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LANDSCAPE, NATURE, AND CULTURE:
A DIACHRONIC MODEL OF HUMAN-NATURE ADAPTATIONS

The relationship between culture and nature has been a topic of intense discussion for thousands of years. Since who we are depends in part on where we are, it is no wonder that people have argued about how much influence nature has had in shaping our lives, and, in turn, about how much freedom we have had in creating nature to fit our lifeways. Basic to this discussion are the concepts of human adaptation, local knowledge, environmental values, place attachments, and cultural landscapes. Critical too is a discussion of what nature is and what role it has in placing limits or even directing human adaptation. We discuss each of these issues in an effort both to explain the intellectual course of this debate and to point to directions where it may lead. The essay will focus on American Indians and their history and culture.

ROLE OF HUMANS IN NATURE

The relationship between humans and nature has been the foundation of a Western philosophical debate that extends back in time to the early Greeks. This debate is beyond the scope of this essay, which is designed to shed light on non-Western views of this issue. Nonetheless, in Western philosophical thought humans are sometimes viewed as being a part of and sometimes separate from nature. Casey (1993, 1996, 1997) has recast this debate with a focus on the role that the concept of place has as a critical aspect of nature.

Biologists and ecologists also have wrestled with this concern. They have attempted to put humans back into the study of nature, especially the biological components of

ecosystems (McDonnell and Pickett, 1993). At a seminal conference in 1991 they resolved (to their satisfaction) this issue by showing that humans always have both dramatic and subtle effects on their environments and thus can never be viewed as being separate from nature. In fact most believe that humans are keystone species (Castille, 1993). Recently a noted evolutionary biologist published an article in *Science* (Palumbi, 2001) which seems to have capped the debate.

At the same time, human culture seems always to be defined in part by where people live. Early debates attempted to explain differences in social structure in terms of the limits placed on them by various environmental factors. They argued that tropical versus temperate climate affected socioeconomic factors. Some even thought that the complexity or simplicity of the topography would influence people's mental development (Mills, 1887).

Julian Steward (1938, 1953), an early founder of modern human ecology, pointed out that only certain aspects of each culture are connected with the environment and then only with specific features. He argued that each culture has a core composed of beliefs, values, and norms which is where these nature-culture connections primarily lie. The culture core should become the focus of human ecological studies. Steward's theory strengthened previous environmental deterministic theories by insisting studies specify which aspects of nature were influencing which aspects of culture. While his views are less deterministic than previous environmental theorists, he still concentrated on what nature did to people rather than the reverse. In addition he believed that subsistence strategies would be most likely to constitute the culture core that is connected to nature and thus failed to allow for cultures' ceremonial and spiritual activities centrally connected to nature. These more abstract activities, he maintained, were not critical to and were generally unrelated to human adaptation. This is a point we wish to rectify in this essay.

Contemporary human ecology studies demonstrate the importance of ceremonial and spiritual activities in relationship to the environment. These activities can serve as critical vehicles for conservation and can symbolize a society's respect for its environment (Rappaport, 1984). Today, many studies of human-nature relationships

look at ceremonial relationships especially as these occur at identified places and among complexes of these places called cultural landscapes.

Places

While debates about the mutual relationships between cultures and ecosystems persist, many scholars have taken the simple idea of a place and a people and tried to understand how the two are intertwined and how these relationships came into being. Tuan's (1977) book, *Space and Place*, may be the most cited on the subject. He combines complex philosophical issues with clear illustrations to demonstrate that it is through experience with places that nature is made real and becomes part of human culture. Basso's (1996) *Wisdom Sits in Places* is an analysis of American Apache Indian place naming as a process of documenting where and how Apaches learned about the environment and how they incorporated these names into social and environmental ethics. Basso's work is a further grounding of Tuan's theory of place-making and a study of how people adapt.

Cultural landscapes

The idea of a cultural landscape as a meaningful way to organize cultural data about places and their relationships with each other has emerged over the past few decades. Today, we refer to larger, integrated, and more abstract phenomena about places and their connections as cultural landscapes. Recent scholarship (Dewey-Hefley *et al.*, 1998; Stoffle, Halmo, and Austin, 1997; Stoffle *et al.*, 2000a,b; Zedeño, 1997, 2000; Zedeño, Austin, and Stoffle, 1997) sheds light on methodological, analytical, and theoretical issues remaining to be resolved before cultural landscapes are understood as networks of connected places.

The concept of cultural landscape derives from the notion that the land exists in the mind of a people and that their imagery or knowledge of the land is both shared among them and transferred over generations. All human groups develop and come to share cultural landscapes. The concept implies that many cultural groups (ethnic groups) can hold different, even conflicting, images of the same land. The imagery of the land that

is held by a people is a result of their past experiences with the land and other cultural perspectives of the people themselves.

A cultural landscape expands the idea that a special place can have dozens of cultural meanings. Central to the concept is the notion that not all places within it have the same culture value even for a single ethnic group. The places may derive their value from interactions between people and natural phenomena (Zedeño, 2000). Tilley (1994: 34) distinguishes between the concepts of place and landscape, with the former emphasizing difference and singularity and the latter encompassing commonalities or relationships among singular locales and events. A cultural landscape should make sense as a kind of culturally defined single area, defined by a common logic and composed of unique and connected places.

Cultural landscapes are nested (Stoffle, Halmo, and Austin, 1997; Tilley, 1994: 20). They exist at different scales but are integrated into a whole. For many American Indians, for example, these levels include, from broadest to narrowest scale, an Eventscape, a Holy Land, songscapes, regional landscapes, ecoscapes, and landmarks. The topographic criteria for defining these categories range from their fit with the natural terrain (i.e., an ecoscape) to a spiritual landscape that exists in terms of its own criteria with minimal reference to the topography of the land (i.e., a songscape).

People may attach more than one cultural landscape to a place. We call this “cultural landscape layering”. Layered cultural landscapes may have very different meanings. One landscape layer may be composed of places visited by a spiritual being. Another may involve an event such as a forced march following military conquest, as in the trail of tears for the Cherokees, the march to Bosque Redondo for the Navajos, or the march to Fort Independence for the Owens Valley Paiutes and Shoshones, all American Indian cultures.

HUMAN ADAPTATION: A DEVELOPMENTAL CYCLE MODEL

One way to understand human adaptation is by using a diachronic¹ model of human adaptation that begins with the hypothetical arrival of a group of people in a new place and observes their initial adaptation to this ecosystem. Eventually, this group begins to

make certain modifications in the environment. The model then moves forward in time over generations to observe how these people become fully adapted and how the place becomes the center of their lives both physically and spiritually. The model is informed by the direct analysis of actual human adaptation and resulting environmental changes.

Three cautionary points need to be made before proceeding. In this discussion we are scaling up; that is we are increasing the variables of space, time, and complexity of typical human ecological analysis. We are moving beyond what is confidently known in order to build a diachronic model with heuristic value for situating and perhaps guiding how we think about these issues. Most human-nature studies have a narrow time frame and focus on only a few species interactions. “Very little ecology deals with any processes that last more than a few years, involve more than a handful of species, and cover an area of more than a few hectares” (Pimm, 1991: xi). Nonetheless Pimm builds food web and temporal variability ecological models from narrow time and focus studies.

Social and natural scientists have had few opportunities for long-term joint research projects; thus we tend not to understand each other’s theories, methods, variables, and analytical techniques. As a consequence, most studies of how humans adapt to and change their environments are conducted by social scientists who know the human side of the equation well but study a very limited aspect of the natural system. Similarly, studies by ecologists that look at the impacts of humans in nature tend to view people as simple consumers of the environment who are without complexity and lack the capacity to modify their behavior. This is something like the basic predator-prey models in natural science. For this reason, the current analysis describes and explains the human dimensions of ecology.

Finally, the model is intended to sequence types of adaptations so we can begin to imagine the cultural implications of adaptive behavior. So, for example, when the Southern Paiute Indians say the Creator made them in Las Vegas Wash below their origin mountain, it can be viewed as the end result of thousands of years of living in this area rather than some inherent aspect of their culture. There are many peoples around the world who have embedded portions of the landscape into their culture and their

definition of self. Our model suggests it takes great periods of time to produce Creation embeddedness, but obviously there is no time rule. For example, the Navajo Indians of the American Southwest maintain they emerged from an underworld in the southwestern corner of the state of Colorado, which is similar to a Pueblo Indian theory of origin (McPherson, 1992). Yet archaeologists and linguists maintain these people arrived from what is now Canada no more than 600 years ago (Towner, 1996). If this is true, then the Navajo people have developed a topographically embedded origin knowledge in record time. The example actually fits sequences of the diachronic model, because the creation knowledge was to follow hundreds of years of occupancy and adaptation to this new land. They only adapted faster than has been recorded for other peoples.

First generation—arriving in a new land

The first generation arrives in a new land². It has high mountain ranges flanking low narrow valleys. Small streams come from the peaks and produce both intermittent and small permanent streams. The area is highly diverse in terms of microniches, which mostly vary by elevation. It is a land that is generally semi-arid with riverine oases in the arid valleys and rain shadows on the eastern sides of the mountains. Because of past geologic events, many soil types exist, including special ones on the flanks of the inactive volcanoes. Animals and plants vary according to econiche.

Approximately 200 people come into this area, which is about 500 square miles in size. This is a population density of about 2.5 persons per square mile, which is defined as the natural carrying capacity of this unaltered land. The people have all the social organization, cultural elaboration, and technology we would expect in a human group after the upper Paleolithic. This base culture/society must contain the following:

- A social structure including hierarchy,
- A knowledge of the supernatural that has been translated into a religion, including a complex ceremonial cycle and religious specialists,
- An understanding of key life cycles—birth, maturity, aging, death—and ceremonial responses to each stage,

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- Knowledge of their former local ecosystem including both its biotic and abiotic dimensions,
- Experience studying and learning from the abiotic and biotic environment and distributing this knowledge, and
- Technology to build homes, make clothes, and acquire and process food.

Although many aspects of this base culture/society will not be useful in the new lands, it remains as background experience carried into and influencing future adaptations. These immigrants are pre-agricultural but have extensive knowledge of plants, animals, and climate.³ They do not bring domesticated plants, but they have the dog.

How does environmental learning occur? The first generation actually learns much from native plants and animals. This foreshadows supernatural explanations of environmental knowledge as having been taught by the land that will become a central feature of their culture many generations in the future. How can animals and plants teach? Plants tell the observant viewer about rainfall and the subsurface distribution of water. Longer-term climatic stories are told by where plants do or do not grow near or in the intermittent streams, which are subject to both unpredictable and cyclical El Niño-type catastrophic flood events. Animals move between ecotones according to weather shifts and availability of food resources.

Why can a culture learn more from mistakes than from successes? It may be that when they fail they have reached a critical limit. On the other hand, they may succeed and never know why because they are working within the limits of the resource being used. People learn by hurting nature and seeing the undesired consequences. When they kill too many large mammals, they learn not to repeat those behaviors because they rely on that resource.

The first generation makes mistakes, learns how not to cause unwanted damage, and then tells family, friends, and perhaps the community. Some first generation lessons remain at the family level.

Second generation—do what parents tell you to do

The second generation can build upon the lessons learned by the first generation. The study of biotic resources continues. The first generation has scrambled to survive; the second generation begins to develop theories of how to learn about the environment. Lessons come from some event: perhaps a person follows a bee to water, or perhaps a person builds his home near a dry wash only to be flooded. Perhaps a person observes an animal healing itself with special white mud. The second generation will develop theories of how data moves between people and the world and becomes useful for short-term survival and longer-term adaptation.

The second generation receives these lessons from living people who can be questioned about the event. Knowledge comes from deep understandings of non-intuitive aspects of the world. Few of these are expected in the first two generations.

We see at this stage what is called “adaptive behavior”. Bennett (1969: 11) defines adaptive behavior as coping mechanisms or ways of dealing with people and resources in order to attain goals and solve problems. Our emphasis here is on patterns of behavior: problem-solving, decision-making, consuming or not consuming, inventing, innovating, migrating, and staying. Bennett documented how different people at different times constructed unique cultures in a single ecosystem in central Canada.

The fifth generation—do what great grandparents tell you to do

The fifth generation (approximately 125 years) is special. They have a firm information base about the environment and know how to use the land without hurting it. Families have experienced birth, life, and death in the new homeland, and these events emotionally connect the people with specific places. They have pushed a number of environmental boundaries, made mistakes, and changed their behavior. By the fifth generation various aspects of successful and sustainable behavior have been put into place.

Environmental learning seems to be directly related to the amount of natural resource scarcity, especially when this occurs in annual and decennial cycles. People

mostly learn to hunt and gather when basic resources are regularly available. It is not until the limits of the resource are reached that they have an opportunity to learn what parameters drive the system. It is at exactly these moments that people decide to modify their environmental resource use patterns in order not to drive other resources into extinction. By this time, they have reduced the possibility of Hardin's (1968) tragedy of the commons (McCay and Atcheson, 1987). If they fail to adopt resource conservation procedures and to build these into the rules by which they govern themselves, then the carrying capacity of the environment will be reduced.

Learning from plants and animals continues during this generation, but the lessons are less intuitive and probably about natural processes that are less accessible to human view. Plants often serve as calendars, like the rabbitbrush (*Chrysothamnus nauseosus*) that blooms when it is time to go into the mountains to harvest pine nuts (*Pinus monophylla*). Smaller animals and insects provide information about pollination, food webs, and landscapes (Nabhan, 1997). Beaver dams keep the ecosystem from eroding and retain water during arid seasons, so the people minimize their consumptive use of beaver. People learn to stay away from water sources because it disturbs the animals.

Proactive adaptive behavior will be normal by this time. This might include selectively increasing the yields of certain species by burning or pruning. Also proactive is the planting of certain species along or diagonally across intermittent and small streams to assist the beaver's efforts to reduce erosion while at the same time retaining the water and moving it to places along the streams where it is needed. By creating a specialized patch ecology that does not occur naturally, the carrying capacity of the land will increase (Lewis, 1982; Lewis and Ferguson, 1999).

The people begin to have adaptive strategies. Bennett (1969: 14) defines these as the patterns formed by the many separate adjustments that people devise in order to obtain and use resources and to solve the immediate problems confronting them. The rules of adaptation become culturally embedded. Bennett (1969: 16) notes that as time passes, the many separate adjustments that have become patterned as strategies can also "enter into culture". As repetitive patterns of actions they people view them as traditions—behavior defined as "right" or "good". These embedded traditions form

part of a group's cultural style. The extent to which adaptive behavior becomes culturally sanctioned varies according to the demands placed on the society by various external factors. If the major changes in the natural system are recognized and occur in predictable cycles there will be a tendency for a given strategic regime to become "sacred".

The population grows as the fit between technology and resources increases the carrying capacity of the land. Basic issues of village life, including the need for seasonal movements of the community or community members, exist.

The sixteenth generation—do it because "We do it like this"

There is a point in the development of a society when the origins of ancestral lessons are vaguely remembered but firmly established as the correct way to treat the environment. This is a time (perhaps by the sixteenth generation or approximately 400 years) when lessons are taught and maintained as general principles. The name of the person who originally learned the lesson probably is not attached to it. People teach their children to behave in certain ways because "it is how we (the members of this community) do it." If you follow "our ways", you will always have food, shelter, and health, and the environment will be in balance.

By now the people have amassed sufficient data from the natural environment so that they begin to develop knowledge about what is happening around them. They recognize pollination of plants by certain species. They have learned many lessons about medicine. They have seen sufficient climate variability that they know with some confidence what the cycles provide in terms of opportunities and threats. There are still other forces that are unclear to them but appear to be variables within the system. The rules for engaging the environment are now well tested and those rules, which have repeatedly proven useful for maintaining and improving the productivity of the environment, are increasingly defined as sacred and not subject to debate.

The population grows, so there are more people to organize, to teach about "how we live here", and to make regulations. The natural resources of the environment are further stressed. New boundaries are reached and perhaps broken. Certain long-term

climatic events have occurred a few times, and there is the recognition that one has to prepare for events that may not come within the lifetime of a generation.

*The 50th generation—environmental ethics defined and sanctioned by
supernatural forces*

The model now skips to the 50th generation, about 1,250 years since arrival. People have lived so long in this ecosystem that they have clear adaptive strategies that have survived a wide variety of temporal and biotic shifts in the ecosystem. Over the period of 1,250 years many natural resource changes also will occur. New plants will come into the ecosystem, and old ones will become extinct. Streams will flow more or less depending on climate change and use.

By this time they have embedded these adaptive strategies in their culture. They have moved key values into the realm of the supernatural, with both the lessons and the sanctions being supernaturally defined. There is a confluence between science and religion, as the scientific findings of past generations have been recognized as essential to life and moved to the realm of the sacred and thus beyond human control.

Despite their useful adaptive strategies, people still have things to learn as scientists. They are still watching and responding to changes in nature. Parents still observe, realize that something is happening, adjust their behavior, and tell their children; this is the continuity of first generation learning. And the children follow the new behaviors to avoid the mistakes made before.

200 generations—we were created here

After 200 generations, approximately 5,000 years, in the same ecosystem many kinds of complex human adaptations can be expected. Only a few biotic features will remain unchanged. Climate changes reduce or even eliminate most fauna and flora and certainly radically alter the food webs (Grayson, 1993). Even the topography can change. Sea levels will rise and fall. Volcanoes will build up the land, and erosion will tear down and transform it. Long wet periods will alternate with long dry periods. What does it mean to have adaptive strategies, which define, organize, and maintain a human group's adaptations to an environment, if this environment itself changes?

Those things that persist in structure and function through a five thousand year period will not only remain but will become increasingly central in the culture. For example, mountain peaks and ranges should remain the same and draw rain from the sky. This is what is called the “sky-island function” (See Crowley and Link, 1989). Mountain ranges are central in the lives of people dependent on related resources. For example, Baboquivari Peak and Mountains, features central in the lives of the Tohono O’odham people (Toupal, 2001), are primary rain makers in southern Arizona.

Biotic and biologic evolutionary forces cause some changes in the environment, while growth in human population size and technological innovations create others. The people know how to listen to the environment and change their behavior.

CASES OF ADAPTATION

The following cases illustrate humans adapting to specific environments. These cases both inform and stretch the diachronic model of cultural adaptation as they follow the course of adaptation in approximately the same time periods. In these cases we see that people usually arrive in areas already occupied by other people, causing a complexity in adaptation which is not considered by the model. This complexity has two major influences on adaptation. The people who already live there can be useful to the immigrants by teaching them and building an informed foundation upon which to adapt (Atran *et al.*, 1999). They can also compete for space and resources, causing a threat to the newcomers that itself may become the focus of adaptation. Our cases also demonstrate that the newly arrived human groups bring important cultural knowledge from previous places. Such knowledge is impossible to model, because it may or may not yield positive adaptations. Newcomers may initially believe they have ways to improve their new land, but these behaviors often cause dramatic natural resource mistakes. Examples of such false adaptations in North America include the suppression of American Indian land and forest burning (Boyd, 1999), the draining of wetlands by eliminating beavers (Cronon, 1983), and the channelization of Western rivers by destroying associated riparian habitats (Dobyns, 1981).

100 years of adaptation—Scandinavian-American folk fishers

In the upper reaches of Lake Superior, approximately thirteen miles from the Canada-United States border, a jagged sliver of volcanic uplift forms what is known as Isle Royale. Now a National Park, its wetlands and tree-covered ridges have provided resources for humans and habitat for caribou, coyotes, moose, wolves, several fur-bearing species, birds, and waterfowl for thousands of years. Its terrestrial-lacustrine interface is comprised of rocky shorelines, small islands, and many harbors, which accommodated fishermen for hundreds of years. While the island is part of the same geologic formation as the Upper Peninsula of Michigan, its proximity and similarity to the North Shore of Minnesota contributed to its becoming a social, cultural, and economic extension of that area.

When a wave of Scandinavian immigrants came to Minnesota in the 1880s, many settled along the North Shore, many of them were fishermen (Toupal, Stoffle, and Zedeño, 2001). Finding the area similar to their homelands, they settled in the protected coves and inlets from which they established fishing areas and subsistence farms. They also developed communities within which they could communicate in their native languages and continue their traditions. They preferred the company of those with whom they could enjoy traditional foods and who had the same style of thinking and work ethic.

Isle Royale attracted many of these fishermen. When they first came to fish the waters, they found other fishermen from diverse ethnic backgrounds including German, Irish, English, French-Canadian, Chippewa, and American (Karamanski, Zeitlin, and Derosé, 1988). These people were displaced within five years of the arrival of the Scandinavians who afterwards and for the next one hundred and twenty years maintained exclusive usufruct rights. These Scandinavian-Americans preferred the solitude and independent lifestyle of fishing on the island (Jentoft and Mikalsen, 1994). They and their families established their fish camps and began adaptations to their new environment that would become the foundations of a new folk culture.

The Scandinavian-American fishermen developed a herring industry. Instrumental in its success was the establishment of an exclusive relationship with the Booth

Company, which instituted credit relationships and provided them with provisions and equipment in the Spring in exchange for their fish throughout the season (Kaups, 1975).

Their Scandinavian fishing heritage had some benefits in the new environment in spite of differences between ocean and lake fishing. Saltwater seine nets had been used to bring catches into the shore, and hooklines had been let down to the ocean bottom. The rocky shorelines of Isle Royale ruled out use of the seine nets, so they began using gill nets of different sizes placed at different depths to catch trout, whitefish, and herring. The lake waters were too deep to fish the bottom with hooklines, so they suspended them with floats and weights to depths up to 200 feet (Kaups, 1975).

Another adaptation occurred with boats. Many of the Swedish immigrants had been boat builders, and they quickly adapted boats like the Mackinaw to handle the conditions of Lake Superior (Toupal, Stoffle, and Zedeño, 2001). Some fishermen built their own herring skiffs, which resembled the *sjekte* used along the inner coast of eastern and southern Norway. These boats ranged from fifteen to seventeen feet long, four to five feet wide, and about two feet deep. The fishermen seldom went more than two miles from shore, the approximate extent of the herring fishery (Kaups, 1975). In some instances, a fisherman might have two boats, a nineteen-footer for fishing closer to shore, and a twenty-four-footer for going further out (Toupal, Stoffle, and Zedeño, 2001).

From these boats, they learned to manage their nets and hooklines in the temperamental lake waters, to read the currents and lake bottom for rock reefs and passages, and to read changes in the weather that might indicate the onset of severe storms. Living on the island from April to November, the fishermen and their families soon learned to read wind, cloud formations, and fog conditions that promised a difficult if not dangerous lake and to gauge how long they might be able to work their nets safely.

Several of the Scandinavian-American fishermen worked with Minnesota fish hatcheries, providing milt and spawn in the fall and planting young fish in the spring prior to the first fishing season. While most of the fishermen used hooklines and gill nets, a few who could afford to do so experimented with pound nets. They found the

pound nets so effective that, particularly when used in spawning areas, they could decimate a fish population within a few seasons. Wanting to maintain healthy populations, they soon abandoned the pound nets for the traditional gill nets, in order to keep their supply of fish.

The fishermen continued to learn about the underwater environment. Small islands, for example, were good net areas because of shallow water, reefs, shelter from the wind, and proximity to deeper waters (Toupal, Stoffle, and Zedeño, 2001). The reefs had bottom structures beneficial for lake trout spawning. They tracked fish populations by reef, noting increases and declines from one season to the next. They could detect changes in fish populations and behavior caused by seasonal and climatic conditions such as equinox disturbances, storms, squalls, and full moons (Toupal, Stoffle, and Zedeño, 2001). This allowed them to determine when a reduced catch was due to natural conditions and when it was due to fishing pressure, the latter resulting in changes in set times or mesh size. They made changes that included mesh size and/or the length of time they would leave nets on the reefs so that fewer and larger fish were taken and the population could recover.

As a five-generation example of adaptation, the Scandinavian-American fishermen of Isle Royale exhibit the characteristics of adapting knowledge of one environment to another in order to obtain and use resources, and of developing new strategies, which ultimately became folk traditions. Succeeding generations increasingly embedded these strategies in their culture. Many families had natural resource connections through “pet” birds, foxes, mink, and moose. Places became special because of their topographic uniqueness, viewscapes, and community and family histories. Collectively the places and natural resources became their homeland, which can be understood as a cultural landscape.

400 years of adaptation—Afro-Caribbean peoples

African people have been in the Caribbean for 16 generations (approximately 400 years). The geography of the Caribbean ranges from volcanoes rising from the ocean

floor throughout the Lesser Antilles, to large, low, flat expanses of limestone in the Bahamas and Barbados, to the large complex mountains on islands like Jamaica and Hispaniola.

African people were brought into the Caribbean as slaves. They immigrated with neither tools, animals, nor domestic plants, yet they were to make many adaptations, which are central features of their contemporary culture. Today there is a debate as to whether these derived from memories of Africa or were gleaned from lessons learned in the Caribbean. The Rastafari of Jamaica are a people who farm the rocky hillsides of mountains. In their gardens, they use swidden horticulture, which turns the limestone rocks into soil. By using terraced walls and rotating fields, they are able improve the soil. They are known to protect many species and varieties of certain crops like yams, which are planted in different niches as a hedge against fluctuations in rainfall and to take advantage of different types of soils.

In the Bahamas, African peoples developed an elaborate system of gardens in which a variety of drought resistant and irrigable crops were planted. Their understanding of the environment is reflected in how they remove land crabs from their gardens. One local plant, Nicker Bean (*Caesalpinia bonduc*), has a hard round marble-like seed. When the land crab makes a burrow in a garden, instead of digging him out or killing him, the seed of this plant is dropped into the burrow. Being hard and round, the seed cannot be moved out the burrow by the crab, who is so finicky that he cleans all foreign objects out of his home. Eventually frustration causes the land crab to move away from the garden and burrow elsewhere.

1,250 years of adaptation—people of Bali

In the middle of the volcanic archipelago of Indonesia is the island of Bali, with habitats ranging from montane forests in the highlands to terraced rice fields on the slopes, to wetlands and coral reefs along the coast. Rice, developed over one thousand years ago, has become a staple food to the Balinese. Fifty generations (approximately 1,250 years) of religious and social practices that sustain rice cultivation represent a series of rational

adaptations that have survived centuries of social instabilities such as shifting kingship boundaries.

The production of rice is embedded with rituals for planting, maintenance, irrigation, and harvesting. The season commences with temple festivals and pilgrimages to the lakes to obtain holy water to sprinkle on the fields. Planting begins by walking the fields with water buffalo to prepare the soil. Ceremonies for planting the fields involve carrying young stems of rice cultivated for this purpose to each field. Water temple priests work with the local *subaks*, or farmer associations, that determine local cropping patterns and arrange the irrigation and planting schedule. This relationship of religion and ecology depends upon the farmers' acceptance of and reliance on the water temple priests who must coordinate irrigation of hundreds of terraced rice fields among hundreds of farming communities.

Beginning at the highest volcanic lake on the island, the water is metered down through many *subaks* in a staggered planting and irrigation cycle. The farmers who receive the water first voluntarily stop irrigating when directed by the water temple priests, and the farmers at the next level, who have just prepared their fields, begin irrigating. This pattern is repeated until the last farmers have received their water. The system results in optimal water sharing, minimal pest problems, and some of the highest rice yields in the world.

As an adaptive system, water temple irrigation combines natural and cultural cycles. Seasonal rains, long growing seasons, rice paddy ecosystems, and pests are integrated with religion to control timing and amounts of irrigation water, which influences planting, care, and harvesting of the rice fields.

5,000 years of adaptation— Numic people of the Great Basin

The Numic-speaking people of the Western United States⁴ have a system of beliefs for the desert ecosystem where they live. They believe that all they know about, use from, and owe to the environment was defined at the moment they were created. In a sense, they and their environment could not survive without each other.

The Numic people believe they were created in this region when all the plants, animals, wind, minerals, and water also came into existence. The Creator made everything and gave each element specific rights and responsibilities, which if exercised and fulfilled will maintain ecosystem-wide balance..

The concept of a “living universe” is an epistemological foundation of Numic culture, or what Rappaport (1999: 263-271; 446) calls an “ultimate sacred postulate”. These terms mean that the concept of a living universe is so basic in Numic culture that you cannot understand many other aspects of culture without first fully recognizing it. A living universe is alive in the same way that humans are alive. The universe has physically discrete components that we will call “elements” and something like energy that these people call *puha*. These are a few general statements that we can make about *puha*:

- *Puha* exists throughout the universe, but like differences in human strength, power will vary in intensity from element to element.
- *Puha* varies in what it can be used for, and so it determines what different elements can do.
- *Puha* is networked, so that different elements are connected, disconnected, and reconnected in different ways, and this occurs largely at the will of the elements that have the power.
- *Puha* originally derives from Creation and permeates the universe in a thin scattering and in definite concentrations with currents, generally where life is also clustered.
- *Puha* exists and can move between the three levels of the universe: upper (where powerful anthropomorphic beings live), middle (where people now live), and lower (where super-ordinary beings with reptilian or distorted humanoid appearance live).

The fundamental meaning of a Numic place derives from the *puha* it exhibits. This *puha* is dispersed in a network of relationships among the elements of the universe—relationships that most resemble spider webs. At various points in this web, power is concentrated, producing powerful places. Zedeño (2000) observes that places

are “made” because they are the loci of human interactions or nature experiences. Therefore, power accumulates at a place as people live or re-live those experiences. Power is cumulative.

Powerful places tend to attract other powerful elements. So, for example, during studies of storied rock sites (rock peckings and paintings), American Indian people tend to look first at the rock on which the painting and peckings occur and then look around for medicinal plants. The basic assumption of interpretation is that the place had to be powerful before the rock paintings or peckings were made there. Indian tobacco often grows out of the cliff face where the peckings have been placed. The Indian interpretation is that the powerful plant went to live on the powerful cliff. Humans derive power from places, causing them to be even more central in Indian culture (Stoffle *et al.*, 2000a).

Numic cultural landscapes are composed of sets of different places, which are connected by webs of *puha* and recognized by humans as collectively having certain ceremonial functions (Stoffle, Halmo, and Austin, 1997). Such landscapes, like the one near Hoover Dam on the Colorado River at the mouth of Black Canyon, may be a combination of a song cave, red paint mineral deposit, hot spring, and a medicine mountain, which when used in sequence permit healing ceremonies that keep individuals, groups, and the world in balance (Stoffle *et al.*, 2000b).

Environmental lessons were defined at Creation and are thus not subject to debate by present generations. A most basic rule is never to touch anything without talking with it about your intentions and asking its permission to move or pick it. Once the rock, plant, animal, mineral, spring, or cave grants permission, then human activities governed by specific rules are permissible. For example, when a woman reaches menses she is taken to an isolated place where older women teach her about female relationships with the world. One of these is how to “whip the trees”. Women are specifically charged with talking to, praying over, and increasing the productivity of pine nut trees. They accomplish the latter by gently whipping the ends of all branches on the tree with a 12-foot long thin pole. This action breaks the ends of all the branches, much like pruning, which causes the branches to grow many more shoots and have many more

pinecones. Given that Numic women did this for thousands of years in every pine nut forest in the region, it is probably the case that they increased the carrying capacity of the land and contributed to its biodiversity. The genetic structure of some plants was modified because of its being regularly selected for certain characteristics and moved to places more useful to humans (Nabham and Dobyns, 1900).

When people arrive in a new place, they probably will not be good for the land. According to Steadman (1997), as many as 2000 bird species became extinct following human colonization of the Pacific islands. Pimm *et al.* (1995) estimate that approximately half of the native avifauna was exterminated after the arrival of humans. Whittaker's (1998: 255) review of these issues caused him to conclude that in the Pacific and on islands around the world, so many species died soon after colonization that often the people died and the islands were abandoned. Whittaker further concludes that the notion that the "noble savage" lived in balance with nature is illusory, that where something like it was achieved, it was only accomplished by trial and plenty of error along the way. He also concludes that people do try to resolve the nature-human problems their presence causes. It seems likely, according to Whittaker, that the Polynesian taboo system, which functions to prevent the over exploitation of natural resources, was started as a result of the extinctions and misuse of other resources (Whittaker, 1998: 233).

Despite the damage to the environment that humans can cause, these well-documented events of early arrival impacts also support the model presented here. Each involves the needed components for adaptation and conservation practices.

This model and these cases document a process of cultural adaptation to the local environment, which seems to be sequential over generations. The process of learning from the environment continues, because the environment is always changing. Certain lessons, however, do not have to be relearned by each generation; some aspects of cultural adaptation are removed from consideration by the living generations and

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placed under the protection of the supernatural. This analysis suggests that local knowledge, environmental values, place attachments, and cultural landscapes are all functionally interdependent.

There is always a difference in the adaptation of a people to a new ecosystem. In general though, when people come into a new environment they are like the first generation in our hypothetical model. If they have power and succeed in overwhelming the native population, they may come to believe that the locals do not know about the environment. Or perhaps the newcomers just do not care to listen to the people they dispossessed.

In recent centuries many environmental mistakes have been made, and these are often enormous in scale compared to any that occurred before. Rivers have been dammed, old growth forests have been cut, air and water systems have been polluted, the earth has been mined, and the great fresh water lakes have been connected to the ocean. Now the challenge is to stop or even reverse ecosystem-damaging activities. Perhaps this can be achieved more quickly by having the lessons of traditional peoples become available to and considered by members of dominant societies.

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¹ A good definition is the study of the development of something, especially a language, through time.

² The hypothetical location of this case is drawn from the ecology of the basin and range topography and arid ecosystem of southern Arizona. Long-term climate changes with resulting fauna and flora changes have actually occurred in this region over the past 10, 000 years.

³ Dillehay's (2000) *The Settlement of the Americans* documents that all of these cultural characteristics were present when early Native Americans arrived in the New World more than 14,000 years ago.

⁴ Numic-speaking people include Owens Valley Paiutes, Northern Paiutes, Western Shoshone, Southern Paiutes, and Utes. They live in four major ecosystems: the western Colorado Plateau, the Great Basin, the Mohave Desert, and the Owens Valley of California.