Climate change and forests

Climate change, energy and biodiversity conservation in Bolivia— roles, dynamics and policy responses

Bernardo Peredo-Videa

Abstract. Biodiversity conservation is an economic, environmental and social process. It is also a political and cultural process in developing nations, characterised by being the richest regions in biodiversity but also the poorest economically. Paradoxically, whilst biodiversity provide socio-economic and environmental benefits, ecosystem degradation has increased. Discussions on the responsibilities of developing countries in climate change and the emerging roles in carbon offsetting and energy change for tropical developing nations are becoming part of policy responses in this regard. Furthermore, conceptions of energy development as part of existing economic policies and the potential opportunities arising from climate change have been considered as trade-offs to obtain economic and environmental benefits. The paper examines the role and dynamics of energy and deforestation and its relationship with climate change and conservation in Bolivia. It also identifies the policy implications and challenges in the existing climate change processes by providing up-to-date empirical evidence and analysis of the responses of the Bolivian government to climate change, energy policies and biodiversity conservation.

Resumen. La conservación de la biodiversidad es un proceso económico, social y ambiental. Es asimismo, un proceso político y cultural en países en desarrollo particularmente, caracterizados por ser regiones ricas en biodiversidad con importantes índices de pobreza. Paradójicamente, a pesar que la biodiversidad provee beneficios socioeconómicos y ambientales, la degradación de ecosistemas continúa inalterable. Discusiones sobre las responsabilidades de países desarrollo en cambio climático y los roles emergentes de sumideros de carbono y cambios energéticos en países tropicales, comienzan a formar parte de análisis en esta temática. De la misma manera, se consideran concepciones sobre desarrollo energético y oportunidades potenciales en el marco de cambio climático que puedan obtener beneficios económicos y ambientales. El presente artículo examina el rol y dinámicas existentes sobre deforestación, energía y su relación con cambio climático y conservación en Bolivia. Asimismo, identifica las implicaciones y desafíos de políticas en el escenario actual de cambio climático mediante análisis empírico de las respuestas del gobierno boliviano en políticas energéticas, cambio climático y conservación.

Introduction

Evidence produced in several studies since the early 1990s suggests that large-scale conversion of tropical forests into pastures or annual crops could lead to changes in the climate. Thus, it has been documented that land-use change impacts regional and global climate through the surface-energy budget as well as through the carbon cycle.[1] As well as influencing local long-term weather conditions, regional-scale land-cover change can impact on the global climate system besides energy emissions of greenhouse gases (GHGs). These aspects of human influence on climate were not accounted for under the Kyoto Protocol. The neglect of land-use effects lead to inaccurate quantification of contributions to climate change.[2]

The role of tropical forests may be significant in this process. Apart from their role as reservoirs, sinks and sources of carbon, tropical forests provide numerous additional ecosystem services. Many of the ecosystem services directly or indirectly influence climate, including the maintenance of elevated soil moisture and surface air humidity, reduced sunlight penetration, weaker near-surface winds and the inhibition of anaerobic soil conditions. Such an environment maintains the productivity of tropical ecosystems.[3]

Deforestation in Amazonia is progressing rapidly, with estimations by several authors suggesting that if deforestation were to continue at the present rate, a significant reduction of Amazonian tropical forests would occur in less than 100 years. Such rapid deforestation is clearly contributing to regional CO_2 emissions. Although, it is considered that deforestation and tropical forests fires contribute globally to about 20 per cent of total CO_2 emissions, the major impact is related to the rapid loss of forest ecosystems and biodiversity.

Academic and policy literature has directly linked deforestation rates with structural adjustment programmes (SAP) implemented in many South American countries, which promoted the expansion of timber and soy exports. In the case of Bolivia, deforestation has increased dramatically since the mid 1990s, particularly because Bolivia was amongst the first Latin American countries to initiate a far-reaching and relatively orthodox SAP, which greatly contributes to forest clearing for soybean exports and to higher timber exports.[4]

Bolivia: biodiversity conservation and deforestation

Bolivia is a landlocked country comprising an area of 1,098,581 km^2, which encompasses a range of different eco-regions. In contrast to what is common assumption, a large portion of the country is covered by forest vegetation. The country's total forest area is 534,000 km^2 which represents 48.60 per cent of the total surface. More than 80 per cent of the forest occurs in the Bolivian lowlands, the remaining 20 per cent is spread out in the highlands and the inter-Andean valleys.

In the lowland forests, four major zones have been identified: i) the humid and evergreen forest of the Amazonian located in northern Bolivia; ii) the Beni plains, characterised by natural savannas and small patches of gallery forests, much of which are seasonally flooded; iii) the Chiquitania region, whose semi-deciduous forests are typical of slightly drier areas; and iv) the semi-arid Chaco region, with lower and less productive forests adapted to dry climates.[5]

In terms of conservation efforts, protected areas in Bolivia play a role not only in conservation but in the support of local livelihoods and social participation as well. The Bolivian government estimates that around 60,000 people live inside protected areas and some 200,000 people live in surrounding areas. Consequently, involving local communities in national park affairs and the promises of development benefits has helped increase interest in conservation.

The National Service of Protected Areas developed the framework of "Parks with People" in 2005, considering the importance and role of protected areas for sustainable livelihoods, poverty alleviation and sustainable development in rural areas, including a significant role on ecosystem services provision.[6] As part of this process, which is currently evolving into a national policy of shared management under the new government administration, not only national areas were represented in the national system of protected areas, but municipal protected areas and neighbouring declared indigenous territories are also seen as areas for biodiversity conservation. The percentage of national territory covered by protected areas in Bolivia has thus increased in the last decade, to approximately 19 per cent of the total surface with representation of all the country's ecosystems (see figure 1).[7]

Nevertheless, several national parks are still constrained in enforcing conservation measures and there remain conflicts regarding access to natural resources, including minerals, hydrocarbons, timber, wildlife and land resources. Therefore, the institution in charge of safeguarding biological diversity in Bolivia is in permanent conflict.

Up until the late 1980s, deforestation rates in Bolivia were among the lowest in Latin America, based on key determinants which included a weak domestic demand for agricultural products and lack of infrastructure.[8] However, two national inventories of forest resources concluded that deforestation increased dramatically during the 1990s especially after the implementation of the structural reforms during the same decade.[9]

In this context, Camacho estimated that more than three million hectares of lowland forests in Bolivia have been cleared, with 1.4 million hectares (46.7 per cent) deforested in the department of Santa Cruz between 1993 and 2000. Consequently, deforestation rates have quadrupled during this time following the structural reforms and policies introduced in 1993. These estimates led to several proposals and studies suggesting that structural adjustment has contributed to increase

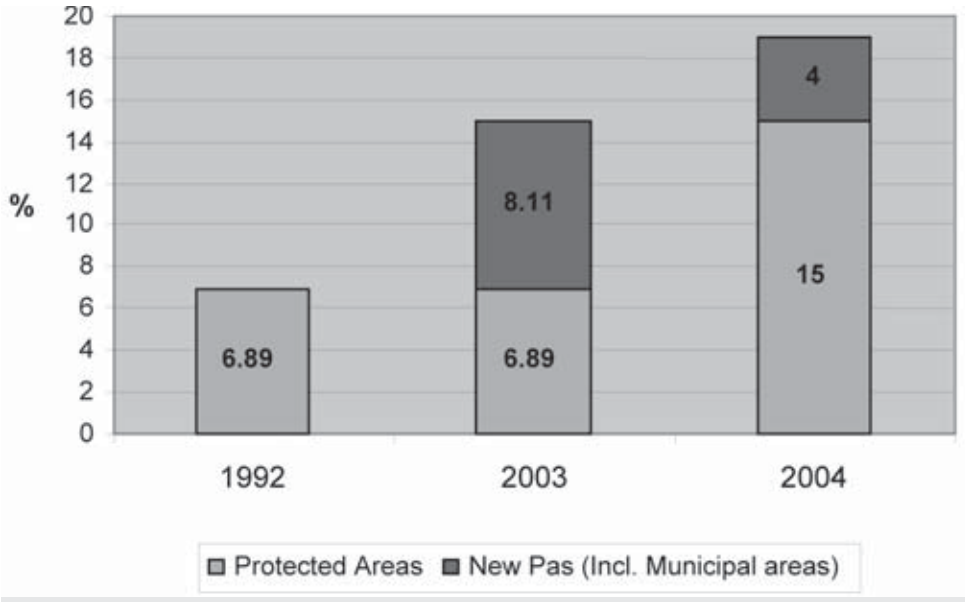

Figure 1. Percentage of territory covered by protected areas in Bolivia

More than three million hectares of lowland forests in Bolivia have been cleared.

deforestation rates for soy and timber exports, by applying economic instruments and policies that removed price controls on soybeans, devalued the Bolivian currency, promoted investments in physical infrastructure such as roads and telecommunications, and introduced tax breaks and fiscal incentives for exporters.[10] Studies argue that the increasing deforestation rates in Bolivia as a whole are indicative of the general weakness of the government in the forestry and environmental sectors. Moreover, municipal governments have been largely ineffective in preventing deforestation.[11] These reasons are also encapsulated in the notion that structural adjustment reduced the role and capacities of the government.

In national terms, deforestation increased from an average of 152,000 hectares per year in the period 1985-1993 to approximately 300,000 hectares per year in 2006 (see figure 2).[12]

CO_2 emissions in Bolivia: the role of deforestation and energy

The second national report on the accomplishment of the Millennium Development Goals in Bolivia estimated that national emissions of CO_2 were 62.614 Gg. for 2002. The official inventories on the emissions source of GHGs indicate that the dominant sector in the emission of CO_2 is land-use change.[13] In this sense, the widespread practice of slash-and-burn and the conversion of land for agro-industry and cattle-stock eliminate vegetation and burn of biomass, which represent the major cause for deforestation, biodiversity loss and CO_2 emissions.

Accordingly, these emissions are distributed in three main sectors. Around 89 per cent of CO_2 emissions are based on land-use change, followed by 10.5 per cent of emissions related to the energy sector and only 0.46 per cent to the industrial process produced by cement factories.[14] It is clear the differences between the first and second sources of emissions in the country.

Around 89 per cent of CO_2 emissions are based on land-use change

Available data on CO_2 emissions as a result of slash-and-burn practices shows a discrepancy between the official data provided by the National Programme of Climate change and those provided by San Andres University (UMSA). The official estimations by the NPCC were 0.044 GT of CO_2 for 1998,[15] while the emissions estimated by the university shows 0.36 GT of CO_2.[16] These scenarios were based in the vulnerability assessment of ecosystems undertaken by the National Programme of Climate Change and supported by different models accepted internationally, such as UKHI, HADCM2, GISSEQ, MAGICC, and the meteorological data available for the country.[17]

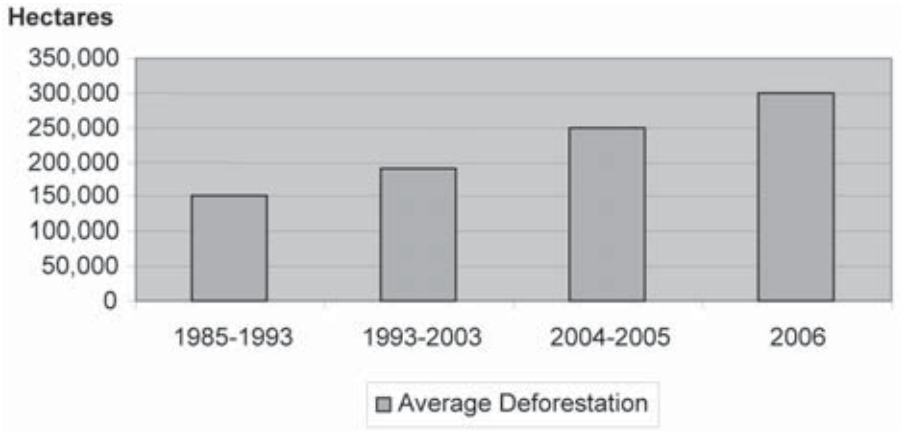

Figure 2. Evolution of Deforestation Rates in Bolivia 1985 - 2006

Such a high share of emissions from land use changes and deforestation are second only to Indonesia and are of a similar value to Malaysia (see table 1).[18] Bolivia and many other Latin American countries are currently undergoing an economic and development transformation, including a steep upward trend of GHG emissions, primarily as a result of deforestation and in lesser degree energy.[19]

Table 1. LULUCF Emissions as share of total GHG emission

Argentina	19%
Bolivia	82%
Brazil	69%
Indonesia	86%
Malaysia	82%
Mexico	16%

In terms of the energy sector, which represents the second source of emission although is of little comparison to deforestation, the Clean Development Office has been developing a project portfolio, which aims to achieve emission reductions of 5,811,046 tons of CO_2, in seven years under a CDM framework.[20]

It is clear that the highest CO_2 emissions in Bolivia are directly related to deforestation and slash-and-burn practices both in forests and savannas in the lowlands region, which are annually undertaken in order to expand the agricultural frontier for cultivation and cattle ranching. Nevertheless, these CO_2 emissions in the country are relatively low compared to other regions on a per capita basis. In Bolivia, they reach only 1.4 TM per capita, while in Latin-American and the Caribbean as a whole these carbon emissions reached 2.5 MT. In contrast, emissions in the United States are about 19.7 TM per capita.[21] Overall in Bolivia, GHGs emissions in terms of CO_2 are only 0.097 per cent of total global emissions.[22] These differences are considered as a major source of inequality (as illustrated in figure 3) and according to several interviews with former and current policy-makers, there is the perception that climate change has been produced by developed economies, and that these countries should be responsible for adopting mitigation, adaptation and compensation measures.

It is clear that the highest CO_2 emissions in Bolivia are directly related to deforestation and slash-and-burn practices both in forests and savannas in the lowlands region, which are annually undertaken in order to expand the agricultural frontier for cultivation and cattle ranching.

These perceptions were enhanced after the unfortunate flooding of January and February 2008, in which more than 47 municipalities were affected, particularly in the Amazonian department of Beni. The floods caused left more than 50 people dead and affected over 45,000 people. Although this event is not directly linked to climate change, there is the perception that there is an increasing role which provokes traditional events to have more severe impacts

Bolivia is a country with high vulnerability to climate change for several reasons: the population density in fragile mountain ecosystems, the expansion of arid zones, the existence of several regions exposed to periodical flooding, particularly in lowlands and the valleys, and the increasing deforestation rate and high poverty levels.[23] Thus in terms

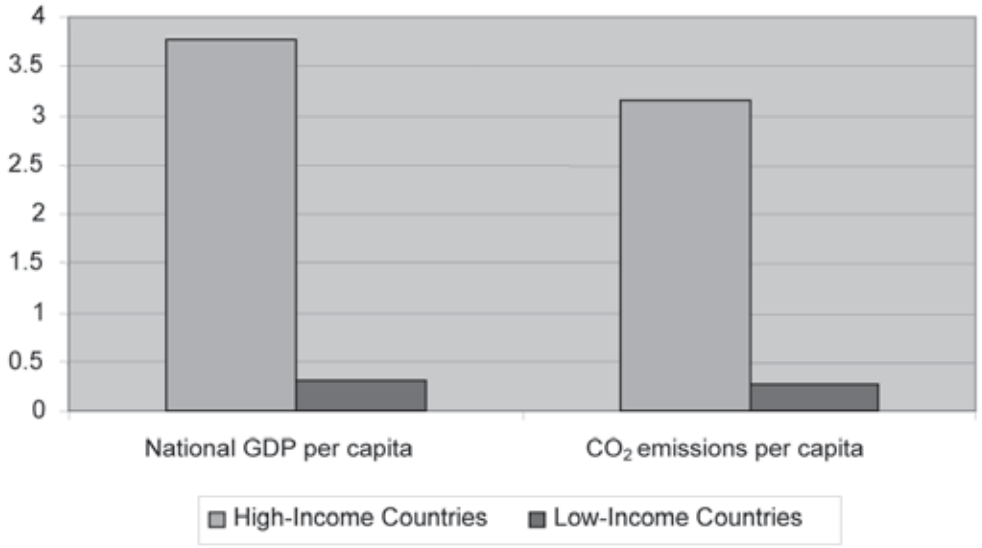

Figure 3. Links between per capita GDP and CO_2 in high and low income countries

of climate change, there is the wide perception that although Bolivia is not a country producing carbon emissions, the impacts of climate change will be severely suffered throughout the country. Climate alterations have already brought droughts in the Andean region, glaciers retraction in the Bolivian highlands and flooding in lowlands and the Amazon. For example, maximum temperature increases are predicted to occur in the high mountains of all Andean countries. If the models are correct, the changes will have important consequences for mountain glaciers and for communities that rely on glacier-fed water supplies.[24] Furthermore, the minimal infrastructure for natural disasters poses additional challenges.

Studies along the Tropical Andes indicate a temperature increase of 0.11°C/decade, compared with the global average of 0.06°C/decade between 1939 and 1998. Eight of the twelve warmest years were recorded in the last 16 years of this period. High-altitude mountain regions are then strongly affected by rising temperatures, as ice masses are declining rapidly.[25]

If water-resource buffers shrink further and some watersheds disappear completely, alternative water supplies may become very expensive or impractical in the face of increased demand as population and per-capita consumption rise. Furthermore, as water resources are affected by reductions in seasonal runoff in Andean countries, where hydropower is the major source of energy for electricity generation, there would be the need to shift to other energy sources, resulting in higher costs and most probably, an increased reliance on fossil fuels.[26]

Policy responses and perspectives

Bolivia has ratified the Kyoto Protocol through the enactment of Law 1988 of July 22, 1999. This ratification was conditioned according to the principles of sustainable development, as the country had a specific policy and mandate to achieve sustainable development. One of the reasons for this ratification, behind the broad ratification made by most countries, was the interest in accessing incentives and economic benefits around clean development mechanisms (CDM).

Initially a proposal for a Carbon Law was presented by the National Programme of Climate Change, which promoted the creation and development of a series of mechanisms for the certification of initiatives in terms of carbon sequestration and emissions avoidance. After several consultation

workshops, it was considered that there was only a very remote possibility to establish a carbon market, given the lack of suitable role models. However, in June 2005, Supreme Decree 28218 was enacted, declaring the implementation of projects and activities for climate change mitigation in forestry and energy sector as a national priority, in order to apply to CDM and other trade emissions schemes.[27] This Decree shows the importance of projects and activities and the interest of policy-makers in these schemes as a way of generating short and long-term income.

Climate change mitigation in both sectors in this legal framework included the following areas: forestation and afforestation, fossil fuels substitution using natural gas, natural gas supply for residential, commercial and industrial consumption, renewable energies, energy efficiency, biogas, the efficient use of biomass and other project that reduce, capture, store and avoid greenhouse gases emissions.

In December 2005, the historic election of Evo Morales and his Movement towards Socialism party (*Movimiento Al Socialismo* in Spanish) with more than 54 per cent of the votes, initiated a series of reforms and different visions on natural resources particularly, under the so-called process of change. These reforms involve a series of structural changes based on the elimination of the neoliberal era, both politically and economically, and the dismissal of sustainable development as a national policy.

These reforms include the active participation by the State both for primary production and for industrialisation in order to improve life conditions of the Bolivia population, particularly indigenous communities. The principles aim to re-establish the balance between nature conservation and economic needs for national development, under the concept of "Living Well". Under this framework, the current administration aims to strengthen the regulatory participation and promotion of the State for the exploitation of natural resources towards guaranteeing sustainable management of natural resources and a fair distribution of benefits resulting in that use, as well as changing the energy matrix. The government thus considers it necessary to consolidate the ownership by the State over natural resources and genetic variability. Through this vision, natural resources will not be able to become subjects of commercial exploitation. Hence, national policies are focused under the implementation of a holistic vision that takes from nature what is needed for the development of the country, but, at the same time, protecting it.[28]

Bolivia's forests and their resources, therefore, are considered as a property of the State, where the State commands and controls forestry resources, even in these forests are located in private lands or are part of concessions to private actors, designated for management, use and exploitation. The National Development Plan presented by the government in 2006 is the major instrument of public policy that would lead the way to this process of change.

In terms of climate change, interest in carbon sequestration has increased based on the results of the Climate Action Project conducted over the last ten years in the Noel Kempff Mercado National Park, which is located in the department of Santa Cruz. The project has generated more than one million tons of CO_2 in certified carbon credits. The possible development of markets and market-based mechanisms for

Picture 1. Land conversion in August 2007 in Santa Cruz.
(*Courtesy Bernardo and Ariadne Peredo*)

ecosystem services sold as commodities, has however been opposed as due to its clearly neoliberal approach. Nonetheless, according to the National Development Plan (NDP), carbon sequestration and certified emissions reduction (CERs) of GHGs represent an important opportunity for income generation at a national level. The policy sees the State participating as the owner of natural resources in the generation of economic surplus through certification, international negotiation, sale and fair distribution of benefits produced by the commercialisation of carbon bonds in international markets. Three programmes have been proposed to implement this strategy:

a. CERs, carbon sequestration and conservation towards the promotion of clean development strategies and mechanisms for international markets: aiming at generating higher income for the country and local communities based on a fair distribution of benefits. This programme promotes investments of CDMs and other relevant schemes.

The main implementation project is related to forestation and reforestation of 10,000 ha in tropical valleys in the department of Cochabamba aiming at sequestering CO_2 through production of vegetal biomass in forestry plantations and community agro-forestry systems in a 30-year period. The government aims to commercialise CERs from this project, as well as achieving the rehabilitation of degraded lands in this region through the integration of native ecosystems with appropriate forestry and agro-forestry systems, which are incorporated to local traditions and uses. Carbon sequestration and potential income generated by the commercialisation of environmental services represent an important incentive for local communities. Accordingly, effective and permanent participation of local communities, municipalities, national authorities and the private sector has been considered as a key factor in this process.

The participation of the private sector has been restricted because of changes introduced by the government and an unfavourable investment climate, which has resulted in the lowest private and foreign direct investment rates in the country for 20 years.

b. National Programme of Carbon Sequestration: according to the NDP, this programme aims to reduce deforestation rates in protected areas and its buffer zones, which are threatened by human intervention by avoiding illegal logging in protected areas and surrounding buffer zones. It aims to promote the certification, negotiation and commercialisation of carbon credits based on the experience of the Climate Action Project in the Noel Kempff Mercado National

Park. This project has duration from 1997 to 2025 and it is estimated that it will produce CERs for more than 990 t CO_2 during the project cycle life.[29]

The project includes the participation of local communities and has two key components: i) To stop industrial timber harvesting, avoiding further timber extraction and damage to vegetation, and ii) Stop slash-and-burn agriculture through community development programmes. It is expected that similar schemes will be created and replicated in other protected areas based on regional and local projects.

c. Transformation and Change of the Energetic Matrix for CERs: this programme is based on the proposal to change the energy matrix and energy efficiency to obtain CERs through the implementation of related projects. This is in-line with government proposals to strengthening the domestic demand of energy for social benefit.

This policy framework was supported and strengthened by the participatory development of an official proposal on climate change presented in September 2006 by the National Programme on Climate Change. This proposal was prepared and discussed with the participation of more than twenty institutions, including the academia, national agencies and municipal governments, as well as NGOs and local organisations from the forestry, environmental and climate change sectors. The proposal, which was coordinated with other developing countries, was presented in Rome in September 2006 and acknowledges and promotes the clear need to include avoided deforestation as a recognised mechanism for emissions reduction. The policy was developed because of the lack of an international agreement taking place under the Kyoto Protocol to address this important source of carbon emissions and any valid alternatives to tackle these causes that will provide social and economic benefits for tropical countries in particular. A key factor in terms of policy responses is that there are few specific policies (outside of protected areas) and measures in the NDP and other sector-related policies in order to reduce deforestation, particularly in the Bolivian lowlands and the Amazon.

Despite the significant potential in the forestry sectors, Bolivia could also offer a variety of mitigation options in the energy sector (for residential, commercial, industrial and transportation sectors). Even considering that gas fired plants and hydroelectricity produce a major part of electricity in Bolivia, a potential for GHG emissions reduction also exists in power generation sector. Switching from diesel and gasoline to compressed natural gas, especially as part of the official policy of the current administration to prioritise domestic use and demand of natural gas, also presents an interesting mitigation option in the Bolivian transport sector, which has great potential of GHG emissions reduction.

There also exists an interesting hydroelectric potential not yet developed in the country, as well as wind and solar energy. Mitigation options exist particularly in rural areas where dispersed populations are not connected to the grid and electricity is usually and commonly produced by diesel power generators, particularly in the Bolivian Amazon, which could be replaced by small hydroelectric plants. However, current policies in terms of hydroelectricity still focus on old-fashioned megaprojects, instead of providing the appropriate support and investment for small and mini plants that would cause less environmental impacts, while

producing social benefits and opportunities for CDM projects. This is the case of the San Miguel del Bala hydroelectric dam, located in the northern part of La Paz, in the Madidi National Park buffer zone. This project was initially conceived in the late 1950s, reconsidered and rejected in the decade of 1990s, and officially supported again by the current administration through the enactment of the Supreme Decree No. 29191 of July 2007.

Recent responses which may prove helpful in the short term to mitigate the impacts if climate change include the National Programme on Climate Change of the Bolivian Government project initiated in April 2008. This agreed the construction of 40 water reservoirs in rural areas of the Bolivian highlands, located in the departments of La Paz, Cochabamba, Tarija and Oruro. These measures are a clear response to water shortages for rural communities and are the first initiatives based on the approval of a National Adaptation Mechanism, representing important step forward in terms of climate change actions.

Future action

Around 97.7 per cent of Bolivia CO_2 abatement potential, which is equivalent to 903 million tons of CO_2, according to the national strategy study prepared in 2001 for the participation of Bolivia in the CDM, is related to changes of policy in relation to deforestation and slash-and-burn practices. This study identifies a mitigation potential for land use, land-use change and in forestry projects of 73.5 million tons of CO_2 per year in average, whilst the average potential in the energy sector is 1.8 million tons of CO_2 per year, even taking into CO_2 conservative assumptions for both of these estimations.

Avoided deforestation is of critical significance particularly following the recent outcomes of the United Nations Climate Change Conference in Bali, given the decision to encourage governments to take actions to reduce emissions from deforestation, and the agreement to consider how to reward those countries who take immediate action. With this encouragement, tropical-forest governments could feel confident that efforts undertaken now could build the institutional and technical capacity needed. In addition, it was also considered to efforts which not only reduce emissions from deforestation and degradation, but options to encourage the maintenance of carbon stocks found in countries with large intact tropical forests, such in the case of Bolivia, in order to prevent future emissions. It is further expected that under these recent outcomes, the consideration of the role of indigenous and local communities will be moved forward to ensure that forest-dependant communities and those most directly connected to forests are not negatively impacted or undermined.

Around 97.7 per cent of Bolivia CO_2 abatement potential, which is equivalent to 903 million tons of CO_2, according to the national strategy study prepared in 2001 for the participation of Bolivia in the CDM, is related to changes of policy in relation to deforestation and slash-and-burn practices.

Three key areas would push the climate change agenda forward locally: economics, the media and political issues. In terms of economics, there is interest not only in the costs and impact of climate change but the opportunities for income generation through CDM schemes, and more significantly,

by implementing avoiding deforestation and similar proposals. The media has given major coverage nationally and internationally since the release of *An Inconvenient Truth* and, currently, climate change is an unavoidable subject on the news. Therefore, there is ground for political support based on this increasing interest in both areas. In Bolivia, political interest is framed under the policy framework which recognises the importance of climate change for future negative impacts and also, for the potential opportunities for income generation. Put together these three areas can help develop the policies and practices outlined here to avoid increased deforestation and thus reduce CO_2 emissions and the continued loss of habitat and biodiversity. Otherwise, deforestation rates may increase and will undoubtedly continue to represent the major source of CO_2 emissions with significant values at the national level unless avoided deforestation or other similar schemes are put practically and realistically in place.

Three key areas would push the climate change agenda forward locally: economics, the media and political issues.

Bernardo Peredo-Videa (bernardo.peredov@green.ox.ac.uk) is a Doctoral Candidate at the Oxford University Centre for the Environment (OUCE) and Consultant to CIFOR. He has been a consultant for the United Nations Development Program, the Canadian International Development Agency, Conservation International, the IFAD's Regional Programme in Support of Indigenous Peoples of the Amazon Basin, the Swiss Intercooperation, Fauna Australis at the Catholic University of Chile, and various national Bolivian organisations and government agencies. He is currently working in environmental governance and political ecology in Bolivia and South America.

Notes

1 Pielke *et al.*, 2002.
2 Claussen, 2002.
3 Betts, 1999.
4 Kaimowitz *et al.*, 1999.
5 MDSMA, 1995.
6 Peredo, 2006.
7 ABDES, 2005.
8 Kaimowitz, 1997.
9 Steiniger *et al.*, 2000; Camacho *et al.*, 2001.
10 Kaimowitz, 1999.
11 Hecht, 2001; Davies *et al.*, 2000; Contreras and Vargas, 2001.
12 Pacheco 1998; Forestry Superintendence, 2007.
13 PNCC, 2003.
14 ABDES, 2005.
15 NPCC, 2003.
16 Gutierrez and Palenque, 2000.
17 PNCC, 2000.
18 Clabbers, 2004.
19 Silva-Chavez, 2005.
20 Trujillo, R in NPCC Informative Bulletin No. 3.
21 World Bank, 2004.
22 PNCC, 2006.
23 Palenque, 2003.
24 Bradley *et al.*, 2006.
25 Vuille *et al.*, 2003; Ramirez *et al.*, 2001; Francou *et al.*, 2003: Kaser *et al.*, 2005.
26 Bradley *et al.*, 2006.
27 Government of Bolivia.
28 PND, 2006.
29 Ulloa, 2006.

References

ABDES. *Informe Bolivia: Implementación de los Objetivos de desarrollo del Milenio relativos a la pobreza, la sostenibilidad ambiental y la gobernanza.* Observatorio de Sostenibilidad. Alianza Boliviana de la Sociedad Civil para el Desarrollo Sostenible. La Paz, Bolivia. 2005.

Andersen L. *Conservación y Desarrollo humano en el Corredor Amboró-Madidi.* Cuaderno de Trabajo, Programa de las Naciones Unidas para el Desarrollo (UNDP). La Paz, Bolivia, 2005.

Betts, R. *"Self-beneficial effects of vegetation on climate in an Ocean-Atmosphere General Circulation Model".* Geophysical Research Letters. 26, 1457-1460, 1999.

Bradley, R. Vuille, M., Diaz, H. and Vergara, W. *"Threats to Water Supplies in the Tropical Andes".* Science, 312, pp.1755-76, 2006.

Camacho, M., Martinez, I. and Rojas, D. *Tasa de deforestación en el Departamento de Santa Cruz: 1993-2000.* Santa Cruz, Proyecto BOLFOR, 2001.

Clabbers, B. *"Possible role of LULUCF in future regimes".* Center for Clean Air Policy. Future Actions Dialogue Meeting, Mexico City. November, 2004.

Claussen, M. *"Does landsurface matter in climate and weather?"* In Vegetation, water, humans and the climate: a new perspective in an interactive system part A. A synthesis of the IGBP core project, Biospheric Aspects of the Hydrological Cycle, 2002.

Contreras, A. and Vargas, M. *Social, Environmental and Economic Dimension of Forest Policy reforms in Bolivia.* Forest Trends, Washington DC, 2002.

Davies, J. Magriños, E., Osinaga E. and Bojanic, A. *Is natural forest management a viable land use option in a colonisation zone in Bolivia*. Overseas Development Institute, London, 2000.

Forestry Superintendence. *Las Cifras del Sector Forestal*. Superintendencia Forestal, INE, Cámara Forestal de Bolivia. Santa Cruz, 2007.

Francou, B. Vuille, M., Wagnon, P., Mendoza, J., and Sicart, J. "*Tropical climate change recorded by a glacier in the central Andes during the last decades of the twentieth century: Chacaltaya, Bolivia, 16°S"* Journal of Geophysics Research. 108, 2003.

Gutierrez, R. and Palenque, E. *Medidas de dióxido de carbono en la Amazonia boliviana.* Primera conferencia científica del LBA. Junio 26-30. Belén, Brazil, 2000.

Hecht, S. "*When Solution Became Drivers in Soybeans, development and conservation on the Amazon Frontier*". Development and Change, 36(2), 375-404, 2001.

Kaimowitz, D., Thiele, G. and Pacheco, P. *"The effects of Structural Adjustment on Deforestation and Forest degradation in Lowland Bolivia".* World Development Vol 27, No. 3, 505-520, 1999.

Kaimowitz, D. *"Factors determining low deforestation: the Bolivian Amazon".* Ambio, 537-540, 1997

Kaser, G. Georges, C., Juen, I., Molg, T. *"Low latitude glaciers: Unique global climate indicators and regional contributors to fresh regional water supply. A conceptual approach*", in Global Change and Mountain Regions: A State of Knowledge Overview, Huber, U.m Bugmann, H, Reasoner, M. (eds) Kluwer, New York, 2005.

Killen, T., Calderon, V. Steininger, M., Harper, G., Siles, T. Solorzano, L. & Tucker, C. *Forty years of land-use change in Bolivia: Who, where, why and how much.* Conservation International, 2005.

Ledezma, J.C. & Painter, L. *Método para el Mapa de Estado de Conservación.* Trabajo No Publicado. Conservation International, La Paz, 2005.

Lozán, J. *Climate of the 21st century: Changes and risks.* Hamburg, Germany, 2001.

McKibbin, W. and Wilcoxen, P. *"The Role of Economics in Climate Change Policy".* The Journal of Economic Perspectives, Vol. 16, No. 2, pp. 107-129, 2002.

MDSMA. *Memoria explicativa: Mapa Forestal*. Ministerio de Desarrollo Sostenible y Medio Ambiente, Secretaría Nacional de Recursos Naturales. La Paz, Bolivia, 1995.

Pacheco, P. *Estilos de Desarrollo, deforestación y degradación de los bosques en las tierras bajas de Bolivia.* CIFOR, Centro de Estudios para el desarrollo Laboral y Agrario. Serie Bosques y Sociedad. La Paz, Bolivia, 1998.

Pacheco, P. *"Agricultural expansion and deforestation in the Lowlands Bolivia: The Import Substitution versus the Structural Adjustment Model".* Land Use Policy, 23, 205-225, 2006.

Palenque, E.R. *Los efectos de la RUV Solar sobre plantas y materiales de uso tecnológico*, In La Radiación Ultravioleta en Bolivia, Zaratti, F. and Forno, R. (eds). OPS/LFA, La Paz, Bolivia, 2003.

Peredo, B. *Oportunidades y Desafíos para el Desarrollo Humano Sostenible: Beneficios de la Biodiversidad y de Servicios Ambientales*. Cuaderno de Trabajo, Programa de las Naciones Unidas para el Desarrollo (UNDP). La Paz, Bolivia, 2006.

Pielke, R.A., Marland, G. Betts, R. Chase, T., Eastman, J. Niles, J., Niyogi, D. and Running, S. *"The influence of land-use change and landscape dynamics on the climate system: relevance to climate change policy beyond the radiative effect of greenhouse gases".* The Royal Society, London. Vol. 360, pp. 1705-1719, 2002.

PNCC. *Escenarios Climáticos: estudio de Impactos y Opciones de Adaptación al Cambio Climático*, La Paz, Bolivia, 2000.

PNCC. *Inventario Nacional de Emisiones de gases de efecto invernadero de Bolivia para la década 1990-2000 y su análisis tendencial*. La Paz, Bolivia, 2003.

PNCC. *Boletín Informativo.* Boletín No. 3. La Paz, Bolivia, 2006.

Ramirez, E. Francou, B., Ribstein, P., Descloitres, M., Guerin, M., Mendoza, J., Gallaire, R., Pouyaud, B., and Jordan, E. *"Small glaciers disappearing in the Tropical Andes: a case study in Boliva— Glacier Chacaltaya*". Journal of Glaciology, 47: 187-194, 2001.

República de Bolivia. *Decreto Supremo No. 29191* del 14 de Julio. La Paz, Bolivia, 2007.

República de Bolivia. *Decreto Supremo No. 28218* del 24 de Junio. La Paz, Bolivia, 2007.

República de Bolivia. *Plan Nacional de Desarrollo*. La Paz, Bolivia, 2006.

República de Bolivia. *Ley 1988 del 22 de julio de 1999*: Ratificación del Protocolo de Kyoto. La Paz, Bolivia, 1999.

Silva-Chavez, G. *Reducing greenhouse gases from tropical deforestation by applying compensated reduction to Bolivia.* In Tropical Deforestation and Climate Change, edited by Moutinho, P. & Schwartzman, M. Amazon Institute for Environmental Research, IPAM, Brazil and Environmental Defense, Washington DC, 2005..

Steininger, M. Tucker, C. Ersts, Townshend, J., P. Killen, Desch, A., Bell, V. and Ersts, P. "*Tropical deforestation in the Bolivian Amazon*". Environmental Conservation 28: 127-134, 2000.

Trujillo, R. *Boletín Informativo*. Boletín No. 3. Programa Nacional de Cambios Climáticos. La Paz, Bolivia, 2006.

Ulloa G. *Bolivia's experience of forest management and emissions avoidance*. Presentation by the Clean Development Office. National Programme of Climate Change. Bolivia, 2006.

World Bank. *Making Services Work For Poor People.* World development Report. Washington DC, 2004.

A Mediterranean response to climate change

Nora Berrahmouni

Abstract. In April 2008, professionals and practitioners met to discuss the impacts of climate change on Mediterranean forests— a global centre of biological diversity. The workshop entitled 'Adaptation to Climate Change in Mediterranean Forest Conservation and Management', was held by IUCN and WWF and organised by Nora Berrahmouni of WWF. The meeting focussed on the need for adaptation opportunities and options to enhance their social and environmental resilience. The resulting statement, reproduced here, is a concise summary of some key elements needed in addressing climate change in the Mediterranean.

Introduction

From 14 to 16 April 2008, Mediterranean experts, scientists, NGOs, conservationists, governmental officials and international organisations met in Athens, Greece to discuss issues related to the impacts of climate change on Mediterranean forests adding to the already ongoing threats and challenges impacting these ecosystems and the people depending on them, and to search for adaptation opportunities and options to enhance their social and environmental resilience

Statement

Mediterranean forests, woodlands and scrub, situated in a transitional zone between the European, African and Asian continents, are one of the planet's centres of biological diversity and are linked to outstanding cultural features. The Mediterranean vegetation includes 25,000 floral species, representing 10 per cent of the world's flowering plants on just over 1.6 per cent of the Earth's surface. It is also the second world leader in plant endemism, with an estimated 50 per cent (13,000) of these species found nowhere else on Earth. Species' groups with a Pan-European distribution, such as fir, beech, pine and oak have the highest species diversity in the Mediterranean region, and the Mediterranean populations are often the most variable ones in terms of genetic diversity. Furthermore, Mediterranean forests also host an amazing faunal diversity, especially when is expressed by the ratio between species richness and area.

Picture 1. Loss of tree cover in Mediterranean regions has contriubuted to soil erosion and flash flooding; studies have shown the economic benefits of restoration (*Courtesy Mark Aldrich, WWF*)

Forests provide vital environmental services— soil, water catchment, timber, food and medicine, stabilisation of urban microclimates, recreation, etc.— on which society depends. This is extremely significant in extreme environments like the Mediterranean climate, where water

Climate change could eventually overstretch the resilience and adaptive capacity of the Mediterranean forest ecosystems.

shortage constitute the main limiting factor and its irregular distribution can easily activate soil erosion and water run-off if forest cover is loss.

Rapid and abrupt land-use changes, mainly due to development pressures and urban sprawl, habitat fragmentation, resource overexploitation and poor management, are the main drivers of Mediterranean forests degradation. Climate change adds to these pressures, mainly through an increased incidence of heat waves, droughts and overall temperature rise, and could eventually overstretch the resilience and adaptive capacity of the Mediterranean forest ecosystems.

Recognising that:

- climate change is occurring and that it is exacerbating the already existing pressures and drivers for forest loss and degradation;
- forest wildfires are among the most direct and immediate consequences of climate change upon Mediterranean forests, and that climate change impacts, such as extended periods of drought, and extreme meteorological phenomena (heat waves and strong winds), combined with unsustainable land uses changes, bad management practices, lack of awareness and lack of adequate fire management strategies encourage the alarming trend of increasing the frequency, intensity and extent of fires;

Forest wildfires are among the most direct and immediate consequences of climate change upon Mediterranean forests.

- Mediterranean countries share common conservation and socio-economic development themes despite the significant disparities that are still present between the shores of the Mediterranean sea in terms of per capita gross domestic product, forest area coverage and landownership structure;

Picture 2. Discussion restoration issues on a WWF forest landscape restoration study tour in Spain and Portugal (*Courtesy Mark Aldrich, WWF*)

- despite the efforts deployed, Mediterranean forest ecosystems present a level of degradation that is still alarming, threatening the natural resources and cultural heritage therein;
- climate change compounded with "mal-adaptive" processes and inadequate land uses (*i.e.* unsustainable rapid land-use changes, rural abandonment and overexploitation of land resources) are likely to reduce the adaptability of Mediterranean forest to autonomously accommodate to climate change, and to increase the frequency and intensity of pathogens' outbreaks, dieback events, uncontrolled fires and other large-scale disturbances;
- the Mediterranean people and economies will be chiefly affected by the diminishing of forested areas, usually replaced by fire prone shrub communities, increased landscape fragmentation, which may consequently

impede migration/dispersal opportunities for a number of species at risk of extinction, and decrease of annual increments and the subsequent income from forests;

The participants:

- Urge all Mediterranean countries to mainstream fire risk reduction and climate change adaptation needs into all sectoral policies, regulations and rural/urban development plans linked with forest ecosystems, at national, regional, and EU levels
  - continue to improve the cooperation among the government, scientific community, NGOs, civil society groups and International organisations for the participatory planning and designing of *fire-smart* landscapes;
  - strengthen relations between managers of forests and rural areas and local communities, to ensure that forests are perceived as opportunities for increased livelihood and for the promotion of mechanisms for sustainable rural development, through information dissemination and public awareness;
  - support the development of participatory rural planning processes that empower land users and rural populations and provide them with resilient land uses and good practices relevant to adaptive farming habits and fuel reduction in forest landscapes;
  - raise awareness for the urgent need to adopt a new approach of "Learning to live with fire" with the aim of changing fire regimen to acceptable levels from a social, economic and environmental perspective, instead of a strict forest fire suppression strategy.
- Urge all Mediterranean countries to shift from predominantly natural catastrophes response strategies, like fire fighting, to integrated fire (or any other major disturbance) management strategies and policies, which
  - incorporate five key components: (1) research on forest fire dynamics and root causes of fires; (2) risk reduction and prevention; (3) readiness; (4) response; and (5) recovery;
  - stress the essential need to accentuate measures for the implementation of innovative fire management actions, assess the effectiveness of tools and policies relevant to fire risk reduction, prevent and control, and integrate vulnerability reduction and fire prevention as part also of wider landscapes planning tools and management practices;
  - recognise the essential role that rural people can play in fire vulnerability reduction, and the need for participatory planning processes supporting the identification and adoption of resilient land uses and landscape patterns;

Urge all Mediterranean countries to shift from predominantly natural catastrophes response strategies, like fire fighting, to integrated fire (or any other major disturbance) management strategies and policies.

- Urge all Mediterranean countries to jointly develop, assess the effectiveness, and fine-tune climate change adaptation strategies and tools through case studies
  - rethinking individual protected areas and regional and national protected areas networks, based

Picture 3. Forest fire sign in the reserve Dadia-Lefkimi and Soufli Forest Game Reserve Greece Project
(© *Michel Gunther/WWF-Canon*)

on the wider landscape scale "ecosystem approach", and securing provisions for both *in situ* persistence of unique Mediterranean reservoirs of forest diversity (genotypes, species and communities), and for the facilitation of species migration needs;

- ▷ *providing recommendations* to forest and land managers to increase forest resilience to climate change, such as the increase of diversity at all levels (genotypes and species composition in forest stands; habitat types and mosaic character of forest landscapes), changes in silvicultural practices (*i.e.* thinning for a wider spacing to improve resistance to drought conditions water shortages; longer rotation periods to increase carbon sequestration), and changes in soil management practices (*i.e.* low tillage and maintenance of permanent soil to reduce erosion rates and downstream flooding and increase water absorption and retention);
- ▷ encouraging forest managers, scientists and practitioners to actively assess and promote the economic valuation and sustainable use of forest products and services, a key step to reduce existing pressures on natural ecosystems and to increase the capacity of ecological and social systems to accommodate to climate change;
- ▷ encouraging forest landscape restoration initiatives that contribute to maintain the basic ecological processes and biodiversity values, to build landscape patterns, habitats and species compositions more resilient to large scale disturbances like fire, and to provide a wide range of benefits for the society;
- ▷ promoting successful results from existing projects and initiatives aimed at increasing the resilience of Mediterranean forests and people to global change impacts and fostering their replicability and adaptation through the development of further relevant initiatives addressing the different Mediterranean ecological and socio-economic contexts.

- ▷ Express the urgent need for Mediterranean North-South cooperation at all levels to face threats, and specifically in terms of improving knowledge sharing, scientific research, developing capacities, and developing partnerships for the implementation of adequate climate change adaptation processes in terms of conservation of biodiversity and cultural values, and nature resource management
  - ▷ The establishment of a body of experts of Mediterranean countries is suggested for regularly meeting to study and evaluate the changes and their expected impacts which may affect Mediterranean ecosystems and rural societies at large and

develop and propose measures and policies;

- The scientific community should commit to make the knowledge and science easily accessible to people and decision makers, and work together with communicators and other relevant actors to facilitate the use of a common language, economic valuations, case studies and visual tools;
- All practitioners should commit themselves to exchange information, experiences and expertise, and work together through regional networks with a balanced "north-south" approach, to promote concrete initiatives on research and monitoring as well as activities aimed at building capacity at all levels;
- A culture of continuous training, development of know-how and exchange of experiences is essential to have skilled land users participating in vulnerability reduction and fire prevention actions and integrating them in their management practices, to create modern, equipped and specialised forest fire-fighting units fully operational, and to secure effective co-ordination systems involving public authorities, land managers, scientific institutions and fire-fighting units;
- Engaging the private sector as partners in conservation, management and restoration work is essential;
- The international organisations of the Mediterranean region such as IUCN, WWF, FAO, UNDP, including the various national and international networks, should commit themselves to increase collaboration on Mediterranean forests and climate change adaptation, in order to ensure an important representation of Mediterranean forests in international environmental policy and fora;
- Regional countries should urgently position forest conservation and sustainable management to become a priority at national, regional and EU level, and develop powerful tools to raise awareness and educate societies on the services that Mediterranean forest ecosystems provide.

Increase collaboration on Mediterranean forests and climate change adaptation, in order to ensure an important representation of Mediterranean forests in international environmental policy and fora.

The participants, furthermore:

- Recognise the important role that Mediterranean countries play in ensuring the presence of highly trained technical and political representation to the international negotiations and fora that deal with forest policy issues;
- Request that governments and all relevant regional partners work together to ensure a wide distribution of the conclusions and outcomes of the meeting.

The participants recognise that this statement can only be implemented in the context of cooperation and solidarity in our region.

This statement can only be implemented in the context of cooperation and solidarity in our region.

Reduction of carbon emissions Brazil— the role of ARPA

Britaldo Silveira Soares Filho, Laura Dietzsch, Paulo Moutinho, Alerson Falieri, Hermann Rodrigues, Erika Pinto, Cláudio C. Maretti, Karen Suassuna, Carlos Alberto de Mattos Scaramuzza and Fernando Vasconcelos de Araújo

Abstarct. The Amazon Region Protected Areas programme (ARPA) is making a substantial contribution to protecting what remains of the great forests of the Brazilian Amazon. One of the many benefits of this conservation achievement is the protection of carbon stocks. This article reports research findings which indicate that the 61 protected areas supported by ARPA are preserving a forest carbon stock of about 4.6 billion tons of carbon (18 per cent of the total stock protected in the Amazon), which is almost twice the level of emissions reduction called for in the first commitment period of the Kyoto Protocol's if fully implemented.

The current and future contribution of protected areas in the Amazon and of the ARPA Programme is therefore crucial for the reduction of deforestation patterns in the Amazon and of its associated carbon emissions and for the planet's biodiversity conservation. Such efforts shall be internationally acknowledged and valued, especially within the context of international negotiations in the scope of the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change.

The Brazilian Amazon forests stretches over 3.3 million km² and holds a large carbon stock of approximately 47±9 billion tons.

Introduction

What is left of the Brazilian Amazon forests stretches over 3.3 million km² and holds a large carbon stock of approximately 47±9 billion tons.[1] Nonetheless, continued deforestation is resulting in substantial emissions of carbon dioxide— in addition to loss of biological diversity and reduced ecosystem services.[2]

The total deforested area in the Amazon already amounts to 616,000 km² (15 per cent of the area)— an area twice the size of Germany. The concentration of deforestation is along a "deforestation arc", extending from northeastern Pará to the eastern region of Acre, encompassing the world's largest expanding agricultural frontier.[3] In the 1990's, annual deforestation rates were of around 17,000 km², and corresponded to average annual emissions of 200 million tons of carbon (considering that one hectare holds an average of 120 tons of carbon).[4] Over the past two years, and after a period of intense deforestation rates in the early 2000, the rates declined to approximately 13,000 km² in 2007.[5]

One of the main causes of deforestation in the Brazilian Amazon is the conversion of forests into extensive

Picture 1. Rio Negro Forest Reserve, Brazil (© *Michel Roggo/WWF-Canon*)

grazing land for cattle ranching.[6] Over 70 per cent of the deforested area of the Amazon is converted to cattle pasture, mainly with low productivity. More recently, the expansion of agribusiness and both the expectation of and the actual paving of regional of roads has been contributing to the maintenance of high deforestation rates, because infrastructure investments induce land speculation. The illegal market for land and timber, due to the government's difficulty in controlling criminal activity, further stimulates deforestation.

On the other hand, the decline of the Brazilian Amazon deforestation rates over the past three years, demonstrates that governance in the Amazon frontier has been increasing. Despite the positive influence of external factors in the reduction of deforestation, *e.g.* the decrease of international prices for soy and beef and the depreciation of the US dollar against the Brazilian Real, which makes exporting more difficult, Brazil has demonstrated greater capacity to enforce and implement conservation policies in the Amazon forest. The 148 new protected areas, equalling a total of 622,000 km², created between 2003 and 2008 is proof of government commitment to conservation.

This conservation effort could be threatened however by the growing demands for agricultural products from national and international markets. If past trends of agricultural expansion and road development persist, 40 per cent of the remaining Amazon forests may be eliminated by 2050.[7] The quantity of carbon to be released into the atmosphere during this period could reach 32±8 billion tons; which is almost equivalent to three years of global carbon dioxide (CO_2) emissions, at 2000 levels. In addition to biodiversity losses, deforestation in the Amazon may lead to major changes in the regional climate regime, such as substantial decrease in rainfall[8] and the consequent increase in forest fire frequency, which in turn contributes to larger emissions of greenhouse gas.[9] In 1998, for example, Amazon carbon emissions to the atmosphere doubled due to the widespread fires resulting from a severe drought that affected the region, caused by the El Niño phenomenon. The simultaneous advance of deforestation and global warming are likely to alter the Amazon climate significantly. Estimates point to a 20-30 per cent reduction of regional rainfall[10] and a 1.8 to 7.5°C increase of average temperatures during the dry season and of 1.6 to 6.0°C during the rainy season by 2080.[11] If the increased frequency and intensity of El Niño due to global warming is added to this scenario,[12] it is possible that the Amazon forest will enter an irreversible cycle of self-destruction.[13]

Picture 2. Cattle grazing near burnt forest in Roraima, Brazil
(© *Nigel Dickinson/WWF-Canon*)

Protected areas

One of the most promising mechanisms with which to stop massive destruction of the Amazon forest has been the creation of large blocks of protected areas. These areas have a role not only in protecting biological or forest diversity, but also in fostering social and cultural well-being by providing economic alternatives to local populations, *e.g.* through extractive reserves, sustainable development reserves and indigenous people's lands etc.[14]

The role protected areas play in halting deforestation has been assessed in several regions of the world. Generally speaking, deforestation rates within protected areas are significantly lower when compared to areas that are not protected.[15] This difference between deforestation rates within and outside protected areas is seen by some as a demonstration of their efficacy as a mechanism for the reduction of forest destruction, especially when these protected areas are properly implemented and, if possible, integrated with local social groups. Conversely, this interior versus exterior comparison has also been seen as a demonstration that the protected areas strategy can foster deforestation in other regions and induce negligence in the conservation of areas which are not protected.[16] Such statements are based on the argument that the establishment of a protected area can, at most, redistribute deforestation throughout a landscape and not decrease it in absolute values. Nonetheless, studies that quantify this effect on the redistribution of deforestation or its decrease are lacking.

The creation of protected areas in the Brazilian Amazon has played an important role in biological diversity conservation in the region and in the protection of extensive tropical forest areas. Approximately 50 per cent of the remaining Amazon forests are protected areas. The most ambitious biodiversity conservation programme related to this expansion of protected areas in the region is the Amazon Region Protected Areas Programme (ARPA), which was created by the Brazilian Government in 2003. Over a 10-year period (2003–2013), the ARPA intends to protect 500,000 km^2 of natural ecosystems, mainly forests.

Protected areas and carbon stocks

There is evidence therefore that protected areas have clear benefits for the conservation of biological diversity, but what about protected areas role in the reduction of greenhouse gas— especially carbon dioxide (CO_2) resulting from Amazon deforestation? To answer this question the partners WWF-Brazil, IPAM (Instituto de Pesquisa Ambiental da Amazônia), The Woods Hole Research Centre and UFMG (Universidade Federal de Minas Gerais) undertook an assessment of ARPA's contribution to the reduction of emissions through analyses of historical deforestation rates between 1997 and 2007 and of estimated future rates obtained from modelling deforestation scenarios for 2050.

Until 1997, most protected areas were strictly protected for nature conservation. However, since 1998 the government has recognised many indigenous people's lands and created over 300,000 km² of sustainable use areas. The carbon study thus addressed protected areas in their widest sense, looking at all protected areas (for nature conservation), indigenous people's lands and military areas. According to figures published in 2004, 43 per cent of the Brazilian Amazon is currently protected, of this, 54 per cent are indigenous people's lands and 44 per cent are strict nature protected areas.

An assessment of ARPA's contribution to the reduction of emissions through analyses of historical deforestation rates between 1997 and 2007 and of estimated future rates obtained from modelling deforestation scenarios for 2050.

The carbon study was undertaken by overlaying a map of these protected areas with historical deforestation maps from 1997 and 2007,[17] making it possible to assess deforestation both within and around protected areas. For the analysis of the region surrounding the protected areas, buffer zones of 10, 20 and 20+ km were defined so as to establish the proximal effects of the protected area. Furthermore, annual deforestation data were used to develop a Bayesian weights of evidence analysis, which calculates the *a posteriori* probabilities and the likelihood of events (deforestation), given a spatial pattern, which in this case is the presence or absence of a protected area.[18]

Results

The results show that protected areas inhibit deforestation. Accumulated deforestation within the areas analyzed was relatively low (1.53 per cent of the total protected area of the Brazilian Amazon), and totalled 28,000 km² from 2002 to 2007. Accumulated deforestation throughout different protected area categories were:

Protected areas inhibit deforestation.

- 2,800 km² (1 per cent of the total protected area) in strict conservation areas
- 13,100 km² (3 per cent) in sustainable use reserves
- 10,700 km² (1.1 per cent) in indigenous people's lands

This result is also confirmed by the findings that the probability of deforestation increases in areas more distant from the protected areas.

This same analysis was employed for each protected area individually, through a sampling of 255 protected areas with records of historical deforestation. In this case, the analysis focused on the contribution of each area to the relative reduction of deforestation, regardless of the increasing or decreasing deforestation trajectories for the Amazon region as a whole. For the purpose of comparison, protected areas were grouped according to four types: indigenous people's lands, strict preservation areas, sustainable use reserves and military areas. The sustainable use and strict preservation areas were separated into areas with and without ARPA support. The assessment compared deforestation rates between 2005 and 2007 with the rates between 1997 and 2004. Overall the effectiveness in reducing deforestation is similar in sustainable use areas, strict conservation areas and indigenous people's lands, whilst military areas have much lower values of relative effectiveness.

The data on the relative effectiveness of deforestation reduction in protected areas supported by the ARPA programme showed a considerable and statistically significant increase (test-t, n=105; $p<0.05$) in effectiveness of deforestation reduction in sustainable use areas supported by the programme. For the strict preservation areas, however, the difference observed was not statistically significant. The relative effectiveness of deforestation reduction in protected areas depends on their proximity to the deforestation arc.

Overall the effectiveness in reducing deforestation is similar in sustainable use areas, strict conservation areas and indigenous people's lands, whilst military areas have much lower values of relative effectiveness.

Future impacts

What role will the current expansion of the protected areas network play in curtailing further deforestation in the Amazon? As this role is still virtually unknown, the study employed a deforestation simulation model developed under the auspices of the "Amazon Scenarios Program" led by the Amazon Institute for Environmental Research (IPAM in Portuguese), The Woods Hole Research Center and the Federal University of Minas Gerais.

"Amazon Scenarios" allows the assessment of various policies, the regional economy, population mobility and infrastructure development scenarios on future Amazon deforestation.[19] The current version of this model "SimAmazonia-2" analyses how the expansion of soy,[20] cattle ranching[21] and logging[22] interact to cause deforestation. In addition, SimAmazonia-2 takes into account public policies, such as the creation and consolidation of protected areas and the implementation of the Forestry Code (Código Florestal) (Law No. 4,771, of 1965, with later amendments), for modelling future deforestation trajectories.[23]

SimAmazonia 2 models the future trajectory of deforestation in the Amazon region by considering a series of conservation measures versus the deforestation drivers. As both show growing trajectories, this conflict becomes increasingly vigorous and sensitive to the speed and timing at which public policies are implemented. In this case, deforestation is a result of the expanding agricultural market and of regional infrastructure investments.

SimAmazonia-2 was used to assess the future role of protected areas recently created (between 2002 and 2008) and areas that are expected to be created under the ARPA Programme. The impact of protected area on the future trajectory of deforestation was analyzed under two extreme scenarios:

- business as usual, *i.e.* the continued expansion of the agricultural frontier and the associated population mobility and extensive paving of roads and highways, and
- governance, *i.e.* moderate agricultural expansion and low population mobility and restricted paving of roads and highways.

In each of these scenarios all other variables were kept fixed to assess the effect of different protected area networks on the trajectory of deforestation until 2050. That is: only the extent and degree of protected areas were changed. The effect of protected areas on the trajectory of future deforestation was thus calculated by the mean value obtained from the two extreme

scenarios, and its uncertainty will be the difference between the extreme values and the mean value. An index of the level of threat by potential deforestation (level of threat corresponds to the year on which a parcel of the protected area will be deforested if it were not created and implemented: Threat = 100*(2050-year+1)/43)) was calculated. This index accounted not only for the chances of future deforestation, but also when it may occur, *i.e*. its suddenness.

The model then calculated the carbon stocks within each protected area supported by the ARPA programme and their respective emission potential if these protected areas did not exist. The figures were calculated by superposing the map of level of threat by 2050 on a map of forest's biomass[24] and assumed that 85 per cent of forest carbon is released into the atmosphere during and after deforestation.[25]

The calculations showed that the 61 protected areas that are currently supported by the ARPA Programme hold 4.6 billion tons of forest carbon; 18 per cent of forest carbon in protected areas of the Brazilian Amazon. With respect to potential emission from deforestation, the analysis on the level of threat shows that these areas have a direct potential in reducing emissions of 1.1 billion tons of carbon; *i.e.* the total released from deforestation by 2050 if they did not exist. The next step of the analysis consisted in modelling the direct and indirect impacts of the existence of protected areas in different scenarios. In other words, this analysis assessed the influence of protected areas on inhibiting deforestation both within as well as around them. By keeping unaltered the set parameters of the extreme-case scenarios and by altering the configuration of protected areas, six additional scenarios were modelled:

- areas created only until the end of 2002— this scenario works as a baseline and allows for comparisons to be made on the reduction of emissions as the protected areas network is expanded;
- by 2008 without the ARPA Programme, *i.e.* areas created until April 2008, except those areas that counted on ARPA support for their creation between 2003 and 2008 (13 protected areas);
- all protected areas created until April of 2008;
- all current protected areas plus the expansion planned for the future years according to the ARPA Programme;

The analysis on the level of threat shows that these areas have a direct potential in reducing emissions of 1.1 billion tons of carbon.

Picture 3. Aerial photograph showing burning tropical rainforest
(© *Nigel Dickinson/WWF-Canon*)

- ▷ all current protected areas, but with the complete impediment of deforestation within them, *i.e.* the maximum effectiveness in reducing deforestation;
- ▷ all current protected areas plus the expansion foreseen for the following years and with complete impediment for deforestation within them.

Therefore, the latter two scenarios represent variants of the third and fourth in which the probability of deforestation within the protected areas are adjusted to zero, thus making them 100 per cent impervious to deforestation.

Summary of results

Only the expansion of protected areas between 2002 and 2008 will allow for a 272±180,000 km^2 reduction of deforestation that could expected for 2050, which is, in other words, equivalent to a reduction of 3.3±1.1 billion tons of carbon emissions. Twelve percent of this global reduction can be attributed to the ARPA Programme, which supported the creation of 13 protected areas during this time period. Moreover, the expansion of 210,000 km^2 planned by the ARPA Programme for 2008 and 2009 could increase this reduction to 350±170,000 km^2, equivalent to 4,3±1.2 billion tons of carbon. Should all the protected areas be 100 per cent impervious to future deforestation, these reductions would reach 324±152,000 km^2 and 409±137,000 km^2 respectively, number that is equivalent to a reduction in carbon emissions of 3.9±1.3 to 4.9±1.5 billion tons of carbon.

Final assessment and recommendations

Nearly 50 per cent of remaining Amazon forests is under some type of protected area designation. Of this total, 16.8 per cent are supported by the ARPA Programme. Historically, protected areas have played a fundamental role in deforestation reduction and are, consequently, a barrier to the advancing agricultural frontier that, when uncontrolled, illegally and predatorily destroys the Amazon forest.

Protected areas not only inhibit deforestation within their lands, but also show an inhibitory effect on reducing deforestation in their surroundings.

Our empirical analysis has shown that protected areas not only inhibit deforestation within their lands, but also show an inhibitory effect on reducing deforestation in their surroundings. Notably, this inhibitory effect has been augmenting over time, as shown by the analysis of the effectiveness of protected areas in impeding deforestation, especially is the case of sustainable use areas supported by the ARPA Programme.

Mosaics, corridors or networks of protected areas play a fundamental role in conserving biological diversity, protecting habitats, maintaining hydrological regimes, as well as in the stability of regional climate. Today, the protected areas of the Brazilian Amazon hold nearly 50 per cent of the remaining

The areas supported by the ARPA Programme alone can reduce potential emissions from deforestation by 2050 of nearly 1.1 billion tons of carbon.

forest carbon stocks. The areas supported by the ARPA Programme alone can reduce potential emissions from deforestation by 2050 of nearly 1.1 billion tons of carbon. Nevertheless, the consolidation of this extensive protected area network represents a great challenge to the Brazilian nation, especially in areas located along the active deforestation front, where numerous land conflicts and other illegal activities threatens the social and natural environment. This challenge is likely to grow in the near future due to increasing demands for agricultural commodities. Thus, those areas located along the deforestation front face greater threats and present the greatest potential for carbon emissions. On the other hands, if efficiently implemented, these same areas also represent the greatest potential for the reduction of carbon emissions. For these reasons they deserve special attention from conservation investments, even though they do not fit the traditional conservation approaches that prioritise protection according to their high biological diversity and low levels of threat.

Picture 4. Aerial view of forest clearing to create grazing pasture for cattle, Juruena National Park, Brazil. (© *Zig Koch/WWF*)

In our view, the best way forward consists in encompassing both strategies. In other words, it is necessary to give priority in protecting key areas against the advance of the deforestation frontier, as well as targeting the highly representative biodiversity samples of the Amazon as a whole. In addition to continuing to expand the Amazon protected network, a substantial allocation of resources is vital to the success of this innovative conservation strategy that aims for the creation and consolidation of protected areas along regions of extreme land use dynamics.

It is necessary to give priority in protecting key areas against the advance of the deforestation frontier, as well as targeting the highly representative biodiversity samples of the Amazon as a whole.

Quantifying reductions of deforestation and associated carbon emissions through the implementation and consolidation of protected areas is an important contribution to the international debate. In the scope of the United Nations Framework Convention on Climate Change, this work brings major contribution to the decisions made by the Conference of the Parties, held in December of 2007 in Bali. The Bali Action Plan (Decision UNFCCC 1/ COP13), which addresses measures and proposals with the objective of increasing the implementation of national and international mitigation, specifically refers to the development of policy approaches and positive incentives on issues relating to reducing emissions from deforestation in developing countries. In a specific decision concerning deforestation (Decision UNFCCC 2/CP 13),

it is noted that sustainable reductions of emissions resulting from deforestation in developing countries require stable and predictable resources. It is also acknowledged that reducing emissions from deforestation in developing countries can foster multiple benefits and complement the objectives of other relevant conventions.

This huge effort towards conservation and reduction of deforestation emissions requires stable and predictable availability of resources.

The estimate of the reduction of emissions resulting from deforestation under various scenarios allow us to conclude that the strategy for the implementation and consolidation of protected areas, especially the ARPA Programme, can be classified as a demonstration activity for reducing emissions from deforestation in Brazil. As highlighted by the COP, this huge effort towards conservation and reduction of deforestation emissions requires stable and predictable availability of resources. It is imperative that the efforts made until the present moment be ensured and continued. The ARPA Programme is ready to become integrated with future formal and/or volunteer mechanism of positive incentives towards reducing emissions from deforestation.

Britaldo Silveira Soares Filho, **Alerson Falieri** and **Hermann Rodrigues** are from Universidade Federal de Minas Gerais (UFMG). **Laura Dietzsch**, **Paulo Moutinho** and **Erika Pinto** are from Instituto de Pesquisa Ambiental da Amazônia (IPAM), and **Cláudio C. Maretti**, **Karen Suassuna**, **Carlos Alberto de Mattos Scaramuzza** and **Fernando Vasconcelos de Araújo** are from WWF Brazil.

Notes

1 Saatchi *et al.*, 2007, Nepstad *et al.*, 2007.
2 Malhi *et al.*, 2008.
3 Morton *et al.*, 2006.
4 Nepstad *et al.*, 2007.
5 INPE, 2008.
6 Margulis, 2003, Alencar *et al.*, 2004.
7 Soares Filho *et al.*, 2006.
8 Sampaio *et al.*, 2007.
9 Nepstad *et al.*, 1999, Nepstad *et al.*, 2008.
10 Nobre *et al.*, 1991.
11 IPCC, 2007.
12 Nepstad *et al.*, 1999.
13 Nobre *et al.*, 1996; Nepstad *et al.* 2007, Nepstad *et al.*, 2008.
14 Naughton-Treves *et al.*, 2005; Maretti *et al.*, 2003; Maretti *et al.*, 2005; Peres, 2005; Schwartzman e Zimmerman, 2005.
15 Bruner *et al.*, 2001; Naughton-Treves *et al.*, 2005; Ferreira *et al.*, 2005; Soares-Filho *et al.*, 2006, Nepstad *et al.*, 2006.
16 Vandermeer, 1995; Cronon, 1995.
17 INPE, 2008.
18 Bonham-Carter, 1994.
19 Soares-Filho *et al.*, 2006.
20 Vera-Diaz *et al.*, 2008.
21 Merry *et al.*, in press.
22 Merry *et al.*, in press.
23 Soares *et al.*, in press.
24 Saatchi *et al.*, 2007.
25 Hougthon *et al.*, 2005.

References

Alencar, A.; Nepstad, N; McGrath, D; Moutinho, P; Pacheco, P; Diaz, M. D. C. V; Soares- Filho, B. *Desmatamento na Amazônia: indo além da emergência crônica***.** Manaus, IPAM, 2004.

Bonham-Carter, G. Geographic information systems for geoscientists: modelling with GIS. New York, *Pergamon*, 1994.

Bruner, A.; Gullison, R.; Rice, R.; Fonseca, G. Effectiveness of parks in protecting tropical biodiversity. *Science***,** 291:125–28, 2001.

Cronon, W. 1995. The trouble with wilderness; or getting back to the wrong nature. In *Uncommon Ground*, ed. W Cronon, p. 69–90, New York, 1995.

Ferreira, L. V.; Venticinque, E.; Almeida, S. O desmatamento na Amazônia e a importância das áreas protegidas. *Estudos Avançados***,** 19:1–10, 2005.

Houghton, R. A.; Skole, D. L.; Nobre, C. A.; Hackler, J. L.; Lawrence, K. T., and Chomentowski, W. H. Annual fluxes of carbon from deforestation and regrowth in the Brazilian Amazon. *Nature***,** 403: 301–304, 2000.

INPE (Instituto Nacional de Pesquisas Espaciais). Monitoramento da floresta amazônica brasileira por satélite: projeto Prodes. http://www.obt.inpe.br/prodes/. Accessed in March 2008

IPCC - Quarto Relatório, Grupo de Trabalho II— capítulo 13: América Latina. p.581-615. 2007.

Malhi, Y. J.; Roberts, T.; Betts, R. A.; Killeen, T. J.; Li, W.; Nobre, C. A. Climate Change, Deforestation, and the Fate of the Amazon. *Science*, 319: 169-172, 2008.

Margulis, S. *Causas do desmatamento da Amazônia brasileira*. 1ª ed. Brasília: Banco Mundial, 2003.

Maretti, C.C.; Sanches, R.A. *et al.* 2003. *Protected areas and indigenous and local communities in Brazil*; Lessons learned in the establishment and management of protected areas by indigenous and local communities. Durban: IUCN, V World Parks Congress. 72 p.

Maretti, C.C. *et al.* From pre-assumptions to a 'just world conserving nature:' the role of category VI in protecting landscapes. In: Brown, J. *et al.* (eds.) *The protected landscape approach: linking nature, culture and community*. Gland: IUCN and others, p. 47–64. 2005.

Merry, F.; Soares-Filho, B.; Bowman, M B.; Nepstad, D.; Rodrigues, H. The Amazon Cattle Industry. (In preparation).

Morton, D. C.; DeFries, R. S.; Shimabukuro, Y. E.; Anderson, L. O.; Arai, E.; Espirito-Santo, F. B.; Freitas, R.; Morisette, J. Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon. *Sustainable Science*. 2006.

Naughton-Treves, L.; Holland, M. B.; Brandon, K. The Role of protected areas in conserving biodiversity and sustaining local livelihoods. *Annu. Rev. Environ. Resour*. 30:219–52. 2005.

Nepstad, D.; Verissimo, A.; Alencar, A.; Nobre, C.; Lima, E.; Lefebrve, P.; Schlesinger. P.; Potter, C.; Moutinho, P.; Mendoza, E.; Cochrane, M.; Brooks, V. Large-scale impoverishment of Amazonian forests by logging and fire. *Nature* 398: 505-508, 1999.

Nepstad, D.; Schwartzman, S.; Bamberger, B.; Santilli, M.; Ray, D.; Schlesinger, P.; Lefebvre, P.; Alencar, A.; Prinz, E.; Fiske, G.; Rolla, A. Inhibition of Amazon deforestation and fire by parks and indigenous reserves. *Conservation Biology* 20: 65–73, 2006.

Nepstad, D.; Soares-Filho, B. S.; Merry, F.; Moutinho, P.; Rodrigues, H. O.; Bowman, M.; Schwartzman, S.; Almeida, O.; Rivero, S. *The Costs and Benefits of Reducing Carbon Emissions from Deforestation and Forest Degradation in the Brazilian Amazon*. Report launched in the United Nations Framework Convention on Climate Change (UNFCCC), Conference of the Parties (COP), Thirteenth session. Bali, Indonesia. December, 2007.

Nepstad, D.; Stickler, C.; Soares-Filho, B. S.; Merry, F. Interactions among Amazon land use, forests, and climate: prospects for a near-term forest tipping point. *Philosophical Transactions of The Royal Society* doi:10.1098/rstb.2007.0036, 1-10, 2008.

Nobre, C. A.; Gash, J. H. C.; Roberts, J. M.; Victoria, R. L. 1996. Conclusions from Abracos. In Gash, J.H.C., Nobre, C.A., Roberts, J.R. e Victoria, R.L. (eds.) *Amazonian Deforestation and Climate*. John Wiley and Sons, Chichester, UK 1996.

Nobre, C. A.; Sellers, P. J.; Shukla, J. Amazonian deforestation and regional climate change. *J. Climate* **4**, 957-988. 1991.

Peres, C. A. Why We Need Megareserves in Amazonia. *Conservation Biology*, p.728–733 V.19, No. 3, 2005.

Saatchi, S. S.; Houghton, R. A.; Dos Santos Alvala´, R. C.; Soares, Z. J. V.; Yu, Y. Distribution of aboveground live biomass in the Amazon basin. *Global Change Biology* 13, 816–837. 2007.

Sampaio, G.; Nobre, C.; Costa, M. H.; Satyamurty, P.; Soares-Filho, B. S.; Cardoso, M. Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion. Geophysical Research Letters, Londres, v. 34, n. doi:10.102, p. 1-7. 2007.

Schwartzman, S.; Zimmerman, B. Conservation Alliances with Indigenous People of the Amazon. *Conservation Biology*, p.721–727, v. 19, No. 3, 2005.

Soares-Filho, B. S.; Nepstad, D. C.; Curran, L. M.; Cerqueira, G. C.; Garcia, R. A.; Ramos, C. A.; Voll, E.; Mcdonald, A.; Lefebvre, P.; Schlesinger, P. Modelagem da Conservação na Bacia Amazônica. *Nature*, 2006.

Soares-Filho, B. S.; Garcia, R. A.; Rodrigues, H. O.; Moro, S.; Nepstad, D. *Nexos entre as dimensões socioeconômicas e o desmatamento: A caminho de um modelo integrado*. In: Batistella, M; Moran, E. Alves, D. (ed.). *Amazônia e Sociedade*. (no prelo).

Vandermeer, J.; Perfecto I. *Breakfast of Biodiversity*. Oakland, CA: Inst. Food Dev. Policy. 1995.

Vera-Diaz, M.; Kaufmann, R.; Nepstad, D.; Schlesinger, P. An interdisciplinary model of soybean yield in the Amazon Basin: the climatic, edaphic, and economic determinants. *Ecological Economics* **3**, p.420-431 2008.