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COMMENTARIES

A New Initiative to Use Carbon Trading for Tropical Forest Conservation

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ABSTRACT

I describe a new initiative, led by a coalition of developing nations, to devise a viable mechanism for using carbon trading to protect old-growth tropical forests. I highlight some of the practical and political hurdles involved in forest-carbon trading, and explain why this initiative is rapidly gaining broad-based political support.

RESUMEN

Describo una nueva iniciativa, encabezada por una coalición de países en desarrollo, para idear un mecanismo de comercio del carbón que proteja a los bosques tropicales prístinos. Destaco algunos de los obstáculos prácticos y políticos involucrados en el comercio de carbón de madera, y explico por qué esta iniciativa esta rápidamente ganando apoyo político de amplia base.

Key words: carbon offsets, deforestation, global warming, greenhouse gases, Kyoto Protocol, old-growth forest, rainforest.

AT FIRST GLANCE, IT IS DIFFICULT TO SEE why anyone would oppose the idea of using carbon trading to slow the alarming pace of tropical forest destruction. Three major assessments suggest that tropical deforestation accounted for at least a quarter of all anthropogenic carbon emissions in the 1980s and 1990s (with estimates ranging from 1.9 to 3.0 billion metric tons/yr; Fearnside 2000, Malhi & Grace 2000, Houghton 2003). Satellite-based estimates of net carbon flux from the tropics are generally lower (from 0.6 to 1.0 billion tons/yr), in part because emissions from deforestation are partly countered by forest regeneration (DeFries *et al.* 2002, Achard *et al.* 2004; but see Fearnside & Laurance 2003, 2004, for criticisms of some low estimates). Despite these differences, there is a broad agreement that tropical deforestation is a massive source of carbon emissions and contributes significantly to global warming and atmospheric change (Fearnside 2000, Malhi & Phillips 2005, Laurance & Peres 2006).

There is also a broad agreement that international carbon markets could be used to help slow deforestation. In theory, the mechanism is simple. Under existing or future international agreements, participating nations agree to reduce their carbon emissions to a certain level. Nations that struggle to meet their emissions targets can buy carbon credits from other nations, which either have no emissions target (as is currently the case for developing nations under the Kyoto Protocol) or have reduced their emissions below their agreed target. Like any tradable commodity, the price of carbon credits is largely determined by supply and demand. If a viable trading and compliance mechanism existed (*cf.*, Pfaff *et al.* 2000), wealthy industrial nations could find it economically attractive to invest in initiatives to slow deforestation in developing countries as part of an overall effort to meet their emissions target. For example, protecting an endangered forest in Madagascar might have the same net benefit, from a carbon-emissions perspective, as improving the efficiency of a coal-fired generating plant in Ohio (see Kremen *et al.* 2000 for a real-world example). A transaction like this could have three important benefits: greenhouse-gas emissions are reduced, a biologically important forest is protected, and Madagascar gains direly needed foreign revenues.

Of course, there can be a large gulf between theory and reality, especially when dealing with international agreements and the inherent uncertainties of global climate change. The first major proposal to use international carbon markets to slow deforestation, under the Clean Development Mechanism of the Kyoto Protocol, was defeated for political reasons (see below). More recently, an alliance of 15 developing countries known as the Coalition for Rainforest Nations, led by Papua New Guinea and Costa Rica, has attempted to revive efforts to use carbon credits to slow deforestation (see http://www.rainforestcoalition.org for further background). Here I highlight the main features of this initiative, explain why it is rapidly gaining political support, and discuss some of the practical challenges that may lie ahead.

RAINFOREST POLITICS

The original effort to slow deforestation under the Kyoto Protocol generated heated resistance from several quarters (*cf.* Fearnside 2001a, 2001c, 2006). First, a number of environmental groups, particularly in Europe, opposed the idea that wealthy nations like the United States might simply try to "buy their way out" of part of their international obligations to control burgeoning industrial and automobile emissions, rather than making substantial and permanent

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emissions reductions. Second, some opponents argued that forest conservation was a risky strategy for battling greenhouse gases. For example, even though one might try to slow deforestation by establishing a new national park in the Philippines, "leakage" could occur if slash-and-burn farmers simply move to other areas and continue destroying the forest. Finally, Brazil, which alone contains 40 percent of the world's remaining tropical rain forest, adamantly opposed carbon trading to reduce deforestation, and lobbied other developing nations to do likewise. In Brazil, as in many countries, national-sovereignty issues are especially sensitive, and the Brazilian Foreign Ministry argued that accepting reduced-deforestation funds from industrial nations could potentially limit their future development options (Fearnside 2006).

Because of these concerns, the reduced-deforestation provision was dropped from Kyoto, at least during its First Commitment Period (2008–2012). To the surprise of many, however, the idea was reborn in December 2005, at international climate negotiations in Montreal, Canada (the Eleventh Convention of Parties to the United Nations Framework Convention on Climate Change, or COP-11 meeting, where discussions began for the Second Commitment Period, from 2013–2017). There, the newly formed Coalition of Rainforest Nations, building on earlier efforts by scientific and environmental organizations (*e.g.*, Moutinho & Schwartzman 2005, Santilli *et al.* 2005), argued persuasively that the issue should be put back on the table (Laurance 2006a, 2006b; Silva-Chávez & Petsonk 2006). For the present moment at least, many of its original opponents appear to be giving the idea a chance.

Why the change in attitude? First, European environmental groups have grown increasingly alarmed by the acceleration of greenhouse-gas emissions worldwide (Fig. 1). This has resulted from continued high emissions from industrial nations as well as the rapid growth of emissions from developing nations, especially China and India, which climbed by 33 percent and 57 percent, respectively, between 1992 and 2002 (World Bank 2006). Simply from a climate-change perspective, the environmental groups realize, failing to address the issue of tropical deforestation is dangerously irresponsible. Second, those worried about the "leakage" issue were mollified when the coalition proposed to tally deforestation at the national level. Thus, if a carbon-offset project slowed deforestation in one part of, say, Cameroon but simply allowed it to increase elsewhere in the country, Cameroon would receive no benefit. Third, Brazil, led by its environment minister, Marina Silva, has agreed to carefully contemplate the proposal, which is also receiving strong support from Brazilian nongovernmental organizations (although certain sectors of the Brazilian government still adamantly oppose the initiative). For the Brazilians, the fact that the initiative is being driven by developing nations has seemingly helped to surmount their suspicions of international reduced-deforestation measures. Lastly, although reluctant, the Bush administration did not attempt to kill or hamstring the proposal—despite its longstanding opposition to Kyoto and binding national-emissions targets—possibly because of widespread criticism it was already receiving in Montreal in response to its policies on climate change (Silva-Chávez & Petsonk 2006).

Although the 15 active members of the Coalition for Rainforest Nations are all small, developing countries, the movement is rapidly gaining political support. As of November 2006, the proposal has been endorsed by the Pacific Island Forum, European Union, British Commonwealth, African Union, and Association of Small Island States, which collectively include more than 150 nations. Notably, the proposal has also been formally endorsed by the Association for Tropical Biology and Conservation, via a resolution sponsored by the ATBC Conservation Committee and unanimously approved by the ATBC Executive Council (ATBC 2006).

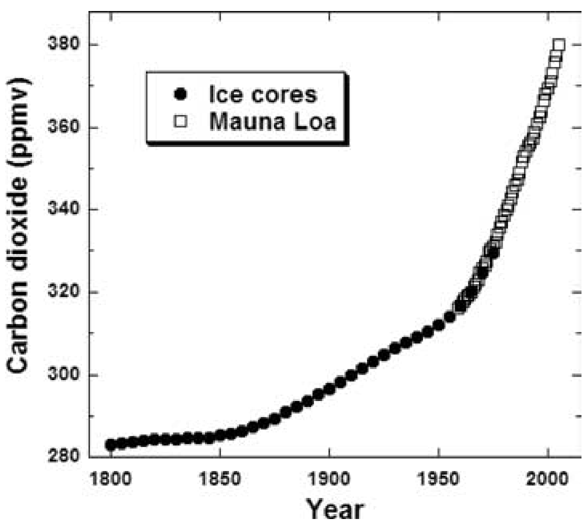

FIGURE 1. Carbon-dioxide levels rose markedly after the industrial revolution and far more dramatically in recent decades. Shown are mean annual concentrations (in parts per million per volume of atmosphere) from two partially overlapping data sources: Antarctic ice cores and monthly concentrations recorded at Mauna Loa, Hawaii (http://cdiac.ornl.gov/trends/co2/contents.htm).

BENEFITS OF FOREST CARBON CREDITS

Aside from its obvious advantages for the atmosphere and forests, using carbon trading to slow deforestation could potentially provide substantial economic benefits for developing nations. Each hectare of old-growth tropical rainforest typically contains 120–400 tons of carbon in its aboveground vegetation (Frangi & Lugo 1985, Rai & Proctor 1986, Brown & Lugo 1992, Fearnside 2000, Houghton *et al.* 2000, Hughes *et al.* 2000, Nascimento & Laurance 2002, Zheng *et al.* 2006) and much more if plant roots and carbon in the soil are considered (Davidson & Trumbore 1995). Most of the aboveground carbon, and some of that belowground, is released to the atmosphere if the forests are cleared (Fig. 2; Fearnside 2000, Houghton 2005). At the current market value for carbon (which varies considerably around the world), a hectare of rainforest, if left intact, could be worth anywhere from $400 to $8000 or more.

At present, economic markets provide few if any incentives to slow deforestation (Myers & Kent 2001). As a result, the opportunity costs of preserving tropical forest are largely born by developing countries, despite the fact that doing so provides a major global benefit (Balmford & Whitten 2003). Many land uses in the tropics, such as swidden farming, small-scale cattle ranching,

FIGURE 2. Intensive land uses such as slash-and-burn farming are a major source of greenhouse gases (photo by W. F. Laurance).

and low-volume timber extraction, are only marginally profitable (Diaz & Schwartzman 2005), permitting individuals to eke out a living, but little more. Moreover, in tropical frontier areas in Brazil, colonists are required to "improve" (*i.e.,* deforest) the land in order to make viable claims for land title (Fearnside 2006). An effective scheme to reward developing nations for conserving forests, especially if it ensures that a sizeable fraction of the benefits reach rural landowners, could radically alter the flawed economic logic and perverse incentives that are driving rapid forest destruction.

TECHNICAL AND POLITICAL CHALLENGES

Developing a workable mechanism to reduce deforestation via carbon trading requires surmounting a number of practical challenges. To claim carbon credits, a developing nation must first establish its "baseline" rate of deforestation. One possible idea for the baseline, for example, is to use the average yearly deforestation rate for each country between 1990 and 2005 (but see Santilli *et al.* 2005 and Achard *et al.* 2006 for regional and pan-tropical alternatives to a national-baseline approach). The main country-level estimates of past deforestation, produced by the U.N. Food and Agricultural Organization (*e.g.*, FAO 2001), are criticized because they are largely based on national statistics that vary among assessments and countries (Grainger 1996, Matthews 2001). Satellite data can provide more reliable estimates of past deforestation (DeFries *et al.* 2005), but generating these estimates requires money and technical expertise. At present only two developing nations, Brazil and India, have long-term programs to monitor forest loss (DeFries *et al.* 2005). To develop the capacity to quantify past deforestation, and to carefully monitor future deforestation, many smaller countries will first require start-up funds from international donors or lenders.

Once the baseline rate is known, a country could then profit by slowing its annual deforestation rate below its baseline rate. Some countries, especially forest-rich nations with high deforestation rates, such as Brazil and Indonesia, could potentially gain large revenues. Suppose, for example, that the baseline rate for Indonesia is 1.5 million ha/yr, and that the government manages to reduce this to 1.0 million ha/yr. If one assumes that every hectare of preserved forest saves 200 tons of carbon emissions and that each ton of carbon is worth $10 on the international market, then Indonesia could gain around $1 billion each year.

Of course, industrial nations or international carbon funds would never provide such large payments without convincing assurances that they were effective in reducing net carbon emissions. Indonesia would need to show that leakage was not occurring and, even more importantly, that the cuts in deforestation were permanent, not temporary. The issue of permanence is one of the key concerns about using forest conservation to reduce carbon emissions (Fearnside 2001b, 2002, 2006). If cash-strapped nations accept carbon funds to protect forests but later allow deforestation to increase, or if future climatic change were to cause major forest declines (*cf.*, Cox *et al.* 2000, Laurance & Williamson 2001), then the emission reductions would not be permanent. Despite such concerns, it is generally agreed that practical mechanisms could be developed (such as an insurance system in which a portion of the carbon-credit funds owed to a developing nation are temporarily held in escrow) to ensure that deforestation reductions are truly long term in nature (Moutinho & Santilli 2005).

The idea of making permanent, binding cuts in rates of forest loss is a major concern of some developing countries, such as Brazil, which fear that their future development options and even national sovereignty might be compromised (Fearnside 2001a, 2001c). One way to help allay such concerns is for carbon buyers to focus on "renting" (rather than purchasing) carbon credits from developing countries, with the annual payments for such temporary credits to be a small fraction of their purchase cost (Kerr & Leining 2000). Although nonbinding and impermanent, such measures would create immediate incentives for nations to reduce deforestation, and thus would help to combat the rapid rise in greenhouse gases (see Fearnside 2001b, 2002, 2006 for extensive discussion). Such temporary measures could have important environmental benefits, reducing short-term pressures on tropical forests while potentially increasing public support in developing nations for longer-term forest-conservation initiatives.

The example discussed previously, in which Indonesia gains $1 billion each year, assumes that the price of carbon would remain stable at $10 per ton. Many believe that carbon credits will exceed this price in the coming one to two decades, but if a number of developing nations cut their deforestation rates simultaneously, then the market might be oversupplied with carbon credits (but see Moutinho & Santilli 2005). As with any tradable commodity, the price of carbon credits is determined by supply and demand. Keeping the price at an adequate but reasonable level means striking a balance between the needs of carbon-credit producers (developing countries) and consumers (industrial nations). Of course, if industrial nations, most notably the United States, were to agree to substantial emissions reductions, then demand for carbon credits could be very high, creating greater incentives for forest conservation.

Even if all goes well with current negotiations, a formal mechanism for rainforest-carbon trading is unlikely to take effect before the Kyoto Protocol's Second Commitment Period, beginning in 2013. However, a recent proposal for "compensated reductions of deforestation" (Moutinho & Santilli 2005, Santilli *et al.* 2005) has generated considerable interest, because it could provide a means to slow forest loss sooner. Under this scheme, nations that reduce deforestation between 2008 and 2012 would receive carbon funds for those reductions, based on the average market value for carbon in 2012. Conversely, nations that increase deforestation during 2008 to 2012 would be penalized, by having to "pay off" their increased emissions by slowing future deforestation, before being eligible to receive carbon funds. By creating such near-term incentives and penalties, a plan like this could potentially kick-start efforts to slow deforestation.

Finally, it is essential that carbon funds be hamessed effectively to reduce deforestation. Such funds could be used for a variety of purposes, such as improving government institutions and capacity, increasing enforcement of environmental laws, providing direct payments to landowners who agree to limit forest loss, and monitoring the landowners to ensure that they abide by their agreements. Costa Rica is already doing this with considerable success, via various tax and incentive mechanisms, but it involves a concerted effort to monitor land use and reward cooperating individuals (Castro *et al.* 1998, Pfaff *et al.* 2000). Similar efforts will be needed in other nations that accept carbon funds, and could be especially challenging in remote, frontier regions, such as the Amazon and Congo Basins, where environmental enforcement is limited and land tenure is often insecure or nonexistent (*e.g.*, Laurance 1998, Vedder *et al.* 2001).

CONCLUDING REMARKS

Creating an effective system for forest monitoring and compliance is a major challenge for any nation (*e.g.*, Pfaff *et al.* 2000), but it must be emphasized that developing countries direly need to develop this capacity, regardless of carbon trading. In many tropical nations, lawlessness, waste, and corruption exact a massive cost on their national economies (Kaufmann 1997, Smith *et al.* 2003). In the Brazilian Amazon, for example, roughly 80 percent of all timber cutting is illegal, meaning that the timber is effectively stolen, with no environmental control over harvest operations or payment of government royalties (Laurance 1998). This has both serious environmental costs and a major impact on government revenues. Hence, using carbon trading to slow deforestation should help governments to stabilize and manage their often unruly frontiers.

Aside from its obvious environmental benefits, the reduced-deforestation initiative might also have important political ramifications. One of the main reasons offered by the Bush administration and the U.S. Congress for failing to support Kyoto was that it neglected to address growing carbon emissions in developing countries. Because deforestation is the biggest source of emissions for many developing nations (Fearnside 2000, Houghton 2003), this initiative might help to remove a key stumbling block for future U.S. climate accords.

Even its proponents expect that much political negotiation and alliance building will be needed before a final agreement to reduce deforestation can be hammered out. It is not yet known, for example, whether the initiative will function within or outside the Kyoto Protocol. Moreover, individual nations will surely try to mold the agreement to benefit their particular interests. For this reason negotiations to date have purposefully focused on a general strategy rather than specific details. One of the biggest fears is that the Bush administration might try to hamstring the ongoing dialogue by insisting, as it has frequently done in the past, on "scientific rigor": that concrete actions to attack global warming must be preceded by virtual scientific certainty. Such certainty is a rare commodity in science, particularly in the complex field of climate change, so a common perception is that such calls are in reality an excuse for inaction.

Despite the many challenges it faces, the Coalition for Rainforest Nations seems determined not to let this rare opportunity fail. I am very pleased that the ATBC is actively supporting this proposition (ATBC 2006; Laurance 2006a, 2006b), for it could help to reduce two of the most serious environmental threats—global warming and tropical deforestation—we face today. This is not a new initiative, but these are new initiators, and the fact that this proposal is being vigorously led by developing nations could be a crucial advantage.

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LITERATURE CITED

ACHARD, F., A. S. BELWARD, H. D. EVA, S. FEDERICI, D. MOLLICONE, AND F. RAES. 2006. Accounting for avoided conversion of intact and non-intact forests: Technical options and a proposal for a policy tool. Technical Report, Institute for Environment and Sustainability, Joint Research Centre for the European Commission, Brussels.

ACHARD, F., H. D. EVA, P. MAYAUX, H. J. STIIBIG, AND A. BELWARD. 2004. Improved estimates of net carbon emissions from land cover change in the tropics for the 1990s. Global Biogeochem. Cycles 18: GB2008, doi 10.1029/2003GB002142.

ATBC. 2006. Resolution in support of efforts to use carbon trading to promote tropical forest conservation. Tropinet Newsletter, 17(3): 5.

BALMFORD, A., AND T. WHITTEN. 2003. Who should pay for tropical conservation, and how could the costs be met? Oryx 37: 238–250.

BROWN, S., AND A. E. LUGO. 1992. Aboveground biomass estimates for tropical moist forest of the Brazilian Amazon. Interciencia 17: 8–18.

CASTRO, R., F. TATTENBACH, L. GÁMEZ, AND N. OLSON. 1998. The Costa Rican experience with market instruments to mitigate climate change and conserve biodiversity. Fundecor and MINAE, San José, Costa Rica.

COX, P. M., R. A. BETTS, C. D. JONES, S. A. SPALL, AND I. J. TOTTERDELL. 2000. Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. Nature 408: 184–187.

DAVIDSON, E. A., AND S. E. TRUMBORE. 1995. Gas diffusivity and the production of CO_2 in deep soils of the eastern Amazon. Tellus 47B: 550–565.

DEFRIES, R. S., G. ASNER, F. ACHARD, C. JUSTICE, N. LAPORTE, K. PRICE, C. SMALL, AND J. TOWNSHEND. 2005. Monitoring tropical deforestation for emerging carbon markets. *In* P. Moutinho and S. Schwartzman (Eds.). Tropical deforestation and climate change, pp. 35–44. Instituto de Pesquisa Ambiental da Amazonia, Belém, Brazil.

DEFRIES, R. S., R. A. HOUGHTON, M. C. HANSEN, C. B. FIELD, D. SKOLE, AND J. TOWNSHEND. 2002. Carbon emissions from tropical deforestation and regrowth based on satellite observations for the 1980s and 90s. Proc. Natl. Acad. Sci. USA 99: 14256–14261.

DIAZ, M. C. V., AND S. SCHWARTZMAN. 2005. Carbon offsets and land use in the Brazilian Amazon. *In* P. Moutinho and S. Schwartzman (Eds.). Tropical deforestation and climate change, pp. 93–98. Instituto de Pesquisa Ambiental da Amazonia, Belém, Brazil.

FAO. 2001. Global forest resources assessment 2000. Paper number 140, United Nations Food and Agricultural Organization, Rome.

FEARNSIDE, P. M. 2000. Global warming and tropical land-use change: Greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation. Clim. Change 46: 115–145.

FEARNSIDE, P. M. 2001a. Environmentalists split over Kyoto and Amazonian deforestation. Environ. Conserv. 28: 295–299.

FEARNSIDE, P. M. 2001b. Uncertainty in land-use change and forestry sector mitigation options for global warming: Plantation silviculture versus avoided deforestation. Biomass and Bioenergy 8: 457–468.

FEARNSIDE, P. M. 2001c. Saving tropical forests as a global warming countermeasure: An issue that divides the environmental movement. Ecol. Econ. 39: 167–184.

FEARNSIDE, P. M. 2002. Time preference in global warming calculations: A proposal for a unified index. Ecol. Econ. 41: 21–31.

FEARNSIDE, P. M. 2004. Tropical deforestation and greenhouse gas emissions. Ecol. Appl. 14: 982–986.

FEARNSIDE, P. M. 2006. Mitigation of climatic change in the Amazon. *In* W. F. Laurance and C. A. Peres (Eds.). Emerging threats to tropical forests, pp. 353–376. University of Chicago Press, Chicago.

FEARNSIDE, P. M., ANDW. F. LAURANCE. 2003. Comment on "Determination of deforestation rates of the world's humid tropical forests." Science 299: 1501a–1502a.

FEARNSIDE, P. M., ANDW. F. LAURANCE. 2004. Tropical deforestation and greenhouse gas emissions. *Ecological Applications* 14: 982–986.

FRANGI, J. L., AND A. E. LUGO. 1985. Ecosystem dynamics of a subtropical floodplain forest. Ecol. Monogr. 55: 351–369.

GRAINGER, A. 1996. An evaluation of the FAO tropical resource assessment, 1990. Geogr. J. 162: 73–79.

HOUGHTON, R. A. 2003. Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management. Tellus 55B: 378–390.

HOUGHTON, R. A. 2005. Tropical deforestation as a source of greenhouse gas emissions. *In* P. Moutinho and S. Schwartzman (Eds.). Tropical deforestation and climate change, pp. 13–21. Instituto de Pesquisa Ambiental da Amazonia, Belém, Brazil.

HOUGHTON, R. A., D. L. SKOLE, C. A. NOBRE, J. L. HACKLER, K. T. LAWRENCE, AND W. H. CHOMENTOWSKI. 2000. Annual fluxes of carbon from deforestation and regrowth in the Brazilian Amazon. Nature 403: 301–304.

HUGHES, R. F., J. B. KAUFFMAN, AND V. J. JARAMILLO. 2000. Ecosystem-scale impacts of deforestation and land use in a humid tropical region of Mexico. Ecol. Appl. 10: 515–527.

KAUFMANN, D. 1997. Corruption: The facts. Foreign Policy 107: 114–131.

KERR, S., AND C. LEINING. 2000. Permanence of LULUCF CERs in the Clean Development Mechanism. Center for Clean Air Policy, Washington, D.C.

KREMEN, C., J. O. NILES, M. G. DALTON, G. C. DAILY, P. R. EHRLICH, J. P. FAY, D. GREWAL, AND R. P. GUILLERY. 2000. Economic incentives for rain forest conservation across scales. Science 288: 1828–1832.

LAURANCE, W. F. 1998. A crisis in the making: Responses of Amazonian forests to land use and climate change. Trends Ecol. Evol. 13: 411–415.

LAURANCE, W. F. 2006a. The value of trees. New Scientist, 15 April, p. 24.

LAURANCE, W. F. 2006b. A change in climate. Tropinet Newsletter 17(2): 1–3.

LAURANCE, W. F., AND C. A. PERES (Eds.). 2006. Emerging threats to tropical forests. University of Chicago Press, Chicago.

LAURANCE, W. F., AND G. B. WILLIAMSON. 2001. Positive feedbacks among forest fragmentation, drought, and climate change in the Amazon. Conserv. Biol. 15: 1529–1535.

MALHI, Y., AND J. GRACE. 2000. Tropical forests and atmospheric carbon dioxide. Trends Ecol. Evol. 15: 332–337.

MALHI, Y., AND O. L. PHILLIPS. 2005. Tropical forests and global atmospheric change. Oxford University Press, Oxford, UK.

MATTHEWS, E. 2001. Understanding the FRA 2000. World Resources Institute, Washington D.C.

MOUTINHO, P., AND M. SANTILLI. 2005. Reduction of GHG emissions from deforestation in developing countries. International submission to the Eighth Convention of Parties to the United Nations framework convention on climate change. Instituto de Pesquisa Ambiental da Amazonia, Belém, Brazil.

MOUTINHO, P., AND S. SCHWARTZMAN (Eds.). 2005. Tropical deforestation and climate change. Instituto de Pesquisa Ambiental da Amazonia, Belém, Brazil.

MYERS, N., AND J. KENT. 2001. Perverse subsidies: How tax dollars can undercut the environment and the economy. Island Press, Washington, D.C.

NASCIMENTO, H. E. M., AND W. F. LAURANCE. 2002. Total aboveground biomass in central Amazonian rainforests: A landscape-scale study. For. Ecol. Manage. 168: 311–321.

PFAFF, A. S. P., S. KERR, R. F. HUGHES, S. LIU, G. A. SANCHEZ-AZOFEIFA, D. SCHIMEL, J. TOSI, AND V. WATSON. 2000. The Kyoto protocol and payments for tropical forest: An interdisciplinary method for estimating carbon-offset supply and increasing the feasibility of a carbon market under the CDM. Ecol. Econ. 35: 203–221.

RAI, S. N., AND J. PROCTOR. 1986. Ecological studies on four rainforests in Karnataka, India I: Environment, structure, floristics and biomass. J. Ecol. 74: 439–454.

SANTILLI, M., P. MOUTINHO, S. SCHWARTZMAN, D. NEPSTAD, L. CURRAN, AND C. NOBRE. 2005. Tropical deforestation and the Kyoto Protocol: An editorial essay. Clim. Change 71: 267–276.

SILVA-CHAVEZ, AND A. PETSONK. 2006. Rainforest credits. Carbon Finance, December/January, p. 18.

SMITH, J., K. OBIDZINSKI, SUBARUDI, AND I. SURAMENGGALA. 2003. Illegal logging, collusive corruption and fragmented governments in Kalimantan, Indonesia. Int. Forestry Rev. 5: 293–302.

VEDDER, A., L. NAUGHTON-TREVES, A. PLUMPTRE, L. MUBALAMA, E. RUTAGARAMA, AND W. WEBER. 2001. Conflict and conservation in the African rain forest. *In* W. Webber, L. J. T. White, A. Vedder, and N. Naughton-Treves (Eds.). African rain forest ecology and conservation, pp. 557–562. Yale Univ. Press, New Haven, Connecticut.

WORLD BANK. 2006. The little green data book 2006. World Bank, Washington, D.C.

ZHENG, Z., Z. FENG, M. CAO, Z. LI, AND J. ZHANG. 2006. Forest structure and biomass of a tropical seasonal rain forest in Xishuangbanna, southwest China. Biotropica 38: 318–327.