FORUM

Conservation and restoration of Mexican forests in the global change scenario: a shared responsibility with multiple benefits

Conservación y restauración de bosques mexicanos en el escenario del cambio global: una responsabilidad compartida con beneficios múltiples

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ABSTRACT

Our planet is facing a strong change induced by human activities, which is usually referred as Global Change. Concern about the socioeconomic consequences of this phenomenon has led to several international commitments for reducing the emissions of greenhouse gasses, which were summarized in the Kyoto Protocol of the United Nations. The Protocol established a number of strategies to mitigate and reduce the atmospheric impacts of CO_2 emissions, which led to the creation of the international carbon market. The extensive forested areas of Mexico may position this country in the carbon market as an important provider of environmental services. Therefore, conservation and restoration of Mexican forests can be viewed as a potential business opportunity that would contribute to the economic and social development of the country. However, reaching these goals requires the joint action of different social sectors, including governments, private companies, the scientific community and the general population. This article illustrates how this interaction can be articulated and how it can provide multiple benefits for contributing parties.

KEYWORDS:
Carbon market, carbon credits, ecosystem services, Kyoto Protocol, sustainable development.

RESUMEN

Nuestro planeta enfrenta hoy un fuerte cambio inducido por las actividades humanas, el cual usualmente se denomina Cambio Global. La creciente preocupación sobre las consecuencias socioeconómicas de este fenómeno dio lugar a varios compromisos internacionales que apuntan a reducir las emisiones de gases de efecto invernadero, las cuales se resumen en el Protocolo de Kioto de las Naciones Unidas. Este protocolo establece una serie de estrategias para mitigar y reducir el impacto atmosférico de las emisiones de CO_2, lo que dio lugar a la creación del mercado internacional del carbono. Las extensas áreas forestales de México pueden situar a este país en el mercado del carbono como un importante proveedor de servicios ambientales. Por lo tanto, la conservación y la restauración de bosques en México pueden verse como una potencial oportunidad de negocios, lo cual contribuiría al desarrollo socioeconómico del país. Sin embargo, para alcanzar estos objetivos se requiere la acción conjunta de diferentes sectores de la sociedad, incluidos gobiernos, empresas privadas, comunidad científica y población en general. Este artículo provee ejemplos acerca de cómo esta interacción puede ser articulada y cómo puede proporcionar múltiples beneficios para los sectores participantes.

PALABRAS CLAVE:
Mercado de carbono, créditos de carbono, servicios ecosistémicos, Protocolo de Kioto, desarrollo sustentable.

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INTRODUCTION: THE GLOBAL CHANGE SCENARIO

Species extinctions are common and recurrent events during the natural history of our planet. Five mass species extinctions, known as the "Big Five", have occurred over the last 400 million years (Raup and Sepkoski, 1982). The causes of these extinction events are not known with certainty, but could be attributed to natural forces that caused strong environmental changes in the planet, such as the continental drift, glaciations, pulses of intense volcanic activity, and the impact of meteorites (Raup and Sepkoski, 1984). The Earth is now facing the sixth mass extinction in its history. Nevertheless, contrary to the previous events, the causes of current extinctions are linked with the environmental changes induced by a single species: *Homo sapiens* (Chapin *et al.*, 1998). Species extinction rates before the appearance of *H. sapiens*, around 200 000 years ago, were 100-1 000 times lower than current extinction rates. Indeed, extinction rates are expected to experience a tenfold increase during the next 100 years (Pimm *et al.,* 1995).

The consequences of human activities on the biosphere are currently summarized as the "Global Change phenomenon" (Chapin *et al.,* 1997). The mass-media information organisms usually link this phenomenon with its most well-known contributing factor: the climate change caused by the greenhouse effect. However, besides climate change, several other factors contribute to Global Change. These factors include: change in land use, habitat loss, habitat fragmentation and biological invasions. Change in land use is the replacement of large areas of natural ecosystems by agricultural, urban of other types of human environments. Inevitably, these changes cause reductions in the amount of habitat that species can use for surviving and reproducing (Brooks *et al.,* 2002). These two factors, land use change and habitat loss, usually lead to fragmented landscapes, where some patches of the original vegetation remain immersed in the human modified matrix (Saunders *et al.*, 1991). These patches may then act as reservoirs of flora and fauna, but their reduced area and the lack of a connection with other patches increase local inbreeding and extinction risks of those species that require large home ranges for survival (Baz and García-Boyero, 1996; Gilbert *et al.,* 1998). Finally, biological invasions can be broadly defined as the intentional or unintentional expansion of the biogeographic range of a given species because of human activities (Rejmánek *et al.,* 2002). This introduction of exotic species into ecosystems may cause strong changes in the structure and functioning of natural communities (Badano and Pugnaire, 2004; Castro *et al.,* 2010), which in turn may lead to the competitive displacement of native species (Callaway and Aschehoug, 2003; Bais *et al.,* 2003). All these human-induced factors are threatening the diversity of life on earth, or biodiversity, as it is often called (Earth Summit, Rio de Janeiro 1992). Biodiversity, however, is an irreplaceable natural heritage and it is crucial for human welfare and economy (Loreau *et al.,* 2006). For these reasons, the preservation and restoration of natural ecosystems have become global aims.

The preservation and restoration of forests have acquired particular relevance in this Global Change scenario. This is because forest ecosystems perform a variety of functions and provide a number of services (Ruiz, 2001). To avoid confusions, we will use the term "ecosystem function" to refer to the outcome of the interactions between organisms and the physical environment (e.g., nutrient cycling, water capture, soil development, carbon sequestration) (Chapin *et al.,*

1997). On the other hand, the term "ecosystem services" will refer to a given set of ecosystem functions which have an associated value for humans, be it economic, social or cultural (Giller and O'Donovan, 2002). The existence of our species depends on ecosystem services, primarily the provision of resources and the maintenance of the biosphere. In this context, forests are important for humans because, among other services they provide, they act as freshwater reservoirs and are the main carbon sinks in the planet (Millennium Ecosystem Assessment, 2005).

MEXICAN FORESTS AND THE GLOBAL CHANGE

Mexico is a megadiverse country with large forestry areas. These ecosystems include tropical, subtropical and temperate forests (Rzedowski, 1978), containing a great part of the animal and plant biodiversity of the world. For these reasons, the larger part of the surface of this country is considered a world conservation priority, and it was included in the traditional Mesoamerican Biodiversity Hotspot (Myers *et al.*, 2000) and the recently defined Madrean Pine-Oak Woodlands Biodiversity Hotspot (Mittermeier *et al.*, 2004). The Mesoamerican Hotspot covers all the tropical and subtropical Mexican forests, irrespectively if they are moist, seasonal or dry forests. This hotspot entirely covers the five southernmost Mexican states (Campeche, Chiapas, Tabasco, Quintana Roo, and Yucatán), but it also extends as far north as northern Sinaloa, on the Pacific Coast, and as far as Tamaulipas, on the coast of the Gulf of Mexico (Myers *et al.*, 2000). The Madrean Pine-Oak Woodlands Hotspot includes temperate forests located on the main mountain chains of Mexico, namely the Sierra Madre Occidental (including the Madrean Sky Islands of southern Arizona and New Mexico), the Sierra Madre Oriental, the Trans-Mexican Volcanic Belt, the Sierra Madre del Sur, the Sierra Norte de Oaxaca, and some isolated mountaintop islands in Baja California (Mittermeier *et al.*, 2004).

However, in spite of the high biodiversity that these forests support, they are strongly threatened because of the uncontrolled wood exploitation. In 2005, the National Forestry Commission of Mexico (CONAFOR) indicated to the advisory group for Global Forest Resources Assessment of the Food and Agriculture Organization (FAO) that the current forestry surface area of Mexico was 64 238,000 hectares (FAO, 2006); this area represents up to 34% of the total surface of the country. However, during the last century, overpopulation, unplanned urban growth and the application of unsustainable industrial and farming technologies have led to overexploitation of these natural resources, strong changes in land use and heavy losses of natural habitats. This history of environmental degradation is well illustrated by the rates of deforestation estimated with data recorded throughout the last 30 years. Lund *et al.* (2002), for example, indicated that Mexico loses up to 2 000 000 ha of forest per year. The FAO, on the other hand, has made more conservative estimations and indicated that these rates range from 350 000 to 650 000 ha per year (FAO, 2006).

Irrespectively of the precision of these estimates, deforestation seems to threat the future of Mexican forests. The World Health Organization (WHO) indicated that Mexico should have had approximately 0,7 ha of forest per habitant during the first decade of this century. However, Mexico only has 0,5 ha of forest *per capita* (Velazquez *et al.*, 2002). This indicates that deforestation rates in Mexico exceed the reforestation efforts of

governmental agencies. The current situation might be even more critical in the future; if deforestation rates remain constant for the next decade, then forest cover by 2025 will be reduced to 0,3 ha *per capita* (Velazquez *et al.*, 2002). This change in land use, together with the increasing air pollution, may injure population welfare in the short term because of the reduction of ecosystems that provide atmospheric cleansing services.

A number of questions arise from this bleak picture: *(1)* Can we effectively reverse this situation? *(2)* Are conservation and restoration practices viable? *(3)* Are there benefits that can be derived from these activities? The next sections attempt to illustrate how cooperation among different sectors of society can contribute to positively answering these questions.

POTENTIAL BUSINESS OPPORTUNITIES BEHIND CONSERVATION AND RESTORATION IN MEXICO

A general analysis of the conservation policies of different Latin American countries (see Appendix) indicates that most of the decisions for preserving natural areas are dependent on the governmental sector. These decisions are mainly rooted in ethical principles (preserving the habitat of endangered species or some natural resource) and recreational purposes (spaces for promoting the interaction between humans and nature). The potential economic benefits of the ecosystem services that natural areas provide are usually not taken into account in these decisions, but it could be crucial for the success of conservation programs. Costanza *et al.* (1997), for example, made a series of economic analyses to determine the value of the ecosystem services that the nature provides. After including several types of ecosystems and their multiple services, these authors indicated that we perceive benefits worth over 33 billion U.S. dollars from natural ecosystems. Therefore, promoting environmental protection activities can be currently visualized as a highly profitable business for governments and private companies disposed to invest in it. But, why should we promote these investments?

Ecosystem conservation and restoration are critical activities for mitigating the expected impacts of climate change. Whether this phenomenon exists or not has been mater of discussion during several years. However, in 1988, the World Meteorological Organization and the United Nations Environment Programme created the Intergovernmental Panel on Climate Change (IPCC). The aim of the IPCC is analyzing scientific information required to assess the environmental and socioeconomic consequences of climate change. Since 1992, the IPCC has provided considerable evidence indicating that: *(1)* the global climate change phenomenon effectively exists, *(2)* it is induced by human activities, and *(3)* it is mainly caused by the emission of greenhouse gases to the atmosphere (carbon dioxide and carbon monoxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride) (IPCC, 2007). In 1997, the increasing concerns about the consequences of climate change lead to an international agreement for reducing greenhouse gas emissions, which is known as the Kyoto Protocol (United Nations Framework Convention on Climate Change, 1998). The party countries that signed this protocol were committed to promote environmentally sustainable economies that, besides reducing emissions of greenhouse gases, must also protect and increase the surface of ecosystems that act as sinks of

these gases. Thirty nine of the 190 countries that originally signed the protocol, most of them developed countries or countries that are undergoing the process of transition to a market economy, accepted targets for limiting or reducing emissions (countries in Annex B of the Kyoto Protocol). These targets were expressed as levels of allowed emissions that these countries could produce over the period 2008-2012. The remaining parties, considered as developing countries, had no such a commitment, and Mexico was included in this last group of countries (Tudela, 2004).

Although these targets should be primarily reached by developing national policies, the Kyoto Protocol also introduced market-based "Flexibility Mechanisms" for reducing the impacts of greenhouse gases on the environment, and especially carbon dioxide (CO_2). The term "flexibility" was introduced in this concept because the geographic difference between the sites where CO_2 is produced and where it is fixed by vegetation does not matter for the climate. Thereby, the protocol led to the creation what is currently known as "carbon offset market" and stated three Flexibility Mechanisms:

1. Emissions Trading (Article 17 of the Kyoto Protocol): This only applies to parties that have accepted targets for limiting or reducing emissions (Annex B of the Kyoto Protocol). If these countries have emission units to spare (emissions permitted, but not used), they can sell this excess capacity to countries that are over their targets.

2. Clean Development Mechanism (Article 12 of the Kyoto Protocol): This mechanism allows those countries that have accepted targets for limiting or reducing emissions to implement emission-reduction projects in developing countries (countries not included in Annex B of the Kyoto Protocol). These projects must generate carbon credits (one carbon credit equals one ton of CO_2 emissions). The projects might involve, for example, rural electrification programs using solar panels, increasing the cover of forests (reforestation) or protecting ecosystems that are fixing large amounts of CO_2.

3. Joint Implementation (Article 6 of the Kyoto Protocol): This mechanism allows a country with an emission reduction or limitation commitment to earn carbon credits in countries not included in Annex B of the Kyoto Protocol, which have no emission reduction commitments. The projects under this mechanism must provide a reduction in emissions by sources, or an enhancement of removal by sinks, that is additional to what would otherwise have occurred; this is known as "additionality" and an example of this is given below.

The extensive natural forested areas of Mexico may position this country in the international carbon market as an important provider of environmental services. Indeed, the adequate implementation of restoration programs on deforested areas might expand the supply of these services on both short and long term bases. Therefore, the introduction of Mexico in the international carbon market would have strong positive impacts on its economic and social development programs, while also promoting the conservation and restoration of natural areas.

A good starting point to illustrate this opportunity for business using carbon fixation is the system of natural protected areas of Mexico. The National Commission of Natural Protected Areas (CONANP) indicates that Mexico currently has 171 natural protected areas covering more than 25,3 million of hectares; this represents 13% of the country's surface (CONANP, 2010). Indeed, after signing the

Nagoya–Kuala Lumpur Protocol (United Nations Environment Programme, 2011), this country assumed the commitment of increasing the surface of its terrestrial protected areas up to 17% by 2020. This environmental policy allows to visualize promising scenarios for Mexico in the world carbon market. This suggestion is rooted in two main facts: *(1)* more than the third part of the current protected areas corresponds to different forest types (temperate forests, tropical forests, among others); and *(2)* the net carbon sequestration is expected to increase continuously during the next years (see Table 1) if the surface area of protected forests is still increasing at the same rate than that observed between 1990 and 2000 (Masera *et al.*, 2001). Therefore, Mexican government should receive significant inflows of money for just having well preserved forests that are fixing enormous amount CO_2 per year. However, this is not the current situation because detailed studies indicating the exact rates of carbon fixation at different forests types are still scarce (but see Ordoñez-Díaz, 1999; Masera *et al.*, 2001). Then, the first step that requires investing founds and time to reach such an economic goal is to determine the annual rates of carbon fixation, or the amount of carbon credits provided per year, for later offering these services on the international market.

Another interesting example for this business opportunity comes from non-protected forests. Since the Agrarian Reform, after the Mexican Revolution at beginning of the XX century, extensive areas of land were expropriated from landowners and assigned to groups of farmers to meet their basic needs. These lands of common use are called “ejidos” and are exploited by rural people usually belonging to the same social group. However, The National Council of Evaluation of Social Development Policy of Mexico (CONEVAL) indicates that several farmers are abandoning lands and looking for work opportunities in the cities because farms are not producing enough to support their families (CONEVAL, 2007). These abandoned farms currently have limited exploitation regimens by the remaining farmers, or they are no longer exploited.

Table 1. Total values of net carbon sequestration (tons) expected for different forest types within protected areas of Mexico in the period 2000-2030. See Masera *et al.* (2001) for full details on the methods used for calculating these estimates.

	Year			
Forest type	*2000*	*2008*	*2012*	*2030*
Temperate forests	0	31 568 000	55 494 000	180 051 000
Tropical evergreen forests	0	26 233 000	45 019 000	141 493 000
Tropical deciduous forests	0	44 864 000	77 424 000	209 097 000
Wetland forests	0	0	0	0
Semi-arid forests	0	5 938 000	19 494 000	99 433 000
All forest types	0	108 603 000	197 431 000	630 074 000

Taking into account this situation, it is important to highlight that several farms cover thousands of hectares and contain relatively low-disturbed native forests. Therefore, after determining the value of these forests as carbon sinks, these forested areas could also be offered in the international market and bring economic benefits to the farmers. Still, this requires an additional investment in order to train farmers and develop sustainable management forestry systems.

Although some of these farms have large forested surfaces, other sites show a worrying picture. At several communal farms, farming has been abandoned because of soil depletion. Further, some companies with high levels of environmental impact, mainly dedicated to oil exploitation and mining, have left large land extensions on which forests were removed. This has led to eroded soils that are now becoming desertified areas. The advance of desertification is a strong problem for countries with limited water resources, as occurs in parts of Mexico (Chapela, 2004). Thus, developing programs aimed to recover soils and their associated vegetation is critical for reversing this situation. From the simplest point of view, the implementation of these activities would increase the capacity of degraded ecosystems for fixing CO_2. Consequently, this would generate new carbon credits that can be tendered in the international market. In the Kyoto protocol, the activities aimed to increase the CO_2 fixing capacity of ecosystems are referred altogether as “additionality”, and they are of crucial interest for companies interested in buying carbon credits. This is because companies cannot acquire credits for the baseline carbon sequestration that is already happening in forests; they can only accept credits if, for instance, a forest restoration action leads to higher net carbon sequestration than that observed at the baseline case. Therefore, all those policies addressed to promote forest additionality through restoration programs may represent a good business opportunity with large positive socioeconomically repercussions on the rural population of Mexico.

FOREST CONSERVATION AND RESTORATION: THE BENEFITS OF A SHARED RESPONSIBILITY

Reaching the goals described above requires the joint action of different social sectors, including governments, private companies, the scientific community and the general population. In this cooperative framework, governments and private companies should increase their financial contributions to the development of applied environmental science. Investments of private companies are crucial for developing this business because they are a main source of greenhouse gases emissions. Nevertheless, governments should also stimulate this flow of money from the private companies. Mexico currently has these types of initiatives, but most of them are aimed to the development of new products and technologies for the productive sector. Environmental sciences, instead, almost entirely depend on governmental funds because they are not visualized as a source of information that can provide economic benefits. Therefore, environmental researchers must be committed to establish adequate communication channels with these two sectors in order to prompt them to expand their visions of science and business.

An increased investment of both governments and companies would allow scientific institutions to acquire specialized equipment and instruments, improving their infrastructure, training the personnel required to determine the value of ecosystem services and contributing to

the development of sustainable management programs. Nevertheless, in this instance, scientists, government and companies must understand that they are investing and developing science to produce social and economic benefits at the short, medium and long term. For this, scientific proposals addressing these issues must make sense in the political and economic framework of the country, and they must lead to specific and viable goals. This, however, requires a switch in the conception of "science" by part of the scientific community. Ecologists, for instance, usually focus their research in developing "pure science", aimed to understand the mechanisms behind the functioning of the nature. This research is important because it provides the scientific bases to develop applied science. However, these "pure scientists" commonly argue that the further applicability of such a research is not matter of their concern. Therefore, the scientific community should also commit itself to dedicate part of its research effort to the development of applied science, besides performing basic science (Day *et al*., 2009). Additionally, scientists should be willing to develop educational activities for sensitizing, but not alarming, the general population of the local environmental problems.

In addition to the net benefits for the environment and society, this joint action can provide a number of specific benefits for participants. Some examples of these benefits are:

Government Sector: (1) economic benefits in the short, medium and long term by selling carbon credits from protected areas; (2) availability of sound scientific basis for the development of profitable and sustainable environmental policies; (3) the global political positioning of Mexico as a country that, besides developing of its own internal economy, also provides environmental services to more developed countries; (4) reduction of desertification and improvement of areas that act as water reservoirs, such as forests; (5) increasing employment in rural areas with high levels of poverty and training the people in forest management.

Private Sector: (1) long term availability of resources needed for developing their activities, such as water; (2) advertising through the dissemination of their activities dedicated to protect the environment; (3) scientific support for obtaining international certifications, such as those indicated in the norm ISO 14000 for the "green seal"; (4) local positioning of the contributing companies as "environmentally and socially responsible companies"; (5) by investing in the development of environmental sciences, companies can also contribute to generate high quality human capital at universities and institutions, which can be later captured by contributing companies as advisers and technicians in environmental matters.

Rural and city population: (1) economic benefits for the rural population by selling carbon credits from the forests located in the common use lands; (2) education and training in environmental and sustainable development for the general population; (3) sustainable availability of resources, such as water and forest resources; (4) improvement of the air quality and reduction in the risks of respiratory diseases; (5) availability of "green areas" for recreation close to urban centers.

Scientific sector: (1) short-term economic benefits by providing advising and consulting services to other sectors in environmental matters; (2) self-sustainability of scientific institutions and improvement of working conditions for scientists; (3) long-term benefits through increases in infrastructure and acquisition of equipment; (4) increased ability to

generate high-quality professionals by developing and expanding the undergraduate and postgraduate study programs of scientific institutions.

CONCLUSIONS

Can we stop the current global change by promoting environmentally friendly policies and promoting conservation and restoration? Unfortunately, the answer to this question is negative. We can, however, mitigate the impacts of this environmental change but, as mentioned above, a "change of mind" is necessary in the different sectors of the society. Although, the globalized market world in which we live today seems to show a disappointing picture for this, it also provides opportunities for economic, social and environmental development in Mexico via the carbon market. For these reasons, Mexico urgently requires the development of policies for promoting the interaction among social sectors, which must be addressed to an environmentally sustainable economy.

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APPENDIX

Examples for the general conservation policies of Latin American countries. The list provides that dates on which these documents were consulted and the hyperlinks to the official WebPages of each country where documents are available

Costa Rica: Ley de Parques Nacionales. Consulted at the Internet on August 25th 2009, available at http://www.tramites.go.cr

Nicaragua: Decreto de Creación del Servicio de Parques Nacionales. Consulted at the Internet on August 25th 2009, available at http://www.ccad.ws

México: Ley General del Equilibrio Ecológico y la Protección al Ambiente y su Reglamento. Consulted at the Internet on August 25th 2009, available at http://www.conanp.gob.mx

Argentina: Ley de Parques Nacionales. Consulted at the Internet on August 25th 2009, available at http://www.fucema.org.ar

Chile: Sistema Nacional de Áreas Silvestres Protegidas del Estado. Consulted at the Internet on August 25th 2009, available at http://www.bienes.cl

Ecuador: Ley Forestal y de Conservación de Áreas Naturales y Vida Silvestre. Consulted at the Internet on August 25th 2009, available at http://www.ambiente.gov.ec

Perú: Ley de Áreas Naturales Protegidas. Consulted at the Internet on August 25th 2009, available at http://www.fonamperu.org

Bolivia: Ley de Vida Silvestre, Parques Nacionales, Caza y Pesca. Consulted at the Internet on August 25th 2009, available at http://www.inra.gob.bo/

Uruguay: Sistema Nacional de Naturales Protegidas. Consulted at the Internet on August 25th 2009, available at http://www.snap.gub.uy

Panamá: Política nacional de biodiversidad. Consulted at the Internet on August 25th 2009, available at http://www.anam.gob.pa

Guatemala: Ley de Áreas Protegidas. Consulted at the Internet on August 25th 2009, available at http://www.mem.gob.gt

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