Natureza & Conservação
Brazilian Journal of Nature Conservation

Policy forums

Natureza & Conservação 11(2):186-190, December 2013

Handling Editor: Jean Paul Metzger
http://dx.doi.org/10.4322/natcon.2013.029

Restoration Reserves as Biodiversity Safeguards in Human-Modified Landscapes

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Globally, human populations are rapidly converting large blocks of tropical old-growth forests into ragged quilts of small forest patches, embedded within human-modified landscapes, consisting mostly of agricultural fields and pasture lands (Chazdon *et al.* 2009). Such landscapes impose a myriad of threats to native biodiversity, including those related to habitat loss and fragmentation, overexploitation of forest resources and matrix-mediated perturbations (Gardner *et al.* 2009). As human-modified landscapes exhibit increasing levels of biotic impoverishment and homogenization (Lôbo *et al.* 2011), scientists, environmentalists, and policy makers are looking for a modus vivendi between conservation and ongoing human demands for land (Phalan *et al.* 2011).

Conservation scientists have argued in favor of "biodiversity-friendly landscapes" as an alternative approach for habitat management in opposition to the "land sparing" view that tend to intensify the use of non-natural habitats in a landscape (Melo *et al.* 2013a). The so-called "biodiversity-friendly landscapes" are characterized by (1) the persistence of large blocks of old-growth forests, (2) the existence of a network of physically-connected protected areas, including those devoted to preserve pristine forest patches, and (3) a more efficient use of matrix in ecological and agricultural perspectives, by improving productivity in suitable areas for agriculture for attending human demands for food, fiber, fuel, and fodder, while freeing-up marginal lands for forest re-growth. In this context, conservation efforts rely on but should go beyond the limits of current protected areas (Chazdon *et al.* 2009). Unfortunately, many tropical biotas have already suffered severe habitat loss and fragmentation, so that forest cover is now mostly composed by a large number of disconnected small forest patches (see an example in Ribeiro *et al.* 2009). In this context, forest remnants large enough to receive public investments for its strict protection have become scarce, while small- and medium-sized, privately owned fragments have played an utmost role for conserving the beleaguered biodiversity.

It is comprehensible that conservation efforts focus on protecting large blocks of forest, but huge amounts of discrete semi-natural habitats could be included in landscapes management plans if treated as part of a management unit as to improve long term sustainability of mixed-use landscapes. However, there is a lack of legal reserve category to protect smaller fragments and at the same time to encourage ecological restoration in areas in between those fragments. On the one hand, the three main IUCN (International Union for Conservation of Nature) reserve categories for protecting ecosystems (i.e. Strict Nature Reserve, Wilderness Area and National Park) were designed to include large tracts of existent habitat, without including significant portions of land not covered by native vegetation within its boundaries (IUCN 2013). On the other hand, the IUCN categories that include relevant portions of altered ecosystems (i.e. Protected Landscape and Protected Area with Sustainable Use of Natural Resources) are focused in the promotion of sustainable management practices on existent natural ecosystems (IUCN 2013), but does not include specifically the recommendation of ecological restoration for the increment of natural ecosystem cover as to support biodiversity conservation. Since a relevant portion of tropical biota persists today in small fragments embedded in human-modified landscapes, we advocate for the creation of a new protected area category, the so-called "Restoration Reserves" (RR), which combines restoration opportunities with conservation demand at the landscape level.

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Restoration Reserves: A New Category of Protected Area

Restoration Reserves are spatial units with remarkable value for landscape connectivity, where the protection of remaining forest patches, the adoption of less degrading agricultural activities in the matrix and, especially, the increase of forest cover through restoration efforts planned in a landscape ecology approach, should be prioritized for supporting biodiversity conservation (Figure 1). Restoration Reserves seek to support the persistence of biodiversity in a collection of functionally connected fragments, rather than in each individual remnant, differently from the traditional approach for establishing protected areas. Our vision is that, although small fragments may individually lose edge-sensitive species, several small- and medium-sized fragments distributed at landscape scale may comprise, as a whole, a network capable to harbour high levels of biodiversity mainly as a result of spatial heterogeneity, extinction debt, the influence of each fragment in the others, and the ability of some species to live in small remnants (Naveh 1994). Those RR can be an important instrument to: (1) increment the amount of protected areas, (2) to reduce edge effects and other human-mediated disturbances in remaining forest fragments, (3) to induce the adoption of less degrading agricultural activities for reducing matrix harshness, and (4) to increase forest cover in valuable areas for improving landscape connectivity, thus allowing biodiversity persistence in tropical regions by contributing for the creation of the so-called "biodiversity-friendly landscapes"

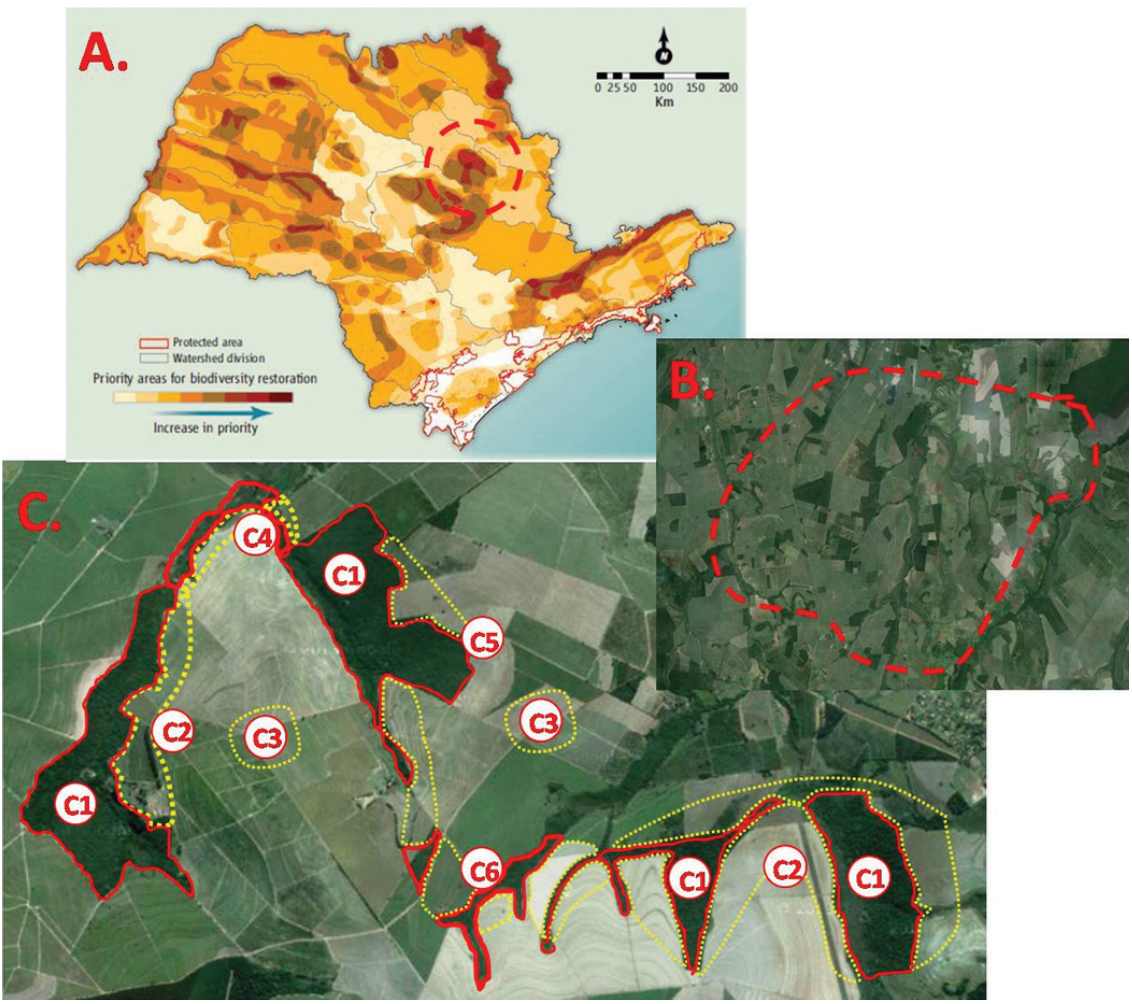

Figure 1. Example of a multi-scale decision making approach for the establishment of a Restoration Reserve: A) definition of priority areas for increasing landscape connectivity through ecological restoration in the state of São Paulo state, Brazil (adapted from Joly *et al.* 2010); B) selection of a given landscape unit where ecological restoration would present a very high importance for increasing landscape connectivity and definition of the boundaries of the Restoration Reserve (red dashed line), based in ecological and socioeconomic criteria; and C) ecological restoration activities planned to increase biodiversity conservation and landscape connectivity within Restoration Reserves: (C1) protection of existent forest remnants and restoration of those degraded (dark green patches with red borders) and restoration of degraded lands (patches with dashed yellow borders) for (C2) reducing border effects of forest remnants, (C3) establishing stepping stones, (C4) enlarging already existent ecological corridors, (C5) improving the shape of forest remnants, (C6) establishing large ecological corridors.

(Melo *et al.* 2013a). Therefore, RR are a complementary type of reserve, not a substitute of traditional ones (already covered by natural habitats), for conserving biodiversity in human-modified landscapes.

This new kind of reserve would be especially indicated for global biodiversity Hotspots, where an extremely rich and unique biodiversity is been threatened by habitat loss and fragmentation. For instance, in the Atlantic forest, only ca. 1% of its original forest cover is now protected by reserves and most remaining forest patches are privately owned and less than 50 ha in size (Ribeiro *et al.* 2009).

Land Use Regime in Restoration Reserves and Funding Opportunities

As described above, the creation of governmental reserves in human-modified landscapes has been hampered in the last years by the lack of very large forest remnants to justify public investments. In this scenario, instead of creating public reserves by expropriating private lands, governments could induce and incentivize the creation of private reserves that use ecological restoration, in a landscape ecology perspective, to support biodiversity persistence in highly-fragmented landscapes. To guarantee a long-term protection of RR in privately owned lands, two main public policies could be adopted, as follows:

- Restoration Reserves would be enacted as private reserves and would be targeted by the government as priority areas for biodiversity conservation and, consequently, for implementing offsetting policies. Therefore, many public policies that require restoration efforts for mitigating and/or compensating environmental degradation, such as biodiversity offset policies and laws requiring restoration of riparian buffers, as well as public-funded PES programs, would be concentrated in such priority areas.
- Restoration plantings in RR would be managed to produce forest products via formally instituted management assisted by experts. In this strategy, ecological restoration would be implemented through models designed for exploiting timber and non-timber forest products (see an example of such models in Brancalion *et al.* (2012a)). The main economic incentives for this strategy would be the creation of attractive loans and credit lines for entrepreneurs interested in producing timber and non-timber forest products from native species.

Promoting Biodiversity-Friendly Landscapes in Restoration Reserves

Fortunately, restoration initiatives have received a growing financial support from both private and public sectors worldwide (Aronson & Alexander 2013) what may give rise to both public and private incentives for establishing RR. The major funding sources has been biodiversity offset policies (Maron *et al.* 2012), law compliance (Ruiz-Jaen & Aide 2005; Calmon *et al.* 2011), market demands for environmental certification of agricultural products (Rodrigues *et al.* 2011; Melo *et al.* 2013b), commercialization of forest products from native species (Brancalion *et al.* 2012a) and payments for ecosystem services (Bullock *et al.* 2011). Indeed, it is estimated that the implementation and maintenance of restoration projects may mobilize as much as US$ 18 billion in global investments per year (Menz *et al.* 2013). More than ever, it is necessary to create synergy and complementarity between the growing investments in ecological restoration, and conservation strategies seeking biodiversity persistence in human-modified landscapes.

In the context of RR, forest restoration initiatives should be used to obtain high-quality habitats and for creating biodiversity-friendly landscapes. As forest fragments are exposed to degrading edge effects, including biomass collapse, restoration of degraded lands surrounding key forest remnants is a practical way to coalesce them and thus obtain large blocks of native vegetation, supporting forest interior habitats and forest-dependent species (Figure 1). To achieve this goal, forest habitat must to be protected against human-mediated disturbances and benefit from management procedures aiming to mitigate the degradation imposed by edge effects, including: 1) selective control of hyper-abundant lianas for enhancing recruitment and growth of native tree species; 2) eradication of invasive species; 3) establishment of enrichment plantings to reintroduce or reinforce populations of endemic, rare, and endangered species, as well as key functional plant groups valuable for restoration efforts; and 4) implementation of restoration plantings from the edges of the fragments inward for improving the shape or increasing the area of forest remnants excessively exposed to edge effects (Brancalion *et al.* 2012b).

In addition, forest restoration may contribute for re-establishing ecological corridors i.e., structural connection of forest fragments via linear and more or less narrow strips of forest vegetation, as well as establishing networks of "stepping stones", i.e., extant or restored forest patches acting as relay stations to enhance recreation of habitat connectivity at multiple spatial scales, and thereby permitting higher levels of biological flows. Thus, restoration must be planned and implemented considering large-scale effects, based on a landscape ecology perspective (see examples of biome-, state-, regional-, and local-scale examples in Tambosi *et al.* (2013), Joly *et al.* (2010, Gama *et al.* (2013), and Tambosi & Metzger (2013), respectively).

Advantages of Restoration Reserves

To date, a large amount of resources devoted to ecological restoration has not led to tangible benefits for biodiversity conservation as a substantial number of initiatives would classify as "environmental gardening" rather than an effective way to safeguard biodiversity within human-modified landscapes (Brancalion *et al.* 2013). Even worse, many forests and other ecosystems wherein restoration has been attempted have ultimately reverted to a prior state of degradation, resulting in a waste of investments (Aronson *et al*. 2011) and, presumably, eroded confidence in the possibility of successful restoration. Such disappointing outcomes usually occur in the context of small-scaled initiatives planned with deficient or inadequate restoration protocols. By using the proposed RR approach, public and private funding would be concentrated in regions with better cost-effectiveness for biodiversity conservation, since the use of a landscape ecology approach for planning restoration projects would allow the selection of areas with reduced land opportunity cost, reduced implementation costs as a result of higher site resilience, and higher chances of ecological sustainability due to the better integration of restoration patches with existent forest remnants (Leite *et al*. 2013). Thus, we would have restoration projects designed under a well-defined approach for supporting biodiversity conservation, instead of projects implemented elsewhere as a bureaucratic requirement for legislation compliance.

Summing up, instead of stimulating individual, small-scaled and spatially and biologically disconnected restoration initiatives, as has been done in the past by biodiversity offsetting policies and laws requiring restoration in private landholdings, legislation and stakeholders should favour the spatial integration of economically-viable restoration initiatives in landscapes with conservation value, and its protection in the context of legally constituted RR.

Restoration Reserves in the Brazilian Context

Restoration Reserves could be easily included in the Brazilian System of Protected Areas (SNUC, acronym in Portuguese) as a new type of "Areas of Environmental Protection" (APA, acronym in Portuguese). Within RR boundaries, ecological restoration should be stimulated by legal instruments and public policies, such as 1) programs to incentivize Forest Act compliance through the protection and restoration of Areas of Permanent Preservation (APP) and Legal Reserves (LR) (Rodrigues *et al*. 2011); 2) Programs of compensation of the deficit of LR from other regions (the "Bolsa Verde do Rio de Janeiro" - http://www.bvrio.org/ - is an example of a pioneering initiative to facilitate the emergent market of compensation of LR); 3) incentives for producing timber and non-timber forest products in restoration schemes (Brancalion *et al.* 2012a); 4) biodiversity offsetting policies; 5) establishment of "Private Reserves of Natural Heritage" (RPPN, acronym in Portuguese) focused in the restoration of degraded lands (for instance, the Fazenda Bulcão received the RPPN recognition in 1998 without having any significant forest cover, but with the compromise to restore 609 ha); and 6) governmental-funded Payments for Ecosystem Services programs (see examples in Guedes & Seehusen 2011).

The need of the RR approach may be particularly relevant in the context of the recently enacted Brazilian Forest Act (see Garcia *et al*. 2013). This new law has established the possibility to compensate LR outside the state where a private landholding is located. Such a spatial and legal transfer may weaken governance and fiscalization instruments already developed to guarantee that restoration initiatives result in biologically viable or self-sustainable forest patches, i.e., truly restored forests. Notwithstanding, there is a bright side. Spatial transference of offset obligations is only allowed by the revised Forest Act if compensation occurs within the biome at issue, e.g., the Atlantic Forest, and in priority areas assigned or set-aside for restoration. Such transference represents a political and economic opportunity (via trading LR quotas) for adopting the RR approach to optimize farmers' investments in legal and environmental compliance while supporting this new instrument for biodiversity conservation. In this context, agriculturally marginal lands, frequently exhibiting lower opportunity costs, would henceforth be devoted to ecological restoration, attracting stakeholders to invest in the emergent markets of PES and production of timber and non-timber forest products, including trading of LR quotas.

Final Statements

In addition to substantial and well-documented conflicts, there are clear synergisms and complementarities among ongoing and planned restoration initiatives, compliance with environmental regulations, appropriate provision of ecosystem services, agricultural systems, and biodiversity persistence in human-modified landscapes. It is not surprising that restoration ecology has drawn growing interest among scientists and conservation practitioners alike. Our lessons learned from over 30 years' effort and study in the Brazilian Atlantic forest have strongly reinforced the need of dialogue among scientists, practitioners and policy makers for improving the quality and scale of both restoration and conservation initiatives. In this context, RR represents a promising opportunity to connect stakeholders and themes that, despite the fact of being highly connected in the real world of land use, remain treated separately by society. We hope to have contributed to the ongoing debate on these potentially fruitful connections, recognizing that the proposed legalization of RR largely surpass the scope of this short essay.

Acknowledgements

We thank James Aronson, Jean Paul Metzger and an anonymous reviewer for comments that greatly helped to improve the manuscript, Ricardo Gomes César for English review, and Jean Paul Metzger for the invitation for submitting this article to the special issue.

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Received: March 2013
First Decision: May 2013
Accepted: December 2013