SUSTAINABILITY FACTORS IN THREE PRE-COLUMBIAN AGRARIAN SOCIETIES OF THE AMERICAS AND PRESENT DAY IMPLICATIONS

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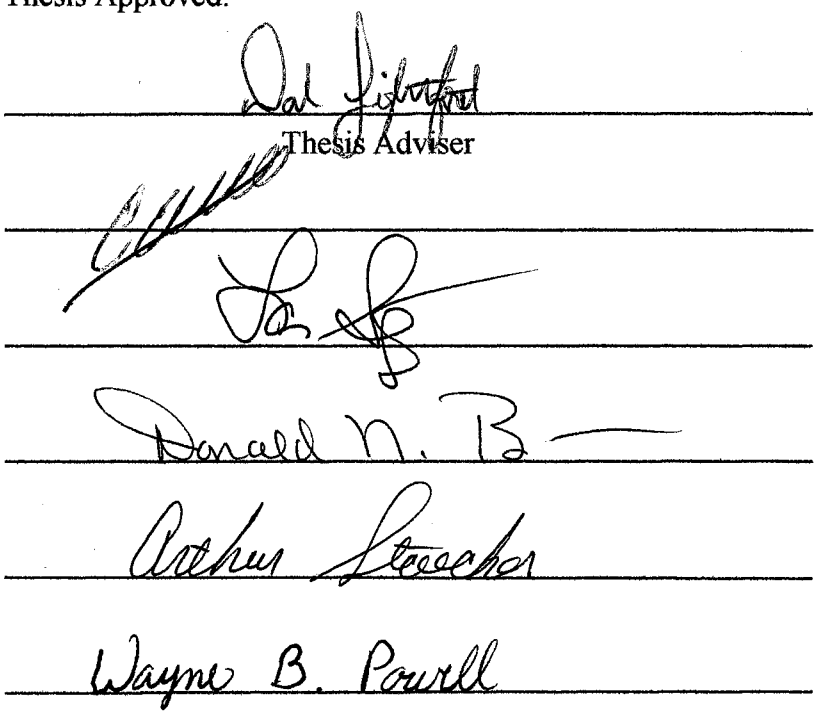

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PREFACE

This research was conducted to provide new insights into the characteristics and conditions responsible for the stability and continuity of three pre-Columbian agrarian societies of the Americas. The work focuses on three ancient cultures that exhibited extended periods of sustainability in markedly different environments. A secondary purpose of this study is to identify contemporary applications of these ancient sustainability insights.

A decision key was crafted for the purpose of ranking ancient factors of sustainability that were identified for the three selected cultures as essential, major, or minor. A formula instrument was constructed to produce an overall numerical sustainability score for individual societies during particular time periods. The formula instrument generated a sustainability score for each of the selected societies during two different developmental periods. A number of conclusions and recommendations were made by the researcher concerning ancient sustainability and the modern applications of some of the uncovered factors.

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CHAPTER I

INTRODUCTION TO THE STUDY

Throughout history, man has assembled resource systems to meet his physical needs and many factors have influenced the stability of these systems. Agricultural productivity and durability, natural resource availability, level of technological innovation, and social organization are some examples of factors that have helped determine the long-term fate of ancient societies. Ironically, the most deleterious element affecting contemporary resource system sustainability may be man himself (Chiras, 1994). Inefficient production methods, substantial waste, and serious pollution continue to compromise the ability of man to meet future needs. Human population has increased from 1 billion in 1850 to over 6 billion today (Brown et al., 1999). This unrestricted growth rate, which continuously increases demands placed upon resource systems, not only affects local areas as in the years prior to 1850, but has grown to affect regional and even global stability. Although ancient societies did not possess the high population growth rates of contemporary civilization, local carrying capacity restrictions undoubtedly affected the level of prosperity over time of these slower growing early cultures.

Long-term, broad-based, contemporary prosperity depends upon the adaptation of a redesigned resource strategy (Hawken, 1993). Modern efforts to devise sustainable resource systems have thus far evolved primarily from contemporary ideas and theory. However, another possible source of sustainable design insights may lie in the past. A number of ancient agrarian societies maintained a stable and prosperous life style for

many centuries. A review of the literature yields only a limited aggregate of research that identifies and examines recurring factors that enabled past agricultural societies to prosper over extended periods of time. The occasional references only briefly discuss the characteristics and conditions that enabled agrarian cultures to continue to thrive. Only during periods of ancient society collapse have researchers sought detailed explanations for the downfall, and many of these scenarios are still inconclusive. The author believes another useful and appropriate research direction is an in-depth investigation of stability and continuity factors for ancient agrarian societies.

An understanding of these repetitive factors of stability throughout pre-history may prove particularly useful to modern society. The strategy of this dissertation includes the identification of stabilizing innovations and conditions from the past. Using a qualitative historical research approach, key environmental factors and cultural components of three durable and persistent societies of ancient America will be identified. These factors will be subjectively ranked according to their contribution toward stability and then used to craft a research instrument that will effectively calculate pseudo-quantitative scores that are representative of the overall ability of ancient agrarian societies to sustain themselves during specific time intervals.

The identified sustainability factors of three past societies will then be applied within a contemporary context. Present-day agriculturally based societies will be examined to identify the prevalence of these ancient sustainability characteristics. This comparison will provide insights into the nature of contemporary sustainable living systems and may suggest useful adjustments for the structuring of a successful modern sustainable civilization. However, a modern application of these commonalities will be

ancillary to the primary focus of researching the sustainable foundations of the three selected pre-Columbian societies of the Americas.

Background of the Study

This dissertation focuses on the sustainability of ancient agrarian societies of the Americas; specifically, common factors of stability and continuity among three pre-Columbian cultures. This chapter provides a background for this research by first introducing the three focus societies and their physical regions of habitation. Next, the purpose, assumptions, and limitations of this study are introduced and discussed. Last, summaries of each chapter of this work outline the overall organization of this qualitative pre-historical dissertation.

Three Pre-Columbian Societies

The three societies selected for this research are the Maya of Central America, the Moche of northern coastal Peru, and the Mogollon of Arizona, New Mexico, and north central Mexico. The selection of these cultures was influenced by four primary factors. First, these pre-Columbian societies utilized agriculture to meet a major portion of their nutritional needs. Agriculture was a unifying characteristic for these cultures and continues to be a major component of contemporary societies, thereby providing an important link between ancient and modern cultures. Second, each these of societies were located in North, Central, and South America; they were geographically isolated and, to a lesser extent, temporally isolated so that social intercourse was undoubtedly minimal. Although each of the selected cultures was located in the Americas, their

isolation provides distinct and separate societies for this investigation. Third, archaeological evidence suggests that consistent levels of prosperity were maintained for a minimum of 600 years by the Moche, for over two millennia by the Maya, and for more than 1000 years by the Mogollon. Clearly, each of these cultures demonstrated the ability to sustain effective long-term resource acquisition and management. Fourth, extensive primary and secondary research has been conducted and published on each of these three cultures, providing considerable anthropological information and discussion for use in this research. The selection of the Maya, Moche, and Mogollon will provide the requisite volume of research data to complete this project.

The Maya

The Maya Pre-classic period began approximately 2000 B.C. when this culture occupied the Guatemalan Highlands and Pacific Coast, through Oaxaca and the Veracruz-Tabasco lowlands. This Pre-classic period lasted until nearly A.D. 250 and included the development of pottery, religion, and intensive agriculture. The first Maya farming village settlement did not appear until approximately 1000 B.C. The inception of the Maya Classic period began approximately A.D. 250 and lasted until A.D. 950 in present-day southeastern Mexico, Guatemala, Belize, and northern Honduras (Figure 1). The Classic period is divided into the early Classic, A.D. 250-600, and the late Classic, A.D. 600-950 and included the development of written language, a social class of political/religious elite, and monument architecture (Culbert, 1973).

Figure 1. Maya Territory Map

This dissertation focuses on the time period in Mayan history from 1000 B.C. until A.D. 950. As mentioned earlier, 1000 B.C. marked the first appearance of village settlements in Maya development. Large ceremonial centers, monument art, and other traits of a more complex society were soon to follow. This was a time of class distinction and the accumulation of material goods, as well as a time of cultural stability and effective trade networks throughout Mesoamerica. During this period, the Maya civilization approached a state society, but many anthropologists still consider it a chiefdom (Culbert, 1973).

This time period was selected for this study for two reasons. First, this era includes the beginning of urbanization with simple village life progressing to complex labor specialization and redistribution of wealth by an elite class. Food production by the

rural farming population supported a growing segment of non-farming Maya specialists much in the same way as in contemporary industrialized nations. Sustainable resource system factors identified during this period may have potential for application to modern urbanized society. Second, this is a long and stable time period for Maya society in which cultural components changed minimally and population growth rates rose very slowly (Culbert, 1973). During the period between 1000 B.C. and A.D. 600, Maya systems of resource acquisition and utilization demonstrated exceptional consistency and reliability.

The Moche

The Moche lived along the river valleys of the arid northern coast of present-day Peru from A.D. 150-750 (Figure 2). Anthropological evidence shows that this society maintained a relatively high standard of ancient living by utilizing ceramics, cotton, fishing, metallurgy, and agriculture with innovative irrigation techniques during this period. Archaeological research reveals an adaptive, opportunistic resource system that met the needs of the Moche consistently throughout most of this 600-year period. Interestingly, the Moche did not disappear in A.D. 750; rather, their descendants became part of the huge Chimù state, the largest political unit in the Andes prior to the Inca Empire (Bawden, 1996).

A number of important characteristics of Moche culture influenced their selection for this study. Throughout their existence, the Moche lived in villages and towns along the river valleys of northern coastal Peru, and worked as fishermen, farmers, craftsmen, builders, traders, and transporters. Theocratic leaders organized the development and

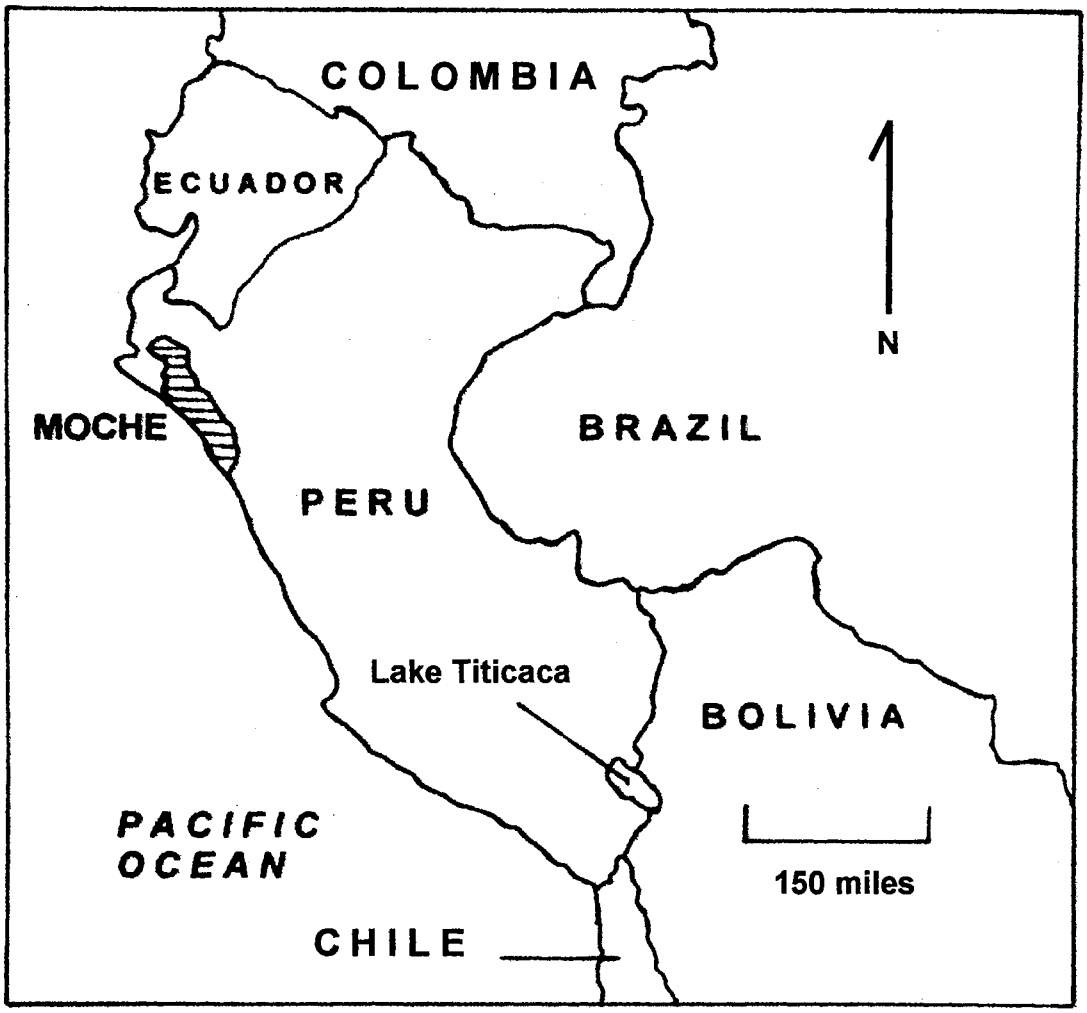

Figure 2. Moche Territory Map

maintenance of their innovative system of irrigation canals from these Andean-fed incised rivers out into the adjacent arid lands. Irrigation agriculture dominated their food acquisition system as Moche farmland expanded into more and more of the previously dry Peruvian desert. As with the Maya, the Moche grew to depend upon agriculture to feed their growing non-farming population of elite leaders and occupational specialists. Although generally not considered a state level polity until their final chapter of existence, the Moche society incorporated at least three levels of stratification,

sophisticated public works projects, and an economy based on the redistribution of wealth. The Moche demonstrated reasonably consistent resource acquisition and management for more than six centuries and this success may also have potential for application to modern urbanized society.

The Mogollon

The Mogollon were a people who lived in the mountains and high plateaus of east-central and southeastern Arizona, southern New Mexico, and northern Chihuahua, Mexico from A.D. 200 - 1400 (Figure 3). This culture is thought to have developed out of the early Cochise people who previously inhabited the Mogollon homeland for at least five millennia (Martin, 1959). The Mogollon not only farmed, but also hunted and gathered extensively, built simple homes, made and used pottery, and accumulated a minimum of material possessions.

Throughout their extended existence, the Mogollon were remarkably adaptive and flexible in their acquisition of resources. They took advantage of many different opportunities of their southwestern high-country environment. They had utilized maize before the Anasazi but did not come to depend upon this cultivated crop until late in their history. They often moved to take advantage of the natural food sources found throughout their mountain homeland. This practice spread their risk between different food sources and was no doubt a factor in their durability as a southwestern culture. They adapted a number of advantageous cultural innovations of neighboring societies such as the bow and arrow and the cultivation of cotton. Although the Mogollon did not achieve the level of societal or technological development of the Maya or Moche, they

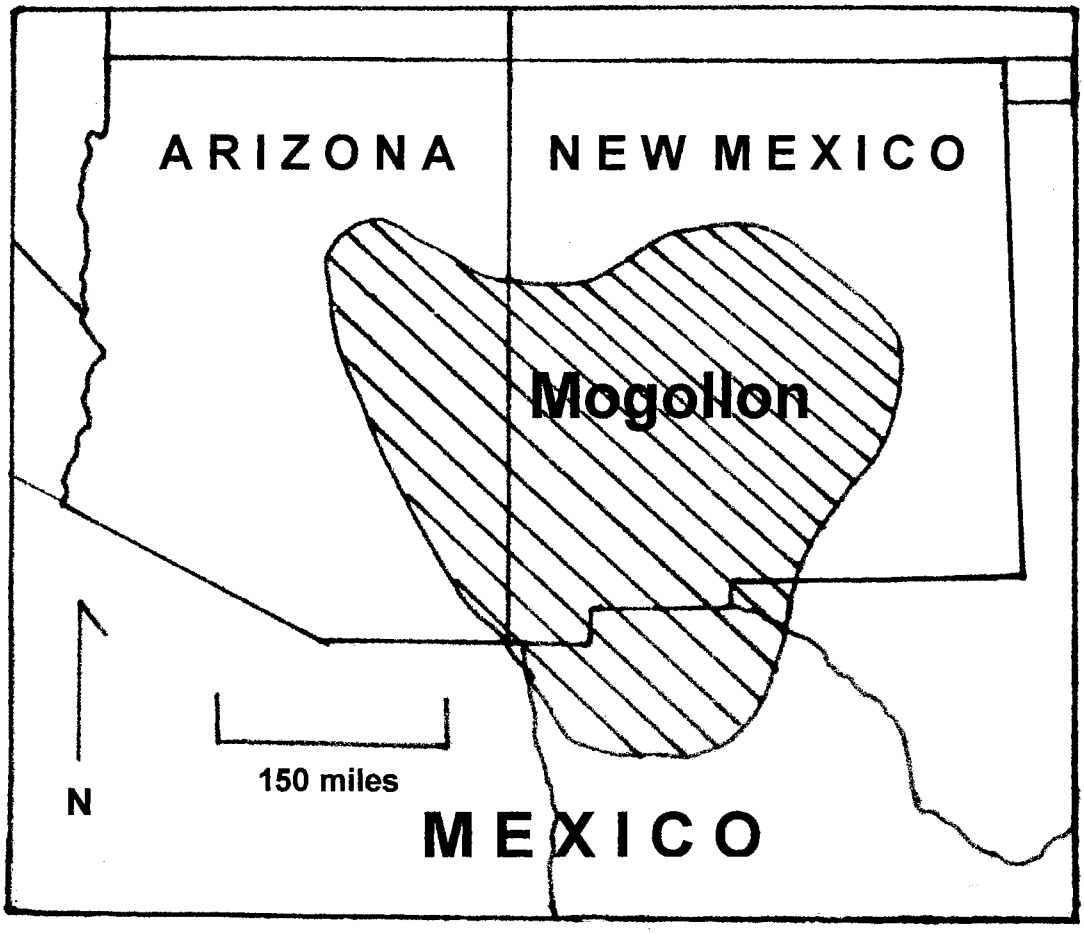

Figure 3. Mogollon Territory Map

did possess other characteristics that led to their selection for this research, including an adaptive and diversified resource system as well as stable population numbers for more than a millenium.

The Maya, Moche, and Mogollon cultures represent a wide range of social development including state, chiefdom, and tribal polities. Agriculture played a major role in food acquisition, settlement patterns, and the relatively consistent prosperity levels during much of the tenure of these societies. Each of these cultures utilized the opportunities offered by their three geographically isolated environments to establish

resource systems that sustained their people for many centuries. The following section provides an overview of the physical environment of each society and the natural processes that affected the development of the various components of these cultures such as agriculture, settlement and social patterns, and religion.

The Three Regions of the Research

The Maya Homeland

The territory of the Maya encompasses the southeastern portion of Mesoamerica, a geographically diverse region that extends from northern Mexico into Middle America. The present-day nations of Mexico, Guatemala, Belize, and Honduras claim the major archaeological sites of the Maya homeland. A wide range of biomes exist including mountains, desert, tropical rainforest, and tropical shrub forest, and this region is generally divided into the coastal plain in the south, the highlands in the center, and the lowlands of the north.

The coastal plain has a tropical climate with two distinct seasons each year: a dry period from January through April, and a rainy season during the remaining months, with an average rainfall of 80-120 inches per year. Mixed oak and pine forests along with stands of remnant rainforest dominate the natural vegetation. The mangrove swamps and lagoons along stretches of this Pacific Ocean coastline provided the ancient Maya with a wide variety of plant and animal resources. The rich alluvial soils in the flood plains of the rivers also provided productive land for a variety of agricultural crops.

The highlands include interior lands over 1000 feet in elevation with a series of active and dormant volcanoes from the southeastern Mexican State of Chiapas through

Guatemala, Honduras, Belize, and El Salvador. Deep deposits of lava and ash that have weathered into a highly variable landscape with deep valleys and high ridges cover these highlands. North of this long cordillera are more igneous and metamorphic bedrock with rolling topography that supports oak forests in the ravines as well as pines and grasses on the hilltops. These highlands are rich in many resources that were important to the ancient Maya including jade, obsidian, serpentine, and granite for grinding stones. Fertile volcanic soils are another resource of the highlands that was utilized by the ancient Maya throughout much of their existence. These volcanic highlands, particularly in the south, also subject human populations to periodic violent volcanic eruptions and severe earthquakes (Sharer, 1996).

The rainy season in the highlands begins in May and usually lasts through October, with an average annual precipitation of 70-110 inches. In the mountain areas above 2500 feet, the climate is generally mild throughout the year with the west side of the cordillera watershed receiving more rainfall than the rain-shadowed eastern slopes. Some of the major highland rivers include the Usumacinta and Grijalva of Chiapas, the Negro, Montaqua, and Saleguar of Guatemala, and the Sarstoon and Belize shared by Guatemala and Belize.

Moving northward out of the highlands, the landscape slowly changes into rolling hills underlined by limestone. The land below 2500 feet elevation exhibit a number of microenvironments determined by local variations in rainfall, topography, and soil type. Annual rainfall in northwestern Yucatan is less than 20 inches, while precipitation in the southern lowlands averages near 120 inches. A number of freshwater natural lakes are found north of the Usumacinta River and the Petén basin of Guatemala. The soils of the

Petén are fairly deep, up to three feet in some places. Yucatan soils, however, are much thinner and tend to harden when exposed to the searing summer sunlight.

Tropical forest is the most common biome type of the lowlands and features mahogany, sapodillas, breadnut, and ceiba trees that form much of a closed vegetative canopy. A wide variety of fauna are found in these forests and the ancient Maya no doubt supplemented their diet by hunting some of the more numerous forest species, such as the jaguar, ocelot, jaguarundis, pacas (large rodents), tapir, deer, rabbits, and various bird and reptile species.

In contrast with the southern lowlands, the soils of the northern lowlands are thin and shallow, and possess a landscape underlined with porous limestone that allows very few flowing rivers or standing lakes. Rainfall diminishes in the north and western portions of the lowlands. Cenotes, or limestone sinkholes, are occasionally found throughout the northern lowlands with depths varying from three or four to several hundred feet, and these sinkholes were utilized as a source of freshwater by the northern lowland Maya.

The Moche Homeland

Two distinct ecological zones characterize northern coastal Peru: the long and relatively narrow coastal desert that runs the length of Moche territory and the deeply incised river valleys that meander from the Andes Mountains across the desert to the Pacific Ocean. This narrow desert plain averages approximately 50 kilometers in width and is composed of calcareous sandstone and light gray sand driven by southeasterly winds. The Moche homeland lies south of the equator between 5° and 10° latitude, which exhibits a high, intense sun in typically clear skies. The daytime is typically hot and the

night generally cold and the average annual temperature is 64° Fahrenheit (Bawden, 1996).

Some of the xerophytic desert flora include carob trees, yucca plants, and various species of cacti. The fauna of this arid land are limited but do include numerous arthropods, reptiles, and even one species of nocturnal desert fox. Sand dunes formed by the prevailing winds sometimes offer protection to both plant and animals from the intense wind and sun. The coastal Peruvian desert is one of the most arid in the world and life is tenuous at best for most species found in this dry land.

Perhaps the most significant environmental influences on the coastal desert plain are the waters and breezes of the Pacific Ocean, specifically the cold Humboldt Current, which flows up from the South Pacific Ocean, along the Chilean and Peruvian coasts, and then westward near the equator. The easterly trade winds are cooled by these waters and then warmed by the hot desert landmass. These winds deliver a dense fog to the coastal desert between May and November but rarely any precipitation. The cold Humboldt Current also provides the Peruvian coast with some of the richest marine fisheries anywhere in the world. The upwelling of these cold, deep waters along the South American coast brings bottom-dwelling plankton to the surface that attract large schools of feeding fish. This marine fishery resource was exploited by most societies of coastal Peru, including the Moche.

Additionally, the small, barren islands located near the coast of northern Peru were used as rookeries for many different species of sea birds and waterfowl, and they subsequently accumulated vast quantities of guano, a potential fertilizer for Moche agriculturists. Both Bawden (1996) and von Hagen (1964) believe that the Moche

regularly traveled to these islands and transported large quantities of this guano back to their river valley farm fields. Although this type of operation would have been labor intensive, these islands had virtually an unlimited supply of this natural fertilizer and would have significantly improved the fertility of intensely farmed desert soils.

The river valleys that meander across this harsh coastal desert offer an attractive contrasting environment for biotic habitation. Moche territory includes the 12 semi-tropical/temperate river valleys of northwestern coastal Peru from the Piura River in the north to the Huarmey River in the south. The physical features and agricultural capacities of these valleys differ significantly from location to location. The amount of arable land available for irrigation in each river valley generally decreases from the north to the south. Rivers in the south also exhibit a lower flow rate than do the northern rivers, which limits the irrigation potential for the southern river valleys (Bawden, 1996). The north coast river valleys, separated from each other by varying expanses of desert, are alluvial-rich and fertilized periodically by seasonal flooding.

Some of the typical vegetation of the river valleys were willow trees, vega, a tall sedge, a lipe bush with edible berries, and other low growing trees, bushes, and grasses. Deer, turkey, guinea pigs, and various types of ducks were indigenous river valley fauna utilized as a food source by the Moche, as was the prodigious ocean seafood resource. The nearby Andes Mountains provided the Moche with llamas for pack animals, alpaca wool for clothing, and copper for tools and ornaments via trade with various high mountain cultures. The Andes themselves are still forming, and they include numerous active volcanoes and have periodic violent earthquakes that no doubt affected pre-Columbian Peruvian people, including the Moche. Gradual geological uplifting of the

coastal regions is another environmental occurrence discussed later that may have significantly affected Moche agricultural productivity (Moseley, 1983).

Infrequent but devastating droughts, sometimes lasting three decades, were endured by the Moche (Shimada, 1991). The prevailing winds exacerbated any prolonged drought conditions and undoubtedly eroded dry soils and filled irrigation canals with windblown topsoil. Archaeological evidence also indicates the rare but devastating occurrence of tsunamis, which could have traveled up a river course and engulfed broad stretches of the littoral that contained Moche towns, villages, and farmland (Bawden, 1996).

El Niño events are yet another example of periodic climatic and oceanic phenomena that affect the north coast of Peru. During these events, warm equatorial waters devoid of the rich plankton replace cold Humboldt currents. A disappearing food supply forces waterfowl and cold-water fish to vacate the region, and these ocean species would not have been available to the Moche fishermen during these periods. Stronger El Niño events would also bring long and heavy thunderstorms to the Peruvian deserts for extended periods of time, resulting in coastal flooding and severe soil erosion.

The Mogollon Homeland

The Mogollon homeland is situated in the Mexican Highland section of the Basin and Range province of North America. More specifically, this territory includes the temperate mountains and high desert of east central and southeast Arizona, southern New Mexico, and northern Chihuahua, Mexico. Much of the exposed rock is extrusive basalt or lava flow produced by nearby volcanoes that caps the softer, older rocks. A large portion of the remaining region is dominated by fine-grained sandstone. Some of the

perennial watersheds are drained by the Mimbres, San Francisco, Blue, Gila, Black, Salt, and Little Colorado Rivers. These river valleys tend to be narrow and steep, making human travel across different watersheds considerably difficult.

Elevation is perhaps the most important factor that dictates local climate, vegetation type, growing season, and rainfall amounts. The northern mountains and high plateaus of the Mogollon homeland are perhaps the best watered of the southwest, with rainfall averaging between 12 and 20 inches per year. Much of the precipitation comes in thunderstorms, and local rainfall amounts are variable from one year to the next. The Mogollon agricultural land was probably concentrated in the fairly broad alluvial river flats (Martin, 1959). From 3500-6000 feet elevation, forests of juniper, oak, and pinyon sometimes mix with grasses and various bushes; above this elevation yellow pine forests dominate. Some of the more important fauna available as a source of food and clothing material included cottontail rabbits, jackrabbits, squirrels, prairie dogs, mule deer, pronghorns, and bighorn sheep.

Life-threatening environmental events such as earthquakes, volcanic eruptions, and floods were not factors of Mogollon human ecology. Two climatic events that did adversely affect the early inhabitants of these mountains and high plateaus were prolonged drought and locally intense thunderstorms. A prolonged drought intensified the scarcity of an already limited water supply. The Mogollon did not practice the irrigation techniques of their nearby contemporaries, the Hohokam. A sustained drought would have drastically reduced Mogollon crop yields, and in extreme cases, could have rendered previously productive soils useless. Although thunderstorms delivered needed moisture to the Mogollon homelands, these locally intense storm events also produced

unexpected negative effects for the agricultural land of these ancient inhabitants. Besides the potentially lethal threat of human lightning strikes, thunderstorms also resulted in considerable erosion of exposed topsoil, particularly on disturbed agricultural fields. Because thunderstorms provided most of the precipitation to this southwest region, the Mogollon farmlands undoubtedly lost considerable topsoil from these brief but energy-intense weather events. Ironically, the coming of intense rains to the arid Mogollon homeland may have had an insidiously negative effect never fully recognized by the early agriculturist.

Statement of the Problem

To date, common factors have not been identified that promoted sustainable living systems for multiple pre-Columbian societies of the Americas. For the most part, anthropologists and archaeologists have limited their discussions to influences on the "stability" of ancient cultures. Furthermore, this topic has only occasionally and briefly been mentioned in the published research literature. A comprehensive investigation of all common factors that supported and maintained past societies over extended periods of time would provide useful insights into the causal agents of sustainability for these societies. This information, when applied to contemporary living systems, could also prove useful for the continued development of contemporary sustainable resource systems. Significant research is needed to identify factors of sustainability of ancient agricultural societies and to search for underlying common ties and applications of these factors to modern sustainability theory and policy.

Purpose of the Study

The primary goal of this dissertation is to identify common factors that continually supported and maintained three selected pre-Columbian agrarian societies of the Americas. These include the Maya of southeastern Mexico, northern Guatemala, western Honduras, and Belize; the Moche of a northern coastal area of Peru; and the Mogollon of eastern Arizona, southern New Mexico, and northern Mexico. Each of these societies remained viable and stable for many centuries in different geographical regions and natural environments. Considerable archeological and anthropological research has been completed and published on the cultural ecology of each of these three societies. Detailed information concerning agricultural techniques, water conservation, trade relations, political and social organization, and religious beliefs is available. This dissertation will extensively utilize past scholarly research in order to compile sustainable resource system factors common in the three selected cultures.

Three primary factors were involved in the selection of these pre-Columbian societies for this research. First, the researcher anticipated an in-depth investigation of all environmental conditions and cultural components for each society using a substantial number of research literature sources. The researcher felt that three was a reasonably prudent number of distinct cultures that could be examined effectively in the detail required by such historical research. Second, the three selected cultures allow the researcher to examine a tribal society, a chiefdom, and a ancient state polity. Many of the sustainability factors identified in this research are present at all three levels of societal organization, which helps substantiate the universality of each commonality. Third, identifying sustainability commonalities in *three* distinct cultures will further support the

validity of the findings. If a single sustainability factor is assessed as crucial within three different cultures, the likelihood of misidentification of a factor is reasonably low.

This study is limited to pre-Columbian societies of the Americas for the purpose of excluding Old World cultural influences. Each of the selected societies developed independently of Old World constituents and influences. Selecting societies from three different regions of the Americas provides each with geographical isolation form the other two societies. Other common factors of sustainability may very well exist only in locations and cultures outside of the Americas, but those are clearly beyond the scope of this dissertation and provide an opportunity for further research.

Although not the primary focus, the research will attempt to identify contemporary applications of the common factors of sustainability of the ancient cultures. The agricultural component of the selected pre-Columbian societies provides a common link between ancient and modern agrarian societies. The author believes that an opportunity for contemporary application of ancient factors of sustainability is improved by this shared component of agriculture between modern and pre-Columbian societies.

Common sustainability factors are classified into a hierarchy of different levels of contribution to ancient sustainability. These assigned levels rank the various factors according to their importance for a society. A decision key crafted for this study classifies environmental and cultural factors into four categories: essential to sustainability, important but not vital to sustainability, substantially useful to sustainability, and no value to sustainability. After the ranking of factors is complete, a formula instrument calculates a numerical score representing the overall ability of an ancient society to sustain prosperity levels at a particular period of time. This instrument

uses the environmental and cultural factors previously identified in the decision key instrument for this purpose. The author hypothesizes that common sustainability characteristics uncovered in the examination of the three pre-Columbian societies will produce a set of general factors common to the sustainability of other pre-Columbian American cultures.

The author believes a complex relationship involving both cultural and environmental factors determines the sustainability of a society, regardless of the time period of its existence. The researcher does not expect to elucidate all relationships between sustainability factors and ancient agrarian societies. It is reasonable to assume that some pairs of factors and even factor groups may combine to synergistically affect sustainability. The purpose of this research is to provide foundational insights into factors of ancient agrarian sustainability in the Americas and to stimulate additional research that will refine our understanding of this nebulous concept.

The secondary objective of this dissertation is to create a bridge from the identified pre-Columbian sustainability factors to contemporary resource systems. Identified common factors with a capacity to improve the sustainability of modern society in a social, economic, or environmental context will be discussed. The contemporary application of these common factors provides insights for the refinement of policy that promotes future sustainable resource system design and development. It is hoped that the conclusions and recommendations of this project will provide important new insights into the nature of sustainability for both modern and ancient societies.

Research Questions

Did common factors exist within the Maya, the Moche, and the Mogollon that facilitated sustainability for many centuries? If common factors existed, do they have potential utility for improving sustainability theory and policy for contemporary society?

This dissertation will utilize archaeological and other pre-historical research to investigate common factors that promoted sustainability for extended periods of time for three pre-Columbian societies. These ancient sustainability factors are often described in a slightly different context by research publications, or, in other instances, they are mentioned as simply a characteristic of the environment or culture with no reference to a stabilizing influence. Subjective judgements have been made by the researcher relating to the degree of sustainability attributed to each identified cultural or environmental characteristic of the ancient societies. Subjectivity is unavoidable for this type of qualitative research and considerable measures have been incorporated into the methodology to minimize any adverse effects. Under the format of this qualitative research, the research questions are testable.

Significance of the Study

Contemporary population growth rate, especially in the developing nations of the south, is exerting an ever-increasing demand on limited natural resource supplies. Today, millions of people inside nations such as China, India, and Pakistan are experiencing acute shortages of basic material needs. Mexico City, São Paulo, Calcutta, and other sprawling urban areas do not have sufficient resource supplies or the social systems necessary for the efficient and equitable allocation of available wealth. A timely and

effective response to this situation is critical for long-term prospects for global human prosperity.

Many contemporary environmentalists have recognized the sagacity of reliable and long-lasting resource systems. If the opportunity does exist to develop a sustainable global community, the researcher believes that the responsibility to work toward that end is clear and compelling. Utilizing available natural resources in such a way as to achieve and maintain affluence while safeguarding the opportunity for the prosperity of future generations is indeed a legacy worthy of our attention. When considering current population growth rate and patterns of resource consumption, the window of opportunity for such an undertaking is diminishing as time passes. To allow the opportunity to expire for the identification and establishment of social policy that significantly promotes long-term human prosperity would be unfortunate and unnecessary.

This research will investigate innovative resource systems from past pre-Columbian societies of the Americas. Cultural and environmental characteristics of long-lived agrarian societies will be examined, including agricultural, social, religious, and technological innovations. The research will improve the understanding of sustainable living processes as well as provide an instrument for the measurement of sustainability of ancient societies. This information will allow contemporary cultures to appropriately incorporate previously overlooked factors of ancient sustainability into present policy and practice. The researcher believes that these specific policy refinements would be unlikely without an investigation of the type contained in this research. The new insights produced by this work will articulate and clarify the pathway to global sustainability. Therefore, this work is timely as well as socially and environmentally significant.

Assumptions

Each of the three ancient cultures of this study utilized a resource system that met their basic physical needs for a minimum of six centuries. The author assumes that common sustainability components existed among the Maya, the Moche, and the Mogollon that significantly contributed to a stable delivery of material resources throughout many centuries. The author assumes that a significant number of these sustainability factors are found in different agrarian societies at various locations throughout the past. The researcher assumes that these common components can be identified and described by using the methodology of this dissertation.

Another assumption is that a valid instrument can be constructed to categorize the sustainability of the various cultural and environmental factors. This dissertation reviews previous scholarly attempts to measure sustainability factors in a variety of settings and scope. Although the criteria for crafting such a sustainability instrument are subjective, an instrument has been created with the capability to categorize each factor of sustainability. More information and discussion concerning the design of this instrument are contained in following sections of this dissertation.

The researcher assumes that a research instrument can be crafted to pseudo-quantify the overall sustainability of pre-Columbian agrarian societies. Although a number of methodologies have been previously employed to quantify sustainability in a contemporary context, none have been created for application to ancient societies. The researcher assumes the technique used in this dissertation is appropriate and valid.

A final assumption is that applications do exist within a contemporary context for ancient factors of sustainability that will clarify the theory and improve the practice of

modern sustainable living systems. The researcher believes that by examining durable and stable ancient societies, a bridge can be built between the past and present. At least some ancient characteristics of sustainability, although perhaps unplanned and unintentional, are assumed relevant and valuable for refining modern sustainable policy. The author assumes the research design of this dissertation will produce the aforementioned desired results.

Definition of Terms

Chiefdom - social organization with specialized occupations and centralized hereditary authority for coordinating social, religious, and economic activities including redistribution of wealth that lacks a military enforcement apparatus

Commonality - a cultural or environmental attribute or feature found in all compared societies

Human resource system – social process assembled by man for the purpose of generating valuable goods and services

Pre-Columbian society - a culture found in North America, Middle America, or South America before 1492

Primitive State - social organization in an early stage of development with specialized occupations and centralized hereditary authority with military enforcement of social, religious, and economic traditions, including the redistribution of wealth inside society

Sustainability - the capacity to remain uncompromised for an indefinite period of time; specifically, the capacity of both the environment and human society to maintain uncompromised and continuous integrity

Sustainability decision key - a series of dichotomous choices used by this research that categorize the degree of sustainability for conditions or characteristics of agrarian societies

Sustainability factor - an environmental condition or cultural characteristic associated with a society that positively affects its stability and durability

Sustainability formula - an research instrument used to determine the degree of sustainability for an ancient agrarian society at a particular point in time

Sustainable - the condition of remaining uncompromised throughout an indefinite period of time; specifically, the condition of a society's resource system that allows a steady rate of consumption indefinitely into the future

Tribe - an egalitarian social organization of a large number of independent kinship groups without occupational specialization and central leadership authority

Limitations

This section discusses five significant limitations that exist for the qualitative research involved in this dissertation. The researcher without further mitigation of these limitations accepts the extent of each limitation as such. A first limitation is that some cultural and environmental sustainability factors of these three pre-Columbian agrarian societies probably left little or no surviving evidence. For example, in the humid rainforest environment of the lowland Maya, decomposition has been particularly complete of most putrescible artifacts such as wooden tools and various plant materials. The existence of such items and their impact upon sustainability remains an irretrievable part of Maya pre-history. In addition, many non-material cultural components of sustainability would have left absolutely no physical record of existence. Contemporary researchers will have great difficulty uncovering many unrecorded components of cultural belief systems. For instance, an ancient tribal custom involving marriages between two different kinship groups would provide a long-term survival advantage of a more diverse gene pool. Another example of a difficult to document sustainability factor would be an extended period of consistent environmental conditions with no catastrophic natural events. These types of irretrievable records will leave unavoidable gaps in the complete social and environmental picture for each society in this research.

A second major limitation is that, after many centuries, each of the pre-Columbian societies eventually did collapse, disperse, and incorporate with other developing

cultures. With sustainability implying the capacity to continue uncompromised for an indefinite period of time, nearly any agrarian group of the past may appear as not having been sustainable. However, the myriad of cultural characteristics and environmental conditions influencing sustainable societies is dynamic throughout time. Sustainable factors no doubt waxed and waned even in the most stable societies. The author believes that because each selected culture had existed at a consistent level for at least six centuries, and in some cases much longer, the reality of a truly sustainable society was likely, at least during these particular extended time periods. The subsequent collapse of these societies was brought on by newly introduced circumstances, which does not diminish the previous accomplishments of a long and stable tenure. The sustainability formula instrument provides the opportunity to substantiate these preliminary conclusions of ancient sustainable societies. The author acknowledges, however, that some critics may take issue with the subjective determination and pseudo-quantification of sustainability for pre-Columbian agrarian societies by the sustainability formula instrument utilized in this research.

A portion of the utility of this research project depends upon the relevance and application of ancient factors of sustainability to contemporary resource systems. Although the main focus of this research is on pre-Columbian societies, a subordinate element does include a connection of past components of sustainability with modern society. A third limitation of this project involves the controversial extent of application of ancient sustainability factors to modern-day society. The last chapter of this dissertation does offer suggestions for the incorporation of newly uncovered sustainability factors into modern systems of sustainable living. However, the exact utility and the extent to which this information may be incorporated into current public policy remains uncertain.

Fourth, the construction and utilization of both the sustainability decision key and the sustainability formula research instruments required a considerable number of subjective decisions throughout each process. This high degree of subjectivity may be viewed as a potential weakness of the research instruments. Qualitative pre-historical research does inherently involve a measured amount of subjectivity; however, the researcher did not only use personal opinion to craft and utilize these important instruments, but also the peer-reviewed work of many scholars. References are provided for subjective decisions made by the researcher while using the sustainability formula to score the sustainability of each pre-Columbian society.

Another factor mitigating the subjectivity inherent in this type of historical research is the large number of variables contained in the sustainability formula. The greater the number of sustainability factors used in the formula, the less the impact upon the final sustainability score for an incorrect single factor decision made by the author. A considerable number of sustainability factors have been processed through the sustainability key and the subjectivity for this stage of the research process has been minimized. Although final decisions concerning the structure, function, and actual use of these instruments have remained with the researcher, the previously mentioned safeguards maintain sufficient integrity and reliability of the process itself.

Last, the determination of a pre-Columbian society as sustainable by the formula instrument does not imply the invincibility of that culture. Unforeseen circumstances such as aggressive new military alliances between neighboring societies as well as deadly disease epidemics introduced by foreign cultures are just two possibilities of existence-threatening situations for ancient societies. Such unpredictable contingents and their

unfortunate outcomes must be accepted as possibilities, even for the most stable and durable cultures.

Organization of the Study

The first chapter of the dissertation introduces a statement of the problem, purpose and significance of the study, definition of terms, the research questions, and all major assumptions and limitations. This chapter effectively orients the reader to the basic information, intentions, and strategy of the researcher for this project. The second chapter contains a summary of all literature reviewed and a discussion of the relevant corresponding issues. This chapter is a distillation of hundreds of hours of literature research and note-taking by the author on various topics germane to this project. The third chapter explains in detail the research methods and techniques employed, including the subjects, instruments, design, and procedure. An overview and explanation of the sustainability decision key and sustainability formula are found in this chapter. The fourth chapter contains the analysis of data and explains the information in meaningful terms. Sustainability scores of the three pre-Columbian societies are discussed in this chapter. In chapter five, suggestions for utilizing the uncovered factors of ancient sustainability for the purpose of contemporary policy refinement are outlined, as well as other conclusions, implications, and recommendations for further research are discussed.

CHAPTER II

REVIEW OF THE LITERATURE

Review of past scholarly research was a major component of this project. The nature of the nebulous concept of sustainability and its application to three ancient societies were thoroughly researched. Literature was examined that offered insight into the factors that promoted ancient social stability and consistency over extended periods of time. Most scholarly commentary on past societies reviewed by the researcher does not offer conjecture or discussion on sustainability factors per se. Rather, the literature review process involved the synthesis of a variety of information sources originally written for purposes other than a discussion of sustainability factors. A large part of the research task involved first uncovering pertinent information about the three societies of the study and then elucidating its sustainability context.

This chapter examines published scholarly research covering the evolution of human society, the contemporary concept of sustainability, and the pre-Columbian cultures selected for this study. The first section of this chapter outlines significant thought on developments in human society. Factors influencing the rise of early social systems and polities are discussed. The second section reviews the evolution, breadth, and utility of the concept of sustainability, sustainable resource system theory, and previous attempts at measuring and quantifying sustainability. In the third section, archaeological and historical records are reviewed concerning each of the three selected pre-Columbian societies. Literature is reviewed and discussed that outlines resource

acquisition methods, standards of living, religious traditions, social structures, agricultural practices, and technological innovations of the three selected societies.

The Evolution of Human Society

The nature and complexity of human social organization has experienced significant changes over the many millennia of man's existence. This development has generally progressed from simple to complex social structure and institutions. The different levels of social organization and the associated characteristics of each level are well documented in anthropological literature. The researcher believes that the broad exposure to this social theory from completing this portion of the literature review has assisted in the identification of common factors of sustainability for ancient agrarian societies.

The three pre-Columbian societies selected for this dissertation are characterized by three distinct levels of social development: the tribe, the chiefdom, and the primitive state. The following section summarizes the major sources of information for this research concerning these primitive types of social organization. These selected sources have led to a clearer understanding for the researcher of the characteristics and nature of these three polities and have served as a reference source for additional in-depth investigations for this work concerning the evolution of human society.

In his article "The Cultural Evolution of Civilizations," Flannery (1972) emphasizes the importance for cultural ecologists to include systems of information transfer within their analysis of human societies. The author believes this is a significant factor that has been largely overlooked by many researchers when investigating the development of human society. During his discussion of sociopolitical complexity,

Flannery lists a number of various characteristic of society that would affect their sustainability. For example, he believes certain "calendric" tribal ceremonies may help maintain certain productive natural environments, limit inter-group raiding, facilitate trade, and positively redistribute natural resources. He later discusses the difficulty for chiefdoms to maintain expensive sumptuary goods for the decision-making elite. The full-time artisans that craft these ritualistic items must have been compensated from a surplus of food that otherwise might be traded for distant goods particularly valuable to the working class. The author, when later discussing the mechanisms for maintenance of the primitive state, cautions that "too great a degree of central control can be as lethal as too little." He sites the example of state decision-makers, who lived a distance from the farming villages and probably did not know local environments as well as village members, and thus set policy that promoted considerable inefficiency in this system. These illustrations, along with other provocative ideas, provided considerable information that influenced portions of this research.

In his book Primitive Social Organization, Elman Service (1962) provides useful commentary on the nature of both tribal and chiefdom societies. This extensive discussion on the different levels of societal development explains the role of leadership, power, religion, trade, and communication with neighboring societies. Service believes that competition between social bands was a more important factor for tribal formation than environmental conditions. He states that external strife and competition from other societies provided the impetus necessary for tribal cohesion. Service believes that the greatest source of disunity in the tribe polity was the feud, which tends to perpetuate within the tribe throughout time. This information suggests a possible factor of

sustainability of a tribal polity may be the existence of non-life-threatening social strife along with social institutions that inhibit clan feuding and promote overall unity.

Service also discusses one requirement for a chiefdom consisting of a natural environment that is conducive to specialization in production and redistribution, with a controlling centralized area. In return for taxed goods and services from the common people, the controlling center of a chiefdom must direct a more efficient per capita resource acquisition and allocation system than a tribal polity. This information suggests that any serious disruption of the natural environment's productivity, such as prolonged drought or loss of productive soils, could threaten the stability of the controlling center and existence of the chiefdom. Any polity that mitigates environmental risks and oversees an appropriate distribution of resources for a society provides a valuable function. A possible factor of sustainability for chiefdoms may be a stable natural environment and one that offers a variety of opportunities for vital resource acquisition.

In his article "The Prime-Mover of Cultural Evolution," Service (1968) stresses that a single factor, or prime mover, *does not* determine the evolution of every society. Service says that individual factors such as technology, competition and conflict, and conscious political schemes *sometimes* determine changes in culture. Rather than a single determiner having similar effects upon all societies, the evolution of individual cultures involves adaptive strategies they may employ to solve the variety of encountered cultural and environmental problems through time. This assertion provides support for a contention of this dissertation that researchers must consider many potential factors of sustainability for a society.

In a later book The Origins of the State and Civilization, Service (1975) writes that the rise of civilization was not founded upon the rise of the primitive state. He believes that the state polity, with densely populated urban areas, was not necessary for the development of cultural components such as larger populations and numerous specialized professions. This idea provides this dissertation with an additional viewpoint on the value of state-derived characteristics for the Maya. Service's opinion served to caution the researcher during the selection of factors of Maya sustainability. The author later discusses the development of the Moche polity in considerable detail, which provides an additional perspective on Moche social structure and organization.

The Evolution of Human Societies by Johnson and Earle (1987) was reviewed primarily for its extensive analysis of the chiefdom and primitive state. The authors go into considerable detail concerning the role of leaders as well as the structure of resource systems in each of these polities. Insight is also offered concerning factors that influenced the development of primitive societies into more socially complex societies. For example, they believed that primitive state formation most often occurred because of new levels of risk from nearby cultures, increasing technological complexity and trade requirements, the need for one ethnic group to maintain dominance over other groups, or some combination of these factors. Rathje (1971) emphasized somewhat earlier that external trade networks could facilitate beneficial alliances. Johnson and Earle also said that state formation requires an intensive subsistence economy, social stratification, expanding food production, increasing population, effective leadership, land tenure, and a dense rural population to support the urban sector.

In his article "Population Pressure and the Social Evolution of Agriculturalists," Michael Harner (1970) contends that increasing population pressure is a major determiner for human social evolution. The author says that both inter-group and intra-group competition for natural resources led to the development of class stratification among ancient agrarian societies. Competition for scarce resources leads to larger local and inter-local social groups in order to acquire and hold scarce natural resources. He says that increasing populations are not the sole determining factor for social evolution and that other processes are also at work. For purposes of this dissertation, Harner's supposition implies that factors influencing population growth rates are of major importance not only to societal complexity, but also to the resource system structure and efficiency. If population pressures do, in fact, exert a major influence on human resource systems, then they would also have a significant effect upon the sustainability of a society.

Moseley (1975a) argues that the rise to civilization was not always linked to the rise of agricultural productivity. He uses the example of how ancient civilizations undeniably arose on the coast of Peru without the benefit of agriculture. He discusses the similarities and differences of social organization between early maritime coastal civilizations and later agriculturally dependent societies. Moseley believes this littoral-based economy pre-adapted the coastal Peruvian populations for large-scale canal irrigation and the development of productive agricultural economies. This suggests that the successful development of civilizations can depend upon a number of interconnected chronological factors working in concert. Also, the sustainability of a society at any particular time period in its development might depend upon past events and social

institutions that either established or eroded a foundation for stability. Incumbent upon this dissertation is the identification of the interconnected determiners of ancient sustainability.

Adams (1981) suggests that increasing Maya population pressure in the early Classic and again in the late Classic Periods produced both a major development in social structure and the shift to intensive agricultural techniques. By A.D. 850, overpopulation, a failed attempt to sustain urban city-states, and ecological abuse from the intensive agriculture are thought to be important factors in the subsequent collapse of the Maya. This study demonstrates the potency of population density increases for fundamental changes in the societal fabric and perhaps the long-term ability of a society to sustain itself.

The Concept of Sustainability

Throughout his existence, man has acquired basic material needs by utilizing many different adaptive strategies. Early innovations of resource acquisition included tool making, plant domestication, trade networks, language, metallurgy, and crop irrigation. During most of this early cultural evolution, inconsistent and unrefined resource acquisition methods had limited human populations to below the one billion mark until the mid-1800s. Not until the industrial revolution and subsequent improvements in supportive technology did exponential population growth and a corresponding rate of resource consumption pose a significant threat to future generations. From 1850 until the present day, the population of the Earth has increased to over 6 billion, which in turn has fueled a corresponding increase in the rate of resource consumption. Despite major technological advances, this accelerating resource demand

is pushing the finite limits of Earth's productive capacity. For the past quarter century, global limits of resource availability are becoming increasingly apparent to significant numbers of resource specialists, scientists, and concerned citizens.

Inefficient production methods, substantial waste, serious pollution, and rapidly increasing populations continue to compromise the opportunity of man to meet present and future resource needs. This dramatic trend has prompted an unlikely coalition of economists, ecologists, sociologists, and environmentalists with a common concern for the viability of natural resources systems over time and across the human landscape. The impending need to maintain future opportunities for the prosperity of prospective generations is at the heart of this movement. Today, the priorities and methods that best maintain functioning and productive natural resource systems are still evolving, and scholarly opinion concerning the most effective techniques for the transformation to sustainable resource systems has also changed. The need for an integrated approach in structuring perpetually healthy and productive resource systems has been recognized for only a relatively short time. A number of developmental stages have occurred during the unfolding of this idea during recent history. The following section traces the evolution of this concept of sustainability and the events that were a major part of its contemporary development.

Early Development

Resource management specialists have used the term sustainability in reference to human resource systems since the late 1960s. Sustainability emerged in political and public arenas in 1972 with the publication of the book Limits to Growth (Meadows et al., 1972) and the United Nations Conference on the Human Environment in Stockholm

(Common, 1995). Limits to Growth researchers used a computer model of the world economy to conclude that the world economic system could not expand indefinitely and that some key policy changes were needed to facilitate an economic system that would be "sustainable far into the future." Throughout the past four decades, the legitimacy of this concept has become increasingly accepted within the biological, economic, and social science disciplines, although the exact definition and scope of sustainability has yet to be determined.

The U.S. government in the late 1970s administered a study that was also based on global computer model simulations. Called Global 2000, this report discussed world population growth, food production, energy use, pollution, and economic development issues. This report received wide circulation and concluded:

> If present growth trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today.
>
> For hundreds of millions of the desperately poor, the outlook for food and other necessities of life will be no better. For many it will be worse. Barring revolutionary advances in technology, life for most people on Earth will be more precarious in 2000 than it is now – unless the nations of the world act decisively to alter current trends (Global 2000 Report to the President, 1980, p.1).

Sustainability received additional international recognition in a 1980 publication by the International Union for the Conservation of Nature called World Conservation Strategy (Holmberg, 1992). This publication was instrumental for introducing the

concept of sustainability to a broad, global audience. Even greater international recognition was achieved in 1987 when the United Nations Commission on Environment and Development published Our Common Future (WCED, 1987), also known as the Brundtland Report, which promoted the idea that economic development and environmental protection are not mutually exclusive. This report emphasized the need for economic growth and sustainable development in which developed nations play a large role with developing nations by improving their efficiency of material and energy use.

By the late 1980s the terms *sustainability* and *sustainable development* were gaining widespread use in resource management policy discussions but their actual meaning was often disputed (Cutter and Renwick, 1999). Ecologists, economists, and sociologists were applying these two terms strictly in reference to their own respective disciplines. These terms had acquired various meanings and some factions confused this issue further by using the increasingly popular term of sustainability to promote their particular causes regardless of its relevance.

Lester R. Brown, founder and president of The Worldwatch Institute, defined a sustainable society as one that satisfies its needs without jeopardizing the prospects of future generations (Brown et al., 1991). Noted environmental policy professor and author Daniel Chiras went a step further in his 1994 definition of a sustainable society to include one that meets its needs without impairing the ability of future generations *and other species from meeting theirs* (Chiras, 1994). In 1996, Paul Wilson, director of the environmental law program at Lewis and Clark Law School offered a succinct

perspective on sustainability as living on interest and not drawing down capital (Wilson, 1996).

Clayton and Radcliffe (1996) contribute a clearly written, comprehensive summary on today's fundamental principles of sustainability. In the book, Sustainability - A Systems Approach, the authors emphasize the importance of an "open systems" strategy in the quest for sustainability. Included are chapters discussing methods for assessing sustainability as well as integrating environmental, economic, and socio-cultural factors of sustainability.

Contemporary Utility

Further investigation of the concept of sustainability reveals three current disciplinary approaches: ecological, economical, and sociological (Goodland and Daly, 1994; Munasinghe and Shearer, 1995). The ecological perspective focuses upon the role of biodiversity and ecosystem health as essential ingredients of sustainability. This process involves restoring and maintaining healthy natural systems as well as limiting human waste according to Earth's absorption capacity. The environmental economist focuses on the long-term economic efficiency of resource utilization, which emphasizes the importance of maximizing the total net social benefits from resource use while maintaining or increasing the productive natural capital of resource systems. The sociological view is quite varied depending on the particular sub-discipline surveyed. For purposes of this dissertation, the targeted sociological perspective advocates equal *opportunity and access* for material prosperity among all current world residents, as well as the maintenance of renewable resource stocks and productive natural systems available

for future generations. This strategy requires direct community access to political and resource management decisions.

This dissertation utilizes and incorporates each of these three perspectives of sustainability. The author agrees with other researchers that these three views must be integrated in any viable sustainability program; therefore, this comprehensive perspective is most appropriate for this dissertation (Goodland and Daly, 1994). This research project provides insights concerning the interrelationships of these components of sustainability and elucidates the nature of this nebulous concept in both a past and contemporary setting.

Criticism of the Sustainability Concept

Critics of the concept of sustainability maintain that there is no need for a departure from our present strategy of resource use. This opposing view contends that the only true constraint of unlimited raw materials at acceptable prices is man's limited technical knowledge. The concerted effort of society should be directed toward advancing technological solutions that improve efficiency of resource use and furnish new resource supplies. Since people generate knowledge, increasing world populations facilitate increased knowledge and productivity. According to some, the present world population growth rate poses no great threat to human prosperity (Simon, 1981).

Skeptics maintain that civilization has never successfully institutionalized the concept of sustainability and no need exists today for such an unrealistic goal. Julius Simon, professor of business administration and author of several important books that refute the conclusions of "The Brundtland Report" and "Global 2000", maintains that no impending resource crisis exists and the future of mankind has never looked better

(Simon, 1996). Simon says that throughout human history, the cost of natural resources has declined relative to personal income. More people today have access to natural resources than in all other periods of human habitation of this planet (Simon, 1996).

In the book The Resourceful Earth (Simon and Kahn (eds), 1984), over two dozen economists and business scholars collaborated on this optimistic report of man's ever improving standard of living and bountiful resource future. These authors insist that technology has already provided for human sustainability and that this new initiative for society is both unnecessary and impractical. They maintain that even if a new direction for global sustainability were a worthwhile goal, the difficulty of orchestrating an ecological, economical, and sociological movement among the hundreds of different cultures of the world would be an insurmountable obstacle. The critics believe that the sustainability movement today is often no more than a front for advancing hidden agendas such as a socialistic world economy and other liberal philosophies. They believe humanity's efforts would be better served by concentrating our efforts on capitalistic ventures and technological research (Simon, 1996).

The purpose of this dissertation is not to debate the value of the contemporary sustainability movement. While critics make some valid points, the basic presumptions of sustainability, such as intergenerational equity and ecosystem resource management, are well founded, logical, and grounded in science. Although the full merit of a global sustainability effort remains somewhat unclear, an operational sustainability strategy would provide society with an opportunity to adjust and improve its long-term natural resource system parameters. The primary goal of this dissertation is to illuminate the nature of sustainability in ancient cultures, and, to whatever extent possible, suggest

appropriate and beneficial policy adjustments for contemporary society. The preponderance of credible information available on the concept of sustainability supports these goals.

Relevant Subtopics of Sustainability

A number of subtopics associated with sustainability exist that are pertinent to this study. The *carrying capacity* of a particular location/environment refers to the number of individuals of a given species (in this case humans) that can be sustained indefinitely (Chiras, 1994). Limits of food, water supplies, and other vital resources are among the factors that determine these population constraints. As other limiting factors such as climate and technology change over time, the carrying capacity of an ecosystem increases or decreases accordingly.

This concept of carrying capacity has been incorporated into the process for determining the sustainability level of each of the three study societies. Recognizing that the environments of each of the three selected pre-Columbian societies had a finite population capacity that could be supported with the available technology during the time period of the research will assist the author in identifying common factors of sustainability. Also noteworthy are two factors that influence the level of carrying capacity: technological advancements and changes in the physical environment. Irrigation techniques and volcanic eruptions near human population centers are examples of a promoting and a limiting influence on the carrying capacity of a particular ancient society environment. The concept of carrying capacity is an appropriate consideration for any legitimate analysis of sustainability.

Another term germane to sustainability is *common property resources.* Common property includes shared commodities such as air and water that are vital to all members of a population. Proprietary rights for common property generally fall within the entire community rather than to individual private citizens. In his classic article "Tragedy of the Commons," Garrett Hardin (1968) points out that throughout history, common property resources have almost always been exploited by individuals for personal gain at the expense of the rest of the community. The treatment of common property resources has been examined for each of the three cultures of this dissertation, and any social characteristic that maintains efficient common property utilization was duly noted. A sustainable society possesses mechanisms that maximize the equitable utilization of common property resources for all its members (Cutter and Renwick, 1999).

Quantifying Techniques

Previous attempts have been made to quantify sustainability from a number of different environmental perspectives. In 1990, the Dutch government requested that the Institute for Environmental Studies of the Free University, Amsterdam, organize two conferences that would bring together environmental economists and other scientists of various disciplines to outline options and strategies for measuring sustainable development. The papers written as a result of these workshops were organized in the book In Search of Indicators of Sustainable Development (Kuik and Verbruggen, 1991).

A primary objective of this Dutch initiative was to organize a system of normative indicators illustrating the capacity of a particular region or environment to sustain economic activity. The term *sustainability indicators* (SI) was used to describe such a capacity and divided the assessment into three distinct sectors: natural resources,

biodiversity, and pollution. These SI measured the overall environmental pressure or impacts as well as changes in the natural capital of a region. The SI also included such factors as the ability for substitution of resources, current technology levels, and management tools available for use. Guidelines were incorporated such as limiting the rate of renewable resource extraction to safeguard appropriate stock levels for regeneration.

This Dutch study monitors environmental capital and environmental quality by using two distinct types of sustainability indicators. One indicator type is called *predictive indicators* and possesses a predictive capacity for future material and environmental welfare. The second type is called *retroactive indicators,* which analyze trends of sustainability levels of current resource systems. The study also emphasizes the importance of producing numerical standards for these sustainability indicators along with clear graphic representations. These representations of both of these sustainability indicators can be fairly easily interpreted by the decision-maker who wants to utilize these data.

In 1993, the U.S. Forest Service hosted a Mexico/U.S. environmental symposium in Santa Fe, New Mexico. The title of the symposium was " Making Sustainability Operational" and one of the products of the proceedings was a publication titled "Indices of Sustainability." The conference identified various biological and social factors of sustainability such as ecosystem resilience, natural and social capital, and human community resilience. According to the symposium proceedings, factors such as biodiversity and nonrenewable resource reserves directly contribute toward the natural capital of a society. A shift toward ecosystem management and an understanding of the

linkages between biophysical and social systems were also reported as significant (Shields et al., 1993). Comprehensive sustainability indices from this symposium provided useful comparisons for the sustainability key and formula of this dissertation; specifically, the criteria used in the determination of indicators of sustainability in the symposium were pertinent in the construction of the sustainability formula of this research.

A second research team from the Netherlands lead by von Pelt (1995) published a journal article titled "Environmental Sustainability: Issues of Definition and Measurement." The team made up of three Dutch economists built upon the Brundtland definition of sustainable development when they defined sustainability and proposed a method to measure the concept in practice. Factors in the assessment process included the social welfare of present and future generations, resource substitution possibilities, risk/uncertainty issues, spatially defined area of reference, and the length of planning horizon. Conditions necessary for sustainability included maintenance of natural capital stock as well as healthy natural system processes. These researchers also stressed the need to use location specific approaches in determining sustainability levels as well as multidimensional policy analysis using cardinal or ordinal scales in reporting their results.

The United Nations University recently published a volume titled Defining and Measuring Sustainability (Munasinghe and Shearer, 1995), which is the result of the collaborative effort of a group of scholars and scientists who attended the 1992 International Conference titled "The Definition and Measurement of Sustainability: The Biological and Physical Foundations." This conference publication examines a number

of key facets of sustainability including the nature and meaning of sustainability, a population and community perspective of sustainability, a list of appropriate indicators of sustainability, and a number of contemporary sustainability case studies. Some of these indicators summarize trends in greenhouse gases, agriculture, freshwater resources, forestry, energy use, and biodiversity. This publication uses a mathematical formula to calculate levels of sustainability in contemporary settings. Even though this publication deals primarily with modern society, it still provides another perspective for identifying sustainability factors for this dissertation.

Other notable works include a 1995 urban perspective of sustainability titled "Developing Indicators of Sustainable Community: Lessons from Sustainable Seattle" (AtKisson, 1996), and a piece by Manyong and Degand (1997) that discusses techniques for calculating the sustainability of African farming systems. The Seattle article divides its list of sustainability indicators into positive factors that move the city toward sustainability and a negative group that moves Seattle away from sustainability. This information adds to the general body of knowledge on sustainability indices and contains ideas on the potential application of the common factors identified within the three ancient societies of this research. The Manyong and Degand article describes a mathematical model to measure sustainability of farming systems in the highlands of Burundi. This article provides another noteworthy technique for calculating sustainability of various cultural and environmental factors.

Implementing Sustainability

A considerable number of scholarly publications have been reviewed that suggest methods for implementing sustainability into public policy. Michael Common (1995), an

Australian Economist, provides a comprehensive text on the nature of sustainability and the policies needed to address this issue. The author provides chapters on a historic overview of the evolution of the current world economy, a transdisciplinary approach to sustainability, a discussion on effective resource and environmental economics, and specific national and unilateral international policies and actions that promote a concerted effort toward global sustainability. Common emphasizes that solutions must continually adapt to changing world circumstances, and that economic policy is a very useful and necessary tool for creating and maintaining sustainable resource utilization and must be a significant part of any successful sustainability movement.

The above text was one of several that provided guidance during the consideration of applications for sustainability commonalities to contemporary society. Several of Common's discussions provide useful perspectives on common links of ancient and modern society, particularly the chapters on historical and future perspectives of sustainability.

The U.S. Forest Service document Making Sustainability Operational: Fourth Mexico/U.S. Symposium (Shields et al., 1993) contains a number of suggestions of institutional mechanisms for implementing reforms promoting sustainability. One of the papers presented at the symposium, "Sustainable Economic Development in Rural Areas: Balancing Economics and Ecology in Rural Economic Development" (DeVilbiss et al., 1993), discusses how broad-based community involvement and leadership is needed for effective sustainable development. The authors discuss other important factors such as the maintenance of ecosystem integrity and a financially efficient strategy that provide an economical, social, and environmental sustainable development process.

Another article of this symposium, "Holistic Resource Management: A Model for Building Sustainable Landscapes" (Grogan, 1993), discusses the need for complex interactions of culture, economy, and ecology to achieve sustainability. This approach incorporates the values of the residents of the landscape as well as economic and ecological factors in the decision-making process. The symposium also addressed a number of resource management issues, such as technology transfers between developed and developing nations that would promote sustainable societies. These symposium articles offered a number of ideas and suggestions for promoting and implementing positive sustainability factors within a contemporary context.

The book Population, Technology, and Lifestyle (Goodland et al., 1992) contains chapters by a number of noted resource management scholars, including Herman Daly and Robert Costanza, that discuss strategies for implementing and evaluating sustainable development. This seminal work discusses in considerable detail numerous factors of contemporary sustainability including the valuation of natural capital as well as reforms for monitoring key economic indicators. The need to recognize limits to both economic growth and world population growth is discussed. Another chapter promotes the formation of an international task force to integrate scientific knowledge regarding the effects of alternative paths of economic development and natural resource use. The authors also contend that this international body will need the authority to choose and enforce concerted and workable guidelines that will move humanity closer to global sustainability. This work has provided considerable information and has proven useful on many of the basic issues involved in factors of sustainability for contemporary societies.

Another useful source is The Ecology of Commerce by Paul Hawken (1993), which explains specific economic policy changes that would reward sustainable utilization of natural resources and promote private sector advances of sustainable resource use. Hawken advocates a restructuring of specific components of capitalistic first-world economies for the purpose of creating a sustainable global economy. Full-cost pricing systems, green taxes on fossil fuel consumption, restructuring of the laws governing corporations, effective regional economies, and the improved efficiency of industrial processes are all tenets of the new direction proposed by Hawken. The author identifies the basic design flaws in present-day capitalism as some of the most important threats to sustainability. His suggestions for improving the sustainability of a society require some of the most substantial changes in natural resource management systems offered in this literature review. Nevertheless, this source has proven useful for clarifying the nature of sustainable resource production systems as well as uncovering other common factors of sustainability for ancient and contemporary societies alike.

Robert Costanza's (1991) book Ecological Economics considers issues such as the need for an ecological economic worldview and strategy, improved accounting and modeling methods, innovations for educational systems, and institutional incentive instruments that foster sustainability. One relevant chapter, "Assuring Sustainability of Ecological Systems," discusses methods used by sustainable traditional cultures, such as religious mores, to bring long-term goals into the local, short-term decision-making process. Costanza, however, emphasizes a different approach for contemporary society that involves the establishment of a hierarchy of international planning and management

goals. These perspectives have been useful when evaluating pertinent sustainability factors of both past and modern societies.

In another chapter, contributing author Stephen Farber (1991) discusses the role of economic and social systems of past societies that failed to achieve sustainability. The author asserts that short planning horizons, failure of property rights systems, and the concentration of economic wealth and political power inside small sectors of society have been some of the basic hindrances to past sustainability. Farber discusses what he considers appropriate local and global incentives for sustainability. This provides still another insightful perspective on the analysis of components of sustainability considered in this dissertation.

During the late 1980s, New Zealand adapted natural resource policy reforms establishing sustainable management as a guiding principle for the maintenance of environmental and economic quality. Authors Owen Furuseth and Chris Cocklin (1995) discuss these changes in their paper "An Institutional Framework for Sustainable Resource Management: The New Zealand Model" (1995). This paper explains the total economic restructuring process, analyzes the administrative and legislative changes that support sustainable management, and offers comments about the future of the New Zealand reform process and its applicability to other nations. This document adds to the available reference materials that promote an understanding of sustainable resource theory within modern society, and this paper influences the contemporary application of identified sustainability factors found within the three selected pre-Columbian societies for this dissertation. The next section discusses the scarcity of available research and accompanying literature concerning ancient sustainability factors.

Ancient Sustainability Information

An abundance of information on contemporary sustainability issues as well as methods that incorporate these characteristics into modern society is contained in the previous sections of this chapter. As mentioned earlier, only in the past few decades has the concept of sustainability been conceptualized and studied by environmentalists, economists, and sociologists. Contemporary scholars from these three disciplines are only beginning to agree on the characteristics and pathways toward global sustainability.

Not surprisingly, the issue of ancient society sustainability has received very little treatment in scholarly literature sources. Anthropologists and archaeologists occasionally and briefly comment on the "stability" of specific cultures and the characteristics that promoted this condition. Other literature sources may describe major characteristics and environmental conditions of an ancient society and discuss their immediate benefits without specifically commenting on their long-term maintenance prospects. An entire text may contain only a handful of sentences covering the topic of sustainability factors for ancient societies.

One of the challenges of this dissertation has been to fill this research void and begin to build a pool of information and discussion on the topic of ancient sustainability. Hopefully, other researchers will contribute to the understanding of ancient sustainability and continue to present different interpretations of existing data. Archaeologists and anthropologists alike are encouraged to look at their data within a perspective of sustainability and search for factors that promoted the durability of a selected culture. Not only will this type of investigation add to the knowledge of ancient agrarian societies

of the Americas, but also will provide possible insights into factors of sustainability that may be shared with contemporary society.

Three Pre-Columbian Societies of the Americas

The Maya

Much research and literature exist on the Maya of Central America, with the preponderance covering the major ancient ceremonial centers and urban centers. The surrounding rural villages and hinterlands have received far less attention. The Maya occupied present-day southeastern Mexico, Belize, northern Guatemala, and western Honduras (Figure 1). This literature review broadly surveys the culture and natural environment of the Maya throughout their long and successful tenure. Sources that offer information on possible contributing factors of stability and longevity of the Maya were specifically investigated, although a greater body of research exists that attempts to explain the sudden collapse of this great civilization of ancient America.

An important source for comprehensive Maya information is Daily Life in Maya Civilization by Robert Sharer (1996). The author has over thirty years of Maya research experience, directing archaeological excavations in El Salvador, Guatemala, and Honduras. This book, which is divided into early, middle, and late Maya periods, reconstructs ancient Maya society with research-supported information, some hypotheses, and occasional speculation. Sections of the text discuss the economic and social institutions that directed the resource acquisition and distribution system of the Maya. Considerable detail concerning agriculture, trade networks, government, religion,

population trends, the spatial organization of settlements, social stratification, and roles of men and women are discussed.

This salient work assisted the author in compiling the common sustainability factors for this research. Sharer would occasionally comment on the long-term effects of the various conditions and characteristics surrounding the Maya. This work was significantly broad in scope and provided information on a number of different Maya sustainability components. A number of references are made throughout this dissertation of this important information source.

Another publication that provides a general overview of prehistoric Maya society is The Maya by Michael Coe (1993). Chapters Two and Three provide considerable detail on cultural developments during the Maya Preclassic period between 1800 B.C. and A.D. 250, and Chapter Four continues with a comprehensive account of the early Classic period until A.D. 600. This dissertation concentrates on the Preclassic and early Classic periods of Maya history and Coe's discussion about the Maya cities, ceremonial centers, social organization, food production, and relationships with outlying cultures has provided useful data for this historical research project. This work has significantly contributed to the overall Maya body of information from which factors of sustainability have been researched and extracted.

In her contribution to The American Southwest and Mesoamerica (Ericson and Baugh, 1993), Patricia McAnany (1993) discusses diverse, localized production, distribution, and exchange systems that dominated many of the individual Maya localities, with many independent sectors operating simultaneously. The author believes that most of the basic necessities were produced locally, at the household level, and

almost always inside the Maya culture. McAnany believes that trade with polities outside the Maya lowlands primarily provided sumptuary goods for the small minority of theocratic elite.

In his book The Collapse of the Classic Maya, T. Culbert (1973) outlines a series of factors responsible for the collapse of the Maya. One of the factors Culbert discusses is failure of the economic system, which was controlled in large part by the ruling aristocracy. He cites inefficient resource information gathering, record keeping, and decision-making of the elite ruling class of the late Classic period as causes of the collapse. Although Culbert believes numerous other conditions are involved in the collapse, he maintains that the degradation of natural resources and a failing resource allocation system were major contributing factors in the collapse of the Maya.

Culbert also lists a number of components that positively contributed to the earlier success of the Maya, most importantly agricultural strategies, pre-Classic population stability, functioning trade networks, and the availability of basic natural resources for the common citizen. Large, semi-autonomous city-states such as Tikal required large amounts of human and natural resources to function efficiently. Culbert discusses the importance of maintaining a political system that does not pit one city-state against another for such vital necessities as prime farmland or skilled artisans. He also asserts that the Maya's failure to maintain a cooperative economy between regions had seriously damaging effects for them.

R. E. Adams (1981) discusses the hypothesis that a major shift in the rate of Maya societal development in the early Classic period was associated with intensification of agriculture and a social structure resembling a generalized feudal pattern. Adams notes

that population increase was extensive between the late Preclassic and late Classic periods; the increase of rural population densities alone during this time was tenfold. Urban centers had upper limits of 25,000 except for Tikal, which had aproximately 50,000 inhabitants. Adams estimates that in order to support the huge urban center of Tikal, more than 100,000 km^2 of surrounding Central and Southern Lowlands were required for agricultural production. During the Preclassic period, regional capitals such as Calakmul, Naranjo, Mirador, and Uaxactum developed. Although these city-states were not as large as Tikal, considerable outlying area was needed to produce the food products required by the non-farming populations of these urban areas. During the early Classic period, agriculture responded to this increased food demand with new intensive farming techniques and the clearing of new lands (Rice, 1991).

A number of journal articles provide significant additional information about Maya culture and resource system dynamics. "Mayan Belief Systems: A Network Interpretation" by John Brennan (1979) explores the role of the priestly class in Maya social structure during the Classic period. The author suggests that political power was not dependent upon a state army but rather "psychic coercion" by the theocratic leadership, and the development of religion and ceremonialism was stimulated by the uncertain crop yields associated with primitive agriculture. According to Brennan, religion functioned to motivate farmers despite difficult circumstances and to pacify them during poor crop conditions. The construction of tall monuments was perceived by the Maya as a mechanism for appealing more successfully to the gods for their benevolence and favorable environmental conditions.

Earlier, Altschuler (1958) emphasized that the Maya moved into the lowlands and successfully exploited the region's agricultural potential for many centuries. According to Altschuler, the Classic Maya collapse was not caused by an inadequate agricultural subsistence base, but rather by the inability of the ruling class to organize effective resource utilization strategies in the lowlands. Cowgill (1961) also believes that Maya subsistence agriculture in the Petén remained productive and was not a factor in the collapse of the culture. Meggers (1954), on the other hand, claims that because of limited agricultural potential of the lowlands, the Classic Maya culture, which had diffused into the lowlands from outside this region, ultimately could not sustain themselves.

Don Rice's (1991) paper titled "Roots" considers the importance of agricultural innovations as Maya populations grew in the Pre-classic and Classic periods and pressure was placed on rural Maya to deliver more and more food supplies. Two techniques that increased the short-term productivity of swidden agriculture in the lowlands were adapting shorter fallow periods and planting several different crops concurrently, each with different plant heights, maturation rates, and soil nutritional requirements. The author also discusses the well-documented practice in the Classic period of terracing sloping fields, which minimized erosion, increased the water absorptive capacity of the soils, and allowed more organic material to build up in the topsoil. Another intensive farming technique was raised field construction, which allowed the Maya to utilize a wetland habitat type for their farming activities. Channels were dug to drain swampy areas and the excavated soil was added to the surface of cultivated plots. The channels not only maintained consistent soil moisture during the dry season but also were sources of fish and other aquatic resources for the Maya agriculturalists.

Rice also discusses some of the negative impacts of a growing Maya population with its intensive farming techniques by the end of the Classic period. These intensive farming practices had no doubt provided higher short-term yields from the lowlands, but many of these regions had much of their forests stripped and previously abundant wild plant and animal resources were significantly diminished. Continual shortening of the fallow periods for slash and burn agriculture significantly debased the organic component and productive capacity of lowland soils. Other researchers have commented that although the degradation of agricultural productivity mirrors the decline in Maya population, the decline in productivity did not begin for many centuries, and Maya agricultural innovations sustained a growing population for several millennia (Wingard, 1992). This conclusion seems to supports the theory that Maya agriculture finally over-taxed its lowland potential and experienced an increasing loss of productivity.

In 1993, John Weeks published a research guide to the Maya that has been used as a reference source for this dissertation. A large section of this work is an annotated bibliography of pre-Columbian Maya literature. An accompanying section lists author, subject location, and subject index to the literature contained in the bibliography. Particularly pertinent entries include Maya economic organization, agriculture, demography, political organization, religious organization, social organization, and settlement patterns. This guide helped locate specific topics of Maya development that were missing or incomplete within the dissertation reference material.

The Moche

The Moche were a people who inhabited the river valleys of the arid coast of northern Peru from approximately A.D. 100 - 750 (Figure 2). Their ancestors, who trace

back at least 2000 years, lived along the Peruvian coast, and worked as fishermen, farmers, hunters, and gatherers. The book titled The Desert Kingdoms of Peru by Victor von Hagen (1964) provides the earliest comprehensive scholarly overview of the Moche reviewed by this study. The author discusses their natural setting, agriculture, language, social organization, architecture, and religion. Von Hagen explains that although the Moche did not have a written language, recovered pottery, artwork, and small figurines have served to illustrate many elements of daily life. This text provides considerable cultural ecology insights that clarify and broaden the total body of information on the Moche. This work provides many insights into the factors of Moche sustainability that have been used in the research instruments of this dissertation.

In his seminal book, The Moche, Garth Bawden (1996) draws on more than a quarter of a century of personal research and extrapolates the salient work of numerous colleagues to chronicle the complex history, social structure, and cultural components of Moche society. Bawden discusses the political and religious institutions, agricultural techniques, relationships with neighboring cultures, and environmental factors of the Moche. Important events are considered such as the abrupt climate change during the sixth century that caused a series of droughts and floods, periods of excessive soil erosion, and sand dune encroachment that were particularly severe throughout the southern portion of the Moche territory.

Bawden reviews both internal and external stresses of the Moche civilization. He discusses the role of internal strife inside the stratified Moche society and the effects of the expansion of a neighboring southern highland people called the Wari. According to Bawden, middle and lower class citizens may have believed that their leaders had

offended the deities and Moche society was being punished with foreign invasions and environmental catastrophes. This unrest may have undermined the ability of the ruling class to preserve social and economic order, as well as maintain an efficient resource system. Bawden explains that this loss of confidence in their leaders was perhaps the chief factor involved in the collapse and dispersal of Moche society.

Bawden's text provides a comprehensive and detailed reference source for Moche cultural components and natural environment. The author comments on various factors that he considers key to Moche stability and then discusses circumstances that undermined their continuity and prosperity. These discussions, as well as numerous other parts of the text, were referenced throughout the identification process of sustainability factors common to the Moche and the two other societies of this research.

Bawden emphasizes the importance of a central Moche ideology that, among other things, legitimizes the religious elite leader class using iconography to reinforce this tenet. This central ideology is one of the essential factors to which the author attributes the centuries of Moche stability and continuity. Bawden explains that considerable wealth was utilized by this elite class to reinforce their propriety in the form of artwork on a variety of sumptuous goods that depicts Moche leaders in roles of power and leadership. The author believes that the dilution of this common Moche belief system was a major factor in the permanent collapse of Moche society.

DeMarrais et al., (1996) dovetail with Bawden in their assessment of ideology as a tool used by the leadership of many ancient cultural systems. These researchers believe ideology was an important source for the attainment and maintenance of social power in many ancient societies. One of the archaeological case studies they used to support this

hypothesis is the Moche. They propose that Moche ideology was controlled by an elite class and was critical for the transition from a chiefdom to a state-level society around A.D. 450. According to these authors, ideology remained a significant source of social power for Moche elite and was supported by two common practices: complex ritualistic ceremonies and the investment of social wealth into the production of symbolic objects for the elite. They believe that ceremonies were conducted and controlled by the Moche elite for the purpose of stabilizing society and legitimizing their own privileged status. By controlling the production and distribution of symbolic objects, the elite further strengthened their vertical hierarchy.

This article provides useful insights into the social institutions and characteristics that held Moche society together. It emphasizes the functioning of the Moche central ideology as a type of cultural glue for a solid social framework. This potential stabilizing ability of a shared ideology was noted in determining the sustainable commonalities of this dissertation's three case study cultures.

An article written by Wilson (1988) discusses the origins and development of Moche communities in the Lower Santa Valley of the southern portion of the Moche homeland. Settlement patterns, social hierarchy with administrative elite, and tribute patterns are all discussed. This work contributes some additional perspectives on life inside Moche society and their resource acquisition systems to this dissertation.

In his 1975 paper titled "Prehistoric Principles of Labor Organization in the Moche Valley Peru," M. Moseley presents a model of prehistoric organizational principles used to coordinate and mobilize the considerable public labor needed for executing large-scale construction projects in the Moche Valley of Peru. Moseley

(1975b) contends that prehistoric construction projects were completed by means of a labor tax system organized by the elite theocracy. In this system, specific units of labor were drawn from distinct communities, and each labor party was responsible for a particular set of tasks that fulfilled a labor tax obligation owed to the Moche theocracy. This paper offers useful insights concerning the nature of Moche political power, public labor projects, and ideology that affected the average citizen.

Shimada (1978) later expounds on Moseley's theme and concludes that spatially segregated stages of craft production, extensive commodity movement and storage, and a public project labor force commuting from elsewhere functioned at the Moche Pampa Grande V site (ca. A.D. 600-700). The author contends that this redistributive and specialized socioeconomic system may have arisen during this late stage of Moche development as a result of economic stresses and environmental deterioration. Both of these articles by Moseley and Shimada have significantly contributed to the author's understanding of Moche society and specific techniques employed in the redistributive economy of the Moche.

Years later, Moseley (1983) published a paper "The Good Old Days Were Better: Agrarian Collapse and Tectonics," which advances the hypothesis of agrarian collapse involving tectonic surface movements that altered watershed patterns. The author explains that tectonic activity can induce gradual ground-slope changes, modifications in topography, and subsequent changes in surface and subsurface water movement. Moseley believes a rise in elevation of key locations may have caused long sections of Moche irrigation canals to become inoperative and force the abandonment of considerable amounts of Moche farmland. This possible unfortunate repercussion of

Peruvian tectonic activity illustrates an unexpected environmental hazard of agrarian irrigation in northern coastal Peru.

Another similar article co-authored by Moseley provides a tectonic-based explanation for the abandonment of specific Moche intervalley canals that today exhibit uphill gradients as well as ancient monuments that are not level (Ortloff et al., 1983). Both of these articles suggest that tectonic activity has played an important role in major disruptions in Moche agricultural and water resources. These data provide pertinent information that has been useful in the development of environmental sustainability factors of this dissertation.

A later hypothesis advancing additional environmental influences on Moche society was proposed by a research team lead by Izumi Shimada (et al., 1991). Researchers analyzed ice core samples from the Peruvian Andes and concluded that a series of severe droughts during much of the sixth century were at least partially responsible for Moche social reorganization during this period. The analysis of these ice cores provides precise temperature and precipitation records that allow archaeologists to assess the impact of these climatic factors upon the Moche. The researchers believe that these droughts caused major reductions in agricultural yields and an economic downturn, which were likely blamed on the Moche theocracy, who were believed responsible for maintaining a benevolent relationship with the gods. This conclusion suggests the strong probability of rejection of the Moche theocracy by the common class due to uncontrollable environmental catastrophic events. By depending upon favorable environmental conditions, the Moche elite may have sealed their fate and the eventual collapse of Moche society.

The Mogollon

The Mogollon were one of the most adaptable and long-lived cultures of the southwestern region of North America (Figure 3). From A.D. 200 - 1400, the Mogollon incorporated pit houses and later pueblos, pottery making, and farming into their semi-nomadic lifestyle in the upper plateaus of the Southwest. The success of these hunters, gatherers, and agriculturists has been documented and discussed by a number of prominent researchers.

Emil Haury was the first archaeologist to propose that the Mogollon were a separate culture from the Anasazi and Hohokam (Reid and Whittlesey, 1997). Prehistory of the American Southwest (Haury, 1986) is an anthology of the author's contribution to southwestern archeology. A significant portion of the text is devoted to the Mogollon and provides an extensive reference for these people of the mountains of the Southwest. Village architecture and settlement patterns, cultural ecology, natural resource acquisition, and conjecture on various facets of Mogollon life that left no physical records are all presented and discussed in considerable detail. This work contains valuable insights on a wide range of Mogollon tradition and culture.

Haury's (1985) book, Mogollon Culture in the Forestdale Valley, contains a variety of insights into Mogollon culture, resources, and environmental influences founded in many years of field research. Part IV of the work, "Phase Chronology in the Forestdale Valley," was particularly useful in this dissertation. This source presents a considerable amount of detailed information concerning this particular Mogollon site in east central Arizona. Specifically, one chapter titled "The Forestdale Valley Cultural Sequence" presents a synopsis of more than a millennia of Mogollon occupation in the

Forestdale Valley. The process of Mogollon cultural evolution and innovation along with foreign cultural influence are chronicled. This comprehensive work has provided pertinent information concerning Mogollon sustainability factors. Haury's clear synopsis enables considerable analysis of Mogollon cultural ecology within the context of this dissertation.

Paul Martin, former chief curator of the Department of Anthropology of the Chicago Museum of Natural History, researched and published some additional foundational work on the Mogollon. In his book, Digging into History, Martin (1959) discusses the evolutionary development of Mogollon society from the earlier Cochise culture. The author provides a clearly written, insightful text that includes significant discussion on the cultural ecology of these southwestern people.

According to Martin, Mogollon population gradually expanded to the carrying capacity of their territory and technology by A.D. 1400. Pottery appeared at the beginning of the first millenium, and by that time, corn, beans, and squash approached the importance of wild plants as the primary food source of the Mogollon. Martin surmises that rugged terrain and limited annual rainfall prevented the Mogollon from developing a larger and more complex political and social structure.

Lightfoot and Feinman (1982) believe that the major cause of Mogollon population growth from A.D. 700-1000 was due to the development of "suprahousehold leadership." These researchers say that excavations of burials at village sites occasionally show individuals of higher class and social standing, who had three noteworthy effects on Mogollon society. First, they encouraged members of their village to produce a surplus of goods for trade. Second, these leaders increased regional trade

ties with the Hohokam and Anasazi. Third, their special status attracted more enterprising individuals to their villages, with the subsequent acquisition of more exotic goods and contact with people outside of the Mogollon culture. Competition no doubt existed among leaders from various villages, which tended to maximize all three of these effects. Other researches believe that this loose confederation of Mogollon villages regularly came together for ceremonial purposes and defense (Reid and Whittlesey, 1997).

Earlier, Martin (et al., 1952) comments that Mogollon cultural homogeneity was possibly compromised several times by the diffusion of foreign ideas and people. He cites changes in grinding stone shapes, projectile points, sandal styles, the production and use of cotton, and the bow and arrow as examples of exotic innovations, and he notes that the time between A.D. 700 and 1000 was the period of greatest change for the Mogollon. In another piece, "Mogollon Cultural Continuity and Change," Martin et al., (1952) offer additional helpful data concerning resource acquisition processes and innovations not restated in Martin's later works. This piece provides useful information that influenced the process of Mogollon sustainability factor identification later in this dissertation.

Another literary contribution by Paul Martin deserves mention in this review is Chapter Six of the book Contemporary Archaeology edited by M.P. Leone (1972), titled "Conjectures Concerning the Social Organization of the Mogollon Indians." As the title implies, this work discusses a number of abstracted trends and possible components of Mogollon social structure from A.D. 500–1000 and provides some thought-provoking conjecture about the cloudier issues of Mogollon history. Martin discusses the decrease in the size of houses but an increase in the density of houses from early to later time

periods. He also talks about the change of village location from higher defensive sites before A.D. 500 to lower, unprotected sites closer to streams and agricultural areas after this time. The profound change of pit houses to multi-room, masonry-walled pueblos beginning around A.D. 1000 was attributed to Anasazi influence and direct migration from the north.

In his important work Broken K Pueblo (1970), J. Hill reports extensively about the occupation of a Mogollon site near Snowflake, Arizona. He maintains that a changing climate of this region during the period A.D. 1100-1400 was the primary factor for the dispersal of Mogollon society in the late fifteenth century. A decrease in population, an increase in the aggregation of the remaining population, and an increase in the cultural integration of the region all resulted from a slightly hotter and drier climate. According to Hill, climate change had an adverse effect on agricultural, forestry, and game resources of the Mogollon.

He also advances the possibility that warfare also played a role in the disappearance of this long-lived and stable society. Hill states that sustained enemy attacks were another plausible factor affecting the integrity and relocation of Mogollon society. Hill's research provides this dissertation with a reliable source of information and scholarly conjecture for the lengthy period of Mogollon fluorescence as well as possible reasons surrounding their decline.

Another important Mogollon publication is Multidisciplinary Research at Grasshopper Pueblo Arizona by William Longacre et al. (1982). This work contains individual papers by 20 different researchers covering a variety of subtopics of Mogollon culture including population dynamics, water resources, and dendrochronology of the

Grasshopper Pueblo village site. Chapters titled "Modern Environment of the Grasshopper Region" and "Geology and Lithic Resources of the Grasshopper Region" both provided important background information for this dissertation on an area typical of Mogollon habitation. Another chapter titled "Pueblo Growth at Grasshopper: Methods and Models" deals with the transition from pit houses to pueblos and their eventual abandonment, as well as the major events and processes affecting the Mogollon population. Minnis and Redman (1990) felt that the pit house period beginning around A.D. 200 coincided with a substantial dependence on agriculture, and the pueblo period marked an even closer reliance on farming. This source provided pertinent information on population dynamics and cultural ecology for incorporation into the factors of sustainability.

The final chapter of this publication titled "Aggression and Abandonment at Grasshopper Pueblo: Evolutionary Trends in the Late Pre-History of East Central Arizona" provides scholarly commentary on the factors that influenced the abrupt human density changes of the major portion of Mogollon territory. This information provides additional hypotheses on the primary causes for the dispersal of the Mogollon, who inhabited this portion of the southwest for many centuries. This text has provided useful Mogollon insights that were used in the process of determining the decision key factors and sustainability factors of the case study societies.

In the book The Archaeology of Ancient Arizona, authors J. Reid and S. Whittlesey (1997) devote a chapter to a comprehensive overview of the Mogollon. This work provides a chronology of Mogollon development from the early pit house period through the pueblo phase. The authors summarize current theory and opinion on all

major characteristics of Mogollon society. This text served as a useful comprehensive reference, especially by providing a broad perspective on a culture that had lived simply and efficiently for over a millenium in the mountains of the desert southwest. This work provided considerable information and analysis that filled gaps and clarified portions of Mogollon human ecology and social patterns.

Finally, Wheat's (1955) journal article, "Mogollon Culture Prior to A.D. 1000," discusses a number of resource issues occurring during a 1200-year period of exceptional Mogollon cultural durability that is focused upon in this research. The author discusses the notable consistency of culture and standard of living of the Mogollon that is characteristic of a sustainable society. Wheat's work contributed to the overall interpretation of the cultural ecology of the Mogollon as well as the identification of sustainability factors of this culture during this time period.

Summary

The literature discussed in this review has provided an extensive and solid foundation for an investigation of the physical environment and natural resource systems of the Maya, the Moche, and the Mogollon. These sources furnished considerable information on the evolution of ancient sustainability and sustainable resource systems and their contemporary applications. The conjecture and opinions expressed by the various authors on these topics were also useful and valuable to this dissertation. Interestingly, when reviewing the information used for the discovery of common factors of sustainability, often only a few sentences from an entire chapter were relevant. But when these nuggets of information were integrated with data from other sources,

commonalities between these societies appeared and plausible factors of sustainability appeared. The next chapter will detail the methodology used to review environmental considerations such as biotic resources and water availability, as well as cultural characteristics such as agriculture, social cohesiveness, foreign relations, and quality of leadership with a sustainability perspective.

CHAPTER III

METHODOLOGY

The primary goal of this dissertation is to identify common factors that supported and maintained three selected pre-Columbian agrarian societies. Chapter II reviewed particularly significant literature concerning the evolution of society, sustainability, and the three ancient societies of this research. This chapter outlines and explains the research methodology employed in this study. It begins with an overview of the research design and the rationale behind the methodological strategy. Next, each of the two research instruments, the sustainability decision key and the sustainability formula, are explained with a discussion following each topic. Finally, the last section summarizes the methodology process and how the research elements are integrated.

Research Design and Rationale

A primary goal for this pre-historical research is the compilation and subsequent ranking of a comprehensive set of environmental and cultural sustainability factors for the three pre-Columbian agrarian societies featured in this dissertation. An extensive literature search uncovered information and insights on a number of sustainability factors as well as sustainability commonalities for ancient agrarian societies. The decision key instrument ranks each established sustainability factor and commonality into one of three categories: essential sustainability component, major sustainability component, and minor sustainability component. After the sustainability key categorizes all factors and

commonalities, this information is ready to be used in the second instrument of this methodology, the sustainability formula.

Current scholarly opinion holds that sustainability is contingent upon a variety of circumstances, both cultural and environmental. The sustainability key assesses both cultural and environmental factors that have been classified into four ranked categories according to their contributions to sustainability. The categories are based on previous research and on the subjective decisions of this dissertation researcher. As discussed in the limitations section of Chapter I, subjective decisions are unavoidable in ancient sustainability assessments, but subjectivity does not negate the utility of qualitative methodology (Gay, 1996). Upon further investigation and assessment, the assigned values for factors can be adjusted and new factors added to the list. This process provides a flexible appraisal and classification system for ancient sustainability factors not available prior to this research.

The sustainability formula pseudo-quantifies the sustainability of ancient societies at a specific period in their development. The formula assigns decision key determined values for sustainability factors associated with an ancient society, totals these values, and produces an overall numerical score indicative of the level of overall sustainability for the ancient society at a particular time period.

This methodology is relatively simple and productive. Additional quantitative analysis techniques are not necessary for the data; the utility of the analysis is in its austerity and straightforwardness. This methodology allows previously noted characteristics of ancient societies to be used within a new perspective of sustainability,

and this methodology also allows the researcher to pseudo-quantify the sustainability of individual ancient societies into a convenient numerical score.

With the characteristics of a modern sustainable society still somewhat in question, factors that served to stabilize and support early cultures exhibit potential contemporary utility. An additional motivation for this methodology is the potential contemporary application of newly uncovered sustainability commonalities of ancient agrarian societies. This methodology identifies factors crucial to past societies and suggests new, effective pathways to future sustainability. Because of this and the previously stated justifications, the researcher believes the methodology involved in this qualitative research is useful and appropriate.

Research Instruments

This section introduces and explains the two research instruments used in this dissertation, the sustainability decision key and the sustainability formula. The sustainability decision key ranks the identified factors of ancient sustainability and the sustainability formula produces a numerical sustainability score for the three agrarian pre-Columbian societies. This formula instrument can also be used to assess the sustainability of other ancient agrarian societies of the world. The following sections explain and discuss this methodology in detail.

The Decision Key

The instrument that assigns the categorical rank of sustainability attributed to each identified factor and commonality within agrarian societies is the sustainability decision

key. This decision key consists of a series of dichotomous choices that ultimately assigns categories of sustainability rank for each identified factor and commonality associated with ancient agrarian societies. The list of sustainability factors was compiled by carefully surveying the volumes of publications noted in the evolution of human society, the concept of sustainability, and the three pre-Columbian society sections of the literature review. A sustainability factor was flagged when at least two literature sources proposed the characteristic to be responsible for significantly influencing the stability and longevity of a society. A sustainability commonality was flagged when it was mentioned in literature sources of all three case-study societies and was determined by this researcher to be likely to influence the sustainability of an ancient society. The commonalities were often commonly accepted general information about each of the ancient American cultures, although the connection to stability and continuity was rarely explicit.

The following is the procedure for processing the sustainability factors and commonalities through the sustainability decision key (Figure 5):

1) One at a time, select each of the researched and compiled sustainability factors or commonalities that are associated with the pre-Columbian societies.

2) Assign one of the following sustainability categories to each factor/commonality using the series of dichotomous choices:

   - Essential sustainability factor
   - Major sustainability factor
   - Minor sustainability factor
   - Not a sustainability factor

   For each sustainability factor and/or commonality ask the following series of questions:

- In almost all cases, does the sustainability factor/commonality provide a product or service that was *substantially useful* to a society over an indefinite period of time?

  If yes, go on to the next question. If no, the factor/commonality is classified as *not a sustainability factor.*

- In almost all cases, does the sustainability factor/commonality provide a product or service that was *significant but not vital* to a society over an indefinite period of time?

  If yes, go on to the next question. If no, the factor/commonality is classified as a *minor sustainability factor.*

- In almost all cases, does the sustainability factor provide a product or service that was *absolutely essential* to a society over an indefinite period of time?

  If yes, the factor is classified as having an *essential sustainability factor.* If no, the factor is classified as a *major sustainability factor.*

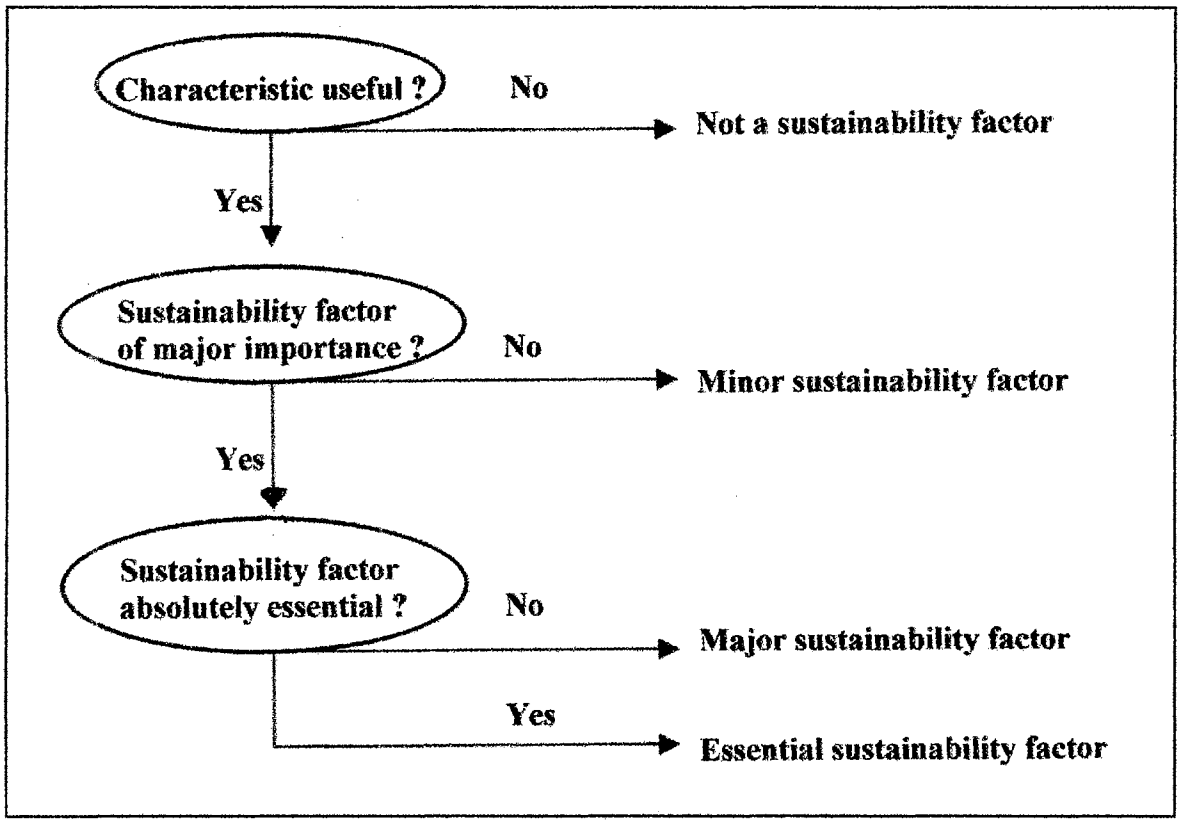

Figure 5. Sustainability Decision Key

Discussion

This two-source requirement for sustainability factors and three-source, three-society requirement for sustainability commonalities was a subjective decision made by this researcher based in large part on the extensive literature investigation required in this project. Two distinct scholarly sources that separately comment on the likelihood of a characteristic or condition influencing the durability of a culture was viewed as adequate for inclusion by this researcher. When each of the three selected pre-Columbian societies had a noteworthy common condition or characteristic identified, this researcher then made a subjective determination concerning the extent of its effect upon the sustainability of the culture. This decision was also appropriately based on the experience and informed opinion of the researcher.

The decision key uses the terms "substantially useful," "significant but not vital," and "absolutely essential" in the series of dichotomous choices to classify the factors. The researcher believes these terms provide sufficient diversity in classification of sustainability factors while not creating an excessive number of subjective category levels. The term *essential sustainability factor* refers to a characteristic that is vital and irreplaceable for a society. The term *major sustainability factor* refers to a characteristic that is important but not vital for a society. The term *minor sustainability factor* refers to a characteristic that is noteworthy and useful but not of major importance.

The Sustainability Formula

This instrument pseudo-quantifies the degree of sustainability for individual ancient agrarian societies at a particular period in time. This sustainability formula

produces a quantitative score that is representative of the overall ability of a society to sustain itself by totaling the values of each applicable sustainability factor for each assessed society. The following is the procedure for quantifying the overall sustainability of a society using the sustainability formula:

1) Assign a 10-point value to each *essential sustainability factor* the researcher has associated with the ancient society under assessment.
2) Record the number of *major sustainability factors* and *minor sustainability factors* associated with the focus society. The point values for the *major* and *minor factor* categories will be calculated by the following two determiners:
    - The value given to each *major sustainability factor* will be twice that given to each *minor sustainability factor*.
    - The point subtotal of all possible *major* and *minor* categories will be as close as possible to, but less than, 100 points.
3) Add the point values of all essential, major, and minor factors of the society under assessment. This total point value will be the sustainability score for the society.

A society possessing all previously identified *essential factors* (plus any *major and minor factors*) will receive a score in the *sustainable* range. A society not possessing all essential factors will receiver a score *not in the sustainable* range regardless of the number of additional major and minor factor values it possesses. Aside from the point value required for a *sustainable* score, a wide range of score values are possible depending upon the sustainability factors the society was found to possess.

Discussion

This sustainability formula requires that a sustainable society possess all essential factors identified by the sustainability key. Essential factors are labeled as such because of their fundamental importance to sustainability. The total score of all major and minor factors is restricted so as to prohibit their combined value from ever equaling the value of an essential factor. Although important, major and minor factors were not essential in a sustainable society and their point value reflects this determination. These non-essential factors are divided into two categories, major and minor, so their scores can represent two different levels of importance while avoiding an excessive number of subjective categories.

Although not vital for sustainability, major and minor factors significantly influenced the sustainability of ancient societies. Sustainability is determined by many factors working in concert over long periods of time. The potency of all factors waxed and waned through time according to their proliferation inside a society. Only societies that possessed all essential sustainability factors were sustainable, and they were only sustainable during that particular time of possession. This author believes a sustainable society that possessed very few major or minor factors was vulnerable and very likely to lose an essential component. Major and minor factors may have provided a buffer for sustainable societies, prolonging their stability and longevity; likewise these same major and minor factors may have provided an impetus for less stable societies in their acquisition of essential cultural sustainability factors they were previously lacking. Additional discussion on the role of major and minor factors of sustainability is contained in Chapter V.

Data Analysis

The first set of data produced by this research is a list of sustainability factors that have been identified within the three focus societies. These data were gathered by carefully reviewing numerous environmental, anthropological, and archaeological sources for factors that contributed to the sustainability of a pre-Columbian culture. These factors were often not referred to in the primary literature as "sustainability factors," but rather as characteristics that enabled stability and continuity of culture. Nevertheless, the literature review identified circumstances or conditions that researchers believe stabilized a society and allowed them access to essential resources on a long-term basis.

Next, a set of sustainability commonalities was uncovered among the three case study societies. Validity for this type of subjective research required hundreds of hours of literature investigation and study of these societies. The researcher realizes that this literature search will not identify every factor that influenced ancient societies throughout time. Undoubtedly, some important factors left essentially no archaeological evidence and have been overlooked. Nevertheless, the commonalities generated by this research are valuable and provide insight into the nature of sustainability in three pre-Columbian societies of the Americas. These data highlight the driving machinery behind sustainable resource systems within a portion of the American past.

The sustainability decision key logically assigns individual categorical rankings to the identified sustainability factors and commonalities by employing a series of dichotomous choices for the researcher. These rankings, although subjective, have proven valuable in that they provide the meaningful criteria to accurately assess the overall sustainability of ancient societies. The rankings are uniformly applied to each of

the chosen societies at each of the time periods analyzed and allow direct comparison of different cultures through time according to a fixed set of standards. The decision key has placed individual sustainability factors into four specific groupings, thereby providing useful information for this and possibly later research pursuits.

The sustainability formula uses these rankings to quantify the series of significant factors of sustainability applicable to a particular society. This formula calculates a score that represents the overall ability of a society, and its resource systems, to indefinitely sustain itself. This information offers a variety of anthropological applications. For example, a series of sustainability scores for one culture at different developmental stages can be used to chronicle the stability of the society over time. Comparisons of sustainability scores between ancient societies will provide additional useful anthropological information and insights. Examples of possible score comparisons are contained in the recommendation section of Chapter V.

Finally, the researcher believes that the data generated by this prehistoric investigation provides useful insights for revising current resource management theory and policy. As with most ancient cultures, the prosperity of contemporary society relies upon productive and sustainable agriculture (Hatfield and Karlen, 1994). Chapter V of this dissertation presents a series of recommendations for potential adjustments of contemporary sustainability strategies, along with a number of suggestions for follow-up research.

Summary

A qualitative methodology has been employed to generate reliable data concerning factors of ancient sustainability. An extensive review of the available anthropological and archaeological literature produced two useful groups of data. First, a list of ancient characteristics was assembled that scholarly sources believed contributed to the stability and continuity of cultures. Second, a list of previously unidentified

cultural and environmental sustainability commonalities for all three selected pre-Columbian agrarian societies was uncovered by this research. The sustainability key and sustainability formula are two research instruments employed to generate this ancient sustainability data. Both instruments delivered the expected reliable and relevant information for this research project. The next chapter presents and explains the specific data generated by this historical methodology and analyzes the research findings.

CHAPTER IV

ANALYSIS AND FINDINGS

The preceding chapter explained the methodology employed in this qualitative pre-historical research. Chapter IV introduces the data generated by this methodology and then provides analysis with accompanying comments. The first section presents the categorical ranking by the sustainability decision key for each of the sustainability factors and commonalities generated in the literature review. This section includes a brief explanation of the rank assignment for each sustainability factor and the accompanying literature sources cited by the researcher. The second section presents the sustainability formula process for each of the three case study societies at two different periods of their development, yielding a total of six separate sustainability formula scores. The final section of this chapter reviews the findings of both the sustainability decision key and sustainability formula and discusses the comprehensive integration of all data generated in the research.

The Sustainability Decision Key Analysis

The decision key assigns the appropriate category of sustainability for each identified factor and commonality within the three pre-Columbian agrarian societies. This key consists of a series of dichotomous choices that assign categories of sustainability for each factor and commonality. The list of sustainability factors was compiled by reviewing the anthropological and archaeological sources of the literature review. A sustainability factor was identified when at least two literature sources

proposed the characteristic to be responsible for significantly influencing the stability and longevity of an ancient agrarian society. A sustainability commonality was identified when it was mentioned in literature sources for all three case-study societies and was judged by this researcher to have influenced the sustainability of the ancient cultures. The commonalities were often part of generally accepted information about each of the ancient American cultures, although the connection to stability and continuity was rarely discussed at length.

This decision key categorizes a total of 15 sustainability factors and five commonalities into three possible rankings: essential sustainability value, major sustainability value, and minor sustainability value (see also appendix A). This section shows the results of processing the environmental and cultural factors as well as the discovered commonalities through the sustainability decision key with a discussion following each factor:

- Environmental factors of sustainability

1) Adequate prime farmland – *essential sustainability factor*

- An essential requirement of ancient sustainability was a sufficient quality and quantity of farmland that, with appropriate farming techniques, had the capacity to indefinitely provide sufficient crop yields to support the agrarian society under consideration. An insufficient amount of land or inappropriate soil type/slope would fall short of the long-term food productivity requirement for a sustainable agrarian society. Farmland had to be adequate throughout periods of population growth as well as times of technological change. Although other factors also affect agricultural productivity, the absence of this

fundamental cropland resource would place the prospects for agrarian society sustainability in considerable jeopardy (Curwen, 1953; Sauer, 1963; Troeh et al., 1999).

2) Adequate water resources – *essential sustainability factor*

- This characteristic includes both agricultural and non-agricultural water supplies. Adequate water provided a number of basic needs including personal consumption, cooking, cleaning, and crop irrigation. Without a sufficient and dependable water supply, pre-Columbian societies would have not been sustainable. Sustainable water supplies also had to be adequate throughout periods of population growth as well as times of technological change. Researchers that stress the importance of dependable water resources include Bawden (1996), Culbert (1973), Downing and Gibson (1974), Gonzalez (1978), and Martin (1959).

3) Adequate utility resources – *essential sustainability factor*

- Utility resources are defined in the research as materials from the immediate environment that provide non-food necessities including fuel, tools, clothing, and shelter. Adequate utility resources met many of the routine but essential needs of early Americans and provided the material foundation for the development of other important components of sustainability. Locations in the Americas with the potential to continually deliver all necessary utility resources for a people were undoubtedly limited. Even though primitive

technology periodically found new resources that could substitute for those in short supply, other utility resources had no possible substitutions. If populations increased, the demand for utility resources of a homeland also increased proportionately, so a sustainable society required an environment that could handle all future basic requirements (Martin, 1959; Reid and Whittlesey, 1997; Sharer, 1996; and von Hagen, 1964).

4) Adequate length of growing season – *major sustainability factor*

- Incumbent upon ancient agrarian societies was the annual task of producing a large portion of their food supply from agricultural sources, and an ample growing season was one of the keys for adequate crop production. A marginal growing season for one or more major crops, such as maize or beans was a distinct disadvantage for an agrarian society. Low crop yields due to inconsistent growing seasons would translate into less winter subsistence rations as well as less tradable food surplus. Minimal winter food resources would have a significantly negative effect upon the overall health, productivity, and stability of a society. A tradable food surplus limited by a marginal growing season would also lower the amount of foreign resources that could be acquired through trade and utilized by a community (Hatfield and Karlen, 1994; Ruttan, 1992).

5) Low probability of natural disaster – *major sustainability factor*

- The occurrence of some type of natural disaster was a possibility for all ancient societies of the Americas at some time during their existence. Severe flood, drought, hurricane, earthquake, or volcanic eruptions are some examples of plausible environmental catastrophes. Although most natural disasters do not destroy an entire society, they were possible contributing factors to the eventual dispersal of the Mogollon by A.D. 1400 (Hill, 1970), the collapse of the Maya in the southern lowlands by A.D. 850 (Sharer, 1996), and the final Moche decline by A.D. 750 (Bawden, 1996). More often, societies eventually recuperated from natural disasters, although considerable time, energy, and resources were expended in the process. Since sustainability requires long-term continuity, a low probability of natural disasters was indeed a contributing factor of ancient sustainability.

6) Accessible trade routes – *major sustainability factor*

- Accessible trade routes enable the movement of people and commodities throughout a region of homogeneous culture or between societies inhabiting completely different regions. Convenient passage throughout a region or between different regions, whether overland or by water routes, promoted economic, social, and political development (Rathje, 1971; Trombold, 1991). Coe (1993) contends that much of the Maya trade moved up and down the coasts since most existing roads were probably only slightly improved trails and trade cargoes were often heavy. The Moche also managed a considerable seafaring trade network to the north of their homeland (Bawden, 1996).

Settled communities benefitted from accessible trade routes because of improved access to resources unavailable in the immediate area. Local economies often benefitted from trade routes due to improved production of scale opportunities for craftsmen and trade specialists. However, it is important to note that benefits from accessible trade routes varied significantly inside a society depending upon the social status of community members, the relative location of settlements, and the type of economy. McAnany (1993) asserts that the Classic Mayan economy was essentially localized and the Maya conducted trade with non-Maya regions primarily for raw materials to create sumptuary goods for the elite. Webb (1964), on the other hand, proffers that the disruption of trade into and out of the southern Maya lowlands was the prime cause of their collapse. Other researchers like Sharer (1996) and Bawden (1996) state that trading of utilitarian goods was extensive for both the Maya and Moche. Coe (1993) and Sharer (1996) point out that trade routes were important conduits for the exchange of ideas and innovations between the Maya and other cultures.

7) Adequate food processing and storage – *major sustainability factor*

- Not only did agrarian societies have to grow surplus quantities of food, but they also had to process and store their crop yields. The soaking, drying, and grinding of maize was very important for many ancient agrarian societies. The various types of hard igneous rock, such as granite, provided a valuable material for grinding stones in cultures that processed large amounts of grain

and seed for human consumption. In addition, the crafting of pottery for cooking and food storage also greatly improved the ability of early man to prepare and store crop harvests, thereby guaranteeing adequate reserves throughout periods of drought or flood. Sources must be secured for specific types of clay and reinforcing materials, such as ground shells, that are required for the crafting of quality pottery. Researchers that discuss the significance of food processing and storage resources include Coe (1993), Culbert (1973), Ericson and Baugh (1993), Haury (1986), and Sharer (1996).

8) Accessible mineral ores – *minor sustainability factor*

- The Moche utilized copper, silver, and gold ore deposits in the Andean foothills for the purpose of crafting symbols of authority for the elite (Bawden, 1996). By A.D. 750 the Maya also used metals for ritual objects and jewelry for their upper class rather than for utilitarian applications such as tools or hunting devices (Sharer, 1996). The Mogollon, on the other hand, never did utilize metal for their rituals or tool construction (Martin, 1959). Mineral ores provided ancient societies the opportunity to substitute metals for stone materials such as obsidian and flint in the construction of ceremonial objects signifying authority, and for various tool applications. If the necessary metallurgy technology was developed or acquired, this additional innovation would benefit society, the degree to which was dependent upon the specific application.

➢ Cultural factors of sustainability

9) Stable population growth rate – *essential sustainability factor*

- When compared to modern society, the rate of technological innovation for ancient cultures was low. Consequently, the ability of an ancient culture to increase the carrying capacity of its environment through technological innovations was limited. The sustainable delivery of vital resources for a society required the demand for such resources to be within a rate that the environment could sustain indefinitely. When populations grew to the point where the environment and technology could not deliver the quantity of resources required, ancient people had to migrate to new and possibly inferior locations or to areas claimed and defended by other cultures. Even the lowland Maya, with their innovative and intensive agricultural strategies, could not sustain adequate food production in the face of unchecked population growth. Mechanisms that maintain stable population growth rates within the carrying capacity of an environment, such as restrictive marriage laws and practices, were instrumental for the maintenance of stable populations. (Adams, 1981; Coe, 1993; Culbert, 1973; Harner, 1970; Johnson and Earle, 1987; Sharer, 1996).

10) Effective Leadership – *essential sustainability factor*

- The tendency for people to follow charismatic leaders has been evident throughout cultural evolution. Throughout prehistory, political, religious, and social leaders have organized various movements and institutions involved in

man's complex cultural development. Tribes, chiefdoms, and primitive states all have benefitted from effective leadership in a number of ways. Lightfoot and Feinman (1982) state that effective leadership in ancient cultures made it possible to support a much higher population than would be possible with a less organized system utilizing the same resource base. Service (1975) notes that a well-managed system of wealth redistribution contributes significantly to the solidarity of a society. Culbert (1973) and Altschuler (1958) listed ineffective leadership as one of the primary factors in the breakdown of the lowland Maya. Ancient sustainability depended upon a number of cultural factors that were organized and supported by leadership inside the society. Ancient sustainability would not have been possible without effective social leadership directing resource acquisition and distribution patterns that provided for the needs of the general population.

11) Maintenance of soil productivity – *essential sustainability factor*

- Just as adequate prime farmland and soil moisture were essential to sustainability, ancient agrarian societies also needed to maintain adequate soil productivity. Productive soils provided the fertility and moisture holding capacity that produced consistent and substantial crop yields to help feed a society. High crop yields also provided a food surplus that in some cases allowed a society to develop, and new occupations such as religious leaders, ancient craftsman, and political leaders to evolve. These specialists produced goods and services more efficiently, and thereby raised the standard of living

inside an ancient society. Loss of soil productivity, on the other hand, prohibited an agrarian society from sufficiently feeding itself over time. Clearly, the maintenance of soil productivity was an essential factor for a sustainable ancient agrarian society (Hatfield and Karlen, 1994; Meggers, 1954; Rice, 1991; Sharer, 1996; Wingard, 1992).

12) Adequate water delivered to agricultural soils – *essential sustainability factor*

- Adequate soil moisture throughout the growing season is a crucial element of productive and dependable farming operations. Relatively few natural environments existed for ancient cultures that consistently provided optimum soil moisture throughout an entire growing season. For their farm sites, the Mogollon chose well-watered valley soils near streams that were adaptable to flood irrigation. The Moche utilized irrigation agriculture through a system of ditches and canals that began at the incised river valleys and extended to the adjacent desert flatlands. The Maya farmed a variety of environments including the fertile volcanic southern highlands and the lowland slopes of the Petén and the northern Yucatan Peninsula. Ancient agricultural water diversion structures used throughout the Americas included terraces, water impoundments, check dams, weirs, and irrigation canals, all of which helped deliver timely supplies of water onto farm fields and dramatically increase crop yields (Donkin, 1979; Doolittle, 1990; Downing and Gibson, 1974; Shimada et al., 1991). An adequate water supply to farm fields was a vital

factor in sustainable ancient agriculture and thereby an essential condition for sustainability.

13) Significant technological innovations – *major sustainability factor*

- Improvements in methods for procuring and utilizing natural resources have increased the stability and living standards of societies throughout the cultural evolution of man. Ancient innovations in tool making and agriculture alone have enabled substantial growth in both social complexity and human population numbers. Technological improvements have assisted man in producing a more consistent flow of vital supplies for larger numbers of people as well as utilizing that resource flow more efficiently. Although the number of notable ancient technological innovations is relatively low when compared to modern society, the utility of each successful idea was nonetheless significant. All three societies of this research have benefited from a variety of innovations and were undoubtedly better suited for a sustainable existence after incorporation of their specific technological advances (Service, 1968; Sharer, 1996; Bawden, 1996).

14) Sufficient food for specialists – *major sustainability factor*

- In order for occupational specialists to function within ancient agrarian societies, farming members of the community had to produce sufficient food surpluses that were available to exchange for the new specialized services. Members of both chiefdoms and primitive state societies benefitted from their

religious, political, tool-making, and engineering specialists who produced familiar goods more efficiently as well as provided new services not previously available (Service, 1962, 1975). The opportunity to complete community projects such as irrigation canals, temples, and dwellings for community ceremonies depends upon consistent surplus food production. Under this more complex economic system of specialists, less surplus food supply translates into fewer occupational specialists and diminished net social benefits for the society. Consistent food for specialists supported a broad-based prosperity and enabled a more efficient utilization of natural resources in primitive states and chiefdoms. Since tribal society generally does not exhibit nearly the degree of occupational specialists as do more complex societies, this factor was not particularly applicable for the Mogollon.

15) Inter-settlement cooperation and cohesion – *major sustainability factor*

- Cooperation between ancient settlements varied considerably with the society, the location, and the developmental period. Mogollon village communication and cooperation was thought to be minimal until the late pit house and pueblo periods, when inter-settlement cooperation within this loose confederation probably included mutual defense, religious ceremonies, and marriage exchanges (Martin, 1959; Reid and Whittlesey, 1997). Within the Moche chiefdom, communities specialized in particular crafts that were traded throughout the polity, with Moche society benefiting from the wide range of specialized production. Also, these communities were thought to have

remained integral parts of a wider social unit with accompanying kinship affiliations and obligations. For example, all Moche society benefitted from the interconnected irrigation network maintained by a variety of locations and communities throughout its course (Bawden, 1996; Service, 1975; von Hagen, 1964). According to Sharer (1996), the lack of cooperation, even to the point of the development of competition, between Classic Maya city-states significantly contributed to the collapse of the lowland Maya society. Although not essential for stable prosperity, settlement cooperation was a major asset for ancient agrarian society sustainability.

- Commonalities of sustainability:

16) Common ideology – *essential sustainability commonality*

- Archaeological and anthropological descriptions of long and stable periods of the Maya, the Moche, and the Mogollon include a common ideology found throughout all levels of society. A commonly held ideology provided a unifying fabric throughout each culture and was an essential element for sustainability. When the majority of its members lost their common ideology, the stability of the society was seriously compromised, often involving major changes of social organization. The Moche ideology lost its universality when the non-elite classes perceived extended environmental hardship as evidence of their theocracy having lost its power to influence the benevolence of the gods (Bawden, 1996; von Hagen, 1964; DeMarrais et al., 1996). Maya ideology was abandoned when the leaders failed to judiciously manage the

resources of the lowlands (Culbert, 1973). Reid and Whittlesey (1997) as well as Wheat (1955) believe the Mogollon lost their unifying ideology when the Anasazi from the north slowly merged into and became a part of the Mogollon culture. They contend that this merger precipitated new beliefs, values, and eventually the abandonment of their mountain homeland, although Hill (1970) proposes that climate changes during the period from A.D. 1100-1300 was the primary factor in the eventual migration.

17) General adaptability – *essential sustainability commonality*

- Perhaps the most commonly shared condition among the three focus cultures of this research was that of change. Seasonal change, changes in neighboring cultures, change of population levels, leadership change, climate change, and the discovery of new resources were just some of the variations that slowly but steadily affected ancient American societies. The capacity to adapt to these changes, minimize stress, and make the most of existing environmental conditions was an indispensable characteristic for stable pre-Columbian societies (Flannery, 1972; Sauer, 1963; Reid and Whittlesey, 1996; von Hagen, 1964). The capacity of ancient systems to accumulate and store vital commodities and emergency reserves was considerably less than that of contemporary systems. Subsequently, pre-Columbian cultures had relatively short periods in which to adjust to significant change, and the nature of their adjustment response was critical to their survival.

18) Social classes not highly differentiated – *major sustainability commonality*

- Distinct social classes are fundamental in the organization of chiefdoms and primitive states. However, complex polities that contain a highly differentiated social structure, such as were found in the late Moche V period and late Classic Maya period, proved counterproductive for sustainability (Flannery, 1972). These highly separate and distinct social classes emphasized differences among society members, fostered disunity and divisiveness, and significantly influenced the collapse of early society (Costanza, 1991). Earlier periods that exhibited less social strata differentiation proved more stable and durable for both the Moche and Maya. The Mogollon, on the other hand, maintained a tribal society that lacked distinct social classes throughout its existence. A relationship does seem to exist in pre-Columbian agrarian societies between greater differences in class structures and increased social instability.

19) Minimum military expenditures – *minor sustainability commonality*

- Although warfare could unite an ancient people for a common cause, the maintenance of a standing army was a costly expenditure. Professional soldiers were compensated for their military services by means of collected taxes from other society members. Although Service (1975) contends that military efforts are often a significant unifying factor for societies, this author believes that extended military operations have not been cost effective over the long-term. Military expenditures drained a portion of wealth of a society

that otherwise could have been traded for more useful goods or redirected to community projects such as irrigation canals, improved settlement amenities, or improved road systems. Cultures in close proximity that share a low propensity for military expenditures constitutes a minor factor of sustainability for the entire region over the long-term.

20) Significant wild food resources – *minor sustainability commonality*

- With only a few plant species adapted for domestication, early agrarian societies came to depend upon their farming endeavors very gradually, often over many centuries, while still relying in part on wild-food resources. Opportunistic cultures such as the Mogollon relied heavily on gathering wild plants and hunting game throughout the majority of their existence. Only in the their last two centuries of homeland occupation did the Mogollon come to depend upon domesticated farm crops for most of their dietary needs. A number of Maya researchers such as Sharer (1996), Coe (1993), and Culbert (1973) state that the Maya also depended heavily on wild foods such as manioc and the breadnut. With intensified swidden agriculture in the lowlands during the late Classic period, major portions of the vegetation were removed, thereby significantly degrading the supply of wild foods. Although pre-Columbian agriculture eventually developed into a very productive food source, the ability of people to harvest wild food supplies provided important substitution options, especially during periods of drought or heavy insect infestations of domesticated crops.

The Sustainability Formula Analysis

The sustainability formula was introduced in the preceding chapter as one of the two research instruments constructed for use in this historical research. The formula pseudo-quantifies the overall sustainability of ancient agrarian societies of the Americas at particular periods in their development. The formula incorporates each sustainability factor and commonality as categorized by the decision key to produce a time-referenced, aggregate score that indicates the overall sustainability of a society.

This formula employs four possible sustainability categories: essential sustainability factor, major sustainability factor, minor sustainability factor, and not a sustainability factor. Each category is assigned a different numerical value, according to its predetermined sustainability worth, with essential factors receiving the highest value and characteristics not involved in sustainability receiving no value.

A sustainability formula assessment begins by selecting an ancient agrarian society at a particular developmental period. A thorough review of pertinent literature is performed for the culture in order to inventory the 20 predetermined sustainability factors of the society under assessment. Each sustainability factor found within the society and time period under assessment is then assigned its predetermined numerical value, and the factor values are totaled for an overall sustainability score. Each of the nine essential sustainability factors is assigned a 10-point value, each of the eight major factors is assigned a one-point value, and each of the three minor factors is assigned a one-half point value. An ancient society would have to score 90 or more points to be considered sustainable, and the maximum score possible for a society with all the sustainability factors would be 99.5 points.

The following are the results of the sustainability formula processes for each of the three ancient agrarian societies during two distinct time periods (see also appendix B). The literature sources that were consulted in these determinations are listed at the end of each data set.

The Maya – 1000 B.C. until A.D. 250

Essential environmental sustainability factors:

1) Adequate prime farmland – *affirmative*, ten points assigned
2) Adequate water resources – *affirmative*, ten points assigned
3) Adequate utility resources – *affirmative*, ten points assigned

Major environmental sustainability factors:

4) Adequate length of growing season – *affirmative*, one point assigned
5) Low probability for natural disaster – *negative*, no point assigned
6) Accessible trade routes – *affirmative*, one point assigned
7) Adequate food processing and storage – *affirmative*, one point assigned

Minor environmental sustainability factor:

8) Accessible mineral ores – *negative*, no point assigned

Essential cultural factors of sustainability:

9) Stable population growth rate – *affirmative*, ten points assigned
10) Effective leadership – *affirmative*, ten points assigned
11) Maintenance of soil productivity – *affirmative*, ten points assigned
12) Adequate water delivered to soils – *affirmative*, ten point assigned

Major cultural factors of sustainability:

13) Significant technological innovations – *affirmative*, one point assigned

14) Sufficient food for specialists – *affirmative*, one point assigned

15) Inter-settlement cooperation and cohesion – *negative*, no point assigned

Essential commonalities of sustainability:

16) Commonly held ideology – *affirmative*, ten points assigned

17) General adaptability – *affirmative*, ten points assigned

Major commonality of sustainability:

18) Social classes not highly differentiated – *affirmative*, one point assigned

Minor commonality of sustainability:

19) Minimum military expenditures – *negative*, no point assigned

20) Significant wild food resources – *affirmative*, one-half point assigned

Summary of sustainability formula results for the Maya (1000 B.C. - A.D. 250):

- This society/period was assessed as sustainable with a *96.5 score*
- This society/period was found lacking:
  - one major and one minor environmental factor
  - one major cultural factor
  - one minor commonality factor

The sources consulted for the above determinations include: Altschuler (1958), Cowgill (1961), Culbert (1973), Ericson and Baugh (1993), Kurjack (1974), Marcus (1993), McAnany (1993), Meggers (1954), Rathje (1971), Sharer (1996), Webb (1964), Wingard (1992).

The Maya – A.D.250 until A.D. 950

Essential environmental sustainability factors:

1) Adequate prime farmland - *negative*, no points assigned

2) Adequate water resources - *affirmative*, ten points assigned

3) Adequate utility resources - *affirmative*, ten points assigned

Major environmental sustainability factors:

4) Adequate length of growing season - *affirmative*, one point assigned

5) Low probability of natural disaster - *negative*, no point assigned

6) Accessible trade routes - *affirmative*, one point assigned

7) Adequate food processing and storage - *affirmative*, one point assigned

Minor environmental sustainability factor:

8) Accessible mineral ores, *negative* - no point assigned

Essential cultural sustainability factors:

9) Stable population growth rate - *negative*, no points assigned

10) Effective leadership - *negative*, no points assigned

11) Maintenance of soil productivity - *negative,* no points assigned

12) Adequate water delivered to farm soils - *affirmative*, ten points assigned

Major cultural sustainability factors:

13) Significant technological innovations - *affirmative*, one point assigned

14) Sufficient food for specialists - *negative,* no point assigned

15) Inter-settlement cooperation and cohesion - *negative*, no point assigned

Essential commonalities of sustainability:

16) Commonly held ideology - *affirmative*, ten points assigned

17) General adaptability - *affirmative*, ten points assigned

Major commonality of sustainability:

18) Social classes not highly differentiated - *negative*, no point assigned

Minor commonalities of sustainability:

19) Minimum military expenditures - *negative*, no point assigned

20) Significant wild foods resources - *negative*, no point assigned

Summary of sustainability formula results for the Maya (A.D. 250 - 900):

- This society/period was assessed as not sustainable with a *54.0 score*
- This society/period was lacking:
  - one essential, one major, and one minor environmental factor
  - three essential and two major cultural factors
  - one major and two minor commonalities

The sources consulted for the above determinations include: Altschuler (1958), Cowgill (1961), Culbert (1971), Ericson and Baugh (1993), Kurjack (1974), Marcus (1993), McAnany (1993), Meggers (1954), Rathje (1971), Sharer (1996), Webb (1964), Wingard (1992).

The Moche – A.D. 150 until A.D. 500

Essential environmental factors of sustainability:

1) Adequate prime farmland – *affirmative*, ten points assigned

2) Adequate water resources – *affirmative*, ten points assigned

3) Adequate utility resources – *affirmative*, ten points assigned

Major environmental factors of sustainability:

4) Adequate length of growing season – *affirmative*, one point assigned

5) Low probability of natural disaster – *negative*, no point assigned

6) Accessible trade routes – *affirmative*, one point assigned

7) Adequate food processing and storage – *affirmative*, one point assigned

Minor environmental factor of sustainability:

8) Accessible mineral ores – *affirmative*, one-half point assigned

Essential cultural factors of sustainability:

9) Stable population growth rate – *affirmative*, ten points assigned

10) Effective leadership – *affirmative*, ten points assigned

11) Maintenance of soil productivity – *affirmative*, ten points assigned

12) Adequate water delivered to farm soils – *affirmative*, ten points assigned

Major cultural factors of sustainability:

13) Significant technological innovations – *affirmative*, one point assigned

14) Sufficient food for specialists – *affirmative*, one point assigned

15) Inter-settlement cooperation – *affirmative*, one point assigned

Essential commonalities of sustainability:

16) Commonly held ideology – *affirmative*, ten points assigned

17) General adaptability – *affirmative*, ten points assigned

Major commonality of sustainability:

18) Social classes not highly differentiated – *affirmative*, one point assigned

Minor commonalities of sustainability:

19) Minimum military expenditures – *negative*, no point assigned

20) Significant wild food resources – *affirmative*, one point assigned

Summary of sustainability formula results for the Moche (A.D. 150 – 500):

- This society/period was assessed as sustainable with a *98.0* score
- This society/period was lacking:
  - one major environmental category
  - one minor commonality category

The sources consulted for the above determinations include: Bawden (1996), Coe (1993, Downing and Gibson (1974), Farrington (1974), Nials et al. (1979), Ortloff et al. (1983), Shimada (1978), Shimada et al. (1991), von Hagen (1964).

The Moche – A.D. 500 until A.D. 750

Essential environmental factors of sustainability:

1) Adequate prime farmland – *affirmative*, ten points assigned

2) Adequate water resources – *affirmative*, ten points assigned

3) Adequate utility resources – *affirmative*, ten points assigned

Major environmental factors of sustainability:

4) Adequate length of growing season – *affirmative*, one point assigned

5) Low probability of natural disaster – *negative*, no point assigned

6) Accessible trade routes – *affirmative*, one point assigned

7) Adequate food processing and storage – *affirmative*, one point assigned

Minor environmental factor of sustainability:

8) Accessible mineral ores – *affirmative*, one-half point assigned

Essential cultural factors of sustainability:

9) Stable population growth rate – *affirmative*, ten points assigned

10) Effective leadership – *negative*, no points assigned

11) Maintenance of soil productivity – *affirmative*, ten points assigned

12) Adequate water delivered to farm soils – *negative*, no points assigned

Major cultural factors of sustainability:

13) Significant technological innovations – *affirmative*, one point assigned

14) Sufficient food for specialists – *negative*, no point assigned

15) Inter-settlement cooperation – *affirmative*, one point assigned

Essential commonalities of sustainability:

16) Commonly held ideology – *negative*, no points assigned

17) General adaptability – *affirmative*, ten points assigned

Major commonality of sustainability:

18) Social classes not highly differentiated – *negative*, no point assigned

Minor commonalities of sustainability:

19) Minimum military expenditures – *negative*, no point assigned

20) Significant wild food resources – *affirmative*, one point assigned

Summary of sustainability formula results for the Moche (A.D. 500 - 750):

- This society/period was assessed as not sustainable with a *66.0* score
- This society/period was lacking:
  - one major environmental factor

- two essential and one major cultural factors
- one essential, one major, and one minor commonality factors

The sources consulted for the above determinations include: Bawden (1996), Coe (1993, Downing and Gibson (1974), Farrington (1974), Moseley (1975a, 1975b, 1978, 1983), Nials et al. (1979), Shimada (1978, Shimada et al. (1991), von Hagen (1964).

The Mogollon – A.D. 200 until A.D. 1150

Essential environmental factors of sustainability:

1) Adequate prime farmland – *affirmative*, ten points assigned
2) Adequate water resources – *affirmative*, ten points assigned
3) Adequate utility resources – *affirmative*, ten points assigned

Major environmental factors of sustainability:

4) Adequate length of growing season – *affirmative*, one point assigned
5) Low probability of natural disaster – *affirmative*, one point assigned
6) Accessible trade routes – *negative*, no point assigned
7) Adequate food processing and storage – *affirmative*, one point assigned

Minor environmental factor of sustainability:

8) Accessible mineral ores –*affirmative*, one-half point assigned

Essential cultural factors of sustainability:

9) Stable population growth rate – *affirmative*, ten points assigned
10) Effective leadership – *affirmative*, ten points assigned
11) Maintenance of soil productivity – *affirmative*, ten points assigned
12) Adequate water delivered to farm soils – *affirmative*, ten points assigned

Major cultural factors of sustainability:

13) Significant technological innovations – *negative*, no point assigned

14) Sufficient food for specialists – *affirmative*, one point assigned

15) Inter-settlement cooperation – *affirmative*, one point assigned

Essential commonalities of sustainability:

16) Common held ideology – *affirmative*, ten points assigned

17) General adaptability – *affirmative*, ten points assigned

Major commonality of sustainability:

18) Social classes not highly differentiated – *affirmative*, one point assigned

Minor commonalities of sustainability:

19) Minimum military expenditures – *affirmative*, one-half point assigned

20) Significant wild food resources – *affirmative*, one point assigned

Summary of sustainability formula results for the Mogollon (A.D. 200 - 1150):

- This society/period was assessed as sustainable with a *97.5* score
- This society/period was lacking:
  - one major environmental factor
  - one major cultural factor

The sources consulted for the above determinations include: Becks (1977), Haury (1985), 1986), Hill (1970), Houk (1992), Lightfoot and Feinman (1982), Longacre et al. (1982), Martin (1959, 1972), Martin et al. (1952), Minnis and Redman (1990), Reid and Whittlesey (1997), Wheat (1955).

The Mogollon – A.D. 1150 until A.D. 1400

Essential environmental factors of sustainability:

1) Adequate prime farmland – *affirmative*, ten points assigned

2) Adequate water resources – *affirmative*, ten points assigned

3) Adequate utility resources – *affirmative*, ten points assigned

Major environmental factors of sustainability:

4) Adequate length of growing season – *affirmative*, one point assigned

5) Low probability of natural disaster – *affirmative*, one point assigned

6) Accessible trade routes – *negative*, no point assigned

7) Adequate food processing and storage – *affirmative*, one point assigned

Minor environmental factor of sustainability:

8) Accessible mineral ores – affirmative, one-half point assigned

Essential cultural factors of sustainability:

9) Stable population growth rate – *affirmative*, ten points assigned

10) Effective leadership – *negative*, no points assigned

11) Maintenance of soil productivity – *affirmative*, ten points assigned

12) Adequate water delivered to farm soils – *affirmative*, ten points assigned

Major cultural factors of sustainability:

13) Significant technological innovations – *negative*, no point assigned

14) Sufficient food for specialists – *affirmative*, one point assigned

15) Inter-settlement cooperation – *affirmative*, one point assigned

Essential commonalities of sustainability:

16) Commonly held ideology – *negative*, no points assigned

17) General adaptability – *negative*, no points assigned

Major commonality of sustainability:

18) Social classes not highly differentiated – *affirmative*, one point assigned

Minor commonalities of sustainability:

19) Minimum military expenditures – *affirmative*, one-half point assigned

20) Significant wild food resources – *affirmative*, one point assigned

Summary of sustainability formula results for the Mogollon (A.D. 1150 - A.D. 1400):

- This society/period was assessed as not sustainable with a *67.5* score
- This society/period was lacking:
  - one major environmental factor
  - one essential and one major cultural factor
  - two essential commonalities

The sources consulted for the above determinations include: Becks (1977), Haury (1985, 1986), Hill (1970), Houk (1992), Lightfoot and Feinman (1982), Longacre et al. (1982), Martin (1959, 1972), Martin et al. (1952), Minnis and Redman (1990), Reid and Whittlesey (1997), Wheat (1955).

Observations

- Four factors were present in all societies and all time periods: adequate water resources, adequate utility resources, adequate length of growing season, and adequate food processing and storage.
- The two factors most often absent in societies and time periods were low probability of natural disaster, and minimum military expenses.

- Each of the three cultures received *sustainable* scores during their earlier developmental periods, and each culture was assessed as *not sustainable* during their later period of final dispersal.
- The score of each society during their later period was at least 24 points below the 90-point total needed to be considered *sustainable*.

Summary

This chapter has introduced data generated in this research and provided an analysis and brief comments of that reported information. This concluding section will summarize the analysis and findings of both the sustainability decision key and sustainability formula, and then explain how these two bodies of data collaborate to support the purpose and goals of this research.

The sustainability decision key took 15 environmental conditions and cultural characteristics selected by this researcher as well as five uncovered commonalities and classified them into a total of nine essential, eight major, and three minor factors of ancient sustainability. Of the nine categorized as *essential* for sustainability, three were environmental, four were cultural, and two were commonalities. Four environmental factors, three cultural factors, and one commonality composed the eight *major* factors of sustainability. One environmental factor and two commonalities were classified having *minor* importance for ancient sustainability.

The sustainability formula used these 20 factors in an assessment process that produced an overall sustainability score for two prolonged time periods for each of the three selected ancient American societies. Although scores were different for each of the

six sustainability formula assessments, some noteworthy similarities were found. Early time periods of each society that were previously considered stable were scored in the *sustainable* category by the formula. Later periods that included the eventual dispersal of each society were scored in the *not sustainable* category. These six score results do not disagree with prevailing anthropological opinion concerning the general stability of each of the three societies during each period of assessment.

More variation was demonstrated between the three late time period assessments than for the three early time period assessments. Early time period *sustainable* scores were Maya - 96.5, Moche - 98.0, and Mogollon - 97.5, which showed a total variation of only 1.5 points. Scores for the late time periods assessed as *not sustainable* were Maya – 54.0, Moche – 66.0, and Mogollon – 67.5, which showed a 13.5-point variation . These two trends may be partially explained by the fact that only a 9.5-point difference is possible within the *sustainable* range of 90.0 to 99.5, while almost a 90-point difference is possible within the *not sustainable* range of 0 to 89.5 (Figure 4).

The next chapter will discuss the relevance of these findings for anthropology and environmental study as well as proffer specific conclusions concerning the ancient sustainability of cultures. Chapter V will also discuss in detail the possible applications of this research for contemporary society, possible adjustments in current policy promoting sustainable modern societies, and recommendations for further research.

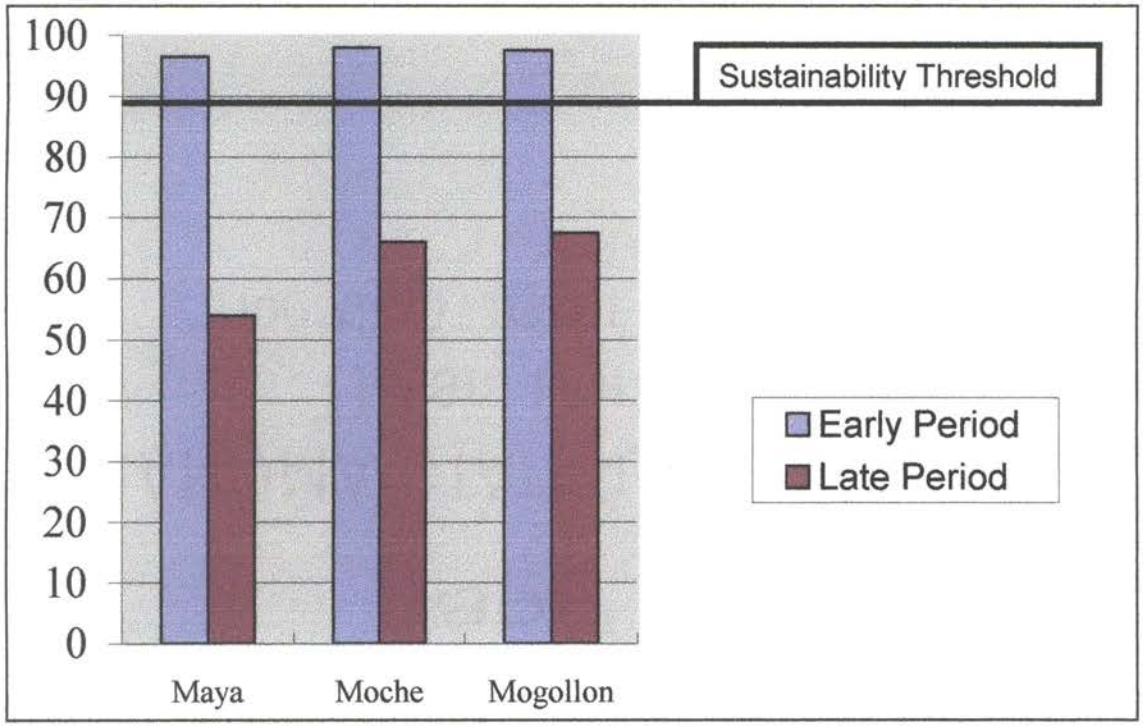

Figure 4. Sustainability Formula Score Results

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This dissertation was designed to identify and categorize ancient sustainability factors for three pre-Columbian agrarian societies of the Americas as well as produce a pseudo-quantitative sustainability score during different time periods for each society. A sustainability key has been created for the purpose of categorizing factors of sustainability into essential, major, and minor groups, and a sustainability formula has been constructed for the purpose of producing an overall sustainability score for the selected cultures in this research. Chapter I introduces the background, purpose, and organization of the study and summarizes the limitations of this research.

Chapter II reviews the major sources of information for this research regarding primitive types of social organization, the concept of sustainability, and the three pre-Columbian societies of this study. Numerous authors discuss tribes, chiefdoms, and primitive states as well as group cohesion, occupational specialization, external competition, and the effects of increased population growth rates upon ancient societies. This chapter considers the significance and utility of sustainability for both ancient and contemporary societies. Earlier attempts of quantifying sustainability for modern society are reviewed, and criticisms of this concept are discussed. The last section of the chapter outlines significant archaeological and anthropological sources of information concerning the Maya, Moche, and Mogollon cultures.

Chapter III explains the research methodology employed in this study. It begins with a brief discussion of the research design and the rationale behind the methodology structure. Next, the design of the two research instruments, the sustainability decision

key and the sustainability formula, are explained with a discussion following each topic. Finally, the last section summarizes the methodology process and explains the integration of the research instruments.

The presentation and analysis of data supplied by the sustainability key and sustainability formula are contained in Chapter IV. Fifteen factors of ancient sustainability and five newly uncovered sustainability commonalities are reported. Each of these items is categorized as having either an essential, major, minor, or no sustainability value for pre-Columbian agrarian societies of the Americas. The sustainability formula produced six sustainability scores for the Maya, Moche, and Mogollon; one during an extended period of stability for each of the three societies and one during the period of collapse for each of the three societies. Each of the three societies scored in the *sustainable* range during their extended period of stability and scored a *not sustainable* score during their period of collapse, with a greater variation of scores noted between societies during the later periods of collapse.

Chapter V presents specific conclusions concerning the nature of ancient sustainability, and the relevancy of the findings for anthropology as well as environmental studies. Possible applications of these findings for contemporary society are discussed, with emphasis on recommendations for potential sustainable natural resource policy refinement. Chapter V also makes recommendations for further research in the areas of ancient and contemporary sustainability issues.

Conclusions

This section presents conclusions regarding the validity, nature, and usefulness of ancient sustainability as well as the sustainability of the Maya, the Moche, and the

Mogollon societies during two lengthy developmental time periods for each culture, an interval of stability and an interval of social upheaval and dispersion.

Ancient Sustainability – A Valid Perspective

This research has investigated ancient agrarian societies within the perspective of sustainability. Inside this framework, sustainability is defined as the capacity to remain uncompromised for an indefinite period of time; specifically, the ability of the environment and human society to maintain uncompromised and continuous integrity. One characteristic of past societies - whether a tribe, a chiefdom, or a primitive state - has been the propensity to perpetuate. Pre-history has shown that even though sustainability may never have been identified as a societal goal, ancient cultures are believed to have shared a desire to continue and maintain themselves. Successful societies adapted traditions and practices throughout time that enhanced resource acquisition continuity for the majority of their members. Clearly, maintaining an uninterrupted flow of basic necessities was the intent of ancient peoples. Although a sustainability perspective may be new for mainstream anthropology and archaeology, this research strongly suggests that sustainability is a valid and appropriate context in which to conduct investigations of ancient cultures.

Ancient Sustainability – Many Different Factors

With the validity of ancient sustainability recognized, the inherent characteristics of this concept become an important concern. This research has indicated that many different factors, both cultural and environmental, worked in concert to determine the

ability of past societies to sustain and perpetuate. These factors were found to affect sustainability in varying degrees; nine factors were categorized as essential, eight factors were categorized as major, and three factors were categorized as minor.

Ancient sustainability was determined by many factors working in concert throughout time. First, a society needed to possess all nine essential factors in order to achieve sustainability during a particular time period. Because the pervasiveness of sustainability factors within cultures changes throughout time, ancient societies were only sustainable when they possessed of all essential factors. Beyond these essential factors, the 11 major and minor factors also influenced the stability of cultures. This author believes major and minor factors provided a buffer for sustainable societies, mitigating their vulnerability to the loss of cultural sustainability factors, including those categorized as essential. A sustainable society that possessed numerous supporting major or minor factors was probably more resistant to losing their cultural factors of sustainability. Likewise, the absence of these same major and minor factors may have rendered otherwise sustainable societies more susceptible to sustainability factor loss.

The sustainability of ancient societies of the Americas was a dynamic condition. The presence of many sustainability factors within individual cultures changed slowly over time, with new ones slowly emerging and previous ones declining. Late in their tenure, the Maya, the Moche, and the Mogollon all lost essential sustainability factors, abandoned many social traditions and institutions, and dispersed from their homelands. Following the collapse of each society, subsequent generations of these three societies most likely merged with new cultures, adopted different traditions, and were subject to new environmental conditions. When systems were in place that delivered adequate

short-term supplies of basic needs, leaders of these emerging societies may have organized social institutions for the purpose of stabilizing and extending the prosperity of these new societies. The continuity of these communities depended upon the same factors of sustainability that determined the fate of earlier agricultural people. Ancient sustainability was enabled by many factors working in concert, each factor possessing its own level of importance; some supplied by the environment, and the remainder provided by society itself.

Appropriate and Valid Research Instruments

The author concludes that ancient sustainability has been effectively treated by the decision key and formula instruments used in this research. The decision key appropriately categorizes twenty sustainability factors according to their effect upon overall sustainability, and the formula instrument generates reliable sustainability scores for each of the three selected past societies during two different periods of development. The results of this research lack quantitative objectivity, but nevertheless provide valuable contributions for current anthropological and environmental thought.

The three societies investigated were from three different regions and environments within the Americas. The tribe, chiefdom, and primitive state polities were represented in the featured cultures. The author believes the research instruments have the capability to assess other pre-Columbian agrarian societies both in the Americas and in other parts of the world. The results of this additional analysis could be compared to the data collected for the Maya, the Moche, and the Mogollon. Comparisons and discussion of the sustainability tendencies for numerous past cultures would help

elucidate the intricate processes and relationships involved in the continuity of ancient societies over time. This would allow the long-term effects of many characteristics and conditions affecting ancient societies to be more clearly understood.

An example illustrating the utility of a sustainability perspective in archaeology occurs in the ancient practice of burying valuable materials and precious commodities with the departed elite members of a society. Although this ritual served to uphold the distinctness of the upper class, it also sequestered wealth that often could have been traded for more pragmatic necessities of the society. The ancient Egyptians are a people who withdrew considerable societal wealth from their economy and entombed it with their deceased leaders. Ancient Indus Valley cultures of modern-day Pakistan, on the other hand, included very little material wealth in the burial chambers of their leaders. Instead, most of the ancient Indus society wealth remained within the economy and directly benefitted the living members of this culture. Although the improved quality of life enjoyed by Indus citizens may not prove as exciting an archaeological topic as gold laden tombs, this pragmatic practice certainly promoted the stability and continuity of these ancient people. Examining such practices in the light of sustainability would ameliorate contemporary investigative perspectives and provide valuable anthropological insights.

The sustainability formula of this research calculates an overall sustainability score for ancient agrarian societies. The structure and process under which this research instrument operates allows for further refinement by the addition of new sustainability factors or the reclassification of established factors. In the future, if such revisions are determined appropriate, the researcher could make the necessary changes and continue to

use the same sustainability formula process to evaluate ancient societies. This flexibility and possibility of modification further adds to the usefulness of this instrument for future research applications involving sustainability assessments of other ancient agrarian societies.

A Sustainability Perspective - Useful for Anthropology and Environmental Studies

With factors of sustainability changing very slowly throughout prehistory, and because many of these factors left little physical evidence, the continued investigation of sustainability patterns is inherently difficult to conduct. This type of inquiry requires a considerable number of subjective determinations, some of which might be dismissed by scholars who require rigorous quantitative investigative techniques. Nevertheless, this researcher has concluded that the adaptation of a sustainability perspective would provide reliable societal insights previously unavailable. Improved understanding of the sustainability factors and patterns of past societies is indeed an appropriate research pursuit for the field of anthropology.

This researcher believes that, in addition to anthropological and archaeological utility, environmental studies has an opportunity to improve the understanding and treatment of sustainability by considering the inclusion of certain factors of ancient sustainability into contemporary theory. Modern society may be able to learn important lessons from ancient peoples such as the Maya, the Moche, and the Mogollon concerning the nature of contemporary sustainability. Although the relevance of ancient resource systems must be carefully considered within a modern context, information from past periods of stability has the potential to aid researchers in their understanding of

contemporary factors of continuity. Minimally, investigators have the opportunity to consider the contemporary utility of factors of stability and continuity of earlier agrarian societies. Optimally, resource policy specialists have the chance to adjust current sustainability theory according to specific information gleaned from the past.

The contemporary utility of pre-Columbian resource management practices is rooted in the common characteristics among ancient and modern societies. One important shared component linking modern and pre-Columbian American societies is agriculture. Present day Americans depend upon agriculture for consistent food supplies as did many pre-Columbian farming societies a millennium ago. Soil and climatic conditions favorable to agriculture, a variety of nutritious cultigens, and sustainable farming practices are requirements of any sustainable agrarian society. Although actual farming techniques differ considerably between ancient and contemporary cultures, both societies share an essential dependence upon productive and stable agriculture in their requirements for sustainability.

Ancient and modern agrarian cultures also share the unifying framework of society itself – the voluntary association of people in cooperative communities and nations with common interests and traditions. Ancient and modern agricultural people have demonstrated a shared commitment to society, and they share major components of culture found today and many centuries in the past. Two examples of cultural interests common to both are political and religious institutions, which organize societal traditions in order to satisfy basic human needs and concerns.

Another important shared component among ancient and modern people is technology – the practical application of the accumulated knowledge of a society. The

complexity of technology has increased dramatically since the first agrarian societies appeared in the Americas. Technology played a major role for both the Maya and the Moche in such areas as agriculture, tool design, and building and monument construction. The Mogollon incorporated a more basic technology into their everyday life, utilizing simple techniques for tool making, shelter construction, and the crafting of clothing and footwear.

Today, technology is involved in most aspects of life in the industrialized nations of the world, where agriculture, transportation, manufacturing, communication, and even food processing are integral parts of contemporary technological systems. Indeed, a popular notion exists that continued advancements in technology will ensure long-term prosperity for nations with a broad-based, modern industrial sector. According to this sentiment, worldwide sustainability is dependent upon a thriving technology, free-market economics, and an expanding international industrial component. Some believe that modern technology has advanced to the extent of having the ability to compensate for a downturn in any environmental or anthropogenic condition. According to this tenet, the only true determiner of sustainability would be technological advancement where the more highly evolved the technology, the more sustainable the society. Advocates of this technological sentiment might question whether any common factors of sustainability are shared between ancient and contemporary societies.

This author has concluded that although modern technology is many more times advanced than any found in pre-Columbian societies, all human society, regardless of the time period, must function within the same complex set of natural systems and processes. Prevailing environmental scientific opinion holds that the carrying capacity of natural

systems cannot be expanded indefinitely and the ability of the Earth to support human population is significantly affected by factors other than human technology levels.

The existence of technology does not insure access to technical information by all or even the majority of modern world population. Vital natural resources, as well as the technology to most efficiently utilize these resources, are not uniformly available today to all nations of the world, nor do they seem likely to become available in the foreseeable future. Although modern technology has been an important contributor to material prosperity, the complex nature of global sustainability involves many more considerations. Rather than the sole determiner of sustainability, this author concludes that technology is a profoundly useful tool that could significantly aid modern society in the quest for a sustainable future.

Although the extent of the utility of pre-Columbian sustainability factors for modern society is not yet known, this author believes that sufficient similarities exist between ancient and modern American societies to provide insights into the characteristics and conditions of contemporary sustainability. The following three sections of this chapter summarize conclusions of the researcher concerning specific conditions of sustainability for the Maya, the Moche, and the Mogollon during both the early and late periods of existence examined in this research.

Maya Sustainability

This research investigates two time periods of Maya development and arrives at specific conclusions concerning the sustainability of the Maya during each of these stages. The first time period extends from 1000 B.C. through A.D. 250 and was

determined *sustainable* by the sustainability formula of this dissertation. This research demonstrates that as long as the Maya experienced the environmental conditions and cultural characteristics found in this period, this culture would have the means to continue indefinitely. The Maya of this period only lacked four non-essential factors of ancient sustainability and continued over 12 centuries with a stable and durable resource management system. During this time period, the Maya benefitted from the effects of nine essential factors of sustainability including adequate water and utility resources, adequate and watered soils, stable population growth rates, effective leadership, a unifying ideology, and a general adaptability to change.

The second Maya time period, which encompasses A.D. 250 until A.D. 950 and represents the period of eventual collapse of the lowland Maya society, was determined as *not sustainable* by the sustainability formula of this dissertation. This research indicates that the Maya lost four essential factors of ancient sustainability, namely stable population growth rate, adequate prime farmland, the maintenance of soil productivity, and effective leadership to direct the cultural adaptations required by their changing circumstances. These absent essential factors, along with the loss of seven major and minor sustainability factors, all contributed to a society that could not maintain itself and subsequently collapsed. All but one of the lost essential factors were cultural, indicating that the Maya had the opportunity to mitigate their fall from sustainability. The loss of the seven major and minor factors also had significant deleterious effects upon the Maya, perhaps increasing their vulnerability to loss of the essential factors. During the periods of collapse of all three societies of this study, the Maya experienced the greatest overall loss of sustainability factors.

Moche Sustainability

This research investigates two time periods of Moche development and arrives at specific conclusions concerning the sustainability of the Moche during each of these stages. The first time period extends from A.D. 150 through A.D. 500 and was determined *sustainable* by the sustainability formula of this dissertation. This research demonstrates that as long as the Moche experienced the environmental conditions and cultural characteristics found in this period, this culture would have the means to continue indefinitely. The Moche of this period only lacked two non-essential factors of ancient sustainability and continued over three centuries with a stable and persistent resource management system. During this time period, the Moche benefitted from the effects of nine essential factors of sustainability including adequate water and utility resources, adequate prime farmland, the maintenance of soil productivity, stable population growth rates, effective leadership, a unifying ideology, and a general adaptability to change.

The second Moche time period, which encompasses A.D. 500 until A.D. 750 and represents the period of dispersal of the Moche society, was determined as *not sustainable* by the sustainability formula of this dissertation. This research indicates that the Moche lost three essential factors of ancient sustainability during this period, namely a common social ideology, adequate water delivered to farm soils, and the effective leadership to direct the cultural changes required by their changing circumstances. All of the lost sustainability factors were cultural, indicating the Moche had the opportunity to mitigate their fall from sustainability. These absent essential factors, along with the concurrent loss of four major and minor sustainability factors, all contributed to a society that could not maintain itself.

Mogollon Sustainability

This research investigates two time periods of Mogollon development and arrives at specific conclusions concerning the sustainability of the Mogollon during each of these stages. The first time period extends from A.D. 200 through A.D. 1150 and was determined *sustainable* by the sustainability formula of this dissertation. This research demonstrates that as long as the Mogollon experienced the environmental conditions and cultural characteristics found in this period, this culture would have the means to continue indefinitely. The Mogollon of this period only lacked two non-essential factors of ancient sustainability and continued over nine centuries with a stable and persistent resource management system. During this time period, the Mogollon benefitted from the effects of nine essential factors of sustainability including adequate water and utility resources, adequate prime farmland, the maintenance of soil productivity, stable population growth rates, effective leadership, a unifying ideology, and a general adaptability to change.

The second Mogollon time period included A.D. 1150 until A.D. 1400 and was determined as *not sustainable* by the sustainability formula of this dissertation. The Mogollon lost three essential factors of ancient sustainability during this period, namely a common social ideology, general adaptability, and the effective leadership to direct the cultural changes required by their changing circumstances. All three essential sustainability components were cultural, indicating that the Mogollon had the opportunity to mitigate their loss of sustainability. The absence of these essential factors, along with the additional loss of three major and two minor sustainability factors, all contributed to a

society that could not maintain itself and subsequently dispersed into different lands in the beginning of the 15th century.

Summary of Conclusions

This research has produced a series of conclusions concerning the composition of ancient sustainability as well as specific applications of sustainability from the Maya, the Moche, and the Mogollon. The perspective of sustainability is demonstrated to be valid and useful for anthropology and archaeology. Many different environmental and cultural factors were responsible for determining the sustainability of ancient agrarian societies, and these factors had different levels of importance: essential, major, and minor. This research identifies nine essential factors of ancient sustainability, and each factor is an irreplaceable component of sustainable ancient agrarian societies of the Americas. Eight major and three minor factors of sustainability also make significant contributions to the durability of ancient cultures of the Americas.

The Maya, the Moche, and the Mogollon all experienced centuries of sustainability that were followed by the gradual loss of three or more essential sustainability factors and the subsequent collapse and dispersal of each society. A shifting in the sustainability factor composition of these ancient cultures was responsible for decreases in their ability to maintain continuity and viability. All but one of these lost essential factors were cultural, indicating that all three societies significantly influenced their own destinies. The absence of major and minor factors may have paved the way for the loss of the irreplaceable essential factors of sustainability. The eventual transformation from a sustainable society to a non-sustainable society was a pattern

repeated by all three cultures of this research. The Maya, the Moche, and the Mogollon could have substantially delayed their loss of sustainability and collapse if they had made adjustments in their social traditions, institutions, and social power structure. If these societies had retained their essential elements of sustainability, their tenure in their respective homelands could have been considerably longer.

Recommendations

The following section discusses a series of recommendations made by the author concerning specific adjustments in contemporary sustainability theory and suggestions for future investigation and application of ancient sustainability. The first three recommendations apply to contemporary sustainability theory and are based upon three specific commonalities uncovered by this research. These are followed by suggestions for three areas of further research that would build upon the work of this dissertation and elucidate the characteristics of societal stability and continuity.

Current Sustainability Theory and Policy

One previously discussed conclusion of this research is the multi-faceted nature of ancient sustainability. Nine essential, eight major, and three minor factors all were determined to have influenced the sustainability of past agrarian societies of the Americas. Many environmental and cultural factors working in concert determined the durability of past cultures. A total of nine factors were categorized by the decision key as fundamental and necessary to the sustainability of ancient agrarian societies.

A Common Ideology

One commonality identified by this researcher for the Maya, the Moche, and the Mogollon during their sustainable time periods was a unifying ideology that extended through all levels of society. This ideology included a similar perception of reality, values, and goals and was contained in a single socio-political ideology for each culture. The researcher believes such a commonly held belief system provided the cement that held these societies together in a unified social order. The Moche leaders, for example, were able to solidify their political and social authority in part by the use of iconography. Moche leaders were depicted as dominating authority figures in scenes of power and control. Their codified symbolism of traditional beliefs was painted on pottery, crafted into metal works, and woven into fabric, and for centuries this doctrine supported the theocratic leadership of Moche culture.

A universal ideology was also an integral part of Maya and Mogollon culture. For extended periods of time these societies maintained a common belief system between social classes and operated under a singleness of purpose and direction. Under commonly held belief systems, both of these societies also functioned within a common framework and direction. All members of society were working toward similar projects and goals, utilizing the same rituals, traditions, and belief systems. The author believes that unity throughout a society is a powerful component for social achievements and success for the present generation as well as for posterity.

A universal ideology includes common values, rules, and goals held by the majority of members of a polity and is not limited to a single race, religion, or political philosophy. A host culture, along with a variety of ethnic groups, is capable of

functioning under a common basic belief system. Ideologies are continually changed and revised by antagonistic forces inside a society, with regional and local variations often apparent. However, a general consensus on such issues as basic morality, form of government, and economic issues are basic characteristics of a common ideology.

After recognizing the importance of a universal societal ideology, a considerable challenge exists for modern society in choosing and implementing an effective strategy for promoting this characteristic. Improved access to all forms of communication throughout societies as well as between cultures would promote the free exchange of ideas while decreasing outdated and inaccurate information. In addition to the advantages of high-tech communication systems in this regard, face-to-face dialog on social issues would provide an enriched form of communication between different factions. Divisiveness among cultures would decrease if a greater percentage of citizens had access to improved communication opportunities. Basic cultural belief systems would mingle and intertwine while retaining unique attributes and perspectives.

Open access within modern society to a variety of perspectives promotes tolerance and acceptance of diverse ideological components. Exposure to different points of view through improved communication opportunities will increase understanding and cooperation between people of different backgrounds and belief systems. Another effective technique for promoting social unity would be a concerted effort from governments, educational institutions, and private enterprise to identify and accentuate the numerous similarities already existing within our modern society. An awareness of common values and beliefs within a diverse society can foster beneficial partnerships between different cultural groups.

Insuring the right of public dialog and free speech is an important component of a universal ideology. The protection of these free speech liberties in this nation, as well as the cultivation of these same freedoms in emerging nations is critical for developing a sustainable global society with a common sense of purpose.

As discussed in Chapter IV, a common ideology provided similar values and goals of agrarian societies and was an essential factor of sustainability. This ancient social consensus minimized conflicts and maximized socially productive activities. This author believes that modern societies possessing a universal ideology experience similar positive rewards. A recommendation of this research is that a universal basic ideology throughout a society be considered an important element of contemporary sustainability. Furthermore, excessive cultural divisiveness compromises sustainability for modern society. Sustainability is an elusive social condition that requires coordination of social, economic, and ecological inputs toward a single stabilizing result. A united society that functions under a common set of basic values, goals, and rules enhances its prospects for stability and prosperity.

General Adaptability

A second commonality identified by this researcher for the Maya, the Moche, and the Mogollon during their sustainable time periods is their ability to adapt to environmental and social change. During the period of A.D. 200 - 1150, the Mogollon were a rugged people that moved with the seasons throughout the mountains and deserts of east central Arizona, southwestern New Mexico, and northern Chihuahua. They were highly adaptable and borrowed ideas from neighboring cultures as necessary. The

Mogollon homeland included some of the most hospitable country of the arid southwest. This high country contained high quality but limited farmland and offered an abundance of wild game and plants that the Mogollon extensively utilized.

The Mogollon of this period were not nearly as dependent upon farming as were their Anasazi and Hohokam neighbors. They frequently moved their village sites and followed the most abundant food source available at the time. Late in this period they incorporated cotton into their agricultural endeavors, which arrived by way of their Hohokam neighbors to the west. The Mogollon, flexible and open to ideas during this period, were quick to take advantage of opportunities presented by their natural environment and neighboring cultures alike.

The Moche showed considerable adaptability in their homeland of the north Peruvian coast during the period A.D. 150 - 500. Their innovative network of irrigation canals, Andean metallurgic technology, and a diverse combination of cultivated, wild, and marine foods demonstrated Moche flexibility and opportunistic endeavors. From the period 1000 B.C. - A.D. 250, the Maya also showed considerable adaptability to a variety of natural environments and developed many innovative agricultural practices as populations increased. Extensive trade networks enabled the transfer of resources and technology to and from numerous Maya and non-Maya sources.

This characteristic of general adaptability was previously identified in Chapter IV as an essential element of ancient sustainability. Clearly, adaptability enabled past societies to respond to opportunities and changes in the environment, thereby improving prospects for prosperity and durability. This author is convinced that general adaptability is an important factor for contemporary sustainability and that a decrease in the general

adaptability of society directly compromises its sustainability. A recommendation of this research is that general adaptability be considered as an important element of contemporary sustainability.

Although modern technology provides the potential for a more focused and effective response to threatening environmental and anthropogenic changes than did ancient practices, an effective coordinated effort also depends upon other integral components. Social systems must be in place to recognize cultural and environmental changes that threaten sustainability. World leaders must design adaptable social and economic institutions that anticipate and respond to the changes occurring in a world of over six billion people with an approximate 50-year doubling-time. They must have access to and utilize up-to-date comprehensive economic, social, and ecological information in order to administer a suitable response. Economic systems must be designed with the ability to adapt policies toward efficient long-term use of natural resources and the maximization of net social benefits from such consumption.

In order for society to have the capability to detect and respond to changing cultural and environmental situations, the continuing education of the average citizen is fundamental. This education may be from formal or non-formal avenues, but the need for an involved and educated core population of all ages is imperative. An informed but diverse citizenship must direct the actions of both government and the private sector toward the principles of sustainability, rather than near-sighted, profit-driven corporate leadership competing with an elitist government sector for the control of societal steerage. Broadly educated citizens have the information necessary for understanding their role in creating adaptable systems necessary for sustainability.

In a sustainable society, the general population must have access to important information and decisions in order to assess and support the most prudent courses of action for changing situations. The ability of contemporary society to adapt to change in a timely fashion is a complex and significant sustainability factor. Although, some authors have individually referenced some of the aforementioned components involved in the adaptability of contemporary societies, the entire concept has not been accorded the significance that it deserves for modern sustainability theory and policy. Hopefully, this recommendation has contributed some insightful persuasion toward the value of adaptability in modern sustainability theory and policy.

Social and Economic Opportunity

A third commonality identified for the three selected societies during their sustainable time periods is social classes that are not highly differentiated. Wide differences between social strata and the resistance to movement between strata most likely fostered disunity and divisiveness among ancient societies. Divisiveness within a culture degrades overall sustainability by segregating the members of society and restricting each person's role not according to ability but by class standing. Although a certain degree of class distinction is necessary and desirable in complex societies such as chiefdoms and primitive states, sustainability is best served when the most competent individuals, regardless of class or ancestry, have access to occupations reflecting their talents. An ancient society that restricted the potential contributions of its members according to social class experienced, among other things, inferior leadership that seriously impeded both short-term and long-term prosperity.

Lineage ties were thought to have determined the leadership positions of the theocratic Moche. Regardless of the outcome, the majority of Moche citizens had little voice in choosing their political and religious leadership with ritual and iconography maintaining rigid class segregation. With the vast majority of citizens restricted from roles of leadership, the Moche experienced divisiveness and failed political leadership at the time of their collapse. A number of researchers likewise contend that the elite class of Maya leaders also failed their subjects by incompetently managing population levels, social class composition, and the productivity of lowland agriculture. Whether anyone in the entire society had the ability to stabilize Maya prosperity during the Late Classic Period is not known. It is noteworthy, however, that the vast majority of its citizenship apparently had no way of influencing important decisions that eventually contributed to the collapse of a civilization that had flourished for many centuries.

The author believes that contemporary sustainability is best served when the most competent individuals, regardless of their social class, are able to assume positions of leadership according to their talent and value for society. Long-term prosperity is enhanced by a social and economic system that encourages and rewards the full productivity of all its members regardless of their ancestry, race, religion, or economic status. Sustainable modern society will remain stratified but accessible education and economic systems will reward productive individuals and allow them to rise in social strata according to their abilities.

Other sustainability factors such as technological development and effective leadership are positively influenced by a social system that rewards all productive members of society. The author believes that social and economic status predicated

solely upon productivity and community value is an important factor of modern sustainability. The author suggests the inclusion and emphasis of this social characteristic into modern sustainability theory and policy. The achievement and maintenance of this sustainability factor significantly increases the stability and prosperity of contemporary civilization.

Positions of leadership and power are essential in a sustainable modern society and the mechanisms that govern the selection of candidates to fill these important roles are critical. Two examples of programs that would improve the opportunities for personal ability to determine employment opportunities and social status of modern citizens include: strict governmental supervision and regulation of economic monopolies coupled with renewed commitments to small business low interest loans, and the elimination affirmative action programs while strictly prohibiting discrimination of race, religion, sex, or nationality in employment hiring procedures.

In summary, this author recommends that three cultural sustainability factors be recognized in current sustainability theory and policy: a universal societal ideology, general adaptability of society for both cultural and environmental change, and the opportunity for talented and productive citizens to rise to positions of prestige and leadership, regardless of their ancestry or economic status. The researcher believes these three factors are only the beginning of useful information that can be gleaned from the continued study of ancient sustainability. The next section outlines directions for further research of ancient factors of sustainability and contemporary application.

Recommendations for Future Research

The idea of examining past societies within a sustainability perspective is a new consideration for anthropology and archaeology, the merits of which have been considered in previous sections of this document. The notion of ancient factors of sustainability providing a practical application for modern theory and policy is also a new consideration for the discipline of environmental studies. This dissertation has begun the process of examining ancient cultures within a context of sustainability and has applied a number of research conclusions to contemporary society. This work focuses upon three pre-Columbian agrarian societies of the Americas and has identified and categorized the factors of sustainability that were common to all. The author believes that this information holds contemporary utility for the improved understanding of modern sustainability. Three recommendations produced as a result of this research concerning potential adjustments in current natural resource management theory were explained in the previous section of this chapter.

This research has set the stage for further investigation of ancient sustainability factors and suggests new directions for such inquisition. Based on the findings of this study, the researcher recommends three areas for further research and study. The first research recommendation is to focus upon uncovering additional sustainability factors of the three ancient agrarian societies used in this research and the subsequent classification of these factors by the sustainability decision key. As an increasing number of archaeological researchers view their data with an eye for social stability and continuity determinants, additional characteristics may be identified as factors of ancient sustainability.

A newly uncovered factor, or factors, would require accompanying adjustments in the sustainability formula, specifically changes in factor point assignments as well as total sustainability scores. The design of the formula instrument allows for the convenient accomplishment of this task. But more noteworthy, a newly uncovered factor would provide additional insight into the nature and ingredients of ancient sustainability.

A second recommendation for additional research is to review existing data on other selected pre-Columbian cultures of the Americas and to process these societies through the sustainability formula of this dissertation. Numerous other ancient societies have adequate archaeological data available that would facilitate the examination process. By processing other ancient American cultures through the formula procedure, researchers would generate overall sustainability scores at certain time intervals, which could be compared with scores already compiled for the Maya, the Moche, and the Mogollon. Another positive outcome of these additional sustainability investigations may be the uncovering of ancient sustainability factors that eluded the research of this dissertation.

A third direction for additional research includes an examination of ancient agrarian societies from other regions of the world, the processing of each selected society through the sustainability formula, and a comparison of these results with previously established sustainability scores and factors from the Americas. An investigation of cultural innovations of non-American societies promoting durability and stability appears particularly interesting. Another intriguing prospect for an expanded investigation of past sustainability would be the search for patterns of sustainability factors inside other geographically isolated locations of ancient cultures. The author expects these additional

studies to uncover new insights and perspectives useful for understanding the elusive characteristics of sustainability in both an ancient and contemporary context.

Summary

Chapter V outlines and discusses seven major conclusions concerning the concept of ancient sustainability, the research instruments, and the sustainability of the Maya, the Moche, and the Mogollon. The study of ancient sustainability factors is concluded to be a worthwhile scholarly endeavor, while ancient sustainability itself is found to be multi-faceted and complex. The sustainability decision key and sustainability formula are appropriate and useful research instruments that yield meaningful results. Examining ancient cultures under a sustainability perspective is advantageous for archaeology and anthropology as well as environmental studies. The Maya, the Moche, and the Mogollon all experienced extended periods of sustainable living, which were followed by periods lacking in essential factors of sustainability with an eventual collapse and dispersal of each society.

Three major recommendations are then made for minor modification in contemporary sustainability theory. The author suggests that a common ideology, a general adaptability to major change, and a socioeconomic system that rewards productivity of all its citizens be recognized as three important factors of contemporary sustainability. Three recommendations for further research were also outlined, specifically a continued investigation of additional ancient sustainability factors within other ancient agrarian societies both inside and outside of the Americas.

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APPENDICES

APPENDIX A

Sustainability Decision Key Results

Essential Sustainability Category	
Factor Type	**Individual Characteristic**
Environmental factor	Adequate prime farmland
Environmental factor	Adequate water resources
Environmental factor	Adequate utility resources
Cultural factor	Stable population growth rate
Cultural factor	Effective leadership
Cultural factor	Maintenance of soil productivity
Cultural factor	Adequate water delivered to agricultural soils
Commonality	Commonly held ideology throughout society
Commonality	General adaptability

Major Sustainability Category	
Factor Type	**Individual Characteristic**
Environmental factor	Adequate length of growing season
Environmental factor	Low probability of natural disaster
Environmental factor	Accessible trade routes
Environmental factor	Adequate food processing / storage materials
Cultural factor	Sufficient food surplus for specialists
Cultural factor	Inter-settlement cooperation and cohesion
Cultural factor	Significant technological innovations
Commonality	Social classes not highly differentiated

Minor Sustainability Category	
Factor Type	**Individual Characteristic**
Environmental factor	Accessible metal ores available
Commonality	Minimum military expenditures
Commonality	Significant wild food resources

APPENDIX B

Sustainability Formula Results

Sustainability Formula Results

Essential Factors	Early Maya	Late Maya	Early Moche	Late Moche	Early Mog	Late Mog
Adequate prime farmland	X		X	X	X	X
Adequate water resources	X	X	X	X	X	X
Adequate utility resources	X	X	X	X	X	X
Stable population growth rate	X		X	X	X	X
Effective leadership	X		X		X	
Maintenance of soil productivity	X		X	X	X	X
Adequate water delivered to farm soils	X	X	X		X	X
Commonly held ideology	X	X	X		X	
General adaptability	X	X	X	X	X	

Major Factors

Adequate length of growing season	X	X	X	X	X	X
Low probability of natural disaster					X	X
Accessible trade routes	X	X	X	X		
Adequate food processing and storage	X	X	X	X	X	X
Sufficient food for specialists	X		X		X	X
Inter-settlement cooperation & cohesion			X	X	X	X
Social classes not highly differentiated	X		X		X	X
Significant technological innovations	X	X	X	X		

Minor factors

Accessible mineral ores			X	X	X	X
Minimum military expenditures	X				X	X
Significant wild food resources	X		X	X	X	X

VITA

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