

Creation of a GIS-based model for buried cultural resources in Kansas

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Introduction

The goal of this project was to develop Geographic Information System (GIS) data layers that spatially delineate different landform-sediment assemblages (LSAs) and depict the associated geologic potential for buried cultural deposits in select counties of eastern Kansas. LSAs are landforms and underlying packages of sediment and associated soils with predictable age relationships. The impetus for considering LSAs in an archeological context is that the archeological record is a component of the sedimentary record; hence, physical processes that remove, modify, and bury sediments control the preservation and visibility of the record of the human past. Conceptualizing the landscape in this manner provides archeologists with a range of powerful tools for locating, evaluating, and interpreting cultural resources preserved in sediments that constitute the modern landscape (Mandel, 2006a). Thus, the developed GIS data layers will inform cultural resource specialists involved in project planning and development as to whether project areas are likely to be free of deeply buried cultural materials or whether subsurface exploration is necessary.

Determining the Potential for Buried Cultural Deposits

In evaluating the potential for buried cultural resources, it is important to consider geomorphic processes, particularly erosion, deposition, and soil development. These processes produce a complex mosaic of LSAs that are differentially but systematically preserved in the landscape, and therefore affect the distribution and detection of archeological materials. For example, LSAs representing areas of net sedimentation (e.g., stream terraces, colluvial footslopes, and alluvial fans) have thick packages of sediment that often span the Holocene. These LSAs typically are formed by pulses of sedimentation punctuated by periods of stability and soil development and, therefore, are more likely to contain buried cultural deposits. In contrast, LSAs such as floodplains and upland drainageways tend to have relatively thin packages of sediment and are relatively young, often post-dating Euro-American settlement in the Plains.

In this project, determining the geologic potential for buried cultural deposits involved consideration of four factors with respect to different LSAs: (1) the age of sedimentary deposits, (2) the soil stratigraphic record, (3) the depositional environment (high energy vs. low energy), and (4) the drainage conditions (poorly drained vs. well drained).

Buried cultural deposits are limited to LSAs that date to the Holocene and terminal Pleistocene. Although the time when people first arrived in mid-continental North America is uncertain, there is strong evidence of a human presence by as early as 13,500 years ago (Holliday and Mandel, 2006, 2017a). Hence, LSAs that were aggrading anytime during the past 13,500 years have potential for containing buried cultural deposits. On the other hand, LSAs that have been stable for the past 13,500 years are not likely to have *in situ* cultural materials in buried contexts. Instead, they may have cultural deposits representing Early Paleoindian through Historic period occupations on their surfaces.

The presence/absence of terminal Pleistocene and Holocene-age buried soils, especially buried A horizons, is an important factor in evaluating the potential for buried cultural deposits (Mandel, 2006a; Holliday et al., 2017). Buried soils represent previous land surfaces that were stable for a long enough period to develop recognizable soil profile characteristics (Mandel and Bettis, 2001). If one assumes that the probability of human use of a particular landscape position was equal for each year, it follows that the surfaces that remained exposed for the longest time would represent those with the highest probability for containing cultural materials (Hoyer, 1980). In stream valleys, buried soils dating to the Holocene and terminal Pleistocene represent those surfaces, and evidence for human occupation would most likely be associated with them.

However, prehistoric cultural deposits, even rich ones, also may be found in sediment that has not been modified by soil development (Hoyer, 1980). Hence the presence/absence of buried soils cannot be used as the sole criterion for evaluating the potentials for buried cultural materials. The mere presence of Holocene and terminal Pleistocene deposits beneath a geomorphic surface offers potential for buried cultural materials.

In the past, humans have been attracted to streams, often living on floodplains, terraces, or alluvial fans and exploiting the abundant resources available in alluvial settings. It is likely that prehistoric people were selective in choosing alluvial landforms for habitation, avoiding high-energy depositional environments, such as flood bars in zones of high-energy flooding and lateral accretion, but favoring relatively stable landforms that are elevated above the floodplain, such as terraces, alluvial fans, and colluvial aprons (e.g., Mandel and Bettis, 2001). Although alluvial landscapes are conducive to the initial accumulation of artifacts and their subsequent burial, fluvial processes may restructure the artifact patterns (Rapp and Hill, 2006: 75). For example, where sites are situated on or near the banks of stream channels, high-energy floods tend to modify cultural deposits dramatically by displacing artifacts vertically and horizontally. In some cases, stream erosion may completely remove artifacts, cultural features, and even entire sites, thereby destroying evidence of human occupation (Mandel et al., 2017). On the other hand, vertical accretion, which is a relatively low-energy process compared to lateral accretion, can result in rapid burial and preservation of cultural deposits in alluvial environments.

Drainage conditions also must be considered when assessing buried site potential. Today, wetlands, including marshes, shallow lakes, and wet basins and meadows, are common on the valley floors of streams and in dune fields, and they were present at various times over the past 13,000 years. Although people undoubtedly visited wetlands for hunting and gathering during that period, it is unlikely that they would have spent much time in such wet environments, and ephemeral camps rarely produce an abundant material record. By contrast, well-drained landforms, such as alluvial fans and colluvial aprons would have been attractive locations for long-term human occupations that tend to leave a rich archeological record (e.g., Almy, 1978; Mandel and Bettis, 2001; Saucier, 1966).

Soil survey data and archeological research

The implementation of systematic soil surveys and soil mapping by national soil survey programs was one of the primary goals in soil-related research through much of the 20th century (Brevink et al., 2016). In the United States, the Natural Resources Conservation Service (NRCS) currently is the primary agency involved in conducting soil surveys and disseminating soil data. The NRCS Web Soil Survey provides online access to a wealth of data on landscapes and geomorphology as well as soils. Engineers, farmers, property appraisers, and others often rely on these data because they either use soil as a material or study its role in the environment (Miller, 2012). Although some scientists have used soil survey data to devise strategies for locating cultural resources (e.g., Beeton and Mandel, 2011; Bettis and Benn, 1984; Mandel, 1992, 2006b; Monger, 1995; Stafford and Creasman, 2002), these data are generally underutilized in archeology, probably because of the agricultural and land-use focus of the surveys (Holliday and Mandel, 2017b). In this study, we use data from the NRCS Soil Survey Geographic database (SSURGO) to provide information on the spatial distribution of different LSAs and to determine the associated geologic potential for buried cultural resources. Based on this information, a GIS-based model was developed to identify the potential for buried archeological material in 25 counties located in eastern Kansas. The model is focused on stream valleys and assigns buried-site potential for alluvial and colluvial (i.e., footslopes) soils.

Methodology

Twenty-five counties in eastern Kansas were selected for this project. Counties include Anderson, Allen, Atchison, Bourbon, Brown, Cherokee, Coffey, Crawford, Doniphan, Douglas, Franklin, Jackson, Jefferson, Johnson, Labette, Leavenworth, Linn, Miami, Montgomery, Neosho, Osage, Shawnee, Wilson, Woodson, and Wyandotte,

GIS data files (ESRI geodatabases) were developed that spatially depict the potential for buried cultural resources. Determining the potential for buried cultural deposits involved consideration of four factors: (1) the age of sedimentary deposits, (2) the soil stratigraphic record, (3) the

depositional environment (high energy vs. low energy), and (4) the drainage conditions (poorly drained vs. well drained). Soil data from the Soil Survey Geographic database (SSURGO) were the primary dataset used to obtain information pertaining to the four factors. Additional descriptions from the NRCS Official Soil Series Descriptions (OSD) database (<https://soilseries.sc.egov.usda.gov/osdname.aspx>) also were used. The four factors were assessed as follows:

1. *Age of sedimentary deposits.* Ages were estimated based on the magnitude of soil development.
2. *Soil-stratigraphic record.* Soil descriptions from SSURGO and OSD databases and soil-stratigraphic information gleaned from field investigations were used to assess the potential for buried soils.
3. *Depositional environment.* Textural information (i.e., coarse grained vs. fine-grained deposits) was used to infer high energy vs. low energy depositional environments.
4. *Drainage conditions.* Soil series in the SSURGO database are associated with seven classes of soil drainage, ranging from excessively drained to very poorly drained. Supporting information on drainage is available via SSURGO and OSD soil horizon descriptions. For example, poorly drained soils typically have gleyed horizons (i.e., Bg horizons), and redoximorphic concentrations and depletions indicate shallow, fluctuating water tables.

The following specific procedures were used to assess potential:

1. Soil data from SSURGO were obtained via the NRCS Web Soil Survey (<http://websoilsurvey.sc.egov.usda.gov>) for each county. Exported data included spatial data in ESRI shapefile format, associated tabular data (as text files), and Microsoft Access databases (mdb files). Each shapefile contains discrete map unit polygons that are defined in terms of their soil characteristics.
2. For each county, SSURGO tabular data were linked to the Microsoft Access database and select tables exported to Microsoft Excel. The following tables were extracted in order to assess the four factors for determining buried potential as well as pertinent geomorphic information (e.g., the type of LSAs on which a given soil series occurs):
 - a. Soils
 - i. hzname – soil horizon name.
 - ii. hzdepth – distance from the top of the soil to the upper boundary of a given soil horizon.
 - b. Depositional Environment
 - i. pmkind –general composition of the soil parent material.

- ii. pmgroupname – parent material modifiers (i.e., texture), kind and origin. Where texture information was not given, data from the OSD was used to determine texture.
- c. Drainage
 - i. drainagecl – natural drainage conditions (7 classes) of the soil.
- d. Geomorphology
 - i. geomdesc – general geomorphic setting. May include multiple features and relationships.
 - ii. geomfrname – specific geomorphic features.
 - iii. ecoclassname – descriptive name of a particular ecological community. Useful for subdividing floodplain units.
 - iv. Localphase – criterion used locally to help identify a soil component.
 - v. FloodFCl – flooding frequency. Useful for delineating geomorphic features (e.g., floodplains from terraces).
 - vi. slope – average slope (in percent) of a given map unit.

Other pertinent tables extracted include:

- a. compname – name (i.e., soil series) assigned to map unit based on range of properties.
 - b. musym – map unit symbol. 4-digit string used to identify map unit name.
 - c. mukey – map unit key. Used to uniquely identify a record in the map unit table.
 - d. cokey – component key. Used to identify a record in the component table.
 - e. compcet – the percentage of the component of the map unit. Used to provide a degree of confidence in the assignment for buried potential.
- 3. Within Excel, map units were separated into two distinct feature classes based on parent material and landscape position/modification. The first feature class labelled “potential” consists of alluvial and colluvial map units. It includes a range of LSAs, such as terraces, floodplains, alluvial fans, and colluvial footslopes. The second feature class, labelled “other” consists of categories of map units associated with loess, till, and outwash parent materials. The “uplands” category includes map units associated with upland alluvium (typically paleoterraces), residual soils, and colluvium (not footslopes). The “modified” category includes soils modified by anthropogenic activity (e.g., urban soils, quarries, landfills, etc.), and finally, a “water” category includes features such as rivers, lakes, sewage ponds, etc.
- 4. Based on SSURGO data, a scoring system was developed for map units with soils developed in alluvium and colluvium (specifically on footslopes). Scores were assigned to each map unit based on the following factors:

Flood frequency/local phase

- frequent – 1
- occasional – 2
- rare/none – 3
- channeled – 0

Drainage

- Very poorly drained/excessively drained – 1
- Poorly drained – 2
- Somewhat poorly drained – 3
- Moderately well drained – 4
- Well drained – 5

Geomorphology/landscape position

- Floodplain (1-3)
 - Depressions, channels, drainageways, swales, flats, wetlands – 1
 - Clayey, sandy, overflow – 2
 - Loamy, silty – 3
- Floodplain step – 4
- Terrace/footslope – 5

Soil horizonation

- Thin A horizons ($A < 50\text{cm}$) – 1
- Gleyed horizons (Bg) – 2
- Overthickened A horizons ($A > 50\text{cm}$) and Bw horizons – 3
- Bk horizons – 4
- Bt horizons – 5

Parent material (texture)

- Sand – 1
- Clay – 2
- Silt/loam – 3

Scores for each factor were summed to provide a measure of potential for buried cultural resources: 0-9 low potential, 10-12 low-moderate potential, 13-15 moderate-high potential, 16+ high potential. Additional notes were provided where pertinent.

5. Scored excel sheets were imported into ArcMap to create geodatabases (composed of two feature classes: “potential” and “other”) for each county that spatially illustrate the potential for buried cultural resources.

GIS data layers created as part of this project are available through the Kansas Historical Society Archaeological Inventory website (<https://maps.kgs.ku.edu/kshs/>). To view the data layer, open the KSHS Map Viewer and navigate to the “Layers” tab in the menu. The GIS layer showing buried potential can be turned on or off from this menu. Note that the layers are only visible depending on the extent to which a user is zoomed in on the map.

Summary and Conclusions

The GIS data layers developed for this project spatially delineate different LSAs and depict the associated geologic potential for buried cultural deposits in 25 counties in eastern Kansas. This GIS resource will allow cultural resource specialists involved in project planning and development to assess whether project areas are likely to be free of deeply buried sites or whether subsurface exploration is necessary. Although this study specifically focuses on eastern Kansas, the results are applicable to many stream valleys in the state because of the similar lithostratigraphy and fluvial response to anthropogenic modifications of stream channels in the region.

One of the main strengths of the approach taken in this study is the ability to readily identify LSAs from SSURGO data. This information is valuable because geoarchaeological studies have shown that specific LSAs are more likely to contain buried soils and therefore buried cultural deposits than others.

One of the major limitations of SSURGO data, however, is that only the upper 1-2 m of soils and parent materials are considered. Buried soils in alluvial settings in Kansas often occur at greater depths and, therefore, key information pertaining the presence/absence of buried soils is missing. Information on types of deposits below ~2 m is important because of the nature of the alluvial stratigraphic record. For instance, unconformable stratigraphic relationships are often present in alluvial deposits and therefore the age of sediments at depth may be significantly greater than at the surface (Mandel, 2008).

A second major limitation is the spatial scale of the soil survey mapping. The prioritization of different landscape features and soil types is inherently different at different spatial scales (Hudson and Culver, 1994; Miller and Schaetzl, 2015). The SSURGO database contains information collected at scales ranging from 1:12,000 to 1:63,360. These scales permit a minimum size for delineating map units of 0.57 ha to 16.2 ha (Soil Survey Division Staff, 1993). Consequently, the scale of most map units as well as the variability inherent in those mapping units is greater than the scale of many archeological sites (Holliday and Mandel, 2017b). Also, the discrete borders of map units may not denote actual soil boundaries because soils do not have sharp contacts and typically grade from one type into another (Holliday and Mandel, 2017b). Finally, many mapping decisions are subjective because soil survey mappers are called upon to

make judgment calls based on whether a particular soil can be mapped consistently and whether it meets the objectives of the survey. For example, having too many map unit delineations may in some cases reduce the overall usefulness of a soil map. Therefore, the degree to which soil survey data accurately depicts soil-geomorphic relationships will vary depending on the training and experience of the soil mapper. Comparing soil maps across county and state boundaries can reveal the effects of this subjectivity (e.g., Sorenson et al., 1987). Also, although mappers attempt to map soil types consistently, the maps often suffer from a lack of rigorous testing to assess their accuracy (Brevink et al., 2016).

The limitations of the soil survey data provided above has hindered their use in archeological surveys. Nevertheless, the GIS data layers developed for this project provide a valuable first approximation of buried-site potential. Detailed field investigations are necessary to confirm and elaborate on those approximations and to establish more appropriate spatial and temporal scales. In the future, data from geoarchaeological localities in eastern Kansas should be used to verify the model. However, while previous investigations are an invaluable resource, the spatial distribution of the research localities is limited; hence more field research within the watersheds and broader region would greatly improve the predictive power of the model developed in this study.

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