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A Paleoethnobotanical Analysis of Three Formative Period Wankarani Sites Located in the Department of Oruro, Bolivia

by
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Abstract

The Wankarani people are often cited as an example of early camelid pastoralism in South America. However, research on early camelid pastoralism has ignored the importance of plants, especially the cultivation of domesticated plants in this region. The Wankarani people lived in the central *altiplano* of the south-central Andes during the Formative period (2000 B.C.-A.D. 400). Previous research has assumed that the Wankarani people were cultivating domestic plants. This research explores the evidence for both wild and domesticated plant use among the Wankarani while furthering the understanding of the development of subsistence strategies of pastoralists cultures.

Using paleoethnobotanical methods of analysis of samples from three different sites, this research identifies wild plant use and domesticated plant use of the Wankarani. The samples analyzed were derived from excavations carried out in 2008 in the Department of Oruro, Bolivia by José Capriles, a doctoral candidate at Washington University in St. Louis. These data provide insight into the importance of the plant economy during the Formative period in the central *altiplano*.

The identification of carbonized parenchyma (plant storage tissue) and seeds confirm that the Wankarani people cultivated tubers and *Chenopodium* plants. Furthermore, the high quantities of remains of these plants at all three sites are evidence that they were important components of the Wankarani economy. Preliminary analysis of chenopod seed demonstrates the cultivation of at least two domesticated *Chenopodium* species. In addition, a fungus that grew on tubers was identified. High quantities of carbonized tubers and fungus fragments indicate that the Wankarani struggled with a plant pathogen. These data confirm the importance of wild and domesticated plant use among the Wankarani peoples and the importance of plants to pastoral populations in the highlands of the Andes.

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A PALEOETHNOBOTANICAL ANALYSIS OF THREE FORMATIVE PERIOD WANKARANI SITES LOCATED IN THE DEPARTMENT OF ORURO, BOLIVIA

The austere environment of the south-central Andes appears to be a formidable place to live, but a group we call the Wankarani people (2000 B.C.–A.D. 400) are a testament to the capacity for human adaptation to the elements. They employed a successful subsistence strategy and adapted to the harsh environment as agropastoralists by exploiting domesticated animals and plants. Archaeological research notes that camelids were foundational in their economy both as a source of food and an icon of ritual culture (Bermann and Estévez 1995; Rose 2001). Researchers cite stone tool technologies such as stone hoes as evidence of agricultural activity, and conclude these data indicate that the Wankarani were agropastoralists who farmed quinoa and potatoes (McAndrews 1998; Fox 2007). However, analysis of stone tools is only a proxy for agricultural activity, and previous research fails to provide conclusive evidence of cultivated plants. I present a report of the tangible evidence of Wankarani plant subsistence and farming activities based on the archaeobotanical record. Furthermore, I explore how the Wankarani peoples used their plant economy as an opportunity to maintain their survival and reduce the risks of living in an arid and difficult environment.

The major goal of this research is to address the gap in the archaeological literature regarding plant use by members of the Wankarani Complex. Research shows that the Wankarani people were participants in the major transitions that occurred during the pivotal chronological transitions between hunter-gatherers and state-level society, including the development of agriculture (Langlie *et al.* 2011). This report examines the Wankarani plant economy in detail. I use these data to address hypotheses regarding adaptation to a marginal high-desert environment. Browman (1997) points out that a cornerstone of Andean pastoralism involved reducing short-term and long-term risks created by the environment. Adapting to life in a harsh environment invariably includes strategies to minimize risk. Plant use for subsistence is a crucial component of adaptation and risk reduction for the survival of both humans and herd animals.

This research is an analysis of 21 paleoethnobotanical samples from three contemporaneous archaeological sites (KCH11, KCH21, and KCH56) of the Formative period in the Iroco Region, Department of Oruro, Bolivia (see Figure 1). José Capriles, a Ph.D. candidate from Washington University in St. Louis, excavated these sites for his dissertation project. The results of this study complement his dissertation by addressing research goals including identifying varied use areas of the three different sites, subsistence practices, and interactions of Wankarani people with the local environment.

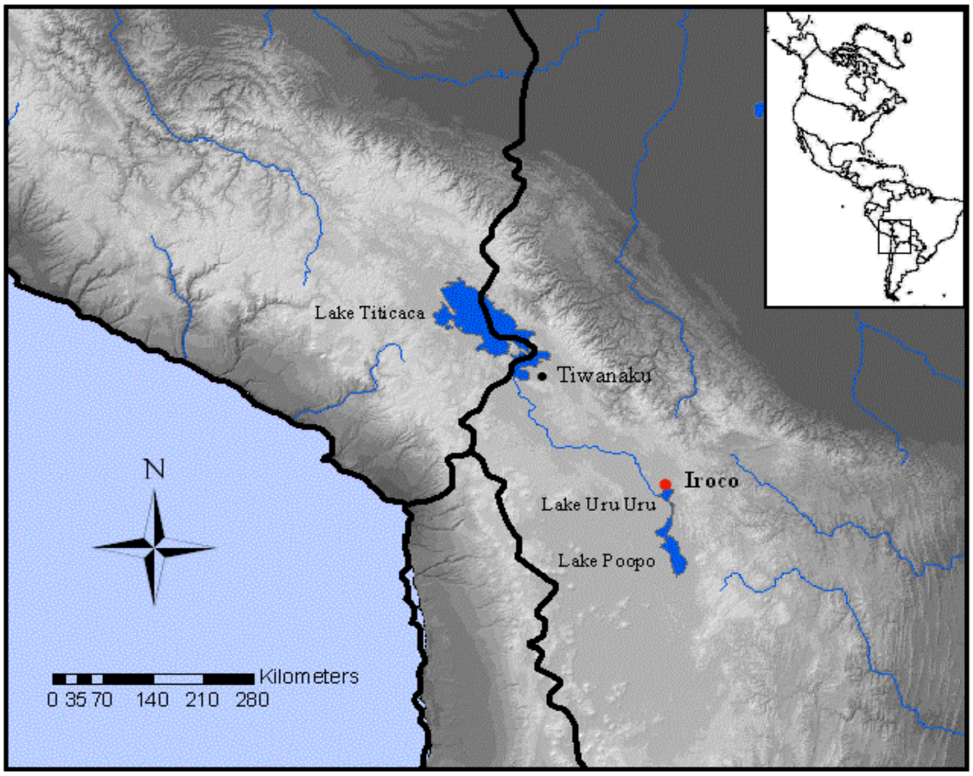

Figure 1. Map of the *altiplano*. Iroco is the study region. The Wankarani people inhabited the area surrounding Lake Uru Uru and Lake Poopó.

Research Goals

First, I discuss the analysis of plant remains from the sites to address questions regarding plant-based subsistence practices. Were the Wankarani peoples cultivating domesticated plants? How much were they utilizing plants other than domestic crops? To answer these questions, I compare presence and abundance of the cultivated plant taxa to wild and non-food taxa.

Second, I contextualize the ecology of recovered plants to learn how the Wankarani people exploited different ecological zones. Were they gathering plants from lacustrine environments or drier ecological zones? Camelid dung is commonly used as fuel source in the *altiplano*. Dung burning carbonizes and preserves plant material consumed and digested by camelids. Archaeobotanical analysis of these carbonized plant materials also reveals grazing and herding practices.

Third, I analyze how the Wankarani people utilized space and architecture at the sites based on the variable distribution of botanical data. I extrapolate on the data from Capriles' (2008) report on the preliminary interpretations of spatial use. Using density, ubiquity, and diversity, I compare pits, hearths, and a possible corral. Samples from inside and outside of structures are included in analysis. Plant use is contextualized in different areas of the site that involved charred plant deposits (cooking, warming, and refuse).

Fourth, I compare variations among the three sites using ubiquity and density of taxa, in an effort to determine if Wankarani people practiced similar plant-based subsistence patterns and interacted with the landscape in a similar manner.

Fifth, I contextualize the aforementioned data within the broader Wankarani Complex theoretical framework. Specifically, I examine how agriculture complemented a pastoral subsistence strategy, minimizing risk in a risky environment. This part of my analysis identifies the role and importance of the plant economy in the central *altiplano*.

The Wankarani and Agropastoralism

Chronology of the Southern Andes

Contextualizing the cultural evolution of the Wankarani peoples involves an understanding of what came chronologically before and after. In the southern *altiplano*, the Wankarani occupied the time period between the Archaic period and the Tiwanaku/Jachakala period (Figure 2). The people of the Wankarani lived during a time referred to as the Formative period in Bolivia, and they were part of the transition to agriculture and plant domestication in the Andes.

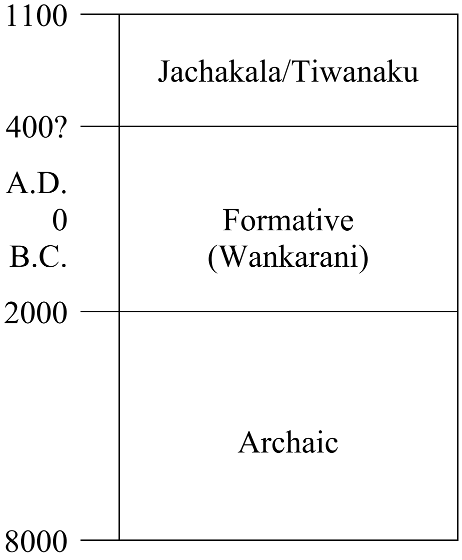

Figure 2. Temporal chronology for the Department of Oruro, Bolivia (Beaule 2002:35; Bermann and Estévez Castillo 1995; Fox 2007:24).

The Archaic Period. The Archaic period (8000-2000 B.C.) is identified archaeologically by a hunter-gatherer subsistence strategy and no evidence of a ceramic tradition. Only limited research has been conducted on the Archaic period in the Bolivian *altiplano*, and no research has been conducted on the plant economy of the time period. Recent archaeological investigations have revealed human presence in the region as early as 10,900 B.C. during the Late Pleistocene period (Capriles and Albarracin-Jordan 2011). During the latter part of the Archaic time period there was a marked increase in the number of people inhabiting the landscape. In the southern *altiplano,* hunter-gatherer groups relied heavily on the wild camelids that still inhabit in the region (McAndrews 1998:61). In the northern part of the *altiplano*, where considerably more research has been conducted, evidence of an increase in camelid hunting (previously considered evidence of domestication) is present as early as 4000 B.C. (Aldenderfer 1989:147; Kent 1982; McAndrews 1998:61). Mengoni and Yacobaccio (2006:239) stated that camelid hunting escalated throughout the Archaic period. Recent pan-Andean archaeological evidence reveals that Andean camelid domestication occurred somewhere between 4400 and 3000 B.P. corresponding to the end of the Archaic period and beginning of the Formative period Oruro (Mengoni and Yacobaccio 2006:239).

In addition to hunting wild camelids, Archaic period peoples of the *altiplano* invariably relied on wild plant collecting as a dietary supplement. Although no archaeobotany has been conducted on the Archaic period in the *altiplano*, I subsume, following Rindos (1984) that a long gathering tradition in the region familiarized populations with the local plants; agriculture was an intensification of the interactions between humans and plants. Based on Formative period archaeobotanical research

(Bruno 2008), I speculate that natural stands of *Chenopodium* spp. and cactus provided part of the foundation of the hunter-gatherers' subsistence economy during the Archaic period that continued into the Formative period.

The Formative Period. An increase in herding and agricultural activities in the *altiplano* during the Archaic, made it possible to live in settlements. The settling of the landscape marks the transition between the Archaic period and the Formative period. The Wankarani Complex is chronologically situated within the Formative period in the southern *altiplano* (2000 B.C.-A.D. 400). There are no known dates in Bolivia that indicate the beginning of the Formative in the Wankarani region. Several researchers have suggested 2000 B.C. as the beginning of the Formative period based on archaeological dates obtained from nearby culture groups (Beaule 2002:35; Bermann and Estévez Castillo 1993:314; Fox 2007:24). A.D. 400 is considered the end of the Formative period; but this date is currently ambiguous in the archaeological literature. McAndrews (2005:33) considers the end of Formative period in Oruro occurred between A.D. 250 and A.D. 500. Beaule (2002:35) relates that in the nearby La Joya region, the Formative period ended around A.D. 150. Regardless, people of the Wankarani Complex began to settle in sedentary villages during the Formative period in Oruro (Rose 2001:V) as part of the transition to an agropastoral subsistence strategy. Settlement and agropastoralism during the early part of the Formative period in the *altiplano* coincided with the onset of a ceramic tradition (Bermann and Estévez Castillo 1995:389).

The Tiwanaku/Jachakala Period. In the Oruro region, the end of the Wankarani Complex and the Formative period is marked by a change in settlement patterning and ceramic styles called the Tiwanaku/Jachakala period (A.D. 400 - 1100). In the northern area of the *altiplano*, just south of Lake Titicaca, the pristine state called Tiwanaku coalesced into an urban city during this time period. Bermann and Estévez Castillo (1993) reported that the central *altiplano* Jachakala culture was influenced by the rise of Tiwanaku. Current evidence indicates that the Jachakala culture is not a colony of Tiwanaku; the Jachakala descended from the Wankarani and were incorporated into the Tiwanaku state (Browman 1997:240).

A change in settlement patterns marks the transition between the Wankarani Formative period and the Tiwanaku/Jachakala period. Research has identified an apparent increase in settlement size and the amount of land occupied during the Tiwanaku period in the central *altiplano* (Beaule 2002). The type-site called Jachakala differs significantly from the Formative period Wankarani Complex in three ways: the site of Jachakala is not a mound; Tiwanaku-style pottery appears in the archaeological assemblage; and architecture and settlement patterns changed (Bermann and Estévez Castillo 1993:333).

The Jachakala did trade with Tiwanaku. Beaule's (2002) research at the site Jachakala corroborates Browman's theory (1997) that the Jachakala participated in long-distance exchange networks. Browman proposes that the Tiwanaku period settlements in the central *altiplano* were way stations, facilitating llama caravan trade between the lowlands and Tiwanaku. Recovered artifacts from the site Jachakala confirm this theory.

Limited research has been conducted on the Jachakala culture group. Current understanding indicates that the Jachakala were a local culture group that maintained economic and lithic traditions of the Wankarani. The Jachakala were influenced and incorporated into the Tiwanaku State. Future research will determine the extent of the Tiwanaku influence in the central *altiplano*.

Wankarani Complex Background

The people of the Wankarani Complex lived in sedentary villages in the central area of the high Bolivian plateau known as the *altiplano*, in the southern Department of La Paz, and the northern Department of Oruro (McAndrews 1998:63). During the mid-20th century the Wankarani people were called the *Megalithic Culture* by Ibarra Grasso (1965) and the *Mound Culture* by Wasson (1967). It was believed that Wankarani settlements were clearly identifiable on the barren landscape by earthen mounds. Excavated mounds reveal that they are the accumulative result of long-term occupation, consisting of adobe and refuse. Mounds are generally between two and six meters high (McAndrews 1998:91) and can cover up to two hectares (Fox 2007:6). Notably, Wankarani settlements are usually strategically located near fresh water and between hills that afford shelter from the harsh winds (Ponce Sanginés 1970). Hills also provided protection to agricultural lands from the strong *altiplano* winds (McAndrews 1998). Typical architecture on the mounds consists of several circular structures, organized into a "village" settlement pattern (Bermann 1995:389; Fox 2007:7-8; Ponce Sanginés 1970). Between 80 and 4,000 people inhabited a single village settlement (Bermann and Estévez Castillo 1995:389). Bermann and Estévez Castillo often refer to Wankarani settlements as villages; however, the upper end of their population estimates indicates that some villages burgeoned into settlements the size of towns.

Villages or towns were dispersed across the landscape in a distinct settlement pattern. Research has identified a pattern of fissioning that is referred to as a “parent/daughter” settlement pattern in the Wankarani Complex. McAndrews (1998:180) suggests that the larger mounds (both in horizontal and vertical dimensional space) represent the progenitors of the smaller settlements, and in turn, the smaller settlements fissoned from the larger ones. Later, I return to this discussion of settlement patterning, and apply it as a model that influences subsistence and risk-reduction strategies.

Architectural styles of the Wankarani settlements are similar across the central *altiplano*. Excavations in mounds recovered structures that range from circular (Ponce Sanginés 1970) to oval (Bermann and Estévez Castillo 1995:390). Stone foundations and adobes mark the walls of structures in the archaeological record (Bermann and Estévez Castillo 1995:390; Wasson 1967). Ethnographic research and archaeological evidence shows that the roofs of structures were made of straw (Bermann and Estévez Castillo 1995:391). Visible floors consisted of compressed soil. Resurfacing of the floors was common and the process is evident in the stratigraphy of excavated structures (Bermann and Estévez 1995:391; Ponce Sanginés 1970).

Wankarani material culture included undecorated ceramics (with rare decorated items), weaving tools (needles made of bone called *wichuñas* and spindle whorls made of ceramic), and stone tools (grinders, scrapers, and bifaces) (Ponce Sanginés 1970; Bermann1995:389; Fox 2007; Janusek 2008:69-70). Evidence of long distance trade was marked by the presence of basalt bifaces, obsidian stone tools, and Pacific marine shell. The closest basalt source was probably over 150 km to the south (Bermann and Estévez Castillo 1995:395; Rose 2001:117), and the closest obsidian sources seem to have ranged between 200-400 km to the north (Janusek 2008:70; Rose 2001:40). Marine shells, including shell pendants, indicate that the Wankarani people traded with the Pacific coast (Fox 2007:218). The distant origins of trade goods are evidence of Wankarani involvement in a large trade network across swaths of the Andes.

Wankarani ritual culture is prominently marked in the archaeological record by the presence of large, stone-tenoned llama head effigies, sometimes measuring up to approximately one meter (López Rivas 1959; Guerra 1977; McAndrews 1998:65; Condarco, 1959:204-205; Ponce Sanginés 1970). Reptile head sculptures have also been recovered, indicating heterogenity in Wankarani ceremonial tradition (Fox 2007:249). Ceramic tubes/trumpets (of unknown use), ceramic spoons, and bone flutes are further evidence of Wankarani ritual and ceremonial activity (Bermann and Estévez Castillo 1995:392; Rose 2001:209). The ceramic tubes or trumpets recovered by Bermann and Estévez Castillo are reminiscent of artifacts regularly recovered in the Titicaca Basin from the Formative period *Pajano* (also called *Pa-Ajanu*) religious tradition. In the *Pajano* religion, archaeologists have considered trumpets as important ritual paraphernalia (Janusek 2008:82). Based on archaeological evidence, the Wankarani and the people who practiced *Pajano* religion interacted.

Several excavated tombs reveal patterns in Wankarani burial practices. The tombs are almost identical in architecture, body interment, and location, and they are encircled by rocks and covered with a single large stone slab. Bodies were recovered from the tombs in a flexed position, and tombs are either situated in the mounds or right next to them (Ponce Sanginés 1970). As of yet, there is no evidence of social stratification based on grave goods (Fox 2007:232).

In summary, previous excavations of mounds and groups of structures reveal that the Wankarani peoples lived in both small and relatively large settlements. There is minimal evidence of social stratification among the Wankarani Complex from previously excavated structures and burials. Fox (2007:6) stated: "In contrast to its neighbors in the Titicaca Basin to the north, Wankarani society appears to have maintained a village-level of organization for as long as two millennia, from at least as early as 1500 B.C. until perhaps as late as A.D. 400. The very long-lived nature of the Wankarani Complex has led archaeologists to characterize this society as an essentially conservative, stable adaptation to the marginal environment of the southern *altiplano*."

Wankarani Agropastoralism

The Wankarani are often referred to as pastoralists and agropastoralists in archaeological reports, publications, and books. Recovered tenoned stone llama head effigies indicate that camelids were important in Wankarani culture and iconographically permeated ritual activity. Previous excavations directly affirm a subsistence strategy based at least in part on camelid pastoralism. Large quantities of camelid bones have been recovered from several Wankarani sites (Bermann 1995; Ponce Sanginés 1970; Fox 2007; Rose 2001). Camelids were domesticated in the southern Andes between 4400 and 3000 B.P. (Mengoni and Yacobaccio 2006:239), and thus it is inferred that the presence of abundant camelid bones in Wankarani assemblages points to the herding of domesticated camelids.

Two species of camelids were domesticated in the Andes: the llama (*Lama glama)* and the alpaca (*Vicugna pacos*). These animals were used as sources of "meat, hide, fiber, dung … and beasts of burden" (Mengoni and Yacobaccio 2006:228). The wild relatives of domesticated camelids were hunted, and camelid utilization increased throughout the Archaic period of the southern Andes. According to Mengoni and Yacobaccio (2006:239), camelids represented 85-100 % of the faunal assemblage in the south-central Andes from 5300-3000 B.P. The intensification of camelid procurement in the faunal assemblage coincides with the emergence of the Wankarani culture.

Rigorous archaeological sampling and analysis of fauna by Capriles (2011) indicates that the Wankarani relied heavily on wild animals to supplement their camelid-based diet. He found evidence that fish and birds were important sources of food for the Wankarani people. The Wankarani relied on both wild and domesticated animals for sustenance.

Andean pastoralism is an economic strategy that is still practiced today. Pastoralism is defined as an economic strategy in which humans depend on domesticated animal products for subsistence, and they organize their lifeways around tending to their herds. Often pastoralists are thought of as primarily nomadic peoples who mobilize their herds to seasonally graze in the most abundant pastures. However, ethnographic studies in Africa identify that some groups relocate their herds and settlements several years apart, rather than annually (Gifford-Gonzalez 2005:188). Pastoralists can also be sedentary. The Wankarani are considered a sedentary pastoralist culture (Browman 1981:410). Evidence of seasonal migration among the Wankarani peoples has not been identified in the archaeological record.

Archaeological evidence confirms the camelid-based pastoral economy of the Wankarani Complex. However, archaeobotanical research is seriously lacking. Pure pastoralists, or people who subsist only on their herd animals and do not practice any type of plant cultivation are rare in the Andes, based on ethnographic research (Browman 1983:242). It is highly probable that the Wankarani also practiced some form of agriculture. In 1970, Ponce Sanginés speculated that the Wankarani cultivated potatoes and quinoa based on the presence of stone hoe fragments. He came to these conclusions in the absence of archaeobotanical evidence. Research continues to focus on the analyses of recovered agricultural tools and their correlation to activities in an attempt to diagnose the presence of agriculture in the Wankarani Complex region. McAndrews (1998:182) uses stone tools as a proxy for agricultural activity. He infers that a greater density of bifaces and retouched flakes correlates with higher amounts of agricultural activity. McAndrews' research and analysis, however, lacks any direct botanical evidence. Furthermore, in his study Fox (2007: 176-181) notes a decrease in ground stones and an increase in basalt bifaces as a proxy for an increase in agricultural intensity. Fox's agricultural inferences, like those of McAndrews and Ponce Sanginés, are based solely on lithic artifacts.

In an in-depth study on the neighboring Formative culture group of Chiripa (1500–200 B.C.), Whitehead (2007:48) states: "No substantial paleoethnobotanical work has been completed for any Wankarani sites. Paleoethnobotanical work in the area south of the Lake Titicaca area would be a great contribution to understanding the pattern of plant use for the Bolivian Formative." This research addresses Whitehead's statement by exploring the direct macrobotanical evidence of the Wankarani Complex and offers a preliminary insight into the plant-based subsistence strategy and ecological interactions of the Wankarani Complex.

Economy and Trade.

Two major models have been proposed for the political coalescence of the Tiwanaku state, which I briefly mention here. These models implicate the Wankarani peoples in the socioeconomic evolution of the region. The first model states that trade between the Tiwanaku core and peripheral colonies in the lowlands intensified and was ultimately organized at the central core and trade was facilitated by llama caravans (Browman 1978). The second model relates that as rituals and feasting escalated, peripheral peoples were incorporated into the religious/political system centered at Tiwanaku (Hastorf et al. 2006). Maize (*Zea mays* L.) and exotic ritual plants such as coca (*Erythroxylum coca* Lam.) that could only be grown in lower altitudes are plants that may be at the core of both models (Hastorf 2008).

Ethnographic research in the Andes has noted the importance of camelid caravans in the historical era (Browman 1971:193-194), which is analogous to their importance to the Tiwanaku state. The Wankarani pastoralists might have led the camelid caravans that facilitated exchange between remote regions and the *altiplano*. Presence of foreign goods in the Wankarani region and the presence of Wankarani goods in remote regions indicate that the Wankarani participated in reciprocal exchange networks. The Wankarani peoples used lithics and other material goods procured from non-local sources. Researchers have identified material goods present in Formative period sites in distant regions (including salt and craft items) that were derived from the Wankarani region (Janusek 2008:72; Rivera 2001:21-24). These goods might be evidence of the earliest caravan networks in the *altiplano*. Such trade networks are fundamental to the aforementioned models concerning the rise of Tiwanaku. Temporal and spatial understanding of the time period when plant commodities were initially exchanged and of who was facilitating the exchange will help further clarify these models, while revealing the role of the Wankarani in these exchanges.

The high altitude, dry and cold weather, and saline soils make it nearly impossible to grow maize in the *altiplano*. However, research at Tiwanaku demonstrates that maize was prevalent, and it was recovered in large quantities throughout the city's residential and elite complexes. Maize played a significant role in feasting activities (Wright *et al.* 2003). This large quantity of maize must have been grown at lower elevations with less harsh ecologies. Maize was brought into Tiwanaku from Cochabamba and Moquegua, based on distinct morphologies of cobs and kernels of archaeological specimens (Hastorf *et al.* 2006). Additionally, coca was imported by caravans from the eastern slopes of the Andes in a region called the *yungas*. Coca was an important ritual plant at Tiwanaku (Hastorf 2008:550). Both maize and coca play an important role in Hastorf's feasting model of socio-religious incorporation of distant people in the Tiwanaku empire.

The Tiwanaku facilitated trade networks of llama caravans, which are the cornerstones of Browman and Hastorf's models about the rise of Tiwanaku. Currently, there is no evidence of the beginning of these caravans. The Wankarani people were accomplished pastoralists who participated in elaborate trade networks, which may have been facilitated by llama caravans led by these people. If the Wankarani facilitated the earliest caravans, I expect to find imported plant commodities in the Wankarani archaeobotanical assemblage. Conversely, a lack of maize and other exotic plant taxa indicates that the Wankarani were not involved in this trade network. If this is the case, then maize, coca, and other exotic plants were not economic concerns in the *altiplano* until the Tiwanaku period.

The Study Region: Iroco

Geography and Ecology

The *altiplano* is located between the western and eastern cordilleras that form the western and eastern boundaries of the plateau. The *altiplano* extends from southern Peru to northern Chile. The prehistory of the region is closely intertwined with climate and ecology. The climate of the Andes has remained relatively stable from 5,000 B.C. to the present (McAndrews 1998:56; Moseley 1992).

The Lake Titicaca drainage basin is located in the northern portion of the *altiplano*. Five percent of the excess water from Lake Titicaca drains southward, down the Desaguadero River (the rest evaporates due to the harsh tropical sun and altitude), and empties into Lake Uru Uru and Lake Poopó in the central region of the *altiplano* in the area, where the Wankarani people once lived (Janusek 2008:37). Several other small rivers, streams and tributaries provide additional runoff for Lake Uru Uru and Lake Poopó.

The three sites in this study are located on the eastern shores of Lake Uru Uru and west of the modern town of Oruro, in a region called Iroco (see Figure 1). The elevation of Oruro is approximately 3,800 masl (Sempertegui *et al.* 2005:16). The ecology of the Iroco region and the central *altiplano* is composed of arid grasslands that stretch across the flat plains. Ridges and rocky hills are strewn across the plain (Capriles 2011:41). A chain of hills borders the Iroco region to the east, and the Karakollu River, a tributary of Lake Uru Uru, forms the western boundary of the region (Capriles 2008:45). Therefore, a gradient of microenvironments of vegetation grow in the rocky hillsides and seasonally in the floodplain flanking the Karakollu River.

The ecology of Iroco is highly dependent on several climatic variables including altitude, solar radiation, water, soil, wind, and variable temperatures (Rose 2001:23; Sempertegui *et al.* 2005). These variables have mandated economic cultural adaptation. The temperature is quite cold, averaging 10˚ C (Sempertegui *et al.* 2005:16), and fluctuates 11 degrees seasonally (Rose 2001:23). Frosts are common in the region and occur all year long. During the dry season between April and November, frosts limits agricultural activity.

Rainfall in the Iroco region is extremely low and seasonally variable, ranging between 300 and 375 mm per year (Sempertegui et al. 1992:16). During the rainy season (December-March), episodic rainfall threatens to drown agricultural fields (Fox 2007:18). Low seasonal rainfall and annual periods of flooding further limit agricultural activity in the Iroco region.

Furthermore, rainfall has varied annually in the Andean region as the result of the ENSO system (El Niño-Southern Oscillation). Episodic ENSO events occurred almost predictable every seven year causing massive droughts and climatic variation. Recorded in the Quelccaya ice core taken from the top of a mountain in the southern Peruvian Andes, evidence of periodic variation in precipitation has been recorded and tentatively linked to ENSO (Thompson *et al.* 1984:50-53). Rainfall from year-to-year is highly variable and unpredictable (Fox 2007:22). As a result, economic activity needs to be able to cope with fluxes in annual precipitation in an already harsh ecology.

The soil composition of the area further limits agricultural production in Iroco. The soil is sandy, coarse, infertile, and low in organic composition. Soils in the region are salt-encrusted (Janusek 2008:72), which limits the diversification and development of native vegetation and cultivation of crops plants. Closer to the lake, lacustrine soils are richer, consisting of clay and silt, and higher organic content (Sempertegui *et al.* 2005:27). The infertile and saline soil composition in Iroco further restricts agricultural activities.

Contextualizing the Sites

The Iroco region was initially investigated as part of the Environmental Impact Assessment of the Kori Chaca mine (Inti Raymi Mining Company) located near the city of Oruro (Albarracin-Jordan 2005). This study involved identifying archaeological sites that were impacted by mining activities. Capriles (2008) expanded upon these data by intensely surveying the region as a part of his doctoral dissertation. Based on survey data, three Formative period Wankarani Complex sites were chosen for excavations in the Iroco region: KCH 21, formally known as Irucirca, KCH56, and KCH11 (Capriles 2008). I analyzed macrobotanical samples from each of the three sites.

All three sites, which are plotted in Figure 3, are located in proximity to Lake Uru Uru, a five-meter deep, shallow and salinous lake that is drainage of Lake Titicaca. Irucirca is mound located in the plains between the hills and the Karakollu River, which is a freshwater tributary that flows into Lake Uru Uru. Irucirca covers an expanse of approximately 0.55 hectares of land, and the mound measures approximately 1 meter vertically (Capriles 2011:114). KCH56 is located on the northwest side of a hill. This site covers approximately 2.54 hectares of land, and the occupation area measures 1.5 meters vertically above the surrounding land (Capriles 2008:129). KCH11 is mound located in an alluvial plain. It covers approximately 0.85 hectares of land and stands 2.5 meters tall (Capriles 2008:133).

All three sites date between 200 B.C. and A.D. 400. Irucirca was previously excavated in 2005 by Dr. Juan Albarracin-Jordan as part of a study that sought to assess the impact of mining on archaeological sites (Albarracin-Jordan 2005). The sites are on the eastern shores of Lake Uru Uru, just west of the town Oruro (see Figure 1). During the 2007 excavation season, four units were excavated at KCH21, one unit at KCH11, and one unit at KCH56, which are plotted in Figure 3. Excavations of the contemporaneous Formative period sites yielded round structures, burials, and a possible corral.

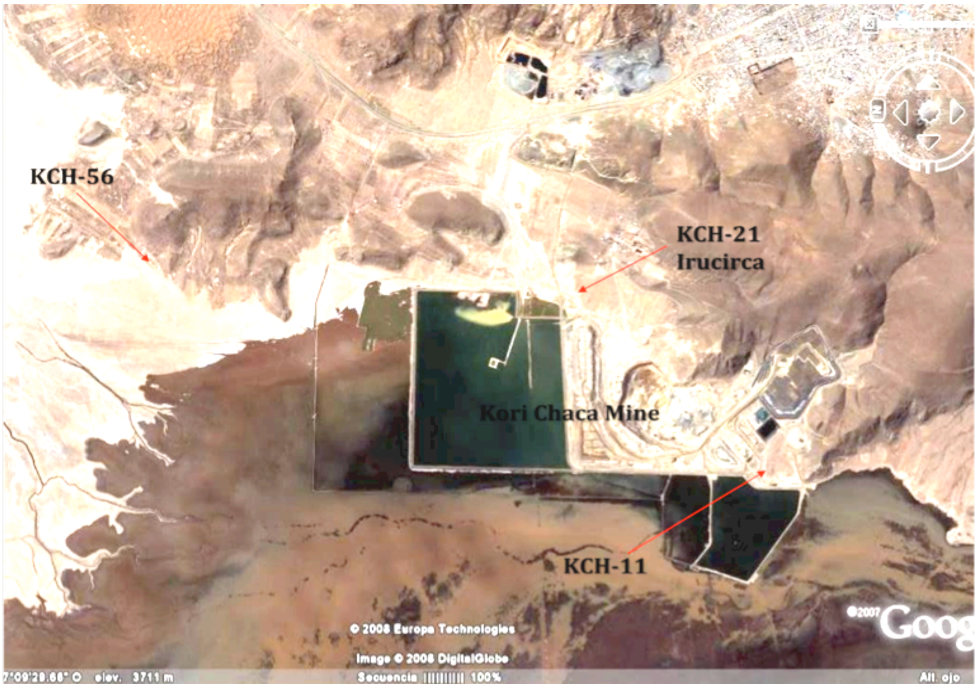

Figure 3. Map plots the locations of KCH11, KCH21, and KCH56 (image from Langlie and Capriles 2011).

Based on AMS dates, KCH21 and KCH56 are contemporaneous, dating to the latter part of the Formative period. KCH 56 dates to 61 BC, based on one AMS obtained from the floor of the second occupation. The calibrated parameters for KCH21 date between 200 B.C. and A.D. 200, which is supported by nine AMS dates from various pit and hearth contexts. Two dates were obtained from burials at KCH11, which revealed later dates as well, corresponding to the Tiwanaku/Jachakala period. Table 1 in Appendix A outlines these dates.

Botanical data of the sites are presented before expounding on the details of the excavations. This order allows for the interpretation of the possible uses of macrobotanical remains at the sites and interpretations of macrobotanical data within specific contexts.

Methods

In the summer of 2010, I was hand delivered samples from José Capriles and began laboratory analysis. In the Washington University in St. Louis Paleoethnobotanical Laboratory, I sorted and analyzed 19 samples under the mentorship of my advisor Dr. Gayle J. Fritz. I identified 3,109 carbonized macrobotanical specimens that included 1,152 carbonized seeds and 1,957 carbonized fragments of other specimens (ie. wood and unidentifiable seeds). I finished sorting the Iroco samples in January 2011. Additionally, Dr. Maria C. Bruno sorted two samples (Locus # 4086/1 and 4129/1) in her Bolivian lab, which are included in this analysis. In these two samples Bruno identified 2,130 specimens that include 1,759 carbonized seeds and 371 carbonized fragments of other specimens. In total, there are 21 samples composed of 5,239 specimens that include 2,911 seeds in this analysis, which includes the two samples that Bruno sorted. The two samples analyzed by Dr. Bruno contained all of the same taxa that I identified, (except for *Plantago* sp. seeds, which may be an issue of deposition) indicating that the identification procedures are congruent.

Field Methods

Excavation and Sampling Strategy. Excavations methods were set forth and implemented by José Capriles and Dr. Juan Albarracin-Jordan, modeled after Bandy and Hastorf (1999), and adapted to the ecology and stratigraphy present at the sites. Field methods included the excavation of four by four meter units or smaller oriented to the north. The units were intentionally positioned based on surface architecture to reveal spatial organization of the sites, and collect samples of associated cultural artifacts (Capriles 2008:210). Capriles and Albarracin-Jordan implemented fine grain recovery techniques including but not limited to macrobotanical remains, phytoliths, pollen, zooarchaeological remains, and micromorphological samples.

Macrobotanical flotation samples were collected from every feature and depositional event (Capriles 2008:22). Termed *blanket* sampling, this method is a decidedly powerful analytical and practical sampling strategy (Pearsall 2000:66-67). Excavators collected 10 liter samples of soil for macrobotanical analysis whenever possible. Sample size was determined by using a pre-measured and marked bucket. Sample volumes ranged between three and 11 liters and averaged 9.4 liters.

Flotation Method. Macrobotanical samples were processed and floated by Dr. Nicole C. Couture and Dr. Maria C. Bruno at the Archaeological Project of Mollokontu. A modified version of Watson's (1976) SMAP machine was used to float the samples. Geological mesh measuring 0.5 mm separated the heavy fraction from the silt, and the light fraction was captured in chiffon fabric. Ninety-four macrobotanical samples were excavated, processed, and floated.

Laboratory Methods

Under the advice of José Capriles, I selected 19 samples from three different context types (pits, hearths, and a possible corral) for laboratory analysis based on the importance of their context. I followed standard paleoethnobotanical procedures for sorting and analyzing the samples, as outlined below.

I measured the total weight of each sample in grams. Then, using USDA geological sieves, I separated the samples into four sizes: larger than 2.00 mm (from the 2.00 mm mesh sieve), larger than 1.00 mm (from the 1.00 mm mesh sieve), larger than 0.5 mm (from the 0.5 mm mesh sieve), and smaller than 0.5 mm (from the pan). I recorded the weight of each of these fractions, labeled, and placed them in a tin for sorting. Then, I sorted each sample using a stereoscopic light microscope with a magnification range of 10X-40X.

Carbonized seeds were identified based on scientific taxonomic terminology to the levels of family, sub-family, genus, and species. For sorted fraction that was larger than 2.00 mm, I sorted all identifiable carbonized organic fragments, including woody fragments, seeds, and parenchyma (which is plant storage tissue such as tubers). For fractions smaller than 2.00 mm I sorted and identified carbonized seeds. I scanned the fraction in the pan (less than 0.5 mm), however only unidentifiable and incomplete seeds were present in this fraction so I did not separate them from the non-botanical material. I excluded noncarbonized botanical materials from analysis, because the antiquity of these materials cannot be verified. I placed noncarbonized and other small artifacts in the original bag for curation.

Woody specimens smaller than 2.00 mm fractions were not removed, because it is difficult to identify wood to genus and species below this fraction. Furthermore, there have been no studies of Andean wood to do date that enable wood identification. Often archaeologists think of wood as a derived from trees. The wood in this study is likely from woody shrubs, because trees are scarce in the *altiplano*. Parenchyma was not sorted from below the 2.00 mm fraction. Wood fragments (larger than 2.00 mm) and parenchyma fragments (larger than 2.00 mm) were identified and counted. Seeds were identified and counted as closely as possible to scientific family, genus, and species. All data and information were recorded on sorting forms (Appendix D), which also includes relevant site and sample information (i.e. location of sample, locus, volume etc.). Other pertinent data were also noted on the Sorting Form, such as the presence of small snails, fish scales, bones, and/or other small artifacts. Finally, these data were entered into a Microsoft Excel spreadsheet. Identified macrobotanical specimens were labeled and placed in gelatin capsules or small tins and curated along with the rest of the sample in the original bag. These samples will be returned to José Capriles and curated in Bolivia, along with other excavated artifacts from excavations.

Methods of Quantification

This study utilizes four primary quantitative methods of analysis: frequency, ubiquity, density, and diversity. These measures are employed to identify and compare depositional events at the levels of context, unit, site, and intra-site analysis.

Ubiquity [Expressed as Percentage Presence]. Ubiquity is an index of absence and presence. Ubiquity expressed as percentage presence is measured by adding the total number of samples a taxon is present in, dividing it by the total number of samples, and multiplying by 100. Ubiquity disregards absolute counts and, therefore, partially mitigates the impact of preservation and recovery issues (in comparison to standardized density) (Popper 1988:60-61). In accordance with Popper, I use this measurement to quantify variations in the presence and absence of taxa between contexts and between sites.

Frequency [Expressed as Percentage]. Frequency measures the percent of each seed type in the analyzed assemblage. I calculated frequency by summing the seeds of a taxon (for a site or a context) and dividing by the total number of seeds analyzed for an assemblage.

Density [Standardized Absolute Counts]. Density is the measure of the sum of the specimens of a taxon divided by liters of soil floated (Miller 1988:72-73; Pearsall 2000:196). This measurement accounts for the variance in soil sample size (Miller 1988:73). Density presents an alternative tool to frequency to quantify taxa distribution throughout the sites, because it measures the quantity of plant usage or deposition in discrete contexts. Density can also be used to reveal intensity of deposition, which Pearsall (1983:129) directly correlates with intensity of occupation. I use this measurement to look at intensity of deposition between contexts between sites. I calculated density by adding the count of a plant taxon for each locus (absolute count) and dividing by the volume (liters floated).

Diversity. This measurement accounts for total number of species and the relative evenness of each species (Pearsall 2000:209). "High diversity results when a large number of species are evenly distributed, that is, when it is difficult to predict what a randomly selected item would be. Low diversity in the number of species present is low when one or a few species account for most of the population (Pearsall 2000:210). To measure diversity, I employ the Shannon-Weaver index commonly used in archaeobotany. Adopted from Popper (1988:67), the equation used is as follows:

$H=\text{Sum }(N_j/N)\log(N_j/N)$

Where N=total number of seeds in the site or context

N_j=total number of seeds of taxon j in the site or context

Botanical Taxonomy and Uses

During laboratory analysis, I identified and employed 13 scientific and taxonomic categories that include: Cactaceae, *Chenopodium* sp., *Lepidium* sp., Cyperaceae, Malvaceae, Fabaceae, *Plantago* sp., Poaceae, *Ruppia* sp., tuber/parenchyma, fungus, dung, and wood. Additionally, I encountered nine unknown and/or unidentifiable seed categories. Images of these are in the Appendix 2.

In this section I provide a brief synopsis of depositional sources, botanical identification, and possibly usages. I present qualitative and quantitative botanical data first, so that I can use these data more effectively in my analysis of the sites.

Sources of Deposition

Here, I focus on both the plants present at the site and possible sources of deposition. Further discussion of deposition is included in quantitative analysis.

The three sites analyzed from Iroco show little evidence of post-abandonment disturbance. Furthermore, all specimens in this study are archaeological, and their source of carbonization and deposition occurred during the Wankarani occupation because there is no evidence of modern occupation. Minnis (1981:144) identifies three possible sources of prehistoric macrobotanical deposition: direct resource use; indirect resource use; and seed rain, which I discuss in relation to this study.

Direct Resource Use. This is defined as the result of “collection, processing, and use/consumption” (Minnis 1981:145). Hearths are an example of direct resource use. Cooked plants intended for consumption often spill into fires and are preserved. Direct resource use of macrobotanicals can be identified in primary or secondary contexts. A hearth is a primary context, whereas a midden is a secondary context.

Dung used for fuel is also direct resource use. Miller (1991) notes that, in high altitude areas, dung is often used for fuel. As a pastoral population, the Wankarani most likely used dung for fuel, similar to their neighbors in the northern *altiplano* at Chiripa (Bruno 2008:474; Whitehead 2007:229). Dung of large mammals, like camelids, often contains large amounts of whole seeds and is a likely source for many of the carbonized seeds in this assemblage. Hastorf and Wright (1999) conducted an experimental archaeological study, during which they charred various animals’ dung from across the Andes. In addition to camelid dung, goat and other Old World animals’ dung were included in their study. Inclusion of Old World animals’ dung in these data is not directly analogous to the Wankarani Complex assemblage. However, Hastorf and Wright (1999) present useful qualitative evidence for identifying dung used for fuel at archaeological sites in the Andes; therefore, I have included their findings in my description of individually identified taxa.

Indirect Resource Use. Indirect resource use of plants can represent both primary (in hearths) and secondary (in pits) depositional contexts. Minnis (1981:145) describes this as the "result of the use of the plant, not the seed." Plants used for architecture, such as thatching for roofs, etc., are in this category. Plants used for fuel, such as shrubs and trees, represent other sources of indirect resource use.

Seed Rain. This source of deposition is defined as "accidental preservation of the prehistoric seed rain unrelated to any use of the seeds or plant" (Minnis 1981:145). Wind is often a source of seed rain, because many plant seeds have natural aeolian dispersal mechanisms that can convey them directly into anthropogenic environments. Minnis identified seed rain as plant remains not used by humans that accidentally blow into fires. In this study, I expand the definition of seed rain to include charred seeds that are carried by the wind and accidentally deposited and preserved in a non-anthropogenic location. For example, in an open-air hearth a strong wind may carry small charred seeds a short distance across the site.

Categories of Plant Use

For analytical purposes, I grouped the identified botanical taxa into five categories based on human use or ecological preference of the plants: food plants, wild plants, plants that prefer aquatic ecological zones, taxa that prefer enriched soils, and other. I compared relative density of botanical taxa to each other, because no previous research has quantified macrobotanicals from Wankarani sites. Ubiquity and frequency are depicted in Table 1. Counts of plant remains are depicted in Table 2.

Table 1. Ubiquity (% presence) of categories and percentage frequency of seed types.

N=21 samples		
Taxa	Ubiquity	Frequency (seeds)
Cactaceae seeds	57%	5.08%
Chenopodium sp. seeds	76%	29.37%
Cyperaceae seeds	76%	14.08%
Fabaceae seeds	48%	3.06%
Lepidium sp. seeds	10%	0.14%
Malvaceae seeds	76%	28.07%
Plantago sp. seeds	10%	0.62%
Poaceae seeds	67%	10.03%
Ruppia sp. seeds	19%	0.41%
Unknown Seeds	38%	9.14%
Parenchyma	81%	-
Dung	24%	-
Fungus	62%	-
Wood	86%	-

Table 2. Raw counts of macrobotanical data from KCH 21, KCH56, and KCH11.

Site	**Locus**	**Context**	**Flot**	**Volume**	**Total weight**	**Wood (> 2 mm)**	**Wood weight**	**Dung (> 2 mm)**	**Parenchyma (> 2 mm)**	**Fungus**	**Cactaceae seed**	***Chenopodium* sp. seed**	**Cyperaceae seed**	**Fabaceae seed**	***Lepidium* sp. seed**	**Malvaceae seed**	***Plantago* sp. seed**	**Poaceae seed**	***Ruppia* sp. seed**	**Unknown seeds 9 types**	**Total Seeds**
				(liters)	(g)	# frags	(g)	frags	# frags	frags	ct.	ct.	ct.	ct.	ct.	ct.	ct.	ct.	ct.	ct.	ct.
KCH21	4052/1	Corral	1024	10.5	7.03	2															**0**
KCH21	4053/1	Corral	1001	11.0	8.54				1			1						1			**2**
KCH21	4054/1	Sterile	1077	9.0	3.50	4	0.01									2					**2**
KCH21	4058/1	Sterile	1050	10.0	1.10																**0**
KCH21	4067/1	Pit	1002	9.5	49.45	133	0.8	13	182	66	2	209	70	3		109		55		4	**452**
KCH21	4080/1	Pit	1033	9.5	8.95	67	0.62		40	2		8	20	4		11		2		1	**46**
KCH21	4086/1	Pit	1086	8.0	7.37	33		2	17	2	28	84	36	13		33	17	6		39	**256**
KCH21	4118/3	Pit	1091	10.0	23.30	107	0.86		81	13	12	21	8			3		8	2		**54**
KCH21	4120/1	Hearth	1055	9.5	24.58	119			178	4	4	54	95	7	1	49		24		7	**241**
KCH21	4121/1	Pit	1006	10.0	42.17	113	1.29	1	57	6	7	9	1	4		1		2		17	**41**
KCH21	4123/1	Pit	1000	3.0	4.64	13	0.11		7	2		5	21			3		1			**30**
KCH21	4124/4	Pit	1080	8.0	16.90	67	0.57		48	17	4	11	7					5	5		**32**
KCH21	4129/1	Pit	1013	9.0	17.11	56		7	20	4	82	387	52	33	3	578	1	176		191	**1503**
KCH21	4131/1	Floor	1075	10.0	35.60	92	0.64	7	106	9	4	32	41	21		9		5	4	5	**121**
KCH21		*Site tot*	*n=14*	*127.0*	*250.24*	*806*	*4.9*	*30*	*737*	*125*	*143*	*821*	*351*	*85*	*4*	*798*	*18*	*285*	*11*	***264***	***2780***
KCH56	4158/1	Pit	1060	7.0	29.53	23	0.25		1		1	2	3	0		2				2	**10**
KCH56	4159/1	Pit	1027	7.0	16.38	13	0.10			1			2	2		4			1		**9**
KCH56	4162/1	Hearth	1028	10.0	30.76	82	0.84		9		1	7	5	1		6		2			**22**
KCH56	4163/4	Pit	1059	10.0	27.99	30	0.18		11			1									**1**
KCH56	4172/1	Hearth	1036	9.5	23.96				22	8	2	17	11	0		2		2			**34**
KCH56		*Site tot*	*n=5*	*43.5*	*128.62*	*148*	*1.37*	*0*	*43*	*9*	*4*	*27*	*21*	*3*	*0*	*14*	*0*	*4*	*1*	*2*	***76***
KCH11	4206/1	Floor	1083	10.0	23.49	33	0.30		1			4	13	1		1					**19**
KCH11	4207/1	Midden	1015	10.0	59.42	105	1.17		13	12	1	3	25			4		3			**36**
KCH11		*Site tot*	*n=2*	*20.0*	*82.91*	*138*	*1.47*	*0*	*14*	*12*	*1*	*7*	*38*	*1*	*0*	*5*	*0*	*3*	*0*	*0*	***55***
		Total	**N=21**	**190.5**	**461.77**	**1092**	**14.01**	**30**	**794**	**146**	**148**	**855**	**410**	**89**	**4**	**817**	**18**	**292**	**12**	**266**	**2911**

Food Plants

The presence of the taxa Cactaceae, *Chenopodium* sp., and parenchyma/tuber can be attributed to their use as a human food resource, although the consumption and preservation of each taxon are distinct. The presence of Cactaceae and *Chenopodium* sp. can also be due to camelid dung used for fuel.

Cactaceae. I identified 148 Cactaceae or cactus seeds. The ubiquity of cactus is 57%, the percentage frequency is 5.08%, and density is 0.63 seeds/L. The relatively high ubiquity of cactus shows that it was common in the Iroco assemblages; however, the percentage frequency and density indicate that the seeds were comparatively less common than other taxa.

Several cacti have been identified in a botanical survey of the Iroco region including *Echinoposis maximiliana* Heyder, *Opuntia boliviana* Salm-Dyck, *Opuntia soehrensii* Britton & Rose, and *Trichocereus pasacana* (Sempertegui *et al*. 2005). In this analysis, I identified one type of cactus seed in the Opuntoideae sub-family and one in the Cactoideae sub-family. For analytical purposes, I grouped these types into their common family because they were probably consumed (by humans or camelids) or used in a similar manner.

Opuntoideae seeds are "comparatively large … flattish-subcircular … with a distinct groove parallel to the margin[s]" (Martin and Barkley 1961:184). Bruno (2008:227) collected an economic cactus in northern Bolivia, on the Taraco Peninsula identified as an Opuntoideae, *Maihueniopsis* cf. *boliviana* (Sam-Dyck) Kiesling, and wrote that the seeds are "round or globular in shape and have three thick ridges that meet at a single point." In both description and photographic comparison, this species appears most similar to the Opuntoideae type encountered in this assemblage (Figure 4).

The identified archaeological cactoideae seeds are large and globular, with a pointed hilum, and a smooth seed coat (Figure 5). Currently, I am only able to correlate this seed to scientific sub-family.

Members of the cactus family have several known direct and indirect uses in the Andes, including the use of spines for tools, the dried stems for fuel (specifically in the Oruro region), as a hedge plant to keep animals away from granaries, and the fruits for human and animal food (Browman 1989:153; Whitehead 2007:176). The seeds of the fruits would not be carbonized if the spines were used for tools or the dried stems were used for fuel, because these uses do not involve contact with fire. Thus, I can rule out these uses. Browman (1989:153) notes that "cactus fruits have been exploited for food at least [for] 10,000-8000 years" in the Central Andes. Bruno (2008:226) adds that camelids forage for cactus fruits, and Hastorf and Wright (1999:218) identified charred cactus seeds in modern dung burned for fuel. Previous researchers have documented direct and indirect resource use of cactus, both of which are plausible scenarios for Wankarani cactus use. I am currently unable to determine the difference between human or camelid deposition; however, based on these ethnographic and research data, the presence of cactus in this assemblage is attributed to fruits consumed for food. Humans consumed the fruits and either deliberately or unintentionally disposed of the seeds in fires, which led to their preservation and recovery. Foraging camelids consumed cactus fruits, and seeds were preserved through the process of dung burning.

Figure 4. Image of archaeological *Opuntia* sp. seed (locus # 4124/4).

Figure 5. Image of archaeological Cactoideae seed (locus # 4124/4).

Chenopodium spp. Domesticated and cultivated in the Andes, quinoa and kañawa (sometimes spelled *cañihua*) are important economic grains in the Amaranthaceae family. This genus contains several other wild and domesticated species native to the *altiplano*. Bruno identified 473 chenopod seeds and I identified 382. A total of 855 chenopod seeds are included in this analysis, with a ubiquity of 76%, percentage frequency of 29.37%, and density of 4.48 seeds/L. The comparatively high ubiquity, percentage frequency (representing the largest portion of seed taxa), and density of chenopod seeds demonstrate that it is one of the most important taxa in the archaeological Iroco assemblage.

Over the last decade Maria Bruno spearheaded research on defining the characteristics of modern chenopod species seeds (Bruno 2001; Bruno 2006:43; Bruno and Whitehead 2003). She analyzed both modern domesticated and wild varieties including *Chenopodium quinoa, Chenopodium quinoa* var. *melanospermum, Chenopodium pallidicaule,* and *Chenopodium ambrosioides.* Identifying domesticated and wild varieties of chenopods in the archaeological assemblage is an integral part of understanding how the Wankarani interacted with their landscape. For example, were the Wankarani people farming or were they collecting wild plants?

Martin and Barkley (1961:151) describe Chenopodiaceae seeds as "circular-lenticular…[with] a notch or groove at one point on the margin [that] varies from evident to obscure" (see Figure 6). More specifically, these fruits have a central perisperm with an embryo wrapping around the periphery, terminating in what is referred to as a beak (where the radicle and seed leaves meet).

Bruno (2006:32) states that Andean varieties of chenopods thrive in disturbed ecological zones. Camelid herding creates opportune environments for chenopod cultivation, because the feces enrich the soil. Browman (1989:143) notes that domesticated Andean chenopods are well adapted to high altitudes, frost, drought, and saline soils. He also states that *kañawa* (as compared to quinoa) grows well at higher altitudes and can grow under conditions where there is less water - exactly the case in the Iroco region.

Chenopodium quinoa Willd. (quinoa) is the best known domesticate in this genus, because it is a modern food staple. Today, quinoa is grown and consumed throughout the Andes, and increasingly, it is consumed throughout the modern world (Hellin and Higman 2003:90). Current research indicates that quinoa cultivation in the Titicaca Basin dates to at least 1500 B.C. (Bruno 2001; Bruno 2006:43; Bruno and Whitehead 2003).

A second domesticated species, *Chenopodium pallidicaule* Aellen, is called *kañawa* in the Andes. Research has paid far less attention to this domesticate. However, currently Maria C. Bruno is working on deciphering its unique characteristics that resulted from human selective pressures. Kañawa grows well in drier regions, as stated above.

Chenopodium quinoa var. *melanospermum* Hunkizer is known commonly as *quinoa negra*, or in local dialect, *ajara,* due to its black color. This species often grows as a weed in quinoa fields and can be seen in packaged quinoa (its black color standing out). *Chenopodium ambrosioides* Aellen is called *paiko* and is a wild chenopod that has not exhibited traits of human selective pressures.

The domestication processes of Andean *Chenopodium* spp. plants have been under increasing scrutiny (Bruno 2001; Bruno 2006; Bruno and Whitehead 2003). Selection by humans through various processes including increased management of wild stands, cultivation, and intensification of chenopod production, to marked phenotypic changes during the southern Formative period in the south-central Andes. Specifically, Bruno and Whitehead (2001) note the increase in seed diameter size during the Formative periods. *Chenopodium* spp. studies have used fruit size, fruit shape, testa texture, testa thickness, and beak prominence to identify human selection pressures. Under selective pressures of cultivation, seed size of chenopods has been shown to increase (Browman 1989:143-148; Bruno 2001, 2006; Bruno and Whitehead 2003). This increase in size was the result of what Harlan (1975) has identified as seedbed competition, where the larger seeds outcompete smaller seeds under cultivation. Furthermore, decrease in relative testa thickness (the seed coat) is an indicator of human-induced selective pressures (Smith 1989:1568).

The earliest evidence of domesticated chenopod cultivation is documented at Wankarani and Chiripa archaeological sites in the *altiplano*. A unique semi-domesticated, morphological chenopod seed type from a hearth at the Formative period Wankarani site, La Barca, was excavated by Marc Bermann and William Castellón Condarco (Langlie *et al.* 2011). This morphological type dates to 1200 B.C., much earlier than the Iroco samples. A study on *Chenopodium* domestication at the site of Chiripa located in the Lake Titicaca basin reveals evidence of phenotypic change associated with human selection pressures by 1500 B.C. (Bruno and Whitehead 2003:350). These two studies reveal that chenopods were cultivated across the *altiplano* region during the early part of the Formative period.

Identifying signatures of chenopod domestication entails a multivariate approach that includes the use of scanning electron microscopy (SEM) and analysis of the above-described attributes. Without conducting a comprehensive analysis using SEM, it is difficult to determine if the seeds analyzed were domesticated or wild. However, I provide some preliminary insights into the status of the Iroco chenopods.

I collected data on four attributes of 219 chenopod seeds from the Iroco site including seed diameter size, presence of a testa (seed coat), testa texture, and relative testa thickness. These data are presented in Appendix C, Table 1. I gathered these data using an ocular micrometer in a light microscope under magnification of 10X-40X.

The diameter range of the 68 seeds with a visible testa is 0.6 mm-1.7 mm and the mean diameter is 1.08 mm. Bruno (2008:207) notes that diameter alone is not an indicator of domestication status of Andean chenopods. Rather, the ranges between the wild and domesticated varieties overlap too much to establish domestication status only on a measurement of diameter.

Testa thickness was visible on seeds with a cracked or partial testa. Based on my previous chenopod seed analysis experience and with the guidance of Dr. Fritz I categorized testa thickness into two categories: relatively thick and relatively thin. These categories correlate thick-testa chenopod seeds to wild or weedy species and thin-testa chenopod seeds to domesticated species. I estimate that the thick-testa chenopod seeds in this study have testa thicknesses larger than 10 μm and the thin-testa seeds have testa thicknesses that range from 0-10 μm. Of the 47 chenopod seeds with a visible testa thickness, 26 seeds had a thick testa, and 21 seeds had a thin testa. The thick-testa chenopods are likely *quinoa negra* (*Chenopodium quinoa* var. *melanospermum*) the weedy variety that coevolved alongside quinoa or *paiko* (*Chenopodium ambrosioides*) a species. The testa thickness of modern *negra* ranges from 22-51 μm, and *paiko* testa thickness ranges from 11-14.5 μm (Bruno 2006:38-39). The thin-testa chenopods likely represent either domesticated quinoa (testa thickness range 1.2-3.75 μm) or domesticated *kañawa* (testa thickness range 4.25-7.5 μm) (Bruno 2006:38-39). Furthermore, I identified 146 chenopods without visible testa. Seed coats of seeds with identifiable testa are sturdier than those of thin testa seeds and hold up better after carbonization. The seed coats may have readily burned away during firing leaving identifiable chenopods seeds' endosperms, leaving identifiably remnants of domesticated thin-testa varieties.

Testa texture, although difficult to identify without an SEM, provided further insight into the presence of cultivated varieties in the Iroco region. I identified testa texture using the light microscope and used the same classifications as Bruno (2006). Sixteen chenopod seeds had a fairly smooth seed coat and a canaliculate testa texture around the beak. This testa texture resembles a modern wild variety of *Chenopodium* sp. plant collected from the Titicaca Basin (Bruno 2008:299). It is also similar to an unknown archaeological taxon identified by Bruno (2008:305) that she has suggested is an intermediary form of *kañawa* that exhibits phenotypic change due to the early stages of human selection pressures. Four seeds had a canaliculate testa texture that looks like modern *kañawa* seeds (Bruno 2006:40). Sixteen seeds exhibited a smooth testa texture similar to modern quinoa (Bruno 2006:40). Twelve seeds had a reticulate testa texture similar to modern *quinoa negra* (Bruno 2006:40). Only one seed had a punctuate testa texture similar to *paiko*.

Only 12 chenopod seeds were smooth and thin coated. The seed diameter of these 12 seeds ranged from 0.7-1.0 mm with a mean diameter of 0.87 mm. The combination of these traits is evidence that these 12 smooth and thin testa chenopod seeds are from plants that are either domesticated quinoa or semi-domesticated quinoa. They might be semi-domesticated because they had a relatively small diameter compared to modern quinoa.

Three seeds had the combined traits of a smooth testa and a canaliculate testa texture around the beak. These three seeds ranged in diameter from 1.0-1.2 mm. Based on the combination of these attributes, these three seeds, if Bruno's (2008:305) hypothesis is correct, are from *kañawa* that is in the early stages of domestication.

Two seeds exhibited the combined traits of a canaliculate testa texture and a thin seed coat. These two seeds were also comparably small to their modern cognate, *kañawa*, ranging from 0.9-1.3mm. Based on the combination of testa texture and testa thickness, these two seeds are *kañawa*.

Twenty-five chenopod seeds had a thick testa. The thick testa chenopod seeds are either wild or weedy varieties with varying testa textures.

The Iroco chenopod assemblage is composed of a mixture of domesticated and wild or weedy types of chenopods. The large quantity of seeds that lack a testa (n=146) are likely correlated with thin-testa cultivated varieties such as quinoa. Humans and/or their herded animals consumed both domesticated and wild chenopod seeds.

The Wankarani macrobotanical assemblage is composed of both direct and indirect resource use of chenopods. Camelids grazed on natural stands of chenopods or in Wankarani fields and enriched the soils with their dung. Subsequently, wild or domesticated varieties of chenopods ended up charred and preserved through camelid dung burning. Browman (1989:165) notes that it is a common practice to parch or dry out chenopods in ceramic vessels for storage. *Chenopodium* spp. seeds became charred during parching, spilled into the fire during cooking, or were disposed of in fires if they were no longer edible.

Figure 6. Image of archaeological *Chenopodium* sp. (locus #4162/1).

Parenchyma and Tubers. I identified 794 carbonized parenchyma/tuber specimens; ubiquity is 81% and density is 4.17 fragements/L. The comparatively high ubiquity and density of parenchyma/tubers indicates that it was an important part of the Wankarani plant assemblage.

Several tubers and roots were domesticated or semi-domesticated as food sources in the Andes, including the potato (*Solanum tuberosum*), oca (*Oxalis tuberosum*), mashwa *(Tropaeolum tuberosum*), ulluco (*Ullucus tuberosus*), and maca (*Lepidium meyenii*) (Flores et al. 2003; Pearsall 2008:107). These plants are adapted to environments with poor soils, constant erosion, and unpredictable rainfall and temperatures, characteristic of the steep slopes of the Andes (Flores *et al.* 2003:161).

Although little is known about the process of domestication of the majority of these plants, recent genetic research has begun to unravel the history of the potato (Spooner *et al.* 2005) and oca (Emshwiller 2006). Browman (1989:149) notes that the charred remains of possibly domesticated potato have been recovered dating to 6000 B.C. from a site called Chilca. Researchers have identifed the earliest evidence of oca cultivation dating to 9000-10,000 B.P., but it is more plausible that it was domesticated between 4000-1000 B.P. (Emshwiller 2006). Although domestication the data regarding tuber domestication is scant and outdated in the archaeological literature, the dates for potato and oca domestication precede the Formative period in the Iroco region. I do not rule out the possibility that the Wankarani people were collecting wild tubers. Based on the early dates recorded for tuber domestication, it is highly probable that the Wankarani people were cultivating domesticated tuber species.

All the above-mentioned tubers and roots are boiled and/or mashed in preparation for consumption. Furthermore, it is a common practice to freeze-dry potatoes (chuño), using the cold nights of the Andes. The processing technique involved in making chuño extracts poisonous glycoalkoloids present in some varieties of wild and domesticated potatoes (Johns 1989:509) .

Tubers and root crops are rarely preserved in the archaeological record. Pearsall (2000:157) states that “the most likely source … of tubers are those discarded as spoiled … and any accidentally charred during roasting.” Although it is easy to identify carbonized parenchyma, it is extremely difficult to determine the plant taxon. Hundreds of colloquial varieties of potatoes of varying morphologies are known in the Andes, which make it even more difficult to identify the scientific genus and species of parenchyma/tuber fragments. An organized cellular structure and non-uniform shape allowed at the very least for a degree of identification of carbonized parenchyma/tuber fragments (Pearsall 2000). Future research using more advance techniques and technologies, such as scanning electron microscopy, may reveal the identities of the tuber taxa present in the Iroco macrobotanical assemblage. Parenchyma/tubers were charred and preserved as the result of refuse disposal (which I will return to later in analysis) or cooking accidents.

Aquatic Plants

The presence of fish bones and scales (Capriles 2008) and the presence of the taxa Cyperaceae and *Ruppia* sp. are evidence that the Wankarani peoples regularly exploited aquatic or lacustrine ecological zones. The dung burning experiments conducted by Hastorf and Wright (1998) identified seeds of these taxa. Thus, I conclude that Cyperaceae and *Ruppia* sp. seeds were carbonized and deposited from camelid dung used for fuel.

Cyperaceae. Sedge seeds are “generally ovate in outline and ... plano-convex to lens shaped … [with a] blunt or pointed style base (Martin and Barkley 1961:137).” The seeds identified in this taxon measure from 0.8-1.3 mm in length and 0.5-1.0 in width, and the style was pronounced. I identified 410 Cyperaceae seeds; ubiquity is 76%, percentage frequency is 14.08%, and density is 2.15 seeds/L. The comparatively high ubiquity, percentage frequency, and density suggest that Cyperaceae was a common and essential plant in the Wankarani plant assemblage. Unable to differentiate species, Bruno (2008:233) argues that the Cyperaceae seeds from archaeological contexts on the

Taraco peninsula were *Schoenoplectus* sp., *Carex* sp., or *Scirpus* sp. She notes that these species all grow in moist soil conditions (Figure 7).

Schoenoplectus californicus is a plant species cultivated in the Andes that has many uses. Its common name is *totora*, and it is the only species of Cyperaceae to grow in the shallow waters of lakes (Bruno 2008:233). Totora is a perennial aquatic sedge (Banack et al. 2004:11); ethnographic research establishes that it is collected from wild stands and intensively cultivated (Banack et al. 2004:12; Orlove 1991:6). Bruno (2008:234) and Browman (1989:150-151) note that *totora* is commonly consumed as food. The white juicy rhizome located at the base is the part of the plant that is consumed. Totora can also be used as thatching for roofing material, boats, mats, tools, cordage, and animal fodder (Browman 1989:151; Whitehead 2007:207; Orlove 1991:6).

In addition to *totora*, Bruno (2008:256) notes that several other Cyperaceae species grow in the *altiplano* including *Carex* cf. *maclaviana* d'Urv., *Eleocharis albibracteata* Nees & Meyrn ex. Kunth, *Schoenoplectus totora, Carex* cf. pinetorum Liebm., *Cyperus sesierioides* H.B.K., *Scirpus deserticola* Phil., and *Scirpus rigidus* (Steed.) Boeckl. Bruno (2008: 255) collected several seed heads of *totora*, none of which produced any mature seeds for comparison. Currently I am unable identify this seed type to genus and, as a result, have placed these seeds in the Cyperaceae family.

Unable to identify whether Cyperaceae seeds are wild or managed totora makes it difficult to assess its use (especially as direct and indirect resource use e.g., humans consuming rhizomes and discarding the seed heads or burning construction materials). Hastorf and Wright (Hastorf and Wright 1998:218) note the presence of charred

Cyperaceae seeds in modern dung burned for fuel. Camelids foraged for Cyperaceae plants, but I cannot determine if these seeds are *totora*. If the seeds are totora, it is possible that it was cultivated as camelid fodder. A limited family level identification of Cyperaceae further limits analyses regarding Wankarani cultivation and consumption of totora.

Figure 7. Image of archaeological Cyperaceae seed (locus # 4162/1).

Ruppia sp. With the assistance of Christine Hastorf and Maria Bruno, I identified *Ruppia* sp. seeds (Figure 8). *Ruppia* sp. is commonly known as a ditch grass. I identified 12 *Ruppia* sp. seeds; ubiquity is 19%, percentage frequency is 0.41%, and density is 0.07 seeds/L. This taxon is comparatively less important in the Wankarani economy, which is evident in the relatively low ubiquity, percentage frequency, and density of seeds. *Ruppia* sp. is an aquatic plant taxon that was carbonized through indirect resource use in camelid dung burned for fuel or as seed rain (Christine A. Hastorf and Maria C. Bruno, pers. comm. 2011).

Figure 8. Image of archaeological *Ruppia* sp. seed (locus # 4131/1).

Enriched Soil Taxa

Two plant taxa recognized in this analysis thrive in disturbed and rich soils: Malvaceae and Fabaceae. Research identifies that, in the *altiplano,* these taxa grow in fallowed fields enriched by animal dung (Bruno 2008:236-241). The presence of these seeds lends further evidence to fact that the Wankarani peoples practiced agriculture.

Malvaceae. I identified 817 Malvaceae seeds (the mallow family) (Figure 9); ubiquity is 76%, frequency is 28.07%, and density is 4.29 seeds/L. Malvaceae seeds represented a large portion of the identified seeds in the Iroco assemblage. Easily identified by a their distinct curved lunate to reniform shape, Malvaceae seeds measured between 0.8-1.5 mm in length and 0.6-1.2 mm in width, and are rounded on one end and come to a point at the opposite end. Lack of distinguishing characteristics between species, does not currently permit genus level identification of Malvaceae seed types.

Several species of Malvaceae grow in the *altiplano*. Bruno (2008:240) collected and identified modern *Urocarpidium shepardae* (I. M. Johnst.) Krapov. from the Taraco

Peninsula. *Tarsa tenella* was identified near Iroco in a botanical survey (Sempertegui *et al.* 2005:80). Browman (1989:152) notes that *Notoriche* sp. and *Malvastrum* sp. grow well in "disturbed areas" (irrigation ditches, fallow fields) around Lake Titicaca. All of the aforementioned *altiplano* Malvaceae species thrive in disturbed and enriched soils (Browman 1989:151-152; Bruno 2008:241; Sempertegui *et al.* 2005:80). The presence of this taxon (especially in such robust numbers) correlates to the presence of enriched soils in proximity to the three Wankarani sites. Hastorf and Wright (1998:218) identified charred Malvaceae seeds in modern dung burned for fuel. Based on this ethnographic research, Malvaceae seeds were carbonized and deposited at the three Wankarani sites in camelid dung burned for fuel.

Figure 9. Image of archaeological Malvaceae seed (locus # 4162/1).

Fabaceae. This seed type appears to be *Trifolium amabile,* a wild legume in the Fabaceae family; but without a reference collection from the Iroco region I hesitate to identify this taxon to genus (Figure 10). None of the seeds had a distinguishable seed coat that might aid in a genus or species level identification. I identified 89 Fabaceae seeds; ubiquity is 48%, percentage frequency is 3.06%, and density is 0.47 seeds/L. The seeds measure 1.2 mm-2.0 mm in length and 0.5-1.3 mm in width. The identified Fabaceae seeds are mitten shaped and oblong.

In the central *altiplano*, Bruno (2008:235-237) identified a small legume as the taxon *Trifolium amabile* H.B.K. Based on gross morphology the seeds in the analyzed Iroco samples appear similar. *Trifolium* sp. species grow readily and vigorously in disturbed and agricultural soils, which lends evidence to cultivation activities (Bruno 2008:236). Brack Egg (1999) notes that in the Andes livestock often consume wild legumes. Hastorf and Wright (1999:218) found that wild legumes are a common plant taxon in dung burned for fuel. Following Bruno's (2008) hypothesis, Fabaceae seeds were carbonized and deposited at the Wankarani sites through dung or plants burned for fuel (indirect resource use).

Figure 10. Image of archaeological Fabaceae seed (locus # 4162/1).

Wild Taxa

The wild taxa category consists of plants that occur naturally in the region, including Poaceae, *Lepidium* sp., and *Plantago* sp. The most likely entrance into the archaeological record was through camelid dung burned for fuel.

Poaceae. The grass family is composed solely of wild taxa in the *altiplano* (and is a relatively large and diverse family. I identified 410 Poaceae seeds; ubiquity is 67%, frequency is 10.03%, and density is 2.15 seeds/L. In the Wankarani assemblage grass seeds are common based on ubiquity, but only moderately important based on frequency and density. Figure 11 depicts a representative archaeological seed. Specimens grouped in this taxon varied in morphology and size. The grass seeds identified measure from 0.8-2.2 mm in length and 0.4-1.3 mm in width. The larger seeds have a ventral sulcus characteristic of the grass genus *Stipa* sp. The smaller grass seeds are rod-shaped and lack any distinct sulci.

Whitehead (2007:222) mentions that near Puno, on the north-western side of Lake Titicaca, 24 genera of grasses have been identified including 85 species of grass. Bruno (2008:246) identified at least 23 species growing in the southern basin of Lake Titicaca, some of which are introduced Old World grasses. She also mentions that the "ichus" are genera in the *altiplano* that thrive in drier areas (Figure 9). These species include *Stipa ichu*, *Stipa leptostachya*, and *Stipa pseudoichu*. Grass species identified in a botanical survey of the Iroco region include: *Nasella meyeniana* (Trin&Rupr.) Parodi, *Asistida enoides* Hack., *Bromus catharticus* Valh*.*, *Eragrostis uvula* (Schrad.) Needs., *Chondrsum simplex* (Lag.) Kunth., *Stipa ichu, Dactylic glomeration* L., *Fistula orthophylla* Pig., and *Bromus catharticus* Valh. (Sempertugui *et al.* 2005). Due to similarities in morphologies and sheer number of species in the *altiplano* grasses, I only identify this seed type to the family level.

Ethnographic research identifies *Ichus* as a documented camelid forage food in the *altiplano* (Bruno 2008:246). They are also used as fodder, fuel, rope, and fiber

(Whitehead 2007:224). The plethora of other grass species are also currently used for animal forage, fodder, basketry, and construction material (for thatching and roofing material) (Bruno 2008:246-247; Whitehead 2007:224). The identified charred Poaceae seeds may have been attached to stems and leaves used as construction material that was accidentally or intentionally burned. Based on the abundant amount of charred grass seeds, a more likely hypothesis is that this taxon of seeds was charred in camelid dung burned as fuel or grass used for fuel.

Figure 11. Image of archaeological Poaceae seed (locus # 4162/1).

Plantago sp. This taxon is a member of the scientific botanical family Plantaginaceae commonly called the plantain family. I identified 18 *Plantago* sp. seeds; ubiquity is 10%, frequency is 0.62%, and density is 0.11 seeds/L. The identified *Plantago* sp. seeds are plump, with thick margins (Bruno 2008:243), and they are "hollowed out like a boat" on one side (Martin and Barkley 1961:199). The seeds are oblong and compressed lengthwise. The identified seeds measure 1.0-1.8 mm in length and 0.6-1.2 mm in width. The species *Plantago sericea* R&P is a likely candidate for the identified archaeological seeds because it currently grows in the study region (Sempertegui *et al.* 2005:27). Bruno (2008:244) points out that the preferred habitat for the genus is undisturbed soils.

Llanten, a variety of *Plantago* sp. identified in the modern period in the northern *altiplano* region around Lake Titicaca, has several medical uses; the presence of this taxon in the archaeological assemblage at Chiripa, as early as 1300 B.C. might be the result of its medicinal value (Browman 1989:152-153). Although difficult to determine, the presence of carbonized *Plantago* sp. seeds in the Iroco archaeological assemblage is more likely due to camelid dung burned for fuel than medicinal use.

Lepidium sp. This genus is in the mustard family (Brassicaceae, formally known as Cruciferae). I identified only 4 *Lepidium* sp. seeds; ubiquity is 10%, frequency is 0.14%, and density is 0.02 seeds/L. Low ubiquity, frequency, and density of this taxon is evidence that *Lepidium* sp. is of minor significance in the Iroco assemblage. *Plantago* sp. seeds are "elongated [with a] folded embryo that gives the seed an ellipsoid shape (Bruno 2008:223)." The end of one portion of the embryo is sharp and the other is enlarged (Figure 12). At this time, I am unable to identify this seed type to species. *Lepidium chichicara* Desv. is the only species of *Lepidium* that has been identified in the study region (Sempertegui *et al.* 2005:68). Furthermore, botanists (Sempertegui *et al.* 2005) note that this species is known to be toxic to animals. *Lepidium meyenii* is an Andean domesticated root crop called *maca* not very widely grown in the current period (Flores *et al.* 2003:163); so the presence of this seed could represent cultivation of *maca*. A more likely scenario is that camelids foraged for the wild species that currently grows in the study region, or a relative of the same genus, and the seeds were carbonized in dung used for fuel. The extremely low occurrence of this seed may be attributed to the fact that the local *Lepidium* sp. plants are toxic so camelids avoided its consumption.

Figure 12. Image of archaeological *Lepidium* sp. seed (locus #4120).

Other Taxa

Wood, dung, and fungus represent categories that do not fit elsewhere in my analysis. Woody shrubs and dung were likely used as a source of fuel.

Wood. Carbonized fragments of woody stem were commonly recognized during analysis. I identified 1,092 wood fragments. Wood fragments are present in 86% of the samples, with a density of 5.56 specimens/L. High ubiquity and density point to a significant importance of woody plants in the analyzed archaeological samples. There are remarkably few species of trees in the *altiplano.* Browman (1989:155) states that *Lepidophyllum* sp. and *Baccharis* sp. known commonly as *tolas* (also spelled *thola*) are woody shrubs that grow in the northern portion of the *altiplano.* The shrubs are used as a common source of fuel in fires. He also states that the roots of *tolas* are less commonly consumed as a famine food, the leaves are used in teas and tonics, and they have a few medicinal uses. The recovered woody fragments may be the result these modern uses, however it is more likely woody products were used to fuel fires.

Dung. I identified 30 fragments of dung in this study. This category was present in 33% of the samples, with a density of 0.25 fragments/L. The sheer presence of charred dung fragments indicates that it was used for fuel. I did not identify any complete pellets; however, there were several fragments that appeared characteristically dung-like. These fragments were identified by their unorganized cellular structure, brownish-black color, and contents of organic fragments. The identification of carbonized dung fragments indicates that the Wankarani people used camelid dung as a source of fuel in fires. These data complement the large proportion of charred wild seeds that were contained within the dung fuel. Dung was not routinely preserved and recovered, because the organic elements were burned in the fire and only the seeds preserved. The comparatively small amounts of dung in the analyzed samples may also be attributed to recovery methods. Charred dung is fragile and might have disintegrated to unidentifiable even smaller fragments during recovery, flotation, and laboratory analysis.

Fungus. Fungus was an unexpected, non-plant find in the archaeological samples from the Iroco region. Fungi are distinct from plants because they lack chlorophyll (the green pigment/molecule in plants that allows for photosynthesis which is how plants capture and produce energy from the sun) (Bessey 1950:2). The cell walls of fungi are made of chitin (the same element in the exoskeletons of bugs), whereas plants are made of cellulose. These attributes of fungi lead to their distinct parasitic mode of reproduction and survival (Bessey 1950:2). The carbonized fungus in this study was identified by the distinct honeycomb pattern when viewed from the top (Figure 14). Turned on its side, the fungal body appear to be a collection of tubes (Figure 13). A single tube is called the hypha, with more than one tube known as hyphae. The tightly bunched group of hyphae as a unit makes up the fungal body called the mycelium. The mycelium is an unbranched tubular structure that is only a few millimeters in length. Composed of numerous strands of hyphae, the mycelium is **a** structure of the fungus that feeds off an external host. Some fungi kill the host, while others maintain a balanced relationship, only extracting enough nutrients to reproduce (Agrios 2005:72). The hyphae are the structures in fungi that contain the spores, which are released and distributed for reproduction of the fungi (Bessey 1950:3).

An entire field of biology, mycology, is devoted to the study of fungi. While a non-specialist in this field, I acknowledge my shortcomings in identification and I have sought aid in this endeavor. Dr. Fritz and I initially identified carbonized mycelia in the analyzed samples. These specimens range from 0.5 mm-2 mm in length and are approximately 2 mm in diameter. The host of the fungus was later identified as a tuber. Mycelia are attached to the exterior part of the tuber (Figure 14); but as previously mentioned, it is nearly impossible to identify fragmented parenchyma/tuber to family, genus, or species.

Dr. James Bradeen from the University of Minnesota Plant Pathology Department referred me to a "classically trained mycologist", Dr. William Kirk, a professor in the Plant Pathology Department at Michigan State University. Initial correspondence with these specialists suggested that the fungus was *Phytopthora infestans*, the culprit of the Potato Famine in Ireland that lead eventually led to the starvation and death of roughly one million people due to crop failure in the 1840's. There is a debate in the mycology world over the origins of this pathology. One group of researchers believes that *P. infestans* is from Mexico, while the other groups argues that it is from the Andes. Based on the presence of resistance genes and genotypic diversity in *Solanum* spp., Grunwald and Flier (2005) contend that the origins of *P. infestans* was in the central highlands of Mexico. However, mitochondrial and nuclear genetics research by Gómez-Alipzar *et al.* (2006) suggests that *P. infestans* evolved symbiotically in the same place that the potato was domesticated - the Andes. This would place the Wankarani fungus directly in the middle of this debate and would offer evidence of an Andean origin. Every mycologist that I have communicated with was excited by this potential find and without hesitation identified the archaeological fungus as *P. infestans*.

Further examination of photographs by Dr. Kirk has revealed that it is unlikely that this fungus is *P. infestans*, based on the gross morphology of the mycelium. The mycelium "of *P. infestans* is very delicate and tend not to be present on the outside of the tuber" (William Kirk, Personal Communication 2011).

Currently, I am unable to determine the genus of this fungus. Future research and collaboration with mycologists and plant pathologists will hopefully lead to an identification of the species of this archaeological fungus.

4121/1).

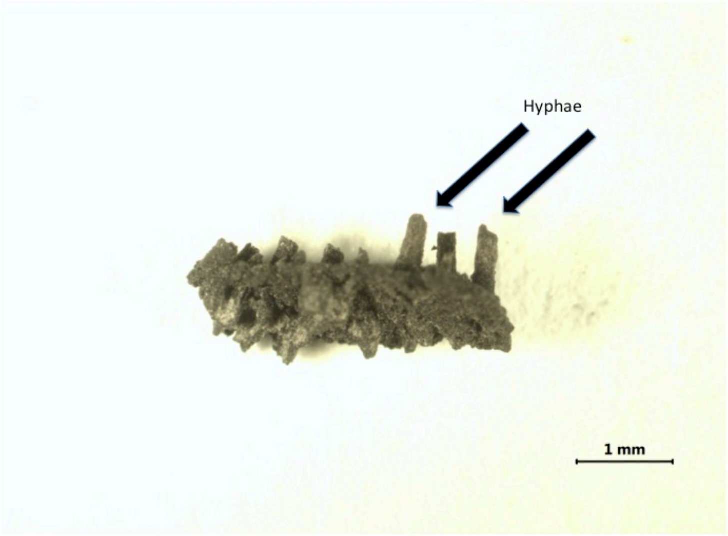

Figure 13. Carbonized archaeological fungus specimen, with arrows pointing to the prominent hyphae (locus # 4067/1).

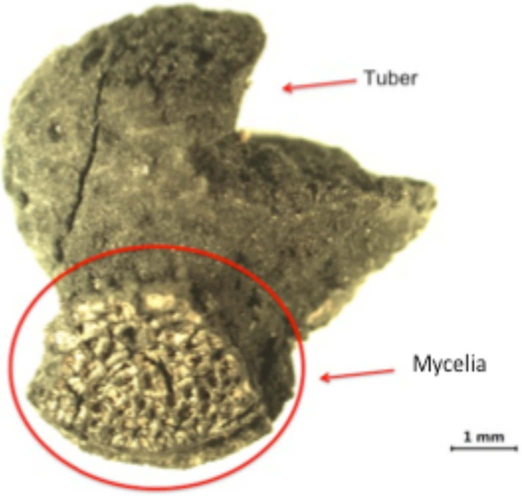

Figure 14. Image of carbonized archaeological fungus attached to a tuber (locus # 4121/1).

Unknown or Unidentifiable Seeds. Nine unknown specimen types were identified and photographed. Some of these specimens are too clinkered to identify and might be unrecognizable grass seeds. Of the 266 unknown or unidentifiable specimens in this study, 230 were in the two samples analyzed by Dr. Maria C. Bruno in Bolivia. I do not have access to them for further study. Images can be found in Appendix B.

Results

In this section I explain the location and contexts of recovered botanical remains from the three Wankarani sites. I offer scenarios of deposition within the contexts of the three sites.

KCH11

A 4 X 4 meter unit was excavated in the central area of the mound at KCH11 (Figure 15). Two groupings of rocks that possibly contained tombs were noted on the surface before excavations began (Capriles 2008:23-26). Three tombs were excavated, which are illustrated in Figure 15. These burials were AMS dated to after the Tiwanaku period (A.D. 800-1000), and no botanical samples were analyzed associated with the tombs. I focused analysis on Formative period contexts. A small semi-circular structure and floor composed of clay was identified in the northeastern area of the unit (Capriles 2011:136). This floor was heavily disturbed (Capriles 2008:23). Calibrated AMS dates indicate that the structure dates to 24 B.C.-A.D.94 (Capriles 2011:137). I analyzed two paleoethnobotanical samples from the Formative period structure.

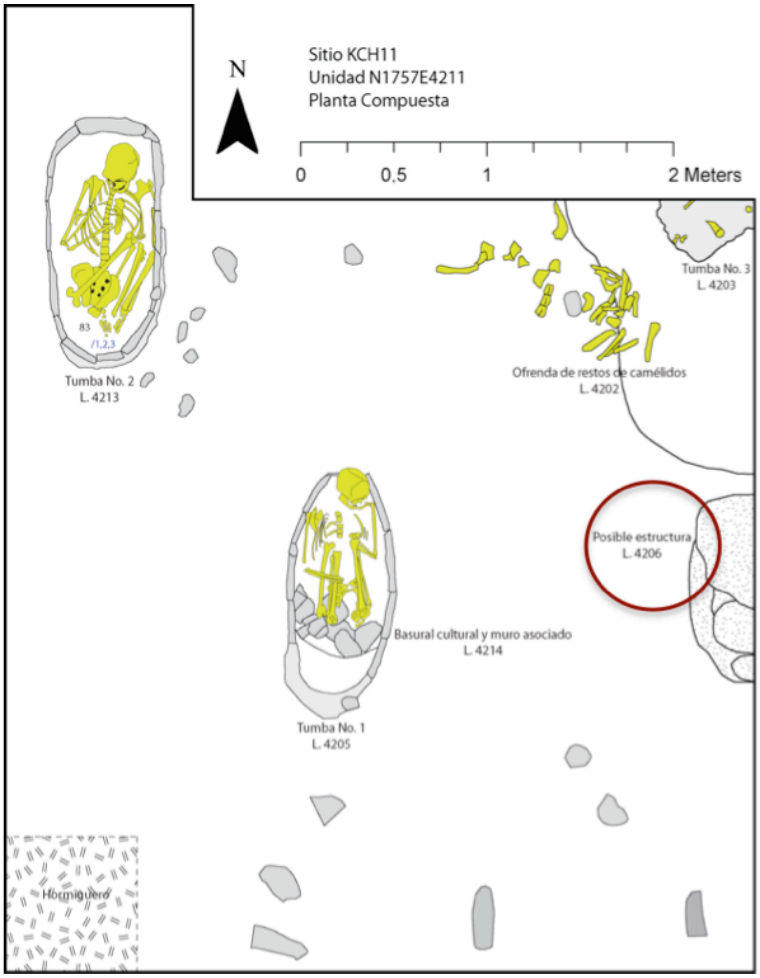

Figure 15. Composite plan of Unit N1757 E4211 from site KCH11 (From Capriles 2008:25, Figure 10). The circle indicates the location of sample L. 4206/1.

Table 3. Density/L of macrobotanical remains from KCH11.

Plant Resources	Site	KCH11	**KCH11**	KCH11	**KCH11**
	Locus	4206/1	**4206/1**	4207/1	**4207/1**
	Context	Floor	**Floor**	Midden	**Midden**
		# seeds/frags	**Density/L**	# seeds/frags	**Density/L**
	Volume	10 L	**10 L**	10 L	**10 L**
Food plants					
Cactaceae seeds		-	**-**	1	**0.10**
Chenopodium sp. seeds		4	**0.40**	3	**0.30**
Parenchyma/Tuber frags.		1	**0.10**	13	**1.30**
Aquatic plants					
Cyperaceae seeds		13	**1.30**	25	**2.50**
Ruppia sp. seeds		-	**-**	-	**-**
Enriched soil plants					
Malvaceae seeds		1	**0.10**	4	**0.40**
Fabaceae seeds		1			
Wild plants					
Poaceae seeds		-	**-**	3	**0.03**
Plantago sp. seeds		-	**-**	-	**-**
Lepidium sp. seeds		-	**-**	-	**-**
Other taxa					
Wood frags.		33	**3.30**	105	**10.50**
Dung frags.		-	**-**	-	**-**
Fungus frags.		-	**-**	12	**1.20**
Total		19	**5.30**	166	**16.60**

I analyzed two samples from KCH 11: L. 4206/1 and L. 4207/1. The raw counts and densities of the recovered macrobotanical remains are displayed in Table 3. Sample L. 4206/1 came from the eastern area of the unit and was recovered from a surface or floor associated with the edge of the exposed structure. This sample contained a low density of carbonized botanical material. Small amounts of food taxa, enriched soils taxa, and wood might be evidence that cooking activity took place within the structure.

The floor was probably cleaned and these taxa accidentally deposited. Sample L. 4207/1 was labeled as a midden and dates to the Formative period. This context also revealed a comparatively low density of botanical taxa. However, 105 wood fragments were identified, indicating that carbonized refuse from hearths may have been disposed of in the midden.

Irucirca or KCH21

Broad exposure excavations at Irucirca uncovered 413 m^2 (Figure 16). A possible corral and several structures that appear to be houses and domestic spaces were exposed. Capriles' (2008:93) "objectives for the excavations were twofold: (1) sample the floor inside the possible corral, to identify the activities conducted inside the structure and (2) sample a wide variety of domestic context that were not previously excavated, employing fine-grained recovery techniques."

Two areas of a possible corral were intensively excavated (Figure 16) that include a 2 x 2 m (four square meters) unit in the center of the corral, and a 1 x 4 meter (four square meters) unit in the northern portion extending from inside the corral wall to outside the wall (Capriles 2008:34, Figure 16). I analyzed four samples from the center of the corral and one sample from a pit located adjacent to the exterior of the corral wall.

The center portion of the corral (unit N3290E5474) revealed a very low density of cultural debris. Four macrobotanical samples were analyzed from the center portion of the possible corral including loci #'s 4058/1, 4054/1, 4053/1, and 4052/1. The raw counts and densities of these samples are presented in Table 4.

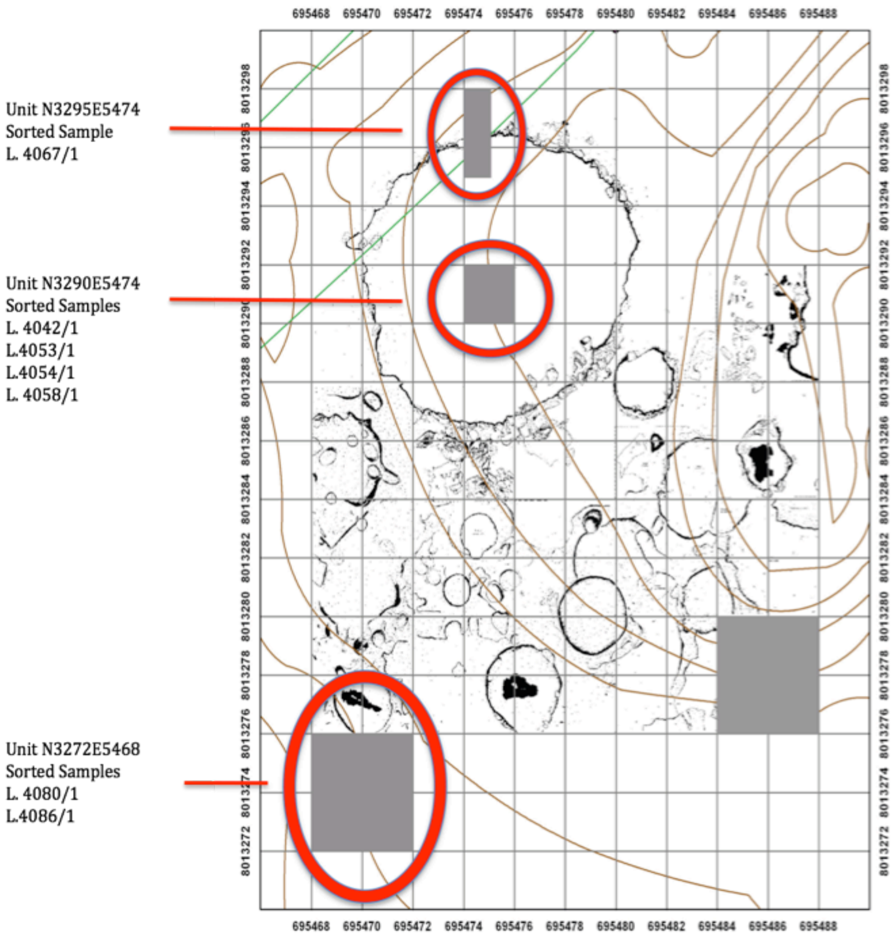

Figure 16. Map of KCH21 the three units excavated in 2007 are circled and labeled with corresponding analyzed archaeobotanical samples (from Capriles 2008:34, Figure 16).

Culturally sterile soil was reached in the lowest stratum, identified by a sandy, deep orange matrix. Sample L. 4058/1 was from the culturally sterile level. The density of this sample is 0 specimens/L, which supports the excavators' interpretations that this level is culturally sterile. Above the sterile soil was an organic, silty stratum of fill material. This stratum contained two circular pits, which were probably the result of burrowing animals and was also interpreted as culturally sterile (Capriles 2008:36). Sample L. 4054/1 from this level was analyzed for macrobotanicals and revealed four wood fragments and a two Malvaceae seeds. The low density of these remains can be attributed to wind-borne seed rain from nearby burning activities, or the seeds are evidence of bioturbation. The recovery of these remains indicates that this level was not culturally sterile and is associated with the Wankarani Complex occupation of the site.

Sample L. 4053/1 was taken from the stratum above sample L 4054/1, above the organic fill event, and below the corral floor. It consisted of a sandy matrix with organic inclusions. Three carbonized remains (a grass seed, a parenchyma/tuber fragment, and a chenopod seed) were recovered from this sample. Similar to L. 4054/1, the charred remains were deposited as seed rain from a nearby fire, or the seeds are evidence of bioturbation. The floor of the corral was identified above this stratum and it consisted of a gray clay matrix. The base of the floor was uneven; however, the surface was very flat and level. Small holes, which appeared to have been caused by burrowing beetles, were apparent on the surface of the floor. I analyzed sample L. 4052/1 from the corral floor. Two fragments of wood were identified in this sample. Once again, it is probable that these charred remains were deposited by seed rain from a nearby fire, or are the result of bioturbation. On top of the floor, there was an aeolian deposit of a natural sandy fill layer that preserved and capped the site (Capriles 2008;36-37).

The botanical remains present in the described corral samples maybe the result of camelids consuming and defecating charred botanical remains. The seeds likely represent seed rain blown in from other activity areas. Additionally, the remains may represent construction events of culturally derived soils that were used to level out the corral area but were obtained from other activity areas in the site.

Table 4. Density/L of macrobotanical remains in unit N3290E5474 and L. 4067 from unit N3295E5474.

Plant Resources	Site	KCH21	**KCH21**	KCH21	**KCH21**	KCH21	**KCH21**	KCH21	**KCH21**	KCH21	**KCH21**
	Locus	4052/1	**4052/1**	4053/1	**4053/1**	4054/1	**4054/1**	4058/1	**4058/1**	4067/1	**4067/1**
	Context	Corral floor	**Corral floo**	Corral	**Corral**	Sterile	**Sterile**	Sterile	**Sterile**	Pit	**Pit**
		# seeds/frags	**Density/L**	# seeds/frags	**Density/L**	# seeds/frags	**Density/L**	# seeds/frags	**Density/L**	# seeds/frags	**Density/L**
	Volume	10.5 L	**10.5 L**	**11 L**	**11 L**	9 L	**9 L**	**10 L**	**10 L**	9.5 L	**9.5 L**
Food plants											
Cactaceae seeds		-	-	-	-	-	-	-	-	2	**2.00**
Chenopodium sp. seeds		-	-	1	**0.09**	-	-	-	-	209	**22.00**
Parenchyma/Tuber frags.		-	-	1	**0.09**	-	-	-	-	182	**19.16**
Aquatic plants											
Cyperaceae seeds		-	-	-	-	-	-	-	-	70	**7.37**
Ruppia sp. seeds		-	-	-	-	-	-	-	-	-	-
Enriched soil plants											
Malvaceae seeds		-	-	-	-	2	**0.22**	-	-	109	**11.47**
*Trif olium*sp. seeds		-	-	-	-	-	-	-	-	3	**0.32**
Wild plants											
Poaceae seeds		-	-	1	**0.09**	-	-	-	-	55	**5.79**
Plantago sp. seeds		-	-	-	-	-	-	-	-	-	-
Lepdium sp. seeds		-	-	-	-	-	-	-	-	-	-
Other taxa											
Wood frags.		2	**0.19**	-	-	4	**0.44**	-	-	133	**14.00**
Dung frags.		-	-	-	-	-	-	-	-	13	**1.37**
Fungus frags.		-	-	-	-	-	-	-	-	66	**6.96**
Total		2	**0.19**	3	**0.27**	6	**0.67**	0	**0**	842	**88.63**

The 1 x 4 meter unit in the northern portion of the corral (unit N3295E5474) straddled both the interior and exterior of the corral, which is illustrated in Figure 16. The corral wall was delimited by two rows of limestone blocks that measured 70 cm x 70 cm (Capriles 2008:39). On the outside of the corral, middens and fill strata were identified. Capriles identified fish bones and bird bones in this area. Several pits were identified intermittently between clay levels (Capriles 2008:37). Macrobotanical sample L. 4067/1 sample was recovered from outside the corral, below several levels of refuse and clay. The results of the analysis of L. 4067/1 are presented in Table 4. This sample was taken from an "X"-shaped pit, and revealed 88.63 specimens/L. The high density of this sample contrasts with the sparseness of samples analyzed from inside the corral. The high density of parenchyma/tuber (19.16 specimens/L), *Chenopodium* sp. (22.00 seeds/L), and the presence of Cactaceae is evidence that the X-shaped pit context is a disposal area from a cooking fire. The presence of the Cyperaceae, Malvaceae, Fabaceae, and Poaceae indicate that camelid dung was burned for fuel, which is further supported by the presence of dung. The high density of wood (14.00 specimens/L) suggests that the original fire was also fueled by wood. Based on the recovered materials and the excavators' identification that this area was a pit, this is a secondary depositional refuse area located adjacent to the corral.

Eight semi-circular to circular shaped structures were exposed during excavations south of the corral. The architecture of these structures was composed of adobe walls and clay floors, and they ranged from 2.4-3.7 meters in diameter (Capriles 2011:118-119). Three of these structures contained a central hearth. A couple of hearths were also excavated adjacent to the outside of the structures (Capriles 2011:12). Numerous pits were located inside and outside the structures, indicating that domestic activity took place both inside and outside (Capriles 2011:120-121

Four structures were intensively sampled from the southwest area of the site (N3272E5468). This unit was identified as an exterior surface occupation level, with two associated hearths, a secondarily deposited sandstone statue, and a high density of cultural debris. Further excavations revealed a lower and thus earlier complex, of four separate structures/houses depicted in Figure 17 (Capriles 2008). In the northern sector of this unit, 11 pits of various shapes and sizes intersected the surface of the clay occupation zone and they extended down to sterile soil. Based on contents recovered during excavations (one pit contained fish bones) and location on the periphery of the mound, Capriles suggests that the function of these pits was for refuse disposal (Capriles 2008:41-43).

Two macrobotanical samples from pits in this unit were sorted and analyzed. Density and raw counts of these samples are presented in Table 5. Sample L. 4080/1 was taken from a circular and cylindrical shaped pit in the northwestern area of the unit, and high densities of fish bones were noted during excavations. Charred food plant remains were not very dense in this pit (Cactaceae 0.00 seeds/L, *Chenopodium* sp. 0.84 seeds/L, and parenchyma/tuber 4.21 specimens/L). Charred wood fragments had the highest density (7.05 specimens/L), which indicated that woody plants were used for fuel. The presence of fungus and parenchyma/tuber points to the destruction (intentional or unintentional) of diseased tubers in the original burning event. However, the location and contents of the pit suggest that it was used for secondary deposit of refuse from a fire, not necessarily associated with cooking as indicated by the low density of food taxa. Sample L. 4086/1, which was sorted by Dr. Bruno, was taken from an adjacent circular pit. In comparison to the other pits in this unit, this sample revealed much higher densities of charred seeds and a lower density of parenchyma/tuber fragments (chenopods 10.5 seeds/L, parenchyma/tuber 2.13 fragments/L). This pit was likely used for refuse disposal from a cooking fire. .

Table 5. Density/L of recovered macrobotanical remains in unit N3272E5468.

Plant Resources	Site	KCH21	KCH21	KCH21	KCH21
	Locus	4080/1	4080/1	4086/1	4086/1
	Context	Pit	Pit	Pit	Pit
		# seeds/frags	Density/L	# seeds/frags	Density/L
	Volume	9.5 L	9.5 L	8 L	8 L
Food plants					
Cactaceae seeds		-	-	28	3.50
Chenopodium sp. seeds		8	0.84	84	10.50
Parenchyma/Tuber frags.		40	4.21	17	2.13
Aquatic plants					
Cyperaceae seeds		20	7.37	36	4.50
Ruppia sp. seeds		-	-	-	-
Enriched soil plants					
Malvaceae seeds		11	11.47	33	4.13
Fabaceae seeds		4	0.42	13	1.63
Wild plants					
Poaceae seeds		2	0.21	6	0.75
Plantago sp. seeds		-	-	17	2.13
Lepidium sp. seeds		-	-	-	-
Other taxa		67	7.05	33	4.13
Wood frags.		-	-	2	0.25
Dung frags.		2	0.21	2	0.25
Fungus frags.		152	16.21	248	33.88
Total		306	16.21	519	33.88

A complex stratigraphic sequence associated with domestic architecture was excavated in the 4 x 4 m unit (N3276E5484) in the southeast area of the site depicted in Figure 17. Four distinct circular structures were identified in the earliest occupation level of this unit. The walls of the structures were identified as compacted earth, which could be weathered adobe. Between the structures, there was a patio area with poorly defined walls that contained several pits. Capriles (2008:48) believes that the pits between the structures were used for storage and/or refuse.

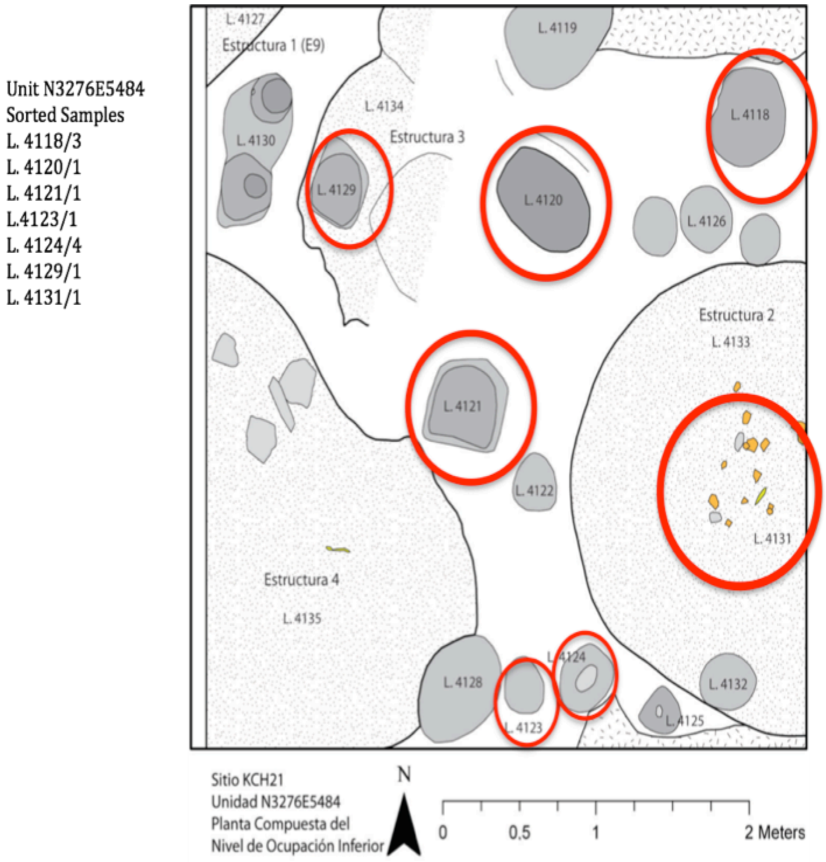

Figure 17. Map of the lowest stratum of Unit N3276 E5484 and the locations noted in circles of the sorted macrobotanical samples (from Capriles 2008:47, Figure 26)

Seven macrobotanical samples were sorted and analyzed from this unit, one from a hearth, one from fill, and five from pits. Based on the location, shape, and macrobotanical analysis of the five analyzed, these features were secondary refuse deposits. The densities of these samples are presented in Table 6. Capriles (2008) notes that some of these pits might have been use for storage. The analyzed pits were used primarily for refuse disposal based on the recovered macrobotanical remains.

Sample L. 4118/3 was taken from a semi-circular shaped ash-pit located in the northeastern portion of the site. The location of this sample was outside of Structure 2 and adjacent to the patio. Based on the low density of charred food plants (Cactaceae 1.2 seeds/L and *Chenopodium* sp. 2.1 seeds/L), the original fire event was probably not a cooking fire.

Sample L. 4120/1 was taken from a hearth located in the outside patio area. The hearth was relatively dense in food plant taxa (*Chenopodium* sp. 5.68 seeds/L and parenchyma/tuber 18.74 specimens/L), which indicates that it was used for cooking. Additionally, it was very dense in aquatic plants (Cyperaceae10 seeds/L) and plants that thrive in rich disturbed soils (Malvaceae 5.16 seeds/L). These data indicate that it might have also been used for food processing, and the charred plant remains are the result of camelid dung burned for fuel.

Sample L. 4121/1 was taken from a round refuse pit located in-between Structure 2 and Structure 4. The density and composition of this pit was remarkably similar to the sample analyzed from pit L.4118/3. The macrobotanical data indicate that both of these pits look like they are the result of cleaning out and disposing refuse from hearths not used for cooking activities.

Sample L. 4123/1 was taken from the southern portion of the unit, and was adjacent to Structure 2 and Structure 4. Excavators recovered this sample from a round storage pit (Capriles 2008:50, Table 2). Sample L. 4124/4 was taken from a round storage pit next to L. 4123/1. These samples are also similar in composition. The low density of charred food remains indicates that these pits were used for the disposal of refuse from hearths not used for cooking activities.

Sample L. 4129/1, which was sorted by Dr. Bruno, had the highest seed density of the analyzed samples, with a total of 1,503 seeds. This sample was taken from a pit located in the northwestern area of the unit, located in the outdoor patio area between the structures. This sample was extremely dense, in edible seed remains (*Chenopodium* sp. 43 seeds/L, Cactaceae 6.89 seeds/L), but relatively low in parenchyma/tuber (2.22 specimens/L). The high density of edible seed remains is evidence that this pit is likely composed of refuse from a cooking hearth. Furthermore, its proximity to the open-air hearth (L.4120/1) indicates that the patio was used as a cooking area.

Sample L. 4131/1 was taken from the floor inside Structure 2. The macrobotanicals identified were similar in density to the other analyzed refuse pits. This might indicate that a small hearth was used to warm up the structures and the carbonized materials (with low densities of food) were disposed of in the small pits between the structures.

Table 6. Density of recovered macrobotanical remains in unit N3276 E5484.

Plant Resourc	Site	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21	KCH21
	Locus	4118/3	4118/3	4120/1	4120/1	4121/1	4121/1	4123/1	4123/1	4124/4	4124/4	4129/1	4129/1	4131/1	4131/1
	Contex	Pit	Pit	Hearth	Hearth	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Fill	Fill
		# seeds/frag	**Density**	# seeds/frag	**Density**	# seeds/fra	**Density**	# seeds/fra	**Density**	# seeds/fra	**Density/l**	# seeds/frag	**Density/l**	# seeds/fra	**Density/L**
	Volum	10 L	10 L	9.5 L	9.5 L	10 L	10 L	3 L	3 L	8 L	8 L	9 L	9 L	10 L	10 L
Food plants															
Cactaceae seeds		12	1.20	4	0.42	7	0.70	-	-	4	0.50	82	6.89	4	0.40
Chenopodium sp. see		21	2.10	54	5.68	84	0.90	5	1.67	11	1.38	84	43.00	32	3.20
Parenchyma/Tuber f		81	8.10	178	18.74	57	5.70	7	2.33	48	6.00	20	2.22	106	10.60
Aquatic plants															
Cyperaceae seeds		8	0.80	95	10.00	1	0.10	21	7.00	7	0.88	52	5.78	41	4.10
Ruppia sp. seeds		2	0.20	-	-	-	-	-	-	5	0.63	-	-	4	0.40
Enriched soil plants															
Malvaceae seeds		3	0.30	49	5.16	1	0.10	3	1.00	-	-	578	64.22	9	0.90
Fabaceae seeds		-	-	7	0.74	4	0.40	-	-	-	-	33	3.67	21	2.10
Wild plants															
Poaceae seeds		8	0.80	24	0.11	2	0.20	1	0.33	5	0.63	176	19.56	5	0.50
Plantago sp. seeds		-	-	-	-	-	-	-	-	-	-	1	0.11	-	-
Lepdium sp. seeds		-	-	1	0.11	-	-	-	-	-	-	3	0.33	-	-
Other taxa															
Wood frags.		107	10.70	119	12.53	113	11.30	13	4.33	67	8.38	56	6.22	92	9.20
Dung frags.		-	-	-	-	1	0.10	-	-	-	-	7	0.78	7	0.70
Fungus frags.		13	1.30	4	0.42	6	0.60	2	1.00	17	2.13	4	0.44	9	0.90
Total		255	25.50	535	56.32	276	20.10	52	17.67	164	20.50	1096	153.33	330	33.00

KCH56

A circular structure containing four distinct levels of occupation was excavated at KCH56, which is depicted in Figure 18. The walls of the structure were composed of large stones lined with adobes. Five macrobotanical samples were analyzed from contexts associated with this structure and the density/L is presented in Table 7.

Figure 18. Map of the second level of occupation at KCH56 (from Capriles 2008:31, Figure 14).

In the earliest stratum of occupation of the structure two small hearths were identified inside the walls of the structure, and it is hypothesized that they were used as a source of heat (Capriles 2008:28). Sample L. 4172/1 was taken from one of these hearths. Analysis revealed that this sample contained a low density of food plant remains (Cactaceae 0.21 seeds/L, *Chenopodium* sp. 1.79 seeds/L, and parenchyma/tuber 2.32 specimens/L). Additionally, the density of carbonized seeds in the hearth was quite low (6.74 specimens/L). While it is possible that this hearth was used for small amounts of cooking activity, it is probable that it was used as a small warming fire inside the structure. Camelid dung was likely used for fuel, based on the absence of wood, and the presence of wild plant remains.

A refuse pit was identified in the southwest wall of the second level of occupation of the structure, and it contained well-preserved camelid bones. A hearth was identified in the middle of the structure in the second stratum of occupation. This level is depicted in Figure 18, with the hearth labeled *Fogón*. Density and counts are presented in Table 7. Sample L. 4163/4 was from the refuse pit adjacent to southern wall of the structure and excavations here recovered camelid bones. The density of this sample was extremely low (4.2 specimens/L). Notably, three fragments/L of wood were identified. I hypothesize that this pit is the result of a wood-fueled fire, and may be associated with the disposal of the camelid bones. But limited botanical depositional activity took place in this area of the structure. Sample L. 4162/1 was taken from the hearth located in the center of the structure. This sample was not very dense (11.3 specimens/L). I propose that this hearth is the result of fire used to warm the structure rather than for cooking purposes.

A patio or courtyard was identified adjacent to the outside of the western portion of the structure, which contained two refuse pits that were circular and cylindrical in shape (Capriles 2008:31-33). Samples L. 4158/1 and L. 4159/1 were taken from outside the western area of the structure. Both of these samples were from distinct refuse pit contexts, and both revealed comparatively low densities of carbonized plant taxa (4.57 specimens/L and 1.43 specimens/L). These pits may present evidence for the cleaning and disposal of warming fires (the hearth) located inside the structure.

Table 7. Density of macrobotanical remains from unit N6341E5595.

Plant Resources	Site	KCH56	KCH56	KCH56	KCH56	KCH56	KCH56	KCH56	KCH56	KCH56	KCH56
	Locus	4158/1	4158/1	4159/1	4159/1	4162/1	4162/1	4163/4	4163/4	4172/1	4172/1
	Context	Pit	Pit	Pit	Pit	Hearth	Hearth	Pit	Pit	Hearth	Hearth
		# seeds/frag	**Density/L**	# seeds/frag	**Density/L**	# seeds/fra	**Density/L**	# seeds/frag	**Density/L**	# seeds/fra	**Density/L**
	Volume	7 L	7 L	7 L	7 L	10 L	10 L	10 L	10 L	9.5 L	9.5 L
Food plants											
Cactaceae seeds		1	0.14	-	-	2	0.10	-	-	2	0.21
Chenopodium sp. seeds		2	0.29	-	-	7	0.70	1	0.10	17	1.79
Parenchyma/Tuber frags.		1	0.14	-	-	9	0.90	11	1.10	22	2.32
Aquatic plants											
Cyperaceae seeds		3	0.43	2	0.29	5	0.50	-	-	11	1.16
Ruppia sp. seeds		-	-	1	0.14	-	-	-	-	-	-
Enriched soil plants											
Malvaceae seeds		2	0.14	4	0.57	6	0.60		-	2	0.21
Fabaceae seeds		0	-	2	0.29	1	0.10		-	0	-
Wild plants											
Poaceae seeds		-	0.14	-	-	2	0.20	-	-	2	0.21
Plantago sp. seeds		-	-	-	-	2	-	-	-	2	-
Lepdium sp. seeds		-	0.14	-	0.57	-	0.60	-	-	-	0.21
Other taxa											
Wood frags.		23	3.29	13	-	82	8.20	30	3.00	-	-
Dung frags.		-	-	-	-	-	-	-	-	-	-
Fungus frags.		-	-	1	0.14	-	-	-	-	8	0.84
Total		32	4.57	23	1.43	116	11.30	42	4.20	66	6.74

Comparing Results

In this section, I make a few broad scale comparisons between contexts and between sites. I use the data to compare botanical deposition in an effort to gain insight into how different areas and structures of the site were used and as a tool to identify variability within and between sites. I choose to focus analysis on comparing hearths, pits, and the corral contexts to better understand how these areas were used. Additionally, I have excluded the two floor samples and the midden sample from this part of analysis because the sample sizes (n=2 for floors) is too small. I have further categorized the plant taxa into food plants that humans might have eaten and non-food plants that camelids probably ate. By analyzing the data this way, I am able to identify how much of the plant assemblage might be attributed to human foodways and how much is attributed to camelid dung used for fuel.

Ubiquity

The ubiquity of the 13 macrobotanical categories expressed as percentage of samples in which they are present is displayed in Figure 19. *Lepidium* sp. seeds and *Plantago* sp. seeds were only found in 10% or two samples, both from KCH56, indicating that these plants were of limited use. Food categories including *Chenopodium* sp., Cactaceae, and parenchyma/tuber were very common, present in more than half of the analyzed samples, and at all three sites. This is evidence that tubers/parenchyma and *Chenopodium* spp. were important plants in the Wankarani economy. Also, the moderately high ubiquity of Cactaceae (57%) indicates that humans might have been consuming the fruits.

Dung fragments were not dense and were completely absent from the samples analyzed from KCH11. Dung was present in 33% of the samples from KCH21. Wood had a high ubiquity, occurring at all three sites in 86% of the samples. The low ubiquity of dung and the high ubiquity of wood may suggest that shrubs were commonly used as a fuel source. I reiterate that carbonized dung is fragile and easily disintegrates. Dung fragments might have broken apart during the original fire, secondary refuse activity (cleaning out of hearths), excavations, flotation, in transport to the US, or during laboratory analysis. However, the high ubiquity percentage of non-food taxa, which camelids commonly consume, were primarily burned and preserved in dung. The carbonized seeds of non-food taxa are signature of dung burning.

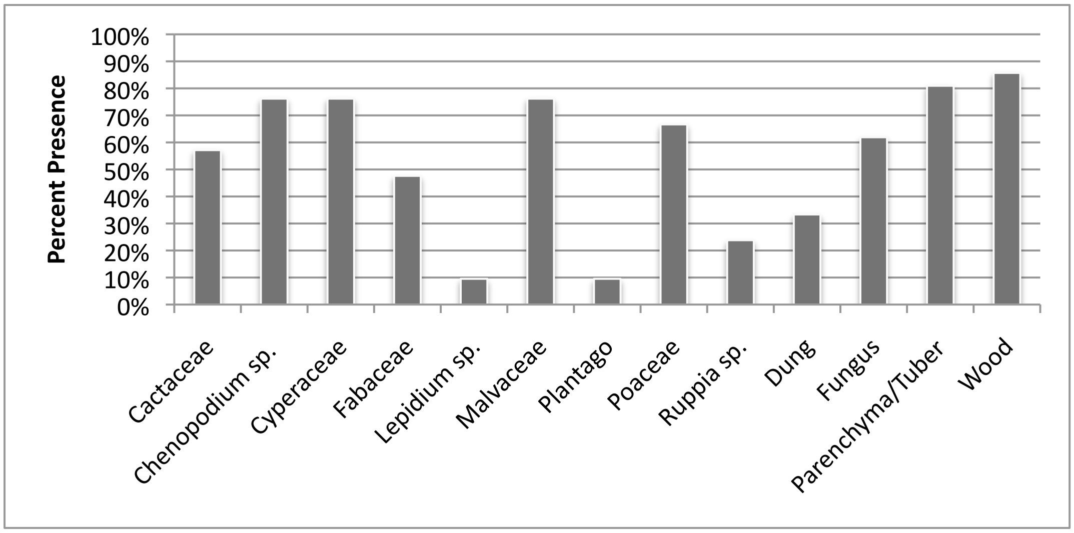

Figure 19. Ubiquity as expressed as a percentage presence.

Fungus and parenchyma/tuber were common, occurring in 62% and 81% of the samples respectively. The high occurrence of these taxa might be linked to intentional destruction of infected portions of the tubers. Furthermore, fungus and parenchyma/tuber were present at all three sites, suggesting that this parasitic taxon is widespread in the Iroco region.

Context comparison of ubiquity is depicted in Figure 20, which focuses analysis on pits, hearths, and corrals. The data presented in this graph are skewed by small sample sizes of hearths and corral contexts. Only Cactaceae., *Chenopodium* sp., Malvaceae, *Plantago* sp., parenchyma/tuber, and wood were present in low ubiquities in corral contexts, further reinforcing the identification of this structure as a corral due to the absence of other fire related activities. This graph reveals that food plant taxa (Cactaceae, *Chenopodium* sp., and parenchyma/tuber) were present in all three hearths. The high ubiquity of food types in hearths might suggest that hearths were used for cooking activities.

All 13 taxa were present in the pits (albeit in lower percentages compared to the hearths). High ubiquity of these materials in the pits could be attributed to the larger sample size (n=13). Dung, *Ruppia* sp., and *Plantago* sp. were absent from the hearths. The absence of dung in pits might be due to the pits representing secondary refuse. Charred dung fragments are fragile in nature and may have broken up into unidentifiable fragments upon secondary deposition.

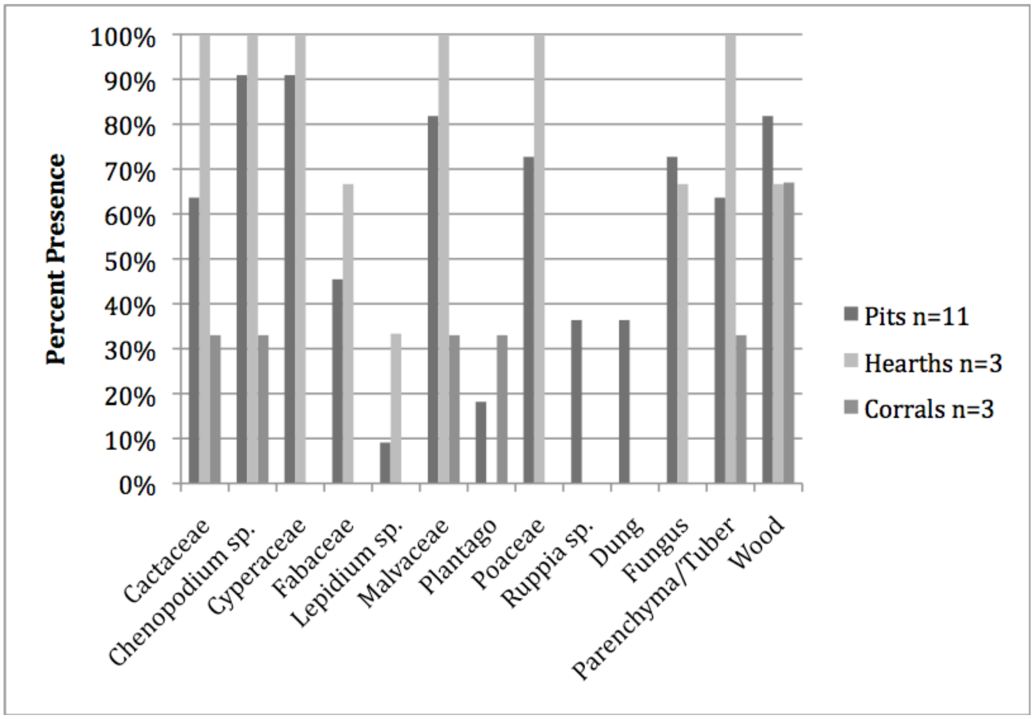

Figure 20. Ubiquity expressed as percentage of presence comparing contexts. Floors (n=2), the midden(n=1), and sterile context (n=1) are excluded from the chart due to small sample sizes, which obscures analysis (midden n=1 so ubiquity would be either 100% or 0%).

Density

Density--or specimens per liter of analyzed soils--is presented in Figures 21 and 22. Corral contexts were very sparse (1.12 specimens/L). Lack of major identifiable burning activities in the corral lends further support to the possibility that the structure was used as a corral. These data indicate that the corral-like structure was not used for activities that involve fire. The low density of seeds in the corral is likely the result of charred seeds blowing into the area as seed rain.

Pit contexts represent the highest standardized density of macrobotanical specimens (35.09 specimens /L). The high density of pits is likely due to what the pits were used for. As previously mentioned, they were likely used as places of refuse disposal, leading me to conclude that they represent several burning events and/or several depositional events that led to their higher density that hearths. Hearths were also relatively dense in charred macrobotanicals (24.78 specimens per liter of soil). This density is attributed to primary use of the hearths as areas of burning activity.

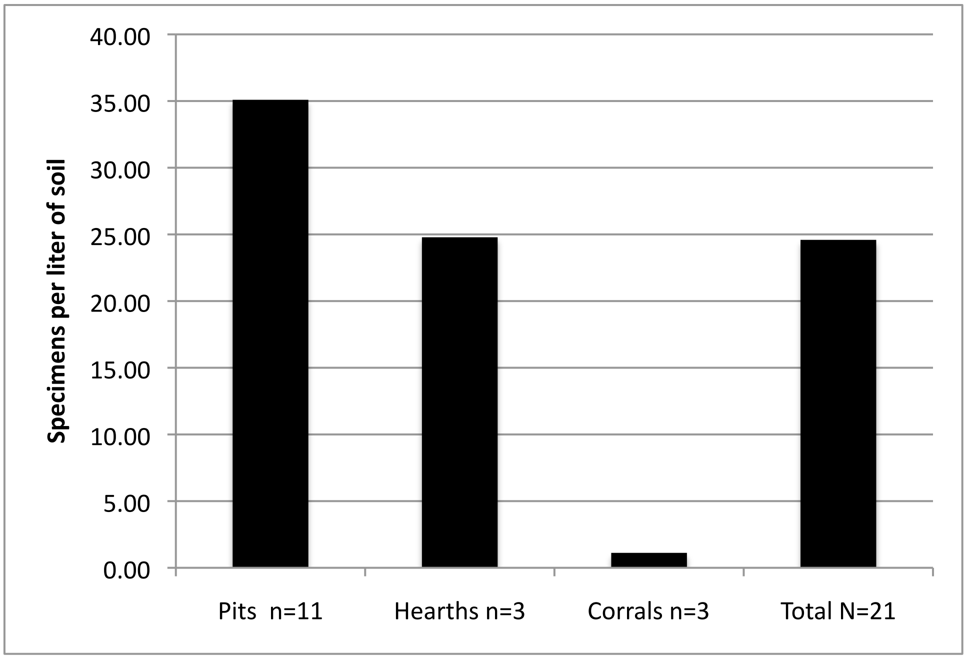

Figure 21. Density of macrobotanical specimens/L. Floors, midden, and sterile contexts are excluded from the chart due to small sample sizes that obscures analysis.

Comparing pits to hearths in Figure 22 reveals that pits contained a higher density of non-food plants, whereas an analysis of hearths revealed a higher density of food plants. This indicates that pits represent refuse activity of hearths used for more fire related activities other than cooking. For example, it is possible that when the Wankarani people cleaned their hearths, they disposed of both warming hearths and cooking hearths into the same refuse pit. Fuel (wood and dung) was comparatively less dense per liter of soil than food and non-food plants, which suggest that the fires were fueled by dung that was too fragile to preserve.

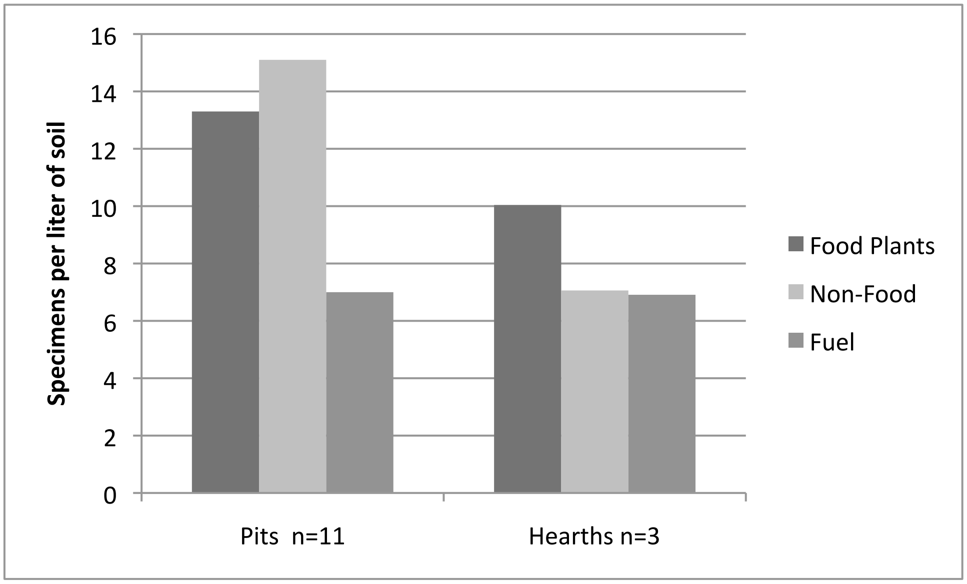

Figure 22. Density of macrobotanical specimens/L comparing pits and hearths. Fuel in this chart includes dung and wood.

Diversity

Diversity is depicted in Figure 23. This graph shows that a comparatively larger number of species are more evenly distributed at KCH21 (H=0.89), as compared to KCH56 (H=0.65) and KCH11 (H=0.51). A larger number of species is also more evenly distributed in pits than hearths. . Most likely, the difference between the sites and between pits and hearths is due to sample size difference. This might be attributed to simple fact that the number of samples analyzed from KCH21 and pits was significantly more than the other sites; there is an expected increase in richness correlated with number of analyzed samples, and thus diversity. It is also possible that the observed diversity differences are a product of sampling error. However, the diversity index may be due to the fact that the intensity of deposition of charred taxa was higher at KCH56 (as shown by density values) than the other sites, and higher in pits than hearths. An interpretation of this variability is that pits are composed of the disposal of several burning events from hearths used for various activities.

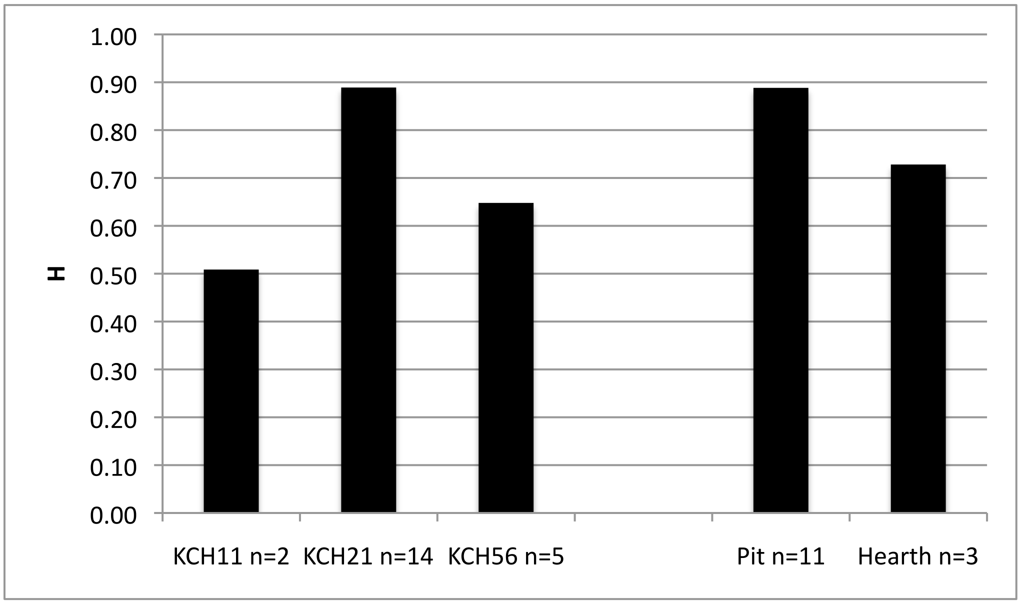

Figure 23. Diversity between sites and contexts using the Shannon-Weaver Index. This data is presented in Appendix A Table 5.

Discussion

This dataset provides researchers with a preliminary report of the plant economy of the Wankarani Complex and thus the ancient inhabitants' relationship with the local ecology. Although limited in scope by the sample size (N=21), several important findings have been revealed. These included the confirmed presence of a tuber and *Chenopodium* sp. based agricultural economy, camelid grazing patterns, and the unexpected presence of a pathological fungus. Furthermore, the widespread presence of pits at the site is associated with refuse activities. In this section, I explore the breadth of these findings.

Food Plants

Chenopodium spp. seeds (n=855 seeds, ubiquity=76%, and frequency=29.37%) were common and abundant at all three sites. Cactus seeds were moderately common, present in 57% of the samples, but not very abundant (n=148 seeds). Furthermore, analysis of the morphology of *Chenopodium* seeds indicates that the Wankarani people were cultivating *kañawa* and probably quinoa. These data support the hypothesis that *Chenopodium* spp. and tubers were essential foods in the Wankarani peoples' diet. In addition to growing cultigens chenopods, wild chenopods were also important. The Wankarani people were either gathering wild chenopods, or their camelid herds were grazing on wild chenopods while the dung was used to fuel fires. Analysis of the thick-testa chenopods points to human or animal interaction with wild stands of chenopods. The chenopods are also evidence of the importance of wild plants to the economy of the Wankarani.

It is highly plausible that Wankarani peoples complemented their chenopod and tuber diet with foraged cactus fruits. Cactus fruits could have been consumed as a sweet and tasty complement to an agropastoral diet; and because of the large size of the seeds, they were discarded and regularly preserved in fires (similar to spitting seeds out of grapes or watermelons). Alternatively, cactus seeds might have entered the site through camelid dung burned as fuel. There is no evidence of collection of other wild-harvested human food resources

Tubers and chenopod seeds are essential and storable carbohydrate-rich plant foods, complementing a protein-rich camelid diet. During lean times between harvests, camelids provided protein and sustenance, which lends to a seasonally stable food economy. In order to minimize risk, cultivation of hearty crops supplemented the Wankarani pastoral subsistence strategies. The adaptability, both seasonally and environmentally, allowed the Wankarani to survive in an otherwise harsh environment.

Absence of Exotic Plants

The presence of foreign lithic materials at other Wankarani sites indicates that the Wankarani participated in long-distance trade. The absence of exotic plants or plant commodities in the archaeobotanical record such as maize, coca, or chili peppers is evidence that these materials were not important to the Wankarani peoples. Furthermore, this supports the hypothesis that these items only became valuable during the rise and consolidation of the Tiwanaku state (Hastorf *et al.* 2006). Alternatively, the small sample size of this study possibly excluded contexts containing exotic plant remains. Future research on the Wankarani plant economy will shed light on importance of trade during the Formative period.

Camelid Grazing Patterns and Recovered Seeds

The ubiquity and density of grasses, Malvaceae, *Plantago* sp., *Lepidium* sp., and Cyperaceae in the total assemblage is indirect evidence of the use of camelid dung for fuel. Diversity of these taxa were higher in pits (H=.89) than in hearths (H=.73). The plants that were carbonized and preserved represent grazing activity. The various taxa identified suggest that a range of ecological zones were exploited by camelids.

Two taxa were present that indicate camelid interaction with aquatic plant resources (*Ruppia* sp. and Cyperaceae). Ponce Sanginés (1970) and others mention that Wankarani settlements were strategically located in proximity to fresh water. The Iroco sites in this study are located in proximity to Lake Uru Uru. Camelids likely visited lacustrine environments where they consumed fresh water for hydration; and while drinking, they grazed on aquatic plants.

Malvaceae and *Fabaceae* thrive in disturbed and organically rich soils in the *altiplano*. The presence of a Malvaceae seed type and a Fabaceae seed type (probably *Trifolium* sp.) at all three sites with a relative high density (4.21 seeds/liter of soil) might be indicative of agricultural activities. Furthermore, humans promoted camelid grazing in fields because dung would have inherently enriched the pastoral soils. Disturbed fallow agriculture fields and feces-enriched fields created a prime environment for plants such as Malvaceae and Fabaceae to thrive. Fallow fields regularly enriched by grazing and defecating camelids would have promoted the growth of these plants.

Fungus and Parenchyma/Tubers

The fungus was identified in samples from all three sites. It was present in 81% of the samples and common in both hearths and pits. The density was comparatively moderate (1.2 specimens/liter of soil in pits, 0.42 specimens/liter of soil in hearths, and 0.78 specimens/liter of soil in total). Furthermore, there appears to be a correlation between the presence of parenchyma/tuber and fungus. In all samples containing carbonized fungus, parenchyma/tuber was identified. I attribute this correlation to the intentional destruction of infected tubers. In this section I present hypotheses regarding the presence and destruction of infected tubers.

Destruction of blighted tubers can be attributed to a conscious avoidance of fungus containing mycotoxins that are poisonous compounds hazardous to humans and animals. There are several species of mycotoxin fungi. Some mycotoxins are "proven carcinogens, may disrupt the immune system, and may retard the growth of animals or humans that consume them" (Agrios 2005:39). If the fungus was poisonous, the high incidence of charred tubers and fungus fragments might be attributed to avoidance and destruction of infected tubers.

Parenchyma/tuber was denser in hearths (7.32 specimens/L) than in pits (4.6 specimens/L). The converse is true for *Chenopodium* sp., which was denser in pits (7.5 seeds/L) than in hearths (2.72 seeds/L). I believe that this is in part due to the intentional destruction of the diseased tubers, whereas *Chenopodium* sp. was unintentionally burned due to accidental spilling or in dung burned for fuel.

I propose two possible scenarios for the transmission of the tuber fungus. The first scenario is relatively simple. The fungus is transmissible and resulted from storage issues. Mold grew on the tubers because they were improperly stored for lengths of time. Often, food spoils and mold grows on food in refrigerators in modern kitchens. Tubers in antiquity were subject to similar storage issues. The pattern of refuse and burning of infected tubers is attributed to peoples' awareness that the tubers spoiled, and they disposed of the moldy portions in fires. This scenario is plausible; however, the practice of freeze-drying potatoes into *chuño* easily solves the storage issue. *Chuño* contains no water, and is not susceptible to mold. The earliest evidence of chuño production has been documented in the *altiplano* at the site Chiripa in a level predating 400 B.C. Soils that supplement a chuño diet and eliminate toxins found in potatoes were identified and cited as possible evidence of chuño production during the Formative period at Chiripa (Browman 1983:35; Browman and Gunderson 1993:415). Based on archaeological evidence of Wankarani interactions with Chiripa, it is plausible that the Wankarani also knew how to mitiagate potato storage related mold issues by freeze-drying their potatoes.

The second scenario for fungus identified in this assemblage is that the blight is analogous to pathologies in human and animal populations that are associated with the transition to agriculture and sedentary life ways.

Cohen (1989:122) states that ethnographic comparisons between hunter-gatherers and farmers in the same location reveal that farmers suffer higher rates of parasitism. With the onset of sedentism during the transition to agriculture, larger groups of people living together provided a situation similar to a petrie dish for disease and infections to spread and thrive. Epidemiologists suggest that tuberculosis and leprosy likely afflicted hunter-gatherers, but they are "primarily [diseases] of dense urban population." (Cohen 1989:136) In other words, early sedentary populations resulted in larger groups of people living together, thus facilitating the spread of diseases among humans.

The same petrie dish scenario played out among animal populations during the agricultural transition, which resulted in increased disease and pathology. In the Andes, disease has been used as an indicator of early camelid management and corralling. Wheeler (1984:405) documents a temporal increase in the occurrence of infant camelid skeletons and uses this as an index of transitioning to domestication at the Telermachay rock shelter in Peru. This research links *Clostridium perfingens*, a bacterium that causes infant death in modern domesticated camelids, to demographic changes in the zooarchaeological record. This bacterium is caused by dirty corrals that facilitate its growth and transmission (Wheeler 1984).

Sedentism and animal management practices contributed to the rapid transmission rate of disease. The high incidence of the fungus in the Iroco Wankarani macrobotanical assemblage is attributed to the petrie dish scenario involving favorable conditions for the increase in pathologies among humans and animal population. During the transition to agricultural life ways, plant populations were also affected.

Both scenarios for the transmission of the tuber fungus are plausible. The identification of this fungus at all three sites points to the fact that the fungus was a regional problem rather than an isolated incident. The high density of tubers and fungus indicates that the fungus was considered a problem, and the solution was to burn it.

Wankarani Response to Plant Pathology. Currently, there is no other archaeological evidence that supports the theory of an economic hardship resulting from this tuber blight. Neither starvation nor emigration is evident in the archaeological literature about the Wankarani. Alternatively, it seems that the Wankarani peoples continued to inhabit the region successfully throughout the Formative period. In part, this was due to the Wankarani peoples' adaptive subsistence strategy. My research has suggested that the Wankarani had a diverse plant and animal economy, composed of camelids, chenopods, foraged cactus fruits, and tubers. The Wankarani people were able to subsist on *Chenopodium* sp. when their tuber crop failed, and their camelid herds were able to forage grass and other unaffected plants. Furthermore, the Wankarani people potentially subsisted on other tuber species such as oca, potatoes, or maca, when the disease-prone tuber crop was infected. It is quite possible that certain tuber species were resistant to the fungus, while others were more vulnerable.

Conclusions

Returning to my original research goals, I offer a synthesis of how each of these was addressed in this study. I conclude with a brief interpretation about how the plant subsistence strategy of the Wankarani Complex complemented pastoralism and social and political interactions.

My first goal was to identify the subsistence strategy of the Wankarani by conducting a paleoethnobotanical analysis. This research offers tangible evidence of agricultural activities of the Wankarani. *Chenopodium* spp. and tubers were cultivated and important components of the Wankarani economy. *Chenopodium* spp. analysis revealed that *kañawa* and quinoa were probably both cultivated.

Fox (2007) believes that Wankarani agriculture intensified through time, based on the increase in density of stone hoes. Future paleoethnobotanical research will either strengthen or fail to support Fox's hypothesis.

My second goal in this study was to identify how the Wankarani were interacting with their environment. The Wankarani were exploiting lacustrine ecological zones, based on the identification of recovered Cyperaceae and *Ruppia* sp. seeds. The identification of wild and charred plant remains indicates that the Wankarani people grazed their herds in natural and cultivated ecological zones.

My third objective was to identify intra-site macrobotanical deposition patterns and the use of architecture and space. Hearths inside structures appear to have been used more for warmth than for cooking. The archaeobotanical evidence analyzed from the hearth between structures indicated that cooking activities likely took place outside. The numerous pits were composed of the refuse from hearths.

The extremely low density of carbonized plant remains in samples L. 4042/1, 4053/1, 4054/1, and 4058/1 supports the hypothesis that this area of the site was used as a corral. Chang and Koster (1986) conducted ethnographic research on animal pens, which notes that low artifact density is a signature of animal corrals. The low densities (or the lacking evidence of other activities) support the hypothesis that this enclosed space was as a camelid corral. Future micromorphological research that identifies chemical signatures of long-term accumulation of urine and dung in the corral area may shed light on the use of the space.

My fourth goal was to identify regional variation. Data presented in this study reveal limited evidence of inter-site variation in plant subsistence strategies. More samples need to be analyzed to make these broader conclusions.

And finally, I addressed the fact that Wankarani subsistence strategies were an adaptation to the environment that reduced risk. The most important evidence that my research offers to the larger body of Andean archaeological literature is that that Wankarani were agropastoralists. Tangible, paleoethnobotanical evidence in the form of identified charred seeds and other specimens confirm that the Wankarani practiced agriculture. Economically, both wild and cultivated plants played an important role in Wankarani subsistence. An agropastoral subsistence strategy reduced risk for the Wankarani peoples in an otherwise difficult environment.

The Wankarani people were the first culture group to live in permanent and sedentary settlements in the central *altiplano*. Subsistence and diet decisions were a fundamental aspect of the transition from a nomadic hunter-gatherer lifestyle to a sedentary lifeway. Choosing where to settle was one of the first decisions the Wankarani peoples had to make during this transition. Understanding the economy of the Wankarani unravels how these decisions were made. Browman's (1974) ethnographic analysis of camelid herders in the Andes points out that pastoralists live in and exploit environments suitable for grazing, such as grasslands with natural and plentiful water supplies. Based on the evidence of cultivated plants in the Iroco archaeobotanical assemblage, the Wankarani also had to consider environments appropriate for agriculture. Settlements were strategically located in places acceptable for both agriculture and herding.

Past research has explored the importance of pastoralism in the Wankarani economy. Camelids were an invaluable portion of the Wankarani diet. These animals are naturally adapted to exploit the highland grasslands of the Andes where agriculture is difficult (Browman 1974:188). Research has focused on the importance of camelids in the Wankarani economy, because the central *altiplano* is opportune for pastoralism. However, in modern pastoral groups in the Andes up to 50% of the diet of humans is composed of non-domesticated animals, and plants are critical components according to Browman (1974). Evidence of agriculture among the Wankarani indicates that cultivated plants complemented a pastoral economy. This research provides evidence that plant foods such as tubers and chenopods were a critical component of the Wankarani economy.

An agropastoral economy is a better-adapted risk reduction strategy than a strictly pastoral economy. The life cycles of plants and animals are different, and plants and animals are vulnerable to different ecological variables. If a crop is lost due to climate variations such as drought or temperature fluctuations, camelid meat could be substituted in the interim. Camelids are less susceptible to short-term climate variations than plants. Herds take years to recuperate their numbers. While a herd is recuperating due to strain from crop failure, annual crops can be substituted in the diet (Browman 1974:189). This flexible and complementary system of agropastoralism is an attuned adaptation to the central *altiplano*.

Ethnographic research documents that agropastoralism in the Andes aims to reduce risk, rather than maximize yields (Browman 1987). While past research has identified the antiquity of pastoralism and sedentary lifeways in the central *altiplano*, this paleoethnobotanical report identifies the antiquity of a complementary agropastoral system. The origins of this risk-reduction strategy herald back to the beginnings of sedentary lifeways in the Andes to the Wankarani culture. I have demonstrated that as suggested previously by Fox (2007:176-181), McAndrews (1998:182), and Ponce Sanginés (1970) the Wankarani were agropastoralists, and that their subsistence choices were attuned to inter-annual environmental fluctuations that are common in the region.

McAndrews (1998) theorizes that community fissioning was common among the Wankarani. The maintenance of small-scale communities allowed for rapid local response to the unpredictable and harsh environment. This small-scale level of socio-political organization also allowed for localized response to botanical pathology. Local peoples were able to adapt to blighted tuber crop years, which might explain why other researchers have not detected the blight. In accordance with studies of African pastoralism (Marshall 1990), these data indicate Wankarani agro-pastoralism is a resilient adaptation to the local ecological conditions. Localized, small-scale response allowed for resilient decision-making policies that were flexible to the marginal environmental conditions.

The absence of traded plant commodities indicates that the Wankarani diet was self-sufficient. Self-sufficiency among the settlements allowed for a certain degree of independence. Other lines of evidence (such as foreign lithics) indicate that the Wankarani were involved in a large web of exchange. While I do not negate this possibility, my research indicates that they did not regularly consume exotic plants. Furthermore, the absence of maize suggests that caravan plant trade (at least in this region) did not intensity until after the Formative period.

Unexpectedly, this study revealed the presence of regional tuber blight. The transition to agriculture was difficult and fraught with many challenges, including responding to crop disease and issues regarding storage. The identification of this fungus raises many questions. What species of fungus is it, and how invasive was it? How widespread was it? How did it affect the Wankarani economy? Are there any signs of economic hardship as a result? This research study offers preliminary insights into tangible evidence of the subsistence strategies of the Wankarani Complex. Furthermore, it raises a plethora of other questions that can only be answered by future paleoethnobotanical research.

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Appendix A

Table 1. AMS dates from the sites (From Capriles 2011, Table 6.1).

Lab Code	Sample ID	Material	14C-age B	d13C	Calendric Age calBP	68% range calBP	Calendric Age	Component	Locus	Contex	Context / Reference
AA84147	KCH21-02	Carbon	2109 ± 53	-22.8	2096 ± 75	2021 - 2171	146 ± 75 BC	KCH21FA	4121/1	A98	Pit outside Structure 10
A14403	KCH21-OR	Carbon	2070 ± 70	-23	2049 ± 88	1961 - 2137	99 ± 88 BC	KCH21FA	1603	A48	Fill above floor Structure 5
AA84148	KCH21-03	Carbon	2061 ± 53	-22.2	2036 ± 70	1966 - 2106	86 ± 70 BC	KCH21FA	4129/1	A84	Pit outside Structure 9
AA84150	KCH21-05	Carbon	2059 ± 57	-22.7	2034 ± 74	1960 - 2108	84 ± 74 BC	KCH21FA	4130/1	A83	Pit outside Structure 10
AA84146	KCH21-01	Carbon	2058 ± 53	-24.2	2033 ± 70	1962 - 2103	83 ± 70 BC	KCH21FA	4067/1	A75	Pit in midden outside corral
AA84152	KCH21-07	Carbon	2016 ± 57	-23.2	1985 ± 70	1915 - 2055	35 ± 70 BC	KCH21FB	4108/1	A11	Hearth SE of the site
AA84151	KCH21-06	Carbon	1995 ± 57	-19.7	1961 ± 65	1896 - 2026	11 ± 65 BC	KCH21FA	4086/1	A65	Pit SW of the site
AA84149	KCH21-04	Carbon	1993 ± 38	-24.2	1948 ± 40	1907 - 1988	AD 2 ± 40	KCH21FA	4072/1	A17	Occupation surface
A14404	KCH21-OR	Carbon	1925 ± 60	-23.5	1873 ± 69	1803 - 1942	AD 77 ± 69	KCH21FA	2406	A58	Hearth of Structure 8
AA84153	KCH56-01	Carbon	2035 ± 57	-23.7	2011 ± 74	1936 - 2085	61 ± 74 BC	KCH56FA	4164/7	B10	Floor of second occupation
AA84154	KCH11-01	Tooth	1160 ± 63	-18.3	1088 ± 80	1007 - 1168	AD 862 ± 8	KCH11Tiw	4205	C02	Burial 1
AA84155	KCH11-02	Tooth	1060 ± 62	-18.8	991 ± 58	933 - 1049	AD 959 ± 5	KCH11Tiw	4213	C03	Burial 2

Table 2. Ubiquity expressed as presence (X), and absence ( ).

Plant Resources			Site		
Common Name	Family	Species			
			KCH11 n=2	KCH21 n=14	KCH56 n=5
Food plants					
Goosefoot	Chenopodiaceae	*Chenopodium* sp.	X	X	X
Parenchyma/Tuber			X	X	X
Cactus	Cactaceae		X	X	X
Enriched soils					
Mallow	Malvaceae		X	X	X
Legume	Fabaceae	*Trifolium* sp.	X	X	X
Aquatic plants					
Sedge	Cyperaceae		X	X	X
Ditch Grass	Rupiaceae	*Ruppia* sp.		X	X
Wild plants					
Grass	Poaceae		X	X	X
Mustard	Brassicaceae	*Lepidium* sp.		X	
Plantain	Plantaginaceae	Plantago sp.		X	
Fuel					
Dung					X
Fungus			X	X	X
Wood			X	X	X

Table 3. Density expressed as taxon/L of analyzed soil.

Plant Resources	Total N=21
Food Plants	
Cactaceae	0.68
Chenopodium sp.	4.52
Parenchyma/Tuber	4.05
Non-Food	
Cyperaceae	2.32
Fabaceae	0.46
Lepidium sp.	0.02
Malvaceae	4.32
Plantago sp.	0.11
Poaceae	1.42
Ruppia sp.	0.07
Fungus	0.78
Fuel	
Dung	0.15
Wood	5.56
Total Density	24.59

Table 4. Diversity expressed using the Shannon-Weaver Index calculated by site and context.

Site			Context	
KCH11 n=2	KCH21 n=14	KCH56 n=5	Pit n=11	Hearth n=3
0.51	0.89	0.65	0.89	0.73

Appendix B:

Image of Unknown Seeds and Macrobotanical Specimens

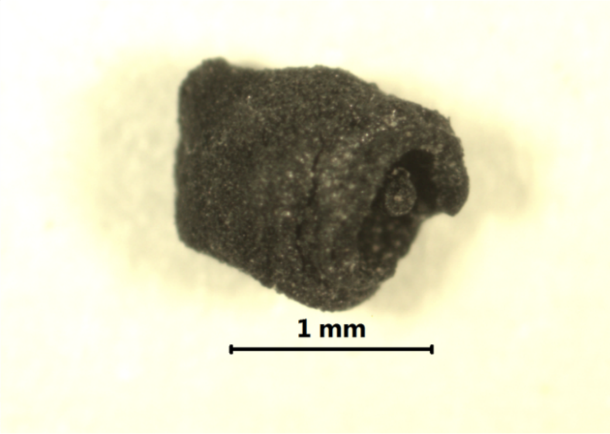

Figure 1. Image of Unknown Specimen #1 (locus # 4120/1). This is probably not a seed.

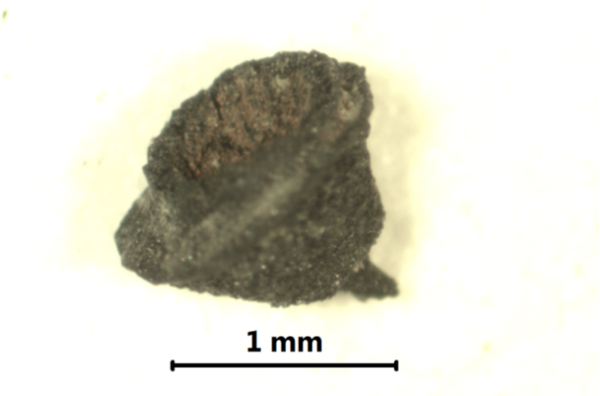

Figure 2. Image of Unknown Specimen #2 (locus # 4120/1). This might be a peduncle but it is very clinkered due to charring.

Figure 3. Image of Unknown Specimen #3 (locus # 4120/1). This appears to be part of a seed casing. It is hollowed out on one side.

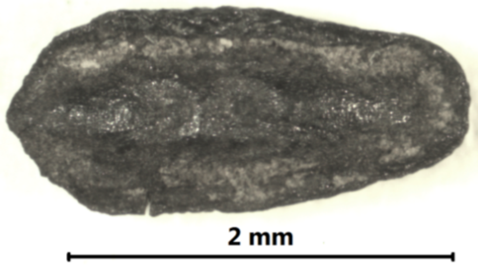

Figure 4. Image of Unknown Specimen #4 (locus # 4131/1). This might be a *Plantago* sp. seed, but is very large and clinkered from charring.

Figure 5. Image of Unknown Specimen #6 (locus # 4162/1).

Figure 6. Image of Unknown Specimen #7 (locus # 4067/1).

Figure 7. Image of Unknown Specimen #8 (locus # 4067/1).

Figure 8. Image of Unknown Specimens #9 (locus # 4067/1). They appear to be grass seeds but under the microscope they look very clinkered.

Figure 9. Image of Unknown Specimen #10 (locus # 4121/1).

Appendix C: Chenopod Data

Table 1: Chenopod analysis data

Site	Locus	Seeds without a testa	Testa Diameter (mm)	Testa Thickness	Testa Texture
KCH21	4131/1	34			
KCH21	4131/1				Reticulate
KCH21	4131/1		1.2	Thick	Canaliculate
KCH21	4131/1		1.2	Thick	Reticulate
KCH21	4131/1		1.1	Thick	Reticulate
KCH21	4131/1		1.1		Reticulate
KCH21	4131/1		0.9		Reticulate
KCH21	4131/1		1.1		Reticulate
KCH21	4131/1			Thin	Smooth/canaliculate beak
KCH21	4131/1		1.3		Smooth
KCH21	4131/1		1.2		Smooth
KCH21	4131/1		0.8	Thin	Smooth
KCH21	4131/1		0.8		Smooth
KCH21	4131/1		0.9	Thin	Smooth
KCH21	4131/1		1	Thin	Smooth
KCH21	4131/1		0.7		Smooth
KCH21	4131/1		0.7	Thin	Smooth
KCH21	4131/1		1	Thin	Smooth
KCH21	4131/1		0.9		Smooth
KCH21	4131/1		1		Smooth
KCH21	4131/1	28			
KCH21	4131/1		1.4	Thin	Reticulate
KCH21	4131/1		1.1	Thin	Reticulate
KCH21	4131/1		1.2		Reticulate
KCH21	4131/1		1.4		Reticulate
KCH11	4206/1	3			
KCH11	4206/1		1.7	Thick	Reticulate
KCH56	4162/1	3			
KCH56	4162/1		1.2	Thick	
KCH56	4162/1		1	Thin	Smooth
KCH21	4121/1	22			
KCH21	4121/1		1	Thin	Smooth/canaliculate beak
KCH21	4121/1		1.1		Smooth/canaliculate beak
KCH21	4121/1		1.2	Thin	Smooth/canaliculate beak
KCH21	4121/1		1.1		Smooth/canaliculate beak
KCH21	4121/1		1.1		
KCH21	4121/1		1.1	Thin	Punctuate
KCH21	4121/1		1.4	Thin	Reticulate

Site	**Locus**	**Seeds without a testa**	**Testa Diameter (mm)**	**Testa Thickness**	**Testa Texture**
KCH21	4121/1		0.8	Thick	Smooth
KCH21	4121/1		0.9	Thick	Smooth
KCH21	4121/1		1.2	Thick	Smooth
KCH21	4121/1		0.7		Smooth
KCH21	4121/1		0.7	Thin	Smooth
KCH21	4121/1		0.9	Thin	Smooth
KCH21	4121/1		0.8	Thin	Smooth
KCH21	4121/1		0.9	Thin	Smooth
KCH21	4124/4		1.5		Smooth/canaliculate beak
KCH21	4124/4		1.3	Thin	Canaliculate
KCH21	4124/4	8	1.4		
KCH21	4124/4		0.7	Thick	Smooth
KCH21	4124/4		1	Thick	Smooth
KCH21	4124/4		1.2		Smooth
KCH21	4124/4		1.1		Smooth
KCH21	4124/4		1.2		Canaliculate
KCH21	4124/4		1.1		Reticulate
KCH21	4124/4		1.1		Reticulate
KCH21	4124/4		1.2		Reticulate
KCH21	4124/4		1		Reticulate
KCH21	4124/4		1.3		Reticulate
KCH21	4124/4	22			
KCH11	4202/1	1			
KCH11	4202/1	3			
KCH21	4120/1	22			
KCH21	4120/1		0.9	Thin	Canaliculate
KCH21	4120/1		0.6		Smooth
KCH21	4120/1		1.1	Thick	Smooth
KCH21	4120/1		1.1	Thick	Reticulate
KCH21	4120/1		1.2	Thick	Reticulate
KCH21	4120/1		1.3	Thick	Reticulate
KCH21	4120/1		1.1	Thick	Reticulate
KCH21	4120/1		1	Thick	Reticulate
KCH21	4120/1		0.7	Thick	Smooth/canaliculate beak
KCH21	4120/1		1	Thick	Smooth/canaliculate beak
KCH21	4120/1		1	Thick	Smooth/canaliculate beak

KCH21	4120/1		1	Thick	Smooth/canaliculate beak
KCH21	4120/1			Thick	Smooth/canaliculate beak

Site	**Locus**	**Seeds without a testa**	**Testa Diameter (mm)**	**Testa Thickness**	**Testa Texture**
KCH21	4120/1		0.8	Thick	Smooth/canaliculate beak
KCH21	4120/1		0.9	Thick	Smooth/canaliculate beak
KCH21	4120/1		0.8	Thick	Smooth/canaliculate beak
KCH21	4120/1		1	Thick	Smooth/canaliculate beak
KCH21	4120/1		0.9	Thick	Smooth/canaliculate beak

Appendix D

Sorting Form

KCH ___

Botanical Analysis Form

Sorter______________________

Date Sorted____/_____/2010__

Flot #____________________

Locus #__________________

Volume__________________

N__________ E__________

Total Weight__________________

> 2.0mm LF Weight__________________

Species	Count	Weight	Notes
Chenopod			
Poaceae			
Wood			

>1.0mm LF Weight__________________

Species	Count	Weight	Notes
Chenopod			
Cyperaceae			
Fabaceae			
Malvaceae			
Poaceae			
Solanaceae			

>0.5mm LF Weight_________________

Chenopod			
Cyperaceae			
Fabaceae			
Malvaceae			
Poaceae			
Solanaceae			

Notes: