

Geoarchaeology of the Clary Ranch Paleoindian Sites, Western Nebraska

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Introduction

This field trip addresses multidisciplinary field research in Ash Hollow basin at both archaeological sites and cut bank exposures that has been conducted since 2001 (Fig. 1). Matthew G. Hill has been instrumental in leading a team of specialists in re-examining the Clary Ranch site and in working at the newly-discovered O.V. Clary site. He secured funding from both the National Science Foundation and National Geographic Society for this research.

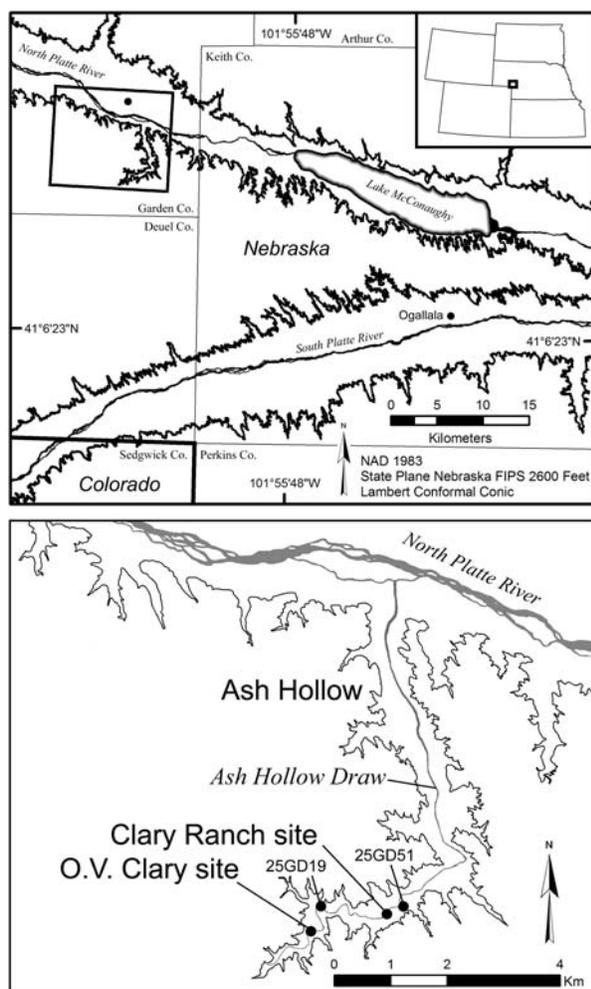


Figure 1. Location of the Clary Ranch sites along Ash Hollow Draw.

Early Holocene Alluvial Stratigraphy of Ash Hollow

Six Early Holocene alluvial depositional units (lithologic units) are recognized in Ash Hollow Valley, designated from oldest (I) to youngest (VI). Color, texture, and sedimentary structures are the most definitive properties of the units and are used to recognize them in different portions of the basin. Unit I was only recognized at cut bank 25. It is well-sorted, massive, coarse sand with fine and medium carbonate concretions and is older than $10,232 \pm 62$ yr B.P. (12,080-11,820 cal yr B.P.; AA62530) (Table 1).

Unit II is generally massive, but is horizontally laminated in Profile 1 in cut bank 21 (west cut bank), indicating that sedimentation rates varied. The generally darker colors and higher organic-carbon contents of the upper part of this unit (Brady Soil) also attest to slower deposition. The basal age of this deposit in cut bank 25 indicates that initial deposition began at the Late Wisconsin-Holocene boundary ($10,232 \pm 62$ yr B.P. [12,080-11,820 cal yr B.P.; AA62530]). Unit II is as young as $9,361 \pm 59$ (10,660-10,510 cal yr B.P.; AA62529) in cut bank 21 (west cut bank).

The Brady Soil that developed at the surface of unit II is the only soil recognized in the Early Holocene alluvium in Ash Hollow. It is significant that the Ash Hollow fluvial system was stable even for a few hundred years ($<9,865 \pm 60$ yr B.P. (11,400-11,240 cal yr B.P.; AA62540) to $9,361 \pm 59$ yr B.P. (10,660-10,510 cal yr B.P.; AA62529) in an environment where more than 16m of alluvium accumulated in less than 6,000 years.

The Brady Soil is recognized over a large area of the uplands across the central Great Plains and serves as a stratigraphic marker for the surface of Late-Pleistocene Peoria Loess; Holocene Bignell Loess buries the Brady Soil in upland settings (Johnson and Willey, 2000; Martin, 1993). In Dankworth Canyon just to the southeast of Ash Hollow Johnson and Willey (2000) have reported ages of $10,780 \pm 110$ yr B.P. (12,880-12,716 cal yr B.P.; ISGS-4099) for the lower Brady Soil and $8,520 \pm 70$ yr B.P. (9,545-9,471 cal yr B.P.; ISGS-4106) for the upper Brady Soil. May and Holen (2003) report an even longer period of pedogenesis for the Brady Soil at an upland location on the south side of the South Platte River downstream from the confluence of the North and South Platte Rivers. Here the Brady formed between

Table I. Summary information on all radiocarbon ages in the Ash Hollow Basin.

Project	Lab No.	Provenience	Unit	Mat.	$\delta^{13}\text{C}$	F	^{14}C age BP	68.2% prob	95.4% prob
CR	AA62529	Cut Bank 21 (West Cut Bank), Profile I	II	C	-24.8	0.3118±0.0023	9,361 ± 59	10,660-10,510	10,740-10,410
CR	AA62530	Cut Bank 25 (East Cut Bank)	II	C	-24.6	0.2798±0.0021	10,232 ± 62	12,080-11,820	12,340-11,650
CR	AA62531	Cut Bank 21 (West Cut Bank), Profile I	II	C	-23.8	0.3191±0.0024	9,177 ± 59	10,400-10,250	10,500-10,230
CR	AA62532	Ash Hollow State Park	V	C	-25.1	0.3270±0.0055	8,980 ± 140	10,260-9,820	10,490-9,630
CR	AA62533	Backhoe Trench, Profile A	II	C	-26.0	0.2910±0.0022	9,917 ± 60	11,400-11,240	11,610-11,210
CR	AA62534	Ash Hollow State Park	V	C	-27.3	0.3231±0.0023	9,077 ± 57	10,270-10,190	10,410-10,160
CR	AA62535	Cut Bank 21 (West Cut Bank), Profile I	IV	C	-25.1	0.3154±0.0035	9,268 ± 90	10,570-10,300	10,670-10,240
CR	AA62536	Cut Bank 25 (East Cut Bank)	VI	C	-24.7	0.3371±0.0023	8,734 ± 56	9,880-9,560	9,910-9,550
CR	AA62537	Cut Bank 25 (East Cut Bank)	V	C	-24.1	0.3206±0.0023	9,137 ± 56	10,380-10,230	10,490-10,210
CR	AA62538	Cut Bank 25 (East Cut Bank)	V	C	-25.2	0.3208±0.0023	9,132 ± 57	10,380-10,230	10,490-10,200
CR	AA62539	Backhoe Trench, Profile B	II	C	-25.3	0.2890±0.0030	9,971 ± 82	11,600-11,270	11,800-11,220
CR	AA62540	Backhoe Trench, Profile B	II	C	-25.1	0.2929±0.0022	9,865 ± 60	11,320-11,210	11,600-11,180
CR	AA62541	Cut Bank 25 (East Cut Bank)	IV	C	-25.3	0.3059±0.0022	9,514 ± 58	11,070-10,700	11,090-10,600
CR	AA62543	Cut Bank 21 (West Cut Bank), Profile I	IV	C	-24.4	0.2948±0.0026	9,811 ± 71	11,290-11,170	11,590-10,890
CR	AA62544	Backhoe Trench, Profile B	V	C	-25.5	0.3223±0.0046	9,100 ± 120	10,490-10,170	10,580-9,910
CR	AA62545	Cut Bank 21 (West Cut Bank), Profile I	V	C	-26.4	0.3199±0.0028	9,157 ± 71	10,400-10,240	10,510-10,210
CR	AA62546	Backhoe Trench, Profile C	V	C	-24.3	0.4650±0.0049	6,151 ± 84	7,160-5,940	7,260-6,800
CR	AA62548	Cut Bank 21 (West Cut Bank), Profile I	V	C	-24.5	0.3206±0.0022	9,138 ± 56	10,380-10,230	10,490-10,210
CR	AA64302	Backhoe Trench	II	C	-26.4	0.2920±0.0020	9,890 ± 56	11,390-11,230	11,600-11,200
CR	AA64303	Backhoe Trench	II	C	-23.6	0.3087±0.0021	9,441 ± 55	10,740-10,590	11,070-10,520
CR	AA64354	Cut Bank 21 (West Cut Bank), Profile I	VI	C	-25.6	0.3365±0.0002	8,749 ± 58	9,890-9,630	10,120-9,550
CR	AA68412	Area A, West; excavations	V	C	-24.9	0.4060±0.0110	7,240 ± 220	8,320-7,870	8,510-7,660
CR	AA68413	Area A, West; excavations	V	C	-24.3	0.3793±0.0030	7,787 ± 63	8,630-8,460	8,750-8,420
CR	AA70974	Area A, West; excavations	IV	C	-24.6	0.3190±0.0020	9,170 ± 49	10,390-10,250	10,490-10,230
CR	AA70975	Area A, West; excavations	V	C	-24.5	0.4220±0.0043	6,927 ± 82	7,840-7,680	7,930-7,620
CR	pending	Area A, West; excavations	V	B					
CR	pending	Area A, West; excavations	V	B					
CR	CAMS-105849	Area A, East; excavations	V	B	-11.4	0.3245±0.0014	9,040 ± 35	10,230-10,200	10,250-10,180
OVC	AA61189	Cut bank	V	C	-9.8	0.3185±0.0018	9,191 ± 45	10,400-10,260	10,490-10,240
OVC	AA65421	Profile 4	V	C	-24.5	0.3231±0.0025	9,076 ± 62	10,280-10,180	10,480-9,970
OVC	AA65422	Cut bank	V	C	-23.3	0.3244±0.0021	9,043 ± 52	10,240-10,190	10,370-9,940
OVC	AA65423	Profile 4	V	C	-24.7	0.3653±0.0028	8,090 ± 63	9,130-8,800	9,260-8,770
OVC	AA65425	Hearth 1	V	C	-24.0	0.3264±0.0022	8,993 ± 54	10,240-9,960	10,246-9,920
OVC	AA65426	Profile 3	IV	C	-24.3	0.3199±0.0022	9,155 ± 55	10,390-10,240	10,490-10,230
OVC	AA70723	Profile 3	V	C	-21.4	0.328±0.0021	8,953 ± 51	10,200-9,940	10,230-9910
OVC	AA70724	Backhoe trench	V	C	-24.6	0.558±0.0027	4,673 ± 38	5,470-5,300	5,580-5,310
OVC	AA70725	Backhoe trench	V	C	-11.7	0.355±0.0021	8,305 ± 46	9,420-9,270	9,440-9,140
OVC	AA70726	Backhoe trench	V	C	-25.1	0.318±0.0019	9,188 ± 48	10,400-10,260	10,500-10,240
OVC	AA70727	Cut bank	V	C	-24.6	0.315±0.0081	9,260 ± 210	10,750-10,200	11,160-9,920

Note: CR = Clary Ranch site; OVC = O.V. Clary site; Mat. (Material), C = charcoal, B = bison bone.

10,360 ± 100 radiocarbon yr B.P. (12,610-11,845 cal yr B.P.; Beta-144070) and 6,090 ± 120 yr B.P. (7,157-6,800 cal yr B.P.; Beta-144071).

Unit III is comprised of silt, sand, and abundant gravel. It is a channel deposit, and thus is aerially limited in distribution. It has only been recognized in the Clary Ranch site backhoe trench, in the lower portion of the

Ash Hollow State Park cut bank, and possibly in an auger hole at the O.V. Clary site. We have no radiocarbon ages for these coarse-grained channel deposits.

Unit IV is comprised of silt and very fine sand that is horizontally laminated to massive. Unit IV was deposited across all landforms that existed in the valley about 9400-9200 radiocarbon yr B.P. It is often horizontally laminated at the base and massive in the upper part as is common in rapidly-accumulating post-settlement alluvium (Knox, 1987). Radiocarbon ages from three localities in the valley indicate deposition of units III and IV occurred after $9,514 \pm 58$ yr B.P. (11,070-10,700 cal yr B.P.; AA62541) and by $9,170 \pm 49$ yr B.P. (10,390-10,250 cal yr B.P.; AA70974).

Unit V is ripple- and horizontally-laminated coarse silt (silt loam) with common mottling. The thickest exposed deposits of this unit are found in cut bank 25, Profile 1 in cut bank 21 (west cut bank), and the Ash Hollow State Park cut bank. This unit accumulated faster than other Early Holocene deposits in Ash Hollow Valley. Sixteen radiocarbon ages for unit V cluster between $9,260 \pm 210$ yr B.P. (10,750-10,200 cal yr B.P.; AA70727) and $8,953 \pm 51$ yr B.P. (10,200-9,940 cal yr B.P.; AA70723) (Table 1). The minimum sedimentation rate for unit V was 0.53 cm/yr, while the maximum rate was 0.85cm/yr, based on elevations and calibrated ages of radiocarbon-dated charcoal samples from within single profiles. These values are of the same order of magnitude as rates of historical, post-settlement sedimentation in valleys across the Midwestern United States (Baker et al. 1993; Knox 1987). Unit V is the unit in which the Late Paleoindian cultural components are found at both the Clary Ranch site (25GD106) and O.V. Clary site (25GD50). Multiple components at both of these sites occur within the lower one meter of this unit. The stratigraphy at these two sites will be discussed later.

Unit VI is coarser than unit V. Only two radiocarbon ages have been determined for unit VI from two localities; thus, it is not possible to calculate a sedimentation rate for unit VI. Ages determined for the lower part of this unit are $8,749 \pm 58$ yr B.P. (9,890-9,630 cal yr B.P.; AA64354) at cut bank 21 (Profile 1) and $8,734 \pm 56$ yr B.P. (9,880-9,560 cal yr B.P.; AA62536) at cut bank 25 (east cut bank).

Stop I: Cut Bank 25 (East Cut Bank)

Cut bank 25 exposes a cross section of Early-Holocene alluvial-fan deposits derived from a short, steep tributary, as well as deposits from Ash Hollow Draw. Here we recognize five lithostratigraphic units (I, II, IV, V, VI) (Fig. 2). Unit I is massive, pale brown (10YR 6/3, moist) well-sorted, coarse sand, loose to very friable (weakly cemented by carbonates), and with common, fine and medium carbonate concretions. It is older than a sample of charcoal collected at the lower boundary of overlying Unit II (elevation of 1052.131 m) that yielded a radiocarbon age of $10,232 \pm 62$ yr B.P. (12,080-11,820 cal yr B.P.; AA62530). It is likely a Late Wisconsin deposit.

Unit II is locally derived from the short tributary to the south. It is massive, brown (10YR 5/3, moist) silt loam with 10% fine and medium, subangular structure, carbonate gravel, common, medium, distinct, dark yellowish brown (10YR 4/6, moist) mottles, very friable, and with many, fine carbonate concretions. The Brady Soil is developed in the surface of this alluvial-fan deposit.

Unit IV is locally derived from the tributary, but there may have been some contribution of alluvium as well from flooding along Ash Hollow. Locally unit IV is horizontally-laminated, dark grayish brown (10YR 4/2, moist) silt loam with 5-8% fine and medium subangular carbonate gravel, with common, medium, prominent yellowish brown (10YR 5/8, moist) mottles, firm, and with common, fine, carbonate concretions. The radiocarbon age of $9,514 \pm 58$ yr B.P. (11,070-10,700 cal yr B.P.; AA62541) from the very basal, laminated clay drapes in unit IV should be considered a minimum age for the surface of the Brady Soil locally, as this is re-deposited material from upslope on the fan.

Unit V is horizontally-laminated silt loam with up to 5% fine and medium carbonate gravel on the alluvial fan, but becomes ripple- and horizontally-laminated silt loam and loamy fine sand with thinner laminae of silty clay loam and about 1% fine and medium carbonate gravels where it was deposited by Ash Hollow Draw at the toe of the fan. Colors range from dark brown (10YR 4/3, moist) at the base of the unit to very dark grayish brown (10YR 3/2, moist) in the upper portion of the channel deposits. Common, fine and medium, distinct,

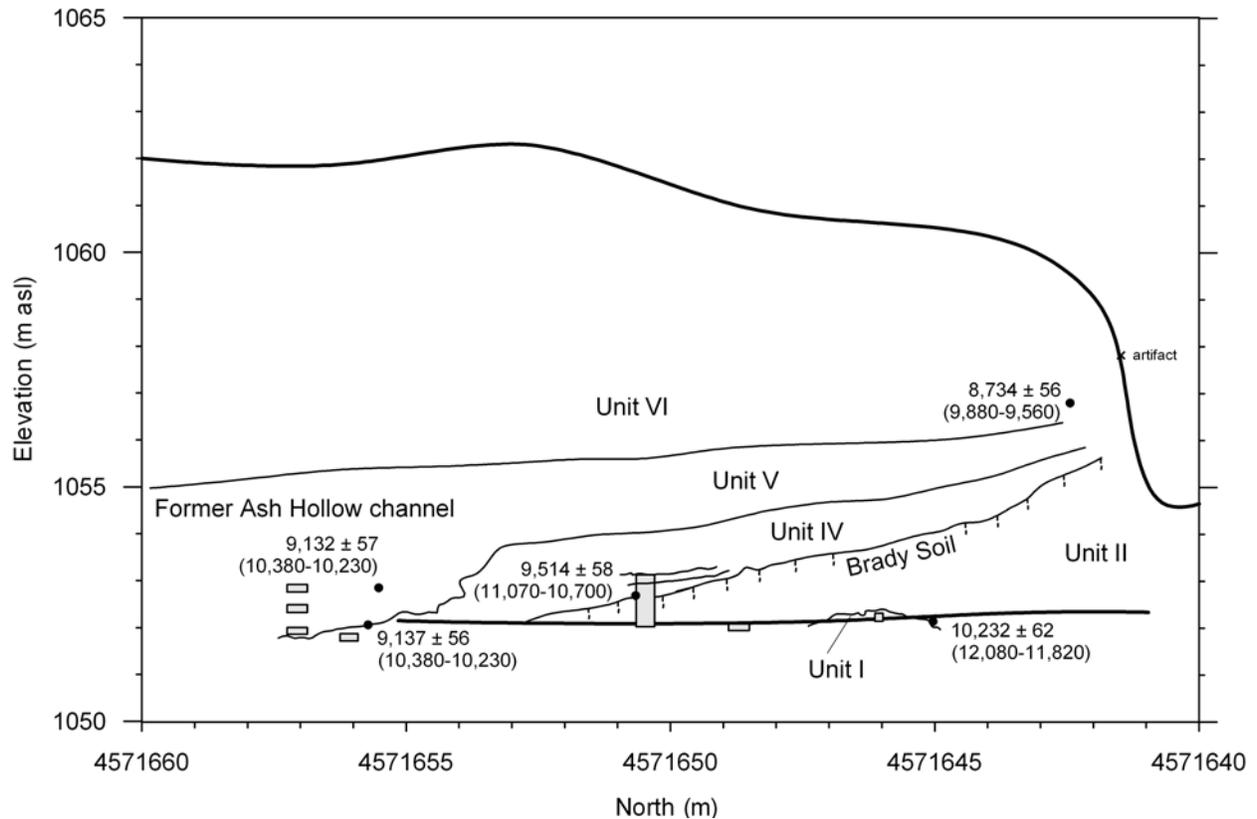


Figure 2. Profile of cut bank 25 (east cut bank) showing the location of profiles and samples from the units. Note: the artifact in Unit VI is an unmodified chipped stone flake.

yellowish brown (10YR 5/6, moist) mottles are common in the lower portions of the channel deposits. Soft sediment deformation is also common at the base of this deposit at the margin of the channel deposits. Fine and medium carbonate concretions are present throughout. Charcoal is present on the surface of many of the finer-grained laminae that comprise flood couplets in this unit.

Charcoal from the base of unit V (elevation of 1052.055 m) in cut bank 25 (east cut bank) yielded a radiocarbon age of $9,137 \pm 56$ yr B.P. (10,380-10,230 cal yr B.P.; AA62537), while a charcoal sample from within the lower part of unit V (elevation of 1052.847 m) yielded a radiocarbon age of $9,132 \pm 57$ yr B.P. (10,380-10,230 cal yr B.P.; AA62538). Unit V accumulated very rapidly in the Ash Hollow channel exposed in cut bank 25.

Unit VI overlies unit V, but was not described. However, a burned root or piece of wood from the base of this unit exposed high on the alluvial fan (elevation of 1056.790 m) yielded a radiocarbon age of $8,734 \pm 56$ yr

B.P. (9,880-9,560 cal yr B.P.; AA62536). This age confirms that unit V accumulated very rapidly (in less than 820 calibrated years).

May described a short profile from just above the channel floor to just above the surface of the Brady Soil (through unit II, the Brady Soil, and basal unit IV) at one of the lowest paleotopographic positions of the Brady Soil (Fig. 2; Appendix A). Here the Brady Soil is dipping both to the north (down-fan) and west (out of the cut bank), and the surface of the paleosol has been eroded. In the overlying basal deposits of unit IV there is a dark, organic-rich lamination that appears to have been derived from erosion of the Brady Soil higher on the alluvial fan.

Stop 2: Clary Ranch Site (25GD106)

Introduction

The Clary Ranch site was reported to the University of Nebraska State Museum in 1970 by rancher Oren V. Clary, who observed artifacts, charcoal, and bison remains eroding from a deeply buried stratum exposed near the base of a high (~15 m), north-facing cut bank of the draw (Fig. 3). In 1979 archaeologist Thomas P. Myers, assisted by vertebrate paleontologists R. George Corner and Lloyd G. Tanner, coordinated the first of four consecutive month-long summer field seasons at the site (Figs. 4 and 5). Volunteer members of the Nebraska Archaeological Society comprised the majority of each season's field crew. Although a preliminary report on the first season of excavations was published, a comprehensive final report never materialized. Myers and Lambert (1983) did, however, use the projectile points in a short but insightful paper on the Dalton Complex on the central Plains, but for all effective purposes, the lithic and faunal assemblage were never analyzed. In fact, only several Paleoindian scholars knew about the work at the site, much less the massive amount of material the museum recovered there. As it happens, this situation began to change course in early 1997 when one of us (Hill) visited the UNSM and discovered the great potential the collections had for contributing new knowledge on Late Paleoindian adaptations. The large bison assemblage was ultimately incorporated into a comprehensive examination of Paleoindian diet and subsistence behavior in the region (Hill 2001). More recently, Holven (2006) conducted a GIS analysis of the site structure. What follows is a synopsis of the UNSM excavations, as gleaned from the field notes, as well as brief discussion of Paleoindian activities at the site, as inferred from assemblage-level analyses of the bison and lithic assemblages.

Summary of 1979-1982 UNSM excavations

The initial excavations in 1979 were located at the center of the site, as then figured, and radiated outward. On the average, 50 1-x-1 m units were excavated each summer, and by the end of the 1982 field season, 182 m² had been excavated at Area A, the main excavation block, and 12 m² at Area B, 8 m west of the main block



Figure 3. Overview of the Clary Ranch site looking downstream (~east). The excavation cover is positioned over the 2004 excavations.



Figure 4. University of Nebraska State Museum excavations in progress. View looking ~north.



Figure 5. Oren V. Clary (center), Lloyd G. Tanner (standing), and Dennis Shimkin (squatting) at the Clary Ranch site (probably 1981 or 1982). Tanner was a geologist/paleontologist at the UNSM, while Shimkin was the superintendent of Ash Hollow State Park.

(Fig. 6). The overall layout of the excavated area is long and narrow, paralleling the draw. The excavation protocol called for only larger faunal remains, articulated units, and formal artifacts to be identified and illustrated on 1-x-1 m unit plan maps by level. Small elements not included in articulated units were usually mapped as well, but often not labeled to element. Small bone fragments and microdebitage were not routinely mapped, but were collected by unit and level as encountered, or in 1/8" mesh dry-screens. Thus each faunal specimen and lithic item recovered has (minimally), 1-x-1 m excavation unit provenience. Horizontal provenience information for many of the larger faunal specimens, articulated units, and formal artifacts has been established to the nearest centimeter from the plan maps. In some excavation units, vertical control was maintained within natural stratigraphic levels, but as discussed below, this is not only a complicated issue, but also an important one.

Myers' field notes indicate the archaeological material was recovered from two natural stratigraphic units, referred to variously as the 'buff silt level' or the 'upper bonebed' and the 'black carbonaceous zone' or 'lower bonebed.' Fig. 7 is a photograph taken at the close of the 2004 excavation of the so-called black carbonaceous zone at the west end of the excavated area. In 1979 and 1980, archaeological material was recovered only from the buff silt, the base of which is gray silty clay; the excavations did not extend below this sediment package. The 1980 excavations are also noteworthy in that several units were excavated into the black carbonaceous zone, the origin of which was suspected as representing the decay of large amounts of organic material in a depression or swale. Descriptions of these units include, "The flakes in this square come predominantly from a 'swirl' area which is slightly darker-colored than the succeeding buff silt and contains many small pieces of charcoal and a lot of bone flakes" (Myers, 1979-82:38). Another important observation made in this unit is that "...large bones on top of the pile—no large ones found deep w/in the pile" (Myers, 1979-82:38). These descriptions mark the first mention of the presence of two bonebeds at the site. Unfortunately, only 26 of 59 1-x-1 m units excavated in 1980 extended into the black carbonaceous zone.

By 1981 it was obvious that one bonebed was associated with the black carbonaceous zone and one bonebed occurred in the buff silt level. From this point forward,

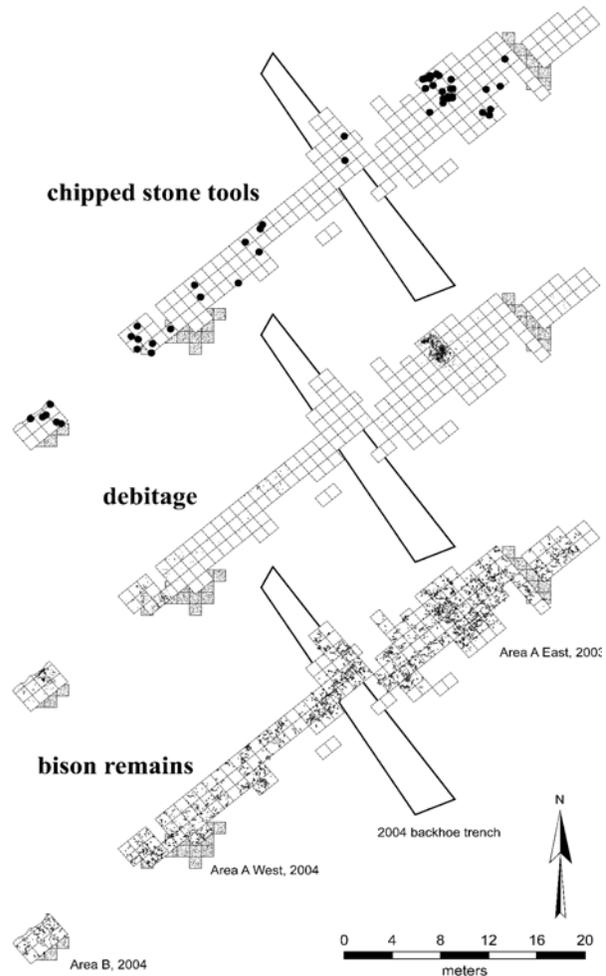


Figure 6. Composite plan maps of various classes of archaeological material recovered by the University of Nebraska State Museum, in relation to recent excavations by Iowa State University, including the backhoe trench.

the bison remains and artifacts from each component were differentiated; however, sorting out the extant material each level has proven to be exceptionally difficult. Although unit plan maps for both levels were often made, the excavated material was often bagged together; in other words, the material from each level was collapsed into a single unit. That said, some plan maps are sufficiently detailed to identify and assign specimens to level, mostly larger faunal remains (e.g., long bone articular ends) and formal artifacts (e.g., projectile points).



Figure 7. Photograph of the 'black carbonaceous zone' or organic mat (arrow) at the close of the 2004 excavations. View looking ~southwest.

Bison Assemblage

The four seasons of excavations by the UNSM resulted in the recovery of a large faunal assemblage, consisting almost exclusively of the fragmentary, scattered, and disarticulated remains of at least 41 bison distributed relatively evenly across the excavated area (Fig. 6). Eruption-wear analysis of the dentitions indicates the animals died in a single mass kill/butchery event occurring in the late summer to early fall, roughly 4-6 months after the peak calving period in late April/early May. With the exception of small compact elements such as carpals, tarsals, and phalanges, most identified remains are fragmentary specimens. Unbroken long bones are few in number, and 247 indeterminate long bone shaft fragments account for a majority of the 300 specimens not identified to element. Cortical surface preservation on most specimens is excellent. Numerous cut marks and other butchery damages are visible.

Two characteristics of the bison assemblage are especially informative with regard to Late Paleoindian subsistence activities at the site. First, the predominance of appendicular elements; and second, the presence of a remarkable record of cortical damage linked directly to carcass exploitation. Overall, the assemblage represents the most intensively, as well as the most extensively processed sample of bison remains from this general time period on the Great Plains. Complete or near-complete limbs removed from carcasses at a nearby mass kill site were transported here; the long bones were dis-

jointed, breached for marrow extraction, and then discarded (Fig. 8). Drying of meat stripped from postcranial axial elements, scapulae, and proximal long bones is strongly suspected as well. In summary, the overabundance of long bones combined with the underrepresentation of meaty postcranial axial elements at the Clary Ranch site supports the interpretation of differential transport by Paleoindians. The former were hauled to the excavated area for marrow extraction, while the latter were taken elsewhere for drying. It is inferred

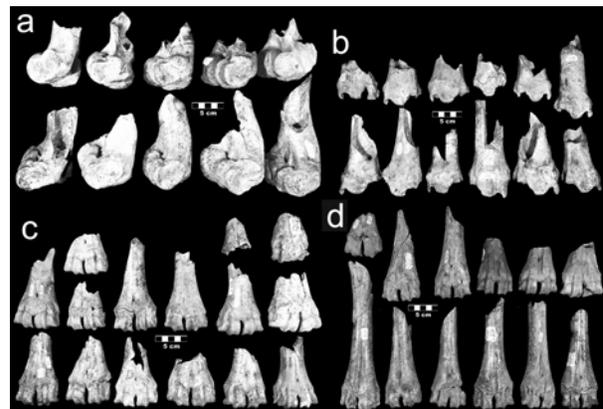


Figure 8. The record of marrow processing at the Clary Ranch site is unmatched for this general time period on the Great Plains. Shown here is a sample of long bones that were breached for marrow: a) distal humeri; b) distal tibiae; c) distal metacarpals; and d) distal metatarsals. In all, 145 of 160 (90%) of the bison long bones were fractured from marrow extraction.

that these subsistence activities were stimulated by anticipated food-resource shortages.

Lithic Assemblage

The lithic assemblage associated with the bison remains includes 35 scrapers, 23 splintered pieces (i.e., wedges), 11 retouched and utilized flakes, 8 projectile point/knives, 5 bifaces, 5 graters, and some ten thousand pieces of microdebitage. Ten hammer/anvil stones are also present. The distribution of the chipped stone specimens is illustrated in Figure 6. Most of the chipped stone artifacts are made from Smoky Hill silicified chalk, which is also commonly referred to as Republican River jasper, Niobrara jasper, and Smoky Hill jasper, among other names. This rock is found well to the south and east of the site in outcrops along tributaries of the Kansas River in north-central Kansas and extreme south-central Nebraska (Stein, 2005). Holen (2001, p. 92) reports that a new source location was recently discovered in the Loup River valley of east-central Nebraska. In addition to a handful of specimens made from quartzite river cobbles and permineralized (“fossil”) wood, both of which are available locally, several artifacts are made from Hartville Uplift chert and White River group silicates. Of special significance here is the fact that the former outcrops in the Hartville Uplift of southeast Wyoming (Miller, 1991), while the latter outcrops in several locations (Hoard et al., 1993; Koch and

Miller, 1996), the best known of which is Flattop Butte in northeastern Colorado. Other reported sources of this toolstone are Table Mountain in extreme eastern Wyoming and in the White River Badlands of southwestern South Dakota. The presence of Hartville Uplift chert leads us to infer that the White River group silicates specimens from the Clary Ranch site are derived from Table Mountain, located along the North Platte River, some 200 km upstream from the site (Fig. 9).

Summary of 2001-2004 Investigations

Over the course of three summer field seasons between 2001 and 2004, a total of 85 field days were spent at the site. The first two seasons (15 days total) were reconnaissance-type investigations involving topographic mapping, re-exposing old excavation areas, identifying areas of intact sediment, geoarchaeological profiling, paleoenvironmental sampling, and assessing the potential of the site for renewed multidisciplinary investigations (Hill et al., 2002). Based on the positive results of this work, an Iowa State University archaeological field school was held at the site in 2003 to enhance the analytical power of the extant data sets (Hill et al., 2003). The primary objective of the 2003 field campaign was to assess how UNSM recovery methods shaped the character of the extant lithic collection; specifically, if microdebitage escaped collection. Second, we also were interested in documenting the vertical distribution of faunal remains and chipped stone items in relation to the black carbonaceous zone.

2003 Investigations

The 2003 excavations centered on Area A East, an ~1-x-7 m block of intact sediment between two areas excavated previously by the UNSM (Figs. 6 and 10). This block was selected for excavation because it provided an uninterrupted, ~north-south cross-section of the archaeological deposit. It was hoped this section of sediment would provide information on the character of the upper bonebed and the lower bonebed. Moreover, the UNSM recovered bison bone in all 10 1-x-1 m excavation units flanking this block, but no lithic artifacts. It was thus an ideal place to assess UNSM recovery methods. To examine this issue, we employed an excavation strategy designed to capture contextual data on very small items. Excavations occurred in 1-x-1 m units divided into 16 25-x-25 cm sixteeners that were excavated in 2 cm arbitrary levels unless it cross-cut natural

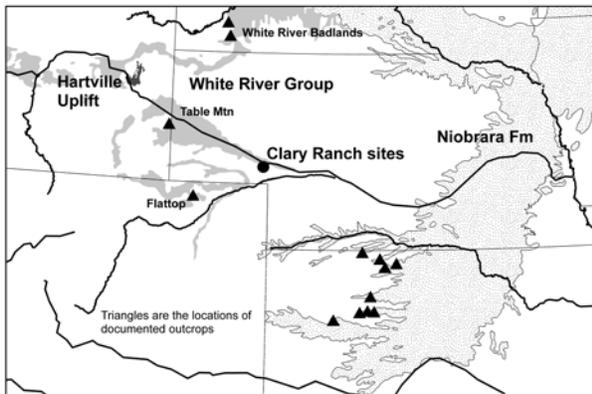


Figure 9. Source locations of the three key chipped stone raw materials found at the Clary Ranch sites. Most specimens at the Clary Ranch site are made from Smoky Hills silicified chalk from the Niobrara Formation, while most specimens at the O.V. Clary site are made from White River Group silicified sediment, most probably from Table Mountain. Both sites contain traces amount of dendritic chert from the Hartville Uplift.

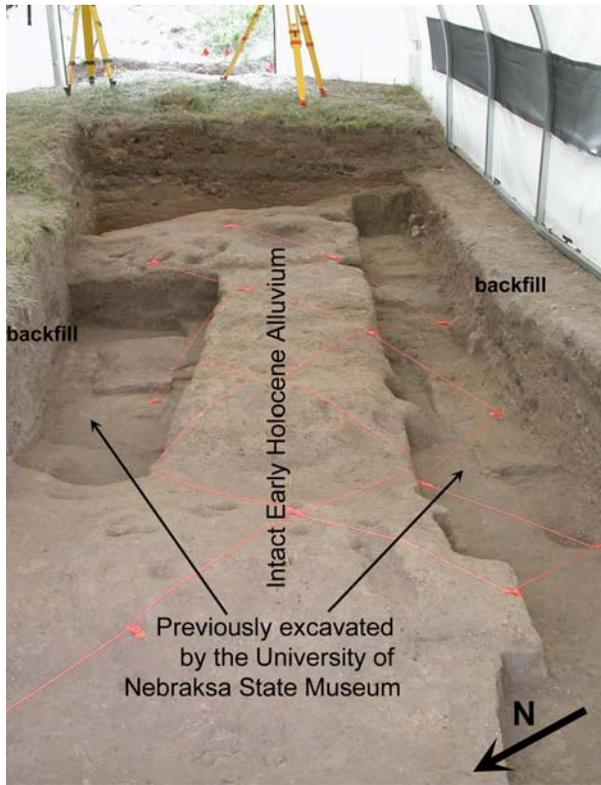


Figure 10. Area A East at the Clary Ranch site at the beginning of the 2003 excavations.

stratigraphy. All specimens 1 cm in maximum dimension were piece-plotted using a reflectorless total station. All excavated sediment was waterscreened.

The 2003 excavations led to several important results. First, collagen extracted from a bison femur shaft fragment produced the first radiocarbon age for the site, 9040 ± 35 B.P. (CAMS-105849) (Hill, 2005), which situates it squarely in the early postglacial period. As well, and to our surprise, although nearly 1,179 ecofacts (i.e., faunal remains and charcoal flecks) and geofacts (i.e., small pebbles) were piece-plotted, not a single chipped stone artifact was recovered in situ. Additional material was picked from waterscreen matrix, including 33 pieces of microdebitage, the largest measuring a whopping 7 mm in length, which quite clearly explains the absence of piece-plotted artifacts. Not only is artifactual material at Area A East uncommon, but it is also extremely small. The significance of this observation is two-fold. First, at least in this area of the site, the sample of material excavated by the UNSM is probably not strongly biased against small artifacts. Second, the effective absence of artifacts here contrasts greatly with

other areas of the site where the UNSM recovered large numbers of tools and debitage, thereby provide strong support for spatial segregation of kill/butchery activities.

The 2003 excavations also confirmed the presence of a distinct black carbonaceous zone at Area A East, but the upper bonebed is diffuse here. The upper bonebed slopes gradually to the northwest and grades into the black carbonaceous (i.e., lower bonebed). Figure 11 shows a complete bison rib in the black carbonaceous zone, while Figure 12 shows several dispersed bison remains in the upper component.



Figure 11. Area A East at the Clary Ranch site showing a complete bison rib in relation to the organic mat.



Figure 12. Area A East at the Clary Ranch site showing several bison remains in the upper component.

Perhaps more importantly, the 2003 excavations effectively demonstrated the high integrity nature of the deposits. The site had enormous potential for additional

archaeological research, but also the sediments preserved numerous proxy paleoenvironmental indicators. Thus, we figured it would be possible to reconstruct the early postglacial environment in order to bring the strong archaeological patterning into clearer focus. In 2004, with funding from the National Science Foundation, we returned to the site to collect the information to address several specific questions.

2004 investigations

Four 10-day field sessions were spent at the site in 2004. The objective of this work was several-fold. First, to document the alluvial history of Ash Hollow Draw and the geoarchaeological context of the site. Second, to characterize the early Holocene environment to serve as a backdrop for reconstructing Late Paleoindian use of the valley. And third, to add details to the general reconstruction of subsistence-related activities at the site, specifically, the organization of activities. To fulfill these objectives, a comprehensive study of the sediments at the site and at selected other locations in the valley was conducted by May. Documenting the site stratigraphy benefited from the excavation of a backhoe trench through the center of the site roughly perpendicular to the draw (Figs. 6 and 13). May also collected hundreds of diachronic paleoecological samples for other project specialists to use in reconstructing valley-bottom environments during the early Holocene.



Figure 13. Backhoe trench at the Clary Ranch site. View looking ~south.

While bison remains are distributed relatively evenly across the UNSM excavation area, cloud-like concentrations of artifacts occur at Area B and near the center and western end of the main block. Since the latter artifact concentration was only partially excavated by the UNSM, the intact portion was selected for excavation. In contrast to Area A East, where the objective of excavations was to evaluate the resolution of the UNSM recovery methods, the objective at Area A West was to examine the structure of a suspected activity area (Fig. 14). Using the same field methods that were employed in 2003 at Area A East, nearly 10 sq m were excavated at Area A West. Compared to Area A East, considerably more archaeological material was recovered here. One biface, 44 pieces of microdebitage, 1,392 ecofacts, and 457 geofacts were recovered in situ. Three hundred eighty three pieces of microdebitage were also recovered from waterscreen matrix.



Figure 14. Area A West at the Clary Ranch site at the beginning of the 2004 excavations.

Without question, the most significant result of the 2004 excavations was the discovery of two distinct archaeological components, separated by ~40 cm, at Area A West. As expected, the lower component straddles the organic mat and contains numerous butchered bison remains and chipped stone artifacts, almost exclusively microdebitage (Fig. 15). The upper component, which was not expected, contains a thin scatter of artifacts – several unmodified flakes – and a handful of bison remains, including a complete tibia and an articulated string of cervical vertebrae. The significance of this discovery is obvious: two stratified archaeological components occur at the Clary Ranch site. The lower component was the focus of the UNSM excavations and



Figure 15. Close-up of the organic mat at Area A West in 2004. Note the bison bones protruding from the profile.

is likely preserved across the entire site area, although we suspect it was not reached in some areas. Late Paleoindian activities represented in this component are associated with secondary processing of bison carcasses derived from a nearby mass kill. The upper component, on the other hand, appears to be preserved primarily (only?) at the west end of the site. As best as can be determined, most of the upper component was unintentionally destroyed during overburden removal activities aimed at expediting the UNSM excavations.

It thus appears that the concentration of material at Area A West on the UNSM composite plan maps (Fig. 6) reflects, at least in part, the “collapse” of two archaeological components (separated by ~40 cm) into a composite plan view. That said, since the vast majority of material is from the lower component, the overprint of upper component material probably has not effected the overall integrity and composition of former. The concentration of material in the lower component at Area A West is, not surprisingly, tied most closely to marrow processing activities. Two hammerstone/anvils were recovered here, along with numerous long bone shaft fragments. Long bone articular ends are found only on the periphery of the activity area, suggesting they were tossed there after processing in order to maintain a clean, debris-free work space. The presence of carbonized and calcined bone fragments indicates a hearth was located within or adjacent to this activity area.

Backhoe Trench Stratigraphy

A backhoe trench was excavated early in the 2004 field season. The trench was excavated through the center of the Area A excavation block perpendicular to the north-

east-southwest trend of Myers’s (1979-1982) excavation units (Figs. 13 and 16). Excavation of the backhoe trench was important for several reasons. First, it explained why the site is linear-it lies within an oxbow lake/meander scar of Ash Hollow Draw. Second, it was possible to confirm that the UNSM excavations did not reach the organic mat (the lower component) at the site. Third, it provided an opportunity to describe and sample deposits below the cultural components. Finally, it allowed us to develop a model of landscape evolution at the site.

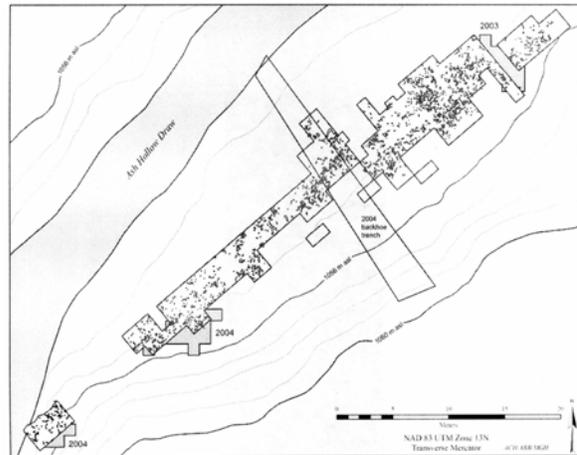


Figure 16. Map of Clary Ranch site excavation units and location of backhoe trench.

The backhoe trench exposed the cross section of a shallow channel. The floor of the channel was evident as a thin (2-3 cm thick) organic-rich stratum that Myers (1979-1982) referred to as the “black carbonaceous zone” at the site and Holven (2006) referred to as the “organic mat” at the site. I refer to it as organic stratum A (OSA). This channel is interpreted to be the cross section of a shallow oxbow lake, or channel scar when it dried out, in the active Early-Holocene meander belt of Ash Hollow Draw. The oxbow lake/channel scar is filled with ripple- and horizontally-laminated clay loam to very fine sand (unit V). The lower cultural component at the Clary Ranch site is generally on the floor of this oxbow lake/channel scar, just below it, or immediately above the floor (above OSA).

May described three profiles in the northeast face of the trench, designated Profiles A, B, and C (Figs. 17 and 18). Profile A is closest to the southeastern margin of the valley and exposes the oldest alluvium. The Late Holocene/Early Holocene unconformity is visible in



Figure 17. Profile of the northeast wall of the backhoe trench at the Clary Ranch site showing positions of Profile A (sampled in background), Profile B (with shovel), and Profile C (deepest part of paleo-channel not yet sampled). Photo by David W. May, June 19, 2004.

this profile (Fig. 19). This profile exposes unit II, the Brady Soil, and unit IV (Appendix B). Unit II is darker in the Clary Ranch site backhoe trench than elsewhere in the basin. The darker color of this unit locally may indicate slower sedimentation, greater moisture availability for riparian vegetation, or both. Denser riparian vegetation also probably contributed to the higher organic-carbon content of the upper part of this unit. The unit fines upward into the Brady Soil (Fig. 20). The unit IV-unit II boundary is evident in the particle-size data by both the increased sand content and the increased variability in sand content in samples from unit IV. The Brady Soil is evident by the higher organic-carbon contents of samples from the upper part of Unit II. Organic carbon contents are much lower within unit IV.

The radiocarbon ages of charcoal samples in and near Profile A from unit II indicate that the sedimentation rate was initially more rapid and then slowed. The sedimentation rate was 0.25-0.42cm/yr between 9,917 yr B.P. (11,400-11,240 cal yr B.P.; AA62533) and 9,890 yr B.P. (11,390-11,230 cal yr B.P.; AA64302). However, during formation of the Brady Soil near the surface of unit II the sedimentation rate dropped to 0.09-0.14 cm/yr between 9,890 yr B.P. and 9,441 yr B.P. (10,740-10,590 cal yr B.P.; AA64303).

Profile B is northwest of Profile A and nearer the channel deposits (unit III) (Fig. 18). The upper part of this profile includes the valley-side margin of the oxbow

lake/channel scar and the Late Holocene/Early Holocene unconformity (Figs. 21 and 22; Appendix C). Profile B exposes units II, IV, and V. Unit II is similar to that in Profile A; particle-sizes generally fine upward in unit II into the Brady Soil (Fig. 23). Unit IV is horizontally laminated to massive in Profile B and contains more sand than unit II. The organic carbon contents of samples from units II and IV in Profile B are less variable than those of samples from Profile A, but the same general trends exist: organic carbon content increases toward the top of unit II (Brady Soil) and is lower in unit IV than in upper unit II. However, organic carbon contents of samples of unit IV in Profile B are higher than those in Profile A, perhaps because Profile B is on the channel bank and may have supported a riparian gallery forest. The base of unit V is the 7 cm-thick black, OSA that delineates the oxbow lake/channel scar margin in Profile B. The OSA is apparent in the organic-carbon-depth plot (Fig. 23).

The radiocarbon age of $9,100 \pm 120$ yr B.P. (10,490-10,170 cal yr B.P.; AA62544) on charcoal from the upper part of OSA in Profile B dates the base of the laminated fill (unit V) in the oxbow lake/channel scar that overlies OSA. However, this age is not as reliable for the age of the base of unit V as an age on bone that came from immediately below OSA in Area A East. Here bone yielded a radiocarbon age of $9,040 \pm 35$ yr B.P. (10,230-10,200 cal yr B.P.; CAMS-105849).

The radiocarbon ages from Profile B in the backhoe trench indicate rapid accumulation of basal unit II. The minimum sedimentation rate was 0.14 cm/yr between 9,971 yr B.P. (11,600-11,270 cal yr B.P.; AA62539) and 9,865 yr B.P. (11,320-11,210 cal yr B.P.; AA62540) for the lower part of unit II. A maximum sedimentation rate cannot be calculated because of overlap in the calibrated years (Table 1). The sedimentation rate for unit IV in Profiles A and B in the backhoe trench is 0.07-0.36 cm/yr, based on the radiocarbon age of 9,441 yr B.P. (10,700-10,590 cal yr B.P.; AA64303) from the upper part of unit II in Profile A and the radiocarbon age of 9,100 yr B.P. (10,490-10,170 cal yr B.P.; AA62544) from basal OSA in Profile B.

The delta-13C values and the resultant calculated percentages of C4 plants contributing carbon to the sediments differ between backhoe Profiles A and B (Figs. 24 and 25). Profile A reveals an overall trend of increasing delta 13C up the profile, with very low values near

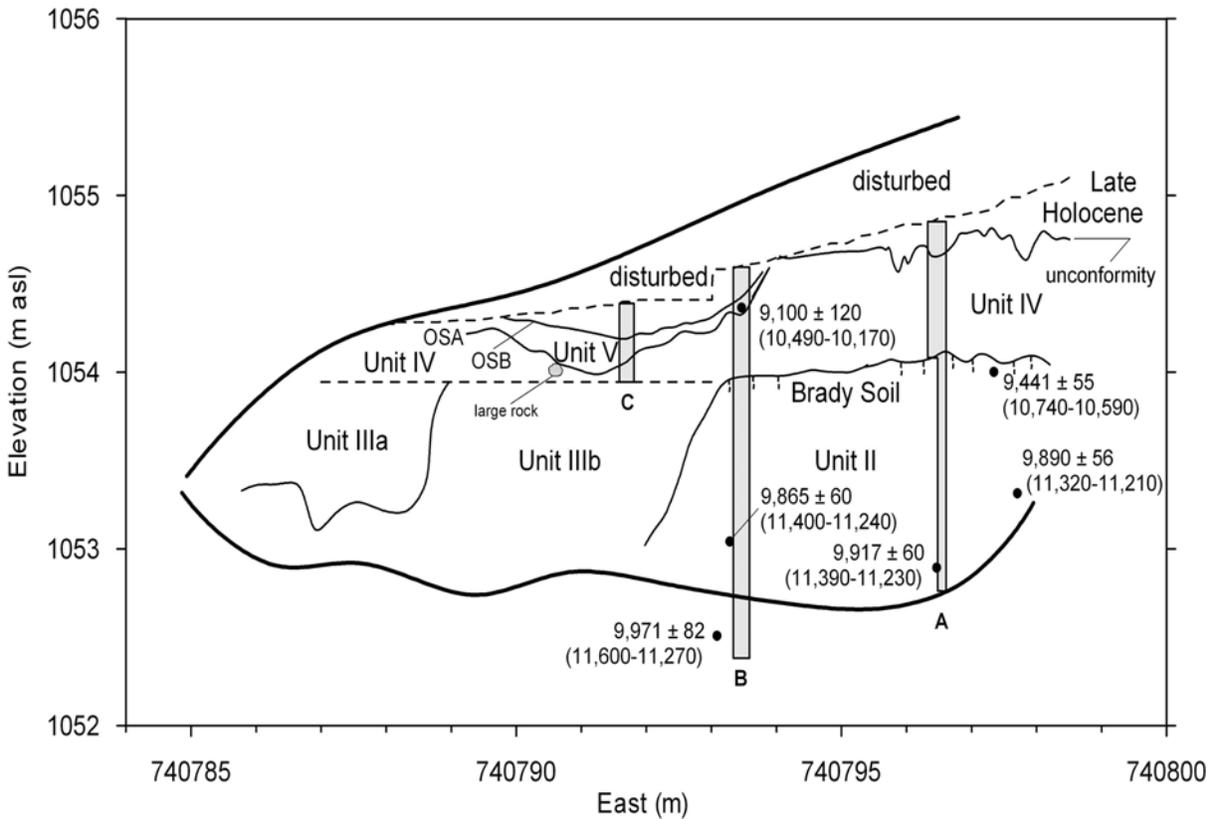


Figure 18. Profile of the entire northeast wall of the backhoe trench at the Clary Ranch site.



Figure 19. Profile A in the northeast wall of the backhoe trench at the Clary Ranch site with David W. May describing profile. Top chaining pin delineates Late Holocene/Early Holocene unconformity. Second chaining pin from top delineates unit IV (above) and unit II (below).

the bottom of the profile. Most of this change occurs between the base of unit II and the top of unit II (Brady Soil). This profile indicates drying in the Early

Holocene between 9,917 and 9,441 radiocarbon years B.P. (11,400-11,240 and 10,740-10,590 cal yr B.P.).

Conversely, the delta-13C values for Profile B show only a very slight increase in the lower part of unit II, and then a slight decrease in unit IV that is punctuated by a very low value in OSA (1054.3 m) at the base of unit V. Clearly, wood charcoal and organic matter from C3 plants contributed carbon and account for the low delta-13C value at the oxbow lake/channel scar margin. In addition to the abrupt drop-off in delta 13C at the elevation of OSA, there are three other abrupt depressions in the delta 13C, including one near the bottom of the profile that produces a value similar to that produced by wood (Smith and Epstein, 1971). The overall percentage of C4 plants is consistently lower in Profile B, and at times, much lower. Taken together these data indicate that more woody vegetation and other C3 plants were growing at the location of Profile B than at Profile A in the Early Holocene before the Clary Ranch site was occupied. This is consistent with the paleo-topography revealed in the northeast wall of the backhoe trench that shows Profile B is on the margin of a channel (Fig. 18).

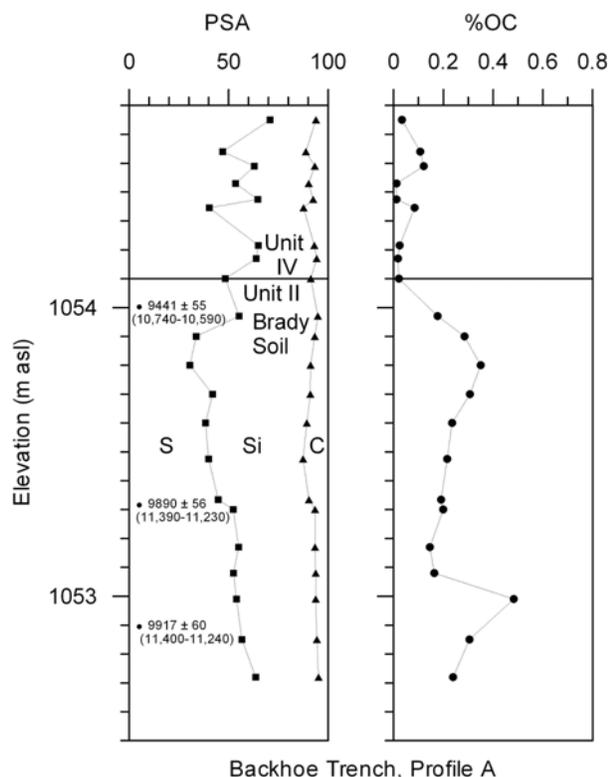


Figure 20. Particle-size distribution and organic-carbon content of sediment samples from Profile A in the backhoe trench at the Clary Ranch site.

The organic-carbon data for the profiles further supports this interpretation (Figs. 20 and 23).

Profile C is just southeast of the deepest portion of the oxbow lake/channel scar where it overlies unit IIIb (Fig. 18). Profile C exposes the fill in the oxbow lake/channel scar at the Clary Ranch site (Fig. 26). The oxbow-lake fill is comprised of ripple- and horizontally-laminated clay loam, silty clay loam, and silt in the lower part (“gray clay” of Myers 1979-1982), and coarse silt or very fine sand in the upper part (“buff silt” of Myers, 1979-1982). Individual laminations are often described for this profile (Appendix D). The lower portion of the oxbow lake/channel scar is gleyed, indicating saturated conditions existed much of the time. The upper boundary of the gleyed deposits was the first stratigraphic marker used by Myers at the Clary Ranch site (Myers, 1979-1982). The upper part of the oxbow lake/channel scar fill includes iron oxide mottling, which is indicative of at least seasonally better drainage than below in the more clay-rich deposits. Profile C is representative

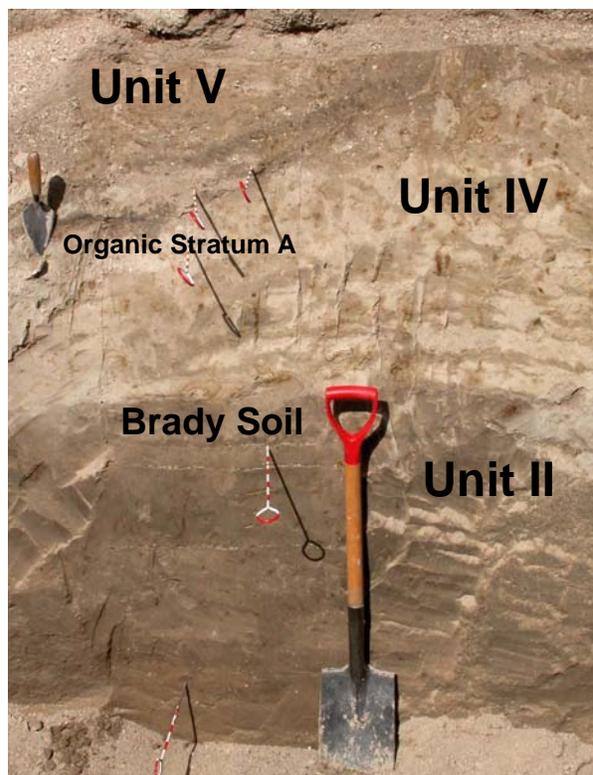


Figure 21. Profile B in the northeast wall of the backhoe trench at the Clary Ranch site before description and sampling. Organic stratum A (lower) and organic stratum B (upper) are evident in the margin of the oxbow lake/channel scar (near top of photo). The Late Holocene/Early Holocene unconformity is at the top of the photo.

of the portion of unit V that contains cultural material at the Clary Ranch site.

Landscape Evolution

The Clary Ranch site is in an oxbow lake/channel scar within the meander belt that existed at the time. The oxbow lake/channel scar runs nearly parallel to the modern channel through much of the site area and accounts, in part, for the linearity of Myers’s (1979-1982) excavation units at the site (Fig. 16). Artifacts have been found just below, in, and on organic stratum A (OSA), and in Area A West, up to 80cm above OSA (upper cultural component). OSA is a stratigraphic marker at the site. OSA also delineates the morphology of the floor of the oxbow lake/channel scar. The oxbow lake/channel scar was shallow (<50 cm deep) and had gently sloping banks (Fig. 18). The oxbow lake/channel scar is filled with unit V deposits that range from clay

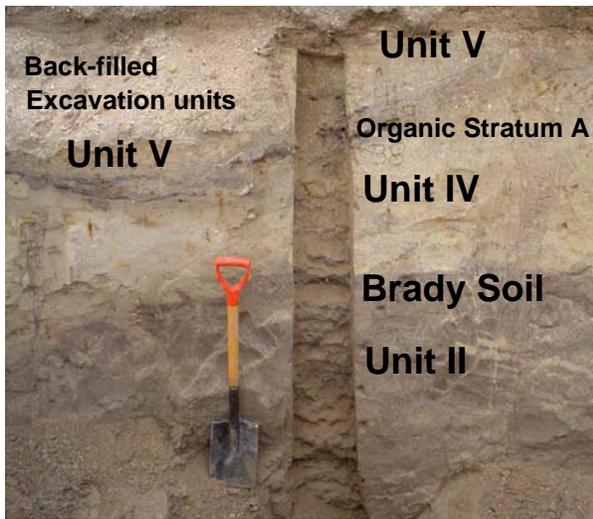


Figure 22. Profile B in the northeast wall of the backhoe trench at the Clary Ranch site after description and sampling. Immediately to the left of the profile is a backfilled 1979 excavation unit that does not reach the floor of the oxbow lake/channel scar and organic stratum A. Photo by David W. May, June 19, 2004.

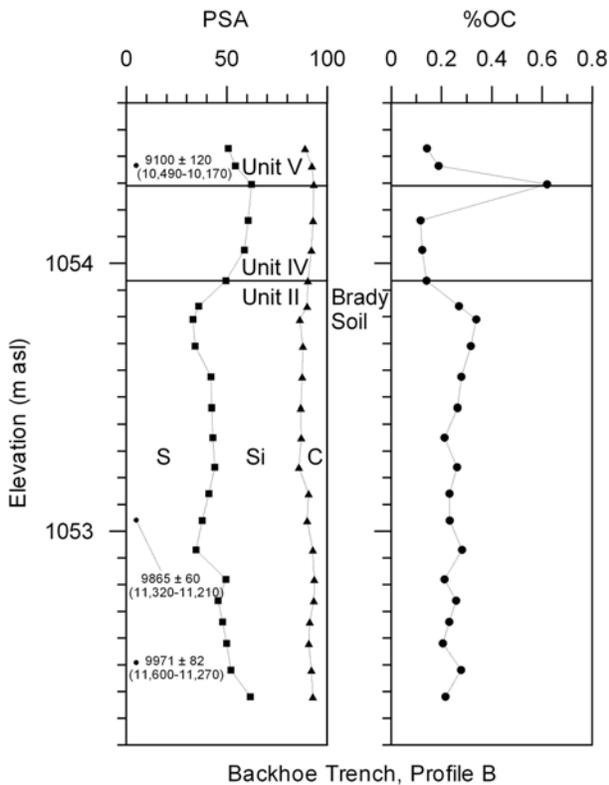


Figure 23. Particle-size distribution and organic-carbon content of sediment samples from Profile B in the backhoe trench at the Clary Ranch site.

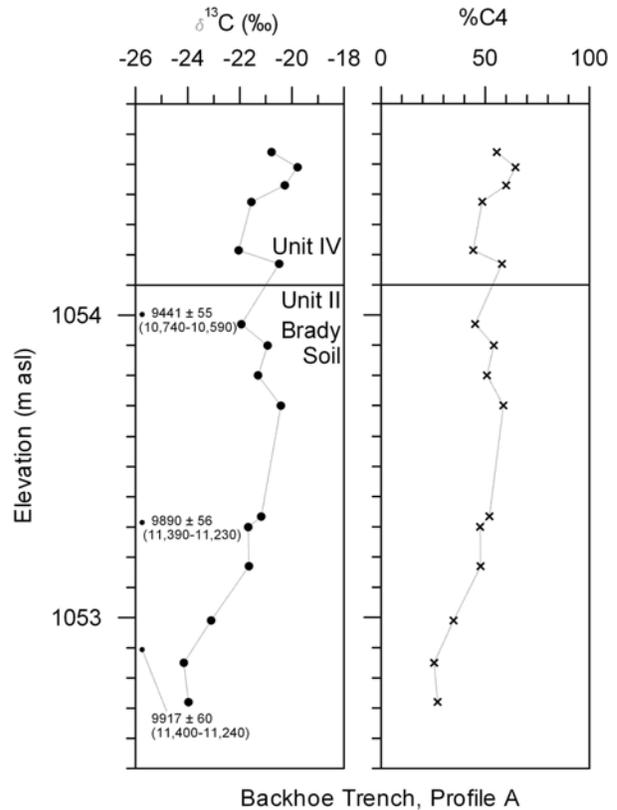


Figure 24. Delta 13C and derived percentage C4 plants in samples from Profile A in the backhoe trench at the Clary Ranch site.

loam to very fine sand. Each lamination is generally less than 3.5 cm thick.

There are three research questions regarding landscape evolution that involve formation and burial of the oxbow lake/channel scar at the Clary Ranch site that can be partially addressed by our research: (1) How did the oxbow lake/channel scar at the Clary Ranch site form? (2) What can we infer about the presence of water in the oxbow lake/channel scar and frequency with which it was flooded? (3) How rapidly did sedimentation occur in the channel scar (i.e. how rapidly were bones and artifacts buried)?

How did the landscape evolve near the site to produce this oxbow lake/channel scar? Ash Hollow Valley was generally aggrading in the Early Holocene, as were valleys across the central Great Plains (Johnson and Logan, 1990; May, 1989, 2002). Channel avulsions are common in aggrading fluvial systems. Unit IIIa at Clary Ranch represents lateral migration of the Ash Hollow channel toward the southwestern margin of the valley

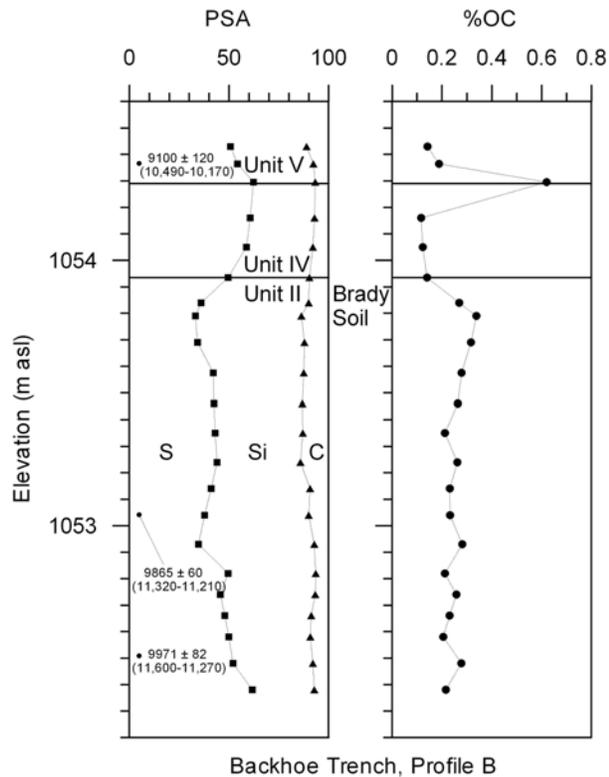


Figure 25. Particle-size distribution and organic-carbon content of sediment samples from Profile B in the backhoe trench at the Clary Ranch site.

and the ultimate area of the site. A channel avulsion to a new channel position, represented by unit IIIb, caused the abandonment of channel IIIa. A very large flood must have been the trigger for the channel avulsion to the IIIb channel. The scour during this flood was deep (below the floor of the trench), and the fine-grained overbank deposits associated with this flood (unit IV) spilled across the meander belt (across unit IIIa) as well as overlapped onto the floodplain to the southwest (across unit II). As the floodwaters waned, organics were trapped in the oxbow lake. They then coated the channel floor as the linear lake dried out. When dry, it would have become a channel scar within the meander belt. Preservation of organic-stratum A on the floor of this oxbow lake/channel scar feature is evidence that it was never re-occupied by the active Ash Hollow channel. However, floods continued to deposit overbank deposits of silt and very fine sand in this abandoned channel/channel scar feature.

Further evidence that the oxbow lake/channel scar at the Clary Ranch site is the surface expression of an aban-

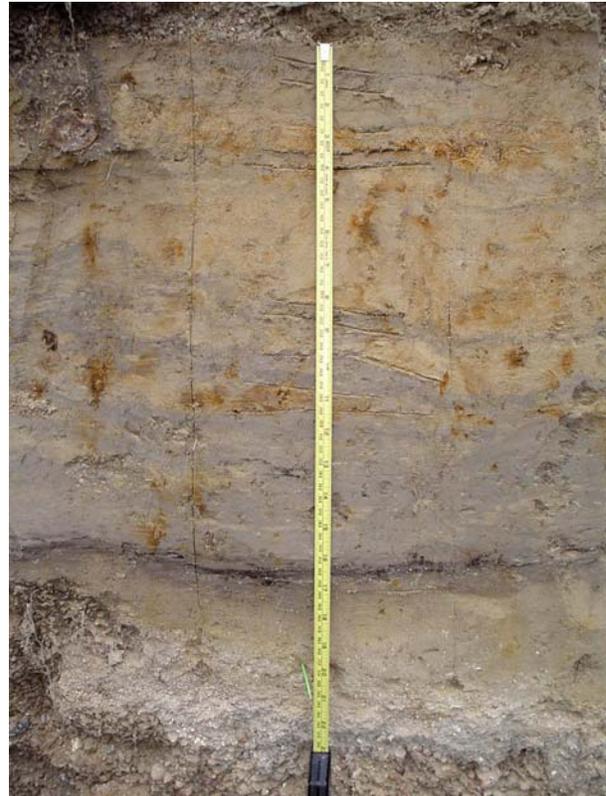


Figure 26. Profile C in the northeast wall of backhoe trench at the Clary Ranch site before described and sampled. The floor of one of Myers's 1979 excavation units is visible at the top of the profile. Photo by David W. May, June 19, 2004.

doned channel and was never re-occupied as the Ash Hollow channel comes from the elevation of an Ash Hollow channel exposed at the toe of the alluvial fan in cut bank 25. Here unit V deposits fill a channel that was incised to below the elevation of the modern channel floor (Fig. 2). The fine-grained deposits exposed in the channel are ripple laminated as at Clary Ranch, but they consist of many series of thicker flood couplets (coarse silt to fine sand capped with clayey silt and organics), consistent with an aggrading active channel. The elevation of the floor of the oxbow lake/channel scar at the Clary Ranch site is one meter above the floor of modern Ash Hollow. Therefore, it is highly unlikely that this channel scar was ever again an active Ash Hollow channel following the flood that formed it. Rather, OSA delineates a temporary oxbow lake that dried out. The Clary Ranch site was first occupied immediately after the oxbow lake dried out, but before a flood in the valley deposited overbank silt and very fine sand in the abandoned channel (oxbow lake) and buried the lower

Paleoindian cultural component. The site was first occupied in late summer/early fall, a time when the oxbow lake/meander scar likely would have been dry.

During overbank flows (floods) from the active channel somewhere northeast of the site, the oxbow lake/channel scar likely would have been at least partially filled with water; some water may have flowed slowly through the oxbow lake/channel scar, especially immediately after it first formed. Standing water may have been present for periods following these floods as well. The oxbow lake began filling with fine-grained (clay-rich) sediments (base of unit V) soon after it was first occupied.

The sediments in the oxbow lake/channel scar consist of many flood couplets (a fine-textured flood drape over a thicker, coarser increment of flood-deposited alluvium). However, most, with the notable exceptions of OSA and the thinner more discontinuous organic stratum B (OSB), lack organics in the upper, fine-grained portion of the flood couplet. The absence of other organic-rich flood drapes in the oxbow lake/channel scar may indicate that floods occurred so often that the oxbow lake did not completely dry out after forming (except during deposition of OSA and OSB). The clay-rich sediments prevented rapid infiltration, further ponding water. The two organic strata (OSA and OSB) that are present in the oxbow lake/channel scar represent the only times when the oxbow lake completely dried out and thus became a channel scar in the meander belt.

There is a variety of sedimentological evidence that the sediments in the oxbow lake/channel scar above OSA remained moist following initial occupation of the site. All areas of the site show some soft sediment deformation, but it is most common in the northeastern portion of the site (Fig. 27). I infer from the spatial pattern of greater soft-sediment deformation toward the northeastern end of the site that the sediments in the oxbow lake/meander scar were moister here longer following deposition of OSA. OSA is thicker here, which also suggests standing water here for a longer time than elsewhere in the site. Soft sediment deformation is less evident and less severe in Profile C in the backhoe trench than in Area A East, and is least in Area A West. Myers, et al. (1981) slightly overstated the mechanism for maintaining moist sediments at the site and the areal extent of the OSA by interpreting the oxbow lake/channel scar as



Figure 27. North walls of 2003 excavation units L34-25 (left) and L35-21 (right) from Area A East illustrating organic stratum A (OSA) in east end of the site.

“the remnants of an old bog,” but they correctly recognized that this area remained wet for long periods.

In addition to the evidence presented above, there are two more lines of evidence arguing for wet sediments and standing water after deposition of OSA. Gleying of the lower 20cm of sediments in the oxbow lake/channel scar suggests that these sediments did not dry out. Additionally, there are no filled cracks in the clayey laminae, which would certainly be expected if the sediments had completely dried out. Other than a brief drying that is indicated by thin OSB, the oxbow lake/channel scar may have remained moist for several days, weeks, or months following deposition of OSA and the lower Late Paleoindian cultural materials associated with the OSA.

The final question that we tackled was the sedimentation rate in the oxbow lake/channel scar. The sedimentological evidence indicates, unequivocally, that the sedimentation rate was very high. The lower boundaries of the laminae in the paleo-channel show few signs of bioturbation and are all abrupt. Nearly all bioturbation is post-depositional and by burrowing mammals.

The sedimentation rate was so high in the oxbow lake/channel scar that it cannot be determined from calibrated AMS radiocarbon ages. The duration of the deposition of about 70-80 cm of the laminated alluvium (basal unit V) at the Clary Ranch site is probably less than the typical standard deviation for an AMS radiocarbon age on charcoal or bone from unit V (Table 1). The sedimentation rate must have been more rapid than

the maximum sedimentation rate (0.85 cm/yr) calculated for unit V in Profile 1 in cut bank 21 (west cut bank). Deposition of unit V appears analogous to post-settlement floodplain sedimentation following the introduction of European agriculture to the upper Midwest, so the sedimentation rate at the Clary Ranch site was probably of the same order of magnitude. The rate for the earliest post-settlement sedimentation was 2 cm/yr (Knox 1987; Baker et al. 1993).

There is archaeological evidence as well for very rapid sedimentation at the site that is based on the preservation of articulated joints of bison processed at the site. Hill (2001, p. 208) indicates that the Clary Ranch site is unique among bison kill sites on the Great Plains in the degree of articulations found at the site. The radius-carpal articulations (wrist) are very weak and don't persist very long when exposed. For these joints to have persisted in articulation they must have been buried quickly, within a year, at most. Although we cannot say precisely how long it took for nearly a meter of sediment to accumulate in the oxbow lake/channel scar and bury two Late Paleoindian components at the Clary Ranch site, it probably occurred within a few years. These are ideal conditions for sealing the cultural material from the atmosphere and for preventing trampling of the bones and scavenging.

Paleoenvironmental Interpretations from Snails (Gastropods)

Introduction

Recent investigations at Clary Ranch coincided with the Southern Plains Gastropod Survey (SPGS), undertaken between 1995 and 2005 to assess living land snail species and populations on the southern Great Plains (Theler et al., 2004). This recent survey of living snails is supplemented by pertinent literature sources (e.g., Bequaert and Miller, 1973; Hubricht 1985; Leonard, 1959; Metcalf and Smartt, 1997) and provides a basis for interpreting the environmental implications of snail species recovered from early Holocene deposits on the ranch and at Ash Hollow State Park (not discussed here).

Five columns of sediment samples (including two pending analysis) provided to the author span portions of the Clary Ranch site sediment deposition from about $9,971 \pm 82$ yr B.P. (11,600-11,270 cal yr B.P.; AA62539) to

$8,749 \pm 58$ yr B.P. (9,890-9,630 cal yr B.P.; AA64354), and thus encompass the Late Paleoindian activities at circa 9,040 yr B.P. The sediment samples were air dried, measured for volume, and water screened, with material larger than 0.425 mm retained in a #40 geologic sieve. All complete and potentially identifiable shell fragments were isolated from the water-screened residue under a low-power (6X to 10X) binocular microscope.

Results

The three analyzed sediment columns contained a total sediment volume of 84 liters and produced 19,588 terrestrial snails having a total of 20 taxa represented, an average density of 271 individuals/liter (ind/l) of sediment. There are 1,591 terrestrial calcareous snail eggshells with a density of 22 ind/liter. In addition, a total of 159 aquatic mollusks of four taxa were recovered (Table 2).

The snail sediment column of backhoe trench Profile A consisted of 22 contiguous samples taken at elevations from 1052.720 m asl (Sample 1) and terminated at 1054.700 (Sample 22) This 2.0 m column covers the time span from circa 9,917 yr B.P. (11,400-11,240 cal yr B.P.; AA62533) to 9,441 yr B.P. (10,740-10,590 cal yr B.P.; AA64303) with a total of 10.3 liters of sediment. It produced 4235 terrestrial snails representing 17 taxa, 235 terrestrial snail eggshells, 31 aquatic snails representing 3 taxa, and 33 specimens of non-snail aquatic taxa including Sphaeriidae clams, Ostroca, and *Chara* sp. (Fig. 28).

The 22 contiguous samples taken as backhoe trench Profile B span a time period from 9,971 yr B.P. to 9,100 yr B.P. (10,490-10,170 cal yr B.P.; AA62544) that encompass a 2.1 m section beginning at elevation 1052.380 (Sample 1) and terminating at 1054.430 (Sample 22), and totaling 14.4 liters of sediment. This column produced 7064 terrestrial snail shells (491 ind/l), 281 terrestrial snail eggshells (20 ind/l), and 77 aquatic taxa, for a total density for Profile B of 515 ind/l (Fig. 29).

A contiguous column of 54 sediment samples was taken as Profile 1 at cut bank 21 (west cut bank). This column runs from an elevation of 1053.355 (Sample 1) to 1060.380 (Sample 54) and covers 7.0 meters of vertical cut bank exposure. The temporal span covers approximately one thousand years based on sequential dates

Table 2. Summary of molluscan fauna samples from the Ash Hollow Basin.

Location	Number of Samples ¹	Terrestrial Snails ²	Terrestrial Snail Egg Shells ³	Aquatic Mollusks ⁴
Cut bank 21 (West cut bank), Profile I	54	8,289	1,075	18
Backhoe trench, Profile A	22	4,235	235	64
Backhoe trench, Profile B	22	7,064	281	77
Backhoe trench, Profile C	5	pending		
Ash Hollow State Park	9	pending		
Subtotal	112	19,588	1,591	159

¹Average sample size ~1 Liter; ²Number of terrestrial shells identified to taxa; ³Eggs of *Vallonia* sp. and *Discus* sp.; ⁴Number of aquatic organisms, including gastropods, identified to taxa.

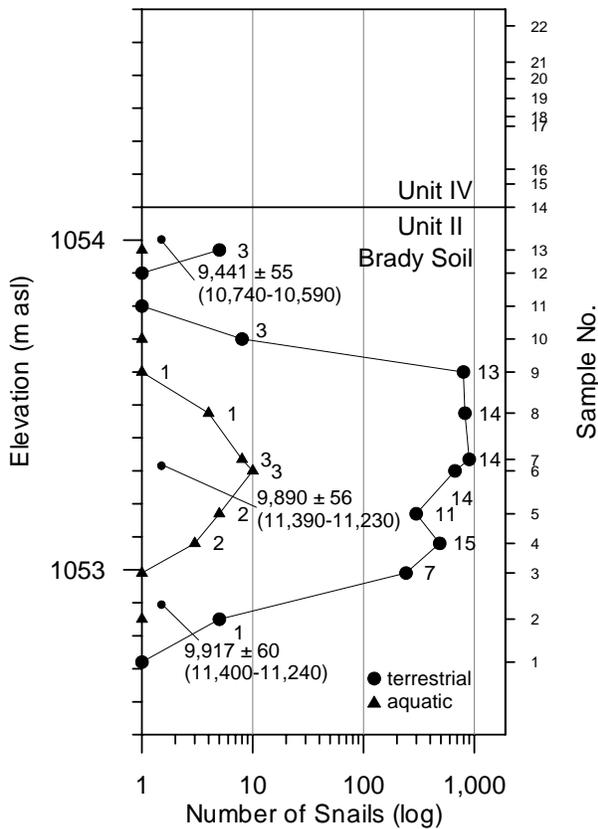


Figure 28. Terrestrial and aquatic taxa from Clary Ranch site backhoe trench Profile A. Number of taxa is indicated adjacent to data points. Samples 14-22 pending.

from 9,361 yr B.P. (10,660-10,510 cal yr B.P.; AA62529) at the lower end of the column to 8,749 yr B.P. (9,890-9,630 cal yr B.P.; AA64354) at the upper end of the column. The total volume of sediment from this column was 47.6 liters and produced 8287 terrestrial snails or 174.1 ind/l. In addition, there were 1075

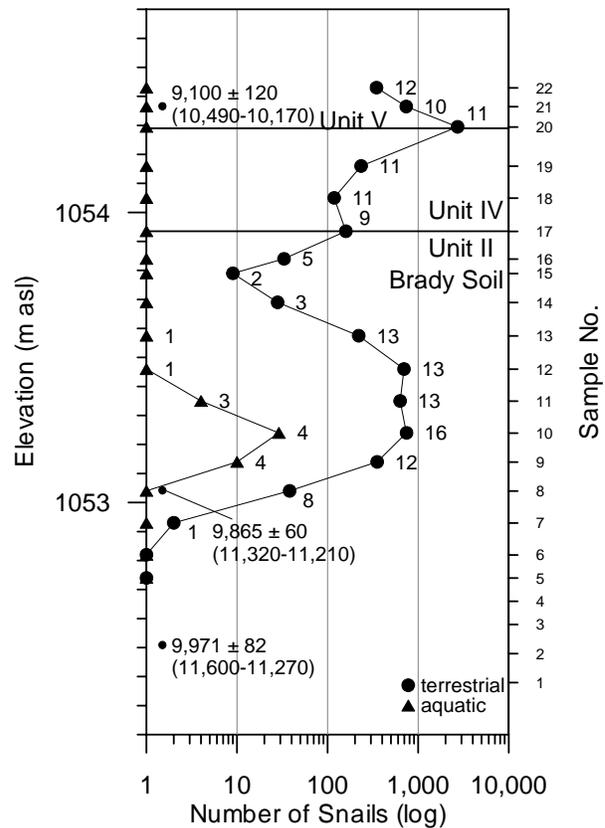


Figure 29. Terrestrial and aquatic taxa from the Clary Ranch site backhoe trench Profile B. Number of taxa is indicated adjacent to data points. Samples 1-4 pending.

snail egg shells (22.6 ind/l) and 18 aquatic mollusks (Fig. 31).

Discussion and Conclusions

Employing data on habitat preferences for specific snail taxon, we may use the habitat signatures of assemblages

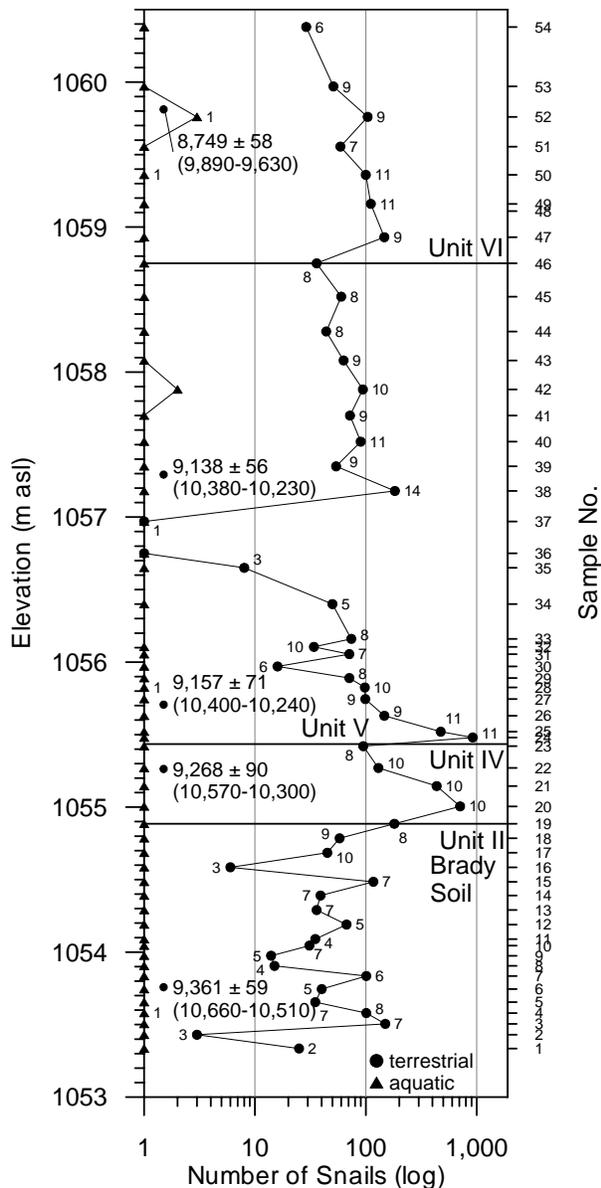


Figure 30. Terrestrial snail taxa from Profile I, cut bank 21 (west cut bank). Number of taxa is indicated adjacent to each data point. Sample no. 48 pending.

as proxy data to describe at least some of the parameters of the local, and by extension, regional environmental and climatic setting for the Clary Ranch locality between circa 10,000 and 8,700 years ago (Table 3).

Circa 9,900-9,600 yr B.P. The samples from the lower portions of backhoe trench Profiles A and B contained the greatest diversity and a high density of land snails and the majority of aquatic organisms. The land snails include a suite of species that require a moist, protected

habitat. These include *Carychium exiguum*, *Gastrocopta tappaniana*, *Discus whitneyi*, *Euconulus fulvus*, and *Vertigo ovata*. These species, with the exception of isolated populations of *G. tappaniana*, do not occur today on the central or southern Plains, but are found at the better watered margins or at higher elevations of the montane region to the west. The aquatic snails found at this period, *Fossaria dalli* and *Gyraulus crista*, both of which are characteristic of well vegetated, low energy or ponded eutrophic waters. The aquatic organisms found in the lower sections of Profiles A and B are entirely consistent with the habitat of the above discussed land snails. The species restricted to the 9,900-9,600 yr B.P. period disappear from the sequence and do not reappear. Their presence in the earliest portion of the sequence may represent species that had persisted regionally since the terminal Pleistocene.

Table 3. Snail trends in the Clary Ranch deposits.

Species Concentrated or Restricted to the Lower Column Samples

- Carychium exiguum* (Say, 1822)/ *Carychium exile* I. A. Lea 1842
- Gastrocopta tappaniana* (C. B. Adams 1842)
- Discus whitneyi* (Newcomb, 1864), *Discus* sp. juveniles
- Euconulus fulvus* (Muller, 1774), *Euconulus* sp. juveniles
- Nesovitrea electrina* (Gould, 1841)
- Vertigo ovata* Say, 1822
- Aquatic gastropods
- Fossaria dalli* (Baker 1907)
- Gyraulus crista* (Linnaeus, 1758)

Species Abundant in the Lower Portion of the Columns A and B, Uncommon in Upper Portion

- Vallonia parvula* Sterki, 1893
- Punctum minutissimum* (I. Lea, 1841)
- Hawaiiia minuscula* (A. Binney, 1841)
- Deroceras laeve* (Muller, 1774) and *Deroceras aenigam* Leonard, 1950
- Helicodiscus singleyanus* (Pilsbry, 1889)

Widespread Species

- Gastrocopta holzingeri* (Sterki, 1889)
- Vallonia gracilicosta* Reinhardt, 1883
- Zonitoides arboreus* (Say, 1816)
- Succineidae

Species Rare Lower, Common Upper

- Gastrocopta abbreviata* (Sterki, 1909)/ *Gastrocopta armifera* (Say, 1821)
- Vallonia perspectiva* Sterki, 1893
- Cionella lubrica* (Muller, 1774), *Cionella* sp. juveniles

Species of Upper Portions of Columns

- Gastrocopta procera* (Gould, 1840)
- Pupoides albilabris* (C. B. Adams, 1841)

Four other terrestrial species are most abundant in the lower sections of the sequences, but do occur in smaller numbers at higher elevations in backhoe trench Profiles A and B. These species include *Vallonia parvula*, *Punctum minutissimum*, *Hawaiiia minuscula*, and *Deroceras laeve*. These species flourish in moist, protected settings, that are typically wooded, but *Hawaiiia minuscula* and *Vallonia parvula* can be found in lesser numbers in rather dry, sparse habitats.

Circa 9,500-9,400 yr B.P. At the level of samples 10 through 12 in both backhoe trench Profiles A and B we observe a sharp truncation in the previously abundant snail populations. Land snails become rare or absent and aquatic snails disappear. This appears to represent a time of increased temperatures and decreased available moisture. The water source clearly present in the earlier period is no longer present. The lack of snails suggests little vegetation cover of any kind and perhaps coupled with a period of erosion.

Circa 9,300-9,100 yr B.P. At this point we see terrestrial snails return in number, but the aquatic snails and six species of terrestrial snail do not return. At circa 9,200 yr B.P., a peak in the lower portion of the cut bank 21 (west cut bank) Profile 1 column is observed with Sample 16, with 238 terrestrial snails representing 14 species, that appears to be the culmination of a peak in available moisture, followed by a truncation of the snail populations, perhaps the result of severe drying and/or erosion with no snails in Sample 17, one snail in Sample 18, followed by a gradual increase that culminated in the highest density of snails in the sequence with Samples 29 through 34 at circa 9,150-9,100 yr B.P. Profile B has a similar increase at the same period to a peak in Sample 16 with 11 species and 2908 individual snails and plus snail eggshells.

Sample 16 and 17 have a high frequency of burned snails at 9 % and 34 % respectively. The large number of snails and eggshells in Sample 16 indicates optimal conditions for reproduction, growth and survival that would be met only with a well establish vegetation community, presumably dense prairie cover with, permitted under an adequate precipitation regime and little erosion. At the period of sample 16-17, there is a fire that burns the vegetation and the associated snails.

At the top of the Profile B (samples 15 and 18) and in the upper portion of cut bank 21 (west cut bank) Profile 1 we see the arrival of two snail species of southwestern

origins *Pupoides albilabris* and *Gastrocopta procera*. *Gastrocopta procera* is a species requires at least 160 frost-free days. At the upper part of the cut bank 21 (west cut bank) Profile 1 sequence we observe the decline in snail diversity and density signaling a changing regional climate resulting in a drier, more open habitat.

Paleoecology of the Clary Ranch Micromammals

Introduction

Micromammals (insectivores, rodents, and rabbits) generally exhibit more restrictive environmental parameters than large mammals and thus offer better insight into prevailing paleoecological conditions during accumulation. The faunal inventory from the Late Paleoindian component at the Clary Ranch site is especially significant for four reasons: (1) The fauna provides relatively detailed insight to ecological conditions associated with a Paleoindian occupation; (2) Time averaging is minimal within the occupation level, representing a 50-year depositional increment (probably less) 10,200 calendar years (9,040 radiocarbon years) ago; (3) It provides an opportunity to evaluate how quickly the post-glacial high plains environment developed after the last glacial and (4) It represents one of the few known early Holocene micromammal localities in North America; these are especially rare on the High Plains (Semken and Falk 1987).

The micromammals recovered from the Clary Ranch site are associated with a concentration of burned bison remains, gastropod shells, and charcoal. This suggests that the specimens accumulated, along with associated artifacts, immediately after a major wildfire in the valley around the time of the occupation. Twelve percent of the dental elements recovered were burned, none were associated with hearths and all were concentrated in fluvial sedimentary structures. This fire severely impacted local environmental conditions around the site and suggests that the micromammals represent a paleoecological snapshot of pre-fire conditions. This interpretation is supported by the presence of a similar number of burned mollusks also recovered from Late Paleoindian component deposits. The micromammals associated with the Late Paleoindian component faunule consists of 215 identified dental elements (NISP), repre-

senting at least 54 individuals (MNI-Minimum Number Individuals) assigned to 16 taxa (Table 4).

Paleoecological Interpretations

The paleoecological associations of the micromammals recovered from the unit V at the Clary Ranch site is interpreted here via two methods: (1) relative abundance with respect to center of modern biogeographic distribution and (2) area of sympatry. Collectively, the two lines of evidence offer strong insight for environmental associations during the deposition of sediments at the site.

Biogeographic Affinities

The 16 identified micromammal taxa from the site were separated (Table 5) by their relative abundance with respect to their centers of distribution within modern North American biomes (Bowles, 1975) and ecoregion maps (Bailey, 1981). While boundaries of ecoregions are somewhat subjective, the regions themselves are well defined (Omernik, 2004). Four of the taxa from the archaeological component are widespread, almost ubiquitous in North America, and do not impact paleoecological interpretation. Six taxa are boreomontane affiliates; five are primarily adapted to steppe environ-

ments, while one has a distribution centered in the eastern deciduous forest. However, in terms of relative number of individuals (Table 5), steppe species are more common than boreomontane specimens, 20 to 13 respectively, at the site. The deciduous forest taxon is represented by a single specimen. This is in sharp contrast with the distribution centers of species now in residence on the Clary Ranch. Only one each of the boreomontane and deciduous forest-centered species remain in the area but all five steppe associates survive. Moreover, both the surviving boreomontane and deciduous forest species present today are at the limits of their respective ranges. The least shrew is at its extreme western limit in the Ash Hollow area and the meadow vole is at its extreme southern limit in western Nebraska. At the time of deposition of the archaeological component at the Clary Ranch site, there was a more diverse environment and hence a broader resource base, at least locally, than at present.

Area of Sympatry

Areas of sympatry -- geographic regions where all or most of the taxa recovered from a chronological unit co-occur at present, delineate areas that provide suitable habitat for all or most component species. . Therefore,

Table 4. Summary of micromammals recovered from the Clary Ranch site.

Taxon	MNI Element	NISP	MNI	MNI %	Distribution	Common Name
<i>Cryptotis parva</i>	L mand	1	1	2	D	least shrew
<i>Eptesicus</i> (cf.)	Rm1	4	2	6	W	big brown bat (?)
<i>Sylvilagus</i> sp.	Lp4	1	1	2	W	rabbit
<i>Lepus</i> sp.	LP/Mx	1	1	2	W	hare
<i>Thomomys talpoides</i>	Lp4	4	1	2	BM	northern pocket gopher
<i>Geomys bursarius</i>	LI	7	2	4	S	plains pocket gopher
<i>Cynomys</i> (cf.)	Ri	1	1	2	S	prairie dog (?)
<i>Spermophilus aff.tridecemlineatus</i>	RM2	3	1	2	S	13-lined/spotted ground squirrel
<i>Tamias minimus</i>	R Max	1	1	2	BM	least chipmunk
<i>Perognathus</i> sp.	L mand	2	2	4	S	pocket mouse
<i>Zapus cf. hudsonius</i>	L Max	1	1	2	B	meadow jumping mouse
<i>Peromyscus</i> sp.	R mand	74	16	29	W	deer/white-footed mouse
<i>Clethrionomys cf. gapperi</i>	Lm2	1	1	2	B	southern red backed vole
<i>Synaptomys cooperi</i>	LMI	19	5	8	B/D*	southern bog lemming
<i>Microtus cf. pennsylvanicus</i>	Lm1	17	4	7	B	meadow/mountain vole
<i>Microtis ochrogaster</i>	Rm1	78	14	25	S	prairie vole
Total: 16		215	54	101		

Note: NISP = Number of Identified Specimens, MNI = Minimum Number of Individuals. Centers of Distribution: B = Boreal forest, BM = Boreomontane, D = Deciduous forest, S = Steppe, W = Widespread.

Table 5. Relative abundance of species and individuals assigned to each ecoregion recovered from the Clary Ranch site.

Region	Clary Ranch Site			Garden County		
	Species	Species %	MNI/Region	%/Region	Species	% Region
Boreal/Boreomontane	6	38	13	24	1	9
Deciduous	1	6	1	2	1	9
Steppe	5	31	20	37	5	46
Widespread	4	25	20	37	4	36
Total	16	100	54	100	11	100

Note: Boreal and boreomontane species are combined.

they represent, in part, potential analogs for paleoenvironmental interpretations. Species from most Holocene sites, unlike non-analog glacial-age sites (Graham, 2005), usually provide a single region in which all species presently are sympatric (Semken, 1983). These analog sympatries may include the recovery location or be totally disjunct from it. The presence of microfauna is essential to produce a sympatry map because most large mammals range too widely to delineate an interpretable area. As a general rule, the greater the number of taxa recovered, the smaller the sympatry. Thus, Falk and Semken (1998) only applied the technique to sites that contained eleven or more mammals, a number that generally separates use of fine-mesh water screen from coarser-mesh dry screen recovery at a site. Also, the larger the faunal list, the greater likely hood a disjunct species will be identified. The Late Paleoindian component faunule of the Clary Ranch local fauna, with 16 micromammal taxa, is appropriate for the technique.

This technique demonstrated that there is no total area of sympatry (Rhodes, 1984) for all Clary Ranch micromammal species from the archaeological component. Fourteen of the 16 species did cluster into a maximal sympatry, centered ~960 km (600 miles) north of the site on the boundary separating South Dakota and Minnesota just below the Canadian border. The technique also revealed an eastern resolved sympatry, with its western border 190 km (150 miles) east of the site (12 of 16 taxa) in central Nebraska and a western resolved sympatry, with an eastern border 150 km (240 miles) west of the site (13 of 16 taxa) in eastern Wyoming/northern Colorado.

The maximal area of sympatry (Fig. 31) the area where most of the subfossil taxa presently co-exist, lies just south of the United States/Canadian border on the Minnesota-North Dakota line. It contains all Clary Ranch taxa except the least shrew (*Cryptotis parva*), a species

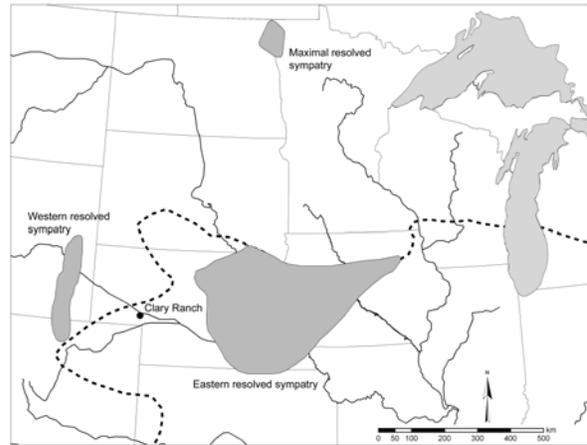


Figure 31. Areas of sympatry for the micromammals recovered from the Late Paleoindian component at the Clary Ranch site. The maximal sympatry hosts 14 of the 16 identified taxa. The eastern and western resolved sympatries support 12 and 13 of the 16 identified taxa, respectively. Component species are listed in Table 10. The dashed line delineates the northern and western limits of the least shrew, *Cryptotis parva*.

with its northern most limit located ~750 km (470 miles) to the south and possibly the prairie dog, with an eastern-most limit 240 km (150 miles) to the west.. The maximal sympatry essentially lies on a region where the Laurentian Mixed Forest, Eastern Deciduous Forest, Tall Grass Prairie and the Aspen Forest Provinces of Bailey (1981) are juxtaposed. This clearly is an ecotonal or edge situation almost uniting four major North American Biomes. The maximal sympatry also is in the Western Lake Section of the Central Lowlands (Jones et al 1985). In contrast, the Clary Ranch site is situated within the Great Plains Short-grass Prairie Province of Bailey (1981) and High Plain physiographic regions as mapped by Jones et al. (1985). The taxa now extirpated to varying distances from the Clary Ranch\Ash Hollow

area, and the ones that signify increased diversity of environmental resources during occupation of the site, are: the northern pocket gopher, least chipmunk, southern bog lemming, red back vole, and meadow jumping mouse. These probably represented a relict community from more widespread Pleistocene faunal distributions. The major differences in climatic parameters between the Ash Hollow area today and that predicted for the area during the Late Paleoindian occupation of the Clary Ranch site, based on the northern (maximal) area of sympatry, are reduced evaporation (hence more effective precipitation) and twice the number of days with snow cover during the occupation. Snow cover would effectively shield the small mammals, especially the least shrew, from the harsh winter temperatures and permit its survival north of its present range. Ash Hollow topography also would provide a protected habitat from postglacial continental climates on the uplands and provide for a relict, post-glacial non-analog population in southwestern Nebraska some 1000 years after more maritime-like glacial climates disappeared from the region.

The eastern resolved sympatry contains 12 of the 16 identified species from the archaeological component. This sympatry, which lies in the tall grass prairie province of central and eastern Nebraska extends into the prairie parkland province of western Iowa but includes the ecotone between this and the tall grass prairie of northwestern Iowa. All of the four Late Paleoindian component species that are absent from this sympatry (northern pocket gopher, least chipmunk meadow, prairie dog (?) and red back vole) are associated with either short-grass prairie and/or higher elevation boreomontane regions to the west or north of Clary Ranch. This sympatry indicates that tall-grass prairie habitat was present in Ash Hollow at the time the micromamals accumulated. The eastern sympatry suggests more mesic conditions in Ash Hollow during deposition of the archaeological component.

The western resolved sympatry is comprised of species which reside totally within the Great Plains short-grass prairie province of Bailey (1981). The least shrew, southern bog lemming and meadow jumping mouse, all with more eastern or northern affinities, are absent from this area. This combination of species strongly suggests a short grass prairie on the uplands surrounding Ash Hollow. This sympatry, as the northern one, indicates a

longer period of snow cover and cooler averages than in the area today.

Summary of Paleoecological Interpretations

The 16 micromammal species associated with the Late Paleoindian occupation at the Clary Ranch site provide insight into paleoenvironmental conditions in and around Ash Hollow ~9000 yr B.P. Initial observations suggest: (1) The overall environment on the uplands closely resembled the modern arid, short-grass prairie but precipitation was more effective than at present. Longer duration and increased snow cover, especially where protected by north-facing valley walls, would increase effective moisture during the period of occupation. (2) A gallery forest in Ash Hollow was better developed than at present and it was associated with tall grass prairie stands, meadows and wet lands. (3) Winter extremes were not as great in the valley. For microfauna, this could have been enhanced by a longer-lasting blanket of snow. (4) Cooler summers, on average, were the norm. (5) The chronological proximity of the Late Paleoindian component to glacial non-analog faunal associations in combination with protective north-facing slopes of Ash Hollow, probably assisted preservation of microenvironments suitable for the relict, late-glacial fauna.

Stop 3: Cut Bank 21 (West Cut Bank)

The Clary Ranch site is present not only beneath the low, Late-Holocene cut terrace that existed in Area A before the site was excavated (Myers et al., 1981), but it is also exposed near the base of a 9 m- to 14 m-high eroded remnant of Terrace 2 to the west of Area B (Figure 3). The sediments beneath this local remnant of the Terrace 2 are well exposed from stream level to the surface of the terrace in cut bank 21 (west cut bank). Organic stratum A (OSA), which is present all across the Clary Ranch site and was used as a stratigraphic marker by Myers (1981, 1982) (“black carbonaceous zone”), can be traced from Area B across about half of cut bank 21 (west cut bank). May described sampled Profile 2 in 2001 and the much longer Profile 1 in cut bank 21 (west cut bank) in 2004 (Appendix E; Fig. 32). The primary purposes for studying Profile 1 were to

gain a better picture of the Early-Holocene deposits that bury the cultural components at the site, and to reconstruct paleoenvironmental trends at the site from before to after site occupation. In this profile another organic stratum (D) (OSD) is exposed continuously from east (downstream) of Profile 1 to near the far west (upstream) end of the cut bank (Fig. 32). Two chipped stone artifacts, both unmodified waste flakes, were found in the stratigraphic position of OSD at the south-west end of the cut bank.

Four of the five Early Holocene alluvial sedimentary units in the Ash Hollow basin are exposed in Profile 1 in cut bank 21 (west cut bank). Unit II (and the Brady Soil), unit IV, and unit V are exposed in the lower part of the cut bank (Fig. 33). Unit V is 3.3 m thick, which is about the same thickness as in cut bank 25 (east cut

bank). Unit VI is comprised of gravelly silt loam, loam, and sand; in short, it is coarser textured than unit V.

Sand content of units II, IV, and lower unit V range from about 50% to 70% in Profile 1 in cut bank 21 (west cut bank) (Fig. 34). Unit II coarsens upward, then fines upward into the Brady Soil as in Profiles A and B in the backhoe trench. Unit IV is slightly finer than unit II in Profile 1 in cut bank 21 (west cut bank), while unit V is generally coarser than unit IV here.

The pattern of organic carbon with depth in Profile 1 in cut bank 21 (west cut bank) is very similar to that in Profile A in the backhoe trench (Fig. 23). It increases, then diminishes, and then increases again upward into the Brady Soil. The organic strata recognized in laminated unit IV in Profile 1 are evident in the organic carbon contents of samples from unit IV (Fig. 34).

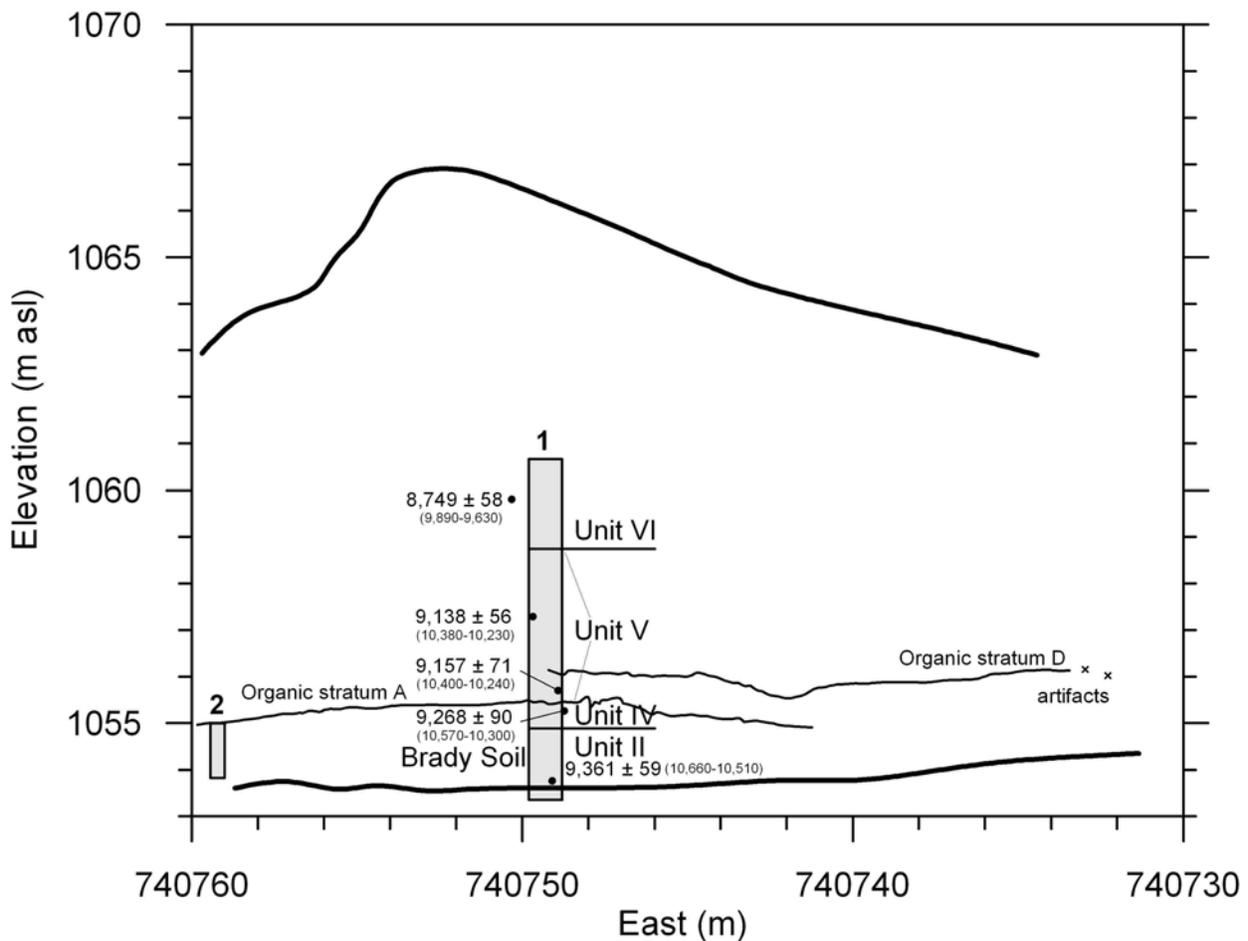


Figure 32. Profile of cut bank 21 (west cut bank) showing locations of Profiles 1 and 2, organic strata A and D (OSA and OSD), and elevations of stratigraphic units.

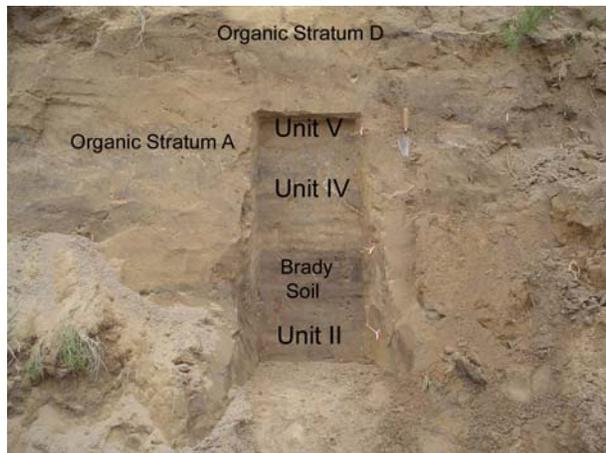


Figure 33. Lower portion of Profile 1, cut bank 21 (west cut bank). Photo by David W. May, June 20, 2004.

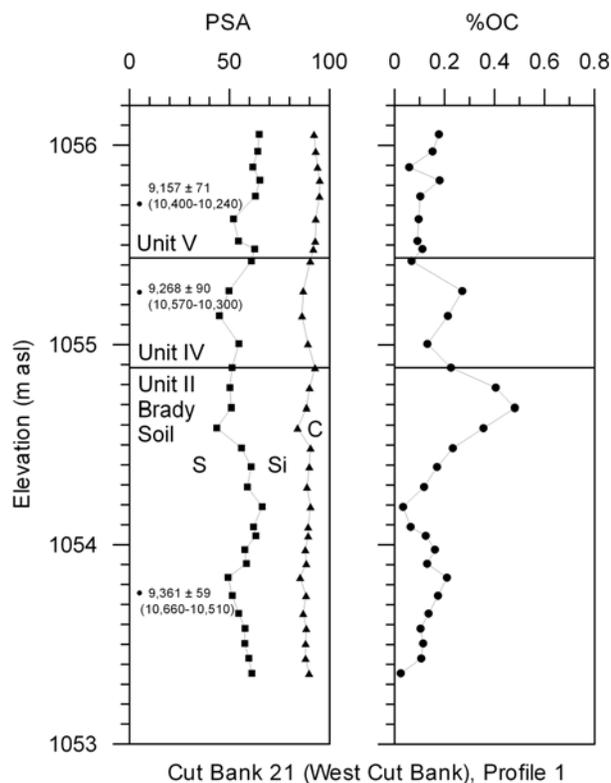


Figure 34. Particle-size distribution and organic-carbon content of sediment samples from Profile 1, cut bank 21 (west cut bank).

Organic carbon contents of samples from unit V are lower than those for unit IV in Profile 1, consistent with the interpretation of more rapid sedimentation of unit V.

In Profile 1 in cut bank 21 (west cut bank), unit II and the Brady Soil are younger than in the backhoe trench and downstream at cut bank 25. In Profile 1 in cut bank 21 (west cut bank) the Brady soil is younger than 9,361 ± 59 yr B.P. (10,660-10,510 cal yr B.P.; AA62529) (Fig. 32). The only age determined for unit IV in the Ash Hollow Basin is from Profile 1 in cut bank 21 (west cut bank), and here charcoal from an elevation of 1055.263 m yielded a radiocarbon age of 9,268 ± 90 yr B.P. (10,570-10,300 cal yr B.P.; AA62535). A maximum sedimentation rate for unit II, based on the elevations of dated charcoal samples from unit II near the channel bed and a sample in approximately the middle of unit IV (1053.758 m and 1055.263 m, respectively) and the calibrated radiocarbon ages of the samples is 41.8cm/yr. A minimum sedimentation rate cannot be determined because of overlap of the calibrated ages.

The two ages from unit V in Profile 1 in cut bank 21 (west cut bank) confirm a very rapid accumulation rate for unit V. The nearly identical ages of charcoal (about 9,150 yr B.P.; Table 1; Fig. 32) from unit V in this profile indicate very rapid deposition. A sample of charcoal from an elevation of 1069.812 m in unit VI yielded a radiocarbon age of 8,749 ± 58 yr B.P. (9,890-9,630 cal yr B.P.; AA64354); this confirms the very rapid sedimentation indicated by the ages of charcoal in unit V (Fig. 32). Using the elevation (1055.706m) and calibrated age of the lowest unit V sample, and the elevation (1059.812 m) and calibrated age of the sample from unit VI, the minimum sedimentation rate for unit V and lower unit VI was 0.53 cm/yr, while the maximum rate was 0.85 cm/yr.

The delta-13C values and the resultant calculated percentages of C4 plants have been determined for the entire Profile 1 in cut bank 21 (west cut bank) (Fig. 35). The delta-13C values vary little up-profile through units II, IV, and the lower half of unit V, with the exception of a sharp increase in OSD at ~1056.1m. However, in the upper half of unit V there is generally a steady increase in delta-13C values beginning slightly before 9,138 ± 56 yr B.P. (10,380-10,230 cal yr B.P.; AA62548) and lasting until after 8,749 ± 58 yr B.P. (9,890-9,630 cal yr B.P.; AA64354). This trend suggests increasingly drier conditions in the valley beginning shortly after occupation of the site.

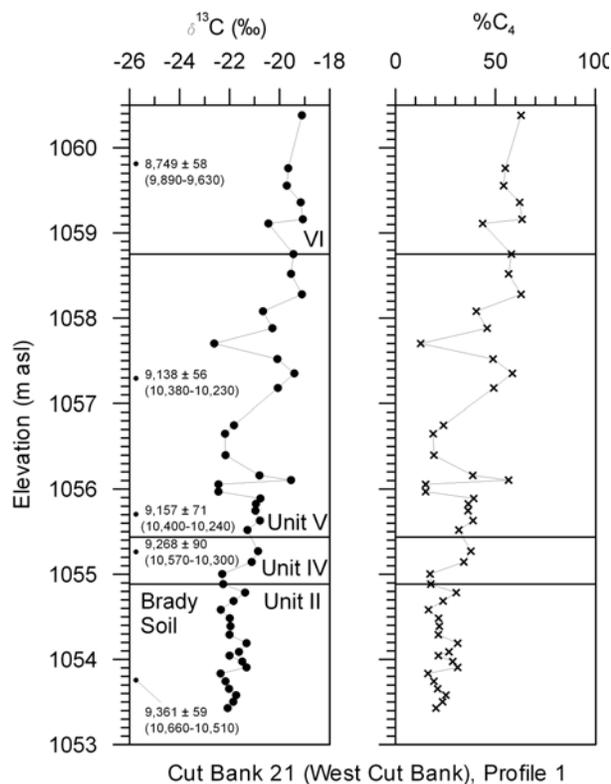


Figure 35. Delta 13C and derived percentage C4 plants in samples from Profile 1, cut bank 21 (west cut bank).

Stop 4: O.V. Clary Site (25GD50)

Introduction

The O.V. Clary site is situated along a straight, east-west trending section of Ash Hollow Draw, a short distance from a point bar where the draw turns abruptly east (Figs. 1 and 36). The site was discovered fortuitously on June 9, 2004 when Hill and two of his graduate students went to collect and GPS the location a mammoth scapula found the day before by an undergraduate field school student. While waiting for the GPS to capture the necessary satellite data, bison remains, charcoal, and chipped stone artifacts were discovered eroding out of the south cut bank in the immediate vicinity of the mammoth scapula. About a month later, on July 2, Hill and May visited together, at which time May strongly suspected the silt encasing the archaeological material was early Holocene in age. May's suspicion was confirmed several months later when a radiocarbon assay on charcoal collected from



Figure 36. Overview of the O.V. Clary site in 2006 looking ~southeast. The excavation cover is positioned over the entire 2005-2007 excavation area.

the cut bank yielded an age of $9,191 \pm 45$ B.P. Although we now regard this date as being unreliable, it inspired us to conduct test excavations at the site in 2005, which in turn led to additional excavations in 2006 and 2007. This work involved archaeological excavations and geoarchaeological investigations, including paleoecological sampling. In 2006, a backhoe trench was also excavated perpendicular to the draw in order to document the site stratigraphy in north-south cross-section (Figure 36). The three components at the site are clearly within unit lithologic unit V in the basin. At present, we have no plans to continue excavations there.

Archaeology of the O.V. Clary site

To assess the potential of the site for future research, limited archaeological excavations and preliminary geoarchaeological investigations were conducted over the course of two twelve-day field sessions in late May/early June of 2005. The goal of this work was to determine the geoarchaeological setting of the site as well as the density, distribution, preservation, and contextual integrity of various classes of archaeological material. The excavation block (7 m sq.) was positioned on the south bank of Ash Hollow Draw, immediately adjacent to the location where the highest density of bone, chipped stone, and charcoal was observed eroding from near the base of a ~2-3 m high cut bank the previous year. Very early in the season, however, while conducting a preliminary inspection of this cut bank, May identified a concentration of burned and unburned fragmentary bone, burned sediment, charcoal,

microdebitage, and several formal artifacts. This feature is a former hearth, and is associated with Component 2 at the site (Fig. 37). Given the rarity of such features in the Paleoindian archaeological record, subsequent research at the site was directed towards learning more about the structure, character, and context of this component.



Figure 37. Cross-section of hearth at the O.V. Clary site.

Nearly 50 square meters of Component 2 were excavated using high resolution methods designed to recover very small items in situ. In all, ~1,400 artifacts, mostly microdebitage, and nearly ten thousand faunal remains measuring greater than one centimeter in maximum dimension were mapped in situ, as were 649 bits of red ochre. Nearly 1500 5-gallon buckets of excavated sediment were also waterscreened, and produced another ~17,500 pieces of microdebitage and ~9300 bits of red ochre (Fig. 38). Dental eruption/wear analysis of teeth in a bison calf mandible and a bison calf maxilla, as well as size comparisons of fetal bison remains, indicates that this material was deposited over the course of a single, continuous occupation that stretched from mid/late summer to very late winter/early spring.

Artifactual, faunal, and site structural evidence from Component 2 indicates it functioned as a residential base camp for a small group of Late Paleoindian hunter/gatherers. Astonishingly, the occupation was situated on the rapidly aggrading, early Holocene floor of Ash Hollow Draw. Although the occupation undoubtedly covers a much larger area, on-site activities in the excavated area were organized around a hearth area. As illustrated in Figure 39, material culture recovered here includes a spectacular variety of organic and non-

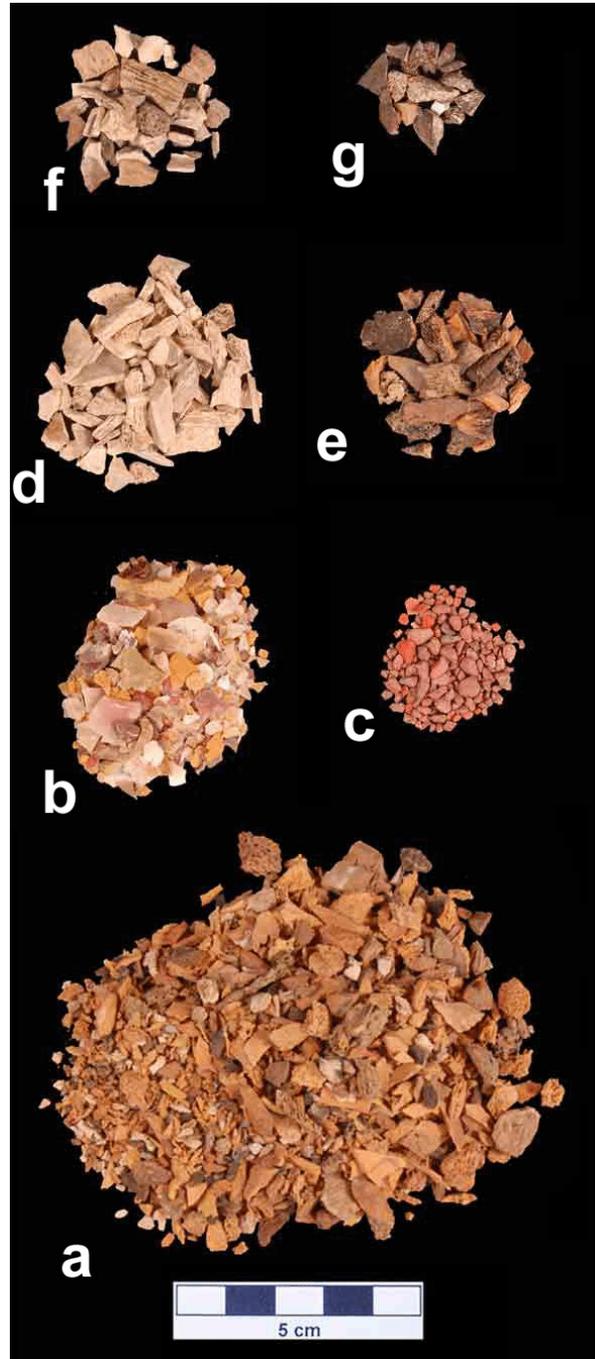


Figure 38. Example of archaeological material recovered in waterscreen matrix from one 50-x-50-x-4 cm excavation quadrant in the hearth area at the O.V. Clary site: a) unburned bone fragments; b) microdebitage; c) red ochre nodules; d) calcined bone fragments; e) partially carbonized bone fragments; f) partially calcined bone fragments; and g) calcined and carbonized bone fragments.

organic remains. The sample of organic artifacts includes 25 bird bone beads (or fragments thereof), 2

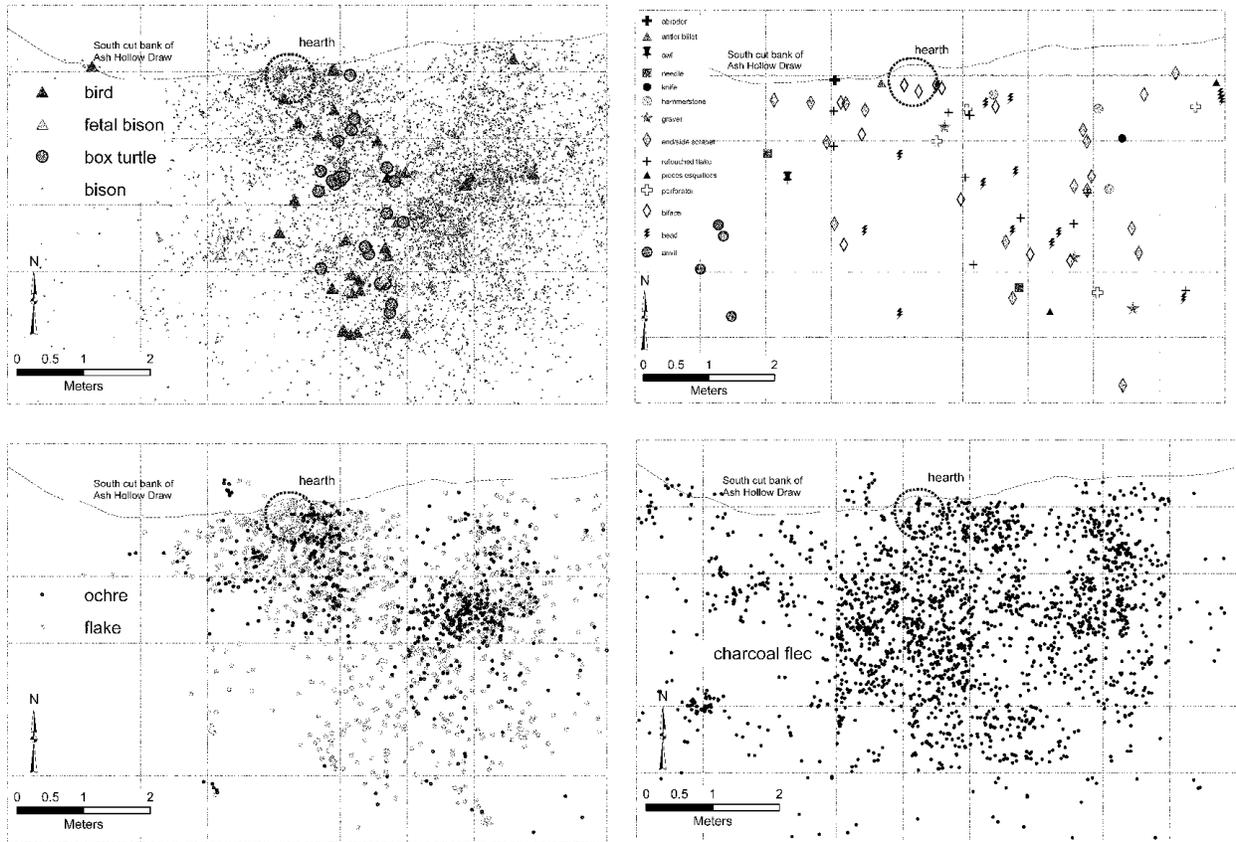


Figure 39. Composite plan maps of various classes of archaeological material contained within Component 2 at the O.V. Clary site.

bone needles, 1 bone awl, and 1 antler billet. The chipped stone assemblage is almost exclusively microdebitage derived from resharpening working edges of unifacial tools and use-spalls detached from the edges of these tools during contact with hard materials. Most of the tools ($n = 52$) are scrapers ($n = 19$) and retouched flakes ($n = 10$). Bifaces ($n = 13$) are represented by tip, base, and edge fragments from finished weapon tips that are thought to have been introduced to the site in transported meat packages. Four perforators, 3 graters, 2 splintered pieces, and 1 knife were also recovered. In contrast to the pattern downstream at the Clary Ranch site, the chipped stone artifacts at the O.V. Clary site are made almost exclusively from White River group silicates. Only a handful of specimens, all unmodified flakes, are made from Smokey Hill silicified chalk. Four anvils, 3 hammerstones and 1 shaft abrader have also been recovered.

Microwear analysis on the scrapers suggests they were held in jam-type hafts and used to process dry hides; the

distal ends of six scrapers are impregnated with red ochre that may have been used as a preservative in finishing the hides. Several utilized flakes have microwear signatures consistent with planing antler. The fact that scrapers, microdebitage, and red ochre are found in the hearth area suggests that activities related to hide finishing occurred here (e.g., tool resharpening, haft maintenance, ochre preparation), though not necessarily the actual process itself as the space requirements would seem too limited. As well, the space was also being used for other domestic-type activities, namely processing and consumption of food packages provisioned by hunters.

Faunal Assemblage

An unusually diverse and exceptionally well preserved sample of faunal remains was recovered from Component 2. Approximately one-tenth of the faunal specimens are bison (NISP = 323) and probable bison (NISP = 1,035) remains. Eight thousand (NISP = 8,499) small,

completely unidentifiable mammal bone fragments are also probable bison remains. Twenty-five (NISP) fetal bison remains are also present. The nonbison fauna includes several birds, one box turtle, and several microfauna. With the exception of the microfauna, interpreted as natural background fauna, the remains of the other taxa display evidence of butchery and/or were recovered from hearth contexts. Considered together, these remains offer a variety of insights on Late Paleoindian subsistence behavior from the perspective of a residential camp.

Bison Remains

No fewer than six bison are discernable in Component 2. Osteometrics of four proximal radii reveals the presence of two bulls and two cows, and tooth eruption/wear indicates the presence of two calves. This age/sex mix suggests that hunters were not preferentially targeting animals of a particular age or sex, while also indicating that the animals were procured singly during encounter-type hunting, and not derived from a multi-animal kill. The pattern of skeletal part representation indicates hunters provisioned consumers with carcass segments cut from animals killed during logistical forays in the general vicinity of the site, either within Ash Hollow or on the uplands surrounding the valley. Long bones far outnumber vertebrae and ribs, suggesting preferential transport of limbs. The presence of scapulae, metapodials, carpals and tarsals further suggests that the transported packages often consisted of complete, or nearly complete, articulated limbs. As Bunn notes, “an articulated limb is, without any modification, an especially convenient package for transporting over the shoulder...[and] a Hadza man has no noticeable problem carrying even the larger hindquarter of a [Cape] buffalo (35-40 kg) for a distance of 5 km” (1993, p. 161-163; see also Bunn et al. 1988, p. 428-429). These inferences are consistent with an extended period of residential occupation during which hunters provisioned consumers on a regular basis with fresh food packages.

At the O.V. Clary site, transported carcass segments were defleshed, disarticulated, and then processed for marrow. All of the long bones display fracture angles and outlines consistent with breakage of fresh, nutritive bone. No complete, unbroken long bones exist in the assemblage. However, in contrast to the Clary Ranch site, where the objective was to quickly and systemati-

cally amass a large quantity of marrow as part of a future-oriented subsistence strategy, marrow processing at O.V. Clary is best characterized as a hearth-centered, down-time subsistence activity occurring throughout the duration of the occupation. This inference is bolstered by the fact that extremely marginal sources of marrow were targeted, specifically, that contained within first phalanges and rib blades.

All of the fetal bison remains were recovered around the hearth. At least three fetuses were harvested from pregnant cows. Since bison rarely give birth to twins (Berger and Cunningham, 1994, p. 114), the specimens provide indirect evidence for the deaths of three individual cows, one more than is represented in the extant sample of bison remains. More important, however, is the recovery context of the fetal remains, suggesting that they were gathered around the hearth for a specific purpose(s). Their consumption, either as a delicacy or to alleviate problems associated with a diet high in lean meat (Malainey et al., 2001, p. 147), seems probable. In addition, the hides may have been used to manufacture bags and/or clothing for children (Speth, 1983, p. 2).

Bird Remains

Though not large, the avifauna offers a fascinating glimpse into Late Paleoindian exploitation of birds. The sample includes the proximal wing of a raven (*Corvus corax*) represented by a partially burned left proximal humerus, plus six distal wing elements belonging to a great horned owl (*Bubo virginianus*). A complete right radius-ulna of an indeterminate medium passerine and a left distal ulna of an indeterminate small passerine were also recovered from hearth-fill. The remainder of the avifauna consists of long bone shaft fragments and flat bone fragments belonging to indeterminate medium to large birds. All of these long bone shaft fragments display spiral fractures, and two are also partially burned. It seems probable that these specimens are either great horned owl or raven remains (or a bird of this general size class). No other Paleoindian site has produced such a diverse avifauna, and the fact that the remains were recovered in secure cultural context makes them all the more significant. The only other site of this general age to produce raven remains is Charlie Lake Cave in British Columbia (Driver, 1999). Thus, the O.V. Clary site is the first Paleoindian site to produce great horned owl remains from a secure cultural context as well as the

first to produce the co-occurrence of great horned owl and raven.

Box Turtle Remains

One turtle is represented among over about fifty burned and unburned carapace pieces. Although the specimens are too fragmentary for definite taxonomic identification, they almost certainly belong to the Ornate box turtle (*Terrapene ornata*), a small, high-domed terrestrial turtle found today throughout the central and southern Great Plains in prairie-type settings (Ernst et al., 1994). This taxonomic assessment is bolstered by the fact that at least two Ornate box turtles have been securely identified at the Clary Ranch site; one individual recovered in 1979 by the UNSM crew, the second recovered during the 2003 excavations. Although none of the box turtle remains from the Clary Ranch site are burned, several carapace fragments display scrapes and cut marks on the ventral aspect that are similar to those recorded on specimens from the O.V. Clary site. Interestingly, only carapace fragments are represented at both sites, and none of the specimens display damage from hammerstone blows directed toward extracting the meaty core (sensu lato Stiner and Tchernov, 1998, Fig. 6). As well, at the Clary Ranch site, the centrums and transverse spines on several neurals were intentionally removed by scraping, cutting, and carving. These observations are consistent with the inference that Late Paleoindians exploited box turtles primarily for their carapaces, perhaps treating them as curated, container-like tools.

Landforms

The O.V. Clary site is present in eroded Terrace-2 fill below two, low, Late-Holocene cut terraces along Ash Hollow Draw. Beneath the lowest cut terrace about 50cm of historical sediment unconformably overly Early Holocene alluvium. In other areas recent channel erosion has removed this deposit and exposed a Late Holocene (prehistoric) fill unconformably overlying Early Holocene deposits. The site also likely extends to the south beneath a third, slightly higher cut terrace. The relief difference among these cut terraces is about one meter between any two. Immediately south of the site there is a remnant of Terrace 1 in the valley, as at the Clary Ranch site. A bucket auger hole revealed that the fill beneath it is coarse; an outlier of bedrock may form the core of this terrace. Further south-southeast of

the site and northwest of the site extensive remnants of Terrace 2 are present in Ash Hollow valley. These remnants stand 18m above the modern channel of Ash Hollow Draw. The site is in the lower one meter of the fill beneath this 18m-high terrace.

Stratigraphy

In 2004 when May and Hill first visited the site together, May recognized the deposits along the draw as being very similar to those at the Clary Ranch site. During the 2005 field season, May confirmed that the three cultural components at O.V. Clary are within the lower portion of unit V in the Ash Hollow Valley -- a similar stratigraphic position to the cultural components at the Clary Ranch site downstream. In 2005 he described nine cut bank profiles during the initial excavation of the site. The most important is Profile 4, which was destroyed during the 2006 season excavations (Figs. 40, 41, 42, 43). Here he recognized that the individual flood couplets (laminations) were the same as in three other bank profiles downstream and in the opposite bank. The contrast within a flood couplet between the more organic-rich flood drape over the flood deposit is much more at O.V. Clary than at the Clary Ranch site. This may relate to the position of the two sites within the small, ephemeral basin (i.e. character of flooding), or to local topography within the meander belt of Ash Hollow at the O.V. Clary site..



Figure 40. Location of cut bank Profile 4 at the O.V. Clary site relative to 2005 excavations. Photo by David W. May, May, 2005.

The flood couplets in lower unit V at the site are each interpreted as representing a single, low-magnitude flood. Each lamination in cut bank Profile 4 was numbered from 1 (lowest within unit V) to 18 (the highest



Figure 41. cut bank Profile 4 at the O.V. Clary site. Photo by David W. May, May, 2005.



Figure 42. Cut bank at O.V. Clary site after it was cleaned off showing the laminations within the lower portion of unit V. Photo by David W. May, May, 2005.

exposed below the Late-Holocene/Early Holocene unconformity) where odd numbers represent the thicker, coarse, less-organic-rich primary flood (aggradation) deposit, and the even numbers represent the thinner, finer-textured, more organic-rich flood drape. Where the individual laminations become thicker and separate into sub laminae, they were subdivided with lowercase letters (e.g. 6a, 6b, etc.). The cultural components are generally associated with laminations 4, 10, and 12. Component 2, which was discussed above by Hill, is present throughout the site on and within lamination 10. It dates to 9043 ± 42 to 8993 ± 54 yr B.P. (AA65422, AA65425). In areas of the densest cultural material, the laminae are disturbed and cannot be identified.

Below unit V at the O.V. Clary site is a deposit (exposed in Profile 4) that is equivalent to unit IV downstream (Fig. 44). It is brown and massive, but contains more pebbles than at the Clary Ranch site. Two explanations are possible. First, the site appears to be on the low part of the floor of the valley (in the active meander belt). Coarser deposits are to be expected in this topographic setting. Second, there is an outcrop of Ogallala Group rock immediately upstream of the site which could have served as a source for the carbonate pebbles in the unit. A bucket auger hole was cored in the floor of the excavated hole below cut bank Profile 4 (Fig. 44). In this hole coarser gravels were recovered, and three separate fining upward sequences of alluvium were identified. Thus, sediments recovered from the auger hole are interpreted as unit III.

At O.V Clary, the sedimentation rate was very high. Because only a little more than a meter of unit V is exposed, it is difficult to estimate sedimentation rates from the radiocarbon ages of charcoal. However, in Profile 3 (north bank) charcoal was recovered from a pit (upper unit IV) excavated below stream level as well as in the cut bank above lamination 12 within unit V. Using the elevations of the samples, and the calibrated radiocarbon ages for the samples (AA65426 and AA70723, Table 1), the sedimentation rate was between 0.13 cm/yr and 1.47 cm/yr for lower unit V and the very uppermost few centimeters of unit IV.

Backhoe Trench

In 2006 a backhoe trench was excavated west of the excavation area (Fig. 36). The stratigraphy of the east wall of the trench was carefully determined (Fig. 45). This trench confirmed that Component 2 was in the deepest portion of the former meander belt of Ash Hollow, but it is not in a defined channel as at the Clary Ranch site. This is likely the result of the smaller drainage area and rapid aggradation. If a well defined channel was present, which we do not believe to be the case, then it existed elsewhere in the narrow valley at the time.

Another observation from the backhoe trench was that cultural material extends upstream of the excavated area. Thus, the site likely covers at least 100 m sq. Significantly, the backhoe trench cut through a second hearth; a base of an Allen point and an endscraper was recovered from it.

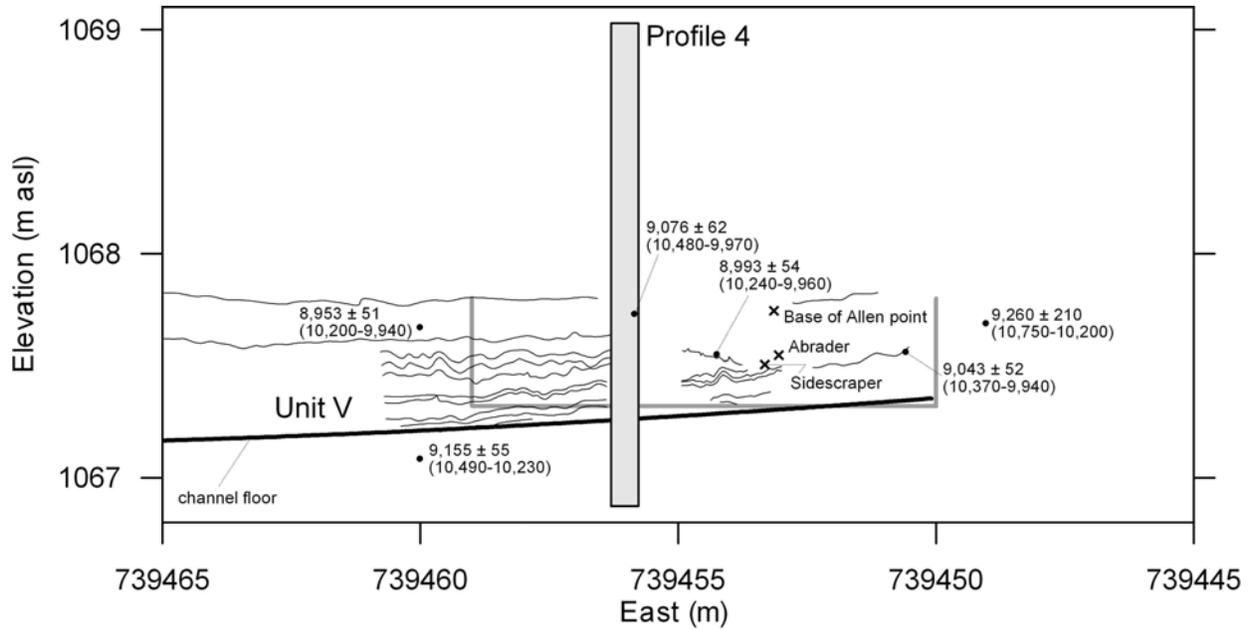


Figure 43. Profile of cut bank at the O.V. Clary site.

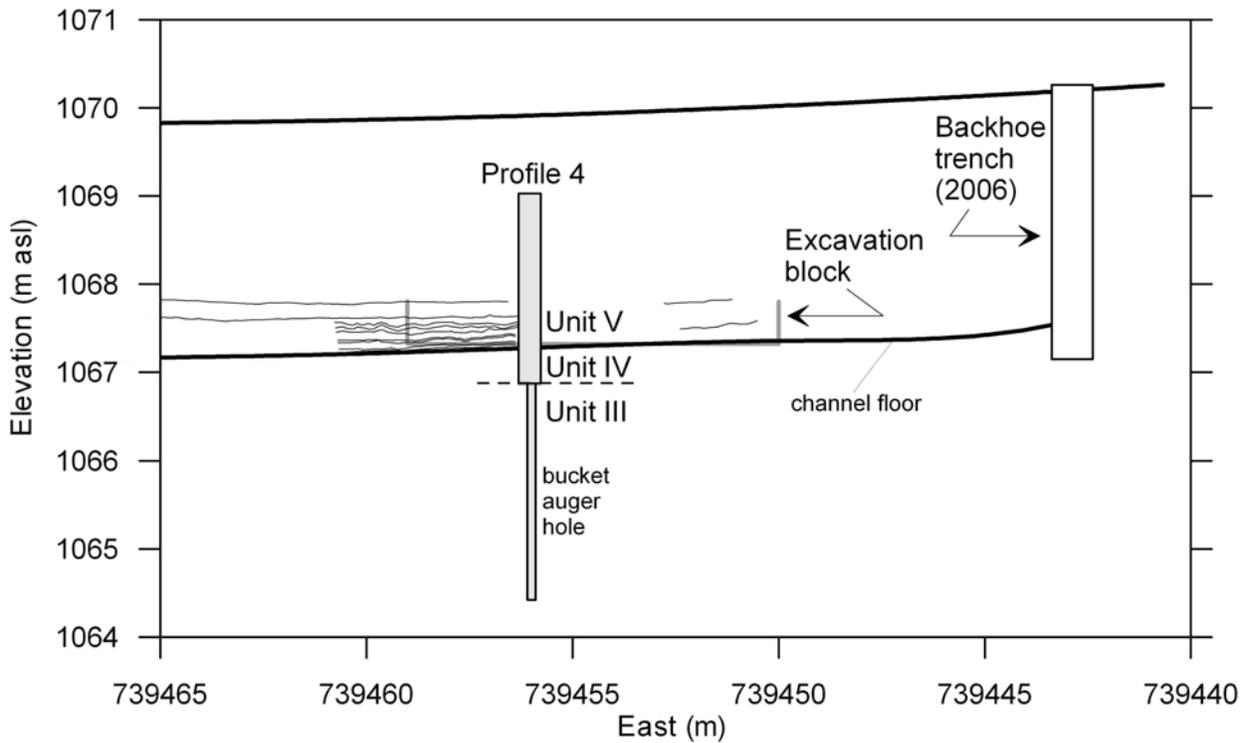


Figure 44. Profile of cut bank at the O.V. Clary site showing complete auger hole below Profile 4.

Finally, the laminations that were identified in the cut bank and the excavation area could also be identified in the trench walls. As in the excavation area, where the

cultural material was densest and in the area of the hearth, individual laminations could not be identified. However, they could be identified on both sides of the

hearth. The trench was perpendicular to Ash Hollow Draw, and this permitted us to observe what happens to the laminations as we moved out of the lowest part of the former valley onto slightly higher areas. Here the laminations merged and some could not be identified at

all. Rather, thicker strata were observed that encompassed several laminations. Cultural material also diminished toward the south edge of the valley in the backhoe trench.

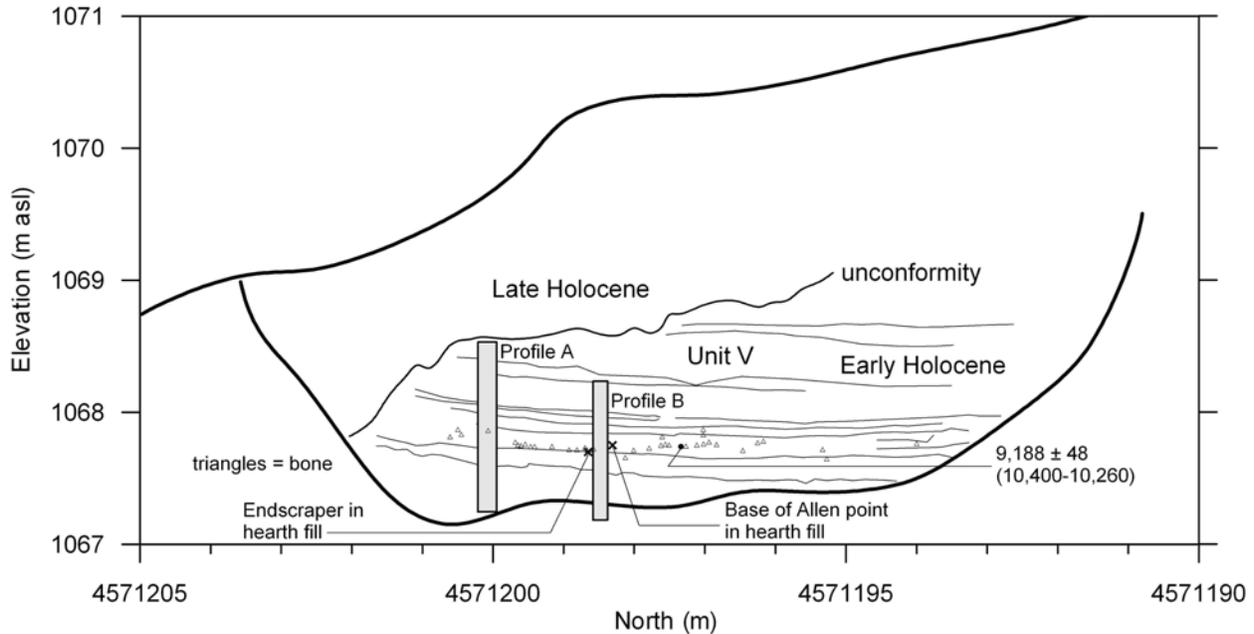


Figure 45. Profile of entire east wall of the backhoe trench at the O.V. Clary site.

Stop 5: Ash Hollow State Park Cut Bank

Ash Hollow State Park (AHSP) cut bank is in a tributary to lower Ash Hollow (Fig. 46). Drainage area above the cut bank is about 2.5 km sq. The cut bank exposes deposits very similar to those in cut banks 21 (west cut bank), and 25 (east cut bank), and in the backhoe trench at Clary Ranch (Fig. 47; Appendix F). Unit III is exposed in the lower third of the cut bank (Fig. 49). It consists of ripple- and horizontally-laminated coarse silt and very fine sand, and low-angle, cross-bedded silty gravel. Unit III here is similar to the gravelly silt and sand channel deposits below Profile C in the backhoe trench at the Clary Ranch site (Fig. 18).

An organic stratum that is stratigraphically equivalent to organic stratum A (OSA) at the Clary Ranch site is exposed across much of the AHSP cut bank and is locally the basal stratum of unit V (Fig. 49). Here the



Figure 46. Ash Hollow State Park cut bank, view northwest. Photo by David W. May, July 2, 2004.

organic stratum is 13cm thick, which is considerably thicker than in cut banks along Ash Hollow and at the Clary Ranch site. Unit V is very similar morphologically to unit V in the main Ash Hollow Valley (i.e.



Figure 47. Ash Hollow State Park cut bank before described and sampled. Shovel handle is just above the surface of the organic stratum in the cut bank. Holes immediately to left of shovel are those created by Bob Diffendal during his mapping in the area. The two, larger, higher holes are where Jim Swinehart collected radiocarbon samples in the early 1990's. Photo by David W. May, July 1, 2004.

thinly ripple- and horizontally-laminated) (Fig. 50). It also contains abundant flecks of charcoal as elsewhere in the basin. Unit V dates between 9,077 yr B.P. (10,270-10,190 cal yr B.P.; AA62534) and 8,980 yr B.P. (10,260-9820 cal yr B.P.; AA62532). In addition, Swinehart et al. (1994) have reported an age of 8820 ± 210 yr B.P. for a sample of charcoal from unit V above the organic stratum (Fig. 49).

Particle-size data for the AHSP cut bank confirm that Unit V is finer than unit III (Fig. 50). According to these data, Unit V is part of a general fining-upward trend from the sand and gravel lenses at the base of the cut bank. The organic stratum does not interrupt this fining-upward sequence. Organic carbon is consistently low throughout unit III, increases in the organic stratum, and then decreases upward into unit V. Unit IV is not recognized in this cut bank.



Figure 48. Close-up of unit V in the Ash Hollow State Park cut bank before described and sampled. Photo by David W. May, July 1, 2004.

Although there are limited delta-13C data from the AHSP cut bank, the data show an overall trend of decreasing delta-13C values through unit III that continues into overlying unit V (Fig. 51). This trend is only interrupted by a slightly higher delta-13C value for the organic stratum. While there are only three values for the lower part of unit V, they fall between -22 and -20 parts per thousand, which is consistent with the other profiles where values have been determined on samples from unit V.

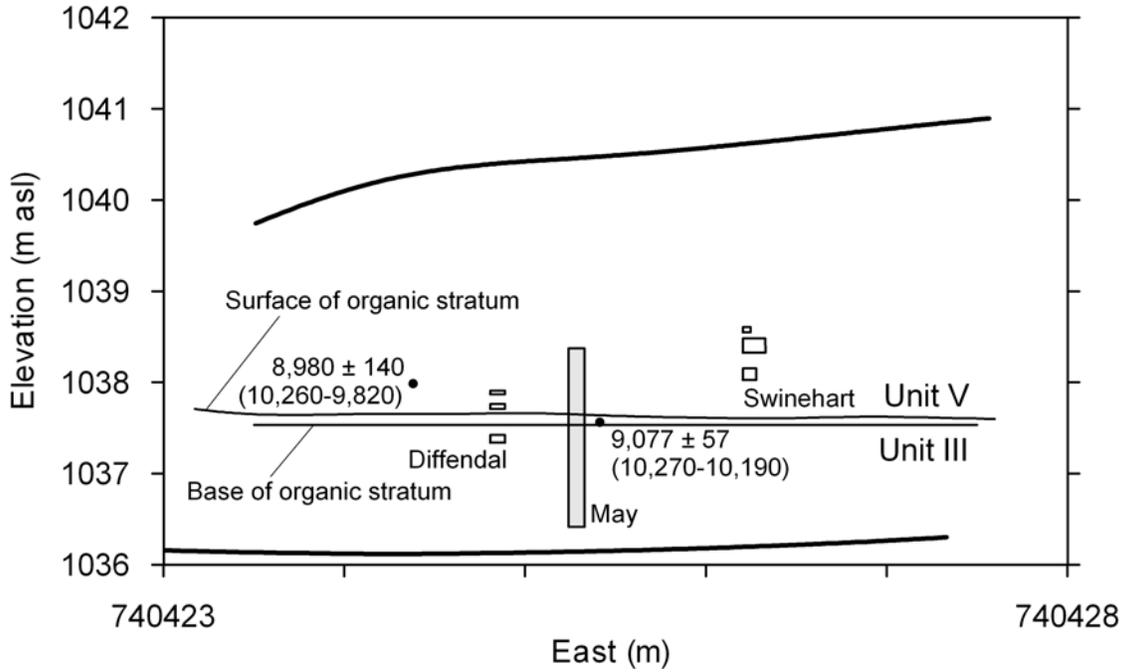


Figure 49. Profile of the Ash Hollow State Park cut bank showing May's profile, locations of samples collected by Bob Diffendal in the 1980's and Jim Swinehart in the early 1990's.

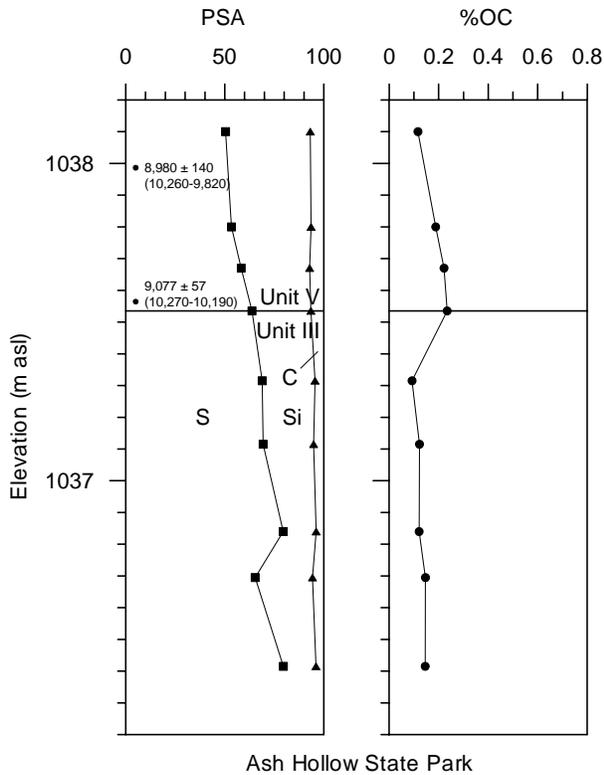


Figure 50. Particle-size distribution and organic-carbon content of sediment samples from Ash Hollow State Park cut bank.

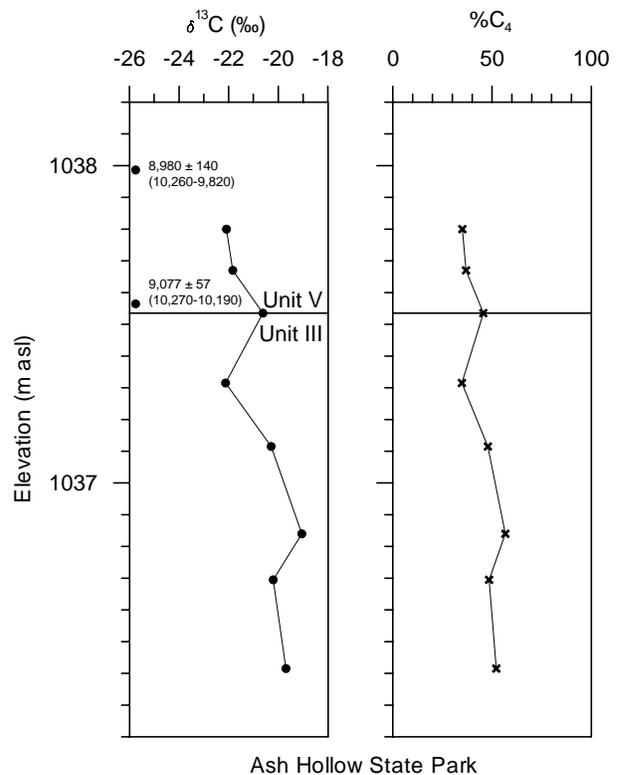


Figure 51. Delta 13C and derived percentage C4 plants in samples from Ash Hollow State Park cut bank.

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Appendices

Appendix A. Description of sediment in cut bank 25 (East Cut Bank) downstream of the Clary Ranch site. Unit II, Brady Soil, and unit IV are described in this profile.

UTM coordinates: N 4571650.650; E 741097.312
 Landform: Eroded Terrace 2 in Central Great Plains terrace sequence
 Sediment: Alluvium derived from loess and the Ash Hollow Fm.
 Land use or vegetation: Pasture
 Described by: David May
 Date described: 6/30/04
 Sample technique: Cleaned cutbank
 Elevation data for profile is the bottom and top of profile: 1052.042 m asl and 1053.140 m asl, respectively

Elevation (m asl)	Description
1052.960-1053.140	Dark grayish brown (10YR 4/2, moist) silt loam with less than 1% locally-derived, fine, carbonate gravel; few, fine, distinct, dark yellowish brown (10YR 4/6, moist) mottles; horizontally laminated with each lamination ranging from about 1-2cm thick and including a lamination of very fine sand; firm; abrupt, smooth lower boundary; very small amount of bioturbation.
1052.890-1052.960	Brown (10YR 4/3, moist) silt loam; few, fine, faint, yellowish brown (10YR 5/4, moist) mottles; massive; very friable; abrupt, smooth lower boundary; lower boundary looks like it might have been slightly eroded before this stratum was deposited; thin, organic-rich lamination at surface of this deposit; looks like this stratum was deposited by Ash Hollow and not derived locally from tributary.
1052.720-1052.890	Dark brown (10YR 3/3, moist) silt loam with 3-6% locally-derived, fine, subrounded, carbonate gravel; few, fine, distinct, yellowish brown (10YR 5/4, moist) mottles; massive; common, fine, carbonate concretions; abrupt, wavy lower boundary; many hackberry seeds and flecks of charcoal; stratum dips out of the cut bank.
1052.670-1052.720	Black (10YR 2/1, moist) silt loam with 3-5% locally-derived, fine, subangular, carbonate gravel; few, fine, distinct, yellowish brown (10YR 5/4, moist) mottles; massive; very friable; few, fine, carbonate concretions; abrupt, wavy lower boundary (erosional); insect bioturbation and one small mammal burrow; lower boundary slopes up into the cut bank, so the apparent gap of 6cm results from cleaning the profile back further into the cut bank; this is an organic-rich stratum at the base of Unit IV derived from erosion of the surface of the Brady Soil; a charcoal sample from within the lower part of this stratum at elevation 1052.683m yielded radiocarbon age of $9,514 \pm 58$ (11,070-10,700 cal yr B.P.; AA62541) and is considered an age for the surface of the Brady Soil.
1052.300-1052.610	Very dark gray (10YR 3/1, moist) (surface several cm) and very dark grayish brown (10YR 4/2, moist) (lower part of stratum) silt loam with 5% locally-derived, fine, subrounded carbonate gravel; common, fine and medium, prominent, yellowish brown (10YR 5/4, moist) mottles; massive; few, fine, carbonate concretions; gradual, smooth lower boundary; surface of this stratum is the surface of Unit II and the Brady Soil (surface has been eroded).
1052.040-1052.300	Very dark grayish brown (10YR 4/2, moist) loam with 5% locally-derived, fine, subrounded, carbonate gravel; common, medium, distinct, yellowish brown (10YR 5/4, moist) mottles; massive; very friable; common, fine, carbonate concretions; stratum immediately below the base of Brady Soil.

Appendix B. Description of sediment in profile A in the northeast wall of backhoe trench at the Clary Ranch site. Units II and IV are described in this profile.

Location (US Public Land Survey): SW 1/4, SE 1/4, NW 1/4, sec. 22, T. 15 N, R. 42 W.

UTM coordinates: N 4571499.160; E 740796.703

Landform: Eroded Terrace 2 in Central Great Plains terrace sequence

Sediment: Alluvium derived from loess and the Ash Hollow Fm.

Land use: Pasture

Vegetation: Grasses

Described by: David May

Date described: 5/27/2004 and 6/15/2004

Sample technique: Cleaned wall of backhoe trench.

Elevation data for description are top of laminated silt (Unit IV) and the bottom of profile

(floor of trench): 1054.703 m asl and 1052.720 m asl, respectively

Elevation (m asl)	Description
1054.700-1054.930	Dark brown (10YR 3/3, moist) loamy sand; horizontally laminated; very friable to loose; abrupt, wavy lower boundary; 5-10% gravel; Late Holocene sands and gravels; base of unit is the Late Holocene-Early Holocene unconformity at the site.
1054.650-1054.700	Brown (10YR 4/3 and 5/3, moist) coarse silt (silt loam); common, fine, distinct dark yellowish brown (10YR 4/4, moist) mottles; ripple laminated with soft sediment deformation features; very friable; common fine carbonates along bedding planes; abrupt, wavy lower boundary; unit pinches out to the northwest and a gravelly silt is present at the same elevation; surface of this stratum is surface of Unit IV.
1054.540-1054.650	Brown (10YR 4/3, moist) coarse silt (silty loam); many, medium, distinct, dark yellowish brown (10YR 4/6, moist) mottles; ripple laminated with evidence of soft sediment deformation; very friable; common, medium and a few coarse carbonate concretions along bedding planes; abrupt, wavy lower boundary.
1054.490-1054.540	Brown (10YR 4/3, moist) coarse silt (silt loam); many, medium, distinct, dark yellowish brown (10YR 4/6, moist) mottles; ripple laminated and weak, fine, subangular blocky; very friable; abrupt, wavy lower boundary; unit is slightly redder than above unit and more mottled than below.
1054.430-1054.490	Brown (10YR 4/3, moist) coarse silt (silt loam); many, fine and medium, distinct, dark yellowish brown (10YR 4/4, moist) mottles; ripple laminated with soft sediment deformation features; very friable; few, fine carbonate concretions; abrupt, wavy lower boundary; unit is slightly darker than above and below.
1054.375-1054.430	Brown (10YR 5/3, moist) coarse silt (silt loam); many, fine and medium, distinct, dark yellowish brown (10YR 4/4, moist) mottles; ripple laminated; very friable; few, fine carbonate concretions; abrupt, wavy lower boundary; unit varies in thickness of 5 to 10 cm along wall.
1054.345-1054.375	Brown (10YR 5/3, moist) silty clay loam; many, fine, faint, yellowish brown (10YR 5/4, moist) mottles; moderate, fine, angular blocky; very friable; abrupt, wavy lower boundary; clay flood drape.
1054.215-1054.345	Brown (10YR 4/3, moist) coarse silt (silt loam); common, fine, distinct, yellowish brown (10YR 5/4, moist) and dark yellowish brown (10YR 4/6, moist) mottles; ripple laminated with soft sediment deformation features and weak, fine, subangular blocky; very friable; abrupt, wavy lower boundary; upper half of unit is coarser than lower half.
1054.170-1054.215	Brown (10YR 4/3, moist) coarse silt (silt loam); common, medium, faint, yellowish brown (10YR 5/4, moist) mottles; ripple laminated with soft sediment deformation features at base and weak, fine, subangular blocky in upper part; very friable; abrupt, wavy lower boundary; unit includes two very fine sand laminae at 1054.170-1054.180 and 1054.180-1054.190.
1054.100-1054.170	Brown (10YR 4/3, moist) coarse silt (silt loam); common, fine and medium, faint, yellowish brown (10YR 5/4, moist) mottles; ripple laminated with soft sediment deformation features at base and massive in the upper part; very friable; abrupt, wavy lower boundary; unit includes a 2-3mm-thick dark grayish brown lamination; lower boundary of this stratum is base of unit IV.
1053.970-1054.100	Very dark grayish brown (10YR 3/2, moist) loam; common, fine and medium, distinct, dark yellowish brown (10YR 4/4, moist) mottles; horizontally; friable; abrupt, smooth lower boundary; 10-15% gravel; surface of this stratum is surface of unit II; a charcoal sample from an elevation of 1054.002m immediately southeast of the profile yielded a radiocarbon age of $9,441 \pm 55$ yr B.P. (10,700-10,590 cal yr B.P.; AA64303).
1053.900-1053.970	Dark grayish brown (10YR 4/2, moist) silt loam; common, fine and medium, distinct, dark yellowish brown (10YR 4/4, moist) mottles; massive; very friable; few, fine, carbonate concretions; abrupt, smooth lower boundary; some bioturbation; few, very small flecks of charcoal.

- 1053.600-1053.900 Very dark grayish brown (10YR 3/2, moist) silt loam; few, medium, distinct, yellowish brown (10YR 4/6, moist) mottles; massive; very friable; few, fine, carbonate concretions; clear, smooth lower boundary; common, very small flecks of charcoal throughout; surface of Brady Soil.
- 1053.475-1053.600 Dark grayish brown (10YR 4/2, moist) silt loam; few, fine, distinct, yellowish brown (10YR 4/6, moist) mottles; massive; very friable; common, fine, carbonate concretions; clear, wavy lower boundary; bioturbation at lower boundary.
- 1053.335-1053.475 Dark brown (10YR 3/3, moist) silt loam; few, fine, distinct, filamentous, yellowish brown (10YR 4/6, moist) mottles; weak, fine, subangular blocky; friable; discontinuous, thin, dark grayish brown (10YR 4/2) clay coatings on ped faces; common, fine, carbonate concretions in upper portion of unit; abrupt, smooth lower boundary.
- 1053.300-1053.335 Very dark brown (10YR 3/2, moist) silt loam; many, fine, distinct, filamentous, yellowish brown (10YR 4/6, moist) mottles; weak, fine, subangular blocky; friable; discontinuous, thin, very dark grayish brown (10YR 3/2) clay coatings on ped faces; few, fine, carbonate concretions; abrupt, smooth lower boundary; a charcoal sample from an elevation of 1053.316m immediately southwest of the profile yielded a radiocarbon age of $9,890 \pm 56$ yr B.P. (11,390-11,230 cal yr B.P.; AA64302).
- 1053.170-1053.300 Brown (10YR 4/3, moist) silt loam; common, fine, distinct, filamentous, strong brown (7.5YR 4/6, moist) mottles; massive; friable; abrupt, smooth lower boundary; common root pores; krotovina present.
- 1053.080-1053.170 Brown (10YR 4/3, moist) silt loam; common, fine, distinct, filamentous, dark yellowish brown (10YR 4/6, moist) mottles; weak, fine, subangular blocky; very friable; discontinuous, thin, dark grayish brown (10YR 4/2) clay coatings on ped faces; abrupt, smooth lower boundary.
- 1052.990-1053.080 Dark brown (10YR 3/3, moist) silt loam; common, fine, distinct, filamentous, dark brown (7.5YR 3/4, moist) mottles along root tubules; weak, fine, subangular blocky; friable; discontinuous, thin, very dark grayish brown (10YR 3/2) organic-clay coatings on ped faces; abrupt, smooth lower boundary; wood fragments, charcoal present.
- 1052.850-1052.990 Very dark grayish brown (10YR 3/2, moist) silt loam; many, fine, distinct, dark yellowish brown (10YR 3/6, moist) mottles; weak, fine, subangular blocky; friable; many, fine, filamentous carbonate concretions; abrupt, smooth lower boundary; a charcoal sample from an elevation of 1052.894m yielded a radiocarbon age of $9,917 \pm 60$ yr B.P. (11,400-11,240 cal yr B.P.; AA62533).
- 1052.720-1052.850 Dark grayish brown (10YR 4/2, moist) silt loam; few, fine, distinct, dark yellowish brown (10YR 4/6, moist) mottles; massive; friable; common, fine, vertical carbonate concretions; coarse sand in lowest 5cm of unit.
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Appendix C. Description of sediment in profile B in the northeast wall of the backhoe trench at the Clary Ranch site. Units II, IV, and V are described in this profile.

UTM coordinates: N 4571503.920; E 740793.589
 Landform: Eroded Terrace 2 in Central Great Plains terrace sequence
 Sediment: Alluvium derived from loess and the Ash Hollow Fm.
 Land use: Pasture
 Vegetation: Grasses
 Described by: David May
 Date described: 6/16/2004
 Sample technique: Cleaned wall of backhoe trench.
 Elevation data for description are top and bottom of profile: 1054.601 m asl and 1052.381 m asl, respectively.

Elevation (m asl)	Description
1054.430-1054.600	Brown (10YR 4/3, moist) loam; many, fine, prominent, dark yellowish brown (10YR 3/6, moist) mottles; massive; very friable; many, fine and medium carbonate concretions; abrupt, smooth lower boundary; lower boundary of this stratum rises to the southeast along the margin of the oxbow lake/channel scar; surface of this stratum is the surface of undisturbed deposits (Unit V) in this profile and the floor of a backfilled 1979 excavation unit immediately northwest.
1054.400-1054.430	Dark gray (10YR 4/1, moist) silty clay loam; many, fine and medium, prominent dark yellowish brown (10YR 3/6, moist) mottles; massive; very friable; common, fine carbonate concretions; abrupt, smooth lower boundary; common, fine roots; this stratum is organic stratum B (OSB); this stratum rises to the southeast along the margin of the oxbow lake/channel scar.
1054.365-1054.400	Very dark grayish brown (10YR 3/2, moist) silt loam; many, medium, prominent, dark yellowish brown (10YR 3/6, moist) mottles; horizontally laminated; very friable; few, fine carbonate concretions; abrupt, smooth lower boundary; common, fine roots; this stratum rises to the southeast along the margin of the oxbow lake/channel scar.
1054.295-1054.365	Black (2.5Y 2/0, moist) and dark grayish brown (10YR 4/2, moist) silt loam; many, medium, prominent dark grayish brown (10YR 3/6, moist) mottles; horizontally- and ripple-laminated; very friable; common, fine, carbonate concretions; abrupt, wavy lower boundary; a few small pebbles present at lower boundary; many, fine roots; organic stratum A (OSA); this stratum rises to the southeast and delineates the margin of the oxbow lake/channel scar; lower boundary of this stratum is the base of unit V; a charcoal sample from elevation 1054.366m yielded a radiocarbon age of $9,100 \pm 120$ yr B.P. (10,490-10,170 cal yr B.P.; AA62544).
1054.160-1054.295	Brown (10YR 5/3, moist) coarse silt (silt loam); many, medium, distinct, dark, yellowish brown (10YR 4/6, moist) mottles; massive; very friable; few, fine carbonate concretions; clear, wavy lower boundary; few, small pebbles scattered throughout with coarser pebbles at the upper boundary; many, fine roots; stratum rises to southeast; surface of this stratum is the surface of unit IV.
1053.935-1054.160	Grayish brown (10YR 5/2, moist) coarse silt (silt loam); many, medium, distinct, dark yellowish brown (10YR 3/4, moist) mottles; ripple laminated and exhibiting soft sediment deformation structures; very friable; abrupt, smooth lower boundary; few, small pebbles in upper part of stratum; laminae in this stratum dip slightly to the northwest; lower boundary of this stratum is base of unit IV.
1053.840-1053.935	Dark grayish brown (10YR 4/2, moist) coarse silt (silt loam); common, fine, distinct, dark yellowish brown (10YR 3/4 and 4/6, moist) mottles; horizontally laminated with weak, fine subangular blocky structure; very friable; abrupt, lower boundary; many roots and root tubules; unit consists of three laminae, the upper and lower of which are darker than the middle, but bioturbation masks this in many places; surface of this stratum is the surface of unit II and of the Brady Soil.
1053.790-1053.840	Grayish brown (10YR 5/2, moist) coarse silt (silt loam); few, medium, distinct, dark yellowish brown (10YR 3/6 and 4/6, moist) mottles; massive; very friable; abrupt, smooth lower boundary; common, fine roots.
1053.575-1053.790	Dark grayish brown (10YR 4/2, moist) coarse silt (silt loam); few, medium, distinct, dark yellowish brown (10YR 3/4, moist) mottles; massive; very friable; few, fine, carbonate concretions; gradual, smooth lower boundary; upper portion of unit darker than lower portion; old bioturbation evident; gastropods present.
1053.240-1053.575	Dark grayish brown (10YR 4/2, moist) silt loam; common, fine and medium, distinct, dark yellowish brown (10YR 4/4 and 4/6, moist) mottles; weak, fine, angular blocky structure; very friable; discontinuous, thin, very dark grayish brown (10YR 3/2) clay coatings on ped faces in lowest 10cm; few, fine, carbonate concretions in upper portion and common, fine, carbonate concretions in lowest 10cm of unit; clear, irregular lower boundary; few tiny root pores; a 3cm-thick, lighter-colored lamination present in lowest 10cm of unit; highly bioturbated; lower boundary of this stratum is the base of the Brady Soil.

- 1052.820-1053.240 Brown (10YR 4/3, moist) silt loam; few, fine, faint, dark yellowish brown (10YR 4/4, moist) mottles along root tubules; weak, fine, subangular blocky structure; friable; continuous, thin, very dark grayish brown (10YR 3/2) clay coatings on ped faces in the upper portion and discontinuous clay coatings in the lower portion; common, fine, carbonate concretions in upper 8cm of unit; gradual, smooth lower boundary; common root tubules; small flecks of charcoal common throughout; a charcoal sample from elevation 1053.042m yielded a radiocarbon age of $9,865 \pm 60$ yr B.P. (11,320-11,210 cal yr B.P.; AA62540).
- 1052.580-1052.820 Dark grayish brown (10YR 4/2, moist) silt loam; common, fine, faint, dark yellowish brown (10YR 4/4, moist) mottles along root tubules; upper portion faintly horizontally laminated, otherwise weak, fine, angular blocky structure; friable; few, fine, carbonate concretions; gradual, smooth lower boundary; common root tubules; small flecks of charcoal common throughout.
- 1052.380-1052.580 Dark grayish brown (10YR 4/2, moist) silt loam; few, fine, faint, dark yellowish brown (10YR 4/4, moist) mottles; weak, fine, angular blocky structure in upper part becoming massive in lower part; friable and firm; many, fine, filamentous carbonate concretions; common root tubules and insect tubules; a charcoal sample from elevation 1052.509m yielded a radiocarbon age of $9,971 \pm 82$ yr B.P. (11,600-11,270 cal yr B.P.; AA62539).
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Appendix D. Description of sediment in profile C (oxbow lake/channel scar) in the northeast wall of the backhoe trench at the Clary Ranch site. Unit IV and V are described in this profile.

UTM coordinates: N 4571505.840; E 740791.585
 Landform: Eroded Terrace 2 in Central Great Plains terrace sequence
 Sediment: Alluvium derived from loess and the Ash Hollow Fm.
 Land use: Pasture
 Vegetation: Grasses
 Described by: David May
 Date described: 6/19/2004
 Sample technique: Cleaned wall of backhoe trench.
 Elevation datum for description is bottom of profile: 1053.944 m asl

Elevation (m asl)	Description
1054.430-1054.445	Dark grayish brown (10YR 4/2, moist) silt; few, fine, distinct, dark yellowish brown (10YR 3/4, moist) mottles; massive (single lamination); very friable; abrupt, wavy lower boundary; this stratum dips to the northwest and is truncated to the northwest by backfilled sediment in 1979 excavation units.
1054.415-1054.430	Grayish brown (10YR 5/2, moist) coarse silt (silt loam); few, fine, distinct dark yellowish brown (10YR 4/6, moist) mottles; horizontally-laminated (couplet); very friable; few, fine carbonate concretions; abrupt, wavy lower boundary; upper 1mm consists of a darker, finer-grained, organic-clay drape.
1054.380-1054.415	Dark grayish brown (10YR 4/2, moist) coarse silt (silt loam); few, fine, distinct, yellowish brown (10YR 5/4, moist) mottles; massive (single lamination), exhibiting soft sediment deformation structures; very friable; abrupt, wavy lower boundary.
1054.360-1054.380	Brown (10YR 5/3, moist) fine sandy loam; many, coarse, prominent strong brown (7.5YR 4/6, moist) mottles; massive (single lamination); very friable; few, fine, carbonate concretions; abrupt, wavy lower boundary; a few very small pebbles present.
1054.350-1054.360	Dark grayish brown (10YR 4/2, moist) coarse silt (silt loam); common, fine and medium, distinct, yellowish brown (10YR 5/4, moist) mottles; massive (single lamination); very friable; abrupt, smooth lower boundary; this lamination is evident for at least two meters to the southeast and to the northwest to under an exposed bone.
1054.245-1054.350	Brown (10YR 4/3, moist) very fine sandy loam; common, medium, distinct, dark yellowish brown (10YR 3/4, moist) mottles; massive; very friable; abrupt, smooth lower boundary; stratum dips slightly to the southeast.
1054.235-1054.245	Dark grayish brown (10YR 4/2, moist) silt; common, medium, distinct, dark yellowish brown (10YR 3/4, moist) mottles; massive; very friable; abrupt, smooth to wavy (ripple-laminated) lower boundary; stratum dips slightly to the southeast.
1054.210-1054.235	Grayish brown (10YR 5/2, moist) coarse silt (silt loam); common, medium and coarse, prominent, dark yellowish brown (10YR 3/6-4/6, moist) mottles; horizontally laminated; very friable; abrupt, smooth lower boundary; unit pinches out 30cm to the southeast and 20cm to the northwest.
1054.180-1054.210	Dark grayish brown (10YR 4/2, moist) silty clay loam; common, medium and coarse, prominent, dark yellowish brown (10YR 3/4, moist) mottles; ripple and horizontally laminated; very friable; common, fine, carbonate concretions; abrupt, smooth lower boundary; stratum dips slightly to the southeast.
1054.165-1054.180	Brown (10YR 5/3, moist) coarse silt (silt loam); many, medium, prominent, dark yellowish brown (10YR 3/4, moist) mottles; massive (single lamination); very friable; common, fine, carbonate concretions; abrupt, smooth lower boundary.
1054.035-1054.165	Dark grayish brown (10YR 4/2, moist) silty clay loam and silt loam; common, medium, prominent, yellowish brown (10YR 5/4, moist) mottles; horizontally laminated and massive; friable; common, fine, carbonate concretions; abrupt, smooth lower boundary.
1054.025-1054.035	Very dark gray (10YR 3/1, moist) silty clay loam; common, fine, prominent, yellowish brown (10YR 5/4, moist) mottles; horizontally laminated; very friable; common, fine, carbonate concretions; abrupt, smooth lower boundary; organic stratum A (OSA); 50cm to the northwest this stratum consists of three, thin (1-4mm-thick) laminae; a charcoal sample from an elevation of 1054.366m yielded a radiocarbon age of $9,100 \pm 120$ yr B.P. (10,660-10,510 cal yr B.P.; AA62544); lower boundary of this stratum is lower boundary of unit V.
1054.005-1054.025	Dark grayish brown (10YR 4/2, moist) silty clay loam and silt loam; common, fine, distinct, yellowish brown (10YR 5/4, moist) mottles; massive (single lamination); very friable; common, fine, carbon concretions; abrupt, wavy lower boundary; surface of this stratum is surface of unit IIIa.
1053.945-1054.005	Grayish brown (10YR 5/2, moist) coarse silt (silt loam); common, fine and medium, distinct, yellowish brown (10YR 5/4, moist) mottles; massive; very friable; common, fine, carbonate concretions in the lower portion; clear, smooth lower boundary; this unit overlies channel sands and gravels (unit IIIa); this unit is 42cm thick in Profile B to the southeast.

Appendix E. Description of profile I in cut bank 21 (west cut bank). Units II, IV, V, and VI are described in this profile.

UTM coordinates: N 4571457; E 740748.095
 Landform: Eroded Terrace 2 in Central Great Plains terrace sequence
 Sediment: Alluvium derived from loess and the Ash Hollow Fm.
 Land use or vegetation: Pasture
 Described by: David May
 Date described: 5/21-24/04 and 6/21-26/04
 Sample technique: Cleaned cut bank
 Elevation datum for profile is base of profile: 1053.355 m asl (others shot in as well)

Elevation (m asl)	Description
1060.380-1060.660	Brown 10YR 4/3, moist) coarse silt (silt loam); horizontally laminated (each lamination is between 1-12 cm thick); very friable; abrupt, smooth lower boundary; a few hackberry seeds; stratum fines upward.
1059.970-1060.380	Brown (10YR 4/3, moist) gravelly sand and silt (30% of stratum comprised of gravel, most of which is near the base of the stratum; horizontally laminated (each lamination is between 1-3cm thick); very friable; abrupt, smooth lower boundary; several hackberry seeds in this stratum.
1059.555-1059.970	Brown (10YR 4/3, moist) coarse silt (silt loam) that becomes very fine sand toward top; horizontally laminated (each lamination is between 1-8cm thick); very friable; few, fine carbonate concretions; abrupt, smooth lower boundary; includes a few laminations comprised of fine and medium sand; stratum dips to the northwest out of the cut bank; a charcoal sample from an elevation of 1059.812m yielded a radiocarbon age of 8,749 ± 58 yr B.P. (9,890-9,630 cal yr B.P.; AA64354).
1059.160-1059.555	Brown (10YR 4/3, moist) coarse silt (silt loam) with 1-2% fine gravel; massive; very friable; few, fine, carbonate concretions throughout stratum; abrupt, smooth lower boundary; 2-3cm thick organic stratum in about the middle of stratum.
1059.110-1059.160	Black (10YR 2/1, moist) silt loam with 10-15% gravel; massive; very friable; few, fine carbonate concretions; clear, smooth lower boundary; organic stratum with gravel, but lateral distribution unknown.
1058.750-1059.110	Brown (10YR 4/3 and 3/3, moist) gravelly silt loam grading upward into silt loam; horizontally laminated (each lamination is between 2-6cm thick); very friable; common, fine, carbonate concretions; abrupt, smooth lower boundary; this stratum is continuous for at least 3m upstream and 3m downstream in cut bank; lower boundary of this stratum is base of unit VI.
1058.280-1058.750	Brown (10YR 4/3, moist) coarse silt and very fine sand; horizontally laminated (each lamination is between 2-4cm thick); very friable; common, fine, carbonate concretions; abrupt, smooth lower boundary; few hackberry seeds; 2cm-thick coarse sand lamination at 1058.500; surface of this stratum is surface of unit V.
1057.880-1058.280	Brown (10YR 4/3, moist) very fine sand; massive, very friable; common, fine, carbonate concretions; abrupt, smooth lower boundary; slightly redder hue than below; rodent burrow in the base of stratum
1057.520-1057.880	Brown (10YR 4/3, moist) silt and coarse silt (silt loam) with lens of gravel at base; horizontally laminated (each lamination is between 1-7cm thick); very friable; few, fine, carbonate concretions; abrupt, wavy lower boundary; sand and gravel lens at base thickens to the southeast.
1057.180-1057.520	Brown (10YR 4/3, moist) loam (coarse silt to very fine sand); horizontally laminated; very friable; few, fine, carbonate concretions; abrupt, smooth lower boundary; includes two darker laminae, one 7cm thick, the other 2cm thick; a charcoal sample from an elevation of 1057.293m yielded a radiocarbon age of 9,138 ± 56 yr B.P. (10,380-10,230 cal yr B.P.; AA62548).
1056.750-1057.180	Brown (10YR 5/3, moist) coarse silt (silt loam); massive; very friable; few fine carbonate concretions; abrupt, lower boundary.
1056.650-1056.750	Very dark grayish brown (10YR 3/2, moist) coarse silt (silt loam) with a few pebbles; few, fine, distinct, brown (10YR 4/3, moist) mottles; massive; very friable; common, fine and medium, carbonate concretions; bioturbation evident; few hackberry seeds; few flecks of charcoal.
1056.160-1056.650	Dark brown (10YR 3/3, moist) coarse silt (silt loam) with a few pebbles; few, fine, distinct, dark yellowish brown (10YR 3/6, moist) mottles; massive; friable; common, fine, carbonate concretions; dense stratum; one krotovina 8cm in diameter.
1056.100-1056.160	Brown (10YR 4/3, moist) coarse silt (silt loam); many, medium to coarse, prominent dark yellowish brown (10YR 4/6, moist) mottles; massive; friable; common, fine, carbonate concretions; clear, smooth lower boundary; this unit is dense because of iron oxide accumulation; this is the basal unit after the profile was stepped back (hence the overlap with units below).

- 1056.105-1056.140 Black (10YR 2/1, moist) silt loam; few, fine, distinct brown (10YR 4/3, moist) mottles; massive; very friable; few, fine, carbonate concretions; abrupt, wavy lower boundary; stratum dips to the northwest (out of cutbank); many hackberry seeds; this stratum is organic stratum D (OSD).
- 1056.055-1056.105 Brown (10YR 4/3, moist) coarse silt (silt loam) with a few pebbles; few, fine, distinct, dark yellowish brown (10YR 3/4, moist) mottles; massive; very friable; few fine carbonate concretions; clear, smooth lower boundary; stratum dips slightly to the northwest and varies in thickness along the exposure.
- 1055.890-1056.055 Brown (10YR 4/3, moist) silt loam with a few pebbles; common, fine, prominent dark yellowish brown (10YR 3/6, moist) and few, coarse, prominent dark reddish brown (5YR 2.5/2, moist) mottles; very friable; continuous, thin, dark brown (10YR 3/3, moist) clay coatings on root tubules and ped faces; many, fine carbonate concretions; abrupt, smooth lower boundary; slightly dips to the southwest.
- 1055.825-1055.890 Dark grayish brown (10YR 4/2, moist) coarse silt (silt loam with some coarse sand); common, fine and medium, distinct, dark yellowish brown (10YR 3/6, moist) mottles; weak, fine, subangular blocky structure; friable; common, fine, carbonate concretions; abrupt, smooth lower boundary.
- 1055.745-1055.825 Dark brown (10YR 3/3, moist) coarse silt (silt loam) with a few primarily carbonate pebbles; common, fine, distinct, dark yellowish brown (10YR 3/6, moist) mottles; massive, very friable; common, fine, carbonate concretions; clear, smooth lower boundary; this organic-rich stratum is organic stratum B (OSB).
- 1055.520-1055.745 Brown (10YR 4/3, moist) coarse silt (silt loam) with a few, primarily siliceous, subrounded pebbles; common, fine, faint, dark yellowish brown (10YR 4/4, moist) mottles; massive; very friable; common, medium, carbonate concretions; abrupt, wavy lower boundary; includes two, poorly-expressed, organic strata; a charcoal sample from an elevation of 1055.706m yielded a radiocarbon age of $9,157 \pm 71$ yr B.P. (10,400-10,240 cal yr B.P.; AA62545).
- 1055.480-1055.520 Very dark gray (10YR 3/1, moist) coarse silt (silt loam); common, fine to medium, distinct, dark yellowish brown (10YR 3/4-3/6, moist) mottles; massive; friable; common medium and coarse carbonate concretions; abrupt, wavy lower boundary; this is organic stratum A exposed again after cut bank stepped back-OSA dips out of the cut bank to the northwest revealing the steep slope of margin of the oxbow lake/channel scar.
- 1055.435-1055.480 Very dark gray (10YR 3/1, moist) coarse silt (silt loam); common, fine, distinct, dark yellowish brown (10YR 4/4, moist) mottles; massive; friable; common, fine, carbonate concretions; abrupt, wavy lower boundary; third organic stratum above Brady Soil here named organic stratum A (OSA); lower boundary of this stratum is base of unit V.
- 1055.330-1055.435 Very dark gray (10YR 3/1, moist) silt loam; band of dark yellowish brown (10YR 4/4, moist) iron oxide in root tubule across profile in upper portion of stratum; massive; friable; many, filamentous, carbonate concretions with strands 3-5mm thick; abrupt, smooth lower boundary; much insect and worm? bioturbation at lower boundary; surface of this stratum is surface of unit IV.
- 1055.270-1055.330 Very dark grayish brown (10YR 3/2, moist) silt loam (more clay than below); common, fine and medium, distinct, dark yellowish brown (10YR 3/6, moist) mottles; massive, firm; many, medium, carbonate concretions; abrupt, wavy lower boundary; bioturbation at lower boundary; second organic stratum above Brady Soil.
- 1055.190-1055.270 Dark grayish brown (10YR 4/2, moist) silt; many, medium, prominent, dark yellowish brown (10YR 3/6, moist) mottles; massive; very friable; many, coarse, carbonate concretions fill 5cm-diameter root tubule; abrupt, smooth lower boundary; bioturbation by burrowing mammal and root tubule disturb sediments in this stratum; a charcoal sample from an elevation of 1055.263m yielded a radiocarbon age of $9,268 \pm 90$ yr B.P. (10,570-10,300 cal yr B.P.; AA62535).
- 1055.145-1055.190 Very dark gray (10YR 3/1, moist) silty clay loam; few, coarse, prominent, dark yellowish brown (10YR 3/6, moist) mottles; massive; friable; many, coarse, carbonate concretions filling root tubule; abrupt, smooth lower boundary; bioturbation at lower boundary; root tubule filled with carbonates and iron-oxide mottling disrupts lower boundary; this is first prominent organic-rich stratum above the Brady Soil.
- 1055.040-1055.145 Dark grayish brown (10YR 5/2, moist) and very dark grayish brown (10YR 4/2, moist) silt loam; few, coarse, prominent dark yellowish brown (10YR 3/6, moist) mottles; massive; very friable; many, fine, carbonate concretions; abrupt, smooth lower boundary; some bioturbation at the lower boundary; large root tubule with heavy iron oxide staining around it.
- 1055.005-1055.040 Dark grayish brown (10YR 4/2, moist) silt loam; few, fine, distinct, dark yellowish brown (10YR 3/6, moist) mottles; massive; very friable; few fine carbonate concretions; abrupt, smooth lower boundary; some bioturbation; similar to other, thin, organic strata below.
- 1054.970-1055.005 Brown (10YR 4/3, moist) loam (some coarse sand); common, fine, distinct, dark yellowish brown (10YR 3/6, moist) mottles; massive; very friable; common, fine carbonate concretions; abrupt, smooth lower boundary; some bioturbation.
- 1054.955-1054.970 Very dark gray (10YR 3/1, moist) silt loam (some clay); few, fine, distinct, dark yellowish brown mottles; massive; very friable; few fine carbonate concretions; abrupt, smooth lower boundary; some bioturbation at lower boundary; a thin organic stratum.

- 1054.930-1054.955 Grayish brown (10YR 5/2, moist) silt loam; common, fine and medium, prominent dark yellowish brown (10YR 3/4-3/6, moist) mottles; massive; very friable; common, fine, carbonate concretions; abrupt, smooth lower boundary; some bioturbation at lower boundary.
- 1054.900-1054.930 Dark grayish brown (10YR 4/2, moist) silt loam; few, fine, prominent, dark brown (10YR 3/2, moist) mottles; massive; very friable; common, fine, carbonate concretions; abrupt, wavy (eroded) lower boundary; stratum dips out of the cut bank (oxbow lake/channel scar margin?); thin organic stratum.
- 1054.885-1054.900 Grayish brown (10YR 5/2, moist) loam with few, fine pebbles; common, fine to medium, distinct, dark yellowish brown (10YR 3/4, moist) mottles; massive; very friable; many, fine, carbonate concretions; some insect and worm? bioturbation at lower boundary; abrupt and smooth lower boundary; lower boundary of this unit is the base of unit IV.
- 1054.485-1054.885 Very dark gray (10YR 3/1, moist) in upper 10cm and very dark grayish brown silt (10YR 3/2, moist) silt loam; common, medium and coarse, prominent, dark yellowish brown (10YR 4/6, moist) and dark brown (7.5YR 3/4, moist) mottles; weak, fine, subangular blocky structure in lower part and massive in upper part; friable; few, fine, carbonate concretions in lowest 10cm; gradual, smooth lower boundary; Brady Soil; surface of this stratum is the surface of unit II.
- 1053.390-1054.485 Brown (10YR 5/3, moist) very fine sandy loam; common, coarse, distinct, dark yellowish brown (10YR 4/6, moist) mottles; ripple laminated; friable; few, fine, carbonate concretions; abrupt, smooth, lower boundary.
- 1053.090-1054.390 Dark grayish brown (10YR 4/2, moist) silt loam to silty clay loam with 2% fine, siliceous gravel; common, fine and medium, distinct dark yellowish brown (10YR 4/6, moist) mottles; weak, fine, subangular blocky structure; friable; discontinuous, thin, dark grayish brown (10YR 4/2, moist) clay coatings on ped faces; common, fine, carbonate concretions; abrupt, wavy lower boundary.
- 1053.045-1054.090 Brown (10YR 4/3, moist) loam to sandy loam with 2-3% fine carbonate and siliceous gravel; common, coarse, distinct dark yellowish brown (10YR 3/4, moist) and common, medium, distinct, yellowish brown (10YR 5/4, moist) mottles; weak, fine, subangular blocky structure; friable; discontinuous, thin, grayish brown (10YR 5/2, moist) clay coatings on ped faces; many, fine and medium, carbonate concretions; abrupt, smooth lower boundary.
- 1053.835-1054.045 Dark grayish brown (10YR 4/2, moist) and brown (10YR 4/3, moist) silt loam with 1-2% fine siliceous gravel; common, fine, distinct dark yellowish brown (10YR 4/6, moist) and few, fine, black (2.5Y 2/0, moist) mottles; weak, fine, subangular blocky structure; discontinuous, thin, brown (10YR 4/3, moist) clay coatings on ped faces; common, fine and medium, carbonate concretions; abrupt, wavy lower boundary.
- 1053.655-1053.835 Dark grayish brown (10YR 4/2, moist) silt loam with 2-3% medium, siliceous gravel; coarse, fine, distinct dark yellowish brown (10YR 4/6, moist) and few fine, black (2.5Y 2/0, moist) mottles; weak, fine subangular blocky structure; firm; continuous, thin very dark grayish brown (10YR 3/2, moist) clay coatings on ped faces; many, fine and medium carbonate concretions; clear, wavy lower boundary; a charcoal sample from an elevation of 1053.758m yielded a radiocarbon age of $9,361 \pm 59$ yr B.P. (10,660-10,510 cal yr B.P.; AA62529).
- 1053.355-1053.655 Grayish brown (10YR 5/2, moist) silt loam with 2% fine, siliceous gravel; coarse, fine, distinct dark yellowish brown (10YR 4/6, moist) mottles; weak, fine, subangular blocky structure; firm; continuous, thin, dark brown (10YR 4/2, moist) clay coatings on ped faces; many, fine and medium carbonate concretions; stream bed elevation is about 1053.600m asl.
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Appendix F. Description of sediment in a cut bank in the southern portion of Ash Hollow State Park. Units III and V are described in this profile.

UTM coordinates: N 4574814.170; E 740425.329
 Landform: Eroded Terrace 2 in Central Great Plains terrace sequence
 Sediment: Alluvium derived from loess and the Ash Hollow Formation
 Land use or vegetation: Pasture
 Described by: David May
 Date described: 7/01-02/04
 Sample technique: Cleaned cutbank
 Elevation datum for profile is the bottom of the profile: 1036.417 m asl

Elevation (m asl)	Description
1039.005-1040.260	Brown (10YR 4/3, moist) coarse silt and very fine sand (silt loam); weakly horizontally laminated; very friable; abrupt, smooth lower boundary.
1038.785-1039.005	Dark brown (10YR 3/3, moist) coarse silt and very fine sand (silt loam); weakly horizontally laminated and weak, fine, subangular blocky structure; very friable; discontinuous, thin, very dark grayish brown (10YR 3/2, moist) clay coatings on about half of ped faces; abrupt, smooth lower boundary; three, thin, organic-rich laminae in this stratum.
1038.400-1038.785	Brown (10YR 4/3, moist) coarse silt and very fine sand (silt loam); common, medium and coarse, distinct, dark yellowish brown (10YR 4/6, moist) mottles; horizontal and ripple laminated; very friable; few, fine, carbonate concretions only at the base of stratum; abrupt, smooth lower boundary; top of unit is comprised of a thin, dark lamination.
1037.800-1038.400	Brown (10YR 5/3, moist) coarse silt (silt loam) and very dark gray (10YR 5/3, moist) silt; common, medium, distinct, yellowish brown (10YR 5/6, moist) mottles in lowest 27cm of stratum; ripple laminated throughout; common, medium, filamentous and vertical carbonate concretions in the upper 31cm of stratum; abrupt, wavy lower boundary; 15 thin, very dark gray laminations; upper 6cm is very dark gray and can be traced across the entire cut bank exposure; a charcoal sample from an elevation of 1037.986m yielded a radiocarbon age of $8,980 \pm 140$ yr B.P. (10,260-9,820 cal yr B.P.; AA62532).
1037.670-1037.800	Dark brown (10YR 4/2, moist) silt loam; common, medium, distinct, yellowish brown (10YR 5/6, moist) mottles; ripple laminated to massive; very friable; common, fine, carbonate concretions; clear, smooth lower boundary; many flecks of charcoal, especially at upper boundary of stratum; this stratum is an individual, thick lamination within a sequence of horizontally-laminated sediment.
1037.535-1037.670	Very dark grayish brown (10YR 3/3, moist) silt loam with scattered fine gravel throughout (2% total); few, fine, prominent, yellowish brown (10YR 5/8, moist) mottles; massive; friable; common, fine, carbonate concretions; clear, smooth lower boundary; much charcoal in this stratum; organic stratum; a charcoal sample from an elevation of 1037.564m yielded a radiocarbon age of $9,077 \pm 57$ yr B.P. (10,270-10,190 cal yr B.P.; AA62534); the lower boundary of this organic-rich stratum is the base of unit V.
1037.315-1037.535	Brown (10YR 5/3, moist) very fine sand with lens of gravelly sand 3cm thick in middle of stratum that accounts for 10% gravel in the entire stratum; few, fine, prominent, yellowish brown (10YR 5/8, moist) mottles; ripple laminated; friable; few fine carbonate concretions, but entire stratum is weakly cemented by carbonates; abrupt, smooth lower boundary; the surface of this stratum is the surface of unit IIIa.
1037.115-1037.315	Dark grayish brown (10YR 4/2, moist) gravelly silt loam to silty gravel (70-80% fine and medium, subangular and sub-rounded siliceous and carbonate gravel; low-angle, trough cross-bedded; friable (some weak cementing by carbonates); abrupt, slightly wavy lower boundary.
1036.840-1037.115	Brown (10YR 4/3, moist) very fine sand; common, medium, prominent, yellowish brown (10YR 5/8, moist) mottles; weakly horizontally laminated to massive; very friable; abrupt, slightly wavy, lower boundary; two krotovina present in this stratum.
1036.695-1036.840	Dark grayish brown (10YR 4/2, moist) coarse silt (silt loam); common, medium, prominent, yellowish brown (10YR 5/6, moist) mottles; ripple laminated (each lamination is 3-4cm thick); very friable; abrupt, slightly wavy lower boundary.
1036.415-1036.695	Grayish brown (10YR 5/2, moist) very fine sandy silt (silt loam); common, fine and medium, yellowish brown (10YR 3/6, moist) mottles; massive; very friable; abrupt, wavy lower boundary.
1036.365-1036.415	Pale brown (10YR 6/3, moist) gravelly coarse sand with 15% fine, subrounded, siliceous and carbonate gravel; loose; stratum exposed at base of bank; only upper 5cm exposed.