Current Trends in Human Ecology

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Edited by

Priscila Lopes and Alpina Begossi

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Preface

EMÍLIO F. MORAN
INDIANA UNIVERSITY

The volume Trends in Human Ecology provides a welcomed update on recent trends and issues in human ecology, derived from a recent international symposium of the Society for Human Ecology held in Rio de Janeiro, Brazil, in October 2007. Organized by Priscila Lopes and Alpina Begossi, the volume provides overviews of very recent new trends in the field—such as interest in climate change, vulnerability, biodiversity conservation, fisheries management—as well as excellent updates on more traditional topics such as slash-and-burn cultivation, indigenous knowledge, and the development of human ecology across the world.

It is no easy task to produce any volume on human ecology that intends to be encompassing of this transdisciplinary subject, particularly within the context of SHE, the Society for Human Ecology. SHE has always been a very open society, which began it seems with a focus on environmental education, but which quickly accepted into the fold nearly all possible disciplines who addressed issues of humans and the environment, whether they were engineers, anthropologists, ecologists, or pedagogues. This has always made the meetings interesting but lacking in some coherence and "take home" messages. The meeting in Rio was different. The organizers kept the door open but they managed to give this one meeting a wonderful coherence around a focus on fisheries and fisheries management around the world. Thus the tradition of SHE was maintained while also having an exceptional focus on a topic very appropriate to its location—since Rio was a fishing community before it became one of the most beautiful tourist destinations.

This volume has several papers on fisheries management, including traditional knowledge possessed by fishers. These are among the strongest papers in the volume, as might be expected given the expertise of the organizers, and the strong focus of the meeting on this topic. This will help readers of the volume to come up to speed on a topic which is less well known to most of the community of human ecologists who are more terrestrial by inclination. This is an important corrective since most of our planet is water, and most people leave within close proximity to the coast,

and yet so much of our research in all disciplines, including human ecology, tends to occur far from the coastlines and to overlook the "fishing mode of production". We think about hunting/gathering, agriculture, pastoralism, and industry but tend to overlook fishing (except as an overlooked appendage to hunting). This volume goes a long way to restore some balance to our view of the various activities that make up our systems of production and reproduction.

There is very little in the volume on hunting/gathering, perhaps reflecting the much reduced attention to these populations in recent years, and their ever diminishing numbers worldwide. The chapter on slash-and-burn is a superb update on a persistent material mode of production, and one that always seems to change and adapt to changing conditions. It still constitutes a basis for the living of many millions of people, who now combine it with more intensive activities as well. The meticulous literature review here is a major service to the human ecology community.

The chapters dealing with climate, culture, and vulnerability highlight the role of social scientists in addressing the climate change dynamics around us. It also shows that there is still a major divide between what social scientists are doing and saying about climate change, and the work of atmospheric and climate scientists in the natural sciences. The discussion here is still more from the view of social science, and does not link to the modelling activities and the uncertainties that are at the center of climate models and the changing scales of these studies. By having this discussion here, we can hope that readers and other scientists will join the climate scientists in having a more integrative approach to climate change that takes into account the human dimensions which are surely as important as the natural processes.

This is consistent with the direction of the field of human ecology, as it moves and joins other scientific tendencies towards Integrative Science, wherein natural and social sciences formulate questions jointly, engage in research in a joint enterprise, and provide integrative analyses with real policy implications that do justice to the human and the natural processes. This volume begins to move us in this welcomed direction, and can be seen as representing the trends in research that must characterize work in the 21st century.

Introduction

ALPINA BEGOSSI AND PRISCILA LOPES

The Society for Human Ecology and its contribution to the development of the field

Human Ecology is the study of all relationships that take place between human beings and nature. Under this discipline, human culture and behaviour are not seen as a sole product of society, but also as the result of the influence of and interaction with physical and biological variables. As such, several ecological concepts ranging in scale from population to evolutionary ecology are commonly applied and associated to economic, anthropological and sociological theories and applications.

Writing about Current Trends in Human Ecology is a dynamic task, due to a diverse domain of research and multiple scales that have resulted in the accelerated development and rapid production of evolving approaches. This can be certainly observed within the meetings of the Society for Human Ecology (SHE) and its themes to date.

This book catches a glimpse of today's intellectual diversity and recent trends in the field of Human Ecology. Based on the XVth SHE International Meeting held in Rio de Janeiro (October 2007), this book shows the varied research lines that were presented at that time. However, this volume goes beyond the meeting as it lays out a detailed cumulative summary of the current trends in human ecology.

SHE has been an institutional foundation that collects up-to-date developments in human ecology topics, facilitating critical analysis and making them available through conferences, peer-reviewed journals and scientific gatherings. As an interdisciplinary field, Human Ecology is a novelty and only recently has it started to be included in the academic curricula, despite its critical relevance, given emerging social and environmental challenges. Borden (2008) wrote a brief history of the Society for Human Ecology, highlighting some of these important aspects inherent to an interdisciplinary field:

> Each discipline has a home territory, architecturally walled off as its own domain. Some of the fiercest barriers divide adjacent fields. It is little wonder that interdisciplinary pursuits have struggled to secure a place in modern universities. These are the obstacles the founders of the Society for Human Ecology confronted. They still remain. It is unlikely they will ever disappear.

The challenge of interdisciplinary pursuit has contributed to maintain the vigour of such a self-motivated field. We agree with Borden (2008) that Human Ecology makes no claim that pursuing specialized knowledge is misdirected. Specialized knowledge leads the mind to specific complex questions. Nevertheless, the open minds of human ecologists bring up heretic questions, linking areas that are traditionally separated, contributing with new methods, and then making human ecology continue to develop within an authentic scientific domain.

Box I-1 – Themes of the Meetings of the Society for Human Ecology.

1. Human Ecology: a gathering of perspectives, College Park, Maryland, 1985.
2. Human Ecology: research and applications, Bar Harbor, Maine, 1986.
3. Human Ecology: steps to the future, San Francisco, California, 1988.
4. Human Ecology: strategies for the future, East Lansing, Michigan, 1990.
5. Human Responsibility and Global Change, Gothenburg, Sweden, 1991.
6. Human Ecology: crossing boundaries, Snowbird, Utah, 1992.
7. Human Ecology: progress through integration of perspectives, East Lansing, Michigan, 1994.
8. Human Ecology: livelihood and liveability, Lake Tahoe, California, 1995.
9. Local and global communities: complexity and responsibility, Bar Harbor, Maine, 1997.
10. Living with the land: interdisciplinary research and adaptive decision making, Montreal, Canada, 1999.
11. Democracy and sustainability: adaptive planning and management, Jackson Hole, Wyoming, 2000.
12. Tourism, travel and transport: a human ecological perspective on human mobility, Cozumel, Mexico, 2004.
13. Human Ecology: research and practice, Salt Lake City, Utah, 2005.
14. Interdisciplinary integration and practice: reconciling humans and nature, Bar Harbor, Maine, 2006.
15. Local populations and diversity in a changing world, Rio de Janeiro, Brazil, 2007.
16. Integrative thinking for complex futures: creating resilience in human-nature systems, Bellingham, Washington, 2008.
17. Human Ecology for an urbanising world, Manchester, United Kingdom, 2009.

The annual meetings of SHE creates a forum that transmits developments in the area of human ecology, reflecting the local and regional issues where the meeting was held. Beginning with a Directory of Human Ecologists (Borden and Jacobs 1989), the society has organized meetings since 1985. Meetings typically have integrative perspectives, as it can be seen by some of the conference themes: "Livelihood and Liveability", in Lake Tahoe, USA, 1995; "Living with the Land", in Montreal, Canada, 1997; "Adaptive Planning and Management", in Jackson Hole, USA, 2000; and "Tourism, Travel and Transport", in Cozumel, Mexico, in 2004 (see Borden 2008, for a brief history of SHE and Box I-1 for a complete list of conference themes).

Human Ecology in Rio: Past and Current Trends

The development of human ecology covers an array of different areas integrating humans and their interaction with the environment. Among some of the authors that have contributed to the development of theories and methodologies it is worth mentioning Richerson (1977), who compared theories between biological and social sciences and then went further with studies on the interactions of gene and culture (Boyd and Richerson 1985); Morán (2007), who has been studying human adaptability, specially on the Amazonian frontiers; and Berkes (1989, 2008), whose contributions are directed towards the theory of the commons and the intersection between local knowledge and adaptation.

Under the domain of Human Ecology, there are different fields approaching the relationships of human populations and nature. After 1980's some areas progressed into their own dynamics, as they changed and adapted to new information from the biological and social sciences. Examples of this include the case of Cultural Ecology (Steward 1955; White 1943; Harris 1977, 1979; Orlove 1980), Ethnobiology (e.g.: Berlin 1992) and applications of modelling behaviour, such as optimal foraging theory and life history strategies (Winterhalder and Smith 1981; Smith and Winterhalder 1992; Borgenhoff Mulder 1992). Sociobiology must also be mentioned, as it covers many different aspects of human behaviour, and currently addresses other social polemic issues, such as religion (Dawkins 2006). We should not forget about the branches of Cultural Transmission models, such as Richerson and Boyd's (2005), and Lumsden and Wilson's (1981). Ethology had its own development side by side to human ecology, and Bekoff (2002) blends the interface between humans-animals and the environment.

Box I-2 – Topics approached in the XVth Society for Human Ecology Conference, Rio de Janeiro, Brazil.

1. Adaptive Co-Management: Building Resilience in Local Management Systems
2. Advances in Ethnoecology and Ethnobotany
3. Agroecology and Sustainable Rural Development
4. At-Distance Education in Human Ecology: Opportunities and Challenges
5. Behavior and Ecology: Psychology Looks at Mind and Nature
6. Climate and Culture
7. Co-managing Common-Pool Resources: Challenges and Advances
8. Community-Based Faunal Management
9. Contributions of Fishers' Local Ecological Knowledge and Scientific Research to Marine Mammals' Conservation
10. Contributions of Human Ecology to Understand and to Manage Artisanal Fisheries
11. Culture Nurturing Nature: A Chance for (Environmental) Change
12. Diversity and Management: from Extractive to Farming systems
13. Environment and Agriculture
14. Environmental Degradation
15. Environmental Pollution and Cultural Pollution
16. Environmentally Significant Consumption (ESC): Emphasis on Food
17. Folk and Indigenous Transformations in the Amazon region: Implications of Contact, Land-Use Schemes and Market Economies
18. Geographic Information Systems and Remote Sensing in Studies of Population and Environment
19. Human Ecology and Health
20. Integrated Analysis of Local Socioecological Systems: Combining Agent-Based and Stock-Flow Modeling Approaches
21. Local Knowledge (LEK/FEK) and the History of Aquatic Ecosystems
22. New Directions in Human Ecology - Higher Education for Sustainable Development
23. Searching the Real Values of the Sea: the ECOST Perspective
24. Shifting Cultivation and Tropical Forests in a Changing World
25. Social-Ecological Systems Analysis: Understanding Complex Social-Ecological Dynamics: Integrating different geographical scales in coastal systems
26. Sustainability and the Impact of Aid on Indigenous People
27. Temporal and Spatial Cross-Scale Approaches in Human Ecology: Implications for Resource Use from Cultural Evolution and Behavioral Ecology
28. The role of Indigenous knowledge in the Adaptive Process
29. Traditional People, Biodiversity and Cultural Diversity
30. Using and Perceiving a Changing Environment

Aspects related to human cognitive features have also played a role within human ecology. Linguistic and evolutionary psychology have emerged with new questions, methods, and a critical view of previous evolutionary approaches (Hauser 2000; Gottschall and Wilson 2005; Pinker

1994). Education has always been part of each of these branches in human ecology. Reviews covering different areas and authors in human ecology are found in Begossi (1993, 2004), Borden (2008), Laland and Brown (2002), among other researchers.

Recently, the need and urgency for natural resource conservation has been globally recognized. Applications, such as ecological economics, local knowledge and management, collective action, socio-ecological modelling, and adaptive management, have addressed the pressing needs of conservation (Berkes 2008; Ostrom 2002). This aspect is recurrently emphasized in all case studies presented in this book.

The XVth Meeting in Rio de Janeiro, Brazil in 2007, which this book is based on, focused on the theme "Local Populations and Diversity in a Changing World". However, given the broad spectrum of the field, the meeting encompassed a sub-set of the above topics, as shown below. Thirty topics were approached by about 200 people who attended the meeting, representing the developments of Human Ecology in 27 countries from all inhabited continents (Box 2). While integrating this meeting, not all the individual topics were included in the organization of this book, in order to provide a synopsis of the main ideas. However, two of these topics also resulted in special volumes of two peer-reviewed journals:

a) *Environment, Development and Sustainability*, organized by Hens and Begossi (volume 10, 2008), based on the session "Diversity and Management: from Extractive to Farming systems" (session 12);

b) *Boletim do Museu Paraense Emilio Goeldi*, organized by Adams and Murrieta (volume 3, 2008), based on the session "Shifting Cultivation and Tropical Forests in a Changing World" (session 24).

In such regard, we minimized redundancy and looked for more general contributions that could bring a state-of-the-art approach on main fields. We must acknowledge that we had pleasure in putting together the pieces of work that will follow in this book, revealing how human ecology enriches our minds, builds tools to adapt to a changing environment, and shows potential mechanisms and policies to sustain it.

This book is divided into three sections. **Section I,** Human Ecology and the Environment, deals with three aspects of environmental concerns and uses of it: slash-and-burn agriculture and its impacts and trade-offs regarding tropical forests; how local cultures perceive and suffer the consequences of ongoing changes in climate; environmental degradation and the cultural context of decisions concerning the environment. **Section II,** Knowledge and Management, explores how knowledge is used to correct previous unsustainable resource exploitation, using theories and methods from human ecology. Examples are drawn from tropical and coastal marine

fisheries. **Section III,** Integrating Human Ecology, brings together areas that have been tangential to human ecology yet inherent to human systems. Specifically, this section focuses on health as a function of environmental conditions, the link between economic valuation and environmental and social costs, and institutional education of human ecology, topics that are typically outside the agenda of human ecology.

Section I, Human Ecology and the Environment, has Chapter One by Pedroso-Junior et al., on slash-and-burn agriculture and tropical forests. It is a much needed review of tropical agriculture, describing impacts of such management, including removal of primary forests and more permanent alterations of the biogeochemical environment. It shows how such changes can affect the soil, for example when the fallow periods of slash-and-burn shrinks, and how subsequent deforestation contributes to greenhouse effects and climate change. Land use changes and alternatives to slash-and-burn are provided through a detailed analysis. The chapter on Climate Change and Culture, by Crate follows, beginning with key concepts from ecology. It describes and compares habitats under transformation using examples of current cultures from high to low latitudes, as well as different altitudes: a review from the current anthropological literature is provided throughout the chapter. Burn's study in Chapter Three draws on culture and its association with environmental degradation. It defines culture in a temporal context, along with its collective meaning and perspective. The ethical, institutional and political foundation of culture is analyzed in the light of environmental changes.

Section II, Knowledge and Management, begins with Chapter Four by Silvano et al. drawing attention to the management of tropical small-scale fisheries. Here, the lack of information in tropical fisheries and the urgency of managing declining and threatened fisheries are described. Paralleling such aspects, an analysis of concepts and methods of local ecological knowledge (LEK) are shown, integrating scientific and local knowledge. A case study illustrating the applications of LEK and its methods with fishermen and cetaceans are shown in the second part of this chapter. In Chapter Five Hanazaki et al. bring a novelty in terms of ethnobotanical applications, describing how fishers use forest resources to improve fishing output, linking biodiversity to local knowledge. The authors show that knowledge about plants can persist among fishers despite current urbanization processes. Morrison and Singh bring a chapter on adaptation and indigenous knowledge. It begins with sustainability concepts, methods and qualitative measures, and links ecological concepts and methods to indigenous knowledge in a historical context. The importance of understanding figurative thought and substantive knowledge (skills and

practises), among other aspects of indigenous knowledge, might bridge authentic dialogue between dominant global culture and indigenous culture. Seixas et al. brings an analysis of co-management in Brazil, using a framework of common property theory. After providing the local context, five case studies are shown, covering a wide diversity in aquatic and coastal habitats. Chapter Eight, the last of Section II, focuses on human ecology of coastal and marine systems. The chapter by Glaeser et al. embodies a conceptual-methodological analysis of integrated coastal zone management (ICZM) using social-ecological system analysis. These authors present an historical background of coastal management along with an interdisciplinary and epistemological analysis. Future prospects such as management, integrative methods, and the difficulties of dealing with uncertainty and complexity in human-nature systems are highlighted.

The book ends with **Section III** closing connections that encompass all previous chapters, conceptually, historically and methodologically. Chapter Nine, by Avila-Pires, Human Ecology and Health, emphasizes mainly the human dimension of human ecology. It focuses on the health of rural and urban populations, and how agriculture and its infrastructure affect the epidemiological processes in human populations. Chapter Ten, by Failler et al., emphasizes the importance of linking management of marine resources to societal benefits, using examples from the international ECOST project. Opening with an evaluation of traditional bio-economic models and their limitations, they analyze valuing processes of fishing activity, considering ecological, economic and social costs. Non market values, such as marine heritage and its cultural symbols are also considered. The 11th and final chapter, by Dyball et al., begins with the future of institutional education of human ecology, approaching current technology, communication processes and online resources. Putting human ecology in an historical and interdisciplinary perspective, the authors contextualize educational networks that came out with the development of the area. The use of at-distance education offers promise for academic curricula in human ecology. Examples of recent institutional developments are provided from various universities around the world, along with incentives for future progress.

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Section I

Human Ecology and the Environment

CHAPTER ONE

Slash-and-Burn Agriculture: A System in Transformation

NELSON N. PEDROSO-JUNIOR, CRISTINA ADAMS AND RUI S. S. MURRIETA

Slash-and-burn agriculture has been practised for thousands of years in the forests around the world, especially in the tropics, where it provides for the livelihood of countless poor rural populations. Characterized by an array of techniques based on crop diversification and shifting land use, this cultivation system has on the utilization of forest decomposing vegetation's energetic capital its main asset. Many studies claim that slash-and-burn agriculture is sustainable when performed under conditions of low human demographic density, maintaining or even increasing local biodiversity. However, it is growing in the academic literature, as well as in development debates, the concern regarding the role that this system has been playing in the deforestation of the planet's tropical forests. This process appears to be closely linked to changes in land use patterns (agricultural intensification) and urban and rural demographic growth. On the thread of these concerns, this article presents a critical review of the international and national academic literature on slash-and-burn agriculture. Thus, this review intend to draw a broad scenario of the current academic debate on this issue, as well as to identify the main alternatives strategies proposed to maintain or replace this cultivation system.

Introduction

Slash-and-burn agriculture has been practised in the world's tropical regions for thousands of years, where it is the cornerstone of the subsistence systems of poor rural populations. Many studies have attempted to understand the dynamic of these systems and their environmental and socio-economic effects. Nevertheless, no hegemonic view emerges from the literature on the issue, where different and often conflicting approaches

have had varying degrees of impact depending on the political and academic backdrop of the day. The literature is full of studies that treat slash-and-burn agriculture, to a greater or lesser extent, as destructive and exploitive of the natural resources of the humid tropics, very often proposing alternatives to replace it. One can also find numerous studies that argue for the system's sustainability and draw up proposals for the maintenance of this traditional mode of agriculture.

In this light, the aim of this chapter is to review the literature on slash-and-burn agriculture in order to understand the different ways in which the theme has been approached, as well as to analyse the alternatives that have been proposed to replace it and what would be the benefits of maintaining the system. Firstly, the text will look at studies that describe the system as a whole, as well as its components separately, in an attempt to characterize it and identify the practices and techniques that promote its sustainability. Secondly, the analysis will turn to the environmental impacts caused by slash-and-burn agriculture, especially those studies that apportion it some of the blame for deforestation and biodiversity loss in tropical forests, for global warming and for soil erosion and impoverishment. In a world of constant environmental and socio-economic change, special attention is paid to studies that analyze changes in forms of land use and their effects on the subsistence of smallholders that practise fire-fallowing. Lastly, the article will run through the proposals being made to either substitute slash-and-burn agriculture or promote its sustainability through low-impact technologies and alternative income sources for the traditional farmer.

Slash-and-Burn Agriculture

Definition and Range

Slash-and-burn agriculture can be broadly defined as any continuous agricultural system in which ground is cleared to make way for fields that will be farmed for shorter periods of time than they are left to fallow (Conklin 1961; Eden and Andrade 1987; Kleinman et al. 1995; Posey 1984). McGrath (1987) defines it as a resource management strategy in which plots are rotated so as to mine the energetic and nutrient capital of the natural forest soil/vegetation complex, which often provides the only source of nutrients for cultivation. Slash-and-burn agriculture is a highly efficient adaptation to conditions in which labour rather than land is the core limiting factor on agricultural production (Boserup 1965).

The process is given many names in the literature, including *swidden* (England), *rai* (Sweden), *coivara, milpa, conuco, roza, chacra, chaco* (Latin America), *shamba, chitemene* (Africa), *jhum* (India), *kaingin* (Philippines), and *ladang* (Indonesia and Malaysia), among others. Nevertheless, the most common designations for this process are *slash-and-burn*, *shifting cultivation* and, less frequently, *swidden*. Eden (1987) suggests the use of the term "swidden" to designate shifting cultivation in the strict sense, where the scorched clearings are farmed for a shorter period than their fallow length. Though the use of the term has been encouraged by anthropologists, it has won little favour with researchers from other areas, who tend to prefer "shifting agriculture" and "slash-and-burn agriculture". However, designations vary and confusion can occur. In an attempt to standardize usage and differentiate between the two systems, Sanchez and collaborators (2005) suggested the use of shifting cultivation to refer to the traditional rotation system with long periods of fallow, which would be equivalent to Eden's "swidden" (1987), and slash-and-burn agriculture to designate other scorched earth systems with short or even non-existent fallow.

As this article is a review, we have opted for the broadest possible term, slash-and-burn agriculture, which, by extension, also includes shifting cultivation in the strict sense. In the interests of coherency with the terminology used by the authors under discussion, the distinction will be made as necessary. However, the degree of shift or proportion between farming and fallow lengths can vary greatly, making such a distinction hard to draw, as suggested by the above mentioned authors.

In terms of range, slash-and-burn agriculture is currently practised throughout the tropics and even into some sub-tropical regions. According to a study published by Lanly (1982), slash-and-burn agriculture was responsible for the formation of two-thirds of the earth's secondary forests. Of all the area under secondary forest cover originating from abandoned plots, 47% is located in Latin America, with the rest distributed between Africa and Asia (Lanly 1982). Some authors argue that, depending on the production activities established on deforested areas, secondary forest may eventually become the predominant ecosystem in the Amazonian landscape (Pereira and Vieira 2001). Although these figures need to be updated, it is estimated that slash-and-burn agriculture ensures the livelihoods of somewhere between 300 and 500 million people worldwide, the majority in the Tropics (Attiwill 1994; Brady 1996; FAO 1985; Lanly 1982), together using 240 million hectares of dense forest and 140 million hectares of open forest, or approximately 21% of the world's total tropical forest cover

(Lanly 1982). In the Amazon, traditional slash-and-burn practices feed some 600 thousand smallholder families (Homma et al. 1998).

History and Concept of Cultural Forests

Slash-and-burn agriculture is probably the oldest system of cultivation (Nye and Greenland 1960), dating back as far as the Neolithic, when human populations gradually switched from hunter-gathering to the more sedentary habits of agropastoral activities (Dean 1996; Harris 1972; Iversen 1956; Mithen 2003). However, before the advent of agriculture, anthropogenic fires may well have contributed indirectly to changes in forest ecosystems and climate (Schüle 1990a, 1990b, 1992a, 1992b). Throughout Antiquity, slash-and-burn practices were widespread in temperate regions, but with population growth in Europe and Asia, especially from the 18th Century onwards, farming activities had to be intensified and the practice was abandoned (Boserup 1965, Worster 2003). According to Boserup (1965), the system's range was limited in these regions to the sparsely populated forest remnants of Eurasia and to the mountains of Japan and Korea. In Switzerland during the Middle Ages (9th to 16th Centuries), the practice was encouraged by the government as a means of ensuring the livelihoods of the poor and of converting forest into inhabitable land, generating more taxes for the kingdom as a result (Hamilton 1997).

In tropical forests like the Amazon, where many of the wild vegetal species are inedible or hard to harvest, slash-and-burn agriculture was an extremely important adaptive strategy to support the subsistence economy in place there (Sponsel 1986). However, some authors have contested the antiquity of slash-and-burn in the Amazon. Denevan (1991) suggests that slash-and-burn agriculture with lengthy fallow periods in the Amazon was a practice introduced shortly after the arrival of the Spanish and Portuguese colonists and adopted only once metal tools had become available. He argues that it would have been very difficult to open clearings in dense Amazonian forest using stone tools, which was why the cultivations were more perennial and were disintensified as slash-and-burn practices spread after colonization. The same would seem to hold for North-America (Doolittle 1992). The importance of slash-and-burn agriculture to the subsistence of pre-Columbian Amazon populations has also been questioned from the perspective of the processes of producing Indian black earth (German 2003; Lima et al. 2002).

One way or another, the fact is that many authors are today questioning the way western science has viewed the tropical forests, i.e., as pristine

formations, when in reality they have been, or may have been, highly managed by people (Adams 1994; Balée and Campbell 1990; Brown and Lugo 1990; Denevan 1992; Lindbladh and Bradshaw 1998; Sanford et al. 1985; Uotila et al. 2002; Willis et al. 2004). Hence the development of new concepts, including those of cultural forest (Adams 1994; Balée 1989), anthropogenic forest (Peluso 1996) and secondary forest (Brown and Lugo 1990; Noble and Dirzo 1997). Gómez-Pompa and collaborators (1987), in Mexico, and Heckenberger and collaborators (2003), in Brazil, have demonstrated that large swathes of forest hitherto considered primary are actually secondary forests previously managed by indigenous societies. In the Atlantic Forest, the stewardship of Pre-Columbian populations can be inferred from evidence of the activities of hunter-gatherers in the region dating back as far as 11 thousand years (Dean 1996). This evidence also indicated a gradual shift from the gathering of vegetal foodstuffs to planting and harvesting through the development of the slash-and-burn technique (Dean 1996).

The Dynamics of the System

Soils and the Nutrient Cycle

When practised in traditional fashion in large forest areas, with low-impact technologies and long fallow periods, slash-and-burn agriculture can be managed in an ecologically sustainable manner, without drastically affecting soil fertility (Johnson et al. 2001; Kleinman et al. 1995; Mendoza-Vega et al. 2003). It is a practice particularly suited to many tropical soils, which are normally not very rich or lack certain nutrients (Adams 2000a). In the Amazon, for example, most of the different soil types are nutrient-poor, except the purple soils and the anthropic variants, such as Indian black earth (Denevan 1996). As such, the system depends on the burning of the biomass accumulated during the clearing in order to boost the nutritional status of the soil and prepare the area for plantation using the ashes, which can vastly increase the potassium, calcium and magnesium content (Andriesse and Schelhaas 1987b; Brinkmann and de Nascimento 1973; Oliveira 2008; Stromgaard, 1984).

The role of organic material and the nutrient dynamic under the slash-and-burn agricultural system have been widely studied in tropical regions of Africa, South America and Asia (Brubacher et al. 1989; Davidson et al. 2007; Frizano et al. 2003; Johnson et al. 2001; Markewitz et al. 2006;

Nakano 1978; Nye and Greenland 1960; Oliveira et al. 1994; Tulaphitak et al. 1985; Van Reuler and Janssen 1993; Zarin et al. 2005). Many of these studies have focused on changes in nutritional status after slash-and-burn (Palm et al. 1996), but few have compared the total nutrient stocks in primary forest soils with those of farmed lands and the successive stages of subsequent brushwood (Frizano et al. 2003; Johnson et al. 2001; Juo and Manu 1996; McDonald et al. 2000; Oliveira 2008; Zarin et al. 2005). Among those who have, Frizano et al. (2003) and Johnson et al. (2001) conclude that the effects of slash-and-burn on C, N, P, K, Ca and Mg stocks are not sufficient to compromise the growth of secondary Amazonian forest, despite the study area having suffered various fire-fallow cycles for agricultural purposes. In the Brazilian Atlantic Forest, Oliveira (2008) has verified that nutrient-capturing mechanisms (litter and end roots) recover relatively quickly (5 years) after the abandonment of a plot. On the other hand, Zarin et al. (2005) have shown that a history of successive burnings reduces the secondary forest growth rate in the Amazon Basin, mainly due to reduced nutrient stocks in cycle. Moreover, forest areas previously burned become more susceptible to fire (Malhi et al. 2008; Zarin et al. 2005).

Some more detailed studies have attempted to calculate approximately how long it takes soils to recover after cultivation. Based on a review of the literature, Brown and Lugo (1990) wagered a period of 40 to 50 years for the soil's pool of organic material to recover sufficiently to resemble that found in adjacent mature forest. This relatively long period of recuperation is due to the high productivity of the growing forest during the first 20 years after the abandonment of the farmed land, when the nutrient cycle is restricted to the top layers of live biomass and litter, without reaching the soil itself. The soil, in turn, will only recover and accumulate organic matter after the twenty-year mark, when the brush growth-rate diminishes and soil nutrient stocks are more efficiently replenished (Juo and Manu 1996). Nevertheless, the delicate balance of the nutrient cycle – biomass topsoil and litter – is compromised by the precocious burning of the cleared vegetation, as the nutrients that were not rapidly absorbed by the vegetation re-colonizing the area will be run off and irretrievably lost (Sanchez et al. 1982). The environmental damage caused to soil's nutritional status and nutrient cycle under the fire-fallow system will be discussed in the following section.

Brushwood and Vegetal Succession

As with the nutritional status of the soil, studies have also been conducted into the dynamic of secondary forests and the richness and similarity of their species load in comparison with the primary forests (Guariguata and Ostertag 2001; Swaine and Hall 1983; Uhl 1987). Brearley and collaborators (2004), for example, conclude that a period of 55 years after the abandonment of a plantation is long enough for the original forest structure to recover, but not for the majority of species found in primary forests to return. Other authors have investigated the issue, but, given the differences in environment and intensity and scale of cultivation, the recuperation periods vary considerably: 60 to 80 years (Brown and Lugo 1990), 150 to 200 years (Knight 1975; Saldarriaga and Uhl 1991), 250 to 500 years (Kartawinata 1994) and centuries (Whitmore 1991). According to Brown and Lugo's review (1990), secondary forests present wood species in similar number to those found in mature forests relatively quickly, within a timeframe of roughly 80 years. In some cases, species recovery took much less than 80s years, and in others the secondary forest presented a higher number of species than the primary forest it replaced. Post-abandonment succession has also been the subject of much study, with many papers focusing on vegetal succession in the initial stages (Aweto 1981; Uhl 1987), while others go on to more advanced stages (Saldarriaga et al. 1988). Some focus on floristic diversity (Saldarriaga et al. 1988; Smith et al. 1999; Stromgaard 1986; Tabarelli and Mantovani 1999), while others emphasize the accumulation of biomass and its relationship with soil recovery (Stromgaard 1985). Ethnoecological studies have sought to investigate the knowledge and use of vegetal species as indicators of different levels of disturbance to the brushwood after the plots have been abandoned (Slik et al. 2003), or even of soil degradation (Styger et al. 2007). Lastly, over the last two decades, the study of secondary forest succession has received a great deal of attention because of the debate on global warming and carbon uptake (Fearnside and Guimarães 1996; Guariguata and Ostertag 2001; Tschakert et al. 2007). This theme will be looked at more closely in the following section, on the damaging effects of slash-and-burn.

Soil use directly influences species composition in secondary forest for many decades to come, making predictions on the succession process extremely difficult to make (Guariguata and Ostertag 2001; Pereira and Vieira 2001). In brushwood, thirty years after the abandonment of a plot, the diversity is greater than that found on former coffee plantations, where the few species used to provide shade there end up predominating (Brown and Lugo 1990). In the Amazon, the brushwood on abandoned pasture is