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ANALYSIS

An economic analysis of the potential for carbon sequestration by forests: evidence from southern Mexico

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Abstract

Forestry has been proposed as a means to reduce net greenhouse gas emissions, by either reducing sources or enhancing sinks. This study assesses the potential of an incentive-based program to stimulate small farmers and communities to adopt biomass accumulating measures such as agroforestry or improved forest management. Current vegetation type, land use and stocks of carbon were assessed for an area of around 600 000 ha in southern Mexico, and the carbon (C) sequestration potential of a number of alternative techniques, based on farmers' preferences, was estimated. Cost and benefit flows in US $ per Megagram ($=10^6$ g) of carbon (MgC) of each current and alternative system were developed. A model was designed to calculate the expected response to financial incentives of between US $0 and $40 per MgC sequestered. The most cost-effective method for sequestering carbon appears to be the improved management of natural forest on communal lands. We estimated that 38×10^6 MgC could be sequestered for under US $15 MgC^{-1}, of which 32×10^6 MgC through forest management. The choice of a baseline rate of biomass loss under a 'business-as-usual' scenario remains a critical issue for estimates of the cost-effectiveness of carbon sequestration by forestry.

Keywords: Carbon sequestration supply; Forest management; Land-use change; Cost-effectiveness analysis

1. Introduction

As concern has grown about the possible impacts of climate change due to anthropogenic greenhouse gas emissions, there has been considerable interest in the potential for increasing the storage of carbon (C) in terrestrial vegetation

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through forest conservation, afforestation and other methods of land management. Several studies have indicated that the global potential for enhancing C storage in forest and agricultural ecosystems may be as much as 60–90 Petagrams ($=10^{15}$) of C (Dixon et al., 1991; Brown et al., 1995).

International measures to control greenhouse gas emissions are likely to include market-based mechanisms that will allow countries to trade in emission reductions in order to comply with their commitments under the UN Climate Change Convention. The question of how forests are to be included in these so-called flexible mechanisms is currently under consideration by the parties to the Convention. The technical options for sequestering carbon through forestry measures include: the conservation and management of existing closed forests; the restoration of degraded or secondary forests; and the establishment of plantations, agroforestry systems and new forests in open areas (Masera et al., 1995; Dixon et al., 1996; Sathaye and Ravindranath, 1997).

Preliminary evidence from a number of specific forestry projects that have been financed on the basis of the expected sequestration effect indicate that the cost of sequestration by forestry or other forms of land management is relatively low in comparison with many engineering solutions to CO_2 emission reductions (De Jong et al., 1995). However, since cost estimates rely to a large extent upon data relating to specific projects, and since current information about the land available for carbon sequestration takes little account of its suitability or of competing uses, doubts remain about the likely costs of sequestering large quantities of carbon. As soon as credits from C sequestration become a tradable commodity under a future emissions control regime, as now being close to implementation in The Netherlands, the supply response to changes in prices for sequestration, as expressed in US$ MgC^{-1}, would be critical in determining the total level of C uptake achieved by the system as a whole.

Since much of the land area in the tropics is effectively managed or influenced by a wide range of semi-subsistence farmers and shifting cultivators, their response to various measures will be a key factor in determining the feasibility and cost of carbon sequestering initiatives.

In this paper we present the results of a study to estimate the response of small farmers and communities in southern Mexico to switch from current land use to forestry and agroforestry. Based on the estimation of the level of required incentives, we calculate the potential supply and cost of C sequestration of a forestry program to be implemented in a land area of about $0.6*10^6$ ha. We assume that farmers will switch to forestry and agroforestry from the point where the incentives are higher than the net present cost (NPC) to implement the alternative land use systems. Experiences to date with the Scolel Té Pilot Project indicate that farmers are generally eager to enter a forestry program, even with lower incentives than estimated (Scolel Té, 1997).

Key questions that are dealt with in this paper are:

- What is the biological potential for carbon sequestration of forest management and agroforestry systems preferred by farmers in developing countries?
- What are the costs and benefits of adopting such systems for the farmers?
- What are these costs in terms of the carbon that can be sequestered?

2. Methods

2.1. Study area

The Central Highlands of Chiapas (Los Altos, 607 500 ha, 1500–2900 m a.s.l., Fig. 1), southern Mexico, contain various forest formations with a very high biodiversity resulting from interactions among biological, geological, edaphological, climatological and anthropogenic factors. The most extensive forest formations are pine forest, pine-oak forest and oak forest (Miranda and Hernández-Xolocotzi, 1963; Breedlove, 1981; González-Espinosa et al., 1995). The regional climate is subtropical to temperate, subhumid (Holdridge, 1967). Mean annual rainfall varies between 1100–2000 mm, of which more than 80% falls between April and November (García, 1982). The soils are predominantly derived from calcareous rocks, and include cambisols, leptosols,