AGRICULTURE IN AUSTRALIA: EXAMINING FOOD PRODUCTION IN ABORIGINAL AUSTRALIA

by

GEOFFREY H. ORENGO

A THESIS

Presented to the Department of Anthropology
and the Honors College of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Bachelor of Arts

June 2000

Approved;

Professor Jon Erlandson

An Abstract of the Thesis of

Geoffrey H. Orengo for the degree of Bachelor of Arts

in the Department of Anthropology to be taken June 2000

Title: AGRICULTURE IN AUSTRALIA: EXAMINING FOOD PRODUCTION IN ABORIGINAL AUSTRALIA

Approved: _____
Professor Jon Erlandson

One conspicuous absence from the archaeological record in Australia is agriculture. Australia offers numerous obstacles to agriculture including poor soils, climatic variability, lack of domesticates, problematic food storage and isolation. The Aboriginal people had numerous innovative responses to the environment, including grass seed harvesting, "fire stick farming," cultivation of yams and fruit trees, eel traps, cycad processing, and moth collecting. This thesis synthesizes data to answer this question of agriculture, and is of importance to the Aboriginal people today. Whether or not "agriculture" existed in Australia, a culturally complex people existed and thrived in a continent that modern technology has yet to overcome.

Acknowledgments

I would like to thank Professor Erlandson, Professor Ayres, and Professor Todd for their help in editing and revising my paper. I would also like to give special thanks to Professor Erlandson, whose class helped bring me to my topic.

I would also like to thank my parents for their help which they have always given freely and without reservation. A big thank you to everyone else who had a part in this thesis, whether it was talking with me about my ideas or putting up with me while I was working on it, I really appreciate it.

Table of Contents

List of Maps and Tables

Introduction

Australia is a unique land, the only continent that is also a country. It is home to flora and fauna found nowhere else in the world. The native people of the Australian continent have a rich cultural past and unique adaptations to the land around them. Between about 50,000 and 60,000 years ago, the ancestors of the native Australians came to the previously unexplored continent. These early explorers quickly spread throughout the continent, adapting to the different environments they found. Even the arid desert interior of Australia has yielded surprisingly early dates; Puritjarra rock shelter located in the center of the continent has a date of 22,000 BP for the lowest artifacts, and new work shows the base of occupation somewhere in the order of 30,000 years (Flood 1995: 81). The long history of native occupation suffered a sharp break when there was contact between native Australians and Europeans. Records exist of contact as early as AD 1629 when a Dutch ship wrecked off the west coast of Australia. The first sustained contact, however, occurred in AD 1788 when Britain established the first European settlement on Australian soil (Ellis 1984: 104).

Prolonged contact with Europeans was disastrous for native Australians. Between AD 1788 and 1921, conservative estimates suggest that native Australian populations declined by 80 percent; other estimates say as much as 95 percent. Most native Australians died from introduced European diseases such as smallpox, diseases that the native people had no history of and consequently no immunity to. Not all native people were killed by disease, however; many were killed outright by European colonizers. What would today be viewed as murder was then seen as a "necessary action" (Ellis 1984: 115).

Much of this destruction is in part due to the stereotype of the native Australian people as the most primitive people on Earth. Living as hunters and gatherers, most native Australians possessed meager material possessions. Even though some groups were semi-sedentary, shifting locations was necessary several times a year at least, and material possessions were limited to what could be carried. The stereotype of the native people as primitives persists to this day and continues to affect the native people.

Before continuing, I should note that many of the terms used in this paper are eurocentric, that is they are names given by the European colonizers and not the native inhabitants of Australia. The term Australia itself is European and not a native term. In this work I use the European term for the native people, Aborigines. I do so to reduce confusion when discussing Australians -- the original inhabitants versus the new colonizers. Many native Australians see this term as derogatory; I use it only to preserve continuity with my sources. Although I use these European terms, it is important to realize that the native people have their own perspective on the land and its history. Most histories of Australia have been told by Europeans or Westerners, and in considering Australia it is necessary to remember that the view from the West is just one perspective, and not the only perspective.

Examining Aboriginal culture necessitates new perspectives. Recently, as European biases are being discarded, many amazing aspects of Aboriginal culture are coming to light. Aboriginal culture was not primitive, but simply specialized to a unique land. Archaeology has uncovered many cultural firsts in the prehistory of Australia. The

initial colonizers of Australia were the earliest known seafarers, and they had the earliest examples of ground stone technology used for the construction of axes, earliest cremation burials, complex and ancient artistic traditions, development of the boomerang, and adoption of the dingo. Aborigines also had complex aspects in their traditional life, such as trade, art, and religion. Aboriginal culture had many technological achievements, including many ingenious modifications to their environment. People have been living in Australia for at least 50,000 years, "and for 99.5 percent of Australia's human history, it is the Aborigines who have been on the stage" (Flood 1995: 10). Their cultural past is relatively unknown, in part because of the devastation and abrupt population decline of the Aboriginal people after European contact. Australian archaeology offers several interesting questions for which no one right answer exists. The question I focus on in this paper is the absence of food production in Australia. Although the importance of this question may seem small, it encompasses many important issues for the Aborigines as well as containing significance for us living an ocean away.

Before further discussion, the term "food production" must be explained. "Food production" is used to describe what most people think of as agriculture, that is the production of food through domestication and cultivation of plants and animals. Food production requires the domestication of either plants or animals, although existing evidence points to domestication starting with plants. Domestication is a term often heard in our modern society, but what exactly qualifies a plant or animal as domesticated? Domesticated plants and animals are those that have been influenced or demonstrably altered genetically by human beings. Human influence can be determined when the

domesticated species can be differentiated from its wild ancestor. For example, wheat is an important modern domesticate that was one of the first plants to be altered by humans. Wheat closely resembles its wild ancestor; however, the wild plant is distinguished by the loss of its seeds (grain) because its rachis shatters. The rachis is a small connection between the individual grains that forms the overall seed head. The modern domesticate retains its seeds because of the mutation of a tougher rachis. The domestication of plants and animals enabled food production independent of the natural world and a much greater *potential* food supply. Potential is stressed because agriculture does rely on the environment for its success.

Food production as it existed elsewhere in the world, with crops grown and influenced by humans, is absent in the archaeological record of Australia. Australia is puzzling because although areas such as the Western desert are unsuitable for agriculture, the southwestern and southeastern areas are suitable and today are centers of farming. The question of why food production did not arise in or spread to Australia is much like an onion; there are many layers in the question and each layer leads to new questions. Many of these issues have proponents with differing opinions and there is still no unique, right answer to the question. Through the process, however, a better understanding will be reached and perhaps better questions can be asked.

Examining the absence of food production in Australia requires a synthesis of a variety of interdisciplinary data. Understanding food production involves knowledge of the environment and climate of Australia, as well as its unique location and history. This can then be applied to understanding food production in light of the environment.

Understanding food production necessitates a look at the rise of food production and how and why it was developed. Then Australia's agricultural "obstacles" can better come to light. After examining these obstacles, the reader will see the environmental modifications the Aborigines developed, including food production without domestication. Australia's environment and geography, not the people, are responsible for the absence of agriculture. Aborigines might eventually have begun producing food, but European contact forever changed the course of human history in Australia.

Australia's Environment

Australia has a unique flora and fauna. It owes much of this to its geological history. Australia's geological history, including continental drift and the importance of geological activity on its soil, are of foremost importance in considering the continent's environment. Next, climate and its influences on flora and fauna are examined. Finally the continent's current topography and climatic zones are explored to offer a knowledge of Australia as it has been for the last 10,000 years.

Geological History

Australia was still connected to the large southern land mass Gondwanaland 100 million years ago. This large body of land included what is now Antarctica and parts of Australia were within the Antarctic circle. At that time, however, the world was warmer and lands lying within the Antarctic circle were not as cold as lands lying at such latitudes today (Flannery 1994: 39). About 80 million years ago, the land mass split along a rift that had been forming for the previous 40 million years. By approximately 40 million

years ago the Australian land mass had completely broken free of Antarctica. Over time it drifted north and split into two smaller land masses, Tasmantis and Meganesia (Flannery 1994). Meganesia is a large plate that contains Australia, New Guinea, and Tasmania. Tasmantis contains New Zealand, New Caledonia, the Chatham Islands, and some other small islands. Much of these two land masses is underwater today.

Once the Australian land mass separated from Antarctica, it slowly drifted north towards its current location. The rate at which the continent drifted proved to be extremely important. Flannery (1994) points out the miraculous balancing act that occurred in the rate of continental drift. Over the past 40 million years, global temperatures cooled considerably. Oscillations in temperature always occur but the general trend has been towards cooler temperatures. For example, the temperatures that existed at 60 degrees south 40 million years ago, now occur at 40 degrees south. The continental drift of the Australian land mass kept pace with the slow change in climate. This remarkable coincidence preserved the unique flora and fauna that had existed for tens of millions of years when Australia was connected to a larger land mass. "Were it moving faster, it would have outstripped the pace of climate change and the cool-adapted Gondwanan fauna and flora would have been lost as Australia moved into the tropics" (Flannery 1994: 76). Since the climate remained so stable, the flora and fauna not only had the time to adapt, but also had the millions of years necessary to diversify to the myriad forms of life found today. The rate of continental drift was just enough to keep Australia north of the latitude where glaciers form. The importance of this lack of

glaciation will be discussed later. In addition to this remarkable coincidence of continental drift, Australia's geological past also offers other surprises.

Importance of Geological Activity on Australia

The absence of geologic activity has kept much of this ancient continent from being recycled by volcanism. Not only have these rocks survived but they have survived largely unaltered, preserving some very ancient fossils. In his work, Flannery (1994: 77) speaks of a scientist who recently found the oldest evidence of life on Earth in Australia, dated to about 3.8 billion years ago. This geological stability is suspected by geologists to be due to "the enormous depth of ancient continental crust under Australia. The crust, they argue, is so old and thick that magma cannot easily penetrate it and, likewise, its thickness and strength prevent it from being easily folded and uplifted into mountain ranges, or torn asunder by rift valleys" (Flannery 1994: 78). The lack of significant geological and glacial activity has greatly affected the soil of Australia as well as its life.

Throughout the world, volcanism and glacial activity have produced fertile soils. Because no other continent has experienced the degree of geological quiet that Australia has experienced over the past 60 million years (Flannery 1994: 77), Australia is unique in its impoverished soil. Australia is one of the flattest places on Earth. Ninety-four percent of Australia lies beneath 2,000 feet of elevation (Diamond 1997: 302) and the lack of high altitudes and cold temperatures, as well as the close proximity to the equator, helped ensure that little or no glaciation occurred in Australia. The continent was without glaciation to grind up the rocks of the mountains, and also lacked numerous rivers to

deposit the minerals in the lowlands and oceans. Consequently, Australia's soil and surrounding oceans remained low in the nutrients necessary to sustain life. Comparative soil studies between the world's semi-arid zones have found Australian soils to contain approximately half the level of nitrates and phosphates (essential nutrients) to equivalent soils found anywhere else (Flannery 1994: 78).

There are small exceptions to this rule, a number of small volcanoes in eastern Australia and New Guinea. None of the volcanoes are now active, most dating to the last 10 million years. It is believed that the continental crust of Australia slowly moved over a "hot-spot" in the Earth's mantle where some volcanic activity was stimulated. The Hawaiian and Galapagos Islands were formed in this way, with the ocean crust moving over a similar hot-spot. "These volcanoes have eroded, producing some of the only fertile soil in Australia. Wherever they occur, they support intensive agriculture or prime grazing land" (Flannery 1994: 79). These fertile areas show the importance of volcanic activity on soil nutrients, and why much of the soil is impoverished. The second example involves the formation of New Guinea 25 million years ago. As discussed by Flannery, the thick continental rock of Australia met the thick continental rock of the Asian plate and the northeastern edge of the Australian plate was what gave (Flannery 1994: 80). The edge buckled, forming a trough near Torres Strait, while the leading edge was uplifted. The result was the mountainous country that today is New Guinea, a land whose volcanic past has given it extremely rich soils and mountains that are tall enough to support one of the world's few tropical glaciers (Flannery 1994: 80). The poor soils resulting from sparse glacial and volcanic activity were only one aspect of the unique forces shaping the biota of

the Australia continent. The unpredictable climate of Australia was another force that in concert with long geological isolation and poor soils created its unique environment.

Climatic Variability

Most American readers are aware of the weather phenomenon El Niño and the drastic climatic changes it can cause. Often the importance of climate isn't appreciated until dramatic changes bring disastrous floods or droughts. Most of the world's climate is either strongly seasonal or relatively predictable year round. This climatic stability is extremely important for all plants, animals, and humans. Whether little difference exists between seasons as in tropical latitudes or marked difference in more temperate latitudes, a predictable annual cycle is of the utmost importance. Even in the most severe winters in high northern latitudes, animals and humans can store up energy and food to last through the winter and then count on good weather and new growth to return. Changes to this predictable cycle often result in disaster. A thaw too early in winter or a freeze late in spring can ruin crops and lead to famine. Although these climatic changes occur sporadically in most of the world, Australia must constantly cope with relatively unpredictable climatic change. "The cycle that drives Australia's strange climate is called 'El Niño Southern Oscillation' or ENSO for short" (Flannery 1994: 81). This climatic event begins in the Pacific Ocean with often disastrous changes in climate for surrounding areas. Flannery discusses the development of the El Niño current and the drastic effects it can have on land. The top layer of water in the ocean off the coast of Peru begins to warm, sometimes as much as four degrees Celsius. These warm waters are normally kept in the vicinity of Australia and the west Pacific by prevailing westerly winds. As these

winds weaken, the water flows eastward and creates drastic consequences for South America. During "normal" years, the usually weak winds of Peru and western South America and the cold top layers of coastal ocean waters prevent the formation of clouds and storms in the area and it is consequently dry. El Niño reverses that and storms batter the landscape, creating large scale erosion and widespread flooding. In Australia, however, the situation is the reverse and the coastal waters are kept cold by El Niño. Cloud formation and evaporation are reduced and the result is severe droughts, sometimes of several years' duration. Other areas as far away as India, Brazil, southern Africa, and central America can also experience drought, but none of these are affected continent-wide like Australia.

Climatic Influences on Australia's Flora and Fauna

The ENSO cycle is of great importance in considering life in Australia, human food production, and potential agricultural productivity. ENSO will be discussed again when I turn to obstacles to food production; now it is important to understand the significance for the flora and fauna of Australia. The high degree of variability in the climatic cycle results in selections specific for that environment. In another example of the need to change perspectives on Australia's past and present, biologists are discovering a different evolutionary process has taken place in Australia. Instead of Darwin's idea that evolution is a process driven by competition between species, Flannery (1994) argued that Australia's environment selects for cooperation. "This is because poor soils and ENSO have put a premium upon retaining and rapidly recycling nutrients. This can be done most efficiently by various species developing intimate relationships" (Flannery 1994: 84). In

light of the low nutrient content of the soils and the high degree of variability in climate, the necessity of species cooperating to survive makes sense.

An examination of Australia's flora and fauna seems to support this view. An adaptation known as scleromorphy highlights an interesting evolution between the plants exhibiting this trait and the animals that feed upon those plants. Many of Australia's plants, such as eucalypts, banksias, bottlebrushes, and tea trees, exhibit scleromorphy. "Its manifestations, such as small leaves and small distances between leaves, are the result of limitations on plant growth which probably result from the small number of new cells that can be sustained at the plant's growing tip" (Flannery 1994: 86). Scleromorphy has been developing for "at least 50 million years in Australia" (Flannery 1994: 86). Biologists are still learning about scleromorphy and its causes, but scleromorphic traits seem to be advantageous in much of Australia's nutrient-impoverished land. The scleromorphic plants that dominate the Australian vegetation are inedible for humans (although they can be used medicinally) and represent another limitation on food production. Even more amazing are the adaptations evident in the animals that feed on scleromorphic plants.

One of the best examples of these animals is the famous koala bear, which feeds solely on eucalyptus leaves. Koalas are very selective in choosing leaves that contain the most nutrients, but these also contain dangerous chemicals and are still relatively low in nutrients. To survive, the koala is an effective energy saver and eats relatively few leaves. The koalas' slow movement and low reproduction weight are fairly evident examples of energy conservation, but one of the most striking examples is the koala's brain. Flannery discusses how the brain is one of the greatest energy users of all the organs. "The brain

weighs a mere two percent of total body mass, but it uses approximately 17 percent of the body's energy" (Flannery 1994: 86). The koala's brain has reduced over time so that it is much smaller than the cranial vault in which it is housed. "Its hemispheres sit like a pair of shriveled walnut halves on top of the brain stem, in contact neither with each other nor the bones of the skull. It is the only mammal on Earth with such a strangely reduced brain" (Flannery 1994: 86). The animals of Australia appear to have adapted to the low energy output of the Australian environment. Marsupials make up most of Australia's native wildlife even though "marsupials in general are not known for their large brains, nor intelligence. The fact that they won out over early placental mammals in Australia suggests that it may indeed pay to be dumb in Australia" (Flannery 1994: 87). This only applies to Australia's animals, however, and not its people. Australia's animals, like its plants, show strong evidence that they have adapted to the low energy conditions of Australia.

Topography

In light of its long past and unique environment, the present day topography and climate are important in examining patterns of food production over the last 10,000 years in Australia. After the rise of sea levels at the end of the last glacial period, the climate and geography of Australia were almost identical to those of today.

Australia is both the flattest and driest continent. Maps of Australia in *The World Book Great Geographical Atlas* (1982) show few mountain ranges (Fig. 1). The most prominent is the Great Dividing Range along the east coast and the Musgrave and Macdonnell ranges in the arid heart of the continent. The largest river, the Murray-

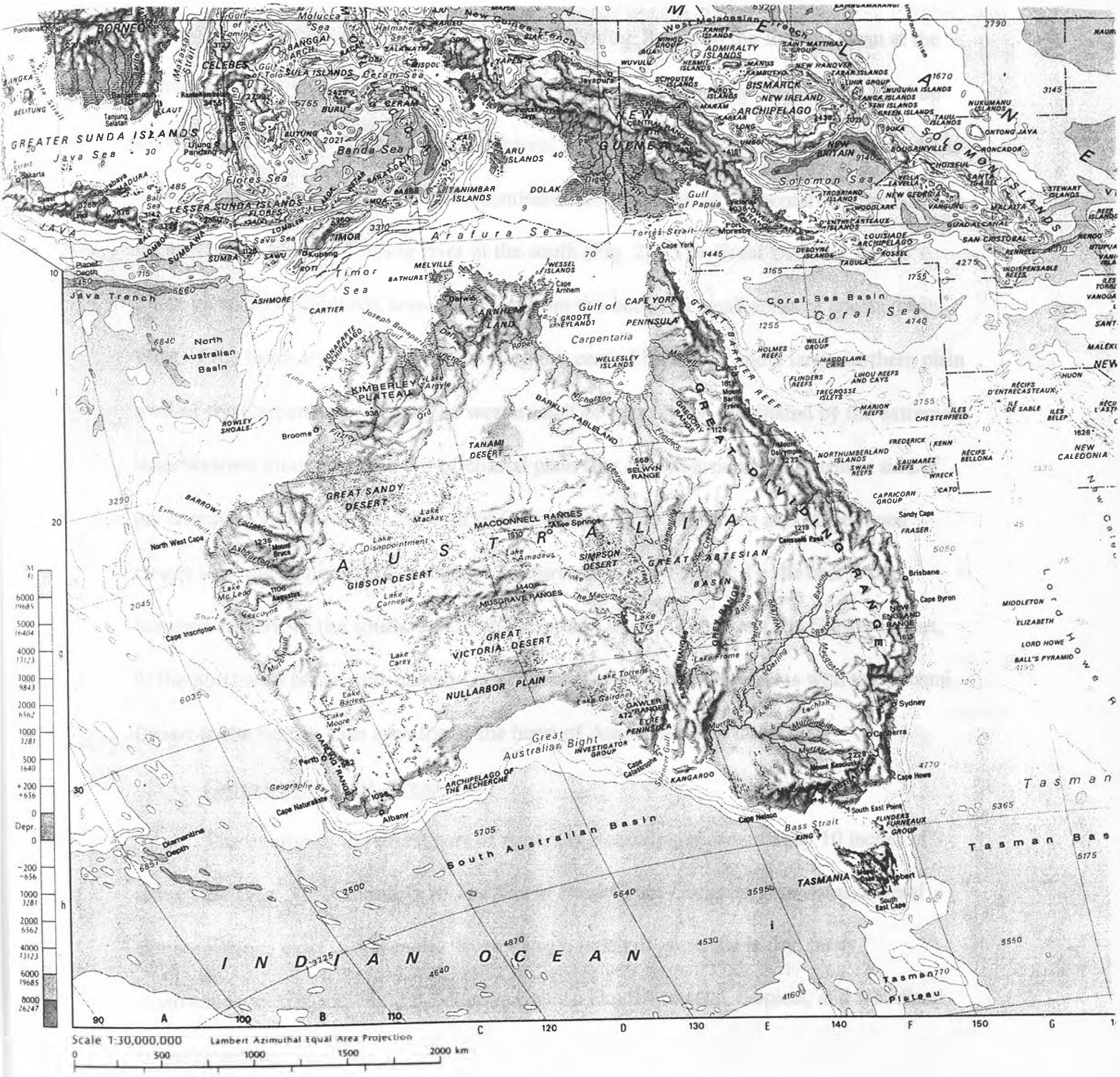


Figure 1. Topographic Map of Australia (adapted from World Book Atlas, 1982)

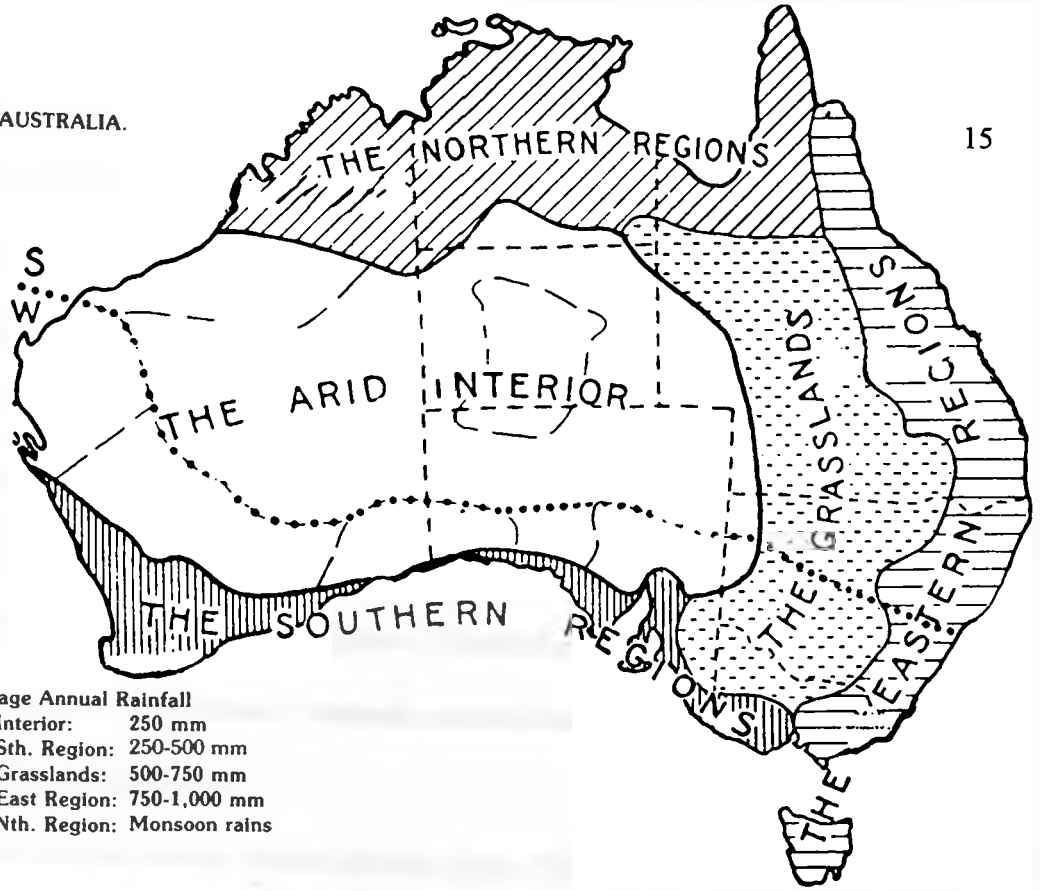
Darling in the southeast, runs from the Great Dividing Range to the Indian Ocean at the southeast coast. In especially long droughts, however, the Murray-Darling has dried up for months at a time. A map of the structural regions of Australia shows three basin areas running along the eastern side of the continent from the Gulf of Carpentaria in the north to the end of the Murray-Darling river in the south (Fig. 2). The Great Dividing Range forms an eastern highlands area separated from the ocean by small areas of coastal plain. West of the basin areas in the east are irregular central highlands and a large northern plain west of the Carpentaria basin. The western half of Australia is dominated by the extremely large western plateau with areas of coastal plain that stretch around the northern side of the continent all the way to the Gulf of Carpentaria. The Musgrave and Macdonnell ranges near the center of the continent are surrounded by desert. To the east is the Simpson Desert, to the south the Great Victorian Desert, to the west the Gibson Desert, to the northwest is the well-named Great Sandy Desert, which intersects with the Tanami Desert in the north. This area forms the heart of Australia's arid interior.

Current Climatic Areas

The interior is the driest part of Australia, receiving approximately 10 inches of rain a year (Fig. 3). According to *The World Book Great Geographical Atlas*, several climate regions exist in Australia. Even though much of Australia is dry, many environments exist, including productive regions like the coastal, tropical, and woodland resource areas.

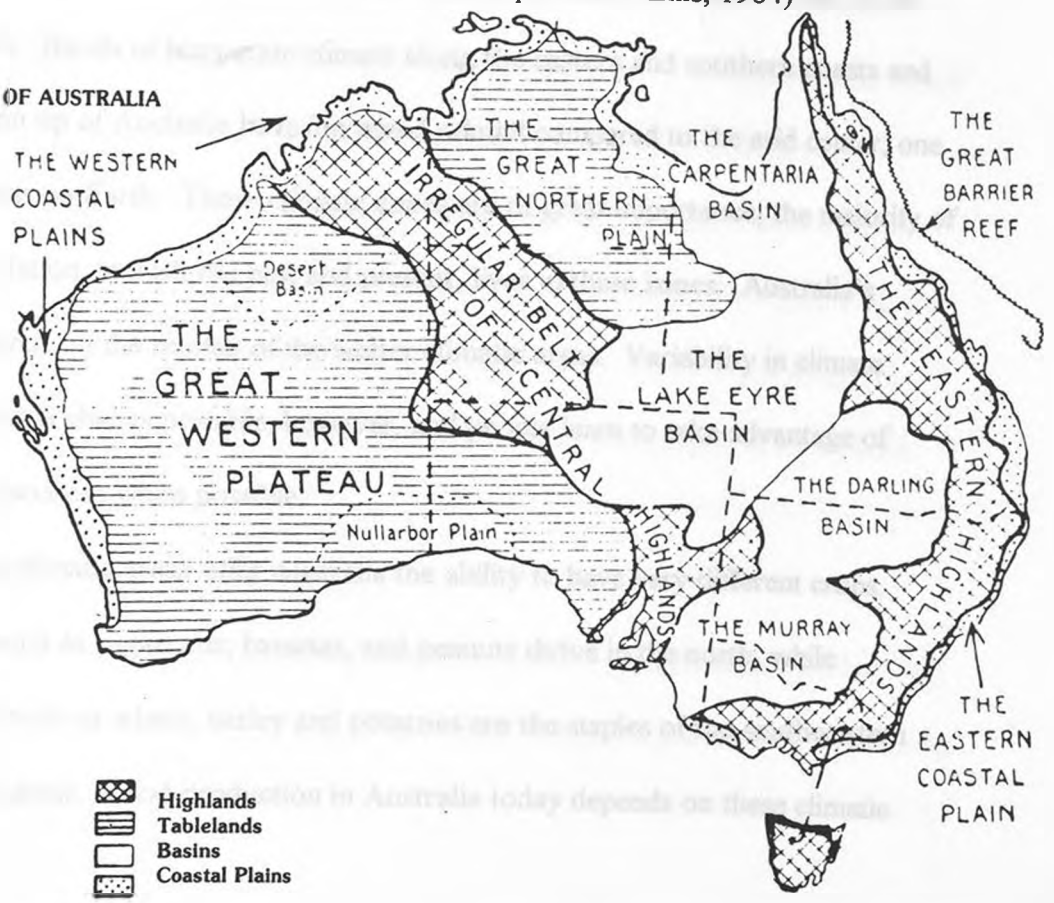
The northern area of Australia is tropical with monsoon rains. The climate becomes arid as one moves south toward the Tropic of Capricorn, except for a band of

CLIMATIC REGIONS OF AUSTRALIA.



(Figure 2, below; Figure 3, above; adapted from Ellis, 1984)

STRUCTURAL REGIONS OF AUSTRALIA



warm temperate climate along the east coast. In the east there is rainfall of 20 to 30 inches a year around the eastern basins, which increases to 30 to 40 inches in the Great Dividing Range. The southwestern tip of Australia also has a warm temperate climate as does a small area around the mouth of the Murray-Darling River, both of which receive between 10 and 20 inches of rainfall a year. Below that small section of warm temperate climate in the southeast, the climate changes to cool temperate for the rest of the southeastern portion of Australia and Tasmania. Rainfall increases in the southeastern tip as one move towards the mountains. Tasmania receives between 30 and 40 inches of rainfall and is fairly mountainous.

Australia includes several distinct climatic zones. The tropical band in the north has a climate far more similar to that of New Guinea and the Indonesian islands than to the rest of Australia. Bands of temperate climate along the eastern and southern coasts and the southwestern tip of Australia have increased rainfall compared to the arid center, one of the driest areas on Earth. These climatic zones are of great importance; the majority of Australian population, in both the past and present, lives in these zones. Australia's agriculture depends on the rainfall of the wetter climatic areas. Variability in climate because of ENSO is always possible, however, and people learn to take advantage of available food resources when possible.

Different climatic areas offer Australia the ability to have very different crops. Tropical plants such as sugarcane, bananas, and peanuts thrive in the north, while temperate plants such as wheat, barley and potatoes are the staples of the southwestern and southeastern areas. Food production in Australia today depends on these climatic

zones and a period of stability from ENSO. ENSO can ruin crops and entire growing seasons, something that "the average Australian farmer, who has to repay loans on an unvarying monthly or annual basis, knows this to great cost" (Flannery 1994: 83). Before I examine the subsistence patterns of food gathering and food production, the role of Australia's variable climate must be stressed. It will reappear when food production in Australia is discussed.

Hunting, Gathering, and Agriculture

The last 50 years has offered both new research and new perspectives on food subsistence patterns. Many people have heard of hunting and gathering as the food subsistence method of people living in remote parts of the world such as the Amazon rainforest, Australia's desert, or the Kalahari desert in Africa. Most people are also aware that in many areas people practiced hunting and gathering until the introduction of agriculture. A common assumption is that domestication and agriculture were natural progressions from hunting and gathering. In some areas of the world, food gathering did lead to domestication and eventually agriculture. Other societies took much longer to acquire agriculture, and some didn't acquire it at all. Large misconceptions exist about these differences.

Food Production as a Continuum

The first misconception is that this process is a unilinear progression from hunting and gathering to agriculture. A better way of looking at different subsistence patterns is to view them as a continuum.

> In this way, particular characteristics or traits can be isolated independently of general categories such as "simple" or "complex." These two classes can then form the two ends of a continuum, with individual societies or traits located along it. Note that the continuum should not necessarily be seen as unilinear or directional in time or space, as no one trajectory is suggested. A varied patchwork of societies may have appeared in both time and space (Lourandos 1997: 9).

Another description of this continuum in human subsistence is that of "a gradient of increasing input of human energy per unit area of exploited land" (Harris 1989: 18). Harris (1989: 18) stresses, however, that this continuum is not unidirectional and deterministic. It is important to see that human societies exist along this continuum and can move in it, with changing subsistence patterns based on both environmental and socio-cultural factors.

One example of environmental factors affecting subsistence patterns comes from New Zealand's South Island and the Chatham Islands, a small group of islands east of the South Island. Towards the end of the Austronesian expansion, Polynesian people believed to have originated in Southeast Asia colonized New Zealand around 1000 BP (before present) (Diamond 1997: 54). These people came to be known as the Maori. Shortly thereafter, part of that population moved to the South Island of New Zealand and then to the outlying Chatham Islands. These southern areas were colder than the North Island of New Zealand, which had been colonized first, and consequently unsuited for the tropical domesticates the Maori arrived with. "The settlers of the Chathams and the cold southern part of New Zealand's South Island were thus forced to abandon the farming legacy developed by their ancestors over the previous thousands of years, and to become hunter-gathers again" (Diamond 1997: 60). This example shows how environmental factors can influence subsistence patterns of different human societies. Socio-cultural factors change

from group to group and some examples from Australia will be explored later. The importance of viewing societies along a continuum relates to the second misconception about differences in human societies.

A great misconception concerning this continuum has been the assigning of the terms "simple" and "complex" to the ends of this continuum. The closer a society comes to the agricultural end of the continuum the more complex that society has traditionally been considered. A new viewpoint is found in Lourandos' discussion of human cultural complexity. "A viewpoint adopted here, therefore, is that all human societies are in some ways complex, that considerable variation exists within and between societies.... Individual societies may have moved back and forth along such a continuum in both the long and short term, as well as spatially" (Lourandos 1997: 9). Hunting and gathering societies may not possess technologies associated with civilizations such as metal working, writing and political organization, yet they do possess complex means of interacting with their environment and complex religious and cultural beliefs. To fully understand these societies the socio-cultural and environmental forces must be more closely examined and not assigned a label as "simple" in a comparison with another society.

Definition of Terms

Before discussing the other misconceptions surrounding hunting and gathering, a definition of terms is necessary. The idea of a continuum is very important; different subsistence strategies exist and should not be considered to be a progression from one to the next. For comparison, subsistence patterns will be either closer to agriculture or to

hunting and gathering. Again, I stress the importance of realizing that these conditions are not static and have changed over time.

Presently, many opinions are held about the origins of agriculture and the differences between various subsistence patterns. Subsistence patterns will describe the food resources relied upon and methods employed by a cultural group for survival. "Food production" is often used to refer to agriculturally oriented subsistence patterns, but I use it to describe intensive methods of food procurement, including non-agricultural pursuits. Food production does apply to all groups because all groups can be seen as producing food through the appropriation of labor. The terms "agriculture" and "domestication" are often heard and have many definitions. In this paper "agriculture" will refer to intensive plant and animal management by a cultural group and will involve large scale cultivation of consciously domesticated crops. This system involves the highest amount of labor input of all subsistence patterns. Large amounts of labor are involved in land clearing, systematic soil tillage, the construction of more permanent residential structures, and food storage. Large scale cultivation will be referred to as agriculture.

"Domestication" will refer to the conscious human alteration of a plant or animal for human agricultural needs. Unconscious domestication will refer to the alteration of a plant through human cultivation. This creates a difference between a cultigen and a domesticate. An example of this difference can be seen with early human interaction with wild strains of wheat. Many wild grains are very similar to those of today except for three traits of uneven ripening, a fragile rachis and to some extent, size. Groups living around these wild grains would certainly have made use of this resource. In collecting this

resource, gatherers would note advantageous mutations in the grain such as a tougher rachis that doesn't shatter and thus retains the seed, plant maturity at an advantageous time, and larger than normal kernels. These selections helped propagate these plants for further cultivation. The principles of domestication may not be understood, but human interaction has altered the wild species of plant. These differences between a cultigen and a domesticate partially form the basis for human cultivation of plants or agriculture.

"Cultivation" refers to a subsistence pattern involving land clearing, soil tillage and regulation of soil fertility. Early food cultivation begins with replacement planting, transplanting, weeding, harvesting, storage, and drainage and irrigation. "Hunting and gathering" will refer to harvesting of resources, both plant and animal, terrestrial and marine. Hunting and gathering also can include careful tending of plants, such as cutting away surrounding vegetation. An important difference between foraging and hunting can be seen in late Pleistocene times (20,000 to 15,000 years ago). Some cultural groups relied on big game hunting, while others focused on foraging or the gathering of plant resources. This latter type of subsistence is believed to be an important precursor to intensive plant cultivation. Other subsistence patterns mentioned are "horticulture" which refers to the greater use of tree and root crops, instead of grain crops as in agriculture. Horticulture is often characterized by smaller garden plots instead of large fields. "Pastoralism" is a subsistence pattern based on the use of domesticated animals such as cattle. Plant foods are either foraged or traded for. "Slash and burn" agriculture refers to areas with somewhat lower nutrient levels and the necessity to burn the vegetation on the planting site for soil enrichment. These subsistence patterns are chosen in some areas

because of their success due to environmental factors and the cultural perspective of the group at that time.

Misconceptions concerning hunting and gathering

Understanding that hunting and gathering, like agriculture, is a generalization of many varied food subsistence strategies leads to a better picture. Misconceptions still exist as to the success and leisure of the hunting and gathering lifestyle. One such misconception that has existed is that the life of a hunter-gatherer is nasty, brutish and short. The reality is quite a different story. Most hunter-gatherers enjoy more leisure time and a more nutritious diet than most agricultural societies. One study done on the !Kung hunter-gatherers of the Kalahari Desert in Africa illustrates this. "Lee's records indicate that the working adults spent on average of about 2.5 days per week in subsistence activities, a working day being defined as about 6 hours. This suggests a total weekly output of about 15 hours or an average of slightly better than 2 hours per day spent in the food quest" (Cohen 1977: 30). Cohen goes on to summarize the efforts spent in the food quest as averaging 780 total hours worked per adult per year. These are later compared to total hours spent in the food quest by agriculturists.

> Clark and Haswell cite a number of studies on labor inputs in tropical Africa and elsewhere providing a wide range of figures for per capita annual labor inputs in subsistence agriculture, all of which, suggest, however, that agricultural labor inputs are at least equal to and in most cases significantly higher than the labor of vegetable gathering attributed to the hunting and gathering group discussed (Cohen 1977: 32).

This may seem surprising to most people. However, only in first-world countries such as the United States does a large part of the population have nothing to do with the

majority of food production, which rests on a small part of the population working full time to produce the country's food and the ability of the country to import food through trade.

Hunter-gatherers also enjoyed a more varied and plentiful diet, and consequently were healthier than most agriculturists. A varied diet resulted from the large inventory of knowledge on edible plants and animals that hunter-gatherers employ in the acquisition of food. Agricultural societies relied more heavily on a few staple crops and thus had a less diverse and nutritious diet than hunter-gatherers.

Agricultural societies were more at the mercy of the environment than hunter-gatherers as well. In times of environmental disaster such as floods or drought, hunter-gatherers could move to safer areas and harvest foods less affected by the weather. Agricultural centers were more vulnerable to the weather than hunter-gatherers because they depended on a smaller array of staple foods and were sedentary and far less inclined to move elsewhere. The sedentary lifestyle of agricultural societies also increased rates of diseases that the sparser bands of hunter-gatherers did not experience. Compared to hunting and gathering, agriculture did have its drawbacks to the overall health of the population. Here we must reconsider the continuum that was discussed above. In each society many different types of subsistence have occurred over time. Hunting and gathering may collect most of a society's food intake yet be supplemented with small-scale agriculture. Larger agricultural societies may still supplement food intake with gathered wild foods. Hunting, gathering, fishing, pastoralism, horticulture, agriculture, and slash and burn agriculture may all be combined to some extent to form the subsistence strategy

of a particular society, depending on the environment and the cultural perspective of that particular society. These methods can remain fluid, changing over time. This is important to remember as we explore trends in subsistence patterns in Australia and elsewhere.

The Rise of Food Production

Before we examine food production in Australia, agriculture's history must be discussed. Diamond (1997) gives a good summary of the areas thought to have independent origins of domestication and the domesticates and earliest attested dates for each area (Fig. 4). The earliest date is for Southwest Asia at 8500 B.C. China soon follows suit, but in Mesoamerica and the Andes it was another 4000 years before domestication occurred. Domestication also occurred in the eastern United States around 2500 B.C. Other areas may be centers of domestication, but it is unclear if domestication was spurred on by the arrival of domesticated crops from elsewhere. Once some plants and animals had been domesticated, food production through proliferation of these domesticates spread slowly through surrounding areas.

Fifteen thousand years ago all people lived as hunter-gatherers, and even though different subsistence patterns existed, no domesticates (with the possible exception of dogs) are known to have existed at that time. Today a shrinking number of cultural groups follow a hunter-gatherer subsistence pattern, and all have varying degrees of contact with agricultural societies. Why this shift occurred has long been explained by the "superiority" of agriculture as a means of subsistence. Examples like the Chatham Islands suggest that agriculture isn't necessarily superior in all environments.

Area	Domesticated		Earliest Attested Date of Domestication
	Plants	Animals	
Independent Origins of Domestication			
1. Southwest Asia	wheat, pea, olive	sheep, goat	8500 B.C.
2. China	rice, millet	pig, silkworm	by 7500 B.C.
3. Mesoamerica	corn, beans, squash	turkey	by 3500 B.C.
4. Andes and Amazonia	potato, manioc	llama, guinea pig	by 3500 B.C.
5. Eastern United States	sunflower, goosefoot	none	2500 B.C.
? 6. Sahel	sorghum, African rice	guinea fowl	by 5000 B.C.
? 7. Tropical West Africa	African yams, oil palm	none	by 3000 B.C.
? 8. Ethiopia	coffee, teff	none	?
? 9. New Guinea	sugar cane, banana	none	7000 B.C.?
Local Domestication Following Arrival of Founder Crops from Elsewhere			
10. Western Europe	poppy, oat	none	6000–3500 B.C.
11. Indus Valley	sesame, eggplant	humped cattle	7000 B.C.
12. Egypt	sycamore fig, chufa	donkey, cat	6000 B.C.

Figure 4. Examples of Species Domesticated in Various Areas

(adapted from Diamond, 1997)

The reasons agriculture was adopted are known to some extent, but many opinions exist. It is also important to remember that as particular environments change, so too can the best subsistence pattern. Each cultural group has its own perspective and the ability to change subsistence patterns. To better understand food production in Australia, an important question should be examined. "Hence the question that we have to ask is why

food production did evolve, why it evolved in some places but not others, why at different times in different places, and why not instead at some earlier or later date?" (Diamond 1997: 106). This question is a formidable one. Diamond distinguishes five factors involved in the rise of food production that are widely supported. The relative importance of each, however, is in great debate.

One factor is the decline in the availability of wild foods (Diamond 1997: 110). At the end of the Pleistocene around 10,000 to 12,000 years ago, many large mammal species became extinct, removing what had been a plentiful supply of meat. There is evidence of cultures developing more intensive food production upon the depletion of wild resources. "...the Polynesians who colonized Easter Island around A.D. 500 brought chickens with them, [but] chicken did not become a major food until wild birds and porpoises were no longer readily available as food" (Diamond 1997: 110).

The second factor relates to the first; as the depletion of large game made hunting less rewarding, climate changes at the end of the last Ice Age expanded the habitats of wild cereals, which could be harvested in great quantities in a short amount of time. "Those wild cereal harvests were precursors to the domestication of the earliest crops, the cereals wheat and barley, in the Fertile Crescent" (Diamond 1997: 110).

The third factor is an important stage in intensifying food production. Shortly after the end of the Ice Age, as the climate changed and the habitats of wild cereals expanded, the technology of hunter-gatherers in the area grew to help with the harvest of wild cereals.

> Those inventions included sickles of flint blades cemented into wooden or bone handles, for harvesting wild grains; baskets in which to carry the grains home...mortars and pestles, or grinding slabs...the technique of roasting grain so that they could be stored without sprouting; and underground storage pits, some of them plastered to make them waterproof (Diamond 1997: 111).

Accumulation of these developments in the Fertile Crescent after 11,000 B.C. constituted the unconscious beginnings of domestication.

A fourth factor is the two-way link between the rise in human populations and food production. "In all parts of the world where adequate evidence is available, archaeologists find evidence of rising densities associated with the appearance of food production. Which was the cause and which the result?" (Diamond 1997: 111). Food production does lead to greater population densities because it yields greater calories per acre. Human populations had been increasing throughout the last Ice Age and accumulations in food procurement technology helped to keep the population increase slow, but constant. These increases in population are believed to be one reason why plant cultivation was intensified. A higher yielding subsistence pattern is necessary to feed a larger population. Diamond noted that this creates an autocatalytic process that goes faster and faster once it has started. "A gradual rise in population densities impelled people to obtain more food, by rewarding those who unconsciously took steps toward producing it. Once people began to produce food and become sedentary, they could shorten the birth spacing and produce still more people, requiring still more food" (Diamond 1997: 111).

These four factors help explain why food production began when it did and where it did. Prior to the end of the Ice Age "wild mammals were still abundant; wild

cereals were not yet abundant; people had not yet developed the inventions necessary for collecting, processing, and storing cereals efficiently; and human population densities were not yet high enough for a large premium to be placed on extracting more calories per acre" (Diamond 1997: 112).

The fifth factor involved the clash between hunter-gatherers and agriculturists. Societies that adopted more intensive methods of food production received technological advantages over time. A surplus of food allowed specialists to devote time to developing technologies instead of food producing. Societies just introduced to agriculture either adopted some domesticated crops or refused to alter their lifestyle. Some societies may have chosen agriculture to remain independent from a more powerful neighbor. The societies that remained closer to hunting and gathering did not always manage to continue their ways of life. Especially when hunter-gatherers occupied prime agricultural land, intensive agriculturists have destroyed or driven off the hunter-gatherer populations. Although many nonviolent interactions probably occurred, the violent conflict over resources and differences in technological accumulation decided the question of agriculture.

Obstacles to Food Production in Australia

Food production had a few challenges from features of Australia's geology, climate, and geography. These environmental factors influence all of Australia's living things. For human beings, however, cultural choices and innovative responses to the environment also shape how people live. Once the obstacles to food production in

Australia are clear, the environmental modifications of the Aborigines take on a whole new light.

Climatic Variability

The climatic instability from ENSO (El Niño Southern Oscillation) is extremely taxing on agriculture. A year of plenty can be followed by a year of famine. Droughts sometimes last for several years, only to be ended with flooding. All of Australia is affected to some degree; life in the arid center becomes particularly hard. One particularly interesting fact about ENSO is that it remained unknown for so long. "It still seems quite extraordinary that such an influential determinant of our climate remained undiscovered by science for so long. Even today, there is still much that we do not understand about ENSO" (Flannery 1994: 83). The full impact of ENSO on the Australian environment is just beginning to be understood and new research will likely bring new discoveries. As Diamond (1997: 308) noted, "Even today, with Eurasian crops and with trucks and railroads to transport produce, food production in Australia remains a risky business." Diamond (1997: 308) also pointed out that "any incipient farmers in Aboriginal Australia would have faced similar cycles in their own populations."

Poor Soils

Another obstacle is the low nutrient levels of Australia's soils. In much of the country, the soil contains half the nutrients of similar environments on other continents (Flannery 1994: 78). Areas with recent (10 million years ago) geologic activity have relatively rich soil. These areas are located primarily in eastern Australia and constitute only a small portion of the continent. Overall low nutrient content in the soil would

predispose many areas against agriculture. Soil can be enriched through the addition of manure from large animals, but there are few large native Australian animals. One of the first Europeans to coax a crop from Australian soil was James Ruse in 1791. "Ruse, along with others who were experimenting with agriculture, complained of a problem from which Australian soils had been suffering for over 35,000 years, for they could find no animal dung with which to fertilise" (Flannery 1994: 348). Soil suitable for extended agricultural use is in short supply in Australia, and certainly would have discouraged early agriculturists.

Isolation

An examination of Australia's geography shows its isolation from other land masses. This isolation was less during glacial periods when much of the world's water was locked in glaciers and Australia was connected by emergent land bridges with Tasmania and New Guinea. This larger continent exposed during glacial periods is referred to as Sahul. Around 11,000 years ago when sea levels rose, Australia became isolated again when its land bridges were flooded. New Guinea and Tasmania were once again separated from Australia and although islands were interspersed in the water gap between New Guinea and Australia, Tasmania was truly cut off. Violent southern waters make the water gap between Australia and Tasmania particularly hazardous, especially considering the somewhat rudimentary seafaring technology of the people inhabiting both sides of the water gap, Bass Strait. Australia's isolation kept them from nearby islands until seafaring improved as evident in the Austronesian expansion that began in Southeast Asia, when seafarers spread throughout the Pacific over the past 3,500 years. These

people possessed agricultural domesticates such as the pig, dog, taro, yams, and coconuts, which they carried throughout the Pacific. They had the seafaring technology to sail to Australia, having reached the islands of New Ireland and New Britain off the New Guinea coast, but no archaeological evidence of an Austronesian presence in Australia has ever been found.

Outside Influences

Australia's isolation and contact with outside cultures is important for understanding what technologies were brought to Australia and how these were accepted or rejected by the Aborigines. The first important fact about outside contact is that prior to European contact, most contact occurred along the northern coast of Australia. The northern coast is the closest to significant land masses where outside technologies most likely would have come from. This could mean that rejection of outside cultural innovation by Aboriginal groups living in the north prevented any of these innovations from diffusing to the rest of the continent. The possibility that Aboriginal groups could have rejected outside ideas comes from two major factors.

The first is recorded hostility from Aborigines toward Macassan fishermen from the Indonesian island of Macassar who established settlements on the northwest and northern coast of Australia. This fishermen were after trepang, or sea slugs, which were "exported...to China, where they were highly valued for making soup and as an aphrodisiac" (Flood 1995: 258). Historical records from Indonesia tell of hostility from the Aborigines and the occasional massacre of an entire prau crew (prau are the Macassan fishing vessels). The initial actions of the Macassan crews are not given, and the contacts

between these two cultures were not always violent: "at times, relations were friendly, and the Aborigines even travelled overseas to Macassar on praus" (Flood 1995: 258).

The second factor includes areas where trade was conducted with outside groups. Between New Guinea and the Cape York Peninsula, the Torres Straits is dotted with small islands, all of which support small populations, several of which even have some form of agriculture. This contact was important for two reasons: it highlights the trade between Australian cultural groups and the people inhabiting the Torres Strait islands, and second, it is context for contact with agriculturists. Trade between Torres islanders and people inhabiting the Cape York Peninsula highlights one important cultural decision. "The bow and arrow were in use in every inhabited continent except Australia during the post-glacial period. It has usually been assumed to be a more efficient hunting and fighting weapon than the spear, but in the case of Australia, at least, this assumption would appear to be wrong" (Flood 1995: 257). Flood explains how spears and spear-throwers were considered as superior weapons for hunting and fighting by the Aborigines of the Cape York Peninsula. Bow and arrow technology existed on the Torres Strait islands, yet spears and spear-throwers were eagerly sought after in the islands closest to Australia. The Aborigines considered spears to be a superior weapon in that area and therefore did not need to adopt the bow. Other cultural innovations were accepted by Aborigines, however, like the dingo.

The dingo was introduced to Australia around 3,500 to 4,000 years ago, when dingo bones first appear in the faunal deposits in archaeological sites (Flood 1995: 221). The dingo is now found throughout most of Australia and was used extensively by

Aborigines, both as a companion and hunting tool. The importance of the dingo, and the rejection of certain other innovations, points to the Aboriginal cultures being very selective, taking what was most useful or most appealing from overseas, but rejecting other practices (Flood 1995: 257).

Food Storage

Another challenge to food production is problems with food storage in Australia, where high temperatures and risk of occasional flooding make food storage unpredictable (Flood 1995: 263). One necessity of an agricultural subsistence pattern is the ability to store surplus harvest for times when the weather will not support a crop. The weather of the Australian continent has made this extremely problematic. Early Europeans were hard pressed to preserve meat longer than a few hours even with their technologies of salting, drying and curing (Flood 1995: 263). In some areas, problems with food storage most likely made the transition to food production far less appealing.

Lack of Domesticates

The last factor mentioned in the development of food production is the lack of suitable species of plants and animals for domestication. Tracing the rise of food production, Diamond (1997) noted an important characteristic of areas where food production originated independently. This characteristic is the size of wild cereal grains in different parts of the world. Out of 56 large seeded grass species, 33 of those species' wild ancestors occurred in West Asia, Europe, and North Africa. "The 56 wild grass species with the heaviest grains include only two Australian species, both of which rank near the bottom of the list (grain weight only 13 milligrams, compared with 40 milligrams

for the heaviest grains elsewhere in the world)" (Diamond 1997: 309). Even modern science, which is capable of determining the genes responsible for domestication in a species, has been able to produce only one domesticate from Australia's flora and fauna, and that is the Macadamia nut. Not only did Australia lack plants that could be domesticated, it also lacked animals suitable for domestication.

No large mammals that were domesticated elsewhere existed in Australia. Pigs, cows, sheep, goats or chickens were all absent from Australia's fauna until introduced with the arrival of Europeans. "The question of the possible domestication of Australian mammals is easily answered: there were no native marsupials suitable for domestication" (Flood 1995: 258). Diamond noted the importance of large domesticated mammals to food production. Large mammals offer excellent fertilizer for fields, supply labor to till fields and transport goods, are a source of food (both meat and dairy products), and can even offer a military advantage as horses did for many Eurasian civilizations.

All of these obstacles made food production a much riskier business in Australia than in other parts of the world. These obstacles are important to consider, but they are not the only consideration for the question of food production in Australia. The environmental modifications and subsistence strategies that Aborigines developed show the result socio-cultural forces can have on a culture. A discussion of these subsistence strategies and modifications will show just how aware of their environment the Aborigines were, and how complex their cultures are.

Environmental Modifications

An examination of food production in Australia has numerous approaches and different factors have been discussed. This section discusses the most complex factor, the socio-cultural forces of groups in a particular area. The adaptations of individual cultural groups to their environments were as diverse as the number of cultures in the world. The Aborigines modified their environment to facilitate food gathering, hunting, and a generally easier way of life. These can be seen in various plants such as cycads, yams, and fruit trees, as well as methods like eel farms, bogong moth collecting, fire stick farming and grass seed harvesting and processing.

Fire Stick Farming

One of the most significant modifications was fire stick farming. Aborigines used fire to modify the environment on a large scale, and this burning shows a deep understanding of the ecology of the Australian country. The Aborigines used fire to alter the landscape to their advantage. Dates from lake cores show high levels of charcoal in the lake sediments, suggesting burning was a practice that began more than 30,000 years ago (Flood 1995: 284). After controlled burning, pathways were kept clear through areas with extensive dense scrub and grasses. Burning kept down the undergrowth and limited the poisonous snakes that lived in that undergrowth. It was used for hunting, both to smoke prey out of the grasses where they could be clubbed, or to lure animals into the open to eat young shoots after a burn. The ashes acted as fertilizer and the frequent burning encouraged the growth of edible plants. The most impressive thing about fire stick farming is that the burning was kept at a low intensity to consume the undergrowth

but not the trees. The benefit can be seen when after the arrival of the Europeans Aboriginal ways slowly disappeared, including controlled burning. After several decades there were huge uncontrollable fires that threatened several major cities. Now the Australian government allows Aborigines to burn in areas to keep fire danger low. "Through [fire's] judicious use, they wrested their daily meat and bread from an otherwise ungiving land, they fought their enemies and expelled their pests" (Flannery 1994: 217-18).

Cycads

One modification was the processing necessary for consumption of the *Macrozamia*, "the most specialized and sophisticated of all the economic systems [in Australia]" (Flood 1995: 237). The *Macrozamia* is a type of cycad, a fern-like plant that produces unique, pineapple-like reproductive centers called "stromboli" that are brightly colored and extremely poisonous. Recently cycads have been found to contain one of the most powerful cancer-causing substances in the world. Aborigines, however, found that with proper preparation cycads could be a great food source. Two methods were used to remove the poison. "One technique was to cut open the kernels and leach out the poison with water...Another approach was fermentation, in which the dissected kernels were placed in large containers or pits for several months. The material was safe to eat when the kernels have either frothed or grown mouldy" (Flood 1995: 238). This proved to be a great food source since "about 43 percent is carbohydrate, 5 percent protein. Many species produce huge quantities of kernels, yielding more food per hectare

than many cultivated crops. Aborigines also increased the size of cycad stands by a careful use of fire to clear competing vegetation" (Flood 1995: 238). The leaching of poison to add another food source is a wonderful example of the Aborigines' ingenious modification of their environment.

Yams and Fruit Trees

Yams were one of the main food staples in Northern Australia. Flood outlines two of the "semi-agricultural" practices carried out by cultural groups in Northern Australia, cultivating yams and fruit trees. Yams were grown and harvested in ways that could almost constitute agriculture. Among the Anbara Aborigines, "when yams were dug out, the top of the tuber was left still attached to the tendril in the ground so that the yam would grow again" (Flood 1995: 259). On the eastern Cape York Peninsula, vines were marked as a sign of ownership. "Yams were also planted on offshore islands to extend their distribution and to ensure a 'reserve' supply" (Flood 1995: 259). This practice is much closer to agriculture than it is to gathering. Flood states the important point that although true agriculture would have a higher yield per plant, much more work would have been involved in tilling the ground.

Cultivating fruit trees was the other semi-agricultural practice of the Anbara. Fruit tree seeds were deliberately spit into debris and refuse pits at the edges of a camp. The decaying matter around these refuse heaps created a rich environment for tree growth, and within a few years the camp site would be well supplied with fruit trees. "Indeed, there is a consistent association between old camp sites and trees with edible fruit. This meant that stands of native fruit trees can be used by archaeologists to discover prehistoric

sites..." (Flood 1995: 260). Cultivating fruit trees and yams is more closely related to agricultural practices than to hunting and gathering practices.

Eel Traps

Eel traps were used in the swamps of southwestern Victoria. Flood (1995) stated that the fertile coastal plain of southwestern Victoria is intersected by a network of small, perennial rivers, swamps, and wetlands. Rainfall occurs mainly in the autumn and winter and used to turn vast sections of land to marsh. Thus there were extensive wetlands each autumn, the main eel fishing season, and elaborate canals and traps were constructed to catch the eels during their migrations. These eel traps were an amazing display of engineering and recognition of the local water systems. "The Aboriginal fishermen understood the hydrology of the lake perfectly. They designed and constructed an ingenious system for catching the maximum number of eels with minimum effort" (Flood 1995: 242). Considerable labor was needed to initially dig the canals, but once completed the traps would have needed no more than twenty people to operate. "The sophisticated network was so cunningly designed that it took advantage of both rising and falling water. Traps were built at different levels, and as the lake rose or fell, different traps came into operation progressively" (Flood 1995: 242). This engineering feat was a very productive method of food production.

Bogong Moths

Using bogong moths as a major food source does not sound appetizing to many Westerners. "Each year these moths migrate in their millions from their breeding grounds on the inland plains to spend the hot summer [in the mountains] of Australia" (Flood

1995: 239). These moths form a great food source during this time when they hibernate. The moths have a high protein content, "and can be eaten by the kilogram for breakfast, lunch and dinner with no ill-effects" (Flood 1995: 240). The moths swarm together in rock crevices, covering the walls of caves and cool, dark places. "As many as 14,000 have been observed on 1 square meter of rock wall" (Flood 1995: 239). The moths were collected by scraping them off the walls and then they were cooked on a rock that had been heated by a fire. The heat burned off everything except the abdomens, which were eaten. "Moth feasts were the occasion for great gatherings of different friendly tribes" (Flood 1995: 239). The large accumulation of hibernating moths in the highlands was a food source used by many groups to feed the large numbers of people involved in ceremonial gatherings.

Grass Seed Harvesting and Processing

The last method of food production I will discuss is the intensive use of grass seed as a food source in several areas of Australia. Grass seed appears to have been most important in the arid center of Australia. "In better watered areas in the north and around coasts, the fruits, nuts and tubers of plants provided the main vegetable food rather than seeds" (Flood 1995: 260). Two areas have produced evidence of relatively intensive grass seed harvesting: in eastern Australia's Darling River basin and in western Australia between the Tanami and Great Sandy deserts. These areas are both arid, the site in western Australia being much drier. The grass species harvested were not domesticated in any way; this proved to be problematic because the grain ripens unevenly. In the Darling Basin, "Bagundji [Aborigines] cleverly overcame this problem by gathering the grass when

the seed was full but the grass still green. The grass was then stacked in heaps and the seeds left to dry and ripen, when they were threshed so that the seeds all fell to the ground in one place" (Flood 1995: 260). Areas where grass seed was harvested can be seen in the archaeological record, with distinctive stone tools used for seed processing. Stone knives with "use-polish" from cutting grass stalks and millstones for grinding seed are the most common artifacts at such sites. For the Darling River basin, grass seeds were a food source exploited in spring and summer as the resources of the Darling River dwindled. In Western Australia, grass seed was an important food source, but required fairly large inputs of labor to use.

> The proportional distribution of grindstones is therefore consistent with the ethnographic evidence indicating that seed processing was a time-consuming and arduous task, and that the effort required for processing made it unprofitable to travel great distances to collect seeds. It is also consistent with the interpretation that in the normal course of events seeds were not used as an important resource unless large quantities of easily gathered seeds were readily available at sites (Cane 1989: 117-18).

Food production involving grass seed exploitation is of great importance because of the role the harvesting of wild grains had in other parts of the world. If grass seed harvesting existed in Australia then perhaps agriculture was not far behind in the list of innovations to come.

Summary and Conclusions

Examining the factors involved in subsistence patterns in Australia and the lack of agriculture has been quite complex. Archaeology does not always give a complete picture of what happened in the past. Although much is discovered through archaeology, many

debates still exist surrounding important issues. In this paper I have summarized and discussed many of the most important factors involved in the lack of agriculture in Australia.

Food production in Australia had two unique forces operating on it, limitations posed by the environment and the socio-cultural forces of the different groups living in Australia.

The environment affected much of Australia's life. Australia's past allowed unique populations of flora and fauna to survive on an extremely ancient and nutrient-impoverished land. Climatic variability in Australia, due to ENSO, also shaped Australia's life. Although these forces shaped much of Australia's flora and fauna, the Australian Aborigines exerted their own influence on the land.

Australia's Aborigines created unique environmental modifications that displayed an amazing ingenuity. Stereotypes of Aborigines as "too primitive" to understand agriculture are ridiculous. It is clear that the Australian Aborigines understood their environment very well, and modified it in a variety of ingenious ways for easier living. Archaeological evidence also demonstrates that Australian Aborigines attained a series of technological milestones, including the earliest evidence for seafaring, cremation burials, ground stone axes, and some of the earliest and most elaborate artistic traditions.

Considering Australia's soil and climatic variability, agriculture is potentially productive only in the few fertile areas. The labor involved in tilling the soil alone made agriculture unprofitable in terms of food energy gained for the energy expended. No area in Australia had agriculture until the Europeans brought temperate crops and animals from

other continents that would flourish in the small temperate areas of Australia. No cultivators from nearby land masses established agriculture for the Aborigines to see and learn about. The Aborigines saw some of the products from agricultural societies like trade items, but it is doubtful that any Aborigine saw full-scale agriculture. The Aborigines were selective with the technologies they adopted, and it is possible that agricultural processes were seen but believed to be inferior or unworthy of the extra effort.

Two important considerations on this perspective are the technology involved in food production and the effort spent looking for agriculture. Ground stone axes were a technological innovation that occurred shortly before the advent of domestication in all other parts of the world (Flood 1995: 283). Their extremely early appearance in Australia suggests that the advent of domestication could have been the next innovation. This is related to the second consideration of whether anyone has yet looked for agriculture in Australia. Since the Aborigines have been hunter-gatherers in historic times, the assumption exists that they must have been hunter-gatherers in prehistoric times. The difficulty of finding early evidence of cultivation relates to the necessity of finding genetic change in crop plants to show human domestication. Cultivation without domestication is virtually invisible in the archaeological record, and thus the possibility exists that early cultivation occurred in Australia but has been overlooked.

I think agriculture was not absent from Australia, but merely came in a different form. By definition, agriculture did not exist, but the intensified food production the Aborigines initiated in each area attests to their superb understanding of the environment. Agriculture was not a successful venture in much of Australia, meaning it produced little

more energy than it took to maintain. Climatic variability and problematic food storage made agriculture that much more difficult. The subsistence patterns of the Aborigines were an adaptation to that environment and better suited to that environment than agriculture. In the areas where grass seed harvesting took place, agriculture might have developed in time. European contact forever changed the course of Australia's human history, and whether agriculture would ultimately have developed is simply theory.

Hunting and gathering is often considered "simpler" or more primitive than agriculture. This view, however, misses the multitude of subsistence patterns that exist between the two ends of the continuum. A closer examination of the hunting and gathering practices of Australia's Aborigines shows much more complex technology than just "hunting" or "gathering." The complexity and ingenuity of these people should be appreciated and these environmental modifications should be seen for the complex technologies that they are.

Most important of all, prejudiced characterizations of a people as primitive or simple should not be tolerated. Archaeology tells us that the Aborigines survived in an often harsh and unpredictable land for at least 50,000 years. Over the millennia they not only survived but thrived without damaging the environment to even a fraction of the extent that European cultures have caused in a little over 200 years. The Australian Aborigines have experienced untold hardships simply for this reason. Perhaps even a first-world country like the United States could learn something from hunter-gatherers. Since its advent, agriculture has taken humans down a steep path on which we walk faster and faster. Agriculture must continue as our subsistence pattern; nothing else can suffice now.

But the path we walk down should be better understood, and not simply assumed to be the "right" or "civilized" one.

Works Cited

Cane, Scott. "Australian Aboriginal seed grinding and its archaeological record: a case study from the Western Desert." *Foraging and Farming: The Evolution of Plant Exploitation*. Eds. Harris, David R. and Hillman, Gordon C. London: Unwin Hyman, 1989.

Cohen, Mark Nathan. *Food Crisis in Prehistory*. New Haven and London: Yale University Press, 1977.

Diamond, Jared. *Guns, Germs, and Steel*. New York and London: W. W. Norton & Company, 1997.

Ellis, Robert. *Aboriginal Australia: Past and Present*. Gladesville, N.S.W.: Shakespeare Head Press, 1984.

Flannery, Tim. *The Future Eaters*. New York: George Brazeller, 1994.

Flood, Josephine. *Archaeology of the Dreamtime*. Rev. ed. Australia: Angus & Robertson, 1995.

Harris, David. "An evolutionary continuum of people-plant interaction." *Foraging and Farming: The Evolution of Plant Exploitation*. Eds. Harris, David R. and Hillman, Gordon C. London: Unwin Hyman, 1989.

Lourandos, Harry. *Continent of Hunter-Gatherers*. Cambridge: Cambridge University Press, 1997.

The World Book Great Geographical Atlas. Chicago: World Book, Inc., 1982.