EXTENDING TREE PLANTING EFFORTS:

Applied Nucleation as a forest restoration strategy

CONSERVATION INTERNATIONAL

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Forest restoration is receiving unprecedented global attention. The UN Decade on Ecosystem Restoration (2021-2030) aims to "massively scale up restoration efforts of degraded and destroyed ecosystems as a proven measure to fight the climate crisis and enhance food security, water supply and biodiversity" (1). Given the critical role that conserving and restoring forests plays in climate change mitigation and adaptation, major tree-planting and forest restoration commitments have launched in the past few years. Support and publicity for tree-planting efforts is increasing from public, private and corporate sectors.

Despite the global attention, resources allocated for restoration are still insufficient to meet global targets. Both additional funds and more cost-effective ways of restoring forests are needed (2). Applied nucleation (AN) makes tree-planting resources and efforts go farther. Instead of planting trees over the entire area to be restored, trees are planted in 'clusters' or 'tree islands' that enable and accelerate forest recovery, working with natural regeneration processes. This approach uses tree planting at a much lower intensity and cost than traditional methods to achieve similar results over time.

MAKING THE MOST OF THE GLOBAL TREE-PLANTING MOVEMENT

Tree planting is only one option for restoration, and it works better in some contexts than others (3–5) (Box 1; Fig. 1). Most reforestation projects employ plantation-style tree planting without considering whether and how much planting is needed to help forests recover (6). But inefficiently designed or unnecessary tree planting can drain resources (time and money), and in some contexts even damage the ecology of recovering forests (7–9).

Practitioners and donors should choose restoration strategies based on local economic

and social needs, ecological site conditions, and the surrounding landscape (4) (Fig. 2). Tree planting can be especially effective where land is highly degraded, or where people require direct income from the land (5, 10, 11). In other places, forests can grow back naturally, and protecting the areas to be reforested from disturbances (such as fire and grazing) can be a lower-cost restoration option (12). Applied nucleation is most appropriate in the middle ground where natural recovery is possible, but is progressing slowly. The AN method holds great promise to make tree planting efforts go farther in a range of tropical contexts (8, 13).

HOW DOES APPLIED NUCLEATION WORK, AND WHY USE IT?

Applied nucleation involves planting small tree islands spaced over the landscape (Fig. 2). These islands 1) attract seed dispersers; 2) create shade to suppress unwanted plants, 3)improve other conditions that enhance tree growth; and 4) provide a seed source for the surrounding landscape. Planted islands make the environment more favorable for forest tree species arriving later, so over time the developing vegetation patches expand and merge together (14) (Fig. 3). In this way, AN helps the surrounding landscape regenerate more quickly than by natural regeneration alone.

Natural Regeneration

In many places, forests may be able to regenerate naturally, and **forest recovery can be achieved by simply protecting these regrowing forests.**

Plantations

Plantation-style tree planting — **where a diversity of native tree species are planted in regularly spaced rows over the entire restoration area** — can be especially effective in degraded areas, and/or areas far from remnant native forests, that are unable or slow to recover unassisted.

Applied Nucleation

Applied nucleation **involves planting strategic islands of trees to accelerate natural forest recovery.** This method is most appropriate in areas where some natural recovery is possible, and can make tree planting efforts go farther in a range of tropical contexts.

Figure 1: Common forest restoration techniques: natural regeneration, plantation-style planting, and applied nucleation.

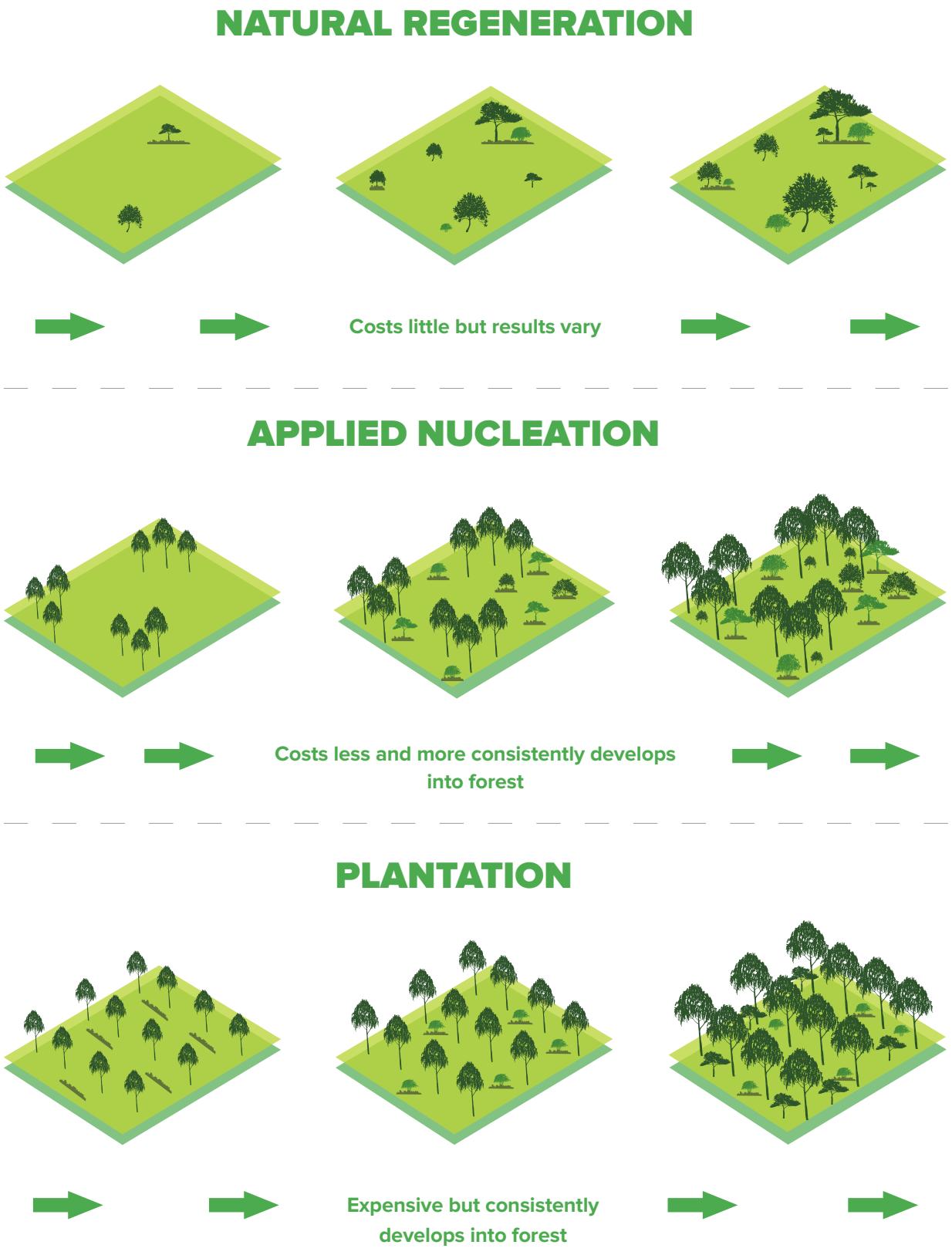

Figure 2: The process and outcomes of natural regeneration, applied nucleation, and plantation-style planting over time (adapted from (14)). For the sake of simplicity, only one tree type is illustrated as being planted, and all the other species colonize naturally. In reality, both tree nuclei and plantations would ideally include multiple species.

Applied nucleation is a good option in places where forests can regenerate naturally (abiotic and biotic conditions are suitable) but the process is slowed by site conditions such as degraded soil/seedbanks and/or could use additional species for social or ecological purposes. The AN process relies on the forests and trees around the site as seed sources: protecting remnant forests and trees is essential.

APPLIED NUCLEATION CAN MAKE TREE PLANTING FUNDS GO FARTHER

Where conditions are right AN can help restore forests as well as traditional tree planting but at lower cost and effort. For example, plots planted using about 25% of the trees as nearby plantation-style plots showed similar degrees of recovery (canopy closure, numbers of new trees regenerating, and species richness) after 10-15 years (13, 15). The appropriate planting intensity for a given site depends on 1) the resources available and 2) how fast forests can regenerate naturally. Applied nucleation is likely a good option for large-scale forest restoration commitments (13), but larger scale tests of this method are needed.

AN is less expensive than traditional tree-planting methods (16) because the costs of planting and maintaining trees are scaled to the area planted. Other costs, such as compensating landholders/other land-use related costs, project planning and monitoring costs are similar for AN, tree planting, and natural regeneration.

APPLIED NUCLEATION TO RESTORE LARGE AREAS

AN holds great promise for restoring forests at large scale, with less cost and effort than traditional tree planting within comparable timeframes. Strategies for adapting AN to larger scale include:

1. **Use AN to accelerate forest recovery in areas where NR is possible but slow.** Within a landscape, determine what areas are most suitable for AN versus other techniques. For example, in a degraded landscape, assisted natural regeneration could be used around the forest edge, AN at farther distances from existing fragments and

Figure 3: Summary of the costs and benefits of different commonly used restoration techniques over the first 15-20 years (adapted from 2). Note that benefits and costs are context dependent - in some degraded sites natural regeneration is slow or unable to occur and would show far fewer benefits. In this figure it is assumed that the site would be amenable to any of the three restoration techniques. The land degradation metric is suggesting when natural regeneration vs applied nucleation vs plantations interventions should be applied (along a gradient of increasing degradation).

trees, and more intensive planting in highly degraded areas or areas far from remnant forest.

2. **Combine AN with other forms of restoration to meet different social goals and legal requirements.** For example, in an agricultural landscape AN might be most appropriate to protect watersheds and on marginal agricultural land, while intensive planting of woodlots and agroforestry systems could be used in and around working farmland.

3. **Design the plantings to meet specific project goals and constraints.** Planting intensity, island size and configuration, species choice and other design elements can all be modified to suit ecological conditions, project goals and timelines, and budgets. For example if full canopy cover is desired rapidly and funding is available, a larger percent of the area (such as 30% or even more), can be planted initially.

SOCIAL AND POLICY CHALLENGES AND CONSIDERATIONS

Applied nucleation is not yet widely used or recognized as a restoration technique, which presents some challenges to implementation. Often people expect restoration to be orderly and to see immediate results. Planting trees in rows can match these expectations, but naturally regenerating areas as take time to grow into a "forest", and may be considered unused or barren (13, 18, 19)(Wilson, unpublished data), and have a greater risk of being cleared (20, 21). Even though in some places natural regeneration is a legally recognized restoration technique, naturally regenerating forests generally do not provide visible evidence of land use in the way that tree planting or agriculture do (22–24).

Applied nucleation can also appear messy but has the advantage of including an active tree planting component, which can be used to engage people and demonstrate investment in the land. To help overcome some of the social barriers to natural forest regeneration, trees can be strategically planted based on local policies and practices. Some examples are:

1. Demonstrate that land is being used (e.g., by configuring plantings to define property lines).
2. Engage communities in all steps (land protection, design, monitoring, maintenance, seed collection, planting, etc).
3. Use tree nurseries and planting as a way to engage communities and provide employment.
4. Place islands closer together to make it easier to see that land is being managed.
5. Plant locally valuable (cultural or economic) species in islands to increase ownership and investment (24, 25).
6. Create demonstration sites where people can see firsthand how effective AN can be.
7. Outreach to landholders in the early stages of implementation may be necessary for widespread adoption and stewardship (23).

TO LEARN MORE

- Conservation International's Applied Nucleation Guide provides a more detailed synthesis of the latest science on AN to provide practical guidance for planning, implementing, and learning from applied nucleation.
- Conservation International's Giving Nature a Hand provides information on alternative restoration techniques, including policy considerations and high-level implementation advice.

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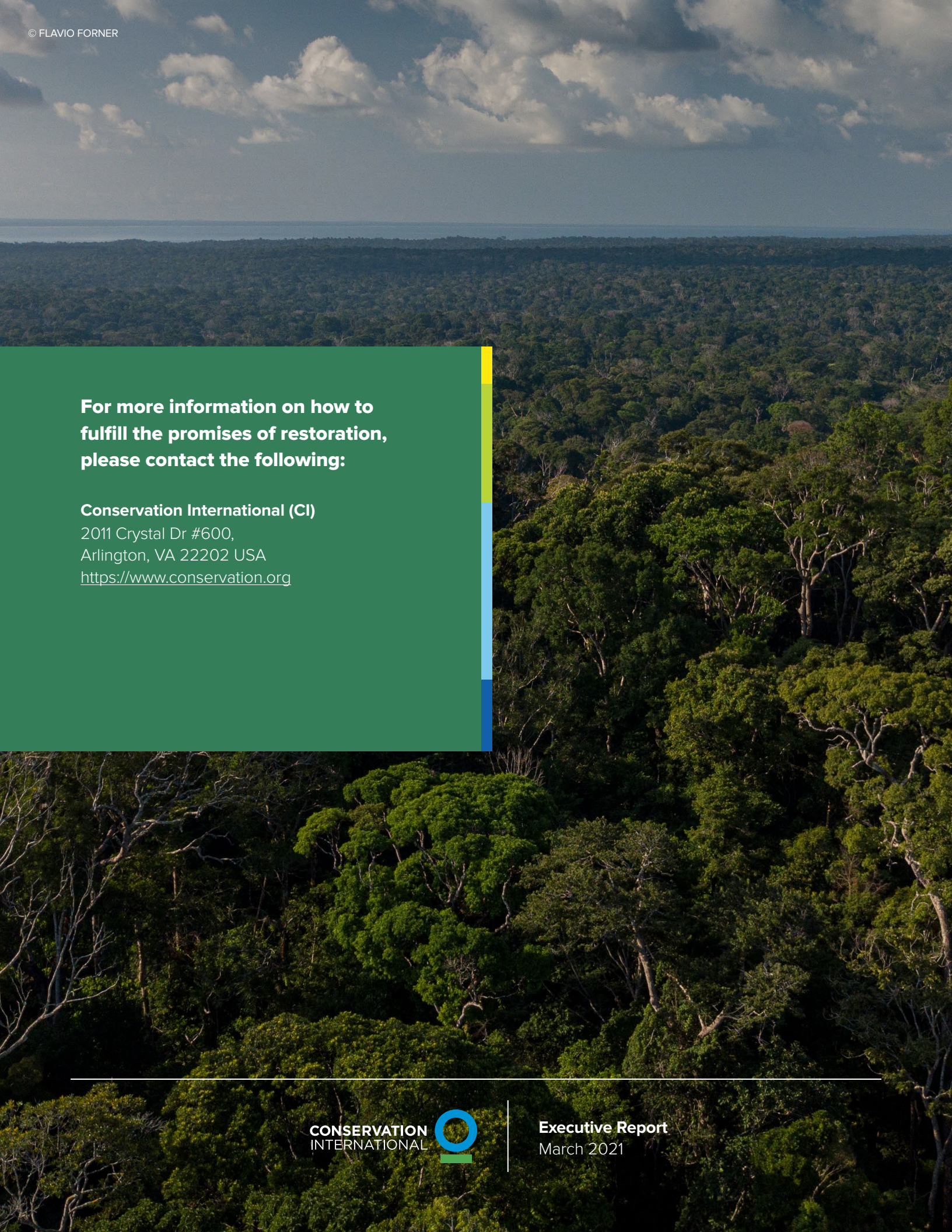

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