KNOWLEDGE IN DEVELOPMENT NOTES

Tropical Deforestation, Biodiversity and Development

Environmental problems are very diverse and often poorly understood, damaging health, productivity, and economic assets in countries across the development spectrum.[1] Environmental research at the World Bank has thus focused strategically on a few issues of widespread relevance where information is particularly sparse. Researchers have devoted particular attention to industrial pollution in the developing world, showing that pollution is by no means an inevitable companion of industrialization. Pollution can often be abated at modest cost with substantial social benefits. An emerging set of institutions involving public disclosure can complement more traditional regulatory and market instruments in realizing these gains.

Research has also focused on tropical deforestation—an important but seemingly intractable global problem. About 10 percent of tropical forests are destroyed every decade, with each decade's loss representing an area about the size of Bolivia. The clearing and burning of these forests releases CO_2 to the atmosphere, accounting for about one-fifth of the annual human effect on global warming. The loss of these forests and other natural habitats places a substantial proportion of the world's plant and animal species in jeopardy of extinction. And these land-use changes can result in local environmental damages, such as flooding and soil erosion.

The dilemma for the Bank, and its clients, is that forest clearing is often related to agricultural expansion and rural development. How can society balance the benefits, including enhanced rural production and employment, against the costs of local and global environmental damage?

To resolve this, we need to understand the causes of deforestation, who benefits and who loses from deforestation, and by how much, and how to set up institutions that balance the interests of these groups and bring about more equitable, efficient, and sustainable land uses.

Our understanding to date

Deforestation is rational, not necessarily a symptom of poverty, and is mostly related to agricultural conversion

It was once thought that deforestation was either irrational, the result of perverse subsidies, or a symptom of extreme poverty. Attention focused on loggers as the culprits. In the Amazon, for instance, agricultural expansion was once blamed on irrational speculation or tax incentives, but is now understood to arise from rational profit-driven conversion to agriculture supplemented by timber exploitation.[2] Deforestation is often undertaken by large commercial interests rather than small subsistence farmers, especially in Latin America and parts of Asia.

Road accessibility, especially in agriculturally favorable areas, stimulates both deforestation and rural development

Road placement in forested areas with agricultural potential is in general a strong promoter of deforestation.[3] This raises important issues for rural development policy, because the extension of rural roads is also a potentially powerful instrument for improving farm incomes.[4] The two effects are clearly related.

Parks and protected areas are often surprisingly effective in deterring deforestation. But the scope for park expansion is limited

Parks have been criticized as being exclusionary of local populations, and as being unenforced and ineffective—"paper parks." But research is finding that deforestation rates within parks are significantly lower than in comparable unprotected areas.[5] Even so, parks have mostly been established in remoter areas, where pressures for conversion are relatively low.

Economic instruments can, in theory, minimize the trade-offs between agriculture and biodiversity conservation

The biodiversity crisis is most grave, and the potential tradeoffs most severe, in the hotspots. Reduced to mere fragments by agricultural and population pressure, these patches of vegetation cover 1.4 percent of the earth's surface but contain about a third of its biodiversity. That biodiversity is at severe risk of near-term extinction unless these fragments are expanded, reconnected, and buffered by more biodiversity-friendly agriculture. But how, in these often densely populated areas, can landholders be induced to make the necessary changes in land management?

The traditional approach has been command-and-control conservation planning. This has achieved some success through the establishment of parks and protected areas. But it is now widely understood that biodiversity conservation requires not only additional parks, but also changes in land use management by private landholders, over wide areas. Here the command-and-control approach has broken down. Although sophisticated technical tools exist to plan biodiversity corridors (ensuring enough contiguous habitat to maintain viable animal and plant populations), attempts at enforcing these plans through zoning have failed to secure compliance. The World Bank, for instance, has loaned hundreds of millions of dollars to Brazil for land use planning and zoning, but concluded that these plans were ineffective.[6]

An alternative attracting interest is the use of economic instruments to induce voluntary cooperation with conservation plans while minimizing the total cost of the plans.[7] A common feature is a payment conditional on some landholder action. Simulations for Brazil (where the conservation-development relationship is of intense policy interest) have shown that the use of economic instruments can in principle drastically reduce the social cost and increase the environmental benefits associated with achieving conservation goals.[8] The reason is that there is substantial spatial cross-variation in the economic and ecological value of land.[9] A surprising finding is that economic instruments appear, in some circumstances, to achieve specific ecological goals (such as conserving contiguous areas) that were thought to require top-down, command-and-control planning.[10]

Payments for forest conservation (or sustainable use) might be financed by the beneficiaries of three environmental benefits: watershed protection, carbon sequestration, and biodiversity conservation as an end in itself

Who might finance payments for conservation (or more sustainable land use), and why—how would they benefit? Hopes have been pinned on the possibility that forest conservation would provide "bankable" benefits that could be financed by local beneficiaries. But many of these hoped-for domestic benefits—such as sustainable extraction of timber products, ecotourism, and bioprospecting—appear to be inadequate to motivate much conservation—because they generate low-per hectare benefits, or are applicable only to very limited areas.[11] Three benefits seem potentially bankable: the local benefits of watershed protection, and the global benefits of sequestering carbon and protecting biodiversity, valued for its own sake rather than as a production input. Since there is as yet no hint of a mechanism to mobilize funding for the latter benefit (aside from the Global Environment Facility), we discuss the prospects for harnessing the demand for watershed maintenance and carbon sequestration to promote forest conservation.

Watershed benefits of forest protection: sometimes important, but with limited scope

Forests are often thought to prevent floods, aid dry season flows, and prevent erosion and sedimentation, and these suppositions have been used to justify significant policy decisions (such as China's decision to ban logging following the Yangtze floods). Modern hydrological science has, however, cast significant doubt on the strength and generality of these relationships.[12] In particular, there has been skepticism about whether there is a link between upland deforestation and flooding in downstream cities (important, because urban willingness to pay for flood mitigation might be large).

Emerging research points to specific geographical situations where forest conservation might result in significant downstream benefits. In Guatemala for instance, small, hydrologically sensitive watersheds cover only one-third the country's area, but contain one-third of the country's poor people and 42 percent of its montane forest.[13] At a global scale, new studies suggest that large-scale deforestation might indeed increase the exposure of downstream populations to flooding, though not to the most catastrophic floods. One study estimated that loss of all critically endangered biodiverse forest areas in the tropics would expose about 100 million floodplain dwellers to increased water flows, likely meaning a greater incidence of flooding.[14]

But deforestation tends to increase rather than decrease dry-season waterflows. And there are alternatives to forest conservation—including agroforestry—which produce many of the same hydrological benefits with higher incomes to landholders though lower biodiversity benefits.

The carbon market could potentially finance forest conservation on a large scale—but there are political barriers to be overcome

The entry into force of the Kyoto Protocol brings with it a large new source of environmental finance. Under the Protocol, developed countries accept limits on their emissions of greenhouse gases. But they have the option to offset their emissions by

purchasing emissions reductions from the developing and transition economies. Emissions reductions are produced when the supplying countries switch to more efficient energy technologies and (to a limited extent) when they sponsor reforestation. This arrangement reduces the global cost of mitigating climate change, while transferring resources and technology to the developing world. The World Bank's Carbon Finance Business has been playing an important role in prototyping and funding carbon projects in the developing and transition economies.

The Kyoto Protocol does not, however, currently allow developing countries to sell emissions reductions based on prevented deforestation—a lost opportunity in economic and environmental terms. In some places at the forest frontier, a hectare of forest is converted to a pasture worth a few hundred dollars, while emitting up to 600 tons of CO_2. Forest conservation could therefore reduce emissions at costs as low as $0.50 a ton, while maintaining irreplaceable biodiversity. In contrast, the going price for emissions reductions in the nascent carbon market ranges from about $3 to $10 per ton CO_2. [15]

What keeps the world from grasping this apparently attractive opportunity? There is a wide range of technical objections to the creation of emissions reductions from forest protection, or from improved farming techniques that boost biomass and soil fertility. These revolve around guaranteeing the integrity of the claimed emissions reductions, reflecting both economic concerns (does protection of one forest merely divert pressure to a neighboring one) and institutional ones (how can long-term permanence of carbon sequestration be guaranteed?). Solutions have been proposed for most of these problems.[16] Further elaboration and discussion of these solutions could help shape decisions for the Kyoto Protocol's Second Commitment period (post 2012), for which negotiations are about to get under way.

Current and future research directions

What exactly is the connection between poverty and deforestation?

It is often asserted that poverty causes deforestation, and vice versa. Uncritical acceptance of this generalization can lead to policy distortions and poorly conceived projects. But a growing portfolio of detailed poverty maps and environmental maps permits a better informed examination of the links between poverty, forests, and deforestation. In general we would expect that different policy instruments may have different kinds of effects on poverty and on deforestation.

Areas under investigation include the following:

- *Vulnerability of forest-dependent communities.* What is the number, location, and vulnerability of populations largely dependent on forest extraction for their livelihoods?

- *Regional development and forested areas*. There may be a general tendency for remoter areas to have higher forest cover, high poverty incidence, but lower population density than more accessible areas. What are the appropriate development options for these areas, taking into account the higher costs of providing infrastructure and social services? Under what circumstances can sales of forest products or forest environmental services provide satisfactory and sustainable livelihoods?

- *Macropolicies, poverty, and deforestation.* Limited evidence suggests that policies favoring agriculture will promote deforestation[17] while possibly alleviating rural poverty. A better understanding of these linkages is necessary—particularly in applying safeguards policies to the Bank's adjustment lending, as is now mandated.

What kind of institutions can effectively regulate deforestation and land use?

The agenda posited here involves the creation of institutions that can balance interests between those who benefit and those who lose from deforestation, arrive at some set of regulations and market-like instruments that shape land use or affect forest extraction, and implement those regulations and instruments. Creating these institutions is difficult, because of imbalances between the winners and losers from deforestation and because of the difficulties of monitoring vast forest areas.

Technical and institutional innovations are changing this picture, and the Bank has been involved in many of them. They include Costa Rica's famous payment for environmental services program; experiments in paying farmers to adopt environmentally friendly silvopastoral techniques in Colombia, Nicaragua, and Costa Rica; Brazilian state initiatives that use satellite monitoring of landholder agreements; auctions of forest concessions and independent monitoring of government and concessionaire compliance in Cameroon; exploratory discussions on the potential to use international legislation on money laundering to deter illegal logging. It will be important to monitor the environmental, economic, and social effects of these initiatives to understand the potential for scaling up.

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Endnotes

Most Bank documents cited in this summary are available through the documents and reports portal of the World Bank http://www-wds.worldbank.org/. The word "processed" describes informally reproduced works that may not be commonly available through library systems.

[1] The introduction and note as a whole draw on the *World Development Report 2003: Sustainable Development in a Dynamic World,* chapter 8.

[2] K. M. Chomitz and T. S. Thomas. 2003. "Determinants of Land Use in Amazônia: A Fine-Scale Spatial Analysis." *American Journal of Agricultural Economics* 85(4): 1016–28; S. Margulis. 2004. "Causes of Deforestation in the Brazilian Amazon." World Bank Working Paper 22. World Bank, Washington, D.C.; S. Wunder. 2000. *The Economics of Deforestation: The Example of Ecuador.* NY: St. Martins; T. Tomich and others. 2001. "Agricultural Intensification, Deforestation, and the Environment: Assessing Tradeoffs in Sumatra, Indonesia. " In D.R. Lee and C.B. Barrett, eds., *Tradeoffs or Synergies: Agricultural Intensification, Economic Development and the Environment.* NY: CABI Publishing.

[3] See K. Chomitz and T. S. Thomas 2003 (cited above); K. Chomitz and D. Gray. 1996. "Roads, Land Use, and Deforestation: A Spatial Model Applied to Belize." *World Bank Economic Review 10*(3): 487–512; M. Cropper, C. Griffiths, and M. Mani. 1999. "Roads, Population Pressures, and Deforestation in Thailand, 1976–1989."

Land Economics 75 (1): 58–73; C. Corson, K. M. Chomitz, G. Harper, M. Honzák, B. Ozler, "Poverty, Population, and Deforestation in Madagascar." Forthcoming in R. Cincotta, ed. *Demographic and Human Geographic Changes and Their Relationships with Biological Diversity*. Springer-Verlag.

[4] H. G. Jacoby. 2000. "Access to Markets and the Benefits of Rural Roads." *The Economic Journal* 110(465): 713–37; S. Fan and C. Chan-Kang. 2004. "Returns to Investment in Less-Favored Areas in Developing Countries: A Synthesis of Evidence and Implications for Africa." *Food Policy* 29(4):431–44.

[5] K. M. Chomitz and D. Gray. 1996 (cited above); Corson and others in prep (cited above); A.G. Bruner and others 2001. "Effectiveness of Parks in Protecting Tropical Biodiversity." *Science* 291(5501): 125–28.

[6] World Bank. 2003. Implementation Completion Report (CPL-34440) on a loan in the amount of US$167.0 million to the Federative Republic of Brazil for a Rondonia Natural Resources Management Project." Report No. 26080. Washington, D.C.

[7] D. Stoms, K. M. Chomitz, and F. W. Davis. 2004. TAMARIN: "A Landscape Framework for Evaluating Economic Incentives for Rainforest Restoration." *Landscape Urban Plan* 68(1): 95–108; K. M. Chomitz, E. Brenes, and L. Constantino. 1999. "Financing Environmental Services: The Costa Rican Experience and Its Implications." *Science of the Total Environment* 240: 157–69

[8] K. M. Chomitz, T. S. Thomas, and A. Salazar Brandão. 2004. "Creating Markets for Habitat Conservation When Habitats Are Heterogeneous." Policy Research Working Paper 3429. World Bank, Washington, D.C.; K. M. Chomitz. 2004. "Transferable Development Rights and Forest Protection: An Exploratory Analysis." *International Regional Science Review* 27(3): 348–73.

[9] K. M. Chomitz, K. Alger, T. S. Thomas, H. Orlando, and P. Vila Nova. "Opportunity Costs of Conservation in a Biodiversity Hotspot: The Case of Southern Bahia." Accepted by *Environment and Development Economics*.

[10] K.M. Chomitz *et al.*, "Biodiversity corridors arising from individual landholder responses to conservation incentives." To be submitted, *Ecology Letters.*

[11] K. M. Chomitz and K. Kumari. 1998. "The Domestic Benefits of Tropical Forest Preservation: A Critical Review Emphasizing Hydrological Functions." *World Bank Research Observer* 13(1): 13–35; R. D. Simpson, R.A. Sedjo, and J.W. Reid. 1996. "Valuing Biodiversity forUse in Pharmaceutical Research." *Journal of Political Economy* 104(1): 163–85.

[12] K. M. Chomitz and K. Kumari. 1998 (cited above); I. Calder. 1999. *The Blue Revolution.* London: Earthscan.

[13] A. Nelson and K. M. Chomitz. 2004. "The Forest-Hydrology-Poverty Nexus in Central America: An Heuristic Analysis." Policy Research Working Paper 3430. World Bank, Washington, D.C.

[14] E. Douglas, K. Sebastian, C. Vörösmarty, S. Wood, and K. M. Chomitz. "The Role of Tropical Forests in Supporting Biodiversity and Hydrological Integrity: A Synoptic Overview." Submitted to *Ecological Application.*

[15] F. M. Lecocq. 2004. *The State and Trends of the Carbon Market*." Washington, D.C.: World Bank Prototype Carbon Fund.

[16] K. M. Chomitz. 2002. "Baseline, Leakage, and Measurement Issues: How Do Forestry and Energy Projects Compare?" *Climate Policy* 2: 35–59; K. M. Chomitz and F. M. Lecocq. 2003. "Temporary Sequestration Credits: An Instrument for Carbon Bears." Policy Research Working Paper 3181. World Bank, Washington, D.C.

[17] S. Wunder. 2003. *Oil Wealth and the Fate of Forests.* Routledge.