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Landscape of the Past, Footprints of the Future

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LANDSCAPES OF THE PAST, FOOTPRINTS OF THE FUTURE

Historical Ecology and the Study of Contemporary Land-Use Change in the Amazon

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THE HISTORICAL ECOLOGICAL approach that emerged during the 1990s is contributing to a growing awareness of the long-term and processual interactions between human populations and environment. It has challenged the recurrent simplification of culture-nature interactions as dichotomous and deterministic and the perception that natural and anthropogenic landscapes are mutually exclusive (Balée 1998; Crumley 1994). This chapter reflects on the potential contribution of an applied historical ecology for the analysis of contemporary land-use change in the Amazon. Land use in contemporary Amazonia does not occur in a historical vacuum despite the overwhelming changes taking place in the region recently. Contemporary land-use change in the region reflects variations in regional historical conditions defining land tenure; migration and access to resources; ethnicity; social organization and class; and demands from external markets and policies. My rationale for integrating historical ecology and land-use studies in examining the region is based on three related points.

First, since colonial times there has been a growing complexity of social groups, economic strategies, and forms of land use and resource ownership in the region. Although substitution of land-use systems and social groups has occurred, forms of land use have coevolved cumulatively, resulting in growing intraregional variability. Indigenous systems now coexist with large-scale industrial enterprises; urban-rural networks mingle with a variety of farming systems and settlement arrangements of multiple sizes. Contemporary land use in the region reflects the historical interaction between macrolevel processes and place-specific conditions underlying land tenure, infrastructure, demographic and social organization, technology and knowledge of resource use, and market-economic arrangements. A historical ecological perspective has much to contribute to the understanding

of processes creating intraregional variation in social and economic conditions and thus in land-use systems in the region today.

Second, contemporary land-use analysis and historical ecology focus on overlapping theoretical concerns regarding human-environment interactions—such as the implications of changes in settlement pattern and resource-management strategies to the formation of anthropogenic landscapes—thus opening the opportunity to build bridges toward theoretical cross-fertilization. Land use has been actively studied from different perspectives in the Amazon for decades. Examples include models of settlement location (Chibnik 1994; Denevan 1996; Hiraoka 1985; Sternberg 1956); swidden cultivation (Albuquerque 1969; Beckerman 1983; Brabo 1979; Denevan 1998; Denevan and Padoch 1987; Hames 1983); environment and adaptation (Clarke 1976; Hames and Vickers 1983; Moran 1981, 1995); soil fertility, population density, and environmental circumscription (Carneiro 1961 and Meggers 1971, to cite just two). However, theoretical tools implicitly or explicitly used in analytical models explaining patterns of deforestation in the region today—such as by Boserup, Von Thünen, and central-place models—are also helpful in understanding various forms of relationships between Amazonian populations and environmental resources (Geist and Lambin 2001; Kaimowitz and Angelsen 1998; Wood and Porro 2002). Although there are variations in language and terminology in the two approaches, a common interest exists between historical ecology and land-use analysis regarding conceptual models utilized to explain human-environment interaction in the region.

Third, historical ecology and land-use analysis have similar concerns regarding the role of units of analysis and spatial-temporal scales in understanding human-environment interactions. Understanding social and environmental change in the region today requires attention to national and international factors interacting with regionally and locally defined conditions and histories. Historical ecologists are familiar with the recurrent tension between considering the region as an organic entity and envisioning it as a mosaic of microrealities resulting from population dynamics, environmental variability, and historical events. A historical ecological approach to land use may help to avoid generalizations and to improve sampling across historically diverse communities and regions, including areas of recent colonization.

The high rates of deforestation in the region since the 1970s, growing awareness of the global implications of Amazonian environmental change, and demand for integrated social environmental policies have produced numerous analysis and prognostic models for interpreting factors affecting land-use change in the region (Carvalho et al. 2002; Fearnside 1984; Goldenberg 1989; INPE 1988–2001; Kaimovitz and Angelsen 1998; Laurence et al. 2001; Nepstad and Uhl 2000; Nepstad et al. 2002; Skole and Tucker 1993; Verissimo, Cochrane, and Souza 2002; Wood and Porro 2002). Development projects, rural and urban population growth, changing infrastructure, and national and international market developments draw attention to macrolevel processes that cannot be ignored in any sensible analysis (Ab'Saber 1997; Browder and Godfrey 1997; Dincão and Silveira 1994; Lená and Oliveira 1992; Moran 1993b; Schmink and Wood 1992; Wood and Porro 2002). Furthermore, the growing integration of the region with global markets will increase regional complexity as these new corridors meet up with a long history of regional occupation.[1] However, the focus on variables of regional and global relevance should not lead to disregarding complex local differences on the basis of their unmanageability or "irrelevance" (Brondízio 2005).

Although macrolevel socioeconomic processes continue to be important, land-use change cannot be generalized because of a growing spatial diversity of inter- and intraregional conditions—for instance, differences in land tenure and in sociocultural, technological, demographic, and environmental conditions. The human decisions—that is to say, the intentionality—central to shaping the regional environment have occurred at micro- and mesoscales, although they have had basinwide cumulative consequences. In this context, variability is a condition increasingly inherent to the region, and accounting for it is necessary to make any research finding useful to policy. Striking a balance between contemporary and historical, local and macroprocesses—in the interplay among national and international forces, regional conditions, and interregional variability—is and will be increasingly necessary for understanding the present and future of the Amazon region.

The term *"intraregional" variability* is used in this paper as a heuristic tool and an analytical unit of research defined empirically to accommodate human populations in relation to their historical, cultural, biophysical, economic, and institutional environment. Nested units of analysis can be defined according to one's research question and scale of analysis and according to regional socioenvironmental conditions: for instance, households in relation to a community, rural communities in relation to a county (*município* in Portuguese), farm lots in relation to a settlement, settlements in relation to a network of settlements, communities in relation to a conservation unit. Defining the level of detail necessary to capture intraregional variability and related historical differences depends on a given study's scale (spatial and temporal), question, and goals. The point here is that attention to a "region's" historical occupation—variation in settlement time, differences in social groups, forms of access to resources and resource-use rights, land-tenure arrangements, and past economic cycles—may contribute to improving research design and sampling and to avoiding generalizations across diverse social realities within the region.

This chapter builds on empirical analysis of multiple rural and indigenous communities in regions representative of contemporary Amazonia, including rural and periurban riverine communities, indigenous territories, colonization

zones, and conservation areas. Data are discussed in the context of historical processes influencing land-use and settlement pattern and the formation of humanized landscapes (Clement, chapter 6, and Erickson and Balée, chapter 7, this volume) in the region. Based on case studies, the chapter relies on ethnographic and archival surveys as well as on multitemporal remote sensing data and geographical information system (GIS) analysis to discuss the variability of factors affecting changing land use and their footprint on the landscape. The chapter is structured to address and discuss each of the three main points presented earlier. It concludes with reflections on the analysis of land-use trajectories in the region today, with a focus mostly on the Brazilian Amazon.

HISTORICAL FORMATION OF AMAZONIAN LAND-USE SYSTEMS: CUMULATIVE STRATEGIES AND GROWING COMPLEXITY

In contrast to other areas of Brazil where large-scale out-migration of rural populations, substitution of land-use systems, and homogenization of landscapes have occurred, a significant part of the Amazon region has increasingly moved toward greater social and land-use complexity. There is no such thing as an "average" cultural landscape in Amazonia either in indigenous areas or in recent colonization settlements. Besides the diversity of environments, variations in social, economic, and cultural history have embedded their footprints in the region. Figure 12.1 illustrates general historical trends in agrarian land-use systems in the region. By and large, Amazonian land use can be seen as evolving according to successive economic and political phases while maintaining some continuity of pre-European indigenous land-use systems and technology. In general terms, land-use systems in the region have evolved along with phases of regional occupation by different migrant groups, government policies, forms of land-tenure grants, and demands from external markets. Along with various new forms deriving from indigenous land-use systems, historically dominant forms of land use have included export-oriented extractivism, cycles of cash crop expansion, and, more recently, large-scale logging, monocrop agriculture, and cattle ranching, together with the implementation of conservation units. Regional settlement patterns were until recently dominated by dispersed rural communities and regional urban centers along the main river networks. Aside from groups such as the Tikuna, occupying the upper Solimões River floodplains, indigenous groups have been characterized as having dispersed but interconnected upland settlements of various sizes, usually associated with the region's main tributaries and transition areas or between types of forests and savannas. During the past 30 years, a complex network of roads connecting urban areas and interspersed by rural settlements evolved. Today, indigenous

areas coexist, commonly in conflict, with a growing number of colonization settlements, logging and mining concessions, large urban centers, and a variety of conservation areas of direct- and indirect-use categories.

Although much remains to be learned about pre-Columbian forms of land use, some level of continuity in swidden and agroforestry cultivation systems and environmental management technologies is usually assumed and ethnographically documented among contemporary populations, indigenous and *caboclo*.[2] The scope and kind of land-use change occurring during the first two centuries of European colonization (Denevan 1998, 2001) is still little understood, but this period of transition was crucial to subsequent land-use systems in the region. Among the processes influencing land use during this period were the scaling down of agriculture under conditions of sociocultural chaos, labor shortage, and migration to new environments. Depopulation, migration, and settlement change as well as diffusion of and experimentation with new technological practices brought to the region led to regional variations in forms of land use. The introduction of new crops into the indigenous agricultural repertoire, such as rice, banana, and sugarcane, further diversified land-use systems based on various forms of swidden agriculture. Responses to colonial demands, new crop varieties, and variation in regional environmental conditions made possible the emergence of different forms of swidden agriculture and its widespread adoption not only among indigenous groups, but arguably among all subsequent rural populations since the seventeenth century (Denevan 1998, 2001).

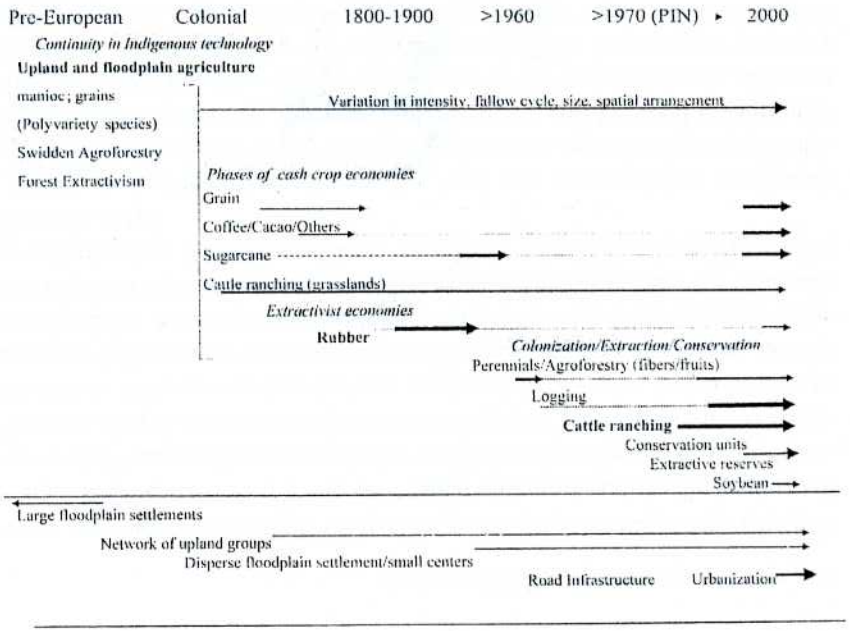


FIGURE 12.1 Historical overview of agrarian and forest use in Amazonia.

Technologies of indigenous origin continue to play a key role within the Amazonian agrarian economy, from the supply of manioc (*Manihot esculenta*) (see, for instance, Albuquerque 1969; Murrieta 2001) and grain staples for rural and urban populations to the dominant açaí (*Euterpe oleracea*) palm agroforestry economy of the Amazon estuary (for a historical review, see Brondízio 2004a). Strategies of swidden agroforestry and resource-management systems are now practiced across indigenous, caboclo, and colonist farming sectors. Continuous diffusion, experimentation, and adoption of land-use technologies underlie variation in land-use practices in different parts of the region today.

The demand for forest products and cash crops intensified during the seventeenth and eighteenth centuries, particularly in the eastern part of Amazonia, which was characterized by Portuguese settlements and missionary villages congregating the remaining indigenous populations. Cacao (*Theobroma cacao*) represents one important example of intensifying production under external demand early in regional history. Although arguments about the level of cultivation versus extractivism are still unanswered, cacao represented an important export for the region during the eighteenth century (R. Anderson 1976; Balée 2003; Santos 1980). Coffee entered Brazil in the seventeenth century through what are now the states of Amapá and Pará. Although modest in production, coffee probably contributed to new forms of perennial agriculture in the region. Also significant to regional land use was the introduction of cattle ranching among Jesuit missions during the seventeenth century and later intensified during the late nineteenth and early twentieth centuries with the introduction of buffalo to Marajó Island. By the mid-1700s, the cattle herd of Marajó Island was estimated at 400,000 (Baena 1969). Sugarcane, already present during the eighteenth century, also experienced a significant cycle of expansion during the nineteenth and twentieth centuries along the floodplains of the estuary with the use of tidal-powered technology to support processing mills. Sugarcane cultivation declined significantly during the latter half of the twentieth century (S. Anderson 1992). Maize was also important among indigenous groups and continues to be among rural populations. Rice has been present at least since the eighteenth century, and, later occupying larger extents of floodplains, it opened the way to mechanization of the floodplains (Baena 1969; Barata 1915; Lima 1956).

It was, however, the rubber economy that definitively shaped land use by articulating merchant capital, land tenure, and social control of labor throughout the Amazon. Rubber attracted new migrants and diverted most of the regional agricultural labor force by shifting attention from the organization of plantation and subsistence agriculture as initially organized during the Directorate period starting after 1750 (see also Cormier, chapter 11, this volume). The arrival of new migrant groups, occupation and claim of forest land, and the opening of colonization settlements represented important changes during this period. After the drastic decline of the rubber economy circa 1910,[3] agricultural systems, in particular cultivation

of rice and sugarcane, emerged for specific periods of time. Regional penetration of colonization settlements along the Madeira-Mamoré and the Bragantina rail lines ended because of economic decline and failures in early colonization efforts. The sociocultural, economic, and land-tenure legacy of the so-called rubber boom, however, is still imprinted across large portions of the region and continues to have great influence on contemporary social organization and land uses, particularly along the Amazon River floodplain and penetrating as far upstream as the hinterlands of Acre, Rondônia, Pará, Amapá, and Amazonas states (R. Anderson 1976; Barata 1972; Becker 1997; Cleary 2001; Dean 1987; Derby 1897; Santos 1980; Weinstein 1983).

After the rubber boom, Amazonian land use retracted into small-scale regional systems with a variety of crop combination, episodic forest and wildlife extractivist cycles (e.g., fur and forest essences), and localized expansion of cash crops. Two significant cycles are noteworthy for their role in the diffusion of land-use technology. The first was the growth of the black pepper economy among Japanese migrants in Tomé-Açu County in the state of Pará during the 1940s and 1950s. The intensive cultivation of black pepper production was unprecedented for the region and assumed international importance until its decline due to plant disease and price changes (Tsunoda 1988; Yamada 1999). The decline of black pepper in the Tomé-Açu area prompted the second cycle: the experimentation with and development of agroforestry systems of fruit production based on Amazonian species such as cupuaçu (*Theobroma grandiflorum*), taperebá (*Spondias mombin*), and graviola (*Annona* sp.), as well as on nonnative fruits such as acerola (*Malpighia glabra*). Few developments in agricultural systems have been as significant for the region today as the cultivation of regional fruits for supplying both internal and external markets (Subler and Uhl 1990). The impact of agroforestry cultivation and particularly of the opening of new markets for regional fruit species and products on today's small-scale agriculture throughout the region is paramount (Brondízio 2004a, 2004b). A second land-use economy of regional significance was the jute cycle, in particular that seen from the 1950s to the 1970s along the lower Amazonian floodplains. Influenced by Japanese migrants, jute cultivation expanded to almost all floodplain populations from Gurupá to Manaus (Gentil 1988). In another vein, cattle ranching along the seasonal floodplains of the lower Amazon River grew in importance considerably before post-1970 road construction. In the Santarém region, cattle ranching increased after the opening of the uplands for colonization. Because of limited water supply in large parts of the upland area and seasonal availability of grazing areas in the floodplains, cattle ranching developed strong linkages between the floodplain and upland areas of the region.

As widely documented, the opening of the Belém-Brasília highway in the 1960s, followed by the TransAmazon, Cuiaba-Santarém, and later Porto Velho–Cuiabá and Manaus–Rio Branco highways, underwrote new phases

of agricultural expansion and land use in the entire region. Small-scale cash cropping promoted by government agencies, subsidies for perennial agriculture, and subsidized (as well as nonsubsidized) small- and large-scale cattle ranching have been widespread in the region during the past 30 years (Aragón and Mougeot 1986; Hecht 1993; Lená and Oliveira 1992; Mahar 1988; Schmink and Wood 1992). At the same time, colonist farmers have adopted swidden and newer technologies for local production (Browder 1989; Caviglia 1999; Moran 1981; Muchagata 1997; Smith et al. 1996). During the past two decades, logging has expanded considerably to large-scale and extensive exploitation. However, several precedents exist in the region. Localized exploitation has been reported for the Santarém region since the 1930s (C. Sena, curator, Centro Cultural Boanerge Sena Archives, personal communication, July 2000), but the floodplains of the Amazon estuary have been subjected to intensive logging since the 1950s (Anderson, Mousasticoshvily, and Macedo 1993; Barros and Verissimo 1996). Pinedo-Vasquez and colleagues (2001) provide a fascinating account of the boom of the 1950s and the postboom logging in parts of Amapá State. In this area, large-scale selective exploitation of prime wood was followed by management of secondary-value species by farmers and communities targeting the local market. Paralleling agricultural change and the granting of logging and mining concessions, various incipient urban settlements have appeared in the region and been interconnected by a network of planned and unplanned roads and waterways. Large municipalities, previously administered by single urban centers, have been divided into several municipalities, thus creating new forms of institutional and political arrangements underlying land use in the region (Aragón and Mougeot 1986; Browder and Godfrey 1997).

Similar to the "original" highway system (e.g., Programa de Integração Nacional [PIN] I and II, POLONOROESTE), the current opening or reopening of new export routes is defining new forms of land use, agricultural expansion, and regional occupation, such as the case of soybean expansion since the year 2000. At the same time, indigenous, caboclo, and colonist groups have intensified their social and political organization. They have gained access to new forms of resource ownership, such as demarcation of territories, extractivist reserves, and privatization of previously unoccupied areas through agrarian reform. Several analogous processes can be observed, such as the rise of the rubber tappers as a social and political movement since the mid-1970s, the organization of indigenous groups in pan-regional coalitions (e.g., in the Negro River basin, in the Xingu-Iriri basin, and in parts of southern Pará State) (ISA 2000). Also relevant are the regional coalitions of rural unions claiming more incentives and land-tenure rights for small-scale producers (e.g., *grito da terra*)[4] (Tura and Costa 2000). Together, these social groups have created a mosaic of stakeholders varying in political strength; these stakeholders inhabit forest reserves, indigenous areas, and colonization settlements, and thus represent multiple forms

of land-tenure and institutional arrangements. These stakeholders are trying to have a voice, a history, together with land claims and visions for land use. On another level, state- and national-level economic-ecological zoning is also lending recognition to different stakeholders, but is not always able to accommodate all groups, so conflict develops.

The northward movement of soybean cultivation from central Brazil through the BR-163 Cuiabá-Santarém highway (and the Cuiabá–Porto Velho highway to the West) to the new Cargill harbor in Santarém marks the definitive presence of large-scale, mechanized, monocultural plantations as a significant land-use system. Although the socioeconomic and environmental impacts are substantial and the rate of rural out-migration high, soybean plantations will in the future likely coexist with rural communities refusing to give up their land and their small-scale production of fruits and other crops, as well as with fishing communities on the floodplain-upland interface. The success of these communities' resistance, however, will depend on local and regional political and economic forces, such as their own internal social organization, access to similar economic incentives as provided to large-scale farmers, and access to market and technologies. Conservation areas, indigenous reserves, logging areas, and unopened forest reserves also coexist with these diverse forms of land use, thus further increasing the spatial complexity of land-use systems even across short distances (Brondízio 2005; Nepstad et al. 2002; Verissimo, Cochrane, and Souza 2002).

In contrast to the Atlantic Forest of Brazil, the scale of deforestation resulting from "cycles" of land use since the seventeenth century in Amazonia was limited until recently (figure 12.2). Cattle ranching has taken advantage of grassland areas in Marajó Island, and rubber extraction was based on native stands. Because widespread swidden agriculture existed under small population density, the proportion of forest to nonforest areas has remained high. The only significant deforestation before 1970 occurred during successive years of colonization of the Bragantina region (east of Belém) starting at the turn of the twentieth century as migrants were settled with the goal of increasing agricultural production to supply the urban population of a growing rubber economy (Penteado 1967). Deforestation in the Bragantina region before 1970, however, pales in comparison to rates documented since the 1970s and exacerbated during the 1990s and 2000s by lower inflation and the economic incentives of governmental development programs, such as Avança Brasil. In this context, the temporal and spatial articulation of a long history of regional occupation creates differential conditions upon which land-use change takes place within and across regions today.

This summary highlights elements relevant to the understanding of processes and units of analysis that account for regional variations in land use. Historically, variability within the region reflects the arrival and emergence of social groups, colonization policies, and external market demand, as well as the opening of new access routes (waterways and roads) and the organization of land

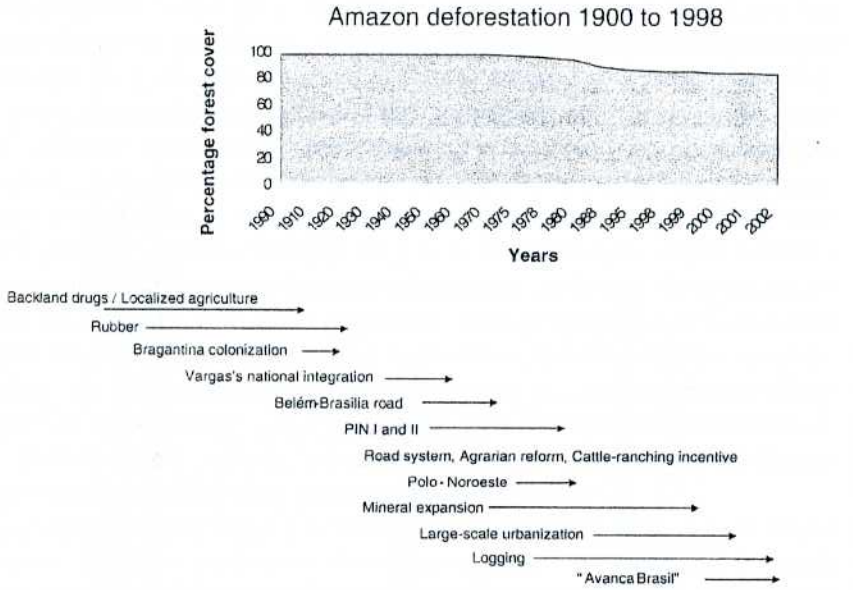


FIGURE 12.2 Historical outline of political and economic events and deforestation in the Amazon.

tenure and control of resources. The implications for research design in historical ecology and analysis of land use are clear because these factors are relevant in defining units of analysis necessary for capturing different processes underlying current transformations of regional landscapes (for prehistoric transformations, see Erickson and Balée, chapter 7; Erickson, chapter 8; Neves and Peterson, chapter 9; and Heckenberger, chapter 10, this volume).

THEORETICAL AND CONCEPTUAL MODELS EXPLAINING SETTLEMENT, LAND USE, AND LANDSCAPE FORMATION

The study of land use has provided themes that integrate the social and environmental sciences for a number of reasons, but particularly because it seeks to understand spatial and temporal dimensions of human behavior related to environmental and socioeconomic problems of local and global interest.[5] In this context, *land use* refers to the purposes and intent of human activities that directly affect and are affected by the biophysical environment (LUCC 1994). Although long recognized as a relevant subject within anthropology, geography, agronomy, ecology, and other fields, land use emerged as a distinctive field of research during the 1990s. International programs such as Land-Use and Cover

Change (LUCC) and Human Dimensions of Global Environmental Change developed by the International Geosphere-Biosphere Program (IGBP) have contributed to consolidating land use as a research field focusing on bridging micro- and macroscales of analysis. In the Amazon, where a long history of land-use studies in the social sciences exists, contemporary research on local and regional land-use change has become one component of the Brazilian-led international program Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). In conjunction with theoretical developments in historical ecology, land-use studies harbor a heuristic framework for those interested in articulating factors affecting and mediating both micro- and macrodimensions of social and environmental change.

The goal of most contemporary analysis of land-use change is to understand factors underlying variation in rate, extent, and direction of environmental change. In particular, such analysis attempts to understand the relationship between the so-called underlying causes ("the initial conditions and fundamental forces that underpin human action towards the environment" [Geist and Lambim 2001:8]) and the proximate sources ("direct human activities affecting the biophysical environment" [Geist and Lambin 2001:5–16; also see LUCC 1994, 1999; Turner, Meyer, and Skole 1994]). In most cases, underlying causes include broadly defined demographic, economic, technological, political, institutional, and sociocultural variables, whereas proximate sources refer to the set of transformation activities broadly defined as agricultural expansion, logging, and infrastructure development (Geist and Lambin 2001). One may argue that in Amazonia, as in most other places, the understanding of factors mediating the interaction between underlying conditions and proximate causes requires attention to historical events and economic cycles, which have influenced patterns of land tenure and resource ownership, demographic changes, and the social and political institutions emerging at different periods and places.

Land-use studies in the Amazon have been approached from different theoretical and methodological perspectives depending on the type of question and scale of analysis. Independent of perspective, there has been a continuous concern with integrating the mosaic of microrealities and local conditions with regional patterns of human-environment interactions. Several conceptual models correlating population dynamics and forms of land use have paid attention to the roles of settlement location, soil fertility, population density, management technology, land tenure, environmental conditions, and market and institutional incentives (see Balée 1989; Brondízio, Safar, and Siqueira 2002; Brondízio et al. 2002; Carneiro 1961; Coomes and Burt 1997; Denevan 1996; Denevan and Padoch 1987; Fisher 2000; Futemma and Brondízio 2003; Hiraoka 1985, 1994a; Lathrap 1970; Moran 1981; Muñiz-Miret et al. 1996; Padoch et al. 1985; Posey and Balée 1989; Roosevelt 1989; WinklerPrins 2002a, 2002b). The study of peasant (e.g., rural caboclos and colonists) economy has also contributed

significantly to understanding Amazonian land use. It includes attention to the participation of small farmers and agricultural workers in commodity production and economic cycles (historical and contemporary), migration and settlement, and land tenure and labor arrangements (Brondízio and Siqueira 1997; Bunker 1985; Chibnik 1994; Nugent 1993; Sawyer 1986; Schmink and Wood 1992; Tura and Costa 2000). No less important has been the role of ethnobotanical studies to local land use analysis (Balick 1988; Nepstad and Schwartzman 1992; Prance and Kallunki 1984).

The bulk of land-use studies over the past decade has focused on measuring and modeling variables to explain deforestation, ranging from the microscale (such as a farm lot) to the macroscale (such as the Brazilian Amazon). Emphasis has been placed on variables of demography; political economy; political institutions and infrastructure (McCracken et al. 1999; Pichón and Bilsborrow 1992; Wood and Skole 1998); colonization programs; fiscal incentives and inflation (Mahar 1988; Ozório Almeida 1972); and disarticulated urbanization (Browder and Godfrey 1997), among others. Attention to infrastructure and the spatial articulation of colonization areas, in particular access to roads, has also been important, even central, to analysis and formulation of predictive models of land-use change (Alves 2002; Batistela, Robeson, and Moran 2003; Laurence et al. 2001; Walker, Moran, and Anselin 2000). In general, however, prognostic and causal models of land-use change have paid insufficient attention to intraregional variability in conditions that seem to be underlying land-use change (Brondízio 2005). Theoretical models supporting these analyses have included, for example, central-place and Von Thünen theories, particularly with the growing importance of urbanization in the region (Browder and Godfrey 1997). Implicitly or explicitly, Boserupian models of land use intensification have been used to look at rates of regrowth, fallow cycle, and crop frequency in relation to population size, labor, technology, and land circumscription (Brondízio and Siqueira 1997; Scatena et al. 1996). In colonization areas, Chayanovian and other models of household cycles, labor arrangements, and land use have also become increasingly used in studies focused on farm-level dynamics (Marquette 1998; McCracken et al. 2002).

There are parallels between theoretical perspectives used within the literature aiming to explain contemporary causes of land-use change[6] and that used to explain long-term human-environment interactions in the Amazon. Historical ecology—with its roots in archaeology, history, anthropology, ecology, and geography—contributes various models to explain linkages between patterns of indigenous settlement, migration and demographic change, and environmental management in different parts of the region (Balée 1994, 1998; Erickson 2000; Heckenberger et al. 2003; E. Neves 1998). To some extent, historical ecology originated out of the necessity to refute models

based on environmental determinism, to engage in long timescales, and to provide cultural context for the study of human-environment interactions. These same problems are also faced in the study of land use in the region today and tend to be dominated by simple and deterministic causality (for example, between road construction and consequent deforestation) and simplified solutions (such as standardized credit programs). Bringing a historical ecological approach to the study of contemporary land use will certainly lead to more emphasis on the role of long-term, processual, spatial, and temporal dimensions of human-environment interactions in the region and help account for the past and present diversity of human experiences and forms of environmental management.

UNITS OF ANALYSIS IN STUDYING HUMAN-ENVIRONMENT INTERACTIONS IN THE AMAZON

As the previous discussion suggests, few aspects are as relevant to the study of human-environment interactions and land-use change as defining units of analysis in space and time. Across disciplines as diverse as anthropology, geography, and ecology, the notion of a unit of analysis has evolved through a long history of definitions and forms of conceptualizing boundaries within which to envision the relationship between human populations and the environment. These concepts include cultural area, community, population, household, niche, ecosystem, landscape, and biome (Geertz 1963; Golley 1992; Hardesty 1975; Kroeber 1939; Moran 1990; Odum 1971; Steward 1946–50, 1955, 1956; Turner, Meyer, and Skole 1994; Vayda and McCay 1975; Vayda and Rappaport 1968).

There is no single way of predefining units of analysis in land-use studies because the exercise in question depends on, among other things, the type of question, data available, time frame for analysis, and the unit of observation within which the data are collected. During the past decade, the emergence and common use of remote sensing data have yielded various levels of spatial and temporal coverage that have contributed to better definition of spatial boundaries and units of analysis. GIS supplies tools for manipulation and querying of spatial data. Global positioning systems furnish location-specific information. Depending on the type of question and level of analysis, one may find a range of possibilities in organizing and nesting spatial units of different categories—for instance, political, institutional, biophysical, sociocultural, demographic, and contextual units (Behrens, Baksh, and Mothes 1994; Evans and Moran 2002; Fox et al. 2003; Liverman et al. 1998; McConnell 2001; McCracken, Boucek, and Moran 2002; Moran and Brondízio 2001; Wood and Porro 2002).[7]

Accounting for the underlying factors that influence land-use change requires integrating field approaches to remote sensing and GIS, including ethnography, survey, and archival work. Rare are "land users" who do not rely on multiple resource and economic strategies, diverse markets, varied forms of resource ownership (private, communal, government), and multiple labor arrangements. For instance, colonization settlements where family and entrepreneurs arrive from different places and at different times often evolve into complex, nonclustered social and economic networks shaped by historical experiences particular to a given context. In regions where occupation dates to the Colonial period, these arrangements are even more complex and embedded in different forms of power relation and class. Throughout the Amazon estuary, for instance, one finds a range of sharecropping arrangements sometimes spanning multiple generations. But a whole sharecropping community may also be the neighbor of a highly organized, cooperative-based community. Although performing different roles and carrying different political and social agendas, middlemen and merchant capital as well as churches, banks, nongovernmental organizations, and development projects often coexist in influencing stakeholders' land use within the same region. Furthermore, intraregional variation among land users may include previous conflicts and power relations underlying local land-tenure arrangements, ascendancy and ethnic differences, varied experience and knowledge of forest resources, cultural preferences in resource use and consumption, and the evolution of social organization and political leadership as well as institutional arrangements underlying local norms, rules, and sanctions regarding land use. Therefore, in moving from the local to a regional scale, where land-use analysis and prognostic models are often developed, the intersection of new colonization areas, older rural communities, urban centers, and indigenous reserves renders focus on the historical context of social and economic differences ever more relevant.

The case studies presented in the next section illustrate this point. These cases illustrate the importance, during research design and sampling, of paying attention to historical processes such as settlement formation, evolving land-tenure arrangement, differences in access to resources among users, and past impacts of environmental management on soil and vegetation, as well as the need for contextualizing the analysis of land-use change observed in a given region today. Even more important, attention to these processes may help to avoid modeling exercises that assume similar conditions and land-use behavior over large socially and environmentally diverse areas. At any level one selects to analyze land-use change, emphasis on the historical differences underlying management of resources may help to avoid unnecessary and flawed generalizations that decontextualize causal relationships between land users and land-use systems.

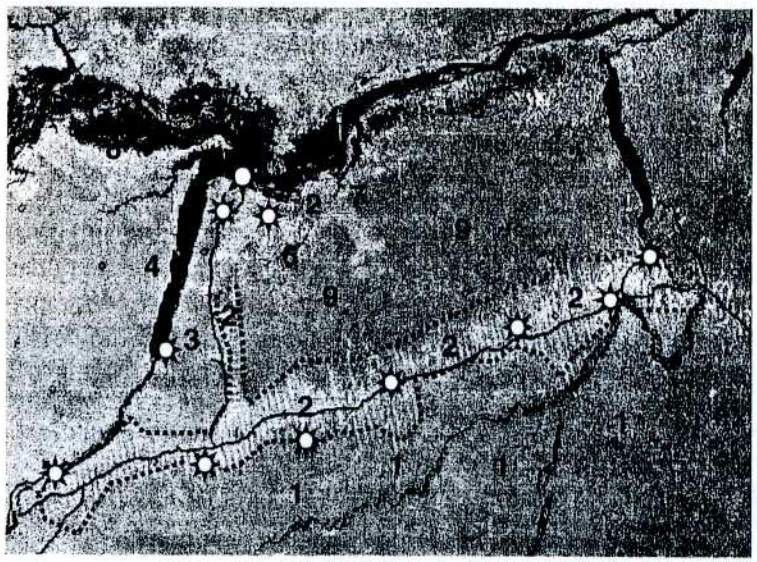
INTERREGIONAL AND INTRAREGIONAL VARIATION IN LAND-USE TRAJECTORIES: IMPLICATIONS FOR THE FORMATION OF CULTURAL LANDSCAPES

I present three examples here to illustrate intraregional variations in land-use systems and in rates of land-cover change resulting from differences in historical and contemporary processes. I selected these examples to represent variation in scale (from larger to smaller areas); types of occupation and social groups (indigenous peoples, caboclos, small-holder colonists, and large farmers); types of land-tenure arrangements (government, communal, sharecropping, and private systems); and forms of access (roads and riverways) at different distances from regional urban centers.

HISTORICAL STRATIFICATION OF COMPLEX AND LARGE REGIONS: FROM THE XINGU RIVER TO THE TAPAJÓS RIVER

An example of regional complexity is illustrated in figure 12.3. The figure presents a satellite image of the region covering the Xingu River in the east to the Tapajós River in the west. On the southern part, one can follow the TransAmazon highway from Altamira to Itaituba and from its intersection (city of Rurópolis) with the Cuiabá-Santarém highway to the city of Santarém at the confluence of the Tapajós and Amazon rivers (ACT 2003). Many different regional realities and historical depth of regional occupation are represented in this image, illustrating the issues discussed here. In simple terms, the region can be divided into at least two parts based on two highway systems: the Santarém-Belterra-Aveiros region to the northwest and the Altamira region to the east. A more comprehensive analysis would also account for occupation along the Xingu, Tapajós, and Amazon rivers, which differ substantially from the two highway areas.

The region of Santarém-Belterra along the BR-163 highway (Cuiabá-Santarém) illustrates well the complexity of land-use conditions found in an area currently undergoing significant changes with the recent arrival of large-scale soybean cultivation. A site recognized for its large pre-European chiefdoms, Santarém has been subjected to successive colonization and occupation for the past 300 years, but more intensively for the past 150 years, including cacao (ca. 1800–1860), rubber exploitation and commerce (ca. 1850–1910), early logging corridors (1930s), jute cycle (1940s–1980s), migration to rural areas (1960s), agrarian reform (since the 1970s), land grants and rural out-migration to cities (1970s and 1980s), creation of conservation and extractivist reserves (1980s–1990s), and more recently soybean expansion (2000–) and new indigenous areas (2003).[8] Along the Tapajos River, Belterra and Fordlândia were created after 1928 as part of rubber plantations and settlements established by the Ford Motor Company. As much as 8,000 hectares



1. Indigenous reserves
2. Colonization settlements (>1970s)
3. Flona Tapajos ("traditional" and migrant communities, logging concessions)
4. Extractive reserve ("traditional" communities)
5. Various rural settlements (>1930s), soybean expansion zone (>2000)
6. Recent farm expansion (>1990s)
7. Government reserve/research area
8. Floodplain communities, lake-management areas, cattle ranching
9. Logging and farm expansion zones

Urban centers and towns

FIGURE 12.3 Regional complexity in the Xingu-Tapajós region. This map is only illustrative; it does not include all conservation units and roads, and it includes only settlement areas shown in figures 12.4 and 12.5.

of forest were cleared with this purpose. Following uneven success, the area was later transferred to the Brazilian government (ca. 1945) as "land of the union." In the late 1990s, as Belterra became a municipality, part of the old settlement was subdivided and distributed as land grants (around 16 hectares) to old and new residents. Buildings, water utilities, and old patches of rubber trees persist and remind one of the area's past. Still, most of the county remains "land of the union" despite its de facto occupation and use by county administration and residents.

The remaining part of Belterra falls mostly within the boundaries of Flona-Tapajos, where more than rural communities exist. Defining the county as a study area—for instance, to analyze deforestation processes—lumps together a variety of groups and processes, such as colonization areas settled at different time periods. However, phases of regional occupation correspond roughly to the opening of key access routes, the immigration and migration of different social groups, and the organization of different land-tenure arrangements. These phases of occupation include, for instance, the settlement of riverine populations along the Tapajós and Amazon rivers (seventeenth to the twentieth centuries), earlier migrants occupying the Curuá-Una and Mojuí dos Campos roads (early twentieth century), the creation of a national forest encompassing dozen of communities along the Tapajós River (1974–), the creation of the Ford Company rubber plantation (1930–), settlement of colonists and large ranchers along the Cuiabá-Santarém highway (1972–), the formation of Belterra County (1997–), and the current arrival of newcomer soybean farmers.

In the example presented here, the region under study has been stratified according to subregions representing phases of historical occupations (including road construction), arrival of social groups, and dominant forms of land use—all based on archival, ethnographic, and remote sensing research,. Figure 12.4 illustrates an example of stratifying the region according to areas representing different periods and forms of occupation (ACT 2000–2003).[9] Stratifying a region according to historical occupation permits flexibility and robustness in sampling for land use and stakeholders, as well as in accounting for demographic, sociocultural, economic, and environmental factors affecting land-cover change in the here and now. Although histories are not units of analysis, the institutions, social groups, and forms of resource ownership and use created through time can be just that. Accounting for variations in land use may help to avoid comparing deforestation rates across regions occupied during different times and in different settlement areas and farm lots of different age and undergoing different stages of occupation.

In contrast to Santarém, Altamira to the east represents a county that has undergone significant colonization and settlement only since the 1970s, despite its earlier history as a riverine settlement early in the twentieth century and as an area important to indigenous communities. In both cases, the temporal depth is a defining factor if one wants to understand variation in deforestation trajectories. The TransAmazon highway west of the town of Altamira was one of most important foci of the Brazilian government colonization program during the 1970s. Altamira grew from a small riverine town based on rubber collection into a booming town of 85,000 due to agropastoral production stimulated by the highway and subsequent colonization along it. Several counties and planned agrarian villages (*agrovilas*) were created along the highway and its feeder roads. Some planned agrarian villages disappeared, while others formed; large numbers of lots have been

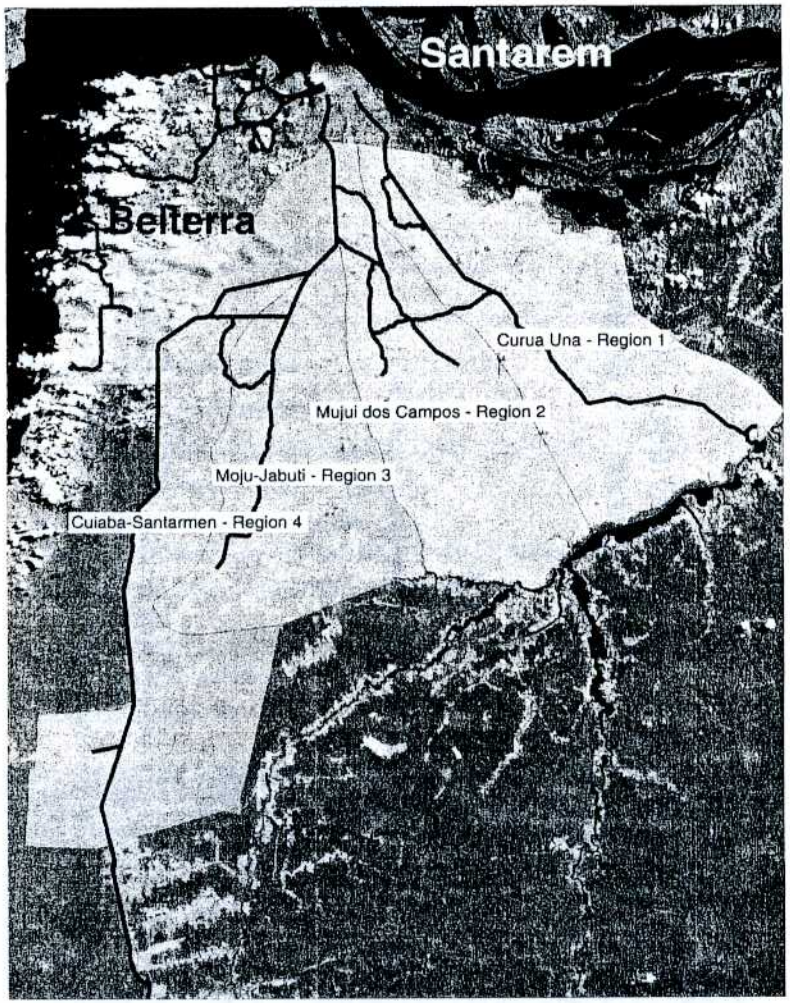


FIGURE 12.4 Example of intraregional stratification representing different periods and forms of occupation. Research example of the Anthropological Center for Training and Research on Global Environmental Change, Indiana University (ACT field data 2000–2003). Floodplain areas not represented. (Map prepared by Scott Hetrick of ACT)

successively sold. Although in the Santarém-Belterra area, which is marked by long-term occupation, subregions indeed can be stratified according to different occupation "routes" (both by roads and rivers) as well as by different social groups (caboclos, immigrants), the recent history of occupation and structure of settlement in the TransAmazon region renders colonization settlements and cohorts of farm lots a suitable choice (Brondízio et al. 2002; McCracken et al. 1999). Such

an arrangement is shown in figure 12.5, a group of approximately 3,800 farm lots arranged according to adjacent settlement projects implemented by the National Agrarian Reform Institute (INCRA) during the past 30 years, which cuts across the counties of Altamira and newly created Brasil Novo and Medicilândia, in the state of Pará (Fearnside 1986; Moran 1981; Smith 1982).

Remote sensing data collected at different times since the 1970s (aerial photography, Landsat MSS, and Landsat TM) have allowed researchers to reconstruct the history of the colonization of the study area (figure 12.5). In this way, farm lots can be classified by the duration of occupation and thus organized into cohorts of arrival time (i.e., groups of farms being established during given periods of time) in the region. Demographic concepts may be particularly helpful in accomplishing this task. Such concepts include *period effects,* such as fluctuations in migration, different credit policies, and inflation; *cohort effects,* associated with the arrival and occupation of farm lots by groups of families; and *age effects,* related to the transformations of households and their farms over time (Brondízio et al. 2002; McCracken, Boucek, and Moran 2002; McCracken et al. 1999; McCracken et al. 2002; Moran, Brondízio, and McCracken 2002; Siqueira et al. 2003). Figure 12.5 shows the history of regional occupation and deforestation since 1970 (*top*), which was used to stratify farm lots (*bottom*) according to cohorts of arrival.

Along this stretch of the TransAmazon highway, deforestation rates vary according to age of settlement, location in the region, and environmental characteristics of the lot (Brondízio et al. 2002; McCracken, Boucek, and Moran 2002; McCracken et al. 1999; McCracken et al. 2002; Moran, Brondízio, and McCracken 2002). As in most colonization areas, "old settlers" coexist with new ones, the latter being recent migrants or second-generation colonists taking over new lots or acquiring them from previous colonists. Although land-use trajectories are shaped by economic and social conditions and by the local environment, understanding them within and across farm lots also requires the researcher to note the time of colonists' arrival, their age of occupation, and the type of settlement being examined. This knowledge is necessary for untangling different types of temporal and spatial factors underlying land-use change.

This temporally and spatially sensitive strategy allows understanding and comparison of deforestation rates and land-use trajectories at the level of farm lot, cohort of farm lots, and entire settlements. The rate and extent of deforestation vary significantly when calculated at each spatial level and when units of analysis are stratified according to their history of occupation (time in the area). My colleagues and I found that though a significant, positive correlation between rate of deforestation and age of settlement obtains, this correlation is conditioned by regional period effects, such as changes in economic, institutional, and infrastructural conditions that motivated or inhibited particular land-use behaviors. We also found that deforestation rates and land-use trajectories

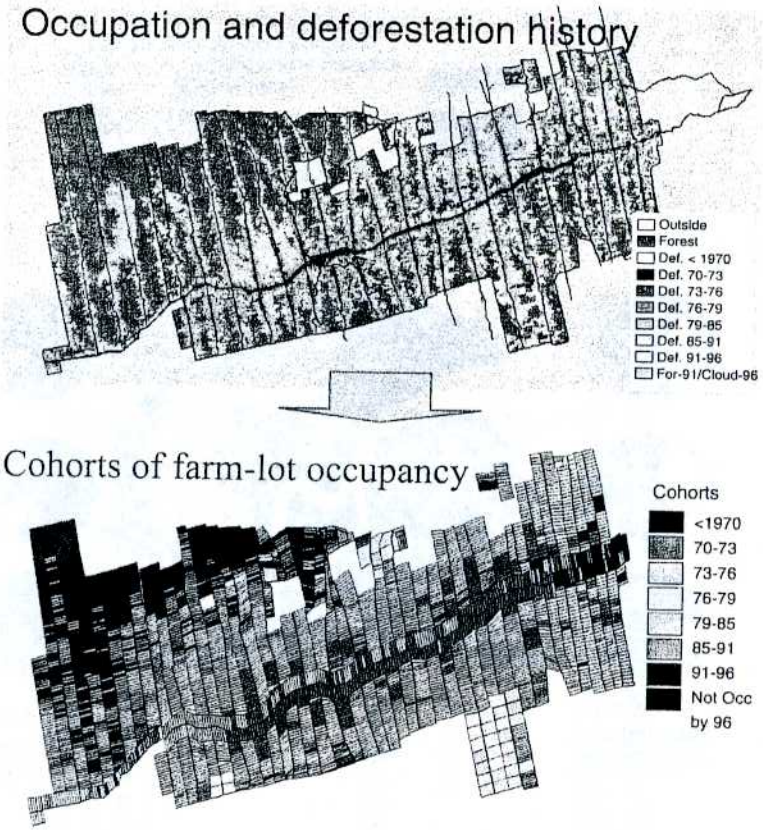


FIGURE 12.5 Reconstitution of occupation/deforestation history and farm lot by cohort of arrival (1970–1996), TransAmazon hghway from Altamira to Medicilândia. Mapped deforestation sequences from 1970 to 1996. (Aerial photographs, Landsat MSS and TM)

are to some extent age dependent in colonization lots, but not necessarily so in indigenous and rural communities predating colonization during and after the 1970s. We have observed deforestation rates characterized by phases of expansion (clearing) and consolidation of colonists' farm lots. However, the magnitude of deforestation during each of these phases varies by cohort (time of arrival and age of occupation) as a function of period effects (regional events) affecting different groups of farmers arriving at different times. Thus, groups of families occupying the region during the past 30 years (the TransAmazon highway and parts of the Cuiabá-Santarém highway) or the past 70 years (Santarém) have encountered different levels of incentives and constraints (period effects) under which to make land-use decisions (see Brondízio et al. 2002; Futemma and Brondízio 2003 for detailed discussion; McCracken, Boucek, and Moran 2002; McCracken et al. 1999, 2002; Moran, Brondízio, and McCracken 2002; Siqueira et al. 2003). Neighboring riverine communities (e.g., along the Tapajós River), floodplain communities (e.g., along the Amazon River), and upland indigenous communities that reflect long histories of land occupation, distinct kinds of social organization (compared to colonist families), and participation in the regional economy present different and lower deforestation rates and different spatial patterns. A far more complex social and environmental scenario exists in this large region, to be sure, but this illustration instantiates the value added and the importance of accounting for ever-increasing regional complexity and historical depth of occupation, both being concerns of historical ecology.

VARIATION IN LAND-USE TRAJECTORIES IN THE AMAZON ESTUARY

The region of Ponta de Pedras offers a microcosm in which to capture land-use changes taking place during the past 30 years in the larger Amazon estuary. Urban population growth and market demand in the nearby state capital of Belém, local development projects and subsidies, and a diversity of plant-utilization forms and local land-use strategies create a constantly evolving landscape. This study area is located in the estuarine region of the Amazon River, on Marajó Island, and in Ponta de Pedras County, Pará (Brondízio 1999; Brondízio et al. 1994, 1996). Occupation dating from the seventeenth century includes *sesmarias* land grants (land concessions by the Portuguese Crown) to individuals and religious missions as well as Directorate land policies (circa 1750) (see Cormier, chapter 11, this volume). The region's current pattern of riverine settlement of dispersed individual households dates back at least to the rubber boom cycle (mid-1800s to 1910). During the past 30 years, development projects, government incentives, and strong market demand for locally produced food products, the açaí palm fruit (*Euterpe oleracea* Mart.) in particular, have resulted in incentives and opportunities for estuarine farmers and communities to intensify their land use in floodplain areas. However, local producers and communities' differential responses to regional market demand and development projects have resulted in diverse land-use systems, even within short distances.

Both household and community are important levels of social organization in this region. Factors affecting these trajectories include historical conditions defining the location of settlement and land tenure, participation in development projects during the past 30 years, and variation in forms of social organization of local communities such as cooperative and sharecropping arrangements. Six rural communities are analyzed in this example (figure 12.6); three are located in upland areas, and three are located adjacent to the floodplains. Their settlement patterns and locations result from land inheritance and sharecropping systems dating back to colonial times (the floodplain), as well as from more

recent Catholic Church–based land acquisition and distribution to communities since the 1960s (the uplands).

Population growth in urban areas has created markets for regionally preferred food sources such as the açaí fruit, which is a key regional staple consumed by rural migrants living in urban centers. Impressive intensification of açaí production followed increased market demand, thereby changing the regional economic profile. Market demand, however, has had differential influence on land users' decisions with regard to intensification depending on several factors affecting production, in particular land tenure and availability of floodplain areas, dependency on middlemen, and access to market centers (Brondízio 2004a, 2004b; Brondízio, Safar, and Siquiera 2002; Brondízio and Siqueira 1997).

Analyzing the expansion of açaí agroforestry at the current time helps, in a broader context, to conceptualize declining deforestation rates, widespread

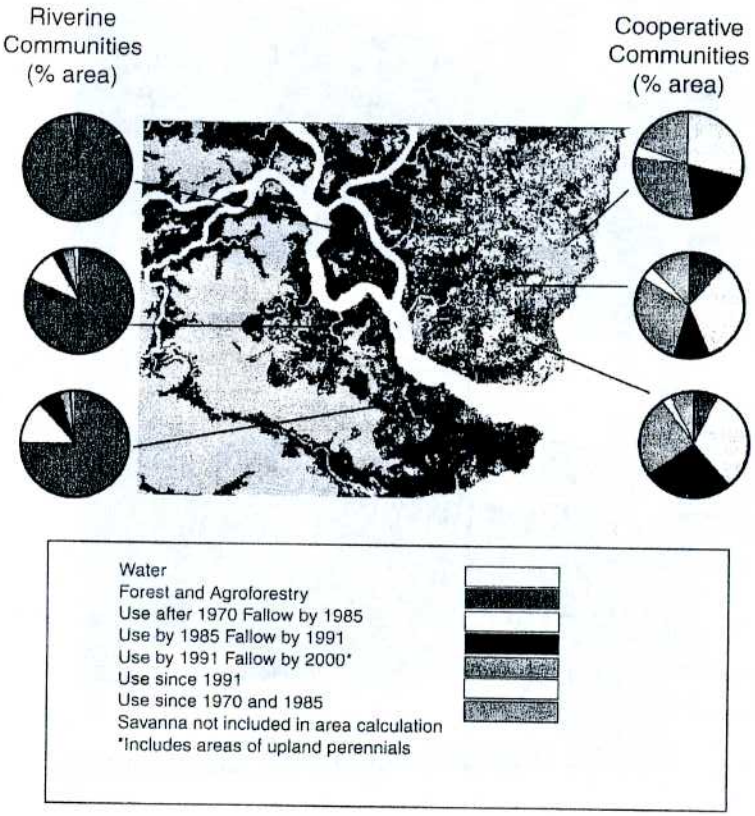


FIGURE 12.6 Intraregional variability in land-use allocation and trajectories 1970–2000: Ponta de Pedras region, Marajó Island, Pará State, Brazil.

formation of secondary vegetation, and relative decline in swidden agriculture even among riverine communities. Remote sensing data from 1969 on show that coinciding with the growth of açaí agroforestry, there has been virtually no deforestation in the area since the mid-1980s, in sharp contrast to the deforestation of other areas of the Amazon basin in Brazil. As illustrated in figure 12.6, a variety of land-use patterns emerges from the differential spread of market incentives as producers cope with land tenure, availability of resources, and access to external incentives, such as credit (Brondízio 2004a).

Analysis of land-cover change since the 1970s reveals different strategies of land-use intensification and extensification among communities (figure 12.6). The different proportions of forest cover, cropland allocation, and secondary vegetation (representing differing lengths of fallow cycles) reflect the variation in dissimilar contemporary and historical conditions within which these communities and households operate. These conditions include availability of resources (e.g., floodplain forest areas), land ownership, subsidies from development projects, and agricultural technology. Riverine communities illustrated in figure 12.6 offer a view of land allocation and fallow-cycle management based on a combination of agroforestry land use and small-scale swidden agriculture. In these communities, forest cover tends to correspond to more than 75 percent of the area. Older secondary vegetation, fallow for 15 to 50 years, tends to occur in larger amounts when compared to younger vegetation. Families tend to maintain up to 2 hectares in production yearly, utilizing a cycle of rotation that depends on the availability of particular types of soil, secondary vegetation, and household needs. This scenario differs radically in upland communities that underwent cooperative development projects. Forests cleared to allocate areas for mechanized cultivation of annual crops, pasture, and coconuts during the 1970s and 1980s can today be encountered in several stages of regrowth. Contrary to land cover in riverine communities, secondary vegetation regrowth of different ages (up to 20 years) tends to represent at least 75 percent of the area of these formerly cleared areas. Several communal projects implemented during the 1970s and 1980s were not successful in the long run. Reasons vary widely, including the failure of cattle and pasture management. For instance, many pastures could not compete with secondary plant species and were therefore deemed to be inadequate as cattle fodder, thus leading to stakeholders' abandonment of the pastures. As a result, one can observe large areas of pasture abandoned by the late 1980s after numerous attempts to manage and weed out secondary growth. During the 1990s, these communities were cultivating smaller areas using mechanization and implementing agroforestry projects in floodplain and upland areas, while letting most of the formerly forested areas recover fully to forest.

In summary, regional history has created variations in land tenure, social organization, and access to resources, markets, and infrastructure influencing

land-use change today across different rural communities located at similar distances to urban areas and sharing in a similar regional context.

TUKANOAN SETTLEMENT HISTORY, SOIL DISTRIBUTION, AND SPATIAL DIMENSIONS OF LAND USE

Understanding the relationship between settlement distribution and the spatial pattern of deforestation is central to many land-use studies. Despite the relative absence of factors common today in many other Amazonian areas, such as urban markets, road access, and colonist populations, the Tukanoan community exemplifies variation in the spatial pattern of land use between two neighboring villages of the northwest Amazon. The areas of Tukanoan-speaking populations are located on the Vaupés basin between Colombia and Brazil in the northwest Amazon. Settlement pattern has been influenced by historical variations in regional migration and missionary occupation, leading to nucleation of the population in village centers (Castro et al 2002; Wilson 1997; Wilson and Dufour 2002). The area is composed of large patches of nutrient-poor Spodosols covered by Amazon "caatinga" (scrubland) intermixed with stretches of Oxisols covered by upland forest. A manioc-based swidden agricultural system characterized by long-fallow cycles is the dominant land-use system in these communities. In this context, land-use choices are closely related to access to appropriate soils (Oxisols), but also influenced by historical events defining the location of each village. Interactions of historical and environmental factors are of paramount importance for understanding the Tukanoans' land use in the present as well as in the recent past. The two neighboring Tukanoan villages are of a relatively similar size (figure 12.7).

The research problem presented here is illustrative of what explains different spatial patterns of land use and land cover between neighboring villages that are otherwise characterized by similar sociocultural conditions and agricultural systems. Although part of the explanation rests on the fact that Community B is surrounded by Spodosols and Community A by areas of Oxisols, their respective locations derive from differences in each settlement's history. In contrast to Community A, Community B moved to this particular site through missionary incentives in previous decades (Castro et al. 2002; Wilson 1997; Wilson and Dufour 2002). In brief, the history of settlement and availability of better agricultural soils has made it possible for Community A to minimize the distance traveled to gardens (farm lots) by opening garden areas near the village center, whereas Community B has to seek appropriate soils by accessing areas via waterways. Consequently, even in the absence of roads, development projects, and private land-tenure arrangements, the same land-use system (i.e., long-fallow, manioc-based swidden agriculture) effects different spatial patterns of land cover (Castro et al. 2002).

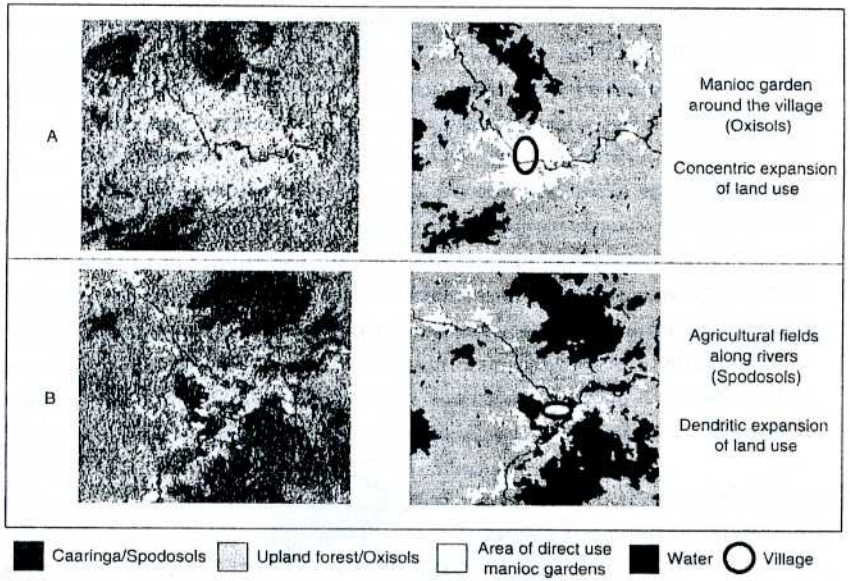


FIGURE 12.7 Biophysical and access factors influencing land-use patterns between neighboring Tukanoan villages (Community A, *top*, and Community B, *bottom*). Adapted from Castro and Brondízio 2000.

Although land-cover patterning may have been impacted by the distribution of soils around these two villages, it is actually the historical fact of the arrival of missionaries, who for their part encouraged village nucleation and relocation, that in the final analysis underlies contemporary differences in spatial patterns found in these two communities. Methodological lessons taken from this case enrich land-use analysis and explanatory models of land-use change, such as those originating in the historical ecology research program. The amount of land-cover change between the two villages may be similar (e.g., percentage of cleared forest and secondary vegetation), but their spatial patterns differ strongly. This difference suggests that intraregional variation in land use and land-cover change is not restricted to recently colonized areas, but is present throughout the Amazon basin, even in areas such as indigenous reserves where land use is considered to be relatively homogeneous. These results represent the importance of accounting for historical factors and intraregional variations in environmental conditions when interpreting regional patterns of deforestation and when designing explanatory, predictive models of land use and land-cover change.

DISCUSSION

The growing complexity in the forms of human-environment interaction in the Amazon region is expressed in the coexistence of diverse social groups and land-use systems across the region. A challenge for land-use analysis and policy is to take into account local factors influencing human land-use behavior, the materialization of these factors at larger spatial scales, and macrolevel political economic forces underlying these processes. Integrating historical, ethnographic, and spatial analysis offers an opportunity to address these issues while promoting theoretical and methodological cross-fertilization between historical ecology and land-use studies in the study of human-environment interactions in the region. Potential research topics include more attention to historical trajectories of forest-cover change and variability in land-use systems within the region.

HISTORICAL TRAJECTORIES OF FOREST-COVER CHANGE

Contemporary land-use change in the region does not occur in a vacuum; land use is history written onto the landscape (Erickson and Balée, chapter 7, this volume). Multiple "historical depths" coexist in different parts of the Amazon basin—from pre-Columbian and colonial times to recent colonization settlements. The region carries the footprints of successive phases of sociocultural and economic change, territorial occupation and agrarian history, and commodity markets of forest resources. These processes of change have created different forms of access to resources and land tenure, different forms of social organization, and different land-use technologies.

Different models explaining long-term use of forest resources in the region have generally emphasized temporal phases based on successive stages of decline and rebound of forest resources coinciding with expansion and retraction of human activities. This emphasis is reflected, for instance, in discussions of the process leading to the formation of anthropogenic forests, of the trajectories of extractivist economic cycles, and of the impact of economic development in the region today (figure 12.8A). The literature on the sociopolitical formation of pre-Columbian Amazonian populations has debated the extent to which human management practices and forms of organization have been used to overcome the region's environmental limitations (e.g., low soil fertility, sparse concentration of resources) (Carneiro 1961, 1995; Denevan 2001; Lathrap 1970; Meggers 1971; W. Neves 1989; Roosevelt 1989). Balée's seminal paper "The Culture of Amazonian Forests" (1989) represents the most significant paradigm shift in this discussion. It argues that a significant portion of the Amazon forest results from different forms of human land uses, including species concentration, fire management, and large-scale cultivation resulting from dense and widespread populations in parts of the region. Concentration and management of

environmental resources allowed for an increase in sedentary populations and for the development of political complexity and multitier settlement patterns. Anthropogenic forests in this case result from successive uses and transformations of forest resources, followed by population decline or migration (as after the European conquest) and by subsequent rebounds of forest cover. Heckenberger and colleagues' (2003) archaeological findings in the upper Xingu River (see also Brondízio 2003; Heckenberger, chapter 10, this volume), showing the articulation of multiple settlements associated with large-scale spread of anthropogenic forests, and previous ethnographic evidence of forest management (e.g., see Anderson and Posey 1989; Brondízio and Siqueira 1997; Denevan and Padoch 1987) seem to corroborate this model (figure 12.8A).

Studies of the region's extractivist economies (e.g., Homma 1993) have suggested that forest resource use goes through phases of large-scale extensive exploitation followed by periods of decline, substitution, and abandonment. Forest resources, depending on market and merchant capital, are exploited to a degree close to exhaustion or to its limited productive capacity until a market decline or a substitute product winds up shifting attention to other areas or resources. Retraction of land users and reduction in exploitation are then followed by eventual regeneration of the resource. However, these trajectories vary according to the type of resource. Although some resources continue to be exploited extensively and continuously (for example, the Brazil nut [*Bertholettia excelsa*] and the babaçu palm [*Attalea speciosa* = *Orbygnia phalerata*]), others became cultivated (such as the açaí palm) (see Brondízio and Siqueira 1997; Clement, chapter 6, this volume). In short, different forms, trajectories, and levels of intensity of forest extractivism and management tend to coexist in the region today (figure 12.8A–C).

A third model discussing the trajectory of forest resources in the region relates to the spread of certain economic development policies during the past four decades. Several explanations for the spread of human occupation and consequent deforestation as a result of this process have been proposed for parts of the region. The region is experiencing a rapid decline in forest due to deforestation resulting from a perception of endless availability of resources, low land value, incentives for forest clearing, and agrarian development policies (Nepstad and Uhl 2000). Although we still do not know the long-term outcome of these processes, national and regional economic policies have used the argument that a period of regional occupation based on high rates of deforestation will lead to economic development, increase in land value, and intensification of land use, which in combination with conservation measures may eventually decrease pressure on remaining forests and potentially allow regeneration of abandoned areas (figure 12.8A). Regional models frequently used as examples to support economic development arguments include the "greening" of parts of the world ranging from Europe and the eastern United States to the Atlantic Coastal

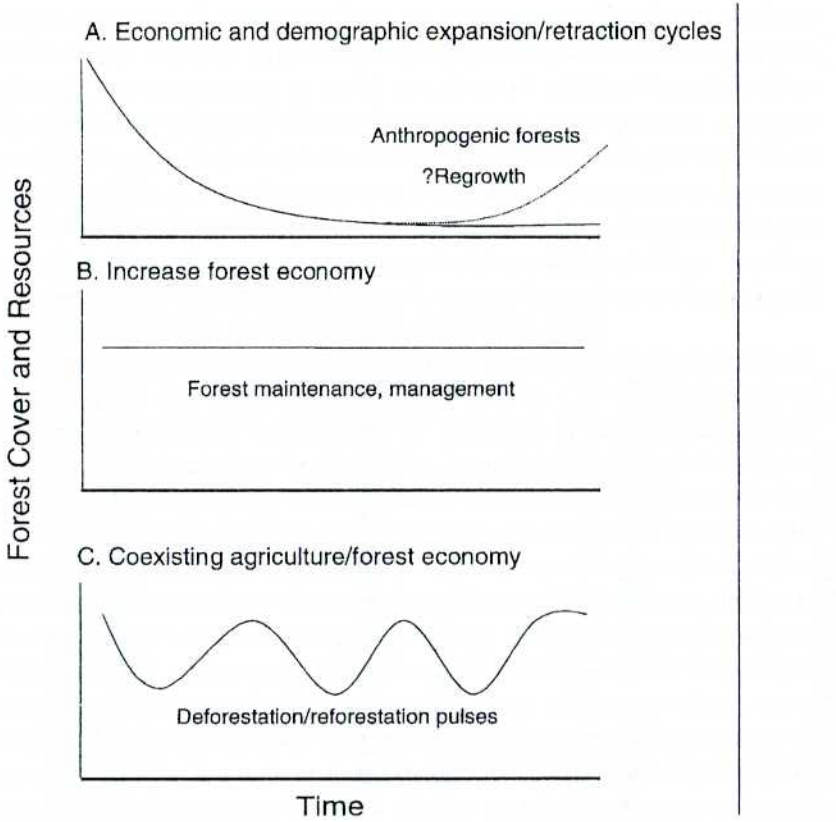


FIGURE 12.8 Coexisting intraregional trajectories of forest cover and resources.

Forest of Brazil (Dean 1996). In all cases, economic development follows the retraction of agricultural frontiers and the increase in industrialization and agricultural intensification. Different arguments explaining these trends occur in academic articles, newspapers, and political discourse (Angelsen and Kaimovitz 2001; Laurence et al. 2001; Nepstad and Uhl 2000; Nepstad et al. 2002; Silveira 2001; Verissimo, Cochrane, and Souza 2002; Wood and Porro 2002). A good example of the political power of the economic development argument is illustrated by the ongoing political debate over the expansion of corporate soybean cultivation into the Amazon (see Sant'ana 2003 and Rohter 2003).

Although it is not my goal here to discuss the explanatory value of these models, they help to elucidate changes in forest cover associated with different historical periods of the region. I have argued that contemporary land use in the region is marked by a high level of intraregional variability resulting from

the intersection of historical and contemporary regional occupation, arrival and transformation of social groups, and cumulative forms of resource ownership and land tenure. Consequently, multiple historical conditions and forms of forest use are nested within any given landscape in the region. The institutional, social, economic, and environmental complexity of the region today requires students of land use to examine multitudinous forms of forest-resource use and to analyze the coexistence of different trajectories of forest resource use. The value of the forest and diverse types of land use vary significantly among different social groups occupying the region today, hence the existence of incentives to maintain the forests. Parts of a given region may undergo decline in forest cover, but others will continue to sustain forest-based economies, and still others will experience episodic changes, such as "pulses" of deforestation, followed by regrowth (figure 12.8A–C). The coexistence of different social groups, occupation corridors, agricultural markets, conservation policies, and forms of agrarian reform within parts of the region create different conditions underlying the ways forest resources can be used. Taking into account historical conditions underlying this variability is necessary to comprehend land-use change in the region today and to account for alternative, prognostic models that can inform regional policies.

DIVERSIFYING LAND-USE ALLOCATION: MINIMIZING RISK, MAXIMIZING RETURNS

Historical and ethnographic accounts of Amazonian land use have consistently highlighted the coexistence of multiple land-use and economic strategies among indigenous and nonindigenous Amazonian populations (Browder 1989; Denevan 1984; Moran 1989; Posey and Balée 1989; Redford and Padoch 1992). This coexistence is also observed among colonist populations (Brondízio et al. 2002; Muchagata 1997). Amazonian farmers are increasingly faced with challenging conditions. Climate and environmental change, stronger competition for resources, and also stronger market fluctuations will offer even greater challenges to Amazonian land users to minimize risks while tapping into new economic opportunities. Knowing the factors influencing historical shifts in land-use economies may contribute to a better understanding of land use in the context of local livelihood strategies.

Variability in environmental resources, market opportunities, and forms of resource ownership are factors that have led land users, in particular small-scale ones, to rely on multiple economic strategies in order to achieve consumption needs and to capture available capital while minimizing the associated risks. The various degrees of engagement in cattle ranching among small and large colonist farmers also illustrate this process (Hecht 1993). Coexisting and shifting land-use strategies continue to be and will increasingly be a characteristic of

local land-use systems. For instance, decline in the price of the annual crops and increase in the external market for Amazonian fruits and wood products have led to a shift from annual agriculture to forest-based economies in different parts of the Amazon estuary (Brondízio 1999; Hiraoka 1994b; Pinedo-Vasquez et al 2001).

Understanding shifts in land allocation occurring in synchrony with local decision making and external factors are at the very core of land-use analysis. The potential cross-fertilization between land-use analysis and historical ecology may help to provide more sophisticated understanding of the range of livelihood and economic strategies across social groups living side by side in the region today.

METHODOLOGICAL IMPLICATIONS

Several practical applications of a historical ecological approach to the study of land use in the Amazon ensue from the foregoing discussion. Historical analysis of settlement formation and forms of regional occupation contributes directly to sampling design, not only in areas experiencing change since colonial times, but in areas recently colonized. A focus on intraregional historical process may even help to bridge tools such as remote sensing, on the one hand, and ethnographic research, on the other. Remote sensing data capture large regions that represent different environmental and historical conditions and often encompass landscapes that display dissimilar spatial patterns resulting from these conditions. Broadly speaking, ethnographic work, in contrast, contributes only to understanding the life histories of local land use systems. Image data may thus be used to inform fieldwork, ethnographic interviews, and survey design, and vice versa. No less important, knowledge of intraregional variability may inform ecological analysis aimed at elucidating the formation of anthropogenic forests. These examples and others (such as Brondízio et al. 1994, 1996; Castro et al. 2000) illuminate the value brought to the table by incorporating historical concerns into regional and local analyses of land-use change.

Accounting for intraregional variability in land use and land cover resulting from historical occupation also helps to facilitate image classification. Integrating remote sensing and ethnographic work on land-use history and management practices helps to fine-tune classification parameters to different parts of a scene where variation in land-cover types may have originated in differences among land-use systems, including ancient, prehistoric ones (see Erickson and Balée, chapter 7; Erickson, chapter 8; Neves and Peterson, chapter 9; Heckenberger, chapter 10, this volume). Different lengths of occupation and forms of land use result in variations in land-cover types, forest structure, and species composition. When digital satellite data are used, these parameters become important for image classification. Although spectral data provide an initial indication

of the main dissimilarities in land-cover structure, spatial patterns, and environmental conditions—such as contiguity and fragmentation of forest cover, shape, and size of patches of the dominant land cover—fieldwork on land-use history, including vegetation inventories, helps to inform and characterize these differences (Brondízio 2005). In summary, cross-fertilization of methods and tools of analysis offers an advance in the daunting task of integrating local and regional levels of analysis for comprehending land-use change.

CONCLUDING REMARKS

The growing complexity in the land uses of the Amazonian region poses challenges and opportunities for understanding human-environment interaction, analyzing land-use change, and contributing to debates and policies on regional development. As the Amazon basin takes a central stage in global and regional environmental change scenarios, analyzing human-environment interactions affecting these processes requires balancing the role of macrolevel and geopolitical forces vis-à-vis local environmental and historical conditions underlying local land-use change. In this context, the current trend in modeling future scenarios of Amazonian land use carries important political implications for different populations in the region. Modeling predictions have an eminent political application in negotiating both the economics of global change at the international level—such as carbon emissions—and national and regional priorities for development policies. The research community thus faces the political and ethical implications of defining causal relationships, developing prognostic models, and informing policy in order to alter or support particular forms of land use and particular land users or stakeholders. Attention to intraregional land-use diversity and the historical dimensions of these uses is critical to minimize misinterpretations and negative long-term consequences of national and international policies for regional development.

This chapter suggests an approach to study land use grounded on the long-term concerns of historical ecology, on the spatial dimensions of remote sensing and other tools for spatial analysis, and on the strength of integrating survey, ethnographic, and ecological tools for capturing local conditions. It is essentially an argument for an applied historical ecology of Amazonia in the immediate context of today and tomorrow. A historical and intraregional perspective to land use among Amazonian populations supplies insight into the complexity of factors affecting social and environmental change in the region. Rather than creating unmanaged complexity for macroregional analysis and policy, a better understanding of regional socioenvironmental diversity will highlight the different needs of regional populations and perhaps address the real problems of deforestation, loss of biodiversity, and poverty in the region.

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NOTES

1. Existing and planned corridors include the "Pacific route" connecting the region through Brazil, Bolivia, and Peru to Asian markets; the "Guianas route" via Amapá State; the "Caribbean route" via the Manaus-Caracas highway; and the "soybean route" via the Santarém/Cargill port, which links central Brazil and western Amazonia to the Atlantic Ocean.
2. For a detailed discussion of the term *caboclo*, see Brondízio 2004b.
3. During the Second World War, another important, though smaller, period of rubber exploitation began through a program of financial cooperation between Brazil and the United States, aiming at overcoming the stalemate of the international rubber market due to Japanese occupation of rubber-production areas in Asia. Motivated by government recruiting, a significant migration movement of Brazilian northeasterners, the Soldados da Borracha (Soldiers of the Rubber), took off particularly to western Amazonia (now the states of Rondônia and Acrê). This process had significant demographic, social, and economic influence on the formation of this part of the Amazon. Today, more than ever, the descendants of these migrants, best represented by the legacy of Chico Mendes, are shaping politically contemporary forms of occupation and land use throughout the region.
4. An approximate translation is "voice of the land"; the phrase refers to a social movement of smallholders and rural workers.
5. Many precedents in the social and biophysical sciences motivated the growth of land-use studies during the 1990s (Brondízio and Siqueira 1997). Ecologically oriented anthropologists and geographers have moved toward scaling up their local unit of analysis due to the need to understand local agriculture and economy on a more encompassing regional scale (e.g., see the human ecology volume Behrens 1994; Conant 1990; Guyer and Lambin 1993; Mertens et al. 2000; Moran and Brondízio 2001; Nyerges and Green 2000; Wilkie 1987). Anthropology in general and environmental anthropology in particular share this task through their interest in agrarian studies, political ecology, and studies of consumption and markets. In contrast, ecological and biophysical scientists working at global and regional scales have perceived the need to scale down in order to understand the impact of local land-use strategies on large-scale processes, such as on biogeochemical cycles and climate (Dale et al. 1993; Liverman et al. 1998; Skole and Tucker 1993).
6. For an up-to-date, good overview of theories used in land-use studies, see Vanwey Ostrom, and Merestisk 2005.
7. One example involves the advances in the analysis of Amazonian deforestation. The literature today shows examples of deforestation analysis at the basin, state, and national levels (e.g, INPE 1988–2001; Moran 1993a; Skole and Tucker 1993; Wood and Skole 1998), studies of vegetation type (INPE 1988–2002), and studies illustrating the articulation of even the smallest units such as the farm lots as well as settlements and municipalities (e.g., Batistela, Robeson, and Moran 2003; Brondízio, McCracken et al. 2002; McCracken, Siqueira et al. 2002; Wood and Porro 2002). Until recently, it was common to see reports of deforestation based on a Landsat scene itself or arbitrarily defined areas.
8. *The region was also influenced by a significant "gold cycle" of the 1970s and 1980s, particularly close to Itaituba along the Tapajós River.*
9. This map represents examples of research taking place at the Anthropological Center for Training and Research on Global Environmental Change (ACT) in this region since 2000. Further spatial stratification of the region has been developed for the purpose of sampling farms and households appearing during different periods of occupation.

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