Pitfalls of Tree Planting Show Why We Need People-Centered Natural Climate Solutions

FORREST FLEISCHMAN, SHISHIR BASANT, ASHWINI CHHATRE, ERIC A. COLEMAN, HARRY W. FISCHER, DIVYA GUPTA, BURAK GÜNERALP, PRAKASH KASHWAN, DIL KHATRI, ROBERT MUSCARELLA, JENNIFER S. POWERS, VIJAY RAMPRASAD, PUSHPENDRA RANA, CLAUDIA RODRIGUEZ SOLORZANO, AND JOSEPH W. VELDMAN

Scientists, corporations, mystics, and movie stars have convinced policymakers around the world that a massive campaign to plant trees should be an essential element of global climate policy. Public dialogue has emphasized potential benefits of tree planting while downplaying pitfalls and limitations that are well established by social and ecological research. We argue that if natural climate solutions are to succeed while economies decarbonize (Griscom et al. 2017), policymakers must recognize and avoid the expense, risk, and damage that poorly designed and hastily implemented tree plantings impose on ecosystems and people.

We propose that people-centered climate policies should be developed that support the social, economic, and political conditions that are compatible with the conservation of Earth's diversity of terrestrial ecosystems. Such a shift in focus, away from tree planting and toward people and ecosystems, must be rooted in the understanding that natural climate solutions can only be effective if they respond to the needs of the rural and indigenous people who manage ecosystems for their livelihoods.

To motivate this shift in focus, we highlight ten pitfalls and misperceptions that arise when large-scale tree planting campaigns fail to acknowledge the social and ecological complexities of the landscapes they aim to transform. We then describe more ecologically effective and socially just strategies to improve climate mitigation efforts.

Ecosystems, not tree planting campaigns, capture and store carbon

In terrestrial ecosystems, plants capture carbon from the atmosphere, which is stored in biomass and soils. Through processes including microbial decomposition, herbivory, and fire, carbon is released back to the atmosphere. Because most ecosystems have the potential to capture more carbon than they lose, a host of natural climate solutions have been proposed to enhance carbon sequestration (Griscom et al. 2017). Despite the importance of belowground biomass and soil organic matter to carbon storage, the most visible and easily measured carbon resides aboveground in trees. The high visibility and cultural resonance of trees has led advocates to elevate tree planting as paramount among natural climate solutions (Veldman et al. 2019). Unfortunately, large-scale tree planting programs have high failure rates, resulting in wasted resources and little carbon sequestration (Duguma et al. 2020). Worse yet, planting in ecosystems with naturally sparse tree cover, such as savannas and peatlands, is destructive for biodiversity and counterproductive for addressing climate change (Temperton et al. 2019). By focusing on forests and trees, scientists and policymakers miss the opportunity to conserve and restore the wide diversity of Earth's ecosystems that contribute to climate change mitigation and adaptation.

Preventing ecosystem destruction is the most cost-effective natural climate solution

Because ecosystems are crucial to carbon sequestration, avoiding deforestation, improving forest management, and protecting grasslands, peatlands, and shrublands from land-use conversion should be the priority (Temperton et al. 2019). Tree planting campaigns divert funding from conservation toward riskier, more costly, and less effective interventions. Planting trees without addressing the social drivers that caused deforestation in the first place will not mitigate climate change because those same drivers will destroy planted forests or shift ecosystem destruction elsewhere. Globally, the most prominent land-based source of carbon emissions is the expansion of commodity agriculture (IPBES 2018). To protect ecosystems from commodity agriculture, it is essential to secure the rights of rural and indigenous people to make land management decisions. Land rights must be coupled with economic policies that support ecosystem-friendly land-use practices, provide just compensation for the carbon that ecosystems store, and

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Figure 1. Government officials inspect a 2-year-old plantation of **Eucalyptus** *clones on government-controlled land in Telangana, India. Low biodiversity, soil disturbance, exacerbated fire risk, altered hydrology, and restricted access to local people mean that this afforested land, although a potentially valuable source of wood fiber for paper, disrupts rural livelihoods and should not be considered a natural climate solution.*

offer incentives for governments, corporations, and land managers to conserve ecosystems (IPBES 2018).

Forests can regrow on deforested land without tree planting

In most places where reforestation is desirable, forests can regenerate naturally from seeds or resprouts, even in landscapes that appear to be highly degraded. Because natural regeneration requires little human intervention, it is usually much less expensive than tree planting. Whereas natural regeneration often leads to faster forest recovery, greater carbon storage, and more cobenefits for biodiversity and people, misapplied tree planting can hinder forest regrowth (Duguma et al. 2020). Where natural regeneration is insufficient, assisted natural regeneration may involve planting a small number of trees targeted to specific goals—such as establishing seed sources or species that are valued by local people—rather than maximizing the number of trees planted.

Tree plantations sequester less carbon, less securely, than naturally regenerated forests

Global forest restoration initiatives promote fast-growing plantations of commercial pulp and timber species as a natural climate solution despite clear evidence that these plantations lead to little long-term carbon storage (figure 1; Lewis et al. 2019). Worse yet, widely planted species in the genera *Pinus* and *Eucalyptus* are extremely flammable and can exacerbate wildfire risk and ecosystem carbon loss (Veldman et al. 2019). To be clear, fast growing trees can serve an economic purpose, but should not be confused for forest restoration or a natural climate solution.

Tree plantations in grasslands, shrublands, and peatlands destroy biodiversity

Many ecosystems that do not naturally support dense tree cover are targeted for large-scale tree planting (figure 2; Veldman et al. 2019). Establishing tree plantations where forests did not historically occur destroys the habitats of plants and animals adapted to open ecosystems and threatens the livelihoods of people dependent on those ecosystems to produce wild game and domestic livestock. The iconic savannas of Africa are a prime example of the ecosystems that are threatened by large-scale afforestation campaigns (Bond et al. 2019). In addition to the biodiversity cost, because fire and tree-killing megafauna, such as elephants, are natural forces in these ecosystems, afforestation provides less long-term carbon storage than maintaining savannas in their open state, where most carbon is protected from fire and herbivory underground.

Trees can reduce water availability

Advocates of tree planting often assume that trees improve ground and surface water recharge, but the reality is more complicated: In the wrong places, planted forests deplete ground water and can cause streams to dry up (Jackson et al. 2005). Although trees can facilitate water infiltration into soils, they also increase evaporation of intercepted rainfall and transpiration from leaf surfaces. The impact of trees on the balance between recharge and evapotranspiration is complicated and depends on many factors (Jackson et al. 2005). If a cobenefit of a proposed tree-planting scheme is to enhance water resources, a careful site-specific evaluation is imperative to determine whether potential gains in recharge will be offset by increased evapotranspiration.

Trees can warm the atmosphere

Trees interact with the climate system in ways that can cause warming to exceed the cooling benefit of carbon sequestration (Li et al. 2015). Trees, particularly evergreen conifers, are darker and taller than most other land covers, and therefore absorb more visible and ultraviolet sunlight (shortwave radiation) compared to highly reflective bare ground, snow, or grasses. When trees replace highly reflective surfaces, the albedo of the ecosystem

Figure 2. As part of an effort to "improve" forest cover in Telangana, India, foresters bulldoze savanna–woodlands to establish a plantation of **Eucalpytus** *clones. Similar plantation activities around the world frequently replace intact ecosystems with commercial tree species that offer few carbon, biodiversity, or livelihood benefits.*

decreases and more shortwave radiation is absorbed, which is emitted as heat (longwave radiation). The warming effect of trees is particularly pronounced in cold, snowy regions, such as alpine and boreal forests, as well as arid and seasonally dry regions, where cloud cover is sparse. In general, natural forest restoration in high rainfall regions, such as the humid tropics, cools the climate, but there are many locations on Earth where tree planting cannot be considered a natural climate solution because of unintended warming (Griscom et al. 2017).

Perverse financial incentives lead to rushed planting and high tree mortality

When ambitious targets for the number of hectares or number of saplings planted are rewarded with large monetary commitments, governments and other organizations tend to focus on the act of planting rather than long-term maintenance to ensure tree survival and growth (Duguma et al. 2020). As a result, many tree planting initiatives have very high tree mortality rates. In the rush to achieve targets, forest restoration fails because trees are planted incorrectly, in the wrong places, and without the support of local people. Successful reforestation programs must plan for long-term maintenance by people who live and work nearby. Glamorizing and rewarding the act of tree planting undermines local institutions and social networks that are required for long-term carbon sequestration.

Tree planting threatens rural livelihoods

Tree planting programs often target ecosystems or farmland that rural people depend on for subsistence livelihoods (Malkamäki et al. 2018). Frequently these people have insecure land tenure, and the land may be viewed by governments or other actors as "available" for tree planting. Replacing croplands with trees can result in unemployment for agricultural workers and elevate food prices (Lewis et al. 2019). Tree planting can bring positive livelihood benefits, but only if land rights enable people to select the trees they need, maintain their local food production systems, and secure the future benefits of ecosystem conservation (Duguma et al. 2020, Malkamäki et al. 2018).

Tree planting targets the global south to capture emissions from the global north

Although the majority of carbon emissions come from the industrialized countries of the global north, large-scale planting schemes focus on the opportunity to plant trees in the global south (Bond et al. 2019, Lewis et al. 2019). Proponents of large-scale tree planting, such as Plant-For-the-Planet and the Trillion Tree Campaign, equate tree planting with climate justice and prosperity for the global south. Unfortunately, these proponents ignore the opportunity costs of using land for trees instead of other economically beneficial activities. Furthermore, they feed the public perception that tree planting at its best is good and at its worst is benign. To the contrary, because tree planting poses significant risks to ecosystems and people, critical questions of social justice must be answered by proponents of tree planting for climate change mitigation. Is it just for the states of the global north to ask the world's poorest people and most threatened ecosystems to bear the costs of fossil fuel emissions?

Effective climate solutions require social systems that support people to conserve ecosystems

Climate change is a complex problem for which tree planting is a simplistic solution that often results in a mismatch between the technical capacity of foresters and the ecosystems and social contexts they target. For natural climate solutions to be effective, they must focus on the people whose decisions determine the long-term viability of ecosystem conservation and carbon storage. Because long-term investments require local support, natural climate solutions are more likely to be successful if they provide benefits for rural and indigenous people who rely on ecosystems for their livelihoods. For small-scale farmers, pastoralists, and forest-dwelling people to prosper while conserving and restoring ecosystems, they must be empowered with decision-making rights over land and must benefit economically from sustainable land management (IPBES 2018).

For example, expansion of commodity agriculture, which is often driven by distant investors, can be checked by securing land rights and enhancing the political power of indigenous and rural people. This involves redirecting investment and using modern technology to monitor and enforce both certifications and bans on commodity agricultural expansion (IPBES 2018). Land managers will invest in restoring carbon storage when their land rights are secure and they are confident that investments in ecosystems will benefit their livelihoods (Duguma et al. 2020).

Increasing the carbon stored in ecosystems is an important element of any climate mitigation strategy. Unfortunately, the current focus on large-scale tree planting initiatives is at best a distraction from this goal. We suggest instead that efforts to implement natural climate solutions should focus on policies that support the restoration efforts of small farmers, hunters, and pastoralists, and hinder the displacement of ecosystems with export-oriented commodity agriculture. Once developed, people-centered climate solutions will be the most effective natural climate solutions because they will align conservation goals and the interests of the rural people responsible for managing ecosystems. Natural climate solutions that count saplings rather than address both the ecological and social drivers of ecosystem destruction are unlikely to succeed.

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Forrest Fleischman (ffleisch@umn.edu) is an assistant professor in the Department of Forest Resources at the University of Minnesota, in St. Paul, Minnesota, United States. Shishir Basant is a doctoral candidate in the Department of Ecology and Conservation Biology at Texas A&M University, in College Station, Texas, United States. Ashwini Chhatre is an associate professor of public policy and executive director of the Bharti Institute of Public Policy, at the Indian School of Business, in Hyderabad, India. Eric A. Coleman is an associate professor of political science at Florida State University, in Tallahassee, Florida, United States. Harry W. Fischer is an assistant professor in the Department of Urban and Rural Development at the Swedish University of Agricultural Sciences, in Uppsala, Sweden. Divya Gupta is a senior research fellow at the Bharti Institute of Public Policy, at the Indian School of Business, in Hyderabad, India. Burak Güneralp is an assistant professor in the Department of Geography at Texas A&M University, in College Station, Texas, United States. Prakash Kashwan is an associate professor in the Department of Political Science at the University of Connecticut, in Storrs, Connecticut, United States. Dil Khatri is the executive director of the Southasia Institute of Advanced Studies, in Kathmandu, Nepal. Robert Muscarella is senior lecturer and associate professor in the Department of Ecology and Genetics, at Uppsala University, in Uppsala, Sweden. Jennifer S. Powers is an associate professor in the Department of Ecology, Evolution, and Behavior and the Department of Plant and Microbial Biology at the University of Minnesota, in St. Paul, Minnesota, United States. Vijay Ramprasad is a senior fellow at the Center for Ecology, Development, and Research in Dehradun, India. Pushpendra Rana is chief conservator of forests at the Himachal Pradesh Forest Department, in Shimla, India. Claudia Rodriguez Solorzano is an adjunct assistant professor in the Department of Forest Resources at the University of Minnesota, in St. Paul, Minnesota, United States. Joseph W. Veldman is an assistant professor in the Department of Ecology and Conservation Biology at Texas A&M University, in College Station, Texas, United States, and a research associate of the Instituto Boliviano de Investigación Forestal, in Santa Cruz, Bolivia.

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