E. ARTHUR BETTIS III

Soil Morphologic Properties and Weathering Zone Characteristics as Age Indicators in Holocene Alluvium in the Upper Midwest

The present landscape consists of a mosaic of various-aged deposits, erosion surfaces, and soils with predictable distributions. Archaeological remains, being deposits, are subject to the same natural processes of burial, weathering, and erosion that affect the preservation and distribution of noncultural deposits. Although all archaeological deposits have been subject to environmental processes that preserve, alter, or destroy the original depositional context, the impact of these processes on the archaeological record is usually not considered on a landscape scale. In most cases the present landscape is assumed to be reflective of past landscapes and proxy environmental/age indicators such as published soil maps, or landforms determined from topographic maps are used to reconstruct the physical environment of various periods of the past. Such approaches ignore all but the shallow subsurface and are incapable of evaluating archaeological deposits associated with portions of past landscapes not present at the modern surface. These types of paleoenvironmental reconstructions in combination with traditional site locating tech-

Iowa Quaternary Studies Group Contribution No. 30.
niques such as pedestrian survey and excavation of shallow test pits result in a bias toward location of shallowly buried or surface archaeological deposits that can produce a skewed perception of the archaeological record (Bettis and Thompson 1982; Hajic 1985; Thompson and Bettis 1981).

The inability of traditional pedestrian survey and shallow testing strategies to adequately sample the archaeological record is a result of two conceptual problems: (1) the belief that the present landscape more or less reflects past landscapes, and (2) failure to consider that the archaeological record has passed through an environmental filter in which burial, alteration, and destruction has occurred. Although both of these concepts are usually discussed in introductory archaeology courses, they usually end up taking a back seat to statistically based environmental or social sampling concepts when strategies for locating archaeological deposits are designed and implemented (e.g., Muller 1975).

Detailed investigations of the alluvial fill sequence in numerous valleys of the Upper Midwest have been accomplished in the last decade (Anderson and Overstreet 1986; Bettis and Thompson 1981; Bettis and Little 1987; Brakenridge 1981; Hajic 1985; Knox et al. 1981; McDowell 1983; Van Nest and Bettis 1990). These studies, all of which include several radiocarbon-dated geologic sections, demonstrate that modern valley landscapes consist of a mosaic of various-age deposits and geomorphic surfaces. Data from these studies and a literature review of other Midwestern alluvial stratigraphic studies that have reported detailed descriptions of radiocarbon-dated deposits, including Munsell colors, notes on the occurrence of mottles, and the grade and type of soil structure, indicate that some morphologic properties of alluvial deposits and soils developed in the deposits are specific to certain age groupings of the deposits.

This paper presents a first approximation of a model useful for differentiating Historic, late Holocene (LH), and early and middle Holocene (EMH) alluvial deposits in the Upper Midwest. The distinguishing criteria are easily observed properties of deposits and soils that can be recorded by archaeologists with only modest knowledge of soils and geomorphology. Application of this model permits division of the landscape elements comprising modern valleys into three groups: (1) those older than about 3000 to 4000 years (EMH), (2) those younger than that age but prehistoric (LH), and (3) Historic deposits. This will permit incorporation of landscape evolution and environmental filter concepts in archaeological survey design where their previous use has been hampered by the lack of a methodology for easily distinguishing and accu-
The exploration of shallow test pits results in the discovery of buried or surface archaeological deposits. These deposits are the result of the archaeological record being preserved by natural processes such as erosion, sedimentation, and burial. The present landscape is a result of these processes acting on the ancient landscape. Although both of these processes are part of the archaeological record, they are often used to identify the age and type of archaeological deposits. The following discussion outlines weathering zones and other morphologic criteria used to distinguish the various alluvial deposits, discusses factors contributing to the morphologic differences, and finally, provides an example of application of the model in an archaeological survey of the central Des Moines River Valley in Iowa.

WEATHERING ZONES IN ALLUVIUM

An easy to use, standardized weathering zone classification scheme for Quaternary deposits in the Upper Midwest has been presented by Hallberg et al. (1978). In this scheme weathering zones in Quaternary sediments are described and differentiated on the basis of interpreted oxidation states as inferred from color, mottling patterns, and matrix carbonate status. For the present analysis only the interpreted oxidation state (color) and mottling pattern of the deposit is used to differentiate weathering zones in alluvium, because the primary matrix carbonate content of alluvial deposits in the Midwest is variable and not necessarily indicative of degree of in situ weathering.

Oxidation of iron is a common weathering phenomenon in alluvial deposits (Carroll 1970). This occurs in an environment where the oxygen supply is high and/or the biological oxygen demand is low. In most cases oxidized sediments indicate that the local water table is or has been at a depth below the oxidized zone. Reduction (deoxidation) occurs in an environment where oxygen supply is limited or where the biological oxygen supply is high. Reduction takes place when either a temporary or permanent water table rise occurs and oxidized sediments enter into an environment of saturation or near-saturation where organic matter and micro-organisms are present. In this environment iron is reduced to a highly mobile ferrous form that may either migrate out of the sediments if there is sufficient ground water movement, migrate to crevices, or other voids in the sediment matrix and be oxidized, or remain in the matrix and react with sulfides in the reduced state (Cate 1964). Data presented by Bradbury et al. (1977) and Daniels et al. (1961) show that progressing from oxidized to deoxidized (reduced) weathering zones, the
relative amount of ferrous iron in the sediment increases. Deoxidized zones exhibit low total free iron and the iron, outside silicate mineral structures, is concentrated in secondary segregations of ferric oxides, such as mottles, tubules, and concretions.

The oxides of iron have distinctive optical properties and therefore there is a relationship between the chemical status and distribution of iron (oxidation state) and the matrix colors of sediments. Table 4-1 pre-

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>oxidized</td>
<td>60% of matrix has hues of 2.5Y or redder (e.g., 10YR, 7.5YR), values of 4 or higher, chroma of 3 or higher, and may have segregation of secondary iron compounds into mottles, tubules, or nodules.</td>
</tr>
<tr>
<td>R</td>
<td>reduced</td>
<td>60% of matrix has hues of 2.5Y or 5Y with values from 6 to 4 and chromas of 1 or 2; hues of N, 5GY, 5G, and 5BG with values of 4 or higher. Colors in this zone are usually mixed as weak mottles, diffuse blends of colors, or as discrete bands. This zone may contain considerable segregation of secondary iron compounds (with oxidized colors) into mottles, nodules, or sheets along bedding or joints.</td>
</tr>
<tr>
<td>U</td>
<td>unoxidized</td>
<td>matrix color is uniform; has hues of 5Y and N with values of 5 or less; 5GY, 5G, 5BG, 5G with values of 6 or less; with no segregation of iron compounds into mottles, nodules, etc. This zone often contains detrital organic matter.</td>
</tr>
<tr>
<td>J</td>
<td>jointed</td>
<td>indicates the presence of well-defined subvertical joints in the alluvium. Joint faces have oxidized and reduced colors, may have coatings of clay or secondary iron oxides, and occasionally other secondary minerals such as calcite.</td>
</tr>
<tr>
<td>M</td>
<td>mottled</td>
<td>refers to zones containing 20–50% contrasting mottles; when used with the unoxidized zone designation it indicates the presence of mottles of reduced colors occupying 20% or less of the matrix.</td>
</tr>
</tbody>
</table>

Table 4-1

Color and Mottling Pattern Criteria for Weathering Zones in Upper Midwestern Alluvial Deposits Used in Table 4.3.
Soil Morphologic Properties and Weathering Zone Characteristics

Sent the color and mottling pattern criteria used to classify a deposit as oxidized, reduced, or unoxidized in the present analysis. Standard soil horizon designations (Guthrie and Witty 1982; Bettis 1984) and descriptive terminology (Soil Survey Staff 1975) are used to describe properties within the solum.

THE MODEL

Associations of weathering zones (defined on the basis of matrix colors and mottling patterns), organic matter content and distribution, and the nature of soils developed in the alluvium permit the tripartite age grouping of alluvial deposits outlined below.

Early to Middle Holocene (EMH) Alluvium

EMH alluvium was deposited between about 10,500 and 4000 B.P. Where these deposits have not been eroded they often comprise the fill of a single or series of low terraces (Figure 4-1). EMH deposits also make up the bulk of most alluvial fans (Bettis et al. 1984; Bettis and Hoyer 1986; Hajic 1981; Styles 1985; Wiant et al. 1983). Texture of the fine-grained component of these deposits ranges from silt loam to loam. EMH deposits exhibit oxidized colors (Table 4-1) and have red, brown, or gray mottles. The lower portion of many EMH deposits is reduced and in this condition the deposit is light gray and exhibits secondary segregation of iron into brown or reddish brown mottles, tubules, or nodules. In Iowa

Figure 4-1. Idealized valley cross section showing spatial relationships among landforms and the alluvial fills described in the text.
EMH alluvial deposits are the Gunder Member of the DeForest Formation, while those comprising alluvial fans are the Corrington Member (Table 4-2; Bettis and Littke 1987).

Modern surface soils developed in EMH alluvium are Mollisols or Alfisols that usually have subsurface argillic (Bt) horizons. These soils exhibit moderate grade soil structure, brown or dark brown B horizons, few to common argillans, and are well horizonated. Figure 4-2 shows an
example of an Alfisol developed in EMH alluvium in eastern Iowa. Archaeological associations and numerous radiocarbon dates indicate that most surface soils on EMH deposits have been developing during the last 2000 to 4000 years (Bettis and Littke 1987; Benn and Bettis 1985; Bettis et al. 1984; Styles 1985).

Late Holocene (LH) Alluvium

LH alluvium was deposited after 3500 B.P. These deposits are usually found within the modern floodplain and can overlap older deposits. The texture of the fine-grained component of LH alluvium is usually loam, silty clay loam, or clay loam. LH deposits are darker colored than EMH deposits, primarily because they contain more organic carbon than the older deposits (Figure 4-3). Most LH alluvial deposits exhibit colors with 10YR hues, values less than 4 and chromas of 3 or less. In most cases prominent red or brown mottles are not present in LH alluvium. LH deposits are assigned to the Roberts Creek Member of the DeForest Formation in Iowa (Table 4-2; Bettis and Littke 1987).

Modern surface soils developed in LH deposits contrast sharply with those developed in EMH deposits. Soils developed in LH deposits are Mollisols or Inceptisols with cambic (Bw) horizons, or Entisols that lack subsurface B horizons. Soils developed in LH deposits usually do not have albic horizons. These soils tend to be dark colored throughout, exhibit weak to moderate grade soil structure, and have weak horizonation (Figure 4-3). These soils have been developing during the last 1500 to 1000 years (Benn and Bettis 1985; Bettis and Littke 1987; Brakenridge 1981; McDowell 1983; Van Nest and Bettis 1990).

Historic Alluvium

The youngest deposits in stream valleys are Historic or very late prehistoric in age. In most cases these deposits began accumulating after Euroamerican settlement. These deposits are characteristically lighter-colored than LH deposits, and where greater than about 50 cm in thickness, exhibit prominent stratification in their lower part (Figure 4-4). Often they contain Historic artifacts. Historic alluvium can be found throughout the valley landscape burying all older surfaces. It is thickest in and adjacent to the modern channel belt, at the base of steep slopes,
Figure 4-3. Exposure of Historic deposits overlying a dark-colored Mollisol developed in LH alluvium. The buried Mollisol at this location has a relatively thick Ab-Bwb profile. Note the stratification in the dark-colored LH alluvium beneath the buried soil. Light-colored deposit at the base of the exposure is EMH alluvium that is separated from the overlying LH alluvium by an angular unconformity.

### TABLE 4-2

**Correlation of Lithostratigraphic Units Used in Iowa with the Regional Age-morphologic Sequence Described in the Text**

<table>
<thead>
<tr>
<th>Age-morphologic group</th>
<th>Lithostratigraphic Unit</th>
<th>Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMH</td>
<td>Corrington and Gunder</td>
<td></td>
</tr>
<tr>
<td>LH</td>
<td>Roberts Creek</td>
<td></td>
</tr>
<tr>
<td>Historic</td>
<td>Camp Creek</td>
<td></td>
</tr>
</tbody>
</table>

126
Soil Morphologic Properties and Weathering Zone Characteristics

Figure 4-4. Historic alluvium with very thin, weakly expressed surface soil (Entisol) and bedding at shallow depth beneath the surface.

and along fence lines. In Iowa, Historic deposits are the Camp Creek Member of the DeForest Formation (Bettis and Littek 1987).

Surface soils developed in Historic deposits are Entisols and have A–C soil profiles. These soils have weak to moderate grade structure, weak horzonation, and are thin. Soils may be absent on rapidly aggrading surfaces.

A summary of important criteria for distinguishing the three age-morphologic groups of alluvial deposits outlined above is presented in Table 4-3.

DISCUSSION

An essential aspect of the field application of the model outlined above is to be able to distinguish soil horizons from geologic deposits. Most
Table 4-3
Outline of Criteria Used to Group Upper Midwestern Alluvial Deposits into the Age-morphologic Groups Outlined in the Text

<table>
<thead>
<tr>
<th>Age-Morphologic Group</th>
<th>Landforms(s)</th>
<th>Bedding</th>
<th>Weathering Zone*</th>
<th>Mottles</th>
<th>Surface Soil (horizon sequence; B horizon color)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMH</td>
<td>terraces</td>
<td>restricted to lower part of section</td>
<td>O; MO; R; or U in part of some sections</td>
<td>common; brown, reddish brown, and/or gray</td>
<td>A-E-Bt; A-Bt; brown B horizon</td>
</tr>
<tr>
<td></td>
<td>alluvial fans</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>colluvial slopes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>lowest terrace; floodplain</td>
<td>usually restricted to lower part of section</td>
<td>color usually 10YR hue, values 4 or less, chroma 3 or less; disseminated organic carbon imparts dark colors; may be oxidized or unoxidized but matrix colors are dark because of organic carbon content</td>
<td>rare—usually not present</td>
<td>A-Bw; dark-colored B horizon</td>
</tr>
<tr>
<td></td>
<td>floodplain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Historic</td>
<td>floodplain, fencelines, footslopes, bury older surfaces</td>
<td>present throughout section if &gt; 50 cm in thickness</td>
<td>O; MO; R; some sections dark colored because of high organic carbon content</td>
<td>can be present or absent; brown, reddish brown, or gray</td>
<td>A-C; no B horizon</td>
</tr>
</tbody>
</table>

*See Table 4-1 for explanation.
important is the distinction between dark-colored, organic-rich A horizons of soils, and dark-colored, organic-rich LH alluvial deposits. Several criteria are useful for making this distinction including: (1) a gradual or clear lower boundary of A horizons as opposed to an abrupt lower boundary in geologic deposits, (2) absence of bedding in A horizons and its presence in geologic deposits, and (3) the presence of granular, or crumb soil structure in A horizons and its absence or weaker development in geologic deposits.

Almost all of the dated localities used to develop this model are located in Iowa and southwestern Wisconsin. Visits to localities in eastern Nebraska and South Dakota, northeastern Kansas, Missouri, Illinois, Minnesota, and Indiana, however, suggest that the model is also applicable to those areas.

The regional extent of the sequence suggests that temporal variations of regionally occurring phenomena produced these morphologic differences in Holocene alluvial deposits and soils. Two important factors influencing depositional processes, weathering, and soil development that are known to have varied from the early and middle to the late Holocene are vegetation and climate. These two phenomena are linked, but during the entire Holocene vegetation varied across the area in which the morphologic sequence occurs (Webb et al. 1983). The differences between EMH, LH, and Historic deposits occur in areas dominated by prairie as well as those dominated by forest, and both Mollisols and Alfisols have developed on EMH deposits. This indicates that vegetation change alone cannot account for the differences among EMH and LH deposits and associated surface soils. Other climate-influenced phenomena may have played a larger role in the evolution of the sequence.

Knox (1976, 1983) has pointed out that the impact of climatic change on fluvial systems has both direct and indirect components. Direct components include changes in atmospheric circulation patterns, resultant changes in precipitation patterns, and their influence on the hydrology of the fluvial system. The principal indirect component, amount and type of vegetation cover, is seen as a major control on surface runoff, sediment yield, and sediment concentration.

Both direct and indirect impacts of climatic change have influenced the EMH-LH morphologic sequence. The major factors involved are rates of hillslope erosion and sediment delivery to valleys, and water table levels. These factors determined the nature of the original alluvial deposits, and influenced the diagenic and pedogenic processes that modified the deposits.
On a regional scale the highest rates of Holocene slope erosion and valley alluviation occurred prior to 3000 B.P. (Bettis and Hoyer 1986; Brakenridge 1981; Knox 1983; Vreeken 1984; Walker 1966). This phenomenon was a function of decreased vegetation cover combined with increased incidence of high-intensity thunderstorms. During this time surface soils were stripped from many valley slopes, the B and underlying C horizons were eroded, and the resultant oxidized sediment delivered to valleys. Alluviation was rapid with a few intervening periods of slower aggradation during which soils developed on exposed valley surfaces.

A drying trend occurred in the early to middle Holocene, culminating between 6500 and 5000 B.P. (Kim 1986; Van Zant 1979). This decrease in precipitation amount, coupled with rapid runoff during high-intensity storms, resulted in decreased infiltration and lowering of water tables. Lowered water tables promoted oxidation of alluvium and degradation of organic matter present in the alluvium.

After 4000 B.P. increased precipitation amount accompanied by greater infiltration resulting from a decrease in the frequency of high intensity storms fostered greater vegetative cover and expansion of forests (Kim 1986; Van Zant 1979). These climatic and biotic changes brought about lower rates of slope erosion and reduced sediment delivery to valleys. Sediment delivered to valleys during the late Holocene was derived primarily from reworking of older alluvial deposits and erosion of the upper, organic-rich horizons of soils, and may have been higher in organic carbon content than sediment delivered to valleys during the early and middle Holocene. Lower average sedimentation rates during the late Holocene allowed for incorporation of additional organic matter by vegetation growing on exposed surfaces and through the activity of other biota. Higher precipitation amounts and increased infiltration caused water tables to rise after 4000 B.P. Higher water tables inhibited oxidation of organic matter in the alluvium resulting in the dark colors, produced by finely disseminated organic carbon, that are characteristic of LH alluvium.

Most valley surfaces underlain by EMH deposits are, or at one time were, slightly to moderately elevated above the floodplain where LH deposits are found. These elevated surfaces have not been flooded as frequently during the last few millennia as the lower-lying surfaces underlain by LH deposits. This contrast in flooding frequency has produced many of the differences observed in surface soils developed in EMH versus LH deposits. Soils developed in LH deposits are overthickened or
cumulic as a result of deposition of overbank alluvium on the soil surface. Such upbuilding inhibits horizontation, fosters thick surface horizons, and limits the development of subsurface B horizons (Johnson 1985; Walker and Coventry 1976). Soils developed in EMH deposits, on the other hand, are flooded less frequently and pedogenesis has not been as interrupted by depositional processes. This has fostered greater horizontation and development of subsurface B horizons in soils developed in EMH deposits. Lowered water tables during the middle Holocene, as well as higher relative elevations of EMH surfaces during the late Holocene, promoted greater overall vertical movement of sediment-free water (precipitation) through the upper part of the EMH deposits. This also acted to produce greater horizontation and development of Bt horizons in soils developed in EMH deposits.

A final factor that could contribute to the differences in morphology of these soils is that they have been developing for different amounts of time. Although time in and of itself exerts no influence on soil development or weathering, the cumulative effect of weathering and pedological processes often differs on surfaces exposed for different amounts of time (Birkeland 1984; Walker and Coventry 1976; Holliday 1988). The EMH-LH morphologic sequence described above at first glance appears to be a generalized chronosequence of soils and weathering zones applicable to alluvial deposits in the Upper Midwest. I would argue, however, that some of the initial conditions of EMH alluvium, particularly the organic matter content, were different than those of LH alluvium and therefore the genetic pathways of soils on EMH alluvium may be quite different than those on LH deposits. Variability in time and space of other factors such as sedimentation history and water table levels have further complicated the genetic pathways of alluvial soils in the Midwest. Finally, soils developed on EMH deposits have formed under different climatic and vegetation conditions than those developed in LH deposits (Webb et al. 1983). The combined effect of these time-independent factors prevent this morphologic sequence from being a chronosequence. Rather, the differences in deposits and soils described in the previous pages result from the combined effect of differences in initial organic matter content, water table history, flood frequency and magnitude, and sedimentation rate. That differential time for pedogenesis has occurred is not debatable, but it cannot be isolated from other factors controlling soil development in this complex system.

Local deviations from the EMH-LH morphologic sequence can occur for several reasons. Dark-colored, organic-rich, unoxidized EMH
deposits occur where the water table was not lowered through the thickness of these deposits during the middle Holocene. These occurrences are restricted to the lower part of thick EMH sections and usually have detrital organic matter associated with them (Table 4-3). Oxidized LH deposits may occur in areas of very rapid sedimentation, or where the deposits were derived from oxidized sources, such as dune fields or older, highly oxidized alluvium. In the thick loess regions along the Mississippi and Missouri valleys, an oxidized alluvial fill was deposited between 3500 and 2000 B.P. in 3rd-order and smaller valleys (Bettis and Thompson 1982; Bettis et al. 1986; Daniels and Jordan 1966). This alluvium was derived from erosion of the thick, oxidized loess in the area, and accumulated very rapidly. It is overlain by dark-colored, younger LH deposits. The morphology of EMH and LH alluvium and associated surface soils in 4th-order and larger valleys draining the thick loess areas conforms to the regional pattern previously outlined. In order to avoid interpretation problems caused by these local variations it is essential to obtain radiometric dates on some deposits in a study area to confirm that the morphologic sequence corresponds to the regional age pattern outlined above.

APPLICATION OF THE MODEL TO AN ARCHAEOLOGICAL SURVEY

Knowledge of the distribution of the various-age deposits that comprise present valley landscapes is essential in order to adequately evaluate those landscapes for evidence of past human occupation. The EMH-LH morphologic sequence of alluvium and associated soils can be mapped throughout valleys and provides the baseline information necessary to devise reasoned approaches for assessing the cultural resource potential of an area. This approach was used in an archaeological survey of the central Des Moines River Valley in Iowa (Benn and Bettis 1985; Benn and Rogers 1985; Bettis and Benn 1984; Bettis and Hoyer 1986). A detailed geologic study of the valley was undertaken prior to an intensive archaeological survey and testing program. The geologic study included extensive subsurface drilling, digging of backhoe trenches, examination of cut banks, and radiocarbon dating.

Five major late Wisconsinan to Holocene landform-sediment assemblages (LSA) were recognized, and over 70 radiocarbon and thermoluminescence ages were obtained to provide a temporal framework.
is not lowered through the thick-Holocene. These occurrences are in EMH sections and usually have them (Table 4-3). Oxidized LH and the thick loess regions along the thick loess fill was deposited or smaller valleys (Bettis and Daniels and Jordan 1966). This allows the thick, oxidized loess in the area, overlain by dark-colored, younger and LH alluvium and associated valleys draining the thick loess areas previously outlined. In order to avoid the local variations it is essential to establish in a study area to confirm that deposits to the regional age pattern out-

APPENDIX TO AN

Various-age deposits that comprise order to adequately evaluate those deposits. The EMH-LH morphologic soils can be mapped on baseline information necessary to evaluating the cultural resource potential from an archaeological survey of the Des Moines Valley (Benn and Bettis 1985; Benn 1984; Bettis and Hoyer 1986). A survey was undertaken prior to an intensive excavation program. The geologic study included use of backhoe trenches, examination

Holocene landform-sediment associations, over 70 radiocarbon and thermoluminescence provide a temporal framework for the LSAs (Bettis and Hoyer 1986). Each LSA consists of a grouping of genetically and temporally related landforms and deposits comprising the landforms. The highest and oldest LSA consists of a series of late Wisconsinan terraces and benches. Four Holocene LSAs were recognized: a high terrace, alluvial fans and colluvial slopes, a low terrace complex and the modern floodplain. Deposits comprising the high terrace, alluvial fan and colluvial slope LSAs accumulated between 10,500 and 4000 B.P. and have characteristics of the EMH morphologic grouping (Table 4-4). Deposits of the low terrace complex LSA are inset into the high terrace, fan, and colluvial slope deposits. Deposits comprising the low terrace LSA accumulated between 4000 and about 750 B.P. and conform to the LH morphologic grouping. Deposits making up the floodplain LSA are younger than 750 B.P. and are inset into, as well as overlap, older deposits. These deposits are stratified throughout, oxidized, and have little or no pedogenic alteration. The floodplain LSA conforms to the Historic morphologic grouping.

Maps were constructed to show the distribution of the LSAs throughout the valley (Figures 4-5 and 4-6). These maps provide valuable information for locating archaeological deposits and for interpreting the pattern of known sites in the area. Table 4-5 presents an analysis of the geologic potential for the occurrence of buried cultural deposits in the various LSAs. EMH deposits (alluvial fan and high terrace LSA) have high potential for containing buried Paleoindian and Archaic components, but LH deposits (low terrace LSA) are too young to contain these cultural components. On the other hand, LH deposits are likely to contain buried Late Archaic and Woodland components. These components will be at or near the surface of EMH deposits. Historic deposits

<table>
<thead>
<tr>
<th>LSA</th>
<th>Age-morphologic group</th>
</tr>
</thead>
<tbody>
<tr>
<td>high terrace</td>
<td>EMH</td>
</tr>
<tr>
<td>alluvial fan/colluvial slope</td>
<td>EMH</td>
</tr>
<tr>
<td>low terrace complex</td>
<td>LH</td>
</tr>
<tr>
<td>floodplain</td>
<td>Historic</td>
</tr>
</tbody>
</table>

133
Figure 4-5. Map of the Boone Bottoms area in the central Des Moines Valley showing the distribution of EMH, LH, and Historic deposits. Wide diagonal pattern is EMH, narrow diagonal pattern is LH, and dot pattern is Historic. Note that large tracts of EMH deposits are present in this part of the valley. Many buried Archaic archaeological deposits are potentially present and late prehistoric sites are likely to be near the modern land surface.
Figure 4-6. Map of Hubby Bridge area in the central Des Moines Valley showing the distribution of EMH, LH, and Historic deposits. Wide diagonal pattern is EMH, narrow diagonal pattern is LH, and dot pattern is Historic. Note that, in contrast to the Boone Bottoms area, this reach of the valley is dominated by LH deposits. Most of the alluvium in this reach is too young to contain Archaic sites and many late prehistoric sites may be buried in this area.
TABLE 4-5

Preservation Potential for Buried Cultural Deposits in the Central Des Moines Valley
(Assuming All Modern Surfaces Cultivated)

<table>
<thead>
<tr>
<th>Cultural Period</th>
<th>EMH Alluvial Fans</th>
<th>EMH High Terrace</th>
<th>LH Low Terrace</th>
<th>Historic Floodplain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paleolindian</td>
<td>++</td>
<td>+ (late)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Early and Middle</td>
<td>+ +</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Archaic</td>
<td>+ +</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Late Archaic</td>
<td>+ +</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Woodland</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Oneota and Great Oasis</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Historic</td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

-, not possible; + - , low potential; +, moderate potential; ++ , high potential

Note: Comparison of this table with Figures 4-5 and 4-6 allows for evaluation of geologic impacts on the archaeological record. This table also indicates where subsurface methods are necessary for locating archaeological sites from the various culture periods.

(floodplain LSA) are too young to contain prehistoric cultural components. Together the maps and Table 4-5 provide the information necessary to devise a plan for sampling the valley landscape for archaeological deposits not detectable using traditional surface survey and shallow test pit site-locating techniques. This approach also allows one to concentrate traditional survey and testing efforts in potentially the most productive parts of the present valley landscape.

If enough subsurface information is available to make accurate estimates of average thicknesses of the various LSAs or EMH-LH-Historic alluvium morphologic groupings, then the next step in devising sampling strategies for buried archaeological deposits is possible; volume estimates of the LSAs or morphologic groupings. Once these estimates are made, the volumes of excavation necessary to sample the valley deposits at the desired level can be determined (see Table 4-4 in Bettis and Hoyer 1986).

Another issue of utmost importance that this approach to assessing the archaeological record brings to light is that the depositional record in valleys is incomplete. Channel activity reworks existing deposits and
## Soil Morphologic Properties and Weathering Zone Characteristics

<table>
<thead>
<tr>
<th></th>
<th>LH</th>
<th>Historic</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Terrace</td>
<td>Low Terrace</td>
<td>Floodplain</td>
</tr>
<tr>
<td>(late)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>-</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

- *, high potential; ++, high potential

Figure 4-5 and 4-6 allow for the evaluation of the subsurface potential, which indicates where subsurface cultural sites from the various culture periods.

### Conclusions

Associations of several morphologic properties of Upper Midwestern alluvial deposits and surface soils developed in the deposits are age-diagnostic. Well-horizonated surface soils with argillic horizons are developed in oxidized and mottled EMH deposits that accumulated before...
4000 B.P. These soils and deposits are found on and beneath terraces in
the region. LH alluvium is found beneath low terraces and floodplains in
the area and accumulated after 3500 B.P. LH deposits are dark colored and
have poorly horizonated surface soils that lack argillic horizons. Historic
deposits often bury older alluvium, are oxidized and stratified, and ex-
hibit slight pedogenic alteration.

Differences in the morphology of EMH and LH deposits and their
associated surface soils are attributed to various impacts that climatic
change has had on the fluvial system. The impacts include both direct
and indirect components that influence hydrology, sedimentation, di-
agenesis, and pedogenesis.

Knowledge of the distribution of EMH, LH, and Historic deposits
that comprise modern valley landscapes is essential for developing sam-
pling strategies that are aimed at locating the record of the human past in
valleys. An example from the central Des Moines Valley in Iowa shows
that apparent Late Archaic and Woodland settlement patterns derived
from traditional surface survey and shallow test pit sampling strategies
may be more reflective of geological processes subsequent to the occupa-
tions than of an actual settlement pattern. Knowing the distribution and
thickness of Historic deposits allows archaeologists to concentrate tradi-
tional sampling methods where they will be most effective for locating
prehistoric sites, and avoid wasted efforts such as extensive surface sur-
vey or digging shallow test pits in areas of thick Historic deposits.

Application of the model outlined in this paper to valleys prior to
archaeological surveys should result in survey strategies that are more
scientifically sound and economically efficient than those relying on tra-
ditional methods alone. This will benefit archaeologists, planners, and
anyone who uses the information derived from these undertakings.

REFERENCES

Anderson, J. D., and D. F. Overstreet
1986 The Archaeology of Coralville Lake, Iowa, vol. 2, Evolution of Holocene Land-
scapes. Great Lakes Archaeological Research Center, Inc., Wauwatosa.

Benn, D. W., and E. A. Bettis III
1985 Archaeology and Landscapes in Saylerville Lake, Iowa. Field Trip Guide, Associa-
tion of Iowa Archaeologists Summer Meeting.

Benn, D. W., and L. D. Rogers
1985 Interpretive Overview of Cultural Resources in Saylerville Lake, Iowa. Center for
Soil Morphologic Properties and Weathering Zone Characteristics

Bettis, E. A. III

Bettis, E. A. III, and D. W. Bemm

Bettis, E. A. III

Bettis, E. A. III, and B. E. Hoyer

Bettis, E. A. III, B. E. Hoyer, and E. R. Hajic

Bettis, E. A. III, and J. P. Littelke

Bettis, E. A. III, J. C. Prior, G. R. Hallberg, and R. L. Handy

Bettis, E. A. III, and D. M. Thompson


Birkeland, P. W.

Brakenridge, G. R.
1981 Late Quaternary Floodplain Sedimentation along the Ponne de Terre River, Southern Missouri. Quaternary Research 15:62-76.

Bradbury, K. M., M. J. Graham, and R. V. Ruhe
Carroll, D.

Cate, R. B., Jr.

Daniels, R. B., and R. H. Jordan

Daniels, R. B., G. H. Simonson, and R. L. Handy

Guthrie, R. L., and J. E. Witry

Hajic, E. R.

Hajic, E. R., and E. A. Bettis III

Hallberg, G. R., T. E. Fenton, and G. A. Miller

Holliday, V. T.

Johnson, W. C.

Kim, H. K.

142
Knox, J. C.


Knox, J. C., P. F. McDowell, and W. C. Johnson

McDowell, P. F.

Muller, J. W. (editor)

Muller

Styles, T. R.
1985 *Holocene and Late Pleistocene Geology of the Napoleon Hollow Site in the Lower Illinois Valley*. Kampsville Archaeological Center, Research Series vol. 5.

Thompson, D. M., and E. A. Bettis III

Van Nest, J., and E. A. Bettis III

Van Zant, K. L.

Vreken, W. J.

Walker, P. H.
1966 *Postglacial Environments in Relation to Landscape and Soils on the Cary Drift, Iowa*. Agriculture and Home Economics Experiment Station, Research Bulletin 549, Iowa State University, Ames.
Walker, P. H., and R. J. Coventry


Wiant, M. D., E. R. Hajic, and T. R. Styles