Conservation Letter

Biodiversity persistence in highly human-modified tropical landscapes depends on ecological restoration

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Abstract

In human-modified tropical landscapes, biodiversity is threatened by a myriad of forces, including habitat loss and fragmentation, land degradation, overexploitation of forest resources, and biological invasions. Ecological restoration offers a promising way to enhance biodiversity persistence and the delivery of ecosystem services by: 1) establishing structural elements in the landscape to enhance connectivity, 2) providing additional forest cover, 3) restoring degraded forest remnants through protection from human-mediated disturbances and reestablishment of successional trajectory, and 4) supporting sustainable socio-economic development in marginalized rural communities, where the lack of job opportunities drives deforestation, forest degradation, and overexploitation. Due to biodiversity requirements, however, this potential will only be realized if restoration is carried out on very large spatial scales. Although conservation biologists have historically doubted the potential of ecological restoration to reverse ecosystem degradation and mitigate species loss, we argue that conservation policies and programs should include restoration among the strategies adopted to mitigate extinction debts and support the creation of biodiversity friendly-landscapes. Otherwise, we will likely continue to describe a slow and irreversible loss of our biological heritage in isolated protected areas in human-modified tropical landscapes.

Key words: Atlantic Forest, biodiversity friendly-landscapes, conservation policy, large-scale restoration, tropical forest restoration.

Resumo: Em paisagens altamente antropizadas, a biodiversidade tem sido ameaçada por fatores como a perda e fragmentação de habitat, degradação, sobre-exploração de recursos florestais e invasões biológicas. A restauração ecológica oferece uma forma promissora para favorecer a persistência da biodiversidade e a provisão de serviços ecossistêmicos por meio 1) do estabelecimento de elementos estruturais na paisagem para aumentar sua conectividade, 2) da ampliação da cobertura florestal, 3) da recuperação de remanescentes florestais degradados pela proteção de distúrbios antrópicos e restabelecimento da trajetória sucessional, e 4) do suporte ao desenvolvimento socioeconômico de comunidades rurais marginalizadas, onde a falta de oportunidades de geração de trabalho e renda tem gerado desmatamento, degradação florestal e sobre-exploração. No entanto, o potencial da restauração será apenas concretizado para a proteção da biodiversidade se essa atividade for realizada em larga escala. Embora biólogos da conservação tenham historicamente olhado com ressalvas para o potencial da restauração ecológica em reverter a degradação dos ecossistemas e mitigar a perda de espécies, nós defendemos nesse artigo que os programas e políticas públicas de conservação devam incluir a restauração dentre as estratégias adotadas para mitigar as extinção de espécies e dar suporte à criação de paisagens amigáveis para a biodiversidade. Caso contrário, nós provavelmente continuaremos a descrever uma perda lenta e irreversível do nosso patrimônio biológico em unidades de conservação isoladas e imersas em paisagens tropicais altamente antropizadas.

Palavras chave: Mata Atlântica, paisagens amigáveis para a biodiversidade, políticas públicas de conservação, restauração em larga escala, restauração de florestas tropicais.

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Introduction

The relentless growth of human activities will continue to alter tropical forest landscapes at such magnitude that even vast tracts of old-growth forests are likely to experience both severe and chronic human-mediated disturbances. Severe disturbances include intense, large-scale habitat loss and fragmentation due to conversion of natural ecosystems to croplands, roads, cities, etc. Chronic disturbances are direct uses of natural resources by humans, such as hunting, logging, firewood harvesting, etc. [1]. Such landscapes are still able to provide shelter for biodiversity and deliver ecosystem services to humans, but there is no guarantee that these benefits will continue in the long term if not adequately managed [2, 3].

Unfortunately, the sources of disturbance mentioned above continue to create "biodiversity-unfriendly landscapes" that already predominate in many or most tropical regions, including the majority of the tropical biodiversity hotspots [4]. Biodiversity-unfriendly landscapes, also known as human-modified landscapes, are dominated by agriculture and/or urbanization and present a reduced native forest cover distributed in small, disconnected remnants, which are commonly exposed to human disturbances such as hunting, logging, fires, soil erosion, biological invasions, etc. Consequently, high-quality habitats are rare, and most remnants are young regenerating forest patches highly exposed to edge effects and dominated by generalist species [3].

Forest restoration is a *post-hoc* way to mitigate such an alarming prospect by promoting biodiversity maintenance and enhancing the quality and quantity of ecosystem services delivered to society [5, 6]. In other words, forest restoration is potentially able to allow biodiversity to persist within intensively occupied agricultural landscapes such as monocultures, minimizing further forest loss as human populations continue to grow and drive global demand for natural resources [7]. Forest restoration is also a way for other models of production such as agroforestry systems to be used on degraded lands, thus coupling both biodiversity protection and food production.

In this paper, we examine how forest restoration can enhance biodiversity persistence and the delivery of ecosystem services in human-modified landscapes. We also describe some programs already underway that offer lessons to apply elsewhere, based on our own experiences for over 30 years in the highly fragmented Brazilian Atlantic biome hotspot.

The role of ecological restoration to safeguard biodiversity

Given that most agricultural land uses are inimical to the majority of forest or disturbance-adapted species, ecological restoration plays an essential role in (1) restoring the landscape to reconnect previously isolated biological populations of plants or animals, and (2) providing additional forest cover. Many agricultural companies in S.E. Brazil have begun to restore riparian corridors on their lands in order to comply with state and federal regulations and obtain environmental certification for their products [8].

In addition to improving landscape structure and creating new forest patches, ecological restoration can also improve ecosystem quality by protecting fragments from human-mediated disturbances and using adaptive management to reestablish the successional trajectory. This in turn can facilitate biodiversity movement between fragmented landscapes through increased density, proximity, and size of suitable habitats for species sensitive to border effects.

However, protection against further degradation will not be enough in most cases for self-recuperation of remnants inside highly-modified human landscapes. Most of the persisting forest remnants in such conditions are experiencing arrested succession, caused by severe edge effects, altered microclimatic conditions, and chronic small-scale disturbances such as intense fragmentation, recurrent fires, logging, and biological invasions [9]. These environmental conditions favor canopy colonization by hyperabundant climbers, community dominance by a small set of pioneer species, and the recruitment of alien species, which may keep forest remnants in an alternative steady state if no adaptive management is adopted. Such management could include: 1) selective control of hyper-abundant weedy vines and lianas that compete against tree species recruitment and growth [10]; 2) eradication of invasive species [11]; and 3) establishment of enrichment plantings to reintroduce/increase populations of endemic, rare, and endangered species, as well as key functional plant groups [12]. It will also be crucial to manage the surrounding areas of these remnants. For instance, restoration plantings from the edges of the fragments inward could reduce edge effects and improve the shape and size of forest remnants excessively exposed to edge effects [1].

In practice, new protected areas could include not only blocks of conserved forest tracts, but also degraded lands to be further restored as natural habitats and/or as productive lands. Less intensive means of production such as agroforestry, sustainable forestry and silvopastoral systems can increase biological flows in the landscape and reduce matrix harshness. Thus, biodiversity would not be “confined” to the protected area and new habitat would be created to favor the population increase of vulnerable species.

The biodiversity benefits of restoration can also play an important role in supporting sustainable socio-economic development in marginalized rural communities, where the lack of job opportunities drives deforestation, forest degradation, and chronic overexploitation. In sharp contrast to exclusive forest protection, ecological restoration is inclusive: it provides a myriad of job options and income generation opportunities for rural communities. A first group of opportunities arise from the implementation and maintenance of restoration projects, which may provide three million direct and indirect local jobs in the Brazilian Atlantic forest [13] and US$ 18 billion in global investments per year [14]. Additionally, a large set of economic opportunities for exploitation of timber and non-timber forest products produced within restoration projects, as well as payments for ecosystem services, can reinforce job and income generation [15]. Certainly, such opportunities add significantly to biodiversity conservation in landscapes experiencing weak governance and generalized poverty, such as those in tropical developing countries.

Scaling up forest restoration

As discussed above, ecological restoration offers a full chest of tools to safeguard biodiversity and provide other benefits in highly-fragmented landscapes [16]. Due to biodiversity requirements, however, this potential will only be realized where restoration is carried out on very large spatial scales, rather than the kind of "environmental gardening" practiced in many situations [15]. Fortunately, many governments and non-governmental organizations around the world have adopted ecological restoration as the main driver of landscape transformation and reintegration for improving biodiversity conservation, delivering ecosystem services, and enhancing land productivity. In recognition of the value of ecological restoration in the current environmental crisis, the United Nations Convention on Biological Diversity's Aichi Target 15 on ecological restoration has set a goal of restoring 150 million hectares by 2020 [14].

In Brazil, large-scale forest restoration initiatives are also blooming. For instance, in 2009 a group of private companies, research institutions, governments, and NGOs launched a pact to restore 15 million ha of the Brazilian Atlantic forest. In just four years, this coalition has brought together 240 members and gained increasing influence among key stakeholders involved with conservation, land management, and ecological restoration throughout the Atlantic Forest biome [13]. In addition, other initiatives such as the "Mata Atlântica" Programs of the Brazilian Bank of Development, the National Plan for Recuperating Degraded Lands, and the recently enacted Forest Law support growing investments by both public and private sectors in large-scale restoration programs.

The way forward

Conservation biologists have historically looked with suspicion at the potential of ecological restoration to reverse ecosystem degradation and mitigate species loss, while restoration ecologists may have overestimated the possible outcome of their projects in the highly-fragmented landscapes that occur throughout the tropics. Indeed, "restoration ecologists tend to be optimistic, and conservation biologists pessimistic" [17]. It is time now to face the reality: although not so effective as some may imagine, ecological restoration is today one of our main alternatives for long-term biodiversity maintenance in highly-fragmented landscapes. But this is not based on a naïve or nostalgic endeavor of reconstructing lost paradises, nor a cynical scheme to offset the ongoing degradation of natural ecosystems [18]. Rather, when well done, restoration represents a very real opportunity to manage landscapes' structure and dynamics to maintain biological diversity and ecosystem resilience. Thus, conservation policies and programs should include ecological restoration among the strategies adopted to mitigate extinction debts and to support the creation of biodiversity friendly-landscapes [19]. Otherwise, instead of taking for granted that ecological restoration is now a global priority [20], we will probably continue to describe a slow and irreversible loss of our biological heritage. We hope this essay stimulates a timely debate about biodiversity persistence and the key role that forest restoration and restoration ecology should play in future policies for biodiversity conservation.

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