation along the perimeter of one large field.

Thirty-six 5 m² surface units were located linearly in East-West and North-South orientation at the field edge (Figure 2.4). One unit located at the junction of the two axes contained some fence thicket vegetation and was excluded from collection procedures. Following surface gridding, randomly selected shovel test locations were instated in each of the surface squares. Figure 2.5 presents shovel test locations. Test unit size (30 cm²), excavation technique (arbitrary 10 cm levels), screen size (.635 cm; .25 inch), and surface collection strategy were consistent with those employed at 40MU86. The use of 5 m² instead of 10 m² units was implemented in an attempt to improve the correspondence between surface collected artifact numbers and plowzone artifact density by increasing the ratio of excavated volume to surface area examined. Surface units were collected only once, but this followed greater rainfall amounts than those documented at 40MU86.

The Phantom Site 40MU409

The Phantom site, another relatively large multicomponent lithic scatter, occupies a gradually rising knoll in the uplands at the head of the Cannon Bend of the Duck River. This upland section of the bend manifests an unusual topographic situation. Elevation of this central isthmus exceeds 35 meters above the river at a constriction where only a few hundred meters separate the sharply curving banks as the river

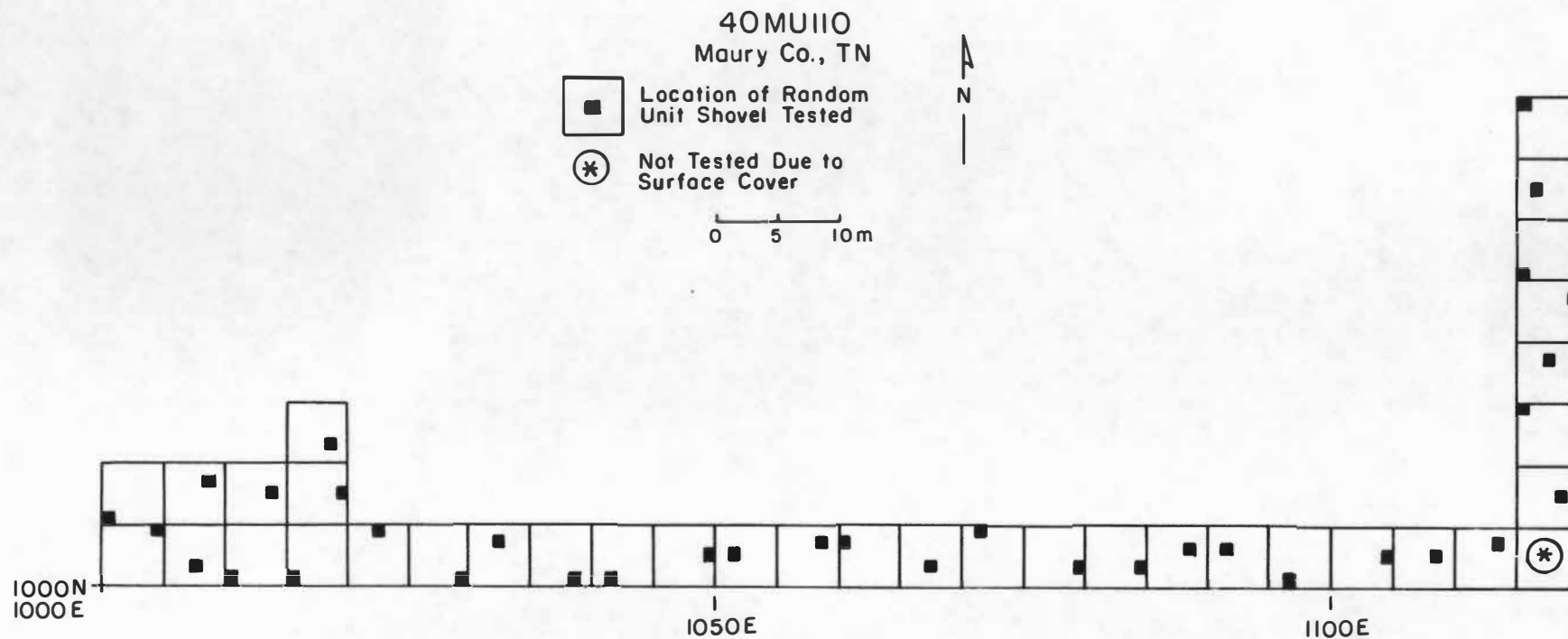


Figure 2.5. Shovel-test locations within transects at 40MU110.

loops inward at the bend head (Figure 2.1). With the exception of the relatively level ridge upon which 40MU409 lies, much of the constriction's width comprises steeply dropping rock-faced slopes. Sediments in the site locality are surprisingly similar to those of the others investigated considering the vastly different landforms in the area. Harmon et al. (1959) describe these sediments as several varieties of Etowah silt loam, but in this case exhibiting somewhat steeper slopes in the 0 to 12% range. Slopes in the intensively investigated portions of the Phantom site are, however, less steep than this range suggests.

Phantom was located in late Summer 1980 during archaeological survey of the Cannon Bend Archaeological District in conjunction with the Tennessee Valley Authority's Columbia Reservoir Project. Unlike the other two sites covered in this study, 40MU409 had been subjected to no previous investigation and was discovered, in addition to many other sites, as a direct result of controlled plowing in this district (Klippel and Turner 1982). Plowing equipment and procedures were carefully monitored to ensure compatibility with previously described work.

Investigations at 40MU409 were both far more extensive and intensive than were those at either 40MU86 or 40MU110 and were designed to complement and benefit from the earlier work. Following plowing and disking, the entire site area was gridded into 10 m² surface units. Subsequently, the most level area within this boundary was subdivided into 5 m² units. Following not less than 12.30 cm

(5 inches) of rainfall, all surface units were collected using the same controlled, intensive measures employed previously. After laboratory processing, listings of lithic artifact numbers were compiled and a distribution map produced displaying surface changes in artifact counts by collection square. For ease of manipulation raw counts were converted to density/unit area figures. Artifact counts, ranging from 0 to 46, were grouped by two artifact increments which resulted in density values within manageable .1 artifact/m² intervals following conversion (Table 2.1). Table 2.1 clearly shows that the density category distribution is far from uniform within the 642 5 m² surface units.

After this partitioning, a stratified, random sample of surface units to receive test squares was selected. Units within each density grouping were assigned a number, and a random sample of 20 was drawn from all categories ranging from 0 to .40-.49 artifacts/m². For density groupings .50-.59 through those ranging above 1.0/m², all units were included (selected) due to the low numbers represented (see also Table 2.1). A total of 168 5 m² surface units was selected for plowzone testing (Figure 2.6). Random test unit locations were chosen in the same manner as in previous work. A random shovel test location chart was constructed dividing the 5 m² units into 25 1 m squares and assigning each of these a random number. A random location was then selected, with the test unit to be located in the southwest corner of the chosen 1 m square.

Table 2.1. Distribution of numbers of lithic artifacts and density/unit area figures for 5m² surface units at 40MU409.

Number of Lithic Artifacts	Density/m ²	Number of 5m ² Units Represented	Number Selected for Testing
0	0	82	20
1-2	.04-.09	156	20
3-4	.12-.19	124	20
5-7	.20-.29	144	20
8-9	.30-.39	44	20
10-12	.40-.49	43	20
13-14	.52-.59	18	18
15-17	.60-.69	14	14
18-19	.70-.79	6	6
20-22	.80-.89	5	5
23-24	.90-.99	1	
25	1.0		
30			
31	>1.0	5	5
46			
TOTAL		642	168

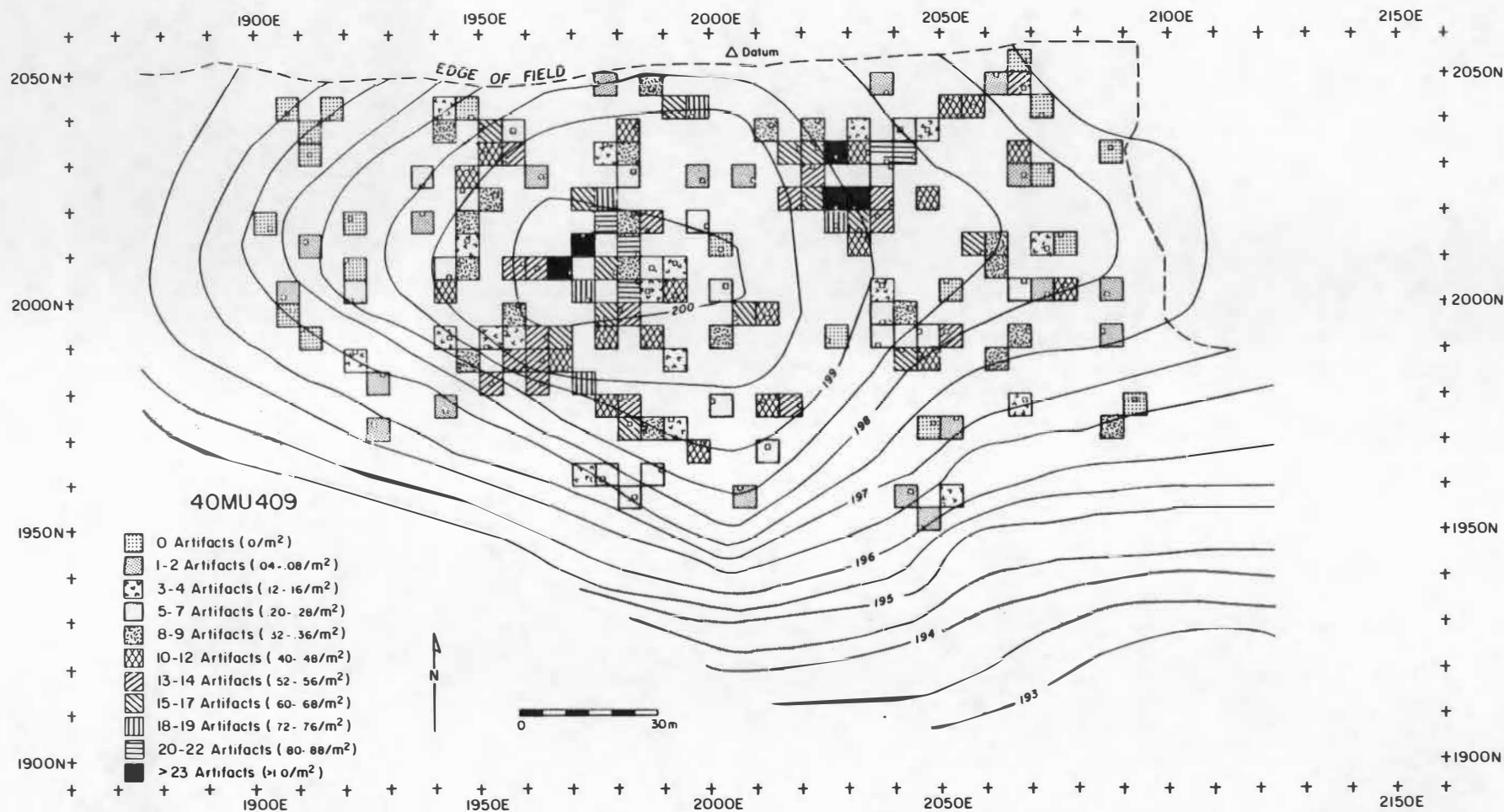


Figure 2.6. Distribution of and lithic artifact surface densities for tested units at the Phantom site, 40MU409 (contour interval .5 m).

Excavation unit size at 40MU409 differed from that used at the other sites examined. Although units were excavated in arbitrary 10 cm levels, they were dug in sequentially graduated sizes. Initial unit size was 25 cm²; this was enlarged to 50 cm², and finally expanded to 1 m² in some cases. This variable unit size design was implemented to test how increasing sample volume would affect ability to predict the surrounding surface density and assemblage composition. To complement this, six of the 5 m² surface units were totally excavated to the plowzone base in 1 m² units to provide baseline data for examining surface to plowzone artifact relationships when using more abbreviated samples provided by the smaller units. Initially, alternate 5 m² units from the lowest (0/m²) through the highest (>1.0/m²) surface density categories were to be completely excavated. Unfortunately, time constraints required modification of this original plan resulting in less uniform coverage. Arbitrary 10 cm levels were maintained once again in all unit segments. Additional recovery procedures were similarly designed to provide comparable surface and plowzone samples by limiting collected surface artifact size to .635 cm (.25 inch) or larger in maximum dimension and by employing a .635 cm (.25 inch) screen to sieve excavated fill.

To test for mechanically induced size sorting of artifacts, sizes of surface and plowzone lithics were compared subsequent to size grading. The graded artifacts were recovered from total collection of three 5 m² surface units and a 20% random sample (n=5 from each surface square) of 1 m² excavation squares contained within each

surface unit (total $n=15$). Because of the relatively sparse surface scatter at 40MU409, the three surface units with the highest artifact densities were purposely chosen to provide the largest possible number of lithic artifacts for comparative purposes. Plowzone artifacts from the five randomly selected 1 m squares excavated within each surface unit were examined separately by level to establish whether vertical size sorting was also present within the plowzone.

The use of 10 cm levels in excavation proved far more important than was first expected. Level volumes at 40MU409 differed drastically due to variability in plowzone depth. This resulted in an inability to make direct volumetric comparisons between units as was possible at both other sites. The larger units further compounded the problem. In many of the 1 m² units and some smaller ones, it was not possible to remove two 10 cm levels before sub-plowzone sediment was contacted. In rare instances, the surface and the sub-plowzone sloped in opposite or greatly different directions. This necessitated employing an additional technique to ensure intrasite sample comparability. The importance of this cannot be overstressed. Results could vary significantly if density/unit volume figures were not adjusted. The plowzone to surface relationship is essentially a comparison of three dimensions to two, and variation in both must be controlled.

Artifact density/liter values were calculated from the plowzone data using the formula $\text{volume} = \text{area} \times \text{average thickness}$. The generalized equation utilizes rectangular grid coordinates and is

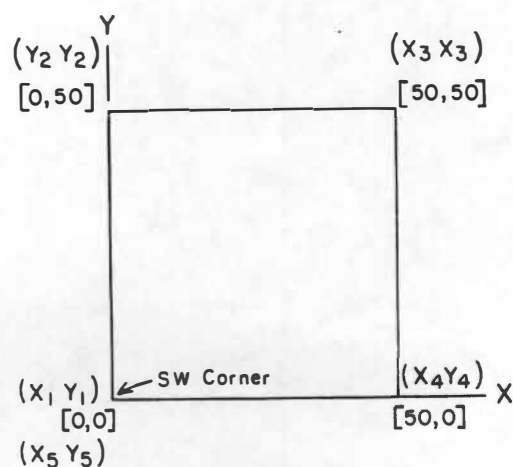
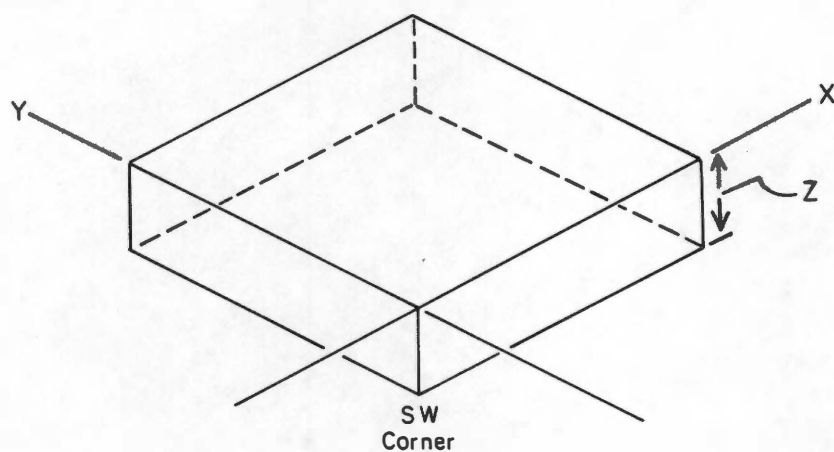
applicable to any polygon for which perimeter angle points have been recorded:

$$\text{Volume} = \frac{\sum_{i=1}^n (X_{i+1} + X_i) (Y_{i+1} - Y_i)}{2} \cdot \frac{\sum_{i=1}^n Z_i}{n}$$

where X and Y are points in the two dimensional grid system and Z the thickness. Figure 2.7 displays how the measurements were derived, an example of coordinate coding for a 50 cm² unit, and the specific version of the volume equation used for the rectangular solid. Values in cm for X, Y and Z were coded for each of the graduated unit segments, as were number of lithic artifacts recovered in each. The program developed and used to calculate plowzone lithic artifact density/liter for intrasite comparison is presented in Appendix A.

Regression analysis was used to evaluate the relationship between artifact density/liter in the plowzone and artifact density/m² recovered from the surface of associated units and how the ability to predict that relationship differs with volume of fill excavated.

Assemblage composition of the plowzone and the surface of 5 m² units was compared using relative percentages of lithic artifact technological categories present in each. Coding of archaeological material utilized in this analysis was accomplished using the standard format developed for the Columbia Archaeological project (Appendix B).



$$\text{Volume} = \left| \frac{\sum_{i=1}^4 (X_{i+1} + X_i)(Y_{i+1} - Y_i)}{2} \right| \frac{\sum_{i=1}^4 Z_i}{4}$$

Figure 2.7. Examples of measurement derivation, coordinate coding procedure, and volume equation used to derive plowzone artifact density figures at 40MU409.

CHAPTER III

SOIL FACTORS AFFECTING PLOWZONE ARTIFACT RECOVERY

The study of sediments in archaeology has received increasing attention in the last decade. This attention has, however, been focused primarily on those sediments from buried horizons or cultural features from which, it is believed, the most pertinent information might be gleaned. With such an orientation, it is not surprising that the importance of plowzone sediments has received little notice. In contrast, the importance and usefulness of surficial cultural remains contained in plowzones has been widely recognized and there are few modern archaeologists who do not consider them sound sources of information (see Lewarch and O'Brian 1981b and references contained therein). The quality of information obtainable from surface sites can be improved even more through methodological rigor as has been demonstrated by studies ranging from plow displacement of artifacts (Ammerman 1985; Mallouf 1982; Roper 1976; Rudolph 1977) to amateur collector activity (Heizer and Clewlow 1968; Lightfoot 1978). By understanding the influence plowzone soil factors have on surface artifact recovery, information quality can be further enhanced.

The following discussion on soil factors affecting surface artifact recovery is taken from soil science and agricultural engineering literature. The terms soil and sediment are used interchangeably during the discussion as is the fashion in the literature cited. Their use in this manner should not be

misconstrued, however, because it is acknowledged that in certain contexts they can have distinctly different meanings. The variables discussed as important were chosen based on those mentioned most often in soil erosion research as vital and those deemed most salient to anthropological interests. Whereas the discussion may appear to meander somewhat as it proceeds through variables that affect surface soil erosion, it should be remembered that erosion exposes artifacts that are collected by archaeologists. Soil-related factors are discussed somewhat isolated from the erosive forces working upon them, and in certain cases reference is made to a subsequent section on rainfall factors which clarifies certain points left partially unclear. Both soil and rainfall/water erosion variables are closely interrelated. The soil factors discussed separately are those that would affect erosion rates if other variables, i.e. rainfall, were kept constant.

Slope

Slope percent, shape, and length have pronounced effects on soil erosion. For the purposes of this study, slope effects are more appropriately discussed in conjunction with rainfall variables (covered subsequently).

Surface Stoniness

Surface stones (Evans 1980) influence soil erosion in much the same manner as do vegetation and crop residues (Wischmeier and

Mannering 1969). In addition to blocking the erosive force of raindrops, infiltration rate is heightened around stones where they contact the soil matrix. In excessively stony or gravelly sediments, or in rare archaeological contexts such as extensively utilized chert quarrying and workshop locations, enough soil surface area may be obscured to effectively limit erosion. Further discussion of rainfall obstruction follows.

Antecedent Soil Moisture

Results of efforts performed in Europe to explore the effects of antecedent moisture on soil erosion have produced equivocal results because of numerous variables that cannot be directly accounted for (Evans 1980). Similar findings resulting from work performed in the United States were reported by Wischmeier and Smith (1958). However, experiments dealing directly with raindrop-splash erosion have produced far clearer determinations (Ekern 1951; Ellison 1944; Free 1960; Young and Wiersma 1973). Splash erosion is definitely accelerated when soil approaches or reaches saturation. It should be noted briefly, however, that soil clods may react differently to raindrop impact than do relatively level soil surfaces (Lyles et al. 1974).

Surface Roughness

The roughness of a plowzone surface is influenced by four major factors: 1) type or types of agricultural equipment used, 2) soil type, 3) moisture content at time of tillage, and 4) planting/

harvesting strategy. Dexter (1977) has demonstrated that there is a quantifiable, sequential reduction in the surface roughness produced initially by a mouldboard plow, followed by a disc, tine cultivator, and rotary cultivator. Burwell et al. (1966) divide surface roughness produced by tillage equipment into two categories; oriented and random, referring to whether or not the direction of tillage is apparent in the final pattern. Regardless of pattern, the increased pore space of rougher surfaces manifests greater infiltration rates and water holding capacities than those of smoother surfaces (Borst and Woodburn 1942; Burwell et al. 1966). Concomitant runoff rates are likewise affected. As random roughness and pore space decrease during rainfall, the likelihood of runoff and sheet erosion increases.

Soil texture or type similarly influences surface texture. Clay soils and soils higher in clay content generally produce rougher cultivated surfaces than lighter-textured ones. Clay-rich sediments have been shown to have as much as 2.3 times greater water storage capacity in a freshly plowed condition and still retain approximately one time greater capacity after seedbed smoothing (Evans 1980).

Increased soil moisture content at the onset of cultivation produces a rougher surface than either optimal or low soil moisture levels. Sediments high in clay content that are tilled when damp produce larger, more erosion-resistant clods (Borst and Woodburn 1942).

Planting configuration refers to whether the seedbed is rowed or unrowed. This oriented surface roughness (Burwell et al. 1966)

affects more than surface erosion and artifact exposure rates. Surface area is obviously increased by the roughening influence of tillage. This change in surface area is difficult to perceive and measure on a randomly roughened plot, but on an evenly rowed surface the magnitude of the difference is clearer. Figure 3.1 shows two widely different surfaces--one rowed, one level. If we assume that the blocks of plowed surface are 10 meters on a side and that the rows are 1 meter apart and .5 meters high, the surface area exposed on the rowed surface is 141.42 m². In contrast, the level block has a surface area of only 100 m². Simply by changing the planting configuration, surface area has been increased by over 40 m², or nearly 50%. This could have a pronounced detrimental effect on the accuracy of quantitative surface artifact estimates if areas within a field have been given different surface preparations.

Soil Aggregation

Soil aggregates are soil particles held together in a single mass or cluster. Their forms have been described as clod, crumb, block, or prism (Brady 1974). Regardless of shape, water-stable aggregates (W.S.A.) have been isolated as an important variable in soil erosion research. The percentage-weight of W.S.A. greater than 3 mm and the percentage-weight of W.S.A. less than .5 mm are demonstrably among the most reliable erosion indicators of all soil indices (Bryan 1974), and can be measured using a simple wet sieving technique developed by Yoder (1936). The following discussion of soil aggregates is summarized primarily from Brady (1974).

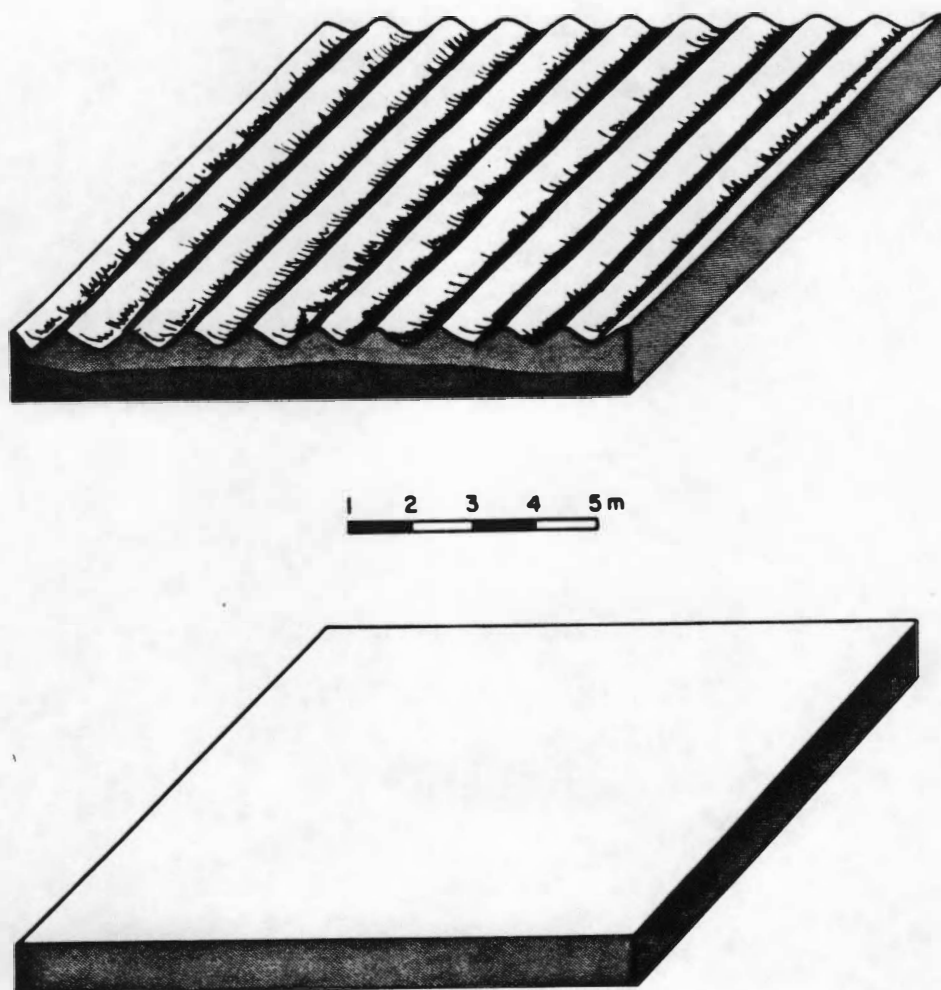


Figure 3.1. Schematic representation contrasting differences in surface area exposure between rowed and unrowed land surfaces.

There are two sets of factors that must be considered in studying soil aggregation: first, those involved in formation, and second, those that influence stability. Those responsible for aggregate or granular formation are listed by Brady (1974:58) as: 1) wetting and drying, 2) freezing and thawing, 3) activity of roots and soil animals, 4) influence of decaying organic matter, 5) modifying effects of absorbed cations, and 6) tillage. Of these six factors only one, influence of decaying organic matter, exerts long-term effects on soil aggregate stability. There are three major factors involved with organic matter effects: 1) temporary mechanical binding action of microorganisms following the introduction of fresh organic matter, 2) the cementing action of intermediate products of microbial synthesis and decay, and 3) the binding action of stable humus components, which provides most of the long-term aggregate stability (Ibid:60-62). Inorganic cations (eg., Ca, Mg, Fe and AL) are believed to bind soil clays and organic matter forming clay-organic complexes thought to be the most stable aggregates. Clay mineralogy has an added effect, with kaolinite and hydrous oxide clays producing the most stable soil aggregates. Other studies have similarly suggested that clay-organic matter bonds are those most resistant to erosion (Greenland 1965a, 1965b; Morgan 1979; Wischmeier and Mannering 1969).

Cultivation has an initial beneficial effect on aggregate formation by distributing organic matter. However, under long-term continuous tillage soil organic matter content declines due to oxidation from air exposure and ultimately reverses the trend (Brady

1975; Skidmore et al. 1975). Stable soil aggregates are less transportable by erosive forces than are the separates that compose them and so improve drainage capabilities by allowing percolation through increased pore spaces. Additionally, they limit surface runoff by preventing crust formation on the surface of sandy soils, which are particularly susceptible to such compaction.

Much of the literature describing soil erosion factors deals primarily with unplowed or "natural" soils. It is encouraging to discover that much of this literature is also directly applicable to cultivated or pulverized sediments. Three studies devised to examine differences in erosion characteristics of soil samples in their "natural" and pulverized states concluded that many characteristics are shared between the two conditions. There was generally more erodibility manifested in corresponding pulverized samples, but as Woodburn and Kozachyn comment, "those soils most susceptible to splash erosion in the undisturbed state were also most erodible in the pulverized state" (1956:752). For concurrent conclusions see Woodburn (1948) and Osborn (1954b).

Particle Size

Soil erodibility indices have been developed and employed as alternatives to actual measurements of soil-loss under controlled laboratory or field conditions. Use of these indices provides several advantages over actual measurement techniques. Erodibility indices can be calculated rapidly from analytical data and require less labor and equipment. They are also purported to be universally applicable,

although this point has been strongly contested (Bryan 1968). Several disadvantages are also inherent in their use. Because they are laboratory-based procedures designed to isolate properties influencing erosion, they often provide only general information about different soil types. They do not produce a quantitative measure of the amount of erosion that occurs when a particular soil is subjected to monitored, controlled rainfall (Hudson 1971). Consequently, with a few exceptions, erodibility indices are best used as heuristic classifiers. This should be expected since they attempt to explain soil erosion without directly considering the major eroding agents, which in this case are rainfall and subsequent overland flow. Such ratios have been criticized for being too general because they are based on a single property or variable when many are interrelated (Hudson 1971). Yet, in the absence of actual, quantifiable measurement techniques (which are discussed with the affects of rainfall), erosion indices remain useful in describing soil properties related to erosion.

The simplest example of an erosion index is the mechanical composition or particle size distribution of a soil. Relative percentages of sand, silt, and clay have been widely used in many disciplines to describe soil texture. This measure does permit relatively reliable classification of soil into erodible and more coherent classes. Evans (1980) plotted particle size data for 76 erodible soils from the United States, Canada, England, and India. His three-way plot shows that 75% of these widely distributed erodible

soils have clay contents 30% or lower and over 85% have clay contents less than or equal to 35% (Evans 1980:117). This distribution suggests that soils with more than 30-35% clay are more coherent and tend to form stable aggregates which are more resistant to raindrop erosion. This observation is, however, based upon a single variable.

A major criticism directed at erosion indices asserts that they are static procedures and untested in dynamic, real-world situations (Morgan 1979). Bryan (1968) tested many such indices against actual soil losses produced in a controlled erosion experiment and found that all five of the most reliable and efficient indicators of erosion were those concerned with aggregate stability. The best were percentage-weight of water stable aggregates >3 mm and percentage-weight of water stable aggregates >0.5 mm (modified from the work of Conaway and Strickling 1962), erosion ratio (Middleton 1930), surface-aggregation ratio (Anderson 1954), modified surface-aggregation ratio, and clay ratio (Bouyoucos 1935). Water stable aggregate percentages produced the most encouraging results, followed by the other four ratios which focus primarily on variables of clay percentage and content (Bryan 1968). Results are based on soil collected in runoff from a 20% slope, and this steepness may account in part for the results.

Soil Profile

Soil profile data are important to the present study for two reasons. First, the existing profile is responsible for sediments

constituting the plow layer (Ap). Second, the sub-plowzone configuration directly affects profile drainage for all sediment horizons from the Ap to bedrock. As an example of this, physical evidence of profile drainage effects can be found in soil capability classifications for sediments within the Central Duck River Drainage. Comparison of capability units I1e-1 (well-drained profile) and I4e-1 (heavy clay layer in subsoil) shows differing suitabilities because of sub-Ap characteristics (Harmon et al. 1959:52, 58). The heavy clay layer of unit I4e-1 "restricts the penetration of air and moisture...." Consequently, the "plow layer absorbs rainfall slowly, and runoff is generally rapid" (Ibid:58). Drainage characteristic differences not only influence suitability for row crop agriculture as inferred in the preceding quote, but would also affect exposure of plowzone artifacts by rainfall.

Soil profile drainage effects have been reviewed by numerous investigators (Brady 1974; Evans 1980; Morgan 1979; Wischmeier and Mannering 1969; among many others). Evans (1980) presents evidence that a well structured, prismatic B horizon drains well, while a platy or bedrock layer near the surface impedes drainage. In a study relating soil properties to erosion, Wischmeier and Mannering (1969) suggest that textural change in the horizon immediately below the Ap decreased infiltration, while in those situations where little change occurred drainage remained good. That is, if the Ap was granular and so was the underlying B, drainage would remain good and unimpeded. It is important to consider that the critical horizon is the one that has

the lowest infiltration rate. In some situations this critical horizon can vary. The formation of a surface crust upon sandy plowzone sediments can drastically change drainage patterns. This compacted layer of no more than 2 mm in depth can be well-sealed enough to promote runoff (Baver 1948; Duley and Kelly 1939; McIntire 1958; Morgan 1979; Neal 1937).

Comparison of Sediments from Areas Tested

General descriptions of soils associated with areas subjected to intensive plowzone data recovery efforts are found in Harmon et al. (1959). Any paginated citations that follow pertain to this source.

Both the Armour silt loam series present at 40MU86 and the Etowah silt loam at 40MU110 and 40MU409 are included in agricultural capability unit IIIe-1 and are classified with the zonal soils in Maury County, Tennessee, which fall within the red-yellow podzolic soils group. The Armour group is described as gently sloping to sloping, derived from high-grade phosphatic limestone, moderately high in organic matter, with surface soils of well-drained friable silt loam, and strong brown yellowish-red subsoil of friable, silty clay loam. Descriptions for the Etowah group closely mirror those for the Armour, differing only in sediment colors and in subsoil structure which can vary from friable to firm (1959:16, 31).

Further comparison of these sediments in accordance with the more specific variables discussed previously also shows them to be generally concordant. The effects of many of these variables were controlled by selecting areas for testing that were free from their

influence. For example, slope is not considered a factor here because areas selected for intensive work were the most level ones at each location (under 5% slope). Surface artifact densities were not great enough to interfere with tillage, and the only sediment deposits with relatively high gravel content were on eroded terrace and hill scarps far from tested areas. Because of these factors, surface stoniness is ruled out as an influence.

Soil moisture was not measured at the onset of tillage, but was judged to be similar at all three locations. Therefore, its influence on surface roughness variation is considered negligible. In each case, agricultural equipment and the mode of its usage were kept comparable and in accordance with tillage practices for row crop production in the region. This included use of a mouldboard plow followed by disking. The exception to standard procedure excluded using a planter of any form as no seed was sown on any of the prepared plots, except for portions of 40MU110 (Chapter II). The potential effects of these two factors on surface roughness variability were controlled to a greater degree in this case by procedural monitoring.

Effects of the combined influences of various soil physical properties on surface conditions cannot be controlled so easily. Tests sites were selected on the basis of apparent sediment comparability, but potential variation in soil aggregation characteristic and particle size distribution across large geographic areas required close examination of similarity. Thus, variation in

soil aggregation characteristics, particle size distribution, and soil profile will be examined most carefully.

Table 3.1 summarizes published information available for Armour and Etowah silt loams. Sediment characteristics compiled from both the American Association of State Highway Officials (A.A.S.H.O.) and the Unified Soil Classification System (Waterways Experiment Station 1953) have been summarized and adapted from Harmon et al. (1959:87). The A.A.S.H.O. classification is geared toward acceptable engineering usage, and is considered too broad and will not be discussed directly. However, the similarity in classification from all horizons for both soils should be noted. The other A.A.S.H.O. classification, moisture-holding capacity in inches/hour, also shows strong correspondence in each case. All classifications based on the Unified system likewise show encouraging similarities. Both shrink-swell potential, based primarily on clay mineralogy, and permeability, which indicates general structure and aggregate relationships, exhibit exact correspondence. The Unified system also shows close correspondence in horizontal soil type classification. This system's classification is based more on particle size and, therefore, deserves closer scrutiny as an initial indicator of sediment similarity.

All soils listed under the Unified classification system in Table 3.1 are considered fine-grained. For a soil to be classified as fine-grained under this system, more than 50% of any given sample must pass through a number 200 sieve. Once a soil's identity has been established as either coarse or fine-grained using this arbitrarily

Table 3.1. Estimated engineering classification and physical properties of soils from sites in shovel test study. Adapted from Harmon et al. (1959:87, Table 29).

Site	Soil Type	Typical Depth of Major Horizons in Inches	Classification		Permeability Inches/Hr.	A.A.S.H.O. Available Moisture Holding Capacity Inches/Hr.	Shrink-Swell Potential
			Unified*	A.A.S.H.O.**			
40MU86	Armour Silt loam	0-12	ML or CL	A-4 or A-6	.2 - .8	.15 - .20	Moderate
		12-24	CL or CH	A-6 or A-7	.2 - .8	.15 - .20	High
		24-36+	MH, CL or CH	A-6 or A-7	.2 - .8	.15 - .20	High
40MU409	Etowah Silt loam	0-10	ML or CL	A-4 or A-6	.2 - .8	.15 - .20	Moderate
10-20		MH, CL or CH	A-6 or A-7	.2 - .8	.15 - .20	High	
40MU110		20-36+	MH, CL or CH	A-6 or A-7	.2 - .8	.15 - .20	High

*Waterways Experiment Station, 1953

**American Association of State Highway Officials

established cut-off, samples are further subdivided into groups based on major constituent particle size and sample liquid limit. The sediments from 40MU86 (Armour silt loam), 40MU409, and 40MU110 (Etowah silt loam) (Table 3.1) will be used as an example of how this classification system operates.

The first letter in each of the paired symbols listed under the Unified classification column represents the major particle-size constituent and the second letter designates the potential liquid limit. For example, the letter M signifies predominately silty materials while the letter C indicates clay as the most abundant component. Similarly, the letter L implies a low liquid limit and the letter H a high one. The pairing of these symbols in Table 3.1, for instance, the ML designation for the first horizon of Armour silt loam, tells us that this zone comprises predominately silty materials with low liquid limit. Correspondingly, the CH designator for the third horizon of Etowah silt loam indicates a predominance of clay with a high liquid limit as one of the possibilities in this zone. General relationships between these sediment groups under this classification system are best shown by means of a plasticity chart which can be described as follows: The plasticity chart (Figure 3.2)....

is a plot of liquid limit versus plasticity index on which is imposed a diagonal line called the "A" line and a vertical line at a liquid limit of 50. The "A" line is defined by the equation $PI = 0.73 (LL - 20)$ except in the lower portion below a liquid limit of about 29, where it becomes a horizontal zone extending from $PI = 4$ to $PI = 7$. The "A" line represents an important empirical boundary between typical inorganic clays (CL and CH), which are generally located

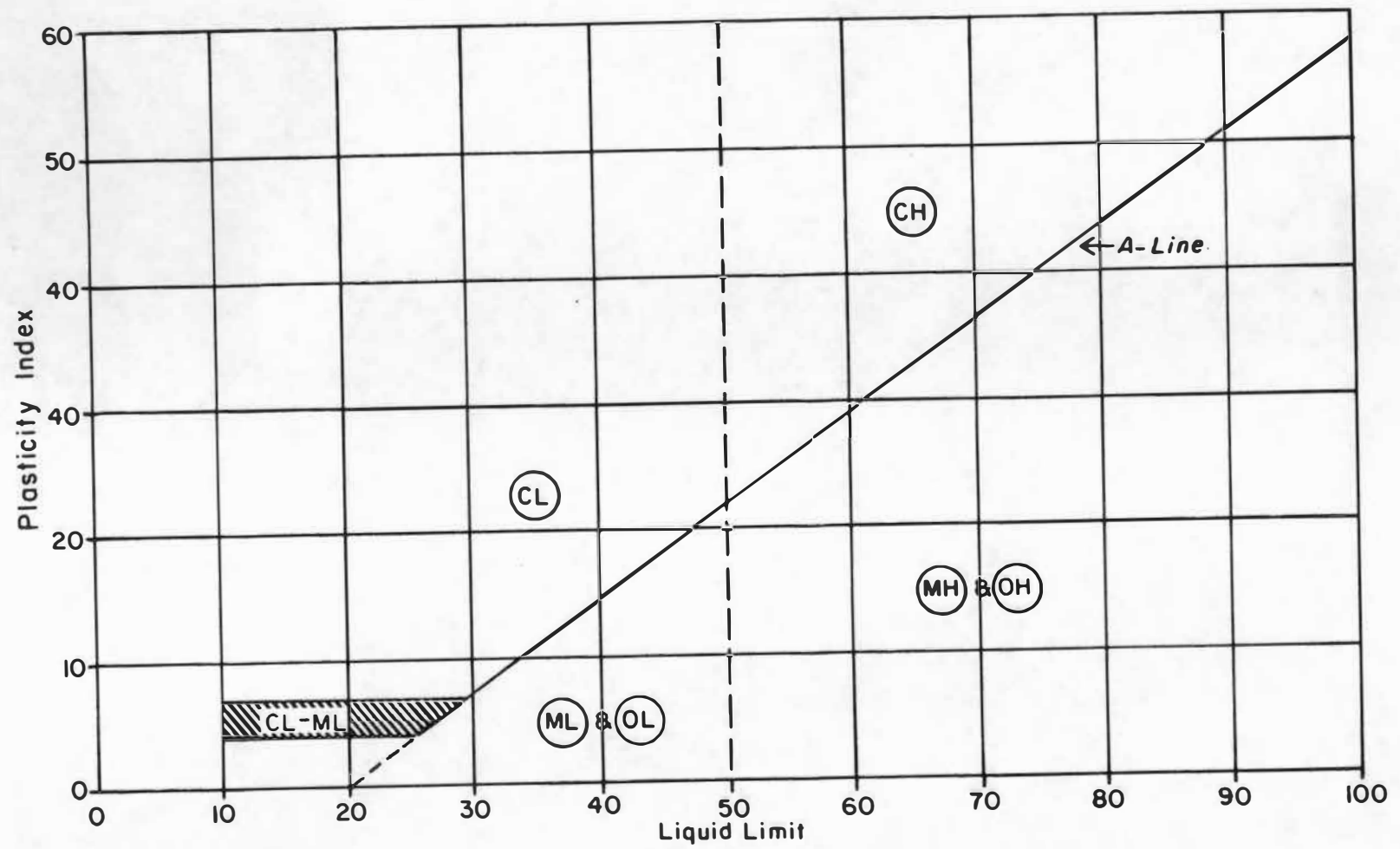


Figure 3.2. Soil plasticity chart.

above the line, and plastic soils containing organic colloids (OL and OH) or inorganic silty soils (ML and MH). The vertical line at liquid limit 50 separates silts and clays of low liquid limit (L) from those of high liquid limit (H). In the lower portion of the chart below a liquid limit of about 29 and in the range of PI from 4 to 7 there is considerable overlapping of soil properties of the clayey and silty soil types. Hence the "A" line in this region has been shown as a zone, and soils falling within it should be classed as borderline.... (Waterways Experiment Station 1953:22-23)

It is clear from Figure 3.2 that proportional silt and clay content are determining factors in a sediments' plasticity. Employing this knowledge would allow meaningful comparison between site soil groups if it were not for the potential variability demonstrated within individual horizons. In spite of the fact that there is general equivalency between corresponding horizons in the Armour and Etowah groups under both the Unified and A.A.S.H.O. classification, and similar conformity in depth of horizonation, permeability, available moisture-holding capacity and shrink-swell potential, more precise resolution of the sediments' mechanical structure is necessary before results of final comparisons can be accepted.

Plowzone and sub-plowzone sediment samples for particle size analysis were taken from each site included in the study. Samples were processed in the archaeological soils lab at the University of Tennessee, Knoxville. Final distribution determinations were produced using the hydrometer method. Results of particle size determinations are presented in Table 3.2. Also included is a clay index as a relative measure of similarity between samples (Bouyoucos 1935). All samples are similar, with sand percentages running slightly higher in

Table 3.2. Results of physical analysis of sediment samples from three test sites.

Sample		Percent			Erodibility* Index
		Sand	Silt	Clay	
40MU86	Plowzone	33.5	52.0	14.5	5.90
	Below Plowzone	34.0	50.0	16.0	5.25
40MU110	Plowzone	20.0	64.0	16.0	5.25
	Below Plowzone	14.0	66.0	19.5	4.10
40MU409	Plowzone	18.0	67.0	15.0	5.67
	Below Plowzone	16.0	66.0	18.0	4.56

*Erodibility index taken from Bouyoucos' clay index (1935) and calculated as the ratio: $\frac{\% \text{ Sand} + \% \text{ Silt}}{\% \text{ Clay}}$

both plowzone and sub-plowzone Armour silt loam. Particle-size distribution of Etowah silt loam from both sites is very similar in spite of considerable geographic separation and physiographic difference. The close correspondence of all samples, and especially the similarity of paired samples from each site, is clearly evident in Figure 3.3. Plotted curve shapes are virtually indistinguishable between plowzone and sub-plowzone from each site and nearly so at different sites. Due to the similarities in critical soil variables shown at these three sites, much of the influence they could exert on artifact recovery is nullified. A close correspondence in recovery is therefore expected between sites, and any similarities or differences manifested are assumed to be genuine and not a function of soil differences.

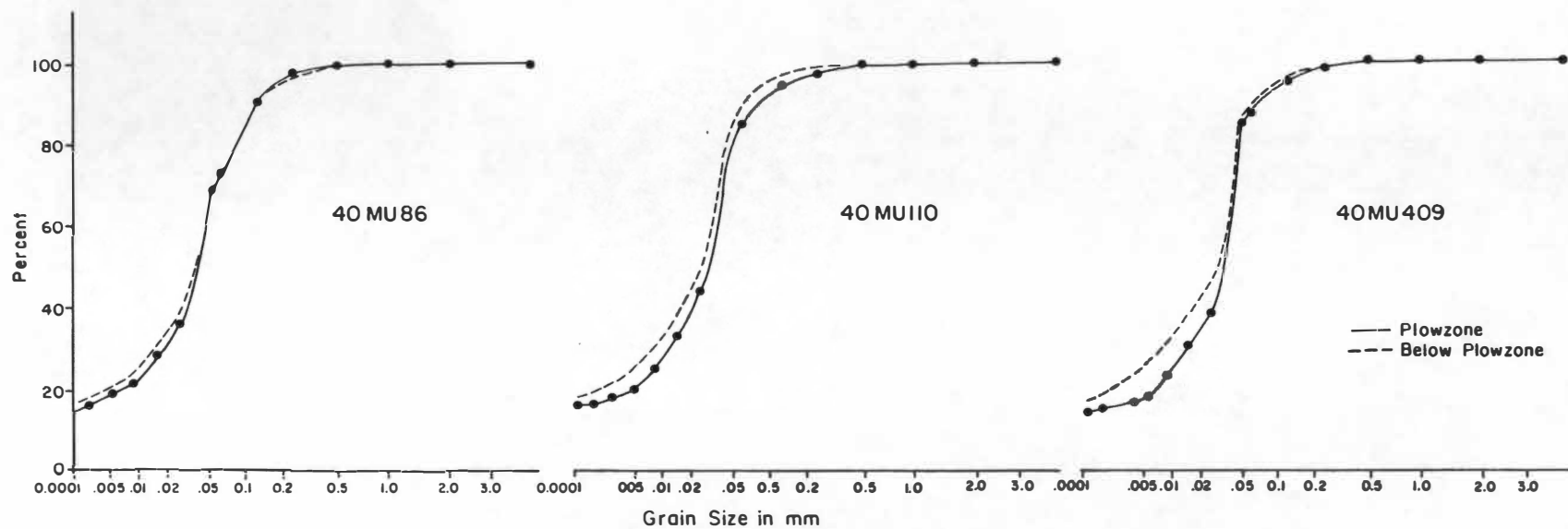


Figure 3.3. Cumulative curves showing results of mechanical analysis for sediment samples from the three sites included in the plowzone study.

CHAPTER IV

RAINFALL VARIABLES INFLUENCING
SURFACE ARTIFACT RECOVERY

In the following discussion, the topic of archaeology is mentioned infrequently. It is emphasized here, as it was at the opening of Chapter III, that the topics discussed pertain just as directly to surface artifact recovery potential as do more obvious variables such as sampling strategy or surveyor interval. At some points this may not seem so, as considerable effort is expended relating such variables as raindrop size to velocity, etc. It must be remembered that surface artifacts cannot be collected if they are not exposed, and it is this topic that the following section concerns.

Rainfall as an Erosive Force

The power of rainfall as a geologic force eroding soil is difficult to comprehend. It is a process composed of cumulative single events acting in a manner similar to waves altering a shoreline or prevailing breezes imperceptibly shifting sand dune locations. But this description pertains only under natural, undisturbed conditions. The clearing of surface cover greatly increases rainfall erosivity. When rain falls unimpeded on a bare surface, the resulting erosion parallels that caused by storm-driven waves and gale-force winds. This was exemplified in the United States around the turn of the century when vast expanses of land were cleared during timber and agricultural resource exploitation. The subsequent land surface

degradation was cataclysmic, fostering a realization that the nation's productive surface soils would be irreparably damaged unless land management practices were improved. This awareness inspired diverse reaction ranging from poetic pleas exulting the "ruthless justice of nature" (Carter 1949) and choices for future generations, i.e. "farmland or wasteland?" (Sampson 1981), to carefully conceived scientific studies, observations and experiments designed to isolate factors contributing to and limiting erosion (i.e. Cook 1936; Duley and Kelly 1939; Ellison 1944, 1945; Ellison and Slater 1945; Free and Palmer 1940; Gerdell 1937; Hendrickson 1934; Horton 1940; Laws 1940; Lowdermilk 1930; Meginnis 1935; Middleton 1930; Neal 1938; Osborn 1954a, 1954b; Peele 1937; Wilm 1943; Wischmeier 1962; Woodburn 1948; Yoder 1936; Zingg 1940; among many others). From these, and other more modern works, can be gleaned not only an understanding of rainfall's erosive power and its control, but also data invaluable to archaeologists. In this particular instance these data concern factors affecting surface artifact recovery.

Before delving directly into the physical characteristics of rainfall as they relate to archaeological recovery, it should prove beneficial to briefly examine some practical examples illustrating the magnitude of the erosive force exerted by rainfall. In a temperate region receiving approximately 40 inches of rainfall/year, in excess of 4500 tons of water fall on each acre, much of it with erosive force (Carter 1949). In the Midwest, for instance, an average thunderstorm of 30 minute duration yields 100 tons of water per acre. With

billions of drops falling at 20 miles/hour within this time, approximately 2,000,000 foot pounds of energy are expended on each acre (Wischmeier and Smith 1958). A third example illustrates the effect this can have. In 1949 a single storm in Guthrie, Oklahoma, resulted in sediment losses as great as 222 tons/acre, or stated another way, the loss of 1.3 inches of topsoil (Wischmeier 1962). This clearly suggests a force of great magnitude. However, catastrophic events such as this are not responsible for much of the long-term losses. Slow, steady, yearly erosion accounts for the greatest part.

Rainfall induced erosion is made up of two intricately interrelated components: raindrop impact or splash erosion, and subsequent overland flow which encompasses both sheet wash and rill erosion. The degree to which these components are interrelated will become clearer in later discussion, but for now it will be sufficient to think of them as a continuum. The energy responsible for sheet erosion is primarily a function of raindrop impact, while the cause of rill or gully erosion stems directly from the energy of sheet erosion (Ellison 1945). No techniques or equipment are available to directly measure the erosivity of rainfall. Consequently, all efforts to do so employ two indirect pluviological methods termed pluvioenergetic and pluviosimulation by Zachar (1982). Pluvioenergetic methods, represented by such studies as those of Free (1952) and Laws (1941), utilize naturally occurring rainfall. In contrast, pluviosimulation methods are laboratory controlled and employ rainulators or rainfall

simulators (i.e., Duley and Hays 1932; Zingg 1940). Both methods manifest advantages and disadvantages, the merits of which are discussed at length in Zachar (1982) and consequently not recounted here. Regardless of technique, results of experiments utilizing these methods are applicable to surface archaeology problems and are included in this study. A useful, general description of raindrop erosion is presented by Ellison's observations of his pluviostimulation experiments:

The soil was air-dry at the start of each experiment, and the first raindrops striking the surface tended to break down aggregates and release fine particles of silt and clay. The splash carried some of these particles and when it returned to the surface, it was no longer clear water as was the original raindrop. Instead, it was composed of a mixture of water, clay, silt, and sand. As returning splashes infiltrated, most of the splashed particles of sand and silt were deposited on the surface, but the clay particles were mostly filtered out immediately below the surface, as the water percolated downward through the soil-mass. These deposits of fines contributed to the surface-sealing process which was well advanced within two to three minutes after the beginning of rainfall. The rate of splash erosion, which reached a maximum at about this time, seemed to be caused by the loose material on the surface being covered with water, with very little cohesion between the particles. Reductions in rates of soil-splash which follow about three minutes after the beginning of rainfall..., were associated with the removal of these loose materials from above the plane of sealing (1945:418).

Contained in this brief quote are seven important stages of rain influenced erosion. They begin, appropriately, with (1) the existing surface upon which the rain falls, followed by (2) raindrop impact and aggregate or clod breakdown, (3) splash of released particles, (4) infiltration of returning splash, (5) surface sealing caused by fine particle illuviation, (6) increase in splash erosion as decreased

infiltration rates produce a thin surface water layer which in turn decreases aggregate cohesion, and finally, (7) a reduction in splash erosion as the majority of loose material is removed from above the surface seal. Should sufficient slope be present, the logical continuation of the erosion sequence would then include (8) pre-rill erosion or sheet wash as surface water deepens, and if subsequent flow becomes channelized, (9) rill or gully erosion. As stated earlier, this description is useful but it is also overly simplistic. There are many variables which can intervene at any of these stages and either change the outcome or influence the order of the transition from one step to sequent ones. Consequently, a discussion follows designed to elucidate pertinent factors influencing rainfall erosion as they relate to surface artifact exposure and prospective recovery.

Initial discussion will focus on existing land surface condition at onset of rainfall. Essential variables here include soil type and condition, slope, and surface cover. Whereas several of these were covered briefly in the preceding chapter (Chapter III), they will be examined more extensively in conjunction with eroding agents as was promised. The remaining discourse will involve aspects of the other erosional steps, all of which are directly related to rainfall energy variables. The framework for discussing rainfall variables is adapted primarily from summaries in Hudson (1971), but numerous other sources are utilized as well. Rainfall variables to be discussed include quantity, intensity, raindrop size and size distribution, terminal velocity, and momentum and kinetic energy.

The Existing Surface as a Factor Influencing the Erosivity of Rainfall

Soil type and surface condition have been shown to influence erosion (Chapter III). It is important to observe specific instances of how different soil types and surface conditions react to rainfall.

Woodburn (1948) performed an experiment to determine the effect soil type has on raindrop splash erosion. Air-dried samples of finely pulverized soil were wet by capillary action prior to the application of simulated rainfall at the rate of approximately 12 inches/hour. Soil types used in this experiment and their mechanical analyses are provided in Table 4.1. Results for pulverized samples are depicted in Figure 4.1 with proper names deleted. Curve shapes for all samples are similar, suggesting roughly parallel relationships of soil loss through time. The major differences lie in the magnitude of these losses. Silt is the most susceptible to splash loss and the clay-rich sediments the most resistant.

A second test demonstrates that surface texture also affects the magnitude of rainfall produced erosion because it influences infiltration rate. Figure 4.2 shows that there is an inverse relationship between infiltration rate and soil loss. With sediment type held constant in this experiment, it is clear that infiltration rate is dependent upon surface roughness, controlled by soil moisture at the time of tillage. The cloddy surface maintained a higher absorption rate throughout the hour-long test. The initial differences in infiltration rates and soil losses manifested by the

Table 4.1. Mechanical analysis for sediments plotted in Figure 4.1. Sediments are ranked from greatest to least splash loss (Data after Woodburn 1948).

Sediment Type	Percent		
	Sand	Silt	Clay
Memphis silt	5	85	10
Standard sand*			
Luverne sandy loam	60	33	7
Ruston subsoil	24	43	33
Houston clay	32	24	44

*Passing 60-mesh standard sieve and retained in 70-mesh.

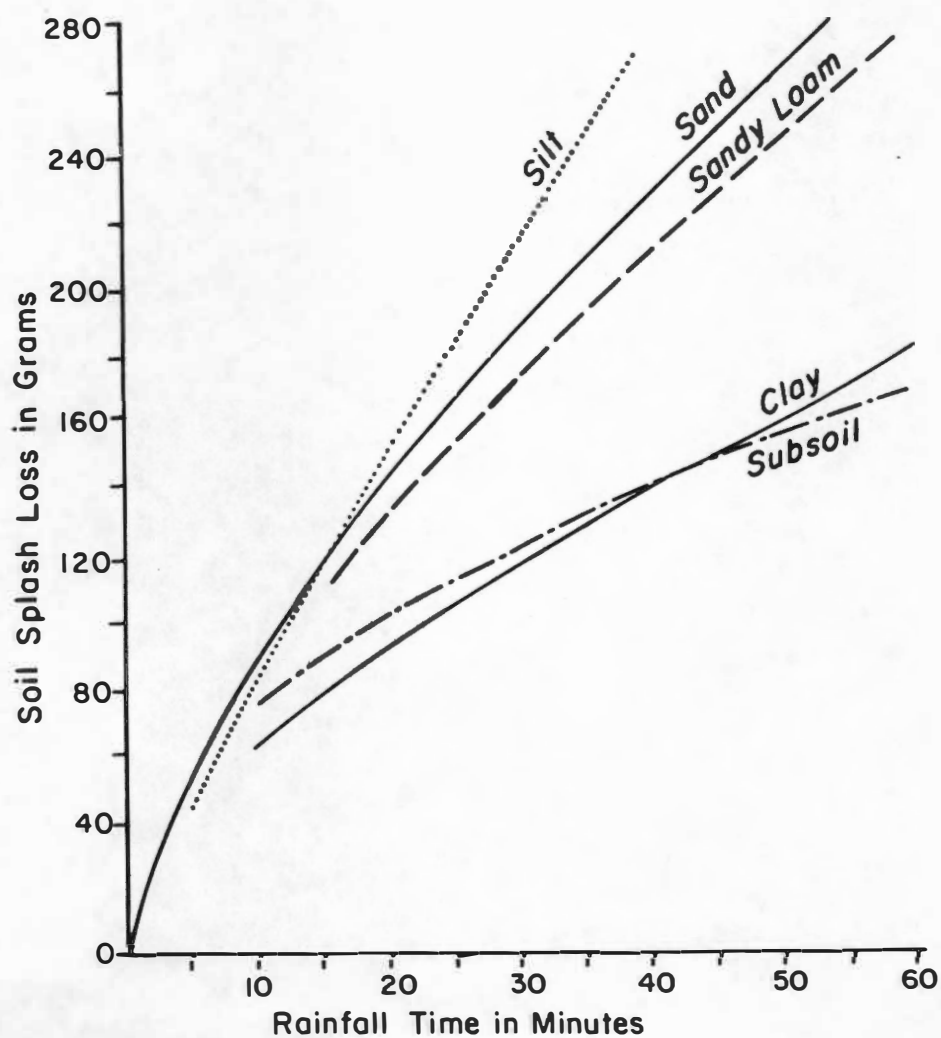


Figure 4.1. Relationship between soil splash loss and length of rainfall episode for pulverized sediment samples of different particle size. (After Woodburn 1948).

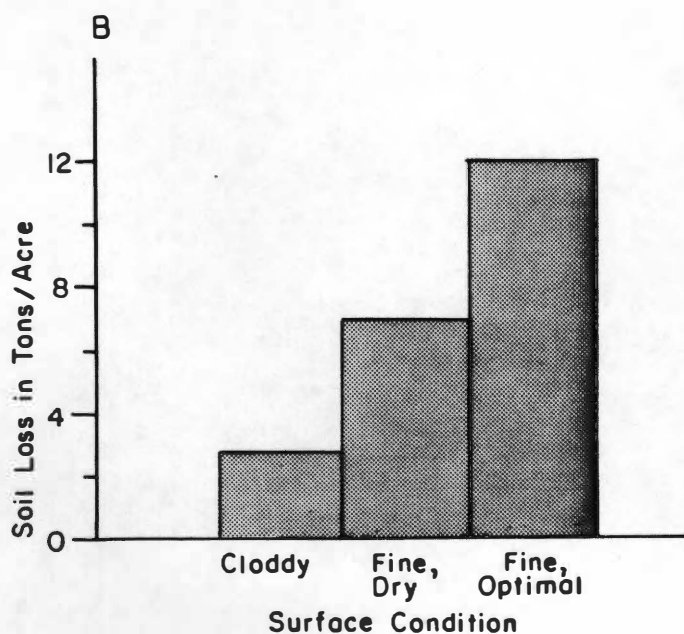
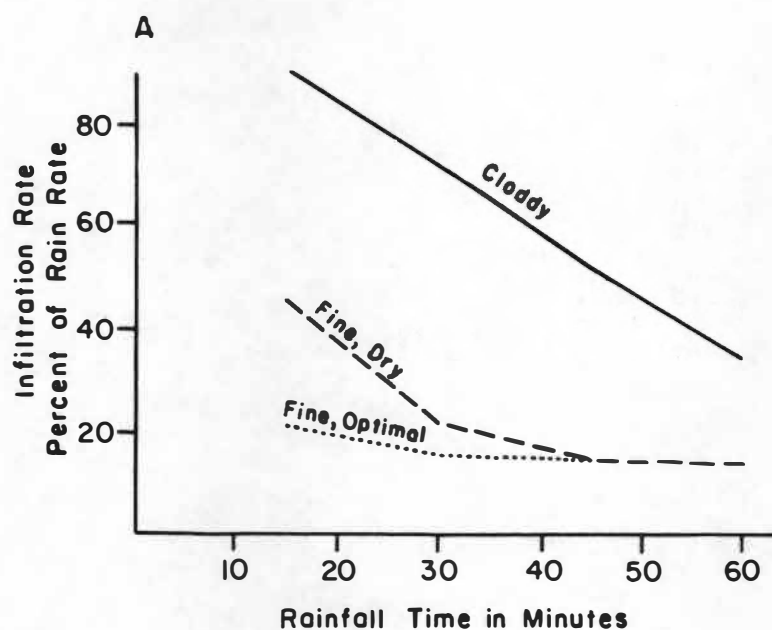


Figure 4.2. Relationship between rainfall duration and infiltration rate for different surface textures (A), and how surface condition affects soil loss (B). (A., modified from Borst and Woodburn 1942; B., from data in Borst and Woodburn 1942).

two finer samples are attributed to differences in soil moisture at the onset of rainfall (Borst and Woodburn 1942).

Slope also affects rainfall induced soil losses. To summarize the conclusions of one study (Zingg 1940), we find the following results: (1) doubling the degree of slope increased total soil loss over two and one-half times, (2) doubling horizontal slope length increased total soil loss in runoff over three times, (3) increasing degree of slope increased total runoff, (4) increasing slope length decreased total runoff, and finally (5) soil moisture content at test completion showed an inverse relationship to total runoff. These results indicate that artifact exposure rates could differ drastically within the same field if sufficient slope variation were present. These relationships of soil losses to slope make intuitive sense when viewed in terms of runoff. A second component of such soil loss, the direction of rain-splashed particle movement, is not so apparent, however.

When raindrops strike a level surface, the splashed particles are more or less randomly redistributed (Statham 1977). However, when drops strike a sloping surface, more material is rebounded downslope than upslope (Ellison 1948). This is evident in illustrations provided by Statham and Ellison. Ellison (1944) measured differences in splash direction on a 10% slope and reported that as much as 75% of splashed material was deposited downslope from the point of drop impact. Although they dealt with steeper slopes, Ekern's (1951) inquiries produced supporting results. For example, on a 50% slope,

essentially all of the splashed material moved downhill. Moseley (1973, as discussed in Statham 1977:127) presents data that further substantiate this evidence. On a 25% slope, over 95% of splashed material traveled downhill.

The influence of the downslope component of splash erosion could be pronounced on surface artifact recovery and distribution. Exposure rates might well vary between level areas and hillsides. Additionally, the redistribution of smaller particles downslope could bias attempts to utilize microdebitage in archaeological distribution studies.

Quantity

As Hudson (1971:47) has pointed out, there is an obvious association between the amount of rainfall and erosion extent. That is, more rain produces more erosion. Yet this relationship is not as straightforward as the statement implies. Many other variables exert strong influences, so much so, in fact, that the correlation between rainfall amount and erosion amount can be quite poor. It is highly unlikely that two storms, each producing equal rainfall, would cause similar soil erosion should storm duration vary. Two inches of rain falling within five minutes would produce different losses than would two inches over a twelve hour period. Add to this the fact that rainfall rate can and usually does change many times during a storm, and it becomes evident that the probability of two identical storms is very unlikely (Wischmeier 1962). Consequently, understanding the influences of other rainfall erosion variables becomes vital.

Intensity

Rainfall intensity and rainfall rate are synonymous and are usually recorded as the amount of rain falling within a standard time span (usually one hour). Rainfall intensities above 75 mm/hour are rare in temperate climates and usually occur only in thunderstorms. Tropical regions, however, regularly experience rates of 150 mm/hour (Hudson 1971). Rainfall intensity variation does not appear to be directly responsible for differing erosion rates. However, other factors involved in intensity changes do generate considerable influence.

Raindrop Size and Drop Size Distribution

Several techniques have been developed to measure drop size. These range from the early work of Lowe (1892), who measured splash marks on a gridded slate, to the more sophisticated dye stain method (Hall 1970) and flour pellet approaches (Hudson 1964; reviewed in Hudson 1971). The importance of drop size determination is evident upon the realization that drop size varies with rainfall intensity (Carter et al. 1974; Evans 1980; Hudson 1971; Statham 1977; Wischmeier and Smith 1958), and that in storms of similar origin (i.e. convectional or frontal) occurring in the same region, drop size can be closely predicted (Best 1950; Ekern 1951).

As the data in Table 4.2 clearly show, raindrop size increases as intensity increases. However, drops larger than approximately 6 mm in diameter are unstable because of air turbulence and tend to fragment into smaller drops (Blanchard 1950). There are some sporadic

Table 4.2. "Typical" drop sizes and related data for storms of different intensities. Data presented in Zachar (1982:215).

Rain Characteristics	Rain Intensity (mm/min ⁻¹)	Typical Drop Size (mm)	Drop Fall Velocity (m/s ⁻¹)
Fog	-	0.01	0.003
Mist	0.0003	0.1	0.25
Drizzle	0.0042	0.2	0.75
Shower	0.016	0.45	2.0
Rain	0.066	1.0	4.0
Heavy rain	0.25	1.5	5.0
Very heavy rain	0.66	2.1	6.0
Downpour	1.61	3.0	7.0

instances in storms above 200 mm/hour intensities where smaller drops merge to form large drops, but such occurrences are rare. Specific examples of drop-size distributions are displayed in Evans (1980:113) and Hudson (1971:53), but for this discussion a more generalized case is appropriate. Figure 4.3 evinces the relationship between rainfall intensity and drop-size distribution occurring in natural rainfall. The tendency for drop diameter to increase with intensity is shown (a), as is the percentage of drops within certain size groups during different intensities (b). Changes in rainfall intensity occurring during a storm further complicate the picture.

Terminal Velocity

The terminal velocity of a free-falling body under gravity's influence is reached when the frictional resistance of the air is equal to the gravitational force. The final speed attained is dependent upon the size and shape of the falling object. For raindrops, terminal velocity is achieved when gravitational force acting on a drop is balanced by the drag of the air it falls through (Hudson 1971; Wischmeier and Smith 1958). Terminal velocity of raindrops has been studied by many researchers using various techniques, all of which produced basically concurrent results (Gunn and Kinzer 1949; Laws 1941; Spilhaus 1948). Data from the first two of these studies have been incorporated in Figure 4.4. Raindrop terminal velocity increases rapidly with size up to the point where drops become large, unstable, and subject to fragmentation. Wind in conjunction with rain adds a sideways velocity component and alters

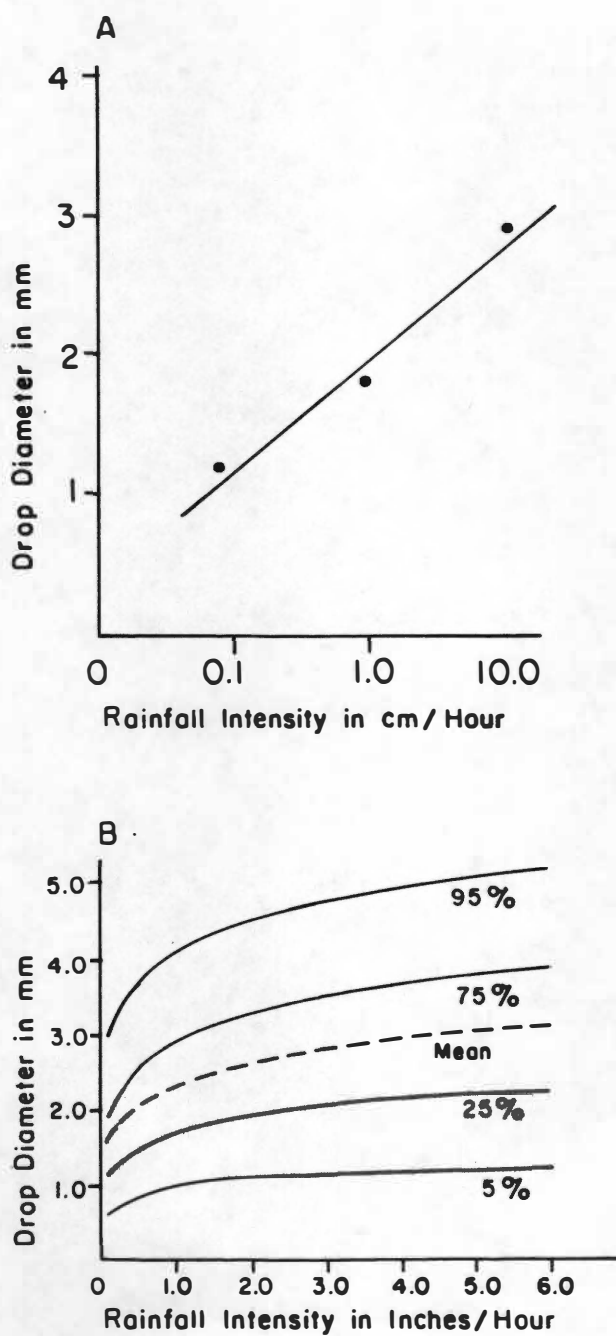


Figure 4.3. Relationship between rainfall intensity and drop diameter (A), and rainfall intensity and drop size distribution (B). (After Statham 1977).

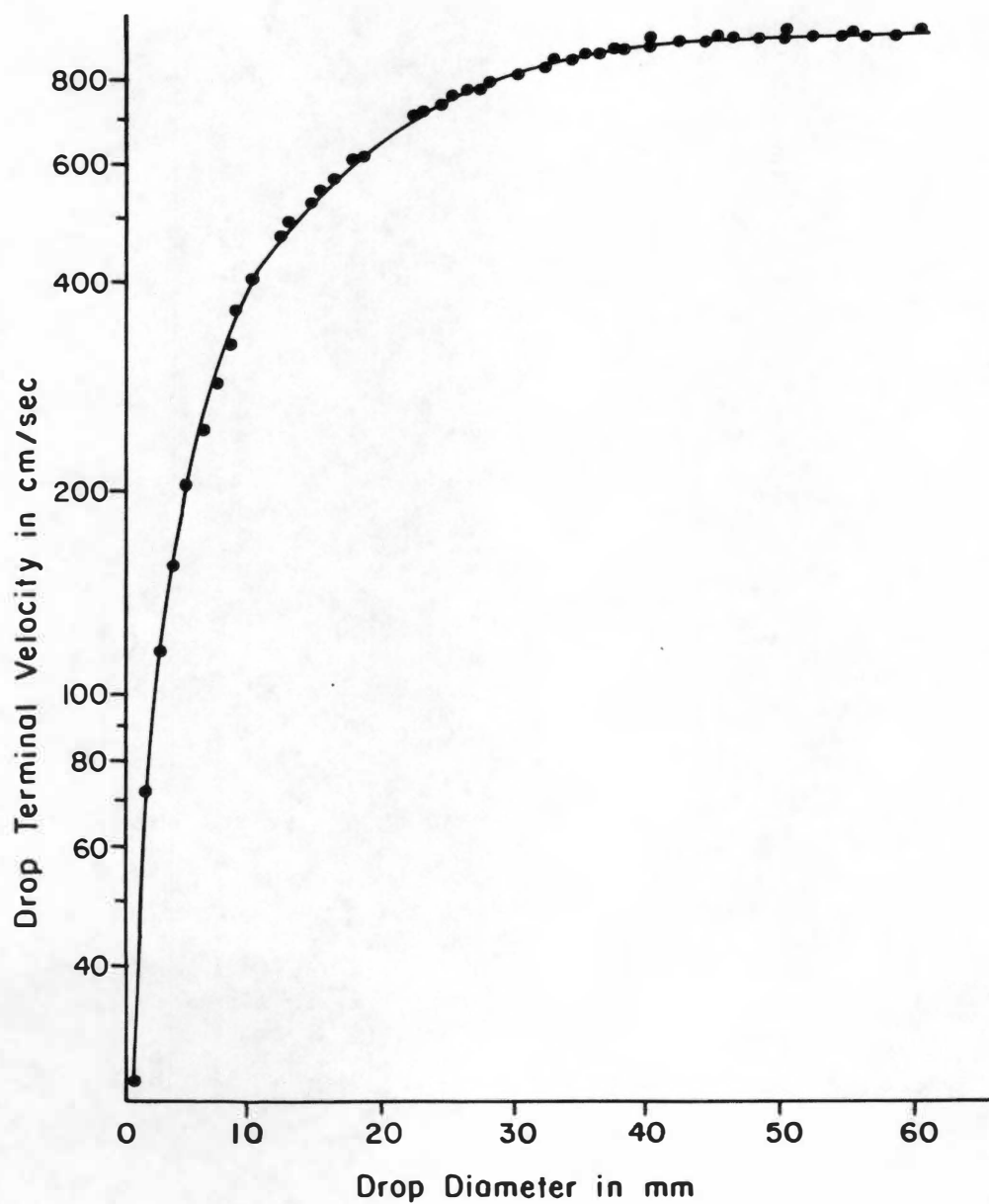


Figure 4.4. Terminal velocities of different sized water drops in stagnant air. (Adapted from Wischmeier and Smith 1958).

still-air derived results. This sideways vectoral velocity has greater effect on smaller drops than larger ones which fall at higher speeds (Hudson 1971).

Momentum and Kinetic Energy

The time expended in previous sections sequentially elucidating the interrelatedness of rainfall quantity, intensity, drop size, and terminal velocity, was a prelude to understanding the associated variables of raindrop momentum and kinetic energy. The momentum of a falling drop can be expressed as the product of its mass and velocity. The kinetic energy of a raindrop is the energy resulting from its motion and is calculated by halving the product of its mass and its squared velocity. Both are measures of the drop's ability to do work. In this case, work refers to the detachment of soil particles or aggregates.

There is divided opinion over which of these measures is the best predictor of rainfall erosivity. Results of experimental inquiries have convinced some researchers that drop momentum is most useful (i.e. Rose 1960; Statham 1977), while others are equally impressed with the utility of raindrop kinetic energy (Ekern 1951; Morgan 1979; Wischmeier et al. 1958; Zachar 1982). Both measures are functions of raindrop mass and velocity, and it has been demonstrated in regard to natural rainfall intensity that drop momentum and kinetic energy are very closely related (Hudson 1971; see also Figure 4.5). The question then becomes not which is better, but which can be more easily measured (ibid). Most measurements of either drop momentum or kinetic

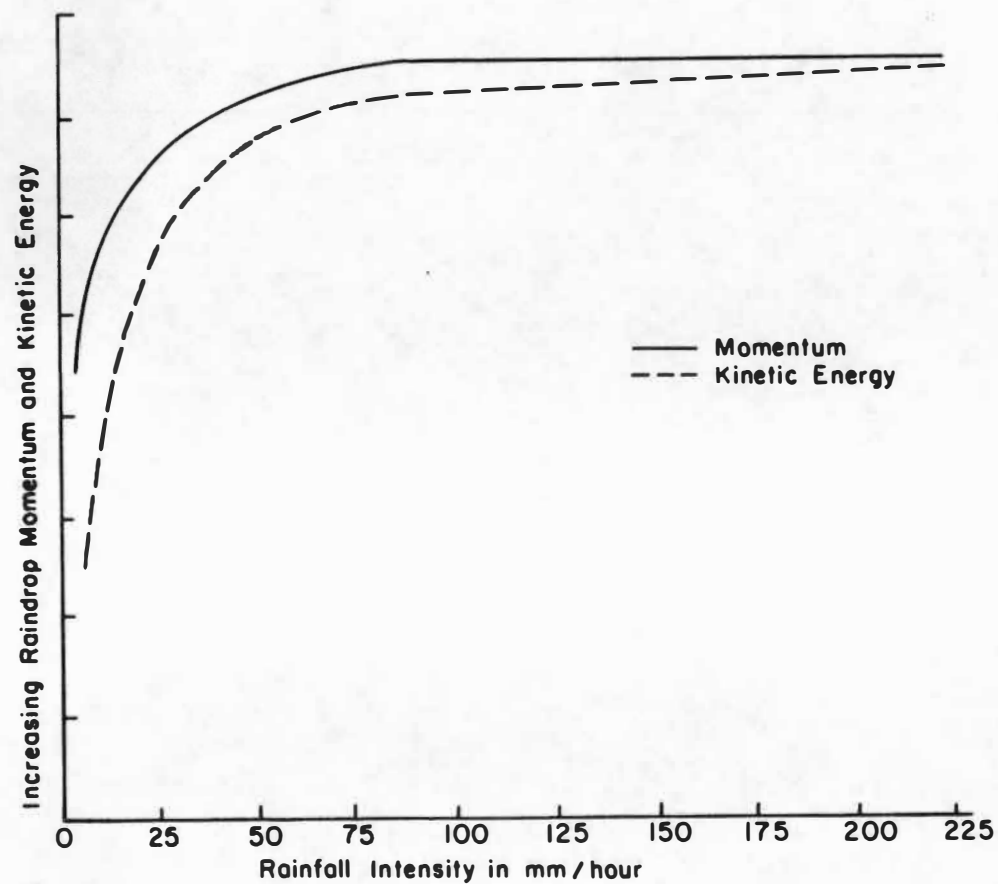


Figure 4.5 Relationship between momentum and kinetic energy. (Modified from Hudson 1971).

energy are done indirectly. That is, in the absence of equipment to accurately and directly measure the energy expended by water droplets (Hudson 1971; Zachar 1982), the amount of soil displaced or splashed by droplets of differing sizes and velocities is often employed as an indicator of energy. Before scrutinizing the relationship between energy and soil splash, raindrop energy (in this case, kinetic energy) should be considered with the other rainfall variables discussed previously.

Figure 4.6 illustrates the relationship between drop size and correspondent terminal velocity to kinetic energy. Kinetic energy is influenced by drop velocity, which is dependent upon drop size, the distribution of which is affected by storm type, etc. The relationship is generally straightforward, but can be affected to a certain degree by drop shape (Ekern 1953; Spilhaus 1948). Typically, increases in drop size and velocity generate concomitant intensifications in kinetic energy up to a drop size of about 4 mm. In some instances, a drop 5 mm in diameter can have as much as 400 times more kinetic energy than a 1 mm drop (Horton 1940: table 2). The power difference between large and small drops is further revealed by the statement:

...the effect of small and large drops is probably more nearly comparable to the difference in effect which would be produced on a lump of hard-packed soil by giving it a million light taps with a pencil, or, on the other hand, giving it a few smart blows with a hammer, the total kinetic energy being the same in both cases. The light taps with the pencil correspond to the effect of very small drops and this effect may be wholly negligible, whereas the few smart hammer blows would more or less completely break down the soil mass (Horton 1940:408).

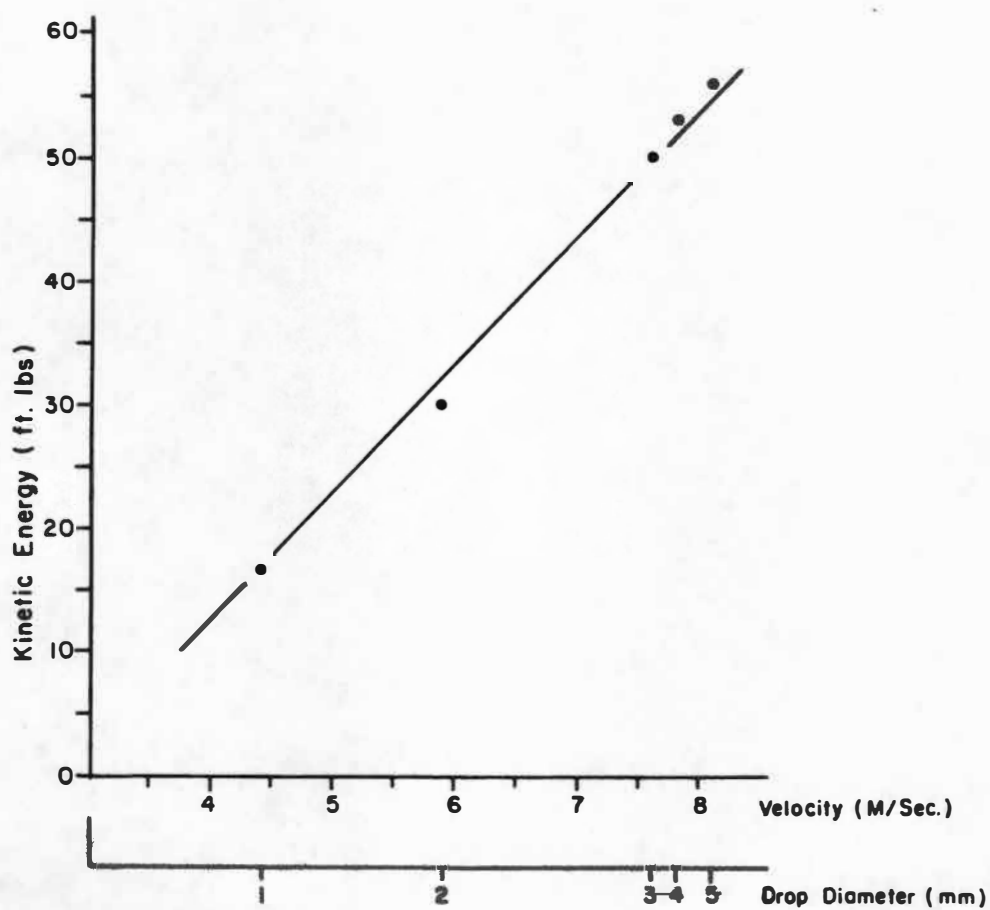


Figure 4.6. Relation of drop velocity and diameter to kinetic energy.
(Drawn from data in Horton 1940).

Wind can disrupt these normal relationships by affecting the shape, size, inclination, and energy of raindrops. Wind increases raindrop vectoral velocity, and the sheer stress (drag) it creates is nearly half as effective as rainfall kinetic energy in detaching aggregates (0.5 to 1.5 inch in diameter) from silt loam clods. Lyles (1977) also found that rainfall driven by a 25 m.p.h. wind detached over 2.5 times more soil than it did in still air. The rate of breakdown was similar for both large and small clods, with larger ones taking longer to disaggregate solely because of their size (Lyles et al. 1969).

The kinetic energy of a storm is calculated from the total number of drops falling at a given intensity, and this is estimated from the distribution of drop sizes within that intensity (Evans 1980). A multitude of experimental data directly links the magnitude of soil losses incurred to a storm's total kinetic energy (Ekern 1951, 1953; Ellison 1944, 1945; Free 1960; Wischmeier 1959, 1962; Wischmeier and Smith 1958; Young and Wiersma 1973; among others). In one instance, the inclusion of other variables such as the maximum 30 minute storm intensity and antecedent soil moisture improved the ability to predict erosion losses (Wischmeier et al. 1958). In this case, the best soil loss predictor was the product of the kinetic energy and the maximum 30 minute storm intensity. This measure, which has become known as the EI_{30} variable, has been widely used in temperate regions, although its applicability in tropical climates has been challenged (Hudson 1971).

Studies of soil particle movement by raindrop impact or splash erosion have taken many forms. Wooldridge (1965) traced radioactive Fe_{59} -treated soil particle movement using radiographic film. However, by far the most prevalent technique measures the distance particles are splashed by trapping them in splash cups or by measuring the percentage of particles splashed out of a contained area (Ellison 1944). Laws (1940) determined that the higher the drop impact velocity, the greater the amount of soil splashed. In a similar experiment, the linearity of the relationship between drop size and speed to amount of soil displaced was demonstrated (Bisal 1959). Ellison (1945) discovered that the size of particles splashed and the distance they traveled was proportional to drop size and velocity (and, hence, drop energy).

Further documentation for the direct relationship between drop energy and amount of soil displacement can be realized from examples involving natural rainfall and in-field conditions (Wischmeier et al. 1958). The close correspondence between soil splashed and soil eroded during a series of four storms is chronicled in Figure 4.7. The correlation coefficient between amount splashed and amount eroded was .98 for this trial conducted on bare soil (Sreenivas et al. 1947).

Surface Crust Formation

To this point, discussion of rainfall erosion has covered topics relevant to the first three stages outlined from Ellison's (1945) description presented earlier: (1) the existing surface, (2) raindrop impact and aggregate breakdowns, and (3) particle splash. The

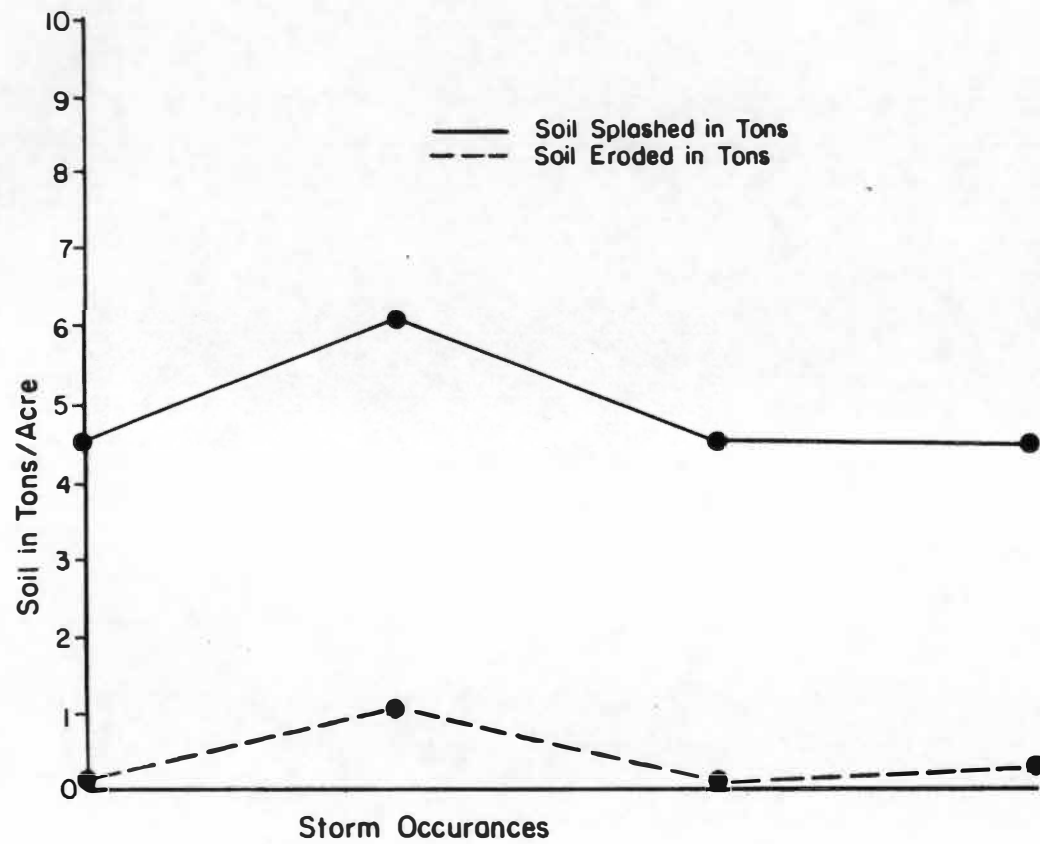


Figure 4.7. Correspondence between soil splashed and soil eroded. (After Sreenivas, et al. 1947).

remaining four stages preceding the onset of surface flow -- infiltration of returning splash, surface sealing, increase in splash erosion as a thin water layer forms, and reduction in splash as loose material is removed from above the surface seal -- can all be subsumed under a discussion covering surface crust formation and decreased infiltration rates.

Crust or seal formation is also directly linked to raindrop striking energy. This conclusion is drawn from evidence provided by two lines of inquiry: one in which the direct raindrop impact is reported to form a seal and impede infiltration (i.e. Baver 1948; Ellison 1945; Ellison and Slater 1945; Epstein and Grant 1967; Free 1952; Free and Palmer 1940; Horton 1940; Laws 1940; Musgrave and Free 1936; Neal 1937; among others), and another in which the interruption of drop impact by surface cover prevents a crust from forming and water intake remains good (Borst and Woodburn 1942; Dulley and Kelly 1939; Langbein and Schumm 1958; Meginnis 1935; Osborn 1954b; Sreenivas et al. 1947; among others). Laws (1940) for instance, reported that as drop size increased, infiltration decreased by as much as 70% (see also Ellison 1945 for similar conclusions). The surface crust that forms from drop impact and fine particle illuviation comprises two separate layers, the uppermost of which is only 0.1 mm thick and nearly impermeable. The lower zone, of approximately 5 mm thickness, is composed of fine inwashed particles (McIntire 1958) and is less permeable than the underlying soil. A cover of mulch was shown to be instrumental in preventing such a crust from forming. Straw placed on

the surface in a proportion of 2 tons/acre effectively checked soil detachment and crust formation (Sreenivas et al. 1947). When similar surface cover was removed during a storm, the soil in runoff increased six times (Borst and Woodburn 1942). Standing crop cover can impart the same influence, suggesting that exposure of surface artifacts would occur at different rates between cultivated rows than on open ground.

Raindrop Energy and Overland Flow

Following surface crust formation and reduced infiltration is the onset of surface flow, should sufficient slope be present. Surface flow (sheet wash) erodes by removing particles released by rainsplash (Held and Clawson 1965). The kinetic energy of sheet wash has been calculated to be as much as 256 times less than that of rainfall (Hudson 1971), and the particles it entrains are generally smaller. Ellison (1944) has shown that sheet wash carries primarily silt and clay (95%) and very little sand (5%), whereas splashed particles from the same plot contained greater sand and gravel than did the original soil (25 to 31%). The combined effects of rainsplash and sheet wash are shown in Figure 4.8 (adapted from Ellison 1945). Following an initially high peak, soil loss steadily declines until rainfall begins. The reduction in erosion after only a few minutes of rain application is presumably due to surface compaction, but the marked erosional increase when surface flow was curtailed may indicate that the film of surface water was deep enough to absorb raindrop impact (see Statham 1977 and Palmer 1964 for opposing viewpoints on the

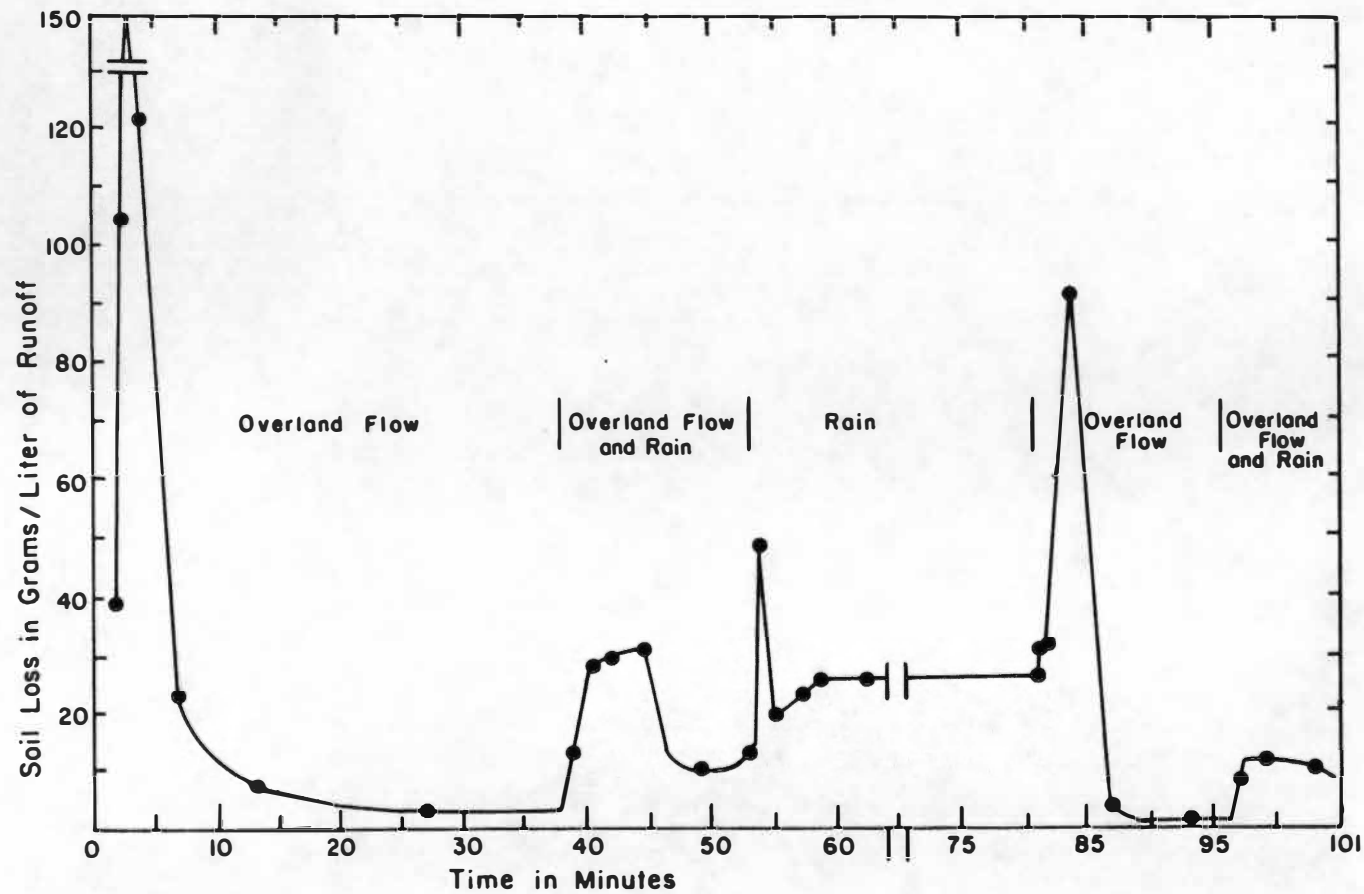


Figure 4.8. Bare surface sediment loss through time when applying rainfall and overland flow separately and in combination. (Adapted from Ellison 1945).

effect of a film of surface water). Loss rates are again high when surface flow is reinstated following a period of particle loosening by rainfall.

Rill or gully erosion does not become a factor unless sheet wash continues for extended periods on erodible soils or slope is steep and uninterrupted for considerable distances. When these variables are present, however, the kinetic energy of the flowing water is greatly enhanced. The ability of water to carry soil particles varies with flow velocity. For example, water moving twice as fast can carry four times as much soil, water flowing three times faster carries nine times the particle load, etc. (Held and Clawson 1965). In most situations, the presence of rill erosion is apparent unless agricultural activities have recently obliterated them.

Raindrop Movement of Large Objects

It should by now be apparent that many interactive variables of soil and rain can influence erosion rates, and by doing so affect exposure of plowzone inclusions, some of which are termed stone pavements by agricultural engineers (Schwab et al. 1966). In a real sense, these "pavements" could be artifact scatters of interest to archaeologists. Transport of relatively large objects downslope by flowing water has been recognized for years. What has yet to be discussed is the direct or indirect movement of objects by raindrops.

The downslope component of raindrop splash erosion was mentioned earlier in relation to soil movement. Raindrops of 5.1 mm diameter have been documented to splash soil particles as far as 5 feet on a

level surface (Ellison 1945). Distances would undoubtedly increase with the longer trajectory afforded a particle moving downslope. Consequently, much downhill soil movement could be due directly to raindrop impact (Ellison 1944, 1945:182, presents a convincing argument for this). Observations on the movement of larger objects are equally surprising.

Kirkby and Kirkby (1974) document that raindrops move particles as large as 50 mm in maximum dimension and that particles 5 mm in diameter were thrown into the air as high as 15 cm. Carson and Kirkby (1972) conclude that rainsplash can directly move debris as large as 10 mm in diameter, and larger objects are moved by undermining of the pedestals formed beneath them by rainsplash. These few examples should serve to illustrate the potential magnitude of downslope artifact movement by drop impact when agricultural surface exposures have been maintained for many years. The combined forces of rainsplash, surface flow, and agricultural machinery should be carefully evaluated when using micro- or macro-debitage samples as indicators of settlement location in archaeological survey (eg., Dunnell 1985).

CHAPTER V

BUILDING A BASIS FOR INTERPRETATION:
RESULTS OF THE SURFACE RECOVERY EXPERIMENTRepeated Collections at 40MU86

The surface recovery study conducted at Pilkinton, 40MU86, was designed to examine the effects of rainfall on artifact recovery rate and assemblage composition (Chapter II). Rainfall amounts preceding collections were carefully measured, and intensities (and related kinetic energies) considered to be moderately high. All storms were convectional thunderstorms under two hours in duration. There were, however, differences in individual storm intensities. Intensities ranged from approximately 2 cm/hr. for the first rainfall (over 1 hr. duration) to as high as around 5 cm/hr. for the third and final storm. The first storm fell on a bare, dry soil surface, whereas the other two impacted upon moist surfaces.

Figure 5.1 depicts pertinent rainfall data for, and stages in, the sequence of four collections from the control block. All exposed artifacts were removed after each rainfall episode. Material from each collection was kept separate, allowing examination of collection contents at any of the four stages. For example, the total collection content after 2.22 cm of rain can be compiled by combining the first two collections (i.e. A and B in Figure 5.1), the content after 6.35 cm of rain by combining the first three collections (i.e. A, B, and C), etc. Viewing the four collections at different points in the

Individual Control Block Collection Stages

Collections Used in Comparative Analysis

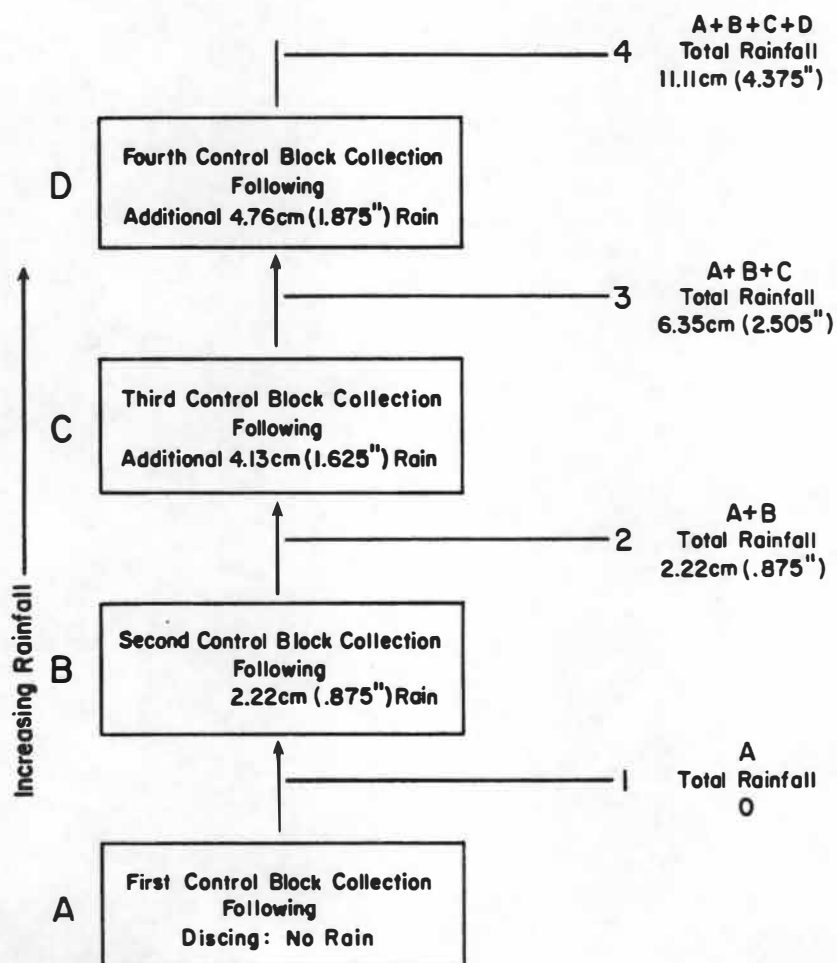


Figure 5.1. Flow chart of sequent stages in repeated control block collections at 40MU86.

collection continuum would produce widely divergent lithic artifact densities for the same area. The ultimate cause of these differences is rainfall amount preceding collection.

A threshold in number of artifacts recovered occurs after 6.35 cm (2.5 inches) of rainfall (Figure 5.2). The first collection, which preceded rainfall, produced only 28% of the total collection obtained from the control block. The second collection produced 42% of all artifacts, and the third and fourth collections yielded 27% and 3% respectively. Viewed cumulatively, the first three collections produced 97% of the total artifacts and were recovered after 6.35 cm of rainfall. An additional 4.76 cm (1.9 inches) of rain falling after this point exposed only 49 more artifacts (3% of total). Lithic artifact density exposed on the surface had thus fallen to less than 3/100 m².

In addition to affecting artifact recovery rates, rainfall amount influences the assemblage composition of the artifacts collected. The relative abundance of certain artifact categories appears to vary significantly between collections (Figure 5.3). The most apparent difference is between the first four lithic artifact categories and the remaining categories (lithic categories are defined in Appendix B). Cores, tested cobbles, bifaces, and flake tools are overrepresented in the early collections relative to other lithic artifact types. All other categories tend to more closely mirror the general recovery trend established for all material collected from the control block.

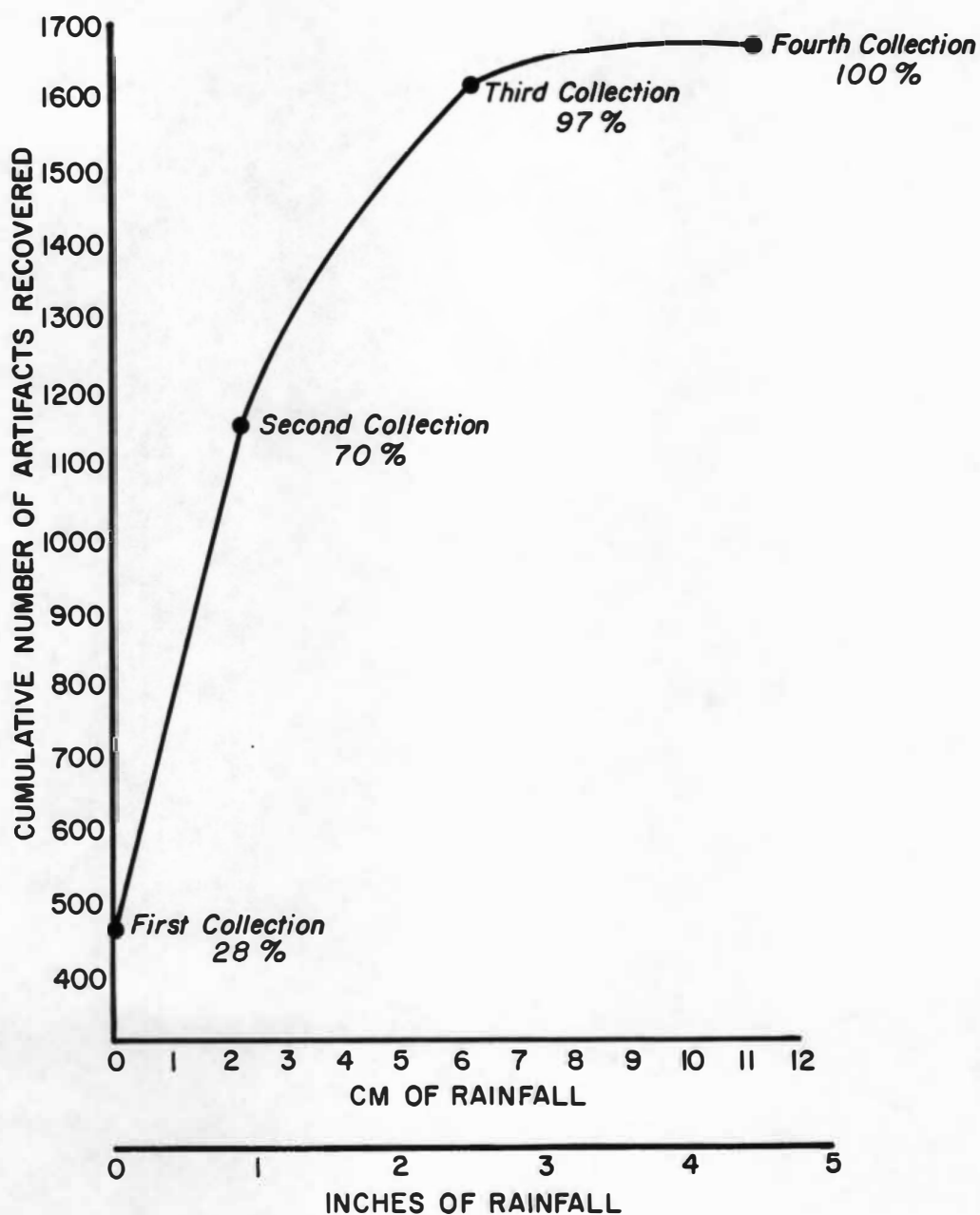


Figure 5.2. Control block surface artifact recovery as a function of rainfall amount at 40MU86.

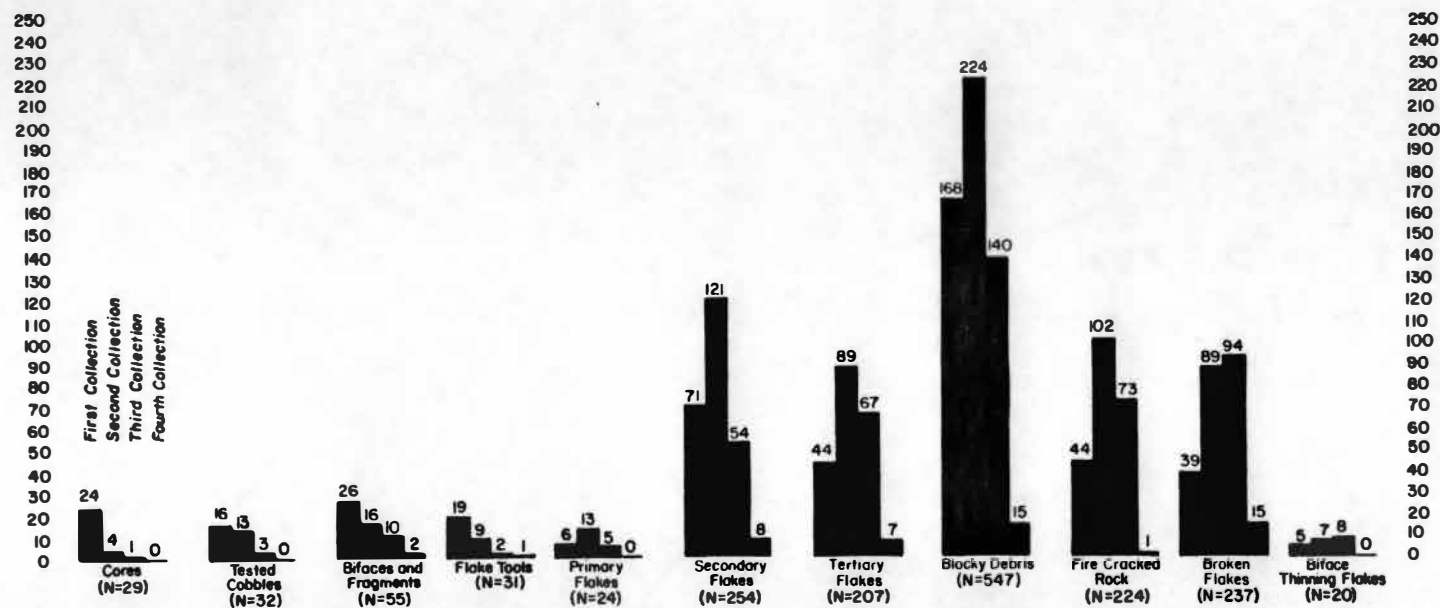


Figure 5.3. Breakdown of control block lithic artifact type recovery by collection at 40MU86.

Table 5.1 presents mean dimensions (to the nearest mm) and weights (to nearest .5 gm) by collection for lithic artifacts recovered from the control block surface. Frequencies listed here, and those shown in Figure 5.3, are for the collection segments, not combinations of segments as previously discussed. Collections are viewed separately to better examine artifact size differences as they relate to rainfall exposure rates. The four categories exhibiting different recovery trends (i.e. cores, tested cobbles, bifaces, and flake tools) are clearly shown to be the largest lithic items that were available for recovery (Table 5.1). This indicates that artifacts collected from a cultivated surface preceding rainfall or following a small amount of rain could well be larger than the overall mean size of artifacts potentially recoverable from a site's surface. A clearer illustration of the size-related recovery trend is depicted in Figure 5.4. The greatest divergence between cumulative curves for the four collections occurs between the largest artifact categories recovered in the initial collection (no rain) and corresponding categories in all subsequent recollections.

Examination of the data in Table 5.1 indicates other size-related artifact recovery trends. Generally, there is a small, systematic decrease in the sizes of all lithic artifacts between successive collections, until the overall recovery threshold is reached (end of third collection). This systematic size reduction also suggests a trend for the potential overrepresentation of large artifacts in surface collections before adequate rainfall has occurred. Further

Table 5.1. Mean dimensions^a for flake categories recovered from the surface of the control block at 40MU86.

	Primary Flakes				Secondary Flakes				Tertiary Flake				Large Biface Thinning Flake				Small Biface Thinning Flake				Broken Flake			
	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt
Cumulative Collections (1-4)	N = 20				N = 253				N = 209				N = 8				N = 10				N = 236			
Mean	27	21	9	6	26	19	7	5	22	16	5	3	23	17	3	1.5	12	9	1	.5	17	12	4	1.5
Standard Deviation	9	6	4	6	9	8	4	8	10	7	3	5	3	2	1	1	4	3	1	-	7	5	3	2
Range	38	28	14	25	55	44	24	61	51	34	17	30	8	5	3	2	12	7	4	-	37	25	18	15
First Collection (1)	n = 6				n = 70				n = 44				n = 2				n = 3				n = 39			
Mean	28	21	8	5	30	23	9	9	26	19	6	5	28	17	3	2	17	12	2	.5	20	14	4	2
Standard Deviation	6	3	3	3	12	10	5	12	9	6	4	6	-	3	2	1	2	1	1	-	6	5	2	1
Range	14	8	7	7	51	43	23	61	37	27	16	30	-	6	2	1.5	3	2	1	-	22	15	9	5
Second Collection (2)	n = 9				n = 120				n = 89				n = 5				n = 2				n = 89			
Mean	27	21	11	8	25	18	7	4	23	16	5	3	21	17	3	2	8	7	1	.5	18	13	4	2
Standard Deviation	12	8	5	8	8	6	3	5	9	6	3	4	1	2	1	1	1	1	-	-	7	5	3	2
Range	38	25	14	25	40	30	13	28	44	33	16	30	2	5	3	2	2	2	-	-	37	22	18	13
Third Collection (3)	n = 5				n = 55				n = 68				n = 1				n = 5				n = 94			
Mean	24	21	8	5	23	17	6	3	19	14	4	3	20	19	2	1.5	11	7	1	.5	16	11	3	1
Standard Deviation	4	5	3	3	8	8	3	5	9	7	3	5	-	-	-	-	3	1	1	-	7	5	3	3
Range	11	10	9	8	40	39	16	25	51	31	13	24	-	-	-	-	8	3	1	-	37	25	10	15
Fourth Collection (4)	n = 0				n = 8				n = 8				n = 0				n = 0				n = 14			
Mean					27	22	8	7	22	16	5	4									17	13	4	2
Standard Deviation					6	6	5	8	11	8	5	7									6	5	3	3
Range					17	21	15	20	32	22	15	25									22	21	9	10

L = Length
W = Width
T = Thickness
Wt = Weight

^aLinear measurements are rounded to the nearest mm. Weights are rounded to the nearest .5 gm.

Table 5.1. (continued). Mean dimensions^a for artifacts and non-flake debris recovered from the surface of the control block at 40MU86.

	Fire-cracked Rock				Tested Cobble				Blocky Debris				Cores				Bifaces				Flake Tools			
	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt
Cumulative Collections (1-4)	N = 221				N = 34				N = 540				N = 32				N = 54				N = 31			
Mean	25	18	10	10	47	35	23	57	32	23	14	22	42	34	25	38	33	23	8	7	39	27	10	12.5
Standard Deviation	11	9	7	22	11	9	9	39	15	12	8	36	11	9	7	27.5	13	9	2	6	14	10	6	17.5
Range	64	57	43	243	41	36	33	157	82	68	47	275	47	42	23	125	59	31	13	29.5	46	32	26	102.5
First Collection (1)	n = 42				n = 18				n = 168				n = 21				n = 26				n = 19			
Mean	29	22	13	20	48	35	24	62	37	27	16	39	42	34	26	36.5	38	26	8	8	42	30	12	16.5
Standard Deviation	14	12	9	43	11	10	8	43	15	13	8	45	11	9	7	25.5	10	7	3	5.5	15	10	6	21
Range	60	52	41	243	41	36	29	156	73	64	40	275	41	40	23	97.5	41	27	13	14.5	63	44	26	102.5
Second Collection (2)	n = 105				n = 12				n = 223				n = 5				n = 16				n = 9			
Mean	25	19	11	8	46	34	23	53	30	21	14	15	43	36	23	51	31	23	8	6	32	21	8	6
Standard Deviation	11	9	6	13	12	8	9	35	12	10	7	19	15	14	9	46	13	8	2	7	11	8	4	6
Range	61	45	32	86	36	26	30	102	64	58	41	131	30	40	20	110	52	29	5	29	32	20	13	19
Third Collection (3)	n = 73				n = 4				n = 135				n = 5				n = 10				n = 2			
Mean	25	17	9	6	48	37	21	47	28	21	14	22	38	30	25	30.5	28	18	7	5	28	21	7	5
Standard Deviation	10	8	5	7	11	11	11	30	16	14	10	43	5	5	9	17.5	15	10	2	6	5	4	2	2
Range	42	32	24	31	26	24	27	68	82	64	47	252	12	12	22	42	45	32	6	19.5	10	7	3	3
Fourth Collection (4)	n = 1				n = 0				n = 14				n = 1				n = 2				n = 1			
Mean	14	10	4	.5					25	18	11	7	50	36	26	38.5	24	19	7	3	47	37	9	15.5
Standard Deviation	-	-	-	-					12	8	5	10					14	11	1	4				
Range	-	-	-	-					42	27	21	34					20	16	6	5.5				

L = Length
W = Width
T = Thickness
Wt = Weight

^aLinear measurements are rounded to the nearest mm. Weights are rounded to the nearest .5 gm.

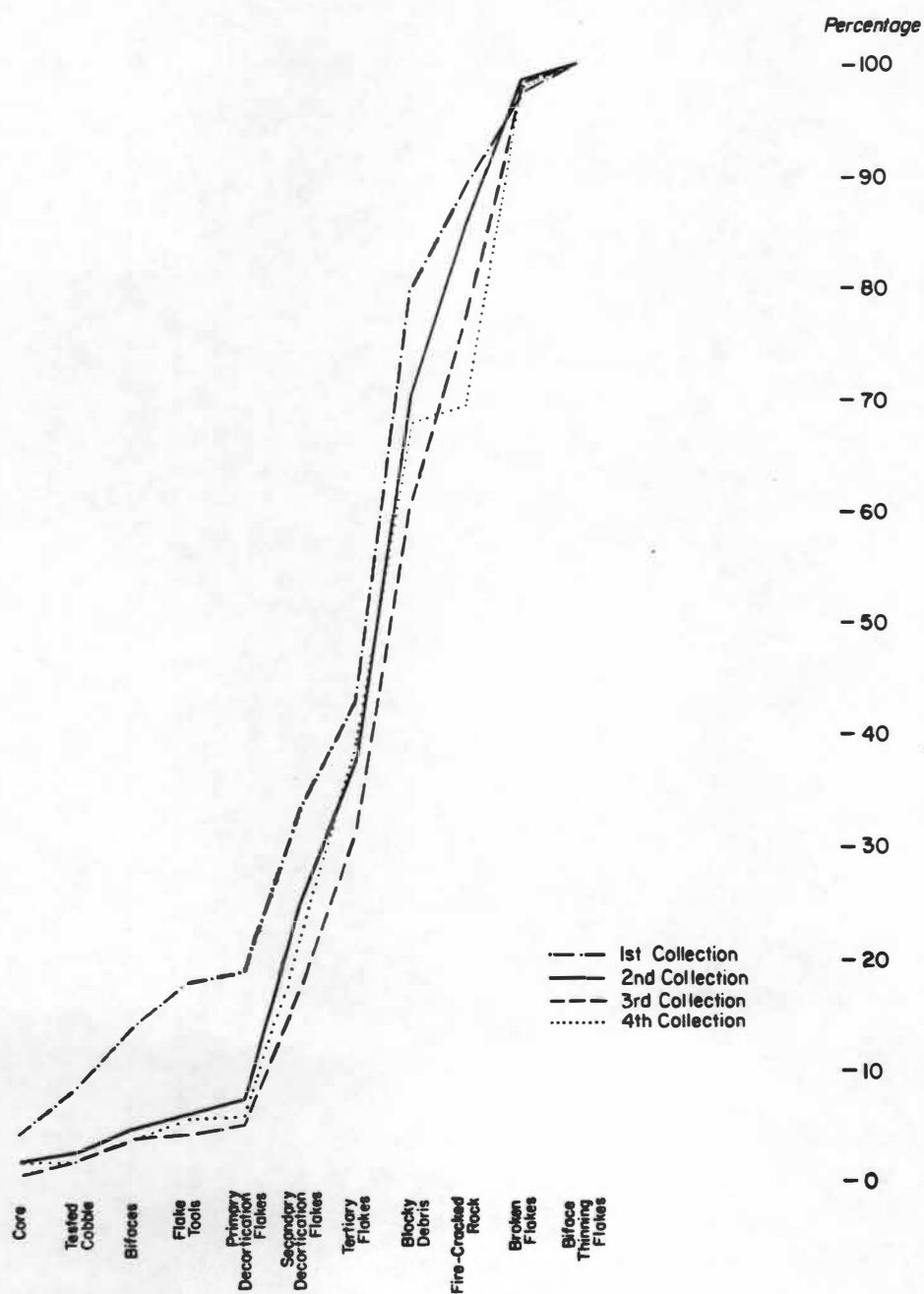


Figure 5.4. Percentage of lithic cultural material type recovered by collection.

support for this tendency is indicated by an increase in the number of broken flakes (smallest measured category) recovered in each stage through the third collection.

To summarize, two trends are apparent from analysis of the repeated collection data from the control block at 40MU86. First, there exists a recovery threshold past which more rainfall exposes few additional artifacts. In this instance the threshold occurred at 6.35 cm (2.25 inches) of rain. By varying either soil or rainfall variables, this cutoff point could be different (see discussions in Chapters 3 and 4). It would be possible for a more intense initial storm to lower the total rainfall amount necessary to reach the recovery threshold. However, some additional support for a cutoff in the area of 6.35 cm rain is provided by Baden (1982). Establishing a recovery threshold is of paramount importance, because until this point is reached, a surface collection is not representative of the potentially recoverable assemblage. Without this knowledge, the value and accuracy of surface to plowzone comparisons would certainly be diminished.

The second trend is that certain artifact categories are more likely to be recovered after little or no rainfall and that this tendency is size dependent. Why more large artifacts were not encountered as additional rainfall melted the soil matrix and increased the exposure depth is difficult to discern from the present data. The effects of modern agricultural implements can, however, be suggested as one possibility. In a review of plow mechanics, Lewarch

(1979) recounts that the majority of large plowzone inclusions are transported to or near the surface during tillage. Should this be the case, most large objects would be visible on the surface after very little rain. This artifact "size effect" (Baker 1978; Baker and Schiffer 1975) has been dealt with by other researchers as well. Ammerman and Feldman (1978) found that artifacts collected from a plowed surface prior to rainfall tended to be larger than those collected after rain. As exposure depth increases with additional rainfall, it may prove more realistic to view collectible artifacts as existing "within the surface" as opposed to on the surface (Ammerman 1985). Baden (1982) shares this view and constructed a model of potential plowzone artifact exposure based on maximum artifact dimension and its depth below and orientation to the surface. The model performed fairly well when experimental results were compared to actual data, but it was found that results were dependent upon soil and rainfall variables. Overrepresentation of large artifacts in surface collections could have pronounced detrimental effects on interpretation, regardless of the mechanisms responsible for their exposure.

Archaeological Implications

Results produced by the repeated collection study will be used as a guideline to ensure comparability in the surface to plowzone artifact comparisons to follow (Chapter VI). But it should not be overlooked that these data have considerable importance in other areas. Differing rainfall amounts on a cleanly plowed surface prior

to collection could alter assessments of site size, artifact density, site occupation length, activities practiced at a location, and intrasite variability, as well as adversely affecting intersite and regional comparisons. Variability would likewise be introduced into research efforts which avoid the traditional site concept (Foley 1981; Thomas 1975) because unmonitored rainfall and soil factors also affect interpretation of cultural material distribution across the landscape.

In a situation where insufficient rain has fallen to expose a representative number of potentially recoverable surface artifacts, only the densest cultural material bearing areas will be located. An occupation area covering thousands of square meters may be "visible" (Campbell 1970; Deetz 1967) as a few small concentrated areas. Similarly, site occupation length is often viewed as being synonymous with material density, and the effect of rainfall variables would be equally obvious here. Intrasite comparisons of material distributions would be unfavorably influenced should more rain fall on one portion of the collection area than another. If surface distribution maps are used in designing excavation strategy (Binford 1964; Binford et al. 1970; Healan 1972), it becomes clear that the unfavorable influence can be spread into realms beyond surface studies.

Historically, there has been considerable discussion on the topic of site definition (Plog et al. 1978). A great deal of the controversy surrounding the definition problem is centered in western areas where some researchers have established density criteria that

must be met before a location of prehistoric activity can be called a site (Doelle 1977, for instance, set a lower limit of 5 artifacts/m²). Whether such a sectioning point between site and non-site is valid or not is a topic for another study. What is important about it, however, is that such decisions often remove a large corpus of archaeological data from analysis (Rodgers 1974).

The site definition problem in the Southeastern United States has also been a topic of discussion, largely as it pertains to loss of data in regional analysis (Brooks 1979; Klinger 1976; Nance 1980). Brooks (1979) has demonstrated how surface conditions (plant cover) affect assessments of site status and result in the improper classification of large sites as loci of cultural activity. This misclassification ultimately resulted in the resources being dropped from analysis. Examination of the changing artifact frequencies in successive control block collections can be used to further illustrate this dilemma (Table 5.2). In the absence of a sectioning point, it is not possible to state at which stage in the rainfall continuum densities would reach those necessary for "site status." But this may not be the point. Densities are nearly four times higher after 11 cm of rain than they were before any rain had fallen. This could not only affect a "site status" determination, but might also result in the lower density manifestations being missed altogether.

Table 5.2. Cumulative rainfall totals and associated lithic artifact densities recovered from the control block at 40MU86.

Total Rainfall (cm)	Lithic Artifact Density/m ²
0.00	.26
.875	.64
6.35	.89
11.11	.92

CHAPTER VI

RELATIONSHIP BETWEEN SURFACE AND PLOWZONE ASSEMBLAGES

The surface to plowzone relationship has been explored by other studies, but never with the degree of control over surface conditions established in Chapter V. Armed with this newly acquired understanding of surface collection reliability, three levels of surface to plowzone examination are undertaken: 1) artifact detection in shovel tests, 2) parameters necessary for artifact density estimation using excavated plowzone samples, and 3) reliability of surface samples as indicators of total plowzone assemblages.

Artifact Detection in Shovel-tests

The first aspect of the surface to plowzone artifact relationship to be explored involved site detection by shovel testing. The specific relationship sought was how dense must a surface scatter be before a shovel test would detect it. This aspect of shovel test research seems to have been underemphasized. Excellent discussions on the probabilities of placing a test within site (target) boundaries, when employing different sampling strategies on areas containing sites of differing sizes and shapes, have been produced in archaeology (i.e. Krakker et al. 1983; McManamon 1984) and other fields (i.e. Koch and Link 1971). While the use of shovel tests for locating artifacts has received much recent attention (Alexander 1983; Chartkoff 1978; Green et al. 1980; Ives and Evans 1980; Kelley et al. 1979; Lovis 1976;

McManamon 1981, 1982; Nance 1979, 1980; Shott 1985; Spurling 1980; Thornbahn 1980; Wood 1975; see also references in Gatus 1980), those instances in which artifact densities necessary for detection have been assessed are largely theoretical and employ little practical evidence (Lynch 1980; Krakker et al. 1983; Stone 1981a, 1981b).

Schiffer et al. (1978) outline the factors influencing site discovery during survey. One of these factors, obtrusiveness, is defined as the probability of site discovery using a particular technique. It is easy to discern from their discussion that they consider shovel testing and other techniques which produce small exposures expensive labor-intensive approaches that miss many sites. Such published examples of disparaging comments concerning shovel-test results are easily found (Casjens et al. 1978). Concern has been expressed, for instance, that shovel-test derived patterns of occupation size and intensity differ from those based on surface evidence (South and Widmer 1977). It is difficult to argue that shovel testing is not time consuming, because it is. But its usefulness can be greatly enhanced by establishing its limitations. Even more important, by establishing what can be predicted from shovel-test data, the pitfalls of the two-result survey (Chapter I) can be avoided.

A total of 278 shovel tests was excavated at three sites, 40MU86, 40MU110, and 40MU409, to establish the surface artifact density necessary for detection using this technique. Details of sampling strategy, surface preparation, rainfall and soil variables for each

site are given in Chapter II. Because of careful monitoring of these factors, all collections upon which surface artifact densities are based are considered comparable and representative of the total assemblage potentially recoverable from the surface of each site (as established in Chapter V). Shovel-testing procedures were also standardized (Chapter II). The exception to this was the use of 10 m² surface collection units at 40MU86 and 5 m² units at the other two sites. Shovel test size was 25 cm² (smallest used) at 40MU409 instead of 30 cm², which was used at both 40MU86 and 40MU110.

For a shovel test to detect the presence of archaeological material only a single artifact need be found. Results of testing at the three sites show a similar pattern. At 40MU86 (Table 6.1), 40MU110 (Table 6.2), and 40MU409 (Table 6.3), detection of a site's presence becomes fairly reliable once the surface density reaches or exceeds .10 artifacts/m². The 83% and 79% detection rates at this surface density for 40MU86 and 40MU409, respectively, continue to improve (with a single exception) as surface artifact density increases. All of the surface densities at 40MU110 were well above this density limit and shovel tests produced 100% positive results. The ability to find material in surface squares producing no surface material is somewhat problematical. Obviously, a test excavated in an area where no archaeological material exists should be negative. The positive tests at both sites are most likely indicative of plowzone artifact densities necessary before artifacts are exposed on the surface. Artifacts are present in the plowzone, but not in sufficient numbers

Table 6.1. Results of controlled surface collection and shovel testing comparisons at site 40MU86.

Surface Density Artifacts/m ²	No. of 10 m Collection Squares	No. of Positive Shovel Tests (30 cm ²)	% Collection Squares with Positive Tests
.00	1	1	100
.01 - .09	16	6	38
.10 - .19	12	10	83
.20 - .29	12	10	83
.30 - .39	13	13	100
.40 - .49	11	11	100
.50 - .59	7	6	86
.60 - .69	6	6	100
.70 - .79	3	3	100
.80 - .89	2	2	100
.90 - .99	3	3	100
1.00 - 1.09	1	1	100
1.10 - 1.19	2	2	100
1.20 - 1.29			
1.30 - 1.39			
1.40 - 1.49	1	1	100
1.50 - 1.59			
1.60 - 1.69			
1.70 - 1.79	1	1	100
1.80 - 1.89			
1.90 - 1.99	1	1	100
2.00 - 2.09			
TOTALS	92	77	

Table 6.2. Results of controlled surface collection and shovel testing comparisons at site 40MU110.

Surface Density Artifacts/m ²	No. of 5 m Collection Squares	No. of Positive Shovel Tests	% Collection Squares with Positive Tests
.00			
.01 - .09			
.10 - .19			
.20 - .29			
.30 - .39			
.40 - .49	2	2	100
.50 - .59	2	2	100
.60 - .69	1	1	100
.70 - .79	2	2	100
.80 - .89	1	1	100
.90 - .99			
1.00 - 1.09	3	3	100
1.10 - 1.19	2	2	100
1.20 - 1.29	2	2	100
1.30 - 1.39	1	1	100
1.40 - 1.49	4	4	100
1.50 - 1.59			
1.60 - 1.69	2	2	100
1.70 - 1.79			
1.80 - 1.89			
1.90 - 1.99	1	1	100
2.00 - 2.09			
2.10 - 2.19			
2.20 - 2.29			
2.30 - 2.39	3	3	100
2.40 - 2.49			
2.50 - 2.59	1	1	100
2.60 - 2.69	1	1	100
2.70 - 2.79			
2.80 - 2.89			
2.90 - 2.99	2	2	100
3.00 - 3.09			
3.10 - 3.19			
3.20 - 3.29	1	1	100
3.30 - 3.39	1	1	100

Table 6.2. (continued)

Surface Density Artifacts/m ²	No. of 5 m Collection Squares	No. of Positive Shovel Tests	% Collection Squares with Positive Tests
3.40 - 3.49			
3.50 - 3.59			
3.60 - 3.69	1	1	100
3.70 - 3.79			
3.80 - 3.89			
3.90 - 3.99			
4.00 - 4.09			
4.10 - 4.19			
4.20 - 4.29	2	2	100
Totals	35	35	

Table 6.3. Results of controlled surface collection and shovel testing comparisons at site 40MU409.

Surface Density Lithic Artifacts/m ²	Number of 5 m Surface Units Receiving Tests	% Positive Tests	
		25 cm ²	50 cm ²
.00	20	45	75
.04 - .08	20	65	95
.12 - .16	14	79	100
.20 - .28	19	94	100
.32 - .36	18	89	100
.40 - .48	18	89	100
.52 - .56	16	100	100
.60 - .68	13	100	100
.72 - .76	4	100	100
.80 - .88	5	100	100
>1.00	4	100	100
TOTAL	151		

to be detected in a surface collection, even under the most ideal conditions.

Data from the 50 cm² tests at 40MU409 show that unit size can affect the ability to detect artifacts. Larger tests reach excellent detection percentages at lower surface densities (.04 artifacts/m²) than do the smaller tests (Table 6.3). All 150 of the 1 m² tests excavated at 40MU409 were positive, even those excavated in units producing no surface artifacts. This strongly suggests that increasing unit size increases the probability of a positive test (Krakker et al. 1983; Lynch 1980; Stone 1981a). If the probability of a positive test is this strongly affected by volume, then the variability in test volume caused by plowzone unevenness at 40MU409 could influence the results displayed in Table 6.3. To determine if results were biased by volumetric variability, volumes of negative tests were tabulated and percentages of negative tests below the projected volume were calculated (Table 6.4). There is no pattern evident for the lower surface densities indicating that the tests with volumes slightly below the projected ones are more likely to be negative. Sample sizes are so small for the higher density categories that results here are equivocal.

Based on these findings, sites with surface densities of 1 artifact/10 m² surface exposure would have approximately an 80% chance of detection in a shovel-test of 12.5 liters, should the probe fall within its boundaries. Detection probabilities increase with surface density of at least 5 artifacts/10 m² surface exposure and above the

Table 6.4. Volumes of negative tests and percent of negative tests below projected volumes* for 25 cm² and 50 cm² excavated at 40MU409. Volumes below projected values are underlined.

Surface Lithic Artifact Density/m ²	Negative Test Provenience	Volume in Liters	
		25 cm ²	50 cm ²
0	1970N 2045E	13.1	53.8
	1995N 1905E	15.8	63.1
	1990N 2025E	7.5	28.1+
	2000N 2050E	<u>8.9</u>	<u>28.1+</u>
	2005N 1920E	<u>12.2</u>	<u>46.9+</u>
	2010N 2000E	<u>15.6</u>	<u>62.5+</u>
	2015N 1900E	15.6	62.5+
	2025N 2070E	<u>10.2</u>	<u>41.25+</u>
	2030N 1910E	<u>16.1</u>	<u>53.75+</u>
	2040N 1915E	12.7	56.9+
% Negative Tests Below Projected Volume		40	0
.04 - .08	1955N 2005E	15.0	57.0+
	1955N 2040E	<u>10.6</u>	56.8+
	1970N 1925E	<u>15.5</u>	61.3+
	1975N 1940E	14.7	58.1+
	1980N 1925E	21.1	71.9+
	2000N 2085E	12.5+	<u>49.4</u>
	2045N 2035E	23.5	<u>95.0+</u>
% Negative Tests Below Projected Volume		14	14
.12 - .16	1990N 1940E	15.0	58.1
	2000N 2035E	<u>10.7</u>	<u>40.6+</u>
	2040N 1940E	<u>15.9</u>	<u>62.5+</u>
% Negative Tests Below Projected Volume		33	0
.20 - .28	1995N 1980E	<u>8.9</u>	<u>33.1+</u>
% Negative Tests Below Projected Volume		100	0

Table 6.4. (continued)

Surface Lithic Artifact Density/m ²	Negative Test Provenience	Volume in Liters	
		25 cm ²	50 cm ²
.32 - .36	1985N 1945E	18.6	73.8+
	1990N 2065E	14.4	60.6+
% Negative Tests Below Projected Volume		0	0
.40 - .48	2040N 2050E	<u>6.7</u>	<u>38.8+</u>
	2040N 2055E	<u>11.1</u>	<u>45.6+</u>
% Negative Tests Below Projected Volume		100	0

*25 cm² x 20 cm deep = Projected Volume 12.5 liters

50 cm² x 20 cm deep = Projected Volume 50.0 liters

+ indicates positive test

small shovel tests recovered artifactual material in all cases. Increasing test unit volume fourfold (50 cm²) improved detection ability so that sites manifesting surface scatters as sparse as .04 artifacts/10 m² exposure were detected 95% of the time. Expanding the test unit to 1 m² (and quadrupling the volume again) predicted material presence in every case, even when surface artifacts were absent. This last phenomenon is believed to be related to material density within the plowzone and will be examined closely in the next section.

Surface to Plowzone Artifact Ratios

The second aspect of the surface to plowzone artifact density relationship examined concerned the ability to predict plowzone density from surface collections or predict surface density from plowzone excavation data. Being able to predict these densities would certainly beneficially augment the site-location data discussed in the previous section. Wide variations in surface to plowzone ratios have been reported in cases where the surface to plowzone artifact relationship has been studied. Studies have been of two kinds: those monitoring existing conditions (Baden 1984; Frink 1984; Hockensmith 1982; Reynolds 1982, discussed in Frink 1984) and those of a structured, experimental nature (Ammerman 1985; Lewarch and O'Brian 1980; Rudolph 1977; Trubowitz 1981). Reported surface to plowzone artifact ratios have ranged from as low as 1:19 to as high as 1:114 (Baden 1982) and 1:18 to 1:83 (Hockensmith 1982) in field studies, to a less widely ranging 1:14 to 1:23 in experimental studies (i.e.

Ammerman 1985). The experimental studies suffer from an inability to include all plowzone and equipment related variables (this by the authors' own admission). Those studies using in-field occurring data were subject to problems arising from differing degrees of natural condition variation (e.g., either rainfall amount or existing surface conditions). These factors could account, at least in part, for the widely disparate ratios. Nearly all of these authors acknowledge the effect surface conditions can have on surface artifact recovery rates; and in the instances where rainfall was monitored (Ammerman 1985; Baden 1982), its effect was pronounced. All of these examples point to the fact that a few artifacts on the surface can mean many more within the plowzone and that low-density scatters may warrant more attention than they presently receive (Ammerman 1985; Tainter 1979).

Surface to Plowzone Comparisons: Volumetric Control

It may well be that surface to plowzone artifact ratios are not the most accurate means by which to assess the degree of correspondence between the surface and plowzone. The major shortcoming lies with the inability to account for the plowzone volume from which the artifacts were recovered. Plowzone volumetric control is as important to correct assessment of excavated artifact densities as standardization of surface conditions was shown to be for surface collected artifacts (Chapter V). It is important that both are controlled when surface to plowzone artifact densities are compared. This is especially true when baseline data are being accumulated for use in continuing studies.

Initial attempts at understanding the surface to plowzone artifact density relationship undertaken in this study were a direct outgrowth of shovel testing at the first two sites examined, 40MU86 and 40MU110 (see Chapter II for methodology). The first attempt involved the comparison of the number of lithic artifacts recovered per 10 m² surface unit to shovel-test lithic density from site 40MU86 using least squares or Model 1 regression (Sokal and Rohlf 1969; Thomas 1976) for which the surface counts were the X or independent variable and plowzone counts the Y or dependent variable. Should any linear relationship exist, it is a weak one (Figure 6.1). Examination of a plot of the residuals (Figure 6.2) reveals a pattern indicating a tendency for error to increase as sample size increases (cf. Neter and Wasserman 1974). The same size shovel-test units were used at 40MU110, but were placed within 5 m² surface collection units. Identical regression analysis procedures were performed. Results showed a much closer correspondence ($r^2=.85$) between surface and plowzone with the smaller surface units. However, surface densities at 40MU110 were much higher than at 40MU86 (Table 6.5 and 6.6). Data on surface and plowzone densities for 40MU409 are presented in Appendix C. Regressions were performed on partitioned data from both sites to test whether higher densities influenced prediction ability (Table 6.7). Correlation coefficients are greater for the higher density categories at 40MU110, but were not as drastically affected at 40MU86, suggesting that smaller surface unit size as well as higher artifact densities increase the ability to predict plowzone density

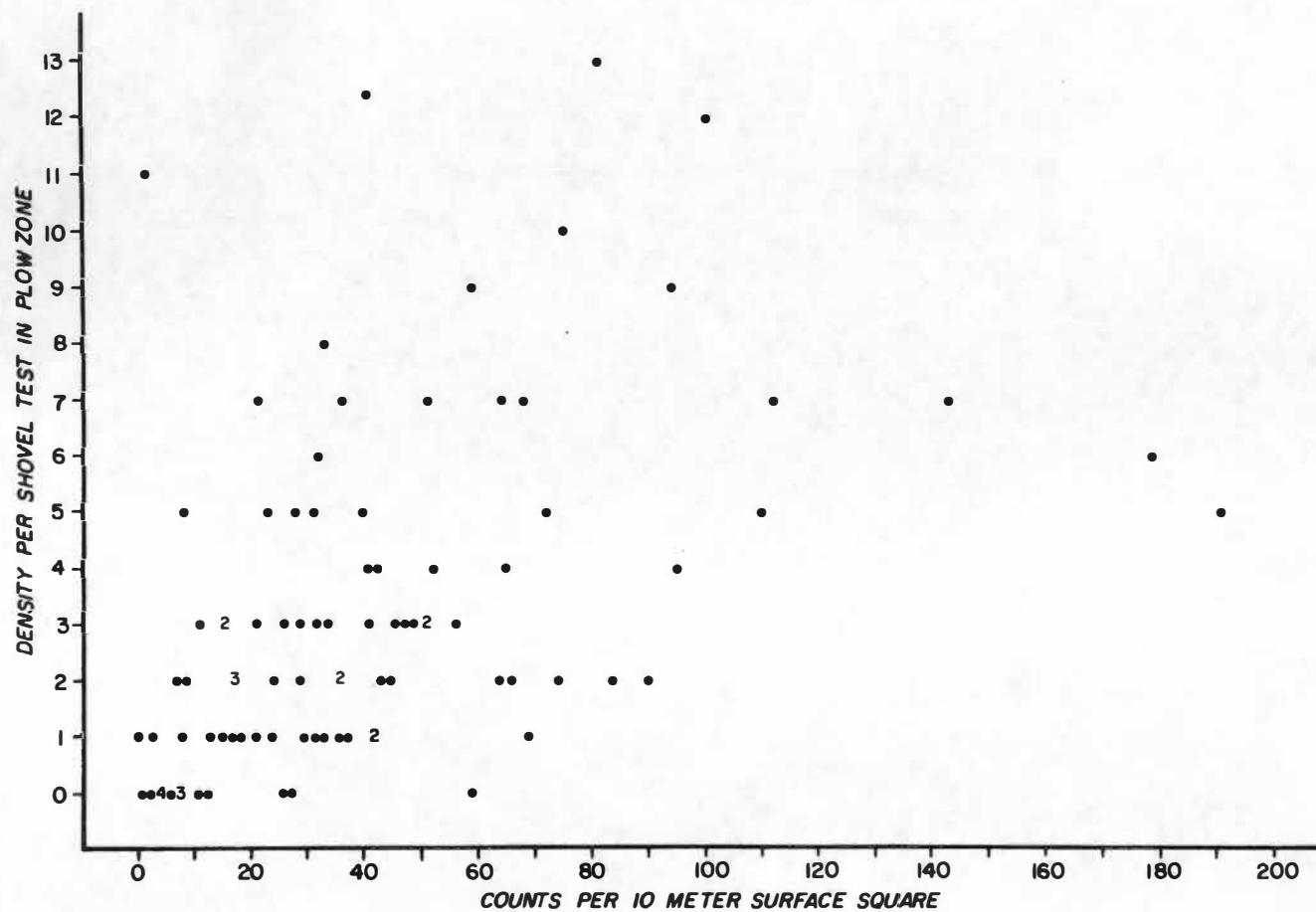


Figure 6.1. Bivariate plot of surface artifact density/unit area to plowzone artifact density at 40MU86.

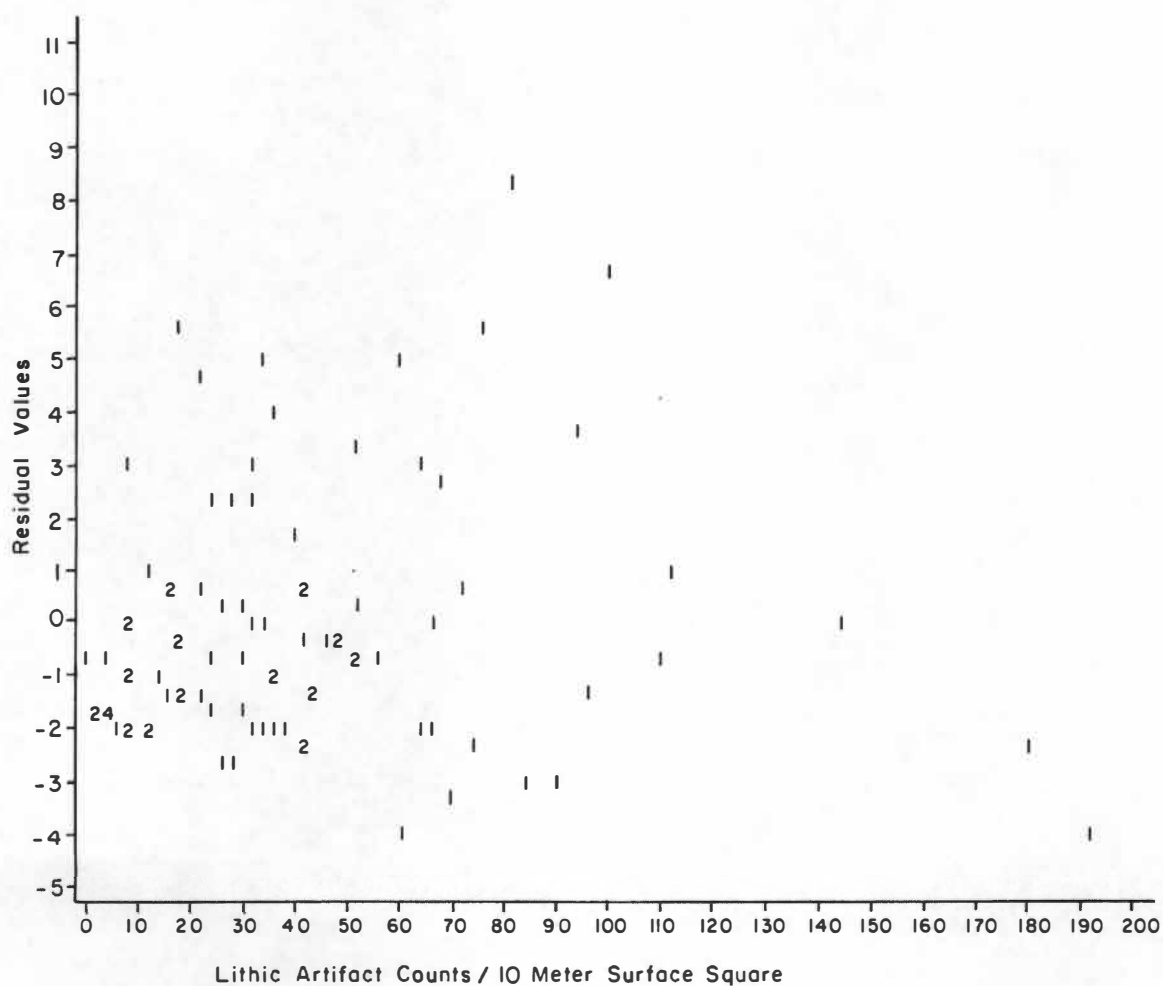


Figure 6.2. Plot of the residuals for surface to plowzone artifact density regression at 40MU86.

Table 6.5. Standardized frequencies for lithic artifacts collected from surface and plowzone contexts at site 40MU110.

Surface Unit	Surface Density/m ² *	Plowzone Density/Liter**
1010N 1015E	1.08	.11
1005N 1000E	1.16	.39
1005N 1005E	1.36	.33
1005N 1010E	1.40	.50
1005N 1015E	1.12	.38
1005N 1115E	.48	.44
1010N 1115E	.48	.44
1015N 1115E	1.28	.61
1020N 1115E	.72	.38
1025N 1115E	1.16	.50
1030N 1115E	1.24	1.06
1035N 1115E	1.04	.66
1000N 1000E	.52	.22
1000N 1005E	.68	.44
1000N 1010E	1.00	.44
1000N 1015E	1.64	.33
1000N 1020E	.72	.67
1000N 1025E	1.36	.61
1000N 1030E	1.92	.50
1000N 1035E	3.28	1.11
1000N 1040E	2.96	1.28
1000N 1045E	2.96	1.56
1000N 1050E	1.68	.67
1000N 1055E	2.56	1.00
1000N 1060E	4.20	1.44
1000N 1065E	4.24	1.67
1000N 1070E	3.68	1.06
1000N 1075E	3.28	1.06
1000N 1080E	2.36	.83
1000N 1085E	2.60	.83
1000N 1090E	2.20	.39
1000N 1095E	2.20	.78
1000N 1100E	1.44	.56
1000N 1105E	.76	.44
1000N 1110E	.36	.28
Mean Density	1.75	.69

*5 m²

**From 30 cm² shovel tests

Table 6.6. Standardized frequencies for lithic artifacts collected from surface and plowzone contexts at site 40MU86.

Surface Unit	Surface Density/m ² *	Plowzone Density/Liter**
1000N 1000E	.33	.44
1010N 1000E	.47	.17
1020N 1000E	.36	.11
1030N 1000E	.52	.22
1040N 1000E	.33	.06
1050N 1000E	.75	.56
1060N 1000E	.42	.06
1070N 1000E	.29	.11
1080N 1000E	.21	.17
1090N 1000E	.17	.06
1100N 1000E	.01	.61
1110N 1000E	.27	.00
1120N 1000E	.48	.17
1130N 1000E	.56	.17
1140N 1000E	.41	.22
1150N 1000E	.43	.11
1160N 1000E	.51	.39
1170N 1000E	.74	.11
1180N 1000E	.34	.17
1190N 1000E	.37	.06
1200N 1000E	.46	.17
1210N 1000E	.42	.06
1220N 1000E	.24	.06
1230N 1000E	.28	.28
1240N 1000E	.51	.17
1250N 1000E	.31	.28
1260N 1000E	.24	.11
1000N 1020E	.36	.39
1010N 1020E	.81	.72
1020N 1020E	1.12	.39
1030N 1020E	1.00	.67
1040N 1020E	.95	.22
1050N 1020E	1.43	.39
1060N 1020E	1.79	.33
1070N 1020E	.84	.11
1080N 1020E	.40	.28
1090N 1020E	.59	.00
1100N 1020E	.90	.11
1110N 1020E	.69	.06
1120N 1020E	.94	.50
1130N 1020E	.68	.39

Table 6.6. (continued)

Surface Unit	Surface Density/m ² *	Plowzone Density/Liter**
1140N 1020E	.29	.17
1150N 1020E	.15	.17
1160N 1020E	.15	.17
1170N 1020E	.21	.06
1180N 1020E	.18	.06
1190N 1020E	.11	.17
1200N 1020E	.36	.11
1210N 1020E	.23	.28
1220N 1020E	.17	.11
1230N 1020E	.07	.11
1010N 1010E	.72	.28
1010N 1030E	.42	.11
1110N 1010E	.41	.17
1160N 1010E	.08	.28
1010N 980E	.65	.22
1060N 980E	.59	.50
1160N 980E	.26	.17
1260N 980E	.13	.06
1010N 970E	.32	.33
1060N 970E	.15	.06
1110N 970E	.07	.00
1160N 970E	.17	.11
1210N 970E	.26	.00
1260N 970E	.03	.00
1010N 960E	.08	.06
1060N 960E	.07	.00
1110N 960E	.03	.00
1160N 960E	.08	.11
1210N 960E	.32	.06
1260N 960E	.00	.06
1010N 990E	.64	.39
1060N 990E	.51	.17
1110N 990E	.36	.06
1160N 990E	.17	.44
1210N 990E	.21	.39
1260N 990E	.30	.06
1110N 1030E	1.10	.28
1160N 1030E	.03	.06
1110N 1040E	.44	.11
1110N 940E	.02	.00
1210N 940E	.05	.00
1010N 950E	.01	.00

Table 6.6. (continued)

Surface Unit	Surface Density/m ² *	Plowzone Density/Liter**
1110N 950E	.03	.00
1160N 950E	.03	.00
1210N 950E	.11	.00
1210N 1010E	.32	.17
1060N 1010E	.64	.11
1010N 980E	.07	.06
1060N 1030E	1.91	.28
1060N 1040E	.66	.11
1210N 980E	.12	.00
Mean Density	.40	.18

*10 m²**From 30 cm² shovel tests

Table 6.7. Sample sizes and r^2 values for partitioned surface and plowzone density category comparisons from 40MU86 and 40MU110.

	Surface Density Category/m ²			
	.00 - .09	.1 - .99	> 1.00	Combined Total
40MU86 (10M ²)				
Sample Size	17	69	6	92
r^2	-0.37	0.18	-0.57	0.39
40MU110 (5M ²)				
Sample Size	0	8	27	35
r^2	-	0.54	0.84	0.85

from surface data. Surface and related plowzone artifact densities at 40MU110 (as high as $4.25/\text{m}^2$ and averaging nearly $2/\text{m}^2$) are drastically higher than those encountered at most lithic scatter sites in the region, making the results derived here interesting but of limited applicability.

Subsequent work undertaken at 40MU409 was designed to help further understand the surface to plowzone relationships by testing in 5 m^2 surface units of previously established density. In addition to the shovel tests excavated here and discussed previously (this chapter), a total of 5 m^2 surface units were excavated in 1 m^2 excavation squares subdivided in 10 cm levels (see discussion in Chapter II). Six 5 m^2 units ranging in lithic artifact surface counts from 0 to 44 were excavated in this manner. Careful scrutiny of the data in Table 6.8 divulges some interesting insights concerning surface to plowzone artifact ratios. Judging by other studies, ratios are higher than could be expected, and seem to be scaled according to surface density. Although ordered in a similar configuration, plowzone lithic artifact density figures seem more appropriate when corrected for excavated volume. This is the case until the lowest two density categories in which the logical relationships are reversed (also true for ratio). This may be a collection-related factor, or, possibly, when plowzone densities reach a certain lower limit, surface artifact exposure may be retarded. The former of these possibilities seems most likely, because artifact density would have been on the order of $.04/\text{m}^2$.

Table 6.8. Raw counts, volumetric data, and surface to plowzone ratios (uncorrected) for lithic artifacts recovered from totally excavated 5 m² units at 40MU409.

Surface Unit	Total Surface Lithic Artifacts	Total Plowzone Lithic Artifacts	Plowzone Volume in Liters	Plowzone Lithic Artifact Density/Liter	Surface to Plowzone Artifact Ratio
2020N 2025E	44	8578	5602.5	1.540	1:195
2040N 1995E	17	3029	6215.0	.487	1:178
2020N 2035E	12	2097	4547.5	.461	1:175
2030N 1980E	8	1210	3902.5	.310	1:151
2045N 2035E	2	641	6600.0	.097	1:321
2040N 2070E	0	698	4520.0	.153	0:698

Regression analysis, again utilizing the least squares model, was applied to data derived from the six totally excavated squares (Table 6.9). The relationship between surface artifact density and plowzone artifact/liter appears to be a strong one ($r^2=.98$), and this is encouraging (Figure 6.3). There would be little reason to further explore the relationship of unit size to prediction ability if the total samples showed a weak association.

Regression analysis (same model) was conducted on data from a series of randomly selected plowzone excavation squares of decreasing size. This was done to investigate how excavation size affects the ability to predict the relationship between surface and plowzone artifact density (results presented in Figure 6.4 through 6.8). As could be logically expected, correlation coefficients range from a high for 4 m² excavation squares (.97) to the lowest value (.29) for the 25 cm² tests. This lowest value closely corresponds to that derived from 40MU86, where similar-sized tests were placed in a site of relatively low artifact density ($r^2=.39$ for 92 cases). In spite of the "obvious" ranking of results, important data on the minimum excavation size usable for reliable density prediction have been established. Density estimations based on 2 m² excavations or larger should be very reliable ($r^2=.95$), while those using 1 m² excavation appear fairly good ($r^2=.87$). Estimates derived from data produced from excavations less than 1 m² in size would be highly suspect.

Although results have been generally encouraging, certain cautions must be addressed. Most of the assumptions necessary for

Table 6.9. Comparison of surface lithic artifacts densities/m² and plowzone lithic artifact densities/liter at 40MU409. All excavation units are 1 meter square.

Excavation Square#	Surface Density/ m ² -0 Surface Coordinate 2040N 2070E P.Z. Density/Liter	Surface Density/ m ² -.08 Surface Coordinate 2045N 2035E P.Z. Density/Liter	Surface Density/ m ² -.32 Surface Coordinate 2030N 1980E P.Z. Density/Liter	Surface Density/ m ² -.48 Surface Coordinate 2020N 2035E P.Z. Density/Liter	Surface Density/ m ² -.68 Surface Coordinate 2040N 1995E P.Z. Density/Liter	Surface Density/ m ² -1.76 Surface Coordinate 2030N 2025E P.Z. Density/Liter
1	.100	.119	.275	.288	.775	1.506
2	.105	.109	.369	.535	.478	1.153
3	.133	.129	.297	.353	.524	1.276
4	.051	.121	.369	.337	.396	1.470
5	.091	.129	.302	.472	.409	1.464
6	.074	.056	.298	.377	.497	2.714
7	.162	.094	.247	.710	.548	1.861
8	.278	.048	.341	.699	.611	.977
9	.197	.121	.400	.346	.316	1.730
10	.194	.123	.279	.622	.338	1.848
11	.367	.089	-	.472	.440	1.393
12	.288	.143	.367	.571	.540	1.684
13	.115	.084	.337	.418	.606	1.857
14	.253	.133	.245	.378	.443	1.539
15	.127	.066	.220	.303	.478	1.353
16	.125	.012	.400	.406	.504	1.746
17	.132	.098	.290	.454	.426	.981
18	.137	.055	.329	.519	.461	1.279
19	.082	.073	.251	.265	.486	1.451
20	.119	.078	.343	.713	.462	2.408
21	.171	.084	.361	.563	.547	1.890
22	.078	.115	.317	.542	.572	1.863
23	.166	.101	.223	.344	.423	1.312
24	.259	.080	.413	.462	.421	1.907
25	.206	.087	.267	.590	.563	1.383
Mean Plowzone Artifact Density/Liter	.153	.097	.310	.461	.487	1.540
Mean Plowzone Artifact Density/100 Liters	15.3	9.7	31.0	46.1	48.7	154.0

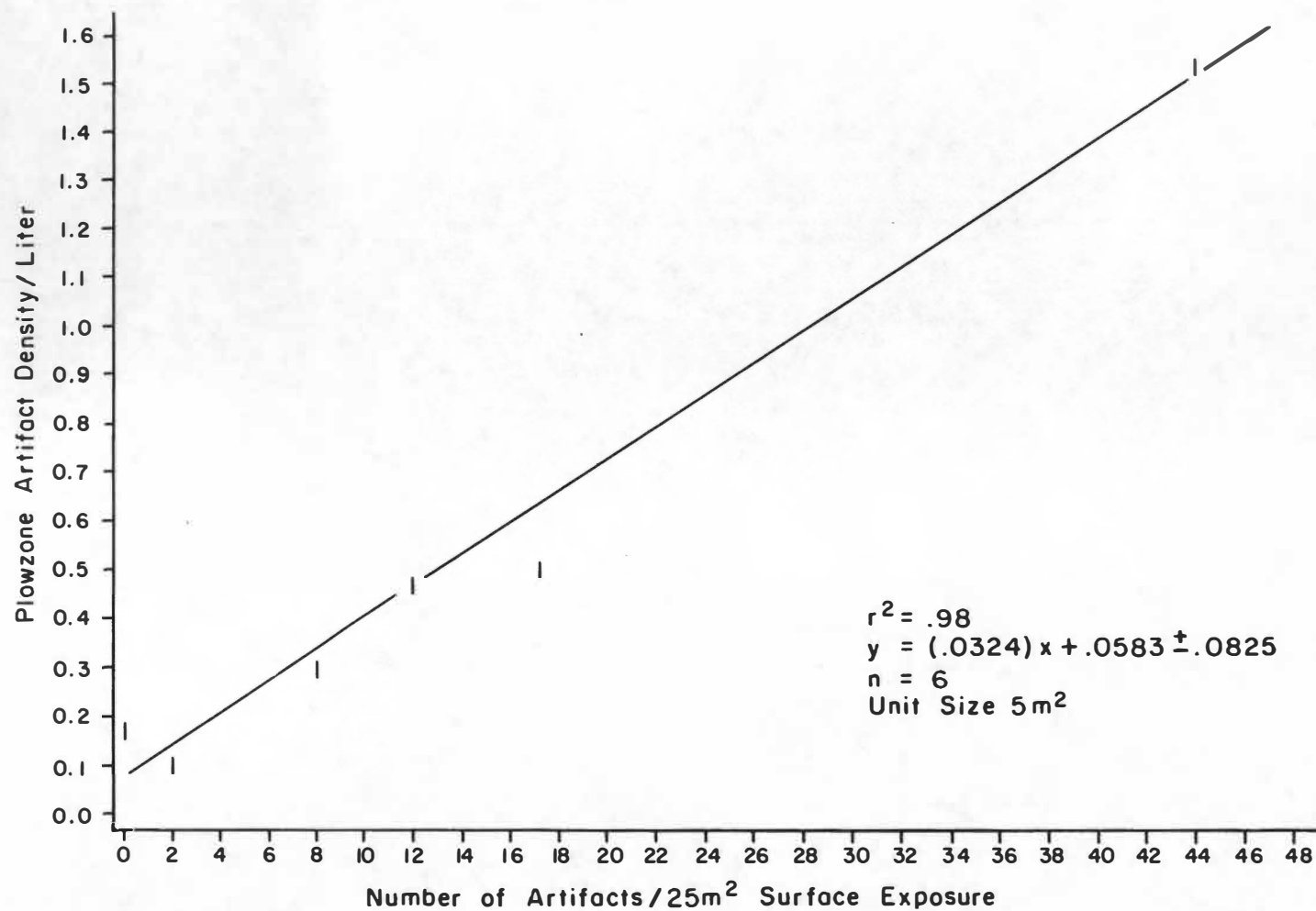


Figure 6.3. Bivariate plot showing the relationship between surface and plowzone lithic artifact densities. Regression based on total plowzone excavation at 40MU409.

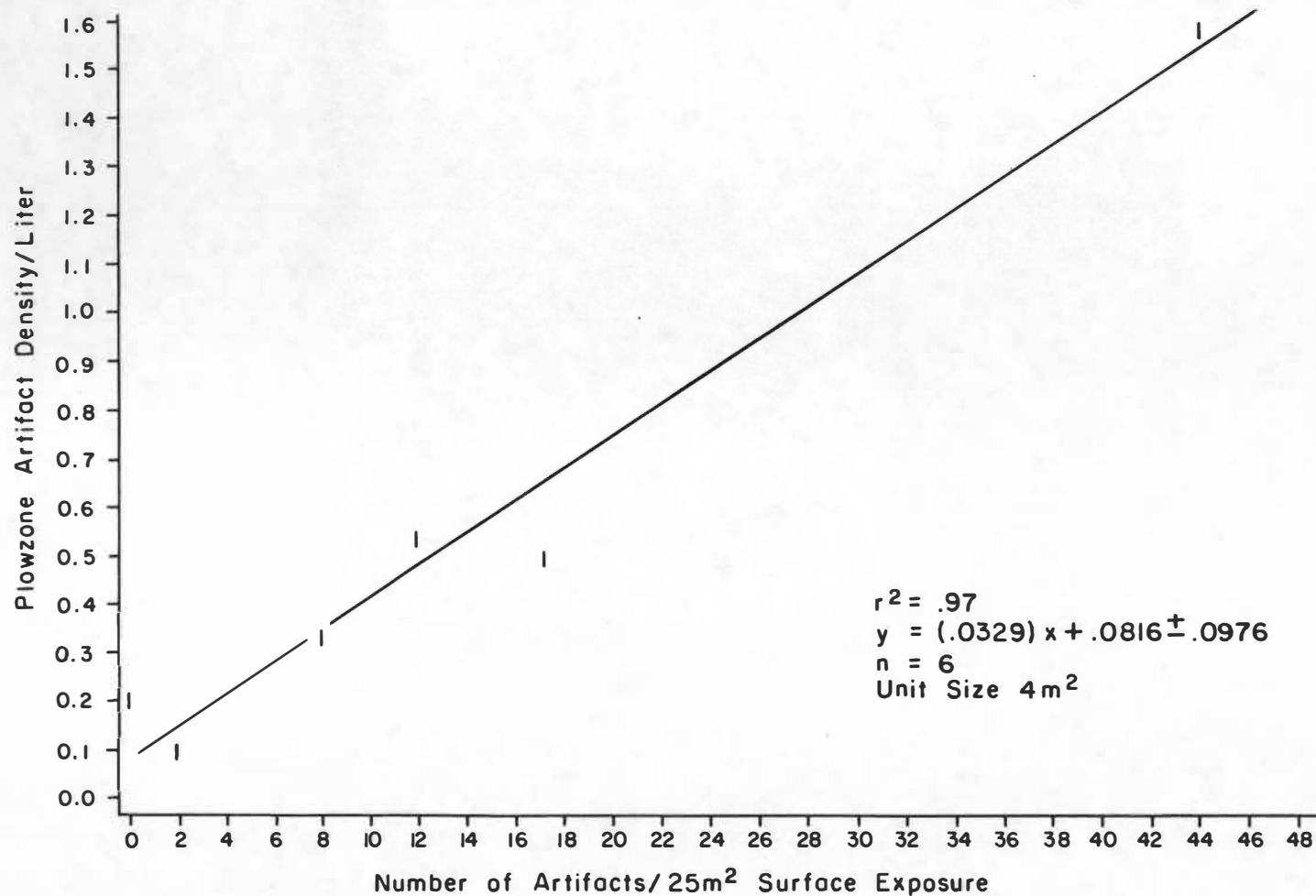


Figure 6.4. Bivariate plot showing the relationship between surface and plowzone lithic artifact densities. Regression based on 4 m² excavations at 40MU409.

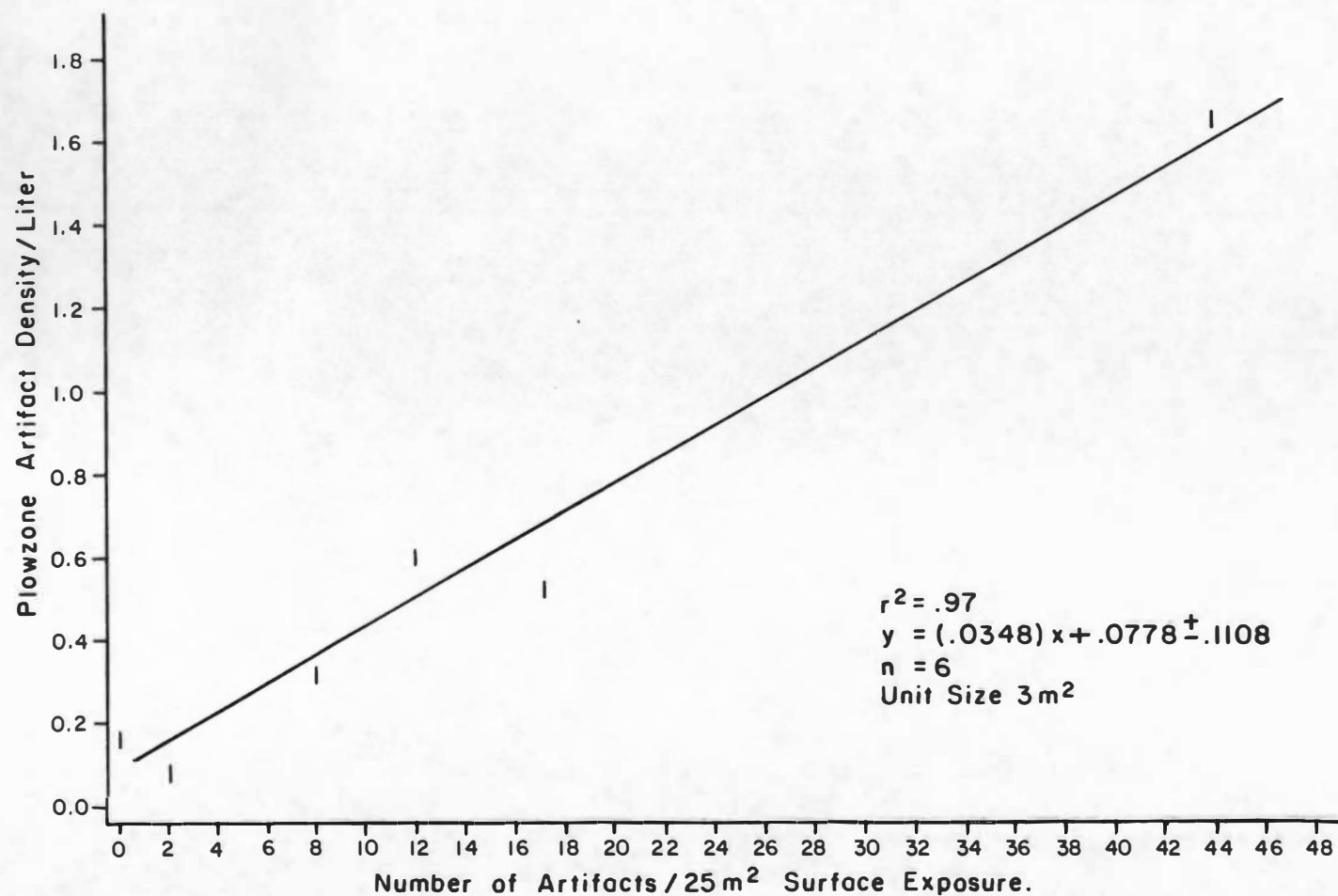


Figure 6.5. Bivariate plot showing the relationship between surface and plowzone lithic artifact densities. Regression based on 3 m^2 excavations at 40MU409.

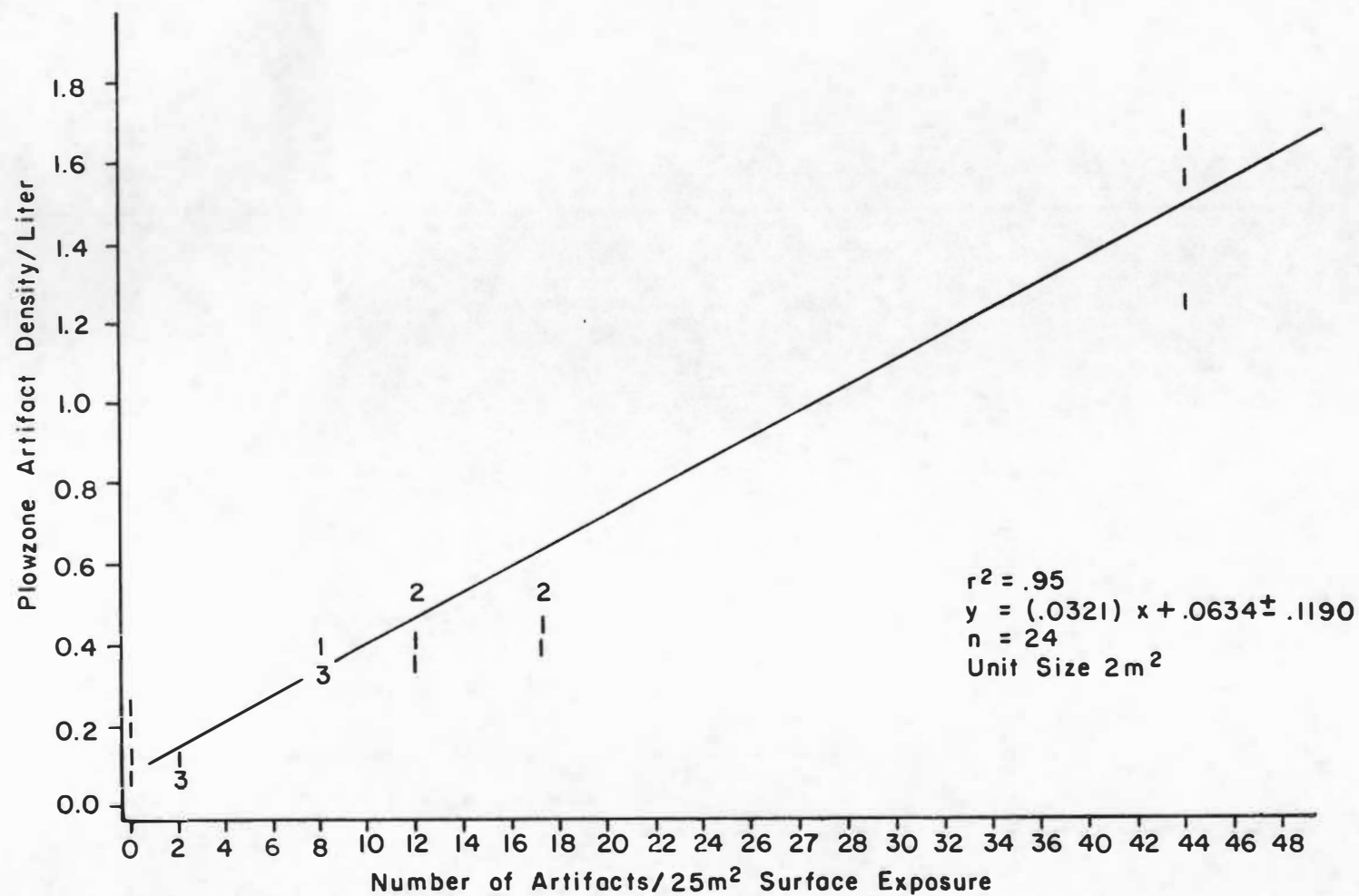


Figure 6.6. Bivariate plot showing the relationship between surface and plowzone lithic artifact densities. Regression based on 2 m² excavations at 40MU409.

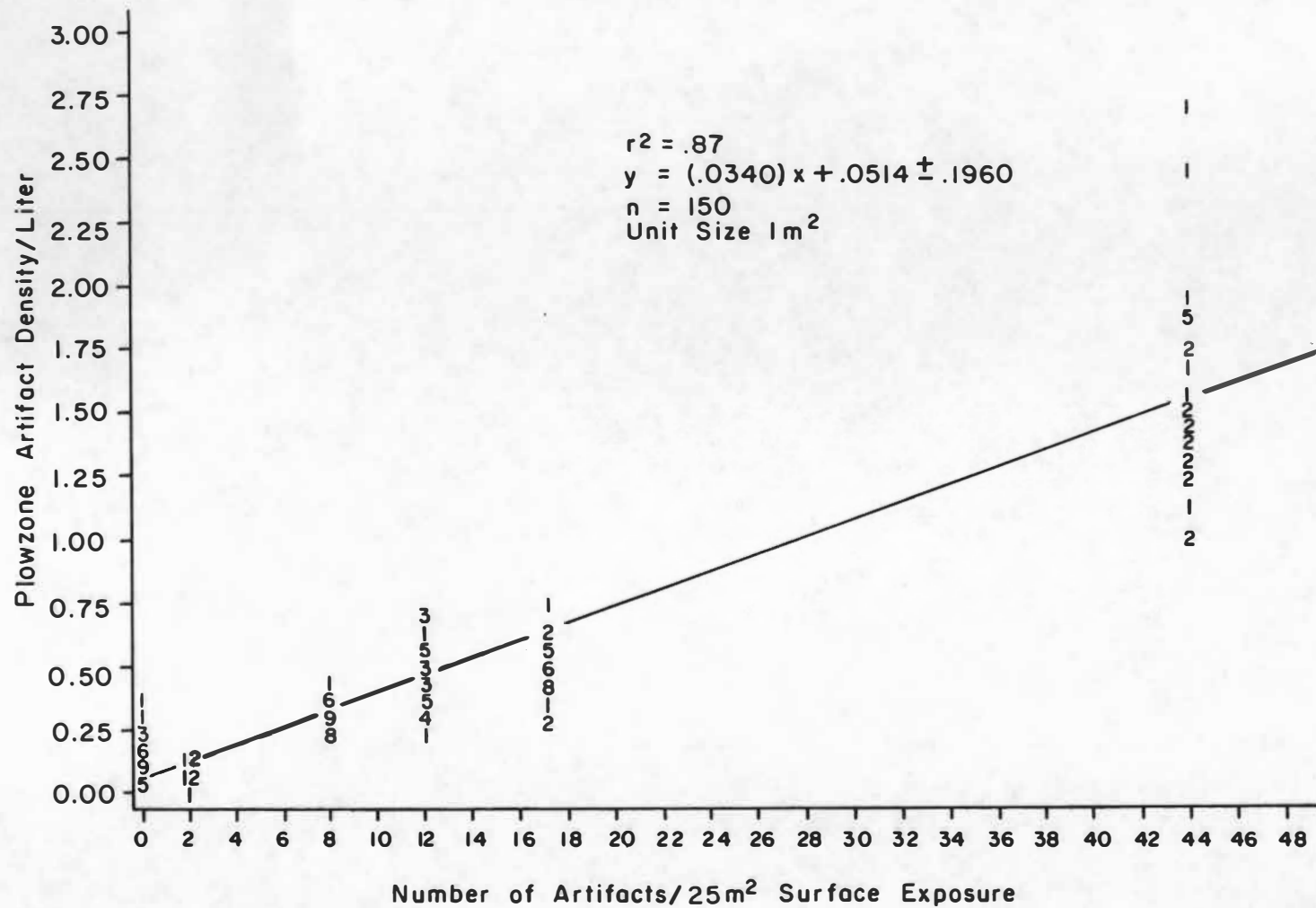


Figure 6.7. Bivariate plot showing the relationship between surface and plowzone lithic artifact densities. Regression based on 1 m^2 excavations at 40MU409.

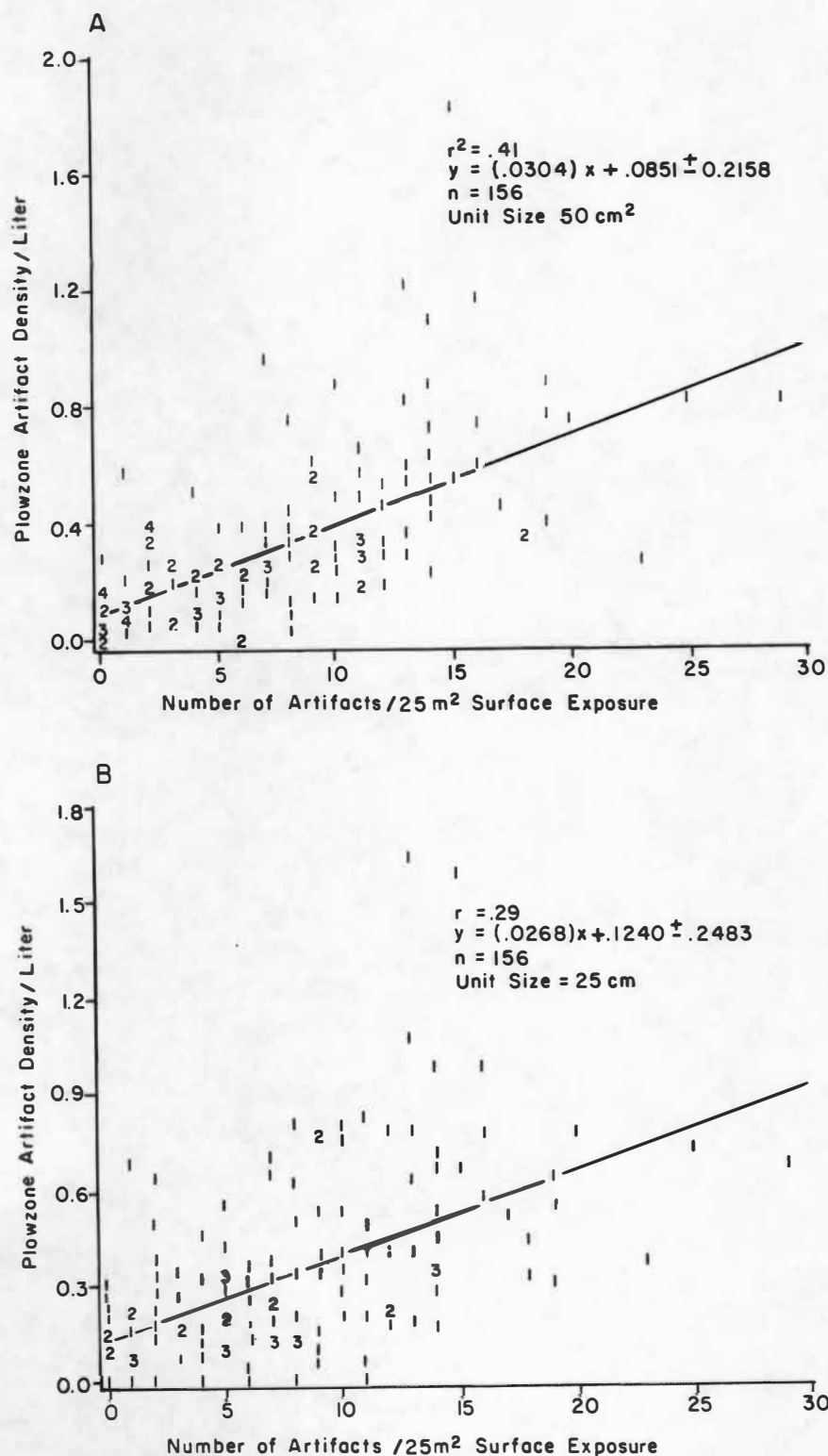


Figure 6.8. Bivariate plots showing the relationship between surface and plowzone lithic artifact densities. A., based on 50 cm^2 tests; B., based on 25 cm^2 tests at 40MU409.

using the least squares model for inference can be met using this data set (Thomas 1976). For example, density distributions around the mean for lithic artifacts recovered from the 1 m² excavations in the totally excavated squares approach a normal distribution (Table 6.10), measurement scales are appropriate, X is measured without error, Y values are randomly selected, etc. However, the predictive value of the model rests on the merits of six cases. Variances of the Y variables are not equal, and there is some indication that the relationship between X and Y is not linear. Evidence of the latter two problems are apparent in Figure 6.7 (as an example), but is clearest in Figure 6.9, which displays the residuals plotted from data in Figure 6.7. The curvilinear pattern suggested by the position of the first two sets of data points is most likely caused by a collection error, which has already been discussed. The increasing variance with concomitant artifact density increase is to be expected. Application of any transformation designed to diminish variance is considered unwarranted because of small sample size.

Reliability of Surface Samples

The reliability of surface collections as indicators of total plowzone assemblage content has recently been a point of concern among archaeologists. This is the third and final facet of surface to plowzone relationships covered in this analysis.

It has been demonstrated (Chapter V) that a certain rainfall threshold must be surpassed (for a particular soil type and surface condition) before a collection reflects what is recoverable from the

Table 6.10. Density distributions around the mean for lithic artifacts recovered from 1 m² plowzone excavations squares at site 40MU409.

	5 m ² Surface Units					
	2040N 2070E	2045N 2035E	2030N 1980E	2020N 2035E	2040N 1995E	2030N 2035E
Mean Number of Plowzone Lithic Artifacts/100 L	15.3	9.7	31.0	46.1	48.7	154.0
Number Above Mean	11	12	11	13	11	11
Number Below Mean	14	13	13	12	14	14

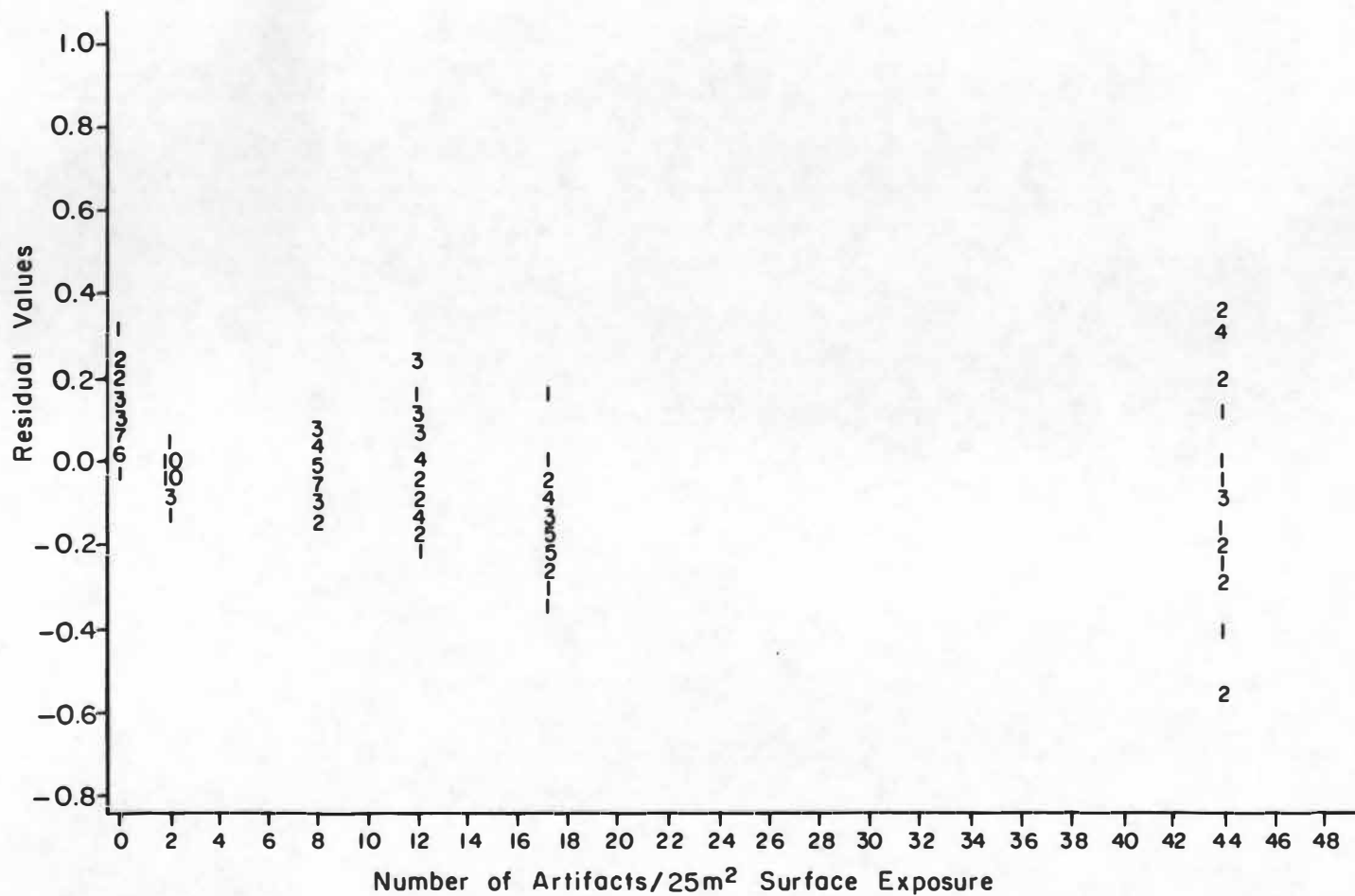


Figure 6.9. Plot of the residual values for the surface to plowzone regression displayed in Figure 6.7. Based on 1 m² excavations.

surface. The relationships between the surface and the plowzone assemblage are also affected by other processes which influence the likelihood of an artifact's exposure on the surface. The nature of these exposure related processes has not been proven to be other than random, at least within certain size classes of material (Ammerman 1985). Size has either been examined in terms of an artifact's greatest dimension (Ammerman and Feldman 1978; Baden 1982; Lewarch and O'Brian 1981a) or in terms of which dimension is most likely to affect its recovery (Frink 1984). Baden (1982) determined through simulation studies that the following percentages of plowzone artifacts within their respective size classes should be recoverable from the surface: 1.5 - 3 inches, 12.3%; 3/4 - 1.5 inches, 7%; and 1/4 - 3/4 inches, 2.9%. Other similar trends in recovery percentages related to artifact size have been reported (Lewarch and O'Brian 1981a).

To examine this size-related phenomenon, size graded artifact percentages were compared from 5 m² surface units and randomly selected plowzone contexts at 40MU409 (Table 6.11). Previous examination of plowzone artifacts had shown them to be proportionately smaller (Table 6.12). Recovery percentages for each of these contexts, as well as size-grade explanations, are presented in Tables 6.13 and 6.14. The 1/8" size grade represents artifacts retained in the 1/4" screen during field operations that could upon size grading be fitted through the screen on a diagonal. All of these are incorporated into the 1/4" size grade for analysis. Large artifacts are grossly overrepresented on the surface as the following breakdown

Table 6.11. 40MU409 plowzone excavation units randomly selected for size grading.

<u>Surface 5 m² Coordinate</u>	<u>Plowzone Excavation 1 m²</u>	
	Unit Number	Coordinate
2030N 2025E	6	2032N 2029E
	10	2030N 2025E
	12	2032N 2025E
	19	2034N 2029E
	21	2031N 2026E
2040N 1995E	11	2043N 1995E
	14	2043N 1997E
	15	2044N 1996E
	20	2040N 1998E
	25	2040N 1996E
2020N 2035E	5	2021N 2039E
	7	2020N 2037E
	8	2021N 2035E
	16	2021N 2038E
	25	2020N 2036E

Table 6.12. Mean dimensions^a for lithic material recovered from the first two 10 cm levels of plowzone shovel tests at 40MU86 (66 percent sample).

	Secondary Flakes N=28				Tertiary Flakes N=23				Large Biface Thinning Flakes N=4				Small Biface Thinning Flakes N=26				Broken Flakes N=40				Blocky Debris N=32			
	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt	L	W	T	Wt
Level 1	N = 18				N = 17				N = 2				N = 10				N = 13				N = 21			
Mean	17	12	4	1	15	11	3	1	19	13	6	1.5	11	8	2	.5	12	8	2	.5	20	14	8	7
Standard Deviation	5	5	2	1	5	3	2	.5	8	6	1	1.5	3	3	1	-	12	3	2	.5	14	11	7	19.5
Range	18	16	6	3	17	6	5	1.5	11	8	1	2	11	9	2	-	13	10	6	.5	46	35	33	76.5
Level 2	N = 10				N = 6				N = 2				N = 16				N = 27				N = 11			
Mean	22	15	6	2.5	16	11	3	.5	20	16	4	1	11	7	1	.5	13	9	2	.5	20	13	9	5
Standard Deviation	8	7	3	2.5	4	3	1	.5	7	8	2	1	3	2	1	-	5	3	1	.5	14	8	6	8
Range	21	23	9	5.5	11	7	3	1	11	11	2	1.5	8	7	2	-	21	15	5	1	33	28	15	20.5

^aLinear measurements are rounded to the nearest mm. Weights rounded to nearest .5 gm.

L = Length
W = Width
T = Thickness
Wt = Weight

Table 6.13. Raw counts, size grade percentages, and total sample percentages (underlined) for lithic artifacts recovered from the surface of selected squares at 40MU409.

	Size Grade*	Primary	Secondary	Tertiary	Large Biface Thinning	Small Biface Thinning	Broken	Blocky Debris	Fire-cracked Rock	Core/Fragment	Hammerstone/Fragment	Biface/Fragment	Flake Tool	Ground Stone	Tested Cobble	Total
Raw Count	3										1					1
Size Grade %											100.00					100.00
Total Sample %											<u>2.13</u>					<u>2.13</u>
	2										1					1
											100.00					100.00
											<u>2.13</u>					<u>2.13</u>
	1						3	4	1						1	9
							33.00	44.44	11.11						11.11	100.00
							<u>6.38</u>	<u>8.51</u>	<u>2.13</u>						<u>2.13</u>	<u>19.15</u>
	3/4			1			1	2					1			5
				20.00			20.00	40.00					20.00			100.00
				<u>2.13</u>			<u>2.13</u>	<u>4.26</u>					<u>2.13</u>			<u>10.64</u>
	1/2		5	2			1	5	2							15
			33.33	13.33			6.67	33.33	13.33							100.00
			<u>10.64</u>	<u>4.26</u>			<u>2.13</u>	<u>10.64</u>	<u>4.26</u>							<u>31.92</u>
	1/4	1	2	4		1	5	2				1				16
		6.25	12.50	25.00		6.25	31.25	12.50				6.25				100.00
		<u>2.13</u>	<u>4.26</u>	<u>8.51</u>		<u>2.13</u>	<u>10.64</u>	<u>4.26</u>				<u>2.13</u>				<u>34.04</u>
TOTAL		1	7	7		1	10	13	3		2	1	1	1		47
		<u>2.13</u>	<u>14.89</u>	<u>14.89</u>		<u>2.13</u>	<u>21.28</u>	<u>27.66</u>	<u>6.38</u>		<u>4.26</u>	<u>2.13</u>	<u>2.13</u>	<u>2.13</u>		<u>100</u>

*Size Grade = Largest screen mesh size in which an artifact is retained; size in inches.

Table 6.14. Raw counts, size grade percentages, and total sample percentages (underlined) for lithic artifacts recovered from plowzone of selected squares at 40MU409.

	Size Grade*	Primary	Secondary	Tertiary	Large Biface Thinning	Small Biface Thinning	Broken	Blocky Debris	Fire-cracked Rock	Core/Fragment	Hammerstone/Fragment	Biface/Fragment	Flake Tool	Ground Stone	Tested Cobble	Total
Raw Count	3														1	1
Size Grade %															100.00	100.00
Total Sample %															<u>.04</u>	<u>.04</u>
2																
1			5	1				5	1	5						17
			29.00	5.90				29.00	5.90	29.00						100.00
			<u>.19</u>	<u>.04</u>				<u>.19</u>	<u>.04</u>	<u>.19</u>						<u>.66</u>
3/4	1	13	6	1		9	14	6				3				53
	1.89	24.53	11.30	1.89		16.98	26.42	11.32				5.66				100.00
	<u>.04</u>	<u>.50</u>	<u>.23</u>	<u>.04</u>		<u>.35</u>	<u>.93</u>	<u>.23</u>				<u>.12</u>				<u>2.04</u>
1/2		85	41	7	2	53	54	17		2			1			262
		32.44	15.65	2.67	.76	20.23	20.61	6.49		.76			.38			100.00
		<u>3.28</u>	<u>1.58</u>	<u>.27</u>	<u>.08</u>	<u>2.04</u>	<u>2.08</u>	<u>.66</u>		<u>.08</u>			<u>.04</u>			<u>10.10</u>
1/4	2	332	331		183	878	300	120				6				2152
	.09	15.43	15.38		8.50	40.80	13.94	5.58				.28				100.00
	<u>.08</u>	<u>12.80</u>	<u>12.77</u>		<u>7.06</u>	<u>33.86</u>	<u>11.57</u>	<u>4.63</u>				<u>.23</u>				<u>82.99</u>
1/8		3	17		20	62	2	3				1				108
		2.78	15.74		18.52	57.41	1.85	2.78				.93				100.00
		<u>.12</u>	<u>.66</u>		<u>.77</u>	<u>2.39</u>	<u>.08</u>	<u>.12</u>				<u>.04</u>				<u>4.17</u>
TOTAL	3	438	396	8	205	1002	375	147	5	2	10	1			1	2593
	<u>.12</u>	<u>16.89</u>	<u>15.27</u>	<u>.31</u>	<u>7.90</u>	<u>38.64</u>	<u>14.46</u>	<u>5.67</u>	<u>.19</u>	<u>.08</u>	<u>.39</u>	<u>.04</u>			<u>.04</u>	<u>100.00</u>

*Size Grade = Largest screen mesh size in which an artifact is retained; size in inches.

showing percentage of total plowzone size classes recovered from the surface depicts.

Table 6.15. Percentages of total plowzone size classes represented by the surface sample from site 40MU409.

Size Grade (inches)	% of Total Artifacts Recovered
3	50.00
2	100.00
1	34.00
3/4	8.60
1/2	5.40
1/4	.07

Sample sizes for large size-grades (over 3/4") are small in comparison to those from smaller size grades recovered in surface and plowzone collections (Table 6.13 and 6.14). Because of this disparity, a different grouping of size-grades was performed to more realistically examine these assemblages. A dichotomous relationship employing >1/2" to <1/2" size grades was established. Comparison of excavated artifact size distribution to that for the corresponding surface collection using this simplified measure (Table 6.16) shows the same pattern as that exhibited when all size grades are used, but in a more easily interpretable form. There is basically a reversal in relationship of larger to smaller artifacts, with a far greater percentage of small ones present in the plowzone (Figure 6.10). A

Table 6.16. Size grade percentages for lithic artifacts recovered from plowzone and corresponding surface collection units from site 40MU409.

	Excavation Unit		Corresponding Surface Unit	
	% < $\frac{1}{2}$ "	% > $\frac{1}{2}$ "	% < $\frac{1}{2}$ "	% > $\frac{1}{2}$ "
2031N 2026E	92	8		
2034N 2029E	93	7		
2032N 2025E	90.5	9.5		
2030N 2025E	87	13		
2032N 2029E	89	11		
Unit %	90.3	9.7	32	68
2040N 1996E	75	25		
2040N 1998E	86	14		
2043N 1995E	79	21		
2043N 1997E	82	18		
2044N 1996E	82	18		
Unit %	80.8	19.2	52	48
2021N 2038E	84	16		
2021N 2035E	81	19		
2020N 2037E	91	9		
2021N 2039E	91	9		
2020N 2036E	76	24		
Unit %	84.5	15.5	33	67
Total Sample %	85.2	14.8	39	61

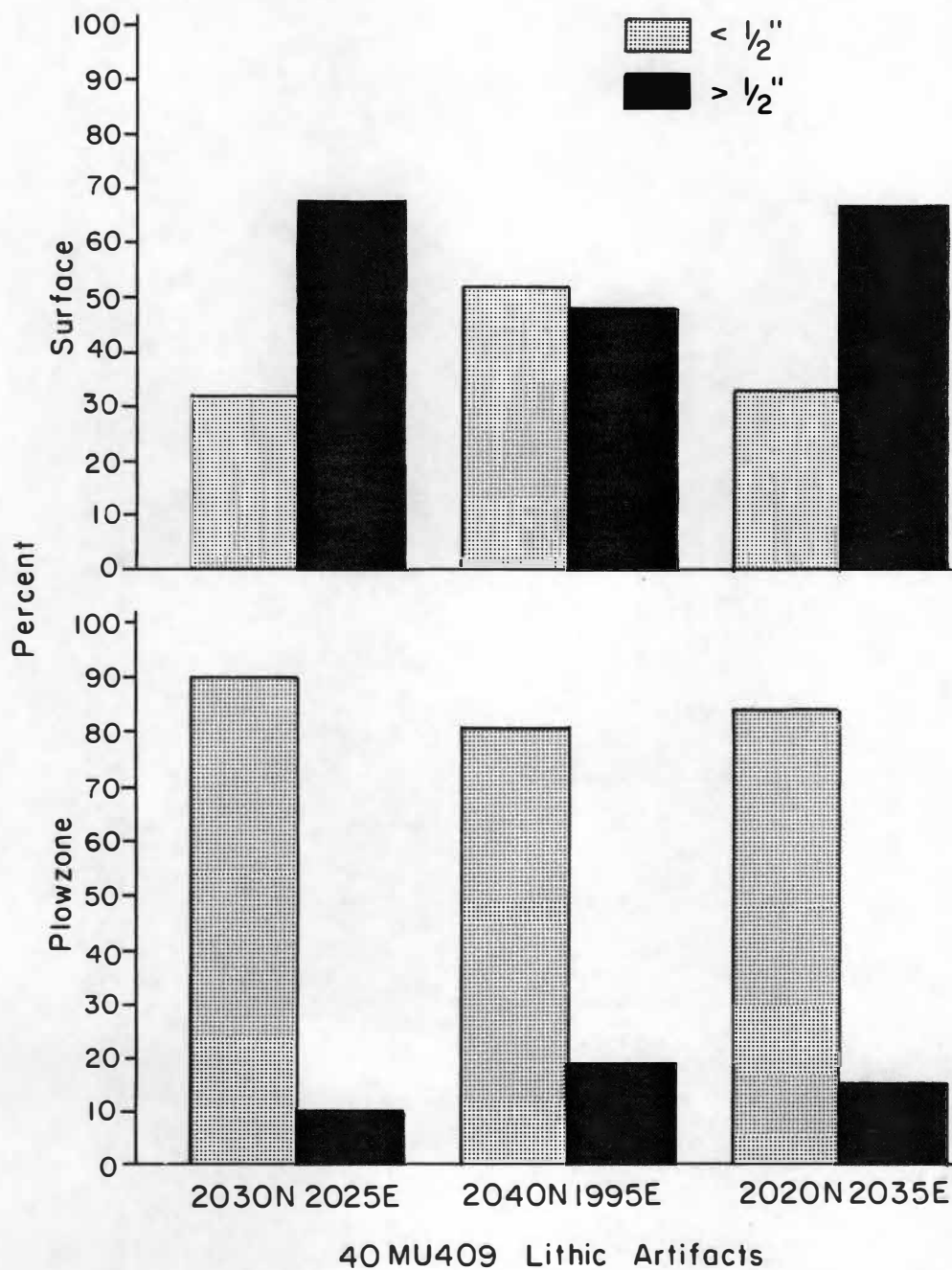


Figure 6.10. Comparison of lithic artifact sizes from surface and plowzone contexts at 40MU409.

closer examination of material distribution by 10 cm level within the plowzone (Table 6.17) revealed a general size homogeneity throughout (Figure 6.11). This homogeneity suggests that perhaps the majority of large objects are indeed moved to the surface after sufficient years of tillage (Lewarch 1979).

The overrepresentation of large artifacts on a plowzone surface could bias archaeological interpretation of activities performed at a particular location. Frink's (1984:358) example can serve as a case in point: "A quartz flake with dimensions equal to a quartz projectile point would be indistinguishable in a purely physical evaluation. The distinction is evident, however, and it is precisely from these culturally derived variables that archaeological inferences are deduced." He continues with an example of how a predominance of choppers and pestles (large-sized items) on a site surface would lead to a functional determination of plant processing. The total plowzone assemblage at 40MU409 is virtually devoid of large items. However, an example can be structured using the existing assemblage that will show how differences in artifact size distribution could bias interpretations of site activities.

The use of lithic debitage as an indicator of prehistoric activities practiced in a location has been widely accepted in recent years (Wright 1980; Newcomer 1971; Mayne and Pokotylo 1981; Collins 1975; Amick 1982, 1985). In fact, some investigators have recommended its use as an alternative to tools for activity area recognition because, in most cases, debitage remains where it was produced

Table 6.17. Summary of size-class percentages by level for plowzone lithic artifacts excavated at 40MU409.

Excavation Unit	Level 1		Level 2		Level 3	
	% < ½"	% > ½"	% < ½"	% > ½"	% < ½"	% > ½"
2031N 2026E	91	9	93	7	92	8
2034N 2029E	93	7	94	6	-	-
2032N 2025E	89	11	92	8	90	10
2030N 2025E	88	12	82	18	-	-
2032N 2029E	90	10	91	9	-	-
Unit Average %	90.2	9.8	90.4	9.6	91	9
2040N 1996E	77	23	75	25	67	33
2040N 1998E	79	21	92	8	-	-
2043N 1995E	89	11	88	12	64	36
2043N 1997E	83	17	84	16	80	20
2044N 1996E	80	20	82	18	88	12
Unit Average %	81.6	18.4	84.2	15.8	74.75	25.25
2021N 2038E	87	13	81	19	-	-
2021N 2035E	77	23	87	13	-	-
2020N 2037E	86	14	98	2	-	-
2021N 2039E	91	9	90	10	-	-
2020N 2036E	65	35	85	15	-	-
Unit Average %	81.2	18.8	88.2	11.8	0	0
Overall Level %	84	16	87.6	12.4	83	17

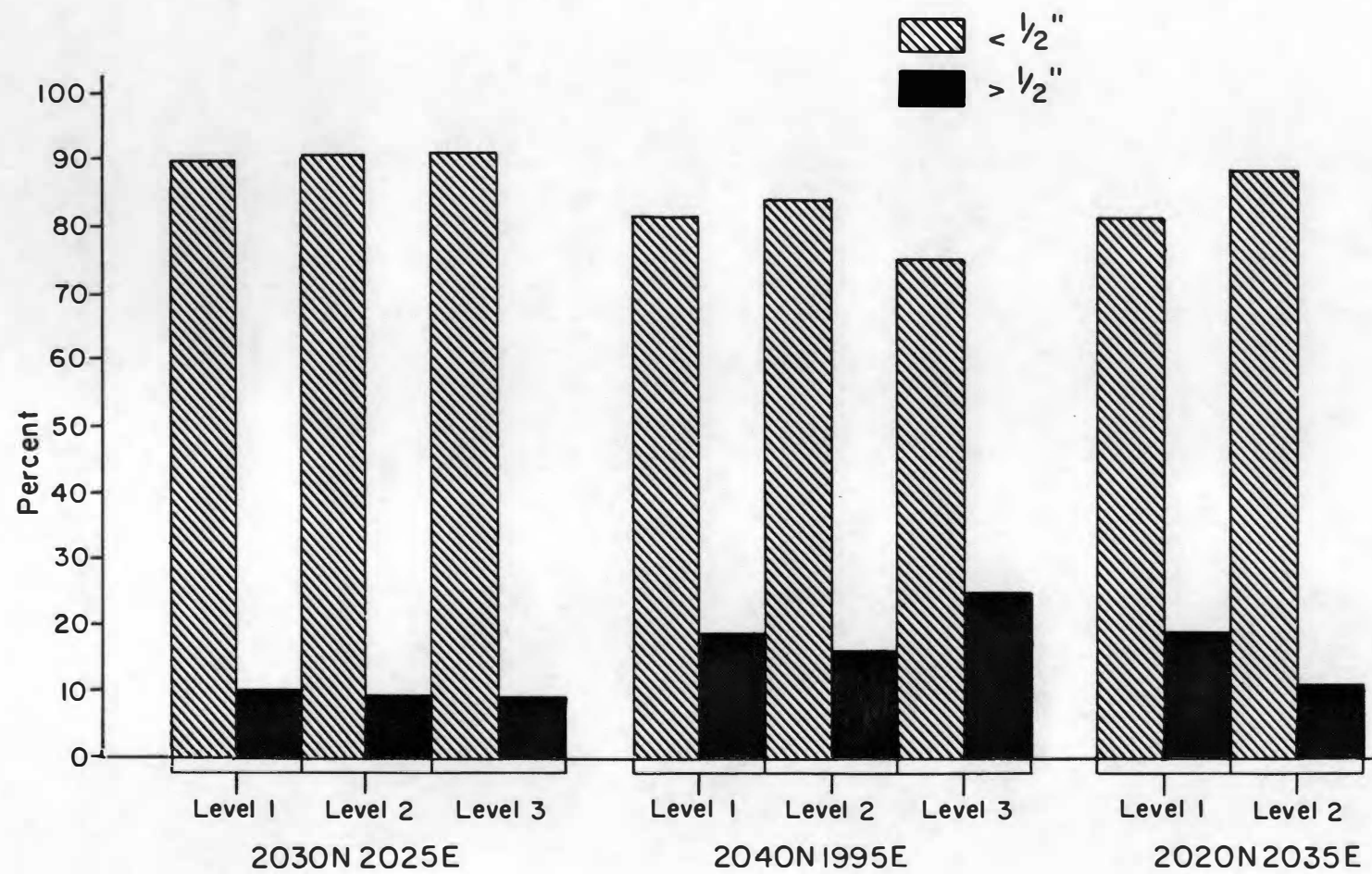


Figure 6.11. Examination of plowzone lithic artifact sizes by level at 40MU409.

(Binford 1973, 1979; Schiffer 1976). The plowzone collections at 40MU409 can be characterized as smaller than those from the surface. This is shown in Figure 6.12 which presents relative percentages of lithic items in total sample collections from the surface and plowzone, as well as relative percentages for each lithic category by size grade.

Except for the obvious differences in large artifact categories (i.e. hammerstones and tested cobbles), blocky debris and broken flakes show the greatest divergence in both the total collection and between size grades. Blocky debris is an indicator of early stage lithic reduction (Appendix B), and its occurrence is higher in the surface collection relative to other artifact categories. Broken flakes (which have no platforms or cortex, Appendix B) are used as an example because their representation in the smallest plowzone size-grade category mirrors that of small biface thinning flakes which are a good indicator of projectile point/knife resharpening. If the broken flakes are, in fact, small biface thinning flakes that had lost their platforms, evidence of retouching activity would be underrepresented in the surface collection. This is a contingency that cannot be validated, and its use is, therefore, as a heuristic device only.

The surface and plowzone assemblages from 40MU409 are actually quite similar in relative percentages of categories represented. This may be due largely to the fact that variables affecting surface collected artifact assemblages have been controlled to a greater

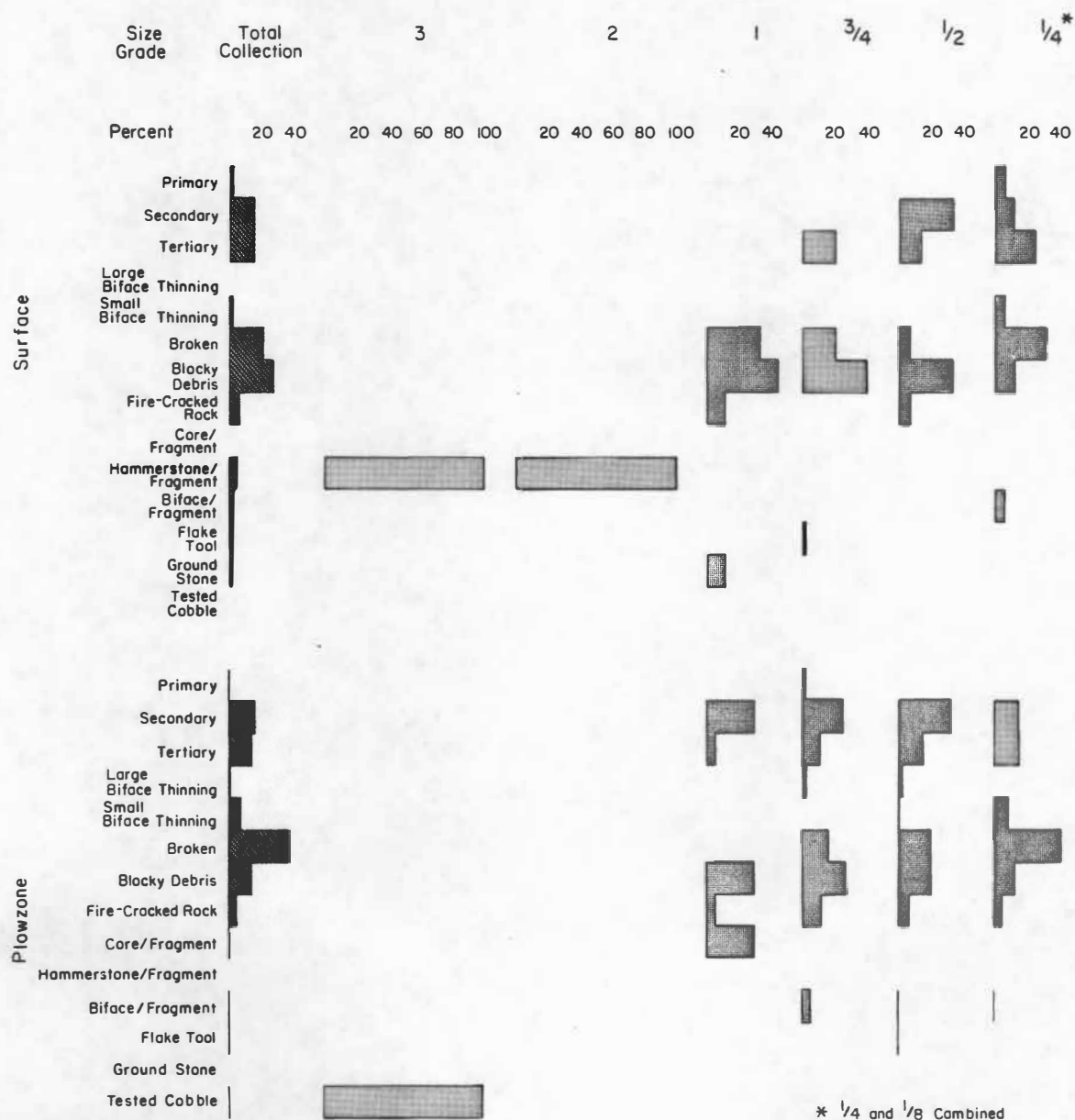


Figure 6.12. Relative percentages for lithic artifact categories by size grade for selected surface and plowzone contexts from 40MU409.

degree than was previously possible. It could also be due to the paucity of larger artifacts in the plowzone at 40MU409.

Three things have been established as a result of surface to plowzone studies. The first is that when using shovel tests as a site locator, surface scatters must have a surface density of .10 artifacts/m² before an 80% chance of artifact detection is reached (30 cm² test). Likelihood of detection increases with surface density and increase in unit size. Second, a minimum excavation unit size has been established which allows prediction of surface density from plowzone samples. Units smaller than 1 m² are not good predictors of density (e.g., .5 m², $r^2=.41$; .25 m², $r^2=.29$). Third, there are differences in artifact size between the surface and plowzone. The overrepresentation of large artifacts in surface collections relative to total plowzone assemblages can bias determinations of site activities. However, exercising control over surface condition variables can most probably reduce this bias.

CHAPTER VII

DISCUSSION

This research has examined the effects of naturally occurring variables on surface artifact recovery. This was accomplished by isolating and reviewing pertinent variables, which are rainfall and soil factors. Information from this review was incorporated into an experiment designed to measure the effects of rainfall on artifact exposure and recovery. The results from the surface recovery experiment were used to form baseline data that allowed meaningful interpretation of three additional plowzone data recovery exercises. These were (1) artifact detection by shovel test, (2) prediction of surface density from plowzone excavation data, and (3) reliability of surface collections as indicators of plowzone assemblage content.

An extensive review of agricultural engineering and soil science literature revealed that the closely interrelated effects of rainfall, soil characteristics, and surface conditions could drastically affect rates of soil erosion from cultivated fields. It was suggested at this time that artifact exposure rates should be concomitantly affected. To test this, a recovery experiment was designed that held soil type and surface conditions as constant as possible, while measuring rainfall amounts as they occurred. Four repeated collections were taken from the same area following precipitation ranging from no rain to more than 11 cm. Lithic artifact densities increased from $.26/m^2$ (preceding rainfall) to nearly $1/m^2$ after

11.11 cm of rain had fallen. Therefore, increased rainfall was responsible for boosting surface artifact density nearly four times. Of equal importance is that a threshold in artifact recovery was reached after 6.35 cm of rain. By this stage in the rainfall continuum, 97% of all artifacts exposed during the experiment had been recovered, suggesting that surface collections become representative after the recovery threshold has been surpassed. Additional recovery trends show that large artifacts are most likely to be overrepresented in collections following little or no rainfall. The repercussions of not considering rainfall and surface conditions when evaluating surface remains can range from missing a site altogether to improper assessments of site size, artifact density, intrasite variability, as well as biasing intersite and regional comparisons.

Rainfall and soil variables were monitored on three sites where shovel testing was conducted to establish the surface artifact density necessary for detection with a small plowzone excavation. Surface collections were made subsequent to rainfall amounts far in excess of that found necessary to produce a representative surface sample. This procedural monitoring was conducted to ensure that the results produced would be applicable on other sites within the region for which soil and surface conditions were comparable. It was discovered that when using small shovel tests of 25 cm² (at least 12.5 liters in volume) that sites with a surface density of at least .10 artifacts/m² would be detected 80% of the time should the test fall within its boundaries. Increasing test size to 50 cm² (and hence quadrupling the

volume) increased discovery probabilities to the point that surface artifact scatters as sparse as $.04/\text{m}^2$ were detected nearly 95% of the time.

The relationship of surface artifact density/ m^2 to plowzone artifact density/liter was explored using the least squares regression model. This procedure was applied to data derived from a site at which a representative surface sample had been collected (using the preceding criteria). The relationship between the artifact density/ m^2 for a 5 m^2 surface collection and the artifact density/liter excavated from beneath it was a very strong one ($r^2 = .98$). The strength of this relationship decreases with excavated volume to a point where densities derived from a 25 cm^2 demonstrate very little association with surface density (r^2 range from $.29$ to $.39$). Surface density estimates based on 2 m^2 plowzone excavations should be reliable ($r^2 = .95$), while those using 1 m^2 tests for predictions are somewhat less so ($r^2 = .87$), but still appear fairly good. Estimates derived from excavations less than 1 m^2 in size would be suspect.

Examination of the reliability of surface collections as indicators of plowzone assemblage contents resulted in some interesting findings. Apart from the general congruence of predictability between numbers of surface and plowzone artifacts, there are some divergent tendencies. The most disparaging of these are size differences. In the surface assemblages measured as much as 70% of the collected material was greater than $1/2"$ in maximum dimension. Conversely, as much as 90% of the material recovered from

the plowzone beneath these squares was less than 1/2" in maximum dimension. This same phenomenon has been reported elsewhere (Baden 1982; Lewarch and O'Brian 1980). Comparison of the surface and plowzone assemblages (at 40MU409) showed few differences in the relative percentages of most artifact categories. There were few very large items and all of these were collected from the surface. There were proportionately more small items in the plowzone, but these were technologically nondescript and would have affected activity assessments based on surface collections very little. But caution should be exercised here. This is a function of the total assemblage present at this site only. Had more large items been present that are culturally linked to specific tasks (such as mortars, pestles, and metates), activity assessments could be biased if surface evidence alone was used.

This research has endeavored to demonstrate the degree to which all survey techniques are or can be related to representative artifact surface distributions. This relationship has been established only for the area in which it was developed, the Central Duck River drainage in Tennessee or for other areas exhibiting similar characteristics. The utility of its application remains contingent on testing in this, as well as other regions. By applying what has been gained from this study, it should be possible to avoid the two-result survey. The probabilities of finding sites of certain density limits are defined by knowledge of site populations in the region, instead of theoretical probabilities.

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APPENDICES

APPENDIX A

PROGRAM USED TO CALCULATE EXCAVATED
PLOWZONE VOLUMES AT 40MU409

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REAL LART
DIMENSION C1(5,3)
CHARACTER IDINFO*25
OPEN(UNIT=1,FILE='VTEST.TWO',ACCESS=SEQUIN')
OPEN(UNIT=21,FILE='VTEST2.OUT')
5  READ(1,100,END=999)IDINFO,(((C1(I,J),J=1,3),I=1,4)),LART
C  WRITE(5,111)IDINFO,(((C1(I,J),J=1,3),I=1,4)),LART
C111  FORMAT(' ',A25,4(F4.0,F4.0,F6.0),F5.0,F10.2)
100  FORMAT(A25,4(F3.0,F3.0,F4.0),F4.0)
C NEED FIRST X,Y COORDS AT END OF ARRAY FOR AREA EQUATION
    C1(5,1)=C1(1,1)
    C1(5,2)=C1(1,2)
C CALC AREA
    SUM=0.
    STHK=0.
    DO 15 I=1,4
    SUM=SUM+(C1(I+1,1)+C1(I,1)) * (C1(I+1,2)-C1(I,2))
15  CONTINUE
    AREA=ABS(SUM/2.)
C CALC AVG THICKNESS
    DO 25 I=1,4
    STHK=STHK+C1(I,3)
    CONTINUE
    AVTHK=STHK/4.
C CALC VOL
    VOL=AREA*AVTHK
    WRITE(21,110)IDINFO,C1(2,2),LART,VOL
110  FORMAT(A25,F4.0,F5.0,F10.2)
    GO TO 5
999  STOP
    END

```

APPENDIX B

COLUMBIA ARCHAEOLOGICAL PROJECT
CULTURAL MATERIAL CODING FORMAT

APPENDIX B

COLUMBIA ARCHAEOLOGICAL PROJECT
CULTURAL MATERIAL CODING FORMAT

CULTURAL MATERIAL INVENTORY: KEY TO COLUMN NUMBERS

COLUMNS:

- 1-4: Consecutive specimen numbers
- 5-9: Site number
- 10-17: Grid coordinates (site specific)
- 18: Type of collection (1=surface, 2=30 cm² test, 3=excavated square, 4=25 cm² test, 5=50 cm² test, 6=1 m² test)
- 19-20: Collection number or level number
- 21: Cortex type on lithic items (0=none, 1=river cobble cortex, 2=matrix cortex/residual cortex, 3=incipient fracture plane)
- 22-23: Lithic raw material type (see below)
- 24: Blank column
- 25-26: Evidence of thermal alteration (see below)
- 27: Blank column
- 28-29: Broad category of cultural material (01=chipped stone and cobble artifacts, 02=stone debris, 03=ground and pecked stone artifacts, 04=organic artifacts, 05=clay-ceramic artifacts, 06=historic materials, 07=organic non-artifactual material)
- 30: Blank column
- 31-32: Specific function categories (e.g. artifact type)
- 33: Blank column
- 34-35: Stylistic categories (e.g. point type and flake type)
- 36: Blank column

37-38: 4th level categories (e.g. PP/K breakage)

39: Blank column

LITHIC RAW MATERIAL TYPE

Columns 22-23:

- 01 - Murfreesboro
- 02 - Ridley
- 04 - Carters
- 06 - Bigby Cannon - fine grained grey
- 07 - Bigby Cannon - coarse grained brown
- 08 - Brassfield
- 09 - Ft. Payne
- 10 - St. Louis
- 13 - Chalcedony
- 14 - Indeterminate Other
- 15 - Ridley/Carters Indeterminate
- 16 - Quartzite
- 17 - Steatite
- 18 - siltstone, fine grained
- 19 - siltstone, coarse grained
- 20 - limestone
- 21 - hematite
- 22 - limonite
- 23 - igneous-metamorphic rocks
- 24 - shale

25 - chlorite schist

26 - agate

LITHIC THERMAL ALTERATION

Columns 25-26:

00 - no evidence of heating-apparently unaltered

01 - fire crazed

02 - crazed and pot lidded

03 - heat spalling, curved or angular fractures

04 - discoloration: smoked, or color change without fractures

05 - lustrous (may or may not be due to heating)

06 - lustrous on some flake scars (heated prior to final flaking)

07 - lustrous and discoloration

08 - pot lidding (may have color alterations, etc.)

09 - heat spalling and lustrous or discoloration

10 - evidence of heating, any form (not just lustrous)

11 - definitely heated/alterd using any of above criteria

12 - unable to determine - indeterminate

CHIPPED STONE AND COBBLE ARTIFACTS (Columns: 28-29 =01)

Columns 31-32:

01 - projectile points

02 - projectile points/hafted knives

03 - hafted knives

04 - end scrapers on reworked points

05 - drills on reworked points

- 06 - burins on reworked points
- 07 - spokeshaves on reworked points
- 08 - scraper/graver on reworked points
- 09 - bifacial scraper
- 10 - bifacial knives
- 11 - bifacial drills
- 12 - bifacial preforms (12-01=initial stage, 12-02=intermediate stage,
12-03=late stage)
- 13 - bifacial blank (lacking notches or use-wear)
- 14 - miscellaneous bifaces and fragments
- 15 - chopping tools
- 16 - spokeshaves
- 17 - notches
- 18 - denticulates (light duty)
- 19 - denticulates (heavy duty)
- 20 - end scrapers
- 21 - side scrapers (heavy duty)
- 22 - side scrapers (light duty)
- 23 - gravers, pointed projections
- 24 - gravers, blunt or rounded projections
- 25 - wedges (pieces esquilees)
- 26 - core scrapers/scraper planes
- 27 - adzes
- 28 - pecking stones (01-28-01-pecking stone spall)
- 29 - knapping hammers (01-29-01-hammer stone spall)
- 30 - perforators (light duty)

- 31 - perforators (heavy duty)
- 32 - cores (32-01=core fragments, 32-02=bipolar cores)
- 33 - blade cores
- 42 - retouched flakes
- 43 - utilized flakes
- 44 - burinated flakes
- 45 - spurred end scraper on flake or blade
- 46 - pounders (on cobbles)
- 47 - combination cutting scraping tools on flake-blade
- 48 - net sinkers (weight)
- 49 - end and side scraper on blade
- 50 - graver on core
- 51 - chipped stone hoe/digging implement (must have polish on bit end)
- 52 - side scraper on blade (01-light duty, 02-heavy duty)
- 53 - hoe/digging implement flake or spall (must have polish on dorsal surface)
- 54 - micro tool
- 55 - core/pecking stone

HAFTED CHIPPED STONE TOOL STYLISTIC TYPE GROUPS
(for projectile points, projectile points/knives, hafted tools)

Columns 34-35:

- 01 - too fragmentary for identification

HAFTED TOOL BREAKAGE

(for projectile points, projectile points/knives, hafted tools)

Columns 37-38:

- 01 - complete
- 02 - basal section (broken across stem)
- 03 - midsection with shoulders (broken across stem and blade)
- 04 - midsection lacking shoulders
- 05 - tip section
- 06 - intact base with fracture across blade
- 07 - tip missing (distal impact or twist fracture)
- 08 - blade corner(s) missing-nearly complete
- 09 - edge of blade section
- 10 - basal corner(s) missing-nearly complete
- 11 - basal corner(s) missing and broken across blade
- 12 - edge section with shoulder (broken across stem and blade)
- 13 - base missing-otherwise complete
- 14 - basal corner and shoulder fragment

STONE DEBRIS

(Columns (28-29)=02)

FLAKE DEBRIS

(Columns (31-32)=01)

FLAKE TYPES

Columns 34-35:

- 01 - Primary decortication flakes (core reduction - platform 90° or more - full dorsal cortex)
- 02 - Secondary decortication flakes (core reduction - platform 90° or more - partial dorsal cortex)
- 03 - Tertiary core reduction flakes (core reduction - no dorsal cortex, but may have cortex on platform only)
- 04 - Biface thinning flakes large variety (greater than 2 cm long or wide, greater than 3 mm thick, may have cortex, usually broad platform)
- 05 - Biface thinning flakes small variety (less than 2 cm long or wide, less than 3 mm thick, no cortex)
- 06 - Broken flakes (flakes lacking cortex and platforms)
- 07 - Core rejuvenation flakes
- 08 - Biface thinning flakes Pentaloid (small platform less than 3 mm wide, flakes less than 2 cm long or wide, widely expanding platform)
- 09 - Shatter (slivers of chipped stone lacking flake attributes - small, generally less than 1 cm)
- 10 - Bipolar debris
- 11 - Blades (parallel dorsal ridge(s), prepared platform)
- 12 - probable biface thinning flakes (lacking platform) - not used in analysis
- 13 - Outre passe

NON-FLAKE DEBRIS

(Columns: 31-32=02)

NON-FLAKE DEBRIS TYPES

Columns 34-35:

- 01 - Fire cracked rock (fire spalled or crazed, thermal alteration but not evidence of conchoidal fracture)
- 02 - Blocky debris (definite evidence of flaking, negative scars, etc. - angular chipped stone not assignable to flake or core categories)
- 03 - tested cobbles (one or few flakes removed)
- 04 - unmodified gravel (less than 5 cm in maximum dimension)
- 05 - unmodified cobbles (greater than or equal to 5 cm in maximum dimension)

PECKED AND GROUND STONE ARTIFACTS

(Columns: 28-29=03)

Columns 31-32:

- 01 - Nutting stones: pitted cobbles with smooth depressions (01-01=pitted only, 01-02=pitted and ground, 01-03=pitted and shaped by pecking, 01-04=pitted, shaped and ground, 01-05=pitted stone/hammerstone)
- 02 - Anvil stones: pitted cobbles with irregular depressions with linear scarring (02-01=anvilstone, 02-02=anvil/hammerstone)
- 03 - Grinding stones (03-01=unshaped, 03-02=pecked and shaped, 03-03=grinding stone/hammerstone, 03-04=pestle, conical or bell shaped)
- 04 - Milling basins (04-01=milling basins or mortar, 04-02=milling basin/anvil stone, 04-03=milling basin/nutting stone)
- 05 - Abraders (05-01=smooth, 05-02=grooved)
- 06 - Bannerstones
- 07 - Boatstones
- 08 - Gorgets
- 09 - Axes
- 10 - Celts

- 11 - Pipes
- 12 - Stone vessel or sherd
- 13 - Ground pigments
- 14 - Miscellaneous ground stone items (unidentified fragments)
- 15 - Miscellaneous pecked stone items (unidentified fragments)
- 16 - Miscellaneous modified rock

ORGANIC ARTIFACTS
(Columns: 28-29=04)

Columns 31-32:

- 01 - shell scrapers
- 02 - bone awls
- 03 - bone knapping tools-flaker
- 04 - bone fishhooks
- 05 - bone needles
- 06 - shell beads
- 07 - bone beads
- 08 - socketed antler handles
- 09 - perforated teeth
- 10 - Turtle carapace bowl

CLAY/CERAMIC ARTIFACTS
(Columns: 28-29=05)

- 01 - potsherds (Columns 34-35=temper [01-chert, 02-grit, 03-grit/sand, 04-shell], Columns 37-38=surface treatment [01-plain, 02-fabric impressed, 03-cord marked], Columns 40-41=referable type)
- 02 - daub-fired clay (02-01=no impressions, 02-02=with impressions)
- 03 - mud dauber nests

HISTORICAL MATERIALS
(Columns: 28-29=06)

Columns 31-32:

- 01 - historic metal items
- 02 - glass items
- 03 - historic ceramics
- 04 - historic wooden items
- 05 - plastic/rubber items
- 06 - historic stone items
- 07 - leather
- 08 - bricks and fragments

ORGANIC NON-ARTIFACTUAL MATERIALS
(Columns: 28-29=07)

Columns 31-32:

- 01 - bone (01-01=mammal, 01-02=bird, 01-03=reptile, 01-04=fish)
- 02 - shell (02-01=bivalve, 02-02=gastropod)
- 03 - botanical remains
- 04 - insect remains (04-01=exoskeleton)

APPENDIX C

PLOWZONE LITHIC ARTIFACT DENSITY/LITER

DATA FOR SITE 40MU409

Table C.1. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density 0 lithic artifacts/m².

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1970N 2045E	3	0	0
1975N 2090E	14	.085	.021
1990N 1910E	9	.274	.126
1990N 2025E	8	0	.036
1995N 1905E	3	0	0
2000N 2050E	15	0	.053
2005N 1920E	9	0	.021
2010N 2000E	22	0	.080
2010N 2075E	15	.315	.262
2015N 1900E	16	0	.016
2015N 1920E	24	.136	.143
2025N 2070E	1	0	.097
2030N 1910E	18	0	0
2030N 2085E	23	.146	.273
2035N 1910E	7	.076	.018
2040N 1905E	25	0	0
2040N 1915E	7	0	0
2040N 1945E	20	.209	.153
2040N 2070E	7	.097	.165
2050N 2065E	6	.240	.156

Table C.2. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .04-.08 lithic artifacts/m² (1-2 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1950N 2045E	10	.377	.158
1955N 2005E	15	0	.035
1955N 2040E	3	0	.070
1970N 1925E	24	0	.049
1970N 2050E	4	0	.023
1975N 1940E	22	0	.035
1980N 1925E	4	0	.028
1980N 2085E	11	.085	.054
2000N 1905E	21	.148	.060
2000N 2070E	16	.278	.255
2000N 2085E	21	.081	0
2010N 1910E	24	.070	.017
2015N 1935E	23	.128	.178
2025N 1960E	13	.223	.207
2025N 1995E	16	.200	.123
2025N 2005E	5	.686	.559
2025N 2065E	13	.173	.088
2045N 1975E	12	.499	.365
2045N 2035E	20	0	.032
2045N 2060E	23	.492	.378

Table C.3. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .12-.16 lithic artifacts/m² (3-4 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1960N 1970E	5	.160	.038
1970N 1990E	15	.191	.289
1975N 2065E	3	.064	.049
1985N 1990E	10	.155	.192
1990N 1940E	13	0	.155
1990N 1955E	11	.324	.395
2000N 1985E	2	.337	.245
2000N 2035E	14	0	.222
2005N 1990E	14	.256	.185
2010N 1945E	14	.219	.312
2010N 2070E	16	.323	.167
2030N 1975E	23	.146	.202
2035N 2045E	18	.063	.133
2040N 1940E	25	0	.016

Table C.4. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .20-.28 lithic artifacts/m² (5-7 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1995N 1980E	13	0	.083
1960N 1975E	21	.128	.136
1960N 1985E	1	.591	.267
1965N 2010E	14	.254	.181
1975N 2000E	11	.320	.174
1990N 2035E	25	.123	.077
1990N 2045E	11	.351	.378
1995N 2035E	7	.331	.121
2000N 1920E	25	.320	.320
2000N 2000E	3	.240	.267
2000N 2065E	4	.410	.253
2005N 1945E	11	.112	.200
2005N 1985E	18	.284	.146
2015N 1995E	5	.178	.043
2020N 2045E	15	.184	.078
2025N 1935E	7	.147	.404
2025N 1980E	3	.557	.385
2025N 2035E	19	.256	.219
2035N 1955E	18	.457	.502

Table C.5. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .32-.36 lithic artifacts/m² (8-9 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1970N 1985E	12	.762	.546
1970N 2085E	25	.029	.015
1985N 1945E	8	0	.068
1985N 2060E	8	.197	.123
1990N 2000E	8	.701	.244
1990N 2065E	1	0	.017
1995N 1955E	4	.623	.354
2005N 1945E	11	.112	.200
2005N 1980E	11	.772	.600
2005N 2060E	13	.133	.313
2010N 2060E	6	.188	.235
2015N 1945E	16	.492	.281
2015N 1980E	4	.808	.747
2020N 1950E	3	.128	.256
2035N 1940E	9	.068	.053
2035N 2010E	3	.656	.960
2035N 2020E	4	.320	.380
2045N 1985E	22	.333	.435

Table C.6. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .40-.48 lithic artifacts/m² (10-12 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1965N 1995E	23	.192	.352
1975N 1975E	9	.147	.243
1975N 2010E	24	.482	.475
1985N 2045E	11	.295	.180
1990N 1975E	2	.093	.359
1990N 1985E	10	.821	.644
1995N 2010E	18	.400	.310
2000N 1940E	20	.204	.286
2000N 1990E	22	.533	.311
2010N 2030E	4	.800	.864
2020N 2045E	12	.753	.480
2025N 1945E	23	.404	.276
2030N 1950E	24	.388	.368
2030N 2030E	6	.528	.557
2030N 2065E	23	.053	.262
2035N 1980E	1	.343	.229
2040N 2050E	23	0	.181
2040N 2055E	18	0	.263

Table C.7. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .52-.56 lithic artifacts/m² (13-14 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1975N 1980E	15	.533	.218
1975N 2015E	6	.480	.565
1980N 1950E	18	.056	.165
1980N 1960E	13	.311	.326
1985N 1955E	17	.404	.359
1985N 1960E	13	.635	.590
1990N 1960E	6	1.070	.810
1990N 2050E	24	.179	.171
1995N 1980E	11	.786	.543
2005N 1955E	1	.356	.469
2005N 1960E	18	.364	.462
2015N 1985E	25	.784	.533
2015N 2035E	24	.711	.862
2020N 2035E	21	.569	.563
2025N 2020E	23	1.631	1.213
2045N 2065E	16	.196	.136

Table C.8. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .60-.68 lithic artifacts/m² (15-17 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
1970N 1980E	14	.770	.591
1985N 2040E	15	.168	.219
1990N 1965E	20	.667	.544
1995N 1975E	2	.093	.359
1995N 2005E	8	.507	.444
2005N 1975E	5	.985	.622
2010N 2055E	17	.667	.545
2015N 2030E	7	.278	1.094
2020N 1970E	17	.441	.724
2030N 2015E	1	.577	1.166
2030N 2020E	3	1.580	1.826
2035N 1950E	11	.340	.239
2040N 1990E	10	.339	.415

Table C.9. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .72-.76 lithic artifacts/m² (18-19 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
2000N 1970E	20	.441	.353
2015N 2025E	22	.546	.878
2020N 1975E	5	.980	.735
2040N 1995E	21	.453	.513

Table C.10. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density .80-.88 lithic artifacts/m² (20-22 artifacts/25 m²).

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
2000N 1980E	19	.371	.259
2010N 1980E	17	.302	.388
2015N 1975E	8	.772	.743
2030N 2035E	20	.400	.317
2030N 2040E	5	.100	.127

Table C.11. Lithic artifact density/liter from plowzone tests at 40MU409. Surface density >1 lithic artifact/m².

Provenience	Unit	Density/Liter	
		25 cm ²	50 cm ²
2005N 1965E	5	.680	.810
2020N 2025E	7	.724	.816
2020N 2030E	25	.640	.760
2030N 2025E	22	2.408	1.890

VITA

William B. Turner was born in Bethesda, Maryland, on August 29, 1948. He attended the public school system in Washington, D.C., until he graduated from Woodrow Wilson High School in June 1966. In September of 1968 he entered the University of Southern Mississippi, Hattiesburg, where he received a Bachelor of Science degree in Anthropology, with a minor in history.

The author came to Tennessee in May of 1978 when he was employed by the University of Tennessee on various archaeological projects until he began study toward a Master's degree at the University of Tennessee, Knoxville. Just prior to that time Mr. Turner became affiliated with the Columbia Archaeological Project as a research assistant and later as a research associate. Since 1968, the author has participated in various archaeological research primarily in Mississippi and Tennessee. He was awarded the Master of Arts degree in Anthropology in August 1986.

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