Supporting Information

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SI Text

CGIAR and ASB Program. According to its charter, "[CGIAR] is an informal association of 64 public and private sector CGIAR Members, from the South and North, committed to mobilizing international agricultural research supporting the sustainable development of agriculture (crops and livestock), natural resource management, fisheries and forestry in developing countries" (1). Further information is available on the Center's Web site (http://www.cgiar.org/index.html) and in the most recent independent review of the Center and its activities (2).

The ASB Program operated from 1994 to 2007 as a systemwide program of the CGIAR. In 2006, it evolved into a new global "Partnership for Tropical Forest Margins," involving more than 90 research institutions, universities, NGOs, community groups, and farmer organizations. Further information is available on its Web site (http://www.asb.cgiar.org/aboutus). ASB operated 12 benchmark sites around the world covering the Amazon, the Congo Basin, northern Thailand, Mindanao, and Sumatra (3). In 2005, ASB won the CGIAR's Science Award for Outstanding Partnership for developing more environment-friendly farming techniques and slowing deforestation.

Authors' Involvement in the CGIAR and ASB. Several of the authors of the present paper are or have been involved in the organizations described here in a number of ways. These relationships have given us special access to the data reported here and, we hope, a base of knowledge on which to interpret those data. We have been careful in the work presented here to keep our regard for the organizations and those within them from influencing our findings and conclusions. Nonetheless, in the interests of full disclosure, here are our relevant associations:

W.C.C. chaired CGIAR's external review of the ASB program in 2005 while serving in his present position as a professor at Harvard University.

T.P.T. served as Global Coordinator of the ASB program from 2000 to 2006. From 1995 to 2000, he served in a number of positions in the CGIAR's ICRAF. Since 2007, he has been a professor at the University of California at Davis, where he serves as the director of the Agricultural Sustainability Institute.

M.v.N. has been with CGIAR's ICRAF since 1993, where he now serves as Global Science Advisor. He played significant leadership roles in ASB and its spin-off program RUPES.

D.C. has been a scientist with ICRAF since 1998, and now works at its Kenya headquarters.

MA. The MA, involving more than 1,300 experts worldwide, was initiated by United Nations Secretary General Kofi Annan in 2001 "to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being" (4). ASB was responsible for the tropical forest margins subglobal assessment (ASB-MA), which it described as follows: "This assessment considers the impact of all drivers of deforestation and environmental degradation in the forest margins. Drivers of deforestation include not only migrant smallholders, who practice slash-and-burn agriculture, but also plantation owners, other medium- and large-scale farmers, ranchers, loggers, and state-run enterprises and projects" (http://www.maweb.org/en/SGA.ASB.aspx). Details of the ASB-MA were published in 2005 as "Forest and Agroecosystem Tradeoffs in the Humid Tropics" (5).

Accountability in Boundary Work of the ASB-MA. Accountability to ASB was achieved through discussion and approval of the ASB-MA by ASB's Global Steering Group. This included representatives of both participating international research programs of the CGIAR and relevant national agricultural research organizations from ASB's host countries. Accountability to the MA was achieved through formal approval of the ASB-MA as an official component of the MA by the MA Board. This included representatives of development organizations and conservation organizations (5, 6).

Negotiation Support in Sumberjaya, Indonesia. Sumberjaya is an upland area of southeast Sumatra originally covered in rainforest, but with substantial tracts later converted by small farmers to coffee production. Beginning in the 1970s, however, local and state governments increasingly expressed concern that the expansion of coffee farming was endangering downstream watershed services. Lands were therefore increasingly classified as state "protective" forests, with the early 1990s seeing intensifying conflict around a series of police actions to evict small farmer "encroachers." Government reforms followed, centered on community forest management with new rules of forest tenure (i.e., HKm), conditioned on farmers meeting a complex set of management requirements. Implementation, however, was slow. This was caused in part by farmers' mistrust of government, and in part by the lack of agreed management practices that would meet goals of watershed conservation and agricultural development (7–9).

Related Analytic Frameworks from the Literature. A "typology of communicative contexts for analysis" with some parallels to the one we present in Fig. 1 and Fig. S1 has been developed by Andrews to explain the use of analysis in decision making for environmental protection in the United States (10). His typology differs in some details from the framework proposed here. However, it is similar in its insistence that the sources and uses of knowledge need to be considered if sense is to be made of the complex array of science-for-policy experiences encountered in today's world. Michaels (11) presents another complementary typology. It differs from ours in being focused on strategies for communication across the science–policy boundary, rather than the conditions that give rise to such strategies.

Method Details. The new RUPES research conducted for this study consisted of an initial workshop in fall 2006 comprised primarily of scholars engaged in the research of boundary theory, organizations, and work. In this workshop, we formalized our understanding of the research questions and developed our initial protocol. Members of the team conducted research at several RUPES locations in Indonesia in 2007 involving archival research, semistructured interviews, and focus groups with farmer groups; local and regional elected leaders; researchers and field workers from RUPES and ICRAF; local, regional, and national representatives from the Ministry of Forestry and its extension workers; officials from hydroelectric companies; and representatives from local and international NGOs involved in the project. We also cohosted an additional workshop with Brawijaya University in Malang, East Java, comprised primarily of practitioners, NGOs, and government officials in addition to a few scholars of boundary work. The purpose of this workshop was to "truth-test" our findings from the fieldwork with those involved in the agroforestry and watershed sustainable development ac-

tivities. Participants provided feedback and analysis of our research findings and also received training on boundary theory and work (12). Follow-up field work and analysis of the data occurred in 2007 and 2008.

1. Consultative Group on International Agricultural Research (2007) *The Charter of the CGIAR System, March 2007* (Consultative Group on International Agricultural Research, Washington, DC).
2. CGIAR Independent Review Panel (2008) *Bringing Together the Best of Science and the Best of Development. Independent Review of the CGIAR System. Report to the Executive Council* (Consultative Group on International Agricultural Research, Washington, DC).
3. Palm CA, Vosti SA, Sanchez PA, Ericksen PJ (2005) *Slash-and-Burn Agriculture: The Search for Alternatives* (Columbia Univ Press, New York).
4. Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis* (World Resources Institute, Washington, DC).
5. Tomich TP, et al. (2005) *Forest and Agroecosystem Tradeoffs in the Humid Tropics. A Crosscutting Assessment by the Alternatives to Slash-and-Burn Consortium Conducted as a Sub-Global Component of the Millennium Ecosystem Assessment* (Alternatives to Slash and Burn Programme, Nairobi).
6. Clark WC, Contreras A, Harmsen K (2006) *Report of the External Review of the Systemwide Programme on Alternatives to Slash-and-Burn (ASB): Evaluation and Impact Assessment of the ASB Programme. Report No. TC/D/A0770E/10.06/500* (Consultative Group on International Agricultural Research Science Council Secretariat, Food and Agriculture Organization, Washington, DC).
7. Colchester M, et al. (2005) *Facilitating Agroforestry Development through Land and Tree Tenure Reforms in Indonesia: Impact Study and Assessment of the Role of ICRAF. ICRAF Southeast Asia Working Paper No. 2* (International Center for Research in Agroforestry, Bogor, Indonesia).
8. Kerr J, Meinzen-Dick R, Pender J, Suyanto S, van Noordwijk M (2005) *Property Rights, Environmental Service and Poverty in Indonesia. BASIS Brief No. 29* (International Center for Research in Agroforestry, Bogor, Indonesia).
9. Kusters K, de Foresta H, Ekadinata A, van Noordwijk M (2007) Towards solutions for state vs. local community conflicts over forestland: The impact of formal recognition of user rights in Krui, Sumatra, Indonesia. *Hum Ecol* 35:427–438.
10. Andrews CJ (2002) *Humble Analysis: The Practice of Joint Fact-Finding* (Praeger, Westport, CT).
11. Michaels S (2009) Matching knowledge brokering strategies to environmental policy problems and settings. *Environ Sci Policy* 12:994–1011.
12. McNie EC, et al. (2008) *Boundary Organizations, Objects and Agents: Linking Knowledge with Action in Agroforestry Watersheds. Report of a Workshop Held in Batu, Malang, East Java, Indonesia, 26–29 July 2007. Report No. 80* (International Center for Research in Agroforestry, Nairobi).

	Boundary Work	**USE of knowledge to support….**		
		Enlightenment (U_0)	**Decision** (U_1)	**Negotiation** (U_m)
SOURCE of knowledge…	**Personal expertise** (S_0)	$S_0 \leftrightarrow U_o$ *Contemplation*	$S_i \leftrightarrow U_j$ *Decision*	$S_i \leftrightarrow \begin{matrix} U_k \\ \updownarrow \\ U_l \end{matrix}$ *Politics*
	Single community of expertise (S_1)	$S_1 \leftrightarrow U_o$ *Demarcation*	$S_i \leftrightarrow U_j$ *Expert advice*	$S_i \leftrightarrow \begin{matrix} U_k \\ \updownarrow \\ U_l \end{matrix}$ *Assessment*
	Multiple communities of expertise (S_n)	$\begin{matrix} S_i \\ \updownarrow \\ S_j \end{matrix} \leftrightarrow U_o$ *Integrative R&D*	$\begin{matrix} S_i \\ \updownarrow \\ S_j \end{matrix} \leftrightarrow U_j$ *Participatory R&D*	$\begin{matrix} S_i & U_k \\ \updownarrow & \leftrightarrow \updownarrow \\ S_j & U_l \end{matrix}$ *Political bargaining*

Fig. S1. Framework for the analysis of knowledge–action dynamics (general version). This is a more general version of the framework for defining contexts of knowledge–action dynamics defined in Fig. 1. The difference here is an additional role, S_o, denoting circumstances in which the potential users of knowledge (U) defined by the columns rely on only their own personal knowledge, or no research-based knowledge at all, to inform their actions. Although this added dimension of the framework was not essential for our boundary work study, it does show the relation of our concerns to a number of common situations, e.g., decision making based on personal judgment and politics whereby power completely dominates knowledge inputs. In addition, there are close parallels between this more general version of our framework and Andrews' previously noted typology of communicative contexts for analysis (10). An exploration of these parallels would almost certainly be useful, but is beyond the scope of the current report.

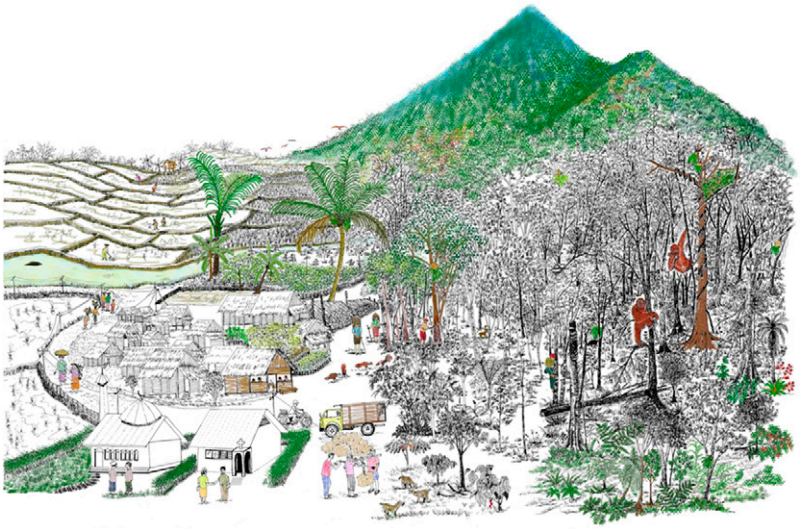

Fig. S2. Preservation of forests for humans and orangutans: a boundary object. The Batang Toru watershed in North Sumatra province, Indonesia, still contains approximately 110,000 ha of forest that harbors a genetically unique orangutan population. Proposals to gazette the area as National Park would imply people moving out. Alternative conservation strategies were proposed to respect and enhance the stability of the agriculture–agroforest–forest gradient. This illustration was developed through revisions of drafts between an ICRAF/Winrock team and villagers as a visual statement that agroforests with planted (rubber) as well as naturally established fruit trees form a buffer between the village and the remaining forest on the hills. The orangutans shown use the agroforest as part of their habitat and are not seen as a threat. The illustration, printed as a poster, served as a boundary object in negotiations among villagers, local government, and conservation authorities, supporting the gradient perspective on integrating conservation and development [Copyright: ICRAF (1)].

1. Tata MH, et al. (2010) *Human Livelihoods, Ecosystem Services and the Habitat of the Sumatran Orangutan: Rapid Assessment in Batang Toru and Tripa. Project Report. Project Report No. RP0270-11* (International Center for Research in Agroforestry, Bogor, Indonesia).

Table S1. The ASB matrix as a boundary object

	Global environmental concerns		Agronomic sustainability			National policymakers' concerns		Smallholders concerns/ adoptability by smallholders	
	Carbon storage	Biodiversity	Plot-level production sustainability			Potential profitability	Labor requirements	Returns to labor	Household food security
Land use system	Aboveground tC/ha (time-averaged)	Aboveground (plants), species per standard plot	Soil structure	Nutrient export	Crop protection	Returns to land (private prices), $/ha	Labor person, d/ha/y	Dollars per person-day (private prices)	Entitlement path (operational phase)
Forest	306	120	0	0	0	0	0	0	NA
Community-based forest management	120	100	0	0	0	5	0.2–0.4	4.77	$ + consumption
Commercial logging	94	90	−0.5	0	0	1,080	31	0.78	$
Rubber agroforest	79	90	0	0	−0.5	0.70	111	1.67	$
Rubber agroforest with clonal material	66	60	−0.5	−0.5	−0.5	878	150	2.25	$
Oil palm	62	25	0	−0.5	0	114	108	4.74	$
Upland rice/bush fallow	37	45	0	−0.5	−0.5	−62	15–25	1.47	Consumption
Continuous cassava/imperata	2	15	−0.5	−1.0	−0.5	60	98–104	1.78	$ + consumption

ASB created the ASB Matrix to show the relationship between alternative land uses (including natural forest) and key evaluation criteria. The matrix served as a "boundary object" at the interface of a variety of information users (who defined the rows and columns of the matrix) and scientists (who devised the metrics and conducted the measurements that fill the cells). Reproduced here is the original version of the matrix as reported in an internal ASB report in 1998 (1). A fuller discussion of the matrix and its uses, together with the final version of the matrix for a number of ASB cites, has been published in the project's final report (2).

1. Tomich TP, et al. (1998) *Alternatives to Slash-and-Burn in Indonesia, Summary Report of Phase II. No. 8* (International Center for Research in Agroforestry, Bogor, Indonesia).
2. Tomich TP, et al. Balancing agricultural development and environmental objectives: assessing tradeoffs in the humid tropics. *Slash-and-Burn Agriculture: The Search for Alternatives*, eds Palm CA, Vosti SA, Sanchez PA, Eriksen PJ (Columbia Univ Press, New York), pp 415–440.