

SLASH-AND-BURN AGRICULTURE

Slash-and-Burn Agriculture

THE SEARCH FOR ALTERNATIVES

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Contents

Foreword ix

Preface xi

Contributors xv

Acronyms and Abbreviations xxxi

I *The Problem and Approach*

1 Alternatives to Slash and Burn: Challenge and Approaches of an International Consortium

Pedro A. Sanchez, Cheryl A. Palm, Stephen A. Vosti, Thomas P. Tomich, and Joyce Kaszyki 3

II *Thematic Research*

2 Carbon Losses and Sequestration After Land Use Change in the Humid Tropics

Cheryl A. Palm, Meine van Noordwijk, Paul L. Woomer, Julio C. Alegre, Luis Arévalo, Carlos E. Castilla, Divonzil G. Cordeiro, Kurniatun Hairiah, Jean Kotto-Same, Appolinaire Moukam, William J. Parton, Auberto Ricse, Vanda Rodrigues, and Syukur M. Sitompul 41

3 Greenhouse Gas Fluxes in Slash and Burn and Alternative Land Use Practices in Sumatra, Indonesia

Daniel Murdiyarso, Haruo Tsuruta, Shigehiro Ishizuka, Kurniatun Hairiah, and Cheryl A. Palm 64

4 The Potential Role of Above-Ground Biodiversity Indicators in Assessing Best-Bet Alternatives to Slash and Burn

Andrew N. Gillison 83

- 5 Below-Ground Biodiversity Assessment: Developing a Key Functional Group Approach in Best-Bet Alternatives to Slash and Burn
David E. Bignell, Jerome Tondoh, Luc Dibog, Shiou Pin Huang, Fátima Moreira, Dieudonné Nwaga, Beto Pashanasi, Eliane Guimarães Pereira, Francis-Xavier Susilo, and Michael J. Swift 119
- 6 Sustainability of Tropical Land Use Systems After Forest Conversion
Kurniatun Hairiah, Meine van Noordwijk, and Stephan Weise 143
- 7 The Forest for the Trees: The Effects of Macroeconomic Factors on Deforestation in Brazil and Indonesia
Andrea Cattaneo and Nu Nu San 170
- III *Site-Specific Alternatives to Slash-and-Burn Agriculture*
- 8 Sustainable Forest Management for Smallholder Farmers in the Brazilian Amazon
Marcus V. N. d'Oliveira, Michael D. Swaine, David F. R. P. Burslem, Evaldo M. Bráz, and Henrique J. B. de Araújo 199
- 9 Permanent Smallholder Rubber Agroforestry Systems in Sumatra, Indonesia
Gede Wibawa, Sinung Hendratno, and Meine van Noordwijk 222
- 10 Coffee, Pastures, and Deforestation in the Western Brazilian Amazon: A Farm-Level Bioeconomic Model
Chantal L. Carpentier, Stephen A. Vosti, and Julie Witcover 233
- 11 Smallholder Options for Reclaiming and Using *Imperata cylindrica* L. (Alang-Alang) Grasslands in Indonesia
Pratiknyo Purnomosidhi, Kurniatun Hairiah, Subekti Rahayu, and Meine van Noordwijk 248
- IV *National Perspectives*
- 12 The Western Brazilian Amazon
Judson F. Valentim and Stephen A. Vosti 265
- 13 The Forest Margins of Sumatra, Indonesia
Soetjipto Partohardjono, Djuber Pasaribu, and Achmad M. Fagi 291

- 14 The Forest Margins of Cameroon
James Gockowski, Jean Tonyé, Chimere Diau, Stefan Hauser, Jean Kotto-Same, Rosaline Njomgang, Appolinaire Moukam, Dieudonné Nwaga, Téophile Tiki-Manga, Jerome Tondoh, Zac Tschondeau, Stephan Weise, and Louis Zapfack 305
- 15 The Peruvian Amazon: Development Imperatives and Challenges
Douglas White, Manuel Arca, Julio Alegre, David Yanggen, Ricardo Labarta, John C. Weber, Carmen Sotelo-Montes, and Héctor Vidaurre 332
- 16 Northern Thailand: Changing Smallholder Land Use Patterns
Plodprasop Suraswadi, David E. Thomas, Komon Pragtong, Pornchai Preechaphanya, and Horst Weyerhaeuser 355
- V *Cross-Site Comparisons and Conclusions*
- 17 Land Use Systems at the Margins of Tropical Moist Forest: Addressing Smallholder Concerns in Cameroon, Indonesia, and Brazil
Stephen A. Vosti, James Gockowski, and Thomas P. Tomich 387
- 18 Balancing Agricultural Development and Environmental Objectives: Assessing Tradeoffs in the Humid Tropics
Thomas P. Tomich, Andrea Cattaneo, Simon Chater, Helmut J. Geist, James Gockowski, David Kaimowitz, Eric F. Lambin, Jessa Lewis, Ousseynou Ndoye, Cheryl A. Palm, Fred Stolle, William D. Sunderlin, Judson F. Valentim, Meine van Noordwijk, and Stephen A. Vosti 415
- Index* 441

Foreword

This remarkable volume addresses the sustainable management of tropical forests with unstinting sophistication, moving the analysis beyond clichés to the true complexities of the challenge. The world's tropical forests, in Latin America, Africa, and Asia, are being cut down, at enormous costs to local and global biodiversity and ecosystem services. The carbon released by tropical deforestation is a significant factor in the overall increase in atmospheric greenhouse gases. Yet the “best bets” to deal with the challenge of tropical deforestation remain far from obvious. The studies collected here offer new conceptual tools and a rich compendium of empirical analyses that will be needed to formulate a set of viable responses to this major global challenge.

The traditional interpretation of tropical deforestation has usually proceeded in something like the following way. A rising population of smallholder farmers at the forest margin—the boundary between farm and forest—leads to deforestation as forests are cut to make room for new farms. At the same time, existing farmland is abandoned because of land degradation, soil erosion, and soil nutrient depletion. The loss of existing farmland is exacerbated by the pressure of shortened fallows, caused by the rise of population densities. In this traditional view, the best way to slow or stop deforestation would be to raise productivity on existing farms in a sustainable manner—for example, through the systematic replenishment of soil nutrients, so that pressures to expand into new lands can be eased.

There are of course important aspects of truth in this conventional view, but as the studies in this volume make clear, the situation is far more complex. Natural population growth on the forest margin is not the only, or even the key, driver of deforestation. Population growth often results from in-migration of settlers, rather than from the natural population increase among existing residents. Ironically, in such circumstances, intensification of agricultural techniques, even in a sustainable manner, can increase rather than decrease the rate of deforestation, by raising the profitability of farming and thereby inducing the in-migration of settlers to the forest margin. There may be a strong case for improving the productivity of agricultural practices, but that step alone may not solve the problem of deforestation.

Moreover, population increases of smallholders, whether by natural population increase or by in-migration, are just part of the overall story. Land clearing results not only from the expansion of land for crop production, but also from cattle ranching, commercial logging, and other extractive activities. Since deforestation for such purposes is often highly profitable for private actors, even if it is socially costly (e.g., due to the loss of biodiversity, or the increase of carbon emissions), deforestation will not be stopped merely through the introduction of sustainable agronomic practices. Policies will be needed that explicitly aim to tilt the incentives toward forest conservation. It may be advisable, for example, to compensate landowners for the conservation of nonmarketed ecosystem services such as conserved habitats and sequestered carbon.

Some economists stop at that point, saying that all that is needed is to “get the prices right,” by putting market prices on ecosystem services. This book explains why that insight, valuable as it might be, only touches the surface of the practical issues. Lurking beneath the idea of setting prices for ecosystem services are measurement and conceptual problems of enormous scientific complexity. Identifying and valuing nonmarket ecosystem services require the very best of ecological, soil, and farming sciences, indeed just what the essays in this volume provide.

How much carbon, for example, is actually sequestered by various land use systems? How does the soil carbon change over time under particular agronomic practices, and how can the soil carbon best be measured and monitored? How can we measure “biodiversity” and “habitat” in a practical manner, in order to promote the conservation of biodiversity in a managed ecosystem? What indicators should be used reliably to link observed land use patterns to economic incentives such as payments for carbon or habitat preservation?

The ASB studies in this volume offer a uniquely informed and up-to-date treatment of these challenging issues, and many more issues as well. The essays combine rigorous science, new conceptual and empirical tools, and thoughtful policy analysis. Moreover, the studies describe these issues in a remarkable range of settings, in all three affected continents and for a wide variety of land use systems. The introduction and concluding essays are masterful in setting out the issues, as well as identifying the practical and policy uncertainties not yet solved by the ASB project. In short, this book is a landmark on the path to sustainable development.

Jeffrey D. Sachs

Jeffrey D. Sachs is Director of the Earth Institute at Columbia University and Special Advisor to U.N. Secretary General Kofi Annan.

Preface

At the start of the twenty-first century an area of humid tropical forest about the size of Nicaragua, New York State, or Greece (130,000 km²) is destroyed every year. Tropical deforestation remains a major worldwide concern because it threatens the high plant and animal biodiversity these forests contain, the large carbon stocks stored in them, and the many ecosystem services they provide. Small-scale farmers practicing slash-and-burn agriculture clear forests to produce food and make a living for their families. To escape poverty, these families often have few options other than to continue clearing tropical forests. Striking an equitable balance between the legitimate interests of these rural households and the equally legitimate global concerns over the environmental consequences of tropical deforestation is one of the major challenges of the coming decades.

The Alternatives to Slash and Burn (ASB) consortium was established in 1992 by a group of concerned national and international research institutions and nongovernment organizations in response to recommendations in the Rio Earth Summit's Agenda 21 to halt destructive forms of shifting cultivation by addressing the underlying social and ecological causes and to reduce damage to forests by promoting sustainable management at the forest margins. At that time, there was much understanding of how slash-and-burn agriculture was performed, but knowledge of its global environmental consequences was sketchy, and what was known about the socioeconomic factors driving slash-and-burn agriculture was not particularly useful to policymakers seeking to reduce deforestation and improve human welfare. Moreover, there were few cross-country studies and almost no cross-disciplinary research efforts involving agricultural scientists, environmental scientists, and social scientists to draw on for scientific or policy guidance.

The ASB consortium—eventually comprising more than forty organizations spread across the humid tropical belt—met this challenge by identifying more sustainable land use practices and enabling policies that help conserve environmental functions of the tropical forest margins while increasing household income and food security for millions of poor people. After initial

support from the Global Environment Facility, ASB became a systemwide program of the Consultative Group on International Agricultural Research in 1994 and has since been supported by its members and by the participating national research institutions in Brazil, Cameroon, Indonesia, Peru, Philippines, and Thailand. The ASB consortium changed the way scientists and policymakers work together to tackle major global challenges.

This book is a synthesis of the first decade of ASB's work, written by a team of seventy-nine soil scientists, economists, ecologists, anthropologists, and foresters encompassing twenty-six nationalities. Forty-one of them are national scientists affiliated with government research institutes, universities, and nongovernment organizations of eight tropical countries, and twenty-six others are affiliated with international agricultural research centers. This synthesis is organized in five sections. The first chapter introduces slash-and-burn activities and the overall research framework used by ASB, including its tradeoff matrix. The second section focuses on the different environmental, agronomic, and socioeconomic dimensions of deforestation and tropical agriculture, including chapters on carbon dynamics, greenhouse gas emissions, above-ground and below-ground biodiversity, agronomic sustainability, and the effects of macroeconomic policy on land and forest use. The third section focuses on specific best-bet alternatives to slash-and-burn, including community forest management, jungle rubber, shade coffee, and reclamation of degraded grasslands and pastures. The fourth section describes the perspectives of the main countries involved—Brazil, Indonesia, Cameroon, Peru, and Thailand—regarding the environmental, economic, and social importance of slash-and-burn agriculture at the local, regional, and national levels and the contribution of ASB to addressing key research and capacity-strengthening issues. The final section compares the different sites and assesses the tradeoffs between the environmental, agronomic, and economic costs and benefits of alternative uses of forests and cleared land and identifies the roles of science and policy action in effecting known tradeoffs today and improving the terms of these tradeoffs in the future.

The editors held ASB leadership positions while working at the Tropical Soil Biology and Fertility Programme (Palm), the World Agroforestry Centre (Sanchez and Ericksen), and the International Food Policy Research Institute and the University of California, Davis (Vosti), in the past decade. All editors want to acknowledge the vision of Nyle Brady, who brought the idea to reality; the assistance of the ASB global coordination office at the World Agroforestry Centre in Nairobi, particularly Joyce Kasyoki for her hard work and institutional memory; the copyediting work of Sherri Mickelson; and the formatting by Rafael Flor. The editors also thank Anthony Juo of Texas A&M University for his review of the early versions of several chapters. We would also like to thank the Australian Centre for International Agricultural Research for funding that supported the production of this book and the symposium that launched the chapters for this book at the American Society of Agronomy meetings in Salt Lake City and the United States

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Acronyms and Abbreviations

AARD	Agency for Agricultural Research and Development
AC	Acre State, Brazil
ACIAR	Australian Centre for International Agricultural Research
AGBD	above-ground biodiversity
AMF	arbuscular mycorrhizal fungi
AMR	mean annual mortality
ANOVA	analysis of variance
ANU	Australian National University
ASB	Alternatives to Slash and Burn Agriculture
ASC	active soil carbon
BAPPENAS	Badan Perencanaan Pembangunan Nasional
BASA	Banco da Amazônia S.A.
BC	benefit:cost ratios
BD	bulk density
BGBD	below-ground biodiversity
BPS	Biro Pusat Statistik
CABI	CAB International
CAP_PRD	improved productivity of capital
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CEB	Casa do Estudante do Brasil
CENFOR	Center for Forestry Research
CGE	computable general equilibrium
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIFOR	Center for International Forestry Research
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Développement
CMU	Chiang Mai University
CODESU	Consorcio para el Desarrollo Sostenible de Ucayali
CPAF	Centro de Pesquisa Agroflorestal
CPAF/AC	Centro de Pesquisa Agroflorestal do Acre
CPATU	Centro de Pesquisa Agroflorestal da Amazônia Oriental

CRFC	Center for Research on Food Crops
CSIRO	Commonwealth Scientific and Industrial Research Organization
DANIDA	Danish Agency for Development Assistance
DF	Distrito Federal
DGE	Directorate General of Estate
Ditjenbun	Direktorat Jenderal Perkebunan
EMATER	Empresa de Assistência Técnica e Extensão Rural
Embrapa	Empresa Brasileira de Pesquisa Agropecuária
EPTD	Environment and Production Technology Division
ESALQ	Escola Superior de Agricultura “Luiza de Queiroz”
FAEALQ	Fundação de Estudos Agrários Luiz de Aueiroz
FaleBEM	Farm Level Bioeconomic Model
FAO	Food and Agriculture Organization
FCCC	Framework Convention on Climate Change
fCFA	Central African franc
FFTC	Food and Fertilizer Technology Center
FGV	Fundação Getulio Vargas
FNMA	National Environmental Fund
FUNTAC	State Technological Foundation of Acre
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GIS	geographic information system
GMS	Greater Mekong Subregion
GPS	global positioning system
GTCE	Global Change in Terrestrial Ecosystems
HDI	Human Development Index
HMSO	Her Majesty’s Stationery Office
HTI	<i>hutan tanaman industri</i> (industrial timber estate)
IBAMA	Brazilian Institute for the Environment and Natural Resources
IBGE	Instituto Brasileiro de Geografia e Estatística
IBMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis
IBSRAM	International Board for Soil Research and Management
ICFORD	Indonesian Center for Food Crops Research and Development
ICRAF	World Agroforestry Centre
IDB	InterAmerican Development Bank
IDESP	Instituto de Estudos Econômicos, Sociais e Políticos
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IGES	Institute for Global Environmental Strategies
IIAP	Institutio de Investigación de la Amazonía Peruana
IICA	Instituto Interamericano de Cooperación para la Agricultura
IIED	International Institute for Environment and Development
IITA	International Institute for Tropical Agriculture

IMAC	Instituto de Meio Ambiente do Acre
INCRA	Instituto Nacional de Colonização e Reforma Agrária
INEI	Instituto Nacional de Estadística e Informática
INIA	Instituto Nacional de Investigación Agraria
INIFAP	Instituto Nacional de Investigación Agrícola, Pecuaria y Forestal
INPE	Instituto Nacional de Pesquisas Espaciais
INRM	integrated natural resource management
IPCC	Intergovernmental Panel on Climate Change
IPEA	Instituto de Pesquisa Econômica Aplicada
IRAD	Institut de Recherche Agricole pour le Développement
IRD	Institut de Recherche pour le Développement
IRR	internal rates of return
ITTO	International Tropical Timber Organization
IUCN	International Union for the Conservation of Nature and Natural Resources
IUFRO	International Union of Forest Research Organizations
JICA	Japanese International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences
KDTI	Dawasan Dengan Tijuana Istimewa (Zone with Distinct Purpose)
LAB_PRD	improved productivity of labor
LANDSAV	improvements in labor and capital productivity that increases the overall productivity of land
LF	long fallow
LN	natural logarithm
LP	linear programming
LUS	land use system
LUT	land use type
MAB	Man and the Biosphere
m a.s.l.	meters above sea level
MDS	multidimensional scaling
MMSEA	mountainous mainland Southeast Asia
MPN	most probable number per unit of soil volume
MPS	mean particle size
NDTR	nutrient depletion time range
NGO	nongovernment organization
NIES	National Institute for Environmental Studies
NNE	net nutrient export
NPV	net present value
NRC	National Research Council
NTFP	nontimber forest product
OM	soil organic matter content
PAM	Policy Analysis Matrix
PAR	photosynthetically active radiation
PC	colonization project
PCARRD	Philippine Council for Agriculture, Forestry, and Natural Resources Research
PESACRE	Grupo de Pesquisa e Extensão em Sistemas Agroflorestais do Acre

PFA	plant functional attribute
PFC	plant functional complexity
PFT	plant functional type
PLP	participatory land use planning
PPP	purchasing power parity
PROCITROPICOS	Programa Cooperativo de Investigación y Transferencia de Tecnología para los Trópicos Suramericanos
PROSEFOR	Proyecto de Semillas Forestales
PSP	permanent sample plot
QFRI	Queensland Forestry Research Institute
RAP	Rapid Assessment Program
RBA	rapid biodiversity assessment
RFD	Royal Forestry Department
RNRV	relative nutrient replacement value
RO	Rondônia
SAM	social accounting matrix
SAREC	Sciences d'Anticipation Reconnaissance Evaluation Contrôle
SC	shifting cultivation
SE	soil exposure
SECTMA	Secretaria de Ciência, Tecnologia e Meio Ambiente do Acre
SF	short fallow
SIF	Sociedade de Investigações Florestais
SIFRECA	Sistema de Informações de Fretes para Cargas Agrícolas
SOBER	Sociedade Brasileira de Economia Rural
SOM	soil organic matter
SPI	Servico de Produção de Informação
SUDAM	Superintendência de Desenvolvimento da Amazônia
SUFRAMA	Superintendência da Zona Franca de Manaus
TAC	Technical Advisory Committee
TDRI	Thailand Development Research Institute
TFP	total factor productivity
TSBF	Tropical Soil Biology and Fertility Programme
UCA	Universidad Centro Americana
UCA/SAREC	Universidad Centro Americana/Science d'Anticipation Reconnaissance Evaluation Contrôle
UEPAE	Unidade de Execução de Pesquisa de Âmbito Estadual
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
USDA-ARS	United States Department of Agriculture, Agricultural Research Service
USGS	United States Geological Survey
WFPS	water-filled pore space
WRI	World Resources Institute
WWF	World Wildlife Fund
ZEE	Zoneamento Ecológico Econômico