INVESTIGATING MANDIBLE DETACHMENT, TONGUE REMOVAL, AND SEASONALITY ESTIMATES AT THE FINCASTLE SITE

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ABSTRACT

Mass bison kill events, such as the Fincastle site, have been the dominant focus of zooarchaeological work on the Great Plains. This research has improved understanding of prehistoric Indigenous cultural activity through the analysis of bison skeletal remains. Specific element frequency patterns identified in the Fincastle bison assemblage created avenues for further research connecting their regularity to cultural activity. Specifically, the process of cranial separation, mandible detachment, and tongue removal were investigated based on skull element portion and frequency. Additionally, the large number of mandibles in the assemblage were used to estimate the seasonality of the kill event. Patterns identified in the eruption and wear sequence of the Fincastle molar cusps indicate the complexity of seasonality models, and that further research is needed in bison dentition analyses to understand the connection between age and seasonality estimates.

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Chapter 1: Introduction

The Fincastle site is a single component Besant bison kill site located in the Northwestern Great Plains (Figures 1 and 2). The site is located within the Fincastle Grazing Reserve in Southern Alberta, which is leased Crown land used for cattle grazing. The area has never been used for agriculture because it is an active dune field and plowing would remove the vegetation holding the topsoil in place. The bone bed is located within a parabolic dune, which is thought to have contributed to the excellent preservation at the site. The site was initially reported to the Archaeological Survey, the branch of the Alberta government responsible for the protection and management of the province's prehistoric cultural resources, by the Royal Canadian Mounted Police (RCMP), as local community members reported looting of archaeological material. The Survey then contacted Shawn Bubel of the University of Lethbridge to investigate and determine the extent of the looting. Bubel visited the site in 2003 and determined the looting had been extensive, but the material recovered through a surface survey warranted further investigation. The University of Lethbridge ran field schools for four seasons (2004, 2006, 2007, and 2012) to determine the extent and nature of the site. They uncovered an extensive bison bone bed with over 11,000 identifiable faunal remains and approximately 200,000 unidentifiable bone fragments recovered from the site to date, with the full extent of the site not fully reached (Figure 3). The Fincastle site has been both radiocarbon and optically stimulated luminescence (OSL) dated to 2,500 CAL BP (Bubel 2014). This places the site within the late Middle Prehistoric time period in Canadian prehistory. The lithic and projectile point analysis confirmed the use of atlatl Besant points, corroborating the chronometric dates.

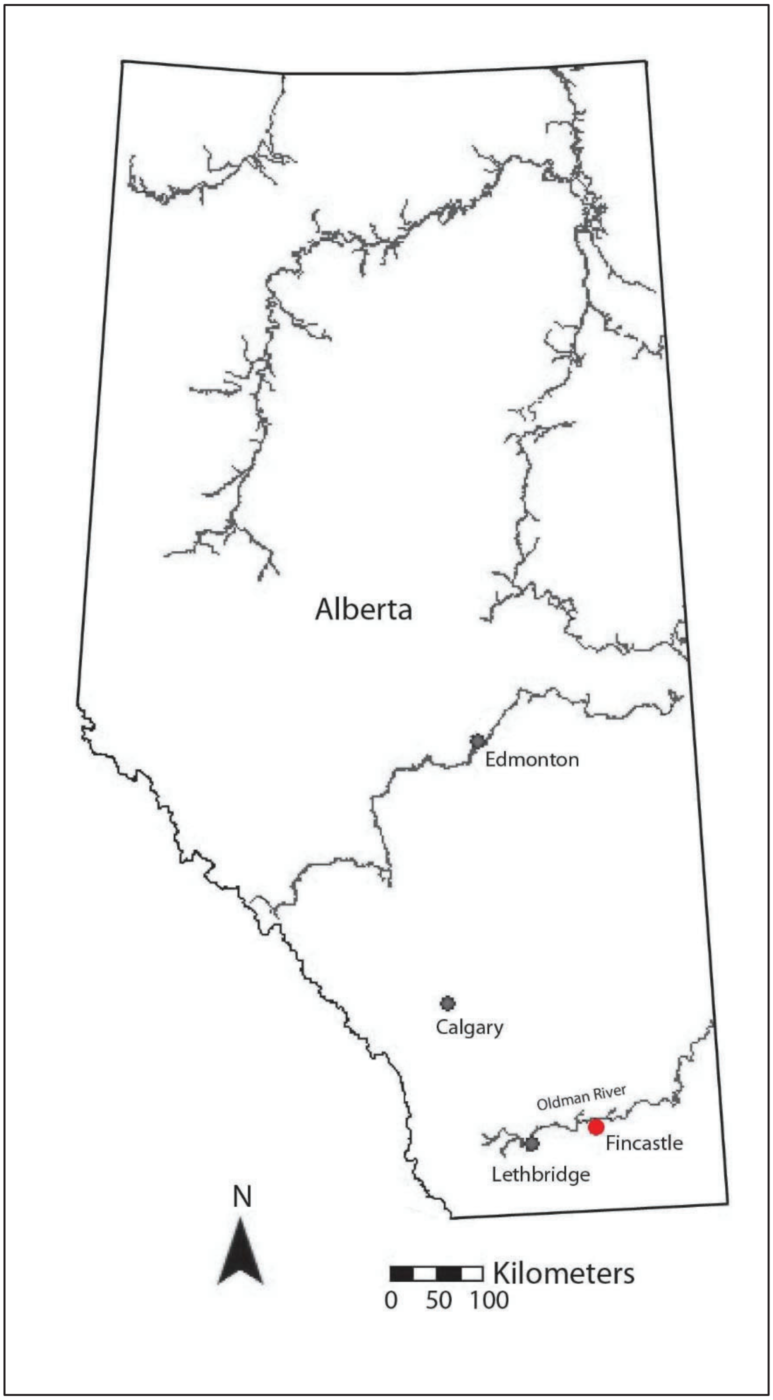

Figure 1: Fincastle location map

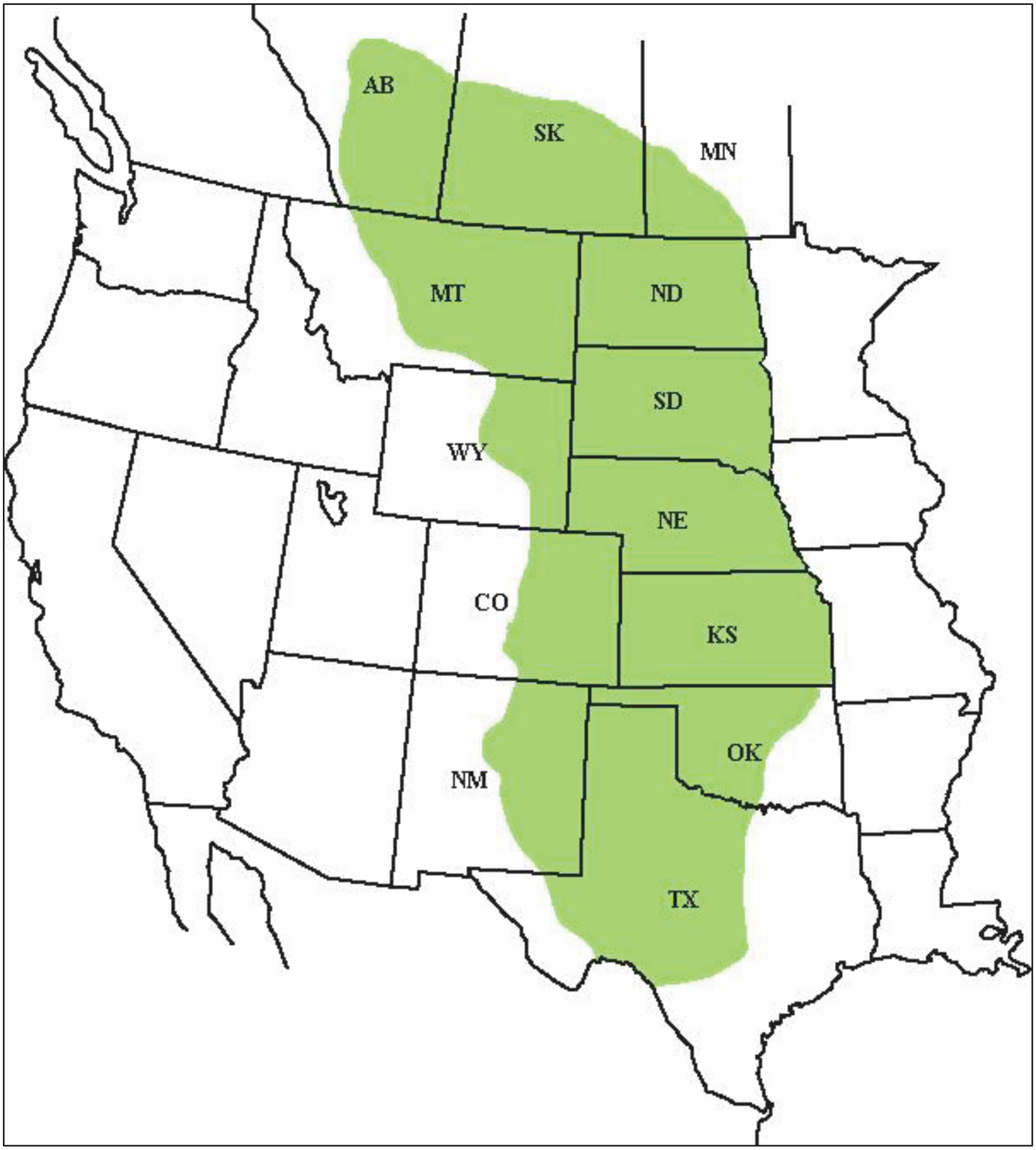

Figure 2: Great Plains location map

Bison kill sites are among the most common archaeological sites in the Great Plains because this geographic area is connected with nomadic bison hunters for at least the last 10,000 years. Bison hunting has consistently occurred despite hunting weapon technology changes from the thrusting spear to the bow and arrow. Three main communal bison hunting techniques have been identified throughout the entire Great Plains region: bison jumping, pound or corral structure, and driving bison into riparian zone arroyos. These techniques were used to kill large numbers of bison, providing Indigenous people with food, shelter, and clothing. To describe the magnitude of resources acquired from successful mass bison kill events at Head-Smashed-In Buffalo Jump, one of the most well-known bison jumps in Alberta, Brink (2008) claims, "there is nothing in the four million years of human evolution when a comparable amount of food was procured at one time" (p. 3). There is no evidence of any of these broad hunting strategies at the Fincastle site. As the site was uncovered in a dune field, there is no topographic drop that could be used for a bison jump. There has been no evidence of post holes uncovered by excavators which eliminates the possibility of a pound. Lastly, there is no natural feature which the hunters could have driven the bison into. Rather, the Fincastle site represents a rarer, but strategic hunting method: ambushing at a watering hole (Bubel 2014). Additionally, several upright features uncovered beneath the glaciolacustrine clay provide intrigue for understanding the cultural activity at this site. Recent research has attempted to understand the function and cultural affinity of these upright features (Foreman 2010, Graham & Ives 2019).

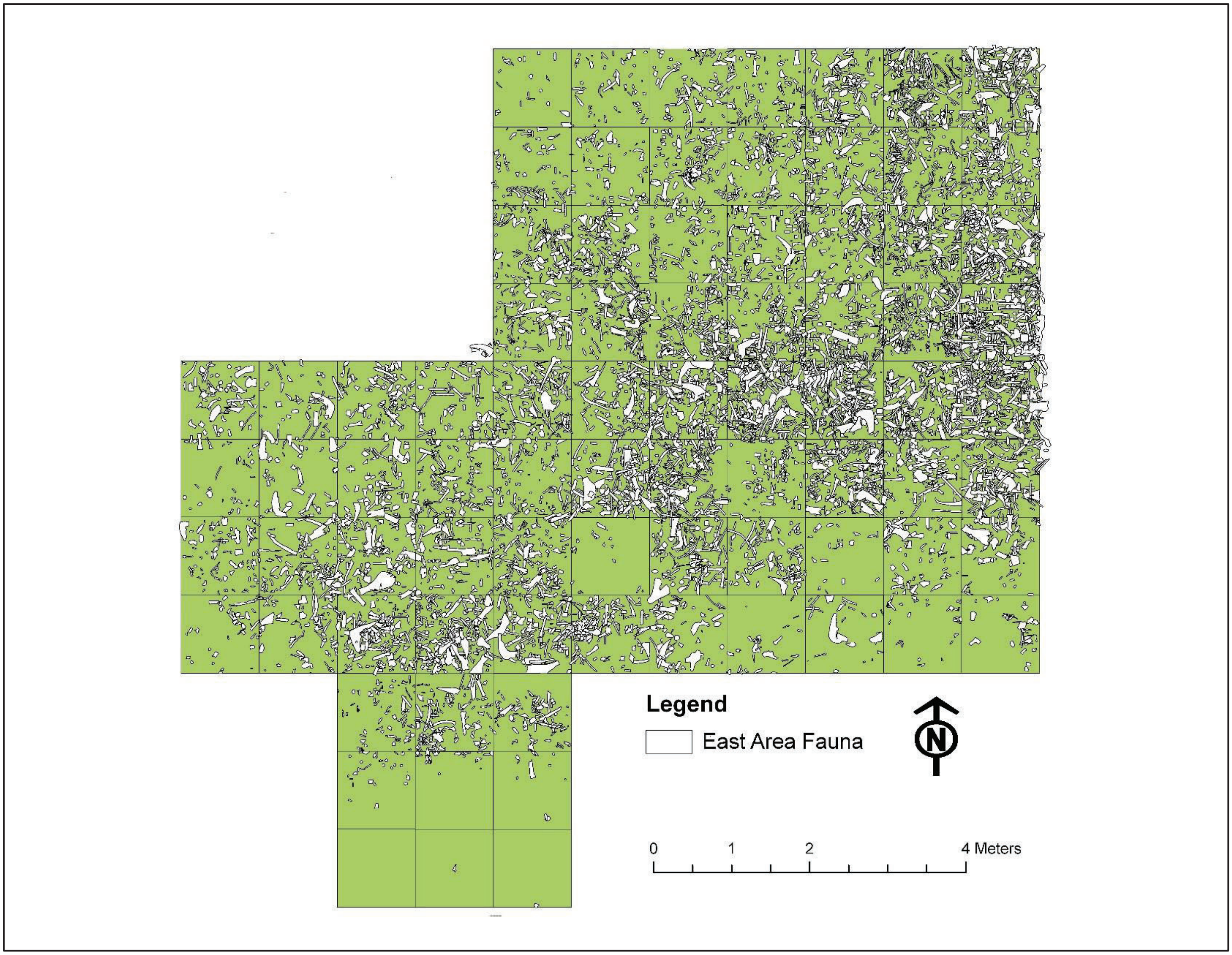

Figure 3: Fincastle East Area excavation map

Research Objectives

My initial intent was to research the hunting, butchering, and processing activities by directly examining the faunal remains in the Fincastle collection. This was not possible due to the global pandemic and reduced access to the archaeological collection that formed the foundation of my research. In turn, I looked for patterns in the Fincastle collection that could reveal information of past cultural activities in the Northwestern Great Plains. My research focused on examining skull elements for understanding the process of cranial separation, as there are few, but telling, cranial fragments in the assemblage. The repetition of the petrous portion, a temporal bone fragment, created a research path for a proposing a new hypothesis for how the cranium was removed from the rest of the bison. Additionally, the close anatomical positioning of the mandibles and hyoids, in context of their frequent representation in the assemblage, created further hypotheses on how mandibular detachment and tongue removal may be linked to this activity. This research was possible because the Fincastle site has little evidence of scavenging, likely owing to the fact that it was quickly buried by a sand dune.

The other major component of this thesis is a bison dentition analysis. There are a number of mandibles in the Fincastle assemblage which could be used for seasonality estimates, a common component of bison kill site analysis. I used the methods developed by Fuller (1959), Frison and Reher (1970b), Reher and Frison (1980), and Brumley (1995) to estimate age which was then correlated with a season of death. My research question during this section of the analysis was whether the methods used to estimate age accurately represented the eruption and wear patterns in the Fincastle collection. These patterns were then used to evaluate whether the seasonality estimates provided by the methods accurately represented the dentition morphologies. This research was possible because Fincastle is a single component bone bed;

there is no evidence of multiple occupations which would skew the age and seasonality estimates.

Thesis Outline

Each chapter begins with a definition or literature review section outlining the method used to calculate values or contextualize previous research. The methods are then applied to the Fincastle assemblage and the results are used to identify evidence of cultural activity. Chapters 3 and 4 conclude with proposals for future research based off of patterns identified in this analysis.

Chapter 2: Basic Quantification begins by following recommendations from Lyman (1994) to clearly explain how quantification values were used to generate an understanding of element portions and frequencies in the Fincastle bison and canid collections. This chapter introduces the Bone Unit (BU) Identification Manual (Brumley 1986), and its important role in this research. The quantification analysis laid the foundation for the rest of the thesis by identifying patterns that required future research.

Chapter 3: Cranial Separation, Mandible Detachment, and Tongue Removal builds off the research from the preceding chapter to identify how the element portions of the cranium, mandible, and hyoid are used as evidence in interpreting cultural activity. Specific attention was paid to the temporal bone for understanding its presence in cranial detachment. The frequency of the mandible and hyoid were examined for understanding the historically documented practice of tongue removal. Both historical records and archaeological interpretations are used to trace the narrative concerning these activities.

Chapter 4: Dentition Analysis and Seasonality Estimate uses the mandibles from the Fincastle site in a traditional dentition analysis to determine age of the bison and seasonality of the kill. This chapter uses the methods developed by Frison and Reher (1970b) for the Glenrock assemblage, along with three other prominent dentition methodologies to contextualize the molar and exostyle eruption and wear patterns in the Fincastle assemblage. This chapter includes a discussion of the winter resource acquisition model for its influence in contextualizing seasonality estimates.

Chapter 5: Site Comparisons examines nine bison kill sites from across the Great Plains to contextualize the element frequencies and patterns identified at Fincastle for interpreting cranial separation, mandible detachment, and tongue removal. This section reviews the dentition analysis methods and results used to estimate age and seasonality at these sites to identify trends in the archaeological literature. The conclusion summarizes general themes from the nine sites associated with the identification of the cultural activities of mandible detachment, tongue removal, and seasonality estimates. The chapter finishes with recommendations for reflecting on the implications of the methods used to interpret cultural activity.

Lastly, Chapter 6: Conclusion summarizes the findings described in the previous chapters. The research in this thesis is relevant for zooarchaeological bison studies in the Great Plains, and the final chapter discusses common themes identified during the course of this research that may be relevant for researchers analyzing mass bison kill events. For example, the use of a standard cataloging device, such as the Bone Unit manual, may improve communication between researchers and simplify inter-site comparisons. Further research into the eruption schedule and wear patterns of mandibular molars is proposed as a way to refine bison dentition aging methods and corresponding seasonality estimates.

Chapter 2: Basic Quantification

Quantification provides vital context for understanding human activities. It involves calculating quantities of elements to produce estimates for how many animals are represented in an assemblage. Understanding how many animals are represented in an assemblage will help the researcher to better understand both the nature of the assemblage and any potential taphonomic alterations. This chapter clearly articulates how quantification was completed for the Fincastle assemblage, which was made possible by the Bone Unit (BU) identification manual for ungulates developed by Brumley (1986), with additions by Bubel (2011). The BU manual is broken down into unique codes for each element fragment with both a written and visual descriptor. The BU code identifies a specific fragment, and a BU 01 is always a complete element. For example, there are 52 BUs for mandibles. A mandible BU 10 is the complete element except for the coronoid process, and a BU 34 is an undifferentiated mandible fragment.

This chapter demonstrates how the use of a standardized cataloguing device broadened the scope of the research by identifying patterns for further research. Using this system of identification virtually eliminates all miscommunication between researchers, as every researcher can verify what specific portions are referenced by the Bone Unit. If more researchers used this manual and shared assemblage data, comparisons between sites would be significantly easier. There would be no need to worry about what portions of elements are present based on analyst descriptions or about the degree of fragmentation from published data sets. If the data was presented as Bone Units, each researcher would confidently know what portion was referenced without ever visually seeing the piece.

Definitions

In following recommendations by Lyman (1994), this chapter states what is meant by each term and acronym. Further, it describes how each quantification value was calculated. This mitigates miscommunications and demonstrates how clarification allows for improved level of analyses. In this thesis, *element* is used as reference to the osteological components that comprise a skeleton: bones, teeth, and ossified cartilaginous sections. This is the broadest term used, as all other terms are indicative of smaller portions. *Fragment* and *bone fragment* are used interchangeably, and they refer to the physical pieces of bone in the assemblage that do not belong to complete elements. They may range from a few millimetres in size to nearly complete elements. *Fragment* is the term used for both identifiable and unidentifiable sections, as they are both incomplete elements. *Portion* refers to sections of elements with anatomical landmarks that aid in identifying fragments. For example, the complete distal lateral articular condyle of the humerus is the portion that allows the condylar fragment to be identified as a humeral element.

Each quantification value provides an interpretation of the nature of the assemblage. There are many external factors, including cultural activity and taphonomic processes, that will impact the ability of the researcher to quantify the assemblage. Zooarchaeologists use four quantification values to produce different interpretations of the assemblage: Number of Identifiable Specimens (NISP), Minimum Number of Elements (MNE), Minimum Number of Animal Units (MAU), and Minimum Number of Individuals (MNI). Each of these four values is discussed in the following sections.

Number of Identifiable Specimens (NISP)

The NISP value is the number of identifiable fragments but may also include the unidentifiable (UID) specimens. It is important for a researcher to clearly state what is included in the NISP value. Comparing NISP to the other values will give an indication of the degree of fragmentation in the assemblage (Cannon 2013). A high NISP value combined with a low MNI value would indicate a high degree of fragmentation, as they are many pieces, but they only belong to a small number of identified individuals. Using a theoretical example, an assemblage drawn from a grease rendering area will have a high NISP value of UID fragments, and a low MNI value of identifiable elements. This implies a high degree of fragmentation, which would strengthen the interpretation of the cultural activity. NISP values may sometimes seem of little value when the assemblage is small because the difference in NISP compared to the other values is not as large. For example, in the Hudson-Meng assemblage analyzed in Barg (2013), only 62 elements were analyzed for an MNI of three animals (p. 95). The small sample size of the assemblage matches the low MNI, which is useful for giving an overall impression of the assemblage. Overall, NISP is a used as a taphonomic indicator with minimal interpretative value beyond the degree of fragmentation and relative element frequency.

Minimum Number of Elements (MNE)

MNE is the first quantification step used when attempting to determine how many osteological components are in the assemblage. This calculation uses portions to determine how many elements are represented, either through a physical or figurative re-fitting. MNE quantification requires a detailed understanding of osteology, as portions and landmarks are used as identifying features for this analysis. This can be mitigated through the use of an osteological reference material, such as the Bone Unit manual, as fragments can be visually compared to the descriptions and illustrations for specific portion identification.

MNE has often been calculated through re-fit analysis, where researchers will physically piece together fragments to identify single elements (O'Brien, 2011). MNE has also been interpreted as presenting only the elements which were mostly or totally complete in the assemblage (Brink & Dawe 1989, Lyman 1994). These two methods will produce drastically different values. In this thesis, MNE values are calculated solely on Bone Units to achieve as precise as possible the number of portions that could mathematically be combined with other portions to calculate element frequency. The enormity of the Fincastle collection prevented physical re-fitting of elements, as there are elements with thousands of fragments (Table 2). However, they could be figuratively re-fit based on anatomical landmarks represented by Bone Unit codes. For example, a rib tubercle (BU 06) and shaft fragment (BU 15) are portions of a rib element. However, if the assemblage had two tubercles and only a single shaft fragment there would need to be at least two ribs in the assemblage because both tubercles could not belong to the same shaft fragment. There is no way to confirm that the tubercle and shaft fragment belong to the same rib, but this is not necessary when calculating MNE. Side and age are accounted for when calculating MNE in this analysis, but the final presented value is cumulative.

To further illustrate how this value was calculated, an additional example is provided. A right proximal femur fragment represented by the femoral head and portion of the accompanying shaft (BU 22) could be refit to a right distal shaft and complete distal articular end fragment (BU 12). However, the distal fragment could not be refit to a fragment of the right supracondyloid fossa (BU 4), because this landmark is present in BU 22.

Standardized MNE (%MNE) indicates the relative proportion of all the elements in the assemblage. The element with the highest MNE value is used as the standard from which all the rest are compared. This is done by dividing the value of each element by the highest MNE value and converting to a percent. This is a useful value because it demonstrates the change in relative frequency as fragmentation becomes a lesser issue. As an example of how to calculate %MNE, the rib MNE value of 880 and the astragalus value of 145 are used (Table 2). The astragalus value of 145 is divided by 880, producing a decimal value of 0.1647. This value is then multiplied by 100 to create a percent, rounded to an integer. This equates to a %MNE value of 16% for the astragalus. This is a useful value because it indicates that the astragalus comprises a much lower percent of the element assemblage than the rib fragments.

Minimum Number of Animal Units (MAU)

The MAU value is a further refinement towards the final quantification value. MAU is obtained by using the MNE for each element and dividing it by the number of times that element occurs in the skeleton. Therefore, MAU is a derived value and requires MNE to be calculated correctly. The results are used to broadly estimate the number of animals in the assemblage without accounting for side, age, and sex.

For example, an assemblage of two proximal and three distal humeral fragments would produce an MNE value of three; two each of the proximal and distal fragments would match, leaving one distal fragment unaccounted for. The MNE value of three is divided by two, because there are two humerii in a bison, producing an MAU value of 1.5. However, half of an animal cannot exist, so the value is always rounded up to an integer. Thus, the MAU would be two animals for this example. MAU is standardized following the same process described for the %MNE.

Minimum Number of Individuals (MNI)

This last quantification value uses MNE and MAU for producing the value that represents the minimum number of individuals in the assemblage. In the previous two methods, side and age have not been accounted for in the final values. MNI accounts for side, age, and sex (if determinable) in the final value, as the goal of MNI is to present an estimate of the population dynamics of the assemblage. MNI is the most specific quantification value because it attempts to account for all faunal variability but is largely dependent on the preceding methods being calculated correctly. MNI is standardized following the same process described for %MNE and %MAU. Returning to the rib example from previously, if both tubercles were left adult fragments, they could theoretically belong to one individual as bison have 14 left and right ribs. However, if one tubercle was a juvenile and the other adult, they would belong to two different animals because they represent different developmental stages.

Recent studies have revealed this is an oversimplification, as animals do not move discretely between developmental stages, but rather as a continuous process (Price et al 2016). Therefore, overlap exists between stages, including within and between bones. For example, the proximal epiphyses of the phalanges may fuse before a tibia, and only if they were found in articulation with each other would they be recorded as the same animal. This is a gap for bison researchers; there is scant literature that confidently link years of age to developmental stages in bison. This research, as do other studies, will operate under the assumption that each developmental stage will only demonstrate their respective level of skeletal fusion.

Methodology

Faunal fragments from the Fincastle site were assigned a species based on their morphological similarity to a reference collection. The majority of the animals were identified as Plains bison (*Bison bison*), with small minority of fragments identified as either small mammal (mainly Rodentia), canid, or cervid. These broad genus or family taxonomic categories represent the inability of zooarchaeologists to assign a fragment to a specific species, or to identify certain species from each other, such as domesticated dogs from wild wolves.

Fragments were assigned to four age categories: foetal, juvenile, subadult, and adult. These four broad categories represent the development and fusion of skeletal elements, largely through epiphysis examination. There are no foetal elements in the Fincastle collection, but foetal remains are identified most often by their small size. Foetal shaft and body fragments are identified based on their lack of epiphyseal caps; the epiphyseal caps are identified based on their surfaces and small size. The use of a comparative collection would aid in their identification. Juvenile elements are identified based on their larger size compared to foetal remains and the presence of epiphyseal surfaces on distal, proximal, or body surfaces. The epiphyses are separate from the rest of the element and are characterized by a rough and billowy texture on their fusion surfaces. Subadult elements are characterized by the fusion of the shaft/body and the epiphysis, but the fusion is not complete, therefore, an epiphyseal line of fusion separates the two. Although the portions cannot be separated at this stage, the epiphyseal line is a clear indicator of a subadult. Finally, an adult element is completely fused, with no epiphyseal lines present. Fragments with no age indicators were categorized as undeterminable (UD). For the purpose of this research, all UD fragments were calculated as adult fragments, as the majority of the animals in this assemblage are adult. The fragments were then assigned a side based on comparison with a reference collection to either right, left, or not applicable if the element belonged to a section of the axial skeleton. Fragments that could not be sided were recorded as UD.

Finally, the fragments were assigned Bone Unit categories using the Bone Unit manual (Brumley 1986). Bone Units were chosen for each individual fragment based on visual comparison to the element diagrams and verified using the associated written description. The faunal data was aggregated into an Access database along with provenience information, applicable metrics, and additional notes on processing evidence. Reports were generated for each element in the assemblage listing the frequency of each Bone Unit broken down into species, side, age, and sex (if determinable). These reports were used to calculate the quantification values along with the Bone Unit manual for MNE mathematical re-fitting.

Results

There are 11,906 identifiable elements in the Fincastle collection, which form the basis of this research. There are an additional 228,483 UID fragments, of which 98% were recovered from screening (Table 1). Approximately 3% of the UID fragments are burnt. The thousands of UID bone fragments are not included in the quantification methodology, but their presence at the site indicates butchering and processing were occurring in great quantity.

Table 1: UID fragments

UID Fragments	
UID	221,720
Screen	217,768
In situ	1,084
Surface	159
Disturbed	2,709
UID, burnt	6,763
Screen	6,690
In situ	48
Disturbed	24
Secondary context	1
Total	**228,483**

There are a minimum of 79 bison represented in the Fincastle assemblage, as determined by the right astragalus (Table 2). It is interesting to note that the MNI is higher than the MNE for the astragalus, because there were 14 more right than left elements. This quantification value is reliable because the navicular cuboid has a close MNI value of 75. Table 3 indicates the relative abundance of the elements in the Fincastle assemblage, broken into quarterly categories. The vast majority of the elements in the assemblage belong to the 25-49% abundance category. Noticeable exceptions to this include the mandible, thoracic vertebra, lumbar vertebra, pelvis, and sacrum (Table 4). The mandibles and thoracic vertebra present were among the highest %MNI values for large elements, and the lumbar vertebra and pelvic girdle were among the lowest. The three sections of the spinal column are represented in varying degrees, with the thoracic vertebra having the highest representation. This likely indicates segmentation of the spinal column as a butchering practice.

Table 2: Bison quantification values

Bison Quantification Table											
Element	**Skeleton**	**NISP**	**MNE**	**%MNE**	**MAU**	**%MAU**	**MNI**	**%MNI**	**Adult**	**Juvenile**	**Subadult**
Astragalus	Appendicular	158	145	16%	73	100%	79	100%	79	0	0
Atlas	Axial	32	21	2%	21	29%	21	27%	21	0	0
Axis	Axial	28	20	2%	20	28%	20	25%	13	5	2
Calcaneum	Appendicular	163	124	14%	62	86%	65	82%	44	17	4
Caudal Vertebra	Axial	172	146	17%	29	4%	-	-	-	-	-
Cervical Vertebra	Axial	377	105	12%	21	29%	22	28%	8	13	1
Cranium	Axial	496	65	7%	33	45%	34	43%	32	1	0
Cuneiform	Appendicular	104	101	11%	51	70%	51	65%	51	0	0
Cuneiform Pes	Appendicular	110	110	13%	55	76%	57	72%	54	0	0
Femur	Appendicular	130	41	5%	21	29%	25	32%	12	2	11
Fifth Metacarpal	Appendicular	59	59	7%	30	41%	59	75%	59	0	0
First Phalanx	Appendicular	527	494	56%	62	85%	62	78%	48	10	4
First Tarsal	Appendicular	62	62	7%	31	43%	34	43%	34	0	0
Humerus	Appendicular	143	44	5%	22	30%	29	37%	20	7	2
Hyoid	Axial	121	52	6%	28	38%	29	37%	25	1	1
Lateral Malleolus	Appendicular	50	49	6%	25	34%	27	34%	27	0	0
Lumbar Vertebra	Axial	185	37	4%	7	10%	8	10%	2	5	1
Lunate	Appendicular	110	105	12%	53	72%	54	68%	54	0	0
Magnum	Appendicular	120	118	13%	59	81%	68	86%	68	0	0
Mandible	Axial	528	121	14%	61	83%	69	87%	56	11	2
Metacarpal	Appendicular	145	81	9%	41	56%	44	56%	22	13	9
Metatarsal	Appendicular	163	78	9%	39	54%	35	44%	24	7	4
Navicular Cuboid	Appendicular	145	144	16%	72	99%	75	95%	74	0	1
Patella	Appendicular	20	19	2%	10	13%	12	15%	12	0	0
Pelvis	Axial	90	34	4%	17	23%	19	24%	15	3	1
Pez	Appendicular	4	4	0%	2	3%	2	3%	0	0	0
Pez II (Manus V)	Appendicular	10	10	1%	5	7%	5	6%	0	0	0
Pisiform	Appendicular	56	55	6%	28	38%	31	39%	31	0	0
Radius	Appendicular	169	62	7%	31	43%	36	46%	16	17	3
Rib	Axial	4658	880	100%	31	43%	36	46%	23	10	3
Sacrum	Axial	28	14	2%	14	19%	14	18%	4	8	2
Scaphoid	Appendicular	101	98	11%	49	68%	50	63%	50	0	0
Scapula	Appendicular	503	62	7%	31	43%	35	44%	32	2	1
Second Metatarsal	Appendicular	33	33	4%	17	23%	19	24%	19	0	0
Second Phalanx	Appendicular	501	472	54%	59	81%	63	80%	53	6	4
Sternum	Axial	2	1	0%	1	1%	1	1%	1	0	0
Third Phalanx	Appendicular	402	387	44%	48	67%	50	63%	50	0	0
Thoracic Vertebra	Axial	764	260	30%	19	26%	20	25%	5	13	2
Tibia	Appendicular	209	52	6%	26	36%	32	41%	16	8	8
Ulna	Appendicular	125	50	6%	25	34%	27	34%	20	5	2
Unciform	Appendicular	103	100	13%	50	69%	55	70%	55	0	0
	Total	**11906**	**4915**		**1374**		**79**				

Table 3: Element standardization relative abundance

Element Standardization Relative Abundance				
Element	**NISP% (4658)**	**MNE% (880)**	**MAU% (72.5)**	**MNI% (79)**
Astragalus	3%	16%	100%	100%
Atlas	1%	2%	29%	27%
Axis	1%	2%	28%	25%
Calcaneus	3%	14%	86%	82%
Caudal Vertebra	4%	-	-	-
Cervical Vertebra	8%	12%	29%	28%
Cranium	11%	0%	6%	5%
Cuneiform	2%	11%	70%	65%
Cuneiform Pes	2%	13%	76%	72%
Femur	3%	5%	29%	32%
Fifth Metacarpal	1%	7%	41%	38%
First Phalanx	11%	56%	85%	81%
First Tarsal	1%	7%	43%	43%
Humerus	3%	5%	30%	37%
Hyoid	3%	6%	36%	29%
Lateral Malleolus	1%	6%	34%	34%
Lumbar Vertebra	4%	4%	10%	10%
Lunate	2%	12%	72%	68%
Magnum	3%	13%	81%	86%
Mandible	11%	14%	83%	87%
Metacarpal	3%	9%	56%	56%
Metatarsal	3%	9%	54%	44%
Navicular Cuboid	3%	16%	99%	95%
Patella	0%	2%	13%	13%
Pelvis	2%	4%	23%	24%
Pez	0%	0%	3%	3%
Pez II (Manus V)	0%	1%	7%	6%
Pisiform	1%	6%	38%	39%
Radius	4%	7%	43%	46%
Rib	100%	100%	43%	46%
Sacrum	1%	2%	19%	18%
Scaphoid	2%	11%	68%	63%
Scapula	11%	7%	43%	44%
Second Metatarsal	1%	4%	23%	24%
Second Phalanx	11%	54%	81%	80%
Sternum	0%	0%	1%	1%
Third Phalanx	9%	44%	67%	63%
Thoracic Vertebra	9%	30%	26%	63%
Tibia	4%	6%	36%	41%
Ulna	3%	6%	34%	34%
Unciform	2%	11%	69%	70%

Legend	
75-100%	▓
50-74%	▒
25-49%	░
0-24%	

Table 4: %MNI element relative frequency

%MNI Element Relative Frequency			
0-24%	**25-49%**	**50-74%**	**75-100%**
Lumbar Vertebra	Cranium	Cuneiform	Astragalus
Patella	Atlas	Cuneiform Pes	Calcaneus
Pelvis	Axis	Lunate	First Phalanx
Pez	Cervical Vertebra	Metacarpal	Magnum
Pez II	Femur	Scaphoid	Mandible
Sacrum	Fifth Metacarpal	Third Phalanx	Navicular Cuboid
Second Metatarsal	First Tarsal	Thoracic Vertebra	Second Phalanx
Sternum	Humerus		Unciform
	Hyoid		
	Lateral Malleolus		
	Metatarsal		
	Pisiform		
	Radius		
	Rib		
	Scapula		
	Tibia		Front
	Ulna		Back

All of the appendicular long bones have relatively equal representation (Table 4). The radius represents the highest MNI value of 36, while the femur represents the lowest at 25. Further, the humerus and femur have relatively equal representation, which has been suggested as a standard for assessing the amount of carnivore scavenging on the assemblage (Landals 2009, p.32). Their relatively equal representation would indicate a low degree of carnivore scavenging, as differential representation would indicate removal of portions by animals. However, their low %MNI value may indicate that the bones have been butchered heavily, as supported by the high

UID value for the assemblage or were moved to another area of the site for further processing which has not yet been excavated.

The ribs presented the highest NISP and MNE values, but because there are 28 ribs in a single bison, the MAU and MNI values are significantly lower. The carpals, tarsals, and phalanges have the highest MAU and MNI values, with the astragalus representing 79 individuals. Traditionally, the high number of carpals, tarsals, and phalanges have been interpreted as purposeful discard at the kill spot because of their low nutritional value. A hunter may not want to haul inedible portions of a carcass a considerable distance, hence their immediate discard at the kill site. The mandible's quantification values place it in the same category as the carpals, tarsals, and phalanges. Would this same interpretation apply to the high number of mandibles at Fincastle? There is no evidence of cutmarks, polishing, or striations that the mandibles were used as expediency tools. Additionally, as the majority of other large elements are underrepresented compared to the carpals, tarsals, and phalanges, it appears to confirm the discard narrative.

To understand the mandible's representation, the elements anatomically associated with them were examined next. There were no complete crania found at Fincastle and cranial fragments comprise only 11% of the NISP total. The Bone Units for the cranium were broken down into their respective elements to understand the representation of different portions of the cranium. A pattern quickly emerged that there was an overabundance of temporal sections compared to the rest of the assemblage. Specifically, the petrous portion, otherwise known as auditory meatus, was repeated (see Table 6 in Chapter 3). The anatomical positioning of the mandible to the temporal bone suggested a connection between the two for their frequency. It is presumed that as the mandibles were being removed from the crania, a sufficient blow would detach the petrous portion along with the mandible leading to a greater representation of this specific cranial portion over other cranial fragments. This relationship became the focus of future research and will be explored in detail in Chapter 3: Cranial Separation, Mandible Detachment, and Tongue Removal.

The vast majority of the elements in the assemblage are adult, or fully fused (Figure 4). This may underrepresent the number of juvenile animals in the assemblage, as fusion rates and yearly ages are not exact matches. Subadult is a minor category for most elements in this analysis, which is not surprising because the subadult phase of bison is relatively short. The exception to this is the femur which has a relatively high percentage of subadult specimens at 44%. Additionally, there are high juvenile values in all of the vertebral sections: cervical 59%, thoracic 65%, and lumbar 63%. They grey peaks beyond the bar data for each element denotes the MNI values using undeterminable (UD) ages for identified elements lacking age landmarks. Developmental age is often not included in faunal data charts, preventing the comparison of this information between sites. As will be demonstrated later in this thesis, bison dentition analysis is the most common method for presenting age estimates. Published information on the developmental ages identified during element analysis may be useful in corroborating dentition analyses, as well as improving understanding of herd population dynamics.

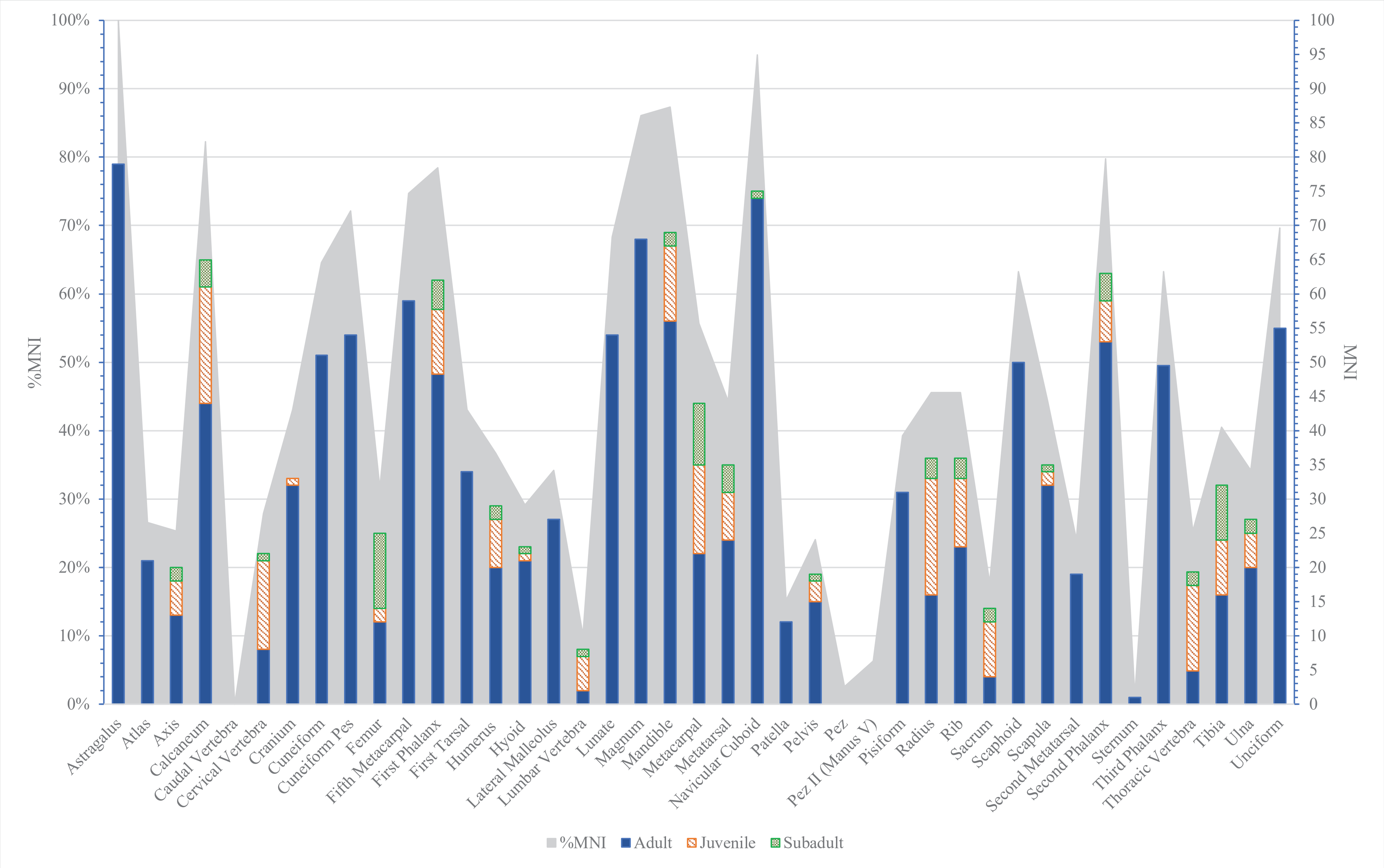

Figure 4: %MNI by developmental age, with UD aged fragments in total percentage calculations

As previously stated, bison are not the only animals represented in the Fincastle assemblage. Canid remains are discussed in detail as this genus has the second most numerable fragments in the collection. Only four cervid remains were identified, and small mammals are considered recent intrusive specimens. There are 41 elements identified as canid, the vast majority of which belong to the anterior half of the animal (Table 5). A detailed analysis was carried out on these remains. The axial skeleton is overrepresented in the assemblage: there are 31 elements belonging to the axial skeleton, which comprises more than 75% of the canid assemblage. This is markedly different from the appendicular skeleton representation, with 10 elements making up 15% of the assemblage.

There are a minimum of two individuals in the canid assemblage, determined by the humerii and radii. There are three identifiable radial elements: catalogue numbers 1549, 20749, and 21723. Radius 1549 is a well-preserved left fragment (BU 14) that is missing the distal articular end but is otherwise complete. Radius 20479 is a well-preserved left juvenile fragment (BU 10) that is missing over half of the shaft and complete distal end. Radius 21723 is a well-preserved right subadult fragment (BU 14) that is missing the distal articular end. Both 1549 and 21723 represent radii with the same BU and they seem to have a similar step fracture pattern, indicating these two radii may belong to the same animal. Additionally, the posterior side of the proximal end for 1549 and 21723 have a slight indentation or grooving immediately below the articular surface. This grooving is absent in 20749, which supports the interpretation that this radius belongs to a separate animal. The MNI based on radii is further strengthened when the humerus is included. There are two humeral elements, 15542 and 21346. Humerus 15542 is a left subadult distal fragment with accompanying shaft (BU 16). Humerus 21346 is a left anterior portion of the distal end missing the olecranon fossa (BU 26) of indeterminate age. As both are sided left, they cannot belong to the same animal. Further, the subadult humerus could belong to the subadult radius. Both humerii were butchered, as evidenced through the long spiral fractures present in both of the shafts. The single complete mandible recovered has cutmarks located on the posterior section of the horizontal ramus. The approximate age estimate for the canid mandible is three to six months, as the adult canine is unerupted (Schmid 1972, p. 77). The immature age estimate pairs well with the juvenile and subadult developmental ages represented by the radii and humerii. A complete canid skull was found in Feature 1, rostral end facing downwards. As with the other upright features uncovered at Fincastle to date, elements in Feature 1 appear to be pushed in and covered by the glaciolacustrine clay. The function of these upright features is unclear, but the inclusion of canid remains in their construction likely indicate the canids died at the same time as the bison kill.

Table 5: Canid quantification

Canid Quantification								
Skeleton	Element	NISP	MNE	%MNE	MAU	%MAU	MNI	%MNI
Axial	Axis	1	1	33%	1	50%	1	50%
	Cervical Vertebra	1	1	33%	0.14	7%	1	50%
	Cranium	11	1	33%	1	50%	1	50%
	Mandible	1	1	33%	1	50%	1	50%
	Rib	2	1	33%	0.04	2%	1	50%
	Sacrum	1	1	33%	1	50%	1	50%
	Tooth, canine	2	-	-	-	-	-	-
	Tooth, incisor	4	-	-	-	-	-	-
	Tooth, molar	4	-	-	-	-	-	-
	Tooth, premolar	4	-	-	-	-	-	-
Appendicular	First Phalanx	1	1	33%	0.05	3%	1	50%
	Humerus	2	2	67%	2	100%	2	100%
	Lateral Malleolus	1	1	33%	1	50%	1	50%
	Navicular Cuboid	1	1	33%	1	50%	1	50%
	Radius	3	3	100%	1.5	75%	2	100%
	Tarsal	1	-	-	-	-	-	-
	Third Phalanx	1	1	33%	0.05	3%	1	50%
	Total	**41**	**30**	**100%**	**2**	**100%**	**2**	**100%**

Conclusion

This chapter explains how the quantification values were calculated for the Fincastle assemblage. This was done to demonstrate how these values were obtained and how element frequency patterns were identified for research. The Bone Unit manual was instrumental in this analysis because it presented standardized element portions that could be re-fit mathematically without having to physically piece together thousands of elements. Additionally, the Bone Unit manual streamlined the quantification process by eliminating potential inter-analyst variation in portion descriptions. In Chapter 5: Site Comparisons, quantification values between Fincastle and other Great Plains sites are compared only superficially because there was often inadequate descriptions of how the values of MNE, MAU, and MNI were calculated, or the descriptions provided by the researchers indicated the values were calculated in substantially different ways. Therefore, it is important zooarchaeologists explain how their quantification values are calculated. This will improve confidence in data values presented by researchers and ease comparisons between sites.

Chapter 3: Cranial Separation, Mandible Detachment, and Tongue Removal

The quantification analysis of the Fincastle assemblage revealed patterns that required further investigating. Specifically, this chapter focuses on how skull elements are described in the literature for understanding cranial and tongue removal. The element portion frequency identified during the preceding quantification process highlighted the need for an improved understanding of these cultural activities with supporting evidence from the faunal data. For clarification, *cranium* refers to the elements belonging to the brain case, eye orbits, maxilla and nasals. *Mandibles* are separate from the cranium, but the mandible and cranium together form the *skull*. This is a common misnomer in the literature; it is erroneous to use skull and cranium interchangeably.

There are no complete skulls or large cranial portions in the Fincastle assemblage. Cranial elements are among the least represented skeletal portions, comprising only 496 elements or 11% of the assemblage (Table 2). The identification of cranial fragments to specific elements revealed an interesting pattern. The temporal petrous portion was represented in relative abundance compared to the paucity of other cranial portions (Table 6). This portion contains the auditory canal and is located on the lateral (exterior) portion of the temporal, inferior to the eye orbit and posterior to the mandibular articular surface (Figures 5 to 7). The petrous portion is considered one of the densest bones in osteology, which along with its identifiable shape is often cited as the reason for its excellent preservation above other cranial elements.

A review of the literature for explaining the archaeological presence of this temporal portion revealed little information beyond being used as evidence of brain removal. Agenbroad (1978) uses the presence and frequency of the petrous portion and occipital fragments as evidence of brain removal (p. 27). He supports this conclusion with evidence from Hartley and

Pokorsky's experiment on detaching modern cow crania (Hartley and Pokorsky 1973 in Agenbroad 1978). Hartley and Pokorsky found that blows directed at the atlanto-occipital joint resulted in the fragmentation of the occipital and temporal elements. However, there are relatively few occipital fragments compared to the temporal bones in the Fincastle assemblage. The lack of occipital fragments did not rule out the cranial detachment method proposed by Agenbroad (1978). Further research was needed to propose an explanation that could account for the petrous portion frequency without the accompanying occipital fragments.

The close anatomical positioning of the petrous portion and the articulation point between the cranium and the mandible indicated mandible breakage may explain the high frequency of the temporal fragment. In conjunction with the low number of other cranial elements, it was hypothesized that mandible detachment was specifically carried out to facilitate cranial separation. Therefore, the frequency of the petrous portion could be used to evidence mandible detachment, and in the case of the Fincastle site, cranial separation. The high number of broken mandibles in the Fincastle assemblage is used to support this conclusion.

The archaeological record links the removal of mandibles to two activities, both of which would be identified based on cultural breakage patterns and processing evidence. First, the removal of mandibles for use as utilitarian tools would be evidenced by use wear such as polishing or striations (Landals 2009). The Fincastle mandible assemblage does not have any evidence of use wear for expediency tools so this activity will not be discussed in further detail. The second theory states that mandible detachment is linked with the cultural activity of tongue removal. Historical records, discussed in detail below, further support the existence of this activity by documenting tongue removal as an important ceremonial component of bison kill events, as tongues were considered a delicacy. Further evidence of tongue removal is often tied to the presence of the hyoid, the bone found at the base of the tongue. This line of reasoning follows that because the hyoid has a physical connection to the tongue, its presence in the archaeological assemblage must indicate tongue removal was occurring. Often the presence of the hyoid is cited as evidence for tongue removal without any explanation for how this activity occurred, how the hyoid is found in association with other elements, or how the hyoid presents any evidence for tongue removal.

The goal of this analysis was to corroborate anatomical positioning of skull elements and fragment frequency in the assemblage to the interpretation of cultural activity. This research led to three focus areas for understanding the Fincastle skull assemblage.

1) What activity or process is responsible for the high number of repeated temporal fragments, and why are they found at Fincastle where there is an overall lack of skull portions?

2) Is there a connection between the mandibles and these temporal portions, and does this evidence tongue removal as suggested by the literature?

3) How is the hyoid used as evidence for tongue removal, and does the Fincastle assemblage provide this evidence?

The following literature review is used to describe how these skull portions are presented as evidence of butchering activity . Then, the Fincastle assemblage is compared to these models. Finally, this chapter culminates in proposals for future research for how to better identify trends and activities when conducting archaeological research. A select example of cranial Bone Units are provided in Appendix III.

Table 6: Cranium element quantification

Cranium Element Quantification					
Element	BU	Landmark	NISP	MNE	MNI
Horn	BU 43	Large Portion	2	3	2
	BU 44	Small - Medium Portion	2		
Malar	BU 14	Zygomatic and Temporal	3	5	3
	BU 19	Dorsal orbit fragment	6		
	BU 27	Zygomatic	2		
	BU 40	Ventral orbit fragment	14		
Maxilla	BU 03	Maxilla with complete tooth row	5	32	19
	BU 07	Maxilla with incomplete tooth row	40		
	BU 39	Dorsal fragment with no tooth row	6		
Nasal	BU 22	Complete	1	10	4
	BU 30	Fragment	9		
Occipital	BU 15	Paramastoid Process	3	9	5
	BU17	Condyle Fragment	8		
	BU 42	Occipital (Including Auditory Meatus), Parietal, Palatine and Maxillary Teeth Row	1		
Palatine	BU 31	Complete	2	4	2
	BU 34	Complete	2		
Parietal	BU 16	Parietal-Temporal Suture	3	-	-
Premaxilla	BU 09	Nasal Process articulated to extreme anterior Maxilla	3	9	4
	BU 18	Complete	2		
	BU 23	Nasal Process with no maxillary articulation	2		
	BU 36	Nasal Process articulated to extreme anterior Maxilla	4		
Temporal	BU 11	Auditory Meatus	8	68	34
	BU 12	Temporal Condyle	2		
	BU 13	Zygomatic Process	5		
	BU 29	Complete	3		
	BU 46	Auditory Meatus	57		
Indeterminate	BU 35	Fragment	271	-	-
	BU 45	Suture Fragment	26	-	-

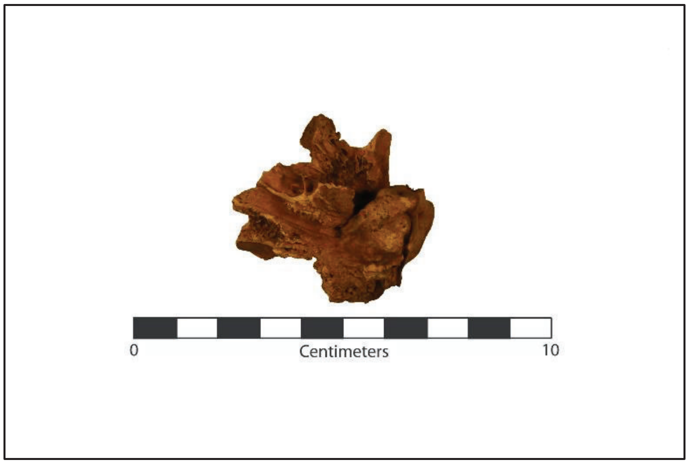

Figure 5: Interior view of petrous portion, catalogue #1137

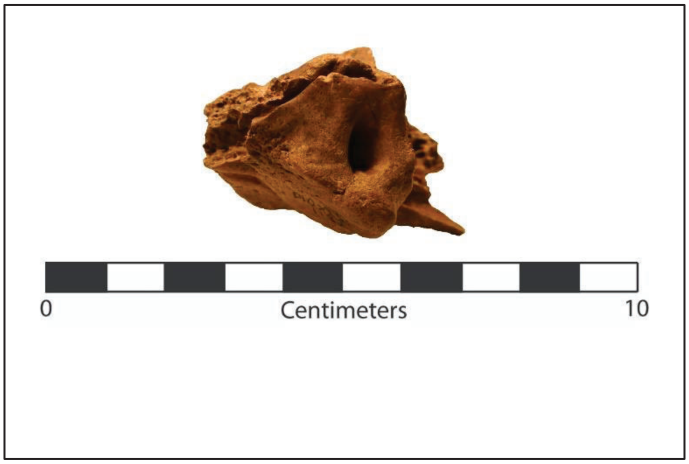

Figure 6: Ventral view of petrous portion, catalogue #1137

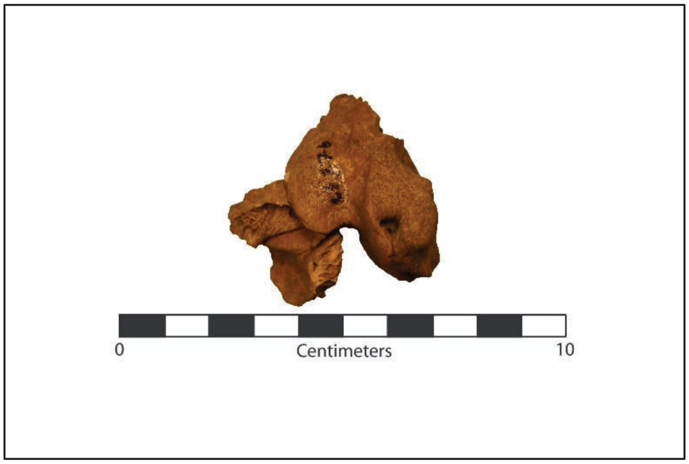

Figure 7: Lateral view of petrous portion, catalogue #1137

Literature Review

This literature review highlights how mandible and tongue removal are presented by researchers, as well as how the petrous portion is described when researchers detail its presence and frequency in assemblages. Specifically, there are two main approaches for understanding mandible removal, both of which are influential in the literature. Researchers seemingly favour one interpretation over the other, or are unaware of the other argument, which has created two opposing descriptions of mandible detachment. Often, the conclusions presented in many articles and reports cannot be evaluated because of the lack of detail in the reports outlining element portions, or even frequencies in some cases. It is also important to note for some of the historical sources, the information was recorded during the protohistoric time period and butchering strategies may have changed.

One of the most thorough historical accounts of tongue removal was recorded by Fletcher and La Flesche (1905) in their monograph, *The Omaha Tribe,* published by the bureau of American Ethnology. Anthropologists from this time period were focused on recording the lifeways and traditions of Indigenous people in the early 1900s, under the fear that population decimation would result in this knowledge being lost forever. For this reason, the aspects of daily life, hunting, social organization, and language were recorded in detail. There are two separate accounts of tongue removal in the text; they do not differ in how the tongue was removed, but when this activity occurred. The first passage presents the order of the butchering process after killing a deer, elk, or bison. Fletcher and La Flesche record a bison kill and subsequent butchering operation in detail, with specific information for the treatment of the tongue:

> “The tongue was the last to be taken out; this was secured by making an incision in the middle of the underjaw, pulling the tongue through the slit and then cutting it off at the roots. If it was late in the day, or the hunters were in haste, the tongue was left untouched.

> When one of the writers [Fletcher] commented on the loss of so dainty a part, she was answered: ‘Men do not pay attention to these little delicacies but when their children ask for them, the men remember.’” Fletcher and La Flesche, The Omaha Tribe, 1905, p. 273

In the second passage, Fletcher and La Flesche document an annual bison hunt, which was identified as a more ceremonial hunt compared to the previous passage. For this hunt, twenty young men are sent out from camp to find a nearby herd to surround. Once they have successfully found a herd, the necessary ceremonies have been completed, and the camp members are prepared, the hunters are sent out to surround the herd on horse and by foot:

> “As soon as the hunters rushed on the herd and a buffalo was seen to fall, these boys pushed in dodging in and out among the animals and hunters, for they must take the tongue from a buffalo before it had been touched with a knife. They carried their bows unstrung and thrust the tongues on them. They had been instructed as to the manner in which the tongues must be taken. An opening was made in the throat of the buffalo and the tongue pulled through and taken out; then the end of the tongue was bent over and the fold cut. It was thought that if a knife was thrust through the tongue to make a hole, it would bring bad luck. Through the slit … the unstrung bow was thrust. Ten tongues were carried on one bow.” Fletcher and La Flesche, The Omaha Tribe, 1905, p. 282

These accounts illustrate two important points for understanding tongue removal. First, the order of the butchering process for when tongues were removed. This historical account places tongue removal as both the first and last activity that happens after a bison has been killed. In one description the authors state that the tongue must be removed before any other butchering activities can occur in the annual hunt. Alternatively, so little attention is paid to the tongue in other hunts they are often left in the animal. It is not clear why tongue removal differs between the two hunts from the monograph, besides using the tongue for ceremony. If the ceremony is not performed with every bison hunt, this might explain why the tongues were not removed.

The second point is how the tongue was removed from the animal. The record states the tongue was removed through an incision in the throat, from which the tongue was pulled out and then removed from the rest of the animal for both hunts. For the annual hunt, the ethnologists further explain how the end of the tongue was bent over and cut to make a slit through which the tongues could be carried on a bow. The end of the tongue is where the hyoid bone is located; it is unclear if the hyoid bone is being removed with the tongue from this description, or whether the tongue is cut free from the hyoid bone, leaving the element in the neck. There is no mention in the monograph of the hyoid bone, but potentially the fold cut at the end of the tongue may leave some evidence of butchering. However, it seems unlikely the hyoid bone would be left at the kill site in this account as the tongue was removed from the immediate kill site.

A similar account was provided in *The Indian Journals 1859-1862* by Lewis Henry Morgan, as the anthropologist travelled throughout the American Great Plains. In this passage, Morgan was travelling aboard a ship up the Missouri River through the Dakotas when the crew spotted a bison on the riverbank. The animal was shot and then dragged onto the ship where it was butchered:

> "The cutting up was done rapidly, and Indian fashion… They placed the buffalo on his belly, extended his hind legs behind him, and left his fore legs under him, and began without cutting his throat which they never do… [After removing the hides and meat from the bison] the animal was then turned on his side. Next the tongue was taken out. The head was turned as to bring up the under side, after which the skin was cut down under the throat and an incision made, and the tongue was quickly removed. All of these pieces were deposited in a pile on the half part of the skin." Morgan (1959), The Indian Journals, pg. 184

Morgan notes the person doing the butchering was not Indigenous, but rather a young Greek man who had spent three years in the service of the American Fur Company and had experience of butchering from watching Indigenous people. This may skew the validity of the account provided by Morgan, but the method of tongue removal is similar to the account detailed by Fletcher and La Flesche. This singular account details tongue removal as one of the last activities to take place, by making an incision in the neck to pull out the tongue before removing it.

However, Morgan's account does not provide any further details on why the tongue was removed, why it was discarded, or any other butchering activities relating to the head of the animal. Morgan does note that this was the process followed when food was not scarce. The account does not provide any details relating to the hyoid bone, and the same questions remain from the reading of Fletcher and La Flesche. How does the hyoid bone relate to the tongue removal process?

Both of these accounts have highlighted how butchering occurred during the historical period, with the use of horses, guns, and metal tools. If the butchering methods changed from pre-contact to post-contact, different patterns might be identifiable in the archaeological record. However, it is valuable to survey the historical record to better understand what has been documented for these activities. Frison and Reher (1970a) cite the accounts of both Morgan (1959) and Fletcher and La Flesche (1905) as evidence for butchering activities.

In the Glenrock publication, Frison and Reher (1970a) explain in detail the butchering process with evidence from the bison assemblage. The authors explain that the head of the animal had to be completely skinned, otherwise, "it does not seem possible to have broken a hole in the frontal bones, broken the temporal bones, removed the mandibles, and split the skull otherwise" (Frison and Reher 1970a, p. 11). With this statement, the authors connect the breakage of the temporal bone and the removal of the mandibles. They further explain this connection by stating that, "the most common method [of mandible removal] was to place the skull face down and with a reasonably heavy but blunt-pointed hammerstone, direct sharp blows downward and slightly inward to the temporal condyles and break them off at the point of articulation with the mandibles," (p. 22). The authors state this was to aid in the removal of the mandibles, but also the removal of the tongue. After the mandibles had been loosened from the cranium, “the tongue was also readily accessible at this time, and the regular appearance of cut marks on the medial side of the mandibles may have been to loosen the mylo-hyoideus muscle” (p. 22). Frison and Reher use these cut marks as direct evidence of tongue removal. They include the hyoid as further evidence of tongue removal by stating that most of the hyoid bones are broken across the greater cornu. Exact details on how the hyoid bone was broken or found in association for the rest of the butchering activities was not discussed. Although the hyoid bone was included in the quantification tables, it was not discussed further in the text.

Frison and Reher state that after the blows had been delivered to the temporal bone, the fragments of the temporal bone would be used to strip the masseter muscles from the crania. They conclude by stating that these fragments, “were then removed with the rest of the meat” (p. 22). The fragments of the temporal described in the text may be the petrous portion, but it is unclear from the publication. This may support the conclusion that a directed blow would be sufficient to detach the portion from the rest of the crania.

This interpretation of the archaeological material differs from the historical accounts detailed previously. Frison and Reher (1970a) acknowledge this prior work by stating, “accounts of Plains butchering (Morgan 1959:159) mention cutting a slit in the throat and pulling out the tongue and cutting it off, but this was using a steel knife and would hardly apply to the Glenrock context,” (p. 11). The acknowledgement of historical accounts and then disregarding them because it does match the same temporal or technological parameters creates a problematic dilemma for archaeologists. Remaining unbiased and allowing for the interpretation of the archaeological material is a worthy goal, but the historical accounts provide important context. Not using evidence because it is from the historical period fails to recognize the possibility of cultural continuity. It is possible there are alternative explanations for the medial cutmarks on the mandibles beyond the suggestion that they are evidence of tongue removal, such as their use in obtaining marrow from the ventral borders (p. 22 & 25).

Frison expanded the idea of the mandibles being detached from the cranium for ease in tongue removal through the mouth, citing evidence at the Ruby and Vore bison kill sites. In the Ruby assemblage, “mandibles were often paired but separated from the skull, which suggests removal of tongues” (Frison 1971, p. 83). Mandibles removed from the crania had cut marks on the lingual side of the mandibles at the Vore site, which was used as evidence for “cutting of the muscles holding the tongue” (Frison 1976, p. 50). Specifically, the issue with the suggestion of tongue removal through the mouth is the lack of explanation for how the hyoid is used as evidence. There is a lack of anatomical clarity for how the hyoid is involved with cutmarks on the lingual side of the mandible. Moreover, there is no information to clarify if the hyoids are transported with the tongue or remained in the animal. The lack of detail makes it difficult to explain how the tongue was removed from the animal, and to identify this activity in the archaeological record based on element portion and frequency.

The second strain of ideas about tongue removal was proposed by White (1953), when he was working with faunal assemblages from village sites in South Dakota. White identified patterns of butchering and removal in several sites dating to approximately 1500-1800 CE. In this passage, White examined the skull elements for evidence of butchering and concluded that:

> “Since none of the jaws appear to have been used for anything, presumably they were brought into the village with the tongue. Certainly, the easiest way to remove the tongue would be to smash the ascending ramus of the jaw and remove the jaws and tongue as a unit for further cutting at a more convenient time…The hyoid would normally be

> removed with the tongue, but it is a small bone and might be over-looked or lost. Some may have been converted into small spatulas or quill flatteners but, after being worked, it is very difficult to be certain of the identification" White 1953, p. 162

White ruled out the mandibles as expediency tools because they demonstrated no use wear. However, the high number of mandibles represented at these village sites indicated they had been transported to the village instead of being discarded at the kill area. White's hypothesis of the mandibles and the tongue being removed as a single unit, with the hyoid being transported with the tongue, is not explained in further detail. How the unit was removed from the animal beyond smashing the ascending ramii is unclear, and any evidence for the hyoid being transported with the tongue is not explained. Nor is it explained why this unit was chosen for processing at a later time or transported over potentially large distances when the cranium "would be unprofitable to transport any distance" (p. 162). The interpretation provided by White is lacking in almost all of the details necessary for understanding how this action was carried out and the reasons for doing so, leaving researchers unable to understand how to apply these claims to their faunal assemblages.

However, this work was influential for later publications, including preliminary research at Hudson-Meng, a proposed Paleoindian bison kill site in Nebraska. Agenbroad (1978) used the proposal by White to understand the distribution of mandibles at the Hudson-Meng site. While it is presently understood that the Hudson-Meng assemblage is best thought of as both natural death assemblages and cultural processing activity areas (Barg 2013), the early interpretations were of a mass bison kill event representing over 600 bison (Agenbroad 1978). The research published by Agenbroad is vital to this conversation for two points. First, Agenbroad used White's work on the Dakota village sites as corroboration for butchering activities. Agenbroad begins by explaining, “it was assumed that the mandibular presence and distribution represents tongue removal, by removal of the mandible (White 1953)” (Agenbroad 1978, p. 27). He then further expands on this idea when explaining:

> “approximately 70% of the mandibles have the ascending ramus broken. White (1953) states this to be the earliest method of extraction of the tongue, removing the mandible and tongue as one unit,” Agenbroad 1978, p. 44

Agenbroad uses these conclusions to infer similar cultural activity at Hudson-Meng, and as Hudson-Meng became an important Paleoindian research site, there is no doubt these conclusions were read countless times by other researchers. The second reason Agenbroad’s work is important for this study is it includes a conversation about the temporal bone, and specifically the petrous portion. As highlighted in the introduction to this chapter, the petrous portion is anatomically close to the articulation point of the mandible to cranium. Agenbroad used research by Hartley and Pokorsky (1973), who experimented on cattle skulls and determined the best way to remove the brain was by delivering blows to the occipital-basilar region, creating cranial fragments of the occipital bone and the associated temporal region (Agenbroad 1978, Barg 2013). These fragments were used as evidence of brain extraction and the mandibular distribution as tongue removal (Agenbroad 1978, p. 27).

Agenbroad’s work served as the foundation for further work completed on the Hudson-Meng faunal assemblage, eventually leading to further excavations and allowing for different interpretations of the bonebed. However, the interpretations of skull butchering activities have remained largely unchanged since 1978. Todd and Rapson (1999), in their re-examination of the Hudson-Meng assemblage, did not change the interpretation of mandibular presence but did account for an increased number of skulls at the site than had previously been identified:

> "With later analysis, it became apparent that skulls were present, though represented primarily by basal-occipital portions and petrous portions… From a formational perspective, the two patterns in need of immediate attention are those serving as the cultural interpretations of the bonebed: 1) relative abundance of cranial portions and 2) differential frequencies of phalanges." Todd and Rapson 1999, p. 488

Todd and Rapson propose differential erosion as the reason for the predominance of basal cranial fragments, including the petrous portion and occipital condyles. They also state that during their five field seasons they uncovered clusters of cranial fragments, indicating deterioration of the crania *in situ* instead of human butchering activity (p. 489). This work expanded on earlier interpretations presented by Agenbroad, who used the cranial fragments as evidence of brain extraction and mandibular breakage for tongue removal. The most recent re-examination of the Hudson-Meng bone bed presented another interpretation of the site, as Barg (2013) found evidence for both cultural activity and taphonomic damage (p. 200). However, Barg reiterated that as the site was at least partially a cultural assemblage; Agenbroad's previous claims of the mandible smashing for tongue removal and pattern of cranial fragments for brain extraction were presented unchanged (p. 26).

Tongue removal was extensively discussed in Wheat's (1972) publication of the Olsen-Chubbuck site, presenting evidence for both methods of removal. Wheat noted there was little historical documentation of mandible smashing by Indigenous populations but this does not eliminate the possibility that this activity occurred. Wheat used commentary on the Fletcher and La Flesche historical description of the annual bison hunt to imply hyoids would have gone with the tongues, although this is not stated clearly in the text (p. 102). In their survey of the literature, Wheat pools information from many different historical records, and concludes:

> "In the late sites, the tongue was removed by smashing the ascending ramus of the jaws and then cutting the tongue free of the skull (White 1953). The jaw was also removed for the same purpose at the Olsen-Chubbuck site, but the vast majority appear to have been

> carefully cut free rather than smashed. In addition, at the Olsen-Chubbuck site many tongues appear to have been removed by the historically recorded technique of slitting the throat, pulling the tongue through the slit and cutting it off." Wheat 1972, p. 163

The mandibles at Olsen-Chubbuck demonstrated smashing at the symphysis (p. 71). Evidence for tongue removal beyond the equal distribution of the hyoid throughout the bonebed is limited, and there is minimal discussion of the butchering or fragmentation of the hyoids (p. 72). Further, if Wheat concludes that both methods were taking place, then perhaps there would be differential evidence based on the portions present. However, there is insufficient information in the article to understand the fragmentation or butchering breaks present on the bones. There was no discussion of the temporal bone or the petrous portion, but there was a number of complete skulls at Olsen-Chubbuck which likely contain these elements.

Two trends have been identified in the literature concerning tongue removal. First, the historically documented method of removing the tongue through an incision in the throat. Second, the archaeologically proposed method of smashing the ascending ramii to detach the mandibles and subsequently cut the tongue free from within the mouth at the kill site or transported with the mandibles for processing later. The shortcomings in the archaeological interpretations stem from the lack of explanation and connection to the specific faunal elements. Archaeologists attempted to reconcile historically recorded activities with their archaeological data without clearly explaining the link between them. The obstacle for applying the historically recorded method is the uncertainty over what happened to the elements involved. The historical accounts are missing key details in their records concerning the faunal elements. Further, the majority of literature focused on concluding mandible and tongue removal had occurred but were unable to provide a satisfactory explanation for how the presence of the hyoid is evidence of tongue removal, or how the petrous portion is a common cranial identifier in assemblages. There was limited discussion linking the anatomical positioning of the portions to the archaeological record to generate a plausible conclusion for how the fragments are evidence of these cultural activities. More research is needed to clearly articulate the link between the activities proposed by researchers and the elemental analysis.

Fincastle Evidence

The preceding literature review highlighted three important challenges for understanding the methods used in mandible detachment, tongue removal, and cranial separation. First, details on how the presence or fragmentation of the hyoid is evidence of tongue removal is sparse, although its presence at a site is routinely used as evidence of this activity because of its anatomical positioning. Additionally, researchers used evidence of smashing on the ascending ramus and alveolar symphysis, and lingual cutmarks on the mandibular ventral borders as evidence of tongue removal. It is not clear from the literature review how the hyoid is involved with any of these activities or connected to tongue removal by these methods. Second, the method of mandible detachment from the cranium was presented in two separate ways; by blows to the temporal condyles and by breaking the ascending ramus. Both of these methods were used to support evidence of tongue removal. There is a disconnect between the process of tongue removal and mandible detachment described in the literature, as it is unclear why mandible breakage was necessary to facilitate tongue removal. Lastly, the petrous portion was minimally discussed in the literature review. The fragment was described by Frison and Reher (1970a) as a way to understand butchering of the skull. The Fincastle assemblage offered a means to study these methods, though there is minimal evidence of cranial butchering because of the lack of cranial elements. The petrous portion may provide evidence of cranial separation, made possible by mandibular detachment. The relationship between mandibular and cranial fragments are discussed in the following sections, with information derived from the Fincastle assemblage to support the conclusion of purposeful cranial and mandible separation.

Hyoid

As mentioned previously, the hyoid is a visceral or splanchnic bone, unique because of its formation in soft tissue and lack of connection to the main skeleton. It is located anatomically inferior to the mandible in the neck of the animal, where it serves as the anchor for the tongue. The hyoid apparatus in bison is comprised of three different bones: stylohyoid, epihyoid, and the ceratohyoid. For the purposes of this study, only the stylohyoid is discussed as this is the most identifiable hyoid piece and is the only bone with bone units in the BU identification manual. The stylohyoid is a shaft with the greater cornu attached; the ceratohyoid and epihyoid are smaller and are more difficult to identify. The apparatus is connected via cartilaginous tissue, and all the elements are delicate and fragile. The preservation of the stylohyoid bone is variable; researchers working in environments with poor bone preservation may not have this element for analysis as taphonomic processes may deteriorate this bone. This clarification is made in an effort to communicate clearly the portions present in the Fincastle assemblage but will be referred to as the hyoid in this discussion. Figures 8, 9, and 10 are photographs of different hyoid fragments from the Fincastle assemblage.

Figure 8: Lateral view of complete stylohyoid, catalogue #16216

Figure 9: Lateral view of stylohyoid shaft, catalogue #4493

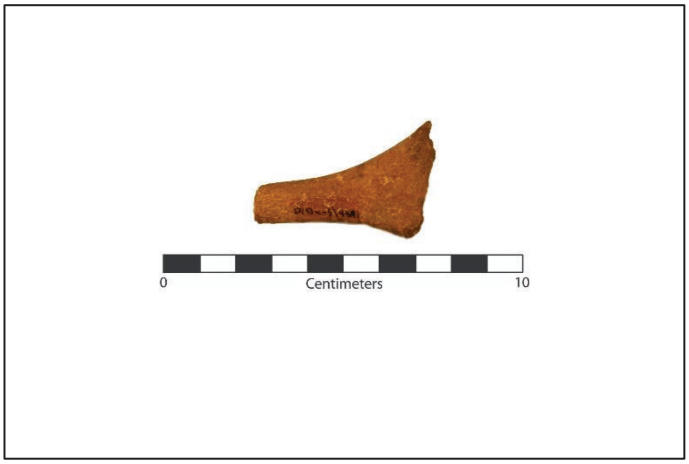

Figure 10: Lateral view of proximal stylohyoid, catalogue #4491

In Figures 11 and 12, the close anatomical position of the mandible, hyoid, and temporal bone are noted. If the tongue is removed through cutting in the mouth, it is clear the hyoid bone will not be reached. The hunters would need to reach down into the throat of the bison and cut the tongue off from within the neck. Simply cutting the tongue free from the mylohyoid muscle in the mouth would not cause damage or breakage to the hyoid. A more plausible explanation for hyoid breakage is the historically documented method of making an incision in the throat underneath the mandibles and cutting the tongue free. In this method, the hunter may cause damage to the apparatus because there is direct access to the hyoid through the underside of the throat. The anatomical positioning of the bones is vital for understanding how cultural activities were completed. The practice of cutting the tongue free through the mouth does not correlate with proposing the hyoid as evidence of this activity.

Figure 11: Osteological position of bison mandible, hyoid, and temporal bone (adapted from Idaho Museum of Natural History)

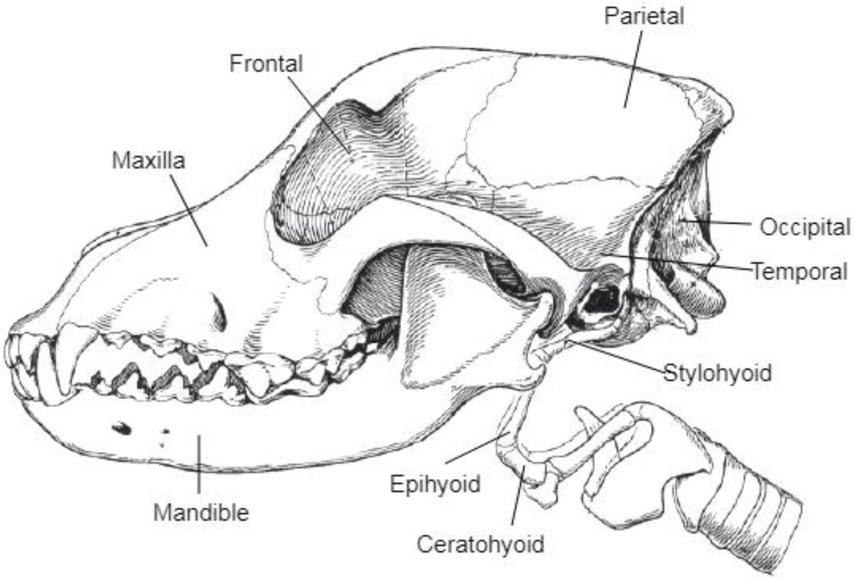

Figure 12: Canid skull diagram (adapted from Evans (1993))

Understanding how the hyoid can be used as evidence of tongue removal begins by identifying which portions of the element are present. The Fincastle hyoid assemblage has a high degree of fragmentation, and no complete hyoids. The fragments are most commonly broken on the extremities, separating the shaft and dorsal branches. For comparison, Wheat states that of the 39 hyoids recorded in the Olsen-Chubbuck assemblage, 23 were complete and 14 were fragmentary (Wheat 1972, p. 72). The vast majority of the hyoid portions found at Fincastle are small fragments of the shaft (BU 08), followed by the medial portion of the dorsal extremity missing the muscular angle and the dorsal cartilaginous surface, with ¼ to all of the shaft present (BU 11). There are approximately equal proportions of lefts and rights in adults (NISP Left 26 and NISP Right 27), with one juvenile and one subadult portion present (Table 8). The hyoid comprises approximately 37% of the MNI (Table 7). The hyoid has among the highest representation values of axial elements, more than the axis, atlas, cervical vertebra, thoracic vertebra, lumbar vertebra, pelvis, and sacrum; only lower to the cranium and mandibles (Table 2). This may evidence that the crania, mandibles, and tongues were separated from the bison, as evidenced by the low representation of axial elements, with the hyoids being cut away from the tongue after removal.

Table 7: Bison hyoid summary quantification chart

Bison Hyoid Summary Quantification Chart						
NISP	MNE	%MNE	MAU	%MAU	MNI	%MNI
121	55	6%	28	38%	29	37%

Table 8: Bison hyoid quantification chart by bone unit

Bison Hyoid BU Quantification Chart			
BU	Side	Age	NISP
BU 02	Left	Adult	3
	Right	Adult	4
BU 03	Left	Juvenile	1
	Right	Adult	3
	UD	Juvenile	1
		Adult	3
BU 04	Left	Adult	4
	Right	Adult	8
BU 05	Right	Adult	2
BU 06	Left	Adult	1
BU 07	Left	Adult	3
	Right	Adult	1
BU08	Left	Adult	4
	Right	Adult	6
	UD	Adult	36
BU 09	Left	Adult	3
	Right	Adult	2
BU 10	Left	Subadult	1
		Adult	1
	Right	Adult	3
BU 11	Left	Adult	12
	Right	Adult	13
BU 12	Left	Adult	1
BU 13	Left	Adult	1
BU 14	Left	Adult	2
	Right	Adult	2
		TOTAL	**121**

There are three possibilities of how the hyoid could be involved with tongue removal, regardless of the butchering technique. The first is the hyoid stays in the animal when the tongue is cut free from the hyoid. This would leave the hyoid in the throat and could represent where the animal was killed. The second possibility is that the hyoid is removed directly with the tongue but discarded after removal, hence the hyoids are no longer associated with the skull. This result could be garnered from Fletcher and La Flesche (1905) when they discuss the fold being cut to string the tongues on bows. This cutting process may lead to breakage of the delicate hyoid bone, as seen in the Fincastle assemblage. However, the historical accounts do not detail the discard of tongue portions either at the kill site or a secondary processing location. The discard of tongue portions would had to have happened for hyoids to be uncovered during excavations. Further, of the 121 hyoid portions identified in the Fincastle assemblage, only two have evidence of cutmarks on them that could support this conclusion. The third hypothesis is that the hyoid is removed with the tongue then transported together to a secondary location. Wheat (1972) proposes this method at the Olsen-Chubbuck site to explain why the skull was often left intact at the kill site. He states that since the tongue was removed through an incision in the throat, there is no reason to detach the mandibles from the crania. He cites Fletcher and La Flesche's monograph to state that, "the hyoids would have normally gone with the tongue" (p. 102). This proposal is reminiscent of White's tongue removal hypothesis but does not necessitate mandible smashing for tongue removal. There are a number of hyoids found at Fincastle meaning that not all of them were transported away from the kill site.

Of the three scenarios concerning the hyoid as evidence of tongue removal, there is support for both immediate discard and transportation at Fincastle. The degree of fragmentation of the hyoids indicates butchering was occurring, which means the hyoids are not left untouched in the animal. Further, there are no complete bison skeletons found at Fincastle to date which negates the possibility that the hyoids remained in the throat. There is a sizeable contingent of hyoid fragments in the assemblage (37 %MNI), but their low %MNI value compared to the astragalus (100%) and navicular cuboid (95%) indicates there are hyoids missing from the assemblage (Table 2). Therefore, the evidence supports the conclusion that as the tongues were removed from the animal, the hyoids were cut from the tongue and immediately discarded. Some may have been removed with the tongues to another location for later removal but it is more likely that hyoid fragments were not able to be confidently identified or that more hyoid fragments will be uncovered elsewhere on site. It is possible the %MNI would increase if more of the Fincastle site was excavated. Further, it appears there is a mix between the two hyoid removal methods, with little support for the conclusion of one dominant approach. However, it is clear that there is more support for the historically documented practice of tongue removal through the throat. This is because the hyoids exhibit a high degree of fragmentation as a result of being directly located where the tongue is being removed. This fragmentation would not be possible if the tongues were removed through the mouth because the hyoid would not be impacted by that activity. If the tongue was removed through the mouth, it seems likely the hyoid would be left articulated in the animal.

Mandible

The mandibles' connection to tongue removal warrants a thorough discussion. The articles included in this literature review present the mandible as evidence to support conclusions of tongue removal. The most common proposed method for tongue removal involves smashing the mandibles on the ascending ramus for access to the tongue. The other commonly proposed technique involves smashing the symphyseal surface connecting the mandibles to improve access into the mouth to then cut the tongue free. Both strategies are used to support tongue removal through the mouth. As discussed above, the removal of the tongue through the mouth would not cause damage to the hyoids, nor does it account for their presence in a butchering context because the anatomical position of the hyoid is unreachable by this technique.

Perhaps it is easier to understand the separation of the mandibles from the cranium without considering them as a part of tongue removal. If the end goal is an intact crania, by way of a disarticulated skull, smashing of the mandibles need not take place at the ascending ramus, but rather at the coronoid process. Although the ascending ramus is connected to the coronoid process, it is this specific portion of the mandible, along with the condylar articulation, that hunters are likely to be more interested in breaking if the end goal is mandible detachment. Frison and Reher (1970a) state the force of the blow directed at the temporal condyle to detach the mandible resulted in the fragmentation of the coronoid process and destroyed the zygomatic arch (p. 22). There are very few zygomatic fragments in the Fincastle collection (Table 6). Therefore, if the goal is an intact cranium, the direction and force of the blow may be different than described at Glenrock.

The most common mandible fragments found in the Fincastle assemblage are BU 18, which is a section of no more than 3 teeth, with teeth present or absent. The second most frequent is BU 34 which is an undifferentiated mandible fragment generally from the ascending or horizontal ramus but lacking any landmarks. Other common fragments are BU 07, a complete coronoid process, BU 15 a section of the horizontal ramus, and BU 29 coronoid process fragment with the tip missing (Table 9).

Table 9: NISP mandible portion breakdown by bone unit

NISP Mandible Portion Breakdown by BU																							
Symphysis				**Body with Ventral Border**				**Body without Ventral Border**				**Ascending Ramus**				**Coronoid Process**				**Complete or Near Completion**			
BU 20	Left	Adult	2	BU 26	Right	Adult	4	BU 49	Left	Adult	1	BU 04	Left	Adult	5	BU 02	Left	Adult	3	BU 01	Left	Adult	3
	Right	Adult	2	BU 48	Left	Adult	6		Right	Subadult	1		Right	Adult	2		Right	Adult	6		Right	Adult	7
BU 39	Left	Adult	2		Right	Adult	2	BU 13	Left	Adult	1	BU 11	Left	Adult	2	BU 27	Left	Adult	7			Juvenile	1
	Right	Adult	2		UD	UD	1	BU 12	Left	Adult	1		Right	UD	3		Right	Adult	3	BU 25	Left	Adult	2
	UD	UD	1	BU 22	Left	Juvenile	1			Juvenile	1	BU 46	Right	Adult	1	BU 03	Left	Adult	3		Right	Adult	1
BU 06	Left	Adult	11		Right	Adult	1		UD	Adult	1	BU 38	Right	Adult	1		Right	Adult	1	BU 10	Left	Adult	1
		Juvenile	1	BU 44	Left	Adult	3	BU 14	Left	Adult	3	BU 36	Right	Adult	1		UD	UD	1	BU 23	Left	Adult	3
	Right	Adult	4		Right	Adult	3			Subadult	1	BU 16	Left	Adult	1	BU 30	Right	Adult	1		Right	Adult	3
		Juvenile	10	BU 08	Left	Adult	2		Right	Adult	6		Right	Adult	1	BU 32	Left	Adult	5	BU 51	Left	Adult	1
	UD	UD	4		Right	Adult	3		UD	Adult	5	BU 17	Left	Adult	2		Right	Adult	6				
BU 41	Right	Adult	2	BU 42	Left	Adult	2	BU 18	Left	Adult	3		Right	Adult	4		UD	UD	2				
	UD	UD	3		Right	Adult	2			Juvenile	1	BU 47	Left	Adult	1	BU 50	Left	Adult	1				
BU 21	Left	Adult	3	BU 05	Left	Adult	3		Right	Adult	12	BU 09	Left	Adult	6		Right	Adult	1				
	Right	Adult	3			Juvenile	1		UD	Adult	73		Right	Adult	1		UD	UD	1				
	UD	UD	10		Right	Adult	6						UD	UD	4	BU 07	Left	Adult	22				
BU 33	Left	Adult	4	BU 43	Left	Adult	7					BU 28	Left	Adult	3		Right	Adult	17				
	Right	Adult	3			Juvenile	1						UD	UD	9		UD	UD	1				
	UD	UD	1			Subadult	1					BU 37	Left	Adult	3	BU 40	Left	Adult	1				
					Right	Adult	7						Right	Adult	3		Right	Adult	3				
					UD	Adult	2									BU 31	Left	Adult	3				
				BU 52	Left	Adult	2										Right	Adult	1				
																	UD	UD	7				
																BU 29	Left	Adult	6				
																	Right	Adult	9				
																	UD	UD	15				
																BU 24	Left	Adult	4				
																	UD	Adult	7				
Total	68			60				110				53				137				22			

When the mandible BU portions are broken down into major landmarks, an interesting pattern becomes clear. Of the 528 mandible fragments in the Fincastle assemblage, a large number are coronoid process fragments (n=137, 26% as seen in Table 9). Fragments of the ascending and horizontal ramus are among the lowest fragments in the assemblage. The fragments in the Fincastle assemblage do not seem to support the conclusion that the ascending ramus of the mandibles are being smashed for tongue removal. Instead, the majority of the breakage occurred where the mandible articulates with the cranium via the coronoid process and condylar articulation, above the ascending ramus. Additionally, there is almost twice the number of mandibles missing their ventral border than those with a ventral border. Frison and Reher (1970a) proposed the lingual ventral border as where cutmarks would be found to support evidence of tongue removal. Instead, it seems as if the mandibles were fractured at Fincastle, perhaps for marrow removal as there is a large marrow cavity in the mandibles. Further, of the 528 fragments only four show evidence of cutmarks, meaning fractures and breakage are the most common evidence of butchering and processing. If the cranium is the element being selectively chosen for and removed, then further processing might occur on the mandibles, hence the variety of fragments. It is also interesting to note the low number of symphyseal fragments in the collection, likely resulting from the disarticulation of the mandibles from each other. This disarticulation does not need to necessarily indicate interest in tongue removal, it may also denote the breaking of mandibles from each other for further processing. Further evidence of cranial separation by mandibular detachment is the number of mandibles uncovered in the assemblage to date. The mandible accounts for 87 %MNI (MNI n=69) of the entire assemblage, among the highest quantification values, ranking with the carpals, tarsals, and phalanges (see Table 2). As the carpals, tarsals, and phalanges were likely discarded, due to their lack of meat and general usefulness, the similar quantification value for the mandible may indicate a similar processing strategy.

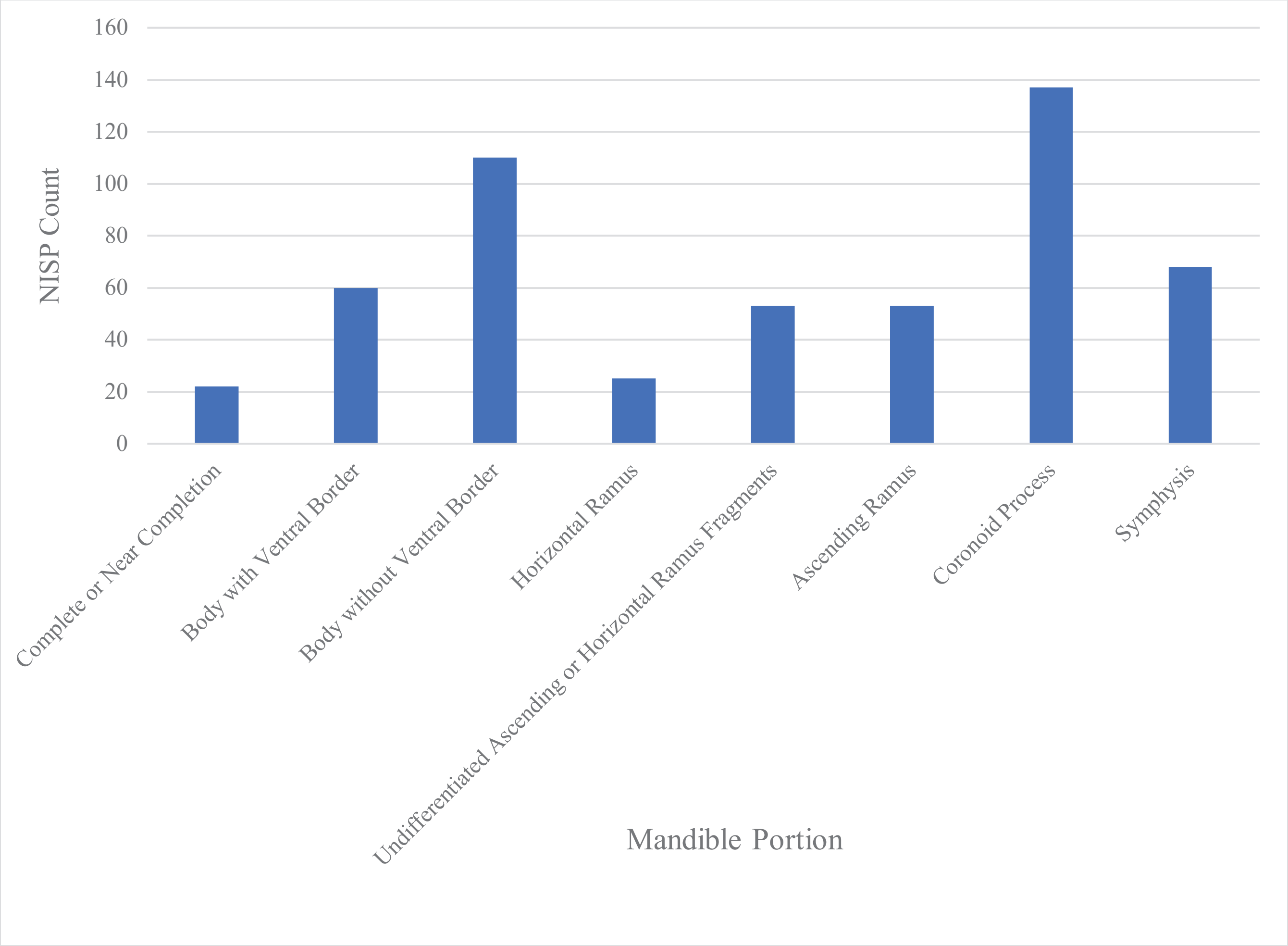

Figure 13: Mandible portion breakdown by NISP

In summary, the high number of mandibles compared to the overall assemblage at Fincastle allowed for a detailed study of portions and butchering evidence to explore the possibility of mandible smashing for tongue removal. In conjunction with the evidence presented in the preceding hyoid section, there is limited support from the Fincastle assemblage for tongue removal by mandible smashing. Rather, there was an overall abundance of evidence for the separation of the mandible from the crania, supported by the evidence of frequent mandibles portions compared to cranial fragments. The low frequency of cutmarks on mandibles does not support tongue removal through the mouth. However, the number of intact mandibles missing their ventral border suggests the cultural activity of marrow removal.

Temporal Bone and Petrous Portion

The lack of complete skulls in the Fincastle assemblage has been used to infer cranial separation. The presence of the petrous portion has been proposed in this thesis as a way to identify the method of separation. Anatomically, the petrous portion is located inferiorly and posterior from the condylar articulation of the mandible to the cranium. The auditory canal is relatively small when looking at an osteological specimen but it is the landmark for this fragment of the temporal bone. The anatomical position of the petrous portion is of interest for its close position to the mandible. The fragmentation of the mandible at the coronoid process is proposed in this research as evidence of cranial separation. The overall abundance of the petrous portion in the Fincastle assemblage, when few other cranial elements have been uncovered, necessitates a better understanding of how its presence can inform archaeological interpretations.

Agenbroad (1978) was among the first to link the petrous portion to cranial butchering. Citing work by Hartley and Pokorsky (1973), they posited the petrous portion would break off of the temporal bone via a blow directed at the back of the skull (occipital bone), to remove the brain of an animal. This laid the theoretical foundation for why this skeletal fragment has been lumped into the discussion of cranial and tongue removal. The petrous portion has since then routinely been cited as one of the more common cranial elements uncovered during excavations, which has often been attributed to its density and therefore its resistance to taphonomic processes. Todd and Rapson (1999) re-examined Agenbroad's work at Hudson-Meng and concluded that the petrous portion frequency was a result of differential taphonomic processes, and not cultural activity. The petrous portion was often found in articulation with other cranial elements, creating a cluster of cranial fragments where a skull had deteriorated over time (p. 488). This section explores how the petrous portion could be used as evidence of cranial separation made possible by mandible detachment because of its anatomical positioning, the low frequency of other cranial elements, and the high number of mandible fragments at Fincastle.

The high number of individual petrous portions were discovered when breaking down the cranium into portions during quantification while looking for differential representation of elements such as the maxilla, occipital, or horn cores. Due to the crania's intricacies, it was deemed useful to breakdown the bone units into the elements they represented in order to better understand the elements present for overall quantification of the assemblage (Table 6). When completing the quantification, it became clear that there were a number of repeated temporal sections which increased the overall quantification. The temporal bone accounts for a significant portion of the cranial assemblage; with the temporal bone the %MNI is 42%, while without the temporal bone it is 24% (Table 10 and Figure 14). The calculated MNI is 34 with the temporal, and 19 excluding the temporal. Clearly, the overrepresentation of this one fragment is an indication of cultural activity because there is no evidence that differential taphonomic processes contributed to this overrepresentation.

Table 10: Cranium with and without temporal quantification values

Cranium with and without Temporal Quantification Values							
Element	NISP	MNE	%MNE	MAU	%MAU	MNI	%MNI
Cranium with Temporal	496	65	7%	32.5	45%	34	42%
Cranium without Temporal	421	32	4%	19	36%	19	24%

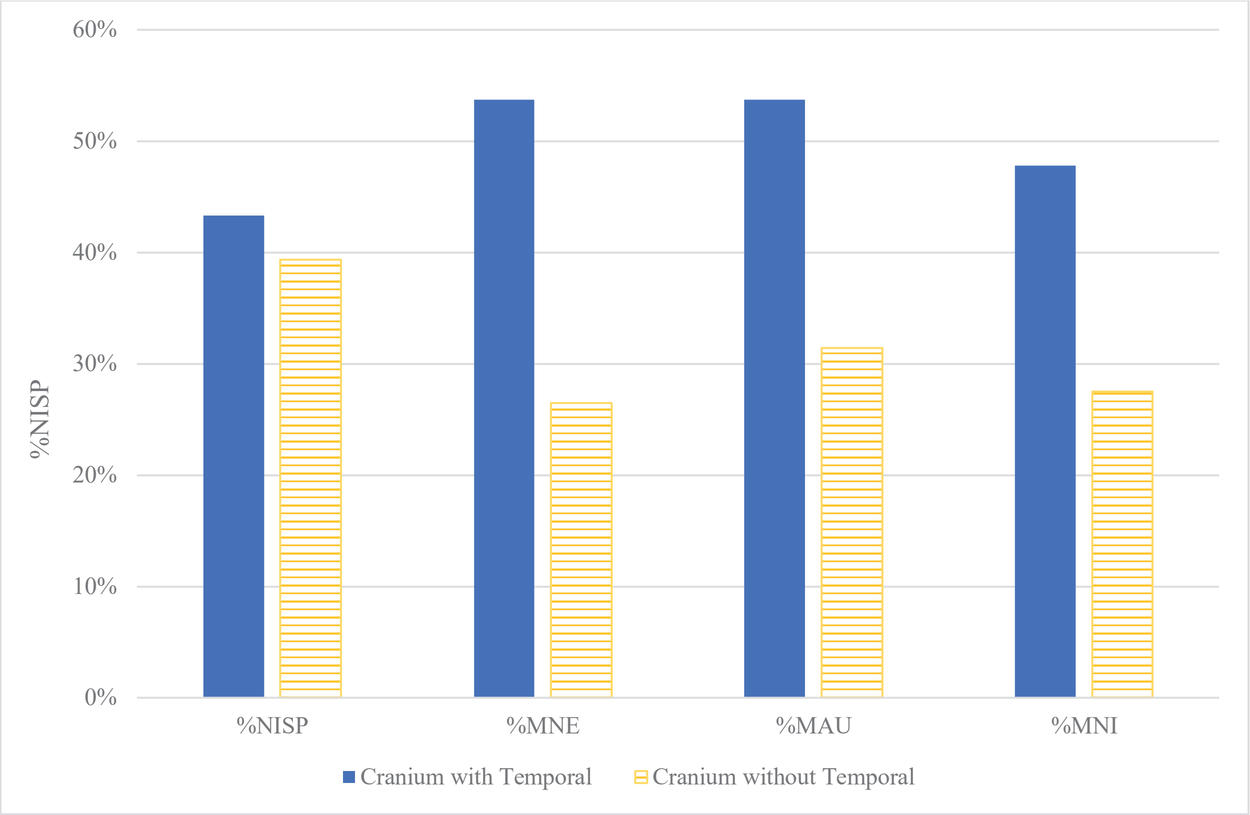

Figure 14: Cranial NISP quantification values varied by inclusion of petrous portion

Of the 75 temporal fragments, three are complete temporal fragments, 57 are complete petrous portions, and eight are petrous portion fragments (91% of the temporal fragments are petrous portion). The portion is uniquely identifiable because of its relatively round and dense shape with the auditory canal running through the centre. Table 6 lists the other cranial values; the low frequency of other cranial fragments is demonstrated by the fact that the next closest value is represented by small dental row fragments of the maxilla. The maxilla values are cautious estimates because they cannot be refitted nor were they uncovered articulated in the ground. However, there are very few occipital fragments, which does not match the interpretation presented by Todd and Rapson for differential preservation based on taphonomic processes. There are very few horn, malar, nasal, palatine, and premaxillary fragments. The overall lack of cranial bones in the assemblage indicates either the cranial elements have yet to be excavated or they were removed from the kill location for other purposes, such as at the Ruby site (Frison 1971).

Comparison

When comparing the standardized quantification values amongst these three bones, the mandible has the highest values of the three elements. More mandibles were uncovered at this site compared to the crania and hyoid elements, indicating they were detached from the crania and discarded (Tables 11 and 12, Figure 15). How the skull was disarticulated at Fincastle may be evidenced by the petrous portion frequency and coronoid process fragments, which differs from the descriptions presented in the literature. Both the anatomical positioning of this bone as an intermediate spot between the mandible and the crania, and its overrepresentation to the rest of the cranial bones is a good indicator of cultural activity centered in this area. Why the mandibles were detached from the cranium is more difficult to answer, but comparisons to sites like the Ruby site may provide some answers (Frison 1971). The high number of mandible fragments suggest that the lower jaw was separated from the cranium and processed further. Tongue removal likely occurred through slitting the throat and pulling out the tongue. Although the hyoid is not represented in high numbers in the assemblage, the high degree of fragmentation makes it more likely the tongue was removed through the historically documented method instead of through the mouth. Some portions of the hyoid likely went with the tongue and other portions were likely at the site. This conclusion is supported by the fact that hyoid fragments were not found in spatially articulated contexts (Figure 16).

Table 11: Cranium, hyoid, and mandible standardized values with temporal bone

Cranium, Hyoid and Mandible Standardized Values with Temporal Bone								
Element	NISP	%NISP	MNE	%MNE	MAU	%MAU	MNI	%MNI
Cranium with Temporal	496	43%	65	54%	32.5	54%	33	48%
Hyoid	121	11%	52	43%	26	43%	23	33%
Mandible	528	46%	121	100%	60.5	100%	69	100%

Table 12: Cranium, hyoid, and mandible standardized values without temporal bone

Cranium, Hyoid and Mandible Standardized Values without Temporal Bone								
Element	NISP	%NISP	MNE	%MNE	MAU	%MAU	MNI	%MNI
Cranium without Temporal	421	39%	32	26%	19	31%	19	28%
Hyoid	121	11%	52	43%	26	43%	23	33%
Mandible	528	49%	121	100%	60.5	100%	69	100%

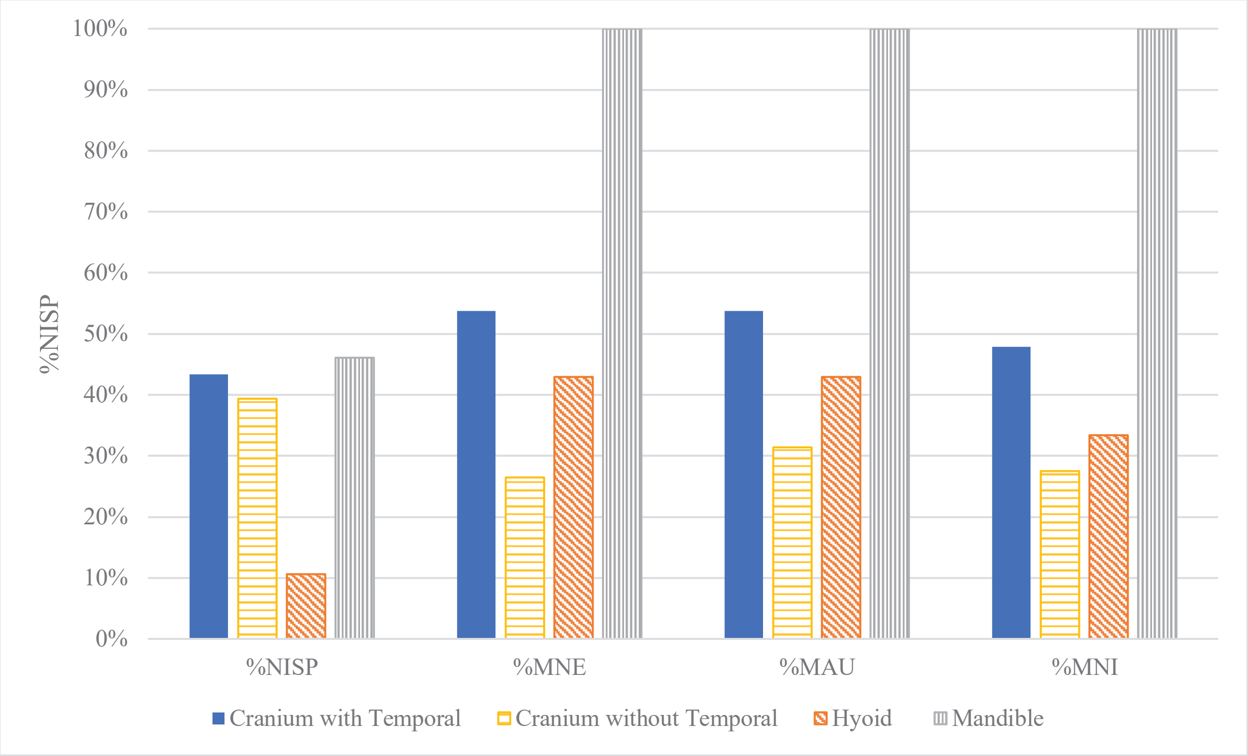

Figure 15: Cranial quantification values by petrous portion, hyoid, and mandible

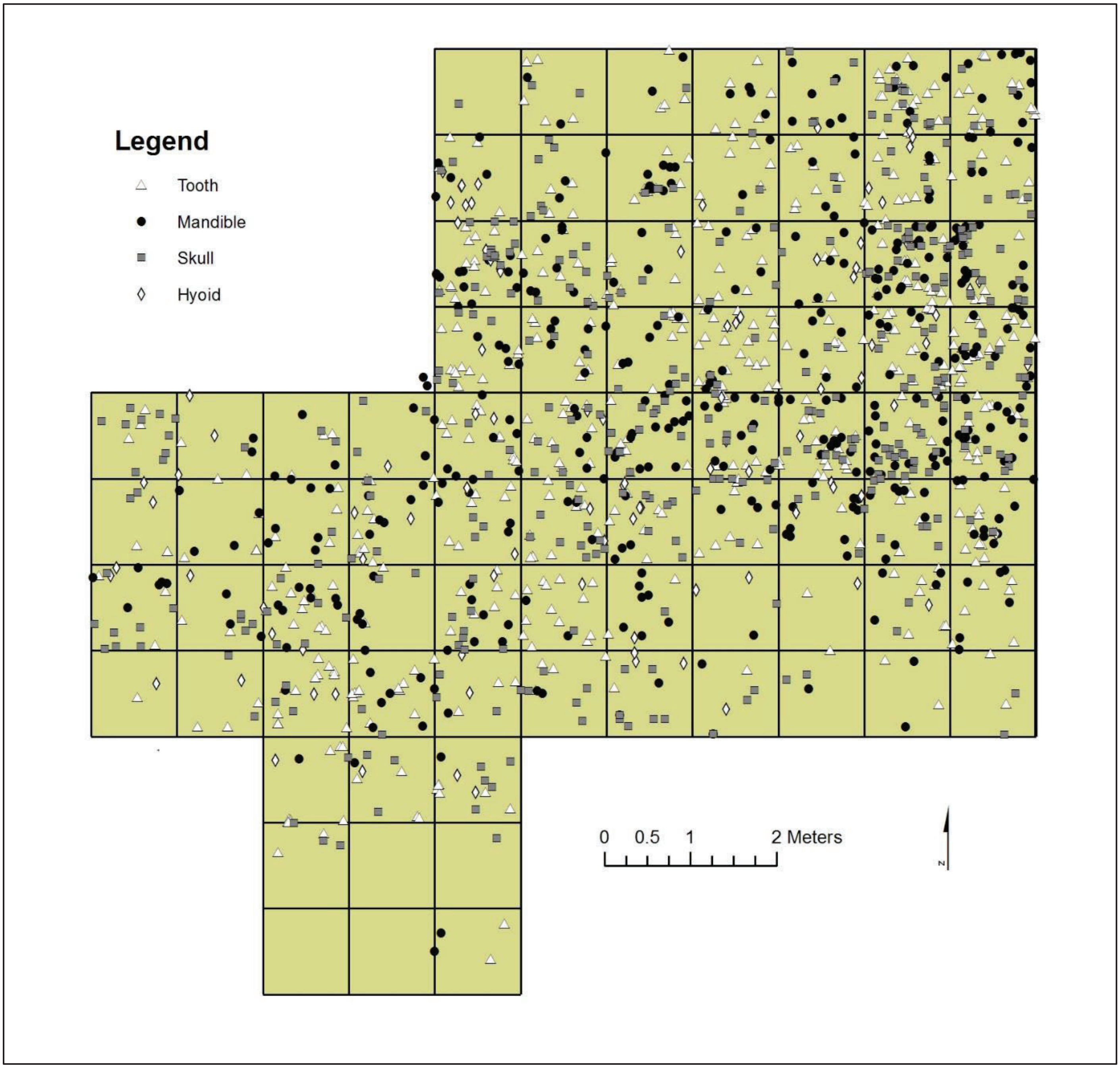

Figure 16: Skull fragment distribution in the East Area of the Fincastle site

Conclusion and Proposals for Future Research

The abundance of mandibles in the Fincastle assemblage, compared to other axial and appendicular elements, indicates a discard strategy similar to carpals and tarsals. The repeated petrous portion fragment appeared anomalous, especially when compared to the relative paucity of other cranial elements. However, the close anatomical positioning of this cranial portion and the mandibles suggests a potential connection between the two. Thus, a purposeful mandible detachment strategy was explored to account for mandible separation because of the lack of cranial elements. The number of coronoid process fragments support the hypothesis that mandibles were being removed in a specific way. The anatomical proximity of the coronoid process to the petrous portion may indicate that a blow delivered to this region, with the intention of detaching the mandible from the cranium, would be sufficient enough to break the petrous portion from the rest of the temporal bone, leading to its detachment from the crania. This can explain the frequency of the petrous portion and mandibles compared to other skull fragments.

The archaeological literature included in this thesis connects the cultural activity of tongue removal to the process of smashing the mandibles on the ascending ramus and cutting the anterior medial side of the mandible. A review of the historical record indicated tongue removal likely occurred through an incision in the throat, not through the mouth. The Fincastle hyoid assemblage has a high degree of fragmentation, which cannot be explained through tongue removal through the mouth as the hyoid is not reachable when cutting the mylohyoid muscle near the dental rows. Therefore, the research presented in this thesis supports the conclusion of tongue removal through the mouth.

This discussion showcases the importance of careful excavation of cranial fragments to better understand the butchering process. The activities discussed in this section are not necessarily the most important part of a bison hunt, but they are a well-documented component. Evaluating the research trends and narratives in the field, examining archaeological evidence, and using detailed data can strengthen conclusions. This chapter set out to determine how these faunal elements are best used to identify cranial and tongue removal activities, but this approach could be used to evaluate hide removal, limb disarticulation, marrow extraction, and grease rendering. Through the careful examination of element portions, supplemented by contextual information provided through anatomical positioning and a comprehensive literature review, a more robust analysis was carried out. The enhanced scope of this research was made possible through the Bone Unit manual and its contribution to zooarchaeological research.

Future researchers should endeavour to use the Bone Unit manual for recording, cataloguing, and disseminating research. It eliminates the hazards of unclear descriptions and allows for researchers to use a consistent method of communication across sites. While the Bone Unit manual was developed for bison studies, many of the same anatomical landmarks are common across animal species, including many of the species found in Great Plains archaeological sites. This resource also allows for ease of quantification, virtually eliminating the need for re-fit analysis, and allows for other researchers to validate the conclusions. It also facilitates ease of quantification across sites, as other researchers can replicate methods for comparing their own assemblages.

Chapter 4: Dentition Analysis and Seasonality Estimate

Determining seasonality has traditionally been done in zooarchaeological bison studies as a way to provide an interpretation for the annual timing of a kill. Seasonality estimates commonly use mandible dentition, specifically the eruption and wear sequence of mandibular molars, to estimate the age of a bison. The age of a bison is tied to seasonality because bison calves are born in the springtime, therefore, their dentition at death corresponds to a season. For example, if a bison mandible was aged at 6 months old, then they would have died in the fall, six months after their birth in the spring. If a bison mandible was aged at 2 years old, they would have died in the spring. This ecological information forms the foundation of the seasonality methodologies developed on the Great Plains.

The large number of mandibles in the Fincastle collection allowed for a robust assessment of seasonality. Four different methodologies, Frison and Reher (1970b), Reher and Frison (1980), Fuller (1959), and Brumley's Tooth Eruption and Wear Sequence (TEWS) (1995), were used to independently determine age of the mandibles based on eruption and wear patterns. Then each specimen was assigned a seasonality based on the age estimate, from either the accompanying reference or determined based on the age estimate. The results of each method were then compared. Hypothetically, the results should be similar because Fincastle has been confidently determined to be a single component kill event; there is no inherent reason for temporal variation in the bone bed that would result in different seasonality estimates.

Mass bison kill events are often linked to a fall seasonality. This idea is heavily influenced by the winter resource acquisition model proposed by Frison and Reher (1970a); large bison kills occurred in the fall as a way to gather resources in order to stockpile for the winter (p. 6). Speth (2017) notes in his overview of communal bison hunting on the Great Plains, that the winter resource acquisition model introduced by Frison, along with the techniques used to examine assemblages, "continue to provide the basic framework for understanding the evolution of communal bison hunting in North America" (p. 531). Therefore, as Fincastle is a mass bison kill site it may reflect this model. The goal of the research presented in this chapter was to assess mandibular molar eruption and wear patterns on the Fincastle mandibles, compare the results to the categories presented in the four different methods, derive seasonality estimates from the age categories provided by the methods, and record any additional patterns noted during the analysis. The overall data generated from the research was then compared to identify trends in mandibular molar eruption and wear sequences, independently of the methods.

Definitions

The mandibles in the Fincastle assemblage were analyzed for both eruption and wear before producing seasonality estimates. There is an important distinction for differentiating between fully erupted and partially erupted molars, which is associated with two different planes or zones in the mouth. The term *alveolar plane* refers to when the tooth erupts from within the mandible and into the mouth, breaking through the bone of the mandible. The term *occlusal plane* refers to when the tooth reaches the same height as the rest of the fully erupted teeth and begins to wear due to mastication. Therefore, a tooth that has erupted but has not been used in mastication has broken the alveolar plane but not the occlusal plane. This is an important distinction for understanding the eruption sequence, as teeth can take several months to move from the alveolar plane to the occlusal plane. During this transitional period, the tooth may be a fraction of the height of the preceding tooth. This information is beneficial for zooarchaeologists to record because it can be used to infer the timing of the eruption schedule.

There are two aspects of bison teeth that allow for eruption and wear studies. First, bison have hypsodont teeth, which are taller than they are wide (Koenigswald 2011, p. 64). Hypsodonty allows for increased wear over the lifespan of the animal, which is seen as an adaptation to abrasive diets and environments; there is more enamel and dentine to wear due to the height of the teeth (Kaiser et al. 2013, p. 34). This feature allows for wear patterns to be identified as it is theorized that teeth wear consistently as the animal ages, thus the amount and location of wear can be associated with an age estimate. Hypsodonty also allows for height measurements of enamel, such as in metaconid height differences, which researchers correlate with age, based on the assumption that bison teeth wear consistently over the lifespan of an individual. Second, bison have a buccal projection of enamel and dentine on mandibular molars that has been referred to as an exostyle, or ectostyle. This stylid is connected at the root-enamel junction, but grows separately from the body of the tooth, often not reaching the occlusal plane until a year or more after the crown. Both the eruption and wear of the stylid is used in conjunction with wear patterns to estimate age. The naming of the stylid is controversial, most archaeologists use exostyle, while few use ectostyle. Zoologists refer to the same projection as ectostylid, and it is unclear where the term exostyle developed (Bärmann & Rössner 2011, p. 765). Due to its prominence in the archaeological literature, exostyle will be used in this thesis. In the future, zooarchaeologists should adopt common terminology and use the terms from zoology to reduce confusion between the disciplines.

Mandibular molars form the majority of this dentition analysis, although there are a few young mandibles in the collection which have a deciduous premolar present. If a deciduous tooth was present, it was indicated by a lowercase *d* immediately before the acronym, *PM* refers to a premolar. Molars are indicated by an *M* with an attached subscript number to indicate either the first, second, or third molar. For example, the dPM_4 indicates the deciduous fourth premolar, and M_3 indicates the permanent mandibular third molar.

Methodology

Mandibles in the Fincastle assemblage were chosen for study based on their corresponding Bone Unit, specifically if they represented at least two teeth, either premolars or molars, in articulation with varying portions of associated mandible. These BUs included BU 01, BU 05, BU 08, BU 10, BU 12, BU 13, BU 14, BU 23, BU 25, BU 26, BU 42, BU 44, BU 48, BU 49, and BU 52; for visual descriptions of a sample of these BUs see Appendix II. A total of 85 mandibles were examined: 81 mandibles were visually examined in the lab and four mandibles were examined based on photographs because these specimens are currently on display at the Royal Alberta Museum (RAM).

Each mandible was assigned an age estimate using Brumley's (1995) Tooth Eruption and Wear Sequence (TEWS) method, Fuller's (1959) method, Frison and Reher's (1970b) method, and their later improved Reher and Frison (1980) method. All four methods were chosen because of their prominence in the field. Reference keys were generated from each methodology, prior to assigning seasonality estimates. This was done to determine ages for each category without unintentionally choosing similar seasons. Information was recorded in tables such as Table 13. The presence of the teeth were denoted with an 'x', and a written description of the cusp and exostyle wear was recorded. These descriptions were most important for Reher and Frison's (1980) and Brumley's (1995) method but served as a source of additional information. Visual descriptors of *light*, *moderate*, and *well* wear were assessed based on visual comparison with the reference keys, most commonly Brumley's (1995) reference. In a case when a single visual descriptor could not be applied, a range was provided (i.e., moderate-well). No measurements were taken. Metaconid heights were only recorded for the M_1 when possible; no bone was removed from the mandible to obtain a measurement. Exostyles were recorded as either *none* when the exostyle was unerupted or not present but the molar was erupted, *present* when the exostyle was erupted but not in wear, *circle* when the enamel was worn exposing dentine but the exostyle was still separate from the molar, and *loop* when the enamel and dentine were extensively worn and incorporated into the molar's wear pattern. Additionally, the exostyles were listed as either *not applicable* when the molar was unerupted, or *unidentifiable* if the tooth was broken or too much plaque covered the tooth preventing a visual examination of the exostyle.

Table 13: Sample mandible data collection form

Mandible#	Incisor 1	Incisor 2	Incisor 3	Canine	Premolar	Premolar	Premolar		Molar 1	Molar 2	Molar 3	*Fuller Age*	5
19311										x	x	*Brumley (TEWS) Age*	19 M_2
								Metaconid Height (mm)				*Frison & Reher 1970b*	4.5
								Cusp Wear		mod	light	*Reher & Frison 1980*	4.5
								Exostyle Wear		circle	none	***Final Age Estimate***	

After the ages of all 85 mandibles were determined using each methodology, they were assigned a seasonality. For Frison and Reher (1970b), all of the mandibles were assigned to fall estimates because their categories are only half year age intervals from the spring birthing season. The Reher and Frison (1980) method used the same foundational principle of age categories based off the spring birthing season as Frison and Reher (1970b) but provided fractional year ranges instead of half year age categories. This required the creation of a calendar breakdown into months and fractional yearly values to link the age estimates to specific months, as this information as not clear from the Vore publication (Tables 14 and 15). After the creation of these tables, the age estimates could be tied to broad seasonality, using the principle that May is spring, and late September to early November is fall. The rest of the seasons were based upon the timing of the solstices and equinoxes for modern seasons. This means that March 1st to May 31st is spring, June 1st to August 31st is summer, September 1st to November 30th is fall, and December 1st to February 28th/29th is winter. Therefore, if a mandible was determined to be 2.1 years of age, it was assigned to a summer death.

Brumley's (1995) method was the only method that tied age estimates to specific calendar dates, but it lacked the accompanying season. Tables 14 and 15 were instrumental in tying age and seasonality estimates together for this method. Each mandible was assessed a Brumley category, then each category was correlated to an age estimate in days, along with a date and month estimate using the calendar tables at the end of the booklet. If possible, a precise age in days was assessed, or a range was given of the two closest estimates. For example, if a Brumley Category 5 was assigned for the M_2, then the age estimate was 476 days, or a September 3rd death. The date of death values were largely ignored because these were based off the assumption of a May 15th birthing peak. In order to compare data sets, it was deemed more beneficial to compare the age ranges than the specific dates. The age estimate in days had to be turned into a monthly estimate, so each value was divided by 30 days to return a monthly value. The age in months was then compared to Table 14, and the monthly column the value fell under was assigned as the seasonality estimate. There was no information on seasonality estimates for Fuller (1959), so it was not included in this section of the analysis.

Therefore, the age and seasonality estimates were completed independently of each other, which would either corroborate the final season estimates of each methodology or demonstrate the inconsistencies when generating estimates. In theory, the four methodologies should support the same seasonality conclusion because Fincastle is a single component kill; there is no supporting evidence of multiple occupations. Ideally, the methods will confirm a single seasonality inherent in a single occupation event, and thereby demonstrate they can provide reliable seasonality estimates. Alternatively, they will demonstrate the need for further research concerning bison dentition studies. The four methods will be discussed in detail below.

Table 14: Age in months calendar breakdown

Age in Months	May	June	July	August	September	October	November	December	January	February	March	April
	0-0.24			0.24-0.49			0.5-0.74			0.75-0.99		
	1	2	3	4	5	6	7	8	9	10	11	12
	13	14	15	16	17	18	19	20	21	22	23	24
	25	26	27	28	29	30	31	32	33	34	35	36
	37	38	39	40	41	42	43	44	45	46	47	48

Table 15: Age in years calendar breakdown

Age in Years	May	June	July	August	September	October	November	December	January	February	March	April
	0-0.24			0.25-0.49			0.5-0.74			0.75-0.99		
	1	1.08	1.17	1.25	1.33	1.42	1.5	1.58	1.67	1.75	1.83	1.92
	2	2.08	2.17	2.25	2.33	2.42	2.5	2.58	2.67	2.75	2.83	2.92
	3	3.08	3.17	3.25	3.33	3.42	3.5	3.58	3.67	3.75	3.83	3.92
	4	4.08	4.17	4.25	4.33	4.42	4.5	4.58	4.67	4.75	4.83	4.92

Fuller (1959)

Fuller (1959) examined approximately 1,800 modern bison jaws from Wood Buffalo National Park in northern Alberta and the Northwest Territories (p. 342). Table 16 lists the ten age categories he created for assessing bison age. Seven of the categories provide discrete age estimates in months based on eruption and three provide broad age estimates based on the amount of mandibular wear. Fuller's method is useful albeit limited because it lacks the level of detail the other methods have. A potential issue with using modern bison for interpreting archaeological age is the differences within species over time, as well as differing environments and available food. It is important to note, that wood bison (*Bison bison athabascae*) form the sample for this method, which is a different species than plains bison (*Bison bison bison*). The differences between the two species is minimal, but since Fuller's method is used for comparing archaeological to modern populations the species distinction may be relevant. If the other methods corroborate Fuller's sequence, then it seems likely that bison eruption followed a predictable pattern regardless of the geographic location and time.

Fuller only provided an age estimate and not a seasonality. All of the animals included in this study were found deceased during the summer months, which the researcher implies confirms season of death, or killed during the annual reduction slaughters held in mid-winter (p. 342). Further, there are descriptions for the youngest age categories when the eruption sequence is occurring, but age estimates beyond 4 years of age is limited to only young adult, adult, and old based on wear (Table 16). Fuller includes wear patterns from the exostyle but refers to it as a style.

Table 16: Fuller (1959) age reference key

Fuller (1959) Dentition Criteria	
Birth	All deciduous
3mo.	anterior cusp of M_1 erupts
9-12mo.	posterior cusps of M_1 erupts
2y.	M_2 erupting to fully grown
3y.	deciduous Incisor 1 & 2 replaced; dPM 2 & 3 replaced; M_3 erupts (third cusp has no wear)
4y.	deciduous Incisor 3 and deciduous Canine replaced; M_3 cusp starts to wear; M_1 exostyle is a circle
5y.	M_2 circle; M_3 no wear
Young Adult	M_1, M_2, and M_3 exostyle circle
Adult	M_1 and M_2 loops; M_3 circle
Old	M_3 loop

Frison and Reher (1970b)

Frison and Reher's (1970a, 1970b) seminal work at the Glenrock Bison drive and jump represents one of the most widely cited pieces of literature for bison aging and mandible studies. Frison and Reher compared the Glenrock mandible assemblage to modern bison specimens and archaeological samples of relatively known age. They created half-year age categories based on the similarity between the reference material and the Glenrock assemblage. Frison and Reher state that if the spring birthing season is correct, and the hunt occurred in late September to early November, then all the animals will cluster in half year age intervals (Frison and Reher 1970b, p. 46).

The age categories described in this method ranged from 0.5 to 4.5 years of age, similar to Fuller (1959), but introduced two new age categories of 5.5 to 9.5 years, and 10.5 to 13.5 years based on the amount of wear identified on the teeth (Table 17). It is interesting to note that although seasonality estimates are more difficult on adult individuals because assessing level of wear compared to eruption schedules is more subjective, the authors created half-year age categories which aligned with their younger age categories in estimating a fall kill. Nevertheless, this method will have a limited resolution for estimating specific ages beyond half year age intervals.

Table 17: Frison and Reher (1970b) age reference key

Frison and Reher (1970) Glenrock Dentition Criteria	
0.5mo.	dPM 2 & 3 mod-well worn; dPM$_4$ mod worn; M$_1$ erupted but not to occlusal plane
1.5y.	dPM 2 & 3 & 4 well worn; M$_1$ mod worn; M$_2$ unworn or not fully erupted
2.5y.	dPM 2 & 3 & 4 extreme worn; M$_1$ & M$_2$ mod to well worn' M$_3$ 1st and 2nd cusps erupted but not 3rd cusp
3.5y.	M$_1$ & M$_2$ well worn; M$_3$ third cusp erupted but not worn
4.5y.	M$_1$ & M$_2$ well worn; M$_3$ slight wear but exostyle unworn
5.5-9.5y.	M$_3$ worn, all teeth in regular use
10.5-13.5y	M$_1$ anterior fossa obliterated, worn into roots, posterior fossa also absent

Reher and Frison (1980)

Improving upon their work at Glenrock, Reher and Frison (1980) refined their dentition aging methodology with an assemblage from the Vore Buffalo Jump. From this assemblage, age categories were created that reflected increased temporal resolution than solely half year intervals. This method provided more data for the eruption sequence and resulted in the creation of a reference key which provided specifics of when particular cusps were erupting and wearing (Table 18). Seasonality is implied in the age estimate using the assumption of a stable May birthing month. This necessitated understanding the breakdown of age estimates over the course of the year. For this purpose, Tables 14 and 15 are used throughout this mandible analysis to clearly break down the association between ages, their corresponding months, and assigned seasonality.

Reher and Frison (1980) added more detail about the eruption schedule and wear patterns to their pioneering dentition study to provide more variability in age assessments. They also introduced the category of *Indeterminate* for animals that were too old to provide a reliable estimate, and scrapped the older age categories, only providing details for animals up until 4.5 years of age. By focusing on the younger individuals, a more accurate estimate can be calculated because morphological changes occur more rapidly and can be tracked with more precision than imprecise wear patterns. The difficulties in assigning fractional year ages occurs because growth by month is not discernable and there is overlap between months and seasons. As an example, it is assumed a birthing season begins on May 1st, and at the beginning of every new month animals become a new age. This is why an age of 1.92 years of age is recorded for April 1st, on April 30th the animal is 1.99 years of age, and becomes 2 years of age on May 1st. The ambiguity in fractional year estimates is concerning because without consensus amongst researchers, seasonality estimates may vary widely. For example, a bison that is aged to 1.8-2.3 years of age ranges from February to August for seasonality, if the values are rounded, which represents three different seasons (early spring to early fall based off of Table 15). For an animal 2.2 – 2.5 years of age, a seasonality estimate of July to November represents two different seasons, even though the age estimate is much narrower. Thus, age windows assume a start age value and seasonality estimates should take this into account. Lack of clarity hinders both age and seasonality estimates; greater resolution will lead to better interpretations of the past. However, one must also recognize that the formulaic calculations may not be possible if growth stages are not separable or have too much overlap, therefore morphological changes must be used to identify age categories.

Table 18: Reher and Frison (1980) age reference key

Reher and Frison (1980) Vore Dentition Criteria	
Birth	All deciduous
0.1-0.2y	M_1 begins to erupt
1.1-1.3y	Incisor 1 erupts; M_2 erupts
1.5y.	M_1 fully erupted with slight wear on anterior cusps (I & II)
1.8y.	M_1 wear on facets III-VIII
2.1-2.3y	Incisor 2 erupts; M_3 first cusp
2.3-2.8y.	PM 2 & 3 erupt; M_3 first two cusps are well erupted, light wear on facets I-II, third cusp is absent
2.8-3.2y.	PM_4 erupt; M_3 third cusp erupts with slight wear beginning across anterior cusps (II-IV)
3.1-3.3y.	Incisor 3 erupts
3.5y.	M_3 third cusp fully erupted but never worn, wear has progressed to IV, with light wear on VI-VIII
4.1-4.3y.	Incisor 4 erupts; M_3 wearing on facets I-VIII
4.5y.	M_3 wear on facets IX and IX'

Brumley's (1995) Tooth Eruption and Wear Sequence (TEWS)

The last methodology used in this analysis was created by Brumley (1995) as a visual comparison for wear patterns. The reference key was created from archaeological sites in the Northwestern Great Plains and used modern birthing seasons as an analogy. It is the most comprehensive of the dentition methodologies, as it provides specific months and days as seasonality estimates. Normally, these can only be applied as a range because the older the animal the sparser the estimates, although for younger animals the estimate is more discrete. The visual reference key is included as Appendix I.

Each of the (d)PM$_4$, M$_1$, M$_2$, and M$_3$ have their own columns with illustrations of progressing wear. If more than one tooth is present in the mandible, then all of the teeth are assigned an age category. Using the example provided in Appendix I, the tooth (M$_2$) and its associated category (19) are then used in the calendar chart to provide an age estimate. In this example, the age estimate would be older than 715 days, or older than 2 years of age. If all of the teeth present are in wear, then the age range provided by the youngest and oldest tooth are recorded. If there is more than one tooth present, and one of them has yet to reach the occlusal plane, then the age is recorded for that tooth. This is because it is more likely to experience less variation in the eruption sequence than the wear patterns.

Applying the Four Methods

Every effort was made to follow the four methods above using the provided age categories; however, there were times when the dentition did not match any of the categories. In these scenarios they were assigned a half category between the two categories the tooth most closely matched; the age was then given as a range. Each mandible was assigned to the youngest age category provided based on the least amount of wear, the exostyle being unworn, or an unerupted tooth. This was done to correct for potential over-wear problems when teeth were extensively worn and inaccurately reflected the overall eruption sequence. Therefore, no individual teeth were included in this study because of the inability to confirm the eruption sequence from surrounding teeth.

Example of Age Estimate

This section explains how results were derived for Mandible 7737 to clarify how the four different methods were used to assess age and estimate seasonality in this research (Figure 18). Information was recorded on a blank version of Table 13, with printout copies of the four age reference keys. First, the presence of each tooth was recorded. For this mandible, 7737, all teeth are present, including the dPM_4. Then, the metaconid height was measured on the M_1 if all the enamel was available for measuring. If the enamel extended below the bone, it was not measured. Next, the cusp wear was recorded for each molar, using the visual descriptions detailed in the Brumley method. Lastly, the presence or wear of the exostyle was recorded for each tooth, following the categories described in the definition section.

Mandible 7737 was then assigned an age for each method using the corresponding reference key. Using the Fuller (1959) method produced an estimate of 3 years of age because the dPM_2 and dPM_3 have been replaced, and the M_3 is half erupted, with the third cusp barely at the alveolar plane. It was not assigned two years of age because the M_2 is fully grown, or four years of age because the M_1 exostyle has not yet reached the occlusal plane and started to wear.

Using the TEWS method, Mandible 7737 was assigned an age category of 4 M_3 because the M_3 is half erupted and has no wear. The eruption sequence was preferred over the wear patterns when possible because visual assessment may be subject to more inter-analyst variation. This provided an age estimate of 781-913 days, or 2.2 to 2.5 years of age.

Using Frison and Reher’s (1970b) method, Mandible 7737 was assessed 2.5 years of age because the dPM_4 is extremely worn, the M_1 has light to moderate wear, the M_2 has light wear, and the M_3 is half erupted. It was not assigned to 1.5 years of age because the M_2 is fully erupted with light wear, and not to 3.5 years of age because the M_2 is not well worn and the M_3 third cusp has just broken the alveolar plane.

Applying Reher and Frison's (1980) method yielded 2.8 to 3.2 years of age because the PM_4 has broken the alveolar plane and is pushing out the dPM_4, and the M_3 third cusp has broken the alveolar plane. It was not assigned to 2.3 to 2.8 years of age because the M_3 third cusp is present, not to 3.1-3.3 years of age because there is no incisor to evaluate, nor to 3.5 years of age because the M_3 has not fully erupted and reached the occlusal plane.

Finally, each age estimate was assigned a seasonality. Fuller's aging method could not be used to estimate seasonality because the method does not include seasonality information. The age result of 2.2 to 2.5 years of age when Brumley's (1995) method was applied corresponded to a summer to fall kill based off the yearly breakdown in Table 15. Frison and Reher's (1970b) method assessed Mandible 7737 to an age of 2.5 years of age. Using the seasonality information provided in the method, the mandible was estimated to a fall kill. Reher and Frison's (1980) method derived an estimate of 2.8 to 3.2 years, which correlated with a winter to summer estimate based on the yearly breakdown provided in Table 15. The results generated from each individual method were recorded, to compare the different methods for trends in seasonality.

Then the results from each method were aggregated to produce a final age estimate. The final age estimate was recorded as 2.2 to 2.8 years of age, derived from the four methods. It was not recorded as 2.2 to 3.2 years of age because this would represent a season of death in any time of the year and three out of the four methods predominantly estimated an animal 2 years of age. The inclusion of the lower range provided by Reher and Frison (1980) was deemed sufficient for this analysis. Then the cumulative age was used to assess seasonality, which produced a winter to summer estimate. The cumulative data was used to assess trends when the four methods were aggregated together.

Figure 17: Buccal view of mandible 7737

Fincastle Evidence

A total of 85 mandibles were analyzed, including mandibles uncovered in Features. Mandibles were distributed throughout the site, with no clear pattern of discard (Figure 16). Most of the mandibles had excellent preservation; teeth were often in articulation with bone and other teeth. This allowed for a detailed analysis of the eruption and wear patterns. For example, Mandible 15325 (Figure 18) has the M_3 still developing within the bone. The eruption context provided by this mandible is helpful in determining when the M_3 erupts compared to the M_2. A high degree of fragmentation, as a result of cultural activity, or poor preservation from taphonomic processes, would make this information more difficult to assess.

The high quantification values calculated for the mandibles indicate their relative abundance at the site compared to other axial and appendicular elements. The MNI of 69 (%MNI 87%) compared to the astragalus of 79 (%MNI 100%) indicates that of all the animals estimated to be represented at the site, a similar number of mandibles were recovered. This may indicate that most of the mandibles from the animals were discarded, signifying the comprehensive nature of the seasonality estimate: almost all the calculated animals were used to estimate seasonality.

Figure 18: Lingual view of mandible 15325

There are clear differences in the results when applying each of the four methods. The Brumley (1995) method provided the most indeterminate estimates (Figure 19). All methods skewed results towards older individuals, especially the Frison and Reher methods. Fuller's method placed animals largely in the 4 to 5 years and older categories, inclusive of young adult, adult, and old. There is a noticeable peak estimate provided by three of the methods for animals 4.5 to 5 years of age, which is unmatched by Brumley's (1995) method. No animals in a discrete age estimate older than 2.5 years of age were identified using Brumley's (1995) method. This is because the method does not detail age information for animals beyond 2.5 years of age. These age estimates were considered as indeterminate because there is no other information to narrow down the range; there is no way to conclude whether the animal is 3 years of age or 6 years of age from that estimate. However, Brumley's (1995) method provided more discrete ages for bison under 2 years, including two animals that were 0.3 years old. This would imply a seasonality event of late August (Table 15). The three other methodologies lacked this resolution and could only provide an estimate of one year.

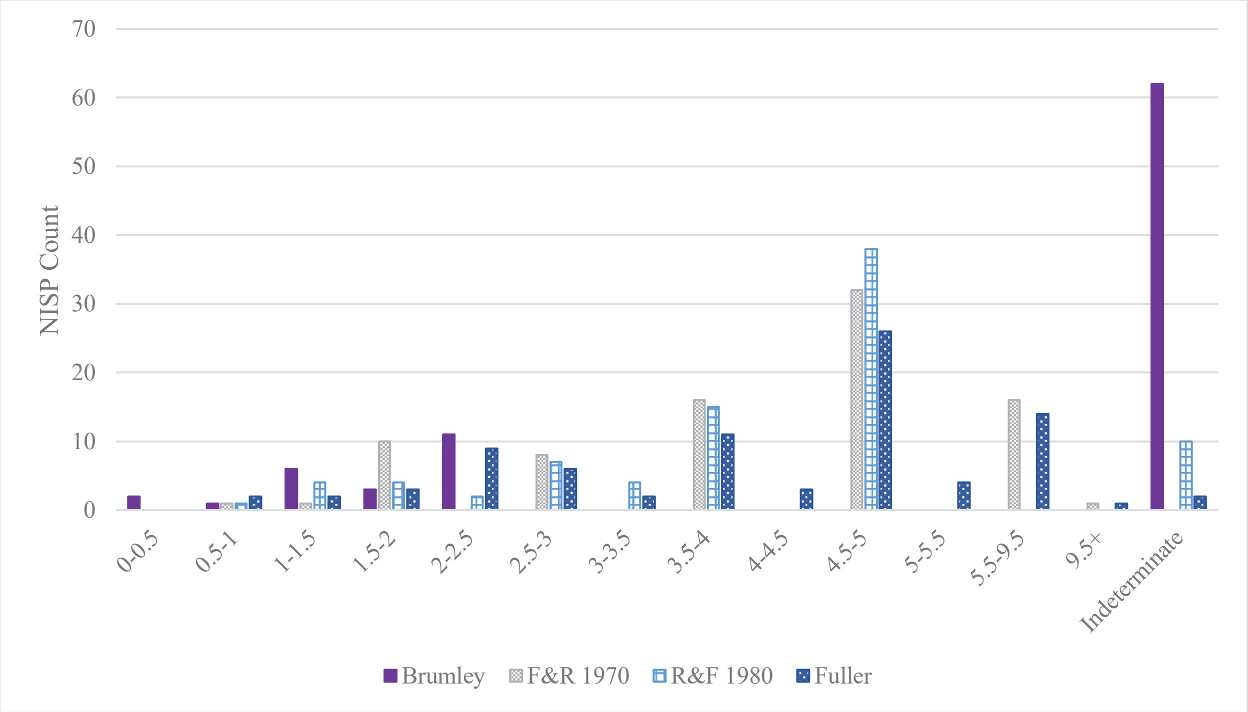

Figure 19: Mandible age estimate results by method

Brumley's (1995) method suffered from the inability to precisely assign age estimates for animals older than several years. For example, if an M_2 was estimated to be older than 2 years but the M_3 is younger than 4.5 years, the lack of age ranges provided by the methods did not allow a more accurate estimate. This hinders the seasonality estimate because of the imprecise age ranges; a two-and-a-half-year age range covers every season for multiple years. For this reason, these ages were recorded as indeterminate. The Brumley (1995) method provided a peak age estimate of 2 to 2.5 years of age and indeterminate age. The seasonality estimate provided by the Brumley (1995) method denotes a summer to fall kill, with the highest proportions of useable estimates represented by these seasons.

Both of Frison and Reher's methods provided age estimates for mandibles largely in the 3.5 to 4.5 age categories, which is matched by the estimates provided through using Fuller's method. This is partially due to the lack of detail in the eruption sequence, especially concerning the M_3. Both methods place the M_3 as erupting over at least two years, with little and extensive wear. This encompasses a wide variety of teeth, and it seems likely that this method is accounting for more tooth eruption variability than is realistic. For example, the Frison and Reher (1970b) method has the M_3 erupting at 3.5 years, partially worn at 4.5 years, and in total wear between 5.5 to 9.5 years of age. There is no further detail or data on the amount of wear to expect. The exostyle is suggested as an additional line of evidence, but without further information for when the exostyle erupts or how fast it wears, this is too broad a category to provide specifics. The authors do not elaborate on the wear pattern on the exostyle, which prevents corroboration between cusp and exostyle wear.

Similarly, the Fuller method also placed the majority of the mandibles into this category, but it suffers from the same issues as Frison and Reher's methodology. Fuller has the M_3 erupting in the third year, with the cusps beginning to wear in the fourth year, and little difference between young adults and adults based on the exostyle wear. The difference between five years of age and young adults in this method is the level of wear on the M_3 exostyle. In the young adult category, all of the exostyles are worn to a circle, which was already apparent in the

4-year category for the M_1 and 5-year category for the M_2. It seems unlikely that the M_1 and M_2 would have stable or minimal amounts of wear for several years while the M_3 cusp and exostyle continued to wear.

Further, these methods largely produced fall seasonality estimates. As demonstrated by Figures 19 and 20, the methods overwhelmingly supported a fall seasonality. Since Frison and Reher (1970b) estimated only fall kill events, which is a product of their age categories only having half-year age intervals, these age divisions impact the Fincastle results. There were two mandibles that could not be tied to a specific age category using the 1970 method. However, because they did not represent the subsequent category, a half category was created and the age estimate was recorded as a range which extended the seasonality estimate to spring. The seasonality estimate was not extended to winter or summer because the seasonality estimate of fall to spring represents half a year, without encroaching on the next age category. The seasonality estimates of these mandibles appear on Figure 19 as the two animals estimated to represent a fall to spring season of death using the Frison and Reher (1970b) method.

The results from Frison and Reher's (1970b) method differ from the other methodologies, which provided shorter age categories and variable seasonality estimates. For example, Reher and Frison's (1980) method provided age categories of 2.8 to 3.2 years of age, which correspond to a winter to summer seasonality. Brumley's (1995) method provided the most variation in the seasonality estimate, ranging from spring and summer to winter. As the TEWS method worked on individuals younger than 2.5 years of age, the variation in the seasonality estimates implies animals of varying ages, instead of discrete clusters. However, the methods predominantly produced results supporting a fall kill event. Even when there is concession for a summer to fall or a fall to winter seasonality, the methods produced fall seasonality estimates. The question then arises, what if the Fincastle site is a fall kill event? What if the methods are correct in assigning ages, and produce a consistent seasonality estimate? In order to better understand the connection between the age estimate and the overall seasonality conclusion, the eruption and wear patterns of the molars and exostyles were examined on the Fincastle mandibles. This was done to understand patterns identified in the morphological changes that appeared during the mandibular analysis, and to better understand the variation unaccounted for by the four methods.

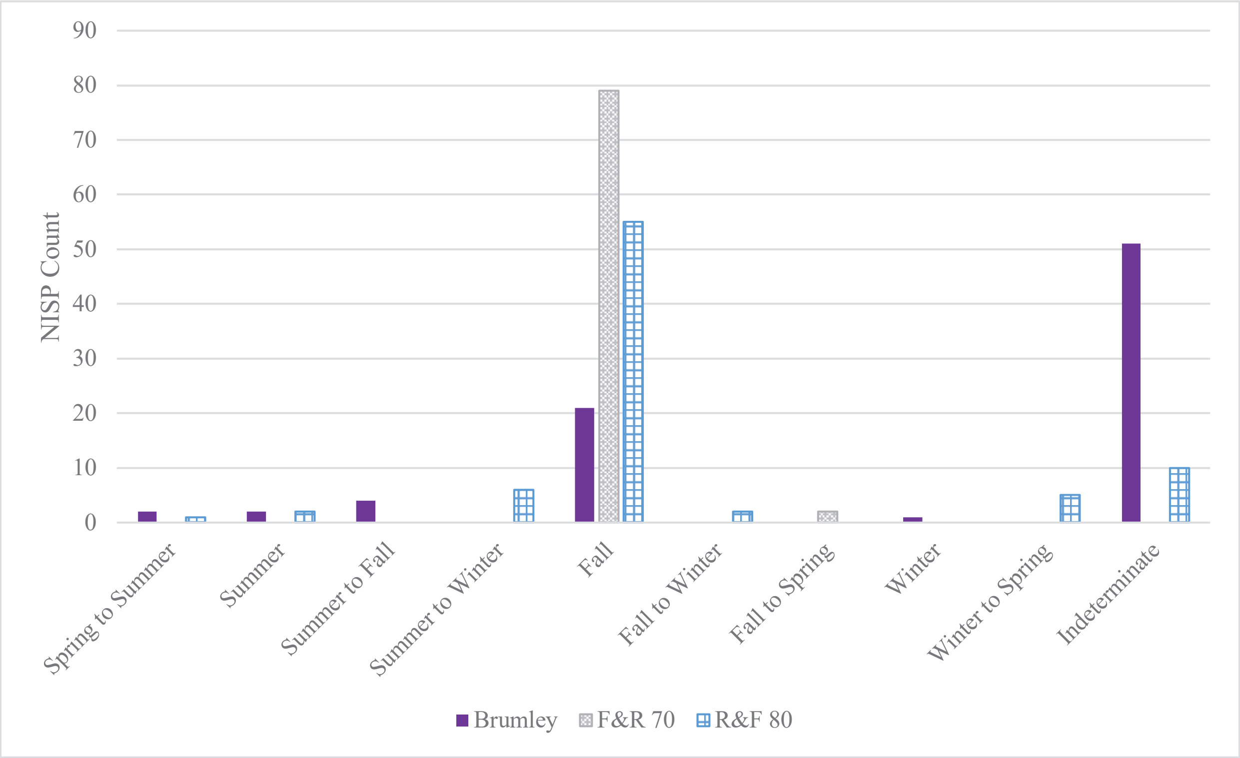

Figure 20: Seasonality estimate results by method

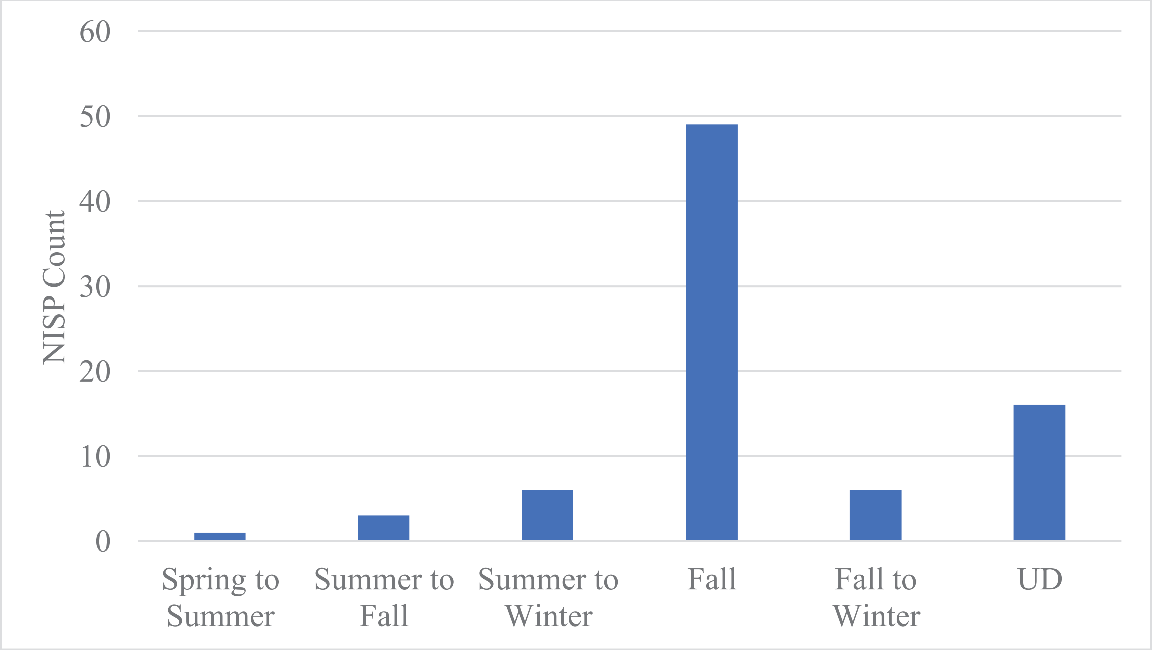

Figure 21: Cumulative seasonality estimate frequency

Cusp Eruption and Wear

To assess cusp wear patterns by year, each mandible was assigned a year of life regardless of seasonality for three reasons. First, mandibles were assigned yearly age categories, to standardize the age estimates that spanned several months. For example, mandibles that were assessed an age of 2.2 to 2.8 are combined into the same category (Year 3). Second, yearly categories follow the format of Fuller (1959) and Frison and Reher (1970b). Instead of representing half year age intervals, the categories reflect yearly cycles. Lastly, using yearly time frames to assess morphological changes is theoretically independent of seasonality, because it does not matter when the year starts. The age estimates in the following graphs are not tied to a seasonality estimate, therefore, only eruption and wear are examined. This was done to identify patterns in the eruption and wear sequence that could be tied to yearly estimates. The goal of this comparison is to identify broad patterns in eruption and wear sequences, that could not be identified when using the age reference keys. As an example, the timing of the M_3 eruption appears to span two years, as seen in Figure 22. Using the age reference key from Frison and Reher (1970b) the M_3 begins to erupt at 2.5 years of age (year 3 in the graph). Similarly, Reher and Frison (1980) indicate the M_3 begins to erupt between 2.1 and 2.3 years of age (Year 3 in the graph). However, the mandibles in the Fincastle assemblage show the M_3 erupts in both Year 2 and 3, providing evidence the M_3 erupts earlier than the two prior methods described. This section is used to describe the patterns seen in the Fincastle assemblage that may not match the eruption and wear schedules described in the four methods.

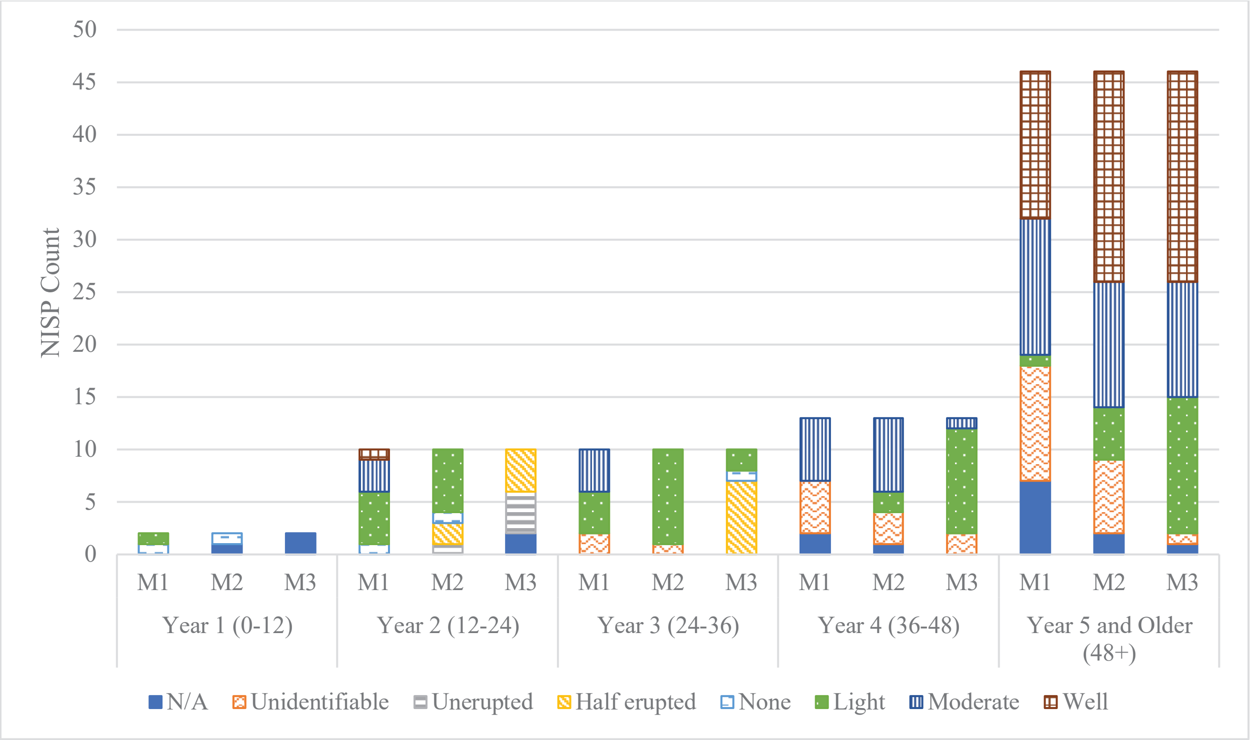

Figure 22: Cusp wear patterns by year

From Figure 22, it is difficult to assess specific trends that could reliably produce accurate age estimates. There is identifiable variation for every single molar in every year of life; there is not a single consistent wear or eruption pattern. Of concern is the M_1 in Year Two, which exhibits a well-worn cusp but based on the context of the half erupted M_2, it is a young individual (Figure 23). This serves as reminder for caution when assessing age on isolated teeth, as potential reasons for over-wear is an issue deserving further research. According to Frison and Reher (1970b), the M_2 is half erupted or has no wear at 1.5 years of age (Year 2) and is moderately to well worn at 2.5 years of age (Year 3). Unfortunately, the M_2 is barely discussed in Reher and Frison (1980) and Fuller (1959). The Fincastle mandibles demonstrate that the M_2 erupts during Year 2 of life, corroborating the eruption estimate from Glenrock, but the wear pattern contradicts the subsequent age category. The M_2s predominantly exhibit light wear, not moderate to well worn. Similarly, the M_1 is only well worn in Year 5, or older than four years of age. This differs from Frison and Reher (1970b) which has the M_1 well worn as early as 2.5 years of age, and then in all subsequent categories. According to Reher and Frison (1980) the M_1 evidenced wear on all cusps as early as 1.8 years of age, and then little further information is provided. This is another potential difference identified in the Fincastle mandible assemblage that does not match the four methods.

Of further interest is the variability in older age groups; it appears there are clusters of wear patterns, but without a reference collection of known age there is no way to assign an age to these animals beyond 48 months. Eruption patterns have been considered the more reliable method of assessing age because of the assumption that eruption follows a predictable pattern. This is the reason Frison and Reher (1970b) suggested using juvenile specimens because of their eruption schedule reliability (p. 46). However, this analysis has demonstrated there is potential variation in the M_3 eruption schedule. Additionally, while the Fincastle mandible collection is not small, it is not very large either. More evidence from further excavation, or analysis of other sites to identify eruption and wear sequences would be useful for identifying additional eruption and wear trends.

Exostyle Eruption and Wear

The exostyle, or ectostyle, has been suggested as an additional line of evidence for corroborating between eruption stages and wear. However, there is minimal research on when the exostyle reaches both the alveolar and occlusal plane for any of the molars. In the age reference keys used in each of the four methods, the exostyle is mentioned in all the descriptions, although only Fuller (1959) provides yearly age estimates for the eruption and wear. If further research is amassed from modern bison and aggregated across archaeological sites, the exostyle may serve as further evidence for age estimates. However, until there is more information on the development of the exostyle, when it erupts, and when it reaches the occlusal plane, it cannot reliably be used to assess age.

For example, mandible 6482 (Figure 23) is at the very top end of the age range for this eruption sequence. This is in large part due to the M_1 having extensive wear and its exostyle being worn to a loop, while the majority of the other exostyles are not present or are present and have no wear. The advanced age of this wear pattern is interesting because if this was a tooth found in isolation it would be attributed to a much older and advanced age (4.5+), but because it was found in the dental row with a dPM_4 and a half erupted M_3, it is attributed a much younger age (2.3 to 2.8 years). This may lead one to question if the exostyles themselves are unreliable for age estimation.

Figure 23: Lingual view of mandible 6482

Comparable to the cusp wear analysis prior, there is minimal consistency amongst each age year and the eruption and wear of the exostyle (Figure 24). The only categories that are consistent is the M_3 in Year One because the M_3 is unerupted, and the M_3 exostyle does not appear to erupt until older than four years of age. To highlight an example, the M_1 in Year 2 has the exostyle worn to a loop, a circle, present at the occlusal plane and unerupted. The same pattern is identified in ear 4, when the exostyle is worn to both a circle and a loop. Fuller (1959) identifies the M_1 exostyle as worn to a circle in year four; however, the Fincastle mandibles with exostyles have more loops than circles. Of the 46 mandibles that were assigned to be older than 48 months, only one M_3 had an exostyle worn to a loop. This would likely indicate a very advanced age, as it is evident it takes years beyond when the M_3 has erupted for the exostyle to reach the occlusal plane. Therefore, only after this point can the exostyle begin to wear, and as bison have hypsodont teeth, this would likely take a significant amount of time. This indicates the possibility that the exostyle could be used as an age indicator for older bison populations; however, without the use of a modern reference collection to provide accurate ages for when this occurs, it is of little value currently for assessing age estimates.

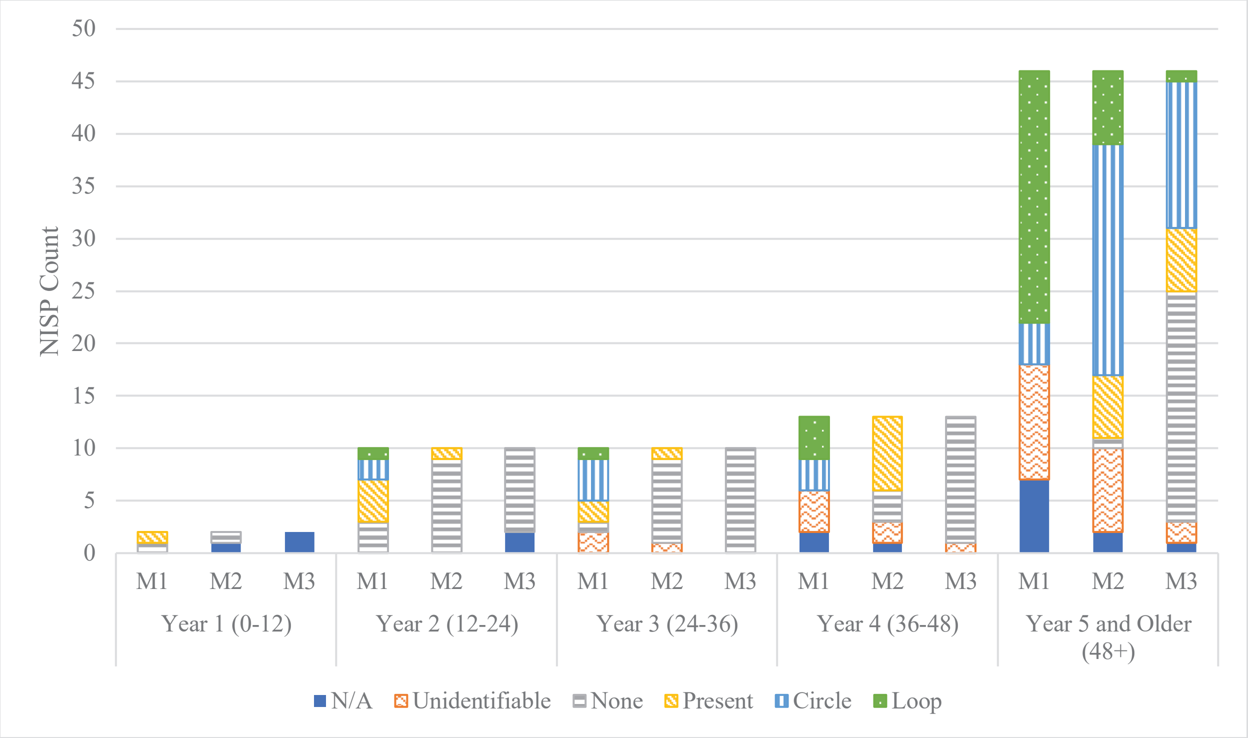

Figure 24: Exostyle eruption and wear patterns by year

Summary of Results

The research goal outlined at the beginning of this chapter was to assess the mandibular eruption and wear patterns of the Fincastle assemblage and assign the specimens to the age categories detailed in the four methods. This chapter has demonstrated that while there is consensus for aging some morphological changes, there was variation in the Fincastle molars that were not matched by the methods. The seasonality estimates largely produced a fall kill event; however, there was some variation presented by the Reher and Frison (1980) and TEWS methods. Brumley's (1995) method produced seasonality estimates which ranged from spring to summer to solely winter events, which does not match the fall seasonality. Additionally, Reher and Frison's (1980) method produced an estimate for winter to spring, which is beyond the fall seasonality window. The variation in these estimates cannot be corroborated by early or late births because they are not centered around the fall season. There is a disconnect between the dentition morphologies identified in the age estimates and the corresponding seasonality, because there is no reason that a single component kill event with predominantly fall kill evidence should produce a seasonality estimate for spring to summer. The potential concerns arising from this research is either the homogenization of eruption and wear patterns to present a single age category, or insufficient information represented in the age categories to estimate varying ages. Many of the same concerns identified during the course of this research were detected by researchers 20 years ago (Whittaker and Enloe 2000), but little has been done to remedy the issues. Primarily, there is not enough connection between the archaeological samples that form the foundations of these analyses, and modern bison reference collections of known age. Brumley (2007) conceded that, "a full description, analysis and report of modern known age bison mandibles … does not exist," and the creation of reference collection was long overdue (p. 15). Rigorous work needs to be done in this field to generate more information on the eruption and wear sequences. This includes the widespread analysis of archaeological and modern samples to develop detailed and comprehensive understandings of dental morphological changes.

Archaeologists using these methods, especially Frison and Reher's (1970b), have routinely produced fall seasonality estimates which has shaped the foundation of our understanding of prehistoric Indigenous lifeways. The implication of using a method which has only half year age intervals, or estimating a fall seasonality without accounting for variation, perpetuates the continued use of the winter resource acquisition model. This research has demonstrated that there is a disconnect between some of the age categories and the corresponding seasonality estimates. As the majority of the dentition methods discussed in this chapter were influenced by processualist approaches, the next section will contextualize the potential theoretical influences inherent in the methods because of the time period they were developed in. This section is used to explore the reasons why mass bison kill events happened, either in the fall or other times of the year.

Theoretical Influences and Thoughts on Seasonality

Frison and Reher (1970a, 1970b) and Reher and Frison (1980) developed their dentition methods at a time when archaeology was dominated by processualist theory. Processual archaeology emphasizes understanding why cultures change, viewing culture as a process (Praetzellis 2015). One of the most prominent theories developed during this time period is optimal foraging theory; the process, as identified by Praetzellis, is how hunters choose to pursue animals. This theory was popularized by Binford's (1980) study of Nunamiut in Alaska and Winterhalder's (1981) study of Cree hunters in Northern Ontario. Winterhalder (1981) recorded that the Cree hunters made choices during the hunt by deciding to pursue animals that yielded the most caloric return for the least energy expenditure. This example of optimal foraging theory presents humans as logical decision makers, who solely make subsistence decisions based on caloric interests.

This theory draws many parallels to the narrative of winter resource acquisition by way of fall bison kill events on the Great Plains. Frison first introduced this theory to the Great Plains zooarchaeological literature as way to make sense of the mass bison bone beds at the Glenrock, Ruby, and Vore sites. Frison and Reher (1970a) explain that mass kill events in the spring and summer months were not, "economically advantageous," because groups dispersed into single or small families to, "better exploit the environment" (p. 5). However, it was advantageous to convene large groups in the fall for a mass bison kill event because, "there were many periods of time of a week or more, during the winter on the Northwestern Plains, when weather conditions made hunting difficult if not impossible and some sort of storage was necessary to provide food during these times" (p. 6). As summarised by Speth (2017), "because of the severity of Northern Plains winters, Indians timed their hunting activity so that it occurred in late fall or early winter," to provide them with the necessary meat and hides to survive (p. 531). This theory is widely accepted as an explanation for mass bison kill events on the Northern Plains. Few alternative explanations for these expansive bonebeds are provided. This winter resource acquisition model implies prehistoric Indigenous populations interacted with bison as optimal foragers with limited options for surviving the harsh winters. Furthermore, optimal foraging theory implies human hunters make choices that only ensure their survival, without influence from cultural choices (Ingold, 2000, p. 31).

Ingold (2000) explores the difference between optimal foragers, who unintentionally act in their own self interest without cultural influence, and enskilled individuals who act in their own self-interest but are able to make choices that actively reflect the constraints of their environment. The difference, although it appears minute, is very important. Using the winter resource acquisition model, Indigenous hunters must successfully kill bison en masse in the fall otherwise they will not survive the winter. This choice is not intentionally made by the humans; rather it is viewed as an adaptation conditioned by their environment. The hunters unintentionally choose this time of the year because it ensures their survival in the harsh winter months, leaving little room for variation. Under this model, mass bison kill events would not make sense in the summer months, because there are no external pressures on hunting decisions. However, using the theory of enskilment, hunters actively take stock of their surroundings and make the active decision to stockpile resources in advance. With this perspective, there is room for variation in hunting strategies because hunters are not solely concerned with making choices that reflect only rational decision making. There is also a difference for evaluating the longevity of these hunting decisions. Using optimal foraging theory, mass bison kill events continue to occur in the fall because people need resources to survive in the winter. With enskilment, hunters can make choices that reflect cultural influences, such as traditional methods and returning to important places. Using enskilment as a lens, returning to the same successful bison jump is seen as an ontological understanding of how to best live within the conditions of an environment. Enskilment implies humans actively decide to return to a place for reasons beyond the hunting activity. This differs from optimal foraging theory, which would see returning to a successful bison jump as a decision predicated on choosing the most successful hunting strategy with the most caloric return for the least energy expenditure. This implies humans choose to return to a place they know will succeed for hunting based off of past understanding of successful resource acquisition. The key difference between the two is the agency afforded to the humans in making decisions and the scope of the entire activity. As Ingold (2000) explains, "human beings are not born with a ready-made architecture of specialized acquisition mechanisms," rather it is through attentive learning that humans learn to live within their environment (p. 29). In this way, humans learn that a successful bison jump requires a multitude of conditions, contextualized by community information.

Ideally, both theories can be used to provide interpretations of assemblages. They would be applied to quantitative values generated by zooarchaeological research as a way to explain cultural patterns in assemblages. What is problematic is when these theories presuppose the results and influence the methods used to analyze assemblages. As explained by Speth (2017), Frison's winter resource acquisition model is extremely pervasive in the academic and professional literature for explaining site seasonality. His dentition analysis methods to determine seasonality, created from the Glenrock assemblage, are used by countless researchers. As discussed previously, all of the age estimates are half-year age intervals which potentially skew the season of death to a single time period, in this case a fall seasonality. Therefore, it appears the seasonality methods and the theoretical approach reinforce each other. For example, if the mandibular analysis provides a fall estimate, then the theoretical interpretation must be correct. In the same vein, the interpretation must also be correct because what other reason other than winter resource acquisition exists for these mass bison kill events? For the Fincastle assemblage, there was variation detected in the analysis that did not match the age categories. Therefore, either information was missing from the age categories, which would unintentionally produce consistent results because the mandibles could not be assigned to other age categories, or age categories amalgamated variation, which would provide evidence of different seasons, potentially as a result of the theoretical influence of fall kill events.

It is impossible to split the theoretical influence from the methods, but future researchers can add information that will improve the methods. Future research should focus on gathering more information about the eruption and wear sequences, from both modern and archaeological samples, as a way to understand whether the apparent variation in dentition morphologies is a result of our limited knowledge or imprecise age category information. This will help researchers interpret past cultural activity by expanding knowledge surrounding age development and potential seasonal variation in hunting strategies.

There are reasons that a fall kill event make sense. First, biomass calculations have discovered that animals are in better condition during the fall. Specifically, ovulating cows are in their best condition around the rutting period, which is when fall kill events would occur (Brink 2008, p. 47). Second, if the hunt is occurring immediately after the rut, then it is expected there will be a mix of males and females if there are young bulls still with their mothers or the adult males have not yet left. This would account for mixed sex herd assemblages. Lastly, the cooler temperatures of the fall mean the bison carcasses will not spoil as quickly, allowing more time for the hunters to butcher and process the animals.

However, there are also reasons that a fall kill may not make sense. First, the climactic conditions of the region may put a time constraint on when hunting can occur. With respect to jumping and pounding strategies, the creation and preparation leading up to the hunt may take weeks to complete. For example, the drive lanes at Head-Smashed-In Buffalo Jump are marked by rock cairns, but Brink hypothesizes that the cairns would have had twigs and branches to mimic human movement, which would have required time to prepare (Brink 2008, p.98-99). In the case of the Fincastle area, the climactic conditions approximately 2,500 years ago were similar to modern conditions in this geographic area, thus conducting a kill event from late September to early November as described in the Glenrock publication, would push the hunt and processing up against the incoming cold and snow conditions (Leyden et al 2006, Sauchyn and Sauchyn 1991). Additionally, considering that climate conditions are cooler from late September to early November, the processing strategies may be hindered. It is believed that a major component of mass bison kill events is the drying of meat to make jerky for longer storage, and to use dried meat in the creation of pemmican (Brink 2008, Bethke et al 2018, Frison and Reher 1970a). Evidence of this activity has been linked to features such as meat drying racks (Bethke et al 2018), residue analysis completed on mauls (Fedyniak and Giering 2016), and berry harvesting (Brink 2008). When compared to the summer season, drying of bison meat would be more difficult in the fall months when the air temperature is colder and could be significantly hindered by freeze and thaw conditions. Brink (2008) states that it was easier to make pemmican because it would dry faster, “if the weather was sunny, warm, and windy” (p. 230). The other plausible option would be to smoke the meat, which would require the use of kindling and a shelter. Another important point to consider is that while pemmican would have comprised a large portion of a diet in the winter months, it would not have been the sole ration. It is likely hunting occurred in the winter and early spring to supplement food supplies, as argued by Quigg (1978).

The discussion above is not meant to dissuade the narrative away from a fall kill event. For certain, there are aspects of bison ecology and human behaviour that make sense for fall bison kill events. While no foetal remains have been identified at Fincastle, they have been identified at other sites in the Northwestern Plains (see Peck 2001 for an extensive summary), evidencing bison hunting in the winter and spring. Undoubtedly hunting occurred in the summer months as well. The enskilled hunters adjusted and adapted their hunting and butchering strategies as required.

Impact on Interpretation: Feature 7

Fincastle has confidently been assessed as a single component bison kill event. Both geoarchaeological analysis and chronometric methods have dated the bone bed to 2,500 CAL BP. There is no evidence of multiple occupations, or of layered bone beds. Additionally, as the site is located within an active dune field, it is likely a dune covered the site rapidly which contributed to the excellent preservation of the bones. There are several upright features at Fincastle, which have received attention because of their unique forms and construction. This thesis will not provide speculation on how the features were formed, or what their potential purpose is, but rather to highlight how these dentition methods may have consequences for interpreting the seasonality of the site.

Feature 7 consists of four mandibles (Figures 25 to 28) and a tibia displayed in a radial fashion with the rostral ends of the mandibles downwards and the culturally fractured tibia with the proximal end upwards. The entire upright feature was found beneath the bone bed, pushed into the lacustrine clay. There are no cutmarks or evidence of butchering on the mandibles. The mandibles were not available for visual examination because the feature is on display at the RAM; however, photographs taken of the elements were used to assess eruption schedules.

Figure 25: Buccal view of mandible 15322

Figure 26: Buccal view of mandible 15323

Figure 27: Buccal view of mandible 15324

Figure 28: Buccal view of mandible 15325

There is a MNI of three individuals based on comparing eruption and wear patterns on the mandibles. It appears two of the mandibles may belong to a single individual as they have the same dental eruption and wear pattern. Mandible 15322 (Figure 25) is a left and 15325 is a right (Figure 28); both have the M_1 completely erupted, M_2 almost at the occlusal plane, and the third molar not breaking the alveolar plane. Additionally, both have the dPM_4 in a well-worn state and being pushed out of the jaw. Given both mandibles were included in the feature and have virtually identical eruption and wear patterns, it seems likely they came from a single individual. The best age estimate for these mandibles is approximately 1.5-2 years of age, using the four methods. Mandible 15323 (Figure 26) does not have a full set of adult dentition, although it is older than the preceding bones. Both the M_1 and M_2 are permanent, although the exostyle for the M_1 is not at the occlusal plane, and the M_2 exostyle is not present. The M_3 third cusp is barely erupted and with no wear, therefore the best age estimate for this mandible is 2.5-3 years of age. The last mandible, 15324 (Figure 27), is considerably older than the others with all three molars fully erupted and in a state of wear, including wear on the third molar and third cusp. The exostyle is worn to a loop on both the M_1 and M_2 but is not present on the M_3. Therefore, although this is an older individual represented, it is not to the age when the exostyle is wearing. The best age estimate for this mandible is beyond 4.5 years of age, or an adult dentition without advanced wear.

Table 19: Feature 7 seasonality estimate summary

Feature 7 Seasonality Estimate											
Mandible	**Fuller Age**	**Brumley Category**	**Brumley Age (days)**	**Brumley Age (Years)**	**Brumley Season**	**F&R 1970b**	**F&R Season**	**R&F 1980**	**R&F 1980 Season**	**Final Age Estimate**	**Final Season Estimate**
15322	2	4 M_2	446	1.2	Late Summer	1.5	Fall	1.8	Winter	1.2-1.8	Summer to Winter
15323	3	10 M_3	1095-1643	3-4.5	N/A	2.5	Fall	2.3-2.8	Late Summer to Winter	2.3-4.5	Summer to Winter
15324	Adult	17 M_3	1643+	4.5+	N/A	4.5	Fall	4.5	Late Fall	4.5+	UID
15325	2	4 M_2	446	1.2	Late Summer	1.5	Fall	1.8	Winter	1.2-1.8	Summer to Winter

The mandibles in this feature suggest successive years of age, with at least three individuals represented. The seasonality estimate of this feature differs from the overall assemblage (Table 19). The Brumley (1995) method provided an estimate of 1.2 years of age, or season of death in the summer for the two youngest individuals. The Frison and Reher (1970b) method yielded a fall kill, but this is the only category that exists in their method. The Reher and Frison (1980) methodology suggests both late summer to winter, and winter. The late fall conclusion for the oldest mandible is essentially a cursory estimate because this mandible is beyond all four methods' age categories and could not be reliably assessed a seasonality. Overall, the impression this analysis provides is a summer to winter seasonality, which is inclusive of a fall kill, but broadens the seasonal range. Additionally, very few of the youngest mandibles in the bone bed had the seasonality range of 15322 and 15325 (Figure 19). This could indicate the mandibles in this feature are not from this kill event and represent animals from another kill event. This may change the interpretation of the construction of the other upright features and their construction at Fincastle if the seasonality of these mandibles does not align with the rest of the bone bed. This conclusion is strengthened with the support of Fincastle as a single component bone bed. The potential issues inherent in the dentition methodologies to date hinder the ability to understand the construction of these uprights. Therefore, while this analysis may indicate these mandibles have different eruption schedules compared to the rest of the assemblage, the lack of reliability in the methods does not confirm this supposition.

There are several other scenarios which may cause an unexpected eruption sequence, including out-of-season births. One of the underlying assumptions in a seasonality estimate is all of the animals represented in the assemblage were born at approximately the same time and died at the same time, meaning they would have successive yearly eruption sequence and wear patterns. Research has indicated that potentially more than 10% of bison calves in a year are born out-of-season (Frison 1978, p. 45). This would skew seasonality interpretations. For example, a calf that was born in May and a calf born in July which were killed at the same time in November would denote a 0.5 and 0.3 year tooth eruption schedule. If a researcher could not confirm a single component event, or assign elements to a unique bone bed, this could be taken as evidence for multiple occupations with different seasonality. This issue aside, further research needs to be done to create a better understanding of bison dentition eruption and wear schedules.

Other Approaches and Future Research

The integration of foetal remains for seasonality studies has been hypothesized as a correcting factor for age estimates. In their work on the Casper and Horner assemblages, Breslawski and colleagues (2020) found divergent support when compared with mandibular studies. The foetal remains from Horner confirmed the fall seasonality event, but the remains from Casper suggested a winter or spring event (p. 432). Vickers and Peck (2004) suggest foetal remains, "provide a rough seasonal estimate between late December and early June; a more precise schedule has yet to be developed" (p. 114). Walde (2006) stated further research would need to be completed on foetal skeletons to confirm ages, because there is insufficient literature in the field for confidently assessing foetal age. No foetal remains have been identified in the Fincastle assemblage to date, which does not allow for this analysis. However, it is apparent that similar methodological flaws are present for foetal bone analysis; there is no modern reference sample to confidently assess age. The lack of standardized comparison sets represents a serious gap in this area of research, that until resolved, will continue to provide imprecise seasonality estimates.

Other seasonality research includes dental cementum increment (DCI) analysis and metaconid height comparisons. DCI is a destructive method that involves abrading away cementum for microscopic viewing, to identify periods of rapid and slow growth that correspond to seasonality (Peck 2001 p. 159-161). This method was as limited in determining seasonality as visually examining eruption and wear patterns. Peck (2001) often could not assign a seasonality beyond several months. For example, specimens taken from Head-Smashed-In Buffalo Jump indicated a time span of five months between late October and late March for a proposed seasonality (p. 181). Metaconid height studies have also been used to estimate seasonality but it is also a destructive methodology. Tischer (2000) explains how bone had to be removed from mandibles to measure metaconids during lab processing, and this was not completed on the Fincastle collection. Metaconid height measurements involves measuring the height of the enamel on the M_1, under the assumption that enamel will wear in annually regulated amounts (Haynes 1984). Whittaker and Enloe (2000) highlighted the variability in wear patterns, stating that, "it cannot be argued that these are quantitative outliers unless the expected, natural range is known from comparative studies" (p. 117).

Conclusion

There was significant variation in how each method generated an age estimate. Each method presented time intervals differently: yearly categories in Fuller (1959), half year intervals in Frison and Reher (1970b), fractional year ranges in Reher and Frison (1980), and age in days in Brumley (1995). Fuller (1959), Frison and Reher (1970b), and Reher and Frison (1980) used written descriptions to describe eruption and wear patterns while Brumley (1995) used visual comparisons. The age categories used in each method were different, namely Brumley's (1995) method did not estimate ages for animals older than 2.5 years of age, and Frison and Reher

(1970b) used categories to describe animals between 10.5 to 13.5 years of age. This research used the Fincastle assemblage to compare results generated from each method and highlight the intricacies inherent in each method. The data were then parsed and contextualized to find ways to compare assemblages assessed using the different methods.

The results demonstrated consensus for a fall kill event, but also revealed inconsistencies that could not be explained by out of season births, such as the eruption of the M_3 and the level of wear on the M_2 and M_3. The Fincastle collection has demonstrated the lack of repeated results when using these four prominent methods; the age methods do not present enough specificity for assessing age, which hinders the reliability of the derived seasonality estimates. Future research should focus on improving understanding of bison dental morphological changes to improve age assessments, which will then improve seasonality estimates. Continued use of these methods without further research to improve data on eruption schedules and wear patterns will contribute to imprecise understandings of Indigenous lifeways.

Chapter 5: Site Comparisons

A common component of zooarchaeological analyses is a comparison of faunal data between sites to contextualize results. Researchers use these comparisons as a way to demonstrate how comparable their assemblage is to temporally and spatially similar sites. Ideally, a zooarchaeological analysis is strengthened when comparable patterns are identified between data sets. Comparisons should also act as a check and balance for methodologies, as many of the same methods are used by different researchers, to ensure they are being used the same way. For the purpose of this thesis, faunal data sets will be compared for two reasons:

1) To identify similar element portions and frequencies related to tongue removal, mandible detachment, and cranial separation recovered at other sites.
2) Assess the methods used to establish seasonality at other sites.

Seven sites were chosen for data comparison to the Fincastle assemblage, which meet at least one of the following three criteria:

1) Assigned to the Besant phase or have a similar radiocarbon date
2) Located in a similar geographic location (NW Great Plains)
3) A prominent bison kill site with well published data sets

There are two additional sites included in this section, the Ruby site and the Hudson-Meng site, but because they do not have accompanying data tables, they are not included in the direct comparison. They are compared with Fincastle primarily because of their prominence in the literature and were analyzed with similar methodologies. They present conclusions from a faunal analysis but the accompany data sets are missing from their publications. A map of all site locations is provided in Figure 29.

Figure 29: Geographic site location map

EgPn-111, Alberta

EgPn-111 is a single component Besant bison kill site located in the Bow Valley near the city of Calgary in southern Alberta. Excavated from 1998 to 2000 by Bison Historical Services Ltd, a minimum of 44 bison were identified based on mandible elements (Head, Murphy, Smith 2002, p. 49). Radiocarbon dates obtained from three atlases, estimated the age of the site to approximately 1410 ± 60 BP (p. 38). Generally, the Fincastle and EgPn-111 assemblages resemble each other (Figure 30). They both lack a structure that would denote that a pound hunting strategy was used, and they have common reoccurrences of similar cranial elements along with the absence of entire skulls. The seasonality was estimated based on dental eruption and wear, following methods developed by Frison and Reher (1970b) to late fall. The authors propose the kill event represents a bison pound, but concede, “there were no specific concentrations that might address the presence or absence of a corral or other structure” (p. 211). Without evidence to support their conclusion and lacking geoarchaeological evidence for a bison jump or arroyo, it is possible the site also represents a surround or ambush hunting style similar to Fincastle.

The dentition studies followed the same patterning and reasoning that was developed in the 1970s by Frison and Reher. Namely, seasonality was precluded based on half year intervals, “relying on the presumption of a stable birthing period of late April,” with the mass kill event occurring in October or November (p. 75). A total of 79 mandibles (40 right and 39 left) were placed into 10 age group categories based on similarities of eruption and wear (p. 74). The authors did not include any individual teeth in the study except for Group 10 (9.5+ years of age), because it extended the number of age groups represented at the site (pg. 80). The authors used the exostyles as a way to differentiate between the advanced mandibles. Head and colleagues propose the M_3 exostyle reaches the occlusal plane at 6.5 years of age, at which point it begins to wear, until 8.5 years of age when the exostyle is a loop. The authors surmise the kill occurred in the late fall based on the eruption and wear of the molars, which aligns with the half year intervals. The authors submitted three M_1s for thin sectioning analysis, which suggested a late December to early January kill event. The authors excluded these results, still suggesting a late fall event (p. 80). The authors conclude the dentition results from EgPn-111 are most comparable to Glenrock (Frison and Reher 1970b), DjPm-116 (Landals 1983, see Landals 2009), and Fitzgerald (Hjermstad 1996).

There are two points worth discussing for this dentition analysis. First, the use of the principle assuming stable and progressive wear. Second, the large time span which the authors suggest correspond with a fall kill event. Beginning with the prior, the authors group together mandibles using the principle of "like with like" for estimating age in older individuals. This does not account for individual variation and potential environmental influence causing advanced wear. Studies on metaconid M_1 heights have shown variable results for the same species of bison (*Bison bison*), in different time periods and environments (Haynes 1984). Further, most reports will not estimate ages beyond 4.5+ years because there is little comparable data for these older age groups. The authors of this report assume stable exostyle wear when estimating age but provide little explanation beyond this statement.

Second, the authors propose four different months within which the fall kill event could have occurred (October, November, December, and January). Their seasonality estimate spans months, beyond the normal constraints of a late fall kill event. Rather, the use of fall kill event terminology may imply a resource acquisition strategy (optimal foraging theory), as discussed in Chapter 4. The authors use this terminology, despite their seasonality estimate spanning into the winter months, because of the implications for interpretation. The dentition methods used at this site left little room for variation. When the thin sectioning analyses expanded the seasonality estimate, the authors maintained the estimate of a late fall kill event. The dentition methods used at this site leaving little room for variation or expanding timelines. The disconnect between the dentition study proposal of October or November, with the DCI proposal of December or January, means there is room for improvement in either method, but they both cannot be a late fall kill event. A third of a year cannot be a single moment. Increasing the accuracy of these methods would open the door to better understanding the variation within mass kill events and the hunting strategies that would have been used.

The authors propose the assemblage represents a primary processing area with evidence of disarticulation into manageable units (p. 70). EgPn-111 has no complete skulls or crania, but a high proportion of identifiable elements. Specifically, the petrous portion (NISP 58), maxillary fragments with molars (NISP 35), and the occipital condyle (NISP 14) represent similar quantities to Fincastle. The authors suggest either butchering or differential preservation for the high frequency of certain elements and absence of others, but do not provide a definitive answer for one or the other (p. 58). Head and colleagues propose the removal of the crania by chopping or directing blows at the atlas-axis joint to disarticulate the skull from the rest of the vertebral column, following the methodology proposed in Frison and Reher (1970a). After the skull was removed, the authors describe three patterns for separating the mandible and cranium: separating the mandible from the cranium by chopping of the coronoid articular process, smashing the horizontal ramus for marrow, and separating of the mandibles by butchering the diastema (pg. 58-59). The second and third steps are seen as resource acquisition phases for marrow extraction and tongue removal. As the mandibles are butchered, “the tongue was removed by further butchering of the horizontal ramus," but this explanation lacks context for how the hyoid is evidence of tongue removal. Specifically, as the authors say, "[the hyoid] appears to have been removed from here suggesting that the tongue was removed as a meat selection … but fragmentary remains collected at the site strongly show evidence of processing of cut and hack marks," (p. 59). The low MNE of hyoids (MNE 8), with a high NISP (NISP 61), indicates a high degree of fragmentation and may suggest some butchering of the tongues; however, the removal of the tongue through the mouth is unlikely to impact the hyoid and cause the level of fragmentation. It is more likely the hyoid would be fragmented if the tongue was removed through the throat, where the hyoid is anatomically situated for cutting. If the hyoid is to be used as evidence of tongue removal the method of removal should be re-evaluated to provide a better understanding of the cultural activity.

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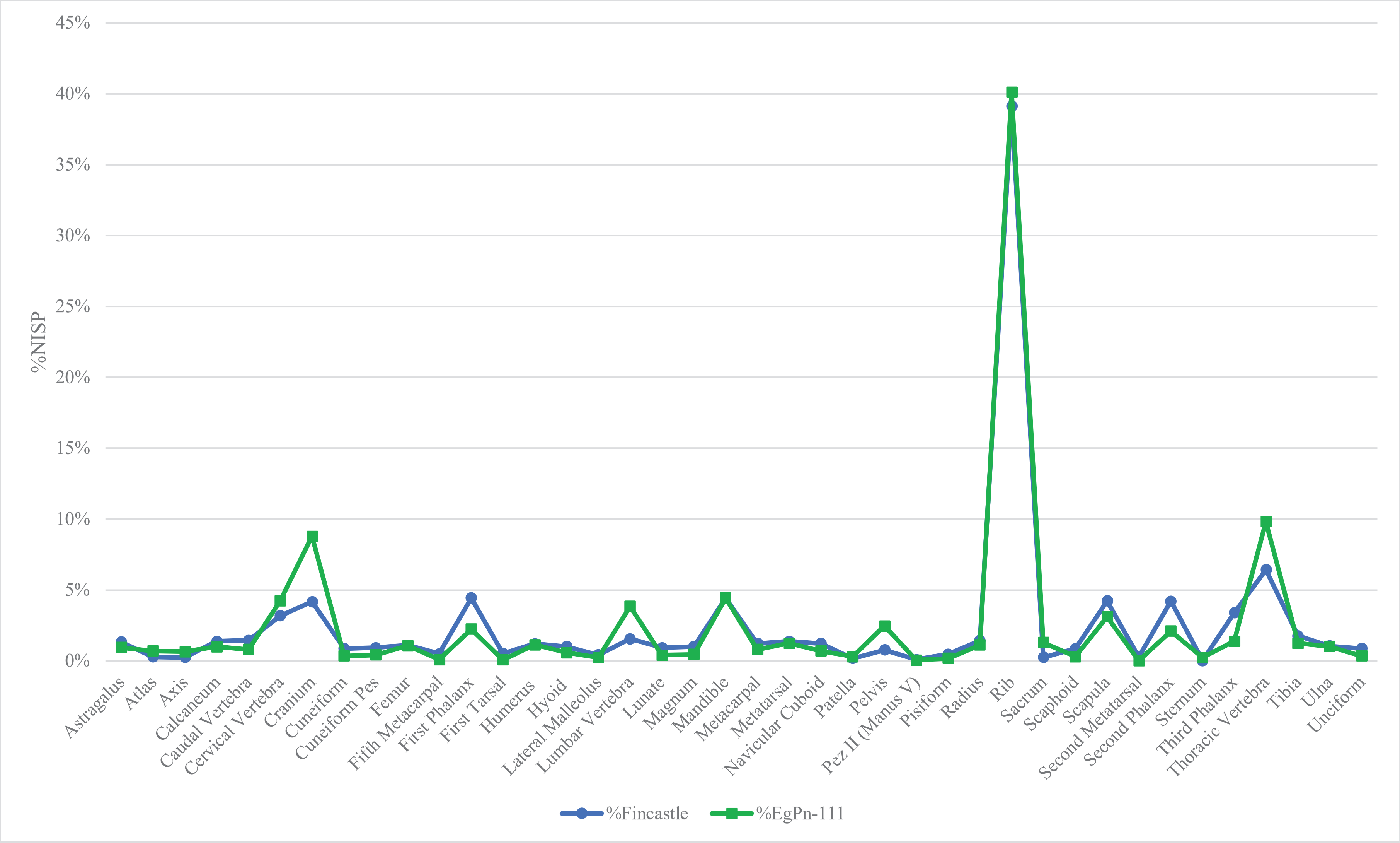

Figure 30: Fincastle and EgPn-111 %NISP comparison

Fitzgerald (ElNp-8), Saskatchewan

The Fitzgerald site is a Besant bison pound located near the Moose Wood Sand Hills, in south central Saskatchewan. The site was labelled as Besant because of the projectile point assemblage, all radiocarbon dates overlap at a 95% confidence interval of 1300 BP (Hjermstad 1996, p. 25). Three different areas were uncovered during the excavations, the bison pound or kill area, an associated processing area, and a burned bone area. A minimum of 49 bison were identified during the course of the analysis, 41 in the kill area and eight in both the processing and burned areas (p. 122). The kill location and processing area had low frequencies of burned bone and was less dense than the burned bone are, which was considerably denser and almost completely comprised of burned bone (p. 121). This was in contrast with the kill and processing area, which were considerably less dense concentrations of bone (p. 121). The burned bone area is not fully understood but may evidence a previous kill or processing area that was burned, or an area where burned bone from cultural activity was discarded (p. 38). Figure 31 is an overall comparison of faunal assemblages between the two sites, and Figure 32 is a comparison of the Fincastle assemblage to the unique areas identified at the Fitzgerald site.

Seasonality was estimated as a fall kill event based on a mandibular study of eruption, cusp wear, and M_1 metaconid heights on 54 mandibles. Though 65 mandibles were recovered during the excavation, only 54 were chosen for study because the M_1 was present. Information was not published on the remaining 11 mandibles because they did not meet the requirements for one aspect of the dentition study, the M_1 metaconid height measurement. If all the aging methods are reliable and produce an accurate seasonality estimate, the cusp and wear analysis should produce the same result as the metaconid data. Given both aging methods were applied to the 54 mandibles and yielded a precise seasonality that matched, it is inferred that the methods work independently of each other. The method used for this study was taken from Frison and Reher (1970b), therefore, the vast majority of their mandibles fell into half year intervals with an expected season of death in the fall (87%). Thus, any conclusion of seasonality should be considered in light of this limitation.

There was one foetal bone recovered during the excavation, which the author uses as evidence for a late fall to early spring seasonality. Walde (2006) found through an analysis of bison foetal development that foetal bone could not be used to give a seasonality estimate more precise than three to four months (p. 489). While this method may be used to provide a broad correlation with other mandibular and aging studies, it should not be relied upon as a sole indicator for seasonality. The foetal bone seasonality lacks the precision of the mandibular study, and cannot corroborate a fall kill event, beyond excluding a summer period.

The final factor of importance when comparing Fincastle and Fitzgerald is the lack of cranial elements in the assemblage. The limited number of cranial elements at Fincastle is not believed to be a taphonomic process of decomposition and eventual erosion, because of the levels of preservation found at these sites, including smaller and more fragile elements (hyoid). While this cannot be ruled out completely, the noticeable trend at the Besant sites used in this comparison is an overwhelming representation of the petrous portion and little to no other cranial elements. At Fitzgerald, the petrous portion accounts, “for nearly 99% of the MAU” (p. 175). Hjermstad argues the mandibular disarticulation took place at the anterior symphysis but acknowledges that the mandibles are largely broken at the “juncture of the corpus and ramus [as] a common pre-contact butchering practice” (p. 181). The proposed reason for breaking the mandibles at the symphysis was to cut the mylohyoid muscle for tongue removal, as it is the muscle that supports the tongue in the mouth. Tongue removal with evidence via the hyoid displays a disconnect in the assumed butchering method because the hyoid cannot be reached by removing the tongue through the mouth, as the hyoid is tucked underneath the mandibles. Therefore, while Hjermstad's supposition that tongue removal took place in the kill area due to the presence of hyoids while not being found elsewhere is seemingly correct, the proposed butchering mechanism is flawed. The anatomical position of the hyoid does not allow it to be reached, cut, or removed with the tongue if the tongue is being removed through the mouth.

In summary, the Fitzgerald site is a Besant bison pound with many noticeable similarities and some stark differences to the Fincastle site. The MNI is higher at Fincastle, with the entirety of the site not believed to have been uncovered. The Fitzgerald site has an excavated area of 73 m^2 excavated, but it is unknown if the entirety of the site has been excavated (p. 46). There are three main discussion points for aging estimates and cranial detachment. First, the continued use of the Frison and Reher (1970b) method which directs only fall kill estimates limits the interpretation of the assemblage. Second, excluding certain mandibles because they potentially do not fit the parameters of one aging method, when they may fit the other, is unfortunate. As presented, the two methods seemingly complement each other in finding the same seasonality but were not used independently. This may have strengthened the overall seasonality conclusion and would have included more elements in the analysis. Lastly, Hjermstad provided few details or consideration for the presence of the petrous portion. Improved information in future publications of the frequency of petrous portion and fragmentation of the skull elements may reveal a pattern for mandible disarticulation and cranial separation that would otherwise go unnoticed.

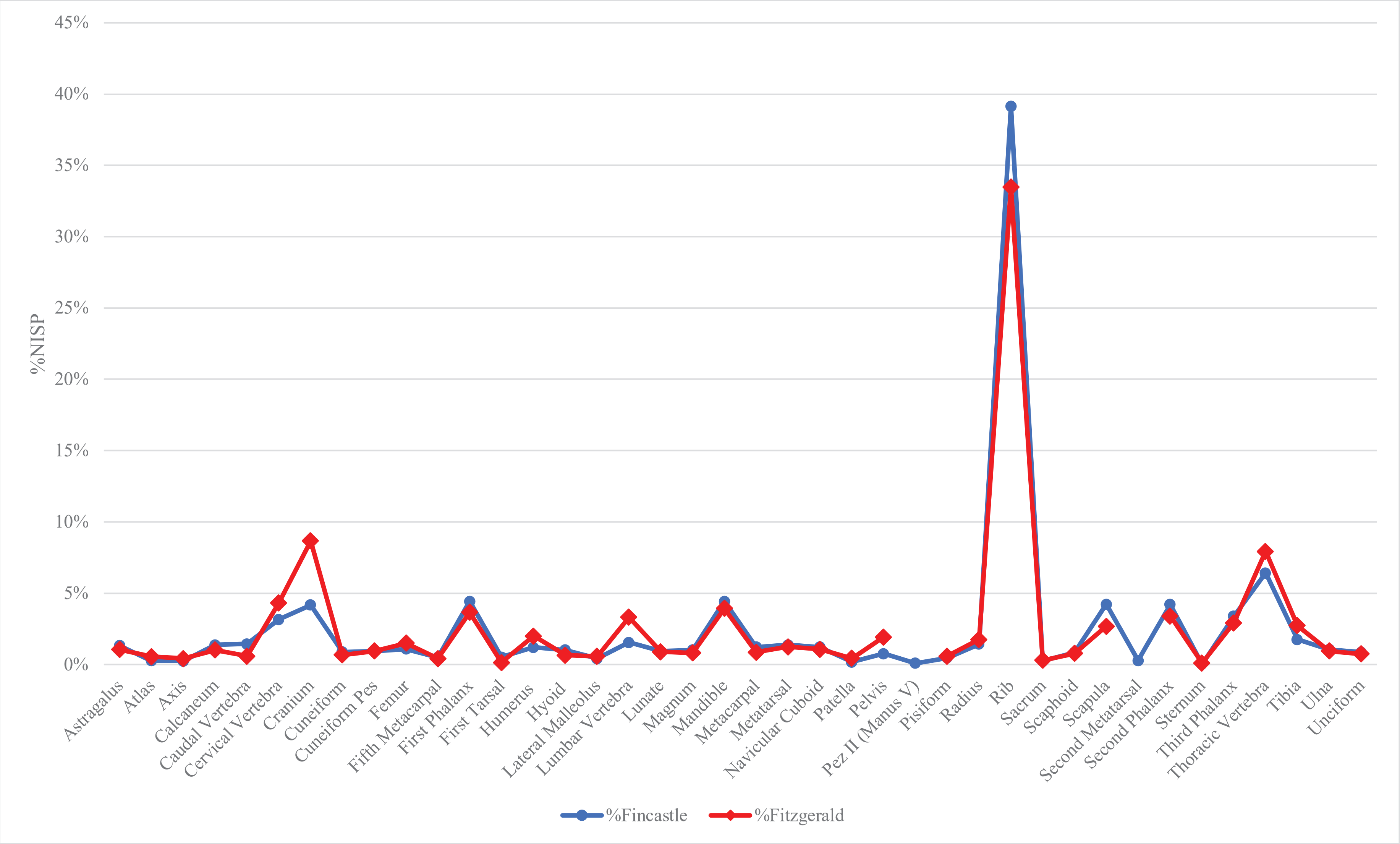

Figure 31: Fincastle and Fitzgerald %NISP comparison

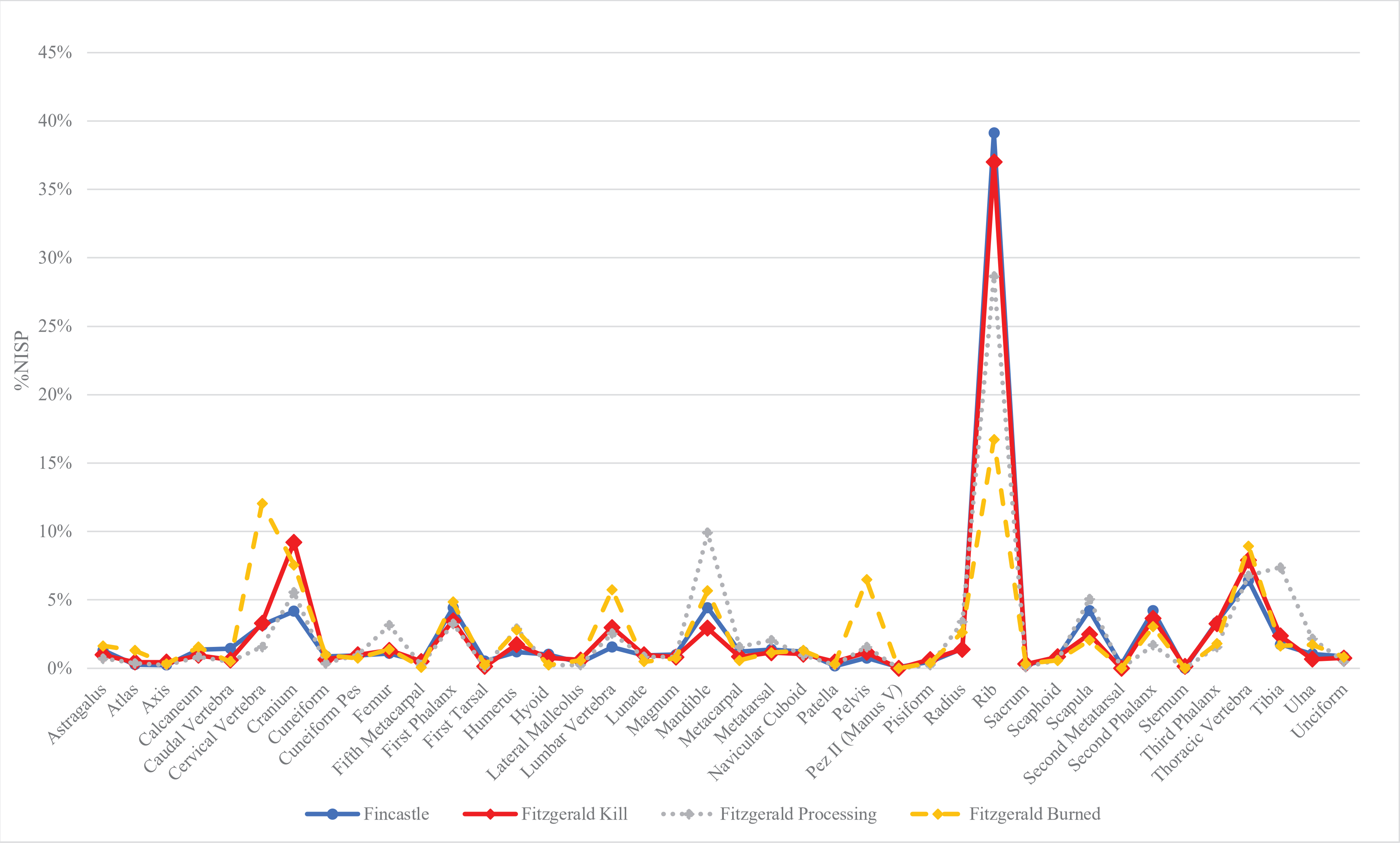

Figure 32: Fincastle and Fitzgerald area %NISP comparison

Glenrock Buffalo Jump (48 CO 304), Wyoming

The Glenrock Buffalo Jump was among the first bison jumps studied intensively on the northern plains. This thesis has used Frison and Reher's (1970a, 1970b) publications to contextualize butchering patterns and to assess mandibular age. This section broadly compares the Fincastle assemblage to the Glenrock assemblage for a discussion of cultural activity identification. Glenrock is located in central Wyoming, and was radiocarbon dated to 210 ± 100 BP from charcoal in associated hearths (p. 7). Bison were driven off a 12 m high cliff to a talus below; the bond bed has varying levels of preservation (p. 5). The assemblage is composed of bison bone, bone tools, projectile points, and lithic tools.

The zooarchaeological analysis published on Glenrock was pioneering work for the time. Early attempts at quantification, butchering pattern identification, and ground-breaking dentition and mandibular studies were all important contributions from this work. The early MNI quantification process produced an estimate of at least 1000 bison. The butchering patterns were outlined in detail (cutmarks and fractures on specific elements), thereby increasing the scope researchers could examine their own assemblages. The mandible analysis method to produce half-year intervals has been replicated countless times. Although many of these aspects have been discussed prior in this thesis, specific attention will now be paid to the methodological approaches for comparing Glenrock and Fincastle on all of these points listed above.

First, the authors explain in detail the butchering process of the bison with evidence from the Glenrock assemblage. The explanation of the cranial and mandibular butchering will be highlighted here although it was the focus of Chapter 3. Frison reasons the skull would have been placed face down while hammerstone blows were delivered to the atlas-axis joint, evidenced by crushing on the dorsal atlas (Frison and Reher 1970a, p. 22). Then, the authors state there are three ways to disarticulate the mandible from the cranium. The first would reveal cutmarks on the anterior ventral border and the anterior medial side of the mandibles, to cut the mylohyoid muscle suspending the tongue in the mouth, evidencing the removal of the mandibles from the cranium and removal of the tongue (p. 11). The second is to place the skull face down and give direct blows to the temporal condyles, which would break the zygomatic arch and coronoid process of the mandible, thereby freeing the mandible from the articulation with the cranium (p. 22). The third way is to break the diastema, rostral to the PM_1. This would cause damage to the premolars and front of the mandibles but would not destroy the articulation with the cranium or the zygomatic arch. Therefore, there are potentially three different patterns of mandible separation. There is no direct mention of the petrous portion in these accounts, or damage to the cranium beyond the zygomatic arch. There is mention of tongue removal, but Frison concludes the tongue would have been removed through the mouth after removal of the mandibles and surrounding muscle. There is no explanation for the breakage of the hyoid bones, although Frison states most of the hyoid bones are broken at the anterior part of the greater cornu (p. 22). Frison acknowledges historic accounts of removing the tongue through a slit in the throat but claims that because this was done with a steel knife it would not be applicable to an archaeological context (p. 11). Damage to the hyoid and the methods proposed for tongue removal are inconsistent with each other; how the hyoid would be damaged with cutting the tongue through the mouth is unclear.

There is an abundance of skulls at Glenrock, with representation from all elements of the crania. Additionally, there are nearly complete sections of crania, showing damage to the parietals and frontal bones for brain removal (p. 23-24). This differs from Fincastle, as there is evidence of crania in the form of petrous portions, but an under-representation of the remaining cranial elements. It is possible the crania were being used for different purposes at Glenrock and Fincastle. At Glenrock, the skulls were discarded after the brain was removed. At Fincastle, it is unclear where the crania are. Perhaps they were moved to a secondary location or were used for a different purpose such as at the Ruby site (Frison 1971), or the primary kill spot is yet to be found.

Third, one of the hallmarks of the pioneering work by Frison and Reher is their mandibular dentition study for determining seasonality. This work has had a remarkable longevity in the field, with many recent bison studies still applying their methods. Frison and Reher divided the mandibles in their collection into half year age intervals. They worked from the assumption that bison jumping was limited from late September to early November and a discrete birthing season occurred from late April to early May. An extrapolation from these assumptions is predictable eruption and wear pattern on the mandibular dentition for animals in the same age cohort (Frison and Reher 1970b, p. 46). To create a reference collection, they used animals of relatively known age from local commercial bison herds, a bison rancher, and a collection from the department of zoology at the University of Wyoming. It is unclear from the publication how the animals in the university collection were obtained, or how their ages were determined (p. 46). By comparing the mandibles of known age with the Glenrock mandibles, they created seven age groupings, including discrete age categories from 0.5 years of age to 4.5 years of age, a mature group of 5.5 to 9.5 years of age, and animals older than 10.5 years of age. Mandibles were determined to be older than 10.5 years of age based on extensive molar wear. The reasoning for yearly categories until 4.5 years of age is mandibular teeth continue to erupt until this point. After 5.5 years of age the permanent dentition is fully erupted and starting to wear. Their age reference key was then used on the Glenrock assemblage and resulted in animals in all seven half year interval categories, peaking around 4.5 years of age (Reher 1970, p. 53).

In terms of the assemblage similarities between Glenrock and Fincastle, there are several noticeable differences. First, the number of crania and the portions present differ, the degree of rib fragmentation at Fincastle is much higher, and there are generally fewer element portions present at Fincastle. However, this superficial analysis is hindered by the inability to compare quantification values beyond NISP. For Glenrock, this is due to the infancy of quantification methods at the time of publication. Figure 33 demonstrates the trends for both Glenrock and Fincastle, but it is important to note that this is information is incomplete because values and portions are not discussed. Second, the Glenrock report provides insight into its methodological influence on subsequent zooarchaeological studies. The dentition studies and butchering details have been cited countless times since its publication as it was pioneering work for the time. Zooarchaeology was in its infancy, but the quality of work published by Frison and Reher is superb. However, as the field has continued to advance, new researchers have contributed to bison studies and more information has become available about bison ecology. Re-examining the literature and evaluating the claims in these pioneering works is important to ensure the field evolves and continues to advance our ability interpret past cultural activity. Consistent engagement and refinement with the material will improve the accuracy and precision needed to analyze archaeological assemblages.

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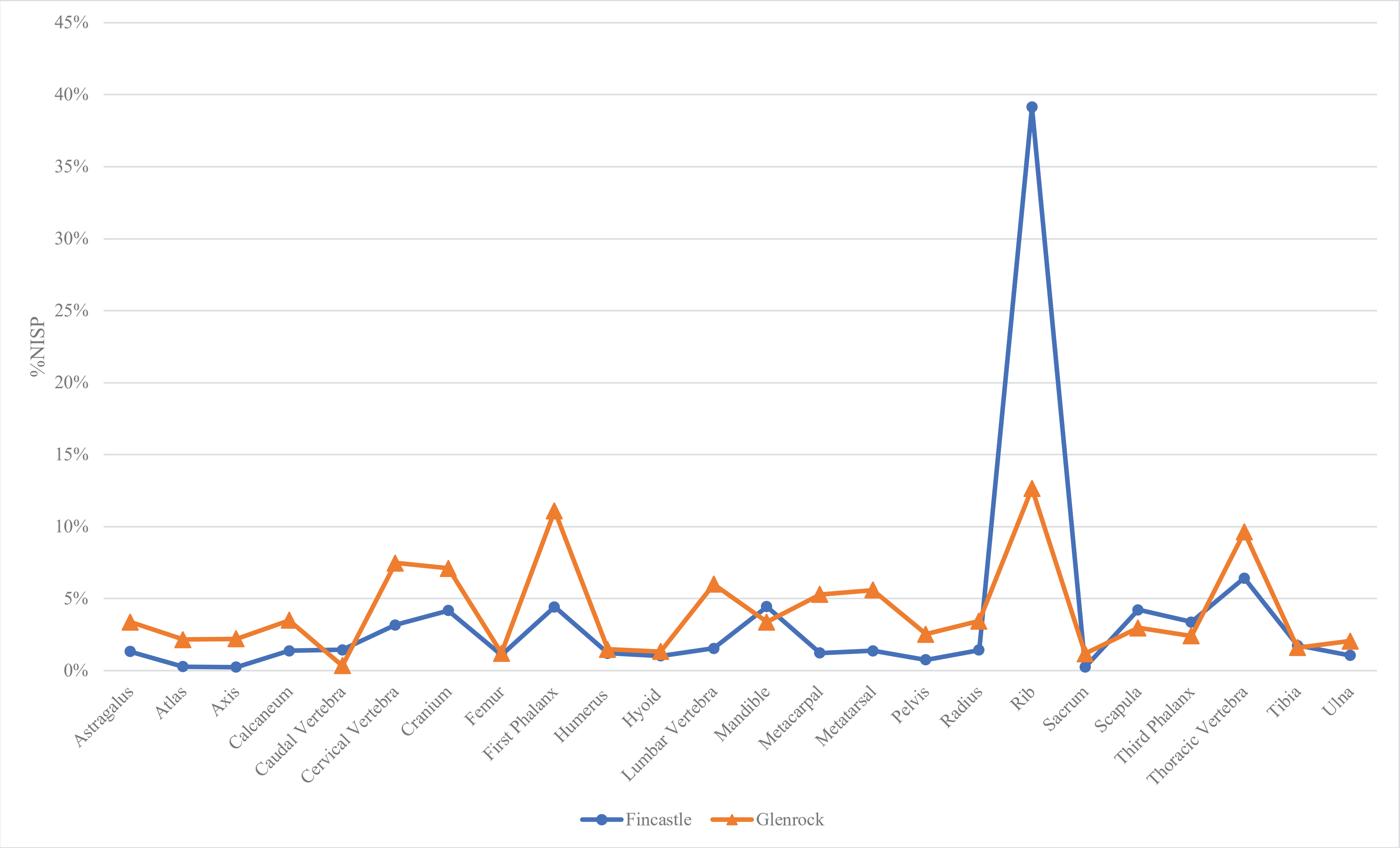

Figure 33: Fincastle and Glenrock %NISP comparison

Head-Smashed-In Buffalo Jump (DkPj-1), Alberta

Head-Smashed-In Buffalo Jump (HSIBJ), located approximately 20 km west of Fort Macleod in southern Alberta, is a UNESCO World Heritage site and is one of the most renowned bison jumps on the Great Plains. Although the use of the jump in the Early Prehistoric period is not well documented or understood, its use in the Middle and Late Prehistoric has revealed frequent reuse since approximately 5,700 BP to present. The cliff is currently approximately 9 m high, although it would have been closer to 15 m high when in use in prehistoric times. The accumulation of bison bones at the base of the cliff over thousands of years and the erosion of the sandstone margins has significantly reduced the height of the cliff.

Seven major excavations have taken place since 1949. Junius Bird first visited the site in 1939. Then Boyd Wettlaufer returned in 1949 under the University of New Mexico to conduct the first ever archaeological excavation in Alberta, after visiting the site during WWII. Brian Reeves excavated in 1965, 1966, and 1972 near the base of the cliff to establish its chronology, specifying its use in different time periods in prehistory. Reeves (1990) uncovered at least four occupation phases at the base of the cliff, which were supported by radiocarbon dates. He determined that the oldest use of the jump was in the Mummy Cave phase, approximately 5700 BP, followed by the Pelican Lake phase, Avonlea, and lastly the Old Women's phase. There is not strong evidence of Besant use of the jump (Reeves 1990 p. 172), but some Besant material has been recovered from the processing area. Reeves draws this as a distinct comparison to the Women's Jump, approximately 90 km to the north along the Porcupine Hills, where Reeves claims Besant is better represented. However, there was no faunal analysis done on the Women's Jump assemblage, which was excavated in the 1960s, and will not be included in this discussion.

Brink and Dawe excavated at HSIBJ from 1983 to 1987 in the processing area adjacent to the cliff face. Their analysis focused on the upper occupation layers corresponding with the Late Prehistoric (Avonlea to Old Woman's phase). Kooyman excavated from 1989 to 1992 in the northern portion of the kill deposit, adjacent to the area excavated by Reeves in 1972. The three upper layers were assigned to the Old Women's phase, with the points belonging to the Cayley series (Peck 2001, p. 180-181). Peck used eight M_1s for DCI, reaching the conclusion of a kill event, or multiple kill events, that began in late October to late December, potentially continuing from late December to late March (p. 181). However, there was one molar which indicated a season of death between mid June to late October, which would extend the seasonality estimate. There was an excavation in 2016 to remove a roasting pit that had been identified by Brink and Dawe in the 1980s. Lastly, in 2021, the RAM and the University of Lethbridge ran a field school. The comparison portion of this discussion will be concerned with the material excavated by Brink and Dawe because their reports contain the most published and accessible information for this study.

There are no concrete age or seasonality estimates from this excavation because of the degree of fragmentation in the processing area. There was only one complete mandible, and without the context provided by the eruption sequence of the dentition in the mandible it is difficult to an assess an age confidently (Brink and Dawe 1989, p. 153-154). Some foetal bone was recovered from the Processing Area and the Spring Channel, areas which were partially excavated by their team (p. 180). Of the entire assemblage, 0.34% was foetal bone; 1.7% of the bone from the Spring Channel was foetal (p. 147). Brink and Dawe state that foetal bone is often used as indicators of a late winter to early spring kill, but the paucity of material in this assemblage could not be used to support this conclusion (p. 155). It is worth noting that the overall level of preservation at the site is poor to moderate and assigning ages to highly fractured or poorly preserved bone is difficult. The majority of the elements recovered were classified as unknown age, because there was no indication of fusion surfaces (p. 154). Little other data is presented in the faunal analysis for a seasonality estimate. Brink and Dawe conclude the enormity of the bison assemblage is a likely indicator of, “surplus spoils,” and affirm the narrative that, “communal bison kills likely produced supplies intended to last … through the winter months” (p. 297). They hedge this argument by conceding that hunts in the spring may also be beneficial for large groups in the summer, but the emphasis is placed on the winter resource acquisition argument (p. 298).

The majority of the cranial elements uncovered at HSIBJ are petrous portions, although there is an overall lack of axial elements, only 13.5% of the entire assemblage (p. 105). Brink and Dawe posit that the presence of petrous portions indicates that crania were transported from the kill to the processing area, but there are very few other cranial elements to support this conclusion (p. 104). The cranial elements and mandibles have similar NISP values, at 3% and 2% respectively (Figure 34). It is possible that the petrous portion was transported with the mandibles when they were removed from the crania, as was discussed in the cranial chapter. The overall absence of hyoids at the site was attributed to removal of the tongue but how this was completed was not explained (p. 144). In later publications, Brink states removal of the tongue was done through the mouth (Brink 2008, p. 177). Overall, there is very little evidence of mandible and tongue removal, but the high degree of fragmentation in the HSIBJ processing assemblage hinders this. These activities may have taken place at the kill location and may be present at the base of the cliff, but these elements, collected by Reeves, have yet to be analyzed.

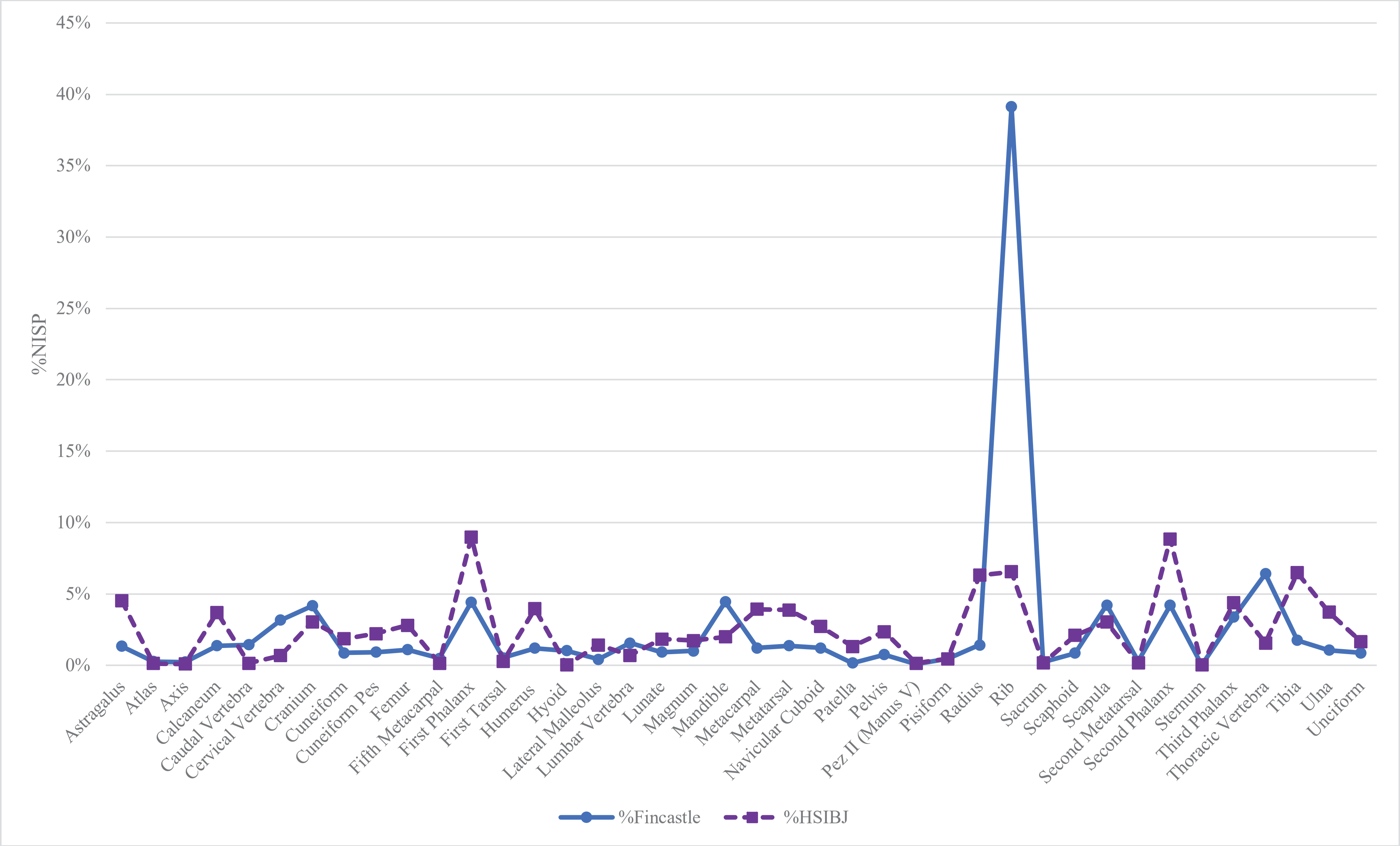

Figure 34: Fincastle and HSIBJ %NISP comparison

In summary, Head-Smashed-In Buffalo Jump provides a useful comparison for the Fincastle assemblage and for examining methods applied to large-scale bison kill sites. Head-Smashed-In is geographically close to Fincastle, and they overlap temporally. The use of Head-Smashed-In during the Besant time period is not well documented, but the close proximity of another mass bison kill event at Fincastle does demonstrate that large-scale bison hunting occurred. Comparison of the assemblages is difficult, largely because quantification at Head-Smashed-In was conducted using NISP values due to the high degree of fragmentation and the infancy of new quantification methods. However, important trends are identified, including the lack of cranial elements, majority of which are petrous portions similar to Fincastle, and minimal hyoid evidence. The same description of tongue removal is used by these researchers, using the absence of hyoids as an indicator of their removal. Brink and Dawe do not explain how the tongue is removed, or how the hyoid is evidence of this. Instead, similar trends identified in the other site comparison articles are repeated. Further, the inability to compare beyond NISP complicates the comparison between sites, which hinders the ability to better understand the patterns across bison kill sites. The lack of mandibles limits the seasonality estimate, but the winter resource acquisition narrative takes over when there are no other data to draw conclusions from. The DCI analysis of eight mandibles from the Kooyman excavation does not provide further clarity as the seasonality estimates range from mid-June to late March, almost a complete year. The foetal bones may provide some correlation, but insufficient information has been recorded on bison foetal development to narrow down seasonality. Therefore, the methods suffer from the same inability to provide an accurate seasonality estimate of the assemblages.

Melhagen (EgNn-1), Saskatchewan

Melhagen is a Besant bison pound in south central Saskatchewan, dating to approximately 1960 ± 90 CAL BP (Ramsey 1991). The site was excavated in the early 1960s by the local chapter of the Saskatchewan Archaeological Society (SAS) and then subsequently in the 1980s by Ramsey. The material excavated by the SAS is referred to as the Phenix collection. The site represents a single bone bed that was at least partially covered by aeolian sand and an increasing water table by a nearby slough. Ramsey (1991) suggests that the hunters herded the bison into a surround, involving the natural topographic drop with a constructed pound feature, although there is no evidence of postholes or structures. Ramsey argues for winter seasonality, hypothesizing that the structure would have been put into ice or barely into the ground, leaving no evidence behind. Their analysis identified 170+ bison, including the Phenix collection, although Ramsey estimates less than 25% of the site had been excavated (p. 2). It is not clear how Ramsey estimates 170+ bison from the quantification tables. Further, through a mandible age and element fusion analysis they concluded there were no calves less than 2 years old, and only two mature animals older than 10.

Ramsey identified few cranial bones in the Phenix collection or during the course of excavation. They did note that the auditory meatus (petrous portion) and maxillary teeth provided evidence of the cranium, similar to Fincastle. There were 23 fragments (9 left and 14 right) of the petrous portion, for an MNI = 14. This is a significantly lower MNI than what is presented by the mandibular third molar (40 left and 50 right), which was used it inform their quantification estimate (Ramsey 1991, p. 310). Ramsey explains that most mandibles at the site were broken at the articular condyle, with the condyles scattered throughout the site, positing that they were broken for marrow because their horizontal ramii had been chopped off. In terms of the analysis presented in this thesis, breakage at the condyles may indicate removal of the mandibles from the crania, similar to the Fincastle assemblage. Although the faunal data does not reveal the number of mandibles missing the articular condyles, the lack of cranial elements and mandible breakage pattern appears to be similar between the two collections (Figure 35). Unfortunately, Ramsey provides no discussion of hyoids or of tongue removal. Further, the hyoid is not included in the element lists or charts. It is unknown if any hyoids were recovered or if they were broken beyond recognition.

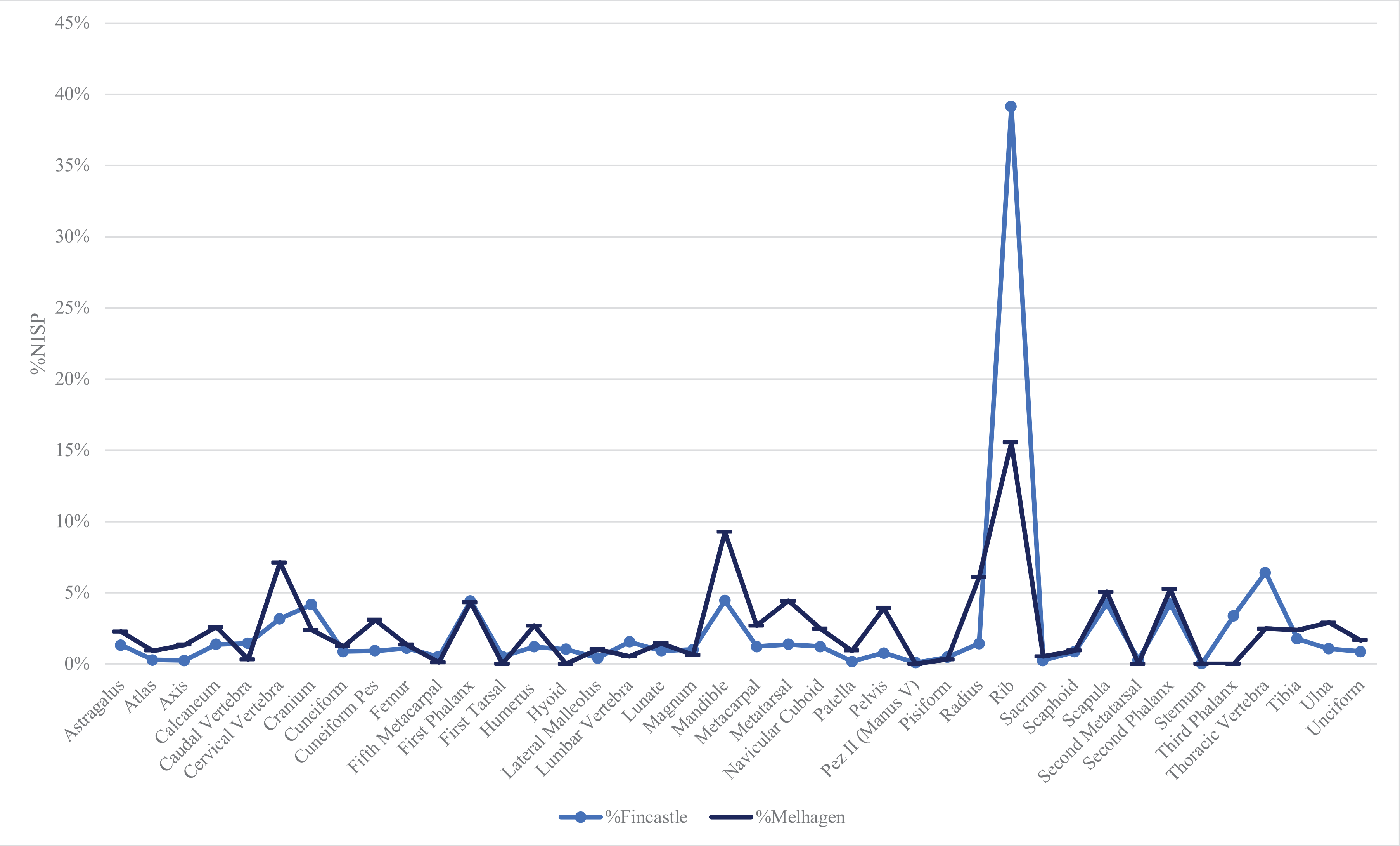

Figure 35: Fincastle and Melhagen %NISP comparison

A problem with the quantification methodology stems from the use of all M_3s, which has potential repercussions for contextualizing the kill event and ensuring reliable quantification values. Both articulated and loose M_3s were used, which may not provide context for the eruption schedule. Previously, Ramsey stated the Melhagen assemblage represents an attritional kill instead of a mass kill event because there were no animals represented under 2 years of age. The Fincastle collection demonstrated that the M_3 erupts in the second and third year of life, which means that it is still in the mandible or forming in the bone before this time. Additionally, the M_3 does not begin to show occlusal wear until 4 years of age. This would make it very difficult to assign an age to a loose M_3 that has no wear because it is only recently erupted into the mouth, from one that is still in the jaw before eruption. Therefore, without the context of the mandible, the teeth cannot be assigned a reliable age estimate. This may be why Melhagen is presented as an attritional kill; without the context of the mandible it is difficult to discern ages for young teeth.

A seasonality estimate was completed by an external dentition specialist, who used categories from Fuller (1959), Frison and Reher (1970b), and Reher and Frison (1980). Results of the seasonality estimate identified a wide range of time, from late fall to early spring (p. 165). However, Ramsey claims the site was in use during the winter because there is no evidence of the pound structure, which forms the basis of their hunting technique proposal.

Melhagen and Fincastle share a number of similarities, including the lack of evidence for a hunting structure. There is evidence at both sites for nearby water, and both present wide ranging seasonality estimates. While a winter seasonality estimate is plausible for both sites, evidence is unable to confirm this theory. Perhaps Fincastle and Melhagen represent similar hunting and cranial removal strategies, which would indicate why similarities are noted between their assemblages. As explored in Chapter 4, the age categories used yield a time span too wide for seasonal certainty.

In summary, the Melhagen site presents a useful comparison for the Fincastle site. Both mass bison kill events date to the Besant time period and, precluding other arguments, evidence some form of a surround or ambush strategy. The similarity of the petrous portions recovered from the site without any complete crania parallels Fincastle, although Ramsey does not include any other information or hypotheses on why there are few cranial remains. The lack of discussion of relating to the hyoid begs the question as to whether it was removed, broken, or unrecognizable during the excavation and analysis. Lastly, the seasonality estimates continue to use the dentition methodologies employed by previous researchers, although they concede there is more variation than a late fall kill. Issues surrounding the quantification and age analysis were addressed through examining the importance of understanding dental eruption and wear contextualized by articulated molars.

The Crowsnest River Kill Site (DjPm-80), Alberta

The Crowsnest River Kill site and the Castle Forks Buffalo Jump are protohistoric sites excavated as a part of the Oldman Dam Project in the late 1980s. Both of these sites will be discussed in this section because their assemblages mirror Fincastle, they employ similar methodologies given their late time frame, and they have a high number of canid remains. Each site is reviewed separately and then discussed together in the conclusion.

The Crowsnest River Kill Site is located on the north side of the Crowsnest River on a low terrace beneath a sandstone cliff. The bone bed represents a single component kill; likely the result of a horse-mounted bison jump because the upper terrain would make a pedestrian hunt difficult. The site was radiocarbon dated to 290 ± 160 BP, and two late prehistoric projectile points were recovered during excavation (p. 41 & 143). The bone was extremely well-preserved, and "fresh looking" (Landals 2009 p. 31). The author recovered 12,543 identifiable bison elements with an MNI of 16, and 437 identifiable canid elements with an MNI = 7 (p. 32 & 38). Landals argues for a gourmet butchering strategy, where only the desirable or choice meats were removed from the bison. Extensive carnivore scavenging, including by canids, did not drastically change the composition of the bone bed.

The hyoid and sternum have the lowest quantification values in the assemblage, under 25%. As a result of the excellent preservation, differential preservation is an unlikely explanation for their absence. Landals argues the sternums were simply broken beyond recognition during the butchering process. The poor representation of the hyoid was attributed to tongue removal, implying the hyoid's removal with the tongue from the bone bed (p. 32-34). The %MNI cranial value is 63%, although Landals does not detail what cranial elements are present. It is implied the cranial fragments have equal representation and would pair well with a gourmet butchering strategy, as the crania were left behind. This quantification comparison only compared %NISP values as it was unclear how the quantification values were achieved (Figure 36). There are interesting trends in the element representation, specifically the high number of cranial elements, and the lower number of mandibles. This is different from Fincastle where the %NISP values are similar.

Landals argues for a winter seasonality of the site, from mid-December to mid-February based on the distribution of age and sex among the bison. She identified a minimum of seven mature males, three mature females, four immature calves, along with several foetal elements. Landals argues the small herd size along with the distribution of males and females with yearlings is characteristic of a wintering herd. Further, Landals uses the dentition scheme from Frison and Reher (1970b) and Frison (1976), which produced a seasonality estimate of half year intervals. However, based on the fusion of the long bones and presence of foetal remains Landals refines the estimate to better fit from mid-December to mid-February. Landals highlights some drawbacks to the dentition methodology, including the potential variability from analyzing wear patterns from animals that lived thousands of years apart and in different environments. The impact of species evolution, along with different environmental factors, has garnered some attention in the literature but the potential impacts have yet to be fully recognized.

Landals used canid remains as another line of evidence for seasonality. Of the seven canid individuals, six were classified as very large domestic dogs, and one was classified as a wolf/dog hybrid with an emphasis on the former (Landals 2009 p. 38). There was no evidence of the canids being killed for food, or any removal of carcass portions as there was equal representation of all the elements. Landals hypothesizes the canids were potentially killed for their pelts, as hunters and trappers in the late 1700s were poisoning bison carcasses as a proxy to kill the canids that would scavenge sites. This activity was documented as occurring in the winter when the pelts were the thickest, which would corroborate the winter seasonality conclusion. Landals uses multiple lines of evidence for seasonality, which strengthens the overall site seasonality estimate. Further, by acknowledging potential flaws in the dentition methods, the presentation of her overall argument appears stronger as she accounts for plausible variability in the seasonality results.

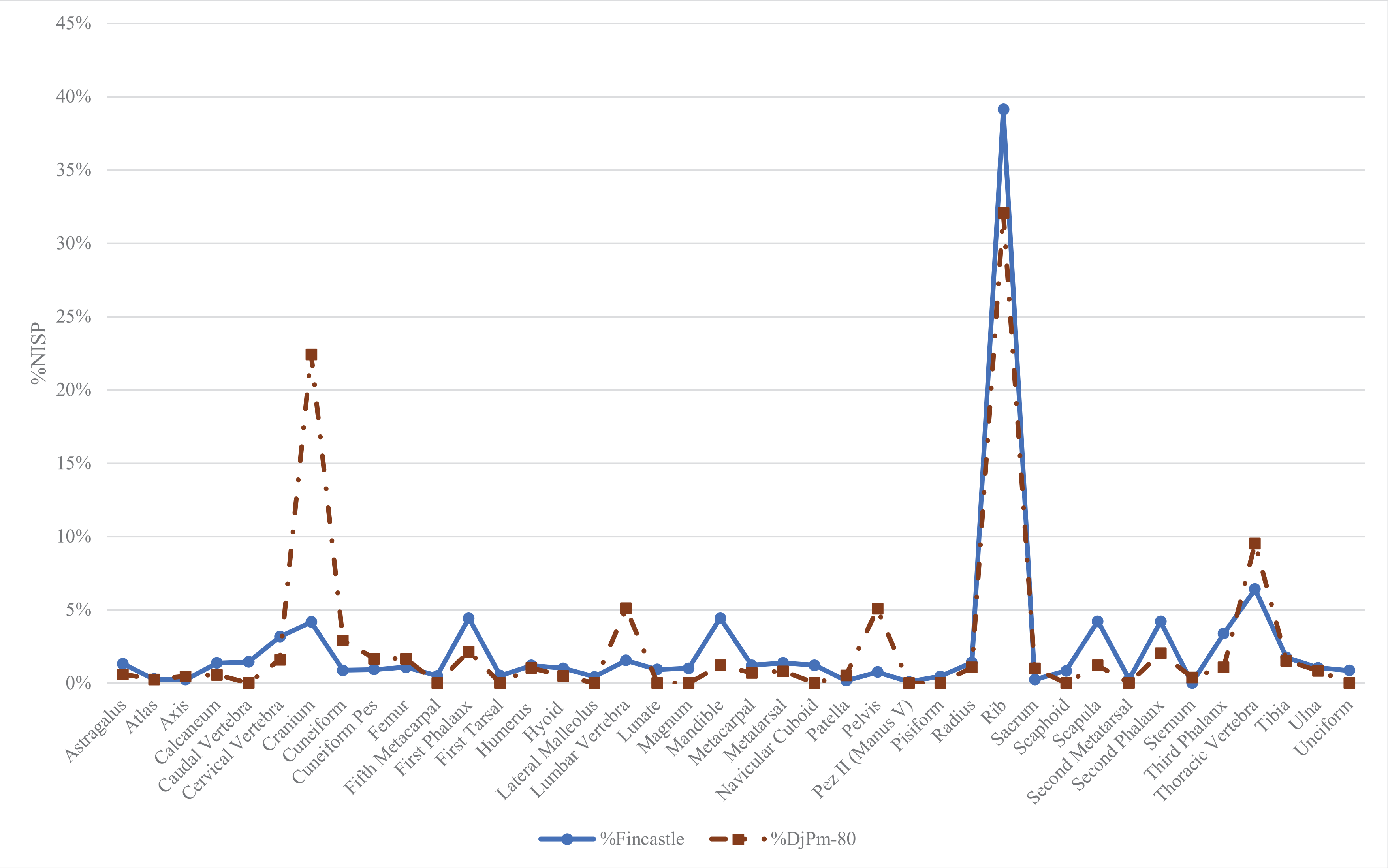

Figure 36: Fincastle and DjPm-80 %NISP comparison

Castle Forks Buffalo Jump (DjPm-126), Alberta

The Castle Forks Buffalo Jump is a multicomponent kill site on the southside of the Oldman River. The full extent of the bison bone bed cannot be accurately estimated as it is believed extensive alluvial erosion has washed away portions of the original bone bed. There were four identifiable cultural layers discovered during excavation, however, only Cultural Unit 1, the dense bone closest to the surface, will be highlighted here. The bone bed is a result of a bison jump and was radiocarbon dated to 290 ± 90 BP. Two metal trade points recovered during excavation confirmed the dense bone layer dates to the protohistoric (p. 145). The older cultural layers have sparse faunal assemblages and represent temporary camp sites.

Cultural Unit 1 (CU 1) is a bone bed with excellent preservation, as demonstrated by the preserved costal cartilage. It is theorized the site was covered rapidly by both alluvial and colluvial processes, thus both carnivore and rodent scavenging is rare. The NISP is 16,531 for bison with a MNI of 23 from both the atlas and axis, which demonstrate little to no breakage. The sex of the herd is largely biased towards males based on the large skull portions recovered, nine of which are classified as males. Additionally, there were 15 large canid fragments, and 19 medium sized canid fragments with relatively equal representation of portions. The MNI of the canids was estimated at two, one large canid and one medium canid. These canid remains had no evidence of butchering or consumption.

The Castle Forks Buffalo Jump has excellent preservation, similar to Fincastle, due to rapid burial. Further, it has a high number of preserved mandibles, but the mandibles largely represent older individuals, and they were used as choppers. Therefore, seasonality could not be accurately determined because of the lack of juvenile dentition. Additionally, there was a high number of discarded and butchered hyoids which were used as evidence of tongue removal.

Landals argues the hyoids were discarded immediately after the removal of the tongue. This differs from the interpretation presented at the Crowsnest River kill site, where the hyoids were removed from the site with the tongues. Landals describes two different explanations for the presence and absence of hyoids, although they both date to the protohistoric time period. However, in neither report does Landals explain how the hyoids are evidence of tongue removal, other than being related to the tongue. Broadly, the DjPm-126 assemblage is similar to the Fincastle assemblage (Figure 37). The major differences are in the cranium, first phalanx, second phalanx, and thoracic vertebra. Cranial fragments are 4% NISP at Fincastle, compared to 23% at DjPm-126. Although, the mandibles are comparable, which may indicate that some mandibles were broken when used as expediency tools, because their values do not match the cranial values. There is no evidence of mandibles being used as expediency tools at Fincastle to date. The lower cranial representation at Fincastle evidences the low number of cranial fragments in the collection. The similar NISP rib values indicate there is a high degree of fragmentation occurring, likely as a result of the butchering activity. This may indicate a similar butchering strategy, even though the sites are from different time periods.

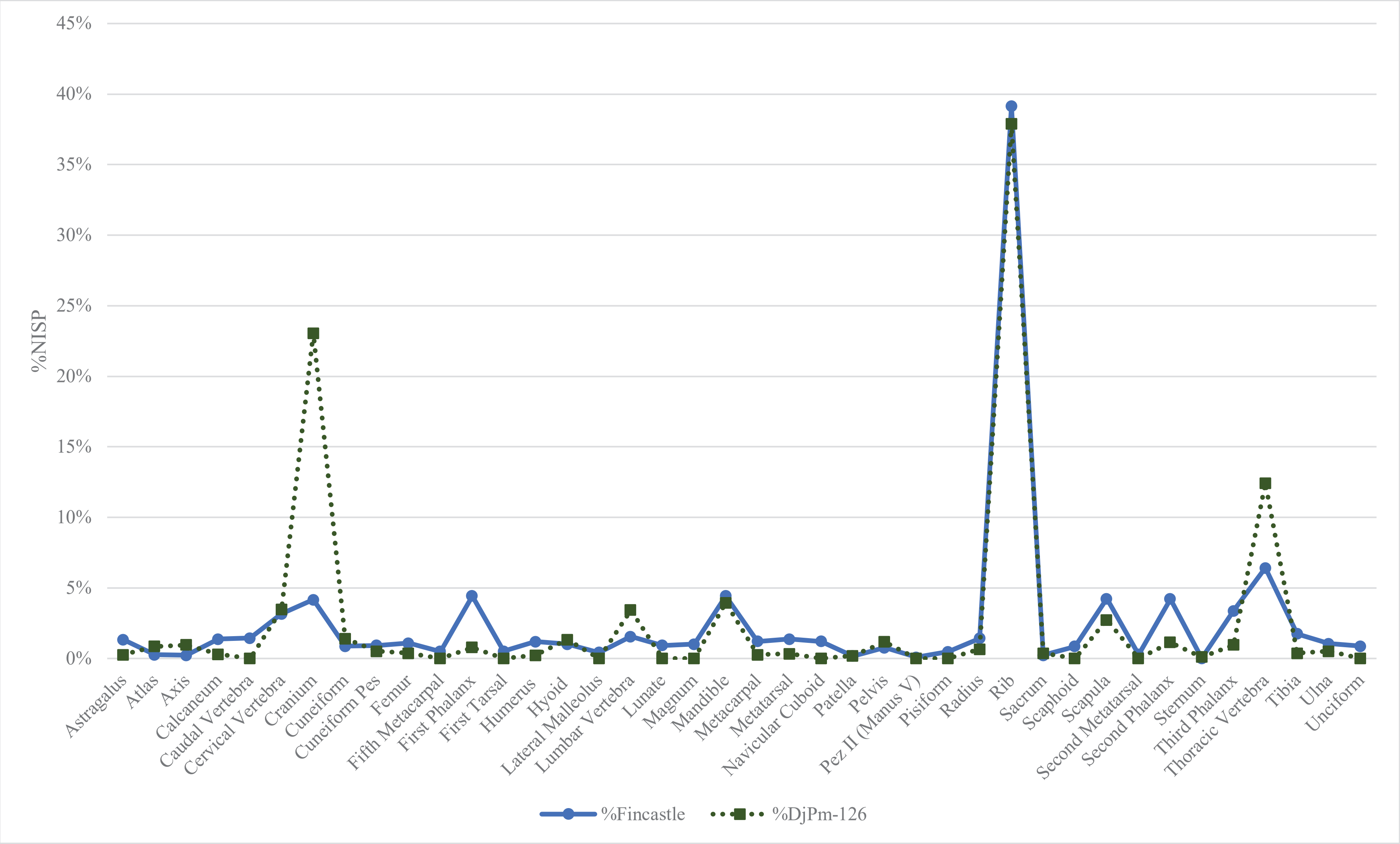

Figure 37: Fincastle and DjPm-126 %NISP comparison

Both of the Oldman River Dam sites discussed in this section date to the protohistoric time period, in contact with European trade goods. Although dating to approximately the same time period, they evidence two different butchering strategies, even though the same hunting technique was used. The Crowsnest River kill site represents a gourmet butchering strategy, evidenced by the taking of only choices pieces of meat, leaving large portions articulated, and the fairly even representation of skeletal elements. In contrast, the Castle Forks buffalo jump represents an acquisition butchering strategy where whole portions were removed for further processing at another location, leaving the axial skeleton at the kill area, which denotes heavy or intensive butchering. While the seasonality cannot be compared because of the lack of reliable and unbroken dentition at Castle Forks, the assumption that the herd is mostly males differs from the mixed male-female herd at Crowsnest. This could mean different seasons are represented, which might help to differentiate the two different butchering patterns, but regardless, they reveal different butchering processes carried out in the same time period using the same hunting strategy. Further, two different hyoid evidence strategies are presented. While it is likely multiple techniques were employed in the past for tongue removal, there is no explanation for how the tongue was removed. Similar to Fincastle, evidence of canids in the assemblage presented additional reasonings for their presence, including both as scavengers and pelt acquisition. The high cranial values compared to the frequency of mandible fragments at DjPm-80 and DjPm-126 may indicate a different processing strategy than identified at Fincastle (Figure 38). The high number of cranial %NISP values at these sites indicate the abundance of these cranial fragments compared to the relative absence mandibular fragments. At Fincastle, there was limited evidence for cranial fragments, indicating their removal. Therefore, it is possible that the mandibles were being used in a different way at these sites, namely as expediency tools as noted by Landals.

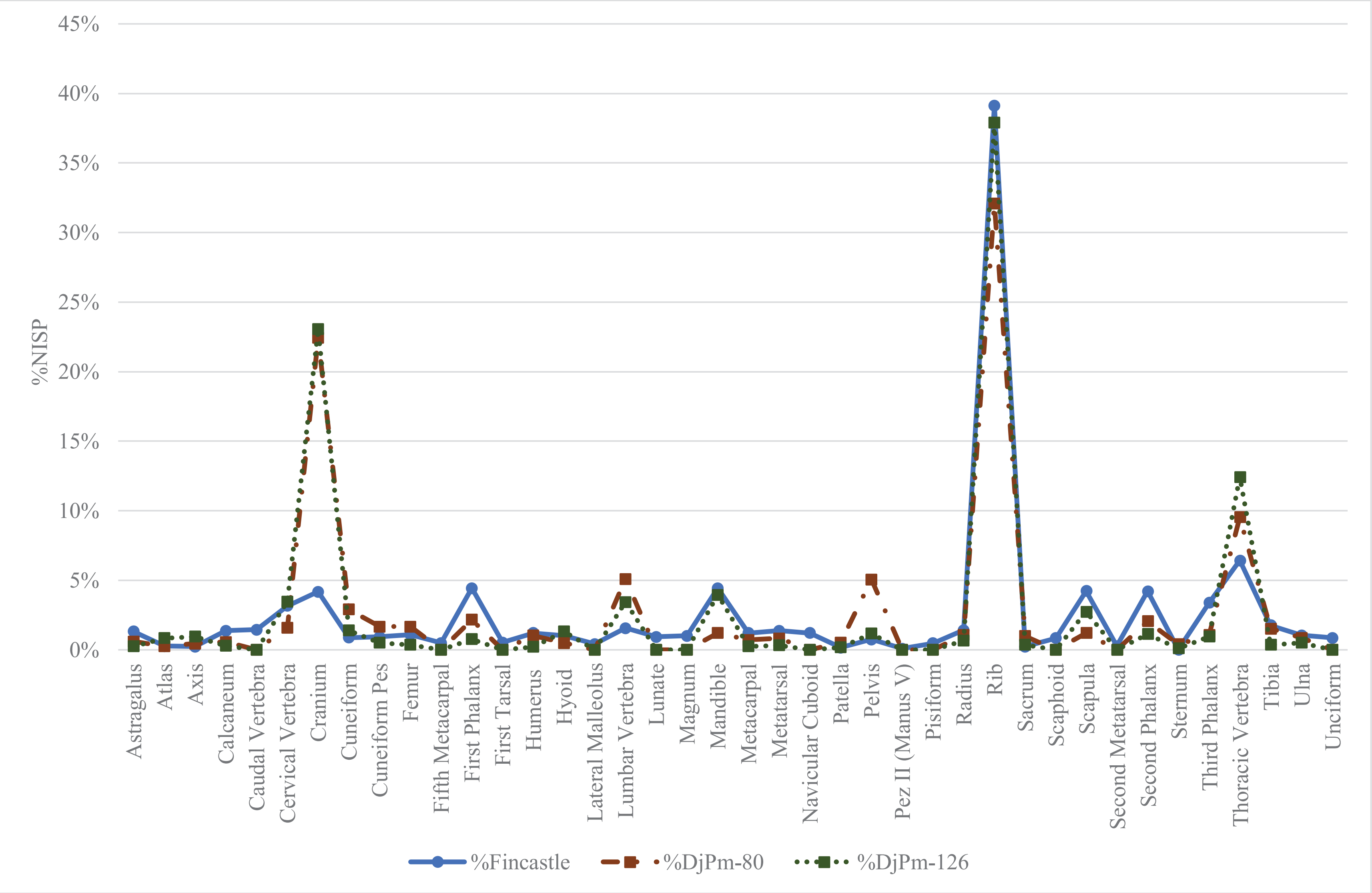

Figure 38: Fincastle, DjPm-80, DjPm-126 %NISP comparison

The Ruby Site (40 CA 302), Wyoming

The Ruby site consists of a bison pound, processing area, and associated ceremonial structure located in the Powder River Basin in Wyoming (Frison 1971). The site was radiocarbon dated to 1670 ± 135 BP, or the Late Middle Prehistoric period (p. 77). Evidence of pound construction was found as wood fragments in the postholes, which were secured by placing additional bison bone around the posts (Frison 1971, p. 80). There is little fauna data published from the Ruby site, preventing an assemblage comparison. The majority of this comparison will be focused on the conclusions drawn from the article, including seasonality and butchering. The site comparison is hindered as there is no way to corroborate the claims due to the lack of published data for the reader to verify.

Mandibles were found often paired but separated from the crania, which Frison credits to removal of the tongues (pg. 83). This is not explained in further detail, nor is the hyoid used as evidence in this claim. No information is presented on the hyoid for the Ruby site. Crania were removed from the pound and processing area and were uncovered in an associated ceremonial structure. The ceremonial structure is approximately 275 m away from the furthest edge of the processing area, six metres from the pound, and two metres away from the closest drive lane which may indicate a closer relationship with preparation for the hunt instead than the butchering of the animals. The structure measures approximately 12 m by 4.5 m round and is outlined by several postholes filled with elements, including thoracic vertebra. At the south end of the structure are six complete bison crania all lacking mandibles. There are two additional crania within the structure that may have been a part of the original cranial display. There was only one artifact found within the structure, which Frison uses as an indicator that the structure was used for ceremony instead of as habitation or a working area (p. 85). It is unclear from the article if there were no cranial elements found in the pound or processing area, as Frison states, “skull deterioration was so complete as to leave no proof of brain removal” (p. 83). There are no quantification values for the Ruby assemblage, and without any NISP or MNI estimates, there is no way to know if the eight crania uncovered in the ceremonial structure are indicative of the quantities in the assemblage. Further, if Frison states cranial deterioration was extensive, does this indicate that there are other cranial elements? If so, why were some cranial pieces removed while others were left to deteriorate? Is it possible that the eight crania uncovered were placed there before the hunt, and represent animals from another hunt? It is plausible that a ceremonial structure would be built before the hunt. Without further information from the Ruby collection, this remains speculation for now. However, there might be an analogous similarity between Fincastle’s Feature 7 and the Ruby site, as there is some evidence that the mandibles represented in Feature 7 do not match well with the rest of the assemblage. This may indicate there are elements being intentionally brought in from other kills in preparation for the current hunt.

Seasonality estimates were succinctly summarized as, “calves in the pound were four to six months of age, “ which fit with a mid-April to mid-June calving window (p. 87). These age estimates provided a seasonality estimate of late September to early November, although Frison states, “October was apparently the central month of communal bison procurement without horses” (p. 87). Frison used the methodology developed for the Glenrock assemblage, although does not provide the same detailed level of analysis in this publication. There is no indication of how many animals are in each cohort, or the ratio between juvenile and adult animals. There were no foetal bones found in the primary butchering area, but some were identified in the processing area. Frison does not provide details on the developmental age of the bones or use them for a seasonality assessment.

Overall, Ruby is an interesting site for comparing against Fincastle, largely because of evidence of cranial separation and transportation to a separate part of the site. Similar features have yet to be uncovered at Fincastle, but the lack of cranial elements in the assemblage to date leads one to wonder if they were removed elsewhere. It would be useful to have faunal data tables to compare the two sites, but trends between them are noted. Ruby would be a better comparison if information was available on element frequency and portion, as the site is renowned for it its hunting and ceremonial structures.

Hudson-Meng (25 SX 115), Nebraska

Hudson-Meng is a controversial bison bone bed in Nebraska of Paleoindian age, radiocarbon dated to between 9,800 and 9,300 BP (Barg 2013, p. 1). The site has already been discussed in the cranial chapter, but the published evidence from several excavations will be evaluated here. It was initially believed that the site represented a secondary processing area from a nearby jump, which Agenbroad (1978) concluded because of the lack of crania in the assemblage. However, recent excavations and re-examination of the assemblage has led to varying interpretations, including multiple bone beds of both natural and cultural origin (Barg 2013). While the nature of the bone bed is still questioned, zooarchaeological research, including quantification through element portion and mandibular analysis, has been completed.

There have been three major excavations of this bone bed. The site was first excavated by Agenbroad (1978) when the site was reported by local ranchers due to the immense amount of bison bone. Second, by Todd and Rapson (1999) whose intention was to determine the nature of the bone bed. Lastly, excavations carried out by field school students from St. Cloud State University expanded the initial excavations to reconcile the competing theories of the bone bed formation. Unfortunately, there is little data presented in the way of faunal tables, which hinders the comparison between Fincastle and Hudson-Meng. However, the researchers from all three excavations did highlight element trends that will be the focus of this comparative analysis.

Agenbroad (1978) claimed the bone bed had to be of cultural origin due to the lack of complete crania in the assemblage. However, in their re-examination of the Hudson-Meng assemblage, Todd and Rapson (1999) identified clusters of cranial elements, indicating that skulls had deteriorated in situ (p. 489). Mandibular studies from the initial excavations confirmed, “the kill took place from mid-October to mid-November, based on a tooth eruption pattern of the calves,” using methods derived from Frison and Reher (1970b), Reher (1973); (1974), and Frison (1976) (p. 33). Approximately 70% of the mandibles excavated had the ascending ramus broken, which Agenbroad uses as evidence of removing the mandible and tongue as a unit (p. 44). The dentition results from Agenbroad were used in both Todd and Rapson (1999) and Barg (2013) as evidence for the seasonality at the site, but it is unclear if any further work was done on the mandibles excavated. As mentioned in Chapter 4, this site was important for Agenbroad’s use of White (1953) as a line of interpretation for mandible and tongue removal. None of the subsequent projects on the Hudson-Meng assemblage have added to this interpretation or explained how the hyoid is evidence of this activity.

Hudson-Meng is included in this comparison chapter even though there is little faunal data to compare with Fincastle. It is a well-known site that suffers from many of the same methodological problems as other lesser-known sites. Additionally, it is one of the first projects to use White’s (1953) method and details evidence of petrous portions in the assemblage. Three different iterations of researchers have examined the Hudson-Meng site and all three have reached vastly different conclusions of the bone bed. Variable results are uncommon, however, the radical differences between natural and cultural origin leave the reader wondering how the researchers are reaching their conclusions. With little to no explanation provided as support for these conclusions, attempting to compare Hudson-Meng to other sites highlights the inconsistencies in the research to date.

Conclusion

The comparison of nine bison kill sites revealed interesting patterns for contextualizing the Fincastle assemblage. First, differences in element portion recording and publication make it difficult to confidently assess values beyond NISP because there is often little explanation for how NISP is turned into an MNI. Table 20, and Figures 39, 40, and 41 compare the NISP values aggregated for all the sites. Second, the cranial values are the highest among the protohistoric sites, with the Besant period sites and HSIBJ having the lowest values. Interestingly, Melhagen has the lowest cranial value, but the highest mandible value. This is a similar trend to Fincastle, which may indicate that the same cranial detachment and mandible removal activity was occurring. If more area of the Fincastle site is excavated, recalculating these numbers would be informative. This is in comparison to HSIBJ, which has very little cranial fragments recovered from the processing area. Fincastle has among the highest hyoid values, although lower than DjPm-126 and Glenrock. This indicates there are high number of hyoids in the collection, if the hyoid value from the Melhagen data was available this would be a useful comparison because of the similar trends in cranial and mandible values. Evidence of the petrous portion was sparse in the literature, although it was mentioned as evidence of the crania in several assemblages. Researchers should publish this information more readily in faunal tables, as repeatable portions may indicate cultural activities. When more information is accumulated across sites and assemblages, specifically relating to the presence and distribution of the petrous portion, in this case, researchers may be better able to understand its role in the archaeological record.

The methods of Frison and Reher (1970b) and Reher and Frison (1980) were used to analyze dentition and estimate seasonality at every site in this analysis, except HSIBJ. As HSIBJ only had one complete mandible in the assemblage; Brink and Dawe (1989) did not complete a dental analysis. However, Brink and Dawe (1989) supported the winter resource acquisition narrative and cited Frison (1978) as evidence for their claim. Few other sites used supplemental lines of evidence, and to varying success. Foetal bones were the most common evidence for fall or winter kills, but there is limited research on bison foetal bone development to confirm when the kill occurred. Table 21 provides a summary of the information presented in this chapter and highlights the consistency amongst seasonality methods.

The purpose of including these sites is to demonstrate the limitations of the analysis when data information is lacking for comparison, and the need for increased communication and clarity to better contextualize archaeological sites. Future studies of bison kill sites should include a critical reflection on the construction and implications of the methods used, as they impact cultural interpretations. Bison kill sites represent one of the most important ways to understand prehistoric lifeways in North America. Rigorous methods are vital for providing repeatable conclusions.

Table 20: NISP site comparison

NISP Site Comparison																
Element	**Fincastle**	**%Fincastle**	**EgPn-111**	**%EgPn-111**	**Melhagen**	**%Melhagen**	**HSIBJ 85/86**	**%HSIBJ**	**Glenrock 70**	**%Glenrock**	**Fitzgerald 96**	**%Fitzgerald**	**DjPm-80**	**%DjPm-80**	**DjPm-126**	**%DjPm-126**
Astragalus	158	1%	101	1%	22	2%	270	5%	212	3%	94	1%	17	1%	7	0%
Atlas	32	0%	74	1%	9	1%	7	0%	135	2%	50	1%	7	0%	23	1%
Axis	28	0%	69	1%	13	1%	5	0%	138	2%	37	0%	13	0%	26	1%
Calcaneum	163	1%	106	1%	25	3%	221	4%	219	3%	92	1%	16	1%	8	0%
Caudal Vertebra	172	1%	85	1%	3	0%	9	0%	21	0%	53	1%	-	-	-	-
Cervical Vertebra	377	3%	455	4%	69	7%	40	1%	468	7%	389	4%	45	2%	94	3%
Cranium	496	4%	942	9%	23	2%	182	3%	445	7%	778	9%	633	22%	625	23%
Cuneiform	104	1%	37	0%	12	1%	111	2%	-	-	60	1%	82	3%	38	1%
Cuneiform Pes	110	1%	45	0%	30	3%	132	2%	-	-	85	1%	47	2%	14	1%
Femur	130	1%	113	1%	13	1%	167	3%	76	1%	135	2%	47	2%	10	0%
Fifth Metacarpal	59	0%	8	0%	1	0%	9	0%	-	-	38	0%	-	-	-	-
First Phalanx	527	4%	239	2%	42	4%	536	9%	695	11%	328	4%	61	2%	21	1%
First Tarsal	62	1%	7	0%	-	-	16	0%	-	-	13	0%	-	-	-	-
Humerus	143	1%	121	1%	26	3%	236	4%	93	1%	179	2%	29	1%	6	0%
Hyoid	121	1%	61	1%	0	0%	1	0%	83	1%	59	1%	14	0%	36	1%
Lateral Malleolus	50	0%	23	0%	10	1%	85	1%	-	-	51	1%	-	-	-	-
Lumbar Vertebra	185	2%	412	4%	5	1%	42	1%	376	6%	298	3%	144	5%	93	3%
Lunate	110	1%	42	0%	14	1%	110	2%	-	-	81	1%	-	-	-	-
Magnum	120	1%	48	0%	6	1%	103	2%	-	-	73	1%	-	-	-	-
Mandible	528	4%	475	4%	90	9%	119	2%	212	3%	354	4%	34	1%	107	4%
Metacarpal	145	1%	86	1%	26	3%	234	4%	331	5%	78	1%	20	1%	7	0%
Metatarsal	163	1%	133	1%	43	4%	231	4%	351	6%	111	1%	23	1%	9	0%

Navicular Cuboid	145	1%	75	1%	24	2%	162	3%	-	-	96	1%	-	-	-	-
Patella	20	0%	31	0%	9	1%	79	1%	-	-	39	0%	15	1%	5	0%
Pelvis	90	1%	264	2%	38	4%	140	2%	158	3%	173	2%	143	5%	32	1%
Pez II (Manus V)	10	0%	5	0%	-	-	9	0%	-	-	-	-	-	-	-	-
Pisiform	56	0%	18	0%	3	0%	27	0%	-	-	52	1%	-	-	-	-
Radius	169	1%	119	1%	59	6%	377	6%	216	3%	157	2%	30	1%	18	1%
Rib	4658	39%	4307	40%	151	16%	391	7%	793	13%	3009	33%	905	32%	1028	38%
Sacrum	28	0%	138	1%	5	1%	10	0%	74	1%	27	0%	28	1%	10	0%
Scaphoid	101	1%	32	0%	9	1%	125	2%	-	-	70	1%	-	-	-	-
Scapula	503	4%	334	3%	49	5%	181	3%	186	3%	240	3%	34	1%	74	3%
Second Metatarsal	33	0%	1	0%	-	-	11	0%	-	-	-	-	-	-	-	-
Second Phalanx	501	4%	224	2%	51	5%	528	9%	-	-	305	3%	58	2%	31	1%
Sternum	2	0%	23	0%	-	-	1	0%	-	-	9	0%	11	0%	3	0%
Third Phalanx	402	3%	147	1%	-	-	261	4%	151	2%	262	3%	30	1%	26	1%
Thoracic Vertebra	764	6%	1053	10%	24	2%	93	2%	603	10%	713	8%	269	10%	337	12%
Tibia	209	2%	132	1%	23	2%	387	6%	100	2%	245	3%	43	2%	10	0%
Ulna	125	1%	109	1%	28	3%	222	4%	129	2%	85	1%	24	1%	14	1%
Unciform	103	1%	37	0%	16	2%	99	2%	-	-	67	1%	-	-	-	-
Total	**11902**	**100%**	**10731**	**100%**	**971**	**100%**	**5969**	**100%**	**6265**	**100%**	**8985**	**100%**	**2822**	**100%**	**2712**	**100%**

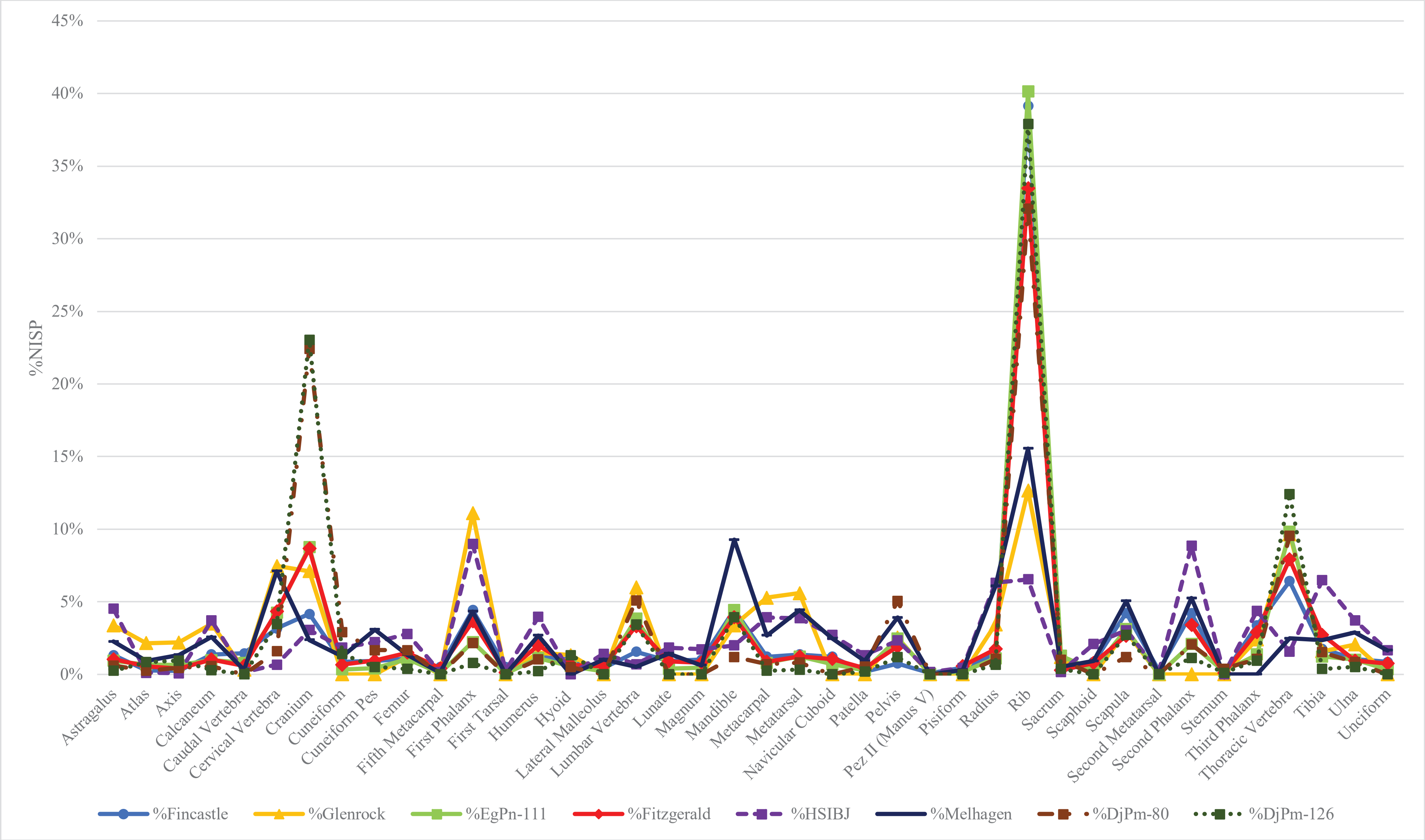

Figure 39: Inter-site %NISP comparison

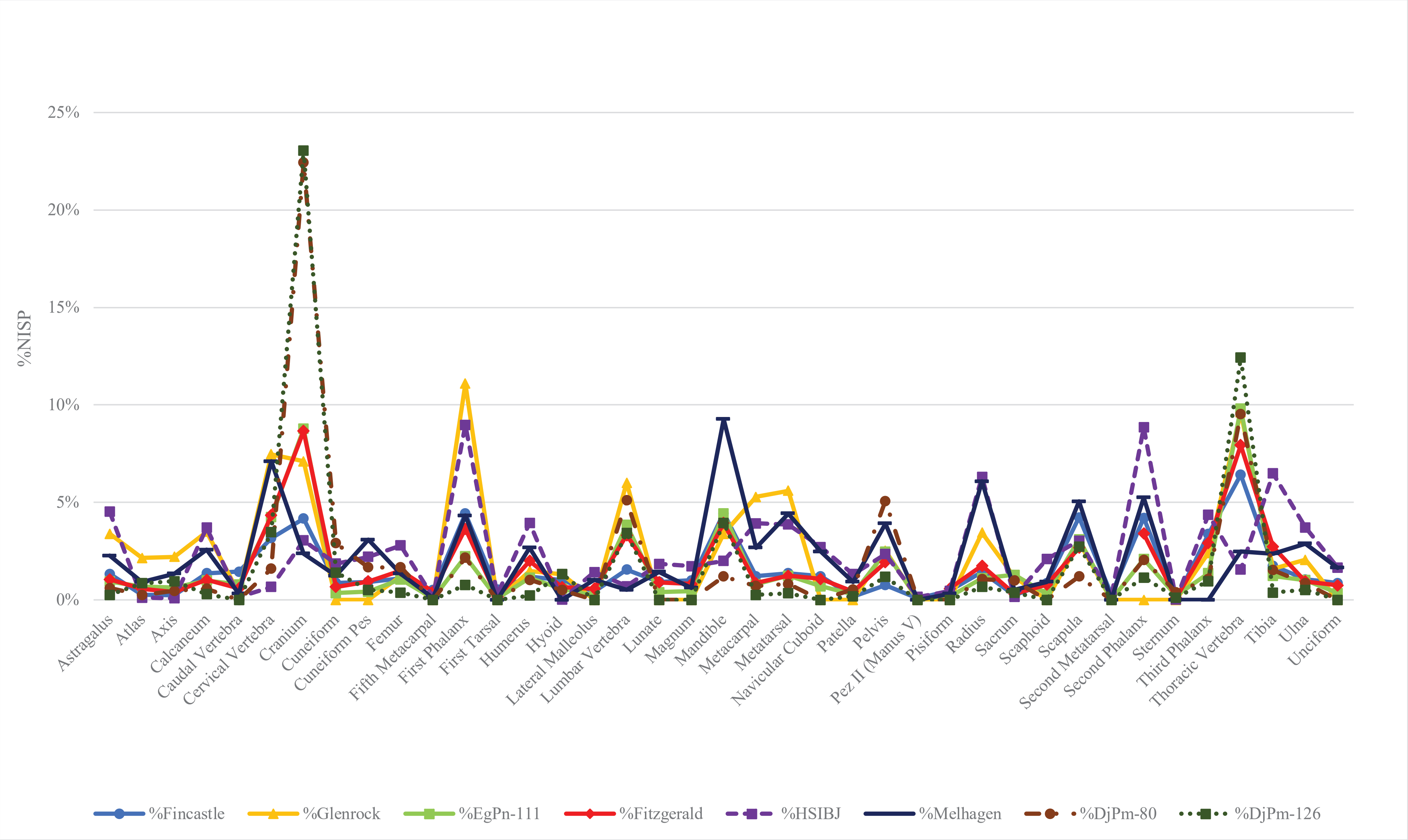

Figure 40: Inter-site comparison without rib

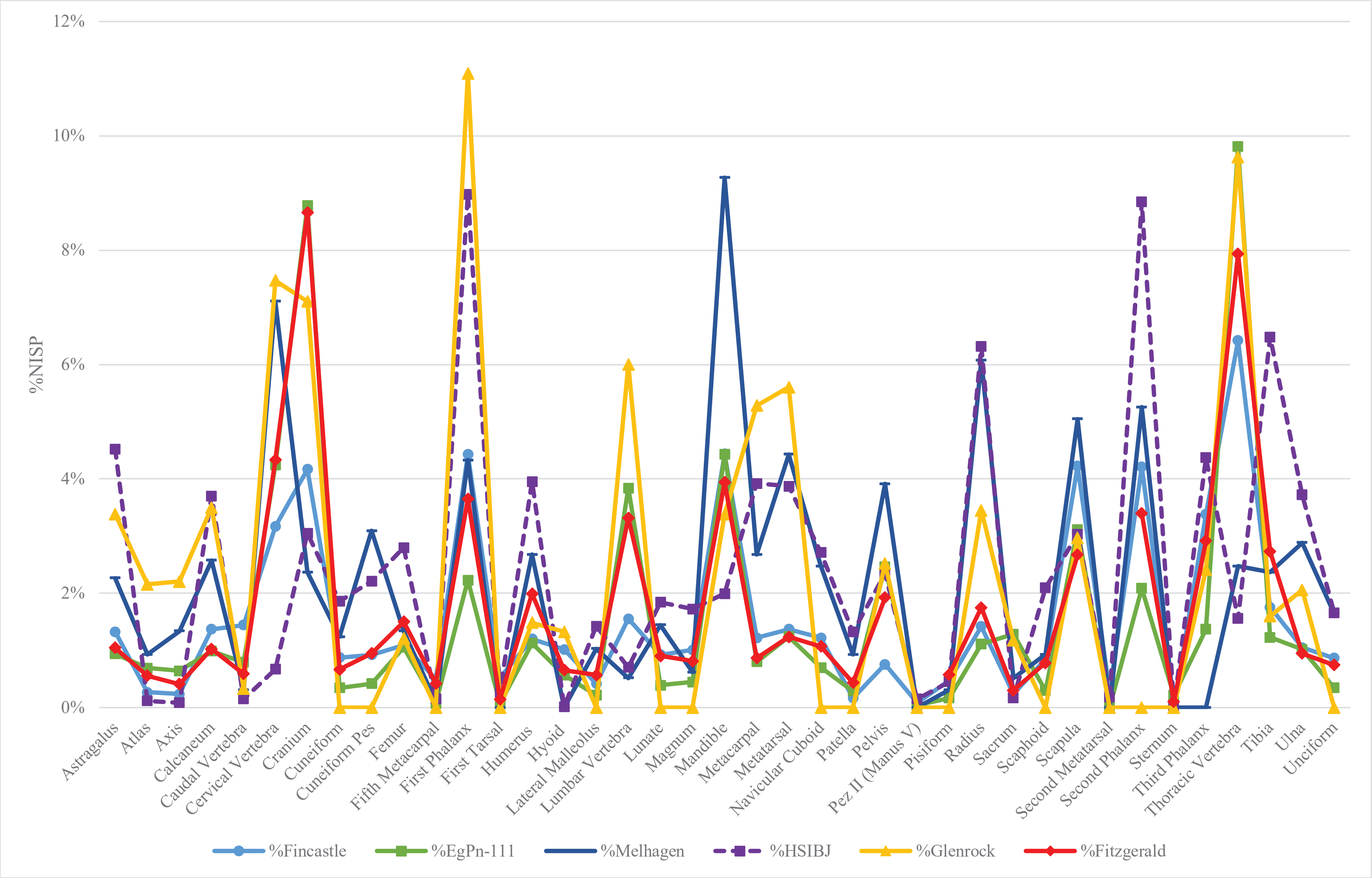

Figure 41: Inter-site %NISP comparison without rib and protohistoric sites

Table 21: Site comparison summary table

Site Comparison Summary Table								
Site	**Province/State**	**Radiocarbon Age**	**Cultural Affinity**	**NISP**	**MNI**	**Seasonality Estimate**	**Methodology Used**	**Source**
EgPn-111	Alberta	1410 +/- 60 BP	Besant	15180	48	Late Fall	Frison and Reher (1970b)	Head et al 2002
Fitzgerald	Saskatchewan	1300 BP	Besant	11287	49	Late Fall	Frison and Reher (1970b)	Hjermstad 1996
Glenrock	Wyoming	210 +/- 100 BP	Late Prehistoric	UID	UID	Late Fall	Frison and Reher (1970b)	Frison and Reher (1970a, 1970b)
Head-Smashed-In Buffalo Jump	Alberta	N/A	Late Prehistoric	UID	UID	Late Fall	Frison 1978	Brink and Dawe (1989)
Melhagen	Saskatchewan	1960 +/- 90 CAL BP	Besant	1020	90	Late Fall	Fuller (1959), Frison and Reher (1970b), Reher and Frison (1980)	Ramsey 1991
Crowsnest River Kill Site	Alberta	290 +/- 160 BP	Protohistoric	12453	16	Late Fall to Winter	Frison and Reher (1970b), extended by presence of foetal bone	Landals 2009
Castle Forks Buffalo Jump	Alberta	290 +/- 90 BP	Protohistoric	16531	23	UID	N/A	Landals 2009
Ruby	Wyoming	1670 +/- 135	Besant	UID	N/A	Late Fall	Frison and Reher (1970b)	Frison 1971
Hudson-Meng	Nebraska	N/A	Cody Complex	UID	N/A	Late Fall	Frison and Reher (1970b), Frison et al (1976)	Agenbroad (1978), Todd & Rapson (1999), Barg (2013)

Chapter 6: Conclusion

There are a few important points to summarize regarding the research in this thesis. First, element portions and fragments in the Fincastle assemblage were used to interpret cultural activity. Specifically, how the temporal petrous portion, mandible fragments, and hyoid were used as evidence for cranial separation and tongue removal was discussed from an osteologically and anatomically grounded analysis. A review of the literature revealed inconsistencies between historical accounts and archaeological interpretations. Close inspection of the faunal assemblage at Fincastle and other sites suggests that the tongue was removed through an incision in the throat, instead of through the mouth. Incisions on the lingual side of the mandibles near the dental row cannot explain damage or fragmentation to the hyoid, as the anatomical position hinders access to the hyoid through the mouth. Instead, when the hunter makes an incision in the throat of the bison, underneath the mandibles, the hyoid is more likely to be cut or fragmentated because the element is readily accessible from this positioning, as the tongue is anchored in the throat of the bison.

Second, the mandibles from Fincastle were examined using four methods to assign age and seasonality. The results support a fall kill event; however, the eruption and wear of the cusps and exostyles identified patterns that were not described in the methods. This includes the eruption of the M_3, wear patterns on the M_2 and M_3, and eruption and wear patterns of the exostyle. The patterns identified in this research indicate that either the methods used lack detail in their age estimate categories, or further research is needed to identify timing of these morphological changes. Future research in bison kill events in the Northwestern Great Plains should focus on improving understanding of bison dental morphologies and standardizing data recording. The creation of a standardized reference collection from archaeological and modern specimens would improve aging schedules.

Lastly, by examining element frequency and seasonality estimates from nine sites across the Great Plains the patterns in the Fincastle assemblage were contextualized. The comparison between sites was limited due to the inability to thoroughly compare data sets for the four quantification values: NISP, MNE, MAU, and MNI. When possible, %NISP values were used. Similar trends of cranial and mandible fragments were identified in the Melhagen assemblage, a Besant bison pound, but no information was published for the hyoid. Cranial elements were among the lowest values for all Besant sites, with mandibles consistently having higher comparative values. This may indicate a consistent trend during the Besant phase. This chapter also demonstrated that information on the petrous portion is sparse in the bison kill site literature but was noted as a common cranial element in the EgPn-111, Fitzgerald, HSIBJ, and Melhagen assemblages. Therefore, identifying the frequency of the petrous portion in future data sets will improve researcher's ability to connect the fragment to cultural activity.

Similar methods were used to assign seasonality for all the sites included in Chapter 5. Many of these methods have had a remarkable longevity in bison kill site analyses, in some cases over 50 years of use in the field. As a result of their longevity, their application is typically taken for granted. Some of the most recent zooarchaeological theses have used these methods to interpret their assemblages (Bugbee 2013, Ramsey 2020). This may unintentionally yield similar results because of the limitations of the methodologies. For example, when I used Frison and Reher's (1970b) method to assess seasonality at Fincastle, all of the mandibles were assigned a fall death (Figure 20). The other methods increased the seasonal variation, providing estimates from spring to winter. Although all the methods provided predominantly fall results, there were seasonality estimates that could not be explained by out-of-season births. Sole reliance on the Frison and Reher (1970b) method may not account for variation in mandible assemblages.

Proposals for Future Research

While traditional zooarchaeological analyses will continue, there is a move in the discipline to embrace new research avenues. Recently, two divergent paths of zooarchaeology have emerged. One branch is focused on the increasingly lab-based ZooMS, zooarchaeological mass spectrometry, in an effort to expand research into microscopic analyses. This research includes protein residue analysis, stable isotope analysis, and ancient DNA (Hill 2017, Larson et al, 2001 McGrath 2019, Steele 2015). Specifically, ZooMS ancient DNA has been proposed as a way to provide species identification for element fragments when traditional morphological analyses have failed (Steele 2015, p. 169). The other branch, influenced by trends in anthropological literature, is increasingly focused on examining the relationship between animals and humans. Referred to as social zooarchaeology, this research is driven by ontological questions of the experience of humans and animals existing within the same environment (Boyd 2017, McNiven 2010, Orton 2012, Overton & Hamilakis 2013, Russell 2011). No matter the branch or approach, traditional analyses serve as the foundation of their research. In a brief survey of social zooarchaeological literature, it is clear that traditional zooarchaeological analyses are commonly used in conjunction with anthropological theory. For example, Overton and Hamilakis (2013) used NISP, MNI, and a dental eruption chart to quantify and age swans at a Mesolithic hunting camp. The authors explored the ontological experience of hunting but used traditional methods to understand the scope of the assemblage. Brown and Emery (2008) analyzed element frequency to identify butchering patterns in their article on ritual hunting shrines in the highlands of Guatemala. McNiven (2010) identified a frequent cranial portion, similar to the petrous portion in this thesis, as evidence of ear-bone charms used in hunting rituals by Torres Strait Islanders. Hill (2017) used dentition and quantification methodologies to assess the state of the Scottsbluff bison bone bed before using stable isotope analysis to confirm their hypothesis that the assemblage suffered from severe taphonomic processes.

As the field expands, these traditional methods will remain as the foundation for theorizing new relationships and presenting new scientific information. However, using methods which require further refinement, such as bison dental morphologies, may skew interpretations provided by these new subdisciplines. Currently, little research has been conducted on Great Plains sites in these new streams, but it will occur. Stable isotope analysis is the most common foray but has mainly focused on canid remains (Bartholody et al 2017, Edwards 2016, Fisher 2019), although some research has been done on the Southern Plains (Carlson et al 2018).

There are four specific considerations for future research, all of which have already been discussed throughout this thesis but are worth reiterating here. First, the increased application of the Bone Unit identification manual for bison research studies will minimize inter-analyst variation. Second, the creation of a standardized reference collection for mandible and dentition analysis that accounts for spatial and temporal variation across species would improve understanding of dental morphological changes. This should include the use of modern specimens and should pay special attention to eruption and wear patterns of mandibular cusps and exostyles. Third, the element frequency patterns identified in the quantification process formed the foundation of a new hypothesis for cranial separation and mandible detachment. This thesis focused on cranial portions, mandibles, and hyoids but could be extended to limb segmentation, hide removal, marrow extraction, or grease rendering. Lastly, the Fincastle site is an outstanding assemblage that deserves a thorough and complete analysis to understand the unique hunting strategy and associated cultural activities. This thesis has only scratched the surface of the information zooarchaeology can reveal about this site. Hopefully in the future, someone will be able to use improved methods to interpret the cultural activity of the Fincastle site.

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Appendix I

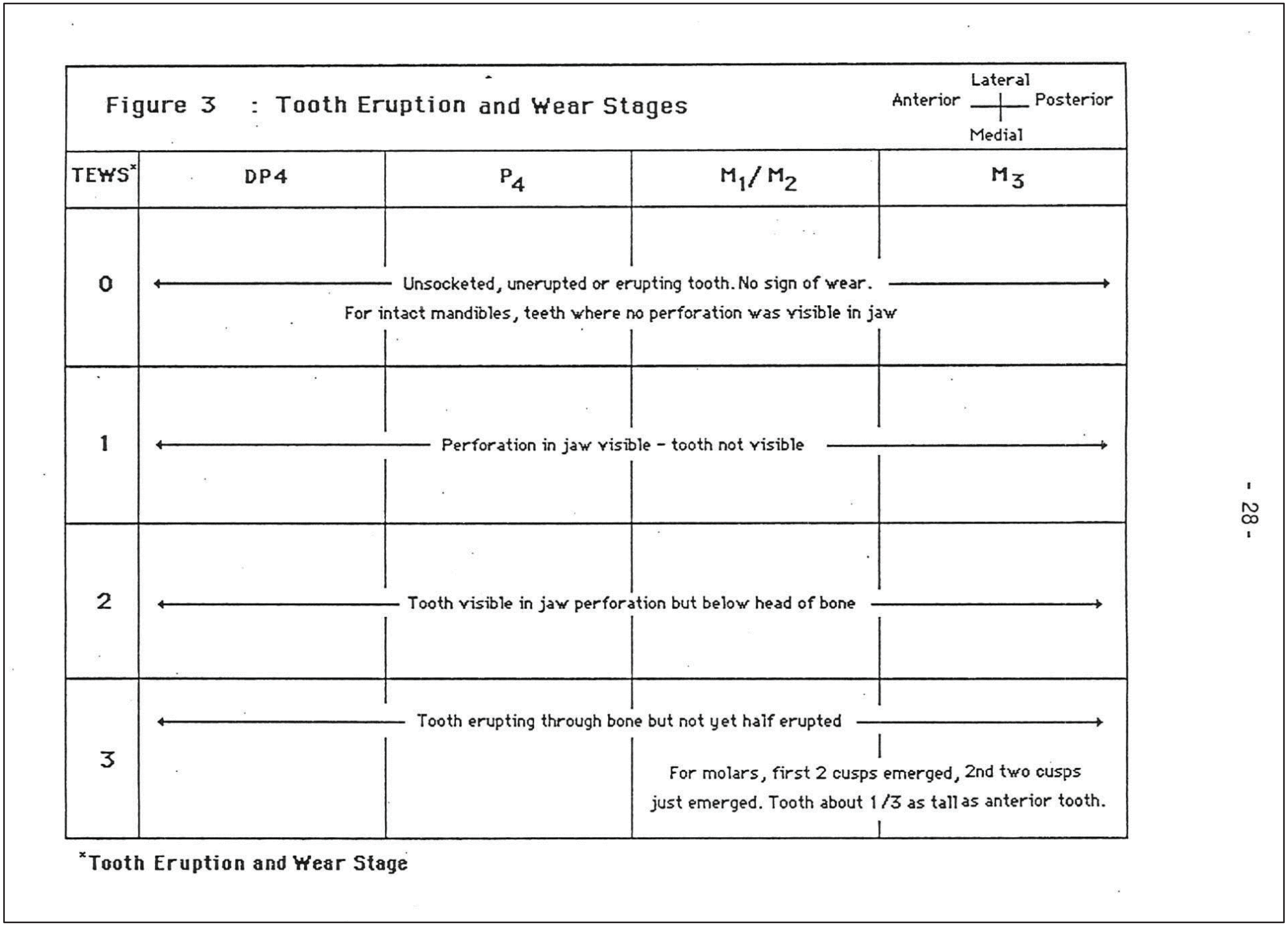


Figure 3 : Tooth Eruption and Wear Stages

Lateral
Anterior ┼ Posterior
Medial

TEWS*	DP4	P4	M1/M2	M3
0	← Unsocketed, unerupted or erupting tooth. No sign of wear. → For intact mandibles, teeth where no perforation was visible in jaw			
1	← Perforation in jaw visible - tooth not visible →			
2	← Tooth visible in jaw perforation but below head of bone →			
3	← Tooth erupting through bone but not yet half erupted →		For molars, first 2 cusps emerged, 2nd two cusps just emerged. Tooth about 1/3 as tall as anterior tooth.	

*Tooth Eruption and Wear Stage

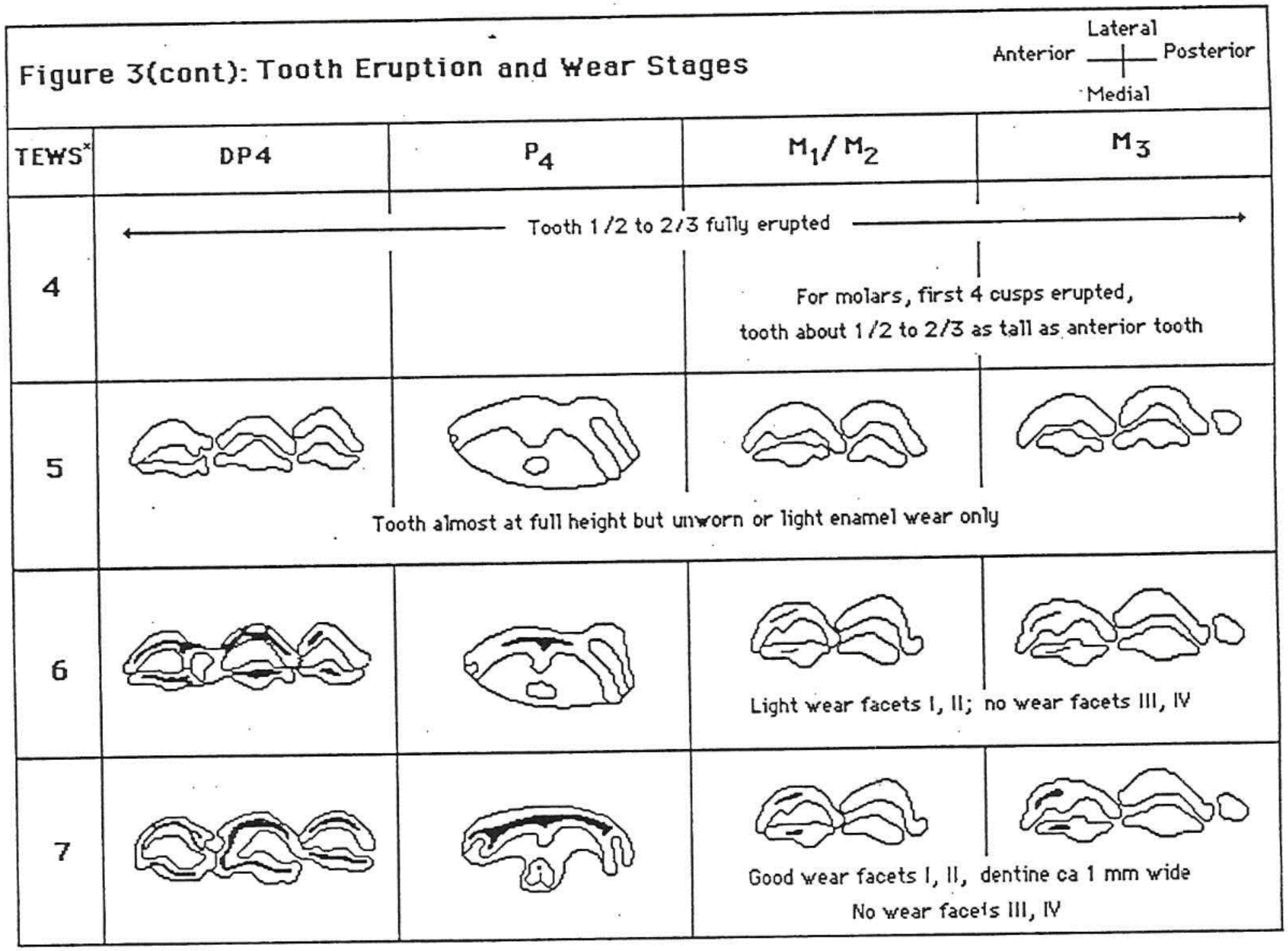
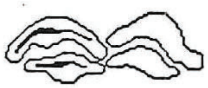
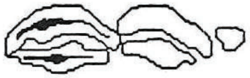
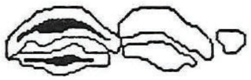
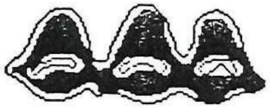


Figure 3(cont): Tooth Eruption and Wear Stages

*Tooth Eruption and Wear Stage

Figure 3(cont): Tooth Eruption and Wear Stages

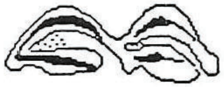
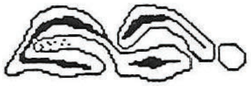
Lateral
Anterior —+— Posterior
Medial

TEWS*	DP4	P_4	M_1/M_2	M_3
8			 Good wear facets I, II, light wear on facets III, IV	
9			 Good wear facets I - IV	
10			 Good wear facets I - IV, light wear facets V, VI	
11			 Good wear facets I - VI	

*Tooth Eruption and Wear Stage

Figure 3(cont): Tooth Eruption and Wear Stages

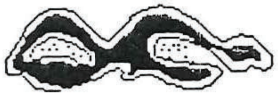
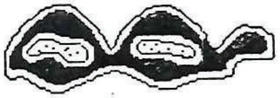
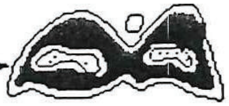
Lateral
Anterior — Posterior
Medial

TEWS*	DP4	P_4	M_1/M_2	M_3
12			 Good wear facets I - VI; light wear facets VII - VIII	
13			 Good wear facets I - VIII	
14			 Continued wear facets I - VIII	 Light wear facet IX or IX'
15			 Continued wear facets I - VIII	 Good wear facets I - IX'

*Tooth Eruption and Wear Stage

Figure 3(cont): Tooth Eruption and Wear Stages

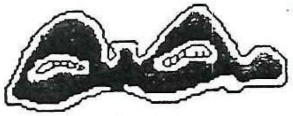
Lateral
Anterior — Posterior
Medial

TEWS*	DP4	P4	M_1/M_2	M_3
16				
17		Exostylid tip may be present and polished, but unworn →		
18		Exostylid tip worn, but no dentine showing →		
19		Exostylid tip worn dentine showing →		

*Tooth Eruption and Wear Stage

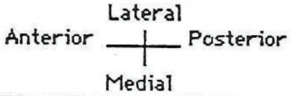
Figure 3(cont): Tooth Eruption and Wear Stages

Anterior — Lateral / Medial — Posterior

TEWS*	DP4	P_4	M_1/M_2	M_3
20				
21				
22				
23				

*Tooth Eruption and Wear Stage

Figure 3(cont): Tooth Eruption and Wear Stages



TEWS*	DP4	P_4	M_1/M_2	M_3
24				
25				
26			 Tooth crown gone. Only separate Socketed roots remaining	

*Tooth Eruption and Wear Stage

Table 3: Correlation of M1 Tooth Eruption and Wear Stages (TEWS) Defined Here in Relation to Age Values Presented by Reher and Frison

INDIVID. TOOTH	BRUMLEY TEWS	Reher &Frison E/W SERIES	EST. MEAN AGE IN DAYS			EST. CALENDAR DATE*		
			BEGIN	MID	END	BEGIN	MID	END
M1	0	-	?	-	126	-	-	Sep-18
M1	1	-	?	?	?	?	?	?
M1	2	-	?	?	?	?	?	?
M1	3	A	37	51	66	Jun-20	Jul-5	Jul-20
M1	4	B	66	81	96	Jul-20	Aug-4	Aug-19
M1	5	C	96	111	126	Aug-19	Sep-3	Sep-18
M1	6	1	126	141	156	Sep-18	Oct-3	Oct-17
M1	7	2	156	171	186	Oct-17	Nov-1	Nov-16
M1	8	3	186	201	216	Nov-16	Dec-1	Dec-16
M1	9	4	216	231	246	Dec-16	Dec-31	Jan-15
M1	10	5	246	260	275	Jan-15	Jan-30	Feb-14
M1	11	6	275	290	305	Feb-14	Mar-1	Mar-16
M1	12	7	305	320	335	Mar-16	Mar-31	Apr-15
M1	13	8	335	350	365	Apr-15	Apr-30	May-15
M1	14	-						
M1	15	-						
M1	16	-						
M1	17	-						
M1	18	-						
M1	19	-						
M1	20	-						
M1	21	-						
M1	22	-						
M1	23	-						
M1	24	-						
M1	25	-						
M1	26	-						

*ASSUMED DATE BASED ON A MAY 15 PEAK OF CALVING

Table 4: Correlation of M2 Tooth Eruption and Wear Stages (TEWS) Defined Here in Relation to Age Values Presented by Reher and Frison

INDIVID. TOOTH	BRUMLEY TEWS	FRISON/REHER E/W SERIES	EST. AGE IN DAYS			EST. CALENDAR DATE*		
			BEGIN	MID	END	BEGIN	MID	END
M2	0		?	-	491	?	?	Sep-18
M2	1		?	?	?	?	?	?
M2	2		?	?	?	?	?	?
M2	3	A	402	416	431	Jun-20	Jul-5	Jul-20
M2	4	B	431	446	461	Jul-20	Aug-4	Aug-19
M2	5	C	461	476	491	Aug-19	Sep-3	Sep-18
M2	6	1	491	506	521	Sep-18	Oct-3	Oct-17
M2	7	2	521	536	551	Oct-17	Nov-1	Nov-16
M2	8	3	551	566	581	Nov-16	Dec-1	Dec-16
M2	9	4	581	596	611	Dec-16	Dec-31	Jan-15
M2	10	5	611	625	640	Jan-15	Jan-30	Feb-14
M2	11	6	640	655	670	Feb-14	Mar-1	Mar-16
M2	12	7	670	685	700	Mar-16	Mar-31	Apr-15
M2	13	8	700	715	730	Apr-15	Apr-30	May-15
M2	14							
M2	15							
M2	16							
M2	17							
M2	18							
M2	19							
M2	20							
M2	21							
M2	22							
M2	23							
M2	24							
M2	25							
M2	26							

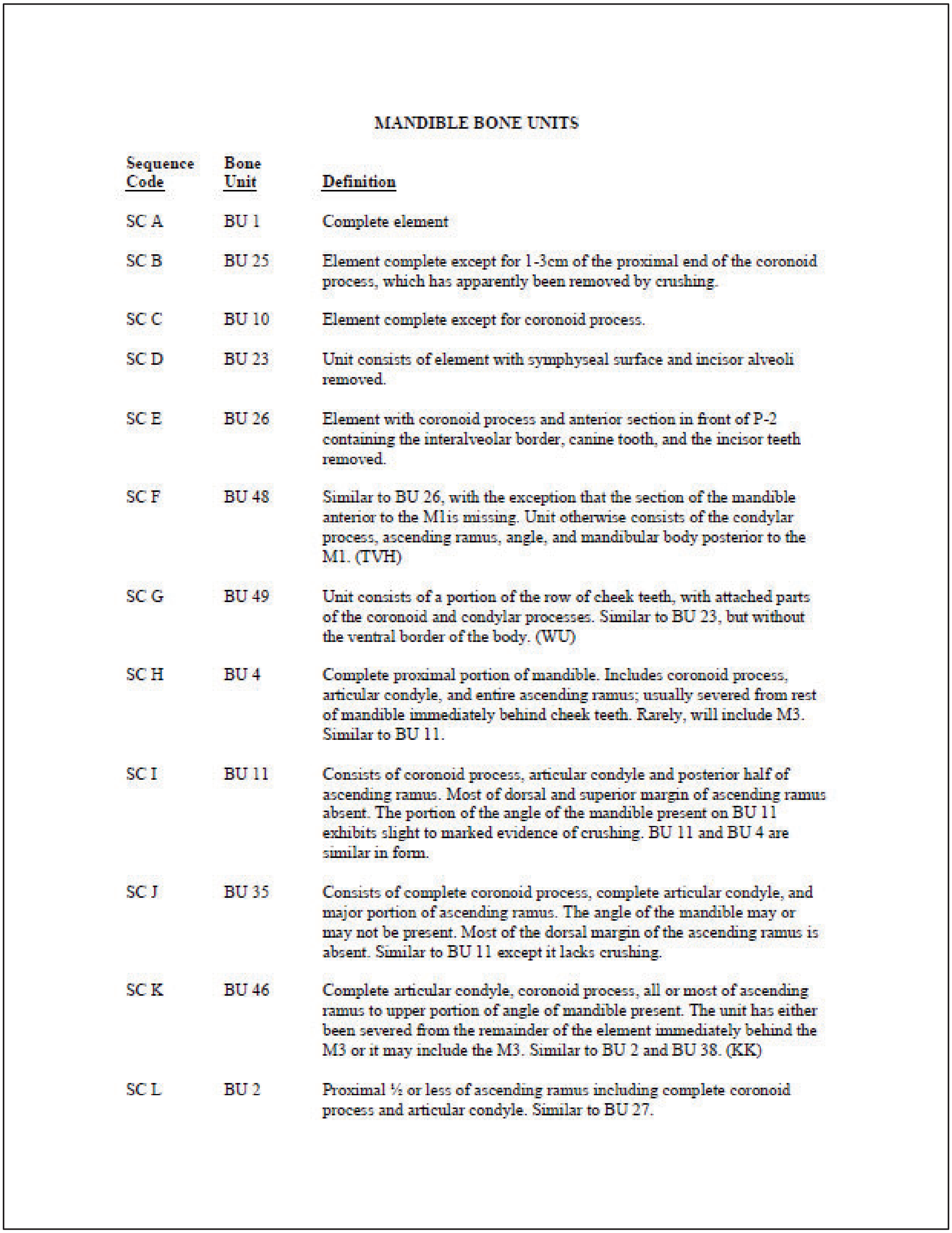
*ASSUMED DATE BASED ON A MAY 15 PEAK OF CALVING

Table 5: Correlation of ~~M2~~ M3 Tooth Eruption and Wear Stages (TEWS) Defined Here in Relation to Age Values Presented by Reher and Frison

INDIVID.	BRUMLEY	FRISON/REHER	EST. AGE IN DAYS			EST. CALENDAR DATE*		
TOOTH	TEWS	E/W SERIES	BEGIN	MID	END	BEGIN	MID	END
M3	0							
M3	1							
M3	2							
M3	3	A	767	781	796	Jun-20	Jul-5	Jul-20
M3	4	B						
M3	5	C		913			Nov-13	
M3	6	1		913			Nov-13	
M3	7	2						
M3	8	3		1095			May-14	
M3	9	4						
M3	10	5						
M3	11	6						
M3	12	7						
M3	13	8						
M3	14	9		1643			Nov-12	
M3	15	10						
M3	16							
M3	17							
M3	18							
M3	19							
M3	20							
M3	21							
M3	22							
M3	23							
M3	24							
M3	25							
M3	26							

*ASSUMED DATE BASED ON A MAY 15 PEAK OF CALVING

Appendix II



MANDIBLE BONE UNITS

Sequence Code	Bone Unit	Definition
SC A	BU 1	Complete element
SC B	BU 25	Element complete except for 1-3cm of the proximal end of the coronoid process, which has apparently been removed by crushing.
SC C	BU 10	Element complete except for coronoid process.
SC D	BU 23	Unit consists of element with symphyseal surface and incisor alveoli removed.
SC E	BU 26	Element with coronoid process and anterior section in front of P-2 containing the interalveolar border, canine tooth, and the incisor teeth removed.
SC F	BU 48	Similar to BU 26, with the exception that the section of the mandible anterior to the M1is missing. Unit otherwise consists of the condylar process, ascending ramus, angle, and mandibular body posterior to the M1. (TVH)
SC G	BU 49	Unit consists of a portion of the row of cheek teeth, with attached parts of the coronoid and condylar processes. Similar to BU 23, but without the ventral border of the body. (WU)
SC H	BU 4	Complete proximal portion of mandible. Includes coronoid process, articular condyle, and entire ascending ramus; usually severed from rest of mandible immediately behind cheek teeth. Rarely, will include M3. Similar to BU 11.
SC I	BU 11	Consists of coronoid process, articular condyle and posterior half of ascending ramus. Most of dorsal and superior margin of ascending ramus absent. The portion of the angle of the mandible present on BU 11 exhibits slight to marked evidence of crushing. BU 11 and BU 4 are similar in form.
SC J	BU 35	Consists of complete coronoid process, complete articular condyle, and major portion of ascending ramus. The angle of the mandible may or may not be present. Most of the dorsal margin of the ascending ramus is absent. Similar to BU 11 except it lacks crushing.
SC K	BU 46	Complete articular condyle, coronoid process, all or most of ascending ramus to upper portion of angle of mandible present. The unit has either been severed from the remainder of the element immediately behind the M3 or it may include the M3. Similar to BU 2 and BU 38. (KK)
SC L	BU 2	Proximal ½ or less of ascending ramus including complete coronoid process and articular condyle. Similar to BU 27.

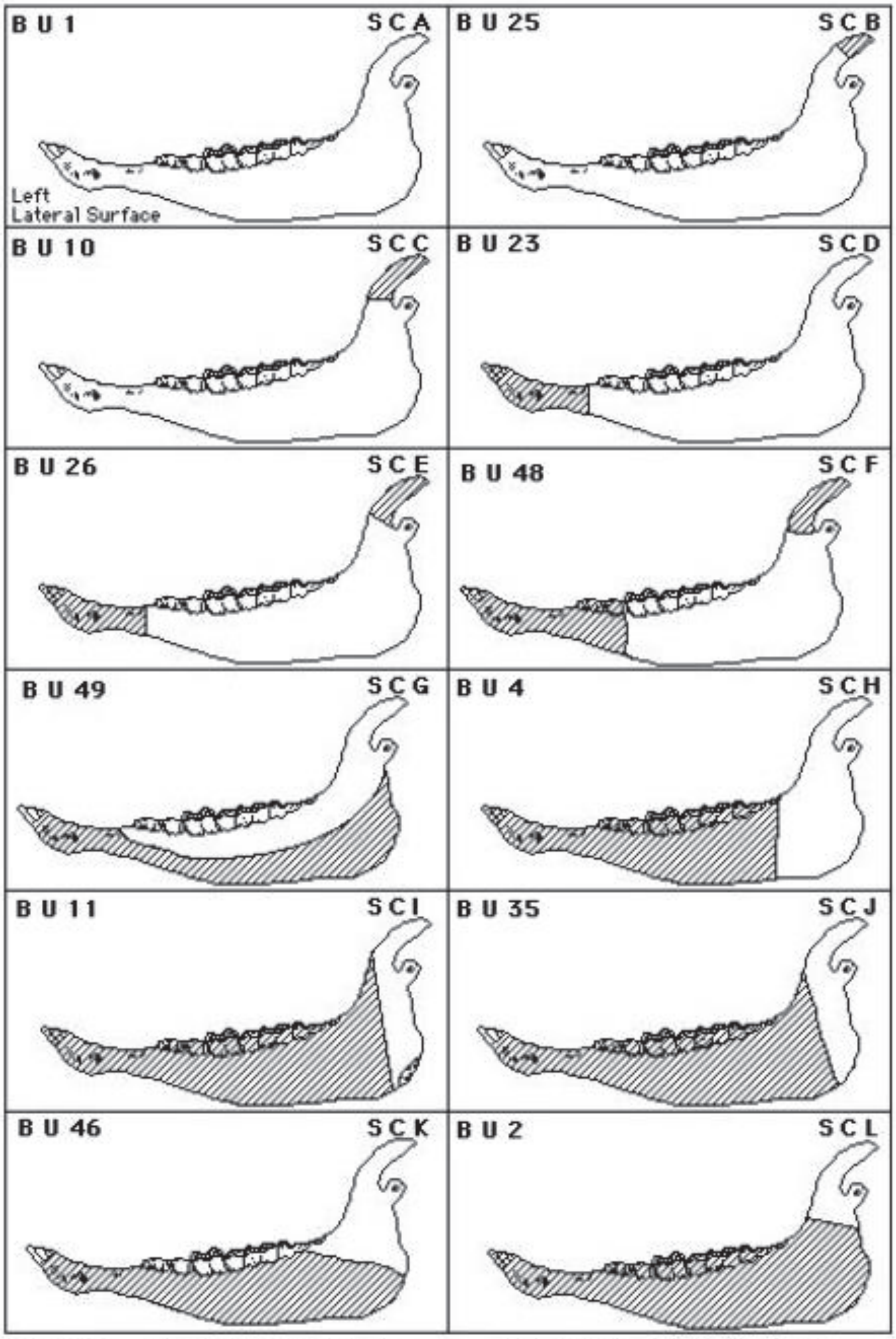


FIGURE___: MANDIBLE BONE UNITS

▨ MISSING ▩ CRUSHED OR GNAWED PORTION

MANDIBLE BONE UNITS

Sequence Code	Bone Unit	Definition
SC M	BU 27	Proximal ½ or less of ascending ramus including complete articular condyle and portion but not all of coronoid process. Similar to BU 2 and BU 3.
SC N	BU 38	Complete articular condyle; coronoid process missing; all of ascending ramus to upper portion of angle of mandible present. The unit has either been severed from the remainder of the element immediately behind the M3; or it may include the M3. If the M3 is present, the horizontal ramus and portion of the angle of the mandible below it is absent. (JB)
SC O	BU 36	Consists of articular condyle and major portion of ramus. The angle of the mandible may or may not be present. Most of dorsal margin of ascending ramus is absent. Similar to BU 16 but lacks crushing.
SC P	BU 16	Unit consists of articular condyle and posterior half of ascending ramus. All or most of dorsal and superior margin of ascending ramus absent. The portion of the angle of the mandible present evidence clear signs of crushing. Similar to BU 36.
SC Q	BU 17	Unit consists of all or most of posterior edge of articular condyle and portion of angle of mandible. No evidence of crushing. Similar to BU 11 and BU 16.
SC R	BU 3	Proximal ½ or less of ascending ramus including articular condyle. Coronoid process absent. Similar to BU 27.
SC S	BU 30	Complete articular condyle with 0-10cm of adjoining ascending ramus. Coronoid process absent. Similar to BU 32. (EMA)
SC T	BU 32	Fragment of articular condyle with from 0-10cm of adjoining ascending ramus present. Coronoid process absent.
SC U	BU 50	Unit consists of the small "U" –shaped fragment for the juncture of the condylar and coronoid processes, with attached small portions of the ascending ramus. Anterior posterior borders of the ramus are removed. Similar to BU 27. (TVH)
SC V	BU 7	Consists of essentially complete coronoid process. Similar to BU 29 and BU 31.
SC W	BU 40	Complete coronoid process plus up to ½ of adjoining surface of ascending ramus. Articular condyle absent. (KK)
SC X	BU 31	Tip of coronoid process. One half or less of superior portion of process represented. (DS)

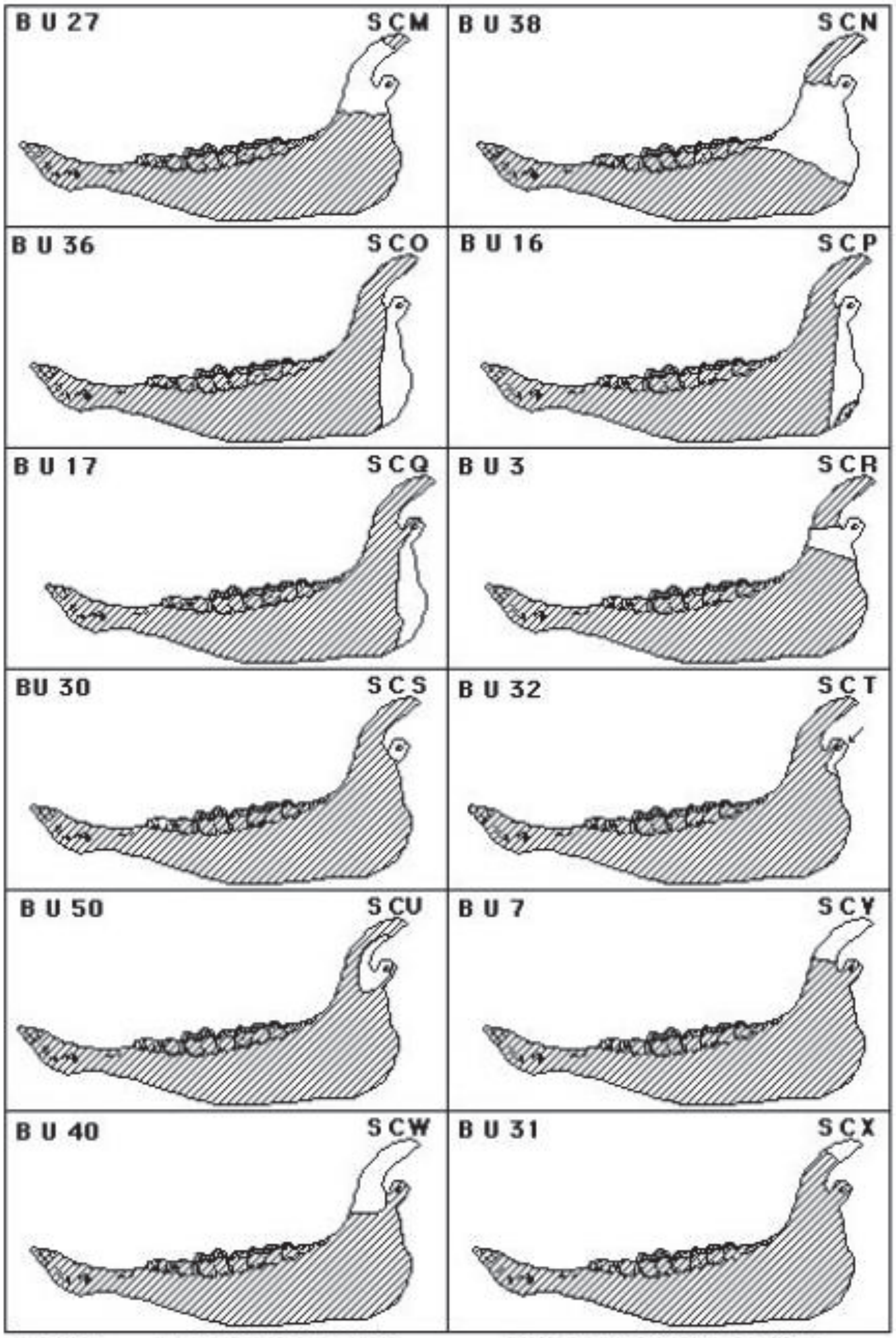
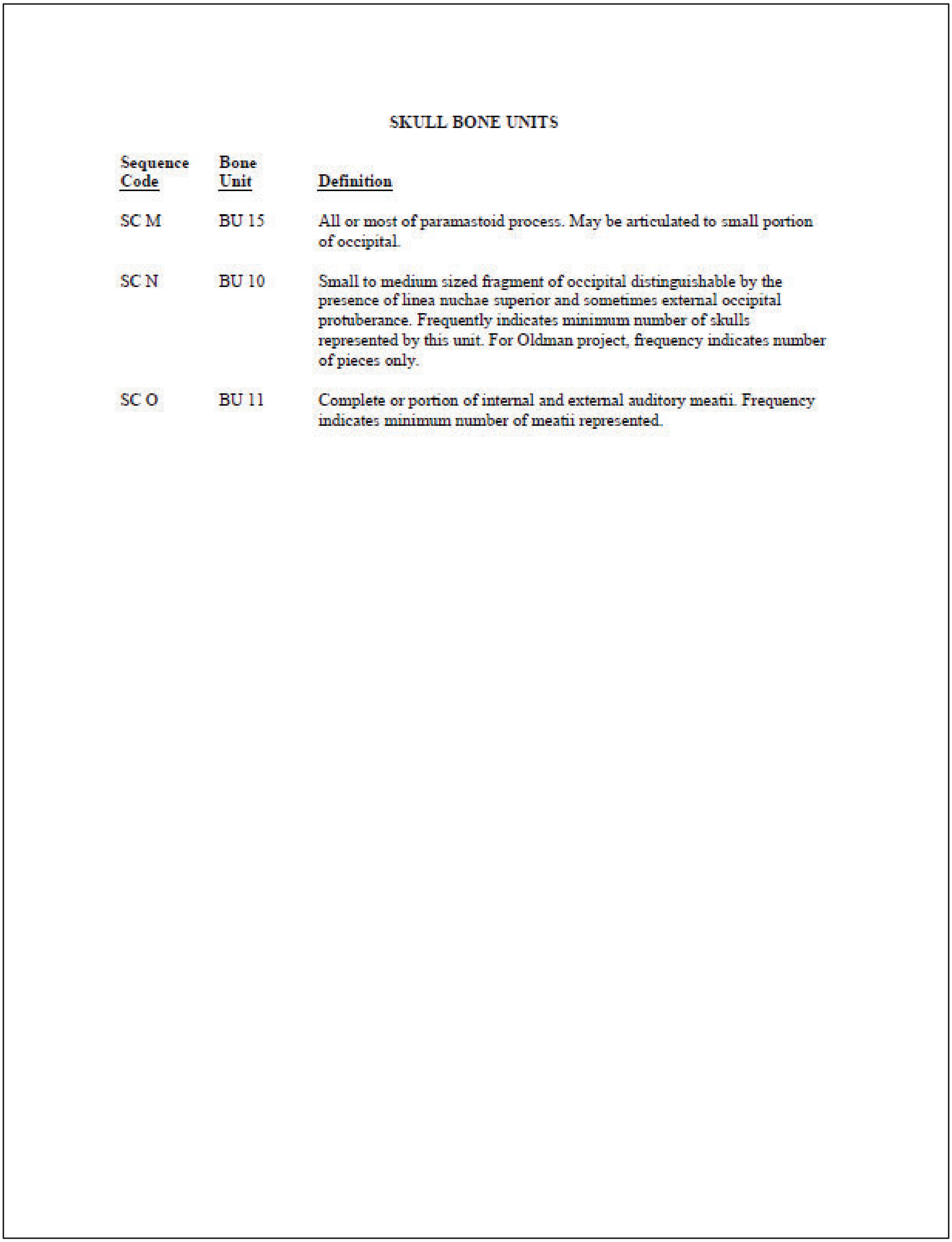


FIGURE__: MANDIBLE BONE UNITS

Appendix III



SKULL BONE UNITS

Sequence Code	Bone Unit	Definition
SC M	BU 15	All or most of paramastoid process. May be articulated to small portion of occipital.
SC N	BU 10	Small to medium sized fragment of occipital distinguishable by the presence of linea nuchae superior and sometimes external occipital protuberance. Frequently indicates minimum number of skulls represented by this unit. For Oldman project, frequency indicates number of pieces only.
SC O	BU 11	Complete or portion of internal and external auditory meatii. Frequency indicates minimum number of meatii represented.

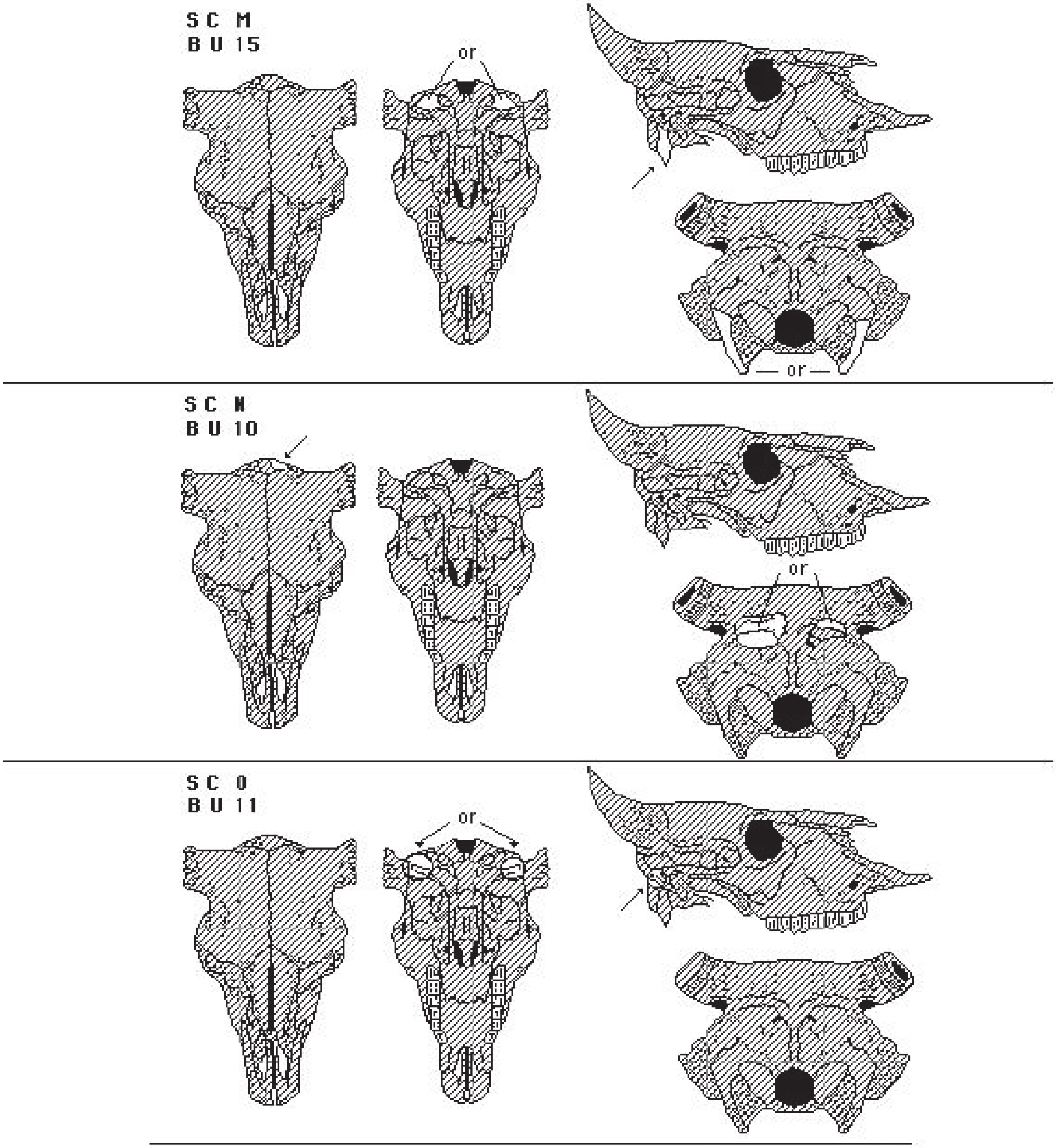
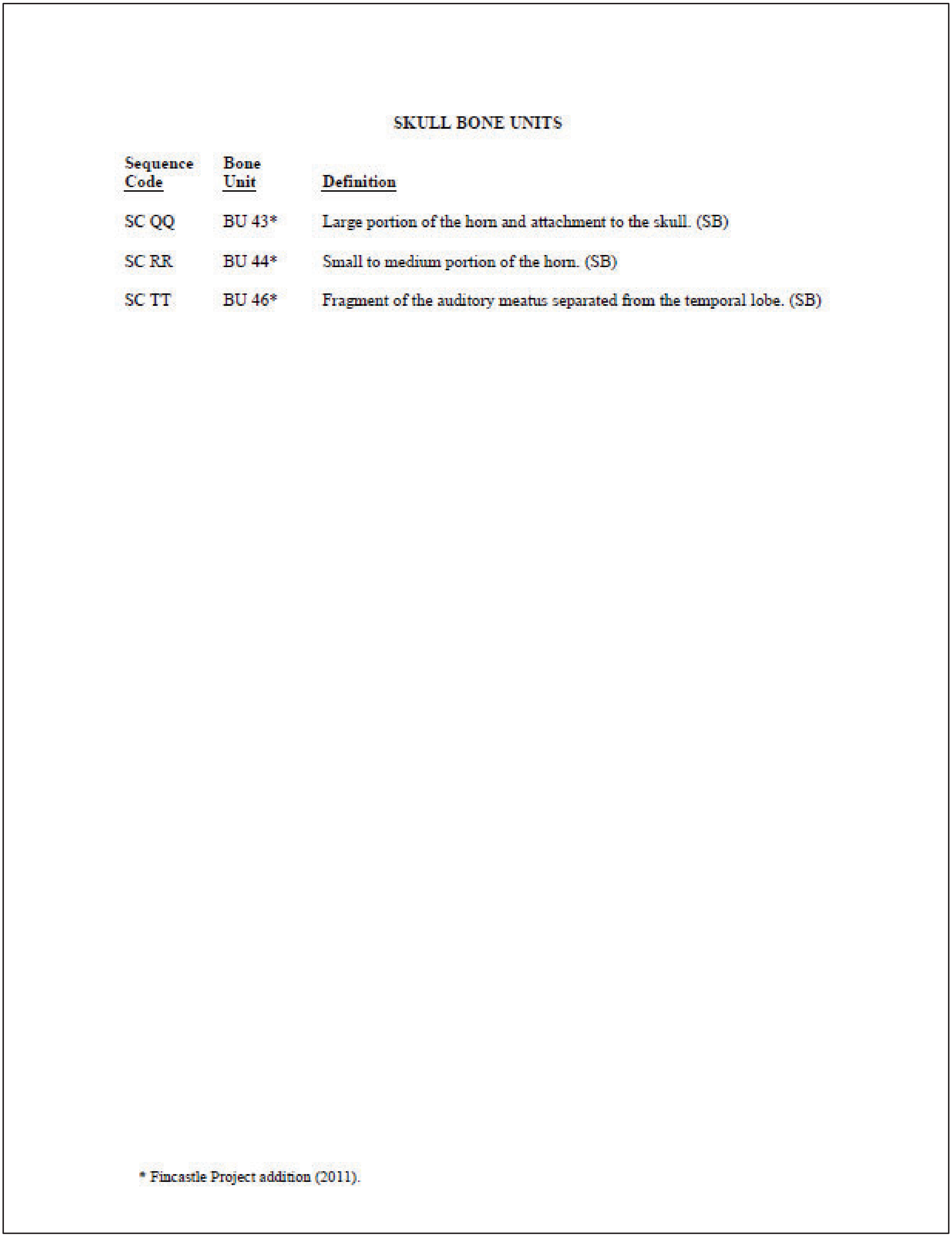


FIGURE___: SKULL BONE UNITS

▨ MISSING ▩ CRUSHED OR GNAWED PORTION



SKULL BONE UNITS

Sequence Code	Bone Unit	Definition
SC QQ	BU 43*	Large portion of the horn and attachment to the skull. (SB)
SC RR	BU 44*	Small to medium portion of the horn. (SB)
SC TT	BU 46*	Fragment of the auditory meatus separated from the temporal lobe. (SB)

* Fincastle Project addition (2011).

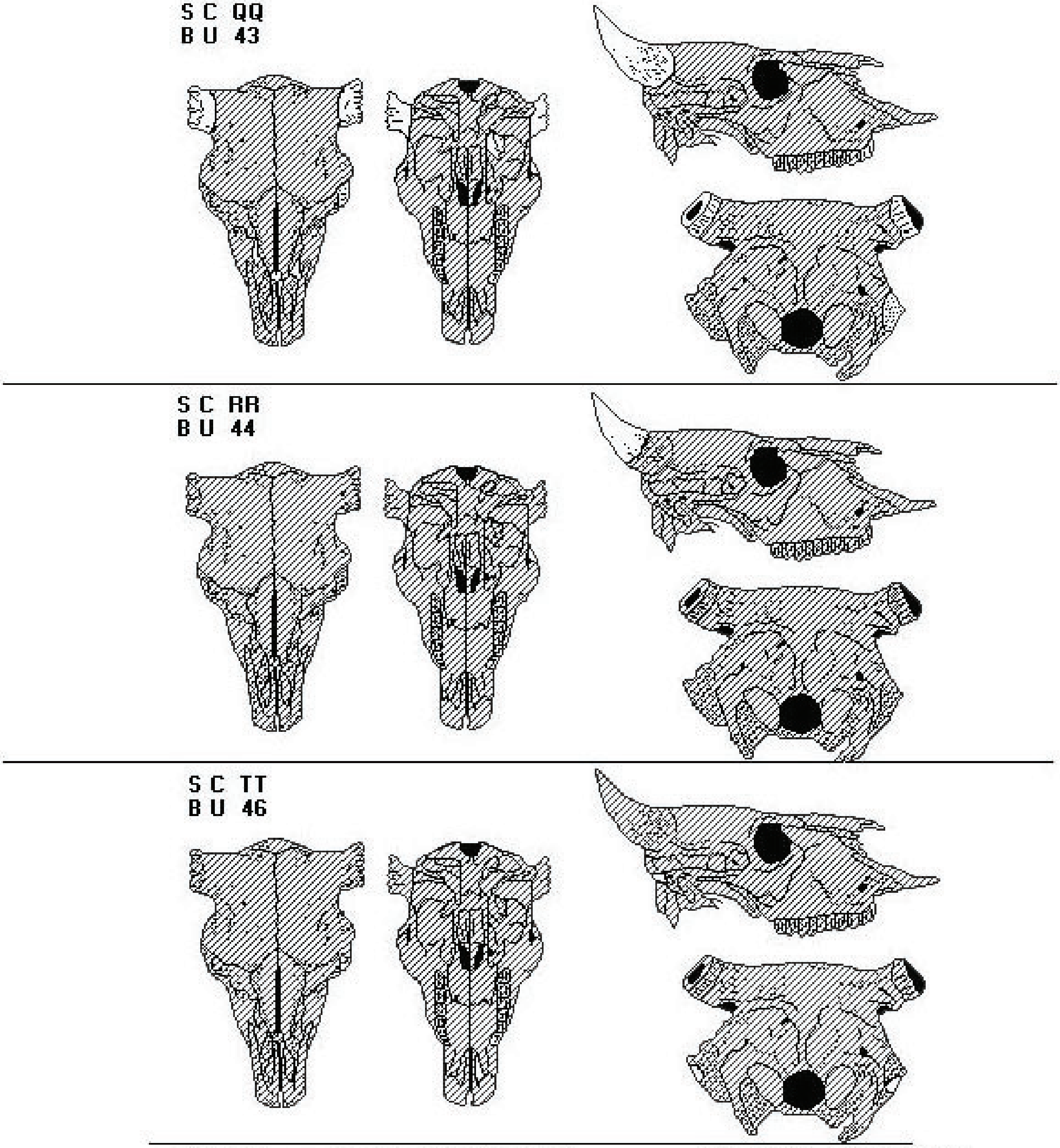


FIGURE___: SKULL BONE UNITS

▨ MISSING ▩ CRUSHED OR GNAWED PORTION

* BU 43, 44, 46 Fincastle Project additions (2011).