Finding the money for tropical forest restoration

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The challenge for advocates of forest restoration is to make it financially viable.

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In the past few centuries, many tropical forests have been modified dramatically by human activity, creating landscapes dominated by agriculture or urban development (Bradshaw, Giam and Sodhi, 2010). This is a problem not only because of the loss of biodiversity, but also because it has affected the supply of many valuable forest products and ecosystem services.

Nevertheless, widespread forest loss and degradation has created new opportunities for ecological restoration, which must now go beyond a solely conservation rationale. In human-modified landscapes in developing countries, tropical forest restoration projects must not only assist the recovery of ecosystems that have been degraded, damaged or destroyed (the most used definition of ecological restoration; SER, 2004), they must also bring economic rewards to landowners.

This article discusses the economic dimension of ecological restoration,

A young tropical forest restoration planting set in pastureland previously used for extensive cattle-ranching in the state of Rio de Janeiro, Brazil. In the future, this project will reconnect isolated remnants of the threatened Atlantic forest and improve the quality of the water supply for the region's growing population

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drawing on experiences in the Brazilian Atlantic forest, which is one of the most biodiverse ecosystems on the planet and also one of the richest in endemism (Myers *et al*., 2000).

CREATING SPACE FOR RESTORATION

Globally, the human population is expected to increase by 50 percent over the next four decades. This surge, when combined with a likely per capita increase in consumption, is projected to require the doubling or tripling of food production by 2050 (Godfray *et al*., 2010). The attendant increased need for fuel, fibre and shelter paints a dramatic picture of future land demand (Smith *et al*., 2010).

The looming land crisis has been receiving increasing attention worldwide. In this context, forest restoration could be seen as just another factor in the demand for land, with the potential to reduce food production, increase food prices and have other unwanted consequences. Moreover, where land is scarce, conserving or restoring areas in one region could induce deforestation elsewhere. This effect, known as "leakage", has been considered in international policy, including in negotiations under the United Nations Framework Convention on Climate Change concerning greenhouse gas emissions from deforestation and degradation (Strassburg *et al*., 2009).

Various studies on food production, however, have argued that when land is scarce, the way to balance food production and environmental needs is to improve the use of existing cleared land (Tilman *et al*., 2002; Herrero *et al*., 2010; Phalan *et al*., 2011). Improving the efficiency of pastureland management, in particular, seems to hold promise, especially as the area of these lands worldwide is double that of agricultural lands (Licker *et al*., 2010). Such thinking can also inform the consideration of food production versus forest restoration – because forest restoration can be seen not as a competitor but, rather, as a way of helping to increase food production and improve livelihoods, and as a way of providing landowners with an economic return.

FINDING ECONOMIC BENEFITS

Only 12 percent of the Brazilian Atlantic forest estate remains, concentrated mostly on the coast (Ribeiro *et al*., 2009). The region that hosts this forest accounts for 62 percent of the Brazilian population and 80 percent of its gross domestic product; the environmental pressures, therefore, are very strong (IBGE, 2012).

Centuries of deforestation and forest degradation have compromised the delivery of ecosystem services and the production of forest goods in the Atlantic forest. Nevertheless, the region presents a huge opportunity for new approaches to ecological restoration and for establishing forest restoration as an economically viable practice (Joly *et al*., 2010). The potential for improving the productivity of pasturelands seems to indicate that a large-scale restoration initiative, such as that proposed by the Atlantic Forest Restoration Pact, can be implemented without adversely affecting food production. Launched by over 80 environmental organizations, private companies, governments, researchers and landowners in 2009 (and today boasting 215 partners), the Atlantic Forest Restoration Pact aims to restore 15 million hectares (ha) of forest by 2050 using native species.

The 30.5 million ha of planted pastureland in the Atlantic forest region (PROBIO, 2009) currently support 36 million head of cattle (IBGE, 2003), a stocking rate of 0.82 head per ha. This is very low by international standards and when compared with similar environments elsewhere when appropriate technology is used (FAO, 2012). Doubling the productivity of these lands over the next three decades (such as through innovative silvopastoral approaches; see Calle, Murgueitio and Chará, 2012) would liberate 15.3 million ha for forest restoration – an area equivalent to the restoration goal of the Pact. In addition, restored tropical forests can

The timber harvested in restoration plantings has the potential to cover the opportunity cost of reducing the availability of land for cattle-ranching. This 3-year-old restoration planting, in Campinas, São Paulo, southeastern Brazil, is designed to produce native timber in a 10-year harvesting cycle. It has been shown that this is likely to generate greater returns for farmers than extensive cattle-ranching

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The temporary use of fast-growing eucalypt species as "economic pioneers" can accelerate the economic return of restoration plantings and help offset the establishment and early tending costs of the restoration, which are usually high. This 1-year-old plantation of native tree species in alternate planting lines with eucalyptus in south Bahia is designed to be exploited six years after planting, when all eucalyptus trees are harvested and substituted by native species

potentially help increase crop productivity, since they harbour crop pollinators and natural enemies of pests. If complementary activities are implemented to increase the productivity of lands currently under agriculture and to favour the conversion of unproductive pasturelands to agricultural uses, as already done in some parts of the Brazilian Amazon (Macedo *et al*., 2012), tropical forest restoration could be supported without risking perverse outcomes for food production. These measures would also help to reduce (or prevent the increase of) the opportunity costs of land, an important barrier to forest restoration efforts. The next sections explore some avenues for making forest restoration pay.

Timber

The Atlantic forest has been exploited to the point where it no longer supplies significant quantities of timber. This reduced supply, combined with increasing demand for native timbers, is pushing prices up.

In effect, therefore, overexploitation has created economically favourable conditions for the production of timber from native species through restoration. Another economic advantage of restoration using native species is that it does not require flat terrain or highly fertile soil and can therefore be done on lands that are marginal for many other land uses.

Restoration plantings serve other purposes as well. Most tree species native to the region have not been domesticated, and they have natural pests that may hamper timber production in low-diversity systems (Rodrigues *et al*., 2009). Using a diverse range of tree species decreases the risk of devastating pest attack, thus aligning economic and ecological interests in restoration efforts at scale.

Ecological restoration can be implemented in extensive, low-productivity pasturelands, a main land use in many developing countries. For example, about 75 percent (211 million ha) of all cleared lands in Brazil have been used for extensive cattle-ranching (Sparovek *et al*., 2010). Since the average return obtained by cattle ranchers in those areas is approximately US$100 per ha per year, the production of native timber in restoration plantings could potentially cover the opportunity costs of reducing the availability of land for livestock.

This hypothesis was tested in a recent study in the Brazilian Atlantic forest. Fasiaben (2010) investigated the potential economic return of a 250 ha restoration planting designed for future native timber production. The results were encouraging: the return was estimated at US$250 per ha per year on the basis of very conservative estimates of both timber prices and tree growth and no value adding to the timber. The Atlantic Forest Restoration Pact has elected to use this type of reforestation for restoring about 7 million ha of degraded pastures on sloping land (Calmon *et al*., 2011).

Timber plantations could play a critical role in scaling up restoration efforts in human-dominated tropical landscapes worldwide (Lamb, 1998). However, an important limitation to the production of native timber in restoration plantings is the time required for an economic return. Agriculture has the advantage of generating ongoing income, with much shorter time horizons between investment and return, while timber production can sometimes take decades to become profitable. Three approaches can be used to address this limitation:

- mixed plantings – i.e. planting a mix of slow-growing and fast-growing species, to allow timber production to begin within about ten years of planting;
- combining various sources of income, such as non-wood forest products (NWFPs) and payments for ecosystem services, to generate regular income for landowners (see the following two sections);
- providing long-term credit at attractive rates.

The production of native seeds, shown here in Ribeirão Grande, São Paulo, southeastern Brazil, to meet the demand of nurseries, could be one of the best NWFP-related avenues for generating income and jobs in local communities through forest restoration

Non-wood forest products

Tropical forests provide a huge range of NWFPs – such as foods, medicines and building materials – the harvest and processing of which often constitute a major source of income and livelihoods for local people, especially in developing countries such as Brazil (Wunder, 1998). To a certain extent, restoration efforts self-generate NWFP-related work for local communities: as such efforts expand they increase the demand for native seeds, which can then be harvested from previously restored areas. Thus, demand for native seeds increases, seed collection and sales increase, and economic opportunities follow (Brancalion *et al*., 2011).

Traditionally, most NWFP harvesting in Brazil occurs in remnants of native forest, but when demand outstrips supply, efforts are needed to cultivate species of interest. There are several examples of this phenomenon related to Brazilian native species. Brazil once led rubber production, when most latex was harvested from native rubber trees (*Hevea brasiliensis*) in the wild. Brazil's production, however, eventually fell behind that of Malaysia, which started to cultivate rubber trees at a large scale. The case of the Brazil nut tree (*Bertholletia excelsa*), the nut of which is the most economically important NWFP harvested in native forests in the Amazon (Peres *et al*., 2003), is similar. In Brazil, nuts continue to be collected in the wild, but in the Plurinational State of Bolivia, investments have been made in cultivation and processing and that country is now the world's biggest producer and exporter of Brazil nut.

There is little industrial-scale investment in the harvesting and processing of NWFPs from native forests because of, among other things, the irregularity and uncertainty of supply, the variable quality of the products, and problems associated with obtaining licences to exploit wild populations. Hence, there is an enormous potential return from producing NWFPs in restoration projects.

Importantly, NWFPs can be crucial for the profitability of restoration by generating an early and regular income for landowners in the period in which timber plantations are not yet ready for harvesting. The case of the endangered palm *Euterpe edulis* in the Brazilian Atlantic forest illustrates the potential of NWFPs to support the economic sustainability of tropical forest restoration. This species produces edible palm heart (the apical meristem and the developing undifferentiated leaves of the palm stem), an expensive delicacy that is much loved in Brazil and elsewhere. Since the extraction of the palm heart causes the death of the plant, overharvesting has drastically reduced the population of this palm to a point where it is at risk of ecological extinction (Reis *et al*., 2000). Restoration plantings of this palm would not only improve its chance of survival, it could prove very profitable.

Moreover, the fruit pulp of *E. edulis* has been introduced as a southeastern equivalent of the Amazonian *açaí* (*E. oleracea*) – a concentrated lipid- and sugar-rich pulp derived from palm fruit that is used for several purposes (Brancalion *et al*., 2012). The plant's seeds have been sold as a byproduct of pulp production. Combined, the production of fruit pulp and seeds could generate revenue of US$2 000 per ha per year, given 100 productive palms per ha. Agroforestry cooperatives have begun to invest in the cultivation of this species and in the commercialization of fruit pulp. In the future, companies that make food, cosmetics, medicines and other products based on NWFPs could create commercial partnerships with farmers' cooperatives to produce such NWFPs in their restoration areas.

Crop production in agrosuccessional restoration schemes

One of the main challenges in restoration plantings in the tropics is the effective control of invasive fodder grasses, which can dramatically reduce tree growth (Campoe, Stape and Mendes, 2010). Since native trees usually take at least three years to completely shade the understorey and outcompete weeds, considerable resources in restoration projects are usually expended on weed control. While the high incidence of light in the initial phases of restoration plantings creates this problem, it also allows the cultivation of agricultural crops between planting lines – a forestry system known as taungya. Then, instead of spending money on herbicides or mechanical weeding, it is possible to earn money early in a restoration project by producing annual crops such as beans, corn, cassava and pumpkin. This is important for reconciling farmers' interests with ecological restoration, especially on small landholdings in poor regions. As suggested by Vieira, Holl and Peneireiro (2009), agrosuccessional restoration may help in "extending the management period of restoration, offsetting some management costs, providing food security for small landholders, and involving small landholders in the restoration process". Therefore, it is another potential source of revenue that can help make tropical forest restoration a profitable land use.

Ecosystem services

There are many examples worldwide of individual and collective, and public and private, initiatives for the maintenance or recovery of ecosystem services – such as those related to water, biodiversity, carbon and pollination – in degraded areas (Stanton *et al*., 2010). Payments made to landowners for such services by, for example, promoting forest restoration on their degraded lands, are collectively called payments for ecosystem services (PES).

In many developing countries, water-related PES projects are growing in number and area, particularly around large urban areas (FAO, 2010). Water companies and end-users interested in improving the water supply or ensuring water security are creating programmes to pay landowners to restore their riparian areas.

In Brazil, PES is also used by watershed committees, which are collectives responsible for the management of water resources within specific watersheds. Established by Brazilian law, watershed committees charge for the use of water within a watershed and return part of this fee through PES to landowners who implement forest restoration projects (Veiga and Gavaldão, 2011). In Extrema, Minas Gerais, in southeastern Brazil, for example, the municipal government pays approximately US$118 per ha per year to more than 100 landowners with low-productivity pastures who have replaced

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The cultivation of cassava among naturally regenerating and planted trees in a restoration project in the Atlantic forest, northeastern Brazil. In such an arrangement, farmers control weeds to obtain a higher crop yield and indirectly favour the development of native tree species by reducing competition. Project revenue is increased by the production of crops and the reduction of maintenance costs

cattle-ranching with forest restoration plantings on riverbanks and around natural springs. Extrema is within the Cantareira, a water-supply system comprising several reservoirs that together provide water to about 10 million people in the São Paulo metropolitan area. The local government and farmers enter into 4-year contracts, which may be renewed in perpetuity. Since the programme covers all the cost of forest restoration, the payments serve as compensation for the revenue that farmers would have earned if the area had been kept as pastureland (i.e. the opportunity cost).

Forest restoration projects can also generate carbon credits, which can be negotiated either through the compliance market, in accordance with obligations laid out in the Kyoto Protocol, or through the voluntary market, which permits the purchase of carbon offsets to mitigate greenhouse gas emissions. The voluntary market for forest carbon is worth millions of dollars per year (Stanton *et al*., 2010) and continues to expand, in part because there is a growing number of companies interested in offsetting their greenhouse gas emissions and in part because the financial return can be attractive to landowners. On average, mixed plantations of native trees in the Atlantic forest accumulate 15 tonnes of carbon dioxide (CO_2) equivalent per ha per year (Miranda, 2008) and therefore about 450 tonnes of CO_2 equivalent per ha over 30 years (which is the usual duration of a contract for carbon credits). After accounting for greenhouse gases emitted during planting and management, as well as during timber harvesting and processing (as further proposed in our model), such plantations would remove about 300 tonnes of CO_2 equivalent per ha over the period.

The price of carbon credits in reforestation projects is highly variable. In 2011, Latin American credits were negotiated in the voluntary market at an average price of US$11 per CO_2 equivalent tonne (Peters-Stanley and Hamilton, 2012). A contract on these terms would be worth US$3 300 per hectare over the 30-year period (a mean annual revenue of US$110). Such an amount would cover all the costs involved in assisted natural regeneration forest restoration projects, but perhaps not all the costs of restoration projects involving tree-planting. Importantly, payments for carbon credits received in the first few years of a forest restoration project would help to compensate landowners for the lack of income from timber, NWFPs and (previously) ranching or agriculture.

One limitation to earning carbon credits from reforestation with native trees is that the cost of the certification and validation processes is high – and it is tempting to use fast-growing (perhaps non-native) species. Strategies and public policies that aggregate landowners are needed to reduce the cost to individuals.

PES schemes can generate synergies (Strassburg *et al*., 2010): those that target one ecosystem service can usually help in obtaining payments for others (Strassburg *et al*., 2012). Bundling several PES schemes can increase the magnitude and diversity of the income generated by forest restoration.

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In Extrema, Minas Gerais, Brazil, landowners are receiving US$118 per ha per year to allow the restoration of riparian areas important for water production, such as this 1-year-old high-diversity restoration planting

TABLE 1. Opportunity cost and potential revenue, forest restoration in the Atlantic forest region

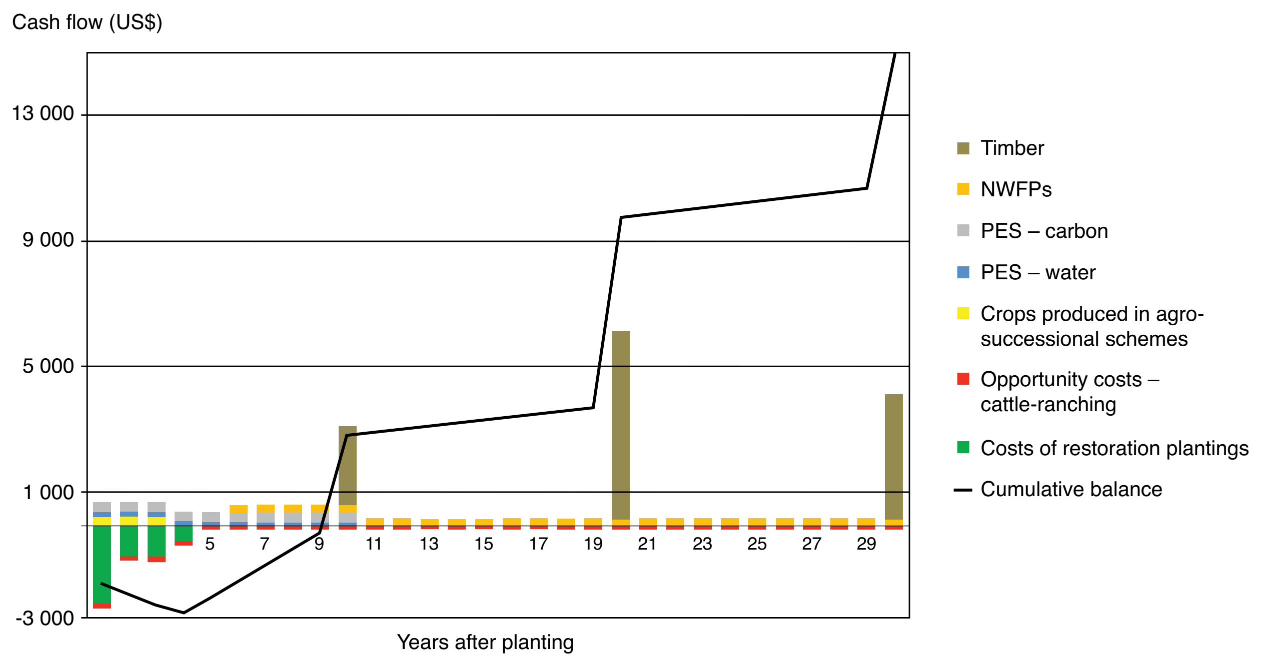
Opportunity cost and potential revenue, forest restoration in the Atlantic forest region	Potential annual revenue[a] (US$/ha/year)	Timeline (years)																														Total accumulated revenue (US$/ha)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Opportunity cost of land for cattle-ranching[b]	-100																															-3 000
Income opportunities through restoration																																
Crops produced in agrosuccessional schemes[c]	300																															900
Payments for ecosystem services – water[d]	118																															1 180
Payments for ecosystem services – carbon[e]	330																															3 300
NWFPs[f]	200																															5 000
Timber – fast-grown species[g]	2 500																															2 500
Timber – moderately fast-grown species[g]	4 000																															4 000
Timber – slow-grown species[g]	6 000																															6 000
Net revenue																																**19 880**

a For activities providing annual income, annual value represents the average income obtained during the period proposed for the activity. In the case of timber, annual revenue is restricted to the year of harvesting (i.e. 10, 20 and 30 years for fast-grown, moderately fast-grown and slow-growing species, respectively).
b Of the costs, only opportunity costs are included in this table, since the cost of restoration is met by the Atlantic Forest Restoration Pact.
c Based on the income provided by annual crops traditionally planted in small landholdings, such as beans, corn, cassava and pumpkin. We believe that these crops can be cultivated between tree-planting lines for a period of three years, after which shading may hamper commercial production.
d Based on the model programme of Extrema, Minas Gerais, southeastern Brazil (Veiga and Gavaldão, 2011). Although such payments may last indefinitely, we restrict them here to a period of ten years.
e Based on a net accumulation of 300 tonnes of CO_2 equivalent per ha in 30 years and an average price of US$11 per tonne. The total value to be paid in the 30-year period is concentrated in the first ten years.
f We consider this to be a conservative estimate.
g These values are based on an economic evaluation carried out by Fasiaben (2010) in the Brazilian Atlantic forest and are conservative estimates of both timber prices and tree growth, and do not consider any type of value-adding.

Note: Values are based on overall values estimated for the Brazilian Atlantic forest and are indicative only. They may vary considerably according to species, system of production, the response of the plants to specific site conditions, and the socio-economic context of the project.

Integrating sources of income

The diversification of income sources helps to reduce risk, a very important decision factor for landowners. Therefore, a key challenge is to create conditions that will bring together the various income-generating opportunities in such a way that restoration projects produce crops, wood and non-wood products and one or more ecosystem service. A conceptual framework for merging these opportunities could be a concentration on PES over the first ten years, followed by the exploitation of NWFPs and possibly fast-grown timber species in a second phase, after which the harvesting of higher-value timber could begin, 20 years or so after initial planting. Using the framework and values proposed in Table 1, and reforestation as the main restoration method, the combination of three or more of the seven proposed income opportunities could easily exceed the baseline cost of US$8 000, which includes the opportunity cost of removing cattle-ranching (US$100 per ha per year for 30 years) and the cost of the restoration effort (estimated at US$5 000 per ha). Ten years after the commencement of the project, tropical forest restoration could become more profitable than the current land use of extensive cattle-ranching (Figure 1).



Note: Values are illustrative only and may vary considerably according to species, the system of production, the response of the plants to specific site conditions, and the socio-economic context of the project.

1
Indicative cash flow for various activities proposed for tropical forest restoration in the Brazilian Atlantic forest

THE WAY FORWARD

Historically, forest degradation has been driven by economic forces such as land speculation, easy profits from predatory timber exploitation and the liquidation of natural capital, the expansion of agricultural lands, cities and mining, and road construction. In most cases, societies have supported these activities by demanding and paying for the agricultural products generated at the expense of forests, and it has financed them through public and private loans.

It stands to reason that if a society collectively decides that it wishes to reverse forest degradation and deforestation, and to mitigate the enormous environmental debt bestowed on future generations, the same economic forces must become allies. Following the economic model of supply and demand, the degradation of forest lands reduces natural capital, which consequently increases the demand for forest goods and ecosystem services. To meet this growing demand, supply must be increased: thus, suitable conditions are created for large-scale forest restoration. The various opportunities to transform marginal lands into sustainably managed forests that are economically viable and not in competition with land for food production are, in effect, income opportunities for entrepreneurs who wish to profit from supplying the multiple products and services provided by restored forests.

In order to create this kind of scenario for ecological restoration, it is necessary to:

- strengthen environmental legislation, taking care to avoid obstacles to the cultivation and subsequent use of native species;
- stimulate the consumption of products originating from the sustainable management of native species in restoration projects;
- create attractive loans and credit lines for entrepreneurs interested in forest restoration, while creating obstacles for activities that cause forest degradation;
- invest in applied research on the cultivation, genetic improvement and processing of native species;
- reinforce the ability of outreach agencies to transfer technology and know-how to farmers;
- build public policies to implement and support these measures.

If economic forces are not incorporated into the design and implementation of restoration projects, forest-restoration advocates are likely to continue practising a kind of "environmental gardening" – projects that are small in scale, have low cost-effectiveness, are not integrated at the landscape level and have negligible participation from landowners and society in general and little impact on degradation. Upscaling tropical forest restoration is urgent and necessary – and eminently economically viable. ◆

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