

Harlan's Ground Sloth (*Glossotherium harlani*) and a Columbian Mammoth (*Mammuthus columbi*) from Stevenson Bridge, Yolo County, California

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ABSTRACT

Skeletal remains of a subadult and adult *Glossotherium harlani* and an adult *Mammuthus columbi* were recovered from fluvial sediments of Putah Creek near Davis, California in July 1975. U/Th radiometric age determination of two mammoth bones suggests a possible late Sangamonian interglacial age (¹⁸O isotope stage 5a) for the site. The mammoth material as well as an adult ground sloth femur show evidence of substantial green bone fracturing and bone surface scratches indicative of trampling prior to final deposition. The subadult ground sloth partial skeleton lacks the extensive fracturing and other bone modification noted for the mammoth and adult ground sloth. Additionally close associations of the skull and first three cervical vertebrae, a partial rib cage, and left scapula and left humerus epiphysis suggest that the subadult ground sloth was deposited with some soft connective tissue remaining on the skeleton. These and other taphonomic inferences were made possible by utilization of appropriate data collection methods at the time of excavation. This emphasizes the significance of how good techniques in the collection of field data and laboratory preparation may permit important taphonomic inferences long after a site has been excavated by other researchers.

INTRODUCTION

Fossil remains of *Mammuthus* and *Glossotherium* are common in the Pleistocene of California, particularly in the San Francisco Bay region (Jefferson, 1991). The Stevenson Bridge locality, possibly late Sangamonian (late ¹⁸O isotope stage 5a) in age, is one of several late Pleistocene sites along Putah Creek that have yielded ground sloth and mammoth remains. Few specimens are as well preserved as those recovered from the Stevenson Bridge locality; partial skeletons of a subadult and adult *Glossotherium harlani* and an adult *Mammuthus columbi* are represented.

The Stevenson Bridge site, located in Yolo County approximately 9 km west of Davis, California, is situated on private land of Mrs. J. Jacob about 100-125 m upstream from Stevenson Bridge along the north bank of Putah Creek at an elevation of 16 m (Figure 1): 38°32'13"N, 121°51'06"W, Merritt, California USGS 7.5' series topographic quadrangle.

HISTORY OF INVESTIGATIONS

In mid-July, 1975 three Dixon, California residents, Mark and Mike Little, and Dennis Danielson discovered a mammoth tusk fragment on the north bank of Putah Creek. Subsequently

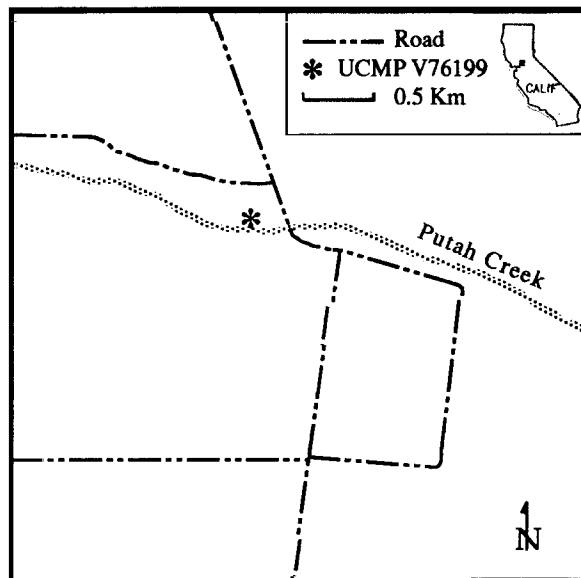


Figure 1. Generalized map noting the location of the Stevenson Bridge locality (V76199) west of Davis, California.

the University of California Museum of Paleontology (UCMP) and Leonard Williams, museum scientist, Department of Anthropology at the University of California (UC) at Davis were contacted about the find.

Following examination of the site Leonard Williams, then graduate students James West and Dwight Simons, and a small field crew from UC Davis began an approximately three week excavation of the locality on July 24, 1975. Photos of the excavation are on file in the supplementary locality records of the UCMP. After excavation specimens were taken to UC Davis for preparation and exhibition. The specimens were later transferred to the UCMP where they were accessioned. The UCMP inadvertently catalogued the site under the name Steven's Creek Bridge, UCMP locality V76199, see Jefferson (1991, p.103). The name has been corrected to read Stevenson Bridge.

GEOLOGY AND TAPHONOMY

The Stevenson Bridge locality and Putah Creek are situated in a 10 m deep by 30 m wide gully incised by the stream (Figure 2). The gully bottom sediments are fluvial deposits of Putah Creek. Geologic outcrops are sparse because dense vegetation covers the gully bottom. Reconnaissance of the creek bank exposures indicates that the typical stream deposits range from clay to pebble size clasts, with sediments larger than gravel a rarity. Presently, Putah Creek, a meandering stream, deposits mostly silt, however this may partially reflect a disruption of natural sedimentation processes because water flow is controlled and partially diverted upstream by Monticello Dam and the Lake Solano Diversion Dam.

Detailed sedimentologic and stratigraphic data are unavailable for this site. Fossils were recovered from a 0.5-0.75 m thick greenish-grey silty clay layer capped by a 0.5-1.0 m thick sequence of brownish sediments of silt, sand and

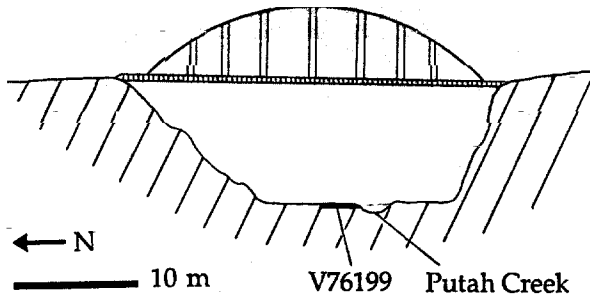


Figure 2. Section through the Putah Creek stream gully, showing Putah Creek, Stevenson Bridge and the Stevenson Bridge locality (V76199).

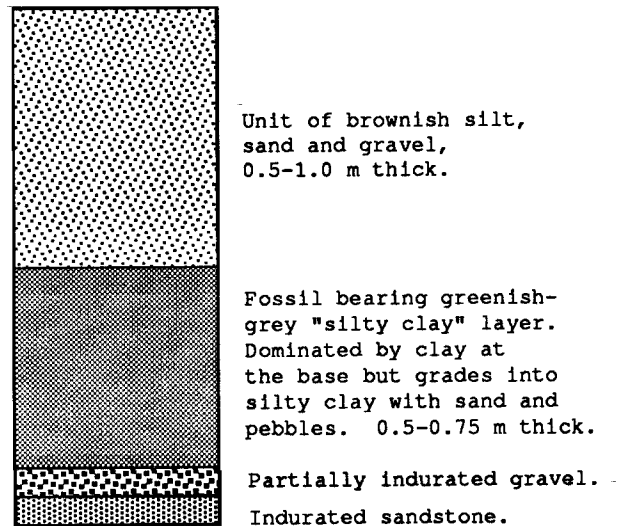


Figure 3. Generalized stratigraphic section at the Stevenson Bridge locality (V76199).

gravel. Underlying the silty clay layer is a partially indurated gravel underlain by an indurated sandstone (Figure 3). Examination of the residual matrix adhering to several of the mammoth bones revealed that sand and pebbles may be common within this "silty clay" layer; the matrix varies from grey to light brown in color. Although the sediments are fluvial channel deposits of Putah Creek, the lack of adequate sedimentologic, lithologic and stratigraphic data precludes an accurate interpretation of the depositional environment. Further inferences would be mere speculation because both channel fill and point bar deposits share some similarities with the general lithologies represented in the above stratigraphic sequence (Allen, 1965; Reineck and Singh, 1980; Behrensmeier, 1988). Misinterpretation of channel deposits is possible when lacking a three dimensional section with adequate lateral and vertical exposures (Behrensmeier, 1988).

Paleocurrent direction was assessed for the fossil bearing stratum by examination of long bone orientations. Although dip angles of skeletal elements were not recorded it appears from the excavation photographs that the bones were lying in or near horizontal position within the same stratigraphic horizon. Therefore, long axes of bones were measured from the excavation map and plotted on a 20° sector rose diagram (Figure 4). A preferred orientation is indicated

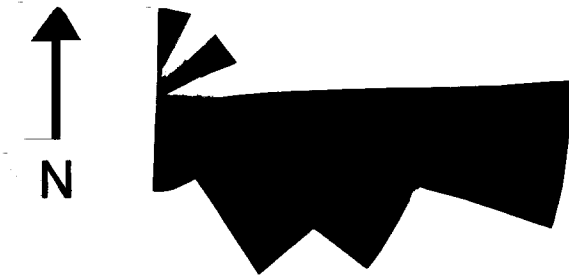


Figure 4. Sector rose diagram showing long axes orientations of Stevenson Bridge locality skeletal elements reflecting paleocurrent direction. Sample size plotted is 17 elements in 20 degree sectors over 180 degrees; 13 of the elements are ground sloth ribs.

particularly with respect to the ground sloth ribs. Long bones may orient parallel or perpendicular to water current direction. Orientation of the long axis parallel to current is characteristic of bones that move by sliding, where one end of the bone is significantly heavier than the other, while bones that roll during transport tend to orient perpendicular to current. Orientation of the long axis parallel to current is typical of most long bones (Voorhies, 1969). In fluvial transport experiments with modern elephant bones, ribs oriented parallel to current with the heavy end pointing upstream (Todd and Frison, 1986), provided that the ribs were unobstructed by other bones, particularly large elements like the pelvis which act as "bone traps" for smaller skeletal elements. It is reasonable to infer that *Glossotherium* ribs also orient parallel to current which would indicate that water flowed roughly along a west-east trend when the ribs were aligned (Figure 4). Considering the confinement of the stream to the gully through which it presently flows, it is likely that Putah Creek flowed in the same direction during the late Pleistocene; i.e. west to east. Additionally, the position of the mammoth mandible implies a west to east current direction because it was found upside down with the symphysis pointing to the west (Figure 5). This is a stable position of elephant mandibles observed in fluvial transport experiments with the symphysis pointing upstream; subsequent movement from this position requires large water volume and velocity (Todd and Frison, 1986).

Taphonomic inferences based on incomplete data are difficult and considerable caution must be exercised particularly when analyzing data collected by other researchers. Yet, sufficient data recorded during excavation of this locality permits some interpretations of the taphonomic history of the fossil assemblage. The bones composing the partial skeletons were found in association but not articulated (Figure 5). Detailed examination of bone surface features revealed the following. The mammoth material is discussed first. The mammoth specimens exhibit little or no abrasion although some show minor surface weathering in the form of shallow surface cracks, probably indicating brief subaerial exposure prior to deposition; the most advanced weathering is comparable to Stage 1 of Behrensmeyer (1978), although most elements are Stage 0. There are no surface marks that can be confidently attributed to carnivore activity. Nearly all of the mammoth specimens are broken and are more widely dispersed than the ground sloth material. Most fractures are spiral in nature with sharp edges; most breakage occurred prior to final deposition as indicated by matrix filling of fractures and the absence of the broken fragments in the fossil assemblage. The mammoth bone breakage cannot be explained as resulting from fluvial processes. Currently Putah Creek, and likely its antecedents, lacks the energy necessary, even at flood stage, to break the mammoth bones. Moreover, experimental evidence indicates that bone is rarely broken by fluvial transport, rather most breakage occurs prior to transport and deposition (Behrensmeyer, 1991). Although large carnivores are capable of fracturing bones of large ungulates and leaving little evidence behind (Haynes, 1980) it is unlikely that the extensive breakage of the mammoth bones is attributable to large carnivore activity particularly since there are no characteristic carnivore gnawing or bite marks present on any of the elements. Furthermore, considering the robustness of some mammoth skeletal elements it is doubtful that even the largest North American Pleistocene predators could cause the fragmentation exhibited by this partial skeleton (Haynes, 1983). This leaves the possibility of trampling as the main agent of bone fracturing. Trampling is a significant cause of large mammal bone breakage (Haynes, 1983). Although weathered bone is relatively brittle and thus more easily fractured when stepped on by large animals, green bone is difficult to break

by trampling (Haynes, 1983). The breakage of large, robust, relatively unweathered mammoth bones is probably the result of trampling by a large herbivore, possibly another mammoth; living African elephants trample and fracture skeletal elements of dead elephants (Haynes, 1991). In addition to bone fracturing other evidence of bone surface modification indicates trampling. Although excavation and preparation techniques caused some of the surface marks evident on the mammoth skeletal elements, other surface striations resemble trample marks made by large herbivores. The marks are identical to shallow sub-parallel and individual scratch marks observed on subaerially trampled bone (Fiorillo 1984, 1989, 1991; Behrensmeyer et al., 1986). Although similar striations may be caused by human butchering techniques (Fiorillo 1987, 1989, 1991; Behrensmeyer et al., 1986) this possibility can be dismissed because this site significantly predates (see age below) the generally accepted first appearance of humans in North America. Trampling striations are caused by scraping the bone surface with a hard object such as sand grains on the bottom of the foot or pressing the bone against a hard substrate when stepping on it; hooves alone, which are softer than bone, are not sufficient to produce scratch marks (Fiorillo 1987, 1989, 1991). Kicking of elephant bones by other elephants, without trampling them, also produces similar striations (Haynes, 1991). The number of scratch marks on bone depends on the extent of trampling and type of substrate; the coarser (sandier) the substrate, the greater potential frequency of scratch marks (Fiorillo 1987, 1991). With the exception of the mandible all of the other mammoth bones exhibit trample marks. The presence of scratch marks are also related to the amount of bone weathering. Scratch marks are more easily preserved on unweathered bone probably because weathered bone surfaces are more likely to fracture and crumble when stepped upon (Fiorillo 1989, 1991). Since the mammoth bones are relatively unweathered, trampling marks are well preserved. It is impossible to infer what animal caused the striations. Scratch marks produced by large herbivores, such as cattle, have been documented but it is unknown how small an animal may be and still produce trample marks (Fiorillo, 1991). Although other physical processes (e.g. fluvial transport) may cause surface marks (Olsen and Shipman, 1988) the

lack of both abrasion and abundant coarse clasts in the sediments suggests that the surface scratches are not produced by fluvial processes. Moreover, fluvial processes would more seemingly produce individual marks rather than the multiple sets of parallel striations observed on these specimens. There is also a distinct difference in the amount of trampling marks on the various mammoth bones; the ilium, for example, exhibits numerous scratches, but mostly on one side. In addition to the striations, the scapula displays a 4.5 cm by 6.5 cm depression fracture on the infraspinous fossa which was probably caused by a large animal stepping on it. In summary, breakage of the robust mammoth skeletal elements coupled with the surface striations indicates trampling prior to burial.

In considering all skeletal material preserved in the fossil assemblage there is an evident bias towards large skeletal elements which suggests the possibility of dispersion by carnivore activity, trampling or hydraulic sorting. The lack of evidence of large carnivore activity suggests that carnivores were an unlikely agent for moving the mammoth skeletal elements, although large carnivores are known to move large elephant bones (Haynes, 1988) and leave little evidence of activity (Haynes, 1983). Trampling is a viable agent for the observed dispersion because trampling often moves skeletal elements (Haynes, 1991). Modern African elephants will scatter skeletal parts of dead elephants (Saunders, 1977; Haynes, 1988), as will other herbivores (Haynes, 1991). With respect to the potential of fluvial transport, the large mammoth bones were not moved far because their large size equates with a low transport potential (Todd and Frison, 1986); limited fluvial transport of these specimens probably occurred during a flood event. If smaller skeletal elements were present, they may have been transported from the area. Analysis of skeletal sorting behavior indicates that lighter elements transport first (Voorhies, 1969; Behrensmeyer, 1990). However, transport potential of smaller mammoth elements such as foot bones and vertebrae are not well studied although transport distance is high relative to the large bones found in this assemblage (Todd and Frison, 1986). Many of the mammoth bones present in the Stevenson Bridge assemblage are bones with the lowest transport potentials of the mammoth skeleton (Todd and Frison, 1986). A similar argument for limited fluvial transport is made for the subadult

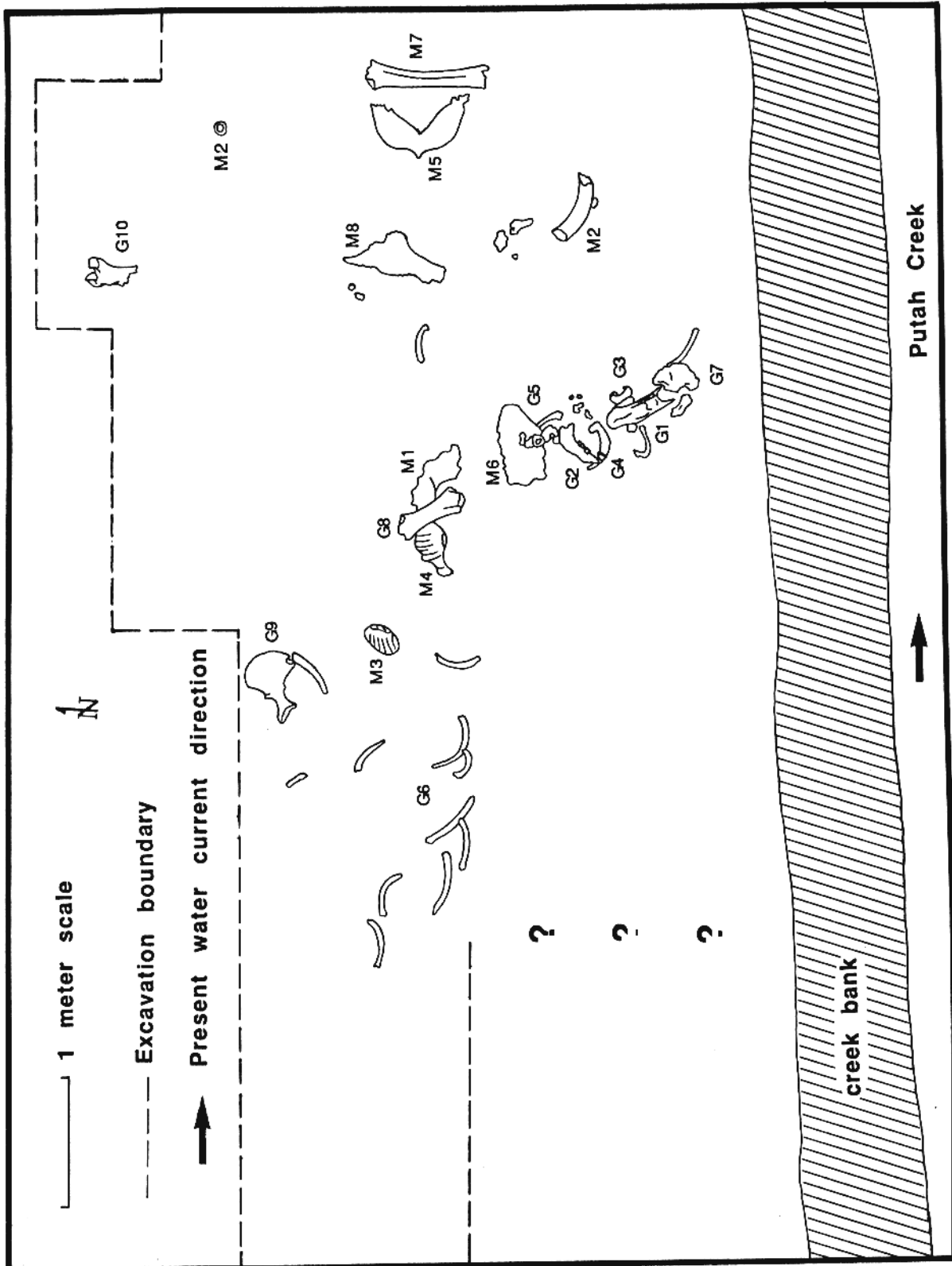


Figure 5. Excavation map of the Stevenson Bridge locality (V76199) showing the positions of the skeletal elements. *Glossotherium harlani*: G1 - mandible; G2 - atlas; G3 - 3rd cervical vertebra; G4 - axis; G5 - mandible; G6 - right femur; G7 - left innominate; G8 - right femur; G9 - right femur; G10 - right femur. *Mammuthus columbi*: M1 - right femur; M2 - tusk fragments; M3 - right M3; M4 - left M3; M5 - left scapula; M6 - mandible; M7 - left scapula; M8 - left ulna; M9 - iliium. Modified from field map by James West.

ground sloth.

The elements of the subadult ground sloth partial skeleton are closely associated (Figure 5). Other than minor weathering (Stage 1) on one side of some of the ribs, there is no evidence of carnivore activity, surface weathering or abrasion. A few of the ribs also exhibit surface striations but not as abundant as on the mammoth material. The specimens are nearly complete with most of the breakage attributable to postdepositional alteration or excavation procedures because either the breaks are fresh and lack matrix in the bone fracture surfaces or many broken fragments were found in proximity to the broken elements. As noted above the ribs exhibit a preferential orientation. Although disarticulated, the spatial proximity of various skeletal elements (partial rib cage, skull and first three cervical vertebrae, left scapula and left humerus epiphysis) (Figure 5) is indicative of soft-anatomy decomposition followed by water currents strong enough to align the ribs but too weak to move the bones very far (Behrensmeyer, 1991). Saunders (1977) cited the presence of abundant dermal ossicles as an indication of *in situ* decomposition of skin and underlying soft tissue. The apparent absence of dermal ossicles at this site may be explained in several ways: 1) little or no skin remained by the time of deposition although some connective tissue was present; 2) subsequent water currents strong enough to align the ribs could transport the pebble-sized ossicles from the site; 3) some dermal ossicles may have been present but not recognized during excavation, as is often the case if workers are unfamiliar with dermal ossicles since they can resemble lithic pebbles. Some sediment was screened for micromaterial but neither micromaterial nor dermal ossicles were noted (G. J. West, pers. comm., 1993).

The adult ground sloth femur exhibits a spiral breakage pattern reminiscent of trampling although carnivore activity cannot be ruled out. A couple of surface marks could questionably be interpreted as carnivore tooth marks; no other evidence of carnivore activity is noted. The presence of abundant shallow sets of parallel and individual striations identical to those on the mammoth material are inferred as trample marks. Also, damage to the distal part of the diaphysis consists of a 10 cm by 11 cm piece of bone missing from the anterior side above the intercondylar articular surface. This fracture likely resulted from a large animal stepping on

the distal diaphysis. The element is very lightly abraded and unweathered.

The following scenario is suggested for the accumulation of this fossil assemblage. Following death and decomposition of soft tissues, the mammoth skeleton underwent minor subaerial exposure prior to final deposition. The large skeletal elements suggest limited fluvial transport. Trampling resulting in extensive breakage of the skeletal elements occurred; timing of trampling with respect to deposition is uncertain, although lack of associated large broken fragments implies breakage before final deposition. Breakage of the mammoth bones occurred before deposition of the subadult ground sloth; otherwise the subadult ground sloth would likely exhibit considerable breakage also. Deposition of the subadult ground sloth material occurred at about the same time as the mammoth or shortly thereafter. The ground sloth material was deposited at the site with some soft connective tissue remaining. Subsequent decay of the soft tissue occurred, the ribs may have been subaerially exposed for a short time and lightly trampled then aligned by water current. The adult ground sloth femur was trampled and fractured but the exact timing of deposition in relation to the other partial skeletons is uncertain. Burial of all skeletal material was rapid, preventing further bone modification.

AGE

The fauna indicates a late Pleistocene age. Although *Glossotherium harlani* occurs throughout the Pleistocene in North America (Kurtén and Anderson, 1980), *Mammuthus columbi* first appears in the late Pleistocene (Maglio, 1973) and both species became extinct between 12,000-10,000 yr. B. P. (Kurtén and Anderson, 1980).

In addition to the biostratigraphic age two bone samples were submitted for U/Th age determination to the radiometric analysis lab at the University of California at Davis. A mammoth bone dated in 1980 yielded a U^{234}/Th^{230} age of $77,664 \pm 404$ yr. B. P. The accuracy of this date is suspect, however. In the age analysis report to J. H. Hutchison of the UCMP, Dennis Garber (UC Davis) states that "The confidence in this age is reduced since the differential between the parent U^{238} and daughter U^{234} was large, indicating a degree of potential leaching. If leaching did occur, then a

younger age would be indicated." The following year a mammoth rib was submitted for analysis and yielded a U/Th age of 81,181 yr. B. P. (Garber, pers. comm. to D. E. Savage at the UCMP, 1981). If these radiometric dates are accurate a late Sangamonian interglacial age (^{18}O isotope stage 5a) is indicated.

SYSTEMATIC PALEONTOLOGY

Class Mammalia Linnaeus, 1758
 Order Edentata Cuvier, 1798
 Family Mylodontidae Ameghino, 1889
 Genus *Glossotherium* Owen, 1840
Glossotherium harlani (Owen), 1840
 Figure 6

Referred specimens: UCMP 116084, partial skeleton including: cranium, mandible, atlas, axis, third cervical vertebra, partial rib cage, left scapula, left humerus epiphysis, right femur, left innominate; UCMP 139027, right femur.

Description: The following pertains to UCMP 116084. The skull is mostly complete. The cranial dentition is intact except for missing the left fifth tooth. The left pterygoid is partially broken. The premaxillae, much of the left squamosal and most of the nasals are broken. Both jugals are detached from the cranium; the right jugal is slightly damaged but only the anterior half of the left jugal is present. The mandible is complete with only minor breakage of the left first and third teeth.

Only the first three cervical vertebrae are represented. The atlas has sustained minor damage to the lateral borders of each wing. The axis is missing the right half of the neural arch and neural spine. The posterior epiphysis of the centrum and parts of both transverse processes are missing. The third cervical vertebra exhibits minor breakage of the neural spine and the ends of the transverse processes. The body of the centrum is slightly damaged and lacks the posterior epiphysis; the anterior epiphysis is present but unfused.

A partial rib cage is represented by thirteen costal ribs which exhibit some breakage of the distal ends. The left scapula is complete with minor damage to the vertebral border epiphysis. The right femur lacks the epiphyses forming the head of the femur and the medial condyle/intercondylar articular surface of the

distal end; the epiphyses are unfused. The left innominate exhibits moderate breakage of the pubis.

UCMP 139027 represents the distal two-thirds of a right femur with damage consisting of a 10 cm by 11 cm section of bone missing from the anterior of the shaft above the intercondylar articular surface to the anterior portion of the medial condyle, which is broken. The condylar epiphyses are fused.

Discussion: Possessing the characteristic lobate teeth of mylodont ground sloths the Stevenson Bridge specimens are morphologically indistinguishable and within the range of variation observed by Stock (1925) for specimens of *Glossotherium harlani* from Rancho La Brea (Appendix 1). With the exception of UCMP 139027, a right femur, all other material appears to represent one individual (UCMP 116084) based on depositional setting, size and condition of the skeletal elements. The presence of several elements with unfused epiphyses indicates that UCMP 116084 was a subadult. The overall size of UCMP 116084 approaches the mean of Rancho La Brea specimens; the cranium is slightly longer and the postcrania slightly smaller than the Rancho La Brea mean.

UCMP 139027, a right femur with fused epiphyses, represents a large adult. The femur is of larger size than the right femur of UCMP 116084. UCMP 139027 is larger than the mean of Stock's (1925) observations (Appendix 1).

Order Proboscidea Illiger, 1811
 Family Elephantidae Gray, 1821
 Genus *Mammuthus* Burnett, 1830
Mammuthus columbi (Falconer), 1857
 Figure 7

Referred specimens: UCMP 116085, partial skeleton including: partial cranium, mandible, left scapula, left ulna, left radius diaphysis, partial ilium, right trapezium, and miscellaneous unidentified fragments, mostly cranial material and portions of limb bone diaphyses.

Description: About 20-25% of the shattered cranium is represented. Part of the occipital region remains intact but most fragments average only 10-20 cm in size. The upper third molars are complete. The mandible with both third molars is mostly complete. The left coronoid process is



Figure 6. UCMP 116084, *Glossotherium harlani* cranium (A) and mandible (B) from the Stevenson Bridge locality, V76199. Bar scale = 10 cm.

partially broken while most of the posterior portion of the right dentary is missing. Nearly all of the supraspinous fossa and about one-third of the infraspinous fossa are missing on the scapula. The scapular tuberosity, coracoid process, acromion process and mid-spinous process are broken. The left ulna is missing the distal articular end and the olecranon process is broken. The right trapezium is complete with minor damage to the articular surfaces for the trapezoid and scaphoid.

Discussion: Confusion exists regarding North American mammoth taxonomy (Maglio, 1973; Kurtén and Anderson, 1980; Graham, 1986; Agenbroad and Barton, 1991) and until a comprehensive revision is undertaken it is particularly important to cite the taxonomy being used. Here the taxonomy follows Maglio (1973) since it is the most often cited. Dental measurements on the M^3 s are presented in Table 1 using procedures outlined by Maglio (1973). Measurements on both teeth were the same. The

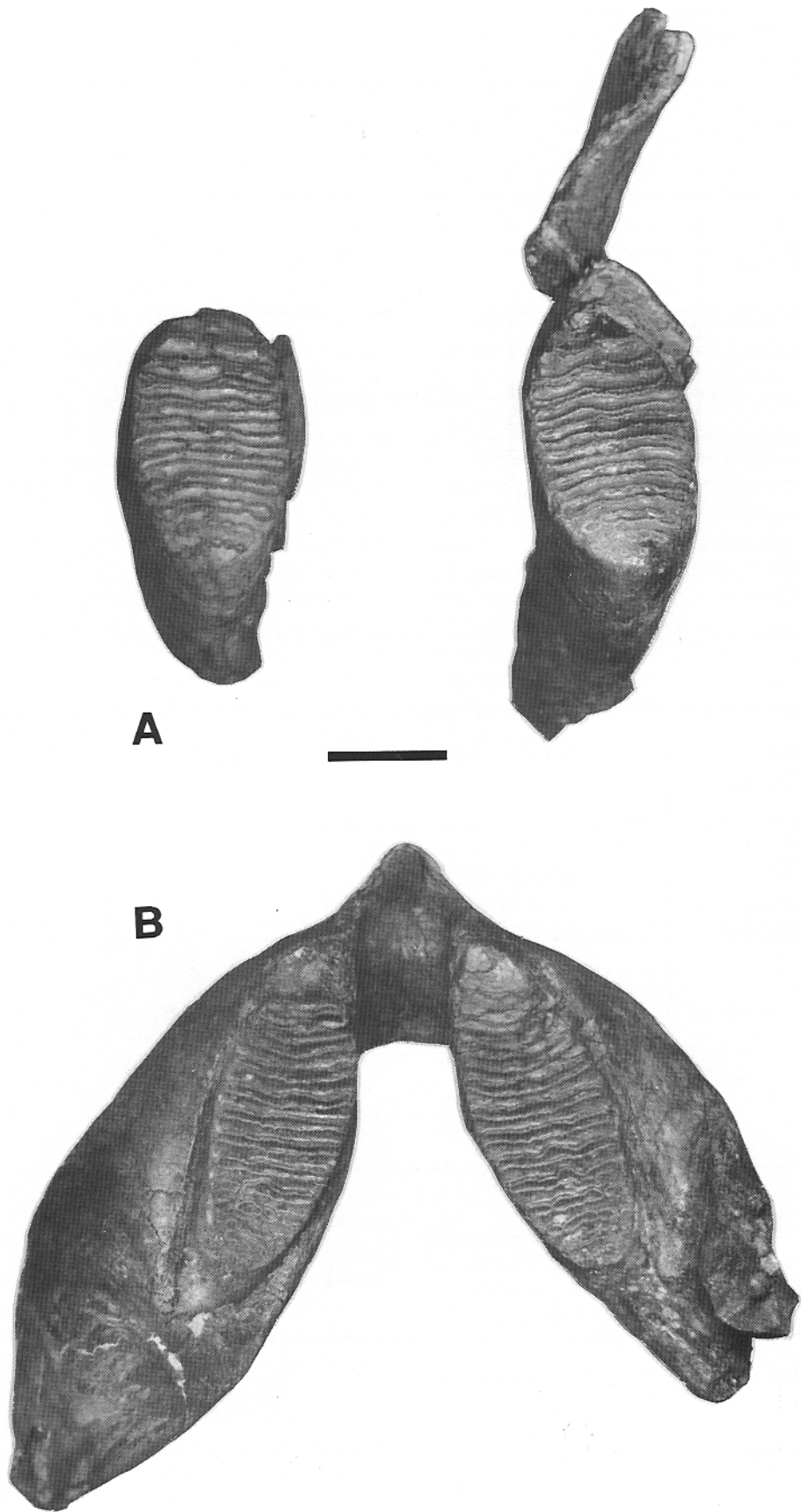


Figure 7. UCMP 116085, *Mammuthus columbi* upper third molars (A) and mandible (B) from the Stevenson Bridge locality, V76199. Bar scale = 10 cm.

Table 1. Measurements of *Mammuthus* left and right M³ from Stevenson Bridge compared with characteristics of late Pleistocene North American mammoth taxa compiled from Maglio (1973).

Characteristics	UCMP 116085	<i>M. columbi</i> (typical form)	<i>M. columbi</i> (derived form)	<i>M. primigenius</i>
lamellar frequency (lophs per 100 mm)	6	5 - 7	7 - 9	7 - 12
enamel thickness	2.0 mm	2.0 - 3.0 mm	1.5 - 2.0 mm	1.0 - 2.0 mm
plates per tooth	21	20 - 24	24 - 30	20 - 27

Table 2. Localities in the vicinity of the Stevenson Bridge site (V76199). A voucher specimen is listed for each taxon.

UCMP Locality Number	Locality Name	Taxa	County
V5430	Putah Creek 1	<i>Smilodon</i> UCMP 44932	Yolo
V6911	Putah Creek Nursery	<i>Mammuthus</i> UCMP 82994	Yolo
V69182	Putah Creek 2	<i>Mammuthus</i> UCMP 139288	Solano
V69183	Putah Creek 3	<i>Mammuthus</i> UCMP 139289 <i>Glossotherium</i> UCMP 139290	Solano
V69184	Putah Creek 4	<i>Glossotherium</i> UCMP 139291	Solano

lamellar frequency, enamel thickness and plate number support the assignment of these specimens to *Mammuthus columbi* (Table 1), in particular the typical southern population of Columbian mammoths as classified by Maglio (1973). All specimens are from an adult, probably one individual. Measurements were not taken on specimens other than teeth because of the incomplete nature of most elements resulting in the lack of useful measurements.

AREA LOCALITIES

The Stevenson Bridge locality is one of several fossil sites in the area along Putah Creek. Nearby localities contain ground sloth and mammoth remains with one locality featuring a *Smilodon* canine (UCMP 44932) (Table 2). Two of these sites, V69182 and V69183, probably represent part of the same bone assemblage as Stevenson Bridge because both contain mammoth remains of similar preservation as Stevenson Bridge and are located directly across the stream on the south bank of Putah Creek. The Yolo/Solano county line runs along Putah Creek in this area, thus localities directly across the stream from one another are in different counties. Errors in Jefferson (1991, p.102) with regard to the location and taxa present at these sites should be amended according to the descriptions in Table 2.

CONCLUSIONS

Although initiated as a project to document well preserved ground sloth and mammoth specimens, this paper quickly evolved into a taphonomic study utilizing data collected nearly 20 years ago by other researchers, underscoring the importance of good field and laboratory techniques, especially in data collection.

As often noted, paleoecological inferences, and resulting evolutionary studies, can only be accurately assessed if taphonomic biases are known (Voorhies, 1969; Behrensmeyer, 1988; Fiorillo, 1988) and taphonomic interpretations depend on accurate and precise field data as well as the application of appropriate excavation and preparation techniques. As Fiorillo (1988) points out, many taphonomic processes (i.e. weathering, trampling, carnivore activity, fluvial transport, etc.) are recognizable through close examination of bone surfaces. Coupled with data on the depositional environment, this provides the necessary information for making paleoecological inferences. Although a taphonomic study was not

the original goal during excavation of this locality, the recording of some data permitted later taphonomic inferences to be made. This serves as a prime example of the significance of how field planning and utilization of appropriate scientific methods can provide important information for future studies even if the data collected during field work will not be used as a part of the current scope of a project.

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Appendix 1. Skeletal measurements of *Glossotherium harlani* from Stevenson Bridge (V76199) compared with specimens from Rancho La Brea. The Rancho La Brea specimen data is taken from Stock (1925); approximate values were not used. All measurements are in millimeters.

Measurements	UCMP 116084	Rancho La Brea		Stock (1925)
		N	Range	Mean
Cranium				
Length from anterior margin of maxillaries to posterior end of occipital condyles.	502	25	461.8-527.6	496.8
Length of palate from anterior end of maxillaries to postpalatine notch.	229	21	176.5-237.8	214.5
Greatest width measured across ventral surface anterior to first teeth.	136	26	118.4-156.0	138.1
Width of palate measured between middle of inner sides of second upper teeth.	67	27	61.8-90.5	73.7
Width of palate measured between inner sides of anterior lobes of fifth upper teeth.	41	27	41.7-62.5	51.7
Least width posterior to fifth upper teeth.	63	28	57.8-77.3	67.2
Greatest width across occipital condyles.	129	25	120.0-143.9	132.0
Transverse diameter of foramen magnum.	52	26	35.8-52.9	44.3
Dorso-ventral diameter of foramen magnum.	43	26	32.9-42.0	37.4
Least width behind postorbital processes.	103	29	96.4-134.0	113.0
Height measured from plane of basioccipital to dorsal plane.	144	27	119.7-157.0	138.3

Appendix 1 continued.

Measurements	UCMP 116084	Rancho La Brea		Stock (1925)
		N	Range	Mean
Mandible				
Length from anterior end of symphysis to posterior end of condyle.	387	25	353.1-409.8	379.8
Greatest length of symphysis.	124	21	90.0-116.4	102.8
Greatest pre-dental width.	133	19	102.7-145.4	132.9
Depth of ramus between third and fourth teeth, measured normal to inferior margin.	85	32	69-97.1	85.4
Upper teeth				
Length of tooth row, alveolar measurement.	148	20	111.3-155.5	132.5
1st antero-posterior diameter.	18	8	14.9-22	17.9
1st transverse diameter.	15	7	13.2-20	15.2
2nd antero-posterior diameter.	29	21	28.8-41.3	33.4
2nd transverse diameter.	16	18	14.8-20.7	17.4
3rd antero-posterior diameter.	26	20	22.2-32.1	27.1
3rd transverse diameter.	23	17	17.8-26.1	22.8
4th antero-posterior diameter.	25	16	20.1-27.8	23.1
4th transverse diameter.	23	18	19.1-28.1	23.9
5th antero-posterior diameter.	22	18	20.9-30.4	24.5
5th transverse diameter.	18	16	16.5-22.8	19.2
Lower teeth				
Length of tooth row, alveolar measurement.	143	18	126.7-151.4	138.9
1st antero-posterior diameter.	25	18	13.2-26.1	21.6
1st transverse diameter.	14	18	12.5-20.2	16.0
2nd antero-posterior diameter.	24	16	24.0-31.3	27.9
2nd transverse diameter.	23	14	19.2-26.5	22.2
3rd greatest diameter across occlusal surface.	30	15	24.6-33.8	28.8
3rd diameter of occlusal surface normal to greatest diameter.	19	12	14.5-20.5	17.8
4th antero-posterior diameter.	54	24	44.4-59.9	51.9
4th greatest diameter of anterior lobe.	30	16	18.9-32.3	23.9
4th greatest diameter of posterior lobe.	23	18	16.1-24.0	20.5

Appendix 1 continued.

Measurements	UCMP 116084	Rancho La Brea		Stock (1925)
		N	Range	Mean
Atlas				
Greatest transverse width across lateral wings.	220.3 minimum	8	211-237	221.7
Greatest antero-posterior diameter.	94	8	77.7-96.8	87.6
Antero-posterior diameter of ventral wall of neural canal along median line.	39	7	33.2-43.9	38.3
Greatest transverse distance between posterior borders of facets for axis.	100	7	89.4-102.3	96.4
Least transverse distance between anterior borders of facets for axis.	46	8	39-55.5	46.0
Greatest antero-posterior diameter of lateral process.	79	8	77.7-97.8	84.5
Axis				
Greatest length along median line of ventral surface.	81 minimum	6	82-92.3	86.9
Least width behind articulating surfaces for atlas.	89	6	76.0-88.0	84.1
Dorso-ventral diameter of centrum across posterior surface.	42	6	45-49.9	47.7
Greatest width of centrum.	57	6	53-62.7	58.7
Greatest transverse diameter of neural canal at anterior end.	55	6	45-61.4	50.0
Least distance from anterior border of neural canal to border of notch below posterior zygapophyses.	22	6	24.3-29.2	26.3
Greatest width across outer ends of lateral facets for atlas.	97	6	85.8-102	98.1
3rd cervical vertebra				
Length of centrum measured over ventral surface.	30 minimum	--	-----	38
Width across centrum measured over anterior face and between inner borders of vertebral arterial canals.	73	--	-----	75.3
Depth of centrum measured over anterior face and normal to dorsal surface.	45	--	-----	50.3
Width across outer sides of anterior zygapophyses.	113	--	-----	114
Greatest width across posterior zygapophyses.	97	--	-----	91.7

Appendix 1 continued.

Measurements	UCMP 116084	Stock (1925) Mean
Scapula		
Length, measured from outer border of glenoid cavity to supra-scapular border and along the base of the spine.	312	327.7
Greatest length, measured from end of clavicular facet to supra-scapular border and parallel to length of spine.	418	435
Greatest width of blade, measured between ends of supra-scapular border.	400 estimate	422.1
Width measured below base of spine.	226	227.3
Height, measured from inner border of glenoid cavity to point directly above on surface of acromial process.	149	162.5
Greatest antero-posterior extent of glenoid cavity.	113	117.5
Greatest transverse width of glenoid cavity.	74	72.3
Greatest width of coraco-acromial arch.	59	68.2
Greatest diameter of supra-scapular aperture inclosed by coraco-acromial arch.	169	168.4

Measurements	UCMP 116084	UCMP 139027	Stock (1925)	
			N	Mean
Femora				
Length, measured from great trochanter to inferior surface of outer condyle.	492	-----	26	525.2
Width, measured from inner surface of head to outer surface of greater trochanter.	262 minimum	-----	26	282.9
Least width of shaft.	153	176	26	164.6
Greatest width across distal tuberosities (above condyles).	227	257	26	234.8
Width across condyles.	-----	196	26	188.5
Width of intercondyloid space.	47	59	26	47
Greatest width of inner condyle.	-----	81	26	88.7
Vertical extent of inner condyle.	-----	123	26	120