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COMMUNITY ESSAY

Sustainable development of the Amazon forest: a fine line between conservation and exploitation?

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Author's Personal Statement:

This essay constitutes a piece of boundary work between science and policy. It illustrates the conflicts, but also the opportunities, that natural resource management encounters in the twenty-first century. I have tried to provide a widely accessible document that argues why a more holistic approach to conservation and natural resource management is imperative. Inspired by the concept of "Integrated Forest Management," I conceived the basics for an "Integrated Sustainable Development" strategy. I have approached the vast topic of "sustainable development in the Amazon" without complicated methodology because I want to present the problem in its inherent complexity and any other manner would largely exceed the length of an essay. A future scientific challenge is to deepen the analysis of why an integrated approach to conservation and ecosystem management is more likely to succeed than a segregative approach. Ultimately, the more political task, however, is to promote dialogue between the manifold and important stakeholder groups in the Amazon to a point where social, ecological, and economic realities are combined and provide a portfolio of sustainable development options.

The Amazon—A Region at Risk

The Amazon region harbors enormous plant and animal biodiversity that provides substantial regional and global ecosystem services (Constanza et al. 1997; Kier et al. 2005; Grenyer et al. 2006). However, Brazil (where most of the Amazon region is located) faces rapid development likely to degrade the Amazon forest, with worldwide consequences for biodiversity and ecosystem services (Cox et al. 2004; Lenton et al. 2008; Malhi et al. 2009). The reasons for such dramatic ecological changes are manifold: deforestation, fragmentation, fire, macroeconomic pressure, and climate change (see Scholze et al. 2006; Betts et al. 2008; Malhi et al. 2008; Nepstad et al. 2008). Meanwhile, the sustainable development of the Amazon forest is vital to conserve its functions and value for humanity. The estimated worth of nutrient cycling, raw materials provision, erosion control, climate regulation, and other ecological functions is estimated to be US$2,000 per hectare per year, making tropical forests one of the most valuable terrestrial ecosystems (Constanza et al. 1997).

A Framework of Barriers and Opportunities

Conservation is seen here as the preservation of the functioning and diversity of an ecosystem in its current but dynamic state. Although change is an inherent feature of natural systems, the emphasis is on maintaining resistant and resilient systems that contribute to the long-term well being of human societies (Kasperson et al. 1995). Contrary, *exploitation* is any purposeful activity aimed at generating short-term financial benefit while altering ecosystem composition. The successful implementation of conservation and exploitation activities faces different barriers and opportunities, discussed in this essay regarding forest ecosystems in the Amazon. The essay then derives implications for the region's sustainable development.

Attacked From All Sides—Various Threats to Forest Conservation in the Amazon

The barriers to conservation of the Amazon forest are *institutional*, *socioeconomic*, *economic*, and *ecological*. They are deeply intertwined, but disentangling them into their principal components helps to make clear their respective importance. The *institutional* barriers for the conservation of the Amazon forest ecosystems comprise administrative/legal challenges and irregularities across and along scales, from the organizational to the national policy level. In remote areas unclear land tenure, relative inaccessibility, and resulting ownership conflicts may hinder conservation efforts. Several authors point out the detrimental effects of poor law enforcement, mismanagement, perverse economic incentives, and corruption that set up a framework for uncontrolled and arbitrary exploitation of natural resources (Binswanger, 1991; Simmons, 2004; Carr et al. 2005; Bulte et al. 2007). Resulting illegal logging and deforestation challenge conservation efforts and contribute to the Amazon's critical situation (Laurance, 1998).

Socioeconomic barriers for conservation in the Amazon are directly related to the population's living conditions. Poverty, demographic pressure from population increase, and global economic forces may drive local people to use the forest irrespective of its conservation status (Geist & Lambin, 2001; Lambin et al. 2001).

Economic barriers related to the conservation of the Amazon forest mostly encompass a global undervaluation of ecological services that do not leave valuable economic alternatives other than clearing the forest (Constanza et al. 1997). Currently, the income from the forest and its products (e.g., wood, fruits) is inferior to competing land uses such as farming. Globalized markets and prices increase the economic pressure to convert forests to cropland and the rate of deforestation of the Amazon has been correlated to relevant crop prices in international markets (Morton et al. 2006).

The *ecological* barriers to conservation in the Amazon mostly result from human action. Although constantly progressing and evolving, the lack of knowledge and associated uncertainties regarding ecological processes and biodiversity functioning is inherent to the science of ecology itself (Hooper et al. 2005). Other anthropogenic interventions that create ecological barriers vary in scale and intensity and range from fuel-wood collection to illegal activities such as logging, mining, and poaching to serious overexploitation of the forest and land-use change due to agriculture and plantations. The fragmentation of the forest through infrastructure development (Laurance, 2004) and the propagation of invasive species place additional constraints on successful forest conservation (Asner et al. 2008). Finally, climate change and associated risks and uncertainties (Parrey et al. 2007; Roe & Baker, 2007; Solomon et al. 2007; Eastaugh, 2008) represent a major challenge for biodiversity conservation across the globe, including the Amazon (Lovejoy & Hannah, 2005; Bonan, 2008). The interplay of these barriers results in a change in structure and composition of the forest and in higher fire intensity and frequency threatening an ecosystem where natural fires had been rare (Aragão et al. 2008; Barlow & Peres, 2008; Bush et al. 2008; Phillips et al. 2008). Other ecological processes such as interspecific interactions or mismatching phenological events may build up further ecological barriers.

Forest Exploitation in the Amazon—Difficulties from Stand to Global Level

Management of a vast forest area such as the Amazon requires a downscaling of measures to the forest-stand level.[1] During management activities, private and public managers may encounter *institutional*, *technical*, *economic*, and *ecological* barriers.

In the Amazon, *institutional* barriers to forest exploitation are mainly related to lack of infrastructure and to corruption (Transparency International, 2008). The application of sound management practices is often hindered by poor quality roads and circumvention of prudent management practices by bribes. *Technical* barriers to forest exploitation in the Amazon are valid for most forested regions of the world. Adequate cost-effective technology for difficult climatic and topographic conditions is lacking and damages from logging are tremendous, causing further forest degradation (Asner et al. 2006). Qualified work forces may exist, but economic pressure and profit maximization hinder their employment. Another important barrier is the interplay of high ecosystem complexity and poor ecological understanding of different species. Thus, silvicultural strategies for these natural forests simplify the forest structure and favor particular species types, such as pioneer species.[2] Remote locations with difficult access also hinder Amazonian forest exploitation.

The main *economic* barrier to managing exploitation of the Amazon forest is the specialization of the timber market into a few commercial timber species. The most prominent example of this selective effect is the quasi-extinction of Mahogany (*Swietenia macrophylla)* due to overexploitation (although numerous other species with similar wood properties exist). The globalized timber market with fluctuating prices and strong pressure for cheap production also undermines sound forest management. Additionally, the comparably lower quality and more difficult processing of timber from natural forests compared to plantation forests (e.g., heterogenous wood properties, large diameters, occurrence of branches) is a further disadvantage for efficacious forest management during economic exploitation. The lack of investment in equipment and staff education for improving forest management is another constraint.

Ecological barriers to forest exploitation are mostly due to the Amazon's inherent complexity. While managers seek simplification and control, it is

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[1] Forest stand level: A group of trees with a certain set of characteristics that qualifies it as a management unit.

[2] Pioneer species: Species with special functional traits and growth strategies (e.g., light-demanding, long-distance dispersal) that emerge after disturbances. In forest gaps, species that perform the transition from nonforest land to forest land.

impossible to integrate this complex ecosystem. Additionally, climate change, through potentially detrimental effects on infrastructure and accessibility, and because of the large uncertainties it imposes on planning and silviculture, has emerged as a new barrier for managing forest economic exploitation. Although climate change might also create new opportunities, such as enhanced productivity, it is generally assumed to be detrimental for the Amazon forest ecosystem and its processes (Bonan, 2008; Bush et al. 2008; Malhi et al. 2008; Phillips et al. 2008).

Innovative Options for Future Conservation Activities

Fewer opportunities than barriers exist for the conservation of Amazon forest and the same framework of *institutional*, *socioeconomic*, *economic* and *ecological* elements applies. *Institutional* opportunities act across and along different scales and incorporate administrative and legal opportunities. Large changes in environmental governance have occurred over the last decades. Sovereign nations have ceded parts of their sovereignty to supranational bodies such as the Convention on Biological Diversity and no country plans environmental policy in isolation (Lemos & Agrawal, 2006). This change in environmental governance may be the biggest opportunity for the conservation of forest ecosystems and comes in conjunction with an increasing global awareness of their value. Furthermore, the elaboration of land-use plans and clear land allocation and land-tenure rights foster the conservation of forest ecosystems (Oliveira et al. 2007; Sunderlin et al. 2008). The increasing acceptance and integration of indigenous knowledge and participative planning of conservation and land use with local communities further strengthens conservation efforts and forest protection (Molnar et al. 2004; Chhatre & Agrawal, 2008). Finally, increasing monitoring and planning of conservation activities with clear timeframes, goals, criteria, and indicators, and expanding species inventories for patents of medicinal plants, improve the situation of forest-ecosystem conservation.

The *socioeconomic* opportunities for the conservation of forest ecosystems in the Amazon are primarily related to the barriers that exist in this respect. Hence, better education and a leveling off of population growth, combined with efforts to combat poverty, present valid opportunities. The *economic* opportunities for forest-ecosystem conservation are increasing. Conservation planners have long focused on further valuation of conservation efforts through ecotourism activities. Moreover, payments for environmental services (PES), and especially carbon sequestration in reducing emission from deforestation and degradation (REDD) schemes, provide a wide framework for financing conservation activities and improving local livelihoods (Canadell & Raupach, 2008; Hall, 2008; Jack et al. 2008). More alternative economic benefits emerge from the use of nonwood forest products (NWFPs) such as fruits, gums, resins, and medicinal plants. The availability of large markets is an opportunity; all these "new" products may be traded on a global scale.

The *ecological* opportunities for conservation of Amazon forest ecosystems are limited and consist of increasing scientific knowledge of ecological processes. In already partly destroyed forest ecosystems, restoration ecology fosters the successful implementation of conservation measures (Dobson et al. 1997).

The Value of Forest Exploitation in the Amazon

The main opportunities for forest exploitation in the Amazon are of a strictly *economic* nature. However, increasing the economic viability of forest exploitation entails other *institutional*, *technical*, and *socioeconomic* opportunities. Although the economic gains of forest exploitation often do not withstand the comparison with competing land-use systems (e.g., cash crops), actually a broad array of products directly result from forest exploitation. The variation in quality and quantity of different product types provides forest managers with the tools for intelligent forest management. Both timber and NWFPs can be produced for certified or uncertified markets. Despite the ecological and socioeconomic importance of specialized NWFPs, fair-trade market schemes, and certification, these cover only niche markets and hence are neither viable nor realistic income alternatives for an entire region such as the Amazon. Forest-certification schemes additionally suffer from being heavily promoted by certain interest groups and excluding other entities more for ideological than rational reasons. Furthermore, these schemes are market-based and consumer choice-driven and hence competing (and often contradictory) certification schemes that are "softer" and "stricter" may confuse consumers and lead to a general distrust of such approaches. Thus, a diverse set of products shelters forest managers from market fluctuations.

Basic principles of sustainable (forest) management are important for the successful implementation of diversified production. Developing and applying management plans and the rejection of "resource mining" production systems are fundamental aspects and increasingly in the minds of policy makers. These economic opportunities, combined with further development of low-impact harvesting techniques (such as reduced impact logging (RIL) for timber or similar considerations for NWFPs) and increasing knowledge on yield capacities and species interactions, improve livelihoods without threatening the forest itself. These considerations align themselves with synergies between forest management and biodiversity conservation, as Putz et al. (2001) point out.

Synergizing Exploitation and Conservation—A Window for Sustainable Development

To only consider the various barriers and opportunities for conservation and exploitation of the Amazon forest is an oversimplification. However, only by carefully disentangling these intertwined factors is there potential to identify the roots of conflicts and possible synergies. In most cases, it is possible that reduction of a barrier will coincide with an increase in an opportunity. For instance, improving the monitoring of species loss reduces ignorance about the ecological system and may lead to patents for medicinal plants. The latter enables synergies that integrate indigenous knowledge into management/conservation.

The different barriers follow similar directions, albeit the focus differs slightly between conservation and exploitation barriers. For instance, lack of education is a bigger problem for conservation than for exploitation but still touches both processes. Institutional, economic, and, to a lesser extent, ecological barriers are very similar for both conservation and exploitation of forest ecosystems. Hence, they are more related to forests and natural resources in general than to their conservation or exploitation specifically. This is an important finding for solving conflicts among competing interest groups and for improving mutual understanding of these two domains.

Similarly, the opportunities for both forest conservation and forest exploitation in the Amazon are complementary. Further economic valuation of conservation "products"—ecosystem services but also ecosystem raw products—is consistent with efforts to elevate the importance of forests from a matter of local livelihoods to a question of urgency for the global community. Contradictions, such as the globalization of markets, persist between barriers and opportunities for conservation and exploitation of forest ecosystems. This situation may also be due to the huge array of phenomena encapsulated by the term "globalization." The lack of infrastructure and the remoteness of the forests in the Amazon act as barriers to forest exploitation. At the same time, the increasing development of infrastructure is an obstacle to conservation and the remoteness of an area is important for the preservation of a forest. Conventional approaches to conservation therefore oppose infrastructure development and access to forests, whereas sound management for economic exploitation (and also to a certain extent for conservation) requires controlled access. These are concrete contradictions, but in the area of conflict between forest exploitation and forest conservation compromises and trade-offs are a natural part of discussion and planning (Figure 1).

Integrating conservation of forest ecosystems and forest exploitation increases synergies between already overlapping sectors and facilitates the accrual of benefits from incipient opportunities in the Amazon region. Development initiatives that simultaneously aim at, for instance, supporting local livelihoods, promoting biodiversity conservation, and sequestering carbon for climate protection address several challenges outlined earlier. An integrated approach is more resilient, and hence also more likely to benefit from arising opportunities than a segregative approach that ignores particular opportunities. It is, however, uncertain whether an integrated approach addresses a single barrier better than a segregative approach, but it has the potential to better mitigate its impacts. A broader variety of management goals, for example, allows switching the administrative focus if necessary and thus increases the flexibility of managers and diversifies the risk of failure. Furthermore, integrative solutions create greater social utility and help to maintain resilient ecosystems (Scheffer et al. 2000; 2002). Moreover, improving economic security and increasing the local population's well being fosters civil society and helps to overcome institutional barriers such as corruption and poor law enforcement. Such a combination of ecological and social efforts and economic benefits has important implications for sustainable development at a broader scale (Tallis et al. 2008). Applying true

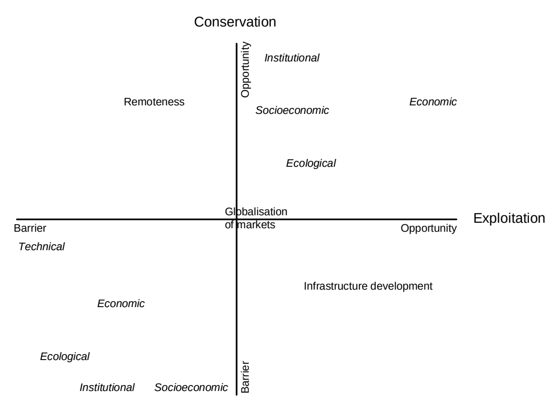

Figure 1 Synergies and contradictions of barriers and opportunities for exploitation and conservation. The position of the terms indicates their relative importance for exploitation (x-axis) or conservation (y-axis) as barrier or opportunity (*italics*). Only specific contradictions between particular barriers and opportunities are displayed in normal font and further explained in the text.

interdisciplinary knowledge in different sectors and ensuring the integration of multiple social actors is imperative for sustainable development and strengthens decision making and implementation processes to counter the ominous findings (i.e., loss of diversity of life, degradation of ecosystem services) of the Millennium Ecosystem Assessment (MEA, 2005; Ehrlich & Pringle, 2008). Furthermore, at the project level, more holistic and less "conservative" biodiversity conservation projects that focus also on the provision of ecosystem-services benefit from a broader array of funding possibilities and attract greater financial support (Goldman et al. 2008). This financial advantage also indicates that an increasing number of such projects will be successfully implemented. A changing forest paradigm, combined with adjusting perceptions of nature and positive feedback of forestry on poverty reduction, also provides further opportunities for forest conservation (Bengston, 1994; Scherr et al. 2004; Willis & Birks, 2006). In this way, an integrated approach is likely to be more efficient in sustaining the Amazon's ecological functioning and biodiversity as well as the long-term economic benefits from forests.

Implementing Integrated Conservation and Exploitation—A Case Study from Costa Rica

The biggest challenges to an integrated approach to forest-ecosystem management are political operationalization, practical implementation, and lack of experience. Furthermore, the implementation of such measures is definitely a matter of scale and easier to conceive at the project level than at the regional level. For instance, the "Klinkii—Reforest the Tropics" initiative, an applied research program in Costa Rica (one of the United Nations Framework Convention on Climate Change pilot projects of the "Activities Implemented Jointly" mechanism), is based on the notion of an integrated, multifunctional forest-management system. Although this is a pasture reforestation program not directly dealing with natural forests, it highlights numerous advantages (e.g., participation and training of local farmers, forest management adapted to climate change) of an integrated approach in addressing several of the barriers outlined earlier. Thus, it is conceptually interesting and illustrates what an integrated approach means in practice.

In the Costa Rican project area, pastures on formerly forested lands have been reforested and restored with mixtures of tree species to create diverse forests that are potentially more stable in the face of climate change. The farm forests are managed for both timber production and carbon sequestration by a nonprofit organization, Reforest the Tropics (RTT), and financed by carbon-offset donations from individuals and enterprises in the United States. These forests also provide habitat and food for forest animals and thus help protect local biodiversity. The participating farmers benefit from training on how to implement the complex silvicultural system. Through an initial grant from donors in the United States for the rights to register in their name the carbon captured by the forest, and later from sales of the timber taken out during thinnings, they are released from financial pressure. There are incentives to convert pasture land to forests that produce income because it is only when the forest is profitable that the farmers will manage it sustainably. The goal of RTT is to demonstrate the effectiveness of this strategy and to develop best practices for future projects (Barres, 2009; Reyer et al. 2009).

Conclusion—Each One, Teach One

Forest conservation and exploitation in the Amazon are constrained by similar barriers, but also share opportunities and important synergies. Actually, both activities are legitimate within a forest ecosystem, an important common property bonding them together. Hence, conservation of forest ecosystems in the Amazon should incorporate more exploitive/management elements and forest exploitation in the Amazon should strive to include more conservation aspects. Such an approach balances conservation and exploitation and enables sustainable development in the Amazon region by respecting economic, social, and ecological realities. Proactive forest conservation, acknowledging the need for development and management to support livelihoods on the one side and less intensive forest exploitation on the other side, resumes the synergies of the various barriers and opportunities for forest exploitation and conservation of the Amazon. The likelihood of addressing the barriers and benefiting from arising opportunities with an integrated approach is higher than with a segregative approach.

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