The Ecology and Economy of Forests

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Abstract: Forests are a critical element in mitigating climatic change due to their ability to slow the rate of greenhouse gas emissions. The types of tree species in the forest, their growth rate, and the age of the forest all affect carbon uptake. Several options for reducing carbon dioxide through the use of vegetation are available which include reducing deforestation, reforestation projects, establishing urban forests, improved forest management, and enhanced harvesting techniques. This study conducted a review of the literature on several afforestation and reforestation projects currently underway. The review culminated in isolating knowledge gaps, or voids, in the literature regarding, how best to use reforestation as a means of mitigating climate change. These gaps include international policies that would facilitate reforestation, the socio-economic benefits to local communities involved with reforestation efforts, varying land tenure schemes, the productivity of lands, as well as the availability of off-farm employment in various locations. Following several case studies, this study concludes by explaining the importance of conservation and restoration as a means of mitigating climate change while improving local ecosystems and livelihoods.

Key-Words: Reforestation, afforestation, management, climate change, carbon dioxide, sequestration

1 Introduction

The connection between vegetation and climate is uncontroverted. During photosynthesis, plants produce oxygen while absorbing carbon dioxide, the major anthropogenic greenhouse gas. Animals require oxygen and exhale carbon dioxide. This symbiotic relationship benefits the entire biosphere. However, between 1600 and 1900, nearly half of the forested land in the United States was cleared [1]. Reasons for the continued loss of forests worldwide include an increase in the demand for wood products and clearing land to raise livestock. More than half of the world`s supply of industrial roundwood, which is cut as timber and processed into veneer, sawnwood, fiberboard, paper, paperboard, and plywood, is produced by Canada, the United States, and Russia. With the global population expected to reach 8 billion by the year 2025, the pressure placed on forest products is certain to rise over the next decade resulting in significant losses of world forests.

2 Climate Change

By the year 2100, global temperatures are forecast to increase by 1 to 3 Celsius degrees, according to the Intergovernmental Panel on Climate Change [2]. The higher temperatures will add another stressor to those forest ecosystems already affected by clear cutting, air pollution, and global demands for beef, palm oil, and fuel wood. These demands, if not factored into planning strategies, would result in the growth of non-sustainable practices. In light of these circumstances, prudent environmental entrepreneurs are restoring old forests, conserving existing forests, and planting new forests in an attempt to lower carbon dioxide levels while raising community living standards.

3 Tropical Forest Regeneration

In tropical forest regeneration, allowing old growth forest remnants to persist is an important component in the conservation of biodiversity as well as the ecosystem services that were previously provided. The effects on woody generation of established trees during secondary succession in tropical dry forests have been investigated [3]. Along fencerows, barns and other structures, these established trees function as regeneration nuclei. Agricultural fields need to retain forest cover in their vicinity to act as biological corridors and to accommodate the pathways of pollinators, seed dispersers, herbivores, and other organisms serving crucial roles in forest regeneration [4]. Also to be considered are the effects of competition and interference imposed by exotic or non-native species of plants [5].

4 Abandoned Farm Fields

In an effort to determine the effects of agricultural land uses on subsequent forest regeneration, two major factors should be considered. These are the general conditions of the environment following the abandonment of the field and the presence of propagules. The areal extent, severity, and length of time of the agricultural disturbance also are important considerations for the success of regeneration. The prevalence of each of these factors will influence the availability of propagules as well as the degree of land degradation. As each of these factors, extent, severity, and duration increases, the regeneration potential decreases.

Using studies from Southern Mexico, Martínez-Ramos et al. determined the dominant pioneer species in recently abandoned fields by using demographic analyses [6]. Hardships, or “bottlenecks,” that trees encounter as they transition from seed to seedling and through subsequent life stages were identified. Additionally, the study addressed successful regeneration at both the field and landscape scales. Information from the farmers who worked the land previously proved more valuable in determining success than were measurements of microclimate and soil conditions. This research provides informative indicators for the selection of specific endemic tree species as well as a broad conceptual framework for successful second growth forest regeneration.

Chazdon and Uriarte addressed a composition of HMLs wherein biodiversity conservation and agricultural productivity are reconciled in a patchwork of agro-ecological systems and agroforestry as they are implanted within a matrix of old growth and second growth forests [7]. The identification of land uses that promote successful forest regeneration, and the determination of ecological tools that will serve to restore degraded lands are critical for constructing positive scenarios of agricultural production, biodiversity conservation, and, eventually, the enhancement of rural livelihoods in HMLs [8].

5 Local Livelihoods

Adams et al. focus on the impacts on the socioeconomic status of local livelihoods from large-scale forest restoration, or forest landscape restoration (FLR). The authors differentiate between what is known and what requires investigation. The products gleaned from forests, wood, non-timber resources, and ecosystem services benefit society as a whole and are particularly significant to rural livelihoods. FLR provides a means of mitigating deforestation while combining ecosystem goods and services with development goals. However, there is only scant evidence of the effects on local livelihoods from large-scale restoration. Most of the literature features case studies (89%) and almost half (49%) of those were conducted in China [9].

6 Knowledge Gaps

The topics addressed most frequently in the literature are income, diversity of livelihoods, employment opportunities apart from the farm, reducing poverty, economic equity, and the supply of timber, energy, and ecosystem services. Most research addresses the high degree of influence of government policies. In this invaluable review of the literature, the socioeconomic benefits on local communities from reforestation and restoration programs were mixed. Determining factors include household characteristics, land productivity, land tenure schemes, availability of off-farm employment, and markets for forest products and ecosystem services. The authors conclude that the close monitoring over time of programs already in place along with the determination of clear indicators for success are needed.

Other key gaps in the existing research were enumerated by Uriarte and Chazdon [10]. At the international policy level, there has been an increasing awareness for the need to implement large-scale forest landscape restoration in light of the extensive loss of tropical forest. However, tree plantations have prevailed at the cost of natural regeneration which provides a cost-effective means of achieving large-scale FLR. The questions that emerge when determining the use of natural regeneration follow. What tools would prove most useful for identifying and mapping target areas for regeneration? What legal and governmental frameworks will best inspire natural regeneration and how do those change among nations? And what financial systems might encourage natural forest regeneration? What are to become the likely tradeoffs among livelihoods, economic and ecological outcomes of land use changes and how do they change with market forces and climate change? The authors admonish that natural regeneration might not address all tensions and conflicts concerning land use, but under the correct circumstances, it could be a cost effective alternative to tree plantations.

Many groups have proposed forest management as a simple way to restrain the increase of atmospheric carbon dioxide and offset global warming. To examine whether forest management is a suitable means of controlling global warming, Barford et al. conducted a decade-long study of carbon exchange between the atmosphere and a 60 year-old northern red oak forest by measuring how much carbon the trees and soils stored and how much they released [11]. The types of tree species in the forest, their growth rate, and the age of the forest all affect carbon uptake. For example, mature trees store less carbon and remove less carbon dioxide from the atmosphere. The number of dead trees also affects carbon balance because as a tree decays, it releases some of its stored carbon back into the air. The researchers suggest that forest management can help mitigate global warming by controlling carbon exchange, but it is a complex process with numerous factors to be considered.

7 Costa Rica

Many of the deforested areas of the world could once again support vegetation under proper management techniques such as the creation of tree plantations or by allowing natural vegetation to regenerate. One of the main reasons for preserving tropical forests is their role in regulating climate and hydrological cycles because tropical forests are involved in the constant exchange of large quantities of energy and matter that takes place between the biosphere and the atmosphere. Tree plantations can have rapid growth rates and yield substantial benefits including an economic return for local people. Streed et al. report that small-scale reforestation in Costa Rica with mixtures of native species have proven to be financially profitable both for investors and farmers [12]. Bangladesh has a huge potential for reforestation, and according to Shin et al. replanted forests there could store an average of 92 tons of carbon per hectare [13].

8 China

Jim and Liu detail the rapid growth and expansion of tree management projects in China, which in addition to sequestering carbon dioxide emissions have an important impact on the mental and physical well-being of local residents [14]. Zhang and Song report China's forest cover increased from 9 percent in 1949 to 18 percent in 2003 [15]. Fang et al. examined 50 years of forestry data and found that beginning with the 1970s, the average carbon density of planted forests in China increased from 15 to 31 megagrams per hectare [16]. In short, forest restoration appears to be a means of improving ecosystem functioning, ecological and economic resilience, and human livelihoods [17].

While reforestation is a popular strategy, it cannot be effective if it legitimizes the continued destruction of old-growth and pristine forests which are rich ecosystems in terms of their biodiversity, symbiotic relationships with organisms outside the ecosystem, as well as in terms of their ecosystem services. Neither can reforestation be viewed as a quick fix by the logging industry and nations with large timber interests if it does not lead to or promote actual emissions reduction. A better approach is to slow the rate of deforestation, which in turn is an effective way to reduce carbon losses from forest ecosystems. With increasing pressure from expanding populations and the use of natural resources, developing countries have to be integrated into a more comprehensive incentive framework that rewards forestry conservation, sustainable forest management, and reforestation [18]. As Lu et al. note, incentive approaches for citizens in the developing world are indispensable for effective conservation and successful management in protected areas [19].

9 Conclusion

Climate change and deforestation are among the most serious environmental problems the world community faces today. There is clear evidence that human activities are involved in the process, largely through the production of greenhouse gases and through deforestation. Deforestation contributes to the increasing amount of carbon dioxide in the atmosphere and is influencing climatic change at the local, regional, and global scales. Because climate plays such an important role in the distribution of plant species, the predicted global and regional climatic changes will likely affect a variety of existing vegetation patterns. Some species will migrate forming new associations while others will be lost completely.

A pragmatic place to start restoring the balance of our global carbon cycle is in our forests. Researchers have identified the coastal redwood and Douglas fir forests of the U.S. Pacific Northwest as having the greatest capacity for increased carbon sequestration of any trees in the world. With proper stewardship, forests will continue to provide carbon sequestration in addition to wood products and other benefits, such as fish and wildlife habitat, biodiversity, clean water, and recreation opportunities. Without good forest stewardship, we are likely to lose the battle with global warming and along with it, the myriad benefits the forests provide.

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