

SLASH-AND-BURN AGRICULTURE

Slash-and-Burn Agriculture

THE SEARCH FOR ALTERNATIVES

*Edited by Cheryl A. Palm, Stephen A. Vosti,
Pedro A. Sanchez, and Polly J. Ericksen*

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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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Cheryl A. Palm, Pedro A. Sanchez, Polly J. Ericksen
The Earth Institute at Columbia University

Stephen A. Vosti
University of California, Davis

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Contributors

- Julio Alegre Senior Soil Scientist, World Agroforestry Centre–Peru; Centro Internacional de la Papa, Apartado 5969, Lima, Peru; e-mail: j.alegre@cgiar.org
- Henrique J. B. de Araújo Forest Engineer, Research Scientist at the Agroforestry Research Center of Acre; Caixa Postal 392, Rio Branco–AC, Brazil, CEP 6990080; e-mail: henrique@cpafac.embrapa.br
- Manuel Arca Research Director, INIA; Av. La Universidad s/no; La Molina, Lima 12, Apartado 2791, Peru; e-mail: marcab@fenix.inia.gob.pe
- Luis Arévalo Research Officer, World Agroforestry Centre–Peru; Km. 4.2 Carretera Federico Basadre, Pucallpa–Ucayali, Peru; e-mail: l.arevalo@cgiar.org
- David E. Bignell Professor of Zoology, School of Biological Science; Queen Mary, University of London, Mile End Road, London, UK, E1 4NS; e-mail: D.Bignell@qmul.ac.uk
- Evaldo M. Bráz Forest Engineer, Research Scientist at the National Forest Research Center–Embrapa Floresta, Curitiba–PR, Brazil; e-mail: evaldo@cnpf.embrapa.br
- David F. R. P. Burslem Senior Lecturer, University of Aberdeen, School of Biological Sciences; Cruickshank Building, St. Machar Drive, Aberdeen AB24 3UU, Scotland, UK; e-mail: d.burslem@abdn.ac.uk
- Chantal L. Carpentier Program Manager, Environment, Economy, and Trade, North American Commission for Environmental Cooperation; 393 St-Jacques O., Suite 200, Montreal, Quebec, Canada H2Y 2A7; e-mail: clcarpentier@cceamt.org
- Carlos E. Castilla Soil and Water Management Program, CENIPALMA; Calle 21, no. 42C-47, Bogota, Colombia; e-mail: cecastilla@unipacifico.edu.co
- Andrea Cattaneo Economist, Resource Economics Division, Economic Research Service, USDA; 1800 M Street, NW, Washington, DC 20036; e-mail: cattaneo@ers.usda.gov
- Simon Chater Director, Green Ink Publishing Services Ltd.; Hawson Farm, Buckfastleigh, Devon, UK; e-mail: s.chater@cgnet.com
- Divonzil G. Cordeiro Soil Scientist, Embrapa–Acre; BR-364, KM 14, Caixa Postal 381, CEP: 69 908–970, Rio Branco, Acre, Brazil; e-mail: matell@mdnet.com.br
- Chimere Diaw Scientist, CIFOR, IITA Humid Forest Ecoregional Centre; B.P. 2008 (Messa), Yaoundé, Cameroon; e-mail: c.diaw@cgiar.org
- Luc Dibog Soil Macrobologist (Termites), Institute of Agricultural Research for Development, IRAD; P.O. Box 2067, Yaoundé, Cameroon; e-mail: lucdibog@yahoo.com, luc.dibog@caramail.com

- Polly J. Ericksen Research Fellow, International Research Institute for Climate Prediction, The Earth Institute at Columbia University; 61 Route 9W, P.O. Box 1000, Palisades, NY 10960, USA; e-mail: ericksen@iri.columbia.edu, p.ericksen@cgiar.org
- Achmad M. Fagi ASB National Facilitator, Indonesian Center for Food Crops Research and Development (ICFORD); Jl. Merdeka No. 147, Bogor 16111, Indonesia; e-mail: crifc@indo.net.id
- Helmut J. Geist Executive Director, Land-Use & Cover Change Project, LUCC International Project Office (IPO); University of Louvain, 3 Place Louis Pasteur, B-1348 Louvain-la-Neuve, Belgium; e-mail: geist@geog.ucl.ac.be
- Andrew N. Gillison Director, Center for Biodiversity Management; P.O. Box 120, Yungaburra, Queensland 4872, Australia; e-mail: andy.gillison@austarnet.com.au
- James Gockowski Agricultural Economist, IITA–Humid Forest Station; B.P. 2008, Yaoundé, Cameroon; e-mail: j.gockowski@cgiar.org
- Kurniatun Hairiah Professor of Soil Biology and Root Ecology, Brawijaya University; Jl. Veteran, Malang 65145, Indonesia; e-mail: soilub@malang.wasantara.net.id
- Stefan Hauser Soil Physicist/Agronomist IITA Humid Forest Station; B.P. 2008, Yaoundé, Cameroon; e-mail: s.hauser@cgiar.org
- Sinung Hendratno Socioeconomic Researcher, Pusat Penelitian Karet Sembawa, Balai Penelitian Sembawa; Jl. Raya Palembang-Sekayu Km 29, Kotak Pos 1127, Palembang, Sumatra, Selatan 300031, Indonesia; e-mail: irri-sbw@mdp.co.id
- Shiou Pin Huang Professor, Departamento de Filopatologia, Universidade de Brasilia; CEP 7099–970, Brasilia, DF, Brazil; e-mail: huang@guarany.cpd.unb.br
- Shigehiro Ishizuka Senior Scientist, Forest and Forest Product Research Institute (FFPRI); 7 Hitsujigaoka, Toyohira-ku, Sapporo, Hokkaido 062-8516, Japan; e-mail: ishiz03@ffpri.affrc.go.jp
- David Kaimowitz Director General, Center for International Forestry Research (CIFOR), Jalan CIFOR; P.O. Box 6596, JKPWB, Jakarta 10065, Indonesia
- Joyce Kasyoki Programme Administrator, ASB; World Agroforestry Centre, UN Avenue, Gigiri, P.O. Box 30677, 00100 GPO, Nairobi, Kenya; e-mail: j.kasyoki@cgiar.org
- Jean Kotto-Same Soil Scientist, Institut de la Recherche Agricole pour le Développement (IRAD); B.P. 2067, Yaoundé, Cameroon; e-mail: jkottosame@yahoo.fr
- Ricardo Labarta Research Assistant Economist, World Agroforestry Centre–Peru; Km. 4.2 Carretera Federico Basadre, Pucallpa–Ucayali, Peru; e-mail: r.labarta@cgiar.org
- Eric F. Lambin Professor, Department of Geography, University of Louvain; 3 Place Pasteur, B-1348 Louvain-la-Neuve, Belgium; e-mail: lambin@geog.ucl.ac.be
- Jessa Lewis Consultant; 8268 Sugarman Drive, La Jolla, CA 92037, USA; e-mail: jessa.lewis@stanfordalumni.org
- Fátima Moreira Soil Microbiologist, Dep. de Ciencia do Solo, Universidade Federal de Lavras; CEP 37200–000, Lavras, Minas Gerais, Brazil; e-mail: fmoreira@esal.ufla.br
- Appolinaire Moukam Deceased; Soil Scientist, Institut de la Recherche Agricole pour le Développement, IRAD, Yaoundé, Cameroon
- Daniel Murdiyarso Professor, Department of Geophysics and Meteorology, Bogor Agricultural University; Jl. Raya Pajajaran, Bogor, 16143, Indonesia; e-mail: d.murdiyarso@icsea.org
- Ousseynou Ndoye Regional Coordinator; Center for International Forestry Research (CIFOR), Regional Office for Central and West Africa; c/o IITA-HFC, B.P. 2008, Yaoundé, Cameroon; e-mail: o.ndoye@cgiar.org

- Rosaline Njomgang Soil Chemist, Institut de la Recherche Agricole pour le Développement (IRAD); B.P. 2067, Yaoundé, Cameroon; e-mail: j.tonye@camnet.cm
- Dieudonné Nwaga Soil Microbiologist, University of Yaoundé, Plant Biology Department; P.O. Box 812, Yaoundé, Cameroon; e-mail: j.tonye@camnet.cm
- Marcus V. N. d'Oliveira Forestry Scientist, Embrapa Acre; BR-364 km 14, CEP 69.901-180, Caixa Postal 321, Rio Branco, Acre, Brazil; e-mail: mvno@cpafac.embrapa.br
- Cheryl A. Palm Senior Research Scientist, The Earth Institute at Columbia University; 167 Monell, Lamont-Doherty Earth Observatory, 61 Route 9W, P.O. Box 1000, Palisades, NY 10960, USA; e-mail: cpalm@iri.columbia.edu
- Soetjipto Partohardjono Principal Researcher, Indonesian Center for Food Crops Research and Development (ICFORD); Jl. Merdeka No. 147, Bogor 16111, Indonesia; e-mail: crifc@indo.net.id
- William J. Parton Senior Research Scientist, Natural Resource Ecology Laboratory, Colorado State University; Fort Collins, CO 80523, USA; e-mail: billp@nrel.colostate.edu
- Djuber Pasaribu Researcher, Indonesian Center for Food Crops Research and Development (ICFORD); Jl. Merdeka 147, Bogor 16111, Indonesia; e-mail: crifc1@indo.net.id, crifc3@indo.net.id
- Beto Pashanasi Lecturer, Universidad Nacional de la Amazonia Peruana, Yurimaguas, Peru; e-mail: larevalo@cgjar.org
- Eliane Guimarães Pereira Environmental Engineer, Soil and Plant Nutrition, Universidade Federal de Itajubá, Av. BPS, 1303, Pinheirinho, Itajubá, Minas Gerais, 37500-903, Brazil; e-mail: elianegp@unifei.edu.br
- Komon Pragtong Division of Silvicultural Research and Botany, National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resources and Environment; Paholyothin Rd., Jatujak, Bangkok, 10900, Thailand
- Pornchai Preechapanya Division of Watershed Conservation and Management, National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resources and Environment Station; 130/1 M4 Don Keaw, Mae Rim, Chiang Mai 50180, Thailand; e-mail: pcpc@loxinfo.co.th, pornchaiP@icraf-cm.org
- Pratiknyo Purnomosidhi Associate Research Officer, World Agroforestry Centre-Kotabumi; P.O. Box 167, Kotabumi 34500, Lampung, Indonesia; e-mail: icrafktb@lampung.wasantara.net.id
- Subekti Rahayu Data Technician, World Agroforestry Centre-Indonesia; Jl. Cifor, Situ Gede, Sindang Barang, Bogor, Indonesia; e-mail: S.Rahayu@cgjar.org
- Auberto Ricse Forestry Scientist, INIA, Agrarian Systems for Mountains Programme; Km. 4 Carretera Federico Basadre, Pucallpa-Ucayali, Peru; e-mail: eepuc@terra.com.pe
- Vanda Rodrigues Soil Scientist, Embrapa-Rondônia; BR-364km, 5, 5, Caixa Postal 406, CEP 78900, Porto Velho, Rondônia, Brazil; e-mail: vanda@ronet.com.br
- Nu Nu San Postdoctoral Researcher, University of West Virginia; 450 Medical Center Dr., Apt. B302, Morgantown, WV 26505, USA
- Pedro A. Sanchez Director of Tropical Agriculture, The Earth Institute at Columbia University; 2G Lamont Hall, Lamont-Doherty Earth Observatory, 61 Route 9W, P.O. Box 1000, Palisades, NY 10964, USA; e-mail: sanchez@iri.columbia.edu
- Syukur M. Sitompul Professor, Agronomy Department, Faculty of Agriculture, Brawijaya University; Jl. Veteran Malang, Jawa Timur 65145, Indonesia; e-mail: smtom@malang.wasantara.net.id

- Carmen Sotelo-Montes Forester, World Agroforestry Centre–Peru; Av. La Molina 1895, La Molina, Lima 12, Peru; e-mail: c.sotelo@cgiar.org
- Fred Stolle Lab de Télédetection, Université Catholique Louvain (UCL); Place Louis Pasteur 3, B 1348 Louvain-la-Neuve, Belgium; e-mail: stolle@geog.ucl.ac.be
- William D. Sunderlin Program Leader Forest, Society, and Policy Program, Center for International Forestry Research (CIFOR); Situ Gede, Sindangbarang, Bogor Barat 16680, Indonesia; e-mail: w.sunderli@cgiar.org
- Plodprasop Suraswadi Director General, Royal Forestry Department; 61 Paholythin Road, Chatujak, Bangkok 10900, Thailand; e-mail: chahut@forest.go.th
- Francis-Xavier Susilo Lecturer, Department of Plant Protection, Faculty of Agriculture, Universitas Lampung; Gedung Bioteknologi Pertanian, Lantai 2 Universitas Lampung, Jalan Sumantri Brojonegoro No. 1, Bandar Lampung, 35145, Indonesia; e-mail: fxsusilo@telkom.net fxsusilo2000@yahoo.com
- Michael D. Swaine Senior Lecturer, Department of Plant and Soil Science, Aberdeen University; Aberdeen AB24, United Kingdom; e-mail: m.swaine@abdn.ac.uk
- Michael J. Swift Consultant, IRD Centre de Montpellier; 911 Avenue Agropolis, B.P. 64501, 34394 Montpellier Cedex 5, France; e-mail: swift@mpl.ird.fr, swiftmj@yahoo.co.uk
- David E. Thomas Senior Policy Analyst, World Agroforestry Centre–Chiang Mai; P.O. Box 267 CMU Post Office, Chiang Mai 50202, Thailand; e-mail: Thomas2@loxinfo.co.th
- Téophile Tiki-Manga Agronomist, Institut de la Recherche Agricole pour le Développement (IRAD); B.P. 2067, Yaoundé, Cameroon; e-mail: j.tonye@camnet.cm
- Thomas P. Tomich Principal Economist and Global Coordinator ASB Programme; World Agroforestry Centre, UN Avenue, Gigiri, P.O. Box 30677, 00100 GPO, Nairobi, Kenya; e-mail: t.tomich@cgiar.org
- Jerome Tondoh Soil Microbiologist, Laboratoire d'Ecologie des Sols Tropicaux; 32 Avenue Varagnat, 93 143 Bondy Cedex, France; e-mail: yazi@bondy.orstom.fr
- Jean Tonyé ASB National Coordinator and Director, Farming Systems, IRAD; P.O. Box 2067, Yaoundé, Cameroon; e-mail: j.tonye@camnet.cm
- Zac Tschondeau Senior Scientist, World Agroforestry Centre, Cameroon; B.P. 2067, Yaoundé, Cameroon; e-mail: Z.Tchoundjeu@cgiar.org
- Haruo Tsuruta Senior Scientist, National Institute of Agro-Environmental Sciences (NIAES); 3-1-1 Kan-Nondai, Tsukuba, Ibaraki 305, Japan; e-mail: tsuruta@niaes.affrc.go.jp
- Judson F. Valentim Pasture Researcher, Embrapa–Acre; KM-14, BR-364, Caixa Postal 392, 69.801–180 Rio Branco–Acre, Brazil; e-mail: judson@cpafac.embrapa.br
- Meine van Noordwijk Regional Coordinator for Southeast Asia, World Agroforestry Centre, Indonesia; P.O. Box 161, Bogor 16001, Indonesia; e-mail: m.van-noordwijk@cgiar.org
- Héctor Vidaurre Forester, World Agroforestry Centre–Peru; Centro Internacional de la Papa, Apartado 5969, Lima, Peru
- Stephen A. Vosti Adjunct Assistant Professor, Department of Agricultural and Resource Economics; Center for Natural Resources Policy Analysis, University of California–Davis, Davis, CA 95616, USA; e-mail: vosti@primal.ucdavis.edu
- John C. Weber Senior Forest Geneticist, World Agroforestry Centre, Peru; 2224 NW 11th Street, Corvallis, OR 97330, USA; e-mail: JohnCRWeber@aol.com
- Stephan Weise Vegetation Management Team Leader and ASB Regional Coordinator, IITA Humid Forest Station; B.P. 2008, Yaoundé, Cameroon; e-mail: s.weise@cgiar.org

- Horst Weyerhaeuser Senior Natural Resource Management Researcher, World Agroforestry Centre/Chiang Mai; P.O. Box 267 CMU Post Office, Chiang Mai 50202, Thailand; e-mail: horst@loxinfo.co.th
- Douglas White Senior Research Fellow, Agricultural and Environmental Economist, Centro Internacional de Agricultura Tropical (CIAT), Centro Eco-Regional-INIA; A.P. 558, Pucallpa, Peru; e-mail: d.white@cgiar.org
- Gede Wibawa Head of Research Bureau, Research Institute for Estate Crops GAPKINDO; Jl. Salak 1, Bogor 16151, Indonesia; e-mail: G.Wibawa@cgiar.org
- Julie Witcover Graduate Student, University of California–Davis; 1429 H St. #1, Davis, CA 95616, USA; e-mail: witcover@primal.ucdavis.edu
- Paul L. Woomer Visiting Scientist, Sacred Africa; P.O. Box 79, Village Market, Nairobi, Kenya; e-mail: plwoomer@africaonline.co.ke, format@nbnet.co.ke, plwoomer@nbnet.co.ke
- David Yanggen Agricultural and Natural Resource Economist, Centro Internacional de la Papa; Apartado 1558, Lima 12, Peru; e-mail: d.yanggen@cgiar.org
- Louis Zapfack Botanist, Senior Lecturer, University of Yaoundé I, Faculty of Sciences, Department of Plant Biology; P.O. Box 812, Yaoundé, Cameroon; e-mail: lzapfack@uycdc.uninet.cm

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