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Reforestation done right is a multi-tasking climate solution

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1 Introduction

Reforestation is an essential component of natural climate solutions to help achieve climate goals based on multiple analyses worldwide (Griscom et al., 2017; Bastin et al., 2019; Marvin et al., 2023). This *Frontiers* contribution makes the argument that to unlock this potential, we must advance the science of "right tree, right place" to a new level of customization for climate resilience, mitigation, and co-benefits such as biodiversity while also strategically using reforestation to enhance fiber supplies to support diverse forest products that offer climate change mitigation benefits.

This contribution will address three issues that underpin the execution of reforestation with the necessary scientific rigor and climate strategy to achieve these outcomes: (1) how to design reforestation for climate resilience; (2) how to leverage reforestation to supply diverse forest products; and (3) how to integrate climate goals with other reforestation outcomes.

The fundamentals of reforestation for climate benefit are undisputed:

- Increasing the number of trees on our planet will create more potential for carbon sequestration (Bastin et al., 2019), as long as the right tree species are used to assure long-term health and resilience, and trees are grown in ecologically appropriate locations.
- While no single tree is a *permanent* source of carbon sequestration and storage, these benefits can be long-lasting—with the lifespan of trees often exceeding 100 years—and together, the cycle of trees growing and dying in a forest creates *perpetual* carbon storage through the carbon cycle (Congressional Research Service, 2023).
- Tree planting is the most resource-intensive reforestation approach and should be prioritized in locations where regeneration will not otherwise occur. This includes the expanding acreage of forestlands burned so severely that regeneration is impaired by factors such as soil condition and seed availability (Higuera et al., 2021).
- Reforesting burned and degraded lands can help stabilize soils and protect soil health (Tzamtzis et al., 2023) in ways that benefit long-term forest productivity, watershed function, habitat, and soil carbon (Nave et al., 2018).

These fundamentals are settled facts, reinforced by data from sources such as the U.S. Greenhouse Gas Inventory (EPA, 2024) that shows the trees, forests, and forest products in the United States are currently providing net sequestration of more than 750 Mt CO2 per year.

Furthermore, numerous leading analyses have shown the potential to increase this annual sequestration through reforestation. One study led by The Nature Conservancy (Cook-Patton et al., 2020) found potential to increase annual carbon sequestration in U.S. trees and forests by more than 314 Mt CO2 per year by maximizing all forms of reforestation on suitable lands, including urban forestry and agroforestry.

With so much to gain, here are three principles we must converge on to capture the full potential of reforestation for climate change, biodiversity, and other goals.

2 We must reforest for climate resilience by using special forestry techniques

All the benefits of reforestation hinge on our ability to grow forests that can survive and thrive in a changing climate. To help meet this need, the non-profit organization, American Forests, has spent the last 5 years developing and implementing a particular four-part model for climate-resilient reforestation.

These four elements include: (1) assessing each site for resilience characteristics and site preparation; (2) aligning tree species and genetics for resilience; (3) identifying a resilient planting design; and (4) putting in place appropriate provisions for adaptive management. This approach is embodied in the climate-resilient planting design for the Camp Fire Burn Scar in the U.S. State of California (American Forests and BLM, 2021).

The first step is to assess what site preparation is needed and identify microsites of natural resilience on each landscape that will be best suited for planting or other regeneration techniques.

The second step is to use climate data to identify the most resilient mix of tree species for that site and to grow seedlings using seeds sourced from trees that show natural resilience to the current and projected climate conditions for that site. This tree selection must balance different variables, from how quickly different species will regenerate to the resilience and resource benefits different species can provide.

As a third step, the density, grouping, and spacing of trees must be strategically designed to withstand future climate stress, such as increased drought and heightened wildfire risk, while also facilitating forestry actions such as prescribed fire that help the forest remain resilient.

The final step is a structured commitment from project partners to monitor each reforestation site and implement adaptive management to adjust the structure and composition of the regenerating forest as dictated by the way that the forest is responding to climate conditions.

With this kind of rigorous approach, actors across the reforestation movement can grow resilient forests even in the most challenging and high-benefit settings, such as areas severely burned by wildfire that will not recover naturally and arid agricultural lands that are being brought back into native forest.

3 We need more working forests to meet our climate goals

Leading climate models to achieve Net Zero by 2050 (e.g., Project Drawdown) agree we will not only need more carbon sequestration from the forest sector but also a range of different forest-based products that offer a lower greenhouse gas footprint than alternatives made from non-renewable and more energy-intensive materials.

While some critics (e.g., Moomaw et al., 2019) have argued for a focus almost exclusively on achieving carbon sequestration through passive management of standing forests, there is substantial demonstrated potential for climate mitigation gains through strategic use of carbon storage in forest products (Zhao et al., 2022) as well as various forms of greenhouse gas emissions avoidance through the displacement value of forest products (Myllyviita et al., 2021). Using a mixture of forest management approaches and the generation of forest products has the potential to increase overall carbon outcomes in some locations (McKinley et al., 2011).

Reforestation is a critical tool to overcome this ideological divide because having more forests can help assure that there is sufficient forest cover to meet diverse needs while reducing real and perceived competition between uses. Global studies (Bastin et al., 2019) and in the United States (Cook-Patton et al., 2020) have indicated the potential to create millions of hectares of additional forest cover.

Capturing this opportunity will require the recognition that not every acre of forest needs to be maximized for older age classes. If we embrace the techniques of high-production forestry on some parts of the land base—including plantations managed with shorter rotations—we have the potential to ease pressure on other forestlands that we might choose to place in a different condition and management regime, emphasizing other ecological outcomes.

4 With smart site selection and restoration design, reforestation can achieve multiple benefits beyond climate mitigation

With the right approach, advancing reforestation to achieve carbon sequestration goals can be performed harmoniously with other needs, such as protection of water quality and biodiversity.

Just consider that over 80% of the world's wildlife lives in forests (UN, 2023) making the extent and quality of forest cover pivotal to stemming the biodiversity crisis. That is why reforestation is so essential for both increasing the extent of priority forest habitats and better connecting them.

An example from the U.S. is taking place in the Rio Grande Valley of Texas, where over 90% of native thorn forest (*Tamaulipan Calcareous Thornscrub*) has been cleared for agriculture and urbanization. Reforestation of these forests has strong carbon benefits (Navar-Chaidez, 2008), yet these forests are also home to more than 500 species of birds, more than 300 species of butterflies, and rare mammals such as the ocelot. Because of the decline of this forest, there are 45 state- and federal-listed species associated with this habitat that can benefit when these forests are restored.

A collaboration led by the U.S. Fish and Wildlife Service is restoring this forest hotspot for carbon sequestration, habitat restoration, and water quality in the Rio Grande River, informed by a spatially explicit (Thornforest Conservation Partnership, 2023) that maps out a connected network of reforestation sites and wildlife crossings. The restoration is also guided by a climate-resilient reforestation plan for this forest type (US FWS and American Forests, 2021) mirroring the climate resilience model outlined above. This study in Texas is just one of many examples of landscape-scale reforestation around the world achieving carbon sequestration and biodiversity goals harmoniously.

In conclusion, it is vital that forest advocates work collectively to advance the scientifically rigorous and holistic approach described here to maximize the potential of reforestation for climate change benefits and related concerns, such as stemming the loss of biodiversity globally. If we can align on the three meta-issues outlined above to set a consensus direction for the reforestation movement, then we can move onto critical capacity issues such as accelerating seed collection and nursery capacity. It is time to put the right reforestation into motion at scale, as the climate crisis has not left a moment to waste.

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Conflict of interest

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