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Edited by William Balée and Clark L. Erickson

TIME AND COMPLEXITY IN HISTORICAL ECOLOGY

STUDIES IN THE-NEOTROPICAL LOWLANDS

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8

THE DOMESTICATED LANDSCAPES OF THE BOLIVIAN AMAZON

CLARK L. ERICKSON

DOMESTICATION IS A comprehensive concept in anthropology referring to the cultural and genetic control of plants and animals and the processes of adopting farming and living in permanent settlements. Native Amazonians domesticated and cultivated a variety of crops (but few animal species) many millennia before the arrival of Europeans. In this chapter, I explore a simple hypothesis: that Amazonian peoples of the past invested more energy in domesticating entire landscapes than in domesticating individual plant and animal species. Through landscape engineering and the use of simple technology such as fire, the past inhabitants "domesticated" the forest, savanna, soil, and water of the Bolivian Amazon, which had profound implications for availability of game animals, economically useful plants, overall biomass, and regional biodiversity. Because the signatures of human activity and engineering are physically embedded in the landscape, archaeology can playa major role in studying these phenomena. The pre-Columbian peoples of the Bolivian Amazon built raised agricultural fields, practiced sophisticated water-management techniques, and lived in large, well-organized communities millennia before European contact. They rearranged soils, altered drainage, constructed earthworks, made marginal lands productive, and in some cases may have increased local biodiversity.

Two themes that are now recognized as myths-one of a pristine environment and the other of the ecologically noble savage-have long dominated the popular and scientific literature on Amazonia. The myth of the pristine environment is the belief that the Americas consisted largely of undisturbed nature before the arrival of Europeans, who subsequently destroyed the environment with their agriculture, mining, and city building. The myth of the ecologically noble savage is the idea that past and present indigenous peoples always existed in harmony with this undisturbed nature. In both myths, nature is imagined as being in a state of perpetual equilibrium with old, undisturbed forests as the ideal form.

Environments portrayed as being in this pristine state are often those with low populations of native peoples practicing "traditional" lifeways. Most or much of Amazonia was considered such a place. In the past few decades, however, research has shown that this state was recently created and not the product of timeless harmonies. Indeed, much of what has been viewed as "pristine wilderness" in the Amazon is the indirect result of massive depopulation after the arrival of Europeans. Within a century, Old World diseases, slavery, missionization, resettlement, and wars eliminated the great majority of the indigenous inhabitants from these landscapes. As a whole, Amazonia did not return to its sixteenth-century population level until the twentieth century. Historical ecologists have shown that before that depopulation occurred, native peoples directly determined much of Amazonia's environmental structure and content. Thus, present-day Amazonian landscapes were shaped by a complex history of past human activities and sudden demographic collapse.

In this chapter, I explore myths, the debunking of myths, and the re-creation of myths in light of contemporary thinking about the relationship between humans and nature in Amazonia. I critique the adaptationist and selectionist approaches that permeate most interpretations of human-environment interaction. Drawing on the insights of new ecology and historical ecology, I argue that the concept of domestication of landscapes provides a powerful alternative perspective. In cultural evolution, the domestication of plants and animals is an important criterion for ranking civilizations or "complex societies." For example, archaeologists have long held in esteem the early domestication of plants and animals and intensive agriculture by societies of the Near East and Asia. Scholars interested in the origins of agriculture rarely recognize the Amazon as a site of agricultural revolution or as a center of crop domestication. My goal in this chapter is to explore a simple hypothesis: that Amazonian peoples of the past invested more energy in domesticating landscapes as a whole than in domesticating individual species of plants and animals. I believe that this domestication of landscape was driven by social demands far beyond the subsistence level.

The new ecology, the archaeology of landscapes, and historical ecology are critical to any understanding of contemporary environments. These approaches highlight the long-term history of landscapes, humans' active role in determining the nature of contemporary environments, and viable models for management of resources and conservation of biodiversity based on indigenous knowledge systems. Daniel Janzen's (1998) metaphor of the gardenification of nature emphasizes that the so-called natural environments of the Americas are actually the historical product of human intentionality and ingenuity, creations that are imposed, built, managed, and maintained by the collective multigenerational knowledge and experience of Native Americans, a point

made some time ago by William Denevan, William Balee, Darrell Posey, and others. I argue that understanding the environment as an indigenous *creation* is much more useful and accurate than the more common practice of describing humans as simply "adapting to," "impacting," "transforming," "altering," or "socializing" a static background.

THE CONCEPT OF HUMAN ADAPTATION

According to Emilio Moran, a prominent advocate of the adaptationist model, nongenetic human adaptation (or, more precisely, "human adaptability") "focuses on those functional and structural features of human populations that facilitate their coping with environmental change and stressful conditions" or their making adjustments in "response to constraints" (1982:4). In this perspective, "[a] human population in a given ecosystem will be characterized by strategic behaviors that reflect both present and past environmental pressures. In general the longer a population has been in a given environment, the greater its degree of adaptation to those environmental pressures" (Moran 1993:163). Thus, the diversity of cultures in the Amazon simply reflects a variety of adaptive strategies to a given, diverse set of environmental and historical conditions. In evolutionary ecology, certain "efficient" cultural practices confer a long-term Darwinian advantage on the members of the societies that choose them (Alvard 1994, 1995; Kuznar 2001; Piperno and Pearsall 1998; Rindos 1984; B. Smith 1995). Moran (1993) and his colleagues therefore rank societies as being well adapted or poorly adapted by various empirical criteria.

As Gould and Lewontin (1979) have argued, this approach risks turning evolutionary biology into a sequence of "just-so stories" in which all features of organisms are "explained" as adaptations to some presumed aspect of the environment. Similarly, this perspective can reduce rich and complex cultural systems to examples of adaptation. The adaptationist model has been justly criticized as "tautological, teleological, reductionist, progressive, and victim-blaming" (Goodman and Leatherman 1998:10). But it has long permeated interpretations of Amazonia's past and present and still does. In my view, this approach seriously limits both our understanding of past and present conditions as well as the resolution of the problems currently facing Amazonian peoples and the environment.

CONTEMPORARY PERSPECTIVES ON AMAZONIAN PEOPLES

In much of the literature, the foraging or hunter-gather-fisher folk of the past and present are considered to be "cold" societies-unchanging "people without history" (Wolf 1982) who have little or no impact on their surroundings. Farming and urban folk, by contrast, are granted the status of "hot" societies, capable of changing their environments and transforming the landscape. In this perspective, contemporary foraging societies in the Amazon are often depicted as representatives or remnants of earlier, simple human societies that occupy the bottom rung on the ladder of social evolution: stable adaptations to marginal environments.

Archaeology and historical ecology provide alternative explanations for the existence of the two contrasting lifeways. Almost forty years ago Donald Lathrap (1968) and Claude Lévi-Strauss (1963, 1968) argued that foragers in both the historical and contemporary ethnographic literature of the Amazon are in fact descendants of farmers who had left or been driven out of prime agricultural lands by more powerful indigenous peoples and adopted a foraging lifeway. In contrast, William Balee's (1994, 1995) "hypothesis of agricultural regression" posits that contemporary foraging societies are the legacy of warfare, disease, and colonization, which disrupted farming and village life. Indeed, Balee (1989) and Bailey and colleagues (1989) have shown that many contemporary hunter-gatherers do not so much exploit the fruits of undisturbed nature as harvest the products of abandoned swidden fields and gardens and implicitly or explicitly profit from the cooperation of their agricultural neighbors. Arguing that foragers could not survive without agriculturalists (the "foraging exclusion hypothesis" [Bailey et al. 1989]) can imply that the Amazon and other tropical regions were uninhabitable before agriculture-an idea that, although provocative, has been extensively critiqued (Colinvaux and Bush 1991; Piperno and Pearsall 1998). In this chapter, I argue for a variant of this idea: that Amazon foragers depend not so much directly on the past and present fruits of agriculture as on domesticated landscapes.

Popular approaches borrowed from evolutionary ecology, such as optimal foraging theory, consider Amazonian peoples to be rational, dynamic decision makers who consciously or unconsciously practice the most efficient short-term subsistence strategies for maintaining and reproducing themselves (Alvard 1994, 1995; Kuznar 2001). Subsistence behavior is thus explained in terms of adaptive fitness. Dietary shifts and rescheduling of activities under environmental constraints and stress eventually lead to the domestication of crops and adoption of agricultural economies (Piperno and Pearsall 1998). From this point of view, agriculture and sociopolitical complexity are more usefully regarded as the results of coevolutionary processes and mutualism than as the products of human intentionality and agency.

In the perspectives advanced by historical ecology and the archaeology of landscapes, the cultural ecological, adaptationist, and evolutionary models are turned on their heads. Foragers do not simply "map onto" resources from their slowly changing, naturally determined environments. Contemporary Amazonian foragers and farmers instead work with the products of a historical trajectory of human landscape creation. The availability, distribution, abundance, and productivity of the fauna, flora, soils, and other inorganic resources used by Amazonian peoples today were largely determined by previous, historically contingent, human activity-both the agriculture of the more immediate past and the domestication of landscape that occurred before it, long before domesticated crops and agriculture became recognizable in the archaeological record. The wild/domestic dichotomy so dear to ecologists, anthropologists, and conservationists (but often not to native peoples) is spurious and masks human agency in creating many neotropical landscapes.

Evidence for this early domestication of the neotropical environment is often subtle and indirect. Archaeologists emphasize the appearance of large sites, domesticated crops, pottery, agricultural hardware (such as stone axes, manioc grater blades, *manos,* and *metates),* and forest disturbance as evidence of full-blown agricultural economies and permanent settlement (Lathrap 1970, 1987; Lathrap, Gebhart-Sayer, and Mester 1985; Oliver 2001; Petersen, Neves, and Heckenberger 2001; Piperno and Pearsall 1998; Roosevelt 1980). These signatures were ubiquitous in Amazonia sites by late prehistory. The parallel and possibly earlier transformation of landscapes between sites is often overlooked.

Agriculture was simply a logical, intentional, historically contingent outcome of long-term intensive occupation, use, transformation, creation, and domestication of the Neotropics by humans. Lathrap's hypothesis (1977) that the roots of agriculture are to be found in the sedentary fishing societies on Late Pleistocene landscapes of the lowland Neotropics is slowly becoming accepted (Oliver 2001; Piperno and Pearsall 1998; Roosevelt, Douglas, and Brown 2002; Roosevelt et al. 1996). Lathrap argued that the transplanting and cultivating of economic species within the context of the house garden, a form of localized domestication of landscape, are central to understanding the Amazonian past. In this perspective, the first inhabitants of the region around 11,000-12,000 years ago had already begun the process of domesticating the landscape, specific economic plants, and society itself. Yen points out that most domesticated species were brought into already domesticated landscapes (1989:68-69). Farming and settled village life added new and often intensive strategies to a preexisting knowledge of landscape creation and management.

THE CONCEPT OF DOMESTICATION

The concept of domestication most often refers to the control of plants and animals by humans; a process that began many thousands of years ago in different parts of the world. Domestication and the practices of agriculture are considered major landmarks in the history of humankind-the basis for production of surplus, of transformation of the earth's surface, and of civilization.

Most scholars define *domestication* as the genetic alteration of plants and animals by humans to produce domesticated crop varieties, the basis of full-scale agriculture (Harlan 1992:63-64, 1995:30-31; Harris 1989, 1996; Rindos 1984). Agriculture also involves scheduled activities (e.g., plowing, planting, and harvesting calendars) and practices that harness energy for transforming the environment into productive land (e.g., irrigation and fertilization). The evidence for and explanations of the origins of plant and animal domestication have been discussed in detail (Harlan 1992, 1995; Harris 1996a; Harris and Hillman 1989; B. Smith 1995).

Scholars place a subtle premium on the number of fully domesticated species and the extent of land transformation through intensive agriculture as hallmarks of cultural development. Although possessing important crops such as maize and manioc that are suitable for intensive agriculture, farming in humid tropical regions such as Amazonia is characterized by numerous semidomesticates, or cultivation of both wild species and species propagated through cloning, swidden agriculture, and active management of standing forests (Balee 1994; Clement 1999 and chapter 6, this volume; Denevan 2001; Rival 1998, 2002; and others). In much of Amazonia, game, fish, and palm fruits rather than domesticated animals were sources of protein (Beckerman 1979). Human labor was emphasized over that of draft animals and labor-saving inventions. Based on these traits, many scholars imply that Amazonian societies did not quite "make it" in terms of agricultural advancement and achievement. Some blame this "failure" on the lack of draft animals and on the limitations of Stone Age technology (simple wooden digging sticks and stone axes). As I show later, however, the characterization of neotropical landscape creation as simple ignores the rich historical ecology of this region.

In the following discussion, I use the concept of domestication to refer to cultural activities that transform land or environment into landscape, a form of built environment,[1] thus redirecting the focus away from domesticates and toward landscape. The engineered built environments or domesticated landscapes of certain Amazonian peoples were as impressive as any Egyptian pyramid, Mesopotamian city, or Chinese terrace-irrigation system. In the Amazon, the transformation was driven by social demands: social group formation, domestic routines, territoriality, local environmental knowledge, gifting, and competitive feasting.

THE DOMESTICATION OF LANDSCAPE

The concepts of domesticated landscape, domesticated environment, humanized environment, or domiculture are more than simple metaphors. The terms first entered the mainstream anthropological literature in publications by R.A. Hynes and A. K. Chase (Chase 1989; Hynes and Chase 1982) and by Douglas Yen (1989).[2] Later scholars adopted the concept to explain the origins of agriculture and processes that lead to it (e.g., Clement 1999 and chapter 6, this volume; Harlan 1992, 1995; Harris 1989, 1996b; Kuznar 2001; Terrell et al. 2003; and others). Chase specifically defines *domiculture* as "hearth-based areas of exploitation (domuses), each carrying with it a package of resource locations, restrictions upon open-ended exploitation (religious prohibitions, strategic planning of delayed harvesting, etc.), and localized technologies to fit particular dornuses" (1989:43). He clearly stresses the intentional, conscious knowledge systems and deliberate activities of humans that can, but do not necessarily, lead to genetic domestication of species (1989:44, 46-47). Thus, the domestication of landscape encompasses *all nongenetic, intentional, and unintentional practices and activities of humans that transform local and regional environments into productive, physically patterned, cultural landscapes for humans and other species.*[3]

The use of the ethnography and history of foragers and cultivators for modeling the evolutionary processes leading to genetic domestication of crops and the origins of agriculture has a long history (for Amazonia, see Clement 1999 and chapter 6, this volume; Hastorf 1998 and chapter 3, this volume; Lathrap 1977, 1987; Piperno and Pearsall 1998; Sauer 1952). In regard to plants, the processes leading to genetic domestication involve planting, transplanting, tending ("husbandry" or "mothering"), cultivation, weeding, transport outside natural habitats, and the use of fire as a management tool to enhance survival of economic species. Contemporary Amazonian peoples are constantly gardening the forest, weeding and pruning here and there, as they move across the landscape. One of the early major contributions by historical ecologists was pointing out that what looks like a "natural" environment rich in resources is often actually an environment constructed and managed as forest fallow in agroforestry regimes (Balee 1994; Denevan and Padoch 1988; Peters 2000; Posey and Balee 1989).

Many researchers have generally treated these practices that domesticate landscapes as distinct from and less sophisticated than the more "advanced" practices of intensive agriculture and genetic domestication. They view burning, collecting and foraging, keeping of wild pets, agroforestry, cultivation, horticulture, gardening, and settlement mobility as evolutionarily more "primitive" than full-blown agriculture. As such, ethnographic case studies are employed as analogy to explain intermediate stages in cultural evolution between foraging, on the one hand, and agriculture and the processes leading to farming, on the other (e.g., Harlan 1992, 1995; Harris 1989, 1996b; Ingold 1987, 1996; Rindos 1984; Shipek 1989; Wiersum 1997a, 1997b; and others). Some also stress the assumed behavioral contrasts between what foragers do to and think about the environment and what farmers do and think: foragers exert low or minimal impact on environments, whereas farmers exert high impact on environments (Ingold 1987, 1996). Drawing on Friedrich Engels, Ingold proposes a distinction between, on the one hand, agriculturalists and pastoralists who truly transform or "master" their environment through food production and, on the other, hunter-gatherers who merely "use it" while collecting and hunting their food (1987:71). "Like the architect's house, the farmer's field is artificial, *engineered* by human action," he states, whereas "the environment of the hunter-gatherer *is not constructed but co-opted, it is not artificial but 'natureficial'"* (72-73, emphasis in original).

In reading this literature, one notes the reluctance to grant agency and history to preagricultural and nonagricultural peoples and to appreciate the subtleties and importance of the domestication of landscape. Instead, the old nature/culture dichotomy is replicated in the form of a forager/farmer dichotomy (e.g., Harris 1989, 1996b: "evolutionary continuum of people-plant interactions"). But as Hynes, Chase, and Yen have stressed, landscape domestication is not only a precursor to plant and animal domestication, but also a sophisticated set of social strategies and practices of its own. As Yen stresses, "None of this [critique of the forager/farmer dichotomy] constitutes a denial of the derivation of agriculture from hunting-gathering roots; rather it questions that contemporary hunter-gatherers are the backwards relicts of a single evolutionary line which most accounts of agricultural development seem to suggest" (1989:66). Burning, collecting, pruning, and other landscape-transforming practices are not performed by static, ahistorical societies as by-products of the road to agriculture. They are chosen strategies, goals, or ends in themselves (Chase 1989; Descola 1996; Hather 1996; Hynes and Chase 1982; Michon and De Floresta 1997; Rival 1998, 2002; Spriggs 1996; Terrell et al. 2003; Yen 1989; also see critiques raised by Lathrap [1968] and Lévi-Strauss [1963, 1968] regarding archaism and the foraging peoples of the Amazon).

Discussions about the domestication of landscape parallel discussions about the distinction between cultivation of plants (wild and domestic species) and agriculture (cultivation of domesticated species) raised by scholars interested in the origins of agriculture (Harris 1996a; Harris and Hillman 1989). Such research differs from historical ecology in that in the former the focus is on the cultivation of particular plants and animals rather than on the cultivation oflandscapes. Yen highlights the contrast in stating that "the effect of the hunter-gatherer domestication of environment may be likened to a form of group selection, in which the plant targets are aggregated as interbreeding units, compared with the individual selection practiced by the agriculturalist, which establishes closer control over the plants' breeding systems and can result in the varietal differentiation of species into physiological types, e.g. wet and dry adaptations in rice and Colocasia taro" (1989:66). Terrell and colleagues (2003) implement these ideas methodologically in their "interactive matrix of species and harvesting tactics" (what they call a "provisions spreadsheet"), which includes numerous economic species affected by human activities in the process of domestication of landscape rather than the genetic domestication of selected plants and animals.

Some evolutionary ecologists and evolutionary anthropologists adopt the concept of domestication of landscape as Darwinian coevolution or mutualism of human-environment interaction. In this view, human culture is often reduced to a form of animal-environment coevolutionary interaction (a stance well critiqued in Balee 1989; Ingold 2000; and Terrell et al. 2003). In contrast to the original concept of domestication of landscape proposed by Hynes, Chase, and Yen and to the perspective of historical ecology presented here, evolutionary ecology includes little or no role for human intentionality and agency. Indeed, evolutionary ecologists regard much of what native peoples did or do to the environment over the long term as epiphenomenal, unintentional, and unconscious (see Alvard 1994, 1995; Kuznar 2001; Rindos 1984; and others). Most historical ecologists (and some ecologists), however, view humans as a "keystone species" rather than as simply another animal with mutualistic relationships (e.g., Kay and Simmons 2002; Mann 2002; O'Neil 200I; Terrell et al. 2003; and others).

I believe that the domestication of landscape occurred before, during, and after plants and animals were genetically domesticated and full-scale agriculture was developed. By placing a premium on the presence of specific domesticated crops, agricultural hardware, and long-term settlements, archaeologists and anthropologists have often missed the importance of landscape domestication. As an anthropological archaeologist and historical ecologist, I also argue that the intentional human behavior is more interesting than the unintentional. These ideas are not new. Certain archaeologists, ethnographers, geographers, and economic botanists who have studied traditional agriculture have long emphasized a human-centric landscape approach to understanding the long-term, historical relationship between humans and the environment (e.g., the numerous studies ofland management by native peoples of the Americas summarized in Denevan 200I; Doolittle 2000; and Whitmore and Turner 2002).

In summary, the concept of domestication of landscape contributes to historical ecology in several ways. First, by redirecting attention away from the Neolithic Revolution, agriculture, and specific domesticated crops as being the most important transformation of environment, one can better appreciate the importance ofhuman cultural activities that do not change the genetics ofthe specific species that lead to domestication, but that influence the presence, availability, and productivity of these species. Second, the focus on multiple species rather than on individual cultivated or cropped species redirects attention toward the landscape as a complex and historical context. Third, by unraveling the unproductive dichotomy between foragers who practice hunting, gathering, fishing, and cultivation and farmers who practice agriculture-a distinction assumed in the perspectives of cultural ecology, human ecology, cultural evolution, and evolutionary ecology-one can better understand more subtle, but important strategies of anthropogenic environmental change. Fourth, by rejecting the simple linear evolutionary continuum from foraging to agriculture, one can appreciate that the domestication of landscape can be an end in itself for the creation of productive landscapes. And fifth, moving beyond a critique of the myths of pristine environments and ecologically noble savages as well as beyond the often concomitant assumptions that all human activities affect the environmeIit negatively, one can begin to appreciate human creativity and environmental transformation if one focuses on conscious activities, application of environmental knowledge, and engineering employed to domesticate landscapes for human use, all of which can often result in changes in biodiversity and in the spatial distribution and availability of economically useful species.

THE ANTHROPOGENIC ENVIRONMENT, BIODIVERSITY, AND HUMAN ACTIVITIES

Most historical ecologists now agree that the Amazonian rain forest is a form of cultural artifact, to at least some degree. We now know that Amazonian peoples practice sophisticated forms of indigenous cultivation, gardening, and agroforestry management. They move seeds and plants around the forest, create gap disturbance, encourage certain economic species, and remove others. The long rest or fallow period between cycles of burning and cultivation in tropical agriculture is actually part of long-term production and harvest strategies (Clement, chapter 6, this volume; Denevan and Padoch 1988; Posey and Balee 1989). The old equilibrium model of ecological succession in Amazonia-the cutting and clearing of a forest patch, cultivation of crops for 2-3 years, then the abandonment of the plot and (re)growth of the forest-is being replaced by more sophisticated and dynamic models that take into account historical contingency and human agency. Long-term human activities and disturbances, not laws of ecological succession, have determined the form and structure of the Amazonian tropical forest.

Simply defining *landscape* as the interaction between humans and environment-or setting up *anthropogenic* in binary opposition to *natural*-does not place enough emphasis on human intentionality. Coevolutionary models (Kuznar 2001; Piperno and Pearsall 1998; Rindos 1984; B. Smith 1995), "dialectical" approaches (Crumley 1994; Crumley and Marquardt 1987), self-organizing systems and resiliency theory (Redman and Kinzig 2003) often depict humans as being swept up in a long-term process that unconsciously modifies the environment.

These long-term anthropogenic processes are often seen as more important than short-term human activities in shaping the neotropical environment. For example, large areas of the Amazon are classified as "black earth" or dark earth, a rich human-produced anthrosol prized by farmers of the region. Amazonian Dark Earth sites are often discussed as an unconscious by-product of settlement by pre-Columbian peoples over thousands of years (Glaser and Woods 2004; Lehmann et al. 2003; Neves and Peterson, chapter 9, this volume; N. Smith 1980). In contrast, I have argued (Erickson 2003) that the phenomenon of Amazonian Dark Earths is actually an excellent example of the intentional domestication of soils-specifically, the creation of ideal conditions or habitat for certain microorganisms that improve and sustain fertility through the incorporation of organic matter and of carbon produced under low temperature into the soil, as recently documented by soil scientists.

Elizabeth Graham (1998) extends the concept of "built environment" to include all soils formed under repeatedly occupied and farmed landscapes of the Americas. In my view, the term applies to most of Amazonia. *Built environment* implies that created landscapes are planned in advance and passed down through generations in a process that might be called "landscape accumulation." Such built landscapes are produced by a conscious indigenous knowledge system operating in a historical context. Because they are historically contingent, they are often complex palimpsests of human activity (Erickson and Balee, chapter 7, this volume).

The relationship between humans and biodiversity in the Neotropics is hotly debated. Biologists, ecologists, geographers, and anthropologists are reaching a consensus that a certain level of disturbance or disequilibrium is critical for creating and maintaining biodiversity and environmental health (Blumler 1996, 1998; Botkin 1990; Connell 1978; O'Neil 2001; Stahl 1996, 2000, and chapter 4, this volume; Zimmerer and Young 1998). Although both natural and anthropogenic disturbances playa role in shaping nature, historical ecologists are concerned with patterned, varied, and sustained human activity.

Do anthropogenic processes exert positive or negative impacts on biodiversity? Whether human activities degrade or enhance biodiversity often depends on how *biodiversity* is defined and measured and at what temporal and geographical scale (Stahl 1996). Nonetheless, many scholars argue that there is a general answer: that indigenous peoples' activities tend to reduce species richness and ecological health (e.g., Redman 1999). In their critique of the myth of the ecologically noble savage, numerous researchers now claim that native peoples hunt game animals to extinction, degrade the environment, and waste precious resources (e.g., Kay and Simmons 2002; Krech 1999; Redford 1991; Stearman 1994). As seen through the lens of evolutionary ecology (including optimal foraging theory), native peoples stress short-term, selfish benefits over long-term goals and thus do not practice resource conservation (Alvard 1994, 1995). Other researchers argue the opposite: that natives enhance biodiversity as resource managers (Balee 1989, 1994, 1995, 1998a, 1998b; Brookfield 2001; Denevan and Padoch 1988; Maffi 2001; Posey and Balee 1989).

Both sides are beginning to agree, however, that there is no "natural" baseline or benchmark of pristine wilderness that should be used as a standard for comparisons (Bennett 1962; Denevan 1992; Hunter 1996; Stahl 1996). The question of whether human activities are positive or negative becomes complicated if humans played a major role in creating the very landscapes where biodiversity and nature are said to exist.

The environment of the Amazon region ·of tropical South America was long considered to be of limited potential. It was commonly believed that in the past, as in the present, the social and political organization of indigenous peoples was simple, that populations were nomadic or widely dispersed over the landscape, and that subsistence was based on hunting, gathering, and small-scale agriculture. The extent to which contemporary tropical forest foragers and small-scale farmers are appropriate models for understanding the Amazonian has been questioned, however (see summary in Heckenberger, chapter 10, this volume; Stahl 2002). Because population densities are low today, many scholars have assumed that early human inhabitants of the Neotropics were "cold," ahistorical societies of foragers who did not significantly alter the environments in which they lived. In the 1950S and 1960s, it was said that the scale of agriculture and settlements was constrained by poor soils (Meggers 1954), and in the 1970S researchers considered the lack of animal protein to be the constraint (Beckerman 1979; Gross 1975).

In the 1960s, the discovery of massive raised-field systems, causeways, canals, occupation mounds and other earthworks, and urban settlements in many parts of Amazonia challenged this perspective (Denevan 1966, 2001). By now, it is generally recognized that most of the 5 to 6 million inhabitants of Greater Amazonia in the centuries before European conquest were agriculturalists living in large permanent settlements. The transformation of the Amazon basin from lightly settled "wilderness" to densely populated agriculture is usually attributed to farmers of late prehistory. I argue instead that the changeover took much longer than has been commonly supposed and that its major focus was not the development of intensive agriculture, but rather landscape transformation, specifically the domestication oflandscape. From their interpretation oflake cores, Piperno and Pearsall (1998) believe that landscape transformation began as early as 11,000 years ago. Roosevelt and colleagues (1996) show that the inhabitants of the Monte Alegre rock shelter on the central Amazon were altering that environment more than 11,000 years ago. The effects of hunting and gathering on the Amazonian environment have been greatly underestimated. Anthropologists have recently shown that small mobile groups of foragers such as the Nukak (Politis 1996) and the Hoti (Zent and Zent 2004) have had profound, massive, and permanent impact on forests through their frequent shifts of residence and discard of edible palm fruits. Thus, agriculture is only one of many anthropogenic processes that shaped the neotropical environment in prehistory (Balee 1994; Descola 1996; Rival 1998; and others).

The debate about the relationship between human activity and biodiversity over time is complex. Ideally, one would be able to compare anthropogenic landscapes with natural landscapes. Most natural scientists assume some natural, pristine, or prehuman baseline or benchmark upon which comparisons can be made: a past or present wilderness devoid of humans and their activities. However, is there a single documented region or locale in the Amazon that has not been disturbed, shaped, transformed, or produced by humans to some degree since the end of the Pleistocene (11,000-10,000 years ago)? I argue that there is no pristine or natural environment for comparison. One might respond that the prehuman environment can be reconstructed on the basis of paleoenvironmental research in Late Pleistocene and Early Holocene period contexts, but the relevancy of such environmental reconstructions would be limited. I doubt that Late Pleistocene ice age environments can be chosen as a natural, pristine, or prehuman benchmark to compare with anthropogenic landscapes, to address contemporary debates about human activities and biodiversity, or to guide contemporary conservation efforts in the Amazon.

THE ARCHAEOLOGY OF DOMESTICATED LANDSCAPES IN THE BOLIVIAN AMAZON

In the Bolivian Amazon, known locally as the Llanos de Mojos (grassland plains of Mojos or Moxos), the domestication of landscape included interrelated and overlapping human activities that over time created a complex, highly structured, engineered cultural landscape (figure 8.1). This domestication of landscape included burning, transplanting, constructing roads, farming, establishing mound and forest island settlements, and creating artificial wetlands that permanently altered topography, soil structure and fertility, hydrology, faunal and floral community structure, local climate, and biodiversity (figure 8.2).

Pre-Columbian farmers heavily modified the savanna and forest landscape of the Bolivian Amazon, creating over time a complex, highly structured, engineered cultural landscape. Erland Nordenskiold (1910, 1913, 2003) at the turn of the twentieth century and William Denevan (1963, 1966, 2001) and George Plafker (1963) in the early 1960s discovered that large expanses of the savannas of the Llanos de Mojos were covered with massive earthworks, including raised fields, canals, causeways, reservoirs, dikes, and mound settlements constructed by the pre-Hispanic inhabitants of the zone." Denevan and his colleagues have found similar raised fields throughout the Americas in the flooded savannas of

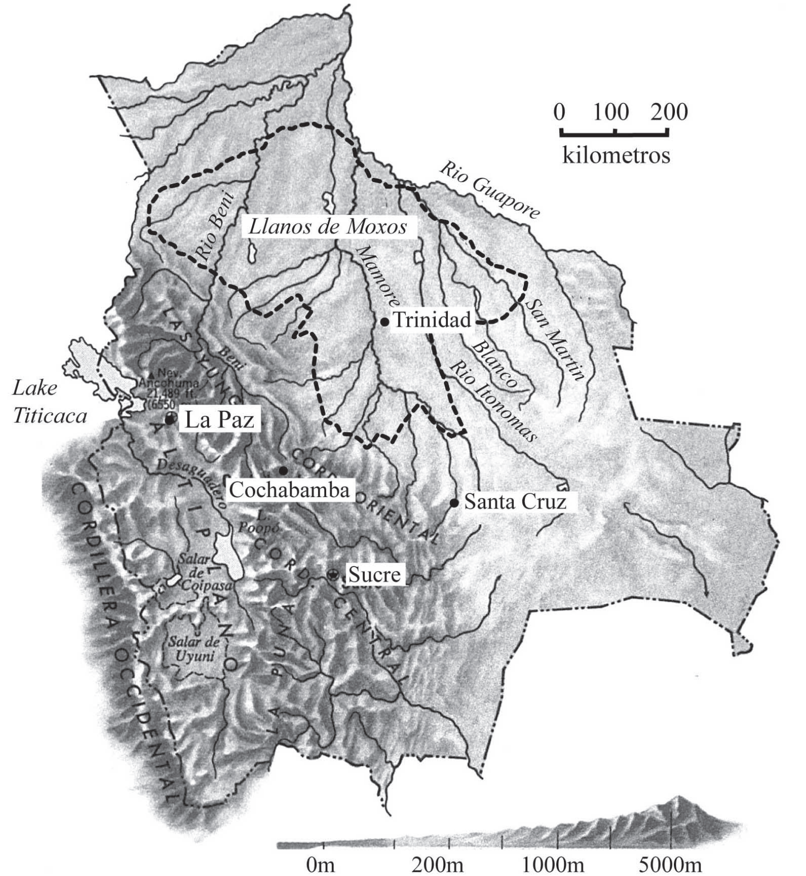

FIGURE 8.1 The Llanos de Mojos, Bolivia.

Colombia, Ecuador, Venezuela, and Surinam, as well as in the Andean region of Peru, Bolivia, Colombia, and Ecuador (Denevan 2001). More recently, scholars have documented other cases of massive landscape transformation (Glaser and Woods 2004; Heckenberger et al. 2003; Lehmann et al. 2003; Raffles and WinklerPrins 2003).

The Llanos de Mojos (or Moxos) is located in the southwestern headwaters of the Amazonian drainage basin. The region corresponds roughly to the modern political boundaries of the Department of the Beni of Bolivia. The area is a relatively flat landscape of forest along rivers and higher ground *(bosque, galeria,* and *islas de monte)* (20,000 square kilometers) and savanna grasslands (pampa), scrub and palm forest, and wetlands (9°,000 square kilometers) (Denevan 2001). Much of the low-lying lands are covered with shallow floodwaters during the rainy season. During the rest of the year, dry conditions prevail, and water

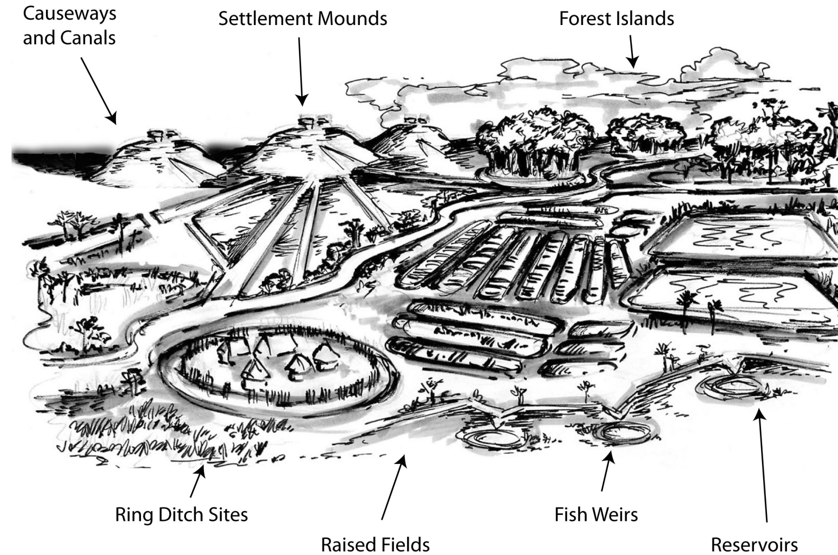

FIGURE 8.2 Major anthropogenic features of the domesticated landscapes of the Bolivian Amazon. (Artwork by Daniel Brinkmeier)

becomes a scarce commodity. Poor soils, the lack of high ground, and the alternation of seasonal floods with dry conditions make farming difficult.

By burning, transplanting, moving vast amounts of earth, establishing mound and forest island settlements, and creating artificial wetlands, the pre-Columbian inhabitants of the Llanos de Mojos permanently altered the region's topography, hydrology, soil structure and fertility, faunal and floral community structure, local climate, and biodiversity, creating a productive anthropogenic landscape. A major part of this transformation of the environment was the construction of raised fields, causeways, canals, reservoirs, mounds, forest islands, ring ditch sites, fish weirs, ponds, and other structures. We now know that this domesticated landscape sustained large populations organized in large villages and towns dispersed within the savannas and forests (Denevan 2001; Erickson 1995; Erickson and Balee, chapter 7, this volume; Walker 2004).

The Bolivian Amazon provides an interesting case study in historical ecology. Tropical savannas and forests are often conceptualized as binary categories. As Fairhead and Leach (1996) point out, much of the contemporary literature in the natural sciences and development theory treats tropical savannas as marginal environments or even, in more extreme cases, as degraded tropical forests. Many scholars still view savannas as the end result of deforestation and overexploitation of the tropical environment and thus as worthless and of little value to study. Yet these "degraded" landscapes supported some of the densest populations and the most elaborate sociopolitical institutions in the Amazon during late prehistory. The native peoples (Mojo, Baure, and others) of the Bolivian Amazon and their ancestors are prime examples of dense, well-organized, indigenous societies living in a constructed, engineered landscape.

BURNING

Burning is now recognized as a major factor in the creation and maintenance of savannas in addition to its use in general forest management (Pyne 1998). Historical records attest that in the past native peoples systematically burned the savannas of the Bolivian Amazon (Denevan 1966; Hanagarth 1993; Langstroth 1996), as do the ranchers, farmers, and hunters who live there now. Large fire fronts, often extending for kilometers, sweep across the savanna during the dry season (figure 8.3). Those who burn today stress that fire removes dead grasses, encourages new grasses for livestock and game animals, keeps the forest at bay, and "cleans" the landscape. Most insist that the 90,000 square kilometers of savanna exist only because of regular anthropogenic burning, although the annual flooding and soils may play some role (Denevan 1966; Langstroth 1996).[5]

I long assumed that raised fields, causeways, canals, and other nonmound earthworks were most appropriate for the present-day savanna and wetlands and that slash-and-burn agriculture, gardening, and agroforestry (which leave little archaeological footprint) were practiced in the forests in a way similar to what

FIGURE 8.3 A 2-kilometet-long flre front during the annual burning of the savannas by ranchers and farmers of the Bolivian Amazon. Anthropogenic fire has been used as an environmental management tool for thousands of yeats.

farmers do today. Thus, based on Denevan's pioneering research, I had expected to find pre-Columbian earthworks in the open savannas, where their construction would be most efficient due to lack of forest and annual flooding. Over the past 13 years, though, colleagues and I have identified many raised fields, causeways, and canals under tall, mature, continuous canopy forest. Large areas of fish weirs and causeway-canal networks are now completely covered with *Mauritia flexuosa* palm forest in Baures in the northeastern Bolivian Amazon.

This complex data set suggests that these locations were either former savanna used for human activities and later colonized by trees or former forest that had been intentionally cleared by humans for farming and other activities, but later (re)grew after agricultural abandonment. Massive depopulation of the region in the Colonial period due to epidemics, mission failure, and exploitive labor demand may account for the regeneration of forest on what was previously open savanna. The phenomenon also suggests that if forest grows there today, either it grew there "naturally" in the distant prehuman past or humans created favorable conditions for its establishment. In the Bolivian Amazon, colleagues and I have found a strong association between areas that are open savanna today and areas where burning has been continuous since the arrival of Europeans. By contrast, areas that were previously savanna with extensive pre-Columbian earthworks are now heavily forested. In some cases, certain anthropogenic characteristics of the landscape (discussed later; see also Erickson and Balee, chapter 7, this volume) facilitated the expansion of the forest, which since the arrival of Europeans has invaded large areas of the savanna.

RAISED F.IELDS

Raised fields are large earthen planting surfaces elevated above the seasonally flooded savannas and wetlands (figure 8.4). Experiments and ethnographic analogy demonstrate that raised fields serve a wide variety of functions, including localized drainage, improved soil conditions (by aerating the soil, mixing soil horizons, and doubling the organic topsoil), water management (for drainage and irrigation), nutrient production, capture, and recycling in the adjacent canals (through sediment sinks, organic muck production, and management of economic faunal and floral resources).

. Until recently, the pre-Columbian raised fields of Mojos remained unstudied (Denevan 1963, 1966; Plafker 1963). Denevan recorded 35,000 raised fields with 6,000 hectares of platform surfaces, based on his interpretation of aerial photographs of savanna (2001:246).6 Analysis of recent aerial photographic coverage has identified the faint traces of raised fields over a much larger area of savanna, and ground survey has located many additional raised fields under dense tree canopy. Raised-field form and size are variable, ranging from 1.5-6 meters wide, 6-300 meters long, and 0.3-1.0 meter in height along the Apere River to 5-20 meters

FIGURE 8.4 Pre-Columbian raised fields north of Santa Ana de Yacuma, Bolivia. Field platforms (lighter areas) measuring 15-20 meters wide, 50-150 meters long, and 0.5-1 meter tall are separated by canals of similar dimensions.

wide, 300 meters long, and 0.5-1.0 meter in height along the Iruyafiez River (Denevan 2001:241-246; Dougherty and Calandra 1984; Erickson 1995; Michel 1993; Walker 2004). Stratigraphic profiles in excavation trenches through raised fields and canals document a considerable volume of earth moved during the construction and maintenance of raised fields. Field patterning is highly structured in some areas; in others, the fields are more informally organized. Discrete groupings of fields, bounded or unbounded by causeways and canals, may reflect pre-Hispanic land-tenure systems and the social organization of farmers who constructed and maintained these fields (Erickson 1995; Walker 2004). Regional distinctions in the types of earthworks that are present suggest cultural and technological diversity (Denevan 1966, 2001; Erickson 1995)·

Whereas previous projects studied settlement and burial mounds, more recent archaeological survey, mapping, and excavations focus on the agricultural earthworks and the associated hydraulic infrastructure. Trenches excavated in pre-Hispanic raised fields and causeways have provided valuable information on the internal structure of the earthworks, construction techniques, rebuilding phases, sedimentation rates, original functions, crops cultivated, soil fertility, and the chronology of field construction, use, and abandonment. Preliminary analysis of pollen from field canals has identified the presence of cocoyam (gualusa, *Xanthosoma* sp.), guayusa (*flex* sp., mate, used for a caffeine-rich drink), and urucu (*Bixa orellana* L., used for red body paint), all of which almost certainly were cultivated (Erickson 1995). Based on historical documents and raised-field experiments, manioc, sweet potatoes, peanuts, beans, squash, and possibly maize were probably the major crops.

Earthwork stratigraphy shows a complex succession of construction, use, maintenance, and expansion episodes. Through radiocarbon dating of raised fields and associated settlements, colleagues and I (Erickson 1995; Erickson et al. 1991; Erickson and Walker n.d.; Walker 2004) have documented human occupation and use of the flooded savannas by 900 BC and the establishment and expansion of raised-field agriculture from 400 BC until the arrival of Europeans, when the system was abandoned.

Experimental archaeology has also contributed to our understanding of the function, labor investment in construction and maintenance, crop yields, and sustainability of raised-field agriculture (figure 8.5). A total of 900 person-days were needed to construct a single hectare of fields and canals using metal bladed shovels and picks tools. Our raised-field experiments at the Biological Station of the Beni produced bountiful harvests of manioc (Erickson 1994, 1995). Experiments by Bolivian agronomists recorded yields of 12-24 metric tons per hectare of manioc, 14 of squash, 12 of sweet potatoes, 0.5 of beans, and 0.2 of maize (Arce 1993; C. Pérez 1995; T. Pérez 1996; Stab and Arce 2000:320, table 16.1). The yields surpassed local production in slash-and-burn fields (with the exception of maize, which was probably cultivated on better soils). This finding is surprising because soil samples analyzed from this experimental site were found to be poor for agriculture (jacob n.d.; Stab and Arce 2000). Although some of the experimental fields have provided substantial production for a number of years, the sustainability of the system without organic inputs is unknown. Additional raised-field experiments demonstrate that yields can be increased by improving soil conditions through incorporating canal sediments, dung, and a mulch of water hyacinth (*Eichhornia azurea*), an aquatic plant that thrives in raised-field canals (c. Pérez 1995; T. Pérez 1996; Saavedra forthcoming; Stab and Arce 2000).7 The Bolivian agronomists and I believe that with sufficient labor input and under proper management, raised-field agriculture is probably productive and sustainable; thus, the technology could have supported large dense populations during its 2,000 years of use.

The volume of earth moved and restructured in the construction of raised fields is impressive (Erickson 1995). The construction of raised fields and canals altered and restructured soil horizons to a depth of 0.5-1.0 meter, and the original vegetation was removed, burned, or buried. Our mapping shows that for any given block of raised fields, the area occupied by canals and platforms is roughly equal. Thus, the construction of a hectare of raised fields involved moving 2,500-5,000 cubic meters of earth (or 250,000-500,000 cubic meters of earth per square kilometer of raised fields). The alternating topography of platforms and canals replaced a relatively flat landscape and substantially changed

FIGURE 8.5 Experimental raised fields with manioc at the Biological Station of the Beni. Manioc is growing on the platforms. Note the continuous terrestrial-aquatic ecotone surrounding each field platform. (Photograph by Robert Langstrorh)

local drainage patterns. The microrelief of platforms and canals dramatically increased the culturally usable area of this highly productive terrestrial and aquatic ecotone or interface (also long recognized to be high in biodiversity). For example, construction of 1.0 hectare of raised fields (0.5 hectares of platforms and canals each) with platforms measuring 5 by 20 meters creates 2·5 linear kilometers of terrestrial-aquatic ecotone (one square kilometer of raised fields creates 250 linear kilometers of terrestrial-aquatic ecotone).

The ridge and swale topography created by raised-field construction also plays a role in the presence and structure of forests today. In many cases, the annual burns, which keep the savannas open, are restricted by the moisture in the old canals between platforms, allowing trees to become established on platforms. Often the resultant anthropogenic forests are highly patterned, with the trees growing in straight, orchardlike rows spaced by the alternation of platform and canal. Our ground survey has shown that most sharp linear boundaries between forest and savanna are due to pre-Columbian canals protecting forests from burns (Erickson 2001:21, figure 6).

CAUSEWAYS AND CANALS

The raised fields, mounds, and forest islands are often associated with complex networks of large, long causeways and canals (Denevan 1966, 1990; Erickson

2000b, 2001). Causeways are constructed of earth removed from canals on one or both sides. On the ground, these causeways are low structures of 0.25-1.0 meter in elevation, 4-6 meters wide, and often 2-5 kilometers long. Most are badly eroded, and many are covered with trees and bushes, a sharp contrast to the surrounding grass-covered savanna (figure 8.6). These pre-Columbian earthworks served for transportation and communication between villages and towns located on mounds, forest islands, and gallery forests (figure 8.7).

Baures in northeastern Bolivia has dense networks of long causeways and canals that cross the savannas, wetlands, and forested islands (Eder [1772] 1985; Erickson 2000b, 2001; Lee 1995). Some segments of old causeways between local settlements and ranches are still used today for communication and transportation during the rainy season. The Baures Hydraulic Complex, located between the San Joaquin and San Martin rivers, has the densest concentration of these features. There are thousands of linear kilometers of causeways and canals in this zone, most of which are remarkably straight and several kilometers long. Many cross one another and some connect to other causeways. In a number of cases, two to four causeways run parallel (figure 8.6). Foot traffic would have used the raised roadways for communication and transportation between settlements and between settlements, rivers, and agricultural fields, and throughout much of the year canoe traffic would have been possible in the adjacent canals (Denevan 1966, 1990). In addition, the builders' obsession with straightness over long distances, the "overengineering" of the designs and construction, and the sheer number of these features suggest that they may have had ritual and political functions, possibly associated with astronomy, calendrics, or specific ceremonies.

In terms of domestication oflandscape, I and others suggest that these earthworks were also part of an integrated system of water management both locally and regionally (Erickson 1980, 2000b; Erickson, Winkler, and Candler 1997; Lee 1979,1995, n.d.). Geographic information system (GIS) analysis of detailed topographic mapping in several agricultural raised-field sites has begun to address this hypothesis. Causeways appear to have been used to block the flow of water, impounding large bodies of shallow water within raised-field blocks. Opening and closing sections of causeways could have maintained optimal water levels for field cultivation. For example, a single r-meter-tall causeway that connected the levees of two rivers 2 kilometers apart would create a shallow to-square-kilometer lake that retained 5 million cubic meters of water (based on an average slope of 20 centimeters per kilometer)."

Nordenskiold (1916) and Denevan (1966) reported cases of the use of artificial canals constructed across the necks of long river meanders and between rivers to shorten canoe travel time. Nordenskiold proposed that these activities may have eventually changed river courses and created new oxbow lakes. In Baures, colleagues and I have documented a number of pre-Columbian, historical, and

FIGURE 8.6 Two parallel causeways and associared canals (rhe dark linear features) covered with palms crossing the savanna between forest islands west of Baures, Bolivia. Because of irregular burning in this unpopulated area, *Mauritia flexuosa* have encroached on the savanna.

FIGURE 8.7 Causeway *(background)* and canal *(foreground)* in use for transportation and communication between fields and settlement mounds *(on horizon).* (Artwork by Daniel Brinkmeier)

ethnographic canals as river meander cutoffs and connections between rivers (Erickson 2000b, 200I; Erickson, Winkler, and Candler 1997). The rivers of the central Llanos de Mojos tend to flow south to north, making east-west travel difficult by canoe. The pre-Columbian inhabitants solved this problem by carving channels between rivers and other natural water bodies for their canoes (Denevan 1966, 1990; Nordenskiold 1916). Although most of these channels are less than a kilometer long, Pinto Parada (1987) mapped a continuous aquatic transportation network of 120 linear kilometers of artificial and natural water bodies between San Ignacio and Casarabe.

MOUNDS

Raised fields and associated earthworks sustained large populations organized as hamlets, villages, towns, and possibly urban centers dispersed across the savannas and forests (Erickson 2000C; Walker 2004). Pre-Columbian inhabitants of the Bolivian Amazon constructed large artificial mounds *(lomas)* of earth and domestic rubbish (Denevan 1966; Erickson 2000C; Erickson and Balee, chapter 7, this volume; Pinto Parada 1987). These mounds range in size from the huge Ibibate Mound Complex (18 meters tall and covering 9 hectares) (Erickson and Balee, chapter 7, this volume) to isolated small mounds and related forest islands that cover the savannas and gallery forests of the Bolivian Amazon (Erickson 2000C; Langstroth 1996; Walker 2004).9 Based on a survey of ranchers, Lee (1995) estimates a total of 10,000 settlement mounds (including forest islands) in the Bolivian Amazon. Many of the larger mounds were occupied continuously for hundreds, possibly thousands, of years, only to be abandoned during the population collapse during the Colonial period. Today they are still valued as dry and fertile locations for settlement, corrals, fields, orchards, and gardens. Archaeological excavations and surface collections have recovered a rich inventory of pottery, animal bones, shell, and stone axes from mounds and forest islands, thus demonstrating that they were important locations for settlement (Bustos 1978a, 1978b, 1978c, 1978d; Denevan 1966; Dougherty and Calandra 1981, 1981-82, 1983, 1984; Erickson 2000C; Langstroth 1996; Nordenskiold 1910, 1913; Paolillo 1987; Pinto Parada 1987; Priimers 2000, 2001, 2002a, 2002b). Many mounds were also used as cemeteries for burying and commemorating the dead, as indicated by large burial urns and human bones. The larger mounds, especially those surrounded by smaller settlements and nonmound earthworks, may have also had ceremonial and political functions within regions.

The construction of mounds had a major impact on the local environment. Their soils contain so much organic and inorganic domestic debris that Langstroth (1996) has referred to them as "sherd soils." These domesticated anthropogenic soils are deep, well drained, and rich in organic matter, so they support considerable biodiversity and are prized for farming (Erickson and Balee, chapter 7, this volume). Rich soils often extend beyond the actual mound, indicating soil improvement through long-term anthropogenic activities. The excavation of earth used in the fill of mounds created large water-filled barrow pits, which supported a thriving aquatic community that provided many economic resources for farmers and collectors.

In summary, these mounds and forest islands (discussed in the next section) functioned as areas for settlement, burial, fortification, and ritual; included gardens fields, orchards, and hunting locations; and served as political boundaries and territorial markers; or a combination thereof (Erickson 2000C).

FOREST ISLANDS

Thousands of forest islands (islas de monte) are found in the savannas of the Bolivian Amazon (Erickson 2000C; Langstroth 1996; Walker 2004). Most forest islands are slightly raised above the flooded savanna (0.5-1.0 meters) and range in area from a small cluster of trees to many hectares (figures 8.2, 8.7, and 8.8). Langstroth (1996) has shown that many forest islands were originally formed on the slight elevation of abandoned river levees and were protected from annual burns by what remains of the old meandering channels. I believe that most forest islands in the Bolivian Amazon are largely anthropogenie-s-locations of small farming communities, orchards, and house gardens that are often surrounded by raised fields, fish weirs, and causeways and canal networks. Colleagues and I have tested and excavated many intact forest islands and investigated others that were disturbed by road construction. All contain refuse debris from long-term pre-Columbian settlement. Many contain dense stands of economically valuable species. Because of their drainage and enhanced anthropogenic soils, forest islands are sought out by local farmers and ranchers as prime locations for settlements, gardens, orchards, corrals, and slash-and-burn agriculture.

RING DITCH SITES

Various forms of small (often one to two per forest island) and large (some surrounding entire forest islands) ring ditches occur in Baures (figure 8.8). In 1995 and 1996, our brief surveys located and mapped nine separate ring-ditched sites on forested islands near Baures (Erickson 2002; Erickson, Winkler, and Candler 1997). The enclosed area of each is estimated to range from 1 hectare to 5 hectares, and can include up to three village sites on a single forest island. The ditches are impressive earthworks of up to 4 meters deep and 10 meters wide, sometimes with steep sidewalls, and have diameters of between 150 and 350 meters. A number of sites also have multiple concentric moat rings. The]asiaquiri and Bella Vista sites have a series of encircling linear canals that enclose areas of several square kilometers.

FIGURE 8.8 A ting ditch site at Jasiaquiti, a large forest island in Baures, Bolivia. The ditch (the darker oval of trees), measuting 5-10 meters wide and up to 4 meters deep, encloses approximately 3 hectares.

The ditches can be round, oval, square, rectangular, D shaped, or irregular in plan. Based on the presence of pottery fragments, it is surmised that some of the ditches enclosed settlements; but others are more enigmatic in function (Erickson 2002; Erickson, Winkler, and Candler 1997). Although unmarked by earthworks, circular villages are a common organizational plan for Amazonian settlements in the historical and ethnographic record (Erickson 2003; Wust and Barreto 1999). The moatlike encircling ditches suggest a function of defending the settlement or, minimally, restricting access to it. The deep ditches around some, but not all, of the pre-Columbian sites would have been excellent barriers against enemies. Eder ([1772] 1985), a missionary living in the Baures region in the early 1700s, reported moat and palisade villages used for defense against raiding by other groups. Other possible functions include use of the sites as elite residences, cemeteries, ritual spaces, and gardens. Many of the larger ring ditch sites are the nodes of radiating networks of straight causeway and canal, suggesting functions as population, political, and ritual centers. Alceu Ranzi (2003) considers the ring ditch villages to be geoglyphs, comparable to the better-known Nazca Lines of Peru, because of their geometry and monumentality.

Many of the forest islands with ring ditch sites are farmed today with short fallow cycles with no apparent decline in crop production. To date, no raised fields have been located in the region of Baures. Kenneth Lee (1995) estimates the total extent of these ring ditch sites, causeways, canals, fish weirs, and other earthworks in Baures to be 12,000 square kilometers, although the area of continuous distribution earthworks is probably smaller. Similar ring ditch sites have been reported for Riberalta in Bolivia and for Acre and the Upper Xingu region in Brazil (Arnold and Prettol 1988; Heckenberger, chapter 10, this volume; Heckenberger, Petersen, and Neves 1999; Heckenberger et al. 2003; Parssinen et al. 2003; Peterson, Neves, and Heckenberger 2001; Ranzi 2003; Saunaluoma et al. 2002).

FISH WEIRS AND RELATED STRUCTURES

Unlike the Mojo peoples, who based their agriculture on raised fields, the Baure people of northeastern Bolivia intensively farmed the forest islands and gallery forests. The imprint of Baure farming is still recognized and exploited by the local folk who call these forests "chocolate islands" *(chocolatales)* because of the orchardlike concentrations of chocolate (domesticated or feral *Theobroma* sp.) found there. The region with the densest remains of earthworks is presently unoccupied.

During a survey of Baures in 1995 and 1996, colleagues and I studied a particular form of narrow linear earthwork that we refer to as "zigzag" structure because of its characteristic footprint (figure 8.9). The zigzag earthworks, clearly distinguished from the grassy savanna because of scrubby vegetation growing on them, are 1 meter wide, 20-30 centimeters tall, and up to 3 kilometers long. Dense networks of zigzag structures cover the savanna between the larger linear causeways and canals that divide the savanna into roughly rectilinear blocks. We found funnel-like narrow openings marked by parallel earthen walls of 1-3 meters long where these structures change direction.

Based on the form, location, and associations of these structures, my colleagues and I are convinced that they functioned as fish weirs during the rainy season (Erickson 2000a; Erickson, Winkler, and Candler 1997). The weirs are similar to those reported for indigenous groups throughout Amazonia. The weirs, combined with the larger causeways, would have impounded a thin sheet of water over a large area. The openings would have allowed excess water to flow across the savanna. The Amazon is home to many fish species that thrive in shallow floodwaters of tropical savannas. Basket or woven textile nets placed at the mouths of the narrow openings in the weirs could have been used to harvest fish (figure 8.10). These openings, possibly lined with logs, were used to pass heavy dugout canoes over the weirs without damaging the weirs. Artificial circular ponds with a diameter of 10-30 meters and a depth of 1-2 meters are associated with most weir openings. These ponds are still teeming with small fish in the dry season. Recent studies have shown that savanna fisheries of the Bolivian Amazon are extremely productive where standing

FIGURE 8.9 Fish weirs (the two irregular dark lines in the center) and causeway-canal *(upper right)* on the savanna between forest islands west of Baures, Bolivia.

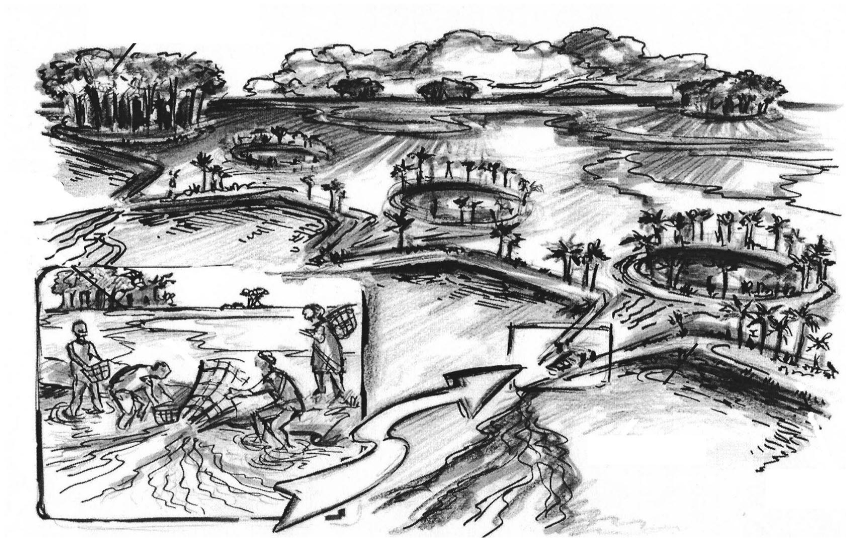

FIGURE 8.10 A landscape of fish weirs (zigzag earthworks), artificial ponds *(center)* ringed by *Mauritia flexuosa* palms, and forest islands with settlements *(in background).* Basket traps are placed in the openings in the fish weirs *(insert lower left).* (Artwork by Daniel Brinkmeier) water can be maintained (Hanagarth 1993). We also identified another aquatic species that may have been "cultivated" in the weir structures. Tens of thousands of shells of an edible gastropod have been found and are associated with the weir structures. *Pomacea,* the apple snail that plagues aquarium owners worldwide, was an important food source of the Baure during the Colonial period.

The weirs also aid in the harvest of game animals. Animal trails run alongside the weirs and channel the peccaries, tapirs, deer, and agoutis that are attracted to the palms *(Mauritia flexuosa)* growing on forest islands, causeways, and weirs. My hunter-guides hunt these animals from their canoes during the wet season. The technique is simply to paddle up to groups of deer and peccary swimming across the savanna and kill them with a blow to the head. These so-called wild game animals are the harvested products of a landscape domesticated more than 500 years ago.[10]

The earthworks provided a sophisticated means of regulating water levels within the savannas to enhance and manage seasonal aquatic resources. Fish weirs cover approximately 550 square kilometers. Using this simple but elegant technology, the Baure converted much of the savanna landscape into a huge aquatic farm that produced abundant, storable, and sustainable yields of animal protein. Hence, there was no need to improve protein production through genetic domestication, the common path taken by other societies.

The permanent impact of the artificial creation of this landscape is highlighted by what happened after the dense indigenous populations were removed from the landscape in the seventeenth century. The pre-Columbian earthworks still structure the abandoned landscape in highly complex patterns of vegetation, fauna and flora, soils, and hydrology-often misinterpreted as a "pristine environment" by nongovernmental organizations, ecologists, conservationists, tour guides, and government officials. Absent the annual burns, much of the savanna has been colonized by dense stands of forest. These landscapes are dominated by the economically important buriti palm, *Mauritia flexuosa*-a sea of hundreds of square kilometers of starch and protein.[11]

THE ISSUE OF ORIGINS

Historical ecology and the archaeology of landscapes assume that human activity takes place in landscapes shaped by previous inhabitants. This assumption raises the issue of origins of the human and environment relationship. The first inhabitants of the Neotropics encountered a "natural" environment in the Early Holocene. These early foragers sought out the economic resources provided by wetlands and naturally disturbed environments. The faunal and floral remains from the Monte Alegre site on the central Amazon dating to 11,000 years ago and from the Pefia Roja site along the Caqueta River in Colombia dating to 9,300-8,700 years ago provide evidence of this strategy, in addition to strongly suggesting early anthropogenic disturbance of the forest and floodplain around these sites (Mora 2003; Roosevelt et al. 1996).

Early inhabitants of the Amazon basin had at their disposal a powerful preindustrial technology for modifying, transforming, managing, and creating desired landscapes-fire. Neotropical scholars have largely ignored human use of fire as a tool for creating anthropogenic landscapes except when combined with slash-and-burn agriculture. Anyone doubting the power of fire to transform landscapes should read Stephen Pyne's excellent fire histories of Australia, California, and the Great Plains (also Blackburn and Anderson 1993; Kay and Simmons 2002). In Pynes view, humans "use their fire power to reshape the planet, to render it more suitable to their needs. In effect, humans began to cook the earth. They reworked landscapes in their ecological forges" (1998:64). Evidence of fire histories for parts of the Amazon basin and Central America begin by 11,000 BP (Piperno and Pearsall 1998). Natural-caused and human-caused fires can be distinguished. As Pyne (1998) points out, the signature, timing, scale, and function of anthropogenic fire are unique. Besides the role of fire in later slash-and-burn agriculture; recent studies of Amazonian Dark Earths demonstrate that pre-Columbian peoples discovered the importance of soil carbon and used low-temperature incomplete burning to produce charcoal that they incorporated into soils, thus creating black earths *(terra preta)* (Glaser and Woods 2004; Lehmann et al. 2003).

In the Bolivian Amazon, I initially assumed that my guides were pathological pyromaniacs by their keen interest in setting fire to everything in our path. To the locals, especially ranchers, a good burn is one that sweeps across a broad expanse of the savanna and clears off the old grass for new grass and opens up the forest understory for weedy species and fruit trees. Regular burns mean more grass for livestock and desired game, as well as shifts in biodiversity. The entire Bolivian Amazon is covered with thick smoke in the dry season as ranchers, farmers, and hunters burn the savannas-something that has been going on for thousands of years. Ironically, the very technology that created and maintained the landscape might soon end because of conservationists' and Green politicians' enthusiastic efforts in recently passing laws controlling and banning much of the annual burns of the savanna (Superintendente Agrario 2000).

GREEN INDIANS, CONSERVATION BIOLOGY, AND LANDSCAPES WITH HISTORY

To those spearheading efforts to preserve nature and protect biodiversity and natural resources, descriptions of nature as a product of human activities and as a cultural invention are considered ecologically damaging (see Soulé and Lease 1995) or at the least overemphasized (see Vale 2002a, 2002b, 2002C, 2002d). Scholars who critique the concept of nature and wilderness (e.g., Cronon 1996) have been accused of reducing nature and wilderness to cultural and linguistic categories and meanings (Soule and Lease 1995). Critics argue that postmodernism and critical theory open the floodgates of hyperrelativism, ignore scientific knowledge, and undermine any positive advances made by conservationists to protect the environment.

Native peoples and their relationship to the environment are often at the center of these debates. The idea that humans have been disturbing, burning, clearing, hunting, and domesticating nature for tens of thousands of years undermines the core political philosophy of groups such as the Nature Conservancy, Conservation International, and the World Wildlife Fund. Many believe that archaeologists and anthropologists' recent critique of biologists' long-held assumptions is more insidious-that it is used or can be used to justify the rape of nature by developers, industry, and agrobusiness or even to reject native peoples' land claims (Meggers 2001, 2003; Soulé and Lease 1995; Vale 2002a).

I believe that it is far more damaging to deny the environment and native peoples their histories." The denial of agency to foragers and small-scale farmers to transform and create landscapes is based on the myth of the ecologically noble savage that still dominates archaeological thinking. Amazonian peoples have been building and managing the environment for a very long time. Many of their intentional and unintentional activities could conceivably be described as deforestation, massive soil erosion, extinction of species, reduction of biodiversity, and environmental degradation (Denevan 1992; Kay and Simmons 2002; Krech 1999; Redman 1999). But characterizations of past and present native peoples as either agents of environmental degradation or as ecologically noble savages are--despite their apparent opposition--based on contemporary Western values, aesthetics, and assumptions. Native peoples did not tiptoe through the forest, nor did they live in harmonious equilibrium with nature. Somehow, they were able to sustain huge populations for long periods of time on landscapes that natural scientists classify variously as "marginal," "fragile," and "pristine." They are also responsible for what we now call nature in the Neotropics. Natural history is best understood in reference to human history.

TOWARD A HUMAN-CENTRIC UNDERSTANDING OF NATURE

The Amazon basin was not a pristine environment in 1492 and probably has not been since the first humans arrived there around 12,000 years ago or earlier. Most of us would agree that humans were and are a factor in shaping the present Amazonian landscape. We probably disagree on the degree of human causality, however. I have pointed out the arbitrariness of any comparison between human causation and some imagined "natural" or "pristine" baseline or benchmark. In the perspective of the new ecology, environmental perturbations, climate change, and catastrophe should be considered normal and *necessary* for the overall health of ecosystems (Blumler 1996, 1998; Botkin 1990; Stahl 1996). Archaeologists and historical ecologists point out that early humans in Amazonia simply added a more sustained and profound level of perturbation for at least 11,000 years (Denevan 1992; Kay and Simmons 2002; Stahl 1996).

The nature/culture dichotomy, ahistorical models of the natural sciences that stress equilibrium and order, and the anthropological concept of human adaptation have limited our understanding of the Amazonian environment. Any attempt to understand how nature came to be and what it will be in the future must consider human action in its long-term historical trajectory. A historicized, politicized, and humanized ecology provides a solid foundation for proactive change (Botkin 1990; Brosius 1999; Escobar 1999; Janzen 1998; Kay and Simmons 2002; Zimmerer and Bassett 2003) Archaeology of landscapes and historical ecology provide a powerful multiscalar, historical, people-centric perspective by which to understand the long-term dialectical relationship between humans and the environments they created. If we accept the idea that human agents have played and continue to play a primary role in creating landscape, there is hope that active human intervention informed by this perspective can confront contemporary issues such as global warming, loss of biodiversity, and unsustainable development.

DISCUSSION AND CONCLUSION

The Bolivian Amazon is an example of a totally domesticated landscape-a humanized landscape. The inhabitants participated in what ecologist Dan Janzen (1998) has referred to as the "gardenification of nature" or what my colleagues and I call "domestication of landscape." Farmers decided which trees would be grown on the landscape and where they would be grown; even today, the results are more like a garden or orchard than natural vegetation communities.

The permanent long-term effects on biodiversity created by the native peoples of the Bolivian Amazon were substantial and long lasting. Wetlands were expanded through intentional water management at a regional scale. The alternating ridge and swale topography locally created by raising field platforms, fish weirs, mounds, and forest islands and by cutting canals, barrow pits, ponds and reservoirs produced heterogeneous microenvironments for terrestrial and aquatic life-millions of linear kilometers of rich terrestrial-aquatic ecotones or edges in what was previously a relatively homogeneous, flat environment. In terms of biological productivity, expanding productive ecotones and introducing a patchwork of artificial landforms increased the presence and available biomass of selected economic species, both wild and domesticated. However, the systematic replacement of natural vegetation by economic and domestic species presumably changed vegetation composition substantially. We will never know because there is no pristine environment for comparison.

Conservation is often defined as intentional practices of short-term constraints on behavior for the long-term benefit of maintaining or improving biodiversity (e.g., Alvard 1994,1995). The degree of planning, design, labor organization, and technology inherent in the complex, highly organized, engineered landscapes of the Bolivian Amazon show clear intentionality and forethought. For landscape archaeologists and historical ecologists working with the coarse and fragmentary archaeological and environmental record, recovering evidence of short-term decisions is often difficult. That the earthworks were used for hundreds and in some cases thousands of years suggests that the knowledge of how to manage the environment was passed down through generations of farmers who both benefit from past inputs and contributed to the landscape-domestication process.

From a long-term perspective, the rich biodiversity recognized in the forests and wetlands of the Bolivian Amazon today is because of, not in spite of, the pre-Columbian farmers who replaced nature with a cultural agroscape or anthropogenic landscape. Were these activities sustainable? Sustainability usually implies harvesting the interest without reducing the principle while maintaining a certain degree of quality of life. Archaeologically, sustainability can be measured in terms of the time depth of continuous intensive agriculture and high human carrying capacity on a given landscape. Again, the 2,000-year record of pre-Columbian intensive agriculture, earthwork construction, and urbanized populations in the Bolivian Amazon strongly suggests sustainability.

The use of fish weirs, raised fields, and other production strategies ended with the arrival of Europeans and their diseases, to which the locals had no resistance, as well as ensuing missionization, enslavement, imposition of new crops and livestock, and civil wars, rather than with the onset of overpopulation, environmental degradation, or unsustainable practices. For the past 300 years, this landscape has been relatively unpopulated. Forests expanded over vast areas of the anthropogenic savanna where annual burning was discontinued. This is not an example of a landscape reverting "back to nature"; the present vegetation is the historical legacy of past human activities.

The international community of conservationists, natural scientists, and most of my anthropologist colleagues consider what the pre-Columbian inhabitants of the Bolivian Amazon did as destructive and degrading of the natural environment. In contrast, although I am cautious about interpreting the landscape aesthetics and values of native peoples before 1492, I am convinced that

the ideal landscape for the inhabitants of the Bolivian Amazon was a nicely gridded landscape of earthworks, roads, and settlements on a relatively treeless plain. This built environment was as productive and sustainable and probably equally species rich as the forests that exist there today.

In this case, historical ecology demonstrates that Amazonian peoples did not "adapt to" and were not "constrained by" or "limited by" the natural environment in Amazon, but rather created those very environments in which they lived and thrived. This domestication of the landscape was an intentional act, at least as it pertains to the engineering and knowledge used to transform the landscape in the pre-Columbian period. Through the perspective of archaeology of landscapes and historical ecology, we are beginning to understand how this impressive environment came to be-its human history-and to propose viable models of land use for sustainable development and conservation of biodiversity. Historical ecologists and now some biologists recognize that biodiversity is increasingly now found in the "countryside," or what historical ecologists would call the anthropogenic landscape. Past peoples constructed and maintained these landscapes; thus, solutions must include active management by present and future peoples based on this complex historical ecology.

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NOTES

1. Several scholars have expanded the concept of domestication beyond plants and animals. For example, Peter Wilson (1988) and Ian Hodder (1990) argue that major social transformation in the Neolithic was not the domestication of specific plants and animals and the adoption of agriculture, but rather the domestication of human society. It was through the permanent, built environment (Wilson focused on village architecture, Hodder on the house) that social roles, relationships, and meaning were inscribed in people's lives. The concept helps us widen the definirion of *domestication* to consider nongenetic issues such as settling in permanent communities; dealing with neighbors; marking fields, village, and territory; and thinking about the environment. The built environment, in this case limited to architecture, becomes both a "model of" and "model for" society as well as a dynamic container of human action. James Snead and Robert Preucel's discussion of the "domestication of nature" and the "naturalization of the social" as an expression of the "dialectic between society and nature" in cultural landscapes (1999:171-174) overlaps with some of the ideas expressed in this chapter.
2. The terms *domestication of landscape* (Terrell et al. 2003), *landscape domestication* (Cunningham 1997), *domestication of environment* (Yen 1989), *domesticated environment* (Blackburn and Anderson 1993), and *humanized landscape* (Butzer 1979:148, 1990:48; Denevan 1992a; Vale 2002a, zoozb, 2002C; Zelinsky 1973:16) refer to roughly the same concept. I thank Bill Denevan for pointing out the early references to me. Some scholars trace the origins of the concept further back in time (Harlan 1992, 1995; Ingold 1996; Terrell et al. 2003:349, n. 13; and others). Douglas Yen (1989:61) and others attribute the concept of domestication of landscape to Edgar Anderson's (1952) "dungheap hypothesis" for the origins of agriculture, adopted from Darwin. Anderson's concept focused on localized anthropogenic conditions where weedy species could thrive and become the focus of genetic domestication. David Rindos (1984) frames some aspects of the concept of domestication of landscape within "incidental" and "specialized" domestication categories of his coevolutionary model, which stresses the unconscious.
3. Whereas my definition stresses the conscious patterning and structure imposed on the landscape by humans, other scholars stress ecology and population in their definitions (Clement 1999; Terrell et al. 2003). Charles Clement defines *landscape domestication* as "a conscious process by which human manipulation of the landscape results in changes in landscape ecology and in the demographics of its plant and animal populations, resulting in a landscape more productive and congenial for humans" (1999:190; see also Clement, chapter 6, this volume, and McKey et al. 1993:22-23). He subdivides domestication of landscape into a continuum of intensity of manipulation: pristine, promoted, managed, cultivated (swidden/fall, monoculture) (1999a:191-192). Clement gives credit to Hynes and Chase (1982) and Chase (1989) for the concept.
4. Erland Nordenskiold (2003) first reported the raised fields of the Llanos de Mojos in 1924 based on observations from fieldwork in 1908-1909. William Denevan (1963, 1966, 200I) and George Plafker (1963) brought the fields' importance in Amazonian archaeology to scholars' notice. In addition to colleagues' and my project research, archaeological research on raised fields includes Bernardo Dougherty and Horacio Calandra (1984), Marcos Michel (1993, 2000), and John Walker (2000, 200I, 2004). Mounds are important symbols in indigenous myths (e.g., Riester 1976) and local public imagination (e.g, Pinto Parada 1987). Mounds have been the traditional focus of archaeologists since Nordenskiold's (1910, 1913) first excavations at the turn of the twentieth century. More recently, numerous national and international projects have explored mounds through survey, mapping, and excavation, including research conducted by Ricardo Bottega, Victor Bustos (1978a, 1978b, 1978c, 1978d), William Denevan (1966), Bernardo Dougherty and Horacio Calandra (1981, 1981-82, 1983, 1984), Juan Faldin (1984), Alicia Fernandez Distel (1987), Wanda Hanke (1957), Kenneth Lee (1979, 1995, n.d.), Rodolfo Pinto Parada (1987), Stig Rydén (1941), and Mario Vilca. More recently, archaeologist Heiko Priimers and his German-Bolivian team have mapped and meticulously excavated the Mendoza Mound (Priimers et al. 2000, 2001, 2002a, 2002b) near Casarabe. Robert Langstroth's (1996) study of the vegetation, soils, and formation of mounds and forest islands is a landmark study.
5. The stability and change in the forest-savanna boundary for the period of prehuman and human occupation in the Bolivian Amazon (Hanagarth 1993; Langstroth 1996; Mayle, Burnbridge, and Killeen 2000) and in Amazonia in general (Piperno and Pearsall 1998) are still under debate.
6. Denevan estimates a total of 100,000 raised fields spread unevenly throughout 180,000 square kilometers of the Llanos de Mojos (200I:246).
7. Kenneth Lee (1979, 1995, n.d.) first suggested the role of water hyacinth as a green manure in raised field agriculture.
8. In an earlier publication, I calculated a figure of 40 square kilometers of surface area and retention of 20 million cubic meters of water based on a slope of 5 centimeters per kilometer (Erickson 2000b:24). Although this is the case in some northern areas of the Bolivian Amazon, a slope of 18-20 centimeters per kilometer is average (Denevan 1966).
9. Large mounds are found along the Mamore, Ibare, Caimanes, Tijamuchi, Apere, Matos, Isiboro, Blanco, and Secure rivers and their tributaries.
10. Charles Bennett (1962) and Olga Linares (1976) have also discussed how Native Americans enhanced the number of game animals through anthropogenic activities (also see Stahl, chapter 4, this volume).
11. For the importance of *Mauritia flexuosa* for Amazonian peoples, see Gragson 1992; Hiraoka 1999; and N. Smith 1999.
12. A point also made by Charles Kay and Randy Simmons, who go as far as to suggest that this denial of history, agency, and anthropogenic environment is racist (2002:xi).

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