1-1-2010

A Bioarchaeological Study Of A Prehistoric Michigan Population: Fraaer-Tyra Site (20sa9)

Allison June Muhammad
Wayne State University

A BIOARCHAEOLOGICAL STUDY OF A LATE WOODLAND POPULATION FROM MICHIGAN: FRAZER-TYRA SITE (20SA9)

by

ALLISON JUNE MUHAMMAD

DISSERTATION

Submitted to the Graduate School

of Wayne State University,

Detroit, Michigan

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2010

MAJOR: ANTHROPOLOGY (Archaeology)

Approved by:

____

Advisor Date

____

____

____

____

ACKNOWLEDGEMENTS

Bismillahi Rahmani Rahim
Ashhadu alla ilaha illa-llahu wa
Ashhadu anna Muhammadan abduhu wa rasuluh

I would like to acknowledge my beautiful, energetic, loving daughters Bahirah, Laila, and Nadia. You have been my inspiration to complete this journey. I would also like to thank my family and friends for their kindness and their support.

I would like to acknowledge the support and guidance of Dr. Mark Baskaran and Dr. Ed Van Hees of the WSU Geology department

I would like to acknowledge the dedication and commitment of my dissertation committee to my success, particularly Dr. Tamara Bray. I would also like to extend my gratitude to Dr. Thomas Killion and Dr. Dorothy Nelson.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES, MAPS, CHARTS, DIAGRAMS

Chapter 1

Introduction

The Archaeological Characterization of Subsistence Routines

Characterizing the development and complexity of prehistoric peoples' subsistence routines that are neither wholly agriculturalist nor wholly hunter-gatherers has become an important topic in recent years in archaeology (Smith 1992, 2001; Zvelebil 2000). Smith (2001) has suggested the problem lies with the evolutionist perspective that plagues the literature. Archaeologists tend to explain subsistence routines as adaptive strategies that immediately, universally, and unilineally shift from hunter-gathering to agriculture. Such a perspective has hindered what Smith calls a description of the 'middle ground' populations that are neither entirely hunter-gatherers nor entirely agriculturalists.

The evolutionist perspective fails to take into consideration hunter-gatherers that have or use agricultural products. Also, the terminology that archaeologists use to describe subsistence is not consistent. Terms such as "hunter-gatherer," "cultigen," "domesticates," "tending", etc., though defined by individual archeologists, are not consistently used across the literature. Furthermore, it has been difficult to establish the dietary importance of domesticates among populations under consideration (Dunham 2000; Keene 1981; Smith 2001). There is also a great temporal-developmental distance (Smith 2001) between the domestication of plants and routines dominated by agricultural pursuits. Agriculture is seen as the most successful adaptation and the ultimate destination in the evolution of subsistence strategies. To overcome some of these problems, Smith (2001) has suggested creating a model that situates populations upon a broad landscape within which they are inter-related and connected in a larger subsistence system. In addition, he suggests that populations be placed on an ascending continuum according to the percentage of the diet that is comprised of domesticates. In his model, middle ground populations would have diets comprising of 30% to 50% domesticates. From his perspective, populations should be categorized according to the increasing importance of domesticates in their diets (Smith 2001) within this landscape of peaks, zones, and valleys, rather than positing a gradual unilineal progression.

In addition to establishing a model that characterizes the subsistence strategies of 'middle ground' populations, there is a need to establish a methodology that can facilitate how archaeologists discuss the nature of human interaction with plants and animals. As Smith (2001) notes, there is a limited amount of relevant information to support the description of this transitional space between hunter-gathering and agricultural pursuits. He has suggested using the increasing caloric intake of domesticates to characterize subsistence strategies of middle ground populations, as they ascend this supposed metaphorical mountain toward agriculture as one possible avenue. Archaeologists have previously used the caloric values of known resources to characterize prehistoric subsistence strategies (Keene 1981). Besides identifying faunal and floral remains, other archaeologists have suggested using archaeological site features, ethnohistoric, and ethno-archaeological information to reconstruct the significance of local products to the diet (Dunham 2000; Hastorf 1995; Mason and Holman 2000; Zvelebil 2000).

In Michigan, Dunham (2000) has suggested that the characterization of subsistence routines in diverse environs should incorporate ethnohistoric information. For Dunham, this type of information allows one to differentiate among sites from a native perspective in terms of environment and significance (e.g., resources, security, etc). Discerning types of sites (e.g. habitation, caching, seasonal short-term, etc.) and the regulatory systems that populations used to claim territory and secure resources are vital to discussing economic cycles (Dunham 2000; Holman and Brashler 1999). A model that does not include a consideration of shifting social roles, power, the behavior of individuals, and access of individuals to resources is incomplete (Hodder 2003, 1995; Zvelebil 2000).

Hunter-gatherer populations have long been characterized as egalitarian while agriculturalists are traditionally assumed to have been ranked societies (Service 1978; Smith 2001; Zvelebil 2000). The idea of a unilineal transition from hunting, gathering, and fishing, to varying degrees of consuming agricultural products, to a complete shift to an agriculturally based system overlooks the nuances suggested by the ethnohistoric record. Hodder (2003, 1995, 1991) has theorized the individual as an agent of culture change and argued that human beings make conscious choices to ensure their survival. These choices should be viewed as preferences rather than matters of expediency aimed at facilitating adaptation. Archaeologists have attempted to consider the individual, male or female, as an agent of culture change. For instance, to re-insert the role of individual agency and engender the discussion of subsistence routines, Zvelebil (2000) has suggested that we try to discern degree of access to resources for women in middle-ground populations as a measure of transitioning to agriculture. Though hunter-gatherer societies are assumed to be egalitarian, anthropologists have noted that labor is divided by sex and age (Service 1978). The economy of these groups relies upon such divisions as well as the socio- political order. We should expect that a shift in subsistence routines would affect the socio-political order as well. Ever-increasing notions of rank would accompany new work regimes. As new work regimes are established to facilitate the subsistence shift, we should expect individuals to negotiate power and authority. Females may have more access to agricultural resources because of cultural practices pertaining to food processing, storage of food, and the division of food within the community. Dunham (2000:242-244) provides ethno-historical accounts about several Native American populations known to "cache" food, the cultural practices regarding the sharing of cached foods, and the subsistence routines that the caching practices were a part of. Specifically, Dunham provides an example of Native American women "caching" corn in order to prevent their husbands from excessive consumption of the resources (2000:244).

Zvelebil (2000) states that females may challenge male authority through controlling access to stored food. Along these lines, Hastorf (1995) has suggested that we use storage features, their spatial distribution on the site, and their spatial relationship to work spaces and occupation areas to discuss how women may have expressed their power and defiance of domination by men. These archaeologists have argued that food procurement and food storage, or caching, is just as important as the subsistence shift itself to the characterization of social roles (Hastorf 1995; Zvelebil 2000).

Though Smith (2001) proposed that a model of middle ground populations should be based on the relative proportion of domesticates in the diet measured by caloric intake, such an approach does not allow archaeologists to characterize the role of individuals in culture change. Interestingly, Smith (2001:18) did not support the use of isotopic data to explore human interaction with plants and animals, suggesting that insights into the issues of tending domesticates, transplanting cultigens, and the protection of cultigens were not attainable through such means. In the present study, I argue that isotopic ratio analysis can contribute to the discussion of population trends and the dietary preferences of individuals.

We can also explore culture change at the level of the individual along the dimensions of gender and age, as well as by region, through the method of isotopic ratio analysis. There are various studies that use isotopic analyses to discuss the degree to which different populations adopt cultigens in a region (Knudson 2008; Rose 2008; Stothers and Bechtel 1987). Archaeologists have addressed culture change is these studies by discussing the distribution of dietary resources, how new foods are introduced and incorporated into existing regimes, and how the latter impact the overall population. Additionally, there are numerous studies that have established age and gender preferences vis-‘-vis diverse foodstuffs (e.g., Katzenberg et. al. 1993; Muldner and Richards 2007). Archaeologists have also been able to discuss a wide range of dietary issues from the weaning of infants with corn meal to the long-distance trade of marine resources via these techniques.

Subsistence Routines in Prehistoric Michigan

This present study explores a Late Woodland period population from Michigan that, in Smith’s terminology (2001), would constitute a “middle ground” population—that is, one that was in-between hunter-gathering efforts and the adoption of agriculture. In my study, I examine the issues surrounding how males and females of different ages negotiated their dietary choices during the introduction of maize to this sector of the Eastern Woodlands. There are several challenges to reconstructing the past life-ways and social organization of Michigan’s Late Woodland peoples. Incomplete data for numerous sites (Norder *et al.* 2003) and the inherent difficulties of handling, processing, and evaluating human remains has left Michigan’s prehistoric past a bit neglected (Halsey 1999)

Late Woodland mortuary behavior (Krakker 1983; Norder *et al.* 2003; O’Shea 1987) and social organization have been characteristically studied through material culture and faunal assemblages (Andrews 1995; Holman and Brashler 1999). Technological advancements have also allowed archaeologists to use human remains as a new body of evidence (Grauer 1995;

Larsen 1997). Isotopic analysis, for instance, can be used as an absolute dating technique as well as for diet reconstruction. Archaeologists may now actually test human remains for consumption patterns and juxtapose such results to botanical elements and faunal remains recovered at sites. Because of our ability to test for the abundance of chemical isotopes in human remains, models of hunter-gatherer mobility and the access to resources have also become subjects of study (Sealy et. al. 1986; Smith 1992; Van Der Merwe and Vogel 1978; Van Der Merwe et. al. 1981; Vogel 1977). With the technique of isotopic ratio testing, we can begin to reconstruct the dietary practices of Late Woodland peoples and add such data to our previous findings, refining old models and possibly reshaping our understanding of the prehistoric past.

Aims of Study

Late Woodland culture dates from approximately AD 500 to the contact period with Europeans, circa AD1650. Late Woodland peoples are normally characterized as having a hunter-gather lifestyle, participate in spring/summer aggregations, and display a wide variety of mortuary behaviors (Halsey 1999, 1976; Holman and Brashler 1999; Norder *et al.* 2003; Walthall 1998). In this study, I will propose that Late Woodland peoples were not simply hunters-gatherers but rather were engaged in an economic system in which each population contributed vital resources to a wider social/regional network. A network would consist of contributing populations that not only supplied information on resource availability, but the resources themselves. The diversity of ceramics and lithics has suggested that communities of the Saginaw Valley region had socio-economic ties to other communities of Southeastern Michigan and Southern Ontario during the Late Woodland period (Andrews 1995; Fitting 1965; Greenman 1937; Holman and Brashler 1999; Stothers 1999). The production and distribution of material culture and food resources could have been based on the niche that each population occupied in the environment (Holman and Brashler 1999:215-219). Some sites in the Saginaw Valley region were known as seasonal camps while others were suspected as being farmsteads and long=term agrarian based villages (Fitting 1965; Holman and Brashler 1999) The Frazer-Tyra population quite possibly 'chose' to remain a middle ground community, engaging in hunter-gatherer efforts while also consuming agricultural products.

The aim of this study is to provide new insights into the subsistence routines of the Frazer-Tyra population, Late Woodland residents of the Saginaw Valley region, and their economic position within the larger trade networks of the greater region. The study is based on a sample of human remains recovered from the Frazer-Tyra site in the late 1960s. This large multi-component site was excavated by Arthur Graves over the course of three field seasons between 1968 and 1970. The human remains recovered from the site date from the proto-historic to the late prehistoric period. The skeletal remains recovered from the site were originally distributed among three universities: Wayne State University (WSU), Central Michigan University (CMU), and the University of Michigan (UM). The portion of the Frazer-Tyra collection housed at Wayne State University consists of 73 individuals, including both adults and sub-adults. A portion of the collection from CMU and WSU was studied by James Krakker. This researcher studied the mortuary variability for the Late Woodland population at the site and estimated the living population during this period as between 100-200 individuals (Krakker 1983).

The Saginaw Valley region of southeastern Michigan contains several sites that have been crucial to reconstructing the life-ways of Late Woodland peoples. These include the Bussinger site, the Younge site, and the Bugai site, among others, all of which contain human remains (Greenman 1937; Halsey 1976; Norder *et al.* 2003) These previously studied sites will be considered in the analysis of the Frazer-Tyra materials in order to gain a regional perspective on local site use, as well as the range of food storage and mortuary features. Like these sites, Frazer-Tyra is considered a Late Woodland village that encompasses a mortuary precinct (Graves 1968; Krakker 1999, 1983; Stothers 1999). To answer questions about regional networks and local economic systems, it is essential that local sites contemporary with Frazer-Tyra and their associated subsistence routines be taken into consideration.

By examining the human remains from the Frazer-Tyra site via carbon and nitrogen isotopes, anthropometry, and making general observations about paleo-pathology, I will define the nature of subsistence for the Frazer-Tyra population of the Saginaw Valley region. Krakker (1983) provided an initial review of mortuary variability at the Frazer-Tyra site in which he suggested that chemical analysis could further the aim of reconstructing the life-ways of the original population. An analysis of the human remains from this site can reveal some aspects of the diet for prehistoric Michigan people. With the isotopic data generated, I will compare the Frazer-Tyra population to other contemporary populations of the Late Woodland period for the Great Lakes region.

The reconstructions of subsistence regimes for native peoples have typically been based on ethnographic analogy, paleo-environments, ceramic assemblages, and faunal remains (Brashler and Holman 1985; Dunham 2000; Greenman 1937; Holman and Brashler 1999, Keene 1981). Late Woodland people are often characterized as having subsistence routines based on the seasonality of resources who faced periodic scarcity and who developed far-flung social relationships as an adaptation for coping with such scarcity. This study will explore the extent to which Late Woodland period residents of the Saginaw Valley relied on wild game, aquatic resources, wild plants, and agricultural products. The literature suggests that late prehistoric people aggregated to trade, form alliances, and share information on resources as well as to cope with the seasonality of resources and scarcity. Such aggregating behavior is thought to have ceased with the dominance of maize agriculture during the historic period. Aggregation may not have ceased during the Late Woodland period but may have become a more complex socio-economic opportunity for its participants. With different social groups present and more domesticates available, when and where aggregation took place may have changed. At the advent of maize cultivation, Holman and Brashler suggested (1999:216) that Saginaw Valley aggregation sites, like Caseville, were also areas where agricultural pursuits are apparent. Late Woodland populations that were accustomed to seasonal aggregation may have tried to maintain their customs and accommodate the new resources and social groups.

The introduction of maize to the Eastern Woodlands, ca. A.D. 1000, has been cited as the cause of major shifts in subsistence routines, population size, and social organization (Holman and Brashler 1999 1985; Smith 1992 1986; Van deer Merwe and Vogel 1978; Van der Merwe *et al*. 1981; Vogel 1977). In the Saginaw Valley region, the transition from short-term seasonal camps to long-term occupied territories together with the recovery of maize and other cultigens (Holman and Brashler 1999; Parker 1996) and an increase in ceramic style diversity implies a pronounced sense of group affiliation that extended well beyond the Saginaw valley region (Holman and Brashler 1999). Another indication of pronounced group affiliation is the occurrence and diversity of exotic cherts in the Saginaw Valley region. According to Holman and Brashler, Saginaw Valley residents maintained relationships with people from the northern most tip of the Lower Peninsula, indicated by the presence of Norwood chert, a raw material from the north as well as with people from Indian, Illinois, and Ohio (1999:217). During the early Late Woodland period, Bayport chert, common to the valley, is believed to be a “gift” exchanged often at aggregation to outsiders (Holman and Brashler 1999:217). The amount of exotic cherts, like Norwood from the north and Upper Mercer from Ohio decrease after AD 1000. On the other hand, there is an increase in types of exotic cherts at sites like Frazer-Tyra (Andrews 1995:191-194). Bayport chert, the common raw material of the valley, becomes the most commonly recovered material (Andrews 1995:192). Andrews reported an increase in the types of exotic cherts from the Late Woodland occupation than from the earlier period of the Early Woodland/Late Archaic, Early Woodland, and Middle Woodland periods (1995:193). It appears as more groups entered the area, the exotic cherts from the north are withheld from circulation along with amount of the local Bayport chert in the Saginaw valley.

With carbon and nitrogen isotopes, I will to test the consumption patterns of the Frazer Tyra population and the significance of maize to the diet during the later phases of occupation. Through anthropometry and general observations, I will reconstruct stature and note the presence of any paleo-pathologies. The Frazer-Tyra site lies within the transitional Canadian-Carolinian biotic zone and has been dated to ca. AD 1200-1400 (Andrews 1995; Krakker 1983). This study will specifically explore whether the people of this site were a part of the culture of maize adoption and experienced the presumed subsistence shift that characterized other Eastern Woodland populations during the late prehistoric period.

Taking carbon and nitrogen isotopes as indicators of individual preferences, I have formulated the following hypotheses. Given the posited transition to maize-based agriculture in this region during the Late Woodland period, I would expect the mean carbon ratio for the population to be greater than -19.5‰ [per mil], indicating the presence of maize in the diet, but I do not expect the carbon ratios to be the equivalent of historic level consumption, which has been measured at -10‰ (Katzenberg *et al* 1993:273; Stothers and Bechtel 1983:148-150). At the MacPherson site, for instance, a Nuetral Iroquoian village in Southern Ontario, Katzenberg *et al.*

(1993:273) found the population had a mean of carbon ratio -10‰. This Historic period population (A.D. 1530-1580) was known to have been agriculturalists and have a maize-based diet. Furthermore, Stothers and Bechtel (1983:139-150) reported the results of isotopic analysis from skeletal remains from 11 sites of the Western Lake Erie region and another 40 sites from other regions within the Eastern Woodlands. These sites date from the Archaic to the Historic period. The carbon ratios demonstrate the increasing importance of maize to the diet. Archaic period populations have carbon ratios between -26‰ and -21‰, Woodland period populations have carbon ratios between -19‰ and -11‰, and Historic period populations have carbon ratios -11‰ to -9‰. The carbon ratios for populations that practiced full-scale maize agriculture and consumption have been previously established (Schoeninger et al. 1983; Stothers and Bechtel 1987:139). My quantitative expectations for the Frazer-Tyra population are in line with a population in the early stages of transitioning from a primary reliance on wild resources to a greater emphasis on corn in the diet.

Because the Frazer-Tyra site is a riverside village, I expect the primary source of protein for the people would be fish rather than game such as deer, bear, or other herbivores. Because of this, I would expect mean nitrogen ratio for the population to be near or above the average of 12.7‰ [per mil], indicating a heavy reliance on aquatic resources. Though deer is a known source for protein to Late Woodland peoples, the trophic level increase, 3-5‰, that one would expect in human bone collagen from the consumption of the animal would be less than 12‰. For example, whitetail deer have nitrogen ratios at 5‰; with the 3-5‰ increase from human consumption, nitrogen ratios in human bone collagen from consumption of deer meat would be between 8‰ and 10‰. If fish were a major source of protein, the expected nitrogen ratios would be higher in the human bone collagen. Schoeninger et al. (1983) proved that the nitrogen ratios of fishers (14-19‰) are higher than that of agriculturalists (8-9‰). These figure are also higher than the known trophic level of deer, the assumed animal of choice in this case (Greenman 1937; Fitting 1965, Cleland 1966). The nitrogen ratios will help distinguish the source of protein for the Frazer-Tyra population.

Once the dietary trends have been established chemically, I will explore issues pertaining to the subsistence regimes and health of the local population. I will compare the Frazer-Tyra population to existing data on other Late Woodland populations from the Saginaw Valley and the wider Great Lakes region in terms of stature and dietary intake. In general, I will make comparisons between adult males and females as well as age groups to test consumption patterns amongst the different segments of the population. It has been suggested that males were primarily the hunters while females were primarily responsible for fishing, gardening, and food processing (Holman and Brashler 1999). This study also investigates Greenman's (1937) proposition that Late Woodland women chiefly exploited the fishing resource (i.e. caught, processed, and consumed). Greenman's assertion was based on observed pathologies that seemed gender specific.

Zvelebil (2000) suggests on the basis of the ethno-historical information, that the assignment of a food procurement task to one gender or another is usually an indicator of an individual's immediate access to the resource. In a middle ground population, we would expect the distribution of resources to be re-negotiated by individuals away from traditional egalitarian customs toward a ranked system more common to agriculturalists (Service 1978; Zvelebil 2000). If fishing was a female occupation, then the nitrogen ratios would be expected to be higher than that of their male counterparts following Zvelebil's argument.

Significance of The Study

This study contributes to the discussion of the subsistence routines of Late Woodland populations through the introduction of isotopic ratio and anthropometric data. To situate the Frazer-Tyra population within a larger regional context, the data generated are compared to those from contemporary sites. This study will allow archaeologists to discuss the subsistence routines of a specific group of Late Woodland peoples from Michigan and the significance of the introduction of maize using a direct line of evidence--the human remains of the actual people.

This study also contributes to the discussion of how to interpret subsistence regimes of "middle ground" populations that are neither wholly hunter-gatherer nor agriculturalists. It considers the individual as an agent of culture change and proposes a model of interpretation that incorporates the individual—both males and females, as active negotiators in the procurement of domesticates and other products that the population does not produce. Specifically, this study addresses notions of a Late Woodland economy that has active individuals accepting and declining domesticates as well as regulating the flow of goods into and out of the community.

Chapter 2

The Frazer-Tyra Site

The Study of the Frazer-Tyra Site Human Remains

The aim of this study is to use the human remains of the Frazer-Tyra collection to situate the Frazer-Tyra site within the discussion of subsistence shifts, health, and demographics during the Late Woodland period. This study will generate a new body of anthropometric data for the purpose of comparing the Frazer-Tyra remains to other Late Woodland remains, such as those from the Younge, Riviere aux Vase, and Bussinger sites, in terms of stature. Furthermore, this study will explore dietary trends along age and gender lines using carbon and nitrogen ratios. By establishing dietary trends via an analysis of the human remains this study can establish definite consumption patterns and infer migratory patterns for this Late Woodland period population.

One of the reasons that this study is significant involves the biotic zone that the Frazer-Tyra population occupied and exploited. The residents of the Saginaw Valley relied upon an environment that does not appear to have supported large scale agricultural pursuits, though the inhabitants were contemporaries with populations that cultivated and grew maize in the general region. Various archaeologists (Branstner 1990; Holman and Brashler 1999; Stothers 1999) have suggested that the Saginaw Valley region saw an influx of intruders that introduced new material culture and subsistence practices during the late Woodland period, possibly initially provoking in the valley's residents a sense of territoriality and later its the abandonment by the original residents (Holman and Brashler 1985, 1999; Monaghan and Lovis 2005; Norder et al. 2003; Zurel 1999). This supposed intruders' presence is signified by the heterogeneity of the ceramics seen during the Late Woodland period of this region. Specifically, Holman and Brashler (1999) wrote that the presence of Iroquoian groups from Ontario is marked by Juntunen ware; Lake

Michigan Basin residents by Traverse ware; and Grand and Muskegon drainage Basin residents by Spring Creek ware in the Saginaw valley. Additionally, there is a noticable restriction of Bayport and Norwood cherts that were once freely traded before AD 1000. Also, there is a rise in the production of small triangular points made of local raw materials (Holman and Brashler 1999).

Finally, the introduction and use of maize and other domesticates is believed to indicate the presence of Upper Mississippian influence from the south and west beginning ca. A.D. 1000-1100 (Cremin 1999; Dunham 2000; Holman and Brashler 1999; Smith 1992; Stothers 1999). Halsey (1999:263) wrote that the Upper Mississippian presence is “faint but undeniable” in the Saginaw Valley. Large, shell-tempered, thin-bodied vessels and shell mask gorgets, traditional elements of Mississippian assemblages, have also been recovered from the Saginaw region (Halsey 1999). The transformation of Saginaw valley sites, like the Caseville Airport site and the Fletcher site, into permanent agricultural settlements becomes apparent at this time (Bigony 1970; Holman and Brashler 1985, 1999; Stothers 1999)

The Frazer-Tyra Site (20SA9)

The Frazer-Tyra site (20SA29) is located in Section 30 of James Township, Saginaw County, Michigan (Graves 1968) (Fig.2.1.). The site lies in the Saginaw Valley drainage along the Tittabawassee River several miles from its juncture with the Saginaw River (Andrews 1995; Graves 1968) and is located on the property of Roman Tyra (Fig. 2.2) The Frazer-Tyra site, at an elevation of 610 ft. above sea level, sits on a bluff overlooking the Tittabawassee River. The Frazer-Tyra site is regarded as having multi-components, containing layers of occupation from as early as the Late Archaic period up until the pioneer period of the nineteenth century (Andrews 1995; Graves 1968; Krakker 1983). Arthur Graves, an avocational archaeologist, conducted excavations on the site for three seasons from 1968 to 1970. Krakker (1983) reported that the excavated area of the site was 20,000 square feet (See Fig. 2.3).

Figure 2.1 Map indicating location of Frazer-Tyra site in Saginaw County, Michigan.

Figure 2.2 is reproduced from Graves' site report (1968) and shows the close proximity of the site to the Tittabawassee River.

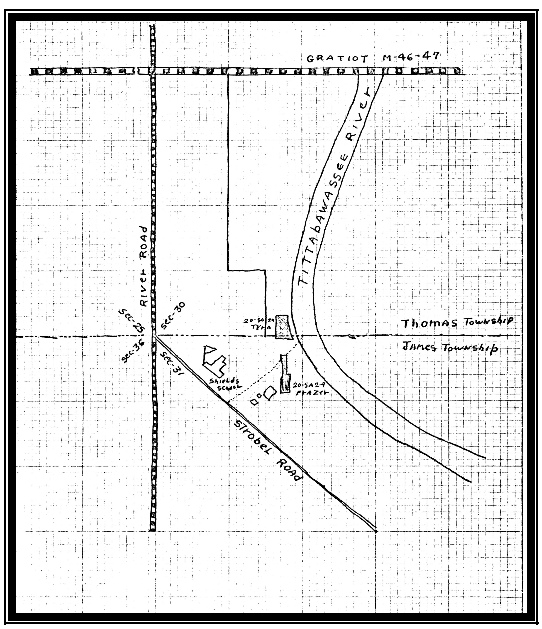
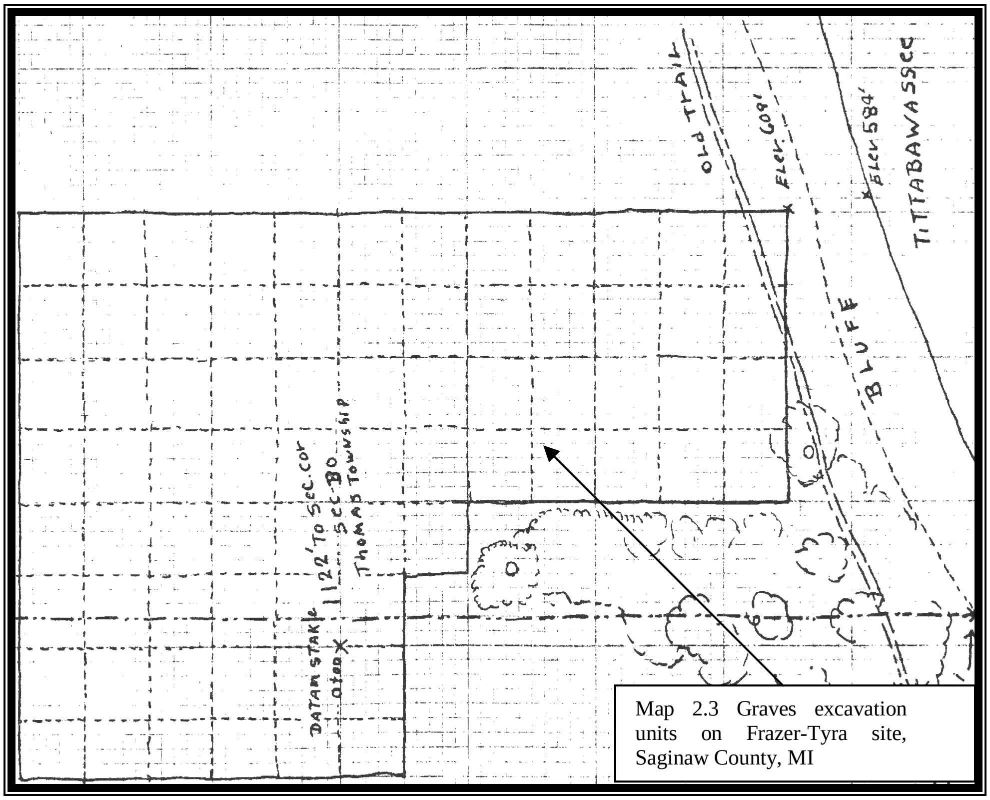


Figure 2.2 indicates the location of the Frazer-Tyra site between the James and Thomas Townships in Saginaw County, Michigan (Graves 1968).



Map 2.3 Graves excavation units on Frazer-Tyra site, Saginaw County, MI

Figure 2.3 shows excavation units from Graves (1968) report. Graves reported on his findings at the site to the Michigan Archaeological Society in 1968. Over the course of three seasons, he recovered at least 114 burials. Of these, 60 were bundle burials , 35 were extended, and three were flexed. He also found 13 skulls and 11 concentrations of cremated remains. He characterized this site as a Late Woodland village and burial ground.

Other recoveries from the site included caches of lithics, such as: the Frazer I cache of 300 turkey-tail and leaf-shaped blades, the Watson cache, the Dustin-Stroebel collection, and the Armstrong Cache. The latter three caches consisted of points, chipped tools, gorgets, hammerstones, anvil stones, adzes, and amulets. Andrews (1995) reported that the caches of lithics indicated human occupation from the Late Paleo-Indian period to the Late Woodland period for the Frazer-Tyra site.

The presence of Levanna points, Levanna/Madison points, Madison points, triangular side-notched points, and side-notched Raccoon points (n= 145), support the Late Woodland assignation of some contexts at the Frazer-Tyra site as does the shell-tempered pottery recovered by Graves (Andrews 1995; Krakker 1983). In his notes and reports, Graves labeled the different features at the Frazer-Tyra site as "burials", "caches", "storage pits", and "fire beds". Table 2.1 list all the adult population for this study by the feature number and includes Graves notes' (1968) on the provenance.

Table 2.1 Frazer-Tyra Burial Features

Feature #	**Unit**	**Depth/Color**	**Other Features in Unit**	**Type of Burial** Krakker 1983 Graves 1968	**WSU Burial #**
2	20N 10W	16" orange sand	Fractured vessel	Articulated (Bundled)	9w733 9w734
2b	20 N 10W	16" orange sand	Fractured vessel	Articulated (Bundled)	9w215
3	20N 10E	20" yellow sand	-Storage pit 56" -Fired bed 15" 3-d	Articulated (Bundled)	9w622 9w720
4	40N 0W	20" no color noted	No notes	Extended	9w345:345 9w345:108 9w345:774 9w345:123 9w645 9w644
6	30N 10E	24"	-Fire pit 22" w/ pot sherds 6-c -Storage pit 38" w/ white sand -Fire bed 20" -Cremation feat #8 24"	Articulated	9w348 9w652a
7	40N 0W	22-24 " no color noted	-Fire bed w/ pot sherds, lavonia pt gorgot frag	Articulated (Bundled)	9w721
10	50W 0W	18" no color noted	-Storage pit 26" west of burial	extended	9w343
11	50N 10E	15" no color noted	-	extended	9w351
64	Between 50N 40 W & 50 N 30W	18" no color noted	Burial feat #61 to west --Fragmented Articulated Burial feat #61-63 NW	extended	9w641
83	10S 30W (in SE corner)	28" yellow sand	-Burial feat #85 26" w/ several pipes	extended	9w217 9w302
85	10S 20W	26" yellow sand		Skull & Torso	9w657

					9w658a, 9w658b 9w585 9w656
89	5S 0W	22”	-Fire bed -14” -Bundle burial to north -Cremated remains over chest of feat #89 burial 14”	extended	9w611 9w609
70	10 N 40W (lies partially in 10N 30W)	28” no color noted	-Feat #70 includes Red ochre staining w/ animal burial w/ -24” -Fire pit 21” in nw corner -Line of post molds north side	extended	9w660
72	10S 30W (middle of pit)	18” no color noted	-Extended Burial Feat #73, #71 interrupt at 10S 40W	extended	9w344:347
90	10S 0W (in corner adjoining 15S 0W)	10” no color noted	-Burial Feature #88 to south	Articulated (Bundled)	9w640
65	Lies between 40N 50W & 40N 40W	13” no color noted	-Lg Burial feat of cremated 12-18”	extended	9w642
88	10S 0W (cntr of pit)	8”	-Burial feature #90 at west corner	skull	9w730
69	10N 30W	12” no color noted	-Burial feat #70 w/ red ochre stain north	extended	9w659
Missing notes	-	-	-	-	9w419
Missing notes	-	-	-	-	9w214a, 9w214b

Figure 2.4 is reproduced from Grave’ notes (1968) and characterizes some of the other features surrounding the articulated (bundled) burials. Feature six includes burials 9w348 and 9w652a as well as fired beds, a storage pit, a few pot sherds, and the cremated remains of feature eight

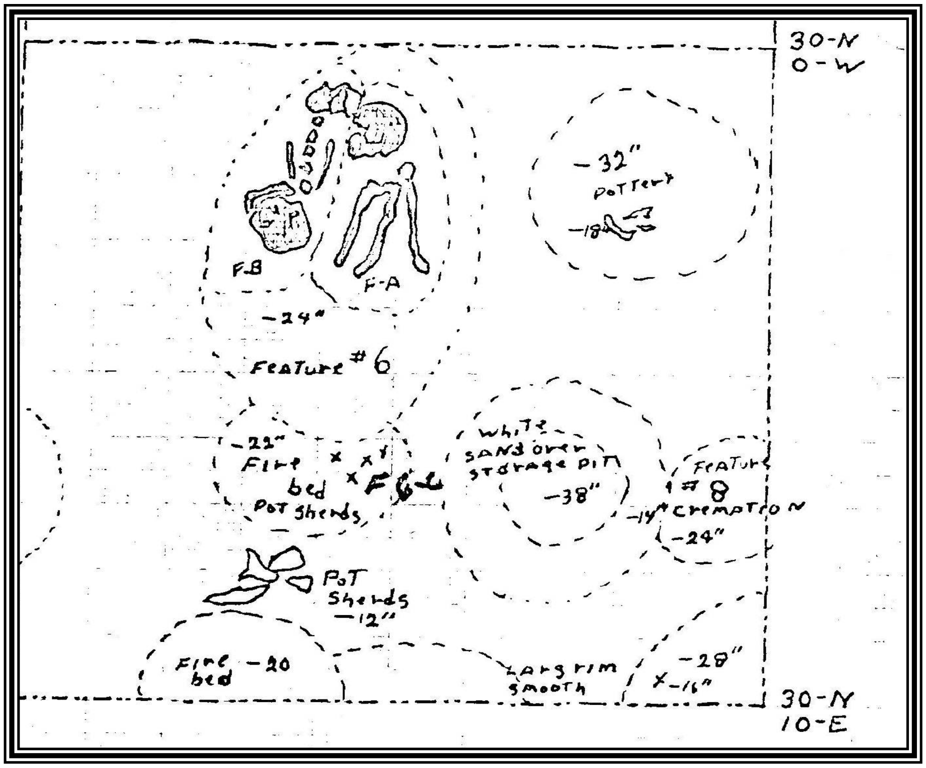


Figure 2.4 is an original plan view of feature six from Graves' notes (1968). The storage pits, fire beds, and ash pits ranged in depth from 12 to 50 inches and typically contained the light-colored sand that characterized the site. Graves' notes (1968) indicate that there were 21 storage pits, eight crematory contexts (identified by the presence of red ochre staining), and 26 fire beds and ash pits that generally contained caches of lithics, pottery fragments, bone tools, fauna (e.g. processed food remnants), and charcoal. There were two large fire bed/ash pit features, each 41 inches deep, that contained well-preserved corn cobs. The faunal remains that were reworked into tools included deer bone (awl), bear (jaw), beaver (tooth).The fauna remnants that were processed as foodstuffs included clam, fish, turtle, and deer.

The human remains from the site have been generally dated to the Late Woodland period (Krakker 1983) and associated with two occupations: an early episode from AD 900-1000, and a later one from AD 1400 to the proto-historic period. Krakker (1983:37) wrote that the number of burials from the Frazer-Tyra cemetery easily exceeded 200 individuals despite incomplete recoveries. Krakker also estimated the living population at the site to be well over 200 individuals during the Late Woodland period. Based upon internal inventories generated for NAGPRA compliance, I determined that the Frazer-Tyra collection consists of a minimum number of individuals (MNI) of 147, of which ±70 are housed at Central Michigan University (CMU) and 74 at Wayne State University (WSU). Graves (1968) did not remove the remains of every individual he found but instead reburied or left in situ at least nine burial features and their contents.

Figure 2.5 demonstrates the proximity of the burial features to one another by the designation of the excavation unit. This figure displays all the burial features under study except for 9w419, 9w214a, and 9w214b because of a lack of notes. Krakker (1983) wrote that articulated remains are a sign of secondary interment.

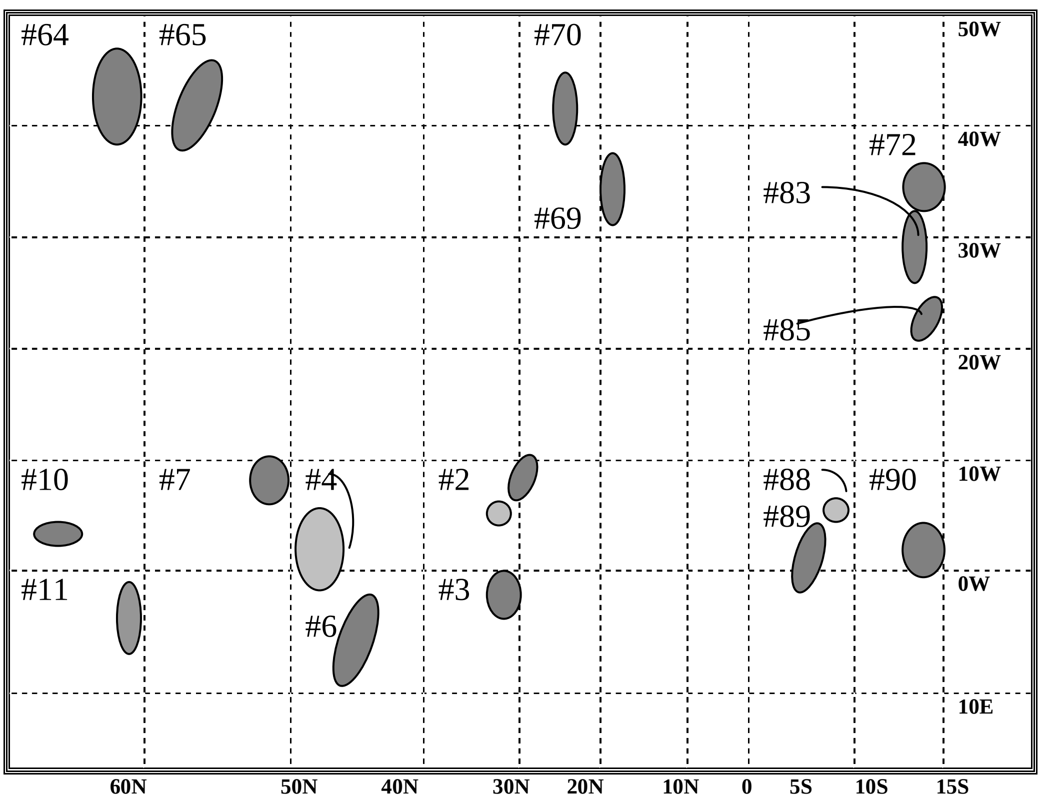


Figure 2.5 demonstrates the sample of the adult population that is under study. The WSU Frazer-Tyra collection of human remains includes adult males, adult females, and children ranging in age from infancy to six years. Archaeologists have previously used human remains, such as those from Frazer-Tyra site to reconstruct the demography of populations, bio-distance, trauma, and to establish patterns of dietary consumption (Bender 1979; Raemsch 1993; Rose 2008; Sauer 1974; Stothers and Bechtel 1987; Wilkinson 1971). In this study, I focus on dietary questions.

Characterizing Late Woodland Culture

There are many challenges to reconstructing the past life-ways and social organization of Michigan's Late Woodland peoples. Poor preservation, incomplete data for numerous sites, and the inherent difficulty of handling, processing, and evaluating human remains has left Michigan's prehistoric human remains on the periphery of recent scientific inquiries.. Even so, there have been a number of studies that have addressed issues surrounding subsistence shifts specific to the Late Woodland period as well as social organization and the nature of culture contact with Upper Mississippian people. Sites within the Saginaw Valley region have long been the focal point of Michigan archaeology. These include such well known sites as Fletcher, Bussinger, Butterfield, Mahoney, Stadelmeyer, Hodges, Stroebel, and Cassasa (Bigony 1970; Dustin 1968; Halsey 1976; Sauer 1976; Taggart 1967). Several studies have addressed the issue of contact between Upper Mississippian peoples and local Michigan people of the Saginaw Valley via settlement pattern (Lovis 1985; Lovis and Egan 1992), social organization (Bender 1979; Krakker 1997; Norder *et al* 2003), ceramic diversity (Holman and Brashler 1999; Stothers 1999), lithic (Andrews 1995; Krakker 1997), and horticultural analyses (Holman and Brashler 1985; Parker 1996; Smith 1992). The Frazer-Tyra site (20SA9) has been included in the regional analysis of the Saginaw Valley with regards to mortuary variability studies (Halsey 1976; Krakker 1983) and in terms of trade networks of lithics and ceramics (Andrews 1995; Krakker 1997). However, the human remains recovered from the Frazer-Tyra site have yet to be situated in the overall discussion of maize adoption, maize consumption patterns, subsistence shifts, and health for the Late Woodland period of the Great Lakes Region.

In the Saginaw Valley region of Michigan**,** the Late Woodland period is dated from circa 600-1600 A.D. Normally characterized by hunter-gather subsistence, spring/summer aggregations, and a wide variety of mortuary behaviors, Late Woodland peoples have a difficult history to reconstruct (Norder *et al.* 2003; Walthall 1998). In the Saginaw Valley, the majority of Late Woodland sites are characterized by frequent reoccupations for short periods of time resulting in typically thin refuse layers (Monaghan and Lovis, 2005). Sites in the Saginaw Valley, such as Bussinger, Bugai, Frazer-Tyra, and Bridgeport, are characterized by the following features: ossuaries, red ochre stained burials, the presence of trophy heads, human remains with extremely worn dentition, cremations, and diversity of floral and faunal remains.

Like its contemporaries, the Frazer-Tyra site promises to add to the discussion on the life-ways of the Saginaw Valley region, which seems to have experienced significant culture change during the late prehistoric period. The Saginaw Valley seems to have attracted many different native populations throughout Michigan's prehistory. The nature of social interaction between different resident populations, shifts in subsistence regimes, and the trade of material culture and technology have all served as entry points for the discussion of regional prehistory (Cremin 1999; Halsey 1999; Holman and Brashler 1999; Krakker 1999).

Though an internal report had previously been generated for a sample of the adult individuals from the Frazer-Tyra site in the collections at WSU (Fischoff and Porter 1983), the Frazer-Tyra materials had never been thoroughly studied. Because the Frazer-Tyra site dates to a period of profound cultural change (i.e. Mississippian intrusion, subsistence shifts, etc), the nature of the population's diet, health, and social organization is of keen interest. There are many unanswered questions surrounding the dietary choices of the Frazer-Tyra population, such as whether fishing was a consistently exploited resource for the population, whether horticultural elements and trade contributed to the population's overall health, and whether the residents resisted or embraced the full scale adoption of maize that characterizes many other Late Woodland populations of this period. These are the types of questions I address in the following chapters.

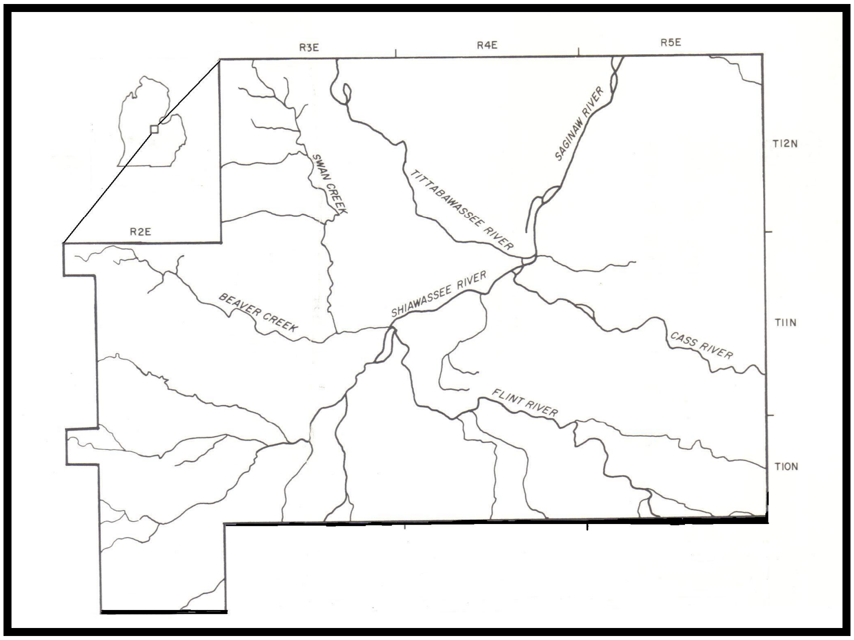
Chapter 3

The Environment

The Environment of the Saginaw Valley

The Saginaw River valley comprises a complex system of waterways that supports a diversity of wildlife. Fred Dustin (1968) reported that by 1929 he personally had located some 25 villages along the Tittabawassee River and some 60 others along related streams. This large number of sites was recorded without even having followed the Flint, the Bad, or the Shiawassee rivers. Dustin went on to describe the waterways of the Saginaw Valley region as ‘the gathering place’, of the Natives of Michigan (Dustin 1968).

Formed by the retreating Saginaw lobe of the Wisconsin Ice sheet, the Saginaw Valley region includes the drainage basin, the Saginaw Bay, and the many small rivers that empty into it (Cleland 1966; Dustin 1968; Keene 1981). Two major river systems unite in the Saginaw district, the Tittabawassee River and the Shiawassee River, and flow into the Saginaw River. The Tittabawassee River’s tributaries include the Chippewa, the Pine, the Salt, the Tobacco, and the Cedar rivers, all supporting wild game, fish, and an abundance of edibles (Dustin 1968). The Shiawassee River’s tributaries include the Shiawassee Lake, the Cass River, the Flint River, and Swan Creek, and the Bad River. This network of waterways was well traveled by Native peoples and constituted the basis of their subsistence in this region throughout prehistory.



Map 3.1 This is a map of the converging waterways of the Saginaw Valley Region (Keene 1981:42). Early explorers would call this system, the *Indian waterways* because they were frequently traverse by the indigenous people in canoes at various times of the year. Early European settlers learned to cross these waterways by imitating the native example. Besides traveling the waterways, nearby residents exploited the diversity of wildlife associated with these streams, ranging from wild game to fish to waterfowl. Archaeologists have long recognized that the Saginaw Valley provided a rich environment for Native peoples as early as the Archaic period ((Greenman 1937; Halsey 1976; Holman and Brashler 1999; McPherron 1967; Taggert 1967).

Flora of the Saginaw Valley

The Saginaw Valley has been characterized as a region that includes dense mixed hardwood forests and the Shiawassee Flats, which is mainly marsh (Cleland 1966; Halsey 1976; Keene 1981). In the better drained uplands, there were oaks, sugar maples, beech, hemlock, and hickory trees. In the low lying areas, there were elm, ash, basswood, and soft maple. Along the landscape of the Tittabawassee River, there were pine, red maples, beech, mixed hardwoods, sugar maples, oak and beech and pine hardwoods (Keene 1981).

Loams and sandy loams were the dominant soil types reported with only 13 percent of Saginaw county's soils being heavier than loams (Keene 1981). Keene (1981) reported that he used the General Land Office Survey (GLOS) survey records to reconstruct the forestry of the valley. These records included witness and line trees to draw the section lines of each Michigan county. Also, Halsey(1976) wrote that the forest that encompassed the Bussinger site, a site within the valley, was composed of mixed hardwoods and conifers, characterizing the valley as a maple-basswood-beech forest.

The contribution of this forested environment to the diet of prehistoric people has been previously discussed (Cleland 1966; Halsey 1976; Keene 1981; Yarnell 1964). Saginaw Valley's botanical community would have provided nuts, acorns, fruits, tubers, greens, weed seeds, and tree sap (Halsey 1976; Keene 1981). Yarnell (1964) wrote that Native peoples used approximately 130 species of plants for food, medicine, utilitarian purposes, charms, dyes, brewing, and smoking. Nuts and acorn would have been available from late summer and produced the highest yields in the autumn. Berries and fruits were available from approximately June to August and were dried and stored for autumn and winter use. Only a few species, like cherries and hawthorn, and hackberry, would have been available during the early autumn. Tubers, greens, and weed seeds were available during the early spring and late autumn. Tree sap collection would have possible during the spring (March and April).

Keene (1981) listed nine species of nut producing trees that lent to the edible resources of the valley with hickory (*Carya ovata*), beech (*Fyus groudifolia*), black walnut (*Juglaus nigra*) and hazel shrubs (*Corylus Americana*) being the preferred species among prehistoric populations. These nut producing trees would give yields beginning in July with the abundance occurring in October. Also, three species of oak produced acorn in the environment, such as the red oak, the white oak, and the black oak. The red and black oaks produced the preferred bitter acorns in the early autumn and as late as November (Keene 1981).

Fruit bearing trees and shrubs were also common in the valley providing stable and reliable resources to prehistoric peoples through the summer and into October. The *Rubus* species (i.e. raspberries, blackberries, dewberries), *Ribes* species (i.e. currants, gooseberries), *Vaccinium* species (i.e. blueberries), *Fragaria virginiana* (i.e. strawberries), and *Smilancia racemosa* (i.e. false Soloman's seal) were the dominant species that were available as early as July and as late as September. Frost grapes, common elder berries, mayapples were also used in the summer months. Autumn resources included black cherries (*Prunus serotina*), hawthorn (*Cratageus sp.*), hackberries (*Celtis occidentalis*), and chokecherries (*P. Virginiana*). Berries were eaten fresh and dried for winter storage (Dunham 2000; Halsey 1976; Keene 1981)

Tubers, greens, and tree sap were exploited in the region. There were 20 known species of tubers in the valley. The aquatic environs produced wapato (arrowhead), groundnut, water chinquapin, and bulrush, with wapato and bulrush being the favored species exploited (Keene 1981). Woodland environs yielded the favored wild leeks and onions (i.e. *Allium* species) and Solomon's seal (i.e. *Polygonatum sp*.). Jack-in-the-pulpit, pepperoot, spring beauty, and false Solomon's seal were also woodland resources. These tubers were boiled and dried and were available in the early spring and autumn (Keene 1981). There were 15 species of greens available in high densities along creeks and streams (Keene 1981). These species included green briar, low parsnip, skunk cabbage, dock, cress, and wood sorrel. Also, tree sap, available in early spring, was a reliable resource. Tree sap was collected from sugar maples, silver maples, yellow birch, basswood, hickory, walnut, and butternut tress, but mainly from sugar maples (Keene 1981). Weeds seeds, chenopodium species (i.e. goosefoot, lambs quarter) and amaranthus species (i.e. pigweed), were not available until late autumn to early winter. They were not a significant resource, because they usually required the disturbed ground of a cleared camp site to produce (Keene 1981)

Fauna of the Saginaw Valley

The Late Woodland peoples of the Saginaw Valley region were known to be small game hunters, fishers, and trappers (Holman and Brashler 1999; Keene 1981; Stothers 1999). They relied on the diversity of the valley and produced food products, clothing, and tools from the available fauna. Large and small mammals, waterfowl, and fish were exploited by the residents of the valley. Animals that lived in great numbers and that required a minimum of effort to procure seemed to be favored. The beaver, muskrat, passenger pigeon, raccoons, common snapping turtle, and fish are reported as primary resources (Dunham 2000; Keene 1981).

Large mammals in the valley were always a profitable target for prehistoric hunters because of the minimal amount of effort required to track and trap the animal, the amount of meat available, and amount of time and effort to process the animal. Bears, deer, elk, and beavers were good sources of protein, but the beaver was the most reliable resource. The beaver (*Castor canadensis*) was an animal that did not migrate, produced large litters and fed on the vegetation native to the valley. These animals did not stray from their lodges and were available year round but were chiefly trapped in the winter for meat and their pelts. Deer (*Odocoileus virginianus*) and the black bear (*Ursus americanus*) are animals that required more effort on the part of prehistoric hunters. Bears were hunted in early winter to take advantage of their hibernation; a period when they would be leaner. The deer, a preferred animal for its skins for clothing, was difficult to acquire. Keene (1981) wrote that this animal experiences dramatic weight changes due to the way it feeds and its 'yarding' behavior. Deer would have prospered more on the edge of forests' borders, lake and marsh margins, and openings. The Saginaw Valley was a poor habitat for the creature and an unreliable resource for humans (Keene 1981). Elk, considered a docile animal (Keene 1981) was a winter resource because the animal tends to congregate in male groups and are easily approached. However, Keene (1981) estimated that this animal was available at two per square mile in the valley but its migration patterns would have made the procurement cost high.

The muskrat, raccoon, squirrel, rabbit, and small fishers would have been valuable small mammals to Saginaw valley residents. The muskrat (*Onadata zibethica*) and the raccoon (*Procyon lotor*) were an abundant and reliable source of meat. The muskrat is adapted to aquatic environs and trapping was the principal means to acquire the animal. Raccoons were caught during their winter dormancy from the hiding places and trees. Like the beaver, the raccoon and the muskrat could be trapped in the winter. Rabbits and squirrels were available, but were not easy prey. Fishers (*Mustelidae*), like the mink, marten, weasel, though present were not considered a valuable food resource (Keene 1981).

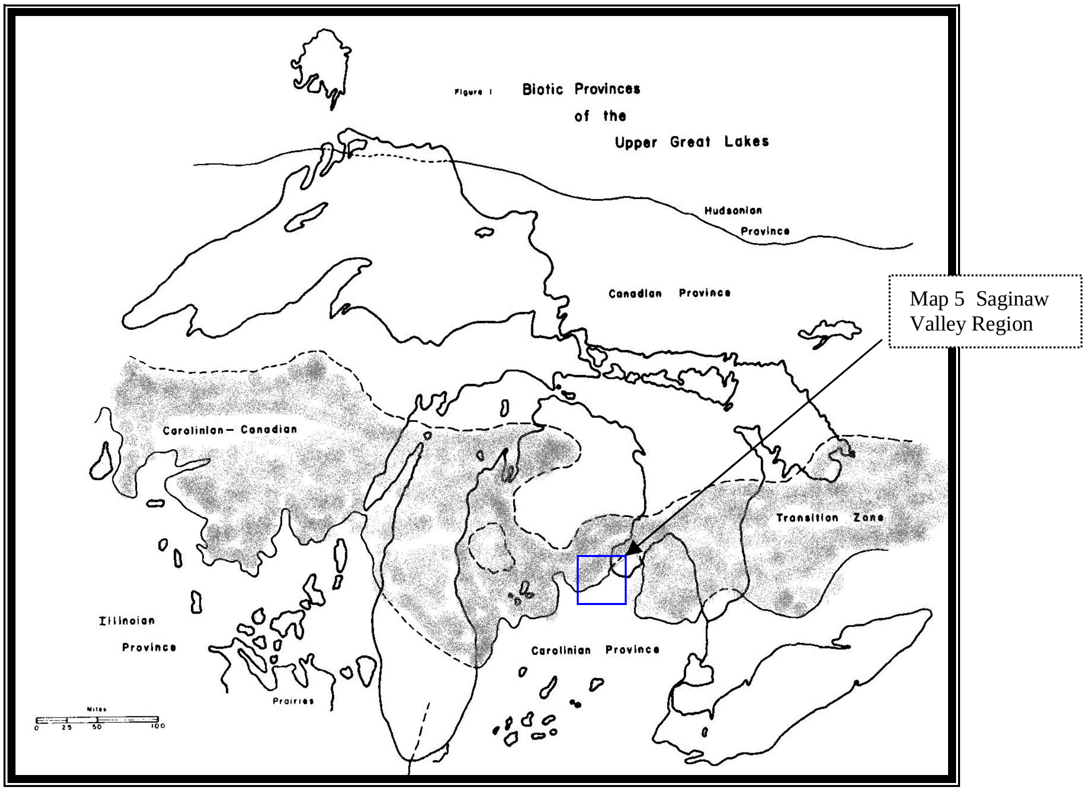
Waterfowl, turtles, and passenger pigeons were also plentiful. Keene (1981) reported over 15 species of waterfowl and seven species of turtle common to the Saginaw valley. The common snapping turtle and the soft shelled turtle were favored by prehistoric hunters. The common snapping turtles were a reliable winter resource because of their aggregation behavior and hibernation cycle. Soft shelled turtles, with no hibernation period, were harder to catch by traditional methods though they did not stray from the aquatic environ. The passenger pigeon (*Ectopistes migratorius*), once existed in Michigan in great numbers, though now extinct (Keene

1981). Squabs were collected as early as the spring and throughout the summer. These squabs were boiled to eat and smoked and dried for storage.

Fish were an abundant resource of the Saginaw valley and fauna recoveries from archaeological sites usually include fish bone (Fitting 1965; Graves 1968; Greenman 1937; Keene 1981; McPherron 1967). Fish were acquired by traps, netting, spears, dams, and harpoons. Assemblages usually include lake sturgeon, the longnose gar, freshwater drum, yellow perch, channel catfish, largemouth bass, brown bullhead, bowfin, and walleye pike. Many of these fish are spring/summer spawners (Hubbs and Lagler 1958). The lake sturgeon, freshwater drum, and the bowfin were the most exploited species. These species were bottom dwellers or preferred shallows and were easy prey for humans.

Paleoecology of the Major Biotic Zones

The prehistory of North America has been divided into several general time periods. These designations are applied to the Saginaw Valley region in the following manner: the Paleo-Indian period (12,000-9,000 B.C.); the Archaic Period (c.a. 9,000 B.C-1,000 B.C.); and the Woodland Period (c.a. 1,000 B.C.- A.D.1500). Each period is characterized by the presence of distinct material assemblages and shifting subsistence strategies.



Map 3.2 Biotic zones of Michigan, between the Canadian and Carolinian zones, is a smaller less defined area, the Carolinian-Canadian biotic zone that is described as a narrow territory in Michigan Cleland (1966:6). There are three biotic zones that characterize prehistoric Michigan. These include the Canadian Biotic zone, the Canadian-Carolinian transitional biotic zone, and the Carolinian zone. Each biotic province's features are directly related to the deglaciation process of the Northern hemisphere. The parameters of Native American subsistence have traditionally been reconstructed based on the nature of these zones.

The Canadian Biotic zone stretches from the southern tip of the Bruce Peninsula of Lower Ontario and cuts at a diagonal into southern Michigan through Saginaw Bay and little Traverse Bay to the western corner of Wisconsin. A heavily glaciated area filled with moraines, ridges, sandy, out-washed plains, rocky outcrops, and swamps, it is considered infertile ground. Cleland (1966) referred to this as the Lake Forest zone because of the modifications made by the surrounding large water masses. Light colored, acidic, sterile soils comprised of stones, gravels, and sands characterize this area (Cleland 1966). The biotic community was dominated by the sugar maple species followed by yellow birch, beech, elm, aspen, basswood, hemlock, and white pine. Cleland (1966) reported this area as having a growing season of approximately 80 to 140 days with temperatures falling between 38°-40° F. Snowfall covers the ground at least 100 days of the year and snowfall ranges from four to ten feet per year. Due to the sterile nature of this biotic province, Cleland (1966:10) wrote that very few mammals exclusively called this area home. However, the summer migratory patterns of the spruce goose, the gray jay, the raven, and the common loon included this zone and would imply that these birds were a seasonal resource. Fish seemed to be the principal resource for humans in this zone.

The waterways of the Great Lakes and its tributaries are known to harbor native Michigan species of fish (i.e. lake sturgeon, common pike, sauger, muskelange, yellow perch, mooneye, burbot, and brook trout) as well as species also found in the Mississippi (i.e. catfish, bowfin, white bass, black bass, crappies, and sheepshead) (Halsey 1976:12). At the European contact, Algonquian speakers (i.e. Chippewa, Ottawa, Menomini, etc.) exploited the waterways and hunted (Cleland 1966) in this biotic zone. Furthermore, Cleland (1966) reported that these bands were known to divide into smaller family units in the winter to hunt and lived in large lakeshore villages during the summer to fish.

The Carolinian Biotic province, which includes southeast Michigan, begins at a diagonal from the southern lobe of Lake Huron running westward to the southern lobe of Lake Michigan and continuing southward. The growing season is about 140-180 days per year with an average temperature ranging 40° and 50° F (Halsey 1976). With an annual rainfall between 28-36 inches per year, the sandy to clayey texture of soils supported bogs, swamps, and forests alike. The forests are characterized as oak-hickory type, including: black, red and white oak, hickories, sugar maples, beech, walnut, butternut, elm, and tulips. This zone supported a multitude of small mammals (i.e. skunks, opossum, mink, raccoon, etc.) as well as deer. At the time of European contact, Native American tribes such as the Huron, Sauk-Fox, Pottowatami, some Siouan speakers, Miami, and Erie, occupied this province and primarily subsisted as agriculturalists. Native peoples of the Historic period were known to have grown corn, beans, and squash as well as collect wild plants, hunt deer, trap small game and fish (Brashler and Holman 1985; Cleland 1966 Stothers 1999).

The zone between these two comprised a transitional region. The southern fringe of the transition zone, meeting the northern boundary of the Carolinian zone, has forests that are akin to the Carolinian biotic zone (i.e. elm, red maple, yellow birch, white pine, aspen, etc.) (Cleland 1966; Keene 1981). Saginaw Valley residents lived within this transitional zone and were known to have exploited the waterways with all the attendant resources (Brashler and Holman 1985; Fitting 1965; Halsey 1976; Holman and Brashler 1999).

The Saginaw Valley's annual precipitation is typically around 27-30 inches and occurs during two periods: May-June and August-September. Average annual snowfall ranges from between 35to 40 inches. The Saginaw Valley has a growing season of 140 to160 days per year (Cleland 1966; Halsey 1976). The Saginaw Valley has fluctuating seasonal extremes, with markedly harsh winters where temperatures dip to as low as -20° to -30 °F and summer temperatures ranging from 30° to 100°F (Halsey 1976). The Saginaw Valley was a rich region at the boundary between the Canadian and Carolinian biotic zones that included species from both biotic provinces. Archaeological sites in this region have yielded faunal remains that reflect the diversity and richness of this region.

General Subsistence Shifts in The Saginaw Valley

The Paleo-Indian period (12,000-9,000 B.C.) in the Saginaw Valley region is denoted by big game hunters who adapted their strategies according to retreating glacial fronts. Early on, hunters used large lanceolate projectile points, fluted with concave bases. Later in this period, these hunters modified the style of their tools to unfluted projectile points. Lithics recovered from the Barnes site and the Gainey site have revealed shifts in the morphology of projectile points (Fitting 1975 Simons *et al.* 1984). These changes are believed to be a response to shifting environmental conditions that created more forest and wetlands (Simons *et al.* 1984).

The Archaic period (9000-1000 B.C.), which is divided into three stages, marks a period when Saginaw residents leave off big game hunting for smaller game and fishing. Brashler and Holman (1985) reported that Early and Middle Archaic artifacts from the Saginaw Valley region though rare, included choppers, scrapers, lanceolate projectile points, and knives usually made of argillite. According to Branstner (1990), discoveries at the Weber I site, site 20BY79, and the Conservation Park site have led to a modified chronology for the Saginaw Valley's Middle Archaic period, which is now referred to as the Dehmel Road Phase, dating from 6200-4500 B.P. The Weber I site, produced a limited sample of lithics similar to the Dehmel Road phase projectile points (Branstner 1990). These are large, side-notched, ground base points of argillite, subgreywacke, and other local cherts. Also, the faunal and botanical assemblages recovered support the idea that subsistence shifted from big game hunting to small game hunting and fishing during the Middle Archaic period.

To explain the subsistence shifts of this period and the nature of the limited recoveries, Lovis *et al.* (2005) have proposed that hunter-gatherer groups began to take advantage of various environs on a seasonal basis. Furthermore, he proposed that these groups migrated in a linear fashion between an interior residential base in the wetlands of the Saginaw Bay outward to the Lake Stanley littoral and other lakeshores (Lovis *et al.* 2005), to explain the residential patterns in the Saginaw Basin. The fauna assemblages from these sites include deer, muskrat, and raccoon, as well as geese, and an array of nuts, turtle, and fish.

The Late Archaic (3000 B.C.-1000 B.C.) period is marked by population growth, new types of burial contexts, grooved axes, chisel-shaped celts, and the use of slate as a common raw material. The Late Archaic period is also marked by permanent residents of the Saginaw Valley (Brashler and Holman 1985). Sites of this period are frequently revisited and mobility becomes optional because climatic conditions have stabilized enough to count on resources.

Changes in the Shiawassee river course would provoke the Saginaw Valley's Early Woodland populations to move more toward the center of the valley along higher ground near the Tittabawassee River. The use of pottery and cultivated plants are diagnostic of this period as well as rounded projectile points related to the Adena of the Ohio Valley. The Middle Woodland stage (200 BC-AD 400) does not seem to represent major shifts in subsistence in the Saginaw region and the local sites do not seem to display the Hopewellian settlement and subsistence patterns.

The Late Woodland stage (AD 500 to AD 1500) is marked by an increase in population, increase in ceramic diversity, and larger settlements. Holman and Brashler (1999, 1985) suggested that these incremental changes (c.a. 1000-1100 A.D.) culminated in a major cultural shift towards the end of the Late Woodland period. The Saginaw Valley's residents purportedly abandoned the valley as a permanent homeland due to the advance of 'intruders' who favored agricultural modes of subsistence around this moment in time (Holman and Brashler 1999). At their time of entry**,** it is possible these new groups were willing to modify the landscape for agricultural pursuits only to find later that the valley's unpredictable seasons were problematic. Changes in land use and establishing a full-time agriculturally based subsistence routine requires human labor. Perhaps, modifying the land for agricultural use may have required more human labor than they had at their disposal. These factors and others may have played a role in the valley's abandonment. Michigan's Late Woodland culture are also characterized by a tendency toward the use of ossuaries, shifting economies resulting from the Mississippian intrusion, a greater diversity of ceramic styles in the region after AD 1000, and the widespread management of storage facilities for small scale cultivated food and collected food.

Challenges in Interpreting Late Woodland Subsistence

Regarding the Late Woodland Period in Michigan, Monaghan and Lovis (2005) suggest approaching the study of prehistoric mobility by dividing the state into distinct ecological zones varying in terms of potential resources for inhabitants. Dividing Michigan into these sub-regions (Monaghan and Lovis 2005:85-86) has allowed archeologists to create models of mobility that explain how people chose and settled these ecologically distinct areas. Prehistoric people are seen as either opportunistically exploiting the natural resources of these zones or as transforming particular areas into an agricultural base (Monaghan and Lovis 2005; Lovis 2003). Using the AD 800-1000 dates for maize adoption in the area as a threshold for change, Michigan archaeologists have seemingly settled on certain "talking points" when discussing Late Woodland subsistence patterns. These include the following: (1) the incorporation of maize into subsistence routines of hunter-gatherers circa AD 800; (2) the increase in site size and use toward the end of the period to accommodate large-scale maize cultivation; (3) technological shifts that enhance food procurement and storage; and (4) the development of systems of mobility that eventually led to the abandonment of the Saginaw Valley as a permanent residence (Lovis *et al.* 1996; Monghan and Lovis 2005). In light of these views, the Saginaw Valley region, with the highest concentration of Late Woodland sites in Michigan, is an anomaly (Monghan and Lovis 2005:90). Saginaw valley sites seem to have been used seasonally (long and short term), have a variety of ceramic types and exotic cherts, and are within close proximity to one another.

Various Michigan archaeologists presented their perspectives on the Late Woodland period in *Retrieving Michigan's Buried Past: The Archaeology of The Great Lakes State* (Halsey and Stafford 1999). Relying on ethno-historical accounts and ceramics, Stothers (1999: 194-211), for instance, wrote that the interpretive models of Late Woodland cultural trends should continue to be tested to sustain inferences about life-ways. He suggested that further research should be conducted to solidify the diversity of prehistoric populations and regional histories. He did suggest that ceramic diversity and ethno-historical accounts support the presence of diverse populations. He also suggests that social interaction was based on shared beliefs that were acted out at aggregation sites in mortuary districts. Holman and Brashler (1999: 212-220) used ethno-historical accounts, faunal remains, and ceramics to discuss subsistence strategies of Late Woodland peoples. On the basis of increased heterogeneity in ceramics and the rise of horticultural pursuits, they have argued that considerable economic changes occurred after 1000 AD (1999:219). Furthermore, they note that these changes are indicative of the need for a more pronounced group affiliation in light of the trading of resources which fluctuated in availability and amount.

James Krakker (1999:228-233) agreed that the uncertainty of resources and the harsh environment of the Great Lakes region may have provoked a type of social organization in which membership was defined beyond age and sex. Krakker believed that a system of exchange and gift giving would have been regulated by a larger kin-based network (Krakker 1999:232).

The latter would have ensured the distribution of resources and thereby the health of the community. Krakker uses the various types of mortuary treatments and burial complexes to reconstruct social organization and status.

Norder *et al.* (2003) suggested that mortuary practices seen at the Brandon and Olson sites in Washtenaw County, Michigan imply that Late Woodland social roles were shifting in such a way as to support the inclusion of adult females into prestigious roles. Furthermore, there appears to have been an exogamous marriage pattern that brought in females from eastern populations. The incorporation of women from Ontario and Ohio was implied for the Late Woodland period based on craniometric data (Norder *et al.* 2003). Finally, Halsey (1999, 1976) also wrote about identifying Late Woodland groups by their burial practices. The shift from individual burials with an array of grave goods toward clusters of secondary interment features (ossuaries) implies a social organizational change. The inclusion of animal remains, skeletal modification, and trophy heads points to even greater implications about group affiliation and conflict. Unfortunately, within these discussions, the actual human skeletal remains are still a peripheral element in reconstructing the past.

Chapter 4

Mortuary Practices in Prehistoric Michigan

Late Woodland Mortuary Precincts

The Late Woodland period date from circa AD 500 to 1650. Stothers (1999) outlined the Younge Tradition of cultural development in the Saginaw Valley region. The Younge tradition is now referred to as the Western Basin Tradition and includes the following phases: the *Gibraltar phase* (AD 500-750 c.a.), the *Riviere Aux Vase phase* (AD 750-1000), the *Younge phase* (c.a. AD 1000-1200), and the *Springwells phase* (AD 1200-1300) and the *Wolfe phase* follows the Springwells phase after AD1300 (Fitting 1965; Krakker 1983) Mortuary patterns have helped to define these phases as much as material assemblages of lithics and ceramics. Stothers (1999:202) has suggested that Western Basin Tradition's mortuary districts, e.g., sites that either included burial mounds or cemeteries, doubled as trade fair grounds. Native peoples are purported to have renewed socio-political alliances, arranged marriages, traded/exchanged goods, and honored the dead by resituating graves, feasting, and holding games of competition at such sites. From ethno-historical data, we know that the Feast of the Dead included the latter social activities and was carried out at mortuary precincts (Bender 1979; Halsey 1976; Greenman 1935; Holman and Brashler 1999; Krakker 1997).

Bender's study of the human remains of the Riviere aux Vase site demonstrates that mortuary districts also served as trade fair grounds. In reconstructing the demography of the Riviere aux Vase population, Bender (1979) discussed the impact of ceremonialism on which individuals were actually present in the cemetery. She faced some difficulties in accounting for minimum number of individuals, age, and sex because of various mortuary treatments practiced by the population. Also, Bender wrote that the Riviere aux Vase site and the Libben site indicated repeated occupation of the same population rather than a cemetery that was shared by numerous populations.

By Stothers' definition (1999:202-207), the Bussinger site, Riviere aux Vase site, Juntunen site, Gibraltar site, the Younge site, the Libben site, the Fletcher site, the Lasanen site, the Miss Island site, and Frazer-Tyra all constituted trade fair grounds. Furthermore, Holman and Brashler (1999) believe that the heterogeneity of ceramic styles and the thick middens, with high artifact yields and feature density, are signs of seasonal aggregation of large groups in the Saginaw Valley. They also wrote that after A.D. 1000, cultural tendencies in the region leaned toward the use of ossuaries surrounding the well known ritual activity, the *Feast of the Dead* (Holman and Brashler 1999:218).

Krakker (1999) discussed changes in mortuary treatment throughout the Late Woodland period. He proposed that such changes are indicative of changes in the larger societal order. He wrote that early Late Woodland burials imply that status was achieved and that individuals were buried according to age and sex. However, through time, there is an ever-increasing occurrence of multiple individual interments, ossuaries, and the size of them (Krakker 1999:232) with a final a very large ‘corporate’ feature at many sites dating to the Late Woodland period. Also, he noted that there is a decrease in artifacts in the mortuary context. Krakker used the mortuary data from the Riviere aux Vase site and the Frazer-Tyra site to demonstrate that prehistoric social organization was based on more than just age and sex but also membership in larger kin-based networks. These mortuary features demonstrate what Krakker called sub-community units (1999:232-233), like clans, villages, and tribes. Such social complexity does not seem akin to bands of hunter-gatherers but of larger social groups that have resources they must manage and distribute. Krakker suggested that a more pronounced sense of social identity and affiliation accompanied increasing ceramic diversity and horticultural pursuits in Southeastern Michigan.

Various studies have been conducted on Michigan's Late Woodland mortuary populations. Physical anthropologists and archaeologists have used Late Woodland remains to discuss demography, diet, violence, stature, bio-distance, and mortality rates of Michigan's prehistoric populations (Barondess 1998; Bender 1979; Halsey 1976; Krakker 1999, 1983; Norder et al. 2003; Raemsch 1993 Wilkinson 1971). Studies on the mortuary precincts at Juntunen, Riviere aux Vase, Younge, Frazer-Tyra, Bussinger, and Fletcher demonstrate that there is a biological and cultural connection between populations of the Saginaw Valley region and the larger Southeastern Michigan region. Figure 4.1 shows the latter mentioned mortuary precinct's proximity to one another:

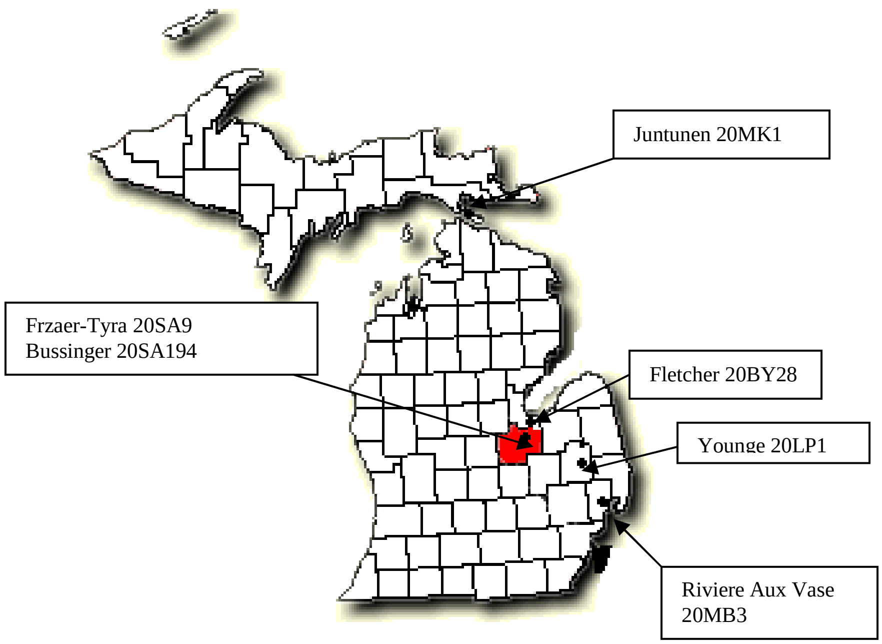


Figure 4.1 Michigan Late Woodland Mortuary precincts Wilkinson (1971) undertook a study on bio-distance between Michigan and Illinois populations using remains from the Bussinger, Younge, and Juntunen sites. He concluded that there is no typical Late Woodland

population of Michigan. It appears rather that populations from Southern Ontario as well as Illinois had a genetic influence on the population at Bussinger. Bender (1979) conducted a study to reconstruct the demographics of the Riviere Aux Vase population. She wrote that she suspected that Riviere aux Vase women were more than likely from other parts of the eastern woodlands, outside of Michigan. Also, it appears that Riviere aux Vase was a site of great ritual activity and the home of a large permanent population. She also found that the mortuary practices at the site indicate that it did not constitute an inter-communal cemetery; perhaps in which more than one band would use during their seasonal migration to inter their deceased.

Hughes (1937) reported on the anthropometry of the Younge site. He reconstructed biological profiles for adults at the site that included notes on paleo-pathologies, craniometric data, and stature reconstructions. Norm Sauer (1976) would compare the data from two Saginaw Valley region sites, Younge and Fletcher, to other Southern Ontario sites to discuss trends in stature from the Late Woodland period to the Historic period. He concluded that Late Woodland people were not significantly taller than Historic period people from the same region. The material assemblages and the mortuary components of these Late Woodland sites have demonstrated that there was a network of social and economic interaction between the Saginaw Valley peoples and those in the surrounding region. In the section that follows, I discuss the salient features of the mortuary components of the best documented regional sites.

Bussinger Site

The Bussinger site (20SA194) is located in Section 7 of James Township, Saginaw County, Michigan. Excavations of this site were conducted by Arthur Graves and the University of Michigan Museum of Anthropology staff from 1965 to 1967. The site is characterized as multi-component and included approximately 130 burials dating from the late Archaic to the

Late Woodland period (Halsey 1976; Wilkinson 1971). The Late Woodland burial component at the site is characterized by sub-adults in bundle burials and adults in either extended or flexed burials.

Halsey called the Late Woodland occupations of the Bussinger site "an interpretative headache" (Halsey 1976:435). The Bussinger site investigation covered a larger area than other previously excavated sites in the region. Halsey (1976) wrote that he could not discern the function of pits because of the miniscule amount of faunal and botanical remains. He also reported that the ceramic types at the Bussinger site indicate that it dated to the Riviere aux Vase phase (c.a. A.D. 750-1000) of the Western Basin Tradition (Younge) tradition.

The Bussinger site remains have been included in several previous studies of Late Woodland populations. The Late Woodland burials from the Bussinger site that were analyzed include 28 out of the approximately 130 burials; they are dated to c.a. A.D. 1000 (Halsey 1976:437; Wilkinson 1971:20). Encompassed within a study of bio-distance in the Great Lakes Region (Wilkinson 1971), the Bussinger remains were analyzed together with collections of Late Woodland remains from Michigan, Illinois, and Ohio sites. Wilkinson's study (1971) also included the remains of the Juntunen site and the Younge site. Through statistical analyses of anthropometric data, he concluded that there was genetic influence from Southern Ontario and Illinois on the Bussinger site population. This site is also considered to have been a mortuary precinct within the Saginaw Valley region.

Riviere Aux Vase Site

The Riviere Aux Vase site (20MB3) is located in Section 28 of Chesterfield Township, Macomb County, Michigan. The site is considered a multi-component site and was excavated by the University of Michigan's Museum of Anthropology in 1936 and 1937. The Riviere aux Vase site yielded 370 individuals from 145 burials (Barondess 1998:32; Fitting 1965). Fitting (1965) dated the site to A.D. 600-1300 with the major occupation period dating A.D. 900 to 1200, and with a brief mid 19th century occupation. The Late Woodland burials, n=343, were dated to ca. A.D. 1000-1300 on the basis of the ceramic types present (Barondess 1998).

Burials and refuse pits are archaeological features that characterized the Rivere aux Vase site. Bender (1979) used the Riviere aux Vase population to conduct a study in paleo-demography. She concluded that more females than males died in the third decade of life, that the average female adult lived to an approximate age of 39 and the average male adult 43, and that the total size of the population at the site was approximately 117 to 137 individuals.

Younge Site

The Younge Site (20LP1) is located in Section 4 of Goodland Township, Lapeer County, Michigan. The Younge site is dated to A.D. 900 to 1100 with one radio-carbon date of A.D.1085 ±100 (Wilkinson 1971). Situated on sandy soil near the divide of the drainage of Lake Huron and Saginaw Bay (Greenman 1937), the site is surrounded by trees common to the Saginaw valley region, such as maple, elm, ash, hickory, and pine. Cultural remains have linked this site to southwestern Ontario and the Younge Phase.

The human remains, which included 88 individuals, were catalogued, aged, and sexed by Byron Hughes (1937) in an appendix of the original site report (Greenman 1937). Because of the similarity in mortuary treatment, Fitting (1965) compared the Riviere aux Vase remains (145 burial groupings) to the Younge Site, calling attention to a persistent ‘Younge’ burial tradition (Fitting 1965). The Western Basin or Younge burial tradition includes double interments, dismembered bodies, modified skeletal elements including perforated skulls, and an assortment of burial positions (Greenman 1937; Raemsch 1993; Stothers 1999) These mortuary treatments unite the Younge site and the Riviere aux Vase site, as well as the Bussinger site (Bender 1979; Raemsch 1993). Wilkinson (1971) included the Younge site in his bio-distance study and concluded that Younge and Juntunen populations were very similar and had a connection to the Serpent Mound site in Ontario.

Juntunen Site

The Juntunen Site (20MK1) is located on Bois Blanc Island in the straits of Mackinac. The site was excavated in 1960 and 1961 by the University of Michigan's Museum of Anthropology. The site, a lakeside fishing village occupied by 20 to 50 individuals, was dated to AD 800 to 1400 (McPherson 1967).

The site produced 65 burials from seven features. The Juntunen site (McPherron 1967) burials are categorized as ossuaries, which are common to the Upper Great Lakes region. Among the 65, there were ten burials with modified crania typical of the Western Basin (Younge) tradition (McPherron 1967:229). There were notable differences in individual male burials, such as the presence of personal tool kits and animal bones. An osteological assessment was done by Eyman (1964) and his unpublished report is in the University of Michigan's Museum of Anthropology. Barondess (1998) also included the Juntunen remains in his dissertation study of the skeletal structure of femora and humeri. His results (1998:125) yielded a mean stature of 165.7 cm for Riviere Aux Vase and the Juntunen site males; and a mean stature of 156.2 cm for females of the same two populations. Sauer (1974:113; also, McPherron 1967:230) reported that all the individuals from the Juntunen site remains had a combined mean stature of 168 cm. In general, stature assessments have been used to discuss the impact of diet, shifts in subsistence, and work stress on the human skeletal structure.

Fletcher Site

The Fletcher site (20BY28) is located near the mouth of the Saginaw River in Bay City, Michigan. With a pending construction project looming, the site was excavated as part of a salvage project from 1967 to 1970 by Michigan State University staff and students. The site has both prehistoric and historic components. Sauer (1976) reported that the excavation yielded 114 individuals, with 21 individuals of whom date to the Late Woodland period. Sauer (1976) studied these remains, constructed biological profiles for the Fletcher population, and compared his results to other populations in Ontario. Through the anthropometric data, Sauer concluded that the Fletcher population experienced a significant level of malnutrition. He wrote that malnutrition could account for the population being shorter than at contemporary sites. Furthermore, there were other signs of malnutrition, such as individuals with osteoporosis and the high prevalence of enamel hypoplasias of the teeth (Sauer 1976: 150-161). A shorter life expectancy could account for the lack of older individuals in the burial cluster. Interestingly, the Fletcher population showed signs of malnutrition while maize cultivation is considered a major resource that was traded and possibly cultivated at this site. Larsen *et al* (2002) wrote that the sole reliance on maize agriculture brought about sever malnutrition in Native Americans. Larsen *et al.* (2002:422) noted that the combination of maize and fish accounted for a low occurrence of pathological conditions, such as cibra orbitalia, and porotic hyperostosis. Furthermore, an increase in dental caries seems to consistently accompany maize-based diets (Larsen *et al.* 2002:420-421).

Holman and Brashler (1999) consider this site vital to understanding the nature of subsistence and culture change in the Saginaw Valley region. They reported that this site was seasonally occupied by larger and larger groups as both a trade fair ground and an agricultural base. The Fletcher site is regarded as a site that was being transformed into farmland for maize cultivation during the Late Woodland period. The Fletcher site has yielded little faunal and botanical remains, indicative of shorter periods of occupation. This lack of faunal or botanical remains is considered consistent with the subsistence shift to agriculture. Fletcher site occupants have been characterized as primarily agriculturalists because of the Historic components of the site (Barondess 1998:39). The Historic populations of Michigan were known to have cultivated domesticates (i.e. squash and corn) and relied on the hunting/gathering of wild food stuffs during the summer and winter (Barondess 1998; Dunham 2000; Holman and Brashler 1999; Sauer 1976).

Chapter 5

Isotopic Analysis and The Collection

Isotopes

The scientific applications of stable isotopes have been widely used by physicists, chemists, and geologists alike Scientists have used isotopes to date geological formations and specimens, in mining exploration, to explore matter, an develop alternative forms of energy, and countless other applications (Faure and Mensing 2005). From the construction of nuclear power plants to hazardous waste management, stable isotope applications have become an integral part of modern life. Faure and Mensing (2005:3-4) trace the discovery of the uses of stable isotopes and radiation from the Curies and other such famous scientists including notable noble prize winners. In general, atoms of the same chemical element that have the same number of protons but a different number of neutrons are called isotopes (Faure and Mensing 2005).When an isotope is considered *stable*, it is not radioactive and does not decay; conversely, radioactive isotopes decay and their loss of abundance in a sample is used to date the sample.

Isotopic fractionation occurs during biosynthesis, because isotopes of an element have different masses. Isotopic analysis is conducted through the use of mass spectrometry. There are approximately 10 stable isotopes that anthropologists have used to reconstruct diets, consumption patterns of products, and the general quality of life for various human populations. These include carbon (C), nitrogen (N), barium (Ba), calcium (Ca), strontium (Sr), and lead (Pb) (Ambrose 1993; Larsen 1999).

Utility of Isotopes for Dietary Trends

The study of the human remains from the Frazer-Tyra site presented below employs stable isotopic ratio analysis. Carbon and nitrogen ratios will be used to reconstruct the diet of the population, explore the dietary preferences of individuals, and consider the system of exchange from which the population drew its dietary requirements. This bio-archaeological approach to the study of the human remains of the Frazer-Tyra site will also include anthropometric data from the human remains, as well as an analysis of site features and associated material assemblages..

For bio-archaeological purposes, samples may be derived from both human remains and fauna. Generally speaking, bone is a combination of organic and mineral components (Crist 1995; Ortner 2003; White 2000). It is also considered a living tissue possessing a blood supply. It is within the mineral reservoir of human bone that major and trace elements lie. The major elements in bone are carbon, calcium, hydrogen, oxygen, nitrogen, and phosphorus. There are vital trace elements in bone, including strontium, iron, selenium, magnesium, cobalt, copper, and lead (Ambrose 1993; Crist 1995; Schwarcz and Schoeninger 1991; Larsen 1999). Dietary reconstruction, evidence of occupational hazards, and seasonal mobility may be obtained through the testing of either major or trace elements in bone samples

Isotopic analysis has been employed by archaeologists for over 30 years to reconstruct paleo-diets and environs, interpret subsistence shifts, and to date samples (Ambrose 1993; Larsen 1999; Katzenberg 1993; Schoeninger and DeNiro 1983; Vogel and Van der Merwe 1977). Archaeologists have employed stable isotopes in a myriad of ways. Specifically, they have used carbon and nitrogen to reconstruct dietary trends in prehistoric populations of North America (Bender et al. 1981; Schoeninger and Deniro 1983; Stothers and Bechtel 1987; Van der Merwe and Vogel 1981). Nitrogen has been used to establish weaning ages and dietary supplements for weaned babies (Katzenberg et al 1995). Nitrogen and strontium have been used to determine which ecological zones were exploited by prehistoric populations (Perry et al. 2008; Sealy and Van der Merwe 1986). Also, trace elements like lead have been used to determine the effect of industrial occupations (Crist 1995; Corrucini et al. 1987), while, strontium has been used to determine an individual's country of origin (Price et al. 2006).

North American Prehistoric Populations and Isotopic Analysis

Archaeologists began testing the validity of stable isotopic ratio analysis in the late 1970s. According to Ambrose (1993:61), it was Robert Hall who predicted that stable carbon isotopes would be useful in differentiating the diet of grazing animals at a 1967 conference. A little over ten years later, Nikolaas Van der Merwe and John Vogel (1977) demonstrated maize consumption was insignificant in human diets prior to A.D. 1000 in North American Woodland populations with the use of $\delta^{13}C$ ratio. Considering the results of Van der Merwe and Vogel's study, Smith (1992, 1989) commented that, though maize was accessible to Hopewellian peoples of the Middle Woodland period, its use was adopted in the context of other pursuits that included other cultigens (i.e. sunflower, beans, tobacco, etc.). Maize would not come to dominate subsistence cycles and become the backdrop of major cultural shifts associated with Mississippian peoples until the Late Woodland period, ca. AD 1100 (Smith 1992).

Using samples from four archaeological collections from New York state, Vogel and Van Der Merwe (1977, 1978) tested human skeletal remains using the carbon isotope ratio. The pilot study revealed that the Late Woodland populations adopted the use of maize and that the consumption level was comparable to that of the early historic period. Late Woodland peoples were consuming enough maize by AD 1000 to distinguish them from Early Woodland populations (Vogel and Van der Merwe 1977:241). Van Der Merwe and Vogel would go onto report (1978) another successful application of the technique using populations from the lower Illinois Valley and Ohio. In Illinois, maize is a traded commodity with very little impact until about 1200 A.D. (Van Der Merwe and Vogel, 1978:816), when a marked increase in use is indicated from the carbon ratios. Though the Ohio sites were still under study, Vogel and Van Der Merwe were still able to assert that women consumed less maize than males, and that the threshold for maize dominance in the Ohio region occurred around AD 1300 (Vogel and Van der Merwe 1978:815). The researchers went on to test skeletal elements from Venezuela, debunking previous notions of when maize became significant to the peoples' diet and a crucial element in supporting a larger population density (Vogel and Van Der Merwe 1981). These seminal works provoked further scientific inquiry by others, including Bender *et al.* (1981), Buikstra (1981, 1987), and Ambrose (1987) who went on to expand the stable carbon isotopic analysis.

Notation for Carbon and Nitrogen Ratios

Carbon ratios are expressed, in parts per thousand, per mil, (‰), relative to Peedee Belemnitella (PDM), an international standard, and as delta (δ) values (Ambrose 1993; Faure and Mensing 2005; Larsen 1999; Schwarcz and Schoeninger 1991). The isotopes of carbon, fourth in abundance of all elements the earth's crust, include ^{12}C, ^{13}C, and ^{14}C. The variation in the isotopic composition of 12C and 13C is defined in terms of $\delta^{13}C$[1]. The fractionation of the two carbon isotopes occurs during photosynthesis and ^{13}C is the heavier of the two isotopes. The $\delta^{13}C$ values are determined on the basis of the metabolic processes through which carbon is incorporated into plants (Faure and Mensing 2005). The first is the Calvin cycle which

[1] $$\delta^{13}C\ ‰ = \left[\frac{(^{13}C/^{12}C)_{smpl} - (^{13}C/^{12}C)_{std}}{(^{13}C/^{12}C)_{std}} \right] \times 10^3$$

encompasses most plants on land. These are C_3 plants (i.e. trees, shrubs, some grasses, tubers, etc.) that grow in temperate climates and yield $\delta^{13}C$ values -23‰ to -34‰. The second type is the Hatch-Slack process which includes aquatic plants, desert and salt marsh plants, tropical grasses and these are C_4 plants (i.e. maize, millet, sorghum, cane sugar, etc.) that grow in hot arid climates and yield $\delta^{13}C$ values -6‰ to -23‰. The third type is the Crassulacean acid metabolism (CAM) process which encompasses cacti and succulents and yield $\delta^{13}C$ values -11‰ to -33‰. Some CAM plants have δ values that overlap with C_3 and C_4 $\delta^{13}C$ values (Ambrose 1993; Faure and Mensing 2005; Larsen 1999; Vogel and Van der Merwe 1977).

Two stable isotopes of nitrogen are also used by anthropologists, ^{14}N and ^{15}N. The nitrogen ratio is defined in samples as $\delta^{15}N$ [2]. Nitrogen ratios are also expressed, in part per thousand, per mil (‰) relative to Ambient Inhalable Reservoir (AIR), an international standard (Ambrose 1993; Faure and Mensing 2005; Larsen 1999; Schwarcz and Schoeninger 1991). With respect to nitrogen, over 99% of the element is bound as N_2 in the atmosphere or dissolved in ocean water (Schwarcz and Schoeninger 1991). There are two processes by which nitrogen is transferred to the biological domain. These involve N_2 fixing organisms and bacterial nodules that yield $\delta^{15}N$ values close to zero or atmospheric N_2. There are also some metabolic processes within an organism that, together with N_2 fixing or bacterial degradation, yield $\delta^{15}N$ values that are higher than atmosphere (Schwarcz and Schoeninger 1991). Nitrogen ratios vary from marine and freshwater plants to terrestrial plants. Nitrogen ratios can be used to distinguish aquatic based human diets from terrestrial ones and the significance of particular resources to overall diets.

---

[2] $$\delta^{15}N\ ‰ = \left[\frac{(^{15}N/^{14}N)_{smpl} - (^{15}N/^{14}N)_{std}}{(^{15}N/^{14}N)_{std}} \right] X10^3$$

Interpreting Carbon and Nitrogen Ratios

People eating C_3 plants and animals that feed on C_3 plants would have $\delta^{13}C$ values at or near -21.4‰, while C_4 eaters (i.e., those who eat maize, cane sugar, etc.) would have values closer to -17.4‰ (Katzenberg and Pfeiffer 1995). A study of human skeletal remains from the historic site of Prospect Hill in Ontario conducted by Katzenberg and Pfeiffer (1995) showed that $\delta^{13}C$ values varied between -21.1‰ and -17.4‰ with an average of -19.5‰. The same set of samples yielded a range for $\delta^{15}N$ between 10.4‰ to 16.6‰, with an average of 12.7‰. The researchers concluded that the diet for this population included some maize and cane sugar and was basically terrestrial (Katzenberg and Pfeiffer 1995). Sealy and Van der Merwe's (1986) study of skeletal remains from South Africa explored seasonal mobility among hunter-gatherer population. They suggested that a diet solely based on marine products would yield $\delta^{13}C$ value of -11.4‰; a 100% terrestrial diet, $\delta^{13}C$ value of -18.9 ‰; and a diet 50% marine and 50% terrestrial diet, $\delta^{13}C$ value of -15.1‰ (Sealy *et al.* 1986:141). They concluded that the inland hunter-gatherer population consumed a negligible amount of marine resources and that coastal people relied primarily on marine food; furthermore, these dietary preferences existed prior to the arrival of Khoi herders and European settlers (Sealy *et al.* 1986:143).

Studies using nitrogen ratios have allowed anthropologists to reconstruct food webs that include aquatic resources. Katzenberg et al. (1993) reported that the range for $\delta^{15}N$ values can be between 10‰ and 15‰ for humans, the range varying greatly between adults and infants. There is a 3-5‰ enrichment per trophic level for $\delta^{15}N$ values (Muldner and Richards 2007; Schoeninger *et al.* 1983). For example, Schoeninger *et al.* (1983) reported that marine mammals had $\delta^{15}N$ values of 16‰ and humans that consumed marine mammals had $\delta^{15}N$ values of 19‰. Schoeninger *et al.* (1983) concluded that $\delta^{15}N$ values are more positive in marine organisms than the terrestrial ones. More importantly, that study (Schoeninger *et al.* 1983) concluded that prehistoric human populations that consumed marine mammals and fish had higher $\delta^{15}N$ values than agriculturalists and fishers that exploited freshwaters environs. Terrestrial, omnivorous diets that consist primarily of legumes were found to have the lowest $\delta^{15}N$ values (Katzenberg and Pfeiffer 1995:226).

Diagenesis of Samples

Though stable isotopic analysis is a technique that can yield substantial information about the environment and human populations, it can give skewed results due to processes of diagenesis. The post-mortem contamination of a sample, due to its interaction with the matrix it is embedded in, can skew the values derived from it. Leaching de-mineralizes bone and enriches the soil, while the opposite can occur and the bone absorbs elements from the soil. Some have suggested that soil samples associated with the bone be obtained and tested. Lower values of elements in the soil, by comparison to the bone, are believed to be a sign that no leaching occurred. Conversely, if higher levels of the element are found in the soil than in the bone sample, then diagenesis has likely occurred (Crist 1995).

Researchers have also argued about the reliability of extracting isotopic samples from faunal remains as opposed to human remains (Perry *et al.* 2008). Others have tested fauna in order to establish known food webs for human consumption (Sealy and Van der Merwe 1986; Schoeninger and Deniro 1984). Archaeologists have also used carbon and nitrogen ratios to test for variance from one bone to the next from the same individual. Such studies concluded that the results do vary from samples taken from cortical bone, trabecular bone, and teeth (Cox *et al* 2001) within a single individual. However, the variance is considered negligible (Ambrose 1993; DeNiro and Schoeninger 1983; Schwarcz and Schoeninger 1991). Other scientists rely on carbon to nitrogen ratios [denotated as C:N] to establish the viability of a sample. If C: N ratios fall between 2.7 and 3.6, then the sample is viable (Lillie and Jacobs 2006; Jay and Richards 2006; Schwarcz and Schoeninger 1991). Though using C:N ratios have been contested (Schwarcz and Schoeninger 1991), the ratios are still relied upon to argue that a sample has not been subject to the effects of diagenesis. The alternative to C:N ratios is using the retained amount of protein from the original sample. Schwarcz and Schoeninger (1991) suggested that viable samples for isotopic analysis should be limited to samples where the organic residue is >1% of the original dry bone weight. Comparing the weight of the original dry bone sample to the yield after the collagen extraction procedure will allow the researcher to determine if the sample is viable.

Researchers do seem to agree that teeth are the most reliable source for testing because the enamel of teeth is least susceptible to diagenesis (Perry *et al.* 2008; Price *et al*. 2006; Schwarcz and Schoeninger 1991). Some bones, such as ribs, are preferable to other elements, though, as stated above, there can be some variance from bone to bone within a single individual (Deniro and Schoeninger 1983). Samples may also be extracted from even smaller aspects of the body, like hair (Roy *et al.* 2005)

<u>Differentiation of marine /aquatic versus terrestial based diets</u>

Schoeninger *et al.* (1983) demonstrated that nitrogen isotopes can serve the same purposes as carbon in identifying marine-based diets. Schoeninger and DeNiro (1984) used nitrogen ratios to distinguish freshwater fish and terrestrial animals and birds from marine fish and marine mammals. They concluded that nitrogen ratios were more positive for marine animals that had a range of 9-23‰ than that for terrestrial animals, 2-10‰ (Schoeninger and DeNiro 1984:631). According to DeNiro and Schoeninger (1983:199-202), DeNiro and Epstein (1978, 1981) expanded the application by using carbon and nitrogen isotopes to prehistoric humans from the Tehuacan Valley, Mexico, dating to the Venta Salada phase. They concluded that the Mexican population consumed a monotonous diet, primarily of maize, because the carbon and nitrogen ratios fell in the range of 1‰ (1983:202).

Ambrose (1993) cites Tauber (1981) as the first scientist to use isotopes as a test for marine resource consumption in populations of Mesolithic fishers, Neolithic farmers and historic fishers in Denmark (Ambrose 1993:62). Others have followed in distinguishing the consumption of domesticated animals from coastal marine fish within the same population (Muldner and Richards 2007; Richards *et al.* 2006). The use of the carbonate of bone and teeth for isotopic analysis was first employed by DeNiro and Epstein (1978).

.Strontium isotopes have also been principally employed to discern marine-based diets from terrestrial-based diets. Recently, strontium isotopes have allowed researchers to establish the origins of historic African-American remains (Price *et al* 2006) recovered from Mexico. Crist (1995:200) wrote that the strontium isotopes can also be used to distinguish plant-based diets from diets rich in meats. Just as with carbon and nitrogen ratios, there can be variation in the amount of strontium from one bone to the next from within the same individual. Sillen and Kavanaugh (1982:76-77) found that levels of strontium vary from tooth to tooth, and from teeth to bones in adults but not in infants. Strontium, an element that substitutes for calcium in the body, has also been used to establish which ecological zones people exploited (Sillen and Kavanaugh 1982) and the migration of Tiwanaku colonizers from the Titicaca basin of South America (Knudson 2008).

C^{14} Dating

Archaeological methods for dating were revolutionized with the advent of radiometric dating. Relative techniques required archaeologists to rely on stratigraphic analysis, artifact patterning, and other techniques related to stylistic changes. However, absolute dating techniques based upon chemical properties and geological processes have produced more accurate results. Willard Libby's work (1952) has resonated for years throughout the archaeological community. Dating archaeological samples based upon the decay rates of elements allow the researcher to calculate time of death and/or deposition. C^{14} is an unstable, radioactive isotope that has been employed by archeologists and geologists to date organic samples. C^{14} has a half-life of 5,730 years (Faure and Mensing 2005). Depending upon the laboratory and the equipment used, the estimation of error for the age can be as low as 25 to 50 years.

Chapter 6

Materials and Methods

Skeletal Sampling Selection

According to the report prepared by Arthur Graves in 1968, 60 bundle burials, 35 extended burials, 3 flexed burials, 13 skulls, 11 concentrations of cremated bone, and 8 red ochre concentrations were excavated at the Frazer-Tyra site. Wayne State University, Central Michigan University, and the University of Michigan all possess a portion of the skeletal collection recovered by Graves from this site. Central Michigan University houses an estimated one-half of the collection, consisting primarily of fragmented, cremated remains, while the University of Michigan has fragmented remains consisting primarily of feet and hands. Wayne State University's collection has the most complete and well-preserved collection of individuals from this site. This portion of the collection was donated to Wayne State in 1969 by A. Weir. The entire Weir accession consisted of the human skeletal remains, fauna remnants (dog), lithics, shell, and some of Mr. Graves' excavation tools (Fischoff and Porter, MSS. on file 1983, WSUMA 11W547). The MNI for the Tyra population housed at Wayne Sate University's Museum of Anthropology is 73 individuals. This sample includes of 24 sub-adults and 49 adults.

This study explores the dietary trends evidenced in the Frazer-Tyra adult population. The sub-adults have been excluded because their remains are commingled and sex cannot be determined. Adults whose sex was not determinable were also excluded. Of the 49 adults in the Frazer-Tyra collection at WSU, sex determination was possible for 34. This study provides basic anthropometric data, where preservation allows, for the cranial and post cranial remains for each of the 34 sexed adults; and offers a basic biological profile for each adult case (e.g.,. an estimation of age, sex, stature). It also provides a carbon ratio and nitrogen ratio analyses for each adult individual to test the dietary trends of the population, as well as explores for relationships between the isotopic, age, and sex data using statistical analyses.

The principal aim of this investigation is to consider the results generated from isotopic analysis of carbon and nitrogen in relation to the overall trends in stature, age, and sex for the Late Woodland population of the Frazer-Tyra site (20SA9). I also discuss subsistence strategies and consumption patterns during the Late Woodland period in the Saginaw Valley region as evidenced from the human remains. The Frazer-Tyra site makes for an ideal study situation given its location because it is a multi-component site. It produced human remains and was occupied during a period of important cultural change. In many ways, the Frazer-Tyra population was a group that straddled two worlds, living in an area that spanned two major biotic zones and during a time period that was culturally transitional.

Sex Assessment

The sex assessments were based on the following skeletal aspects: (1) Phenice's method (1969) of assessing the innominates; (2) other observable characteristics of the innominates (Bass 2005; Buikstra and Ubelaker 1994); (3) sacral curvature (Stewart 1979); and (4) other observable characteristics of the crania (i.e. supraorbital ridges, mental protuberance, gonial angle, mastoid process) (Buikstra and Ubelaker 1994; Walker 2008). The Frazer-Tyra population has 16 observed females and 18 observed males. Other anthropometric techniques were used to test the observed sex assessments, such as the measurement of the vertical diameter of the humeral head (Bass 2005; Stewart 1979).

Stature Assessment

Stature reconstruction is based upon several factors, including whether any long bones were present or not, which of the long bones was available, the level of preservation, and the measurements that could be taken based on the level of preservation. Because stature reconstruction is primarily ethnic specific and secondarily sex specific, Bass (2005) suggested using the stature formulas proposed by Sciulli and Giesen (1993;Sciulli et al.1990) for prehistoric Native Americans based on their study of prehistoric populations from Ohio. Their stature reconstructions are based on the femur, tibia, and the humerus according to sex for prehistoric Native American populations (Bass 2005; Sciulli and Giesen 1993; Sciulli et al.1990)

The results from the stature formulas for the Frazer-Tyra remains will be compared to the mean skeletal heights of remains from sites contemporary with Frazer-Tyra in the Saginaw Valley region, as well as from Southern Ontario, where data is available (Barondess 1998; Sauer 1974; Wilkinson 1971). The regional comparison will help to assess whether there is a correlation between the isotopic ratio analyses and stature.

Age Assessment

The Frazer-Tyra population will be divided into the following age categories: young adults aged 18 years to 25 years; middle-aged adults 26 to 45 years; and older adults aged >50 years. Determination of age categories will be based on the following techniques: the Mann method for palatine suture closures (Ginter 2005; Gruspier 1991; Mann et. al. 1987; Bass 2005); the McKern and Stewart method for 'aging' the pubic symphyseal face (Stewart, 1979); the tooth eruption sequence **(**Bass 2005; Buikstra and Ubelaker 1994); sacral fusion (Stewart 1979); and general observations about endocranial suture closings and long bone fusion (Bass 2005).

Dental Assessment

Dental assessments will be generated for each individual with an associated cranium and/or loose teeth present. These dental records include notes on peri-mortem and postmortem tooth loss, tooth eruptions, dental caries, wear patterns, crown loss, and any other observable pathological conditions. Because the teeth of individuals from this region are characteristically worn and decayed (Halsey 1976; Sauer 1976; Cleland 1971; Greenman 1937; Fitting 1965), this condition has been only generally noted.

Sampling for Carbon and Nitrogen ratio tests

Bone collagen is the preferred biochemical aspect of bone for dietary analysis (Ambrose 1993:71). The extraction procedure is a chemical process to separate the collagen from the other components of bone, such as the lipids, carbonate, proteins, and other substances present due to diagenesis. The procedure requires only a small amount of bone or tooth dentin, e.g. two grams. The collagen analyses were performed at Wayne State University and the University of Western Ontario's (UWO) Laboratory for Stable Isotope Science (LSIS).

The majority of the bone collagen extraction procedure was performed in the lab of the Geology Department at WSU. A modified Longin (1970) method was utilized on each bone sample. One sample (2 g) was taken from each of the 33 adults from one of the following skeletal elements: a rib, a femur or humerus, or the skull. Preference was given to ribs. One adult case (WSUMA 9w609) was excluded from this analysis due to the extreme deterioration of the skeletal elements. The adults used in the study were separated by sex and age and the source of each sample was noted (See Appendix B).

The samples were reduced for the lipid separation phase. The lipids were separated with a solution of chloroform, methanol, and water. Then the leaching of the bone was done with 0.25M of HCL acid. The separation of the collagen from the remaining materials was done with HCL acid. The samples were then freeze-dried and weighed (See Appendix A). The first ten samples, with an additional four duplicates for an error test were prepared at WSU and UWO. The other 23 samples were completely prepared at WSU's Geology lab and the WSU School of

Medicine's Microbiology and Genetics lab and submitted to LSIS for the final phase of analysis using the mass spectrometer. The final analyses were carried out, using mass spectrometry at the LSIS at the UWO. The precision of the $\delta^{13}C$ and the $\delta^{15}N$ analysis is 0.1‰. A core set of samples were analyzed to evaluate the accuracy and the results are given in appendix D.

Carbon 14 Dating Technique

Though the Frazer-Tyra site remains had been previously assigned to the Late Woodland period, no absolutes had ever been previously attained. The site is considered a multi-component site because of the array of lithics that stylistically point to other periods, including the Archaic and Middle Woodland (Andrews 1995). Also, the red ochre staining in some of the burial features at the Frazer-Tyra site is practice associated with the Archaic period (Graves 1968; Krakker 1997; Pleger 2000). In order to obtain better chronological control over the collection, two Carbon 14 dates were obtained. Bone material from two individuals was sent for radiocarbon dating and sent to the Center for Applied Isotope Studies laboratory at the University of Georgia (CAIS) AMS facility. These two individuals were selected on the basis of their carbon ratios; one individual with one of the most negative carbon ratios and one individual with one of the most positive carbon ratios.

Statistical Analysis

To analyze the data, SPSS 17.0 was used to explore correlations between $\delta^{13}C$ and $\delta^{15}N$ values in relation to age and sex. Because of the sample size, descriptive statistics` were also employed. To situate the Frazer-Tyra population with respect to other contemporary Michigan and Southern Ontario populations, a comparison of stature means by sex was also made with data from the following sites: Riviere aux Vase, Juntunen, Younge, Bussinger, Fletcher, Fairty, and Serpent Mound.

Chapter 7

Results of Study

This chapter presents the results of the bio-archaeological study of the human remains from the Frazer-Tyra site. These include an assessment of sex and age, a stature reconstruction, and a regional comparative analysis of stature. Also presented are the results of the isotopic analyses and the carbon and nitrogen ratios from each individual, which are discussed in relation to previously reported isotopic data associated with maize consumption.

Sex Assessments on Frazer-Tyra Remains

Sex assessments on the adult population from the Frazer-Tyra site were based on a holistic approach due to preservation issues. Sexually dimorphic characteristics of the cranium (i.e. mastoid process, gonial angle, supraorbital ridge, nuchal crest, and mental protuberance) were used to determine sex. Observable traits of the innominates were employed (i.e. the greater sciatic notch, preauricular sulcus). Using Phenice's method (1969) and other observable characteristics of the innominates (Bass 2005; Buikstra and Ubelaker 1994; Stewart 1979) were noted to support sex assessments. Lastly, the vertical diameter of the humeral head measurement was taken, when applicable, to support the other observations. Stewart (1979) has noted that the humeral head is a more reliable measurement for sex than the femoral head. Individuals with a measurement of 45mm or less are considered females, while humeral heads with measures 45 mm and greater are considered male. Stewart (1979:99-101) has noted that there is an overlap at 45 mm between male and female individuals. Of the 34 adult individuals, the measurement could only be taken on 9 individuals; allowing sex determination to be confirmed anthropometrically for 3 males and 6 females. Table 7.1 shows the individual cases where the latter measurement could be taken and the sex assignment as a result of the measurement:

Table 7.1 Sex Assessment based on Vertical diameter of Humeral head

Burial #	**Sex by Observable Characteristics**	**Humeral Head (mm) measurement**	**Sex Determined by Humeral Hd**
9w721	Male	46 mm	Male
9w215	Male	45 mm	Male
9w345:108	Male	44 mm	Transition- Male
9w652a	Male	50 mm (r)	Male
9w642	Female	44.5 mm (r)	Female
9w351	Female	40 mm	Female
9w658b	Female	40 mm (r)	Female
9w641	Female	36 mm	Female
9w214a	Female	39 mm	Female
9w733	Female	40mm	Female
9w660	Female	41 mm	Female

These cases demonstrate that the sex assessment based on the measurement of the vertical diameter of the humeral head supports the sex assessments based on observations of specific characteristics.

Phenice's method (1969), designed to overcome preservation issues specific to archaeological collections in determining sex, was also employed where possible. Of the 34 adults, 14 actually had innominates associated. Of these, only four cases (9W345, 9w215, 9w108, and 9w721) were sufficiently intact to be examined using Phenice's method (1969). All four cases were determined to be male, consistent with the other observed sexually dimorphic characteristics of the individuals. In total, the Frazer-Tyra population housed at WSU has 18 adult females and 16 adult males(See table 7.2).[3]

Table 7.2 Sex Determination of Frazer-Tyra Individuals

WSUMA # Males		**WSUMA# Females**	
9W302	9W774	9W645	9W214a
9W644	9W345:108	9W640	9W343
9W652a	9W217	9W419	9W734
9W657	9W721	9W660	9W622a
9W658a	9W659	9W641	9W730
9W215	9W656	9W348	9W658b
9W345:345	9W214b	9W347:344	9W733
9W585	9W610:609	9W611	9W123
		9W351	9W642
Total n=16		**Total n=18**	

Stature Estimation

Living stature is ideally reconstructed based on the Fully method (1956) using collections acquired for medical purposes. However, for archaeologically collected populations, in which an individual's remains are seldom complete, regression formulas are employed to compensate for missing bones. Sciulli and Geisen (1993; Sciulli et al. 1990) have employed an ethnic specific regression formula for reconstructing the stature of prehistoric Native Americans. In the present study, there were 18 adult individuals with skeletal elements available for the stature reconstruction (Bass, 2005; Sciulli and Geisen, 1993, Sciulli, et. al. 1990). The average skeletal

[3] Sex assessments were also previously done by Fischoff and Porter (MSS., on file as WSUMA 11w547) for 25 sets of remains from the collection. Ten of the assessments concurred with my own, while 15 did not. Fischoff and Porter included 2 cases that I excluded from this study. Their assessments reflect a common bias toward males.

Table 7.3 Frazer-Tyra Stature Reconstruction

Burial #	**Sex**	**Formula**	**SKHT**	**Measure Used**	**Notes**
9W660	F	34.189 +1.404(LX)	157.8cm	XF=43.9cm;XT=37.0cm	+10.0
9W645	F	62.360+2.706(XH)	153.8 cm	XH=30.1 cm	+10.0
9W733	F	34.189 +1.404(LX)	162.4 cm	XF=45.8cm;XT=38.4cm	+10.0
9W214	F	44.253 +2.336(XF)	160.1 cm	XF=45.3 cm	+10.0
9W622a	F	62.360+2.706(XH)	156.8 cm	XH=31.2	+10.0
9W611	F	62.360+2.706(XH)	157.6 cm	XH=31.5	+10.0
9W351	F	62.360 +2.706(XH)	154.4 cm	XH=30.3cm	+10.0
9W658b	F	44.253 +2.336(XF)	159.6 cm	XF=45.1cm	+10.0
9W641	F	44.253 +2.336(XF)	156.6 cm	XF=43.8cm	+10.0
9W642	F	44.253 +2.336(XF)	157.0 cm	XF=44.0cm	+10.0
Total	**10**				
9W658a	M	50.721+2.680(XT)	158.5 cm	XT=36.5 cm	+10.0
9W217	M	42.805 +2.443(XF)	157.1 cm	XF=42.7cm	+10.0
9W345	M	39.630 +1.360(LX)	164.5 cm	XF=45.4cm;XT=38.7cm	+10.5
9W652a	M	50.721 +2.680(XT)	166.8 cm	XT=39.4cm	+10.5
9W215	M	42.805 +2.443(XF)	170.3 cm	XF=47.9cm	+10.5
9W108	M	48.829 +3.229(XH)	157.3 cm	XH=30.5cm	+10.0
9W659	M	39.630 +1.360(LX)	170.9 cm	XF=47.5cm;XT=41.3cm	+10.5
9W721	M	48.829 +3.229(XH)	169.1 cm	XH=34.0cm	+10.0
Total	**8**				

[4]

height for the population proved to be 160.8 cm (approximately 5’4”) with an average for males (n=8) of 164.3 cm (5’5”) and an average for females (n=10) of 157.6 cm (5’3”) (See Table 7.3).

[4] **Key:** XF= maximum femur length; CMT= condyle malleolus tibia length; XT=maximum tibia length; XH=maximum humerus length; LX= (XT+XF)

Males	**Females**
SKHT=39.630+1.360(LX)	SKHT=34.189+1.404(LX)
SKHT=42.805+2.4443(XF)	SKHT=44.253+2.336(XF)
SKHT=48.829 +3.229(XH)	SKHT=62.360+2.706(XH)
SKHT=50.721+2.680(XT)	SKHT=49.527+2.668(XT)

***Rules for completion**

To obtain stature add 10 cm to skeletal heights of 153.3cm or less; 10.5cm to skeletal heights of 153.6-165.4 cm; 11.5 to skeletal heights of 165.5cm or greater.

There are several other Late Woodland populations for which stature was reconstructed that are available for comparison. These include Riviere aux Vase and Juntunen sites (Barondess 1998; Wilkinson 1971), the Younge site (Greenman 1937), the Fairty site, and the Serpent Mound site (Sauer 1974). There are also two historic sites, the Fletcher and Lasanen sites that have yielded stature data (Clute 1971; Sauer 1974) (See Table 7.4)[5].

Table 7.4 Stature of Prehistoric Michigan Populations

Late Woodland Sites	**Frazer-Tyra**	**Bussinger**	**Younge**	**RAV/ Juntunen**	**Juntunen**	**Fletcher**	**Lasanen**	**Serpent Mound**	**Fairty**
Population Mean	160.8 cm**	160.6 cm**	159.2cm**	161cm**	168 cm*	163.7cm	-	-	169.3 cm*
	n=18	n=12	n=23	n=191	n=29	n=35			
Males	164.3 cm**	165.3cm**	165.7**	165.8cm**	163.8cm**	163.2cm	168.8 cm	170.7cm	-
	n=8	n=7	n=12	n=98	n=18	n=15		-	-
Females	157.6cm**	154.0cm**	152.6cm**	156cm**	156cm**	153.6cm	163.6 cm	165.9cm	-
	n=10	n=5	n=11	n=93	n=11	n=20		-	-

Figure 7.4 depicts the mean for the Frazer-Tyra population as compared to the mean stature for other Late Woodland populations. Sauer (1974) has noted that discrepancies occur when stature is estimated using differing formulas and when the sexes are pooled. To overcome

5 *sexes pooled for entire multicomponent site (Barondess 1998; Clute 1971; McPherron 1967; Sauer 1974; Wilkinson 1971)
**calculated from raw data reported by Wilkinson (1971), Barondess (1998), and Hughes (1937) with Sciulli and Giesen (1993) formulas

the latter, I used the raw data reported for Late Woodland populations (Barondess 1998; Hughes 1937; Wilkinson 1971) and calculated stature with the Sciulli and Giesen (1993) formulas for the Younge, Bussinger, the Riviere aux Vase/ Juntunen populations. The population means for the Late Woodland sites are very similar with a range of difference of 0.2 cm to 8.5 cm. The tallest Late Woodland population was from the Fairty site of Southern Ontario. Excluding the Fairty population, the range is between 0.2 cm and 7.6 cm. Excluding the Juntunen population from the Upper Peninsula, the range becomes even smaller, 0.2 cm to 1.6 cm. Hughes (1937:172) characterized the Younge population as of sub-medium height and powerfully built. The Frazer-Tyra population was most comparable to the Bussinger and the Younge populations. The Juntunen population was reported to have a mean of 168 cm (McPherron 1967; Sauer 1974). However, when the population mean was recalculated using Sciulli and Giesen (1993), the mean was 160.8 cm, to provide a consistent view of stature given the discrepancies different formulas may create (Sauer 1974). There was very little or no difference between Juntunen and the other Late Woodland groups of Southeastern Michigan using the Sciulli and Giesen formulas (1993).

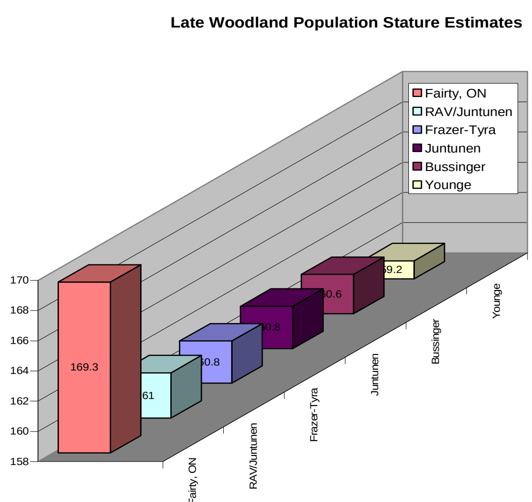


Figure 7.1 Frazer-Tyra population mean stature as compared to other Late Woodland groups. Dividing the population on the basis of sex, the females in the Frazer-Tyra population are slightly taller, by 2.9 cm, than other Late Woodland populations from Southeastern Michigan whose females were an average of 154.7cm. Figure 7.2 also demonstrates the slight differences in height for females from the Late Woodland period to the Historic period. The stature of females from the Historic period sites, e.g., Lasanen and Fletcher, also varied. Interestingly, the females from the site of Lasanen are significantly taller. Figure 7.2 compares the mean female stature among the Late Woodland and Historic period sites.

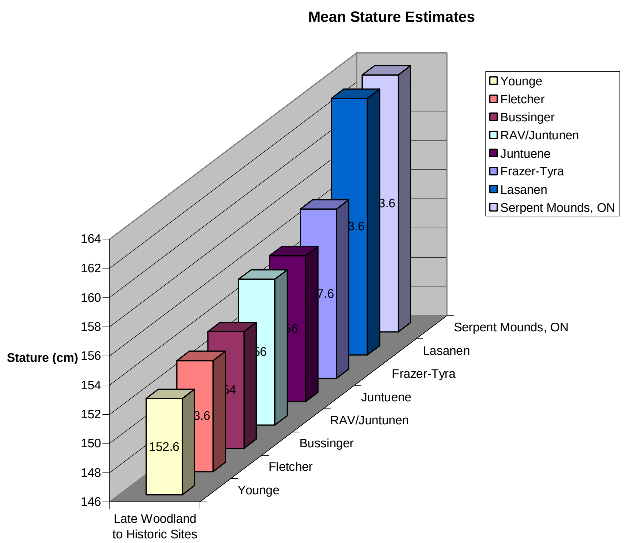


Figure 7.2. Frazer-Tyra mean female stature compared to other Late Woodland groups.

Lasanen (20MA21) is a Historic site in Mackinac County Michigan dated to AD 1670-1700. According to Barondess (1998) the inhabitants were primarily hunters and fishers that supplemented their diets with some agricultural products and trade with Europeans. In general, populations from the Upper Peninsula and Southern Ontario seem to be taller than those of Southeastern Michigan.

As indicated in Figure 7.3, the males in the Frazer-Tyra population (n=8) seem to be very close to the Bussinger, Younge, Juntunen, and Riviere aux Vase populations in terms of stature.

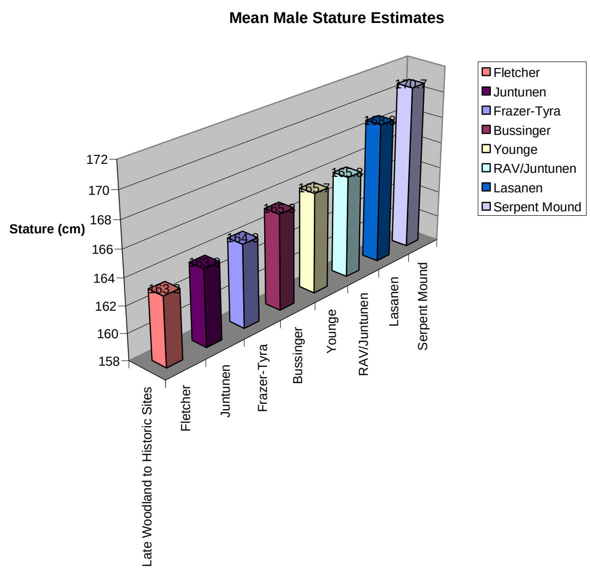


Figure 7.3. Frazer-Tyra mean males stature as compared to other Late Woodland groups. The mean for the other Late Woodland males is 165.2 cm with a range of difference from Frazer-Tyra of 0.5 cm to 1.5 cm. The males from the Historic sites vary greatly. Lasanen males appear to be significantly taller than the males of Fletcher. In general, males are taller than females and males from the Upper Peninsula site (e.g., Juntunen) and Southern Ontario (e.g., Serpent Mounds) are taller than males from Southeastern Michigan.

Sexual dimorphism likely accounts for the difference in statures between the males and females of the Frazer-Tyra population. Figure 7.1 demonstrates that the Frazer-Tyra population, as a whole, was shorter than other Late Woodland populations in Southern Ontario as well as the Upper Great Lakes, though comparable to the southeastern Michigan populations at the Younge site and the Bussinger site.

Age Assessments of Frazer-Tyra Remains

The adult Frazer-Tyra population was grouped into three age categories: Age I (18-25yrs.), Age II (26-45yrs), and Age III (+50 yrs.), based on Mann's technique of palatine suture closures. Because so many individuals lacked innominates, had partial innominates, or had innominates missing the pubic symphyseal face, I could not rely on the Todd-McKern or the Suchy-Brooks (Stewart 1979) method of age determination. There was only one exception- a male for whom the pubic symphyseal face was present and intact enough to assign him to the Age II category. This age determination was supported by the palatine suture technique. Aside from this case, there were 13 individuals who had innominates present, but only two that had pubic bones, both of which were too eroded to evaluate Thus, the observation of palatine suture closures (Ginter 2005; Gruspier *et al.* 1991; Mann 1987; Mann *et al.* 1991), tooth eruption and absorption (Bass 2005; Buikstra and Ubelaker 1994), long bone fusion (Bass 2005; Buikstra and Ubelaker 1994; White 2000), and cranial suture appearances was employed (Stewart 1979; White 2000) to assess age. Though the revised palatine suture technique (Mann *et al.*1991) allows for five age categories, the fragmentary nature of the collection allowed for the use of only three in the present study. Only 21 of the 34 adult cases had maxillary elements available to be evaluated with this method. Each palatine suture (i.e. incisive, transverse palatine, and the posterior median palatine and the anterior median palatine) and the greater palatine fossa being scored and observed were recorded (see Table 7.5).

Table 7.5Age Assessment for Frazer Tyra Population 20SA9

Age Group	Group I (+18-25 yrs)	Group II (+26-45 yrs)	Group III (+50 yrs)
	WSU #	**WSU #**	**WSU #**
Females			
	9w348	9w123	9w343
	9w645	9w658b	9w214a
	9w419	9w733	
	9w660	9w734	
	9w640	9w351	
	9w641	9w642	
	9w347:344	9w622a	
		9w611	
		9w730	
Males			
	9w302	9w585	9w721
		9w345:108	9w217
		9w215	9w610:609
		9w652a	9w656
		9w658a	9w659
		9w345:345	9w657
		9w345:774	9w214b
		9w644	
Total n=34	**n=8**	**n=17**	**n=9**

The Age I (18-25 yrs) individuals not only had observable incisive sutures (<25 yrs) but also included partially erupted third molars along with observable metaphyseal lines on the long bones to support the assignation of age. The incisive suture is completed obliterated by the age 26 years (Mann *et al.* 1991; Ginter 2005). Age II (26-45 yrs) individuals were observed to have completely obliterated incisive sutures and had significant closure of the transverse palatine suture and the posterior median palatine suture, pitting of the palate, and a smaller greater palatine fossa. Furthermore, the complete eruption of all M3, significant signs of tooth wear and loss, no metaphyseal lines on the long bones, and the widening wavelengths of cranial sutures support the age assignation. Age III (+50 yrs) individuals have been observed as either having a completely obliterated PMP or having crucial obliteration of the anterior median palatine suture just below the greater palatine fossa alongside obliterated incisive sutures and transverse palatine suture. Also, they exhibit significant tooth loss, obliterated cranial sutures, and deteriorated vertebra.

The Age I category has eight individuals, the Age II category has 17 individuals, and the Age III category has 9 individuals.[6] (see table 1). Table 7.6 provides a summary that divides the Frazer-Tyra population by sex and age categories.

Table 7.6 Summary of Age Groups For Frazer-Tyra (20SA9)

Frazer-Tyra	**Age I (18-25yrs)**	**Age II (26-45yrs)**	**Age III (+50yrs)**	
Females	8	9	2	
Males	1	8	7	
Total	**9**	**17**	**9**	**34**

Dental Observations

In general, the Frazer-Tyra adult population displays tooth wear patterns consistent with other prehistoric Native American populations from the region (Barondess 1998; Larsen 1999). The pattern of wear on the occlusal surfaces of the adults is extensive and is not exclusive to any

[6] There were 23 age assessments performed by Fischoff and Porter (MSS. on file (1983) WSUMA 11W547. The primary age assessment technique employed was the observation and scoring of cranial suture closure (i.e. coronal, sagittal, and lamdoid). In addition, observations of long bone fusion were used to support the age derived from the cranial suture closure scores. This method resulted in 17 individuals to be assigned an age between 40 and 60 years. Fischoff and Porter assigned the remaining 6 cases to a general 'adult' category because they lacked diagnostic skeletal elements for a more specific assignment. Generally, the latter age assessments categorized Frazer-Tyra individuals as older individuals. Their assessments probably varied because they primarily relied on cranial suture closures rather than a holistic approach.

particular age set. Posterior and anterior teeth alike display the extreme occlusal wear in which the inner chamber of each tooth is exposed. Furthermore, out of the 34 adult cases, 8 adults showed evidence of caries alongside the extensive occlusal wear. An increase in carious teeth is considered an indicator of maize reliance in the New World (Larsen *et al*. 2002).

Chemical Analyses

Carbon 14 Dating

Krakker (1983) indicated that the Frazer-Tyra site had two Late Woodland occupation episodes, one beginning slightly before AD 1000 and ending around AD 1200, and a second episode beginning after AD 1400 and lasting perhaps till the proto-historic era. Though these two occupation episodes are separated by about 200 years, they both fall within the Late Woodland period, AD 500 to 1650. To clarify the dates associated with the Late Woodland burial cluster at the Frazer-Tyra site, two bone samples were submitted to the CAIS laboratory of the University of Georgia for carbon dating. The samples are UGAMS #03504 (WSUMA 9w217), which pertains to a male who had the most negative δ^{13}C in the total population; and UGAMS #03505 (WSUMA 9w640), a female and the individual with one of the most positive δ^{13}C in the total population. The carbon dates from the CAIS AMS facility are given in Table 7.7.

Table 7.7 Carbon 14 Dating Results for Frazer-Tyra samples

CAIS #	**WSUMA**	**Lab#**	**Sex**	**Age**	**Material**	**Radiocarbon**	**$^{13}\delta$C‰**
UGAMS #03504	9W217	AM-10	M	III	collagen	940±25 (YBP)	-19.4
UGAMS #03505	9W640	AM-20	F	I	collagen	865±25 (YBP)	-14.6

The male individual (WSUMA 9w217) thus is dated to A.D. 1010±25, while the female individual (WSUMA 9w640) is dated to A.D. 1085±25. This information suggests that the Frazer-Tyra remains housed at WSU Museum of Anthropology date to the earlier occupation of the Late Woodland component of the site. Graves noted that the burial features of the Frazer-Tyra site were situated in area of yellow sand, approximately ten feet deep. The adults in this study were noted in features ranging from eight inches to 28 inches in depth. The male individual (9w217) was recovered from feature 83 at a depth of 28 inches. The female individual (9w640) was recovered from feature 90 at a depth of ten inches. Both individuals were recovered from the same general area of the excavated area. Many burial features are close to one another and are surrounded by caches and storage pits. Furthermore, these AMS dates tie this Saginaw Valley population to the threshold for corn consumption within the continental U.S. (Van der Merwe and Vogel 1978; Vogel and Van der Merwe 1977).

Dietary Reconstruction

The principal aim of this study- to reconstruct the diet of the Frazer-Tyra population using the carbon and nitrogen ratios from the human skeletal remains recovered from the site- was achieved using a modified procedure of the Longin method (1970). Samples were taken from 33 of the 34 adults using primarily postcranial remains, and cranial remains when the latter were not present.

Carbon and Nitrogen Isotopic Analysis

The Frazer-Tyra population $\delta^{13}C$ mean is -16.1 ‰. One female individual from the Age III group (AM-25) was excluded from the analysis because the C:N (3.72) was outside the range for acceptable bone preservation. The $\delta^{13}C$ mean for females is -15.8‰. The $\delta^{13}C$ mean for males is -16.4‰. The results of the carbon ratios confirm C_4 plant (i.e. maize) consumption for the population (Bender 1981; Rose 2008; Schwarcz and Schoeninger 1991; Stothers and Bechtel 1987; Vogel and Vander Merwe 1977). Furthermore, the Frazer-Tyra population $\delta^{15}N$ mean is 12.5‰. The $\delta^{15}N$ mean for females is 12.5‰ and the $\delta^{15}N$ mean for males is 12.4‰. The results of the nitrogen ratios confirm the consumption of freshwater fish as a primary life-long dietary resource (Ambrose 1993; Muldner and Richards 2007; Rose 2008; Schwarcz and Schoeninger 1991; Schoeninger *et al.* 1983).

The results of the carbon and nitrogen ratio tests for the Frazer-Tyra site are presented in Table 7.8, which is arranged by age groups and sex:

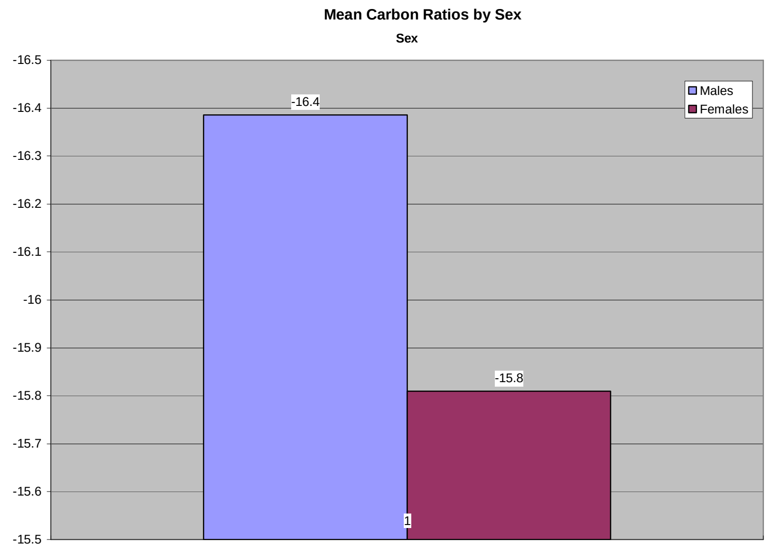
Table 7.8 Frazer-Tyra site Carbon and Nitrogen Ratios by Age and Sex

Sample	$\delta^{13}C_{VPDB}$ ‰	$\delta^{15}N_{air}$ ‰	C/N $_{AR}$ ‰
Age I (18-25yrs)-Females			
AM-9	-14.8	11.9	3.2
AM-8	-15.9	12.6	3.1
AM-6	-16.0	12.8	3.2
AM-34	-16.5	12.5	3.2
AM-20	-14.4	12.2	3.1
AM-2	-17.2	13.1	3.2
AM-17	-14.3	12.2	3.2
Mean Age I Females	**-15.6**	**12.5**	**3.2**
Stan Deviation σ	**0.98**	**0.4**	**0.05**
Age I (18-25yrs)-Males			
AM-33	**-19.1**	**12.9**	**3.1**
Age II (26-45yrs)-Females			
AM-3	-15.8	12.5	3.2
AM-12	-16.8	12.7	3.1
AM-15	-17.5	13.1	3.2
AM-28	-15.7	12.7	3.3
AM-29	-15.5	12.9	3.2
AM-35	-15.6	12.3	3.3
AM-23	-15.3	12.5	3.4
AM-30	-16.7	12.3	3.2
AM-31	-15.4	12.4	3.2
Mean Age II Females	**-16.0**	**12.6**	**3.2**
Stan Deviation σ	**0.74**	**0.25**	**0.08**
Age II (26-45yrs)-Males			
AM-24	-17.0	11.7	3.1
AM-21	-16.3	12.9	3.2
AM-22	-13.2	12.7	3.2
AM-26	-16.2	12.4	3.2
AM-27	-15.8	11.5	3.4
AM-4	-15.7	12.8	3.2
AM-32	-17.6	12.5	3.3
AM-36	-11.7	10.1	3.3
Mean Age II Males	**-15.4**	**12.1**	**3.2**
Stand Deviation σ	**1.85**	**0.88**	**0.08**
Age III (+50yrs)-Males			

AM-10	-20.1	11.8	3.3
AM-13	-18.2	13.2	3.2
AM-18	-18.1	13.3	3.2
AM-11	-13.4	12.7	3.2
AM-19	-16.7	12.5	3.2
AM-37	-16.8	12.5	3.3
Mean Age III Males	**-17.2**	**12.7**	**3.2**
Stand Deviation σ	**1.7**	**0.49**	**0.05**
Age III (+50yrs)-Females			
AM-1	-15.3	12.7	3.2
AM-25	-19.2	12.8	3.7
Mean Age III Females	**-17.2**	**12.7**	**3.5**
Stand Deviation σ	**1.95**	**0.05**	**0.25**

With regard to my first hypothesis, I expected the δ ^{13}C population mean to be more positive than -19.5‰, indicating maize as a resource but not a primary resource. I did not expect the population mean to be -10‰, as historic groups known for heavy reliance on maize have δ ^{13}C values around -10 ‰.

As I expected, the Frazer-Tyra population's δ^{13}C mean was greater than -19.5‰. The population mean, δ^{13}C -16.1‰ indicates maize consumption, with individual values ranging from -20.14‰ to -11.71‰. Figure 7.4 shows the mean δ ^{13}C value for the female segment and the male segment within the Frazer-Tyra population. Figure 7.4 Frazer-Tyra population mean carbon ratio according to sex.



The Pearson correlation test indicated that there was no significant relationship between sex and the carbon ratios (r=0.176; significance two-tailed) 0.336. The non-parametric, Manny-Whitney U Test was also used to test whether females were consuming significantly more maize versus males. Again, there was no statistical significance across sex (U=87.0, prob.= 0.132). There was also no significant relationship found between the carbon ratios and age (r= -0.180, significance (two-tailed) 0.324). The non-parametric Kruskal-Wallis Test was used to explore whether age was a factor in the consumption of maize. Again, no statistically significant difference in mean consumption across age groups was indicated (H= 0.390).

My second hypothesis was that I expected the $\delta^{15}N$ population mean to be near or above the average of 12.7‰, indicating a reliance on freshwater fish. As I expected, the $\delta^{15}N$ population mean is near or above 12.7‰. The $\delta^{15}N$ population mean is 12.5‰, with a range from 10.13‰ to 13.28‰, which indicates a reliance on freshwater fish. The Kruskal-Wallis test indicated there was no statistically significant difference in the mean consumption across the age groups for nitrogen ratios (H= 0.675). Below, Figure 7.5

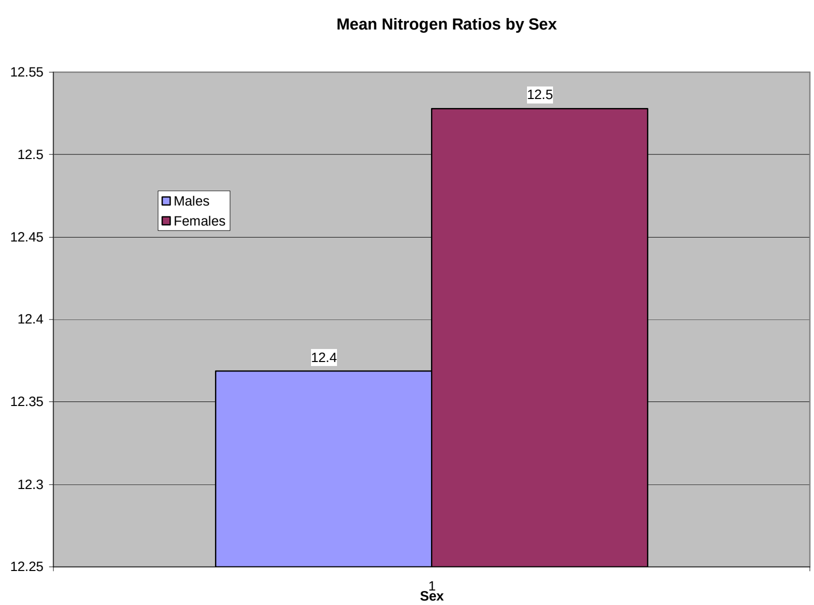
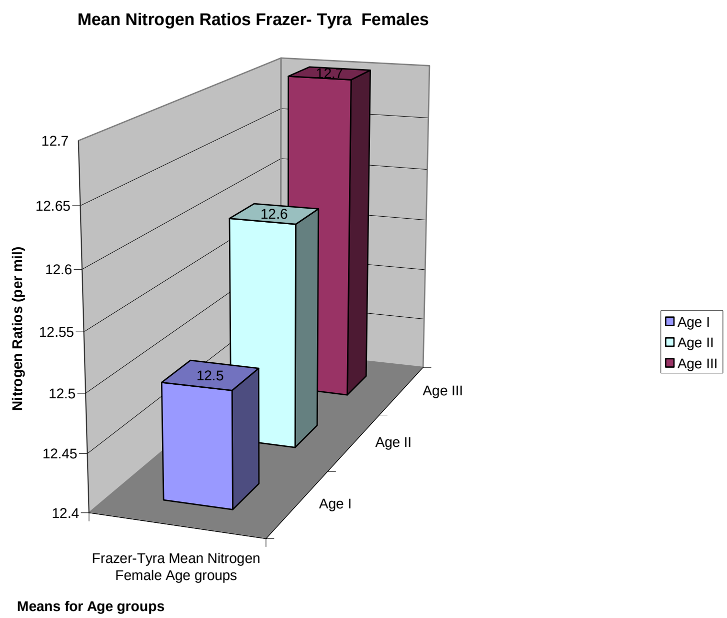


Figure 7.5 demonstrates the $\delta^{15}N$ means by sex. As can be seen, the mean values between males and females are extremely close. Again, there is no statically significant relationship between sex and the isotopic nitrogen ratios (r=0.150).

My third hypothesis concerned the question of whether females consumed more aquatic



resources. In general, I expected women to have a higher $\delta^{15}N$ population mean than men. The mean $\delta^{15}N$ values varied slightly for the male segment and the female segment. The female population $\delta^{15}N$ mean was 12.6‰ and the male was 12.4‰. A difference of 1‰ is interpreted as a different diet (Ambrose 1993). Female individuals' $\delta^{15}N$ values range 11.9‰ to 13.1‰ (Fig. 7.5). In addition, a comparison of means by age group among females shows no significant difference along these dimensions either. Figure 7.6 Mean Nitrogen values by age groups. Male individuals' $\delta^{15}N$ values range from 10.23 ‰ to 13.28 ‰, with a mean of 12.37‰. The non-parametric, Mann-Whitney U test, U= 0.970, demonstrated that there was no statistically significant difference by sex in terms of the $\delta^{15}N$ values. There is a difference of 0.6‰ between Age II and Age III males.

The $\delta^{13}C$ mean for females was slightly more positive (-16‰) than the $\delta^{13}C$ mean for males (-16.4‰). There was no statistically significant correlation found between carbon ratios and age groups. However, a general observation can be made that the older the individual, the more negative the $\delta^{13}C$ value tended to be. The boxplot in Figure 7.7 suggests that corn may have been consumed in varying degrees by individuals in different age groups. Because there is no statistical significance, all of these "patterns" could equally be due to chance.

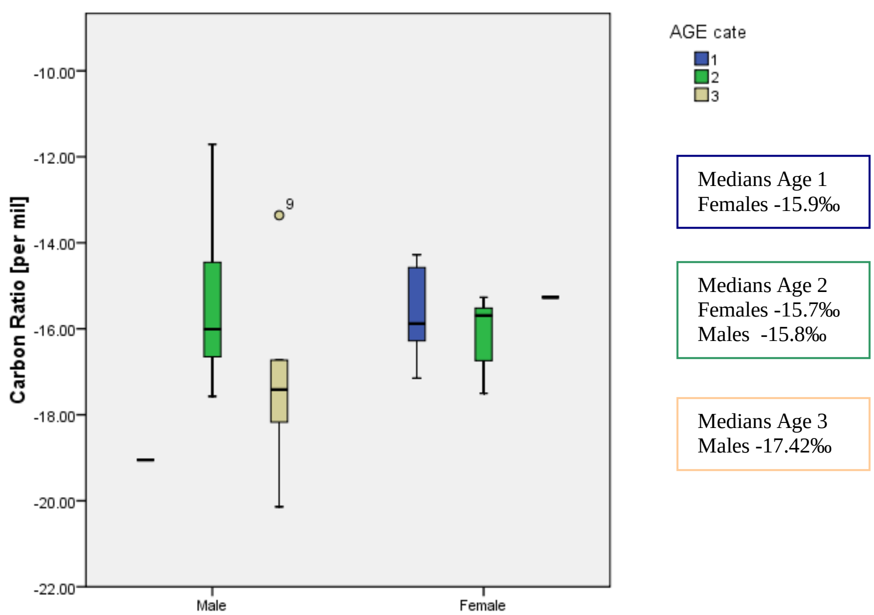


Figure 7.7 Boxplot of carbon ratios values for age groups by sex. There is only one individual in the Age I male category and the Age III female category. The $\delta^{13}C$ medians for female groups are consistently negative. For males, the $\delta^{13}C$ medians vary, with only the Age Group II males consistent with the females of the population. The only male individual in Age I

Group has a carbon ratio of -19.1‰, comparable to older males. The older female individual in Age III was comparable to the other females of Age Group I and II, with a value of -15.3‰. The older female individual of Age Group III that was excluded from the statistical analysis because of poor preservation had a carbon ratio of -19.2‰ (9w214a).

The boxplot chart in Figure 7.8 demonstrates the range of isotopic values and implies that the diet was highly variable from one individual to the next with respect to maize consumption.

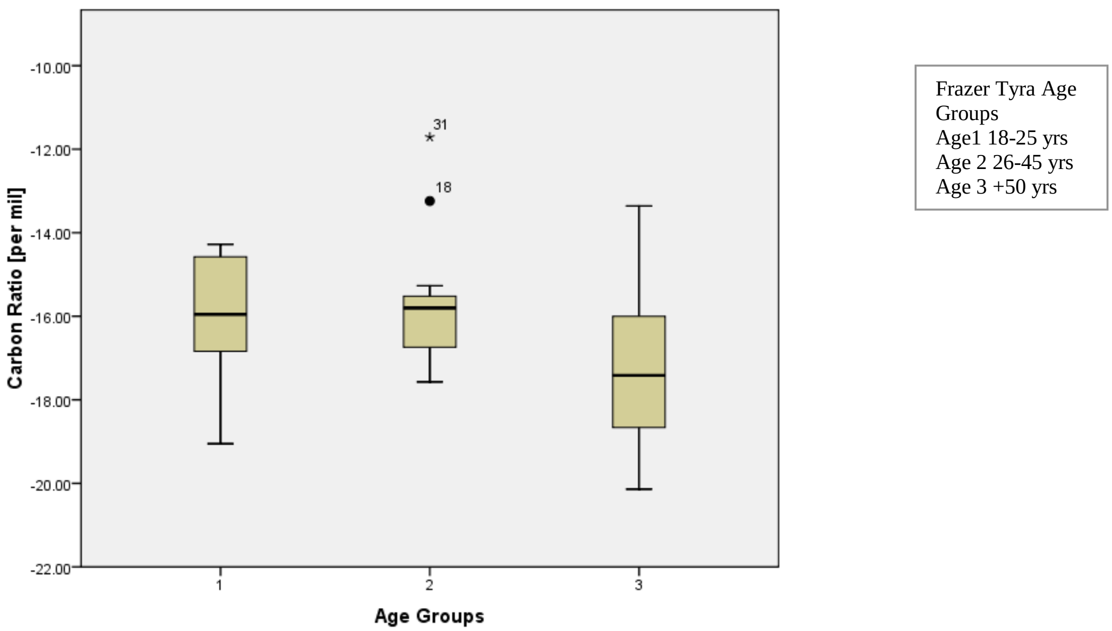


Figure 7.8. This demonstrates the medians for each age group. Age 1 (18-25 yrs) Age 2 (26-45 yrs), and Age 3 (+50 yrs).

The median for Age Group I is -15.96‰. The median for Age group II is -15.8‰. The median for Age Group III is -16.8‰. The lower edge of the box is the 25th percentile and the upper edge of the box is the 75th percentile of scores. The horizontal lines represent the medians. There are only two cases that are outliers in the carbon ratio values. These individuals have a different diet than the rest of the Age Group II individuals with regards to maize consumption. A test of the median values in $\delta^{13}C$ consumption across the age groups indicates no statistical significance, (M=0.286).

The boxplot chart in Figure 7.9 shows the results of the nitrogen ratios by age groups and sex:

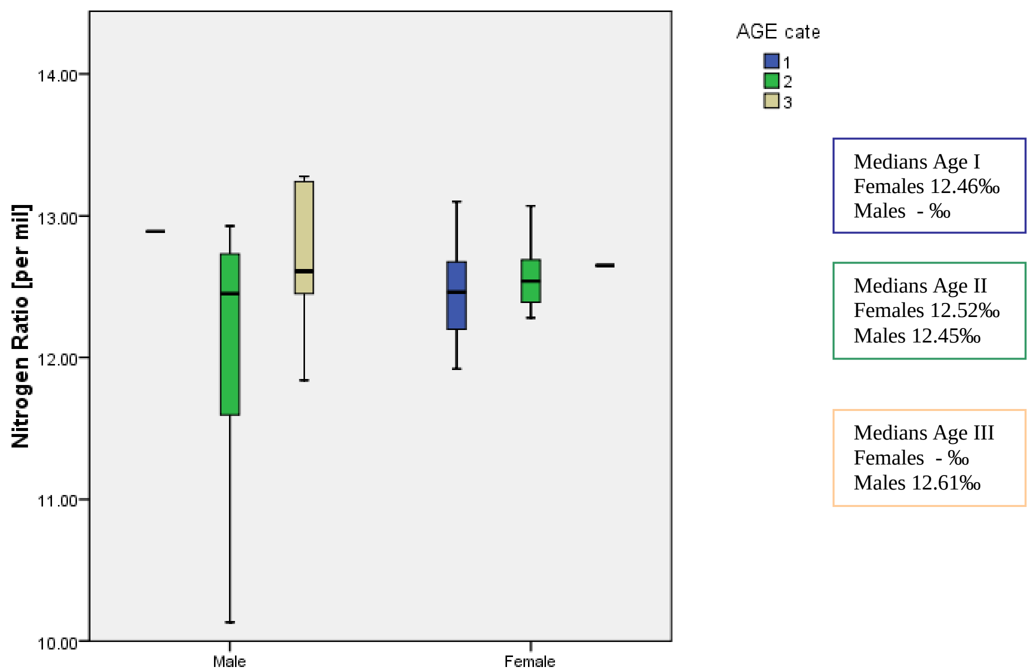
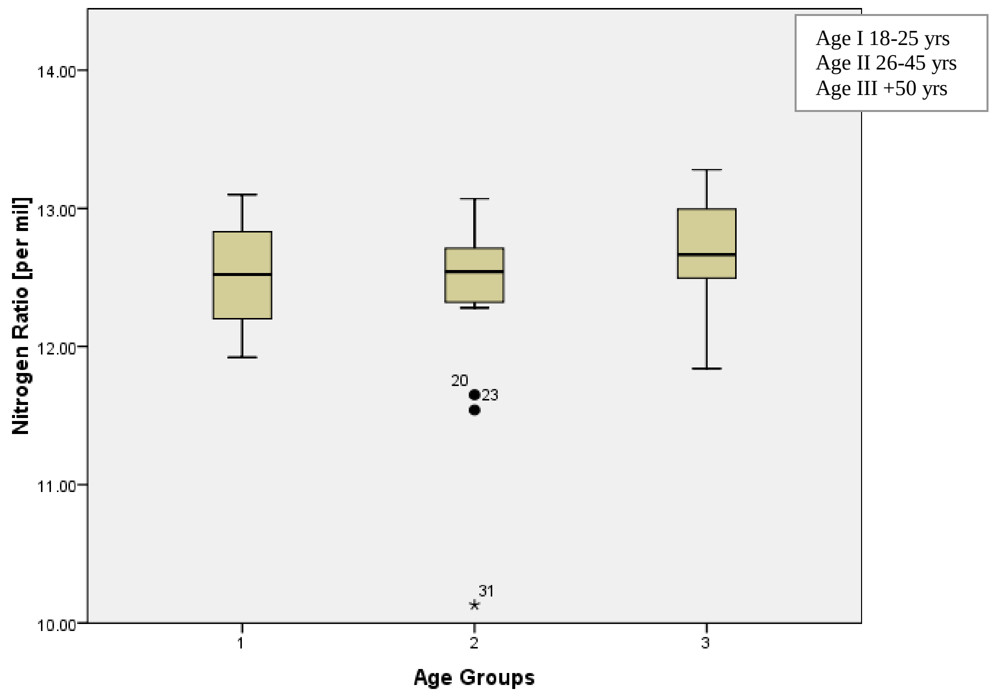


Figure 7.9 Boxplot of nitrogen ratio values for age groups by sex. The medians demonstrate a consistent consumption of protein, from aquatic resources by all age groups in both males and females. Two subsets that had one individual still had nitrogen ratios within the range of the population's mean. The young male individual of Age Group I has a 12.9 ‰ nitrogen ratio. Also, the older female individual of Age Group III has a nitrogen ratio of 12.7 ‰. The boxplot chart Figure 7.10 on the following page demonstrates that medians are consistent with respect to age groups. Figure 7.10 Boxplot of nitrogen ratio values for age groups Age 1 (18-25yrs), Age 2 (26-45yrs) and Age 3(+50yrs). The median for Age Group I is 12.5 ‰. The median for Age Group II is 12.5 ‰.



Also, the median for Age Group III is 12.7 ‰. There are three outliers that fall below the 25th percentile of the population in Age Group II. These individuals are consuming a different diet from the rest of Age Group II.

Chapter 8

Conclusions

The results of the present study indicate that the Frazer-Tyra population engaged in hunter-gatherer pursuits along with some maize consumption. This site is located in a biotic zone in which agricultural pursuits would have been difficult to manage. Though the population mean is consistent with other Late Woodland sites isotopic data, the values for individuals represented between age groups and sex is distinct.

Historic groups that heavily relied upon maize agriculture tended to have more positive $\delta^{13}C$ ratios, around -10‰ (Bender et. al. 1981). Archaic hunter-gatherer population tend to have more negative $\delta^{13}C$ ratios, between -26‰ to -20‰ (Stothers and Bechtel 1987). Corn adoption and consumption is believed to have led to increases in population density, shifts in social organization, and the adoption of a more sedentary lifestyles, as well as dietary shifts that created nutritional deficiencies and dental pathologies (Larsen 1999, Larsen et. al. 2002; Norder *et al.* 2003 Smith 1992, 1989). Van der Merwe and Vogel (1977) reported a northern limit for established maize consumption in New York State at the Snell 4 and Snell 5 sites, dated to A.D. 1000-1300. Late Woodland remains from these sites had $\delta^{13}C$ values of -14‰ and -16‰ (Van der Merwe and Vogel 1977:241). Additionally, there are Southern Ontario sites from which isotopic data has been reported. The Fairty site, dated to A.D. 1350 had a $\delta^{13}C$ of -11.3‰. There are two occupations of Serpent Pits, Southern Ontario one dated to A.D. 1440 with $\delta^{13}C$ -15.3‰ and the other dated to A.D. 1290 with $\delta^{13}C$ -15.8‰.

Table 8.1 shows the range of carbon ratios for Late Woodland sites in Southern Ontario and New York as reported by a number of researchers. As can be seen, sites dating towards the end of the Late Woodland into the Historic period (AD1350-1580) exhibit more of a reliance on maize than sites dated earlier (AD 1000-1400).

Table 8.1 Reported Isotopic Data for Late Woodland Sites Southern Ontario and New York

Site	**Date**	**δ^{13}C ‰**	**δ^{15}N ‰**	**Reference**
MacPherson site, S. Ontario CN	AD 1530-1580	-10.0‰	12.4‰	Katzenberg, et. al. 1993
Snell 4, New York	AD1000-1300	-14.0‰	-	Vogel and Vander Merwe 1977
Snell 5, New York	AD 1000-1300	-16.6‰	_	Vogel and Van der Merwe 1977
Fairty Ossuary, S. Ontario CN	AD 1350	-11.30‰	-	Stothers and Bechtel 1987
Serpent Pits, S. Ontario, CN	AD 1440 ±60	-15.30‰	-	Stothers and Bechtel 1987
Serpent Pits, S. Ontario, CN	AD 1290± 60	-15.80‰	-	Stothers and Bechtel 1987
Frazer-Tyra	AD 1010-1085±25	-16. 1‰	12.5‰	Muhammad 2010

Here, carbon and nitrogen ratios were expected to indicate a reliance on aquatic resources alongside small scale maize consumption for the Frazer-Tyra population. The nitrogen ratios for the human remains from the site are consistent with significant fishing and the carbon ratios are consistent with some maize adoption. Previous research (Deniro and Schoeninger 1983; Schwarcz and Schoeninger 1991) shows that the difference in carbon and nitrogen ratios between males and females in any population is usually negligible. Deniro and Schoeninger (1983) have suggested we should look for variation within a population at the isotopic level. Bender et al. (1981) suggests that corn consumption varied greatly from one individual to another in each population from the Late Archaic to the Woodland period that was sample from across the Eastern Woodlands. The results of the present study demonstrate that though all individuals had access to maize, individual consumption of maize seems to have varied while fishing and hunting efforts were consistent. In other words, at the Frazer-Tyra site the introduction of a new food product had not profoundly changed the mixed character of the existing subsistence routine.

Variability Among Individuals

The variability seen within the Frazer-Tyra population warrants further discussion about maize adoption, subsistence routines, and the preferences of individuals. As cases in point, we can look at the male individual in Age III category (WSUMA 9w217), whose remains were radiocarbon dated to A.D. 1010±25 and the female individual in Age Group I category (WSUMA 9w640) whose remains were dated to a slightly later time period, A.D. 1085±25. The young, female individual had one of the most positive $\delta^{13}C$ values, -14.39‰, and clearly consumed maize. The older male individual had the most negative $\delta^{13}C$ value, -20.14‰, and seems to have consumed very little maize. The latter value is comparable to levels found in Late Archaic and Middle Woodland populations (Bender et. al. 1981; Smith 2001, 1992; Stothers and Bechtel 1987).

The carbon ratios obtained may also suggest that older Frazer-Tyra individuals consumed less maize than younger individuals. Figure 8.1 demonstrates that females across age groups are consuming a different diet. More than a 1‰ difference in isotopic ratios indicates a different diet (Ambrose 1993; Schoeninger et al. 1983). The difference exists between the females of Age

Group I and Age Group III; also, Age Group II and Age Group III.

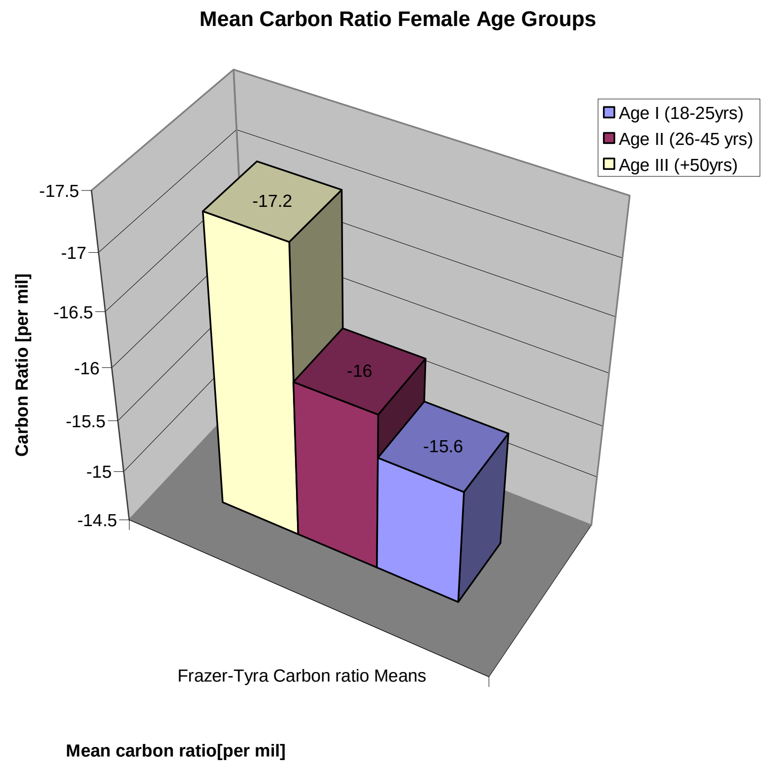


Fig. 8.1 This graph demonstrates the mean differences between female age groups. There is a 1.6 ‰ difference in the means between the Age III group and the Age I group of females. The female Age Groups I and II do not have a 1‰ difference, suggesting a similar diet.

There are female individuals within the same age group with similar carbon ratios. There are also female individuals from the different age categories with similar carbon ratios. For example, a young female individual from Age Group I (9w660) has a $\delta^{13}C$ of -17.2 ‰ indicating maize consumption below the population mean, and $\delta^{15}N$ of 13.1 ‰ indicating a freshwater fish based diet. There is another female of the same age group (9w645) that had a $\delta^{13}C$ -16.5‰ and a $\delta^{15}N$ of 12.5‰. Another female individual, from Age Group II (9w642), has a $\delta^{13}C$ of -17.5 ‰ and a $\delta^{15}N$ of 13.1 ‰. Like the latter two cases, there are other parallels within the data within and between age groups.

The dilemma in interpreting the isotopic data rests in interpreting the individual carbon ratio values next to the population mean given the overall population sample size is small. There are also a few male cases that demonstrate the dilemma of the wide range of results in individuals. A male individual of Age II category (9w774) has the lowest $\delta^{15}N$ value, 10.1‰, and has a $\delta^{13}C$ value -11.7‰, indicating he consumed maize at a level near that of native peoples in the Historic period. Another male from Age Group III (9w659) was the tallest individual (5 ft 8in) in the population, ate a diet rich in protein, $\delta^{15}N$ value 13.3‰, but consumed maize below the population mean, $\delta^{13}C$ value -18.1‰. Another male in Age group II (9w658a) displays heavy maize consumption $\delta^{13}C$ -13.24‰ and has a average nitrogen 12.7‰, yet was below the average stature for males, measuring 158.54 cm (5ft 3in) implying that corn consumption does not necessarily correlate with taller men.

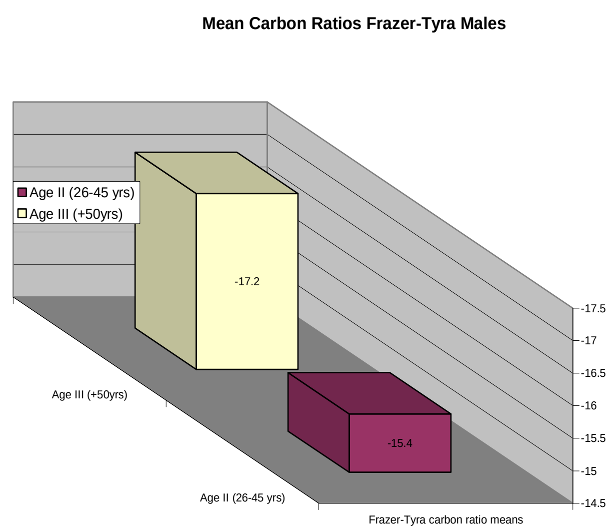
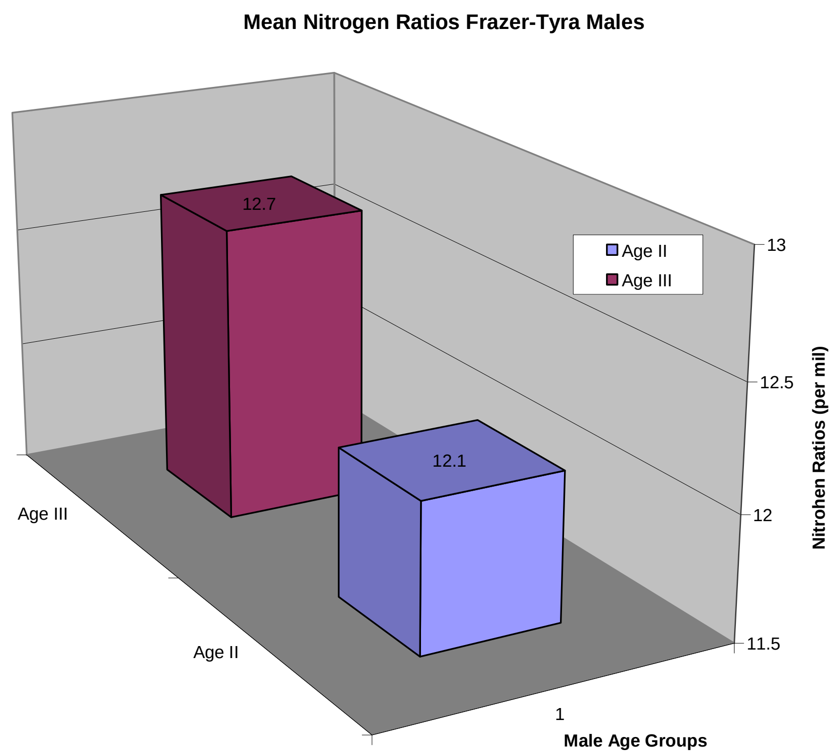


Figure 8.2. This graph demonstrates the 1.8 ‰ difference in $\delta^{13}C$ mean values between male age groups. Maize was not consumed the same between age groups of males. Age Group I

is not represented in Figure 8.2 because there was only one male individual (9w302) whose $\delta\ ^{13}C$ is -19.1‰. The same male individual (9w302) has a carbon ratio comparable to Age Group III individuals, male and female rather than those of Age Group I and II. Figure 8.3 demonstrates a 0.6‰ difference in the mean nitrogen ratios between male age groups. It appears that the sources of protein were consistently available to all males.



:

Figure 8.3 the graph demonstrates that all Frazer-Tyra males consistently had access to aquatic resources. Acquiring protein through hunting was not as reliable as the exploitation of aquatic resources. Wild game adapts to the hunting pattern of the people and hunting grounds are subject to sharing with other groups. Also, hunting does not provide the necessary dietary fat to promote health (Keene 1981; Walthall 1998).

Aggregation of prehistoric peoples is a strategy for coping with the scarcity of resources. The timing of aggregation can be linked to the dietary sources available. The Frazer-Tyra population has nitrogen ratios that are consistent with the consumption of aquatic resources. This population would have to occupy this location in the Saginaw Valley as a semi-permanent or permanent settlement in order to meet their nutritional needs. The isotopic data represents a life-long pattern of consumption of aquatic resources as a significant element of their diet.

Mortuary Behavior and Food Security

Metcalf and Huntington (1991) state that the mortuary treatment of individuals and the construction of mortuary monuments and formalized burial areas reflect a strategy aimed at the legitimizing of power and prestige. Individuals within a community often pronounce claims to land, wealth, and prestige on the basis of affiliation with a well-known ancestor. Affiliations are pronounced ritually through the memorial of a well respected or 'titled' ancestor. It is the secondary interment of these well respected individuals on land that the living claimants seek to control that is the vital aspect of the ritual (Metcalf and Huntington 1991:148). Late Woodland mortuary precincts in the Great Lakes region can be construed as constructions whereby populations attempt to establish their rights to land and pronounce their legitimacy to others in the region (Krakker 1999, 1997).

There is evidence that Late Woodland sites such as, Frazer-Tyra, Bussinger, Younge, and Riviere aux Vase, were actually used and occupied at different times as villages, trade fair grounds, and mortuary precincts. Possible living floors, burial features, storage pits, and middens have been noted at these sites (Fitting 1965; Graves 1968; Greenman 1935; Halsey 1976; Zurel 1999). Interestingly, earthenworks, circular or horseshoe like in shape around the site, have also been noted as a type of feature of Late Woodland sites (Zurel 1999: 244). These enclosed sites in southeastern Michigan have been noted to occur along the biotic zones approximately 28 miles apart (Zurel 1999:247-248). Mortuary practices, lithics, and ceramics recovered from these sites have been dated from the Archaic to the Historic period (Andrews 1995; Fitting 1965; Greenman 1935; Halsey 1976; Krakker 1999; Stothers 1999).

Furthermore, Metcalf and Huntington have suggested, based on the Berawan, Thai, and the Balinese, that when one sees individualized burials that have been secondarily interred, the mortuary program is about the legitimization of prestige and wealth (1991:144). Early Late Woodland burial precincts of the Saginaw Valley region include more individualized burials alongside smaller ossuaries rather than large ossuaries. This change would reaffirm larger and more extended group affiliation. For example, at the Riviere Aux Vase site (AD 1000-1300), the ossuaries pattern is evident, along with rearticulated remains (e.g. reinterred) and individualized burials of distinction in which there are trophy heads (Fitting, 1965: 73-75). There were approximately 110 individualized burials and 128 ossuaries out of the 350. The Bussinger site (AD 750-1000) of the Saginaw Valley region also had a few distinctive male burials (Halsey 1976; Norder *et al.* 2003:147). The Younge site (AD 900-1100) had very distinctive individualized male burials (Greenman 1937) in which there were modified skulls and trophy heads. Norder *et al.* (2003) wrote that the individualized burial of a female at the Brandon site (AD 890-1000) demonstrated that male and female alike could achieve a distinctive status in the Late Woodland period. What that exact status was could not be determined, but the female burial at the Brandon site had comparable grave goods to the male burial from the Olson sit. Grave goods (i.e. modified faunal remains, and, lithics) in the female burial included items associated with high-ranking males (Norder *et al.* 2003: 154). The fact that a female burial at the Brandon site was stone-lined is another indication of high status (Norder *et al.* 2003:149).

Krakker noted that the Frazer-Tyra burials patterns were tied to the social and settlement changes that were occurring through the Saginaw Valley ca. AD 1000 (1983:41). He concluded that the large number of burials indicated a large living population at the site that carefully prepared and maintained this area for mortuary activity. Because there were only few individualized burials with ritual objects (i.e. pipes, shell items, and red ochre staining), he surmised that “social affiliation may be expressed through the location within the cemetery rather than with artifacts” (Krakker 1983:40). Also, that only a few individuals were accompanied by grave goods, implies that prestige was pronounced for the larger clan or community level. Additionally, Krakker proposed that the consistent orientation of the burials suggests a shared social identity at the community level (1983:41). The rearticulated (bundled) burials and individualized burials at the Frazer-Tyra site imply ritualized secondary interment programs (Graves 1968; Krakker 1983). The mortuary features of the Frazer-Tyra site indicate that there was a semi-permanent or permanent settlement and that there were ritualized interments.

Burials in the Saginaw Valley might have represented more than just larger group affiliation. Quite possibly they were expressions of territorial claims on a land with vital resources. The waterways, on which the valley populations relied heavily, were vital resources. In the face of intruders, it is unlikely that valley residents did not seek to control access to such vital resources. The Frazer-Tyra population would have tried to control access in and around their riverside village. The site has suffered many disturbances due to construction and farming. There is no direct evidence for defensive walls on the site. However, other sites in the area have been noted to include earthenworks believed to be for defense (Zurel 1999:244-249) The population’s nitrogen ratios demonstrate a marked reliance on aquatic protein even when there was access to domesticates, like maize. They would have had to defend and control their waterways to maintain access to their preferred resources.

Ethno-historical data has demonstrated that native peoples maintained caches of food and tools throughout the Saginaw Valley region (Fitting 1965). The procurement and storage of foodstuffs also requires the control of territory. Caching is a measure of food security (Dunham 2000; Hastorf 1991; Keene 1981; Zvelebil 2000). Dustin noted that the Saginaw Valley has storage pits or “corn pits” all across its landscape (Dustin 1968:48). These caches are usually three feet deep and have foodstuffs including corn. Keene (1981) has also noted that dried fruits and fish were subject to storing by people during this period. The Frazer-Tyra site had a number of storage pit features with faunal and botanicals, including charred maize (Graves 1968).

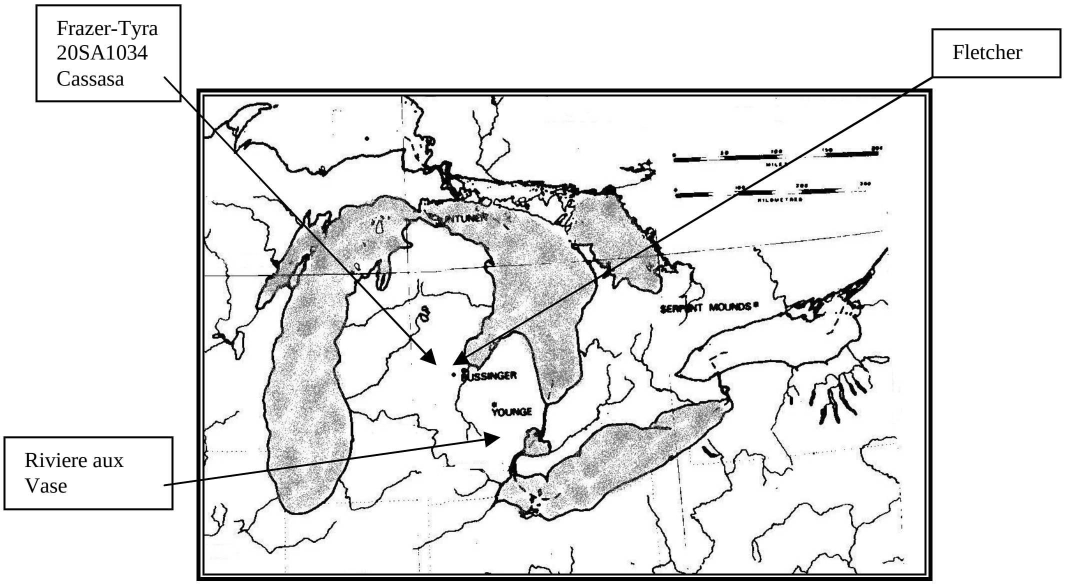
The Frazer-Tyra site lies in a transitional zone between the Carolinian and Canadian biotic zones. The Saginaw Valley itself had a diverse ecosystem with the population growth that appears to have accompanied a Mississippian intrusion (Holman and Brashler 1999; Stothers 1999). It is important, however, to question the carrying capacity of the Valley. It seems corn consumption is visible for the Frazer-Tyra population though there is no evidence to support the idea that they were growing the crop themselves. It would appear that the Frazer-Tyra population operated within a trade network that allowed them to acquire maize, and obviated the need to leave off their hunting/fishing pursuits. Outside of the corn recovered from the noted two storage features, there is no evidence to indicate that corn was cultivated at the Frazer-Tyra site itself (i.e. flotation samples, cultivated fields, etc.). The presence of maize in storage features does not necessarily support local cultivation nor does it exclude it.

Parker (1996:313) proposed using finer screens and a larger number of flotation samples in order to re-evaluate sites regarding maize cultivation and general horticultural pursuits in the

Saginaw Valley region. Botanical samples from site SA1034, on the Flint River, revealed that there were domesticates present during the Late Woodland period, such as maize, tobacco, sunflower, cucurbit, and chenopod (Parker 1996:316-325). Parker concluded that maize was cultivated near the site as part of a mixed strategy because of low material density and the absence of midden development (Parker 1996:327-328). She believed that residents of SA1034 were a small and mobile group that occupied the area seasonally (1996:328). Specifically, Parker suggested that this site was strategically selected by Saginaw Valley residents in order to secure nearby tillable soil (1996:328).

Defining the nature of maize adoption during the Late Woodland period in the Saginaw Valley region, and Michigan at large, revolves around determining the importance of corn versus other resources, showing how corn consumption became a part of the subsistence routine and its affects on the migratory patterns of people, and how archaeologists tie the latter into what is viewed as the abandonment of the Saginaw valley as a permanent territory for prehistoric people (Lovis et al. 1996:296) The introduction of maize to Michigan has been estimated to have occurred around A.D. 800-1000 (Ambrose et al. 2003; Monaghan and Lovis 2005). Lovis and his colleagues have argued that while maize was present in limited quantities at the Fletcher site (1996:254) other Saginaw Valley residents continued to rely on wild food resources.

Late Woodland sites in Michigan are characterized as being seasonally occupied save for a few like Fletcher, Moccasin Bluff, and RAV where seasonal aggregation took place (Holman and Brashler, 1983, 1996; Lovis, et al. 1996). Krakker (1997) wrote that as early as the Archaic period, there was a regulatory system in place that supported the transporting of exotic materials as demonstrated by the recovery of non-local lithics (Andrews 1996, Krakker 1997). Such a system, he suggested, would have been used in times of scarcity to acquire food and negotiate territory. Holman and Brashler have also argued for an intensified system of exchange and territoriality due to what they call the Mississippian intrusion (1996:213). Intensification of territorial behavior (i.e. earthen enclosures, domestication of plants) correlates at sites dating to Late Woodland period with new diverse ceramic types (Holman and Brashler 1985; Zurel 1999)..



Map 8.1 Michigan and Southern Ontario have cultural affiliations and similar subsistence practices (Wilkinson 1971). Early Native people were exploiting the waterways, hunting, collecting, and engaging in small-scale horticultural pursuits to support their communities (Holman and Brashler 1996; Lovis 1996; Parker 1996). Holman and Brashler (1996) have characterized Late Woodland subsistence routines as including a migratory pattern that involved the following seasonal routes: spring/summer encampments at the mouth of the Saginaw River, a late autumn dispersal through the interior radial network of the valley's riverine system, and winter encampments along the interior edges of the valley. The seasonal aggregation during late summer at larger sites like Fletcher would have been an opportunity to exchange gifts and reinforce relationships (Holman and Brashler 1996).

Though his aim was to discuss subsistence strategies for the Early Holocene period, Walthall (1998) uses ethnographic data from the Historic period to propose a migratory pattern that has people exploiting the waterways for fishing and dispersing late in the winter. He cites Binford's (1990) discussion on the difficulties inherent with terrestrial hunting as opposed to fishing and adds a discussion on resource availability, the stress of group size, and the nutritional value of terrestrial game at the most stressful time of year for bands, which is winter (Walthall 1998). Aggregation, whether it is in the fall or the winter season serves to reinforce relationships through various social activities, games, marriage alliances, gift exchange, rituals, etc. Also, the sharing of information and the exchange of acquired resources and other materials is an essential aspect of aggregate behavior (Krakker 1997; Walthall, 1998).

A discussion of the diet of prehistoric populations of the Late Woodland period should take into account the entire economic system within which they participated. The position each population occupied within the system more than likely had an effect on the goods that they had access to and the foods they consumed. Late Woodland economies included the exchange of exotic cherts, ceramics, and probably foods. Though the population tested in this study was too small to establish statistical significance between age groups and sex, the variation amongst individuals suggests that subsistence routines are dependent upon social networks. Further testing may reveal patterns of accessibility to foods based upon status groups defined by age and sex.

The Frazer-Tyra site was characterized as a Late Woodland village and burial place that may have had a living population of approximately 200 individuals (Graves 1968; Krakker 1983, 1999). Based upon the nitrogen ratios found in the human remains from the site, I propose that the Frazer-Tyra population semi-permanent or permanent occupants of this site and principally relied upon fishing. Nitrogen ratio values have allowed archaeologists to distinguish fishers from hunters that consume terrestrial animals. Fishers tend to have higher nitrogen values than agriculturalists, particularly in the Great Lakes region (Schoeninger et al. 1983; Schurr and Powell 2005). North American agriculturalists tend to an average of $\delta^{15}N$ 8‰, while fishers were $\delta^{15}N$ 14‰ and hunters that ate marine mammals and fish were $\delta^{15}N$ 19‰ (Schoeninger *et al.* 1983). Furthermore, if the Frazer-Tyra population's sole source of protein was the deer, then the nitrogen values should be higher by 3-5‰ over the deer's nitrogen ratio as a herbivore, $\delta^{15}N$ 5.8‰. Humans consuming deer as their primary source of protein would have nitrogen ratios between 8‰ and 10‰ (Schoeninger and Deniro 1983). Freshwater fish and aquatic resources are responsible for high nitrogen values in the absence of other sources such as dairy. Walthall (1998) argued that the deer alone was not a sufficient dietary source of protein and fat. Additionally, the reported faunal recoveries from the Frazer-Tyra site were primarily from aquatic sources, principally fish and clam (Graves 1968).

I did not expect the Frazer-Tyra population to be heavy consumers of maize given their close proximity to the Canadian Biotic zone and because the biotic zone within which the site lies is not known for being temperate enough for significant agricultural pursuits. Carbon ratios indicated that the Frazer-Tyra population did consume maize, but not at the Historic period level, -10‰. Archaic populations that did not consume maize have carbon ratios near-26‰. Since the carbon ratios have established that the Frazer-Tyra individuals consumed maize, the question becomes how did they acquire maize? Graves (1968) reported that charred corn was present on the site in two of the largest storage pits. Dustin (1968) wrote that the entire Saginaw valley was full of storage pits that included caches of lithics, ceramics, and food products. I suggest that an extensive economic system, like that which Krakker (1997) discussed as being responsible for the appearance of exotic cherts and ceramics, would have brought maize into the Saginaw Valley region and dispersed it to the social units that lived there. Transporting foods along with other materials may have been done via the waterways. Also, the maintenance of inter-communal storage facilities may have also supported accessibility to maize for populations that did not cultivate maize, but were in the trade network. It is plausible that these same groups would have adopted maize alongside their existing subsistence routines in the early Late Woodland period. The variability of maize consumption amongst individuals within the sample population suggests that maize acquisition was social and network based and not a necessity due to scarcity.

The effort to procure food is not simply a matter of individuals extracting resources from the primary environment. Nor is the distribution of resources amongst a group's members simply done in accordance with the internal social structure. Food procurement occurs within a larger social arena in which small social units some times make agreements and develop good relations in order to secure access to foreign goods (i.e. raw materials, foods, and ceramics), from an external larger social milieu. Within this larger external social structure, affiliation is pronounced and may dictate degrees of access for an individual. Furthermore, each participating social unit consumes the available products at different rates and may not have equal access to all potential resources within a system. Depending on how well a group socializes with others in a given economic system, it may gain greater access to exotic products, or not.

I propose that the Frazer-Tyra population held a strong position in the Late Woodland economic systems of exchange. Their position brought them maize, possibly from the Fletcher site area or SA1034 on the Flint River. Also, this same network brought exotic cherts (Andrews 1995) and ceramics (Graves 1968). The mortuary variability of the site implies that the population may have wanted to secure its territory against intruders whose presence brought the foreign goods (Holman and Brashler 1996). The Frazer-Tyra population may have actually traded the same aquatic resources they were exploiting. Also, the secondary interments along with the permanent occupation of the site would suggest that the Frazer-Tyra population was trying to control the area around the Tittabawassee River.

Prehistoric Women and Economic Systems

Bio-archaeological studies allow us to establish the presence of women and men at a site, and through isotopic analysis, we can explore differences in the food they ate and potentially divergent roles within Late Woodland economies. Archaeologists have discussed issues surrounding the social status of Native American women, the health of reproductive women and infant mortality, and an overall engendering of the nature of human activity (Gero and Conkey 1991; Hastorf 1991; Katzenberg et al. 1993; Katzenberg and Pfieffer 1995; Watson and Kennedy 1991). Raemesch (1993) wrote of prehistoric Native American women as being the victims of violence and the potential source of conflicts between social units at the Riviere aux Vase site. Keene (1981) wrote that sites with a great variety of lithics, stored caches, and evidence of tool production is an indication of female presence as well as the long term occupation of a site (i.e. processing foods, tool production, and other chores) - not just the tools of male individuals involved in hunting activities. Norder et al. (2003) wrote that prehistoric Michigan mortuary patterns suggest that certain specialized roles were achieved by adult males and females during the Late Woodland and Historic periods. Burial goods indicated that females had prestigious positions but not the traditional prestige items of a male (i.e. beaver teeth, tool kits, etc.) and not the traditional burial items of a female (i.e. pots). It is possible that various visitors to the Saginaw Valley, during the Late Woodland period, brought foreign women into the Great Lakes region and that status may have been negotiated at the time of their arrival (Bender 1979; Norder et al. 2003).

Social activities associated with aggregation behavior in the Great Lakes region are likely to have included the arrangement of marriage alliances, feasting, competitions, negotiation of conflicts, the sharing of information, and the exchange of gifts (Holman and Brashler 1996, 1985; Krakker 1997). Perhaps aggregation can be viewed more as economic activity than simply opportunities to socialize. Krakker (1997:2-5) wrote that amongst Native Americans of the area, no social interaction was complete without the exchange of gifts, a social obligation but also an economic one. Aggregation behavior is economic and includes the sharing of information about available resources, negotiating the access and use of territories, making alliances, trading valued material items, and feasting are all economic activities. Marriage, for instance, is an economic arrangement in which goods and services are exchanged and heirs are produced. Young women may have been at the center of the social network that secured economic interests (i.e. exchanges, gifts, competitions, etc.). It is possible that this same regulatory system that brought in exotic cherts and a diversity of ceramics may have fostered the dispersal of domesticates using women as the vehicles to foster such exchanges.

Young women of the Frazer-Tyra population consumed more maize than older women, their male counterparts, and older men within the Frazer-Tyra population. Carbon and nitrogen ratios are based on life time patterns of consumption. These young women would have been consuming this product all of their lives, implying several possibilities: 1) they may have come from communities that cultivated the maize, not communities that acquired the maize through trade (i.e. Southern Ontario or nearby sites in the Saginaw Valley with tillable soil); 2) they may have had privileged access because of their reproductive roles; and/or 3) they may have had a maize rich diet because they had not transitioned from a maize enriched diet as youngsters into the normal adult diet that did not include a lot of maize. The variability of carbon ratios between female age groups could be interpreted along several lines. Bio-distance and DNA may shed more light on these differences. The implication that the variation in carbon ratios amongst females could be due to bio-distance and DNA would be very interesting. Populations in Southern Ontario and further south in Michigan may be possible targets for such an inquiry. Nitrogen ratios support the notion that the entire community relied upon aquatic resources and supplemented that diet with maize.

Future Research

The size of the sample population studied for this project was small and the lack of statistical significance was expected given the sample size. However, including other late Woodland populations in a comparative manner has compensated somewhat for the small sample size. The discussion of subsistence routines and maize adoption can certainly be explored further with additional stable isotopic analyses of Michigan's early native populations. Performing isotopic analysis on the sub-adult segment of the Frazer-Tyra population, for instance, using nitrogen ratios would allow archaeologists to test whether maize was incorporated as a food for weaning. Katzenberg *et al.* (1993) used nitrogen isotopes to establish weaning practices amongst prehistoric people. Also, using carbon and nitrogen ratios to perform a multi-regional analysis of Michigan would assist archaeologists in reconstructing subsistence routines in the various biotic provinces within the state. The latter type of study would require samples from populations from the southeastern corner of the state, the Upper Peninsula and the southwestern sector of the state. Rose (2008) conducted such a study to discuss trends in subsistence for Illinois using carbon and nitrogen isotopes for Middle Woodland to Mississippian cultures. To explore whether the Frazer-

Tyra population cultivated maize themselves, flotation samples could be collected from the site with the use of finer screens as Parker proposed (1996). Parker suggested refining our collection of samples may help answer pending questions surrounding maize adoption. Lastly, the applications of strontium and lead isotopes to explore the origin of Michigan's Late Woodland populations, particularly females, would be of great interest. It has been suggested that Mississippian intruders, as well as contact with Southern Ontario, may have been factors responsible for many of the cultural shifts of the Late Woodland. To explore the nature of that contact, lead and strontium isotopes could be employed using teeth and soil samples (Knudson 2008; Price *et al.* 2006). A discussion of biological contact along with economic systems could be generated with isotopic analysis in a regional study of Southeastern Michigan.

Appendix A

Collagen Extraction Procedure

The following is a description of the collagen extraction procedure adopted from the University of Western Ontario's L.S.I.S. Technical Memorandum #02-7 (August, 2002):

Step 1. Approximately 1.5g of bone was weighed, pulverized, and weighed again.

Step 2. Lipid Extraction

i) I added 20 ml/g of 20:10:8 methanol:chloroform:water solution to the pulverized bone sample in a 150ml beaker. The solution was stirred with a glass rod and the solution was quickly poured into a fritted glass filter, leaving as much of the bone in the beaker.

ii) The latter step was repeated 2 more times.

iii) I added 20 ml of methanol to the beaker to wash the sample into the filter. Methanol was used to help wash all of the material from the beaker into the filter.

iv) I dried the sample in the filter at room temperature under the fumehood. The sample was weighed again.

Step 3. Collagen Extraction

i) I added 40 ml of 0.25M of HCL to the sample to destroy the inorganic material of the bone. The sample was covered with plastic wrap and stored in a refrigerator. Because the pH is advised to be less than 2 during the leaching process, the pH of refrigerated samples was checked every 3 hours.

ii) After the sample had the desired consistency and appearance, the HCL was poured from the beaker into a centrifuge tube. The solution was centrifuged at the speed of 7500rpm for 9 minutes; at the WSU Geology laboratory, the time was doubled because the centrifuge's maximum speed was 3500rpm. Poured off the acid into a waste beaker.

iii) I washed any solids at the bottom of the centrifuge tube back into the beaker with acid. Added more fresh acid to the beaker to bring the volume up to 60-80 ml.

iv)The process of centrifuging and adding fresh acid was repeated until the solid collagen "ghosts" were translucent and felt spongy when pressed with a glass rod.

v) When the samples were ready, they were centrifuged to remove the acid, and then washed 3 times with distilled water. All of the sample was transferred to the centrifuge tube. The pH of the solution was checked; advised not to be over 3.

vi) The washed collagen ghosts were transferred to 60 ml glass bottles, and then brought up to volume with 10^{-3}M HCL. The pH was checked to be at the advised pH of 3. The glass bottles were covered with a piece of saran wrap, capped, and placed in a 90-95°C oven to solubilize the collagenous material for 6 hours. After 6 hours, the liquid was poured into a centrifuge tube and spun. The clear liquid was placed back in the 150 ml beaker (rinsed with distilled water) and placed in the drying oven to evaporate. Transferred any solids back to the glass vials, refilled the vials with 10^{-3}M HCL, and solubilized again for a minimum of 6 hours. Centrifuged the sample, and place the liquid in the 150 ml beaker to evaporate in the oven.

vii) Weighed out 10cc glass vials (without the lids) and recorded weights before the transfer of the collagen into them. When the level in the 150 ml beaker evaporated to approximately 10-15 ml, the solution was transferred to the smaller glass vial. Distilled water was used to rinse any collagen solution (from the beaker) into the small glass vial. When the samples in the small vials were completely dry, they were weighed again, and their weights (vial and yield) were recorded.

viii) The collagen, in the vials, was then frieze-dried and carefully ground to a powder using a flat-tipped spatula.

Appendix B

Frazer-Tyra Adult Population Included in Study (Females)

WSUMA Catalog #	Geology Lab#	Age Group	Sample Source
Females			
9W645	AM-34	I	MANDIBLE
9W640	AM-20	I	RIB
9W419	AM-17	I	RIB
9W660	AM-2	I	RIB
9W641	AM-8	I	RIB
9W348	AM-9	I	RIB
9W347:344	AM-6	I	RIB
9W611	AM-3	II	RIB
9W351	AM-12	II	RIB
9W642	AM-15	II	RIB
9W123	AM-23	II	MANDIBLE
9W733	AM-28	II	HUMERUS
9W658b	AM-29	II	HUMERUS
9W730	AM-30	II	HUMERUS
9W622a	AM-35	II	HUMERUS
9W734	AM-31	II	FEMUR
9W343	AM-1	III	RIB
9W214a	AM-25	III	HUMERUS
Total N= 18			

Appendix B

Frazer-Tyra Adult Population Included in Study (Males)

WSUMA Catalog #	Geology Lab#	Age Group	Sample Source
Males			
9W302	AM-33	I	MANDIBLE
9W644	AM-4	II	RIB
9W652a	AM-24	II	RIB
9W345:108	AM-21	II	RIB
9W658a	AM-22	II	RIB
9W215	AM-26	II	HUMERUS
9W345:345	AM-27	II	HUMERUS
9W585	AM-32	II	CRANIAL ELEMENT
9W774	AM-36	II	MANDIBLE
9W217	AM-10	III	RIB
9W657	AM-11	III	RIB
9W721	AM-13	III	RIB
9W659	AM-18	III	RIB
9W656	AM-19	III	RIB
9W214b	AM-37	III	MANDIBLE
Total N=15			

*1 adult 9w609 excluded due to extreme deterioration

Appendix C

Frazer-Tyra Population $\delta^{13}C$ and the $\delta^{15}N$ Results

Sample	WSU MA#	Wgt (mg) C	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{air}$	Calc. Val%C	Calc. Val%N	SEX (F1; M2)	AGE	C/N AR
AM-1	9w343	0.49	-15.27	12.65	40.89	14.76	1	3	3.23
AM-2	9w660	0.49	-17.15	13.1	40.91	14.84	1	1	3.21
AM-3	9w611	0.49	-15.82	12.54	41.59	15.09	1	2	3.21
AM-4	9w644	0.51	-15.67	12.75	41.19	15.08	2	2	3.19
AM-6	9w347: 344	0.52	-16.03	12.77	40.83	14.8	1	1	3.22
AM-8	9w641	0.5	-15.88	12.58	39.47	14.86	1	1	3.10
AM-9	9w348	0.51	-14.76	11.92	38.67	14.24	1	1	3.17
AM-10	9w217	0.49	-20.14	11.84	35	12.45	2	3	3.28
AM-11	9w657	0.49	-13.36	12.68	41.26	15.22	2	3	3.16
AM-12	9w351	0.51	-16.84	12.68	40.4	15.16	1	2	3.11
AM-13	9w721	0.51	-18.17	13.24	36.07	13.35	2	3	3.15
AM-15	9w642	0.49	-17.5	13.07	39.57	14.46	1	2	3.19
AM-17	9w419	0.489	-14.28	12.17	40.06	14.43	1	1	3.24
AM-18	9w659	0.522	-18.06	13.28	39.08	14.05	2	3	3.24
AM-19	9w656	0.497	-16.73	12.54	41.15	15.06	2	3	3.19
AM-20	9w640	0.467	-14.39	12.23	39.38	14.74	1	1	3.12
AM-21	9w345: 108	0.491	-16.29	12.93	39.06	14.36	2	2	3.17
AM-22	9w658a	0.525	-13.24	12.71	36.79	13.34	2	2	3.22
AM-23	9w123	0.50	-15.27	12.5	34.22	11.63	1	2	3.43
AM-24	9w652a	0.497	-17.01	11.65	25.86	9.67	2	2	3.12

Appendix C (con't)

Frazer-Tyra Population $\delta^{13}C$ and the $\delta^{15}N$ Results

Sample	WSU MA#	Wgt (mg) C	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{air}$	Calc. Val%C	Calc. Val%N	SEX (F1; M2)	AGE	C/N AR
AM-25	9w214a	0.495	-19.16	12.75	9.79	3.07	1	3	3.72
AM-26	9w215	0.495	-16.22	12.36	21.49	7.72	2	2	3.25
AM-27	9w345:345	0.537	-15.8	11.54	16.25	5.6	2	2	3.38
AM-28	9w733	0.528	-15.69	12.69	31.95	11.45	1	2	3.25
AM-29	9w658b	0.524	-15.52	12.9	30.33	11	1	2	3.22
AM-30	9w730	0.498	-16.74	12.28	37.23	13.5	1	2	3.22
AM-31	9w734	0.49	-15.4	12.39	36.02	12.95	1	2	3.24
AM-32	9w585	0.504	-17.57	12.54	28.17	9.93	2	2	3.31
AM-33	9w302	0.507	-19.05	12.89	35.96	13.32	2	1	3.15
AM-34	9w645	0.502	-16.53	12.46	34.66	12.78	1	1	3.16
AM-35	9w622a	0.517	-15.61	12.32	23.28	8.3	1	2	3.27
AM-36	9w774	0.483	-11.71	10.13	19.91	7.01	2	2	3.31
AM-37	9w214b	0.494	-16.77	12.45	29.53	10.5	2	3	3.28

Appendix D

Frazer-Tyra Population $\delta^{13}C$ and the $\delta^{15}N$ Results

Duplicates for Error Testing

Sample	Wgt (mg) C	$\delta^{13}C_{VPDB‰}$	$\delta^{15}N_{air‰}$	Calc.Val%C	Calc. Val%N	SEX (F1; M2)	AGE Group	C/N AR
L.S.I.S .								
AM-37(Dup)	0.499	-16.8	12.5	29.37	10.52	2	3	3.26
AM-24 (Dup)	0.49	-17.0	11.7	21.27	7.9	2	2	3.14
AM-27(Dup)	0.531	-15.8	11.7	16.48	5.73	2	2	3.35
AM-12(Dup)	0.51	-16.8	12.7	40.13	15.09	1	2	3.10
AM-1 (Dup)	0.5	-15.4	12.5	39.36	14.35	1	3	3.20
W.S.U.								
AM-7	0.51	-16.3	12.9	41.38	15.02	1	1	3.21
AM-16	0.51	-17.4	13.1	40.93	14.92	1	2	3.20
AM-5	0.51	-16.0	12.7	36.86	12.75	2	2	3.37
AM-14	0.51	-18.4	13.1	40.59	15.2	2	3	3.11

*Duplicates are noted for quality control of the mass spectrometer and laboratory discrepancies

Appendix E

Frazer-Tyra Cranial Measurements (Males)

Case WSU#	MxCrn Lng	Mx Cr Brdth	Bzy Dmtr	Bs-Brg Hgt	Crn-Bs Lng	Bs-Prsth Lng
9w108	-	140	-	145	-	-
9w217	184	130	-	132	108	103
9w585	182	-	-	131	-	-
9w659	156	135	-	135	103	-
9w657	186	125	-	132	102	93
9w609	176	138	-	131	104	-
9w721	190	137	143	141	107	94
Mean	**179**	**134**	**-**	**135**	**105**	**97**
Total	**n=6**	**n=6**	**n=1**	**n=7**	**N=5**	**n=3**

***Unit in Millimeters**

1. **MxCrn Lng-** Maximum Cranial Length (g-op)- distance between glabella and opisthocranion in the midsagittal plane, measure in a straight line
2. **MxCr Brdth-** Maximum Cranial Breadth (eu-eu)- maximum width of skull perpendicular to midsagittal palne whenever it is located with the exception of the exception of the inferior temporal lines and the area immediately surrounding them
3. **Bzy Dmtr-** Bizygomatic Diameter (zy-zy)- direct distance between most lateral points on the zygomatic arches
4. **BsBrg Hgt-** Basion-Bregma Height (ba-b)- direct distance from the lowest point on the anterior margin of foramen magnum
5. **CrnBs Lng-** Cranial Base Length (ba-n)- direct distance from nasion to basion
6. **BsPrsth Lng-** Basion-Prosthion Length (ba-pr)- direct distance from basion to prosthion

Appendix E Continued (Males)

Case WSU#	Mx Alv Brd	Mx Alv Lng	Biar Brd	Up Fc Hgt	Mn Frnt Brd	Up Fc Brd	Nas Hgt	Nas Brd
9w656	-	-	-	-	104	126	-	-
9w108	68	38	-	77	105	111	59	26
9w644	-	-	128	-	-	-	-	-
9w217	57	39	119	67	96	108	46	30
9w659	67	44	124	-	99	110	-	-
9w657	62	40	121	74	98	111	56	27
9w609	-	-	132	-	99	105	-	-
9w721	66	52	129	80	107	111	57	30
9w658a	-	37	-	-	-	-	-	-
Mean	64	42	126	75	101	112	55	28
Total	**n=5**	**n=6**	**n=6**	**n=4**	**n=7**	**n=7**	**n=4**	**n=4**

***Unit in millimeters**

1. **Mx Alv Brd-** Maxillo-Alveolar Breadth (ecm-ecm)- maximum breadth across the alveolar borders of the maxilla measured on the lateral surfaces at the location of the second maxillary molars(ecm)
2. **Mx Alv Lng-** Maxillo-Alveolar Length (pr-alv)-direct distance from prosthion to alveolon
3. **Biar Brd-** Biauricular Breadth (au-au)- least exterior breadth across the roots of the zygomatic processes(au) wherever found
4. **Up Fc Hgt-** Upper Facial Height (n-pr)-direct distance from nasion to prosthion
5. **Mn Frnt Brd-** Minimum Frontal Breadth (ft-ft)-direct distance between the two frontotemporale
6. **Up Fc Brd-** Upper Facial Breadth (fmt-fmt)-direct distance between the two external points on the frontomalar suture
7. **Nas Hgt-** Nasal Height (n-ns)-direct distance between from nasion to the midpoint of a line connecting the lowest points of the inferior margin of the nasal notches
8. **Nas Brd-** Nasal Breadth (al-al)-maximum breadth of the nasal aperture

Appendix E Continued (Males)

Case WSU#	Orb Brd	Orb Hgt	BiOrb Brd	InterOrb Brd	Frntl Chrd	Prtl Chrd	Occp Chrd	Frmn Mag Lng
9w656	-	-	-	-	-	102	-	-
9w108	46	36	104	24	124	115	-	-
9w644	-	-	-	-	-	-	95	-
9w217	48	37	104	25	111	115	92	40
9w585	-	-	-	-	-	116	91	39
9w659	-	-	-	-	116	121	91	39
9w657	38	34	101	24	111	112	93	41
9w609	43	32	-	24	89	105	84	39
9w721	42	39	103	27	104	117	95	39
Mean	**43**	**36**	**103**	**25**	**109**	**113**	**92**	**40**
Total	**n=5**	**n=5**	**n=4**	**n=5**	**N=6**	**n=8**	**n=7**	**n=6**

***Unit in millimeters**

1. **Orb Brd**- Orbital Breadth (d-ec)-laterally sloping distance from dacryon to ectoconchion
2. **Orb Hgt**- Orbital Height-direct distance between the superior and inferior orbital margins
3. **BiOrd Brd-** Biorbital Breadth (ec-ec)- direct distance between right and left ectoconchion
4. **InterOrb Brd**- Interorbital Breadth (d-d)-direct distance between right and left dacryon
5. **Frntl Chrd**- Frontal Chord (n-b)- direct distance from nasion to bregma taken in the midsagittal plane
6. **Prtl Chrd**- Parietal Chord (b-l)- direct distance from bregma to lambda taken in the midsagittal plane
7. **Occp Chrd**- Occipital Chord (l-o)- direct distance from lamda to opisthion taken in the midsagittal plane
8. **Frmn Mag Lng**- Foramen Magnum Length (ba-o)- direct distance from basion to opisthion

Appendix E Continued (Males)

Case WSU#	Frmn Mag Brd	Mstd Lng	Chin Hgt	Hgt Mnd Bdy	Brd Mnd Bdy	Bgnl Wdth
9w214b	-	-	27	30	17	108
9w108	-	28	35	37	12	106
9w774	-	-	24	27	10	-
9w644	-	29	34	31	-	-
9w217	28	29	29	31	10	97
9w302	-	-	35	34	11	94
9w585	-	33	-	-	-	-
9w659	-	28	30	32	27	
9w657	30	23	34	35	11	92
9w609	32	26	-	-	-	-
9w721	30	31	29	31	13	94
9w658a	-	-	33	34	10	95
Mean	**30**	**28**	**31**	**32**	**13**	**98**
Total	**n=4**	**n=8**	**n=10**	**n=10**	**n=9**	**n=7**

***Units in millimeters**

1. Frmn Mag Brd- Foramen Magnum Breadth- distance between the lateral margins of foramen magnum at the points of greatest lateral curvature
2. Mstd Lng- Mastoid Length- vertical projection of the mastoid process below and perpendicular to the eye-ear (Frankfort) plane.
3. Chin Hgt- Chin Height (id-gn)-direct distance from infradentale to gnathion
4. Hgt Mnd Bdy- Height of the Mandibular Body- direct distance from the alveolar process to the inferior border of the mandible perpendicular to the base at the level of the mental foramen
5. Brd Mnd Bdy- Breadth of the Mandibular Body- maximum breadth measured in the region of the mental foramen perpendicular to the long axis of the mandibular body
6. Bgnl Wdth- Bigonial Width- direct distance between right and left gonion

Appendix E Continued (Males)

Case WSU#	Bcndlyr Brd	Mn Rms Brd	Mx Rms Brd	Mx Rms Hgt	Mnd Lng
9w214b	124	38	43	62	103
9w108	-	32	42	67	93
9w774	119	37	41	70	101
9w217	118	34	40	60	84
9w302	121	34	41	62	84
9w659	145	38	41	63	91
9w657	-	36	42	62	84
9w721	130	30	45	69	85
9w658a	-	30	33	61	70
Mean	**127**	**34**	**41**	**64**	**88**
Total	**n=6**	**n=9**	**n=9**	**n=9**	**n=9**

*Unit in millimeters

1. **Bcndlyr Brd-** Bicondylar Breadth (cdl-cdl)- direct distance between the most lateral points on the two condyles
2**. Mn Rms Brd-** Minimum Ramus Breadth- least breadth of the mandibular ramus measured perpendicular to the height of the ramus
3. **Mx Rms Brd-** Maximum Ramus Breadth- distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on the condyle and the angle of the jaw
4. **Mx Rms Hgt**-Maximum Ramus Height- direct distance from the highest point on the mandibular condyle to gonion
5. **Mnd Lng-** Mandibular Length- distance of the anterior margin of the chin from a center point on the projected straight line placed along the posterior border of the two mandibular angles*

Appendix F

Frazer-Tyra Cranial Measurements (Females)

WSU Burial #	MxCrn Lng	Mx Cr Brdth	Bzy Dmtr	Bs-Brg Hgt	Crn-Bs Lng	Bs-Prsth Lng
9w214a	181	128	-	140	103	-
9w660	173	156	-	-	-	-
9w348	165	134	-	151	134	129
9w343	184	125	129	135	105	98
9w351	177	-	-	138	105	97
9w611	179	133	-	124	98	84
9w730	170	129	-	139	-	-
9w640	171	134	-	132	101	91
9w642	177	139	-	-	-	-
9w641	166	128	123	126	89	88
9w347:344	166	-	-	-	-	-
Mean	**174**	**134**	**126**	**136**	**105**	**98**
Total	**n=11**	**n=9**	**n=2**	**n=8**	**n=7**	**n=6**

***Unit in millimeters**

1. **MxCrn Lng-** Maximum Cranial Length (g-op)- distance between glabella and opisthocranion in the midsagittal plane, measure in a straight line
2. **MxCr Brdth-** Maximum Cranial Breadth (eu-eu)- maximum width of skull perpendicular to midsagittal palne whenever it is located with the exception of the exception of the inferior temporal lines and the area immediately surrounding them
3. **Bzy Dmtr-** Bizygomatic Diameter (zy-zy)- direct distance between most lateral points on the zygomatic arches
4. **BsBrg Hgt-** Basion-Bregma Height (ba-b)- direct distance from the lowest point on the anterior margin of foramen magnum
5. **CrnBs Lng-** Cranial Base Length (ba-n)- direct distance from nasion to basion
6. **BsPrsth Lng-** Basion-Prosthion Length (ba-pr)- direct distance from basion to prosthion

Appendix F Continued (Females)

WSU Burial #	Mx Alv Brd	Mx Alv Lng	Biar Brd	Up Fc Hgt	Mn Frnt Brd	Up Fc Brd	Nas Hgt	Nas Brd
9w214a	-	-	123	-	96	-	-	-
9w660	69	57	137	-	105	103	-	-
9w348	60	31	127	61	98	102	47	28
9w343	59	52	129	62	96	106	36	28
9w351	58	52	124	60	96	106	44	27
9w611	-	-	118	-	90	96	-	-
9w730	-	-	119	-	98	-	-	-
9w640	67	47	128	62	107	103	46	28
9w642	-	47	127	-	94	-	-	-
9w641	59	50	118	64	97	95	46	21
Mean	**62**	**48**	**125**	**62**	**98**	**102**	**44**	**26**
Total	**n=6**	**n=7**	**n=10**	**n=5**	**N=10**	**n=7**	**n=5**	**n=5**

***Unit in millimeters**

1. **Mx Alv Brd**- Maxillo-Alveolar Breadth (ecm-ecm)- maximum breadth across the alveolar borders of the maxilla measured on the lateral surfaces at the location of the second maxillary molars(ecm)
2. **Mx Alv Lng-** Maxillo-Alveolar Length (pr-alv)-direct distance from prosthion to alveolon
3. **Biar Brd-** Biauricular Breadth (au-au)- least exterior breadth across the roots of the zygomatic processes(au) wherever found
4. **Up Fc Hgt-** Upper Facial Height (n-pr)-direct distance from nasion to prosthion
5. **Mn Frnt Brd**- Minimum Frontal Breadth (ft-ft)-direct distance between the two frontotemporale
6. **Up Fc Brd**- Upper Facial Breadth (fmt-fmt)-direct distance between the two external points on the frontomalar suture
7. **Nas Hgt-** Nasal Height (n-ns)-direct distance between from nasion to the midpoint of a line connecting the lowest points of the inferior margin of the nasal notches
8. **Nas Brd-** Nasal Breadth (al-al)-maximum breadth of the nasal aperture

Appendix F Continued (Females)

WSU Burial #	Orb Brd	Orb Hgt	BiOrb Brd	InterOrb Brd	Frntl Chrd	Prtl Chrd	Occp Chrd	Frmn Mag Lng
9w214a	-	-	-	21	123	112	91	36
9w660	-	-	-	-	110	113	-	-
9w348	38	35	-	22	108	103	93	37
9w343	43	36	106	22	114	111	93	39
9w351	41	36	100	21	113	107	94	38
9w611	40	36	-	21	100	102	93	33
9w730	-	-	-	-	89	103	86	37
9w640	42	31	100	21	111	97	88	38
9w642	-	-	-	24	99	103	-	-
9w641	38	32	89	20	102	114	90	37
9w347:344	-	-	-	-	-	100	-	-
Mean	**40**	**34**	**99**	**21**	**107**	**106**	**91**	**37**
Total	**n=6**	**n=6**	**n=4**	**n=8**	**n=10**	**n=11**	**n=8**	**n=8**

***Units in millimeters**

9. **Orb Brd**- Orbital Breadth (d-ec)-laterally sloping distance from dacryon to ectoconchion
10. **Orb Hgt**- Orbital Height-direct distance between the superior and inferior orbital margins
11. **BiOrd Brd**- Biorbital Breadth (ec-ec)- direct distance between right and left ectoconchion
12. **InterOrb Brd**- Interorbital Breadth (d-d)-direct distance between right and left dacryon
13. **Frntl Chrd**- Frontal Chord (n-b)- direct distance from nasion to bregma taken in the midsagittal plane
14. **Prtl Chrd-** Parietal Chord (b-l)- direct distance from bregma to lambda taken in the midsagittal plane
15. **Occp Chrd**- Occipital Chord (l-o)- direct distance from lamda to opisthion taken in the midsagittal plane
16. **Frmn Mag Lng**- Foramen Magnum Length (ba-o)- direct distance from basion to opisthion

Appendix F Continued (Females)

WSU Burial #	Frmn Mag Brd	Mstd Lng	Chin Hgt	Hgt Mnd Bdy	Brd Mnd Bdy	Bgnl Wdth
9W214a	30	29	37	38	9	96
9W660	-	29	29	31	14	101
9W348	36	24	27	24	19	109
9W343	30	24	31	17	10	104
9W351	31	24	27	22	11	106
9W611	31	18	-	-	-	-
9W730	36	-	-	27	11	-
9W658b	-	21	-	-	-	-
9W640	32	22	25	28	10	-
9W642	-	27	25	28	9	114
9W641	31	23	32	31	9	96
9W347:344	-	22	29	27	11	-
Mean	**32**	**24**	**29**	**27**	**11**	**104**
Total	**n=8**	**n=11**	**n=9**	**n=10**	**n=10**	**n=7**

***Unit in millimeters**

1. Frmn Mag Brd- Foramen Magnum Breadth- distance between the lateral margins of foramen magnum at the points of greatest lateral curvature
2. Mstd Lng- Mastoid Length- vertical projection of the mastoid process below and perpendicular to the eye-ear (Frankfort) plane.
3. Chin Hgt- Chin Height (id-gn)-direct distance from infradentale to gnathion
4. Hgt Mnd Bdy- Height of the Mandibular Body- direct distance from the alveolar process to the inferior border of the mandible perpendicular to the base at the level of the mental foramen
5. Brd Mnd Bdy- Breadth of the Mandibular Body- maximum breadth measured in the region of the mental foramen perpendicular to the long axis of the mandibular body
6. Bgnl Wdth- Bigonial Width- direct distance between right and left gonion

Appendix F Continued (Females)

WSU Burial #	Bcndlyr Brd	Mn Rms Brd	Mx Rms Brd	Mx Rms Hgt	Mnd Lng
9w214a	-	32	45	60	70
9w660	124	35	44	58	77
9w348	129	35	40	53	80
9w343	126	28	36	49	78
9w351	135	32	42	59	81
9w640	-	34	43	54	87
9w642	124	33	40	52	83
9w641	113	30	37	58	87
9w347:344	117	35	44	-	-
Mean	**124**	**33**	**41**	**55**	**80**
Total	**n=7**	**n=9**	**n=9**	**n=8**	**n=8**

***Unit in millimeters**

1. **Bcndlyr Brd-** Bicondylar Breadth (cdl-cdl)- direct distance between the most lateral points on the two condyles
2**. Mn Rms Brd-** Minimum Ramus Breadth- least breadth of the mandibular ramus measured perpendicular to the height of the ramus
3. **Mx Rms Brd-** Maximum Ramus Breadth- distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on the condyle and the angle of the jaw
4. **Mx Rms Hgt**-Maximum Ramus Height- direct distance from the highest point on the mandibular condyle to gonion
5. **Mnd Lng-** Mandibular Length- distance of the anterior margin of the chin from a center point on the projected straight line placed along the posterior border of the two mandibular angles*

Appendix G

Frazer-Tyra Cranial Indices (Males)

Case WSU#	Height Length	Height Breadth	Fronto-Parietal	Cranial Facial	Cranial Module	Cranial Index	Orbital	Nasal	Upper Facial	Gnathic	Zygo-Frontal
9W657	70.97	105.6	78.4	-	147.66	67.20	89.5	48.2	-	91.17	-
9W659	72.6	100	73.0	-	152	72.58	-	-	-	-	-
9W610:609	74.43	94.9	71.73	-	148.33	78.41	74.42	-	-	-	-
9W217	71.74	101.5	73.8	-	148.66	70.65	77.08	65.2	-	95.37	-
9W721	74.21	102.91	78.1	104.38	156	72.11	92.9	52.6	-	87.9	74.8
9W345:108	-	103.6	75.0	-	-	-	78.3	44.06	-	-	-
9W585	71.98	-	-	-	-	-	-	-	-	-	-
Mean	72.66	101.42	75.0	-	150.53	72.19	82.44	52.52	-	91.48	-
Total	**n=6**	**n=6**	**n=6**	**n=1**	**n=5**	**n=5**	**N=5**	**n=4**	**n=0**	**n=3**	**n=1**

Key:

Height-Length- H/L- cranial height/length

Height –Breadth- H/B- cranial height/breadth

Fronto-Parietal- MF/B- min frontal breadth/breadth

Cranial Facial- BZ/B- bizygomatic diameter/breadth

Cranial Module- Cranial length, breadth and height/3

Cranial Index Bass- Max Cranial Breadth x100/max cranial length

Orbital- OH/OW- Orbital Height/Width (breadth)

Nasal- NW/NH- nasal width/nasal height

Upper Facial- NA/BZ- nasion alveolar/bizygomatic breadth

Gnathic- BP/BN-endobasion-prosthion/endobasion nasion

Zygo-Frontal- MF/BZ-min frontal breadth/bizygomatic breadth

Appendix H

Frazer-Tyra Cranial Indices (Females)

Case WSU#	Height Length	Height Breadth	Fronto-Parietal	Cranial Facial	Cranial Module	Cranial Index	Orbital	Nasal	Upper Facial	Gnathic	Zygo-Frontal
9W660	-	-	67.31	-	-	90.17	-	-	-	-	-
9W348	91.51	112.7	73.13	-	150	81.21	0.9211	0.5957	-	78.42	-
9W640	77.19	98.51	79.85	-	145.67	78.36	0.7381	0.6087	-	90.10	-
9W641	75.9	98.44	75.78	96.09	140	77.11	0.8421	0.5217	52.03	98.9	78.86
9W730	81.77	108.0	75.96	-	146	75.88	-	-	-	-	-
9W351	75.14	-	-	-	-	-	0.878	0.6136	-	92.38	-
9W611	69.27	93.23	67.67	-	145.33	74.30	0.9	-	-	85.71	-
9W642	-	-	67.6	-	-	78.53	-	-	-	-	-
9W343	73.37	108.0	76.8	103.2	148	67.93	0.837	0.777	48.06	93.3	74.4
9W214a	77.35	109.0	75	-	149.67	70.72	-	-	-	-	-
Mean	**77.69**	**103.99**	**73.23**	**99.65**	**146.38**	**77.13**	**85.27**	**62.33**	**50.05**	**89.8**	**76.63**
Total	**n=8**	**n=7**	**n=9**	**n=2**	**n=7**	**n=9**	**n=6**	**n=5**	**n=2**	**n=6**	**n=2**

Key:

Height-Length- H/L- cranial height/length

Height –Breadth- H/B- cranial height/breadth

Fronto-Parietal- MF/B- min frontal breadth/breadth

Cranial Facial- BZ/B- bizygomatic diameter/breadth

Cranial Module- Cranial length, breadth and height/3

Cranial Index Bass- Max Cranial Breadth x100/max cranial length

Orbital- OH/OW- Orbital Height/Width (breadth)

Nasal- NW/NH- nasal width/nasal height

Upper Facial- NA/BZ- nasion alveolar/bizygomatic breadth

Gnathic- BP/BN-endobasion-prosthion/endobasion nasion

Zygo-Frontal- MF/BZ-min frontal breadth/bizygomatic breadth

Appendix I

Frazer-Tyra Post-Cranial Measurements (Males)

Male Long Bone Measurements: Humerus

WSU Burial	Hmr Mx Lng		Hmr Epi Brd		Hmr Vrt Dmtr Hd		Hmr Mx Dmtr Mdshft		Hmr Mn Dmtr Mdshft	
	right	left	right	left	right	left	right	left	Right	left
9w215	341	338	69	67	44	45	24	24	17	16
9w108	316	305	-	-	-	-	20	-	13	-
9w345	316	312	59	-	45	44	22	23	15	16
9w658a	-	323	-	-	-	-	-	-	-	-
9w721	340	-	60	-	46	-	24	-	18	-
Mean	**328**	**320**	**63**	**-**	**45**	**45**	**23**	**24**	**16**	**16**
Total	**n=4**	**n= 4**	**n=3**	**n=1**	**n=3**	**n= 2**	**n=4**	**n= 2**	**n=4**	**n= 2**

***Unit measurements in millimeters**

1. Hmr Mx Lng- Humerus Maximum Length- direct distance from the most superior point on the head of the humerus to the most inferior point on the trochlea
2. Hmr Epi Brd- Humerus Epicondylar Breadth- distance of the most laterally protruding point on the lateral epicondyle from the corresponding projection of the medial epicondyle
3. Hmr Vrt Dmtr Hd- Humerus Vertical Diameter of Head- direct distance between the most superior and inferior points on the border of the articular surfaces
4. Hmr Mx Dmtr MdShft- Humerus Maximum Diameter at Midshaft- maximum diameter at midshaft
5. Hm Mn Dmtr Mdshft- Humerus Minimum Diameter at Midshaft-minimum diameter at midshaft

Appendix I

Male Long Bone Measurements: Femur

WSU Burial	Side	9w652a	9w215	9w345	9w659	Mean	Total
Fmr Mx Lng	right	-	480	457	-		
	left	-	479	454	475	469	n=3
FmrBicn Lng	right	-	-	450.5	-	-	n=1
	left	-	-	452	472	462	n=2
Fmr Epi Brd		-	-	-	-	-	n=0
Fmr Mx Dmt	right	50	-	46	45	47	n=3
	left	-	-	-	46	-	n=1
Fmr A-P	right	-	-	29	25	27	n=2
	left	-	-	26	27	27	n=2
Fmr M-L Sbtrc	right	30		21	37	29	n=3
	left	-	-	22	39	31	n=2
Fmr AP Mdsft	right	28		28	-	28	n=2
	left	-	-	27	33	30	n=2
Fmr M-L	right	-		22	-	-	n=1
	left	-	-	22	29	26	n=2
Fmr Mdshft	right	-		90	-	-	n=1
	left	-		89	96	93	n=2

***Unit measurements in millimeters**

1. Fmr Mx Lng- Femur Maximum Length- distance from the most superior point on the head of the femur to the most inferior point on the distal condyles
2. FmrBicn Lng- Femur Bicondylar Length- distance from the most superior point on the head to a plane drawn along the inferior surfaces of the distal condyles
3. Fmr Epi Brd- Femur Epicondylar Breadth- distance between the two most laterally projecting points on the epicondyles
4. Fmr Mx Dmtr Fmr Hd- Femur Maximum Head Diameter- the maximum diameter of the femur head
5. Fmr A-P SubtrDmtr- Femur Anterior-Posterior (Sagittal) Subtrochanteric Diameter- distance between anterior and posterior surfaces at the proximal end of the diaphysis, measured perpendicular to the medial-lateral diameter
6. Fmr M-LSbtrchDmtr- Femur Medial-Lateral (Transverse) Subtrochanteric Diameter- distance between medial and lateral surfaces of the proximal end of the diaphysis at point of its greatest lateral expansion below the base of the lesser trochanter
7. Fmr AP Mdsft Dmtr- Femur Anterior-Posterior (Sagittal) Midshaft Diameter- distance between anterior and posterior surfaces measured approximately at the midpoint of the diaphysis, at the highest elevation of linea aspera
8. Fmr M-L Mdshft Dtr- Femur Medial-Lateral (Transverse) Midshaft Diameter- distance between the medial and lateral surfaces at midshaft. Measured perpendicular to the anterior-posterior diameter
9. Fmr Mdshft Circ- Femur Midshaft Circumference- circumference measured at the level of the midshaft diameters (#7 and #8)

Appendix I

Male Long Bone Measurements: Tibia

WSU Burial	Tib Lng		Tib MxPrxE Brd		Tib Mx DstE Brd		Tib MxDmtr NF		Tib M-LDmtr NF		Tib Circ NF	
	right	left	right	left	right	left	right	left	right	left	right	left
9w215	-	403	78	-	73	75	31	34	24	23	93	96
9w345	387	387	-	76	45	44	32	35	21	20	97	95
9w659	-	413	-	0	-	52	-	24	-	37	-	100
9w652a	394	-	-	-	51	-	38	-	26	-	-	-
Mean	**391**	**401**	**-**	**-**	**56**	**57**	**34**	**31**	**24**	**27**	**95**	**97**
Total	**n=2**	**n=3**	**n=1**	**n=1**	**n=1**	**n=3**	**n=3**	**n=3**	**n=3**	**n=3**	**n=2**	**n=3**

***Unit measurements in millimeters**

1. Tib Lng- Tibia Length- distance from the superior articular surface of the lateral condyle to the tip of the medial malleolus
2. Tib MxPrxEBrd- Tibia Maximum Proximal Epiphyseal Breadth- maximum distance between the two most laterally projecting points on the medial and lateral condyles of the proximal articular region (epiphysis)
3. Tib Mx DstE Brd- Tibia Maximum Distal Epiphyseal Breadth- maximum distance between the two most laterally projecting points on the medial malleolus and the lateral surface of the distal articular region (epiphysis)
4. Tib MxDmtr NF- Tibia Maximum Diameter at the Nutrient Foramen- distance between the anterior crest and the posterior surface at the level of the nutrient foramen
5. Tib M-LDmtr NF-Tibia Medial-Lateral (Transverse) Diameter at the Nutrient Foramen- straight line distance of the medial margin from the interosseous crest at the level of the nutrient foramen
6 Tib Circ NF- Tibia Circumference at the Nutrient Foramen- circumference measured at the level of the nutrient foramen

Appendix J

Frazer-Tyra Post-Cranial Measurements (Females)

Female Long Bone Measurements: Humerus

WSU Burial	Hmr Mx Lng		Hmr Epi Brd		Hmr Vrt Dmtr Hd		Hmr Mx Dmtr Mdshft		Hmr Mn Dmtr Mdshft	
	right	left	right	left	right	Left	right	left	right	Left
9w214a	-	310	-	38	-	39	-	15	-	12
9w660	306	-	54	-	41	40	-	-	-	-
9w733	-	-	62	61.5	40	-	-	-	-	-
9w351	306	303	59	59	40	40	20	20	14	13
9w641	-	-		-	-	36	-	-	-	-
9w658a	323	-	-	-	40	-	20	-	12	-
Mean	**312**	**307**	**58**	**53**	**40**	**39**	**20**	**18**	**13**	**13**
Total	**n=3**	**n=2**	**n=3**	**n=3**	**n=4**	**n=4**	**n=2**	**n=2**	**n=2**	**N=2**

***Unit in millimeters**

1. Hmr Mx Lng- Humerus Maximum Length- direct distance from the most superior point on the head of the humerus to the most inferior point on the trochlea
2. Hmr Epi Brd- Humerus Epicondylar Breadth- distance of the most laterally protruding point on the lateral epicondyle from the corresponding projection of the medial epicondyle
3. Hmr Vrt Dmtr Hd- Humerus Vertical Diameter of Head- direct distance between the most superior and inferior points on the border of the articular surfaces
4. Hmr Mx Dmtr MdShft- Humerus Maximum Diameter at Midshaft- maximum diameter at midshaft
5. Hm Mn Dmtr Mdshft- Humerus Minimum Diameter at Midshaft-minimum diameter at midshaft

Appendix J

Female Long Bone Measurements: Femur

WSU Burial		9W214a	9W733	9W658b	9W642	9W641	Mean	Total
Fmr Mx Lng	right	-	458	448	-	-	453	n=2
	left	453	-	451	-	438	447	n=3
FmrBicn Lng	right	-	449	447	-	-	448	n=2
	left	450	-	448	-	433	444	n=3
Fmr Epi Brd	right	-	-	-	-	-	-	n=0
	left	59	-	-	-	68	64	n=2
Fmr Mx Dmtr Fmr Hd	right	39	43	-	-	-	41	n=2
	left	39	-	43	41	37	40	n=4
Fmr A-P SubtrDmtr	right	-	28	27	-	-	28	n=2
	left	43	26	26	24	21	28	n=5
Fmtr mr M-LSbtrchDmtr	Right	-	23	-	-	-	-	n=1
	left	26	24	29	22	19	24	n=5
Fmr AP Mdsft Dmtr	right	-	27	28	-	-	28	n=2
	left	22	-	28	-	22	24	n=3
Fmr M-L Mdshft	right	-	23	23.5	-	-	23	n=2
	left	27	-	25	-	22	25	n=3
Fmr Mdshft	right	-	85	85	-	-	85	n=2
	left	80	-	86	-	75	80	n=3

***Unit in millimeters**

1. Fmr Mx Lng- Femur Maximum Length- distance from the most superior point on the head of the femur to the most inferior point on the distal condyles
2. FmrBicn Lng- Femur Bicondylar Length- distance from the most superior point on the head to a plane drawn along the inferior surfaces of the distal condyles
3. Fmr Epi Brd- Femur Epicondylar Breadth- distance between the two most laterally projecting points on the epicondyles
4. Fmr Mx Dmtr Fmr Hd- Femur Maximum Head Diameter- the maximum diameter of the femur head
5. Fmr A-P SubtrDmtr- Femur Anterior-Posterior (Sagittal) Subtrochanteric Diameter- distance between anterior and posterior surfaces at the proximal end of the diaphysis, measured perpendicular to the medial-lateral diameter
6. Fmr M-LSbtrchDmtr- Femur Medial-Lateral (Transverse) Subtrochanteric Diameter- distance between medial and lateral surfaces of the proximal end of the diaphysis at point of its greatest lateral expansion below the base of the lesser trochanter
7. Fmr AP Mdsft Dmtr- Femur Anterior-Posterior (Sagittal) Midshaft Diameter- distance between anterior and posterior surfaces measured approximately at the midpoint of the diaphysis, at the highest elevation of linea aspera
8. Fmr M-L Mdshft Dtr- Femur Medial-Lateral (Transverse) Midshaft Diameter- distance between the medial and lateral surfaces at midshaft. Measured perpendicular to the anterior-posterior diameter
9. Fmr Mdshft Circ- Femur Midshaft Circumference- circumference measured at the level of the midshaft diameters (#7 and #8)

Appendix J

Female Long Bone Measurements: Tibia

WSU Burial	Tib Lng		Tib MxPrxE Brd		Tib Mx DstE Brd		Tib MxDmtr NF		Tib M-LDmtr NF		Tib Circ NF	
	right	left	right	left	right	left	right	left	right	left	right	left
9w733	384	383	74	74	48	46	37	36	28	22	100	99
9w641	-	358	-	64	-	44	-	28	-	15	-	78
Mean	**-**	**371**	**-**	**69**	**-**	**45**	**-**	**32**	**-**	**19**	**-**	**89**
Total	**n=1**	**n=2**	**n=1**	**n=2**	**n=1**	**n=2**	**n=1**	**n=2**	**n=1**	**n=2**	**n=1**	**n=2**

***Unit in millimeters**

1. Tib Lng- Tibia Length- distance from the superior articular surface of the lateral condyle to the tip of the medial malleolus
2. Tib MxPrxEBrd- Tibia Maximum Proximal Epiphyseal Breadth- maximum distance between the two most laterally projecting points on the medial and lateral condyles of the proximal articular region (epiphysis)
3. Tib Mx DstE Brd- Tibia Maximum Distal Epiphyseal Breadth- maximum distance between the two most laterally projecting points on the medial malleolus and the lateral surface of the distal articular region (epiphysis)
4. Tib MxDmtr NF- Tibia Maximum Diameter at the Nutrient Foramen- distance between the anterior crest and the posterior surface at the level of the nutrient foramen
5. Tib M-LDmtr NF-Tibia Medial-Lateral (Transverse) Diameter at the Nutrient Foramen- straight line distance of the medial margin from the interosseous crest at the level of the nutrient foramen
6 Tib Circ NF- Tibia Circumference at the Nutrient Foramen- circumference measured at the level of the nutrient foramen

REFERENCES

Ambrose, S. H. (1993). Isotopic Analysis of Paleodiets. *In Methodological and Interpretive Considerations in Investigations of Ancient Human Tissue: Chemical Analyses in Anthropology*. Langhorne, VA: Gordon and Breach Science Publishers.

Ambrose, S. and Katzenberg, M. A. (eds.), (2000). *Biogeochemical Approaches to Paleodietary Analysis*. New York: Kluwer Academic/Plenum Publishers.

Angel, J. L., Kelly, J. O., Parringtton, M., Pinter, S. (1987). Life Stresses of the Free Black Community as Represented by The First African Baptist Church, 8th and Vine Streets. Philadelphia, 1824-1846. *American Journal of Physical Anthropology*, 74, 213-229

Angel, J. L., (1976). Colonial to Modern Skeletal Changes in the U.S.A. *American Journal of Physical Anthropology*, 45, 723-735

Andrews, J. P. (1995). A Lithic Analysis of The Frazer-Tyra Site (20SA9). *The Michigan Archaeologist*, 41 (4), 139-200

Barondess, D. (1998). *Anthropometric and BioMechanical Assessment of Skeletal Structural Adaptations in Bioarchaeological Populations from Michigan and Western New York.* Ph.D. dissertation Michigan State University. Ann Arbor: UMI Dissertation Services.

Baskaran, M., Hong, G. H., Kim, S. H., and Wardle, W. J. (2005). Reconstructing Seawater Column Sr90 based upon Pb/Ra Disequilibrium dating of mollusk Shells. *Applied Geochemistry*, 20, 1965-1973.

Baskaran, M., Hong, G. H., Dayton, S., Bodkin, J. L., and Kelly, J. J. (2003). Temporal Variations of Natural and Anthropogenic Radionuclides in Sea Otter Skull tissue in The North Pacific Ocean. *Journal of Environmental Radioactivity*, 64, 1-18.

Bass, W. (2005). *Human Osteology: A Laboratory and Field Manual 5th Ed.* Missouri Archaeological Society, Special Publication No.2. Columbia.

Bender, M. M., Baerreis, D. and Steventon, R. L. (1981). Further Light on Carbon Isotopes and Hopewell Agriculture. *American Antiquity*, 46 (2), 346-353

Bender, S. M. (1979). Paleodemographic Analysis of a Late Woodland Site in Southeastern Michigan. *Midcontinental Journal of Archaeology*, 4, 183-208

Bigony, B. A. (1970). Late Woodland Occupations of The Saginaw Valley. *The Michigan Archaeologist*, 16 (3-4), 115-214.

Binford, L. (1990). Mobility, Housing, and Environment: A Comparative Study. *Journal of Anthropological Research*, 46,119-152.

Blakey, M. L. (2001). Bioarchaeology of African Diaspora in the Americas. *Annual Review of Anthropology*, 30, 387-422.

Blakey, M. L. (1986). Fetal and Childhood Health in Late 18th and Early 19th century Afro-Americans: Enamel Hypoplasia and Hypocalcification in the FABC Skeletal Population. *American Journal of Physical Anthropology* 72, 179 (abstract).

Blakey, M., Leslie, T. E., and Reidy, J. P. (1994). Frequency and Chronological Distributions of Dental Enamel Hyoplasia in Enslaved African Americans: A Testing of the Weaning Hypothesis. *American Journal of Physical Anthropology*, 95 (4), 371-383

Branstner, M. (1990). *The Great Lakes Gas Transmission Company Natural Gas Pipeline Corridor (MP562.6-972.9): A preliminary Sensitivity Model and Testing Strategy*. Generated under auspices of Great Lakes Research, Williamston, MI.

Brashler, J. and Holman, M. (1985). Late Woodland Continuity and Change in the Saginaw Valley of Michigan. *Artic Anthropology*, 22 (2), 141-152.

Brose, D. (1978). Late Prehistory of the Upper Great Lakes. In *Handbook of North American Indians Vol. 15.* (569-582). D.C.: Smithsonian Institution.

Buikstra, J. (1981). Diet and Disease in Prehistory In *Current Directions in Midwestern Archaeology.* Occas. Publications in *Minnesota Anthropology* No. 9: 56.

Buikstra, J. E. and Charles, D. (1999). Centering the Ancestors: Cemeteries, Mound, and Sacred Landscapes of the Ancient North American Midcontinent. In Ashmore, W. and Knapp, B. (eds.), *Archaeologies of Landscape: Contemporary Perspectives*. (201-228). Oxford: Blackwell.

Buikstra, J. and Ubelaker, D. (1994). Measurements and Standards for Data Collection from Human Skeletal Remains. *Arkansas Archaeological Survey Research Series* No. 44.

Cleland, C. E. (1982). The Inland Shore Fishery of the Northern Great Lakes: Its Development and Importance in Prehistory. *American Antiquity*, 47 (4), 761-784.

Cleland, C. E. (1971). The Lasanen Site: An Historic Burial Locality in Mackinac County, Michigan. *Museum of Michigan State University Anthropological Series* Vol. 1.

Cleland, C. E. (1966). The Prehistoric Anima; Ecology and Ethnozoology of the Upper Great Lakes Region. In Anthropological Papers No. 29 Museum of Anthropology. Ann Arbor, MI: University of Michigan.

Crist, T. (1995). Bone Chemistry Analysis and Documentary Archaeology: Dietary Patterns of Enslaved African Americans in the South Carolina Low Country. In Grauer, A. (ed.), *Bodies of Evidence: Reconstructing History Through Skeletal Analysis,* (197-220). New York: Wiley-Liss Inc.

Corruccini, R. S., Handler, J., Aufderheide, A., and Wittmers, L., Jr. (1987). Patterning of Skeletal Lead Content in Barbados Slaves. *Archaeometry*, 29, 233-239

Deniro, M. J. and Schoeninger, M. J. (1983). Stable Carbon and Nitrogen Isotope Ratios of Bone Collagen: Variations within Individuals, Between Sexes, and Within Populations Raised on Monotonous Diets. *The Journal of Archaeological Science*, 10, 199-203.

Dunham, S. (2000). Cache Pits: Ethnohistory, Archaeology, and the Continuity of Tradition. In Nassaney, M. S. and Johnson, E. S. (eds.), *Interpretations of Native North American Life: Material Contributions to Ethnohistory*. (225-260). Gainesville, Fl: University Press of Florida.

Dustin, F. (1968). Saginaw Valley Archaeology. *The Michigan Archaeologist*, 14 (1-2), 1-30.

Echo-Hawk, R. (1997). Forging a New Ancient History for Native Americans. In Anyon, R. (ed.), *Native Americans and Archaeologists: Stepping Stones to Common Ground*, (88-102). Walnut Creek, CA: Alta Mira Press.

Faure, Gunter and Mensing, T. (2005). *Isotopes: Principles and Applications*. New York: John Wiley and Sons.

Fischoff, Arlene and Porter, S (n.p.d.). *Methods in Physical Anthropology: Tyra Collection.* Manuscript # 11W547 (1983) Wayne State University Museum of Anthropology.

Fitting, J. (1975). *The Archaeology of Michigan*. Bulletin 56. Bloomfield Hills, MI: Cranbrook Institute of Science.

Fitting, J. (1965) Late Woodland Cultures of Southeastern Michigan. *Anthropological Papers Museum of Anthropology*, No.24, Ann Arbor, MI: University of Michigan.

Gero, J. M. and Conkey, M. (eds.), (1991). *Engendering Archaeology: Women in Prehistory*. Oxford: Basil Blackwell Ltd.

Ginter, J. (2005). A Test of the Effectiveness of The Revised maxillary Suture Obliteration Method in Estimating Adult Age at Death. *Journal of Forensic Sciences*, 50 (6), 1303-1309

Graves, Arthur H. (n.p.d.). *The Tyra Site presented to The Michigan Archaeological Society*. Manuscript #11W547b (1968) Wayne State University Museum of Anthropology.

Greenman, Emerson. (1937). *The Younge Site: An Archaeological Record from Michigan*. Ann Arbor, MI: University of Michigan Press.

Griffin, James. (1976). The Prehistory of Ohio Valley *In Handbook of North American Indians Vol. 15*: 547-568. D.C.: Smithsonian Institution.

Gruspier, Kathy L. and Mullen, G. (1991). Maxillary Suture Obliteration: A Test of the Mann Method. *Journal of Forensic Sciences*, 36 (2), 512-519

Halsey, John R. (1999). Late Woodland Burial Practices. In Halsey, J. R. (ed.), *Retrieving Michigan Buried Past*. (234-241). Bloomfield Hills, MI: Cranbrook Institute of Science.

Halsey, John R. (1976). *The Bussinger Site: a Multicomponent Site in The Saginaw Valley of Michigan with a Review of Early Late Woodland Mortuary Complexes in the Northeastern Woodlands*. *Unpublished dissertation*. Chapel Hill Press: University of North Carolina.

Hastorf, Christine A. (1991). Gender, Space, and Food in Prehistory. In Gero, J. and Conkey, M, (eds.), *Engendering Archaeology: Women and Prehistory*. (132-162). Oxford: Basil Blackwell Ltd.

Hodder, Ian. (2003). *Archaeology Beyod Bialogue*. Salt Lake City, UT: The University of Utah Press.

Hodder, Ian. (1995) Material Culture in Time. In Hodder, I. et al. (eds.), *Interpreting Archaeology: Find Meaning in The Past*. (164-168). London: Routledge.

Hodder, Ian. (1991). Reading the Past: Current Approaches to Interpretation in Archaeology. Cambridge: Cambridge University press.

Holman, M. and Brashler, J. (1999). Economics, Material Culture, and Trade in the Late Woodland Lower Peninsula of Michigan. In Hodder, I. et al. (eds.), *Retrieving Michigan's Buried Past*. Bloomfield Hills, MI: Cranbrook Institute of Science.

Holman, M. and Kingsley, R. (1996). Territoriality and Societal Interaction During the Early Late Woodland Period. In Garland, E. B. et al. (eds.), *Investigating the Archaeological Record of the Great Lakes State*. (341-382). Kalamazoo, MI: Western Michigan University Press.

Hubbs, C. and Lagler, K. F. (1958). Fishes of the Great Lakes Region. Bulletin No.26. Bloomfield Hills, MI: Cranbrook Institute of Science.

Hughes, B. O. (1937). Appendix on Anthropometry of the Younge Population. In *The Younge Site: An Archaeological Record From Michigan*. Ann Arbor, MI: University of Michigan Press.

Jemison, G. P. (1997). Who Owns The Past? In Swidler, N. et al. (eds.), *Native Americans and Archaeologists: Stepping Stones to Common Ground*, (57-63). Walnut Creek, CA: Alta Mira Press.

Katzenberg, M. A. (1992). Advances in Stable Isotope Analyses in Prehistoric Bone. In Saunders, S. R. and Katzenberg, M. A. (eds.), *Skeletal Biology of Past Peoples: Research Methods*. (105-119). New York: Wiley-Liss.

Katzenberg, M. Ann and Susan Pfeiffer (1992). Nitrogen Isotope Evidence from Belleville, Ontario, In Grauer, A. (ed.), *Bodies of Evidence: Reconstructing History through Skeletal Analysis*. (221-235). New York: Wiley Liss.

Katzenberg, M. Anne, Saunders, S. R. and Fitzgerald, W. (1993). Age Differences in Stable Carbon and Nitrogen Isotope Ratios in a Population of Prehistoric Maize Horticulturalist. *American Journal of Physical Anthropology*, 90, 267-281.

Keene, Arthur S. (1981). *Prehistoric Foraging in a Temperate Forest: A Linear Programming Model*. New York: Academic Press.

Knudson, Kelly J. (2008). Tiwanaku Influence in the South Central Andes: Strontium Isotope Analysis and Middle Horizon Migration. *Latin American Antiquity*, 19 (1), 3-23.

Krakker, James. (1999). Late Woodland Settlement Patterns, Population, and Social Organization Viewed from Southeastern Michigan. In Hodder, I. et al. (eds.), *Retrieving Michigan's Buried Past*. (228-233). Bloomfield Hills, MI: Cranbrook Institute of Science.

Krakker, James. (1997). Biface Caches, Exchange, and Regulatory Systems in The Prehistoric Great Lakes Region. *Midcontinental Journal of Archaeology*, 22 (1), 1-41.

Krakker, James. (1983). Mortuary Patterns at the Frazer Site, Saginaw County Michigan. Manuscript #11W547, Wayne State University Museum of Anthropology.

Larsen, Clark Spencer (2002). Bioarchaeology: The Lives and Lifestyles of Past People. *The Journal of Archaeological research*, 10, 119-165.

Larsen, Clark Spencer. (1997). Bioarchaeology: Interpreting Behavior from the Human Skeleton. Cambridge: Cambridge University Press.

Larsen, Clark, Crosby, A. W., Griffin, M., Hutchinson, D., Ruff, C. Russell, K. Schoeninger, M. J., Sering, L., Simpson, S., Takacs, J. and Teaford, M. (2002). A Biohistory of Health and Behavior in the Georgia Bight. In Steckel, R. H. and Rose, J. C. (eds.), *The Backbone of History*. (406-439). New York: Cambridge University Press.

Lovis, W., Donahue, R., and Holman, M. (2005). Long Distance Logistic Mobility as an Organizing Principle Among Northern Hunter-Gatherers: A Great Lakes Holocene Settlement System. *American Antiquity*, 70 (4), 669-725.

Lovis, W., Egan, K., Monaghan, G. W., Smith, B. and Prahl, E. (1996). Environment and Subsistence at the Marquette Viaduct Local of the Fletcher Site. In Garland, E. B. et al. (eds.), *Investigating the Archaeological Record of The Great Lakes State*. (251-306). Kalamazoo, MI: Western Michigan University Press.

Longin, K. (1970). New Method of Collagen Extraction for Radiocarbon dating. *Nature*, 230, 410-414.

Mann, R., Jantz, R., Bass, W. and Willey, P. (1991). Maxillary Suture Obliteration: A Visual Method for Estimating Skeletal Age. *Journal of Forensic Sciences*, 36 (3), 781-791.

Mason, C. and Holman, M. (2000). Maple Sugaring in Prehistory: Tapping the Sources. In Nassaney, M. S. and Johnson, E. S. (eds.), *Interpretations of Native North American Life: Material Contributions to Ethnohistory*. (261-271). Gainesville, FL: University Press of Florida.

McPherson, A. (1967). The Juntunen Site and The Late Woodland Prehistory of The Upper Great Lakes Area. *Anthropological Papers Museum of Anthropology*, No. 30. Ann Arbor, MI: Univ. of Michigan

Metcalf, P. and Huntington, R. (1991). *Celebrations of Death: The Anthropology of Mortuary Ritual*. Cambridge: Cambridge University Press.

Monaghan, G. William and William A. Lovis (2005). *Modeling Archaeological Site Burial in Southern Michigan: A Geoarchaeological Synthesis*. Lansing, MI: Michigan State University press.

Muldner, Gundula and Michael Richards (2007). Diet and Diversity at Later Medieval Fishergate. *American Journal of Physical Anthropology*, 134, 162-174.

Norder, J, Baxter, J. E., Nelson, A. R. and O'Shea, J. M (2003). Stone Tombs and Ancient Rituals: Status Marking and Social Roles in Early Late Woodland of Southeastern Michigan. *Midcontinental Journal of Archaeology*, 28 (2), 145-174

Parker, Kathyrn (1996). Three Corn Kernels and a Hill of Beans: The Evidence for Prehistoric Horticulture in Michigan. In Garland, E. B. et al (eds.), *Investigating The Archaeological Record of The Great Lakes State*. (307-340). Kalamazoo, MI: Western Michigan University Press.

Phenice, T.W. (1967). A Newly Developed Visual Method of Sexing the Os Pubis. *The American Journal of Physical Anthropology* 30, 297-302

Price, T. D., Tieslar, V. and Burton, J. (2006). Early African Diaspora in Colonial Campeche, Mexico: Strontium Isotopic Evidence. *American Journal of Physical Anthropology*, 130, 485-490.

Raemsch, C. A. (1993). Mechanical Procedures Involved in Bone Dismemberment and Defleshing in Prehistoric Michigan. *Midcontinental Journal of Archaeology*, 18, 217-244.

Rose, Fionnuala (2008). Intra-Community Variation in Diet During Adoption of New Staple Crop in The Eastern Woodlands. *American Antiquity*, 73 (3), 413-427.

Roy, D. M., Hall, R., Mix, A., and Bonnichsen, R. (2005). Using Stable Isotope Analysis to Obtain Dietary Profiles from Old Hair: A Case Study From Plains Indians. *The American Journal of Physical Anthropology*, 128, 444-452.

Ruff, C. (1992). Biomechanical Analyses of Archaeological Human Skeletal Samples. In Saunders, S. R. and Katzenberg, M. A. (eds.), *Skeletal Biology of Past Peoples: Research Methods*. (41-61). New York: Wiley-Liss.

Sauer, N. (1974). An Analysis of The Human Skeletal Material From The Fletcher Site (20BY28). Ph.D. dissertation, Michigan State University, East Lansing.

Sealy, J. and Van der Merwe, N. J. (1986). Isotope Assessment and Seasonal- Mobility Hypothesis in the Southwestern Cape of South Africa. *Current Anthropology*, 27 (2), 135-150.

Service, E. R. (1978). *Profiles in Ethnology*. New York: Harper and Row Publishers.

Schwarcz, Henry P. and Schoeninger, M. J. (1991). Stable Isotope Analysis in Human Nutritional Ecology. *Yearbook of Physical Anthropology*, 34, 283-321.

Schoeninger, M. J. and DeNiro, M. J. (1984). Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals. *Geochimica et Cosmochimica Acta*, 48, 625-639.

Schoeninger, M. J., DeNiro, M. J. and Tauber, H. (1983). 15N/14N Ratios of Bone Collagen Reflect Marine and Terrestial Components of Prehistoric Human Diet. *Science*, 220, 1381-1383.

Schurr, M. R. and Powell, M. L. (2005). The Role of Changing Childhood Diets in The Prehistoric Evolution of Food Production: An Isotopic Assessment. *The American Journal of Physical Anthropology*, 126, 278-294.

Sciulli, P. W. and Giesen, M. J. (1993). Brief Communication: An Update on Stature Estimation in Prehistoric Native Americans of Ohio. *The American Journal of Physical Anthropology*, 92, 395-399

Sciulli, P., Schneider, K., and Mahaney, M. (1990). Stature Estimation in Prehistoric Native Americans of Ohio. *The American Journal of Physical Anthropology*, 83, 275-280.

Sillen, A. and Kavanagh, M. (1982). Strontium and Paleo-dietary Research: A Review. *Yearbook of Physical Anthropology*, 25, 67-90.

Simons, D., Shott, M. and Wright, H. (1984). The Gainey Site: Variability in a Great Lakes Paleo-Indian Assemblage. *Archaeology of Eastern North America*, 12, 266-279.

Smith, B. D. (2001). Low-Level Food Production. *Journal of Archaeological Research*, 9 (1), 1-43.

Smith, B. D. (1992). Rivers of Change. Smithsonian Institution Press. Washington D.C.

Smith, B. D. (1991). Bioarchaeology in A Broader Context. In *What Mean These Bones*, edited by Mary Lucas Powell, Patricia Bridges, and Ann Marie Wagner Mires, pp.165-.171. Tuscaloosa, FL: University of Alabama Press.

Smith, B. D. (1989). Origins of Agriculture in Eastern North America. *Science* 246:1566-1571.

Steckel, R. and Rose, J. (2002). The Backbone of History: Health and Nutrition in The Western Hemisphere. New York: Cambridge University Press.

Stothers, D. (1999). Late Woodland Models For Cultural Development in Southern Michigan. *In Retrieving Michigan Buried Past*, pp. 194-211. Bloomfield Hills, MI: Cranbrook Institute of Science.

Stothers, D. and Bechtel, S. (1987). Stable Carbon Isotope Analysis: An Inter-regional Perspective. *Archaeology of Eastern North America*, 15,137-154

Stothers, D. and Yarnell, R. (1977). An Agricultural Revolution in The Lower Great Lakes. Geobotany Conference. (209-232). Bowling Green University. New York: Plenum Press.

Swidler, N., Dongoske, K., Anyon, R., and Downer, A. S. (eds.), (1997). Native Americans and Archaeologists: Stepping Stones to Common Ground. Walnut Creek, CA: Alta Mira Press.

Taylor, K. C., Demeter, C. S. and Weir, D. (n.p.d.). Phase II Archaeological Testing At The Emerson, Fitzhugh, Salt/Fraser, and Webber CSO Facilities, 1992. City of Saginaw, Saginaw County, Michigan 48601-2599 for Commonwealth Cultural Resources Group.

Tsosie, R. (1997). Indigenous Right and Archaeology. In Swidler, N. et al. (eds.), *Native Americans and Archaeologists: Stepping Stones to Common Ground*. (64-76). Walnut Creek, CA: Alta Mira Press.

Van Der Merwe, N. and Vogel, J. C. (1978). $^{13}\delta C$ Content of Human Collagen as A Measure of Prehistoric Diet in Woodland North America. *Nature*, 276 (21/28), 815-816.

Van Der Merwe, N., Roosevelt, A. C., and Vogel, J. C. (1981). Isotopic Evidence for Prehistoric Subsistence Change at Parmana, Venezuela. *Nature*, 292 (6), 536-538.

Vogel, J. C. and Van Der Merwe, N. (1977). Isotopic Evidence for Early Maize Cultivation in New York State. *American Antiquity*, 42 (2), 238-242.

Walker, P. L. (2008). Sexing Skulls Using Discriminant Function Analysis of Visually Assessed Traits. *The American Journal of Physical Anthropology*, 136, 39-50.

Walthall, John A. (1998). Overwinter Strategy and Early Holocene Hunter-Gatherer Mobility in Temperate Forests. *The Midcontinental Journal of Archaeology*, 23 (1), 1-22.

Watson, P. J. and Kennedy, M. C. (1991). The Development of Horticulture in The Eastern Woodlands of North America: Women's Role. In Gero, J. and Conkey, M. (eds.), *Engendering Archaeology: Women in Prehistory*. (255-275). Oxford: Basil Blackwell Ltd.

White Deer, G. (1997). Return of The Sacred: Spirituality and the Scientific Imperative. In Swidler, N. et al. (eds.), *Native Americans and Archaeologists: Stepping Stones to Common Ground*. (37-43). Walnut Creek, CA: Alta Mira Press.

Yarnell, R .A. (1964). Aboriginal Relationships between Culture and Plant Life in the Upper Great Lakes Region. University of Michigan Museum of Anthropology, Anthropological Papers 23, Ann Arbor, MI.

Zimmerman, Larry J. (1997). Remythologizing the Relationship Between Indians and Archaeologists. In Swidler, N. et al. (eds.), *Native Americans and Archaeologists: Stepping Stones to Common Ground*. (44-56). Walnut Creek, CA: Alta Mira Press.

Zurel, Richard L. (1999). Earthwork Enclosure Sites in Michigan. In *Retrieving Michigan Buried Past*. (247-248). Bloomfield Hills, MI: Cranbrook Institute of Science

Zvelebil, Marek (2000). Fat Is A Feminist Issue: On Ideology, Diet, and Health in Hunter-Gatherer Societies. In Donald, M. and Hurcombe, L. (eds.), *Gender and Material Culture in Archaeological Perspective*. (209-221). New York: St. Martin's Press.

ABSTRACT

A BIOARCHAEOLOGICAL STUDY OF A LATE WOODLAND POPULATION FROM MICHIGAN: FRAZER-TYRA SITE (20SA9)

by

ALLISON JUNE MUHAMMAD

May 2010

Advisor: Dr. Tamara Bray

Major: Anthropology

Degree: Doctor of Philosophy

The Saginaw Valley Region has been the focus of Michigan archaeology for many decades. The Late Woodland period of the Saginaw Valley has been characterized as an area that prehistoric people abandoned as a permanent resident, but exploited seasonally during times of scarcity. Furthermore, the valley's resources were exploited by a diverse group of prehistoric peoples, both native to Michigan and those Mississippian 'intruders' (Halsey 1976; Holman and Brashler 1999; Norder *et al.* 2003; Stothers 1999). Though previous studies of the Frazer-Tyra site (20SA9) have included ceramic and lithic analysis (Andrews 1995; Halsey 1976) and a study of mortuary variability (Krakker 1997, 1983), an osteological report had not been generated for the human remains nor a significant inquiry into dietary trends for the population. The aim of this study is to situate the Frazer-Tyra population within the discussion of maize adoption and dietary shifts that are common to the Late Woodland period in Michigan's Prehistory. Using carbon and nitrogen isotopes, this study will explore maize adoption and patterns of consumption for this Late Woodland population.

AUTOBIOGRAPHICAL STATEMENT

Allison Dennis Muhammad is a native of Detroit, Michigan. She graduated from Cass Technical High School in 1992 with an emphasis in chemistry-biology. She was honored as one of the top graduating seniors in the city of Detroit by the honorable Mayor Coleman A. Young in 1992. She was a recipient of several scholarships including the Coleman A. Young Foundation scholarship and a Ford Foundation scholarship.

Allison Muhammad is a graduate from Howard University in 1996, magna cum laude. She majored in Anthropology and minored in Classics. At Howard University, she had her first opportunity to work on a major project, the African Burial Ground project under the auspices of Dr. Michael Blakey. During her years at Howard, she learned the value of anthropological research and its impact on the African-American community at large. Inspired by her undergraduate experience, she wanted to pursue a graduate program that allowed her to continue her studies in human osteology and the history of African-Americans. Allison has participated in archaeological fieldwork in Michigan and Ecuador under the auspices of Dr. Tamara Bray. She graduated from Wayne State University with a Master's degree in Anthropology/Archaeology in 1998. She was admitted into the doctoral program for Anthropology/Archaeology in 2000 at Wayne State University. Her research interests include the origin of colonial-era African Americans, their health, diet, status, and mortuary practices. Also, using stable isotope applications, she intends to continue to explore subsistence shifts in New World populations.