Jamestown Colony:
From Food Dependence
To Food Independence

Faunal Analysis for
Second Well (JR2158):
Layers H, N, P, U, X, and AA

Report submitted to:
Jamestown Rediscovery Foundation
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Project Lead:
Dr. Joanne Bowen

Introduction by:
Dr. Joanne Bowen
Susan Trevarthen Andrews

Faunal Report of Second Well (JR2158) by:
Susan Trevarthen Andrews

Contributions to report by:
Stephen C. Atkins

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Acknowledgements

We would like to first thank Preservation Virginia and Jamestown Rediscovery for giving us the opportunity to analyze the faunal remains recovered from the Second Well (JR2158). In order for this project to be successful, many individuals were essential for its completion. From the Jamestown Rediscovery staff, we would like to thank Alexis Ohman, former Associate Curator/Zooarchaeologist, and Leah Stricker, Associate Curator. Ohman took on the daunting task of preparing the grant proposal for this project, organizing the curatorial aspects for the faunal remains, overseeing the volunteers who helped with initial cataloging, and finishing some of the cataloging when the Covid-19 pandemic prevented volunteers from working in the Jamestown lab. Stricker provided us with first-hand accounts from Jamestown and secondary documents related to foodways and provisioning at Jamestown. Both Ohman and Stricker have been extremely helpful in answering all of our questions related to both the archaeological and historical evidence presented in this report. They have also both served as our connection to Jamestown Rediscovery and have both been indispensable in the completion of this project.

As part of our immediate team, Stephen Atkins, former Associate Curator of Environmental Archaeology at Colonial Williamsburg, completed the initial presorting of the faunal material, analyzed and identified all of the fish bones, as well as assisting in the production of the final report. Dr. Joanne Bowen, former Senior Curator of Environmental Archaeology at Colonial Williamsburg, has served as Principal Lead for this project and co-wrote the introduction for the final. Finally, Susan Trevarthen Andrews, contract faunal analyst, worked on completing the identifications for this project, entering data into the faunal program, analyzing the data results, co-writing the introduction of the report, and writing and editing the final descriptive section on the faunal results.

We would also like to thank several people and organizations who helped us navigate around problems we faced due to the Covid-19 pandemic. Typically, wild bird bones from Jamestown would have been taken to the bird department of the Smithsonian's Museum of Natural History. Their extensive collection of bird skeletons, particularly raptors and ducks, have been used for previous Jamestown faunal assemblages to help identify specific species. Unfortunately, due to Covid-19, the Smithsonian museums were closed to researchers for most of 2020 and were still closed at the completion of this report.

In an attempt to work around this setback, many organizations were contacted to see if comparative specimens could be loaned for the project. While many institutions had suspended all loans (due to Covid-19), Dr. Elizabeth Reitz, Professor Emerita of the Zooarchaeology Laboratory at University of Georgia, was able to grant us loans of several duck, goose, and other waterfowl skeletons from the Georgia Museum of Natural History. The loans from Dr. Reitz, were essential in narrowing down many of the wild waterfowl bones to at least the level of family.

Accessing raptor bones, also presented issues since organizations or individuals have to have a government permit to have possession of these bones. Getting a temporary loan of raptor skeletons was not possible, so other museums were contacted to see if an "in-person" visit was possible. The Carolina Raptor Center, located outside of Charlotte, North Carolina, was excited about the Jamestown project and agreed to prepare a skeletal comparative collection of raptors accessible at their center. Kristin Dean, Bird Curator, and Mathias Engelmann, Senior Rehabilitation Coordinator, were fundamental in developing the collection, giving Susan Andrews permission to access the collection. Engelmann also shared his knowledge and expertise on raptors, their skeletal structure, and fowling. Without their comparative collection of raptor skeletons, an important and interesting component of this project would have been missed.

PART 1: Jamestown from 1607-1620s, A Look at History, Relationships with Virginia Indians, Wildlife, and Provisions

Introduction

For generations, our knowledge of the origins of the Chesapeake plantation economy has been shrouded in beliefs about Jamestown, how the colony struggled, unable to successfully produce a commodity. There were problems; the Virginia Company that sent settlers exerted centralized control, expecting settlers to survive by relying on provisions and livestock they sent, trading with the Virginia Indians, and to fish and hunt for whatever wildlife they could. However, the settlers lacked the skills needed to successfully grow crops, hunt, or fish, and relationships with the Powhatan and other Virginia Indians remained tenuous. Soon, food scarcity, disease, and death prevailed in the fort, culminating during the winter of 1609-1610, when the Powhatan lay siege to the fort, trapping 300 settlers, forcing them to feed on all forms of life, including the dead. Come springtime the 60 who survived packed up and were on their way back to England when a new contingent arrived and forced them to return. Within two years, John Rolfe discovered a sweet-scented tobacco that thrived in Chesapeake soils, finally providing the settlers with a viable commodity which would save the colony.

The analyses of faunal remains undertaken in 2000, 2008, and 2013 (Bowen and Andrews 2000; Andrews 2008; Bowen and Andrews 2013), have helped to uncover how the success of the colony depended not only on the emergence of a viable plantation economy able to produce a commodity, but also the ability of the colony to produce their own food.

Dating from the earliest period, May 1607 on through the 1620's, the faunal assemblages show how the Jamestown settlement and its plantation economy evolved in four stages, beginning with initial steps to gain a foothold, followed by the Powhatan surrounding the fort during the winter known as the "starving time." At the brink of collapse, the colony entered a third phase, when new leadership imposed martial law to restore order, protect provisions, introduce livestock, and gain control over the surrounding land by initiating a series of attacks on the Virginia Indians. Finally, a fourth phase began in 1618, when the Virginia Assembly issued the Great Charter that established a General Assembly and ended Martial Law. Together, these steps gave settlers ownership of land, commodities, and foods they produced on their own plantations.

To date, analyzed faunal assemblages cover only the first, second, and fourth phases of Jamestown's growth. Thus, when Jamestown Rediscovery requested Bowen, Andrews, and Atkins take on the task of analyzing the faunal remains recovered from the Second Well (JR2158), we readily agreed, as the analysis of these bones would illuminate how the colony regrouped after the "starving time" to emerge into a successful plantation system. With funding generously provided by a grant from The Conservation Fund and from Jamestown Rediscovery Foundations' donors, Bowen, Andrews, and Atkins analyzed over 150,000 bones recovered from Layers H, N, P, U, X, AA of this well.

When combined with faunal analyses dating from 1607-1610 and the 1620s, available documentation, and ethological evidence on herd behavior, the analysis of faunal remains from the Second Well (JR2158) provide crucial evidence on how the colony evolved from the Virginia Company's corporate governing structure to one supporting individual ownership of the land, livestock, and labor (Walsh et al. 1997; Walsh 1999, 2001; Bowen 2021). Analyses show how the very survival of the colony, its governance, leadership, and relations with Virginia Indians *centered* on obtaining food to feed the colony. When integrated with Jamestown's rich documentary record, faunal analyses reveal how the Virginia Company failed in providing the basic foods needed to survive at Jamestown. Further, they show how the expectation that provisions and trade with Virginia Indians would suffice to feed the settlers, left the colony itself vulnerable to Chief Powhatan, who used trade as a tool to expunge the English from his territory.

To facilitate the discussion on how the faunal evidence from the Second Well (JR2158) fits into the narration of Jamestown's history, we opted to take a comprehensive look at Jamestown from the early years until the 1620s when the plantation economy solidified. To assist our effort in integrating the documentation with the zooarchaeological data, we opted to construct a timeline showing important leadership changes at Jamestown, fluctuations in the population of the fort, periods of hostilities and trading with the Virginia Indians, arrivals of provisions from England, and first-hand accounts of livestock development (see Appendix A, page 165). Using this timeline as a guide, the following sections of this report will look at four general phases of Jamestown's development in terms of foodways including the pre "starving time," "starving time," post "starving time," and the time of "stability" in the livestock herds. Discussions will include a general history of each phase using first-hand accounts to highlight specifics relating to provisions, livestock, wildlife, and trading with the Virginia Indians. In addition, zooarchaeological results from the Second Well (JR2158) and previously analyzed assemblages will be summarized to examine the status of provisions, the development of livestock herds, and the importance of wild species within each phase. Although attempts have been made to ensure the faunal data align with the correct phase, it must also be understood some faunal data may overlap from one phase to another.

Detailed analysis of the Second Well (JR2158) can be found in the second section of this report, along with summaries on English and Virginia Indian techniques for fishing, hunting, fowling, and livestock husbandry. Faunal data for the other phases can be found in previous faunal reports submitted to Jamestown Rediscovery (Bowen and Andrews 2000, 2008; Andrews 2013). To see an overview of all the phases, Table 1 summarizes the biomass data for specific species identified in 17 Jamestown assemblages (an explanation of biomass can be found on page 48 in the second half of this report). These biomass results will be addressed in the discussions of each phase.

Table 1
Biomass Percentages for Select Species from Analyzed Jamestown Faunal Assemblages

											Second Well Layers										
Assemblage	**Cellar Struc. 166**	**Pit 8**	**Pit 9**	**Pit 10**	**Pit 11**	**AVG.**	**Pit 1**	**Pit 3**	**Kitchen Cellar**	**AVG.**	**H**	**N**	**P**	**U**	**X**	**AA**	**AVG.**	**Ditch 7**	**Ditch 6**	**Midden 1**	**AVG.**
Time Period	**1607-1610**						**1610**				**1610-1617**							**Post 1620**	**Post 1630**	**2nd Q. 17th ca.**	
	Pre-Starving Time						**Starving Time**				**Post Starving Time**							**Stability Herds**			
Provisions and Livestock																					
Cattle	31.6	17.6	13.4	13.8	13.2	**17.9**	14.0	15.0	6.7	**11.9**	3.7	6.1	2.9	3.8	7.3	-----	**4.8**	42.3	49.9	47.6	**46.6**
Swine	4.3	5.1	2.0	-----	-----	**3.8**	4.7	4.7	9.7	**6.3**	25.7	23.9	5.3	17.8	27.1	26.1	**21.0**	15.8	14.6	20.2	**16.9**
Sheep/Goat	-----	0.1	-----	-----	-----	**0.1**	0.5	-----	1.0	**0.7**	1.1	0.1	0.6	3.0	2.7	3.1	**1.8**	0.3	2.1	1.3	**1.2**
Horse	-----	1.4	-----	-----	-----	**1.4**	14.4	-----	14.6	**14.5**	-----	-----	0.1	-----	-----	-----	**0.1**	------	------	------	**------**
Chicken	-----	<0.1	0.7	-----	<0.1	**0.3**	0.1	0.1	Birds Not I'D	**0.1**	0.3	0.1	0.2	0.1	0.4	0.2	**0.2**	0.6	<0.1	<0.1	**0.2**
Wild Species																					
Deer	4.4	10.2	22.1	-----	23.0	**14.9**	5.6	5.1	7.2	**6.0**	14.2	21.3	21.7	23.1	18.4	19.2	**19.6**	9.2	6.0	1.6	**5.6**
Crab	-----	<0.1	<0.1	-----	-----	**<0.1**	<0.1	-----	<0.1	**<0.1**	<0.1	<0.1	<0.1	<0.1	-----	-----	**<0.1**	------	------	------	**------**
Sturgeon	8.7	13.0	12.1	24.0	2.8	**12.1**	18.1	6.5	0.2	**8.3**	5.3	8.8	19.0	14.9	8.8	7.0	**10.6**	------	------	0.1	**0.1**
Other Fish	3.1	2.7	1.6	1.9	2.3	**2.3**	5.0	2.1	0.5	**2.5**	3.8	6.3	5.1	4.3	2.0	2.0	**3.9**	0.7	0.2	0.3	**0.4**
Turtle	8.2	3.1	3.2	10.7	3.2	**5.5**	12.8	1.8	0.5	**5.1**	1.0	0.9	0.8	1.0	0.4	0.1	**0.7**	------	------	1.6	**1.6**
Snake	------	<0.1	-----	-----	----	**<0.1**	<0.1	<.01	-----	**<0.1**	<0.1	<0.1	<0.1	<0.1	-----	-----	**<0.1**	------	------	------	**------**
*Other ID'd W. Mammal	5.4	7.4	5.9	13.9	7.0	**7.9**	6.0	2.0	6.4	**4.8**	1.7	2.2	1.2	0.9	0.3	-----	**1.3**	5.9	------	0.9	**3.4**
**ID'd Wild Fowl	0.7	4.1	5.2	6.7	1.6	**3.7**	3.0	2.3	Birds Not I'D	**2.6**	4.0	4.1	1.9	2.2	6.5	14.2	**5.5**	1.7	0.5	0.2	**0.8**

(Andrews 2008; Bowen and Andrews 2000, 2013)
------ = species not present in assemblage
*Other ID'd W. Mammal = includes just identified species, does not include Artiodactyla or Indeterminate Medium Mammal found in the Bone Summary Charts
**ID'd Wild Fowl = includes just identified species, does not include the Indeterminate Wild Bird category found in the Bone Summary Charts

Early Years at Jamestown 1607-1609

Historical Background Information: Early Jamestown

In December 1606, the Virginia Company of London issued their first charter instructing the settlers bound for Virginia to find a safe port in a navigable river and not offend the Virginia Indians. On April 26, 1607, settlers arrived in the Chesapeake Bay. Following the Company's orders, 13 men who made up a governing council appointed Edward Wingfield as the first president (Smith in Haile 1998:145). Exploring upstream to find a location they could defend against a Spanish attack; they discovered an island the local Powhatan tribes found unsuitable for habitation. To these newcomers, the landscape surrounding the island was wild, a coastal plain, with undulating hills, numerous rivers, tidal marshes, and dense hardwood forests. Here the Powhatan lived in a chiefdom composed of about 32 political districts and dozens of settlements, with a total population of about 15,000 (Rountree 1989:148; Rountree and Turner 2002:37; Gallivan 2007:87). Living in semi-permanent villages, they moved over the landscape to forage for plants, fish the waterways, and hunt for other wildlife. Using slash-and-burn techniques, they cleared land surrounding their villages to grow maize and other crops in mounds. As soil fertility declined, they abandoned used fields and cleared new ones, creating a patchwork of dispersed settlements set among groves of trees and fields in various states of use. They cleared woods of underbrush so effectively, colonists noted, "a man may gallop a horse amongst these woods any waie" (Rountree 1989:17-78; Rountree and Davidson 1998:1-46; Horn 2005:11-22).

As soon as the settlers arrived, they followed the Company's directive by focusing on discovering gold, silver, or a passage to the Orient. As the Company intended, they relied on the provisions sent from England and whatever they could procure through trade, hunting, and fishing (McCartney 1997:29-61; McCartney 2000:33-34, 46-56; Horn 2005:54-98; Bowen and Andrews 2000; Bowen 2021). This corporate expectation, combined with a multitude of factors, meant success would not come overnight. The men the Company sent had few agricultural skills or were unwilling to plant corn, thinking this was a job below their status. While a few men had the knowledge to hunt or fish, they quickly found they needed to trade with the Powhatan and other Virginia Indians to provide them with sufficient food. Although relations with the Powhatan and other Virginia tribes were tentative during the early years at Jamestown, settlers did procure some food, including items such as corn, deer, bread, raccoons, and turkeys. They also learned new fishing techniques by observing methods used by Virginia Indians. However, within weeks of their arrival, hostilities resulted in 200 Powhatans attacking Jamestown, resulting in the death of one settler and several Powhatan. Subsequent hostilities included the Paspahegh and other Virginia Indians attacking the fort and killing colonists as they explored the region looking for Virginia Indians willing to trade and/or supply the colony with foods (Smith in Halle 1998:147-149, 154, 173, 239, 441, 503). By the end of 1607, only 38 settlers survived (Smith in Haile 1998:338).

Over the next two years, power struggles centered around food, and leadership changed from Edward Wingfield to John Ratcliffe. Then, in September 1608, as additional colonists arrived at the fort, Captain John Smith became president. Faced with the task of finding Virginia Indians willing to trade with the English for food, he completed a series of expeditions. He also established a new law at Jamestown to make sure every person pulled their weight in the fort:

> I speak not this to you all, for divers of you I know deserve both honor

> and reward better than is yet here to be had, but the greater part must be more industrious or starve. However you have been heretofore tolerated by the authority of the council from that I have often commanded you, you see not that power resteth wholly in myself, you must obey this now for a law that he that will not work shall not eat, except by sickness he be disabled. For the labors of thirty or forty honest and industrious men shall not be consumed to maintain an hundred and fifty idle loiterers (Smith in Haile 1998:314).

Despite Smith's proclamation and efforts, food shortages continued. In August 1609, 300 more settlers arrived, putting more pressure on Smith. To reduce the population in the fort and the stress of feeding so many, Smith sends some of his men upriver to the falls, and others downriver towards the bay to establish new settlements (Smith in Haile 1998:329). The arrival of new hungry mouths fueled dissension among the fort's leaders and in September 1609, George Percy became president (Smith in Haile 1998:333). At that point, Smith was injured from a gunpowder explosion and returned to England (Percy in Haile 1998:502). His departure marks the end of the first phase of Jamestown's evolution from provisioned outpost to plantation economy.

Livestock and Provisions: Early Jamestown

While the Virginia Company intended colonists to rely on provisions and livestock sent from England, supplies to Virginia were sporadic over the next decade. Ongoing mismanagement and internal politics within the fort created an inherent instability in this vital resource. Additional unforeseen circumstances plagued settlers in their ongoing attempts to receive provisions. For example, Captain Christopher Newport left for England on June 22, 1607, leaving the fort with only 13 to 14 weeks of provisions (Smith in Haile 1998:147). It was another 28 weeks before Newport returned to Virginia with fresh provisions and additional men. It was a welcome relief, but short-lived as a fire broke out in the fort on January 7, destroying most of the buildings in the fort, including storehouses containing the newly arrived provisions. In April, Newport left again for England but does not return until September 1608, bringing additional mouths to feed, provisions, and possibly livestock (Perkins in Haile 1998:133; Smith in Haile 1998:292).

In addition to the inconsistent supplies of provisions from England, leadership within the fort also threatened food availability. The settlers accused President Wingfield of hoarding food and drink while the colony starved (Horn 2005:57). In September 1607, his replacement, John Ratcliff, proved to not be much better. The Council imprisoned Ratcliff for mismanagement, forcing men to hard labor, and for not maintaining the provisions properly, allowing some to spoil in the rain (Horn 2005:87, 99). Leadership at Jamestown changed again as Ratcliff was removed and John Smith became president in September 1608 (Smith in Haile 1998:278). As Smith quickly got to work creating order in the fort and building up food supplies for the winter, Captain Christopher Newport arrived and proceeded to shift efforts to produce valuable commodities for the Virginia Company (Horn 2005:111).

As Smith lost authority and witnessed how settlers continued to suffer, he sent news of these affairs to England. As a result, he influenced the Virginia Company to issue a second charter that would change the government at Jamestown from a governing council to a governor who had absolute control (Haile 1998:15; Horn 2005:135). In May 1609, the new charter gave the governor power to make and enforce laws and to grant land according to a person's merit and status (Haile 1998:16; Horn 2005:135).

Even then, securing and keeping provisions safe and apportioning them to the settlers remained a problem. In June 1609, difficulties continued as the third supply composed of nine ships left England with a new governor, Sir Thomas Gates, 500-600 new settlers, livestock, and a years' worth of provisions. During their voyage a hurricane struck, scattering the fleet, sinking one ship, and causing another to shipwreck off the island of Bermuda (Strachey in Haile 1998:414). By August, the seven surviving ships arrived into Jamestown with about 300 men, women, children, and the first horses (Archer in Haile 1998:351; Smith in Haile 1998:327). In three days, they devoured the colony's field of corn. John Smith later described the men on these ships to be "reckless young fobs" who had traveled to the colony to "escape evil destinies." When they arrived and found none of the comforts they were used to in England, they described Virginia as "a miserie, a ruine, a death, a hell" (McCartney 1997:35). Already facing a shortage of provisions, the new arrivals placed an additional burden on providing everyone with food.

Gabriel Archer, who arrived with the Third Supply, commented on how he found the colony and who he blamed for their condition:

> Whereupon Captain Newport and others have been much to blame to inform the council of such plenty of victual in this country, by which means they have been slack in this supply to give convenient content. Upon this, you that be adventurers must pardon us if you find not return of commodity so ample as you expect, because the law of nature bids us seek sustenance first and then to labor to content you afterwards (Archer in Haile 1998:352).

While provisions sent from England were few, the establishment of livestock in the colony fared a bit better. Based on Smith's accounts, the first livestock to arrive in Jamestown was probably three swine and some chickens. Within a year their numbers appeared to have increased as Smith writes, "Of three sows in eighteen months increased 60 and odd pigs, and near 500 chickings brought up themselves without having any meat given them" (Smith in Haile 1998:319). Smith continued his account describing how the settlers kept the swine on Hog Island, where they also built a blockhouse to keep any eye out for ships. This environment allowed the swine to roam freely, relatively safe from the threat of wolves and Virginia Indians (Smith in Haile 1998:319). While it is not clear how much additional livestock came to Jamestown on the Third Supply ships or if some of the swine came from Bermuda, it is clear by the time Smith left Jamestown for England in October 1609, Jamestown had by his count, "six mares and a horse, five or six hundred swine, as many hens, goats, sheep, and horses" (Smith in Haile 1998:335)

Wildlife and Trading with the Virginia Indians: Early Jamestown

The abundance and diversity of wildlife astonished settlers, whose homeland placed many of the species they saw, with the exception of raptors, rodents, and snakes, as highly desirable cuisine and markers of wealth and prestige. Undoubtedly, settlers would have eagerly sought out the fish, fowl, and other wildlife around them (Bowen and Andrews 2000:1-20). As the largest estuary in North America, the Chesapeake Bay and its tributaries were the primary destination of immense numbers of migratory birds and fowl, some of which were only eaten by the gentry in England. Smith reported,

> In Winter there are great plenty of Swans, Cranes, gray and white with blacke wings, Herons, Geese, Brants, Ducke, Wigeon, Cotterell, Oxeies, Parrats, and Pigeons. Of all these sorts great abundance, and some other strange kinds, to us unknowne by name. But in sommer not any, or a very few to be seen (Bowen and Andrews 2000:63; Smith in Barbour 1986:111).

Fish species were also plentiful, especially sturgeon, which Smith commented when they first arrived, "We had more sturgeon that could be devoured by dog and man," (Bowen and Andrews 2000:9; Smith in Haile 1998:320). Showing the diversity of fish available to the settlers, Smith wrote:

> of fish we were best acquainted with Sturgeon, Grampus, Porpus, Seales, Sting-graies, whose tailes are very dangerous. Bretts, Mullets, White Salmonds, Trowts, Soles, Plaice, Herrings, Conyfish, Rockfish, Eeles, Lampreys, Catfish, Shades, Pearch of three sorts, Crabs, Shrimps, Crevises, Oysters, Cocles, and Muscles (Bowen and Andrews 2000:51; Smith in Barbour 1986:2:111).

While fish appear to have been initially plentiful, it also became clear the settlers lacked fishing skills and adequate equipment. Sturgeon and crabs, found in shallow water, were taken with little effort (Pearson 1942:355), while during winter freezes dead fish were also easily gathered. Settlers took fish they found in the ice, "so fat they could be fried in their own fat without adding butter or such thing" (Perkins in Haile 1998:133). With the aid of the Powhatan, they also learned how to make efficient weirs. When these methods were not successful or available, the settlers also learned to improvise, as evidenced by Smith's description in the summer of 1608,

> We found… in diverse places, that abundance of fish lying so thick with their heads above the water, as for want of nets, our barge driving amongst them we attempted to catch them with a frying pan; but we found it a bad instrument to catch fish with…Our captaine sporting himself to catch them by nailing them in the ground with his sword, set us fishing in that manner. By this devise, we tooke more in an houre than we all could eat (Smith in Barbour 1986:168).

Although early first-hand accounts give detailed lists of the fowl and fish present in Virginia, reports of the wild mammals the first settlers encountered, are also part of early descriptions of encounters with the Virginia Indians and narratives of trading experiences. Smith, in particular, frequently commented on wild mammals used in clothing for the Virginia Indians or presented to him during feasts or through trading. He mentioned how weasels became headdresses, deer skins were used for clothing, and canoes were filled with skins of fox, otter, bear, and deer (Smith in Haile 1998:163, 236, 261). Venison appears to have been the primary meat traded with the Virginia Indians, while raccoon and squirrel meat were used as gifts to the English (Smith in Haile 1998:158, 165, 168, 297, 320). Edward Wingfield, also mentioned squirrel, which he "generously" shared with Ratcliff, who was apparently sick at the time (Wingfield in Haile 1998:192).

Procuring food was a negotiating tool used by both the Virginia Indians and settlers. Realizing that providing or withholding food from the English would establish control in the relationship, the Virginia Indians often traded. In June 1607, even though the Paspaheghs and other tribes attacked the fort, the Powhatan tribes initially supplied colonists with food. By December 1607, however, food brought by neighboring tribes had dwindled. In response, Smith and his men initiated several expeditions to trade with other tribes located further away from the fort (Smith in Haile 1998:232). Smith described one of these expeditions with a tribe in Chesapeake, stating:

> The king at our arrival sent for me to come unto him. I sent him word what commodities I had to exchange for wheat…He signified to me to come ashore and sent a canoe with four or five of his men, two whereof I desired to come aboard and to stay, and I would send two to talk with their king ashore; to this he agreed. The king we presented with a piece of copper, which he kindly accepted and sent for victuals to entertain the messengers. …The king kindly feasted us, requesting us to stay to trade till the next day; which have done, we returned to the fort (Smith in Haile 1998:173-174).

After a fire in the fort destroyed much of the provisions one of the supply ships had brought, Smith and Newport met with the Powhatan chief in February 1608 to trade again for provisions. Powhatan continued to send Smith and Newport once or twice a week, gifts of deer, bread, and raccoons (Smith in Haile 1998:165). Off and on trading continued until September 1609, when Newport brought Chief Powhatan a ceremonial crown to symbolize his subordination to the English king. Reminding the English, he was also a king, Chief Powhatan refused to kneel during the ceremony, demonstrating he still had power over the English (Smith in Haile 1998:282; Horn 2005:107). This event marked a turning point in relations between the English and the Virginia Indians. When Smith set out in December 1608 to trade for food in order to get the settlers through the winter, he quickly discovered Powhatan had used his power by instructing tribes not to trade with the English or provide them with food (Horn 2005:118). After several more attempts at trading with Virginia Indians and facing several attempts on his life, Smith finally realized he could no longer rely on the Powhatans or other tribes to help with their ongoing fight against famine.

Although a decade-long drought also impacted the Virginia Indians' ability to find food for their own use, Powhatan strategically used his "food" relationship to learn English ways, trade for desired items, and stay informed of English movements throughout his kingdom. Thus, life-giving food became Chief Powhatan's tool to keep the English in his control and attempt to abolish their colony.

Zooarchaeological Evidence: Early Jamestown

A zooarchaeological study of faunal assemblages dating to ca. 1610 demonstrates the extent to which colonists did not produce their own food. In terms of biomass estimates, the data shows colonists either procured wildlife from the Virginia Indians or by hunting and fishing; together these sources were critical to their survival. In total, wildlife contributed 46.4% to their meat diet. Following in importance, domestic livestock and fowl made up a substantial 23.5% of the total biomass. For this report, several previously analyzed features were chosen to summarize zooarchaeological findings from the first years at Jamestown. The features selected were all found within the walls of the fort and include the cellar from Structure 166, and pits 8, 9, 10, and 11, also known as the soldier's pits. While the results from previous faunal analysis are summarized in this report, a detailed analysis of these features can be found in a 2008 faunal report by Andrews (Andrews 2008).

Table 2
Biomass Percentages for Select Species
Early Jamestown Assemblages

Assemblage	Cellar Struc.166	Pit 8	Pit 9	Pit 10	Pit 11	Average
Provisions and Livestock						
Cattle	31.6	17.6	13.4	13.8	13.2	**17.9**
Swine	4.3	5.1	2.0	-----	-----	**3.8**
Sheep/Goat	-----	0.1	-----	-----	-----	**0.1**
Horse	-----	1.4	-----	-----	-----	**1.4**
Chicken	-----	<0.1	0.7	-----	<0.1	**0.3**
					TOTALS FOR DOMESTIC	**23.5**
Wild Species						
Deer	4.4	10.2	22.1	-----	23.0	**14.9**
Crab	-----	<0.1	<0.1	-----	-----	**<0.1**
Sturgeon	8.7	13.0	12.1	24.0	2.8	**12.1**
Other Fish	3.1	2.7	1.6	1.9	2.3	**2.3**
Turtle	8.2	3.1	3.2	10.7	3.2	**5.5**
Snake	------	<0.1	-----	-----	----	**<0.1**
***Other ID'd W. Mammal**	5.4	7.4	5.9	13.9	7.0	**7.9**
****ID'd Wild Bird**	0.7	4.1	5.2	6.7	1.6	**3.7**
					TOTALS FOR WILD	**46.4**

(Andrews 2008)
------ = species not present in assemblage
*****Other ID'd W. Mammal = includes just the identified species, does not include Artiodactyla or Indeterminate Medium Mammal bones found in the Bone Summary Charts
******ID'd Wild Fowl = includes just the identifiable species, does not include the Indeterminate Wild Bird category found in the Bone Summary Charts

Livestock and Provisions: Early Jamestown

Faunal data from the early assemblages, along with historical accounts suggesting colonists introduced live cattle (*Bos taurus*) only after the "starving time," demonstrate how the first colonists depended on provisions from England and introduced livestock. In total, imported livestock and fowl made up 23.5% of the total biomass during the first years (see Table 2). When looking at the importance of each individual domestic species, cattle ranked first at 17.9%, followed by swine (*Sus scrofa*) at 3.8%, horse (*Equus* spp.) at 1.2%, chicken (*Gallus gallus*) at .3%, and last sheep/goat (*Ovis aries/Capra hircus*) at 0.3%.

Looking deeper into the data and comparing the normal element distributions for each species with element distributions present in the faunal assemblages, it is possible to identify provisioned meat from meat which came from introduced livestock. Aggregated into head, body, and feet parts, cattle faunal remains show proportionately greater ratios of body parts than a normal skeleton. At the same time, swine and sheep/goat proportions suggest all portions of the animals were available to the Jamestown settlers (see Table 3). From this, it is fair to conclude salted beef provisions sent from England contributed a significant if not crucial amount to their meat diet, while live animals contributed far less.

Table 3
Element Distribution for Domestic Mammals
Early Jamestown Assemblages

	Head		Body		Feet	
	No.	%	No.	%	No.	%
Cattle Normal		29.7		42.2		28.1
Cattle Early Jamestown	3	7.1	30	71.4	9	21.4
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Swine Normal		28.2		34.5		37.3
Swine Early Jamestown	30	54.5	10	18.2	15	27.3
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Sheep/Goat Normal		29.7		42.2		28.1
Sheep/Goat Early Jamestown	1	100	0	0	0	0

(Andrews 2008:52-54)

A review of beef data from the Cellar, and Pits 8, 9, 10, and 11 reveals variability ranged anywhere from a consistent 13-14% biomass in most features, one with 17.6%, and the cellar with 31.6% (see Table 2). At present, artifacts from the Structure 166 Cellar indicate a person of wealth possibly lived in this structure and deposited these remains (Deetz et al. 2008:46-47). It is presumed the pits are associated with soldiers, or persons of lower rank. While additional research could refine these associations, these data support the interpretation that, like President Wingfield, who was accused of hoarding, this individual consumed more than his/her share of provisions!

In terms of other domestic mammal and bird remains, documentation from the first years at Jamestown described settlers placing swine and possibly chickens on a nearby island for protection. Besides keeping the animals in one area, this would have ensured the Council had some control over their food resources and who had access to the animals. It is not clear from the historical records whether subsequent shipments of sheep, goats, and horses were also placed on the island. Neither is it clear if some of these animals roamed freely in and around the fort. Faunal remains recovered from the Cellar and Pits 8-11, make it clear colonists consumed provisions of beef sent from England and then livestock including swine, sheep/goat, and chicken. While a single fragmented mandible from a horse was recovered from Pit 8, it is not clear if it represents the remains of a meal. In total, the faunal data suggests provisions made up 17.9% of the diet and livestock totaled 5.3%, a small but not insignificant contribution to the settlers' meat diet (see Table 2).

Wildlife and Trading with the Virginia Indians: Early Jamestown

Identified wild species, composed in biomass estimates, made up 46.4% of all meat consumed during the early years (see Table 2). A lengthy list of fish, turtle, bird, small mammal, and large mammal species reported in the 2000 and 2008 faunal reports, testify to how the early settlers fished, fowled, or hunted species which were readily available around the fort and its environs (Bowen and Andrews 2000, 2008). While the identified species from the early period at Jamestown cover a broad spectrum, they show the colonists procured those species in small but significant numbers. They are: 1) fish species including catfish (family Ameiuridae), suckers (family Catostomidae), white perch (*Morone americana*), and gar (*Lepisosteus* spp.); 2) turtle species including marine turtles (family Cheloniidae), snapping turtle (*Chelydra serpentina*), sliders (*Chrysemys* spp.), and the diamondback terrapin (*Malaclemys terrapin*), and box turtle (*Terrapene carolina*); 3) bird species including numerous duck species (Duck spp.), Canada geese (*Branta canadensis*), turkeys (*Meleagris gallopavo*),and the occasional swan (*Cygnus* spp.), whooping crane (*Grus americana*), gulls (family Laridae), turkey vulture (*Cathartes aura*), double-crested cormorant (*Phalacrocorax auratus*), and a number of raptors (family Accipitridae); 3) mammal species including the white-tailed deer (*Odocoileus virginianus*), bottle-nosed dolphin (*Tursiops truncates*), Eastern gray squirrel (*Sciuris carolinensis*), Eastern fox squirrel (*Sciuris niger*), and the raccoon (*Procyon lotor*).

Breaking down wildlife in terms of dietary importance, deer ranks first with 14.9% of the biomass totals, probably representing a combination of deer the settlers hunted on their own or procured through trade (Andrews 2008). Ranked second is fish including numerous sturgeon (*Acipenser* spp.) scutes that may inflate the sturgeon's actual dietary contribution. The relative importance of sturgeon ranges from 2.8% to 24% among the different features. This striking difference is intriguing, suggesting the higher percentages in some features may represent a seasonal catch from a spring or fall migration as sturgeon moved up and down the river, or the by-product left from settlers' attempt to salt sturgeon. As a highly prized fish in England, the settlers may have eagerly consumed sturgeon, along with other wild species considered food for the elite, including bottle-nosed dolphin identified in Pit 8.

In these early features, the element distribution percentages for deer bones helps support first-hand accounts of trading with the Virginia Indians for venison. As Table 4 shows, 63.2% of the deer elements were bones from the body of the animal including long bones, vertebrae, and ribs. Bones from the head and feet were identified in numbers significantly lower than what is found in a normal skeletal distribution. This pattern suggests the colonists did not have access to the whole animal. They may have killed deer away from the fort and only brought back the meatier elements or traded with the Virginia Indians for selective cuts of venison.

Table 4
Element Distribution for Deer
Early Jamestown Assemblages

	Head		Body		Feet	
	No.	%	No.	%	No.	%
Deer Normal Skeleton		29.7		42.2		28.1
Early Assemblages	20	17.1	74	63.2	23	19.7

(Andrews 2008)

Starving Time at Jamestown 1609-1610

Historical Background Information: Starving Time

By the fall of 1609, many problems had festered at Jamestown, including growing hostilities with some of the Virginia Indians and increasing difficulty getting enough food to feed all the new arrivals to the fort. Some of the English went to live with the nearby tribes, paying them in copper for provisions, while other groups traveled up and down the river to set up new settlements. Those staying in the fort faced starvation and diseases such as dysentery and typhoid leading to the death of many settlers. In addition, the island environment proved to be inhospitable as the water supply was brackish and the ongoing drought saw the decrease in many fish, mammals and birds which had previously inhabited the forests and waterways. By November, Virginia Indians lay siege on the fort, killing livestock and trapping about 300 settlers within its walls (Horn 2005:175). Those trapped in the fort during the winter found it was too cold to wade into the water to gather oysters, and they were compelled to subsist on roots they dug from the frozen ground and whatever else they could find (McCartney 1997:35). They became too weak to gather food for themselves, with the omnipresent Powhatan and other tribes waiting outside to pick off anyone who dared to venture out of the fort. This siege during the winter of 1609-1610 has become known as the “starving time.” As all in the fort felt the “sharp prick of hunger, ” they first consumed all animals in the fort, including horses, dogs, cats, rats, and mice. Once these were depleted, they braved the woods to feed upon “serpents and snakes.” Eventually, they even consumed the bodies of those who had died (Percy in Haile 1998:505; Kelso 2017).

The devastation also destroyed what livestock they had brought with them:

> And our people together with the Indians not to friend had the last winter destroyed and kill’d up all our hogs, onsomuch as of five or six hundred, as it is not a hen nor a chick in the fort; and our horses and mares they had eaten with the first” (Letter to Virginia Company in Haile 1998:459).

By spring of 1610, nearly three-quarters of the individuals in the fort, some 160 souls, had either perished through disease or starvation, or had run away to join the Powhatan. By early May, when the local tribes lifted the siege on the fort, the remaining 60 survivors were near death (Smith in Haile 1998: 339-340; Horn 2005:176). When it was safe to leave the fort, George Percy, president of the colony, made his way to see how the men fared who were living at Fort

Algernon. He found the men to be in moderate health, well stocked with fish, crabs, and swine. Upon questioning, Percy discovered the men had been gathering supplies for their trip back to England. If Percy had known of the abundance at Fort Algernon, he might have tried to send some settlers down there, saving additional lives that winter (Percy in Haile 1998:506; Horn 2005:177).

In May 1610, the *Sea Venture,* shipwrecked on Bermuda, finally arrived at Jamestown. On board was Sir Thomas Gates, the newly appointed governor, whose charge was to bring order and establish martial law. However, after seeing the condition of the colonists, the fort, the buildings, and the lack of food, Gates decides to abandon the fort and return everyone to England (Strachey in Haile 1998:420). As he and the surviving settlers set sail for England, they met Lord De La Warr and three ships of supplies and more settlers (Horn 2005:180). Forcing them to turn back, De La Warr, the new leader, initiated a new settlement phase, supported by new laws and the reestablishment of livestock needed to support the colony.

Livestock and Provisions: Starving Time

As the Powhatan prepared to lay siege on the fort, Smith reported the colony had several horses, hens, goats, sheep, and around 500 swine (Smith in Haile 1998:335). He later writes in Book 4 of his *General History* that after his departure from the colony,

> As for corn, provisions, and contribution from the savages we had nothing but mortal wounds with clubs and arrows. As for our hogs, hen, goats, sheep, horse, or what lived, our commanders, officers, and savages daily consumed them. Some small proportions sometimes we tasted till all was devoured (Smith in Haile 1998: 339).

In May 1610, when Sir Thomas Gates, arrived on the *Sea Venture*, he was shocked to see the state of the fort and the lack of provisions and livestock. Not aware of the situation at Jamestown, the settlers arriving from Bermuda had only sufficient provisions for their trip, not enough to feed all the starving colonists they found. When the remaining provisions were proportioned out to everyone, they lasted "no longer than sixteen days" (Strachey in Haile:426). Besides the quickly dwindling provisions, Gates noticed the settlers were weak, there was no corn in the ground, no sturgeon in the river, and the fort's fishing nets had fallen into disrepair (Strachey in Haile 1998:419). He also discovered the livestock had either been eaten by the settlers or destroyed by Virginia Indians, who had gone to Hog Island and "kill'd up all our hogs" (Letter to Virginia Company in Haile 1998:459). Gates quickly decides without the needed provisions and livestock to sustain the settlers they should abandon the fort and return to England.

Wildlife and Trading with the Virginia Indians: Starving Time

Although they were not aware of it, the settlers were facing drought conditions which lasted from 1606-1612 (Blanton 2000). Undoubtably this would have impacted salinity levels, which in turn, impacted fish populations (Lippson and Lippson 2006). William Strachey noted how, "the river, which were wont before this time of the year to be plentiful of sturgeon, had not now a fish to be seen in it" (Strachey in Haile 1998:425). Given the increased salinity levels near Jamestown, the sturgeon would have most likely bypassed Jamestown in the Spring of 1610, continuing upriver to find freshwater to spawn.

The Virginia Indians ability to fish would also have been hindered by the drought, making it harder for them to procure fish for their own consumption. Confirming this, George Somers wrote in 1610, "…we found no savages, for they were afraid to com thither, for they did not trade with our men these many months. The truth is they had nothing to trade withal but mulberries" (Somers in Haile 1998:446). Even before he left, Smith was aware trading with the nearby tribes had become extremely limited. He commented he did not have the items the Powhatan chief requested and in turn, they did not have any corn to give the English (Smith in Haile 1998:336). Now that the English and the Virginia tribes competed for the same resources, Chief Powhatan vowed to starve the remaining settlers.

Table 5
Biomass Percentages for Select Species
Starving Time Assemblages

Assemblage	Pit 1	Pit 3	Cellar/ Kitchen	AVG.
Provisions and Livestock				
Cattle	14.0	15.0	6.7	**11.9**
Swine	4.7	4.7	9.7	**6.3**
Sheep/Goat	0.5	-----	1.0	**0.7**
Horse	14.4	-----	14.6	**14.5**
Chicken	0.1	0.1	Birds Not I'D	**0.1**
			TOTAL BIOMASS DOMESTIC	**33.5**
Wild Species				
Deer	5.6	5.1	7.2	**6.0**
Crab	<0.1	-----	<0.1	**<0.1**
Sturgeon	18.1	6.5	0.2	**8.3**
Other Fish	5.0	2.1	0.5	**2.5**
Turtle	12.8	1.8	0.5	**5.1**
Snake	<0.1	<.01	-----	**<0.1**
*Other ID'd W. Mammal	6.0	2.0	6.4	**4.8**
**ID'd Wild Fowl	3.0	2.3	Birds Not I'D	**2.6**
			TOTAL BIOMASS WILD	**29.3**

(Bowen and Andrews 2000, 2013)
------ = species not present in assemblage
*Other ID'd W. Mammal = includes just the identified species, does not include Artiodactyla or Indeterminate Medium Mammal bones found in the Bone Summary Charts

**ID'd Wild Fowl = includes just the identified species, does not include the Indeterminate Wild Bird category found in the Bone Summary Charts

Zooarchaeological Evidence: Starving Time

When faunal remains dating from the "starving time" were analyzed, the biomass results still show the colonists relied primarily on domestic species, at least while they lasted. Domestic mammals and domestic fowl contributed approximately 33.5% to the biomass totals while wild species comprised 29.3% of the biomass. The data for this time period comes from three features excavated within the fort, including Pit 1, Pit 3, and a cellar/kitchen. The largest faunal assemblage came from the cellar/kitchen which contained evidence of metal working and two bread ovens carved into the walls (Jamestown Rediscovery 2000sa). Based on artifacts found in the cellar/kitchen, it is believed to have been filled in with trash from the fort when De La Warr arrived in 1610 and ordered the fort to be cleansed. Not only did the cellar contain evidence of butchered horse and dog bones, but it also included skull and leg bone from a young girl. Forensic analysis of the bones concluded the girl had been the victim of survival cannibalism, signifying the harsh reality of the "starving time" (Jamestown Rediscovery 2000sb). While the results from the faunal analysis are briefly summarized in this report, a detailed analysis of these features can be found in faunal reports from 2000 and 2013 by Bowen and Andrews.

Livestock and Provisions: Starving Time

The biomass summary from Pit 1, Pit 3, and the cellar/kitchen shows the settlers, during the "starving time," relied on domestic livestock for their primary source of meat. First-hand accounts tell us domestic animals were quickly consumed in and around the fort as the winter of 1609-1610 began. Virginia Indians slew swine by the hundreds, offered no trading opportunities, and provisions from England had become scarce (Perkins in Haile 1998:133; Smith in Haile 1998:319; Horn 2005:99).

The biomass estimates from this time period show that in terms of dietary importance horse (*Equus* spp.) averaged 14.5%, cattle (*Bos taurus*) 11.9%, swine (*Sus scrofa*) 6.3%, sheep/goat (*Ovis aries/Capra hircus*) 0.7%, and chicken (*Gallus gallus*) 0.1% (see Table 5). These percentages differ from the "early Jamestown" assemblages where the domestic mammals ranked cattle first, swine second, horse third. The decrease in cattle remains really shows how barreled beef diminished as the hurricane dispersed the supply ships. The butchered horse bones from the cellar show how desperate the settlers were, eating animals they would have considered to be "taboo." With horse ranking first in importance, it demonstrates how the meat would have given the settlers a temporary reprieve from their hunger.

When the element distributions for cattle, swine, and sheep/goat are compared to the normal element distribution patterns, it is clear the swine and sheep/goat were livestock raised at Jamestown. All parts of swine and sheep/goat are included in the assemblage in percentages similar to a normal skeleton pattern. The cattle bones show proportionately greater ratios of body elements and far fewer head and feet elements than ratios in a normal skeletal pattern. This pattern suggests the settlers were most likely still getting the majority of their beef from salted beef provisions sent from England (see Table 6) (Bowen and Andrews 2000:90-91; Bowen and Andrews 2013:27-29).

Table 6
Element Distribution for Domestic Mammals
Starving Time Assemblages

	Head		Body		Feet	
	No.	%	No.	%	No.	%
Cattle Normal		29.7		42.2		28.1
Cattle Starving Time	31	18.5	115	68.9	21	12.6
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Swine Normal		28.2		34.5		37.3
Swine Starving Time	186	26.2	354	49.9	170	23.9
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Sheep/Goat Normal		29.7		42.2		28.1
Sheep/Goat Starving Time	33	38.8	25	29.4	27	31.8

(Bowen and Andrews 2000; 2013)

Wildlife and Trading with the Virginia Indians: Starving Time

Biomass results from the "starving time" demonstrate wild species contributed 29.3% to the diet (see Table 5), a significantly lower amount than in the early Jamestown assemblages where wild species made up 46.4% of the biomass. This difference may relate to the settlers not being able to leave the fort to hunt, fish, or fowl as freely as they had done before the "starving time." This fear of being attacked by the Virginia Indians, coupled with the end of trading with them for provisions, most likely resulted in fewer bones from wild animals in these assemblages.
In terms of fish species, sturgeon (*Acipenser* spp.) contributed the highest percentage to the biomass, which may also be a result of their easily identified scutes inflating their dietary importance. Many scutes were found in the cellar/kitchen in an ash layer associated with two ovens carved into the walls. These remains and the ovens may be evidence of sturgeon processing and using sturgeon in bread making. Smith remarked,

> We had more sturgeon than could be devoured by dog and man, of which the industrious by drying and pounding, mingled with caviar, sorrel, and other wholesome herbs, would make bread and good meat" (Smith in Haile 1998:320).

Other fish species identified in "starving time" assemblages include gar (*Lepisosteus* spp.), herring (family Clupeidae), shad (*Alosa sapidissima*), sucker (family Catostomidae), freshwater catfish (family Ameiuridae), sunfish (*Lepomis* spp.), white perch (*Morone americana*), striped bass (*Morone saxatilis*), sheepshead (*Archosargus probatocephalus*), and snapper (family Lutjanidae). While the majority of the fish species were local to the waters near Jamestown, snapper, found in tropical and subtropical marine waters, may have been brought with the settlers who had been shipwrecked on the island of Bermuda during the winter of 1609-1610 (Bowen and Andrews 2000:51).

Another Bermuda connection identified in the assemblages is the Bermuda cahow (*Pterodroma cahow*), a large diving petrel related to albatrosses and shearwater birds. Identified cahow elements included only bones from the wing region and long bones, suggesting meat-bearing elements were salted, preserved, and used as provisions for the settlers while shipwrecked on Bermuda and for their voyage to Jamestown. The cahow nest in shallow burrows on Bermuda from October till December, which would have made it easy for the settlers to catch. William Strachey commented on this:

> Our men found a pretty way to take them, which was by standing on the rocks, or sands by the seashore, and holloing, laughing, and making the strangest outcry that possibly they could, with the noise whereof the birds would come flocking to that place, and settle upon the very arms and head of him that so cried, and still creep nearer and nearer, answering the noise themselves; by which our men would weigh them with their hand, and which weighed heaviest they took for the best and let the other alone; and so our men would take twenty dozen in two hours…" (Strachey in Haile 1998:398-399).

In addition to the cahow, other identified wild bird remains from "starving time" assemblages include duck (Duck spp.), goose (Goose spp.), turkey (*Meleagris gallopavo*), crow (family Corvidae), woodpecker (family Picidae), gull (*Laurus* spp.), and raptors (order Falconiformes), including hawks (*Buteo* spp.) and bald eagle (*Haliaeetus leucocephalus*). It is unclear if the raptors in these assemblages suggests the settlers were eating these birds during the "starving time." Raptors would have typically been used only for falconry and considered "taboo" species to use as food. However, the presence of bones including butchered horse, butchered dog, and burned snake vertebrae all suggest these "taboo" species were food sources during the "starving time" (Bowen and Andrews 2000).

The percentage of wild mammals in the "starving time" assemblages decreased as compared to the early Jamestown assemblages. For example, small mammals decreased from 8% to 5% of the biomass totals. The identified small mammals from the "starving time" assemblages include opossum (*Didelphis virginiana*), cottontail (*Sylvilagus floridanus*), woodchuck (*Marmota monax*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethica*), otter (*Lontra canadensis*), mink (*Neovison vison*), and raccoon (*Procyon lotor*). Two of the most frequently identified wild species from these assemblages are the eastern gray squirrel (*Sciurus carolinensis*) and the eastern fox squirrel (*Sciurus niger*), animals which could have been hunted or trapped close to the fort (Bowen and Andrews 2000).

Deer (*Odocoileus virginianus*) remains in the "starving time" assemblages demonstrates a striking decrease from an average of 14.9% to 6.0%, a sign that opportunities to hunt large game had diminished. The deer element distribution percentages show the body elements decreased from 63.2% in the early assemblages to 55.5% in the "starving time" assemblages (see Table 7). The percentage of bones from the head slightly increased in the "starving time" assemblages from 17.1% to 18.2%, while bones from the feet decreased slightly from 19.7% to 18.2%.

Overall, the deer bones percentages are closer to a normal skeletal distribution pattern in the "starving time" assemblages, than the deer bones from the early assemblages. While further analysis from all phases of Jamestown is needed, first-hand accounts from this period suggest trading with the Virginia Indians had ceased and hunting away from the fort was extremely dangerous for the settlers. The faunal evidence backs this up by showing a decrease in the dietary importance of the deer in the diet of the settlers during the "starving time."

Table 7
Element Distribution for Deer
Starving Time Assemblages

	Head		Body		Feet	
	No.	%	No.	%	No.	%
Deer Normal Skeleton		29.7		42.2		28.1
Starving Time Assemblages	26	26.3	55	55.5	18	18.2

(Bowen and Andrews 2000, 2013)

Post Starving Time at Jamestown 1610-1619

Historical Background Information: Post Starving Time

On June 10, when Lord De La Warr arrived at the fort, he saw the survivor's plight and reprimanded them for their "idleness" and vanity which he felt had led them to their dire circumstances (De La Warr in Haile 1998:466). To establish order and control of the colony, he first selected his new council including Sir Thomas Gates, Sir George Somers, Captain Christopher Newport, Sir Ferdinando Weinmann, Sir William Strachey, Sir George Percy, and four men to serve as militia captains (Strachey in Haile 1998:433). Together the new leadership went to work by first having the settlers clean up the fort and build a store of provisions. However, as Lord De La Warr quickly discovered, in terms of food, they:

> "did not have any kind of flesh, deer, or what else of that kind could be recovered from the Indian, or to be sought in the country by the travail or search of his people; and the old dwellers in the fort, together with the Indians not to friend, who had the last winter destroyed and killed up all the hogs, insomuch as of five or six hundred…there was not one left alive; nor an hen nor chick in the fort; and our horses and mares they had eaten with the first; and the provision which the lord governor and captain general had brought, concerning any kind of flesh, was little or nothing…" (Strachey in Haile 1998:433).

Assessing the lack of provisions, Del La Warr and the Council sent Captain Somers to Bermuda to "fetch six months' provision of flesh and fish and some live hogs to store our colony again" (Strachey in Haile 1998:432). At the same time, they sent Captain Robert Tindall, on his ship, to fish the waters between Cape Henry and Cape Charles (Strachey in Haile 1998:433).

Lord De La Warr and his council also began to enforce the martial laws that Gates had introduced in May 1610, with additions inserted by Dale in 1611. These laws, known as *Lawes Divine, Morall and Martiall*, allowed the Council run the colony like a military unit; enforcing strict protocols and executing severe punishments, including death, to any who risked breaking them. Not wanting to repeat what had happened during the "starving time," it is not surprising over a quarter of the laws centered on preserving food sources and leveling severe punishments for any infractions concerning livestock, gardens, trading, hunting, fishing, and the allocation of rations. Some laws dealt with stealing from the store or hoarding rations, while other laws made it clear if the settlers expected to receive their morning and evening rations, they had to attend church daily and perform the work assigned to them.

> Everie man and woman duly twice a day upon the first Towling of the Bell shall upon the working daies repaire unto the Church, to hear divine Service upon pain of losing his or her days allowance for the first omission, for the second to be whipt, and for the third to be condemned to the Gallies for six Moneths (Strachey 1612:Law 6).

The laws worked to establish order and ensured everyone received equal shares of available provisions. For example, individuals could not trade with Virginia Indians or with incoming ships unless appointed by lawful authority (Strachey 1612:Laws 15 and 19). Leadership at Jamestown also monitored the keepers of the store to make sure they did not steal, sell, or give food away "to any Favorite" (Strachey 1612:Law 17). Gardens, both private and public, were also protected by law, promising to put to death any individual who tried to rob any roots, herbs, flowers, or crops without permission (Strachey 1612:Law 31).

While the martial laws aimed to control the settlers within the fort, the council and De La Warr worked to control the Virginia Indians outside the fort. Initially, De La Warr took a conciliatory approach to his dealings with the Powhatan, asking them to stop attacking his men and taking their tools and weapons. He continued, requesting punishment to the Powhatans who killed English settlers and demanded the Powhatans return stolen items. Finally, he warned the Powhatan if they did not comply with his instructions, the English would use force to retrieve their property and the English who left the fort to live with the Virginia Indians (Horn 2005:184).

Not to be intimidated, the Powhatan responded to De La Warr by letting him know their chief was the king of this country and the English needed to leave or they would resume attacks on the fort. As expected, De La Warr retorted by promising to kill any Virginia Indians they came across during their travels and explorations of the region. This exchange ignited a four year war between the English and the Powhatan, resulting in many deaths on both sides. As the English destroyed entire villages, they attempted to starve the Virginia Indians by taking their crops in the fields and any food they could find (Horn 2005:185,188).

Within six months of his arrival, De La Warr fell sick and returned to England in March 1611, leaving George Percy in charge as deputy governor until the arrival of Thomas Dale in May 1611. Knowing additional settlers would arrive to Jamestown in a couple of months, Dale expanded the martial laws, detailing the roles of the settlers. He made it clear there would be severe punishments for those who did not follow the laws. As one example, men found stealing from the common store, found themselves tied to trees and allowed to starve to death (Horn 2005:196-197).

Settlers who reported harsh punishments, unjust laws, and little food criticized Dale's use of martial discipline and controlled rations to keep the colony under control. The settlers described daily rations as:

> …only eight ounces of meale and half a pinte of peas for a daye, the one and the other mouldy, rotten, full of Cobwebs and Maggotts loathsome to man and not fytt for beasts, which forced many to flee for reliefe to the Savage Enemy (Tyler 1946:422-423).

Letters written by Don Diego de Molina, a Spanish prisoner held captive at Jamestown for five years, support these accounts. He wrote about the conditions at Jamestown in 1613 and 1614 saying the English were "held captive by their masters" (Diego De Molina in Haile 1998:789). He revealed the settlers were suffering and, if attacked by the Spanish, the English would not resist (Diego De Molina in Haile 1998:790).

While the settlers suffered, Dale wanted to expand English presence around the York and James Rivers, establish new settlement and towns in healthier locations, and send expeditions to assert control over the Virginia Indians (Horn 2005:198). As part of his expeditions, he also sent some colonists to explore the Eastern shore where they would be able to extract salt from seawater to preserve fish (McCartney 1997:37). He also "established several settlements toward the head of the James River" (McCartney 1997:37). By 1618, the colony was divided into four cities, with acres reserved for the Company and the local administration.

As the English expanded across Virginia, Samuel Argall took the opportunity to capture Matoaka (Pocahontas), daughter of the Powhatan chief. He held her prisoner until the Powhatan agreed to return the English living with them, as well as stolen weapons and tools. A year later, Dale and Powhatan finally meet in person where they came to an agreement and ended the first Anglo-Powhatan War. Soon after, Matoaka (Pocahontas) and John Rolfe married in April 1613, establishing a more peaceful, albeit brief, period between the settlers and the Powhatan (McCartney 1997:37; Dale in Haile 1998:844-848).

Even though Chief Powhatan carefully orchestrated his relationship with the English, feigning allyship, Dale was still able to increase land development and establish a sound footing for the colony. In addition to achieving better relations with the Virginia Indians, Dale was an effective leader for the Virginia Colony. As described by John Rolfe in 1616, Dale required all farmers had to defend their own settlements and the colony. They also were required to perform public service, provide their household with food and clothing, and contribute 2 ½ barrels of Indian corn per male to the common store. To ensure this contribution, farmers were prohibited from planting tobacco until they had placed corn into production. At this time, of the 50 people who lived on Jamestown Island, 32 were farmers. Each new male immigrant received his first year's corn supply, a home rent-free, and 12 English acres of ground where he could grow herbs and corn (McCartney 1997:37-38).

In 1616 Dale left Jamestown and sailed to England, leaving George Yeardley in charge as interim governor (Haile 1998:67). During his tenure as Deputy Governor, Dale taught settlers the invaluable lesson that they could produce their own food supply and the "colony's success depended upon its inhabitants' being allowed to profit from their own labor" (McCartney 1997:37).

Livestock and Provisions: Post Starving Time

By the end of the "starving time" the colonists had eaten or lost all of their livestock. When Dale arrived in May 1611, he brought 300 hundred new settlers and at least eight months' worth of provisions. Soon after, in August, Gates returned to Jamestown with six ships carrying more men, provisions, and live cattle (Hamor in Haile 1998:821, 823). The supply ships following the "starving time" represented a second chance for the settlers to reestablish their livestock.
To become self-sufficient and not rely on the Company for provisions, leaders at Jamestown took extreme measures to protect and grow their herds of livestock. Included in the martial laws, one law specifically addressed livestock, stating:

> wee do strictly charge and command, that no man shall dare to kill, or destroy any Bull, Cow, Calfe, Mare, Horse, Colt, Goate, Swine, Cocke, Henne, Chicken, Dogge, Turkie, or any tame Cattel, or Poultry, of what condition soever; whether his owne, or appertaining to another man, without leave from the Generall, upon paine of death in the Principall, and in the accessory, burning in the Hand, losse of his eares, and unto the concealer of the same foure and twenty hours whipping, with the addition of further punishment, as shall be thought fitte by the censure, and verdict of a Martiall Court (Strachey 1612:Law 21).

Besides controlling when and who could kill livestock, Jamestown leaders took other approaches to protect the herds. After making peace with the Powhatan, Dale met with the Chickahominy Indians and agreed to peace, provided they would agree to "never kill any of our men or cattle. But if either our men or cattle should offend them or run to them, they should bring them home again, and should receive satisfaction for the trespass done them" (Hamor in Haile 1998:811). A second step was to enclose areas with fences to contain their livestock. In one area, Hamor describes a fence "about twelve English miles" for their hogs to feed in and another area with a fence and houses "in which hundred our hogs and other cattle have twenty miles circuit to graze in securely" (Hamor in Haile 1998:824, 826). In a letter written by Dale in 1613, he laid out a plan to encourage the growth of livestock when he stated:

> Every man is to have a sow of the colony's and to keep her as his own for V years; and he is to have to the number of 4 female swine to bring pigs, so that he is to have all the male pigs every year to kill for his own provision; and the female swine of those 4 sows are for the colony to dispose to other men as they shall come over; so that every man shall kill 12 swines every year for his provisions, and at the 5 years' end he shall have VI sows given him forever (Dale in Haile 1998:778).

In this same letter Dale confronted the recipient (presumed to be the Company) by letting them know the livestock they sent were the "worst sort and condition you can imagine," even sending some swine that were neutered. He also reminded them he had frequently requested "100 she-asses" or several horses to be used as work animals to plow the ground and pull their carriages (Dale in Haile 1998:780). Finally, he let the Company know he also hoped to increase the number of goats in the colony, stating as "soon as goats can be gotten from the Indies or increase here, every man is to have 2 female goats for himself" (Dale in Haile 1998:778).

Dale's efforts to protect the livestock seem to have succeeded for by 1614, Hamor wrote:

> The colony is furnished with two hundred neat cattle, as many goats, infinite hogs in herds all over the woods, besides those to every town belonging in general and every private man; some mares, horses, and colts, poultry great store, besides tame turkeys, peacocks, and pigeons, plentifully increasing and thriving there, in no country better! Of our young steer, the next winter we doubt not to have three or four plows going, which once compass'd we shall in short time be able to repay England the corn they have lent us (Hamor in Haile 1998:818).

Even with livestock increasing in numbers, the General Assembly still felt the need in 1619 to control when cattle could be killed:

> No man without leave from the governor shall kill any neat cattle whatsoever, young or old, especially kine, heifers, or cow calves, and shall be careful to preserve the steers and oxen and to bring them to plough and such profitable uses, and, without having obtained leave as foresaid, shall not kill them upon penalty of forefeiting the value of the beast so killed (McIlwaine and Kennedy 1915:13).

Wildlife and Trading with the Virginia Indians: Post Starving Time

The martial laws not only controlled who had access to livestock, but also had some control over procuring wildlife. Law relating to fishing included regulating sturgeon and other fish processing so that fishermen did not take any fish for themselves. Hunting also appears to have been regulated in some aspects as, "No Souldier shall unprofitably waste his pouder, shot, or match, by shooting it idly away, or at birds, beasts, or fowle." Punishments for these offences included "losing his eares," serving time in the gallies, and lying in "Irons head and heeles together eight & forty hours" (Strachey 1612:Laws 37, 41).

Other laws controlled how the settlers should interact with the Virginia Indians. Trading with Indians was not allowed, under penalty of death, unless settlers had lawful authority. In addition, they could not use force to take anything from Indians who came to the fort to trade (Strachey 1612:Laws 15 and 16). Although these laws appear to have discouraged contact with Virginia Indians, according to Smith, when Yeardley became governor in 1616, he "had a savage or two so well trained up to their pieces they were as expert as any of the English, and one he kept purposely to kill him fowl" (Smith in Haile 1998:860).

By 1619, laws limiting interactions with Virginia Indians appeared to have loosened, as new laws encouraged settlers to teach Indian children Christianity, permitted trading, and with the consent of the Governor, allowed some Virginia Indians to live in the colony to help with fishing and hunting. The law, however, still shows the settlers remained cautious:

> As touching the instruction of drawing some of the better disposed of the Indians to converse with our people and to live and labor among them, the assembly , who know well their dispositions, think it fit to enjoin at least to counsel those of the colony neither utterly to reject them nor yet to draw them to come in…though some among them many may prove good, they are a treacherous people and quickly gone when they have done a villainy (McIlwaine and Kennedy 1915:10, 12)

Although interactions with Virginia Indians fluctuated in the years following the "starving time," the end of the First Anglo Powhatan War in 1614 allowed the settlers to seek peace with other tribes which, in turn, permitted the settlers to hunt more freely without fear of being attacked (Horn 2005:218-219). Ralph Hamor provided a detailed account in his *True Discourse* of all the wildlife available to the settlers to use for provisions. For mammals he listed beavers, deer, otters, foxes, raccoons, opossums, rabbits, muskrats, and squirrels and commented, "Of each of these beasts…myself have many times eaten, and can testify that they are not only tasteful but also wholesome and nourishing food" (Hamor in Haile 1998:817). For birds he mentioned eagles, turkey, cranes, hawks, buzzards, swans, owls, geese, ducks, cormorants, and small birds such as sparrows, woodpeckers, and pigeons, which he saw in flocks so thick "they shadowed the sky from us." Finally, he listed close to 20 different species they caught and consumed from the rivers, including crabs, oysters, eel, and many species of fish. Many of the species Hamor mentioned are seen in the faunal assemblages analyzed from the Second Well (JR2158).

Zooarchaeological Evidence: Post Starving Time

The faunal evidence for the post "starving time" period comes from the analysis of six layers from the Second Well (JR2158). While the results will be briefly summarized in this section, detailed analyses for this time period are found in the second half of this report. Associated features and artifacts excavated from the well suggest it was dug around 1610-1611 and filled in by 1617-1618. Overall, when combined, the well layers show wild species make up 41.6% of the biomass, while domestic species account for 27.9% of the biomass (see Table 8). These percentages are more like the results from the early Jamestown assemblages, where wild species made up 46.4% of the biomass and domestic species made up 23.5%.

Livestock and Provisions: Post Starving Time

The biomass results for livestock following the "starving time" show swine (*Sus scrofa*) provided a significant portion of the meat diet, making up 21.0% of the biomass, followed by cattle (*Bos taurus*) at 4.8%, and sheep/goat (*Ovis aries/Capra hircus*) at 1.8% (see Table 8). Horse (*Equus* spp.) and chicken (*Gallus gallus*) contributed less than 1% to the biomass results.

Table 8
Biomass Percentages for Select Species
Post Starving Time Assemblages

	Second Well Layers						
Assemblage	**H**	**N**	**P**	**U**	**X**	**AA**	**AVG.**
Provisions and Livestock							
Cattle	3.7	6.1	2.9	3.8	7.3	-----	**4.8**
Swine	25.7	23.9	5.3	17.8	27.1	26.1	**21.0**
Sheep/Goat	1.1	0.1	0.6	3.0	2.7	3.1	**1.8**
Horse	-----	-----	0.1	-----	-----	-----	**0.1**
Chicken	0.3	0.1	0.2	0.1	0.4	0.2	**0.2**
						TOTAL BIOMASS DOMESTIC	**27.9**
Wild Species							
Deer	14.2	21.3	21.7	23.1	18.4	19.2	**19.6**
Crab	<0.1	<0.1	<0.1	<0.1	-----	-----	**<0.1**
Sturgeon	5.3	8.8	19.0	14.9	8.8	7.0	**10.6**
Other Fish	3.8	6.3	5.1	4.3	2.0	2.0	**3.9**
Turtle	1.0	0.9	0.8	1.0	0.4	0.1	**0.7**
Snake	<0.1	<0.1	<0.1	<0.1	-----	-----	**<0.1**
*Other ID'd W. Mammal	1.7	2.2	1.2	0.9	0.3	-----	**1.3**
**ID'd Wild Fowl	4.0	4.1	1.9	2.2	6.5	14.2	**5.5**
						TOTAL BIOMASS WILD	**41.6**

Data found in this report pages 102-117
------ = species not present in assemblage
*Other ID'd W. Mammal = includes just the identified species, does not include Artiodactyla or Indeterminate
Medium Mammal bones found in the Bone Summary Charts
**ID'd Wild Fowl = includes just the identified species, does not include the Indeterminate Wild Bird found in the Bone Summary Charts

These percentages differ from the early Jamestown and the "starving time" assemblages, which show swine contributing between 4% and 6% and cattle between 12% and 18%. This increase in the importance of swine and the decrease in cattle may have resulted from the martial laws which worked to preserve the livestock and increase the herds. In addition, swine are prolific breeders, omnivorous, and require little care, making it easier to increase their numbers than cattle. For this reason, leadership at Jamestown may have focused on preserving cattle by not allowing settlers to kill them for provisions too frequently.

Table 9
Element Distribution for Domestic Mammals
Post Starving Time Assemblages

	Head		Body		Feet	
	No.	**%**	**No.**	**%**	**No.**	**%**
Cattle Normal		29.7		42.2		28.1
Cattle Post Starving Time	3	3.5	78	92.8	3	3.5
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Swine Normal		28.2		34.5		37.3
Swine Post Starving Time	776	47.8	534	32.9	313	19.3
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Sheep/Goat Normal		29.7		42.2		28.1
Sheep/Goat Post Starving Time	24	36.4	24	36.4	18	27.3

Data found in this report pages 120-123

The low percentage of cattle in the biomass may also relate to provisions sent from England to the settlers at Jamestown. When the element distribution percentages from the Second Well (JR2158) are compared to a normal skeleton pattern, the percentages of swine and sheep/goat head, body, and feet bones are similar to a normal skeletal pattern (see Table 9). Although the percentage of swine head bones for the well is higher than a normal pattern, it is due to a significant number of swine teeth which tend to survive better than the more fragile bones from the head. For cattle, body elements make up 92.8% of the identified cattle bones, suggesting the settlers were still getting most of their beef as barreled provisions sent from England. If they were killing their own cattle, this should be reflected in the distribution pattern by showing higher percentages of head and feet bones.

Wildlife and Trading with the Virginia Indians: Post Starving Time

Like the early Jamestown assemblages, the post "starving time" faunal data shows wild species contributing an average of 41.6% to the biomass totals (see Table 8), which is significantly higher than the "starving time" assemblages where wild species only contributed an average of 29.3% to the biomass. This difference may be related to the end of the First Anglo Powhatan War in 1614 and the beginning of peaceful interactions with Virginia Indians for a time, allowing the settlers to return to the woods to hunt, to the rivers to fish, and for the leaders of Jamestown to trade again with nearby tribes.

It is interesting to see deer (*Odocoileus virginianus*) contributed 20.0% biomass to the meat diet, almost as much a swine at 21.0%. When the element distribution patterns for deer are compared to a normal skeletal pattern, it is clear all portions of the body are present in the assemblage in percentages close to a normal skeletal pattern (see Table 10). These percentages suggest the colonists were hunting their own deer or having Virginia Indians hunt for them, as Governor Yeardley supposedly did in 1616 (Smith in Haile 1998:860). In both cases, the whole deer appear to have been returned to the fort for processing, allowing the settlers to make use of the whole animal and their skin. If the settlers were trading with Indians for deer, the percentages would probably show a significantly higher number of the meatier portions of the body.

Table 10
Element Distribution for Deer
Post Starving Time Assemblages

	Head		Body		Feet	
	No.	**%**	**No.**	**%**	**No.**	**%**
Deer Normal Skeleton		**29.7**		**42.2**		**28.1**
Post Starving Time Assemblages	**316**	**22.4**	**775**	**54.8**	**322**	**22.8**

Data found in this report page 224

After deer, sturgeon (*Acipenser* spp.) and other fish make up 14.5% of the biomass results with species including skates (order Rajiformes), gar (*Lepisosteus* spp.), bowfin (*Amia calva*), sucker (family Catostomidae), freshwater catfish (family Ameiuridae), white perch (*Morone americana*), drum (family Sciaenidae), spotted seatrout (*Cynoscion nebulosis*), striped bass (*Morone saxatilis*), shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), herring (family Clupeidae), sunfish (*Lepomis* spp.), sheepshead (*Archosargus probatocephalus*), yellow perch (*Perca flavescens*), and weakfish (*Cynoscion* spp.). The drought that plagued the settlers during the "starving time" and caused a decline of fish in the rivers appeared to have been over by 1617 when John Rolfe wrote about the conditions in Virginia. In regards to fish, he stated there were:

> …two seasons in the year to catch fish, namely the spring and the fall…one hale with a seine caught five thousand [fish], three hundred of them as big as cod, the least of the residue a kind of salmon trout two foot long…Likewise two men with axes and suchlike weapons have taken and kill'd near the shore and brought home forty as great cod in two or three hours' space…(Rolfe in Haile 1998:869-870).

Following the contribution of fish, wild fowl make up 5.5% of the biomass totals, a percentage higher than the early Jamestown assemblages at 3.7% and the "starving time" assemblages at 2.6%. While identified wild fowl include swans (*Cygnus* spp.), ducks (Duck spp.), geese (Geese spp.), gulls (*Larus* spp.), sandpipers (family Scolopacidae), cranes (order Gruiformes), and other small birds (order Passeriformes), some of the more interesting identifications in the Second Well (JR2158) are raptors, such as bald eagles (*Haliaeetus leucocephalus*), red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), osprey (*Pandion haliaetus*), and owls (order Strigiformes). Raptors were also identified in the early Jamestown and "starving time" assemblages but not in the same numbers as in the post "starving time" assemblages. Together the early Jamestown assemblage and the "starving time" assemblage had 20 raptor bones, while the post "starving time" assemblages have a total of 124 raptor bones. Most of these bones are from bald eagle (*Haliaeetus leucocephalus*) with 67 elements and turkey vulture (*Cathartes aura*) with 24 bones.

While it is plausible the raptor bones from the "starving time" assemblages may represent the remains of a meal, the significant number of raptor bones following the "starving time" is still a mystery. Did the settlers kill them to use the feathers and other parts as trade items with the Virginia Indians? Could the settlers have seen raptors as a threat to their young livestock or as competition for the same food resources? Further research is needed to help explain their increased presence of raptors in the Second Well (JR2158) assemblages.

Although the percentage of raptors bones increased from the early assemblages to the post "starving time" assemblages, the percentages of small wild mammals decreased. In the early Jamestown and the "starving time" assemblages, wild mammals make up 7.9% and 4.8% of the biomass. In the post "starving time," small wild mammals only contribute 1.3% to the biomass. The lower percentage may relate to the increased importance of deer during this time. The identified small mammal species from the post "starving time" are consistent to other Jamestown assemblages where opossum (*Didelphis virginiana*), squirrel (*Sciurus* spp.), otter (*Lontra canadensis*), muskrat (*Ondatra zibethica*), mink (*Neovison vison*), and raccoon (*Procyon lotor)* are the most frequently identified species.

Emergence of Tobacco Plantations and Herd System 1620s+

Historical Background Information: Stability Herds

Success for Jamestown had been elusive. By the 1620s, the colonists fully understood there was no gold or silver to be found, but of land, there was plenty, to grow the sweet-scented tobacco John Rolfe had introduced. The foundation laid by the Virginia Company and Governor Dale had the opportunity to establish plantations to produce their own food.

In 1612 the Virginia Company received its third and last charter from King James I. Continuingly plagued by financial problems and shouldering costs to develop and maintain the colony, this charter encouraged expanding colonization and reaffirmed the Company's governance over its colony. In 1618 the Company ratified its Great Charter that initiated a new phase of settlement. At this time the Company understood the existing martial laws were too strict and would discourage many settlers from coming to Virginia. To help with this, the Company instructed Governor George Yeardley in 1619 to end martial law and set up two self-governing councils; one made up of individuals selected by the Company to support the governor and another with individuals representing each town and plantation. Meeting at least once a year, the General Assembly would work to discuss matters of the colony. The first meeting occurred on July 30, 1619, where the General Assembly established new laws, listened to the colonists' grievances, and discussed matters related to Native tribes (Horn 2005:239-241). In sum, the Great Charter established the General Assembly, and in doing so, set forth a new phase for Jamestown, where colonists could acquire real estate and work for personal gain (McCartney 1997:38-39). According to the Company's instructions, taking the reins of government, Sir George Yeardley, Virginia's new governor subdivided the colony into four corporations, James City, Charles City, Henrico City, and Kecoughtan (or Elizabeth City) (McCartney 1997:39-40).

Building on Dale's steps to create a foundation for colonists to produce their own food, the General Assembly had the ability to make laws for themselves, lift martial laws that controlled individual access to food and land, and initiate a new policy that would encourage potential settlers to migrate to Virginia, where they could reap the benefits of growing tobacco. This policy was known as the headright system, where "Ancient Planters" who had arrived in the colony before 1616 acquired 100 acres, and newcomers acquired 50 acres of land plus 50 additional acres for each person they brought with them. Those whose passage was paid would serve as indentured labor to pay off their debt (Haile 1998:37-38; Ancient Planters of Virginia in Haile 1998:909; McCartney 1997-42-44; Horn 2005:239). By instituting these changes, the Company shifted land ownership to individuals and, in doing so, established the foundation of the plantation economy. Inadvertently, in August 1619, a Dutch frigate brought another source of labor, 20 Africans that were exchanged for needed provisions and subsequently sold into servitude (McCartney 1997:41-42). These steps, plus the additional African labor, enabled individuals to integrate food production into their plantation economy and no longer depend on provisions from England or wildlife for their survival. With these developments, settlers soon spread out from the island along riverways and established commodity-focused plantations supported by an extensive herd system that would enable colonists to produce their own subsistence. By 1620, colonists had established more than 23 independently owned settlements (McCartney 1997:4243; Haile 1998:37).

Virginia Indians and the English Colonists:

By 1617, Matoaka Rebecka (Pocahontas) died from sickness while in England, and her husband John Rolfe returned to Jamestown alone. In 1618 her father, the paramount chief, Powhatan, died, and Opechancanough, assumed power to lead the Powhatan (Haile 1998:50-51). During Powhatan's reign, a distant and reserved presence was maintained with the English but Opechancanough chose a different approach. He interacted with the English openly with the appearance of being an ally.

As the settlements increased, Virginia Indians, such as the Chickahominies, Paspaheghs, and Weyanocks, began to be forced off their land and pay tributes to the English. Watching this, Opechancanough continued to feign an alliance with the English, while planning a surprise attack (Horn 2005:253). Opechancanough coordinated an attack with several tribes so that approximately 500 warriors assaulted the English at various locations at the same time. Using the settlers' own tools and weapons, warriors attacked without warning on March 22, 1622, wiping out a quarter of the colony's population and their livestock (Horn 2005:255-256). As described in *The Ancient Planters of Virginia*:

> …we being too secure in trusting of a treacherous enemy, the savages. They, whilest we entertained them friendly in our houses, took their opportunities and suddenly fell upon us, killing and murdering very many of our people, burning and devasting their houses and plantations (*Ancient Planters* in Haile 1998:910).

Having been warned, Jamestown was one of the only settlements to escape the massacre. Although Opechanough had not successfully killed all of the English, he destroyed many settlements, forcing the colonists to abandon their outlying plantations and move to fortified settlements once again. The Company tried to assist the colonists by sending more weapons and armor, as well as new settlers. Sir Francis Wyatt, who became governor of Virginia in 1621, planned retaliatory attacks on the Virginia Indians, killing them, burning their homes, destroying their canoes, and stealing their fishing weirs and crops. In unpredictable attacks, English raiding parties were sent out, while the Virginia Indians continued to kill off any English they found. These constant attacks and the reduction of livestock led to the second "starving time" for the Virginia colony during the winter of 1622-1623, and the deaths of colonists from starvation and sickness (Horn 2005:267-268).

In July 1624, a pivotal battle took place between the English and the Pamunkey. For two days, the Pamunkey defended their villages, including their stores of corn. The English eventually prevailed. Although conflicts and random attacks continued for the next eight years, this battle marks the beginning of the demise of the Powhatan empire (Horn 2005:272). The Second Anglo Powhatan War ended in 1632 when a final peace was reached with the Powhatan (Rice 2021).

1624 also saw the end of the Virginia Company when King James I revoked their charter on May 24, ending the Company's rule and making Virginia a royal colony. In March 1625, when James I died, King Charles I continued what his father had started and proclaimed the king would continue to protect and support the royal colony of Virginia. By this time, the colony's population had grown, the tobacco trade was profitable, and livestock herds had increased again (Horn 2005:277-282).

Livestock and Provisions: Stability Herds

The surprise attack by the Powhatans in 1622 resulted in the death of 347 colonists and numerous livestock. Sickness and starvation followed the attacks as a "generall death of men and Cattle" plagued Virginia during the winter of 1622-1623. As one colonist wrote, "he that had 40 hoggs about his house hath one or two: and a hundredth henns hath now 3 or 4…" (Kingsbury 1935[4]:229, 235). Another wrote,

> As you know this land hath felt the affliction of Warr, sense of sickness and death to a great number of men, likewise among the Cattle for dogs have eaten in this winter more flesh than the men . . . and for tame Cattle there have so many died and been killd otherways that there is no more to be had" (Brown and Sorrells 2004:22).

Following this event, laws attempted to prevent colonists from killing livestock for fear of execution. Even so, hungry settlers shot calves, an offense they paid for by serving the colony for seven years (Brown and Sorrells 2004:24). In 1624, a census counted only 365 cattle, 518 swine, 215 goats, and one horse (Anderson 2002:382). With the dissolution of the Virginia Company in 1624, livestock imports decreased dramatically, and natural increase became the singular driving factor in herd growth. The House of Burgesses continued to support herd growth by prohibiting the slaughter of breeding animals. Even with an additional raid in 1644 that killed 400 English, livestock herds continued to grow, and by 1649 Virginians owned about 20,000 head of cattle, 200 horses, 50 asses, 3,000 sheep, 5,000 goats, and "innumerable" swine and poultry (Brown and Sorrells 2004:28; Anderson 2002:382).

The new government created a system capable of producing a commodity and food to feed planters, their families, and servants in a system where livestock could thrive. Planters took the initiative by creating fields to grow tobacco and corn. Using techniques learned from Virginia Indians, forests were cleared by girdling and burning trees. Then tobacco and other crops were planted, in the process establishing a phenomenally successful system that required no fertilizer. For about two to three years, the newly cleared space and the ashy remains of burned trees provided rich soil. However, tobacco leached nutrients, and within a few years, planters would sow corn in place of tobacco (Craven 1926:11-19, 25-39; Walsh 1989:2001). When soil fertility declined even further, planters abandoned fields and left them in fallow for as long as twenty years. Over time, this practice created a diverse yet natural-looking landscape composed of hardwood and pine forests, interspersed with an ever-increasing patchwork of fields in cultivation and those in fallow. By increasing the pasturage in this manner, livestock could feed on stubble after harvest and on fields in fallow.

When combined with domestication and ethology studies, faunal remains show how livestock colonized the land in tandem with the colonists. Together they co-created a herd system where livestock roamed freely, with relatively few constraints (Ingold 1980; 1994; O'Connor 1997; Clutton-Brock 1999; Zeder 2012; 2015). While some have suggested this solution amounted to no system at all, biologists have shown differently. Except for the cat, domesticated mammals are social by nature; they live in hierarchical groups, and do not defend a territory. Furthermore, they can accept humans as leaders within their social structure (Clutton-Brock 1999). Through long association with humans as leaders, planters and their livestock co-evolved an extensive herding system. The animals acted instinctively within the loose boundaries the colonists placed on their free-ranging behavior.

In the woods, cattle and swine found vines, broad-leafed trees, mast, tender roots, and the young shoots of hardwood trees, and along streams and shorelines, they found salt marsh grasses, roots, and oysters (Clayton in Force 1836-1846[3]:25-26; Beverley 1855:125; Jones in Morton 1956:781; Silver 1990:171-177; 2001:149-166). Lastly, in abandoned fields in various stages of regrowth, cattle, and pigs found native grasses, herbaceous plants, vines, and young trees. As these fields increased in number, they became near-perfect foraging conditions, whether or not the farmers themselves recognized the benefits of the horticultural cycle (Van Soest 1994:36-38, 93-99, 188; Heady and Child 1999:208-226). For example, in 1629, Captain John Smith remarked how most of the woods around Jamestown, Virginia, had been cut down and "…converted into pasture and gardens; wherein doth grow all manner of herbs and roots we have in England in abundance and as good grass as can be. . . ." (Crosby 1986:157).

The following paragraphs will examine more closely the herd behavior, productive habitat, and the colonists' husbandry techniques used to increase Virginia's swine, cattle, and sheep/goat herds.

Swine

Studies of the wild progenitor and its domesticated form provide the basis for reconstructing swine husbandry (Sweeney 1970). These animals are omnivorous social generalists, with a wide diet including leaves, nuts, fruits, grasses, fungi, roots and tubers, tree seedlings, and melons, as well as small mammals, crustaceans, and carrion (Grandin 1998). As diurnal feeders, feral and wild hogs prefer feeding in the evening and staying within their home ranges as long as resources are available. Herds composed of two to four sows and their recent and juvenile offspring will remain within a home range of 247-1235 acres (Fradrich 1974:135-140; Grigson 1982:297-312; Gonyou 2001:149). At 7-8 months of age, juvenile boars are forced out and remain solitary except to join a herd during mating season. The hierarchical structure of this herd is strong, and the composition rigid, sufficiently that non-members are not welcomed. As generalist feeders and prolific breeders, wherever there is abundant food, feral and wild populations can farrow twice a year, producing litters of five to six piglets in just four months (Sweeney 1970; Grigson 1982; Gonyou 2001:163).

In England, where woodlands remained, farmers practiced an old form of husbandry known as pannage husbandry. In these locations, swine were born at home, weaned at three months, and then sent to the woods to feed alongside their elders. They remained until the end of the mast season, when farmers herded them home to be butchered (Trow-Smith 1957:50-55; Grigson 1982:297-312; White 2011; Hamilton and Thomas 2012). Even when left in the woodlands, they were constrained in pens where they were kept by night. So successful was this herding system, it was not until the late eighteenth century when woodlands had decreased in many parts of Britain, and the commercial production of pigs had increased, that pig- keeping diverged from pannage husbandry to a more controlled system based on penning (Trow-Smith 1957:51; Grigson 1982:297-312).

Pannage husbandry was perfect for the heavily-wooded Chesapeake. Not surprisingly, more than any other species, colonists allowed swine to run free in the woods, where they reportedly swarmed, "like Vermine upon the Earth . . . [They] run where they list, and find their own Support in the Woods, without any Care of the Owner . . .*"* (Beverley 1855:236). Even so, colonists understood their instinct to live in hierarchical herds, as is evidenced by Robert Beverley. He wrote, "If a Proprietor could find and catch the Pigs, or any part of a Farrow," then they could claim ownership of all that ran together, since "as they are bred in Company, so they continue to the End" (Beverley 1855:236). Remaining in their home range as long as desirable food sources were available, swine fed in salt marshes on oysters and roots, in forests on tender roots, carrion, seedlings, acorns, on fields after harvest, and in orchards on their favorite--peaches (Bowen 1999:360).

Cattle

Cattle are social mammals (Reinhardt and Reinhardt 1981:121-151; Reinhardt 1983:251-264; Phillips 1993:33-74; Albright and Arave 1997:45-66). Unlike sheep, who are true grazers, cattle can digest acorns and leaves of trees, tree shoots, and bushes in addition to grasses, an attribute that gives them great flexibility. Feeding in small and well-defined home ranges, they can take advantage of open areas, woodlands, scrubland, and marshy wetlands (Hall 2002:134; Jordan 1993:22). In semi-wild or wild cattle herds, the social organization takes the form of matriarchal groups consisting of females and their young and bachelor groups of bulls. Organizing around natural resources, these herds move in large groups when resources are plentiful, and when scarce, they break into smaller kin groups. When necessary, feral herds will range over large areas searching for food (Bouissou et al. 2001).

In England, there was precedent for free-ranging cattle. In areas where woodlands were common, farmers permitted cattle to graze alongside swine (Trow-Smith 1957:23-24; Thirsk 1987; 2000). In the Chesapeake, colonists followed suit (Gray 1933; Laing 1954; Miller 1984; Bowen 1994, 1999; Walsh et al. 1997; Dyer 2000:97-211; Short 2000:122-149; Brown and Sorrells 2004; Anderson 2004; Carson et al. 2008). Knowing their cattle would stay together in herds, colonists placed them on islands or in an area defined by a palisade (Smith in Tyler 1946:330; Gates in Kingsbury 1935[3]:18). While some livestock escaped to form feral herds, colonists did exert some oversight, as evidenced by this statute requiring that "Catle [should] be kept in heards waited and attended on by some small watch or so enclosed by them selues that they destroy not yor corne and other seed provisions . . ." (Kingsbury 1935[3]:18).

Nonetheless, documents show cattle did range with relative freedom, as a traveler in 1687 observed cattle grazing "in the woods or on the untilled portions of their plantations, where they shelter nightly rather by instinct than from any care given them" (Durand de Dauphine 1934:122). Historian Anderson (2004:110) drove this point home when she remarked, "For all the thousands of farm animals reportedly in the Chesapeake by midcentury, few appeared to live on anyone's farm." To establish ownership and distinguish them from the feral stock they referred to as "'wild gangs"' that lured tame cows to join their harems, owners protected their mobile property by marking them with an earmark and registering them at the county court (Anderson 2004:126-132).

Both feral and tame cattle served as colonizers, grazing freely and dropping manure, inadvertently depositing Old World grass seeds that clung to their hooves or were in their stomachs. These grasses, which had co-evolved with herbivores for thousands of years, contained certain essential proteins that New World grasses lacked. Little by little, these herbivores and the Old -World grasses restarted the process of co-evolving in the New World (Crosby 1994:37-41, 66-69; Van Soest 1994:78). In the Chesapeake, each cow required twenty to thirty acres to stay healthy, but land was plentiful, and cattle flourished with some supplemental feed shortly before slaughter. Faunal remains corroborate documentary sources with relative dietary estimates that show the colonists' beef consumption rose from 14% percent in the first half of the century to as much as 58% percent by the third quarter of the century.

Sheep/Goats

Sheep and goats are both social mammals preferring to live within a home range, with a social structure based on dominance hierarchies and a dominant leader (Clutton-Brock 1999; Arnold and Dudzinski 1978:51, 81-86; Fisher and Matthews 2001:211-245). What distinguishes goats and sheep from territorial species such as the white-tailed deer, is that neither species defends the home range in which they travel in search of food.

Feral herds, such as the highly gregarious Soay sheep, provide information on how introduced caprines might have formed social herds. In the Soay males and females of reproductive age remain segregated during the non-breeding seasons. Led by a leader, each group feeds in separate home ranges. Young males remain with their mothers until puberty, when they form loosely defined bachelor herds (Fisher and Matthews 2001:212-216; Arnold and Dudzinski 1978:51).

Sheep groups vary in size according to breed and local conditions. They tend to form compact groups that instinctively bunch together in response to threats such as potential predators, like wolves or dogs bred to herd sheep. When sensing danger, they tend to flee in groups, a fact that made them easy prey for Chesapeake wolves (Fisher and Matthews 2001:218-219). Goats, like sheep, form flocks, but unlike young lambs that bond and immediately follow their mothers, kids remain frozen in one spot while its mother grazes. Group behavior reflects this as flocks tend to be less defined with often no clear leader. When threatened, rather than bunching together like sheep, goat flocks typically form a thin line. When pursued they tend to break up the line, a trait that enabled them to better withstand wolf attacks (Hafez and Scott 1969:320-321).

These herding characteristics, combined with their browsing behavior, made the adaptable goat the ideal colonizer. Not surprisingly, they were among the first domesticated animals to be transported to the Chesapeake (Clutton-Brock 1999). Additionally, goats could browse on a diverse diet, a trait that enabled them to feed widely and broadly through woodlands, brush, and fields in various stages of regeneration.

Sheep were also among the first to be introduced, but they did not do well in the region's dense forest brush. Their numbers did not increase successfully due to the lack of suitable vegetation and brush which pulled off their wool. Additionally, sheep are inveterate grazers needing open meadows, so their flocks did not grow until sufficient fields were cleared and left to fallow. Sam Elswick's excellent research shows the bounties for killing off wolves occurred after sheep numbers increased (Elswick 2003). Supportive evidence for the relative importance of sheep and goats come from *Colonial Williamsburg's Provisioning Early American Towns, the Chesapeake: A Multidisciplinary Case Study*, showing the number of sheep and goats recorded in York County probate inventories (Walsh et. al, 1998:32-33, 72). As the probate inventories show, between 1620-1660, goats made up 5.6% of the recorded livestock, while sheep were nonexistent (see Table 11).

Table 11
York County, Va. Probate Inventories
Livestock, 1620-1660

	1620-1660	
York County	**No.**	**Pct.**
Cattle	432	59.1
Swine	231	31.6
Sheep	0	0.0
Goats	41	5.6
Horses/Mules	26	3.5
Total	**730**	**100.0**

(Walsh et al. 1997)

Wildlife and Trade with the Virginia Indians: Stability Herds

With the massacre of 1622 etched in their memory, it is not surprising trading with the Powhatan ceased as attacks continued between the English and local tribes. Instead, the colonists traveled long distances to trade with enemies of the Powhatan near the Eastern Shore and as far as the Potomac River (Horn 2005).

As the livestock herds began to recover after the massacre, colonists faced threats from Virginia Indians and the wolves, an enemy the colonists had not had to worry about in England since the 15th century (Anderson 2002:380). The hunting and feeding habits of wolves began to change as woods were cleared for agricultural fields. Prey, such as deer, woodchucks, and rabbits, increased as new food sources became available, bringing wolves closer to human settlements. In addition, the introduction of livestock roaming freely in forested lands and cultivated fields also attracted wolves, as they served as a year round source of meat. With these conditions, the wolf population quickly exploded in the mid-17th century, while the deer population decreased from over hunting and fur trading (Elswick 2003:24-25, 29).

By 1632, Virginia's House of Burgesses passed the first of many acts to help reduce the wolf population by offering bounties and allowing Virginia Indians to be hired to kill wolves. While some accounts of wolves may have been exaggerated, the continual renewal of wolf bounty acts by the House of Burgesses and the number of wolf bounty payments made well into the 1730s, suggests the threat of wolves was a continual menace to the establishment of the livestock herds in the Chesapeake (Anderson 2002:380; Elswick 2003:44).

Zooarchaeological Evidence: Stability Herds

Faunal data from Jamestown dating from the 1620s until the 1650s comes from three assemblages, including Ditch 7 (1620), Ditch 6 (Post 1630), and Midden 1 (second quarter of 17th century). These three assemblages were combined together to represent Jamestown when livestock was becoming established and the herds were finally becoming stabile. While the results will be briefly summarized in this report, a complete analysis can be found in a 2000 faunal report written by Bowen and Andrews.

As the results show, domestic species dominate the biomass results averaging 64.9% of the assemblage, while wild species only account for 11.9%. When the results from Jamestown assemblages dating to ca. 1607-1610 and ca. 1620-1650 are put side by side with other 17th century faunal assemblages (see Figure 1), it becomes clear that the consumption of wildlife decreased by the second quarter of the seventeenth century. By 1620-1650, the percentages shift to show domestic species making up the majority of the biomass at 64.9% and wild species and wild species making up 11.9%. It is clear from this data and corroborated by documentary sources, during the second quarter of the 17th century, Jamestown colonists shifted from a reliance on wildlife to a reliance on domestic livestock. The other sites, dating to the second quarter of the 17th century, show how plantations and herds of livestock had spread throughout the region; these assemblages show diversity with wildlife consumption ranging from 18% to as little as 6%, but each have a marked reliance on domesticates. Taken as a whole, they demonstrate how quickly a herd system evolved to supplant the early dependence on provisions and wildlife.

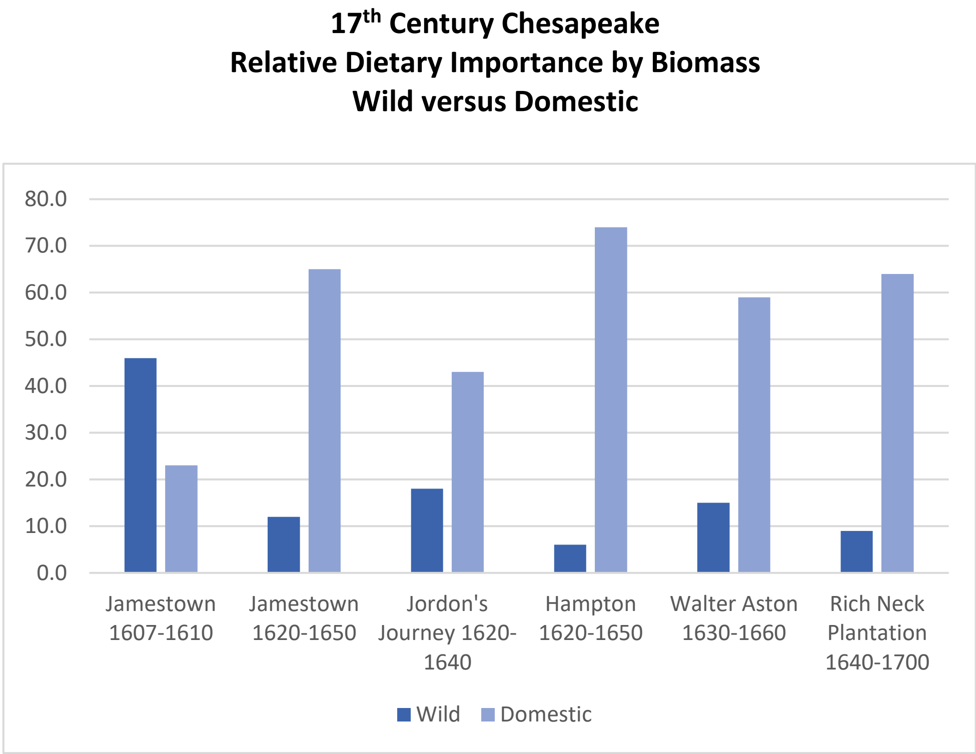

Figure 1. (Data from Andrews 1999; Andrews et al. 1997; Bowen 1996; Bowen and Andrews 2000, 2013; Edwards et al. 1988)

Livestock and Provisions: Early Jamestown

The biomass results for livestock from the 1620s, post 1630s, and 1650s shows domestic species making up most of the meat diet, accounting for 59.0% to 69.1% of the totals (see Table 12). In the post "starving time" assemblages, swine (*Sus scrofa*) was the most significant contributor to the biomass. By the 1620s, as herds grew, cattle (*Bos taurus*) became the most important livestock in terms of food. In these assemblages, cattle contribute between 42.3% and 49.9% to the biomass, followed by swine between 15.8% and 20.2%, and sheep/goat (*Ovis aries/Capra hircus*) between 0.3% and 2.1%. Horse (*Equus* spp.) remains are no longer found in the assemblages and chicken (*Gallus gallus*) make up less than 1% of the diet. Overall, these biomass totals demonstrate the colonists were finally successful at establishing the herds to ensure they were no longer dependent on England for provisions.

Table 12
Biomass Percentages for Select Species
Stability Herds Assemblages

Assemblage	**Ditch 7**	**Ditch 6**	**Midden 1**	**AVG.**
Time Period	**Post 1620**	**Post 1630**	**2^{nd} Q. 17^{th} ca.**	
Provisions and Livestock				
Cattle	42.3	49.9	47.6	**46.6**
Swine	15.8	14.6	20.2	**16.9**
Sheep/Goat	0.3	2.1	1.3	**1.2**
Horse	------	------	------	------
Chicken	0.6	<0.1	<0.1	**0.2**
Total for each time period	**59.0**	**66.6**	**69.1**	
Wild Species				
Deer	9.2	6.0	1.6	**5.6**
Crab	------	------	------	**------**
Sturgeon	------	------	0.1	**0.1**
Other Fish	0.7	0.2	0.4	**0.4**
Turtle	------	------	1.6	**1.6**
Snake	------	------	------	**------**
*Other ID'd W. Mammal	5.9	------	0.9	**3.4**
**ID'd Wild Fowl	1.7	0.5	0.2	**0.8**
Total for each time period	**17.5**	**6.7**	**4.7**	

------ = species not present in assemblage
*****Other ID'd W. Mammal = includes just the identified species, does not include Artiodactyla or Indeterminate Medium Mammal bones found in the Bone Summary Charts
******ID'd Wild Fowl = includes just the identified species, does not include the Indeterminate Wild Bird found in the Bone Summary Charts

The emergence of cattle herds can also be seen in the element distribution patterns for the combined three assemblages representing the "stability herds." In the earlier assemblages for Jamestown, cattle bones were predominately from the body, with few bones from the head and feet. This distribution patterns suggests the cattle remains most likely represent salted meat provisions sent from England. As Table 13 shows, when the cattle bones from the combined assemblage are compared to a normal skeletal pattern, the results show percentages very similar to a normal pattern. Head elements are almost identical to a normal pattern a 29.3%, while bones from the feet are slightly higher representing 37.0% of the elements. Finally, body elements are no longer elevated but fall slightly below the normal percentage at 33.7%. This pattern suggests the colonists were raising and consuming their own cattle.

Table 13
Element Distribution for Domestic Mammals
Stability Herds Assemblages

	Head		Body		Feet	
	No.	**%**	**No.**	**%**	**No.**	**%**
Cattle Normal		29.7		42.2		28.1
Cattle Stability Herds	72	29.3	83	33.7	91	37.0
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Swine Normal		28.2		34.5		37.3
Swine Stability Herds	145	46.0	101	31.9	71	22.4
	Head		**Body**		**Feet**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Sheep/Goat Normal		29.7		42.2		28.1
Sheep/Goat Stability Herds	11	64.7	1	5.9	5	29.4

(Bowen and Andrews 2000)

Wildlife and Trading with the Virginia Indians:

The bones recovered from ca. 1610 Jamestown show how early on, the colonists depended heavily on local resources like deer (*Odocoileus virginianus*), small mammals, turtles, and fish, as well as dolphins (family Delphinidae), herons (family Ardeidae), cormorants (family Phalacrocoracidae), gulls (family Laridae), and waterfowl. Unfortunately, assemblages dating to the post-1620 period are small: Ditch 7 (ca. 1620) with 91 NISP; Ditch 6 (Post 1630) with 167 NISP; and Midden 1 (1625-2650) with 1625 NISP. Since much larger assemblages are needed to provide an accurate estimate of the wildlife, comments remain tentative. Future analyses of periods dating immediately after the Headright System was instituted and in the following years would greatly assist our understanding of the evolution of the plantation economy and its herding system that supported planter households and their laborers.

Until more Jamestown faunal data for this period is analyzed only general conclusions are possible. Progressively from 1620 to 1650, during the 1620s, wildlife contributed 17.5% biomass, in 1630, 6.7%, and from 1625 to 1650 4.7%. Although the NISP sample sizes are small, it is possible to see how deer changes in each assemblage. For example, in the 1620s assemblage deer makes up 9.2% of the biomass, decreases in the 1630s assemblage to 6.0%, and contributes only 1.6% by the 1625—1650 assemblage. Also visible are reduced amounts of fish, small mammals, and fowl, a pattern suggesting the colonists' decrease dependence on wildlife.

Research Summary

Faunal data from Jamestown has previously come from assemblages representing the first years of the fort, features dating to the "starving time," and assemblages dating from the 1620s till the second half of the 17th century. What has been missing in the faunal data is the period immediately following the "starving time" when martial law controlled the colonists and how they procured their food. When compared alongside the other periods, the analysis of the Second Well (JR2158) has shone a light on the long-term trajectory of Jamestown's development from a struggling colony, dependent on the Virginia Company and the Virginia Indians for fundamental subsistence, into a stabilized colony able to produce both a commodity and their own food.

Throughout the four phases identified in this study, subsistence, as seen in the balance between provisions, livestock, and wildlife, played a pivotal role in the development of Jamestown. Along with the first leaders and the settlers, food, livestock, and provisions have their own story at Jamestown that is best told through the synthesis of documentary and archaeological evidence. Food was one of the only aspects of the early settler's daily life that was not only a biological necessity but also a complex symbol connected to social status, political authority, and social relationships both in and outside the fort.

The Virginia Company set the stage by wrongly assuming that relying on the Virginia Indians for food carried with it no connotations of submission. While the Company controlled when and what limited provisions and livestock they sent to Jamestown, the Company expected their supplies, combined with hunting and fishing would be enough to sustain the colonists. Unfortunately, they did not adequately supply the colonists with the needed tools and experience.

Relationships between the settlers and the Virginia Indians also centered around food. Given the challenging language barrier between the English and the Virginia Indians, food was often one of the most direct ways to communicate with each other. It was used as a tool by the Indians to assert power over the English, acquire knowledge about their ways, and eventually oppress them during the "starving time." The colonists, in turn, used food as a way to drive the Indians away from the English by stealing their crops and stores of fish and wild game.

Within the fort, some early leaders used position as a way to supply themselves with extra food, signaling they felt they were more worthy than others of lesser status. Later, leaders at Jamestown used food as an equalizer when martial law was instated. Everyone had a job to do and no one received their rations until their work was completed. Livestock was viewed as a precious resource, protected by law under penalty of death.

Finally, food and livestock had the power to motivate and inspire the colony to start over again and again. After the "starving time" it was the new shipment of colonists, provisions, and livestock which provided new energy and opportunity for the colonists to start over. Following establishment of the head right system and the massacre of colonists and livestock in 1622, the reestablishment of new livestock herds and the economic promise of tobacco finally allowed the colony to gain a solid foothold in Virginia. By this time, the food story at Jamestown had shifted from dependence on Indian foods and whatever they could hunt or fish on their own, to the establishment of a self-governing political system that provided individuals with land and labor, the means through which colonists could support *themselves*.

Zooarchaeological Summary

As seen in the phase discussions, the faunal analysis of the earliest sites and the biomass percentages of wildlife, indicate the first years at Jamestown were a time when the colonists were 'out and about' hunting, fishing, and to an extent trading with local Indians. Provisions and introduced livestock provided essential nutrition. In total, based on biomass estimates, all domesticates totaled 24.9% of their meat diet. Of these, cattle contributed the most – almost 17.9% of their intake of meat. Based on element distributions that show a predominance of body parts, cattle bones represent provisions, not the animals that colonists brought with them.

By the "starving time," the faunal assemblages demonstrate a system in collapse, when the Virginia Indians were in control. The presence of taboo foods such as horse, dogs, and rats testify to the colonist's hunger and despair, and the relatively small proportion of deer, fish, birds, and turtles testify the extent to which colonists were trapped inside the fort. Lastly, the presence of swine, sheep/goat, chicken, and cattle remains show how the remaining livestock and provisions provided life-giving sustenance.

Following the "starving time," the faunal assemblages dating from 1610-1617 support documents describing how the colony struggled to regain its footing and how the Company and General Assembly took steps to protect provisions and livestock. These animals brought to Jamestown would become the foundation of future herds so plantations could eventually provide for themselves. It was a time, according to Spanish reports, when strict control over individual's access to resources, provisions, livestock, and hunting wildlife meant personal hardship. Relations with Virginia Indians were at a low, and as skirmishes were fought many livestock were killed.

The faunal evidence from this time provides some clues to how important the martial laws were to the reestablishment of cattle in Virginia. Compared to other periods, cattle remains contributed only an average of 4.8% biomass, the least of any time. That body parts among these remains made up 92.8% is a clear indication colonists consumed provisions, *not* cattle brought to become herds. Cattle herds could and did expand through natural growth. Additionally, swine data that show more pork was consumed during this period than any other supports martial laws, which did not specifically protect proliferating herds of swine. Substantial amounts of wildlife, including large quantities of venison, fish, turtles, and wildfowl (totaling 41.6% biomass) indicate colonists did have access to these resources.

Finally, faunal assemblages from the second quarter of the seventeenth century again support documentary sources. With domesticates making up 59% to 69% of the biomass results, these assemblages clearly demonstrate that as documents claim, herds had grown to the point that they could support colonists. Wildlife consumption was reduced to between 4% and 17.5%, again a clear signal that individual ownership had stabilized the emergent plantation economy. No longer did colonists depend on provisions, hunting, fishing, or Virginia tribes.

Recommendations for Future Research

This analysis of six layers from the Second Well and synthesis of previously analyzed assemblages from the pre-starving time, starving time, and post 1620's phases has provided a broad brush that shows the transition for a Company-focused and controlled subsistence system to one where planters could own land and produce their own subsistence. Data shows changing trends, such as greater and lesser amounts of cattle, sturgeon, swine, and deer. Future research with archaeological data from these assemblages and more well-defined assemblages has the potential to identify variability related to status and occupation. Also, by analyzing other assemblages from well dated Jamestown assemblages, particularly from the 1620s after the Martial Laws were rescinded, we can gain a better understanding of this vital period in the emergence of the colony's plantation economy. Finally, at this point it is not possible to identify which remains of wildlife, particularly deer, were the result of trading with the Virginia Indians. However, analysis of the deer element distribution patterns and the butchery evidence on deer remains from the Second Well (JR2158) did suggest some uniformity. A closer study of these remains and a comparison to deer remains recovered from other Jamestown assemblages, as well as, known Virginia Indian sites, might help to distinguish butchery patterns and differential distribution of meat cuts between the English and the Indians. This information is critical to determining the extent to which colonists succeeded in obtaining venison from the Virginia Indians.

PART II: Faunal Analysis of Second Well (JR2158)

Description of Site

This section of the faunal report examines the zooarchaeological evidence recovered from the Second Well (JR2158) from James Fort. Excavations of the square-shaped well began in 2006 and produced many artifacts, including over 150,000 faunal remains. Based on datable artifacts, Jamestown Rediscovery archaeologists believe the 16 foot deep well was probably dug around 1610-1611 and was filled in and sealed by 1617-1618 (Alexis Ohman 2019, pers. comm.). At least thirteen layers of fill were identified during excavations of the well, with six layers chosen for faunal analysis. As Table 14 shows, 153,841 bones were analyzed from the Second Well (JR2158) with at least 41,517 bones identifiable to at least the taxonomic order of family.

This descriptive part of the report will discuss the specific laboratory and analytical techniques used to examine the bones from the Second Well (JR2158). It will also examine the results from the faunal analysis, including identified taxa, taphonomic influences, relative dietary importance of species for each layer, element distribution patterns for each layer, kill-off data for livestock, butchery evidence for livestock, and seasonality of wild species. Following discussions of the faunal data from the individual layers, a summary section will compare the layers with each other and with other analyzed Jamestown assemblages.

Table 14
Layers Analyzed from the Second Well (JR2158)

	Identifiable Bone[1]	Indeterminate Bone	Total Bone
JR2158H	2222	10442	12664
JR2158N	6157	39370	45527
JR2158P	25561	38586	64147
JR2158U	4318	20335	24653
JR2158X	1784	3566	5350
JR2158AA	475	1025	1500
TOTALS	**41,517**	**113,324**	**153,841**

[1] Identifiable bones include bone identified to at least the taxonomic level of family.

Recovery Methods

Quarter-inch screening is a standard technique used on prehistoric and historic period sites. As early as 1969, David Hurst Thomas demonstrated screening has an enormous positive influence on the recovery of bone, particularly the recovery of smaller or more fragile elements. The smaller the screen size, the better the recovery rate, but screening through very fine mesh is often cost-prohibitive. Combining flotation sampling and ¼-inch screening is a responsible compromise allowing comparison with other sites excavated in a similar manner.

During excavations of the Second Well (JR2158), the soil from all the natural layers was screened through 1/8 inch mesh. It should be noted that Layer AA, is an arbitrary level made when the water table was reached during excavation. This layer was also screened through 1/8 inch mesh (Deetz et al 2008; Leah Stricker 2021, pers. comm.). Although most of the bones recovered from the well are very fragmented and not identifiable to species, the presence of many fish, turtle, bird, small mammals, along with medium and large mammal bones, suggests a fair sample of the original assemblage was recovered during excavation. It should be noted that some soil was also wet screened and float samples were taken. Bone recovered from these samples are not included in this analysis.

Work Plan for Project/Laboratory Techniques

With over 150,000 bones recovered from six of the layers from the Second Well (JR2158), the work plan for this project involved multiple steps and the coordinated efforts of many individuals. The first phase began in 2017, when Stephen Atkins, former Associate Curator of Environmental Archaeology for Colonial Williamsburg Foundation, worked in the Jamestown Rediscovery Lab to conduct a preliminary sort of the faunal remains into taxon/species groupings. Working with Jamestown volunteers, Atkins first sorted the bones by class, such as fish, amphibian, reptile, bird, and mammal. From the mammal group, Atkins sorted the bones further by deer, swine, cattle, sheep/goat, and Artiodactyla (even-toed ungulates such as deer, swine, and sheep/goats). From these species groups he sorted the bones into head, body, and foot remains. He also pulled out any mammal bones which appeared to be the bones of small mammals, such as raccoon, opossum, dog, and squirrel. Remaining mammal bones were considered indeterminate and were sorted into categories such as large mammal, medium mammal, and small mammal.

He applied this process to each class of animals, sorting bird bones into domestic species, wild species, and indeterminate remains. Fish were sorted by separating out the easily identifiable sturgeon scutes from other identifiable and indeterminate fish bones. Finally, reptile and amphibian bones were sorted into identifiable and indeterminate groups. When done, volunteers counted and entered the indeterminate remains where results were entered into an Excel based data program.

Developed as a way to streamline identifications, this sorting process enabled analysts to assess the transition from a dependence on wildlife to domesticated livestock at Jamestown. It also allowed the analysts to determine how the layers from the well might enhance previous faunal research concerning the development of a provisioning system and livestock herds for Jamestown Fort. Based on the preliminary results from the sorting, combined with a tightly datable context, the faunal material from the Second Well (JR2158) suggested there may be evidence of the transition in material culture related to the installment of Martial Laws on the colony immediately following the "starving time."

Using this data, along with previous faunal research related to Jamestown, Alexis Ohman, former Associate Curator/Zooarchaeologist for Jamestown Rediscovery Foundation, completed the second phase of the project which included the preparation and submission of a proposal to the Conservation Fund for a grant related to the Material Culture Studies of 17th and 18th Century

Chesapeake. Upon the approval of the grant for the faunal analysis of the Second Well (JR2158), a detailed work plan evolved to complete the analysis and final report. At this time, the faunal analysis was split among Atkins, Ohman and Susan Trevarthen Andrews, independent faunal analyst. Overseeing and directing the project has been Dr. Joanne Bowen, former Senior Curator of Environmental Collections for Colonial Williamsburg Foundation.

During the last phase of the faunal analysis, Ohman directed volunteers at Jamestown in recording all the indeterminate bones, the weighing of all sturgeon scutes and blue crab remains, and the identification of tooth remains from livestock and deer. Simultaneously, Atkins worked on recording the identifiable fish bones and Andrews worked on the identifications of the wild and domestic mammal and bird bones, as well as the reptile and amphibian bones. For the domestic livestock and deer bones, Andrews recorded element, weight, side, long bone fusion, butchery marks, and measurements for each individual bone. Small mammal, bird, and reptile/amphibian bones were grouped by species and then by element. For example, all of the raccoon femurs were weighed together. The combined weight of the femurs and the number of bones was logged into the database as a single entry.

Upon completion of the faunal identifications, Andrews entered all the data into an Excel based computer program. Finally, Andrews, Atkins, and Bowen prepared the final report, which includes the faunal data compiled from the six layers of the well, as well as, historical research and accounts related to the subsistence patterns evident at Jamestown.

Analytic Techniques

Zooarchaeologists use several methods of quantification to estimate relative dietary importance. These quantification methods include determining the Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI), Usable Meat Weight, and Biomass. The most common goal of these measures is to identify the relative dietary importance, but zooarchaeologists have long debated their relative strengths and weaknesses (Wing and Brown 1979; Reitz and Cordier 1983; Grayson 1984). To analyze as much of the faunal data for this project as possible, all parties agreed to only calculate the NISP and the Biomass for each of the layers of the Second Well (JR2158). Besides these techniques, element distribution patterns and butchery evidence were also recorded for the domestic mammals. Other analytic techniques completed during the analysis include measuring relevant domestic mammal faunal specimens and documenting evidence of burning, gnawing, and weathering for the domestic species. The following paragraphs will discuss these analytic techniques.

NISP

At the simplest level, the Number of Identified Specimens (NISP) calculates the relative abundance of any species within a faunal assemblage. After identification, all the bones within each species are added together to determine the frequency of fragments for each animal. Though still the most frequently used measure of abundance, this method has several shortcomings, most notably its assumption the bones being counted represent the sampled population, and each item is independent of every other item. There is no method, however, to show which bone fragments came from different individuals across an entire faunal sample. Other problems with this method include the unequal numbers of elements per individual, differential preservation rates, uneven fragmentation rates occurring with different classes and sizes of animals, and the misrepresentation of complete skeletons that are often intermixed with fragmented pieces from an indeterminate number of individuals (Grayson 1984).

From an interpretive standpoint, NISP represents only the number of fragments identified to taxon. It does not consider the differences in size and meat weight between various classes of animals. For this reason, as well as the potential biases described above, many zooarchaeologists have come to the conclusion this technique alone cannot provide an accurate assessment of the relative dietary importance of various species.

Biomass

Known as the "biomass" or "skeletal mass allometry," this technique has become a standard procedure in zooarchaeological analysis. Developed for zooarchaeology by Elizabeth Reitz and others, this method bases its calculations on the biological premise that the weight of bone relates to the amount of flesh it supports. Using the weight of the individual bone and a specific formula for each type of taxon, the body size and body weight is determined. Since a specific quantity of bone represents a predictable amount of tissue, the results of this analysis can be roughly translated into the ranked dietary importance of each species (Reitz and Cordier 1983; Reitz and Scarry 1985). This estimate, therefore, provides a balance to the NISP method. It also helps to counter the problem of interdependence, since it accounts for the presence/absence of partial and complete skeletons. Another advantage is it does not rely on thoroughness or assemblage composition, and fragmentation is not a problem. It does require each bone (or group of bones) be weighed individually.

Although most early faunal analysis is based on usable meat weight, biomass estimates are given in this report. Research by Bowen and others, show biomass estimates to be far more consistent than meat weight estimates, particularly when large numbers of fish are present in assemblages (Bowen in Walsh et al. 1997). This allows the weight of the fragments identified only to class to become part of the dietary estimates, it avoids the idiosyncrasies of the MNI method, and it circumvents the "averaging" problem that plagues any assemblage containing a large proportion of fish.

Element Distribution

Many historical zooarchaeologists focused their analysis of faunal remains on determining the social and economic status of households (Schulz and Gust 1983; Lyman 1987; Crader 1984, 1990; Reitz 1987; Bowen 1992). By looking at the presence or absence of various cuts of meat in an assemblage, they interpret the presence of feet and heads to be less valuable cuts and therefore indicators of low social and economic status. Consequently, the presence of fleshier cuts of meat, indicated by body elements, is more valuable and in turn, an indicator of a household with high status (Crader 1984; Miller 1984; Bowen 1992, 1994). However, preferences for heads and feet as cuts of meat have changed throughout history. For example, from the 17th through the early 19th centuries, heads, particularly those of swine and calves, were considered to be delicacies, not necessarily considered a less valuable cut of meat.

In general, zooarchaeologists have not been able to identify distinctive characteristics of ethnic groups or high- and low-status diets (Bowen 1992, 1994). For example, in faunal assemblages from 17th though early 19th centuries assemblages from the Chesapeake, "low" and "high" quality cuts of meat are commonly found intermingled in both high- and low-status assemblages (Walsh et al. 1997). In his comparisons of known high-status and low-status 17th century sites in Virginia, Henry Miller found very few differences in the distribution of particular elements. Similar species and cuts of meat were present in similar proportions in both types of sites, and in both, elements from "high-quality" cuts made up the majority of the bones (Miller 1984:360).

In studies of the enslaved African-American diet, zooarchaeologists have assumed the enslaved (presumably "low status") received primarily cuts of meat their owners did not want. Attempting to demonstrate heads and feet were low status, Diana Crader looked for the presence of different cuts of meat to define the status of enslaved households associated with Monticello. In her comparative study of enslaved individuals associated with Thomas Jefferson's main house and separate enslaved households, she found a greater number of "low-quality" cuts in faunal assemblages from cabins of the enslaved, and a greater number of "high-quality" cuts in faunal assemblages associated with the main household. But like Miller, Crader found both high-quality cuts in assemblages related to enslaved individuals and low-quality cuts in the main household assemblage (Crader 1984, 1990).

In assessing possible patterns in the cuts of meat for the Jamestown settlers, the domestic mammal bones were examined using a method called element distribution analysis. This method is similar to other approaches, such as the minimum number of elements (MNE), which is derived by determining how many elements are represented in a sample of fragmented bones (Reitz and Wing 2008). Both approaches share the goal of attempting to quantify the relative representation of skeletal elements in a faunal assemblage. For this report, element distribution analysis was chosen as a valid measurement for examining the differential representation of body elements for the domestic species. This method which exposes possible patterns in the fragmented bones, can help determine how provisioning may have been influenced either by the scale of the regional provisioning system or status of the occupants of the site (Bowen 1992; Bowen in Walsh et. al. 1997).

Element distributions, derived from NISP, compare the distribution of elements found in a normal skeleton with those present in the faunal assemblage. For example, in cattle skeletons, 29.7% of the bones are from the cranium, 42.2% of the bones are from the body, and 28.1% of the bones are from feet. When the distribution patterns of cattle bones from archaeological sites are similar, it suggests the entire animal was consumed, while dissimilarities suggest certain parts of the carcass were being selected over others or were not available to the occupants of the site. Analysis of element distribution patterns was calculated for the domestic mammal bones recovered from six of the layers from the Second Well (JR2158).

Kill-Off Data

To help understand husbandry techniques underlying the availability and the production of food resources, analysis included using aging methods for the domestic mammal bones recovered from the six analyzed layers of the Second Well (JR2158). There is a direct relationship between agricultural economies and how farmers breed, raise, and slaughter their livestock. In subsistence farming, animal husbandry focuses on raising livestock to serve multiple purposes. For example, a farmer might raise cattle for milk, meat, and draft uses, or sheep for both their wool and their meat. Farmers typically raise livestock to provide for their own household's needs, selling any surplus. On the other hand, specialized farming focuses on raising livestock to produce a product directly for market, and the focus shifts to managing livestock to produce the greatest profit. In this commercially-oriented farming, the concentration shifts from managing livestock for personal use to producing livestock for the greatest profit.

As an example, in the Chesapeake region, specialized production of livestock developed directly out of the region's plantation economy. Livestock first arrived with the earliest of settlers at Jamestown and by the 1620s herds of cattle and swine were thriving within a protected woodland environment. Domestic herds were doing so well that in 1619 John Pory wrote cattle "do mightily increase here, both kine, hogges and goates, and are much greater in stature, than the race of them first brought out of England " (Tyler 1946: 213).

During the mid-17th century, when tobacco had become an established, profitable crop in the Chesapeake, farmers continued to cut down trees to make room for more fields. By the early 18th century, in the area surrounding Jamestown Island tobacco farming had depleted the soil and lush environment on which livestock that had once thrived had disappeared. By the late 17th century, references to domestic herds reflect this degradation by describing a decline in the size and health of the animals. In 1688, John Clayton wrote in a letter the cattle "have little or no Grass in winter, so that (they) are pinned and starved, and many that are brought low and weak, when the Spring begins, venture too far into the Swamps after the fresh Grass, where they perish; so that several Persons lose ten, twenty or thirty heads of Cattle in a Year" (Clayton in Force 1836-1846 [3]:25-26). During the 18th century, when cities in the West Indies market had grown, planters began to grow grain and raise livestock not only for food but also for profit. In response to these developments in the new market, farmers began to provide animals with specialized feed, construct pens to hold large animals, and build stalls with roofs to keep their livestock and food warm and dry. This more intensive form of animal husbandry allowed livestock to reach a good slaughter weight faster than if they simply free-ranged without supplemental feed (Walsh et al. 1997; Carson et al. 2008, Bowen 2021).

Kill-off patterns studied from 18th century sites in the Chesapeake, reflect these changes that occurred in animal husbandry techniques. Slaughter ages of cattle from sites dating from the early 17th century show typically 51% of the cattle population killed when they were four years and older. By the late 17th century, the number of cattle killed at greater than four years of age increased to 68%. This pattern has been attributed to grass feeding, where it takes about four years for cattle to reach their mature slaughter weight. Faunal assemblages from the 18th and early 19th centuries include larger percentages of younger cattle aged between 24-28 months. This reflects a more specialized form of cattle husbandry allowing the cattle to mature to a slaughter weight in less than four years of age (Walsh et al. 1997).

The kill-off patterns for swine from sites from the 17th century show during the first half of the century, almost half of the population of slaughtered swine was less than a year old. Over the next hundred and fifty years, this number decreased until by the last half of the 18th century only 19%-28% of the killed swine were less than a year old. In contrast, swine between the ages of 12-24 months increased from 11%-17% in the 17th century to 31%-38% in the late 18th and early 19th centuries. Again, this change reflects a shift in husbandry patterns related to the introduction of commercial markets and the increase of specialized farming (Walsh et al. 1997).

In accessing the husbandry patterns from Second Well (JR2158), the slaughter ages presented in this report are from the epiphyseal fusion of long bones. Like every aging method, fusion patterns also have biases. First, long bone epiphyses fuse at different times in the maturation of the mammalian skeleton, making it difficult to establish precise age groups; the exact age at which individual epiphyses fuse varies according to health, breed, and diet. Studies on bone fusion have also shown immature bones degrade more rapidly than mature bone. Taking all these factors into consideration, analysts opted to group fusion data into broadly defined age groups using numerical designations given by Reitz and Wing (2008). These age groups are defined in more detail for each of the domestic mammal species in the summary of the kill-off analysis.

Another bias to consider in accurately assessing the kill-off patterns from an assemblage, is large numbers of bones are needed in proportions roughly even to the number of bones found in a normal skeleton. Unfortunately, kill-off data for cattle and sheep/goat could not be accurately determined from the layers of the Second Well (JR2158) due to the lack of enough ageable bones. Swine bones did produce more ageable bones, allowing for general conclusions to be made about the kill-off data. For the purpose of future comparative work, the epiphyseal fusion tables for all of the domestic mammals from all of the layers in the Second Well (JR2158) are included in Appendix B, Tables 37-47.

Taphonomy and the Analysis of Butchering

There are many physical, chemical, and biological processes impacting the preservation of bones and by extension, the interpretation of faunal assemblages. The study of these mechanisms is known as "taphonomy," or the study of environmental phenomena and processes affecting organic remains after death (Efremov 1940, Reitz and Wing 2008). The determination of, for example, which cuts of meat are represented in a faunal assemblage cannot reasonably proceed without the careful analysis of taphonomic modifications. Identifying alterations resulting from natural processes such as temperature variation which can dry out, split, or otherwise degrade bone, carnivores and rodents that gnaw bone, and human feet that can further fragment bone, an important first step to looking at purposeful modifications such as butchery and intentional burning (Gifford 1981; Lyman 1987; Johnson 1985; Bonnichsen and Sorg 1989; Reitz and Wing 2008).

During the identification phase of this project, burn marks, evidence of gnawing by carnivores and rodents, weathered appearance, and butchering evidence were all recorded for the domestic mammal and deer bones. Bones recorded as "burned" include those with distinctive charring or scorched marks. Experiments on cooking bones, by either roasting or boiling, have shown it often takes extreme temperatures to produce burn marks on a bone. The size and density of the bone, combined with the temperature and type of cooking, influences the appearance of burn marks on bones (Pearce and Luff 1994).

Evidence of gnawing on bones can be seen as puncture holes made by canine teeth or by specific gnawing patterns left on the surface of the bone. Carnivores such as dogs will typically gnaw on the soft ends of long bones to create channels allowing them to get at the marrow. Smaller bones belonging to fish, birds, and small mammals are easily broken and digested by carnivores, so there is rarely any evidence of carnivore gnawing on these bones. Gnaw marks left by rodents leave a characteristic pattern made by incisor teeth.

Faunal analysts attribute the cracking or flaking on the surface of the bone as evidence of weathering. A weathered appearance on the surface of a specimen often occurs on bones left in the open, where exposure to extreme temperatures and changing elements effects its appearance. Usually, bones left exposed for a period of time are susceptible to gnawing by animals and fragmentation from the trampling of feet. Weathering can also occur because of the actual chemistry of the soil, which has a direct influence on bone preservation. Generally, the ideal pH for bone preservation is between 7.8 and 7.9 (Reitz and Wing 2008).

Finally, butchering leaves obvious taphonomic signs on the bone, including hack marks made by axes or cleavers. Evidence of butchering was seen on many of the bones from the Second Well (JR2158) and carefully recorded. A more in-depth discussion of butchery patterns for the domestic mammal and deer is addressed in a later section of this report.

Identified Taxa from the Second Well (JR2158)

With Discussions on Fishing, Fowling, Hunting, and Animal Husbandry

The six layers from the Second Well (JR2158) analyzed for this report produced 153,841 bones identifiable to at least 26 different species or family of species. These include 1 crustacean, 25 fish, 9 reptile/amphibians, 29 wild and domestic birds, and 17 wild and domestic mammals (see Table 15). The following section will summarize the fishing, fowling, hunting, and animal husbandry techniques possibly implemented by the settlers at Jamestown. This section also includes a brief description of each species, their diet, and their habitat to provide additional clues to how the Jamestown settlers utilized their environment for provisioning purposes.

Table 15
Taxa Identified from Six Layers of JR2158:
2158H (H), 2158N (N), 2158P (P), 2158U (U), 2158X (X), and 2158AA (AA)

Taxonomic Name	Common Name	Well Layers
CRUSTACEAN		
Callinectes sapidus	blue crab	H, N, P, U
FISH		
class Chondrichthyes	cartilagenous fish	N, X
family Carcharinidae	requiem shark	H, N, P, U, AA
order Rajiformes	skates or rays	H, N, P, U, X
class Osteichthyes	bony fish, indeterminate	H, N, P, U, X, AA
Acipenser spp.	sturgeon	H, N, P, U, X, AA
Lepisosteus spp.	gar	H, N, P, U, X, AA
Amia calva	bowfin	H, P
order Clupeiformes	herring, shad, or anchovy	P
family Clupeidae	herring	N
Alosa spp.	shad or herring	N, P
Alosa sapidissima	American shad	P, U
Alosa pseudoharengus	alewife	N
family Catostomidae	sucker	H, N, P, U, X
family Ameiuridae	freshwater catfish	H, N, P, U, X, AA

Table 15 cont'd

Gadus morhua	Atlantic cod	P, U
family Moronidae	temperate bass	H, N, P, X
Morone americana	white perch	H, N, P, U, X, AA
Morone saxatilis	striped bass	N, P, U, X, AA
family Serranidae	grouper or seabass	P
Lepomis spp.	sunfish	P, U
Perca flavescens	yellow perch	N, P
cf. *Caranx* spp.	jack	P
cf. *Archosargus probatocephalus*	sheepshead	N, AA
family Sciaenidae	croaker or drum	H, N, P, U
Pogonias cromis	black drum	N
Sciaenops ocellatus	red drum	H, N, P, U, X
Cynoscion spp.	weakfish	N
Cynoscion nebulosis	spotted seatrout	H, P
REPTILES/ AMPHIBIANS		
class Amphibia	amphibian, indeterminate	N, U
order Anura	toad or frog	H
Rana spp.	frog	N, P, U
Rana catesbeiana	bullfrog	P
class Reptilia	reptile, indeterminate	H, N, U
order Testudines	turtle	H, N, P, U, X, AA
Chelydra serpentina	snapping turtle	H, N, P, U
family Kinosternidae	musk or mud turtle	H, N, P, U, X
family Emydidae	box or cooter	P
Chrysemys spp.	cooter or sliders	H, N, P, U, X
Malaclemys terrapin	diamondback turtle	N
Terrapene carolina	box turtle	H, N, P, U, X
Trionyx spp.	soft shell turtle	H, P
family Colubridae	snake	H, N, U
family Viperidae	viper	P
BIRDS		
class Aves, domestic	domestic bird, indeterminate	H, N, P, U, X, AA
class Aves, wild	wild bird, indeterminate	H, N, P, U, X, AA
class Aves/Mammalia III	bird or small mammal	H
family Ardeidae	heron or egret	U
Ardea herodias	great blue heron	N, P
family Phalacrocoracidae	cormorant	U
family Procellariidae	shearwater or petrel	N, P
family Anatidae	swan, goose, or duck	N, P
Cygnus spp.	swan	H, N, P, U, AA
goose spp.	goose	H, N, P, U, X, AA
Anser spp.	goose	U, X
Anser anser	graylag/domestic goose	H, N, P, U, X, AA
Chen caerulescens	snow goose	H, N, P, X
Branta spp.	Canada or brant goose	H, N, P, U, X, AA
Branta canadensis	Canada goose	H, N, P, U, X, AA
Branta bernicula	brant goose	P
duck spp.	duck	H, N, P, U, X, AA
Anas spp.	dabbling duck	H, N, P, U, X
Oxyura jamaicensis	ruddy duck	H, N, P
Aix sponsa	wood duck	H, N, P, U, X, AA

Table 15 cont'd

Aythya spp.	pochard	H, N, P, X
Aythya americana	redhead	P
order Gruiformes	crane or rail	H, P
order Charadriiformes	shorebird, gull, auk	N
family Scolopacidae	sandpiper	P
family Laridae	gull	P
Laurus spp.	gull	N, P, U
order Falconiformes	vulture, hawk, or eagle	H, P, U, X
Cathartes aura	turkey vulture	H, N, X, AA
family Accipitridae	hawk or eagle	N, P, U, AA
Pandion haliaetus	osprey	P
Haliaeetus leucocephalus	bald eagle	H, N, P, U. X, AA
Buteo jamaicensis	red-tailed hawk	N
Circus cyaneus	northern harrier	P
order Strigiformes	owl	U
Bubo virginianus	great horned owl	U
family Phasianidae	grouse/partridge/pheasant	H, N, P, U, X
Meleagris gallopavo	turkey	H, N, P, U, X, AA
Gallus gallus	chicken	H, N, P, U, X
Colinus virginianus	bobwhite	U
order Passeriformes	perching bird, indeterminate	N, P, X
family Corvidae	raven or crow	P, U
Cyanocitta cristata	blue jay	H
MAMMALS		
class Mammalia	mammal, indeterminate	H, N, P, U, X, AA
class Mammalia I	large mammal, indeterminate	H, N, P, X, AA
class Mammalia II	medium mammal, indeterminate	H, N, P, U, X, AA
class Mammalia III	small mammal, indeterminate	H, N, P, U, X, AA
Didelphis virginiana	opossum	H, N, P, U, X
Scalopus aquaticus	eastern mole	N
order Rodentia	rodent	U
Sciurus spp.	squirrel	H, N, P, U, X
Sciurus carolinensis	eastern gray squirrel	H, N, P, U, X
Sciurus niger	eastern fox squirrel	H, N, P, X
Ondatra zibethica	muskrat	H, N, P, U
rat spp.	rat	H, N, P, U, AA
family Delphinidae	ocean dolphin	P, X
Canis familiaris	dog	H, N, P, U
Canis spp.	dog or wolf	N
Procyon lotor	raccoon	H, N, P, U, X
Neovison vison	mink	U
Lontra canadensis	river otter	N
Felis domesticus	domestic cat	N, U
Equus spp.	horse	P
Odocoileus virginianus	white-tailed deer	H, N, P, U, X, AA
order Artiodactyla	sheep, goat, deer, or swine	H, N, P, U, X, AA
Sus scrofa	domestic swine	H, N, P, U, X, AA
Ovis aries/Capra hircus	domestic sheep/goat	H, N, P, U, X, AA
Bos taurus	domestic cattle	H, N, P, U, X
OTHER BONE		
subphylum Vertebrata	other vertebrate, indeterminate	H, N, P, U, X, AA

Fishing and Identified Fish/Crustacean Species

The presence of many fish bones recovered from the six layers of the Second Well (JR2158) is not surprising due to Jamestown's proximity to the James River and the Chesapeake Bay. Starting with the first settlers at Jamestown, fishing has played a pivotal role in the subsistence of the Chesapeake region. In his early descriptions of Virginia in 1607, Captain John Smith commented on the many fish species he encountered:

> Of fish we were best acquainted with Sturgeon, Grampus, Porpus, Seales, Sting-graies, whose tailes are very dangerous. Bretts, Mullets, White Salmonds, Trowts, Soles, Plaice, Herrings, Conyfish, Rockfish, Eeles, Lampreys, Catfish, Shades, Pearch of three sorts, Crabs, Shrimps, Crevises, Oysters, Cocles, and Muscles (Smith in Barbour 1986[2]:111).

The bounty of fish in the Chesapeake was still being boasted by Ralph Hamor in his 1614 description of the rivers in Virginia:

> For fish, the rivers are plentifully stored with sturgeon, porpoise, bass, rockfish, carp, shad, herring, eel, catfish, perch, flatfish, trout, sheepshead, drummers, garfish, crevises, crabs, oysters and divers other kinds, of all which myself have seen great quantity taken (Hamor 1626:21).

Although fish appear to have been abundant, other accounts from Jamestown show the first colonists were not always successful in acquiring fish to use as provisions. Reasons for this include a combination of cultural, situational, and environmental circumstances including the lack of experience for the type of fishing needed in Chesapeake waters, a scarcity of proper fishing equipment, and insufficient skills needed to keep fishing equipment in working condition. The settlers also lacked the knowledge and supplies needed to properly preserve any surplus fish they caught.

To begin with, many of the men who first arrived in Jamestown were considered "gentleman" and did not come the working class. Most of these men may have had experience fishing only on small ponds and rivers using a simple hook and line. Other individuals arriving to Jamestown may have lived away from the English coast and were not familiar with large scale fishing needed to sustain a new colony. While professional fishermen would have been available among the coastal communities of England, early records suggest few of these men were among the first Jamestown settlers (Schmidt 2006). In fact, by 1610, the colonists requested the Virginia Company to include at least 20 fisherman and 6 netmakers among the new arrivals to the colony (Brown 1890: 469-470).

Although there are first hand accounts of fishing with seine nets by some of the early colonists at Jamestown, it is also apparent the nets they brought with them fell into disrepair. A description of the nets is mentioned in 1610 by William Strachey who wrote, "They suffered fourteen nets (which was all they had) to rot and spoil, which by orderly drying and mending might have been preserved. But being lost, all help of fishing perished" (Strachey in Haile 1998:441). These seine nets had a weighted bottom line and an upper line kept afloat by corks or wooden floats. In the best of circumstances, as the fish became trapped in the net, the fishmen would pull the two ends of the seine ashore or into a boat. Unfortunately, the offshore waters of the James River were often littered with downed trees presenting hazards which could have torn the nets. Also, since the nets were typically made from hemp twine, if not properly dried after use, they would have quickly rotted (Schmidt 2006).

Another fishing technique used by both the Virginia Indians and the early colonists, was the use of fishing weirs or traps. Used in rivers in England, this method was probably familiar to some of the colonist (Schmidt 2006). Even if they were not familiar with the technique, Francis Perkins remarked in a letter from 1608, that the Virginia Indians showed them how to make certain tools and productively catch fish with weirs (Perkins in Haile 1998:134). William Strachey described in detail the construction of the weirs he saw produced by the Virginia Indians:

> …ingenious enough in their own works as may testify their weirs in which they take their fish, which are certain enclosures made of reeds and framed in the fashion of a labyrinth, or maze, set a fathom deep in the water with divers chambers or beds, out of which the entangled fish cannot return or get out once in, well may a great one by chance break the reeds and so escape (Strachey in Haile 1998:633).

Other types of fish traps practiced by the Virginia Indians involved placing rock dams in a V-shape from the shore. Where the sides of the dam converged, they placed a trap made from reeds and grass to catch the fish. While this was useful for small streams and rivers, they constructed a much larger trap for estuaries, bays, and large rivers. In this situation, they built a “fence” perpendicular to the shore. As fish encountered the wall, they would swim parallel to it to try and reach deeper water. At the end of the “fence” a funnel shaped trap allowed fish to easily enter but have difficulty in exiting (Rountree 2021).

Probably the most common methods for catching fish by the early colonists were by either rod and line or by hand lines with hooks. Using wooden poles with attached horse hair line and hook, the first method would have been most useful for shallow water fishing from the shore (Schmidt 2006). Smith confirms this when he mentions, “In the small rivers all the year there is a good plenty of small fish, so that with hooks those that would take pains had sufficient “ (Smith in Barbour 1986:104; Schmidt 2006:83). A similar approach was the use of a line with a lead weight and hook, allowing the fisherman to reach greater depths. Used from a boat, the fisherman would bring in the line by winding it around a wooden frame. Instead of being made from horse hair, the line would have probably been made from hemp so it could support heavier fish (Schmidt 2006).

Excavation at Jamestown, including the Second Well (JR2158) have produced a variety of fish hooks and lead weights of varying styles and lengths, indicating these methods of angling were probably the most fruitful for the early colonists. While the Virginia Company could have supplied fishhooks to Jamestown, a resident blacksmith could have also made them (Schmidt 2006). The Virginia Company appears to have controlled the fishing gear until around 1623, when colonists began to purchase their own fishing equipment and boats. The listing of estates around this time also began to include fishing lines, hooks, and seines (Pearson 1943).

The Virginia Indians also had methods of angling which involved the use of forked sticks for the rod, fish hooks made from bone, and line made from a variety of material including the bark from trees, deer sinew, or grasses. Other recorded methods include using javelins to spear fish in shallow water or shooting fish with bow and arrow (Rountree 2021). The variety of fishing methods employed by the Indians, along with their experience, ensured their attempts at procuring fish were most likely superior to the first English residents at Jamestown. This may have still been the case in 1619, when the First General Assembly of Virginia passed a law allowing up to six Virginia Indians to live in established English settlements if they engaged in providing fish for the inhabitants of the settlement (Kennedy 2015). A similar arrangement probably continued until local disputes between the colonists and the Virginia Indians led to an uprising in 1622 which brought a renewed instability for English subsistence.

While the colonists worked to find ways to improve their fishing skills, they still faced another problem, which was the lack of supplies needed to preserve fish. If fish were caught in great numbers, they likely went to waste as there was no way to save them for winter food. Fish tended to be more numerous in the summer months when they would either spoil quickly from the heat or the summer storms would make it difficult to successfully sun-dry the fish (Wharton 1957:2). It would not be until 1614 when attempts at salt making began on Smith's Island located on the Eastern Shore. Twenty-one men from Jamestown worked to extract salt from sea water by washing the sand and boiling the water. With approximately 440 gallons of seawater needed to produce just one bushel of salt, the manufacturing of salt was discontinued before 1620. Around this time the Virginia Company, after hearing reports of the colonists becoming sick from only eating fresh, unseasoned meat, requested a second attempt at salt making. This second effort used skilled salt makers from France who used a method of evaporation in clay-lined ponds to extract salt. This attempt also failed, as well as another in 1627, and another in 1630. Although the demands for salt production increased with the arrival of more colonists and the need for meat preservation, it was never a successful endeavor. Virginia depended upon imports of salt from Britain and the West Indies for many years leading up to the Revolutionary War (Straube 2020).

Besides the lack of fishing experience and proper equipment, environmental conditions also affected the presence and absence of fish including water salinity, water temperature, the amount of oxygen in the water, the availability of food for the fish, and the time of year. Unfortunately, when the first colonists arrived in Jamestown, they were unaware they had arrived at start of a six year drought. While brackish water, a mixture of fresh and salt water, typically surrounded Jamestown Island, the drought caused the salinity levels to rise and freshwater to decrease. This would have directly affected what fish would have been available to the colonists, as well as, altering any seasonal migration of fish the colonists may have been relying on (Schmidt 2006). One example of changes in the seasonal migration, was the presence of sturgeon in the James River which John Smith mentioned in 1607 as being available from May to September (Smith in Haile 1998:230). By the spring 1610, however, the drought had severely influenced the migrating patterns of sturgeon so much Strachey commented, "there was not one eye of sturgeon yet to come into the river" (Strachey in Haile 1998:419).

Along with the drought conditions, as winter months approached, the colonists would have found many species of fish not available since many migratory fish leave the James River and the Chesapeake Bay for oceanic waters. Even some estuarine species, which are typically found in shallow water during warm months, would have left the waters around Jamestown Island to find deeper waters. While fishing in winter would not have been very productive, one account from Francis Perkins, who arrived to Jamestown in the harsh winter of 1607-1608, described in a letter how the settlers acquired some fish in the frozen James River:

> So excessive are the frosts, that one night the river froze over almost from bank to bank, in front of our harbour, although it was there as wide as that of London. There died from the frost some fish in the river, which were taken out after the frost was over, were very good and so fat that they could be fried in their own fat without adding butter or such thing (Perkins in Haile 1998:133).

The first decades of fishing at Jamestown were definitely a time of experimentation and adaptation. If fishing had been the only problem the first colonists needed to address, it still would have been a challenging situation. However, it must be kept in mind, it was also a time of disease, starvation, and changing relationships, often violent, with the Virginia Indians. All of these factors also played a role in how fishing was used for acquiring provisions at Jamestown.

The establishment of the Martial Laws in 1610 also had a direct influence on some aspects of fishing by controlling who was allowed to fish and how the fish was allocated to the colonists. One of the laws stated those who were appointed to fish, particularly for sturgeon, were obligated under the law to account for every part of the fish. In dressing the fish, these appointed fishermen could not demand parts of the fish as payment for their job or take portions, such as meat and caviar, for their own consumption. In turn, cooks preparing the daily rations could not remove portions of the fish, or any meat, for their own consumption or to give to other members of the colony. The positions of fishermen and cooks appear to have been appointed by the Colony and their work regulated by the law. Those who dared to break these laws faced penalties including losing their ears for a first offense, spending a year in the "gallies" for a second offence, and three years in the "gallies" for a third offense (Strachey 1612).

Knowing all the challenges which limited the success of fishing at Jamestown, the following section will discuss the specific species identified in the six analyzed layers from the Second Well (JR2158). There are six main categories of fish inhabiting the Chesapeake and its tributaries—freshwater, estuarine, marine, anadromous, semianadromous, and catadromous. Generally, freshwater fish can live in waters with a salinity as high as 10%, while estuarine fish typically live in tidal waters with salinities ranging from 0% to 30%, and marine fish live in oceanic waters with a salinity greater than 30%. Anadromous fish include those species that migrate from ocean waters to freshwater to spawn and semianadromous fish move from waters of higher salinity to waters of lower salinity to spawn. The last category of fish, called catadromous species, are rare in the Chesapeake and include fish which migrate during spawning from freshwater habitats to the ocean (Murdy et al. 1997).

Crustacean

Blue Crab

Layers H, N, P, and U from the Second Well (JR2158) produced 1,154 calcined pincers from blue crabs (*Callinectes sapidus*). Distributed along the Atlantic Coast, the blue crab is most prevalent in the Chesapeake Bay area (Lippson and Lippson 2006). Their remains, mostly calcined claws, are frequent in many colonial-period sites throughout the Chesapeake region. Due to the fragile quality of the claws, crab remains typically survive only if burned. Crabs were harvested from the waters of the Chesapeake primarily during the summer months, but also limitedly during spring and fall; during the winter months they become dormant, burrowing into the sandy bottom. Smith remarked in his *General History* the inhabitants of Jamestown lived on crabs and sturgeon from May to September 1607 while they waited for their first shipment of supplies (Smith in Haile 1998:230).

Again, since crab claws usually survive only when burned, the number of calcined pincers identified in four of the well layers is not an indicator of abundance. However, it is interesting to note layers X and AA, the lowest layers studied from the well, did not produce any crab remains.

Fish

Sharks (mostly marine, few species are anadromous)

Recovered from all six analyzed layers of the well, are at least nine teeth and vertebrae identified to either class Chondrichthyes (cartilagenous fish) or family Caracharinidae (requiem shark). These sharks are strong swimmers found to be more active at night, dawn, or dusk. They are aggressive predators feeding on other sharks, rays, bony fish, turtles, and seabirds. Common species of requiem shark found in Chesapeake waters include the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), the sandbar shark (*Carcharhinus plumbeus*), the dusky shark (*Carcharhinus obscurus*), and the bull shark (*Carcharhinus leucas*). Although most of these species prefer the deeper, high salinity waters of the Chesapeake Bay, other species like the bull shark can also frequent brackish waters or low-salinity rivers. Bull sharks feed on bony fish, crustaceans, turtles, and mammals and have been recorded in the Chesapeake as far north as the Paxtuxent River. Their meat is considered tasty and today, anglers often catch them using only hooks and long lines (Murdy et al. 1997).

Although mentioned by Smith and others in general descriptions of fish species they encountered, John Lawson mentions sharks in greater detail in his accounts from the Carolinas in 1700. Although he had not tried shark, his accounts suggest early colonists used shark for several purposes:

> Their Livers make good Oil to dress Leather withal; the Bones in their head are said to hasten the Birth, and ease the Stone, by bringing it away…Their meat is eaten in scarce times; but I never could away with it, though a great lover of fish... The dogfish are a small sort of the Shark Kind; and are caught with Hook and Line, fishing for Drums. They say, they are good Meat; but we have so many other sorts of Delicate Fish, that I shall hardly ever make Tryal of what they are (Lawson 1709).

Skates or Rays (estuarine, marine)

A total of 13 dermal plates recovered from Layers H, N, P, U, and X were identified as belonging to the order Rajiformes (rays and skates). Rays and skates, found along the Atlantic Coast from Florida to New England, feed on crustaceans, shrimp, mollusks, squid, and small fish (Hildebrand and Schroeder 1972). While skates and rays are typically found in deep ocean waters, there are some species of rays found in shallow water and even freshwater areas. Some of the barbless species preferring shallow water include the clearnose skate (*Raja eglanteria*), the spiny butterfly ray (*Gymnura altavela*), and the smooth butterfly ray (*Gymnura micrura*). These three species are all seasonal visitors to the lower Chesapeake from summer till fall, where they are found in shallow water with a soft bottom. Species in this order, which possess one or several serrated venomous spines, include the southern stingray (*Dasyatis americana*), the Atlantic stingray (*Dasyatis sabina*), and the bluntnose stingray (*Dasyatis say*). These species of stingrays also prefer the shallow waters of the Chesapeake during the summer and early fall, where they are usually caught, accidently, in nets or by rod and reel (Murdy et al. 1997).

Not typically considered for human consumption today, one anecdote in *The General History* describes Smith's encounter with a stingray while fishing with his sword:

> But it chanced our captain taking a fish from his sword, not knowing her condition, being much of the fashion of a thornback, but with a long tail like a riding rod, whereon the middest is a most poisoned sting or two or three inches long, bearded like a saw on each side, which she struck into the wrist of his arm near an inch and a half. No blood nor wound was seen, but a little blue spot. But the torment was instantly so extreme that in four hours had so swollen his hand, arm, and shoulder and part of his body as we all with much sorrow concluded his funeral and prepared his grave in an island, as himself directed. Yet, it pleased God by a precious oil Doctor Russell at the first applied to it when he sounded with probe [that] ere night his tormenting pain was so well assuaged that he ate of the fish to his supper, which gave no less joy and content to us than ease to himself, for which we called the island 'Stingray Isle' after the name of the fish (Smith in Haile 1998:262).

Sturgeon (anadromous)

Present in all of the analyzed layers from the Second Well (JR2158) are at least 30,135 sturgeon (*Acipenser* spp.) bones. Sturgeon is among the most easily identified of fish species due to their hard bony "scutes" which lie in five rows along their bodies. The sturgeon is a bottom-dwelling anadromous fish found in a variety of habitats. Usually found along the continental shelf, the largest species, the Atlantic sturgeon (*Acipenser Oxyrhynchus)*, sometimes enters larger rivers to spawn while the shortnose sturgeon (*Acipenser brevirostrum*), is more commonly found in river mouths, tidal rivers, estuaries, and bays. Sturgeon can live up to fifty years and become quite large, averaging six to eight feet in length. They were and are today important commercially; their roe provides high-quality caviar, their flesh eaten smoked or fresh, and isinglass (a type of adhesive) made from their swim bladders (Robbins et al. 1986).

The 1609-1610 Council of Virginia, realizing the importance of sturgeon, instructed the first Jamestown colonists, "Once the ships are unloaded at Jamestown, the sailors shall be put to work fishing for sturgeon" (Haile 1998:25). Initially, sturgeon was so plentiful in the James River, Smith remarked while they were waiting for provisions, "We had more sturgeon than could be devoured by dog and man, of which the industrious by drying and pounding, mingled with caviar, sorrel, and other wholesome herbs, would make bread and good meat" (Smith in Haile 1998:320).

The early attempts to export sturgeon to England failed since the products did not keep well on the long voyage back. In 1610, the Virginia Company sent instructions concerning the proper methods of pickling sturgeon flesh and utilizing the other parts of the fish:

> Sturgeon which was last sent, came ill conditioned, not beinge well boyled; if it were cut in small peeces, and powdered, put up in caske, the heads pickled by themselves, and sente hither, it would doe farre better… Rowes of the said Sturgion make Cavearie according to instructions formerlye given… Soundes (air-bladder) of the said Sturgion will make Isinglasse according to the same instructions (Brown 1890[1]:386).

After the sturgeon fishing expeditions of 1610, records suggest sturgeon was shipped to England sporadically while the colonists still tried to make it a profitable commodity. Regulations regarding the procurement of sturgeon are mentioned in the martial laws of 1611 which stated:

> All fishermen, dressers of sturgeon, or such like appointed to fish or to cure the said sturgeon for the use of the Colony, shall give a just and true account of all such fish as they shall take by day or night, of whatsoever kind, the same to bring unto the Governor. As also all such kegs of sturgeon or caviar as they shall prepare and cure upon peril for the first time offending herein of losing his ears, and for the second time to be condemned a year to the galleys, and for the third time offending to be condemned to the galleys for three years (Strachey 1612).

English interests in establishing a sturgeon fishery in Virginia continued into the 1620s. By 1626, however, records of the General Court of Virginia noted the “Sturgeon fishery here costs adventurers 1700£ but no accounts of their profit begun…” (Pearson 1943:4). This apparent lack of success in the sturgeon industry was best defined by the Dutch traveler David De Vries, who wrote:

> When the English first began to plant their colony here, there came an English ship from England for the purpose of fishing for sturgeon; but they found that this fishery would not answer, because it is so hot in summer, which is the best time for fishing, that the salt or pickle would not keep them as in Muscovy whence the English obtain many sturgeon and where the climate is colder than in the Virginias (De Vries in Pearson 1943:4).

Today, over-fishing, pollution, and dam construction reduced the population of the sturgeon. In the Chesapeake Bay, fishing for the Atlantic sturgeon peaked in 1890, after which the fishery rapidly declined with each passing year. In 1938, Virginia passed a law which prohibited the removal of sturgeon less than four feet long. By 1974, it became “unlawful to take or catch and retain possession of any sturgeon fish” in Virginia, so currently Virginia does not allow sport fishing for Atlantic sturgeon. This law and other conservation regulations may be the reason limited spawning of sturgeon has once again been occurring in the James and the York rivers. For now, however, controlled sturgeon fisheries in New York and Canada provide high-quality caviar and other commercial products for export (Murdy et al. 1977).

Gar (freshwater)

Also excavated in all of the six well layers are 790 bones identified as gar (*Lepisosteus* spp.), an ancient group of predatory fish distinguished by their elongated, cylindrical bodies covered with diamond-shaped, hard scales. Gars also have distinctive long, beaklike jaws which contain sharp teeth of various sizes (McClane 1965). Often found inhabiting quiet, weedy waters, gars feed on minnows and other small fish. Today, only one species, the longnose gar (*Lepisosteus osseus*), still exists in the waters of the Chesapeake Bay. This species can reach a length of six feet and may have once been a common sight in the waters of the James River (Hildebrand and Schroeder 1972). In his book, *The History of Travel into Virginia Britannia*, William Strachey described gar in the waters of Virginia by saying, "There is the garfish, some of which are a yard long, small and round like an eel and as big as a man's leg, having a long snout full of sharp teeth" (Strachey in Haile 1998:684).

Bowfin (freshwater)

Three bones from Layers H and P indicate bowfin (*Amia calva*) may have also been a source of food for the early occupants of Jamestown. The bowfin is a prehistoric fish which dates to the Triassic period (about 210-245 million years ago). They are carnivorous fish, with large mouths and strong teeth allowing them to eat a variety of food including crustaceans, mollusks, and insects. Commonly found in the tributaries of the Chesapeake Bay, bowfin prefer sluggish waterways, swampy rivers, and shallow lakes. Although not valued as a source of food, bowfin is still caught today using hooks or lures (Murdy et al.1997).

Herring (anadromous)

Layers N, P, and U were the only assemblages to contain bones identified to the herring family (family Clupeidae) or more specifically to shad/herring (*Alosa* spp.), American shad (*Alosa sapidissima*), and alewife (*Alosa pseudoharengus*). The biology and the ecology of clupeids vary: some species live predominately in freshwater, and some only enter fresh water to feed or spawn. Although this family comprises of at least 180 species, only 10 species frequent waterways associated with the Chesapeake Bay. The two identified species, Amerian shad and alewife, along with Atlantic menhaden (*Brevoortia* tyrannus) and Atlantic herring (*Clupea harengus*), represent the most common species found in the waters of the Chesapeake.

The alewife and Atlantic herring spawn from late March through April in locations of large rivers, returning to the ocean by summer. The American shad also prefers to spawn during the spring months, living in fresh to low-salinity waters of the Chesapeake's tributaries. Finally, the Atlantic menhaden spawn during the early spring and again in the fall in shelf waters off the bay. Robert Beverley mentions the springtime presence of herring in the tributaries of the Chesapeake in 1705:

> In the Spring of the Year, Herrings come up in such abundance into their Brooks and Foards, to spawn, that is almost impossible to ride through, without treading on them. Thus do those poor Creatures expose their own Lives to some Hazard, out of their Care to find a more convenient Reception for their Young, which are not yet alive (Beverley 1855:117).

Alexander Whitaker also noted this seasonal appearance of herring in 1613 when he commented:

> The sea-fish come into our rivers in March and continue the end of September. Great schools of herrings come in first; shads of a great bigness and the rockfish follow them (Whitaker in Haile 1998:743).

William Strachey described the meat of shad as being known "for sweetness and fatness a reasonable good fish" (Strachey in Haile 1998:684). While the Jamestown settlers could have been eating fresh herring and shad, record show during the 17th and 18th centuries they were most commonly salted down. As early as 1626, the early colonists had over 58,000 pounds of salt fish on hand and over the course of the following century, salt herring played a major role in the diet of servants, slaves, and land owners (Noël Hume 1978).

Suckers (freshwater, estuarine)

Present in all layers, except for Layer AA, are 339 fish bones identified as bones belonging to the sucker family (family Catostomidae). Bottom-feeding suckers are a numerous and varied group of fish represented by approximately 75 different species. Although they prefer freshwater, the three species found in the Chesapeake region are also found in brackish waters with salinities of less than 5%. These species include the quillback (*Carpiodes cyprinus*), the white sucker (*Catostomus commersoni*), and the shorthead redhorse (*Moxostoma macrolepidotum*). These species typically ascend small creeks in the spring where they prefer to spawn in swiftly moving waters. When they are not spawning, suckers are found in moderate size streams when they can reach a length of two feet and weight up to five pounds. They feed mostly on zooplankton but they can also ingest small larvae, amphipods, and snails. Although suckers are known as a bony fish, they are still considered a good food fish (Hildebrand and Schroeder 1972). Being a non-migratory fish, suckers could have been a source of food for the colonists during the winter months at Jamestown (Wharton 1957).

Freshwater Catfish (freshwater)

Another type of non-migratory fish identified in all of the layers of the Second Well (JR2158) is freshwater catfish (family Ameiuridae). Behind sturgeon, catfish were the second most frequently identified fish species in the well assemblages, accounting for 1,337 of the fish bones. Freshwater catfish are abundant in all Chesapeake Bay tributaries, including lakes, rivers, ponds, streams, and estuarine waters where they feed on a variety of insects, fishes, and crustaceans. One of the most common species of freshwater catfish in the Chesapeake is the white catfish (*Ameriurus catus*). While the white catfish is usually found in tidal tributaries of rivers, during the spring and early summer they move upstream to spawn. Because of their lack of small bones, the white catfish has been praised as a fine fish for eating (Lippson and Moran 1974).

Two other species found in the Chesapeake, include the yellow bullhead (*Ameiurus natalis*) and the brown bullhead (*Ameiurus nebulosus*). Both species are found in all tributaries of the Chesapeake including ponds and lakes. Spawning takes place in April through June, with eggs deposited in nests. While the yellow bullhead builds its nest out in the open, the brown bullhead prefers its nest to be under an overhang, log, or rocks. They both feed on insects and bottom-dwelling organisms, such as mollusks and crustaceans (Murdy et al. 1997).

Studies on the energy value of fish suggest the number of calories a fish can provide a person is directly related to the fat content of the fish. When calculated, catfish provide some of the highest calories per pound for fish species, around a 1,000 calories per pound (Sauer 1968). For this reason and for the fact catfish were available to the colonists throughout the year, it is not surprising we have identified many catfish bones from Jamestown archaeological features.

Cod (marine)

Layers P and U produced at least seven bones identified as the bones of Atlantic cod (*Gadus morhua*). While cod have occasionally been caught in the Chesapeake Bay in late winter or early spring (Hildebrand and Schroeder 1972), they are more commonly found in large numbers off the waters of New England. The habitat of the Atlantic cod is within a fathom of the sea bottom, generally in temperatures ranging between 32 to 68 degrees. In the summer and early fall adult cod congregate in the polar waters around Labrador, withdrawing in later fall and winter to the south or into deeper waters. For this reason, along the New England coast, cod are taken commercially only in fall, winter, and early spring. They usually appear in southern Massachusetts in mid-October, and migrate northward in early May. Younger cod, and others less sensitive to water temperature, remain in shoals and river mouths, usually on rocky bottoms, year-round (Bigelow and Schroeder 1953).

Although their remains have appeared in most, if not all, New England historic faunal assemblages, the presence of cod in Jamestown assemblages raises the question of whether these bones are the remains of imported cod or were they brought from nearby waters. As mentioned, cod are not typically found in the Chesapeake region, but some early historic references suggest cod may have been taken in waters north of Jamestown and in the Bay. For example, Captain Christopher Newport wrote in 1607:

> And within sight of land into the sea we expect at time of year to have a good fishing for cod, as both at our entering we might perceive by palable conjectures, seeing the cod follow the ship… as also out of my own experience not far off to the northward the fishing I found in my first voyage to Virginia (Newport in Wharton 1957:4).

A year later, during his first expedition up the Bay, Smith also referred to cod being in the Chesapeake Bay when he commented:

> Neither better fish, more plenty, nor more variety for small fish had any us ever seen in any place so swimming in the water than the Bay of Chesapeack… Some small cod also we did see swim close by the shore by Smith's Isles, and some as high as Riccard's Clifts, and some we have found dead upon the shore (Smith in Barbour 1986[2]:168).

In 1611, Lord De La Warr also mentioned the presence of cod in his report to the Council of Virginia and the possibility of cod as export product:

> There is also found an excellent fishing bank for cod and ling as good as can be eaten and of a kind that will keep a whole year in ships's hold with little care, a trial whereof I now have brought over with me (De La Warr in Haile 1998:532).

While cod may have been available in limited quantities to the Jamestown colonists at certain times of the year, records indicate the majority of their cod was imported. As early as 1610, efforts were made by the colony to supply themselves with cod they fished for in the waters off the coast of New England. But due to the lack of sea-worthy fishing vessels and skilled fishermen, Jamestown became dependent on English interests for their supply of cod brought from New England and Canada. Salted codfish, as well as other cured fish, became a staple in the diet of early colonists and by 1624-25, the Virginia Census recorded 58,000 pounds of fish was being stored in 15 settlements near the James River (Pearson 1943:6).

Temperate Bass (estuarine, marine)

The assemblages from Layers H, N, P, and X produced at least 50 fish bones identified as only as temperate bass (family *Moronidae*). Members of the temperate bass family include moderate to large-sized fish found in marine, brackish, and freshwater habitats. The two species of temperate bass found in the Chesapeake Bay include the white perch (*Morone americana*) and the striped bass (*Morone saxtilis*).

A total of 396 white perch bones were identified in Layers H, N, P, U, and X, with at least 246 of these bones recovered from Layer P. The white perch is a species of fish found in all tributaries of the Chesapeake Bay. Preferring level bottoms of silt, sand, mud, or clay, white perch migrate from April through June to fresh or low-salinity waters of large rivers. After spawning, adults move back downstream toward the Bay to spend the summer feeding in deeper waters, while the young gradually move down to join them. Due to their value as a food fish, white perch has long been considered one of the most important recreational and commercial fishes in the Chesapeake Bay (Murdy et al. 1997).

In addition to the white perch, at least 39 fish bones from Layers N, P, U, X, and AA appear to be from striped bass (*Morone saxtilis*). During summer and winter, striped bass prefer the deep channels of the Chesapeake Bay, while in the fall, they are more concentrated in the lower reaches of rivers. In the spring they return to the sand or mud bottoms of freshwater to spawn. They are carnivorous, feeding on various kinds of animal life such as fish, crustaceans, worms, and insects. Also called rockfish, the striped bass has long been a favorite saltwater fish for food (Hildebrand and Schroeder 1972).

Grouper/Seabass (marine)

Three bones from Layer P belong to family Serranidae, which includes grouper and seabass. Members of this family are large-mouthed, robust bottom dwellers ranging in length from several inches to several feet. Feeding on crustaceans and fish, they inhabit a variety of habitats from the shoreline to depths of 660 feet or more. While this family of fish primarily inhabit tropical and temperate waters, there are three known species to seasonally inhabit the Chesapeake Bay including goliath grouper (*Epinephelus itajara*), the gag (*Mycteroperca microlepis*), and the black sea bass (*Centropristis striata*). The goliath grouper, known as the jewfish until 2001, is mentioned by Ralph Hamor in his 1614 list of fish found in Virginia. They are seen more commonly in southern waters but have also been found near the mouth of the Chesapeake Bay (Murdy et al. 1997). The black sea bass is common in the lower Chesapeake

Bay from spring to late autumn where they inhabit rocky bottoms near pilings, wrecks, and jetties (Murdy et al. 1997).

Sunfish (freshwater)

The faunal assemblages from Layers P and U produced six bones identified as fish from the sunfish family (*Lepomis* spp.). In the Chesapeake, there are at least ten species found in brackish waters, with the most common species being the largemouth bass (*Micropterus salmoides*), the smallmouth bass (*Micropterus dolomieu*), redbreast sunfish (*Lepomis auritus*), bluegill (*Lepomis macrolophus*), and the pumpkinseed (*Lepomis gibbosus*). All the male members of this family build nests in the spring by making depressions in the sand or mud for the females to lay their eggs. While all sunfish prey on similar foods such as insects, small crustaceans, and small fish, they differ in their habitats. The bluegill, redbreast, and pumpkinseed prefer quiet, warm, non-flowing lakes, ponds, and reservoirs, while the smallmouth bass prefers the cool, slightly-flowing waters of streams and rivers. The largemouth bass prefers lakes with extensive shallow areas, but can also inhabit large, slow-moving rivers or streams (Murdy et al. 1997).

Yellow Perch (estuarine and freshwater)

At least 23 bones from Layers N, P, U, and AA represent yellow perch (*Perca flavescens*). Distributed from Canada to South Carolina, the yellow perch is abundant in most tributaries of the Chesapeake Bay. While they typically inhabit the upper portions of estuaries, they will migrate even further upstream to spawn in small shallow streams in late February and early March. Feeding on insect larvae, crustaceans, and small fish, yellow perch inhabit shorelines where vegetation provides food, cover, and spawning habitats. Considered excellent eating fish, anglers commonly catch them with baited hook during their spring spawning runs (Murdy et al. 1997).

Jack (marine)

Two fish bones from Layer P of the Second Well (JR2158) belong to *Caranx* spp., which includes species of jack fish. In waters of the Chesapeake, the most common species of jack include the crevalle jack (*Caranx hippos*) and the blue runner (*Caranx cryos*). Both species are found in the lower region of the Chesapeake during the summer and fall where they travel in large schools feeding on smaller fish and invertebrates. While they both spawn offshore, they are also found near shore in brackish waters or fast moving rivers (Murdy et al. 1997).

Sheepshead (estuarine)

Layers N and AA produced at least two bones belonging to sheepsheads fish (*Archosargus probatocephalus*). As a summer visitor to the lower Chesapeake, sheepshead live near jetties, wharves, pilings, shipwrecks, and other structures encrusted with barnacles, mussels, and oysters, their primary prey. The meat from sheepshead is highly regarded and is often mentioned in early descriptions of fish from the Chesapeake (Murdy et al. 1997). One of these descriptions comes from Thomas Glover in this 1676 accounts of Virginia to the Royal Society of London:

> In the Rivers are great plenty and variety of delicate Fish; one kind whereof is by the English called a Sheepshead, from the resemblance the eye of it bears with the eye of a Sheep: This fish is generally about fifteen or sixteen inches long, and about half a foot broad; it is a wholesome and pleasant fish, and of easie digestion.

> A planter does oftentimes take a dozen or fourteen in an hours time, with hook and line (Glover 1676).

Croaker/Drum/Seatrout (marine, estuarine)

A total of 72 fish bones from Layers H, N, P, and U belong to family Sciaenidae, which includes species of croaker, drums, and seatrout. While species in this family primarily inhabit coastal marine and estuarine waters, others live in freshwater environments. In 1614, Ralph Hamor references "drummers" in his description of fish found in the rivers near Jamestown (Hamor 1626). Since croakers and drums are named for their swim bladder which produces croaking or drumming sounds, Hamor may have categorized both species under the same heading. He may have been referring to the Atlantic croaker (*Micropogonias undulatus*), a species which moves into the Chesapeake Bay in April in waters with low salinity. In the fall, adult croakers move into deeper water while young croakers move into tidal rivers for the winter. The young fish stay in the rivers until the following fall when they migrate with other adult fish to deeper water (Murdy et al. 1997).

At least one bone from Layer N was identified as black drum (*Pogonias cromis*) and seventy-five bones from Layers H, N, P, U, and X were identified as red drum (*Sciaenops ocellatus*). Adult black drums enter the Chesapeake Bay in April, congregating near Cape Charles during the spawning season. After spawning they move throughout the Bay, feeding on clams, oysters, mussels, and crabs which they crush with their grinding teeth (Murdy et al. 1997). Red drum reside near the mouth of the Chesapeake Bay from May through November, where they are easily caught from the shoreline. Although they tend to migrate between northern and southern waters in the spring and fall, red drum prefers to stay in the bay during mild winters (Murdy et al. 1997).

During the colonial period, drum were valued not only for food, but also for their suggested medicinal purposes. Some people believed the "jelly-like" material found in the head could be dried, beaten, and then used in broth to help women in labor (Noël Hume 1978). Thomas Glover mentioned this in his accounts of Virginia in 1676:

> There is another sort which the English call a Drum; many of which are two foot and a half or 6 or three foot long. This is likewise a very good fish, and there is great plenty of them. In the head of this fish there is a jelly, which being taken out and dried in the Sun, then beaten to powder and given in broth, procureth speedy delivery to women in labour (Glover 1676).

Besides the black and red drum, there are at least two bones from Layer N identified as weakfish/seatrout (*Cynoscion* spp.) and two bones from Layer H and P identified as spotted seatrout (*Cynoscion nebulosus*). Seatrout like to inhabit the shallow waters of the Chesapeake Bay where they find shelter near submerged vegetation or structures. Spawning occurs at night from late May through July near the mouth of the bay or in coastal waters. In summer and early fall, the young prefer intertidal creeks or submerged vegetation near the shore. Considered opportunistic carnivores, their diet changes depending on their size. Young spotted seatrout feed primarily on crustaceans, while adults eat fish or shrimp (Murdy et al. 1997).

Weakfish (*Cynoscion regalis*), found north of Cape Hatteras, have a spring and summer migration northward and inshore, while in fall and winter they move southward and offshore. Swimming in schools, adults like to frequent shallow, sandy bottom areas where they feed on small fish, shrimp, crab, and large zooplankton. Spawning, between April and August, takes place near the mouth of the Chesapeake Bay and in waters near the shore. Young fish can then be found in low salinity waters of river habitats. They grow rapidly during the fall months and move into more saline waters in the early winter (Maurdy et al. 1997).

Reptiles/Amphibians

Frog

A total of 13 bones from Layers H, N, P, and U were identified as either order Anura, which includes all species of frogs and toads or to *Rana* spp, which includes only frog species. With 27 different native species of toads and frogs found in Virginia, it was not possible to identify the exact species represented in the well assemblages. However, there is at least one bone from Layer P identified as a bullfrog (*Rana catesbeiana*). Bullfrogs are aquatic and prefer larger areas of water than compared to other species of frogs. They inhabit lakes, ponds, marshes, and sluggish streams where there is sufficient vegetation for cover, but large enough to avoid overcrowding. When better habitats are not available, bullfrogs will occupy smaller streams (Behler and King 1995).

Bullfrogs have played an interesting role in the history of American cuisine. Frog legs were common on the tables of Europeans in the 17th and 18th centuries and often classified as a type of fish. Recipes for frog legs did not appear in American cookbooks until the late 19th century, where recipes show they were eaten fried, sautéed, or part of a gumbo or stew (Smith 2013). As an excellent source of protein, frogs were and still are captured using a multipronged tool known as a "gig." Frog gigging has typically been a nighttime event when the frogs are most active and can be found along the banks of lakes and streams. Using a bright light or torch, the animals are blinded and easily caught (Deutsch and Murakhuer 2012).

Turtle

Due to the small fragment size or lack of distinguishing characteristics, at least 229 turtle carapace and plastron fragments recovered from Layers H, N, P, U, and X were only classified to the order of turtles (order Testudines). Virginia has over 20 species of land turtles, so it is not surprising turtles found their way on the plates of the Jamestown settlers. As William Strachey wrote in his descriptions of Virginia, "of the land tortoises we take and eat daily" (Strachey in Haile 1998:684). Strachey's statement is supported by the presence of at least six turtle species identified in the faunal assemblage from the Second Well (JR2158). These species include snapping turtle (*Chelydra serpentina*), musk or mud turtle (family Kinosternidae), slider or cooter turtles (*Chrysemys* spp.), box turtle (*Terrapene carolina*), soft shell turtle (*Trionyx* spp.), and diamondback turtle (*Malaclemys terrapin*).

Identified in Layers H, N, P, and U are 135 turtle bones identified as snapping turtle, the largest of the turtle species found in Virginia. The snapping turtle inhabits areas of permanent freshwater, but may enter brackish water at times. They often bury themselves in mud, exposing only their eyes and nostrils. More active at night during the warmer months, most enter a dormant stage by late October, burrowing into mud bottoms, beneath logs or vegetable debris, where they remain until spring. They feed on insects, crabs, shrimp, clams, earthworms, fish, frogs, toads, small turtles, snakes, as well as plant material (Ernst and Barbour 1972). Weighing over 40 pounds, the meat of snapping turtle is considered delicious. Typically prepared in turtle stew, it has been eaten, continually from the colonial period until the present (Noël Hume 1978).

Every layer of the well, with the exception of Layer AA, produced a total of 135 carapace and plastron fragments from musk or mud turtles. Preferring fresh or brackish waters, all musk or mud turtles have two pairs of musk glands beneath the border of the carapace. The secretions, which are very offensive, is the reason why these turtles are commonly called “stinkpots” (Behler and King 1995). For this reason, the mud/musk turtle bones may represent food eaten during a time when other food sources were limited.

Also found in all layers, except for Layer AA, are turtle bones identified as being from the water turtle family of slider and cooters. These turtles inhabit sluggish rivers, shallow streams, marsh areas, lakes, and ponds with aquatic vegetation. Some prefer soft bottom habitats while others use areas with support overhangs for sunning (Ernst and Barbour 1972). Two of the more common species of water turtle found in Virginia are the red-bellied turtle (*Chrysemys rubiventris*) and the yellow-bellied pond slider (*Trachemys scripta*). Both species like to bask near still waters such as ponds and lakes, as well as, slow-moving rivers. They both feed on snails, crayfish, tadpoles, small fish, and aquatic vegetation (Behler and King 1995).

Four bones from Layer N are carapace fragments from a diamondback terrapin (*Malaclemys terrapin*). Distinguished by the deep growth rings on the carapace, diamondback terrapins can be found in salt-marsh estuaries, tidal flats, and lagoons where they feed on marine snails, clams, and worms (Behler and King 1995). The early colonists at Jamestown might have eaten the terrapin prepared in the Virginia Indian fashion, roasted whole in hot coals and opened at the table where the meat was extracted by fingers. Due to its delicious meat, the diamondback terrapin quickly gained fame and became an indispensable course on menus designed for royalty and the elite (Wharton 1957:7).

Represented by 252 bones, the box turtle is the most frequently identified turtle species from Layers H, N, P, U, and X. The box turtle is a small terrestrial turtle which normally inhabits open woodlands, but can also be found in pastures and marshy meadows. They forage during the cooler times of the day and avoid the heat by hiding under rotting logs, in mud, or shallow pools. As the temperature begins to drop in the fall, box turtles burrow into loose soil, sand, vegetation, or animal burrows, where they become dormant. Omnivores, they consume roots, stems, leaves, fruit, seeds, mosses, insects, fish, frogs, toads, and carrion. (Behler and King 1995). They not only provided a dietary source, Virginia Indians would use their upper shells, called carapaces, for a variety of uses such as containers or rattles (Swanton 1979).

The last group of turtles, identified from Layers H and P, is the softshell turtle. The bones found in the Second Well (JR2158) are probably from the spiny softshell (*Trionyx spiniferus*). This species lives not only in small ponds but also large, fast moving rivers. While their eggs and meat are considered a delicacy, these turtles are fast moving both on land and in the water. They are elusive and difficult to catch, which may be the reason only five fragments of softshell carapace shells were identified in the layers of the Second Well (JR2158).

Snake/Viper

There are 37 vertebrae from Layers H, N, P, and U identified only to the broad classification of snake (Family Colubridae). Colubrids, the largest family of living snakes, include approximately 1,500 species, inhabiting every possible ecological niche (Linzey and Clifford 1981:37-117). The thirty species of nonpoisonous snakes found in Virginia are found in a variety of environments including trees, above ground, underground, and in the water. In addition to their diverse habitats, their food preferences are also varied. Some species specialize in certain prey, while others are generalists, eating almost anything small enough to be swallowed. Possible species present on the island include water snakes (*Nerodia* spp.), semi-aquatic reptiles typically found in water, basking in the sun, or in tree branches. Another possible group represented is *Elaphe* spp. (rat snakes), large powerful constrictors which kill their prey by wrapping their bodies around it. One, the back rat snake (*Elaphe obsoleta*) crawls along the woodland floor, scaling trees in search of food.

A single vertebra from Layer P was classified as a viper. The viper family includes poisonous snakes with curved, retractable, hollow fangs near the front of the upper jaw. Along the eastern coast of Virginia, the most common vipers include the copperhead (*Agkistrodon piscivorus*) and the cottonmouth (*Agkistrodon piscivorus*). While the copperhead prefers wooded hillsides or rocky outcrops, the cottonmouth inhabits swamps, lakes, rivers, and irrigation ditches (Mitchell 1994). Although the snakes and vipers may have been accidental visitors to the site, George Percy wrote during the “starving time,” “…some were forced to search the wood and to feed upon serpents and snakes…” (Percy in Haile 1998:505).

Fowling and Identified Bird Species

The Chesapeake Bay is the largest estuary in North America and the primary destination of millions of migratory waterfowl during the winter months. Birds, including wild ducks and geese, would have been available to the settlers at Jamestown in larger amounts during the winter months. Other types of birds such as turkey, shore birds, perching birds, and birds of prey could have been available as year-round potential sources of food. Ralph Hamor sums up the diverse species found near Jamestown in his 1615 discourse:

> There are fowl of divers sort – eagles, wild turkeys much bigger than our English, cranes, herons white and russet, hawks, wild pigeons (in winter beyond number or imagination. Myself have seen three or four hours together flocks in the air so thick that even they have shadowed the sky from us), turkey buzzards, partridge, snipes, owls, swans, geese, brants, duck and mallard, divers, sheldrakes, cormorants, teal, widgeon, curlews, pewits, besides other small birds, as blackbird, hedge sparrow, oxeyes, woodpeckers, and in winter about Christmas many flocks of parakertoths (Hamor in Haile 1998:817).

Based on the number of wild bird bones and the diverse avian species list, it is apparent fowling played a significant role in supplementing the diet of the colonists at Jamestown. Coming from

England at the beginning of the 17th century, the colonists would have been familiar with wild birds and their eggs as being a source of food. Besides supplementing their provisions, the early settlers would have also valued feathers as a useful by-product for stuffing mattresses, pillows, quilts, and cushions. Feathers were also used for quill pens, paint brushes, arrows, decorations for clothing, and flies for fishing. More specialized forms of fowling were also used to obtain live, small song birds to sell or trade as pets to the upper class or to capture birds of prey to be used for falconry (Shrubb 2013).

At Jamestown, the perception of wild fowl as food may have been viewed differently depending upon the social position of the men. For the gentry men, some wild fowl species represented in the faunal record may have reminded them of high-style cuisine reserved for the tables of English and European aristocrats. Birds such as herons, cranes, and swans were reserved for those of high status during the 16th century and not typically eaten by the lower class. An extreme example of this involved a meeting between Henry VIII and the King of France in 1532 where wild fowl on the menu included a total 86 bitterns, 801 night herons, over 440 grey herons, 304 common cranes/storks, 65 spoonbills, 48 great bustards, 361 swans, 1,800 partridges, 5,947 quail, and 3,120 snipe (Bourne 1981). Feasts and dinners such as these were common among the upper class during the first half of the 16th century, where they served birds roasted, stewed in pottages, or baked in pies. Elaborately presented as "still alive," some wild fowl were presented with their skins sewn back over the roasted meat (Wheaton 1983).

By the late 16th century, however, while some fowl was still part of the high-style cuisine, some seabirds and freshwater birds began to lose their appeal. This decline in the palatable interest of wild birds continued into the 18th century when birds such as gulls, cranes, and herons fell out of favor for being too fishy. The list of acceptable land birds as cuisine also dwindled as species such as blackbirds, thrushes, and finches were not as popular in local markets or included in recipes in cookbooks. One of the only exceptions to this, was the swan which was continually considered food of the gentry well into the end of the 18th century (Wilson 1974).

With the presence of swan, heron, gull, and cormorant bones in the layers of the Second Well (JR2158), it is interesting to speculate how the lower status men at Jamestown would have viewed these birds. Would they have seen these wild birds as a luxury food source, a solution to their food shortages, or an ironic twist of fate that food once reserved for the wealthy was now being eaten by all.

Not only were the working class at Jamestown eating wild fowl once considered high status food but they were also taking part in the hunting of birds. Fowling, considered a "sport" for the upper class in 17th century England, was a necessity for all those trying to survive at Jamestown. When they arrived in 1607, all of the colonists, despite their social standing, were probably familiar with the gaming laws (1603-1610) instituted by King James I. These laws changed earlier regulations by increasing the amount of land, money, or possessions an individual needed in order to be allowed to hunt. The establishment of these laws ensured only individuals with high social standing were allowed to hunt in England, therefore ensuring a specific class structure (Berry 2001). In Jamestown, however, English laws were not enforced in the new colony, so presumably any man could hunt to provide provisions for themselves or for the settlement.

Although there are no first-hand accounts of specific techniques, the first men at Jamestown probably employed a variety of fowling methods including the use of snares, traps, string, nets, and clubs. In his book on fowling, written in 1621 and dedicated to the new plantation of Virginia, Gervase Markham writes in great detail about the various means to catch wild birds, including raptors. The simplest methods he describes involve various styles of nets depending on whether the fowler was pursuing water or land fowl. Other methods include the use of string, branches, or even a whole bush coated with bird lime, a sticky substance made from holly, mistletoe, or other plants. When spread on areas the birds frequent, small birds end up sticking to it as they land upon it. To help with these methods he also suggested bait be used to attract the birds to the nets or the hunter could employ bird calls to draw the birds in (Markham 1621).

Other more elaborate techniques used "stalking" horses, trained to be still even when a gun fired below their necks. The process involved the fowler hiding behind the horse as the animal approached the fowl, either on water or land. If an actual horse was not available, Markham also recommended using artificial horses, oxen, or deer made from a canvas to look like a real animal, often using real hide, as well as, horns and antlers to help make it look authentic. If the fake animals were unsuccessful, he also described ways to use shrubbery or small trees to act as a wall to hide behind and slowly approach the fowl (Markham 1621).

In addition to the "stalking" techniques, Markham also suggested live decoys and "call-birds" as effective fowling techniques. Real birds, placed in cages or tethered to poles, attracted other birds with their calls or movement. Nets placed near the decoy and cage, were then used to capture the birds (Markham 1621).

Individuals at Jamestown might have also observed Virginia Indians using artificial decoys to attract ducks. As early as the tenth century, Indians made waterfowl decoys as part of their hunting traditions. These initial decoys were made using duck skins wrapped over floating logs or tightly bound grass or reeds. As ducks naturally flock together, placing the decoys in an easily accessible area would bring the birds in close range of the hunters (Charleston Museum 2021). When early Europeans saw this, they quickly adopted this approach and later modified it by carving decoys out of wood that would float.

While Markham does not mention artificial decoys in his book, he does emphasize the importance of using a water dog to flush and retrieve fowl and the effectiveness of a proper fowling piece. He goes into great detail describing the proper look and training of water dogs, and the best barrel lengths for accuracy in shooting. Fowling pieces began to be manufactured in the early 1600s, with both long and short varieties. Markham describes the best fowling piece as "which is of the longest barrell, as five foote and a half, or six foote, and the bore indifferent … fier locke [wheel lock] or snaphaunce [a flint and steel lock], rather that a corcke and tricker [matchlock], for it is safer and better for carriage, readier" (Markham 1621:43). Although it is not clear whether they were used in fowling, at least 2 wheel lock ignition systems and over 14 snaphaunce mechanisms have been excavated from early contexts at Jamestown (Straube 2006).

Besides fowling pieces, a more ancient form of fowling may have also taken place at Jamestown. The method of using raptors, such as hawks and falcons, to hunt for prey, originally came from Asia and began to be practiced in Europe during the third century. In the Medieval Ages, falconry in England was reserved primarily for those in the upper echelons of society and raptors were often given as gifts to kings and nobility (Shrubb 2013). Some of the first settlers at Jamestown may have been familiar with falconry and brought this form of hunting with them to the New World. Those acquainted with falconry may have also been aware of the methods used to catch live raptors. Markham included in his book several ways to catch live raptors including taking young while still in the nest, carefully using nets, and using bird lime (Markham 1621).

While there is little mention of falconry being practiced in colonial Chesapeake, nearly every early 17th century faunal assemblage contains the bones of eagles, hawks, and owls. Jamestown is no exception to this as we have identified raptor bones in assemblages dating from 1607 until the 1620s, including the Second Well (JR2158). One reference to raptors, hints at the possibility of using them for hunting at Jamestown. Written by William Strachey, between 1609-1612, *The History of Travel in Virginia Britannia: The First Book of the First Decade* mentions:

> I brought home from hence this year myself a falcon and a tassel {tercel}, the one sent by Sir Thomas Dale to His Highness the Prince and the other was presented to the Earl of Salisbury, fair ones, what the proof of them may be I have not learned. They prey most upon fish (Strachey in Haile:682).

Although secondary food history texts have been absolute that raptors were used for hunting, not for food, some of the raptor bones, including bald eagle and turkey vultures, from Jamestown have cut marks on the surface of the bones, butchered dog, horse, and even human remains suggest the desperate settlers resorted to eating food once considered taboo, in order to survive. Although there are no known first-hand accounts of eating raptors, it does seem plausible.

The degree to which falconry was practiced at Jamestown is not clear from the faunal remains or from the historical accounts, but it is certain fowling was essential to the first settlers to protect their crops and supplement their larder. The following sections describe the wild fowl identified from the Second Well (JR2158) assemblages and provides habitat information and their availability in the Chesapeake region.

Wild Birds

Heron

Three bones from Layer U are from the family of herons and egrets (Family Ardeidae) and three bones from Layers N and P belong to a great blue heron (*Ardea herodias*). The heron and egret family includes wading birds with long legs, necks, and bills used for stalking food in shallow water. Often seen perching in trees, herons and egrets prefer areas near marshes, swamps, ponds, and rivers. Some members of this family, including the least bittern (*Ixobrychus exilis*), yellow-crowned night heron (*Nyctannassa violacea*), and the green-backed heron (*Butorides striatus*), only visit the Chesapeake region during the spring and summer months. Other species inhabit the waters of the Chesapeake all year around including the black-crowned heron (*Nycticorax* nycticorax), the little blue heron (*Egretta* caerulea), the snowy egret (*Egretta thula*), the great egret (*Casmerodius albus*), and the great blue heron (*Ardea herodias*) (National Geographic Society 1983).

The great blue heron can grow to be 4 feet tall but will only weigh 5 to 6 pounds. They feed mainly on fish, insects, crustaceans, and amphibians which they find while silently stalking their prey in shallow waters or along the shoreline (National Geographic Society 1983).

Crane or Rails

Seven bones from Layers H and P have preliminary been identified to order Gruiformes, which includes several families of birds such as cranes, rails, and coots. In the Chesapeake, the most common species from this order include the clapper rail (*Rallus longirostris*), the Virginia rail (*Rallus limicola*), and the American coot (*Fulica americana*). Other species which are occasionally seen in the waters of the Chesapeake include the king rail (*Rallus elegans*), the clapper rail (*Rallus longirostris*), and the sandhill crane (*Grus canadensis*). All of these species are typically found along shorelines or marshes searching for food (National Geographic Society 1983). Due to the sheer number of species in this order which frequent the Chesapeake at different times of the year, it is difficult to determine the exact species.

Shorebirds and Gulls

Because of Covid-19 restrictions and not being able to access the comparative skeletal bird collections at the Smithsonian, some bird bones have preliminary been classified to order Charadriiformes, a large order including shorebirds, gulls, and auks. Twenty-three bones from Layer N appear to be from this order and seem to be different bones all from a single bird. Using skeletal loans from University of Georgia and from our own comparative collections, at least 1 bone from Layer P appears to be a sandpiper (family Scolopacidae), while 25 bones from Layers N, P, and U appear to be from gulls (family Laridae and Laurus spp.).

In the Chesapeake region there are approximately 25 species of sandpiper and 9 species of gulls. Some of the more common species of sandpiper include the greater yellowlegs (*Tringa melanoleuca*), lesser yellowlegs (*Tringa flavipes*), the willet (*Catoptrophorus semipalmatus*), the sanderling (*Calidris alba*), the American woodcock (*Scolopax minor*), and the common snipe (*Gallinago gallinago*). While most of these species live along the shoreline, the American woodcock prefers damp woodlands and thickets. There are approximately nine species of gulls, with the most common being the laughing gull (*Larus atricilla*), the ring-billed gull (*Larus delawarensis*), the herring gull (*Larus argentatus*), and the great black-backed gull (*Larus marinus*). While the ring-billed is typically a winter visitor to the Chesapeake, the other three species can be found year-round (National Geographic Society 1983).

Cormorant

Using a comparative specimen on loan from the University of Georgia, a single bone from Layer U was identified as belonging to the cormorant family (family Phalacrocoracidae). Two species of cormorant found in the Chesapeake include the great cormorant (*Phalacrocorax* carbo) and the double-crested cormorant (*Phalacrocorax auritus*). While the great cormorant is only an occasional winter visitor to the Chesapeake, the double-crested cormorant is a year-long resident of the Chesapeake. As a water bird, the cormorant is found along rocky coasts, beaches, inland lakes, marshes, and rivers. Their dark body, set-back legs, and hooked bills makes the cormorant an easily identified bird. They typically dive from the surface for fish and may swim submerged to the neck (National Geographic Society 1983).

Shearwater or Petrels

Layers N and P produced at least two bones identified as family Procellariidae (family of shearwaters or petrels). One of the few shearwater species which is present in the waters of the Chesapeake is the sooty shearwater (*Puffinus griseus*). Rarely seen from shore, this gull-size bird prefers the open water and has a plumage which is primarily dark with whitish sections under their wings.

These bones may also be from the Bermuda cahow (*Pterodroma cahow*) which was identified in faunal assemblages dating from the "starving time." The identified cahow bones at Jamestown confirmed the accounts of early colonists who lived on the island of Bermuda after their ships wrecked from a hurricane. The presence of meat bearing elements suggests the birds had been salted, preserved, and sent as provisions for the colonist's journey to Jamestown and to help sustain them when they arrived.

As the national bird of Bermuda, the cahow is a diving petrel with large nostrils enclosed in a prominent tube along the hook-tipped beak. Their wingspan is typically 35 inches across and their plumage is grayish-black on the top of the body and white plumage on the bottom. They spend their first several years and summers on the open ocean, only returning to Bermuda during the breeding season. Under the cover of night, the cahows return in October to nest in shallow burrows and rock crevices. Both the male and female take turns tending to the nest until late December when they leave to feed at sea. They typically leave for two weeks and then return to incubate their single egg. For the next seven weeks, both parents take two week turns sitting on the egg, while the other is looking for food. Except for the first few days of their life, newly hatched chicks stay by themselves in their burrows except when being fed (Schreiber et al. 1987).

Although cahows are now making a comeback from near extinction, they have had a turbulent history not much different from Jamestown's history. In 1603, a Spanish sea captain sought shelter from a storm on an unknown island in the western Atlantic. According to legend, the sailors were horrified when millions of shrieking, winged shapes swirled around the masts of the ship in the dark night. The sailors later sought their revenge on the birds by eating them by the thousands. They named the bird "cahow" after their loud call (Schreiber et al. 1987).

At one time the cahow had large breeding colonies on the islands of Bermuda. These colonies disappeared with the arrival of the British colonists and their swine which destroyed the nests and ate the young. When two of the ships headed to Jamestown shipwrecked on the island of Bermuda, William Strachey described in detail these island birds that knew no fear of humans and which sustained the settlers:

> A kind of web-footed fowl there is, of the bigness of an English green plover, or sea mew, which all the summer we saw not, and in the darkest nights of November and December (for the night they only feed) they would come forth, but not fly far from home, and hovering in the air and over the sea, made a strange hollow and harsh howling. Their color is inclining to russet, with white bellies, as are likewise the long feathers of their wings russet and white. These gather themselves together and breed in those islands which are high, and so far along into the sea that the wild

> hogs cannot swim over them; and there in the ground they have their burrows, like conies in a warren, and so brought in the loose mould, though not so deep; which birds with a light bough in a dark night, as in our lowbelling (rung to stupefy the birds who were then netter), we caught. I have been at the taking of three hundred in an hour, and we might have laden our boats. Our men found a pretty way to take them, which was by standing on the rocks or sands by the seaside, and hollowing, laughing, and making the strangest outcry that possibly they could, with the noise whereof the birds would come flocking to that place, and settle upon the very arms and head of him that so cried, and still creep nearer and nearer, answering the noise themselves; by which our men would weight them with their hand, and which weighed heaviest they took for the best and let the other alone; and so our men would take twenty dozen in two hours of the chiefest of them; and they were a good and well-relished fowl, fat, and full as a partridge. In January we had a great store of their eggs, which as great as an hen's egg, and so fashioned and white-shelled, and have no difference in yolk nor white from an hen's egg. There are thousands of these birds, and two or three islands full of their burrows, whither at any time in two hours' warning we could send our cockboat and bring home as many as would serve the whole company; which birds, for their blindness (for they see weakly during the day) and for their cry and hooting, we called the 'sea owl.' They will bite cruelly with their crooked bills
> (Strachey in Haile 1998:398-399).

By 1609, the settlers had devasted the cahow population on the main island of Bermuda. When a plague of introduced rats caused a famine on the island, the settlers looked to the cahows on the smaller surrounding islands (Halliday 1978). Finally, fearing the demise of the cahow, the governor or Bermuda issued a proclamation in 1616 and 1621 to stop "the spoyle and havock of the Cahowes." Unfortunately, the proclamations were not effective and the cahow was not seen in the Bermuda Islands for over 300 years (Halliday 1978).

In 1951, a systematic search for the species revealed a few nests (about 18) were on offshore, rocky islands where many tropical birds also nest. With the help of Bermuda's conservation department, artificial burrows with protective covers were installed, which only the cahows could squeeze into. These measures have helped to increase the cahow population, but in the 1960s a new threat was evident. Eggs were failing to hatch and chicks were dying from DDT residues the cahows had picked up from the ocean environment. Legislation has finally controlled the use of DDT in North America which has resulted in the cahow making another comeback (Schreiber et al. 1987).

Due to the Covid-19 pandemic, these bones were not able to be taken to the Smithsonian's Museum of Natural History to compare them to cahow skeletal specimens When the museum allows researchers to access the comparative collections, the bones can then be taken for positive identification.

Goose

As a result of the Covid-19 pandemic, it was not possible to compare the Jamestown geese bones against the comparative geese bird skeletons found in the Smithsonian's Natural History

Museum. Thanks to Dr. Elizabeth Reitz and the University of Georgia's Natural History Museum, we secured loans for several goose skeletal specimens. These loans, in addition to our skeletal collections, ensured all possible wild goose species found in the Chesapeake were available for comparison. As the most identified family of wild birds identified in the Second Well (JR2158), geese account for over 500 of the identified bird bones. From this total, at least 351 bones from all layers could only be identified as goose spp. These bones either did not have enough distinguishing characteristics or they were too fragmented to determine the exact species. There were, however, at least three species of geese identified in the Second Well (JR2158).

Layers H, N, P, and X have 16 bones identified as snow geese (*Chen caerulescens*). During the winter, snow geese inhabit grasslands, agricultural fields, and the coastal waters of the Chesapeake, particularly the Eastern Shore. As their name suggests, they are predominately all white with black tips visible on the end of their wings. They breed in the Artic tundra and travel in flocks which can number several hundred thousand (National Geographic Society 1983).

The two other identified geese from the Second Well (JR2158) include the Canada goose (*Branta canadensis*) and the brant (*Branta bernicla*). At least 51 bones from all layers of the well belong to *Brant* spp. since it was not possible to determine their exact species. Canada goose is represented by 96 bones from all layers of the well, while the brant goose was positively identified in Layer P. Preferring to breed in open or forested areas near water, the Canada goose is the most common of wild geese. When they migrate, the flocks usually fly in a V-formation, and stop to feed in wetlands, grasslands, or cultivated fields. The Canada goose is a common visitor and often year-around resident of the Chesapeake region (National Geographic Society 1983).

The brant goose is smaller and stockier than the Canada goose and is typically only a winter visitor along the shores of Virginia. Their plumage differs slightly from the Canada goose with a black head, a distinct white "necklace" around their necks, and a brown body which turns white near the tail. They prefer to eat grasses and aquatic vegetation, as well as, grazing in agricultural fields (National Geographic Society).

Swan

Twenty-one bones from Layers H, N, P, U, and AA are from swan (*Cygnus* spp.). These bones are most likely from the tundra swan (*Cygnus columbianus*), a native species of swan in North America. This species builds their nests and raises their young in the frozen tundra of Alaska and northern Canada. During the winter, they migrate south, sometimes traveling up to 3,000 miles. Their journey takes them to the Chesapeake Bay where they inhabit sheltered fresh-water areas, bays, estuaries, and flooded fields. The only other native swan found in North America is the trumpeter swan (*Cygnus buccinator*), but is only a rare visitor to waters of the Chesapeake (National Geographic Society 1983).

Duck

With at least 28 different species of duck identified in waters of the Chesapeake, it is always a challenge to accurately identify the exact species represented in a faunal assemblage. Skeletal comparative collections need to have a variety of sizes and different sexes of the same species to solidify the identifications. Even then, some species of duck interbreed with other species which can also affect identifications. Previously, duck bones from Jamestown were taken to the extensive bird skeletal collections housed in the Smithsonian's Museum of Natural History. However, because of Covid-19 restrictions this was not possible for this project. To work around this problem, the faunal team and Jamestown Rediscovery agreed the duck bones, when possible, would be taken to the classification of family and species if appropriate. When the Smithsonian's bird skeletal collections open back up to allow researchers, the identifications of the bones can be finalized. Using skeletal loans of ducks from Dr. Elizabeth Reitz and the University of Georgia, many of the duck bones from the Second Well (JR2158) could be classified at least to family. Families and species of ducks available for comparison with the Second Well (JR2158) bones included dabbling ducks, pochards/diving ducks, perching/woodland duck, and stiff-tailed ducks. Families of duck not available for comparison include sea duck and merganser species which may be found among the 98 duck bones recorded as duck spp. These bones either did not have enough distinguishing characteristics to identify species or did not appear to be from any of the duck families available for comparison.

Identified duck include 53 bones classified as *Anas* spp., a group of ducks which feed by tipping their tails up to reach aquatic plants, seeds, and snails. Found in freshwater shallows or salt marshes, some species would have been available to the colonist year-around including the mallard (*Anas platyrhynchos*) and the American Black Duck (*Anas rubripes*). Other species, such as the gadwall (*Anas strepera*), the green-winged teal (*Anas crecca*), and the American widgeon (*Anas penelope*) would have been available mostly in the fall and winter months (National Geographic Society 1983). It is often difficult to determine the exact species of these ducks since some of the wild species do interbreed with each other, as well as, with domestic species

Another group of duck, represented by at least 34 bones from Layers H, N, P, and X, are species belonging to *Aythya* spp (pochards). Pochards are diving ducks with legs set far back and far apart making walking awkward. Their heavy bodies require them to have a running start on water for take-off. There are five species of pochards found wintering in the Chesapeake area including the canvasback (*Aythya valisineria*), the redhead (*Aythya americana*), the ring-necked (*Aythya collaris*), the greater scaup (*Aythya marila*), and the lesser scaup (*Aythya affinis*). At least one bone from Layer P appears to be from a redhead, a duck which would have been found wintering in marshes, pond, or lakes (National Geographic Society 1983).

Specific duck species identified in the Second Well (JR2158) include the wood duck (*Aix sponsa*) and the ruddy duck (*Oxyura jamaicensis*). Both species are the only ones in their families found in the Chesapeake. Represented by 43 bones from all layers of the well, the wood duck is a striking colored duck with iridescent green heads, red eyes, and white stripes on their heads and bodies. Equipped with sharp claws for perching on stumps or branches, the wood duck is the only species of duck in the Chesapeake region which prefers to nest in tree cavities in wooded areas near ponds or rivers. They inhabit the waters of the Chesapeake from April through November, and their diet consists mainly of seeds, acorns, various wetland grasses, and various insects (National Geographic Society 1983).

The ruddy duck, identified from 10 bones found in Layers H, N, and P, is a small, stiff-tailed, diving duck that frequents the Chesapeake during the fall and winter months. Males are easily recognized by their bill which turns blue during the breeding season. They feed on bay grasses, pondweeds, insects, mollusks, and vegetation they find in rivers, marshes, and freshwater lakes (National Geographic Society 1983).

Turkey

A total of 51 bones from all layers of the Second Well (JR2158) are from turkey (*Meleagris gallopavo*). The turkey is essentially a woodland bird. When Europeans first colonized North America, the turkeys inhabited wide forests, preferring wooded swamps and mature hardwood forests. As the land was cleared, they adapted to open fields, savannas, and meadows as they foraged for insects, berries, and other foods (Bent 1963). In his description of the wildlife in Virginia, William Strachey remarked:

> Turkeys there be great store wild in the woods like pheasants in England, 40 in company, as big as our tame here, and it is an excellent fowl, and so passing good meat as I may well say it is the best of any kind of flesh which I have ever yet eaten there (Strachey in Haile 1998:683).

Faunal assemblages from prehistoric and historic sites in Virginia commonly include turkey, and John Smith commented "in March and April [local Indians] live much upon the fishing weares, and feed on fish, turkies, and squirrels…" (Smith in Barbour 1986:162).

Wild turkeys were taken to Europe, domesticated, and reintroduced to North America (Bent 1963). Since they continued to breed with their wild progenitor, it is not surprising osteological distinctions are not possible between wild and domestic animals. For the Second Well (JR2158) analysis, turkey is considered wild and therefore is included with wild fowl in the relative dietary estimates.

Other Phasianidae

At least 68 bird bones from Layers H, N, P, U, and X belong to order Phasianidae (fowl-like birds. While some of these bones do not have enough distinguishing characteristics to identify the exact species, others will need to be taken to the bird skeletal collections at the Smithsonian once Covid-19 restrictions are lifted for researchers. All of these bones have been compared to domestic chickens (*Gallus gallus*), ruffed grouse (*Bonasa umbellus*), and northern bobwhite (*Colinus virginianus*) but with no exact matches. These fowl-like bones may be from the now extinct heath hen (*Tympanuchus cupido cupido*). The heath hen was a subspecies of the greater prairie chicken (*Tympanuchus cupido*), once found along the coast from Massachusetts to Virginia. Common during Colonial times, settlers hunted the hen regularly for both food and sport. Populations quickly declined from overhunting, loss of habitat, and diseases introduced from domestic fowl (Heisman 2016).

Falcons, Hawks and Eagles

In 1612, William Strachey commented in his book, *The History of Travel into Virginia Britannia*:

> Of birds the eagle is the greatest devourer, an many of them there. There by divers sort of hawks, sparrow hawks, lannerets, goshawks, falcons, and ospreys

(Strachey in Haile 1998:682).

Raptors have continually been identified in faunal assemblages from Jamestown, and the assemblages from the Second Well (JR2158) are no exception (Bowen and Andrews 2000; Andrews 2008). Previously, raptor bones from Jamestown were taken to the ornithology department at the Smithsonian to compare with their raptors in their skeletal collections. Unfortunately, due to Covid-19, it was not possible to visit the Smithsonian, which is one of the few organizations with permits allowing them to possess raptor remains. Live or dead raptors, including their feathers, eggs, nest, and skeletons, are federally protected under the Migratory Bird Treaty Act of 1918 and the Bald and Golden Eagle Protection Act of 1962. To work with raptor bones, individuals or organizations need permits from federal government and state governments. If certain regulations are met, the permits are granted for scientific research, religious use, animal damage control, and falconry (Millsap et al. 2007). For this reason, the faunal team analyzing the Second Well (JR2158) does not have any birds of prey in their comparative collections. To assist in the identifications, the Carolina Raptor Center, located in Huntersville, North Carolina, was contacted to see if they had skeletal remains of raptors. While they did not have a skeletal collection, they agreed to work with us and develop a comparative collection which we could access at their facility. They have now developed an extensive skeletal collection of hawks, owls, and vultures for research purposes. The only raptor skeletons the Carolina Raptor Center may not possess are the bones of bald and golden eagles. The bodies of these raptors must be sent to the federally operated Eagle Repository located in Denver, Colorado. This facility stores and distributes dead bald and golden eagle parts and feathers to federally recognized Native American tribes, museums, and approved organizations. Although it was not possible to physically handle bald eagle bones, the identification of bald eagle in the Second Well (JR2158) is supported by use of skeletal manuals, visual inspections of the bones by members of the Carolina Raptor Center, and on-line sites such as the Royal British Columbia Museum’s Virtual Bone Identification Guide.

At least 20 bones from Layers H, P, U, and X, were only classified to order Falconiformes which includes a broad category of vultures, hawks, eagles, or falcons. Another 30 bones from Layers N, P, U, and AA were narrowed down to family Accipitridae, which includes just hawks and eagles. Within this family several species were positively identified including bald eagle (*Haliaeetus leucocephalus*), red-tailed hawk (*Buteo jamaicensis*), northern harrier (*Circus cyaneus*), and osprey (*Pandion haliaetus*).

Bald eagles are represented by 67 bones recovered from all layers of the Second Well (JR2158). In the Chesapeake. Bald eagles are present all year in the Chesapeake and in forested areas near rivers, wetlands, and other waterways. Easily identified by their white head and tail feathers, they are often seen in tall trees or on cliffs along the James River hunting for fish (National Geographic Society 1983). Some of the bald eagle bones from the “starving time” faunal assemblages suggested they may have served as an emergency source of food to the settlers (Bowen and Andrews 2000). Several bald eagle bones from Layer P also have cut marks on the surface. It is not clear, however, whether these marks indicate eagles were being eaten or if the cuts are the result of processing the eagles for another purpose, such as removing the feathers.

Another year-around resident of the Chesapeake is the red-tailed hawk, identified by one element from Layer N. Found throughout the United States, the red-tailed hawk is a year around resident along the East Coast. Their habitat varies including woodlands, open fields, plains, and even the desert, where they feed on rodents (National Geographic Society 1983).

Layer P has one bird bone classified as a Northern harrier. Also known as marsh hawks, these birds inhabit the Chesapeake during the fall and winter months. They typically perch low and can be see flying close to the ground searching for mice, rats, and frogs (National Geographic Society 19830).

The osprey, represented by two bones, was also identified in Layer P. As spring and summer visitors to the Chesapeake, ospreys return to the area in March where they make their nests nest near salt or fresh water. By late July, most young ospreys in the Chesapeake area are on the wing, and by the end of August they begin their journey to the wintering grounds in the Caribbean, Central America, and South America. Ospreys primarily hunt for fish and are seen hovering over the water, then diving and plunging feet first to retrieve their prey. Once a fish is caught, osprey rearrange their talons to make sure the fish facing forward. Carrying the fish in this method reduces drag and makes it easier for the osprey to fly (National Geographic Society 1983).

The second most frequently identified raptor in the Second Well (JR2158) is the turkey vulture (*Cathartes aura*). Identified by at least 24 bones from Layers H, N, X, and AA, the turkey vulture is a year-around resident of the Chesapeake. With weak talons ill-suited for holding live prey, turkey vultures rely on their small, featherless heads and hooked bills to aid in the consumption of carrion. They do not build nests but lay their eggs in sheltered areas such as cliffs, caves, or hollow logs (National Geographic Society 1983). Like the bald eagle bones, some of the turkey vulture bones from Layer N have cut marks on the surface possibly made by a knife. Some of the vulture bones identified from assemblages related to the “starving time” also had possible cut marks suggesting this unlikely bird may have been a source of food.

Also represented in the Second Well (JR2158) are two bones from Layer U identified to order Strigiformes (all owls) and one bone from Layer U identified as belonging to a great horned owl (*Bubo virginianus*). Great horned owls inhabit a variety of habitats from forests, deserts, swamps, and along the edges of open areas. While they primarily eat smaller prey such as rodents, frogs, and small birds, they can also take larger prey including ospreys, falcons, and other owls (National Geographic Society 1983). As a nocturnal species found year-round in Virginia, the settlers at Jamestown may have seen them at dusk sitting in trees or along the cliffs of the James River.

Perching Bird

Twenty-eight bones recovered from Layers N, P, and X belong to the large order of perching birds (order Passeriformes). With close to 200 species in this order found in Virginia, it is often quite difficult to narrow down the species or even the family of bird the bones represent. Some of the larger species in this order, however, are more likely to be identified than the smaller species. In the Second Well (JR2158) faunal assemblage, three species have so far been identified including three bones from Layer H identified as blue jay (*Cyanocitta cristata*) and six bones in Layers P and U identified to family Corvidae (crows).

The blue jay, identified by three bones from in Layer H, is one of the identified perching birds. A member of the crow family, the blue jay is recognized by its blue and white plumage and its distinctive call. They live throughout the East Coast and often migrate in large flocks. The six bones identified to the crow family are from Layers P and U and do not appear to be from a blue jay. Instead, these bones are more similar to either an American crow (*Corvus brachyrhynchos*) or the fish crow (*Corvus ossifragus*). As one of the largest species in the crow family, the American crow is identified not just by its size but also by its familiar *caw* call. They can be found in a variety of habitats throughout the United States and are very common in Virginia (National Geographic Society 1983). The fish crow, also common in Virginia, and gets it name because they prefer habitats such as marshes or low lying areas along rivers. Both species would have been available to the early settlers all year-round.

Domestic Bird

Domestic Geese

At least six bones from Layer U have been identified as *Anser* spp., meaning they are most similar to domestic geese (*Anser anser*) but not positively identified. Bones confidently identified as domestic geese include at least 55 bones from Layers H, N, P, U, and AA. Although it is clear when the first domestic geese arrived at Jamestown, their bones are noticeable since they are typically quite larger than their wild counterparts. Domestic geese would have been useful to the early settlers by not only providing eggs and meat, but also feathers for stuffing beding and for use as writing instruments.

Chicken

Chicken (*Gallus gallus*) remains include at least 111 bones from Layers H, N, P, U, and AA. Chickens were some of the first domesticated species brought to Jamestown, providing a source of fresh meat and eggs to the early colonists. In terms of the actual amount of meat, chickens were not as important as wildfowl, wild mammals, livestock, or fish but they would have provided supplemental provisions available throughout the year.

Commensal or Identified Non-Food Species

Commensal species are those living near or with another species. They typically share food and often, both animals benefit from each other through this association (Davis 1987). Four commensal species which live in close proximity to humans were found in the well assemblages. Except in times of emergency, these species are rarely eaten and typically not considered food remains in normal zooarchaeological studies.

Mole

A single element recovered from Layer P is from an eastern mole (*Scalopus aquaticus*). Eastern moles prefer habitats with well-drained loam and sand such as grassy fields and forest floors. They build tunnels typically 6 to 24 inches below the ground's surface where they have passages to nest cavities and feeding areas (Webster et al. 1985). Since moles are proficient excavators of the soil and not considered a source of food, this mole most likely represents an "accidental" visitor to the site.

Rats

Twenty-two rat bones came from all layers of the Second Well (JR2158), except for Layer X. Although the exact species of rat was not identified, rat bones from other Jamestown assemblages include mainly Old World rats (*Rattus spp.*). Old World rats consist of the Norway rat (*Rattus norvegicus*) and the roof rat (*Rattus rattus*) species.

Also known as the black rat, the roof rat is an arboreal animal, preferring to live in trees, shrubs, vines, and the attics and walls of buildings. They feed on a variety of grains, fruits, and vegetables and are most active in the late afternoon and evening hours. A native of the Old World, the roof rat came to North America with early explorers and colonists where they quickly became distributed in the eastern portion of the United States (Jackson 1982). Captain John Smith remarked on their productivity when he wrote, "In searching our casked corn we found it half rotten and the rest so consumed with so many thousands of rats that increased so fast (but their original was from the ships) as we knew not how to keep that little we had" (Smith in Haile 1998:319). The Norway rat did not reach North America until around 1775, when they gradually drove the roof rat from much of its range. Today they are likely found near shipping ports, such as Baltimore, Norfolk, Wilmington and Charleston (Webster et al. 1985).

Cat

Layers N and U include bones identified as domestic cat (*Felis domesticus*). Identified in other Jamestown faunal assemblages, it is not surprising to find cat bones in the Second Well (JR2158) (Bowen and Andrews 2000). Cats would have been first kept on the ships to keep rat populations in check, and they kept in homes and farms to serve as mousers and ratters.

Dog

At least five bones from Layers H, P, and U belong to domestic dog (*Canis familiaris*). While dogs may have been brought to Jamestown to serve as companions, they also would be used to aid in hunting, serve as protection, serve as ship dogs, and to guard livestock. William Strachey mentions using dogs to hunt wild swine on the island of Bermuda, while George Percy talks about dogs as an emergency source of food during the "starving time" (Strachey in Haile 1998:400; Percy in Haile 1998:505). John Smith gave chief Powhatan a white grey hound as a gift, along with "a suit of red cloth…and a hat" (Smith in Haile 1998:166). The grey hound must have been quite different from the dogs the Virginia Indians had which Peter Winne described in a letter from November of 1608:

> "…only the dogs which are here are a certain kind of curs like our warrener's hey-dogs in England, and they keep them to hunt their land fowls, as turkeys and suchlike, for they keep nothing tame about them" (Winne in Haile 1998:204).

In addition to domestic dog remains, five bones from Layer N were classified to the category of *Canis* spp., which includes both dogs and wolves. As wolves were abundant at that time, a discussion of wolves in included in the section on wild mammals.

Hunting and Identified Wild Mammal Species

When the promoters of the Virginia colony were trying to lure people to the New World, they often portrayed the resources in Virginia in an overly favorable light. Other descriptions of wildlife and accounts of plentiful sources of food were written by explorers who often visited the New World in the bountiful spring and summer. In England, they considered fishing and hunting to be a leisure activity for the aristocrats, but in the New World these skills became crucial to their survival. Although the colonists arrived with fishing and hunting equipment, their new surroundings proved challenging. As John Smith lamented in the early 1600s, "Though there be fish in the sea, fowls in the air, and beasts in the woods, their bounds are so large, they are so wild, and we so weak and ignorant, we cannot much trouble them" (Smith in Wharton 1957:3). When the settlers attempted to adapt their previous lifestyle to the New World, they brought with them preconceived ideas of hunting. As relationships with the Virginia Indians progressed, they learned new methods of hunting which changed as the colony developed.

In terms of hunting, a variety of factors influenced the early colonists. To begin with, the English brought with them ideas about wild game and the social precepts of hunting. In the seventeenth century hunting in England was considered a recreation activity restricted to royalty, nobility, and the private gentlemen (Cox 1697). In the 17th century there were few large wild animals left in England, and those that did remain were enclosed in deer parks and used exclusively by the nobility and the well-to-do. Although the lower class wanted the same access to wild game to supplement their diet, poaching by yeomen was punishable under forest laws (Thomas 1983). Many of the early Jamestown colonists were from privileged families and many may have had experience with game hunting as a sport.

Although the archaeological artifacts indicate the first James Fort colonists brought crossbows, longbows, matchlock muskets, small animal traps, and snaphaunce fowlers (Straube 2006), the early writings from Jamestown contain few descriptions of the hunting techniques practiced by the colonists. Instead, the accounts from the Jamestown colony indicate that before the 1622 uprising, colonists relied heavily on trade with the Virginia Indians in acquiring wild game, especially deer. The Virginia Indians were skilled, experienced hunters which John Smith commented on in his descriptions of Virginia:

> In their hunting and fishing they take extreame paines; yet is being their ordinary exercise from their infancy, they esteeme it a pleasure and are very proud to be expert therein. And by their continuall ranging, and travell, they know all the advantages and places most frequented with Deere, Beasts, Fish, Foule, Roots and Berries (Smith in Barbour 1986:118).

Knowing the Indians success in hunting, the early colonists must have adapted some of their hunting techniques for the New World. William Strachey commented on some of the hunting techniques of the Virginia Indians in his book *The History of Travel into Virginia Britannia* (1612). For example, when large hunting parties set out to acquire deer, Strachey wrote:

> With the sun rising, they call up one another and go forth searching after the herd, which when they have found they environ and circle with many fires;

> and betwixt the fires they place themselves, and there take up their stands, making the most terrible voices that they can. The deer being thus feared by the fires and their voices betake them to their heels, whom they chase so long within that circle that many times they kill 6, 8, 10, or 15 in a morning (Strachey in Haile 1998:640).

Another technique for group hunting involved driving the deer herds onto a narrow point of land forcing them into the river. Once the deer were in the water, individuals waiting in boats would seize the swimming deer (Strachey in Haile 1998:640). When hunting alone, the tracker often used a method where they placed over their body the skin of a deer with a stuffed head. Once camouflaged, the hunter could then stalk the herd and shoot a deer with bow and arrow at close range (Willoughby 1907).

When relationships with the Virginia Indian became strained in 1609, the colonists no longer had a reliable trading source for food. To make matters worse, the seven year drought had left both the Virginia Indians and colonists with little food surplus. Since they were now competing for the same food sources, Chief Powhatan ordered his men to attack any colonists or livestock found outside of the fort. After the "starving time," leadership at Jamestown established the Martial Laws which defined how livestock and fish were to be distributed among the survivors and the new colonists. The presence of many deer bones in the layers of the Second Well (JR2158), suggests venison played a major role in the provisions of the colonists after the "starving time" and that the Martial Laws may not have clarified how wild game was to be distributed. The high percentage of deer bones may be related to the settler's defeat of the Paspagegh Indians in 1610. The colonist's success meant they no longer had to travel off the island to hunt for wild species. They could now pursue deer and other animals without the constant fear of being attacked (Merry Outlaw 2021, pers. Comm.).

In 1619, in response to their precarious relationship with the Virginia Indians, a new hunting law promised "severe censure of punishment by the Governor and Council" if anyone went out hunting without a sufficient number of well-armed men (Wharton 1957:10). Other hunting laws and restrictions soon followed dictating where people could hunt and what they could hunt. In a 1632 statute, colonists were encouraged to hunt for wolves and game in the forests. The colony provided training in the use of firearms, not only for the wolves, but also to help to keep the Virginia Indians at a distance (Hening 1823[1]:199). Professional hunters were also being hired for the cost of powder, food, drink, and lodging. This practice of hiring hunters enabled some of the more affluent landowners to focus their attentions on planting and developing the surrounding land (Miller 1984).

The following paragraphs will discuss the habitats of the small wild mammals, such as opossum, squirrel, raccoon, muskrat, and otter, and larger wild mammals, such as deer, wolves, and dolphins, all of which were identified in the layers from the Second Well (JR2158). When possible, first-hand accounts referring to these animals is also mentioned.

Wild Mammal

Opossum

At least 114 bones of opossum (*Didelphis virginiana*) were identified from Layers H, N, P, U, and X. Distributed throughout the eastern portion of the United States, the opossum lives in a variety of habitats, including woods, swampy areas, agricultural fields, and suburban areas where they seek refuge in hollow trees, brush, or man-made structures. They are solitary creatures seldom remaining in a single location for more than a few days. Opossums are mainly active at night when they scavenge for a variety of food from invertebrates, fruits, berries, bird eggs, small vertebrates, and carrion (Webster et al. 1985).

William Strachey described them in 1612 as "gray color, it hath a head like a swine, ears, feet, and tail like a rat……and eats in taste like a pig" (Strachey 1612). Ralph Hamor also depicted opossums in his account on the estate of Virginia in 1615 as "the bigness and likeness of a pig of a month old, a beast of as strange as incredible nature" (Hamor in Haile 1998:817).

Besides Strachey and Hamor, opossums intrigued other colonists so much, some animals were sent back to England. In Reverend Alexander Whitaker's 1612 "*Good News from Virginia*," he communicated:

> There be two kinds of beasts amongst these most strange. One of them is the female opossum, which will let forth her young out of her belly and take them up into her belly again at her pleasure without hurt to herself. Neither think this to be a traveler's tale, but the very truth, for nature hath framed her fit for that service. My eye have been witness unto it, and we have sent of them and their young ones into England (Whitaker in Haile 1998:742).

Squirrels

A total of 96 bones from Layers H, N, P, U, and X were identified as *Squirus* spp., a classification including both eastern gray squirrel (*Sciurus carolinensis*) and fox squirrel (*Sciurus niger*). With many squirrel bones identified in Jamestown faunal assemblages, squirrel appears to have served as a food source for both the colonists and the Virginia Indians. William Strachey described squirrels in his *History of Travel*:

> Squirrels they have and those in great plenty are very good meat. Some are near as great as our smallest sort of wild rabbits, some blackish or black and white like those which are here called silver-haired, but the most are gray (Strachey in Haile 1998:681).

The large squirrels Strachey mentions were probably fox squirrels while the silver-haired squirrels were most likely gray squirrels. In the assemblages from Layers H, N, P, U, and X, 259 bones are from gray squirrel while 16 bones from Layers H, N, P, and X are from fox squirrels. The gray squirrel prefers a habitat of mature hardwoods where they forage for a diversity of foods including acorns, other nuts, fruits, seeds, tree barks, fungi, young birds, eggs, and insects. The range of its habitat may vary depending on food availability, population size in the area, and their age.

As the largest of the North American tree squirrels, the fox squirrel has a large, gray body and bluish gray or black face. At the time of the Jamestown settlement, the fox squirrel was found throughout the mid-Atlantic region. Today, however, they inhabit the coastal area of South Carolina, the southeastern coastal plains of North Carolina, and the mountain regions of both North Carolina and Virginia. Their restricted distribution is due to the decline of their natural habitat of mature longleaf pine and hardwood forests. Although they will feed on a variety of fruits and nuts, they prefer pine seeds eating both green and mature pinecones (Webster et al. 1985).

Muskrat

At least 11 bones from Layers H, N, P, and U are from muskrat (*Ondatra zibethica*). The muskrat is a semiaquatic mammal abundant in marshes found in the Chesapeake area. While they often make their dens from large mounds of vegetation, they also make tunnels or holes in the banks of streams and ponds. Like the beaver, the colonists valued the muskrat not only for their pelt but also for their meat. In 1612, William Strachey mentioned muskrats as:

> proportioned like a water rat…a cod within him which yieldeth a strong scent like unto musk. It is a good meat if the cod be taken out, otherwise the flesh will taste most strong and rank of the musk; so will the broth wherein it is sod (Strachey in Haile 1998:681).

Raccoon

The bones of raccoon (*Procyon lotor*) include at least 222 bones recovered from Layers H, N, P, U, and X. The raccoon is a nocturnal carnivore found in areas near water sources such as marshes, hardwood swamps, and flood plain forests. Found across the state of Virginia, they make their dens in hollow trees, caves, rocky ledges, or abandoned buildings. Omnivorous and opportunistic when finding food, raccoons consume both plants and animals, including fruits, berries, grasses, nuts, insects, small rodents, crayfish, frogs, snakes, fish, and eggs (Webster et al. 1985). Since raccoons are active throughout the winter, they could have served as a food source to the colonists year-round. While they provided the colonists with a source of meat, the Virginia Indians also used their pelts for clothing. John Smith accounted for this when he described a visit with Powhatan, "Before a fire upon a seat like a bedstead, he sat covered with a great robe, made of Rarowcun skinnes, and all the tayles hanging by" (Smith in Barbour 1986 [2]:150). Although the colonists could have hunted raccoons themselves, other accounts suggest they may have also acquired them through trading. In his descriptions of the land and the animals found near Jamestown, Williams Strachey mentioned:

> There is a beast they call *aroughcoune*, much like a badger, tailed like a fox, and of a mingle black and grayish color, and which useth to live on trees as squirrels do, excellent meat. We kill often of them, the greatest number yet we obtain by trade (Strachey in Haile 1998:680).

Mink

A single bone from Layer U appear to be from a mink (*Mustela vison*). Captain John Smith remarked about minks in his narratives of Virginia writing "…Minks we know they have, because we have seene many of their skins, though very seldom any of them alive" (Smith in

Barbour 1986 [2]:111). Nocturnal, minks live throughout eastern North America and prefer habitats near marshes, swamps, and along the borders of lakes, streams, and rivers. Their waterproof fur allows them to hunt for prey such as fish, frogs, crustaceans, small birds, and small mammals. Their soft fur has also made them a target of trappers, as their pelt has long been of value to the fur industry (Webster et al. 1985).

River Otter

Layer N produced a single bone identified as an otter (*Lontra canadensis*). The river otter is a large, long-bodied, semiaquatic animal with webbed toes and short, dense fur. Historically, they have occurred along waterways from streams to lakes where there is a good supply, clean water, and relatively low levels of human disturbance. They feed on fish, but also on crabs, amphibians, and other aquatic organisms. Extremely intelligent and inquisitive, the population of river otters has greatly diminished due to trapping, pollution, and the destruction of habitats (Webster et al. 1985). As with the beaver and the mink, the river otter has always been valued for its pelt. Early accounts suggest as the colonists became familiar with the Virginia Indians, they traded items such as knives, glasses, and combs for the skins of beavers, otters, and minks (Barbour 1986 [2]:94).

Some colonists may have been familiar with otters, as they were mentioned in hunting manuals such as *A Short Treatise of Hunting* (1591) by Thomas Cockaine. In his book he recommended going out early in the morning with hounds to find the place where the otters lodged the night before. The hunters then take positions upriver and downriver with their otter spears, barbed tridents or two-pronged forks. The dogs would then be let loose to flush the otters out of their lairs into the water, where the hunters would spear them from the shore. Cockaine comments another way to hunt them is at night where "He maketh the best sporte in a moon-shine night, for then he will runne much ouer the land, and not keepe the water as he will in the day" (Cockaine 1591).

Wolves

At least five bones from Layer N were identified to the category of *Canis* spp., which includes both domestic dog (*Canis familiaris*) and gray wolf (*Canis lupus*). While there were dog bones also found in Layer N, the size of these bones suggest they could have been from either a large dog or possibly a wolf. The gray wolf occupies a variety of habitats from forests to open plains, existing as long as there is available prey. They normally live and hunt in packs, working together to take down large prey such as deer (Webster et al. 1985). When the first settlers established Jamestown, wolves lived throughout the eastern United States. However, as wolves threatened livestock and competed with humans for wild games, settlers began to kill wolves in large numbers. By the 1630s, new laws in Virginia promised payment for dead wolves, in the form of cash, tobacco, corn, and blankets. Initially, colonists killed wolves for being a threat to their livestock but later, when the fur trade increased, they were also killed for their pelts (Fogleman 1989).

Dolphin

Three tooth fragments from Layers P and X belong to family Delphinidae, which includes all species of ocean dolphin. The two most common species of dolphin found in the waters of the Chesapeake are the bottle-nosed dolphin (*Tursiops truncates*) and the saddle-back dolphin

(*Delphinis delphis*). Bottle nosed dolphin are medium to dark gray on their dorsal side and pale gray to whitish on their underbelly. They can measure up to 12 feet in length and weigh as much as 600 pounds. While these dolphins live along the Atlantic coast, they are unique since they prefer to inhabit inshore waters. They are frequently seen in sounds, rivers, and tidal creeks, where they feed on squid, fish, shrimp, and even octopus (Webster et al. 1985).

The saddle-backed dolphin is multi-colored with grayish black backs, whitish belly, and yellow or tan flank markings. Found in the Gulf Stream or in oceanic waters, this dolphin can reach a length of 7 feet long and weigh around 180 pounds. They like to forage near the continental shelf where they eat other fish, shrimp, and squid (Webster et al. 1985).

Dolphins have been a food source throughout the history of the Chesapeake. John Fontaine, an English visitor to Virginia in 1715 considered it "a very dry fish and requires a great deal of sauce (Alexander 1972). Francis Louis Michel, who also visited Virginia in the early 18th century, referred to porpoises in his report. Although the harbor porpoise (*Phocoena phocoena*) is often found in the inshore waters and coastal bays of Virginia, Michel's description of porpoise could also be a description for dolphins due to their similarities in appearance. He reported:

> A good fish, which is common and found in large numbers, is the porpoise. They are so large that by their unusual leaps, especially when the weather changes, they make a great noise and often cause anxiety for the small boats or canoes. Especially do they endanger those that bathe. Once I cooled and amused myself in the water with swimming, not knowing that there was any danger, but my host informed me that there was (Michel in Hinke 1916:34).

White-Tailed Deer

White-tailed deer (*Odocoileus virginianus*) was identified from 1,454 bones excavated from all layers of the Second Well (JR2158). White-tailed deer are herbivores inhabiting most environmental settings and consume a diversity of foods, selecting the most nutritional and tasty foods available. Their activity depends several factors, including population size, season of year, and weather (Hesselton and Hesselton 1982).

During the initial settlement period deer were quite prevalent, as seen in the large numbers of deer bones identified from early historic sites. While the colonists could have hunted deer in the surrounding woods of Jamestown, Captain John Smith also remarked on Indian traders who provided the colonists with venison. Impressed by their hunting skills, Smith wrote in detail how the Virginia Indians hunted deer both in large groups and as a single hunter:

> One Salvage hunting alone, useth the skinne of a Deere slit on the one side, and so put on his arme, through the neck, so that his hand comes to the head which is stuffed, and the hornes, head, eyes, eares and every part as artificially counterfeited as they can devise. Thus shrowding his body in the skinne by stalking, he approacheth the Deere, creeping on the groun from one tree to another (Smith in Barbour 1986 [2]:118).

Beginning in the mid-17th century in the coastal region of the Chesapeake, deer populations declined, as evidenced by the decreasing number of bones found on archaeological sites from this time period (Miller 1984). Settlers looked to deer for subsistence and, to a lesser degree, for sport, which contributed to the decline of the deer population. The diminished deer population, coupled with the increasing utilization of swine and cattle, greatly curtailed the importance of deer in the diet.

Animal Husbandry and Identified Livestock

Early accounts by John Smith suggested the mild climate, the fertile soil, and nearby rivers as the main reasons livestock would do well in Virginia, "Here will live any beasts, as horses, goats, sheepe, asses, hens, etc. as appeared by them that were carried thether" (Smith in Barbour 1986 [2]:113). Francis Perkins went even further in a letter from 1608 stating, "There is here the greatest abundance of pasturage for any kind of cattle, especially for pigs and goats, even if there were a million of them" (Perkins in Haile 1998:134). Despite the idyllic descriptions of the environment, the first colonists at Jamestown did not consider other factors which would eventually influence the survival of livestock at Jamestown. Some of these issues included their shifting interactions with the Virginia Indians, unexpected extreme weather and drought conditions, and the threat of predators such as wolves. Also, the arrival of new colonists drained their food resources and supplies from England were often sporadic. Finally, the first settlers at Jamestown would have had limited time to tend to their livestock and minimal knowledge of animal husbandry techniques needed for the new environment. Besides these issues, the first colonists at Jamestown could not have predicted the leadership of the colony and the establishment of martial laws which would eventually play a major role in the survival of the colony, as well as, the success of establishing livestock herds in the New World.

Although there is no official written account, the initial livestock brought to Jamestown probably came on the first ship which arrived in May of 1607. These first animals appear to have been chickens and swine, which quickly multiplied during the first year. John Smith refers to their productivity when he wrote, "of 3 sowes in one year increased 60 and od pigges, and neere 500 chickens brought up themselves (without having any meate given them) but the hogges were transported to Hog Ille" (Smith in Haile 1998:319). Hog Island was a peninsula located across the river and downstream from Jamestown. Being mostly flat with tidal marshes and pine forests, it served as an ideal location to leave the swine, keeping them contained within a limited area and allowing them to forage for themselves.

Supply ships arriving to Jamestown in January and September of 1608 probably brought additional livestock, but again there no official records providing the type and number of imported livestock. When ships arrived with the third supply in August 1609, horses are mentioned for the first time as being part of the cargo of the *Blessing*. Gabriel Archer, captain of the *Blessing*, remarked in a letter that cargo for their trip to Jamestown included at least "six mares and two horses" (Archer in Haile 1998:350). His statement is confirmed by accounts from John Smith who left Virginia for England in October 1609. When he left, Smith reported the animals present in the fort included "six Mares and a Horse, five or sixe hundred swine; as many Hennes and Chickens; some Goats; some sheepe; what was brought or bred there remained"

(Smith in Haile 1998:93). While the number of livestock appears to have been robust when Smith left, he had little way of knowing all livestock would be gone within several months.

The "starving time" brought the demise of the first livestock at Jamestown as colonists faced limited food supplies, sickness, and the threat of being killed by Virginia Indians if they left the fort to look for other food sources. During the winter of 1609-1610, the Indians killed all of the swine the colonists left on Hog Island, leaving the inhabitants of the fort with no other option but to consume their horses, along with the remaining livestock.

Although all the livestock became depleted at Jamestown, some swine did survive at Fort Algernon, a smaller fort located at Point Comfort. George Percy wrote that when he was well enough, he made a trip from Jamestown to Fort Algernon where he found the inhabitants to be in adequate health, having lived on swine which had been fed "crab fishes." The swine were being kept concealed to serve as provisions in case the settlers there returned to England. Although it is not clear if the swine remained at Fort Algernon or returned to Jamestown, Percy was swift to tell them the swine and the food they were feeding the swine could have saved lives at Jamestown (Percy in Haile 1998:506).

The next appearance of livestock may have occurred in May 1610 with the arrival of the *Sea Venture*, the ship which had wrecked on the island of Bermuda. They most likely brought swine with them in the form of preserved pork and perhaps a few live specimens but not in numbers to feed all the remaining inhabitants left at Jamestown. When Lord De La Warr's ships arrived in June 1610, he surveyed the condition of the fort and quickly sent George Sommers and Samuel Argall to Bermuda and northern waters to fish and bring back live hogs "to store our colony again" (Strachey in Haile 1998:433). Unfortunately, it does not appear any Bermuda swine or fish came back to Jamestown from these expeditions since Argall's ship encountered a storm and ended up in Cape Cod and Sommers ending up dying in Bermuda in November 1610.

Faunal remains recovered from Jamestown features dating from 1607-1610 support the first-hand accounts of swine, domestic fowl, and horses as being the first livestock brought to the New World. While cattle bones have been identified in these early assemblages, they most likely represent barreled provisions since the bones are mainly body elements with very few head or foot bones. The low number of cattle head and foot bones in relation to the body elements suggests the entire animal was not available to the inhabitants of the fort. Although there are no ship manifests listing delivered cargo, the first live cattle to arrive in Jamestown were probably on the ships arriving with De La Warr. This conclusion comes from accounts made by De La Warr to the Council of Virginia, after his return to England in 1611. He wrote:

> The country is wonderfull fertile and very rich, and make good whatsoever heretofore hath been reported of it, the Cattell already there, are much increased, and thrive exceedingly with the pasture of that Countrey: The Kine all this last Winter, though the ground was covered with Snow, and the season sharpe, lived without other feeding than the grasses they found with which they prospered well, and many of them readie to fall with Calve; Milke being a great nourishment and refreshing to our people, serving also (in occasion) as well for Physicke as food; so that it is no way to be doubted but when it shall please God that Sir Thomas Dale and Sir Thomas

> Gates shall arrive in Virginia with their extraordinary supply of one hundred kine and two hundred swine" (De La Warr in Haile 1998:531).

When De La Warr arrived to Jamestown, he, along with Gates and Dale, established new restrictions on Jamestown which were aimed at controlling and regulating the colony, both the people, as well as, the livestock. With the "starving time" fresh in the minds of the survivors and the new comers to Jamestown, it is not surprising a quarter of the Martial Laws relate to provisions, including several which directly referred to livestock. Understanding the colony's need to be self-sufficient and the importance of increasing the livestock numbers, one law stated:

> No man shall dare to kill or destroy any Bull, Cow, Calfe, Mare, Horse, Colt, Goate, Swine, Cockle, Henne, Chicken, Dogge, Turkie, or any tame Cattel, or Poulry, of what condition soever; whether his own, or appertaining to another man, without leave from the General, upon paine of death in the Principall (Strachey 1612).

As the extreme laws worked to preserve the livestock, it is not clear the amount of additional domestic mammals and fowl that arrived to Jamestown on additional supply ships. By 1614-1615 Ralph Hamor claimed in his *A True Discourse*:

> The colony is already furnished with two hundred neat cattle, as many goats, infinite hogs in herds all over the woods, besides those to every town belonging in general and every private man; some mares, horses, and colts, poultry great store, besides tame turkeys, peacocks, and pigeons, plentifully increasing and thriving there, in no country better! (Hamor in Haile 1998:819)

To entice new individuals to come to Jamestown, Hamor also insinuated the colony was so well ordered by this time, they had enough livestock to "loan" every new colonist "…poultry and swine, and, if he deserves it, a goat or two, perhaps a cow given him" (Hamor in Haile 1998:816). However, by 1616, John Rolfe wrote in his update on the state of Virginia that the number of cattle had decreased to include "cows, heifers, cow calves, 83; steers, 41; bulls, 20: in all, 144" (Rolfe in Haile 1998:877). It is not clear whether Hamor had exaggerated the availability of cattle in 1615 or if Rolfe's testimony suggests the total number of cattle reduced in one year.

A possible decrease in livestock, such as the cattle, might relate to how the animals were being maintained. Unfortunately, little is known regarding the actual husbandry techniques practiced in the first two decades at Jamestown. Based on the glowing descriptions of the land in the Virginia Colony, individuals arriving to Jamestown were probably under the impression they could easily transfer the animal husbandry techniques seen and practiced in England to their new surroundings. However, based on descriptions of 17th century English farmers, laboring with and taking care of livestock could consume over fourteen hours of a farmer's day. English farmers spent these hours carefully monitoring the diet of livestock, controlling the location of their animals, determining when breeding would take place, and deciding when was the most profitable time to slaughter their livestock whether for personal consumption or for market (Markham 1638).

While the care of livestock in England took up substantial amounts of a farmer's time, the first colonists at Jamestown had little extra time or labor to spend on animal husbandry, as they focused on establishing their colony, trading, and protecting themselves from the Indians, and assessing potential products to send back to England. In England, oxen and horses were commonly used for draft purposes and therefore kept close by and carefully tended. In the early years at Jamestown, the settlers did not use livestock for this purpose, so there was little reason to keep the animals close by (Anderson 2002). This may have changed by 1615, as Ralph Hamor commented he hoped Virginians would soon have "three or foure Ploughes going" (Hamor in Haile 1998:819).

In 1609, the Virginia Council believed the new colonists could easily transfer English techniques of husbandry to the new settings of the Chesapeake. They instructed Gates, "give order that yor Catle by kept in heards waited and attended on by some small watch" (Virginia Council 1609:18). Some first-hand accounts suggest the colonists attempted to follow this request, as well as, attempting to follow other English husbandry traditions. For example, English traditionally created fences around pastures and meadows to contain their livestock. In 1611, Gates may have been following English tradition by ordering a palisade to be constructed to safeguard their swine (Anderson 2002:387). Also in 1611, Thomas Dale recorded "to prevent the Indians from killing our cattle, a house to be set up to lodge our cattle in the winter, and hay to be appointed in his due time to be made" (Dale in Haile 1998:523). It is not clear if Dale's directives were completed at Jamestown but by 1615 Ralph Hamor states that at Rochdale Hundred, land in Charles City County, they had "a cross-pale well-nigh four miles long is also impaled, with bordering houses all along the pale, in which hundred hogs and other cattle have twenty miles circuit to graze in securely" (Hamor in Haile 1998:826).

Although some attempts were made to contain the domestic mammals, livestock at early Jamestown and later throughout Virginia primarily roamed free. Sometimes water barriers were used to restrict how far the animals could roam, such as the swine deposited on Hog Island, but overall free-range husbandry became the standard for raising livestock until the end of the 17th century. It was such a common practice, the Virginia Company legally sanctioned in 1643 that colonists would have to fence in their fields, not their livestock (Hening 1809:245). The assembly went even further in 1646 to define a "sufficient" fence had to be four and a half feet high to prevent leaping cattle, goats, or horses, and closed in on the bottom to thwart any swine from rooting. Only when these mandates were met could a planter receive compensation for damages to his property from someone else's livestock (Hening 1809:332).

Free-range husbandry brought many challenges to both the owners and the livestock. For one, allowing the animals to roam at will may have delayed the development of herds and effected the size of the animals. Even as late as the end of the 17th century, Thomas Glover wrote that Virginia's cattle "might be much larger than they are, were the Inhabitants as careful in looking after them and providing fodder for them as they in England are" (Glover 1676:19). At Jamestown and other early settlements, livestock was left to find their own food, survive harsh weather conditions, and endure the threats of predators, such as wolves.

In addition to affecting the overall health of the livestock, free-range husbandry was a cause of altercations with Virginia Indians when wandering livestock destroyed their property and fields. Disputes of livestock ownership and property damage from animals also existed between colonists, with issues often handled before the General Assembly. Despite all of the problems surrounding raising livestock in Jamestown, and later Virginia, the colonists and the animals persisted. The 17th century saw many changes in animal husbandry techniques in the Chesapeake as stalls and stys became more common, fodder was provided for the animals, fences were used to contain animals, and breeding was controlled to improve the size and health of the livestock.

Livestock

Swine

A total of 1,628 bones from all layers of the Second Well (JR2158) are from swine (*Sus scrofa*). While some of the swine bones excavated from Jamestown were from animals raised and butchered at Jamestown, other swine bones may be from animals raised on the island of Bermuda and then brought to Jamestown. Various accounts indicate the colonists were capturing some of the wild boars while on the island of Bermuda and may have transported some of them to Virginia. Future analysis of either DNA samples or phytoliths surviving on the plaque remaining on swine teeth from the Second Well (JR2158) might help to determine whether these early hogs were from Bermuda.

As William Strachey wrote of Bermuda swine in 1610:

> We had knowledge that there were wild hogs upon the island at first by our own swine preserved from the wreck and brought to shore. For they straying into the woods, a huge wild boar followed down to our quarter, which at night was watched and taken in this sort: one of Sir George Summers' men went and lay among the swine. When the boar being come and groveled by the sows, he put over his hand and rubbed the side gently of the boar, which then lay still, by which means he fast'ned a rope with a sliding knot to the hinder leg, and so took him, and after him in this sort two to three more.
>
> But in the end (a little business over), our people would be a-hunting with our ship dog, and sometime bring home thirty, sometimes fifty boars, sows, and pigs in a week alive. For the dog would fasten on them and hold whilest the huntsmen made in. And there be thousands of them in the islands, and at that time of the year – August, September, October, and November – they were well fed with berries that dropped from the cedars and the palms…And in our quarter we made sties for them and gathering of these berries served them twice a day, by which means we kept them in good plight…" (Strachey in Haile 1998:399).

Although the ranking of pork among early diets may be argued by some, it is clear domestic swine were an important food source from the initial years of settlement on through the 20th century. A prolific breeder, thriving on mast, roots, and tubers in an open woodland setting, swine were born in the spring and by the next winter had grown to a good slaughter weight.

Compared to cattle which provided only about 50-60% of dressed meat per individual after slaughter, swine provided 65-80% and its flesh when salted was perfect for use as a year-round source of preserved meat (Reitz, Gibbs, and Rathbun 1985; Bowen 1990a, 1990b).

Archaeologically, swine are omnipresent in sites throughout the Southeast. In every faunal assemblage their bones account for a substantial proportion, either in terms of NISP, MNI, usable meat weight, or biomass. Previous faunal analysis from archaeological sites in the Chesapeake as shown from the first years of settlement, pork contributed 10% of the biomass, by 1620-50 anywhere from 6% to 17%, by 1660-1700 an average of 11%, and throughout the 18th century on rural plantations anywhere from 12% to 17% (Walsh et al. 1997:351). For the Second Well (JR2158), the bone summary charts in this report show swine contributing an average of 21.0% to the overall biomass, a percentage higher than in Jamestown features dating from 1607-1610. The archaeological evidence, backed by historical accounts, demonstrate swine did well in Virginia. Smith wrote, "Of three sows in eighteen months increased 60 and odd pigs…But the hogs were transported to Hog Isle, where also we built a blockhouse with a garrison…" (Smith in Haile 1998:319).

Although swine were raised at Jamestown, it is not clear whether the bones from the Second Well (JR2158) represent animals they raised themselves, swine brought live to Jamestown from either Bermuda or Britain, or barreled pork brought as supplies from Bermuda or Britain.

Cattle. Domestic cattle (*Bos taurus*) were identified by at least 84 bones from all layers of the well except for Layer AA. By 1610, cattle arrived on Jamestown Island. They flourished in the woodland environment, and as early as the 1620s, herds had become so large beef became the mainstay of the colonists' diet, a pattern which stood firm throughout the colonial period (Miller 1984; Bowen 1990a). Throughout the colonial period cattle provided primarily meat, but also some milk and dairy products (Miller 1984; Bowen 1994). In terms of their contribution to the meat diet, studies of faunal assemblages from the coastal region of the Chesapeake have shown in ca. 1610 cattle contributed 14% to the total biomass, by 1620-1650 anywhere from 37 to 57%, by 1660-1700 47%, and throughout the 18th and early 19th centuries on rural plantations anywhere from 34 to 56% of the total biomass (Walsh et al. 1997:351). The cattle remains from the Second Well (JR2158) show beef contributing an average of 3.6% to the biomass, a percentage quite lower than remains analyzed from earlier sites at Jamestown. These remains probably represent barreled beef sent as provisions from England.

Caprines. A total of 66 bones from all the layers of the well represent either a sheep (*Ovis aries*) or goat (*Capra hircus*). Despite their outward appearance, faunal analysists usually group the species together since they are almost skeletally indistinguishable (Reitz and Wing 2008).

Starting in the mid-17th century, sheep were commonly raised on rural sites in the south. While swine and cattle roamed free, sheep never became really profitable since they could not defend themselves from predators and would not freely reproduce (Reitz 1979). In the coastal south, it was not until the last quarter of the 17th century when the wolf population had declined, did it become viable to raise sheep. The sheep were raised primarily for their wool, while mutton, remained a relatively small but important meat in the diet of individuals throughout the colonial period (Noël Hume 1978: Walsh et al. 1997).

Introduced to the New World possibly from the early supplies shipped to Jamestown, goats were hardy, they browsed on the undergrowth, and they were better able to protect themselves from predators than sheep (Dandoy 1997; Walsh et al. 1997). In the first years of colonization, they supplied both milk and meat, but as fields became established and predators brought under better control, sheep gradually increased. By the mid-17th century sheep became more popular than goats, though occasionally still were raised for their milk (Walsh et. al. 1997).

In terms of contribution to the meat diet, in ca. 1610 caprines (sheep and goats combined) contributed 2.4% of the total biomass. By 1620-1650 they contributed anywhere from .7% to 4.3%, by 1660-1700 anywhere from 1 to 12.5%, and throughout the 18th century on rural plantations anywhere from 2 to 10% of the total biomass (Walsh et al. 1997:351). As the bone summaries will show, sheep/goat contribute an average of 1.7% to the biomass results from the Second Well (JR2158), an average which is comparable to other faunal assemblages analyzed from Jamestown.

Taphonomic Influences

As mentioned earlier in this report, taphonomic influences, including scorch marks, gnaw marks, signs of weathering, and butchering evidence were recorded for the livestock and deer bones from the Second Well (JR2158). The following section will examine the taphonomic influences recorded for domestic mammal and deer bones.

Layer H

Out of the 596 identified domestic mammal and deer bones from Layer H, several exhibit signs of taphonomic influences (see Table 16). While there are no domestic mammal or deer bones with signs of weathering, there are five bones with gnaw marks on the surface of the bone, including a cow vertebra, a cow innominate, a swine innominate, a swine femur, a swine patella, and a deer femur. These bones appear to have been gnawed by a carnivore. As mentioned earlier in the analytical section of this report, carnivores such as dogs like to gnaw on the edges of bones to reach the marrow. They may have also gnawed on smaller bones belonging to fish, birds, and small mammals. Since these bones break easily and are digested by carnivores, there is rarely any evidence of carnivore gnawing on these bones.

Scorch marks related to burning were present on at least 68 of the swine bones, 3 of the sheep/goat bones, and 19 deer bones. It must be kept in mind it takes high temperatures to leave scorch marks on a bone, so while marks may not be visible on the surface of the bone, it does not mean the bones were not exposed to high temperatures.

The most frequently recorded taphonomic influence on the bones from Layer H was evidence of butchering using an instrument such as an ax or a cleaver. Bone with hack marks include at least 6 cattle bones, 80 swine bones, 4 sheep/goat bones, and 43 deer bones. As discussed earlier in the "Analytic Techniques" section of this report, most of the faunal remains from the Second Well (JR2158) were butchered, resulting in many highly fragmented bones simply too small to identify to species or to element. Butchering was recorded only on bones identified to element and species. These bones are discussed in general terms in the butchery section of this report (see page 126).

Layer N

Layer N of the Second Well (JR2158) has 926 domestic mammal bones and 292 deer bones, all of which were examined for taphonomic evidence (see Table 16). Weathering, noted by flaking on the surface of the bone, was not visible on any of the bones, suggesting the bones were not exposured to the elements for an extended period. In addition to the lack of weathering evidence, less than 1.0% of all the domestic mammal and deer bones have gnaw marks on the surface, suggesting the bones were not left in the open for carnivores to scavenge. Bones with evidence of gnawing include one swine metacarpal with gnaw marks characteristic of rodent activity. Besides rodent gnaw marks, there is also at least one swine innominate with marks possibly made from human incisors making indentations on the surface of the bone (Carver 1997). There is also one swine ulna, one swine vertebra, one deer rib, and one deer innominate with gnaw marks made by a carnivore.

At least 123 swine and 47 deer bones show visible scorch marks on the bone. It must be kept in mind it often takes extreme temperatures and exposure to open flames to leave scorch marks on the surface of bones. For this reason, burn marks should not be used to interpret cooking methods.

Evidence of butchering appears on at least 72.7% of the cattle bones, 21.3% of the swine bones, and 44.2% of the identified deer bones. Hack marks on these bones suggest an ax or a cleaver was used to butcher them. Included in these percentages are also three swine bones and one deer bone with knife marks on the surface of the element. A detailed discussion of the individual butchered bones is given in the butchering and cuts of meat section of this report (see page 126). It is also interesting to note in addition to the domestic mammals and deer bones, there are also at least two bald eagle bones and one turkey vulture bone with cut lines on the surface possibly made by a knife.

Layer P

As the largest assemblage from the Second Well (JR2158), Layer P has 268 domestic mammal bones and 684 deer bones (see Table 16). As with the other layers, none of the bones from Layer P appear to have a weathered appearance suggesting exposure to the elements for an extended period of time before being buried. There are also no domestic mammal or deer bones with obvious scorch marks on the surface of the bone. Gnaw marks made by carnivores, however, are on several bones including seven swine bones and eleven deer bones. Many of these bones were long bones with gnawing evident on the ends of the bones. As mentioned earlier in the analytical techniques section of this report, carnivores such as dogs will typically gnaw on the soft ends of long bones to create channels allowing them to get to the marrow. They can also leave puncture holes from piercing the surface of the bone with their canine teeth. This assemblage also has at least two deer radius bones with gnaw marks possibly made by a human. While it is difficult to see the difference between carnivore and human gnaw marks, these bones have tentatively been marked as evidence of human chewing based on indentations possibly made by incisor teeth (Carver 1997).

At least 40.0% of the identified domestic mammal and deer bones have cut marks made by either an ax or a cleaver. These bones include 8 cattle, 74 swine, 7 sheep/goat, and 325 deer bones. It must be kept in mind most of the faunal remains from the Second Well (JR2158) are butchered, resulting in many fragmented bones too small to identify to species or to element. Only bones identifiable to element and species were examined for butchery evidence. A general discussion of these bones is found in the butchering and cuts of meat section of this report (see page 126).

Table 16
Taphonomic Influences on Livestock and Deer Bones
All Layers of the Second Well (JR2158)

Taxon	Total Count	Gnawed No.	Gnawed Pct.	Hacked No.	Hacked Pct.	Weathered No.	Weathered Pct.	Burned No.	Burned Pct.
Layer H									
Cattle	12	2	16.6%	6	50.0%	0	0.0%	0	0.0%
Swine	418	3	0.7%	80	19.1%	0	0.0%	68	16.3%
Sheep/Goat	16	0	0.0%	4	25.0%	0	0.0%	3	18.7%
Deer	150	1	0.7%	43	28.7%	0	0.0%	19	12.7%
Layer N									
Cattle	22	0	0.0%	16	72.7%	0	0.0%	0	0.0%
Swine	611	4	0.6%	130	21.3%	0	0.0%	123	20.1%
Sheep/Goat	1	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Deer	292	2	0.7%	129	44.2%	0	0.0%	47	16.1%
Layer P									
Cattle	35	0	0.0%	8	22.8%	0	0.0%	0	0.0%
Swine	221	7	3.1%	74	33.5%	0	0.0%	0	0.0%
Sheep/Goat	22	1	4.5%	7	31.8%	0	0.0%	0	0.0%
Deer	684	13	1.9%	325	47.5%	0	0.0%	0	0.0%
Layer U									
Cattle	8	0	0.0%	6	75.0%	0	0.0%	0	0.0%
Swine	190	3	1.6%	61	32.1%	0	0.0%	0	0.0%
Sheep/Goat	11	0	0.0%	8	72.7%	0	0.0%	0	0.0%
Deer	195	4	2.0%	95	48.7%	0	0.0%	0	0.0%
Layer X									
Cattle	7	0	0.0%	5	71.4%	0	0.0%	0	0.0%
Swine	139	3	2.1%	64	46.0%	0	0.0%	5	3.6%
Sheep/Goat	14	2	14.3%	11	78.6%	0	0.0%	0	0.0%
Deer	86	0	0.0%	34	39.5%	0	0.0%	2	2.3%
Layer AA									
Cattle	0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Swine	49	1	2.0%	20	40.8%	0	0.0%	21	42.8%
Sheep/Goat	2	0	0.0%	1	50.0%	0	0.0%	0	0.0%
Deer	47	2	4.2%	13	27.6%	0	0.0%	5	10.6%

Layer U

Like Layer P, none of the domestic mammals or deer bones from Layer U appeared to have a weathered appearance or visible scorch marks (see Table 16). It often takes extreme temperatures to leave scorch mark on the surface of the bone so this should not be a measurement or interpretation of cooking methods.

Swine bones with visible gnaw marks include one innominate, one scapula, and one metacarpal. Four of the deer bones also have gnaw marks including one humerus, one ulna, one femur, and one innominate. All of these bones look like they were gnawed by carnivores, such as dogs or wolves. These animals often leave marks on long bones from where they were trying to access the bone marrow or on thin bones such as innominates.

Analysis of the bones shows butchery marks on at least 75.0% of the cattle, 32.1% of the swine, 72.7% of the sheep/goat, and 48.7% of the deer bones. The butchered bones have hack marks on surface made from either an ax or a cleaver. It must be remembered most of the indeterminate bones were also affected by butchering practices but are too fragmented to identify to species. A general discussion of the butchery cuts for the domestic mammals and deer bones is in the butchery section of this report (see page 126)

Layer X

A total of 160 domestic mammal and 86 deer bones from Layer X were examined for taphonomic influences (see Table 16). As with the other layers, none of the bones have a peeling or flaking surface suggesting a weathered appearance from exposure to the elements. If the bones had been left uncovered on the surface, one would be expected to have many bones with gnaw marks from opportunistic carnivores. Only three of the swine and two of the sheep/goat bones have visible gnaw marks on the surface of the bone. Scorch marks on five of the swine and two of the deer bones represent evidence of burning.

Butchering was the most frequently recorded taphonomic influence on the identified domestic mammal and deer bones from Layer X. At least 78.4% of the cattle, 46.0% of the swine, 78.6% of the sheep/goat, and 39.5% of the deer bones have hack marks made from either an ax or a cleaver. Found in another section of this report, is a more detailed discussion of these bones and possible cuts of meat (see page 126).

Layer AA

As the deepest layer analyzed from the Second Well (JR2158), Layer AA only has 49 swine bones, 2 sheep/goat bones, 47 deer bones, and no cattle bones (see Table 16). None of these bones have a weathered appearance indicating exposure to extreme temperatures and changing weather conditions for an extended period of time. Scorch marks, however, noted by visible marks on the surface of the bones occurs on at least 42.8% of the swine bones and 10.6% of the deer bones.

Gnaw marks appear on at least three bones including one swine innominate, one deer femur, and one deer vertebra. All of these bones have a distinct pattern on the surface of the bones suggesting gnawing by carnivores. Carnivores particularly like to gnaw on the ends of long bones creating channels allowing them to reach the marrow. They may have also gnawed on smaller bones belonging to fish, birds, and small mammals but these bones are easily digested and rarely display any marks on the surface of the bone.

Evidence of butchering, by either an ax or a cleaver, can be seen on at least 20 swine bones, 13 deer bones, and 1 sheep/goat bone. A more detailed discussion on the butchering and cuts of meat is discussed in another section of this report (see page 126).

Relative Dietary Importance

The following section discusses the relative dietary importance of each taxon based on the NISP and the Biomass quantification methods mentioned earlier in the "Analytic Techniques" section of this report. It must be realized these are relative measures and do not reflect anything absolute about the amount of meat consumed.

For the bone summary charts for the Second Well (JR2158), there are several bone classifications which are not included under the main headings of fish, reptile/amphibian, wild bird, domestic bird, commensal, wild mammal, and livestock. Bones identified to class mammalia, class mammalia III, and class aves/small mammalia III fall under the heading of "Other Bone Identified to Class." For these indeterminate bones it was not possible to determine the size of the mammal they originated from, the species of small mammal they represent, or whether the bones are from birds or from small mammals. The category of "Bones Not Identified to Class" include bones classified as subphylum Vertebrata, which means any animal with a vertebrae. Indeterminate bones in this category are typically so fragmented it is not possible to determine if the bone fragments are from fish, bird, reptile/amphibian, or mammal.

Other indeterminate bone classifications, such as class Osteichtyhes, class Reptilia, and class Mammalia I (large mammals) are under the main headings of fish, reptiles/amphibians, and livestock. For the indeterminate fish and reptile bones, while it was not possible to determine the exact species, we know these bones are from fish and from reptiles. Indeterminate large mammal is under the heading of livestock because although it was not always possible to accurately determine the exact element or species, these bones from Jamestown most likely represent either cattle or horses.

There are other classifications for indeterminate bones which could, theoretically, be under both domestic and wild categories. For example, all of the layers of the well have a high percentage of indeterminate bird bones which could be either the remains of wild or domestic species. Since these bones make up a significant portion of the NISP and the biomass totals, we split these bones between the wild and domestic bird headings to reflect a more accurate representation in the faunal data. To do this, the NISP totals for identified wild bird bones and the NISP totals for identified domestic bird bones were added together. Percentages were calculated to determine the ratio of identified wild bird bones to identified domestic bird bones. These same percentages were then used to split the NISP totals for indeterminate bird between the wild and domestic headings. The same process was used with the biomass totals for the identified wild and identified domestic bird species. While these percentages are an estimate for the indeterminate remains, they still represent the proportion of the identifiable wild to domestic birds for the NISP and biomass totals. Table 17 shows the ratio of wild to domestic birds for each layer of the well without the indeterminate bones and with the indeterminate bones.

Table 17
NISP and Biomass Ratio of Wild Bird to Domestic Bird
Without the Indeterminate Bird Bones and With the Indeterminate Bird Bones

Well Layers	Wild Bird					Domestic Bird			
	NISP	%	Biomass	%		NISP	%	Biomass	%
Layer H (w/o IND)	546	4.43	8.069	6.78		37	0.30	1.388	1.17
Layer H (w/IND)	2777	21.95	14.552	12.2		188	1.49	2.503	2.11
Layer N (w/o IND.)	775	1.67	10.986	5.99		50	0.11	0.837	0.46
Layer N (w/ IND.)	1923	4.17	17.206	9.40		124	0.27	1.311	0.72
Layer P (w/o IND.)	511	0.76	8.246	2.26		44	0.07	1.165	0.32
Layer P (w/ IND.)	1970	3.03	12.693	3.47		169	0.26	1.795	0.49
Layer U (w/o IND.)	200	0.80	4.243	2.69		15	0.05	0.564	0.35
Layer U (w/ IND.)	795	3.21	7.172	4.54		59	0.23	0.781	0.49
Layer X (w/o IND.)	147	2.74	5.490	6.51		31	0.58	0.884	1.05
Layer X (w/ IND.)	879	16.42	11.061	13.1		63	1.18	1.067	1.27
Layer AA (w/o IND.)	278	18.53	5.852	20.0		26	1.73	1.294	4.42
Layer AA (w/ IND.)	720	48.00	7.236	24.7		68	4.53	1.569	5.36

w/o IND = without indeterminate bones
w/IND = with indeterminate bones

We then took a similar approach to the NISP and biomass totals for bones classified as either indeterminate medium mammal or as Artiodactyla. The indeterminate medium mammal category represents bones which are from medium sized mammals (such as deer, swine, and sheep/goat) but not identifiable to the exact element. These bones are usually grouped to broad categories such as cranial, limb bone, and vertebrae. Bones catalogued as Artiodactyla also include deer, swine, and sheep/goat species but are identifiable to a specific element. Because of the high number of deer bones in the layers of the well, many of the indeterminate medium mammal and Artiodactyla bones probably represent not only swine and sheep/goat but also deer. For this reason, the NISP and biomass totals for the identified deer bones and the totals for the identified swine/sheep/goat bones were added together to calculate the ratio of deer to swine/sheep/goat. These percentages were then used to split the NISP and the biomass totals for the indeterminate medium mammal and the Artiodactyla bones between the domestic and the wild mammal categories. Table 18 shows how the NISP and biomass totals changed when the indeterminate medium mammal and the Artiodactyla bones were proportioned between the wild and domestic mammal/livestock categories.

Table 18
NISP and Biomass Ratio of Wild Mammal to Livestock
Without the Indeterminate Mammal Bones and With the Indeterminate Mammal Bones

Second Well Layers	Wild Mammal					Livestock			
	NISP	%	Biomass	%		NISP	%	Biomass	%
Layer H (without IND.)	252	1.99	18.834	15.86		453	3.58	37.272	31.38
Layer H (with IND.)	1440	11.38	28.95	24.39		2941	23.24	56.307	47.41
Layer N (without IND.)	464	1.02	43.044	23.50		657	1.44	59.081	32.24
Layer N (with IND.)	923	2.01	57.254	31.25		1619	3.55	75.105	40.99
Layer P (without IND.)	1016	1.57	84.010	22.89		339	0.53	39.553	10.78
Layer P (with IND.)	2622	4.07	188.808	51.47		909	1.41	67.919	18.52
Layer U (without IND.)	318	1.28	37.855	23.98		226	0.92	42.040	22.61
Layer U (with IND.)	689	2.78	54.468	34.5		609	2.47	56.891	36.01
Layer X (without IND.)	99	1.85	15.746	18.71		182	3.40	34.490	40.97
Layer X (with IND.)	289	5.35	20.256	24.06		521	9.74	41.786	49.64
Layer AA (without IND.)	47	3.14	5.631	19.20		53	3.52	9.350	31.88
Layer AA (with IND.)	94	6.27	6.723	22.92		103	6.85	11.008	37.53

without IND. = without indeterminate bones
with IND. = with indeterminate bones

Layer H

Layer H produced a total of 12,664 bones identifiable to at least 43 different species (see Table 19). Indeterminate bones were the most frequently recorded bones making up 81.8% of the NISP figures. The total for the indeterminate category includes 16% fish, 21% bird, 1% reptile, 31% mammal, and 12% "other bone" and subphylum vertebrata. The remaining 18.2% of the NISP totals is attributed to identifiable bones, with the greatest contributions from sturgeon (8.5%), swine (3.3%), and white-tailed deer (1.2%). All other identified species contribute less than 1% to the NISP totals. In total, the bones of wild species make up 60.6% of the NISP totals with domestic species only making up 24.7%.

The overall biomass results show domestic and wild species contributed almost equal amounts at 49.5% and 46.8%. For the identified domestic species, swine are the greatest contributor at 25.7%, followed by cattle at 3.7%, and sheep/goat at 1.1%. The domestic category for biomass also includes a percentage of the indeterminate bird bones (0.9%), a percentage of the medium mammal bones (14.6%), a percentage of the Artiodactyla bones (1.4%), and the indeterminate large mammal bones (1.0%).

In the identified wild species category, white-tailed deer account for the largest percentage of the biomass at 14.2%, followed by sturgeon at 5.3%, goose spp. at 1.1%, and raccoon at 1.0%. Each of the remaining identified wild species contributed less than 1% to the biomass totals. Included in the overall biomass totals for the wild category are also a portion of the indeterminate bird bones at 8.3%, a portion of the indeterminate medium mammal bones at 7.8%, indeterminate fish bones at 2.5%, and a portion of the Artiodactyla bones at 0.7%.

Table 19
Bone Summary
Layer H, Second Well (JR2158)

	NISP		Biomass	
	No.	Pct.	Kg.	Pct.
Crustacean				
Callinectes sapidus (blue crab)	16	0.13	0.000	0.00
Fish				
family Carcharinidae (requiem shark)	2	0.02	0.345	0.29
order Rajiformes (skates or ray)	2	0.02	0.191	0.16
class Osteichythyes (bony fish, indeterminate)	1980	15.63	2.941	2.48
Acipenser spp. (sturgeon)	1073	8.47	6.263	5.27
cf. *Acipenser* spp. (sturgeon)	1	0.01	0.043	0.04
Lepisosteus spp. (gar)	10	0.08	0.082	0.07
cf. *Amia calva* (bowfin)	1	0.01	0.011	0.01
family Catostomidae (sucker)	16	0.13	0.090	0.08
family Ameiuridae (freshwater catfish)	57	0.45	0.321	0.27
family Moronidae (temperate bass)	1	0.01	0.005	0.00
Morone americana (white perch)	27	0.21	0.060	0.05
family Sciaenidae (croaker or drum)	5	0.04	0.199	0.17
Sciaenops ocellatus (red drum)	9	0.07	0.214	0.18
cf. *Sciaenops ocellatus* (red drum)	1	0.01	0.014	0.01
Cynoscion nebulosis (spotted seatrout)	2	0.02	0.019	0.02
Reptile/Amphibian				
order Anura (toad or frog)	4	0.03	0.000	0.00
order Testudines (turtle)	155	1.22	0.080	0.07
Chelydra serpentina (snapping turtle)	4	0.03	0.110	0.09
family Kinosternidae (musk or mud turtle)	45	0.36	0.240	0.20
Chrysemys spp. (slider or cooter)	34	0.27	0.465	0.39
Terrapene carolina (box turtle)	13	0.10	0.237	0.20
Trionyx spp. (soft-shell turtle)	3	0.02	0.099	0.08
family Colubridae (snake)	3	0.02	0.004	0.00
Wild Bird				
**class Aves (wild bird, indeterminate) (some to still be identified)	374	2.96	3.348	2.82
*class Aves (wild bird, indeterminate) (estimated)	2231	17.62	6.483	5.46
cf. *Cygnus* spp. (swan)	1	0.01	0.033	0.03
Goose spp. (goose)	37	0.29	1.252	1.05
cf. Goose spp. (goose)	3	0.02	0.062	0.05
Chen caerulescens (snow goose)	1	0.01	0.069	0.06
cf. *Chen caerulescens* (snow goose)	1	0.01	0.022	0.02
Branta spp. (Canada goose or brant)	11	0.09	0.544	0.46
Branta candadensis (Canada goose)	10	0.08	0.904	0.76
cf. *Branta candadensis* (Canada goose)	5	0.04	0.132	0.11
Duck spp. (duck)	32	0.25	0.172	0.14
Anas spp. (dabbling duck)	12	0.09	0.179	0.15
cf. *Oxyura jamaicensis* (ruddy duck)	5	0.04	0.015	0.01
cf. *Aix sponsa* (wood duck)	8	0.06	0.040	0.03
Aythya spp. (pochard)	6	0.05	0.115	0.10

Table 19 cont'd

cf. *Aythya* spp. (pochard)	1	0.01	0.044	0.04
cf. order Gruiformes (crane or rail)	1	0.01	0.026	0.02
cf. order Falconiformes (vulture, hawk, or eagle)	11	0.09	0.092	0.08
Cathartes aura (turkey vulture)	1	0.01	0.013	0.01
cf. *Cathartes aura* (turkey vulture)	2	0.02	0.100	0.08
cf. *Haliaeetus leucocephalus* (bald eagle)	14	0.11	0.673	0.57
family Phasianidae (grouse, partridge, or pheasant)	2	0.02	0.005	0.00
Meleagris gallopavo (turkey)	3	0.02	0.148	0.12
cf. *Meleagris gallopavo* (turkey)	2	0.02	0.074	0.06
cf. *Cyanocitta cristata* (blue jay)	3	0.02	0.007	0.01
Domestic Bird				
*class Aves (domestic bird, indeterminate) (estimated)	151	1.19	1.115	0.94
Anser anser (domestic goose)	7	0.06	0.599	0.50
cf. *Anser anser* (domestic goose)	3	0.02	0.414	0.35
Gallus gallus (chicken)	21	0.17	0.290	0.24
cf. *Gallus gallus* (chicken)	6	0.05	0.085	0.07
Wild Mammal				
*class Mammalia II (medium mammal, indeterminate) (estimated)	1169	9.23	9.220	7.76
*order Artiodactyla (sheep, goat, deer, or swine) (estimated)	19	0.15	0.896	0.75
Didelphis virginiana (opossum)	23	0.18	0.590	0.50
Sciurus spp. (squirrel)	8	0.06	0.031	0.03
Sciurus carolinensis (eastern gray squirrel)	15	0.12	0.116	0.10
cf. *Sciurus niger* (eastern fox squirrel)	2	0.02	0.045	0.04
cf. *Ondatra zibethica* (muskrat)	2	0.02	0.022	0.02
Procyon lotor (raccoon)	52	0.41	1.182	1.00
Odocoileus virginianus (white-tailed deer)	134	1.0614.76112.43		
cf. *Odocoileus virginianus* (white-tailed deer)	16	0.13	2.087	1.76
Commensal Mammal				
Rat spp. (rat)	2	0.02	0.014	0.01
Canis familiaris (dog)	1	0.01	0.047	0.04
cf. *Canis familiaris* (dog)	1	0.01	0.062	0.05
Domestic Mammal (Livestock)				
class Mammalia I (large mammal, indeterminate)	7	0.06	1.157	0.97
*class Mammalia II (medium mammal, indeterminate) (estimated)	2449	19.34	17.349	14.61
*order Artiodactyla (sheep, goat, deer, or swine) (estimated)	39	0.31	1.686	1.42
Sus scrofa (domestic swine)	407	3.21	28.291	23.82
cf. *Sus scrofa* (domestic swine)	11	0.09	2.223	1.87
Bos taurus (domestic cattle)	6	0.05	2.489	2.10
cf. *Bos taurus* (domestic cattle)	6	0.05	1.854	1.56
Ovis aries/Capra hircus (domestic sheep/goat)	14	0.11	1.087	0.92
cf. *Ovis aries/Capra hircus* (domestic sheep/goat)	2	0.02	0.171	0.14
Other Bone Identified to Class				
class Aves or Mammalia III (bird or small mammal, indeterminate)	2	0.02	0.000	0.00
class Mammalia (mammal, indeterminate)	179	1.41	3.155	2.66
class Mammalia III (small mammal, indeterminate)	162	1.28	1.132	0.95
Other Bone Not Identified to Class				
subphylum Vertebrata (other vertebrate, indeterminate)	1507	11.90	0.000	0.00

Table 19 cont'd

Totals				
Crustacean	16	0.13	0.000	0.00
Fish	3187	25.18	10.798	9.10
Reptiles/Amphibian	261	2.05	1.235	1.03
Wild Bird	2777	21.95	14.552	12.24
Domestic Bird	188	1.49	2.503	2.11
Wild Mammal	1440	11.38	28.950	24.39
Commensal Mammal	4	0.04	0.123	0.10
Domestic Mammal (Livestock)	2941	23.24	56.307	47.41
Other Bone Identified to Class	343	2.71	4.287	3.61
Other Bone Not Identified to Class	1507	11.90	0.000	0.00
Wild (Crustacean, Fish, Reptiles/Amphibians, Bird, Mammal)	7681	60.65	55.535	46.76
Domestic (Bird, Mammal)	3129	24.71	58.810	49.52
Identified	2308	18.22	72.855	61.35
Indeterminate	10356	81.78	45.900	38.65
Totals	12664	100.0	118.755	100.00

Note: NISP= Number of identified specimens; MNI=Minimum number of individuals. "2/2" under MNI means 2 adult, 2 immature; "1" means 1 adult.

*The NISP and biomass estimates for indeterminate bird, indeterminate medium mammal, and Artiodactyla represent a ratio calculated between the NISP and biomass totals for wild and domestic birds and between the NISP and biomass totals for deer and swine/sheep/goat bones. Please see pages 100-101 for a detailed explanation for how these numbers were calculated.

**Some of these bones still need to be identified when the Smithsonian opens their comparative collections to researchers

Layer N

At least 53 different species have been identified in the 45,527 bones recovered from Layer N of the Second Well (JR2158). Indeterminate bones account for 85.9% of the 45,527 bones with identifiable bones making up the remaining 14.1% of the NISP totals (see Table 20). The breakdown for the indeterminate bones includes approximately 8% fish, 4% bird, 3% mammal, and 70% subphylum Vertebrata bones which are too fragmented to even identify the class of animal. For the identified species, the greatest contributors to the biomass totals include sturgeon at 7.3%, gar at 1.1%, and swine at 1.3%. Each of the remaining species make up less than 1% of the NISP totals.

When the biomass results for wild mammal, wild bird, fish, and reptile/amphibians are combined, they account for wild species making up the majority of the biomass totals at 56.6%. Some of the more significant identified wild species contributing to this total include white-tailed deer at 21.3%, sturgeon at 8.8%, and raccoon at 1.4%. The 40 remaining identified wild species each contributed less than 1% to the biomass totals. Although most of the wild species make up less than 1% of the biomass, the contributions by indeterminate wild bones account for much of the wild biomass results. These bones include indeterminate fish bones at 4.0%, a portion of indeterminate bird bones at 5.2%, a portion of indeterminate medium mammal bones at 6.0%, and a percentage of the Artiodactyla bones at 1.8%.

The domestic bird and mammals comprise 41.7% of the biomass totals with the greatest contributions by swine at 23.9%. Domestic cattle account for 6.1% of the biomass, while chicken, domestic goose, and sheep/goat contribute less than 1.0% of the total. Like the biomass results for the wild category, the domestic category also includes a percentage of the indeterminate bird (0.3%), a percentage of the indeterminate medium mammal (6.8%), a percentage of Artiodactyla (2.0%), and all of the indeterminate large mammal (2.2%).

Table 20
Bone Summary
Layer N, Second Well (JR2158)

	NISP		Biomass	
	No.	Pct.	Kg.	Pct.
Crustacean				
Callinectes sapidus (blue crab)	211	0.46	0.000	0.00
Fish				
class Chondrichthyes (cartilagenous fish, indeterminate)	2	0.00	0.102	0.06
family Carcharinidae (requiem shark)	1	0.00	0.140	0.08
order Rajiformes (skates or ray)	1	0.00	0.046	0.03
class Osteichythyes (bony fish, indeterminate)	3848	8.45	7.324	4.00
Acipenser spp. (sturgeon)	3343	7.34	15.929	8.69
cf. *Acipenser* spp. (sturgeon)	6	0.01	0.186	0.10
Lepisosteus spp. (gar)	507	1.11	0.601	0.33
family Clupeidae (herring)	2	0.00	0.003	0.00
Alosa spp. (shad or herring)	2	0.00	0.010	0.01
Alosa pseudoharengus (alewife)	2	0.00	0.006	0.00
family Catostomidae (sucker)	51	0.11	0.152	0.08
cf. family Catostomidae (sucker)	1	0.00	0.002	0.00
family Ameiuridae (freshwater catfish)	276	0.61	1.346	0.73
family Moronidae (temperate bass)	8	0.02	0.031	0.02
Morone americana (white perch)	62	0.14	0.106	0.06
Morone saxatilis (striped bass)	22	0.05	0.199	0.11
Perca flavescens (yellow perch)	1	0.00	0.004	0.00
cf. *Archosargus probatocephalus* (sheepshead)	1	0.00	0.009	0.00
family Sciaenidae (croaker or drum)	57	0.13	0.579	0.32
cf. *Pogonias cromis* (black drum)	1	0.00	0.141	0.08
Sciaenops ocellatus (red drum)	17	0.04	0.788	0.43
Cynoscion spp. (weakfish)	2	0.00	0.006	0.00
Reptile/Amphibian				
class Amphibia (amphibian, indeterminate)	1	0.0	0.000	0.00
Rana spp. (frog)	1	0.00	0.000	0.00
class Reptilia (reptile, indeterminate)	159	0.35	0.000	0.00
order Testudines (turtle)	1	0.00	0.007	0.00
Chelydra serpentina (snapping turtle)	13	0.03	0.286	0.16
cf. *Chelydra serpentina* (snapping turtle)	3	0.01	0.101	0.06
family Kinosternidae (musk or mud turtle)	34	0.07	0.203	0.11
cf. family Kinosternidae (musk or mud turtle)	1	0.00	0.034	0.02
Chrysemys spp. (slider or cooter)	15	0.03	0.278	0.15
Malaclemys terrapin (diamondback terrapin)	3	0.01	0.103	0.06
cf. *Malaclemys terrapin* (diamondback terrapin)	1	0.00	0.043	0.02
Terrapene carolina (box turtle)	52	0.11	0.556	0.30
family Colubridae (snake)	1	0.00	0.001	0.00
cf. family Colubridae (snake)	3	0.01	0.003	0.00
Wild Bird				
**class Aves (wild bird, indeterminate) (some to still be identified)	452	0.99	3.448	1.88
*class Aves (wild bird, indeterminate) (estimated)	1148	2.50	6.220	3.39
cf. *Ardea herodias* (great blue heron)	1	0.00	0.030	0.02
cf. family Procellariidae (shearwater or petrel)	1	0.00	0.005	0.00
family Anatidae (swan, goose, or duck)	1	0.00	0.098	0.05

Table 20 cont'd

Cygnus spp. (swan)	8	0.02	1.265	0.69
cf. *Cygnus* spp. (swan)	5	0.01	0.505	0.28
Goose spp. (goose)	96	0.21	1.820	0.99
cf. Goose spp. (goose)	2	0.00	0.026	0.01
Chen caerulescens (snow goose)	5	0.01	0.101	0.06
cf. *Chen caerulescens* (snow goose)	2	0.00	0.131	0.07
Branta spp. (Canada goose or brant)	13	0.03	0.644	0.35
Branta candadensis (Canada goose)	19	0.04	0.709	0.39
Duck spp. (duck)	37	0.08	0.160	0.09
Anas spp. (dabbling duck)	25	0.05	0.289	0.16
Oxyura jamaicensis (ruddy duck)	2	0.00	0.015	0.01
Aix sponsa (wood duck)	5	0.01	0.028	0.02
Aythya spp. (pochard)	18	0.04	0.181	0.10
cf. order Charadriiformes (shorebird, gull, auk)	23	0.05	0.083	0.05
Larus spp. (gull)	3	0.01	0.017	0.01
Cathartes aura (turkey vulture)	14	0.03	0.492	0.27
family Accipitridae (hawk or eagle)	12	0.03	0.167	0.09
Haliaeetus leucocephalus (bald eagle)	10	0.02	0.626	0.34
Buteo jamaicensis (red-tailed hawk)	1	0.00	0.015	0.01
family Phasianidae (grouse, partridge, or pheasant)	3	0.01	0.038	0.02
Meleagris gallopavo (turkey)	1	0.00	0.040	0.02
cf. *Meleagris gallopavo* (turkey)	1	0.00	0.020	0.01
order Passeriformes (perching bird)	15	0.03	0.033	0.02
<u>Domestic Bird</u>				
*class Aves (domestic bird, indeterminate) (estimated)	74	0.16	0.474	0.26
Anser anser (domestic goose)	12	0.03	0.578	0.32
Gallus gallus (chicken)	38	0.08	0.259	0.14
<u>Wild Mammal</u>				
*class Mammalia II (medium mammal, indeterminate) (estimated)	386	0.85	10.978	5.99
*order Artiodactyla (sheep, goat, deer, or swine) (estimated)	73	0.16	3.232	1.76
Didelphis virginiana (opossum)	28	0.06	0.929	0.51
Sciurus spp. (squirrel)	17	0.04	0.069	0.04
Sciurus carolinensis (eastern gray squirrel)	34	0.07	0.261	0.14
cf. *Sciurus niger* (eastern fox squirrel)	5	0.01	0.122	0.07
Ondatra zibethica (muskrat)	2	0.00	0.045	0.02
Procyon lotor (raccoon)	84	0.18	2.468	1.35
cf. *Procyon lotor* (raccoon)	1	0.00	0.066	0.04
Lontra canadensis (river otter)	1	0.00	0.116	0.06
Odocoileus virginianus (white-tailed deer)	272	0.60	37.355	20.39
cf. *Odocoileus virginianus* (white-tailed deer)	20	0.04	1.613	0.88
<u>Commensal Mammal</u>				
Scalopus aquaticus (eastern mole)	9	0.02	0.029	0.02
Rat spp. (rat)	8	0.02	0.040	0.02
Canis spp. (dog or wolf)	5	0.01	0.200	0.11
Canis familiaris (dog)	1	0.00	0.051	0.03
Felis catus (domestic cat)	1	0.00	0.038	0.02
<u>Domestic Mammal (Livestock)</u>				
class Mammalia I (large mammal, indeterminate)	23	0.05	4.056	2.21
*class Mammalia II (medium mammal, indeterminate) (estimated)	808	1.77	12.380	6.76
*order Artiodactyla (sheep, goat, deer, or swine) (estimated)	154	0.34	3.644	1.99
Sus scrofa (domestic swine)	552	1.21	39.596	21.61
cf. *Sus scrofa* (domestic swine)	59	0.13	4.175	2.28

Table 20 cont'd

Bos taurus (domestic cattle)	14	0.03	9.456	5.16
cf. *Bos taurus* (domestic cattle)	7	0.02	1.461	0.80
cf. *Bos taurus*, calf (domestic cow, calf)	1	0.00	0.239	0.13
Ovis aries/Capra hircus (domestic sheep/goat)	1	0.00	0.098	0.05
Other Bone Identified to Class				
class Mammalia (mammal, indeterminate)	40	0.09	0.802	0.44
class Mammalia III (small mammal, indeterminate)	258	0.57	1.866	1.02
Other Bone Not Identified to Class				
subphylum Vertebrata (other vertebrate, indeterminate)	31904	70.08	0.000	0.00
Totals				
Crustacean	211	0.46	0.000	0.00
Fish	8213	18.01	27.710	15.13
Reptiles/Amphibian	288	0.62	1.615	0.88
Wild Bird	1923	4.17	17.206	9.40
Domestic Bird	124	0.27	1.311	0.72
Wild Mammal	923	2.01	57.254	31.25
Commensal Mammal	24	0.05	0.358	0.20
Domestic Mammal (Livestock)	1619	3.55	75.105	40.99
Other Bone Identified to Class	298	0.66	2.668	1.46
Other Bone Not Identified to Class	31904	70.08	0.000	0.00
Wild (Crustacean, Fish, Reptiles/Amphibians, Bird, Mammal)	11558	25.39	103.785	56.64
Domestic (Bird, Mammal)	1743	3.83	76.416	41.71
Identified	6424	14.11	135.577	73.99
Indeterminate	39103	85.89	47.650	26.01
Totals	45527	100.0	183.227	100.00

Note: NISP= Number of identified specimens; MNI=Minimum number of individuals. "2/2" under MNI means 2 adult, 2 immature; "1" means 1 adult.

*The NISP and biomass estimates for indeterminate bird, indeterminate medium mammal, and Artiodactyla represent a ratio calculated between the NISP and biomass totals for wild and domestic birds and between the NISP and biomass totals for deer and swine/sheep/goat bones. Please see pages 100-101 for a detailed explanation for how these numbers were calculated.

**Some of these bones still need to be identified when the Smithsonian opens their comparative collections to researchers

Layer P, Second Well (JR2158)

As the largest assemblage from the Second Well (JR2158), Layer P has 64,147 bones with 40.5% identifiable to at least 58 different species (see Table 21). This high percentage of identifiable bones, as compared to the other well layers, is because of the large number of identified bones from wild species and specifically, the 21,121 sturgeon bones which account for 32.9% of the NISP totals. Except for white-tailed deer at 1.1% and freshwater catfish at 1.4%, none of the other 55 identified species contribute more than 1% to the NISP figures. When just the identified domestic species are combined, they still contribute only 0.4% to the NISP totals.

Although the percentage of identifiable bones is high in Layer P, indeterminate bones still make up the greatest percentage of the NISP at 59.4%. The percentage for the indeterminate category comes from indeterminate fish at approximately 8%, indeterminate bird at 3%, indeterminate mammal at 4%, and subphylum Vertebrata at 44%. When bones from the Artiodactyla, indeterminate medium mammal, and indeterminate bird categories are included with the identified bone count, wild remains make up 53.0% of the NISP, while domestic bones only make up 1.7%. The remaining NISP totals are from the commensal species and bones included in the "other bone" categories.

The biomass results also show wild species with the highest percentage at 79.9%, while domestic species only make up 19.0% of the biomass totals. The high percentage of wild species in the biomass is from the contributions of white-tailed deer at 21.7%, sturgeon at 18.9%, and freshwater catfish at 1.1%. Other significant contributors to the wild biomass results include indeterminate fish at 3.2%, a portion of indeterminate bird at 1.8%, a portion of indeterminate medium mammal bones at 26.4%, and a portion of the Artiodactyla bones at 2.2%.

For the domestic species, swine contribute 5.3% to the biomass and cattle contribute 2.9%. Even when combined, the remaining domestic species of domestic geese, chicken and sheep/goat contribute less than 1% to the biomass figures. Like the biomass results for the wild category, the domestic category also has contributions from some of the indeterminate bones including a portion of the indeterminate bird at 0.2%, indeterminate large mammal at 1.9%, a portion of the medium mammal at 7.1%, and a portion of the Artiodactyla at 0.6%.

Table 21
Bone Summary
Layer P, Second Well (JR2158)

	NISP		Biomass	
	No.	Pct.	Kg.	Pct.
Crustacean				
Callinectes sapidus (blue crab)	899	1.40	0.000	0.00
Fish				
family Carcharinidae (requiem shark)	1	0.00	0.067	0.02
order Rajiformes (skates or ray)	3	0.00	0.135	0.04
class Osteichythyes (bony fish, indeterminate)	5346	8.33	11.872	3.24
Acipenser spp. (sturgeon)	21121	32.93	68.311	18.63
cf. *Acipenser* spp. (sturgeon)	49	0.08	1.275	0.35
Lepisosteus spp. (gar)	189	0.29	0.421	0.11
Amia calva (bowfin)	2	0.00	0.020	0.01
order Clupeiformes (herring, shad, or anchovy)	6	0.01	0.007	0.00
Alosa spp. (shad or herring)	4	0.01	0.006	0.00
Alosa sapidissima (American shad)	3	0.00	0.013	0.00
family Catostomidae (sucker)	148	0.23	0.353	0.10
family Ameiuridae (freshwater catfish)	882	1.37	3.942	1.08
Gadus morhus (Atlantic cod)	3	0.00	0.031	0.01
cf. *Gadus morhus* (Atlantic cod)	3	0.00	0.087	0.02
family Moronidae (temperate bass)	11	0.02	0.017	0.00
Morone americana (white perch)	246	0.38	0.327	0.09
Morone saxatilis (striped bass)	3	0.00	0.022	0.01
family Serranidae (grouper/sea bass)	3	0.00	0.113	0.03
Lepomis spp. (sunfish)	4	0.01	0.008	0.00
Perca flavescens (yellow perch)	3	0.00	0.010	0.00
cf. *Caranx* spp. (jack)	2	0.00	0.005	0.00
family Sciaenidae (croaker or drum)	3	0.00	0.134	0.04
Sciaenops ocellatus (red drum)	35	0.05	1.014	0.28
cf. *Cynoscion nebulosis* (spotted seatrout)	1	0.00	0.014	0.00
Reptile/Amphibian				
Rana spp. (frog)	5	0.01	0.000	0.00
cf. *Rana catesbeiana* (bullfrog)	1	0.00	0.000	0.00
order Testudines (turtle)	147	0.23	0.536	0.15

Table 21 cont'd

cf. order Testudines (turtle)	10	0.02	0.058	0.02
Chelydra serpentina (snapping turtle)	57	0.09	0.733	0.20
cf. *Chelydra serpentina* (snapping turtle)	8	0.01	0.132	0.04
family Kinosternidae (musk or mud turtle)	40	0.06	0.197	0.05
family Emydidae (box or cooter)	1	0.00	0.020	0.01
cf. *Chrysemys* spp. (water turtle)	6	0.01	0.139	0.04
Terrapene carolina (box turtle)	142	0.22	1.138	0.31
cf. *Terrapene carolina* (box turtle)	18	0.03	0.116	0.03
Trionyx spp. (soft-shell turtle)	1	0.00	0.017	0.00
cf. *Trionyx* spp. (soft-shell turtle)	1	0.00	0.007	0.00
family Colubridae (snake)	27	0.04	0.049	0.01
cf. family Colubridae (snake)	2	0.00	0.001	0.00
family Viperidae (viper)	1	0.00	0.005	0.00
Wild Bird				
**class Aves (wild bird, indeterminate) (some to still be identified)	202	0.31	1.472	0.40
*class Aves (wild bird, indeterminate) (estimated)	1459	2.27	4.447	1.21
Ardea herodias (great blue heron)	2	0.00	0.072	0.02
cf. family Procellariidae (shearwater or petrel)	1	0.00	0.011	0.00
family Anatidae (swan, goose, or duck)	4	0.01	0.493	0.13
cf. family Anatidae (swan, goose, or duck)	4	0.01	0.095	0.03
Cygnus spp. (swan)	1	0.00	0.092	0.02
cf. *Cygnus* spp. (swan)	3	0.00	0.415	0.11
Goose spp. (goose)	88	0.14	1.404	0.38
cf. Goose spp. (goose)	11	0.02	0.055	0.02
cf. *Chen caerulescens* (snow goose)	2	0.00	0.024	0.01
Branta spp. (Canada goose or brant)	1	0.00	0.019	0.01
Branta candadensis (Canada goose)	15	0.02	0.750	0.20
Branta bernicula (brant goose)	3	0.00	0.107	0.03
Duck spp. (duck)	13	0.02	0.074	0.02
Anas spp. (dabbling duck)	10	0.02	0.107	0.03
Oxyura jamaicensis (ruddy duck)	3	0.00	0.022	0.01
Aix sponsa (wood duck)	4	0.01	0.035	0.01
cf. *Aix sponsa* (wood duck)	1	0.00	0.005	0.00
Aythya spp. (pochard)	3	0.00	0.033	0.01
Aythya americana (redhead)	1	0.00	0.020	0.01
cf. order Gruiformes (crane or rail)	6	0.01	0.038	0.01
cf. family Scolopacidae (sandpiper)	1	0.00	0.003	0.00
family Laridae (gull)	2	0.00	0.050	0.01
cf. family Laridae (gull)	2	0.00	0.007	0.00
Larus spp. (gull)	6	0.01	0.040	0.01
cf. *Larus* spp. (gull)	10	0.02	0.049	0.01
order Falconiformes (vulture, hawk, or eagle)	2	0.00	0.077	0.02
family Accipitridae (hawk or eagle)	3	0.00	0.020	0.01
cf. family Accipitridae (hawk or eagle)	10	0.02	0.074	0.02
cf. *Pandion haliaetus* (osprey)	2	0.00	0.083	0.02
Haliaeetus leucocephalus (bald eagle)	10	0.02	0.215	0.06
cf. *Circus cyaneus* (northern harrier)	1	0.00	0.003	0.00
family Phasianidae (grouse, partridge, or pheasant)	28	0.04	0.185	0.05
cf. family Phasianidae (grouse, partridge, or pheasant)	15	0.02	0.062	0.02
Meleagris gallopavo (turkey)	22	0.03	1.645	0.45
cf. *Meleagris gallopavo* (turkey)	6	0.01	0.351	0.10
order Passeriformes (perching bird)	11	0.02	0.019	0.01
family Corvidae (raven or crow)	2	0.00	0.020	0.01
Domestic Bird				
*class Aves (domestic bird, indeterminate) (estimated)	125	0.19	0.630	0.17

Table 21 cont'd

Anser anser (domestic goose)	7	0.01	0.316	0.09
cf. *Anser anser* (domestic goose)	1	0.00	0.100	0.03
Gallus gallus (chicken)	31	0.05	0.700	0.19
cf. *Gallus gallus* (chicken)	5	0.01	0.049	0.01
Wild Mammal				
*class Mammalia II (medium mammal, indeterminate) (estimated)	1450	2.26	96.751	26.39
*order Artiodactyla (sheep, goat, deer, or swine) (estimated)	156	0.24	8.047	2.19
Didelphis virginiana (opossum)	61	0.10	1.461	0.40
Sciurus spp. (squirrel)	50	0.08	0.182	0.05
cf. *Sciurus* spp. (squirrel)	1	0.00	0.006	0.00
Sciurus carolinensis (eastern gray squirrel)	142	0.22	0.897	0.24
cf. *Sciurus niger* (eastern fox squirrel)	8	0.01	0.161	0.04
Ondatra zibethica (muskrat)	3	0.00	0.053	0.01
cf. family Delphinidae (ocean dolphin)	2	0.00	0.051	0.01
Procyon lotor (raccoon)	56	0.09	1.420	0.39
cf. *Procyon lotor* (raccoon)	9	0.01	0.161	0.04
Odocoileus virginianus (white-tailed deer)	631	0.98	73.552	20.06
cf. *Odocoileus virginianus* (white-tailed deer)	53	0.08	6.066	1.65
Commensal Mammal				
Rat spp. (rat)	5	0.01	0.024	0.01
Canis familiaris (dog)	2	0.00	0.150	0.04
Domestic Mammal (Livestock)				
class Mammalia I (large mammal, indeterminate)	60	0.09	6.874	1.87
*class Mammalia II (medium mammal, indeterminate) (estimated)	515	0.80	26.186	7.14
Equus spp. (horse or ass)	1	0.00	0.553	0.15
**order Artiodactyla (sheep, goat, deer, or swine) (estimated)	55	0.08	2.178	0.59
Sus scrofa (domestic swine)	185	0.29	14.993	4.09
cf. *Sus scrofa* (domestic swine)	36	0.06	4.355	1.19
Bos taurus (domestic cattle)	27	0.04	9.563	2.61
cf. *Bos taurus* (domestic cattle)	8	0.01	0.969	0.26
Ovis aries/Capra hircus (domestic sheep/goat)	18	0.03	1.574	0.43
cf. *Ovis aries/Capra hircus* (domestic sheep/goat)	4	0.01	0.672	0.18
Other Bone Identified to Class				
class Mammalia (mammal, indeterminate)	179	0.28	2.310	0.63
class Mammalia III (small mammal, indeterminate)	307	0.48	1.600	0.44
Other Bone Not Identified to Class				
subphylum Vertebrata (other vertebrate, indeterminate)	28547	44.50	0.000	0.00
Totals				
Crustacean	899	1.40	0.000	0.00
Fish	28071	43.71	88.204	24.06
Reptiles/Amphibian	467	0.72	3.148	0.86
Wild Bird	1970	3.03	12.693	3.47
Domestic Bird	169	0.26	1.795	0.49
Wild Mammal	2622	4.07	188.808	51.47
Commensal Mammal	7	0.01	0.174	0.05
Domestic Mammal (Livestock)	909	1.41	67.919	18.52
Other Bone Identified to Class	486	0.76	3.91	1.07
Other Bone Not Identified to Class	28547	44.50	0.000	0.00

Table 19 cont'd

Wild (Crustacean, Fish, Reptiles/Amphibians, Bird, Mammal)	34029	53.05	292.853	79.87
Domestic (Bird, Mammal)	1078	1.68	69.714	19.01
Identified	25957	40.46	214.509	58.50
Indeterminate	38190	59.54	152.142	41.50
Totals	64147	100.0	366.651	100.00

Note: NISP= Number of identified specimens; MNI=Minimum number of individuals. "2/2" under MNI means 2 adult, 2 immature; "1" means 1 adult.

***The NISP and biomass estimates for indeterminate bird, indeterminate medium mammal, and Artiodactyla represent a ratio calculated between the NISP and biomass totals for wild and domestic birds and between the NISP and biomass totals for deer and swine/sheep/goat bones. Please see pages 100-101 for a detailed explanation for how these numbers were calculated.

****Some of these bones still need to be identified when the Smithsonian opens their comparative collections to researchers

Layer U

Layer U produced a total of 24,653 bone specimens identified to at least 46 different species (see Table 22). Despite the diverse species list, the identified bones only make up 18.7% of the NISP totals, while the indeterminate bones make up 81.3% of the NISP. The high percentage of indeterminate bones is due to the significant amount of small, fragmented bone that could not even be identified to class. These bones, classified as subphylum vertebrate, make up 59.4% of the NISP totals. Other indeterminate bones include indeterminate fish at 10.4%, indeterminate reptiles/amphibians at 0.2%, indeterminate bird at 3.0%, and indeterminate mammal at 8.1%. When looking at individual species, sturgeon account for a significant portion of the NISP totals at 12.5%, all remaining species contribute less than 1% to the NISP.

The biomass totals show wild animals, including crab, fish, reptile/amphibian, wild bird, and wild mammal, make up 59.1% of the total. This is due to the wild mammals and fish which contribute 34.5% and 19.2% to the biomass, specifically white-tailed deer and sturgeon. For the domestic category, all the combined bird species contributes 0.3% to the biomass totals, while swine makes up 17.8%, followed by cattle 3.8%, and sheep/goat at 2.6%. In addition to the identified species, the domestic category also includes a percentage of the indeterminate bird (0.2%), indeterminate large mammal (0.1%), a portion of the indeterminate medium mammal (3.9%), and a portion of the Artiodactyla bones (5.5%).

Table 22
Bone Summary
Layer U, Second Well (JR2158)

	NISP		Biomass	
	No.	Pct.	Kg.	Pct.
Crustacean				
Callinectes sapidus (blue crab)	28	0.11	0.000	0.00
Fish				
family Carcharinidae (requiem shark)	1	0.00	0.125	0.08
order Rajiformes (skates or ray)	6	0.02	0.422	0.27
class Osteichythyes (bony fish, indeterminate)	2577	10.45	4.325	2.74

Table 22 cont'd

Acipenser spp. (sturgeon)	3085	12.51	23.256	14.72
cf. *Acipenser* spp. (sturgeon)	10	0.04	0.306	0.19
Lepisosteus spp. (gar)	67	0.27	0.332	0.21
Alosa sapidissima (American shad)	2	0.01	0.009	0.01
family Catostomidae (sucker)	161	0.65	0.361	0.23
family Ameiuridae (freshwater catfish)	129	0.52	0.564	0.36
Gadus morhus (Atlantic cod)	1	0.00	0.055	0.03
Morone americana (white perch)	52	0.21	0.085	0.05
Morone saxatilis (striped bass)	2	0.01	0.087	0.05
Lepomis spp. (sunfish)	2	0.01	0.008	0.01
Perca flavescens (yellow perch)	3	0.01	0.008	0.01
family Sciaenidae (croaker or drum)	7	0.03	0.116	0.07
Sciaenops ocellatus (red drum)	10	0.04	0.281	0.18
Reptile/Amphibian				
class Amphibia (amphibian, indeterminate)	4	0.02	0.000	0.00
Rana spp. (Frog)	3	0.01	0.000	0.00
class Reptilia (reptile, indeterminate)	54	0.22	0.000	0.00
order Testudines (turtle)	51	0.21	0.280	0.18
Chelydra serpentina (snapping turtle)	46	0.19	0.491	0.31
cf. *Chelydra serpentina* (snapping turtle)	4	0.02	0.043	0.03
family Kinosternidae (musk or mud turtle)	6	0.02	0.073	0.05
cf. family Kinosternidae (musk or mud turtle)	6	0.02	0.060	0.04
Chrysemys spp. (slider or cooter)	17	0.07	0.112	0.07
cf. *Chrysemys* spp. (slider or cooter)	2	0.01	0.083	0.05
Terrapene carolina (box turtle)	16	0.06	0.363	0.23
cf. *Terrapene carolina* (box turtle)	4	0.02	0.094	0.06
family Colubridae (snake)	1	0.00	0.005	0.00
Wild Bird				
**class Aves (wild bird, indeterminate) (some to still be identified)	99	0.40	0.833	0.53
*class Aves (wild bird, indeterminate) (estimated)	595	2.41	2.780	1.76
family Ardeidae (heron or egret)	3	0.01	0.092	0.06
family Phalacrocoracidae (cormorant)	1	0.00	0.015	0.01
Cygnus spp. (swan)	2	0.01	0.433	0.27
Goose spp. (goose)	27	0.11	0.599	0.38
cf. Goose spp. (goose)	2	0.01	0.037	0.02
Branta spp. (Canada goose or brant)	8	0.03	0.315	0.20
Branta candadensis (Canada goose)	4	0.02	0.240	0.15
duck spp. (duck)	6	0.02	0.042	0.03
Anas spp. (dabbling duck)	3	0.01	0.033	0.02
Aix sponsa (wood duck)	2	0.01	0.026	0.02
cf. *Aix sponsa* (wood duck)	3	0.01	0.022	0.01
cf. *Larus* spp. (gull)	2	0.01	0.017	0.01
order Falconiformes (vulture, hawk, or eagle)	2	0.01	0.020	0.01
family Accipitridae (hawk or eagle)	2	0.01	0.050	0.03
cf. family Accipitridae (hawk or eagle)	1	0.00	0.009	0.01
Haliaeetus leucocephalus (bald eagle)	3	0.01	0.549	0.35
cf. *Haliaeetus leucocephalus* (bald eagle)	2	0.01	0.052	0.03
family Phasianidae (grouse, partridge, or pheasant)	14	0.06	0.064	0.04
Meleagris gallopavo (turkey)	7	0.03	0.719	0.46
cf. *Meleagris gallopavo* (turkey)	1	0.00	0.028	0.02
cf. *Colinus virginianus* (bobwhite)	1	0.00	0.005	0.00
cf. order Strigiformes (owl)	2	0.01	0.040	0.03
cf. *Bubo virginianus* (great horned owl)	1	0.00	0.009	0.01
family Corvidae (raven or crow)	2	0.01	0.005	0.00
cf. family Corvidae (raven or crow)	2	0.01	0.015	0.01

Table 22 cont'd

Domestic Bird				
*class Aves (domestic bird, indeterminate) (estimated)	44	0.18	0.366	0.23
Anser anser spp. (goose)	6	0.02	0.194	0.12
Anser anser (domestic goose)	5	0.02	0.292	0.18
Gallus gallus (chicken)	3	0.01	0.067	0.04
cf. *Gallus* gallus (chicken)	1	0.00	0.011	0.01
Wild Mammal				
*class Mammalia II (medium mammal, indeterminate) (estimated)	250	1.01	6.945	4.40
*order Artiodactyla (sheep, goat, deer, or swine) (estimated)	121	0.49	9.668	6.12
Didelphis virginiana (opossum)	13	0.05	0.459	0.29
cf. *Didelphis virginiana* (opossum)	1	0.00	0.040	0.03
order Rodentia (rodent)	6	0.02	0.026	0.02
Sciurus spp. (squirrel)	17	0.07	0.064	0.04
Sciurus carolinensis (eastern gray squirrel)	64	0.26	0.478	0.30
cf. *Sciurus carolinensis* (eastern gray squirrel)	2	0.01	0.009	0.01
Ondatra zibethica (muskrat)	4	0.02	0.122	0.08
Procyon lotor (raccoon)	15	0.06	0.218	0.14
Neovison vison (mink)	1	0.00	0.026	0.02
Odocoileus virginianus (white-tailed deer)	180	0.73	34.061	21.56
cf. *Odocoileus virginianus* (white-tailed deer)	15	0.06	2.352	1.49
Commensal Mammal				
Rat spp. (rat)	4	0.02	0.024	0.02
Canis familiaris (dog)	1	0.00	0.163	0.10
Felis catus (domestic cat)	3	0.01	0.200	0.13
Domestic Mammal (Livestock)				
class Mammalia I (large mammal, indeterminate)	17	0.07	3.582	2.27
*class Mammalia II (medium mammal, indeterminate) (estimated)	259	1.05	6.209	3.93
*order Artiodactyla (sheep, goat, deer, or swine) (estimated)	124	0.50	8.642	5.47
Sus scrofa (domestic swine)	181	0.73	26.581	16.83
cf. *Sus scrofa* (domestic swine)	9	0.04	1.488	0.94
Bos taurus (domestic cattle)	6	0.02	5.361	3.39
cf. *Bos taurus* (domestic cattle)	2	0.01	0.602	0.38
Ovis aries/Capra hircus (domestic sheep/goat)	9	0.04	3.914	2.48
cf. *Ovis aries/Capra hircus* (domestic sheep/goat)	2	0.01	0.512	0.32
Other Bone Identified to Class				
class Mammalia (mammal, indeterminate)	1265	5.13	5.056	3.20
class Mammalia III (small mammal, indeterminate)	212	0.86	1.260	0.80
Other Bone Not Identified to Class				
subphylum Vertebrata (other vertebrate, indeterminate)	14657	59.45	0.000	0.00
Totals				
Crustacean	28	0.11	0.000	0.00
Fish	6115	24.78	30.340	19.21
Reptiles/Amphibian	214	0.87	1.604	1.02
Wild Bird	797	3.22	7.049	4.47
Domestic Bird	59	0.23	0.930	0.58
Wild Mammal	689	2.78	54.468	34.50
Commensal Mammal	8	0.03	0.387	0.24
Domestic Mammal (Livestock)	609	2.47	56.891	36.01

Table 22 cont'd

	NISP No.	NISP Pct.	Biomass Kg.	Biomass Pct.
Other Bone Identified to Class	1477	5.99	6.316	4.00
Other Bone Not Identified to Class	14657	59.45	0.000	0.00
Wild (Crustacean, Fish, Reptiles/Amphibians, Bird, Mammal)	7843	31.81	93.461	59.12
Domestic (Bird, Mammal)	668	2.71	57.821	36.60
Identified	4620	18.74	126.628	80.15
Indeterminate	20033	81.26	31.357	19.85
Totals	24653	100.0	157.985	100.00

Note: NISP= Number of identified specimens; MNI=Minimum number of individuals. "2/2" under MNI means 2 adult, 2 immature; "1" means 1 adult.

*The NISP and biomass estimates for indeterminate bird, indeterminate medium mammal, and Artiodactyla represent a ratio calculated between the NISP and biomass totals for wild and domestic birds and between the NISP and biomass totals for deer and swine/sheep/goat bones. Please see pages 100-101 for a detailed explanation for how these numbers were calculated.

**Some of these bones still need to be identified when the Smithsonian opens their comparative collections to researchers

Layer X

As one of the smaller assemblages, Layer X has 5,350 bones identified to at least 31 different species (see Table 23). In this assemblage, indeterminate bones account for 66.6% and identifiable bones account for 33.3% of the NISP totals. A little over half of the indeterminate bones classify as subphylum Vertebrata, meaning they were too small or too fragmented to even determine the class of the bones. The rest of the indeterminate bones consist of indeterminate fish at 5.6%, indeterminate bird bones at 14.3%, and indeterminate mammal bones at 9.7%. For the identified species, the greatest contributors to the NISP include sturgeon, white-tailed deer, and swine.

In terms of biomass results, domestic species account for the greatest amount at 51.0%, followed closely by wild species at 48.4%. When looking at individual species, swine make up the greatest amount at 27.1%, followed by white-tailed deer at 18.4%, sturgeon at 8.8%, cattle at 7.3%, sheep/goat at 2.7%, bald eagle at 2.1%, and Canada goose at 1.4%. All remaining identified species make up less than 1% of the biomass totals. Overall, this assemblage suggests livestock was the primary source of meat for the settlers at Jamestown, but they supplemented their domestic food sources with an almost equal amount of wild meat, including deer, fish, and fowl.

Table 23
Bone Summary
Layer X, Second Well (JR2158)

	NISP		Biomass	
	No.	Pct.	Kg.	Pct.
Fish				
class Chondrichthyes (cartilagenous fish, indeterminate)	1	0.02	0.020	0.02
order Rajiformes (skates or ray)	1	0.02	0.055	0.07
class Osteichythyes (bony fish, indeterminate)	298	5.57	0.969	1.15
Acipenser spp. (sturgeon)	1241	23.20	7.287	8.66
cf. *Acipenser* spp. (sturgeon)	3	0.06	0.102	0.12

Table 23 cont'd

Lepisosteus spp. (gar)	14	0.26	0.076	0.09
family Catostomidae (sucker)	9	0.17	0.033	0.04
family Ameiuridae (freshwater catfish)	17	0.32	0.111	0.13
family Moronidae spp. (temperate bass)	30	0.56	0.146	0.17
Morone americana (white perch)	9	0.17	0.018	0.02
Morone saxatilis (striped bass)	6	0.11	0.168	0.20
cf. *Sciaenops ocellatus* (red drum)	3	0.06	0.112	0.13
Reptile/Amphibian				
order Testudines (turtle)	10	0.19	0.111	0.13
family Kinosternidae (musk or mud turtle)	3	0.06	0.057	0.07
Chrysemys spp. (slider or cooter)	5	0.09	0.083	0.10
Terrapene carolina (box turtle)	6	0.11	0.127	0.15
cf. *Terrapene carolina* (box turtle)	1	0.02	0.025	0.03
Wild Bird				
**class Aves (wild bird, indeterminate) (some to still be identified)	277	5.18	2.987	3.55
*class Aves (wild bird, indeterminate) (estimated)	455	8.50	2.506	2.98
Goose spp. (goose)	51	0.95	1.182	1.40
Chen caerulescens (snow goose)	1	0.02	0.042	0.05
cf. *Chen caerulescens* (snow goose)	4	0.07	0.118	0.14
Branta spp. (Canada goose or brant)	12	0.22	0.344	0.41
cf. *Branta* spp. (Canada goose or brant)	2	0.04	0.101	0.12
Branta candadensis (Canada goose)	21	0.39	1.150	1.37
duck spp. (duck)	7	0.13	0.065	0.08
Anas spp. (dabbling duck)	2	0.04	0.077	0.09
cf. *Anas* spp. (dabbling duck)	1	0.02	0.009	0.01
Aix sponsa (wood duck)	3	0.06	0.033	0.04
cf. *Aix sponsa* (wood duck)	2	0.04	0.047	0.06
Aythya spp. (pochard)	4	0.07	0.064	0.08
cf. *Aythya* spp. (pochard)	2	0.04	0.028	0.03
order Falconiformes (vulture, hawk, or eagle)	5	0.09	0.044	0.05
Cathartes aura (turkey vulture)	1	0.02	0.020	0.02
cf. *Cathartes aura* (turkey vulture)	1	0.02	0.044	0.05
Haliaeetus leucocephalus (bald eagle)	16	0.30	1.771	2.10
family Phasianidae (grouse, partridge, or pheasant)	6	0.11	0.037	0.04
Meleagris gallopavo (turkey)	4	0.07	0.303	0.36
order Passeriformes (perching bird)	2	0.04	0.011	0.01
Domestic Bird				
*class Aves (domestic bird, indeterminate) (estimated)	32	0.60	0.261	0.31
cf. *Anser anser* spp. (goose)	1	0.02	0.017	0.02
Anser anser (domestic goose)	10	0.19	0.503	0.60
Gallus gallus (chicken)	16	0.30	0.246	0.29
cf. *Gallus gallus* (chicken)	4	0.07	0.118	0.14
Wild Mammal				
*class Mammalia II (medium mammal, indeterminate) (estimate)	163	3.00	3.345	3.97
*order Artiodactyla (sheep, goat, deer, or swine) (estimate)	27	0.50	1.165	1.38
Didelphis virginiana (opossum)	1	0.02	0.058	0.07
Sciurus spp. (squirrel)	3	0.06	0.006	0.01
Sciurus carolinensis (eastern gray squirrel)	2	0.04	0.017	0.02
cf. *Sciurus niger* (eastern fox squirrel)	1	0.02	0.024	0.03
cf. family Delphinidae (ocean dolphin)	1	0.02	0.014	0.02
Procyon lotor (raccoon)	5	0.09	0.159	0.19
Odocoileus virginianus (white-tailed deer)	74	1.38	14.272	16.95
cf. *Odocoileus virginianus* (white-tailed deer)	12	0.22	1.196	1.42

Table 23 cont'd

Domestic Mammal (Livestock)				
class Mammalia I (large mammal, indeterminate)	22	0.41	3.255	3.87
*class Mammalia II (medium mammal, indeterminate) (estimate)	290	5.42	5.412	6.43
*order Artiodactyla (sheep, goat, deer, or swine) (estimate)	49	0.92	1.884	2.24
Sus scrofa (domestic swine)	131	2.45	20.573	24.44
cf. *Sus scrofa* (domestic swine)	8	0.15	2.221	2.64
Bos taurus (domestic cattle)	5	0.09	5.602	6.65
cf. *Bos taurus* (domestic cattle)	2	0.04	0.575	0.68
Ovis aries/Capra hircus (domestic sheep/goat)	13	0.24	1.992	2.37
cf. *Ovis aries/Capra hircus* (domestic sheep/goat)	1	0.02	0.272	0.32
Other Bone Identified to Class				
class Mammalia (mammal, indeterminate)	22	0.41	0.344	0.41
class Mammalia III (small mammal, indeterminate)	23	0.43	0.177	0.21
Other Bone Not Identified to Class				
subphylum Vertebrata (other vertebrate, indeterminate)	1896	35.44	0.000	0.00
Totals				
Fish	1632	30.52	9.097	10.81
Reptiles/Amphibian	25	0.47	0.403	0.48
Wild Bird	879	16.42	10.983	13.04
Domestic Bird	63	1.18	1.145	1.36
Wild Mammal	289	5.54	20.256	24.06
Domestic Mammal (Livestock)	521	9.74	41.786	49.64
Other Bone Identified to Class	45	0.84	0.521	0.62
Other Bone Not Identified to Class	1896	35.44	0.000	0.00
Wild (Fish, Reptiles/Amphibians, Bird, Mammal)	2825	52.80	40.739	48.39
Domestic (Bird, Mammal)	584	10.92	42.931	50.99
Identified	1784	33.35	64.734	76.89
Indeterminate	3566	66.65	19.456	23.11
Totals	5350	100.0	84.190	100.00

Note: NISP= Number of identified specimens; MNI=Minimum number of individuals. "2/2" under MNI means 2 adult, 2 immature; "1" means 1 adult.

*The NISP and biomass estimates for indeterminate bird, indeterminate medium mammal, and Artiodactyla represent a ratio calculated between the NISP and biomass totals for wild and domestic birds and between the NISP and biomass totals for deer and swine/sheep/goat bones. Please see pages 100-101 for a detailed explanation for how these numbers were calculated.

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Layer AA

Layer AA represents the deepest level of well fill analyzed for this project and also the smallest faunal assemblage. With only 1,500 bones, this layer has 20 identified species including seven fish, one reptile/amphibian, eight birds, and four mammals (Layer 24). The NISP numbers show indeterminate bones making up the greatest percentage at 67.1%. At least 44.0% of the NISP for the indeterminate comes from bird bones which are predominately too fragmented to determine species. The rest of the indeterminate bones include fish (6.5%), mammals (6.9%), and subphylum Vertebrata (9.6%).

Identifiable bones make up 32.9% of the NISP, with sturgeon accounting for almost half of this total at 13.5%. Other species with significant contributions to the NISP include swine (3.3%), white-tailed deer (3.1%), and Canada goose (1.5%). The remaining identified species contribute less than 1% to the NISP. When the indeterminate bird, indeterminate mammal, and Artiodactyla categories are combined with the identifiable bones wild or domestic bones, wild species account for 77.3% of the assemblage while domestic bones make up only 11.4%. Not included with either the wild or domestic categories are bones from commensal mammals and bones classified as "other bone" categories.

Bones from wild animals also make up most of the biomass results at 56.2%. Wild fowl contribute the greatest amount to the wild biomass results with species such as Canada goose (4.7%), bald eagle (2.4%), and turkey (1.1%) making significant contributions. Wild mammals make up 22.9% of the wild biomass including white-tailed deer accounting for 19.2% of this total. Finally, fish make up 9.0% of the wild biomass with sturgeon contributing the most at 7.0%.

The domestic bones account for 42.9% of the biomass totals with swine contributing the most at 26.1%, followed by domestic goose at 3.7%, and sheep/goat at 3.0%. Other bones included in the domestic category are indeterminate large mammals (2.7%), a portion of the indeterminate medium mammal (4.2%), a portion of the indeterminate bird (0.9&) and a portion of the Artiodactyla (1.4%). It is interesting to note there are no identified cattle bones in this assemblage. There are, however, two indeterminate large mammal bones which may represent either a cow or a horse.

Table 24
Bone Summary
Layer AA, Second Well (JR2158)

	NISP		Biomass	
	No.	Pct.	Kg.	Pct.
Fish				
family Carcharinidae (requiem shark)	1	0.07	0.153	0.52
class Osteichythyes (bony fish, indeterminate)	98	6.53	0.209	0.71
Acipenser spp. (sturgeon)	203	13.53	2.052	7.00
Lepisosteus spp. (gar)	3	0.20	0.008	0.03
family Ameiuridae (freshwater catfish)	16	1.07	0.072	0.25
Morone americana (white perch)	16	1.07	0.035	0.12
Morone saxatilis (striped bass)	6	0.40	0.080	0.27
cf. *Archosargus probatocephalus* (sheepshead)	1	0.07	0.028	0.10
Reptile/Amphibian				
order Testudines (turtle)	2	0.13	0.032	0.11
Wild Bird				
**class Aves (wild bird, indeterminate) (some to still be identified)	176	11.73	1.845	6.29
*class Aves (wild bird, indeterminate) (estimated)	442	29.47	1.242	4.24
Cygnus spp. (swan)	1	0.07	0.372	1.27
Goose spp. (goose)	29	1.93	0.454	1.55

Table 24 cont'd

cf. Goose spp. (goose)	5	0.33	0.035	0.12
Branta spp. (Canada goose or brant)	3	0.20	0.193	0.66
cf. *Branta* spp. (Canada goose or brant)	1	0.07	0.134	0.46
Branta candadensis (Canada goose)	19	1.27	1.279	4.36
cf. *Branta candadensis* (Canada goose)	3	0.20	0.106	0.36
Duck spp. (duck)	2	0.13	0.007	0.02
cf. Duck spp. (duck)	1	0.07	0.005	0.02
Aix sponsa (wood duck)	14	0.93	0.106	0.36
cf. *Aix sponsa* (wood duck)	1	0.07	0.026	0.09
Cathartes aura (turkey vulture)	3	0.20	0.055	0.19
cf. *Cathartes aura* (turkey vulture)	2	0.13	0.188	0.64
family Accipitridae (hawk or eagle)	2	0.13	0.017	0.06
Haliaeetus leucocephalus (bald eagle)	11	0.73	0.689	2.35
cf. *Haliaeetus leucocephalus* (bald eagle)	1	0.07	0.017	0.06
Meleagris gallopavo (turkey)	3	0.20	0.313	1.07
cf. *Meleagris gallopavo* (turkey)	1	0.07	0.011	0.04
Domestic Bird				
*class Aves (domestic bird, indeterminate) (estimated)	42	2.80	0.275	0.94
Anser anser (domestic goose)	17	1.13	1.072	3.66
cf. *Anser anser* (domestic goose)	3	0.20	0.167	0.57
Gallus gallus (chicken)	6	0.40	0.055	0.19
Wild Mammal				
*class Mammalia II (medium mammal, indeterminate) (estimated)	39	2.60	0.821	2.80
*order Artiodactyla (sheep/goat, deer or swine) (estimated)	8	0.53	0.271	0.92
Odocoileus virginianus (white-tailed deer)	46	3.07	5.521	18.83
cf. *Odocoileus virginianus* (white-tailed deer)	1	0.07	0.110	0.37
Commensal Mammal				
Rat spp. (rat)	3	0.20	0.006	0.02
Domestic Mammal (Livestock)				
class Mammalia I (large mammal, indeterminate)	2	0.13	0.788	2.69
*class Mammalia II (medium mammal, indeterminate) (estimated)	42	2.80	1.247	4.25
*order Artiodactyla (sheep/goat, deer or swine) (estimated)	8	0.53	0.411	1.40
Sus scrofa (domestic swine)	44	2.93	7.255	24.74
cf. *Sus scrofa* (domestic swine)	5	0.33	0.411	1.40
Ovis aries/Capra hircus (domestic sheep/goat)	2	0.13	0.896	3.05
Other Bone Identified to Class				
class Mammalia (mammal, indeterminate)	4	0.27	0.081	0.28
class Mammalia III (small mammal, indeterminate)	17	1.13	0.175	0.60
Other Bone Not Identified to Class				
subphylum Vertebrata (other vertebrate, indeterminate)	145	9.67	0.000	0.00
Totals				
Fish	344	22.94	2.637	9.00
Reptiles/Amphibian	2	0.13	0.032	0.11
Wild Bird	720	48.00	7.094	24.69
Domestic Bird	68	4.53	1.569	5.36
Wild Mammal	94	6.27	6.723	22.92
Commensal Mammal	3	0.20	0.006	0.02
Domestic Mammal (Livestock)	103	6.85	11.008	37.53
Other Bone Identified to Class	21	1.40	0.256	0.87

Table 24 cont'd

Other Bone Not Identified to Class	145	9.67	0.000	0.00
Wild (Fish, Reptiles/Amphibians, Bird, Mammal)	1160	77.33	16.486	56.22
Domestic (Bird, Mammal)	171	11.40	12.577	42.89
Identified	493	32.87	22.642	77.21
Indeterminate	1007	67.13	6.683	22.79
Totals	1500	100.0	29.325	100.00

Note: NISP= Number of identified specimens; MNI=Minimum number of individuals. "2/2" under MNI means 2 adult, 2 immature; "1" means 1 adult.

*****The NISP and biomass estimates for indeterminate bird, indeterminate medium mammal, and Artiodactyla represent a ratio calculated between the NISP and biomass totals for wild and domestic birds and between the NISP and biomass totals for deer and swine/sheep/goat bones. Please see pages 100-101 for a detailed explanation for how these numbers were calculated.

******Some of these bones still need to be identified when the Smithsonian opens their comparative collections to researchers

Element Distributions for Livestock

As mentioned in the Analytic Techniques section, to analyze cuts of meat represented in an assemblage, the bones in a faunal assemblage are compared to the distribution of elements found in a normal skeleton. When the distributions are similar, the pattern suggests the entire animal was consumed, while dissimilarities suggest certain parts of the carcass were being selected over others or were not available to the occupants of the site. As an example, in complete cattle skeletons, 29.7% of the bones are from the cranium, 42.2% of the bones are from the body, and 28.1% of the bones are from feet. These percentages are then compared to the percentages of the cattle elements recovered from the Second Well (JR2158). The following paragraphs will examine the element distribution figures for the domestic mammal bones recovered from six layers of the well.

Cattle Element Distribution

As Table 25 shows, the layers from the Second Well (JR2158) produced very few cattle bones. To accurately access the element distribution patterns, a large numbers of excavated bones are typically needed. However, even with small amounts of cattle bones, it is clear predominately body or meat-bearing elements were available to the early Jamestown settlers, a pattern similar to other Jamestown faunal assemblages dating from 1607-1610. Bones from the head (particularly teeth) and feet, are very dense and tend to survive in a variety of soil conditions. At first glance, the concentration of body elements may indicate a certain bias towards "high-quality" cuts of meat. This is unlikely since historical documents and first hand accounts suggest the settlers at Jamestown often faced food shortages, even before and after the "starving time." If the settlers had access to the whole animal, then all parts of the animal, including head and feet elements, should be present in the archaeological record. As a comparison, faunal analysis from rural Chesapeake sites dating from the 1620s through the 18th century, has shown rural households consumed all parts of the cow, even the heads and feet. Faunal assemblages from urban sites also indicate all parts of the cow were available but in different percentages than their rural neighbors. Typically, in urban assemblages, there is a greater than normal percentage of body elements, a slightly less than normal proportion of head elements, and a far less than normal proportion of foot elements. This disproportionate distribution indicates a highly developed market system where individual parts of the animal are sold to the consumer (Bowen in Walsh 1997). The skewed element distribution pattern for the Second Well (JR2158) and other early assemblages from Jamestown, most likely represents beef barreled in Britain and brought to Jamestown with other supplies.

This pattern differs greatly from what we have seen in Jamestown faunal assemblages from the 1620s-1650. When different assemblages are combined together, the cattle bones show a distribution of cattle elements almost identical to a normal skeletal distribution. This suggests by the 1620s, cattle herds had become established and colonists had access to the entire animal.

Table 25
Element Distribution for Cattle
The Second Well (JR2158) Compared to Other Jamestown Assemblages

	Head		Body		Feet		
	No.	%	No.	%	No.	%	NISP
Cattle Normal		29.7		42.2		28.1	
Second Well							
Layer H	2	16.7	10	83.3	0	0.0	12
Layer N	0	0.0	20	90.9	2	9.1	22
Layer P	0	0.0	35	100.0	0	0.0	35
Layer U	1	12.5	6	75.0	1	12.5	8
Layer X	0	0.0	7	100.0	0	0.0	7
Layer AA	0	0.0	0	0.0	0	0.0	0
Other Jamestown Assemblages for Comparison:							
Pre-Starving Time	3	7.1	30	71.4	9	21.4	42
Starving Time	31	18.5	115	68.9	21	12.6	167
Post-Starving Time	3	3.5	78	92.8	3	3.5	84
Stability Herds (1620s+)	72	29.3	83	33.7	91	37.0	246

Data for other Jamestown Assemblages: Bowen and Andrews 2000, 2013; Andrews 2008
Pre-Starving Time Features = Structure 166 Cellar, Pit 8, Pit 9, Pit 10, Pit 11
Starving Time Features = Pit 1, Pit 3, and Cellar (JR3081)
Post-Starving Time Feature = Second Well (JR2158), Layers H, N, P, U, X, AA
Stability Herd Features = Ditch 6, Ditch 7, Midden 1

Swine Element Distribution

The six analyzed layers from the Second Well (JR2158) produced more swine bones than previous Jamestown assemblages dating from the first years of the fort until 1650. Having such a large number of swine bones, also increase the chances of getting accurate distribution patterns. Table 26 shows Layers U, X, and AA all have body elements as the most frequently identified bones accounting for 38.5% to 53.1% of the assemblages. This pattern is like other early analyzed Jamestown assemblages where body elements are the frequently recorded, followed by bones from the head, then bones from the feet.

Layers H, N, and P of the Second Well (JR2158), all have head elements as the most frequently identified bones making up 49.5% to 61.0% of the assemblages. This pattern is comparable to the swine element distribution pattern seen in the Jamestown assemblage dating from the 1620s-1650. It is also similar to faunal assemblages from other sites in Virginia dating to 1620-1660 (Bowen in Walsh 1997). In these Chesapeake sites, bones from the head of swine typically make up 66.6% of the swine elements. It is not clear why there is a discrepancy between the layers of the Second Well (JR2158), as well as, a difference in the swine element patterns from the early and later period Jamestown assemblages. One reason is there are significantly more swine bones in the upper layers of the well and in the assemblages from the 1620s-1650 time period. The presence of more bones might allow for a more accurate representation of the swine element distribution. Another possible reason is teeth are more durable than bone and are less susceptible to the effects of butchering allowing them to stay intact and easily identified. Finally, more teeth and bones from the head may reflect changes in cuisine where swine heads were considered more of a delicacy.

Table 26
Element Distribution for Swine
The Second Well (JR2158) Compared to Other Jamestown Assemblages

	Head		Body		Feet		
	No.	%	No.	%	No.	%	NISP
Swine Normal		28.2		34.5		37.3	
Second Well							
Layer H	255	61.0	90	24.5	73	17.5	418
Layer N	309	50.6	181	29.6	121	19.8	611
Layer P	109	49.5	105	47.7	6	2.7	220
Layer U	51	26.8	80	42.1	59	31.0	190
Layer X	36	26.7	52	38.5	47	34.8	135
Layer AA	16	32.6	26	53.1	7	14.3	49
Other Jamestown Assemblages for Comparison:							
Pre-Starving Time	30	54.5	10	18.2	15	27.3	55
Starving Time	186	26.2	354	49.9	170	23.9	710
Post Starving Time	776	47.8	534	32.9	313	19.3	1623
Stability Herds (1620s+)	145	46.0	101	31.9	71	22.4	317

Data for other Jamestown Assemblages: Bowen and Andrews 2000; 2013, Andrews 2008
Pre-Starving Time Features = Structure 166 Cellar, Pit 8, Pit 9, Pit 10, Pit 11
Starving Time Features = Pit 1, Pit 3, and Cellar (JR3081)
Post-Starving Time Feature = Second Well (JR2158), Layers H, N, P, U, X, AA
Stability Herd Features = Ditch 6, Ditch 7, Midden 1

The element distribution for swine in these early Jamestown assemblages also raises several question regarding their origin. First, since all parts of swine were typically salted in the 17th century, there is the possibility the swine bones represent barreled provisions imported from England. However, when you compare the percentages from the combined element distribution pattern of the Second Well (JR2158) to the percentages from features dating from post 1620s, when the herds were well established, the percentages are very similar. This helps support the theory the bones from the well were from swine the settlers were raising themselves. What is unclear is whether the swine were born and raised at Jamestown or were they imported live from either Bermuda or Britain? Further research, such as isotope analysis, may provide some answers to these questions.

Sheep/Goat Element Distribution

None of the layers from the Second Well (JR2158) have enough sheep/goat bones to accurately access the element distribution patterns (see Table 27). The skewed distribution patterns are most likely due to a small sample size. When all of the sheep/goat bones are added together from all of the layers, they total 66 elements which include 36.4% bones from the head, 36.4% bones from the body, and 27.3% bones from the feet. With more elements, the element distribution pattern resembles a normal skeletal pattern and suggests all portions of the animal were available to the Jamestown occupants. When compared to the cattle data, which is predominately body elements, it is clear these were animals the settlers were raising and killing themselves, not provisions sent from England.

Table 27
Element Distribution for Sheep/Goat
The Second Well (JR2158) Compared to Other Jamestown Assemblages

	Head		Body		Feet		
	No.	%	No.	%	No.	%	NISP
Sheep/Goat Normal		29.7		42.2		28.1	
Second Well							
Layer H	9	56.2	1	6.2	6	37.5	16
Layer N	1	100.0	0	0.0	0	0.0	1
Layer P	8	36.4	8	36.4	6	27.2	22
Layer U	2	18.2	8	72.7	1	9.1	11
Layer X	3	21.4	7	50.0	4	28.6	14
Layer AA	1	50.0	0	0.0	1	50.0	2
Other Jamestown Assemblages for Comparison:							
Pre-Starving	1	100.0	0	0.0	0	0.0	1
Starving Time	33	38.8	25	29.4	27	31.8	85
Post Starving Time	24	36.4	24	36.4	18	27.3	66
Stability Herds (1620s+)	11	64.7	1	5.9	5	29.4	17

Data for other Jamestown Assemblages: Bowen and Andrews 2000, 2013; Andrews 2008
Pre-Starving Time Features = Structure 166 Cellar, Pit 8, Pit 9, Pit 10, Pit 11
Starving Time Features = Pit 1, Pit 3, and Cellar (JR3081)
Post-Starving Time Feature = Second Well (JR2158), Layers H, N, P, U, X, AA
Stability Herd Features = Ditch 6, Ditch 7, Midden 1

Kill-Off Patterns for Livestock

As discussed in the analytic techniques section of this report, there is a direct relationship between agricultural economies and how livestock are bred, raised, and slaughtered. To help interpret husbandry techniques, fusion data for the domestic mammal bones for each layer were analyzed to determine approximate age of death. To accurately access the kill-off patterns from an assemblage, large numbers of bones are required in proportions roughly even to that of a normal skeleton. Unfortunately, the layers from the Second Well (JR2158) did not produce enough ageable cattle or sheep/goat bones to accurately access age distribution patterns. Even when the ageable bones are added together from all the layers, there is still only four cattle bones and nine sheep/goat bones appropriate for age analysis. The layers from the Second Well (JR2158) did produce some ageable swine bones, with Layer N producing the most with 64 bones. The following paragraphs will assess the swine bones and discuss some generalizations about the kill-off data. For future comparative work, the epiphyseal fusion tables for all of the domestic mammals are included in Appendix B, Tables 37-47.

Swine Kill-Off Patterns

Swine were an adaptable livestock commonly raised in the Chesapeake region from the 17th through the 19th centuries. Generally speaking, swine husbandry techniques developed from subsistence-oriented practices. From the initial settlement at Jamestown, swine free ranged with little or no supplemental feed. With the increase of commercially oriented swine farming came the increased use of stys and fattening methods. Slaughter ages have varied, but typically swine were killed at approximately 8-10 months or between 18-24 months of age. Historians and zooarchaeologists specializing in British agriculture have stated swine under 12 months have been the target slaughter age for subsistence farming, and the approximate 18-24 months population as being the target age for slaughtering swine intended for sale (Walsh et al. 1997). Swine slaughtered at a younger age had been born in the spring, allowed to mature throughout the summer and then during the fall fattened and slaughtered as soon as the temperature dropped. Those slaughtered at 18 months had been kept over the winter, allowed to fatten over the summer to a more mature weight, then fattened and slaughtered the next fall. This pattern fits in perfectly with faunal results gathered from archaeological sites in the Chesapeake region. Typically, early 17th century data have shown almost half of the swine population was less than a year old when slaughtered than in subsequent time periods when the youngest age group fluctuates between 19% and 28%. The approximate 12-24 months age group, on the other hand (which encompasses the commercial target age of 18 -24 months), has shown an increase over time, particularly during the second half of the 18th century and early 19th century. From the 17th and the first half of the 18th century, this age group ranged from 11% to 17% of the total population, but by the end of the 18th century and early 19th century, it jumps to 31% and 38% of the population. This pattern has been seen in faunal assemblages from Williamsburg, signaling when rural planters began to alter their husbandry techniques in response to the growing commercial markets. At this same time, urban consumers became increasingly dependent upon commercially produced goods, rather than those they might have produced themselves or obtained from friends and relative living in the nearby countryside (Bowen in Walsh et al. 1997, Bowen 2021).

The swine epiphyseal fusion results from the layers of the Second Well (JR2158) are broadly classified into age groups using numerical designations given by Reitz and Wing (2008). These groups include: I, representing approximately 0-12 months of age; II, representing approximately 12-24 months of age; III, representing approximately 24-36 months of age; IV, representing approximately 36-42 months of age; and V, representing over 42 months of age.

As Table 28 shows, most of ageable swine bones from each of the layers fall into Group III (approximately 24-36 months), averaging between 60% and 75% of each assemblage. Most of the remaining bones are either from Group I (approximately 0-12 months) or Group II (approximately 12-24 months). Layer U stands out because the majority of the ageable swine bones indicate most of the swine from this layer were killed approximately between 36 to 42 months of age (Group IV).

Knowing the early settlers of Jamestown were not yet focusing on raising swine for profit in 1611-1616, the skewed kill-off data suggests they were probably killing some young swine for subsistence but also keeping a greater number of older swine for breeding purposes. When no longer used for breeding, the older swine could then be killed for food. The establishment of the Marshall Laws in 1611, specified “young cattell, & Breeders may be cherished, that by the preservation, and increase of them, the Colony here may received in due time assured and great benefite” (Strachey 1612). Not wanting to find themselves again without sources of subsistence, Jamestown colonists were not allowed to kill any domestic livestock or poultry without approval. By controlling when and who could kill livestock, the individuals in charge were attempting to establish and increase herds of cattle and droves of swine so they could sustain themselves and not have to rely on supplies from England. The high number of older swine in these assemblages fits with the idea the colony, at this time, focused on increasing the number of livestock and killing the majority of the swine when they were no longer beneficial for breeding purposes.

The Second Well (JR2158) kill-off data for swine may also suggest the settlers at Jamestown, after the “starving time,” were familiar with the biology, fertility rates, and herd behavior of feral hogs. According to contemporary research, feral hogs typically live six to eight years with some individuals living up to fourteen years of age. For sows, which are typically found in groups with other females and piglets, the size of their litters begins to decrease after the 5th litter, which is typically when the sow reaches four to five years of age. Mature sows can breed multiple times during a year, when food resources are abundant, while younger sows usually only have one litter. Boars, which are mostly solitary, are typically sexually mature as young as four to five months, reaching their sexual peak between three to five years of age. During the breeding season, boars will lose up to 20-25% of their body weight and demonstrate more aggressive behavior including the destruction of cultivated fields (Cooperative Extension 2019).

Most of the swine from the combined Second Well (JR2158) assemblage indicate they were killed primarily at three years of age, which is past the optimum age for subsistence farming. Could this be a result of the settlers killing off the boars at a younger age to protect the sows until their breeding productivity declined? Were the boars more destructive to their crops endangering their food resources? Whatever the reason, it is clear from the kill-off data that from the time of stability herds, a shift occurred and settlers were killing most of their swine before two years of age which is the optimum time for killing swine for subsistence farming. Overall, the swine age data from Jamestown raises some interesting questions regarding changes in swine husbandry patterns and how the implementation of the Martial Laws may have played a role in these changes.

Table 28
Kill-Off Pattern Based on Long Bone Fusion for Swine
Second Well (JR2158)

Assemblage	I	II	III	IV	V	Number Of Bones
Second Well						
Layer H	16.7%	8.3%	75.0%	0.0%	0.0%	47
Layer N	15.4%	17.9%	59.6%	0.0%	7.1%	65
Layer P	100.0%	0.0%	0.0%	0.0%	0.0%	15
Layer U	18.2%	0.0%	10.4%	71.4%	0.0%	26
Layer X	0.0%	27.3%	72.2%	0.0%	0.0%	30
Layer AA	0.0%	0.0%	100.0%	0.0%	0.0%	5
Other Jamestown Assemblages for Comparison:						
Pre-Starving	0.0%	100.0%	0.0%	0.0%	0.0%	4
Starving-Time	34.0%	46.8%	7.7%	0.0%	11.5%	157
Post Starving Time	18.4%	9.0%	54.9%	3.0%	14.8%	188
Stability Herds (1620s+)	6.2%	35.5%	20.8%	0.0%	37.5%	42

Data for other Jamestown Assemblages: Bowen and Andrews 2000, 2013; Andrews 2008. See Appendix C.
Pre-Starving Time Features = Structure 166 Cellar, Pit 8, Pit 9, Pit 10, Pit 11
Starving Time Features = Pit 1, Pit 3, and Cellar (JR3081)
Post-Starving Time Feature = Second Well (JR2158), Layers H, N, P, U, X, AA
Stability Herd Features = Ditch 6, Ditch 7, Midden 1

Butchering and Cuts of Meat

Although every zooarchaeologist must deal with butchery daily when analyzing faunal remains, few working with historical sites have dealt with butchery-related problems in print. With notable exceptions, such as Lyman (1987,) and Crader (1990), zooarchaeologists have left their observations as only a laboratory function. Yet butchering data holds fascinating information on the transformation in foodways which occurred during the 17th through the 19th centuries, along with the commercialization and industrialization of food production, distribution, processing, and consumption of foods.

Based on data from analyzed faunal assemblages, it has become apparent a fundamental change occurred in butchering techniques during the 17th, 18th, and early 19th centuries. By working closely with the archaeologists to create tightly dated assemblages, we have observed when butchering techniques shifted from chopping to sawing and have formulated ideas on how and why this change occurred.

In his illustrative encyclopedia, Diderot (1978) depicts butchers in the 17th century with cleavers, knives, and broad axes, but no saws. Drawings of markets and butcher shops from 18th century London also show broad axes and cleavers, not saws. Saws begin to appear only during the late 18th century or early 19th century. In fact, the earliest evidence of a saw is a 1799 drawing of Philadelphia, where a butcher is holding a saw (Bowen and Manning 1994).

Analyzed faunal assemblages suggest the earliest sawn food remains first appear in urban sites. In an assemblage dating to the turn of the century, the Narbonne House in Salem, Massachusetts, there are several sawn veal bones (Bowen 1982). In most 19th century faunal assemblage there are sawn bones, mixed in varying proportions with chopped bone. It appears in the 19th century saws were increasingly used to butcher meat, particularly cattle bones and occasional swine and sheep/goat bones. In the early 19th century, bones appear to have been sawn into cuts similar to the large cuts common during the previous century, but over the century meat cuts decreased into smaller pieces closely resembling the thin steaks and chops we find in the grocery stores today (Bowen and Manning 1994).

When identifying the faunal remains from the Second Well (JR2158), evidence of butchering was recorded for the livestock and deer bones. As discussed earlier in the "Analytic Techniques" section of this report, almost all of the bones from the Second Well (JR2158) were probably butchered. However, the process of butchering often leaves many highly fragmented bones which are simply too small to identify to species or to element.

The following paragraphs will discuss the overall evidence of butchering found on cattle, swine, sheep/goat, and deer bones. As Table 29 shows, most of the bones recorded as butchered were from deer and swine and the majority of these elements are long bones.

Table 29
Elements with Evidence of Butchery for Cattle, Swine, Sheep/Goat, and Deer

	Cranial	Vertebrae	Rib	Innominate	Scapula	Long Bones	Lower Leg	Foot
Layer H								
Cattle	1	2		2		1		
Swine	34	8		5	4	25		4
S/G	1					1	1	1
Deer	1	6	3	4	1	24	1	3
Layer N								
Cattle		9	1		5	1		
Swine	32	22	3	4	11	50		8
S/G								
Deer	3	12	7	8	4	49	39	7
Layer P								
Cattle					6	2		
Swine	3	15	10	10	3	32		1
S/G				3		4		
Deer	22	68	47	21	8	149		10
Layer U								
Cattle		3		1		2		
Swine	11	12	7	6	10	11		4

S/G				1	1	5		1
Deer	6	13	7	11	11	45	2	
Layer X								
Cattle		2		2		1		
Swine	14	11	1	4	7	20		7
S/G	1			3		3	4	
Deer		4	3	3	6	17	1	
Layer AA								
Cattle								
Swine	5	7	4		2	2		
S/G	1							
Deer	3	4	1			5		

Heads

Most of the butchered cranial bones are from swine, accounting for 72% of all the butchered cranial bones (see Table 29). The swine cranial elements are mainly maxilla or mandible bones hacked perpendicularly to the axis of the bone. Some of these bones show hack marks only on one side, while others have hack marks on both sides.

Vertebrae

In addition to the head bones, butchered vertebrae and sacrum bones were identified from the deer, swine, and cattle bones (see Table 29). The majority of the vertebrae for both the domestic mammals and deer have longitudinal hack marks in a method used to split the carcass in half. Generally speaking, vertebrae are split along the axis, either along the center line or along either side of the centrum. At least two of the vertebrae from Layer AA also have visible knife marks on the surface of the bone.

Ribs

Analysis of the domestic mammal and deer bones show at least 68 deer ribs have butchery marks, along with 1 cow rib and 25 swine rib bone (see Table 29). The butchery evidence suggests ribs were commonly hacked parallel to the vertebral column. Variations to these cuts include where the division took place and the size or the portions created by the cut. Many of the rib bones have been chopped through the vertebral end or the rib, either at or just below the articulation with the vertebrae. This was probably done in order to separate the rib section from the vertebrae. Other ribs were hacked so as to leave a more substantial portion of the bone was left attached to the vertebrae.

Scapulae

Butchered scapula bones were found in every layer, except Layer AA, with most of the them from deer and swine (see Table 29). As Figures 2 and 3 show, most of the deer scapula were butchered through the distal end, far below the glenoid. The cuts, made by either an ax or a cleaver like tool, were mainly visible through the lateral border of the bones. Since the flat bone of the scapula is fragile, there are also many stress fractures in the flat body of the bone. The cut of these bones is very similar suggesting the same person was making the cuts or individuals were following a similar method for butchering. In addition to the hack marks, visible cut marks made by a knife were found on one deer scapula from Layer U.

Figure 2. Butchered Deer Scapula, Layer P (Photo by Andrews 2021)

Figure 3. Butchered Deer Scapula, Layer U (Photo by Andrews 2021)

For the swine scapula, Figures 4 and 5 show most of them were hacked through the glenoid and neck, or through the blade itself. The goal of these two cuts seems to have been to sever the shoulder from the front leg, and secondly to bisect the shoulder itself. Since the flat bone of the blade is so fragile, there were also many fragments possibly broken due to stress fractures. In addition to the hack marks, cuts made by knives were noted on scapula bones from Layers N and X.

Figure 4. Butchered Swine Scapula, Layer H (Photo by Andrews 2021)

Figure 5. Butchered Swine Scapula, Layer N (Photo by Andrews 2021)

Long Bones

The most frequently recorded butchered elements are long bones from all of the domestic mammal and deer bones from all layers of the Second Well. In all, there are 7 adult cattle long bones, 140 swine long bones, 13 sheep/goat long bones, and 289 deer bones (see Table 29). All of these long bones had been hacked, probably with the intention of separating the joints. Most often the cuts were made below the proximal epiphysis through the shaft or above the distal epiphysis through the shaft (see Figures 6 through 11). Experiments on butchering have demonstrated the ease with which these cuts can be made. Two hits of a cleaver are enough to snap the long bone in two; one well-aimed hit of an axe will snap a joint in two. These cuts are part of the primary butchering process, not simply cuts made by those attempting to release the marrow from inside the shaft. Visible knife marks were also recorded for one deer femur from Layer U, two swine femurs from Layer N, and two deer tibia from Layer P.

Figure 6. Butchered Deer Tibia, Proximal End/Shaft, Layer P (Photo by Andrews 2021)

Figure 7. Butchered Deer Tibia, Distal End/Shaft, Layer P (Photo by Andrews 2021)

Figure 8. Butchered Deer Humerus, Distal End/Shaft, Layer N (Photo by Andrews 2021)

Figure 9. Butchered Deer Humerus, Distal End/Shaft, Layer P (Photo by Andrews 2021)

Figure 10. Butchered Deer Radius, Proximal End/Shaft, Layer P (Photo by Andrews 2021)

Figure 11. Butchered Deer Radius, Distal End/Shaft, Layer P (Photo by Andrews 2021)

Innominates

Every layer from the Second Well (JR2158), with the exception of Layer AA, has butchered innominate bones. The butchered innominates include 5 cattle, 29 swine, 7 sheep/goat, and 47 deer bones (see Table 29). Like the scapula, the pelvic bones are vulnerable to breakage, and once butchered, its soft cancellous bone, covered by a thin layer of compact bone, makes it an easy target for dogs and feet. By viewing the deer innominates as a group (see Figures 12 and 13), it is clear the bones were typically butchered on the proximal end of the bone just above the acetabulum. For the domestic mammals, the cuts on the innominates were more varied with some on either side of the acetabulum, through the ilium, ischium, and sometimes the pubis. Cut marks made from a knife were also recorded on two of the deer innominate fragments from Layer U and from one deer innominate from Layer N.

Figure 12. Butchered Deer Innominate, Layer P (Photo by Andrews 2021) (Photo by Andrews 2021)

Figure 13. Butchered Deer Innominate, Layer U (Photo by Andrews 2021)

Lower Legs and Feet

The majority of the butchered lower legs bones are deer metacarpals and metatarsals from Layer N (see Table 29). Most of these elements were hacked mid-shaft either below the proximal end or above the distal end. These cuts include the ends of the bones as well as much of the shaft. There are also a couple of bones with no ends but hacked through both the proximal shaft and the distal shaft. All of these cuts would have ensured a large amount of meat remained on the bone. The remaining lower leg deer bones from the other layers were cut in a similar fashion. It is interesting to note there are no deer lower leg bones in either Layer P or Layer AA.

Butchered foot bones from deer and swine were primarily calcaneous bones hacked either longitudinally or transversely through the bone. Other butchered foot bones include deer and swine astragalus hacked transversely through the proximal end. There are also several swine metacarpal and metatarsal bones hacked through the shaft. Most of these cuts are probably the result of separating the feet from the rest of the body. Along with butchery cuts, one deer second phalange from Layer N has knife cut marks along the surface.

Discussion of Seasonality and Environment

As part of the analysis of the faunal material from the Second Well (JR2158), the identified wild species were examined to see if they could provide any insights into which season the animals were procured and deposited in the well layers. Seasonality studies are based on the idea certain species are present or abundant at certain times of year, making them more accessible for individuals to exploit. However, seasonality studies are far more complicated than this and incorporate many direct and indirect influences on the presence and absence of species in an assemblage. In addition to not considering these influences, general conclusions are often made about the seasonal habits of certain species which do not hold true for every site. For example, turtles brumate during the winter in some areas suggesting their presence in archaeological sites indicates a warm weather deposition. In other areas, turtles are active all year and cannot be used to determine a seasonal use of a site. Seasons vary in length of time from year to year and in any given place it is often hard to establish an absolute calendar for the occurrence of species in an area (Monk 1981, Reitz and Wing 2001).

Another aspect to consider in seasonality studies is not only evaluating the seasonal appearance of a species for a specific site, but understanding the human influences on what is found in the archaeological food record. Humans gather and disperse at different times for different reasons, such as ceremonies, changing camps, or hunting expeditions. Refuse disposals can be affected not only by these fluctuating cycles of human populations, but also how humans hunt, how they transport their provisions, preserve food, and how they store their provisions. For sites only occupied for part of the year, the refuse may only contain a few species, not necessary showing all of the species eaten and available in a particular season. For these reasons, it can be difficult to determine if the animals deposited in the archaeological record were actually killed in the same season or may represent food stored for provisions to be eaten in another season (Reitz and Wing 2001).

Besides the human influence on refuse deposits, there are also many biological factors which can have an effect on seasonality analysis. Not only do seasons vary each year by their length, but they can differ each year in their intensity and their climatic activity. There can be unpredictable variations in seasons resulting in extreme environmental changes which, in turn, can influence the birth rate of animals, their rates of growth and development, and their availability in a particular season (Reitz and Wing 2001).

At Jamestown, the type and quantity of provisions was also affected by the settler’s relationships with the Virginia Indians. The Anglo-Powhatan War, occurring from 1609-1613, was largely centered on conflicts with the English wanting food the Indians had and the Indians trying to protect their sources of food. Settlers hesitated leaving the boundaries of the fort for fear of being killed by Indians, while trading with Indians had mostly stopped. These factors would have directly impacted what the settlers could acquire for provisions, not necessarily trying to hunt or fish for the most abundant species available. The end of the Anglo-Powhatan War in 1612, would have changed how the settlers approached their surrounding environment. With the fear of being killed by Virginia Indians gone, they could now focus on their planting, hunting, and fishing while looking for the most effective ways to acquire wild species (Horn 2005).

The ending of the Anglo-Powhatan War also coincided with the end of a five year drought which affected the environment at Jamestown from 1607-1612 (Blanton 2000). The extreme climate change influenced the presence and absence of many species by changing the salinity levels of waters in the region, which in turn had a great impact on the seasonal movements of fish species between the rivers and the Chesapeake Bay. The food cycles and the predictable seasonal appearance of fish, birds, reptiles/amphibians, and mammals were all disrupted as food sources disappeared and species altered their habitats and food consumption.

For the purpose of this report, a minimal seasonality table was made showing each species identified in the Second Well (JR2158) and their typical seasonal availability in the Chesapeake region. This table is based on present day data provided in fish, bird, reptiles/amphibian, and mammal identification guides for regions including southeast Virginia. Table 30 includes all of the species and family of species (indicated in bold) identified in all of the layers of the Second Well (JR2158). For bones recorded to family, possible species (indicated in grey) are given under each heading. Similar charts for each individual well layer are given in Appendix D, Tables 52-57. The following paragraphs will address the possible seasonality information seen in the presence of species identified in the Second Well (JR2158).

Crabs

As Table 30 shows, although blue crabs are more abundant in the warmer months, they are actually present all year. In the winter, crabs typically move to deeper water where they burrow in the mud until the water temperature rises. The remains of crabs have been identified in all of the layers of the well with the exception of the lowest layer, Layer AA. It is interesting that in the first-hand accounts of Jamestown, John Smith mentions what the settlers lived on as they waited for the first supply ship to arrive. He comments, "From May to September, those that escaped lived upon sturgeon and sea crabs; fifty in this time we buried" (Smith in Haile 1998:230). It is not clear if Smith means they buried the sturgeon or the crabs, but it does suggest they may have tried to preserve some of the crabs for future consumption. This is a similar account to the one Percy wrote about after the "starving time" when he went to visit the settlers living at Fort Algernon. He found they had survived the winter and had been feeding their hogs "crab fishes" (Percy in Haile 1998:506). Again, this suggests the settlers may have been storing crabs to be used as provisions at a later date, making it questionable to use their remains as a seasonal indicator.

Fish

Certain fish species identified in faunal assemblages are often used as indicators of seasonality. Typically, modern data is used to show patterns in the availability of fishes in general areas at certain times of the year. For the Jamestown Second Well (JR2158) assemblages, however, it is difficult to determine when fish were available to the settlers for many reasons.

As mentioned earlier, during the drought years, the salinity levels increased in the rivers and tributaries of the Chesapeake, causing some fish species to move to other areas. Sturgeon, for example, are usually more abundant in spring when they leave the Bay and make their way to the James or York Rivers to spawn in freshwater. They are also common in the fall when they leave the rivers and the Bay and head for coastal ocean waters. In 1610, the sturgeon did not arrive causing William Strachey to write:

> the river, which were wont before this time of the year to be plentiful of sturgeon, had not now a fish to be seen in it. And albeit we labored and haul'd our net twenty times a day and night, yet we took not so much as would content half the fishermen" (Strachey in Haile 1998:425).

This account was also confirmed in a letter to the Virginia Company in July 1610, when Lord De La Warr and his council reported that even if there were sufficient seines or nets to be found at Jamestown, it would not have mattered since, "not any of sturgeon come into the river" (Governor and Council in Virginia in Haile 1998:457). Most likely, the sturgeon did come through the James River that year but continued past the island to find freshwater further upstream. For this reason, it is not clear if the sturgeon bones, found in all of the analyzed well layers, represent sturgeon acquired during one of the spring or summer runs or whether the drought significantly changed the timing of their spawning, as well as, their exodus to deeper water.

In addition to the effects of the drought, many of the identified fish species are year-round residents in the waters of the Chesapeake Bay and its tributaries. For example, at certain times of the year some fish move from saltwater to freshwater or they move from inshore locations to deeper waters. Although there are accounts of men being sent out on fishing expeditions from Jamestown, it is not certain if they had the proper equipment and fishing skills needed to reach the fish living in deeper water. Also, by 1609, some of Jamestown's men had moved downstream to Fort Algernon at Point Comfort, while other moved upstream and established Henrico by 1611 (Horn 2005). Could they settler at Jamestown been acquiring fish from these outlying forts? If so, the fish accessible in these areas may have differed seasonally from what the settlers acquired at Jamestown Fort. For example, in William Strachey's accounts from 1612, he writes, "Sturgeon great store, commonly in May, if the year be forward. I have been at the taking of some before Algernoone Fort and in Southhampton River in midst of March. And they remain with us June, July, and August…" (Strachey in Haile 1998:684).

With all of the "unknowns" surrounding fishing at Jamestown, including not knowing what techniques and tools were available to the settlers and how the climatic changes affected the presence of fish species, determining seasonality of the well layers from the fish species is unfortunately quite complicated. It is not just a question of what fish they were catching and when they were catching them, but it also involves where were they catching the fish.

Reptiles/Amphibians

Turtles, snakes, and frogs would have been more abundant in the warmer months to the Jamestown settlers but were still present all year. As winter approaches, reptiles and amphibians go into a state of brumation where they become sluggish and inactive. While it is not a true hibernation, they do go into a deep sleep to conserve energy. Although turtle remains were recovered from all of the analyzed well layers, their presence does not definitely suggest they remains were deposited in the warmer months. If the settlers knew where to look, it could have been possible for them to dig the turtles out of the burrows during the winter months.

Wild Birds

Often, the presence of certain migratory fowl can provide some insights into the seasonality of a site's deposition. Migratory fowl have been identified in the well's layers including species of geese, duck, and swan. Unfortunately, due to restrictions from Covid-19, it was not possible to access the skeletal bird collections at the Smithsonian's Museum of Natural History. While this limited the ability to identify the bones to exact species, duck and goose skeletal loans from University of Georgia's Museum of Natural History, did allow for many of the bones to be identified to at least the category of family. Like the fish, it is not certain how the drought conditions may have affected the migratory patterns of the water fowl.

Wild Mammals

All of the wild mammals identified in the well layers would have been available to the settlers throughout the year, including the dolphin. For this reason alone, the mammals are not a useable source to try and identify the seasonality of the well layers.

Future Recommendations for Seasonality Studies

The analysis of six of the Second Well's (JR2158) layers has provided a foundation for looking at the possibility of a more in-depth seasonality study. It is clear the presence and absence of certain species in the well is intwined with the environmental impact of the drought, the settler's relationships with the Virginia Indians, their expansion to other areas with different environmental settlings, and their hunting and fishing capabilities. It is recommended the faunal material from the remaining layers of the well be analyzed and then compared with the layers from this report. Also, the faunal material from the wet screen and flotation would enchance the diversity to include smaller species not captured in the screen material. All migratory fowl remains should then be taken to the Smithsonian when the museum opens up its collections to researchers. If some of the bones can be taken to the exact species, it might provide more accurate representation for seasonality analysis. Then, when the faunal analysis for the whole well is finished, the data can be studied alongside the botanical analysis to see how the different species fit into the seasonal landscape of Jamestown.

Table 30
Seasonality of Wild Species

Key to Table:
species/ family name in bold indicates they were identified in the assemblages
species name in grey are examples of possible species, not identified species
C = common (fairly certain to be found in proper habitat)
U = uncommon (probably present, but will often be missed)
O = occasional (not always present)
R = rare (not always seen)
-------- = not typically present at this time of year
Brumate = a state or condition of sluggishness, inactivity, or torpor exhibited typically by reptiles during winter or extended periods of low temperature

CRAB

Taxon	Winter	Spring	Summer	Fall	All Year
Blue Crab	Brumate	C	C	C	X

FISH

Taxon	Winter	Spring	Summer	Fall	All Year
Requiem Shark (possible species below)					
Atlantic sharpnose	------	------	R	------	
Sandbar shark	------	------	C	C	
Dusky shark	------	------	C	------	
Bull shark	------	------	O	------	
Skate or Ray (possible species below)					
Clearnose skate	------	------	C	C	
Winter skate	O	O	------	------	
Little skate	O	O	------	------	
Atlantic stingray	------	------	O	O	
Cownose ray	------	------	C	C (Females)	
Sturgeon (possible species below)					
Atlantic sturgeon	------	C	C	C (Males)	
Shortnose sturgeon	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	X
Gar (possible species below)					
Longnose gar	C	C	C	C	X
Bowfin	C	C	C	C	X
Alewife	------	C	C	C	
American Shad	C (Age 4 to 6 years)	C	C	------	
Sucker (possible species below)					
Quillback	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	X
White sucker	C	C	C	C	X
Shorthead redhorse	C	C	C	C	X
Freshwater Catfish (possible species below)					
White catfish	C	C	C	C	X
Brown bullhead	C	C	C	C	X
Yellow bullhead	C	C	C	C	X
Atlantic Cod	R to O	R to O	------	------	
White Perch	C (Moveto deep water)	C	C	C	X
Striped Bass	C (Spawn upstream)	C (Coastal waters)	C	C	X
Grouper/Sea Basses (possible species below)					

Black sea bass	------	C	C	C	
Gag	------	------	O	O	
Sunfish (possible species below)					
Redbreast sunfish	C	C	C	C	X
Bluegill	C	C	C	C	X
Pumpkinseed	C	C	C	C	X
Yellow Perch	C	C	C	C	X
Jack (possible species below)					
Crevalle jack	------	------	O	O	
Horse-eye jack	------	------	R	R	
Blue runner	------	------	O	O	
Yellow jack	------	------	R	------	
Sheepshead	------	------	O	R to O	
Black Drum	------	C	C	C	
Red Drum	------	C	C	C	
Spotted Seatrout	------	C	C	C	

REPTILES/AMPHIBIANS

Taxon	**Winter**	**Spring**	**Summer**	**Fall**	**All Year**
Frog (varying species)	Brumate	C	C	C	X
Snapping Turtle	Brumate	C	C	C	X
Musk or Mud Turtle	Brumate	C	C	C	X
Slider or Cooter	Brumate	C	C	C	X
Diamondback Terrapin	Brumate	C	C	C	X
Box Turtle	Brumate	C	C	C	X
Soft-Shell Turtle	Brumate	C	C	C	X
Snake (varying species)	Brumate	C	C	C	X
Viper (varying species)	Brumate	C	C	C	X

BIRDS

Taxon	**Winter**	**Spring**	**Summer**	**Fall**	**All Year**
Great Blue Heron	C	C	C	C	X
Cormorant (possible species below)					
Double-crested cormorant	C	C	U	C	
Great cormorant	U	O, R	------	O, U	
Shearwater or Petrel (possible species below)					**Rare, usually only seen after tropical storms**
Wilson's storm-petrel					
Sooty Shearwater					
White-faced storm-petrel					

Swan					
Tundra	C	U, O	------	O, C	
Snow Goose	C	O	------	C	
Canada Goose	C	C	C	C	X
Brant Goose	C	U,O	------	U, C	
Dabbling Duck (possible species below)					
Mallard	C	C	C	C	X
American black duck	C	C	C	C	X
American wigeon	C	C, O	R	O, C	
Northern shoveler	U	R	------	O, U	
Green-winged teal	C	O	------	C	
Northern pintail	O	R	------	R, O	
Blue-winged teal	R	U, C	R, O	O	
Ruddy Duck	C	O, R	R	C	
Wood Duck	O	U, C	C	C, U	
Pochard (possible species below)					
Redhead	R, O	------	------	R, O	
Canvasback	R	------	------	R, O	
Ring-necked duck	C, U	R, U	------	O, C	
Greater scaup	U	U, R	------	O, U	
Lesser scaup	C	O, R	------	O, C	
Crane or Rail (possible species below)					
Sandhill crane	------	R	------	R	
Rallidae (possible species below)					
Black rail	U	T, C	C, T	U	
Clapper rail	C	C	C	C	X
King rail	R	R	------	R	
Virginia rail	C	C	C	C	X
American coot	C	C, O	R, O	C	
Sora	R	U, C	------	O, R	
Sandpiper (possible species below)					
Spotted sandpiper	------	O, C	R, O	R, O	
Solitary sandpiper	------	O, C	O	O, R	
Greater yellowlegs	C	C	C	C	X
Willet	C	C	C	C	X
Lesser yellowlegs	R	O, C	C	O, R	
Upland sandpiper	------	R	R	------	
Whimbrel	R	R	O, C	O, R	
Marbled godwit	O	O	R	O	
Semipalmated sandpiper	------	O, C	C	O, R	
Western sandpiper	C	O, R	C	C	

Least sandpiper	------	O, C	C	C, O	
Short-billed dowitcher	C	C, O	C	C	X
Long-billed dowitcher	R	R	R	R	
American woodcock	C	C, O	R	O, C	
Gull (varying species)					
Laughing Gull	R	C	C	C, O	
Ring-billed gull	C	C	U	C	
Herring Gull	C	C	C	C	
Bonaparte's Gull	C	U, R	------	U, C	
Turkey Vulture	C	C	C	C	X
Osprey	R, U	U, C	C	O,R	
Bald Eagle	C	C	C	C	X
Northern Harrier	C	O	U	C	
Red-Tailed Hawk	C	C	C	C	X
Turkey	C	C	C	C	X
Bobwhite	C	C	C	C	X
Great Horned Owl	C	C	C	C	X
Raven or Crow					
American crow	C	C	C	C	X
Fish crow	C	C	C	C	X
Perching Birds (varying species)					
Blue Jay	C	C	C	C	X

MAMMALS

Taxon	Winter	Spring	Summer	Fall	All Year
Opossum	C	C	C	C	X
Eastern Mole	C	C	C	C	X
Eastern Gray Squirrel	C	C	C	C	X
Eastern Fox Squirrel	C	C	C	C	X
Muskrat	C	C	C	C	X
Rat (varying species)	C	C	C	C	X
Ocean Dolphin					
Bottlenose Dolphin	C	C	C	C	X
American Mink	C	C	C	C	X
Raccoon	C	C	C	C	X
River Otter	C	C	C	C	X
White-Tailed Deer	C	C	C	C	X

(Behler and King 1995; Eastern Shore of Virginia National Wildlife Refuge 2012; Lippson and Lippson 2006; Murdy et al 1997; Stokes and Stokes 2013; Webster et al 1985; Williams 2012)

Comparisons Between the Layers of Second Well (JR2158)

When comparing the layers of the Second Well, there are differences and similarities which may provide clues to how the provisioning system was evolving at Jamestown during the initial years following the "starving time" and the establishment of the Martial Laws. During this time livestock began to be reestablished with the animals brought on Lord De La Ware's ship, and later on Dale's and Gates's supply ships. Coinciding with the marriage of Matoaka (Pocahontas) and John Rolfe, this period also includes the end of the first "Anglo-Powhatan" War. This meant, for at least a time, colonists could resume hunting and fishing without the continual fear of being attacked by members of Powhatan's tribe.

Table 31
Comparison of Biomass Percentages for Specific Species
Second Well (JR2158) Layers

Well Layers	H	N	P	U	X	AA
Wild						
Crab	<0.1	<0.1	<0.1	<0.1	------	-----
Sturgeon	5.3	8.8	19.0	14.9	8.8	7.0
Other Fish	3.8	6.3	5.1	4.3	2.0	2.0
Reptiles/ Amphibians	1.0	0.9	0.9	1.0	0.5	0.1
Deer	14.2	21.3	21.7	23.1	18.4	19.2
*Other ID'd W. Mammal	1.7	2.2	1.2	0.9	0.3	------
**ID'd Wild Fowl	4.0	4.1	1.9	2.2	6.5	14.2
Domestic						
Cattle	3.7	6.1	2.9	3.8	7.3	-----
Swine	25.7	23.9	5.3	17.8	27.1	26.1
Sheep/Goat	1.1	0.1	0.6	3.0	2.7	3.1
Horse	------	------	0.1	------	------	-----
Chicken	0.3	0.1	0.2	0.1	0.4	0.2

Notes Regarding Table:
------ = species not present in assemblage
*****Other ID'd W. Mammal = includes just the identifiable species, does not include the categories of Artiodactyla or Indeterminate Medium Mammal bones proportioned in the Bone Summary Charts
******ID'd Wild Fowl = includes just the identifiable species, does not include the Indeterminate Wild Bird category found in the Bone Summary Charts

Overall, the layers of the Second Well (JR2158) represent a critical period in the history of Jamestown. The faunal material from the layers shows a reliance primarily on swine and wild species such as deer, raccoon, opossum, fish, and wild fowl. The small percentages of beef in the layers suggests the settlers were still receiving and consuming imported barreled beef while adhering to the Martial Laws as they conserved their live cattle to repopulate the herds. The faunal assemblages also suggest the settlers were killing raptors for what purpose is still unclear. Further analysis of the remaining layers of the well may provide some additional insight into the provisioning system that was evolving during the initial years following the starving period. The following paragraphs will take a closer look at the biomass results for some of the identified wild and domestic species. The results will then be examined to look for similar patterns or distinct differences between the layers.

Wild Species

Crustacean

As Table 31 shows the biomass results for the six layers of the Second Well (JR2158) show that calcined blue crab remains were only found in the top four layers of the well. Although crab contributes less than 0.1% in each of these four layers, it is interesting to note that in Layers H and U less than 30 shell fragments were found in each layer. Greater amounts were found in Layer N with 211 fragments and in Layer P with 899 fragments.

Fish

For the comparison of fish biomass results, the sturgeon remains were recorded separately from the other fish remains (Table 31). By separating the fish results in this manner, it is clear that in Layers P and U, sturgeon contribute the highest amounts to the biomass at 19.0% and 14.9%. The other layers have sturgeon supplying between 5.3% to 8.8% of the biomass. It is not clear if these differences indicate a seasonal deposit of sturgeon which would have typically been more available during the spring and fall runs. These layers may also represent some of the early attempts to export sturgeon to England. It was during this time in 1610, efforts were made to pickle sturgeon and preserve caviar so it could successfully make the long voyage to England. To help facilitate this endeavor and to ensure no one was stealing the products, one of the Martial Laws from 1610 directly mentions dressers of sturgeons and requests they "shall give a just and true account of all such fish as they shall take by day or night…and bring unto the Governor: As also of all such kegges of Sturgeon or Caviar" (Strachey 1612). Penalties for not obeying the law included "loosing his eares" for the first offence, condemned to the galley for a year as a result of second offence, and three years in the galley for a third offence (Strachey 1612).

The biomass results for the "other" fish identified in the layers, show that the lowest layers of the well have the least amount with fish only contributing 2.0%. The remaining layers have fish ranging from 3.8% to 6.3% of the biomass totals. Overall, the differences between the biomass results for the "other" fish category are not as dramatically different as the sturgeon contributions to the biomass.

Reptiles/Amphibians

Biomass results for reptiles and amphibians are very similar in the top four layers analyzed for this report (see Table 31). While those layers show reptiles/amphibians making up approximately 1.0% to the biomass, the lower two layers show reptiles/amphibians making up only 0.5% and 0.1% to the biomass totals. It must be kept in mind Layer AA is an arbitrary level not a layer reflecting changes in soil deposition. In all of the layers, turtles, including snapping turtles, box turtles, water turtles, soft-shell turtles, and diamond back terrapins, were the primary contributors to this category.

Wild Mammals

When looking at the biomass results for wild mammals, deer remains are shown separately from the other identified wild mammal category, which includes raccoon, opossum, squirrel, muskrat, dolphin, otter, and mink (see Table 31). Layer AA (arbitrary layer) does not have any "other" identified wild mammals, while Layers U and X have minimal contributions of "other" mammals at 0.9% and 0.3% of the biomass totals. The top three analyzed layers have "other" wild mammals contributing higher amounts ranging from 1.2% to 2.2%. This suggests in the earlier layers, wild mammals (other than deer) were not being sought out as they were in the upper layers. The increase in small mammals in Layers H, N, and P may be reflective of the time when relationships with the Virginia Indians had improved with the ending of the first Anglo-Powhatan War. The ending of the war probably allowed the settlers to hunt more frequently and openly without the fear of being attacked.

The biomass results for deer indicate venison made up a substantial portion of the settler's diet, following pork. The bottom five layers have deer contributing between 19% and 23% to the diet, while Layer H only shows deer making up 14% of the biomass totals. The decrease in deer in Layer H may be a result of adding "other" wild mammals to the diet or an indication that swine was becoming more established.

An interesting observation from the deer bones can be seen in the element distribution data from the Second Well (JR2158). Initially, the deer elements from all the layers of the Second Well (JR2158) were combined and compared with deer element distributions complied from previously analyzed Jamestown faunal assemblages. As Table 32 shows, the Second Well (JR2158) produced a significant number of deer remains when contrasted to the other assemblages. Although there are significant differences in the total amount of deer elements for each time period, there are only slight differences in the overall percentages of deer elements for the "pre-starving time," "starving time," and "post starving time." In all of these combined assemblages, body elements make up the majority of the remains in percentages higher than what is seen in a normal distribution pattern. For the head and feet elements, while they differ in importance between the three assemblages, overall, they percentages are close to each other indicating all parts of the animal were present.

Table 32
Deer Element Distribution % by NISP
Second Well (JR2158) Compared to Other Jamestown Assemblages

Normal Element Distribution	Pre-Starving Time Assemblages 1607-1610		Starving Time Assemblages 1610		Post Starving Time 2nd Well Assemblages 1611-1616		Stability Herds Assemblages Post 1620s	
	NISP	%	NISP	%	NISP	%	NISP	%
Head (29.7%)	20	17.1	26	26.3	312	22.1	8	40.0
Body (42.2%)	74	63.2	55	55.6	775	55.0	6	30.0
Feet (28.1%)	23	19.7	18	18.2	322	22.9	6	30.0
TOTAL	117	100.0	99	100.0	1409	100.0	20	100.0

When the deer remains from the Second Well (JR2158) are sorted by layer and then by individual element, there are some similarities and differences between the assemblages. As Table 33 shows, body elements were the most frequently identified deer remains, with vertebrae bones being the most numerous. Fragmented bones from the skull make up some of the highest NISP numbers for Layers P, U, X, and AA, while tooth fragments account for 14.9% of the deer elements from Layer H. Phalanges from the feet of deer are some of the most frequently identified elements from Layers H, N, and X. For the most part, all elements from deer are represented in each layer of the well with varying percentages. One noticeable exception to this is the category of metacarpals and metatarsals, which are bones making up the front and back lower legs of deer. These elements are nonexistent or are only represented by one or two bones in Layers H, P, U, X, and AA (highlighted in blue). However, in Layer N, these elements are present in relatively high numbers. The bones are complete or predominately large fragments and represent at least four adult deer (see Figures 14 and 15).

Figure 14. Deer Metatarsals, Layer N
(Photo by Andrews 2021)

Figure 15. Deer Metacarpals, Layer N
(Photo by Andrews 2021)

In studies of meat and marrow yields for white-tailed deer bones, metacarpals and metatarsals rank the lowest in meat utility indexes. On marrow utility indexes, metatarsals typically rate the third or fourth most important element following the tibia, femur, and humerus. The metacarpal, on the other hand, ranks as one of the lowest producers of marrow (Jacobson 2000; Madrigal and Holt 2002). Knowing these elements were not productive for meat and varying in their importance for producing marrow, it is not clear why these elements are found in Layer N, and not in the other layers of the well. Could they represent a single hunting expedition where they brought back the complete body of the deer, as opposed to bringing back just parts of the animal butchered at the kill site? Could they represent a single trading expedition with local tribes, who kept the best parts of the animal for themselves? A more detailed analysis of the deer remains represented in the Second Well (JR2158) may provide some additional information on the dietary importance of deer in the diet and how the different elements may have ranked in their consumption.

Table 33
Deer Element Distribution by NISP
Comparison Between Layers of the Second Well (JR2158)

Element Type	LAYER H		LAYER N		LAYER P		LAYER U		LAYER X		LAYER AA	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Skull	4	2.7	9	3.1	118	17.4	20	12.4	10	11.6	9	19.1
Antler	4	2.7	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0
Mandible	5	3.4	5	1.7	23	3.4	7	4.3	1	1.2	6	12.8
Tooth	22	14.9	14	4.8	38	5.6	9	5.6	4	4.7	3	6.4
Vertebra	21	14.2	31	10.7	111	16.4	20	12.4	10	11.6	8	17.0
Rib	6	4.1	10	3.5	47	6.9	10	6.2	3	3.5	2	4.3
Innominate	10	6.8	12	4.2	24	3.5	8	5.0	3	3.5	2	4.3
Scapula	1	0.7	9	3.1	19	2.8	16	9.9	11	12.8	0	0.0
Humerus	5	3.4	10	3.5	29	4.3	7	4.3	2	2.3	5	10.6
Ulna	0	0.0	12	4.2	36	5.3	12	7.5	0	0.0	0	0.0
Radius	2	1.4	14	4.8	23	3.4	11	6.8	4	4.7	1	2.1
Carpal	3	2.0	9	3.1	16	2.4	7	4.3	2	2.3	1	2.1
Metacarpal	1	0.7	18	6.2	0	0.0	0	0.0	2	2.3	0	0.0
Femur	14	9.5	14	4.8	48	7.1	8	5.0	6	7.0	2	4.3
Tibia	10	6.8	16	5.5	45	6.6	6	3.7	8	9.3	2	4.3
Tarsal	7	4.7	32	11.1	46	6.8	6	3.7	3	3.5	3	6.4
Metatarsal	0	0.0	22	7.6	0	0.0	2	1.2	0	0.0	0	0.0
Metapodial	7	4.7	3	1.0	0	0.0	1	0.6	2	2.3	0	0.0
Phalange	24	16.2	37	12.8	28	4.1	8	5.0	13	15.1	3	6.4
Sesamoid	0	0.0	5	1.7	5	0.7	1	0.6	0	0.0	0	0.0
Carpal/Tarsal	0	0.0	1	0.4	2	0.3	0	0.0	2	2.3	0	0.0
Patella	1	0.0	3	1.0	9	1.3	0	0.0	0	0.0	0	0.0
Sacrum	1	0.7	2	0.7	11	1.6	2	1.2	0	0.0	0	0.0
Total NISP	148	100	289	100	678	100	161	100	86	100	47	100

Wild Birds

Overall, six to eighteen wild bird species have been identified in each assemblage, making up between 2% and 14% of the biomass totals (see Table 31). Layer AA has the greatest percentage of wild fowl at 14%, with over half of the wild fowl (7.5%) attributed to wild geese. It must be kept in mind that Layer AA is an arbitrary level so it is not clear if the geese bones are from the same deposition. However, it is interesting to note that Layer X, also has a high percentage of geese, making up at least 3.5% of the biomass totals. The remaining layers show geese contributing only between .7% and 2.5% of the biomass totals. Although there are differences in the individual percentages, it is clear the settlers at Jamestown had a reliance on waterfowl such as swans, ducks, geese, and shorebirds. Turkey and various perching birds were also important in the diet as they were all identified in the well layers.

Raptors are another group of wild birds identified in the layers of the Second Well (JR2158). The higher layers (H, N, P, and U) of the well show raptor remains making up between .1% to .7% of the biomass, while in the lower layers (X and AA), raptor remains account for 2.2% and 3.3% of the biomass totals. Although these may seem like low percentages, when you compare these numbers to what has previously been found in other Jamestown assemblages, it does raise some questions.

As Table 34 shows, raptor remains are included in the assemblages dating from before the "starving time" and during the "starving time." Knowing the desperation for provisions during these times, the raptor remains may represent a possible source of food in the first years of settlement. While the raptors, particularly vultures, would have been considered taboo food to the Jamestown settlers, the presence of butchered horse and dog remains in some of the same assemblages supports the historical documentation of the English consuming animals they would have previously considered to be off-limits (Bowen and Andrews 2000).

When the layers of the Second Well (JR2158) are combined together, it becomes evident the well not only has a high number of raptor remains, but also a diverse list of raptor species. The most frequently identified raptor species is the bald eagle, found in every layer of the well. A total of 67 bald eagle bones have been identified with 14 from Layer H, 10 from Layer N, 10 from Layer P, 5 from Layer U, 16 from Layer X, and 12 from Layer AA. Another frequently recorded species is the turkey vulture which is found in Layers H, N, X, and AA. At least two of the bald eagle bones and one of the turkey vulture bones from Layer N have visible cut marks on the surface of the bones.

Table 34
NISP and Biomass % for Raptors from
Second Well (JR2158) and Other Jamestown Assemblages

	Pre-Starving Time	Starving Time	Post Starving Time	Stability Herds
	Assemblages	Assemblages	2nd Well Assemblages	Assemblages
	1607-1609	1610	1611-1616	Post 1620
	NISP/Biomass %	NISP/Biomass %	NISP/Biomass %	NISP/Biomass %
Hawk, Eagle, or Vulture	1 NISP/<0.1 Bio.	—	20 NISP/<0.1 Bio.	—
Hawk or Eagle	7 NISP/0.1 Bio.	1 NISP/<0.1 Bio.	28 NISP/<0.1 Bio.	—
Bald Eagle	—	1 NISP/0.1 Bio.	67 NISP/0.6 Bio.	—
Hawk	—	2 NISP/<0.1 Bio.	—	—
Red-Tailed Hawk	1 NISP/<0.1 Bio.	—	1 NISP/<0.1 Bio.	—
Northern Harrier	—	—	1 NISP/<0.1 Bio.	—
Osprey	4 NISP/0.1 Bio.	—	2 NISP/<0.1 Bio.	—
Turkey Vulture	3 NISP/0.1 Bio.	—	24 NISP/0.1 Bio.	—
Owl	—	—	2 NISP/<0.1 Bio.	—
Great Horned Owl	—	—	1 NISP/<0.1 Bio.	—
TOTALS	**16 NISP/0.3 Bio.**	**4 NISP/0.1 Bio.**	**124 NISP/0.8 Bio.**	**0 NISP/0.0 Bio.**

(Andrew 2008; Bowen and Andrews 2000; 2013)

The significant presence of raptor remains, including some with cut marks, raises some interesting research questions. With the Martial Laws constricting the type and amount of provisions being given to the Jamestown settlers after the "starving time," could raptors served as another source of food? While documentary evidence suggests this was still a time of food shortages, there is no first-hand account of the settlers consuming the "taboo" species eaten during the "starving time." Also, in the well assemblages there are no butchered horse or dog remains as was found in assemblages dating from the "starving time." If this was the case an argument could be made that the settlers used the raptors as a food source.

Could the settlers have acquired these birds for other purposes such as using their bones for tools or using their feathers for trading with the Indians? In his descriptions of the Virginia Indians, William Strachey mentions how birds were used in decorations worn by the Indians:

> Many wear the whole skin of a hawk stuffed with the wings abroad, and buzzards' or other fowls' whole wings…Their ears they bore with wide holes commonly two or three, and in the same they do hang chains of stained pearls, bracelets of white bone, or shreds of copper beaten thin and bright and wound up hollow, and with a great pride certain fowls' legs, eagles, hawks, turkeys, etc… (Strachey in Haile 1998:632).

While the raptor feathers and bones could have been used as trading items, raptor remains in the Second Well (JR2158) may simply represent birds killed for being a nuisance or for competing for the same food resources as the Jamestown settlers. Fish, domestic fowl, small wild mammals, and immature domestic mammals would have been easy prey for raptors such as eagles and large hawks. With the settlers trying to reestablish their swine, cattle, sheep/goat, and domestic fowl, it may have been advantageous for the Jamestown inhabitants to kill local predators such as wolves and raptors.

Domestic Species

Domestic Fowl

For most of the layers, domestic fowl, including chicken and goose, contribute less than 2.1% to the overall biomass totals. The only exception to this is Layer AA which has a total of 5.4% attributed to domestic fowl (see Table 31).

Domestic Mammals

For the livestock values, the average contribution to the biomass is 38.3% . The two layers which stand out for being distinctive are Layer P with only 18.5% attributed to livestock and Layer X with 49.6%. When looking at the contributions of the individual domestic species to the biomass, it is clear beef was not a significant contributor to the diet of the settlers in any of the well layers. Pork, on the other hand, does make a significant contribution in all of the layers with the exception of Layer P, which only had swine contributing 5.3% to the biomass (see Table 34). Overall, these percentages suggest the settlers may have been trying to preserve the cattle they had in an attempt to reestablish their herds. Swine were easier to maintain and multiplied quickly, allowing them to be a suitable choice for their main source of meat, along with deer. The Martial Laws of 1610 also support this idea of preserving the herds, which states:

"Sithence we are not to bee a little careful, and our young Cattell, & Breeders may be cherished; that by the preseruation, and increase of them, the Colony heere may receive in due time assure and great benefits, and the adventurers at home may be eased of so great a burden, by sending unto us yearly supplies of this kinde, which now heere for a while, carefully attended, may turne their supplies unto us into provisions of other qualities, when of these wee shall be able to subsist our selves…" (Strachey 1610).

Table 35
Comparison of Livestock Biomass %
Second Well (JR2158)

	Cow	Swine	Sheep/Goat
Second Well, Layer H	1.6	25.7	1.1
Second Well, Layer N	6.1	23.9	0.1
Second Well, Layer P	2.9	5.3	0.6
Second Well, Layer U	3.8	17.8	2.8
Second Well, Layer X	7.3	27.1	2.7
Second Well, Layer AA	0	26.1	3.0

Table 36
Cattle Element Distribution % by NISP
Second Well (JR2158) Compared to Other Jamestown Assemblages

	Pre-Starving Time Assemblages 1607-1610		Starving Time Assemblages 1610		Post Starving Time 2nd Well Assemblages 1611-1616		Stability Herds Assemblages Post 1620s	
Normal Element Distribution	NISP	%	NISP	%	NISP	%	NISP	%
Head (29.7%)	3	7.1	31	18.5	3	3.5	72	29.3
Body (42.2%)	30	71.4	115	68.9	78	92.8	83	33.7
Foot (28.1%)	9	21.4	21	12.6	3	3.5	91	37.0
TOTAL	42	100.0	167	100.0	84	100.0	246	100.0

(Andrew 2008; Bowen and Andrews 2000; 2013)

Other evidence from the faunal data to support this idea of preserving and expanding the cattle herds, can be seen in the cattle element distribution patterns from the layers of the well. When the well cattle data is compared to the cattle element distribution data from other Jamestown assemblages, it is evident the settlers were undoubtedly consuming barreled beef (see Table 35). As discussed in the element distribution section of this report (see page 120), when the whole animal is being consumed it is reflected in the faunal remains which show elements in percentages similar to what is seen in a normal skeletal pattern. In the “pre-starving time,” “starving time,” and “post starving time” assemblages, body elements dominate the cattle remains with significantly lower head and foot elements, suggesting these are probably the remains of barreled beef sent as provisions to Jamestown. By the time cattle herds are finally established in the mid-1620s, it can be seen in the faunal remains which show a more normal element distribution pattern. This pattern indicates the colonists were raising their own cattle and had access to all parts of the animal for consumption.

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APPENDIX A:
Timeline For Jamestown:

-Important Dates Related to Government and Main Events at Jamestown
-Important Dates Related to Virginia Indians
-Important Dates Related to Livestock and Provisions at Jamestown

Important Dates Related to Government and Main Events at Jamestown

1607:

-May 14/Arrival at Jamestown
-13 man Council is set up (Smith, Newport, Ratcliffe, Kendall, Wingfield, Gosnold, Hunt, J. Marten, R. Marten) Wingfield becomes President of Council (Smith in Haile 1998:145)

June 22/ Newport leaves for England, leaving provisions (Smith in Haile 1998:147)

Summer-Early Fall /Half of original settlers have died, mostly from disease (Smith in Haile 1998:149)

September/ Wingfield replaced with Ratcliff as President of Council at Jamestown (Smith in Haile 1998:149)

October 8/Newport leaves England with 2 supply ships (Perkins in Haile 1998:132)

End of 1607/ Only 38 settlers remainin (Smith in Haile 1998:338)

Important Dates Related to Virginia Indians

1607:

-May/Newport and Smith meet Powhatan Indians and Openchancanough (Smith in Haile 1998: 146)
-May/Hostilities between colonists and Virginia Indians. 200 Indians attack resulting in death of one settler and several Indians
(Smith in Haile 1998:147)

-June 8/Fort is attacked by Paspaheghs and other tribes but Powhatan tribes supply colonists with food (Smith in Haile:148)

November/ Smith trades with Virginia Indians for corn (Smith in Haile 1998:154)

December/Smith and 2 men travel up Chickahominy River to look for Indians willing to trade/supply colony with food. They are captured by Opechancanough (brother to Chief Powhatan) (Wingfield in Haile 1998: 195) They are taken to Powhatan, other men killed, Smith "saved" by Matoaka (Pocahontas)
(Smith in Haile 1998:239)

Important Dates Related to Livestock and Provisions at Jamestown

1607:

-according to Smith possibly 3 swine and chickens were brought with colonists
-swine taken to Hog Island to forage (Smith in Haile 1998: 319)

June 22/ Newport leaves for England, leaving provisions for 13 to 14 weeks (Smith in Haile 1998:147)

Summer/ Smith comments "only of sturgeon we had great store" (Smith in Haile 1998:148)
"From May to September, thos that escaped lived upon sturgeon and sea crabs (Smith in Haile 1998:230)

Late Summer-Early Fall/Smith reports Indians bring corn and bread (Smith in Haile 1998:148-149)
Smith reports "there came such abundance of fowls into the rivers as greatly refreshed our weak estates" (Smith in Hail 1998:149)
Smith remarks they try fishing but "could not effect by reason of the stormy weather" (Smith in Haile 1998:149)

Important Dates Related to Government and Main Events at Jamestown

1608:

Jan. 2/Smith returns to find most of the colonists trying to leave and return to England but one of Newport's supply ships (*John and Francis*)comes with additional 100 colonists. Other supply ship is lost (*Phoenix*) (Perkins in Haile 1998:133)

Jan.7/Fires destroys many buildings and recently brought provisions (Perkins in Haile 1998:133)

April/ Newport and *John and Francis* sails for England (Smith in Haile 1998:173). Lost 2nd ship *(Phoenix*) arrives with 40 more colonists and supplies (Smith in Haile 1998:249)

June/ *Phoenix* returns to England (Smith in Haile 1998:142)

September/Smith elected president to Council. Later says if you do not work you will not eat (Smith in Haile 1998:278, 314)

September/Newport arrives with Second Supply of provisions, 70 colonists (1st women) (Smith in Haile 1998:292)

December/ Newport leaves for England with "tryals of Pitch, Tarre, Glasse, Frankincense, Sope Ashes…" in an effort to find products to export (Smith in Haile 1998:287)

Important Dates Related to Virginia Indians

1608:

Jan./Powhatan provides food for colony and teaches settlers how to catch fish (Perkins in Haile 1998: 134)

Feb./Smith, Newport + others meet with Powhatan to exchange hostages and trade for food. Thomas Savage remains to live with Powhatans and Namontack goes with English to live at Jamestown (Smith in Haile 1998:168)

September/ Newport brings Chief Pow. a ceremonial crown to symbolize subordination to English King. Chief Pow. refuses. Relations with Powhattan begin to deteriorate (Smith in Haile 1998:282)

December/Settlers attempt to trade with local NA but Chief Powhatan has told them to refuse (Smith in Haile 1998:285)

Important Dates Related to Livestock and Provisions at Jamestown

1608:

Smith comments "3 sowes increased to 60 and they had near 500 chickens brought up themselves without having any meat given them. But the hogs were transported to Hog Isle, where also we built a blockhouse…" (Smith in Haile 1998:319)

Winter / an abundance of wild fowl and fish frozen in the river (Perkins in Haile 1998:133)

Jan.7/Fire destroys provisions (Perkins in Haile 1998:133)

Perkins reports there is "abundance of pasturage for any kind of cattle, pig, and goats" (Perkins in Haile 1998: 134)

Winter/ Powhatan send Smith each week deer, bread, raccoon, corn (Smith in Haile 1998:165)

April/ Powhatan send sends Newport (?) turkeys in exchange for swords (Smith in Haile 1998:173)

Important Dates Related to Government and Main Events at Jamestown

1609:

May/ Supply ships leave England (Archer in Haile 1998: 350)

May 23/ King James I issues Second Charter to Virginia Company and replaces governing council with a Governor (Haile 1998:15)

June 2/ 3rd supply with 9 ships and 500-600 colonists, livestock, etc. leaves England (Smith in Haile 1998:327)

July 25/ Supply ships run into hurricane, the *Sea Venture* shipwrecks at Bermuda (Strachey in Haile 1998:414)

August/ Ships that survive hurricane arrive at Jamestown, w/ 300 additional people

-Summer/ Smith sends some men out to live elsewhere due to food shortage including Point Comfort, upriver, and down river (Smith in Haile 1998:320)

September/ George Percy elected president of Council (Smith in Haile 1998:333)

Important Dates Related to Virginia Indians

1609:

January/ Smith meets with Chief Powhatan. He violates custom by not disarming in Powhatan's presence. They attempt to have Smith killed (Smith in Haile 1998:302)

-Colonists and Virginia Indians continue through the year to raid and ambush each other

September/ Martin and men go to Nansemond territory to try and purchase island. Chief's son is killed, two English killed, Nansemond's town and crops burned (Percy in Haile 1998:501)

September/Men living up the upriver and downriver from Jamestown continue to clash with local Virginia Indian groups (Percy in Haile 1998:502)

September/ Smith attempts to buy fortified town of Powhatan, but the deal fails (Smith in Haile 1998:330)

Important Dates Related to Livestock and Provisions at Jamestown

1609:

August/ First horses arrive with third supply, "Here we took into the *Blessing* (being the ship wherein I went) six mares and two horses" (Archer in Haile 1998:350

October/Smith returns to England after being injured by gunpowder (Smith in Haile 1998:332) October/ Fort Algernon estabished at Point Comfort (Strachey in Haile 1998:418)	Fall/ Chief Powhatan moves his capital near Chickahominy River, away from English (Strachey in Haile 1998:615) October/ Ratcliff establishes new fort in the territory of the Kecoughtan tribe (Percy in Haile 1998:503)	October/ When Smith leaves for England he records, "6 mares and a horse, 5 or 600 swine, as many hens, goats, sheep, and horses at Jamestown" (Smith in Haile 1998:335)
	November/ Powhatans attack James Fort, trapping about 300 settlers with little food (Horn 2005:175)	
	Late Fall/Ratcliffe and men lured to Orapax with promise of corn, instead they are ambushed and killed by Powhatans (Strachey in Haile 1998:441)	
Winter 1609-1610/ Starving Time	Percy writes "To eat, many of our men this starving time did run away unto the savages, whom we never heard of after" (Percy in Haile 1998:506)	Smith writes about Starving Time…"Yea, even the very skin of our horses – nay, so great was our famine.." (Smith in Haile 1998:340) Smith writes, "As for our corn, provision, and contribution from the savages we had nothing but mortal wounds with clubs and arrows. As our hogs, hen, goats, sheep, horse, or what lived, our commanders, devoured" (Smith in Haile 1998:339) Percy writes, "A world of miseries ensued, as the sequel will express unto you, insomuch that some, to satisfy their hunger, have robbed the store, for the which I caused them to be executed. Then having fed upon horses and other beasts as long as they lasted, we were glad to make shift with vermin, as dogs, cats, rats, and mice. All was fish that came to net to satisfy cruel hunger, as to eat boots, shoes, or any other leather some could come by" (Percy in Haile 1998:505)

Percy recovering from sickness travels to Fort Algernown and finds they were feeding their hogs “crab fishes” to have enough food to return to England (Percy in Haile 1998:506)

Important Dates Related to Government and Main Events at Jamestown

1610:

By Spring/ 75% of fort's population is dead from starvation and disease

Early May/ Seige of Powhatan is lifted, 60 survivors in fort
May/ The shipwrecked *Sea Venture* and other ships arrive from Bermuda with supplies and new leaders for Jamestown (Gates, Somers, and Strachey)
May 24/ Gates implements martial law with strict codes of behavior and severe punishments (Haile 1998:28)

June 7/ Gates decides to abandon the Fort due to lack of supplies (Percy in Haile 1998: 508)
June 8/ As Gates and others are leaving, the meet the supply ship with Lord De La Warr, who makes them return (Percy in Haile 1998:508)
June 9/ Lord De La Warr lands at Jamestown (Smith in Haile 1998:342)
June 10/ De La Warr orders cleanup of Fort and establishes Martial Law (Haile 1998:27)
June 10/ De La Warr sends fishermen to bring back fish and Sommers to Bermuda to bring back swine -not a successful trip (De La Ware in Haile 1998:466)

Important Dates Related to Virginia Indians

1610:

June/ Strachey writes that when they arrival to Jamestown, "And it is true the Indian killed as fast without, if our men stirred but beyond the bounds of their blockhouse, as famine and pestilence did within…" (Strachey in Haile 1998:419

Martial Law/ No man of what condition soever shall barter, trucke, or trade with the Indians, except he be thereunto appointed by lawful authority Upon paine of death (Martial Laws 1610)

Important Dates Related to Livestock and Provisions at Jamestown

1610:

May/ Strachey writes about time in Bermudas, "We had knowledge that there were wild hogs upon the island at first by our own swine preserved from the wreck and brought to shore. For they straying into the woods, an huge wild boar followed down to our quarter, which at night was watched and taken..." "…our people would go ahunting with our ship dog, and sometimes bring home thirty, sometimes fifty boars, sows, and pigs in a week alive (Strachey in Haile 1998:399-400)

June/ Strachey writes, "For we had brought from Bermudas no greater store of provisions (fearing no such accidents possible to befall the colony here) than might well serve one hundred and fifty for a sea voyage; and it was not possible at this time of the year to amend it by any help from the Indians. For besides that they at their best have little more than from hand to mouth…Nor was there at the fort, as they whom we found related unto us, any means to take fish, neither sufficient seine nor other convenient net; and yet, if they had, there was not one eye of sturgeon yet come into the river (Strachey in Haile 1998:419)

Martial Laws/ “Sithence we are not to bee a little carefull, and our young Cattell, and Breeders may be cherished, that by preservation, and increase of them…”
“no man shall dare to kill, or destroy any Bull, Cow, Calfe, Mare, Horse, Colt, Goate, Swine, Cocke, Henne, Chicken, Dogge, Turkie, or any tame Cattel, or poultry of what condition soever; whether his owne, or appertaining to another man, without leave from the Generall, upon paine of death…” (Martial Laws 1619)

June 10/ Del La Warre,” I sent fishermen out to provide fish for our men, to save our provision, but they had all but ill success. Likewise I dispatched Sir George Sommers back again to the Barmudas, the good old gentleman out of his love and zeal not motioning but most cheerfully and resolutely undertaking to perform so dangerous a voyage and, if it please God he do safely return, he will store us with hog’s flesh and fish enough to serve the whole colony this winter (De La Warr in Haile 1998:466)

June-July/Council of Virginia publishes a report that all is well at Jamestown, “our transported cattell, as horses, kine, hogs, and goats do thrive most happily; which is confirmed by a
a double experiment; one, of Sir Ralph Lane, who brought Kine from the West Indian Island, the other of our Colony, who need take no other care of them, but least they should straie too fare or be stolen” (Council of Virginia 1610)

July 7/ Letter to Virginia Company, ""And our people together with the Indians not to friend had the last winter destroyed and kill'd up all our hogs, insomuch as of five or six hundred, as it is not a hen nor a chick in the fort; and our horses and mares they had eaten with the first.." (Letter to Virginia Company in Hail 1998:459)

July 9/ After settler is killed near Point Comfort, Gates and men attack the town of Kecoughtan, killing some inhabitants and driving the others off (Percy in Haile 1998:508)
July/Gates orders Powhatan to give back any stolen weapons or captives or they will take them by force (Percy in Haile 1998:509)

Chief Powhatan continues to forbid trading with the English and tells them to stay in Fort or leave (Strachey in Haile 1998:424 and 436)
July/ Gates returns to England taking with him a Virginia Indian Chief and his son (Strachey 1998:438)

August 9/ Percy leads attack on Paspahegh town. Burn it down, destroy cornfields, take queen and children, later executes them (Percy in Haile 1998:510)

Important Dates Related to Government and Main Events at Jamestown

1611:

March 28/ De La Warr leaves for England leaves Percy in charge, only 150 settlers left due to disease (Smith in Haile 1998:899)

May 12/ Dale (new Deputy Governor) arrives with 300 mean, armor, and provisions (Smith in Haile 1998:899)

June/ At Point Comfort the English capture three Spanish including Don Diego de Molina. They are held as prisoner (Accounts of 1611 in Haile 1998:540)

August 2/ Gates returns with 280 settlers and livestock (Smith in Haile 1998:899)

August 17/ Dale writes in a letter, "For the two plantations, the on at Arsahatacks, the other at the head of the Falls upon the main, of Tanx Powhatan's land, do so nearly neighbor all the chief and only variety and change of towns and houses belonging to the Great Powhatan as either he would join friendship with us or will leave then to our possessions of his country, and thereby leave us in security. Upon them we might nourish our own breeders, and hunt and fowl upon the land, and

Important Dates Related to Virginia Indians

1611:

June/ Dale leads campaign against Nansemond Indians, burning houses, cutting cornfields, taking captives (Percy in Haile 1998:514)

Important Dates Related to Livestock and Provisions at Jamestown

1611:

May 12/Dale arrives with more people and "his provisions for them of such quality for the most part as hogs refused to eat, some whereof were sent back to England to testify the same (Smith in Haile 1998:899)

May 19/Dale describes Jamestown and states, "I found here likewise no corn set, some few seeds put into a private garden or two, but the cattle, cows, goats, swine, poultry, etc. to be well and carefully on all hands preserved, and all in good plight and liking." He proposes to build "a stable for our horses…a sturgeon house…a blockhouse to prevent the Indians from killing our cattle, a house to be set up to lodge our cattle in the winter, and hay to be appointed in his due time to be made…" (Dale in Haile 1998:523)

June 25 1611/ De La Warr reports to Council of Virginia, " "…the Cattell already there, are much increased, and thrive exceedingly with the pasture of that Country: The Kine all this last Winter though the ground was covered with Snow, and the season sharpe, lived without other feeding than the grass they found with which they prospered well, and many of them readie to fall with Calve; Milke being a great nourishment and refreshing to our people…but when it shall please God that Sir Thomas Dale, and Sir Thomas Gates, shall arrive in Virginia with their extraordinary supply on one hundred kine and two hundred swine…" (De La Warr in Haile 1998:531) fish in the rivers, and plant our corn….And upon the arrival of those 2000 men, may they be here before next April, though sent at two several times, if but sent hither furnished with six month' provision of corn, I would never after charge the Company for any commodity or supply in that kind again for them so long as they stay'd in the country" (Dale in Haile 1998:556)

<ins>September/</ins> Dale establishes with 350 men the settlement of Henrico, near falls of James River (Smith in Haile 1998:900)

<ins>September/</ins> Dale skirmish with local tribes near Henrico (Percy in Haile 1998:517)

<ins>November/</ins> Spanish report about Jamestown to their king, "They have brought to this colony 100 cows, 200 pigs, 100 goats, and 17 horses and mares…for August they expected four more ships with some people and a large quantity of cattle, and all under the care of Don Thomas Gates" (Accounts of 1611 in Haile 1998:540)

Important Dates Related to Government and Main Events at Jamestown

1612:

March 12/ King James I renew the charter for Virginia Company and extends colony's boundaries to Bermuda. Colony is more self-governing (Haile 1998:16)

April 22/ Percy returns to England (Percy in Haile 1998:518)

John Rolfe exports first tobacco (Hamor in Haile 1998:820)

Important Dates Related to Virginia Indians

1612:

Important Dates Related to Livestock and Provisions at Jamestown

1612:

Important Dates Related to Government and Main Events at Jamestown

1613:

Important Dates Related to Virginia Indians

1613:

April/ Matoaka (Pocahontas), daughter of Chief Powhatan is kidnapped by Argall and held for ransom at Jamestown. Powhatan releases some prisoners and offers corn, but English want their stolen weapons and tools (Hamor in Haile 1998:802-806)

Important Dates Related to Livestock and Provisions at Jamestown

1613:

May 13/ "We also discovered a multitude of islands bearing good meadow ground and, as I think, salt might easily be made there is there were any ponds digged, for that I found salt kerned where the water had overflown in certain places" (Argall in Haile 1998:756)

June 10/ Dale writes possibly to the Council of Virginia, "Every man is to have a sow of the colony's and to keep her as his own for v years; and he is to have to the number of 4 female swine to bring pigs, so that he is to have all the male pigs every year to kill for his own provision; and the female swine of those 4 sow are for the colony to dispose to other men as they shall come over; so that every man shall kill 12 swines every year for his provisions, and at the 5 years' end he shall have vi sow given him forever. As so soon as goats can be gotten from the Indies or increase here, every man is to have 2 female goats for himself" (Dale in Haile 1998:778)

Dale continues…."Kine we have received some, but of the worst sort and condition you can imagine; and among the swine which they have sent us, we found at least xx *spay'd sows*! These things be monstrous!....How often have I written for 100 she-asses, which, as I have said, you know for 6 or 7 crowns the head they best may be had. These beasts with a few horses would do us an infinite pleasure to bear our burdens, to draw our carriages, and to plow our grounds for us" (Dale in Haile 1998:780)

Important Dates Related to Government and Main Events at Jamestown

1614:

Feb./ Gates leaves Va., leaving Dale as deputy gov. (Percy in Haile 1998:508)

April 5/ Matoaka (Pocahontas) marries John Rolfe at Jamestown, ending the First Anglo-Powhatan War (Whitaker in Haile 1998:848)

June 14/ Don Diego de Molina (Spanish prisoner) sends letter and states, "I have lived these three years with these pooe people, held captives by their masters – I look upon them as my brothers whose sorrows I feel more than my own, because living in their midst and seeing their sufferings, they look me in the face and ask,What is the King of Spain doing? Where is his mercy? Why does he not show it to so many unfortunate ones by releasing us from our chains or by cutting off all our heads…." (Diego de Molina in Haile 1998:790)

Important Dates Related to Virginia Indians

1614:

March/ Powhatan not responding to ransom, although he did not use the tools and weapons, "it delighted him to view and look upon"….three months later, he returned seven men who each had a broken musket and the message he would give them 500 bushels of corn for his daughter. English want remaining stolen arms and refuse his offer (Hamor in Haile 1998:804)

Dale and 150 men attack villages, burning houses and killing some several Powhatans (Hamor in Hail 1998:806)

Summer/ After the end of the first Anglo-Powhatan War, the Chicohominies also made peace with the English. They promised to become Englishmen and were told to "never kill any of our men or cattle. But if either our men or cattle should offend them or run to them, they should bring them home again, and should receive satisfaction for the trespass done them" (Hamor in Haile 1998:811)

Important Dates Related to Livestock and Provisions at Jamestown

1614:

June 18 Hamor writes, "The colony is already furnished with two hundred neat cattle, as many goats, infinite hogs in herds all over the woods, besides those to every town belonging in general and every private man; some mares, horses and colts, poultry great store, besides tame turkeys, peacocks, and pigeons, plentifully increasing and thriving there, in no country better! Of our young steers, the next winter we doubt not to have three or four plows going, which once compass'd we shall in short time be able to repay England the corn they have lent us" (Hamor in Haile 1998:819)

In his descriptions of the settlements, "For the further enlargement yet this town on the other side of the river, by impaling likewise – for we make no other fence – is secured to our use, especially for our hogs to feed in, about twelve English miles of ground…Rochdale Hundred by a cross-pale well-nigh four miles long is also already impaled, with bordering houses all along the pale, in which hundred our hogs and other cattle have twenty miles circuit to graze in securely…" (Hamor in Haile 1998:825-826)

Important Dates Related to Government and Main Events at Jamestown

1615:

January 30/ Thomas Rolfe is born to Motoaka (Pocahontas) and John Rolfe (Haile 1998:53)

Important Dates Related to Virginia Indians

1615:

Important Dates Related to Livestock and Provisions at Jamestown

1615:

Important Dates Related to Government and Main Events at Jamestown

1616:

Rolfe writes there are six English settlement in Virginia and 351 colonists (Rolfe in Haile 1998:870)

May/ Rolfe, Rebeka Matoaka (Pocahontas), their son, and several other Indians return to England with Dale. The purpose was to create publicity for the Virginia Company (Smith in Haile 1998:858-863)

Yeardly becomes Deputy Governor when Dale leaves. (Smith in Haile 1998:859)

Important Dates Related to Virginia Indians

1616:

Important Dates Related to Livestock and Provisions at Jamestown

1616:

Rolfe writes, "These things (may some say) are of great consequence toward the settling of a plantation, but where are the beasts and cattle to feed and clothe the people? I confess this is a main want. Yet some there are already, as neat cattle, horses, mares, and goats, which are carefully preserved for increase, the numbers wereof hereafter shall be set down in a particular note by themselves. There are also great store of hogs, both wild and tame, and poultry great plenty, which every man if they will themselves may keep" (Rolfe in Haile 1998:868)

Rolfe continues, "For howsoever we could well defend ourselves-towns and seat-from any assult of the natives, yet our cattle and corn lay too open to their courtesies and too subject to their mercies. Whereupon a peace was concluded which still continueth so firm that our people yearly plant and reap quietly, and travel in the woods a-fowling and a-hunting as freely and securely from fear of danger or treachery as in England" (Rolfe in Haile 1998:869)

Important Dates Related to Government and Main Events at Jamestown

1617:

March 17/ Matoaka (Pocahontas) dies in England. John Rolfe returns to Virginia while Thomas stays in England (Rolfe in Haile 1998:888)

May 15/ Argall returns to Jamestown as the new Deputy Governor (Rolfe in Haile 1998:888)

Important Dates Related to Virginia Indians

1617:

Important Dates Related to Livestock and Provisions at Jamestown

1617:

June/ Rolfe writes, " We found the colony, God be thanked, in good estate…The cattle thrive and increase exceeding well, the plows yarely work, and oxen are plentiful" (Rolfe in Haile 1998:888)

Important Dates Related to Government and Main Events at Jamestown

1618:

Chief Powhatan dies and is succeeded by his brother, Opitchapam (Haile 1998:50, 53)

June 7/ Governor Lord De La Warr dies at sea on way to Virginia (Haile 1998:65)

November/ Yeardly becomes new governor of Virginia (Haile 1998:67)

November 18/ Virginia Company issues the Great Charter (Martial Law ends) and a General Assembly is established with white men of property choosing representatives (Haile 1998:37) The Great Charter also establishes the "headright" system, giving 50 acres of land to anyone who pays for their own passage to Virginia and 50 extra acres for each person they bring with them (often indentured servants) (Haile 1998:38)

Men who had arrived in colony before 1616 were given 100 acres to encourage additional settlement (Colonial Records of Virginia 1874:69)

Important Dates Related to Virginia Indians

1618:

Important Dates Related to Livestock and Provisions at Jamestown

1618:

Important Dates Related to Government and Main Events at Jamestown

1619:

March/ Virginia Company writes, "Whereas during the time of Sir Thomas Dales residence in Virginia therewas by his mean sundry Saltworks set up to the great good and benefit of the Plantation, since which time they are wholly gone to wrack and let fall in so much that by defect thereof the inhabitatants are exceedingly distempered by eating porke and other things meats fresh and unseasoned…"
Virginia Company sets up committee for "set-tlinge of Salt Workes" (Kingsbury, editor 1906)

April 18/ Yeardly arrives at Jamestown as new governor (Haile 1998:67)

July 30-August 4/ First meeting of the General Assembly at Jamestown (Haile 1998:37) New Laws established

August/ First Africans arrive at Jamestown

Important Dates Related to Virginia Indians

1619:

August 2-4/ New laws state Indians should not be rejected or drawn in to settlement "But in case they will of themselves come voluntarily to places well peopled, there to do service in killing of deer, fishing, beating corn, and other work…"
Also, "It shall be free for every man to trade with the Indians, servants only excepted…"(Proceedings of the Virginia Assembly 1619)

Important Dates Related to Livestock and Provisions at Jamestown

1619:

August 2-4/ New laws state, "No man without leave from the governor shall kill any neat cattle whatsoever, young or old, especially kine, heifers, or cow calves, and shall be careful to preserve their steers and oxen…" (Proceedings of the Virginia Assembly 1619)

Important Dates Related to Government and Main Events at Jamestown

1620:

May 27/ 90 women arrive in Virginia to marry planters

May/ Virginia Company writes, "For Salt, if men skilled in making it in Pitts and by the Sun be not to be had at home to procure them from France and by all means to set forward the making of it in abundance being a very great help to increase the Plantation" (Kingsbury, editor 1906)

December/ The Virginia Company of Plymouth is revived to grant land patents to the Pilgrims

Important Dates Related to Virginia Indians

1620:

Important Dates Related to Livestock and Provisions at Jamestown

1620:

Important Dates Related to Government and Main Events at Jamestown

1621:

Yeardly is replaced by Sir Francis Wyatt as governor (Haile 1998:67)

August-September/ 57 more women arrive at Jamestown to marry planters

Important Dates Related to Virginia Indians

1621:

Important Dates Related to Livestock and Provisions at Jamestown

1621:

Important Dates Related to Government and Main Events at Jamestown

1622:

March/John Rolfe dies (Haile 1998:54-55)

Winter of 1622-1623/ Second Starving Time, disease, and war with the Virginia Indians leads to death of hundreds of colonists

Important Dates Related to Virginia Indians

1622:

March 22/ Large scale surprise attack by Virginia Indians among the English settlements kills 347 colonists and several settlements. Jamestown is warned and is spared.

This even begins the Second Anglo-Powhatan War, lasting a decade

Important Dates Related to Livestock and Provisions at Jamestown

1622:

Important Dates Related to Government and Main Events at Jamestown

1623:

Important Dates Related to Virginia Indians

1623:

Important Dates Related to Livestock and Provisions at Jamestown

1623:

Important Dates Related to Government and Main Events at Jamestown

1624:

May 24/ Virginia company loses it charter and Virginia becomes a colony

Important Dates Related to Virginia Indians

1624:

Important Dates Related to Livestock and Provisions at Jamestown

1624:

APPENDIX B:
Kill-Off Data for Domestic Livestock Layers of the Second Well (JR2158)

Table 37
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer H
***Sus scrofa* (Domestic Swine)**
N=47

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	2	0
Innominate	3	0
Humerus - distal	1	1
Radius - proximal	2	0
Second phalange - proximal	7	2
	15	3
Percent of Age Range	**83.3%**	**16.7%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	2	2
First phalange - proximal	6	0
Tibia - distal	4	2
	12	4
Percent of Age Range	**75.0%**	**25.0%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	0	5
Metatarsal	0	2
Fibula - distal	0	1
	0	8
Percent of Age Range	**0.0%**	**100.0%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	0	1
Ulna - proximal	0	1
Ulna - distal	0	0
Femur - proximal	0	2
Femur - distal	0	1
Tibia - proximal	0	0
Fibula - proximal	0	0
	0	5
Percent of Age Range	**0.0%**	**100.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 38
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158, Layer N
***Sus scrofa* (Domestic Swine)**
N=65

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	2	0
Innominate	5	0
Humerus - distal	3	3
Radius - proximal	4	0
Second phalange - proximal	8	1
	22	4
Percent of Age Range	**84.6%**	**15.4%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	0	2
First phalange - proximal	7	2
Tibia - distal	3	1
	10	5
Percent of Age Range	**66.7%**	**33.3%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	1	9
Metatarsal	0	3
Fibula - distal	0	1
	1	13
Percent of Age Range	**7.1%**	**92.9%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	0	3
Ulna - proximal	2	1
Ulna - distal	0	0
Femur - proximal	0	1
Femur - distal	1	0
Tibia - proximal	0	1
Fibula - proximal	0	1
	3	7
Percent of Age Range	**30.0%**	**70.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 39
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer P
***Sus scrofa* (Domestic Swine)**
N=15

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	0	0
Innominate	0	5
Humerus - distal	0	0
Radius - proximal	0	0
Second phalange - proximal	0	0
	0	5
Percent of Age Range	**0.0%**	**100.0%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	0	0
First phalange - proximal	1	0
Tibia - distal	0	1
	1	1
Percent of Age Range	**50.0%**	**50.0%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	0	0
Metatarsal	0	0
Fibula - distal	0	1
	0	1
Percent of Age Range	**0.0%**	**100.0%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	1
Radius - distal	1	1
Ulna - proximal	0	0
Ulna - distal	0	0
Femur - proximal	0	3
Femur - distal	0	0
Tibia - proximal	0	1
Fibula - proximal	0	0
	1	6
Percent of Age Range	**14.3%**	**85.7%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 40
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer P
***Ovis aries/Capra hircus* (Domestic Sheep or Goat)**
N=3

Group I/Age of Fusion - 6 to 10 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	0	0
Innominate	2	0
Humerus - distal	0	0
Radius - proximal	0	0
	2	0
Percent of Age Range	**100.0%**	**0.0%**

Group II/Age of Fusion - 12 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Ulna - proximal	0	0
Ulna - distal	0	0
Metacarpal	0	0
Femur - proximal	0	0
Tibia - distal	0	0
Metatarsal	0	0
Metapodial	0	0
Calcaneus	1	0
First Phalange - proximal	0	0
Second Phalange - proximal	0	0
	1	0
Percent of Age Range	**100.0%**	**0.0%**

Group III/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	0	0
Femur - distal	0	0
Tibia - proximal	0	0
	0	0
Percent of Age Range	**0.0%**	**0.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 41
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer U
***Bos taurus* (Domestic Cattle)**
N=2

Age of Fusion - 0 to 12 Months		
Bone and Epiphysis	**Fused**	**Not Fused**
Scapula	0	0
Innominate	1	0
	1	0
Percent of Age Range	**100.0%**	**0.0%**

Age of Fusion - 12 to 24 Months		
Bone and Epiphysis	**Fused**	**Not Fused**
Humerus - distal	0	0
Radius - proximal	0	0
First Phalange - proximal	0	0
Second Phalange - proximal	0	1
	0	1
Percent of Age Range	**0.0%**	**100.0%**

Age of Fusion - 24 to 36 Months		
Bone and Epiphysis	**Fused**	**Not Fused**
Metacarpal	0	0
Tibia - distal	0	0
Metatarsal	0	0
Metapodial	0	0
	0	0
Percent of Age Range	**0.0%**	**0.0%**

Age of Fusion - 36 to 48 Months		
Bone and Epiphysis	**Fused**	**Not Fused**
Humerus - proximal	0	0
Ulna - proximal	0	0
Ulna - distal	0	0
Radius - distal	0	0
Femur - proximal	0	0
Femur - distal	0	0
Tibia - proximal	0	0
Calcaneus	0	0
	0	0
Percent of Age Range	**0.0%**	**0.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979.

Table 42
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer U
***Sus scrofa* (Domestic Swine)**
N=24

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	3	1
Innominate	1	1
Humerus - distal	0	0
Radius - proximal	0	0
Second phalange - proximal	5	0
	9	2
Percent of Age Range	**81.8%**	**18.2%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	4	0
First phalange - proximal	1	1
Tibia - distal	0	0
	5	1
Percent of Age Range	**83.3%**	**16.7%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	0	1
Metatarsal	4	1
Fibula - distal	1	0
	5	2
Percent of Age Range	**71.4%**	**28.6%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	1
Radius - distal	0	0
Ulna - proximal	0	0
Ulna - distal	0	0
Femur - proximal	0	0
Femur - distal	0	1
Tibia - proximal	0	0
Fibula - proximal	0	0
	0	2
Percent of Age Range	**0.0%**	**100.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 43
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer U
***Ovis aries/Capra hircus* (Domestic Sheep or Goat)**
N=2

Group I/Age of Fusion - 6 to 10 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	0	0
Innominate	0	0
Humerus - distal	0	0
Radius - proximal	1	0
	1	0
Percent of Age Range	**100.0%**	**0.0%**

Group II/Age of Fusion - 12 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Ulna - proximal	0	0
Ulna - distal	0	0
Metacarpal	0	0
Femur - proximal	0	0
Tibia - distal	0	0
Metatarsal	0	0
Metapodial	0	0
Calcaneus	0	0
First Phalange - proximal	0	0
Second Phalange - proximal	0	0
		0
Percent of Age Range	**0.0%**	**0.0%**

Group III/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	0	0
Femur - distal	0	0
Tibia - proximal	1	0
	1	0
Percent of Age Range	**100.0%**	**0.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 44
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer X
***Bos taurus* (Domestic Cattle)**
N=2

Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	0	0
Innominate	1	0
	1	0
Percent of Age Range	**100.0%**	**0.0%**

Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - distal	0	0
Radius - proximal	0	0
First Phalange - proximal	0	0
Second Phalange - proximal	0	0
	0	0
Percent of Age Range	**0.0%**	**0.0%**

Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	0	0
Tibia - distal	0	0
Metatarsal	0	0
Metapodial	0	0
	0	0
Percent of Age Range	**0.0%**	**0.0%**

Age of Fusion - 36 to 48 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Ulna - proximal	0	0
Ulna - distal	0	0
Radius - distal	0	0
Femur - proximal	0	1
Femur - distal	0	0
Tibia - proximal	0	0
Calcaneus	0	0
	0	1
Percent of Age Range	**0.0%**	**100.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979.

Table 45
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer X
***Sus scrofa* (Domestic Swine)**
N=30

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	5	0
Innominate	2	0
Humerus - distal	3	0
Radius - proximal	2	0
Second phalange - proximal	1	0
	13	0
Percent of Age Range	**100.00%**	**0.0%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	1	3
First phalange - proximal	6	0
Tibia - distal	1	0
	8	3
Percent of Age Range	**72.7%**	**27.3%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	0	3
Metatarsal	0	0
Fibula - distal	0	0
	0	3
Percent of Age Range	**0.0%**	**100.0%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	0	2
Ulna - proximal	0	0
Ulna - distal	0	1
Femur - proximal	0	0
Femur - distal	0	0
Tibia - proximal	0	0
Fibula - proximal	0	0
	0	3
Percent of Age Range	**0.0%**	**100.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 46
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer X
***Ovis aries/Capra hircus* (Domestic Sheep or Goat)**
N=4

Group I/Age of Fusion - 6 to 10 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	0	0
Innominate	2	0
Humerus - distal	0	0
Radius - proximal	1	0
	3	0
Percent of Age Range	**100.0%**	**0.0%**

Group II/Age of Fusion - 12 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Ulna - proximal	0	0
Ulna - distal	0	0
Metacarpal	0	0
Femur - proximal	0	0
Tibia - distal	0	0
Metatarsal	0	1
Metapodial	0	0
Calcaneus	0	0
First Phalange - proximal	0	0
Second Phalange - proximal	0	0
		1
Percent of Age Range	**0.0%**	**100.0%**

Group III/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	0	0
Femur - distal	0	0
Tibia - proximal	0	0
	0	0
Percent of Age Range	**0.0%**	**0.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 47
Age Distribution Based on Epiphyseal Fusion
Second Well (JR2158), Layer AA
***Sus scrofa* (Domestic Swine)**
N=5

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	%0	0
Innominate	1	0
Humerus - distal	0	0
Radius - proximal	1	0
Second phalange - proximal	1	0
	3	0
Percent of Age Range	**100.00%**	**0.0%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	0	0
First phalange - proximal	1	0
Tibia - distal	0	0
	1	0
Percent of Age Range	**100.0%**	**0.0%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	0	1
Metatarsal	0	0
Fibula - distal	0	0
	0	1
Percent of Age Range	**0.0%**	**100.0%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	0	0
Ulna - proximal	0	0
Ulna - distal	0	0
Femur - proximal	0	0
Femur - distal	0	0
Tibia - proximal	0	0
Fibula - proximal	0	0
	0	0
Percent of Age Range	**0.0%**	**0.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

APPENDIX C:
Kill-Off Data for Domestic Livestock
Combined Assemblages
Pre-Starving Time Assemblages
Starving Time Assemblages
Post Starving Time Assemblages
Stability Herds Assemblages

Table 48
Age Distribution Based on Epiphyseal Fusion
Pre-Starving Time Assemblages
(Structure 166 Cellar, Pit 8, Pit 9, Pit 10, Pit 11)
***Sus scrofa* (Domestic Swine)**
N=4

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	0	0
Innominate	1	0
Humerus - distal	0	0
Radius - proximal	0	0
Second phalange - proximal	0	0
	1	0
Percent of Age Range	**100.0%**	**0.0%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	0	0
First phalange - proximal	0	1
Tibia - distal	0	0
	0	1
Percent of Age Range	**0.0%**	**100.0%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	0	1
Metatarsal	0	0
Fibula - distal	0	0
	0	1
Percent of Age Range	**0.0%**	**100.0%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	1	0
Ulna - proximal	0	0
Ulna - distal	0	0
Femur - proximal	0	0
Femur - distal	0	0
Tibia - proximal	0	0
Fibula - proximal	0	0
	1	0
Percent of Age Range	**100.0%**	**100.0%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 49
Age Distribution Based on Epiphyseal Fusion
Starving-Time Assemblages
(Pit 1, Pit 3, Cellar JR3081)
***Sus scrofa* (Domestic Swine)**
N=157

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	4	4
Innominate	8	5
Humerus - distal	1	5
Radius - proximal	3	2
Second phalange - proximal	17	1
	33	17
Percent of Age Range	**66.0%**	**34.0%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	1	15
First phalange - proximal	7	22
Tibia - distal	2	5
	10	42
Percent of Age Range	**19.2%**	**80.8%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	0	6
Metatarsal	3	12
Fibula - distal	0	5
	3	23
Percent of Age Range	**11.5%**	**88.5%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	3
Radius - distal	1	3
Ulna - proximal	1	3
Ulna - distal	0	2
Femur - proximal	0	6
Femur - distal	2	4
Tibia - proximal	0	2
Fibula - proximal	0	2
	4	25
Percent of Age Range	**13.8%**	**86.2%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 50
Age Distribution Based on Epiphyseal Fusion
Post-Starving Time Assemblages
(Second Well JR2158, All Layers Combined)
***Sus scrofa* (Domestic Swine)**
N=188

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	12	1
Innominate	12	6
Humerus - distal	7	4
Radius - proximal	9	0
Second phalange - proximal	22	3
	62	14
Percent of Age Range	**81.6%**	**18.4%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	7	7
First phalange - proximal	22	3
Tibia - distal	8	4
	37	14
Percent of Age Range	**72.5%**	**27.4**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	1	19
Metatarsal	4	6
Fibula - distal	1	3
	6	28
Percent of Age Range	**17.6%**	**82.3%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	2
Radius - distal	1	7
Ulna - proximal	2	2
Ulna - distal	0	1
Femur - proximal	0	6
Femur - distal	1	2
Tibia - proximal	0	2
Fibula - proximal	0	1
	4	23
Percent of Age Range	**14.8%**	**85.2%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

Table 51
Age Distribution Based on Epiphyseal Fusion
Stability Herds Assemblage
, Post 1620s (Ditch 6, Ditch 7, Midden1)
***Sus scrofa* (Domestic Swine)**
N=42

Group I/Age of Fusion - 0 to 12 Months

Bone and Epiphysis	Fused	Not Fused
Scapula	2	0
Innominate	4	0
Humerus - distal	4	0
Radius - proximal	0	1
Second phalange - proximal	5	0
	15	1
Percent of Age Range	**93.7%**	**6.2%**

Group II/Age of Fusion - 12 to 24 Months

Bone and Epiphysis	Fused	Not Fused
Metacarpal	0	2
First phalange - proximal	6	1
Tibia - distal	1	2
	7	5
Percent of Age Range	**58.3%**	**41.7%**

Group III/Age of Fusion - 24 to 36 Months

Bone and Epiphysis	Fused	Not Fused
Calcaneus	1	4
Metatarsal	1	1
Fibula - distal	1	0
	3	5
Percent of Age Range	**37.5%**	**62.5%**

Group IV/Age of Fusion - 36 to 42 Months

Bone and Epiphysis	Fused	Not Fused
Humerus - proximal	0	0
Radius - distal	3	1
Ulna - proximal	0	0
Ulna - distal	0	0
Femur - proximal	0	0
Femur - distal	0	1
Tibia - proximal	0	0
Fibula - proximal	1	0
	4	2
Percent of Age Range	**66.7%**	**33.3%**

Source of Fusion Ages: Silver 1969; Chaplin 1970; Maltby 1979; Reitz and Wing 2008.

APPENDIX D:
Seasonality of Species Charts for Each Layer of the Second Well (JR2158)

Table 52
Seasonality of Wild Species
Second Well (JR2158), Layer H

Key to Table:
species/ family name in bold indicates they were identified in the assemblages
species name in grey are examples of possible species, not identified species
C = common (fairly certain to be found in proper habitat)
U = uncommon (probably present, but will often be missed)
O = occasional (not always present)
R = rare (not always seen)
-------- = not typically present at this time of year
Brumate = a state or condition of sluggishness, inactivity, or torpor exhibited typically by reptiles during winter or extended periods of low temperature

CRAB

Taxon	Winter	Spring	Summer	Fall	All Year
Blue Crab	Brumate	C	C	C	X

FISH

Taxon	Winter	Spring	Summer	Fall	All Year
Requiem Shark **(possible species below)**					
Atlantic sharpnose	------	------	R	------	
Sandbar shark	------	------	C	C	
Dusky shark	------	------	C	------	
Bull shark	------	------	O	------	
Skate/Ray (possible species below)					
Clearnose skate	------	------	C	C	
Winter Skate	O	O	------	------	
Little Skate	O	O	------	------	
Atlantic stingray	------	------	O	O	
Cownose ray	------	------	C	C (Females)	
Sturgeon (possible species below)					
Atlantic sturgeon	------	C	C	C (Males)	
Shortnose sturgeon	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	X
Gar (possible species)					
Longnose gar	C	C	C	C	X
Bowfin	C	C	C	C	X
Sucker (possible species below)					
Quillback	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	X
White sucker	C	C	C	C	X

Shortnose redhorse	C	C	C	C	X
Freshwater Catfish (possible species below)					
White catfish	C	C	C	C	X
Brown bullhead	C	C	C	C	X
Yellow bullhead	C	C	C	C	X
White Perch	C (Move to deep water)	C (Move to deep water)	C	C	X
Red Drum	------	C	C	C	
Spotted Seatrout	------	C	C	C	

REPTILES/AMPHIBIANS

Taxon	Winter	Spring	Summer	Fall	All Year
Frog	Brumate	C	C	C	X
Snapping Turtle	Brumate	C	C	C	X
Musk or Mud Turtle	Brumate	C	C	C	X
Slider or Cooter	Brumate	C	C	C	X
Box Turtle	Brumate	C	C	C	X
Soft-Shell Turtle	Brumate	C	C	C	X
Snake (varying species)	Brumate	C	C	C	X

BIRDS

Taxon	Winter	Spring	Summer	Fall	All Year
Swan					
Tundra	C	U, O	------	O, C	
Snow Goose	C	O	------	C	
Canada Goose	C	C	C	C	X
Dabbling Duck (possible species below)					
Mallard	C	C	C	C	X
American black duck	C	C	C	C	X
American wigeon	C	C, O	R	O, C	
Northern shoveler	U	R	------	O, U	
Green-winged teal	C	O	------	C	
Northern pintail	O	R	------	R, O	
Blue-winged teal	R	U, C	R, O	O	
Ruddy Duck	C	O, R	R	C	
Wood Duck	O	U, C	C	C, U	
Pochard (possible species below)					
Redhead	R, O	------	------	R, O	
Canvasback	R	------	------	R, O	
Ring-necked duck	C, U	R, U	------	O, C	
Greater scaup	U	U, R	------	O, U	
Lesser scaup	C	O, R	------	O, C	

Crane or Rail (possible species below)					
Sandhill crane	------	R	------	R	
Rallidae (possible species below)					
Black rail	U	T, C	C, T	U	
Clapper rail	C	C	C	C	X
King rail	R	R	------	R	
Virginia rail	C	C	C	C	X
American coot	C	C, O	R, O	C	
Sora	R	U, C	------	O, R	
Turkey Vulture	C	C	C	C	X
Bald Eagle	C	C	C	C	X
Turkey	C	C	C	C	X
Perching Bird (varying species)					
Blue Jay	C	C	C	C	X

MAMMALS

Taxon	Winter	Spring	Summer	Fall	All Year
Opossum	C	C	C	C	X
Eastern Gray Squirrel	C	C	C	C	X
Eastern Fox Squirrel	C	C	C	C	X
Muskrat	C	C	C	C	X
Rat (varying species)	C	C	C	C	X
Raccoon	C	C	C	C	X
White-Tailed Deer	C	C	C	C	X

(Behler and King 1995; Eastern Shore of Virginia National Wildlife Refuge 2012; Lippson and Lippson 2006; Murdy et al 1997; Stokes and Stokes 2013; Webster et al 1985; Williams 2012)

Table 53
Seasonality of Wild Species
Second Well (JR2158), Layer N

Key to Table:
species/ family name in bold indicates they were identified in the assemblages
species name in grey are examples of possible species, not identified species
C = common (fairly certain to be found in proper habitat)
U = uncommon (probably present, but will often be missed)
O = occasional (not always present)
R = rare (not always seen)
-------- = not typically present at this time of year
Brumate = a state or condition of sluggishness, inactivity, or torpor exhibited typically by reptiles during winter or extended periods of low temperature

CRAB

Taxon	Winter	Spring	Summer	Fall	All Year
Blue Crab	Brumate	C	C	C	X

FISH

Taxon	Winter	Spring	Summer	Fall	All Year
Requiem Shark **(possible species below)**					
Atlantic sharpnose	------	------	R	------	
Sandbar shark	------	------	C	C	
Dusky shark	------	------	C	------	
Bull shark	------	------	O	------	
Skate/Ray (possible species below)					
Clearnose skate	------	------	C	C	
Winter Skate	O	O	------	------	
Little Skate	O	O	------	------	
Atlantic stingray	------	------	O	O	
Cownose ray	------	------	C	C (Females)	
Sturgeon (possible species below)					
Atlantic sturgeon	------	C	C	C (Males)	
Shortnose sturgeon	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	X
Gar (possible species)	C	C	C	C	X
Longnose gar					
Alewife	------	C	C	C	
Sucker (possible species below)					
Quillback	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	X
White sucker	C	C	C	C	X
Shortnose redhorse	C	C	C	C	X

Freshwater Catfish **(possible species below)**					
White catfish	C	C	C	C	X
Brown bullhead	C	C	C	C	X
Yellow bullhead	C	C	C	C	X
White Perch	C (Move to deep water	C	C	C	X
Striped Bass	C (Spawn upstream)	C (Coastal waters)	C	C	X
Yellow Perch	C	C	C	C	X
Sheepshead	------	------	O	R to O	
Black Drum	------	C	C	C	
Red Drum	------	C	C	C	
Spotted Seatrout	------	C	C	C	

REPTILES/AMPHIBIANS

Taxon	Winter	Spring	Summer	Fall	All Year
Frog **(varying species)**	Brumate	C	C	C	X
Snapping Turtle	Brumate	C	C	C	X
Musk or Mud Turtle	Brumate	C	C	C	X
Slider or Cooter	Brumate	C	C	C	X
Diamondback Terrapin	Brumate	C	C	C	X
Box Turtle	Brumate	C	C	C	X
Soft-Shell Turtle	Brumate	C	C	C	X
Snake **(varying species)**	Brumate	C	C	C	X

BIRDS

Taxon	Winter	Spring	Summer	Fall	All Year
Great Blue Heron	C	C	C	C	X
Shearwater or Petrel **(possible species below)**					**Rare, usually only seen after tropical storms**
Wilson's storm-petrel					
Sooty Shearwater					
White-faced storm-petrel					
Swan					
Tundra	C	U, O	------	O, C	
Snow Goose	C	O	------	C	
Canada Goose	C	C	C	C	X
Dabbling Duck **(possible species below)**					
Mallard	C	C	C	C	X
American black duck	C	C	C	C	X
American wigeon	C	C, O	R	O, C	
Northern shoveler	U	R	------	O, U	

Green-winged teal	C	O	------	C	
Northern pintail	O	R	------	R, O	
Blue-winged teal	R	U, C	R, O	O	
Ruddy Duck	C	O, R	R	C	
Wood Duck	O	U, C	C	C, U	
Pochard (possible species below)					
Redhead	R, O	------	------	R, O	
Canvasback	R	------	------	R, O	
Ring-necked duck	C, U	R, U	------	O, C	
Greater scaup	U	U, R	------	O, U	
Lesser scaup	C	O, R	------	O, C	
Gull (varying species)					
Laughing Gull	R	C	C	C, O	
Ring-billed gull	C	C	U	C	
Herring Gull	C	C	C	C	
Bonaparte's Gull	C	U, R	------	U, C	
Turkey Vulture	C	C	C	C	X
Bald Eagle	C	C	C	C	X
Red-Tailed Hawk	C	C	C	C	X
Turkey	C	C	C	C	X
Perching Bird (varying species)					
Blue Jay	C	C	C	C	X

MAMMALS

Taxon	Winter	Spring	Summer	Fall	All Year
Opossum	C	C	C	C	X
Eastern Mole	C	C	C	C	X
Eastern Gray Squirrel	C	C	C	C	X
Eastern Fox Squirrel	C	C	C	C	X
Muskrat	C	C	C	C	X
Rat (varying species)	C	C	C	C	X
Raccoon	C	C	C	C	X
River Otter	C	C	C	C	X
White-Tailed Deer	C	C	C	C	X

(Behler and King 1995; Eastern Shore of Virginia National Wildlife Refuge 2012; Lippson and Lippson 2006; Murdy et al 1997; Stokes and Stokes 2013; Webster et al 1985; Williams 2012)

Table 54
Seasonality of Wild Species
Second Well (JR2158), Layer P

Key to Table:
species/ family name in bold indicates they were identified in the assemblages
species name in grey are examples of possible species, not identified species
C = common (fairly certain to be found in proper habitat)
U = uncommon (probably present, but will often be missed)
O = occasional (not always present)
R = rare (not always seen)
-------- = not typically present at this time of year
Brumate = a state or condition of sluggishness, inactivity, or torpor exhibited typically by reptiles during winter or extended periods of low temperature

CRAB

Taxon	Winter	Spring	Summer	Fall	All Year
Blue Crab	Brumate	C	C	C	X

FISH

Taxon	Winter	Spring	Summer	Fall	All Year
Requiem Shark **(possible species below)**					
Atlantic sharpnose	------	------	R	------	
Sandbar shark	------	------	C	C	
Dusky shark	------	------	C	------	
Bull shark	------	------	O	------	
Skate/Ray (possible species below)					
Clearnose skate	------	------	C	C	
Winter Skate	O	O	------	------	
Little Skate	O	O	------	------	
Atlantic stingray	------	------	O	O	
Cownose ray	------	------	C	C (Females)	
Sturgeon (possible species below)					
Atlantic sturgeon	------	C	C	C (Males)	
Shortnose sturgeon	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	
Gar (possible species)					
Longnose gar	C	C	C	C	X
Bowfin	C	C	C	C	X
American Shad	C (Age 4 to 6 years)	C	C	------	
Sucker (possible species below)					
Quillback	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	X
White sucker	C	C	C	C	X

Shortnose redhorse	C	C	C	C	X
Freshwater Catfish (possible species below)					
White catfish	C	C	C	C	X
Brown bullhead	C	C	C	C	X
Yellow bullhead	C	C	C	C	X
Atlantic Cod	R to O	R to O	------	------	
White Perch	C (Move to deep water)	C	C	C	X
Striped Bass	C (Spawn upstream)	C (Coastal waters)	C	C	X
Grouper/Sea Bass (possible species below)					
Black sea bass	------	C	C	C	
Gag	------	------	O	O	
Sunfish (possible species below)					
Redbreast sunfish	C	C	C	C	X
Bluegill	C	C	C	C	X
Pumpkinseed	C	C	C	C	X
Yellow Perch	C	C	C	C	X
Jack (possible species below)					
Crevalle jack	------	------	O	O	
Horse-eye jack	------	------	R	R	
Blue runner	------	------	O	O	
Yellow jack	------	------	R	------	
Red Drum	------	C	C	C	
Spotted Seatrout	------	C	C	C	

REPTILES/AMPHIBIANS

Taxon	Winter	Spring	Summer	Fall	All Year
Bull Frog	Brumate	C	C	C	X
Snapping Turtle	Brumate	C	C	C	X
Musk or Mud Turtle	Brumate	C	C	C	X
Slider or Cooter	Brumate	C	C	C	X
Box Turtle	Brumate	C	C	C	X
Soft-Shell Turtle	Brumate	C	C	C	X
Snake (varying species)	Brumate	C	C	C	X
Viper (varying species)	Brumate	C	C	C	X

BIRDS

Taxon	Winter	Spring	Summer	Fall	All Year
Great Blue Heron	C	C	C	C	X

Shearwater or Petrel **(possible species below)**					**Rare, usually only seen after tropical storms**
Wilson's storm-petrel					
Sooty Shearwater					
White-faced storm-petrel					
Swan					
Tundra	C	U, O	------	O, C	
Snow Goose	C	O	------	C	
Canada Goose	C	C	C	C	X
Brant Goose	C	U,O	------	U, C	
Dabbling Duck (possible species below)					
Mallard	C	C	C	C	X
American black duck	C	C	C	C	X
American wigeon	C	C, O	R	O, C	
Northern shoveler	U	R	------	O, U	
Green-winged teal	C	O	------	C	
Northern pintail	O	R	------	R, O	
Blue-winged teal	R	U, C	R, O	O	
Ruddy Duck	C	O, R	R	C	
Wood Duck	O	U, C	C	C, U	
Pochard (possible species below)					
Redhead	R, O	------	------	R, O	
Canvasback	R	------	------	R, O	
Ring-necked duck	C, U	R, U	------	O, C	
Greater scaup	U	U, R	------	O, U	
Lesser scaup	C	O, R	------	O, C	
Crane or Rail (possible species below)					
Sandhill crane	------	R	------	R	
Rallidae (possible species below)					
Black rail	U	T, C	C, T	U	
Clapper rail	C	C	C	C	X
King rail	R	R	------	R	
Virginia rail	C	C	C	C	X
American coot	C	C, O	R, O	C	
Sora	R	U, C	------	O, R	
Sandpiper (possible species below)					
Spotted sandpiper	------	O, C	R, O	R, O	
Solitary sandpiper	------	O, C	O	O, R	
Greater yellowlegs	C	C	C	C	X
Willet	C	C	C	C	X
Lesser yellowlegs	R	O, C	C	O, R	

Upland sandpiper	------	R	R	------	
Whimbrel	R	R	O, C	O, R	
Marbled godwit	O	O	R	O	
Semipalmated sandpiper	------	O, C	C	O, R	
Western sandpiper	C	O, R	C	C	
Least sandpiper	------	O, C	C	C, O	
Short-billed dowitcher	C	C, O	C	C	X
Long-billed dowitcher	R	R	R	R	
American woodcock	C	C, O	R	O, C	
Gull (varying species)					
Laughing Gull	R	C	C	C, O	
Ring-billed gull	C	C	U	C	
Herring Gull	C	C	C	C	
Bonaparte's Gull	C	U, R	------	U, C	
Osprey	R, U	U, C	C	O,R	
Bald Eagle	C	C	C	C	X
Northern Harrier	C	O	U	C	
Turkey	C	C	C	C	X
Perching Birds (varying species)					
Raven or Crow					
American crow	C	C	C	C	X
Fish crow	C	C	C	C	X

MAMMALS

Taxon	Winter	Spring	Summer	Fall	All Year
Opossum	C	C	C	C	X
Eastern Gray Squirrel	C	C	C	C	X
Eastern Fox Squirrel	C	C	C	C	X
Muskrat	C	C	C	C	X
Rat (varying species)	C	C	C	C	X
Ocean Dolphin					
Bottlenose Dolphin	C	C	C	C	
Raccoon	C	C	C	C	X
White-Tailed Deer	C	C	C	C	X

(Behler and King 1995; Eastern Shore of Virginia National Wildlife Refuge 2012; Lippson and Lippson 2006; Murdy et al 1997; Stokes and Stokes 2013; Webster et al 1985; Williams 2012)

Table 55
Seasonality of Wild Species
Second Well (JR2158), Layer U

Key to Table:
species/ family name in bold indicates they were identified in the assemblages
species name in grey are examples of possible species, not identified species
C = common (fairly certain to be found in proper habitat)
U = uncommon (probably present, but will often be missed)
O = occasional (not always present)
R = rare (not always seen)
-------- = not typically present at this time of year
Brumate = a state or condition of sluggishness, inactivity, or torpor exhibited typically by reptiles during winter or extended periods of low temperature

CRAB

Taxon	Winter	Spring	Summer	Fall	All Year
Blue Crab	Brumate	C	C	C	X

FISH

Taxon	Winter	Spring	Summer	Fall	All Year
Requiem Shark **(possible species below)**					
Atlantic sharpnose	------	------	R	------	
Sandbar shark	------	------	C	C	
Dusky shark	------	------	C	------	
Bull shark	------	------	O	------	
Skate/Ray (possible species below)					
Clearnose skate	------	------	C	C	
Winter Skate	O	O	------	------	
Little Skate	O	O	------	------	
Atlantic stingray	------	------	O	O	
Cownose ray	------	------	C	C (Females)	
Sturgeon (possible species below)					
Atlantic sturgeon	------	C	C	C (Males)	
Shortnose sturgeon	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	X
Gar (possible species)					
Longnose gar	C	C	C	C	X
American Shad	C (Age 4 to 6 years)	C	C	------	
Sucker (possible species below)					
Quillback	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	X
White sucker	C	C	C	C	X
Shortnose redhorse	C	C	C	C	X

Freshwater Catfish (possible species below)					X
White catfish	C	C	C	C	X
Brown bullhead	C	C	C	C	X
Yellow bullhead	C	C	C	C	X
Atlantic Cod	R to O	R to O	------	------	
White Perch	C (Move to deep water)	C	C	C	X
Striped Bass	C (Spawn upstream)	C (Coastal waters)	C	C	X
Sunfish					
Redbreast sunfish	C	C	C	C	X
Bluegill	C	C	C	C	X
Pumpkinseed	C	C	C	C	X
Yellow Perch	C	C	C	C	X
Red Drum	------	C	C	C	------

REPTILES/AMPHIBIANS

Taxon	Winter	Spring	Summer	Fall	All Year
Frog (varying species)	Brumate	C	C	C	X
Snapping Turtle	Brumate	C	C	C	X
Musk or Mud Turtle	Brumate	C	C	C	X
Slider or Cooter	Brumate	C	C	C	X
Box Turtle	Brumate	C	C	C	X
Snake (varying species)	Brumate	C	C	C	X

BIRDS

Taxon	Winter	Spring	Summer	Fall	All Year
Heron/Egret					
Great Blue Heron	C	C	C	C	X
Cormorant (possible species below)					
Double-crested cormorant	C	C	U	C	
Great cormorant	U	O, R	------	O, U	
Swan					
Tundra	C	U, O	------	O, C	
Canada Goose	C	C	C	C	X
Dabbling Duck (possible species below)					
Mallard	C	C	C	C	X
American black duck	C	C	C	C	X
American wigeon	C	C, O	R	O, C	
Northern shoveler	U	R	------	O, U	
Green-winged teal	C	O	------	C	
Northern pintail	O	R	------	R, O	
Blue-winged teal	R	U, C	R, O	O	
Wood Duck	O	U, C	C	C, U	

Gull **(varying species)**					
Laughing Gull	R	C	C	C, O	
Ring-billed gull	C	C	U	C	
Herring Gull	C	C	C	C	
Bonaparte's Gull	C	U, R	------	U, C	
Bald Eagle	C	C	C	C	X
Turkey	C	C	C	C	X
Bobwhite	C	C	C	C	X
Great Horned Owl	C	C	C	C	X
Raven or Crow (possible species below)					
American crow	C	C	C	C	X
Fish crow	C	C	C	C	X

MAMMALS

Taxon	**Winter**	**Spring**	**Summer**	**Fall**	**All Year**
Opossum	C	C	C	C	X
Eastern Gray Squirrel	C	C	C	C	X
Muskrat	C	C	C	C	X
Rat **(varying species)**	C	C	C	C	X
American Mink	C	C	C	C	X
Raccoon	C	C	C	C	X
White-Tailed Deer	C	C	C	C	X

(Behler and King 1995; Eastern Shore of Virginia National Wildlife Refuge 2012; Lippson and Lippson 2006; Murdy et al 1997; Stokes and Stokes 2013; Webster et al 1985; Williams 2012)

Table 56
Seasonality of Wild Species
Second Well (JR2158), Layer X

Key to Table:
species/ family name in bold indicates they were identified in the assemblages
species name in grey are examples of possible species, not identified species
C = common (fairly certain to be found in proper habitat)
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O = occasional (not always present)
R = rare (not always seen)
-------- = not typically present at this time of year
Brumate = a state or condition of sluggishness, inactivity, or torpor exhibited typically by reptiles during winter or extended periods of low temperature

CRAB

Taxon	Winter	Spring	Summer	Fall	All Year
Blue Crab	Brumate	C	C	C	X

FISH

Taxon	Winter	Spring	Summer	Fall	All Year
Requiem Shark (possible species below)					
Atlantic sharpnose	------	------	R	------	
Sandbar shark	------	------	C	C	
Dusky shark	------	------	C	------	
Bull shark	------	------	O	------	
Skate/Ray (possible species below)					
Clearnose skate	------	------	C	C	
Winter Skate	O	O	------	------	
Little Skate	O	O	------	------	
Atlantic stingray	------	------	O	O	
Cownose ray	------	------	C	C (Females)	
Sturgeon (possible species below)					
Atlantic sturgeon	------	C	C	C (Males)	
Shortnose sturgeon	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	X
Gar (possible species)					
Longnose gar	C	C	C	C	X
Sucker (possible species below)					
Quillback	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	C (Large tributaries)	X
White sucker	C	C	C	C	X
Shortnose redhorse	C	C	C	C	X

Freshwater Catfish **(possible species below)**					
White catfish	C	C	C	C	X
Brown bullhead	C	C	C	C	X
Yellow bullhead	C	C	C	C	X
White Perch	C (Moveto deep water)	C	C	C	X
Striped Bass	C (Spawn upstream)	C (Coastal waters)	C	C	X
Red Drum	------	C	C	C	

REPTILES/AMPHIBIANS

Taxon	Winter	Spring	Summer	Fall	All Year
Musk or Mud Turtle	Brumate	C	C	C	X
Slider or Cooter	Brumate	C	C	C	X
Box Turtle	Brumate	C	C	C	X

BIRDS

Taxon	Winter	Spring	Summer	Fall	All Year
Snow Goose	C	O	------	C	
Canada Goose	C	C	C	C	X
Dabbling Duck **(possible species below)**					
Mallard	C	C	C	C	X
American black duck	C	C	C	C	X
American wigeon	C	C, O	R	O, C	
Northern shoveler	U	R	------	O, U	
Green-winged teal	C	O	------	C	
Northern pintail	O	R	------	R, O	
Blue-winged teal	R	U, C	R, O	O	
Wood Duck	O	U, C	C	C, U	
Pochard (possible species below)					
Redhead	R, O	------	------	R, O	
Canvasback	R	------	------	R, O	
Ring-necked duck	C, U	R, U	------	O, C	
Greater scaup	U	U, R	------	O, U	
Lesser scaup	C	O, R	------	O, C	
Turkey Vulture	C	C	C	C	X
Bald Eagle	C	C	C	C	X
Turkey	C	C	C	C	X
Perching Birds **(varying species)**					

MAMMALS

Taxon	Winter	Spring	Summer	Fall	All Year
Opossum	C	C	C	C	X
Eastern Gray Squirrel	C	C	C	C	X
Eastern Fox Squirrel	C	C	C	C	X
Raccoon	C	C	C	C	X
White-Tailed Deer	C	C	C	C	X

(Behler and King 1995; Eastern Shore of Virginia National Wildlife Refuge 2012; Lippson and Lippson 2006; Murdy et al 1997; Stokes and Stokes 2013; Webster et al 1985; Williams 2012)

Table 57
Seasonality of Wild Species
Second Well (JR2158), Layer AA

Key to Table:
species/ family name in bold indicates they were identified in the assemblages
species name in grey are examples of possible species, not identified species
C = common (fairly certain to be found in proper habitat)
U = uncommon (probably present, but will often be missed)
O = occasional (not always present)
R = rare (not always seen)
-------- = not typically present at this time of year
Brumate = a state or condition of sluggishness, inactivity, or torpor exhibited typically by reptiles during winter or extended periods of low temperature

FISH

Taxon	Winter	Spring	Summer	Fall	All Year
Requiem Shark **(possible species below)**					
Atlantic sharpnose	------	------	R	------	
Sandbar shark	------	------	C	C	
Dusky shark	------	------	C	------	
Bull shark	------	------	O	------	
Sturgeon (possible species below)					
Atlantic sturgeon	------	C	C	C (Males)	
Shortnose sturgeon	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	C (Freshwater low salinity)	X
Gar (possible species)					
Longnose gar	C	C	C	C	X
Freshwater Catfish **(possible species below)**					
White catfish	C	C	C	C	X
Brown bullhead	C	C	C	C	X
Yellow bullhead	C	C	C	C	X
Striped Bass	C (Spawn upstream)	C (Coastal waters)	C	C	X
Sheepshead	------	------	O	R to O	

REPTILES/AMPHIBIANS

Taxon	Winter	Spring	Summer	Fall	All Year
Turtle (varying species)	Brumate	C	C	C	X

BIRDS

Taxon	Winter	Spring	Summer	Fall	All Year

Swan					
Tundra	C	U, O	------	O, C	
Canada Goose	C	C	C	C	X
Wood Duck	O	U, C	C	C, U	
Turkey Vulture	C	C	C	C	X
Bald Eagle	C	C	C	C	X
Turkey	C	C	C	C	X

MAMMALS

Taxon	Winter	Spring	Summer	Fall	All Year
White-Tailed Deer	C	C	C	C	X

(Behler and King 1995; Eastern Shore of Virginia National Wildlife Refuge 2012; Lippson and Lippson 2006; Murdy et al 1997; Stokes and Stokes 2013; Webster et al 1985; Williams 2012)

APPENDIX E:
Detailed Deer Element Distribution for Second Well (JR2158) Compared to Other Jamestown Assemblages

Table 58
Deer Element Distribution by NISP
Second Well (JR2158) Compared to Other Jamestown Assemblages

	Pre-Starving Time Assemblages 1607-1610		Starving Time Assemblages 1610		Post Starving Time 2nd Well Assemblages 1611-1616		Stability Herds Assemblages Post 1620s	
Element Type	No.	%	No.	%	No.	%	No.	%
Skull	3	2.6	2	2.0	170	12.0	2	10.0
Antler	8	6.8	1	1.0	5	0.3	0	0.0
Mandible	2	1.7	1	1.0	47	3.3	4	20.0
Tooth	7	6.0	22	22.2	90	6.3	2	10.0
Vertebra	18	15.4	12	12.1	201	14.2	0	0.0
Rib	10	8.5	5	5.1	78	5.5	0	0.0
Innominate	3	2.6	5	5.1	59	4.2	0	0.0
Scapula	8	6.8	5	5.1	56	3.9	1	5.0
Humerus	6	5.1	3	3.0	58	4.1	1	5.0
Ulna	1	0.8	6	6.1	60	4.2	1	5.0
Radius	3	2.6	8	8.1	55	3.9	1	5.0
Carpal	1	0.8	2	2.0	38	2.7	0	0.0
Metacarpal	2	1.7	0	0.0	21	1.5	0	0.0
Femur	6	5.1	3	3.0	92	6.5	2	10.0
Tibia	18	15.4	6	6.1	87	6.1	0	0.0
Tarsal	1	0.8	3	3.0	97	6.8	5	25.0
Metatarsal	5	4.3	5	5.0	24	1.7	0	0.0
Metapodial	4	3.4	1	1.0	13	0.9	0	0.0
Phalange	3	2.6	5	5.0	113	8.0	1	5.0
Sesamoid	2	1.7	1	1.0	11	0.8	0	0.0
Carpal/Tarsal	5	4.3	1	1.0	5	0.3	0	0.0
Patella	0	0.0	0	0.0	13	0.9	0	0.0
Sacrum	1	0.8	2	2.0	16	1.1	0	0.0
Other	0	0.0	0	0.0	8	0.6	0	0.0
Total NISP	117	100.0	99	100.0	1417	100.0	20	100.0

(Andrews 2008, 2013: Bowen and Andrews 2000)

APPENDIX F:
Bone Measurements for Domestic Mammals and Deer Bones

Key to Bone Measurements

From

A Guide to the Measurement of Animal Bones From Archaeological Sites

By Angela Von Den Driesch

Maxilla

27- Length of the cheektooth row
27a- Length of the cheektooth row, Molar 3 to Premolar 2
28- Length of the molar row
29- Length of the premolar row
31- Breadth of Molar 3 measured near base of the crown

Mandible

3- Length of Molar 3
7- Length of the molar row, Molar 3 to Premolar 1
7a- Length of the molar row, Molar 3 to Premolar 2
8- Length of the molar row
9- Length of premolar row, Premolar 1 to Premolar 4
9a- Length of the premolar row, Premolar 2 to Premolar 4
12- Length of the median section of the body of mandible
13- Aboral height of the vertical ramus
14- Middle height of the vertical ramus
15a and 16a - Height of the mandible behind Molar 3
15b and 16b – Height of the mandible in front of Molar 1
15c and 16c and 22c– Height of the mandible in front of Premolar 2

Atlas

GB – Greatest breath over the wings
BFcr – Greatest breadth of the facies articularis cranialis
BFcd – Greatest breadth of the articularis caudalis
H - Height

Axis

BFcr – Greatest breadth of the facies articularis caudalis

Vertebra

GB – Greatest breath over the wings
GLPa – Greatest length from the processus articulares craniales
BFcr – Greatest breadth of the facies articularis cranialis
BFcd – Greatest breadth of the articularis caudalis

Scapula

SLC – Smallest length of neck of scapula
GLP-Greatest length of the processus articularis
LG – Length of the glenoid cavity
BG – Breadth of the glenoid cavity

Humerus

Bp – Greatest breadth of the proximal end

Bd – Greatest breadth of the distal end
SD – Smallest breadth of the diaphysis
BT – Greatest breadth of the trochlea (equids and ruminants)

Radius

Bp – Greatest breadth of the proximal end
Bd – Greatest breadth of the distal end
SD – Smallest breadth of the diaphysis
BFp – Greatest breadth of the facies articularis proximalis
BFd- Greatest breadth of the facies articularis distalis

Ulna

LO – Length of the olecranon
DPA – Depth across the processus anconaeus
SDO – Smallest depth of the olecranon
BPC – Greatest breadth across the cornoid process

Innominate

LA – Length of the acetabulum including the lip
LAR – Length of the acetabulum on the rim
LFo – Inner Length of the forman obturatum
SB – Smallest breadth of the shaft of the ilium

Femur

Bp – Greatest breadth of the proximal end
Bd – Greatest breadth of the distal end
SD – Smallest breadth of the diaphysis
DC – Greatest depth of the caput femoris

Tibia

Bp – Greatest breadth of the proximal end
Bd – Greatest breadth of the distal end
SD – Smallest breadth of the diaphysis

Astragalus

GLl – Greatest length of the lateral half
GLm – Greatest length of the medial half
Dl – Greatest depth of the lateral half
Bd – Greatest breadth of the distal end

Calcaneus

GL – Greatest length
GB – Grestest breadth

Patella

GB- Greatest Breadth

Metapodials

GL – Greatest length
Bp – Greatest breadth of the proximal end
SD – Smallest breadth of the diaphysis
Bd – Greatest breadth of the distal end

Phalanx I

GLpe – Greatest length of the peripheral half
GL – Greatest length
Bp – Greatest breadth of the proximal end
SD – Smallest breadth of the diaphysis
Bd – Greatest breadth of the distal end

Phalanx II

GL – Greatest length
Bp – Greatest breadth of the proximal end
SD – Smallest breadth of the diaphysis
Bd – Greatest breadth of the distal end

Phalanx III

DLS – Greatest diagonal length of the sole
Ld – Length of the dorsal surface
MBS – Middle breadth of the sole

Taxon Description:

Odocoileus = *Odocoileus viginianus* (White-Tailed Deer)
Sus = *Sus scrofa* (Domestic Swine)
Ovis/Capra = *Ovis aries/Capra hircus* (Domestic Sheep/Goat)

Table 59
Bone Measurements

UBNo	Context	Taxon	Element	Location	Measurement (mm)
	2158H				
1241	2158H	Odocoileus	Mandible	9	34.5
1241	2158H	Odocoileus	Mandible	15b	16
1241	2158H	Odocoileus	Mandible	15c	12.2
1183	2158H	Odocoileus	Scapula	SLC	17.2
1183	2158H	Odocoileus	Scapula	BG	23.2
1165	2158H	Odocoileus	Humerus	Bp	50.7
1151	2158H	Odocoileus	Femur	SD	19.2
1152	2158H	Odocoileus	Femur	SD	20.7
1153	2158H	Odocoileus	Femur	SD	21.0
1179	2158H	Odocoileus	Femur	DC	24.0
1186	2158H	Odocoileus	Femur	DC	25.8
1154	2158H	Odocoileus	Tibia	SD	22.1
1155	2158H	Odocoileus	Tibia	Bd	38.2
1156	2158H	Odocoileus	Tibia	Bd	36.9
1158	2158H	Odocoileus	Tibia	Bd	36.8
1163	2158H	Odocoileus	Tibia	Bd	34.3
1163	2158H	Odocoileus	Tibia	SD	21.9

1196	2158H	Odocoileus	Astragalus	GLl	25.1
1196	2158H	Odocoileus	Astragalus	GLm	23.9
1196	2158H	Odocoileus	Astragalus	Dl	13.9
1196	2158H	Odocoileus	Astragalus	Bd	16.6
1197	2158H	Odocoileus	Cen./4th Tarsal	GB	31.5
1201	2158H	Odocoileus	Cen./4th Tarsal	GB	30.2
1225	2158H	Odocoileus	1st Phalanx	GL	43.6
1225	2158H	Odocoileus	1st Phalanx	Bp	14.4
1225	2158H	Odocoileus	1st Phalanx	SD	11.4
1225	2158H	Odocoileus	1st Phalanx	Bd	11.7
1226	2158H	Odocoileus	1st Phalanx	Bp	16.1
1231	2158H	Odocoileus	1st Phalanx	Bp	15.1
1231	2158H	Odocoileus	1st Phalanx	SD	10.4
1227	2158H	Odocoileus	2nd Phalanx	GL	34.2
1227	2158H	Odocoileus	2nd Phalanx	Bp	14.6
1227	2158H	Odocoileus	2nd Phalanx	SD	11.3
1227	2158H	Odocoileus	2nd Phalanx	Bd	10.3
1228	2158H	Odocoileus	2nd Phalanx	GL	33.8
1228	2158H	Odocoileus	2nd Phalanx	Bp	14.5
1228	2158H	Odocoileus	2nd Phalanx	SD	10.8
1228	2158H	Odocoileus	2nd Phalanx	Bd	10.6
1229	2158H	Odocoileus	2nd Phalanx	GL	33.0
1229	2158H	Odocoileus	2nd Phalanx	Bp	14.9
1229	2158H	Odocoileus	2nd Phalanx	SD	11.1
1229	2158H	Odocoileus	2nd Phalanx	Bd	10.5
1230	2158H	Odocoileus	2nd Phalanx	GL	30.1
1230	2158H	Odocoileus	2nd Phalanx	Bp	13.9
1230	2158H	Odocoileus	2nd Phalanx	SD	10.8
1230	2158H	Odocoileus	2nd Phalanx	Bd	9.1
1232	2158H	Odocoileus	2nd Phalanx	Bp	13.2
1233	2158H	Odocoileus	2nd Phalanx	Bd	9.9
1234	2158H	Odocoileus	3rd Phalanx	DLS	31.9
1234	2158H	Odocoileus	3rd Phalanx	Ld	29.4
1234	2158H	Odocoileus	3rd Phalanx	MBS	8.2
1235	2158H	Odocoileus	3rd Phalanx	DLS	32.8
1235	2158H	Odocoileus	3rd Phalanx	Ld	27.7
1235	2158H	Odocoileus	3rd Phalanx	MBS	7.5
1236	2158H	Odocoileus	3rd Phalanx	DLS	34.5
1236	2158H	Odocoileus	3rd Phalanx	Ld	29.9
1236	2158H	Odocoileus	3rd Phalanx	MBS	7.4
1334	2158H	Sus	Mandible	13	100.8
1334	2158H	Sus	Mandible	16a	59.8
1335	2158H	Sus	Mandible	16a	45.4

1346	2158H	Sus	Mandible	16a	48.9
1347	2158H	Sus	Mandible	16c	41.9
1367	2158H	Sus	Mandible	16b	35.0
1252	2158H	Sus	Scapula	SLC	22.6
1254	2158H	Sus	Scapula	GLP	32.6
1254	2158H	Sus	Scapula	LG	28.2
1254	2158H	Sus	Scapula	BG	22.5
1260	2158H	Sus	Ulna	BPC	22.7
1261	2158H	Sus	Radius	Bp	29.6
1262	2158H	Sus	Radius	Bp	30.4
1272	2158H	Sus	Humerus	SD	10.0
1269	2158H	Sus	Femur	SD	21.6
1270	2158H	Sus	Femur	SD	18.4
1263	2158H	Sus	Tibia	Bd	27.9
1263	2158H	Sus	Tibia	SD	20.9
1265	2158H	Sus	Tibia	Bp	29.9
1265	2158H	Sus	Tibia	SD	19.5
1267	2158H	Sus	Tibia	SD	19.5
1279	2158H	Sus	Innominate	LA	41.7
1279	2158H	Sus	Innominate	LAR	33.5
1451	2158H	Sus	Astragalus	GLl	42.1
1451	2158H	Sus	Astragalus	GLm	39.4
1451	2158H	Sus	Astragalus	Dl	21.5
1451	2158H	Sus	Astragalus	Bd	27.0
1452	2158H	Sus	Astragalus	GLl	44.5
1452	2158H	Sus	Astragalus	GLm	40.0
1452	2158H	Sus	Astragalus	Dl	23.7
1452	2158H	Sus	Astragalus	Bd	27.6
1453	2158H	Sus	Astragalus	GLl	40.3
1453	2158H	Sus	Astragalus	GLm	36.1
1453	2158H	Sus	Astragalus	Dl	23.1
1453	2158H	Sus	Astragalus	Bd	25.4
1454	2158H	Sus	Astragalus	GLl	44.4
1454	2158H	Sus	Astragalus	GLm	42.0
1454	2158H	Sus	Astragalus	Dl	23.1
1454	2158H	Sus	Astragalus	Bd	22.8
1434	2158H	Sus	Metapodial	GL	74.4
1434	2158H	Sus	Metapodial	Bp	18.2
1434	2158H	Sus	Metapodial	SD	14.2
1434	2158H	Sus	Metapodial	Bd	17.6
1435	2158H	Sus	Metapodial	GL	74.6
1435	2158H	Sus	Metapodial	Bp	18.0
1435	2158H	Sus	Metapodial	SD	14.9
1435	2158H	Sus	Metapodial	Bd	17.5
1436	2158H	Sus	Metapodial	Bp	0.5

1436	2158H	Sus	Metapodial	SD	0.8
1472	2158H	Sus	1st Phalanx	Glpe	44.4
1472	2158H	Sus	1st Phalanx	Bp	21.0
1472	2158H	Sus	1st Phalanx	SD	15.8
1472	2158H	Sus	1st Phalanx	Bd	18.5
1473	2158H	Sus	1st Phalanx	GLpe	40.8
1473	2158H	Sus	1st Phalanx	Bp	15.8
1473	2158H	Sus	1st Phalanx	SD	13.8
1473	2158H	Sus	1st Phalanx	Bd	14.8
1474	2158H	Sus	1st Phalanx	GLpe	36.8
1474	2158H	Sus	1st Phalanx	Bp	21.0
1474	2158H	Sus	1st Phalanx	SD	16.4
1474	2158H	Sus	1st Phalanx	Bd	17.5
1475	2158H	Sus	1st Phalanx	GLpe	39.8
1475	2158H	Sus	1st Phalanx	SD	14.1
1475	2158H	Sus	1st Phalanx	Bd	12.7
1475	2158H	Sus	1st Phalanx	15a	11.6
1476	2158H	Sus	1st Phalanx	GLpe	27.3
1476	2158H	Sus	1st Phalanx	Bp	10.8
1476	2158H	Sus	1st Phalanx	SD	8.2
1476	2158H	Sus	1st Phalanx	Bd	8.4
1481	2158H	Sus	2nd Phalanx	GL	25.1
1481	2158H	Sus	2nd Phalanx	Bp	17.3
1481	2158H	Sus	2nd Phalanx	SD	14.8
1481	2158H	Sus	2nd Phalanx	Bd	14.3
1482	2158H	Sus	2nd Phalanx	GL	28.4
1482	2158H	Sus	2nd Phalanx	SD	15.9
1483	2158H	Sus	2nd Phalanx	GL	26.7
1483	2158H	Sus	2nd Phalanx	Bp	18.2
1483	2158H	Sus	2nd Phalanx	SD	15.7
1483	2158H	Sus	2nd Phalanx	Bd	15.4
1484	2158H	Sus	2nd Phalanx	GL	25.1
1484	2158H	Sus	2nd Phalanx	Bp	15.9
1484	2158H	Sus	2nd Phalanx	SD	13.7
1484	2158H	Sus	2nd Phalanx	Bd	13.6
1485	2158H	Sus	2nd Phalanx	GL	23.6
1485	2158H	Sus	2nd Phalanx	Bp	15.9
1485	2158H	Sus	2nd Phalanx	SD	13.6
1485	2158H	Sus	2nd Phalanx	Bd	13.5
1494	2158H	Sus	3rd Phalanx	DLS	33.6
1494	2158H	Sus	3rd Phalanx	Ld	31.6
1494	2158H	Sus	3rd Phalanx	MBS	15.0
1495	2158H	Sus	3rd Phalanx	DLS	22.5
1495	2158H	Sus	3rd Phalanx	Ld	19.1
1495	2158H	Sus	3rd Phalanx	MBS	8.0

1496	2158H	Sus	3rd Phalanx	DLS	22.6
1496	2158H	Sus	3rd Phalanx	Ld	20.3
1496	2158H	Sus	3rd Phalanx	MBS	18.1
1538	2158H	Ovis/Capra	Radius	SD	17.8
	2158N				
831	2158N	Odocoileus	Mandible	3	47.1
831	2158N	Odocoileus	Mandible	7	84.9
831	2158N	Odocoileus	Mandible	8	48.2
831	2158N	Odocoileus	Mandible	9	35.9
831	2158N	Odocoileus	Mandible	12	62.6
831	2158N	Odocoileus	Mandible	13	62.2
831	2158N	Odocoileus	Mandible	14	96.1
831	2158N	Odocoileus	Mandible	15a	31.7
831	2158N	Odocoileus	Mandible	15b	22.0
831	2158N	Odocoileus	Mandible	15c	20.8
481	2158N	Odocoileus	Ulna	BPC	21.9
481	2158N	Odocoileus	Ulna	DPA	34.0
481	2158N	Odocoileus	Ulna	SDO	31.6
482	2158N	Odocoileus	Ulna	BPC	19.9
482	2158N	Odocoileus	Ulna	DPA	34.3
482	2158N	Odocoileus	Ulna	SDO	29.8
483	2158N	Odocoileus	Ulna	BPC	20.3
483	2158N	Odocoileus	Ulna	DPA	41.0
484	2158N	Odocoileus	Ulna	BPC	20.1
484	2158N	Odocoileus	Ulna	DPA	35.1
484	2158N	Odocoileus	Ulna	SDO	29.5
363	2158H	Odocoileus	Radius	Bp	39.3
389	2158N	Odocoileus	Radius	SD	18.1
491	2158N	Odocoileus	Radius	BP	36.4
491	2158N	Odocoileus	Radius	BFp	34.3
491	2158N	Odocoileus	Radius	SD	21.3
492	2158N	Odocoileus	Radius	SD	21.1
493	2158N	Odocoileus	Radius	Bp	34.2
493	2158N	Odocoileus	Radius	BFp	33.4
493	2158N	Odocoileus	Radius	SD	21.1
494	2158N	Odocoileus	Radius	Bp	37.3
494	2158N	Odocoileus	Radius	BFp	35.9
494	2158N	Odocoileus	Radius	SD	19.8
497	2158N	Odocoileus	Radius	BFd	31.0
499	2158N	Odocoileus	Radius	BFd	31.5
499	2158N	Odocoileus	Radius	Bd	32.3
841	2158N	Odocoileus	Radius	Bd	34.4
511	2158N	Odocoileus	Humerus	Bd	36.0
512	2158N	Odocoileus	Humerus	Bd	37.0

513	2158N	Odocoileus	Humerus	Bd	41.2
514	2158N	Odocoileus	Humerus	Bd	38.5
514	2158N	Odocoileus	Humerus	SD	19.1
515	2158N	Odocoileus	Humerus	Bp	30.8
517	2158N	Odocoileus	Humerus	SD	19.1
375	2158N	Odocoileus	Scapula	BG	26.3
375	2158N	Odocoileus	Scapula	LG	28.0
375	2158N	Odocoileus	Scapula	GLP	37.3
572	2158N	Odocoileus	Scapula	BG	24.3
572	2158N	Odocoileus	Scapula	SLC	19.8
834	2158N	Odocoileus	Scapula	GLP	45.2
834	2158N	Odocoileus	Scapula	LG	36.4
834	2158N	Odocoileus	Scapula	BG	35.8
834	2158N	Odocoileus	Scapula	SLC	32.0
843	2158N	Odocoileus	Scapula	GLP	33.9
843	2158N	Odocoileus	Scapula	LG	29.5
843	2158N	Odocoileus	Scapula	BG	24.4
843	2158N	Odocoileus	Scapula	SLC	20.3
842	2158N	Odocoileus	Innominate	LA	44.2
528	2158N	Odocoileus	Femur	SD	22.5
540	2158N	Odocoileus	Femur	Bp	64.1
835	2158N	Odocoileus	Femur	Bd	48.5
835	2158N	Odocoileus	Femur	SD	24.6
836	2158N	Odocoileus	Femur	SD	20.7
837	2158N	Odocoileus	Femur	SD	16.9
838	2158N	Odocoileus	Femur	SD	22.5
833	2158N	Odocoileus	Tibia	Bp	44.2
833	2158N	Odocoileus	Tibia	SD	25.8
382	2158N	Odocoileus	Metacarpal	Bp	26.9
384	2158N	Odocoileus	Metacarpal	Bd	27.2
385	2158N	Odocoileus	Metacarpal	Bd	28.0
854	2158N	Odocoileus	Metacarpal	Bp	30.7
854	2158N	Odocoileus	Metacarpal	SD	22.3
855	2158N	Odocoileus	Metacarpal	Bp	28.6
855	2158N	Odocoileus	Metacarpal	SD	17.4
855	2158N	Odocoileus	Metacarpal	Bd	29.4
856	2158N	Odocoileus	Metacarpal	Bp	28.5
856	2158N	Odocoileus	Metacarpal	SD	15.5
857	2158N	Odocoileus	Metacarpal	Bp	29.6
857	2158N	Odocoileus	Metacarpal	SD	16.0
860	2158N	Odocoileus	Metacarpal	Bd	30.8
860	2158N	Odocoileus	Metacarpal	SD	18.2
865	2158N	Odocoileus	Metacarpal	SD	16.6
863	2158N	Odocoileus	Metacarpal	SD	13.3
381	2158N	Odocoileus	Metatarsal	Bd	32.9

381	2158N	Odocoileus	Metatarsal	SD	19.3
845	2158N	Odocoileus	Metatarsal	Bp	26.6
845	2158N	Odocoileus	Metatarsal	SD	15.9
846	2158N	Odocoileus	Metatarsal	Bp	26.9
846	2158N	Odocoileus	Metatarsal	SD	15.9
847	2158N	Odocoileus	Metatarsal	Bp	27.6
847	2158N	Odocoileus	Metatarsal	SD	14.1
848	2158N	Odocoileus	Metatarsal	Bp	29.3
848	2158N	Odocoileus	Metatarsal	SD	19.1
850	2158N	Odocoileus	Metatarsal	SD	15.5
879	2158N	Odocoileus	Astragalus	Bd	23.8
879	2158N	Odocoileus	Astragalus	Dl	21.1
880	2158N	Odocoileus	Astragalus	Bd	23.4
880	2158N	Odocoileus	Astragalus	Dl	22.6
881	2158N	Odocoileus	Astragalus	GLl	39.8
881	2158N	Odocoileus	Astragalus	GLm	37.7
881	2158N	Odocoileus	Astragalus	Dl	23.2
881	2158N	Odocoileus	Astragalus	Bd	24.3
882	2158N	Odocoileus	Astragalus	GLl	40.3
882	2158N	Odocoileus	Astragalus	GLm	38.2
882	2158N	Odocoileus	Astragalus	Dl	22.5
882	2158N	Odocoileus	Astragalus	Bd	25.1
883	2158N	Odocoileus	Astragalus	GLl	40.8
883	2158N	Odocoileus	Astragalus	GLm	38.6
883	2158N	Odocoileus	Astragalus	Dl	22.4
883	2158N	Odocoileus	Astragalus	Bd	25.4
884	2158N	Odocoileus	Astragalus	GLl	39.6
884	2158N	Odocoileus	Astragalus	GLm	38.2
884	2158N	Odocoileus	Astragalus	Dl	22.2
884	2158N	Odocoileus	Astragalus	Bd	25.0
885	2158N	Odocoileus	Astragalus	GLl	39.3
885	2158N	Odocoileus	Astragalus	GLm	37.4
885	2158N	Odocoileus	Astragalus	Dl	22.0
885	2158N	Odocoileus	Astragalus	Bd	25.1
402	2158N	Odocoileus	1st Phalanx	GL	31.5
402	2158N	Odocoileus	1st Phalanx	Bp	12.8
402	2158N	Odocoileus	1st Phalanx	SD	10.3
402	2158N	Odocoileus	1st Phalanx	Bd	9.3
912	2158N	Odocoileus	1st Phalanx	GL	46.7
912	2158N	Odocoileus	1st Phalanx	Bp	16.5
912	2158N	Odocoileus	1st Phalanx	SD	13.0
912	2158N	Odocoileus	1st Phalanx	Bd	14.3
913	2158N	Odocoileus	1st Phalanx	GL	42.9
913	2158N	Odocoileus	1st Phalanx	Bp	15.4
913	2158N	Odocoileus	1st Phalanx	SD	11.5

913	2158N	Odocoileus	1st Phalanx	Bd	12.7
914	2158N	Odocoileus	1st Phalanx	GL	45.0
914	2158N	Odocoileus	1st Phalanx	Bp	15.0
914	2158N	Odocoileus	1st Phalanx	SD	10.2
914	2158N	Odocoileus	1st Phalanx	Bd	11.5
915	2158N	Odocoileus	1st Phalanx	GL	44.5
915	2158N	Odocoileus	1st Phalanx	Bp	15.9
915	2158N	Odocoileus	1st Phalanx	SD	11.6
915	2158N	Odocoileus	1st Phalanx	Bd	12.5
916	2158N	Odocoileus	1st Phalanx	GL	46.3
916	2158N	Odocoileus	1st Phalanx	Bp	16.4
916	2158N	Odocoileus	1st Phalanx	SD	12.7
916	2158N	Odocoileus	1st Phalanx	Bd	14.0
917	2158N	Odocoileus	1st Phalanx	GL	43.0
917	2158N	Odocoileus	1st Phalanx	Bp	15.8
917	2158N	Odocoileus	1st Phalanx	SD	12.0
917	2158N	Odocoileus	1st Phalanx	Bd	12.6
918	2158N	Odocoileus	1st Phalanx	GL	43.1
918	2158N	Odocoileus	1st Phalanx	Bp	15.0
918	2158N	Odocoileus	1st Phalanx	SD	11.1
918	2158N	Odocoileus	1st Phalanx	Bd	12.5
919	2158N	Odocoileus	1st Phalanx	GL	43.5
919	2158N	Odocoileus	1st Phalanx	Bp	15.8
919	2158N	Odocoileus	1st Phalanx	SD	12.5
919	2158N	Odocoileus	1st Phalanx	Bd	12.9
920	2158N	Odocoileus	1st Phalanx	GL	44.2
920	2158N	Odocoileus	1st Phalanx	Bp	15.3
920	2158N	Odocoileus	1st Phalanx	SD	12.9
920	2158N	Odocoileus	1st Phalanx	Bd	13.4
921	2158N	Odocoileus	1st Phalanx	GL	40.3
921	2158N	Odocoileus	1st Phalanx	Bp	14.4
921	2158N	Odocoileus	1st Phalanx	SD	10.5
921	2158N	Odocoileus	1st Phalanx	Bd	12.0
923	2158N	Odocoileus	2nd Phalanx	GL	33.6
923	2158N	Odocoileus	2nd Phalanx	Bp	13.3
923	2158N	Odocoileus	2nd Phalanx	SD	10.9
923	2158N	Odocoileus	2nd Phalanx	Bd	9.0
924	2158N	Odocoileus	2nd Phalanx	GL	33.8
924	2158N	Odocoileus	2nd Phalanx	Bp	12.2
924	2158N	Odocoileus	2nd Phalanx	SD	10.2
924	2158N	Odocoileus	2nd Phalanx	Bd	9.3
925	2158N	Odocoileus	2nd Phalanx	GL	33.2
925	2158N	Odocoileus	2nd Phalanx	Bp	13.0
925	2158N	Odocoileus	2nd Phalanx	SD	9.8
925	2158N	Odocoileus	2nd Phalanx	Bd	9.6

926	2158N	Odocoileus	2nd Phalanx	GL	34.0
926	2158N	Odocoileus	2nd Phalanx	Bp	14.5
926	2158N	Odocoileus	2nd Phalanx	SD	11.0
926	2158N	Odocoileus	2nd Phalanx	Bd	11.7
927	2158N	Odocoileus	2nd Phalanx	GL	29.8
927	2158N	Odocoileus	2nd Phalanx	Bp	13.7
927	2158N	Odocoileus	2nd Phalanx	SD	10.9
927	2158N	Odocoileus	2nd Phalanx	Bd	10.3
928	2158N	Odocoileus	2nd Phalanx	GL	30.0
928	2158N	Odocoileus	2nd Phalanx	Bp	13.6
928	2158N	Odocoileus	2nd Phalanx	SD	10.8
928	2158N	Odocoileus	2nd Phalanx	Bd	10.3
929	2158N	Odocoileus	2nd Phalanx	GL	34.5
929	2158N	Odocoileus	2nd Phalanx	Bp	14.3
929	2158N	Odocoileus	2nd Phalanx	SD	10.9
929	2158N	Odocoileus	2nd Phalanx	Bd	10.2
930	2158N	Odocoileus	2nd Phalanx	GL	30.0
930	2158N	Odocoileus	2nd Phalanx	Bp	13.0
930	2158N	Odocoileus	2nd Phalanx	SD	10.0
930	2158N	Odocoileus	2nd Phalanx	Bd	9.0
869	2158N	Odocoileus	3rd Phalanx	DLS	30.5
869	2158N	Odocoileus	3rd Phalanx	Ld	28.8
869	2158N	Odocoileus	3rd Phalanx	MBS	17.7
870	2158N	Odocoileus	3rd Phalanx	DLS	32.3
870	2158N	Odocoileus	3rd Phalanx	Ld	28.5
870	2158N	Odocoileus	3rd Phalanx	MBS	17.4
871	2158N	Odocoileus	3rd Phalanx	DLS	32.9
871	2158N	Odocoileus	3rd Phalanx	Ld	29.1
871	2158N	Odocoileus	3rd Phalanx	MBS	16.9
872	2158N	Odocoileus	3rd Phalanx	DLS	32.5
872	2158N	Odocoileus	3rd Phalanx	Ld	29.3
872	2158N	Odocoileus	3rd Phalanx	MBS	16.7
873	2158N	Odocoileus	3rd Phalanx	DLS	35.7
873	2158N	Odocoileus	3rd Phalanx	Ld	33.0
873	2158N	Odocoileus	3rd Phalanx	MBS	8.9
874	2158N	Odocoileus	3rd Phalanx	DLS	32.5
874	2158N	Odocoileus	3rd Phalanx	Ld	27.9
874	2158N	Odocoileus	3rd Phalanx	MBS	6.9
875	2158N	Odocoileus	3rd Phalanx	DLS	34.2
875	2158N	Odocoileus	3rd Phalanx	Ld	27.6
875	2158N	Odocoileus	3rd Phalanx	MBS	7.5
765	2158N	Sus	Maxilla	28	59.0
765	2158N	Sus	Maxilla	31	28.1
769	2158N	Sus	Maxilla	28	63.0
769	2158N	Sus	Maxilla	31	32.4

776	2158N	Sus	Mandible	9a	32.4
812	2158N	Sus	Mandible	16b	34.4
285	2158N	Sus	Atlas	GB	88.6
285	2158N	Sus	Atlas	H	45.8
285	2158N	Sus	Atlas	BFcd	62.1
285	2158N	Sus	Atlas	BFcr	59.5
354	2158N	Sus	Radius	Bp	28.7
246	2158N	Sus	Humerus	Bd	33.5
352	2158N	Sus	Humerus	Bd	35.8
516	2158N	Sus	Humerus	SD	16.2
679	2158N	Sus	Humerus	Bd	41.6
679	2158N	Sus	Humerus	SD	16.6
670	2158N	Sus	Scapula	GLP	39.2
670	2158N	Sus	Scapula	LG	32.7
670	2158N	Sus	Scapula	BG	30.4
670	2158N	Sus	Scapula	SLC	26.4
671	2158N	Sus	Scapula	SLC	26.6
672	2158N	Sus	Scapula	GLP	25.1
672	2158N	Sus	Scapula	BG	18.4
672	2158N	Sus	Scapula	SLC	15.2
673	2158N	Sus	Scapula	GLP	24.9
673	2158N	Sus	Scapula	BG	14.3
673	2158N	Sus	Scapula	SLC	15.9
343	2158N	Sus	Femur	SD	20.2
344	2158N	Sus	Femur	SD	21.4
536	2158N	Sus	Femur	SD	15.7
541	2158N	Sus	Femur	SD	56.4
686	2158N	Sus	Femur	SD	19.1
345	2158N	Sus	Tibia	Bd	28.8
364	2158N	Sus	Tibia	Bd	28.1
682	2158N	Sus	Tibia	SD	22.1
682	2158N	Sus	Tibia	Bd	28.7
683	2158N	Sus	Tibia	Bd	35.7
684	2158N	Sus	Tibia	SD	19.7
351	2158N	Sus	Astragalus	GLl	48.2
351	2158N	Sus	Astragalus	GLm	45.7
351	2158N	Sus	Astragalus	Dl	29.2
351	2158N	Sus	Astragalus	Bd	31.0
358	2158N	Sus	Astragalus	GLl	41.4
358	2158N	Sus	Astragalus	GLm	39.3
358	2158N	Sus	Astragalus	Dl	24.7
358	2158N	Sus	Astragalus	Bd	24.2
986	2158N	Sus	Astragalus	GLl	40.6
986	2158N	Sus	Astragalus	GLm	37.6
987	2158N	Sus	Astragalus	GLl	42.1

987	2158N	Sus	Astragalus	GLm	39.2
355	2158N	Sus	Carpal/Tarsal	Bp	15.0
357	2158N	Sus	Carpal/Tarsal	Bp	17.9
992	2158N	Sus	Metapodials	Bp	17.2
993	2158N	Sus	Metapodials	Bp	14.9
951	2158N	Sus	1st Phalanx	Glpe	40.9
951	2158N	Sus	1st Phalanx	Bp	17.3
951	2158N	Sus	1st Phalanx	SD	14.4
951	2158N	Sus	1st Phalanx	Bd	15.6
952	2158N	Sus	1st Phalanx	Glpe	37.4
952	2158N	Sus	1st Phalanx	Bp	16.4
952	2158N	Sus	1st Phalanx	SD	13.7
952	2158N	Sus	1st Phalanx	Bd	15.6
953	2158N	Sus	1st Phalanx	Glpe	41.8
953	2158N	Sus	1st Phalanx	Bp	18.5
953	2158N	Sus	1st Phalanx	SD	14.6
953	2158N	Sus	1st Phalanx	Bd	15.9
954	2158N	Sus	1st Phalanx	Glpe	36.8
954	2158N	Sus	1st Phalanx	Bp	15.2
954	2158N	Sus	1st Phalanx	SD	11.8
954	2158N	Sus	1st Phalanx	Bd	13.0
964	2158N	Sus	2nd Phalanx	GL	21.9
964	2158N	Sus	2nd Phalanx	Bp	13.7
964	2158N	Sus	2nd Phalanx	SD	10.0
964	2158N	Sus	2nd Phalanx	Bd	9.6
965	2158N	Sus	2nd Phalanx	GL	23.4
965	2158N	Sus	2nd Phalanx	Bp	15.9
965	2158N	Sus	2nd Phalanx	SD	13.4
965	2158N	Sus	2nd Phalanx	Bd	12.6
966	2158N	Sus	2nd Phalanx	SD	10.4
966	2158N	Sus	2nd Phalanx	Bd	11.9
967	2158N	Sus	2nd Phalanx	SD	8.7
967	2158N	Sus	2nd Phalanx	Bd	8.7
968	2158N	Sus	2nd Phalanx	GL	23.8
968	2158N	Sus	2nd Phalanx	Bp	15.0
968	2158N	Sus	2nd Phalanx	SD	13.2
968	2158N	Sus	2nd Phalanx	Bd	13.0
969	2158N	Sus	2nd Phalanx	GL	24.5
969	2158N	Sus	2nd Phalanx	Bp	13.4
969	2158N	Sus	2nd Phalanx	SD	10.5
969	2158N	Sus	2nd Phalanx	Bd	10.1
970	2158N	Sus	2nd Phalanx	GL	24.6
970	2158N	Sus	2nd Phalanx	Bp	15.1
970	2158N	Sus	2nd Phalanx	SD	13.1
970	2158N	Sus	2nd Phalanx	Bd	12.7

971	2158N	Sus	2nd Phalanx	GL	11.5
971	2158N	Sus	2nd Phalanx	Bp	14.2
971	2158N	Sus	2nd Phalanx	SD	12.4
971	2158N	Sus	2nd Phalanx	Bd	11.6
976	2158N	Sus	3rd Phalanx	DLS	29.9
976	2158N	Sus	3rd Phalanx	Ld	27.5
976	2158N	Sus	3rd Phalanx	MBS	11.8
977	2158N	Sus	3rd Phalanx	DLS	28.5
977	2158N	Sus	3rd Phalanx	Ld	26.2
977	2158N	Sus	3rd Phalanx	MBS	10.4
978	2158N	Sus	3rd Phalanx	DLS	22.3
978	2158N	Sus	3rd Phalanx	Ld	19.5
978	2158N	Sus	3rd Phalanx	MBS	8.3
979	2158N	Sus	3rd Phalanx	DLS	21.5
979	2158N	Sus	3rd Phalanx	Ld	17.4
979	2158N	Sus	3rd Phalanx	MBS	9.3
980	2158N	Sus	3rd Phalanx	DLS	19.4
980	2158N	Sus	3rd Phalanx	Ld	16.8
980	2158N	Sus	3rd Phalanx	MBS	16.1
981	2158N	Sus	3rd Phalanx	DLS	22.8
981	2158N	Sus	3rd Phalanx	Ld	20.8
981	2158N	Sus	3rd Phalanx	MBS	8.2
982	2158N	Sus	3rd Phalanx	DLS	15.5
982	2158N	Sus	3rd Phalanx	Ld	10.8
982	2158N	Sus	3rd Phalanx	MBS	6.5
983	2158N	Sus	3rd Phalanx	DLS	17.9
983	2158N	Sus	3rd Phalanx	Ld	13.9
983	2158N	Sus	3rd Phalanx	MBS	16.8
984	2158N	Sus	3rd Phalanx	DLS	18.7
984	2158N	Sus	3rd Phalanx	Ld	15.8
984	2158N	Sus	3rd Phalanx	MBS	16.1
985	2158N	Sus	3rd Phalanx	DLS	16.5
985	2158N	Sus	3rd Phalanx	Ld	14.5
985	2158N	Sus	3rd Phalanx	MBS	8.6
986	2158N	Sus	3rd Phalanx	DLS	13.2
986	2158N	Sus	3rd Phalanx	Ld	12.3
486	2158N	Ovis/Capra	Ulna	SDO	27.6
486	2158N	Ovis/Capra	Ulna	LO	49.9
486	2158N	Ovis/Capra	Ulna	DPA	36.4
487	2158N	Ovis/Capra	Ulna	LO	64.7
	2158P				
2593	2158P	Odocoileus	Atlas	BFcr	46.2
2595	2158P	Odocoileus	Axis	BFcr	44.1
2280	2158P	Odocoileus	Ulna	BPC	19.9

2280	2158P	Odocoileus	Ulna	DPA	38.0
2281	2158P	Odocoileus	Ulna	BPC	20.9
2282	2158P	Odocoileus	Ulna	LO	57.5
2282	2158P	Odocoileus	Ulna	SDO	36.4
2283	2158P	Odocoileus	Ulna	DPA	31.9
2283	2158P	Odocoileus	Ulna	BPC	18.8
2284	2158P	Odocoileus	Ulna	LO	51.0
2284	2158P	Odocoileus	Ulna	SDO	31.4
2284	2158P	Odocoileus	Ulna	DPA	33.7
2284	2158P	Odocoileus	Ulna	BPC	20.9
2285	2158P	Odocoileus	Ulna	LO	48.9
2285	2158P	Odocoileus	Ulna	SDO	32.6
2285	2158P	Odocoileus	Ulna	DPA	34.1
2285	2158P	Odocoileus	Ulna	BPC	20.9
2286	2158P	Odocoileus	Ulna	LO	47.1
2286	2158P	Odocoileus	Ulna	SDO	28.3
2286	2158P	Odocoileus	Ulna	DPA	31.2
2286	2158P	Odocoileus	Ulna	BPC	18.4
2287	2158P	Odocoileus	Ulna	DPA	34.8
2287	2158P	Odocoileus	Ulna	BPC	22.0
2288	2158P	Odocoileus	Ulna	DPA	33.2
2288	2158P	Odocoileus	Ulna	BPC	19.6
2289	2158P	Odocoileus	Ulna	DPA	36.1
2289	2158P	Odocoileus	Ulna	BPC	23.2
2297	2158P	Odocoileus	Ulna	LO	62.7
2297	2158P	Odocoileus	Ulna	SDO	33.9
2297	2158P	Odocoileus	Ulna	DPA	41.0
2297	2158P	Odocoileus	Ulna	BPC	23.0
2142	2158P	Odocoileus	Radius	Bd	33.3
2142	2158P	Odocoileus	Radius	BFd	32.1
2142	2158P	Odocoileus	Radius	SD	24.1
2143	2158P	Odocoileus	Radius	Bd	32.0
2143	2158P	Odocoileus	Radius	BFd	30.5
2143	2158P	Odocoileus	Radius	SD	21.5
2144	2158P	Odocoileus	Radius	Bd	30.1
2144	2158P	Odocoileus	Radius	BFd	29.0
2145	2158P	Odocoileus	Radius	Bd	32.2
2145	2158P	Odocoileus	Radius	Bfd	30.6
2145	2158P	Odocoileus	Radius	SD	21.6
2146	2158P	Odocoileus	Radius	Bd	32.6
2146	2158P	Odocoileus	Radius	BFd	31.7
2146	2158P	Odocoileus	Radius	SD	21.5
2147	2158P	Odocoileus	Radius	Bd	31.6
2147	2158P	Odocoileus	Radius	BFd	30.2
2147	2158P	Odocoileus	Radius	SD	20.7

2148	2158P	Odocoileus	Radius	Bp	41.3
2148	2158P	Odocoileus	Radius	BFp	38.2
2148	2158P	Odocoileus	Radius	SD	26.9
2149	2158P	Odocoileus	Radius	BP	35.8
2149	2158P	Odocoileus	Radius	BFp	33.8
2149	2158P	Odocoileus	Radius	SD	20.0
2150	2158P	Odocoileus	Radius	Bd	34.2
2150	2158P	Odocoileus	Radius	BFd	32.1
2151	2158P	Odocoileus	Radius	Bp	33.1
2151	2158P	Odocoileus	Radius	BFp	31.0
2151	2158P	Odocoileus	Radius	SD	20.9
2152	2158P	Odocoileus	Radius	Bp	36.7
2152	2158P	Odocoileus	Radius	BFp	34.1
2152	2158P	Odocoileus	Radius	SD	20.1
2154	2158P	Odocoileus	Radius	Bd	36.1
2154	2158P	Odocoileus	Radius	BFd	34.0
2154	2158P	Odocoileus	Radius	SD	23.2
2155	2158P	Odocoileus	Radius	Bp	34.8
2155	2158P	Odocoileus	Radius	BFp	33.0
2555	2158P	Odocoileus	Radius	Bp	35.4
2160	2158P	Odocoileus	Humerus	Bd	38.2
2160	2158P	Odocoileus	Humerus	BT	34.9
2162	2158P	Odocoileus	Humerus	Bd	41.7
2162	2158P	Odocoileus	Humerus	BT	38.2
2163	2158P	Odocoileus	Humerus	Bd	35.6
2163	2158P	Odocoileus	Humerus	BT	33.9
2164	2158P	Odocoileus	Humerus	Bp	41.9
2165	2158P	Odocoileus	Humerus	SD	21.9
2166	2158P	Odocoileus	Humerus	SD	17.9
2167	2158P	Odocoileus	Humerus	Bd	48.7
2167	2158P	Odocoileus	Humerus	SD	21.0
2170	2158P	Odocoileus	Humerus	Bd	36.7
2170	2158P	Odocoileus	Humerus	BT	33.2
2171	2158P	Odocoileus	Humerus	Bd	38.1
2171	2158P	Odocoileus	Humerus	BT	34.9
2174	2158P	Odocoileus	Humerus	Bp	36.6
2177	2158P	Odocoileus	Humerus	BT	33.8
2177	2158P	Odocoileus	Humerus	Bd	37.5
2178	2158P	Odocoileus	Humerus	BT	33.2
2178	2158P	Odocoileus	Humerus	Bd	36.8
2178	2158P	Odocoileus	Humerus	SD	16.9
2179	2158P	Odocoileus	Humerus	SD	17.0
2180	2158P	Odocoileus	Humerus	BT	34.5
2180	2158P	Odocoileus	Humerus	Bd	38.1
2309	2158P	Odocoileus	Scapula	GLP	46.6

2309	2158P	Odocoileus	Scapula	LG	37.0
2309	2158P	Odocoileus	Scapula	BG	35.0
2309	2158P	Odocoileus	Scapula	SLC	26.9
2310	2158P	Odocoileus	Scapula	GLP	39.1
2310	2158P	Odocoileus	Scapula	LG	31.9
2310	2158P	Odocoileus	Scapula	BG	27.2
2310	2158P	Odocoileus	Scapula	SLC	22.7
2311	2158P	Odocoileus	Scapula	BG	25.1
2312	2158P	Odocoileus	Scapula	GLP	35.9
2312	2158P	Odocoileus	Scapula	LG	28.3
2312	2158P	Odocoileus	Scapula	BG	26.6
2312	2158P	Odocoileus	Scapula	SLC	21.2
2313	2158P	Odocoileus	Scapula	GLP	38.3
2313	2158P	Odocoileus	Scapula	LG	30.5
2313	2158P	Odocoileus	Scapula	BG	26.8
2313	2158P	Odocoileus	Scapula	SLC	21.8
2314	2158P	Odocoileus	Scapula	LG	33.9
2314	2158P	Odocoileus	Scapula	BG	33.6
2314	2158P	Odocoileus	Scapula	SLC	26.2
2315	2158P	Odocoileus	Scapula	GLP	42.4
2315	2158P	Odocoileus	Scapula	LG	33.4
2315	2158P	Odocoileus	Scapula	BG	30.8
2315	2158P	Odocoileus	Scapula	SLC	25.5
2316	2158P	Odocoileus	Scapula	GLP	39.3
2316	2158P	Odocoileus	Scapula	LG	29.0
2316	2158P	Odocoileus	Scapula	BG	28.3
2316	2158P	Odocoileus	Scapula	SLC	22.1
2317	2158P	Odocoileus	Scapula	GLP	39.1
2317	2158P	Odocoileus	Scapula	LG	30.5
2317	2158P	Odocoileus	Scapula	BG	26.7
2317	2158P	Odocoileus	Scapula	SLC	21.4
2318	2158P	Odocoileus	Scapula	GLP	38.1
2318	2158P	Odocoileus	Scapula	LG	31.3
2318	2158P	Odocoileus	Scapula	BG	28.8
2318	2158P	Odocoileus	Scapula	SLC	21.1
2319	2158P	Odocoileus	Scapula	GLP	39.9
2319	2158P	Odocoileus	Scapula	LG	29.9
2319	2158P	Odocoileus	Scapula	BG	28.9
2699	2158P	Odocoileus	Scapula	GLP	33.0
2699	2158P	Odocoileus	Scapula	BG	23.0
2340	2158P	Odocoileus	Innominate	LA	36.7
2340	2158P	Odocoileus	Innominate	LAR	30.4
2341	2158P	Odocoileus	Innominate	LA	38.8
2341	2158P	Odocoileus	Innominate	LAR	32.5
2341	2158P	Odocoileus	Innominate	SB	12.1

2341	2158P	Odocoileus	Innominate	LFo	48.5
2342	2158P	Odocoileus	Innominate	LA	35.6
2342	2158P	Odocoileus	Innominate	LAR	27.3
2342	2158P	Odocoileus	Innominate	LFo	52.8
2344	2158P	Odocoileus	Innominate	LA	38.8
2344	2158P	Odocoileus	Innominate	LAR	30.6
2344	2158P	Odocoileus	Innominate	SB	12.5
2344	2158P	Odocoileus	Innominate	LFo	52.5
2347	2158P	Odocoileus	Innominate	LA	37.2
2347	2158P	Odocoileus	Innominate	LAR	33.2
2348	2158P	Odocoileus	Innominate	SB	14.1
2352	2158P	Odocoileus	Innominate	LA	39.0
2352	2158P	Odocoileus	Innominate	LAR	32.5
2192	2158P	Odocoileus	Femur	Bd	50.8
2195	2158P	Odocoileus	Femur	SD	26.1
2200	2158P	Odocoileus	Femur	Bp	64.2
2200	2158P	Odocoileus	Femur	DC	26.8
2202	2158P	Odocoileus	Femur	SD	21.7
2203	2158P	Odocoileus	Femur	SD	21.6
2207	2158P	Odocoileus	Femur	SD	21.9
2209	2158P	Odocoileus	Femur	SD	19.7
2210	2158P	Odocoileus	Femur	Bp	58.3
2210	2158P	Odocoileus	Femur	DC	25.3
2211	2158P	Odocoileus	Femur	DC	27.0
2212	2158P	Odocoileus	Femur	DC	26.7
2213	2158P	Odocoileus	Femur	DC	25.2
2214	2158P	Odocoileus	Femur	DC	25.3
2220	2158P	Odocoileus	Femur	Bd	60.8
2220	2158P	Odocoileus	Femur	DC	26.2
2221	2158P	Odocoileus	Femur	SD	21.5
2707	2158P	Odocoileus	Femur	SD	19.9
2231	2158P	Odocoileus	Tibia	Bd	33.2
2231	2158P	Odocoileus	Tibia	SD	20.6
2233	2158P	Odocoileus	Tibia	Bd	33.2
2233	2158P	Odocoileus	Tibia	SD	22.0
2234	2158P	Odocoileus	Tibia	Bp	51.9
2235	2158P	Odocoileus	Tibia	Bp	53.4
2236	2158P	Odocoileus	Tibia	Bp	55.6
2236	2158P	Odocoileus	Tibia	SD	22.1
2237	2158P	Odocoileus	Tibia	SD	20.6
2237	2158P	Odocoileus	Tibia	Bd	35.0
2238	2158P	Odocoileus	Tibia	Bp	58.4
2239	2158P	Odocoileus	Tibia	Bp	60.2
2241	2158P	Odocoileus	Tibia	Bd	32.5
2242	2158P	Odocoileus	Tibia	Bd	32.4

2243	2158P	Odocoileus	Tibia	Bp	57.7
2247	2158P	Odocoileus	Tibia	Bd	34.8
2248	2158P	Odocoileus	Tibia	Bd	33.4
2250	2158P	Odocoileus	Tibia	SD	18.2
2456	2158P	Odocoileus	Astragalus	GLl	38.8
2456	2158P	Odocoileus	Astragalus	GLm	38.2
2456	2158P	Odocoileus	Astragalus	Dl	23.0
2456	2158P	Odocoileus	Astragalus	Bd	24.9
2457	2158P	Odocoileus	Astragalus	GLl	41.0
2457	2158P	Odocoileus	Astragalus	GLm	38.3
2457	2158P	Odocoileus	Astragalus	Dl	22.5
2457	2158P	Odocoileus	Astragalus	Bd	25.0
2458	2158P	Odocoileus	Astragalus	GLl	38.2
2458	2158P	Odocoileus	Astragalus	GLm	35.5
2458	2158P	Odocoileus	Astragalus	Dl	21.1
2458	2158P	Odocoileus	Astragalus	Bd	22.5
2459	2158P	Odocoileus	Astragalus	GLl	38.3
2459	2158P	Odocoileus	Astragalus	GLm	35.0
2459	2158P	Odocoileus	Astragalus	Dl	22.7
2459	2158P	Odocoileus	Astragalus	Bd	23.5
2460	2158P	Odocoileus	Astragalus	GLl	37.3
2460	2158P	Odocoileus	Astragalus	GLm	34.3
2460	2158P	Odocoileus	Astragalus	Dl	20.6
2460	2158P	Odocoileus	Astragalus	Bd	23.1
2461	2158P	Odocoileus	Astragalus	GLl	36.0
2461	2158P	Odocoileus	Astragalus	GLm	33.8
2461	2158P	Odocoileus	Astragalus	Dl	21.2
2461	2158P	Odocoileus	Astragalus	Bd	22.0
2462	2158P	Odocoileus	Astragalus	GLm	36.8
2462	2158P	Odocoileus	Astragalus	Dl	21.0
2462	2158P	Odocoileus	Astragalus	Bd	24.7
2463	2158P	Odocoileus	Astragalus	GLl	39.9
2463	2158P	Odocoileus	Astragalus	GLm	37.9
2463	2158P	Odocoileus	Astragalus	Dl	22.1
2463	2158P	Odocoileus	Astragalus	Bd	24.2
2464	2158P	Odocoileus	Astragalus	GLl	33.4
2464	2158P	Odocoileus	Astragalus	GLm	30.9
2464	2158P	Odocoileus	Astragalus	Dl	18.6
2464	2158P	Odocoileus	Astragalus	Bd	20.8
2465	2158P	Odocoileus	Calcaneous	GL	84.5
2465	2158P	Odocoileus	Calcaneous	GB	26.4
2466	2158P	Odocoileus	Calcaneous	GB	26.0
2467	2158P	Odocoileus	Calcaneous	GB	26.2
2479	2158P	Odocoileus	Carpal/Tarsal	GB	29.1
2480	2158P	Odocoileus	Carpal/Tarsal	GB	31.4

2481	2158P	Odocoileus	Carpal/Tarsal	GB	29.9
2482	2158P	Odocoileus	Carpal/Tarsal	GB	31.7
2483	2158P	Odocoileus	Carpal/Tarsal	GB	30.0
2484	2158P	Odocoileus	Carpal/Tarsal	GB	28.0
2485	2158P	Odocoileus	Patella	GB	31.4
2488	2158P	Odocoileus	Patella	GB	18.3
2487	2158P	Odocoileus	Patella	GB	27.5
2487	2158P	Odocoileus	Patella	GL	35.5
2488	2158P	Odocoileus	Patella	GB	27.5
2488	2158P	Odocoileus	Patella	GL	40.0
2489	2158P	Odocoileus	Patella	GB	37.5
2489	2158P	Odocoileus	Patella	GL	26.1
2490	2158P	Odocoileus	Patella	GB	28.9
2490	2158P	Odocoileus	Patella	GL	34.9
2491	2158P	Odocoileus	Patella	GB	27.5
2491	2158P	Odocoileus	Patella	GL	35.6
2532	2158P	Odocoileus	1st Phalanx	GL	48.9
2532	2158P	Odocoileus	1st Phalanx	Bp	15.5
2532	2158P	Odocoileus	1st Phalanx	SD	13.1
2532	2158P	Odocoileus	1st Phalanx	Bd	12.9
2533	2158P	Odocoileus	1st Phalanx	GL	49.5
2533	2158P	Odocoileus	1st Phalanx	Bp	15.9
2533	2158P	Odocoileus	1st Phalanx	SD	12.1
2533	2158P	Odocoileus	1st Phalanx	Bd	12.9
2534	2158P	Odocoileus	1st Phalanx	GL	51.5
2534	2158P	Odocoileus	1st Phalanx	Bp	17.0
2534	2158P	Odocoileus	1st Phalanx	SD	13.7
2534	2158P	Odocoileus	1st Phalanx	Bd	13.4
2535	2158P	Odocoileus	1st Phalanx	GL	46.7
2535	2158P	Odocoileus	1st Phalanx	Bp	14.0
2535	2158P	Odocoileus	1st Phalanx	SD	10.2
2535	2158P	Odocoileus	1st Phalanx	Bd	11.4
2536	2158P	Odocoileus	1st Phalanx	SD	11.8
2536	2158P	Odocoileus	1st Phalanx	Bd	13.4
2538	2158P	Odocoileus	1st Phalanx	GL	43.5
2538	2158P	Odocoileus	1st Phalanx	Bp	14.2
2538	2158P	Odocoileus	1st Phalanx	SD	11.6
2538	2158P	Odocoileus	1st Phalanx	Bd	11.9
2539	2158P	Odocoileus	1st Phalanx	GL	46.5
2539	2158P	Odocoileus	1st Phalanx	Bp	15.1
2539	2158P	Odocoileus	1st Phalanx	SD	9.9
2539	2158P	Odocoileus	1st Phalanx	Bd	11.1
2540	2158P	Odocoileus	1st Phalanx	GL	46.9
2540	2158P	Odocoileus	1st Phalanx	Bp	15.8
2540	2158P	Odocoileus	1st Phalanx	SD	11.9

2540	2158P	Odocoileus	1st Phalanx	Bd	12.4
2541	2158P	Odocoileus	1st Phalanx	SD	12.5
2541	2158P	Odocoileus	1st Phalanx	Bd	13.1
2518	2158P	Odocoileus	2nd Phalanx	GL	33.5
2518	2158P	Odocoileus	2nd Phalanx	Bp	12.6
2518	2158P	Odocoileus	2nd Phalanx	SD	10.4
2518	2158P	Odocoileus	2nd Phalanx	Bd	10.0
2519	2158P	Odocoileus	2nd Phalanx	GL	33.9
2519	2158P	Odocoileus	2nd Phalanx	Bp	13.9
2519	2158P	Odocoileus	2nd Phalanx	SD	11.6
2519	2158P	Odocoileus	2nd Phalanx	Bd	10.0
2520	2158P	Odocoileus	2nd Phalanx	SD	11.5
2520	2158P	Odocoileus	2nd Phalanx	Bd	10.3
2521	2158P	Odocoileus	2nd Phalanx	GL	34.7
2521	2158P	Odocoileus	2nd Phalanx	Bp	13.1
2521	2158P	Odocoileus	2nd Phalanx	SD	9.9
2521	2158P	Odocoileus	2nd Phalanx	Bd	8.9
2522	2158P	Odocoileus	2nd Phalanx	SD	10.6
2522	2158P	Odocoileus	2nd Phalanx	Bd	10.1
2523	2158P	Odocoileus	2nd Phalanx	GL	34.0
2523	2158P	Odocoileus	2nd Phalanx	Bp	14.6
2523	2158P	Odocoileus	2nd Phalanx	SD	11.3
2523	2158P	Odocoileus	2nd Phalanx	Bd	11.2
2524	2158P	Odocoileus	2nd Phalanx	GL	35.4
2524	2158P	Odocoileus	2nd Phalanx	Bp	14.4
2524	2158P	Odocoileus	2nd Phalanx	SD	11.3
2524	2158P	Odocoileus	2nd Phalanx	Bd	11.0
2526	2158P	Odocoileus	2nd Phalanx	GL	34.9
2526	2158P	Odocoileus	2nd Phalanx	Bp	12.8
2526	2158P	Odocoileus	2nd Phalanx	SD	10.3
2526	2158P	Odocoileus	2nd Phalanx	Bd	8.7
2527	2158P	Odocoileus	2nd Phalanx	GL	38.9
2527	2158P	Odocoileus	2nd Phalanx	Bp	15.6
2527	2158P	Odocoileus	2nd Phalanx	SD	12.6
2527	2158P	Odocoileus	2nd Phalanx	Bd	11.2
2528	2158P	Odocoileus	2nd Phalanx	GL	38.0
2528	2158P	Odocoileus	2nd Phalanx	Bp	15.5
2528	2158P	Odocoileus	2nd Phalanx	SD	12.4
2528	2158P	Odocoileus	2nd Phalanx	Bd	10.5
2529	2158P	Odocoileus	2nd Phalanx	SD	10.5
2529	2158P	Odocoileus	2nd Phalanx	Bd	10.6
2531	2158P	Odocoileus	2nd Phalanx	Bd	10.8
2141	2158P	Sus	Radius	Bd	30.0
2141	2158P	Sus	Radius	BFd	34.8
2141	2158P	Sus	Radius	SD	20.0

2172	2158P	Sus	Humerus	SD	21.5
2186	2158P	Sus	Humerus	SD	14.2
2191	2158P	Sus	Femur	SD	20.5
2267	2158P	Sus	Tibia	SD	21.0
2543	2158P	Sus	1st Phalanx	GL	42.0
2543	2158P	Sus	1st Phalanx	Bp	17.1
2543	2158P	Sus	1st Phalanx	SD	13.4
2543	2158P	Sus	1st Phalanx	Bd	16.1
2517	2158P	Ovis/Capra	Calcaneous	GL	61.8
2553	2158P	Ovis/Capra	Tibia	SD	17.9
2554	2158P	Ovis/Capra	Tibia	SD	17.4
	2158U				
1774	2158U	Odocoileus	Mandible	7	79.9
1774	2158U	Odocoileus	Mandible	8	46.9
1774	2158U	Odocoileus	Mandible	9	32.0
1774	2158U	Odocoileus	Mandible	13	59.8
1774	2158U	Odocoileus	Mandible	15a	29.1
1774	2158U	Odocoileus	Mandible	15b	22.3
1774	2158U	Odocoileus	Mandible	15c	20.5
1777	2158U	Odocoileus	Mandible	7	82.3
1777	2158U	Odocoileus	Mandible	8	48.0
1777	2158U	Odocoileus	Mandible	9	32.2
1777	2158U	Odocoileus	Mandible	15a	24.6
1777	2158U	Odocoileus	Mandible	15b	20.0
1777	2158U	Odocoileus	Mandible	15c	17.5
1878	2158U	Odocoileus	Vertebra	GB	92.5
1878	2158U	Odocoileus	Vertebra	GLP	70.5
1878	2158U	Odocoileus	Vertebra	BFdc	58.0
1878	2158U	Odocoileus	Vertebra	BFcr	57.0
1640	2158U	Odocoileus	Radius	Bp	36.8
1644	2158U	Odocoileus	Radius	Bp	34.7
1646	2158U	Odocoileus	Radius	SD	21.8
1648	2158U	Odocoileus	Radius	Bd	34.5
1649	2158U	Odocoileus	Radius	Bp	34.7
1651	2158U	Odocoileus	Radius	Bp	35.9
1652	2158U	Odocoileus	Radius	SD	29.2
1654	2158U	Odocoileus	Radius	Bp	37.5
1690	2158U	Odocoileus	Radius	Bp	34.2
1657	2158U	Odocoileus	Ulna	LO	48.8
1657	2158U	Odocoileus	Ulna	SDO	30.5
1657	2158U	Odocoileus	Ulna	DPA	31.9
1657	2158U	Odocoileus	Ulna	BPC	21.1
1658	2158U	Odocoileus	Ulna	SDO	27.4
1658	2158U	Odocoileus	Ulna	DPA	32.2

1658	2158U	Odocoileus	Ulna	BPC	18.5
1659	2158U	Odocoileus	Ulna	LO	48.8
1659	2158U	Odocoileus	Ulna	SDO	32.5
1659	2158U	Odocoileus	Ulna	DPA	34.1
1659	2158U	Odocoileus	Ulna	BPC	20.9
1660	2158U	Odocoileus	Ulna	LO	46.5
1660	2158U	Odocoileus	Ulna	SDO	29.1
1660	2158U	Odocoileus	Ulna	DPA	31.6
1660	2158U	Odocoileus	Ulna	BPC	20.9
1661	2158U	Odocoileus	Ulna	LO	52.0
1661	2158U	Odocoileus	Ulna	SDO	32.9
1661	2158U	Odocoileus	Ulna	DPA	35.0
1662	2158U	Odocoileus	Ulna	LO	48.6
1662	2158U	Odocoileus	Ulna	SDO	20.6
1662	2158U	Odocoileus	Ulna	DPA	33.0
1662	2158U	Odocoileus	Ulna	BPC	16.2
1663	2158U	Odocoileus	Ulna	DPA	34.6
1663	2158U	Odocoileus	Ulna	BPC	19.6
1664	2158U	Odocoileus	Ulna	SDO	29.6
1664	2158U	Odocoileus	Ulna	DPA	32.4
1664	2158U	Odocoileus	Ulna	BPC	20.8
1570	2158U	Odocoileus	Humerus	SD	19.3
1572	2158U	Odocoileus	Humerus	SD	13.3
1679	2158U	Odocoileus	Humerus	SD	19.3
1679	2158U	Odocoileus	Humerus	BT	33.0
1679	2158U	Odocoileus	Humerus	Bd	34.2
1680	2158U	Odocoileus	Humerus	BT	38.8
1680	2158U	Odocoileus	Humerus	Bd	39.2
1681	2158U	Odocoileus	Humerus	Bp	36.6
1682	2158U	Odocoileus	Humerus	SD	20.0
1682	2158U	Odocoileus	Humerus	BT	36.1
1682	2158U	Odocoileus	Humerus	Bd	37.4
1683	2158U	Odocoileus	Humerus	BT	34.8
1683	2158U	Odocoileus	Humerus	Bd	37.0
1684	2158U	Odocoileus	Humerus	SD	19.4
1641	2158U	Odocoileus	Scapula	BG	24.9
1641	2158U	Odocoileus	Scapula	SLC	22.2
1643	2158U	Odocoileus	Scapula	LG	32.8
1643	2158U	Odocoileus	Scapula	GLP	38.9
1643	2158U	Odocoileus	Scapula	BG	28.1
1643	2158U	Odocoileus	Scapula	SLC	24.4
1645	2158U	Odocoileus	Scapula	LG	31.1
1645	2158U	Odocoileus	Scapula	GLP	40.8
1645	2158U	Odocoileus	Scapula	BG	27.9
1645	2158U	Odocoileus	Scapula	SLC	22.8

1647	2158U	Odocoileus	Scapula	LG	30.6
1647	2158U	Odocoileus	Scapula	GLP	36.6
1647	2158U	Odocoileus	Scapula	BG	22.8
1647	2158U	Odocoileus	Scapula	SLC	21.1
1650	2158U	Odocoileus	Scapula	LG	31.0
1650	2158U	Odocoileus	Scapula	BG	27.3
1650	2158U	Odocoileus	Scapula	SLC	24.6
1653	2158U	Odocoileus	Scapula	LG	31.2
1653	2158U	Odocoileus	Scapula	GLP	38.5
1653	2158U	Odocoileus	Scapula	BG	27.2
1653	2158U	Odocoileus	Scapula	SLC	22.5
1655	2158U	Odocoileus	Scapula	BG	26.4
1670	2158U	Odocoileus	Scapula	LG	34.9
1670	2158U	Odocoileus	Scapula	GLP	43.9
1670	2158U	Odocoileus	Scapula	BG	31.6
1670	2158U	Odocoileus	Scapula	SLC	26.6
1671	2158U	Odocoileus	Scapula	LG	29.3
1671	2158U	Odocoileus	Scapula	GLP	37.1
1671	2158U	Odocoileus	Scapula	BG	27.6
1671	2158U	Odocoileus	Scapula	SLC	22.0
1672	2158U	Odocoileus	Scapula	LG	37.2
1672	2158U	Odocoileus	Scapula	GLP	44.9
1672	2158U	Odocoileus	Scapula	BG	34.2
1672	2158U	Odocoileus	Scapula	SLC	23.2
1668	2158U	Odocoileus	Innominate	SB	10.6
1669	2158U	Odocoileus	Innominate	SB	10.2
1673	2158U	Odocoileus	Innominate	Lfo	51.9
1673	2158U	Odocoileus	Innominate	LAR	40.4
1673	2158U	Odocoileus	Innominate	LA	30.4
1674	2158U	Odocoileus	Innominate	LAR	31.5
1674	2158U	Odocoileus	Innominate	LA	41.2
1686	2158U	Odocoileus	Femur	Bd	48.2
1686	2158U	Odocoileus	Femur	SD	20.5
1694	2158U	Odocoileus	Femur	SD	20.7
1695	2158U	Odocoileus	Femur	SD	19.9
1689	2158U	Odocoileus	Tibia	SD	22.5
1689	2158U	Odocoileus	Tibia	Bd	34.2
1692	2158U	Odocoileus	Tibia	Bd	32.6
1693	2158U	Odocoileus	Tibia	Bd	33.2
1696	2158U	Odocoileus	Tibia	SD	21.5
1696	2158U	Odocoileus	Tibia	Bd	33.7
1812	2158U	Odocoileus	Calcaneous	GL	82.5
1812	2158U	Odocoileus	Calcaneous	GB	23.0
1815	2158U	Odocoileus	Astragalus	GLl	38.0
1815	2158U	Odocoileus	Astragalus	GLm	35.7

1815	2158U	Odocoileus	Astragalus	Dl	20.7
1815	2158U	Odocoileus	Astragalus	Bd	22.5
1817	2158U	Odocoileus	1st Phalanx	GL	46.5
1817	2158U	Odocoileus	1st Phalanx	Bp	15.5
1817	2158U	Odocoileus	1st Phalanx	SD	12.9
1817	2158U	Odocoileus	1st Phalanx	Bd	13.5
1818	2158U	Odocoileus	2nd Phalanx	GL	36.1
1818	2158U	Odocoileus	2nd Phalanx	Bp	13.9
1818	2158U	Odocoileus	2nd Phalanx	SD	11.8
1818	2158U	Odocoileus	2nd Phalanx	Bd	10.3
1819	2158U	Odocoileus	3rd Phalanx	DLS	33.9
1819	2158U	Odocoileus	3rd Phalanx	Ld	30.4
1819	2158U	Odocoileus	3rd Phalanx	MBS	8.2
1736	2158U	Sus	Maxilla	27	107.8
1736	2158U	Sus	Maxilla	27a	96.8
1736	2158U	Sus	Maxilla	28	64.1
1736	2158U	Sus	Maxilla	29	41.9
1736	2158U	Sus	Maxilla	31	30.7
1738	2158U	Sus	Maxilla	29	46.5
1744	2158U	Sus	Mandible	7a	87.6
1744	2158U	Sus	Mandible	8	56.9
1744	2158U	Sus	Mandible	9a	30.5
1744	2158U	Sus	Mandible	16a	43.2
1744	2158U	Sus	Mandible	16b	36.8
1723	2158U	Sus	Radius	SD	18.5
1712	2158U	Sus	Humerus	SD	20.2
1711	2158U	Sus	Tibia	SD	23.9
1710	2158U	Sus	Scapula	GLP	36.0
1710	2158U	Sus	Scapula	LG	31.8
1710	2158U	Sus	Scapula	BG	26.4
1710	2158U	Sus	Scapula	SLC	25.1
1720	2158U	Sus	Scapula	GLP	36.9
1720	2158U	Sus	Scapula	LG	30.3
1720	2158U	Sus	Scapula	BG	27.8
1720	2158U	Sus	Scapula	SLC	24.4
1707	2158U	Sus	Innominate	LA	34.8
1707	2158U	Sus	Innominate	LAR	26.6
1718	2158U	Sus	Innominate	LA	39.0
1718	2158U	Sus	Innominate	LAR	33.4
1747	2158U	Sus	Metapodial	GL	97.1
1747	2158U	Sus	Metapodial	Bp	16.4
1747	2158U	Sus	Metapodial	SD	13.7
1747	2158U	Sus	Metapodial	Bd	16.6
1748	2158U	Sus	Metapodial	GL	95.7
1748	2158U	Sus	Metapodial	Bp	24.8

1748	2158U	Sus	Metapodial	SD	14.2
1748	2158U	Sus	Metapodial	Bd	17.0
1749	2158U	Sus	Metapodial	GL	89.7
1749	2158U	Sus	Metapodial	Bp	18.4
1749	2158U	Sus	Metapodial	SD	14.4
1749	2158U	Sus	Metapodial	Bd	16.4
1750	2158U	Sus	Metapodial	GL	80.0
1750	2158U	Sus	Metapodial	Bp	17.1
1750	2158U	Sus	Metapodial	SD	12.2
1750	2158U	Sus	Metapodial	Bd	15.7
1751	2158U	Sus	Metapodial	GL	82.0
1751	2158U	Sus	Metapodial	Bp	13.1
1751	2158U	Sus	Metapodial	SD	12.2
1751	2158U	Sus	Metapodial	Bd	14.5
1752	2158U	Sus	Metapodial	GL	60.9
1752	2158U	Sus	Metapodial	Bp	15.3
1752	2158U	Sus	Metapodial	SD	13.1
1752	2158U	Sus	Metapodial	Bd	14.4
1753	2158U	Sus	Metapodial	GL	72.2
1753	2158U	Sus	Metapodial	Bp	15.1
1753	2158U	Sus	Metapodial	SD	11.0
1753	2158U	Sus	Metapodial	Bd	13.8
1756	2158U	Sus	Metapodial	GL	57.0
1755	2158U	Sus	Astragalus	GLm	46.0
1755	2158U	Sus	Astragalus	Dl	25.3
1755	2158U	Sus	Astragalus	Bd	27.9
1764	2158U	Sus	1st Phalanx	Glpe	38.7
1764	2158U	Sus	1st Phalanx	Bp	13.9
1764	2158U	Sus	1st Phalanx	SD	13.5
1764	2158U	Sus	1st Phalanx	Bd	16.3
1765	2158U	Sus	1st Phalanx	Bd	16.4
1766	2158U	Sus	2nd Phalanx	GL	27.3
1766	2158U	Sus	2nd Phalanx	Bp	17.1
1766	2158U	Sus	2nd Phalanx	SD	13.8
1766	2158U	Sus	2nd Phalanx	Bd	13.3
1767	2158U	Sus	2nd Phalanx	GL	23.8
1767	2158U	Sus	2nd Phalanx	Bp	16.6
1767	2158U	Sus	2nd Phalanx	SD	13.5
1767	2158U	Sus	2nd Phalanx	Bd	13.6
1768	2158U	Sus	2nd Phalanx	GL	19.1
1768	2158U	Sus	2nd Phalanx	Bp	14.3
1768	2158U	Sus	2nd Phalanx	SD	12.2
1768	2158U	Sus	2nd Phalanx	Bd	11.5
1769	2158U	Sus	2nd Phalanx	GL	20.1
1769	2158U	Sus	2nd Phalanx	Bp	12.5

1769	2158U	Sus	2nd Phalanx	SD	10.8
1769	2158U	Sus	2nd Phalanx	Bd	10.5
1770	2158U	Sus	2nd Phalanx	GL	16.9
1770	2158U	Sus	2nd Phalanx	Bp	11.7
1770	2158U	Sus	2nd Phalanx	SD	10.5
1770	2158U	Sus	2nd Phalanx	Bd	9.6
1773	2158U	Sus	3rd Phalanx	DLS	23.0
1773	2158U	Sus	3rd Phalanx	Ld	19.9
1773	2158U	Sus	3rd Phalanx	MBS	8.0
1822	2158U	Sus	3rd Phalanx	DLS	27.4
1822	2158U	Sus	3rd Phalanx	Ld	25.4
1822	2158U	Sus	3rd Phalanx	MBS	10.3
1845	2158U	Ovis/Capra	Mandible	7	84.7
1845	2158U	Ovis/Capra	Mandible	8	54.8
1845	2158U	Ovis/Capra	Mandible	9	26.2
1845	2158U	Ovis/Capra	Mandible	15a	38.5
1845	2158U	Ovis/Capra	Mandible	15b	24.5
1845	2158U	Ovis/Capra	Mandible	15c	17.5
1838	2158U	Ovis/Capra	Radius	Bp	30.2
1838	2158U	Ovis/Capra	Radius	SD	20.2
1839	2158U	Ovis/Capra	Ulna	SDO	16.1
1839	2158U	Ovis/Capra	Ulna	DPA	31.2
1839	2158U	Ovis/Capra	Ulna	BPC	21.9
1841	2158U	Ovis/Capra	Humerus	Bd	31.4
1840	2158U	Ovis/Capra	Tibia	Bp	40.9
	2158X				
1927	2158X	Odocoileus	Scapula	GLP	41.5
1927	2158X	Odocoileus	Scapula	LG	33.2
1927	2158X	Odocoileus	Scapula	BG	33.4
1927	2158X	Odocoileus	Scapula	SLC	26.0
1928	2158X	Odocoileus	Scapula	GLP	35.4
1928	2158X	Odocoileus	Scapula	LG	26.4
1928	2158X	Odocoileus	Scapula	BG	24.6
1928	2158X	Odocoileus	Scapula	SLC	18.7
1929	2158X	Odocoileus	Scapula	GLP	28.9
1929	2158X	Odocoileus	Scapula	BG	27.1
1929	2158X	Odocoileus	Scapula	SLC	22.2
1934	2158X	Odocoileus	Humerus	BT	35.5
1934	2158X	Odocoileus	Humerus	SD	22.1
1947	2158X	Odocoileus	Radius	Bd	35.1
1949	2158X	Odocoileus	Radius	Bd	32.9
1943	2158X	Odocoileus	Femur	SD	20.6
1936	2158X	Odocoileus	Tibia	Bp	54.1
1936	2158X	Odocoileus	Tibia	SD	23.2
1937	2158X	Odocoileus	Tibia	Bp	54.5

1937	2158X	Odocoileus	Tibia	SD	24.0
1938	2158X	Odocoileus	Tibia	Bd	34.0
1938	2158X	Odocoileus	Tibia	SD	18.5
1939	2158X	Odocoileus	Tibia	Bd	32.7
1940	2158X	Odocoileus	Tibia	Bd	37.2
1941	2158X	Odocoileus	Tibia	Bd	35.7
1942	2158X	Odocoileus	Tibia	SD	23.5
1952	2158X	Odocoileus	Innominate	LA	40.9
1952	2158X	Odocoileus	Innominate	LAR	33.6
2079	2158X	Odocoileus	1st Phalanx	GL	45.1
2079	2158X	Odocoileus	1st Phalanx	Bp	16.4
2079	2158X	Odocoileus	1st Phalanx	SD	11.1
2079	2158X	Odocoileus	1st Phalanx	Bd	11.9
2080	2158X	Odocoileus	1st Phalanx	GL	50.0
2080	2158X	Odocoileus	1st Phalanx	Bp	15.3
2080	2158X	Odocoileus	1st Phalanx	SD	10.6
2080	2158X	Odocoileus	1st Phalanx	Bd	12.0
2081	2158X	Odocoileus	1st Phalanx	GL	48.0
2081	2158X	Odocoileus	1st Phalanx	Bp	16.6
2081	2158X	Odocoileus	1st Phalanx	SD	11.8
2081	2158X	Odocoileus	1st Phalanx	Bd	12.8
2082	2158X	Odocoileus	1st Phalanx	GL	49.8
2082	2158X	Odocoileus	1st Phalanx	Bp	15.1
2082	2158X	Odocoileus	1st Phalanx	SD	10.2
2082	2158X	Odocoileus	1st Phalanx	Bd	12.1
2083	2158X	Odocoileus	2nd Phalanx	GL	35.8
2083	2158X	Odocoileus	2nd Phalanx	Bp	13.0
2083	2158X	Odocoileus	2nd Phalanx	SD	10.5
2083	2158X	Odocoileus	2nd Phalanx	Bd	10.3
2084	2158X	Odocoileus	2nd Phalanx	GL	34.7
2084	2158X	Odocoileus	2nd Phalanx	Bp	14.3
2084	2158X	Odocoileus	2nd Phalanx	SD	12.7
2084	2158X	Odocoileus	2nd Phalanx	Bd	10.6
2085	2158X	Odocoileus	2nd Phalanx	GL	35.6
2085	2158X	Odocoileus	2nd Phalanx	Bp	12.7
2085	2158X	Odocoileus	2nd Phalanx	SD	10.3
2085	2158X	Odocoileus	2nd Phalanx	Bd	9.1
2086	2158X	Odocoileus	2nd Phalanx	GL	35.6
2086	2158X	Odocoileus	2nd Phalanx	Bp	14.3
2086	2158X	Odocoileus	2nd Phalanx	SD	10.5
2086	2158X	Odocoileus	2nd Phalanx	Bd	9.5
2088	2158X	Odocoileus	3rd Phalanx	DLS	33.7
2088	2158X	Odocoileus	3rd Phalanx	Ld	29.9
2088	2158X	Odocoileus	3rd Phalanx	MBS	7.4
2089	2158X	Odocoileus	3rd Phalanx	DLS	31.0

2089	2158X	Odocoileus	3rd Phalanx	Ld	28.3
2089	2158X	Odocoileus	3rd Phalanx	MBS	8.1
2090	2158X	Odocoileus	3rd Phalanx	DLS	35.3
2090	2158X	Odocoileus	3rd Phalanx	Ld	31.0
2090	2158X	Odocoileus	3rd Phalanx	MBS	6.8
2091	2158X	Odocoileus	3rd Phalanx	DLS	30.3
2091	2158X	Odocoileus	3rd Phalanx	Ld	28.2
2091	2158X	Odocoileus	3rd Phalanx	MBS	7.5
2005	2158X	Sus	Maxilla	29	43.2
2006	2158X	Sus	Maxilla	29	43.6
1956	2158X	Sus	Radius	Bp	36.0
1956	2158X	Sus	Radius	SD	23.4
1968	2158X	Sus	Radius	Bp	35.0
1969	2158X	Sus	Radius	Bd	34.2
1962	2158X	Sus	Ulna	SDO	32.7
1962	2158X	Sus	Ulna	DPA	45.9
1962	2158X	Sus	Ulna	BPC	25.1
1955	2158X	Sus	Humerus	BT	34.8
1955	2158X	Sus	Humerus	Bd	43.5
1957	2158X	Sus	Humerus	BT	32.7
1957	2158X	Sus	Humerus	Bd	40.4
1959	2158X	Sus	Humerus	BT	32.9
1959	2158X	Sus	Humerus	Bd	37.0
1963	2158X	Sus	Scapula	GLP	38.2
1963	2158X	Sus	Scapula	LG	33.3
1963	2158X	Sus	Scapula	BG	29.0
1964	2158X	Sus	Scapula	GLP	35.0
1964	2158X	Sus	Scapula	LG	28.9
1964	2158X	Sus	Scapula	BG	27.0
1964	2158X	Sus	Scapula	SLC	21.9
1965	2158X	Sus	Scapula	GLP	37.7
1965	2158X	Sus	Scapula	LG	32.8
1965	2158X	Sus	Scapula	BG	27.5
1965	2158X	Sus	Scapula	SLC	24.7
1966	2158X	Sus	Scapula	GLP	36.9
1966	2158X	Sus	Scapula	LG	30.2
1966	2158X	Sus	Scapula	BG	28.6
1966	2158X	Sus	Scapula	SLC	25.9
1974	2158X	Sus	Scapula	GLP	38.1
1974	2158X	Sus	Scapula	LG	31.6
1974	2158X	Sus	Scapula	BG	30.5
1974	2158X	Sus	Scapula	SLC	25.3
1961	2158X	Sus	Femur	SD	19.5
1973	2158X	Sus	Humerus	BT	33.0
1973	2158X	Sus	Humerus	Bd	40.3

1978	2158X	Sus	Humerus	SD	17.9
2019	2158X	Sus	Carpal/Tarsal	GL	87.1
2019	2158X	Sus	Carpal/Tarsal	Bp	18.8
2019	2158X	Sus	Carpal/Tarsal	SD	16.7
2019	2158X	Sus	Carpal/Tarsal	Bd	17.0
2020	2158X	Sus	Carpal/Tarsal	Bp	21.0
2020	2158X	Sus	Carpal/Tarsal	SD	17.7
2022	2158X	Sus	Carpal/Tarsal	Bp	17.0
2022	2158X	Sus	Carpal/Tarsal	SD	15.0
2024	2158X	Sus	Carpal/Tarsal	Bp	21.0
2024	2158X	Sus	Carpal/Tarsal	SD	16.9
2025	2158X	Sus	Carpal/Tarsal	Bp	15.1
2061	2158X	Sus	Carpal/Tarsal	Bp	31.1
2061	2158X	Sus	Carpal/Tarsal	SD	16.3
2033	2158X	Sus	1st Phalanx	Glpe	43.9
2033	2158X	Sus	1st Phalanx	Bp	15.1
2033	2158X	Sus	1st Phalanx	SD	14.0
2033	2158X	Sus	1st Phalanx	Bd	15.9
2034	2158X	Sus	1st Phalanx	Glpe	43.9
2034	2158X	Sus	1st Phalanx	Bp	15.5
2034	2158X	Sus	1st Phalanx	SD	13.7
2034	2158X	Sus	1st Phalanx	Bd	16.0
2035	2158X	Sus	1st Phalanx	GLpe	37.1
2035	2158X	Sus	1st Phalanx	Bp	17.5
2035	2158X	Sus	1st Phalanx	SD	14.3
2035	2158X	Sus	1st Phalanx	Bd	16.5
2036	2158X	Sus	1st Phalanx	Glpe	43.5
2036	2158X	Sus	1st Phalanx	Bp	15.3
2036	2158X	Sus	1st Phalanx	SD	13.9
2036	2158X	Sus	1st Phalanx	Bd	16.0
2037	2158X	Sus	1st Phalanx	Glpe	43.4
2037	2158X	Sus	1st Phalanx	Bp	18.2
2037	2158X	Sus	1st Phalanx	SD	15.6
2037	2158X	Sus	1st Phalanx	Bd	17.1
2038	2158X	Sus	1st Phalanx	SD	11.6
2038	2158X	Sus	1st Phalanx	Bd	12.6
2039	2158X	Sus	2nd Phalanx	GL	23.1
2039	2158X	Sus	2nd Phalanx	Bp	14.3
2039	2158X	Sus	2nd Phalanx	SD	12.9
2039	2158X	Sus	2nd Phalanx	Bd	12.8
2042	2158X	Sus	3rd Phalanx	DLS	16.6
2042	2158X	Sus	3rd Phalanx	Ld	13.5
2042	2158X	Sus	3rd Phalanx	MBS	13.2
2043	2158X	Sus	3rd Phalanx	DLS	15.9
2043	2158X	Sus	3rd Phalanx	Ld	12.9

2123	2158X	Ovis/Capra	Mandible	15a	34.7
2113	2158X	Ovis/Capra	Radius	Bp	28.5
2113	2158X	Ovis/Capra	Radius	SD	16.5
2114	2158X	Ovis/Capra	Radius	SD	16.5
2119	2158X	Ovis/Capra	Ulna	BPC	17.8
	2158AA				
1570	2158AA	Odocoileus	Humerus	SD	19.3
1572	2158AA	Odocoileus	Humerus	SD	13.3
1568	2158AA	Odocoileus	Femur	Bd	47.2
1623	2158AA	Odocoileus	Calcaneous	GL	91.5
1623	2158AA	Odocoileus	Calcaneous	GB	26.4
1624	2158AA	Odocoileus	Calcaneous	GL	80.6
1624	2158AA	Odocoileus	Calcaneous	GB	21.7
1560	2158AA	Odocoileus	1st Phalanx	GL	36.7
1560	2158AA	Odocoileus	1st Phalanx	Bp	17.4
1560	2158AA	Odocoileus	1st Phalanx	SD	16.1
1560	2158AA	Odocoileus	1st Phalanx	Bd	17.1
1561	2158AA	Odocoileus	2nd Phalanx	GL	25.9
1561	2158AA	Odocoileus	2nd Phalanx	Bp	14.0
1561	2158AA	Odocoileus	2nd Phalanx	SD	11.2
1561	2158AA	Odocoileus	2nd Phalanx	Bd	11.6
1547	2158AA	Sus	Maxilla	29	42.8
1548	2158AA	Sus	Maxilla	29	42.4
1545	2158AA	Sus	Mandible	9a	30.9
1546	2158AA	Sus	Mandible	9a	36.0
1566	2158AA	Sus	Radius	Bp	29.3
1565	2158AA	Sus	Ulna	SDO	29.1
1565	2158AA	Sus	Ulna	DPA	37.5
1565	2158AA	Sus	Ulna	BPC	21.6
1625	2158AA	Sus	Calcaneous	GB	20.4
1559	2158AA	Sus	1st Phalanx	SD	12.5
1559	2158AA	Sus	1st Phalanx	Bd	13.2
1632	2158AA	Ovis/Capra	Metatarsal	Bp	22.6