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FOUNDATION FOR CLIMATE RESTORATION

FOREST CARBON PRACTICES

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OVERVIEW

The Foundation for Climate Restoration is committed to restoring a climate that supports the long-term survival of humanity and our natural world. To this end, the Foundation's explicit goal is to reduce atmospheric carbon dioxide to preindustrial levels of 300 parts per million (ppm) by 2050.

This is the second installment of the Foundation's Solution Series, which examines a diverse portfolio of natural and technological approaches that can remove CO_2 from our atmosphere and return us to safe, preindustrial levels of carbon.

In this paper, we explore Afforestation, Reforestation, and Forest Management, known collectively as *forest carbon practices*, through a climate restoration lens. This paper focuses mainly on the United States context for these practices, but most of the following applications can be generalized to a broader international context. We also discuss the ability of these methods to achieve durable, scalable, financeable, and equitable outcomes and then provide ways for readers to advocate for their safe and thoughtful implementation.

INTRODUCTION

Trees are the lungs of the Earth, and an estimated 80% of land animals and plants live in the forest and depend on it for survival.[1] Deforestation, the intentional clearing of forested land, not only threatens these ecosystems but is also responsible for 8% of global emissions.[2] As a result, proforestation, the conservation of existing forests,[3] has become a climate restoration priority. Naturally regenerated forests[4] can store 40 times more carbon than a tree plantation,[5] while leaving rangelands and conservation areas untouched. Given that proforestation is the more effective way to store carbon,[6] deforestation should be avoided to the extent possible, and the planting of new trees should be considered a supplemental carbon storage solution.

In the past few decades, planting trees has come to symbolize a relatively simple solution to the climate crisis. The technical terms for planting trees are afforestation (AF) and reforestation (RF). AF is the process by which trees are planted in an area that has not been inhabited by trees for at least 50 years.[7]

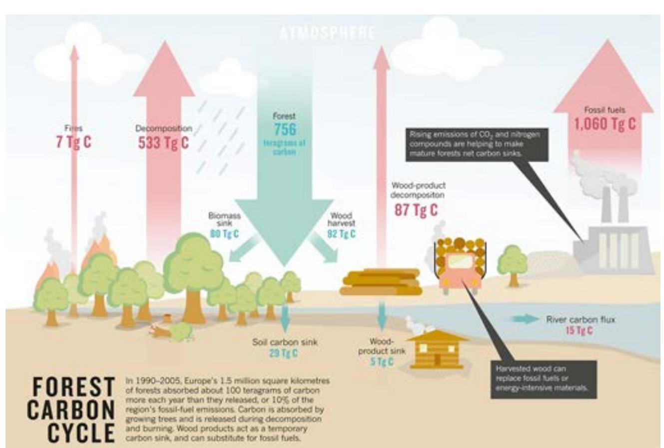
At scale, AF can have serious environmental impacts, including potentially exacerbating the effects of climate change.[8] It can also compound risks related to food and water security[9] given that the forested area disrupts the local water cycle by diminishing the water supply[10] and using more water than the previous land.[11] However, AF can have a beneficial impact on biodiversity by providing habitats to millions of organisms and encouraging ecosystem recovery.[12]

In contrast to AF, RF involves replanting trees in an area that recently housed trees, and it is considered one of the most practical ways of sequestering and storing carbon, while also protecting and restoring biodiversity.[13] However, about 45% of all new projects for RF are expected to be monocultures,[14] which are mostly based on cheap and non-native species[15] that will bring fewer ecological benefits.[16] Because forests influence water cycles by reducing surface runoff, increasing infiltration to groundwater, and improving water quality, RF can restore hydrological processes, thereby improving water supply and quality.[17] Robust site identification is critical to both AF and RF because of this high water and land footprint: if done in inappropriate locations,[18] deployment at scale can threaten the livelihoods of local communities.

Improved forest management (IFM) is another commonly proposed solution and refers to the active modification of forestry practices to promote greater forest biomass and carbon storage.[19] Another concept receiving increasing attention is sustainable forest management (SFM), which aims to maintain and enhance the economic, social, and environmental value of all forests for the benefit of present and future generations.[20] These management practices can mitigate floods and drought, improve the nutrient levels of soil, prevent erosion, reduce air pollution, and build natural systems' resilience.[21]

Collectively, these forest carbon practices have the potential to contribute to climate restoration. However, deployment must be thoughtful and measured, or we risk disrupting entire ecosystems, increasing a forest's susceptibility to pests and fire,[22] and misusing land that could otherwise be used for food production in developing countries.[23] While forest carbon practices can accelerate both mitigation and restoration efforts, employing these methods alone or haphazardly is not enough to return the climate to preindustrial levels of carbon.

HOW FOREST CARBON PRACTICES WORK



Credit: S. Luyssaert et-al.[24]

Trees and all living plants remove carbon dioxide from the atmosphere via photosynthesis.[25] The absorbed carbon is then stored in the ground and in the tree's biomass (i.e., its leaves and wood). Therefore, we can scale a tree's natural

[26]**Forest regeneration** is the process by which new tree seedlings become established after forest trees have been harvested or have died from fire, insects, or disease. Regeneration is key to sustainable forestry.

[27]**Assisted natural regeneration** is a blend of active planting and passive restoration, where local people intervene to help trees and native vegetation naturally recover by eliminating barriers and threats to their growth, leaning on their knowledge of the land and on ancestral traditions.

capacity to sequester and store carbon by encouraging forest regeneration,[26] assisted natural regeneration,[27] enrichment planting,[28] native tree plantations,[29] and directed tree planting[31] in agroforestry systems and urban areas.[32]

The success of these initiatives largely depends on:

- The location of the project (e.g., tropical regions that have historically supported forests)
- The species selection and early site management (e.g., greater species diversity or selection of polycultures[33] should be informed by adaptive potential[34] and native tree species)
- Long-term management of carbon (e.g., investigating soil properties and using scientifically-backed methods to maximize soil carbon storage in forests)
- The fate of the wood (e.g., the use of wood in place of steel, stone, and concrete generally eliminates between 1 and 3 tons of carbon emissions per ton of wood carbon).[35]

FOREST CARBON PRACTICES AS A CLIMATE RESTORATION SOLUTION

DURABILITY[36]

The carbon uptake in trees is considered relatively long-term given that much of the CO_2 is stored in the trees' woody stems and roots[37] and is not released back into the atmosphere until the trees rot or are burned.[38] Consequently, the ability of forest carbon practices to store carbon for at least 100 years depends largely on the maintenance of the forest area.[39] Carbon can be stored for far longer if the management practices emphasize biodiversity, productivity, regenerative capacity, vitality, and the fulfillment of relevant ecological, economic, and social functions.[40] However, forest maintenance will become increasingly difficult as climate change-driven disturbances fuel wildfire, drought, and harmful insects, all of which result in widespread tree mortality and the release of stored CO_2 back into the atmosphere.[41]

The durability of forest carbon practices can be enhanced by ensuring and measuring permanent storage, which requires robust monitoring, reporting, and verification (MRV). MRV of forest carbon is challenging due to:

- The speed at which the amount of carbon stored in a forest can change (e.g., carbon can be released quickly during a wildfire)
- The variability of carbon storage in different areas of forest (e.g., densely populated forest areas may store more carbon than sparsely forested areas)
- The time needed to generate estimates of carbon storage using any particular method (generally, weeks to months)
- The lack of standardization of MRV practices across regions
- The uncertainty of MRV estimates.[42]

In the United States, domestic MRV is managed by the Department of Agriculture's Forest Service,[43] and internationally, it is led by the United Nations

[28]**Enrichment planting** (also known as line-, strip-, gap-, and under-planting) is defined as the introduction of valuable species to degraded forests without the elimination of valuable individuals already present.

[29]**Plantations** are intensively managed stands of trees that have been artificially planted with native or exotic species, laid out in rows.

[31]Tree planting that is managed with considerations to location, species, and site management

[33] Mixed plantings of various kinds of trees

[34]Adaptive potential of a tree population can be defined as its capacity to respond to a given environmental change, by modifying its own genetic composition and/or by modifying its phenotypic expression.

REDD+ program. In particular, Indigenous Peoples have been actively engaged in ensuring MRV approaches are robust, transparent, and participatory. They have focused not only on ensuring that emissions are reduced, but they have also prioritized monitoring and reporting on social, economic, environmental, and governance safeguards.[44]

The Open Forest Protocol system[45] can also improve MRV by prioritizing transparency, inclusivity, and longevity to ensure global standardization, accessibility, and accountability.[46] Compensating local communities to manage forests has also been shown to increase the durability of carbon storage.[47] Ultimately, making it more profitable to protect trees rather than to cut them down, specifically in areas of immense poverty, helps protect both forests and the surrounding communities in the long term.

SCALABILITY[48]

Estimates of the scalability of forest carbon practices vary, and there is still limited understanding of the factors determining the rate of carbon sequestration in afforested and reforested areas.[49] The scaling up of AF projects has required high land and water requirements,[50] leading to reductions in agricultural land.[51] However, these same projects can present agroforestry opportunities[52] that involve planting different types of species between trees to benefit the forest. Sequestering one gigaton (Gt) of CO_2 through AF would likely require 70 to 90 million hectares—a land area twice the size of California.[53] With this in mind, scaling of AF will only be possible if proforestation is a top priority.

The annual rate of carbon sequestration in forests could potentially reach up to 3.6 Gt CO_2 by 2050 and up to 7 Gt CO_2 by 2100, depending on the location, species, and management of trees planted.[54] Research shows that adding 2.5 billion acres of forest globally could store up to 205 Gt of carbon[55] and halt global warming to 2.7 degrees by 2050.[56] However, scaling to this rate of carbon storage would require planting 1 trillion trees over an area the size of the United States.[57] The practical limitations on dramatically scaling forest carbon practices mean that they could not feasibly reach 10 Gt CO_2 removal per year by 2030.

LOCATION

Tree planting is not suitable everywhere. In some cases, planting trees in barren land can be more beneficial than in a depleted forest,[58] as the existing land is not supporting much biomass and thus not sequestering much carbon. However, in other native non-forested ecosystems, restoring natural ecosystems instead of afforesting them would more effectively increase carbon storage and the area's resilience. For example, peat bogs can store much more carbon than forests planted on drained bogs, so AF on a former peat bog generally results in a net loss of carbon storage. Locating projects in highly productive, formerly forested areas, like those commonly found in tropical or subtropical ecosystems, can ensure that RF projects become carbon sinks rather than carbon sources.[59] Choosing an appropriate site is thus critical in reaching large-scale carbon removal with forests, but appropriate sites are not available in sufficient acreage to reach 10 Gt CO_2 per year.

SPECIES

Over 99% of new plantation forests in the past 50 years have been monocultures,[60] since they are fast-growing. However, monocultures are more susceptible to disease, and while some non-native species may grow well in a particular climate, they may not be resilient to the extreme weather events that occur in that region. It is therefore important to plant a mix of native species to support biodiversity, ecosystem health, and carbon storage. Forests take time to reach their carbon storage potential, so the selected species should be able to last many decades.

MANAGEMENT

Because most carbon storage in forests takes place in the soil and not the trees, the management of forest soil can impact the amount of carbon that is ultimately captured and re-released (e.g., the accumulation of tree litter on the soil, the removal of rotting fallen trees, and the thinning of forests to promote more growth in fewer trees all benefit soil carbon storage in forests). Therefore, we need a strong understanding of soil properties in order to optimize carbon storage, but more research is needed in this area. At the very least, IFM and SFM can improve the scalability of carbon storage in a forest without requiring more land for the forest area.

FINANCEABILITY[61]

Forest carbon practices are considered financeable because funding is widely available, though most estimates indicate that it would be more costly to restore forests than to preserve existing ones.[62] Thus, funding should be allocated to SFM and IFM whenever possible. There is also ample government and private funding for AF and RF projects via NGO grants,[63] private donations,[64] online search engines,[65] and policies like the National Climate Bank Act, which will invest $35 billion in low-carbon technologies, agriculture and forestry projects, quality job creation in frontline communities, and the creation of green banks.[66] Other policies that could provide investment in US forestry projects include the Clean Energy and Sustainability Act, the Climate Stewardship Act of 2020, and the 21st Century Conservation Corps Act.[67]

While plenty of financing opportunities exist, the question of whether that financing is sufficient depends on the cost of AF and RF in terms of dollars per ton of CO_2. Globally, cost estimates for forest carbon practices range from $5 to $50 per ton of CO_2 sequestered, with natural regeneration sometimes having no cost when forests are left to recover on their own.[68] The cost of carbon removal therefore depends on the level of forest degradation and how difficult it is to restore.[69]

EQUITY[70]

PROCEDURAL JUSTICE

For forest carbon projects to be procedurally just, decisions must incorporate the input of frontline and marginalized communities and consider a range of ecological, physical, social, and economic factors.[71] Importantly, a significant proportion of land earmarked for RF and AF is inhabited and used by Indigenous Peoples, whose knowledge of forests and land use comes from hundreds of thousands of years of stewardship.[72] The United Nations Declaration on the Rights of Indigenous People can serve as a valuable framework for co-developing forest projects in collaboration with marginalized and Indigenous communities.[73] These projects should employ long-term land use management agreements and utilization rights[74] and protect the well-being of the Indigenous communities that depend on the biodiversity and ecosystems of impacted areas.[75] Mechanisms like Free, Prior, and Informed Consent can ensure the trust and accountability needed to implement RF and AF projects.[76]

DISTRIBUTIVE JUSTICE

In terms of distributive justice, forest carbon practices present a number of co-benefits to local communities, including:[77]

- Improved mental and physical wellbeing[78]
- Increased accessibility to natural resources and recreational activities
- Increased shade, which lowers energy costs and enables outdoor recreation[79]
- Erosion prevention and reduced flood risk for coastal communities[80]
- Local job creation, including support for the timber industry
- Increased rural incomes and improved rural working conditions, which are considered some of the worst in the world[81]
- Improved air quality, better fire management, and protection from climate shocks like drought
- An improved habitat and expanded bioeconomy.[82,83]

For projects to incorporate distributive justice, the co-benefits outlined above should be equitably distributed by:

- Selecting project locations only with the agreement of the local community
- Factoring historical context into discussions of safeguards and monitoring
- Ensuring that benefits do not accrue only to wealthy landowners but also to small-holders[84]
- Ensuring that revenue flows back into the local community.[85]

[84] A person who owns or manages an agricultural holding smaller than a farm

REPARATIVE JUSTICE

To further reparative justice in the deployment of forest carbon practices, land used for these projects should be returned to the Indigenous communities who were forcibly displaced[86] and who have been shown to outperform government agencies and conservation organizations in supporting biodiversity, sequestering carbon, and generating other ecologic benefits on their land.[87] The Land Back movement[88] advocates for the transfer of decision-making power to Indigenous communities and maintains that Indigenous governance is possible, sustainable, and preferred for the public lands being used for AF and RF projects.[89]

TRANSFORMATIVE JUSTICE

Transformative justice in the context of forest carbon practices requires better regulation of the carbon offset programs[90] that disproportionately harm Indigenous people and other frontline communities.[91] Carbon offsets, predominantly in the form of reforestation projects in the Global South, are used to reduce, avoid, or sequester the equivalent amount of CO_2 that is emitted elsewhere.[92] In order to prevent wealthy countries from controlling forests in the Global South, governments, NGOs, and industry coalitions should step into the voluntary carbon market to monitor and regularly verify carbon offset programs.[93]

Additionally, projects should provide immediate and sustained support for those who would have otherwise used AF and RF sites for agriculture. Forest carbon projects can support the prosperity of these underserved communities, allowing them to experience the co-benefits of forests while addressing underemployment and poor environmental health.[94] To this end, AF and RF projects might include:

- Agroforestry training and compensation for farmers
- Education in sustainable farming techniques
- Incentives for sustainable industries
- Clear policies for deforestation
- Reserved land for agriculture and grazing
- Policies that protect Indigenous communities
- Government compensation for protecting the land, among others.[95]

HOW TO ACCELERATE FOREST CARBON PRACTICES

Advocates can request that their local, regional, national, and international representatives increase funding, support, and commitments to scaling forest carbon practices.[96] In the United States, the government has pledged to invest in reforestation practices as part of its commitment to reducing economy-wide greenhouse gas emissions by up to 52% by 2030.[97]

The United States also passed the REPLANT Act in 2021, which quadrupled the investment for reforestation projects, funding the planting of 1.2 billion trees and creating over 49,000 jobs in the next 10 years.[98]

Advocates can also encourage their local governments to incorporate SFM and IFM practices into their natural resource management plans, as San Francisco did.[99] They can also volunteer with park management departments in their areas to help maintain healthy forests in their own communities. These opportunities are excellent venues for meeting like-minded people and providing education about forest carbon management.[100]

The IPCC recommends that, rather than planting trees in non-forested ecosystems, supporters hoping to enhance carbon capture and reduce the harmful effects of climate change can advocate to address the causes of deforestation, forest degradation, and widespread ecosystem loss, reduce carbon emissions from fossil fuels, and focus on ecosystem restoration over tree planting.[101]

CONCLUSION

Forest carbon practices have a major role to play in safeguarding existing carbon stores in our forests and increasing the carbon removal and storage capacity of our ecosystems. Collectively, forest carbon practices can contribute to climate restoration efforts to some degree, while providing important ecosystem services and other co-benefits.

However, the uncertainties relating to durability, scalability, financeability, and equity mean that forest carbon practices, as we understand them now, fall somewhat short of the mark for climate restoration. Restoring and protecting native forests is essential in combating climate change,[102] and forest carbon practices can be scaled to provide jobs, alleviate poverty, and ensure the health of forests in the long term. Still, the intensive land and water needs of these projects must be considered, and more research into durability, scalability, and equity is required. In the interim, climate restoration supporters can advocate for the adoption of forest carbon practices in their communities and for the environmental, social, and economic monitoring and verification needed for forest projects to succeed.

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29. Plantations are intensively managed stands of trees that have been artificially planted with native or exotic species, laid out in rows.

31. Tree planting that is managed with considerations to location, species, and site management

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33. Mixed plantings of various kinds of trees.

34. Adaptive potential of a tree population can be defined as its capacity to respond to a given environmental change, by modifying its own genetic composition and/or by modifying its phenotypic expression.

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