5-2012

Chenopodium berlandieri and the Cultural Origins of Agriculture in the Eastern Woodlands

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Recommended Citation

Robinson, Daniel Shelton, " *Chenopodium berlandieri* and the Cultural Origins of Agriculture in the Eastern Woodlands. " Master's Thesis, University of Tennessee, 2012.
https://trace.tennessee.edu/utk_gradthes/1198

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I am submitting herewith a thesis written by Daniel Shelton Robinson entitled " *Chenopodium berlandieri* and the Cultural Origins of Agriculture in the Eastern Woodlands." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Michael H. Logan, Major Professor

We have read this thesis and recommend its acceptance:

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Chenopodium berlandieri and the Cultural Origins of Agriculture in the Eastern Woodlands

A Thesis Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Daniel Shelton Robinson
December 2011

DEDICATION

This thesis is dedicated to American farmers, past and present, who have lived and died, loving and understanding the beauty, hardships and distinctive pleasures associated with raising your own dinner from soil to sky.

"…eating is an agricultural act. Eating ends the annual drama of the food economy that begins with planting and birth." Wendell Berry (1990)

ACKNOWLEDGMENTS

I would like to thank my family and friends for their love and encouragement, and for being supportive even though I talk and think about obscure plants far too often. My mother, Shelly, especially deserves credit for being my constant supporter. My work has always been inspired by the way you taught me to love all life, even the weeds that make me sneeze. Thanks to my father, Bill, for reading each word I write with the wisdom only a lifelong educator could have and for always giving thoughtful comments and advice. Thanks are also due to Joey for reminding me about the magic of the living world, cells, and evolution; all while providing a much needed source of humor and fun when I needed it most.

Thanks also go to my committee: Dr. Michael Logan, Dr. Gerald Schroedl and Dr. Kandace Hollenbach. Dr. Logan, I am forever grateful to you for helping me to come study at the University of Tennessee. Your advice and guidance have continually reminded me that a healthy curiosity is the basis for all research and that a holistic approach to anthropology is a worthwhile goal. Dr. Schroedl, your archaeological theory class was my first in graduate school; I could not have had a better foundation. Dr. Hollenbach, I hope I have absorbed a small part of your encyclopedic knowledge of Eastern plants and paleoethnobotany.

ABSTRACT

The development of agriculture in the New World has been a topic of prominent historic interest, but one that has ignored some regions in favor of others. The woodlands of Eastern North America have felt this bias in the investigation of agricultural origins, but this has not prevented the development of theories to explain the emergence of a complex of indigenous agricultural plants in the region. Data collection and technological advances have in large part validated these theories, creating a model for domestication. By emphasizing farming over other cultural practices, however, these theories lack explanatory power with regards to the domestication of some plants indigenous to the region, such as *Chenopodium berlandieri* Moq.

As one of the predominant plants of the Eastern Agricultural Complex, investigation of *Chenopodium berlandieri* supports alternative possibilities for plant use and adoption, in addition to or separate from agriculture. Based on ethnographic and archaeological evidence, it seems likely that alternative aspects of this plant were a driving force in both its initial use and its continued cultural value to the peoples of the Eastern Woodlands. Weedy plants, such as those utilized in Eastern North America, have a special relationship with human populations. That these same plants have a high proportion of active chemical compounds that are useful for medicine and food preservation suggests that a reevaluation of traditional perspectives of agricultural development is necessary. Any holistic understanding of plant use in the Eastern Woodlands should consider all possible cultural values in considering the nature of human-plant interaction.

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CHAPTER ONE

THE IMPORTANCE OF PLANTS IN OUR EVERYDAY LIVES

Introduction

The food we eat is critical to our daily survival, but in our struggles to keep pace with the ephemeral and fast-paced nature of our technologically oriented world, we may overlook where our food comes from and how it was grown or secured. This routine aspect of our day-to-day lives goes unnoticed by most people. We tend to disregard the details of our morning coffee procurement, the simple workday lunch sandwich, or our weeknight casserole dinners. However, the recurrence of these seemingly mundane actions belies the incredible complexity of their construction. Our diet is a blend of biological, cultural and historical factors that structure the way we eat. And while it is intriguing to delve into the origins of modern foods, like the hamburger and the ice cream cone, the evolution of our relationship with food and eating over time reveals the tremendous structural changes human dietary and subsistence practices have undergone. The shift from the historically dominant and successful hunting andgathering mode of subsistence to large-scale agricultural production is foremost among the many factors influencing the human diet. However, this revolution should not be seen so much as the triumph of agriculture, but as a fundamental reorientation of human knowledge and experience. This revolution in human culture and practice had its most profound effect on the plants and animals of our local, and now distant, environments. The changing suitability and desirability for an affordable diet resulted in the eventual domestication of a few species of plants and animals in regions worldwide, which in turn led to the origins of our modern food cultures.

Critically, this perspective on the development of agriculture requires not only that the process of domestication be explained, but also the motivations involved in the selection of a particular plant or animal species over other available options. Determining the rationale for using one plant over another is important because it allows an understanding of the current state of human knowledge and experience. Similarly, changing utilization of the same species over time informs us of the alterations found in related human practice. The shift from hunting and gathering to a more dominant agricultural mode of subsistence can best be understood by looking for species whose utilization has varied over time. Differential use of a particular plant over time reflects an alteration of a group's needs over time. In this way, plant use is a powerful marker of cultural change. By investigating the reasons for the use of particular plant species, it will be possible to further explain cultural changes on both a local and a regional scale. This process may seem straightforward, but the rationale for the human use of plants is not always clear, especially in those cases where the peoples who grew and used the plants died long ago.

Humans employ plants for a variety of purposes, including food, but also medicine, tools, clothing and shelter. The purpose and utility of a plant may change dramatically over time and place, and the shift can occur in any number of directions, not just from an occasional foraging snack to a high-intensity productive food source. In terms of domestication and the development of agriculture, these unusual transitions should provide important information about the degree and type of cultural changes occurring within a society. The shift of a plant's value from being used as construction material to being a cultivated, brewed and distilled drink at the center of ritual represents a dramatic challenge and adjustment to more traditional perspectives of plant use and culture. By examining shifts in human practice and culture in terms of plants, a more detailed picture will emerge concerning domestication and the development of agriculture.

Objectives

The primary goal of this study is to examine a specific instance of human plant use in the past to determine the reasons guiding the adoption, use and eventual domestication of a plant species in terms of cultural change. It may seem paradoxical, then, that the plant species that will be examined in detail here has been labeled a weed and generally ignored in contemporary times. While it is true that *Chenopodium berlandieri* Moq. is a common and vigorous flowering plant species found in the Eastern United States, it is also a member of the Amaranth family which has a long and storied history of human interaction and use. *Chenopodium berlandieri* was a valuable plant resource for peoples in Eastern North America for many thousands of years. Its use began in the early periods of foraging and through domestication it became a critical component of Eastern agricultural production until its replacement by corn, *Zea mays* L. This extended period of use means that in comparison to other indigenous species, *Chenopodium berlandieri* has a relatively well-documented history in the archaeological record. This record permits a detailed investigation into the utilization of *Chenopodium berlandieri* over time by peoples in Eastern North America. Though most interpretations of its use are subsistence-based, the close relatives of *Chenopodium berlandieri* provide a number of other interesting, and relatively uninvestigated possibilities for its adoption by peoples in Eastern North America. These alternative uses, ranging from medicinal to preservative, indicate the various and distinctive ways humans interact with plants. Alternative reasons for adoption may also provide evidence of the types of dramatic cultural shifts that occur prior to domestication and the development of agriculture. *Chenopodium berlandieri*, through its changing utilization over time and the relationship of this use to cultural change, has the power to provide new insight into the very human processes behind domestication.

This is first and foremost a study of human culture and its unique adaptive capacities. However, the theory utilized here is not limited to cultural anthropology or any other discipline. To achieve the goal of understanding the use of *Chenopodium berlandieri* in the past, a number of related and disparate theoretical approaches will be utilized, whether apparent or not. This holistic approach is a valuable asset to anthropology that allows for the development of explanatory models that utilize a variety of available evidence. This study will include the interaction of cultural anthropology, archaeology, ecology, evolutionary biology, chemistry and history, among others. By drawing together these approaches, it is hoped that old ideas will be compared, altered and merged to develop a number of new and intriguing perspectives on plant use in Eastern North America. It is hoped that these views will be incorporated into the larger discussion of the cultural history of Eastern North America through systematic testing and research. Although no direct experiments have been incorporated into this study, it will raise a number of testable conclusions for such future research, which will be discussed. By examining the reasons guiding the use of *Chenopodium berlandieri* in the Eastern United States, this study will aggregate both resources and ideas that will highlight avenues for further research.

Structure of the Thesis

The discussion of the problem of plant use begins with a background in the historical perspectives on the origins of agriculture. Chapter 2 outlines a historical perspective on the process of plant domestication. This begins with the many historical ideas concerning domestication, primarily in the Near East, and ends with a discussion of the impact of historical views of domestication on Eastern North America. Chapter 3 provides an overview of the ecology of the region, focusing on the general type of environment, the nature of important river systems and the changes to the regional environment that have occurred before and after human occupation of the region. Chapter 4 presents a detailed description of the plant species of discussion, *Chenopodium berlandieri*, from high taxonomic level to distinctions on the species and subspecies levels. Chapter 5 focuses on the history of the study of agricultural origins within Eastern North America. A discussion of the impacts of environmental changes on local populations is integral to the elaboration of models of plant use. This section ends with a discussion of the most prevalent theory of plant domestication in North America, the floodplain weed theory. Chapter 6 raises the possibility of cultural selection playing an important part of the process of domestication. The implications of cultural selection will be incorporated into existing models of domestication for Eastern North America. Chapter 7 evaluates the two major selective reasons for the initial use and later domestication of indigenous plant species, subsistence and medicine. This section focuses on the application of human behavioral ecology to understandings of subsistence. It also elaborates the inherent medicinal possibilities of weedy plant species. Chapter 8 applies the idea of cultural selection and medicinal plant use to the unique situation seen within Eastern North America. This section uses *Chenopodium berlandieri* as a primary example of the possibility of medicinal plant use guiding initial human-plant interaction. The shift in the nature of this interaction seen with the development of agriculture and plant domestication can be understood by applying alternative use models. Finally, Chapter 9 reviews major points and offers suggestions for future research.

CHAPTER TWO

HISTORICAL PERSPECTIVES ON AGRICULTURAL ORIGINS

The Transitional Clash

Though the transition to an agricultural way of life from foraging may seem to be the result of a natural progression over generational time, in practice, agriculture represents a dramatic shift away from a relatively comfortable and productive way of life. While our contemporary position as post-industrial agriculturalists has undoubtedly altered our perspective on subsistence, for almost the entirety of our existence, human beings have relied on a hunting and gathering mode of subsistence. This way of life has often been characterized as the "most successful and persistent adaptation man has ever achieved" (Lee and DeVore 1969:3). When this characterization was adopted in the 1960s, it was revolutionary in the way it promoted the comprehensive study of nonagricultural populations, in both historic and contemporary contexts. And though extensive data collection throughout the twentieth century substantially reinvigorated the subject of subsistence, the challenge of evaluating foraging and agriculture quickly became apparent (Kelly 1995). Neither way of life was a perfect solution to the problems encountered by human populations, nor were these methods of subsistence completely diametric. Hunting and gathering was not a lost Eden of mankind or the original affluent society, but neither was agriculture a progressive leap towards civilization and cultural dominance (Sahlins 1968). As a transitional phase between these two forms of subsistence, the origins of agriculture have been a hotspot of historical, archaeological and anthropological investigation. Then-current perspectives concerning the nature of these two important lifeways heavily influenced the tone and focus of these investigations. With this limitation in mind, the historical development of theories of plant use and domestication has had a dramatic impact on the way we understand the indigenous plants of Eastern North America, such as *Chenopodium berlandieri*. This chapter will explore theories of the development of agriculture from traditional to contemporary perspectives.

Early Religious Perspectives on Agriculture

A fascination with plants, and nature in general, has played a guiding role in the development of culture, especially in terms of ideology. The adoption and use of plants as part of the natural environment has been central to human culture, beginning with the rationalization of the environment and religious ceremony. This early interaction represents the source of later discussions of the origins of plants and many other mundane items. These initial explorations into local plant communities focused on the origins and use of particularly important species. Critically, even this early discussion and conjecture was centered in the hands of specialists in the natural realm, most notably in the form of shamans. These masters of the realm between the cultural and natural worlds were, as will be shown in later chapters, central to the knowledgeable use of both edible and medicinal flora. This animistic and practical understanding of the environment was primarily relayed through the construction and dissemination of stories, legends and tales. Though the mode of exploration of plant origins and development has shifted in modern archaeological and genetic investigations, the birth of agriculture is still at its core profoundly mythological.

The deep-seated position of the origins of agriculture can be traced throughout the spectrum of cultures known worldwide, ranging from Cherokee corn myths to the Greek explanation of the pomegranate in the story of Persephone. These stories, of varying complexity and type, have been developed to explain the existence of the plants and animals that sustain us. The elementary position of our biological relationship with plants underlies our fascination with their characteristics and abilities. The allure and value of specific plants is easily seen in the earliest documented explanations for the appearance of plants. These accounts typically see plants, particularly fruits and vegetables, as gifts or offerings of nature, spirits or the gods (Harlan 1992). The idea of the gift and the reciprocation of needed items are central to both daily and ritual human interaction among many cultural groups (Mauss 1954). Applying the methodology of gifting and reciprocity to the natural world was an expected extension of a preexisting ethos. With this traditional foundation in place, the development of a full-fledged botanical mythos based in religion is not difficult to imagine. The process of reciprocity requires interaction between two agents. While nature in general might be suitable for most results, a more specific location or spirit could easily become attached to particular plants or animals (Sandstrom 1992). Through generations of experience, processes of interpretation and elaboration concluded with the formation of deities whose identities were primarily botanical in character. These same gods and goddesses were later filtered and concentrated through routes in parallel with the development of agriculture, such as population growth and concentration. The resulting agricultural divinities were the zenith of the godly gift explanation of plant existence and are a cross-cultural phenomenon spanning societies as diverse as the Mesoamerican fertility and corn deities; Cinteotl, Xochiquetzal and Quetzalcoatl to the Greek goddess of fertility, grains and the seasons, Demeter (Harlan 1992). Through cults, worship and ceremonies involving these gods and goddesses, global cultures directly and indirectly worshiped plants of local value

(Turner 1967). Though with time these traditions of natural gifts have become at best quaint stories or cultural identifiers to the West, the mythological nature of agricultural origins has remained entrenched in its study and dissemination. The deep cross-cultural value inherent in unraveling the mysteries of the beginnings of plant domestication has continually influenced the course of historical and academic explanations for this critical point in the human and botanical past.

Towards a Scientific Study of Agricultural Origins

The mythological allure of agricultural origins is undoubtedly one of the primary reasons for the breadth of literature written on the subject by historians, archaeologists and other social scientists. Despite this proliferation of publication on the topic, a rather narrow selection of critical moments and theories has defined the search and understanding of agricultural development in Western thought. It should be rather unsurprising, then, that one of the earliest investigations of plant domestication was by the father of modern evolutionary theory himself, Charles Darwin. Plants were only supplementarily involved in his *The Origins of the Species*, but in his 1868 volume The *Variation of Animals and Plants under Domestication*, Darwin postulated about the origins of contemporary agriculture. The position of humans in this process is clear to him: “From a remote period, in all parts of the world, man has subjected many animals and plants to domestication or culture” (Darwin 1868:2). This perspective was a sea change in scientific thought, but the role of Darwinian evolution in plant domestication would not be fully explored until later in the twentieth century, after anthropology and archaeology had matured as investigative disciplines. Unfortunately, a similar academic fate met the son of one of Darwin’s scholarly inspirations, the late nineteenth century French-Swiss botanist Alphonse Pyrame de Candolle. De Candolle (1885) was among the first scientists to integrate botanical data from a variety of sources to outline the primary regions responsible for plant domestication. De Candolle noticed that culturally vital subsistence plants tended to have origins in some of the same general geographic areas. De Candolle's attempts to define regions of domestication would eventually play a foundational role in the study of agricultural origins by giving archaeologists distinct areas to look for early plant use, even if many European historians and philosophers already had distinct opinions concerning the matter (Barnard 1999). However, it would be almost a full generation later, in the early twentieth century, when the Russian botanist and geneticist Nikolai Vavilov expanded upon de Candolle's work that the description of centers of domestication began to dramatically influence archaeological investigations.

By the early twentieth century, new information was becoming available to botanists interested in studying the origins of specific plant species, particularly developments in early genetics. This provided an invaluable resource in typing plant species and locating their geographical source locations. By combining genetic information with a number of other resources, Nikolai Vavilov was able to further define origins of plant development and domestication. With the financial backing of the Russian government, Vavilov mapped worldwide crop origins according to patterns of variation and diversity. Origins were established based upon the area with the highest genetic diversity for a specific plant species. These areas of high diversity were Vavilov's probably "centers" of domestication or "hearths." Notably, Vavilov also emphasized the role of human interference in the process of plant domestication. In the end, Vavilov (1926) defined eight independent centers of agricultural origins based on his data collection, including the Mediterranean, Middle East, Mexico-Guatemala, Peru-Ecuador-Bolivia-Chile-Brazil, Ethiopia, Central Asia, Indo-Burma, and China, notably excluding any part of the Americas north of Mexico. This approach dominated scientific though until the more recent development of evolutionary models of plant origins, which have revealed biogeography to be a truly complex matter. Vavilov's work was the primary force inspiring early investigations into the origins of notable crop plants in the Near East and Mesoamerica (Cowan and Watson 1992). Vavilov's theory of plant domestication had a particularly dramatic effect on the nascent field of archaeology, which had grown into a refined scientific discipline.

While anthropologists interested in explaining agricultural origins since the mid-nineteenth century had espoused a variety of theories for the shift from foraging, the archaeologist V. Gordon Childe developed the most prominent and practical theory of domestication. Childe, a noted European prehistorian, characterized the transition to agriculture from foraging as a relatively abrupt event induced by dry climate shifts in the Near East in the early Holocene. The increased desiccation of the local environment through time gradually placed plants, animals and humans into close quarters near the most resilient bodies of water as they followed the materials necessary for life. Childe (1952) felt that this close proximity and dire circumstances of humans in terms of subsistence made to the eventual domestication of particularly valuable plant species unavoidable. Childe (1936) termed the series of events that precipitated domestication the "Neolithic Revolution," a dramatic shift from hunting and gathering to intensive food production. The influence of Childe's theory, in combination with Vavilov's genetic evidence for plant domestication, spurred the development of large-scale archaeological projects designed explicitly to test for the remains of agricultural origins. Robert

Braidwood's Iraq-Jarmo Project, in particular, sought to answer Childe's theory with archaeological evidence, while other investigations tried to explain similar processes in Vavilov's other centers of domestication, such as Richard MacNeish's search for the origins of corn in Mesoamerica (Cowan and Watson 1992). While Childe's Neolithic Revolution in agricultural development has not been borne out by the archaeological work it stimulated, the idea of agriculture as a radically transformative process has continued to affect opinions on origins.

The search for the dramatic effects of the Neolithic Revolution continued until the 1960s when a new generation of anthropologists began to question the established views of domestication in light of mid-century projects like those of Braidwood and MacNeish. Most critically, these anthropologists found that the view of plant domestication as an exceptional revolution in human lifeways and culture tended to highlight the dichotomy between hunter-gatherers and agricultural subsistence rather than bridging the two. Revolutionary models also failed to explain instances where foragers remained foragers and agriculturalists reverted to hunting and gathering (Rowley-Conwy 2001). Dissatisfaction with previous approaches and theories led to the New Archaeology of processualism, which sought to develop an ethno-historical and theoretical framework to analyze archaeological questions, like domestication (Willey and Phillips 1958). Lewis Binford (1980), Kent Flannery (1973) and others reacted to this prevalent view by developing gradualist evolutionary and systems-based models that emphasized continuity between the two modes of subsistence. This renewed theoretical discussion in archaeology was accompanied by fresh perspectives on hunter-gatherer groups, with new and detailed ethnographic evidence and the Man the Hunter conference in 1966 doing much to reassert the rationality of a foraging mode of life in the face of the agricultural revolution (Kelly 1995; Lee and DeVore 1968; Sahlins 1968). While the degree of affluence for hunter-gatherers was overstated in this period in response to earlier negative works, the shift away from the immensely successful adaptation of foraging became a new center of focus for studies of agricultural origins. This new perspective emphasized an evolutionary continuum of ecological change based upon human interaction with local ecosystems, rather than an abrupt alteration of previous lifeways. The reassertion of human control or understanding of the environment, particularly in foraging groups, provided a new impetus for change aside from general ideas of progress long associated with agricultural adoption (Barnard 1999). As the degree of agency of hunter-gatherers in their own lives was reestablished, strict ethnohistorical or systems models were no longer capable of elucidating the types of cultural change apparent in plant domestication. This theoretical problem was one of the primary reasons for the adoption of an ecological-evolutionary paradigm in the 1980s, which has since dominated studies of the development of agriculture. This theoretical perspective reestablished the significance of Darwinian evolutionary theory to the process of domestication, characterized by Darwin's own late nineteenth century insights into plant and animal domestication. This contemporary perspective has been dominated by the concept of the symbiotic coevolution of plants and humans, characterized in the work of David Rindos (1989). By avoiding the potential pitfalls of intentionality and determinism, the coevolutionary continuum model of human-plant interaction and domestication provides an established perspective from which plant use and domestication can be understood. This model is inherent in most recent literature concerning domestication and development, whether apparent or not. This framework will provide much of the theoretical foundation with which plant domestication will be discussed in this study, although a modified cultural approach to evolution will be applied in later discussion.

A Mesoamerican Bias

The idea of agricultural centers of development was fundamental to the project of the investigation of domestic origins, but the attentive reader will have noticed the absence of certain geographical areas in the discussion so far, namely the regional focus of this inquiry, Eastern North America. The source of this absence can be linked to the prominence of Nikolai Vavilov's eight centers of domestication in international archaeology. Vavilov did not include North America in his discussion of plant diversity and genetics in relation to origins and this oversight was perpetuated for much of the first half of the twentieth century. Vavilov's work was among the first of its kind and predated significant current American literature on the subject. While in this early work the omission of America was understandable, a more conspicuous bias was also at work. North America has long been the subject of bias in scientific studies because of the cultural differences it has with the peoples of Mesoamerica. The monolithic cultures of Mesoamerica have many of the classic features apparent in the characterization of civilization, including monumental architecture, cities, intensive agriculture, trade and metallurgy. North America, and the East in particular, lacks the striking stone pyramids and temples of the Aztec and Maya (Coe 2005; Coe and Koontz 2008). This has led some to portray the peoples of Eastern North America as a relative cultural backwater (Chomko and Crawford 1978). The independent centers of agricultural origins model developed by Vavilov and adapted by others such as Jack Harlan (1971) was prey to this long-held preconception. Following this model, the cultures of Eastern North America were depicted as the receiving end of the cultural breakthroughs of the civilizations of Mesoamerica, with some crops making fantastic journeys to fulfill this view (Chomko and Crawford 1978; Flannery 1973; Watson 1989). The tenuousness of the major independent center model of agricultural development became clear as empirical evidence of agricultural origins mounted worldwide. Though the approach was adapted to include more centers of domestication and nebulous "noncenters," the definition of a center of origin was too difficult to apply to the reality of early evidence of domestication (Harlan 1971, 1992).

As luck would have it, most of the earliest evidence for plant use and domestication originally came from Mesoamerica. Although at first these dramatic discoveries of early corncobs and gourds appeared to validate Mesoamerica and Mexico as a major center of domestication, the lack of evidence from North America was primarily due to differential conditions of preservation, funding and academic interest. Much of the evidence for plant domestication in Mesoamerica was derived from dry caves that while occurring in Eastern North America required a different and more intensive methodology for recovery of paleobotanical remains (Coe and Koontz 2008). The discovery of seed caches from caves did occur in North America, but the source plants, *Chenopodium* in particular, were less prominent than maize (Gilmore 1931; Jones 1936). The emphasis on Mesoamerica in terms of early domestication took time as evidence for intensive plant use in Eastern North America was slowly established. The sheer numbers of paleoethnobotanical remains from North America were lacking until a number of methodological innovations forever altered the view of plant origins in the Americas. The paucity of paleoethnobotanical evidence due to acidic soils and more humid conditions in

Eastern North America was rectified by the advent of rigorous techniques for the flotation and recovery of small-scale archaeological remains by Stuart Struever (1968) and others. Flotation allowed for the recovery of botanical remains that would be destroyed through more vigorous sifting methods or lost through larger sizes of sifting screens. Flotation works particularly well with the relatively moist soil types found throughout much of Eastern North America (Pearsall 2000). The implementation of flotation techniques was gradual, but its effects on the understandings of plant domestication in the region were remarkable. Most importantly, the proportions of seeds and botanical remains recovered from archaeological contexts in North America increased dramatically, allowing for new perspectives on domestication to develop with a focus on Eastern North American plants and peoples (Struever and Vickery 1973; Yarnell 1976). The advent of reliable and precise scanning electron microscopy, accelerator mass spectrometer (AMS) dating and stable carbon isotope analysis has allowed for the accurate determination of age of botanical samples and the examination of minute morphological changes in seed structure associated with plant domestication (Fritz and Smith 1988). These advances in combination with increased representation of botanical remains through flotation screening led to the reevaluation of historical models for agricultural development in Eastern North America, particularly resulting in the gradual expansion of the idea of independent centers of domestication.

Ideas concerning the advent of plant domestication have travelled a long distance from our original divine and spontaneous conceptions of agricultural origins. Much of this transition to a scientific understanding of domestication is a product of Nikolai Vavilov’s idea that most domesticated plants originated in hearth-like centers. This approach pushed an archaeological renaissance in terms of a grand theory of human and plant evolution. The result of this early and mid-twentieth century studies were anything but concrete, however. The absence of Eastern North America in these models is primarily indicative of a lack of date, rather than an inability to understand all localities of culture and domestication. Advances in archaeological and scientific methods, such as flotation screening and accurate AMS dating, finally allowed anthropologists to make conjectures about North American plant use and development. The history of plant domestication theories in this region logically flowed outside of an origins model and in many ways it has profited from this disconnect. The history of plant domestication in Eastern North America will be discussed in Chapter 4, but a general understanding of the environment of North America is necessary for this discussion. In the next chapter, a general ecological description of flora and fauna, riverine systems, and climate change will be elaborated to establish a context for a discussion of plant domestication in Eastern North America, particularly with respect to the plant of focus, *Chenopodium berlandieri*.

CHAPTER THREE

THE ENVIRONMENT OF EASTERN NORTH AMERICA

Defining Eastern North America

As the discussion of the history of models of agricultural origins has made clear, understandings of plant use and domestication are critically related to the local environment. Early investigations into domestication in the Near East, such as those by V. Gordon Childe and Robert Braidwood, show just how important the environment can be, particularly processes of climate change. The contemporary Near East seems like hardly the place for agriculture to develop, but somehow it did. By describing and understanding the environment of Iran and Iraq, we discover that much of the region was not dry and dusty desert ten thousand years ago. In the same and less dramatic way, it is therefore vital that the regional setting of Eastern North America be rendered in enough detail to establish where and how local human and plant populations lived and interacted. This chapter covers the three principal components that define a regional environment, namely the nature of the terrestrial landscape, the riverine systems and the environmental changes seen over time due to climatic shifts. These three factors play a major role in defining the type and mode of human interaction with the environment and the visible shifts in this interaction that can be viewed archaeologically and historically. To understand this interaction, it will be necessary to simplify many of the environmental variations seen in Eastern North America and ignore some of the more unique habitats. A broad and more generalized regional picture provides a more integrated perspective on environment and it directly corresponds with climatological shifts and the relatively low-density spread of archaeological sites in the Eastern Woodlands.

Eastern North America, as a region, can be rather simply defined as the eastern half of the continent. This description roughly correlates with all of the areas east of the Mississippi River. However, despite its general accuracy, such a definition ignores the complex realities of North American geography, ecology, and climate. Thus, it is best to describe the region of Eastern North America by its major ecological feature: the presence of temperate deciduous forests across much of the region. Forests occupy approximately 40 percent of land in the eastern half of the United States. In the past, the amount of forestland was even higher (Yahner 2000). Despite the overwhelming variety of the region's climate, a majority of its trees are deciduous. These types of trees contrast with evergreens by their seasonal patterns of loss and renewal. Deciduous trees evolved as an adaptation to a climate of cold winters compared to a growing season that is warm, long and humid. Every spring, fresh green leaves replace those that are shed each fall. Similarly, there is an understory of small trees and shrubs that are also deciduous. The temperate deciduous forest usually has multiple stories with the uppermost canopy reaching heights of between 25 to 40 meters. This superior story contains the trees that are usually deemed the dominant species. These are the deciduous tree types that designate subregional variation in the forest. The maximum longevity for dominant deciduous tree species is between 200 and 600 years, making them particularly useful as ecological categories that survive many short-term changes (Delcourt and Delcourt 2000). The typical dominant deciduous hardwood trees found in Eastern North America include oak, hickory, chestnut, beech, basswood and maple (Shelford 1963). Evergreen trees, such as hemlock and pine, are also found in throughout this region, with greater prevalence in the southeastern coastal plain and nearing the boreal forests of Canada. Beneath this upper canopy of trees, there is an equally rich diversity of ephemeral perennial and annual plant species. These herbaceous species have annual life cycles that complement those of the deciduous trees of the forest, relying particularly on the abundance of light in the early spring in the absence of a dense leaf canopy. This herbaceous layer is another indicator of forest type (Gilliam and Roberts 2003). The lower layer reacts in part to the upper layers, but also indicates more localized conditions. Its status reflects local resources and geography (Braun 1950). The local herbaceous layer tells much about the age and state of development of a forest. The association between plant communities differs according to many factors, such as temperature, water availability, soil type, nutrients, and geography. These elements are the primary contributors to variability and internal complexity within the region of Eastern North America.

Across the region, different species of deciduous trees and plants dominate local areas in relation to the above factors that relate to environment compatibility (Yahner 2000). The general compatibility of the deciduous forests to Eastern North America is mainly related to the seasonal distribution of rainfall and the length of the growing season. Both of these factors favor the development of a deciduous forest in the East. Where these elements shift, the deciduous forests adjust into more ecologically appropriate types. This allows for a spatial demarcation of Eastern North America as a region to the west, north and south.

To the west, precipitation decreases away from the Mississippi River and toward the Rocky Mountains. Deciduous forests are spatially limited to small spaces in ravines and valleys between masses of prairie. Further north, the growing season shortens and temperatures reach extreme winter lows that eliminate deciduous species at increasingly high latitudes. Deciduous trees intermix with evergreens until these limits, where the boreal coniferous forest is dominant (Braun 1950).

A similar replacement occurs in the southern limits of the United States. Pines become more prevalent to the south and southeast as the soil type shifts to sand and average annual temperatures rise. Deciduous trees still occur, but only where the soil conditions are adequate. The lack of a lengthy cold season in the extreme south prevents deciduous species from growing. Southern longleaf pines are able to adapt to these conditions, as well as the frequently occurring fires that occur in the area during the summer months (Christensen 2000). Finally, deciduous trees continue towards the Atlantic Ocean in the east, only stopping close to the ocean. These are the major limiting factors of the deciduous forests of Eastern North America.

A map showing the deciduous forest area can be seen in Figure 3.1. It is important to note that many of the same limiting factors for trees constrain the growth and development of many other herbaceous plant species, making the region relatively homogenous considering the degree of geographic, climatic, and ecological differences encountered throughout the Eastern United States. The major subdivisions of the deciduous forests of Eastern North America will demonstrate this point well.

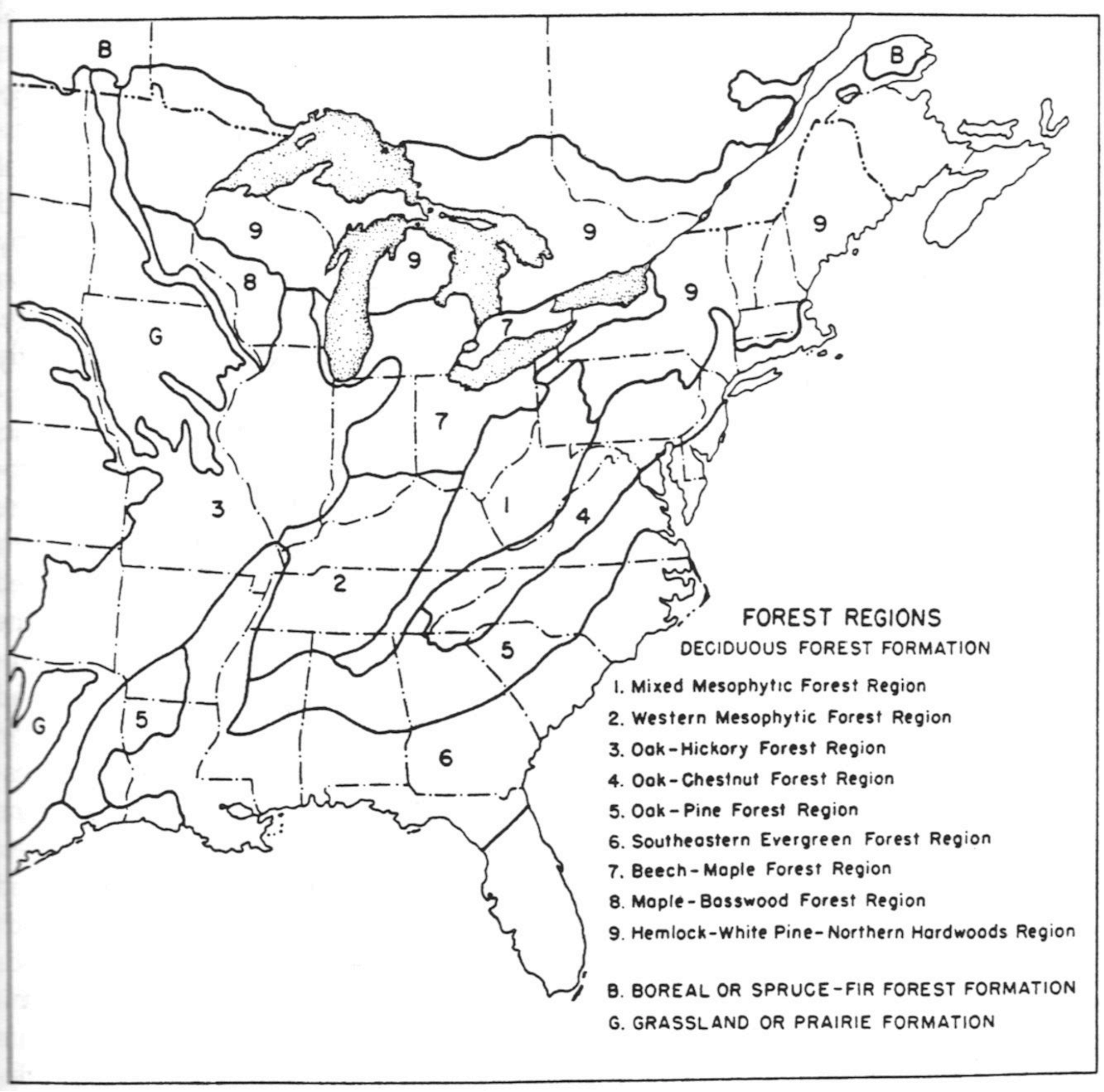

Figure 3.1. Forest regions of Eastern North America (Delcourt and Delcourt 2000).

Forest Subregions of Eastern North America

As noted earlier, there are a number of subregional variations in the dominant tree species seen in Eastern North America. These distinctions are central to understanding the prevalent types of tree resources available to local human populations. These subregions are also useful in distinguishing the other types of plant and animal life that are typically found in the local environment. The boundaries of these different forest types have been categorized in a number of ways, but the most widely recognized map was drawn up by the botanist E. Lucy Braun (1950). Braun sampled virgin growth forest communities across Eastern North America and found nine major types. A map of the principal forest regions outlined by Braun can be seen in Figure 3.1 (Delcourt and Delcourt 2000:361; see also Braun 1950). These regions may seem idealistic, but are the best representation of the state of Eastern North American vegetation for the majority of the present geological time period. This includes most of the time that Native Americans occupied North America. Modern maps of forest vegetation would show the effects of hundreds of years of logging and deforestation by Europeans and their descendants and make Braun's distinctions less appropriate (Delcourt and Delcourt 2000). The five predominant deciduous subregions of Braun's nine major subregions will be detailed to give some sense of the environments found in Eastern North America.

Perhaps the most central subregion is the Mixed Mesophytic forest region, which is centrally located in the Eastern United States. This region occupies much of the Appalachian Plateaus and its plants require a moderate amount of water in moist, but well-drained areas. The climax association of this region is typically dominated by a number of tree species. These include the beech, tuliptree, basswood, sugar maple, buckeye, chestnut, hemlock, and red and white oak. This region grades into the somewhat uneven and transitional Western Mesophytic forest region to the west. This region is similar, but includes a number of different types of tree and plant communities, lending it a mosaic appearance. These two regions have relatively similar flora and fauna. Some understory trees in the western region are magnolias, sourwood and holly. Shrubs include spicebush, witchhazel, pawpaw, hydrangea and dogwood. A wide-variety of smaller plant species also abound. The white-tailed deer is the most prevalent large animal species, although black bear, wolves, elk, mountain lion, turkey, fox and other mammals were also present at times (Shelford 1963).

To the east of these regions in the Blue Ridge Mountains and Piedmont Plateau areas lies the Oak-Chestnut forest region. It is characterized by a climax of chestnut, red oak, chestnut oak, tulip tree and white oak on a steeply dissected, mountainous landscape. This region has undergone tremendous change in the past century with the death by 1935 of the American chestnut through chestnut blight (Braun 1950). Since the chestnut blight, this region is becoming oak dominated. In some areas, chestnuts made up to 80 percent of the forest canopy. Smaller understory trees like red maple, sweetgum, black locust, sassafras and sourwood have filled these gaps. Subordinate plants include mountain-laurel, rhododendron, lady’s slipper, jack-in-the-pulpit, azalea and others. The animals found here are largely similar to those of the mixed mesophytic regions, but elk were also once common here (Shelford 1963).

Far to the west of both the Oak-Chestnut and Mesophytic forest regions lies the Oak-Hickory area. This climax is centered in the Interior Highlands of the Ozarks and runs from western Indiana to eastern Oklahoma and Texas. This region represents the western boundary of the deciduous forest. To the west, the grasslands of the Great Plains are the dominant ecological feature. This region is characterized by post oak, white oak, black oak, blackjack oak, scarlet oaks, shagbark hickory, mockernut hickory and pignut hickory. These trees are confined to moist habitats, north-facing slopes and coves (Delcourt and Delcourt 2000). The understory in this region is largely dependent on the location's provenience east or west. The western understory may include blueberry, holly, sumac, dogwood, hawthorn, coralberry and others. To the east, sourwood, rhododendron, and crab apple trees are common. The same deciduous forest animals are found in this region, but with different proportions. Black bear populations are small, while turkey, deer, wolf and bobcat populations are increasingly important. Smaller mammals like the raccoon, possum and skunk are prevalent here. A large variety of snake and amphibian species are also common (Shelford 1963).

A forest region similar to the Oak-Hickory area may be found to the southeast of the Mixed Mesophytic area. This variation is known as the Oak-Pine, but should be thought of as the Oak-Hickory region plus the dominance of pines. The Oak-Pine region extends along the Piedmont Plateau from Virginia south and across the Gulf States. It is primarily a transitional region between the northern Mixed Mesophytic region and the southern Southeastern Evergreen forest region (Braun 1950). Loblolly and yellow pines are dominant, although deciduous species occur where soil and water conditions allow. There is an extensive shrub layer with scrub oak, blueberry, and huckleberry (Christensen 2000). Animals and flora here are similar to surrounding regions.

Towards the Atlantic Ocean and the Gulf of Mexico, this region shifts towards the Southeastern Evergreen forest, which dominates the dry and sandy soils. Great expanses of long-leaf pine forest are prevalent here (Braun 1950). Three additional subregions lie to the north of the areas described above, but these environments (Beech-Maple forest, Maple-Basswood forest, and Hemlock-White Pine-Northern Hardwoods regions) are less critical towards understanding the indigenous development of agriculture. This general description of these subregions will be helpful in understanding the types of environments in which indigenous peoples lived during the past. However, this ecological sketch has yet to address perhaps the most critical element supporting the success of both the forest and its animal inhabitants, the waterways of Eastern North America.

River Systems of Eastern North America

Water plays a critical role in both structuring and maintaining the environment on both a regional and local level. All living things require water in some form to survive, and they typically receive it via precipitation. Water gradually coalesces to form networks of many types and dimensions that snake their way across the landscape. These flows of water are called streams and rivers, depending on volume and size of the channel (Naiman and Bilby 1998). The movement of water in streams and rivers has had a dramatic impact on the features of Eastern North America over millions of years. The landscape of Eastern North America is largely defined by the interaction between the previously mentioned terrestrial environments and aquatic resources. Streams and rivers slowly cut impressive valleys into the Appalachian Mountains and formed entirely new ecosystems with the deposition of carried sediment outward from the continental divide into rivers leading to the Mississippi River Delta basin and the Atlantic coast (Benke and Cushing 2005). Through their historical action, the rivers and streams of Eastern

North America have become central features on the geographic landscape acting to integrate and organize both the natural environment and human culture (Naiman and Bilby 1998). Plants and animals, humans included, must exist near a steady water supply. The deciduous forest communities that dominate the region are especially reliant on a moderate level of water, which is provided by rain and local waterways. This interplay between water and local environment has had an integral role in both ecological and social developments in the region. The richness of archaeological sites in major river drainages, even during the earliest periods of human occupation in North America, confirms this relationship (Sassaman 2010). However, there is more to this connection than a simple requirement for water. Rivers and streams are not just varying quantities and flows of water; they are highly complex and variable ecological systems that favor the development and maintenance of life (Naiman and Bilby 1998). Both the immediate living contents of waterways and the land immediately adjacent to them are invaluable resources for all members of the local ecosystem, particularly human populations. The ecosystem located on the banks or floodplains of a river is defined as a riparian area.

Riparian areas represent a gradient of terrain connecting upland deciduous forest communities and aquatic environments. Numerous interactions between water and local material produce the large variety of riparian areas. These connected processes include large shifts in the river channel and its associated features, but also sediment deposition, soil-formation, changes in water availability and maintenance of a flood-prone vegetational zone (National Research Council [NRC] 2002). Each of these developments contributes to the larger productivity of the riparian gradient, but the changeable flow dynamics of rivers and streams have the most profound influence on shaping these areas. Water flow determines the nature and rate of sediment deposition in the water channel. As a rough rule, coarse material is deposited first, followed by finer materials like sand and silt in lower-velocity stretches. This pattern is true in terms of the length of the waterway, as well as its width. Mountain streams contain most of the larger stone cobbles while coastal segments receive predominantly fine sediment. Similarly, the center flow of the waterway serves to channel most sediment, but finer material will be deposited in low velocity environments such as a bend in the river. The constant process of sediment accumulation and dispersal defines riparian areas (NRC 2002).

This activity is heavily influenced by climate. In the pronounced seasonal climate of Eastern North America, the yearly freeze-and-thaw cycle has a tremendous impact on stream and river flow patterns. The annual or semiannual flooding and disturbance of the waterway channel plays a dominant role in the life cycle of local vegetation. The flow variation and disturbance provides a source of new nutrients for local vegetation, controlling the germination and establishment of seedlings. The annual cycle of flow and disturbance regime promotes the growth of tree and plant species that can tolerate these conditions. Due in large part to riverine processes, riparian areas maintain a uniquely rich pattern of vegetation (NRC 2002). These same conditions also sponsor a wide variety of riparian vegetation types regionally by climate. Humid areas have much more stable flood regimes than arid regions. Vegetation may also vary by elevation and adjoining environments. Generally, riparian areas have higher species diversity than nearby upland forests, although the opposite is true for some areas of the eastern deciduous forest region (NRC 2002). This diversity is the result of a wide variety of local riparian environments that structure broad plant communities of varying age and composition. Despite annual cycles of change, riparian areas provide an environment that allows for plants to persist in their range. Floodplain disturbances also allow for the movement and regeneration of plants through their seeds, also encouraging perpetuation. Through these means, riparian areas are a refuge for rare and unique plant species that may have died out elsewhere (NRC 2002).

With this exceptional ecological diversity, the attractiveness of riparian areas as a habitat for animals and a central locale for humans is doubly apparent. In many ways, local peoples maximized this potential through various use strategies. Waterways were a refuge from the heat, a source of drinking water, transportation corridors, a source of fresh meat and perhaps most importantly, a provider of berries, seeds, roots, herbs and other imminently useful plants (NRC 2002). These characteristics of riparian areas and their systems of change also may have played an integral role in the development of early indigenous agriculture, but the riparian areas of Eastern North America did not always resemble their elaborate contemporary forms. The extant environment and rivers of North America are the product of many environmental and geographic changes over the past 20,000 years, a shift that largely coincides with the arrival and growth of incipient human populations on the continent.

A Climatological History

The current, deciduous-dominant environment of Eastern North America is a relatively recent phenomenon in terms of geologic time. Many of the characteristics used to describe and delineate the region are products of the past 6,000 to 10,000 years. North America has undergone a series of dramatic changes that have had a profound affect on its environment. A landmass resembling contemporary North America only appeared some 65 million years ago, many millions of years before humans or their closest ancestors existed. Over time, the continent lost its inland seas and the cooling climate allowed for the emergence of early broadleaf deciduous tree forms. However, the distribution and types of tree and plant species did not yet resemble that of contemporary Eastern North America as described above. Only in the late Miocene Epoch, some ten million years ago, did the formation of the Rocky Mountains begin to sponsor the evolution and expansion of the mid-continental grasslands (Delcourt and Delcourt 2000). The emergence of modern environmental characteristics was a long process with many elements that did not coalesce until the current geologic time period, the Quaternary. The Quaternary Period began some two and a half million years ago, roughly coeval with the appearance of the earliest members of our human genus. The principal environmental feature of the Quaternary Period is the alternating cycle of glacial and interglacial intervals. These climatic cycles last approximately 100,000 years and contain a long period of cooling, typically 90,000 years, followed by a shorter 10,000 year period of warmer climate. These cycles and their associated climatic changes dramatically affected the distribution and number of plant and animal species in North America.

During glacial periods, the distribution of vegetation remained relatively stable, but during warmer interglacial times, particularly during the past 10,000 years, plants and animals diversified and spread (Delcourt and Delcourt 2000). During glacial times, coniferous forests characterized much of Eastern North America, while deciduous tree species survived in the few warmer local areas like present-day Florida. The end of the last glacial period at about 12,000 years ago initiated a series of large-scale environmental and vegetational changes due to the warmer average temperatures and greater seasonal contrast. These changes established the beginnings of the current geological and environmental epoch, the Holocene.

Beginning about 11,700 years ago, the Holocene is the latest of the interglacial intervals and the impact of the warming climate was felt throughout North America in a number of different ways. The climate change can generally be characterized as moving from cool and moist in the early Holocene to warm and dry in the middle Holocene (also known as the Hypsithermal or Climatic Optimum), with a return to cool and moist climate in the late Holocene (Knox 1983). This tripartite division of climate is useful in organizing the recent environmental changes in North America. However, this climatic evolution should not be seen as a continuing cycle. The current cool and moist conditions have arisen from different causes than those seen in the early interglacial. The early Holocene climatic changes were directly associated with the gradual disintegration of the ice sheets covering most of northern North America. After the dissipation of the Cordilleran and Laurentide ice sheets from 10,000 to 6,000 B.P., the air circulation patterns over much of North America shifted to their current configuration, largely favoring warm and dry westerly zonal airflows and more humid meridional flows. However, these airflow patterns did not shift to their current winter and summer positions until after the final ice sheets dissipated. The central presence of the westerly warm zonal airflows from roughly 9,000 to 5,000 B.P. corresponds to the warmest period of the interglacial, the Hypsithermal (Knox 1983). Only after these dry conditions began to subside did much of Eastern North America begin to approach its modern environmental conditions. By the early Holocene, the tree species characteristic of the deciduous forest, such as oak, hickory, chestnut and beech, came into prominence. These vegetational shifts in the late Holocene also affected the changes seen in the region's river systems. In general, the end of the glacial period led to a much-increased period of river alluviation. Massive amounts of silt accumulated in the Hypsithermal period, when floods were uncommon. However, as climate shifted again to a meridional circulation, the flow of rivers increased, as did the frequency of flooding. The dramatic vertical aggradations of rivers slowed and modern erosive processes became more commonplace. The gradual alluviation of rivers became a central environmental process during this time, leading to the growth of riparian areas. Frequent annual flooding of rivers led to the horizontal accumulation of sediment in river valleys and floodplains (Knox 1983). This rich alluvial sediment encourages vegetation growth and development. Sediment and vegetation accumulation may also change the nature of the river channel itself, as it migrates laterally in meanders or braids (Benke and Cushing 2005). During the late Holocene at about 6000 years B.P., these river processes became relatively stable and the addition of the newly dispersed deciduous forest formed the basis of current environmental conditions. The transition from glacial to modern conditions is notable because the first human immigrants to North America arrived during the last glacial period.

Human Migration and Climate

These Pleistocene hunter-gatherers took advantage of the low sea levels during the close of the last glacial period to travel to the North American continent from Asia. Although many theories for the population of the Americas during this time period exist, migrations across the Bering Strait land bridge from what is now Russia hold the most evidentiary support, such as DNA and archaeological remains (Schroder et al. 2009). The Beringia theory posits that the first human groups came north into eastern Russia across a land bridge, which now lies under the Pacific Ocean. The sea levels were low enough for this event to occur from 80,000 to 20,000 years ago, but were even lower between 20,000 and 10,000 years ago. During this later time, the Bering land bridge was a broad landmass about a thousand miles wide. It is likely that during this time of lowest sea levels, Asian migrants pursued their favored animal prey into the Bering region and eventually the Americas. Migrating herds of game animals were critical to human survival, but other plant and animal resources were also available (Merchant 2002). When the North American ice sheets began to recede around 10,000 years ago, these hunter-gatherer groups had already spread throughout the Americas even reaching the tip of South America. Critically, the way these groups interacted with their local environment had to change. The large game animals of the Pleistocene became extinct due to a combination of over-hunting and climate change. Additionally, as has been shown, the regional environments of North America were changing quite rapidly. Sea level rose up to 300 meters in some places in the world, and river flows increased dramatically (Lamb 1995). The Paleoindian lifestyle of large mammal hunting, which once dominated cultures in North America, was no longer viable, leading to the development of new cultural forms. The changing adaptations of the indigenous population of North America to environmental change continued over the rest of the Holocene. The Archaic cultural period includes most of this time, spanning from 8,000 to 4,000 B.P. As shown above, it was during this period that environmental change stabilized in Eastern North America, resulting in the deciduous woodlands that now characterize it.

Large-scale climatic changes produced the Eastern deciduous forest and its riverine systems. However, while the scale of these changes has decreased throughout time, it is critical to recognize that the environment of Eastern North America is not a static system. The deciduous forest that so well defines the region is a relatively recent formation. So too are the wide river floodplains of the region. The environmental systems and changes described in this chapter are essential elements to consider when understanding the human condition in the past. Certain subsistence methods are only possible in specific environments. This is perhaps most evident in more extreme examples, such as the hunters of Pleistocene megafauna, but it will also prove to be integral to understanding human use of plants and the development of agriculture in Eastern North America. The ability of humans to have an impact on the environment through both interaction and direct influence is a critical factor in domestication, but it also has an effect on the environment writ large. It is only through careful examination of the environment that the natural state and the historical characteristics that are the product of human agency can be separated (Schiffer 1983). The domestication of plants and of *Chenopodium berlandieri* in particular are just one example of the processes of passive and direct human modification, which will be explored in the following chapters. However, the deciduous forests and great rivers of Eastern North American provide the palette from which this change can occur. Local environment has a powerful influence on the possibilities of human action.

CHAPTER FOUR

INDIGENOUS AGRICULTURAL PLANTS IN EASTERN NORTH AMERICA

The Eastern Agricultural Complex

While Eastern North America can be easily defined regionally by its wide swaths of deciduous forest nestled around weathered mountains and more recent riverine systems, the layer of vegetation composing the understory is an equally important component of the local environment. There are numerous small trees, shrubs and plants that compose the vegetative layer of ecosystems throughout the Eastern United States. These more localized environments have a composition that is uniquely adapted to specific sets of conditions, whether it is in the Appalachian Mountains or the American Bottom of the Mississippi River. The great variety of these local conditions is indicated in part by the great diversity of plant species found in Eastern North America. There are about 5,100 native vascular plant species located in the southeast alone. This subregional diversity is greater than that found within European countries, like Italy or France (Watts 1983). Eastern North America is remarkable for the richness of its vegetation. This incredible selection of native plants did not go unnoticed by the peoples occupying the region over time. From this diverse spectrum of greenery, an unambiguous collection of species became thoroughly integrated in the lives of these populations. Plants were a critical part of life for cultural types principally limited to stone and naturally produced technology. Accordingly, the plants of Eastern North America filled a number of roles, generally characterized by their utility, whether as a food, medicine, building material or other uses. The human proclivity for discovery and development was thoroughly applied to the plants of the region. In the Eastern United States, the set of plants with the most sustained and widespread use by local populations has been termed the Eastern Agricultural Complex.

The Eastern Agricultural Complex refers to the most prominent plants used for sustenance in Eastern North America. The idea of the Eastern Agricultural Complex was developed mainly in the 1970s and 1980s as a thorough and large-scale dataset for the region become firmly established. This direction was different from earlier efforts that focused on equating the maize complexes described for Mexico and pre-contact North America (Linton 1924). While the maize complexes differ in their focus on a central plant, the Eastern Agricultural Complex features many species of indigenous plants. The maize complexes are typically depicted as variations on the fundamental theme of maize utilization, with schemas that feature different secondary crops that coordinate with maize production locally, such as beans, peppers, squash, and amaranth. Although there was a general form for plant use in Eastern North America, the seemingly concrete nature of an entity such as the Eastern Agricultural Complex belies the nebulous nature of the plants included within it. In distinct times and places, differing assortments of plants were utilized in the Eastern United States. The factor that these plants share and make it possible to describe them collectively is their indigenous origin. Before the arrival of maize in the area, the plants used for food were entirely local species, selected for their individual merit and productivity. It is, therefore, less helpful to define regional complexes as is done in the early twentieth century descriptions of maize use, but rather to determine the plant species that are most utilized by specific populations based on archaeological and historical evidence. The evidence for plant use in the region will be set forward in Chapter 5, but the dominant plant species in the Eastern Agricultural Complex are squash (*Curcurbita pepo*), goosefoot (*Chenopodium berlandieri*), sumpweed (*Iva annua*), sunflower (*Helianthus annuus*), erect knotweed (*Polygonum erectum*), little barley (*Hordeum pusillum*) and maygrass (*Phalaris caroliniana*) (Fritz 1990).

These species are found in regular use throughout Eastern North America beginning with the first inhabitants in the early Paleoindian period up through the eventual domination of maize in the Mississippian. Originally the subject of gathering, these species were eventually cultivated and became domesticated, forming the foundation of an indigenous agricultural economy on terms similar to the other world centers of agricultural development. Understandably, the plants of the Eastern Agricultural Complex have been a leading subject of inquiry by anthropologists for decades and several theories for their adoption and use have been developed. Although these theories have become better suited to the evidence over time, specific aspects of Eastern North American plant use have been overlooked.

A Description of Chenopods

This investigation aims to examine some alternative theories of agricultural development by focusing on one of the better-known plants of Eastern North America, goosefoot or *Chenopodium berlandieri*. Before jumping into questions about the use of plants, it will be helpful and appropriate to describe the species in question in some detail. This chapter contains a description of *Chenopodium berlandieri* from the level of Order to subspecies. Although the exact botanical distinctions and terminology may seem inscrutable at times, even to the author, a general depiction of goosefoot as a plant will emerge. In combination with the first chapter’s description of regional environment, goosefoot's place in Eastern North America will become clear, establishing its position in relation to connections that will be determined in later chapters.

Chenopodium berlandieri is a member of the Order Caryophyllales. The Caryophyllales are an angiosperm or flowering group of dicotyledons (seed with two embryonic leaves or cotyledons) found in a wide range of environments worldwide. This rank of taxonomic classification represents the least complicated and most secure of the many levels leading to the species, *Chenopodium berlandieri*. Below the level of Order, the classification of *Chenopodium berlandieri* may differ slightly depending on the type of taxonomic system being used. Traditionally, taxonomies have established a separate Family, Chenopodiaceae, for the goosefoots, but more recent advances in genetics have garnered the possibility of a change in the established organization. Genetic taxonomies have relocated the Chenopod species based upon their close relation to the Family Amaranthaceae with a subfamily designation of Chenopodioideae. Although it is not entirely clear how this reorganization will be resolved, the distinction in classification mainly affects the ranking and organization of the high-level groups and does not affect most classifications at the genus or species levels. This merger of the Chenopods and Amaranths into one Family has been a source of lasting confusion in the literature describing Chenopods in both botany and in archaeology, even if the relationship between Chenopods and Amaranths has long been assumed (Fritz 2007). While species-level classifications are typically not problematic, establishing an evolutionary scheme remains a lingering problem with some lineages, such as *Sarcobatus* (Welsh et al. 2003).

In light of these current problems, the traditional Family classification of Chenopodiaceae will be utilized for its historical prominence in both botanical and archaeological literature. The additional level of taxonomic separation also benefits description by providing an additional set of unique morphological attributes for classification. However, the close genetic and physical proximity of Chenopods and Amaranths should be acknowledged, particularly in regard to their historical significance.

Following this established dichotomy, the Family Chenopodiaceae is a group of herbaceous, flowering, annual or perennial herbs, subshrubs, shrubs or trees noted for their uniquely shaped leaves (Jones 2005). The common designation of the plants as Chenopods or Goosefoots references this distinctive leaf shape, as can be seen in Figure 4.1. The name Chenopod describes this shape with the combination of the Greek words "chen", meaning goose, and "pous", foot. Notable members of the Chenopodiaceae Family include quinoa, spinach, beet, sugar beet, Mangelwurzel, chard, and epazote. The Chenopodiaceae are found in temperate, subtropical, semidesert and desert regions throughout the world, with approximately 100 genera and 1,800 species (Welsh et al. 2003). Many species in this family are quite resilient and thrive in saline or alkaline environments that would prove inhospitable for many other plant species. This niche specialty has been a dominant factor in their worldwide presence and their overall anatomy is representative of this environmental preference, as many Chenopodiaceae have distinct anatomical adaptations to arid or saline habitats.

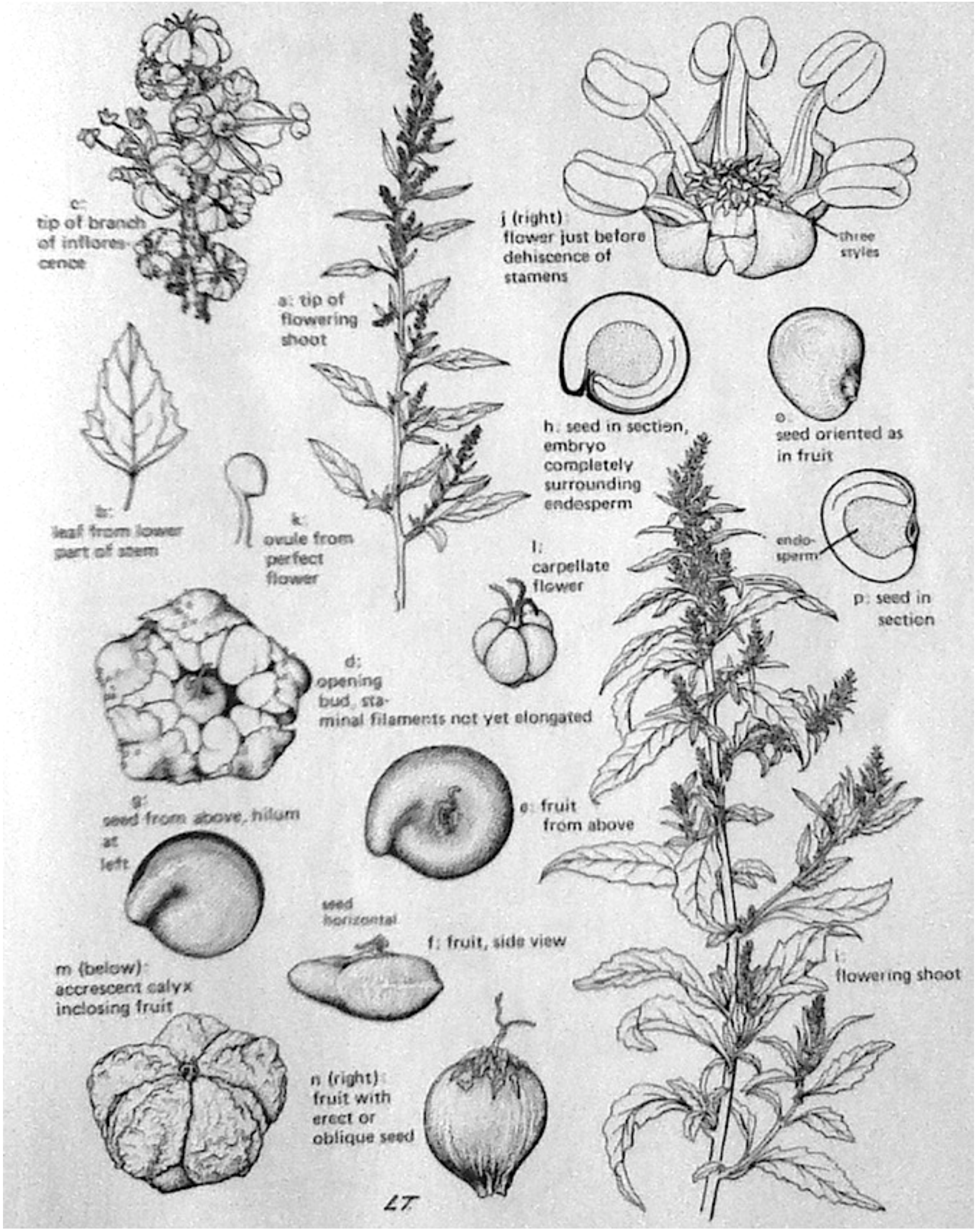

Figure 4.1. Anatomy of the Genus *Chenopodium* (Wood and Shaw 1974).

Environmental resilience begins with a root system that is often fibrous, taprooted, sometimes spindle-shaped and bulbous. Species of beet (*Beta*) are known for their development of the latter. Their root is a bulbous, fleshy and thickened storage organ. Most other Chenopod species have a large, fibrous root system. Although the stems emerging from this root system demonstrate a great deal of variability and plasticity in accordance with their suite of other ecological adaptations, the bodies of the Chenopodiaceae are typically succulent, storing water in their tissue, giving them fleshy stems and leaves. These pale gray, green and ruddy-colored stems are erect or prostrate in position. The stem shape will typically be round or angular with ridges in cross-section. Stems branch and articulate with joints that insert into each other. This branching is opposite with two stems or alternate with one stem diverging at the same node and across from each other on the stem. This branching often occurs at or below the inflorescence or flowering chute (Jones 2005).

The outer covering or bark of the stems varies, but can be characterized as slippery, aromatic, spiny, and glandular. These glands often result in a distinctive scurfy (flaky) covering when inflated salt glands deteriorate into white flakes over time (Reaume 2009). Chenopod's distinctively shaped leaves are simple, not divided or branched. These leaves are also usually arranged in an alternate pattern, singly on the stem, lacking stipules or small-modified leaves at the leaf's stalk. Chenopod's undivided leaves have one flat or semi-cylindrical blade. The edges can be straight, toothed or lobed in appearance. The leaves can be smooth or with glandular hairs. The leaves also tend to have glands that result in a scurfy covering similar to the stem, resulting in a pale dorsal surface on many Chenopod leaves (Jones 2005).

Although Chenopods are flowering plants, the chutes of blooms or inflorescences are not prominent. They are small, densely branched, and found in solitary or tight clusters called glomerules at the terminal ends of branching stems. In these clusters, flowers can be arranged in spikes, an unbranching, elongated and narrow inflorescence along a central axis; in panicles, compound and many-branched with flowers attached to secondary stems or cymes with terminal buds. In either case, flower structure is pentamerous, consisting of five lobes on the perianth or protective envelope united at their base. These flowers can be either unisexual or bisexual, with stamens and pistils. These sexual organs range from one to five stamens and one to three pistils (Reaume 2009). Pollination is generally accomplished by means of wind, although self-pollination and fertilization by small insects also occur. The fruits of Chenopodiaceae are small and abundant, forming in late spring or summer and persisting into winter months. These fruits are one seeded and remain closed at maturity. They typically have thin walls or pericarps that are easily removed (Reaume 2009). One seed occurs per fruit and are nutlets or achenes (Jones 2005). These seeds are miniscule, kidney-shaped or lenticular like a double-convex lens. The surface of the black, brown or reddish brown seed is smooth, pitted or wrinkled, shiny or opaque. Seed morphology is highly variable, even within one species. Features that vary include the thickness of the seed coat or testa, overall seed siz, and dispersal features. These differences may be advantageous for survival by enabling diverse dispersal lengths and times. Seed dispersal is normally facilitated by wind, water and animals (Kühn 1993).

The Example of *Chenopodium berlandieri*

From this description of general features, a clearer picture of *Chenopodium berlandieri* emerges. Although this plant appears unspectacular in appearance and constitution, following the taxonomic levels down to more inclusive units reveals more exceptional features. Continuing the categorical descent, *Chenopodium berlandieri* is found within the Subfamily Chenopodioideae. This Subfamily is distinguished from the rest of the Family by well-developed leaves; dense, branching flowering chutes; five perianth (floral envelope) lobes; and a persistent perianth or bracteole (flower stalk leaf) in the fruit. One further step down, plants in the Tribe Chenopodieae, like *Chenopodium berlandieri*, lack bracteoles (small leaves near the inflorescence) with just a persistent perianth and are covered with hairs on the stems and leaves (Kühn 1993). The Genus *Chenopodium* and its 100+ species of small plants and shrubs include all of the above attributes, but are characterized by the following exceptional features. The surfaces of the leaves, stems and flowers are noted for their characteristic flaky, scurfy or scaly covering that is white or gray. The upper part of the stem and the lower surface of the leaves are also naturally white or gray in color. The stems are not jointed, armed or fleshy (Jones 2005).

The main leaves are alternate, with or without stalks. The leaf blades are typically oblong, elliptical, egg-shaped, triangular, or lanceolate in shape with glandular hairs. The leaves are broader in the lower or middle half, being one and one half to five times longer than they are wide. The leaf margins can be unbroken, dentate or irregularly notched. The inflorescences are spiked and terminal with glomerules. The flowers are predominantly bisexual, with five ridged or keeled perianth lobes covering the fruit. The seed is lenticular with a black, brown-black or reddish-brown seed coat. The embryo is ring-like and horseshoe-shaped (Clements and Mosyakin 2003).

From this list of features, the Genus *Chenopodium* reads like a typical member of the Chenopodiaceae and they are. The genus has the distinctive resilience to environmental distress and can be found in many areas worldwide, particularly those that have been recently disturbed or disrupted. This general preference for some of the most unforgiving global environments on earth has been misconstrued by most with the terms such as “weed”, “wild” and other terms synonymous with undesirability. On the contrary, the aforementioned features are specifically what make this genus so critically important to cultural developments in Eastern North America.

Though many of the members of the Genus *Chenopodium* would make for a fascinating focus of cultural inquiry, *Chenopodium berlandieri*, the Pit-seed Goosefoot stands out. Although members of the Chenpodiaceae are found throughout the Americas, *Chenopodium berlandieri* is exclusive to North America (Flora of North America [FNA] 2003). Like other Chenopods, it can be found locally in grasslands, dry sloughs, riverbeds, floodplains and other disturbed open ground. Its six varieties retain the features of its family and genus, but are most closely identified by its more specific measurements as shown in Figure 4.2. It is typically from 40 to 150 cm tall from a taproot. The erect, solid, ridged and round stem is stiff and reddish towards the base. The leaves, however, are one of the main identifiers of the species (Reaume 2009). At their largest, these dull yellowish-green leaves have central lobes that are only slightly longer than their two basal lobes, resembling a goosefoot. *Chenopodium berlandieri*’s smaller leaves are usually unlobed, but all have a toothy or serrate margin. These narrow to broadly lanceolate or egg-shaped leaves are aromatic (Small 1933). They also have the typical mealy, white or gray waxy powder covering below (FNA 2003).

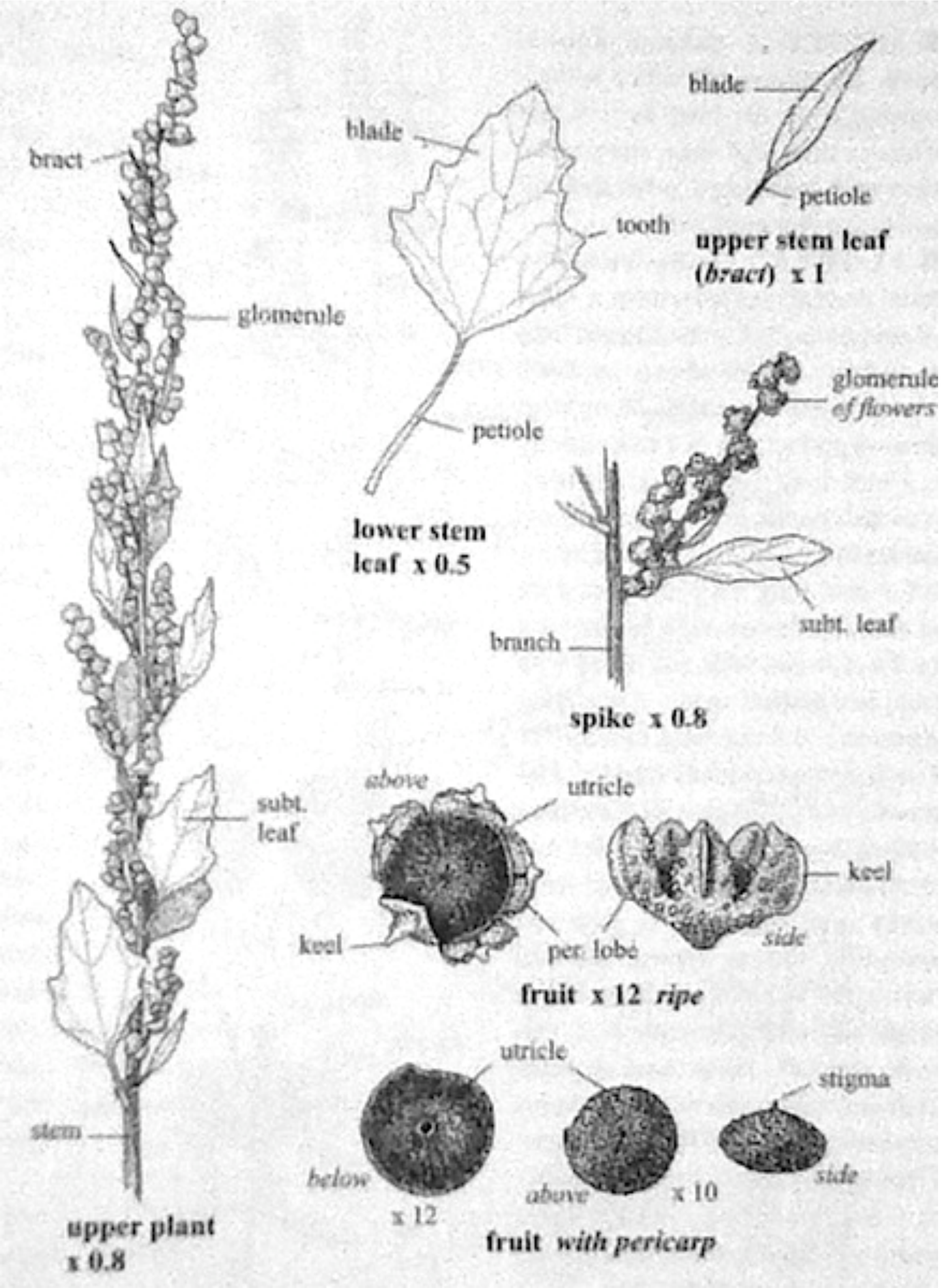

Figure 4.2 Anatomy of the Species *Chenopodium berlandieri* (Reume 2009)

The flowering chutes are limited to irregularly rounded clusters in continuous or interrupted spikes of lengths of 5 to 17 cm. The small flowers bloom from June to September and range from green to pale pink in color. They have five perianth segments, with prominently keeled lobes of egg or triangular shape. The flowers also maintain five stamens and two stigmas. The fruits contain one round seed that is one to two millimeters in diameter with rounded, convex margins that are less than a millimeter thick. These seeds have a shiny brown or black coat color with the species' namesake honeycomb pits (Reaume 2009).

In terms of general anatomy and features, the pitseed goosefoot seems to be quite unexceptional, but in the relative terms of the environs of Eastern North America it is an exceptional plant species. It is a hardy and abundant plant species with some unique aspects, such as the flaky appearance of its leaves and a faint odor. While these features will be shown later to have fundamental importance, the species' most apparent benefits are those relating to its known use as a source of nourishment. Both the leaves and seeds of *Chenopodium berlandieri* are edible and reasonably nutritious. This may be hard to fathom for those familiar with the pitseed goosefoot as a weed and allergen, but an inspection of the species' close taxonomic relatives of spinach (*Spinacia oleracea*) and chard (*Beta cicla*) should make its utility less of a surprise, particularly in terms of nutrition. While the edible allure of many of this group focuses on their abundant leafy greens, another attractor of local hunter-gatherer peoples to *Chenopodium berlandieri* would be its numerous, if miniscule starchy seeds. These pitted seeds would become one of the central foci of a North American horticultural revolution. The plants of the Eastern Agricultural Complex, including the pitseed goosefoot, were in a front-seat role for the transition from dispersed foraging cultures to a complex hierarchical system of agricultural polities and chiefdoms throughout Eastern North America. Although maize would eventually come to dominate the agricultural scene in the time before and after European involvement, the uniquely adapted native plant species were the object of the initial innovation of cultivation in North America, a process whose means and mode are the primary subject of inquiry here.

CHAPTER FIVE

AN AMERICAN MODEL OF PLANT DOMESTICATION

Establishing an American Ethnobotany

The climate and environment of Eastern North America provide a dramatic contrast to the other milieus where the origins of agriculture unfolded. In retrospect, many of the region's environmental features do not fit into a model that favors a small ecologically productive source area as may be seen in the river valleys of Mesopotamia, Asia, Africa, and Mesoamerica. Eastern North America as a region is dramatically larger than any of these other locales. In theory, it contains thousands of rich river valley and forest sites that were suitable for subsistence in both foraging and horticultural terms. North America was generally ignored in terms of early research due to a lack of data and prominent legacy species other than sunflower that persisted. Eastern North America simply did not fit the theoretical model established to understand domestication processes elsewhere. However, this perspective did not hold in the face of overwhelming archaeological evidence gathered during the late twentieth century. In particular, the advent of techniques to recover botanical materials from sites in Eastern North America, which are characteristically damp, is continually rewriting our views of domestication within the region. Critically, these relatively recent innovations are only revolutionary in terms of redefining Eastern North America's importance on a world stage. The data collected in the 1970s and 1980s by American anthropologists and archaeologists provided the evidence needed to establish North America as an independent locality of domestication. While most of the rest of the world was ignoring the seemingly nebulous developments in Eastern North America, specialists have considered various theories and explanations for plant use and domestication in the area. This chapter will highlight the major historical points relative to North American plant domestication, with specific reference to *Chenopodium berlandieri*, before documenting the prominent theories for plant domestication leading to the present.

While Eastern North America had been ignored as a possible center for plant domestication for the better part of two centuries by scholars abroad, recent methodological techniques have largely endorsed the work of early American archaeologists such as Melvin R. Gilmore and Volney H. Jones, who documented paleoethnobotanical remains, but lacked both the massive contemporary data set and radiocarbon dating. While Nikolai Vavilov was amassing the colossal genetic and diversity information to show that eight hearths of domestication existed in the world, researchers in North America were also investigating agricultural origins, albeit focusing on maize. Ralph Linton (1924) was among the first anthropologists to raise the possibility that food production economies in the Eastern Woodlands of the United States, but he was focused on maize use, rather than indigenous plants know known to be important. These naturally occurring Eastern species used as crop plants were important enough that they gained a formal name by the 1970s, the Eastern Agricultural Complex. The Complex is variously composed of a variety of species, but squash (Curcurbita pepo), goosefoot (*Chenopodium berlandieri*), erect knotweed (Polygonum erectum), maygrass (Phalaris caroliniana), marsh elder (Iva annua), and sunflower (Helianthus annuus) are the most prominent members. These plants are all characterized by their oily or starchy seeds, which are useful for consumption. In some cases, the leafy matter of the plants is also valuable for subsistence.

This would not take long, for the first graduate program in ethnobotany was established at the University of New Mexico in 1930. Ethnobotany, or the study of the human use of plants, was not a new field, but its earlier study was limited to anthropologists who had also studied and practiced botany. These two historical approaches met at the University of Michigan during the 1930s in the form of the research team of Melvin R. Gilmore and his assistant and successor, Volney H. Jones. Gilmore and Jones established the earliest ethnobotanical laboratory at the University of Michigan Museum of Anthropology and radically altered the scientific face of both North American ethnobotany and theories on agricultural origins. Gilmore and Jones analyzed a great amount of ethnobotanical evidence, but plant remains from the Ozark Bluff rock shelters of Arkansas and Missouri, and Newt Kash ineastern Kentucky were fundamental in supporting a separate origin of agriculture in the Eastern United States (Gilmore 1931; Jones 1936). As a result of their work, the nature and extent of native food production became a focus for American anthropology. Notably, this early evidence, mainly *Chenopodium* seeds, was similar in provenience to other important plant finds in Mexico and the Near East in the unique preservation circumstances of the caves in which they were found. This exceptional preservation, in one case the woven container was almost new in appearance, maintained the pericarp, which allowed for the eventual determination of a North American rather than a Mesoamerican origin for the relatively large *Chenopodium* seeds (Aellen and Just 1943; Fritz 2007). Such preservation is often critical in determining the intensity of use of a particular plant species, since minute physical differences often are the factors that point to either foraged wild plants or domesticated crops. The work of Gilmore and Jones was vital in terms of understanding and evaluating this dichotomy.

Delineation of Changes Related to Domestication

In strict terms, morphological changes in plants are generally the result of selective pressures, whether they be naturally or culturally based. In the case of plant domestication, determining the source of these changes corresponds to the degree of human utilization. Intense human use results in selective pressures that change related plant morphology from the wild type condition (Wilson 1981). While some of the morphological differences seen in recovered samples were originally thought to be a product of natural phenotypic diversity, the magnitude of specific changes evident in the excess of archaeological evidence of plant use resulting from the methodological improvements discussed earlier has shown the degree of human intervention in certain plant species. The most common characteristics associated with an artificial environment due to human selection include flowering part compaction and terminalization, loss of shatter mechanisms, uniform maturation of fruit, reduction of germination dormancy and increased food reserves for germination. These changes can be seen in samples of *Chenopodium berlandieri* gathered from archaeological contexts (Asch and Asch 1977; Smith 1984). The most obvious change has been to the relative shape of the plant and its flowering parts (Wilson 1981). Domesticated plants show a general compactness of the flowering parts that contrasts with the quite less dense wild varieties, a trait which is evident in Figure 4.1. However, the moist soil of the Eastern Woodlands generally only leaves evidence for the reduction of germination dormancy and increased food reserves in fractured, carbonized seeds. These traits can be seen in terms of changes in the relative testa or seed coat thickness, making it the most important morphological characteristic for differentiating wild and domestic forms of plants like *Chenopodium* in archaeological contexts (Gremillion 1993). A thick outer testa is the primary mechanism plants have for the prevention of early germination. A thick seed coat is adaptive in wild varieties of plants where the prevention of germination is critical for surviving the extremes of environmental fluctuation. In situations of human intervention, the thickness of the coat is reduced significantly to a translucent layer or the coat is lost entirely (Smith 1984). Thin-testa seeds, seen in the domesticated variety *Chenopodium berlandieri ssp. jonesianum*, germinate quickly and grow rapidly, indicating human intervention in plant life cycles. The difference in coat thickness between wild and cultivated forms is striking, all wild forms have a testa thickness of about 40 to 80 microns, whereas cultigens are under 20 microns and average around 10 microns (Smith 1989).

The reduction in seed coat also results in a change in the shape and cross section of the fruits. The fruits move from lenticular or elliptical in shape to rectanguloid with a truncated margin. The change in shape allows for increased internal fruit volume that is comparable to selection for a higher yield crop. Evidence for this difference in size can be found in average seed diameter. Seed diameter is around 10 to 40 millimeters larger on average in domesticated forms. The domesticated varieties like *Chenopodium berlandieri ssp. jonesianum* also share a larger seed "beak" (Gremillion 1993). All of these characteristics can be seen in some degree or form in relation to archaeological sites in the eastern United States and show that fast growing seeds were being selected for among local populations. So while the argument by Asch and Asch (1977) that these morphological changes, particularly reduced seed coat thickness, can be explained by normal genetic variation in wild species of *Chenopodium* is not entirely without merit, the context of the samples is crucial. While the thin-testa morph is present in small numbers among wild populations, it composes almost the entirety of archaeological samples

(Gremillion 1993). It is unlikely that such a high percentage, upwards to 100 percent, could be assigned to natural variation, particularly in the context of nonrandom human occupation where these changes would not be advantageous to the plants. While both wild and domesticated forms of *Chenopodium* appear at archaeological sites, they can be differentiated on account of the characteristics mentioned above, even among thin-coated wild and domesticated varieties (Smith 1985a, 1985b).

Forming a Timeline for Domestication

These morphological differences have been the factor that has driven any discussion of plant domestication and agriculture in Eastern North America. In many archaeological cases, the exact species or variety of plant is not apparent, but minute variations in form detectable with scanning electron microscopy can prove human influence. In fact, seed coat differences in combination with AMS dating were the primary force in finally setting Eastern North America apart from Mesoamerica. Thin-testa variants of *Chenopodium berlandieri* have not been found in archaeological contexts in Mesoamerica before the sixteenth century, supporting a model of independent domestication for North America (Smith 2006). In temporal terms, *Chenopodium berlandieri* was harvested as a wild plant as early as 8,500 B.P. and was an important domesticated crop until sometime after European settlement (Asch and Asch 1985; Smith 2006). The earliest evidence for the domestication of *Chenopodium berlandieri* in the eastern United States is from the Newt Kash and Cloudsplitter rockshelters in eastern Kentucky. The specimens found at these sites have been radiocarbon dated to 3,400±150 and 3,450±150 B.P. (Smith 1989). In comparison, *Zea mays* (maize) does not appear in the area until 2,200 B.P., almost two millennia after the domestication of squash, sunflower and marshelder (Smith 1989). Similar determinations have qualified this separation in most of the other plant species of the Eastern Agricultural Complex. By around 2000 B.C., the four major plants in the Eastern Agricultural complex were under intensive use leading to domestication. In addition to *Chenopodium*, marshelder, sunflower and squash had undergone morphological changes associated with domestication some 500 to 1,200 years earlier (Smith 2006). For squash, the change to cultigen is generally associated with a thickening of the rind, as well as increases in the seed size, fruit size and peduncle size. In marshelder and sunflower, an increase in the size of achenes can be shown. All of this evidence provides a relatively clear time frame during which domestication took place within various subregions of the Eastern United States. The gap between the time of earliest use and earliest evidence of domestication in the Eastern United States gives upwards of four thousand years for the domestication of *Chenopodium berlandieri*. While the evidence in support of the independent domestication of indigenous plants in Eastern North America is unambiguous, how these plants, *Chenopodium* in particular, were domesticated in the local terrestrial and riverine environments of North America remains another question entirely.

Effects of Environmental Stabilization on Subsistence Methods

As demonstrated in the Chapter 3's discussion of Eastern North American environment, the deciduous-forest-dominated ecosystems of the region have not always existed in their current forms. In fact, many of the changes seen through time are relatively recent products in terms of geological and human evolutionary time scales. The transition from the cold-dominated Pleistocene to the gradual warming of the early Holocene period had substantial impacts on human populations in North America. The glacial period of the Pleistocene and the subsequent interglacial period beginning 10,000 to 15,000 years ago were the major environmental forces allowing for human migration to the Americas from Asia, whether over the Bering land bridge, boats, or other possibilities. Once in the Americas, the climate transition from the Pleistocene to the Holocene steadily influenced the subsistence methods of the Paleoindian populations of North America, changing patterns of plant used dramatically over the 13,000-year prehistory of the Eastern United States. Though the extinction of Pleistocene mega-fauna is a much-debated topic, Paleoindian groups had relatively low population densities that had a comparatively minimal impact on the immediate postglacial landscape. The lower density of plant resources and processing technologies in this time period are argued by some to reflect relatively low plant use and a heavy reliance on hunting by Paleoindian groups (Waguespack and Surovell 2003). The climatic transition's effects on plant life in the Eastern Woodlands from the Pleistocene to the Holocene were wide-ranging and remarkable. By 9,000 B.P., deciduous tree taxa had emerged in force among river drainages in the Eastern United States. This represents the foundation of the modern environment of the region, especially as the new ecological systems began to stabilize by 6000 B.P. This stability translated directly into a shift from highly nomadic hunting activities, to a more generalized subsistence based around the creation of a yearly cycle of hunting and gathering activities within a more proscribed space during the Archaic, as variations in the growing season evened out (Gremillion 2011). The forests of Eastern North America were rich in game and plant food resources and could easily support the type of specialized hunting economy of Paleoindian groups, but population growth required diversification. The broad-based foraging subsistence that characterizes hunter-gatherer groups in the Southeast from the Middle to Late Holocene emerged in this environment (Meltzer and Smith 1986). Just as trees played a vital role in the stabilization of riparian ecology, they also were critical in terms of food resources. The nut-producing trees of Eastern North America were an incredibly rich source of protein and other nutrients, for humans and local fauna with black bear, white-tailed deer, turkey, and squirrel being highly salient. The mast resources of species of hickory, walnut and oak, being compact packages, were also relatively easy to gather and store for a period of shortage (Fritz et al. 2001; Gardner 1997). Until a relatively stable ecological state was reached, the periodic fluctuation of the plant foods would have resulted in increased mobility during specific seasons. Periodic fluctuation of local resources also helped to foster the development of social and cultural activities that served to reduce the seasonal variability in diet such as increased intergroup contact and exchange (Cowan 1985).

The shift away from Paleoindian subsistence strategies was unambiguous by the Middle Archaic (Moore and Delke 2010). Archaeological assemblages showing foraging activities of great breadth are apparent throughout the East. Recent work at Dust Cave in Alabama is just one example of the subsistence typical of the region in the late Paleolithic (Carmody 2009; Hollenbach 2009). This type of activity was only possible in the recently established forests of the region. The relationship of these forest ecosystems was also crucial to the stabilization of riparian ecosystems, as has been demonstrated. Within the broad-based subsistence of the Middle and Late Archaic, riparian ecosystems became increasingly important to local populations. Shifting patterns of settlement favored river camps due to the high degree of locally accessible resources and the proximity of rivers to a number of other ecotones. By the Late Archaic, Eastern groups had firmly expanded their diets to include a broad spectrum of aquatic resources, such as shellfish, fish and turtles (Dye 1996). The degree of the consumption of shellfish is particularly apparent in the accretion of large piles of refuse from these dietary patterns (Claassen 1996). The cultural importance of riverine life is evident in the number of deep shell and midden-mound settlements of the Shell Mound Archaic in the central Ohio and Tennessee River valleys (Sassaman 2010). The stability provided by the diversity of available foods and materials allowed for the long-term annual occupation of these sites. Increasingly stable settlement can also be seen in the significant quantities of nutshell found at shell mounds (Crawford 2005). The proximity of many of these archaeological sites to abundant aquatic resource localities demonstrates the penetrating sociocultural effects that the stabilization of river valleys and warming of climate in the Middle Holocene had. Though still strictly foraging groups in terms of subsistence, Archaic populations had new opportunities to intensify their relationships with a local environment dominated by deciduous oak-hickory forests in which they could reside successfully throughout most of the year's seasons. This relative seasonal permanence allowed for the results of certain plant management practices to be seen by local peoples and the increased number of mast resources seen in the archaeological record is also indicative of the shifting nature of human-plant interaction. It should be no surprise that settlement and population size, local and regional cultural identity, intergroup competition and interaction, and material and cultural complexity in practices such as food preparation emerged as a result of environmental stabilization in Eastern North America (Sassaman 2010). While each of these events in its own right could be considered one of the bases of increasing magnitudes of social and cultural development, the routine contact of peoples and plants in this ecologically stable milieu was perhaps the most essential aspect of the transition from foraging to agricultural subsistence behaviors.

Towards a Functional Ecological Model of Plant Domestication

It was under these long-term climate changes and environmental stabilization processes that peoples of the Eastern United States most likely came into regular contact with the weedy annuals of the Eastern Agricultural Complex. These plants become increasingly visible in rock shelter sites throughout the region. Again, it is essential to understand that in this sense weedy is not a pejorative term, but one denoting both the hardiness and overall environmental specialization of these indigenous plants. These weedy annuals are predominantly early colonizer species that are most likely to appear in circumstances where the environment has been disturbed or modified in some way. The riparian ecosystems of Eastern North America are a naturally occurring source of disturbance, allowing for new soil and nutrients to be regularly replaced on the riverbanks with seasonal floods. In many ways, the river floodplains and mud flats were ideal locales for plants such as *Chenopodium berlandieri* (Munson 1984). As time progressed in the Holocene, however, a remarkable new niche for these species was created by the environmental and cultural stabilization of local human populations. With population growth and the intensification of environmental interaction, whether through increased foraging, resource gathering, use of fire for clearing and attracting game, or refuse production and dumping, populations in Eastern North America created a new habitat highly suitable for weedy colonizer species.

This scenario is the foundation for most theories of agricultural development and plant domestication in the woodlands of Eastern North America. Though some early theories argued for plant domestication as a product of the increased efficiency of human groups at exploiting forest resources, Joseph Caldwell's (1958) Primary Forest Efficiency model, an ecological model of domestication has been the most prominent in historical discussion. The human tendency to alter their local environments was a trait that was recognized by almost all members of the scientific community particularly by the 1940s and '50s, when human environmental modification and control over nature was seen as the highest mark of progress. In an early display of cultural relativity from all members of the scientific community, this tendency was also ascribed to our prehistoric ancestors, whether European or indigenous. The political implications of this perspective are still being felt, but for the purposes of understanding the processes of plant domestication, it represented a sea change in American prehistory. The international anthropological research symposium "Man's Role in Changing the Face of the Earth", organized in 1955, was one of the first attempts at an interdisciplinary understanding of the interface between humans and environment. Its conference and edited collection are representative of the shift towards a functional ecological view of human-environment interaction. Although the ecological perspectives of the conference are limited by contemporary standards, the recognition of an inherent human inclination to tinker was fundamental. The relationship between weedy colonizers and people was highlighted: the act of "clearing an area caus[es] changes of vegetation around the camps, such as the stimulation of chenopods, by the accumulation of organic refuse" (Narr 1956:135). Although in this case the author was talking about the routine clearing of the land around camps for construction materials and fuel in prehistoric European cultures, the application of similar ideas to North America is not difficult. American species of *Chenopodium* are equal in vigor to their European counterparts, as many a highway maintenance crew may attest. Weedy species like *Chenopodium* take advantage of circumstances that most other plants avoid. They "have the capacity to get along in man's vicinity" (Anderson 1956:764). In this way, weedy plants are the botanical version of animals that are commensal with humans, like house mice and brown rats.

Having been given up as an annoyance for most people, the weeds of Eastern North America were noticed by the botanist Edgar Anderson, who made the important connection between the archaeological evidence of indigenous plant use triumphed by Melvin Gilmore and Volney Jones, as well as the ecological characteristics of weeds. He correlated the number of weed-derived crops with the characteristic tendency of weeds to thrive in disturbed anthropogenic circumstances. Anderson (1952) surmised that open habitats resulting from humans, like gardens and dump heaps, were the likely location where discarded plant remains would germinate after being gathered and used. Anderson's perspective of human-plant interaction came to be called the "dump heap" model, with the name belying its critical importance to our understandings of domestication in the Eastern Woodlands. This model proposed that floodplain weeds are in a unique position to be manipulated by humans because they are dominant in the disturbed habitats of human production.

Though Anderson's model was influential and practical, providing the circumstances behind domestication in the particular environment of Eastern North America in the Archaic, it notably lacked the selective forces necessary to explain the coevolution of plants and humans towards domestication. Melvin Fowler (1971) connected the midden model with increasing sedentism in the Archaic as a force for domestication. Stuart Streuver and Kent Vickery (1973) expanded on this idea further by proposing that the floodplains and mudflats of river valleys would be a suitable location for domestication, in accordance with archaeological evidence. However, it was De Wet and Jack Harlan (1975) who finally connected domestication with the role that human behavior plays in plant development. Domestication indicates that plants have become dependent on humans to some degree for their survival; strictly speaking, cultivated weeds may continue to thrive even when they have been ignored or abandoned by humans. Thus, the intentionality of humans is a distinguishing factor between wild plants and domesticates (Heiser 1988). Human behavior has a direct effect on the transformation of colonizer plants to domesticates, more so than other non-weedy species. The acts of harvesting and the deliberate planting of these seeds provides the highly selective forces that produce the morphological changes within cultivated populations of plants (De Wet and Harlan 1975). These changes are the factors visible to the archaeologists and paleoethnobotanists who recover and analyze seeds, such as the reduction in seed coat thickness in *Chenopodium berlandieri* (Gremillion 1993). As mentioned above, with advancements in technology like scanning electron microscopy, these differences have become easier to quantify. Even in the light of the greatly increased sample size of paleobotanical specimens, Anderson's original "dump heap" model has survived the past half-century relatively intact. The more recent additions of more precise AMS dating have provided a better chronology for plant use, which has been demonstrated by Bruce D. Smith (1989) and others. The improvements to Anderson's model were integrated by Smith into the floodplain weed theory of agricultural development that incorporates the historical changes that were occurring in local indigenous populations during the time period of agricultural intensification during the Late Archaic Period. The permanence of shell midden settlements allowed for the maintenance of the coevolutionary relationships between humans and the annual weedy plants that were harvested each fall (Smith et al. 1992). The driving force behind Smith's model is the high economic potential of floodplain weeds: "their seeds had long represented a dependable, high yield river valley source" (Smith et al. 1992:30). By 5,000 to 3,800 B.P., the plants of the Eastern Agricultural Complex had been domesticated and formed a part of an intensified agricultural economy that remained prominent until they were gradually surpassed by maize from Mesoamerica around A.D. 1000 (Smith and Yarnell 2009). This was a process that result in some domesticates, notably *Iva annua*, reverting to a wild state (Heiser 1992). Although the probable harvest yield of floodplain plants (500-1000 kg/ha) is similar to that of domesticated maize (400-1400 kg/ha), the benefit in utilizing floodplain weeds relative to other traditional local plant and animal food sources is not entirely clear (Smith 1989:1569). These perspectives did not address how Eastern foragers were interacting with plants, nor did they incorporate changing human perceptions of the local environment or plant resources (Moore and Delke 2010).

The history of the study of agricultural development and plant domestication in North America has arisen from the shadow of other centers of agriculture and emerged as an important location in its own right. This was not through fault of the work of American archaeologists who pioneered the study of paleoethnobotany and made many critical finds early in the twentieth century. The improvement of both methodology appropriate to finding botanical remains in the environment of the Eastern Woodlands and technology to describe these remains has allowed for evolutionary theories to finally explain the development of the Eastern Agricultural Complex in detail. The description of differences between wild and cultivated plants has been a major player in theoretical progress. The ascription and influence of humans in their surrounding ecology was equally important in making this distinction at mid-century. Theories of plant domestication in Eastern North America are thoroughly reliant on perspectives of human ecological intervention. The clarification of the spatial and temporal distribution of wild and cultivated weedy species has been the major refinement to early theories such as Anderson's "dump heap" model. Smith's floodplain weed theory is simply a continuation and clarification of this view of human environmental intervention, which draws upon evidence of artificial selection and chronology. Despite the applicability of these ecological theories to the available evidence, they are lacking in their explanation and interaction with local cultural behavior and processes. To date, the domestication of plants has played a large explanatory role in cultural history, but the effects of culture, especially changing perspectives towards food, on domestication processes have been relatively ignored (Caldwell 1958).

CHAPTER SIX

CULTURAL SELECTION MODELS AND PLANT DOMESTICATION

Theoretical Origins of Cultural Evolution

Investigations into the origins of plant domestication have made incredible progress over the last century. North America and its indigenous crop complex have come full circle in terms of both recognition and scientific understanding. Models that attempt to explain domestication in the Eastern Woodlands have progressed from elaborate "just so stories" to full ecological models of subsistence intensification and later, coevolutionary models explained the proximity of human populations to the rich riparian ecosystems of Eastern North America. In many ways ecologically based models are satisfactory for understanding plant-human interaction and they correspond well with the available climatological and archaeological evidence. But within a holistic model of anthropological change, these models generally fail to account for the suite of factors encompassed by the broad term of culture. Ecological models do well to establish the basic science of interactive relationships seen in evolution. However, the focus of these inquiries has often centered on proximate causes for agricultural development, such as population growth, climate change, forced proximity of plants and humans, or enhanced power relations. While these causes all had some impact on the development of agriculture, the most critical changes were in terms of culture related to plant use. Culture is one of the ultimate causes of human behavior and as such, it largely governs why, how and what humans do. An accurate model of cultural development is necessary to understand the cultural changes that allowed for and occurred during the domestication of plants. Outside forces, in this case humans, affect the environment to promote the morphological and genetic changes diagnostic of plant cultivation.

Human interaction is proven through archaeobotanical evidence, but human motivation is the major unexplained factor in agricultural development in the Eastern Woodlands.

The following chapters will attempt to rationalize possible human motivations for the use of plants in the Eastern Agricultural Complex through the continued investigation of *Chenopodium berlandieri*. Before theories of usage are evaluated, it is necessary to provide a theoretical background for the investigation of cultural motivation. While psychological, agency or praxis models would be informative, the degree of change in cultural practices to be explained lends the study of agricultural development to a model of cultural evolution. Cultural evolutionary models are typically geared towards understanding human evolution and adaptation to the environment through Darwinian natural selection theory and provide a reasonable methodology for interpreting human cultural change within and between populations.

Although many human groups have experienced some degree of intensified plant cultivation, as has been shown, Eastern North America offers a unique situation for examining the interplay between culture change and plants. Although the focus so far has been on the original domestication of indigenous plants, cultural groups in Eastern North America actually underwent at least two major shifts in the types of plants under cultivation. First, between 4,000 and 3,000 B.P., native North American plant species were domesticated and later emerged as the basis for indigenous food economies in the east. Then, after arriving in Eastern North America from Mesoamerica in the early centuries A.D., maize became the center of food production in agricultural societies around 1000 B.P. (Smith 1989). Of these two major shifts in cultivation, the original adoption and domestication of indigenous plant species demonstrates the greatest changes that occurred in terms of the changing human perspective of plant life, not to mention the changes in climate and local environment in the Holocene. As such, the use of plants associated with this major shift is incredibly important. Of the plants of the Eastern Agricultural Complex that were domesticated, *Chenopodium berlandieri* is broadly representative of the weedy annuals of North America and provides the most compelling example of the complexities of cultural change. By understanding the relationships this plant held with local cultures, it may be possible to explain both its original adoption and its later place in the development of the food economies of intensive agriculture in Eastern North America.

Agricultural development is explicable through the methodology of cultural evolution, but cultural evolution is a diverse field of theory with many variations, old and new. As such, an elaboration of the mode of cultural evolution will be central to a discussion of its impacts on plant use and development. Evolutionism has played a central role in the development of the social sciences, particularly anthropology. Despite its widespread influence, the application of evolutionism to culture has been a subject of much contention. This has much to do with the early and problematic applications of evolutionism to social development. The nineteenth century perspective of cultural evolution or Classical Evolutionism, espoused by Lewis Henry Morgan and Edward Burnett Tylor among many, was one of directional change or progress towards an end result of civilization. This view was understandably problematic for many reasons, not the least of which were its European bias and broad stereotyping of modes of subsistence not reliant on intensive agriculture (Sanderson 2007). In a critical response to this type of evolutionism, American anthropologists in the Boasian tradition developed theories that abandoned the prospect of applying evolutionary thinking to culture. Grand theories of development were largely avoided in favor of a cultural historical perspective that typically documented local traditions and culture in a relative historical vacuum.

This method of anthropology could not continue, especially in the subfield of archaeology where processes of historical change on a time scale are so critical to understanding culture. A resurgence of cultural evolution in the mid-twentieth century was largely a result of paradigm shifts in archaeology, which, for example, led to the investigation of agricultural origins by V. Gordon Childe (1952). The impact of innovations in physics and chemistry also had widespread reverberations across all of the sciences. This paradigm of grand atomic-age science can be seen in neoevolutionary theory, including the unilinear evolutionary work of Leslie White (1943) and multilinear theories of Julian Steward (1955). This new application of evolution to culture demonstrated that it is entirely feasible to correct the mistakes of prior theories and provided a solid ethnographic and scientific foundation for future discussion of the evolution of culture. These changes allowed for a new form of nondirectional cultural evolution to develop from the 1970s to the present that is regularly changing and growing in response to new evidence and criticism (Sanderson 2007). These new theories of critical cultural evolutionism are important for their application of Darwinian evolution. These perspectives draw directly from Darwin’s natural selection theory to understand cultural evolution as a system that generally selects for practices that are the most adaptive or beneficial to a specific population. The application of natural selection means these theories are better termed cultural selection. Where cultural evolution looks at the mode and results of change, cultural selection is inherently only concerned with the process (Rindos 1984). While this type of thinking was originally limited to genes and large-scale morphological changes, such as those seen in plant domestication, selection theory can also be applied to cultural adaptations. Culture, like genes, can be the subject of selective forces (see Durham 1991), where highly beneficial behaviors and habits, like plant use, often spread widely among human populations. In this system, genes and culture are separate, but intertwined systems of inheritance (Richerson and Boyd 2005). Dual inheritance theories of cultural evolution allow us to redefine culture in terms of a variety of meaningful interactions involving genes, culture, and environment.

Cultural Selectionism and Transmission

Cultural evolution is a powerful way of viewing the processes involved in cultural change over time, but defining culture in a meaningful way is critical to this goal. There are innumerable definitions of culture, but for the purposes of evolutionary theory, "culture is information capable of affecting individuals' behavior that they acquire from other members of their species through teaching, imitation, and other forms of social transmission" (Richerson and Boyd 2005:4). Culture's position as information that is transmitted between individuals and populations is the key to applying Darwinian selection theory. Cultural information is similar to genes, except without any of the reproductive limitations. Indeed, like genetic variation, worldwide and historical cultural variation is a result of differences in this information between groups and individuals. By this means, it would be possible to understand any aspect of culture through an evolutionary lens, but it is particularly useful in viewing change, such as the onset of plant domestication. Domestication represents not only an evolutionary shift for the plants, but also for the culture effecting the domestication, as shown in the general history of populations in the Eastern Woodlands in the Holocene. Instead of explaining proximate causes for subsistence changes as ecological models do, cultural selection searches for the ultimate reasons a specific type of culture is in use (Rindos 1984). Cultural change is the result of the increased or decreased frequency of a particular variation of culture. Variation is a simple difference in an idea or the information represented by or to a culture. Small variations in culture over time can result in profound long-term changes. Alternatively, cultural selection, the selective retention of certain information usually with adaptive advantages, allows for the rapid change of particularly powerful ideas at an advantageous place and time. The evolutionary forces that select for or against specific variations are those highlighted by Darwinian cultural evolution. These forces are similar to those of biological evolution and include cultural mutation, cultural drift, guided variation, biased transmission and natural selection (Richerson and Boyd 2005). All of these cultural evolutionary forces impact the frequency of specific variations in culture in relation to alternative variations with the end result being cultural change. The evolutionary forces themselves do not generate cultural changes, but do so in a relationship with individuals and their social and ecological environments (Rindos 1989). Human motivation is key and cultural selection aims specifically to explain this question of why.

Botanical Knowledge and Selection

Although human life is a composition of social and environmental interaction, the focus here is on one of the primary relationships humans have with their local environment: plant use. All people, of course, are dependent on plants. This relationship is partially one of necessity: plant-based resources form the majority of subsistence for most hunter-gatherer groups, including Paleoindians (Kelly 1995). Plants are also useful for many other aspects of survival and include numerous objects of material culture. Plants comprise the majority of our medicines, the source of our clothing and fiber, the fuel for cooking and warmth, and the roofs sheltering us (Minnis 2000). Although our intimate link with plants has not disappeared in postindustrial society, foraging peoples undoubtedly had and have a better comprehension of their local natural environments. The complexity of indigenous systems of classification has been a striking feature of numerous anthropological works (Berlin 1992; Lévi-Strauss 1966). Human beings are capable of recognizing many different patterns in local flora and fauna, which emerge as a natural system (Berlin 1992; Carneiro 1978). As a primary component of understanding and interacting with the environment, it should not be surprising that the botanical knowledge of hunter-gatherer peoples is both remarkably sophisticated and numerous (Logan and Dixon 1994). The production of this information over time was likely due to both random and non-random processes. In terms of cultural selection, human interaction with the environment is shaped by our culture and its impact on our individual systems of learning. The interaction of plants and humans is never a blind, unguided, or completely random process outside of a chance discovery or accident; it is always mediated by culture. Cultural selection, in combination with genetics, has taught humans that specific indicators like smell, sight, feel and taste are powerfully informative in determining the usefulness of individual plant species. Through a series of complex chemical and biological adaptations, humans can make powerful inferences concerning the edibility of individual plants through taste and smell. Many plant species have chemical compounds that are critical for defense, but highly toxic. The advantages involved in the avoidance of toxic substances in food should be obvious (Johns 1990). Sometimes, however, cultural selection has provided us with opportunities that seem counterintuitive in terms of strict biological adaptation. Foragers may utilize a plant that is known to be bitter in taste, generally an indicator of toxicity, due to real or perceived medicinal benefits (Richerson and Boyd 2005). The medicinal properties of the plant may spread through a population, overriding all indications to avoid the bitter and potentially toxic plant. Through this sort of selection over time, human and plant interaction becomes nonrandom, as people strive to utilize distinct or unusual species of plants for a variety of functions. Through processes of cultural selection, human interaction with the environment becomes incredibly focused, at least among many hunter-gatherer groups (Logan and Dixon 1994). The relationship between plants and medicinal use outcomes will be explored further in later chapters.

Applying Cultural Selection to Eastern North America

This process of cultural selection can be applied to the indigenous plants utilized in Eastern North America. As noted earlier, the peoples in this region domesticated a group of native plants including squash (*Cucurbita pepo*), goosefoot (*Chenopodium berlandieri*), sumpweed (*Iva annua*) and sunflower (*Helianthus annuus*). While archaeologists have traditionally focused on the dates and process of domestication of these plants within Eastern North America, the rational for these changes have been unquestioned (Smith 1984, 1989, 2006; Smith and Cowan 1987; Gremillion 1993). The independent domestication of indigenous plants in Eastern North America is relatively unambiguous, but the cultural reasons for the initial use and eventual domestication of this group of plants continue to remain understudied. By the Late Archaic period, the generalized foraging pattern of populations in the east was successful enough to have promoted many features typically considered to be indicative of agricultural adoption, such as permanent settlements and complex systems social and economic interaction (Sassaman 2010). Given the success of this lifestyle, the need for intensification and plant domestication is not clear. Cultural selection demands an adaptive reason for the intensification of plant use in addition to the ecological relationships seen in Bruce Smith's floodplain weed theory (Smith et al. 1992). Agriculture is not an end in itself, but the result of a series of selective processes. If a selective advantage occurs, the spread of agriculture will also occur.

However, the use of plants is not limited to food, despite the necessity of eating. Other possibilities exist for the adaptive use of botanicals, with medicine, shelter, and clothing being most prominent. In terms of the weedy annuals of Eastern North America, our ability to evaluate these possibilities can be limited due to the restrictions of archaeological evidence. It is generally apparent that the archaeological remains of these species are due to human actions, not just a product of "seed rain" during or after site occupation (Minnis 1981). Seeds have been found in obvious storage situations within rock shelter sites such as those in the Ozarks, Kentucky and Alabama, which indicate a special relationship between floodplain plants and humans (Gremillion 1996). In terms of use, the most conclusive information can be found in the form of prehistoric fecal remains, which have been shown to include seeds from these plants. This evidence makes the human consumption of these plants indisputable (Faulkner 1991, Gremillion 1996). While it is generally assumed that these plants were utilized only for their nutritive properties as a food resource, the evidence does not rule out other unusual or distinct characteristics of plants that attracted the attention of local peoples who incorporated these species into their culture. This prospect will be examined regarding *Chenopodium berlandieri*, whose earlier description makes it seem like a rather curious candidate for domestication as a bountiful food resource.

Despite early problems with its biased application, contemporary theories of Darwinian cultural selection are apt to deal with the interface between humans and their environments. Culture represents a primary source guiding human action and behavior. By making the assumption that some information contained in culture is better in certain situations and environments, human cultural variation can be explained in terms of selection for general adaptability. In contrast to strictly ecological models, the process of cultural selection requires human action and motivation for change to occur. This recognition of human agency makes cultural selection a powerful tool in explaining the dramatic cultural changes surrounding plant domestication. This theoretical framework uses all the information seen in earlier ecological models, but aims to find the source for archaeologically documented changes. The next chapter will evaluate the three major possibilities for the use and adoption of *Chenopodium berlandieri* in this general adaptive context. Since archaeological evidence has primarily demonstrated *Chenopodium berlandieri* use in the diet, other potential uses of this plant need to be addressed. These pertain to its nutritive, medicinal and preservative properties. As will be shown, these are not necessarily mutually exclusive, but the objective is to show that selection will favor plants with a high degree of adaptive benefits.

CHAPTER SEVEN

THEORIES AND MODELS OF PLANT USE

Applying a Human Behavioral Ecology Model

The widespread archaeological evidence of its use and domestication shows that *Chenopodium berlandieri* and other indigenous weedy plants held considerable cultural value to the peoples of Eastern North America. In comparison to its relatives in the genus *Chenopodium* and *Amaranthus*, *Chenopodium berlandieri* does not appear to be of much intrinsic significance, unlike many other species within this genus. Little has been written in terms of its specific usefulness (Moerman 1998). For example, *Chenopodium quinoa* is a colorful pseudo-grain with an extensive range and history in South America (Hastorf 1990). Quinoa can even be found in many suburban supermarkets throughout the United States. *Chenopodium ambrosioides*, commonly known as Epazote, is a powerful emetic and antihelminthic found in the Southwest United States and Mexico (Logan et al. 2004). It also holds cultural value in Hispanic cuisine, particularly as a flavoring agent in cooked beans, making it a regular item for sale in ethnic markets. It would be unthinkable "to cook black beans without it" (Kennedy 1978:239). In comparison, *Chenopodium berlandieri* seems almost invisible outside of the disciplines of anthropology, botany, and agronomy. While this is partially a result of a recent Western bias against "weedy plants" that leads us to greatly underestimate the value of many plant species, it is also a function of our colonial disconnect with our local environment (Fritz 2007). This general bias and ignorance of indigenous crop complexes makes defining local agricultural development important. *Chenopodium berlandieri*, as one of the primary species among the weedy floodplain plants, is a perfect place to start reasserting and defining the cultural value of Eastern Woodland plant use. This chapter will examine *Chenopodium berlandieri* as it relates to consumption. As will become clear, the cultural value of the species within the Eastern Agricultural Complex is not straightforward like later additions to regional agriculture, such as maize and beans. *Chenopodium berlandieri* and its fellow indigenous plant species are special for what they are not.

The most common explanation for the use of any of the individual plants of the Eastern Agricultural Complex is also probably the most straightforward reason for their eventual domestication: nutrition. The use of plants as food is highly apparent even in our own society. In fact, a trip to the supermarket may be many peoples' primary mode of interaction with the botanical variety seen in the environment. Everyone understands that plants are mainly used for food, and there is a general assumption that acquiring food has always been a principal cultural focus. As such, food acquisition behavior has become a central point of study for ethnographers and archaeologists (Kelly 1995). Perhaps most importantly, for the sake of research and analysis, the collection and consumption of food resources can be strictly described and monitored on a variety of levels familiar to the modern nutritionist. This collected information, primarily in the form of numerical values, can be used as a basis for models of subsistence processes and changes that make understanding the complicated practice of foodways a relatively straight-forward examination of the adaptive benefits of human behavior within specific environmental contexts. These models are found within a theoretical framework known as human behavioral ecology, whose basic premise is that behavior will tend to optimize returns for labor invested. By examining the optimization strategies, models of human behavioral ecology can examine the efficiency of particular choices or actions within a variety of contexts. Behavioral ecology models can be used to describe much of human behavior, but its focus has been on the capture of food energy. By expressing the scientific rationality of specific behavioral choices, behavioral ecology attempts to show that transitions from hunting and gathering to agricultural intensification through plant domestication are logical (Winterhalder and Kennett 2006). However, as will be shown, the results of applying a human behavioral ecology model to the indigenous plants of the Eastern Woodlands indicates a number of problems for larger-scale ecological models of domestication such as the floodplain weed theory, even before one tries to account for cultural variability.

Optimal foraging models have been developed in human behavioral ecology that use economic principles to deconstruct the complexities of human action into costs and benefits based on different choices (Smith and Winterhalder 1992). Of the models within the spectrum of human behavioral ecology, the “diet breadth” model is the oldest and most commonly used (Winterhalder 1987). Diet breadth directly analyzes the energetic implications of food choices. It focuses on the decisions made when a certain food item is encountered, whether a plant or animal is pursued, or passed by in the expectation of a more valuable resource. The model maximizes the overall energetic efficiency in a hunter-gatherer’s environment. Food types are ranked according to return rates, or energy per unit time, which include the costs of searching for and handling of resources. Higher-ranked items should be consistently favored over lower-ranked, harder to find or harvest resources. The abundance of higher-ranked resources determines if lower-ranked resources will be used (Winterhalder and Goland 1997). It is unlikely that rabbit or squirrel will be the primary target of hunting, for example, if white-tailed deer are plentiful. The shift from the hunting focus of Paleoindians to the broad-based foraging subsistence found across the Eastern Woodlands has been explained in this context. When large game disappears, smaller game and nutrient-rich plant resources should be more heavily utilized. The floodplain weeds with their miniscule seeds could be difficult to harvest relative to other resources, particularly protein-rich mast resources. Their incorporation into the diets of local peoples would only make sense according to optimal foraging models if their profitability improved or other resources became scarce. Though profitability does generally increase as domestication occurs and use intensifies, within the environmental context of the Eastern oak-hickory woodlands, the use of *Chenopodium berlandieri* as a prominent food source is unlikely in relation to the other resources available to foragers, particularly before agricultural intensification in the broad-spectrum diet of Archaic foragers, though there is clear evidence of its use at sites such as Dust Cave, Alabama in the Paleoindian period (Hollenbach 2009).

The Costs of Harvest

The high costs of harvesting *Chenopodium* are evident when one considers the minute size of its oily seeds, which although occurring in vast numbers, their size would make collecting enough seeds for the daily or long-term subsistence needs of an individual or group challenging. As nutritionally rich as small grain plants like *Chenopodium berlandieri* are, the relative cost of procurement and processing in quantities sufficient for a meal was a limiting factor in their use (Gremillion 2004). In general terms of nutrients per weight, *Chenopodium berlandieri* is the least nutrient-efficient plant of those exploited by native peoples in Eastern North America. The energy return for one kilogram of *Chenopodium* is 2729 kcal, in comparison to 6570 kcal per kilogram of hickory and 5350 kcal of *Iva annua* (Gremillion 2004). When these energy returns are adjusted for the time and energy put into processing, wild *Chenopodium* is surprisingly no longer among the lowest return rates of Eastern small grain species. Wild *Chenopodium* has an estimated return rate of 433 kcal per hour of processing in comparison to the 272 kcal per hour for wild *Iva annua*. Despite some problems with the experimental data used for *Chenopodium*, notably that harvest-cost does not change with domestication, it is clear that none of the Eastern Agricultural Complex plants meet the predicted outcomes expected for a food staple. In many cases, they have return rates lower than mast resources. Hickory nuts have a return rate of about 2,000 kcal/kg (Gremillion 2004:222). Acorns nuts have a relatively high cost in processing, but still return 400 to 800 kcal per kilogram, with more efficient methods closer to 1,500 kcal per kilogram. Even acorns at a minimum of 400 kcal per kilogram are probably more efficient than the weedy floodplain annuals. For comparison, vertebrate resources such as white-tailed deer can yield in excess of 1,000 kcal per kilogram (Gremillion 2004). These experimental results from a human behavioral ecology model indicate that the indigenous plant taxa of Eastern North America are not efficient resources to exploit in terms of optimizing nutrients by effort. The numbers demonstrate that processing costs are the primary limiting factor for the use of plants and domestication has little impact on reducing overall handling costs. Adding in factors such as meal preparation and cooking would lower the return rates even further, as would documenting travel costs, which are much higher for most animal resources.

The experimental harvesting data provided by a human behavioral ecology model makes a floodplain weed theory model inconsistent with the archaeological data on plant utilization. The intensification of contact and use of these floodplain plants cannot explain why such inefficient resources would have been adopted and eventually domesticated in a broad-based foraging economy. In fact, such a model fails to account for the rich diversity of resources available to hunter-gatherers in the Eastern oak-hickory woodlands. The plant resources seen at higher elevations, such as acorns and hickory nuts, remind us that the environment of the Eastern United States is not limited to the immediate riparian ecosystems. As will be remembered, some of the earliest, most well preserved, and prominent botanical remains in Eastern North America come from rock shelter sites high above the natural river floodplain and terrace, such as Newt Kash and Hooten Hollow in Kentucky (Gremillion 1996). The space between river and mountaintop covers the breadth of the forests described by Braun (1950) and others. Local populations occupying a cross-section of this landscape would have access to the full spectrum of resources offered by the Mixed Mesophytic forest region. Intriguingly, though, optimization models centered on rock shelter sites also demonstrate that weeds like *Chenopodium berlandieri* were not economically viable unless grown locally. Hillside cultivation has emerged as an alternative model to the floodplain weed theory to explain the domestication of the indigenous weedy annuals, but it is apparent that on the hillsides of Eastern North America, *Chenopodium* was still largely irrelevant as a food source (Gremillion 2006). Rock shelter sites are even closer to resources like oak and hickory, as well as large animal species like elk, white-tailed deer, and turkey. Mast foods ripen in the same autumn period as *Chenopodium* seeds, practically assuring that local peoples would be in the woodlands gathering nuts, instead of harvesting floodplain plants. Clearly, there was little space for grasses and weedy seeds in a diet and lifestyle that included rich riparian resources like shellfish and hillside foods like mast, even if it is subject to a degree of annual variability.

Alternative Prescriptions of Use

The cooperative efforts required to gather these largely seasonal products was a primary factor that gradually resulted the increased sedentism seen in the Late Archaic period. This sedentism and the increased competition associated with population growth would have eventually required some people to rely on indigenous grain crops as valuable wild, local resources were depleted and claimed (Moore and Delke 2010). That indigenous species became highly prominent as social relationships intensified is quite clear in terms of the archaeological record, but it does not explain the early use and appearance of plants like *Chenopodium berlandieri*. The relatively small quantities of indigenous crops found at early foraging sites likely means that they were supplemental in strict dietary terms. This suggests indigenous plants were used often for their edible leafy greens, which would make a meal more substantial due to their fiber content. They could be added to meals as potherbs for flavoring. Some of these plants could have been utilized for medicinal purposes (Scarry 2003).

Of the 28,014 taxa included within the North American flora, roughly 10 percent are "weeds" (Kartesz and Meachem 1999). Within this group, approximately 26 percent are used for medicinal purposes. Similarly, weeds compose about 23 percent of the medicinal plant taxa of North America. In comparison, only 8 percent of the medicinal plants are derived from nonweedy taxa (Stepp and Moerman 2001). Clearly there is a preference for weedy plants for medicinal applications, at least within the indigenous populations in North America. The apparent question here is why are weeds utilized so heavily as medicines. Strangely enough, the same characteristics that make these plant species the scourge of contemporary gardeners makes them a great source of medicine. First, weedy plants are abundant. Species like *Chenopodium* *berlandieri* can grow in the most desolate of environments and thrive due to their evolved preferences for dry, saline and disturbed settings. This abundance means that it will not be difficult for local peoples to find and utilize these plants for medicine. When treating sickness, proximity of medicinal agents is highly preferable. Secondly, weedy plant species thrive in the same environments that forager populations exploit. As has been shown, these weedy plants love disturbed, anthropogenic environments (Anderson 1952, 1956). Medicinal plants appear to be collected more often from habitats of disturbance than virgin forest or grasslands. Among some Mesoamerican groups, almost 80 percent of medicinal plants come from non-forested disturbed environments (Frei et al. 2000). These locales coincide with those preferred for human habitation. Traditional foraging groups typically do not live in the primary forest, but on its edges in cleared or riparian environments (Stepp and Moerman 2001). These are the same patterns seen with hunting and gathering populations within Eastern North America and are integral to Bruce Smith's floodplain weed theory. However, it is the appearance of biochemically active compounds in weeds that makes them so important for indigenous medicine.

Recent evidence suggests that weeds often contain relatively high amounts of biologically active secondary chemical compounds in their leaves and stems that have medicinal value. Secondary compounds in plants exist because they have vital ecological functions. These allelochemicals function primarily to inhibit the growth of nearby plants and to prevent predation by insects, mammals or microorganisms (Johns 1990). In the realm of anti-herbivory chemical defenses, mobile or quantitative defenses have provided the chemical compounds most associated with medicine. These toxic chemical compounds typically include alkaloids, cardiac glycosides, or terpenoids. Weedy annual plants are twice as likely to have alkaloids as a defense as perennial species (Stepp 2004). Plants that have a high turnover of parts, like leaves, are likely to possess these chemicals because the chemicals need to be constantly synthesized (Coley 1988). There is also evidence that environmental stressors, such as riparian disturbance, are likely to increase allelochemical production in weeds (Putnam 1985). Thus, within this context, it should not be surprising that the largest weed families are those that are important for medicinal plants. Chenopodiaceae, Asteraceae, Fabaceae, and Solanaceae are among these families. This family list includes all of the major Eastern Agricultural Complex plants (Holm 1978). The family of Poaceae (grasses), while known for its weediness, is more reliant on physical defenses, such as silica, than chemical ones. While the evidence for an original use of these plants as medicinals is at best circumstantial, the importance of weedy plant families in ethnomedical practice cannot be understated. The antibacterial properties of *Chenopodium ambrosiodes* are just one example of a list of uses described in Chapter 8 (Moerman 1998).

The use of the plants within the Eastern Agricultural Complex does not appear to be reliably explained by optimization models of human behavior and subsistence. The expectations of human behavioral ecology and diet breadth models do not favor a mode of subsistence based heavily on these plants. The harvest and processing costs of indigenous grains and oil seeds are higher than other resources available to populations living in the woodlands of Eastern North America. The mast resources of hickory, oak, and chestnut have much higher return rates than the weedy annuals. The autumn nature of this resource, coupled with other higher altitude seasonal foods, such as white-tailed deer and turkey, make floodplain plant harvesting for subsistence impractical. A hillside cultivation model for indigenous plant use of weedy annuals skirts the issue of transport costs since these weedy annuals appear naturally in riverine environments. Moreover, due to the availability of other wild resources, it seems that horticulture played only a small role in the diet of Archaic and Woodland period cultures. In light of this generally supplemental use, a medicinal model for plant use makes sense. Weeds, such as those of the Eastern Agricultural Complex, form a prominent source of medicinal plants. The prevalence of weeds in medicine is likely due to their environmental preferences and proximity to human groups. The short and difficult life of annual weedy species has also led them to have a high degree of bioactive compounds for defense. These same compounds form the base of many traditional medicines and modern-day pharmaceuticals. A medicinal explanation of plant interaction seems to fit the historical circumstances of Eastern North America well. The next chapter will explore the possibilities of a medicinal model for initial plant use and domestication through the continued analysis of *Chenopodium berlandieri*. A medicinal model fits all of the existing evidence of domestication, especially from a perspective of cultural selection, even though some of it seems contradictory at first glance.

CHAPTER EIGHT

TOWARDS A CULTURAL MODEL OF PLANT DOMESTICATION

Shifting Perspectives of Plant Use

While the predominant ecological model for plant domestication in Eastern North America meets all of the available archaeological evidence, the floodplain weed theory and its correlates are lacking in their explanatory power. After examining the experimental data related to the costs of subsistence, the idea that the relationships between plant and human populations were primarily one of subsistence is a hard sell. The major theoretical model for examining subsistence choices among hunter-gatherers - diet breadth - shows that it is unlikely that the early use of the plants of the Eastern Agricultural Complex was solely for food. The return rates for *Chenopodium berlandieri* and other weedy floodplain species are too low compared to other available options, namely mast resources, to be considered a rational choice in many circumstances. The lack of firm support for a subsistence basis for weedy plant use indicates that alternative reasons guiding the initial use of these species are more tenable. An examination of ethnographic and ethnopharmacological data supports a medicinal use pattern for at least some of the American domesticates. The weedy annuals of Eastern North America are remarkably similar in environmental terms to other species used for medicinal purposes found elsewhere in the Americas (Stepp and Moerman 2001). Weedy plants' preference for disturbed environments, their proximity to human populations, and the likelihood that they possess biochemical defenses make them prime candidates for medicinal use by local human populations in the past. This chapter will examine the possibility that the original use of plants within the Eastern Agricultural Complex arose due to their medicinal value. This chapter will also explore the shift from a medicinal use pattern to a later pattern of intensive agricultural use. Cultural selection theory will be revisited and adapted to describe the domestication of *Chenopodium berlandieri*.

So far, the examination of agricultural origins has only been peripherally linked to *Chenopodium berlandieri*. As a member of the Eastern Agricultural Complex, this plant exhibits evidence of domestication through its distinct morphological changes and archaeological visibility. However, like many other species, the reasons for its use have never been questioned. Nonetheless, *Chenopodium berlandieri* may have held considerable values as a medicinal agent. As noted above, the evidence in favor of its use as a primary item of subsistence among hunter-gatherers is problematic when judged from the perspective of efficiency. Yet at some point within the history of interaction between humans and *Chenopodium berlandieri*, there was a definite shift in how this species was utilized. It went from an occasional member of archaeological samples to a full-fledged seed crop found in almost every archaeological context (Smith 1989). The change from hunting and gathering to agriculture does not represent a change in social complexity; the size and developing social relationships present in the Archaic period demonstrate this (Rowley-Conwy 2001; Sassaman 2010). It does, nonetheless, represent a fundamental shift in the way local populations approach and view the natural world. It has already been argued that the shift from Paleoindian hunting to a broad-based subsistence pattern in the Archaic was a consequence of a series of environmental changes related to climate that favored the development of new forms of plant utilization among foragers. The shift to horticulture and later agriculture represented the escalating importance of plants to Late Archaic peoples (Moore and Delke 2010). That a circumscribed group of indigenous plant species came to dominate subsistence shows the intensity of the relationship between plants and human populations. While the exact details of this cultural shift of plant use may never be fully known, the case of *Chenopodium berlandieri* provides one intriguing possibility for understanding the process of domestication.

Current theories of *Chenopodium*'s relationship to domestication are related to subsistence and are indicative of such a change in cultural perspective. The first evidence for the use of *Chenopodium berlandieri* in wild forms comes from around 12,500 B.P., and is rather sparse (Hollenbach 2009). Archaeologists account for this scarcity by arguing that early *Chenopodium* use was primarily for its leaves. Notably, leaf utilization circumvents the problems associated with seed procurement. In this context, the archaeological presence of seeds would be expected. Evidence of leaves would not survive, however. The plentiful greens of *Chenopodium berlandieri* could have been eaten raw or cooked with other foods as potherbs (Scarry 2003). Yarnell and Black (1985) have argued that the later use of *Chenopodium berlandieri* for its grain may actually have emerged out of the earlier use of its leaves. By the end of the Archaic, *Chenopodium berlandieri* shows all of the morphological changes associated with domestication by 3,500 B.P. (Smith 2006). The chronological data suggests that at some point in the Middle Archaic, the grains of *Chenopodium berlandieri* became increasingly important. The consumption of leaves most likely continued as well. As will be remembered, it was during this same period that a number of changes were occurring in the cultures of Eastern North America. Though a foraging mode of subsistence was still prominent, it was becoming intensified in relation to shellfish and mast resources. Competition for these seasonally and regionally diverse foods increased as demographic processes such as population growth made foraging across large territories increasingly difficult. The interrelationships between local groups also became complicated during this period, as specialization and trade resulted from the emerging necessity of resource territoriality. At some point during this period of immense cultural change, the use of *Chenopodium berlandieri* increased dramatically (Fritz 1990). The increasing amounts of seed found in archaeological contexts corroborate this pattern, especially in the form of large storage pits and supply caches. The utilization of *Chenopodium berlandieri* for subsistence peaked in the Woodland period between 250 B.C. and A.D. 800, as it became a central part of the productive food economies in Eastern North America (Smith 1989). Its use had come full circle as the supplemental use of leaves appears to have been largely overshadowed in relation to the use of seeds as a primary form of subsistence.

This change in the use of *Chenopodium berlandieri* was widespread, indicating that once the cultural shift in use patterns occurred, it likely spread quickly across Eastern North America. As the floodplain weed theory makes clear, the proximity of human settlement to the natural environment of *Chenopodium* made its adoption relatively straightforward. Additionally, since its leaves were already in some degree of use in the broad-based foraging subsistence mode found across Eastern North America, populations would be familiar with the edibility of its seeds. Since this pattern of subsistence persisted for well over 5,000 years in the East before agriculture emerged, *Chenopodium berlandieri*'s use as a leafy green must have been particularly salient. The value of *Chenopodium berlandieri*'s leafy greens must have been such that it promoted this particular variation of subsistence behavior among the cultures of Eastern North America. Though this may just have been related to processing costs, this is unlikely to be the only reason for favoring leaf use over the seeds. Intriguingly, though, the leaves of weeds are a primary location for the synthesis of defensive bioactive compounds associated with medicinal plant use. The use of the leaves of *Chenopodium berlandieri* may have held additional benefits for foraging peoples that promoted their use within their cultural systems. Such medicinal applications would have been powerfully adaptive and could explain the prevalence of the species throughout Eastern subsistence. For many plants, the potential medicinal functions are well-documented within the literature; however, *Chenopodium berlandieri* is not one of these plant species (Moerman 1998). The populations concerned also left no written record of use and even the information known from European colonization is limited. This means that determining any medicinal benefits of *Chenopodium berlandieri* is complicated. Even though the medicinal potential of weedy plants is recognized, the scholarly bias against weedy species is apparent (Fritz 2007). Despite the lack of specific evidence of medicinal use, closely related species of *Chenopodium* can provide interesting correlates for use of *Chenopodium berlandieri* leaves until additional chemical analyses are done.

The Medicinal Possibilities of *Chenopodium berlandieri*

Chenopodium berlandieri is a favorable candidate for medicinal plant use in part due to its well-known relatives. As Chapter 4 indicated, *Chenopodium* is related to a number of prominent agricultural crops, such as beets, quinoa, and spinach. However, other members of the genus have unusual properties that have lead to their cultural importance. These unique characteristics include medicinally beneficial chemical compounds. In botanical terms, these properties are in part advertised by the bitter smell and taste of many *Chenopodium* species, especially their leaves (Moerman 1998). This bitter taste, found in a small degree with *Chenopodium berlandieri*, is a known indicator of the defensive bioactive chemicals associated with medicinal plant use (Johns 1990). Although the chemicals responsible for this taste in *Chenopodium berlandieri* have not been investigated, one of its most intensely smelling relatives is a recognized medicinal plant species. This relative is a Mesoamerican domesticate called *Chenopodium ambrosioides*, also known as epazote. Epazote has a relatively important role in Mexican cuisine and is a well-documented antihelminthic plant in addition to being a supplement to subsistence. It's leaves and stems are typically consumed raw, cooked together with food or in a type of infused tea (Logan et al. 2004). Investigations by Reinhard et al. (1985) and others have demonstrated that prehistoric populations that consumed a high proportion of *Chenopodium ambrosioides* in their diets were substantially less affected by endoparisites. Berlin et al. (1996) demonstrated that it is the remedy of choice for the treatment of intesetinal worms among the Highland Maya of Chiapas, Mexico. In addition to its vermifugal properties, *Chenopodium ambrosioides* is used to alleviate gastrointestinal ailments, headaches and fevers (Bye 1986). The leaves of *Chenopodium ambrosioides* are the location of bioactive compounds and have the highest levels of the phytochemical ascaridole, a known antihelminthic and vermifugal agent. Many other species of *Chenopodium*, including *Chenopodium album* and the South American species *Chenopodium quinoa*, have shown similar medicinal properties (Duke 1998; Moerman 1998). Surprisingly, *Chenopodium berlandieri* seeds have been found in correlation with endoparasites in some archaeological samples of ancient feces (Faulkner 1991). This may indicate that *Chenopodium berlandieri* consumption was linked to a common medical ailment of hunter-gatherer populations, that of intestinal parasites (Armelagos 1990).

In addition to being a vermifuge, recent research on *Chenopodium ambroisiodes* has suggested that the plant has value as an antibacterial agent when it is incorporated in the cooking process as a flavoring additive. Research has shown that beans cooked with the plant's stems and leaves typically remain edible longer than those cooked without them. Logan et al. (2004) prepared black beans with and without epazote (one tablespoon of epazote for every half cup of dry beans) and found dramatic results regarding bacterial counts over time. After sitting for forty-two hours, the sample without epazote contained around 800 colony-forming units of bacteria per ml. Notably, however, the sample cooked with epazote had no bacteria. Following another thirty hours, the sample without epazote contained more than 160 million colony-forming units to the epazote batch's 11,000. In other words, cooked beans, when prepared with epazote, remained edible for a longer period of time than similar dishes made without this *Chenopodium ambrosiodes*. The antibacterial action of epazote was found through further testing to reside within two component phytochemical compounds, geraniol and safrole. These experimental data have also shown that *Chenopodium berlandieri* may also inhibit spoilage due to bacteria, although the specific chemical compounds have not yet been determined (Logan et al. 2004). After discovering any one of these potential properties, local populations would have certainly made *Chenopodium* part of their cultural repertoire of medicinally valuable plants. Its local prominence and availability certainly would have aided this process. A medicinal use with obvious benefits would have quickly been included into the cultural knowledge of native peoples. The lack of archaeological evidence of *Chenopodium* use outside of seeds makes such a determination complex. Tests of *Chenopodium berlandieri* for secondary bioactive chemical compounds would be highly informative in validating one of these potential medicinal use patterns and explaining its initial adoption by populations in North America.

Selection and Transmission of Plant Knowledge

Confirming the possible use of *Chenopodium berlandieri* as a medicinal or preservative agent would add significantly to current theories regarding its use in aboriginal populations. Archaic period hunter-gatherers in Eastern North America would have been familiar with chenopods, which are found worldwide. Moreover, many of the individual species within this genus closely resemble each other morphologically (Reaume 2009). These band-level societies certainly had already developed the cultural information required to indentify unusual and potentially useful plants based on a number of sensory characteristics (Johns 1990). Weeds, due to their proximity to human populations, would have been an early candidate for uses other than subsistence (Stepp and Moerman 2001). Given *Chenopodium*'s unique smell, taste and texture, it most likely stood out among other wild plant species (Johns 1990), particularly those included in the Eastern Agricultural Complex. These characteristics are highly suggestive of a use pattern centering on leaves and stems as part of a cultural complex of medicinal remedies and cooking. Unfortunately determining these types of uses for *Chenopodium* would be difficult to reconcile archaeologically since leaves do not preserve. However, in fitting the pattern of other medicinal weedy plant species used by foragers, *Chenopodium berlandieri* would be an easy plant to find and gather, given its preference for disturbed and anthropogenic environments. The cultural information on *Chenopodium berlandieri*'s potential medicinal use would quickly pass throughout the Eastern United States after its discovery because this information is highly adaptive in terms of cultural selection. If eating *Chenopodium* leaves eliminated or reduced intestinal parasites or prevented the spoilage of a meal when added to other foods, these qualities would have selective benefits. The real or perceived efficacy of *Chenopodium berlandieri* in this role would assure a relatively high frequency of its knowledge and use, especially considering its availability across the variety of Eastern North American environments. Since the cultural pattern of leaf use, despite being widespread, was not directly reliant on gathering the seeds of *Chenopodium berlandieri*, selective changes representative of domestication would not be apparent. Thus, no morphological changes in seed size or seed coat thickness would be seen. Since leaves could easily be gathered and stored for extended periods of time in dry forms at peak chemical levels around the time of seeding, processing costs would be minimal. The gathering of leaves could be accomplished with other trips to riparian environments to gather shellfish and other aquatic resources. The sparse evidence of carbonized *Chenopodium berlandieri* seeds found early in the archaeological record could be explained through hanging and drying whole plants above fires in rock shelters and homes. Leaves would only be needed in specific situations where the culturally perceived medicinal or flavoring properties were deemed useful. Human and plant interaction would be culturally specialized. It seems likely, then, that *Chenopodium berlandieri* maintained a relatively stable and moderate use pattern for a long period of time before its use in agriculture.

That this stability ends in the Middle or Late Archaic (5000-2000 B.C.) with a shift towards heavy use and domestication suggests a change in the cultural perceptions regarding *Chenopodium berlandieri* (Smith 1989). This shift from leaf use to agricultural levels of seed use is visible in the amount of seeds found in the archaeological record of the Eastern United States. Clearly, the cultural understanding of *Chenopodium berlandieri* changed dramatically at some point in the Middle Archaic. This change corresponds with a number of other cultural changes within the region during the Archaic period including the increased contact and exchange between local populations. By the Late Archaic, the paramount settlements and activities focused on the river valleys of the Eastern United States (Sassaman 2010). In contrast to the mobility of earlier hunter-gatherer groups, these settlements were occupied on a long-term basis (Smith 1989). It was under these circumstances that local peoples came into sustained contact with the plants of the Eastern Agricultural Complex (Munson 1984). At this point in time, the cultural relationship between people and plants changed. Constant contact and the need for additional, stable food resources available year round increased the attractiveness of the floodplain plants for regular consumption as the variability of traditional resources like hickory and acorn increased. With such long-term interaction, *Chenopodium berlandieri* was always understood to be edible, but until this point it was hardly worth the effort of harvesting its minute seeds except in times of shortage or famine. Although *Chenopodium berlandieri* may have become a prominent source of subsistence in this new economy, it never would have lost its original role as a medicine. *Chenopodium berlandieri* would easily have served dual roles. Medicinal plants hold powerful roles in the lives of people that would not be easily abandoned. This use could be continued despite large scale changes to the subsistence economy, such as those seen in the Woodland and Mississippian periods with indigenous domesticates and maize, respectively (Etkin 2006). The existing cultural importance of *Chenopodium berlandieri* as a medicinal plant may have made it a highly desirable species to grow in house gardens in these nascent settled communities. In a medicinal role, the wild type may have been viewed as more powerful than a domesticated version, evidenced by domestication's gradual weakening of toxic compounds in plants (Johns 1990). The alternating importance of specific uses may be seen in the period of time where *Chenopodium berlandieri*, though cultivated, still interbred with local wild plants, producing a range of morphological variation in its seeds. This may also explain the slow and late domestication of *Chenopodium berlandieri* relative to other Eastern Agricultural Complex plants (Smith 2006). During and after domestication, the cultural view of *Chenopodium berlandieri* focused on its subsistence value, while its role as a medicinally valuable species, while essential, was overshadowed in terms of production. The intentionality of humans is important in distinguishing between wild plants and domesticates (Heiser 1988). In the case of *Chenopodium berlandieri*, this intentionality changed as a result of a cultural shift due to changes in the use of the species. In terms of cultural selection, the productive role of *Chenopodium berlandieri* became increasingly important to local groups. *Chenopodium berlandieri* maintained its cultural value to populations in Eastern North America throughout these changes, by means of cultural selection for a different use pattern, further solidifying its relative cultural and economic significance.

Although *Chenopodium berlandieri* and the other plants within the Eastern Agricultural Complex formed a central part of indigenous subsistence, there is little doubt that *Chenopodium berlandieri*'s original use evolved out of some earlier supplemental relationship with local human populations. While the example of *Chenopodium berlandieri* is used to demonstrate the possibilities inherent in a medicinal model of human-plant interaction resulting in later domestication, it is likely that the other indigenous weedy plants of the Eastern Agricultural Complex had some other roles outside of subsistence. They share with *Chenopodium berlandieri* the problems of their low return rates and high processing costs compared to other nutritional options. The possibility of alternative plant uses reveals how little is known about the original motivations lying behind the adoption and use of *Chenopodium berlandieri* and a wealth of other species. Subsistence explanations are popular, but they frequently ignore the unique qualities of the plants themselves. Given the inefficiency of using its seeds, it seems likely that *Chenopodium berlandieri* was originally adopted for its leaves. Looking to *Chenopodium berlandieri*'s close relatives provides an interesting variety of medicinal reasons for its initial use. Cultural selection theories support a strong adaptive use as the originator of human and plant interaction. When the needs of these peoples shifted, their cultural perceptions changed as well. The example of *Chenopodium berlandieri* demonstrates that culture is a critical aspect to include when trying to determine the nature of large-scale changes like agriculture. Plant domestication does not necessarily represent a natural continuation of the cultural information and behavior of hunter-gatherers. The domestication of plants requires that the cultural understanding of those same plants be altered prior to a dramatic shift in use patterns. Only by understanding these types of interactions related to plant use can inquiries be made into the causes of dramatic shifts like that of the development of agriculture in Eastern North America.

CHAPTER NINE

SUMMARY AND CONCLUSIONS

Overview of Salient Points

The domestication of plants and animals represents one of the most significant changes in human history. The shift from foraging to large-scale agriculture has had lasting impacts on human health and cultural development (Cohen and Armelagos 1984). Agriculture has become associated with the development of urban centers and the social hallmarks we consider to be civilization. Despite this predominant view of agricultural intensification, the reality of early human relationships with the environment reveals a more complicated picture. Agriculture was not so much the result of progress, but a process of the reorientation of human knowledge, experience and behaviors within specific environments. Eastern North America provides a specific instance of the complexity related to understanding the development of agriculture. Though much knowledge has been gained since the earliest investigations into agricultural origins, it is clear that there is more to learn and resolve with regards to the particular plants, like *Chenopodium berlandieri*, and the environments where domestication occurred worldwide. The foundations for agricultural innovation were laid by foraging peoples whose behavior was not guided by end goals or enlightenment, but the mundane daily interactions with their local environments governed by the necessities of life. Our understanding of plant domestication has been clouded by not fully understanding the environmental context of human-plant interactions. This has been especially true for native North America.

Although American anthropologists eventually debunked the notion that North America was not a center of agricultural origins, a bias exists against the agricultural plants of North America compared to Mesoamerica or the Near East. This can be seen in the relative prominence of significant archaeological finds by Richard MacNeish at Coxcatlán (Cowan and Watson 1992) and Kent Flannery (1973) in Oaxaca. All but the most ardent American archaeologists overlooked similar and equally impressive finds from North America. New methodological techniques, like scanning electron microscopy and accelerator mass spectrometry validated early theories for plant domestication involving indigenous weedy species by documenting morphological changes that could only be associated with domestication.

This represented a landmark moment for American archaeology, particularly in terms of validating the cultural ingenuity and complexity of the prehistoric populations of Eastern North America. The prevailing models for domestication focused on the ecological zone or intersection between forests and rivers of the region. Though the complexity of these theories increased through time, Edgar Anderson's (1952) original "dump heap" theory of development proved to be an accurate assessment of the nature of interaction between the weedy indigenous species of the Eastern Agricultural Complex and local human populations. While human ecological theories of plant domestication accurately follow the available archaeological and environmental evidence, they lack specific explanatory power in terms of evaluating the culture value of using specific plant species. To fill this gap, a model of cultural selection is appropriate in its adaptive explanation of cultural behavior and the spread of important information. It is clear, however, that the human motivation lying behind plant domestication needs to be explained. Although archaeological evidence of plant use is restricted mostly to subsistence and consumption, this does not mean alternative uses for indigenous plant species were not possible.

In fact, a purely subsistence-oriented model fails to make much sense in terms of the efficiency of procurement of plant resources. Human behavioral ecology models have long been used to evaluate the rationality of specific behaviors related to human dietary choice. The diet breadth model assumes that humans will make decisions based on the quality and amount of resources to be gained from their actions. Some resources will always be chosen over others if available. The weedy annuals of the Eastern Woodlands would be far from an optimal choice. As the example of *Chenopodium berlandieri* has shown, the costs of processing would be excessive in comparison to returns. Additionally, other available food products, such as mast and faunal resources, would be highly preferred if present. In light of this evidence, other reasons for the use of the plants should be investigated. An alternative explanation for the use of the weedy plants of Eastern North America can be found in terms of their possible medicinal applications. Weedy plants are proportionally favored sources of medicine in the ethnographic record for North American peoples. The prevalence of weedy medicinal plants can be directly linked to their biology. Weedy annuals are more likely to develop defensive compounds in the form of bioactive chemicals. Weeds also favor disturbed environments that arise due to human activities.

Areas for Future Research

The utility of a medicinal model is readily apparent with respect to *Chenopodium berlandieri*. As noted earlier, long-term use of this plant makes little sense when judged in strict terms of subsistence. The similarities between *Chenopodium berlandieri* and its medicinally useful relatives should not be ignored. The most prominent of these, *Chenopodium ambrosioides*, is a widely known vermifuge and a potential food preservative. Its leaves have a pungent smell and bitter taste; traits humans have long associated with medicine. *Chenopodium* *berlandieri* also shares some of these qualities, thus making its potential medicinal value a real possibility. Early foraging peoples in Eastern North America most likely originally saw value in its leaves, not its seeds. This perspective avoids the problems associated with the inefficiency of harvesting and processing the plant's tiny seeds. The use of leaves would correspond with the relative scarcity of Early Archaic archaeological examples of *Chenopodium* use, as well as its late domestication relative to other indigenous plants. While powerfully adaptive, its use as a medicine would have been overshadowed by social developments occurring at the same time as the increase in the use of *Chenopodium berlandieri* for its starchy seeds. Such a "dual use" model for weedy plant use in Eastern North America has considerable explanatory potential, yet it remains to be explored in much greater detail than what was possible here.

Although a great deal of progress has been made in understanding the nature of plant domestication and agricultural origins in Eastern North America, the complexity of the process remains evident in what is still left to decipher. The history of the study of agriculture in North America demonstrates that by ignoring specific parts of the larger picture, important details are glossed over. This remains the case with the assumption that the indigenous crops of Eastern North America were all originally and only used in terms of subsistence. Not only does such a model ignore the complexities of human-plant interaction, it also restricts our understanding of other cultural roles held by plant species seen within the archaeological record. It may be impossible to fully understand the cultural perspectives from which local populations understood their botanical neighbors, but this should not preclude investigations. As a member of the Eastern Agricultural Complex, *Chenopodium berlandieri* is a prime candidate for additional research. Its chemical constituents and possible medicinal properties have only been briefly examined in the anthropological and botanical literature. In terms of medicinal use, the species has been absent from most seminal ethnobotanical volumes and phytochemical databases (Duke 1998; Moerman 1998). Tests for and analyses of bioactive chemical compounds would likely resolve questions about the use of *Chenopodium berlandieri* by forager groups in Eastern North America, but they have not yet been done. In-depth tests should be done for all of the weedy plants of the Eastern Agricultural Complex, particularly those that have been undervalued and understudied. Although the literature surrounding these plants is relatively clear from an archaeological standpoint, alternative reasons for their use and adoption should be explored. Once the biochemical structure of these plants is understood, the cooking context could be examined for these compounds in the form of potsherd and cooking tool residues. The medicinal use may be evident in the concentration of these compounds. A chemical signature may even be detectible through the analysis of human bones, which could demonstrate some threshold of use intensity, if not entirely determining *Chenopodium berlandieri*'s specific use as a potherb or medicine. It is only by examining all the practical applications of these plants that we can begin to understand their long-term and complicated interaction with humans. The weedy floodplain plants of the Eastern Agricultural Complex are the only living legacy to the processes that led to agricultural development within the rivers and woodlands of Eastern North America.

LIST OF REFERENCES

Aellen, Paul, and Theodor Just
1943 Key and Synopsis of the American Species of the Genus *Chenopodium* L. American Midland Naturalist. 30:47-67.

Anderson, Edgar
1952 Plants, Man and Life. Boston: Little Brown and Co.

1956 Man as a Maker of New Plants and New Plant Communities. *In* Man's Role in Changing the Face of the Earth. William L. Thomas, Jr., ed. Pp.763-777. Chicago: University of Chicago Press.

Armelagos, George J.
1990 Health and Disease in Prehistoric Populations in Transition. *In* Disease in Populations in Transition: Anthropological and Epidemiological Perspective. Alan C. Swedlund and George J. Armelagos, eds. Pp. 127-44. South Hadley: Bergin and Garvey.

Asch, David L., and Nancy B. Asch
1977 Chenopod as Cultigen: A Reevaluation of Some Prehistoric Collections from Eastern North America. Midcontinental Journal of Archaeology 2:3-45.

1985 Prehistoric Plant Cultivation in West-Central Illinois. *In* Prehistoric Food Production in North America. Richard I. Ford, ed. Pp. 149-203. Anthropological Papers No. 75. Museum of Anthropology, University of Michigan, Ann Arbor.

Barnard, Alan
1999 Images of Hunters and Gatherers in European Social Thought. *In* The Cambridge Encyclopedia of Hunters and Gatherers. Richard B. Lee and R. Daly, eds. Pp. 375-383. Cambridge: Cambridge University Press.

Begon, Michael, Colin R. Townsend and John L. Harper
2006 Ecology: From Individuals to Ecosystems. Oxford: Blackwell Publishing.

Benke, Arthur C. and Colbert E. Cushing
2005 Background and Approach. *In* Rivers of North America. Arthur C. Benke and Colbert E. Cushing, eds. Pp. 1-18. Boston: Elsevier Academic Press.

Berlin, Brent
1992 Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies. Princeton: Princeton University Press.

Berlin, Brent, D.E. Breedlove, X. Lozoya, M. Meckes, M.L. Villarreal, and J. Tortoriello
1996 Medical Ethnobotany of Principal Species Used to Treat Regular Worms. *In* Medical Ethnobotany of the Highland Maya of Chiapas, Mexico. E.A. Berlin and B. Berlin, eds. Pp. 413-17. Princeton: Princeton University Press.

Berry, Wendell
1990 What are People For? New York: North Point.

Binford, Lewis R.
1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. American Antiquity 45(1):4-20.

Braun, E. Lucy
1950 Deciduous Forests of Eastern North America. New York: Hafner Press.

Bye, Robert A., Jr.
1986 Medicinal Plants of the Sierra Madre: Comparative Study of Tarahumara and Mexican Market Plants. Economic Botany 40(1):103-124.

Caldwell, J. R.
1958. Trend and Tradition in the Prehistory of the Eastern United States. Springfield, IL: American Anthropological Association Memoir 88.

Carmody, Stephen B.
2009. Hunter/gatherer foraging adaptations during the Middle Archaic Period at Dust Cave, Alabama. MA thesis, Department of Anthropology, University of Tennessee, Knoxville.

Carneiro, Robert L.
1978 The Knowledge and Use of Rain Forest Trees by the Kuikuru Indians of Central Brazil. *In* The Nature and Status of Ethnobotany. Richard. I Ford, ed. Pp.201-216. Anthropological Papers No. 67. Museum of Anthropology, University of Michigan, Ann Arbor.

Childe, V. Gordon
1936 Man Makes Himself. London: Watts.

1952 New Light on the Most Ancient East. 4th ed. London: Routledge and Kegan Paul.

Chomko, Stephen A. and Gary W. Crawford
1978 Plant Husbandry in Prehistoric Eastern North America: New Evidence for Its Development. American Antiquity 43(3):405-8.

Christensen, Norman L.
2000 Vegetation of the Southeastern Coastal Plain. *In* North American Terrestrial Vegetation. Michael G. Barbour and William D. Billings, eds. Pp. 397-448. New York: Cambridge University Press.

Claassen, Cheryl
1996. A Consideration of the Social Organization of the Shell Mound Archaic. *In* Archaeology of the Mid-Holocene Southeast. K. E. Sassaman and D. G. Anderson, eds. Pp. 235-58. Gainesville: University Press of Florida.

Clemants, Steven E. and Sergei L. Mosyakin
2003. Chenopodium. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=106630, accessed March 12, 2011.

Coe, Michael D.
2005 The Maya. New York: Thames and Hudson.

Coe, Michael D. and Rex Koontz
2008 Mexico: From the Olmecs to the Aztecs. New York: Thames and Hudson.

Cohen, Mark N. and George J. Armelagos, eds.
1984 Paleopathology at the Origins of Agriculture. Orlando: Academic Press.

Coley, P.D.
1988 Effects of Plant Growth Rate and Leaf Lifetime on the Amount and Type of Anti-herbivore Defense. Oecologia 74:531-6.

Cowan, C. Wesley
1985 Understanding the Evolution of Plant Husbandry in Eastern North America: Lessons from Botany, Ethnography and Archaeology. *In* Prehistoric Food Production in North America. Richard I. Ford, ed. Pp. 205-243. Ann Arbor: Museum of Anthropology, University of Michigan.

Cowan, C. Wesley and Patty Jo Watson
1992 Introduction. *In* The Origins of Agriculture: An International Pespective. C. Wesley Cowan, Patty Jo Watson and Nancy L. Benco, eds. Pp. 1-6. Tuscaloosa: University of Alabama Press.

Crawford, Gary W.
2005 Plant Remains from Carlston Annis (1972, 1974), Bowles, and Peter Cave. *In* Archaeology of the Middle Green River Region, Kentucky. W. H. Marquardt and P. J. Watson, eds. Gainesville: Florida Museum of Natural History Institute of Archaeology and Paleoenvironmental Studies Monograph 5.

Darwin, Charles
1868 The Variation of Animals and Plants Under Domestication. Vol. 1. London: J. Murray.

De Candolle, Alphonse
1885 Geógraphie Botanique Raisonnée. V.Masson: Paris.

De Wet, J. M. J. and J.R. Harlan
1975 Weeds and Domesticates: Evolution in the Man-Made Habitat. Economic Botany 29(2):99-107.

Delcourt, Hazel R. and Paul A. Delcourt
2000 Eastern Deciduous Forests. *In* North American Terrestrial Vegetation. Michael G. Barbour and William D. Billings, eds. Pp. 357-395. New York: Cambridge University Press.

Duke, James A.
1998 Dr. Duke's Phytochemical and Ethnobotanical Databases. Electronic document, http://www.ars-grin.gov/duke/, accessed February 28, 2011.

Durham, William H.
1991 Coevolution: Genes, Culture, and Human Diversity. Stanford: Stanford University Press.

Dye, David H.
1996. Riverine adaptations in the Midsouth. *In* Of Caves and Shell Mounds. K. C. Carstens and P. J. Watson, eds. Pp. 140-58. Tuscaloosa: University of Alabama Press.

Etkin, Nina L.
2006 Edible Medicines: an Ethnopharmacology of Food. Tucson: University of Arizona Press.

Faulkner, Charles T.
1991 Prehistoric Diet and Parasitic Infection in Tennessee: Evidence from the Analysis of Desiccated Human Paleofeces. American Antiquity 56(4):687-700.

Flannery, Kent V.
1973 The Origins of Agriculture. Annual Review of Anthropology 2:271-310.

Flora of North America
2003 Chenopodium berlandieri. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=242415441, accessed March 12, 2011.

Fowler, Melvin L.
1971. The Origin of Plant Cultivation in the Central Mississippi Valley: a Hypothesis. *In* Prehistoric Agriculture. Stuart Struever, ed. Pp. 122-8. Garden City, NY: Natural History Press.

Frei, Barbara, Otto Sticher and Michael Heinrich
2000 Zapotec and Mixe Use of Tropical Habitats for Securing Medicinal Plants in Mexico. Economic Botany 54:73-81.

Fritz, Gayle J.
1990 Multiple Pathways to Farming in Precontact Eastern North America. Journal of World Prehistory 4(4): 387-435.

2007 Pigweeds for the Ancestors: Cultural Identities and Archaeobotanical Identification Methods. *In* The Archaeology of Food and Identity. Katheryn C. Twiss, ed. Pp. 288-307. Carbondale: Southern Illinois University Press.

Fritz, Gayle J. and Bruce D. Smith
1988 Old Collections and New Technology: Documenting the Domestication of *Chenopodium* in Eastern North America. Midcontinental Journal of Archaeology 13(1):3-27.

Fritz, Gayle J., Virginia Drywater Whitekiller, and James W. McIntosh
2001 Ethnobotany of Ku-Nu-Che: Cherokee Hickory Nut Soup. Journal of Ethnobiology 21(2):1-27.

Gardner, Paul S.
1997 The Ecological Structure and Behavioral Implications of Mast Exploitation Strategies. *In* People, Plants and Landscapes. Kristen J. Gremillion, ed. Pp. 161-78. Tuscaloosa: University of Alabama Press.

Gilliam, Frank S. and Mark R. Roberts
2003 Interactions Between the Herbaceous Layer and Overstory Canopy of Eastern Forests: A Mechanism for Linkage. *In* The Herbaceous Layer in Forests of Eastern North America. Frank S. Gilliam and Mark R. Roberts, eds. Pp. 198-223. New York: Oxford University Press.

Gilmore, Melvin R.
1931 Vegetal Remains of the Ozark Bluff-Dweller Culture. Papers of the Michigan Academy of Science, Arts, and Letters 14:83-102.

Gremillion, Kristen J.
1993 Crop and Weed in Prehistoric Eastern North America: The Chenopodium Example. American Antiquity 58(3):496-509.

1996 Early Agricultural Diet in Eastern North America: Evidence from Two Kentucky Rockshelters. American Antiquity 61(3):520-536.

2004 Seed Processing and the Origins of Food Production in Eastern North America. American Antiquity 69(2):215-233.

2006 Central Place Foraging and Food Production on the Cumberland Plateau, Eastern Kentucky. *In* Behavioral Ecology and the Transition to Agriculture. Douglas J. Kennett and Bruce Winterhalder, eds. Pp. 41-62. Berkley: University of California Press.

2011 Ancestral Appetites: Food in Prehistory. Cambridge: Cambridge University Press.

Harlan, Jack R.
1971 Agricultural Origins: Centers and Noncenters. Science 174:468-73.

1992 Crops & Man. 2nd ed. Madison: American Society of Agronomy.

Hastorf, Christine A.
1990 The Effect of the Inka State on Sausa Agricultural Production and Crop Consumption. American Antiquity 55:262-290.

Heiser, Charles B.
1985 Of Plants and People. Norman: University of Oklahoma Press.

1988 Aspects of Unconscious Selection and the Evolution of Domesticated Plants. Euphytica 37:77-81.

Hollenbach, Kandace D.
2009. Foraging in the Tennessee River Valley, 12,500 to 8,000 Years Ago. Tuscaloosa: University of Alabama Press

Holm, L.
1978 Some Characteristics of Weed Problems in Two Worlds. Proceedings for Western Society of Weed Science. 31:3-12.

Johns, Timothy
1990 With Bitter Herbs They Shall Eat It: Chemical Ecology and the Origins of Human Diet and Medicine. Tucson: University of Arizona Press.

Jones, Ronald L.
2005 Plant Life of Kentucky: An Illustrated Guide to the Vascular Flora. Lexington: The University of Kentucky Press.

Jones, Volney
1936 The Vegetal Remains of Newt Kash Hollow Shelter. *In* Rockshelters in Menifee County, Kentucky, William S. Webb and William D. Funkhouser, eds. Pp. 147-65. University of Kentucky Reports in Anthropology and Archaeology 3(4).

Kartesz, J.T. and C.A. Meacham
1999 Synthesis of the North American Flora, Version 1.0 (CD-ROM). Chapel Hill: North Carolina Botanical Garden.

Kelly, Robert L.
1995 The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways. Washington, D.C.: Smithsonian Institution Press.

Kennedy, Diana
1978 Recipes from the Regional Cooks of Mexico. New York: Harper and Row.

Knox, J.C.
1983 Responses of River Systems to Holocene Climates. *In* Late-Quaternary Environments of the United States, vol. 2: The Holocene. H.E. Wright, ed. Pp. 26-41. Minneapolis: University of Minnesota Press.

Kühn, U.
1993 Chenopodiaceae *In* The Families and Genera of Vascular Plants, vol. 2: Flowering Plants and Dicotyledons. K. Kubitzki, J.G. Rohwer, and V. Bittrich, eds. Pp. 253-281. New York: Springer-Verlag.

Lamb, H.H.
1995 Climate, History and the Modern World. 2nd edition. New York: Routledge.

Lee, Richard B. and I. DeVore
1968 Problems in the Study of Hunters and Gatherers. *In* Man the Hunter, edited by R. B. Lee and I. DeVore, pp. 3-12. Chicago: Aldine Publishing.

Lévi-Strauss, Claude
1966 The Savage Mind. London: Weidenfeld and Nicolson.

Linton, Ralph
1924 The Significance of Certain Traits in North American Maize Culture. American Anthropologist 26(3):345-9.

Logan, Michael H. and Anna R. Dixon
1994 Agriculture and the Acquisition of Medical Plant Knowledge. *In* Eating on the Wild Side. Nina L. Etkin, ed. Pp. 25-45. Tucson: University of Arizona Press.

Logan, Michael H., Kimberly D. Gwinn, Tina Richey, Beth Maney and Charles T. Faulkner
2004 An Empirical Assessment of Epazote (*Chenopodium ambrosioides* L.) as a Flavoring Agent in Cooked Beans. Journal of Ethnobiology 24(1):1-12.

Mauss, Marcel
1954 The Gift: Forms and Functions of Exchange in Archaic Societies. Glencoe: Free Press.

Mangelsdorf, Paul C.
1974 Corn: Its Origin, Evolution and Improvement. Cambridge: Belknap Press.

Meltzer, D. J. and Smith, Bruce D.
1986 Paleoindian and Early Archaic subsistence strategies in eastern North America. In Foraging, Collecting, and Harvesting: Archaic Period Subsistence and Settlement in the Eastern Woodlands (ed. S. W. Neusius). Carbondale: Southern Illinois University Center for Archaeological Investigations Occasional Paper No. 6, pp. 3–31.

Merchant, Carolyn
2002 The Columbia Guide to American Environmental History. New York: Columbia University Press.

Minnis, Paul E.
1981 Seeds in Archaeological Sites: Sources and Some Interpretive Problems. American Antiquity 46(1):143-52.

2000 Introduction. *In* Ethnobotany: A Reader. Paul Minnis, ed. Pp. 3-10. Norman: Univesity of Oklahoma Press.

Moerman, Daniel E.
1998 Native American Ethnobotany. Portland: Timber Press.

Moore, Christopher R. and Victoria G. Delke
2010 Hickory Nuts, Bulk Processing and the Advent of Early Horticultural Economies in Eastern North America. World Archaeology 42(4):595-608.

Munson, Patrick J.
1984 Weedy Plant Communities on Mud-Flats and Other Disturbed Habitats in the Central Illinois River Valley. *In* Experiments and Observations on Aboriginal Wild Plant Food Utilization in Eastern North America. Patrick Munson, ed. Pp. 379-85. Prehistoric Research Series 6(2). Indiana Historical Society, Indianapolis.

Naiman, Robert J. and Robert E. Bilby
1998 River Ecology and Management in the Pacific Coastal Ecoregion. *In* River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Robert J. Naiman and Robert E. Bilby, eds. Pp. 1-10. New York: Springer-Verlag.

Narr, Karl J.
1956 Early Food-Producing Populations. *In* Man’s Role in Changing the Face of the Earth. William L. Thomas, Jr., ed. Pp.134-151. University of Chicago Press, Chicago.

National Research Council
2002 Riparian Areas: Functions and Strategies for Management. Washington D.C.: National Academy Press.

Pearsall, Deborah
2000 Presenting and Interpreting Results and Issues and Directions in Macroremain Analysis. *In* Paleoethnobotany: A Handbook of Procedures, pp. 188-247. San Diego: Academic Press.

Putnam, A.R.
1985 Weed Allelopathy. *In* Weed Physiology, Vol. 1: Reproduction and Ecophysiology. S.O. Duke, ed. Pp. 131-55. Boca Raton: CRC Press.

Reaume, Tom
2009 620 Wild Plants of North America. Regina: University of Regina.

Reinhard, Karl J., J. Richard Ambler and Magdalen McGuffie
1985 Diet and Parasitism at Dust Devil Cave. *American Antiquity* 50(4):819-824.

Richerson, Peter J. and Robert Boyd
2005 Not by Genes Alone: How Culture Transformed Human Evolution. Chicago: University of Chicago Press.

Rindos, David
1984 The Origins of Agriculture: An Evolutionary Perspective. Orlando: Academic Press.

1989 Darwinism and its Role in the Explanation of Domestication. *In* Foraging and Farming: The Evolution of Plant Exploitation. David R. Harris and Gordon C. Hillman, eds. Pp 27-41. Unwin Hymin, London.

Rowley-Conwy, Peter A.
2001 Time, Change and the Archaeology of Hunter-Gatherers: How Original is the 'Original Affluent Society'? *In* Hunter-Gatherers: An Interdisciplinary Perspective. Catherine Panter-Brick, Robert H. Layton, and Peter Rowley-Conwy, eds. Pp. 39-72. Cambridge: Cambridge University Press.

Sahlins, Marshall D.
1968 Notes on the Original Affluent Society. *In* Man the Hunter, Richard B. Lee and Irven DeVore, eds. Pp. 85-89. Chicago: Aldine Publishing.

Sanderson, Stephen K.
2007 Evolutionism and Its Critics: Deconstructing and Reconstructing an Evolutionary Interpretation of Human Society. London: Paradigm Publishers.

Sandstrom, Alan R.
1992 Corn Is Our Blood: Culture and Ethnic Identity in a Contemporary Aztec Indian Village. Norman: University of Oklahoma Press.

Sassaman, Kenneth E.
2010 The Eastern Archaic, Historicized. New York: AltaMira Press.

Scarry, C. Margaret
2003 Patterns of Wild Plant Utilization in the Prehistoric Eastern Woodlands. *In* People and Plants in Ancient Eastern North America. Paul E. Minnis, ed. Pp. 50-104. Washington D.C.: Smithsonian Books.

Schroeder, Kari B., Mattias Jakobsson, Michael H. Crawford, Theodore G. Schurr, Simina M. Boca, Donald F. Conrad, Raul Y. Tito, Ludmilla P. Osipova, Larissa A. Tarskaia, Sergey I. Zhadanov, Jeffrey D. Wall, Johnathon K. Pritchard, Ripan S. Malhi, David G. Smith and Noah A. Rosenberg
2009 Haplotypic Background of a Private Allele at High Frequency in the Americas. Molecular Biology and Evolution. 26(5):995-1016.

Schiffer, Michael B.
1983 Toward the Identification of Formation Processes. American Antiquity. 18:675-706.

Shelford, Victor E.
1963 The Ecology of North America. Urbana: University of Illinois Press.

Small, John K.
1933 Manual of the Southeastern Flora. Chapel Hill: The University of North Carolina Press.

Smith, Bruce D.
1984 *Chenopodium* as a Prehistoric Domesticate in Eastern North America: Evidence from Russell Cave, Alabama. *Science* 226(4671):165-7.

1985a *Chenopodium berlandieri* ssp. *Jonesianum*: Evidence for a Hopewellian Domesticate from Ash Cave, Ohio. Southeastern Archaeology 4:107-133.

1985b The Role of *Chenopodium* as a Domesticate in the Pre-maize Garden Systems of the Eastern United States. Southeastern Archaeology 4:51-72.

1987 The Economic Potential of *Chenopodium berlandieri* in Prehistoric Eastern North America. Journal of Ethnobiology 7:29-54.

1989 Origins of Agriculture in Eastern North America. Science 246(4937):1566-1571.

2006 Eastern North America as an Independent Center of Plant Domestication. Proceedings of the National Academy of Sciences, USA. 103(33):12223-12228.

Smith, Bruce D. and C. Wesley Cowan
1987 Domesticated *Chenopodium* in Prehistoric Eastern North America: New Accelerator Dates from Eastern Kentucky. American Antiquity 52(2):355-7.

Smith, Bruce D., C. Wesley Cowan and Michael P. Hoffman
1992 Rivers of Change: Essays on Early Agriculture in Eastern North America. Washington, D.C.: Smithsonian Institution Press.

Smith, Bruce D. and Richard A. Yarnell
2009 Initial Formation of an Indigenous Crop Complex in Eastern North America at 3800 B.P. Proceedings of the National Academy of Sciences, USA. 106(16):6561-6566.

Smith, Eric A. and Bruce Winterhalder
1992 Evolutionary Ecology and the Social Sciences. *In* Evolutionary Ecology and Human Behavior. Eric Alden Smith and Bruce Winterhalder, eds. Pp. 3-24. New York: Aldine de Gruyter.

Stepp, John R.
2004 The Role of Weeds as Sources of Pharmaceuticals. Journal of Ethnopharmacology 92:163-66.

Stepp, John R. and Daniel E. Moerman
2001 The Importance of Weeds in Ethnopharmacology. Journal of Ethnopharmacology 75:19-23.

Steward, Julian H.
1955 Theory of Culture Change: The Methodology of Multilinear Evolution. Urbana: University of Illinois Press.

Struever, Stuart
1968. Flotation Techniques for the Recovery of Small-Scale Archaeological Remains. American Antiquity 27:564-87.

Struever, Stuart and Kent D. Vickery
1973 The Beginnings of Cultivation in the Midwest-Riverine Area of the United States. American Anthropologist 75(5):1197-1220.

Turner, Victor W.
1967 The Forest of Symbols: Aspects of Ndembu Ritual. Ithaca: Cornell University Press.

Vavilov, N.I.
1926 Studies on the Origins of Cultivated Plants. Bulletin of Applied Botany, Genetics and Breeding 16:139-248.

Waguespack, N. M. and Surovell, T. A.
2003 Clovis hunting strategies, or how to make out on plentiful resources. American Antiquity, 68(2): 333–52.

Watson, Patty Jo
1989 Early Plant Cultivation in the Eastern Woodlands of North America. *In* Foraging and Farming: The Evolution of Plant Exploitation. David R. Harris and Gordon C. Hillman, eds. Pp. 555-571. Unwin Hymin, London.

Watts, W.A.
1983 Vegetational History of the Eastern United States 25,000 to 10,000 Years Ago. *In* Late-Quaternary Environments of the United States, vol. 1: The Late Pleistocene. H.E. Wright, ed. Pp. 294-310. Minneapolis: University of Minnesota Press.

Welsh, Stanley L., Clifford W. Crompton and Steven E. Clemants
2003 Chenopodiaceae. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=10185, accessed March 12, 2011.

White, Leslie A.
1943 Energy and the Evolution of Culture. American Anthropologist. 45(3):335-356.

Willey, Gordon R. and Philip Phillips
1958 Method and Theory in American Archaeology. Chicago: University of Chicago Press.

Wilson, Hugh D.
1981 Domesticated *Chenopodium* of the Ozark Bluff Dwellers. Economic Botany 35(2):233-9.

Winterhalder, Bruce
1987 The Analysis of Hunter-gatherer Diets: Stalking an Optimal Foraging Model. *In* Food and Evolution: Toward a Theory of Human Food Habits. Marvin Harris and E. B. Ross, eds. Pp. 311-39. Philadelphia: Temple University Press.

Winterhalder, Bruce and Carol Goland
1997 An Evolutionary Ecology Perspective on Diet Choice, Risk, and Plant Domestication. *In* People, Plants, and Landscapes: Studies in Paleoethnobotany. Kristen J. Gremillion, ed. Pp. 123-160. Tuscaloosa: University of Alabama Press.

Winterhalder, Bruce and Douglas J. Kennett
2006 Behavioral Ecology and the Transition from Hunting and Gathering to Agriculture. *In* Behavioral Ecology and the Transition to Agriculture. Douglas J. Kennett and Bruce Winterhalder, eds. Pp. 1-21. Berkley: University of California Press.

Wood, Carroll E. and Elizabeth A. Shaw
1974 A Student's Atlas of Flowering Plants: Some Dicotyledons of Eastern North America. New York: Harper and Row.

Yahner, Richard H.
2000 Eastern Deciduous Forest: Ecology and Wildlife Conservation. 2nd edition. Minneapolis: University of Minnesota Press.

Yarnell, Richard A.
1976 Early Plant Husbandry in Eastern North America. *In* Culture Change and Continuity. Charles E. Cleland, ed. Pp. 265-73. New York: Academic Press.

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