PREHISTORIC NON-IRRIGATED AGRICULTURE IN ARIZONA:

A HISTORIC CONTEXT FOR PLANNING

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Those interested in the history and prehistory of the Southwest are fortunate in being able to view the past through the persisting traditions of native peoples. Nevertheless, the cultural patterns of all inhabitants of this region have been heavily influenced for three centuries by domestic livestock and other economic elements of Old World origin. Like their recent neighbors, the Native American peoples of Arizona quickly recognized the benefits of incorporating cattle and sheep into new land use strategies. Herding has been important throughout the time span reflected in living memory and most oral history. Thus, even for Native Americans, archaeological studies provide information about farming prior to the adoption of historic practices.

Surviving traces of non-irrigation agriculture, combined with modern examples of ancient techniques, are keys to reconstructing prehistoric agricultural practices. Indications of farming are among the most fragile classes of archaeological remains. Unfortunately, they are also among the most poorly documented. These agricultural features consist primarily of constructions from local rock and earth, designed to collect and control water and to enhance field conditions for crops. In many cases, such features have not been recognized because they are simple in form, occur in extensive but widely dispersed distributions, and are associated with few artifacts. When recognized, systematic recording has often been neglected. The majority of non-irrigated agricultural features are exposed on the surface or only shallowly buried. Even single episodes of activities such as off-road driving or brush clearing can cause major damage. Each year there are fewer intact examples to discover and investigate.

Definition of Prehistoric Non-Irrigated Agriculture

The State of Arizona (SHPO) Request-for-Proposal suggests that non-irrigated agriculture was undertaken without the use of canals diverted from rivers, and includes floodwater farming, dry farming, and farming that utilized small-scale ditches from springs or run-off catchments. More generally, "irrigation" could simply be defined as the artificial application and distribution of water onto otherwise dry land to facilitate cultivation (Doolittle 1990:12). Following this definition, most prehistoric agriculture practiced in the arid Southwest was "irrigated", with only dry-farming qualifying as "non-irrigated" agriculture. The reader should be aware that these terms remain controversial, and that different authors use different definitions.

Extreme variation existed in agricultural practices among the Native American inhabitants of Arizona. The Pueblo and O'odham peoples developed elaborate rituals, large villages, and a complex social organization based on very different agricultural traditions. Other groups, such as the Yavapai, planted and then ignored their crops until harvest time (Gifford 1936). Only 25

Origins of Southwestern Agriculture

The earliest non-irrigated agricultural features represent important information for understanding how farming was first adopted by Southwestern hunters and gatherers. The earliest methods do not appear to have included irrigation. Settlements appear earlier than previously thought, at least 1,000 years before the birth of Christ, but it is doubtful that the inhabitants were sufficiently numerous or organized for diverting large rivers and constructing canals. The earliest agricultural features are almost 3,000 years old and are likely to have been very simple; none have yet been found. A concentrated effort will be necessary to locate and date evidence for the initial methods of cultivation.

The predecessors of Arizona's first farmers are poorly known. The time of transition to farming was during the Late Archaic period. Few details are known about the hunting and gathering strategies that were followed just before the advent of agriculture, which is marked by the appearance of corn. In contrast, studies in the eastern United States have revealed the cultivation of native species for several thousand years prior to the wholesale planting of corn, beans, and squash. The importance of indigenous plants such as sunflower, marshelder, and chenopods was eventually overshadowed by cultigens of Mexican origin. Without botanical remains from the pre-corn era in the Southwest, the question of prior tending of native plants cannot be addressed.

Excavations during the 1950's at Bat Cave in west-central New Mexico yielded early corn. The apparent age of these materials, incorrectly dated to 5,000 years ago, led archaeologists to believe that farming was practiced for 3,000 years without visible impact on Native American societies. Other early corn was found in caves in the Sierra Madre Mountains in Mexico. Emil Haury synthesized these findings into a model for the diffusion of corn into the Southwest (Haury 1962). Presumably adapted to moist environments and high elevations, early corn was thought to have been transmitted from Mexico into the Mogollon Highlands of New Mexico and Arizona. Farming later spread across the Southwest when corn with broader ecological tolerance became available.

This model of agricultural origins has not been confirmed by subsequent investigation. Redating of the Bat Cave corn has shown it to be about 2,000 years younger than originally thought and contemporaneous with corn in other regions (Ford 1981; Wills 1988). Today, early corn from a variety of locations has been dated to the centuries between 1,000 B.C. and the beginning of the Christian era. This corn is botanically similar in type, and must have been suited to many different environments. The locations where early corn is found suggests that a number of non-irrigated farming techniques were employed. Numerous groups with hunting and gathering lifestyles saw the benefits of farming, even though it required remaining near fields during the growing season.

Why would pre-agricultural Archaic groups change their lifestyles to accommodate the planting of corn and other crops? Early corn in the Southwest is small in size and likely was less productive than later varieties. Wills (1988), who conducted recent work at Bat Cave, believes that hunters and gatherers grew limited quantities of corn and other crops near sites in the Mogollon Highlands as storable supplements to diets reliant on wild food. The mountains provided sparse resources in early spring, but bountiful harvests of native resources later in the season. Crop harvests furnished a predictable supply that could be stored to support early spring occupations at mountain camps. During this time, the location and condition of developing wild resources could be noted and plans made accordingly. Rather than a major component of the diet, this early corn was more a means to improve the efficiency of foraging.

A different arrangement of early farming settlements has come to light in the desert basins near Tucson and in southeastern Arizona. Exciting new work has revealed previously unknown settlement patterns, including small clusters of pit houses accompanied by burials, middens, and large, bell-shaped storage pits predating the time of Christ (Fish and others 1992; Huckell 1990). Examination of burned vegetal remains shows a substantial proportion of corn among recovered plant remains. Sites are located alongside large drainages. Floodplains appear to have been favored field locations for farming. Additional site locations suggest early farming of low basin alluvial fans and mountain edges in the Tucson vicinity.

Corn about 3,000 years old has been found in the northern Southwest in the Four Corners region. The earliest dates come from rock-shelters, caves, and one small surface site, most of which include storage pits (see Matson 1991 for an excellent summary). The chemical composition of human bone and plant remains in middens and in preserved human feces provides evidence for appreciable amounts of corn consumption by Late Archaic peoples. Matson believes that both corn and farming techniques from Mexico required environmental conditions like those in the warm deserts of southern Arizona. After farming began in the desert regions, migrants later carried crops and agricultural lifeways to the Anasazi and Mogollon (Figure 2-1). The similarities between projectile point and basketry styles of southern Arizona and those of the north support this hypothesis. According to this view, newcomers, rather than Plateau Archaic populations, were the first farmers in that region.

Knowledge about the Late Archaic farmers is sketchy, and ideas may change dramatically with new discoveries. Dates between 2,000 and 3,000 years ago for sites with corn show that Late Archaic groups across the Southwest became cultivators long before the addition of pottery. Ceramic styles help to distinguish broad traditions among Southwestern archaeological cultures including the Anasazi, Mogollon, Hohokam, and Patayan. These societies, located in the plateau, mountains, and desert, respectively (Figure 2-2), began to differentiate and develop during the early centuries of farming

life. Factors contributing to this process are embodied within the agricultural sites of Arizona's first farmers.

The Evolution of Regional Agricultural Traditions

The transition to agriculture is a topic of major theoretical and historical significance not limited to particular societies and places. The regions ascribed to the Hohokam, Mogollon, Anasazi, and Patayan contained resident Archaic populations which appear to have formed the demographic basis for later agricultural phases (Doyel 1991a; Matson 1991; Simmons 1986; Vivian 1990; Wills 1988). Archaic occupations have been documented throughout the Colorado Plateau. Early pit house villages often underlay the stone pueblos found in the Mogollon Highlands. Few early sites have been found in the Phoenix Basin, although early farming sites have been found near Tucson. The absence of preceramic populations in the Phoenix Basin suggests a high degree of contrast between the evolution of agriculture in this area and elsewhere in the desert region. Questions of this nature are of interest to archaeologists and have a bearing on research designs necessary to investigate the evolution of non-irrigated agriculture.

It is probable that sedentary villages developed across the Southwest because of a concentrated and significant increase in crop yield and food value to be had with agriculture by comparison to widely distributed native food plants. Labor intensification would have been required to obtain higher yields to sustain larger, settled populations. Some degree of specialization may have been necessary to free-up a portion of the labor force to care for agricultural resources. This process may have led to changes in social organization designed to incorporate agricultural resources into subsistence patterns, which may imply some type of larger political organization for successful management. Populations capable of producing and storing agricultural produce could have played a key role in trade networks involving areas that did not offer environments conducive to large-scale food production, but had other environment-specific resources to offer in return.

The Southern Deserts

The most important survival factor in the desert was water. Large tracts of potentially exploitable desert resources reveal no trace of Hohokam use, apparently due to a lack of water. A technological solution to water availability was the construction of earthen reservoirs that were used to store water captured during storm runoff. Reservoirs were incorporated into canal systems at large village sites, such as Los Muertos and Las Colinas in the Phoenix area. Reservoirs were used as water sources for personal and domestic use and, in the more arid areas, for agricultural purposes (Bayman and Fish 1992, Bayman 1992).

Along the rivers and arroyos, overbank flooding had created broad floodplains. Broad, flat surfaces called terraces also existed along the floodplains. Large irrigation canals, for which the Hohokam are famous, were constructed on the floodplains and on the terraces, the latter being located above the active flood zones. Canopies of trees lined the drainages, while a diversity of animal and plant life abounded. Moving away from the drainages, the land slopes gently upward toward the mountains and forms bajadas. Streams and arroyos cut through the bajadas and spread their waters onto the floodplains. Bajadas were rich in plant and animal life and provided numerous farming opportunities.

By the time of Christ, small hamlets based on agriculture, hunting, and gathering were present in the upland areas in southern Arizona and throughout the Southwest. A cultural pattern including pit houses, red and brown pottery, flexed burials, large projectile points, floodwater farming, basin metates and handstones, shell jewelry, and cloud blower pipes existed between the Phoenix Basin and the Rio Grande (Doyel 1993a). This cultural pattern and time period is known as the Early Formative (A.D. 0-700).

Research near Tucson has revealed a long-term settling-in process by local populations, suggesting that the transition to agriculture in this area was based upon sedentism developed during the Late Archaic period in the resource-rich upland aspect of the Sonoran Desert (Fish and others 1990). Late Archaic residential sites reveal a consistent presence of corn and storage pits, which suggests a major dietary reliance on corn. Near-river localities show the greatest occupational density, and are associated with small reservoirs. Nearby alluvial fans provided localities to plant crops and to harvest stands of seedy annual plants. A basic settlement pattern of multi-site communities was established during the Late Archaic period and continued until the Hohokam Classic Period (Fish and others 1990).

The high rainfall combined with diverse natural resources in the Tucson Basin provided a basis for residential stability that culminated in the transition to agriculture. The higher rainfall (over twice the average in Phoenix), combined with access to a wider range of resources, provides a high level of contrast to the Phoenix Basin. Based on current evidence, only after a commitment was made to floodwater agriculture in the uplands, perfected by generations of experience, did a successful sedentary adaptation appear in the Phoenix Basin. The earliest evidence of agricultural reliance in the Phoenix Basin - the Red Mountain phase - appears as a develped pattern, including pottery, storage, architecture, and inferentially, improved water control technology (Cable and Doyel 1987).

Direct evidence of agricultural practices dating to the Early Formative period is lacking, but the permanency of the houses, the presence of small villages and higher population levels suggest

that more intensive production systems had developed. Corn remains are common in sites, and the appearance of the trough metate and two-handed mano technology, designed for grinding corn, further suggests increased reliance on agriculture. Floodwater farming, which was most likely practiced during this period, can be intensified by using water control features, such as diversion dams, ditches, and levees, to increase the amount of cultivated land. Unfortunately, subsequent land use and flooding along the floodplains has erased the traces of these early systems.

The Phoenix Basin Hohokam may have maintained a flexible settlement pattern during the Early Formative period. Permanent villages were located near the floodplains on the edges of the first or second terraces. Using the Gila River Yuman people as a model (Kelly 1977), segments of the population may have dispersed during the growing season into smaller specialized hamlets; some of these were located in the floodplain close to agricultural fields, while other sites were located in the foothills near native resources.

Deployment of irrigation technology during the subsequent Late Formative period (ca A.D. 700-1100) opened new agricultural lands removed from the river floodplains. The growing importance of agriculture is revealed in the presence of specialized small-structure sites located along canals and other farming sites between primary villages or in outlying areas throughout the Basin. The stability of agricultural field locations and the labor costs associated with canal construction and maintenance stimulated more cooperation and economic ties among family groups. A commitment to irrigation agriculture was a strong factor in reducing residential mobility and promoting village stability. Irrigation agriculture placed a premium on labor, which encouraged an increased birthrate, as well as the inflow of labor from adjacent areas as the system expanded beyond the Phoenix Basin (Doyel 1991a).

The innovations dating to the Late Formative period had lasting effects on Hohokam society and those surrounding the Phoenix Basin area. Deployment of irrigated and non-irrigated agricultural systems resulted in sedentary lifestyles, population growth, and ritual elaboration, culminating in a period of rapid cultural change and growing cultural complexity (Cable and Doyel 1985). A system of villages containing ceremonial ball courts developed during this period, which facilitated trade and exchange. By A.D. 1050, over 225 ball courts had been constructed, with 60 percent located within the Phoenix Basin (Wilcox and Sternberg 1983).

The earliest evidence for agriculture along the Colorado River also occurred during the Late Formative period. By A.D. 900, villages supported by non-irrigated (floodwater) agriculture, supplemented by fishing, plant gathering and hunting, were common in the Patayan area (Stone 1991:61). Trade in subsistence products with upland groups may have contributed to the economic security of both riverine and upland groups (Stone 1991:66). Similar economic

patterns appear to have survived into the historic period. There is also evidence to suggest interaction of an unspecified nature between lowland Patayan groups and Hohokam groups located along the lower Gila and lower Salt Rivers between Gila Bend and Phoenix.

By the end of the Late Formative period, villages reliant on agriculture were distributed throughout the Gila-Salt region. Some villages contained several hundred people. Reservoirs were constructed to maximize settlement opportunities in outlying areas (Bayman 1992; Teague and Crown 1983). Diverse site locations were occupied, including non-riverine areas, where extensive run-off systems were developed. This period was one of "niche-packing", wherein populations occupied a wide range of environments.

The Classic period (ca. 1100-1450) was a time of change. Long-held patterns of community organization underwent radical restructuring. Changing spatial and architectural patterns within villages suggest the development of new social relationships. Increased reliance on intensive agriculture, and specifically canal irrigation, had a profound influence on Classic period culture in the Phoenix Basin.

Agricultural intensification and subsistence diversification were both aspects of Classic period subsistence. Intensification is indicated by the hundreds of kilometers of irrigation canals constructed within the Phoenix Basin area. Diversification is indicated in both the range of crops and native species used and in the types of agriculture practiced. Communities on the edges of the Phoenix Basin, such as Brady Wash, McClellan, and Marana, emphasized non-canal irrigation agriculture along with increased use of agave and mesquite. Communities located on the northern and eastern sides of the Basin where rainfall was more abundant emphasized run-off agriculture on the terraces above the rivers.

New forms of non-irrigated agricultural features known as "trincheras" appear during the Late Formative to Classic period transition and continue throughout the Classic period in southern Arizona. Trincheras sites are characterized by walls and terraces made of dry-laid stone placed on the slopes and tops of hills; in southern Arizona the hills are usually of volcanic origin. The trincheras site located above the Hohokam site of Los Morteros along the Santa Cruz River near Tucson contains 250 such terraces. Some of these were used for habitation, while other were used for crop production (Fish and others 1992:34).

Between A.D. 1350 and 1450, the Classic period mysteriously ended. Small sites lacking the complex traits of the Classic period have been located within the Phoenix Basin and represent the Polvoron phase. The presence of corn and cotton documents the practice of agriculture, but whether or not irrigation systems were operative remains in question. The locations of sites away from the rivers, such as El Polvoron and Brady Wash, suggest that a diversified settlement-subsistence pattern was present. The Polvoron phase

appears to represent a transition between the Classic period and the less complex cultural patterns of the Protohistoric period (Doyel 1991a). The respective roles of non-irrigated versus irrigated agriculture in Protohistoric period (A.D. 1450-1700) subsistence systems remains a significant question.

Central Mountains

Water was not a limiting factor for agriculture or settlement in the Central Mountain zone. Other variables, however, operated to render agriculture precarious, including the absence of flat land, poor exposures, thin soils, slope erosion, and short growing seasons. The limited-scale agriculture conducted during historic times in the mountains, even given modern technology and crops adapted to northern European conditions, may provide an indication of the limited viability of agriculture during the prehistoric period. Techniques were developed to ameliorate the effects of environment and climate through the use of ridging, mulching, staggered planting, and planting near thermal masses (Peterson 1988:123). Archaeological research has demonstrated that some areas did witness the growth of large communities based on agriculture for short periods of time during prehistory.

Archaic period use of the Central Mountains is known for numerous localities (Macnider and Effland 1989). Archaic occupation may have represented a part of an economic cycle, focusing on hunting and gathering. Redman and Hohmann (1986) reported a date of A.D. 300-600 for an aceramic level in Horton Rock Shelter near the Payson Basin that was associated with large projectile points.

Maize pollen has been found in association with Archaic materials at both the Cienega Creek Site near Point of Pines and in the Cibeque area (Matson 1991). Similar occupations occur in the Mogollon Highlands to the east (Wills 1988). Early agricultural occupations in the Central Mountains would consist of technological assemblages similar to the Archaic with the addition of plainware pottery. The cultural relationship between the Archaic period occupants and the subsequent early ceramic-horizon people remains to be identified.

Pit house and other habitation sites containing metates and pottery have been recorded at elevations above 2100 m (7000 ft) on the Tonto National Forest (Macnider and Effland 1989; Doyel and Macnider 1991). Non-irrigated agriculture may have occurred under well-watered alluvial conditions in meadow and stream-side situations in the Central Mountain zone. It is also possible that native resources were equally attractive in these situations.

Water control and soil retention facilities including rock piles, check dams, and terraces have been reported from Buckhead Mesa and the Brushy Basin-Cedar Mesa localities at elevations below 1650 m (5,500 ft) southwest of Payson. Bedrock metates, roasting pits,

ground stone tools, field houses, and storage structures have also been recorded (Doyel and Macnider 1991). Sites containing check dams and other water control features have been recorded in the Payson area near Shoofly Village; much of this activity dates between A.D. 1000 and 1200 (Doyel 1991b; Hohmann and Redman 1988).

Woodbury's (1961) pioneering study of prehistoric agriculture at Point of Pines documents a range of variation in non-irrigated features that date to the period between A.D. 1000 and 1400 when the local population was at its maximum size. The tops, and perhaps the bottoms, of ridges containing sufficient soil were farmed using a runoff strategy that included a variety of water control features situated in diverse topographic and environmental settings, including bordered gardens, check dams, and contour terraces. Many features appear to have been designed to prevent soil erosion, but also served to conserve moisture. Slopes were lined with stone terraces parallel to contours with gradients of less than five percent to prevent water loss through runoff. Collection of rocks and boulders to construct the terraces provided cleared spaces for growing crops.

Research in the Grasshopper region suggests that prehistoric populations exploited different elevations for resources on a seasonal basis (Reid 1989). From Grasshopper Pueblo, located below the Mogollon Rim at around 1800 m (6,000 ft), groups of people moved south into the chaparral and transition zones between the spring and fall seasons to gather plants and to farm, apparently using alluvial and groundwater techniques. Late in the sequence, this mixed-subsistence strategy was replaced by agriculture-dependent villages. Agriculture near Grasshopper apparently occurred in meadows with sufficient moisture and soil development, and perhaps in small fields in conjunction with water control features (Tuggle, Reid and Cole 1984).

Sullivan (1982, 1984) contends that small plots of thin soil were enhanced by intentional burning of the accumulated duff (pine needles, etc.), often located in non-alluvial soils in upland settings. This "burn-plot farming" would have been a cultural solution to environmental limitations on agricultural productivity in the Mogollon area (Sullivan 1982:9). He suggests that this strategy was practiced in the Grasshopper region.

Hundreds of sites associated with Mogollon communities based on agriculture have been reported from the Reserve and Pine Lawn areas located along the Arizona-New Mexico border. A similar situation likely existed on the Arizona side of the border. Early pit house sites were located near large floodplains. Sites in upland areas were located along drainages where agriculture could be conducted. Dams and other features were constructed to divert water (Accola 1981:161-164). Agricultural diversification occurred through time, culminating in multi-site communities distributed around central sites with communal lodges. Field houses, farmsteads, check dams,

"rock spreaders" (diversion features), and possibly dikes and wells were associated (Peterson 1988:114, 123). Farming strategies appear to have involved both groundwater and alluvial systems. Agricultural systems and local populations were at their maximum distribution during the Reserve phase (ca. A.D. 1000-1100); most agriculture appears to have been based on groundwater farming strategies (Peterson 1988:125).

Colorado Plateau

Like the desert, water was the critical variable for agriculture on the arid northern plateau. While modern corn requires 45-60 cm (18-24 in) of water, traditional varieties of maize can be grown on the Hopi mesas with only 25-33 cm (10-13 in) (Vivian 1992). With an annual average of 20 cm across the Plateau, supplemental moisture was often needed to grow crops.

The Chaco culture, centered in northwestern New Mexico, arose in one of the most inhospitable portions of the Anasazi domain. Research has suggested that the Chaco cultural expression represented a social and technological adaptation that touched most of the Anasazi world, perhaps reaching as far west as Flagstaff, Arizona. Chaco-related villages existed in northeastern Arizona along Chinle Wash, the Rio Puerco, the Zuni River and elsewhere, making the Chaco example relevant for this discussion (Gilpin 1989a; see papers in Doyel 1992). At the heart of the debate regarding the Chacoan adaptation are questions about social organization and subsistence practices focusing on agriculture.

Within the lower 15 km of Chaco Canyon, 28 drainage zones on the north side of the Canyon produced run-off that was used to water fields. Vivian (1992) speculates that the canyon bottom on the north side was developed into gridded fields, with a total catchment area of 4,250 ha for 400 ha (1000 acres) of farmland.

Vivian (1992) feels that a cultural focus was placed on the management of labor to maximize the unpredictable nature of the water supply. Due to the nature of summer storms, the latitude for crop watering may have been only a matter of hours, so that coordination of labor for achieving maximum results would have been critical for success. Individual drainages may have been regulated by corporate groups living in nearby great houses or within the community. In this view, the massing of population near fields in villages and great houses may have been a direct response to the type of agriculture practiced by the Chacoans.

Three different methods of floodwater farming were practiced in Chaco Canyon. The method used in any particular situation was determined by the nature of the water source: 1) ak chin and sand dune farming were practiced where fields received water along the edges and mouths of drainages that spread across side canyons, 2) sheet runoff was used to water gardens on natural stone terraces

in cliff areas, and 3) stone terraces were constructed to hold soil and water that drained over the cliff edges (Vivian 1992). Also present were canal-fed fields in the canyon bottom and dry farming fields located along the canyon edges. Stone terraces, diversion canals, reservoirs, dams, and gridded fields are associated with agricultural fields in Chaco and in surrounding areas. The use of check dams and linear borders increased through time, while mulched gardens were added later.

Dean (1992) has pointed out that around A.D. 925 when the Chaco culture was being formulated, environmental conditions shifted from incised drainages and low water tables to aggradation (channel filling) and rising water tables, both of which would have been beneficial to agriculture. Alluviation would have recharged the soil with nutrients while higher water tables made precipitation of secondary importance in crop production. According to Dean, environmental conditions favorable to agriculture existed across the Colorado Plateau between A.D. 900 and 1130.

As populations increased, elaborate water management systems more dependent on rainfall were developed to increase production. Reliance on water harvesting techniques made the system more vulnerable to high frequency natural processes such as variation in rainfall. A severe drought began around A.D. 1130 that lasted for several decades. Combined with lower ground water levels and less effective redistribution systems, the Chaco culture underwent reorganization that included abandonment of numerous great house communities and the growth of new centers.

The Chaco example reveals that agriculture was not an unchanging form of land use during prehistory. Other examples can be cited. In the upper Little Colorado River Valley, floodwater, ground water, and sand dune farming systems preceded irrigation systems, which developed late in the prehistoric sequence (Doyel and Debowski 1980). During the Basketmaker and early Pueblo periods, farming hamlets were distributed in a variety of environmental settings. Late in the sequence, gridded gardens, check dams, terraces and canals appear in association with large pueblos along the river (Longacre 1964; Plog and Garrett 1972). Like Chaco, the archaeology of the Little Colorado River Valley reveals that agriculture as a subsistence strategy represented an integral component of a larger adaptive system that involved environment, population, social organization, and technology.

Other agriculture sequences can be identified for the plateau area. Near the Grand Canyon, non-alluvial landforms in the upland forest areas were abandoned in favor of lower, unforested alluvial settings after A.D. 1300 (Alan Sullivan, personal communication 1992). Near Homolovi, a sequence of use from sand dunes, to small drainages, to diversion systems can be identified (Charles Adams, personal communication 1992). Water control facilities become more diverse through time in the Chinle Valley (Gilpin 1989b).