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UNIVERSITY OF CALGARY

Paleoethnobotany of the Lake Managua Region, Nicaragua

by

Ruth Dickau

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF ARTS

DEPARTMENT OF ARCHAEOLOGY

CALGARY, ALBERTA

MARCH 1999

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Paleoethnobotany of the Lake Managua Region, Nicaragua" submitted by Ruth Dickau in partial fulfillment of the requirements for the degree of Master of Arts.

P. M

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13. April. 1999
Date

Abstract

Flotation for macrobotanical remains was undertaken at three sites in the Lake Managua region of Nicaragua dating from prehistoric to historic periods. These sites were N-MA-36, Sc-J-A, and León Viejo. Ethnohistorical accounts and artifactual evidence indicated that maize agriculture was an important part of the subsistence system of this area at the time of Spanish contact. Remains found from these sites show that maize was being cultivated, but that it did not dominate the diet. Coyol palm fruit, *Crotalaria*, chenopods, amaranths were also found, and passionfruit, squash, sweet potato, beans, *Abutilon*, and sapodilla were tentatively identified. This variety of species is interpreted to show that the past inhabitants of the region used a variety of subsistence systems to obtain their food and other resources, and were not completely reliant on agriculture. In addition, the recovery of archaeobotanical remains demonstrates that flotation is a viable paleoethnobotanical technique in this area.

Acknowledgements

A thesis is supposed to represent the research and work of one person in the attainment of a degree. In reality, nothing is farther from the truth. I am deeply indebted to many people for their help in bringing this thesis into fruition.

Funding for this research was provided by several generous sources: University of Calgary Thesis Research Grant, the Alcaldía of Managua, Nicaragua, the Dirección de Patrimonio Cultural, Nicaragua, and the Martha Biggar Anders Memorial Award. These institutions put their faith in me to complete this project, and provided the necessary financial support to get the job done.

More than anyone, I am indebted to Dr. Frederick Lange, who provided me the opportunity to do research in Nicaragua. Dr. Lange invited me to participate in the 1997 Proyecto Arqueología de la Zona Metropolitana de Managua. His trust in my abilities, his insight, and his generosity are greatly appreciated. I also owe a great deal of gratitude to Deborah Cornavaca, UCLA. She provided her flotation samples and data from the two sites she had excavated, as well as lent me her flotation equipment to process the samples from the sites we were excavating in Managua.

Identifications were made with the help of Dr. David Lentz at the New York Botanical Gardens. Dr. Lentz generously allowed me to use his personal comparative collection, and the NYBG library, seed collection, and herbarium. As well, he provided lab space for me while I was in New York, and graciously assisted me with identifying many of the strange and unusual things I had found. Thank you as well to the rest staff of the NYBG who facilitated my research there, and to Camille Tipton and Mr. Wizard who

kindly opened their home to me and provided a friendly place for me to stay in the foreign land of the Bronx. Prior to going to New York, Dr. Alwynne Beaudoin of the Archaeological Survey of Alberta helped with the preliminary identification of material.

I would like to thank Norma Rodriguez Pizzi and family for providing me a home away from home in Nicaragua. The students 1997 Managua field project helped me in many ways throughout the field season, most importantly by their friendship. I am grateful to Ed Fiedler for his mechanical assistance, and to Luvy Pichardo, Sarah Piziali, Martha Sanchez, Lionel Alvarez, and Matt Cunningham for their help in sorting the massive amounts of heavy fractions. A special thank you to Claudia Sanchez, Carol Wood, and my roommate Laurie Rinfret for calming me down and restoring my perspective when things seemed at their worst in the field.

I would like to thank my supervisor, Dr. Peter Mathews for his advice, and his encouragement, even when the subject area in which I chose to work was slightly outside his expertise. I would also like to thank Dr. J. Scott Raymond for his advice over the course of this thesis, and for putting me in contact with Dr. Lange in the first place. And I would like to thank Dr. Denise Brown for agreeing to be on my committee.

Finally, the support of my friends and family has made this possible. Becky Goyan assisted with the figures, and Rejane Boudreau retrieved some important information for me from the Nicaraguan archives. Faculty and peers at the Department of Archaeology have offered lots of support, encouragement, and advice. Thanks especially to Trevor for all those late night slushie and hot chocolate runs. Without the love and support of my family I would have never made it this far. Look Mom and Dad, I did it!

Dedication

To my parents,

for their continuing love and support,

no matter where my journey takes me.

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CHAPTER 1
INTRODUCTION

In 1959, Willey described Lower Central America, plus Columbia, parts of Venezuela, and Ecuador, as the "Intermediate Area". This was in reference to Central America's intermediate position between the two largest centres of social complexity in the New World; Middle America and the Andean Area. This intermediate area has received far less archaeological attention than these other two areas, but is considered critical to the understanding of the relationship between the Mesoamerica and the Andean culture areas. More recently, the view of Central America as a conduit between more complex societies has changed, and focus has switched to looking at the area as a unique cultural area with its own important internal cultural developments (Lange 1971).

Part of the ongoing work in Central American archaeology attempts to discern the nature of the relationship between the environment and the societies that existed in this environment and depended on it for their survival. One of the methods employed in this quest is paleoethnobotany. Paleoethnobotany is the study of the relationship between humans and plants in the past. It is not a new study, but many recent developments and new techniques have made the recovery of archaeobotanical remains more efficient for many different environments. Flotation, the technique used by this study, is by no means new; there is a long and established history of flotation being used to separate botanical material from a matrix. However, flotation has been under-used in tropical environments.

As mentioned, one of the main goals of paleoethnobotany in Central America is to understand the cultural adaptation to the environment in this area. The environment of

Central America is extremely diverse. In a general sense it may be characterized as "neotropical", but this term includes a wide range of climate, soil, vegetational, and geographical types. The environment of Central America includes everything from rocky shorelines, fertile volcanic valley and slopes, large lakes, rugged mountains, pine forests, cloud forests, rivers, deciduous tropical forest, and savannahs, to lowland coast, mangrove forests, rainforest, bays, inlets, reefs, mixed tropical forest, islands, and sandy beaches. With this range it is not difficult to understand why Central America is difficult to describe as a unified region. It also reflects on the regional diversity seen in the archaeology of this large isthmus of land.

The archaeological work done in Central America up to this point has been somewhat criticized for being too regional in scope (Willey 1980). However this is in large part a reflection of the diverse nature of environment and prehistoric Central America. It is also a reflection of the limited amount of work that has been done here. Perhaps in the future, more pan-area syntheses will be made, when there is more basic archaeological information on which to base these syntheses. An important part of this will be an examination of how past societies of the Central American isthmus interrelated with their environment, and if there are pan-regional patterns to this interaction.

Within this framework, the present study examines the relationship between past peoples and plants in one region of Central America: the Lake Managua (or Lago Xolotlán) region of the modern country of Nicaragua. Paleoethnobotanical analysis was done at three sites near Lake Managua: N-MA-36, Sc-J-A, and León Viejo (Fig. 1.1). This analysis consisted of the retrieval of macrobotanical remains through flotation, and

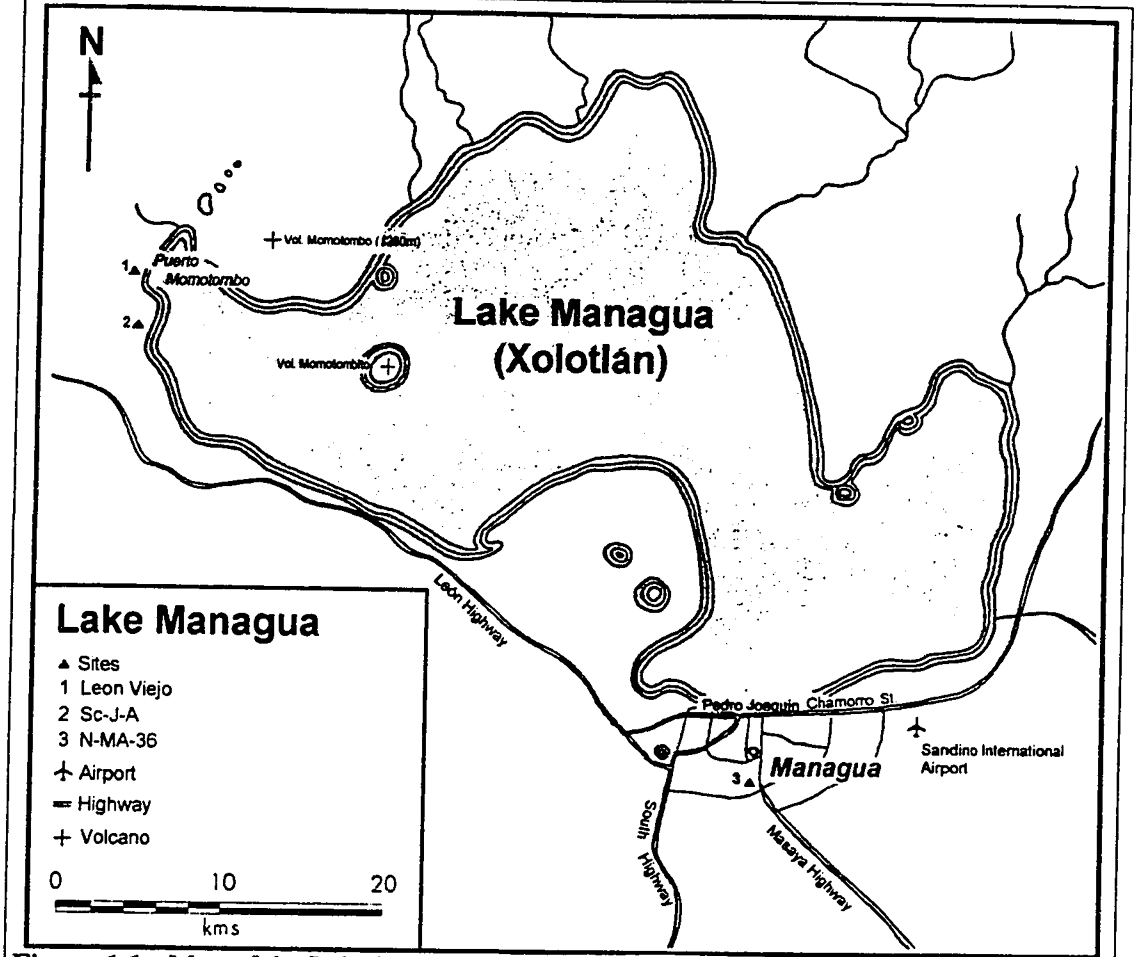

Figure 1.1: Map of the Lake Managua region, showing the location of the sites N-MA-36, Sc-J-A, and León Viejo.

the processing and interpretation of these remains. This was only the second time that flotation had been used in Nicaragua (Magnus 1978), and it was the first time botanical remains were systematically recovered from excavated contexts there.

The sites of N-MA-36 and Sc-J-A are pre-Columbian indigenous sites. The chronology of N-MA-36 extends from approximately 1000 B.C. to Contact. The chronology of Sc-J-A is somewhat shorter, and extends from approximately A.D. 800 to 1600, and possibly earlier. Sc-J-A was occupied during both pre-Contact and Colonial times, but there is no evidence that N-MA-36 was occupied during the Colonial period. Both these sites are interpreted as indigenous villages. León Viejo is somewhat different from the other two sites. It represents a relatively short Colonial occupation from 1527 to 1600, with traces of previous indigenous activity prior to the arrival of the Spanish.

All three sites lie within three to four kilometres of the lake shore. In the past, people living at these sites would have had access to a wide range of habitats; lacustrine, savannah, and seasonal tropical forest. In addition, the sites lie near the volcanic axis of western Nicaragua. The soils of the area are fertile and productive for agriculture. Samples were taken from these three sites during archaeological excavations in 1996 and 1997, using a combination of bulk (blanket) sampling and feature (opportunistic) sampling. Samples were processed using a machine assisted flotation system. The resulting light and heavy fractions were sorted and analyzed for archaeobotanical material. Identifications of this material were made with the assistance of Dr. David Lentz of the New York Botanical Gardens.

Paleoethnobotanical analyses of the three sites in the Lake Managua region were undertaken to answer three main research questions.

1) Is there botanical evidence of agriculture in western Nicaragua, and if there is, what was the role of agriculture in this area just prior to the arrival of the Spanish? Ethnohistoric accounts indicated that agriculture was a major subsistence activity in this region, particularly maize agriculture, at the time of contact. These accounts also comment on the fertility of the region, and the cultivation of beans, cotton, cacao, sweet potato, and other crops. Artifactual evidence, such as manos and metates, is

used to support the argument that domestic species were grown and processed in this area. These implements are traditionally interpreted to represent the processing of the domesticate maize, but may have also been used for processing wild resources. The occurrence of these artifacts is infrequent in western Nicaragua when compared to an area such as lowland Yucatán, where maize is known to be a major dietary staple in pre-Columbian times. In addition, the role of root crops is not emphasized in the ethnohistoric accounts, although some artifacts found may indicate the processing of these crops. Botanical remains provide direct evidence of the cultivation and use of agricultural crops, and can be used to verify ethnohistorical accounts and the interpretation of food processing artifacts.

2) What is the nature of human-plant interaction in the Lake Managua Region? Specifically, how did people adapt to their environment and make use of the plant resources available, particularly for subsistence? The area in which the Lake Managua residents lived was fertile for the growing of crops, but it was also extremely rich in other resources according to Spanish accounts. Indigenous people would have had access to a variety ecological zones, including: lakes, wetlands and rivers, savannahs, and seasonal tropical forest. How were these different ecological zones exploited, and what sorts of patterns of plant use are visible in the archaeobotanical record? Many other sites in Central America for which paleoethnobotanical analyses have been done show a diversity in subsistence strategies, especially those located inland away from the coast and the marine resources available there. Archaeobotanical remains at inland sites show a range of

species being used, and by interpretation, a range of environments. This mixed economy was never dominated by any one species. Western Nicaragua lies close Mesoamerica, and is believed to have been heavily influenced by Mesoamerica in the past. By extension, it is possible that the use of plants in the area reflects this influence, particularly the dominance of seed crop agriculture and the use of maize. The analysis of botanical information from Nicaragua will be able to determine if this is indeed the case, or if indigenous people in western Nicaragua had a more diverse economy.

3) Lastly, is the use of flotation and the recovery of macrobotanical remains from archaeological sites a worthwhile objective in Nicaragua, and by extension, in Central America? Most tropical soils are not particularly conducive to preservation of fragile organic remains. One of the reasons often cited for not doing flotation at tropical sites is that remains are not expected to be present. The frequent wetting and drying, and the clay-like nature of many tropical soils hinder preservation of remains, to the point where some excavators feel it is not worth the time and resources to try and recover them (Mahaney *et al.* 1994). This a particularly difficult question in an area where little archaeological work has been done. The realities of research force archaeologists' attention and resources to be focused more on more basic research goals like refining the ceramic chronology and culture history of the area rather than recovering ephemeral archaeobotanical remains. Most of the previous studies of macrobotanical remains in Central America have reported low rates of recovery.

Despite this, the results yielded by these paleoethnobotanical analyses are helping to make more clear the nature of human-plant interaction in the past in Central America.

Approximately 740 litres of soil from the three sites were floated by Deborah Cornavaca's team in 1996, and by myself in 1997. Botanical remains were recovered from all three sites. This thesis presents the results of this study. Species found included maize, coyol palm, Malvaceae, *Crotalaria* sp., chenopodia, purslane, and amaranth, as well as possible tree fruit, beans, Cucurbitaceae, chayote, sweet potato, and passion fruit. No one species dominated the assemblage from any of the sites. The densest remains and the widest variety of species came from Sc-J-A, which is not surprising considering this site showed the densest occupation based on other artifacts. Most of these species are interpreted to have been used as food, although several have possible religious significance, and others have medicinal properties or are used in Central American folk medicine in modern times. The wide range of species found from the three sites is interpreted to represent a mixed subsistence economy and a use of a variety of ecological zones. Plant resources were cultivated, encouraged, and gathered. Species represent agriculture, garden-plot horticulture, collection of tree fruit and the possible tending or management of these trees, and gathering of wild resources.

For the amount of soil processed, large amounts of remains were not found, and of those that were, many were eroded or fragmented, and difficult to identify. This led to many tentative identifications. Despite this low rate of recovery and the poor quality of the remains, this study has shown that archaeobotanical remains are present in the Lake

Managua region. These remains have yielded valuable, if somewhat preliminary, information regarding past human-plant interaction in this area.

A major goal of this study was to try flotation in Nicaragua, evaluate its usefulness, and make recommendations for future research. The lessons learned while doing flotation in Nicaragua will lead to more efficient and productive studies in the future. I feel strongly that flotation is an important and valuable component of archaeological research in Nicaragua, as well as Central America. Flotation, along with other techniques of paleoethnobotany, should be a part of all excavations in this "intermediate area" where the potential for the recovery of botanical remains exists. The information gained will help answer the question of how the societies of this area developed as they did, situated between complex culture areas to the north and south, as well as lead to an improved understanding of past human adaptation to this environment.

CHAPTER 2

THEORETICAL PERSPECTIVE

This thesis sets out to examine the paleoethnobotany of the Lake Managua area of Nicaragua. Before this is done, however, it is important to understand what paleoethnobotany is and the method and theory behind it. The purpose of this chapter is to present a brief review of literature on the topic of paleoethnobotanical theory, and to provide an indication of where my own theoretical biases lie. The first section of this chapter presents definitions of paleoethnobotany and archaeobotany, and discusses the importance of studying the relationship of plants and human culture. The second section reviews the history of paleoethnobotany. This is followed by a discussion of the techniques used for the retrieval of archaeobotanical material, and the methods used in paleoethnobotany. Because this study is based on the retrieval of macroremains by flotation, the final part of the chapter expands upon on the technique of flotation.

PALEOETHNOBOTANY: DEFINITIONS AND THEORETICAL PERSPECTIVE

Paleobotany is the general study of plants from any time in the past, from the Paleozoic origins of land plants up until more recent times. *Paleoethnobotany* is specific to the study of plants in the past that were used or affected by human beings, and the social significance of plants in a culture. Paleoethnobotany has become an important tool of archaeology in its goal to understand the past. It is particularly useful in understanding the relationship and adaptation of past human cultures to the surrounding environment.

The related term of *archaeobotany* is also used when talking about prehistoric cultural plant remains. There is some disagreement as to the difference between paleoethnobotany and archaeobotany within the literature (Popper and Hastorf 1988). Some authors treat the terms as interchangeable (Miksicek 1987), while others make a clear distinction between the two (Ford 1979, Popper and Hastorf 1988). Ford (1979:299) defines archaeobotany as only the recovery and identification of plant remains from an archaeological context. It does not include the interpretation of past human culture based on the recovery of these remains. In this sense archaeobotany is the methodological aspect of studying cultural plant remains, whereas paleoethnobotany encompasses the broader interpretation and integration of human-plant interaction in the past and how this influenced cultural patterns. Popper and Hastorf (1988) likewise differentiate between archaeobotany and paleoethnobotany; for them paleoethnobotany includes a more ecological and anthropological approach. In their volume, paleoethnobotany is defined as the "analysis and interpretation of archaeobotanical remains to provide information about the interaction of human populations and plants" (Popper and Hastorf 1988:2). This thesis accepts Popper and Hastorf's definition of paleoethnobotany as its basis.

Throughout their history, human beings have used plants to fulfill many needs. The most universal of these is probably the utilization of plants as food. However, the use of plants in most cultures, past or present, goes far beyond subsistence. Plants provide many elements of daily life such as fuel; constructional materials for shelter, furniture, transportation, and containers; pottery temper; insulation; cordage and fiber;

clothing; chemicals for tanning, glue, resins, gums and dye material; a variety of tools; and paper (Dimbleby 1967). Beyond basic physical needs, plants play an important cultural role in their use for medicine and ritual, and other social activities (Popper and Hastorf 1988). The social significance of plants in a culture, and the value attached to different species, is what ethnobotany seeks to elucidate. Paleoethnobotany attempts to understand this social significance in past cultures. Thus paleoethnobotany is not only about the use of plants by a past culture, but the social context in which these plants were used, and how this shaped the culture.

Significantly, it must be borne in mind that plants were not simply "used" by people; there was a complex relationship between human beings and plants in most cultures, whereby a dynamic interaction had effects not only on the culture, but on the plant community, and the ecosystem as a whole. As Pearsall (1989:2) reminds us, the nature of human-plant relationships takes on many forms: "how plants are used as fuels, foods, medicines or in ritual; how seasonality of plant availability affects settlement systems; the extent and nature of human-plant interdependency, and the impacts of humans on vegetation." In this sense, paleoethnobotany is part of the theory of human ecology which pervaded Processual archaeology (Willey and Sabloff 1993). Human society was seen as a complex system which interacted with its environment as part of a larger ecosystem (Clarke 1968, Flannery 1968). Many of the ideas of human ecology continue to be important in contemporary archaeological theory, and paleoethnobotanical studies play a major role in most archaeological investigations.

According to Ford (1979), the methods and contributions of paleoethnobotany are determined by the specific problem orientation of each study. Ford (1979) defines six main categories of paleoethnobotanical research focus: uses of plants (economic studies), origins of agriculture, migrations and cultural contacts, environmental reconstruction, human adaptation, and prehistoric ideology. There are various approaches to paleoethnobotanical studies: from taxonomic identifications, to interpreting phylogenetic relationships of crop plants, determining migration and diffusion of domesticated plants, investigating the ecological relationships at play between humans and plants, explaining past patterns of plant use through ethnographic analogy, and looking at subsistence and settlement patterns as related to plant exploitation. Ideally, paleoethnobotany goes beyond a simple taxonomic listing of plant species used in the past. It involves the interpretation of these identifications and the implication of the presence of these plants on the lives of the people who interacted with them.

HISTORICAL OVERVIEW OF PALEOETHNOBOTANY

Paleoethnobotany as a discipline grew out of ethnobotany, the anthropological study of human-plant interrelationships in different contemporary cultures (Popper and Hastorf 1988). The term was first used by Helbaek in 1959. However, the formal study of preserved plant remains can be traced back to 1826 when Kunth analyzed preserved botanical remains from dry Egyptian tombs (cited in Miksicek 1987). The development of paleoethnobotany is often divided into two traditions or schools; the European and the American (Pearsall 1989). The European tradition is older, and the American tradition owes much to early studies in Europe such as Heer's (1866, cited in Renfrew 1973) analysis of waterlogged remains from lakeside Swiss villages, the flotation of mud bricks from Egypt to retrieve plant remains (Wittmack 1905), J.G.D. Clark's (1954) famous study at Star Carr, and the economic prehistory group at Cambridge with their interest in food crops in the Near East (Higgs, ed. 1972). Even before most of these studies, deCandolle (1855) recognized the value of archaeology in the study of domesticated crop origins. In both Europe and the Americas, questions about the origins of agriculture became one of the main driving forces in the development of paleoethnobotany.

The earliest paleoethnobotanical work in the Americas was done in Peru by European scholars (Saffray 1876; de Rochebrune 1879; Harms 1922, cited in Renfrew 1973). But there was little interest by American archaeologists in the research of their European colleagues (Ford 1979). It was not until an invitation was made by Guthe in 1930 to archaeologists, encouraging them to send their material to the University of Michigan to be identified by Melvin R. Gilmore and later Volney Jones, that botanical remains began to be collected more regularly by American archaeologists (Jones 1957; Pearsall 1989; Ford 1979). Jones's (1936) landmark study of the plant remains from Newt Kash Hollow, Kentucky, was particularly motivating for archaeologists by showing the potential for paleoenvironmental and archaeological interpretation from plant remains (Pearsall 1989). Ford (1979) credits Jones with broadening the research scope of paleoethnobotany from simple identifications and listing of possible uses, to placing plant remains in an environmental and cultural context. Interest in the information that could be yielded by archaeobotanical remains grew quickly in the 1950's and 1960's, when the theoretical shift in archaeology to Processualism produced in part an emphasis on environment and ecology.

Most of the earliest paleoethnobotanical studies were based on material recovered *in situ* from exceptional preservation environments, usually dry, desiccated sites, or those that were waterlogged. Botanical material from these sites was obvious to the observer and could be easily seen and described. Struever (1968) is credited with popularizing flotation as a paleoethnobotanical method in his landmark article on Apple Creek. Archaeologists realized that botanical remains could be found in contexts other than the exceptionally dry or waterlogged. Flotation became a routine part of archaeological excavation, and other methods such as pollen analysis and phytolith studies were introduced and developed to provide an even more comprehensive picture of prehistoric human-plant interactions (Pearsall 1989). Paleoethnobotany is a fairly recent development, and undergoing rapid growth in a diversity of new techniques that help to recover even more information, as well as quantification methods and theoretical models for the interpretation of this information.

METHODS OF PALEOETHNOBOTANY

Paleoethnobotany uses a variety of methods to examine human-plant interactions in the past. The most common methods for the recovery of archaeological plant remains are flotation, palynology, wet or dry sieving, coprolite analysis, phytolith analysis, starch grain analysis, and chemical residue analysis. Each method produces a different category of evidence, but generally the archaeobotanical remains recovered by these methods can be divided into two types; macrobotanical remains and microbotanical remains. Macrobotanical remains are plant remains obtained by flotation or sieving, visible by the naked eye or with low powered microscopy, once they are separated from the soil matrix. Microbotanical remains or microfossils (Bohrer and Adams 1977) are plant remains such as phytoliths, pollen, and starch grains which require high powered microscopy in order to be seen.

The methods of paleoethnobotany provide information on such things as probable dietary patterns, plant utilization for things such as fuel, medicine, clothing, and ritual, and human manipulation of plant genetics in the process of domestication and agriculture. As well, these methods supply information on the surrounding environment, both locally and regionally. Pollen cores are usually used to elucidate change over time of regional environmental conditions. For example, a switch from abundant tree pollens to grass type pollens may indicate a drying out of the climate, or human intervention causing deforestation. Phytoliths are microscopic silicate bodies in plants which are left after organic parts of the plant have decomposed. Different types of plants, and different parts of some plants form different shapes of phytoliths. Therefore recovery of these microscopic remains can indicate types of plants growing in a certain area, or plant parts brought to a locality and processed there by people. Phytolith analysis is a more recent archaeobotanical method, and emerged primarily as a method for examining domestication of plants and environmental changes. Phytoliths are particularly useful in tropical areas where other evidence may be poor or lacking (Piperno 1995). Because they are silicate based, they preserve in some conditions better than macrobotanical remains, and may reveal an entirely different assemblage of plants than those seen from other methods such as flotation or sieving.

Flotation (discussed further below) uses water separation to recover macrobotanical remains. It is useful for looking at change of subsistence over time, the morphological changes leading to domestication of cultivated plants, and local environment. Fine sieving or wet sieving is also useful in these regards, but instead of floating the remains out of the matrix, soil samples are sieved through a series of graduated geological screens, separating the sample by particle size, and botanical materials are sorted out from each of these screens. Sometimes water is used to gently wash the different sized particles through the screens, and to wash away fine silt. It is more refined than field screening, where larger gauge screen is usually used, permitting small remains to fall through the screen. Additionally, remains in the field screen may be undetected because they are caked with mud, or may be damaged or fragmented by the shaking across the screen.

Of all the methods of paleoethnobotany, coprolite analysis is the only one which can provide direct physical evidence of prehistoric diet. But unfortunately, coprolites are not always common in archaeological sites, especially those sites which do not possess the optimum dry or frozen conditions for preservation of coprolite material. One of the most recently developed methods for recovery of archaeobotanical remains from coprolites, as well as from other contexts, is starch grain analysis. This method involves looking at the characteristics of starch grains using high powered microscopy and identifying the grains to species based on these characteristics. Also relatively recently, a whole series of chemical analyses have been applied to the problem of detecting prehistoric plant use by looking at residues. These analyses are used on artifacts that would have come into contact with plants, such as tools and pots. Organic food residues on cooking pots such as lipids can be detected by analysis (Rottlaender and Schlichterle 1980, cited in Pearsall 1989), and stable isotope studies have also been done on pot residues (Hastorf and DeNiro 1985). Ford (1994) sees a trend towards biochemical methods of analysis in paleoethnobotany, however Hillman *et al.* (1993) caution that the trend might be progressing a little too fast.

There is no one optimal method for the retrieval of archaeobotanical remains. Often certain methods will yield better results than others dependent upon field situation and conditions; for example, phytoliths may survive in a soil environment deleterious to pollen preservation. Sometimes almost mutually exclusive plant lists may be generated from remains recovered by different methods (Pearsall 1995). Each method complements the others and when used together, all methods present a comprehensive picture of the past environment and human-plant interaction.

During the current investigation, only one method, flotation, was used to retrieve archaeobotanical remains. This was due to limits on time and resources. However, it is hoped in the future that other lines of archaeobotanical evidence such as palynology and phytolith studies will be employed at the archaeological sites around Lake Managua to broaden the paleoethnobotanical understanding of this area.

FLOTATION

Flotation, or water separation, is the oldest and most widely used method for the recovery of paleoethnobotanical remains. The earliest account of flotation being used to recover botanical remains is from Egypt where adobe bricks were floated in an enclosed bucket to separate out plant remains (Wittmack 1905:6). In the early twentieth century, an enclosed bucket procedure was used in laboratories, but it was not until Struever's (1968) article in *American Antiquity* where he used an immersion technique with screen-bottomed tubs, that flotation in the field was widely recognized as a economical and easy technique to recover large quantities of remains (Hunter and Gassner 1998:143). Since then, flotation systems have been modified and improved to better suit different situations (see Pearsall 1989 for a review of different types of flotation systems).

Despite the wide variety of systems used, all flotation works on simple and general principles. Water, or sometimes a chemical solution, is used to separate light macrobotanical remains from a soil matrix, based on differential densities. Organic material which is less dense than the liquid floats to the surface, while soil, pebbles, and heavier materials sink. Microscopic botanical remains such as seeds and plant parts are often found in the floated material. This method permits the recovery of material that would generally not be visible during regular excavation, and therefore lost in the backdirt (Bohrer and Adams 1977). The main drawback of flotation is that the wetting and drying of preserved botanical material, particularly that which is charred, is hard on the remains and can result in fragmentation. Precautions, such as drying botanical material slowly in the shade, are taken to minimize these problems.

Several studies have been published comparing the efficiency of different flotation systems or techniques (Watson 1976; Keeley 1978; Wagner 1982; Pendleton 1983; Hunter and Gassner 1998). Generally, different systems are suited to different research questions, field situations, and budgetary and logistical constraints. Flotation systems can be divided into two main types; manual flotation systems, and machine assisted flotation systems. Machine assisted flotation allows the processing of greater amounts of material and more uniform results than manual flotation; however, the equipment and maintenance costs are much higher, and the system is more difficult to move. Manual flotation can be set up almost anywhere, and requires minimal equipment, but it is very fatiguing on the operators, and this can lead to irregular recovery of remains.

Unless an archaeological site has unusual preservation conditions such as waterlogging, a frozen environment, acidic soils, or permanent desiccation, most of the botanical remains recovered by flotation from open archaeological sites are charred or carbonized. The majority of archaeological sites are located in open, well drained areas with alternating wetting and drying conditions, favourable to bacteria, fungi, insects, and other decomposers that break down organic material (Miksicek 1987). Generally, prehistoric botanical material will only preserve if it is charred; once something is charred, it is virtually impossible to destroy by chemical means (Smith 1980:151). Mechanical damage (fragmentation) is about the only process that will destroy completely charred plant material (Miksicek 1987). Charring of material occurs in reducing conditions, usually found in the ash at the base of the fire, rather than the oxidizing conditions of the open flames which rapidly reduces organic tissue to mineral ash (Hather

1991). The specific conditions required for the preservation of macrobotanical material have major implications for patterns of deposition and botanical assemblages; the probability that a plant species will be preserved in the archaeobotanical record is related to whether or not it was exposed to fire during processing for consumption, disposal, or storage (Miksicek 1987). And to further complicate the situation, charring and preservation requirements of each species are different. So a fire situation that may have preserved maize may have destroyed other types of seeds. Several experiments have been conducted examining the charring and taphonomy of different botanical species in varying conditions (Boardman and Jones 1990; Lopinot 1985; Wilson 1984), but more work needs to be done on this subject.

The chances that a plant species once used by people will be represented in the macrobotanical remains recovered by flotation are somewhat poor when considering the necessary conditions required for preservation. Plants require exposure to fire to have had the opportunity for carbonization, but not consumed by the fire. Those remains which were carbonized then needed to survive intact the taphonomic process, including not being trampled, washed away by alluvial processes or blown away by the wind, disturbed by plant roots, burrowing animals or insects, or disturbed by later cultural activities. The taxonomic range of remains recovered by flotation likely represents only a small fraction of the great variety of plant species used by people in the past. The realization that the archaeobotanical record is not an accurate and complete representation of prehistoric plant use is disheartening, particularly when the quantification of remains is used to assess species importance (Dennell 1976). But taphonomy and preservation are problems encountered throughout all of archaeology. Through the enumeration of possible factors of bias and further experiments on preservation, a greater understanding of the taphonomic process allows some interpretations and conclusions to be drawn regarding the remains found.

According to Ford (1994:xvii), flotation produced a revolution in paléoethnobotany by permitting the recovery of an entirely new range of archaeobotanical material that had previously gone unnoticed. Flotation is now a standard activity of nearly every archaeological excavation. Other more recently developed methods of gathering botanical data have appeared, and are used to compliment flotation data. All sources of data lead to a greater understanding of human-plant interaction in the past. At one time, plants were believed too fragile to preserve in most archaeological sites, and not worth looking for unless exceptional preservation conditions were present (Jones 1957). Flotation, and other techniques, have shown that an entire data set on the use of plants in the past is indeed present, and should not be ignored.

Human societies, past and present, do not exist in a void. Cultures are shaped in large part by the surrounding environment, of which the plant kingdom is a major part. Paleoethnobotany seeks to understand the relationship between plants and cultures in the past. Humans utilized and interacted with plants, and the nature of their society was affected by this interaction. In turn, the nature of the surrounding plant environment was affected by human activities. This relationship in prehistory was fascinating and complex, and through the methods of archaeobotanical research and paleoethnobotany, understandable to archaeologists today.

CHAPTER 3

ARCHAEOLOGY OF NICARAGUA AND LOWER CENTRAL AMERICA: Review of Literature

INTRODUCTION

Nicaragua is the largest Central American nation, but it is the least known archaeologically. Most archaeological work has focused on the Pacific side of Nicaragua (Espinoza *et al.* 1994, Haberland 1986, 1992; Healy 1980; Lange, ed. 1995, 1996; Lange *et al.* 1992; Norweb 1964; Rigat and González 1996; Salgado 1996). But according to Lange (1992a:xvii), these efforts have been fragmented, never systematic, and never on a regional scale. Today, the majority of Nicaragua's population lives in this region, and it is likely that the majority of people in Pre-Columbian times also lived here (Healy 1980). Archaeologically, Nicaragua is considered part of the Intermediate Area, a culture area originally defined more by lack of certain cultural traits seen in the bordering High Culture areas of Mesoamerica and the Andean area, than by traits it possessed (Kirchhoff 1943). While the concept of the Intermediate Area as defined has generally fallen out of favour, the term is still used for the sake of convenience, and attempts are being made to redefine it (Lange 1996b). Nicaragua represents an important transition zone between the southern Mesoamerican frontier in El Salvador and Honduras and the heart of the Intermediate Area in Costa Rica and Panama. The site patterns and artifact assemblages are completely different between these areas, and the archaeology of Nicaragua constitutes the "missing link" between these very different prehistoric cultures (Lange 1992a:xviii).

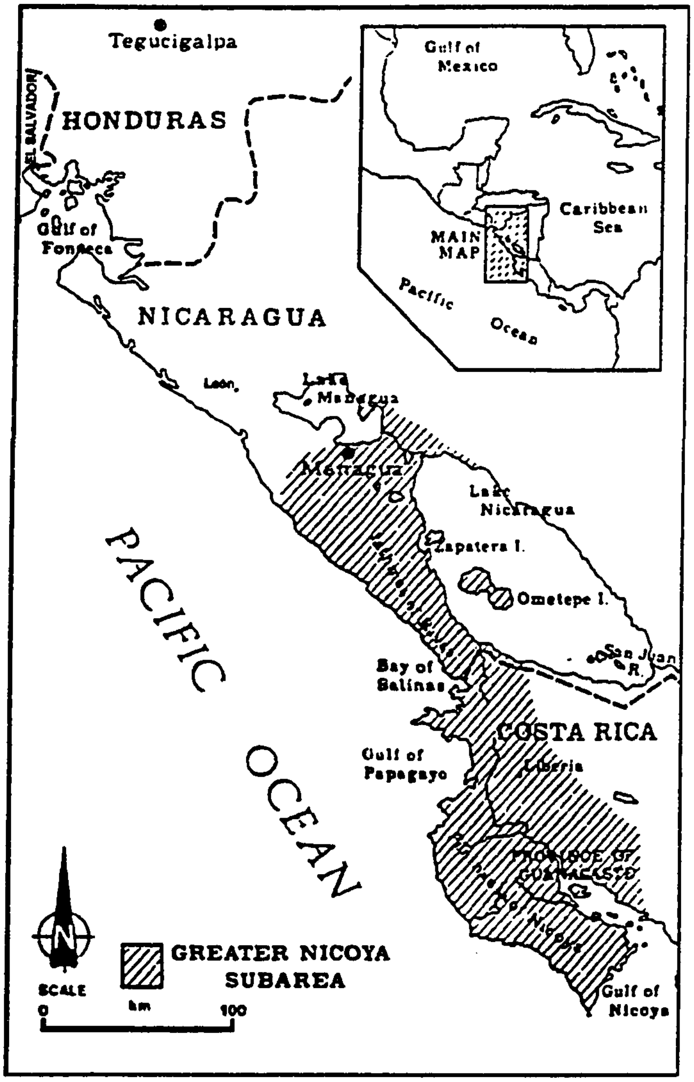

Figure 3.1: Map of the Greater Nicoya Archaeological Subarea (from Day and Tillett 1996).

The sites surveyed in this thesis lie in western Nicaragua, just to the north of the Greater Nicoya Archaeological Subarea. The Greater Nicoya Subarea encompasses Pacific Nicaragua and north-western Costa Rica, with its northern boundary just to the south of Managua (Lange *et al.* 1992)(Fig. 3.1). The site of N-MA-36 (UCA/Villa

Tiscapa) lies close enough to the boundary to be considered part of the Greater Nicoya Subarea. While the other two sites, León Viejo and Sc-J-A, lie outside the boundaries of the Subarea as defined by Lange *et al.* (1992), there was no doubt heavy influence on these sites from the Subarea.

GEOGRAPHY AND ENVIRONMENT OF WESTERN NICARAGUA

Cultural Geography

Lange (1984b) and Healy (1980) provide overviews of the cultural geography of Nicaragua. Their work is briefly summarized here.

Nicaragua can be divided into three main zones geographically: the Misquito coast, or Atlantic lowlands; the Central Highlands; and the Pacific coast, which includes the Central Depression and the volcanic chain (Fig. 3.2). The area of interest in this study, the Pacific coast zone of western Nicaragua, is the most complex physical area of Nicaragua (Healy 1980). This zone includes a narrow coastal lowland with very few major rivers, rising up to the Diriamba Highlands and the Sierra de los Morabios, a range of active volcanoes and calderas. This range of volcanoes is separated from the central Nicaraguan highlands by the large Nicaraguan Depression. This fertile lowland basin extends from the Gulf of Fonseca south-east to the Río San Juan and the Atlantic lowlands of Costa Rica. Within this basin lie the two largest lakes in Central America, Lake Managua (Xolotlán) and Lake Nicaragua (Cocibolca). These lakes were once part of the Pacific, but tectonic activity lifted up an area of land between the lakes and the Pacific Ocean (the Diriamba Highlands) cutting the lakes off from the Pacific. Vestiges

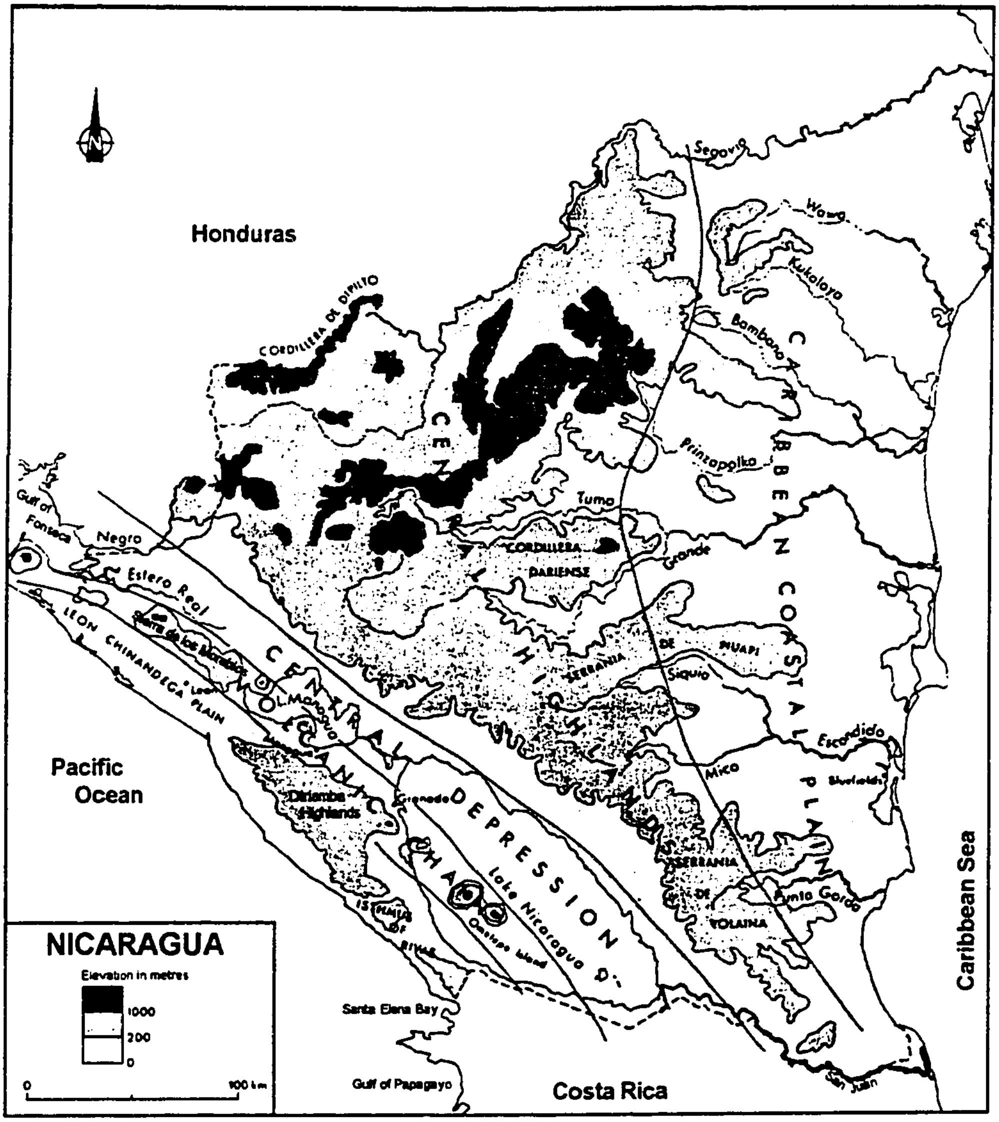

Figure 3.2: Map of Nicaragua showing the major geographical zones.

of this oceanic origin can still be found in Lake Nicaragua, which contains the world's only freshwater sharks.

The sites discussed in this thesis are located around Lake Managua and are part of this large basin. Based on what little settlement data is available for Nicaragua, this basin was the most densely populated area in Nicaragua during prehistory. The majority of sites of western Nicaragua have been found here, despite alluvial and volcanic depositional processes that can deeply bury sites in this area (Lange *et al.* 1992). Virtually no archaeological sites have been located on the Pacific shoreline of Nicaragua, despite survey work there. Conversely, the majority of sites in the Guanacaste area of Costa Rica to the south are located near the ocean shore. These areas are considered together as the Greater Nicoya archaeological subarea because they share many cultural traits. However, the settlement patterns between the northern sector and the southern sector are very different. This may be due in part to resource availability and extraction. Nicaragua has a relatively straight Pacific shoreline which lacks the protective bays and coves found along the north-western shoreline of Costa Rica (West 1964). These protective bays and irregular shoreline create favourable conditions for the development of marine subsistence resources (Lange 1984b:43). Therefore, one of the possible reasons that settlement in prehistoric Nicaragua was focused inland rather than on the coast was because marine resources were not plentiful and were difficult to exploit (Lange 1984b).

León Viejo, Sc-J-A, and N-MA-36 (UCA/Villa Tiscapa) are located in the basin of Lake Managua fairly close to the shoreline of the lake (Fig. 1.1). Sc-J-A and León Viejo are located on the north-west shore of the lake, in the shadow of the volcano Momotombo. The site of N-MA-36 is located within the present day city of Managua, south of the Laguna de Villa Tiscapa. All the sites lie within three kilometres of the current shoreline. León Viejo, the colonial site, is the closest to the lake. It is possible that these sites were closer to the lake shore during prehistory, but dropping lake levels (or uplift of the land - Dengo 1962, cited in Healy 1980) have increased the distance from the sites to the lake. According to Lange *et al.* (1992), Lake Managua and Lake Nicaragua were at one time a single body of water within the central Nicaraguan basin, but water levels dropped to leave a 25 km stretch of land between the two lakes. Lake Managua is a relatively shallow lake, reaching depths of only two to three metres (Lange *et al.* 1992).

Agricultural Potential: Soils and Climate

The area around Lake Managua and Nicaragua has water-retentive lacustrine clays which have been conducive to agriculture from pre-Columbian times to the present (Stevens 1964:309). The entire Pacific coast of Central America is covered by soils derived from recent volcanic materials; however, there is a misconception that all volcanic soils are extremely fertile. Their fertility is actually highly variable, dependent upon parent material and the age of the soils. Recently weathered volcanic soils can be very ashy, unable to retain water and easily leached. The soils of Pacific Nicaragua are relatively fertile according to Stevens (1964). These soils have long been favoured by human populations. Generally, the soils derived from volcanic activity are capable of sustaining more agricultural use and abuse than the weak, clay-laden soils which are more common in tropical regions. High human populations are often found in volcanic areas, despite the danger of catastrophes. Superior soils in many volcanic areas support denser human populations than otherwise would be possible (Lange *et al.* 1992:6).

The climate of the area in which the sites are situated is classified as Aw' in the Koeppen system of climate types (Vivó Escoto 1964). This tropical climate type is characterized by a definite and extended winter dry season from November to May. Temperatures vary between 24° and 30° centigrade, and the hottest part of the year is usually March to May. The marked wet and dry seasonality of this climate affected settlement patterns in terms of access to year-round water. The seasonality would have also affected agricultural subsistence because there would have been only one growing season without artificial irrigation (Lange *et al.* 1992).

There is little information on the stability of the climate over the last 5000 years in western Nicaragua. Generally it is assumed to have remained relatively stable, similar to that seen today. The environment has not remained static however, under the influence of volcanic activity and human occupation (Lange 1984b). Due to the prevailing winds from the east, most of the volcanic ash would have been deposited on western side of the volcanic axis. The depth of deposits can be highly variable even within a small area (Sheets 1979). As yet, no major cultural events or changes in nearby Guanacaste have been linked to natural volcanic events (Lange 1984b); this aspect of cultural geography has not been reported on in western Nicaragua. Earthquakes are also common in the area, but Lange (1984b) believes that their impact was likely less than that of volcanoes since there was no monumental architecture to collapse and injure people. Impact was probably limited to landslides, floods, and stream course alterations.

Native vegetation

It is difficult to determine the native vegetation of western Nicaragua since human activity over the last 5000 years has altered the environment so much. Even determining the pre-Columbian vegetation of the area is difficult due to the accelerated deforestation and landscape changes which have occurred since the Spanish arrival, particularly in the last two centuries (Daugherty 1969). The plant life of western Nicaragua is called "seasonal formation" by Wagner (1964:222), characterized by tropical evergreen or semi-evergreen forest to deciduous forest. Tropical semi-evergreen forest once covered most of western Nicaragua (Taylor 1963), but during both pre-conquest and post-conquest times, this landscape was being transformed by the inhabitants into cleared fields and scrubby woodland savannah, especially in the drier regions.

The seasonal formation forest is home to many native species of trees that bear an abundance of nutritious fruits. Cashew or *marañon* (*Anacardium occidentale*), hog plum (*Spondias* sp.), guava or *guayabo* (*Psidium guajava*), *mamon* (*Meliccoca bijuga*), wild papaya (*Carica papaya*), *mamey* or *zapote grande* (*Calocarpum mammosum*), green zapote or *ingerto* (*Calocarpum viride*), white zapote or *matasano* (*Casimiroa edulis*), sapodilla or *níspero* (*Zapota zapotilla*), star apple or *caimito* (*Chrisophyllum cainito*), custard apple or *anona* (*Annona* sp.), and avocado or *aguacate* (*Persea* sp.) were all important sources of food in the past, and are eaten in abundance today as well. These economically important trees were likely planted and tended in and around settlements in Pacific Nicaragua in the past, just as they are today (Fowler 1981).

The drier scrub woodland savannah encouraged the expansion of a number of taxa like the "calabash", or *jícaro* (*Crescentia cujete*), and the *nance* (*Byrsonima crassifolia*). The fruit of the *jícaro* is surrounded by a hard shell-like rind that was of major importance for its use as containers and utensils. The *nance* can be eaten as a fresh fruit.

PLANT USE IN PREHISTORIC NICARAGUA

Plants play an important role in almost any culture, archaeological or modern. This was certainly true for western Nicaragua as well. However, thus far, no direct botanical evidence has been found and analyzed to provide answers to questions about how the prehistoric and colonial populations in the Lake Managua region interacted with plants. Information on the use of plants in the Lake Managua region has been inferred only from ethnohistorical sources and artifactual evidence.

Ethnohistorical Evidence

Ethnohistoric accounts of the New World are often useful for providing a description of the local flora which the Spanish were encountering for the first time. Additionally, many accounts included a description of the subsistence economy and the plants used or cultivated by different groups of people. Also, of course, these accounts can provide important information on the colonial settlements themselves. Unfortunately, these accounts can only give a glimpse of prehistoric lifeways and the environment at the time of conquest. They are limited in time depth and cannot provide an account of how human-plant interaction may have changed over time prior to conquest (Abel-Vidor 1980a, 1981).

Oviedo (1959, 1976) was the most thorough and comprehensive chronicler of western Nicaragua. One of his greatest interests was the flora and fauna of the New World. He describes western Nicaragua as "Mohammed's paradise"; a rich and fertile area, agriculturally productive, with more fish and game than anywhere else in the Indies (Oviedo 1959:vol. 4, 359). This account may have been slightly exaggerated in order to attract Spanish settlers to the area; Healy (1980:338) calls it one of the earliest public relations efforts. But the area was likely fairly rich in natural resources. Oviedo was in Nicaragua from 1527-1529, and he documented a diversity of subsistence strategies, including maize agriculture, along with root crops, tree crops, other seed crops, hunting, and fishing (Oviedo 1976; see Healy 1980:333-339).

Oviedo (1976) makes many references to agriculture being practised in the western Nicaragua area. Agriculture was a common occupation of the commoners of Nicarao society according to Oviedo (1959). He mentions many crops such as maize, beans, indigo, cacao, cotton, and tobacco. Interestingly, squash is not mentioned in the ethnohistorical documents, but it is still believed to have been an important crop item (Fowler 1981).

Oviedo (1959) writes a fair amount about maize, its cultivation and preparation, and consumption throughout Central America. He places special emphasis on the *tortillas* eaten by the Indian groups in Nicaragua who had originally migrated from Mexico. Oviedo also mentions alcoholic and non-alcoholic beverages made from maize, including *mazamorra* made with honey and ground maize. Maize was an important tribute item to the caciques (Werner 1995), along with cacao, cotton, and tobacco, and was a major commodity for sale in the markets (Oviedo 1959).

Beans were grown in great abundance in Nicaragua at the time of contact (Oviedo 1959); hundreds of *fanegas* (approximately a bushel) of beans were harvested each year.

Common beans (*Phaseolus vulgaris*), broadbeans (possibly *P. lunatus* or lima bean), and others, some yellow, some speckled, were described.

Cotton (*Gossypium hirstum*) growing and textile manufacture was a main industry in Pacific Nicaragua. Oviedo (1959:vol. 4, 363) reports that in Nicaragua there was "a great abundance of cotton, and much good clothing made from it, and the Indian women of the land spin and weave it; and it is an annual crop, for each year they sow and pick it". The regions around Léon and Granada were especially important in the production of cotton (López de Velasco 1894, cited in Fowler 1989:110). In the early 17th century, Vázquez de Espinosa (1942) reported that Pacific Nicaragua produced very good cotton.

Cacao (*Theobroma cacao*) was reportedly introduced from Mesoamerica into western Nicaragua by migrating groups, such as the Nicarao, previous to the Spanish arrival. According to Oviedo (1959:vol. 4, 388), the Chorotega, whom the Nicarao apparently displaced, did not cultivate cacao. The length of the dry season in western Nicaragua would have meant that irrigation would have been necessary to grow cacao (Fowler 1981:760). Bergmann (1969) does not believe that cacao was commercially used as tribute in pre-Columbian Nicaragua, because the Spanish began taxing the Nicaraguan indigenous population in Spanish *fanegas* of cacao, rather than the native units of *zontales* used in all other parts of Mesoamerica. In other parts of Mesoamerica and Central America, paying tribute to a ruler in *zontales* was carried over into conquest times. Nicaragua did not have this system, so Spanish units were used instead, according to Bergmann's argument. This suggests that the pre-Columbian antiquity of cacao was not that great, and may even have been introduced by the Spanish as a cash crop, rather than by the Nicarao as stated by Oviedo (Bergmann 1969). Cacao became a major export from western Nicaragua during colonial times.

Indigo (*Indigo* sp.) was another major export of western Nicaragua during colonial times (Vázquez de Espinosa 1942:170). It is likely that this crop was originally grown in the area during pre-colonial times. The distribution of early indigo estates in Nicaragua is poorly known but the Rivas region was the most important area in Nicaragua for indigo production (Radell 1969). Other important dye plants such as *achiote* (*Bixa orellana*), *jagua* (*Genipa americana*), and *nacascolo* (*Cesalpinia coriaria* or *Libidibia coriaria*) are mentioned by Oviedo (1959), Vázquez de Espinosa (1969), and Fuentes y Guzmán (1932-1933). Oviedo (1959:vol. 1, 252-253) notes the use of *jagua* and *achiote* particularly for their use in aboriginal body painting.

The use of coca (*Erythoxylon coca*) by the Nicaraguan Indians was reported by Oviedo (1959:vol. I, 179). Another drug grown and used in western Nicaragua was tobacco (*Nicotiana* sp.).

Ethnohistorical accounts list several types of palms and many types of fruit trees which were economically valuable to the indigenous people of western Nicaragua. These trees were often cultivated and tended near settlements (West 1964) and provided a great deal of food. Oviedo (1959) reports that the Chorotega-Mangue had stands of *nispero* or *zapote* fruit trees (*Calocarpum sapota*) near their homes. Palms provided abundant amounts of fruit, but also provided other products. The leaves of the *corozo* palm (*Orbygnia* sp.) were used for thatch and fire fans, and the wood for fuel (Oviedo 1959, Fuentes y Guzmán 1932-1933). Many types of palm fruits were crushed to produce oil.

Coconut (*Cocos nucifera*) and *coyol* (*Acrocomia* sp.) were also mentioned in the accounts.

Other trees were valued for different reasons. Oviedo (1959:vol. I, 288) writes that ceiba (*Ceiba* sp.) was an important shade tree in Nicaragua, especially at the markets, and the fibre from the fruit capsule was used for making beds of high-ranking officials. However, according to the ethnohistorical accounts, the ceiba does not seem to hold the same mythological or ritual significance in Nicaragua as it did for the Maya (Fowler 1981). Another valued tree commented upon by the Spanish was the *jicaro* (*Crescentia atala*) which produced a hard outer rind that was used to make drinking vessels and utensils. Some of these vessels were apparently exported by the indigenous groups to Panama. The Spanish often referred to this tree as the calabash tree.

The Spanish chroniclers of the Nicaragua area, particularly Oviedo, described many species of flora. They attempted to emphasize those which were of economic importance to the Indians. Spanish accounts indicate that at the time of conquest, the Indians of Pacific Nicaragua practised agriculture with the principal crops of maize, beans, and cotton. As well, they cultivated and encouraged palms, fruit trees, and collected a variety of other wild foods. This diet was supplemented with the abundant game and fish of the area. Overall, agriculture formed only part of a wide and varied diet.

Artifactual Evidence

Artifacts are the other main source of evidence that has been used to infer plant use among the prehistoric populations of western Nicaragua and the surrounding regions.

The artifacts associated with plant use are usually manos and metates, bark beaters, mortars and pestles, and celts. All of these artifacts are made from ground stone, with the exception of celts which may be ground stone or chipped stone.

Manos and metates are the most frequently cited evidence of prehistoric plant use in Central America. In the Intermediate Area, they come in many different shapes and sizes, but generally the mano is a cylindrical or loaf-shaped stone, used on a flat or slightly curved slab of stone called the metate.[1] It can safely be said that the utilitarian version of these tools were used to grind vegetable material, usually seeds. In western Nicaragua, as with most areas in Central America, utilitarian manos and metates are often equated with the processing of maize and therefore are seen to indicate the practice of agriculture. The unifunctional interpretation of manos and metates for maize processing is unwarranted according to Sheets (1992a:23). Similarly, Newsom (1993:21) writes: "since direct associations between grinding equipment and wild or semi-domesticated pancoid grass [other than maize] have been demonstrated for other regions of tropical America in premaize contexts...the extrapolation from grinding tools to maize...is not secure." Ethnographic and ethnohistoric accounts indicate that manos and metates were used for processing many other substances as well (Hummer 1983). One type of metate found in Costa Rica is rimmed around the outer edges. Stone (1966:27) suggests that

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[1] Many "decorative" metates have been found in Central America. These metates are carved on the bottom or sides, or have "trophy heads", or other decorative detail. There is some debate as to whether these were ever used as functional plant processing tools, or were symbolic seats or stools (Stone 1966). Only "functional" metates are considered in this chapter; those with no decoration, or which shown definite signs of wear. Some decorated metates from Costa Rica exhibit wear in a small area in the center (Snarskis 1984). Snarskis suggests that these metates may have had a ceremonial role and may have been used for the grinding of small amounts of special food or narcotics.

these rimmed metates may have been used for processing softer vegetable matter with water, and that the rim helped keep the mixture on the metate.

Nonetheless, the frequency of manos and metates is often used as an indicator of the reliance on maize in a society. Sites in western Nicaragua exhibit a paucity of utilitarian manos and metates when compared with sites in El Salvador or the Maya area (Lange *et al.* 1992). Judging by artifactual evidence, maize, or at least seed resources, were more of a staple in El Salvador than in Nicaragua, particularly during Periods IV and V (1000 B.C. to A.D. 800). There appears to be a slight increase in mano/metate frequency in western Nicaragua in Period VI (A.D. 800- 1530), possibly due in part to the migration of the Nicarao into the area during this period (Lange *et al.* 1992). However, there is still significantly fewer of these types of artifacts found in western Nicaragua when compared with Mesoamerica, even during Period VI. Healy (1980) reports that 28 metate fragments and 42 mano fragments were found in excavations at seven sites in the Rivas area. Several mano and metate fragments were surface collected from sites surveyed by Lange *et al.* (1992) in western Nicaragua. Manos and metates are present, but not in large quantities.

Whole manos and metates were found nearby in La Guinea in north-west Costa Rica, but generally manos and metates are rare for this area as well (Lange 1984a). Excavation revealed mostly broken implements; no blanks or other indications of manufacture were found (Lange 1984a:182). It is possible that broken manos and metates were reworked into mortars and pestles (nutting stones), but these are not abundant either in north-western Costa Rica or western Nicaragua during any time.

Mortars and pestles are thought to have been used for processing palm fruits and other hard nuts or tree fruits. More pestles than mortars seem to be found in Central America, perhaps because the mortars were reworked into other tools, or possibly because wooden mortars or natural depressions in rocks were used. Pestles were found from La Vanilla (Lange *et al.* 1992:169) and sites in the Rivas region (Healy 1980) in Nicaragua. Mortars and pestles may have taken on a more "natural" form than that which is typically identified for the Intermediate Area. From the Sapoá region of north-west Costa Rica, Lange (1971:265) reports of "milling bins" ground into the volcanic rock at three sites dating to the Zoned Bichrome period (1000 B.C. to A.D. 500), along with river stone mullers to process nuts and other wild foods.

Celts are found throughout western Nicaragua, as well as Central America. These seem to have had a symbolic significance in some cases. The presence of celts, whether ground and polished, or chipped, is used to infer the clearing of forest for agriculture. These artifacts seem to be fairly common in western Nicaragua. Healy (1980) identified ten groundstone celts from the Rivas sites. Celts were recovered by surface collection from La Ceiba Sur, Moyuá, Cerro de la Vaca, and Santa Leónor (Lange *et al.* 1992). Chipped stone celts seem to outnumber ground stone celts in western Nicaragua (Lange *et al.* 1992:169).

Barkbeaters are another artifact occasionally found in western Nicaragua which indicate plant use and processing. These artifacts are made of ground stone and have parallel ridges on the pounding surface. These are not commonly found, but are strong indicators of bark or fibre processing. Barkbeaters have been found at Las Padillas

(Lange *et al.* 1992:169). Another artifact associated with the processing of plants are budares, flat griddles interpreted as cooking plates for manioc bread. These have not yet been found in western Nicaragua.

Compared with other known agricultural areas in Mesoamerica, the amount of artifacts associated with plant use and agriculture is quite small in western Nicaragua, as well as neighbouring Costa Rica (Coe and Baudez 1961). During the Late Polychrome Period prior to European contact, the artifactual evidence is limited for agriculture, even though it is believed to have been practised during this time period, and Spanish accounts emphasize its importance (Lange 1984a). The overall pattern suggested by the artifacts is that plant processing, particularly of agricultural crops, was not as important to the subsistence economy of western Nicaragua as it was to regions farther north in Mesoamerica. However, this "lack" of artifactual evidence may exist for other reasons. First, as has been mentioned, broken ground stone artifacts which were used in plant processing may have been recycled and made into smaller tools (Lange 1971). Second, it is possible that patterns of deposition may preclude these artifacts from being found in large quantities. In Mesoamerica, particularly the Maya area, broken metates and other artifacts are often disposed of in the rubble fill of house platforms and other architecture. Excavations concentrate on these structures, and therefore, many artifact fragments are found. In Central America, by contrast, there is little monumental architecture, and the disposal patterns of broken household tools seems to be much different. The third alternative, ultimately, is that there simply were not as many manos and metates used in Central America as there were in Mesoamerica. This may indicate that agriculture was not as important, or crops and plant foods were being processed differently (for example, maize being used as a "green" vegetable, rather than ground for tortillas).

The ethnohistorical and artifactual evidence for plant use in prehistoric and colonial Nicaragua is limited and difficult to evaluate. Lange (1984a:189) cautions for the Greater Nicoya area:

> Given the lack of artifactual evidence, contact period documentary data for agriculture must be carefully interpreted and, if accepted, utilized with caution as to temporal and geographical extrapolation. A mixed economy with local variation seems to be the best present interpretation.

This is also true of the Lake Managua area. More evidence is needed to make statements about plant use and agriculture in this area. Despite the limited evidence, scholars have speculated on the subsistence patterns of western Nicaragua and neighbouring Greater Nicoya. With more evidence, such as archaeobotanical material, the picture of plant use in prehistoric western Nicaragua can be further refined.

AGRICULTURE AND SUBSISTENCE

If the standard chronology of development for the Intermediate Area is accepted, agriculture would have appeared in western Nicaragua in Period III (4000 B.C. to 1000 B.C.). This is known generally throughout the Intermediate Area as the Incipient Agriculture period, where it is believed that a switch in subsistence strategies throughout Central America from fishing, hunting, and gathering, to agriculture, gave rise to permanent settled communities (Sharer 1984; Willey 1971). However, it is becoming unclear if western Nicaragua, or the nearby Greater Nicoya Subarea for that matter, neatly fit this traditional model of cultural development for Central America.

Recent osteological data from the Arenal region of Costa Rica indicates that this transition from fishing and gathered resources to maize never happened. Based on stable isotope analysis of human bones, maize never exceeded more than 12% of the diet, even in the period prior to Spanish Conquest when the most intensive maize cultivation was thought to have been taking place (Norr 1990; Sheets 1992a). In Arenal, a primary reliance on abundant wild foods continues at least to the Spanish Conquest. Yet isotopic analysis of skeletal material from the site of La Guinea in north-western Costa Rica indicates a 69% dietary dependency on maize (Norr 1991). Isotopic data from coastal Guanacaste in north-west Costa Rica indicate that during the period prior to contact, maize become less important in diet and was replaced by marine resources (Norr 1996). All these sites are from the Greater Nicoya Subarea of north-west Costa Rica, yet even in the same area, there appears to be a wide range of subsistence patterns and the changes of these over time. It is a reminder that generalizations about subsistence patterns are difficult to make in an area as regionally diverse at Central America.

The model of a Central American switch to maize farming in Period III (4000 B.C. - 1000 B.C.) does not appear to hold true for western Nicaragua either. Based on ethnohistorical accounts and artifactual evidence, it is generally accepted by most researchers that agriculture did not become the primary subsistence base of western Nicaragua until Period V (A.D. 300-800, also known as the Early Polychrome Period). But it was likely practised on a small level long before this (Healy 1980; Lange *et al.*

1992). This seems to be true for other regions as well: "the presence of maize in early deposits in Costa Rica and Panama indicates that it was known and utilized" but did not play a major role in the Incipient Agricultural period (Hoopes 1988:146). It is not until Period V that manos and metates make a solid appearance in Greater Nicoya, possibly indicating a more substantial switch in subsistence (Baudez and Coe 1962). On Ometepe Island at this time, the frequency of manos and metates increases (Haberland 1992). But pestles also become more frequent during this period in both the Rivas area (Healy 1980), and on Ometepe Island (Haberland 1992). This suggests an expansion of the subsistence base and an increased use of items such as wild nuts, berries, and gathered palm fruits, rather than a narrowing of the subsistence base to maize and other cultigens.

The role of maize in the subsistence patterns of western Nicaragua is still debated. While it is almost definite that it was used from fairly early times, its importance likely varied according to region and time period. Generally, maize agriculture seems for the most part to be part of a mixed subsistence in western Nicaragua, that included other crops, many gathered plants, lacustrine fish and turtles, and terrestrial fauna (Lange 1984a). Marine resources do not seem to have been a large part of the diet here, especially in the Lake Managua area, sue to the limited access to the coast. Instead, maize and other crops may have been more important here, along with fish from the lake. Archaeobotanical evidence will help in determining just how important agriculture might have been in this area.

Most of the attention on agriculture in western Nicaragua and surrounding areas tends to focus on seed grain agriculture. This is probably because the artifacts associated with it are easily found, and more emphasis was placed on it by the Spanish. It is possible that root cultivation was taking place as well. This type of cultivation may be older than seed grain cultivation, originating in the wet lowland tropics of South America (Sauer 1952; Lathrap 1970), but it does not receive much attention as seed agriculture since the artifact and botanical evidence for it are extremely hard to find, or non-existent. If Lange's (1984a) view of a more mixed economy in western Nicaragua and Greater Nicoya is accepted, root crops such as manioc must be considered, even though the evidence is lacking. Sharer (1984) and Sheets (1984a) even speculate that root and tree crops may have been present in the northern and western parts of Central America prior to the rise of seed crops like maize and beans as staples. This contradicts the traditional dichotomy set up between the Atlantic and Pacific sides of Central America. The vegetational part of the subsistence base of the eastern or Atlantic regions is suggested to have been mainly root and tree crop based, whereas the western or Pacific regions were more focused on maize and seed crops. This is related to spheres of influence; the Atlantic side of Central America traditionally thought to have been more tied to South America and the tropical root and tree crop subsistence pattern, and the Pacific side more under the influence of Mesoamerica, dominated by maize. It is apparent that this dichotomy is too general and does not take into consideration regional variation.

With more recent research, the subsistence picture in Central America has grown much more complex. Willey, who once supported the idea of different spheres of influence (1971), now suggests that maize and manioc, and the crop systems they represent, were adapted to local settings, at various times and places, and that their archaeological history is complex and defies easy generalization (1984). According to Lange (1996b:317), "the dietary strategies of prehistoric Central American populations were more complex and much less monolithic" than assumed. Lange (1996b) calls for further research into the development of prehistoric subsistence patterns and related social patterns. Paleoethnobotanical studies can provide clues to this complexity of subsistence patterns and resource exploitation.

PREVIOUS PALEOETHNOBOTANICAL STUDIES IN LOWER CENTRAL AMERICA

The interaction of prehistoric people and plants in Lower Central America has largely been inferred from artifacts and ethnohistorical accounts (Willey 1984). In Mesoamerica, direct archaeobotanical evidence of plant use by people such as the Maya and prehistoric Mexicans has been recovered. But this direct archaeobotanical evidence is relatively scarce in Central America from the southern border of Mesoamerica to South America. This is mostly a symptom of the limited amount of archaeological work that has been done here overall.

The few paleoethnobotanical studies which have been done in Lower Central America have yielded interesting results. They show that broad generalizations concerning plant use in the Intermediate Area as a whole are difficult to make. Different regions followed different subsistence patterns, and there does not appear to be a widespread pattern such as the maize-beans-squash triad of Mesoamerica. According to Lange *et al.* (1992), differential access to lacustrine environments, variable soil quality and hydrological potential suggest a potential for complex and regionally multivariate subsistence systems in western Nicaragua. This statement could also refer to the Intermediate Area as a whole. Despite variation in environments and plant use, some generalizations can be made, according to Smith (1988). Palm remains have been found from every Intermediate area site from which macrobotanical remains have been recovered. Smith (1988:170) states:

> Altogether, the evidence from macroremains of plants in the Intermediate Area is that the cultivation of annual crops, maize, and beans was superimposed on an old dietary pattern which relied heavily on palms and broad-leaved fruit trees including nance, ciruela or hogplum, and fruit from members of the Sapotaceae.

This statement is based on archaeobotanical data, and is more valid for the western part of the Intermediate Area, since virtually no archaeobotanical studies have been done on the eastern coastal plain. The following sections review the previous paleoethnobotanical studies which have been done in Central America. This information is summarized in Table 3.1 at the end of the chapter. Figure 3.3 shows the location of the sites mentioned.

El Salvador

Some studies have been done in El Salvador, but most of these are in the western part of the country which is generally considered part of the Mesoamerican culture area, rather than the Intermediate Area. At the southern Maya site of Cerén, casts have been made of the cavities left by entire maize and agave plants when they were rapidly covered in volcanic ash (Sheets 1992b). Botanical remains found in ceramic vessels include a variety of domesticates and wild plants showing a diverse subsistence base (Lentz *et al.*

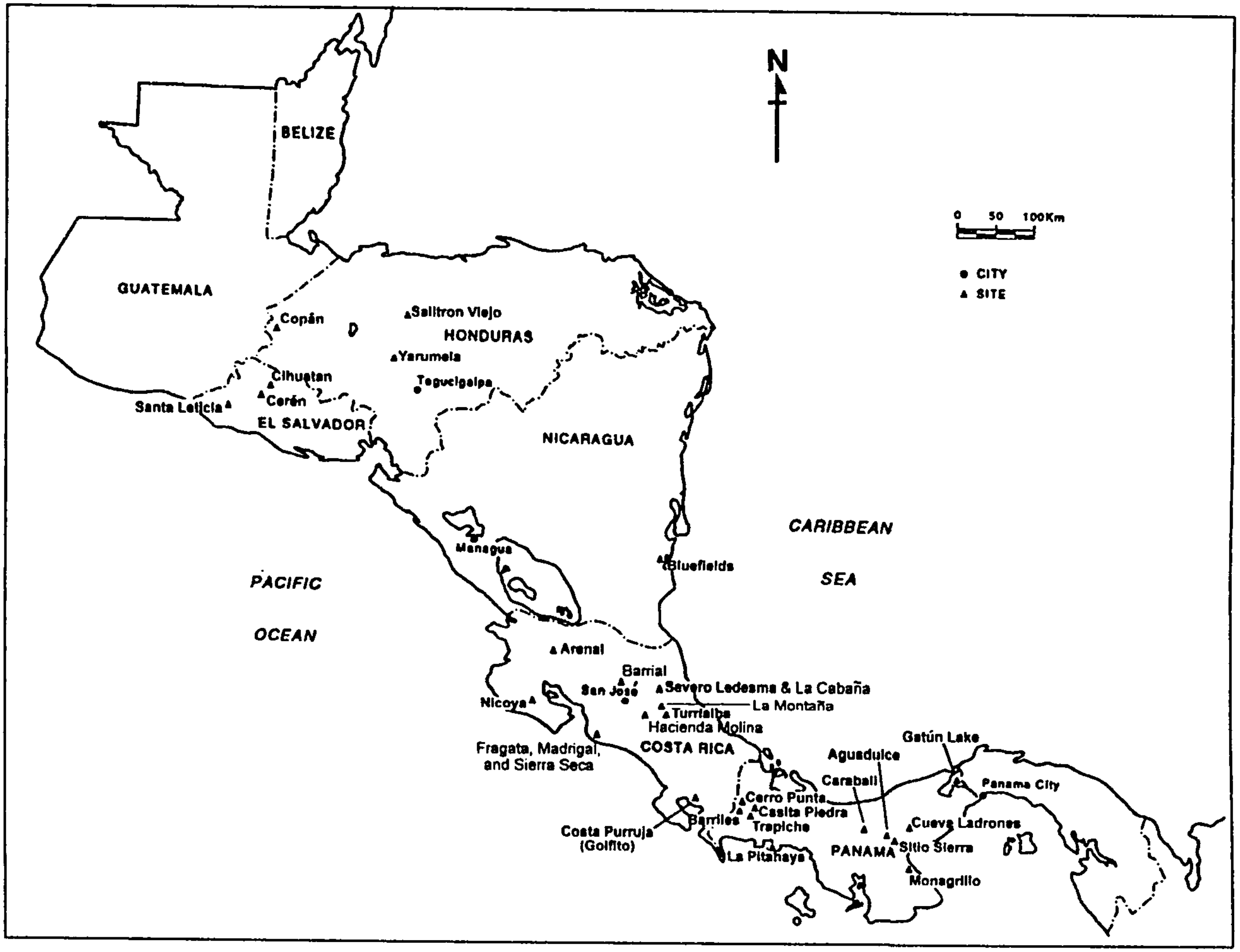


Figure 3.3: Map of Central America showing the locations of sites where previous archaeobotanical remains have been found.

1996). Remains include maize, beans, squash, cotton, manioc, avocado, nance, chili peppers, coyol palm fruits and cacao. The highland site of Santa Leticia near Chalchuapa (located even farther north-west than Cerén into the Maya area) had bell-shaped pits in which Demarest (1980, cited in Sheets 1984a) found remains of maize, sunflower seeds, and the tree fruit *ciruela* or hogplum (also sometimes called *jocote*). Miksicek (1979, cited in Fowler 1989) reports of indigo seeds found at Cihuatán. There do not appear to be any reports of botanical remains from sites in eastern El Salvador.

Honduras

The Maya site of Copán and the surrounding valley have received considerable paleoethnobotanical attention (Lentz 1991). East of this valley is considered the frontier between Mesoamerica and the Intermediate area. In this eastern part of Honduras, the only paleoethnobotanical information I am aware of comes from Yarumela in the Comayagua valley, and the site of Salitron Viejo. Maize, *Cucurbita* sp. rind, and many types of wood charcoal, from both pine and hardwood trees, were found at Yarumela, dating from between 1000 B.C. to A.D. 250 (Lentz *et al.* 1997). At Salitron Viejo, maize, beans, mamey, nance, hogplum, negrito, and coyol were found (Lentz 1984, cited in Smith 1988:166; Lentz 1989).

Nicaragua

No paleoethnobotanical studies have been conducted in western Nicaragua previous to the current study. Magnus (1978) used flotation at several coastal sites he excavated in Atlantic Nicaragua near Bluefields, but no macrobotanical remains were recovered, possibly due to poor preservation. Artifacts such as metates at the sites indicate plant foods were being used. Magnus (1978) suggests that a possible future avenue of archaeobotanical recovery may be pollen. To date, subsistence patterns and plant use in western Nicaragua have been inferred from artifacts or ethnohistorical accounts, as discussed above.

Costa Rica

Costa Rica has received more archaeological attention than Nicaragua, and many archaeobotanical remains have been found there. In north-western Costa Rica, part of the Greater Nicoya subarea, Vázquez (1986) reports carbonized palm nuts found along with evidence of marine resource exploitation during the Bagaces period (A.D. 300 - 800) from the coastal site of Nacascolo. Stone (1977:90,95 note 2) describes a Mesoamerican type of maize found as an offering in an Ometepe Period (A.D. 1350-1520) burial at a inland cemetery near the modern city of Nicoya. She identifies the maize as Oloton-Tepecintle, a variety derived from Mesoamerica.

A comprehensive paleoethnobotanical study was carried out for sites in the Arenal region of Costa Rica. Matthews (1984) and Mahaney *et al.* (1994) looked at macrobotanical remains recovered both *in situ*, and by flotation, while Clary (1994) examined pollen remains, and Piperno (1994) conducted phytolith analysis for the project. The presence of maize was indicated by all three types of archaeobotanical evidence. Maize kernels, cupules and cob fragments were recovered, dating from as early as the Tronadora Phase (1000 -500 B.C.) right up to the Tilarán Phase (A.D. 1000-1500). The early presence of maize was also corroborated by phytolith and pollen evidence (Piperno 1994; Clary 1994). Macrobotanical remains of maize appeared in every occupation phase, and it was the most common non-wood macrobotanical remain, suggesting it was a major dietary staple (Mahaney *et al.* 1994). However, stable isotope data from the area indicate that maize only made up about 12% of the diet (Sheets 1984b). Mahaney *et al.* (1994) suggest that a large part of the diet may have been made up of root crops, which unfortunately hardly ever show up in the archaeobotanical record; they rarely are preserved as macrobotanical remains, and do not produce identifiable phytoliths (Piperno 1994).

Other macrobotanical remains recovered were bean cotyledons, avocado seed fragments, remains of pejibaye palm, jícaro, nance, *Croton* sp., and a pericarp fragment from an unidentified genus of squash. *Elaeis oleifera* or *Scheelia rostrata* palm fragments were also tentatively identified. Pollen evidence for bean and avocado supports the macrobotanical record, which is unusual since these types of pollen are normally rare. Overall, pollen was not well preserved at the Arenal sites (Clary 1994). Palms such as *Scheelia, Oenocarpus*, and *Elaeis* were represented in the phytolith record, but the absence of pejibaye (peach palm) is significant, since it was found in the macrobotanical record and is known to be an excellent phytolith producer.

Other phytoliths found showed interesting trends. The earliest phase contained phytoliths from mature tropical forest and had the highest frequency of palms from any of the time periods. Piperno interprets this to mean that forested environments were common in the Tronadora Phase, but were cleared over successive occupations of the area. Strengthening this interpretation is an increase over time in the frequency of weed and grass phytoliths. Arboreal fruit phytoliths are more frequent in earlier periods, and their decline in later phases may indicate a shift away from arboreal resources, possibly to more field and garden crops. Pollen indicates some vegetational disturbance over time, but the pollen was poorly preserved at the sites, so generalizations are hard to make.

In summary, the paleoethnobotanical evidence from the Arenal region indicates that maize agriculture was practised from approximately 1000 B.C. onwards, as part of a diverse diet of tree crops and possibly root crops, along with wild resources. Mahaney *et al.* (1994) believe that the evidence shows a general trend over time towards more cultivated species and a growing reliance on agriculture. This is supported by phytolith and pollen evidence which show an accelerated tropical forest clearance after 500 B.C. in the Arenal region.

On the Atlantic side of Costa Rica, archaeobotanical remains were found at the Severo Ledesma site in the Atlantic highlands (Snarskis 1976, 1984). Almost 100 fragments of carbonized palm nuts (inner kernels), were recovered and these were identified as *Elaeis oleifera.* Ethnographically, this species is used for its oil. A carbonized maize cob was also found, which Snarskis (1976) identified to the South American variety Pollo. The maize was found in an El Bosque midden (300 B.C. to A.D. 500). Dunn (1978) disagreed with Snarskis' interpretation that the single cob could be interpreted as evidence of South American influence in Costa Rica, based on the limited remains (one cob), and the problematic nature of maize race identifications and origins.

The only other carbonized botanical material from the site has been identified as grass stems and dicotyledonous charcoal (Snarskis 1984:212). Nearby, botanical remains from the pre-Contact period include maize at the site of Hacienda Molino, and a fragment from a gourd container (possibly *Cucurbita pepo*) from La Cabaña (Snarskis 1984:230).

Also in the Atlantic lowlands of Costa Rica, Snarskis (1984:221) reports of another maize cob, also identified to a South American variety, found at the Turrialba cemetery site. At the site of La Montaña just north of Turrialba, an avocado seed fragment was found, along with other unidentified seeds and charcoal dating to around 500 B.C. (Snarskis 1984:204).

At the site of Barrial de Heredia north of San José in the Central Highlands, bottle-shaped pits were uncovered which had a 10 to 20 cm layer of carbonized plant remains on the floor. The botanical analyses are apparently still underway, but Snarskis (1984:214-215) reports that preliminary observations indicated the features contained thousands of maize kernels, five cob fragments, pieces of unidentified nuts or hard-shelled fruits, unidentified rhizomes, desiccated, cherry-like pitted fruits, two varieties of *Phaseolus vulgaris*, and seeds from Convolvulaceae, possible *Ipomoea* sp. (based on personal communications to Snarskis from R. McK. Bird, L. Kaplan, and D.F. Austin). The majority of the maize kernels were found in fist-sized lumps with the cherry-like fruit and the *Ipomoea* seeds. These features are dated to the Pavas phase (300 B.C. to A.D. 500), and are believed to be storage pits, similar to those found in Mesoamerica (*chultuns*) (Snarskis 1984).

New research in Pacific Central Costa Rica has yielded carbonized remains of an early variety of pejibaye at the site of Sierra Seca and other sites in the Jacó plains (Corrales and Mora Urpí 1990). Coyol palm was found in the Fragata and Madrigal sites, in the Jacó Valley (Corrales and Quintanilla 1996). Corrales and Quintanilla (1996) believe that the area saw a mixed subsistence economy between 300 B.C. and A.D. 300, with both agriculture and gathered resources.

Archaeobotanical remains were also recovered from the marine midden site of Costa Purruja, near Golfito (Hoopes 1994). Most of the macrobotanical remains found were wood charcoal; disappointingly little evidence was present on the use of cultigens or wild plant foods, despite adequate preservation and careful hand-picking, fine screening and flotation techniques. Only three samples yielded carbonized palm fruits of *Bactris* sp. or *Elaeis* sp. (*corozo*). Hoopes suggests that the midden from which the samples came from may not be representative, or that food preparation did not permit carbonization. Phytolith preservation was excellent, but did not yield any cultigens either. Palm phytoliths were found however, concentrated mostly in the upper levels, indicating that they were important only in later periods. Phytoliths also seem to indicate a shaded, forest environment during the deposition of the midden.

Panama

Outside of the Maya area, Panama has probably seen the most comprehensive paleoethnobotanical research in all of Central America. Many sites have been sampled for macrobotanical remains, as well as phytoliths and pollen. These include: Cerro Punta

(Sitio Piti), Barriles, the Casita de Piedra and Trapiche rockshelters, and La Pitahaya, all in the Chiriqui area; Carabali, Monagrillo, Sitio Sierra, Cueva de los Ladrones, and the Aguadulce Rockshelter from the Santa María drainage in central Panama; and the Gatun basin.

One of the earliest paleobotanical studies done in Panama was a pollen analysis from the Gatun basin to the north-west (Bartlett *et al.* 1969). Pollen data from here shows a noticeable increase over time in the frequencies of *Gramineae* and *Compositae* pollen, as well as charcoal fragments, from 1150 B.C. to A.D. 150. *Zea mays* and *Manihot esculenta* pollen have been found in the same context (Bartlett *et al.* 1969; Bartlett and Barghoorn 1973), indicating both crops were grown at the same time nearby, and formed a part of a varied subsistence pattern.

Many sites in the Chiriqui region have yielded archaeobotanical remains on which Smith (1980) reports. Preceramic macrobotanical remains at the Chiriqui Rockshelters of Casita de Piedra and Trapiche indicate that tree fruits were important from earliest periods onwards. Carbonized macrofossils of palm nuts (*Scheelia* and *Acrocomia* sp.), tree legumes (*Hymenea courbaril*) and nance (*Byrsonima* sp.) were found at these sites, dating to around 300 B.C. (Smith 1980, 1988). Maize cobs from house-floor and hearth contexts were found at Cerro Punta (Linares *et al.* 1975). Galinat (1980) identifies them as belonging to a race intermediate between Nal-tel and Pollo varieties and believes that the Panamanian maize was derived from South America. Beans (*Phaseolus vulgaris*) were also found at this site, along with corozo palm fragments, avocado, *algarrobo*, chili peppers, and even a tuber (possibly *Ipomoea batatas*) (Linares *et al.* 1975). The majority of botanical remains from La Pitahaya were palm fruit shells, possibly cultivated. Maize was also recovered at the site. The site of Barriles did not have any actual plant remains, but unusual casts of palm fruits.

Macrobotanical and microbotanical remains were both recovered at Sitio Sierra in western Panama. Maize cobs, kernels and stalk fragments were recovered in large quantities, trampled into house floors, in pit fill, and around hearths. Some carbonized maize remains were also found associated with a male burial, and appear to have been an intentional offering (Cooke 1984). These maize remains date as early as 300 B.C., along with fragments of beans and palm fruits (Ranere and Hansell 1978; Smith 1988). Phytolithic evidence from the site also demonstrates the presence of maize, along with Palmae (Piperno and Clary 1984). The palm phytoliths were found only in one location, concentrated on the floor of a house; they are interpreted by Piperno and Clary (1984:100) to be the result of a collapsed thatched roof.

The Carabali rockshelter has macroremains of palm nut, maize, and beans (Smith 1988:166). The site of Monagrillo yielded considerable amounts of wood charcoal, but little else in the way of plant remains, other than a few palm nuts fragments (species not identified)(Ranere and Hansell 1978:49). Other rockshelters on the Pacific drainage have yielded palm fragments, panamá (*Sterculia* sp.), and possibly seed coat fragments from sapotaceous species (Smith 1988). Unfortunately, Smith does not name these sites.

The Aguadulce Rockshelter and Cueva de los Ladrones are located in the same watershed as Sitio Sierra in western Panama, and contain deposits dating from the preceramic and early ceramic (5000 B.C. to 1500 B.C.). Piperno and Clary (1984) found phytolithic evidence that maize was being consumed at these rockshelters from very early times, as far back as the pre-ceramic (3000 B.C. to 1000 B.C.). Palmae, Gramineae, Marantaceae, Moraceae, Compositae, *Heliconia, Piper, Ficus, Curatella americana, and* Heliotropium were also identified for the sites from phytoliths. The pollen record showed the presence of cashew, Cucurbitaceae, Gramineae, manioc, and *Bauhinia emarginata*, a leguminous tree, from the Ladrones site, as well as Malvaceae, Convolvulaceae, and Bombacaceae at the Aguadulce shelter. In terms of macrobotanical remains, only wood charcoal was recovered from Cueva de los Ladrones (Bird and Cooke 1974, cited in Ranere and Hansell 1978:53). The shelters in which maize was found were not close to the coast, whereas other sites from roughly the same time period near the coast did not have maize and were more focused on aquatic resources. Maize is not present at these early sites despite good preservation of botanical remains (Ranere and Hansell 1978). Smith (1988) believes these shelters were temporary resting places for people who did not carry cultivated food or did not stay long enough to cultivate crops.

SUMMARY

Western Nicaragua was densely populated in prehistoric times. This was likely due to the high agricultural potential of the area, and abundant wild terrestrial and lacustrine resources. Ethnohistorical information indicates that the indigenous population of the area at the time of contact used a wide variety of the resources of the area; hunting, fishing, gathering food, cultivating fruit trees, and practising agriculture. Artifactual evidence indicates the processing of both wild and cultivated plants. Based on these lines of evidence, agriculture has been seen as an integral part of the subsistence patterns of the prehistoric populations of the Lake Managua Basin and surrounding regions. Some paleoethnobotanical studies have been done in other parts of Central America, and these were described briefly in order to place the current study in context.

Table 3.1: Systematic list of archaeobotanical remains found at sites in Lower Central America, mentioned in the text.

Taxon	Common Name	Sites	Type of Remain	Reference
Agavaceae				
Agave sp.	agave	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
Anacardiaceae				
Anacardium occidentale	cashew	Cueva de los Ladrones, Panama	pollen	Piperno and Clary 1984
Spondias sp.	hogplum, ciruela	Santa Leticia, El Salvador	macroremains	Demarest 1980
		Salitron Viejo, Honduras	macroremains	Lentz 1989
Arecaceae (Palmae)				
Acrocomia sp.	coyol palm	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
		Salitron Viejo, Honduras	macroremains	Lentz 1989
		Fragata and Madrigal, Costa Rica	macroremains	Corrales and Quintanilla 1996
		Costa Purruja, Costa Rica	phytoliths?[a]	Hoopes 1994
		Chiriqui Rockshelter, Panama	macroremains	Smith 1980
Bactris gasipaes (*Guilielma gasipaes*)	pejibaye, peach palm	Arenal, Costa Rica	macroremains	Mahaney *et al.* 1994
		Sierra Seca, Costa Rica	macroremains	Corrales and Mora Urpí 1990
		Costa Purruja, Costa Rica	macroremains?, phytoliths	Hoopes 1994
Elaeis oleifera	corozo, oil palm	Severo Ledesma, Costa Rica	macroremains	Snarskis 1984
		Arenal, Costa Rica	macroremains?, phytoliths	Mahaney *et al.* 1994, Piperno 1994
		Costa Purruja, Costa Rica	macroremains?	Hoopes 1994
		Cerro Punta, Panama	macroremains	Linares *et al.* 1975
Oenocarpus sp.		Arenal, Costa Rica	phytoliths	Piperno 1994
Scheelia sp.		Chiriqui Rockshelters, Panama	macroremains	Smith 1980

Table 3.1: Continued...

Taxon	Common Name	Sites	Type of Remain	Reference
Scheelia rostrata		Arenal, Costa Rica	macroremains?, phytoliths	Mahaney *et al.* 1994, Piperno 1994
		Costa Purruja, Costa Rica	phytoliths?	Hoopes 1994
unidentified	palm	Sitio Sierra, Carabali, Monagrillo, other sites in Panama	macroremains	Smith 1988, Ranere and Hansell 1978
		Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno and Clary 1984
		La Pitahaya, Panama	macroremains	Smith 1980
Asteraceae (Compositae)				
Helianthus annuus	sunflower	Santa Leticia, El Salvador	macroremains	Demarest 1980
unidentified		Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno and Clary 1984
Bignoniaceae				
Crescentia alata	jícaro, calabash	Arenal, Costa Rica	macroremains	Mahaney *et al.* 1994
Heliotropium sp.		Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno and Clary 1984
Bombacaceae				
unidentified		Aguadulce Rockshelter, Panama	pollen	Piperno and Clary 1984
Caesalpiniaceae				
Bauhinia emarginata		Cueva de los Ladrones, Panama	pollen	Piperno and Clary 1984
Convolvulaceae				
Ipomoea sp.		Barrial, Costa Rica	macroremains	Snarskis 1984
unidentified		Aguadulce Rockshelter, Panama	pollen	Piperno and Clary 1984
		Cerro Punta, Panama	macroremains?	Smith 1980

Table 3.1: Continued...

Taxon	Common Name	Sites	Type of Remain	Reference
Cucurbitaceae				
Cucurbita sp.	squash	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
		Arenal, Costa Rica	macroremains	Mahaney *et al.* 1994
		La Cabaña, Costa Rica	macroremains	Snarskis 1984
unidentified		Cueva de los Ladrones, Panama	pollen	Piperno & Clary 1984
Euphorbiaceae				
Manihot esculenta	manioc	Cerén, El Salvador	macroremains	Lentz *et al.*. 1996
		Gatun, Panama	pollen	Bartlett *et al.* 1969
		Cueva de los Ladrones, Panama	pollen	Piperno & Clary 1984
Croton sp.	croton	Arenal, Costa Rica	macroremains	Mahaney *et al.* 1994
Fabaceae				
Hymenea courbaril	guapinol	Chiriqui Rockshelters, Panama	macroremains	Smith 1980
Indigofera suffructicosa	indigo	Cihuatán, El Salvador	macroremains	Miksicek 1979
Phaseolus vuglaris	beans	Cerén, El. Salvador	macroremains	Lentz *et al.* 1996
		Salitron Viejo, Honduras	macroremains	Lentz 1989
		Arenal, Costa Rica	macroremains, pollen	Mahaney *et al.* 1994, Clary 1994
		Barrial, Costa Rica	macroremains	Snarskis 1984
		Sitio Sierra, Panama	macroremains	Ranere & Hansell 1978
		Carabali, Panama	macroremains	Smith 1988
		Cerro Punta, Panama	macroremains	Smith 1980
Lauraceae				
Persea americana	avocado	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
		La Montaña, Costa Rica	macroremains	Snarskis 1984
		Arenal, Costa Rica	macroremains, pollen	Mahaney *et al.* 1994, Clary 1994
		Cerro Punta, Panama	macroremains	Linares *et al.* 1975

Table 3.1: Continued...

Taxon	Common Name	Sites	Type of Remain	Reference
Malpighiaceae				
Byrsonima crassifolia	nance	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
		Salitron Viejo, Honduras	macroremains	Lentz 1989
		Arenal, Costa Rica	macroremains	Mahaney *et al.* 1994
		Chiriqui Rockshelters, Panama	macroremains	Smith 1980
Malvaceae				
Gossypium hirsutum	cotton	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
unidentified		Aguadulce Rockshelter, Panama	pollen	Piperno & Clary 1984
Marantaceae				
unidentified		Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno & Clary 1984
Moraceae				
Ficus sp.	fig	Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno & Clary 1984
unidentified		Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno & Clary 1984
Musaceae				
Heliconia sp.		Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno & Clary 1984
Piperaceae				
Piper sp.	cordoncillo	Aguadulce and Cueva de los Ladrones, Panama	phytoliths	Piperno & Clary 1984
Poaceae (Gramineae)				
Zea mays	maize	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
		Santa Leticia, El. Salvador	macroremains	Demarest 1980
		Salitron Viejo, Honduras	macroremains	Lentz 1989
		Turrialba, Costa Rica	macroremains	Snarskis 1984

Table 3.1: Continued

Taxon	Common Name	Sites	Type of Remain	Reference
Zea mays (cont.)	maize	Severo Ledesma, Costa Rica	macroremains	Snarskis 1976
		Nicoya, Costa Rica	macroremains	Stone 1977
		Arenal, Costa Rica	macroremains, pollen, phytoliths	Matthews 1984 and Mahaney *et al.* 1994, Clary 1994, Piperno 1994
		Barrial, Costa Rica	macroremains	Snarskis 1984
		Hacienda Molina, Costa Rica	macroremains	Snarskis 1984
		Gatun, Panama	pollen	Bartlett *et al.* 1969
		Sitio Sierra, Panama	macroremains, phytoliths	Cooke 1984a, Piperno and Clary 1984
		Carabali, Panama	macroremains	Smith 1988
		Aguadulce and Cueva de los Ladrones, Panama	phytoliths, pollen	Piperno and Clary 1984
		Cerro Punta, Panama	macroremains	Smith 1980
		La Pitahaya, Panama	macroremains	Smith 1980
Sapotaceae				
Pouteria mammosa	mamey, zapote	Salitron Viejo, Honduras	macroremains	Lentz 1989
unidentified		sites in Pacific Panama	macroremains?	Smith 1988
Simarubaceae				
Simarouba glauca	negrito, aceituno	Salitron Viejo, Honduras	macroremains	Lentz 1989
Solanaceae				
Capsicum sp.	chili pepper	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
		Cerro Punta, Panama	macroremains	Linares *et al.* 1975
Sterculiaceae				
Theobroma cacao	cacao	Cerén, El Salvador	macroremains	Lentz *et al.* 1996
Sterculia sp.	panamá	sites in Pacific Panama	macroremains	Smith 1988

[a] A question mark ("?") indicates a possible identification.

CHAPTER 4
SITE DESCRIPTIONS AND ARCHAEOLOGICAL CONTEXT

Archaeobotanical samples were taken from three sites in the Lake Managua region (Fig. 1.1). The following chapter is a brief discussion of each site and the archaeological context from which the samples came.

N-MA-36

N-MA-36 is a large site within the city limits of metropolitan Managua (Fig. 4.1). Excavations at the site were carried out by the Proyecto Arqueología de la Zona Metropolitana de Managua from 1995 to 1997 under the direction of Dr. Frederick Lange. Prior to 1997, N-MA-36 was considered two separate sites, Villa Tiscapa (N-MA-36) and Universidad Nacional de Ingeniería or UNI (N-MA-62). The Villa Tiscapa site was situated on military land used for housing, and the UNI site was located on the sports field of the Universidad de Ingeniería. These two sites were separated by an undeveloped tract of land owned by the Universidad de Centroamerica (UCA). In 1997, excavations were carried out on this tract of land for two main reasons: 1) to ascertain if Villa Tiscapa and UNI were part of the same site, and 2) to evaluate the archaeological impact of the proposed development of the tract of land by UCA into a sports field. It was decided at the end of the 1997 field season that Villa Tiscapa, UCA, and UNI were all parts of a single site (Rinfret *et al.* 1997). This site was designated N-MA-36. (The site number N-MA-62 was retired.) With future archaeological work, the boundaries of N-MA-36 may be further expanded.

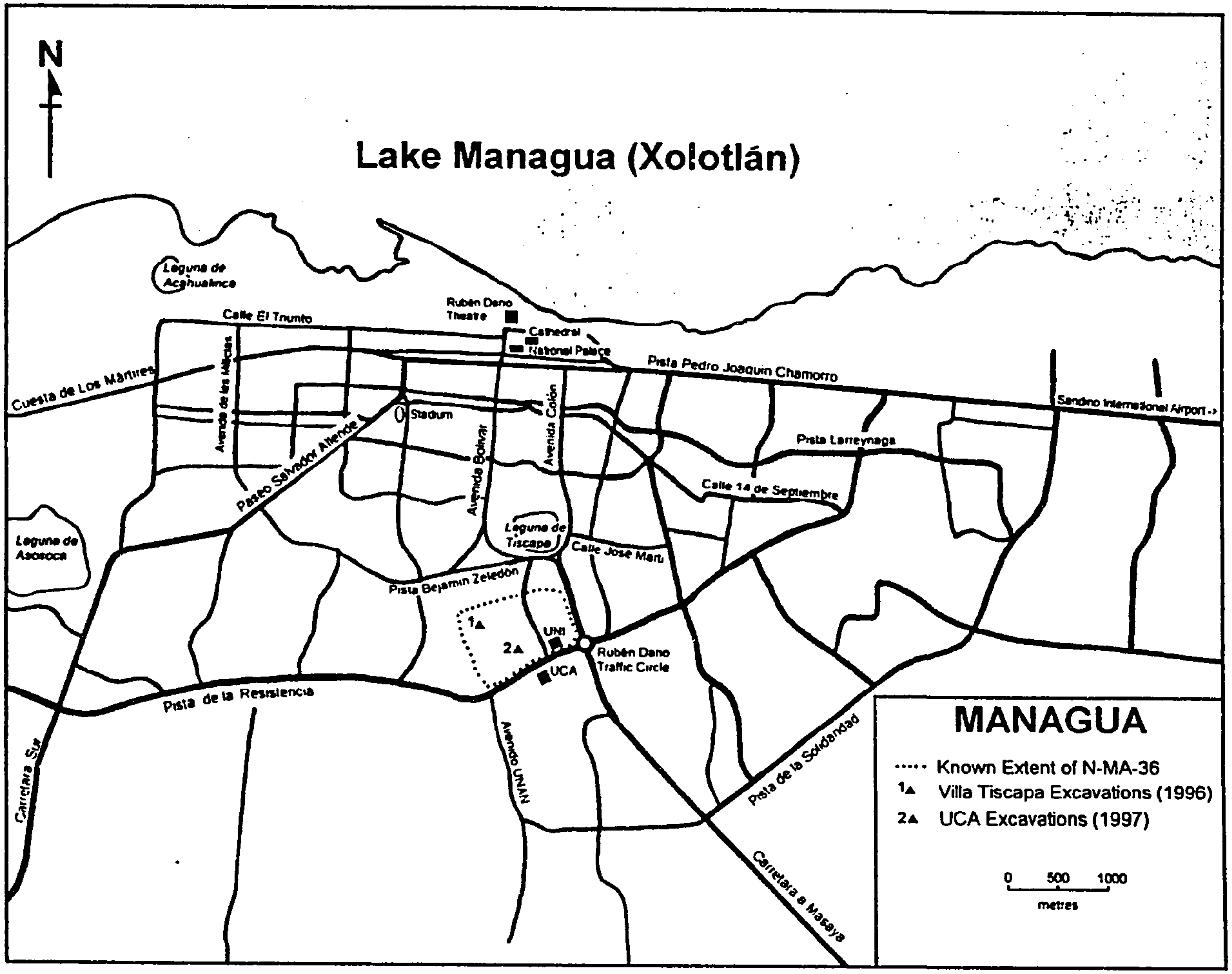


Figure 4.1: Map of Managua showing the known extent of N-MA-36, and the location of the Villa Tiscapa and UCA excavations.

The flotation samples from N-MA-36 came from two separate excavations; the Villa Tiscapa excavations from 1996, and the UCA excavations from 1997. Although technically from the same site, these flotation samples were analyzed separately because they were from different excavations.

Villa Tiscapa Excavations

In 1995, a surface survey of the Villa Tiscapa area turned up ceramics from as early as 600 B.C., falling within the Orosí Period (1000 B.C. - 500 B.C.)(Pullen 1995)(Table 4.1). This prompted the excavation of a four by four metre test unit. This test unit yielded even earlier ceramics, previously unseen before in the Managua area (Espinoza 1995). These ceramics were similar to Tronadora type pottery from Guanacaste, Costa Rica, which dates as far back as 1500 B.C. (Hoopes 1994). Because of this early phase is represented at the site, further excavations were recommended (Pullen 1995).

A six by six metre horizontal excavation was opened up the next year (Brown *et al.* 1996). During excavation, several architectural features were encountered, including rock clusters, rocks in alignment, hearths, a plaster floor and a post hole. The evidence of domestic architecture at Villa Tiscapa was the first of its kind in the region: despite estimates of a large prehistoric population in the region, little indication of architecture had previously been found (Lange 1996a). Brown *et al.* (1996) interpret the site to have three components. The first component at 40 cm B.S. (below surface) is stratigraphically the most recent. The majority of ceramics are from the Tempisque Period (500 B.C. -

Table 4.1: Comparison of general and regional chronologies (adapted from Salgado 1996)

Date	*Lower Central America*	*Greater Nicoya*	*Managua*	*León*
1500	Period VI Late Terminal Period	Late Polychrome	Ometepe	El Diamente
1400				
1300		Middle Polychrome	Sapoá	
1200				
1100				Pulpería La Cruz B
1000				
900	Period V Regional Development Period			Pulpería La Cruz A
800			Bagaces	
700		Early Polychrome		Santa Rosa
600				
500				El Cortezal B
400	Period IV Formative Period	Zoned Bichrome		
300				
200			Tempisque	El Cortezal A
100				
0				
100				
200				
300				
400				
500				
600			Orosí	
700				
800				
900				
1000				
1100	Period III Early Incipient Agriculture		Tronadora	
1200				
1300				
Source	Lange and Stone 1984	Coe and Baudez 1961	Vázquez *et al.* 1994	Wykoff 1976 (cited in Salgado 1996)

A.D. 300) with some from the Bagaces Period (A.D. 300 - 800). This component included rock clusters and a fire pit. The flotation sample analyzed for this study was collected from this fire pit, along with a carbon sample (Beta-95901) which yielded a calibrated date of A.D. 70 ± 40 (Lange, personal communication). This places the date of the hearth and the archaeobotanical remains found within it to the Tempisque Period and fits with the ceramic data. The rocks clusters found at this level may have been used as foundations for a wattle and daub structure.

Two more components occurred below the first. The second component, marked by a plaster floor and a post hole, was found 20 cm below the first (60 cm B.S.), but was also from within the Tempisque Period based on ceramics. Some earlier Orosí material was found, but was likely disturbed from below by excavations of garbage pits, hearths, and other features (Brown *et al.* 1996). The third component was found at 80 cm B.S. and remains undated. This component was marked by a hearth and a layer of rocks, some of which were aligned and are interpreted as a possible foundation or collapsed wall. Regrettably, no other flotation samples were taken from these components. The sample taken from the fire pit of the first component was floated one year later in 1997.

UCA Excavations

As mentioned, excavations at the UCA sports field were initiated in 1997 for two reasons. Firstly, this field separated the Villa Tiscapa site (N-MA-36) and the UNI site (N-MA-62). Previous excavations at these sites had indicated similar cultural patterning and remains, particularly in the later prehistoric periods of the area (Sapoá, A.D. 800 - 1350, and Ometepe, A.D. 1350-1530)(Pullen 1995, Pichardo and Zambrana 1995, Brown *et al.* 1996, Bargnesi *et al.* 1996). Investigations in the UCA field helped determine if the UNI site was, in fact, a continuation of later period Villa Tiscapa. Secondly, the

Universidad de Centroamerica (UCA) planned to develop the field into a sports field and complex. Excavations became part of a CRM project for the area, and recommendations were made to UCA assessing the impact of the proposed development on the cultural heritage of the area.

At the time of excavation, the field itself was a vacant lot, owned by UCA and slated to become a sports field complex. A small herd of cattle sometimes grazed on the field during the excavation season. At the south end of the field, there were no trees or shrubs, the vegetation was low herbaceous cover, dominated by grass and weeds adapted to colonizing disturbed habitats (Plate 1). In the northern part of the field, the vegetation field consisted of more shrub-like species than the southern part of the field. A couple of large trees had been left standing, one of which was identified as a floss-silk tree (*Chorisia* sp.). The difference between the two parts of the field was a result of maintenance (regular clearing of vegetation by machete) in southern part of the field for a playing field. A set of goal posts were in this southern section of the field. Based on experience elsewhere in Central America, plants are extremely quick to colonize and grow in an open field, and the shrubby growth in the north end of the field likely represented only one or two years of growth. Despite efforts to take samples as uncontaminated as possible, some modern seeds from the surrounding vegetation managed to find their way into the flotation samples.

A surface survey of the field yielded substantial scatters of ceramic and lithic material from the Tempisque Period onwards until just before Spanish contact (Rinfret *et al.* 1997). Nine 2x2 m test units were put in, 20 m apart (Fig. 4.2). While these test units

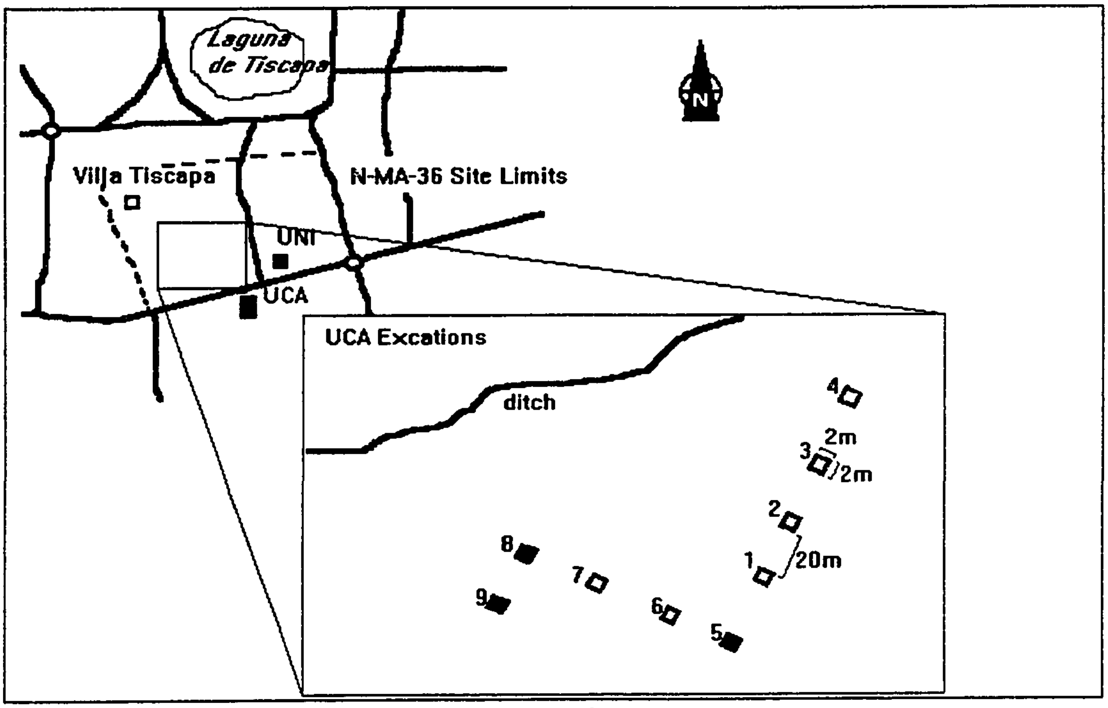


Figure 4.2: Plan view of UCA units (not to scale).

were not exceptionally rich in cultural material, most yielded ceramic sherds, lithic debitage, and faunal material that supported the merging of Villa Tiscapa, UNI, and the intervening UCA field into one site, which was designated N-MA-36.

From the flotation samples taken during the UCA excavations, regular bulk and feature flotation samples were processed from Units 5, 8, and 9, and one flotation sample from around a rock cluster in Unit 7 was also processed. Some carbonized remains were found *in situ* from Unit 1, but regular flotation samples were not taken from this unit.

During excavation, no carbon samples were taken for dating due to a lack of any carbon concentrations. Relative dating was based on ceramics. The presence of Orosí ceramics in some of the units indicated that this area had been occupied as early as 600 B.C. Ceramics were found corresponding to all time periods of the Greater Nicoya regional chronology (Table 4.1). Unfortunately the provenience of the ceramics at UCA do not show strong temporal patterning. The earliest ceramics (Orosí) are not found in the deepest levels. Analysis of classified ceramics and corresponding levels seem to indicate substantial mixing or disturbance. For example, in Unit 1, the deepest identified ceramic sherd from level 19 falls into the Sapoá period, whereas Orosí period ceramics are found only as deep as level 8. In Units 8 and 9, Orosí ceramics are encountered in the first 40 cm, whereas below one metre, only ceramics from the Tempisque, Bagaces, and Sapoá periods appear.

This problem may be due to several factors. Very few of the total number of ceramics recovered were classifiable (only 15.8%). It is difficult to confidently date a level on the basis of only three or four identifiable ceramic sherds. In addition, human error in identification of the ceramic types is always possible. And, as mentioned, substantial mixing of the stratigraphy may have also occurred in the past. This idea is strengthened by the discovery of modern glass at a depth of 102 cm B.S. in Unit 7. This modern deposit likely occurred with the nearby placement of a drainage pipe (Rinfret *et al.* 1997).

This stratigraphic mixing makes the dating of the site problematic. The presence of Orosí ceramics indicates that the site was occupied at least 2500 years ago. However, the sporadic occurrence of Orosí ceramics prevents assigning a solid date to any particular level. The majority of identified ceramics come from the Bagaces (A.D. 300 - 800) and Sapoá (A.D. 800 - 1350) periods, and it is hypothesized that this was the time of most intense occupation (Rinfret *et al.* 1997). Bulk flotation samples were taken from every level in the hopes of seeing changes over time in prehistoric plant use. However, this is not valid due to the mixed up nature of the site stratigraphy.

A large drainage ditch running northeast/southwest through the northern part of the field appeared to have been recently dug. As evidenced by the disturbance in Unit 7, there are likely other buried drainage pipes throughout the field. This may help to explain some of the incongruities in stratigraphy. Material excavated from deeper contexts would have been dumped on the ground surface, and then possibly smoothed over the surface. This would also explain the large amount of material found during the surface survey. The field was also extensively littered with all sorts of modern garbage: construction material, plastic, glass, and metal. In the first two or three levels of most units, modern garbage was found mixed with prehistoric cultural material, indicating an obviously disturbed context.

The UCA field sloped slightly to the north-west, and the soil deposits of the area were a complex mix of alluvial sedimentation and volcanic ash. The upper levels of many of the units consisted of fairly dense clay. It was often necessary to bail out these units the morning after a rainfall because they retained water very well.

No flotation samples were collected from Unit 1, however, an *in situ* carbonized nut shell fragment was found in Level 8. The only identified Orosí period ceramic from Unit 1 came from this same level, however the only other identified ceramic from this level was from the Sapoá period. With only these two ceramic sherds identified, and the generally mixed stratigraphy at the site, it is difficult to assign any date to the *in situ* macrobotanical find. In the level below, a Bagaces period sherd and a Sapoá period sherd were found. Below this was a 20 cm thick layer of consolidated volcanic ash (*talpetate*). Very few ceramics or other artifacts were found below this layer. One ceramic sherd below it was identified to the Tempisque period, and another was identified to the Sapoá period (questionable). Obsidian, chalcedony, jasper, and andesite debitage were found in the unit as well. Unit 1 was the only unit which was excavated through this volcanic layer to a depth of over two metres. Based on this stratigraphy, it would appear that while there may have been settlement before the volcanic event which caused the *talpetate* layer, the area was resettled much more densely after the volcanic event. This volcanic event has not been dated.

Unit 5 was excavated 20 metres south of Unit 1. Bulk flotation samples were taken from every level. The stratigraphy graded from clay soils in the first 40 cm B.S. to increasing volcanic ash. Excavation was halted at 90 cm B.S. because of a heavy layer of volcanic ash and the absence of any more cultural material (Rinfret *et al.* 1997). This corresponds to the *talpetate* level found in Unit 1 at approximately the same depth.

Unit 8 and 9 were locate approximately 60 metres south-west of Unit 1, and were the two units closest to the Villa Tiscapa excavation (approximately 700 metres north-west). These two units were also the richest in cultural remains relative to the other units. Unit 9 in particular produced a considerable amount of ceramic sherds, earspool fragments, and some bone, but no lithic material. The abundance of material indicates that this area was a possible trash midden, and while no remains of architecture were found in the unit, Rinfret *et al.* (1997) consider it a good possibility that future excavation around Unit 9 would reveal a nearby associated structure.

The stratigraphy of Unit 8 and 9 was unlike that of Unit 1 and 5, probably due to the slight slope of the area to the north-east. The upper levels were composed of the usual heavy dark clay topsoil. This became more loam-like through the next few successive levels, and at 60 cm B.S., the soil also became quite pebbly. In Level 7 and 8 (60-80 cm B.S.), there was a fairly rapid change to a large grained sandy soil, dark in colour with rounded grains. It is likely that this represented some past alluvial activity. Despite this change, the frequency of cultural material did not seem to change. At about 90 cm B.S., the soil type returned to a clay loam. Due to time constraints, Unit 8 was only excavated to a depth of 100 cm, and Unit 9 was excavated to 110 cm. The *talpetate* layer found in Unit 1 and 5 was not encountered in Units 8 and 9. Because of the slope of the land, it is likely that this layer was deeper than 110 cm B.S. in this area. This hypothesis is reinforced by the fact that in Units 1 and 5, the highest density of sherds occurred in Level 1, whereas in Unit 8 and 9, the highest density of sherds was in Level 6 and 8, respectively. Level 1 on the west side of the field appears to be the same as Level 8 on the east side of the field.

The identified ceramics in Unit 8 came mostly from Tempisque and Bagaces periods, with a few from the Orosí and Sapoá periods. This is unlike Unit 1 where the majority came from the Sapoá period. (Too few sherds were found in the other units to show any pattern) This situation is also true of Unit 9 where the Tempisque and Bagaces periods are strongly represented, and only a few sherds are from earlier and later periods. Regrettably, there is no solid temporal patterning to the distribution of sherds relative to stratigraphy. Obsidian, chert, chalcedony, and andesite debitage were found throughout both units. As well, Units 8 and 9 produced figurine fragments, adornos, and some bone fragments.

Like Unit 5, flotation samples were taken from every level in Unit 8 and 9. In Unit 8, additional samples were taken from possible features. A small rock cluster was found in Level 5 in the south-west corner. At first this cluster was thought to be a hearth or possibly remains of architecture, but further excavation did not show any additional associated rocks and it was decided that the cluster was not architectural. Below this cluster, in Level 6, the soil contained a scatter of very small flecks of carbon. A soil sample was taken from this area. In the north-east quadrant of Level 6, there was also a soil discolouration from which another soil sample was taken. This discolouration did not have any carbon flecks visible, but was slightly darker in colour than the surrounding soil.

Like the Villa Tiscapa and UNI excavations, most of the material recovered at the UCA field was domestic in nature. In particular, sherds of León Punctate (thought to be used for cooking tortillas) and Combo Colander ceramics, two mano fragments, and the presence of lithic debitage from stone tool manufacture, points to a domestic site. Faunal remains were surprisingly uncommon at the site, despite the domestic context. White-tailed deer (*Odocoileus virginianus*) bone was identified from Unit 1 and Unit 8, and a fragmented cotton-tail rabbit (*Sylvilagus floridanus*) mandible and maxilla were found in Unit 1 as well, but no fish bones or turtle bones were recovered (Humphrey, personal communication). This is surprising given the location of the site only three kilometres from Lago de Managua. (Some deer and turtle bone was recovered at Villa Tiscapa, but none from UNI).

The extent of N-MA-36 and the artifacts found there suggests a small village, permanently settled from at least 600 B.C. up until Spanish contact, with an economy based on local resources and horticulture or agriculture. Recovery and analysis of macrobotanical remains will contribute our understanding of subsistence and economy at the site.

SC-J-A (SOCORRO-JULIO-A)

The site of Sc-J-A was excavated in 1996 by Deborah Cornavaca. The site is named after is location; Finca Socorro, landowner Julio, excavations in Land Lot A. This site is located near the north-west shoreline of Lago de Managua (Fig. 4.3). Excavations were undertaken to investigate the indigenous occupation of the area near León Viejo, the first Nicaraguan colonial settlement. Previous survey work of León Viejo by Ortega *et al.* (1988) had shown evidence of indigenous settlements around the colonial town, particularly to the south and west.

The site is located in lowland area between the lake shore and low hills approximately two kilometres to the west. This area has an uneven surface of low mounds and sand dunes likely due to many factors, including; alluvial action, volcanic debris, modern land use (plowing), and lake activity. The lake shore to the east is littered with artifacts either washing ashore, or eroding, and the entire area from the lake shore to the hills is reported by the local ranchers to be full of indigenous artifacts and ruins. The

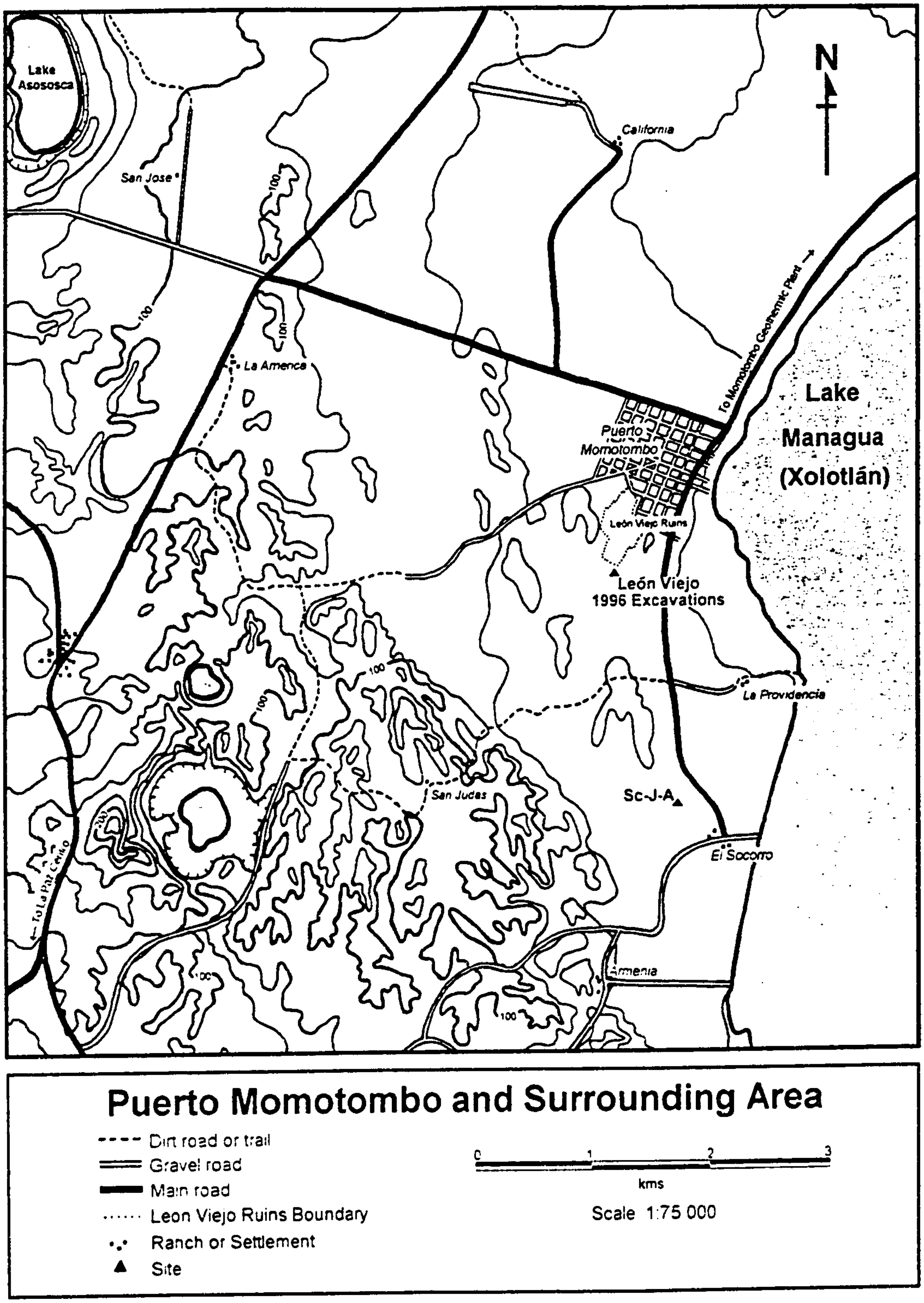


Figure 4.3: Map of Puerto Momotombo and surrounding area, showing the locations of Sc-J-A and León Viejo.

area is believed to be the site of an pre-colonial indigenous village. North of this location, towards the León Viejo colonial ruins, is situated a supposed native cemetery, identified by archaeologist Arturo Cuadro Sella in 1916-1918 (Cornavaca, personal communication). However there are no known finds to substantiate this.

The site area is used primarily as pasture, and at the time of excavation was covered with dense herbaceous scrub interspersed with occasional shrubs and trees (Plate 2). This area was chosen for excavation based on discussions with land owners and results from previous 1x1 m test units (Cornavaca, personal communication).

Excavations at Sc-J-A were focused on a low lying house mound approximately 75 m from the current lake shore. Eight 2x2 m units were excavated in a checkerboard pattern on the high point of the mound, which was approximately 10 m in diameter (Fig. 4.4). Sc-J-A was a multi-component site, with two, and possibly three, major occupations. The first was a pre-colonial occupation, which extends from Levels 11 to 19. Based on features such as fire pits, middens, and possible architectural remains, this pre-colonial component can probably be divided into at least two different components. The third occupation was colonial, likely by indigenous people, found between Levels 8 to 10.

The upper seven levels of the excavation (to a depth of approximately one metre or so) had few cultural remains, and were believed to be a post-abandonment accumulation of debris. A flotation sample was taken from Level 2 because of a high carbon content visible in the soil, but it is likely that this carbon was the result of recent field burnings. At approximately 90 cm B.D. (below datum) a layer of volcanic debris

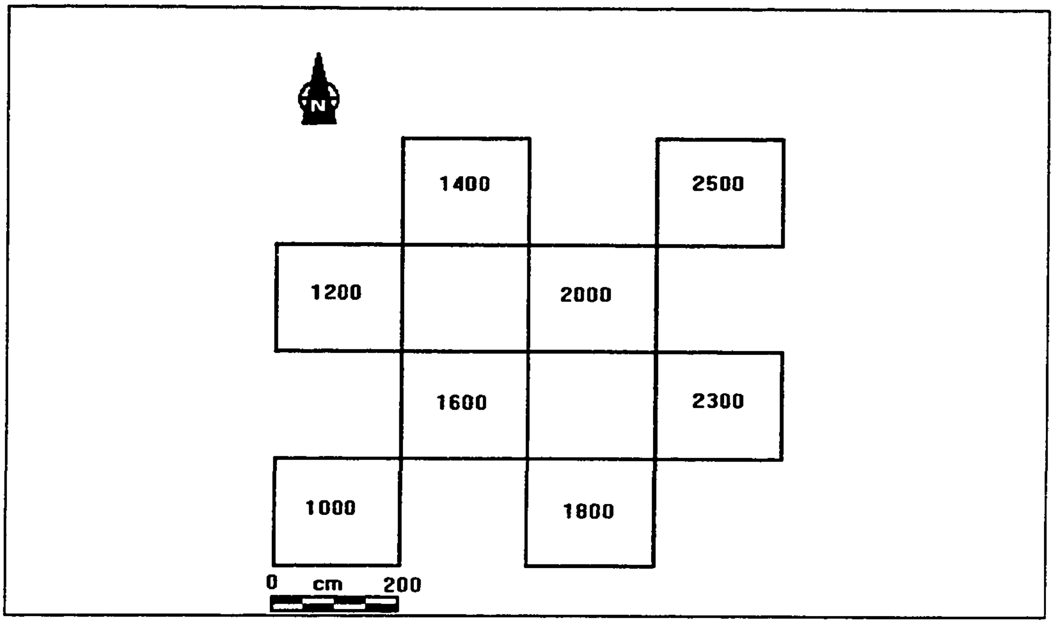


Figure 4.4: Plan view of Sc-J-A units

was encountered, possibly from a small eruption from nearby Momotombo. This eruption has not been dated precisely, but appears to signify the colonial period abandonment of the site around A.D. 1600. The first historic cultural layer (Level 8) was found under this volcanic layer and had signs of architecture in the form of post holes, probably from pole and thatch structures. A midden deposit was also found in this cultural layer, from which flotation samples were taken. This midden appeared to be a secondary deposit, where garbage and the ash from a fire pit were disposed. It contained a significant amount of artifacts, including metal, a clear indication that the cultural level and associated architectural features dated to the Colonial period.

Colonial occupation extended down as far as Level 10 (approximately 120 cm B.D.). While there was no clearly defined boundary between contact and pre-contact levels, Level 11 and below do not have any artifacts from Spanish times, and are therefore considered pre-contact (Comavaca, personal communication). During pre-contact times, there is some evidence of architecture around Level 12 to 14 (140-160 cm B.D.), in the form of post holes, again probably from pole and thatch structures, and rock scatters which may have been stone foundations. None of these rock clusters form definite walls or alignments, but may indicate some type of structure. Layers of pumice and clay were also found, possibly remnants of collapsed adobe walls.

A large deep midden found in Units 18, 23, and 25 was likely associated with this structure. This midden was dense with artifacts such as ceramics, obsidian, bone, and lithics. In addition, an urn burial was found in Unit 23 near the bottom of the midden. The midden lies to the east and south of the excavation, whereas the majority of architectural indicators appear in the central units and to the north west of the excavation. Several flotation samples were taken from this midden.

A possible third component exists at approximately 190 cm B.D. This possible component may in fact be continuous into the component described above at Level 12 to 14. There is no definite break between the two levels such as a volcanic cap, or a sterile layer with no artifacts. This possible component is identified as such due to a fire pit in unit 1700 and a rock cluster in unit 1600, which may be part of a foundation for a structure associated with the fire pit.

Two fire pits were discovered during excavations. One was found in Unit 20 (about in the centre of the entire excavation), at Level 10, or approximately 160 cm B.S., in the eastern part of the unit. A C14 sample was taken, but dates are not yet available.

This fire pit is slightly above the above mentioned structure. Another fire pit or hearth was found in Unit 10 located in the south west part of the mound. This hearth was at a lower depth of approximately 210 cm B.S., and was located in the north-west quadrant of the unit. It was surrounded by rocks, possibly used for balancing cooking vessels over the fire. A concentration of rocks found at approximately the same level in a different unit may be the remains of architecture associated with this fire pit.

Sc-J-A seems to have been a domestic site throughout its history. This is evidenced by the large amount of household trash found in the middens, including bone, ceramics, lithic, and obsidian, as well as the possible indicators of architecture and the fire pit/hearth features. It is also possible that a certain amount of manufacturing activity went on here, indicated by the large amounts of obsidian debitage found.

In addition to the excavation of the mound, three 1x6 m test trenches were excavated about 15 m north of the main excavation in a low lying area of the field. These trenches were named 60 B, D, and F, and were placed one metre apart running east/west. They were dug to see whether there was evidence of architecture and remains off the mound. Flotation samples were only taken from the eastern 1x1 m of each trench.

The trenches were excavated to a level of 110 cm B.D., and yielded evidence of architecture in the form of a stone wall foundation, and many artifacts. Levels up until 90 cm B.D. contain colonial artifacts such as metal and porcelain, but those below this level did not contain colonial artifacts and may therefore be pre-contact. At 110 cm B.D. in trench D, an alignment of large rocks was located which is believed to be a collapsed wall. Excavation ended at this point and the rocks were left *in situ* until they could be excavated in a future season.

Flotation samples were taken from colonial levels in these trenches. Associated artifacts were indigenous ceramics and lithics, as well as porcelain, glass, and metal. In addition, a metate fragment was found approximately 78 cm B.D. The cultural material appears to fit the same stratigraphic pattern as the excavated mound, and show a continuation of the cultural levels encountered in the mound to the location of the trenches. These trenches demonstrated how poor an indicator the surface topography is for locating cultural remains and architecture (Cornavaca, personal communication).

The chronology of Sc-J-A spans from Period V through to Contact, and into the Colonial period (A.D. 500 - 1570) based on ceramics. Samples for C14 dating were taken from different contexts, but results are not yet available. Sc-J-A was a indigenous pre-contact as well as a contact site, but was abandoned probably within 100 years of European Contact (Cornavaca, personal communication). It appears that the site was primarily used by indigenous inhabitants, and that the Spanish artifacts found in the colonial layer were trade goods. During colonial times, the Spanish likely stayed in their own settlement of León Viejo to the north (Fig. 4.3).

LEÓN VIEJO

León Viejo is a colonial site on the north-western shore of Lake Managua, near the modern town of Puerto Momotombo at the foot of the Momotombo volcano (Fig. 4.3). It was founded in 1524 by Francisco Hernández de Córdoba (along with the town of

Granada) on behalf of Pedrarias Dávila, Governor of Castillo del Oro (Panama) at that time. Colonial towns were established where large numbers of Indians could provide the colonists with food, and be exploited as sources of labour (Newson 1987, Radell 1976). The location of León Viejo was chosen in the middle of the populous Province of Imabite; according to ethnohistoric estimates, 15,000 native Indians lived around the outskirts of the settlement (Pedrarias Dávila 1525, cited in Arguello 1969).

A fortress and a church were immediately built, and around these the first houses were constructed of pole and thatch, in the manner of the indigenous population of the area. In the plots around these homes, gardens and fruit trees were planted (Arguello 1969). The area was fertile with fields of corn, cacao, and cotton, according to the chronicler López de Velasco (1894). Two hundred *vecinos* settled in the town (Oviedo 1959, vol. 4, p. 364). León was designated the capital of the new province of Nicaragua, and the seat of the bishop was situated there.

Colonial agriculture was slow to develop and was oriented more towards subsistence needs rather than export crops. Early colonists at León relied on the Indians to provide food: tribute crops were extracted from indigenous communities. The most important of these was maize, followed by beans, and cotton. The Spanish depended heavily on the Indians for food and other goods, since imports from home were inadequate and erratic (Newson 1987). Later, colonists used Indian labour to develop agriculture as an industry, and more commercial export crops were grown, such as cacao, indigo, and sugarcane. Wheat was introduced, but was not well suited to the climatic conditions of Pacific Nicaragua. Citrus was introduced and was very successful (Newson 1987).

Despite the richness of the area, the colonial settlement of León Viejo experienced problems from the very start. In 1526, two years after the founding of León (Viejo), Dávila accused Córdoba of mismanagement, and sentenced him to death. Dávila became Governor of Nicaragua two years later, and ruled from León (Meléndez 1976, in Abel-Vidor 1980a). Unfortunately, there was a lack of interest in the colony from Spain, which was more intent on exploiting the riches of Mexico and Peru at that time. In the 1530's, the Spanish population declined as many colonists left in search of wealth in the newly conquered province of Peru.

Other problems followed. The large surrounding Indian population which supplied labour and goods, and which was the economic reason for the location of the town, was rapidly decimated by disease and the slave trade (Radell 1976). There was a shortage of potable water, since the water of Lake Managua contained heavy minerals and was undrinkable, and the nearest rivers were more than three kilometres away (Ortega *et al.* 1988). Communal wells were dug instead. The area was characterized as excessively hot and unsanitary, and a poor location for commercial traffic, particularly to the Pacific coast. In 1550, León Viejo's reputation was seriously tainted at the assassination of Bishop Valdivieso there. And for many years, the town's inhabitants braved volcanic eruptions from the nearby Volcán Momotombo, frequent tremors, and occasionally destructive earthquakes. The location was abandoned in 1610, after an earthquake buried the town. All these things contributed to the decision to move the city of León to its present location in 1611 (Ortega *et al.* 1988).

The site was initially excavated and partially restored by the Universidad Nacional Autónoma de Nicaragua (UNAN) in the late 1960's (Thieck 1970). Excavations centred in the downtown area of the town, around the church and larger buildings. In 1981, the Nicaragua Ministry of Culture took over responsibility for the protection and salvage of the ruins. A plan was created for the conservation of the site, as well as future systematic survey and excavations. More comprehensive and scientific excavations were carried out in 1983 by Cuban archaeologist Lourdes Domínguez in both the interior and exterior of some of the downtown Spanish buildings. Domínguez uncovered indigenous artifacts below a house foundation, which led her to postulate that the colonial ruins had been built overtop of an indigenous site. In early 1985, a survey of the site by Sanoja examined the outlying mounds, and extended the limits of the site.

In August 1985, a systematic surface survey of the entire area was undertaken by Narvarro *et al.* (1985). They surveyed both the known area of the colonial ruins as well as the area up to two kilometres south of the known site. Part of the colonial ruins were determined to be under the present town of Puerto Momotombo. The survey mapped the raised areas of the visible structures and recommended that markers be placed at the limits of the site. In 1988, excavations were conducted by Ortega *et al.* to investigate the stratigraphy of the site and determine habitation levels, to investigate cultural material, to verify the chronicles, and also to obtain information on events and things not recorded in the historical documents.

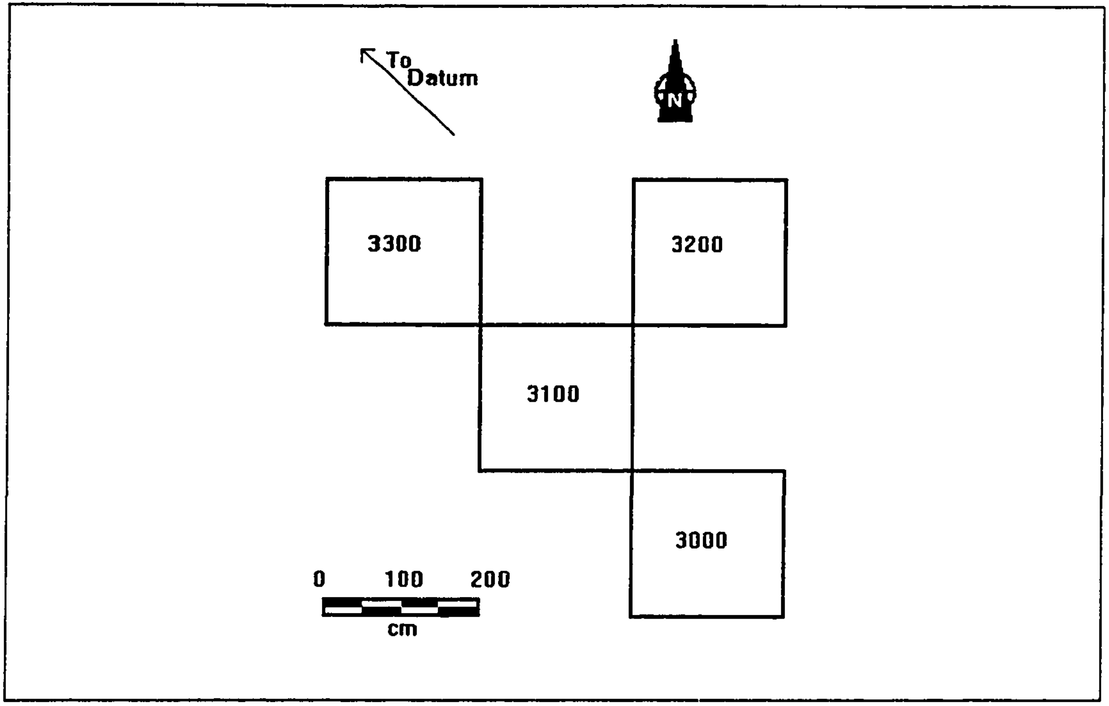


Figure 4.5: Plan view of 1996 León Viejo units.

As the one of the best preserved colonial settlements in Lower Central America, the site was submitted for World Heritage designation and protection, but was turned down. The site was almost completely covered in 1982 by mud as a result of torrential rains and flooding from Hurricane Alleta (Lange *et al.* 1992). The condition of the site at the present time as the result of Hurricane Mitch (Nov. 1998) is unknown.

Excavations at León Viejo were renewed in 1995 and 1996 by Deborah Cornavaca. The flotation samples under consideration came from the 1996 excavations, located on a house mound 10 m south of the previous year's excavation. Four units were excavated in a checkerboard pattern similar to that of Sc-J-A, just south of the boundaries of the protected area of León Viejo (Fig. 4.5). At the time of excavation, the area was being used as pasture, and had the typical vegetation of grass and low herbaceous scrub, with some larger shrubs and trees scattered throughout (Plate 3). The topography is generally flat, with small undulations and depressions.

Units 31, 32, and 33 shared a similar stratigraphy. The first 100 cm or so B.D. was black volcanic sand, with few artifacts. This was likely deposited from a volcanic or flooding event. Under this top layer, a brown loam dense with artifacts was found. Artifacts included many Spanish remains such as metal and porcelain, and remains suggestive of mud and pumice walls were found as well. This level was interpreted as post-colonial Spanish fill, possibly from indigenous or Spanish settlers reoccupying the site after its abandonment (Cornavaca, field notes). This level in these units extended from the end of the volcanic sand to approximately 150-165 cm B.D., until a hard black compact layer was encountered. According to Cornavaca, this layer was not quite hard enough to be definitely identified as a floor, but may have been a living surface at one time. Flotation samples were taken from the post-colonial fill, but regrettably, none were taken from the surface of the black compact layer.

Below this layer, Spanish and indigenous artifacts were found, until a second compact surface was found approximately 10-20 cm below the black compact surface, at about 170 cm B.D. Artifacts found between these two compact levels included a mano fragment, lots of ceramics, including some punctated varieties, lithics, obsidian, metal, carbon, and a possible collapsed wall. A float sample was taken from just above the second floor in Unit 31. The second floor itself had evidence of architecture in the form of large and small post holes.

Colonial artifacts were found below this floor, and approximately 10 cm below the floor, a very dense layer of artifacts was found in all three units, but especially in Unit 32, and 33. This dense layer is interpreted as a Spanish midden or work area, and artifacts included abundant ceramics, obsidian, lithic, glass, bone, metal, and carbon. A float sample from this level was taken in Unit 33 and Unit 31. Below this midden, the density of artifacts decreases quickly, and no further clearly Spanish artifacts are found, leading Cornavaca to suggest that the midden or work area represents the first Spanish occupation of the area, and that material below this represents limited indigenous use of the area before the arrival of the Spanish. Artifacts from this level beneath the midden include ceramics, lithic, obsidian bone, carbon, and a few interesting finds such as a figurine, and an axehead with usewear. Many of the flotation samples processed were from this layer. Excavation stopped at about approximately 250 cm B.D. when a layer of black volcanic rock was encountered. This layer had been identified as the start of a significant volcanic deposit and end of cultural levels, based on excavations the year previous.

Unit 30 was somewhat different in stratigraphy than the other three units. The unit similarly began with black volcanic sand which changed to the brown loam of the post-colonial occupational fill, although the volcanic sand layer ended sooner in Unit 30, due possibly to the topography of the mound. Within the post-colonial fill layer, a denser level of artifacts appeared, along with a bone feature at 120-130 cm B.D. To the north, a possible wall was found in this layer. Unlike the other units, a black compact surface was not found. Instead, from 170 to 190 cm B.D., a dense layer of Spanish roof tiles, metal, ceramic, porcelain, bone, lithic, and other cultural material was found. This layer was interpreted as a collapsed roof that fell onto a floor cluttered with Spanish artifacts, inside a building. The roof tile layer in this unit corresponds closely to the second compact floor found in the other three units to the north. Flotation samples were processed from just above the roof collapse in the brown loam post-colonial fill, as well as within the layer of roof tiles and artifacts. Unit 30 is interpreted as being inside a building, whereas Units 31, 32, and 33 are believed to be a patio area outside the structure, used as a work area, and possibly a midden before being surfaced over with a patio floor.

In Unit 30, below the roof collapse, artifacts continued to be found throughout the fill, although no clearly Spanish material was found. A slightly more dense layer of material was found approximately 210 cm B.D. (the same level as the axe head in Unit 32), including a substantial amount of carbon. A flotation sample was processed from this layer. Artifact density decreased sharply after this layer, until the black volcanic rock was encountered at 250 cm B.D. and excavation ended.

The colonial settlement of León Viejo may have had some pre-contact use of the area by indigenous people, but it was not significant. Cornavaca (personal communication) believes that the site was not permanently inhabited by indigenous people when the Spanish arrived, due to the unfavourable location in the shadow of the Momotombo volcano. The indigenous artifacts found at the site were likely brought to the site by the Indians who worked for the Spanish, or obtained by the Spanish from the surrounding populations through trade since supplies were difficult to obtain in the colonial town (Arguello 1969). Macrobotanical remains from colonial habitation levels the site will reflect plants used by the Spanish, or plants used by the Indians who worked in the households of the Spanish. Remains from below these levels will reflect possible indigenous exploitation of the area on a temporary basis, or environmental occurrences.

CHAPTER 5
METHODS

Flotation methods are quite variable between projects (e.g. Jarman *et al.* 1972, Bohrer and Adams 1977, Struever 1968), presenting a problem in the comparability of results. When a detailed description of methods used to obtain flotation data are provided, results from different studies can be more easily compared. Until flotation procedures become more standardized, special care must be taken to be explicit in describing the methods used in a particular project. This includes detailing the sampling methodology, treatment of samples, the type of flotation system used, mesh sizes of screens used to capture remains, and laboratory methods of sorting and analysis (Watson 1976, Ford 1979). Wagner (1988) also suggests providing the original raw data for other researchers to compare. Detailing the flotation methodology reveals the recovery biases of the particular method. This in turn facilitates comparisons between studies.

SAMPLING

Sampling in archaeology is a major theoretical issue (Mueller, ed. 1975, Shennan 1997). Because it is usually impossible to excavate an entire site, choices are made of a sampling strategy to gain a representative picture of the site. All aspects of an excavation are affected by sampling methodology, and macrobotanical investigations are no exception. It is virtually impossible, and impractical, to float all the soil from an archaeological excavation. Therefore, sampling is employed to gain a representation of the macrobotanical remains present in the site (Van Der Veen and Fieller 1982, Van Der

Veen 1984, Wagner 1988). The way samples are taken depends a great deal on the types of questions being investigated (Renfrew 1973), and has a large impact on later analysis and interpretation (Van Der Veen 1984). Therefore it is important to provide a full account of sampling strategies.

Flotation sampling methods used in archaeology vary considerably. However, these methods can be grouped into two main strategies: blanket sampling, and opportunistic sampling (Pearsall 1995; Van Der Veen [1984] calls these strategies random sampling, and judgment sampling). In blanket sampling, also called bulk sampling, regular soil samples are taken from every level. This may be in the form of column sampling, where soil samples are taken from the same locality in every level (forming a column in profile), or pinch sampling, where the total sample is composed of many small scoops or pinches from throughout the level.

In opportunistic sampling, soil is sampled from in and around features (Pearsall 1995). Archaeological features are believed much more likely to yield remains (although this may not always be the case [Helbaek 1969]), and are generally considered a priority to sample. However, blanket sampling is much more representative of the overall site, and can provide a "control" for comparison to rich feature deposits (Van Der Veen 1984). Most authors argue against using solely opportunistic sampling; this gives a skewed view of human-plant interaction (Ford 1979, Toll 1988, Wagner 1988). In addition, occupation levels or hearths cannot be considered a prerequisite for plant preservation, since most botanical remains are not visible to the eye during excavation (Jarman *et al.* 1972). Blanket sampling ensures that all possible sources of botanical material are represented.

A combination of these strategies is suggested for the neotropics, an area infamous for preservation problems (Pearsall 1995). Both strategies were used in the sampling of the Nicaraguan sites under study, although the sampling strategy varied slightly from site to site. The sampling strategy for each site is provided below.

There was an attempt to keep the volumes of the soil samples taken for flotation in Nicaragua standardized between sites. As much soil as possible was taken for flotation when a feature was sampled. During bulk stratigraphic sampling, a minimum of eight litres was taken for flotation. According to Popper and Hastorf (1988), an adequate sample depends on the questions asked, as well as preservation. A larger volume of soil is more time-consuming to process, but increases the amount of remains recovered. Poor preservation and hence low recovery of remains in the tropics is usually remedied by increased sample size.

Samples were taken from the three sites discussed in the previous chapter. I was involved only in the 1997 excavations of N-MA-36 (the UCA excavations), and therefore only had control over the way the samples from that excavation were taken. The sampling of the UCA excavations was intended to be as similar as possible to the sampling of the Léon Viejo and Sc-J-A excavations, in order that the results from these different sites might be more comparable. Not all soil samples taken in the field were processed by flotation, due to time constraints. Appendix A gives a list of the samples taken, and those which were processed.

Sampling of N-MA-36

The Villa Tiscapa Excavations

During the 1996 excavation of Villa Tiscapa, part of the N-MA-36 site, a 16.5 litre soil sample was taken from a hearth feature found at approximately 60 cm below surface (Operacion 2, Sondeo 2) (Brown *et al.* 1996). This hearth was part of the first component as described in Chapter 4. Other than the soil sample from this hearth, no other samples were taken for flotation from these excavations.

The UCA Excavations

During the excavations on the UCA sports field in 1997, bulk samples were taken from every level of each unit, beginning at Level 2 (20 cm below surface). It was surmised that the soil above Level 2 was highly disturbed and contaminated with modern refuse, and therefore of limited value for paleoethnobotanical studies. Bulk soil samples were taken from the NW quadrant (unless otherwise noted) before any other excavation activity commenced on the level.

Before taking the sample, the surface of the level was scraped with a trowel to remove as many contaminants as possible. Unfortunately, some contaminants, such as modern seeds carried into the unit by workers' boots, or drifting on the wind, still seemed to make their way into the samples. According to Keepax (1977), this is not an unusual occurrence in flotation studies, even with the most careful sampling. After the surface of the level had been scraped, chunks of soil were removed by trowel and placed directly into bags. A minimum of eight litres of soil was taken from each level. Every bag was double tagged.

Samples were also taken from in and around all features encountered. The volume of soil sampled from the features varied depending on the size of the feature; generally, as much soil as possible was taken from around the features.

Sampling at Sc-J-A

Unlike N-MA-36, bulk samples were not taken from every level at Sc-J-A, but rather whenever the excavators felt there was reason to sample the level (Cornavaca, personal communication)(see Appendix A). Bulk samples were taken from the level before any other excavation activity was begun on the level. The surface of the level was scraped with a trowel in an attempt to remove contaminants such as modern seeds, and then soil was dug out in clumps using a trowel or shovel. Care was taken not to mash the clumps, in order that any remains were not crushed. The soil was placed in bags, which were double tagged with a tag inside the bag and another used to tie the bag shut.

In addition to bulk soil samples, soil samples were taken from features such as artifact concentrations and fire pits. The volume of these samples varied with the feature. Fire pits were bisected and one half of the soil went directly into flot sample bags (Cornavaca, personal communication).

Sampling At León Viejo

The sampling of soil from León Viejo followed the same method as described above for Sc-J-A. Again, bulk soil samples were not taken from every level, but taken when it was considered advantageous to do so (see Appendix A). Features were also sampled.

FLOTATION

Soil samples from the 1997 excavations at N-MA-36 were transported from the field to the field laboratory in Managua for cataloguing and flotation. Those samples which came from previous excavations at Villa Tiscapa, León Viejo, and Sc-J-A were transported from storage to the laboratory. All samples were catalogued in the lab and assigned a catalogue number. This number consisted of a letter code for the site, the year the sample was taken, and a short number to identify the sample. For example, SC-96-34 stands for: soil sample from Sc-J-A, taken in 1996, catalogue number 34. Generally, the catalogue numbers were arbitrary, and had nothing to do with the provenience; however, an attempt was made to keep the samples in order, whereby a sample from Unit 1, Level 13 came before a sample from Unit 2, Level 3.

Soil was not dried prior to flotation as is generally recommended (Pearsall 1989, Renfrew 1973). It was felt that because of the clayey nature of the soil, drying it would have formed hard clay peds that would have taken a long time to disintegrate in the flotation system. In addition, the drying and then rewetting in the flotation system of any possible fragile charcoal remains was thought to be too great a risk.

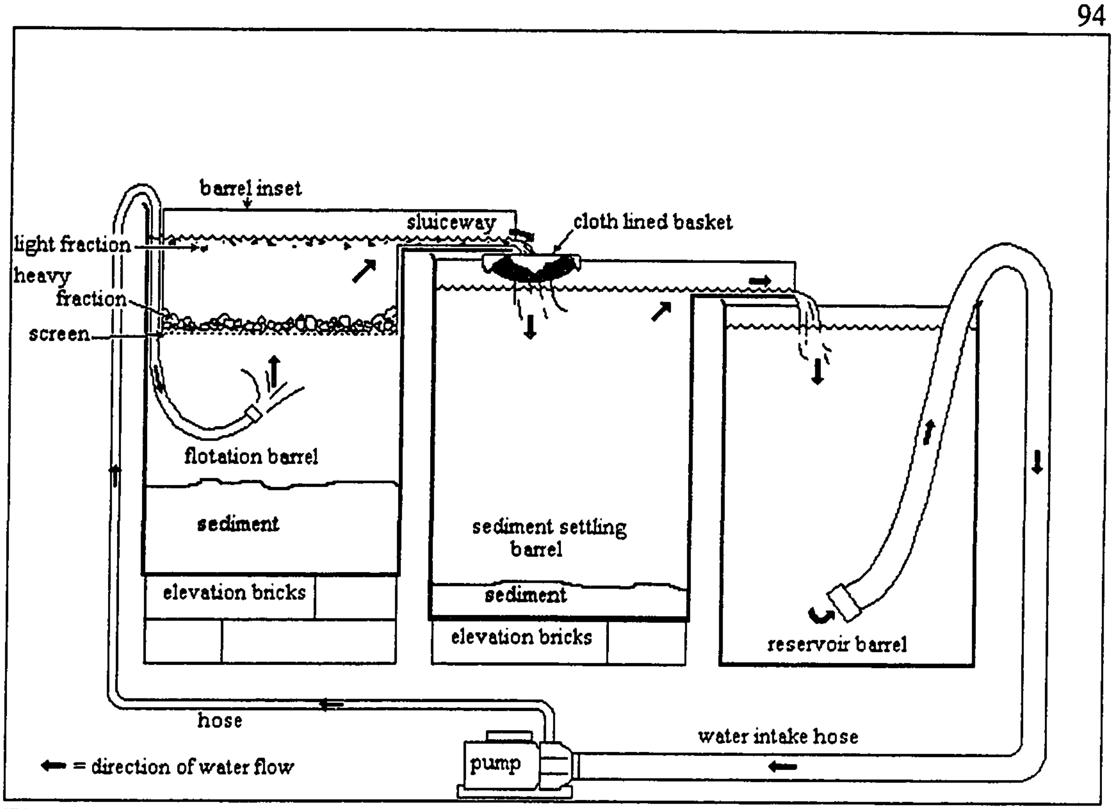


Figure 5.1: Schematic diagram of the flotation system.

Flotation was carried out using a mechanically assisted water flotation system, similar to the SMAP and Ankara systems described by Pearsall (1989) (Fig. 5.1). A rigid barrel inset with a 1.7 mm screen in the bottom and a sluiceway on one side was set within a large modified 55 gallon barrel. The heavy fraction was caught by the bottom screen, whereas the light fraction (all floating material) was carried over the sluiceway and trapped in a chiffon cloth lining a small basket. The mesh size of the cloth was 0.5 mm. Water was pumped into the upper barrel and bubbled under the sample in the barrel inset. This helped raise the floating material to the surface. A second lower barrel under the sluice captured the water flowing through the light fraction cloth and basket, and was used to settle out fine sediment in the water stirred up by the agitation in the upper barrel.

Water was captured in a final lower barrel and recirculated through the system by a gasoline powered pump.

Once the pump had been primed and started and the water was circulating through the system, the first step in the flotation process was to measure out the volume of soil to be floated. For regular bulk stratigraphic samples, the volume floated was maintained at eight litres per sample; for features, the entire volume of soil collected during excavation was floated. Volume was always recorded in the flotation logbook. The measured volume of soil was emptied slowly and as evenly as possible into the barrel inset in the top barrel.

The flotation sample was allowed to run until all the sediment had passed through the screen in the barrel inset. The sample was stirred very gently by hand once or twice during the process to encourage the disaggregation of clay lumps and the release of trapped buoyant material in the sediment. Deflocculation aids such as trisodium phosphate were not used. When most of the sediment had passed through the bottom screen of the barrel inset (usually about 20 minutes), a hand sieve was passed through the water in the barrel inset to capture any remaining floating material as well as any semi-buoyant material (approximately 7 cm below the surface or less) (Plate 4). The hand sieve was rinsed out into the light fraction cloth.

At the end of the flotation, the corners of the light fraction cloth were collected, twisted together, and tied with the string and first provenience tag from the original soil sample to form a small bag. This light fraction was hung to dry in the shade. The barrel insert was lifted out of the upper barrel, and the hose was used to wash the heavy fraction which had accumulated in the bottom of the barrel inset down to one side. The heavy fraction was dumped out onto a large square of cloth and the barrel insert banged a few times on the ground to get as much material out as possible. The second provenience tag from the sample bag was attached to the large square of cloth, and the heavy fraction was then left to dry in the sun. After the light fraction and the heavy fraction were thoroughly dry, they were individually bagged with their provenience tags for latter sorting.

After a sample was completed, the barrel insert was thoroughly rinsed out and the flotation system was left to run for approximately five minutes to clear out any remaining contamination before the next flotation sample was processed. This was done to prevent cross-contamination between samples.

LABORATORY METHODS: SORTING, ANALYSIS, AND IDENTIFICATION

Sorting and Analysis

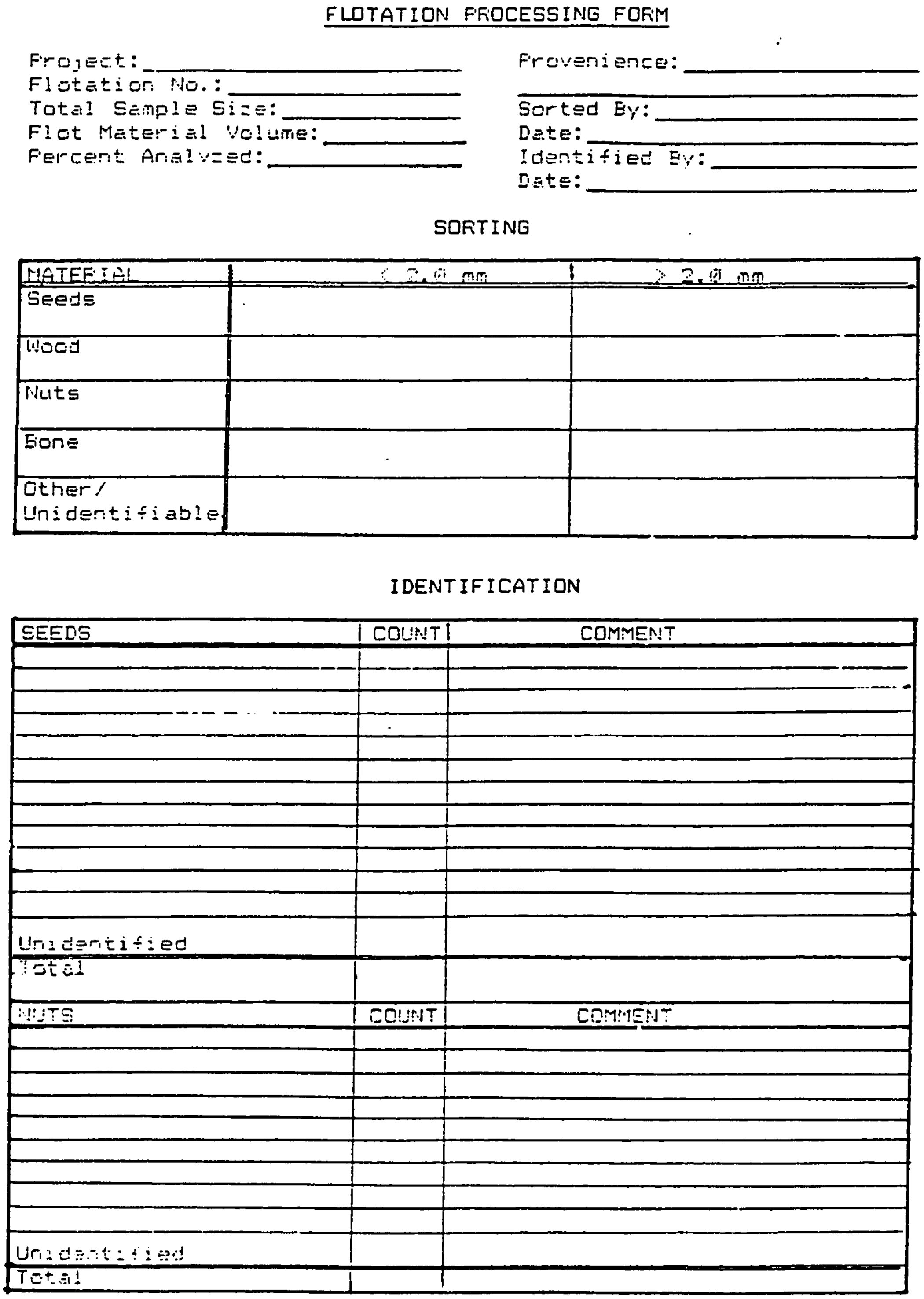
Light Fraction

After flotation, two fractions were left; the light fraction and the heavy fraction. Much of the light fraction was made up of non-archaeological material such as small pieces of pumice, silt, and modern rootlets, along with archaeological carbonized remains. Preliminary hand sorting removed all carbonized material and any other unusual material from the sample to be examined in more detail, quantified by weight, and identified.

After the light fraction had dried thoroughly, the first step in the sorting procedure was to record the provenience of the sample on an individual flotation processing form

(Fig. 5.2, adapted from Pearsall 1989:109). Every sample was given its own form. The total volume of the light fraction was measured and recorded on the processing form, as well as entered into the flotation log. It was decided that volume rather than weight (Pearsall 1989) would be a better measure to quantify the light fraction for two reasons. First, the light fraction was composed of a variety of materials of different masses in different proportions, making the weight of each sample variable and difficult to compare. Secondly, the soil samples for flotation had been measured by volume, therefore quantification by volume of the light fraction permitted ratio calculations of floated material to original soil sample volume.

After measurement, the light fraction sample was split using a 1.7 mm screen in order to make analysis easier. This was done for several reasons. First, this creates smaller, more manageable units of analysis. Second, it has practical value when using a microscope: it is time-consuming to be continually refocusing a microscope with a relatively narrow depth of focus on varying sizes of remains (Pearsall 1989). Third, it presents a rapid way of sorting material like seeds into broad taxonomic divisions by using different screen sizes (Toll 1988). For example, seeds of cultivated species will typically be larger than 2.0 mm. Most grass and weed seeds would be found in a 0.5 mm split or smaller. (Toll 1988:38). Only one split was used during the current analysis. (The split of 1.7 mm was used because this was the measurement of an available kitchen sieve; at the time I did not have access to a 2.0 mm geological sieve (No. 10) which I would have preferred).



FLOTATION PROCESSING FORM

Project: ____________
Flotation No.: ____________
Total Sample Size: ____________
Flot Material Volume: ____________
Percent Analyzed: ____________

Provenience: ____________
____
Sorted By: ____________
Date: ____________
Identified By: ____________
Date: ____________

SORTING

MATERIAL	< 2.0 mm	> 2.0 mm
Seeds		
Wood		
Nuts		
Bone		
Other/ Unidentifiable		

IDENTIFICATION

SEEDS	COUNT	COMMENT
Unidentified		
Total		

NUTS	COUNT	COMMENT
Unidentified		
Total		

Figure 5.2: Flotation processing form (adapted from Pearsall 1989). Wood and Unidentified are on the reverse.

The >1.7 mm split was first sorted using the naked eye. Only carbonized plant material was saved and this was later examined under the microscope. Uncarbonized plant remains such as seeds and roots were present in many of the samples, but these were not kept since they were likely modern. It is unlikely that uncarbonized plant remains would have preserved in the tropical clay-loam soils of the three sites since pre-Columbian or contact times. None of the sites exhibited conditions such as waterlogging that would indicate exceptional preservation of organic materials over long periods of time (Keepax 1977, Miksicek 1987). And none of the uncarbonized remain showed signs of mineralization or calcification, another method of exceptional preservation sometimes found in shell mounds (Newsom 1993). As Ford (1979:299) remarks: "the probability that uncharred material dropped on open soil will become part of the archaeological record is quite remote, owing to the decomposition processes of the soil flora, arthropods, and chemical action." In the samples under examination, any uncharred plant material was treated as modern.

According to Keepax (1977), it is relatively easy to dismiss any uncharred seed as modern and not part of the archaeological record. But some carbonized seeds may also be modern, especially in the areas from which the Nicaraguan samples were taken. The slashing and then burning of vegetation is a common practice for clearing land in the tropics. León Viejo and Sc-J-A were both located in grassy farmer's fields, likely used as pasture, but possibly used for other purposes in the past. The UCA site was located in a vacant field in downtown Managua, which at the time of excavation was covered with grass and low herbaceous scrub plants. The land owners of the Sc-J-A and León Viejo sites reported having burned the vegetation in the last two to five years. It is likely that N-MA-36 had also had its vegetation burned off in the recent past. In such a process, seeds of modern plants which were recently burned have a good chance of being charred and thus preserved in the top layers of soil (see Keepax 1977). Distinguishing these from those of archaeological value is a problem, and it must be recognized that they present a possible source of error in data tabulation in macrobotanical studies.

The <1.7 mm split of the light fraction was sorted using a stereoscopic microscope. Because of the time and intensity of labour required for microscopic sorting, many of these splits were subsampled for analysis. For samples over 20 ml, 50% was analyzed, and for samples over 70 ml, 25% was analyzed. The percent of the light fraction analyzed was recorded on the flotation form. Carbonized seeds and other unusual material were pulled out of the fraction and placed in gel caps for later analysis and identification. The presence or absence of wood charcoal was noted, but charcoal was not removed from the sample as this would have been enormously time consuming. In quantification, the amount of charcoal in the smaller split usually makes little difference in the overall weight of the charcoal from the entire sample (Pearsall 1989).

Heavy Fraction

The heavy fraction from flotation is composed of the particles of material that sink in water, but which are too large to be washed through the bottom screen by the circulating water. The heavy fractions from the Nicaraguan soil samples were mostly composed of a large amount of pebbles, pumice, and clay peds, along with artifacts such as small bones and bone fragments, lithic debitage flakes, ceramic sherds, and fragments of non-buoyant charcoal. The heavy fraction volumes were measured and recorded, and then a 25% subsample of each one was sorted to separate out the above mentioned cultural materials. Several tests were carried out to determine the randomness of the subsampling method. In a test, the entire sample was divided into 25% subsamples, and the remains from these tallied and compared.

The heavy fraction yields interesting artifacts which are generally missed or lost during regular dry screening of soil in the field. Of particular interest was the non-buoyant charcoal which was collected, analyzed, and quantified by weight. Small artifacts such as fish bones and small lithic retouching flakes found in the heavy fraction can contribute a great deal of information to the interpretation of the site which would otherwise be lost. The artifacts found in the Nicaraguan heavy fractions were quickly quantified using presence/absence, and relative amounts (Appendix B). However, these artifacts await future in-depth quantification and identification.

Quantification

Quantification of botanical remains presents a constant dilemma (Dennell 1976, Popper 1988). Ideally, quantification should provide information that can be used to look at the importance of certain species compared to others, and the change in importance over time. Unfortunately, not all plants used are represented in an assemblage, and certain species may be underrepresented due to differences in preservation for each species. In addition, broad trends in the data can not be demonstrated unless there is a statistically large number of remains. As will be discussed in Chapter 6 and 7, the use of quantification and statistical analysis was limited in this study because of the small number of remains recovered, and the tentativeness of many of the identifications. Smith (1980:152) feels that quantification is not appropriate to apply to archaeobotanical remains; because of all the variables in the depositional process, the number of fragments has no significance beyond indicating the plants used. I believe this is somewhat extremist, and that quantification methods can reveal some interesting information, as long as appropriate caution is used in interpreting the results.

During the present study, I chose to quantify wood charcoal by weight, rather than fragment counts. This is because of the tendency of some wood charcoal to fragment easily in numerous smaller bits, thus changing the results. Seeds, faunal remains, and unidentified material from the light fractions, were tabulated by absolute counts. Ubiquity of each species was calculated to determine in how many contexts a particular species was present. As well, density ratios (amount of botanical material per soil sample) were calculated for each sample. This permitted a comparison of rate of return between samples of different sizes and the effectiveness of flotation in different contexts (Miller 1988).

Identification

Much of the value from doing flotation depends on the accurate identification of the types of plants found in the archaeological site. These identifications form the basis for interpreting the botanical remains and allow conclusions to be made about human-plant interaction at the site in prehistory. The main types of plant tissue encountered during sorting were seeds and wood. During preliminary sorting, all seeds encountered were drawn on index cards along with written descriptions, average size, and the first sample in which the seed was found. In addition, each seed drawn was assigned a type number for easy future reference, since identifications had not yet been established. The frequency of each type of seed was recorded per sample on the flotation sheet.

There is no comprehensive illustrated guide to the taxonomy of seeds from Central America, unlike many areas in North America (e.g. Delorit and Gunn 1986, Martin and Barkley 1961, Montgomery 1977). Therefore the identification of the seeds found in Nicaragua depended on a comprehensive reference collection. Because a reference collection was not made during field work in Nicaragua, an accessible existing reference collection had to be located. The seed collection and the herbarium of New York Botanical Gardens, as well as the personal comparative collection of Dr. David Lentz of the NYBG, were used for identifying the macrobotanical remains. Before accessing these reference collections, seeds were broadly classed to family level using the following references: Berggren (1969), Beyerinck (1947), Delorit (1970), Gunn (1972), Hillman and Henry (1940), Martin and Barkley (1961), Montgomery (1977), and Wasylikowa (1986). This allowed for easier identification and more economical use of time when using the reference collection to check genera and species. Floras of Guatemala (Standley and Steyermark 1946, 1949), Nicaragua (Seymour 1980), and Panama (Standley 1928) were relied upon to determine geographical ranges of species and if they were likely to be present within the study area. Wood was not identified to family, genera, or species during this particular project, but may provide a possible future research project.

All identifications were assigned a confidence rating from 1 to 4, with 1 equaling 100% confidence, and 4 representing about 50% confidence (Appendix B, raw data tables). The importance of the confidence rating is discussed in Chapter 7.

SUMMARY

Methodology from sampling to flotation to laboratory processing has been described. The methods for each of the sites sampled were kept as similar as possible, to allow for inter-site comparability. It is vital to report the methodology used in macrobotanical studies, in order that biases in the sample may be ascertained, and recommendations made to improve recovery and analysis. In addition, because there is no standardized methodology established for flotation studies, description of the methods used for a particular project allows for easier comparison between the results from different projects.

CHAPTER 6
RESULTS AND INTERPRETATION

INTRODUCTION

This chapter presents the results of the flotation and identification of the botanical remains recovered from the three sites of Sc-J-A, León Viejo, and N-MA-36. The first section examines the remains themselves and their identification to various species. Because of the relatively small amount of remains found and identified, the data do not support complex statistical tests. Instead, simple species presence is given by site, and ubiquity is calculated for the sample. In addition, samples will be examined by provenience, with particular attention focused on features. This information will be used in Chapter 7 to address what types of plants were being used by western Nicaraguans, whether there was any patterning present in the botanical assemblage, and whether agriculture was part of the economic strategy in the area.

The second part of the chapter focuses on flotation and the rate of recovery from different contexts and different sites. This information is used in the next chapter to assess the methodology used, and make recommendations regarding future paleoethnobotanical studies.

RESULTS OF ARCHAEOBOTANICAL ANALYSES

Presence

Table 6.1 presents a list of the species found and the sites at which they were recovered. Complete data tables for each site providing absolute counts, confidence

Table 6.1 Identified species present at each site

Identifications			Sites		
Family	***Species Identified***	***Common Name***	***Sc-J-A***	***León Viejo***	***N-MA-36***[a]
Aizoaceae	*Mollugo verticillata*	carpetweed	x		
Amaranthaceae	(S1)[b]	Amaranth family	x		x
Amaranthaceae	(S20)	Amaranth family	x	x	
Arecaceae	*Acrocomia* sp.	coyol palm	x		x
cf. Asteraceae[c]	(S61, S74)	Aster family	x	x	
cf. Butomaceae	*Limnocharis flava*	*cebolla de chucho*	x		
Chenopodiaceae	*Chenopodia* sp.	Goosefoot family	x		x
Chenopodiaceae	*Salsola kali*	Russian thistle	x		
Convolvulaceae	*Ipomoea* sp.	morning glory	x		x
cf. Crassulaceae	*Sedum* sp.	*colchón*	x		
cf. Cucurbitaceae		Squash family	x		
cf. Cucurbitaceae	*Sechium edule*	chayote	x		
cf. Cyperaceae	*Scleria* sp.	scleria sedge			x
cf. Euphorbiaceae	(S45)	Spurge family		x	x
Fabaceae	*Crotalaria* sp.	rattlebox, *chipilín*	x	x	
Fabaceae	*Crotalaria* sp./rugose var.	rattlebox, *chipilín*	x	x	x
Fabaceae	cf. *Desmodium* sp. or *Rhynchosia* sp.	tickclover or rhynchosia			x
Fabaceae	cf. *Stylosanthes* sp.	*lengua de rana*			x
Fabaceae	*Phaseolus* sp.	bean	x		
Fabaceae	cf. *Trifolium* sp.	clover	x		x
cf. Juglandaceae	(S8)	Walnut family	x		
cf. Malvaceae	(S29)	Mallow family	x		x
Malvaceae	cf. *Abutilon* sp.	flowering maple	x		
Malvaceae	cf. *Anoda* sp.	*malva*	x		
Malvaceae	cf. *Hibiscus* sp. or *Abutilon* sp.	hibiscus	x		
Passifloraceae	*Passiflora* sp.	passion flower	x		
Poaceae		Grass family	x		x
Poaceae	Pancoideae (S35)	Pancoid grass	x		
Poaceae	cf. *Pancium* sp. or *Tridens* sp.	Pancoid grass	x		
Poaceae	cf. *Digitaria* sp. or *Eragrostis* sp.	crabgrass	x		
Poaceae	*Zea mays*	maize	x	x	
Portulacaceae	*Portulaca* sp.	purslane	x	x	x
Portulacaceae	cf. *Talinum* sp.	*lechuguilla* (Salv.)	x		x
cf. Rosaceae	(S7)	Rose family	x		
cf. Sapotaceae		Sapodilla family			x
unidentified		tree fruit	x		

[a] Includes both the Villa Tiscapa excavations (1996), and the UCA excavations (1997).

[b] During initial sorting, types of seeds were given a numerical designation until identified. Those which were unidentifiable to species retained their preliminary designation.

[c] cf. indicates a possible or tentative identification.

rating, part(s) found, and comments in addition to species identifications appear in Appendix B.

Table 6.1 represents only identified material. Overall, nearly 44% of non-wood material was classified as unidentified[1] (see Appendix B). Many of the identifications are tentative, as indicated by 'cf.' in Table 6.1. During initial sorting, 70 carbonized, non-wood remains (mostly seeds) were noted from the three sites and assigned a numerical designation. Only thirty-four (48.6%) of these were identified or tentatively identified and are represented in the Table. Of these, eleven (32.4%) were identified confidently to family, six (17.6%) to genus, and only two (5.9%) to species (*Zea mays* and *Mollugo verticillata*).

This is a low rate of confidence in identifications, and is due to several reasons. First, some plant species are more easily distinguished based on seed morphology than others. For example, *Mollugo verticillata* has very distinctive seeds. Some remains were identifiable to family, such as Amaranthaceae, but based on seed morphology alone, were not identifiable to genus or species. Second, the remains from all the sites were badly eroded. Most of the remains were highly fragmented and small. Other than some pieces of wood charcoal from fire pits, carbonized fragments tended to be no larger than one centimetre in diameter. As well, seed coats, which are one of the main sources of information for identification, were eroded in many cases. Third, the quantity of each type of remain was usually small, with the majority of species being represented by only

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[1] A total of 858 fragments of non-wood charred material (seeds, parenchymous tissue, nut shells, cupules, amorphous tissue, etc.) were found from the three sites. Of this, 43.7% (by absolute count) was classified as unidentified.

one or two specimens. When an element, such as a type of seed, was represented more than once, identification was made easier, because certain features were visible in one specimen that were not visible in another, and a greater range of variation was present.

As mentioned, many species identified or tentatively identified have very few specimens representing them, often only one. For a number of reasons, the absolute frequency of each taxon represented can not be interpreted to reflect all of human-plant interaction in prehistory (Popper 1988). Individual species are affected differently through initial use and deposition, preservation, and recovery. Absolute counts do not accurately reflect prehistoric rates of use. They reflect preservation of specimens.

I argued in Chapter 2 that paleoethnobotanical studies should go beyond simple taxon lists. However, in a case such as this, too few remains found do not permit complex statistical analysis. Most of the identifications are tentative, and conclusions can not be made which the data do not support. A more simple analysis technique, which the data support, is ubiquity.

Ubiquity

Ubiquity disregards absolute counts and instead focuses on the frequency of a particular taxon as it occurs in a group of samples. Ubiquity is the number of samples in which the species is present, divided by the total number of samples, and expressed as a percent. For example, at Sc-J-A, evidence of maize was found in 5 of a total of 51 samples from the site, giving it a ubiquity rating of 9.80 (i.e. 9.8% of the samples had maize in them). Ubiquity uses only presence/absence rather than specimen counts. A taxon is present whether the sample contains one specimen or one hundred specimens of the taxon (Popper 1988). This rating allows easier comparison of a taxon between sites. It does not allow direct comparison between different taxa (Hubbard 1980), but can provide information on the relative importance of taxa. Results are dependent on grouping and number of samples; different groupings can reveal different trends (Popper 1988).

Table 6.2 presents the ubiquity of each species found for each site, as well as an overall ubiquity calculated for all sites combined. This information is also presented graphically in Figure 6.1 and Figure 6.2. For purposes of calculating ubiquity, confidence ratings are ignored, and all identifications are used as though they are certain. This is in no way meant to diminish the importance of the confidence ratings, but is done to allow the application of ubiquity to demonstrate any possible trends. However, again the caution against using tentative results as though they were definite results must be applied to the ubiquity analysis, since the data from which these ratings are derived are tentative. Therefore any trends shown by ubiquity analysis, and interpretations of them, are also tentative.

It should also be noted that samples are defined as the material coming from one defined context. In many cases, such as Villa Tiscapa, one *sample* was taken but bagged and possibly processed in two or more *parts*. These parts are still treated as one sample. Popper (1988) cautions that too few samples can skew results and make them incomparable to other groups. The solitary frequency score from Villa Tiscapa shows a

Table 6.2: Ubiquity of species for each site, and total species ubiquity of all sites combined.

Species		Ubiquity[a]			
Family	*Species*	*Sc-J-A*	*León Viejo*	*N-MA-36*	*Total Ubiquity*[b]
Aizoaceae	*Mollugo verticillata*	1.9			1.0
Amaranthaceae	(S1)	3.9		3.3	3.0
Amaranthaceae	(S20)	13.7	5.2		7.0
Arecaceae	*Acrocomia* sp.	3.9		3.3	3.0
cf. Asteraceae	(S61, S74)	1.9	5.2		2.0
cf. Butomaceae	*Limnocharis flava*	3.9			2.0
Chenopodiaceae	*Chenopodia* sp.	7.8		23.3	12.0
Chenopodiaceae	*Salsola kali*	1.9			1.0
Convolvulaceae	*Ipomoea* sp.	7.8		3.3	5.0
cf. Crassulaceae	*Sedum* sp.	3.9			2.0
cf. Cucurbitaceae		1.9			1.0
cf. Cucurbitaceae	*Sechium edule*	1.9			1.0
cf. Cyperaceae	*Scleria* sp.			10.0	3.0
cf. Euphorbiaceae	(S45)		5.2	3.3	2.0
Fabaceae	*Crotalaria* sp.	3.9	5.2		3.0
Fabaceae	*Crotalaria* sp./rugose var.	47.0	15.7	40.0	39.0
Fabaceae	cf. *Desmodium* sp. or *Rhynchosia* sp.			3.3	1.0
Fabaceae	cf. *Stylosanthes* sp.			3.3	1.0
Fabaceae	*Phaseolus* sp.	3.9			2.0
Fabaceae	cf. *Trifolium* sp.	3.9		3.3	3.0
cf. Juglandaceae	(S8)	1.9			1.0
cf. Malvaceae	(S29)	1.9		3.3	2.0
Malvaceae	cf. *Abutilon* sp.	5.8			3.0
Malvaceae	cf. *Anoda* sp.	1.9			1.0
Malvaceae	cf. *Hibiscus* sp. or *Abutilon* sp.	1.9			1.0
Passifloraceae	*Passiflora* sp.	1.9			1.0
Poaceae		3.9		3.3	3.0
Poaceae	Pancoideae (S35)	1.9			1.0
Poaceae	cf. *Pancium* sp. or *Tridens* sp.	1.9			1.0
Poaceae	cf. *Digitaria* sp. or *Eragrostis* sp.	1.9			1.0
Poaceae	*Zea mays*	9.8	5.2		6.0
Portulacaceae	*Portulaca* sp.	3.9	15.7	6.6	7.0
Portulacaceae	cf. *Talinum* sp.	3.9		16.6	7.0
cf. Rosaceae	(S7)	5.8			3.0
cf. Sapotaceae				10.0	3.0
unidentified		1.9			1.0

[a] Number of samples in which a species is present divided by the total number of samples in the group, expressed as a percent.

[b] Ubiquity of a species for all sites combined.

prime example of this. Only one sample was taken from Villa Tiscapa, and therefore any taxon, such as the *Talinum* sp. seed identified, receives a 100% frequency. This is not comparable to León Viejo, in which *Talinum* sp. occurs in only two of nineteen samples, and therefore has only a 10.5% frequency.

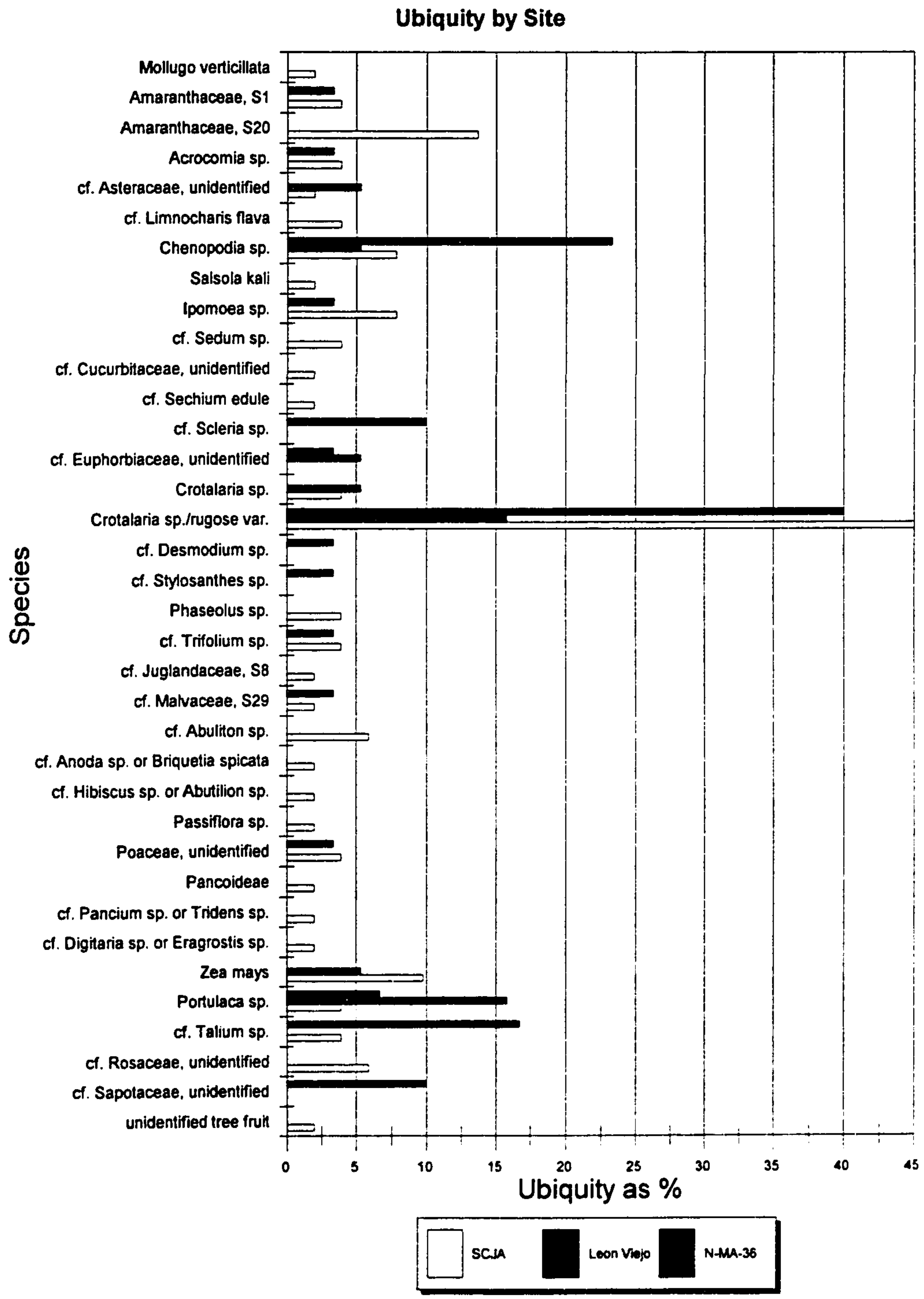

Figure 6.1: Graph of species ubiquity by site.

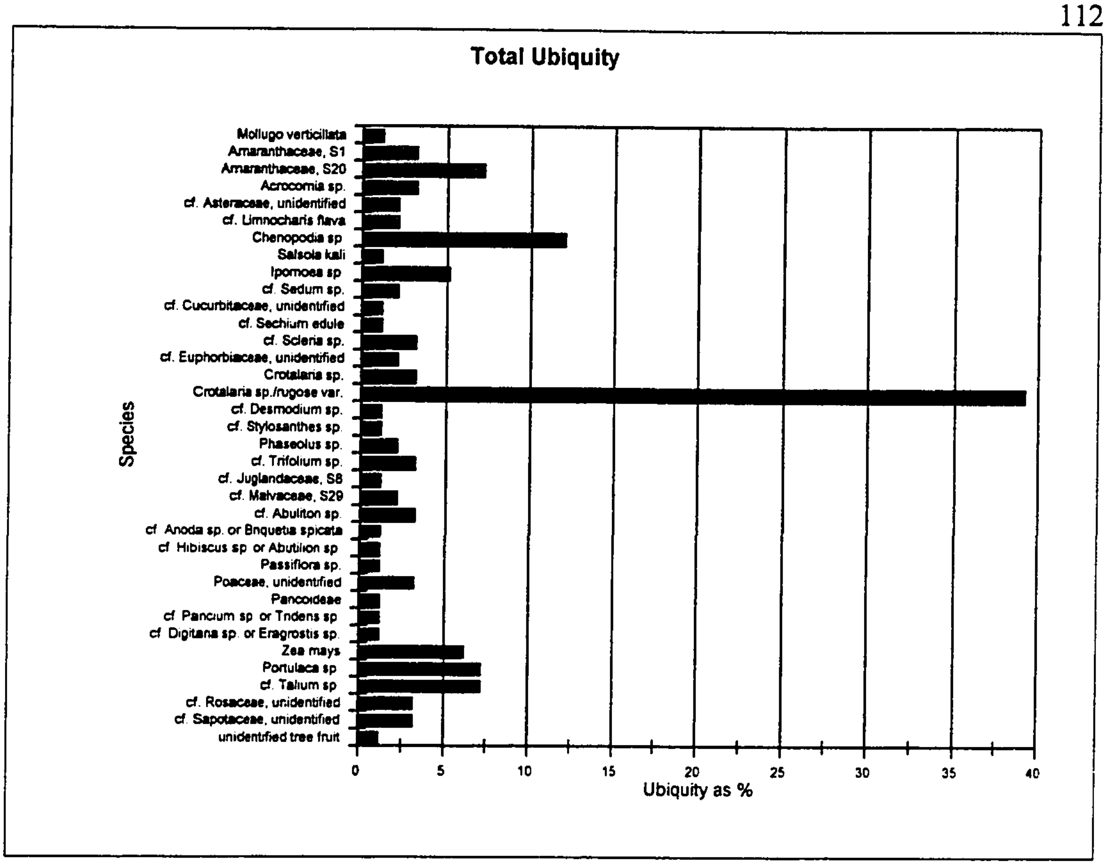

Figure 6.2: Graph of total ubiquity (all sites combined).

As can be seen in the graph of the results (Fig. 6.1), the species with the highest ubiquity by far is a species of the Fabaceae (Leguminosae), tentatively identified as *Crotalaria* sp./rugose variety. "Rugose" is not an actual variety of *Crotalaria*, but a distinction I applied to the species in reference to the seed coat, to differentiate it from other *Crotalaria* species found. While examining comparative collection of the New York Botanical Garden, and researching written descriptive sources (Miller 1967), no *Crotalaria* species was found that had this characteristic wrinkled seed coat. Hence it is only tentatively identified as a member of the *Crotalaria* genus. The prevalence of this particular species is suspect. Only two other items found in the light fraction had a similarly high ubiquity throughout the sites. One was a small light seed from a modern Asteraceae species that likely drifted into the samples, despite the cautionary steps taken to prevent this type of contamination. The other was a small black spherical item, likely a type of fungal spore found throughout the soil (Lentz, personal communication). These two items were found in various quantities in virtually every soil sample floated, and both are considered modern contaminants. The *Crotalaria* sp. seeds in question were black, and appeared carbonized, but it is possible they were not, and were modern contaminants.

The antiquity of some other species identified is questionable on different grounds. *Salsola kali* and *Mollugo verticillata* are historical introductions from Europe, and were not present in Nicaragua before contact. Both were carbonized, but this could have easily been a result of recent farming practices: weedy fields are sometimes burned to encourage new growth[2]. A modern specimen of *Mollugo verticillata* was found during flotation as well from Sc-J-A, strengthening the case that the carbonized specimens found were accidentally charred modern seeds. Other questionable species may be some members of Chenopodiaceae and Amaranthaceae. The seeds from some species in these families are black, and it is possible they could be mistaken for carbonized seeds, skewing the results somewhat.

Figure 6.3 combines the ubiquity of the northwestern sites (Sc-J-A and León Viejo) and contrasts it with that of the southern site (N-MA-36, in part Villa Tiscapa, and UCA). This graph conclusively shows that taxa occur more frequently at the north-

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[2] At the site of Sc-J-A, the landowner Julio reported that he had burned the field two years before (in 1994).

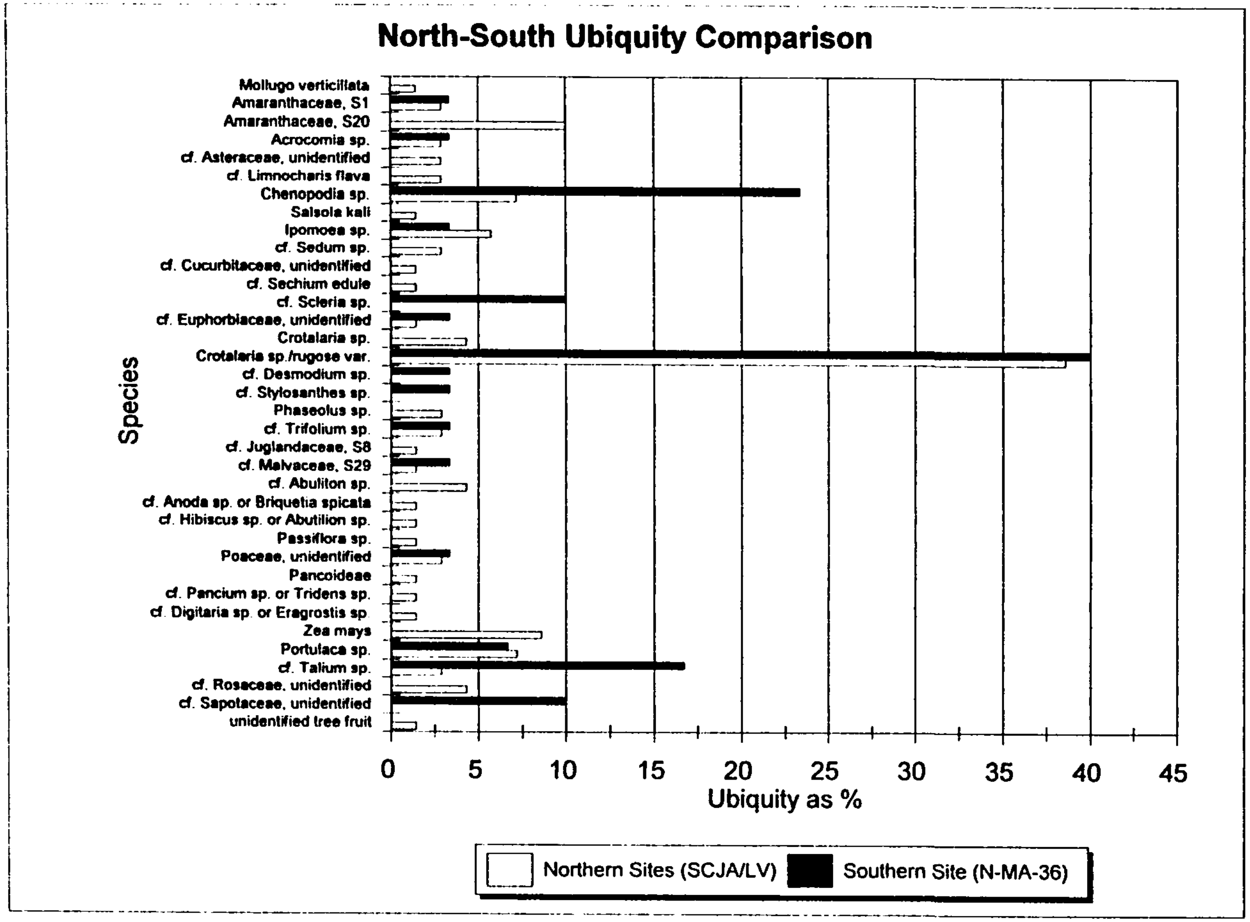

Figure 6.3: Graph comparing ubiquity between northern and southern sites.

western sites. This is a result of site composition and preservation. Sc-J-A and León Viejo were abundant in terms of cultural material. In particular, Sc-J-A had many features that were represented in the flotation samples, including two fire pits. N-MA-36, on the other hand, was a comparatively sparse site, with only one fire pit sampled from Villa Tiscapa, and no features at UCA. In addition, the heavy clay soils over top of volcanic sand at UCA were not ideal for preservation. The loamy-clay soils at Sc-J-A and León Viejo were better for the preservation of botanical remains. The ubiquity comparison between the two areas highlight the differences in excavation and recovery. This issue will be re-addressed in the section in the next chapter regarding suggestions for future paleoethnobotanical research in the area.

According to Popper (1988), ubiquity analysis is useful for showing general trends when one has little control over the sources of patterning in the data. Because I was not involved in the excavation, retrieval, and flotation of the samples from Sc-J-A, León Viejo, or Villa Tiscapa, I did not have control over how these samples were taken. During the UCA excavations, I attempted to use a sampling strategy similar to that of the other sites, in order that the results from the different sites might be somewhat comparable. Ubiquity analysis assists in making the results from these different sites more comparable, because it reduces the data to a type of index. Ubiquity analysis can reduce (but not entirely eliminate) the effects of preservation and sampling differences.

Provenience

One of the fundamental questions this thesis seeks to address is how humans used and interacted with plants in the Lake Managua area during Period VI. An important part of this question is to examine the contexts in which different species were found. This helps determine if there is any patterning to the data temporally (to examine, if possible, how human-plant interaction changed over time), and spatially (for example, certain types of remains associated only with certain features or areas of a house). By looking at provenience and relative dating of samples in relation to frequencies of certain taxa, one can examine whether a particular plant became more or less important over time, or whether there were large scale shifts in vegetational patterns.

Tables 6.3 a-c present a summary of the archaeobotanical remains by provenience for each site. Arbitrary excavation levels have been condensed into stratigraphic levels or components for each site. A more comprehensive table listing taxa by individual provenience appears in Appendix B.

N-MA-36

Table 6.3a presents the remains from N-MA-36, organized by strata. As discussed in Chapter 4, the site stratigraphy of N-MA-36 (UCA excavation) appears to be heavily disturbed. For this reason, a level by level examination of the remains will probably reveal little information regarding changing plant use patterns over time. Remains from UCA are grouped in one large component, dated to a large range of time from the Orosí Period to the Sapoá Period (1000 B.C. to A.D. 1350). Because the stratigraphy of Villa

Table 6.3a: Botanical remains found in each component at N-MA-36.

Component[a]	cm B.S.[c]	Species Identified	Count	Associated Artifacts	Wood	Comments
pre-Columbian (UCA)	20-110	Amaranthaceae	4	- ceramics from all periods, most from Tempisque and Bagaces periods scattered obsidian and lithic debitage (andesite, chert, chalcedony) - earspool frag., figurine frags., adornos, some bone (mammal) - no architecture remains	- virtually no carbon visible - only trace amounts in float. samples float average: 0.01g	-float proveniences: all float samples from UCA; Unit 5, 8, and 9 - modern seeds and roots, esp. in upper levels - soil variable depending on unit and, level complex and mixed stratigraphy, from alluvial, volcanic, and human action - upper levels generally clay and loam - sandy loam and sand in lower levels - grades into volcanic ash - lots of sediment in l.f., esp. from clay levels
		cf. *Acrocomia* sp. endocarp frag.	1			
		Cheno-Am	1			
		Chenopodia ambrodsioides	8			
		Ipomoea sp.	1			
		cf. *Scleria* sp.	4			
		cf. Euphorbiaceae	1			
		Fabaceae	6			
		cf. Fabaceae	1			
		cf. *Crotalaria* sp./rugose var.	159			
		cf. *Desmodium* sp. or *Rhynchosia sp.*	1			
		cf. *Stylosanthes* sp.	2			
		cf. *Trifolium* sp.	1			
		cf. Malvaceae	3			
		cf. Poaceae	1			
		Portulacaceae	2			
		cf. *Portulaca* sp.	8			
		cf. *Talium* sp.	35			
		cf. Sapotaceae fruit pericarp	9			
		unidentified hilum	1			
		unidentified seed	64			
		unidentified stem	2			
		unidentified amorphous tissue	3			
		unidentified unknown	6			
Tempisque Period (Villa Tiscapa) A.D. 70±40[b]	60	cf. *Talium* sp.	1	- sample from domestic hearth at Villa Tiscapa - floor surface - ceramics, bone, lithic	- carbon visible around hearth - float amount: 20.52 g	- float provenience: hearth in Unit 2, Feature 2 - lots of insect parts, some pumice - unknown soil type
		unidentified stem	1			
		unidentified amorphous tissue	5			
		vascular tissue	1			

[a] UCA excavations are treated as one component due to the mixed stratigraphy of the site. No C 14 dates are available, and ceramics come from 600 B.C. to A.D. 1350 without stratigraphic patterning. See Chapter 4.

[b] Calibrated C14 date from Villa Tiscapa hearth.

[c] Centimeters below surface.

Tiscapa was more intact, and the one sample taken from a hearth had a directly associated C14 date, this sample is treated separately within the chart, although technically it would fit into the broad time range covered by the UCA component. Obviously, no trends are possible to discern at this site.

Sc-J-A

Fortunately, the stratigraphy of Sc-J-A is more intact than N-MA-36, and Table 6.3b indicates which species were present at each component at this site. Arbitrary levels are condensed into cultural components in the table. These components are: post-occupational fill, contact/colonial, pre-Columbian A, and pre-Columbian B. No C14 or ceramic dates are available for these time periods, but approximate dates are given based on knowledge of the colonial history of the area, and the belief that the pre-Columbian occupation of the site dates back to Period V (Cornavaca, personal communication). Pre-Columbian A and B are divided at the level of a possible floor or living surface of which remnants were found in several units. Occupation of the site was probably continuous from pre-Columbian A to pre-Columbian B (and also into the contact period), but they are divided to better group the data in order to see any trends. Even so, the time span of occupation at Sc-J-A is believed to only be about 300 years (Cornavaca, personal communication). This limits the expression of any major trends that would be visible over a longer period of time.

Unfortunately, with so few botanical remains, it is difficult to discern trends through time, such as those elucidated by Pearsall (1988) for the Panaulauca Cave site in

Table 6.3b: Botanical remains found in each component at Sc-J-A.

Component[a]	cm B.D.[c]	Species Identified	Count	Associated Artifacts	Charcoal	Comments
post-occupation (A.D. 1600-present)	34-87	cf. Amaranthaceae Cheno-Am *Crotalaria* sp. cf. *Crotalaria* sp./rugose var. *Ipomoea* sp. cf. *Limnocharis flava* *Mollugo verticillata* cf. *Passiflora* sp.	6 1 2 5 6 1 1 1	- low density of artifacts ceramics, bone, obsidian, lithic - float. from shallow burned area, from field burning?	- lots of visible carbon throughout component, from modern field burnings? - float carbon: 0.97 g	- float. provenience: 12-02 - sample from burned area, charcoal in screen - brown-gray sandy loam, few pebbles - lots of roots and pumice
colonial/ contact (A.D. 1525-1600)	88-120 (off-mound 76-92)	cf. *Abuliton* sp. cf. Amaranthaceae cf. *Anoda* sp. cf. *Crotalaria* sp./rugose var. Fabaceae cf. Juglandaceae cf. Portulacaceae cf. Rosaceae cf. *Zea mays* unidentified seed unidentified amorphous tissue	1 1 1 5 1 1 7 1 1 12 25	- in mound, start of component dense layer of cultural material, on top of floor surface with post holes - lots of ceramics, some with feet, lithic tools and debitage, obsidian, carved & blue painted bone, ceramic beads - Spanish brick frags, metal nail - off mound, Spanish artifacts; porcelain, glass, metal, brick - also ceramics, bone, obsidian, lithic, metate frag. - seeds found and collected	- some carbon visible - several carbon concentrations - small amounts in float; more in mound than off-mound - float average: 0.07 g	- float proveniences: 12-08, 14-08, 25-08, 60-04B, 60-04D, 60-04F, 60-05F, 60-06B, 60-06D - level begins after layer of gray volcanic rock and sand - dark brown sandy loam dense with cultural remains - lots of modern seeds esp. in off-mound trench
pre-Columbian B (A.D. 1450-1525)[b]	121-160	cf. *Acrocomia* sp. endocarp frag. Amaranthaceae Cheno-Am cf. *Crotalaria* sp. cf. *Crotalaria* sp./rugose var. cf. *Digitaria* sp. or *Eragrostis* sp. cf. Fabaceae cf. *Limnocharis flava* Pancoidae cf. *Phaseolus* sp. cotyledon cf. Rosaceae or Passifloraceae cf. *Talium* sp.	1 7 1 1 34 1 1 2 2 4 1 1	- dense pre-Columbian component - several rock clusters, pumice concentrations, suggesting architecture - possible floor surface at bottom of component - hearth in 2000 - ash scatter from hearth - possible midden in 1800 and 2500 associated with hearth - lots of ceramic, bone, some burnt, some worked, lithic	- carbon visible throughout component - large amounts in association with hearth - average small amounts elsewhere with some minor concentrations - burnt branch in 23-11.1	- float proveniences: 10-13, 10-14, 12-11, 12-13, 14-12, 18-11, 14-14 16-10, 16-12, 18-13, 20-09.1, 20-10, 20-10.1, 23-11.1, 23-12.1 23-12.2, 25-11, 25-12, 25-13 - soil variable, depending on context - generally dark brown loam, with varying amounts of clay and sand - roots, insects and modern seeds in many samples - rodent tunnels in some units

Table 6.3b: cont.

Component[a]	cm B.D.[c]	Species Identified	Count	Associated Artifacts	Charcoal	Comments
pre-Columbian		cf. *Trifolium* sp.	1	debitage and tools, incl. scraper,	- float average:	
B		cf. *Salsola kali*	1	possible mano frag., lots of	24.66 g	
(cont.)		cf. *Sechium edule*	1	obsidian, ceramic beads, figurine		
		Zea mays cupule	7			
		cf. *Zea mays* cupule	2			
		unidentified seed	67			
		unidentified vascular tissue	5			
		unidentified parenchymous tissue	2			
		unidentified amorphous tissue	21			
pre-Columbian	160-230	*Abutilon* sp.	1	- component begins after	- carbon visible	- float proveniences: 10-16, 10-17,
A		cf. *Acrocomia* sp. endocarp frag.	1	possible floor at 160 B.D.	throughout	10-17.1, 12-16, 14-15, 14-16, 16-15,
(A.D. 1200-		Amaranthaceae	2	- not as many potential	component	16-17, 16-18, 16-18.1, 16-21, 18-15,
1450)[b]		cf. Amaranthaceae	9	architectural remains	more dense in	18-16, 20-14, 23-13, 23-14, 23-15,
		cf. Asteraceae	1	(rocks, pumice, adobe)	some areas than	23-15.1, 23-15.2, 23-17, 23-19,
		Chenopodiaceae	1	as component above	others	25-16
		Crotalaria sp.	1	- second hearth at 1017.1,	- large amounts	- soil variable between contexts
		cf. *Crotalaria* sp./rugose var.	59	also associated with ash deposits	associated with	- generally medium brown
		cf. Cucurbitaceae rind	1	and possible living surface	hearth	clay-loam grading to light brown
		cf. Fabaceae	1	- large midden in 2300 and 2500,	- large pieces also	sandy-loam with pumice
		cf. *Hibiscus* sp. or *Abutilon* sp.	2	incl. burial urn, dense ceramics,	found in midden	- modern seeds and some roots
		Ipomoea sp.	1	bone, lithic, obsidian, beads	- density declines	
		cf. *Ipomoea* sp.	4	- artifacts throughout component;	after hearth	
		cf. Juglandaceae	1	lots of ceramic, some blackened,	- float average:	
		cf. Malvaceae	3	tripods and handles,	0.72 g	
		cf. *Phaseolus* sp. cotyledon	1	obsidian blades and debitage		
		Poaceae spikelet base	2	fish and mammal bone, lots burnt,		
		Portulaca sp.	2	some worked, lithic incl.		
		cf. Rosaceae	1	scrapers, hooked lithic piece,		
		cf. *Sedum* sp.	2	axehead, mano, hematite in 18-15,		
		cf. *Talium* sp.	2	several pipe-like clay objects,		
		cf. *Trifolium amabile*	3	function unknown,		
		Zea mays cupule	1	mini-incensario 23-19		
		cf. *Zea mays* cupule	6	- concentrations of ceramic		

Table 6.3b: cont.

Component[a]	cm B.D.[c]	Species Identified	Count	Associated Artifacts	Charcoal	Comments
pre-Columbian A (cont.)		cf. *Zea mays* kernel	2	obsidian, lithic, bone, and carbon;		
		cf. tree fruit endocarp frag.	3	activity areas?		
		unidentified tree fruit frag.	3	- artifact density decreases		
		unidentified seed	64	gradually after hearth		
		unidentified parenchymous tissue	4	until sterile at about 330		
		unidentified amorphous tissue	29			

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[a] Component dates are approximate. No C14 dates or relative dates based on ceramics are available.

[b] Division of the pre-Columbian component into pre-Columbian A and pre-Columbian B is based on remnants of a compact surface (possible floor) found at the same depth (160 B.D.) in some units. It is likely that pre-Columbian occupation was continuous from later Middle Polychrome to contact (A.D. 1200 to 1525). The floor surface selected as the dividing point has not been dated (see note above), A.D. 1450 was selected as an arbitrary mid-point.

[c] Mean average depths. Actual depths vary between units.

Peru. Only nine positively identified fragments of maize came from three different levels at Sc-J-A. No conclusive statements can be made regarding maize use over time based on such a small number of remains. However, it appears that more maize was more common in the pre-Columbian components than in the colonial/contact component. This is likely due to the location of hearths in the pre-Colombian components where the maize remains were better preserved. It can also be said that the diversity of species and overall amount of remains is much higher for the pre-Columbian components than the colonial/contact component. Economic species such as *Acrocomia* sp., *Phaseolus* sp., and *Ipomoea* sp. are identified or tentatively identified for pre-Columbian periods. Again this may be the result of differential preservation, or an increased sample number from the pre-Columbian components.

The amount of wood charcoal from flotation is the lowest in the colonial/contact component, and highest in the pre-Columbian B component. Pre-Columbian A is lower than pre-Columbian B, despite the fact that both components had a hearth. The large amounts of charcoal from the pre-Columbian B hearth may have skewed the results somewhat. But overall, charcoal seems to be a good indicator of the level of cultural activity. Component B, and then component A seem to have had the most cultural activity, based on artifacts and architectural indicators. The amount of unidentified material remains fairly constant through all components, indicating that fragmentation and erosion of specimens is relatively stable over time.

León Viejo

Table 3.6c presents the provenience of León Viejo remains. The stratigraphy at León Viejo allows for a clear division into post-colonial fill, colonial, and pre-colonial components. Although C14 and ceramic dates are unavailable for the site, dates for each component are provided based on the known colonial history of the site.

As with Sc-J-A, very few botanical remains make it difficult to make conclusions regarding trends through time. Post-colonial levels had a variety of remains, but very little charcoal. The colonial levels were the richest in terms of both botanical and cultural remains, and on average had the most charcoal of the three components. (However, this amount was still fairly moderate if compared to the high charcoal averages from Sc-J-A.) This was the only component which had evidence of maize. The pre-colonial component had low diversity of identified species, and a lower average amount of wood charcoal than the colonial level, but higher than the post-colonial component. This fits with Cornavaca's (personal communication) impression of the site that there was some indigenous occupation of the locality prior to the Spanish, but that it was not significant. The pre-colonial component also had the highest number of unidentified fragments of charred tissue compared to the other components, even when the differing number of samples from each component are taken into account. It is possible that remains were more eroded from these levels. This erosion may be related to depositional or soil type factors.

Table 6.3c: Botanical remains found in each component at León Viejo.

Component[a]	cm B.D.[b]	Species Identified	Count	Associated Artifacts	Wood Charcoal	Comments
post-colonial fill (1610-present)	80-169	Chenopodiaceae or Amaranthaceae cf. *Crotalaria* sp./rugose var.[c] cf. Fabaceae *Portulaca* sp. unidentified vascular tissue unidentified amorphous tissue unidentified seed frag.	1 2 1 7 1 1 8	- Spanish artifacts; metal, incl. pin or key, & sword, some brick & roof tile frags. - possible adobe wall in Units 3000 & 3100 - shell, porcelain, ceramic incl. comal/olla frag., & glazed piece, obsidian debitage & blade, lithics, mano frag., bone	- small amounts in float. sample - carbon visible throughout component - float average: 0.01 g	- float. proveniences: 30-04, 30-10, 30-14, 31-04, 33-02 - soil medium brown sandy-loam - many small volcanic rocks and pumice - lots of pumice in float samples - roots, some burnt
colonial (1527-1610)	170-192	cf. Asteraceae *Crotalaria* sp. cf. *Crotalaria* sp./rugose var. *Zea mays* cupule unidentified fruit pericarp unidentified tree fruit frag.? unidentified amorphous tissue	1 2 1 1 1 1 10	- roof collapse inside house (3000); dense layer of roof tiles & Spanish household artifacts: metal, glass, brick, obsidian, bone, ceramic - plaza floors with post holes outside house, overtop midden or work area(3100, 3200, 3300);dense ceramics, some polychrome, abundant obsidian, lithics, metal, glass, bone	- carbon visible throughout component - more charcoal in float. samples than previous component - float average: 0.60 g	-float. proveniences: 30-15, 31-09, 31-11, 33-07 - soil variable, depending on level; black compact clay-loam, brown compact clay-loam, fine brown loam to medium sandy-loam to coarse volcanic sand between surfaces, in midden, and in roof-fall - common volcanic rocks except with roof fall in house - pumice & roots in some floats
pre-colonial (1350-1526)	193-250	Convolvulaceae or Euphorbiaceae dicot seed frag. unidentified seed unidentified possible seed unidentified, one side grooved unidentified amorphous tissue	1 1 3 1 1 29	- no Sp. artifacts - polished lithic axehead, obsidian & lithic debitage, ceramics, including adorno, bone, some burnt - after 220 cm B.D. artifacts density decreases rapidly	- carbon visible throughout, some large pieces - higher density in float. samples at beginning of component, but decreases like artifacts - float average: 0.26 g	- float. proveniences: 30-17, 30-18, 30-19, 31-12, 31-13, 31-14, 31-15, 32-10, 33-08, 33-09 - roots still continue, some burnt - fine sandy-loam, common pebbles - bottom of component marked by layer of volcanic rock

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[a] Component dates are approximate based on known colonial history of the site. No C14 dates or relative dates based on ceramics are available.

[b] Centimetres below datum. Mean average depths. Actual depths vary between units.

Features

Three types of features found during the excavations of León Viejo, Sc-J-A, and N-MA-36 are considered important places to find concentrated botanical remains. These are hearths, floor or living surfaces, and middens. Hearths, also called fire pits, are obvious hotspots of botanical deposition and preservation. Accidents while cooking, burning of fuel, and deposition of garbage are just some of the ways botanical remains find their way into a fire pit and are preserved through carbonization. Domestic debris, including plant parts like stray seeds, often fall onto the floor. The preservation of botanical remains is not as great on floor surfaces as it is in hearths or midden, since objects often get trampled into the ground. However, sometimes events such as renewing (resurfacing) the floor, or quick abandonment and rapid deposition of sediment preserve more fragile botanical remains. Lastly, middens are garbage piles or pits, where unwanted objects are dumped. Unusable parts of plants or overcooked food may be thrown out here, and botanical remains are likely to be present if the midden is a general household garbage dump.

In the following discussion, hearths, floor surfaces, and middens are examined from each of the sites in order to see what types of remains were found in each and to test the hypothesis that these features are areas of more intense botanical deposition. The three categories are intertwined. Ashes and material from the fire pits are often dumped into middens. Material from a fire pit can end up on a surrounding floor surface. Flotation samples from some specific contexts from the three sites could have been included in two different sections. Each sample is treated once under one classification, and not discussed again to avoid repetition. It may however be mentioned in a different section. One species, *Crotalaria* sp./rugose var., was found in almost every feature context. This species is left out of the analysis because of its ubiquity and probable modern origin (see above).

Hearths

Table 6.4 compares the results of analysis from fire pits sampled from all sites. All three hearths were dense with charcoal, but the amount of charcoal recovered by flotation from Sc-J-A 20-10.1 far exceeded the other two hearths. Sc-J-A 20-10.1 was the richest also in terms of species diversity; at least six species are represented, although only two were identified or tentatively identified. Sc-J-A 20-10.1 yielded seven maize (*Zea mays*) cupules, the highest of any context from the three sites, as well as four possible bean (*Phaseolus* sp.) cotyledons.

Table 6.4: Comparison of hearth samples from all sites.

Site	Provenience	cm B.D.	Associated Date or Period	Wood (g)	Species Identified	Count	Comments
N-MA-36 (Villa Tiscapa)	2-Feature 2	60	cal. A.D. 70± 40 (Tempisque or Zoned Bichrome)	20.52	cf. *Talinum* sp. unid. stem? unid. amorph. tissue unid. vascular tissue	1 1 5 1	- lots of insect parts in sample
Sc-J-A	10-17.1	190	pre-Columbian, Mid to Late Polychrome	13.26	Poaceae spikelet base cf. Asteraceae	1 1	- wood charcoal is very splintery, dif. than. 20-10.1, dif. use area?
Sc-J-A	20-10.1	130	pre-Columbian, Late Polychrome	462.47	*Zea mays* cupules cf. *Phaseolus* sp. unid. round seed unid. oval seed unid. rounded seed unid. seed frag. unid. amorph. tissue	7 4 2 1 2 1 7	- sample is basically all charcoal - very eroded seeds

The lack of species from the Villa Tiscapa fire pit and the Sc-J-A 10-17.1 fire pit is rather mystifying. Both these pits were found in what appear to be a domestic contexts and were therefore not likely used for industrial purposes such as ceramic firing. Industrial hearths tend to be found in special buildings, or away from domestic architecture (Abel-Vidor 1980b). Rocks were found around both these fire pits. These rocks are also indicative of a domestic context; they are usually interpreted as supports for cooking vessels. Interestingly, while Sc-J-A 20-10.1 had more evidence of cooking remains than these two other hearths, it did not have rocks surrounding it.

At Villa Tiscapa, a possible *Talinum* sp. seed was found (part of the Portulacaceae family), along with some unidentified tissue. The fire pit at Sc-J-A 10-17.1 had evidence of some type of grass spikelet, and a possible seed from the Asteraceae family.

Much of the surrounding area around the Sc-J-A fire pits contained ash deposits. These have been interpreted as secondary deposits, where the contents of the fire pits were cleaned out and dumped, to allow reuse of the fire pit. From the area surrounding the 20-10.1 fire pit, a coyol endocarp fragment (*Acrocomia* sp.), a possible maize cupule, and sugary tissue likely from tree fruit were found, along with several unidentified non-wood remains. From the surrounding area and ash deposits associated with 10-17.1, legume seeds (cf. *Trifolium* sp.), possible maize cupules and a kernel, a possible tree fruit endocarp, portulaca seeds (*Portulaca* and *Talinum* sp.), *Abutilon* sp., *Crotalaria* sp., *Amaranth* sp., and possible sweet potato seed (*Ipomoea* sp.), as well as unidentified non-wood remains were found.

In both fire pits from Sc-J-A, a more diverse assemblage of species was found outside the hearth rather than in the hearth deposit itself. This would seem to indicate that floors and middens associated with fire pits are excellent places to look for botanical remains. No sample was taken outside of the Villa Tiscapa fire pit, so it is impossible to know if this fire pit would follow the same pattern.

Floor Surfaces

Floor surfaces are another potential area for increased botanical deposition from the accidental dropping of refuse during daily activities. Table 6.5 presents a summary of the potential floor or living surfaces from which flotation samples were taken. While a floor surface was found at N-MA-36 at the Villa Tiscapa excavations, no float was taken from this context.

Table 6.5: Summary of flotation samples taken from floor surface features, or slightly above.

Sc-J-A (Unit-Level)	**León Viejo** (Unit-Level)
12-08 (post holes, same surface as 14-08) 14-08 (post holes, same surface as 12-08) 16-18.1 (compact soil under rock concentration) 20-10 (associated with fire pit and midden) 23-11.1 (pumice layer, possible wall fall or floor) 23-12.2 (hard surface in part of unit, associated with midden) 25-13 (possible surface in north of unit, associated with midden)	30-15 (roof collapse in top of interior floor) 31-09 (brown compact surface with post holes)

For the most part, the surfaces identified at Sc-J-A are better classified as compact layers or potential living surfaces. None exhibited the hardness needed to be truly called a floor. Other floor surfaces were found at León Viejo at 31-10, 32-06, 32-08, 33-04, 33-06. These where either not sampled for flotation, or in the case of 33-04, a flotation sample was taken but not processed.

The floor surface found at Sc-J-A 12-08 and 14-08 had evidence of architecture in the form of post holes. Artifacts were common on this surface, including many ceramic sherds, some with feet, worked bone, some of which was carved and painted blue, a bead, obsidian and lithic debitage, and lithic tools. Carbon was visible in the soil, and flotation yielded slightly more than usual amounts of wood charcoal. A possible Juglandaceae nut, and some unidentified seeds and tissue were found in the samples.

The compact surface at 16-18.1 was found under a concentration of rocks, believed to be remnants of some sort of architecture. The artifact assemblage was unremarkable, with the usual ceramics, obsidian, bone, and carbon present. A possible maize cupule was found on this surface, although its identification is very tentative. In addition a grass spikelet base fragment, a possible Crassulaceae seed, and other unidentified seeds, were found. Despite the carbon visible in the soil, only a trace was found in the flotation.

The floor surface of 20-10 is associated with the fire pit feature 20-10.1 and was considered under the previous discussion of this fire pit feature. Botanical remains included a coyol (*Acrocomia* sp.) fragment. The pumice layer found at 23-11.1 is thought to be either the remnants of a collapsed wall, or of a floor. Artifacts associated with this layer include ceramic, obsidian, lithics, and carbon. A large piece of burnt branch, and some burnt bone were also found in the level. Only an unidentified seed was found in the flotation from this level.

Feature 23-12.2 is a section of hard soil found in part of the unit. The other part of the level was composed of soft black soil, and is considered a pit feature. This hard section of soil was associated with lots of ceramics and a large amount of obsidian debitage, along with lithic, bone, and carbon. The flotation sample from this feature contained slightly higher than average charcoal, along with a pancoid grass seed and several other unidentified seeds and tissue. Provenience 25-13 contains a possible floor to the north of the unit. This level is at the bottom of a midden, and continued to have large amounts of ceramics, obsidian, lithics, worked bone, and visible carbon from the midden. Surprisingly, only a small amount of charcoal turned up in the light fraction, along with an unidentified seed and some unidentified tissue.

The floor surfaces at León Viejo were more defined than those at Sc-J-A. Regrettably only two flotation samples were taken and processed from these surfaces. At 30-15, a dense layer of roof tiles and other artifacts were found, including metal, obsidian, porcelain, ceramics, carbon, and bone. This layer is interpreted to be a collapsed roof which fell onto the abandoned living surface inside a house structure. The botanical remains from this level found in the flotation sample were mostly unidentified seeds and tissue, although some of the tissue is believed to be carbonized sugary fruit flesh, and a possible tree fruit endocarp fragment. There was also a higher than average amount of charcoal in the unit. There is not enough charcoal, nor any burned surface that would suggest this structure was burned after abandonment.

In Units 31, 32, and 33, a black compact surface was found at about the same level. Under this surface was an earlier brown compact surface which, in two of the units, had post holes. These two surfaces are thought to be plaza floors from different times, outside the structure found in Unit 30. A flotation sample from 31-09 comes from just above the brown compact surface with post holes. This sample is associated with a high density of ceramics, obsidian fragments, lithic debitage, and some carbon. Flotation from the level yielded a maize cupule and a *Crotalaria* sp. seed (not rugose var.). Charcoal amounts were about average.

Overall, with the exception of the floor surfaces associated with the fire pits discussed in the preceding section, the floor surfaces from Sc-J-A did not show the expected increase in diversity and amount of botanical remains compared to other levels. However, this may be due to the fact that most of the surfaces discussed were not securely identified as floors, but rather were compact soil levels which may have been caused by factors other than intentional construction or trampling. At León Viejo, the floor surfaces were more securely identified as such, and flotation did yield some interesting botanical remains from these surfaces. Remains were still not overly abundant, but do seem to indicate domestic use of the inner and outer living surfaces of the household there.

Middens

All three sites had contexts which were classified as middens. These were identified based on an abundance of ceramic sherds, bones, and lithic debitage. Table 6.6 summarizes the locations of these middens.

The midden from Unit 9 at N-MA-36 was predominated by ceramic sherds. Very little bone or lithic debitage was associated with it, and therefore this is not a midden in the truest sense. However, as the level with the most artifacts seen anywhere during the UCA excavations, it is considered in this discussion. The flotation samples from this area had little in the way of botanical remains, other than a chenopodia seed and some unidentified non-wood tissue. Only a trace of wood charcoal was found in this context. The matrix was very sandy, with large round grains, possibly deposited from alluvial action, and it is possible that this soil was detrimental to the preservation of charred remains.

Table 6.6: Summary of flotation samples taken from midden contexts.

N-MA-36 (Unit-Level)	**Sc-J-A** (Unit-Level)	**León Viejo** (Unit-Level)
9-8 to 9-10	14-16	30-17 to 30-18
	18-11	33-07
	18-13	
	23-13 to 23-15	
	25-11 to 25-12	
	25-16	

The midden deposits at Sc-J-A were dense with artifacts. The middens located at 14-16, and 18-11 from Sc-J-A are associated with the two hearths found (10-17.1 and 20-10.1 respectively). A possible maize cupule was found at 14-16, along with some unidentified seeds. Some sugary amorphous tissue, possibly from fruit was found in 18-11, along with some unidentified vascular tissue. The midden at 18-13 contained lots of bone, in addition to ceramics, obsidian, lithic, and visible pieces of carbon. However, only a possible Passifloraceae or Rosaceae seed was found, along with unidentified seeds and other tissues. The midden deposit at 23-13 to 23-15 was a very dense midden with large quantities of ceramics and obsidian debitage, along with other lithic debitage, bone, and visible carbon. In addition, beads, an ear spool, and a urn burial were found within the midden. Flotation samples from this midden yielded seeds from amaranth, portulaca, Malvaceae (cf. *Abutilon* sp.), palm or tree fruit endocarp, a possible Juglandaceae nut, and many unidentified seeds and tissues. The amount of wood charcoal for this midden was slightly above average, but this is not surprising since carbon was visible in the soil. The midden deposit at 25-11 to 25-13 had ceramics, lithic debitage, obsidian, worked bone, and visible carbon. This midden was also disturbed by rodent tunnels, which had artifacts in them. Carbon was visible in the soil, but little wood charcoal was found in the flotation sample. Non-wood remains included legume seeds (cf. *Trifolium* sp.), and a grass seed (cf. *Digitaria* sp.), along with several unidentified seeds and tissues. The midden deposit at 25-16 contained ceramics, bone (some burnt), a bead fragment, obsidian, lithic, including a large scraper, and visible carbon. Other than some unidentified seeds and tissue, only an amaranth seed was identified from this context.

At León Viejo, the midden identified at 30-17 to 18, included the usual assemblage of artifacts. Flotation yielded more than average amounts of wood charcoal, but only a Convolvulaceae or Euphorbiaceae seed, and unidentified seeds and tissue. The midden from 33-07 included Spanish artifacts along with indigenous ceramics, lithics, obsidian and bone. Seeds were collected from the level, but I have not seen these to identify them. The flotation sample had about average amount of charcoal, and the remains of Asteraceae and unidentified tissue.

Despite their use for disposing garbage, most of the identified middens from N-MA-36, Sc-J-A, and León Viejo did not have significantly more amounts of discarded botanical material than normal contexts. Only when these middens were associated with a fire pit was there any sort of increase in material.

RESULTS OF FLOTATION ANALYSES

Rate of Recovery Within Sites

It is expected that flotation samples taken from features would generally have more botanical remains than regular bulk samples taken from non-features. Table 6.7 examines this hypothesis with some interesting results. The information from Table 6.7 is presented in graphic form in Figure 6.4.

Table 6.7: Comparison of botanical material recovery between features and non-features.

Measurement	**Context**[a]	**Site**		
		N-MA-36	*Sc-J-A*	*León Viejo*
Diversity/sample[c]	Features	3.5	3.6	2.2
	Non-features	2.4	4.0	1.7
Diversity[b]	Features	10	49	9
	Non-features	32	60	18
Non-wood Remains[d]	Features	4.5	10.5	3.6
	Non-features	12.0	8.9	3.9
Wood Charcoal[e]	Features	0.75	3.15	0.10
	Non-features	0.01	0.02	0.03

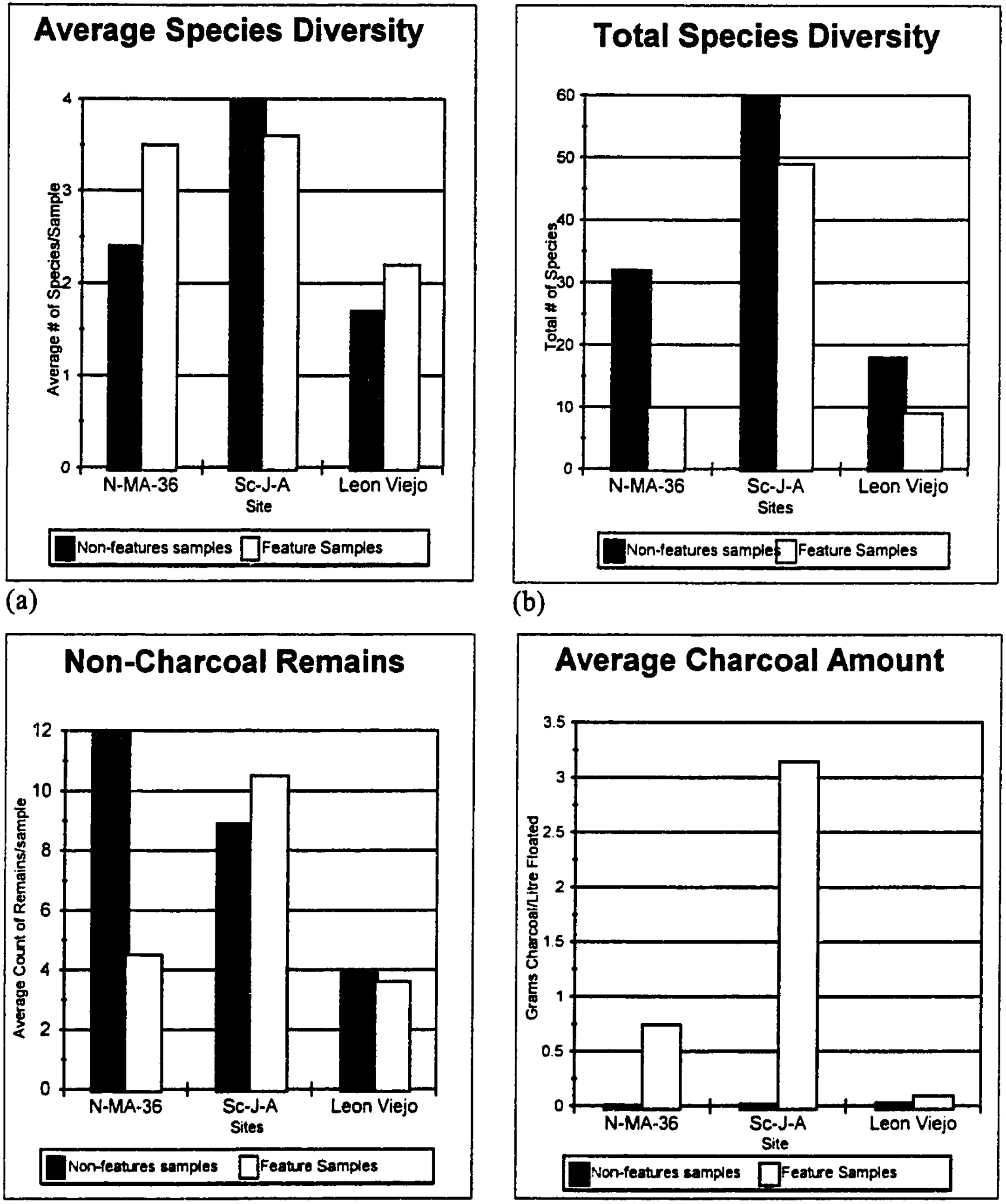
[a] Feature samples includes fire-pit, midden, and floor surface contexts.

[b] Total species diversity, i.e. the total number of different species found in either feature or non-feature contexts.

[c] Average species diversity, i.e. the average number of different species per sample.

[d] Average count of remains, i.e. the average number of seeds and other non-charcoal remains found per sample. (Absolute counts, does not take diversity into account.)

[e] Average amount of wood charcoal, i.e. the average amount of wood charcoal in grams per one litre of soil floated from feature or non-feature contexts.



(a) (b)

(c) (d)

Figure 6.4: Comparisons between feature and non-feature samples: (a) Comparison of average species diversity per sample between feature and non-feature samples, (b) Comparison between total number of different species found in feature and in non-feature samples, (c) Comparison of average number (count) of non-charcoal remains per sample between feature and non-feature samples, and (d) Comparison of average charcoal amounts (g/L of soil floated) between feature and non-feature samples.

Four categories or measurements were used to compare the yield of botanical material from features and from non-features. For the purpose of the comparison, features are considered to be any samples from a fire pit, floor surface, midden, or any sample taken using opportunistic sampling (see Chapter 4). Not all samples which are considered feature samples in this particular analysis were opportunistically sampled. Some were taken as regular bulk samples, but are still considered to be from feature contexts. For example, a midden or floor usually extends across the entire unit, therefore a regular bulk sample taken in the NW quad of the unit would still be part of that midden or from that floor surface.

The first measurement (Fig. 6.4a) used for testing the hypothesis was Diversity, or total species diversity. This analysis tabulated how many different species were found from features, and how many were found outside of features for each site. Some species were found in both contexts. It was expected that greater total species diversity would be found in features as opposed to non-features. All three sites showed the opposite.

The second measurement (Fig. 6.4b) was Diversity/Sample, or average species diversity. Instead of examining the number of different species totaled for feature contexts and non-feature contexts, this measurement calculated the average species diversity per individual sample. Individual samples were grouped as either feature or non-feature, and the average number of different species per sample for each category was determined. N-MA-36 and León Viejo show the expected results, where on average, more species were found per sample in feature contexts. However, Sc-J-A surprisingly showed the opposite trend, where greater average species diversity was found in non-features.

The third analysis (Fig. 6.4c) examined absolute counts of non-wood charcoal remains. The counts of seeds and other non-charcoal remains were tallied for all samples in the features category, and all samples in the non-features category, and then divided by the respective number of samples to obtain a average count of remains per sample. For N-MA-36, the non-feature sample had more remains by far. At Sc-J-A, feature contexts had slightly more remains on average, and at León Viejo, the average amount of remains was almost equal between features and non-features.

The fourth measurement (Fig. 6.4d) looked at the average wood charcoal amount for each group. Charcoal from the light and heavy fraction of each sample was totaled and divided by the total amount of soil floated from each context. This amount is expressed as grams of charcoal per litre of soil floated. Not surprisingly, the feature group of samples from N-MA-36 and Sc-J-A had much greater average amounts of charcoal than non-feature contexts. Fire pits were found at these sites. At León Viejo, no fire pit was found, but charcoal amounts from features is still slightly higher than from non-features. More charcoal on average was found in León Viejo non-features than N-MA-36 non-features. This is not surprising given that charcoal was visible in the soil during excavation of both León Viejo and Sc-J-A, but no charcoal was seen during the excavation of N-MA-36(UCA).

In all four analyses, it was expected that feature samples would yield greater diversity and greater amounts of remains than non-feature samples. In half of the cases, this was true. But in the other half of the cases, non-feature samples had the greater diversity and amounts of remains. This suggests that sampling should not only focus on feature contexts but on non-feature contexts as well, where botanical remains are not thought to be as dense. This issue will be re-addressed in the next chapter.

Rate of Recovery Between Sites

This section looks at comparing the density of botanical material found from each site. Table 6.8 a-c present the index of charcoal density for each sample for each site. This density index was calculated by dividing the weight of charcoal recovered (in both light and heavy fractions) by the volume of the total soil sample, and multiplying it by 10^5. Density ratios measure the amount of botanical material recovered in each sample against the volume of floated soil in order to test assumptions about uniform deposition, preservation, and recovery rates (Miller 1988). Only charcoal was considered in calculating the density ratios for the three sites; seeds and other material accounted for very little of the overall weight of botanical material, and were not included. Wood charcoal is also a good measure of density, because it is found in almost every sample, whereas seeds are not.

The overall average recovery rate for N-MA-36 was an index rating of 4.91, compared to a average of 5.59 from León Viejo, and 162.26 from Sc-J-A. These rates change if the samples from fire pits are removed from the calculations. N-MA-36 decreases to an average of 0.09, León Viejo remains at 5.59, since no fire pit features were found and sampled, and Sc-J-A drops substantially to 14.77. The decreases in N-MA-36 and Sc-J-A were expected because fire pits are concentrated with wood charcoal.

Table 6.8a: N-MA-36 charcoal index by sample.

Unit	Level	Feature	Charcoal Index
5	2		0.0
5	3		0.0
5	4		0.0
5	5		0.0
5	6		0.0
5	7		0.1
5	8		0.0
5	9		0.0
7	3	1	0.0
8	2		1.1
8	3		0.1
8	4		0.0
8	5		0.1
8	5	1	0.0
8	6		0.0
8	6	2	0.0
8	7		0.6
8	8		0.0
8	9		0.0
8	10		0.0
9	2		0.1
9	3		0.0
9	4		0.0
9	5		0.0
9	6		0.0
9	7		0.0
9	8		0.3
9	9		0.0
9	11		0.0
Villa Tiscapa		2	144.4
		average	4.9

Table 6.8b: Sc-J-A charcoal index by sample.

Unit	Level	Feature	Charcoal Index
10	13		0.5
10	14		4.0
10	16		2.2
10	17		6.9
10	17	1	767.5
12	02		52.3
12	08		14.8
12	11		0.0
12	13		0.9

Table 6.8b: Sc-J-A cont.

Unit	Level	Feature	Charcoal Inde
12	16		4.2
14	08		23.8
14	12		3.6
14	14		27.4
14	15		35.4
14	16		8.3
16	10	NEQ	0.5
16	12		1.5
16	15		17.1
16	17		7.0
16	18		39.3
16	18	1	49.4
16	21		9.8
18	11		3.3
18	13		17.8
18	15		81.3
18	16		0.3
20	09	1	1.0
20	10		67.8
20	10	1 East	6713.2
20	14		18.6
23	11	1	8.2
23	12	1	17.2
23	12	2	45.0
23	13		3.7
23	14		38.7
23	15		66.7
23	15	1	18.0
23	15	2	7.8
23	17		5.1
23	19		2.4
25	08		5.9
25	11		10.3
25	12		11.6
25	13		15.0
25	16		10.8
60	04	B	0.9
60	04	D	22.2
60	04	F	3.8
60	05	F	0.3
60	06	B	0.0
60	06	D	0.0
		average	162.2

Table 6.8c: León Viejo charcoal index by sample

Unit	Level	Charcoal Index
30	04	2.6
30	10	n/
30	14	0.3
30	15	27.5
30	17	28.6
30	18	21.2
30	19	1.9
31	04	1.0
31	09	5.0
31	11	5.1
31	12	4.2
31	13	0.1
31	14	2.6
31	15	0.2
32	10	2.2
33	02	0.0
33	07	1.1
33	08	0.1
33	09	1.9
	average	5.5

Even when the distortion of fire pits are removed from the calculation of density averages, results from Sc-J-A again demonstrate that this site was more dense with botanical remains than León Viejo and N-MA-36 (Fig. 6.5). Principal sampling and flotation methodology was kept the same for each of the sites, therefore this should not have had a drastic effect on recovery. This density may be due to natural preservation factors (soil type and fragmentation), but is more likely due to cultural factors. Sc-J-A was known to be very dense with artifacts, and have signs of human habitation including architecture, living surfaces, and middens. The UCA excavations at N-MA-36 had a paucity of artifacts, and no architectural features. The overall charcoal density per site corresponds with other archaeological measures of occupational intensity and activity for each site.

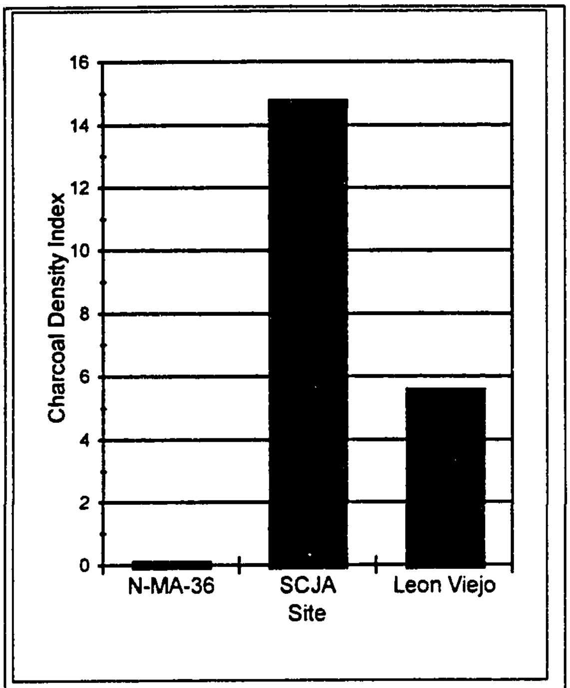


Figure 6.5: Comparison of average charcoal density between sites (excluding hearths).

Overall, some amount of charcoal was found in virtually every sample from Sc-J-A and León Viejo (see Table 6.8a-c). Sometimes this amount was very small, but was present nonetheless. At N-MA-36, charcoal was not found in every sample (although many of the zeros in Table 6.8a represent trace amounts of charcoal that were not measurable, and therefore were reported as zeros). Despite this, the presence of at least some wood charcoal at every site shows that preservation of macrobotanical remains does occur in this area. Where charcoal is preserved, other plant materials will be preserved. Recovery studies have shown that there is adequate preservation of wood charcoal at the sites to expect other types of botanical material to be preserved. While no recovery testing was carried out on the flotation system itself[3], the recovery of wood charcoal from most levels indicates there is preservation of charred material at the sites, it is being recovered by flotation, and enough soil is being floated from each context.

SUMMARY

The results of flotation have been presented. These are divided into results of archaeobotanical analysis and results of recovery analysis. The archaeobotanical analysis has shown that a total of 36 species were identified or tentatively identified from the three sites. A few of these were charred modern specimens, but the majority appear to be archaeological. Ubiquity calculations showed that *Crotalaria* sp./rugose var. was so ubiquitous that it was likely modern. Most species showed low ubiquity, being found in only a few samples. Of the remains considered archaeological, *Chenopodia* sp., Amaranthaceae (S20), *Portulaca* sp., *Talinum* sp., and *Zea mays* were the most ubiquitous. A comparison between northern and southern sites shows that a greater number of species are found in the northern sites, while a smaller number of species found in the southern site are more ubiquitous in that site.

An organization of the data by provenience did not show any strong temporal patterning. This is not surprising considering the mixed stratigraphy at N-MA-36, and the relatively short time depth of Sc-J-A and León Viejo. More botanical remains were present at Sc-J-A during the pre-Columbian periods, whereas more botanical remains

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[3] Recovery testing usually involves a test called the "poppy-seed test". A known number of poppy-seeds are mixed in with a sample and the number recovered is used to comment on the effectiveness of the flotation system and sorting procedures.

were found at León Viejo during the colonial period. These results corresponded to the density of occupation, based on other cultural remains. An analysis of features showed that hearths and their surrounding floor surfaces had lots of botanical remains. Similarly, middens had some interesting remains, mostly as a result of the depositing of fire pit ashes, or household garbage.

The second section of this chapter examined the rate of recovery between features and non-features within sites. Surprisingly, features were not always more rich with botanical remains than non-features, especially in the category of diversity. Comparison showed that bulk samples are just as important as feature samples for recovery of remains. Lastly, recovery between sites was analyzed. As was shown by ubiquity and provenience analyses, the rate of recovery of botanical material corresponded to the density of occupation, as demonstrated by other artifacts. Sc-J-A showed dense occupation, and had the best rate of recovery of the three sites, whereas N-MA-36 had much less artifacts, and had the lowest rate of recovery of archaeobotanical remains. However, archaeobotanical remains were found at every site, and nearly every level, demonstrating that botanical material does preserve in this part of the neotropics.

CHAPTER 7
DISCUSSION

INTRODUCTION

This study was the first of its kind in Western Nicaragua. While flotation did not yield large amounts of remains from the Lake Managua area, several interesting species were found. This demonstrated that there is archaeobotanical information to be found in this region of the world, if one looks for it. From this research, recommendations can be made to improve future paleoethnobotanical studies in Nicaragua, and inspire researchers to include the collection of macrobotanical remains in their excavation plan.

This chapter attempts to bring the results of the paleoethnobotanical research done in Nicaragua into a broader context. The first section examines the remains found and the information they can provide to answer the original research questions of the thesis. These questions were: 1) Is there botanical evidence of agriculture in the Lake Managua area prior to the arrival of the Spanish (to corroborate ethnohistorical and artifactual data), and if so, what importance did agriculture have in pre-contact and contact Nicaraguan subsistence? 2) What was the nature of human adaptation to the lake basin area, in terms of the human relationship with plants?

The second section of the chapter examines the methodology used and problems encountered during the research. This is used to address the third research question of the viability of flotation as part of a paleoethnobotanical investigation in a neotropical context. The chapter concludes with recommendations to improve methodology for future research projects.

THE BOTANICAL REMAINS

Appendix C presents a description of each recovered taxon, its common uses, and its occurrence at the sites.

Economic Species

Out of a total of 36 species identified or tentatively identified, two (possibly five) are considered agricultural domesticates. Domesticates are defined as plants which have been genetically altered through their interaction with humans and do not normally exist outside of human cultivation. These are *Zea mays*, *Phaseolus* sp., and possibly *Sechium edule*, *Ipomoea* sp. (if it is *Ipomoea batatas*), and a possible Cucurbitaceae species. Several other species found or possibly found from the Lake Managua area are cultivated today or have ethnographic documentation of being cultivated. Cultivation is defined as the active tending and encouraging of certain economical species of plants, but these plants have not been genetically altered and survive in wild populations. Amaranthaceae, *Acrocomia* sp., *Juglandaceae* sp., *Passiflora* sp., *Portulaca* sp., Sapotaceae, and an unidentified tree fruit are considered cultivated or encouraged species, or have cultivated members in their families, but were not domesticated in prehistory. An unidentified species of *Chenopodia* was found as well. Depending on the species, it may be a domesticate, a cultivated species, or simply a wild species. Two species of *Chenopodia* are considered domesticates (*C. berlandieri* ssp. *nuttalliae* and *C. quinoa*), and another has not been found outside of domestication (*C. pueblense*), but the majority are wild or cultivated (see Appendix C).

The following is a discussion of each of the economic species found. They are divided into domesticated species, cultivated or encouraged species, and gathered species. Many of the species identified do not fit neatly into any one category, as exemplified by the discussion of *Chenopodia* spp. above, particularly when identifications have not been made to the species level for most specimens.

Domesticated Species

Agriculture in the Lake Managua area is evidenced by maize (*Zea mays*) remains in the form of cupules and possible kernels. No cob fragments were found. The presence of solid botanical evidence of maize in Nicaragua is the first for this country. Both ethnohistorical accounts and artifactual evidence suggested that maize was an important crop in this area at Contact. There is now botanical evidence from this study to support this. The positively identified cupules were measured according to the measurements set out by Bird and Goodman (1977), but no definite assignment to race was possible because of the limited number of remains, and the lack of cobs. Therefore I can make no comment in support or against the infiltration of Mesoamerican or South American varieties of maize into Central America.

Possible bean (*Phaseolus* sp.) cotyledons were also found. Their identification is tentative however. If these remains are in fact beans, it is not surprising that they were found in the same site, and even the same context, as maize. These two crops are well known to compliment each other both agriculturally when growing, and nutritionally when eaten. Possible evidence for the third part of the Mesoamerican triad of crops, squash (Cucurbitaceae), was also found from Sc-J-A, but this evidence is very tentative. A rind fragment was found, and this may have been from a domesticated or wild species.

The species of *Ipomoea* found was unfortunately not identified to species, although the size and morphology of the seeds were within the range of *I. batatas*, the sweet potato. This species is believed to have originated in South America, and is the only economic species of the genera. No charred tubers were found to lend evidence to this identification, but charred sugary tissue was found, which may have been from tree fruit, or from sugary tubers such as those produced by *I. batatas*. Unfortunately this charred tissue was in small fragments and eroded, and therefore unidentifiable. No other evidence of root crops was found in the flotation samples.

Chayote (*Sechium edule*) is a well known Central American vegetable. It occurs in the wild, but is more commonly found as a domesticated variety under cultivation today. Similarly, it was probably cultivated in western Nicaragua in the past for its squash-like fruits. Shoots, flowers, and roots are also edible, and may have been used. The archaeobotanical remains found are very tentative, so it can not definitely be said that it was a domesticate, or even that it was grown at Sc-J-A for food. If it was, it would have likely been cultivated in a door-yard garden along with other fruits and vegetables.

Cultivated or Encouraged Species

Amaranthaceae, *Chenopodia* sp., and *Portulaca* sp. present an interesting case as economic species. They are all closely related, and all have ethnographic and ethnohistoric evidence for use as food crops. Certain members of Amaranthaceae, Chenopodia, and Portulaca are considered domesticates, but they are discussed under this section on cultivation because identifications were not made to species level, and therefore it cannot be safely said if the specimens found in Nicaragua represent domesticates. In modern times these plants have been documented being used as grain crops and as pot herbs. There is evidence from Mexico that certain *Chenopodia* and *Portulaca* species were cultivated in the past as grain crops. Wild species were gathered for food. If the seeds found at the sites in Nicaragua are culturally deposited, it is possible that these seeds were cultivated or gathered from the wild for food. *Amaranthus*, *Chenopodia*, and *Portulaca* also had important religious significance in Mexico. The paste from these seeds was used to make dough figures for use in religious ceremonies (Sahagún 1570, see Appendix C). It is impossible to say whether there was religious significance associated with these plants in Nicaragua as there was in Mexico, but because of the pre-colonial migration of Mesoamerican groups into the Managua region, this possibility exists. However, as far as I know, the ethnohistorical accounts for Nicaragua do not mention these plants, nor any sort of ritual figures made of dough.

Coyol palm (*Acrocomia* sp.) was an important food source throughout Central America. There is considerable evidence of its use, both ethnographical and ethnohistorical. There is also archaeobotanical evidence for the use of coyol from other sites in Central America. The palm fruits were collected for their nut meat, which was highly nutritious and rich in oil. Ethnographic accounts also show the use of coyol for making palm wine. *Acrocomia* palms grow in dense stands, and are adapted to growing in disturbed areas, such as cleared fields. It is likely that these trees were actively encouraged and cultivated, and that the harvest of palm nuts was an important component of the diet. Smith (1980) believes that the palm fruit found at Pitahaya in Panama represents intentionally encouraged and cultivated trees, rather than gathered from the wild.

Other potential tree fruit and nuts were found as well, including possible walnut (Juglandaceae), zapote or nispero (Sapotaceae), and unidentified tree fruit endocarp fragments (all are tentative identifications). It is likely that tree crops were an important part of the diet at these sites.

Passion fruit (*Passiflora* sp.) is another species that may have been collected or cultivated. Several species are wild and have small fruit not well suited for eating. But several have larger fruits, and would have likely been also grown in a garden plot, similar to *Sechium edule*.

Gathered Species

Other potentially economically useful species were tentatively identified. There is ethnographic evidence that some species of *Crotalaria* are collected and eaten as pot-herbs. Standley and Steyermark (1946) report seeing bunches of *Crotalaria* for sale in local Guatemalan markets. Several species of *Crotalaria* are also excellent fodder crops. While the indigenous people did not have livestock prior to the Spanish arrival, it is possible that the Spanish may have collected *Crotalaria* for their livestock at León Viejo. Several unidentified grasses were found in the flotation samples, and the seeds of some of these may have been gathered as food, the grass used for fodder by the Spanish for their animals, or the grass used in construction (making mud brick or for thatching). A possible Rosaceae seed was found. Several berries belong to the Rosaceae, and if that is what the remains are, it would suggest either cultivation or collection of wild foods. Possible evidence of *Abutilon* sp. was found. Several species of this genus produce long tough fibres in their stems, which are used in parts of Central America for making cordage, according to Standley and Steyermark (1946).

Many of the species tentatively identified also have medicinal properties or are used in local remedies (Standley and Steyermark 1946, 1949). For example, *Hibiscus* is used to treat snake bites, as well as colic in some regions. Some species of *Acrocomia* are used medicinally. *Chenopodium ambrosioides*, known as Mexican wormseed, is commonly grown in Panamanian gardens today as a medicinal plant, used to treat intestinal parasites, and also as a sleep inducer and for poultices (Standley and Steyermark 1946). And *Crotalaria* is used in some regions to treat insomnia, as a purgative, and for other uses.

Alcoholic beverages are made from maize and coyol palms in many parts of Central America, and such beverages may have been made in the past as well. Other tree fruits also have the potential to be made into fermented beverages. In Central America, as with the Mesoamerican area and South America, alcoholic beverages play an important role in social and religious festivals, and may have done so in the past as well. Strong evidence of this comes from Belt (1874) who describes the technique of making palm wine among the Indians in Nicaragua. He writes that a large grove of coyol palms near Granada were cut down by the government due to the "excesses of the Indians, who use to assemble there on their festivals, and get drunk on the palm wine" (Belt 1874:232). These plants and others are discussed more fully in Appendix C.

Patterns of Plant Use

Large quantities of remains were not found, and of those found, no one species pre-dominated. Interpretation is difficult to make based on such small amounts of remains. However, the species represented suggest that subsistence was based on a variety of plants, and was not dominated by any one system of procurement, or any one type of food. From flotation, there was evidence of seed-crop agriculture, garden-plot horticulture, fruit-tree harvesting (probably from both wild sources and encouraged stands), and possible collecting of wild resources. These systems are extrapolated from how individual species grow and are harvested in ethnographic and ethnohistorical cases. For example, maize is a domesticate, reliant on humans for reproduction. It is usually grown in fields as a staple crop, and is therefore classified as part of a seep crop agriculture subsistence system. *Sechium edule*, on the hand, is normally found growing in small horticultural plots or in door-yard gardens. Fruit trees are sometimes planted in door-yard gardens, or grow wild or in encouraged stands in the forest. The wide diversity of economical botanical remains indicates a diverse subsistence base.

In the Lake Managua area from approximately A.D. 800 to 1600, there is a mix between the traditional seed agriculture and crops associated with Mesoamerica, and the use of palm and tree fruits, suggestive of a horticultural garden-plot system associated with South America.[1] However, I do not mean to suggest that seed agriculture came from the North, and tree fruits and root horticulture came from the South, to be blended in Central America. This is a very simple view of plant-use patterns that does not do justice to the apparent complexity and local development of the subsistence strategy used by the inhabitants of the Lake Managua basin.

There were likely influences from outside Nicaragua with the introduction of crop species, particularly from Mesoamerica. Ethnohistorical and linguistic evidence indicate several migrations of Mesoamerican groups into the area during the Sapoá and Ometepe periods (A.D. 800-1520). It was formerly believed that these people (the Chorotega, and later the Nicarao) brought their customs with them and heavily influenced the culture of those living in the area. This popular view has begun to change somewhat (Lange 1992). Based on study of ceramic types and style, lithics, iconography, and other cultural characteristics, it seems this influence did not occur only in one direction. The new settlers were heavily influenced by local traditions, as much or even more than they influenced the surrounding cultural landscape. Similarly, their use and interaction with plants in the Lake Managua region of Nicaragua relied on knowledge of local resources. Certain farming practices, and different values associated with certain crops may have been introduced to the area, but the new populations also adopted local resources, and the different economic values associated with these resources.

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[1] Root crops are also commonly part of the horticultural garden-plot system associated with South America. Other than *Ipomoea* sp., root crop species were not obvious in the assemblage, but this does not mean they were not part of the diet. Root crop remains often do not preserve.

One might assume that these Mesoamerican migrants brought their familiar crop plants when they came, and introduced them to the area. However, evidence from Costa Rica and Panama show that the crops most often associated with Mesoamerica (maize, beans, and squash) were being grown in Central America since 1000 B.C. (see Chapter 3). The Central American isthmus was an important channel for many early domesticates north and south (Stone, ed. 1984). There is even strong evidence that one type of squash, *Cucurbita moschata*, was domesticated in Lower Central America (Piperno and Pearsall 1998). These crops existed in Lower Central America long before the Mesoamerican migration; they were definitely not introduced by it. It is possible that the Mesoamerican influence changed agricultural patterns, or introduced new varieties. But these people were just as influenced by local culture, and perhaps more importantly, by local environment and resources.

The presence of tree and palm fruit reveals that there was an important interaction and adaptation to the deciduous tropical forest environment in which the indigenous people lived. The inhabitants of the sites around Lake Managua lived in a rich environment, with high agricultural potential, but also with deciduous tropical forests with an abundance of economic species. Rather than completely clearing these trees for agricultural fields, I hypothesize, based on the remains found, that Nicaraguans living from approximately A.D. 800 onwards until A.D. 1600 used both cleared field agriculture and managed forest silviculture, along with small door-yard gardens, to procure their food.

This mixed exploitation model fits with faunal data as well. Although faunal analysis has not been completed for Sc-J-A and León Viejo, initial impressions from these sites show animals from a wide variety of habitats being exploited. Deer would have been attracted by secondary growth associated with garden plots and fields. They may have even been intentionally encouraged and managed by the inhabitants (Linares 1976). Large amounts of fish bone and some turtle bone were found from lacustrine environments. And species such as peccaries, which prefer a more forested environment, were also possibly used.

Comparison to Other Sites in Central America

This section sets out to look at the remains found from Nicaragua in the broader context of Central America, and the botanical remains recovered at other sites.

The closest project to Lake Nicaragua for which paleoethnobotanical analysis has been done is the Arenal project in Costa Rica. Like the Lake Managua sites, the Arenal region lies just on the border of the Greater Nicoya Subarea, and is an inland site. Most of the sites in the southern section of the Greater Nicoya area are located near the coast (mostly in Guanacaste and Nicoya, north-west Costa Rica), and subsistence data shows that these sites were focused primarily on marine resources (Lange 1984a). The Arenal region is located in the highlands, and has a freshwater lake (Lake Arenal), and nearby volcano. Other than being at a higher elevation, the Arenal sites share many geographic similarities with the Lake Managua sites. At Arenal, Matthews (1984) found that the most frequently occurring cultivar was corn. Beans, avocado, and possible palm, jícaro, and other legumes were also found. She suggests a mixed tree crop, vegeculture, and seed agriculture subsistence strategy. Gathered resources became less important over time (Mahaney *et al.* 1994), but maize never dominated the diet, according to stable isotope studies. Mahaney *et al.* (1994) propose that tuber crops were important in the diet but are poorly represented in the botanical assemblage. Remains of avocado and jícaro were not found at Lake Managua, but it is probable that they were used. The mix of species found at Lake Managua sites is comparable to the mixed subsistence strategy proposed by Matthews (1984). With further work, regional differences would be refined.

Salitron Viejo and Yarumela in central Honduras showed a mixed subsistence strategy (Lentz 1989; Lentz *et al.* 1997). Like Arenal, maize was the most common species found in the samples, but other economic species such palm fruits and gathered species were important resources. Lentz *et al.* (1997) draw the conclusion that the economy here was based on an amalgamation of seed-crop agriculture, root-crop agriculture, and fruit tree exploitation.

Farther south, in the highlands of Panama, carbonized plant remains from Chiriqui rockshelters show the use of corozo palm, nance, and algarrobo from 4000 B.C. to 500 B.C. This is a much earlier time period than is represented in the sites from Lake Managua. These remains are from palms and fruit trees which were harvested in the wild, although some tending may have taken place. There is little evidence of selection for larger fruit size at these highland sites, unlike the site of La Pitahaya on the coast where it appears palm trees were brought under cultivation (Smith 1980). Trees tend to be unsuitable for domestication, because of their slow rate of maturing (Linares and

Ranere 1980). Later in the Chiriqui highlands, settlement took the form of villages rather than in rock shelters. Linares *et al.* (1975) found that a strong maize-bean agricultural complex was present around A.D. 400-600, but that these crops did not dominate the diet. Palm fruit, avocado, algarrobo, and possibly sweet potato were also found, along with artifactual evidence suggesting manioc processing (Smith 1980). This indicates to Linares *et al.* (1975) that sites around Volcán Baru in highland Panama had a diversified, predominantly agricultural economy during this time, with tree fruit remaining important in the economy, particularly in lower altitudes.

The coastal sites of Panama, in what is now the Santa Maria drainage area, had a surprising lack of botanical remains (Smith 1980). Maize was not as common as it was in more inland sites. This is interpreted to indicate that the inhabitants of these sites were dependent on marine resources rather than agriculture (Ranere and Hansell 1978).

Unlike many of the coastal sites in Costa Rica and Panama, the sites studied in Nicaragua were inland, on the shores of a freshwater lake. Faunal analysis for Sc-J-A and León Viejo is not complete, but as of now, no evidence of marine foods in the diet have been found. Reliance was on inland or lake resources, from hunting, fishing, collecting fruits and plants, and growing agricultural crops. Yarumela, Salitron Viejo, Arenal, Severo Ledesma, Barriles, and Cerro Punta are also situated inland. Data are not overwhelming, but many of these sites show a subsistence economy based on a variety of strategies, not just maize agriculture. A lot of emphasis is often put on maize agriculture in literature on the prehistory of Central America, at the expense of other subsistence strategies it seems. This is a factor of the artifact assemblage (such as manos, metates, and comals), and the preservation qualities of maize and other seed crops versus tree fruit, gathered plants, and root crops. Of particular note at all the inland sites mentioned, the harvesting of tree fruits is evidenced. The role of palm fruit is receiving more attention in the paleoethnobotanical literature, as it should. It is interesting to note that at the Lake Managua sites, as with other Central American sites, pestles (or nutting stones) used in the processing of palm fruit, are just as common as metate and mano fragments. Palm fruit was an extremely important part of the diet in many parts of Central America.

Most paleoethnobotanical studies in Central America report low or disappointing returns of material from flotation. As well, virtually all researchers commented on the problem of modern seeds being mixed in the sample in some way. Despite these problems, botanical material is present at nearly every site. I turn now to look at the rate of recovery at the Lake Managua sites, and make suggestions to improve this rate.

ASSESSMENT OF FLOTATION

A major component of this research was to investigate the potential for flotation studies in Nicaragua. Generally there seems to be an assumption that flotation is not worthwhile in Nicaragua, and will yield poor or no results. An assessment of flotation and the remains recovered is provided, and recommendations are made for improving flotation studies in the future.

Recovery of Remains

Many factors must be taken into consideration when making the judgement of whether flotation is a valuable thing to do in a specific area. Even though some remains were found, the amount floated and the time and energy input may not be worth the returns. This part of this discussion examines the quality and quantity of material recovered, and attempts to address the question of whether macrobotanical studies are worthwhile in Nicaragua, and in the tropics in general.

Quality

Very few remains were found from the Lake Managua sites, and of the remains that were found, most were unidentified or only tentatively identified. There are several reasons for this. First, this low rate of identification was in part a result of my unfamiliarity with botanical material, and my inexperience in identification. Second, the remains were quite eroded and fragmented compared with other sites (Lentz, personal communication). This eroded state may have been caused by depositional factors, or flotation wear and tear. All identifications were assigned a confidence rating from 1 to 4, with 1 equalling 100% confidence, and 4 representing about 50% confidence. These confidence ratings are important, since mis-identification can lead to faulty conclusions. However, tentative identifications also make for weaker conclusions. Any paleoethnobotanical study is fundamentally based on accurate identification of the remains found. Without identification of these remains, little can be said regarding any aspect of human-plant interaction.

Depositional factors affecting the quality of the remains such as alluvial action, tectonic action, or the nature of the matrix (acidic, granular, wet and dry, etc.), are uncontrollable factors. There is little that can be done to improve the condition of the remains as they come out of the ground. The best that can be done is to understand the geomorphology of the site and the soil types encountered, and determine how this will affect preservation. The upper level soils at the UCA excavation were very clayey, but the lower soils were large grained and sandy, deposited by alluvial action. Both types of soil are detrimental to botanical preservation. Clay soils tend to fragment remains, because of the expansion and contraction caused by wetting and drying. This cycle of wetting and drying in and of itself is also detrimental to charcoal, and causes it to shatter and fragment. As well, charred material mixed with sand will also fragment and erode rapidly. As a matrix, sand can shift and grind together, causing further fragmentation of charred remains. However, sand drains well and does not allow the remains to be water logged for long periods of time. Soil acidity is also a major factor in preservation of organic material. Unfortunately, no pH tests were done on the soils from the Managua sites, so I do not know how acidity or alkalinity may have affected preservation. The soils at Sc-J-A were generally loamy clay, with some variation between units and levels. This loamy clay seems to have been better for preservation of material. It was fairly well drained, but not granular enough to break up charred material. León Viejo had a variety of soils, but generally the soil matrix around the cultural levels was also a loam type soil.

Tropical soils are typically viewed as poor soils for preservation, and this is one of the reasons often given for the dearth of botanical studies in the tropics. Tropical soils do present some challenges, particularly in areas where rainfall is higher. However, tropical soils are not all the same. There is great variation in soil types throughout Central and South America, and soil types need to be analysed at a local level to evaluate their relationship to preservation of organic material.

Unlike depositional factors, fragmentation and erosion caused by recovery methods such as sampling, storage, and flotation are controllable. Recommendations can be made to improve recovery and maintain as best as possible the state of the botanical remains as they were preserved in the ground. At the Nicaraguan sites, samples were 'chunked' out before excavation on a level began, in order to prevent trampling as much as possible, and to prevent potential remains from passing through the field screen. Bags were not piled on top of one another, and the soil was not permitted to dry out too much.[2] The light fraction was trapped in a cloth rather than a metal geological sieve in an attempt to prevent abrasion of the remains. During processing, the light fraction was passed though one sieve to split it into two parts. This sieve was metal, and care was taken to be as gentle as possible with the remains during this procedure. Despite these precautions, erosion of the remains was still a factor in identification. Some further recommendations are made below to combat this problem, but it is possible that the fragmentation and erosion of the specimens is a result of depositional factors, and therefore not controllable. The remains may in fact be in the best condition that can be retrieved.

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[2] Pearsall (1989:50) suggests that soil should in fact be completely dried out before flotation. She does not give a complete explanation, other than to say that it is widely recognized that dry soil is better for flotation. It may be that if the soil, and hence the remains, are drier, they will float better and more will be captured in the light fraction cloth.

Quantity

Very few remains were found from flotation in the Lake Managua region. Any meaningful quantification and statistical analyses were virtually useless. There was not enough material to show importance of any species over others, nor the change in importance over time. At the UCA excavations of N-MA-36, this was a product of a sparse site. Sc-J-A and León Viejo had more remains, and much denser occupation, but remains were still limited. Not enough samples were taken from Villa Tiscapa to provide a basis for comparison.

Mahaney *et al.* (1994) wrote that after the first attempt at flotation for sites in Arenal, Costa Rica, it was decided that macrobotanical analysis would be excluded from any future paleoethnobotanical studies for the site. In their evaluation of the rate of recovery, flotation did not yield adequate results to make it efficient. This was a judgement made by Mahaney *et al.* (1994) based on preservation of the macrobotanical remains, and the information which could be obtained through other paleoethnobotanical methods such as pollen and phytolith studies. They felt that these latter microbotanical analyses could provide as much information as flotation, and more. Similarly, at Costa Purraja, Hoopes (1994) was surprised by the lack of non-wood macrobotanical remains, despite the careful processing of samples, and the preservation of wood charcoal. He does not, however, make any comment as to whether he feels flotation is still a viable method of paleoethnobotanical analysis. Like Mahaney *et al.* and Hoopes, Lentz *et al.* (1997) found that the rate of return from flotation at the Yarumela site in Honduras was less than outstanding. However, they believe that "meager as the paleoethnobotanical record may be, much can be learned about the Yarumela inhabitants in terms of their environmental extractive preferences, subsistence habits, and interactions with external cultural spheres" (1997:71). An evaluation of flotation effectiveness was not provided in any other study from Central America.

Both the Arenal project and the Yarumela project floated between 0.5 and 2.5 litres of soil per sample. The flotation samples from Nicaragua were 4 to 8 litres of soil. This amount of soil did yield more remains than the previously mentioned projects, but the quantity of remains was still minimal. Pearsall (1995:116) recommends adjusting the amount of soil floated per sample in the tropics until at least 20 pieces of wood charcoal are present in each test sample. The amount of soil required in order to recover what Pearsall would call sufficient remains would take weeks more work in the field, and months more in the laboratory. As it was, based on rate of recovery, my sample size was not large enough, and yet I did not have enough time to finish floating all of the samples I hoped to.[3] Possibly with more organization and experience, things would move more quickly and the process would be more efficient. But it would still consume a large amount of time.

Another factor to consider when examining the viability of flotation in Nicaragua is the state of archaeology in the country. The archaeology of Nicaragua is still in its infancy, and researchers here are still deducing the basic ceramic chronology and culture history of the region. Some excavations, such as UCA, are in fact salvage archaeology, to be done as efficiently and quickly as possible. The realities of funding, field work, and

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[3] This was in large part also a result of mechanical problems with the flotation system.

limited time and resources must be considered. Paleoethnobotanical studies are typically not a high priority for a project with insufficient funds and little time, especially if the rate of recovery is expected to be low.

Evaluation

Despite these arguments against flotation, I feel that it is worthwhile and important to do as part of paleoethnobotanical studies in Nicaragua. This study demonstrates that macrobotanical remains exist in archaeological sites in Nicaragua, and that these remains provide useful information about subsistence, construction, possibly medicine, agricultural practices, and environmental adaptation. Solid botanical proof of maize and palm use was found. Prior to this, maize agriculture and palm fruit harvesting had been assumed based solely on artifactual, ethnohistorical, and contextual (i.e. other sites in Central America) evidence. Possible evidence of other grain and tree fruit use was also found. This gives an indication of a complex subsistence strategy which made use of both cultivated and gathered resources. Other remains found provide hints as to the use of plants outside of subsistence.

In addition, this flotation study from the Lake Managua region confirms that botanical remains do preserve in tropical soils, contrary to some archaeologists' beliefs. There has been a tendency to assume that these remains are not present and therefore not worth looking for. These remains are present, albeit in less abundance than would be ideal. Although the rates of return were not exceptionally high, and considerable amounts of work were needed to extract the small amount of remains found, I believe that the information obtained was worth the time and energy spent. Future studies will be able to build on these results.

Recovery rates may be improved through adjustments in flotation strategy and methodology. Studies such as this provide experience and help formulate recommendations which will help improve future research design, so that an optimum and efficient recovery is facilitated. Recommendations are made below in order to improve extraction and analysis of botanical remains. Methods such as pollen analysis and phytolith analysis should be used in concert with macrobotanical recovery, to optimize the information gained from Central American sites. Ideally, all types of botanical remains should be recovered to provide the best possible picture of plant use in the past. Isotopic analysis of human remains would also assist in the reconstruction of past subsistence patterns.

In terms of paleoethnobotany's place in the developing archaeology of Nicaragua, I believe strongly that it is an integral part of understanding the prehistory of the area. Paleoethnobotany should not be considered a "luxury" study, done only after basic chronologies and culture histories are created. It is fundamental to understanding the past, just as much as ceramic, lithic, or faunal analyses. Nicaragua as a region is extremely important in terms of understanding the prehistory of Central America. And it is integral to understanding the relationship between the two most socially complex areas in the New World. In particular, Central America provides not only the connecting conduit between these areas, but also unique environments and cultural traditions.

Paleoethnobotany is fundamental to understanding the prehistory of the people who interacted with these environments, and lived within these cultural traditions.

Recommendations for Future Research

Sampling

I did not participate in sampling from Sc-J-A, León Viejo, or the Villa Tiscapa excavations of N-MA-36. In all three cases, I believe additional sampling would have improved this study. During the actual floating of remains in the field, I was unable to finish floating the samples I had, so the question is raised, why take additional samples? It is better to take too many float samples and not have the need to float them all, than to take too few and wish later that samples were available from certain contexts.

At Villa Tiscapa, only one sample from a fire pit was taken. Samples from outside this feature would have provided important background data; for example if certain types of remains were only found within the hearth, or if they were part of the background seed rain. Villa Tiscapa also had interesting architectural features, including the earliest floor found in Nicaragua. No samples were taken from above or around this floor, despite the potential for remains. Similarly at León Viejo, some possible living surfaces did not have flotation features taken from them.

Samples were not taken from every level in Sc-J-A. Of particular concern is that for many levels in which carbon was visible and collected during excavation, flotation samples were not taken. A combination of blanket and feature sampling provides the best results, especially when excavators are coming down on a floor that they may not realize is there. With blanket sampling, even if a feature sample is not taken off the floor surface, the regular bulk sample from the level will usually be close to the floor surface. Blanket sampling also gives a background record against which to evaluate the yield of feature samples.

Ideally, flotation should be done for every site and every level. If resources and time are extremely limited, the excavator may need to make a decision whether to take samples or not. In such a case, flotation should be done where charcoal is visible in the matrix. This indicates that preservation conditions are sufficient for remains to be found. If architectural features are present, flotation should also be done at the site for all levels.

Contamination

Modern uncharred seeds were found in many contexts, despite efforts to take careful samples and minimize contamination. Several possible reasons for this contamination have been mentioned previously. They are briefly reiterated here.

Modern seeds can be blown in to a unit, or into the flotation system by the wind. Modern seeds are also carried into units on excavators' boots and clothing. A major possible source of contamination was rodent activity. Sc-J-A and León Viejo both had evidence of rodent burrows, some of which were still actively used. A snake burrow was found in Sc-J-A Unit 14. Modern seeds are brought to lower levels by the activities of these animals. Earthworms and insects also may aid in the dispersion of modern seeds and botanical material in lower levels.

Modern charred material was often the result of field burnings. Context sometimes helps to determine if the material is modern or not. For example, a large variety of charred seeds and material was found in Sc-J-A 12-02. This was a shallow level showing a burned area, and this particular level lacked significant cultural remains, not only in this unit, but in other units as well. Based on this information, it is fairly safe to assume that this context and the material found there represents a recent slash-and-burn episode. At N-MA-36 (UCA excavations), the stratigraphy appears to be very mixed. Therefore it is difficult to determine if contamination exists and to what extent it is present.

The ubiquity of certain species, and the discovery of Old World species, also raise suspicions regarding contamination. Even when these species are charred, and found in deeper levels, they have the possibility of being modern. *Crotalaria* sp./rugose var. was found in almost every context, despite its appearance of being charred. I am at a loss as to explain how this seed type was so prevalent. It does not appear light enough to be wind-borne.

Contamination seems to be a reality in every paleoethnobotanical study. It is difficult to control for natural sources of contamination; however, features such as animal burrows should be marked, mapped as best as possible, and avoided when taking samples. Cultural sources of contamination are easier to control. If field burning is a problem, samples should not be taken until well below plow zone. If flotation samples are taken from the first few levels of an excavation, they should be ranked as low priority and marked as possibly contaminated.

The sampling procedure used for this study involved taking a sample from each level prior to excavation. The surface was scraped in an attempt to remove any contaminants. I feel that if this method was done with enough care that contamination should not have been a problem. However, an alternative sampling method would have been to leave a column of soil in one of the corners of the unit and then to have taken this column out level by level at the end of the excavation. From experience on other excavation projects where this technique has been used, I found that the soil dries quickly in this column, which makes it very difficult to remove. Alternatively, a defined block of soil may be removed from each level as it is excavated (for example, 25 x 25 x 10 cm in the NW corner). Because the soil is in a defined block, it in essence forms a column sample, but is removed level by level. This reduces the surface area exposed to contamination to a minimum. Other recommendations are to make sure that the bags and the trowel used for taking the sample are clean. The flotation system should be covered when not in use to prevent stray wind-borne debris from falling into the tanks.

In the end, it is probably impossible to eliminate all contamination. It is important therefore to be very aware of all possible sources of contamination, try to minimize their impact on the paleoethnobotanical study as much as possible, and account for all potential sources in the written report.

Flotation

No recovery tests were run on the flotation machine. These tests are recommended to be run occasionally to evaluate the efficiency of the flotation system. In the future these tests should be run at regular intervals during the field season.

The flotation system was loaned from Deborah Cornavaca. It was slightly more complex than a regular SMAP system, but was designed to conserve water. One problem which arose with this system was the amount of sediment in the water, causing "dirty" light fractions. This sediment problem occurred more frequently with different types of soils. Clay soils with high silt content appeared to be the worst contributors to this problem. The silt stayed suspended far longer in the water than normal and ended up being washed into the light fraction cloth, rather than settling to the bottom of the barrel. Large amounts of sediment in the light fraction increased sorting time considerably. Material such as pumice also contributed to large light fraction sizes, but this material is unavoidable in a volcanic area. Sorting is usually the process that takes the most amount of time in any macrobotanical study. Ideally, the light fraction should contain mostly botanical remains, with little or no sediment.

One recommendation would be to change the water more frequently, but the system was designed to avoid this, and be used where water is not readily available. A better filtering system on the water recirculation hose or pump may be a better solution. Another solution may be to use a slightly larger gauge cloth. This would allow sediment particles to pass through, but still trap most macroremains. However, some very small remains may be lost.

In addition, I had many mechanical problems with the flotation system. The type of flotation system used and its upkeep is crucial to providing maximum efficiency. The system (if mechanized) should be in top working order, as down-time is costly and severely limits the samples which can be run.

Subsampling

As mentioned, sorting is the most time consuming part of any paleoethnobotanical project. Because of time constraints in the field and in the lab, subsampling became necessary. Due to my inexperience, I had not foreseen this problem and was not adequately prepared. Studies comparing subsampling techniques suggest that a riffle box is one of the most reliable subsampling techniques (see Pearsall 1989). However I did not have this equipment readily available in the field.

The heavy fraction was subsampled by 25% unless otherwise marked (see Appendix B). A rough variation of the grid method was used. The <1.7 mm split was subsampled by 50% if the light fraction volume was greater than 20 ml, and by 25% if the volume was greater than 70 ml. Subsampling of the light fraction was done by alternatively pouring 2 ml of material into a petri dish to be analysed, and pouring 2 ml into a separate container, left unanalyzed, until all material was separated. Most of the subsampling techniques which were used were developed in the field, and used materials which were easily obtainable. They were simple and field-ready, but probably not very reliable. To compensate, I attempted to analyse the largest subsample that was economically possible. In future studies, subsampling techniques should be better designed and necessary equipment brought to the field if possible.

Comparative collection

I should have made a comparative collection while I was in Nicaragua, particularly of the vegetation surrounding the excavations. This would have allowed easier determination of modern species and the extent of contamination. However, despite efforts to locate manuals on plant identification in Nicaragua, virtually none exist. Without these I could not begin to identify plants around the site. Bringing the pressed plants back to a herbarium requires considerable planning to acquire proper permits. In addition, I did not have enough time to complete the flotation aspect of the study, and had no time whatsoever to prepare a comparative collection. If making a comparative collection in the field is unfeasible, the research proposal should include plans for access to a established comparative collection.

After arriving back from the field I spent several months attempting to locate a adequate comparative collection. Dr. David Lentz and the NYBG kindly allowed me access to their herbarium and seed collection. Locating a comparative collection before going into the field, or making the time to make one should have been a greater priority. In the future, better planning regarding this issue will save time and frustration.

Wood Identification

Wood was the best preserved and most frequent type of material found. Unfortunately, time and resources prevented the identifying of wood species represented by the charcoal. This should be a priority in future studies. Culturally, wood can be used to look at cultural selection and which species were being used in what frequency. It can also be used to analyze different activity areas at a site. For example, the charcoal from one of the fire pits found at Sc-J-A was very splintery, and it fragmented easier than the wood from the other fire pit. This suggests to me that possibly a different species of tree was being burned at 10-17.1 than at 20-10.1. This may indicate a change in fuel choice over time, a change in availability of fuel, or a difference in activities associated with the fire pits. Environmentally, wood identification allows the study of environment and indications of change in the vegetation of a region.

Wood is a valuable, and commonly preserved, botanical remain that can yield significant information on human-plant interaction. Not only can it show human use of wood and cultural preference, it can show the impact humans have on the environment, and how they adapt to the local environment. These potential data should be a prime focus of paleoethnobotanical studies in tropical Central America. The identification of wood charcoal from tropical sites should be a higher priority in future studies. A local comparative collection should be created for use in the future, and a illustrated, comprehensive guide to wood identification would be extremely useful. Possibly in the future, the wood from the Lake Managua sites will be identified and the results will be published.

Communication

Paleoethnobotanists need to work closely with excavators in order to understand the nature of the site and the research goals of the project. Ideally, the paleoethnobotanist should be part of the project team and present at the archaeological site during excavation. They are responsible for the analysis of the botanical material from a site, and for that reason they should be involved in the sampling of that material. In order to fully understand the nature of the stratigraphy, the surrounding vegetation, and the preservation conditions, there is no substitute for being present at an excavation. Unfortunately, the realities of paleoethnobotanical research often involve receiving a batch of soil samples or processed flotation samples and being asked to analyze them without ever having worked at the site. This was the situation I found myself in with Sc-J-A, León Viejo, and Villa Tiscapa.

Floats were taken from some contexts at León Viejo and Sc-J-A which were not floated due to lack of time. In order to prioritize which floats are more important and definitely need to be done, clear communication needs to exist between excavator and paleoethnobotanist if the paleoethnobotanist is unable to be at the excavation in person. In addition, interpretations of archaeobotanical material can not be made without contextual information. If the paleoethnobotanist is not present at the site, they require all recorded information about the dig in order to interpret data. Due to forces beyond control, I did not receive excavation data for Sc-J-A and León Viejo until much later in my research, and this substantially delayed my analyses. I was unfamiliar with the sites and what other remains had been found there. This information is critical for interpreting the botanical data. For future projects, a copy of all field notes and forms should accompany any unprocessed botanical samples, or no analyses will be done.

Summary of Recommendations

1. Take samples from every layer if possible. If this is not possible, samples should be taken from every cultural level and feature along with a few outside of cultural levels as background samples.
2. Familiarize all excavators at a site with regular soil sampling procedure so that samples are standardized.
3. Be aware of potential sources of contamination, try to minimize them, and discuss them in the final report.
4. Carry out pH tests on the soil, so comment can be made regarding preservation conditions.
5. Make sure flotation equipment is running well. Have tools and knowledge on hand to fix the system if something goes wrong.
6. Do recovery tests on flotation equipment.
7. If time permits, experiment with different flotation systems to find the one most suited to the conditions, both efficient and economical.
8. Experiment with a deflocculant with clay soils.
9. Determine the adequate amount of soil to float. Find a balance between adequate macrobotanical yield, and time constraints on processing of samples.
10. Adjust the gauge of the light fraction screen or cloth so that sediment is not trapped.
11. Design subsampling techniques before going into the field, and be prepared with adequate equipment such as a rifflebox.

12. Make sure there is access to a comparative collection arranged before starting project, or incorporate the creation of a comparative collection into the project.
13. Identify as well as possible the species of plants surrounding excavation. Make a comparative collection of seeds from these plants if possible. Take seed samples from plants in seed around the excavation to compare with possible stray modern contaminants latter.
14. Acquire all copy of field notes and relevant information about a site along with the flotation samples if doing the paleoethnobotany study for a site you did not work on. Become familiar with the site stratigraphy and contents before beginning flotation in order to prioritize samples.
15. Have reasonable expectations of the amount of material likely to be found.

It is hoped that these main recommendations, as well as others mentioned previously, will help make flotation more productive and efficient in Nicaragua in the future.

CHAPTER 8
SUMMARY AND CONCLUSIONS

Paleoethnobotany is the study of human interaction with plants in the past. Paleoethnobotanical studies seek to elucidate how human beings adapted to the vegetational environment; how they made use of the resources within this environment for subsistence, construction, medicine, and cultural needs; and how they affected this environment. These goals are achieved through the study of various types of archaeobotanical remains, recovered by different methods. The most common of these is flotation for macrobotanical remains. The principle behind flotation is fairly simple: botanical material is lighter than the soil matrix, and will therefore float in water. In this way archaeobotanical material can be separated relatively efficiently from the soil of an archaeological site, and analyzed.

Flotation was done in the Lake Managua region of Nicaragua at three archaeological sites for this research. This region is located in a fertile lowland basin, which had a dense indigenous population prior to the arrival of the Spanish. Ethnohistoric accounts indicate that this area was rich in resources, and excellent for agriculture. The Spanish write of many crops being grown here, and emphasize the widespread cultivation of maize. Artifactual evidence such as manos and metates also indicate the use of maize in the area, and mortars and pestles are interpreted to show the use of gathered resources such as palm fruit. However, prior to this study, no solid botanical evidence was found for either of these plants, nor any others being exploited by the inhabitants of the region. Other paleoethnobotanical studies have been done in Lower

Central America, although these are few in number. Many of these have shown the human use of a fairly diverse variety of plants. If any general statement can be made about plant use patterns in Lower Central America, it is that there was no dependency on any one single species. Many different resources were exploited.

The three sites sampled for this research are all located within three kilometres of the present day Lake Managua shoreline. The site of N-MA-36 is a large site within the city of Managua. Samples came from two separate excavations at this site; the Villa Tiscapa excavation, dating from as early as 1000 B.C. to A.D. 1350; and the UCA excavations, which were difficult to date due the mixed stratigraphy of the area, but it appears to have been occupied as early as 1000 B.C. up to A.D. 1530, with the densest occupation occurring during the time from A.D. 300 to A.D. 1350. N-MA-36 is interpreted as a large indigenous settlement near the lake shore. The site of Sc-J-A is located on the north-western shore of Lake Managua. This site is also interpreted as a indigenous settlement, occupied intensively from approximately A.D. 800 to one hundred years or so after the contact with Spanish in the area. León Viejo, the third site, is a colonial site, with some traces of indigenous activity prior to colonial settlement. It was occupied by the Spanish from A.D. 1527 to 1610. Dates are not available for the indigenous component of the site, but occupation is estimated to go back to A.D. 800 at this particular site.

Samples for flotation were taken from these sites using both opportunistic sampling and blanket sampling. The soil sampled was floated using a machine assisted flotation system, similar to a SMAP system. In an effort to keep the results between the sites comparable, eight litres of soil were floated for all regular samples. After flotation, both the heavy fraction and the light fraction were sorted and analyzed. Botanical material was identified using a comparative collection at the New York Botanical Gardens.

This study was the first of its kind in Nicaragua. While flotation did not yield large amounts of remains from the Lake Managua area, several interesting species were found. Maize was conclusively shown to be present at Sc-J-A, and possibly present at León Viejo. Palm endocarp fragments, likely from coyol palms, were found at Sc-J-A and N-MA-36. Amaranth and portulaca were found at all three sites, and chenopodia seeds were found at Sc-J-A and N-MA-36. Other species found included *Ipomoea* sp., which may have been *Ipomoea batatas* (sweet potato), passion fruit, and beans. Potentially, evidence of cucurbits, Sapotaceae fruit, Juglandaceae nuts, and *Abutilon* sp. was also found. Unfortunately, many of the identifications are tentative, and few specimens were found of each species. However, the species identified show a range of resources being used. Species were found that typically belong to different types of resource extraction systems. Domesticated, encouraged, and wild species are all represented.

The range of plants found has been interpreted to show that no one subsistence pattern dominated in the Lake Managua region. Seed-crop agriculture is represented by maize, beans, and possible chenopodia, amaranth, and portulaca. Horticulture or door-yard garden cultivation is represented by the possible Cucurbita species, fruit trees, and the possible evidence of sweet potato. Possible management of fruit trees is evidenced by palm nut fragments, possible Juglandaceae nuts, and possible Sapotaceae fruit fragments. Gathering of wild resources is represented by the use of *Crotalaria* sp. and amaranth, possibly as pot herbs, *Abutilon* sp., and other species. Plant species were being used not only for food, but for medicine, fibre, construction, and possibly religious and social reasons. The pattern of plant use in this region appears to be one of a mixed and diverse economy, based on the use of various ecological regions, and various subsistence systems. This pattern fits with that seen from other Central American sites, although there is likely regional variation. This regional variation would be further defined with continued research.

Not only did this study provide definite botanical remains of certain species in Nicaragua, it also provided an opportunity to evaluate the usefulness of flotation as a paleoethnobotanical technique in the Lake Managua region. There is a general consensus among researchers that tropical soils are difficult to float, and that they are unfavourable for preservation, particularly of fragile organic remains. While on certain levels this is true, this does not preclude that macrobotanical remains are never present in tropical soils. In nearly all studies from Central America where flotation has been used, macrobotanical material has been found. The more important question to ask is whether flotation is a useful analysis to do in this region, and if the rate of recovery is sufficient to warrant the time and resources spent on such a study.

Despite the many unidentified fragments of botanical material, and the relatively low rate of recovery, I believe flotation at the three sites in the Lake Managua region yield interesting and important results. These results were worth the time and effort spent to obtain them. More importantly, the greatest value of this study is the experience it provided. This allowed me to make many recommendations regarding how to improve future flotation studies in Nicaragua, as well as the rest of Lower Central America. Modifications to methods of sampling, flotation, and laboratory analysis would increase the efficiency and recovery of future flotation projects. More experience with identification of seeds, making wood identification a priority, and the use of other methods of archaeobotanical recovery such as pollen and phytolith analysis would give better results, and assist in obtaining the most information from the data.

Paleoethnobotanical information is important in the quest to understand the prehistory of western Nicaragua, or any region. It provides vital clues to not only subsistence strategies, but to human adaptation to certain environments. This study has shown that botanical remains are present at archaeological sites in Nicaragua, and the extraction of these remains can provide useful data on agriculture, and resource exploitation. It is hoped that the knowledge I gained from doing this study has provided useful recommendations for future paleoethnobotanical studies in this area by myself and others. More importantly, I hope that this study provides the inspiration for additional paleoethnobotanical work in Nicaragua.

REFERENCES CITED

Abel-Vidor, S.

1980a The Historical Sources for the Greater Nicoya Archaeological Subarea. *Vínculos* 6:155-176.

1980b Dos hornos precolombinos en el sitio Vidor, Bahía Culebra, Guanacaste. *Vínculos* 6:43-50.

1981 Ethnohistorical Approaches to the Archaeology of Greater Nicoya. In *Between Continents/Between Seas: Precolumbian Art of Costa Rica*, edited by E. Benson, pp. 85-92. H.N. Abrams, New York.

Arguello, A.

1969 *Historía de Leon Viejo.* Editorial Antorcha, Leon, Nicaragua.

Austin, D.F.

1978 The Ipomoea batatas complex - I. Taxonomy. *Bulletin of the Torrey Botanical Club* 105:114-129.

Baker, H.G.

1978 *Plants and Civilization*, 3rd edition. Wadsworth Publishing, California.

Balick, M.J.

1990 Production of Coyol Wine from *Acrocomia mexicana* (Arecaceae) in Honduras. *Economic Botany* 44(1):84-93.

Bargnesi, K., K. Hartman, and M. Dirksen

1996 Excavación en el Sitio N-MA-62 (UNI). In *Abundante Cooperación Vecinal: La Segunda Temporada del Proyecto "Arqueología de la Zona Metropolitana de Managua"*, edited by F.W. Lange, pp. 37-48. Alcaldía de Managua, Nicaragua.

Bartlett, A.S. and E.S. Barghoorn

1973 Pytogeographic History of the Isthmus of Panama during the Past 12,000 Years (A History of Vegetation, Climate, and Sea-Level Change). In *Vegetation and Vegetational History of Northern Latin America*, edited by A. Graham, pp. 203-299. Elsevier, Amsterdam.

Bartlett, A.S., E.S. Barghoorn and R. Berger

1969 Fossil Maize in Panama. *Science* 165:389-390.

Baudez, C.F., and M.D. Coe

1962 Archaeological sequences in northwestern Costa Rica. *Proceedings, 34th International Congress of Americanists* 1:366-373. Vienna.

Beadle, G.W.

1977 The origins of Zea mays. In *Origins of Agriculture*, edited by C.A. Reed, pp. 615-636. Mouton, The Hague.

1980 The Ancestry of Corn. *Scientific American* 242:112-119

Belt, T.

1874 *The Naturalist in Nicaragua*. John Murray, London.

Berggren, G.

1969 *Atlas of Seeds and Small Fruits of Northwest European Plant Species, Part 2 Cyperaceae*. Swedish National Science Research Council, Stockholm.

Bergmann, J.F.

1969 The distribution of cacao cultivation in Pre-Columbian America. *Annals of the Association of American Geographers* 59:85-96.

Beyerinck, T.

1947 *Zadenatlas der Nederlandsche Flora*. Veenman Zonen, Wageningen.

Bird, J. and R.G. Cooke

1974 Excavations arqueológicas en las Cueva de los Ladrones, Districto de La Pintada, Provincía de Coclé, Panamá. Report submitted to the Patrimonio Histórico de I.N.A.C., Panamá.

Bird, R.McK.

1984 South American Maize in Central America? In *Pre-Columbian Plant Migration*. Edited by D.Z. Stone, pp. 39-66. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 76. Harvard University Press, Cambridge, Mass.

Bird, R.McK. and M. Goodman

1977 The Races of Maize V: Grouping Maize Races on the Basis of Ear Morphology. *Economic Botany* 31:471-481.

Boardman, S., and G. Jones

1990 Experiments on the Effects of Charring on Cereal Plant Components. *Journal of Archaeological Science* 17:1-11.

Bohrer, V.L., and K.R. Adams

1977 Ethnobotanical Techniques and Approaches at Salmon Ruin, New Mexico. *Eastern New Mexico University Contributions in Anthropology*, No. 8. Eastern New Mexico University.

Brown, M., M. Krieg, and C. Wilmott

1996 La Segunda Temporada en el Sitio Villa Tiscapa (N-MA-36). In *Abundante Cooperación Vecinal: La Segunda Temporada del Proyecto "Arqueología de la Zona Metropolitana de Managua"*, edited by F.W. Lange, pp. 9-36. Alcaldía de Managua, Nicaragua.

Clark, J.G.D.

1954 *Excavations at Star Carr: An Early Mesolithic Site at Seamer, near Scarborough, Yorkshire.* Cambridge University Press, London.

Clarke, D.L.

1968 *Analytical Archaeology.* Methuen, London.

Clary, K.H.

1994 Pollen Evidence for Prehistoric Environment and Subsistence Activities. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P.D. Sheets and B.R. McKee, pp. 293-302. University of Texas Press, Austin.

Cobley, L.S.

1976 *An Introduction to the Botany of Tropical Crops,* 2nd edition. Revised by W.M. Steele. Longman, New York.

Codex Mendoza

1938 *Codex Mendoza*, Edited by James Cooper Clark. Waterlow and Sons, London (originally inscribed in the 1540's, Mexico).

Coe, M.D., and C.F. Baudez

1961 The Zoned Bichrome Period in northwestern Costa Rica. *American Antiquity* 26(4):505-515.

Cooke, R.

1984 Archaeological Research in Central and Eastern Panama: A Review of Some Problems. In *The Archaeology of Lower Central America*, edited by F.W. Lange and D.Z. Stone, pp. 263-303. SAR, University of New Mexico Press, Albuquerque.

Cooley, J.S.

1951 The Sweet Potato - Its Origin and Primitive Storage Practices. *Economic Botany* 5:378-386.

Corrales U., F. and I. Quintanilla J.

1996 The Archaeology of the Central Pacific Coast of Costa Rica. In *Paths to Central American Prehistory*, edited by F.W. Lange, pp. 93-118. University Press of Colorado, Niwot.

Corrales U., F. and J. Mora Urpí

1990 Sobre el Protopejibaye en Costa Rica. *Pejibaye* 2(2):1-11.

Daugherty, H.E.

1969 Man-Induced Ecological Change in El Salvador. Ph.D. dissertation, University of California, Los Angeles. University Microfilms, Ann Arbor.

Dávila, Pedrarias

1525 *Carta al Emperador del 10 de Abril de 1525*, Tomo I, Colección Somoza, Managua, Nicaragua.

Day, J.S. and A.C. Tillett

1996 The Nicoya Shaman. In *Paths to Central American Prehistory*, edited by F.W. Lange, pp. 221-236. University Press of Colorado, Colorado.

deCandolle, A.

1884 *Origin of Cultivated Plants*. Kegan Paul, Trench, London.

Delorit, R.J.

1970 *An Illustrated Taxonomy Manual of Weed Seeds*. Agronomy Publications, River Falls, Wisconsin.

Delorit, R.J. and C.R. Gunn

1986 *Seeds of Continental United States Legumes (Fabaceae)*. Agronomy Publications, River Falls, Wisconsin.

Demarest, A.

1980 Santa Leticia and the Prehistory of Western El Salvador. Unpublished manuscript, Anthropology Department, Harvard University.

Dengo, G.

1962 *Investigación de la geológica de Guanacaste, Costa Rica*. Instituto de Geografía, San Jose.

Dennell, R.W.

1976 The Economic Importance of Plant Resources Represented on Archaeological Sites. *Journal of Archaeological Science* 3:229-247.

de Rocheburne, A.T.
1879 Recherches d'ethnographie botanique sur la flore des sepultures péruviennes d'Ancón. *Actes de la Société Linnéenne de Bordeaux* 3:343-358.

Dimbleby, G.
1967 *Plants and Archaeology*. Humanities Press, New York.

Domínguez, L.
1983 Excavaciones realizadas en León Viejo, Nicaragua. Unpublished report. National Museum, Managua, Nicaragua.

Dunn, M.E.
1978 Suggestions for Evaluating Archaeological Maize. *American Antiquity* 43:97-99.

Espinoza Pérez, E.
1995 La Cerámica Temprana de Nicaragua y Sus Vínculos Regionales. In *Descubriendo las Huellas de Nuestros Antepasados: El Proyecto "Arqueología de la Zona Metropolitana de Managua"*, edited by F.W. Lange, pp. 17-24. Alcaldía de Managua, Nicaragua.

Espinoza Pérez, E., R. Gonzalez, y C. Ringat
1994 Gran Nicoya y la Cuenca del Lago de Managua. En *Taller sobre el futuro de las investigaciones arqueológicas y etnohistoricas en Gran Nicoya*, editado por R. Vázquez. *Vínculos* 18-19:139-172.

Eubanks, M.
1995 A cross between two maize relatives: *Tripsacum dactyloides* and *Zea diploperennis* (Poaceae). *Economic Botany* 49:172-182

Flannery, K.V.
1968 Archaeological Systems Theory and Early Mesoamerica. In *Anthropological Archaeology in the Americas*, edited by B.J. Meggers, pp. 67-87. Anthropological Society of Washington, Washington, D.C.

Ford, R.I.
1979 Paleoethnobotany in American Archaeology. In *Advances in Archaeological Method and Theory; Vol. 2*, edited by M.B. Schiffer, pp. 285-336. Academic Press, New York.
1994 Preface to the Second Edition: Ethnobotany - 1994. In *The Nature and Status of Ethnobotany, 2nd Edition*, edited by R.I. Ford, pp. viii-xxxii. Anthropological Papers, Museum of Anthropology, University of Michigan, No. 67. Ann Arbor, Michigan.

Fowler, W.R., Jr.

1981 *The Pipil-Nicarao of Central America.* Ph.D. dissertation. Dept. of Archaeology, University of Calgary, Calgary, Alberta.

1989 *The Cultural Evolution of Ancient Nahua Civilizations: The Pipil-Nicarao of Central America.* Norman: University of Oklahoma Press.

Freytag, G.F.

1953 The coyol palm as a beverage tree. *Missouri Botanical Garden Bulletin* 41(3):47-49.

Fuentes y Guzmán, F.A. de

1932-33 *Recordación Florida: Discurso historical y demostración natural, material, militar y política del reyno de Guatemala.* 3 vols. Forward by. J.A. Villacorta. Sociedad de Geografía e Historía, Guatemala.

Galinat, W.C.

1965 The Evolution of Corn and Culture in North America. *Economic Botany* 19:350-357.

1975 The evolutionary emergence of maize. *Bulletin of the Torrey Botanical Club* 102:313-324.

1980 The Archaeological Maize Remains from Volcán Panama - A Comparative Perspective. In *Adaptive Radiations in Prehistoric Panama*, edited by O.F. Linares and A.J. Ranere, pp. 175-180. Peabody Museum Monographs No. 5. Harvard University Press, Cambridge, Mass.

1988 The origin of corn. In *Corn and Corn Improvement*, Agronomy Monograph No. 18, pp. 1-31. ASA-CSSA-SSSA, Madison, WI.

Gunn, C.R.

1972 Seed collecting and identification. In *Seed Biology III*, edited by T.T. Kozlowski. Academic Press, New York.

Guthe, C.E.

1930 Identification of botanical material from excavations. *National Research Council, Division of Anthropology and Psychology, Circular* No. 6.

Haberland, W.

1986 Settlement Patterns and Cultural History of Ometepe Island, Nicaragua: Preliminary Sketch. *Journal of the Steward Anthropological Society* 14(1982-1983):369-386. Steward Anthropological Society, Urbana.

1992 The Culture History of Ometepe Island: Preliminary Sketch (Survey and Excavations, 1962-1963). In *The Archaeology of Pacific Nicaragua*, by F.W. Lange, P.D. Sheets, A. Martinez, and S. Abel-Vidor, pp. 63-118. University of New Mexico Press, Albuquerque.

Hammond, N., D. Pring, R. Wilk, S. Donaghey, F.P. Saul, E.S. Wing, A.V. Miller, and L.H. Feldman

1979 The earliest Lowland Maya? Definition of the Swasey Phase. *American Antiquity* 44(1):92-110.

Harms, H. von

1922 Übersicht der bisher in altperuanishen Graben gefundenen Pflanzenreste. In *Festschrift Eduard Seler*, pp. 157-186. Stuttgart.

Hastorf , C.A., and M.J. DeNiro

1985 Reconstruction of prehistoric plant production and cooking practices by a new isotopic method. *Nature* 315:489-491.

Hather, J.G.

1991 The identification of charred archaeological remains of vegetative parenchymatous tissues. *Journal of Archaeological Science* 18:661-675.

Healy, P.F.

1980 *The Archaeology of the Rivas Region, Nicaragua.* Wilfred Laurier University Press, Waterloo, Ontario.

Heer, O.

1866 Treatise on the plants of the lake dwellings. In *The Lake Dwellings of Switzerland and Other Parts of Europe*, edited by F. Keller, trans. by J.E. Lee. Longman and Green, London.

Helbaek, H.

1959 Domestication of Food Plants in the Old World. *Science* 130:365-373.

1969 Plant collecting, dry farming and irrigation in prehistoric Deh Luran. In *Prehistory and Human Ecology of the Deh Luran Plain: An Early Village Sequence from Khuzistan, Iran*, edited by F. Hole, pp. 244-383. Memoirs of the Museum of Anthropology, University of Michigan No. 1, Ann Arbor, Michigan.

Higgs, E.S., ed.

1972 *Papers in Economic Prehistory.* Cambridge University Press.

Hillman, G., S. Wales, F. McLaren, J. Evans, and A. Butler

1993 Identifying Problematic Remains of Ancient Plant Food: A Comparison of the Role of Chemical, Histological and Morphological Criteria. *World Archaeology* 25(1):94-121.

Hillman, F.H. and H.H. Henry
1940 *Know Your Seeds: Drawings of Forage Plant Seeds and Weed Seeds Commonly Found with Them.* Seed World, Chicago.

Hoopes, J.W.
1988 The Early Formative Period and Inland Adaptations in Lower Central America. In *Diet and Subsistence: Current Archaeological Perspectives*, Proceedings of the 19th Annual Chacmool Conference, edited by B.V. Kennedy and G.M. LeMoine, pp. 141-148. Chacmool Archaeological Association, University of Calgary, Alberta.
1994 Contributions of Non-Agricultural Subsistence Strategies to the Formation of Complex Society in Coastal Zones of Southern Costa Rica. Paper presented at the 59th Annual Meeting of the Society for American Archaeology, Anaheim, California.

Hornell, J.
1946 How Did the Sweet Potato Reach Oceania? *Journal of the Linnean Society of London* 53:41-62.

Hubbard, R.N.
1980 Development of agriculture in Europe and the Near East: Evidence from quantitative studies. *Economic Botany* 34(1):51-67.

Hummer, A.
1983 Ground Stone of the Zapotitán Valley. In *Archaeology and Volcanism in Central America: The Zapotitán Valley of El Salvador*, edited by P.D. Sheets, pp. 229-251. University of Texas Press, Austin.

Hunter, A.A., and B.R. Gassner
1998 Evaluation of the Flote-Tech Machine-Assisted Flotation System. *American Antiquity* 63(1):143-156.

Hunziker, A.T.
1952 Los pseudocereales de la agricultura indígena de America. *Museum Botanica de Córdoba, Miscellaneous Publications 3.*

Hutchinson, J.
1964 *The Genera of Flowering Plants, Vol. 1.* Oxford University Press, London.

Iltis, H.H.
1983 From teosinte to maize: the catastrophic sexual transmutation. *Science* 222:886-894.

Janzen, D.H.

1971 The fate of *Scheela rostrata* fruits beneath the parent tree: a predispersal attack by bruchids. *Principes* 15(3):89-101.

1983 *Acrocomia vinifera* (Coyol). In *Costa Rican Natural History*. Edited by D.H. Janzen, pp. 184-185. University of Chicago Press, Chicago.

Jarman, H.N., A.J. Legge, and J.A. Charles

1972 Retrieval of Plant Remains from Archaeological Sites by Froth Flotation. In *Papers in Economic Prehistory*, edited by E.S. Higgs, pp. 39-48. Cambridge University Press, Cambridge.

Jones, V.H.

1936 The vegetable remains of the Newt Kash Hollow shelter. In *Rockshelters in Menifee County, Kentucky*, edited by W.S. Webb and W.D. Funkhouser. *University of Kentucky Reports in Archaeology and Anthropology* 3:147-165.

1957 Botany. In *The Identification of Non-artifactual Archaeological Materials*, edited by W.W. Taylor, pp. 35-38. National Academy of Sciences-National Research Council Publication No. 565.

Kaplan, L.

1965 Archaeology and Domestication in American *Phaseolus* (Beans). *Economic Botany* 19:358-368.

Keeley, H.C.M.

1978 The Cost-effectiveness of Certain Methods of Recovering Macroscopic Organic Remains from Archaeological Deposits. *Journal of Archaeological Science* 5:179-183.

Keepax, C.

1977 Contamination of Archaeological Deposits by Seeds of Modern Origin with Particular Reference to the Use of Flotation Machines. *Journal of Archaeological Science* 4:221-229.

Kirchhoff, P.

1943 Mesoamérica: sus limites geográficos, composición étnica y carácteres culturales. *Acta Americana* 1:92-107.

Kunth, C.

1826 Examen botanique. In *Catalogue raisonné et historique dé antiquités découverte en Egypte*, edited by J. Passalaqua. Musées Nationaux, Paris.

Lange, F.W.

1971 *Culture history of the Sapoa River Valley, Costa Rica.* Ph.D. dissertation, Dept. of Anthropology, University of Wisconsin.

1984a The Greater Nicoya Archaeological Subarea. In *The Archaeology of Lower Central America*, edited by F.W. Lange and D. Stone, pp. 165-194. University of New Mexico Press, Albuquerque.

1984b Cultural Geography of Precolumbian Lower Central America. In *The Archaeology of Lower Central America*, edited by F.W. Lange and D. Stone, pp. 33-62. SAR, University of New Mexico Press, Albuquerque.

1992 Preface. In *The Archaeology of Pacific Nicaragua* by F.W. Lange, P.D. Sheets, A. Martinez, and S. Abel-Vidor, pp. xvii-xix. University of New Mexico Press, Albuquerque.

1996a Los antecedentes y los resultados de la Segunda Temporada del Proyecto "Arqueología de la Zona Metropolitana de Managua". In *Abundante Cooperación Vecinal: La Segunda Temporada del Proyecto "Arqueología de la Zona Metropolitana de Managua"*, editado por F.W. Lange, pp. 1-8. Alcaldía de Managua, Nicaragua.

1996b Gaps in Our Databases and Blanks in Our Syntheses: The Potential for Central American Archaeology in the Twenty-First Century. In *Paths to Central American Prehistory*, edited by F.W. Lange, pp. 305-326. University Press of Colorado, Colorado.

Lange, F.W., ed.

1995 *Descubriendo las Huellas de Nuestros Antepasados: El Proyecto "Arqueología de la Zona Metropolitana de Managua".* Alcaldía de Managua, Nicaragua.

1996 *Abundante Cooperación Vecinal: La Segunda Temporada del Proyecto "Arqueología de la Zona Metropolitana de Managua".* Alcaldía de Managua, Nicaragua.

Lange, F.W. and D.Z. Stone, eds.

1984 *The Archaeology of Lower Central America.* SAR, University of New Mexico Press, Albuquerque.

Lange, F.W., P.D. Sheets, A. Martinez, and S. Abel-Vidor

1992 *The Archaeology of Pacific Nicaragua.* University of New Mexico Press, Albuquerque.

Lathrap, D.W.

1970 *The Upper Amazon.* Thames and Hudson, England.

Lentz, D.L.

1984 *A Description of the Plant Communities and Archaeoethnobotany of the Lower Sulaco and Humuya River Valleys, Honduras.* Ph.D. dissertation, University of Alabama.

1986 Ethnobotany of the Jicaque of Honduras. *Economic Botany* 40(2):210-219.

1989 Botanical Remains from the El Cajón Area: Insights into a Prehistoric Dietary Pattern. In *Prehistoric Cultural Ecology*, edited by K.G. Hirth, G. Lara Pinto, and G. Hasemann, pp. 187-206. *Archaeological Research in the El Cajón Region*, vol. 1. Memoirs in Latin American Archaeology No. 1. University of Pittsburgh, Pittsburgh.

1990 *Acrocomia mexicana*: Palm of the Ancient Mesoamericans. *Journal of Ethnobiology* 10(2):183-194.

1991 Maya Diets of the Rich and Poor: Paleoethnobotanical Evidence from Copán. *Latin American Antiquity* 2(3):269-287.

Lentz, D.L., M.P. Beaudry-Corbett, M.L. Reyna de Aguilar, and L. Kaplan

1996 Foodstuffs, Forests, Fields, and Shelter: A Paleoethnobotanical Analysis of Vessel Contents from the Cerén Site, El Salvador. *Latin American Antiquity* 7(3):247-262.

Lentz, D.L., C.R. Ramírez, and B.W. Griscom

1997 Formative-Period Subsistence and Forest-Product Extraction at the Yarumela Site, Honduras. *Ancient Mesoamerica* 8:63-74.

Linares, O.F.

1976 "Garden Hunting" in the American Tropics. *Human Ecology* 4(4):331-349.

Linares, O.F. and A.J. Ranere

1980 Introduction to Part Four, Cultural Inferences from Organic Remains. In *Adaptive Radiations in Prehistoric Panama*, edited by O.F. Linares and A.J. Ranere, pp. 146-150. Peabody Museum Monographs, No. 5. Harvard University Press, Cambridge, Mass.

Linares, O.F., P.D. Sheets, and E.J. Rosenthal

1975 Prehistoric Agriculture in Tropical Highlands. *Science* 187:137-145.

López de Velasco, J.

1894 *Geografia y Descripción Universal de las Indias.* Boletín de la Sociedad Geográfica, Madrid.

Lopinot, N.H.

1985 *Archaeobotanical formation processes and late Middle Archaic subsistence.* UMI, Ann Arbor, Michigan.

Lötschert, W. and G. Beese

1983 *Tropical Plants.* Translated by Clive King. Harper Collins Publishers, London.

Magnus, R.W.

1978 The Prehistoric and Modern Subsistence Patterns of the Atlantic Coast of Nicaragua: A Comparison. In *Prehistoric Coastal Adaptations: The Economy and Ecology of Maritime Middle America.* Edited by B.L. Stark and B. Voorhies, pp. 61-80. Academic Press, New York.

Mahaney, N., M.H. Matthews, and A.B. Vargas

1994 Macrobotanical Remains of the Proyecto Prehistórico Arenal. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P.D. Sheets and B.R. McKee, pp. 303-311. University of Texas Press, Austin.

Manglesdorf, P.C.

1974 *Corn: Its Origins, Evolution, and Improvement.* Harvard University Press, Cambridge, MA.

1986 The origin of corn. *Scientific American* 254:80-86.

Mangelsdorf, P.C., R.S. MacNeish, and W.C. Galinat

1967 Prehistoric Wild and Cultivated Maize. In *The Prehistory of the Tehuacan Valley, Vol. 1, Environment and Subsistence.* Edited by D.S. Byers. Pp. 178-200. University of Texas, Austin.

Matthews, M.H.

1984 Results of Macrobotanical Analysis for the Proyecto Prehistorico Arenal: Preliminary Evidence of Resource Use and Subsistence Strategies. *Vínculos* 10(1-2):193-205.

Martin, A.C., and W.D. Barkley

1961 *Seed Identification Manual.* University of California Press, Berkeley.

Meléndez, Ch., C.

1976 *Hernández de Córdoba: Capitán de Conquista en Nicaragua.* Colección Cultural, Serie Histórica No. 9. Banco de América, Managua.

Miksicek, C.H.

1979 Preliminary Impressions of Archaeobotanical Work at Cihuatán. Unpublished manuscript, Dept. of General Biology, University of Arizona.

1987 Formation Processes of the Archaeobotanical Record. In *Advances in Archaeological Method and Theory; Vol. 10,* edited by M.B. Schiffer, pp. 211-247. Academic Press, New York.

Miksicek, C.H., R.McK. Bird, B. Pickersgill, S. Donaghey, J. Cartwright, and N. Hammond

1981 Preclassic Lowland Maize from Cuello, Belize. *Nature* 289(5793):56-59.

Miller, N.F.

1988 Ratios in Paleoethnobotanical Analysis. In *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*, edited by C.A. Hastorf and V.S. Popper, pp. 72-85. University of Chicago Press, Chicago.

Miller, R.H.

1967 *Crotalaria Seed Morphology, Anatomy, and Identification.* U.S. Dept. of Agriculture Technical Bulletin 1373.

Montgomery, F.H.

1977 *Seeds and Fruits of Plants of Eastern Canada and Northeastern United States.* University of Toronto Press, Toronto.

Mueller, J.W., ed.

1975 *Sampling in Archaeology.* University of Arizona Press, Tucson.

Navarro, R., V. Holguín, and E. Espinoza

1985 Informe Preliminar Prospección Arqueológica de León Viejo. Unpublished report. Dirección de Arqueológia, Ministerio de Cultura, Managua.

Newsom, L.A.

1993 Native West Indian Plant Use. Ph.D. dissertation. Dept. of Anthropology, University of Florida. UMI Press, Michigan.

Newson, L.A.

1987 *Indian Survival in Colonial Nicaragua.* University of Oklahoma Press, Norman, Oklahoma.

Norr, L.

1990 Nutritional Consequences of Prehistoric Subsistence Strategies in Lower Central America. Unpublished Ph.D. dissertation, Dept. of Anthropology, University of Illinois, Urbana-Champaign.

1991 Dietary Diversity along the Northwestern Coast of Costa Rica. Paper presented at the 48th International Congress of Americanists, New Orleans.

1996 Prehistoric Coastal Subsistence in Northwestern Costa Rica: Geographical Diversity and Chronological Trends. In *Paths to Central American Prehistory*, edited F.W. Lange, pp. 253-270. University Press of Colorado, Niwot.

Norweb, A.H.

1964 Ceramic Stratigraphy in Southwestern Nicaragua. In *Actas, 35th International Congress of Américanists* 1:551-561.

Oakes, A.

1939 *Economic Annuals and Human Cultures*. Botanical Museum of Harvard University, Cambridge.

Ortega, E., E. Espinoza, and R. Gonzalez

1988 Informe de las Excavaciones Arqueologicas del Sitio Historico de Leon Viejo, Mayo 24 - Junio 24 de 1988. Unpublished manuscript, Managua, Nicaragua.

Oviedo y Valdez, G.F. de

1959 *Historia General y Natural de las Indias, Islas y Tierra Firme del Mar Océano*. Real Academia Española, Madrid.

1976 *Nicaragua en los Cronistas de Indias: Oviedo*. (Excerpts from *Historía General y Natural de las Indias* relating to Nicaragua) Serie Cronistas No. 3. Fondo de Promoción Cultural, Banco de América, Managua.

Pearsall, D.M.

1978 Early Movement of Maize between Mesoamerica and South America. *J. Steward Anthropological Society* 9:41-75.

1988 Interpreting the meaning of macroremain abundance: The impact of source and context. In Current Paleoethnobotany: *Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*, edited by C.A. Hastorf and V.S. Popper, pp. 119-144. University of Chicago Press, Chicago.

1989 *Paleoethnobotany: A Handbook of Procedures*. Academic Press, New York.

1995 "Doing" paleoethnobotany in the tropical lowlands: adaptation and innovation in methodology. In *Archaeology in the lowland American* *tropics*, edited by P.W. Stahl, pp. 113-129. Cambridge University Press, Cambridge.

Pendleton, M.
1983 A Comment Concerning "Testing Flotation Recovery Rates". (Reply to G. Wagner, 1982) *American Antiquity* 48(4):615-616.

Pichardo P., L. and J. Zambrana F.
1995 Prospección y Excavación Arqueológica, Sitio N-MA-62 UNI, Managua. In *Descubriendo las Huellas de Nuestros Antepasados: El Proyecto "Arqueología de la Zona Metropolitana de Managua"*, edited by F.W. Lange, pp. 75-82. Alcaldía de Managua, Nicaragua.

Piperno, D.R.
1994 Phytolith Records from the Proyecto Prehistórico Arenal. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P.D. Sheets and B.R. McKee, pp. 286-292. University of Texas Press, Austin.
1995 Plant microfossils and their application in the New World tropics. In *Archaeology in the lowland American tropics*, edited by P.W. Stahl, pp. 130-153. Cambridge University Press, Cambridge.

Piperno, D.R. and K.M. Clary
1984 Early Plant Use and Cultivation in the Santa María Basin, Panamá: Data from Phytoliths and Pollen. In *Recent Developments in Isthmian Archaeology*, edited by F.W. Lange, pp. 85-121. BAR International Series, 212. BAR, Oxford, England.

Piperno, D.R. and D.M. Pearsall
1998 *The Origins of Agriculture in the Lowland Neotropics.* Academic Press, San Diego.

Plotkin, M.J. and M.J. Balick
1984 Medicinal Uses of South American Palms. *Journal of Ethnopharmacology* 10(2):157-179.

Popper, V.S.
1988 Selecting Quantitative Measurements in Paleoethnobotany. In *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*, edited by C.A. Hastorf and V.S. Popper, pp. 53-71. University of Chicago Press, Chicago.

Popper, V.S., and C.A. Hastorf

1988 Introduction. In *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*, edited by C.A. Hastorf and V.S. Popper, pp. 1-16. University of Chicago Press, Chicago.

Pursglove, J.W.

1963 Some Problems of the Origin and Distribution of Tropical Crops. *Genetica Agraria* 17:105-122.

1965 The Spread of Tropical Crops. In *The Genetics of Colonizing Species*, edited by H.G. Baker and G.L. Stebbins. Academic Press, New York.

1968 *Tropical Crops: Dicotyledons*, Parts I and II. John Wiley and Sons, New York.

1972 *Tropical Crops: Monocotyledons*, Part II. Longman, London.

Pullen, H.

1995 Prospección Arqueológica en Villa Tiscapa, Sitio N-MA-36. In *Descubriendo las Huellas de Nuestros Antepasados: El Proyecto "Arqueologia de la Zona Metropolitana de Managua"*, edited by F.W. Lange, pp. 41-50. Alcaldía de Managua, Nicaragua.

Radell, D.R.

1969 *An historical geography of western Nicaragua: the spheres of influence of León, Granada, and Managua, 1519-1965.* Ph.D. dissertation, University of California, Berkeley. University Microfilms, Ann Arbor.

1976 The Indian Slave Trade and Population of Nicaragua During the Sixteenth Century. In *Native Populations of the Americas in 1492*, edited by W.M. Denevan, pp. 67-76. University of Wisconsin Press, Madison.

Ranere, A.J. and P. Hansell

1978 Early Subsistence Patterns Along the Pacific Coast of Panama. In *Prehistoric Coastal Adaptations*, edited by B.L. Stark and B. Voorhies, pp. 43-59. Academic Press, New York.

Reed, H.S.

1944 An account of sixteenth century agriculture on the Mexican Plateau. *Journal of the Washington Academy of Science* 34:209-213.

1950 A New Species of Chenopodium from Mexico. *Madoño* 10:139-142.

Renfrew, J.M.

1973 *Palaeoethnobotany: The prehistoric food plants of the Near East and Europe*. Methuen, London.

Rigat, D. and González R., R.
1996 Preliminary Research in Chontales and the Lake Managua Basin, Nicaragua. In *Paths to Central America Prehistory*, edited by F.W. Lange, pp. 177-190. University Press of Colorado, Niwot.

Rinfret, L., E. Fiedler, K. Armstrong, and W. Collins
1997 Investigations at UCA, N-MA-36. Field report in author's possession.

Rottlaender, R.C.H. and H. Schlichterle
1980 Gefässinhalte - eine kurz Kommentierte Bibliographie. *Archaeo-Physika* 7:61-70.

Safford, W.E.
1918 *Chenopodium nuttalliae*, a food plant of the Aztecs. *Journal of the Washington Academy of Science* 8:521-527.

Saffray, D.
1876 Les antiquités Péruviennes à l'exposition de Philadelphia. *La Nature (Paris)* 4:401-407.

Sahagún, B. de
ca. 1570 *Historia general de las cosas de Nueva España.* Editado por F. del Paso y Troncoso. México 1938.

Salgado G., S.
1996 The Ayala Site: A Bagaces Period Site Near Granada, Nicaragua. In *Paths to Central America Prehistory*, edited by F.W. Lange, pp. 191-220. University Press of Colorado, Niwot.

Sanoja, M.
1985 Informe de Asesoría Proyecto León Viejo. Unpublished report. Managua, Nicaragua.

Sauer, C.O.
1952 *Agricultural Origins and Dispersals.* American Geographical Society, New York.

Sauer, J.D.
1950 The Grain Amaranths: A Survey of Their History and Classification. *Annals of the Missouri Botanical Garden* 37:561-623.

Seymour, F.C.
1980 *A Checklist of the Vascular Plants of Nicaragua.* Phytologia Memoirs No. 1, H.N. Moldenke and A.L. Moldenke, New Jersey.

Sharer, R.J.

1984 Lower Central America as Seen from Mesoamerica. In *The Archaeology of Lower Central America*, edited by F.W. Lange and D. Stone, pp. 63-84. SAR, University of New Mexico Press, Albuquerque.

Sheets, P.D.

1979 Environmental and Cultural Effects of the Ilopango Eruption in Central America. In *Volcanic Activity and Human Ecology*, edited by P.D. Sheets and D. Grayson. Academic Press, New York.

1984a The Prehistory of El Salvador: An Interpretive Summary. In *The Archaeology of Lower Central America*, edited by F.W. Lange and D.Z. Stone, pp. 85-112. School of American Research, University of New Mexico Press, Albuquerque.

1984b Summary and Conclusions. *Vinculos* 10(1-2):207-223.

1992a The Pervasive Pejorative in Intermediate Area Studies. In *Wealth and Hierarchy in the Intermediate Area*, edited by F.W. Lange, pp. 15-42. Dumbarton Oaks, Harvard University, Washington, D.C.

1992b *The Ceren Site: A Prehistoric Village Buried by Volcanic Ash in Central America.* Case Studies in Archaeology Series, Harcourt Brace Jovanovich, Fort Worth, Texas.

Shennan, S.

1997 *Quantifying Archaeology*. Academic Press, New York.

Simmonds, N.W.

1965 The Grain Chenopods of the Tropical American Highlands. *Economic Botany* 19:223-235.

Smiley, J.T.

1983 *Passiflora foetida* (Bombillo, Calzoncillo, Ñorbo, Granadilla del Monte, Passion Flower). In *Costa Rican Natural History*. Edited by D.H. Janzen, pp. 298-299. University of Chicago Press, Chicago.

Smith, B.D.

1997 The initial domestication of *Cucurbita pepo* in the Americas 10,000 years ago. *Science* 276:932-934.

Smith, C.E.

1980 Plant Remains from the Chiriqui Sites and Ancient Vegetational Patterns. In *Adaptive Radiations in Prehistoric Panama*, edited by O.F. Linares and A.J. Ranere, pp. 151-174. Peabody Museum Monographs, No. 5. Harvard University, Cambridge.

1988 The Recovery of Plant Remains from Intermediate Area Sites. In *Diet and Subsistence: Current Archaeological Perspectives*, edited by B.V. Kennedy and G.M. LeMoine, pp. 165-171. Proceedings of the Nineteenth Annual Chacmool Conference, University of Calgary, Alberta.

Snarskis, M.J.

1976 Stratigraphic Excavations in the Eastern Lowlands of Costa Rica. *American Antiquity* 41(3):342-353.

1984 Central America: The Lower Caribbean. In *The Archaeology of Lower Central America*, edited by F.W. Lange and D.Z. Stone, pp. 195-232. University of New Mexico Press, Albuquerque.

Standley, P.C.

1928 *Flora of the Panama Canal Zone*. Contributions from the U.S. National Herbarium, Vol. 27. Smithsonian Institute, Washington.

Standley, P.C. and J.A. Steyermark

1946 *Flora of Guatemala*. Fieldiana: Botany. Vol. 24, part I-V. Chicago National History Museum, Chicago.

Standley, P.C. and J.A. Steyermark

1949 *Flora of Guatemala*. Fieldiana: Botany. Vol. 24, part VI. Chicago National History Museum, Chicago.

Stevens, R.L.

1964 The Soils of Middle America and their Relation to Indian Peoples and Cultures. In *Handbook of Middle American Indians*, edited by R. Wauchope and R. West, 1:265-315. University of Texas Press, Austin.

Stone, D.Z.

1966 *Introduction to the Archaeology of Costa Rica*. Revised edition. National Museum of Costa Rica, San Jose.

1977 *Pre-Columbian Man in Costa Rica*. Peabody Museum Press, Cambridge, Mass.

Stone, D.Z. (ed.)

1984 *Pre-Columbian Plant Migration*. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 76. Harvard University Press, Cambridge, Mass.

Struever, S.

1968 Flotation Techniques for the Recovery of Small Scale Archaeological Remains. *American Antiquity* 33(3):353-362.

Swallen, J.R.
1955 Grasses of Guatemala. In *Flora of Guatemala*, by P.C. Standley and J.A. Steyermark. Fieldiana: Botany. Vol. 24, part II. Chicago National History Museum, Chicago.

Taylor, B.W.
1963 An outline of the vegetation of Nicaragua. *Journal or Ecology* 51:27-54.

Thieck, F.
1970 Las Ruinas de León Viejo. *Universidad Autónoma de Nicaragua, cuadernos Universitarios No. 12*, pp. 85-103. León, Nicaragua.

Toll, M.S.
1988 Flotation Sampling: Problems and Some Solutions, with Examples from the American Southwest. In *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*, edited by C.A. Hastorf and V.S. Popper, pp. 36-52. University of Chicago Press, Chicago.

van der Veen, M.
1984 Sampling for Seeds. In *Plants and Ancient Man*, edited by W. van Zeist and W.A. Casparie, pp. 193-200. A.A. Balkema, Boston.

van der Veen, M. and N. Fieller
1982 Sampling Seeds. *Journal of Archaeological Science* 9:287-298.

Vázquez de Espinosa, A.
1942 *Compendium and Description of the West Indies.* Translated by C.U. Clark. Smithsonian Miscellaneous Collections, vol. 102. Smithsonian, Washington, D.C.

Vázquez L., R.
1986 Excavaciones de Muestreo en el Sitio Nacascolo: Un Paso Adelante Dentro del Proyecto Arqueológico Bahía Culebra, Costa Rica. In *Prehistoric Settlement Patterns in Costa Rica*, edited by F.W. Lange and L. Norr, pp. 67-92. *Journal of the Steward Anthropological Society* 14 (1982-1983). Steward Anthropological Society, Urbana.

Vázquez L., R., F.W. Lange, J.W. Hoopes, O. Fonseca Z., R. Gonzalez R., A.C. Arias, R.T. Bishop, N. Borgnino, A. Constenla U., F. Corrales U., E. Espinoza P., L.A. Fletcher, J.V. Guerrero M., V. Lauthelin, D. Rigat, S. Salgado G., and R. Salgado G.
1994 Hacia Futuras Investigaciones en Gran Nicoya. *Vínculos* 18-19:245-279.

Vivó Escoto, J.A.

1964 Weather and Climate of Mexico and Central America. In *Handbook of Middle American Indians, Vol. 1*, edited by R. Wauchope and R.C. West, pp. 187-215. University of Texas Press, Austin.

Wagner, G.

1982 Testing Flotation Recovery Techniques. *American Antiquity* 47:127-132

1988 Comparability among Recovery Techniques. In *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*, edited by C.A. Hastorf and V.S. Popper, pp. 17-35. University of Chicago Press, Chicago.

Wagner, P.L.

1964 Natural Vegetation of Middle America. In *Handbook of Middle American Indians, Vol. 1*, edited by R. Wauchope and R.C. West, pp. 216-263. University of Texas Press, Austin.

Wasylikowa, K.

1986 Analysis of Fossil Fruits and Seeds. In *Handbook of Paleoecology*, edited by B.E. Berglund, pp. 571-590. John Wiley, Chichester, England.

Watson, P.J.

1976 In Pursuit of Prehistoric Subsistence: A Comparative Account of Some Contemporary Flotation Techniques. *Mid-Continental Journal of Archaeology* 1(1):77-100.

Werner, P.S.

1995 Managua Metropolitana en la Crónicas de Nicaragua en el Siglo XVI. In *Descubriendo las Huellas de Nuestros Antepasados: El Proyecto "Arqueología de la Zona Metropolitana de Managua"*, edited by F.W. Lange, pp. 119-128. Alcaldía de Managua, Nicaragua.

West, R.C.

1964 The natural regions of Middle America. In *Handbook of Middle American Indians, Vol. 1*, edited by R. Wauchope and R.C. West, pp. 363-383. University of Texas Press, Austin.

Whitaker, T.W. and H.C. Cutler

1965 Cucurbits and Cultures in the Americas. *Economic Botany* 19:344-349.

Williams, L.O.

1981 The useful plants of Central America. *Ceiba* 24(1-2):1-342.

Willey, G.R.
1959 The "Intermediate Area" of Nuclear America: Its Prehistoric Relationships to Middle America and Peru. *Proceedings of the 33rd International Congress of Americanists* 1:184-194.
1971 *An Introduction to American Archaeology, Vol. 2: South America.* Prentice-Hall, Englewood Cliffs, New Jersey.
1980 Foreword. In *Archaeology of the Rivas Region, Nicaragua*, by Paul F. Healy. Wilfred Laurier University Press, Waterloo, Ontario.
1984 A Summary of the Archaeology of Lower Central America. In *The Archaeology of Lower Central America*, edited by F.W. Lange and D.Z. Stone, pp. 341-378. School of American Research, University of New Mexico Press, Albuquerque.

Willey, G.R. and J.A. Sabloff
1993 *A History of American Archaeology, 3rd Edition.* W.H. Freeman and Co., New York.

Wilson, D.G.
1984 The carbonisation of weed seeds and their representation in macrofossil assemblages. In *Plants and Ancient Man: Studies in Paleoethnobotany*, edited by W. Van Zeist and W.A. Casparie. A.A. Balkema, Rotterdam.

Wilson, H.D.
1990 Quinoa and Relatives. *Economic Botany* 44(3, supplement):92-110.

Wilson, H.D. and C.B. Heiser, Jr.
1979 The Origin and Evolutionary Relationships of 'Huauzontle' (*Chenopodium Nuttalliae* Safford), Domesticated Chenopod of Mexico. *American Journal of Botany* 66(2):198-206.

Wittmack, L.
1905 Our Present Knowledge of Ancient Plants. In *Transactions of the Academy of Science of St. Louis, XV, No. 1.* St. Louis, Missouri.

Wykoff, L.L.
1974 *The Nicaraguan Archaeological Survey: A Preliminary Report.* Museum of the American Indian, Heye Foundation, Indian Notes 10:99-107.
1976 The Role of Northwestern Nicaragua in the Relations Between Mesoamerica and the Greater Nicoya Sub-Area. Master's thesis, Dept. of Anthropology, Wesleyan University, CT.

Yen, D.E.
1974 *The Sweet Potato and Oceania: An Essay in Ethnobotany.* Bernice P. Bishop Museum Bulletin 236. Bishop Museum Press, Honolulu.

Plates

Plate 1: The 1997 UCA excavations at N-MA-36. The figure in the striped shirt to the left is Project Director Dr. Frederick W. Lange.

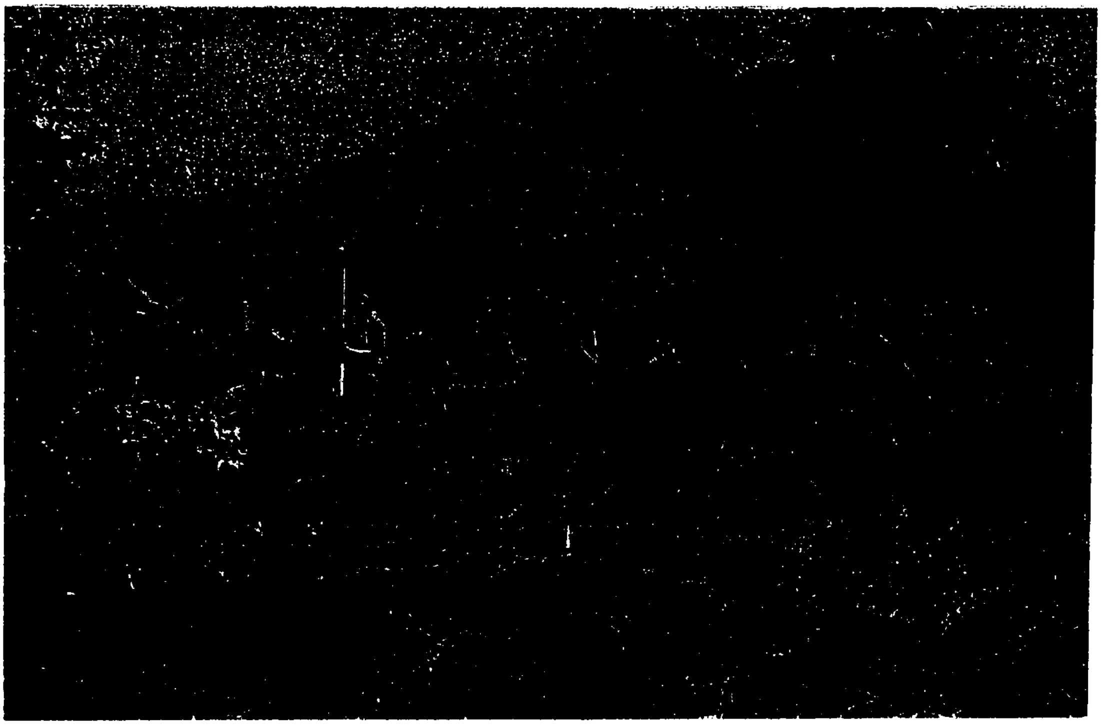

Plate 2: The Sc-J-A site; surveying prior to excavation in 1996 (courtesy Deborah Cornavaca).

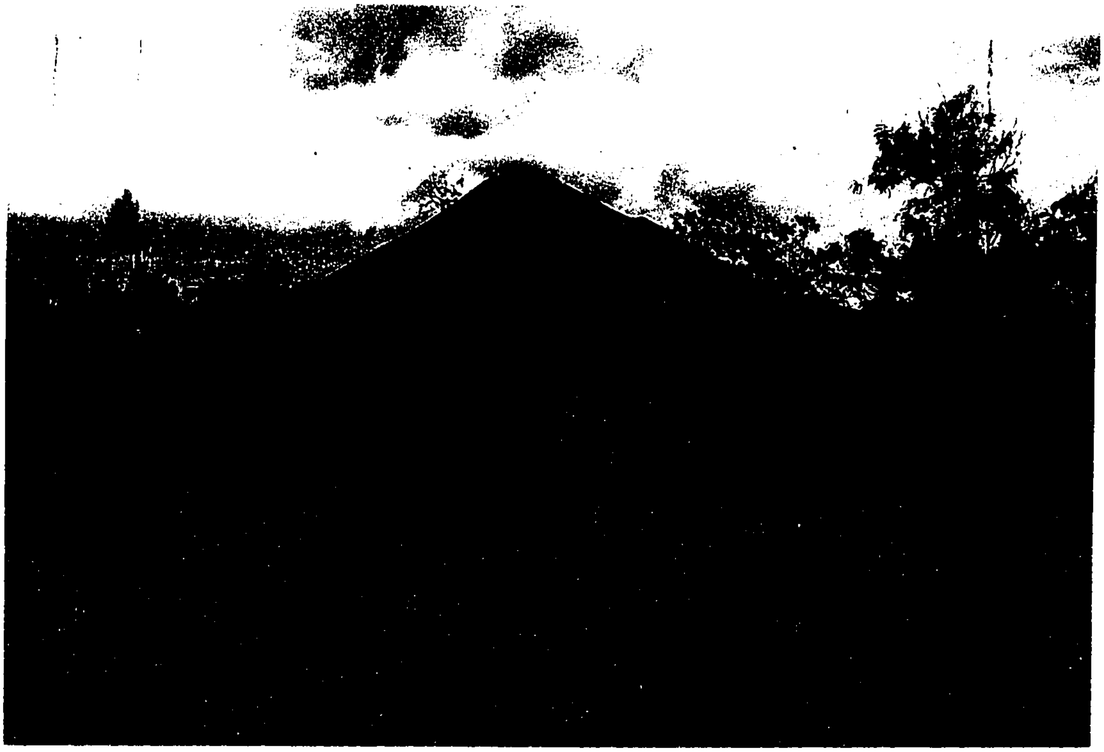

Plate 3: The León Viejo ruins, with Volcán Momotombo in the background.

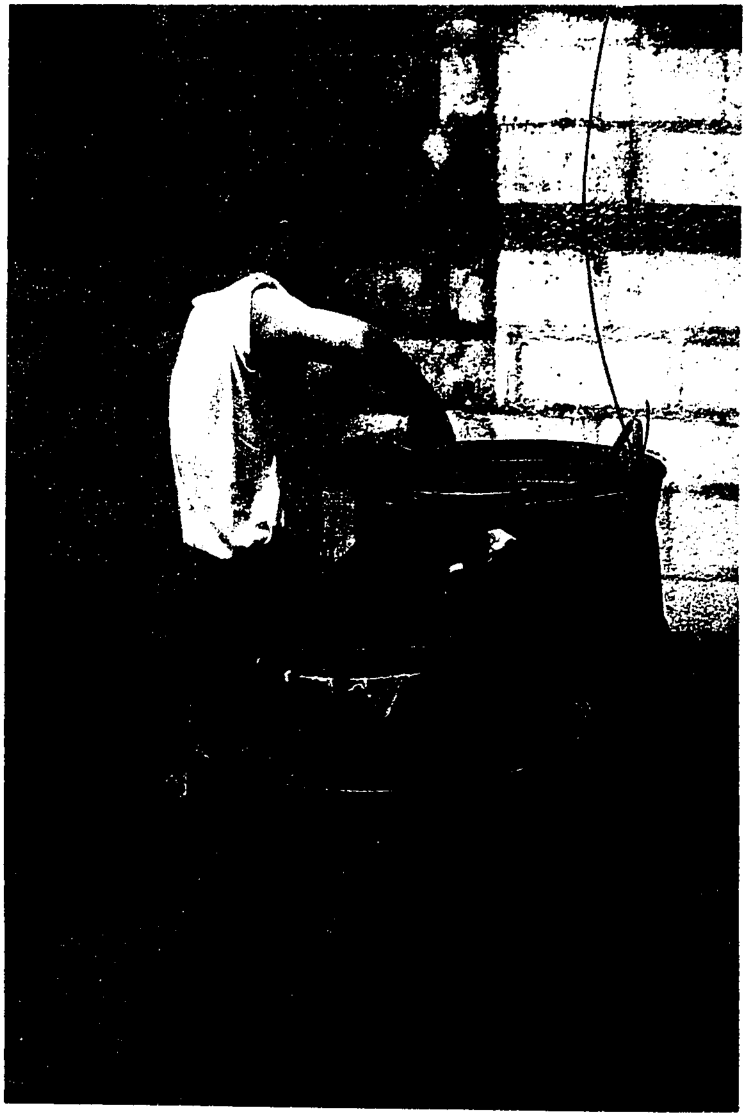

Plate 4: The flotation system.

APPENDIX A
List of Flotation Samples Taken and Processed

Floatation Samples from N-MA-36

Unit	Level	Feature	Date Taken	Processed	Lab I.D. #
Villa Tiscapa					
2		2 - hearth	03/07/96	x	VT-96-01-05
UCA					
5	2		09/06/97	x	UCA-97-01/02
5	3		09/06/97	x	UCA-97-03/04
5	4		11/06/97	x	UCA-97-05/06
5	5		11/06/97	x	UCA-97-07/08
5	6		12/06/97	x	UCA-97-09/10
5	7		12/06/97	x	UCA-97-11/12
5	8		12/06/97	x	UCA-97-13/14
5	9		12/06/97	x	UCA-97-15/16
6	2		09/06/97		UCA-97-17/18
6	3		10/06/97		UCA-97-19/20
6	4		10/06/97		UCA-97-21/22
6	5		11/06/97		UCA-97-23/24
6	6		11/06/97		UCA-97-25/26
6	7		12/06/97		UCA-97-27/28
6	8		12/06/97		UCA-97-29/30
6	9		12/06/97		UCA-97-31/32
6	10		12/06/97		UCA-97-33/34
6	11		13/06/97		UCA-97-35/36
6	12		13/06/97		UCA-97-37/38
7	2		09/06/97		UCA-97-39/40
7	3		12/06/97		UCA-97-41/42
7	3	1, rock cluster	12/06/97	x	UCA-97-43
7	4		12/06/97		UCA-97-44/45
7	5		12/06/97		UCA-97-46/47
7	6		12/06/97		UCA-97-48/49
7	7		13/06/97		UCA-97-50/51
7	8		13/06/97		UCA-97-52/53
7	9		13/06/97		UCA-97-54/55
7	10		13/06/97		UCA-97-56/57
8	2		09/06/97	x	UCA-97-58/59
8	3		10/06/97	x	UCA-97-60/61
8	4		10/06/97	x	UCA-97-62/63
8	5		11/06/97	x	UCA-97-64/65
8	5	1, rock cluster	11/06/97	x	UCA-97-66/67
8	6		12/06/97	x	UCA-97-68/69
8	6	2, soil discolouration	13/06/97	x	UCA-97-70
8	7		13/06/97	x	UCA-97-71/72
8	8		16/06/97	x	UCA-97-73/74
8	9		16/06/97	x	UCA-97-75/76
8	10		16/06/97	x	UCA-97-77/78

Floatation Samples from N-MA-36 (cont.)

Unit	Level	Feature	Date Taken	Processed	Lab I.D. #
9	2		09/06/97	x	UCA-97-79/80
9	3		10/06/97	x	UCA-97-81/82
9	4		11/06/97	x	UCA-97-83/84
9	5		12/06/97	x	UCA-97-85/86
9	6		12/06/97	x	UCA-97-87/88
9	7		12/06/97	x	UCA-97-89/90
9	8	midden	13/06/97	x	UCA-97-91/92
9	9	midden	16/06/97	x	UCA-97-93/94
9	11		16/06/97	x	UCA-97-95/96

Flotation Samples from Sc-J-A

Unit	Level	Feature	Date Taken	Processed	Lab I.D. #
10	13		24-Jul-96	x	SC-96-01/02
10	14	floor surface	25-Jul-96	x	SC-96-03/04
10	16		25-Jul-96	x	SC-96-05/06
10	17	midden	26-Jul-96	x	SC-96-07/08
10	17	1- hearth	26-Jul-96	x	SC-96-09
12	02		16-Jul-96	x	SC-96-10
12	08	floor surface	20-Jul-96	x	SC-96-11/12
12	11		23-Jul-96	x	SC-96-93/94
12	13		26-Jul-96	x	SC-96-13/14
12	16		02-Aug-96	x	SC-96-15/16
14	08	floor surface	20-Jul-96	x	SC-96-17/18
14	12		27-Jul-96	x	SC-96-19/20
14	14		03-Aug-96	x	SC-96-21/22
14	15		03-Aug-96	x	SC-96-23/24
14	16	midden	06-Aug-96	x	SC-96-25/26
16	10		20-Jul-96	x	SC-96-27/28
16	12		26-Jul-96	x	SC-96-29/30
16	15		01-Aug-96	x	SC-96-31/32
16	17		15-Aug-96	x	SC-96-33/34
16	18		16-Aug-96	x	SC-96-35/36
16	18	1 - floor surface	16-Aug-96	x	SC-96-37
16	21		20-Aug-96	x	SC-96-38/39
18	11	midden	24-Aug-96	x	SC-96-40/41
18	13	midden	02-Aug-96	x	SC-96-42/43
18	15		03-Aug-96	x	SC-96-44/45
18	16		03-Aug-96	x	SC-96-46/47
20	09	1 - ash deposit	23-Jul-96	x	SC-96-92/95
20	10	floor surface	24-Jul-96	x	SC-96-48/49
20	10	1 - hearth	24-Jul-96	x	SC-96-50/51
20	14		01-Aug-96	x	SC-96-52/53
23	11	1 - floor surface	27-Jul-96	x	SC-96-54/55
23	12	1 - pit	27-Jul-96	x	SC-96-56/57
23	12	2 - compact surface	27-Jul-96	x	SC-96-58/59
23	13	midden	01-Aug-96	x	SC-96-60/61
23	14	midden	07-Aug-96	x	SC-96-62/63
23	15	midden	07-Aug-96	x	SC-96-64/65
23	15	1 - burial urn	13-Aug-96	x	SC-96-66/67
23	15	2 - urn contents	13-Aug-96	x	SC-96-68/69
23	16		13-Aug-96	x	SC-96-89
23	17		15-Aug-96	x	SC-96-70/71
23	19		16-Aug-96	x	SC-96-72/73
25	08		19-Jul-96	x	SC-96-74/75
25	11	midden	23-Jul-96	x	SC-96-91/96
25	12	midden	25-Jul-96	x	SC-96-76/77
25	13	floor surface	25-Jul-96	x	SC-96-78/79
25	16	midden	06-Aug-96	x	SC-96-80/81

Flotation Samples from Sc-J-A (cont.)

Unit	Level	Feature	Date Taken	Processed	Lab I.D. #
60 B	04		10-Aug-96	x	SC-96-82
60 D	04		10-Aug-96	x	SC-96-83
60 F	04		10-Aug-96	x	SC-96-84
60 F	05		13-Aug-96	x	SC-96-85/86
60 B	06		14-Aug-96	x	SC-96-87
60 D	06		14-Aug-96	x	SC-96-88

Flotation Samples from León Viejo

Unit	Level	Feature	Date Taken	Processed	Lab I.D. No.
30	04		03/07/96	x	LV-96-35
30	05		03/07/96		
30	07		05/07/96		
30	08		05/07/96		
30	10		10/07/96	x	LV-96-01/02
30	10	1 - bone concentration	09/07/96		
30	14		10/07/96	x	LV-96-03/04
30	15	roof collapse	10/07/96	x	LV-96-05/06
30	16		11/07/96		
30	17		11/07/96	x	LV-96-07/08
30	18		11/07/96	x	LV-96-09
30	19		11/07/96	x	LV-96-11/12
31	02		03/07/96		
31	04		03/07/96	x	LV-96-36
31	09	floor surface	10/07/96	x	LV-96-13/14
31	11	midden	12/07/96	x	LV-96-15/16
31	12		12/07/96	x	LV-96-17
31	13		12/07/96	x	LV-96-19/20
31	14		12/07/96	x	LV-96-21/22
31	15		12/07/96	x	LV-96-23
32	02		03/07/96		
32	05		09/07/96		
32	07		09/07/96		
32	10		10/07/96	x	LV-96-25/26
33	02		03/07/96	x	LV-96-27
33	04		09/07/96		
33	05	floor surface	09/07/96		
33	07	midden	11/07/96	x	LV-96-29/30
33	08		11/07/96	x	LV-96-31/32
33	09		11/07/96	x	LV-96-33/34

APPENDIX B
Raw Data Tables

Heavy Fraction Raw Data Table for N-MA-36

Lab I.D. #	Prov.	Botanical					Faunal					Lithic				Ceramic			
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Quartzite*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frags*																
VT-96-01	2-2	1.185	120				5			4?			7						1
VT-96-02	2-2	1.015	68																
VT-96-03	2-2	0.100	29				1(burnt?)		7		10		12						
VT-96-04	2-2	0.432	50								5		1						
VT-96-05	2-2	0.587	103								4								3
UCA-97-01	5-2																		
UCA-97-02	5-2																		
UCA-97-03	5-3	0.005	1																
UCA-97-04	5-3																		
UCA-97-05	5-4																		
UCA-97-06	5-4																		2
UCA-97-07	5-5																		
UCA-97-08	5-5										2								
UCA-97-09	5-6										1								8
UCA-97-10	5-6																		
UCA-97-11*	5-7	0.015	5						1?		3								
UCA-97-12	5-7																		
UCA-97-13	5-8																		
UCA-97-14	5-8										1								4
UCA-97-15	5-9																		
UCA-97-16	5-9																		
UCA-97-43	7-3.1										1								
UCA-97-58	8-2								1?										
UCA-97-59	8-2										5		2						2

Heavy Fraction Raw Data Table for N-MA-36 (cont.)

Lab I.D. #	Prov.	Botanical					Faunal					Lithic				Ceramic			
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Quartzite*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frags*																
UCA-97-60	8-3	0.002	1																
UCA-97-61	8-3																		
UCA-97-62	8-4																		5
UCA-97-63	8-4																		2
UCA-97-64	8-5	trace	1																2
UCA-97-65	8-5										1								
UCA-97-66	8-5.1																		
UCA-97-67	8-5.1										2								2
UCA-97-68	8-6											1							
UCA-97-69	8-6										5								
UCA-97-70	8-6.2										7								
UCA-97-71	8-7														2				5
UCA-97-72	8-7																		
UCA-97-73	8-8																		4
UCA-97-74	8-8												2						
UCA-97-75	8-9																		
UCA-97-76	8-9										3								
UCA-97-77	8-10										7								
UCA-97-78	8-10																		1
UCA-97-79	9-2											1	4						
UCA-97-80	9-2										4			1 jasper					3
UCA-97-81	9-3												4						
UCA-97-82	9-3												2						
UCA-97-83	9-4										6		3	3 jasper					
UCA-97-84	9-4										1								2
UCA-97-85	9-5										1				1				
UCA-97-86	9-5													1					

Heavy Fraction Raw Data Table for N-MA-36 (cont.)

Lab I.D. #	**Prov.**	**Botanical**					**Faunal**					**Lithic**				**Ceramic**			
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Quartzite*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frags*																
UCA-97-87	9-6																		
UCA-97-88	9-6												2		1				
UCA-97-89	9-7												5						
UCA-97-90	9-7																		
UCA-97-91	9-8										4								3
UCA-97-92	9-8	0.009	2						1 burnt		13	1	3	1					3
UCA-97-93	9-9							2											3
UCA-97-94	9-9								1			1		1					
UCA-97-95	9-11								1										3
UCA-97-96	9-11	trace	1										2						3
Totals		3.350	381	0	0	0	6	2	12	4	86	4	49	7	4	0	0	0	61

* indicates entire heavy fraction was analyzed. In all other cases, only 25% of heavy fraction was analyzed.

Heavy Fraction Data Table for Sc-J-A

Lab I.D. #	**Prov.**	**Botanical**					**Faunal**					**Lithic**			**Ceramic**			
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent Teeth*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frags.*															
SC-96-01*[a]	10-13																	4
SC-96-02	10-13										7	3	1		1		1	
SC-96-03*	10-14	0.137	2			3			63			2 spurs	2	2	1	1 Papagayo		20
SC-96-04	10-14	n/a[b]																
SC-96-05	10-17																	
SC-96-06	10-17	0.030															1	3
SC-96-07*	10-17	0.195	1			1			1		7	1		2				2
SC-96-08	10-17																	
SC-96-09	10-17.1	4.360	10						1									
SC-96-10*	12-02	1.123				3												
SC-96-11	12-08							1	6		3	1 blade		1				10
SC-96-12	12-08	0.206	1				2		1		10	5						3
SC-96-13	12-13	0.009							2		12		1	1		1 Segovia Orange		3
SC-96-14	12-13	n/a																
SC-96-15	12-16																	
SC-96-16	12-16	0.036	1				1		11		18							2 + 1 leg
SC-96-17	14-08	0.235			1?		3											
SC-96-18	14-08	n/a																
SC-96-19	14-12										6	1		2				7
SC-96-20	14-12	0.066				2					1							1
SC-96-21	14-14	0.271	1			3		1	1		1	2						15
SC-96-22	14-14	n/a																
SC-96-23*	14-15	1.319	5			4					6	2			1	1 León Punctate	1	8
SC-96-24	14-15	n/a																
SC-96-25	14-16	0.080	1			2			13			1 blade					2 red slip	10
SC-96-26	14-16	n/a																
SC-96-27	16-10													1				3
SC-96-28	16-10	0.006									5							1

Heavy Fraction Data Table for Sc-J-A (cont.)

Lab I.D. #	Prov.	Botanical					Faunal					Lithic			Ceramic			
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent Teeth*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frags.*															
SC-96-29	16-12	0.015									11							10
SC-96-30	16-12	n/a																
SC-96-31	16-15	0.169						1 deer	1(burnt)			3		1				8
SC-96-32	16-15																	
SC-96-33	16-17	n/a																
SC-96-34	16-17	0.062					3		3		7			2			1	6
SC-96-35	16-18	0.385	2						4								3	9
SC-96-36	16-18	n/a																
SC-96-37	16-18.1	0.494	1				9		35		4						2	5
SC-96-38	16-21	n/a																
SC-96-39	16-21	0.096	1	3(frag			1											1
SC-96-40	18-11	0.022									9		2	1			1	14
SC-96-41	18-11	0.019					3		1		10	1				2 Potosí?	1	10
SC-96-42	18-13	0.347	1				2		6		10	1						8
SC-96-43	18-13								10									
SC-96-44	18-15	0.812	1					1										5
SC-96-45	18-15	n/a																
SC-96-46	18-16																	
SC-96-47	18-16	n/a																
SC-96-48*	20-10	0.055	1								2	1						9
SC-96-49*	20-10	0.104					14		15									8
SC-96-50	20-10.1	44.825																
SC-96-51	20-10.1	27.767	lot				1											3
SC-96-52	20-14	n/a																
SC-96-53	20-14	0.139	1														1	2
SC-96-54	23-11.1	n/a																
SC-96-55	23-11.1	0.080	2				2				12						2	12

Heavy Fraction Data Table for Sc-J-A (cont.)

Lab I.D. #	Prov.	Botanical					Faunal					Lithic			Ceramic			
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent Teeth*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frags.*															
SC-96-56	23-12.1	n/a																
SC-96-57	23-12.1	0.170				2	2		9		5	3					1	17
SC-96-58	23-12.2	0.393	4								19						3	15 + 1 leg
SC-96-59	23-12.2	n/a																
SC-96-60	23-13	0.068				1		1 deer	7		8	2, core				1 Cervantes?	2	21
SC-96-61	23-13																	
SC-96-62	23-14	n/a																
SC-96-63	23-14	0.284	1						13		66	2						9
SC-96-64	23-15	1.219	5				2		6		44	1 blade		2			1	8 + 1 leg
SC-96-65	23-15	0.076					1		1		5	1						11
SC-96-66	23-15.1	0.354	3			1	7	3 human	30		21	2						
SC-96-67	23-15.1								18									
SC-96-68	23-15.2	0.153	1					2 human	15		25				1			2
SC-96-69	23-15.2																	
SC-96-70	23-17	n/a																
SC-96-71	23-17	0.087	1								10	1						2
SC-96-72	23-19																	
SC-96-73	23-19	0.089							3		21							5
SC-96-74	25-08	0.029							3		7							12
SC-96-75	25-08	0.032									4							4
SC-96-76*	25-12	0.458	1	1(frag							6			2	2	2 Potosí	2	13 + 1 leg
SC-96-77	25-12	n/a																
SC-96-78	25-13	n/a																
SC-96-79	25-13	0.148						1(burnt?)			5				1	1 León Punctate		10
SC-96-80*	25-16	0.176	4			1	1		15		6	3	6	2				19
SC-96-81	25-16	0.158	1			1						1		2				3
SC-96-82	60-04B	0.009							1		16	1 blade						10
SC-96-83	60-04D	0.220	3								12		3					19

Heavy Fraction Data Table for Sc-J-A (cont.)

Lab I.D. #	Prov.	Botanical					Faunal					Lithic			Ceramic			
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent Teeth*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frags.*															
SC-96-84	60-04F	0.036							1		2	1		2				5
SC-96-85	60-05F						2		1		11							15
SC-96-86	60-05F	0.005							9		3			1				17
SC-96-87	60-06B										29							4
SC-96-88	60-06D																	
SC-96-89	23-16	0.096	1				7	5	49	1 turt.			1 drilled					10
SC-96-92	20-09	0.019																
SC-96-95	20-09								1		10	1	1					
SC-96-93*	12-11												2	2			1	5
SC-96-94	12-11										3		2				1	4
SC-96-91	25-11																	2
SC-96-96*	25-11	0.047	8	1		8	1(burnt?)		6		20	4	2					7
Totals		87.790	87	5	1	32	76	16	362	1	499	56	23	26	7	9	27	458

[a] an '*' indicates entire heavy fraction was analyzed. In all other cases, only 25% of heavy fraction was analyzed.

[b] n/a indicates that the heavy fraction was missing for the particular sample (usually one bag, which equals one half the heavy fraction).

Heavy Fraction Data Table from León Viejo

Lab I.D. #	Prov.	Botanical					Faunal					Lithic					Ceramic		
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent Teeth*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Quartz*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frag.*																
LV-96-01	30-10	n/a[b]																	
LV-96-02	30-10	n/a																	
LV-96-03	30-14	0.007	2											1	1				2
LV-96-04	30-14								3		4								4
LV-96-05	30-15	0.010	1						1		3			2				3	17
LV-96-06	30-15						5	50 (cow)											
LV-96-07	30-17	0.022	4																5
LV-96-08	30-17	0.022	4								2								3
LV-96-09*[a]	30-18	0.581	8								3							1	
LV-96-11*	30-19	0.023	4																3
LV-96-12*	30-19	0.055	7					1											2
LV-96-13	31-09	0.039	11																
LV-96-14	31-09	0.022	5								3				1				2
LV-96-15	31-11	0.058	7			1					7	1 blade				1			8
LV-96-16	31-11	0.022	8																72
LV-96-17*	31-12	0.168	6				2		8		10			2 blade		1		1	8
LV-96-19*	31-13										4	2 blade							2
LV-96-20	31-13								2		2			1					4
LV-96-21	31-14	0.020	1								2								1
LV-96-22	31-14	n/a																	
LV-96-23	31-15										4								
LV-96-25*	32-10	0.021	1																
LV-96-26	32-10	0.036	4						3 (burnt)										3
LV-96-27	33-02										1								
LV-96-29	33-07										1					1			8
LV-96-30	33-07	0.015	1				2		1		7								1
LV-96-31*	33-08										3							1	3
LV-96-32	33-08	n/a																	

Heavy Fraction Data Table for León Viejo (cont.)

Lab I.D. #	Prov.	Botanical					Faunal					Lithic					Ceramic		
		Charcoal		*Seed*	*Nut*	*Unid.*	*Rodent Teeth*	*Mammal*	*Fish*	*Shell*	*Unid.*	*Obsid.*	*Basalt*	*Chert*	*Quartz*	*Beads*	*Identified*	*Unid. Rim*	*Unid. Body*
		Weight (g)	*Frag.*																
LV-96-33	33-09	0.037	3								5					1			
LV-96-34	33-09								1		5								1
LV-96-35	30-04	0.024	2								1				1				
LV-96-36	31-04	0.011	2																
Totals		1.193	81	0	0	1	9	51	15	0	71	3	0	6	3	4	0	6	149

[a] an '*' indicates entire heavy fraction was analyzed. In all other cases, only 25% of heavy fraction was analyzed.

[b] n/a indicates that the heavy fraction was missing for the particular sample (usually one bag, which equals one half the heavy fraction).

Light Fraction Raw Data Table for N-MA-36

Lab ID#	Prov.	cm B.S.^{a}	Sample Vol. (ml)	L.F. Vol. (ml)	Wood (g)	Species Identified	Part Found	#^{b}	C.R.^{c}	Comments
VT-96-01	2-2	60	3000	38	4.43					some insect bits
VT-96-02	2-2	60	3500	75	10.02	Portulacaceae, *Talium* sp.	seed	1	3	lots of ant exoskeleton bits
VT-96-03	2-2	60	3000	26	1.59	unidentified	stem?	1		some insect bits
VT-96-04	2-2	60	3500	43	1.87	unidentified	amorphous tissue	2		some insect bits, lots of pumice
						unidentified	vascular tissue	1		
VT-96-05	2-2	60	3500	41	2.61	unidentified	amorphous tissue	3		lots of insect parts, also a gastropod
UCA-97-01/02	5-2	20	8000	51	trace	unidentified	seed	1		S63, possibly Fabaceae, lots of sediment in sample
UCA-97-03/04	5-3	30	8000	26	trace	Chenopodiaceae, *Chenopodia ambrosioides*	seed	1	1	S15
UCA-97-05/06	5-4	40	8000	20	trace	Fabaceae, *Crotalaria* sp./rugose var.				
UCA-97-07-08	5-5	50	8000	15	none	unidentified	seed	1		modern seeds
UCA-97-09/10	5-6	60	8000	25	trace	Chenopodiaceae, *Chenopodia ambrosioides*	seed	1	2	S15
						unidentified	seed	1		S64, could be grass or sedge, or Brassicaceae, *Lepidium* sp.
UCA-97-11/12	5-7	70	8000	34	trace					modern seeds
UCA-97-13/14	5-8	80	8000	20	trace	unidentified	seed	1		
UCA-97-15/16	5-9	90	8000	15	trace	unidentified	seed	1		
UCA-97-43	7-3.1	30	3500	12	trace	Portulacaceae, *Talium* sp.	seed	2	2	could be modern? other modern seeds in sample
UCA-97-58/59	8-2	20	8000	39	0.09	Fabaceae, *Crotalaria* sp./rugose var.	seed	88	2	sample was contaminated with plastic (surface garbage)
						Portulacaceae, *Portulaca* sp.	seed	8	3	
						Portulacaceae	seed	2	1	
						Chenopodiaceae, *Chenopodia ambrosioides*	seed	1	2	
						unidentified	seed frag	2		
						unidentified	amorphous tissue	3		
UCA-97-60/61	8-3	30	8000	24	0.01	Fabaceae, *Crotalaria* sp./rugose var.	seed	42	2	lots of modern seed fragments
						Cyperaceae, *Scleria* sp.	seed coat frag	2	4	
						Portulacaceae, *Talium* sp.	seed	29	2	
						Chenopodiaceae, *Chenopodia ambrosioides*	seed	1	2	S15
						Fabaceae, *Desmodium* sp. or *Rhynchosia* sp.	seed	1	4	S65
						unidentified	seed?	1		has a hole going into it
						unidentified	seed	6		

Light Fraction Raw Data Table for N-MA-36 (cont.)

Lab ID#	Prov.	cm B.S.^{a}	Sample Vol. (ml)	L.F. Vol. (ml)	Wood (g)	Species Identified	Part Found	#^{b}	C.R.^{c}	Comments
UCA-97-62/63	8-4	40	8000	56	trace	Cheno-Am	seed	1	1	very dirty light fraction
						Chenopodiaceae, *Chenopodia ambrosioides*	seed	2	2	S15
						Fabaceae, *Crotalaria* sp./rugose var.	seed	5	2	
						Cyperaceae, *Scleria* sp.	seed	1	4	
						Portulacaceae, *Talium* sp.	seed	1	2	
						Malvaceae	seed	3	4	
						unidentified	seed	1		S13
						unidentified	seed	1		
UCA-97-64/65	8-5	50	8000	39	0.01	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						Euphorbiaceae	seed	1	3	
						Sapotaceae	charred fruit fles	2	4	
						unidentified	hilum	1		oval, possibly from a legume
						unidentified	seed	2		
UCA-97-66/67	8-5.1	50	8000	83	trace	Fabaceae, *Trifolium* sp.	seed	1	3	S24
						Fabaceae, *Stylosanthes viscosa*	seed	1	3	S68
						unidentified	seed	1		S67, Vitaceae, *Urtica* sp.? Lamiaceae, *Salvia* sp.?
						Chenopodiaceae, *Chenopodia ambrosioides*	seed	1	2	S15
						unidentified	seed	1		
						Sapotaceae	charred fruit fles	1	4	tissue fragile and vacuous, like charred sugar
						unidentified	seed frag?	1		
UCA-97-68/69	8-6	60	8000	69	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	3	2	
						Fabaceae	seed	1	2	
						Sapotaceae	charred fruit fles	6	4	tissue fragile and crumbly
						unidentified	stem or petiole	2		
						unidentified	seed	6		
UCA-97-70	8-6.1	60	4000	3	trace	Cyperaceae, *Scleria* sp.	seed	1	4	
UCA-97-71/72	8-7	70	8000	19	0.05	unidentified	seed	1		
UCA-97-73/74	8-8	80	8000	19	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						unidentified	seed frag?	1		
UCA-97-75/76	8-9	90	8000	15	trace	unidentified	seed	5		2 bone fragments in l.f.

Light Fraction Raw Data Table for N-MA-36 (cont.)

Lab ID#	Prov.	cm B.S.[a]	Sample Vol. (ml)	L.F. Vol. (ml)	Wood (g)	Species Identified	Part Found	#[b]	C.R.[c]	Comments
UCA-97-77/78	8-10	100	8000	18	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	3	2	
						unidentified	seed	1		
UCA-97-79/80	9-2	20	8000	22	0.01	Fabaceae, *Crotalaria* sp./rugose var.	seed	12	2	lots of insect parts
						Fabaceae	seed	6	1	like S65
						Fabaceae, *Stylosanthes* sp.	seed	1	3	S68
						Portulacaceae, *Talium* sp.	seed	3	2	
						Amaranthaceae	seed frags	4	2	S1
						Convolvulaceae, *Ipomoea* sp.	seed	1	2	S70
						unidentified	seed	1		roundish
						unidentified	seed	27		embryos and seed coats, many look like Cheno-Ams or legume family
UCA-97-81/82	9-3	30	8000	26		Poaceae	seed	1	2	S71, badly eroded
						unidentified	unknown	2		
UCA-97-83/84	9-4	40	8000	35	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	large wad of roots
UCA-97-85/86	9-5	50	8000	23	trace	unidentified	unknown	1		
UCA-97-87/88	9-6	60	8000	27	trace	unidentified	unknown	1		
UCA-97-89/90	9-7	70	8000	32	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						unidentified	unknown	1		
UCA-97-91/92	9-8	80	8000	26	0.02	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						unidentified	unknown	1		
UCA-97-93/94	9-9	90	8000	14	trace					L.F. had a ceramic sherd in it, unusual
UCA-97-95/96	9-11	110	8000	17	trace	Chenopodiaceae, *Chenopodia ambrosioides*	seed	1	2	S15
						unidentified	possible seed frag	1		
UCA-97-97	1-8	80	in situ find			Arecaceae, *Acrocomia* sp.	endocarp	1	2	
Totals			240000	105	20.7			33		

[a] Below Surface.
[b] Number of specimens or fragments found (Count).
[c] Confidence Rating: 1-4, 1=100%, 4=50%.

Light Fraction Raw Data Table for Sc-J-A

Lab ID#	Prov.	cm B.D.	Sample Vol. (ml)	L.F. Vol. (ml	Wood (g)	Species Identified	Part Found	#[b]	C.R.	Comments
SC-96-01/02	10-13	150	8000	110	0.04	Amaranthaceae	seed	4	1	lots of modern material, also a gastropod
						Fabaceae	seed	1	2	possibly only a frag. of *Crotalaria* sp./rugose var.
						Fabaceae, *Crotalaria* sp./rugose var.	seed	8	2	
						Butomaceae, *Limnocharis flava*	seed	2	2	
						unidentified	seed	3		S19
						unidentified	seed	1		S21
						Cheno-Am	seed	1	3	
						Portulacaceae, *Talium* sp.?	seed	1	2	like S18
						unidentified	seed frag.	13		
SC-96-03/04	10-14	160	8000	150	0.05	Fabaceae, *Crotalaria* sp./rugose var.	seed	3	2	2 gastropod
						Amaranthaceae	seed	1	1	S1
						unidentified	seed	1		bumpy sphere
						Poaceae, *Zea mays*	cupule	1	3	long and thin, highly eroded
SC-96-05/06	10-16	180	8000	100	0.06	Portulacaceae, *Talium* sp.	seed	2	2	
						Fabaceae, *Crotalaria* sp./rugose var.	seed	3	2	
						unidentified	seed	1		like S19
						unidentified	seed	5		curved, possibly embryos
SC-96-07/08	10-17	190	8000	160	0.36	Fabaceae, *Trifolium amabile*	seed	3	2	S24, sample has roots, and grains of dirt are larger
						Fabaceae	seed	1	3	possible legume
						Poaceae, *Zea mays*	cupule	1	4	
						unidentified, tree fruit	endocarp frag	1	4	
						unidentified	amorphous tissue	1		
SC-96-09	10-17.1	190	4000	95	13.26	Poaceae	spikelet base	1	1	charcoal is very splintery,
						Asteraceae	seed	1	2	dif. from 20-10.1 hearth, dif. use area?
SC-96-10	12-02	45	4000	32	0.97	Butomaceae, *Limnocharis flava*	seed	1	3	S23, could also be *Crotalaria* sp.
						Amaranthaceae	seed	6	2	S20
						Fabaceae, *Crotalaria* sp./rugose var.	seed	5	2	sample from burned area, charcoal in screen
						Fabaceae, *Crotalaria* sp.	seed	2	1	S46, could be *C. pumila*, *C. purshii*, or *C. usaramoensis*
						Aizoaceae, *Mollugo verticillata*	seed	1	1	S25, may be modern
						Passifloraceae, *Passiflora* sp.	seed	1	2	S26
						Cheno-Am	seed	1	3	5 gastropods also found in sample
						Convolvulaceae, *Ipomoea* sp.	seed	6	1	S47, there are about 250 *Ipomoea* spp. in the Neotropics

Light Fraction Raw Data Table for Sc-J-A (cont.)

Lab ID#	Prov.	cm B.D.	Sample Vol. (ml)	L.F. Vol. (ml	Wood (g)	Species Identified	Part Found	#^{b}	C.R.	Comments
SC-96-11/12	12-08	100	8000	80	0.36	Fabaceae, *Crotalaria* sp./rugose var.	seed	3	2	post holes found at this level, with carbon and ceramic scatter
						unidentified	amorphous tissue	7		1 gastropod, 1 fish vertabrae
SC-96-93/94	12-11	130	8000	90	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	12	2	lots of roots, insects and modern seeds
						unidentified	seed	1		bumpy sphere
SC-96-13/14	12-13	150	8000	80	trace	unidentified	seed coat	2		dirty fraction, lots of roots, contaminated by modern seeds
						unidentified	amorphous tissue	2		
						unidentified	possible embryo	1		
SC-96-15/16	12-16	180	8000	30	0.05	Malvaceae	embryo or seed	3	3	S29
						Malvaceae, *Abutilon* sp.	seed	1	1	S2
						Malvaceae, *Hibiscus* sp. or *Abutilon* sp.	seed	1	2	S48
						Fabaceae, *Crotalaria* sp./rugose var.	seed	2	2	l.f. also contains 1 rodent tooth, 1 gastropod, and 1 fish vertabrae
						Fabaceae, *Crotalaria* sp.	seed	1	1	S46, *C. pumila*, *C purshii*, or *C. usaramoensis*
						Portulacaceae, *Portulaca* sp.	seed	1	1	S4
						Convolvulaceae, *Ipomoea* sp.	seed	3	2	lots of *Ipomoea* sp. in Neotropics
						Amaranthaceae	seed	1	1	
						unidentified	seed	1		S28
						unidentified	seed	1		ovoid
						unidentified	seed	1		bell shaped
						unidentified	seed	1		like S19
SC-96-17/18	14-08	100	8000	50	0.03	unidentified	seed	2		post holes found at this level, match 1208
						unidentified	amorphous tissue	1		with a groove
SC-96-19/20	14-12	140	8000	133	0.03	unidentified	possible embryo			
SC-96-21/22	14-14	160	8000	30	0.03	Fabaceae, *Crotalaria* sp./rugose var.	seed	2	2	insect bits, modern seeds present
						Fabaceae, *Crotalaria* sp.	seed frag	1	2	also a bone frag. in l.f.
SC-96-23/24	14-15	170	8000	70	0.20	Fabaceae, *Crotalaria* sp./rugose var.	seed	4	2	some modern seeds, also a rodent tooth
						Convolvulaceae, *Ipomoea* sp.	seed	1	1	
						Convolvulaceae, *Ipomoea* sp.?	seed	1	3	missing seed coat
						Poaceae, *Zea mays*	possible cupule	1	4	like S43, but larger
						unidentified	seed	1		

Light Fraction Raw Data Table for Sc-J-A (cont.)

Lab ID#	Prov.	cm B.D.	Sample Vol. (ml)	L.F. Vol. (ml	Wood (g)	Species Identified	Part Found	#^{b}	C.R.	Comments
SC-96-25/26	14-16	180	8000	60	0.03	Fabaceae, Crotalaria sp./rugose var.	seed	4	2	
						Poaceae, *Zea mays*	cupule	1	3	possible cupule frag.
						unidentified	seed	3		
						unidentified	petiole?	1		
SC-96-27/28	16-10	120	8000	52	0.02	unidentified	amorphous tissue	2		
						unidentified	unknown	1		long, irregular shape, with projections and processes
SC-96-29/30	16-12	140	8000	91	trace					modern seeds, also a rodent tooth
SC-96-31/32	16-15	173	8000	40	0.02	unidentified	seed	1		accidentally shattered
						unidentified	seed frag	3		l.f. contains 2 bone frags.
						unidentified	seed coat	1		
						unidentified	parenchymous tissue	3		
						unidentified	amorphous tissue	1		
SC-96-33/34	16-17	190	8000	50	0.07	unidentified	seed	1		odd shape
						unidentified	seed	6		modern seeds in sample, also a bone frag.
SC-96-35/36	16-18	200	8000	60	0.07	Poaceae, *Zea mays*	seed	1	2	S49
						Crassulaceae, *Sedum* sp.	seed	1	4	S32
						unidentified	seed	3		
						unidentified	amorphous tissue	2		
SC-96-37	16-18.1	200	4000	20	trace	Poaceae, *Zea mays*	possible cupule	1	4	like S43
						Poaceae	spikelet base	1		2 bone frags.
						Crassulaceae, *Sedum* sp.	seed	1	4	S32
						unidentified	seed	1		
						unidentified	seed tissue?	4		
SC-96-38/39	16-21	230	8000	70	0.02	Rosaceae	seed	1	4	S34
						unidentified	seed	4		bumpy sphere
						unidentified	seed	2		bone frag.
						Cucurbitaceae	rind	1	4	may also be *Acrocomia* sp. endocarp
						unidentified	amorphous tissue	1		
						Poaceae, *Zea mays*	possible cupule	1	4	like S43, odd shape with groove

Light Fraction Raw Data Table for Sc-J-A

Lab ID#	Prov.	cm B.D.	Sample Vol. (ml)	L.F. Vol. (ml	Wood (g)	Species Identified	Part Found	$\#^{b}$	C.R.	Comments
SC-96-01/02	10-13	150	8000	110	0.04	Amaranthaceae	seed	4	1	lots of modern material, also a gastropod
						Fabaceae	seed	1	2	possibly only a frag. of *Crotalaria* sp./rugose var.
						Fabaceae, *Crotalaria* sp./rugose var.	seed	8	2	
						Butomaceae, *Limnocharis flava*	seed	2	2	
						unidentified	seed	3		S19
						unidentified	seed	1		S21
						Cheno-Am	seed	1	3	
						Portulacaceae, *Talium* sp.?	seed	1	2	like S18
						unidentified	seed frag.	13		
SC-96-03/04	10-14	160	8000	150	0.05	Fabaceae, *Crotalaria* sp./rugose var.	seed	3	2	2 gastropod
						Amaranthaceae	seed	1	1	S1
						unidentified	seed	1		bumpy sphere
						Poaceae, *Zea mays*	cupule	1	3	long and thin, highly eroded
SC-96-05/06	10-16	180	8000	100	0.06	Portulacaceae, *Talium* sp.	seed	2	2	
						Fabaceae, *Crotalaria* sp./rugose var.	seed	3	2	
						unidentified	seed	1		like S19
						unidentified	seed	5		curved, possibly embryos
SC-96-07/08	10-17	190	8000	160	0.36	Fabaceae, *Trifolium amabile*	seed	3	2	S24, sample has roots, and grains of dirt are larger
						Fabaceae	seed	1	3	possible legume
						Poaceae, *Zea mays*	cupule	1	4	
						unidentified, tree fruit	endocarp frag	1	4	
						unidentified	amorphous tissue	1		
SC-96-09	10-17.1	190	4000	95	13.26	Poaceae	spikelet base	1	1	charcoal is very splintery,
						Asteraceae	seed	1	2	dif. from 20-10.1 hearth, dif. use area?
SC-96-10	12-02	45	4000	32	0.97	Butomaceae, *Limnocharis flava*	seed	1	3	S23, could also be *Crotalaria* sp.
						Amaranthaceae	seed	6	2	S20
						Fabaceae, *Crotalaria* sp./rugose var.	seed	5	2	sample from burned area, charcoal in screen
						Fabaceae, *Crotalaria* sp.	seed	2	1	S46, could be *C. pumila*, *C. purshii*, or *C. usaramoensis*
						Aizoaceae, *Mollugo verticillata*	seed	1	1	S25, may be modern
						Passifloraceae, *Passiflora* sp.	seed	1	2	S26
						Cheno-Am	seed	1	3	5 gastropods also found in sample
						Convolvulaceae, *Ipomoea* sp.	seed	6	1	S47, there are about 250 *Ipomoea* spp. in the Neotropics

Light Fraction Raw Data Table for Sc-J-A (cont.)

Lab ID#	Prov.	cm B.D.	Sample Vol. (ml)	L.F. Vol. (ml	Wood (g)	Species Identified	Part Found	#^{b}	C.R.	Comments
SC-96-52/53	20-14	170	8000	46	0.38	Chenopodiaceae	seed	1	1	shattered
						Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						Fabaceae, *Phaseolus* sp.	cotyledon	1	3	
						Poaceae, *Zea mays*	cupule	1	1	
						unidentified	amorphous tissue	5		
						unidentified	unknown	1		flat tissue
SC-96-54/55	23-11.1	140	8000	175	0.02	unidentified	seed	9		roots, insect parts, modern seeds
SC-96-56/57	23-12.1	150	8000	165	0.02	Amaranthaceae	seed	2	2	bone frag. in sample
						Poaceae, Pancoidae	seed	1	1	possibly *Pancium* sp. or *Tridens* sp.
						Chenopodiaceae, *Salsola kali*	seed	1	3	not native
						Cucurbitaceae, *Sechium edule*	seed	1	4	could also be tree fruit frag., not enough material to identify
						Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
SC-96-58/59	23-12.2	150	8000	226	0.46	unidentified	seed	4		modern seed and roots, also a small obsidian flake
						unidentified	unknown	1		rodent tooth, possible fish scale
						Poaceae, Pancoidae	seed	1	1	S35
SC-96-60/61	23-13	160	8000	82	0.03	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						unidentified	seed	1		bumpy sphere
						unidentified	amorphous tissue	1		
						unidentified	parenchymous tissue	1		
						unidentified	possible seed	1		unusual "toothed" ridge
						unidentified	unknown	1		angular tissue
SC-96-62/63	23-14	170	8000	400	0.83	unidentified	endocarp	2		thick, shell-like tissue with vascular tube
						unidentified	seed	3		bumpy sphere
						unidentified	unknown tissue	2		sample also has an obsidian flake, modern seeds, burnt bone frag.
SC-96-64/65	23-15	180	8000	285	0.16	unidentified	amorphous tissue	5		some modern seeds in sample, also rodent tooth

Light Fraction Raw Data Table for Sc-J-A (cont.)

Lab ID#	Prov.	cm B.D.	Sample Vol. (ml)	L.F. Vol. (ml	Wood (g)	Species Identified	Part Found	$\#^b$	C.R.	Comments
SC-96-66/67	23-15.1	180	8000	25	0.02	Amaranthaceae	seed	4	3	S1
						Amaranthaceae	seed	4	2	S20
						Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	sample has lots of insect parts in it
						Portulacaceae	seed	1	1	6 bone frags.
						Malvaceae, *Abutilon* sp. or *Hibiscus* sp.	seed	1	2	S2
						Cheno-Am	seed	1	4	
						unidentified	seed	5		bumpy sphere
						unidentified	amorphous tissue	4		
SC-96-68/69	23-15.2	180	8000	30	0.02	Fabaceae, *Crotalaria* sp./rugose var.	seed	38	2	lots of modern seeds, rodent tooth
						unidentified	seed frag	1		rounded corner of a seed
						unidentified	seed	2		
						unidentified	seed	1		bumpy sphere
SC-96-70/71	23-17	200	8000	130	0.06	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						unidentified	possible fruit rind	2		S54, unusual scooped surface
						unidentified	amorphous tissue	2		
SC-96-72/73	23-19	220	8000	30	0.02	unidentified	seed	2		bumpy sphere
SC-96-74/75	25-08	70	8000	35	0.23	Rosaceae	seed	1	3	S7
						Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						Malvaceae, *Anoda* sp.	seed	1	3	S59
						unidentified	seed frag	1		S55, possibly a sedge or a grass
						Poaceae, *Zea mays*	seed	1	4	S56, twisted, missing attachment scar
						unidentified	seed	1		bumpy sphere
						unidentified	amorphous tissue	4		
						unidentified	seed	1		
						unidentified	unknown	1		"knob" with a hole through it, attachment to something larger
SC-96-96	25-11	130	4000	5	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	sample has insect parts, roots and modern seeds
SC-96-76/77	25-12	140	8000	105	0.02	Poaceae, *Digitaria* sp. or *Eragrostis* sp.	seed	1	3	S57
						Fabaceae, *Crotalaria* sp./rugose var.	seed	2	2	
						Fabaceae, *Trifolium* sp.	seed	1	3	S24
						unidentified	amorphous tissue	1		

Light Fraction Raw Data Table for Sc-J-A(cont.)

Lab ID#	Prov.	cm B.D.	Sample Vol. (ml)	L.F. Vol. (ml	Wood (g)	Species Identified	Part Found	#[b]	C.R.	Comments
SC-96-78/79	25-13	150	8000	65	0.02	unidentified	seed	4		modern seeds in sample
						unidentified	amorphous tissue	2		
SC-96-80/81	25-16	180	8000	unknown	0.06	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	gastropod in l.f.
						Amaranthaceae	seed	1	2	S20
						unidentified	seed	1		
SC-96-82	60-04B	76	4000	15	trace	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	lots of modern seeds
						unidentified	seed	1		concentration of seeds taken out of this unit
SC-96-83	60-04D	78	4000	40	0.01	Fabaceae	seed	1	1	like S24, but more angular
						Malvaceae, *Abuliton* sp.	seed	1	3	fragmented, S62
						unidentified	seed-like tissue	3		sample has lots of modern seeds
						unidentified	amorphous tissue	10		
SC-96-84	60-04F	73	4000	40	0.01	Portulacaceae	seed	1	2	S4
						unidentified	seed frag	1		
						unidentified	seed?	1		"claw-like"
SC-96-85/86	60-05F	80	8000	120	0.01	Portulacaceae	seed	6	2	lots of modern seeds
						unidentified	seed	1		shattered
						Amaranthaceae	seed	1	3	
						unidentified	amorphous tissue	2		
SC-96-87	60-06B	92	4000	40	trace					modern seeds
SC-96-88	60-06D	90	4000	40	trace					modern seeds, bone frag.
Totals			372000	6417	485.9			45		

[a] Below Datum.

[b] Number of specimens or fragments found (Count).

[c] Confidence Rating: 1-4, 1=100%, 4=50%.

Light Fraction Raw Data Table for León Viejo

Lab ID#	Prov.	cm B.D.^{a}	Sample Vol. (ml)	L.F. Vol. (ml)	Wood (g)	Species Identified	Part Found	#^{b}	C.R.^{c}	Comments
LV-96-01/02	30-10	140	8000	450	0.01	Chenopodiaceae or Amaranthaceae	seed	1		lots of pumice, bone frag.
						unidentified	vascular tissue	1		
						unidentified	amorphous tissue	1		
						unidentified	seed frag	1		
LV-96-03/04	30-14	177	8000	300	trace	unidentified	seed frag	5		lots of pumice
						unidentified	seed frag	2		
LV-96-05/06	30-15	191	8000	1350	2.12	unidentified	tree fruit frag?	1		
						unidentified	amorphous tissue			
						unidentified	fruit pericarp (sugary flesh)?	1		lots of pumice
LV-96-07/08	30-17	210	8000	160	2.11	Convolvulaceae or Euphorbiaceae	seed	1		some relatively large pieces of wood
						dicot	cotyledon frag	1		
						unidentified	amorphous tissue, possible wood	5		
						unidentified	amorphous tissue	1		
LV-96-09	30-18	220	4000	29	0.27	unidentified	amorphous tissue	3		
						unidentified	one side grooved	1		
LV-96-11/12	30-19	235	8000	21	0.07	unidentified	amorphous tissue	3		some charcoal very fragile, possible seed parts?
LV-96-13/14	31-09	170	8000	195	0.16	Fabaceae, *Crotalaria* sp.?	seed	1	3	S37
						Poaceae, *Zea mays*	cupule	1	2	S40
						unidentified	amorphous tissue			also a bone frag. in l.f.
LV-96-15/16	31-11	185	8000	160	0.09	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	S16, sample has 2 bone frags.
						Fabaceae, *Crotalaria* sp.	seed	1	3	like S37
LV-96-17	31-12	200	4000	2	trace					
LV-96-19/20	31-13	210	8000	19	0.01	unidentified	possible seed	1		2 bone frags.
						unidentified	flat, amorphous tissue	1		
LV-96-21/22	31-14	225	8000	35	0.05	unidentified	seed frag.	1		2 bone frags.
						unidentified	amorphous tissue	8		
LV-96-23	31-15	255	4000	10	0.01	unidentified	seed frag.	1		
						unidentified	amorphous tissue	3		

Light Fraction Raw Data Table for León Viejo (cont.)

Lab ID#	Prov.	cm B.D.[a]	Sample Vol. (ml)	L.F. Vol. (ml)	Wood (g)	Species Identified	Part Found	#[b]	C.R.[c]	Comments
LV-96-25/26	32-10	210	8000	20	0.02	unidentified	seed	1		lots of burnt (?) roots
						unidentified	amorphous tissue	6		
LV-96-27	33-02	120	4000	10	trace	Portulacaceae, *P. pilosa* or *P. oleracea*	seed	1	1	lots of burnt (?) roots, seed possibly moder
LV-96-29/30	33-07	187	8000	50	0.03	Asteraceae	seed	1	3	badly eroded, possibly modern
						unidentified	amorphous tissue	6		
LV-96-31/32	33-08	193	8000	10	0.01					
LV-96-33/34	33-09	200	8000	30	0.01					
LV-96-35	30-04	80	4000	5	0.01	Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						Portulacaceae, *Portulaca* sp.	seed	1	1	
LV-96-36	31-04	112	4000	2	trace	Portulacaceae, *Portulaca* sp.	seed	5	1	
						Fabaceae, *Crotalaria* sp./rugose var.	seed	1	2	
						Fabaceae	seed	1	2	
			12800	2858	4.98			7		

[a] Below Datum.

[b] Number of specimens or fragments found (Count).

[c] Confidence Rating: 1-4, 1=100%, 4=50%.

APPENDIX C
Species Found and Discussion of Each

AIZOACEAE Carpetweed Family

Mollugo verticillata L.

Common names: carpetweed, *clavellina montés* (Salv.)

Found in: Sc-J-A 12-02.

The Aizoaceae is mostly represented in Africa, with only a few genera and species in Central America. Four species are recorded for Nicaragua (Seymour 1980). Of the *Mollugo* genus, *M. verticillata* is the only species present in Central America (Standley and Steyermark 1946). The seed found at Sc-J-A is likely modern. Although it appeared charred, it was found close to the surface, within a level identified as post-colonial deposition. In addition, modern seeds of *M. verticillata* were found in other samples from the area. The charred seed from this particular sample was likely the consequence of recent farming practices of slash and burning the pasture to encourage new growth for livestock.

AMARANTHACEAE Amaranth Family

Species unknown, possibly *Amaranthus* genus

Common names: amaranth, pigweed, *huauhtli*, *quelite* (both Nahuatl), *bledo*

Found in: UCA 9-2, Sc-J-A 10-13, 10-14, 12-16, 23-12.1, 23-15.1, and 60-05F.

Possibly found in: Sc-J-A 12-02, 25-16, and León Viejo 30-10.

At least two different species were recognized within the samples, possibly three. Two were drawn and given a species number (S1 and S20). However, these were unidentified past family; tentatively, they are all identified to the genus *Amaranthus*.

The Amaranthaceae is a large family of about 50 genera widely distributed in both hemispheres. In the Western hemisphere, the family is best represented in tropical South America. Twelve genera exist in Central America, most are weedy species which are adept at colonizing waste-places (Standley and Steyermark 1946). Seymour (1980) lists ten genera found in Nicaragua, with 42 species.

Amaranths are very similar to Chenopods, in both morphology and their colonizing behavior (see below under Chenopodiaceae). The seed morphology in particular is very similar for some species, and therefore many seeds in the samples from Nicaragua were often identified only as "Cheno-Ams" (Seeds from Sc-J-A 10-13, 12-02, 23-15.1, León Viejo 30-10 and UCA 8-4). The Chenopodiaceae tend to be more temperate or highland species. Cultivated Amaranthaceae are also found commonly in the tropical highlands, but most wild species are more common in the lowlands.

Of the Amaranthaceae, the *Amaranthus* genus seems to be the only one of economical value. Some species are reportedly used as pot-herbs (Standley and Steyermark 1946), and some as grain crops (Pursglove 1968). *Amaranthus caudatus* L. was a grain crop of the Andes, but there are no reports of it being found north of South America until recently when it became popular as an ornamental plant. *A. cruentus* L. is an occasional grain crop in Guatemala and other Central American regions today, and likely in the past as well (Standley and Steyermark 1946). *A. leucocarpus* S. Wats. is the most widespread and important of the grain amaranths cultivated throughout Central America and Mexico, as well as into the Southwest United States (Pursglove 1968, Sauer 1950). *A. leucocarpus* is still cultivated in Mexico and Guatemala where the small seeds are ground into flour. According to the Codex Mendoza (1938) and other Spanish ethnohistoric accounts, the Aztec leader Moctezuma received an annual tribute of 200,000 bushels of seed, called *huauhtli*. Based on linguistics and the regions of cultivation, this crop was probably *A. leucocarpus* (Sauer 1950) although some have argued that *huauhtli* is actually *Chenopodium berlandieri* ssp. *Nuttalliae* (Saff.) Wils. and Heis (Safford 1918, Reed 1950).

According to Safford (1918), the name *huauhtli* is used by residents in regions of Mexico to describe *C. berlandieri* ssp. *Nuttalliae*. Sauer (1950) reports other cases of *Amaranthus leucocarpus* being called *huauhtli*. It is likely that the name is used for both plants (and possibly other plants as well); the ethnohistorian Sahagún's (ca. 1570) drawings show the name *huauhtli* being applied to more than one type of plant even during colonial times (Sauer 1950). In Nahuatl, *huauhtli* means fish eggs or insect eggs, and is likely used for amaranths and/or chenopods because of their roe-like appearance (Sauer 1950:567).

Huauhtli was extremely valuable to the Aztecs, not only as a food crop, but for religious reasons. Cortés wrote in one of his letters to the King of Spain that the Aztecs made heathen idols of dough made of various seeds, milled and kneaded with blood from sacrifices. There is good evidence that one of these grains was amaranth. Sahagún (ca. 1570) writes of various festivals in which idols made of *zoale* were ceremonially broken and eaten. Sahagún writes that *zoale* was made from the seeds of *bledo*, a Spanish term still used today for amaranths (Standley 1928, Sauer 1950). Amaranth is grown today in some regions of Mexico, and possibly Central America (Sauer 1950). Production is limited to household or community use, and it is not the major economic crop it once was before the conquest. The decline in amaranth production after the conquest may be due in part to the Spanish suppression of this crop because of its importance in Mexican religious ceremonies (Sauer 1950, Pursglove 1968). The use of the seeds in making dough idols was considered a heathen practice, and the breaking and eating of these idols a terrible blasphemy and mockery of the sacred Holy Communion of the Catholic church (Sauer 1950).

Amaranths were also used in more domestic ways as well. Whole seeds were parched or popped, and milled seeds were used in making gruel and a beverage in Central Mexico (Sauer 1950). Amaranths were also commonly used as pot herbs (Sahagún ca. 1570). In fact, amaranths such as *A. dubius* Mart., *A. gangeticus*, and *A. hybridus* L. are still used today in Central America as pot herbs (Pursglove 1968). Some scholars argue that the importance of amaranths and chenopods is overlooked in the study of New World agricultural development. Wilson (1990), for instance, believes that the cultivation and domestication of grain amaranths and chenopods is very ancient and preceded that of maize. They may represent the initial stages in the evolution of agricultural systems. The use of amaranths and chenopods in Aztec ceremony suggests cultural depth and antiquity for the crop (Wilson 1990).

Because of the pre-contact Nicaraguan connection with southern Mexico, it is possible that amaranth may have been similarly used as a pot herb in prehistoric Nicaragua in the very least, and possibly cultivated for its grain. Prehistoric Nicaraguans may have even attached some religious significance to it, but this is difficult to demonstrate. Ethnohistorical records of the area do not include information that connects amaranth to ceremonial practices, as do the ethnohistorical sources for Mexico.

ARECACEAE (PALMAE) Palm Family

The Arecaceae is one of the oldest families of woody plants. Palms are also recognized as one of the most economically important families in the world, both in modern and prehistoric times. They provide basic necessities like food, shelter, fuel, and fiber, as well as spices, oils, waxes, gums, poisons, and medicines (Plotkin and Balick 1984). Arecaceae is second only to Poaceae in economic importance (Pursglove 1972). Palms form a characteristic feature of tropical vegetation and are found in all habitats (forests, saline lagoons, freshwater swamps, savannas, deserts, and mountains). Despite their importance, the taxonomy of palms is imperfectly understood, with many species having been reclassified and renamed (Standley and Steyermark 1946).

Acrocomia sp.

Common names: coyol palm, wine palm

Found in: UCA 1-8, Sc-J-A 18-16, and 20-10.

Three species of *Acrocomia* have been described for Central America; *A. mexicana* Karw. ex Mart., *A. vinifera* Oerst., and *A. belizensis* Bail. (Lentz 1990). But taxonomic boundaries are unclear, and many scholars treat these names as synonyms for the same species (Standley and Steyermark 1946, Williams 1981). Throughout Mexico and Central America, most *Acrocomia* species are called *coyol* (a Nahuatl name), and most produce edible fruits. The tall trunks of this genus are densely covered with long hard spines, making the fruit difficult to harvest until it falls to the ground. The seeds are made up of a thin outer pericarp, surrounding a pulpy mesocarp, within which is a hard, bony endocarp. Inside this endocarp is a kernel of solid white edible tissue, similar to coconut meat (Lentz 1990:184).

The coyol was an ideal crop in prehistory. Nutritionally, the kernel is rich in oil and has a high caloric content, as does the edible mesocarp (Lentz 1990:189). The kernel also provides a fair amount of protein. The trees are productive, and provide two crops a year, the first around March-June and a second crop around November- December (Lentz 1990). The March-June harvest is right at the end of the dry season, and would have provided an excellent famine food in years of low stores (Lentz 1990). The fruits also store well, and would have been available in between harvests (Janzen 1983). Productivity assessments of *A. mexicana* show it was capable of contributing considerably to pre-Columbian diets in Central America (Lentz 1990).

A. mexicana is widely distributed throughout lowland Central America. According to Standley (1928:95): "In many places along the Pacific coast of Central America this palm forms extensive forests," called coyolares. *A. mexicana* takes advantage of disturbed habitats, and grows rapidly up to 15 metres tall (Lentz 1990:187). Strangely, however, it is uncommon in traditionally recognized disturbed areas such as creek bottoms and river banks (Janzen 1971), but this is probably due to its dislike of constantly wet soils, which would be found in such areas (Lentz 1990). It may have taken advantage of natural clearings created by fire, but it was agricultural clearing and disturbance contributed greatly to its expansion (Lentz 1990). Lentz (1990:188) suggests that the creating of habitat for coyol was unintentional at first, but as people realized its potential, they began actively encouraging it and dispersing seeds. Coyol is commonly encouraged or cultivated by farmers today throughout Central America (Lentz 1990:185).

A. mexicana is eaten by the Jicaque Indians of Honduras, where it is grown in the household compound. (Interestingly, this was the only member of the palms Lentz reported that the Jicaque ate.) The exocarp is cut open with a machete, and the bony endocarp smashed with a rock (Lentz 1986). In prehistory, coyol was likely one of the main products processed using the "nutting stones" found in Central America. The only way to get to the kernel is to crack the hard endocarp using rocks or nutting stones (Standley and Steyermark 1946). This is also why archaeobotanical endocarps are typically found in fragments. The remains from Nicaragua follow this pattern as well; *Acrocomia* sp. was represented only by fragments of dense, carbonized endocarp shells, likely discarded into the fire, and therefore charred and preserved. Endocarps are among the most durable plant tissues, and are routinely discarded (Lentz 1990:186).

Today, the fruit is boiled with sugar and offered for sale in Guatemalan markets, although the mesocarp does not provide much food (Standley and Steyermark 1946). The soft kernels are eaten fresh (Lentz 1986).

Some *Acrocomia* species are used for the production of palm wine (Standley 1928, Balick 1990). Balick (1990) describes the process from central Honduras. Mid-aged trees are felled and a trough is cut into the inner wood of the tree where sweet sap collects. This sap can be consumed as is, but more commonly it is allowed to ferment naturally for 24 hours (Balick 1990). The technique of making palm wine apparently goes back to pre-Columbian times. Fuentes y Guzmán (cited in Fowler 1989) recorded this method being practiced by the Indians in Guatemala. Belt (1874:232) describes this technique used also in Nicaragua. He also reported that a large grove of coyol palms near Granada were cut down by the government due to the "excesses of the Indians, who used to assemble there on their festivals, and get drunk on the palm wine." In southern Honduras today, coyol vinegar is flavored with peppers and onions (Freytag 1953). On average, two bottles of sap per day can be harvested from one tree for 25 days. Coyol wine has little nutritional value but may have been an important intoxicant during festivals (Balick 1990). The production does require the felling and the destruction of the tree, but the local population did not suffer greatly from local production. Balick (1990) believes that *Acrocomia* species are one of the more resistant palms in Central America.

Other *Acrocomia* species are also useful. *A. antioquiensis* Posada-Arango (corozo) has been used for medicinal purposes, as well as fiber, oil, and wood for construction (Plotkin and Balick 1984). *A. sclerocarpa* Martius is used for making palm wine, medicinal purposes, oil, wood, and fiber (Plotkin and Balick 1984). *A. vinefera* was also used for wine (Janzen 1983). *A. vinefera* is common from Mexico to Panama, and is never found in any habitat other than sites disturbed by humans, such as pastures, old fields, roadsides, and house sites. It rapidly invades pastures that are not burned annually.

ASTERACEAE (COMPOSITAE) Aster or Sunflower Family

Species unknown.

Possibly found in: Sc-J-A 10-17.1, and León Viejo 33-07.

The Asteraceae is one of the largest families. In Nicaragua, Seymour (1980) has recorded at least 99 genera and 308 species. It is characterized by disk or ray type flowers, and the seeds often have pappus at the summit. On archaeobotanical seeds, this pappus is usually not preserved, but a attachment ring is left on the top of the seed. The most economically important member of the Asteraceae is the sunflower (*Helianthus annuus*).

Many medicinal plants come from the Asteraceae. Commonly recognized ones include chamomile and fleabane. *Stevia ovata* Willd. of the Asteraceae family is used by the Jicaque Indians of Honduras. They make a tea of the ground up leaves to soothe stomach pains (Lentz 1986).

BUTOMACEAE Butoma Family

Limnocharis flava (L.) Buch.

Common name: *cebolla de chucho* (Standley and Steyermark 1946)

Possibly found in: Sc-J-A 10-13, and 12-02.

There are about four genera and 12 species worldwide in the family Butomaceae, in both tropical and temperate regions. *Limnocharis flava* is one of only two species represented in Central America (the other being *Hydrocleis Standleyi*) (Standley and Steyermark 1946) and the only species recorded for Nicaragua (Seymour 1980:37). It is a common plant in mud or shallow water. The common Spanish name is *cebolla de chucho* (Standley and Steyermark 1946), which literally translated means "onion of the mud". Regardless of the name, no uses are given for the plant.

The seeds found in the Nicaraguan samples were difficult to identify, and may only be a variation of *Crotalaria* sp., rugose variety.

CHENOPODIACEAE Chenopodium Family

Chenopodium sp.

Common names: chenopodium, *epazote* or *apazote* (Nahuatl), *cauhzontli*, *huauhtli* or *uauhtli*, *huauquilitl*, *uauhtzontli*, Mexican wormseed.

Found in: UCA 5-3, 5-6, 8-2, 8-3, 8-4, 8-5.1, 9-11, and Sc-J-A 20-14.

Possibly found in: León Viejo 30-10.

There are probably 80 species or more in this family, 50 known in North America, chiefly in temperate regions. Only a handful are known for Central America, and the majority grow in highland regions (Standley and Steyermark 1946). Of the New World Chenopods, *Chenopodium quinoa* L. was the most economically important. The seeds were used as a major grain staple in the Andean region, and it is still cultivated there today, although not to the same extent as in prehistory. Although *C. quinoa* was introduced into central Mexico in the past, and is grown there today for food in some highland areas (Standley and Steyermark 1946), the seeds are fairly large, and it is doubtful the carbonized seeds found in the Nicaraguan samples are this species. In Guatemala, *C. berlandieri* Wils. and Heis. is used as a pot herb like spinach, and the species *C. graveolens* and *C. ambrosioides* L. are also found. *C. ambrosioides* is the only species reported for Nicaragua by Seymour (1980), and is found in the interior highlands. However, other species may exist which have not been documented yet for Nicaragua. The species *C. pueblense* Reed and *C. berlandieri* ssp. *nutalliae* (Saff.) Wils. and Heis., are reported for Mexico. *Chenopodium* seeds are 14-15% protein, which is higher than most cereal grains (Simmonds 1965).

C. pueblense Reed has been identified by Reed (1950). This species is indigenous to Mexico, and is reported not to occur outside of cultivation. The range of this species is not given. The common name, *cauhzontli*, is from Nahuatl. Reed (1950) reports that this species has use in modern Puebla, Mexico, where young plants are cooked and eaten as greens, and immature inflorescences (when the seeds are in the "milk" stage) are dipped in egg-batter and fried.

C. berlandieri ssp. *nuttalliae*, along with *C. quinoa*, is considered a domesticate; it is not found in a wild state (Safford 1918). It is most closely related to the wild *C. berlandieri*, and likely evolved from an ancestral *C. berlandieri* type along with two other Mexican cultivars (*C. pueblense* and *C. berlandieri* ssp. *zschackei*) under human selection in Mexico (Wilson and Heiser 1979). The prehistoric range of *C. berlandieri* ssp. *nuttalliae* is not fully known, but it was being cultivated in the Mexican states of Michoacan, Oaxaca, Veracruz, and Tamaulipas at the time Safford wrote his description (Safford 1918). According to Safford (1918), the local residents called it *huauhtli* or *uauhtli*, the name used in the Aztec Codex Mendoza for a tribute crop. This name also seems to be used for cultivated amaranth species in Mexico, and there is some disagreement as to which species the Codex Mendoza refers to (Reed 1944, Sauer 1950, Hunziker 1952) (See above under Amaranthaceae). Different parts of the plant, when used, also had different names. *Huauquilitl* referred to the cooked greens of the plant, whereas *uauhtzontli* referred to the seed heads or grain (Safford 1918). At the time Safford wrote his description, bunches of the green plant in bud were available for sale in the market. The leaves were cooked like spinach. The inflorescence spikes were washed and dipped in batter, then fried. Stems were then pulled through the teeth to remove and eat the unripe "milk" seeds (Nuttall, personal communication to Safford 1918).

C. ambrosioides is widespread throughout Central America, and one of the most common species. It is known in parts of Central America as *epazote* or *apazote*, a Nahuatl term. In Seymour's (1980) checklist, it is the only *Chenopodium* species listed for Nicaragua, collected in the northern highlands. *C. ambrosioides* is a weedy species found in cultivated fields and secondary growth areas around human disturbances. It has a distinctive fetid odor and has long been known as an effective agent for expelling intestinal parasites by both indigenous populations of Guatemala, and in pharmacopoeias where it is referred to as "Mexican wormseed" (Standley and Steyermark 1946). It is also used for other medicinal purposes; narcotic, poultice, and sleep inducement. In Panama, it is grown in gardens for medical use (Standley 1928). Lentz (1986) reports that the Jicaque Indians of Honduras use *C. ambrosioides* L. as medicine for stomach aches. The seeds are ground and mixed with cool water to form a paste which is filtered and then ingested.

Salsola kali

Common name: Russian thistle

Possibly found in: Sc-J-A 23-12.1

Salsola kali is an Old World species which was introduced to North and South America after European contact. It is therefore probable that the seed found was modern.

CONVOLVULACEAE Morning Glory Family

There are about 45 genera and 1000 species in this family, mainly twining annual and perennial herbs, but also erect herbs and shrubs (Pursglove 1968). They are widely distributed in the world, especially in the tropics. Seymour (1980) lists 12 genera and 75 species, with *Ipomoea* being by far the largest genus in Nicaragua with 46 species. Latex is often present in members of this family (Pursglove 1968).

Species unidentified

Possibly found in: León Viejo 30-17

Ipomoea sp.

Common name: morning glories

Found in: UCA 9-2, Sc-J-A 12-02, and 14-15.

Possibly found in: Sc-J-A 12-16.

There are approximately 250 *Ipomoea* species in the New World tropics (Standley and Steyermark 1946) abundant in the lowlands. The seeds from these are generally very similar to one another, with most differences in size, and hilum area. *Ipomoea* species are generally twining plants, with trumpet-shaped flowers. Most species do not have tuberous roots, and of those that do (outside of *I. batatas*), most are unpalatable or even violently purgative (Cooley 1951). Based on the comparative collections examined, the *Ipomoea* seeds were within the size and shape of *Ipomoea batatas* (L.) Lam., however at this point, it can not be stated confidently that this was the species from which the seeds came. *I. batatas* (sweet potato) is recognized as an important food plant throughout the New World tropics. There are no other economically important species of the genus *Ipomoea* according to Cobley (1967). However, the tubers of other *Ipomoea* species have been used in North America for food (*I. leptophylla* Torr. in the west, and *I. pandurata* Mey. in the southwest) (Cooley 1951).

The tuberous roots of *I. batatas* are an important food, especially in tropical areas. The tubers are eaten boiled, roasted, ground into flour, or fermented into an alcoholic drink called *mobby* or *mormoda* in the West Indies and Latin America (Lötschert and Beese 1983:180). Ethnohistorical accounts indicate that it was an important crop at the time of contact as well. *I. batatas* is an unusual species in that it is found prehistorically in both tropical America and the Pacific Islands. It originated somewhere in tropical America, and spread very early on to the Pacific (Pursglove 1968, Yen 1974, Cobley 1976). By the time of Columbus, it was grown throughout tropical America. No wild species has been found that is definitely the progenitor of sweet potatoes, and most wild species differ greatly from modern cultivars (Cooley 1951). *I. tiliaceae* (Wild.) Choisy and *I. trifida* (HBK.) G. Don are considered the most closely related wild species (Cobley 1976). Both species are from tropical America around the Caribbean and *I. tiliaceae* was cultivated throughout tropical America and the West Indies prior to Spanish contact (Cooley 1951). Austin (1978, in Pearsall and Piperno 1998) suggests that *I. trifida* may be the wild descendant or feral forms of escaped *I. batatas*, not the wild ancestor. Regardless, the distribution of *I. trifida* suggests an origin for sweet potatoes in the Neotropics (Piperno and Pearsall 1998). How the sweet potato made its way to Polynesia prior to European exploration and trade is a matter of much speculation. Different theories have been postulated on possible prehistoric contact between Polynesians sailing to South or Central America (Hornell 1946) or vice versa. The lexical parallels between Polynesian words for sweet potato and the Peruvian term for it are too similar to be coincidental (Yen 1974).

Like other root crops in Central America, *I. batatas* had the advantage over other foods in that it could be left in the ground until needed, rather than being stored. The fleshy root was very perishable when storage conditions were not ideal (Cooley 1951). Oviedo (1959, vol. 1, pp. 234-235) mentioned that sweet potatoes could be carried across the Atlantic to Spain when they were well cured and the ship made a quick passage, but more often than not they did not last. Because of *I. batatas* inability to last, Pursglove (1968) believes it is unlikely that tubers would survive the trip on a raft to Polynesia. He originally speculated that the species may have been independently brought into cultivation in each area (Pursglove 1963), but later changed his view. The seed capsules float, and seeds can germinate even after exposure to salt water, hence it is entirely possibly that capsules spread to Polynesia via the Pacific currents, according to Pursglove (1965). Yen (1974) questions the natural spread of *I. batatas*. He supports a tripartite hypothesis in which three different transfers of *I. batatas* from tropical America took place; one in prehistory, and two in colonial times. Whether Polynesians or Amerindians are responsible for prehistoric transfer of *I. batatas* is difficult to answer, and there is a lack of evidence for either side. Yen (1974) appears to favor a Polynesian contact with Pacific South America, based on agricultural patterns which developed in Polynesia. *I. batatas* is one of only three crops that were common to both hemispheres prior to Columbus. The other two are *Cocos nucifera* L. (coconut) and *Langenaria siceraria* (Molina) Standl.(bottle gourd). These latter two spread by floating on the ocean currents.

I. batatas yields well under a range of climates and soil conditions, but does best in light sandy soil with annual rainfall around 1000 mm. It is not a drought tolerant crop, but does not like to be waterlogged either. Often it is grown in small mounds or on ridges (Pursglove 1968). The vine flowers readily and produces viable seed, but the crop is usually propagated vegetatively. The fruit is a globular, dehiscent capsule containing up to four small black seeds. A single plant produces several tubers which vary greatly in size. In Africa, Indonesia, and the Philippines, the shoots and young leaves are used as a pot herb (Pursglove 1968), although so far there is no evidence or reports of this use in the American tropics.

Nutritionally, the amounts of carbohydrates, protein, fat, and sugar *I. batatas* contains varies depending on species, maturity at harvest, storage period, and weather during growth (Cobley 1976). According to Lötschert and Beese (1983:179), the closer they are grown to the equator, the higher the sugar content. They have fifty percent more calories than potatoes (*Solanum* spp.), and are rich in Vitamin A (Pursglove 1968).

I. silvicola House. is known by the Jicaque Indians of Honduras, but not used for any purpose (Lentz 1986). *I. polyanthes* stems are used in El Salvador to string tobacco leaves up to dry, and the juice is said to be used for coagulating rubber sap (Standley 1928). Lysergic acid occurs in the seeds of *Ipomoea* (Baker 1978) and in this century has been used as a neurological stimulant. I am unaware of any ethnohistoric or ethnographic accounts which report the use of *Ipomoea* seeds as drugs in Central America.

CRASSULACEAE

Sedum sp.

Common names: *colchón*

Possibly found in: Sc-J-A 16-18, 16-18.1.

Sedum is a large genus with 125 or more species worldwide. In Central America it is mostly found in mountainous regions. Sedums are succulents, with fleshy leaves. One species, *S. praealtum*, has been recorded as being used medicinally, to treat inflammation of the eye and mouth, but no uses for other species are known (Standley and Steyermark 1946). Some species are grown in North America today as ornamental garden plants.

Seymour (1980) lists only one member of Crassulaceae being found in Nicaragua, *Bryophyllum pinnatum*. He does not report any *Sedum* species.

CUCURBITACEAE Squash Family

There are about 90 genera and more than 700 species of Cucurbitaceae widely distributed over the warm parts of the world (Cobley 1976). Most are tendril climbing or prostrate herbaceous annuals. All are intolerant of frost, and are most widely grown in the tropics. Cultivated species belong to *Cucurbita* (squashes), *Lagenaria* (bottle gourds), *Luffa*, *Momodica*, *Sechium*, and *Trichosanthes* genera. Of lesser importance is *Cyclantera pedata*, which is sometimes cultivated for its ovoid yellowish fruit (Pursglove 1968).

Species unknown, possibly *Cucurbita* sp.

Common names: squash, pumpkin, gourd, calabash

Found in: Sc-J-A 16-21.

Cucurbita are all of New World origin. The main cultivated species in Central America are *C. maxima* Duch., *C. moschata* (Lam.) Poir., *C. argyrosperma* Huber (syn. *C. mixta* Pang.), and *C. pepo* L. There is considerable confusion as to the identity of cultivated species, and common names such as winter squash, pumpkin, and marrow are often used indiscriminately between species (Pursglove 1968).

Today, cucurbits are cultivated in North America mainly for their flesh, which is eaten as a vegetable or desert. However, cucurbits were likely first cultivated for their edible seeds and usefulness as containers, as the flesh of wild species is stringy and bitter (Piperno and Pearsall 1998). These uses continue today in parts of Central America. For example, the Jicaque eat both the seeds and the flesh of *C. pepo*, and sometimes make containers from the sun-dried rinds (Lentz 1986). Young leaves and shoots of some cucurbits may be also eaten as pot herbs. Nutritionally, the flesh of most *Cucurbita* species are composed of 90% water, with some carbohydrates and nutrients (Pursglove 1968). Immature fruits contain more water and less nutrients. The seeds, on the other hand, are rich in oil and have some protein.

Pre-Columbian *C. maxima* seeds have been found in Peru, but no prehistoric remains have been found in Mexico or Central America (Pursglove 1968). It appears to have been domesticated in S. America, but not taken elsewhere until after European contact. It is related closely to the wild *C. andreana* of Argentina and Bolivia, and hybridizes readily with it. *C. andreana* may be a progenitor, or a weedy offshoot (Pursglove 1968, Piperno and Pearsall 1998).

C. pepo is indigenous to arid areas of northern Mexico and prefers a drier climate (Pursglove 1968). In the humid lowlands, there is often a problem with fungus and mildew. *C. pepo* has been recorded at many sites; it is the oldest known domesticated cucurbit with remains dating to 7000 B.C. from Guilá Naquitz in Mexico (Smith 1997). *C. texana* grows wild in Texas and is proposed by Pursglove (1968) as a possible progenitor or a weedy offspring.

Unlike other cultivated species of *Cucurbita*, *C. moschata* is adapted to warm humid conditions rather than drier conditions, which supports the hypothesis that it was domesticated in the humid lowland forests of Central America, possibly in central Panama or the northern Columbia (Piperno and Pearsall 1998). A wild relative was recently discovered in Panama (Piperno and Pearsall 1998). There is good archaeological proof that *C. moschata* was widely distributed in both North and South America prior to European contact. It occurs in early levels in both Mexico (Tehuacán) and Peru (Huaca Prieta) dating to 3400-1000 B.C. (Whitaker and Cutler 1965).

At Contact, *C. argyrosperma* was distributed from southwestern United States to Pacific Guatemala (Pursglove 1968). It is adapted to cooler conditions and is more drought tolerant than *C. moschata*, and therefore was thought to be more closely related to *C. pepo* (Pursglove 1968). But recent allozyme and chloroplast DNA studies suggest that *C. argyrosperma* is more closely related to *C. moschata* (Piperno and Pearsall 1998). At Tehuacán *C. argyrosperma* seeds were recovered in greater abundance than any other species, and it was cultivated as early as 3500 B.C., possibly as early as 5000 B.C. (Whitaker and Cutler 1965).

The specimen from the Nicaraguan sample was a possible rind fragment, which is virtually unidentifiable to species without the aid of a scanning electron microscope.

Sechium edule (Jacq.) Sw.

Common name: *chayote*

Possibly found in: Sc-J-A 23-12.1.

Sechium is a monotypic genus, indigenous to southern Mexico and Central America. It is cultivated throughout Central America where the fruits, called *chayotes* in Spanish, are a common vegetable. The fruit is smooth, light green, and pear shaped, and contains a single large seed, unlike other members of the Cucurbitaceae. The young shoots and leaves of the plant are also edible and are cooked like spinach (Pursglove 1968). The large tuberous roots, called *raíz* in Costa Rica, and *chinta* or *chintla* in El Salvador, are boiled and eaten in some areas, and "delicious *dulces* are prepared from them" (Standley 1928:370). Virtually every part of the plant can serve as food at one time or another (Standley 1928). However, the fruits are the most commonly eaten, and ethnohistoric accounts document *chayotes* as a common vegetable among the Aztecs prior to the conquest (Pursglove 1968). *S. edule* is cultivate by the Jicaque Indians of Honduras for food. The fruits are boiled and eaten, often in a stew with other vegetables and meat (Lentz 1986).

Nutritionally, the fruits of *S. edule* are composed of mostly water, with some carbohydrates and nutrients. More importantly, they are an excellent source of Vitamin A (Pursglove 1968). There are more carbohydrates in the roots than in the fruit (Pursglove 1968). *S. edule* prefers areas of moderate rainfall such as the deciduous tropical zone found along the Pacific coast of Central America. The fruits can be stored for several weeks (Pursglove 1968).

CYPERACEAE Sedge Family

Scleria sp.

Common name: scleria sedge, sawgrass

Possibly found in: UCA 8-3, 8-4, 8-6.1.

The Cyperaceae or Sedge family is one of the largest plant families, and members are found in all parts of the world. The genus *Scleria* is best developed in the tropics, and contains about 200 species worldwide (Standley and Steyermark 1946). In Nicaragua, *Scleria* has 22 species recorded (Seymour 1980). The Jicaque Indians of central Honduras recognize the plant *S. pterota* var. *melaleuca* (Reichb.) Uittien., but do not use it (Lentz 1986). This particular species is the most common representative of the genus in Central America, according to Standley and Steyermark (1946). No members of *Scleria* are listed with any economical use. Some species are referred to as sawgrass or cutting-grass because of their sharp edged leaves which cut the skin (Standley and Steyermark 1946).

EUPHORBIACEAE Spurge Family

Species unknown

Possibly found in: UCA 8-5, and León Viejo 30-17.

Euphorbiaceae is one of the largest and most poorly defined families of tropical plants (Pursglove 1968). Nicaragua has at least 30 genera and 149 species (Seymour 1980). Many members of this family produce milky sap or latex, and the oil from some species in the *Croton* genus is strongly purgative (Lötschert and Beese 1983). The economically important species of *Hevea brasiliensis* Muell. Arg. (rubber tree) and *Manihot esculenta* Crantz. (manioc) belong to this family. Many of the species belonging to this family are used in household medicine for bites, sores, certain diseases, and burns. The Jicaque of Honduras use a paste made from ground flowers *Phyllanthus niruri* L. mixed with water to soothe spider bites (Lentz 1986).

FABACEAE (LEGUMINOSAE) Legume Family

Fabaceae is the third largest family of flowering plants, behind Orchidaceae and Asteraceae (Compositae). It consists of approximately 480 genera and more than 12,000 species of herbs, shrubs, trees, and climbers. In the past, Faboideae was treated as a subfamily of Leguminosae, along with Caesalpinoideae and Mimosoideae (Pursglove 1968, Gunn 1972:111). Hutchinson (1964), proposed that Leguminosae should be an order, Leguminales, and that Caesalpiniaceae, Mimosaceae, and Fabaceae (syn. Papilionaceae) should be classified as their own families. This is the generally accepted organization today. The first two families, or subfamilies, are mostly tropical and of little economical importance. Fabaceae is the largest with about 12,000 species widely distributed in tropical and temperate regions (Pursglove 1968). This family provides a large number of crops and economically important plants.

Legumes are widely known for their ability to improve soil fertility through nitrogen fixation. This knowledge has been used since ancient times to improve crop yields, especially grain crops which are particularly hard on the soil and quickly deplete it of nutrients. Nodules on the roots of legumes contain bacteria which fix atmospheric nitrogen and make it available to the host, as well as other plants when the nodules sloughed and disintegrate into the soil. In return, the host legume plant provides the bacteria (*Rhizobium* sp.) with carbohydrates (Pursglove 1968). Beans and maize evolved together, and their close relationship is in part likely related to the nitrogen fixation ability of the beans and the heavy nitrogen use of maize. The ability of legumes to fix nitrogen allows them to use the nitrates to make useful amino acids (Baker 1978). For this reason, legumes are one of the richest plant sources of protein.

Pulse crops (dry edible seeds) are one of the most important food crops in the world, along with grains and tubers. Beans contain more protein than any other plant product. They also have low moisture content and a hard testa which allows for long term storage (Pursglove 1968). Seeds of legumes are relatively large, and mostly filled by the two cotyledons of the embryo plant. Some Fabaceae are eaten green (pod peas), or used as pot herbs. Other economical members of the family are used for dyes (e.g. *Indigo* sp.), fiber, insecticide and fish poison, and medicine (Pursglove 1968).

Crotalaria sp.

Common names: rattlebox, *chipilín* (Nahuatl, Salv., Guat.), *chichín* (Hond.), *espadilla* (Salv.)

Found in: Sc-J-A 12-02, 12-16, and 14-14.

Possibly found in: León Viejo 31-11, and 31-09.

Crotalaria is a large genus of about 350 species, found in the tropics and the subtropics. Most are found in Africa, but the Americas have a fair number of species indigenous to the continents. Twelve species are listed for Nicaragua, most found on the Pacific side of the country (Seymour 1980). Seeds of *Crotalaria* species are usually loose and rattle inside the dry pod when mature, prompting the name "rattlebox" for many of the species in the New World. Standley (1928) reports that the young shoots of *Crotalaria* species are popular as a spinach-like vegetable in El Salvador. *Crotalaria longirostrata* Hook. & Arn. is an important food plant in Guatemala, probably the *Crotalaria* sp. most used as food. *C. vitellina* is also consumed (Standley and Steyermark 1946). Young leafy shoots are cooked and eaten like spinach, and large quantities of the plant, tied in small bunches, are sold in all the markets. These are often gathered from the wild or from maize fields, but the plant is also grown in the garden like other vegetables. It is stated that when this plant is eaten, it sometimes produces drowsiness; some species contain small amounts of a poisonous alkaloid. Roots are considered poisonous in Guatemala, and are sometimes mixed with maize paste and placed in fields to poison marauding animals. In Jocotán region, the leaves are used as a purgative or vomitive (Standley and Steyermark 1946). Another species, *C. mollicula* HBK., is also used in folk medicine. The Indians of Huehuetenango, Guatemala believe that a branch of the plant placed under the pillow will induce sleep (Standley and Steyermark 1946) The species *C. vitellina* Ker in Lindl. is known by the Jicaque of Honduras, but not used for any purpose (Lentz 1986). However, according to Standley and Steyermark(1946), it is commonly used as a vegetable in Central America.

Crotalaria sp./rugose variety

Found in: UCA 5-4, 8-2, 3, 4, 5, 6, 8, 10, 9-2, 4, 7, 8, Sc-J-A 10-13, 10-14, 10-16, 12-02, 11, 16, 14-14, 15, 16, 18-13, 15, 16, 20-14, 23-12.1, 13, 15.1, 15.2, 17, 25-08, 11, 12, 16, 60-04B, León Viejo 30-04, 31-04, and 31-11.

This was by far the most ubiquitous species. It appeared to be a *Crotalaria* sp., but examination of herbarium specimens and literature on the genus (Miller 1967) did not aid in identifying this species. Due to its ubiquity, this species is thought to be modern.

Desmodium sp. or *Rhynchosia* sp.

Common names (*Desmodium*): tickclover

Possibly found in: UCA 8-3

There are many species of *Desmodium*, found throughout the temperate and tropics worldwide. Small abundant uncinate hairs are found on most species, and the leaves and stems stick to clothing, and the pods cling tenaciously to skin, fur, feathers, or clothing, giving the plant its name. *Desmodium* indet. is known by the Jicaque, but not used (Lentz 1986). *D. nicaraguense* Oerst. provides excellent forage for livestock.

This specimen may have also been *Rhynchosia* sp. Pulverized seeds of *R. discolor* Mart. & Gal. are reported as a remedy for snake bites in Zacapa. Stems and leaves of *R. pyramidalis* (Lam.) Urban. are used in Salv. to scrub dirt from clothing, and the seeds are sometimes used to make jewelry. It is popularly believed in Central America that the seeds are poisonous.

Phaseolus sp.

Common names: bean

Possibly found in: Sc-J-A 20-10.1, and 20-14.

There are about 150 species of the genus *Phaseolus*. Thirteen are listed for Nicaragua by Seymour (1980). Most are twining herbs. *P. vulgaris* L. is the most familiar of these, and was an extremely important food plant in the past, and continues to be a staple crop of Central America today. The earliest remains of domesticated *P. vulgaris* comes from Coxcatlan cave in Tehuacán, from about 5000 B.C. (Kaplan 1965). It was and is an extremely important source of protein for people who do not have access to a large amount of animal protein. Beans are in important supplement to carbohydrate staples like maize, and they are rich in amino acids lysine and tryptophane which compliments those found in maize (Pursglove 1968). Indigenous groups such as the Jicaque in Honduras cultivate it along with maize and other crops using slash-and-burn agricultural techniques (Lentz 1986). *P. vulgaris* likely evolved together along with maize (Cobley 1976). Oakes (1939) goes as far as to say that maize may not have become as important as it did if it were not for beans. *P. vulgaris* is more tolerant of dry conditions than maize, but it does not do well in year round heavy rainfall or high humidity. It will produce well in poor soils where other crops fail. *P. vulgaris* today takes on two main types, bushy and climbing (Cobley 1976). According to Pursglove (1968), *P. vulgaris* is also used as a pot herb. Interestingly, one of the traditional foods described by Standley and Steyermark (1946) for Guatemala combines three of the species found at the Nicaraguan sites. "*Shepes*", carried by travelers in Guatemala, is made of maize paste and beans boiled dry, heavily salted, and mixed with minced flowers of *Crotalaria*. This paste is wrapped in corn husks and boiled two hours in water.

Other important *Phaseolus* species include *P. acutifolius* (tepary bean) of which archaeological remains have been found at Tehuacán dating to 3000 B.C. (Kaplan 1965). *P. coccineus* L. (syn. *P. multiflorus*, scarlet runner bean) is eaten both green and mature, and its fleshy tubers are boiled in eaten in Central America (Pursglove 1968). It occurs wild in the highlands of Chiapas and Guatemala (Pursglove 1968). Perennial forms were domesticated and are still cultivated in this area, as well as in Costa Rica, Panama, and Colombia, although to a more limited extent (Kaplan 1965). Archaeological remains of this species found in Mexico date to 7000-5000 B.C., and were probably wild. According to Baker (1978), wild *Phaseolus* contain poisonous glycosides which create hydrocyanic acid when chewed; the domestication process included eliminating this substance. *Phaseolus* is believed to have developed in both Mesoamerica in the Andes or highlands of Central America from a diverged wild species from western Ecuador/northern Peru (Piperno and Pearsall 1998).

Stylosanthes sp. Swartz

Common name: *lengua de rana*

Possibly found in UCA 8-5.1, and 9-2.

About 30 species exist in this genus, mostly in tropical America (Standley and Steyermark 1946). None have significant economic value.

Trifolium sp. L.

Common name: clover

Possibly found in: UCA 8-5.1, Sc-J-A 10-17, and 25-12.

The *Trifolium* genus (clovers) is more common in temperate areas than tropical ones. One species is listed for Nicaragua, *T. amabile* HBK. (Seymour 1980).

JUGLANDACEAE Walnut Family

Species unknown, S8

Possibly found in: Sc-J-A 14-08, and 23-13.

Seven genera are known, with approximately 60 species, mostly from temperate regions. Standley and Steyermark (1946) report that in the tropics, species from this family are confined to the mountain regions. Only the genera *Engelhardtia*, *Alfaroa*, and *Juglans* are found in Central America. The nuts of this family are often edible, and the wood is used for construction and furniture. The trees also produce tannins, especially in the husks, which may be used in tanning.

MALVACEAE Mallow Family

This relatively small family has about 50 genera and 1000 species worldwide, of which 15 genera and 62 species can be found in Nicaragua (Seymour 1980). Plants of this family usually have mucilaginous sap and tough bark fiber (Standley 1928). Economically, several members of this family are important sources of fiber, including *Cannibis* sp. (hemp), and *Gossypium hirsutum* L. (cotton). Cotton was extremely important throughout Central America for producing cordage and textiles. In addition, the fruits of some *Hibiscus* species are edible (Pursglove 1968).

unknown species, S29

<u>Possibly found in</u>: Sc-J-A 12-16 and UCA 8-4.

Abutilon sp.

<u>Common names</u>: flowering maple, *malva, pompón, pastor* (Salv.), *mapola, campanilla*

<u>Possibly found in</u>: Sc-J-A 60-04D.

There are about 100 species in tropical and sub tropical regions worldwide, but only a few are found in Central America (Standley and Steyermark 1949). Seymour (1980) lists seven species of *Abutilon* found in Nicaragua. The stems of *A. giganteum* and other species contain a fine tough fiber used in some parts of Central America for making cordage (Standley and Steyermark 1949). Many species are grown today as ornamental shrubs in gardens.

Anoda sp.

<u>Common names</u>: *malva, violeta de monte, malvilla, malva abrisca, malvavisca* (Guat., Salv.)

<u>Possibly found in</u>: Sc-J-A 25-08.

There are 14 species of this New World genus, mostly Mexican. Only *A. acerifolia* (Zucc.) DC and *A. cristata* (L.) Schlecht are known in Central America according to Standley and Steyermark (1949). *A. acerifolia* is fairly uncommon, occurring only in certain regions, but *A. cristata.* is widely distributed in tropical America. Standley and Steyermark (1949) write that it is a frequent weed in cornfields and other cultivated ground, or in disturbed areas around dwellings and along roadsides.

Hibiscus sp. or *Abutilon* sp.

Common names: (Hibiscus): hibiscus, *mahoe*

Possibly found in: Sc-J-A 12-16.

Hibiscus is a common genus in the tropics with many species. There are at least nine species in Nicaragua (Seymour 1980). The stems of many species yield fiber, such as *H. tiliaceus* L. (Pursglove 1968). *H. Abelmoschus* L. is used for fiber in some regions, and the seeds crushed for perfume, as well as a local remedy for snake bites and colic (Standley and Steyermark 1949). Many ornamental Old World species have been introduced into Central America. *Abutilon* has been discussed previously.

PASSIFLORACEAE Passionflower Family

Passifloraceae is a small family, with twelve genera of about 500 species (Pursglove 1968). Nicaragua only had the genus *Passiflora*, with 28 species recorded (Seymour 1980). They take the form of herbaceous and woody plants, most often climbing by tendrils, and are found in warm tropical regions. Several in the *Passiflora* genus have edible fruits.

Passiflora sp.

Common names: passionflower, passionfruit, *granadilla*, *maracuyá*

Found in: Sc-J-A 12-02

Possibly found in: Sc-J-A 16-21, 18-13

Passiflora consists of about 400 species, mostly native to tropical America, although with a few from Asia and Australia (Pursglove 1968). The name passionflower was given to the plant by early missionaries in South America because the parts of the flower represented to them the implements of the crucifixion (Pursglove 1968). The fringe-like corona represented the crown of thorns, the five stamens represented the five wounds of Christ, and the three styles are broadened at the end into club-shaped stigmas, which makes them look like the three nails (Lötschert and Beese 1983).

Some species of *Passiflora* are cultivated for their fruit; most common are *P. quadrangularis* L. which produces large market fruit, and *P. edulis* Sims, used mostly for juice (Pursglove 1968). Both are cultivated in Nicaragua today (Seymour 1980). *P. laurifolia*, *P. ligularis* Juss., *P. antioquiensis*, and *P. foetida* L. are wild species that also have edible fruit and are sometimes encouraged (Pursglove 1968). *P. ligularis* and *P. foetida* are recorded by Seymour (1980:202-203) for Nicaragua, with three varieties of *P. foetida* distinguished. *P. foetida* is common in pastures and other disturbed habitats, and is distributed widely throughout the tropics. The fruit is acidic and it is difficult to separate out the seeds from the pulp (Smiley 1983). Therefore it is little used. *P. seemanni* is edible but not widely cultivated (Standley 1928). According to Lötschert and Beese (1983), *P. edulis* has alkaloids present in the leaves which reduces blood pressure, but there is no indication in ethnohistorical or ethnographic accounts that any of the passionflower species were used for medicinal purposes. Passionfruit is mostly water (72.1%), with some carbohydrates (17.3%). More importantly, it is a good source of Vitamin C (Pursglove 1968).

POACEAE (GRAMINEAE) Grass Family

The Grass family is an extremely large family. In Nicaragua, 92 genera and 338 species have been recorded so far by Seymour (1980), and there are likely more.

unknown species

Found in: UCA 9-3, Sc-J-A 10-17.1, and 16-18.1.

Subfamily Pancoideae, unknown species

Found in: Sc-J-A 23-12.2.

Pancium sp. or *Tridens* sp.

Found in: Sc-J-A 23-12.1.

Pancium is a tropical grass, with about 600 species worldwide. The Jicaque of Honduras know the plant *P. sellowii* Nees., but have no specific use for it (Lentz 1986). The range of *Tridens* is not known, but may not be found in Central America. It is not listed in Standley and Steyermark (1946) and may be a mis-identification.

Digitaria sp. or *Eragrostis* sp.

Common name: (*Digitaria*): crabgrass

Possibly found in: Sc-J-A 25-12

Digitaria sp. (crab grass) is a common weedy species. There are probably over 300 species in both tropical and temperate regions worldwide (Swallen 1955). Seven species of *Digitaria* and 20 species of *Eragrostis* are listed by Seymour (1980) for Nicaragua, most occurring throughout the country.

Zea mays

Common names: maize, corn

Found in: Sc-J-A 20-14, 20-10.1, 16-18, and León Viejo 31-09.

Possibly found in: Sc-J-A 18-16, 20-10, 14-16, 10-14, 10-17, 14-15, 16-18.1, 16-21, 18-15, and 25-08.

Zea mays is probably one of the most studied plants in the world. Its genetics are the most thoroughly known. Despite this, its origins are still somewhat of a mystery, and the source of much debate and study. The genus *Zea* is most closely related to the genus *Tripsacum*, and natural hybrids occur. Researchers do agree that its origin was in southern Mexico and that it rapidly spread out from there. They do not agree, however, as to the evolution and ancestry of maize. *Z. mays* is a completely human creation and cannot exist in a wild state. Yet there is no easily identifiable ancestor; it represents "the most dramatic alteration of morphology seen between a major domesticated plant and its wild ancestor" (Piperno and Pearsall 1998:160). Maize is one of the most genetically malleable species and hundreds of varieties are in existence today.

The origin of maize has been the source of much debate. Generally, the most accepted theory is that maize originated from teosinte (*Z. mays* ssp. *parviglumis*) (Beadle 1977, 1980; Galinat 1965, 1975, 1988; Iltis 1983). But Mangelsdorf (1974, 1986) and recently Eubanks (1995) disagree, and believe that maize descended from an extinct wild ancestor related to *Tripsacum*, similar to pod corn. Both sides in the argument use genetics and experimental hybridization and back-crossing as evidence for their case. The story is likely much more complex than a linear evolution from teosinte, or a wild ancestor, to domesticated maize. Various crosses and back-crosses assuredly occurred during the initial stages of domestication (Bird 1984). Maize is amazingly plastic in its genetics, and this was one of the main reasons that it arose so quickly from a insignificant grass to the major food staple it became in the New World. There is no archaeological evidence that wild *Zea* species were commonly used plants prior to domestication. In 1967, Mangelsdorf, MacNeish, and Galinat identified what they described as wild maize in the Coxcatlan cave in the Tehuacán valley. In earlier levels, the grass *Setaria* is the most common remain found, not teosinte. The tiny maize ears Mangelsdorf *et al.* (1967) found dated to 5000 B.C. and were less than an inch long, with long glumes, and fragile cobs that would have allowed easy dispersal. These still remain the earliest archaeological evidence of maize. However, genetic and population study indicate the most probable hearth of maize domestication was the Balsas River valley in southwestern

Mexico (Piperno and Pearsall 1998). As of yet, this area has not seen intensive archaeological study.

By 4000 B.C., domesticated maize had reached southeastern Guatemala, and crossed with teosinte there to form new varieties (Bird 1984:46). Introgression with teosinte helped develop varieties more suited to highland areas and is likely that maize migrated first to South America via the lowland areas, and later developed into highland varieties separately in Mexico, Central America, and again in Columbia (spreading then into Peru) (Piperno and Pearsall 1998). According to Bird (1984), maize reached Peru around 3000 B.C., although Pearsall (1978) believes it arrived earlier. It is difficult to discern the ancestry of maize since it has been modified so much through human manipulation. Maize cannot survive without human assistance in spreading its seeds. Because the cob is covered by the husk, dispersal of the seeds is prevented. This is ideal for humans harvesting the crop, but if the cob falls to the ground, the kernels will germinate all at the same time and none will likely survive (Baker 1978).

Maize is amazingly variable and has been selected and bred to fit a wide range of environments. It can also be eaten in a variety of ways: green or immature cobs can be roasted or boiled as a vegetable, mature dry kernels can be ground into flour to make flat bread, gruel or soup, or it can be fermented into beer. Some early varieties were taken to South America, and developed there until they were reintroduced in 1500 B.C. along with pottery (Bird 1984:40). Bird (1984) proposes that between 500 B.C. and A.D. 500, various maize race complexes were spread over the Intermediate Area from Peru to Chiapas, and that the majority of these came from South America where they had been developed over hundreds of years from the first primitive maize introduced there from Mexico. South American varieties of maize were found at Cuello in Belize (Hammond *et al.* 1979, Miksicek *et al.* 1981).

Cupules, such as those found in Nicaragua, are tough subunits of the cob that resist deterioration. Cupule width increases over time although there are many specimens which do not fit this generalization. There are many different measurements of the cob, used in determining variety. Regretfully, no cobs were found in the Nicaraguan samples, and it is impossible to assign the remains to a specific variety.

Z. mays is the main dietary staple of the Jicaque Indians of Honduras, and was grown in slash-and-burn fields (Lentz 1986). The endosperm is a valuable source of starch with some proteins, oils, and vitamins available from the aleuron layer and the embryo. Maize flour can be made into unleavened bread, but lacks the gluten required for the formation of leavened bread (Baker 1978).

PORTULACACEAE Portulaca Family

There are about fifteen genera in the family Portulacaceae, mostly in the New World. Species are more common in cool climate of temperate and arctic latitudes (Standley and Steyermark 1946, cf. Cobley 1976), but five genera are represented in the tropics.

Portulaca sp.

Common names: portulaca, purslane, pulsey, *verdolaga*, *colchón de niño*, *hiedra* (Hond.)

Found in: UCA 8-2, Sc-J-A 12-16, 23-15.1, León Viejo 33-02, 30-04, and 31-04.

Possibly found in: Sc-J-A 60-04F, 60-05F.

Of the *Portulaca* genera, only three species are recorded for Nicaragua: *P. oleracea* L., *P. grandiflora* Hk., and *P. pilosa* L. (Seymour 1980). *P. oleracea* is one of the most widely distributed weedy plants, found almost all over the world (Standley and Steyermark 1946). It is cultivated extensively in arid regions for its succulent leaves and tolerates heat very well (Cobley 1976). It also grows wild in most places in the tropics, sometimes as a troublesome weed. The young stems and leaves are used today as a pot-herb in Central America (Standley 1928). *P. pilosa* is reportedly grown only for ornament in gardens, and in the wild is found in both moist and dry environments.

Talinum sp.

Common name: *lechuguilla*, *orejilla*, *verdolaga* (Salv.), espinaca (Hond.)

Possibly found in: Villa Tiscapa, UCA 9-2, 7-3.1, 8-3, 8-4, Sc-J-A 10-13, and 10-16.

Of the *Talinum* genus, only two species exist in Central America (Standley and Steyermark 1964), and both are found in western Nicaragua (Seymour 1980:135). *T. paniculatum* (Jacq.) could be used as a pot-herb, according to Standley and Steyermark (1946), but no evidence or information exists regarding this. *T. triangulare* (Jacq.) is known to be used as a pot-herb, cooked like spinach in highland Guatemala. In fact it is called *espinaca* in Honduras, and is also known as Philippine spinach (although is native to Central America and not from the Philippines) (Standley and Steyermark 1946).

ROSACEAE Rose Family

unknown species

Possibly found in: Sc-J-A 25-08, 16-21, 18-13

Rosaceae is a large family, represented throughout the world, including many genera in Central America. Seymour (1980) records seven genera and 17 species in Nicaragua, but there are likely many more. Many members of the Rosaceae have edible fruits or berries (*Prunus*, *Rubus*, *Malus*).

SAPOTACEAE Sapote Family

unknown species

Possibly found in: UCA 8-5, 8-5.1, 8-6

Six genera and 13 species are known from Nicaragua (Seymour 1980). Trees of this family generally produce milky latex and edible fruit. *Manilkara achras* (syn. *Achras zapota* and *Manilkara zapotilla*) is the sapodilla tree, which is taped for chicle. It also produces edible fruit (*níspero*) which Oviedo (1939:vol. 1, p. 262) considered "the best of all fruits". The wood is hard and durable, and used for constructing furniture and other objects (Standley 1928, Lötschert and Beese 1983:225). *Calocarpum sapota* is the sapote tree, which bears edible fruit (*mamey*), and the seeds are ground for flavoring chocolate and candy. It is widely cultivated from Mexico to South America (Pursglove 1968). The oil of the seeds was reportedly used by the Aztecs for dressing their hair. The seeds are also used as domestic medicine (Standley 1928).