Ecosystem restoration, protected areas and biodiversity conservation

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Ecosystem restoration on a landscape scale strengthens biodiversity conservation in protected areas.

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This article focuses on the opportunities for ecosystem restoration to contribute to biodiversity conservation within and outside protected areas (as discussed, for example, in Brancalion *et al*., 2013a).

Ecosystem restoration on a landscape scale, alongside the sustainable management of other land-use types including agriculture, pasturelands, forestry, and the expansion and consolidation of protected areas, is increasingly recognized as a necessary part of a package of activities for biodiversity conservation, enhanced ecosystem services and sustainable development (SCBD, 2014; Aronson and Alexander, 2013; Menz *et al*., 2013; Rey Benayas *et al*., 2009; Bullock *et al*., 2011).

Above: Blooming* Handroanthus impetiginosus *tree (Bignoniaceae) in the Brazilian Atlantic Forest

The Convention on Biological Diversity (CBD) states that each Party shall, as far as possible, "rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, including through the development and implementation of plans or other management strategies".[1] To further the implementation of this provision and Aichi Biodiversity Targets 14 and 15 (Box 1), the Conference of the Parties (COP) to the Convention adopted a comprehensive decision on ecosystem

[1] Article 8(f) of the Convention: http://www.cbd.int/convention/text/.

Box 1
Strategic Plan for Biodiversity 2011–2020

The Strategic Plan for Biodiversity 2011–2020 was adopted by the CBD COP at its tenth meeting in Nagoya, Japan, in October 2010. It is supported by the other biodiversity-related conventions and by the United Nations. It thus provides an internationally agreed framework for action on biodiversity with a vision that foresees that:

> By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people.

The Plan includes twenty Aichi Biodiversity Targets including Target 15:

> By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 percent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

Actions to achieve the Aichi Targets should be undertaken in a coherent and coordinated manner. In particular, efforts to achieve Target 15 on ecosystem restoration should be closely linked to those aimed at halving deforestation and reducing the loss and degradation of other natural habitats (Target 5), promoting sustainable agriculture and forestry (Target 7) and protecting at least 17 percent of terrestrial areas through a system of protected areas integrated into the wider landscape (Target 11). Achieving these targets will together help to protect threatened species (Target 12), genetic diversity (Target 13) and ecosystem services (Target 14). The full text of the Targets is available at: http://www.cbd.int/sp/targets/default.shtml.

At the national level, implementation of the Strategic Plan for Biodiversity is promoted through national biodiversity strategies and action plans. Attaining the Aichi Biodiversity Targets will in most cases require the implementation of a package of actions, typically including legal or policy frameworks, socioeconomic incentives aligned to such frameworks, public and stakeholder engagement, monitoring and enforcement. Coherence of policies across sectors and the corresponding government ministries is also necessary.

Meeting the Aichi Biodiversity Targets would contribute significantly to broader global priorities addressed by the post-2015 development agenda, namely: reducing hunger and poverty; improving human health; ensuring a sustainable supply of energy, food and clean water; contributing to climate change mitigation and adaptation; combating desertification and land degradation; and reducing vulnerability to disasters (SCBD, 2014).

restoration in 2012,[2] backed up by the Hyderabad Call for a Concerted Effort on Ecosystem Restoration.[3] To provide support to developing-country Parties on implementing these decisions and achieving these targets, the Forest Ecosystem Restoration Initiative, supported by the Government of the Republic of Korea through the Korea Forest Service (KFS), was launched at CBD COP 12 in October 2014.

These aspirations are reflected in the Bonn Challenge[4] to restore 150 million ha of degraded land by 2020. On the margins of the UN Climate Summit in September 2014[5] a number of governments, as well as civil society and private-sector organizations, signed the New York Declaration on Forests, extending the goal by an additional 200 million ha to be restored by 2030.[6]

[2] Decision XI/16: http://www.cbd.int/decision/cop/default.shtml?id=13177.

[3] The Hyderabad Call for a Concerted Effort on Ecosystem Restoration was made by the Governments of India, the Republic of Korea and South Africa (as then COP Presidents of the CBD, UNCCD and UNFCCC) and heads of a number of international organizations: http://www.cbd.int/doc/restoration/Hyderabad-call-restoration-en.pdf.

[4] http://www.forestlandscaperestoration.org/topic/bonn-challenge; http://www.forestlandscaperestoration.org/sites/default/files/topic/the_bonn_challenge.pdf.

[5] See http://www.un.org/climatechange/summit/.

[6] See Panel-5 discussions at http://www.un-redd.org/Portals/15/documents/Report%20on%20the%20Forests%20Pavilion%2023%20September%202014%20v2.pdf.

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Community-managed agroforests made up of banana, manioc and* juçara *(an endangered native palm, the fruits of which are exploited for pulp production), at the borders of the Serra do Mar State Park in the Atlantic Forest of São Paulo, Brazil. Such agroforests supply food and provide income to traditional populations living around the protected area, thus avoiding illegal harvesting of wood and non-wood forest products in the reserve. In this context, forest restoration and rehabilitation are useful to reduce human-mediated disturbances in protected areas and to improve the connectivity of landscapes that embrace protected areas

Efforts to restore ecosystems also contribute to other internationally agreed goals, including ecosystem-based adaptation and climate change mitigation under the United Nations Framework Convention on Climate Change (UNFCCC),[7] land-degradation neutrality under the United Nations Convention to Combat Desertification (UNCCD),[8] the wise use of wetlands under the Ramsar Convention on Wetlands,[9] and the four Global Objectives on Forests of the United Nations Forum on Forests.[10] Ecosystem restoration is also recognized in the Sustainable Development Goals.[11]

Ecosystem restoration at the landscape scale reflects a paradigm shift in conservation science, putting spatial pattern and scale at the centre of conservation strategies, where, instead of focusing exclusively on reserves, conservation efforts maximize the value of rural landscapes for biodiversity persistence, preventing extinctions, and for the provision of ecosystem services (Chazdon *et al*., 2009). This shift was also reflected in the discussions and outcomes of the 5th International Union for Conservation of Nature (IUCN) World Parks Congress in 2003 under the overarching theme of "Benefits beyond boundaries", as well as in the goals and activities of the Programme of Work on Protected Areas adopted under the CBD in 2004.

WHY LANDSCAPE RESTORATION IS NEEDED FOR BIODIVERSITY CONSERVATION

Significant efforts have been made in recent years to develop protected area networks within the framework of the CBD's Programme of Work on Protected Areas. The world is now on track to protect 17 percent of terrestrial areas by 2020, in line with Aichi Biodiversity Target 11 (SCBD, 2014). However, achieving a well-managed and representative network will require greater efforts. Moreover, extrapolations of current trends indicate that pressures on biodiversity will continue to increase and the status of biodiversity will continue to decline. Analysis of the major primary sectors indicates that drivers linked to agriculture account for some two-thirds of the projected loss of terrestrial biodiversity (SCBD, 2014).

Many protected areas are embedded within human-modified landscapes (Melo *et al*., 2013a), where agriculture

[7] http://unfccc.int/2860.php.

[8] http://www.unccd.int/.

[9] www.ramsar.org.

[10] www.un.org/esa/forests.

[11] For details, see https://sustainabledevelopment.un.org/sdgsproposal, and in particular for restoration targets 6.6 (water-related ecosystems), 14.2 (marine and coastal ecosystems), 15.1 (terrestrial and inland freshwater ecosystems), 15.2 (degraded forests), and 15.3 (degraded land and soil).

and urbanization have determined landscape structure and may represent major disturbances to natural ecosystems. Habitat loss and fragmentation is a major threat to biodiversity conservation in this context. Recent studies have shown that below certain percentages of habitat cover, human-modified landscapes show an abrupt decline in biodiversity as a result of the lack of connectivity among remaining habitat patches (Rappaport *et al*., 2015). Thus, when embedded in landscapes with very low habitat cover – predominant in many regions – protected areas without connectivity to the surrounding landscape have a limited potential to avoid further species extinctions. The critical habitat cover for biodiversity conservation varies according to ecosystem type, landscape matrix, and focus organisms (Fahrig, 2001) and, although theoretical research has indicated 20–30 percent habitat cover as a relevant threshold, further empirical testing is required (Fahrig, 2003). For example, forecasting by Ferro *et al*. (2014) found that most protected areas in the Brazilian Atlantic Forest would become climatically unsuitable for maintaining the diversity of tiger moths (*Arctiinae*) by 2080. Climate change will likely impose additional challenges for biodiversity confined to reserves. Some species may be forced to shift their geographical ranges in order to find climate refuges. For example, not only are marsupial species in Brazil forecast to shift ranges towards the southeast of the country, culminating in high species richness in that area, but most species will also experience significant range contraction and loss of climatically suitable areas within their geographic range (Loyola *et al*., 2012). Thus, protected areas increasingly need to be functionally connected to other habitat patches in the landscape to allow species movement to more favourable sites. In a changing world, we have to improve the dynamic interaction between protected areas and the other components of the inter-habitat mosaic (Hobbs *et al*., 2014). In other words, we have to manage the system (i.e. the landscape), and not only its parts (i.e. protected areas and other patches of natural habitat).

Thus, to sustain desirable levels of connectivity and foster biodiversity conservation in protected areas, the maintenance and restoration of smaller remnants in the landscape need to be taken into account, and in highly fragmented landscapes may be the only option available. In such conditions, landscape restoration is vital to support biodiversity conservation over time, complemented by improved coverage of isolated semi-natural habitats in landscape management plans. In human-modified landscapes, the conservation

Multiple landscape restoration interventions in the Brazilian Atlantic Forest: silvopastoral systems, living fences, natural regeneration in marginal agricultural areas and restoration plantations on mountaintops and steep slopes

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A large part of the Vassununga State Park in the Brazilian Atlantic Forest burned in a fire that began at the borders of the road that crosses the park. Climate change tends to intensify and increase the frequency of forest fires in tropical regions, representing an important risk for protected areas. If protected areas are connected to other remnants in the landscape through ecological corridors established by restoration interventions, fauna can better escape from areas submitted to human-mediated disturbances, and the recolonization process of destroyed or disturbed parts of protected areas can be facilitated

focus thus needs to move beyond the protection of existing remnants, while addressing landscape constraints and interactions to support the persistence of biodiversity (Gardner *et al*., 2009).

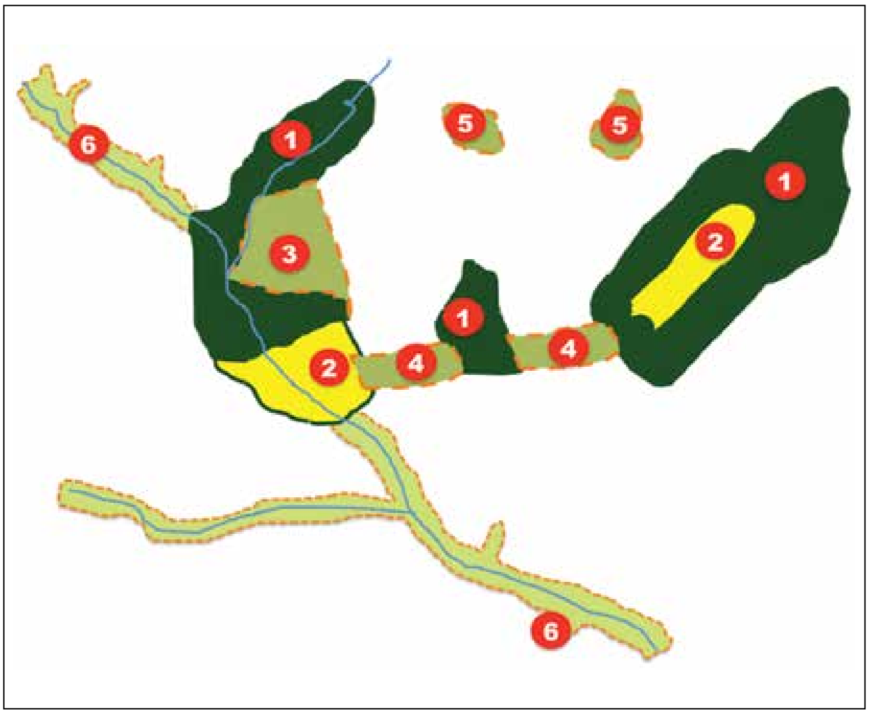
Such an approach is consistent with Aichi Biodiversity Target 11, which calls for "effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures […] integrated into the wider landscape and seascape". The CBD Programme of Work on Protected Areas elaborates on the concept of integrating protected areas into wider land- and seascapes,[12] and Ervin *et al*. (2010) have produced a relevant guide in the CBD Technical Series.

In identifying possible areas for restoration, consideration should be given to improving the extent, quality and connectivity of high-biodiversity areas, including areas that are home to threatened or endangered species, and those that deliver important ecosystem services (Tambosi *et al*., 2014). Restoration must be informed by a vision of enhancing native ecosystem functions and avoiding further reduction or conversion of natural habitat cover, or loss in other natural ecosystems (Latawiec *et al*., 2015). Vulnerable areas with the potential to contribute to a matrix of conservation and sustainable use can be accorded appropriate levels of protection and targeted for restoration as needed. Areas can be protected against human-mediated disturbances and reconnected to other habitat remnants in the landscape. In addition, the hospitability of the agricultural landscape "matrix" (within which protected areas and other areas of native vegetation are embedded) to species that may move among these natural patches can be improved through various forms of landscape restoration. This may include forest restoration and interventions to increase tree cover in agricultural landscapes, such as agroforestry, "living fences", and the establishment of appropriate tree plantations.

Brancalion *et al*. (2013b) proposed an approach in which forest and landscape restoration (FLR) supports biodiversity conservation in protected areas embedded within human-dominated landscapes. The approach is based on the premise that, in many tropical areas, forest remnants large enough to receive public investments for strict protection have become scarce, while small- and medium-sized, privately owned fragments may play a significant role in conserving stressed biodiversity. Historically, the conservation role of such small remnants has been underestimated by conservationists because these areas may harbour far lower levels of biodiversity than do the larger protected or otherwise conserved remnants. This reflects a limited view of biodiversity conservation, as small remnants can serve as ecological corridors or stepping stones. The approach, which the authors call "restoration reserves", uses the following multi-scale decision-making scheme:

1. definition of priority areas for increasing landscape connectivity through ecological restoration at the regional scale;
2. selection of a given landscape where ecological restoration shows high

[12] Goal 1.2 of the Programme of Work on Protected Areas: http://www.cbd.int/protected/.



1
Priority areas for restoration at the landscape level from a biodiversity conservation perspective.
Dark green areas (1) depict areas of native vegetation (e.g. remnants of old-growth forest). These areas are a priority for conservation and may already be included in protected areas. The areas shown in yellow (2) and bounded by dark green lines represent degraded native vegetation. Ecological restoration of these areas would improve the integrity of the associated high-conservation areas. Areas shown in mid-green, bounded by broken brown lines (3–6), depict priority areas for restoration from agriculture or rangeland areas, with the following rationales: improving the integrity of existing areas of native vegetation (3) by reducing edge effects and increasing size; providing ecological corridors (4) or stepping stones to improve connectivity (5); and protecting riparian areas from erosion (6). Finally, the hospitability of the agricultural landscape matrix may be improved through agroforestry.

potential for increasing landscape connectivity, using this to define the boundaries of the area within which landscape-scale restoration is to be promoted; and

3. implementation of ecological restoration activities aimed at increasing biodiversity conservation and landscape connectivity within these areas, such as
   - protection of existing forest remnants;
   - restoration of degraded areas of native vegetation;
   - increasing of the size and/or improvements to the shape of remnants to reduce edge effects; and
   - restoration of some lands that have been converted to agriculture, especially degraded or low-productivity lands, to establish ecological corridors and stepping stones or to enlarge existing corridors (Figure 1).

Ecosystem restoration is not a substitute for conservation, nor should it be used to justify degradation or unsustainable use. Old-growth forests and other areas of near-pristine native vegetation are the main repositories of biodiversity in human-modified landscapes, and are a necessary source of biodiversity for colonizing restoration sites within agricultural landscapes.

Indeed, although restoration has been effective in increasing biodiversity levels in degraded sites, it has not been enough to achieve the reference values of conserved ecosystems (Rey Benayas *et al*., 2009). Consequently, a main premise of landscape restoration should be to halt habitat loss, especially of those ecosystems that provide essential ecosystem services and have a higher potential to retain their biological composition and functions. Although some tropical landscapes have experienced a forest transition where forest gains have surpassed deforestation and thus brought about a net gain in forest cover, old-growth forest remnants have nevertheless often been replaced by crop fields and pasture-lands in areas favourable for agricultural production (Ferraz *et al*., 2014). This significantly affects the viability of species in existing and future restoration sites, as well as pollination, pest control, and other ecosystem services mediated by biodiversity in agroecosystems. Restoration outcomes are also affected by landscape structure, land-use history and disturbance regime, which increase the risk of using restoration to offset biodiversity losses in natural ecosystems (Maron *et al*., 2012).

Diversity between and within species is important for effective ecosystem restoration, not only to promote high conservation value in the restored ecosystems but also to ensure the success of the restoration process itself (Thomas *et al*., 2014; Bozzano *et al*., 2014). Restoration activities should also be undertaken in a manner consistent with the ecosystem approach developed under the CBD.[13] In particular, forest landscape restoration should only be undertaken where ecologically appropriate. Although afforestation and reforestation are part of forest-restoration strategies, such measures should be critically assessed in natural ecosystems. Working across the whole landscape with

[13] Ecosystem approach operational guidance: https://www.cbd.int/ecosystem/operational.shtml and Principles: http://www.cbd.int/ecosystem/principles.shtml.

a mosaic of land uses requires assessments of the ecological conditions, sociocultural dynamics and other enabling factors in order to assess trade-offs and adjust land-use plans accordingly. Each country needs to determine what is ecologically appropriate and establish its baseline maps, with monitoring systems in place to track and guide progress in the various ecosystems. Countries will need to assess opportunities for restoring deforested and degraded landscapes and factor in the rehabilitation of degraded agricultural lands to improve productivity in mosaic landscapes, without causing loss or conversion of native forests, grasslands or other natural ecosystems (Veldman *et al*., 2015).

THE CASE OF THE BRAZILIAN ATLANTIC FOREST

Despite growing international recognition of the importance of ecological restoration, large-scale FLR programmes are only at their beginning, which limits our understanding of the real needs and success factors of such activities for complementing biodiversity conservation in protected areas. To improve understanding, we selected the restoration of the Brazilian Atlantic Forest as a case study. The study provides local lessons in ecosystem conservation and restoration with regard to protected-area management, and is a concrete example of a contribution to globally agreed goals under the Strategic Plan for Biodiversity 2011–2020 and the emerging Sustainable Development Goals. It was chosen on the basis of the biological importance of the biome concerned, which is among the top five Global Biodiversity Hotspots (Laurance, 2009), and the existence of a large-scale, successful programme for FLR: the Atlantic Forest Restoration Pact (Melo *et al*., 2013b).

Only 1.05 percent of the original extent of the Brazilian Atlantic Forest is protected in reserves, which are mostly embedded in highly fragmented landscapes (Ribeiro *et al*., 2009). Since less than 12 percent of the original Atlantic Forest cover (1.2 million km²) remains today, these

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Protection of a water spring and of a riparian buffer by forest restoration interventions in a private landholding in the Brazilian Atlantic Forest. Although protected areas may be more successful in conserving terrestrial ecosystems, the conservation of freshwater systems relies on management of the whole watershed, and can only be achieved if complementary interventions are made at the watershed scale

protected areas are frequently isolated from neighbouring forest remnants and, considering the small size of the reserves, are often part of landscapes below the habitat-cover threshold required to avoid an abrupt loss of biodiversity. For instance, Banks-Leite *et al.* (2014) observed in this biome an abrupt decline in the community integrity of vertebrates when habitat cover fell to approximately 30 percent. Consequently, maintaining existing protected areas is not enough, in this case, for the long-term persistence of biodiversity. Nor is creating new, formally recognized protected areas on a significant scale a feasible solution, since forest remnants large enough to receive public investments for strict protection have become scarce. However, conserving small- and medium-sized, privately owned fragments, while restoring small areas around protected areas, has been shown to improve the connectivity of landscapes (Brancalion *et al.,* 2013b). In addition, improving tree cover in agricultural landscapes, for example through agroforestry and commercial tree plantations, may also lead to increased landscape hospitability to some endangered species. Further, in highly fragmented landscapes, protecting small remnants and restoring others may be the only option available to reach an adequate level of representativity: this is the case in the protected area network of the Atlantic Forest, where six of its seven biogeographical regions are poorly protected. In such conditions, FLR is even more crucial to support biodiversity conservation over time.

To address this need, a coalition of non-governmental organizations (NGOs), private companies, governments, and academia launched in 2009 the Atlantic Forest Restoration Pact, which currently consists of more than 300 institutions working together to restore 15 million ha of forests by 2050, including a pledge of 1 million ha within the framework of the Bonn Challenge (Melo *et al*., 2013b). If this restoration target is met, the Atlantic Forest would reach 30 percent of forest cover, achieving the estimated minimum threshold for biodiversity persistence, in association with the maintenance and improvement of the protected areas network.

The Pact has developed methodologies for identifying priority areas for restoration that take into account the factors discussed in the previous section (see also Figure 1) with a view to optimizing the contribution to biodiversity conservation without neglecting socioeconomic factors. This view incorporates a well-developed framework for land-use planning, in order to create space for large-scale restoration in agricultural areas and avoid displacing agricultural activities that may cause deforestation elsewhere (Latawiec *et al*., 2015). To achieve its goal, the Pact developed a thematic map of potential areas for restoration, in which nearly 7 million ha of less productive pasturelands (slope >15°) – with a low opportunity cost (less than US$50/ha/year) due to their low productivity and returns to farmers – were targeted for restoration (Pinto *et al*., 2014). The Pact proposes that the implementation of restoration models designed to produce timber and non-wood forest products, as well as to receive payments for ecosystem services, can be profitable and overcome the opportunity costs of less productive pasturelands (Brancalion *et al*., 2012). Maps of priority regions for increasing landscape connectivity have also been produced (Tambosi *et al*., 2014), which may optimize restoration efforts, especially in the regions more recently affected by deforestation. In addition, to increase the cost-effectiveness of restoration through spatial planning, the Pact also looks at the quality of restoration interventions. A reference book summarizing most of the technical and scientific information available on forest restoration in the Atlantic Forest provides scientific guidance to practitioners on environmental diagnosis and planning, restoration methods and operational interventions, seed and seedling production, including genetic issues, and monitoring (Rodrigues *et al*., 2009). More recently, a monitoring protocol was launched to assess the ecological, socioeconomic and management effectiveness of restoration projects and programmes developed by Pact members, and to identify the key obstacles to successful restoration and provide collective solutions (Pinto *et al*., 2014).

The Atlantic Forest Restoration Pact has been integrated not only into global initiatives such as the Bonn Challenge, focusing on large-scale restoration, but also into new laws and policies supporting forest restoration in Brazil. The consequent development of innovative models to transform restoration into an economically and socioecologically viable land-use option thus opens promising perspectives.

CONCLUSIONS

Ecosystem restoration at the landscape level is an essential part of efforts to protect biodiversity and contribute to sustainable development. To be successful in this regard, ecosystem restoration must:

- help to protect the integrity of existing areas of native vegetation, including protected areas, by increasing the size of such areas and reducing edge effects;
- improve connectivity in the landscape, for example by providing ecological corridors or "stepping stones" between existing areas of native vegetation, including protected areas;
- make use of a wide diversity of species in restored areas, taking into account genetic diversity;
- complement efforts to reduce degradation and habitat loss, thereby protecting old-growth remnants and other near-pristine habitats; and
- be implemented in an ecologically appropriate manner, avoiding, for example, afforestation of non-forest natural ecosystems.

Efforts are needed at the landscape level to manage the system rather than just its individual components. This includes not only manipulating its biophysical components, but involving the socioeconomic drivers of both habitat degradation and loss and ecosystem restoration. A key step towards the implementation of effective ecosystem and landscape restoration programmes is to develop governance mechanisms that enable restoration advocates to provide better conditions and incentives for restoration activities, while creating barriers to stop degradation. But overcoming socioeconomic thresholds can be even more challenging than tackling biophysical factors.

Concerted actions for ecological restoration in forest and other landscapes, together with biodiversity conservation in protected areas and a range of complementary interventions to promote sustainable agricultural, rangeland and forest production, will help meet the needs of today and ensure sustainable development for future generations. ◆

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