ASSISTED NATURAL REGENERATION: A GUIDE FOR RESTORING TROPICAL FORESTS

CONSERVATION INTERNATIONAL

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EXECUTIVE SUMMARY

Innovative and cost-effective ways of restoring forests are urgently needed to meet global restoration and climate targets, and provide forest benefits at scale. Assisted natural regeneration (ANR) works with natural recovery processes to reforest degraded landscapes. Where the conditions are right, it holds great promise to restore biodiverse forest at scale.

In many deforested places, trees can grow from seeds and roots. But these young recovering forests are often at risk of being cleared, grazed, or burned. ANR accelerates the natural recovery process by protecting regenerating trees. Suppressing fire, preventing grazing, caring for individual trees, removing invasive plants, and strategically planting supplemental trees are common techniques (13, 19, 20, 25; Figure 1).

ANR works best in places where trees can grow back naturally but need help to thrive (13, 26; Figure 3). Moderately to lightly used sites with a relatively short time since clearing and that are close to native forests are good candidates for ANR. Social conditions are also critical, and ANR typically works best where the opportunity cost of the land is low, or where landholders and communities have stable land tenure and stand to benefit from having natural forest return to the landscape (e.g., rely on forests or forest ecosystem services).

When used in appropriate contexts, ANR:

- Is a cost-effective approach to restoring natural landscapes. It often costs less than tree planting, but is more reliable and sometimes faster than natural regeneration alone.
- Produces comparable (or better) biodiversity and carbon results than tree planting. In the wrong contexts planting trees can make forests more homogeneous, reducing biodiversity and leaving them vulnerable to disease. Where forests can recover, encouraging natural regrowth can boost biodiversity and carbon benefits.
- Can be readily adopted by local landholders with proper training. Because ANR does not require setting up nurseries and planting trees, local restoration practitioners and landholders may be able to adopt techniques more quickly when provided with high quality technical training.
- Is readily scalable. Because less effort and inputs are required, ANR can be used to restore larger areas.
- Allows for community engagement. Once communities understand the pros and cons of ANR, it gives them a more complete and nimble toolbox of restoration strategies. Building fences and tending trees provide local engagement opportunities. In some cases, selective tree planting can also introduce economically, culturally, or ecologically important species.
- Is applicable in a wide range of contexts. ANR has been successfully used in both tropical and temperate areas, and over a wide range of elevations and ecosystem types. There are large areas of the tropics where natural succession could be enhanced, and are thus suitable for ANR.

Planting green firebreaks in La Coulée.

Designing and implementing ANR requires a series of steps, including:

1. Deciding where and when to use ANR versus other techniques (like tree planting). Identifying areas suitable for ANR, where some forest recovery is possible but it could be accelerated is a key first step.

2. Understanding the policy context. Are policies amenable to allowing ANR to meet restoration requirements? Do perverse policies encourage landholders to clear regenerating native forests? These questions should be researched prior to using ANR.

3. Assessing the local needs and experiences with regenerating forests. ANR may be less appropriate than tree planting in areas where people require direct income or specific products from forests.

4. Providing extensive education, training and outreach. Because ANR is not as widely recognized as a conventional restoration strategy as tree planting, providing information about the technique is important. This might include providing signage to post on regenerating areas, outreach campaigns in the community, and demonstration sites.

5. Planning for monitoring and maintenance. Naturally regenerating areas can be less predictable and are also at potential risk of clearing. Monitoring includes choosing appropriate metrics, ensuring that forests remain protected, and determining if desired species are returning to the site.

INTRODUCTION

PURPOSE AND SCOPE

Assisted Natural Regeneration (ANR) uses nature's recovery processes to restore forests. It is a process of protecting regenerating trees and plants to restore forest ecosystems where they have been degraded or converted to other land uses (1). Where conditions are right, ANR can be a cost-effective restoration tool (1, 2). This guide focuses on using ANR to restore forests at scale to mitigate and adapt to climate change, provide benefits to landholders and communities, and conserve biodiversity (3). It will help project developers, practitioners and decision makers assess if ANR is a good fit in a given social and ecological context. It also provides guidance on designing, implementing, and monitoring ANR approaches that are socially and ecologically appropriate, stakeholder driven, and balance competing environmental and social benefits. (4)

WHY ASSISTED NATURAL REGENERATION?

In March 2019, the United Nations General Assembly declared 2021-2030 the UN Decade on Ecosystem Restoration, with the aim 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" (5). Leaders and scientists around the world now recognize that the majority of the world's forests have been destroyed or degraded - about half of the world's original forest cover remains, a third of which has been degraded (6). Recognizing the critical role that conserving and restoring forests plays in climate change mitigation (7, 8) tree planting and forest restoration commitments have multiplied in the past few years — the Paris Agreement, Land Degradation Neutrality goals, the Trillion Trees Challenge, Bonn Challenge, and others — all propose to reforest and restore landscapes at vast scales.

Often, tree planting is promoted as a way to restore forests by industry, governments, and philanthropy. But tree planting is only one strategy for restoring forests (Figure 1), and is not necessarily the most cost-effective (9), locally appropriate option in many contexts (10). Where forests can regenerate naturally, ANR can be used to initiate the forest recovery process, with fewer inputs. In the Brazilian Atlantic forest, for example, ANR was found to be 30-70% less costly than tree planting (9). In the right ecological conditions, ANR can also produce more diverse forests than planting trees (depending on the species planted) (11). Suitable contexts are areas that have the ecological potential to regenerate (for example, viable seeds/tree material at the site; proximity to other seed sources and dispersers), but could benefit from additional assistance and/or protection. Because these conditions are found across large areas of the tropics and subtropics, the potential for ANR is huge (12, 13).

Naturally regenerating forests in SE Asia.

Reforestation at the scale required to meet global restoration targets and significantly mitigate climate change must be cost-effective, long-lasting, and beneficial for local people and biodiversity. To achieve this, restored forests will need to be resilient, diversified, and fit within the broader land use strategies of those who work or live on the land. In the rush to plant trees, alternative strategies that are less well known are overlooked. Used in the right contexts, ANR has the potential to make the most of limited resources and transform global and national targets into implementable plans. This guide describes a process of using ANR to facilitate socially beneficial, scalable and sustainable restoration. This approach produces important co-benefits which ultimately helps to ensure that restored areas are adapted to their site and will persist in the landscape.

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SECTION 1:

WHAT IS ANR, AND WHEN SHOULD IT BE USED?

WHERE DOES ANR WORK BEST?

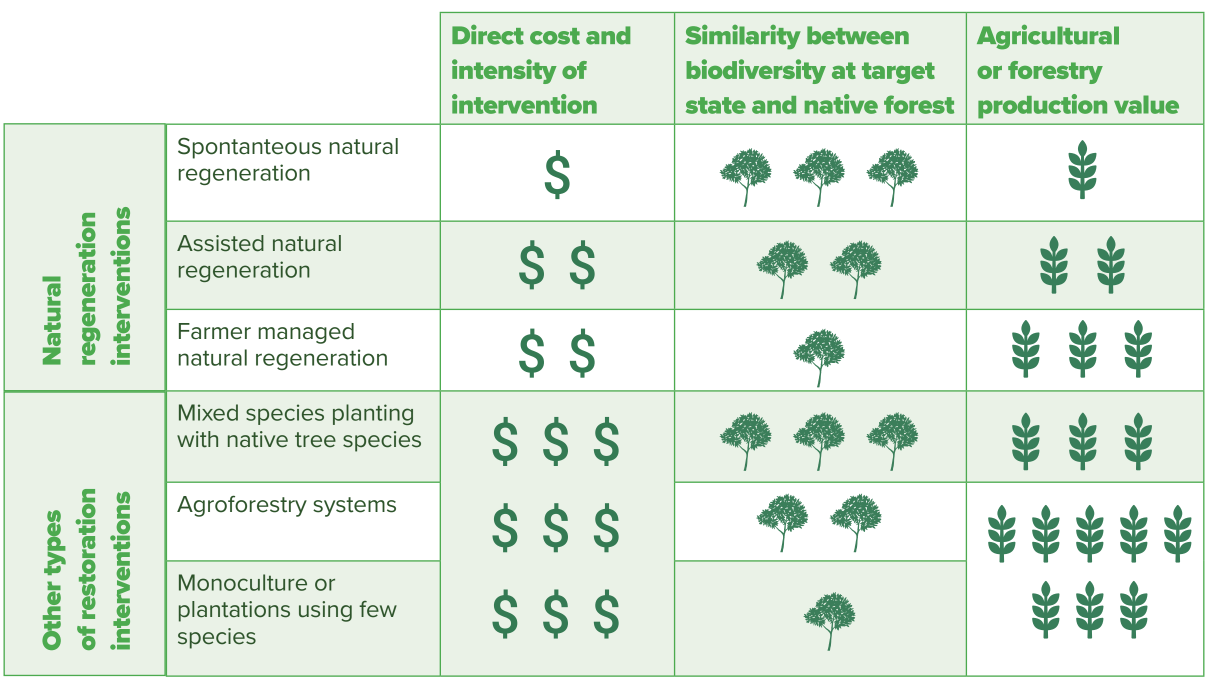
There are many ways to restore a forest (Figure 1). The amount of effort and intervention needed to restore a forest depends on 1) the ecological condition of the site, 2) the landscape context (e.g., are there forests nearby), 3) the livelihood and cultural needs of local peoples, and 4) the local governance structures. Different interventions can also be effectively combined in a single forest landscape, as is illustrated in the Atlantic Forest of Brazil (9).

On one end of the spectrum is natural regeneration (NR), where forests spontaneously regenerate unassisted (14; Figure 1). NR often occurs when land is abandoned or unused for a period, which is often triggered by outmigration, increased reliance on remittances, and other larger socioeconomic forces (15, 16). Where ecological conditions allow, forests grow back naturally when land use ceases.

Tree planting is on the other end of the spectrum. Planting trees can jump start forest recovery in areas where it would not be possible otherwise (Figure 2) or re-introduce key tree species of ecological, economic or cultural importance (17). Tree planting is thus especially effective where forests fail to regenerate well on their own, or where tree planting is needed to generate economic or social benefits for local communities (18). Planting trees in restoration sites, agroforests, silvopastoral systems and woodlots often requires more initial investment (labour, funds) than other natural-regeneration based strategies.

FIGURE 1

The cost, biodiversity, and production potential of methods using natural regeneration and other methods (101).



ANR uses a range of interventions to enhance and accelerate natural forest regeneration. For ANR to work, forests must be able to grow back to some extent. It works best where land use is moderate to light and the land was recently cleared (Figure 2), but where regenerating forests are at risk of being cleared or forest recovery could be accelerated. Interventions generally involve protecting regenerating forest and/or tending to individual regenerating trees (13, 19, 20; Figure 1).

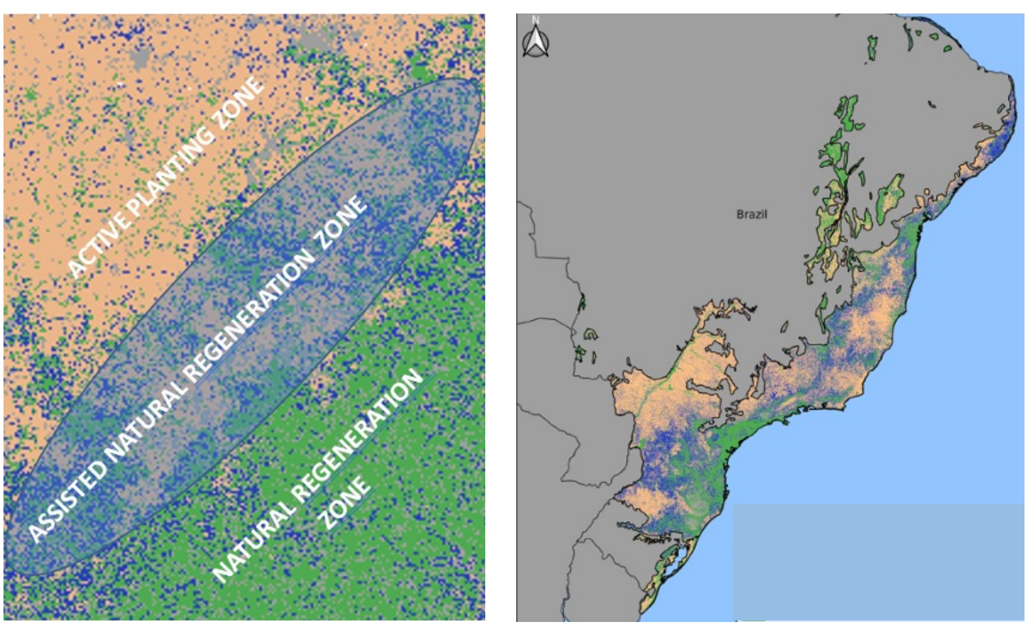
Direct seeding — where seeds are collected, prepared to germinate, and dispersed — also falls between tree planting and NR in terms of investment, with seed collection requiring the most time and resources.

Each restoration method has its appropriate environmental and socioeconomic context (Figure 3). Most current forest restoration focuses on planting trees (22). Often, programs and projects fail to assess if forests could regenerate naturally, or consider how strategic planting could be used to aid natural forest recovery. Tree planting is essential in some situations, such as with heavily degraded land or under certain social conditions. But planting trees where it is unnecessary can actually be detrimental to natural ecosystems because it can create forests that are homogeneous in age, genetic composition, and structure (23). Tree planting projects also often prioritize getting many trees in the ground quickly versus creating long-term strategies for their maintenance and protection (18).

Where the ecological and social conditions allow, strategies involving natural regeneration can reduce costs and make restoration resources go farther. Although outcomes are often less predictable than tree planting (24), forest regeneration at large spatial scales holds great promise for generating biodiversity, climate, and other forest ecosystem benefits.

FIGURE 2

Map identifying where to use tree planting, and where forests might regenerate naturally in the Brazilian Atlantic Forest (modified from 21).



WHAT IS ASSISTED NATURAL REGENERATION?

"Natural regeneration is called by many different names: fallow vegetation, secondary forest, succession, natural stocking, passive restoration, regrowth, second-growth, and scrub. The same process underlies these terms: following deforestation, logging, and land use, new forest cover can emerge — spontaneously or with human assistance — from the ecological memory of the prior forest ecosystem and the surrounding landscape" — Chazdon et al., 2017.

ANR intentionally enhances and accelerates NR by protecting regrowth from seeds or rootstocks naturally present at the site (25). ANR typically involves intentionally excluding threats and disturbances and includes suppressing fire, putting up fencing, tending to young regenerating trees, preventing grazing, regulating tree harvests, removing invasive plants and in some cases planting trees in 'islands' (13, 19, 20; Figure 1). Assisted natural regeneration works best in places where forests have the ecological potential to regenerate but could benefit from additional assistance and/or protection (13, 26; Figure 3). Potential sites could include marginal agricultural land, selectively logged areas, land around ravines, gullies and water sources (27, 28), or land in the buffer zone around protected areas. For example, ANR is especially well suited to degraded lands around protected areas, which can serve as a source of seeds or seedlings, seed dispersal agents and pollinators to facilitate regeneration (29). Potentially suitable conditions are present across large areas of the tropics and subtropics (19, 30).

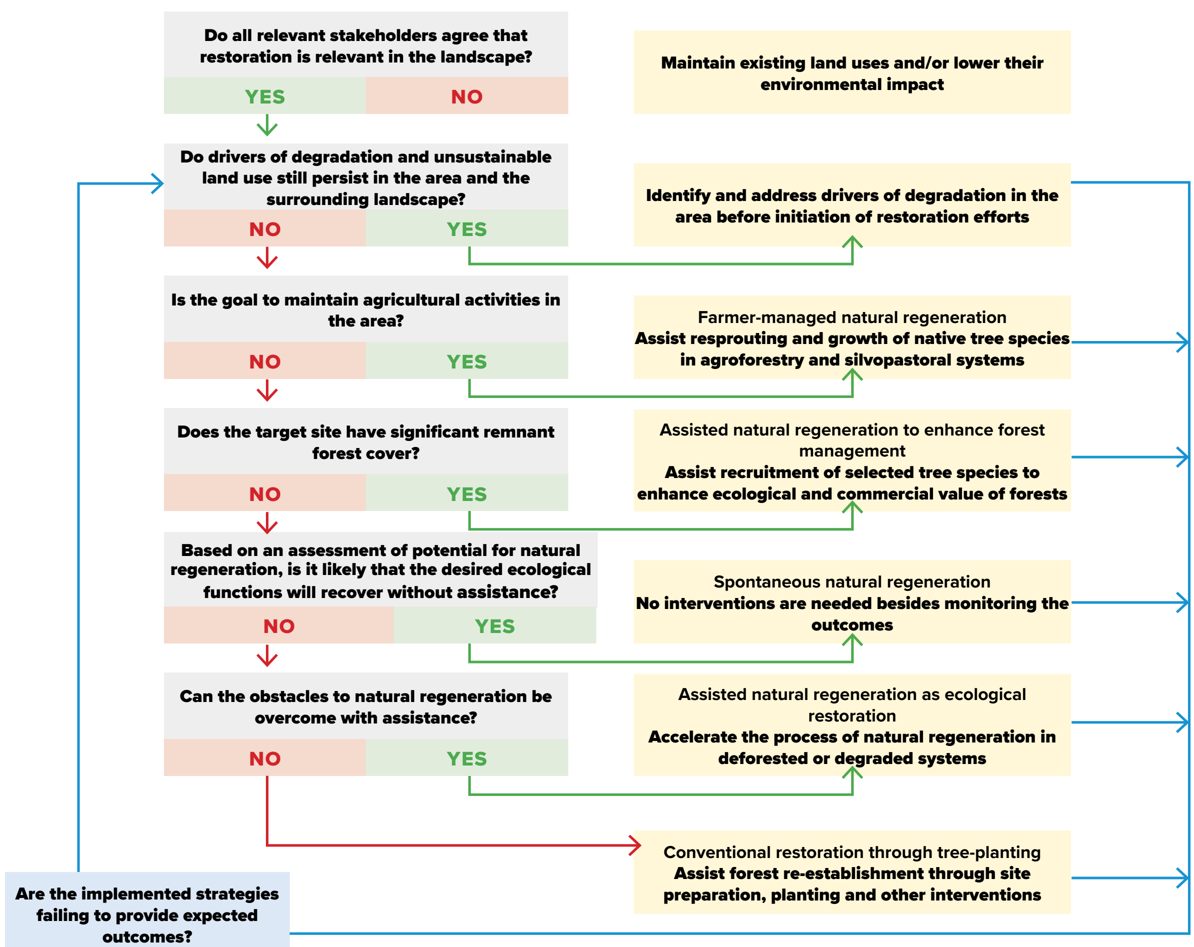
ANR can complement other common reforestation techniques that involve planting trees, such as agroforestry, silvopastoral systems (28), and planting for restoration (13), depending on the ecological and social context and the project goals (19, 26; Figure 2). When used together and coordinated at the landscape or regional level (26), these techniques can provide a range of ecological and social benefits.

ASSISTED NATURAL REGENERATION APPROACHES

This section describes commonly used ANR approaches, the contexts in which they are most suitable, and potential advantages and challenges of each. Approaches are arranged from lowest to highest level of investment (cost, labor, other resources). Practitioners should select an approach for a given local context via stakeholder consultation processes based on the ecological conditions, socio-political context, and the goals for the restoration (Figure 3; Box 1). When selecting an ANR approach it is important to understand the ecological context — species richness, disturbance history, and how well forests can regenerate — and the social and economic conditions — land tenure arrangements, livelihood strategies, and governance systems (31). We include direct seeding and applied nucleation here as both techniques bridge ANR and tree planting. AN in particular can be used to make tree planting funds go farther, when money slated for tree planting is combined with naturally regenerating areas.

FIGURE 3

Decision-making tree for choosing a restoration approach, comparing ANR with other strategies. From Shono et al., 2020 (19).

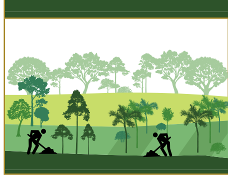


A summary of ANR approaches and how they compare to a wider spectrum of other conservation and restoration approaches can be seen in Figure 4. Note that 'protection', described in the lowest level of intervention, will be necessary in all cases. The specific techniques used in each of these approaches are described in more detail in Section 4 of this guide.

FIGURE 4

Restoration approaches. The appropriate approach depends on both ecological conditions and local goals. Protection is an important component of every strategy, and sometimes may be sufficient to allow natural recovery alone, but not always.

* COLOR CODING: green for conservation/areas of largely intact forest, blue for ANR approaches, brown for seedling planting approaches

Type of Intervention		Description
	**Conserved Forest***	Protecting existing mature/older forest.
	**Protecting Regenerating Forests**	Preventing disturbances and land uses that threaten regrowing forests by protecting deforested/degraded areas so they can regenerate naturally.
	**Managed Natural Regeneration**	Protection from disturbance + marking and monitoring regenerants + weeding or silvicultural treatments (thinning) if necessary.
	**Farmer-Managed Natural Regeneration (FMNR)**	Regreening agricultural land by: 1) protecting regenerating seedlings and 2) managing + harvesting trees to promote growth
	**Applied Nucleation**	Protection + planting native 'tree islands' or rows of trees to encourage regeneration between; maintaining planted trees and sometime regenerating trees.
	**Enrichment Planting**	Planting + maintaining seedlings to increase regenerating forest health (e.g., species diversity or late-successional species).
	**Agroforestry: Tree planting in Agricultural Land***	Integrating trees into agricultural lands to enhance environmental conditions and food production/livelihoods. Includes forest gardens, intercropping, alleycropping, silvopastoral, and other agroforestry systems with multifunctional trees.
	**Direct/Broadcast Seeding**	Protection + seeding areas with native seeds. May include weeding around native seedlings.
	**Tree Planting for Restoration***	Protection + planting and maintaining trees over the whole restoration site. Involves planting and maintaining a diverse mix of mainly native tree seedlings in degraded areas, usually in rows or a grid pattern.

1. Protecting Regenerating Forests

Protecting regenerating forests involves controlling anthropogenic or natural disturbances that prevent the forest from growing back. Major disturbances that threaten regenerating forests include fire, encroachment of invasive species, grazing, clearing for other land uses, and illegal harvests (21, 32).

The specific techniques required depend on the disturbances impeding regeneration, but often include preventing and suppressing fires, excluding livestock, or preventing tree felling for timber or fuelwood. Protection alone may be sufficient in contexts where: 1) natural regeneration is quick and diverse (e.g., ecological site conditions are good), and 2) people do not require direct, predictable economic benefits from regenerating forests (18, 32, 33). Remnant trees in croplands or pastures can add to the potential for natural regeneration by attracting seed dispersing animals (34-36).

Unless sites are very remote and inaccessible, protection involves costs of patrolling and inspecting areas for intruders (policing). Enforcement can also be done through community activities, so long as rules are made and enforced. Communities/stakeholders need to articulate who can use the forest, what activities are acceptable, and who is responsible for managing the forest and forest-based activities.

Protection alone is best suited for areas where:

- Natural regeneration is quick and a range of species are able to establish. Generally, this occurs in places near existing forests or within degraded forests, where forest clearing was relatively recent, where land use was light (e.g., used for timber extraction or cropland; no repeated burning; no planted pasture grass; 37-39).
- Where local communities do not require substantial economic benefits, specific forest species, goods, or products from regenerating forests.
- The time that forests take to recover is flexible with respect to project goals.
- The need or interest to manage natural regeneration through processes like invasive or weed removal (see strategy on next page) is low.
- Local communities have secure tenure or where clearing forest is not required to demonstrate use.
- Areas with remnant trees, living fences, or close to forest fragments to attract seed dispersers.

Advantages:

- Lowest level of investment/cost compared to other strategies because it does not involve managing or planting trees. (Note that all areas will likely require some protection in addition to other management techniques).
- Low labor requirements after implementation, as it does not include managing individual trees but may require extensive monitoring.
- Less training and capacity building required.
- Seedlings have local genetics that are adapted to local conditions.

Potential challenges: Note that these apply to many ANR strategies listed below.

- Regenerating land without obvious intervention may be seen as messy, unused, or barren, and may be at risk of being cleared or encroached upon, especially where land tenure is uncertain (21, 24).
- A lower level of investment in the site may mean less stewardship.
- Forest harvests or yields are less reliable than those obtained by planting trees.
- Regenerating forest may be missing species of key ecological or social importance.
- Perverse incentives may exist at the policy level — for example, when forests reach a certain age/size, they are controlled by the state (40). Landholders react by clearing forests before they reach this size.

Activities include:

- Building firebreaks (digging trenches or installing 'green' firebreaks).
- Installing physical fencing or 'social fencing' (rules around grazing enforced by the community).
- Creating and enforcing local rules around forest use and harvesting, potentially though a forest user group.

Firebreak around a naturally regenerating forest.

2. Managed Natural Regeneration

Managed natural regeneration is the process of protecting and managing individual trees in a target area undergoing natural forest regeneration. This typically involves identifying, marking, and monitoring natural regenerants and if necessary, removing and controlling species that are inhibiting the regrowth of the regenerants (41). Management could also involve enrichment planting with economically important species for timber and non-timber products (42). This method generally also involves protecting the area from disturbances as described in Approach 1, preceeding page.

Managed natural regeneration is best suited for areas where:

- Natural regeneration is possible but inhibited/slowed by grasses, ferns, or shrubs (32).
- Communities or individuals have secure tenure, or where clearing land is not required to demonstrate use.
- Land-use pressure is not intense.
- Adequate labor is available to conduct needed weeding/grass pressing, fire management, etc.

Advantages:

- Can encourage natural regeneration in areas where it would otherwise be impeded (32).
- May increase the species diversity and overall speed of natural regeneration (32).
- Relatively low cost (but higher investment than protection alone).
- Maintenance and monitoring can provide jobs/economic benefits to local communities and increase stewardship.

Potential challenges:

- Regenerating forests can appear unused or visually unappealing, etc.
- Forest harvests or yields are less predictable than those obtained by tree planting.
- Regenerating forest may be missing species of key ecological or social importance.
- Regenerating forests may not clearly demonstrate land management or may not be able to be legally used by local peoples.

Activities include:

- Selecting and marking individual trees.
- Clearing vegetation from around selected trees.
- Planting select species for specific ecological/economic goals.
- Pruning or otherwise caring for select trees.

Farmer-Managed Natural Regeneration (FMNR)

Farmer-managed natural regeneration (FMNR) is used to help trees grow back in and around farmland (33, 43, 44). The main goals are to "return degraded croplands and grazing lands to productivity" while restoring biodiversity, increasing resilience, and sequestering carbon (45). It makes use of remaining forest legacies, including stumps, seeds, and roots which are protected and pruned. Activities may include: 1) marking and protecting regenerating seedlings, coppicing stumps/roots; and 2) managing and harvesting these trees in a way that promotes regrowth (43). Unlike other ANR methods, the goal is to restore trees to agricultural land, not necessarily to convert agricultural land back to forest.

This approach is best suited for areas where:

- Lands are being used for agriculture or pasture but are degraded/low productivity.
- Existing seedbanks, roots and stumps are present.
- Resources from trees (fuelwood, posts, fodder) are desirable to local communities.
- Local peoples can legally use timber and nontimber resources coming from naturally regenerated trees.
- Crops being grown are not adversely affected by shade or the presence of trees.

An in-depth case study is available in the guide by Shono et al., 2007 (165) and by Wilson et al. https://crowtherlab.com/wp-content/uploads/2021/12/Restor_Case_Study_4_Niger_Int.pdf

Staking naturally regenerating seedlings for protection.

Advantages:

- Economic and social benefits are clear and flow directly to landholders (32).
- Oriented towards production landscapes and smallholders.
- Farmers are often willing to adopt it after seeing the results (can increase crop yields/production in *some* agroforestry systems) (32).
- Relatively low cost and low risk option for improving farmland productivity.
- No investments are needed other than farmer's time and care.

Potential Challenges:

- Although FMNR increases carbon sequestration compared to agricultural systems without trees, FMNR will generally have a lower per hectare carbon sequestration potential than other ANR methods, because trees will likely be restored at a lower density in agricultural landscapes.
- Although trees in agricultural lands may increase some essential ecosystem services to agriculture and improve agricultural biodiversity (46), they have a lower overall biodiversity conservation value compared to ANR techniques that promote forest restoration.
- Requires education, training, and demonstration plots with local communities.

Activities include:

- Selecting trees — marking and protecting regenerating seedlings or coppicing stumps/roots.
- Managing and harvesting trees in a way that promotes regrowth.

3. Direct/Broadcast Seeding

Direct/broadcast seeding involves dispersing seeds, manually or mechanically, to enrich the existing seed bank. Ideally seeds come from a variety of native species. After seeding, the site may also need to be protected and/or managed for regeneration (see Sections 1 and 2 on Protection and Management). Site preparation prior to seeding may be required, including removing species that suppress natural regenerants or adding fertilizer (47).

Young regenerating forest.

Direct seeding is best suited for areas where:

- Some natural regeneration can occur, but the availability of seed sources in the surrounding landscape is limited (48).
- land is remote and additional species should be added, but planting is difficult due to location or large scales (49).
- There is a high local availability of seeds and collection capacity.

Advantages:

- Introduces species at a lower cost and larger scale than tree planting (50).
- Can be used in more remote areas where tree planting would be costly/challenging.
- Can increase the speed and efficacy of natural regeneration in degraded sites.

Potential Challenges:

- Land appears unused in early stages (see the previous Protection section).
- Suitable only for a limited range of species. For example, large-seeded species are more likely to survive using this technique than small-seeded species (49).
- Seed establishment/germination rates may be low (seed predation is high, conditions for germination might not be met) (51, 52).
- May require extensive seed collection and availability of viable seeds that can germinate through direct/broadcast seeding.
- Can be difficult to locate and care for emerging seedlings.
- May require site treatment such as removing existing vegetation, fertilization, or scarification of soil to allow seeds to establish.

Activities include:

- Collecting seeds.
- Preparing seeds for germination.
- Preparing the site/removing vegetation.
- Dispersing seeds, manually or with machinery.
- Experimenting with different local species to understand germination and establishment requirements.

4. Tree Islands / Applied Nucleation

Applied nucleation involves planting and maintaining 'tree islands' of diverse native seedlings to promote regeneration between them (53). This approach uses other ANR strategies in the area between the islands (54). Typically, the area planted is only 20-30% of the restoration area (compated to 100% in traditional plantation-style tree planting) (55). Tree islands facilitate natural regeneration by 1) attracting seed dispersers and 2) creating local conditions for natural succession to occur (56). Planting fruting tree species that are attractive to birds and other dispersers can also enhance forest recovery (57, 58).

Similar to ANR is the "framework species" method, first developed in the tropical rainforests of Queensland, Australia, and subsequently applied in many areas of the tropics (59). The framework species approach involves planting selected areas of the restoration site with 20 to 30 species of trees — both pioneers and climax species — selected for their ability to survive and grow rapidly on highly degraded sites, quickly shade out grasses and herbaceous weeds, and fruit at a young age thereby attracting seed-dispersing wildlife (60, 61). Under the framework species approach, seedlings are closely planted, with as many as 2,000 trees per hectare, with individual species being randomly located. The planted trees rapidly create a "framework forest" which can be colonized by additional species brought in from nearby remnants by seed dispersers (60). The "Rainforestation" approach developed in the Philippines further adapts this concept by emphasizing the planting of fruit trees and other crops alongside forest trees to provide income to farmers (62).

Applied nucleation is best suited for areas where:

- Some natural regeneration can occur but is slow/impeded by local conditions or a lack of seed dispersers (55).
- Some intervention is needed to speed up succession, but intensive tree planting is impractical/ too costly (18, 55, 63, 64).
- The land has the capacity to regenerate naturally but introducing additional species early on could help to meet ecological or social goals.
- Funds are available for tree planting, but there is flexibility to make these funds go farther/be used over a larger area.
- The framework species approach is well suited for more degraded sites where remnant forests are lacking/lack key species of the restored ecosystem. It relies less on the composition of remnant vegetation than applied nucleation.

Advantages:

- Accelerates succession and can increase species diversity at a lower cost than tree planting (56, 64-66).
- The survival and establishment of seedlings typically higher than the direct/broadcast seedling method (65).
- Can introduce income-generating or ecologically important species.
- Can increase opportunities for community engagement and income generation via tree planting.
- Demonstrates land use and management more clearly than more ANR approaches because of the tree planting component.
- Allows funds designated for tree planting to have a larger impact across landscape.
- Framework species and rainforestation also can serve to reinstate forests with high ecological and social value into more degraded/species poor areas.

Potential Challenges:

- More costly than managed natural regeneration and direct/broadcast seeding.
- Planted trees typically require maintenance for the first 2-3 years.
- Requires technical planning and training on ANR + planting techniques.

Activities include:

- Growing seedlings in nurseries.
- Preparing the site for planting/regeneration (e.g., removing vegetation, soil treatment).
- Tending to/maintaining planted and regenerating trees.
- Educational activities with communities to understand the goals and process.

5. Enrichment Planting

Enrichment planting involves planting seedlings of forest species that are not currently present, or to increase the abundance of species with ecological, cultural, and/or economic importance Enrichment planting can be used alone or in combination with other forms of restoration, and can be used in in young secondary forests (67), degraded forests (68), plantations (69), and agroforests (70). In areas where sources of seeds or seed dispersers are not present, enrichment planting can add later-successional species that would otherwise be unable to colonize the site (71).

Examples of enrichment planting objectives include establishing species of conservation concern (72, 73), improving a forest's its ability to harbor biodiversity (74-77), increase carbon storage/sequestration (78), or promote the production of timber (79) or nontimber forest products (80).

Enrichment planting is best suited for:

- Secondary forests with an absence of later successional species (81-83).
- Plantations with low diversity and low proximity to sources of seeds of certain functional groups (84).
- Recovering areas or degraded forests missing species of ecological, cultural, or economic importance (26).
- Recovering areas or degraded forests where economic benefits from targeted tree species are a key project goal (85-87).
- Forest degraded by logging with timber species absent (88).

Advantages:

- Helps to establish species that require more closed canopy conditions.
- Can add economic and cultural value to forests.
- Can be used to enhance recovery in degraded forests or deforested areas undergoing ANR (26).
- Increases forest age and canopy structure and can be used to increase both biodiversity and functional diversity (83, 89).
- Can also be used to establish non-tree species/ valuable non-timber forest products (85, 90, 91).

Potential Challenges:

- Requires effort to establish, long-term monitoring and additional maintenance of planted trees.
- Sources of native trees can be difficult to locate; may require establishing local nurseries if specific native species are required but unavailable.

Activities include:

- Selecting and propagating key species.
- Monitoring to decide when and where to plant trees.
- Planting in regenerating and/or degraded forests, sometimes at more than one interval.

BOX 1: OTHER RESTORATION STRATEGIES

While other restoration strategies can be effective climate mitigation strategies, they are not the focus of this guide. Resources for tree planting and agroforestry establishment, and other strategies, are listed in Annex 1. Popular restoration strategies non-ANR include traditional tree planting, agroforestry and silvopastoral systems:

1. **Tree planting** for restoration involves planting and maintaining a diverse mix of mainly native tree seedlings. Because this approach involves a supply chain of tree seedlings from nurseries and additional labor to plant and tend trees, it is often the costliest option for restoration (24, 92).

2. **Agroforestry** involves intentionally growing and maintaining trees in agricultural and pastoral settings, with other crops and/or livestock. Forest gardens, intercropping, alleycropping, shade-grown agriculture, and silvopastoral systems are all forms of agroforestry. Assisted natural regeneration/ FMNR can be used to establish the trees used in agroforestry systems; for example, promoting trees in pastures to establish silvopastoral systems (93).

If ANR restoration approaches are successful, the project will eventually produce vegetation that will need to be conserved and managed successfully in the long term. For this reason, conserved forest marks one end of the range of ANR approaches and their contextualization (Figure 1; Figure 4). As trees grow, ANR approaches like protecting regenerating vegetation and managing natural regeneration will look increasingly like protecting and managing conserved forest, and long-term plans should be designed to this effect (See Section 4).

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SECTION 2:

SOCIAL AND CULTURAL CHALLENGES FOR USING ANR TO RESTORE FORESTS

ANR has been used by local people as part of traditional cultivation systems across many different geographies and time periods (94, 95). But as a restoration strategy implemented by governments, NGOs, and businesses, it is not as widely used as it could be. Outreach, education, and visible demonstrations of both ecological and social benefits are key to promoting ANR at national and local scales. Some of the major barriers and challenges to implementing ANR at scale are described on the following pages.

Failure to recognize ANR as an effective way to restore forests. Despite its promise, ANR is largely overlooked by most national governments. Many policy makers do not know about ANR or do not understand how it works. Conflicting or outdated policies, weak governance and regulatory frameworks, and a lack of awareness limit how widely ANR is integrated into government planning and restoration targets. For example, in the 2020 Nationally Determined Contributions to the Paris Accord, there are twice as many quantitative national commitments involving planted forests and woodlots than those using other restoration strategies, and nine times more than those using ANR (96). This emphasis on tree planting at the national level can translate to a lack of knowledge/training for technicians, agencies, and local practitioners to implement ANR (97, 98; Case Example 1, East Timor). Where ANR is used, the area implemented and outcomes are often underreported because restoration monitoring is chronically underfunded (as it is for all restoration techniques), or because the practices are not identified as restoration interventions.

National policies that fail to support or even discourage natural regeneration. Large-scale restoration initiatives, national plans, and incentives tend to promote tree planting as the 'go-to' method for reforestation (97, 99). In some countries, national policies aimed at protecting forests may actually discourage landholders from allowing forests to regenerate, as once forests reach a certain size it is no longer legal to clear them (99-101). Young regenerating forests may also not be defined as "forest" under policy or by local landholders until they reach a certain size, cover a certain area, or until key species return (102, 103). Regenerating vegetation is at greater risk of being cleared until the forest has satisfied these criteria (104, 105). Some national policies allow landowners to harvest and use planted trees/plantation trees, but not trees in "natural forests". There also tend to be many programs that fund and subsidize "tree planting" but few that compensate efforts to regenerate forests naturally. Some countries don't recognize or value naturally regenerating forests, seeing them as "scrub land" or "unused land" and tax it at higher rates than land planted with trees.

Lack of technical skills/skill transfer to large-scale restoration practitioners. In many cases, because ANR is not supported by national policies and decision makers at higher levels, staff 'on the ground' are not trained in ANR techniques, limiting the adoption of widespread incentives for ANR implementation (106, 107). This problem is confounded because clear, accessible guidance on implementing ANR is lacking. Individuals in local communities possess traditional or indigenous knowledge about how and when to apply ANR techniques, and the scientific community has extensively studied natural regeneration processes. But this knowledge is often inaccessible (in terms of vocabulary, language, and the availability of information) to local communities and other restoration practitioners (108).

Cultural barriers. Demonstrating to potential implementers that ANR works can be a major challenge (21, 43, 109, 110). Compared to tree planting, naturally regenerating areas usually take time to grow into something that looks like a "forest." They are often perceived as "messy" — scrubbier and less orderly, which may not align with cultural norms and preferences (66, 111). The ecological or economic outcomes of ANR are not as clear nor predictable and have been less well documented than other forest sector interventions such as timber plantations (99, 106). Allowing forests to regenerate naturally can require a major shift in thinking about land use and management (112, 113). It requires less intensive interventions on the part of landholders and is very different from the investment and orderliness required by farming or plantation-style tree planting.

Land tenure. Activities such as forest clearing, grazing, or tree planting can have an added benefit of demonstrating use and asserting land tenure. However, young regenerating forests are often seen as unclaimed, abandoned, or even “barren” land (21, 114). Unlike tree planting, which immediately demonstrates ownership, ANR lacks the same tangible results (111). Early on, naturally regenerating sites may be at risk of being reclaimed by others for non-forest purposes such as grazing or agriculture (21, 66). Dedicating land to ANR can be a long-term process that requires enforcement and law/policies to be in place.

Lack of reporting on ANR. A lack of reporting on ANR projects hinders its spread and mainstream use. Many different interventions are considered ANR, and there are no widely agreed upon set of terms used to describe these actions, nor standardized practices for monitoring ANR. This makes it difficult to locate and compare programs in different locations, develop a clear understanding of where this work has occurred, and share practices between different locations. Documented ANR outcomes are lacking and many people and organizations working at different scales perceive the survival of trees and success of successional processes to be low. Demonstration sites could go a long way towards promoting ANR as a restoration technique (106).

Flawed metrics/indicators. Often, restoration implementers and funders use overly simple indicators to measure ‘success’, such as total number of trees planted. While these indicators are easy to measure, they don’t tell the whole story, and can provide an incentive to plant trees even in areas where ANR would be more effective and less costly (18, 24, 92). Programs with limited metrics which do not account for long-term monitoring often fail to account for the number of trees that survive beyond the duration of the program. Indicators that are tailored to the local context and include a temporal component are important for capturing outcomes and better understanding the potential of ANR as a restoration technique.

Opportunity cost of restoring land through ANR. ANR doesn’t provide the economic benefits of farming and many other non-forest land use activities. There is a general lack of opportunities for local people and landowners to benefit financially from ANR. In areas where people rely on the land to meet daily needs, external interventions must ensure that livelihoods are complemented, not compromised, by ANR. Restrictions on uses of natural forests (e.g., from forest protection measures), perverse tax structures in which regenerating land is more heavily taxed because it is not considered ‘productive’, and a lack of incentives/subsidies for ANR as compared to tree planting all have been known to make ANR less financially viable (115). In Section 5 Step 4, several potential solutions for this challenge are listed.

Political influence of the forestry industry. In many countries, government agencies are strongly allied with the forestry sector and the forest industry (116). There is no “political lobby” that promotes ANR and conservation advocates often emphasize the protection of old-growth forest over the creation of second-growth forest. As a result, ANR falls in the cracks between forestry, conservation and agricultural sectors (115).


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SECTION 3:

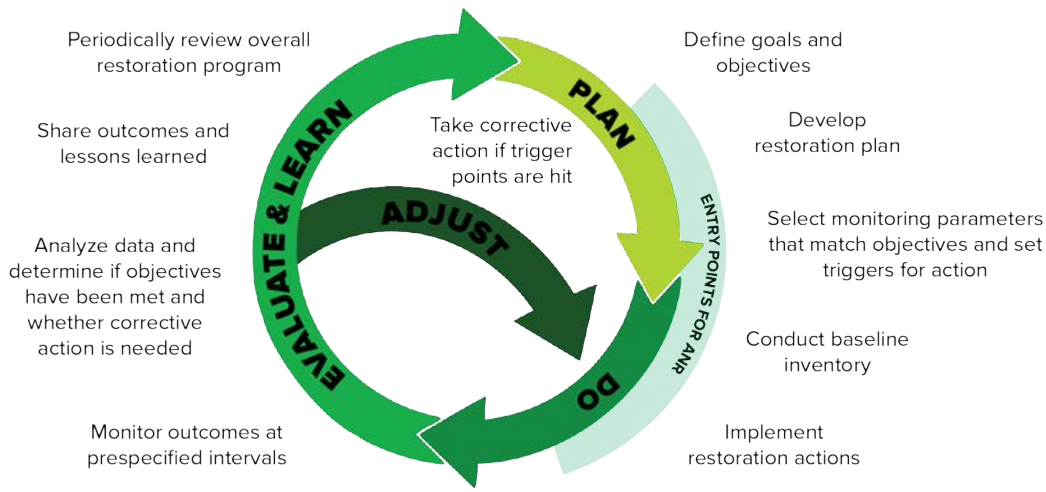
PLANNING & DESIGNING FOR ANR

THE RESTORATION PLANNING AND DESIGN PROCESS

Restoration is an adaptive process. The first step is setting goals and objectives, from which all other activities will be based (26, 55; Figure 5). Within an overarching goal, specific objectives should be tailored to the local conditions. Effective goal and objective setting require that practitioners 1) understand local social, political, and ecological context, and 2) work with local people and other stakeholder groups to set goals for restoration that reflect local conditions and needs (26, 55, 117).

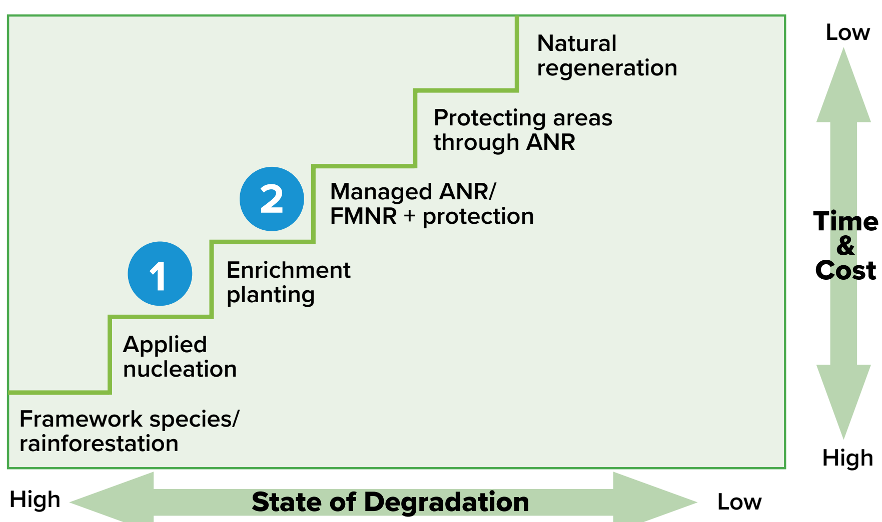
The planning and design phase involves developing a process to work with local stakeholders, and laying out how restoration will be implemented and monitored (26, 55, 117). Effective planning often combines scientific and local, place-based knowledge (118) to select a restoration approach (or approaches) to meet project goals. Implementers can then use plans and goals as guidance while allowing flexibility to troubleshoot and adapt. Monitoring protocol and indicators should be aligned with project goals, and should also be established during the planning phase.

FIGURE 5



Overview of the restoration planning and implementation process. Modified from Holl et. al, 2020 (55).

FIGURE 6



The assisted natural regeneration staircase, based on the restoration staircase in Chazdon 2008. Depending on the state of degradation of a previously forested ecosystem, different ANR approaches can be used to encourage forest recovery, and at least partially restore biodiversity and key ecosystem services. Note that some approaches include specific objectives: 1) Enrichment planting can be used in combination with any of the approaches, or alone, to recover key species, and 2) FMNR is used to improve agricultural yields/resilience. Modified from Chazdon et. al, 2008 (119).

Specific restoration approaches should be chosen based on ecological conditions at local and landscape scales, social and political contexts, and project goals (Figure 3; Figure 6). Once goals are established through a process involving key stakeholder, two components are needed: 1) a spatially explicit ecological assessment of the regeneration capacity of the areas to be restored, including their context within the landscape, and 2) knowledge of the local social, political, and economic conditions, including local laws, policies, governance structures and land tenure. Spatial information should include locations of remnant forest cover, protected areas, and degraded areas, information about the extent of the degradation, and relevant land tenure information. Species distributions and information about the ways in which local communities depend on forests may also be helpful. Combined, this information can help identify priority areas for ANR within the target landscape or region (13). For a detailed guide on conducting spatial analyses for restoration, see CI's Spatial Analysis Guide (31).

This section outlines how to choose an approach for a given context, guidance for undertaking the approach, and detailed references for each step. Note that some steps will be iterative, such as the process of defining goals, and many can/should occur concurrently. For example, creating a "shared vision" of what is desired from the restoration activities is critical and should evolve from engagement with partners at all levels. A "shared vision" is essential for success in any case and is a necessary underlying "Step 1".

Step 1: Understanding policies and setting goals: Define and engage relevant partners and stakeholders in ANR at national, regional and local levels.

Project planners should begin by developing a basic understanding of the policies that affect restoration at national and subnational levels. Relevant policies might be found in the forestry, agricultural, or other land-use sectors. This process could be followed by engaging policy makers to establish a favorable and supportive policy environment conducive for ANR, if needed.

An inclusive community-centered approach is critical to identify who should be involved in setting goals and identifying local needs. When local stakeholders are identified and engaged, the project is more likely to succeed and persist (32).

"Stakeholders include the men, women and youth of the community, majority and minority ethnic groups, sedentary and nomadic land users, community leaders and influencers, local government representatives, agriculture and forestry department representatives, local partners, and other nongovernmental organizations (NGOs), etc. Women and children are particularly crucial because in most societies, women are responsible for fuelwood collection and children are often required to clear and burn the trees in agricultural fields before planting time. Children are also receptive to new ideas and they are the next generation of farmers." (45)

Local NGOs, farmers groups and associations can be key partners in planning and implementing restoration, and should be brought on board early to describe the local context — including specific ecological conditions — and identify other key stakeholders. People with cultural ties to the land, indigenous groups, women, landowners, and people with customary rights to the land should also be represented (see ROAM Guide in Annex 2). Government representatives, donors, and others who control resource allocation (monetary and human capital) should also be included in the goal-setting process. It can be helpful to identify 'primary' stakeholders who should be involved in core planning sessions, and 'secondary' stakeholders who might be brought in at later stages (120).

The following questions are intended to start a general stakeholder mapping process that ensures that local land users, including women and minority groups, are represented alongside decision-makers, direct implementers, and other potential beneficiaries.

- What local partners on the ground have established working relationships and trust with communities?
- What are the local land or tree tenure arrangements?
- Do processes for stakeholder engagement around land use exist?
- Who are the key land use users, custodians, influencers and actors (32, 121)?
- Who bears the costs of restoration and who benefits from it?
- Which stakeholders will have the highest interest or see the greatest benefits from ANR?

For more references/tools on identifying stakeholders, see Annex 2.

Step 2: Conduct ecological surveys/ assessments and other biophysical measurements.

To make the most of limited restoration resources, the minimum level of intervention should be used to help forests recover. Mapping forest regeneration capacity (31, 99, 122) is a key first step, as outlined below. This step can also help set a baseline prior to restoration. Local partners and stakeholders are often well situated to inform ecological site assessments and provide valuable information on site conditions and forest recovery potential. The following questions can help guide an assessment and determine the interventions needed to restore a forest.

1. **To what extent can the forests regenerate naturally?** Abundant native tree seedlings on a site are a good indication that natural regeneration is underway and will continue (123). In these places, protecting regenerating forest from risks like fire, grazing, competition from weedy grasses or shrubs, or being repurposed for another land use may be sufficient interventions to assist the forest's recovery. Most important is the presence of tree seedlings/saplings and/or root stock on the site. Even if there is a heavy presence of competing grasses or other vegetation, with an adequate number of tree "regenerants" present, protecting and nurturing the trees can allow them to grow and overcome the competing vegetation.

If areas have not had sufficient time to recover, or if little natural regeneration is apparent, consider the following:

a. **Survey land to see if natural regeneration is occurring.** Areas where forests are already regenerating with woody species make good ANR candidates.

b. **Test natural regeneration potential by allowing the land to recover for 1.5 to 2 years.** If the project schedule allows, protect the land from disturbances and monitor its recovery. If forest species start to return after this time, the site may be a good candidate for ANR (123). This is especially important where land has otherwise not been given an opportunity to recover free from disturbance. Potential metrics are % grass cover, % canopy cover, and tree seedling density (123).

c. **When it is not possible to wait 1-2 years, conduct a survey with local key informants (e.g., leaders, community groups, landholders, natural resource users) to determine its regeneration potential. The survey should include:**

   i. ***The intensity of past land use:*** If an area has had a history of less-intensive past land use, protecting sites may be sufficient to promote natural regeneration. Areas with more intensive past land uses, such as those which have been repeatedly burned or have resulted in more degraded or eroded soils, are less likely to recover naturally (37, 124, 125) and, may require more intensive methods to restore.

   ii. ***History of fire:*** Has the land been repeatedly burned (e.g., over several fallow cycles?) → if so, forest recovery may be impeded due to a lack of seed bank and other propagules (37, 124, 125). Frequent wildfires may also make a site difficult to restore because surrounding vegetation such as grasses or ferns may be highly flammable (more so than forests) (126). Sites with a history of repeated fires may require the establishment of fire breaks and more intensive fire protection.

   iii. ***Soil conditions****:* Have soils been severely eroded or compacted? → if so, natural seedling establishment could be inhibited. It may be necessary to plant tree species that that can remediate soils (e.g., nitrogen fixing species) and/or add compost to enrich the soil prior to planting (39).

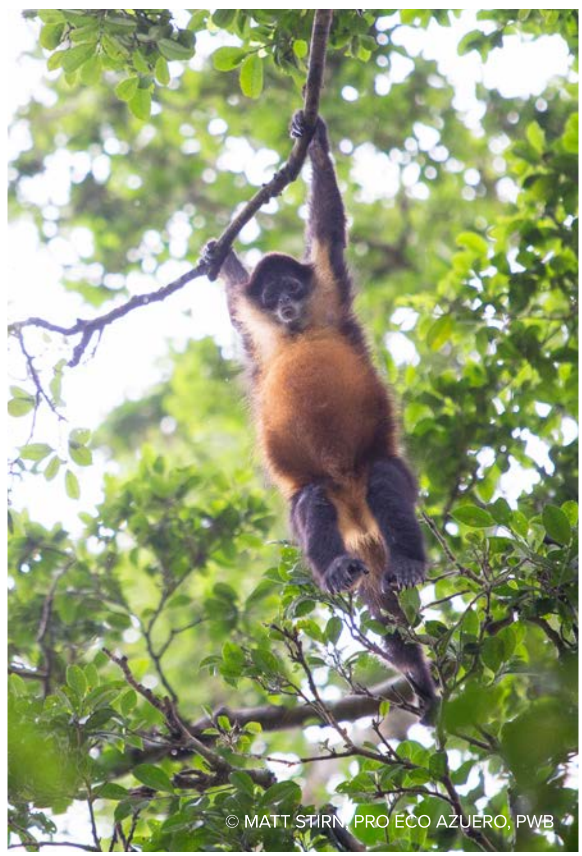
iv. ***Time since clearing:*** When was the site cleared? → Longer durations of anthropogenic land use are often associated with poorer recovery (37) since soils become less fertile with ongoing use and the seed bank diminishes over time. More intensive ANR methods or tree planting may be required in sites that have been cleared for longer periods.

v. ***Presence of invasive species.*** Are invasive species present, and if so, what kind are they? → Invasive species are a major impediment to forest recovery (37). Sun-loving invasives such as pasture grass may need to be removed initially and maintained clear until the tree canopy has established. However, invasive shade-tolerant species such as invasive trees could mean that ANR is not a good candidate for that site (56).

vi. ***Presence of forest fragments, trees, living fences, and shrubs in the agricultural landscape:*** These serve as seed sources and habitat for seed dispersers. Proximity to existing forests is one of the most important variables determining if forests will regenerate or not (24, 127, 128).

vii. ***Presence of seed dispersers:*** These include animals that disperse both small and large seeds, including birds, bats, monkeys, and other mammals (128-131). Dispersers can be assessed using direct observation through bird counts and camera traps.

2. **What is the quality of forests in the surrounding landscape?** The quality of nearby forests and trees, and existing vegetation on the site (e.g., root and stump sprouts, small seedlings/saplings) affect the species composition of regenerating forests. If nearby forests are diverse, intact, and contain mainly native species, regenerating species are more likely to reflect a native forest composition. If nearby forests are degraded, missing key species, or contain many invasive species (especially shade-tolerant species; see v. in the list above), then regenerating forests are likely to reflect that composition and may require further intervention. In some sites, existing root and stump sprouts and small seedlings/saplings play a bigger role than seed dispersal from nearby forests/trees. Restoring degraded remnant forests through enrichment planting or silvicultural techniques can also bolster the success of ANR interventions within the landscape over time.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3. **What are the deforestation drivers and risks to restoration in the landscape that could destroy regenerating vegetation and how can they be managed?** Deforestation drivers and risks could include grazing, fire, clearing for agriculture/pasture, invasive species, harvesting fuelwood or timber, and other human land use pressures. Secondary regrowth is often cleared within years to decades of starting to regenerate (105, 132). For any forest restoration strategy to be effective, threats to the regenerating forest need to be managed/removed, especially when the forest is young (133). Historically, human-based deforestation drivers have been managed through strategies like production of non-timber forest products or provision of alternative livelihoods.

For more references on ecological assessments for restoration, see Annex 1.

BOX 2: INTEGRATING TRADITIONAL ECOLOGICAL KNOWLEDGE INTO ECOLOGICAL PLANNING FOR RESTORATION

In addition to providing important information on social conditions that affect restoration, Traditional Ecological Knowledge (TEK) can play an important role in identifying where and how to restore lands from an ecological perspective (137, 138). “The localized and site-specific nature of traditional knowledge makes it particularly applicable to restoration design, which is also site-specific.” (137, 139) TEK can be applied to understand many attributes of the forests/landscape, including:

- Reference conditions of an ecosystem.
- Traditional land management practices and historical land-use practices, which can help both identify goals and reference systems, and understand the level of intervention needed to achieve them.
- Practices for restoring fallow lands using traditional methods that fulfill family needs while initiating the restoration process (140).
- Selecting species for restoration planting (26).
- Selecting sites that are best suited to restoration due to ecological or cultural reasons.
- Practices for managing invasive species.
- Assessing and mapping components of ecological memory (141, 142) that promote forest recovery within the landscape.

Engaging and partnering with indigenous people and local communities from the start (rather than consulting later in the process) is important for integrating social considerations and ecological guidance in the design of a restoration project. Projects will also be stronger if they recognize customary institutions and land tenure arrangements and are able to incorporate both long and short-term benefits into restoration plans (143).

For more references/tools on integrating indigenous and local knowledge in restoration, see Annex 2.

Step 3: Understand the social landscape and engage communities.

A series of community engagement and visioning workshops with relevant stakeholders can also identify local values and needs that could be addressed through restoration and identify how ANR can fit with other land uses and within the socioeconomic context.

Workshops may involve setting objectives for ANR projects, taking stock of traditional knowledge and local practices, understanding local needs and preferences, and identifying local drivers of forest degradation/deforestation. They can be used to explain how ANR works. Workshops can also involve identifying locally available resources for restoration, including potential species to be incorporated, equipment, access to sites, trainings needed, and other issues that must be addressed. Workshops should be led by a dedicated, trusted facilitator. A typical workshop includes a broad visioning session, followed by a process of prioritizing, ranking, refining, and/or constraining big ideas into workable goals and solutions in each context (134). Constraints should be clearly stated to allow for novel solutions to be created within these constraints.

The results of the ecological surveys should be on hand in the community engagement and visioning workshops. Activities such as creating hand-drawn or digital maps can help participants imagine future scenarios (135), hone in on specific goals and constraints, and generally engage a range of people in the process (136).

Each workshop should include a mix of technical expertise and stakeholders with on-the-ground knowledge. Technical expertise should include people with knowledge of ANR specifically. Maintaining a gender balance is important and it may be worth holding gender-specific workshops (see ROAM guide in Annex 2).

Key subjects to address are:

- **The degree to which local people rely on the land.** This includes identifying locally important products, access to markets, and whether ANR can be incorporated into existing land uses. Do men and women have different ways of using the land?
- **Current land tenure arrangements and associated challenges and opportunities for ANR.** Who owns the land? How secure is land tenure? What limitations/constraints are placed on land and resource use?
- **Local processes for conflict resolution around issues such as land disputes, and their relevance for ANR implementation.** How do local people set rules and resolve conflict? How can these processes support implementing and managing ANR?
- **Current reliance on and use of forests.** Can ANR fit with, build on, or help to make existing forest use more sustainable? For example, can it relieve pressure on existing forests or enhance the sustainable use of other forest products?

Participatory workshops can be combined or integrated into participatory rural appraisal techniques to understand the local context and how restoration might fit with local goals and needs. For more resources on stakeholder engagement and participatory rural appraisal, see Annex 2.

Step 4: Merging social and ecological data to plan where and how to use different ANR approaches.

Information from Steps 2 and 3 should be used to produce a map of what ANR approaches would be most appropriate to meet social needs and ecological conditions. Multiple approaches can be used depending on the heterogeneity of the landscape and the needs and goals of stakeholders. Other restoration techniques could also be used in combination with ANR to meet additional needs or ecological conditions. Integrating indigenous and local knowledge can inform both social and ecological planning elements (Box 2). In addition to identifying sites to restore, locating areas that have similar conditions but could be left as 'control' areas for monitoring purposes could be helpful at this stage. These areas can be much smaller than the area under restoration. For detailed guidance on mapping for restoration, see CI's restoration planning guide (31).

Step 5: Establish a plan to help restoration persist on the landscape.

Many restoration projects do not meet their objectives because of socio-economic factors, such as insufficient access to financial and information resources, lack of leadership, and failure to sustain participation and stewardship in restored areas (144). However, incentives, good community relations, and the overall relevance of the project to local peoples can lead to longer lasting restoration (144-146). The appropriate incentives for ANR will depend on land tenure and the extent to which communities rely on the land to meet their needs. For example, incentives to restore will be different in areas where people generally make a living off-farm, landowners are absentee, and lands are not primarily used for production compared to areas where people use the land and rely on it for their incomes, ecosystem services, or other uses.

POTENTIAL INCENTIVES WHERE LOCAL PEOPLE RELY LESS ON THE LAND FOR THEIR LIVELIHOODS:

- Payment for Environmental/Ecosystem Services (PES) schemes.
- Devolving management to local communities/people.
- The creation of policies that support ANR such as subsidies for producing sustainable non-timber forest products, the provision of credit to farmers who engage in ANR, or the provision of ANR technical support or "extension services" (147).
- Changing policies that limit natural regeneration. For example, policies that require demonstrated land 'use' to secure tenure or that claim control by the state when forests reach a certain size.

IN AREAS WHERE PEOPLE RELY MORE ON THE LAND FOR THEIR LIVELIHOODS, THE ABOVE STRATEGIES STILL APPLY. ADDITIONAL STRATEGIES MAY INCLUDE:

- Using ANR to enhance and sustain livelihoods by:
    - Improving local employment opportunities to aid restoration.
    - Creating forests from which NTFP, firewood, or selective timber can be harvested for subsistence or sale. If for sale, facilitating appropriate market access.
    - Establishing agroforestry through FMNR or enrichment planting on agricultural land that is needed to continue to produce food.
    - Providing access and support for growing subsistence or cash crops in fire breaks.
    - Using ANR to enhance local ecosystem services.
- Provide other infrastructure that communities need in conjunction with ANR programs.
- PES schemes should complement other livelihood activities rather than be thought of as the main source of income.

For more references/tools on restoration planning and encouraging the persistence of ANR, see Annex 1.


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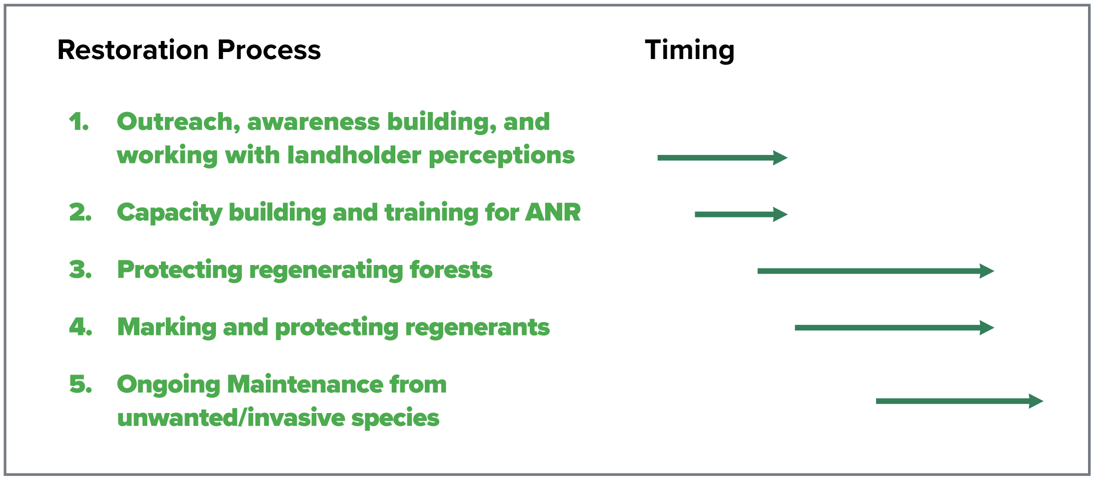
SECTION 4:

IMPLEMENTING ANR

Because it is the most 'visible' stage, implementation is often prioritized over other essential components of restoration, such as participatory goal setting, community engagement, planning, and monitoring. But for restoration to be successful in the long term, implementation must be one step of the larger restoration process outlined in this guide (26, 148; Figure 7). For organizations partnering with communities and landholders, implementation starts with outreach, building awareness around ANR approaches to restoration, and building capacity for local agencies and practitioners. This is followed by visible action on the ground, such as putting up fencing, creating firebreaks, marking regeneration, and controlling invasive plants. In the following section we break down ANR implementation into five main steps, including outreach and awareness, building capacity, protecting regenerating forest, managing regenerants, and ensuring species diversity and resilience in the longer term.

FIGURE 7



1. OUTREACH, AWARENESS BUILDING, AND WORKING WITH LANDHOLDER PERCEPTIONS

Because naturally regenerating young forests look different from mature forests — and are not generally what people picture when they think of forest restoration — raising awareness and educating the public about what is occurring at the site and the benefits and limitations of ANR is important at the local/community level (21, 32). Creating pilot ANR sites can be an excellent way to demonstrate the process and results.

Below are some practical measures that can help overcome social barriers to implementing ANR.

- Promote knowledge transfer between people, and connect communities who practice ANR with those planning to practice ANR.
- Create and promote demonstration sites and research plots. Ideally, these can show different stages of recovery in different contexts.
- Hold workshops that explain general techniques for ANR, discuss potential challenges, and explore how young forests are locally perceived/valued (149, 150).
- Provide support and training for site monitoring and maintenance to prevent disturbance and show that the land is being restored (21).
- Work with well-respected and trusted local leaders who can help influence how ANR is implemented, and motivate people to adopt ANR (32, 151, 152).

The following critical insight stemmed from a workshop on using ANR in 2009: “Getting humans to assist natural regeneration needs to happen ‘naturally’. The forest will come back if the land is not perceived as government-owned, but as a locally managed resource. The activities will continue if they are viewed as part of the stakeholders’ way of life and not belonging to a project, a government programme or an NGO.” (153).

For more references/tools on outreach and awareness building for ANR, see Annex 2.

2. CAPACITY BUILDING AND TRAINING FOR ANR

Capacity building is critical for the success of most restoration, including ANR. It can provide local stakeholders with the skills to do the work, offer employment, and increase local engagement (154). It can include orientation programs, demonstration sites, technical support, training and guidance, and support during the implementation process to promote iterative learning. In cases where people see benefits to the restoration, capacity building can serve as compensation for implementing the work. Capacity development programs can also help sustain restoration once external support is withdrawn, so long as it is tailored towards developing the skills needed into the future (155).

Practitioners and local extension agencies may be less familiar with ANR than other restoration techniques (such as tree planting). As such, ANR projects may need to dedicate extra resources or time to provide training for specific techniques and for education and outreach.

KEY CAPACITY BUILDING STEPS

1. Assess capacity building needs. Understand the experiences and diverse knowledge sets that communities and agencies have of restoration approaches.
2. Provide technical guidance on how to implement different ANR techniques (154).
3. Create connections to share ANR work, including community exchanges, demonstration sites, and peer-to-peer learning (98, 154, 156; Case Example 2).
4. Make technical and conflict-resolution support available, especially early on in implementation (154).

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FOUR ELEMENTS CRITICAL FOR EFFECTIVE CAPACITY BUILDING (158)

1. Activities should be tailored to the local context and needs of communities.
2. Capacity building should incorporate knowledge and experience from a diverse range of sources and disciplines, including TEK.
3. Capacity building should provide training for implementers to select between different restoration approaches most suitable for a given context.
4. Capacity building should include a wide range of skill sets of local relevance and interest (for example, marketing, alternative forest-friendly agriculture, etc.) as appropriate.

For more references/tools on capacity building for restoration, see Annex 2.

BOX 3: CONTINUED ENGAGEMENT WITH LOCAL COMMUNITIES TO IMPLEMENT RESTORATION

Engaging stakeholders in all phases of the project, including planning, implementation, monitoring, and maintenance, is critical for successful restoration (158). Engaging local community members can help to ensure that restored forests are protected and that local people continue to receive benefits from them (150, 159). Local people may have local knowledge of the land, trees and forests, and are on-site for work, ongoing protection, and maintenance (150, 159, 160). In many contexts, local small-scale farmers and community-based organizations can be some of the best candidates to partner with when implementing ANR (155).

Detailed guidance on stakeholder engagement for natural resource management is available through the references below. A few key points important for ANR are highlighted here:

- **Engage stakeholders early** in the site selection and planning processes.
- **Engage with and/or work through local institutions** such as existing forest management groups or farmers associations.
- **Understand and work with local motivations for restoration**, and allow restoration to continue to adapt to local needs during and after implementation (156, 161-163).
- **View local employment for implementing as a restoration 'benefit' as well as a cost** (32, 158, 164).
- **Empower local communities and institutions through the ANR process, but provide financial and technical assistance for implementing large-scale restoration** (150, 154).
- **Encourage local rule-making and locally accepted or developed forms of conflict resolution***,* throughout the process of implementing ANR (32, 156).
- **Where possible, encourage policy reform to promote or allow the use of ANR as a restoration technique** (99, 107, 165, 166).

3. PROTECTING REGENERATING FORESTS

Protecting regenerating forests from disturbance is an essential component of all ANR interventions (13, 24, 159, 165). Effective protection will require long-term participation from local people during and after implementation (165).

CONTROLLING LIVESTOCK GRAZING

Grazing livestock often damage regenerating plants. Methods for excluding grazers vary with context and the type of grazers.

- **Fencing** has the advantage of demonstrating that land is being used. But fences are also costly and require maintenance (32).
- **'Social fencing'**, wherein land users agree on a strategy for preventing livestock from entering regenerating sites and commit to the strategy's implementation. This can be effective and less expensive, but requires the participation of all livestock owners (167).
- **Tethering** domesticated animals until tree crowns are above browse height requires less upfront cost and maintenance than fencing, but also requires the active participation of all animal owners.
- **Collecting grass/weeds as fodder** from regenerating sites can protect trees and make use of weeds removed from the site (32). This is labor intensive and may be best suited to areas in which clearing around regenerating trees is required as a part of ANR.
- **Using grazing to promote tree growth**. If managed carefully, under certain conditions livestock can also play a useful role in reducing grass competition and fertilizing the site (168). For example, in Indonesian *Imperata* grasslands, rotational livestock grazing can be an alternative to burning pastures to suppress the grass and allow trees to establish and grow (168). Livestock can also graze fuel/fire breaks (169-171).

CLEARING OR ILLEGAL HARVESTING

Clearing land for other uses or overharvesting regenerating trees can occur when 1) people are unaware that the land is being used or who is using it (21), 2) land is insufficiently monitored or patrolled (166), 3) landholders decide to revert to non-forest land uses (100). These scenarios are best prevented when communities are engaged with ANR and stand to benefit from it in both short and long-term (Case Example 2).

PREVENTING FIRES

Fire can decimate young regenerating forests and impede natural regeneration in a range of contexts (109, 172, 173). While fire sometimes occurs naturally in moist tropical forests it is very rare, and many species are ill-adapted to frequent human-caused fires. Naturally regenerating forests (125, 174) and forest fragments are particularly vulnerable to fires (175).

The impacts of fires on a regenerating site can be reduced by 1) working to educate and reduce fire risk in the surrounding communities and 2) protecting the regenerating areas through a variety of strategies.

Step 1: Understand the causes and uses of fire.

The first step to managing fire is to assess how much of a fire risk there is for the regenerating forests and where and how the fires originate. In many tropical contexts, fire has traditional uses in land management. Understanding how fire is used by local people is critical to understanding how and to what extent its use can be reduced.

Historical fire maps and other fire data can be powerful tools for identifying where fires originate and how frequent/severe they are (176). Interviews with local partners and local experts can also help to understand practices around fire use and management.

Once the sources of fire have been identified, a plan to work with local stakeholders to manage and/or reduce fires can be developed. Targeted outreach, education, and general support for the project are important to ensure that "communities living in the vicinity support the ANR project and understand the need to prevent the occurrence of fires" (32). If fires have been used traditionally for specific purposes it is important to work with users, develop alternatives to fire, and promote practices for controlling fire, rather than banning fires outright (177, 178).

Local people are also well situated to be employed as fire patrols for regenerating areas (32). Once the parameters for reducing the causes of fire have been defined, using technical approaches to limit fires around restored sites can be an important next step (Case Example 4).

"While restoration projects in fire-prone landscapes often require fire protection in the first few years to ensure seedlings become established, at some stage fires must be allowed or be reintroduced to ensure that normal successional processes continue to operate. Local experience will be needed to determine when to switch from fire protection to fire introduction. In other situations, different forms of intervention may be needed." (179)

Step 2: Controlling fire around regenerating sites.

The methods below can be combined to control fire at a site. The effort put into fire control will depend on the risk of fire and local conditions.

- **Community outreach, education, and commitment to the restoration project.** Striking a balance between reducing fire and maintaining local practices, and meeting local needs is important, as is the understanding that not all fire is 'bad'. However, practices to control fire are important.
- **The installation and maintenance of firebreaks** can create a non-flammable boundary to stop fires before they reach the regenerating site. These should be around the entire perimeter and bisecting the site, creating smaller forest 'blocks'. Firebreaks should be cleared of vegetation ~3 times per year, or more. Firebreaks should generally be at least 6m in width. Wider firebreaks will stop fires more effectively. Firebreaks can be multifunctional, occurring along paths and designed to provide food, grazing for livestock, and other livelihood benefits.
- **Controlled burns and reducing fuel load** through regular maintenance can reduce the spread or intensity of fires. Pressing grass — a common maintenance

technique for ANR can also help to reduce the severity of fires (32; Box 4). Controlled burns can be used to create firebreaks, although they should only be used by people with the appropriate technical expertise.

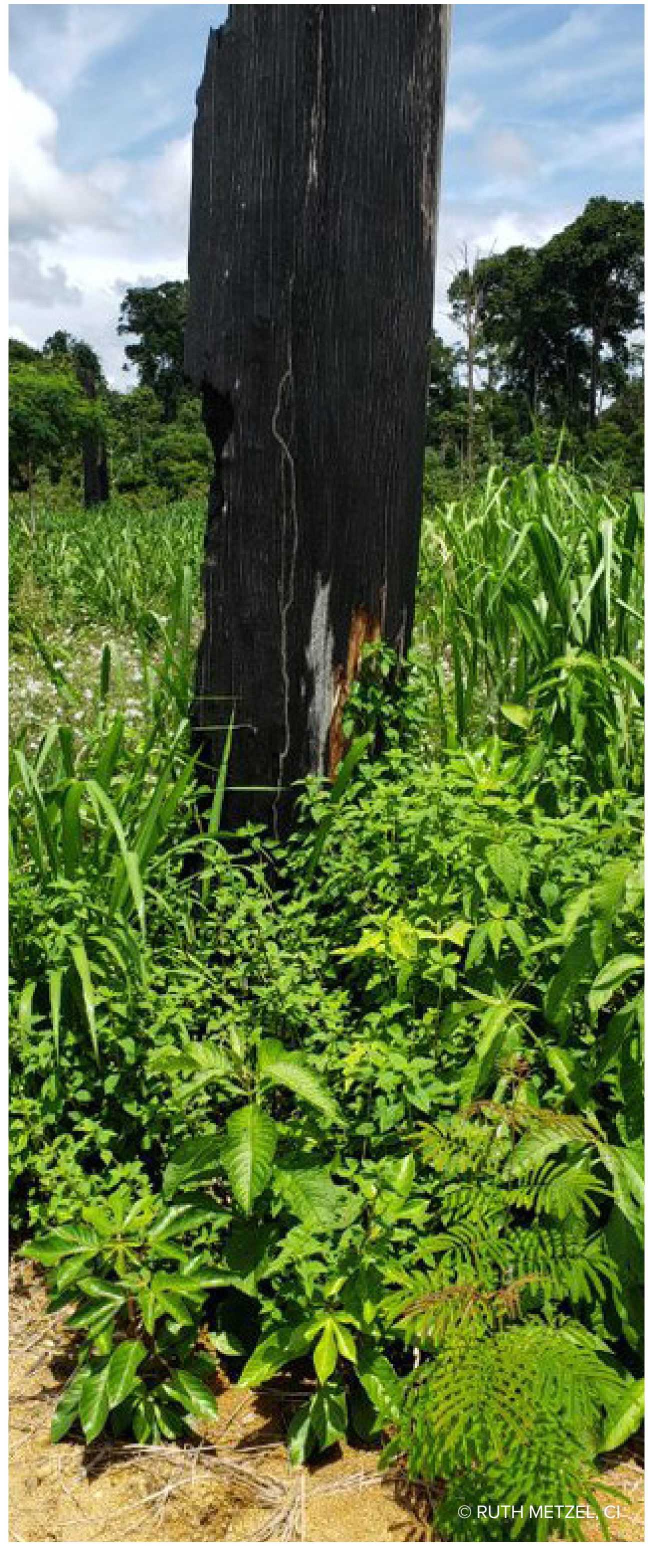
- **Planting fire-resistant species** in strategic locations can be used in ANR approaches that already incorporate tree planting. For example, if using applied nucleation, less flammable species can be planted on the outside of tree islands to buffer those that are in the core and more fire sensitive (110).

For more references/tools on protecting regenerating forests, see Annex 1.

4. MARKING AND PROTECTING REGENERANTS FROM UNWANTED/ INVASIVE SPECIES

Where pasture grass or other species that suppress tree growth are present, ANR will require regular maintenance. Grass and other invasive or dominant species can be a major impediment to natural forest regeneration (24, 180-183) and prevent tree species from establishing. Managing grass and other invasive or unwanted dominant vegetation can improve the outcomes and speed of natural regeneration (182, 184). It can also be used as part of a site assessment process to determine if additional interventions, such as enrichment planting, are needed to achieve project goals.

A common strategy is to locate, mark and protect regenerating seedlings, and then manually clear or "press" other vegetation surrounding the seedlings (168). Marking the seedlings ensures that the act of removing the vegetation doesn't harm the regenerating forest. Pressing grasses kills the stems while shading plants at the ground level and making it easier to work with the young trees (32; Box 4).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HOW TO MARK REGENERANTS AND REDUCE COMPETITION FROM OTHER SPECIES ADAPTED FROM FAO, ET. AL, 2019 (165).

- **Step 1: Mark regenerating trees**
  Develop criteria for which trees should be marked with visible stakes (32, 165) and how many of each species. These will depend on budgetary and time constraints and the intended purpose of the trees. Depending on the context, practitioners may also consider setting a goal based on the number of regenerants desired. For example, in the moist forests of the Philippines, marking and protecting ~ 800 regenerants has been found to be sufficient to shade out aggressive pasture grass after about 3 years (185) (if 800 are not present, they note that additional planting may be necessary). The number of regenerants to mark will vary with ecological context, project goals, and budget constraints (32, 165, 185). Depending on the restoration goals and monitoring processes in place, regenerants could also be tagged and their height recorded to monitor growth, and the species recorded if feasible (165). FAO, et. al, 2019 suggests, "in moderately sloping terrain, one worker can complete locating and marking 400 to 500 spots in 1 hectare within eight hours."

- **Step 2: Encourage the growth of regenerating trees**
  A 0.5m radius around each regenerating seedling should be cleared to encourage seedling growth (32, 98, 165). This can be done by uprooting weeds using hand tools and hand weeding close to the seedling to avoid damaging roots (32, 98, 165). If there is reason to believe soils are depleted of key nutrients, fertilizer can be applied. Mulch from cut weeds should then be placed around each regenerant, leaving at least 3 cm from the stem to prevent fungal infection (11). Cleaning around regenerants is typically required every 3-4 months for 2-3 years, or until regenerants are robust enough to survive on their own (32, 165).

- **Step 3: Suppress grass or other weedy vegetation**
  Where grass at least 1 meter tall dominate the site, "pressing" it down using a board may be more effective than cutting, as cutting can stimulate growth (32; Box 4). Other methods of controlling weeds include using herbicides, hand weeding, prescribed burns, or controlled grazing, but it is important to carefully weigh the risks, costs, and benefits of each of these approaches (186-188).

BOX 4: CONTROLLING GRASSES THROUGH "PRESSING" TECHNIQUE

Pressed grass can act like mulch, killing weeds by blocking new seeds from the sun. Those weeds that do survive grow back much slower. Pressing also helps reduce erosion and fire severity. The practice of killing grasses by pressing them flat with a wooden board is known as "Lodging".

Lodging or pressing is done with a wooden board approximately 15 to 30 cm wide and 1 to 1.2 m long. Attach a sturdy rope to both ends of the board, making a loop that is long enough to pass over your shoulders. Ensure that the rope is long enough for the board to lay flat on the ground when you are standing upright. Adjust the rope length according to your height by knotting the rope. Lift the board onto the weed canopy and step on it with full body weight to fold over the stems of grasses and herbs near the base. Repeat this action, moving forward in short steps. The weight of the plants should keep them bent down. It is important to monitor to make sure the grass does not spring back up. This is particularly effective where the vegetation is dominated by soft grasses such as *Imperata*. If the grasses are particularly tough or when you are trying to press down bushes, turn the board onto its narrow end and use the leverage of the full length of the plank to press the vegetation down. Pressing is best carried out when the weeds are about 1 m tall or taller as shorter plants tend to spring back up shortly after pressing. The best time to press grass is a few weeks after the start of the rainy season and before the end of the rainy season when the grass stems are softer. A simple way to test whether an area is ready for lodging, particularly for *Imperata*, is to flatten a small section and wait overnight. If the grass starts to spring back up by the morning, then wait a few more weeks before trying again. Always press the weeds in the same direction. On slopes, press grasses downhill.


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In the Philippines, a person can press 1 ha of grass in a 40-hour week, which is about half the time it takes to cut the grass with a machete or similar tool (165). Pressing can last for up to 6 months, whereas weeding/cutting is generally required every 3-4. Ferns and other vegetation amongst the grass should still be cut.

5. ENSURING SPECIES DIVERSITY AND RESILIENCE

Restoring stable forest ecosystems with multiple forest functions requires genetic, species and functional diversity (189). If applied in the appropriate contexts, natural regeneration can be more effective at restoring biodiversity than other restoration methods (190). However, in places where forests are unable to recover or are species-poor, this is not the case, and other methods that import genetic material into the landscape may be more effective (191).

HOW TO ENCOURAGE BIODIVERSITY IN ANR SITES

1. **Use the appropriate level of intervention for the site.** When conditions are amenable, use natural regeneration.
2. **Use well-established second-growth forests in the area as reference points to gauge expected recovery of species composition.**
3. **Have a monitoring plan and practice adaptive management based on site progression.**
4. **Protect seed dispersers**, which are crucial for carrying biodiversity held in seeds from remnant forests to the site. This is especially true of later successional species (32, 180, 181).
5. **Practice enrichment planting if need be.** Enrichment planting can be used to reintroduce species that fill important roles in the forest, such as attracting animal seed dispersers.
6. **Species with high ecological, cultural, or economic significance are good candidates for enrichment planting** (26, 32). It may be necessary to enrich the site with late successional or larger-seeded species.

6. ONGOING MAINTENANCE

The activities carried out during implementation should be continued until the regenerated forest is able to sustain itself and/or restoration goals are achieved.

- **Patrolling the site** is important to ensure that grazing rules are being respected and fences are in working order (165). It can also be a source of employment for local people or communities.
- **Dialogues** should continue within the community around the restoration site. It is important that community members stay aware that an area has been set aside for regeneration and continue to benefit from its restoration.
- **Fire patrols** should continue to keep a watch for fires and inspect firebreaks.
- **Fences** should be regularly inspected and repaired when necessary. Explore options for living fences, which require less maintenance. In small areas, solar-powered electric fences could be used.

- **Weeds** should be controlled at least until trees are over the height of the surrounding vegetation and can survive on their own. Cleaning around regenerants is typically required every 3-4 months, although it may be every 6 months if using the pressing method. Typically, trees will need to be kept free of weeds for at least 2-3 years or until trees can survive on their own (32, 165).

- **Monitoring** should be continually evaluated, and adaptive management used to improve the effectiveness of restoration. This includes assessing species diversity and whether it will be necessary to introduce new species through enrichment plantings in the future.

- **Publicize local successes** to advocate for polices that support ANR and increase public support.

BOX 5: ASSISTED NATURAL REGENERATION'S BENEFITS FOR CLIMATE ADAPTATION:

Climate adaptation involves lessening the impacts of climate change on people and ecosystems by helping communities prepare for future climactic changes. Forest restoration can be a part of a climate adaptation strategy by increasing landscape productivity and resilience for climate-vulnerable communities. In particular, in many places naturally regenerated forests are functionally, structurally, genetically, and age diverse. Biodiverse forests are generally more resilient to fluctuations in climate (192), pest outbreaks, and diseases than tree monocultures (109, 193). Biodiversity also contributes to forest ecosystem functioning which provides many benefits, including pollination, seed dispersal, fire regulation, defense against pests, carbon sequestration, habitat for other species, and cultural services (194). Many of these benefits also promote further effective forest regeneration, creating a virtuous cycle.

Naturally regenerated forests also can serve as a climate adaptation strategy for local communities. They can provide locally available materials, including both timber and nontimber forest products, as well as ecosystem services including forest-based foods (24, 92).

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SECTION 5:

MONITORING ANR

Monitoring is a crucial part of any restoration program as it helps to ensure that a work is progressing in the right direction. Monitoring involves tracking a project site against its baseline pre-restoration and/or against an alternative site with no restoration actions taken. It is based on tracking a set of indicators from which progress towards the project's objectives can be assessed (Figure 8). Monitoring can be as simple as photo point monitoring (taking a photo in the same place periodically), or can involve on-site sampling designs, periodic data collection, and/or remote sensing.

Many ANR projects do not plan for monitoring, but it is a critical part of the ANR process. Monitoring can help to (adapted from Rinaudo et al., 2019) (195):

- Mobilize stakeholders to promote ANR.
- Inform adaptive management to improve ANR practices.
- Demonstrate the cost and benefits of ANR practices.
- Attract funding for ANR projects, and establish the basis for incentive payments cor subsidies for ANR-based restoration.
- Generate information to advocate for policy changes supporting ANR.

Monitoring should be included in the initial planning process, account for the interests of all stakeholders, and include a shared vision of success between stakeholders. Participatory monitoring can be particularly effective for engaging local partners. For more information on participatory monitoring, see (196).

Monitoring ANR can take a variety of approaches, depending on partner organizations, project objectives, resources, and technical expertise available. This guide focuses on large-scale restoration, which is socially beneficial, uses native biodiversity and sequesters a significant amount of carbon. Much of the monitoring protocol discussed in this chapter comes from the CI-WRI Monitoring Framework (197).

Establishment of landscape level control sites (counterfactuals) allows comparison against a 'background' rate of regeneration. Having information about the background rate enables the implementers to determine what regeneration is due to the project intervention and what would be there naturally. This is also referred to as additionality. In the context of assisted natural regeneration, it is especially important to have good baseline data because some regeneration is often present without the intervention being done. Adequate baselines allow the implementer to accurately quantify what was present on a restoration site prior to the intervention, which also contributes to determining the additionality of the project.

FIGURE 8

General Monitoring and Adaptive Management

1 Identify what to monitor (develop criteria and indicators related to objectives); → **2 Establish** threshold points where further intervention is needed; → **3 Develop** a sampling design (measure indicators of the selected criteria);

4 Collect and analyze data; → **5 Evaluate** results and communicate to stakeholders; → **6 Re-evaluate** the process in order to guide future efforts.

Key Steps in monitoring and adaptive management (Adapted from Stanturf et al., 2017; pg. 67).

POTENTIAL INDICATORS FOR ASSISTED NATURAL REGENERATION:

Inconsistencies in monitoring across projects make it challenging to track the impacts and effectiveness of ANR, but to date there are no internationally agreed upon, consistent metrics for ANR projects. More consistent monitoring techniques that are still adaptable to the needs of different programs and organizations could help advance policies in support of ANR and mobilize stakeholders to increase ANR adoption. Below are some key indicators that apply to most ANR sites and can be used to compare projects across different contexts, especially those which have objectives of biodiversity, social benefits, and carbon sequestration.

Indicators can be measured using a combination of field-based techniques (vegetation surveys, household surveys, etc.) and remote techniques, such as remote sensing. This hybrid monitoring process maximizes efficiency and accuracy while minimizing burdens placed on implementing partners (197).

For indicators that are measured using remote sensing, it will be critical to have a GIS shapefile of the boundaries of the area(s) being restored, to establish baseline metrics, and to select similar sites that can be used as landscape-level control units. Having the boundaries of the exact restoration area is important for both field and remotely sensed monitoring methods because, at a minimum, it verifies how large the restoration area is and therefore provides the basis for other measurements collected in real-time or retroactively. More guidance on this can be found in a tree restoration monitoring framework co-developed by CI and WRI (197).

Indicator 1: Number of hectares under restoration

The total area being restored is an important metric for many reasons, such as compliance with policies, national pledges, measuring impacts, communicating results to funders, etc. The area under restoration should be defined as "The total land or water surface area (measured in hectares) with restoration interventions in planting or monitoring stages, defined using the GIS shapefiles of the restoration activities" (198). The ecosystem type and restoration intervention type should also be defined.

Indicator 2: Number of trees regenerating per hectare under restoration

Many restoration programs determine their objectives based on target numbers of trees planted. For tree planting projects, the key metric is the number of trees planted, but a more meaningful number is the total number regenerating per unit area. This can include the number of trees per hectare restored during a project implementation, and more specifically, due to ANR interventions. Ideally, this would also be disaggregated by species and size class, where resources allow, as this allows practitioners to better understand how the restore forest is developing and the successional direction (198).

Regenerating trees should be surveyed prior to project interventions (baseline study) and after pre-determined time intervals, such as 2, 5, 10, and 15 years. It is important to have a robust sampling design, relative to the size of the restoration area. It is also important to identify and mark the existing trees on site at the beginning of implementation to avoid counting them again during monitoring. If trees are marked during inventories and DBH is measured, growth rates and survival rates can be determined. Involving researchers in monitoring efforts could add considerable information that could be used to guide future interventions and adaptive management.

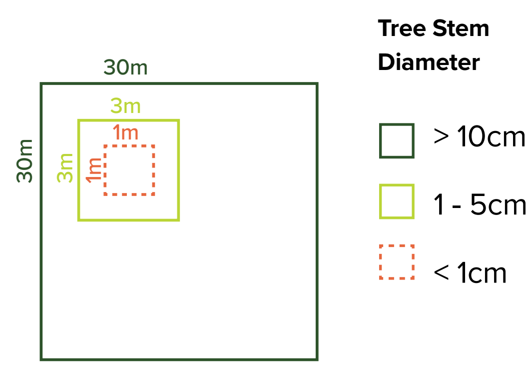
Remote Sensing Techniques: Estimates of tree densities can be made using GIS/remote sensing technologies such as Collect Earth Online or the Trees in Mosaic Landscapes dataset (199). However, if GIS/remote sensing is used, field data collection is still necessary to verify the remote sensing techniques until remote sensing protocols are refined and their accuracy determined. Recording tree species will likely need to be done in the field until remote sensing technologies improve. Baselines should be established using the most recent satellite imagery available prior to implementation of restoration program and compared to values at a pre-determined amount of time following restoration implementation.

Field-based Monitoring Techniques: Fixed area plots can be used to monitor restoration on the ground. Beyond a simple count of trees, information such as height, diameter, and species may be recorded, depending on the monitoring plan and interests. The restoration area may need to be stratified into sections with similar vegetation, land use, baseline condition, slope, etc. A first pass at stratification can be done using satellite imagery, and then using on the ground observations. The number of plots sampled should be determined based on a desired sampling ratio. It is especially important to have adequate sampling in ANR contexts to help determine what is due to the project and therefore additional and what is background or prior natural regeneration. This distinction is key for showing the impact *assisted* natural regeneration has had compared to natural regeneration as a non-human associated process.

The area to be sampled should be representative of entire restoration area, and more heterogenous restoration areas should have a greater proportion of area sampled. Measurements from the fixed area sampling plots can then be extrapolated to broader restoration area. Monitoring plots should be randomly located with a nested design (Figure 9) to follow different size classes of trees. The thresholds for the sizes of trees measured in each plot will depend on the site conditions, stages of restoration, and restoration goals — an example of standard classes is provided in Figure 9.

FIGURE 9

Suggested model for setting up nested plots to monitor trees of different size classes (197) trees of different diameters are measured in each nested plot. Note that the size class thresholds can be changed depending on the site conditions, project goals,



For an overview of field-based techniques for monitoring the number of trees restored, refer to the Tree Restoration Monitoring Framework Subprotocol 4- Vegetation Monitoring (197). Monitoring small plots will mostly contain common species. To survey for rare or uncommon species, much larger areas would be needed.

Indicator 2.1: Number of trees per hectare restored during project implementation

The number of trees that regenerated during the implementation period can be determined by subtracting the number of established trees present at the baseline from the total number of established trees at the time of evaluation.

Indicator 2.2: Number of trees per hectare under restoration as a result of ANR interventions

The number of trees per acre established due to assisted natural regeneration practices can be determined by comparing the trees per ha established during the implementation period in the restoration area to similar sites with no ANR treatments. This requires setting aside a control area with no interventions in the project's planning phase.

Indicator 2.3: Number of trees under restoration disaggregated by species

The number of naturally regenerated trees per ha disaggregated by species can be used to predict future forest compositions and the potential need for future enrichment plantings. Species information that is not currently possible to obtain with remote sensing would need to be collected during the field data collection.

Indicator 3: Change in Forest Tree Cover

A canopy reaching full closure is an important milestone in restoration programs, especially at sites that are dominated by shade intolerant vegetation such as grasses. Changes in percent crown cover is an important indicator of progress towards a restored forest and can be analyzed using new remote sensing techniques (198). This is related to the tree size and density and is influenced by bioclimatic factors. Program targets should use the best available data on potential tree covers for the region in which the project is located. Established protocols exist for measuring changes in tree cover using remote sensing technologies. To achieve the most accurate measurements, a high-resolution dataset should be used. Both absolute and relative changes in tree cover in the target area should be calculated. If field methods are preferred, tree basal area can be calculated from tree DBH measurements and be used as a proxy indicator of forest cover.

Indicator 4: Estimated Carbon Benefits

Tons of CO_2 to be sequestered in above and belowground woody biomass as a result of the restoration action is best calculated using data on tree abundance and dimensions, if available, from ground measurements.

If field data is not available, tons CO_2 can be estimated with remote sensing datasets using the shapefiles of the restored areas. Note that remote datasets rely on assumptions of general models or geographic trends and field data is more reliable. In reality there are wide site differences, even among similar-aged plots undergoing natural regeneration. The Tree Restoration Monitoring Framework (121) recommends using a global database of carbon dioxide removal rates from natural regeneration activities, specifically, the one published by Cook-Patton et al., 2020 (200).

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This will generate an estimation of potential new carbon sequestration due to the restoration activity. Estimates should be done before considering changes to additionality resulting from the restoration activities and therefore should not be used to make carbon claims, which would require much more rigorous monitoring methods.

Indicator 5: Major disturbances observed

Major disturbances such as flood, fire, grazing, pest outbreaks, and intentional clearing can have huge impacts on the success of a restoration program. Preventing such disturbances is a major component of ANR interventions. Whenever major disturbances occur, they should be reported to as part of a monitoring program. Details should include the type of disturbance, time period in which it occurred, intensity, and extent of the damage (197, 201).

Indicator 6: Social/Community benefits

Restoration can provide important benefits to communities, ranging from creating jobs to receiving other forms of socioeconomic support to providing ecosystem services. It is important to quantify and document these benefits. Social impacts can be measured using a variety of methods, including focus groups, surveys, or phone-based interviews. Care should be taken to not introduce selection bias when relying on technology for survey distribution. When interviewing communities, it is important to define the participating communities, identify households in the community, and randomly select samples to be surveyed. It has been suggested that 6 to 25% of participating communities should be sampled, but this will depend on the number of people/communities participating (202). Communities or households not participating in restoration can serve as controls. Surveyors should be carefully selected and trained to minimize the introduction of biases.

For an extensive list of potential social/community indicators see *Farmer Managed Natural Regeneration (FMNR) Manual* (192). Two social/community benefits that can be easily tracked are the number of person-days of work created and the number of other socioeconomic beneficiaries (197).

Indicator 6.1: Number of person-days of work created

The number of jobs a project creates can be quantified in terms of the number of 8-hour person-days worked per year by project participants. This number is easier to compare than metrics such as "jobs created." It should be disaggregated by volunteer work or paid work, gender, indigenous/non, etc., as much as possible. This can also be used to assess labor equity and opportunities for participation by women and local/indigenous peoples (197). The compensation rate could also be used to calculate the economic importance of these work days.

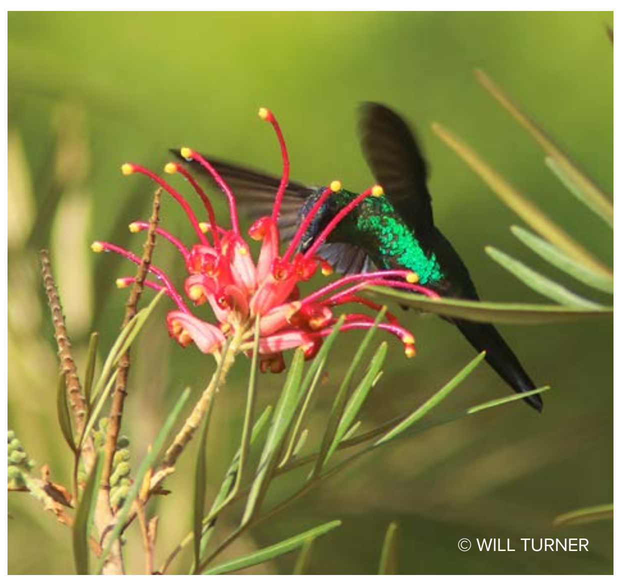
Indicator 6.2: Number of restoration partners involved

Restoration can have both direct and indirect socioeconomic benefits. Direct restoration partners are those who receive direct support from the program, including both monetary and non-monetary forms of support, who are aware of this support. Indirect restoration partners and family members of those who receive direct support and people involved with organizations and partnerships that may bring jobs in the future. The number of restoration partners should be recorded, ideally disaggregated by direct and indirect beneficiaries, gender, age, and ethnicity. If that level of detail is not feasible, the number of families engaged can be a good proxy. Types of benefits received should also be recorded (197).

Indicator 7: Number of ecosystem service beneficiaries

"Ecosystem services from forests include water, energy, food, and timber, as well as livelihoods, medicines, materials, and culture/spiritual/identity. Furthermore, forests provide climate change adaptation services key to disaster risk reduction such as reducing flooding, wind damage, and landslides during extreme rainfall events" (197).

Restored forests can increase the capacities of the landscape to offer many ecosystems services and can help local communities adapt to changing climates. As accurately as possible, these ecosystem services should be identified and the number of people who receive ecosystem service benefits quantified. This can be done by counting the number of people who live in or near areas that are being restored, such as those who live in a watershed that is fed by the restored area, gain livelihoods from nontimber forest products produced in the restored areas, or otherwise benefit from improved or secured ecosystem services. Benefits may increase the resilience of vulnerable communities to climate change, contributing to climate change adaptation.



Indicator 8: $ cost per tree grown or per area of area restored

It is important to measure the opportunity, monetary and in-kind costs to the organizations and local people leading restoration, from planning through implementation and monitoring. This will help to assess the comparative cost-effectiveness of different restoration techniques and inform future investment in restoration. This should occur over a set time period, with the total applicable cost standardized by cost per tree or cost per hectare. Note that both the indirect and direct costs to local people should also be considered, as should administrative costs.

Indicator 9: Biodiversity

Biodiversity can be monitored using a variety of taxa as indicators, depending on the local ecological context, available resources, and technical expertise. Biodiversity monitoring is not a simple task and is usually poorly done in restoration projects. Local researchers who can identify the local species and have advanced training regarding methodology and data analysis are key leaders of these types of studies.

Indicator 10: Water quantity/quality

Reliable supplies of clean water are of critical importance and value to people everywhere, including both local and downstream communities. There are many misconceptions and misunderstandings about forest/water interrelationships, with some people believing (often incorrectly) that increased forest cover will increase water yields or flow. Forest/water relationships are highly complex and change with the growth and maturity of forest stands. In virtually every instance, however, long-term water *quality* is improved with increased forest cover in watersheds.

Given the critical importance of water quantity and quality, monitoring water flows and quality in areas being restored with ANR — compared with baseline or historical data — is very important. Relevant indicators include stream volume flows, peak and low flow, volumes, lake or pond levels, water levels in wells, etc. Water quality is measured in terms of sediment levels, and periodic chemical analysis.

Water monitoring for smaller projects can practically be done informally and with anecdotal documentation, although simple, systematic measurements are preferable (203, 204). Basic water flow monitoring, including peak and low flows, can be accomplished using relatively simple stream-flow gauges (e.g., float and cross-section method or pygmy meters); surface runoff can be monitored with run-off plots; and seasonality of stream flows can readily be directly observed. Larger restoration efforts, covering more extensive landscapes and with larger budgets, can implement more comprehensive, sophisticated and systematic water monitoring approaches including automatically recording stream flows, chemical water quality analyses, modeling, inventorying aquatic species, and remote sensing. The Food and Agriculture Organization of the United Nations has developed a useful "Forest & Landscape Water Ecosystem Services (FL-WES) Tool" which can help restoration managers identify appropriate and practical water monitoring indicators and methods of monitoring for various types of restoration projects and programs (205).

OTHER FORMS OF MONITORING:

- Photo points are a simple, low-cost form of monitoring ANR projects. These involve setting a fixed pole in the ground from which photos can be regularly taken, recording changes in the landscape over time from a fixed vantage point.
- Drones may become increasingly used for monitoring restoration. As drone costs decrease and expertise increases, there are many potential applications within restoration monitoring.
- Camera traps, acoustic monitoring, and eDNA for biodiversity assessment.

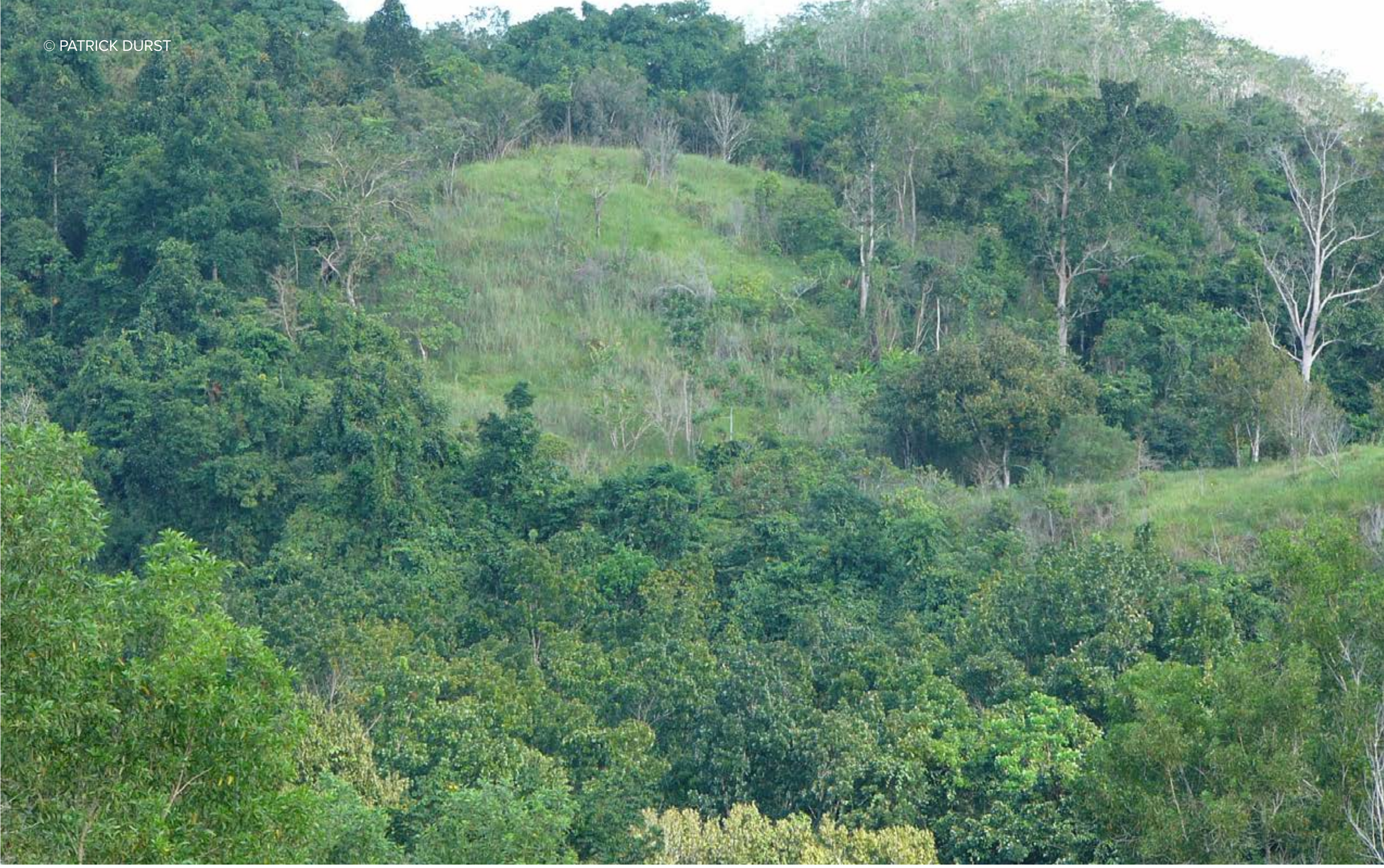
COMPARING WITH ALTERNATIVE TREATMENTS

Results should be compared to similar sites that have received no restoration treatments to determine project success based on chosen indicators. These can be other similar sites or control plots within the restoration area (197).

SHARING RESULTS

Long term monitoring can help provide useful information for improving management, writing policy, and gaining funding for restoration projects in the future. In addition, it is important that the results of monitoring be shared with all stakeholders and be made public to inform future restoration projects.

> *"Monitoring results should be shared verbally and in writing with all stakeholders, for discussion and action for correction of problems and continuous improvement. Discussion and dissemination of monitoring results ensures that knowledge and learning create a feedback loop that includes all stakeholders, rather than being 'extractive' that is, only taking information away from the project to provide to donors, etc." — Rinaudo et al., 2019*



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SECTION 6:

LEARNING FROM PRACTICE – CREATING FIELD "EXPERIMENTS"

Each restoration project produces valuable lessons that can inform and improve future restoration activities. However, ANR projects are often not planned nor implemented with a goal of recording and transferring this experience or knowledge gained. Planning, implementing, and monitoring ANR projects in ways that achieve project goals while providing useful information about successful ANR efforts would be extremely helpful for advancing the field of ANR. When a project is planned and implemented with a robust monitoring program and an intention of learning from practice at its outset, results and lessons learned can support ANR adoption in diverse contexts around the world.

KEY QUESTIONS TO BE ADDRESSED THROUGH ANR APPLIED EXPERIMENTS

Despite its promise as a restoration technique, there are still significant research gaps that could inform ANR practices. This section describes key research questions that would be useful for ANR projects to commit to understanding, as well as suggestions for addressing them while implementing them in the field.

- How well does ANR work across different forest types? For example, high elevation forests, dry forests, mangroves?
- How does ANR work at larger scales? What are the economics of restoring forests at large scales using ANR?
- What conditions/thresholds determine whether enrichment plantings are needed to restore biodiversity?
- Which species that can be restored through ANR fill both ecological functions and social needs?
- What are the costs of the various types of ANR restoration?
- At what point and to what extent should enrichment planting be considered as a strategy for increasing biodiversity in a naturally regenerated forest?
- How are ANR practices perceived and implemented by local communities?
- How quickly and under what circumstances is ANR adopted (for example, on private farms)?
- What are the specific specific challenges to implementing ANR in a range of contexts?
- What are the potential outcomes of ANR for livelihoods and land use?

BASIC CONSIDERATIONS FOR SETTING UP ANR PROGRAMS AS APPLIED EXPERIMENTS

To understand how well ANR works as compared to other common restoration methods, implementation should include two basic treatments — Control treatments (through one of several approaches) and ANR Treatments:

1. **Naturally regenerating control(s):** Ideally one with protection from disturbances but no ANR treatment, one without protection but with no direct control over the land use/maintenance (a ‘counterfactual’ site), and one with a deliberate continuation of the business-as-usual practice (grazing, burning, clearing, etc.). In these control treatment sites, no "pre-treatments" should be applied to match the restoration treatments.
2. **ANR treatment(s):** The application of the 'assist' method. Where possible, it is beneficial to test different methods applied to different sites or different areas within the same site. Methods can also be combined.

The baselines should be recorded for each area, including species present, regeneration, number of mature trees, pre-existing tree cover, etc. Costs should also be recorded for each treatment.

Treatments must be applied in areas with as similar site characteristics as possible. This includes land use history, distance from forest remnants, slope, aspect, and elevation. All these attributes should be recorded, along with the forest type, rainfall, and other relevant ecological attributes. Alternatively, there should be enough replicates (sites) that can account for variability in the landscape.

At a minimum, ecological experiments will require monitoring: A) Canopy cover and B) Number and species of regenerating trees at 2 and 5 years. Ideally, they would also include monitoring at longer intervals (e.g., 10-15 years). They also would:

- **A.** Identify regenerants by dispersal mechanism and seed size to understand how successional processes develop in forests restored using ANR. This could be useful for classifying "successional status" if the information is available. Chazdon et al. 2011 (206) describe a process for identifying successional specialists and generalists.
- **B.** Monitor other aspects of forest recovery, particularly if there is local expertise that can be used (e.g., bird, plant, or arthropod surveys).
- **C.** Record the cost of implementing and maintaining treatments, including supplies, labor, and transportation.

Recording the process for implementation is an important step toward obtaining social data. Participatory appraisal techniques are important for the planning phases in many contexts and can be used to assess baseline conditions and measure follow-up after implementation. Even if it is not possible to set up projects with an experimental component, regular monitoring using standardized procedures is critical for learning from individual projects and comparing across projects.

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SECTION 7:

CASE EXAMPLES

Case Example 1:

Rising from the Ashes: Farmer-managed natural regeneration restores forests and farmland in Aileu, East Timor.

Project: Aileu region, BRACCE project implemented by World Vision 2011-2016

Summary: Assisted natural regeneration was used to restore 51 hectares on 46 community demonstration plots plus at least an equal amount on private land across four Aileu districts in East Timor. The project resulted in positive impacts for 12000 people (207).

Context: Swidden fallow was common in Aileu, but a growing population combined with reduced forest area made this practice unsustainable. Overgrazing and annual burning led to declining soil fertility, water storage capacity, erosion, and landslides.

Implementation: Farmer managed natural regeneration (FMNR) was implemented as a holistic land management strategy to improve farming and sustain livelihoods. Key features of its implementation were demonstration plots, community trainings and capacity building, and supplementing natural regeneration with planted trees to achieve specific outcomes like fruit, fodder, or timber production. Farmer uptake was very high. The strategy for promoting FMNR involved identifying the main environmental problems communities faced and how a change in practices could solve them. The Aileu outcomes below show that FMNR can have dramatic results in only one year (208).

Challenges and overcoming them:

- **Land tenure:** This project strengthened legally binding tree ownership or user rights through community-based mapping exercises.
- **Cultural barriers:** Demonstration plots were used to help change policy and local perceptions of forests and trees on farms.
- **Conflict resolution:** A high level of community participation made it possible to resolve conflicts around fire and grazing animals, two of the biggest threats to trees and seedlings.
- **Coordination and support:** local organizations, including farmers associations and governance structures, were supported and activities between them coordinated.
- **Policy and wood certification:** Policy was changed with a certification scheme to allow legal, transparent means of selling wood and NTFPs and increase the economic benefits and rationale.

Outcomes:

1 year: Forest cover, biodiversity, and soil fertility increased. Soil erosion declined. 51 ha of forests were restored in demonstration plots, inspiring additional regreening of private land in the landscape. A decrease in burning trees and the adoption of slash and mulch created darker, richer soils and allowed trees of different species to regenerate (previously most trees were Eucalyptus).

5 years: Management of natural resources and conflict resolution methods improved, forest cover increased. Farmer uptake rates were very high — over 90% of farmers aware of FMNR adopted elements of the land management strategy. Farmers also report an increase in income through improved vegetable, fruit and livestock production. Ultimately, 51 ha were restored in 46 community demonstration plots and 50+ ha on private land, with positive impacts for 12,000 people (208-210).

Case Example 2:

Engaging communities in FMNR in Niger

"A farmer-managed natural regeneration pilot site in Niger. Prior to ANR this landscape was virtually devoid of trees" (211).

Summary: FMNR has been promoted by international organizations and through farmer-to-farmer transfer of knowledge in the Niger and other Sahelian countries since the early 1980s. It has been estimated that about 25-50% of farmers have adopted FMNR practices, restoring trees to 5 million acres of land, benefiting 4.5 million people (212).

Context: Decades of degradation from the 1950s-1980s left Niger's arid landscape devoid of trees. Farmers viewed brush as 'messy', and 'good' farming practices included clearing bushes and organic matter from the site. Heavy winds damaged and dried crops and frequently forced farmers to replant crops. Top-down approaches to reforestation had been failing. In the mid-1980s, in response to a drought, the government started promoting FMNR and getting trees back in the landscape. This began with the government enacting a food for work program, putting thousands of people to work, restoring land through FMNR approach. Early on, benefits were short-lived, but gradually, it caught on. International organizations have been promoting this movement alongside local farmers for the last several decades.

Implementation: In Sahelian countries, FMNR typically is integrated with livestock and crops. Farmers practice FMNR by selecting 2-3 leader twigs on established stumps, allowing them to grow into trees. Because the trees have deeper roots, they can grow 2-3 meters per year rather than the 20-40 cm that a seedling would grow in that time. Every 2-6 months, trees are pruned, opening the canopy for crops, and providing wood that can be sold. Most organizations promote leaving 40 trees per hectare in the ground.

Some promoters of FMNR claim the restoration strategy costs $10 per hectare, (44), compared to $200 per hectare for planting. This includes 100% survival compared to 20% survival in planted restoration in the same region (213). One study showed the sale of firewood to increase household income by $72 per year (214).

One specific program that has promoted FMNR is Niger is the Desert Community Initiative. Their planning and implementation strategy involved conversations around goal setting and decision-making both within and between villages, including the most marginalized voices of women and Fulani herders (both groups who often use and rely on the land). A key part of the initiative was establishing 53 village committees of three or four villages each. These are recognized by both the government and traditional leadership, which allowed communities to be involved in all stages of the project, including implementation. Trees were established on over 130,000 ha as a part of agricultural systems. "Inclusion of all stakeholders (women and men, village residents and sedentary Fulani herders living outside the villages) in decision making has been pivotal to the successful adoption and spread of FMNR." (215, 216).

Challenges and overcoming them:

Tree tenure: Until recently, all trees were legally considered property of the government, creating a disincentive for farmers to let trees grow on their land. Traditionally, trees on private land were considered open for anybody to harvest and there was not a culture of reporting tree theft. In 2020, a new law was passed, giving landowners rights to manage trees in their agricultural fields. Villages could set up committees for monitoring legal tree harvesting, which could also coordinate with local district agents and forestry agencies to enforce laws.

Access to markets: Road access was improved to allow farmers to get their wood to the market. Investments were made in infrastructure for processing and selling wood products.

Widely held beliefs: Through monitoring, widely held beliefs that trees reduced agricultural yields were disproven. Rather, it was demonstrated that trees can increase yields in some situations.

Education and technical support: Farmer to farmer spreading of information has been one of the most important means of promoting FMNR in Niger.

Outcomes:

FMNR has reduced the impacts of drying winds on crops, improved water infiltration, and improved fertility and nutrient cycling on farms. Famers receive greater crop yields, a variety of timber and nontimber forest products, fodder for livestock, improved pest control, tree-based foods, and habitat for biodiversity. Overall income by farmers has been increased, diversified, and staggered throughout year, resulting in reduced conflict over scarce resources. Farmers can now stockpile grains, which improves their resilience against droughts, which are increasing due to climate change. Women specifically benefit by reducing the amount of time they spend harvesting fuelwood.

Lessons learned (from Wilson et al., 2021) (217):

- *Flexibility and adaptability are key*: had practitioners dictated to farmers exactly how to do FMNR, it is unlikely to have developed such widespread appeal.
- *Desperate times can lead to restoration*: In the face of a lack of viable alternatives, farmers were willing to change their practices and incorporate on-farm trees.
- *Seeing is believing*: Having a farmer see firsthand and exchange experiences directly with fellow farmers living and working under similar conditions is the easiest way forward and helps explain how FMNR spread so widely and quickly.
- Restoration based on FMNR takes the support of a village. In places where social cohesion was lower, FMNR was not adopted as widely.
- Engaging farmers is critical for widespread restoration using FMNR.

See also the National Geographic article on FMNR in Niger (218).

Case Example 3:

Normalizing Assisted Natural Regeneration (ANR) as a strategy for restoration in the Danao Watershed, the Philippines


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Summary: In 2006, the ANR project was initiated within the Danao municipality of Bohol, Philippines to 1) restore a degraded and deforested watershed area and 2) demonstrate and promote the potential of ANR as a forest restoration strategy. Tree planting efforts in the region had recently failed, leaving local communities and government officials looking for alternatives. A collaboration between local, private, and government sectors, this case example demonstrated that ANR can be an ecologically effective and inexpensive way to restore forests in the Philippines, helping to spur large-scale commitments to restore forests using ANR around the country.

Implementing partners/stakeholders: The Bagong Pagasa Foundation, Food and Agriculture Organization of the United Nations (FAO), Philippines Department of Environment and Natural Resources, local organizers, and governments.

Area restored: In Danao, ANR was implemented on a 25 ha demonstration plot along with several others elsewhere in the country. ANR was subsequently accepted as a viable restoration strategy for large-scale regreening programs, including: 1) the Upland Development Program, which aimed to restore +13,000 ha via ANR in 2009-2010, 2) the Integrated Natural Resources and Environmental Management Program which was involved in restoring 78,800 ha across 23 watersheds using ANR, and 3) additional commitments from industry (219-221).

The Context: Land in the Danao watershed had been degraded and deforested as increasing population pressure rendered traditional slash and burn agriculture unsustainable. Deforested areas were dominated by fire-prone grasses that inhibited natural forest recovery. Although many local communities and governments recognized the need for restoration, tree planting was seen as the primary way to restore forests, but this faced resistance from local people because of past failures. Stakeholders at multiple levels were unfamiliar with the concept and potential of ANR as a restoration technique until local champions of ANR and NGOs introduced this method to the region (219-221).


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The Intervention: ANR in Danao involved establishing firebreaks, employing community patrols to prevent fire, staking naturally regenerated saplings, reducing competition from grass, and controlling grazing and fuelwood gathering. Farmers also planted food crops on firebreaks to provide economic benefits during restoration (222, 223).

The Turning Point: Although the Department of Environment and Natural Resources (DENR) accepted and began promoting ANR for forest restoration in 1989, it was not significantly implemented until much later because of a lack of technical expertise and resistance within the government to restoration techniques other than tree-planting. Because stakeholders were not familiar with ANR as a restoration technique, training events were organized to introduce and instruct the Danao project participants on ANR. Ultimately, a group of ANR experts and practitioners was created within the stakeholder groups of the DENR, NGOs, the academic community, research institutions, civil society organizers, and local community members.

This case created support for ANR from multiple levels of government, outside organizations, and local practitioners. Farmers participated because local degradation was apparent and detrimental to their livelihoods, and ANR promised multiple economic opportunities and benefits to farming. Many local practitioners then altered their strategies to include ANR techniques following training. Civic groups made up of volunteers were assembled to maintain and protect the ANR site from fire and some groups even "adopted" nearby areas to restore (64). The mayor of Danao "enthusiastically embraced ANR", and continued support from the DENR set the stage for expanding ANR throughout the Philippines.

Challenges and overcoming them:

The main challenge faced by the Bohol project — and what it aimed to overcome — was the widely held misconception that tree planting was the only way to restore forest. At its inception stakeholders at multiple levels — donors, governments, landholders, and managers - were unaccustomed to using ANR. Specifically, ANR was impeded because:

- Governments at multiple levels resisted change from a strategy of tree planting.
- A lack of evidence of the cost effectiveness and potential for restoration success using ANR.
- A lack of awareness of how ANR works at all levels.
- A lack of skills and expertise required to implement ANR at local and regional levels.

Training events aimed at these diverse stakeholders helped to introduce ANR as a cost-effective restoration method with potential for broad application. Furthermore, by encouraging the planting of food and cash crops along fire breaks and non-timber forest products (e.g., rattan, bamboo, and nito) within the restoration area, local people gained economic benefits and raw material to produce handicrafts. This gave local people greater incentive to protect restoration sites against harmful grazing or fuelwood gathering (64).

Identifying key stakeholders, encouraging local stakeholder participation in the planning process, securing the support of local NGOs and educational institutions, continuous consultation with communities, and patient communication among these groups were key components that led to the success of the demonstration project and subsequent trainings. Local NGOS and the FAO contributed different areas of expertise, contributing to the overall success of the project.

Outcomes:

Broad adoption and learning: The major outcome of the Danao project was establishing ANR as a cost-effective approach for forest restoration with outcomes that were comparable to tree planting. The Danao site has become a "showcase" of ANR success and feasibility with multiple workshops and studies held there to inform restoration work around the world. Based on its success, an increasing number of government agencies, NGOs, and donors in the region now recognize and recommend ANR as a strategy. The Danao local government subsequently passed a resolution to declare itself an "ANR municipality", the first in the Philippines (224).

Low cost: Compared to conventional tree planting, ANR was nearly 50% less expensive. Over a 3-year implementation period, ANR cost US$579 per hectare; conventional restoration (tree planting) cost US$1048 per hectare at the time (225).

Large-scale ANR commitments: As a result of the success of the project at Danao and the other demonstration sites in the early 2000s, ANR was included as a restoration method within several larger projects. The Upland Development Programme of the DENR included the use of ANR, committing 9,992 hectares to be restored by ANR in 2009 and another 3,191 hectares in 2010. The Forestland Management Project targeted 5,000 hectares of degraded land and the Integrated Natural Resources and Environmental Management Program 78,800 hectares within 23 different watersheds to be restored using ANR.

Policy change: In 2009, the DENR released a national policy that promoted ANR as a major tool for forest restoration across multiple land tenure types. ANR is also a recommended activity under the "Philippine National Action Plan on FLR 2016-2018" (226). To date, ANR is included as a restoration option in most Forest Land Use Plans (181).

Increased ecological integrity: In Danao, prior to ANR there were three main vegetation types: grassland, secondary forest, and plantation forest. After the application of ANR techniques, there were observable changes in biodiversity within 17-18 months, most notably in the grassland areas. Several tree species naturally regenerated in these areas and a botanical inventory concluded that ANR results in "a highly diverse natural forest comprising native species well adapted to the site" (225). However, species that indicate a more mature forests were not yet present in the grassland areas after the initial 18 months.

Local economic benefits: ANR provided socio-economic opportunities for community members. Planting cash crops on firebreaks created income generating opportunities, and local people that were also employed to patrol against illegal harvesting, grazing, and fires received an income from this activity. ANR activities also improve the prospect of expanding the ecotourism industry in the area.

Key takeaways:

The ANR pilot project in Danao demonstrated that ANR is an inexpensive and effective method that results in ecologically sound forest restoration. It demonstrated that ANR 1) is approximately half the cost of conventional tree planting and 2) results in "a highly diverse natural forest comprising native species well adapted to the site" (225). It also emphasized the importance of collaboration between important stakeholder groups, including involving local NGOs, governments, and local practitioners in the decision-making process.

Case Example 4:

Improving fire management in New Caledonia to deliver assisted natural forest regeneration

Authors: François Tron[1], Cédric Haverkamp[1], Adrien Bertaud[2], Martin Brinkert[3] & Marie Toussaint

*Author affiliations: 1) Conservation International; 2) Observatoire de l'Environnement en Nouvelle Calédonie (ŒIL); 3) Province nord

Summary: In New Caledonia, fire is traditionally used for hunting and other purposes. Participatory fire management programs have involved local groups in mapping fires and developing strategies for controlled use of fire. Engaging communities around managing invasive species for watershed protection can be an effective way of getting communities involved with fire management. Monitoring using satellite imagery has improved the abilities to understand where and when fires occur, as well as the abilities respond to fires with legal action.

Context: New Caledonia is the southernmost Melanesian archipelago in the southwest Pacific Ocean. It contains the highest density of endemic plants in the world, and is also home to the highest density of endemic plants in the world. It is also home to the world's largest coral reef lagoon.

Every year, across the country, thousands of fires blacken the landscape, sometimes spanning thousands of hectares and burning for several days. For two decades, outreach campaigns have raised interests for improved fire control without being able to assess their effectiveness and relevance.

Fire has traditionally had – and still has – many uses within indigenous communities, especially for agriculture, hunting and invasive species management purpose. Considering fire often triggers conflicts and fuels resentment within local communities, between communities and public institutions. A sensitive approach is required.

A "Technical Group on Fires" was set up in 2015, bringing all interested groups together for shared learning and collective strategic planning for impact. Country-wide mapping began in 2017. Since then, according to the Observatory of the Environment in New Caledonia (OEIL), as of 2020, tens of thousands of bushfires burn 0.5-3% of the total land mass every year and account for 1-25% of new Caledonian greenhouse gas emissions. Global Forest Watch suggests that since 2011, New Caledonia has lost 1.6% of its forests with fires as the primary driver of forest loss. Bushfires foster erosion, degrade rivers, and negatively impact coral reef health. These fires are a major impediment to forest regeneration in the country and foster intense debates over what should and can be done to reduce fire impacts. Improving fire management is thought to be the most critical and efficient intervention to deliver Assisted Natural Regeneration (ANR) and strategic conservation benefits with climate change adaptation and mitigation co-benefits in New Caledonia.

Since 2016, an early alert system, called Vulcain and developed by OEIL, allowed responders to rapidly react to fires in a region. In 2017 a new algorithm was developed to map burned areas. It is currently used to trigger automatic information that can be used in legal cases in high conservation areas.

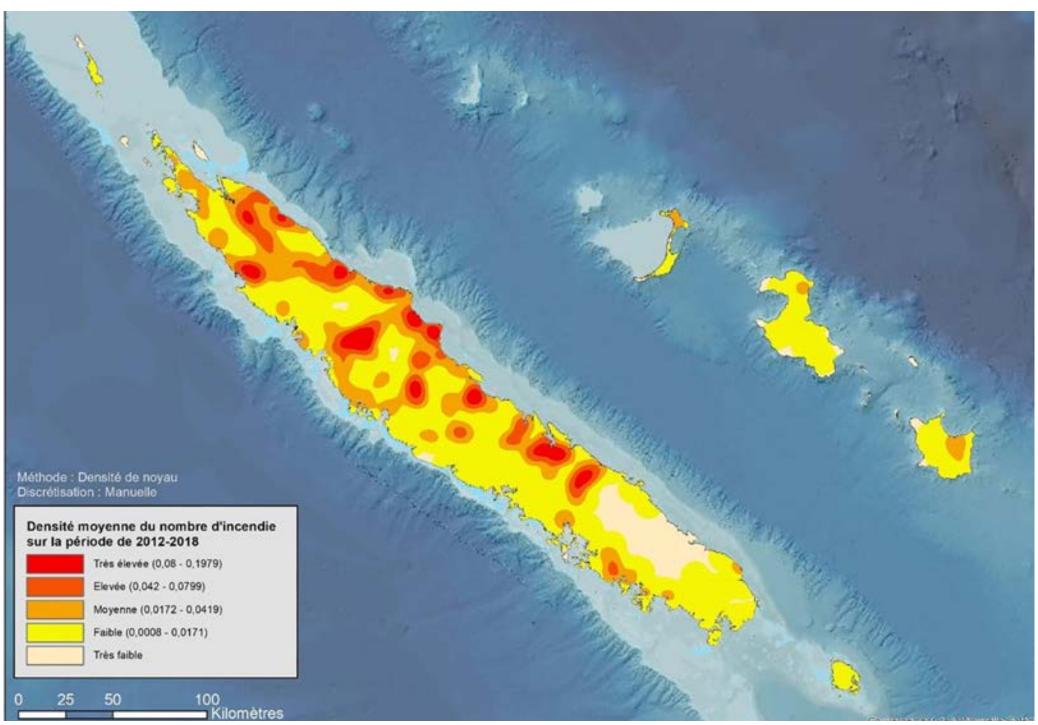
Local efforts to improve fire management:

Several sites have benefitted from local efforts to improve fire management, especially on the northeastern coast of New Caledonia, an area which is predominantly indigenous, quite mountainous, and has highly fragmented forests. Mt. Panié is New Caledonia's highest mountain at 1,629 m. Surrounding the mountain in Mt. Panié wilderness reserve, local hunters have been formally involved in an indigenous conservation co-management program around invasive deer and pig control since 2011. While historic data on fire regimes and forest cover change is still missing, it seems that burned areas have reduced and the forest is indeed regenerating.

In 3 communities of Touho, a neighboring site from Mt Panié, all burnt areas were mapped over 2000-2019. It was identified that:

- An average of 100 fires/year have cumulatively burnt 60% of the savannahs.
- 60% of the areas that have burned have done so once or twice during this time.
- Most of these fires are distant from households, close to forests and are thought to be related to invasive deer habitat management and hunting practices.

These facts and figures suggest fires are intensively used and a systematic fire ban would not be appropriate. Strategic areas for delivering efficient ANR have been identified. Reviving traditional rules for fire management while involving local people in formal controlled burning should significantly reduce burned areas, facilitate invasive deer and pig control, and assist natural forest regeneration.



Fire history map of New Caledonia from 2012-2018, showing the incidence of fire. Red is very high number of fires, dark orange is high, light orange is medium, yellow is low, and white very low.

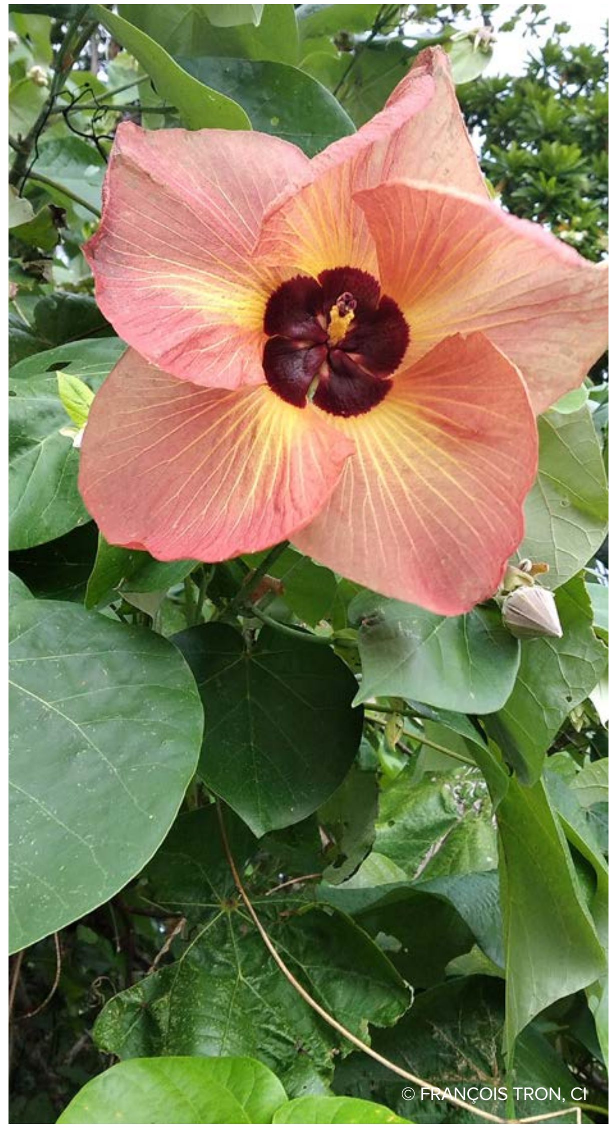
Lessons learned:

Analyzing 12 years of participative reforestation program over 10 sites, supported by the Northern Province, it is clear that local communities are eager to restore the forest. They consider many services provided by forests, such as the provision of freshwater. Local communities also want to plant trees to restore what was degraded by fire and to reduce fire risk in the future. In several cases, local communities have set up their own rules to manage fire. Reducing the cost of this program (currently at ca 20.000 USD/hectare) and strengthening the monitoring and evaluation of fire regimes and forest cover are key to making ANR more fundable in this context.

This case example demonstrates the benefits of involving public authorities, local communities, and civil society organizations in watershed restoration. Local communities can be particularly helpful in mapping past fires and identifying where the fires usually start and end. This has opened a fruitful dialogue around identifying shared solutions. A few tree species, including *Hibiscus tiliaceus and Crossostylis grandiflora*, have thus been identified for the potential to reduce fire propagation. They are planned to be used in targeted strategic plantations using applied nucleation or tree island approaches.

Important approaches for getting ANR programs to succeed at scale include sound initial participatory planning, a strong monitoring and evaluation system, and actively engaging local communities with deep consideration for their vision, practices, capacity and needs.

A final interesting conclusion is that invasive species management for forest conservation and watershed restoration can also help motivate local communities to become involved in fire management and facilitate Assisted Natural Regeneration.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ANNEX 1.

QUICK GUIDE TO EXISTING RESOURCES ON RESTORATION STRATEGIES

The following is a non-comprehensive list of resources that may serve as a first step to finding out more information about a wider range of restoration strategies:

1. Forest Landscape Restoration (FLR):
    a. Issues in Forest Conservation: Rehabilitation and Restoration of Degraded Forests
    b. Restoring Forest Landscapes: An Introduction to the Art and Science of Forest Landscape Restoration
    c. The Forest Landscape Restoration Handbook
    d. Guidelines for Forest Landscape Restoration in the Tropics
    e. Implementing Forest and Landscape Restoration, A Practitioner's Guide

2. Agroforestry:
    a. Agroforestry delivers a win-win solution for ecosystem services in sub- Saharan Africa. A meta-analysis.
    b. Agforward Agroforesty for Europe: Identification of Agroforestry Systems and Practices to Model.
    c. An Agroforestry Guide For Field Practitioners: The World Agroforestry Centre
    d. Agroforestry Systems: Productive, Socioeconomic and Environmental Functions/ Sistemas Agroforestales Funciones productivas socioeconomicas y ambientales

3. Applied Nucleation/Tree Islands:
    a. Applied Nucleation Guide for Tropical Forests: Conservation International

4. Farmer-Managed Natural Regeneration:
    a. The Forest Underground: Hope for a Planet in Crisis

5. Assisted Natural Regeneration:
    a. Restoring Forest Landscapes Through Assisted Natural Regeneration (ANR) – A Practical Manual
    b. The Role of Assisted Natural Regeneration in Accelerating Forest and Landscape Restoration: Practical Experiences from the Field | World Resources Institute.
        i. Assisted natural regeneration: harnessing nature for restoration.

c. Farmer Managed Natural Regeneration:

   i. Farmer Managed Natural Regeneration (FMNR): A Technique to Effectively Combat Poverty and Hunger Through Land and Vegetation Restoration

   ii. Farmer Managed Natural Regeneration (FMNR) Manual | World Vision.

6. Enrichment Planting:

   a. Issues in Forest Conservation: Rehabilitation and Restoration of Degraded Forests

7. Mangrove Tree Restoration:

   a. A Technical Guide to Mangrove Restoration

8. Peat Restoration:

   a. Global Peatland Restoration: Demonstrating Success

9. Seed Dispersal/Direct Seeding:

   a. Standards for Native Seeds in Ecological Restoration

10. Silvopasture:

   a. Silvopastoral Systems as Alternative for Sustainable Animal Production in the Current Context of Tropical Livestock Production

   b. Silvopasture: Establishment & management principles for pine forests in the Southeastern United States

   c. Practical Guide for Establishing Silvopastoral Systems on the Azuero Peninsula of Panama/Guía Práctica para Establecer Sistemas Silvopastoriles en la Península de Azuero de Panamá

11. Tree Planting:

   a. Guidance For Successful Tree Planting Initiatives

12. Wetland/Riparian Restoration:

   a. Wetland Restoration, Enhancement, and Management

   b. Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats

ANNEX 2.

QUICK GUIDE TO RESOURCES ON STAKEHOLDER ENGAGEMENT, PARTICIPATORY APPROACHES, AND COMMUNITY BENEFITS IN RESTORATION

The following is a non-comprehensive list of resources that may serve as a first step to finding out more information about stakeholder engagement, participatory approaches, and community benefits in restoration.

Tools and resources for the general process of understanding local use and engaging stakeholders:

- A Guide to the Restoration Opportunities Assessment Methodology (ROAM): Assessing forest landscape restoration opportunities at the national or subnational Level. IUCN: International Union for Conservation of Nature & WRI: World Resources Institute, 2014. (see pages 58 to 63 for the Stakeholder Prioritization of Restoration Interventions tool and other relevant information).
- Land Use Dialogue Guide: Dialogue as a tool for landscape approaches to environmental challenges. TFD: The Forests Dialogue, 2020. (for more information, visit https://theforestsdialogue.org/initiative/land-use-dialogues-luds).
- Peace Corps Participatory Analysis for Community Action (PACA) Training Manual. Peace Corp, 2007. (Oriented towards use at the community level).
- Good Practices in Participatory Mapping: A review prepared for the International Fund for Agricultural Development (IFAD). IFAD, 2009.
- Rapid Rural Appraisal and Participatory Rural Appraisal: A manual for CRS field workers and partners. Freudenberger, K. S., CRS: Catholic Relief Services, 2008.

For understanding how to make ANR more relevant to local land users:

- Assisted Natural Regeneration: Methods, results and issues relevant to sustained participation by communities. Dugan, P. In Forest Restoration for Wildlife Conservation. Elliott, et al. (Eds), ITTO: International Tropical Timber Organisation & FORRU: The Forest Restoration Research Unit, 2000.
- Chazdon, R., and M. Guariguata. 2018. Decision support tools for forest landscape restoration: current status and future outlook. CIFOR Occasional Paper.

References/tools for engaging traditional/indigenous knowledge in restoration:

- Time to Decolonize Aid
- Indigenous Negotiations Resource Guide
- Decolonial Model of Environmental Management and Conservation: Insights from Indigenous-led Grizzly Bear Stewardship in the Great Bear Rainforest

For resources on how to incorporate adaptation/resilience benefits into restoration, see:

- Ensuring that Nature-based Solutions for climate mitigation address multiple global challenges
- Synergies between Climate Mitigation and Adaptation in Forest Landscape Restoration


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