Chapter 11

Amazonia: The Historical Ecology of a Domesticated Landscape

CLARK L. ERICKSON

INTRODUCTION

When one thinks of Amazonia, images of large towering trees, dark and humid forests, brightly colored frogs, and smiling native people decorated in paint and feathers come to mind. In addition to engaging public awareness, these popular images are used to raise funds for conservation, to advance green politics, and to promote cultural and ecotourism. They are updated versions of nineteenth century imagery common in travel books and explorers' accounts of Amazonia as a Green Hell or as the Garden of Eden. Surprisingly, many colleagues in the natural sciences and conservation still hold similar notions about Amazonia. These romantic views of nature are contrasted to the reality of contemporary humans destroying the ecosystems of Amazonia through modern development. Loss of biodiversity, extinction of species, deforestation, erosion, pollution, and global warming are attributed to humans and their activities. Recent studies argue that humans have been involved in environmental degradation, ecological catastrophe, and global change throughout their existence.

Traditional historical, geographical, anthropological, and archaeological perspectives on native Amazonia share these negative views. In the classic literature, past and present Amazonian cultures are considered to have been determined largely by the environment to which they adapted. What appears to be a lush, bountiful setting for human development is actually a counterfeit paradise according to some scholars (e.g., Meggers 1971). Environmental limitations, such as poor soils and a lack of protein, combined with a limited technology, few domestic animals, and abundant unoccupied land restricted social development. The simple societies of Amazonia did not evolve into what we recognize as civilization. In this traditional view, the environment as an immutable given or a fixed entity to which human societies adapt (or do not, and thus, fail, and disappear). The basic assumption is that poor environments produce simple societies (band societies of hunters, gatherers, and fishers or

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tribal societies of subsistence farmers) and the corollary, that rich environments produce complex societies (chiefly and state societies of urban and rural folk).

Historical ecology provides a radical, alternative perspective for understanding human-environment interaction over the long term and the complex human histories of environments. Historical ecology focuses on *landscape* as the medium created by human agents through their interaction with the environment. Although landscapes can be the result of unintentional activities, historical ecologists focus on the intentional actions of people and the logic of indigenous knowledge, particularly the understanding of resource creation and management. Historical ecologists, borrowing from the new ecology, argue that disturbance caused by human activities is a key factor in shaping biodiversity and environmental health. Because much of human-environmental history extends beyond written records, the archaeology of landscapes plays an important role. Through the physical signatures or footprints of human activities, technology, engineering, and knowledge embedded in the landscape, historical ecologists have a historical perspective of over 11,000 years about human-environment interaction in Amazonia.

What Amazonian people did to their environment was a form of *domestication of landscape* (Erickson 2006). Domestication of landscape implies all intentional and non-intentional practices and activities of humans that transform the environment into a productive landscape for humans and other species. Domesticated landscapes are the result of careful resource creation and management with implications for the diversity, distribution, and availability of species. Through their long-term historical transformation of the environment involving transplanting of plants and animals, selective culling of non-economic species and encouragement of useful species, burning, settlement, farming, agroforestry (forest management), and other activities discussed in this paper, humans created what we recognize and appreciate as *nature* in Amazonia. Through the perspective of historical ecology, however, we see that nature in Amazonia more closely resembles a *garden* than a pristine, natural wilderness. Rather than "adapt to" or be "limited by" the Amazonian environment, humans created, transformed, and managed cultural or anthropogenic (human-made) landscapes that suited their purposes. The cultural or anthropogenic landscapes range from the subtle (often confused with "natural" or "pristine") to completely engineered.

In this chapter, I introduce historical ecology, new ecology, landscape, and domestication of landscape as key concepts for understanding complex, long term interactions between humans and the environment. I show how historical ecology challenges traditional assumptions and myths about Amazonia. Later, I survey examples of human activities that have created, transformed, and managed environments and their association to biodiversity.

In this chapter, I use the term *Amazonia* to refer to the Amazon basin (the entire region drained by the Amazon River and its tributaries) and more loosely to refer to the tropical lowlands of South America or Greater Amazonia (cf. Lathrap 1970; Denevan 2001). As an anthropogenic environment and interacting culture area of considerable time depth, Amazonia is tied to the neotropics or tropical regions of the Americas.

BIODIVERSITY

Any discussion of humans and the environment invokes debates about biodiversity. Dirzo and Raven define *biodiversity* as "the sum total of all of the plants, animals, fungi, and microorganisms on Earth; their genetic and phenotypic variation; and the communities and ecosystems of which they are a part" (2003: 138). Biodiversity is measured through *alpha diversity* or the number of species within a locality, *beta diversity* or the change in the composition of species between adjacent areas, and *gama diversity* or all species in a region. The highest biodiversity is found in tropical regions such as Amazonia.

Biodiversity is assumed to benefit ecosystem function by increasing biomass, resilience, and productivity – although this is under intense debate. Biodiversity provides humans with food shelter, medicines, fiber, fuel, and other services (drinking water, air, and purification of contaminants) and a vast gene pool for future use. Humans have contributed agrodiversity or domesticated biodiversity through genetic selection of useful plants and animals (Brookfield 2002). Although these selected plants and animals are only a small number of the total species on earth, they provide most of our food and other resources. Semi-domesticates and wild economic species such as medicines, spices, ornamentals, pets, and utilitarian plants also rely on humans for their protection, propagation, and availability; they are not usually considered in discussions of biodiversity but are significant.

HISTORICAL ECOLOGY

At its most basic, historical ecology is about people and their interactions with the environment through time (Balée 1989; 1998, 2006; Balée and Erickson 2006b; Crumley 1994). Although the case studies presented here focus on the contributions of the archaeology of landscapes, historical ecology is inherently multidisciplinary with contributions from botany, zoology, linguistics, soil science, agronomy, anthropology, history, geography, ecology, genetics, demography, climatology, geology, soil science, and many other fields (for examples, Balée 1998; Balée and Erickson 2006a; Crumley 1994; Glaser and Woods 2004; Hayashida 2005).

In doing historical ecology of landscapes, archaeologists practice a form of *reverse engineering*. Recognizing fragmentary physical patterns in sites and landscapes as reflecting human culture, archaeologists carefully document and analyze the evidence within its temporal and spatial context for insights into original logic, design, engineering, and intentionality of human actions. Due to the incomplete nature of the archaeological record, interpretation relies on careful use of analogy to specific historical and ethnographic cases or general cross-cultural models about human behavior. In the case of historical ecology, reverse engineering helps reveal the infrastructure and strategies of environmental management embedded in landscapes. Using this approach, historical ecologists can document and evaluate the successes and failures of human strategies through an examination of continuity and disjuncture in the archaeological record. Distinguishing between natural and cultural (or anthropogenic) processes of environmental change is possible with careful contextual analysis.

Traditional perspectives on human-environmental interaction separate and oppose people and nature. Humans are said to either co-exist in harmony with nature or over-exploit and degrade nature. In cultural ecology, human ecology, cultural materialism, and evolutionary ecology, nature is a fixed given entity that humans interact with and adapt to and their success and failure are measured (Moran 1982; Sutton and Anderson 2004). In cultural evolution and cultural ecology, societies are assumed to pass through sequential stages of development from simple to complex. Increasing control of energy, elaboration of technology, population growth, and formation of political hierarchy are implicit to this lineal scheme as societies advance towards civilization. Differing degrees of human impact and transformation of the environment are attributed to each cultural evolutionary stage.

Bands societies are assumed to have low or minimal impact while states are understood to have high impact (e.g., Redman 1999; Sutton and Anderson 2004).

In contrast to evolutionary approaches where natural selection and ecological processes determine the course of interaction of the human species and environments, historical ecologists propose that "the human species is itself a principal mechanism of change in the natural world, a mechanism qualitatively as significant as natural selection" (Balée and Erickson 2006b: 5). While not ignoring evolutionary and ecological processes, historical ecologists prioritize the historical processes, temporal and geographic scales appropriate for study of humans (often multiple), and human agency (intentionality, innovation, aesthetics, and creativity). Rather than "adapt" to an environment, humans practice *resource management* through which they create the environment in which they live. Balée defines resource management as "the human manipulation of inorganic and organic components of the environment that brings about a net environmental diversity greater than that of so-called pristine conditions, with no human presence" (1994: 117).

THE NEW ECOLOGY

A basic principle of ecology is succession theory or ecological succession (Clements 1916). Nature is assumed to have an ideal state or "climax community". A community such as a forest evolves through a series of orderly stages. At its mature, final stage, a community is said to be in equilibrium with a stable composition of specific species. Although equilibrium can be thrown out of balance by natural phenomena (windstorms, landslides, and wildfires), the community is assumed to recover and return to its optimal state. Much of traditional ecology, environmental science, and conservation are based on the notion that equilibrium and stability are good for nature. The mature, age old rainforests of Amazonia are rich with biodiversity and are considered prime examples of undisturbed, mature wilderness or a climax community.

In recent decades, *new ecologists* have questioned the assumptions of succession theory (Botkin 1990; Connell 1978) and criticize traditional conservation based on succession theory's idea that nature should be protected from disturbance, change, and people. In contrast to succession theory, the *new ecology* considers natural disturbances not only common, but, integral to ecosystem health and biodiversity. The instability, non-equilibrium, and at times chaos created by disturbance encourage environmental heterogeneity through the creation of patches, mosaics, and edges of distinct habitats where diverse species can compete and thrive (Botkin 1990; Zimmerer and Young 1998).

Borrowing insights from the new ecology, historical ecologists focus on human activities as a major source of disturbance (Balée and Erickson 2006a; Stahl 2000, 2006; Zimmerer and Young 1998). In contrast to natural disturbances, human or anthropogenic disturbances are highly patterned in timing, frequency, intensity, scale, context, complexity, and diversity (Blumler 1998; Erickson 2006; Pyne 1998). Common examples of human disturbance are burning, erosion, settlement, roads, farming, and deforestation, but can also include subtle activities such as weeding, transplanting, cultivation, fertilizing, and seeding which encourages certain species over others and which may increase overall biodiversity and biomass. Despite the negativity implied, disturbance by humans usually involves intentionality and planning, although the long term effects may be unknown and unintended when they occur.

Building on the findings of new ecologists that intermediate levels of disturbance are optimal for species diversity, Blumler (1998) suggests that a variety of disturbances and timing or *disturbance heterogeneity* are as important as intensity. Human disturbances keep the environment in a form of arrested succession and disequilibrium. Secondary rather than primary forest is encouraged, which may increase biodiversity, biomass, and ecosystem heterogeneity, especially of wild and domesticated species exploited by humans that thrive in such contexts.

LANDSCAPES

Whereas most traditional archaeologists study *sites*, archaeologists doing historical ecology focus on the largely ignored space between sites or *landscape* (Ashmore and Knapp 1998). In the rural Andes and Amazon where I work, people do most of their daytime activities such as farming, building walls, visiting neighbors, sharing labor, and collecting wild resources in the landscape rather than within the confines of sites which are primarily used for eating and sleeping. Because the totality of people's lives in the past is important, archaeologists must include landscapes in their studies.

Because they are physical and created by repetitive activities through time, landscapes are ideal artifacts for historical ecologists. Archaeologists often apply the metaphor of "reading" landscapes in the sense that cultural patterns created through human activity have meaning and intent that can be deciphered through contextual analysis. Permanent improvements to the land are considered *landscape capital*, investments that are handed down generation after generation (Brookfield 2002). Later generations benefit from the labor and knowledge of their ancestors embedded in landscape. In a recursive relationship, their lives are often structured by roads, trails, paths, field boundaries, irrigation canals, and clearings for houses imposed on the landscape by past inhabitants. Multiple, often contrasting, landscape patterns, which represent different systems of land use and management, are often embedded in landscapes as palimpsests or layered, sequential traces.

AMAZONIA: WILDERNESS OR CULTURAL LANDSCAPE?

The high canopy tropical rainforest, famous for its complexity and biodiversity, is the focus of contemporary research and conservation. Many scholars and the public consider the mature, tropical rainforest to be the ideal natural state of Amazonia, a classic wilderness. In succession theory, mature rainforest is assumed to be the climax community in stable equilibrium. Because these rainforests are relatively devoid of humans today, one might assume that biodiversity is highest in environments undisturbed by humans.

Amazonia-as-wilderness is an example of the *Myth of the Pristine Environment* (Denevan 1992), the belief that the environments of the Americas were relatively untouched by humans prior to European conquest. Native people are believed to have been too few in number, technologically limited, or living harmoniously with the Earth to significantly impact nature. The assumption is also based on the *Myth of the Noble Savage* (or Ecological Indian)—that past and present native people lived in harmony with nature until Europeans and modern world systems arrived, which negatively and permanently transformed the previously pristine environment (Redford 1991).

Archaeologists, however, have demonstrated that much of Amazonia was occupied by dense populations of urbanized societies practicing intensive agriculture that significantly contributed to creating the environment that is appreciated today (Denevan 1992;

Erickson 2006; Heckenberger 2005; Lehmann et al. 2003; Stahl 1996). Scholars now argue that much of the tropical rainforest is the result of a "rebound effect" created by the removal of these people and their activities by European diseases, civil wars, ethnocide, slavery, and resource expropriation. Without the insights of historical ecology, Amazonia is easily misinterpreted as pristine wilderness.

Contrary to popular notions, Amazonia is diverse in environments and was probably more so in the past. While rainforest covers approximately one third of the region, the majority of Amazonia is deciduous forest, palm forest, liana forest, forest island, savanna, and wetland (Goulding et al. 2003; Moran 1993; Smith 1999). Other classic distinctions include riverine (*várzea*) vs. upland (*terra firme*) and white, clear, and black water rivers.

In addition, historical ecologists argue that much of Amazonia's diverse ecological patchwork of diverse habitats is anthropogenic and historical (Posey and Balée 1989; Balée and Erickson 2006a). Before the native population collapse after 1492, archaeologists show that much of Amazonia was transformed by burning, settlement, roads, agriculture, and agroforestry into forest clearings, savannas, parkland, countryside, and forest islands (Denevan 1992, 2001; Erickson 2006; Heckenberger 2005; Heckenberger et al. 2003; Posey 2004; Stahl 2006). The "natural" fauna and flora composition were replaced by anthropogenic formations. Amazonia had fewer trees five hundred years ago and the existing forests were more similar to gardens, orchards, and game preserves than wilderness.

AMAZONIA: A COUNTERFEIT PARADISE OR ANTHROPOGENIC CORNUCOPIA?

Environmental determinism has a long history in anthropological studies since the nineteenth century. Scholars believed that races, cultural diversity, cultural stability and change could be explained by the environmental conditions under which these traits developed. In this view, the environment is treated as a given fixed context to which societies adapt or fail. In Amazonia, the limitations include soils, technology, protein, and catastrophic climate change. The main spokesperson of environmental determinism, Betty Meggers (1954, 1971, 2001) explained the presence of simple societies and relatively nomadic lifeways of Amazonian people in the historical and ethnographic accounts as evidence of environmental limitations imposed on human cultural development. According to her Theory of Environmental Determinism, societal development is encouraged or limited by the conditions to which humans have to adapt. In the case of Amazonia, the poor quality of tropical soils is said to have restricted agriculture to simple systems such as slash-and-burn (swidden) (Carneiro 1960; Meggers 1971). Adopting the idea from natural scientists and developers that the lush, rich vegetation of the tropical forests is actually fragile ecosystem growing on poor soils, Meggers (1971) coined the term *counterfeit paradise* to describe Amazonia.

Swidden is the most common traditional agriculture today, involving clearing isolated patches of forest, drying and burning the felled vegetation, and planting crops among the ash Crops are rotated for several years and the field is abandoned eventually as weeds and secondary growth increase labor (abandonment was originally thought to be due to soil exhaustion). Over a period of 10–20 years, secondary forest covers the plot. Because the farmer clears and burns another stand of forest every 3–5 years, a large area is needed and settlements are frequently relocated; thus, slash-and-burn agriculture is assumed to support low population densities. Without large populations, surplus to support non-farmers and class stratification, and cities, Amazonia could never develop civilization. Environmental determinists also point to primitive technology as a reason for simple agriculture: the wooden digging stick, stone ax, and wooden machete.

Others examined the lack of animal protein as an environmental limitation. According to the Hypothesis of Protein Limitations, scholars proposed that the availability of protein determined settlement, population density, and inter and intra-societal relationships in Amazonia (Gross 1975). Unlike societies in the Old World, Amazonian people had few domesticated animals to provide reliable protein; and thus, they were assumed to have relied on unpredictable and easily overexploited hunting of wild animals. Based on ethnographic cases, scholars argued that typical settlement size, duration, and regional patterns could be explained by the lack of protein. In more extreme interpretations, Amazonian patterns of warfare, settlement spacing, and mobility, were explained by the fierce competition over limited hunting resources (Chagnon and Hames 1979).

Meggers (1979, 1995, 2001) proposes catastrophic climate change as a new element of environmental determinism to explain periodic settlement abandonment and changes in pottery styles in the archaeological record. She hypothesizes that cycles of mega-El Niño events throughout prehistory caused severe and extended floods and droughts that caused frequent societal collapse, encouraged nomadic patterns of settlement, and limited social development. Recent El Niño events have caused droughts and flooding in Amazonia, often resulting in large forest fires that have been exacerbated by uncontrolled development of the region. Pre-Columbian societies faced similar challenges and survived. However, the evidence presented for catastrophic climate change by mega-El Niños and its impact on humans has been challenged (e.g., DeBoer et al. 1996; Erickson and Balée 2006; Stahl 1991; Whitten 1979).

Few contemporary scholars support environmental determinism. Carneiro (1960) points out that slash-and-burn agriculture under careful management can be highly productive, yield surpluses, and sustain large, sedentary villages of 1000 to 2000 people. Others highlight the importance of bitter manioc, a crop that thrives on poor soils and can be converted into a storable surplus as dry flour (Lathrap 1974; Heckenberger 1998).

In the 1960s, scholars documented intensive agriculture in pre-Columbian Amazonia including house gardens, river levee farming, raised fields, terraces, Amazonian Dark Earth (ADE), and anthropogenic forest islands (Denevan 2001; Denevan et al. 1988; Langstroth 1996; Lathrap 1970, 1985, 1986; Posey 2004). In contrast to low energy, extensive agriculture such as slash-and-burn, which requires long periods of fallow during which fields regain fertility, intensive agriculture, which has little or no fallow period and fertility, is maintained through inputs of labor and organic matter. Archaeologists and geographers highlighted the potential of farming river levees and banks when floods recede (Hiraoka 1985; Smith 1999). Raised fields, terracing, and ADE (discussed below) are capable of continuous, high yields and are associated with dense populations, large permanent settlements, and complex society (Denevan 2001; Erickson 2006; Lehmann et al. 2003; Neves and Petersen 2006; Valdez 2006; Walker 2004). These strategies take advantage of patches of naturally fertile soil and technologies of soil creation, transformation, and management and negate environmental determinism. Slash-and-burn agriculture depends on metal axes and machetes to efficiently to clear primary forest. These tools were unavailable until after 1492 (Denevan 2001). Pre-Columbian farmers, using digging sticks and stone axes probably continuously cultivated fields and practiced agroforestry rather than clear primary forest.

In critiquing the Hypothesis of Protein Limitation, scholars noted that most groups studied as examples of protein limitation live inland, far from major water bodies and fish. In fact, Amazonian people were primarily riverine cultures and relied on fish and other aquatic resources as the main source of protein rather than game animals (Beckerman 1979). In addition to rivers and lakes, fish were systematically harvested in large numbers using networks of fish weirs (Erickson 2000). Furthermore, maize is a storable staple crop and provider of protein (Lathrap 1987; Roosevelt 1991) and other sources of protein were available, including nuts, fruits, and insects common in the humanized forests (Beckerman 1979; Clement 2006).

NATIVE AMAZONIAN PEOPLE: WITH OR AGAINST NATURE?

Indigenous people of Amazonia have become the subject of an intense debate about whether native people enhance or degrade biodiversity and environmental health. In some more extreme critiques, Amazonian people are considered to be no better or worse than Westerners (Alvard 1995; Redford 1991). But modern Western society often views the relationship of native people to the environment as positive in contrast to its own. Assumed to be living in harmony with nature, it is thought that native people must have an innate conservation ethic and thus, are considered the natural stewards of the environment. This powerful belief is the Myth of the Noble Savage. Much of the debate about native Amazonia focuses on documentation of over hunting of game animals. Rather than being omniscient curators of their environment, it can be argued Amazonian people were environmentally friendly due to low, dispersed populations, plenty of resources, simple technology, and settlement mobility rather than an innate conservation ethic.

In studies debunking the myth, game animals are treated as a natural and immutable resource subject to unsustainable overexploitation. Historical ecologists point out that the important game animals feed heavily on fruits and nuts provided by the anthropogenic forests established by the past inhabitants of Amazonia. Oligarchy or forests of a single species, usually a tree valuable to humans and game animals, is attributed to past human management (Peters 2000). In addition, most contemporary hunter-gatherers rely on the economic species of anthropogenic forests, the landscape capital of their ancestors. Human created the conditions for the "natural" resources that they are blamed for degrading.

While scholars debate humans as agents of conservation vs. humans as agents of degradation, historical ecologists eschew the distinctions and argue that humans are neither (Balée 1998; Balée and Erickson 2006b). Rather than possessing an innate conservation ethic of preservation, native Amazonians consciously exploited their environments for subsistence while practicing resource creation and management. The management, a form of multigenerational indigenous knowledge about the environment, is based on local practical indigenous knowledge. Some historical ecologists consider humans to be a keystone species: a species that plays a disproportionate role in ecosystem health and the abundance and availability of other species (Balée and Erickson 2006b).

Whether human activities degrade or enhance biodiversity often depends on how biodiversity and environmental health are defined and measured, the temporal and geographical scale used for comparison, and the standard or a benchmark to which altered environments can be compared and evaluated. Because the impact of human activities is so early, widespread, and profound in Amazonia, most historical ecologists argue that there is no appropriate pristine benchmark for comparison. In some cases, Amazonian people enhanced biodiversity and practiced environmentally sustainable practices; in other cases the diversity of species was reduced and environments degraded. What may have been negative impacts over the short term and locally may actually enhance biodiversity over the long term and at the regional scales and vice versa. In many documented cases, human creation, transformation, and management of the Amazonia over thousands of years resulted in the high biodiversity that is appreciated today.

AMAZONIAN PEOPLE: ADAPTATION TO OR CREATION OF ENVIRONMENTS?

Culture ecologists emphasize the concept of adaptation, modified from natural science and evolution, to explain cultural variation and the success and failure of native societies in Amazonia (e.g., Meggers 1971; Moran 1982; Sutton and Anderson 2004). Cultural ecologists consider adaptations to the environment through human culture (material culture, technology, social organization, and settlement patterns) that undergo selection with beneficial behaviors favored and passed to future generations. The adaptation concept treats the environment as a static, fixed, often limited resource to which humans adapt. The concept is also believed to explain human cultural diversity through reference to unique adaptations to the exigencies of their particular environmental context.

Historical ecologists reject the assumptions of adaptation. Rather than adapt or respond to the environment, Amazonian people created, transformed, and managed those very environments in which they lived and thrived through their culture and accumulated multigenerational knowledge and management practices (Balée 1989, 2006; Balée and Erickson 2006a; Erickson 2006).

ELEMENTS OF A DOMESTICATED LANDSCAPE

Evidence of landscape creation, transformation and management of domesticated, engineered, humanized landscapes in Amazonia includes: anthropogenic burning, settlements and associated landscapes, mounds, anthropogenic forest islands, ring ditch sites, Amazonian Dark Earth (ADE), raised fields, transportation and communication networks and, water management, fisheries management, and agroforestry.

Anthropogenic Burning

Fire is the oldest and most powerful technology of environmental creation, transformation, and management available to native people (Figure 11.1). Thousands of fires can be detected daily on satellite imagery of Amazonia. For most natural scientists and conservationists, fires caused by humans are considered to be the worst threat to Amazonian rainforests and biodiversity. Complex fire histories documented in lake sediment cores, soil stratigraphy, and archaeological sites suggest that humans regularly burned Amazonia in the past (Oliveira and Marquis 2002; Lehmann et al. 2003; Sanford et al. 1985). Anthropogenic fires are distinguished from natural fires by their regularity, context, timing, and patterns (Pyne 1998).

Hunters and gatherers burn landscapes to remove old vegetation for new to attract browsing game, clear the understory for easier movement and harvesting of wild plants, encourage economic species attracted to light gaps and disturbance, and hunt game through cooperative drives employing fire and smoke. Farmers employ burning to clear and prepare

Figure 11.1. Savanna management using fire in the Bolivian Amazon. Baures in 1999. (Clark Erickson)

fields, gardens, orchards, and settlements, fertilize fields, incinerate garbage, and reduce bothersome insects (Pyne 1998). Regular burning prevents runaway fires stoked by accumulated fuel. Burning and the production of charcoal is a key element in the formation of Amazonian Dark Earth (discussed below).

Most scholars now agree that fire plays a key role in the creation and maintenance of Amazonian environments, in particular savannas and dry deciduous forests that cover much of Amazonia (Langstroth 1996; Oliveira and Marquis 2002).

Settlement and Associated Landscape

Human settlements may be one of the most persistent and permanent transformations of the Amazonian environment. Scholars have recorded a wide variety of settlement types and regional settlement patterns for past and present Amazonian people (Denevan 1996; Durán and Bracco 2000; Erickson 2003; Heckenberger 2005; Neves and Petersen 2006; Roosevelt 1991; Wust and Barreto 1998). While most settlements were small (less than 1 ha), the archaeological site under the present day city of Santarem in Brazil covers 4 km^2 and the Faldas de Sangay site in Ecuador is possibly 12 km^2 (Roosevelt 1999). Traditional communities had large, open, clean central plazas and streets along which houses were arranged in linear, grid, radial, or ring patterns.

The typical Amazonian house is a simple example of resource use and local landscape transformation (Figure 11.2). The foundation requires 4 to 6 upright wooden posts plus additional beams (each representing a tree). Earthen floors are often raised 10–20 cm for drainage during the wet season (1.5–3.0 m^3 for a 3 × 5 m house). Thick layers of palm and grass thatch cover the roof. A typical Pumé community would require 13,498 fronds of palm which is replaced every 2 to 3 years, and 750,000 fronds from 125,000 palms for a large communal house of the Bari (Gragson 1995). Vegetation around the house is cleared to bare ground for protection against snakes and for aesthetic reasons. A small but densely packed house garden is established for spices, colorants and dyes, medicinal

Figure 11.2. Amazonian house, clearing, work areas and house garden. Fatima in 2006. (Clark Erickson)

plants, tobacco, cotton, hallucinogens, and fish poisons. The garden is also a compost pile for kitchen waste. In humid tropical regions, houses last 5 to 10 years. In summary, the environmental impact of a single house is profound: rearranging and altering soils, accumulation of organic matter through garbage and human wastes, deforestation and opening of forest canopy, cutting of construction and roofing materials, replacement of natural vegetation with economic garden, crop, and orchard species, and mixing of the soil horizons. Denevan (2001) estimates a pre-European conquest native population of 6.8 million for Amazonia. Assuming 5 people per household, some 1,360,000 houses were required in a single moment. The environmental impact described above for a single household is now multiplied by over one million houses across the landscape.

House gardens were associated with individual residences and there was a larger clearing for staple crops in the forest with raised fields in savannas and wetlands or on exposed river banks beyond the settlement. Stream channels and wetlands were criss-crossed with fish weirs (corrals for harvesting fish). Any standing forest within a 5-km radius was a managed forest. Pathways were hacked through the forest and roads within settlements were often raised or defined by earthen berms, and other infrastructure. In the savannas, large earthen causeways with adjacent canals served as roads and canoe paths. In addition, each settlement required firewood, game, fish, and other wild resources in quantity.

A community's permanent transformation of the environment for these basic needs and infrastructure is staggering (Figure 11.3). As a result, the forested environments that are typical today were scarce in the past and of a much different character. Based on the archaeology, these communities were stable, long-lived, and sustainable despite this impact.

Figure 11.3. The Amazonian settlement and adjacent landscape of gardens, fields, agroforestry, roads, paths, orchards, garbage middens, and forest regrowth at various stages. The dark circular feature in the center is a precolumbian ring ditch site. Jasiaquiri, Baures in 2006. (Clark Erickson)

Mounds

Many Amazonian cultures were impressive mound builders (see chapters in Section IV of this volume) (Denevan 1966; Durán and Bracco 2000; Erickson and Balée 2006). Farmers built mounds in the Llanos de Mojos of Bolivia, Marajo Island and the lower and central Amazon basin and Pantanal of Brazil, the Llanos de Venezuela, Mompos basin of Colombia, Sangay in the Upano Valley and Guayas Basin of Ecuador, and the coastal plains of Guyana, Brazil, Uruguay, and Ecuador. Mounds were constructed of earth with the exception of the *sambaquis* of coastal Brazil which are primarily of shell. Excavations show that many mounds served multiple functions, often simultaneously. Mounds generally contain fill or layers of domestic debris (bones, shell, and other organic food remains, pottery, and stone tools) typical of settlements. Some mounds have such a high percentage of broken pottery that scholars apply the term "potsherd soils" (Langstroth 1996). Mounds were formed over considerable time through the collapse and leveling of wattle and daub buildings, accumulation of refuse and construction debris, and the intentional addition of fill from adjacent large borrow pits, often filled with water. Mounds in the Llanos de Mojos and on Marajo Island contain hundreds of human burials in which a large pottery urn with lid was used for a coffin (Nordenskiöld 1913; Roosevelt 1991). Other mounds were used as chiefly residences or ceremonial centers (Rostain 1999; Lopez et al. 2002).

Although most are small, the Ibibate Mound Complex in the Bolivian Amazon covers 11 ha and is 18 m tall with over 250,000 m^3 of fill (Erickson and Balée 2006). Mounds are often found in groups of up to 40 for Marajo Island (Roosevelt 1991), and more than 50 mounds for the Huapula site (Rostain 1999). Mounds, as highly visible monumental features on the landscape, were probably a source of civic pride, a place where ancestors were buried in urn coffins, and an elevated spot above annual floodwaters to establish residences, gardens, cemeteries, ceremonial centers, elite complexes, and public space.

Mound construction required mass movement of soils, transformation of local topography, soil enrichment, and change in vegetation composition. Our study of the Ibibate Mound Complex in the Bolivian Amazon demonstrates that the biodiversity on the mounds was much significantly richer than that of the surrounding landscape and consists primarily of economic species, some 400 years after abandonment as a settlement (Erickson and Balée 2006).

Anthropogenic Forest Islands

Forest islands are common throughout the savannas and wetlands of Amazonia (Figure 11.4). Forest islands range in size from a few hectares to many square kilometers. Most are raised less than one meter and often surrounded by ponds or a moat-like ditch. Excavations in forest islands in the Llanos de Mojos and Pantanal document their anthropogenic origins and use for settlement, farming, and agroforestry (Erickson 2000a, 2006; Walker 2004; Langstroth 1996). In Bolivia, archaeologists estimate the existence of 10,000 forest islands (Lee 1995; CEAM 2004). The Kayapó of Central Brazil create forest islands (*apêtê*) of improved soils through additions of organic matter from household middens and recycling of crop debris for intensive cultivation of crops (Posey 2004; Hecht 2003). These anthropogenic features are known for their high biodiversity and agrodiversity.

Figure 11.4. Forest island in the savanna, Machupo River, in 2006. (Clark Erickson)

Ring Ditch Sites

Ring ditch sites are reported in the Bolivian Amazon (Figure 11.5), Matto Grosso, Acre, and Upper Xingu River regions (Erickson 2002; Heckenberger 2005; Parssinen et al. 2003; Ranzi and Aguiar 2004). These sites consist of a closed or U-shaped ditched enclosure or multiple ditches. Heckenberger (2005) describes numerous sites with large open plazas and radial roads marked by earthen berms extending through residential sectors enclosed by deep semi-circular moat-like ditches and embankments. Early explorers described villages that were protected by wooden palisades and moats. If palisaded, typical ring ditch site would require of hundreds or thousands of tree trunks, a considerable environmental impact.

Ring ditch sites in Acre and the Bolivian Amazon, described as geoglyphs because of their impressive patterns (circular, oval, octagon, square, rectangle, and D-shapes), appear to be more ceremonial than residential or defensive (Figure 11.6). Some ring ditch sites are

Figure 11.5. Precolumbian ring ditch site. The main ditch is approximately 3 m deep. A smaller ditch can be seen to the left. Baures in 2006. (Clark Erickson)

Figure 11.6. An octagon-shaped ring ditch site in the Bolivian Amazon. The ditch measures 108 m in diameter and 2 m deep. Santiago, Baures in 2006. (Clark Erickson)

associated with ADE. Modern farmers in the Bolivian Amazon intensively farm these sites and those covered with forest are good locations for hunting game and gathering fruit.

Amazonian Dark Earth (ADE)

As discussed earlier, soils have been central in debates about environmental potential and cultural development in Amazonia and play a major role in enhancing resource biodiversity and biomass. Rather than adapt to limited soils, we now recognize the ability of Amazonian farmers to improve and manage marginal tropical soils through creation of settlement mounds, forest islands, raised fields, and Amazonian Dark Earth (ADE).

ADE or Indian black earth (*terra preta do indio*) is an important subclass of anthrosols or anthropogenic soils and associated with archaeological sites (Smith 1980; Erickson 2003; Lehmann et al. 2003; Glaser and Woods 2004; Neves and Petersen 2006). A lighter color ADE, *terra mulata*, often surrounds *terra preta*. ADE is estimated to covers between 0.1 to 10% or 6000 to 600,000 km^2 of the Amazon basin. ADE sites range from less than one hectare to as large as 200 ha in size. ADE was probably used for settlement, house gardens, and permanent fields rather than slash-and-burn agriculture, the common practice today. Scholars believe that these soils were created specifically for permanent farming. Today ADE is prized by farmers for cultivation and in some cases, mined as potting soil for markets in Brazilian cities.

ADE is a rich in typical domestic debris found in archaeological sites including potsherds, bone, fish scales, shell, and charcoal. The extremely dark color and fertility is due to large quantities of charcoal and other organic remains that sharply contrast to the surrounding poor reddish tropical soils. In contrast to slash-and-burn agriculture where complete combustion of felled forest is the goal, ADE farmers practiced "slash and char," a technique to produce biochar or charcoal through low temperature, incomplete combustion in a reduced atmosphere. Biochar has been shown to be a high quality soil amendment for enhancing and maintaining soil fertility over hundreds of years. In addition, ADE is a rich habitat for beneficial microorganisms. Once established, ADE is a living entity that may sustain and reproduce itself (Woods and McCann 1999). The presence of intact ADE after 400 to 500 years is evidence its permanence, sustainability and resilience. Ethnobotanical studies document high biodiversity on ADE (Balée 1989; Smith 1980). The number of soil microorganisms in ADE alone may be quite large. Although understudied, potential contribution of microorganisms in ADE to overall biodiversity is substantial.

If ADE was formed as the simple unintentional byproduct of long-term residence in a locale, we would expect to find black earth sites at any location where past human occupation was dense and of long duration. Archaeological sites fitting these criteria are common throughout Amazonia but do not have ADE. This suggests that ADE formation, which involves careful production of biochar and management of soil microorganisms, is intentional soil engineering. ADE is an excellent example of landscape domestication below the ground.

Raised Fields

Raised fields are probably the most impressive example of landscape engineering at a regional scale in Amazonia (Denevan 1966, 2001; Erickson 1995, 2006; Walker 2004). Raised fields are large platforms of earth raised in seasonally flooded savannas and permanent wetlands for cultivating crops (Figure 11.7). Excavations and agricultural experiments suggest that raised fields served multiple functions, including drainage of waterlogged

Figure 11.7. Precolumbian raised fields, canals, and causeways in the Bolivian Amazon. The clearing is now a ranch and the causeways are used as paths. San Ignacio in 2006. (Clark Erickson)

soils, improvement of crop conditions (soil aeration, mixing of horizons, and doubling of topsoil), water management (drainage and irrigation), and nutrient production, capture, and recycling in canals alongside each platform. Crop production in experimental raised fields is impressive and up to double that of non-raised fields (Erickson 1995, 2006; Stab and Arce 2000; Saavedra 2006). Based on high productivity and substantial labor costs to construct, raised fields were probably in continuous production. In addition to traditional crop cultivation on the platforms, aquatic resources such as edible fish, snails, reptiles, and amphibians could be raised in the adjacent canals. Canals also trap organic sediments and produce organic "green manure" and "muck" that can be periodically added to the platforms for sustained cropping.

Raised field agriculture represents a massive landscape transformation at a regional scale through rearranging soils, changing hydrology, and imposing a heterogeneous microtopography of alternating terrestrial and aquatic ecosystems on landscapes that originally were relatively flat and biologically homogeneous and of limited production. Landscape engineering of this magnitude substantially increased biodiversity and biomass in savannas and wetlands. The presence of raised fields in deep forests of the Bolivian Amazon suggests that the landscape was open savanna maintained by regular burning when the fields were used. After abandonment and cessation of burning, forests returned with trees arranged in orchard-like rows on the eroded raised fields.

Transportation and Communication Networks and Water Management

Transportation and communication networks in the present and past have significant environmental impacts at the local and regional scale. Paths, trails, and roads connect settlements and people and, like modern roads, bring development and new settlements, expand farming, and cause environmental change. All Amazonian societies use elaborate networks of paths and trails and roads between settlements, gardens, fields, rivers, resource locations, and neighbors. The Kayapó maintain thousands of kilometers of paths (Posey 1983 in Denevan 1991). Posey (2004) documents subtle anthropogenic impact along Kayapó paths created by the discard of seeds from meals and snacks and transplanting of economic species along path clearings. These resources also attract game animals, making them easier to find and hunt. The long linear disturbance and light gap created by clearing and maintenance of paths produces distinct anthropogenic vegetation communities that penetrate deep into the forest.

Some advanced Amazonian societies built impressive formal roads, causeways, and canals of monumental scale (Figure 11.8). Large and small sites in the Tapajós and the Upper Xingú regions are connected by traces of networks of straight roads with earthen berms suggesting hierarchical socio-political organization at a regional scale (Nimuendajú 1952; Heckenberger 2005). The earliest explorers of the Amazon River reported similar wide straight roads connecting large riverine settlements to the distant hinterlands (Denevan 1990).

The late pre-Columbian inhabitants of the Llanos de Mojos and Baures regions in the Bolivian Amazon completely transformed the environment into a highly patterned landscape of complex networks of raised earthen causeways and canals (Denevan 1990; Erickson 2001, in press). These earthworks had multiple functions including transportation and communication, water management and production of aquatic resources, boundary and territorial markers, and as monumental ritual and political statements. Their

Figure 11.8. Four precolumbian causeways and canals connecting forest islands in the Bolivian Amazon. The palm covered causeways are 3 to 4 m wide and 1 m tall with adjacent canals of 2 to 3 m wide and 1 m deep. Baures in 2006. (Clark Erickson)

construction was often intended for water management and the creation of artificial wetlands at the local and regional scale. On near flat savanna, a causeway of 1 m tall and 2 km long between the high ground of two adjacent river levees could potentially impound 5 million m^3 of water. Canals brought water for irrigation and provided drainage when necessary.

Amazonians are classic canoe people and transport and communication by water is a basic element of tropical forest culture (Lathrap 1970; Lowie 1948). Most Amazonian people would rather paddle a canoe than walk. Nordenskiöld (1916) pointed out that most of the major headwaters of Amazonian river drainages connect to the headwaters of adjacent river drainages. Some of these aquatic connections such as the Casquiare Canal between the major Negro and Orinoco drainages and the Pantanal between the Guaporé and the Paraguay drainages are partially anthropogenic. Artificial river meander short cuts are common in the Llanos de Mojos of the Bolivian Amazon, Amapá Region of the Central Amazon basin, and the Ucayali River of Peru (Abizaid 2005; Denevan 1966; Nordenskiöld 1916; Raffles and Winkler-Prins 2003). The large meander loops of typical rivers of Amazonia are challenges to canoeists, often requiring hours or even days of paddling to move short lineal distances. The problem is solved by cutting short linear canals or repeatedly dragging a heavy dugout canoes in the same location between the neck of a large looping meander to save travel time. In a number of cases, these anthropogenic canals created a new river course, dramatically and permanently changing the regional hydrology.

Inter-river canals are common in the Llanos de Mojos of Bolivia. Pinto (1987) describes a complex network of natural channels combined with artificial canals to allow canoe traffic over 120 km perpendicular to natural river flow. In other cases, artificial canals tapping the headwaters of two adjacent rivers diverted the flow of one into the other permanently transforming the hydrology of two drainage basins (CEAM 2003).

Fisheries Management

Fishing is now recognized as the major traditional source of protein in the Amazon basin (Chernela 1993; Beckerman 1979; Erickson 2000b). In contrast to other civilizations that domesticated fish, Amazonian people artificially enhanced the natural habitats of wild fish to increase availability through creation of artificial wetlands and expanding the capacity of existing wetlands through construction of raised field canals, causeways and other water management techniques.

The Baures region of Bolivia is an excellent example of landscape domestication for the improvement of natural fisheries (Erickson 2000b). Low linear earthen ridges zigzag across the seasonally inundated savannas between forest islands with funnel like opening located where the earthworks changed direction (Figure 11.9). These features are identified as fish weirs based on descriptions in the ethnographic and historical literature. Fish weirs are fences made of wood, brush, basketry, or stones that extend across bodies of water. Baskets or nets are placed in openings to trap migrating fish. Most fish weirs are simple ephemeral structures on a river or shallow lake. In contrast, the fish weirs of Baures are permanent earthen features covering more than 550 km^2. Small artificial ponds associated with the weirs are filled with fish and other aquatic foods when the floodwaters recede. These were probably used to store live fish. Through fisheries management, the native people of Baures transformed savannas and wetlands into a productive landscape capable of providing hundreds of tons of protein to sustain large populations.

Figure 11.9. A network of precolumbian fish weirs in the Bolivian Amazon. The brush covered fish weirs measure 1 m wide and 50 cm tall. Straight features at the top and bottom of the image are causeways and canals, and circular features are artificial fish ponds. Baures in 1999. (Clark Erickson)

Agroforestry

Countering the view of Amazonian forests as pristine and natural, historical ecologists show that these forests are, to a large degree, the cultural products of human activity (Balée 1989; Balée and Posey 1989; Denevan and Padoch 1988; Posey 2004). Amazonian people past and present practiced agroforestry: tree cultivation and forest management (Peters 2000).

Analysis of pollen, opal phytolith, and sediment from lakes document local and regional anthropogenic disturbances of Amazonia over thousands of years including burning, clearing, farming, and agroforestry (Piperno and Pearsall 1998; Mora 2002; Piperno et al. 2000). Much of what was originally misinterpreted as natural change due to climate fluctuations is now considered anthropogenic. Records show a steady increase of "weeds" and secondary forest species, many of which are economic species, and later domesticated crops that thrive in open conditions and heterogeneous mosaic of forest and savanna and intermediate states created by human disturbance. At the same time, the frequency of species characteristic of closed canopy forests decreases until the demographic collapse after 1491. Fire histories are also documented in association with the formation of the anthropogenic forest. Evidence of fruit and nut tree use and human disturbance is documented by 10,500 years ago in the Central Amazon (and see discussion of dates in the Colombian Amazon in Roosevelt 1996; Mora 2002; see discussion of evidence for domesticated crops at some sites in Amazonia in Piperno and Pearsall 1998; Piperno et al. 2000; see also Chapter 12 in this volume).

The long-term strategy of forest management was to cull non-economic species and replace them with economic species. Sometimes, this involves simple thinning, planting, transplanting, fertilizing, coppicing, and weeding of valued species to enhance their productivity and availability. Many wild plants are often found outside their natural range due to transplanting, cultivation, and habitat improvements. In other cases, wild and domesticated trees are tended as orchards. Useful plants that in the distant past relied on natural forces now depend increasingly on humans for seed dispersal, survival, and reproduction.

Slash-and-burn agriculture is characterized by low labor inputs, limited productivity per land unit, and short period of cultivation followed by longer periods of fallow or rest. Historical ecologists point out that slash-and-burn fields are never truly abandoned and unproductive during fallow. In Amazonia, agriculture is combined with agroforestry. In the initial cutting and burning to clear a field or garden, certain economic species are left to thrive while unwanted species are removed. In addition to basic food crops, useful fruit and palms are often transplanted to the clearing. As fields fall out of cultivation because of weeds and forest regrowth, the plots continue to produce useful products, long after "abandonment".

Anthropogenic forests are filled with fruit trees, an important component of agroforestry. Eighty native fruit trees were domesticated or semi-domesticated in Amazonia (Clement 2006). Fruit trees, originally requiring seed dispersing frugivores attracted to the juicy and starchy fruits, became increasingly dependent on humans through genetic domestication and landscape domestication for survival and reproduction. In addition, humans improved fruit tree availability, productivity, protein content, sweetness, and storability through genetic selection. Oligarchic forests, characterized by a single tree species, often a palm, provide mass quantities of protein and building materials, and food for the game animals. In the Bolivian Amazon, thousands of kilometers of the burití palm, the Amazonian tree of life, contributes protein and materials for buildings, basketry, weapons, and roofing. Forest islands of chocolate trees are agro-forestry resource legacies of the past inhabitants of the region (Erickson 2006).

Agroforestry and farming also attract game animals that eat the abundant crops, fruits, and nuts. Farmers often grow more food than necessary to attract game. As a result, "garden hunting" is a particularly efficient (Linares 1976). Many game animals of Amazonia would have a difficult time surviving without a cultural and historical landscape of human gardens, fields, orchards, and agroforestry. The biodiversity of animals can also be enhanced by domestication of landscape. In coastal Ecuador, Stahl (2000, 2006) reconstructs biodiversity and the character of the anthropogenic environment through the remains of diverse animals in garbage middens of 4,000-year old settlements. The majority of identified animals thrive in a disturbed mosaic environment with light gaps, edges, old gardens and field clearings.

Even hunters and gatherers contribute to anthropogenic forests. The nomadic Nukak of the Colombian Amazon change campsites 70 to 80 times a year (Politis 1996). When establishing a new location, a small number of trees are felled and hundreds of palm fronds are collected for construction of a simple lean-to structure. Wild fruits and nuts are collected and some end up discarded. After the camp is abandoned, palm seeds take root in the clearing and thrive. Repeated over hundreds of years, the selective cutting of trees for nomadic camps, creation of small light gaps or openings, and distribution of seeds can substantially change the forest composition to one rich economic species of plants and animals.

While agroforestry focuses on management of certain economic species, studies show that overall biodiversity may be enhanced in anthropogenic forests (Peters 2000; Balée 1994, 2006). The Ibibate Mound Complex in the Bolivian Amazon is a well studied case of a biologically diverse anthropogenic forest (Erickson and Balée 2006). Surveys of forest growing on pre-Columbian mounds abandoned 400 years earlier and non-mounds were compared showing a significantly higher biodiversity in forest on the mounds, in addition to non-local economic species. Economic studies show that anthropogenic forests are more valuable for sustainable collection of renewable resources than logging (Balick and Mendelsohn 1992).

CONCLUSIONS: LESSONS FROM THE PAST?

Western environmental history is characterized by humans, especially those living in farming and urban societies, who overexploit and degrade the environment. Some scholars now argue that environmental catastrophes are an ancient rather than recent historical phenomenon. Other scholars contrast the environmental failures of Western civilization to non-western societies practicing efficient, productive, and sustainable strategies. Another group declares this a myth and that all human activities are negative for the environment. Rather than assume that humans are either *Homo ecologicus* or *Homo devastans*, historical ecologists attempt to evaluate these debates through careful investigation of particular case studies at multiple scales of analysis.

Amazonian Dark Earths, agroforestry, raised field agriculture, transportation and communication networks, urban settlements, mounds, artificial forest islands, river cutoffs, water control, and fisheries management are clear examples of landscape creation, transformation and management by pre-Columbian native people in Amazonia (Figure 11.10). Through the domestication of landscape, native people shaped the landscape as they wanted it and made it work for them. What they transformed was often less productive and biologically diverse than what resulted. In other cases, human activities reduced biodiversity. Most landscapes, which are today appreciated for their high biodiversity, have evidence of human use and management, even if those landscapes are relatively unoccupied today. Environments with high biodiversity are a result of, rather than in spite of, long human disturbance of the environment.

My Bolivian informants state that the best hunting and farmland is on pre-Columbian earthworks deep in the forests (Figure 11.11). Recognized as having the highest biodiversity in

Figure 11.10. Precolumbian domesticated landscape of settlements, mounds, forest islands, raised fields, causeways, canals, and agroforestry. (Artwork by The Monkey Project)

Figure 11.11. Precolumbian raised fields under forest. When the fields were in use, the landscape was treeless. San Ignacio in 2006. (Clark Erickson)

Bolivia, the Tsimane Indigenous Territory is covered with raised fields, causeways, canals, and settlements under what is now continuous forest canopy (Erickson and Walker 2005). These cases of present day biodiversity, treasured by scholars and the public alike, were ironically created under conditions of intensive farming, urbanized settlement, and dense populations. Anthropologists have recently pointed out that regions of high biological diversity tend to map onto high cultural diversity (Maffi 2006). These finding contradict the Myth of the Pristine Environment that biodiversity should be associated with an absence of humans. To historical ecologists, this association makes sense.

Were these native practices sustainable? Sustainability usually refers to rational continuous harvest of a resource without destroying the capacity of that resource to reproduce. According to Janzen, sustainable development is "living off the interests rather than consuming the capital" (1997: 413). The longevity of settlements, agriculture, and cultural traditions and the dense populations supported in what are now considered biologically diverse environments are evidence of sustainability.

Are the past strategies of environmental management defined by historical ecology applicable to the modern world? Many goals of pre-Columbian native people, modern inhabitants of Amazonia, scientists, planners, and the general public coincide: the management of environmental resources for a comfortable life and sustainable future in what most consider a fragile ecosystem. Increasingly, the reservoir of existing biodiversity is found in humanized landscapes. The failure of traditional solutions such as fencing off nature and excluding native people highlights the need for strategies that embrace the co-existence of nature and humans. Environmental management informed by time-tested strategies for specific landscapes may be more appropriate than existing solutions. Because humans played a role in the creation of present day biodiversity, solutions will have to include people.

ADE as a means to mitigate global warming is an example of applied historical ecology. Low temperature biochar or charcoal, the key ingredient of ADE, and ammonium bicarbonate produced from urban wastes are the byproducts of biofuel production. Burial of biochar treated with ammonium bicarbonate is an excellent nitrogen based organic fertilizer *and* an ideal form of carbon sequestration (Marris 2006). Controlled burning, traditionally considered degrading to the environment, is being re-introduced as a management strategy in many biodiversity reserves. Once removed from their homelands in the establishment of parks, native people are now integral participants in the management of some ecological reserves and indigenous territories (Chapin 2004; Posey 2004). Many small farmers living along the Amazon River continue to practice sustainable strategies from the past within a modern urban context (Smith 1999).

Many conservationists consider the idea that, humans as a keystone species created, transformed, and managed biodiversity through their activities dangerous and detrimental to fundraising to protect what they advertise as pristine wilderness (Chapin 2004). Native rights advocates worry that Amazonian people will be viewed as "bad" by Westerners in terms of environmental stewardship and lose claims and control of indigenous territories (Redford 1991; Chapin 2004; Conklin and Graham 1995). Others declare that historical ecologists who argue against the ideas of the Amazon as a counterfeit paradise fan the flames of tropical rainforest destruction by encouraging reckless development of already transformed landscapes (Meggers 2001).

Historical ecologists respond that ignoring the complex human history of environments in Amazonia would be unwise. A vast indigenous knowledge spanning hundreds of generations about the creation, transformation, and management of environments is physically embedded in the landscape, encoded in the distribution and availability of plant and animal species, documented in historical and ethnographic accounts, and in some cases, still practiced by native Amazonians.

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