

LATE PREHISTORIC BONE MARROW EXTRACTION: A CASE STUDY IN WESTERN  
WISCONSIN

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**ABSTRACT**

The Swennes Upper Garden Terrace site (47Lc333) in La Crosse County, Wisconsin has been the location of multiple excavations by the Mississippi Valley Archaeology Center at the University of Wisconsin-La Crosse since 1995. Of the many late prehistoric Oneota pit-features discovered at the site, Feature 30 was found to contain several hundred white-tailed deer (*Odocoileus virginianus*) bone fragments. These bones displayed characteristics indicating they had been systematically fractured in the production of “bone grease.” Bone grease is obtained by boiling the fatty bone marrow out of the cancellous tissue of bones and is high in nutrients. Its production and use is documented ethnographically and archaeologically in various regions and climates. This paper examines the bone fragments from Feature 30 through quantitative analysis and the use of ethnographic, archaeological, and experimental literature, with the goal of interpreting the human processes resulting in their deposition within the feature.

## INTRODUCTION

The Swennes Upper Garden Terrace site (47Lc333) located near the town of Holmen in La Crosse County, Wisconsin, has been the location of multiple excavations by the Mississippi Valley Archaeology Center (MVAC) since 1995. The Oneota, the last native peoples to live in western Wisconsin and much of the Midwest before European contact, most likely occupied the area as a winter habitation site. The significance of this is that most research has suggested that winter occupation is minimal and the Oneota left the area for the winter and traveled west to hunt bison.

One of the features opened up during the 2008 excavations, Feature 30, contained several hundred white-tailed deer (*Odocoileus virginianus*) bone fragments. These bones displayed characteristics indicating they had been systematically fractured in the production of “bone grease.” Bone grease is the fat and marrow from within the spongy bone in the ends of long bones and is very high in fat, nutrients, and energy. It is obtained by breaking spongy bone into fragments and boiling them in water. The fat and marrow then float to the top and can be scooped off.

This paper examines the bone fragments from Feature 30 with the goal of explaining the human processes resulting in their deposition within the garbage pit. The fragments have been identified with the assistance of two comparative specimens. Those that were unidentifiable were divided into several categories. The unidentifiable shaft fragments were further divided by type of fracture and structure of their interior surfaces. Quantitative analysis of the divisions has yielded interesting data. Experimental work and ethnographic literature have been used as a base for explaining these specimens.

## **BACKGROUND**

### THE DRIFTLESS AREA

The unglaciated Driftless Area of the Upper Mississippi River Valley features exposed bedrock formations and thousands of deep, narrow valleys. Theler and Boszhardt (2006) write of a range of vegetation ranging from wetland forest and marshes to prairies and oak savannas that prehistorically covered the region unlike the deciduous forests that cover the area today. The variety of environments yielded resources that were unique to each biome, providing much more diversity than can be found today.

The oak savannas were maintained by periodic burning by Native Americans. The oak savannas and prairies were found in the upland ridges and terraces and offered sporadic nut trees, berries, birds, small mammals, elk, and white-tailed deer. Flood plains of the many rivers in the region, including the Mississippi River, contained fish, freshwater mussels, cattail, arrowleaf, wild rice, grapes, resident and migratory waterfowl, beaver, muskrat, otter, other small mammals, and white-tailed deer. The combination of prairies and deciduous forests on the north- and east-facing slopes of ridges offered the perfect environment for deer, elk, and small game (Theler and Boszhardt 2003:29-32).

Erosion has created many rockshelters in the bedrock formations, which are home to many winter occupation sites. Also, the erosion reveals deposits of flint-like material that can be used for production of stone tools. Sources of high-quality tool stone were revisited on a regular basis to acquire material. Major sources of high-quality material were highly valued because the upper Mississippi River Valley has relatively poor quality flinty rock.

The climate of the Driftless Area today is not too different from how it was for the Oneota. The region experiences four true seasons, summer, fall, winter, and spring. Winters are cold and harsh and summers can be hot and humid. The warm seasons offer an abundance of plant and animal resources, while in the winter months large game are primarily available. The Oneota experienced warmer and moister climate between about A.D. 1000 and 1250 during the Neo-Atlantic climatic shift, a dryer period for about 200 years, a short reoccurrence of the warm and moist patterns, and a much cooler and moister period from about A.D. 1550 on called the Neo-Boreal (Theler and Boszhardt 2003:37).

## ONEOTA

The prehistoric peoples of the Driftless Area lived as hunters and gatherers for thousands of years. They depended on a seasonal round of subsistence, exploiting lakes, rivers, and wetlands during the summer and retreating to rockshelters in the hills during the winter. The last tradition of people to really live this way were the Late Woodland peoples, who carried their particular cultural traits in Wisconsin from about A.D. 700 until around A.D. 1200. Around A.D. 1050 the Middle Mississippian culture began rapidly developing in the region of Cahokia, just across the Mississippi River from present-day St. Louis. During this period there is evidence of Mississippian expansion north into Woodland peoples' regions. One of the most famous sites to demonstrate this is Aztalan in Jefferson County, Wisconsin, which had a palisade wall and large platform mounds suggestive of those at Cahokia. In Trempealeau, Wisconsin are a series of three connected platform mounds and their borrow pits. Red-slipped pottery was found, with shell tempering. These pottery types are confirmed to be Middle Mississippian Lohmann phase

types (Theler and Boszhardt 2003:147). Another site, the Fred Edwards site in Grant County, Wisconsin, contained potsherds with both Woodland and Mississippian characteristics. Some of the vessels were even identified to have been manufactured at Cahokia (Theler and Boszhardt 2003:149). The site also features rectangular-shaped houses, an architectural design that is distinctly Mississippian, as well as a palisade line. Many points were found that were made from materials imported from the Cahokia region, were of Mississippian style, or both. The Hartley Fort site in northeast Iowa was similar and also had a palisade wall. The stockades at these sites signify the need for defensive strategy in response to population increases and territorial pressures due to decreased mobility and increased reliance on corn agriculture.

As the Woodland peoples left the Driftless Area and adopted Mississippian traits such as shell-tempered pottery and intensive corn agriculture, the Oneota culture formed as clusters of major agricultural villages around the Red Wing, Minnesota area and the Apple River in Illinois. They adopted a new seasonal round in which intensive corn agriculture and wetland exploitation were undertaken in the summer. In the winter many of the Oneota moved west of the Mississippi and hunted bison on the Plains. This is suggested by the accurate depictions of bison in rock art and a heavy Plains influence in styles and iconography (Theler and Boszhardt 2003:159).

#### THE SWENNES UPPER GARDEN TERRACE SITE (47LC333)

The Swennes Upper Garden site is one of four locations at the broader Swennes site. The Upper Garden Terrace is one of two high terrace locations, along with the Upper Terrace. The other two locations are low terrace locations, A and B. The Upper Garden Terrace overlooks the major bend of the Long Coulee Creek, a small tributary of the Mississippi River. Surface

collections were performed at the site in 1990 and the site was first excavated in 1995 by the University of Wisconsin-La Crosse field school (Burkart and Woolley 1996).

Cultural remains from the site are indicative of the Oneota culture and features demonstrate Oneota living patterns. Feature 1 of the Upper Garden Terrace, a refuse pit, contained well preserved artifacts, including a bison scapula hoe and a decorated rimsherd. The rimsherd is typical of the Pammel Creek Phase Oneota in the La Crosse area, which is accepted as A.D. 1400 - A.D. 1500. Feature 1 also contained a collection of broken deer bones not unlike those analyzed in this paper. Unfortunately due to time constraints focus had to be placed on the bones from only one feature.

Feature 30 was excavated during the 2008 field season by MVAC's public field school. The feature was initially discovered to contain a large ring of fire-cracked rock, demonstrating the feature's use as an earth-oven. Underneath the hearth was a "Red Zone" of reddened soil. The collection of white-tailed deer bone fragments was found below the Red Zone, along with turtle shell, potsherds, and fire-cracked rock. This entire collection of material was removed as matrix. The nature of the feature suggests it was initially used as a refuse midden for disposing of the bone, shell, potsherds, and fire-cracked rock. The refuse was then covered over with soil and the upper section of the feature was used as an earth-oven. One rimsherd from Feature 30 is diagnostic of the Pammel Creek Phase, placing the feature within the same temporal context as the rest of the site.

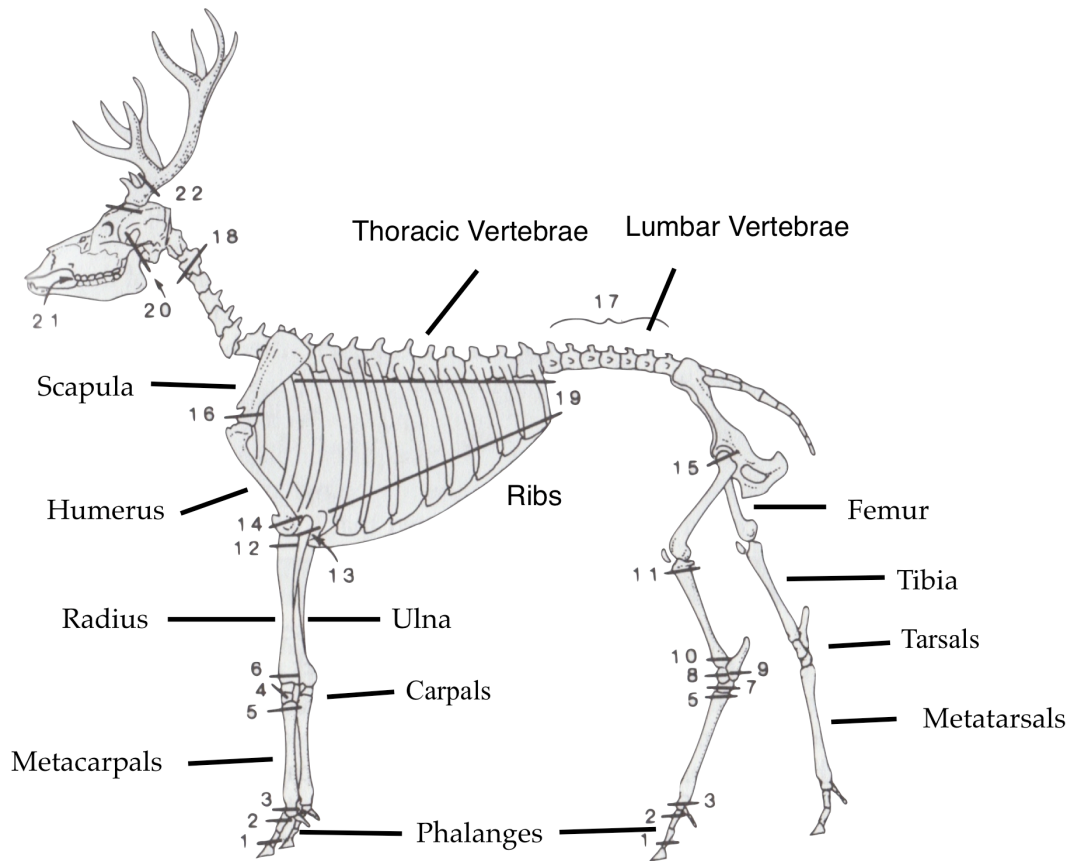
## WHITE-TAILED DEER

The white-tailed deer (*Odocoileus virginianus*) was the most economically important animal to prehistoric peoples, being one of the largest animals in the region, with the periodic exception of elk (*Cervus canadensis*), bison (*Bison bison*), and black bear (*Ursus americanus*). Deer remains are most numerous at pre-Oneota fall-winter occupations in rockshelters, which can contain thousands of bone fragments and represent dozens to hundreds of deer. Inhabitants of the Driftless Area heavily relied on the animal as the primary winter food source (Theler 2000:127). Their size, anatomical characteristics, and nutritional qualities form a perfect package of quality meat, fat, and hide in an easy-to-carry bundle (Gramly 1977; Madrigal and Holt 2002). Bucks are rarely larger than 42 inches at the shoulder, and does are typically under 32 inches. An average buck weighs 240 pounds and an average doe, about 160 pounds (Jackson 1961).

White-tailed deer are one of the most abundant animals among archaeological sites in western Wisconsin. There are identified remains at over 30 different Archaic, Woodland, and Oneota sites, including the Cade sites, Raddatz Rockshelter, Mill Pond site, Pammel Creek site, the Valley View site, the Gunderson site, the Sand Lake sites, the Krause site, and others (Theler 2000:129).

White-tailed deer prefer a mixture of vegetation communities as opposed to tight forests and wide open grasslands, which it typically avoids. This variation in vegetation types easily provides the more than a hundred plant species it feeds on, including a wide variety of hardwoods, shrubs, herbs, and conifers. It prefers woodland borders and thrives in agricultural areas (Jackson 1961).

Figure 1: Artiodactyl skeletal anatomy (Modified from Lang and Harris 1984:Figure 11)



Methods for butchering an animal seem to be dictated by the anatomy of the animal itself. Modern hunters (Madrigal and Holt 2002:747), even with the aid of a steel knife, butcher white-tailed deer in the most practical fashion. Cut marks present on artiodactyl bones from the Arroyo Hondo collection (Lang and Harris 1984:78-84) suggest similar methods of butchering, although the order of meat removal is not necessarily clear.

To skin the deer, cuts were made at the carpal and tarsal ankle joints. Long cuts were made through the skin along the forelimbs and hindlimbs, along the belly towards the chin, and near the head. Cuts through the cartilage and ligaments of the carpal and tarsal joints would free the lower limbs, still attached to the hide (see Figure 1) (Lang and Harris 1984:80). From here

the hide could be pulled off the carcass. This method results in the full hide, minus the head, with lower legs still attached, which can be used as “handles” for carrying the hide. Portions of meat and other remains being kept could be very easily carried in the hide as a bundle.

In removing meat from the animal, both modern and prehistoric hunters remove muscles from the legs, loin, neck, and back, making cuts at articulate ends of long bones, thoracic and lumbar vertebrae, ribs, and neck (Madrigal and Holt 2002:747; Lang and Harris 1984:82). Bones were sometimes smashed in preparation for extraction of bone marrow, or bone grease, resulting in the fragmentary remains typically found.

#### BONE GREASE PRODUCTION

Ethnographic literature (Leechman 1951; Wilson 1924), ethnoarchaeology (Binford 1978; Outram 1998, 1999), and experimental archaeology (Madrigal and Holt 2002; Outram 2001) have demonstrated that bone marrow was prehistorically, and continues to be, an important source of fats and nutrients to peoples in a variety of regions and climates. The shafts of long bones can be easily broken to reveal several grams of marrow which can be easily scooped out. Besides the marrow easily obtained from the shafts of long bones and other elements, marrow locked in the spongy cancellous tissue of long bone articulate ends and vertebrae was also a strongly desired resource. To obtain this marrow, much more work is required. The bone must be smashed into small pieces and then boiled to extract the marrow, which is referred to as “bone grease.”

Dan Witter (Binford 1978:153-155) describes two process of initial bone fracturing and marrow extraction among the Nunamiut Eskimos. The first was a simulation of hunting camp

conditions. During this ethnographic demonstration bones were broken for snacking on marrow from the shafts and not for bone grease production. Since the purpose was to obtain the shaft marrow, once the shafts were cracked open and the marrow was removed the bones were discarded. This resulted in many articulate ends having long, sharp “bayonets” of bone attached to them.

The second demonstration was a permanent camp simulation. In this demonstration the articulate ends of bones were broken off with the intention of saving them for bones grease production. If a fracture produced a long, “bayonet” break on an articular end, the long, sharp piece of bone was broken off. The shaft marrow could still be easily poked out of the tubular shafts (Binford 1978:155). The articulate ends would then be stored until enough were accumulated to make the process of fracturing the ends and boiling them worthwhile (Binford 1978:157).

When enough ends had been stored, they are broken into smaller pieces by placing the bone on a sturdy rock and then smashing it with a hammerstone. While cracking long bone shafts can be done quickly with a moderate blow, breaking the articulate ends of long bones is significantly more difficult. The term “spongy” bone is misleading, because this type of bone is not at all soft, but is very strong due to its arching and webbing of bone.

In boiling the bones, the Hidatsa (Wilson 1924) and Nunamiut (Binford 1978:32) kept the processing of axial and limb bones separate, as a different sort of grease is produced by each. Water was boiled by first heating stone in a fire, and then placing the hot stones into the water with the bones (Binford, 1978:159). When boiled, the fat and marrow within the spongy bone comes out and floats to the top of the water where it can be skimmed off. By cooling the water,

the fat and marrow coagulate and are easier to skim off and control (Binford 1978:158; Wilson 1924).

## BONE BREAKAGE

As previously mentioned, rockshelter deer-bone collections sometimes consist of thousands of bone fragments. It is possible to determine reasons for fragmentation by studying the fracture surfaces themselves. Different bone usages require fracturing the bone at different times. As bones dry out they develop micro-cracks that affect the way the bone fractures. Heating or freezing bone can also affect the way the bone will fracture (Outram 1998). Fresh bones fracture in helical or spiral patterns; the breaks wind around the bone shaft like a spiral staircase. The fracture surface tends to be smooth and will be at either an obtuse or acute angle to the bone's cortical surface (Johnson 1985; Morlan 1984; Outram 1998). Therefore if the bone fragments exhibit spiral fractures, the bone was fragmented when it was still fresh. Points of impact can also be detected; Dynamic impacts leave conical scars, from which helical fractures rotate outward.

As bones dry out, there is a greater tendency that the fractures will be straight, the fracture surface will be perpendicular to the bone's cortical surface, and the texture of the surface will be rough (Johnson 1985; Morlan 1984). These types of fractures are called "dry bone" fractures. Identifying fracture type (and in return, freshness of the bone at time of fracturing), is a practical technique because it can be performed on otherwise unidentifiable fragments of bone.

## METHODS

The following section describes the methods used in analyzing a collection of several hundred pulverized white-tailed deer (*Odocoileus virginianus*) bones from Feature 30 at the Swennes Upper Garden Terrace site (47Lc333) in La Crosse County, Wisconsin. The bone fragments were laid out onto trays for sorting and were identified via two modern *O. virginianus* specimens, a four and a half year old adult female and a six month old young female. Both specimens were provided by Dr. James Theler, Department of Sociology and Archaeology at the University of Wisconsin-La Crosse and were aged by dental eruption. The six-month-old was used for identifying unfused epiphyseal fragments. Identified fragments were immediately laid out by element and side and are discussed below. Unidentifiable fragments appearing to be from articulate ends or with diagnostic markers were bagged as a group and total 98. “Chunks” of spongy bone with zero or minimal exterior surface were bagged as one group and total 124.

The remaining 117 unidentifiable shaft fragments were then examined one by one and grouped into one of four groups based on two criteria. Fragments were separated into those where the structure of the interior surface is greater than or equal to one-half spongy bone tissue, and where the structure of the interior surface is less than one-half spongy bone tissue.

The fragments were further divided based on fracture type, dividing between green-bone fractures and dry-bone fractures. The result of this second division was four groups: (1) Green-bone fracture and < 50% spongy; (2) Green-bone fracture and  $\geq$  50% spongy; (3) Dry-bone fracture and < 50% spongy; and (4) Dry-bone fracture and  $\geq$  50% spongy. The results of the sorting are presented in Tables 1 and 2.

Table 1: Total bone fragments

<b>Identified Fragments</b>	164
<b>Spongy Bone “Chunks”</b>	124
<b>Unidentified Articulate Ends</b>	98
<b>Shaft Fragments</b>	117
<b>TOTAL FRAGMENTS</b>	503

Table 2: Unidentifiable shaft fragments

<b>Dry/&lt; 50%</b>	6
<b>Dry/≥ 50%</b>	33
<b>Green/&lt; 50%</b>	19
<b>Green/≥ 50%</b>	59
<b>TOTAL</b>	117

There were a total of 503 fragments of white-tailed deer and probable-deer bone. Neither the unidentifiable articulate fragments nor the spongy bone chunks are further used in this discussion. Care was taken to minimize fragment breakage and deterioration during handling.

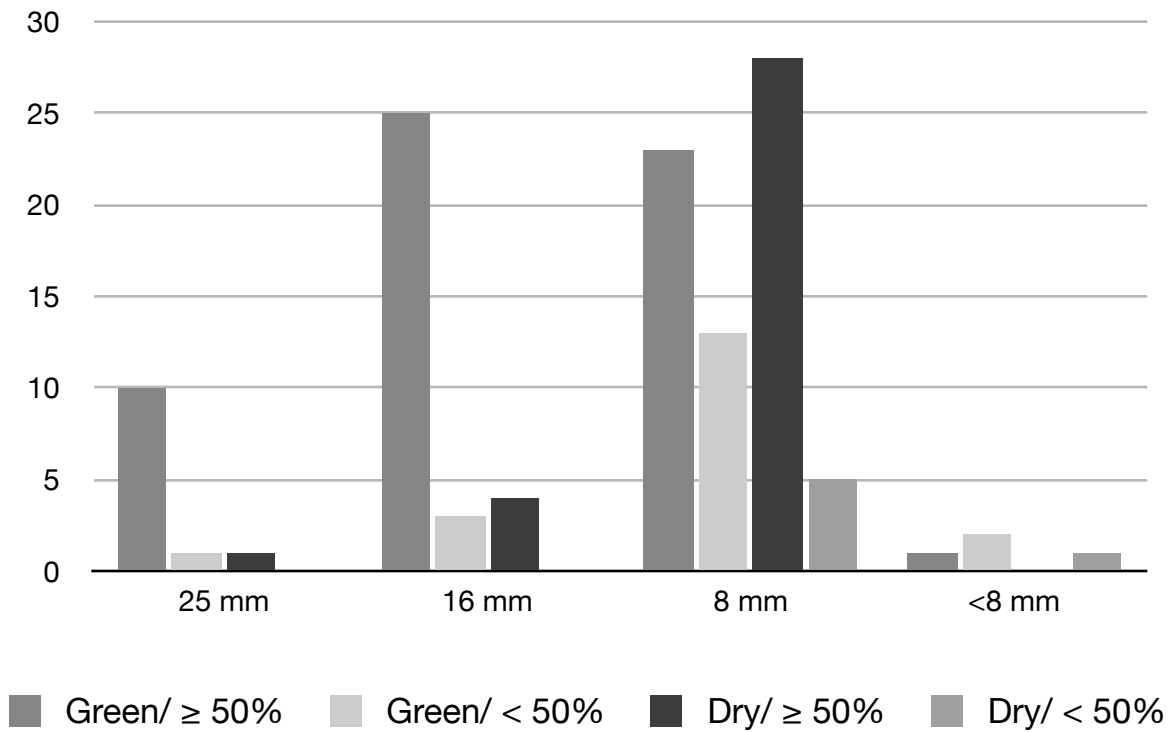
All fragments were passed through a series of 25 mm, 16 mm, and 8 mm geological sieves to sort them by size. Fifty-six percent of identifiable fragments were between 16 mm and 25 mm, 21 percent were larger than 25 mm, and 22 percent were only larger than the 8 mm screen. No identified fragment was smaller than 8 mm. Three spongy bone chunks were larger than 16 mm and the rest were either larger than 8 mm (69 fragments) or were smaller than 8 mm. The fragments smaller than 8 mm were weighed rather than counted because of the fact that they crumbled extremely easily. These fragments made up the majority of the spongy bone chunks and weighed 23.6 g. Fifty-eight percent of unidentifiable fragments with diagnostic markers were larger than 8 mm. Those larger than 16 mm made up 38 percent. Fragments larger than 25 mm made up two percent and those smaller than 8 mm made up one percent.

The unidentifiable shaft fragments were size graded within their four sorted groups. These results are presented in Table 3 and Figure 2.

Table 3: Shaft Fragments Size Grading

	25 mm	16 mm	8 mm	<8 mm	Totals
<b>Green/ <math>\geq</math> 50%</b>	10	25	23	1	59
<b>Green/ &lt; 50%</b>	1	3	13	2	19
<b>Dry/ <math>\geq</math> 50%</b>	1	4	28	0	33
<b>Dry/ &lt; 50%</b>	0	0	5	1	6

Figure 2: Shaft Fragments Size Grading



There are several types of quantitative values that can be obtained from minimally sorted faunal assemblages. The first is NISP (number of identified specimens), which counts each bone and fragment of bone as one unit. Simply put, every bone or bone fragment is counted and the total number is the value assigned. This can lead to an overestimation of the number of individuals represented by the assemblage, because many fragments can be from the same whole

bone. It also does not take into consideration the size or importance of bones or fragments. Ten small fish bones are hardly equal to 10 bison tibiae.

Another technique is to calculate the minimum number of individuals (MNI). The purpose of this method is to calculate the minimum number of individuals that could possibly be represented by an assemblage. This is done by separating the most abundant element of the species found into right and left components and using the greater number as the unit of calculation. The most abundant element is found by locating multiple presences of particular diagnostic markers on the bones. Contrary to NISP, this method may result in slight conservative error, because it is difficult to know if all the rights match all the lefts. MNI can be made more accurate by dividing the specimens into age groups and using those to determine how many rights could possibly be matched to lefts within the same age group.

MNI is perhaps most useful because it allows for the calculation of meat-weight and other qualities (White 1953:397). The specifications of one individual can be extrapolated to the entire assemblage by multiplying by the MNI. For example, a white-tailed deer has about 23 kg of meat (Kubisiak 2001:81, Figures 5.8, 5.11). If a collection of white-tailed deer bones has an MNI of four, 23 kg of meat times four individuals equals 92 kg of meat represented by the collection.

NISP and MNI are presented by element in Table 4.

Table 4: NISP and MNI by element, side

	Femur	Tibia	Metatarsals	Humerus	Ulna	Radius	Metacarpals
<b>NISP</b>							
Left	29	18	0	29	3	5	0
Right	30	16	4	10	8	10	3
<b>MNI</b>							
Left	3	4	0	4	2	2	0
Right	3	3	1	2	3	3	1

## RESULTS/DISCUSSION

The tibiae and humeri each provide a final MNI of four individuals. It is interesting to note that only two elements' sides have an MNI of four; five elements' sides have an MNI of three. MNI is discussed in further detail below.

Upon identifying fragments by element and side, the observation was made that there is an uneven representation of elements in the collection. While some elements (femurs and tibiae) have equal or near-equal numbers of fragments, other elements (humeri, metatarsals, metacarpals, ulnae, and radii) have many fragments of one side and few or none of the other (Figure 3).

This uneven representation can be seen, although to a lesser extent, in the MNIs of the elements as well (Figure 3). However, it should be noted that low MNI values can magnify the difference between elements. Again there is an even representation of left and right femurs and a near-equal representation of left and right femurs. Radii and ulnae are also near-equal between lefts and rights. There are twice as many left humeri (four) as there are rights (two). Left humeri have an NISP of 29 and right humeri have an NISP of 10, a ratio of over 3:1 (Figure 3). It is noteworthy that this ratio does not carry over to MNI. Again there is an unusually low

representation of metatarsals and metacarpals compared to the other elements, with only one bone represented for both elements.

The very limited presence of metacarpals and metatarsals and complete lack of phalanges, both in NISP and MNI, is probably because they were most often left attached to hides to be used as handles. This would result in those elements being separated from the broken-off articulate ends being kept for bone grease production. Also, if a hide were to be traded away, the lower leg bones would be completely removed from the site.

Madrigal and Holt (2002:Figure 2a) have identified the elements with highest gross yield of marrow, in declining order, to be the tibia, femur, radius, metatarsal, humerus, metacarpal, mandible, and phalanxes. As shown in Figure 3, most identifiable fragments come from femurs, humeri, and tibias, all high in gross marrow content. Madrigal and Holt (2002:Figure 2b) have also calculated return rates for marrow extraction. In declining order, elements with highest marrow return rates are the tibia, femur, humerus, radius, metatarsal, mandible, metacarpal, and phalanxes. Perhaps it should be no surprise that the most common fragments in this collection are from elements containing high gross marrow yield and the highest return rates for marrow yields.

Figure 3: Number of individual fragments per element and side. \*Tibiae, femurs, and humeri are high in marrow content and in marrow return rates (Madrigal and Holt 2002:Figure 2a, Figure 2b).

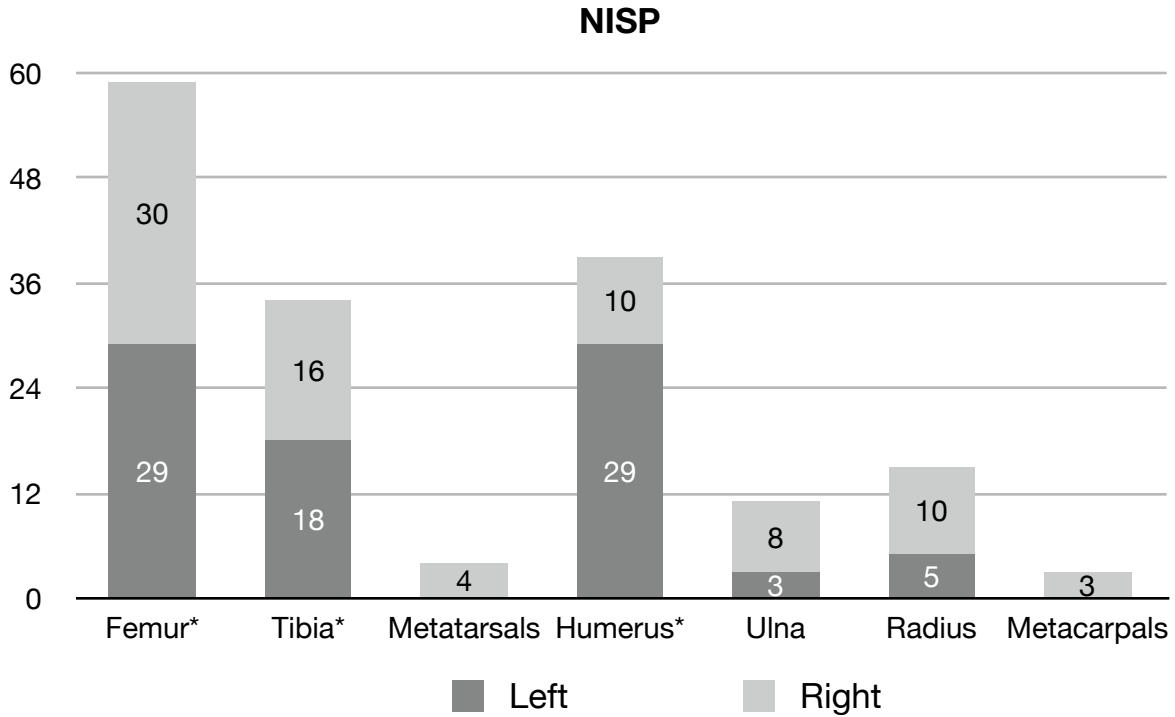
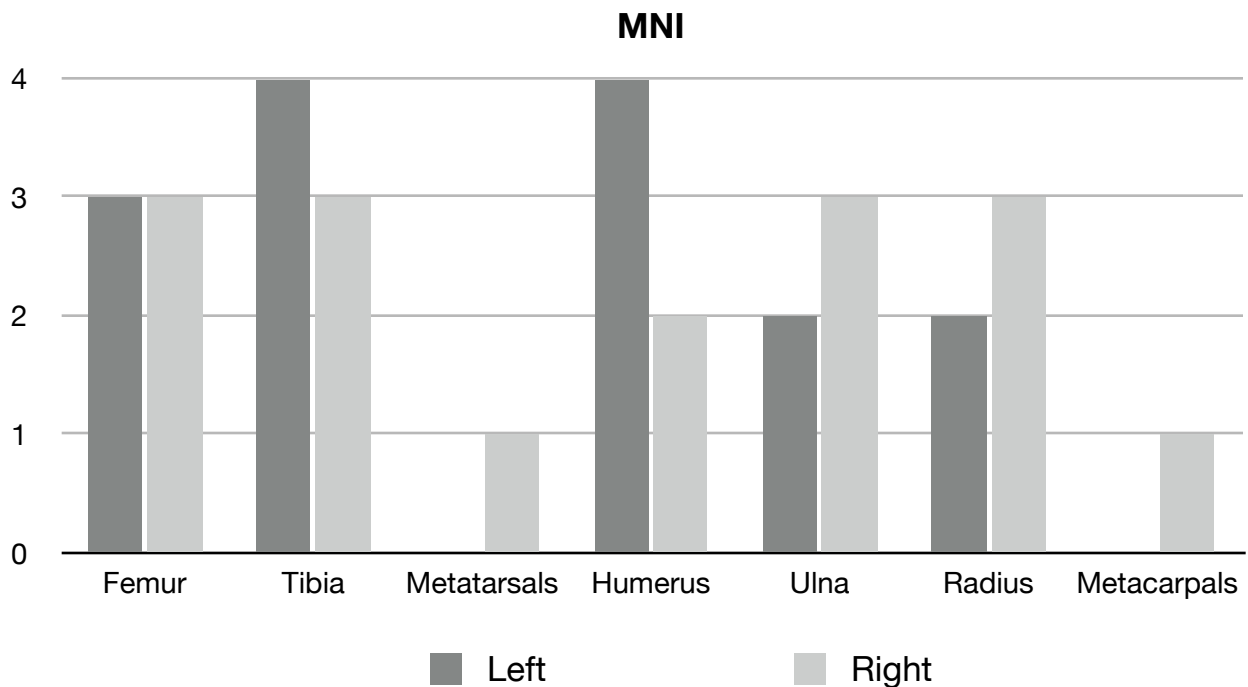


Figure 4: Minimum number of individuals represented, by element and side



The varying numbers of elements and sides of elements represented in the collection are probably a result of storing articulate ends for bone grease production (Binford 1978:154; Outram 2001). When enough were stored up to make the process worth while, they were then taken for processing. If bone grease was not immediately needed when enough pieces had been acquired, additions to the storage would continue in order to create a surplus in preparation for times of subsistence stress, when bone grease production would be more intense (Binford 1978).

When it was time to produce bone grease, end-pieces were removed from the store. One can imagine reaching into a pile of articulate ends and taking the amount needed off the top. If the store has an excess of pieces, perhaps from four individuals, it could be easy to grab multiple of some elements and few of others. That is precisely what is seen in this collection; there is an equal representation of left and right femurs, slightly unequal left and right tibia, ulnae, and radii, and a quite unequal representation of left and right humeri.

The unidentifiable shaft fragments can also tell us about the human processes represented in the collection. Figure 5 depicts the distribution of types of shaft fragments, divided by type of fracture and amount of spongy bone in the structure of the interior surface. Half of all shaft fragments were green bone fractures with an interior surface structure composed of at least 50 percent spongy bone tissue. Only five percent of the shaft fragments were dry-bone fractures with an interior surface structure being less than 50 percent spongy bone tissue.

Figure 5: Unidentifiable shaft fragments, broken down by type of fracture and amount of spongy bone present in interior.

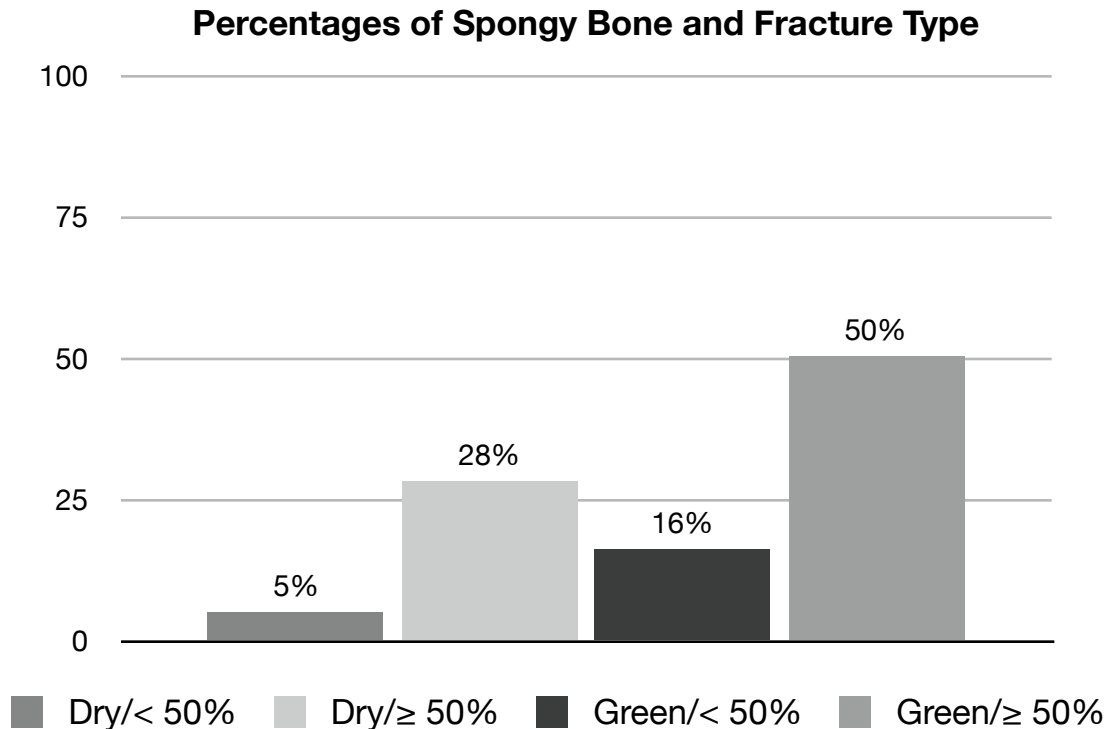


Figure 6 shows only the percentages of amounts of cancellous tissue in the interior surface structure of the shaft fragments. The vast majority (79 percent) of fragments have an interior structure composed of at least 50 percent spongy bone tissue, while only 21 percent of fragments are less than one-half spongy bone on their interior.

Figure 7 shows the percentages of fracture types present on the unidentifiable shaft fragments. While there is not quite as stark a contrast as demonstrated in Figure 6, Figure 7 still shows a clear majority. The amount of fragments exhibiting green-bone fractures is 67 percent and the amount of fragments exhibiting dry-bone fractures is 33 percent. It should be noted that any breakage during excavation and handling would result in dry-bone fractures. Because of this, the percentage of fragments with dry-bone fractures may be slightly high.

Figure 6: Percentages of amount of spongy bone in interior structure of unidentifiable shaft fragments

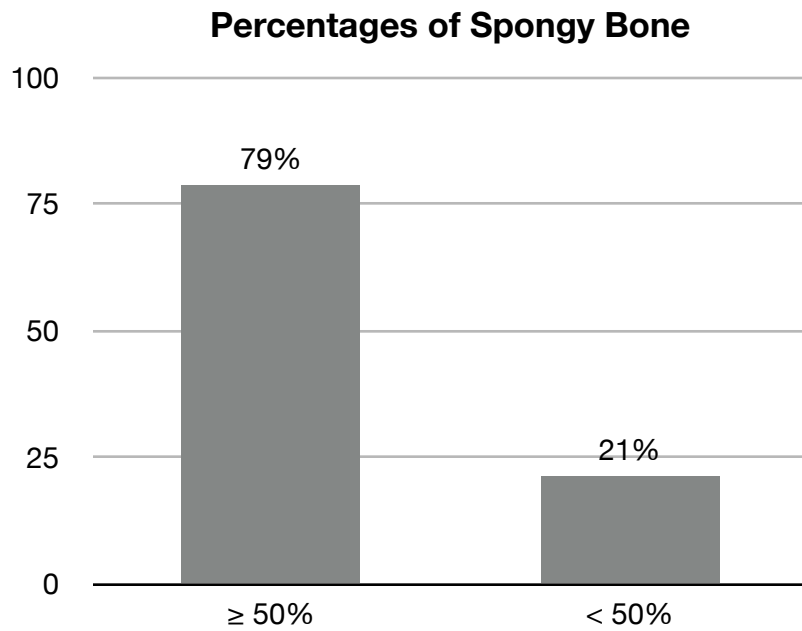
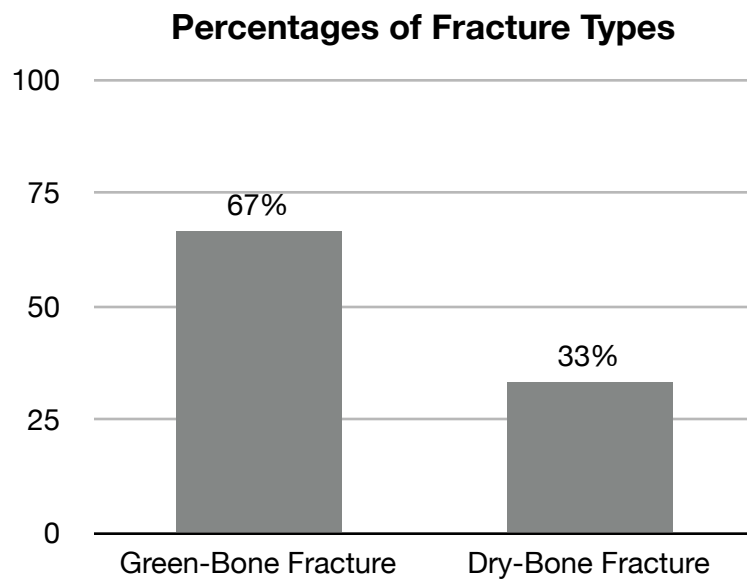


Figure 7: Percentages of fracture types on unidentifiable shaft fragments.



The fact that the majority of fragments exhibit green-bone fractures indicates that most bone breakage occurred when they were still fresh. As described previously, when bones are desired specifically for bone grease production, the spongy bone filled articulate ends are fractured off during butchering (Binford 1978:154). Marrow from the shafts can then be easily extracted if desired. This end-removal process would surely leave some shaft pieces attached to the end pieces, resulting in their presence in this collection.

Supporting this explanation is the fact that 79 percent of the shaft fragments have an interior structure composed of at least 50 percent spongy bone tissue — the type of bone tissue present in the articulate ends of long bones, not in the shafts. Theoretically, the more spongy bone on the interior of a fragment, the closer to the end of the bone that fragment comes from. Therefore, most of the unidentifiable shaft fragments are from near the ends of the bones and the midsections of shafts are more poorly represented than expected.

A total MNI of four means that there is a minimum of four individuals represented in the feature. While these bone fragments represent bone grease production, it is possible to determine how much meat and protein would have been provided by the four deer represented. On average, one person's protein requirement for one day is about 50 g. Fresh venison provides 21 g of protein per 100 g of meat (Watt and Merrill 1963:65), meaning one would need to consume 238 g of meat per day to satisfy the protein requirement. For comparison, one would need to eat a little more than two quarter-pound venison burgers to obtain the same amount of protein (The Daily Plate 2009). A white-tailed deer has about 23 kg of meat (50% of its field-dressed weight). Therefore, one deer can supply 100 person-days of protein. This feature thus represents 92 kg of

meat and 1,932 kg of protein, or roughly 400 person-days of protein — enough to provide a group of 25 adults with enough protein for 16 days.

McCullough and Ullrey (1983) have determined the energy content of marrow to be 9.37 kcal/g (kilocalories per gram). Table 4 (Madrigal and Holt 2002:Table 3) shows the wet- and dry-weights of bone marrow by element (before and after oven drying to remove water). It should be noted that Madrigal and Holt do not make known if the extracted marrow consisted of shaft-marrow, cancellous-marrow, or both; they merely say they used a hammer stone on anvil technique to fracture bones and that marrow was extracted (Madrigal and Holt 2002:748). Using dry-weights for calculations, this results potentially in a total of 592 g of marrow represented in the collection (ulnae were not factored into the calculations because their marrow weights were not given by Madrigal and Holt). This results in a total of 5,547.04 kcal/g. Based on a modern 2,500 calorie (kcal) diet, the marrow obtained from the elements represented in the feature would have supplied 2.2 person-days of energy.

Table 4: Marrow weight in grams, by element  
(Madrigal and Holt 2002:Table 3)

Element	Weight (g)	
	Wet	Dry
Humerus	17	13
Radius	15	13
Metacarpal	9	8
Femur	31	27
Tibia	44	38
Metatarsal	15	13
1st Phalanx, ant.	1	1
2nd Phalanx, ant.	1	1

## CONCLUSIONS

The white-tailed deer bone fragments from Feature 30 of the Swennes Upper Garden Terrace site (47Lc333) were identified via two comparative specimens, an adult female and a six-month-old female with unfused epiphyses. The unidentifiable fragments were sorted into three groups: (1) unidentifiable articulate end pieces; (2) “chunks” of spongy bone; and (3) unidentifiable shaft fragments. The shaft fragments were further divided based on type of fracture exhibited and amount of spongy bone in the interior structure of each fragment.

The bone fragments analyzed here represent a series of events in winter-subsistence strategy. It appears as though the bones were initially kept specifically for the production of bone grease before being deposited in Feature 30. The fact that the majority of the unidentifiable fragments exhibit green-bone fractures supports that they were broken soon after the animals were butchered. Also, most of the fragments had interior surfaces that were composed mostly of spongy bone. This suggests that the fragments in the collection were located near the ends of the long bones. Ethnographically among the Nunamiut, when bone grease production is desired the long bones are broken at both ends of the shaft, separating the spongy-bone filled articulate ends, which can then be more easily stored (Binford 1978:155).

When bone grease production is desired and a sufficient number of pieces have been accumulated, multiple of one element and few of another could very easily be pulled from the store, temporarily leaving unneeded bones. After the marrow extraction process is complete, used bone fragments would have been discarded with other refuse in garbage pits. I propose the Feature 30 deer bone collection demonstrates this based on the NISP and MNI of elements

represented, shaft fracturing, and bone condition at time of fracturing. The process of storing bones and producing bone grease in preparation for times of subsistence stress coincides with other evidence (Aurit 2007) that the Swennes Upper Garden Terrace site is a winter occupation site.

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