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Palynological Investigations of Agropastoralism and Ecological Change at LA 20,000, New Mexico

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PALYNOLOGICAL INVESTIGATIONS OF AGROPASTORALISM AND ECOLOGICAL CHANGE AT LA 20,000, NEW MEXICO

A Thesis Presented

by

ANYA GRUBER

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PALYNOLOGICAL INVESTIGATIONS OF AGROPASTORALISM AND ECOLOGICAL CHANGE AT LA 20,000, NEW MEXICO

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ABSTRACT

PALYNOLOGICAL INVESTIGATIONS OF AGROPASTORALISM AND ECOLOGICAL CHANGE AT LA 20,000, NEW MEXICO

August 2018

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How did Spanish colonialism alter the landscape of north-central New Mexico? Agropastoral practices imported by Spanish colonists made indelible impacts on an anthropogenic landscape already shaped by hundreds of years of Pueblo agriculture. However, the precise nature of these changes is poorly understood. This project uses two sets of archaeological pollen data from LA 20,000, a Spanish *rancho* in New Mexico, to demonstrate how 17th century agriculture and animal husbandry made geographically specific, multifaceted changes to the environment. First, patterns analyzed from a pollen column illuminates fluctuations in plant communities over time, indicating localized ecological shifts. Second, sediments collected from 17th century deposits across the site characterize the nature of agriculture and animal husbandry at LA 20,000.

ACKNOWLEDGMENTS

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CHAPTER ONE

INTRODUCTION

In 1598, a band of colonists led by don Juan de Oñate journeyed north from Santa Barbara, New Spain, to found the New Mexico Colony. In this remote settlement, separated by a forbidding landscape from the core of Spanish influence in the Americas, a distinct New Mexican identity emerged (Jenks 2017:213). Informed by interaction with Native peoples, a decades-long sojourn in New Spain, and a desire to uphold Iberian traditions, this distinctly colonial New Mexican cultural landscape, in turn, shaped the physical landscape.

This project uses archaeological pollen data from LA 20,000, a Spanish *estancia*, or small livestock ranch (Trigg 1999:44), located in La Cienega, New Mexico, to demonstrate how 17th-century Pueblo and Spanish agriculture made long-term, multifaceted changes to the environment. There are two main parts to this project. The first part uses data collected from a pollen column to understand fluctuations in plant communities in response to the human activities that were taking place on and near the site. The second part of this project uses soil samples collected stratigraphically from open excavation units in the field season of 2017 at LA 20,000 to more precisely understand the nature of agropastoral practices on the site.

LA 20,000, also known as the Sanchez site, typifies the early Spanish colonial ranch. This site is located about 19 km southwest of New Mexico's capital, Santa Fe, and about 5.5 km from the 17th-century Pueblo village La Cienega (Trigg 1999:84; Figure 1). LA 20,000 was occupied between A.D. 1630 and 1680 with no known subsequent occupation and is considered the most complex and complete early colonial *estancia* in New Mexico (Trigg 2017:1). The site was first excavated in the 1980s and 1990s by Mr. David H. Snow and Dr. Marianne L. Stoller from Colorado College. In the 2010s, excavations at LA 20,000 came under the direction of Dr. Heather Trigg from the University of Massachusetts Boston.

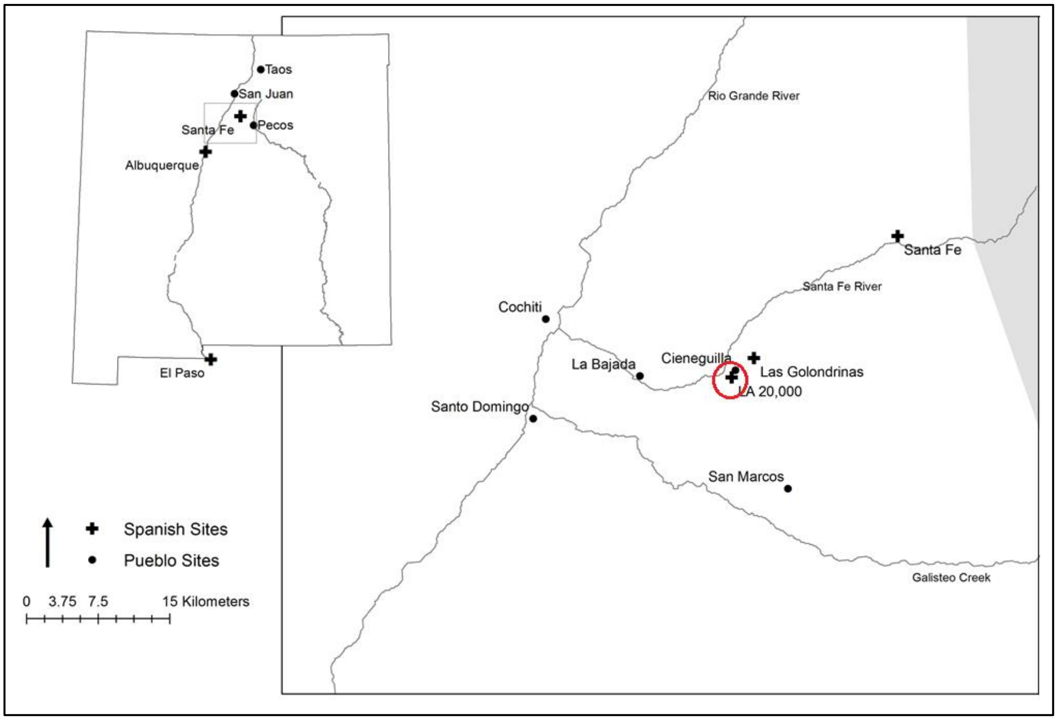

Figure 1. Map of archaeological sites near LA 20,000. Image adapted from Edwards (2015).

Archaeopalynology—the analysis of pollen deposits in the archaeological record—is a suitable methodology for investigating the environmental impacts of Spanish colonialism in New Mexico for a number of reasons. First, pollen analysis provides a record of environmental change over time. Palynological patterns transcend the prehistory/history divide which has needlessly separated the ecological impacts of indigenous and European inhabitants (Lightfoot 1995). Archaeopalynology is also useful in environmental reconstruction (Traverse 2008:2) because it allows one to track the changing populations of a variety of taxa over a long period of time. The relationships between species, their rise, and their decline provides invaluable information about the nature of past landscapes. For example, it is possible to use pollen analysis to discern whether a given site was more like a grassland or a riparian forest in the past (Hevly 1981:41).

The samples for this study were collected in two separate field seasons: 2015 and 2017. Each set of data addresses a separate suite of questions. The 2015 samples were collected as a pollen column from unit G, on the southern edge of the main site. Here, the 2015-G patterns are comparatively analyzed alongside data collected by Edwards (2015) from a core taken at the nearby Leonora Curtin Wetland Preserve in order to understand how the local environment immediately surrounding LA 20,000 compared to the regional patterns.

The second set of samples was collected during the 2017 field season from six layers in four different excavation units. Each sample was collected from a stratigraphic layer dating to the period of occupation at the site, A.D. 1630-1680. The data extrapolated from these samples complement the 2015-G profile by elucidating highly localized ecological patterns directly on the site. Rare agricultural taxa constitute strong evidence for the cultivation of cereal crops.

The most landscape-modifying practice undertaken by Pueblo agriculturalists was the implementation of fields for maize agriculture, creating some of the oldest identified agricultural fields in what is now the United States. Pueblo agricultural technologies made scientifically observable changes to the environment in nutrient level and soil quality (Homburg et al. 2005:661). When colonists settled in the region, they brought with them not just different crops, but a distinctive suite of practices which shaped on the character of the landscape.

There were economic and social motivations for the implementation of a European-style agropastoral complex. The Spanish—not only in New Mexico, but across the Americas—focused on controlling the land they settled in order to access the raw materials and resources that were valuable to the Spanish Crown in the colonial mercantile economy, such as metal and sugar (Deagan 1996:6). Furthermore, tracts of land were required to maintain flocks of sheep, the most economically important animal imported by the Spanish, though herds of cattle were also kept. Colonial New Mexico had a thriving textile industry, bolstered by the production of wool (Trigg 2005:99).

The desire for European cereals was a motivating factor in the development of Iberian-style agriculture. Wheat (*Triticum aestivum*) was a defining aspect of Spanish cultural identity. Religion was at the core of Spanish culture, and communion wafers made from wheat flour were crucial to Catholic ritual practices (Trigg 2005:128). As wheat was infrequently available, maize (*Zea mays*) or barley (*Hordeum vulgare*) were often substituted for communion wafers, though it was far less desirable (Kessell

1995:340). Furthermore, the consumption of European grain was an ethnic and status marker, as bread was expensive and difficult to come by (Candau et al. 1994:69; Trigg 2005:128). Indeed, wheat and other Old World crops were so important that the Spanish believed they had a moral obligation to maintain their European diet, and that without it, they lost part of their identity (Super 1988:38).

It has been demonstrated that food and identity are closely linked. Archaeologists in many contexts across the world have used a number of methodologies to understand how humans have used food, food choice, and cuisine to assert social, cultural, and ethnic identities (Allard 2015; Bowes 2011; Logan et al. 2012; Pilcher 1996; Popper 2016; Rodríguez-Alegría 2005; Super 2002; Trigg 2004). For example, in a project at Neolithic Çatalhöyük, Turkey, Atalay and Hastorf (2006:285) argue that food procurement and preparation is the “ultimate habitus practice”. Food is an intimate part of daily life. The way that cultures define cuisine and edibility is closely tied to identity at a personal and performative scale, as eating is central to socialization, beginning at a young age (Atalay and Hastorf 2006:284). The centrality of food choice in the formation of identity is an important facet of exploration when understanding the importation of agropastoral regimes in New Mexico.

Spanish and Pueblo agricultural regimes, informed by cultural identity, altered the physical landscape over the course of centuries. Understanding human-environment relationships is a fundamental aspect of archaeological research, particularly in colonial contexts, where the landscape becomes imbued with social and economic significance as cultures interact. In New Mexico, a semi-arid region with little rainfall (Scurlock 1998:11), it could be difficult at times to survive the harsh environment. Therefore, understanding environmental fluctuations and ecological processes of the past can illuminate the role of human action and agency within the dynamic landscape of New Mexico.

In the chapters to follow, I discuss the settlement history of New Mexico, focusing on the greater Santa Fe region. Then, I describe the ecozones characteristic of the region, with an emphasis on the physical environment of LA 20,000. Next, I define the methodological aspect of this project and the lab analysis portion. Then, I describe the results of the pollen analysis. In the penultimate chapter, I offer interpretations of the data. In the final chapter, I offer ongoing research possibilities and discuss the wider significance of this project.

CHAPTER TWO

SETTLEMENT HISTORY

The landscape of north-central New Mexico is characterized by the Rio Grande river, which runs approximately 1,200 km from the mountains of Colorado to the U.S.-Mexico border (Phillips et al. 2003:1). Historically, the Rio Grande provided the American Southwest with much of its aquatic resources, and many settlements were established along its banks (Porter 2011:ix).

The Southwest had been populated by diverse indigenous communities for many centuries prior to the arrival of European settlers. Ancestral Pueblo history is divided into different eras with corresponding archaeological signatures, and numerous projects have undertaken the task of understanding Pueblo history through settlement patterns (Adams and Duff 2004; Adler 1996; Barrett 2002; Liebmann et al. 2005; Liebmann and Preucel 2007; Van West 2016). This study focuses on the eras comprising the end of the Rio Grande Classic period (A.D. 1325-1598) through the Late Colonial period (A.D. 1692-1848; Edwards 2015:20).

Pueblo History and Archaeology

Before approximately the 12th century, most indigenous communities in the Rio Grande region lived in "provinces," defined as socially hierarchical groups running independent economies (Adler 2016:4). By the 15th and 16th centuries, communities were often organized according to clan, based on lineage from a common ancestor. In other communities, kinship groups were grouped by moieties, in which people were divided into dual categories, such as Summer and Winter, or South and North (Kessell 2012:11).

Pueblo groups are associated with the area they inhabit, e.g., Cochiti Pueblo, Jemez Pueblo, or Northern Tiwa. "The Pueblo" were far from a single, homogeneous group, as there was significant variation in not only language but traditions and cultural affiliation (Liebmann 2012:30). At the beginning of the 17th century, Spanish documents indicated the existence of approximately 100 Pueblo settlements, speaking a diverse array of dialects and languages (Barrett 2002:1; Figure 2).

Maize and squash seeds were introduced from trade trails originating in Mesoamerica by 1500 B.C. (Kessell 2012:9), but at that point, hunting and foraging were the primary methods of food procurement. The structure of Pueblo society began to change in the 13th and 14th centuries when agriculture intensified and population increased. Local production of pottery and the construction of kivas became more widespread (Snow 1990:290–291). The kachina belief system, characterized by multi-formed ancestor spirits such as the Sun Father and Earth Mother, was introduced from the south and became widespread around 400 years prior to the late 16th-century appearance of the Spanish, who ultimately suppressed the adherence of kachinas (Kessell 2012:11–12).

Pueblo architecture is characterized by clusters of earth-and-stone dwellings (Kessell 1997:46), although there were also large, multi-story cliff dwellings, adobe structures, and villages built from rock which still stand today (Cordell and McBrinn 2016:19–21). Some of the most well-known and best-preserved "great houses" built during the Bonito Phase (A.D. 860-1140) still remain at Chaco Canyon in northwestern New Mexico (Wills and Dorshow 2012:138).

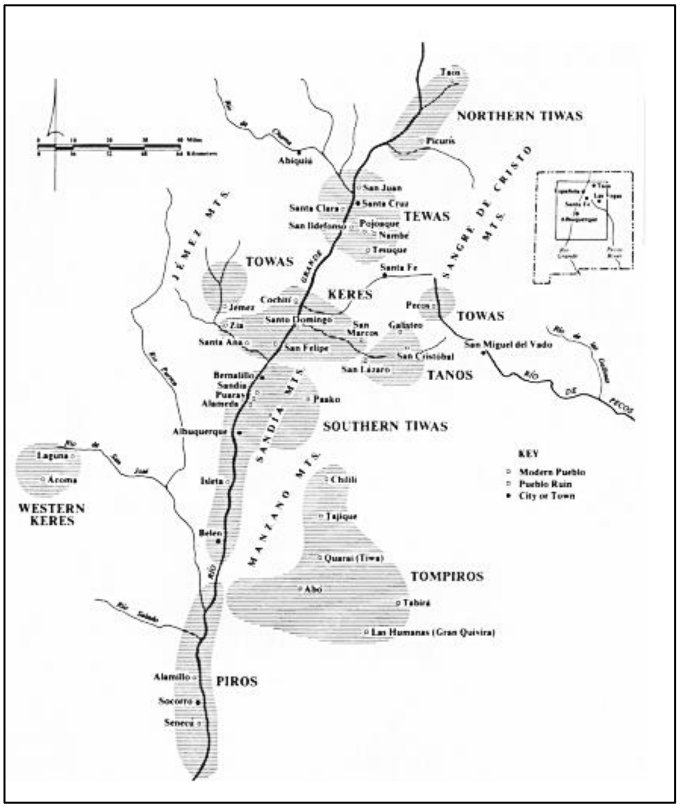

Figure 2. Pueblo language groups (Kessell 1997:47).

Extensive roadways are another notable aspect of Pueblo architecture. Ancestral Pueblo communities maintained thriving trade connections with many other Native communities across North America, particularly with Plains tribes. These relationships directly supported Pueblo food supplies, providing communities in the Southwest with goods such as bison fat and meat in exchange for maize (Spielmann et al. 1990:746–747).

The Spanish in New Mexico

In September 1595, a petition in Zacatecas, Mexico, appointed don Juan de Oñate to venture northward into what is now the American Southwest to establish colonies on behalf of the Spanish Crown (Hammond and Rey 1953:42). Other groups of Spanish colonists originating in Mexico (then known as New Spain) had attempted to establish permanent settlements in New Mexico previously, but were largely unsuccessful (Barrett 2002:6). In 1598, colonists were deployed from Zacatecas, a silver mining town, in search of mineral wealth (Figure 3). However, they were not successful at finding deposits with easily obtainable silver in New Mexico (Trigg 2005:41).

Though the Southwest did not offer these particularly valued resources, individuals continued occupation and accumulated landholdings in order to gain higher social status granted by the Spanish Crown (Trigg 2005:41). Furthermore, the Spanish Crown was interested in expanding its territories as other superpowers including France, England, the Netherlands, and Russia eyed the Americas (Trigg 1999:11). At least eleven private estates and about twenty-five missions had been built in New Mexico by the mid-1640s. Most of these establishments were concentrated in the greater Rio Grande Valley region (Ivey 1994:78). Missions were particularly important and well-funded because

Spain was piously Catholic and had a strong interest in converting the Native peoples of the Americas (Trigg 1999:12).

The colonial New Mexican economy relied on the importation of supplies from caravans traveling north from Mexico (Trigg 2017:4). These supplies were particularly important during the 1670s, when the colonies were plagued by a series of famines. Food shortages caused major problems for indigenous and Spanish communities alike (Ivey 1994:83).

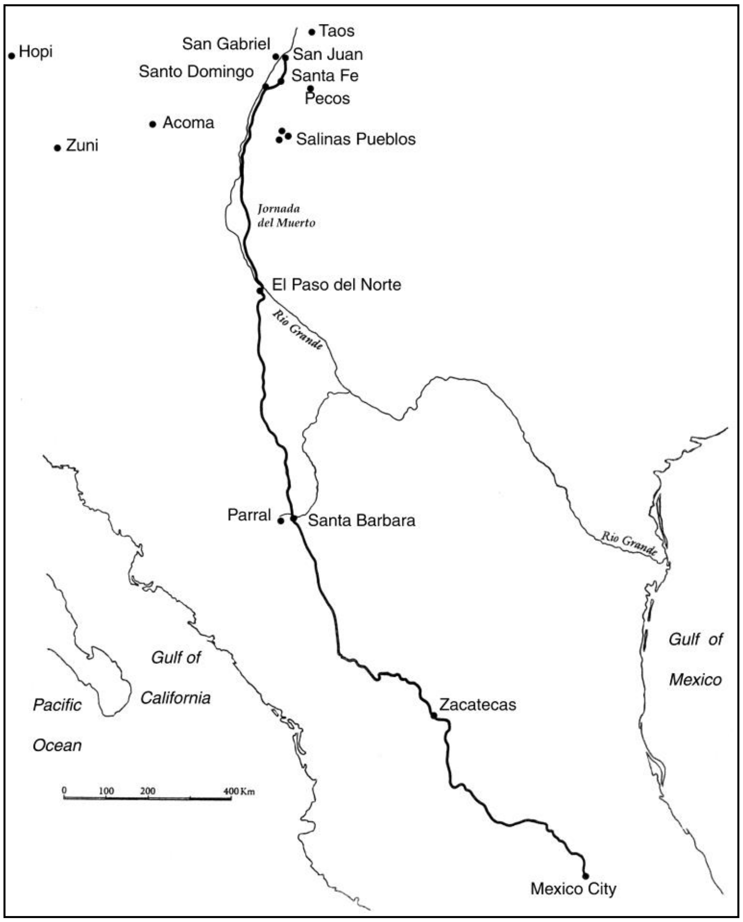

Figure 3. Map of the American Southwest and Northern Mexico (Trigg 2005:4).

Historic documents suggest the Spanish were impressed with Puebloan architecture (Barrett 2002:8). The Spanish distinguished the agricultural, sedentary Pueblo from the “barbaric” nomadic tribes they associated with wilderness, including the Apache, Teya, and Querecho (Kenner 1969:8). Considering them industrious, the Spanish Crown commanded to proselytize rather than enslave the Pueblo (Kessell 1997:46).

As the Spanish perceived a dearth of natural resources, they eventually began to exploit the Pueblo themselves for labor and goods, forcing them to pay tribute in the form of material goods, land, and labor (Kessell 1997:50). By 1600, Spanish landowners demanded two thousand *fanegas* (each equal to approximately 2.6 bushels) of maize from Pueblo households biannually as *encomienda* tribute. Later, cotton and wool blankets were added to tribute requirements (Snow 1983:350).

Since most of the early settlers to New Mexico were born and raised in the Americas, their relationship to Spain and its traditions were different from those settlers who had been born in Europe. This was reflected in the colonial diet; Mediterranean foods such as wheat bread, olive oil, and wine remained desirable, but New World items such as maize and peppers had been incorporated into the diet (Trigg 2005:106).

This desire for Iberian cuisine informed the Spanish introduction of European-style land modification and crop cultivation. Areas of intensive Spanish settlements depended on the availability of irrigable land for agricultural production. This was arguably the most important factor influencing locations of settlement. Colonists depended on the availability of irrigable land in order to produce the volume of food necessary to sustain their villages. The Spanish colonists in New Mexico, at the request of the Spanish Crown, implemented a number of land regimes which consolidated the populations of New Mexico and displaced huge numbers of Pueblo inhabitants (Liebmann 2012:31).

The influx of Spanish colonists also severely disrupted the social ties among indigenous societies throughout the Southwest. Prior to colonization, the Pueblo frequently traded with seasonally mobile Plains tribes, including the ancestral Apache, Ute, and Navajo. The introduction of Spanish goods, particularly livestock, replaced and devalued trade goods made from hunted bison. These actions increased hostilities between the Pueblo and the Plains peoples, leading to violence and destruction of Pueblo communities (Liebmann 2012:42).

LA 20,000: History and Archaeology

LA 20,000 was first excavated in the spring of 1980 when 17th-century material was recovered during trenching for the construction of a gas line. Following initial excavations by archaeologists at the Museum of New Mexico’s Lab of Anthropology, the site came under the direction of Dr. Marianne Stoller and Mr. David H. Snow, assisted by students from Colorado College. Stoller and Snow conducted a total of 44 weeks of excavations from 1980 to 1992 until the site was purchased and donated to El Rancho de las Golondrinas, a living history museum. The upper course of a cobblestone footing was recovered in 1982, which was the first sign of an architectural footprint at the site (Snow 1994:3).

Snow and Stoller described three main components of LA 20,000; the house (Units A and E), barn (Unit B), and corral (Units C and D). Excavations throughout the

1980s described the extent of Unit A, including multiple individual rooms. An *horno*, or bread oven, was excavated during the 1988 and 1989 field seasons. Unit B and Unit C are defined by a series of basalt wall footings. Excavations in 1991 and 1992 in Unit D, on the easternmost edge of the site, revealed a sequence of parallel basaltic rock footings and stone-and-mortar columns surrounded by ash and burnt material, likely deposited in 1680 during the Pueblo Revolt (Snow 1994:5–9).

Since 2014, excavations at LA 20,000 have been directed by Dr. Heather Trigg with support from the National Science Foundation (Trigg 2017:3). The most recent field seasons have focused on further exploring and defining the extent of the site's architectural footprint, particularly the interior walls (Trigg 2017:9).

The material culture recovered from the site has supported the interpretation that LA 20,000 was culturally pluralistic, with people of diverse ethnic, racial, and cultural backgrounds inhabiting the site. Based on cooking implements and archaeobotanical evidence, the food prepared at the site likely had colonial and Pueblo influences, like many other settlements housing people of indigenous and Spanish descent. Pueblo-made ceramics, including soup plates (a form introduced by the Spanish), *comales* (griddles), a few *manos* and one *metate,* as well as Mexican-made majolica and olive jar fragments have been found at the site (Trigg 2017:12). This material evidence is relevant to palynological interpretation. It illuminates the varied demand for certain food items and ingredients, which are the reflected in the pollen record.

CHAPTER THREE

ECOLOGICAL AND AGRICULTURAL HISTORY

Pollen enters the archaeological record in a variety of ways depending on the species and the overall environmental context. Therefore, it is important to understand the vegetation patterns in the environmental zones surrounding LA 20,000 and wider La Cienega before interpreting palynological data. New Mexico hosts diverse environments with a wide variety of plants and animals. There are a few main ecological zones in north-central New Mexico. These zones roughly include the cottonwood *bosque*, pinyon-juniper forest, sagebrush steppe, and mixed conifer forests. Each of these areas have different weather and climatic patterns, providing plants, animals, and humans with various habitats and natural resources (Edwards 2015:12).

The Physical Environment of La Cienega

The area surrounding LA 20,000 looks different now than it did in the 17th century. The modern landscape is dry with no flowing water directly on the site. The vegetation on and near the site today includes saltbush (*Atriplex* sp.), rabbitbrush (*Chrysothamnus* sp.), juniper (*Juniperus* spp.), cottonwood (*Populus fremontii*), willow

(*Salix* spp.), mallow (*Sphaeralcea* sp.), groundcherry (*Physalis* sp.), several species of cactus (*Opuntia* spp.), Siberian elm (*Ulmus pumila*), and Russian olive (*Elaeagnus angustifolia*). There is a slope to the north of the site, which has influenced erosion and deposition patterns of sediment on the site itself.

In the past, this site was much wetter, with a perennial stream known as La Cienega creek fed by a nearby spring. Modern demand for water associated with increased population in this area of New Mexico has resulted in a lower water table (Johnson et al. 2015:61). Only recently has this stream begun to run dry; as recently as the 1990s it still appeared after periods of rainfall (Trigg 1999:86). Geomorphological analysis conducted by Snow in 1995 suggested that the land immediately surrounding LA 20,000 in the 17th century may have been quite wet, perhaps even too marshy for crops (Trigg 199:86).

The Leonora Curtin Wetland Preserve, also located in La Cienega, is a riparian *bosque* ecozone (Edwards 2015:13) characterized by plants such as willow and horsetail (*Equisetum* spp.). Botanists have worked to return the preserve to its “natural” state with native plants, insects and wildlife (Hillerman 2009:151-152), though many invasive species such as Russian olive and Siberian elm remain. The Leonora Curtin Wetland Preserve is fed by the El Dorado buried valley at the base of the Ancha aquifer which, despite yearly fluctuations in water level, has continued to feed this marshy area (Johnson et al. 2015:2). Several dams across the preserve have created ponds out of previously flowing streams (Edwards 2015:42).

Environmental Zones of New Mexico

The greater Rio Grande Valley area is home to four major ecological zones, each with its own distinct plant communities and climatic conditions: the cottonwood *bosque*; pinyon-juniper forest; sagebrush steppe; and mixed conifer forests. The differences in the climates of each zone can be attributed to elevation, intensity of human settlement, and average rainfall and other weather patterns, among other factors (Edwards 2015:12).

The forested riparian zone along the banks of the Rio Grande is known as the *bosque* (Molles et al. 1998:750). The *bosque* is characterized by cottonwood, quaking aspen (*Populus tremuloides*), willow, and birch (*Betula* sp.) (Scurlock 1998). Riverine zones rely on groundwater and flowing streams for a constant supply of moisture, which cottonwoods and other members of the *Populus* genus prefer (Bhattacharjee et al. 2006:691). In the past, the banks of the Rio Grande flooded the surrounding *bosque* after spring brought rising temperatures. However, 20th-century levees and dams have largely stopped this formerly seasonal rise in water levels. Because the plant communities had learned to expect regular episodes of flooding for centuries (Howe and Knopf 1991:218), these modified patterns have diminished the ability of cottonwood and willow trees to thrive in their usual habitat (Molles et al. 1998:749).

The loss of cottonwood-willow stands has been further impacted by the late 19th-century proliferation of salt cedar (*Tamarisk* sp.), an invasive species. Salt cedar has colonized the *bosque* and limited the habitat ranges of cottonwoods and willows (Ellis et al. 1997:13). Alongside salt cedar and invasive Russian olive, common understory shrubs of the *bosque* include the seepwillow (*Baccharis salicina*), coyote willow (*Salix exigua*), and false indigo bush (*Amorpha fruticosa*) (Howe and Knopf 1991:219). The coniferous woodlands of New Mexico are primarily pinyon-juniper forests found at higher elevations and farther from flowing water (Dick-Peddie 1999:87). Typically, pinyon-juniper woodlands are found at elevations of 1,500–2,500 m (Huffman et al. 2008:2097) on mountainsides and mesas (Dick-Peddie 1999:88).

Vegetation patterns vary strongly according to elevation. Lower, drier elevations are dominated by juniper species, while higher slopes and peaks are dominated by ponderosa pine (*Pinus ponderosa*) (Huffman et al. 2008:2097–2098). Vegetation at the pinyon-juniper woodlands tend to be more widely spaced than those at higher elevations, where trees grow closer together. Areas with sparse tree growth amid low-lying grasses and shrubs at the edge of grasslands are known as transitional savanna zones (Dick-Peddie 1999:87).

Mixed grassland steppe, dominated by sagebrush (*Artemisia tridentata*), is another important environmental zone in Northwestern New Mexico. Sagebrush steppe is often found along the boundaries between grasslands and pinyon-juniper woodland (Dick-Peddie 1999:88–90), growing alongside other species including Mexican cliffrose (*Purshia mexicana*) and Apache plume (*Fallugia paradoxa*) (Huffman et al. 2008:2099). Sagebrush is also found in fallow and abandoned fields along with other weedy grasses and shrubs (Homburg et al. 2005:669). Wild fire patterns, combined with the historic introduction of livestock grazing, strongly affect the fluctuating boundaries between mixed sagebrush grasslands and the pinyon-juniper woodlands. Contemporary studies using dendrochronology and palynology have suggested that wild fires and animal grazing have contributed to the overall expansion of the sagebrush steppe across New Mexico (Miller and Rose 1999:550).

Forests at the highest elevations primarily consist of ponderosa pine trees (*P. ponderosa*) (Figure 4). Douglas fir (*Pseudotsuga menziesii*) and Engelmann spruce (*Picea engelmannii*) are also common in these mountainous zones, depending on the elevation. Ponderosa pines prefer 850-1,300 m. At mid-elevations, Douglas fir dominates, and at the highest elevations—approximately 2,000 m—spruce can be found in abundance (Pierce et al. 2004:88). These species prefer moister soils than the semi-arid zones of the pinyon-juniper forests and sagebrush grasslands, and cooler temperatures than riparian zones (Homburg et al. 2005:669). Like the pinyon-juniper zones, woodlands dominated by fir and ponderosa pine have suffered habitat loss due to increased wild fire damage as well as erosion due to animal grazing, though studies have also suggested that the increase in global temperature over the last century has also detrimentally affected the growth of ponderosa pines and other high-elevation conifers (Pierce et al. 2004:87–88).

Figure 4. Mixed-conifer stands at Bandelier National Monument. Photo by the author.

Pueblo Agriculture and Ethnobotany

Though ancestral Pueblo communities diverged in language and customs, agricultural production was a common interest across the Southwest (Vlasich 2005:xiii), with maize being the most important staple crop. In addition to comprising 70-80% of the diet (Snow 1990:289), maize was an important source of economic income as a trade product as early as the 10th century (Van West 2016:216).

Since maize cultivation requires water, a precious resource, the Pueblo developed a number of water control strategies which made agriculture possible. Agricultural terraces captured the sporadic summer rainfall through a series of upstream damming systems. There is evidence that this type of technology was used as early as 500 B.C. in the American Southwest (Sandor et al. 1990:71). This system required modification of the existing landscape, including altering gradients and the direction of streams. “Dry farming” utilized mountain run-off or water catchment to irrigate. This system did not require heavy modification of existing landforms (Woosley 1980:318). Despite the development of water control technologies, droughts were still a serious problem in this region and, as has been suggested by some researchers, may have contributed to the abandonment of numerous communities in both pre-colonial and colonial periods (Chavez 2006:21).

Maize appeared in the American Southwest by approximately 2100 B.C. (Reed and Geib 2013:103) and is considered the earliest staple crop for ancestral Pueblo populations (Cordell et al. 2001), as stable isotope analysis suggests that maize was a major component of the diet by at least 400 B.C. (Reed and Geib 2013:103). Palynological and macrobotanical analysis has been used extensively in New Mexico in order to trace the introduction and development of maize agriculture in the region (Benson et al. 2003; Benson et al. 2009; Hall 2010).

In addition to maize, the Pueblo raised beans (*Phaseolus vulgaris*) and squash (*Cucurbita* spp.) on a smaller, horticultural scale. Wild plants such as goosefoot (*Chenopodium* spp.) and prickly pear cactus (*Opuntia* spp.) were also important components of the Pueblo diet (Cordell and McBrinn 2016:19). People ate the edible inner bark of ponderosa pine trees, though that was possibly consumed only during famines (Swetnam 1984).

Spanish Agriculture and Ethnobotany

The most visible Spanish alteration to the landscape of New Mexico was the introduction of plants and animals including cattle *(Bos taurus*), sheep (*Ovis aries*), and Old World cereal grains including wheat and barley (Jones 2015:1698). Old World grains, particularly wheat, were highly prized by the Spanish, but required a significant amount of water for irrigation, which placed a huge demand on limited resources (MacCameron 1994:28). Due to the difficulty of producing wheat, the Spanish were left with the more widely-available maize. This is corroborated by the presence of Pueblo cooking implements associated with maize consumption on Spanish sites, including LA 20,000 (Trigg 2017:12), as well as written documents which indicate the wider availability of maize than wheat (Knaut 2015:62–63).

Macrobotanical, palynological, and documentary evidence have demonstrated that the Spanish colonial diet included peas, peaches, apricots, cabbage, onion, lettuce, peppers, barley, cantaloupe, garlic, and watermelon, among other vegetables, fruits, and herbs (Trigg 2005:105). Plants such as chamomile, rue, marshmallow, and dill were used for medicinal purposes (Trigg 1999:202). When supply caravans traveled north to New Mexico from Mexico, traders frequently brought additional stores of food (Ivey 1994:81). Some herbs and vegetables they brought included raisins, olives, peppers, capers, rosemary, hazelnuts, sesame, and penny-royal (Trigg 1999:202).

Animal husbandry was also a critical aspect to the economy in colonial New Mexico. Documents detailing the first colonists' stock of good show that they brought both *ganador menor*—smaller animals including sheep, goats and pigs—as well as *ganador mayor*—larger animals including cattle, mules, and horses (Trigg 1999:194). Sheep were of particular importance in 17th-century New Mexico (MacCameron 1994:22).

The economic potential for trading animal products, such as wool, leather, tallow, and milk in Spain's colonial mercantilist economy as part of a thriving textile industry were major motivations for the importation of the European-style agropastoral complex, beyond the use of these mammals for food (Trigg 2005:99). The archaeological evidence of animal husbandry on *estancias* like LA 20,000 is plentiful, even though written records seldom allude to livestock production in rural areas (Trigg 1999:196).

Colonists also believed the green expanses they described in written documents were best put to use by grazing sheep. In the 1580s, the earliest years of Spanish exploration in the American Southwest, observers in the Chamuscado-Rodriquez and Espejo expeditions described the landscape as "lush grasslands" and "untouched pastures" (MacCameron 1994:22). Quickly after the introduction of domesticated herbivores, however, many of these formerly lush fields were denuded by herds of herbivores. This was a common phenomenon across the Spanish Americas. For example, before the New Mexico colony was established, even small flocks of sheep in Mexico swiftly consumed the grasses in designated pasture land. As pasture lands shrank, sheep began to decimate wild grasslands, exacerbated as sheep populations increased (Melville 1990:31). As Melville (1990) noted, in the Valle de Mezquital, Mexico, the introduction of Old World domesticated livestock contributed to the alteration of a grassy landscape into an eroded expanse. The overgrazing of sheep in many areas in and around the Valle de Mezquital made the soil infertile for agriculture, suitable only for the continued grazing of sheep despite the deleterious ecological effects (Melville 1990:31–32).

Just as indigenous agriculturalists had implemented water control technology, colonists also required methods of guiding water to their fields. As agricultural production grew, the Spanish introduced a number of irrigation projects including flumes, dams, and movable wooden ditch gates. In the 17th and 18th centuries, the Spanish built irrigation channeling allowing the allocation of water among separate properties, called *acequias* (Crawford 1993:xi; Wise and Crooks 2012:563). These waterways were inspired by technologies introduced to Spain in the centuries before by Muslim influence in Granada, Valencia, and Murcia. Since governing bodies in New Mexico differed from those on the Iberian Peninsula, the *acequia* canal system in the New World was not identical in form or construction as Spain’s, but the general function was replicated (Clark 1987:12).

Colonists also introduced metal European tools, including hoes and shovels (Quintana 1990:289), but these implements did not immediately or completely overtake indigenous agricultural tools generally made from wood (Dunmire 2004:152; Rodríguez-Alegría 2008). The Andalusian scratch plow (Kessell 2013:7) was another notable contribution from the Iberian agricultural complex. The scratch plow was built from iron, wood, or steel, and cut into the ground about 6 inches deep, eroding the soil more significantly than was possible with Pueblo tools but less than the deep cutting plows used elsewhere in the New World, particularly in New England (MacCameron 1994:25–26). The scratch plow soon became ubiquitous across New Mexico (Kessell 2013:7). Overall, the most significant aspects of Spanish environmental colonialism are the introduction of animal husbandry and the intense desire for wheat agriculture. These importations, collectively known as the Iberian agropastral complex had long-term implications on the environment and culture of New Mexico

CHAPTER FOUR

METHODS

Pollen analysis is useful in understanding long-term changes to the land because it provides a profile of vegetation over time, illuminating how environmental conditions fluctuate throughout history. This study uses pollen diachronically and synchronically. First, pollen profiles are used to characterize how Pueblo and Spanish land-use practices made long-term changes to the local landscape within the context of regional environmental patterns, with a particular focus on the effects of agropastoralism. Then, intra-site pollen analysis, focusing on the 17th century early colonial period, will be used in order to understand cereal crop production at LA 20,000 and animal foddering practices.

The diachronic aspect of this project illuminates how Pueblo and Spanish land use impacted the local plant populations, with a particular focus on agropastoralism. This analysis is complemented by Kyle Edward's research (2015), which focused on understanding the long-term changes to the environment at the Leonora Curtin Wetland Preserve, located approximately two miles from LA 20,000. Edwards used a sediment core taken at the preserve to observe a series of vegetation changes during the Pueblo, Spanish, and Anglo occupations of the area, showing different uses of the land.

Similarities between Edwards' data and mine will indicate larger regional patterns, while differences should indicate localized variation.

Pollen Dispersal Processes

First, in order to effectively analyze past vegetation patterns, it is imperative to understand the habits of pollen deposition. Pollen enters the archaeological record when it falls from a plant, a process called "pollen rain" (Bryant and Hall 1993:278). Since different plant species employ various pollen dispersal behaviors, pollen can be analyzed on a broad or highly localized scale, in some cases simultaneously (Ford 1979:309). There are four main mechanisms of pollination: wind, water, animal, and self-pollination (Pearsall 2015:190).

Generally, plants which disperse pollen on the wind create a relatively large number of pollen grains, upwards of 10,000 per anther, and release it indiscriminately in a wide-reaching pollen rain (Pearsall 2015:190). For example, ponderosa pine, pinyon pine, and firs disperse pollen in this way. Pine pollen has been known to disperse as far as 1,800 miles (ScienceDaily 2010). Wind-dispersed pollen tends to comprise a high percentage of the pollen assemblage because it is produced in such large numbers.

Zoophilous taxa, whose pollen is transported by animals or insects, tend to create far fewer pollen grains per anther. Zoophilous pollen does not disperse far from the parent plant on its own, rather relying on its sticky oils or spines to attach it to a passing pollinator such as bats or birds (Bryant 1974:412). Plants in the Onagraceae family, such as evening primrose (*Oenothera biennis*), pollinate in this way. It is much more difficult to find zoophilous pollen in the archaeological record because it does not disperse as widely as wind-pollinated species (Pearsall 2015:190).

Insect-pollinated plants, like zoophilous plants, rely on living, mobile vectors to disperse pollen, but primarily attract bees, butterflies, moths, flies, and other insects. Many food plants are pollinated by insects, such as squash, carrot, and apple (Calderone 2012:1). Importantly for this project, maize pollen is dispersed by both wind and insects (Emberlin et al. 1999:2), though the exact patterns of dispersal depend on the specific ecological conditions in which the plant is growing (Klein et al. 2003). The many anthers on the maize plant produce prodigious amounts of pollen, upwards of 2,000, but the pollen is heavy, so it does not disperse widely (Emberlin et al. 1999:4). Experimental data shows that maize pollen travels approximately up to 100 m (Jarosz et al. 2005:2). Because of this, observing maize pollen archaeologically suggests local use or harvest.

Water-pollinated plants are often hard to detect in archaeological sediments, as they tend to be thin and fragile, thus preserving poorly (Pearsall 2015:191). No water-pollinated taxa were identified in this project.

Because self-pollinating plants do not rely on outside vectors, they produce relatively low quantities of pollen and do not disperse them widely. Many crop plants, including Old World cereals, are self-pollinated (Klein et al. 2007:303). This is why observing European cereal pollen in archaeological samples is notable; there is little of it to begin with, so identifying it is strong evidence of its nearby presence. Macrobotanical remains from sites in and around Santa Fe show that domesticated cereal grains were some of the most important species in the early Spanish colonial period, though often the most difficult to recover palynologically (Dean and Wolcott Toll 1995).

Wheat is self-pollinating (Waines and Hedge 2003), and based on laboratory research, wheat pollen generally falls within a distance of 8 meters of the parent plant. The exact dispersal area depends heavily on ambient environmental conditions including temperature, wind conditions, and rainfall (Loureiro et al. 2007:25; Wilcock and Neiland 2002:262). In addition, the pollen remains inside the closed flower head. As a result, wheat pollen is not released into the ambient environment until it is disturbed in some way, for example, threshing and processing for consumption. Thus, large quantities of wheat pollen are interpretively significant because it indicates very specific human activities (Kelso and Beaudry 1990:69).

Since different taxa have varying behaviors and pollen dispersal habits, their representation and relationship between parent vegetation and archaeopalynological representation is different. Therefore, these patterns illuminate different aspects of the ecological past. Arboreal, shrub, and certain herbaceous pollen including pine, fir, sagebrush, and aspen, are better for understanding large-scale ecological changes because of their wide dispersal area. On the other hand, herbaceous and domesticate pollen is more suited for detecting patterns in microregional land use. The depositional patterns of pollen grains are important to consider in order to understand not only how pollen entered the archaeological record, but also in identifying whether pollen was dispersed according to natural processes or due to cultural, anthropogenic activities (Bohrer 1981).

For the sake of interpretation in this project, pollen is broadly categorized as “domesticate,” “natural background,” and “land use” (Kelso and Beaudry 1990:61). “Domesticate” pollen refers to taxa that have been intentionally selected and raised by human beings. “Natural background” pollen refers to the trees, shrubs, and other plants in the environment that do not necessarily reflect human activities. “Land use” pollen refer to ruderal, “weedy” plants that colonize disturbed soils and are often associated with human agricultural clearance (Kelso and Beaudry 1990:61).

These categories are used as guides for understanding the role of each taxon within the larger picture of the environments surrounding LA 20,000. Generally, “arboreal” species, such as pines and fir, refer to “natural background.” However, because other arboreal species, such as juniper and cottonwood, can indicate anthropogenic activities such as deforestation, some are categorized under “land-use.” “Shrub” pollen, too, encompasses these two categories, as some shrubs including saltbush are better indicators of background patterns, while herbaceous Cheno-ams are indicative of field clearance and thus more appropriate under “land-use.” All domesticated taxa, including barley, wheat, and maize, belong under “domesticate.”

Sampling Methods

This project used two discrete sets of data, sampled in different years using different methods. The diachronic data was obtained in 2015 as a continuous pollen column from a unit called 2015-G. The location of the 2015-G samples was chosen strategically in an area near the immediate site (Figure 5), with the intent that it would encompass local and regional patterns but would not be directly disturbed by human activity such as construction or midden heaping.

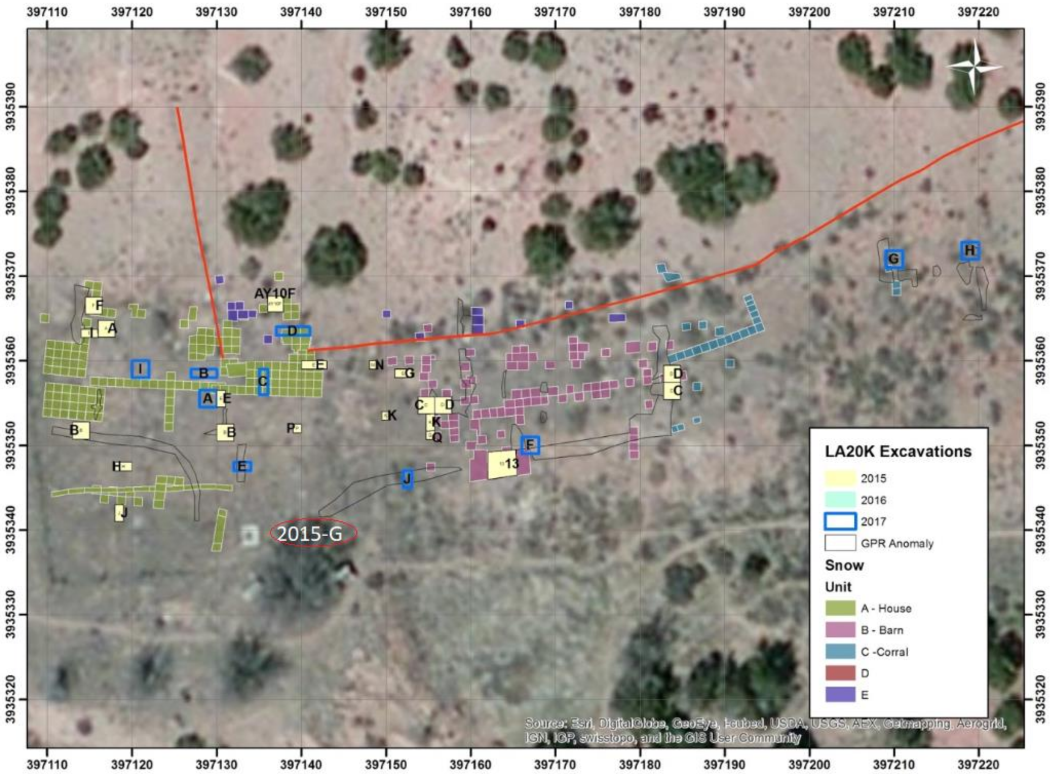

Figure 5. Site map of LA 20,000 showing location of 2015-G pollen column. Image adapted from Trigg (2017).

For the collection of these samples, a single 50 cm x 50 cm unit was excavated and the pollen samples collected continuously as a column every two centimeters. The unit was excavated for the sole purpose of sediment collection. Thirty-three samples in total were collected over 60 cm. Based on AMS dates (Table 1), five of these samples were selected for pollen analysis, chosen strategically to capture the pollen profile of the target time period – the 17th century – as well as approximately one hundred years before and after that period. Based on the nature of radiocarbon dates, it was difficult to determine which samples would be most exemplary of the 17th century and which indicated the centuries before and after that target date, but a combination of dates and sedimentation rates provided an approximate time frame for each sample.

Table 1
Provenience Data for 2015-G Pollen Column Samples from LA 20,000, New Mexico

FS #	**Sample #**	**Context #**	**Cm below surface**	**Date ± 10 years***
292	9	224	16-18	A.D. 1790
293	10	225	18-20	A.D. 1712
295	12	227	22-24	*A.D. 1673*
296	13	228	24-26	*A.D. 1634*
297	14	229	26-28	*A.D. 1595*
299	16	231	30-32	*A.D. 1517*

*Italicization indicates date extrapolated from radiometric dating results.

Samples #9, #10, and #22 were sent to Beta Analytic Testing Laboratory for radiometric dating using organic compounds occurring in the soil. Sample #9 dated to BP±10 228 (calibrated date A.D. 1790). Sample #22 dated to BP±10 1248 (calibrated date A.D. 770) but was not analyzed for pollen because it was outside the time period scope of this project. Sample #10 was intended to help refine the dates for sample #9, according to whether it was determined to be around the same time period as #9. However, the dates for #10 were not easily interpreted and it did not end up being particularly helpful in dating the remainder of the samples.

Sedimentation rates were calculated using samples #9 and #22 with the extrapolated radiocarbon as well as measured centimeters below surface (Mudie and Byrne 1980). The difference between the years 770 A.D. and 1790 A.D. (1,020 years) was divided by the difference in the centimeters below surface (26 centimeters) to yield a sedimentation rate of 39 years/cm. Using this rate, the dates of the remaining samples were extrapolated. This put samples #12 and #13 at the target 17th century. The dates span approximately 180 years, with the occupation of LA 20,000 falling approximately in the middle of the sample range.

The second series of data was collected in the 2017 field season from across the three main components of the site (Figure 6). These samples were taken in order to understand intra-site differences in pollen patterns, which might suggest cultural activities across the site while it was inhabited between 1630 and 1680. Eight samples were selected for pollen extraction (Table 2).

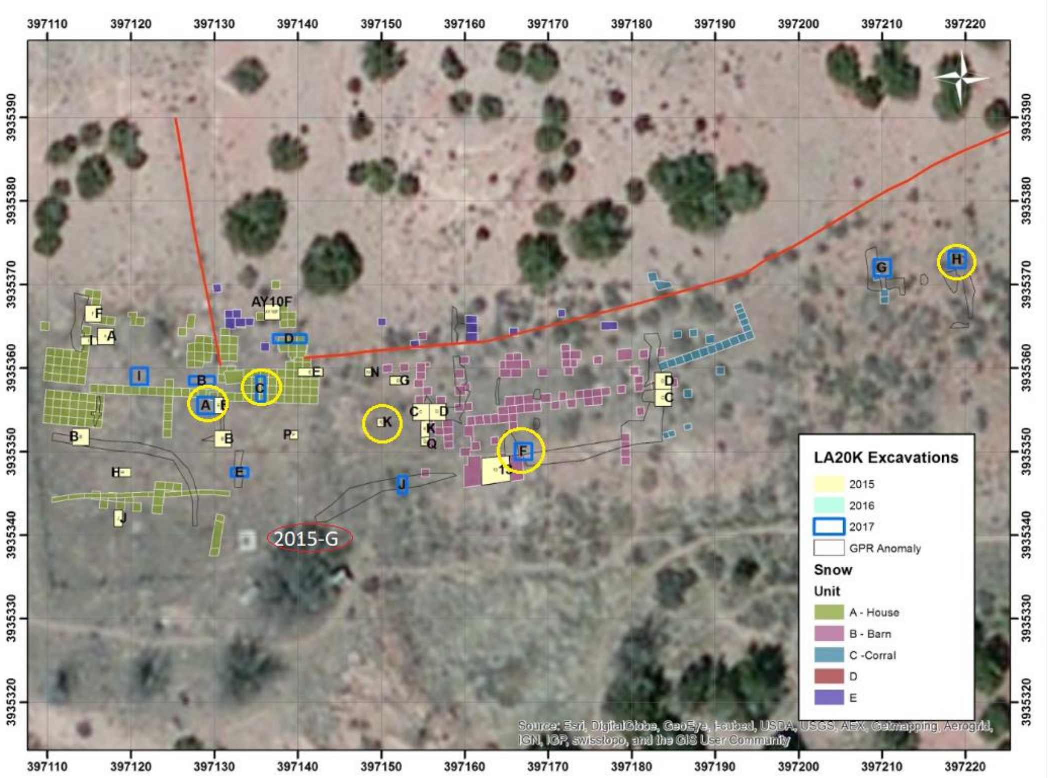

Figure 6. Site map of LA 20,000 showing locations of on-site samples. Image adapted from Trigg (2017).

Sample #420 was collected from a stratum believed to be the floor of the house in EU 2017-A. Sample #454 was from EU 2017-C.2, also from a floor stratum in the house area. Samples #321 and #323 were from 2016-K, above and between two burn layers thought to be associated with the barn area. Samples #439 and #442 came from 2017-F, inside the barn area. Sample #439 is associated with a manure layer, whereas #442 is believed to be from a floor surface. Samples #450 and #451 were taken from EU 2017-H, in the corral area. Thick layers of alternating reddish and greenish sediment in the strata of this unit were interpreted as manure layers in various states of decomposition.

Table 2
Provenience Data for On-site Pollen Samples from LA 20,000 New Mexico

FS#	**EU**	**Level**	**Context**	**Unit**	**Cm below surface**
321	2016-K	4	Above burn layer	Barn	68
323	2016-K	6	Between first and second burn layers	Barn	84
420	2017-A	3	Floor sample	House	78
439	2017-F	1	Manure layer	Barn	30
442	2017-F	3	Manure layer	Barn	55
454	2017-C.2	Pinch sample	Floor surface	House	80
450	2017-H	4	Red and green lamination – manure layers	Corral	52
451	2017-H	5	Red and green lamination – manure layers	Corral	55

The samples were purposely collected from each major areas of the site in order to detect intra-site variation of possible crop production and understand agropastoral patterns and the presence of smaller-scale horticultural operations. Manure samples were also specifically targeted in order to understand what kinds of grazing patterns these animals had, and whether they were mostly feeding on wild grasses or fodder grown in fields near the site or were allowed to stubble graze.

Pollen Extraction

In the fall following the 2017 summer field season, sediment samples were shipped to Boston and analyzed in Dr. Heather Trigg's Paleoethnobotany Laboratory at the Andrew Fiske Memorial Center for Archaeological Research at the University of Massachusetts Boston. In order to extract the pollen from the surrounding soil in the samples, it was treated with a series of chemical rinses. This process aids the ability to observe pollen under a microscope (Pearsall 2015). The extraction was completed based on standard palynological practices and is described below.

First, each sample was dried in its own beaker in a fume hood for two to three days. Then, approximately 25 mL of hydrochloric acid (HCl), which dissolves calcium and calcium carbonate, was added to 20 g of the dried soil. Two *Lycopodium* tablets were added to each sample at this stage (Brugam 1978). After two hours, the HCl was poured off. To rinse to neutral pH, distilled water was added and then the sediment was centrifuged at 2,000 R.P.M. for seven minutes repeatedly until the sediment reached neutral pH. Then, 50 mL of hydrofluoric acid (HF) was added to dissolve the silicates in the sediment. After soaking in HF overnight, the samples were centrifuged and rinsed to neutral. Glacial acetic acid was added to draw out any remaining distilled water in the samples. In the final step, acetolysis, one mL of acetic anhydride ($(CH_3CO)_2O$) and 9 mL of sulfuric acid (H_2SO_4) were added to the sediment. Then, the samples were warmed in a hot water bath for five minutes. This process breaks down remaining organic compounds in the sediment and makes the pollen easier to identify by staining the grains (Traverse 2008:62). The final samples were placed into vials with distilled water and ethyl alcohol, which preserves the sediment by inhibiting bacteria growth.

In order to identify the pollen, a glass pipette was used to place a few drops of the preserved sample onto a small amount of glycerin placed on a microscope slide, with a microfilm slide cover placed on top. The slides were then observed under 400x magnification using a compound microscope. Glycerin is the preferred medium for this process due to its low refractive index, making it easier to see the pollen than other mounting media (Edwards 2015:48).

Pollen keys were utilized throughout this study to aid in the identification of the species. Paldat.com, Ronald Kapp's (1969) detailed field guide, and the extensive reference collection at the Fiske Center for Archaeological Research at University of Massachusetts Boston were crucial resources for the pollen identification involved in this project.

According to Hall (1981), pollen recovered archaeologically virtually always experiences some degree of deterioration. Hall also found that pollen grains with certain structures are more likely to deteriorate more severely. Cupressaceae and *Pinus,* two of the most common taxa recovered in the samples for this study, are especially susceptible to deterioration (Hall 1981:198). Hall also describes the difficulty of identifying deteriorated Poaceae grains. Many Poaceae grains observed in this project were crushed, folded, or torn. Therefore, it was difficult to measure and differentiate maize, Old World grains, and non-domesticated grasses. Poor preservation also affected the ability to observe a pore or annulus, and these features were often obscured by debris.

Pollen generally preserves well in anaerobic environments, such as peat bogs, where it is less likely to degrade as a result of bacterial activity (Pearsall 2015:185). Typically, pollen preserves poorly in semi-arid zones like the American Southwest. In these environments, the main factor impacting pollen preservation is soil moisture, and even small differences in rainfall between one area and another can have a significant impact on the quality of preservation over time (Hall 1985:101).

In order to control for the inevitability of decayed pollen grains, palynologists have developed a method of quantifying the preservation rate of archaeological pollen deposits. This is calculated by using the density of the pollen in each sample in units of grains per gram. This is obtained by using the following equation:

$$\frac{O_L}{K_L} = \frac{O_P}{x}$$

Where O_L=observed number of *Lycopodium* tracer spores during pollen identification; K_L= known number of *Lycopodium* spores added to the sample; and O_P= observed number of pollen grains. This equation provides the approximate number of total pollen grains in the sample, based on the proportion between the number of observed tracer spores, observed pollen, and known quantity of spores. The result of this equation is then divided by the weight in grams of the sample, which results in the pollen density in grains/gram. The known number of spores is obtained from the manufacturer.

Two *Lycopodium* tablets were dissolved in each, corresponding to 37,166 spores (at 18,583 spores in each tablet). Hall (1981) studied the state of pollen preservation in the American Southwest and introduced an empirically-based threshold for determining the severity of deterioration in pollen samples from this region. According to Hall (1981), adequate preservation requires at least 1,000 grains per gram. This threshold was met by all of the samples analyzed for this project (Appendix A).

CHAPTER FIVE

RESULTS

Using the raw data obtained from observing pollen grains under the microscope, I created diagrams in order to observe the relationships between land-use, the history of LA 20,000 and the resulting impacts on the physical environment. This chapter provides an overview of the results and wider trends suggested by the data. First, I l discuss the observed pollen profile in the diachronic 2015-G column. Then, I describe the spatial orientation of the on-site data and the relationships between the locations and the proportions of specific taxa.

Taxa Observed

In all, 35 taxa were identified in this project, including 13 different arboreal taxa, 3 shrubs, 15 herbs, and 4 domesticates (Table 3). While this is generally considered to be a relatively low rate in palynological studies, it is not unusual in the American Southwest where preservation is often poor (Hall 1981). Characteristics such as size, surface sculpturing, aperture appearance, and exine thickness are all used in pollen identification. It can be difficult to distinguish the pollen of related species because they often are morphologically similar. Therefore, pollen is generally identified to genus or family rather than species (Pearsall 2015:225).

Table 3

Identified Taxa

Taxon	**Common name**	**Group**
Pseudotsuga menziesii	Douglas fir	Arboreal
P. ponderosa	Ponderosa pine	Arboreal
P. edulis	Pinyon pine	Arboreal
Abies spp.	Fir	Arboreal
Pinus spp.	Pine	Arboreal
Larix spp.	Larch/ tamarack	Arboreal
Pinaceae	Pine family	Arboreal
Juniperus spp.	Juniper	Arboreal
Populus spp.	Cottonwood/ aspen	Arboreal
Cupressaceae	Cypress family	Arboreal
Salix sp.	Willow	Arboreal
TCT	Cypress, Juniper, Aspen category	Arboreal
Rosaceae	Rose/ peach family	Arboreal
Ephedra spp.	Ephedra	Shrub
Artemisia tridentata	Sagebrush	Shrub
Ambrosia artemisiifolia	Ragweed	Shrub
Plantago spp.	Plantain	Herb
Portulaceae	Purslane family	Herb
Crassulucaceae	Stonecrop family	Herb
Chenopodiaceae-*Amaranthus*	Goosefoot genus/ amaranth family	Herb
Atriplex canescens	Saltbush	Herb
Sphaeralcea sp.	Globemallow	Herb
Compositae/ Asteraceae	Daisy family	Herb
Tamarix sp.	Salt cedar	Herb
Onagraceae	Evening primrose family	Herb
Typha spp.	Cattail	Herb
Opuntia spp.	Prickly pear cactus	Herb
Ranunculaceae	Buttercup family	Herb
Poaceae	Grass family	Herb
Zea mays	Maize	Domesticate
Cucurbita spp.	Squash family	Domesticate
Triticum spp.	Wheat	Domesticate

Pinus, including both pinyon and ponderosa, appeared frequently in these samples. Though they look very similar, it is possible to tell them apart based on their size, structure, and ornamentation (Hansen and Cushing 1973). Pinyon pine, at approximately 60 microns long, is smaller than ponderosa pine, which averages 100 microns long (Hansen and Cushing 1973:1187–1190). The distinction between these two species of pine is important in understanding the subtleties of regional environmental change at LA 20,000 over time because these two species have different growing habits and preferred habitation zones. Pinyon pine prefers lower elevations and tolerates a more arid climate. Ponderosa grows best in wetter conditions at higher elevations. In cases where the two species were too difficult to distinguish, they were grouped together as "unidentifiable *Pinus*." Pine pollen is especially fragile and susceptible to crumpling because of its size (Hall 1981). In this project, bladders of pine pollen grains were frequently separated from the bodies, which complicated accurate counting. Isolated bladders were tallied, and every two bladders were ultimately counted as one complete grain**.** The bladders alone were not identified as either pinyon or ponderosa pine and categorized alongside ponderosa and pinyon pine under "Total Pine."

Cheno-ams also appeared frequently in both the 2015-G and 2017 data. "Cheno-am" is the category referring to species in the family Chenopodiaceae and the genus *Amaranthus* in the Amaranthaceae family, which are closely related and morphologically similar (Hevly et al. 1965:128). Some notable species included in this broad category are goosefoot (*Chenopodium album*), quinoa (*C. quinoa*), saltbush (*Atriplex canescens*), and amaranth (*Amaranthus* spp.) (Tsukada 1967:157). Several of these species, including goosefoot and amaranth, were important sources of nutrition in the ancestral Puebloan diet (Trigg 2005:45). Cheno-ams are particularly important to the interpretation of palynological data in areas impacted directly by human settlement because they thrive in disturbed soils, especially agricultural fields (Scharf 2010:163).

Saltbush, though considered a Cheno-am, is distinguishable from other Cheno-ams based on pore frequency. Many Chenopodiaceae pollen have 75 or more pores whereas saltbush has 40-45 pores (Kapp 1969). Therefore, saltbush is counted separately from the rest of the Cheno-ams.

The Compositae family was another important classification in this project. Two categories of Compositae pollen, high- and low-spine, refer to the grain's surface sculpturing. The high-spine Compositae, including sunflower (*Helianthus annuus*), have at least 2.0 micron-long spines. High-spine Compositae are generally insect pollinated and their pollen does not travel far from the parent plant.

The low-spine Compositae include ragweed (*Ambrosia* sp.), whose spines are less than 2.0 microns long, generally measuring approximately 1.5 microns (Hevly et al. 1965:128). Ragweed is one of the three "shrub" species identified in this project. Low-spine Compositae are generally wind pollinated, and they generate abundant pollen, which is widely dispersed. Ragweed is an important species in the study of colonial ecologies, as it is closely associated with the clearance of woodlands and the establishments of large tracts of farmland, particularly in the Northeast United States, where the so-called "*Ambrosia* rise" is highly characteristic of the 17th century (Cronon 2003:143). Like Cheno-ams, ragweed grows profusely in disturbed soils (Fuller et al. 1998:80).

Sagebrush and ephedra are the other two “shrub” species identified in this project aside from ragweed. Sagebrush, as mentioned in Chapter Three, is an important plant in the savanna ecozones of the New Mexico and tends to prefer arid areas with little tree cover (Dick-Peddie 1990:91). Ephedra thrives in desert conditions and rapidly adapts to changing climatic conditions (Carlquist 1989:442), often growing on well-drained slopes alongside grasses, cactuses (Brand 1936:41). Mallows (*Sphaeralcea* spp.) are bushy, drought-tolerant perennial flowering plants common in the Southwest (Lady Bird Johnson Wildflower Center). Mallows are particularly important in the arid regions because they are restorative plants that replenish nutritionally deficient desert landscapes (Shryrock et al 2015:1304). These were common in the 2015-G pollen profile. Cattail (*Typha* spp.) is a common marsh species, more frequent in Edwards’ samples than mine (2015:65). Cattails are distinctive with tall, slender leaves, often growing as clumps in standing water (Wooten and Standley 1915:39).

Distinguishing between wild grasses and domesticated cereal grains, including both Old and New World varieties, was a crucial methodological aspect of this study. Poaceae pollen is monoporate, meaning it has a single pore, and typically psilate, meaning it has a smooth surface without sculpturing. Grain size is an important determinant when identifying grasses. Wild grains are smaller, approximately 20-30 microns, whereas domesticated grains are significantly larger. Wheat pollen is generally about 50 microns in diameter, while barley averages 32-45 microns. Maize pollen grains are even larger, measuring about 100-110 microns. The size of the annulus–the thickened ridge around the pore–is also indicative of wild versus cultivated varieties. Wild grains have smaller annuli, approximately 5 microns, while domesticated grains are larger, about 7-10 microns. The annulus wall is also slightly thicker on domesticated pollen grains (Tweddle et al. 2005).

Palynologically, wheat and barley pollen are morphologically very similar. However, wheat is larger. In many instances, the grains were too degraded to be able to differentiate them confidently, but the better-preserved grains demonstrated this size differential more readily. However, since I could not routinely differentiate between wheat and barley, all European cereals are categorized together as “Old World cereal grains.”

In order to observe fluctuations in past plant populations, the pollen counts were entered into TiliaGraph, a computer program which calculates the sums of each taxon within each sample (Table 4; Table 5). The 2015 data were then converted into a pollen diagram to graphically represent comparative fluctuations in pollen levels. The taxa appear at the top of the graph along the *x* axis, while the *y* axis shows the depth of the samples in centimeters below surface, sample number, and radiometric date. The 2017 on-site data were not converted into pollen diagrams. A typical pollen diagram was not used because these data represent spatial rather than temporal differences. The pollen diagram generated by the 2015-G data (Figure 7) shows a series of fluctuating pollen patterns. The samples range in date between 1517 and 1751 A.D. a time scale of approximately two centuries, which encompasses the occupation of LA 20,000. The diagram also captures the pollen profile immediately before and after the occupation of LA 20,000, which is important in order to understand how the inhabitation of this area impacted the environment within the longer-term trajectory of the local ecology.

Table 4

2015-G Pollen Counts

Name	**Group**	**Sample #9**	**#10**	**#12**	**#13**	**#14**	**#16**
Pseudotsuga	Arboreal	1	1	0	2	0	1
P. ponderosa	Arboreal	78	53	29	42	16	32
P. edulis	Arboreal	103	105	55	61	18	45
Total *Pinus*	Arboreal	198.5	170	114.5	195.5	81	140.5
Abies spp.	Arboreal	19	6	8	7	3	6
Juniperus spp.	Arboreal	21	18	22	52	47	45
Populus spp.	Arboreal	21	19	42	68	49	47
Cupressaceae	Arboreal	13	5	2	0	4	7
Salix spp.	Arboreal	7	4	8	7	6	5
Ephedra sp.	Shrub	1	1	1	2	1	3
Ambrosia artemisiifolia	Shrub	10	5	12	5	11	1
Artemisia tridentata	Shrub	0	0	2	3	0	0
Cheno-am	Herb	106	105	123	258	119	96
Atriplex canescens	Herb	11	10	22	16	12	24
Sphaeralcea	Herb	4	0	11	18	3	0
High-spine Compositae	Herb	0	0	0	1	0	0
Low-spine Compositae	Herb	8	2	13	20	8	5
Typha sp.	Herb	0	0	0	0	0	1
Ranunculaceae	Herb	1	0	0	9	0	0
Wild grass	Herb	0	0	1	0	3	3

Table 5

2017 Pollen Counts

Taxa	**Group**	**Sample #321**	**#323**	**#439**	**#420**	**#442**	**#450**	**#451**	**#454**
Pseudotsuga	Arboreal	0	0	1	0	1	0	0	0
P. ponderosa	Arboreal	14	30	32	38	12	23	22	40
P. edulis	Arboreal	13	30	23	70	18	41	29	55
Total *Pinus*	Arboreal	32.5	65	67.5	112	35.5	66.5	53	102
Abies spp.	Arboreal	5	7	7	6	5	7	3	7
Larix spp.	Arboreal	0	0	0	0	0	0	0	0
Juniperus spp.	Arboreal	23	23	15	20	17	31	9	13
Populus spp.	Arboreal	19	25	16	22	16	21	13	14
Cupressaceae	Arboreal	0	1	1	0	1	0	1	0
Salix spp.	Arboreal	14	16	19	3	15	21	3	5
Ephedra spp.	Shrub	4	0	2	2	1	2	3	1
Ambrosia artemisiifolia	Shrub	10	6	14	7	5	1	1	15
Artemisia tridentata	Shrub	3	0	6	0	0	4	11	4
Cheno-am	Herb	53	61	92	69	175	67	35	89
Atriplex canescens	Herb	24	11	10	10	17	22	11	12
Sphaeralcea spp.	Herb	22	15	9	22	1	13	10	8
High-spine Compositae	Herb	9	20	0	3	2	3	4	3
Low-spine Compositae	Herb	36	13	20	7	18	13	16	13
Onagraceae	Herb	1	2	1	0	1	1	1	0
Ranunculaceae	Herb	6	3	1	1	0	0	0	0
Wild Grass	Herb	33	32	28	20	24	52	140	16
Zea mays	Domesticate	11	14	2	0	0	5	1	1
Hordeum vulgare	Domesticate	1	0	1	1	0	0	0	0
Triticum spp.	Domesticate	0	3	2	0	3	0	0	0
Cucurbita spp.	Domesticate	2	1	0	0	0	0	0	0

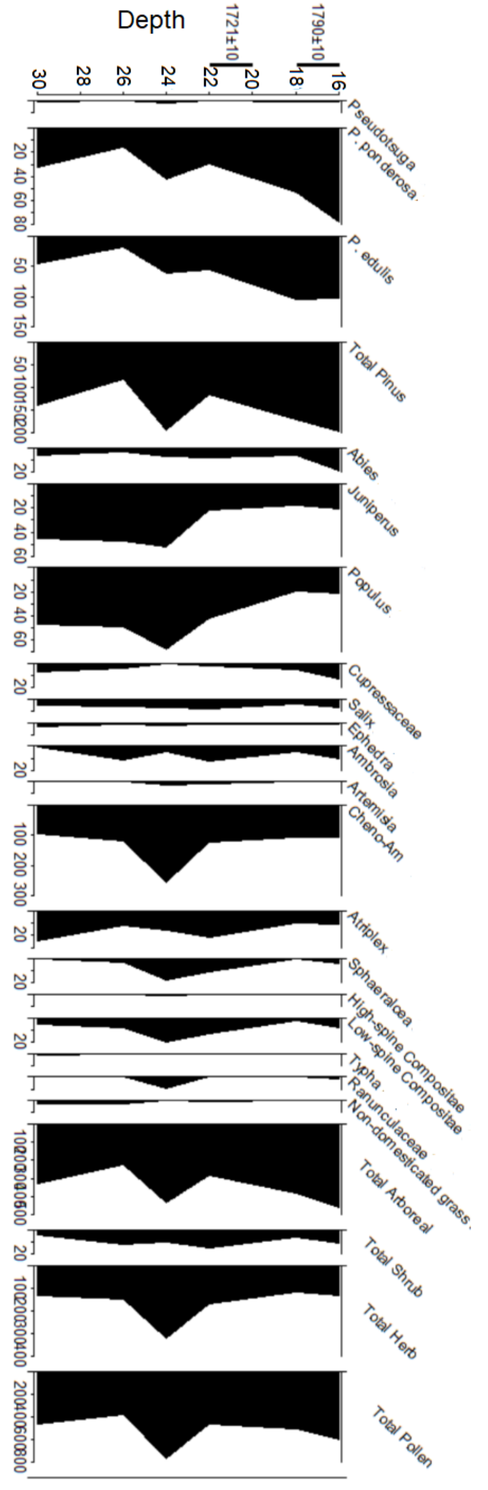

Figure 7. Pollen diagram showing 2015-G profile.

Environmental Change Over Time at LA 20,000

The earliest dates in the 2015-G core refer to samples that were 26-32 cm deep (samples #14 and #16) and reflect the time prior to the Spanish occupation of the site, from A.D. 1517-1595 (Figure 8). This time period demonstrates the decreasing presence of arboreal pollen, most notably, pinyon and ponderosa pine. Fir and willow, too, decrease over time, but less dramatically than pine. Juniper and cottonwood remain steady. Shrubs, including ephedra and saltbush, and herbs, including ragweed and Cheno-ams, remain steady.

LA 20,000 was inhabited between 1630 and 1680, corresponding to sediments at 20-26 cm in depth (samples #12 and #13) (Figure 9). During this interval, the vegetation had changed in a number of ways. Pine, both ponderosa and pinyon, increase dramatically while fir increases slightly. These patterns indicate changes in the plant communities immediately around the collection area. The marked increase in fir furthermore suggests an increase in long-distance dispersal of wind-pollinated arboreal pollen. Juniper and cottonwood both increase, but juniper less markedly so. Ephedra remains steady. Other shrubs including sagebrush and saltbush increase. The most notable change during this interval is the dramatic increase in Cheno-ams. Cattail, a marshy plant, occurs at the early and late ends of this time period.

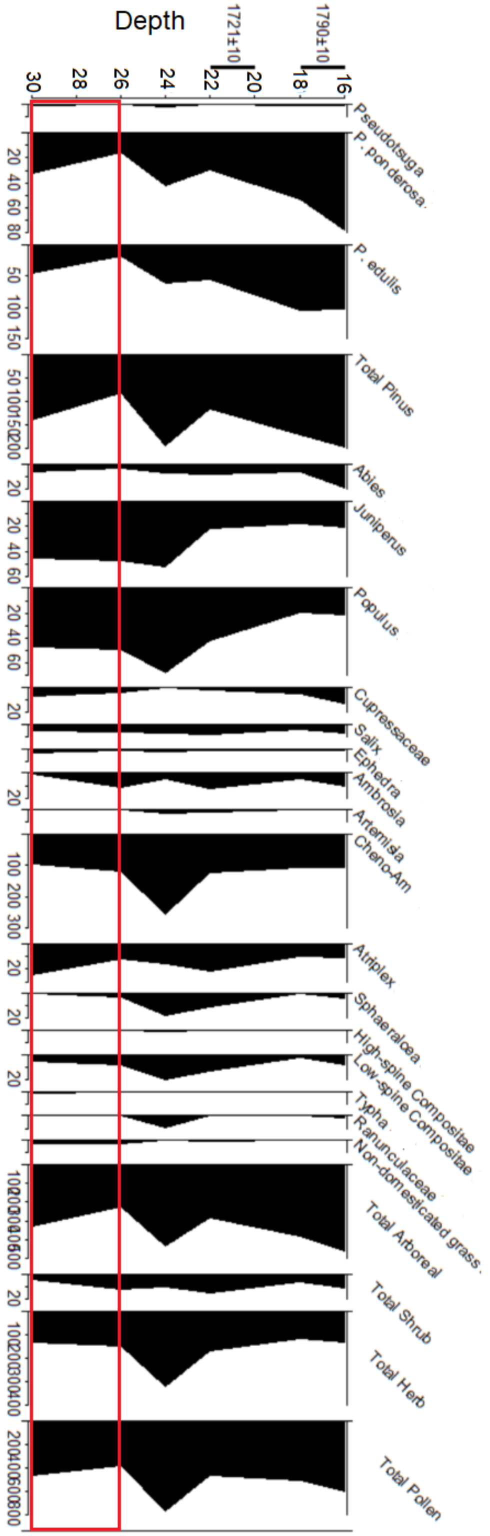

Figure 8. Pollen diagram highlighting A.D. 1517-1595.

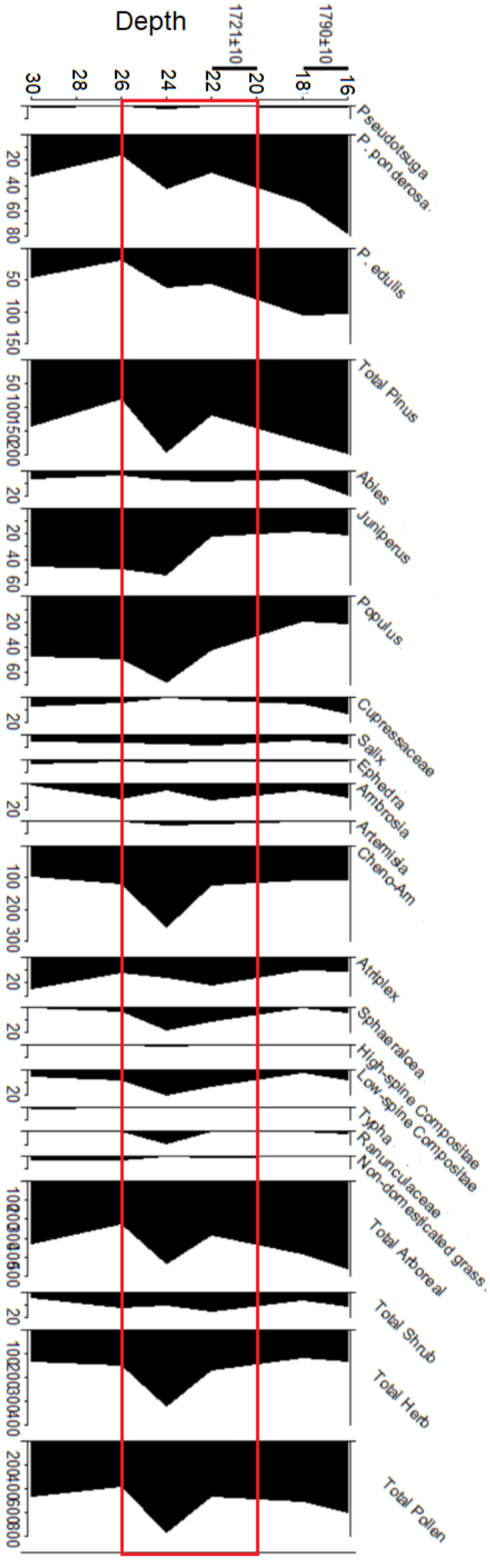

Figure 9. Pollen diagram highlighting A.D. 1634-1673.

The samples at a depth of 16-20 cm correlate to the years A.D. 1712-1790 (Figure 10). Ponderosa pine increases during the first half of this time period, and spikes again in the late 18th century. Pinyon pine increases, and then slightly decreases around the same time that ponderosa pine increases again. Fir remains steady until the latter half of the 18th century when it slightly increases. Juniper, willow, and cottonwood dip at the 18 cm mark but increase slightly thereafter. Sagebrush decreases, and its presence tapers off at 16 cm. Ephedra remains steady. Saltbush decreases slightly. Cheno-ams remain steady. No marshy plants, such as cattail, were recovered from this suite of data.

One grain of maize was recovered from sample #9, at a 16-18 cm depth, in preliminary analysis, but no grains after that were identified and maize was not included in the final counts. However, its presence does corroborate existing palynological evidence of agricultural maize production in the area (Edwards 2015:61), but dating well after the occupation of the site.

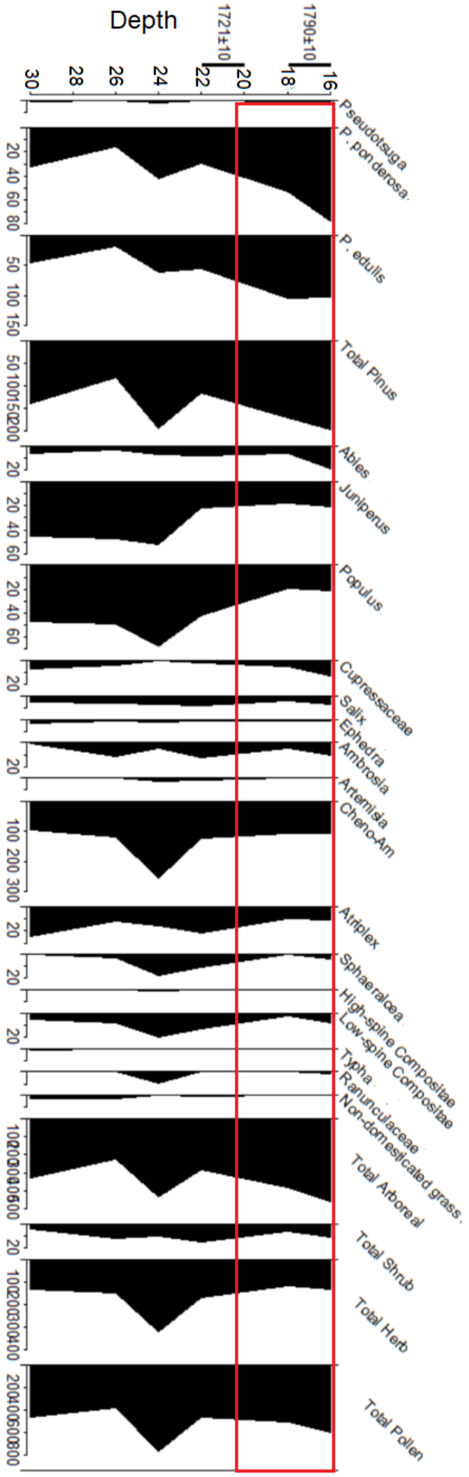

Figure 10. Pollen diagram highlighting A.D. 1712-1790.

Activity Areas and Microregional Palynological Signatures

The arboreal and shrub species observed in the on-site samples did not vary significantly from the 2015-G profile. However, the on-site samples included domesticated species including wheat, barley, maize, and cucurbits. These taxa are interpretatively significant because they indicate the presence of agropastoral activities at LA 20,000 during the 17th century. The presence of cereal pollen is also noteworthy because these species are rare to find in the archaeological record.

A greater variety of insect-pollinated species, including flowers in the evening primrose family, prickly pear cactus, and ephedra were found in these samples. Non-domesticated grasses were observed with far more frequency in the on-site samples than in 2015-G.

Even though “rare” taxa appeared in these samples, the majority of the observed pollen grains belonged to arboreal or ruderal plants. This is not unusual because, as discussed in Chapter Four, these “natural background” species produce great amounts of pollen which fall across a wide area, thus, are far more frequently identified than insect- or self-pollinated species (Kelso and Beaudry 1990:61).

CHAPTER SIX

DISCUSSION

By contextualizing fluctuations observed in pollen profiles with known palynological signatures associated with agriculture and animal grazing, changes in vegetation can be correlated with what is already known about agropastoral practices at LA 20,000 based on architectural, faunal and macrobotanical evidence. The pollen record reveals complex, interconnected patterns of ecological change, including changing populations of land-clearance weeds, riparian species, and woodland arboreal species.

Additionally, the presence of wheat in these samples is highly significant. Documentary evidence of wheat cultivation in early colonial New Mexico was abundant, in the forms of letters, inventory lists, and reports (Hammond and Rey 1953; Trigg 1999). It was clear from these documents that the difficulty of wheat cultivation did not dampen enthusiasm for the European crop. Indeed, by 1601, the first mill to process wheat had been built, and a number of productive wheat fields had been established (Trigg 1999:202-203).

The presence of Old World grain pollen is significant. Prior to this project, Edwards (2015) observed maize pollen in his core from the Leonora Curtin Wetland Preserve, but no Old World grains. Trigg (1999) recovered wheat and barley seeds in flotation samples in midden deposits, and Jacobucci (Jacobucci and Trigg 2011) tentatively identified one cereal pollen grain in a poorly defined context at LA 20,000. Therefore, this project provides the first securely identified Old World cereal pollen from LA 20,000. These findings were significant in themselves, especially combined with the presence of an *horno* (a bread oven) at LA 20,000. Until this project, however, no Old World domesticate pollen had been recovered from a 17th-century site. These data significantly contributes to the knowledge of early colonial wheat cultivation in New Mexico, demonstrating that rural *estancias* were producing Old World grains.

LA 20,000 Within the Context of Regional Ecological Change

One objective of this study is to understand the local environment around LA 20,000 as it reflects human activity at the site. Because pollen assemblages typically have local *and* regional pollen inputs, it can be difficult to disentangle local from regional signatures. Some archaeopalynologists have suggested that arboreal pollen reflects regional vegetation patterns, whereas herbaceous pollen is indicative of local vegetation (Kelso and Beaudry 1990:61). However, in an environment as open as that of LA 20,000 and where changes in local tree cover could signal important activities, I sought a more refined way of identifying vegetation around the site.

In order to accomplish this, I compared my 2015-G pollen assemblage with previous palynological research undertaken at the Leonora Curtin Wetland Preserve, a 35-acre protected area managed by the Santa Fe Botanical Garden, by Edwards (2015; Edwards and Trigg 2016). The Leonora Curtin Wetland Preserve is located approximately two miles away from LA 20,000, but represents a very different ecological zone, and thus captures very different palynological signatures from the same time period (Figure 11). Variation elucidates specific activities at LA 20,000 itself that did not necessarily affect the regional environment. The 2015-G profile does not encompass a time span as wide as Edwards', rather, focuses more specifically on the targeted colonial period during the occupation of LA 20,000. Edwards' data offer a more comprehensive understanding of the environment before and after the occupation of LA 20,000.

Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan,

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 11. La Cienega, New Mexico. Image by the author.

Edwards described the pollen profile from A.D. 1414 to the present, illuminating major ecological changes throughout the centuries. In the Leonora Curtin core, the most drastic changes appeared in the 18th and 19th centuries. His research characterized the early colonial period by subtle increases in ruderal taxa associated with land clearance, a continuing pattern from pre-Hispanic agriculture when the Pueblo were using large tracts of land for growing maize (Edwards 2015:16). Later decreases in shrubs and riparian trees, along with dramatic increases in pines were associated with later 19th-century grazing intensification.

There were both similarities and differences between the 2015-G pollen column and Edwards' Leonora Curtin core. The earliest years encompassed by these data approximately correspond to A.D. 1517 to 1595, reflecting the environment prior to the Spanish occupation of the site. This interval shows that LA 20,000 was located near a riverine environment, characterized by the presence of trees such as cottonwood, willow and aspen, which all prefer to grow near rivers and streams. Edwards' data indicated that the pre-Hispanic environment was dominated by a meadow-like landscape with high levels of ruderal taxa based on the relative percentages of high-spine Compositae and Cheno-ams (Edwards 2015:60–61). Edwards also found higher levels of cattail and plants in the parsley family (Apiaceae). Together, these species suggest standing water. The presence of these particular taxa is unsurprising, due to the fact that the core was taken from pond sediment in a wetland.

The 2015-G profile also indicates a proximity to water; however, the observed taxa were less directly associated with marshes or standing water. This is interpreted from the lack of plants such as cattail and Apiacaeae that are well known to thrive in standing water. The 2015-G pollen column also lacked water-pollinated plants. Water-pollinated species are very rarely observed archaeologically, so this result was not surprising.

Instead of marshland, seventeenth-century inhabitants of LA 20,000 had access to a flowing stream, rather than wetlands like Leonora Curtin (Trigg 1999:86). These differences in hydrology – one with marshy, standing water and the other with a fast-running stream – could contribute to these observed differences in the pollen record. It is also possible that Edwards' data reflect a more local characterization of what the pre-Hispanic environment looked like. Prior to the permanent establishment of Spanish settlement and the introduction of their grazing animals, the colonists described the landscape as a green and "untouched" (MacCameron 1994:22). This description aligns with the lush landscape described by Edwards, and parallels the patterns from 2015-G, but to a lesser extent.

Another major difference between the Leonora Curtin core and the 2015-G pollen column is the divergence in populations of low-spine Compositae and Cheno-ams. Edwards' data show demonstrably higher levels of low-spine Compositae as compared to the 2015-G data. Conversely, the 2015-G data show higher levels of Cheno-ams than Edwards'. This, too, could be attributed to the differential hydrologies of LA 20,000 and Leonora Curtin. Schoenwetter (1962) suggests that Cheno-ams prefer to grow in dissected floodplains with low water tables, whereas low-spine Compositae can more consistently be found in wet, marshy environments with higher water tables. Since the area around LA 20,000 was characterized by the La Cienega stream, it is likely that the Cheno-ams proliferated in the soil disturbed by this fast-moving stream. Conversely, the wet soils of Leonora Curtin would have been more hospitable to low-spine Compositae (Edwards 2015; Schoenwetter 1962).

During the occupation of LA 20,000, which corresponds to Zone III of Edwards' data and samples #15, #14, #13, and #12 in the 2015-G pollen profile, pollen patterns include steady herb and shrub levels, high proportions of ruderal pollen including low-spine Compositae, and high percentages of pine pollen. Overall, Zone III showed an increase in arboreal pollen over the course of the early colonial period (Edwards 2015:70). The relative percentages and proportions of taxa are similar between Edwards' data and mine. That is, both datasets demonstrate relatively high percentages of pine – likely due to the significant pollen production and wide dispersal range of these wind-pollinated trees – as well as high proportions of Cheno-ams, but lower levels of high-spine Compositae. One maize pollen grain was recovered from Edwards' Zone III; the only maize pollen from 2015-G was found at relatively the same time.

Furthermore, differential profiles of cottonwood and juniper between Leonora Curtin and LA 20,000 suggest localized patterns relating directly to the establishment of LA 20,000. Edwards' data show low and steady levels of these trees throughout the profile. This suggests that there were changes to juniper and riverine trees in the early 17th century that were localized to LA 20,000 and did not extend to the wider region. Ponderosa pine, pinyon pine, and fir all increase as juniper and cottonwood experience a spike, and then a dramatic decrease. As I explain in more detail below, I believe that these patterns – of the simultaneous increase of alpine trees with the sudden decrease of riverine trees – are interrelated.

According to historic documents, juniper and cottonwood were used for fuel, construction, food, dyes, medicines, and tools in the early Spanish colonial period. A high volume of charred wood fragments has been recovered in flotation samples from a midden at LA 20,000. It is likely that the majority of the charcoal was burned in a thermal feature such as a hearth (Trigg 1999:108). Some species recovered from charcoal analysis include juniper, various types of pine, oak, willow, and cottonwood (Trigg 1999:107).

Ponderosa pine and fir pollen do not grow at elevations as low as at LA 20,000, rather preferring alpine zones. As mentioned before, the pollen of many species in the Pinaceae family, including ponderosa pine and fir, can travel upwards of hundreds of miles away. Therefore, these trees did not likely constitute the majority of the vegetation immediately surrounding LA 20,000, but they are still represented in the data. According to the 2015-G data, over time, pine pollen experiences a steady increase. This could partly be a methodological problem, as pine pollen is easier to identify due to its distinctive morphology.

Alternatively, these interrelated patterns may suggest local deforestation. As species such as cottonwood and juniper diminished, pine pollen then had a greater range uninhibited by this vegetation at lower elevations and could, therefore, deposit itself more prolifically. This could account for this increase in pine pollen through time. This pattern of deforestation at the site is one I have characterized as local variation unique to LA 20,000, as Edwards' data does not offer evidence of deforestation across the wider area until later in history. This suggests that the felling of trees was restricted to the site, and likely used on a household basis. Additionally, a spike in the Cheno-ams suggests intensified agricultural field clearance, as these plants thrive in soils disturbed by agriculture and grazing livestock.

These data indicate numerous patterns that have various implications for the interpretation of local specificity in the archaeological pollen record. By comparing data describing the Leonora Curtin Wetland Preserve with the 2015-G pollen column, complementary patterns emerged showing how, despite geographical similarity, nearby sites can have very different ecological histories. Furthermore, this project demonstrates that it is possible to use pollen data to understand these highly specific regional variances.

Agropastoralism in 17th-Century New Mexico

While the 2015-G data focus on the ecological history of LA 20,000, the on-site data provide an even more site-specific understanding of the physical environment and land use in 17th-century New Mexico. The on-site data tackle the importance and environmental implications of the Spanish-introduced Iberian agropastoral complex which centered on Old World grains and domesticated mammals.

While Pueblo foodways did not rely on domesticated animals for meat, agropastoralism was a significant aspect of Spanish foodways and economic production. Turkeys were tamed by some Pueblo communities, but they were mostly kept for their symbolic value and use of their feathers (Lipe et al. 2016:98). Overall, the ancestral Pueblo supplemented their cultivated crops and gathered plants with hunting and fishing (Vlasich 2005:4).

In Mediterranean Spain, on the other hand, grapes, wheat, olives, cattle, pigs, and sheep were important sources of food (Butzer 1988:29-30; Vassberg 1978:47-48), and perhaps even more importantly, they exported products in the form of olive oil, wine, wool textiles, leather and soap (Phillips and Phillips 2010:115). Sheep, cattle, horses, and other Old-World mammals were introduced in the 16th and 17th centuries with the advent of Spanish settlement in the region. Animal husbandry required large tracts of grassy plains for grazing.

As discussed in Chapter Three, there were significant ecological costs associated with the introduction of the Iberian agropastoral complex. Generally, the most visible deforestation, desertification, and erosion in New Mexico's ecological history occurred when Anglo-Americans began flooding into the west, causing significant environmental damage due to the dramatic increase in population (Liebmann et al. 2016:696). However, there were detectable ecological fluctuations caused by Pueblo agriculture, as well as substantial landscape changes wrought by Spanish colonists in the early colonial period (Edwards 2015:72).

The introduction of animal husbandry is apparent in the archaeopalynological record on both a large and small scale. The emergent patterns in the 2015-G data, discussed above, allude to regional changes in the environment in the decades following the introduction of domesticated herbivores. On a smaller scale, pollen analysis of domestic surfaces in archaeological contexts has shown that taxa identified from indoor floors suggest foddering and bedding practices. For example, researchers found a high percentage of Poaceae pollen from stratigraphic layers associated with floor contexts at Moel-y-gar, an experimental reconstruction of an Iron Age house in Hampshire, England.

These taxa were associated with the types of grass on which the animals grazed, thus demonstrating that this kind of analysis can show livestock diet (Macphail et al. 2004:181).

At LA 20,000, the importance of livestock is demonstrated by the relatively extensive barn and corral complex. Pollen sampling from manure layers in the barn and corrals suggest what types of plants that the animals on the site were consuming. Determining whether wild grasses, domesticated cereal grains or other plants appear in animal dung illuminates foddering practices (Rosen 2005:2). For this reason, I specifically targeted strata containing layers of manure in the barn and corral. Samples #439, #442, #450, and #451 were samples from manure layers in order to analyze the diets of the livestock on-site.

However, not all of the on-site samples are associated with manure layers. Samples #321 and #323 were collected above and between burn layers. Samples #420 and #454 were collected from historic floor surfaces. These samples, taken from the barn and the house, were collected in order to understand how pollen deposited differently across the site and how those patterns correspond to activity areas.

In the following discussion, data from the 2017 samples are displayed in a different way from traditional pollen analysis. Instead of interpreting these data through diagrams, I used spatial analysis in GIS to visualize the deposition of the taxa across the site. The data are presented as pie charts on a map rather than as a pollen diagram. This kind of spatial analysis, while common for other types of archaeological data, is relatively rarely done in palynological studies.

The first map of the on-site data with pie charts showing the proportions between types of vegetation shows the relationships between arboreal, herb, and domesticate species (Figure 12). For the sake of simplicity, “shrub” species are included in “arboreal.” In this map, arboreal and herb species dominate, so it is overall difficult to understand the spread of domesticate species.

However, it is important to note that while arboreal and herb pollen dominates, there is an observably high level of domesticated species in the barn and corral areas. It is also interesting that arboreal and herb pollen is so common across the site, even inside the house. This suggests that the pollen rain from these species was significant enough across the site that people would have tracked it into the house, perhaps on their shoes and clothing. It is particularly noteworthy that the herb species appear in such high quantities; in almost all the units, there is even more herb than arboreal pollen. This supports the 2015-G interpretation that ruderal weeds—the most frequent type of herb species in the data—thrived at LA 20,000, further indicating soil disturbance at the site.

In order to more closely examine the patterns of domesticate cereal pollen deposition across the site, it is necessary to distill the most relevant species onto the map and eliminate the “natural background” taxa. Excluding arboreal and herb pollen (except for wild grasses) makes it easier to understand exactly which taxa besides domesticates appear in the manure layers. Based on macrobotanical evidence from the site, it is possible that livestock were consuming some Old World grains, particularly barley, which was grown as animal feed, along with non-domesticated grasses that grow well in disturbed soils (Trigg 1999:157). The on-site pollen data corroborates the macrobotanical evidence that livestock were eating Old World grains alongside wild grasses (Figure 13).

Figure 12. On-site arboreal, herb, and domesticate occurrence.

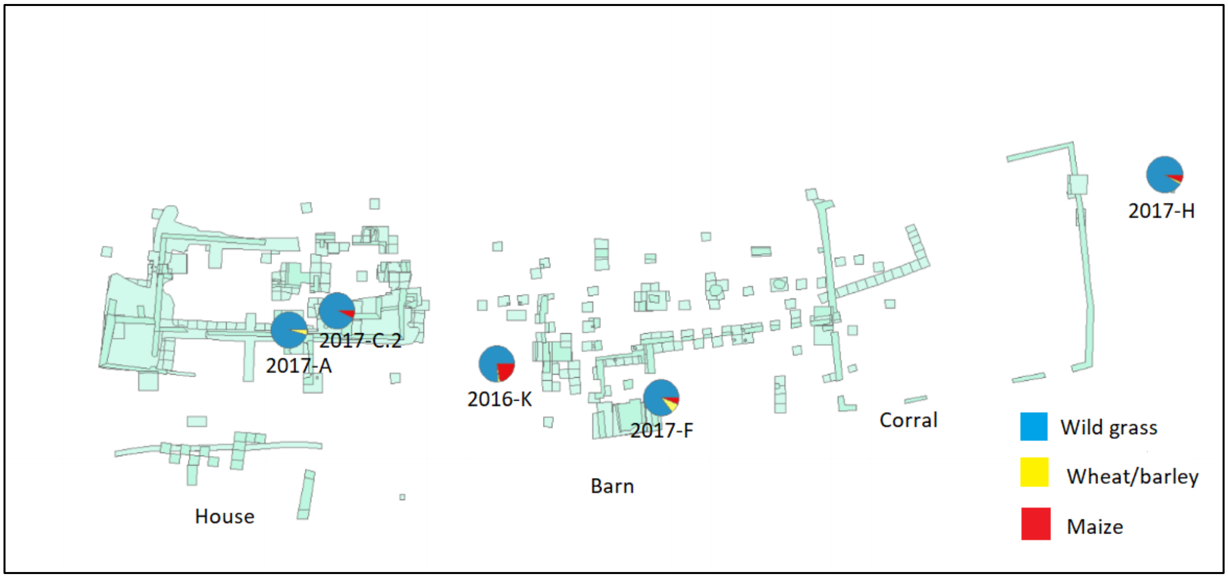

Figure 13. On-site wild grass, wheat/barley, and maize occurrence.

In two of the units with manure layer contexts—2017-H and 2017-F—there is a relatively high proportion of Old World cereals, suggesting that the livestock were eating wheat and/or barley. This is not surprising, given the macrobotanical evidence from barn deposits at LA 20,000. In Spain, barley was a lower-status grain and was mostly used for animal feed (Simmons 1996:72). Thus, it seems likely that barley may have been a source of food for the livestock at LA 20,000, therefore accounting for the presence of Old World pollen grains in the manure layers of the barn and corral. The combined presence of wheat and barley suggests that livestock were stubble grazing on the fields surrounding LA 20,000 after they had been harvested (Raish 1996:190).

Maize, a New World grain with little prestige according to the Spanish, appeared in overall greater quantities than Old World cereals. This corroborates documentary evidence that Spanish livestock grazed on (and in the process, frequently destroyed) Pueblo maize fields, thus accounting for the preponderance of New World grains in these samples (Kessel 2013:40). Furthermore, this evidence indicates that there were maize fields near LA 20,000 (Edwards 2015:61).

An interesting pattern emerged from the proportions between Old and New World grains in 2017-A and 2017-C.2. Both of these units are inside the house. They are both dominated by wild grasses, but 2017-A has a higher incidence of Old World species, while maize dominates 2017-C.2. A possible interpretation for this could be that both these cereals were being made into food items (such as bread or tortillas) inside the house, thus accounting for the deposition of pollen inside.

Several species of horticultural pollen were found in 2016-K, where wheat pollen was also found. Garden plants are grown on a smaller scale than agricultural field crops.

A horticultural taxon found in this data includes a species in the Cucurbitaceae family. This suggests that the area surrounding 2016-K may have once been the home of a horticultural kitchen garden. Interestingly, prickly pear cactus pollen was found at the site. Cactus was an important source of food for many years for Pueblo communities across New Mexico (Reinhard et al. 2006:104) and may have also been consumed at LA 20,000. These data, along with macrobotanical remains of horticultural plants such as peaches, apricots, and apples, suggest the production of small-scale garden plants to supplement food procured through agriculture and foraging. The higher percentage of maize in 2016-K may indicate that the inhabitants on the site were perhaps shucking corn in this area, which would deposit high levels of maize pollen.

The palynological data from LA 20,000 exemplifies how the colonization of New Mexico altered the character of the physical landscape. Pueblo agriculture shaped the environment in a uniquely anthropogenic way, while the Spanish introduction of agropastoralism left a distinct ecological footprint. The palynological signatures observed at LA 20,000 demonstrate perceivable differences from the characterization of the Leonora Curtin Wetland Preserve, thus illuminating local patterns. Meanwhile, synchronic data from the site illustrates the nature of agriculture and animal husbandry.

CHAPTER SEVEN

CONCLUSION

New Mexico, with its long, culturally pluralistic history, has captivated archaeologists for decades. Ancestral Pueblo communities had been raising crops and altering waterways for hundreds of years when colonists from New Spain introduced a different kind of agriculture alongside animal husbandry. LA 20,000 embodies the diverse nature of the colonial *estancia*, with people of different backgrounds experiencing life on the ranch in deeply divergent ways. These lived experiences were manifested on the physical landscape through the production of both Old and New World crops, as well as long-term impacts to local ecologies due to collection of wood and increased clearance for wheat agriculture. This project sought to add to the dialogue about how food, identity, agriculture, animal husbandry, and human-environment relationships intersect to create uniquely anthropogenic landscapes that can be examined through archaeopalynological analysis.

A main goal of this study was to identify localized variation in the long-term pollen profile of LA 20,000, with a focus on the period of settlement between 1630-1680. The other main goal was to characterize the palynological signatures of agropastoral practices at LA 20,000 through the analysis of barn and house deposits. Two sets of data—one diachronic, the other synchronic—were used to explore these questions.

The diachronic samples collected from a pollen column on the southern edge of the site, 2015-G, showed fluctuations in plant communities which represent the dynamic nature of the physical landscape changing in response to human land-use. This dataset was also used to define local versus regional environmental patterns using previously analyzed data observed in a pollen core taken from lake sediment at the Leonora Curtin Wetland Preserve. These complementary data illuminate a few important patterns: That LA 20,000 was located near a perennial stream, while Leonora Curtin was significantly marshier with standing water; and that there was likely more intensive, earlier deforestation at LA 20,000 than Leonora Curtin.

Some of the changes ushered in by Spanish colonists have had long-lasting impacts and have directly informed the character of the landscape of La Cienega today. A number of studies (Ellis et al. 1997; Farley et al. 1994; Howe and Knopf 1991) have demonstrated how historic deforestation continues to shape the modern environment. Cottonwood populations, in particular, have suffered not only from deforestation but from changes in the flow of rivers and streams over the past century as water supplies are redirected into agricultural fields (Howe and Knopf 1991:218). Invasive species, including salt cedar, introduced by colonists in the 18th and 19th centuries, also have negatively impacted riparian environments as they out-compete native species (Howe and Knopf 1991:219).

The on-site data tell a slightly different story. The presence of wheat pollen on the site is significant in itself, as this is the first time that wheat pollen has been securely identified at LA 20,000. The use of a common archaeological method of spatial analysis allows for the interpretation of these on-site data more effectively than traditional pollen diagrams. The presence and distribution of domesticated cereal grains elucidates foddering and agricultural practices. Both New and Old World crops were recovered from the sediment samples collected at LA 20,000, supporting documentary and macrobotanical evidence of maize, wheat, and barley agriculture in 17th-century New Mexico. The spatial distribution of these species illuminates foddering practices, suggesting that livestock probably subsisted primarily on wild grasses, supplemented by stubble grazing on maize, wheat and barley fields. These data also indicate that wheat, barley, and maize were likely processed in some way inside the house.

These on-site data are particularly relevant to discourse surrounding food and identity. In this case, as the Spanish colonists arriving from New Spain were devout Catholics, the data speak to the desire for wheat for religious ceremony. It is well documented that wheat was as coveted as it was difficult to grow. Thus, its existence at the site represents a larger issue of identity expression that is inextricable from agricultural production.

Going forward, the types of questions posited in this study could be used in other archaeological sites in New Mexico to further refine regional and localized patterns. Archaeopalynological analysis at missions and 17th-century Pueblo communities would be beneficial to diversify the site type in this kind of study in the future. There would likely be different palynological signatures at various sites, and it would be fascinating to see the variation among then, especially if analyzed alongside ethnohistoric data. These ideas could also be applied other regions where colonial land regimes were imposed atop and comingled with existing patterns.

Furthermore, in future research, the data from this study would benefit from a more explicit examination through the lens of labor and race relations. The production and consumption of European grains are a direct product of the labor regimes enforced at Spanish colonial sites at the expense of Pueblo and Plains people, thus contributing to the inequalities than culminated in the Pueblo Revolt in 1680 and the resulting temporary halt of Spanish occupation. Indeed, impositions set by the Spanish including proselytization and displacement were closely tied with rights to land, which directly contributed to the violence in the Revolt (Belfy 2004:696; Liebmann 2012:29). In future research, palynological data could be used explicitly alongside ethnohistoric documents to understand the tangled web of relationships between land-use, identity, and economic production.

APPENDIX A

POLLEN DENSITIES IN GRAINS/g

Sample	**Pollen Observed**	**Lycopodium Observed**	**Lycopodium Total**	**Sample Weight (g)**	**Pollen Density (grains/g)**
9	421.5	71	37,166	25.93	8,509.08
10	346	30	37,166	26.73	16,036.21
12	379.5	63	37,166	29.61	7,560.10
13	485.5	124	37,166	23.03	6,318.58
14	347	74	37,166	28.11	6,199.87
16	378.5	147	37,166	25.73	3,719.24
321	313.5	41	37,166	21.54	13,193.31
323	326.5	159	37,166	20.43	3,735.62
420	301.5	76	37,166	20.42	7,220.44
439	318.5	53	37,166	20.92	10, 676. 22
442	335	32	37,166	23.93	16,259.2
450	326	44	37,166	25.41	10,836.93
451	315	76	37,166	26.14	5,893.0
454	309	84	37,166	23.4	5,842.64

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