GIVING NATURE A HAND

Innovations in planning to assist natural regeneration of forests to mitigate climate change, save species from extinctions, and enhance well-being

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SUMMARY

The climate crisis impacts the lives of hundreds of millions of people worldwide. Unless the global community can achieve net removal (negative emissions) of carbon dioxide from the atmosphere through emission reduction and sequestration, climate change will have catastrophic consequences for billions of people and lead to the extinction of up to a million species. Fostering tree and vegetation growth is a highly cost-effective way of removing carbon from the atmosphere at scale.

Restoring landscapes can contribute to food security and livelihoods, provide protection from extreme weather (flooding, wind and drought), play an essential role in regulating water flows, provide fuel for cooking and heating, and improve and maintain healthy, fertile soils. Restored forest landscapes also provide habitat for a vast diversity of species, many of which provide essential ecosystem services such as pollination and pest control, sources of medicines, and ecotourism. Preventing further deforestation and forest degradation and restoring forests are critical to meeting regional, national and international climate, environmental, and sustainable development goals. Successful forest restoration efforts require prioritizing the most cost-effective and locally appropriate restoration strategies.

It is now possible to leverage the latest social and ecological science to identify and legislate for the potential of assisted natural regeneration of forests – the most-cost effective restoration strategy.

Assisted natural regeneration is critical to scaling up forest and landscape restoration (FLR) and can be complemented by more costly and smaller-scale active restoration strategies based on tree planting.

This report outlines a new approach based on systematic, spatially explicit planning for landscape scale restoration that: (1) guides practices that maximize a variety of long-term benefits, while minimizing restoration implementation costs and reducing impacts on agricultural production, (2) takes into account stakeholders preferences, budget limitations, social needs and other key factors, (3) provides powerful tools for facilitating restoration, and (4) can be used to inform robust policy making. The report provides scientific support for decision makers across government, civil society and the private sector that demonstrate how predicting and prioritizing assisted natural regeneration of forests and enacting specific policies can help reach or even exceed global restoration targets without compromising food security.

TERMINOLOGY

Forest and landscape restoration (FLR)	A strategy that aims to regain ecological functionality and enhance human well-being in deforested or degraded landscapes. FLR is not an end in itself, but a means of regaining, improving and maintaining vital ecological and social functions, in the long-term leading to more resilient and sustainable landscapes (Besseau et al., 2018). This report focuses on assisted natural regeneration of forests as a key strategy for FLR.
Natural regeneration	The spontaneous (meaning unassisted) recovery of forest cover from seeds or rootstocks already present in the soil or newly dispersing from neighboring forests. This type of restoration happens regardless of any kind of human intervention, including site protection, and is often a by-product of unplanned land abandonment triggered by larger socioeconomic forces. In this case, natural succession happens uninhibited and requires no support (Shono et al., 2007; Crouzeilles et al., 2017).
Assisted natural regeneration	In areas that have the socioeconomic and ecological potential to regenerate from the seedbank or neighboring seed sources, but are not doing so or are doing so poorly, human interventions are used to secure, catalyze or enrich the process. Such interventions can include fencing, weed and/or fire control and enrichment planting. Farmer managed natural regeneration, where farmers intentionally manage trees regrowing in their agricultural areas to secure a variety of benefits, is also included here. Assisted natural regeneration does not include intentional and systematic planting of species grown offsite in order to create an agroforestry system (Shono et al., 2007; Crouzeilles et al., 2017).
Restoration planting/ active restoration	The active growth and maintenance of seedlings in nurseries and the planting of seedlings in a systematic way. This includes planting for restoration plantations, woodlots, agroforestry plots, silvopastoral systems or biodiversity habitat corridors. Initial plantings can serve to stimulate natural regeneration where it would not otherwise be possible (Crouzeilles et al., 2017).
Agroforestry and silvopasture	A subset of active land-use management system in which trees or shrubs are grown around or among crops or pastureland.

INTRODUCTION

Human activities have already caused an average 0.87°C of warming over pre-industrial levels, with warming likely to reach 1.5-2°C between 2030 and 2052 (IPCC, 2018). Global warming impacts physical and biological systems in many ways that affect ecosystem services and human well-being. This includes changes to extreme weather conditions such as heat waves, drought and precipitation that can profoundly affect agricultural and ecological systems, and directly impact people by endangering life or property.

Limiting global warming and mitigating its impacts requires substantial reductions in greenhouse gas emissions and increased sequestration of carbon from the atmosphere. Specifically, the IPCC predicts that somewhere between 100-1000 gigatonnes of CO_2 will have to be removed from the atmosphere by 2100 to avoid catastrophic impacts (IPCC, 2018).

Restoration and improved land management (hereto referred to together as "restoration") are some of the most reliable and cost-effective strategies for removing carbon from the atmosphere and storing it, while delivering a variety of other benefits

1. Restoration is a proven strategy that has the potential to be applied at scale and could achieve carbon dioxide sequestration rates of more than 5 gigatonnes per year, or up to 400 gigatonnes by 2100. This is equivalent to over 15% of the total climate mitigation needed to avoid catastrophic climate change impacts by 2030 (Griscom et al., 2017).

2. Restoration provides many other social and environmental benefits above and beyond carbon sequestration, unlike carbon capture and storage technologies, including biodiversity habitat, water filtration, flood control, air filtration, and enhanced soil fertility (Griscom et al., 2017).

3. Restoration is a low-tech, low-risk, low energy strategy relative to some of the high-tech alternatives that can be implemented in a wide variety of places. A recent report found that if carbon capture and storage technologies were deployed today to remove carbon from the atmosphere at scale, they would require more than half of today's global energy consumption (Realmonte et al., 2019).


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In addition to the need to leverage restoration to mitigate future climate change, restoration is an imperative for addressing existing social and environmental challenges. Over three billion people are currently impacted by land degradation worldwide, many of whom live in rural areas with increasingly limited resilience to extreme weather events (IPBES, 2018). Restoring the ecosystems that support rural livelihoods can strengthen a community's resilience, food security, and, in many instances, lower its gender disparities (IPBES, 2018). What's more, every year land degradation is costing 10% of the global GDP (IPBES, 2018). Yet, on average, for every dollar spent on restoration, $10 dollars could be generated in economic benefits (IPBES, 2018). This means that it costs the world more to leave land degraded than it does to restore it. Unfortunately, although governments have committed to restoring 170 million hectares by 2030, less than 30 million ha of land have undergone restoration since 2011 (NYDF Assessment Partners, 2019). Yet more than 0.9 billion hectares of land could be restored without impacting crop production (Bastin et al., 2019).

What is stopping this global potential from being fulfilled? There are many reasons, ranging from inadequate stakeholder coordination to insufficient funding. However, this progress report argues that a main reason is that the most cost-effective method for restoring forests, assisted natural regeneration, is not being properly prioritized.

FOREST AND LANDSCAPE RESTORATION

Forest and landscape restoration (FLR) can be achieved using a variety of strategies, such as natural regeneration, assisted natural regeneration, agroforestry, active restoration using tree planting and commercial forestry or woodlots (Figure 1).

Figure 1. Different restoration strategies can be used for different purposes, and have different tradeoffs.

Each strategy has different associated costs and benefits. In general, active restoration strategies that involve tree planting and site preparation are the most costly and can result in a mix of tree species that can favor direct economic benefits over conservation and carbon sequestration benefits. Conversely, encouraging natural or assisted natural regeneration of forests is far less costly and results in a mix of tree species with stronger conservation and carbon sequestration benefits, but with less options for direct economic benefits (Chazdon & Guariguata, 2016).

Each restoration strategy has its appropriate environmental and socioeconomic context, and a rigorous process of assessing spatial predictive models that identify where each restoration strategy is best suited, with ecological and social on-the-ground validation, is critical for selecting the right restoration strategy (Figure 2).

Active forms of restoration are often favored over natural regeneration: over 45% of restoration commitments by governments to the Bonn Challenge are in the form of monocultural tree plantations, 21% is pledged to agroforestry, and 34% is pledged to assisted natural regeneration (Lewis et al., 2019). Active restoration strategies can be effective at achieving forest restoration over a predictable time frame and with control over the mix of tree species (Chazdon & Guariguata, 2016). This can include economically valuable species used for food or timber production.

However, active restoration strategies are labor intensive and expensive, costing between US$ 1,400 and 34,000 per hectare worldwide (Crouzeilles et al., 2017). These strategies can also result in restored forests that have less value for biodiversity or carbon sequestration compared to naturally regenerating forests (Chazdon & Guariguata, 2016; Crouzeilles et al., 2017). On average, monocultural tree plantations have been found to sequester 40 times less carbon than forests undergoing natural regeneration when tree harvesting is taken into account (Lewis et al., 2019).

Decision makers often favor historically more predictable, faster and intensive active restoration strategies over assisted natural regeneration of forests for at least five reasons. Assisted natural regeneration:

1. Is not part of the culture of resource management agencies.
2. Has limited knowledge available to guide policies and actions regarding where it occurs and could potentially occur, how much area could be regenerated, and how long it could persists and takes to deliver specific outcomes.
3. Lacks sound economic projections and business models based on assisted natural regeneration of forests to evaluate socio-economic effectiveness.
4. Has not been considered an activity requiring human agency and therefore cannot be enforced as a policy.
5. Is affected by some pervasive policies, such as agrarian reform laws that obligate farmers to cultivate land, and authorities can confiscate uncultivated land.

In order to meet international carbon sequestration targets, millions of hectares of forest must be restored within forest biomes, and this is only feasible using a highly cost-effective strategy.

It is prohibitively expensive to achieve such targets through active restoration alone. For example, the ambitious Bonn Challenge commitment to restore up to 350 million hectares of global degraded and deforested lands by 2030 could potentially cost between US$ 4.9 and 12 trillion if active restoration is the only restoration strategy implemented (Crouzeilles et al., under review). In contrast, as one example of an assisted natural regeneration strategy, excluding cattle from pasture land with an inexpensive barbed wire fence may be all that is required to facilitate natural regeneration of forests.

Meeting global objectives for FLR will require drawing on the full portfolio of restoration strategies and sustainable land uses for agriculture and forestry. There are many areas of the world where, for social and ecological reasons, assisted natural regeneration of forests is not a viable option. In these areas, appropriate forms of active restoration need to be selected and prioritized.

However, assisted natural regeneration of forests remains the most cost-effective restoration strategy for regaining ecological integrity and removing carbon from the atmosphere (Crouzeilles et al., 2017).

A recent estimate based on the amount of forest cover surrounding a landscape suggest that 238 million hectares of restorable lands within tropical and temperate forest countries are promising candidates for assisted natural regeneration of forests, yet only a small percentage of this potential is being fully harnessed (Crouzeilles et al., in press).

The key to unlocking the full potential of natural and assisted natural regeneration of forests lies in identifying those areas where this strategy is likely to proceed well from both social and ecological perspectives (Crouzeilles et al., under review). This report presents an approach for identifying where to restore and what strategy to use based on spatial predictive models, quantitative planning and optimization methods that identify priority areas for cost-effective restoration.

The approach presented in this report is part of a five step planning process:

1 → **Engage and understand** stakeholders' needs and preferences when targeting, planning and implementing forest restoration initiatives.

2 → **Identify** areas where assisted natural regeneration of forests is feasible and where there is a need for active restoration.

3 → **Balance** trade-offs and develop a concrete, spatially explicit and policy supported restoration strategy.

4 → **Validate, disseminate and work with** key stakeholders to operationalize the strategy.

5 → **Monitor** impacts and return to step 1 to adaptively manage.

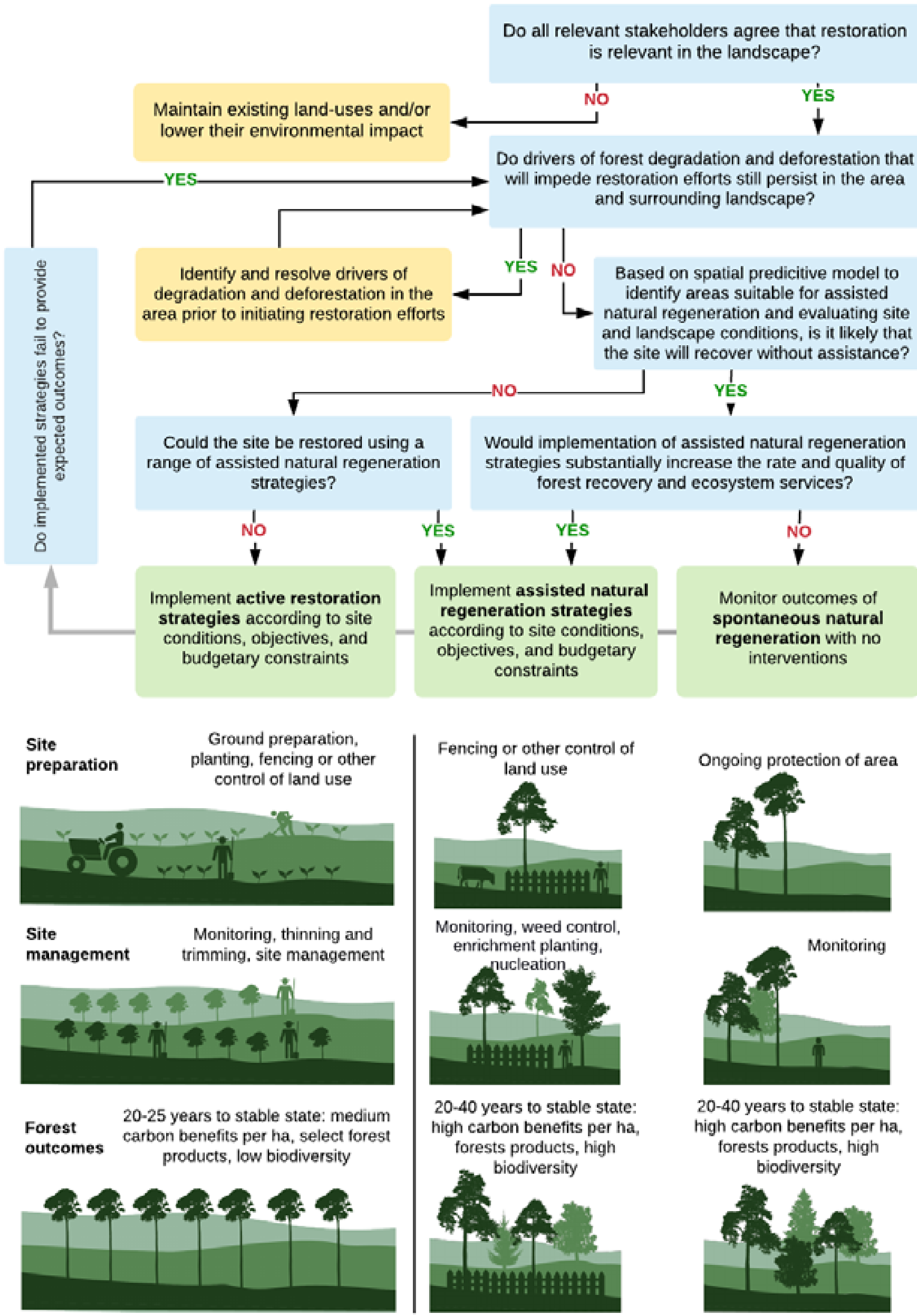

Figure 2: Decision tree to help determine when to use natural regeneration or assisted natural regeneration versus active restoration, and the associated benefits and costs of the different approaches.


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IDENTIFYING AREAS WHERE ASSISTED NATURAL REGENERATION OF FORESTS IS FEASIBLE

Secondary forests (forests that have regrown after they've been cut or degraded) are often derived from spontaneous natural regeneration. Secondary forests that are less than 140 years old are estimated to cover 2.63 billion hectares worldwide (Pugh et al., 2019). Within the lowland Neotropics, 290 million hectares of forests (33%) were estimated to be less than 100 years old in 2008 (Chazdon et al., 2016). Secondary forests are a major component of overall forest cover and will make increasingly important contributions to meeting both international carbon sequestration and restoration targets.

“The challenge is to identify strategies that reduce the uncertainties associated with where assisted natural regeneration of forests can occur and persist, while maximizing the multiple benefits arising from forest restoration” (Crouzeilles et al., 2017).

The history of natural regeneration of forests in recent decades provides a basis for developing “spatial predictive models” of where assisted natural regeneration is likely to be feasible in the coming decades. Such models can account for a wide range of biophysical, ecological and socioeconomic factors and can have high predictive accuracy. Spatial predictive models that have strong accuracy are particularly useful for informing management plans because higher certainty in management outcomes can reduce the need to invest in risk assessment and mitigation measures.

Recent work (Crouzeilles et al., under review) has addressed these issues in Brazil’s Atlantic Forest, a 130 million hectare biome that is one of the world’s most threatened biodiversity hotspots and one of the largest forest restoration opportunities in tropical regions (Brancalion et al., 2019). Widespread deforestation over the last centuries has spared only 34.1 million hectares (26.4%) of the original forest cover, including many highly-fragmented remnants. However, between 1996 and 2015, at least 2.7 million hectares are estimated to have regenerated naturally, mainly due to land abandonment and restrictions on deforestation (Crouzeilles et al., under review). This area is equivalent to 8% of the existing remnant forest area. Based on these patterns, spatial predictive models were built using physical variables (e.g., elevation, soils, climate), ecological variables (e.g., distance to intact forests) and socioeconomic variables (e.g., population density) that have an 80% accuracy rate in predicting where assisted natural regeneration of forests is likely to occur during the next 20 years (Figure 2).

The model indicates that an additional 21.6 million hectares, out of almost 70 million hectares available for restoration, could be suitable for assisted natural regeneration, assuming that factors preventing forest recolonization are excluded.

At the global scale, tree coverage (i.e. new forests) could take place in 0.9 billion hectares – almost the size of the United States (Bastin et al., 2019) – yet the potential for assisted natural regeneration of forests remains to be fully studied.

The authors on this report are currently developing, for the first time, a global spatial predictive model and map of the potential for assisted natural regeneration of forests within tropical regions,

which is based on the same method developed by Crouzeilles et al. (under review). Predictive models can help to resolve the key uncertainty around where assisted natural regeneration of forests is likely to be feasible if key processes preventing natural regeneration are eliminated.

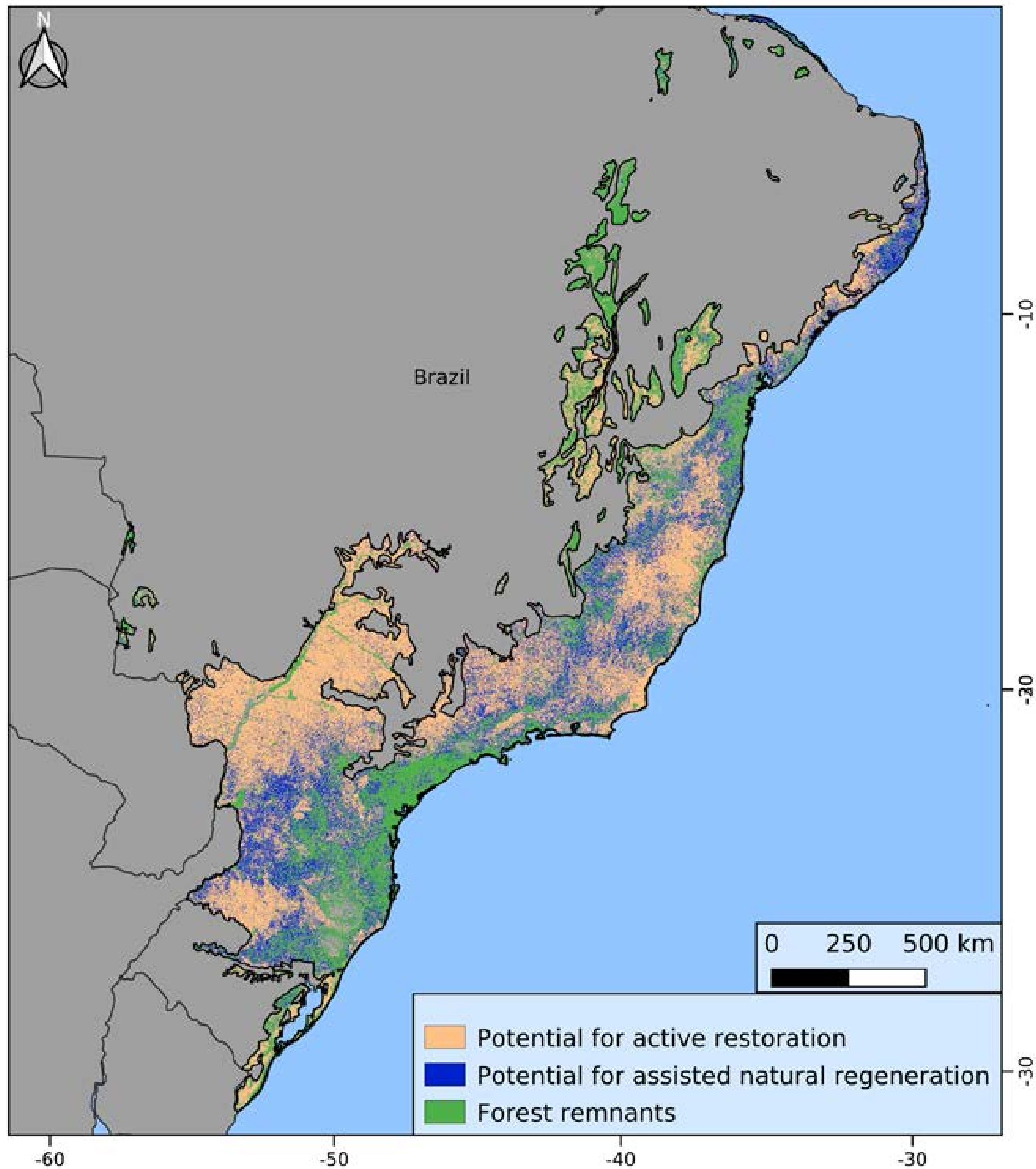

Figure 3: Case study of how to predict and map the potential for assisted natural regeneration in the Brazilian Atlantic Forest (from Crouzeilles et al., under Review). In this study, the predicted potential for assisted natural regeneration in the Brazilian Atlantic Forest is at 30 x 30 m resolution.


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BALANCING TRADE-OFFS TO MAXIMIZE OPPORTUNITIES

There is substantial variation in the expected economic, carbon sequestration and conservation values that can be derived from forest restoration, depending on where investments occur (Strassburg et al., 2019). Variation in biophysical conditions that affect growth rates and carbon sequestration rates, and surrounding landscape conditions, influence the conservation and biodiversity value of restored patches of forest. Some restored forest patches are likely to benefit many more species than others, depending on the location of the patch in the landscape and how close and well-connected those patches are to other forested areas.

Similarly, a restoration strategy must be suitable to the socioeconomic and community context within which it is implemented, both to respect local needs and to reduce the risk of project failure. Thus, determining where to prioritize forest restoration can profoundly impact the benefits derived from it.

As this variation in expected benefits can be described spatially, we can adopt "systematic planning" methods that minimize conflicts and maximize the benefits derived from forest restoration. More specifically, we can identify priority areas for restoration that perform well against a suite of potential benefits while minimizing costs. These methods are also used to describe trade-offs among competing objectives (e.g., carbon sequestration and food security) in order to help planners identify optimal, cost-effective solutions.

An analysis in the Brazilian Atlantic Forest found that systematic planning based on optimization methods (linear programming) can achieve an eightfold increase in cost-effectiveness for biodiversity conservation in a scenario that seeks to maximize benefits to species' conservation, compared with a baseline of non-systematic restoration planning (Strassburg et al., 2019).

A compromise solution seeking to balance benefits for both climate change mitigation and biodiversity conservation while limiting

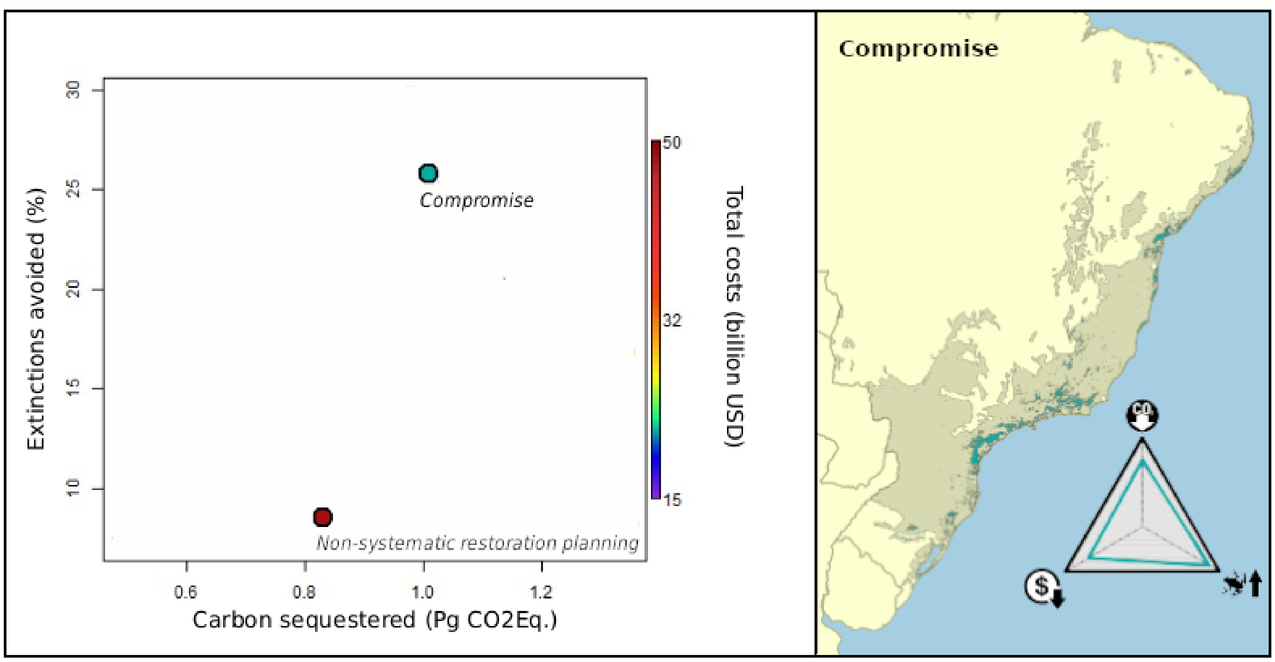


Figure 4: Case study of multi-objective planning and restoration prioritization in the Brazilian Atlantic Forest (Strassburg et al., 2019). In this study, scenarios analyses are used to compare compromise planning (seeking to maximize biodiversity conservation and climate change mitigation while minimize restoration costs) to non-systematic restoration planning approaches, among others.

costs would avoid 26% of the current extinction debt in the Brazilian Atlantic Forest (2,864 plant and animal species) and sequester 1 billion tonnes of CO_2-equivalent.

Compared to a baseline of non-systematic restoration planning, these results predict an increase of 257% in avoidance of species extinction, a 105% increase in carbon sequestration and a 57% decrease in restoration costs (Figure 4).

Using optimization methods based on linear programming to inform planning has at least four main advantages (Strassburg et al., 2019). They:

1. Are able to identify solutions that are optimized across a number of key stakeholder interests, including costs and environmental benefits. These solutions often outperform not only plans that are simply identified opportunistically or in non-systematic ways, but also conventional systematic planning methods by more than 33% (Beyer et al., 2016). In particular, they can result in highly cost-effective solutions that achieved greater overall benefits with limited resources.

2. Provide an explicit framework for describing trade-offs among objectives and identifying suitable compromises between them.

3. Provide a transparent, objective and defensible framework for planning.

4. Can also be used to reduce risk by identifying solutions that are robust to uncertainty. Such decision support approaches cannot solve all problems and shouldn't be thought of as a replacement to extensive stakeholder engagements. However, they can be used to inform more strategic and cost-effective decision making among stakeholders. Once robust plans are developed, restoration practitioners can draw from existing guides to implement assisted natural regeneration (see FAO, 2019) and combine it with active restoration methods.

POLICY RECOMMENDATIONS

Assisted natural regeneration of forests can be used to help countries meet their nationally determined contributions (NDCs) to the Paris Agreement, post-2020 targets under the Convention on Biological Diversity (CBD), Land Degradation Neutrality targets, as well as increase ecosystem service provisioning to rural communities (e.g., pollination, soil control, and water quality/quantity) and urban areas (water quality, food).

Our recommendations for maximizing the potential of assisted natural regeneration of forests to meet those targets include:

1. Legislation that requires landowners to maintain specified levels of native forests on their land (e.g., Brazil's Native Vegetation Protection Law)

2. Legislation governing land clearing and penalties for illegal land clearing (e.g., Australia's Environmental Protection and Biodiversity Conservation (EPBC) Act)

3. Science-driven legislation governing offsetting (replacing lost forest) when land is legally cleared for development, including minimum offset ratios (such as five hectares restored for every one hectare cleared), and adapted to specific ecosystem types (e.g., US wetland mitigation banking under the Clean Water Act)

4. Legislation requiring ranchers to provide shade trees for animal welfare and production purposes, which could be supported by regulated labeling of ethically produced food products (e.g., Argentina's cost-sharing program for improved forest cultivation ; case study)

5. Policies that encourages integrated landscape management to ensure that forest restoration achieves many benefits including carbon sequestration, biodiversity conservation, erosion and runoff reduction (watershed management), freshwater supply management and economic value (e.g., Rwanda's ongoing environmental policy integration work)

6. Incentive programs that provide payments for ecosystem services and provide technical assistance to encourage landowners to restore forests on their land (e.g., Costa Rica's Forest Law 7575)

7. Incentive programs for sustainable production of timber and non-timber products from naturally regenerating forests (e.g., the US state of Vermont's Value Appraisal Forestland Tax Program)

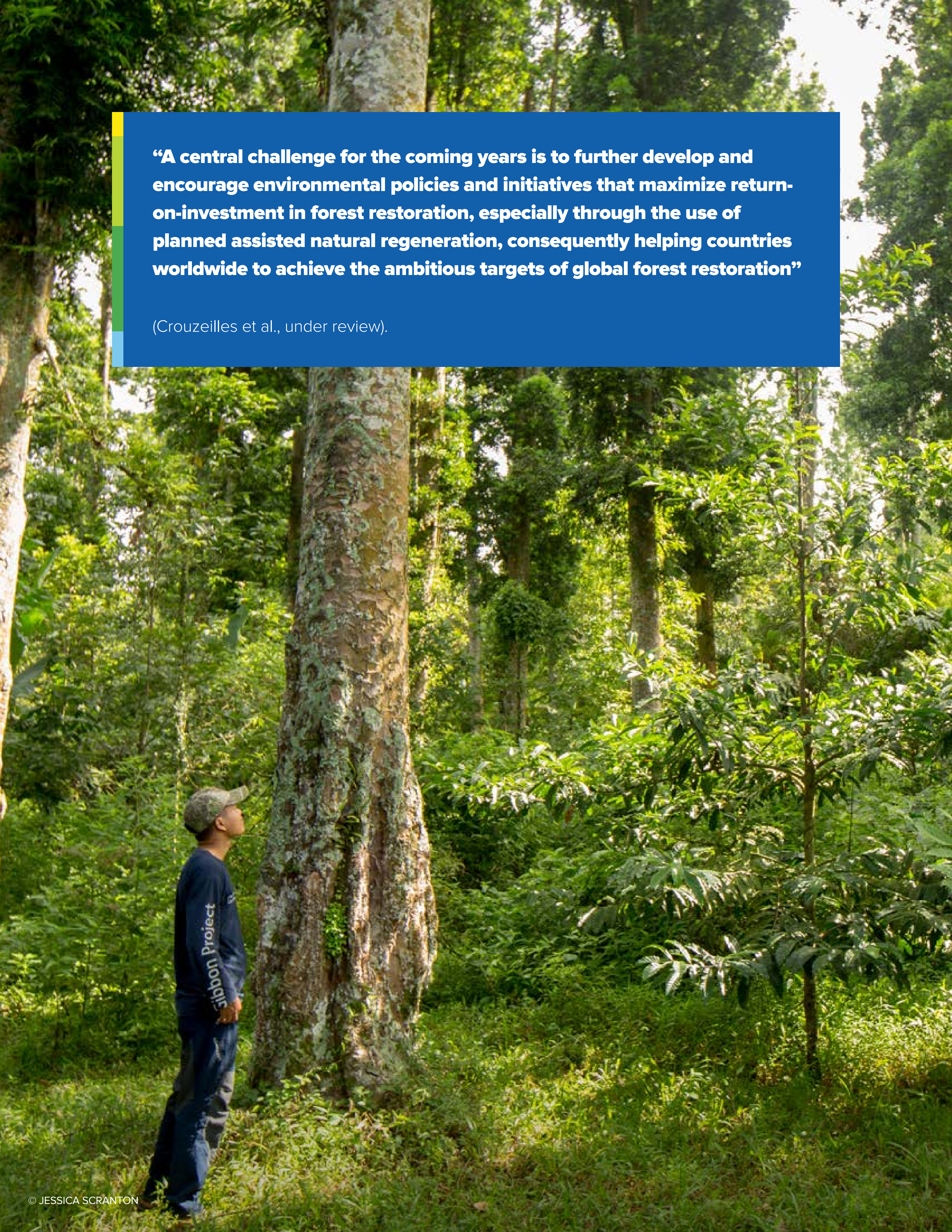
8. Incentive programs for sustainable forestry based on native species and agroforestry, to be applied as a complement to assisted natural regeneration of forests and to provide alternatives that produce economic benefits for landowners (e.g., Panama's Law No. 69 of October 30th 2017)

9. Financing for monitoring and enforcement of environmental laws governing forest loss and regrowth (some examples can be found here)

10. Establishing market trading schemes for environmental offsets, thereby allowing some landowners to maintain high levels of agricultural production (e.g., Germany's production-integrated compensation (PIC) program)

“A central challenge for the coming years is to further develop and encourage environmental policies and initiatives that maximize return-on-investment in forest restoration, especially through the use of planned assisted natural regeneration, consequently helping countries worldwide to achieve the ambitious targets of global forest restoration”

(Crouzeilles et al., under review).



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CONCLUSION

Assisted natural regeneration of forests to maximize carbon sequestration and support biodiversity is a better alternative than active restoration in many contexts (Crouzeilles et al., 2017; Nunes et al., 2017). Identifying the specific contexts where assisted natural regeneration has a high likelihood of success is a fundamental step in restoration planning at regional and national scales. Traditional drawbacks associated with assisted natural regeneration, such as uncertainty over where assisted natural regeneration is feasible, can be effectively reduced using an approach based on scientific research and modeling methods (Figure 2).

The substantially lower costs associated with assisted natural regeneration mean that it is a key strategy for achieving FLR at scale relevant to meeting international climate mitigation and restoration targets. Spatially explicit, systematic planning based on optimization methods that account for costs and a range of objectives can be used to identify opportunities to greatly improve the benefits derived from landscape-scale forest restoration programs (Figure 3). These scenarios for the spatial planning of assisted natural regeneration of forests can then be validated and used during community-led landscape planning workshops to facilitate discussions about priorities and trade-offs. Ultimately, such spatial planning tools should be used to inform the design of local and national restoration policies.

The UN has announced that 2021-2030 will be the Decade of Ecosystem Restoration from 2021-2030. We now have less than 10 years to remove massive amounts of carbon from the atmosphere to avoid climate catastrophe. The time has never been more appropriate to ensure the best science is used to deliver on the many promises of restoration. The organizations on this report are actively working to deliver easy-to-use decision support tools for policy makers, funders, and entrepreneurs to identify where natural regeneration is likely to occur and how to unlock its potential. The upcoming first ever global map on the potential for assisted natural regeneration could revolutionize restoration planning, radically reduce restoration costs, and help land managers understand their ecosystems to harness nature's inherent resilience.

It is crucial governments, civil society, and the private sector come together to embrace, and act on, assisted natural regeneration as a priority for fulfilling the planetary needs.

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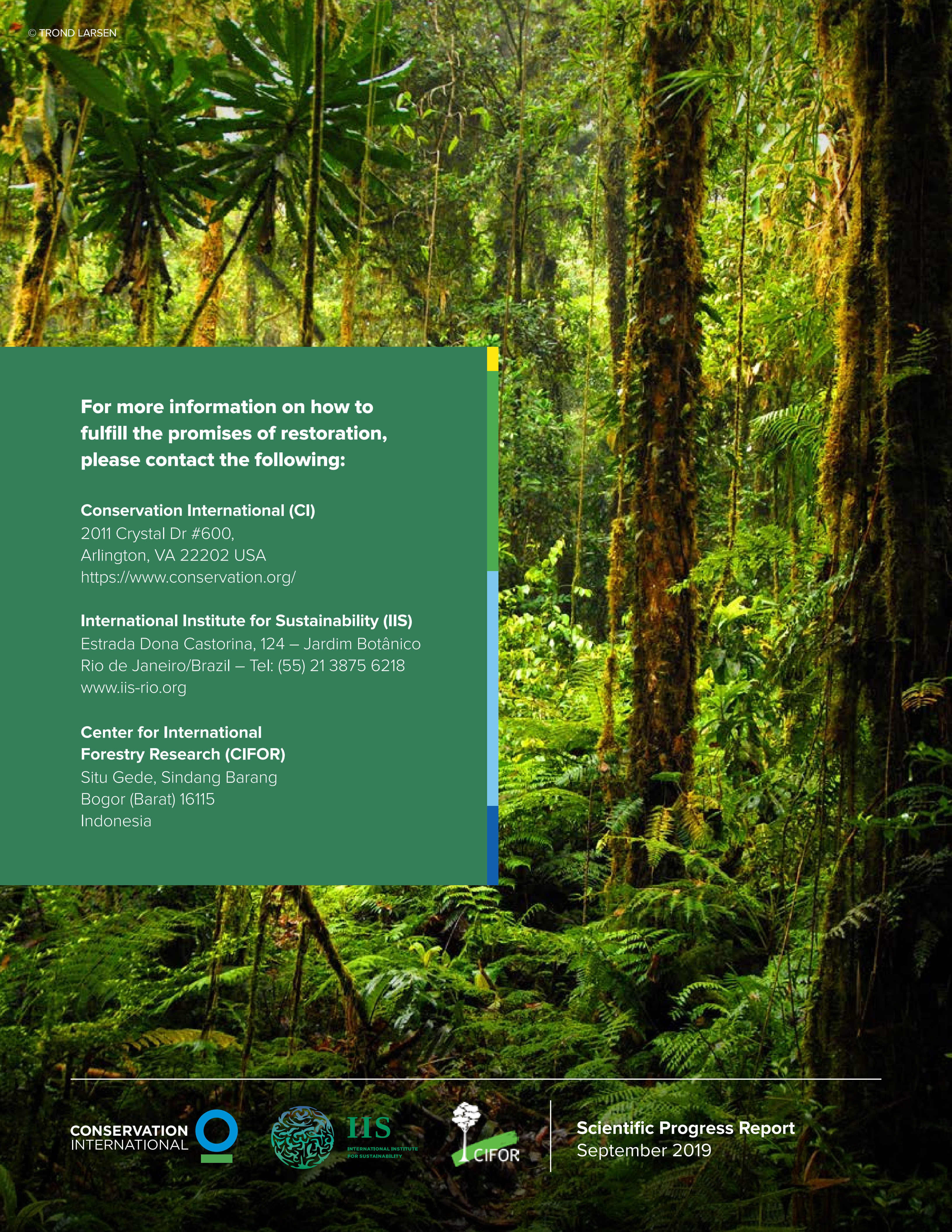

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