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# Using markets to leverage investment in forest and landscape restoration in the tropics

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ABSTRACT

Governments and international organizations are promoting or drafting programs to undertake Forest and Landscape Restoration (FLR) of hundreds of millions of hectares of degraded tropical landscapes to support the provision of ecosystem goods and services. But the challenge to recover economic and ecological functionality could be far beyond their financial capacity. Here, we explore the potential of markets and their interaction with policies to leverage investment for FLR in the tropics. We first review the challenges and opportunities of exploiting market forces for FLR, which can be essential for kick-starting the implementation of programs globally. We identify four key opportunities for regulating markets to promote FLR: economic mechanisms; technological, educational or infrastructural investment; legal and enforcement mechanisms; and market-led standards and certification schemes. Finally, we present five pitfalls that may arise when relying on markets to promote FLR. Governments will need to play a critical role in establishing appropriate policy frameworks and institutional arrangements to leverage investments when market signals are not strong enough to initiate changes in traditional land use or farming practices, or to regulate reforestation activities when market signals become so strong that they overwhelm all other land-use activities, leading to a transformed and homogenized landscape.

## 1. The scale of restoration potential in the tropics

The extent of degraded land around the world poses a growing concern. Although degradation is used to describe a range of contexts (Ghazoul et al., 2015; Gibbs and Salmon, 2015; Hobbs, 2016), wide consensus holds that anthropogenic impacts have remarkably changed Earth's natural processes and compromised the capacity of ecosystems to supply benefits to humanity (Lewis et al., 2015). The short-term profits of unsustainable exploitation of natural resources are largely uncompensated by the negative economic consequences of longer-term restrictions on the capacity of ecosystems to provide goods and services to people (Costanza et al., 1997; Balmford et al., 2002). Reducing perverse incentives for degrading activities and instead promoting those that support ecosystem recovery are thus key issues to be addressed by the global economy to provide a better future to all (Hoekstra and Wiedmann, 2014; Diaz et al., 2015; Newbold et al., 2016).

Throughout human history, population densities have normally been sufficiently low to ensure that environmental resources are available and accessible to people, and that the future provision of natural benefits was safeguarded. However, the large expansion of intensive agriculture, urbanization, and global population in the 20th century means that ecosystem goods and services (EGS) are no longer freely available for a large share of humans. Harvesting forest products from natural ecosystems is no longer an option for supplying the high and still growing demand. Land scarcity and concentration of population in large urban centers mean that migration is unable to improve access to EGS essential for human wellbeing. Today, large regions of the globe face water security risks (Vorosmarty et al., 2010), are threatened by climate change (Heltberg et al., 2009), and/or have agricultural

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production constrained by soil degradation (Zika and Erb, 2009) and deficits of pollination (Garibaldi et al., 2013) and pest control services (Boyles et al., 2011; Karp et al., 2013).

In the most biologically diverse, populated and poor regions of the planet, deforestation has been one of the main drivers of declines in EGS to people and biodiversity loss (Hansen et al., 2013; Sloan and Sayer, 2015). Although deforestation has declined in some tropical regions as a consequence of effective national and international policies and programs (Boucher et al., 2014; Nepstad et al., 2014), losses in forest cover were so high in the past that large-scale reforestation is now needed to safeguard the provision of essential EGS to society (Chazdon et al., 2016b; in this article, we use reforestation in the broad sense of returning forest overstorey to land where it has been removed). Forest and Landscape Restoration (FLR) has emerged as a promising activity to recover economic and ecological functionality of large territories deteriorated by the depletion of natural resources in previously forested landscapes (Sabogal et al., 2015). A recent assessment has suggested that, globally, 2 billion ha of land present opportunities for some form of FLR (WRI, 2014). Many governments and international organizations are now promoting or drafting programs to undertake FLR (Menz et al., 2013; Suding et al., 2015; Chazdon et al., 2016b), at scales of hundreds of millions of hectares.

The variety of contexts and implementers creates a variety of approaches being contemplated. Some governments are primarily concerned with traditional forms of reforestation, especially planting trees in plantation monocultures to generate goods such as timber or pulpwood (Xu, 2011; Temperton et al., 2014). Others are more concerned with forms of reforestation that are able to recover biodiversity and supply the EGS once provided by the original native forests (Melo et al., 2013). These mostly involve more complex, multi-species silvicultural systems (Lamb, 2014; Stanturf et al., 2014). Both approaches represent a deliberate new land use choice at a particular location. But it is also likely that much of any future increase in tree cover, as in the past, will be achieved through unplanned and uncertain spontaneous natural regeneration in abandoned former agricultural areas (Aide et al., 2013; Gilroy et al., 2014). FLR could thus include commercial monoculture tree plantations, smallholder woodlots, shifting cultivation, agroforests, restoration plantations and natural regeneration, each of which provide specific outcomes for generating forest products, conserving biodiversity, supplying EGS, and safeguarding cultural, religious and aesthetic values of human groups (Chazdon et al., 2016a). FLR differs from ecological or ecosystem restoration, which aims to assist the recovery of native ecosystems to achieve some level of similarity to their pre-disturbance species composition, structure, and functioning (SER, 2004). Rather, FLR's ultimate goal is to re-shape highly deforested landscapes to better meet human needs, which includes – but is not restricted to – ecological restoration.

However, despite the growing enthusiasm for increased reforestation amongst governments and international bodies, current efforts being undertaken by individuals and communities will not be sufficient in itself to achieve the aspirational targets set for FLR and associated outcomes for EGS provisioning, which rely on shifts in land use at larger spatial scales. New policies are then needed to leverage a massive engagement of landholders and unlock the potential of FLR to re-shape vast extensions of degraded landscapes. One of the critical factors that will likely influence the success of policies to promote FLR is their capacity to provide material benefits to those directly affected, because in developing countries with large numbers of rural poor, reforestation will not be a success unless it also improves livelihoods (Baynes et al., 2015b). Financial impacts to landholders from supplying goods like timber or receiving payments from generating one or more ecosystem services can then make a difference (Edwards et al., 2010; Brancalion et al., 2012). However, the scale of the reforestation effort being contemplated is likely to be far beyond the financial capacity of many governments, NGOs or aid agencies to support its implementation and, thus, to generate material benefits to participants. An alternative or complementary approach is to take advantage of the power of market forces. If FLR is able to produce EGS with a significant financial value in the market system, it may overcome land opportunity costs of degrading activities dominating landscapes and, consequently, replace them by various forms of reforestation. Although governments alone may not have financial capacity to support the scale of reforestation contemplated by international FLR programs, they can develop policies to support the transformation of FLR into a new economic activity, broadening the basis of financial support for its successful implementation. With this in mind, here we explore the potential of markets and their interaction with policies to leverage investment for FLR in the tropics.

## 2. A role of markets in promoting restoration?

Markets are human constructs, created or collapsed depending on societal incentives and historical contexts. Exploiting markets to achieve social change is a strategy that is more than two centuries old, as exemplified by the sugar-boycott campaign against the British slave trade, which begun in 1787 and finally succeeded more than half a century later (Hochschild, 2005). Notably, in the last decade, NGO pressure on the companies involved in trading and making products from agricultural commodities has resulted in important zero net deforestation commitments from major corporations covering the large component of global trade (Nepstad et al., 2014). The economic value of branding and the importance of corporate image are now so great that the mere threat of bad publicity can change the behavior of multi-billion-dollar corporations.

The challenge is to extend such success from deforestation to reforestation, where the objective is not simply to end negative actions but to create large-scale incentives for positive ones. In southeastern Brazil, for example, agricultural companies have engaged in forest restoration to comply with the national Forest Code, as a pre-requisite to obtaining environmental certification for their products and competitive advantages in market (Rodrigues et al., 2011). However, such conditions might not apply in most areas targeted for FLR. For instance, the current land use(s) or landholders may not be integrated into the international commodities market. At the national level, legal instruments able to promote restoration may not exist or existing legislation may not be enforced. In addition, the costs of restoration may not be compensated adequately by the financial benefits arising from various forms of environmental certification. Therefore, the use of restoration to improve corporate image or access to markets does not seem to be enough to promote FLR at the scale needed to face current environmental challenges.

In other cases, markets alone are not enough, in particular in the presence of so-called "market failures" (Sandler, 1993; Bulte and Engel, 2006; Cubbage et al., 2007). These classic economic problems include information asymmetry, incomplete or absent markets and, crucially, externalities. Externalities describe the benefit or harm that an action taken by one stakeholder has on other stakeholders but is not taken into account by the one making the decision (Fisher et al., 2009). When the externalities are positive (as in the case of EGS provision), the failure to take them into account leads to underinvestment and a suboptimal provision of the service in question (Fisher et al., 2009). FLR also suffers from incomplete or absent markets, in particular related to the EGS provided by restoration. The economy of ecosystem services provision, in particular, is beset by market failures, which calls for governmental interventions such as incentive schemes, regulation and educational campaigns (Gottfried et al., 1996; Cubbage et al., 2007).

Although the power of markets per se can be enough to unlock the potential of FLR to receive private investments, past experiences have shown that most emerging economic activities still require appropriate government support, in terms of credit lines, regulations and policies, to develop. Indeed, markets may not be sufficiently robust or stable to initiate restoration even though the need is significant. In this context it is noticeable that some of the world's largest reforestation programs (e.g. South Korea, China, Vietnam) have been undertaken by government agencies. Authoritarian governments, poorly developed private sector, and insufficient market signals to attract private investments are factors potentially related to the predominance of public investments to kick starting large-scale reforestation. But then, once government sponsored restoration programs are underway and have exceeded a critical scale, it may be possible to withdraw these government interventions, like observed now in South Korea (Lee and Miller-Rushing, 2014; Temperton et al., 2014). By this stage, technologies have been developed and the nature of the risks involved in investing in reforestation is better understood.

Scale is important. Similar to other economic activities, FLR may depend on economies of scale, with growing cost advantages with increasing size of operations. In addition to affecting economic efficiency, scale is a key issue for FLR because most of its products and services can only be obtained at expected levels if this activity is implemented at very large spatial extents. Therefore, FLR has to be treated by markets and governments as a "big" field of activity, similar to agricultural commodities production and infrastructure, and receive the type of incentives dedicated to them. If large-scale FLR is viewed as a narrowly focused environmental activity without appropriate consideration of its broad potential to generate jobs and income, alleviate poverty and to deliver EGS with economic value to society, it is likely to fail. In this context, the Sustainable Development Goals provide a core framework for large-scale application of the FLR agenda (Griggs et al., 2013).

Similar to other new "green" business, the "free rider problem" represents another bottleneck to use markets to leverage investments in FLR (Engel et al., 2008). This economic problem is related to the externalities discussed before, and occur when some of the beneficiaries of a certain intervention do not contribute towards paying for the costs of that intervention. This problem may particularly apply to FLR, since many of the EGS supplied are not yet paid for by those who benefit from them. For private sector investors to be willing to invest in a FLR project, they need to be able to capture sufficient benefits to make the investment worthwhile. Overcoming free-riding by making the beneficiaries of reforestation-produced EGS pay for them might have large impacts in the revenue stream of such investments. The classic example is that reforestation (or improved catchment management that restricts agricultural practices) may improve water quality in a catchment, but those downstream users that benefit the most (e.g. city residents) do not need to pay for the value of this improvement. Markets have to be structured by policies that recognize the need to improve EGS for the quality of life of people, the costs associated to their supply, and the benefits suppliers might receive to encourage their engagement in FLR. In the case of ecosystem services, the polluter/payer and, especially, the supplier/receiver principles have been used to develop the market. This can be done directly, for example via payment for ecosystem services schemes, or indirectly, for example by public subsidies (perhaps derived from government-run user fees) that recognize wider societal benefits of certain activities (Holl and Howarth, 2000; Engel et al., 2008).

Using the case of water, some cities use part of their water fees (taxes, rates) to invest in FLR in the countryside to reinforce the provision of watershed services (Richards et al., 2015). In the case of ecosystem goods, it is necessary to remove perverse incentives promoting degrading activities (e.g. illegal logging) and establish supportive incentives for FLR in such a way that societal demand for forest products is supplied by activities that contribute to ecosystem recovery, rather than causing its degradation. Pilot projects are then needed to demonstrate the potential of FLR and mobilize more audacious investors to support the first large-scale programs. However, reforestation types have to be carefully matched to specific program goals and contexts to prevent failures and demonstrate the full potential of this emerging activity to mobilize investments and generate profits (Fig. 1). A key challenge to developing markets for FLR is matching reforestation types, which vary in cost of implementation and the immediate direct benefits that they provide, with appropriate stakeholder group and market motivations. This challenge arises because each reforestation type represents a solution for a given problem, and has to be implemented based on a sound social, economic, cultural, political, ecological and biophysical diagnosis (IUCN/WRI, 2014). If the wrong intervention is applied to solve a given problem, failures will be likely. We present in Table 1 an overview of different reforestation types included in FLR and their appropriateness for specific stakeholder group and market motivations, and describe in the next section some critical issues to be considered for investment in some of the EGS with the greatest potential for commercialization in FLR.

## 3. Markets for restoration of goods and services

Forest and landscape restoration can supply many different EGS that have the potential to be sold. The extent to which these EGS can be traded and at what prices vary considerably due to factors such as the good/service type, distance from markets, scarcity within a local or international market, transaction costs etc. Ecosystems goods and services can be classified into many different categories (see de Groot et al., 2002; MEA, 2005; Diaz et al., 2015), which present a useful framework to assess their market potential in FLR. However, it is beyond the scope of this article to discuss all (or even most) of the potential EGS. Instead we focus on a small number of EGS that have shown to have the greatest potential for FLR. These will be further described to better link their particular characteristics with the context in which their exploration by markets could have higher chances of success.

### 3.1. Ecosystem goods

Wood is the most easily recognized good produced from reforestation. Wood products, including firewood, timber, pulp, resins, and others, can be produced from a range of different planting systems under FLR, including industrial plantations, smallholder and community forestry and agroforestry, along with regenerating secondary forests (Lamb, 2014; Stanturf et al., 2014; Chazdon et al., 2016a). Each of these reforestation systems produce different types and qualities of wood products and have varying degrees of access to local, national and international markets. In general, the markets for wood-based products are well established with active national and international markets for round logs, sawn lumber and pulp obtained from a relatively small number of tropical species (e.g. species of *Eucalyptus*, *Acacia* and *Pinus*) produced from industrial plantations.

All markets require that participants make judgments concerning financial returns and the risks of being involved in that market. Most of the initial reforestation undertaken to produce goods such as timber was originally done early in the 20th century by governments, often with financing by the World Bank, because the private sector regarded the risks of reforestation as being too great. It was only after government forestry departments developed appropriate silvicultural regimes and demonstrated that tree growing could be profitable that the corporate sector became involved (Lamb, 2014). Even then, many companies relied not just on market conditions but on various forms of government assistance, such as help with acquiring suitable land and reduced taxation and other types of financial assistance (Enters et al., 2003). Many timber companies reforesting land for the first time (*c.f.* those able to buy former government-owned plantations) prefer to grow trees on short rotations for pulpwood because the short timeframe limits their exposure to the risks involved in growing trees on long rotations, and in some cases, such timber companies are legally required to reforest with a single exotic timber species (e.g., in Malawi). In short, it has taken some time for timber markets to become attractive to the corporate sector and even then, markets alone are sometimes insufficient to attract investments and incentives are needed.

Smaller individual landholders face the same challenge of balancing


**Fig. 1.** Examples of reforestation types, the usual ecosystem goods and services targeted by them, and the socio-ecological contexts in which they are mostly implemented in the tropics. All images are from reforested areas in the Atlantic Forest of South-eastern Brazil. Photo credits. Pedro H. S. Brancalion.

the prospective financial returns from investing in tree growing against the risks arising from doing so. Several factors affect landholder decisions. First, supply chain infrastructure, especially seedling availability and quality, will underpin decisions about which species can be grown. Key issues are whether or not to use the same species and reforestation methods as corporate growers, and identifying which markets to target. It may be feasible (or, in some instances, only possible) to use the same species and methods if they can act as out-growers to a large corporate timber company and supplement the timber grown in its own plantations. Otherwise using similar species and methods may be a risky option, especially if growers are some distance away from these markets, lack the economies of scale available to large companies and are only able to harvest small volumes of timber episodically. In that case, corporate market conditions work against them.

A second problem for small individual growers concerns timber prices. Some smaller growers may only produce low-quality logs (e.g. with poor form or with large knots), which will generate low prices in local markets. It may make more sense for such growers to invest more in management (e.g. pruning, thinning) and grow species such as those producing high-value timbers that are able to attract higher prices and sustain longer transport distances. But high-value timber markets can be difficult to locate. Where there has been a tradition of using valuable timber species harvested from native forests, their uses and wood properties are often well-known in local markets. However, except for a few well-known hardwoods, such as *Tectona* or *Swietenia* spp., there is often little recognition of local indigenous high-value species in international markets.

A third problem for individual landholders considering the opportunity costs of tree-growing is that financial returns are often delayed until many years after planting. This might be addressed by using multi-species plantings in which fast-growing species are grown with slower-growing species. The former could be harvested within 10 years (e.g. for firewood), whereas the latter might be higher-value species that take at least several decades to reach a marketable size. Harvesting the faster-growing species not only generates an early cash-flow but acts as a thinning to improve the growth of the slower-growing species and reduces the overall risk to the grower by producing goods for several different markets (Nguyen et al., 2014). Some growers and owners of regrowth forests might also be able to diversify and reduce risks even further by growing non-timber-forest-products such as rattans and food

**Table 1**
Typical reforestation types included in Forest and Landscape Restoration and their appropriateness for specific stakeholder group and market motivations (Edwards and Laurance 2012; Gray et al., 2014; Giam et al., 2015; Nepstad et al., 2014; Waern, 2015; Bruel et al., 2010; Esquivel-Rios et al., 2014; Russo, 2009; Richards et al., 2015; Ceccon and Miranda, 2012; Darlington, 1998).

| stakeholder | market motivation | context | reforestation types: natural regeneration | agro-forestry | multi-purpose woodlot | restoration plantations | commercial monocultures | Example |
|---|---|---|---|---|---|---|---|---|
| Large farmers and companies | certification | own land | ■ | | | ■ | | Large-scale ecological restoration programs implemented in the Atlantic Forest of Brazil by pulpwood companies to comply with the national Forest Code and obtain certification for exporting their products |
| | | own land/ adjacent lands | | | | | | Round-table for Sustainable Palm Oil certification in Dipterocarp forests of Malaysia and Indonesia, which has been used to improve access to major purchasers in lucrative western markets. 2.8 million hectares of plantations were already certified under this scheme in 2016, which requires restoration of riparian buffers along river edges (Edwards et al. 2011; Gray et al. 2014; Giam et al. 2015) |
| | market exclusion | own land | ■ | | | | | Examples include the soybean roundtable in Brazil, zero deforestation oil palm in Southeast Asia, and financial mechanisms for the mining sector in Equator and Africa (Nepstad et al. 2014) |
| | corporate social responsibility | own land | ■ | | | ■ | | Restoration of the Yayasan Sabah state forest in Borneo, Malaysia, supported by IKEA. This project started in 1998 and 12,400 ha of degraded forests have been restored by 2014, via management of hyperabundant climbers and pioneer trees, and enrichment planting with >1.7 million tree saplings of native late successional species. US$750,000/year have been invested in seedling nurseries and labour (Waern 2015) |
| | forest goods | | | | | | ■ | Production of rubber, palm oil, pulpwood and timber in commercial plantations established across all tropical regions in lands already converted to agricultural land uses in the past. Although monoculture tree plantations causing deforestation and socio-ecological problems should not be considered a FLR approach, some forestry operations may help to achieve FLR objectives in forest landscapes already deteriorated by agriculture and cattle ranching, especially when production stands are spatially planned to create mosaic landscape |
| Smallholders and communities | external markets | PES carbon | ■ | | | ■ | | Carbon sequestration project financed by the American Electric Power Corporation, Chevron and General Motors (US$18.4 million of investment) to compensate their emissions of greenhouse gases. This program supported the creation of a 19,000 ha of forest reserves in the Atlantic Forest of Brazil, in which 1,500 ha of degraded lands were restored (US$2,500/ha of investment) (Bruel et al. 2010, Ferreti and Britez, 2006) |
| | | ecotourism | ■ | | | ■ | | Ecotourism project in temperate forests of Mexico to conserve and restore monarch butterfly (Danaus plexippus) habitat in the Biosphere reserve, created to protect this species. Restoration projects started in 1986 and covered 56,259 ha, and were implemented in partnership with local populations, which received payments for ecotourism and restoration activities (Esquivel-Rios et al. 2014). |
| | | certification | ■ | ■ | | | | In 2009, Guayakí became the first Fair Trade Certified yerba mate company in the world. Guayaki has built relationships with growers of yerba mate (*Ilex paraguariensis*) that are committed to sustainable forest production. Guayaki's partners sustainably harvest organic yerba mate from rainforest grown cultivations and reforestation projects, generating a renewable income stream, which enables local communities to improve their lives and restore their lands. Their forest restoration projects are primarily based in the yerba mate native growing regions of the Atlantic Forest biome in Argentina, Paraguay and Southern Brazil. |
| | | conservation | ■ | | | ■ | | Establishment of 22 ecological corridors by 240 hectares of restoration plantations to reconnnect isolated populations of the golden lion tamarin (*Leontopithecus rosalia*), one of the most threatened primates of the world, in the Brazilian Atlantic Forest (Russo et al. 2009). |
| | local markets | PES water | ■ | ■ | ■ | ■ | | PES program focused on watershed services in the Brazilian Atlantic Forest, which was based on the restoration of native forests in riparian buffers to improve hydrological processes in a region that supports drinking water supply to 10 million people in the metropolitan regions of São Paulo. The government of the city of Extrema, in partnership with NGOs, private companies and research institutions, have transferred funds to farmers to overcome land opportunity costs and provide seedlings, materials, technical assistance and field labor to implement restoration (Richards et al. 2015). |
| | | forest goods | ■ | ■ | ■ | | | Establishment of local associations to foster the development of small Eucalyptus woodlots (~1ha) in smallholdings to be used as fuelwood. This program was financed by fees charged from small fuelwood consumers of the region and resulted in the implementation of 55,000 ha of woodlots (Ceccon et al. 2012). |
| | non-market | | ■ | | | | | The promotion of educational programs and conservation/restoration activities by the preaching of "ecology monks" in Thailand. Modifications in traditional ceremonies were made to raise funds for local development projects, including donation of seedlings, which are given to villagers to reforest degraded areas (Darlington 1998) |

or medicinal plants alongside their timber, especially in early stages of plantation growth when light availability is high (Vieira et al., 2009).

Many landowners growing trees for the first time may also have trouble in maximizing the financial returns they are able to get from their plantations (Lamb, 2010). Poor silviculture can result in substantial losses of potential value (Herbohn et al., 2014). For example, in many smallholder plantations, thinning and pruning is minimal and often is carried out in an ad hoc and opportunistic manner rather than being based on silvicultural principles (e.g. see (Herbohn et al., 2014; Nguyen et al., 2014). The economic consequences of poor silviculture can be substantial. For instance, in the Philippines it has been estimated that most smallholder woodlots produce merchantable volumes < 44% of their site potential, resulting in disillusionment of smallholders (Le et al., 2012). In addition, smallholders may not understand the ways that trees are valued (e.g. whether trees are sold simply by the number of logs, the diameter or length of each log, by the log volume or as partially sawn log flitches) or the effect of location on the log price they are likely to receive (e.g. price at the stump, at the road side or at the mill door) (see (Baynes et al., 2015a) for the factors that affect the value of smallholder timber). Intermediaries can play an important role in facilitating relationships between growers and markets (Box 1).

Market opportunities and the financial returns from tree-growing are not the only factors affecting the attractiveness of this activity to smallholders. They must also decide how much of their land to devote to this new land use activity and how tree-growing might be linked with their other land-use activities. This obviously depends on such things as the financial return and opportunity costs of tree growing, but might also be dependent on non-market factors such as local community attitudes and what their neighbors think: some landholders may be reluctant to begin tree growing if it has not been a traditional land use activity in the past, irrespective of market realities (Pannell, 1999; Lamb, 2010). In short, markets for forest products can often trigger reforestation but may sometimes be insufficient. In such cases the financial returns are seen as being too modest while the impediments and risks remain significant. A good part of the problem is due to the fact that many non-corporate landholders are unfamiliar with tree-growing and with formal markets for forest products. This means governments wishing to encourage plantation forestry may need to build technical capacity amongst such landholders, provide financial incentives via cheap loans and/or tax breaks, and also assist them to take advantage of existing market opportunities or help them develop new ones.

### 3.2. Ecosystem services

#### 3.2.1. Carbon sequestration

The sale of carbon offsets from FLR offers one of the clearest market opportunities for ecosystem services (Newton et al., 2012). REDD + schemes also now explicit support forest restoration as part of their "enhancement of carbon stocks" modality. In fact, many of the well-known FLR programs launched in the last years have paid specific attention to the potential of FLR to mitigate global climate change by sequestering carbon in forest and tree biomass, especially the New York Declaration on Forests announced at the United Nations Climate summit, which aims to halt deforestation and restore 150 million ha of degraded landscapes and forestlands by 2020, and 350 million ha by 2035 (Suding et al., 2015). The intended Nationally Determined Contributions (iNDCs), submitted by countries in advance of the 21st Conference of the Parties on Climate Change also open a new window of opportunity for leveraging carbon payments in the FLR context, since governments will have to invest public funds or catalyze private investments in activities promoting climate change mitigation, including reforestation. For instance, the Brazilian government set the reforestation commitment of 12 million ha as part of its iNDC, and a national restoration plan has been developed to establish appropriate policy and incentives to up-scale restoration (Brancalion et al., 2016). In spite of clear potential for carbon markets to leverage investments in FLR, payments for carbon credits are not yet available for most landowners. Also carbon payments might be able to finance a larger share, or the totality, of cheaper restoration projects based, for instance, on natural regeneration.

Despite initial optimism, voluntary and "regulated" (usually called "compliance") carbon markets have not emerged at the speed and magnitude initially expected (only US$200 million in 2012), and have remained tiny compared to government support for REDD + (over US $7 billion in 2014) (Boucher, 2015). However, both carbon markets and REDD + have a limited economic potential to counter the main export drivers of deforestation, estimated at US$134 billion (Rautner et al., 2013; Boucher, 2015). Furthermore, benefits delivered by REDD + to participants are still modest, and in most reforestation programs, especially when active restoration approaches are adopted, carbon payments have not been enough to offset land opportunity costs and expenses with reforestation implementation (Birch et al., 2010). This financially unattractive scenario is evidence that, although climate mitigation has been targeted as one of the main expected outcomes of FLR programs, carbon payments may not be the main driver of these programs. However, as discussed in the next section, carbon payments may be bundled with other payments for ecosystem services, as well as to projects planned for exploiting timber and non-timber forest products, to make restoration more attractive to landowners; it might also represent a welcome monetary contribution to restoration programs that would be implemented anyway, independently of receiving funding from the carbon market. One important element that will

**Box 1**
The role of intermediaries in linking landholders and markets for forest products.

Intermediaries or 'middlemen' can sometimes provide a valuable service linking growers with markets. These are usually independent entrepreneurs who sense an opportunity to service the needs of local growers and industry. They are likely to be especially valuable when:

- Many tree-growers have only small plantations that generate small volumes of marketable logs at infrequent intervals.
- Plantations are scattered over large areas and growers lack the means of taking their products to markets.
- There are complicated bureaucratic impediments that must be overcome when marketing goods (e.g. harvest permits, transport licenses, local and regional taxes and road fees, etc.).
- Market knowledge is limited and growers do not know how to obtain/negotiate the best price for their goods.

Under these circumstances, intermediaries can locate and assemble commercially attractive volumes of logs and deal with the bureaucratic necessities concerning their sale. An example of the complexities of marketing is given by Le et al. (2004) who describe the challenges faced by small-scale producers of forest products in Vietnam and the role of intermediaries in some local market chains. But such intermediaries can also be predatory. This can happen when markets are not transparent and when collusion between buyers takes place. Governments have a role in regulating the role of intermediaries.

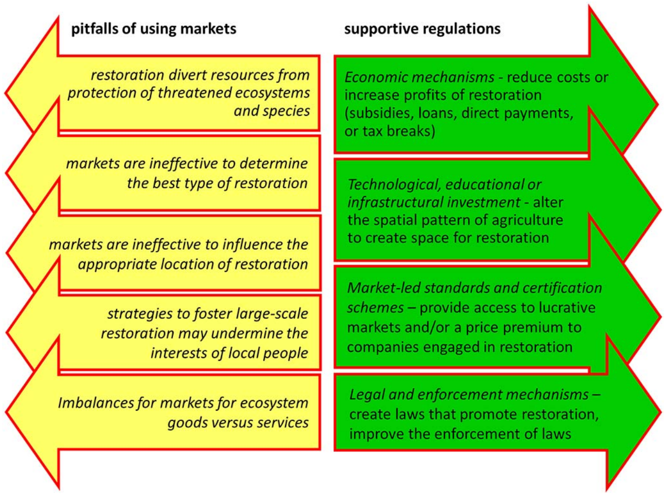


**Fig. 2.** Potential pitfalls and regulation opportunities of using markets for leveraging investments in forest and landscape restoration in the tropics.

determine the impact that carbon funding might have for FLR is the timing of the payments: schemes that manage to anticipate payments based on planned or early stage restoration results will have a much bigger impact than those where payments are made over time in parallel to carbon sequestration, as most restoration costs occur in the first few years.

#### 3.2.2. *Watershed protection*

Watershed services are often a primary target of FLR programs in developing countries (Huang et al., 2009; Brancalion et al., 2014; Murcia et al., 2016). In contrast to carbon, payments for watershed services are already part of the economy of most regions supplied by piped water, in the form of water fees. In this case, government regulations have been the first step to allocate funds to pay for watershed services provided by farmers, who have to adopt best land-use practices, including restoration of riparian buffers and other important zones for hydrological functions (Richards et al., 2015). In most cases, payments are not calculated based on the direct value of watershed services, which is a methodologically complex issue. Rather, programs have focused on compensating farmers for the opportunity costs of changing land use (e.g. covering the revenues obtained by beef production in riparian buffer where restoration interventions were established) and for transaction and implementation costs (e.g. fencing, plantation implementation, fire protection). Thus, farmers may not profit beyond compensation payments from reforestation in this context, a clear limitation for expanding FLR.

Leveraging investments in watershed services has been constrained by several major barriers. One of these is that reforestation may need to exceed a threshold area to generate the desired ecosystem service or to offer the most optimal benefit/cost ratio (e.g., Holmes et al., 2004). To maximize environmental services, this means that many landholders will likely need to be involved and especially those in certain critical landscape locations, such as steep hilly areas. Maximizing beneficial outcomes will thus require complex planning and prioritization across large spatial and temporal scales, while accounting for risks (Wilson et al., 2011). Other barriers include: i) amounts received per area tend to be very small relative to potential revenue from other sources (timber, agriculture, cattle ranching); ii) high transaction costs of administering payments of small amounts to many parties; iii) difficulties in identifying who should be paid for the service and lack of formal regulations to coordinate transactions; iv) monitoring issues, which have to be addressed and protocols agreed upon as a basis for payments; and v) ensuring that the type of reforestation used by all landholders will be sufficient to generate the targeted ecosystem service. In spite of these limitations, typical for new markets and economic activities, ecosystem services have some potential to mobilize investments in watershed FLR (Holmes et al., 2004; Wilson et al., 2011) especially if nested with the production of forest products, as discussed in the next section.

### 3.3. *Bundling ecosystem goods and services*

Payments for ecosystem services may provide an early and continuous cash flow stream with potential to offset land opportunity costs, but the monetary values received tend to be low and are often not enough to offset restoration costs and provide profits to farmers. Therefore, there is an important economic synergy in exploring ecosystem services and forest goods in the same project, so bundling them can be a viable solution to support reforestation (Brancalion et al., 2012). This strategy can also help overcome the problems of high transaction costs of payments for ecosystem services, especially if a single payment is made for all of the services bundled together rather than separate payments for carbon, water, soil protection etc. Another promising approach is to bundle EGS supply with biodiversity conservation. Although a key principle of FLR is to help conserve biodiversity, most financing is expected to target restoration outcomes with more immediate and direct benefits to people. For instance, the global regions with higher potential to sequester atmospheric carbon are also those with higher biodiversity levels (Strassburg et al., 2010). Conservation organizations could then take advantage of market opportunities related to EGS to mobilize investments to implement FLR in priority areas for biodiversity conservation (e.g. (Gilroy et al., 2014)), and use the most appropriate forms of reforestation to achieve this goal. Since FLR is a multi-purpose approach, bundling EGS makes more sense than targeting each restoration outcome separately.

## 4. Market regulation for promoting restoration

Markets can be manipulated or regulated via a range of methods to promote socially and ecologically balanced restoration. A portfolio of these methods will likely create the optimal conditions for restoration, while some of these methods have the added bonus of creating economic environments that promote substantial private market investment (Fig. 2).

### 4.1. *Economic mechanisms*

These could include methods that reduce costs (or increase profits) of restoration, via subsidies and price supports, subsidized finance (loans), direct payments, or tax breaks, and those that increase costs (or reduce profits) of damaging activities that compete with restoration, such as pollution, water use or land taxes. An array of these methods can be integrated to promote corporate investment and local-scale involvement in restoration projects, and may be particularly effective when coupled with PES schemes for carbon sequestration and watershed protection. Monitoring and penalization methods need to be in place to prevent cheaters from exploiting incentives (e.g. accepting payments for activities that they planned to do anyway) to ensure that compensation is performance-related. In general, economic incentives should be used to nudge private behavior towards optimum societal outcomes, for instance by providing higher subsidies for activities with greater positive socio-environmental externalities. This principle can be applied even within the restoration sector, where ideally restoration methods that provide greater societal benefits, or are located in areas that lead to better outcomes for society, would receive higher incentives.

### 4.2. *Technological, educational or infrastructural investment*

Governments may be able to manipulate markets to alter the spatial pattern of agriculture by investing in improved agricultural outputs in farmed regions with high yield potential but large yield gaps, via yield enhancing technologies and education, or by improving transport networks (Laurance et al., 2014), especially if combined with economic incentives. Under the land sparing argument, such yield improvements combined with less post-harvest waste will allow demand to be met from less land area, reducing profitability in marginal areas, typically areas too steep or dry for modernized agriculture (Phalan et al., 2016). In turn, this may create space for restoration via land abandonment in marginal areas via rural to urban migration (Latawiec et al., 2015, but see Rudel et al., 2009 who argue that improved yielding methods are applied to greater land area). Land sparing-induced abandonment is particularly likely when focusing on staple crops, in which demand is inelastic to price changes, rather than luxury, export or biofuel crops (Byerlee et al., 2014), when the promoted technology and methods are labor or capital intensive (Angelsen, 2010), and when governments couple improved yield with designated areas for conservation (Phalan et al., 2016). Intensification of agribusiness (as well as conflict-induced land abandonment in some areas) is likely encouraging the phase of forest recovery across Latin America and the Caribbean, equating to over 360,000 $km^2$ of new woody vegetation between 2001 and 2010 (Aide et al., 2013). However, many marginal agricultural lands may not spontaneously regenerate if maintained under use by extensive activities, such as cattle ranching, or if ecosystem resilience is low. FLR projects thus have to provide some sort of financial benefit to encourage natural regeneration or tree planting.

### 4.3. Legal and enforcement mechanisms

Introduction of new laws or enforcement of existing legal frameworks that restrict access to some areas could result in passive reforestation or could encourage companies to engage in active restoration. These will be particularly important in cases where existing economic activity is causing ecological or socio-economic harm, such as deforestation for agriculture on steep slopes or abandoned land post mining. Under the Brazilian Forest Code, for instance, landowners are required to restore native ecosystems in pre-determined environmental conditions (riparian buffers, steep slopes, mountain tops etc.) and to reach a minimum percentage of the farm to be covered by these ecosystems (Brancalion et al., 2016). Over 70 million farms, covering an area of 397 million ha (97.3% of private farms in Brazil) were already registered in an official system for supporting the compliance of this law, suggesting that millions of farmers will soon be engaged in restoration activities, and that restoration companies may find good market opportunities to profit.

### 4.4. Market-led standards and certification schemes

Voluntary schemes that provide access to lucrative markets and/or a price premium, such as the Round Tables for Sustainable Palm Oil (RSPO) and for Responsible Soy (RTRS) (Edwards and Laurance, 2012), can include restoration as a key requirement for certification. Many producers have tended to overlook legal stipulations to avoid planting up to river edges, on particularly steep slopes, or above a threshold area of land holding. Certified producers must restore forest if such conditions prevail. With > 2.8 million ha of oil palm already certified (~20% of total area), potential for market-based certification is sufficient to promote large-scale forest restoration. The RSPO is working hard to certify groups of small-holders and work with a landscape-level approach to conservation planning (Edwards and Laurance, 2012), which could also promote restoration.

## 5. Pitfalls of using markets

Although incorporating markets into the restoration process offers big potential, we highlight five key unanswered questions and associated dangers that require further research (Fig. 2).

### 5.1. Might restoration divert resources from protection of threatened ecosystems and species?

Restoration has clear synergies with biodiversity conservation (Possingham et al., 2015), which have enabled the inclusion of FLR amongst the main global efforts to combat species loss (Janishevski et al., 2015). Recognizing this, traditional conservation organizations have broadened their scope to embrace restoration as part of their mission, and used part of their budget to support restoration programs. Since FLR provides more perceived socio-economic benefits and is closer linked to economic development than conservation, funding can eventually migrate from protecting threatened ecosystems and species to restoring ecosystems with high importance for ecosystem services provisioning and livelihoods, but potentially lower conservation outcomes. This problem can be particularly observed in the case of uncharismatic species or those without any economic use, and for species and ecosystems that supply little or no ecosystem services to areas of high human population density ("the night parrot effect" (Wilcove and Ghazoul, 2015)). Conservation policies and organizations have then to recognize that, in spite of the synergies, conservation and restoration might compete for resources in some circumstances, and funding for traditional conservation approaches have to be secured to safeguard the protection of species and ecosystems poorly integrated into the FLR agenda.

### 5.2. How successful are markets at determining the best type of restoration?

With specific legal or certification-related frameworks, markets are guided to ecologically sound restoration decisions, such as the Brazilian Forest Code and certification scheme requirement for natural forest restoration along riverine edges. However, in the absence of specific regulations, markets will likely make the most financially, but not necessarily ecologically, sound decisions, or be based on short-term rather than long-term benefits/gains. In particular, decision-making by small-scale local markets is likely to operate under a high discount rate, placing a premium on short-rotation woodlots and rapid growing species (e.g., eucalyptus) over longer-term and ecologically more valuable restoration options. Here, a key aspect is to work with small-scale landowners to find rapidly growing native species and to enhance the diversity of restored lands. More generally, if market-driven restoration takes too long to generate a particular ecosystem service, then this could delay investment or even kill the market. Decisions about which kind(s) of restoration is most appropriate entail significant investor and market risk, which could manifest itself in investment peaks and troughs mirroring market returns and shifting the locations and kinds of restoration in which the market will invest. Understanding future demand and the likely magnitude of market volatility for different restoration commodities over time are important research questions. Another key question is how different restoration systems will differ in the level of positive externalities generated for society, which should inform economic incentive policies.

### 5.3. How successful are markets at influencing the location or spatial prioritization of restoration?

The most important locations for restoration from biodiversity conservation, watershed protection, and other ecosystem service perspectives will often not match those that seek to simply maximize profitability from timber production or carbon sequestration and stocking. To maximize profitability, market-based restoration is likely to focus on marginal areas with lower opportunity costs, areas with secure land tenure, locations lacking many small landholders who increase transaction costs and/or locations with low transport costs to market. Another issue is that although carbon-based conservation might provide substantial benefits for biodiversity conservation (Strassburg et al., 2012), some key biodiversity conservation areas that are relatively carbon poorer might be severely disadvantaged by investments based solely on carbon (Strassburg et al., 2010). Perversely, therefore, in many locations and situations, a profit-driven market could work to prevent more environmentally beneficial kinds of restoration. For instance, there is limited market appetite for more expensive carbon that offers biodiversity or other co-benefits. More often, the voluntary carbon market and non-market public sector payment-for-performance agreements offer low prices – in 2014, voluntary market prices were $5.4 per $tCO_2$, and Norway and Germany used a proxy price of $5 per $tCO_2$ in non-market payments to Brazil's Amazon Fund and Guyana (Goldstein, 2015) – which automatically restricts the locations where the market can operate.

### *5.4. Can we obtain market-based restoration at landscape scales?*

Many ecosystem service or timber enterprises require economies of scale to become profitable (and enhance profitability). Similarly, to be of most ecological value, larger-scale restoration will reduce edge and isolation fragmentation effects, improving the potential for biodiversity recolonization and persistence. Persuading multiple landholders within a landscape to achieve sufficient restoration to generate economies of scale and ecological sustainability and resilience is a major challenge. In part, this challenge could depend upon the relationship between international or national and more local markets. The former is likely to target bigger-scale planning, whereas the latter is likely to be smaller scale and more isolated. But if international- or national-mediated investment ignores the needs of local people, then this could undermine project longevity and even been seen as neo-colonialism.

### *5.5. How to balance markets for goods versus markets for ecosystem services?*

Given the diversity of options of EGS, a core challenge is to better understand the synergies and tradeoffs between these options in terms of their ecological and financial returns. For example, might the market for plantation-grown pulpwood be more attractive than the market(s) for diverse ecosystem services? Such an understanding can inform landscape planning to identify the locations in which one (or a package of) markets will maximize benefits and profitability and where the operation of a free market may have to be constrained (e.g. to protect watersheds or biodiversity). While we suggested above that large-scale restoration projects will likely yield higher benefits, social concerns may require landscape partitioning to harness both kinds of markets. The question therefore is finding the best scale for mixing to meet social requirements while preventing the breakdown of economies of scale and landscape connectivity. One potential is to use market manipulation, via subsidies, cheap finance, or legal and policy frameworks, to promote socially and ecologically balanced restoration that is attractive to market investors.

## 6. A way forward – how to harness power of markets to accelerate restoration?

It seems that markets can sometimes drive reforestation of deforested and degraded landscapes and that once the process is initiated then further market opportunities can arise (e.g. businesses involving seed collection, seedling production, plantation management contracting, harvesting of forest products etc.) that may drive the process further. But market situations reflect two distinct modalities. In one, the market signals are not strong enough to initiate changes in current land use or farming practices. In such cases, governments or NGOs are needed to complement existing market forces and reduce perceived risks by building the capacity of landholders to engage in reforestation and advising them on how to increase benefits including financial returns. The other situation is when the market signal is, instead, so strong that it overwhelms all other land use activities and leads to a transformed and homogenized landscape. This has occurred with agricultural crops such as wheat or oil palm, but also with tree plantations such as rubber or pulpwood (e.g. *Acacia mangium* across parts of Southeast Asia).

In the first case, traditional extension activities and knowledge-sharing could eventually be enough to generate changes in attitudes and encourage reforestation, although financial incentives may also be needed, at least initially, to overcome perceived opportunity costs. In the second case, the power of the market may need to be redirected or curtailed in some way. This might be achieved by land-use planning that seeks to diversify the types of reforestation undertaken (e.g. greater emphasis on native species or mixed-species plantations) or that emphasizes reforestation of certain types of land (highly degraded areas, steep slopes, riparian areas). These latter strategies may be easier if the power of the market for forest products can be complemented by a market for ecosystem services. In each case, history suggests governments have a critical role to play in establishing appropriate policy settings and institutional arrangements.

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