

## ARTICLE OPEN ACCESS

# Vegetal Infrastructure: Rwanda's Eucalyptus Boom and the Material Politics of Tree Planting as a 'Nature-Based Solution'

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## ABSTRACT

Planting trees has become a global obsession. Forest restoration and afforestation have been rebranded as 'nature-based solutions' to climate change. Nations, corporations and non-profits together aim to plant trillions of trees, roughly equivalent to a new Amazon. This article considers the local implications of this terrestrial transformation. It reports on empirical findings from Rwanda, where over fifty million trees—mostly eucalyptus species—have been planted during the past fifteen years. Based on fieldwork with four rural communities, I demonstrate how the material properties of eucalyptus intersect with state and market rationales to make tree planting profitable, scalable and legible. Building from geographic thinking on infrastructure and human-plant relations, I develop the concept of *vegetal infrastructure* to analyse how trees are enrolled in political projects, producing durable inequalities that become a palpable fixture on the landscape. The article emphasises the urgent need to diversify global reforestation mandates and offers vegetal infrastructure as a lens to assess their local implications.

## 1 | The Afforestation Imperative

President Donald Trump's 2020 executive order for the United States to lead in planting one trillion trees globally (Neumayr 2020) surprised many given his administration's environmental record (Wallace-Wells 2023). Yet this was not an isolated pledge. It brought the US into a global movement consolidated earlier that year by the World Economic Forum (WEF) under their Trillion Trees ([1t.org](https://www.1t.org)) platform (United States Congress 2020). The WEF views tree planting as a \$230 billion opportunity (Schwab 2022), a 'nature-based solution' (NBS) that can sequester atmospheric carbon, protect biodiversity and facilitate climate change adaptation. The scientific basis for planting a trillion trees traces to a few influential studies that identified how global forest cover could feasibly increase by 25% (Bastin et al. 2019), potentially absorbing 30% of

all carbon emissions since the Industrial Revolution (Strassburg et al. 2020). While controversial,<sup>1</sup> these findings generated considerable enthusiasm (Einhorn 2022) for tree planting as a NBS, expressed here by the WEF:

Nature-based solutions are a cost-effective, natural technology that is available to us right now and can provide a third of what is needed to limit climate change. Trees, and more specifically, forests, are a crucial part of that.

(World Economic Forum, Lotspeich 2023).

The rise of NBS marks a significant shift in how we think about the natural world. No longer just a substrate for human activity,

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ecosystems are instead imagined, governed and invested in as a form of ‘green’ infrastructure (Nelson and Bigger 2021). Trees have become a flagship of this new paradigm. The long-standing perception of tree-planting as an environmental ‘good’ (Bäckstrand and Lövbrand 2006), coupled with physical properties that make trees’ ecological functions readily quantifiable (Davis and Robbins 2018), has allowed them to be framed as manageable, investable infrastructure. In urban settings, trees are planted to mitigate ‘heat islands,’ manage stormwater and filter air. In rural landscapes, afforestation is promoted as vital infrastructure for carbon sequestration and flood mitigation. This positions trees as functional, predictable assets, akin to pipes, dams and wires.

The promise of trees has proved patently fundable. The trillion trees platform noted above is tightly linked to the ‘Bonn Challenge’ (a goal of restoring 350 million hectares of land by 2030) and the United Nations’ ‘Decade on Ecosystem Restoration’ (2021–2030). The massive scale and global extent of these initiatives raise urgent questions about who benefits from trees as infrastructure, including whether NBS generate new problems and conflicts (Duguma et al. 2020; Osborne et al. 2021). These questions demand attention to social-environmental dynamics in specific locales, moving beyond global carbon accounts to the lived realities of landscape change (Schultz et al. 2022; Levien and Paprocki 2026). One concern is how framing trees as infrastructure obscures the unruly materiality of the vegetal. As biological entities, trees’ life processes can generate unpredictable outcomes for social-ecological worlds (Head et al. 2014; Lawrence 2022).

This article contributes to this critical perspective by examining the expansion of eucalyptus in Rwanda, where planting trees on farms is seen as key to achieving net zero carbon emissions while mitigating floods and soil erosion (Mugabowindekwe et al. 2023). Drawing on twenty months of fieldwork, I demonstrate how afforestation is entangled with state and development actors’ ambitions for rural modernisation, histories of colonial forestry, the gendered dynamics of rural livelihoods and the material properties of a particular tree genus. This critique does not seek to nullify the potential value of tree planting for Rwanda or elsewhere, but rather to problematise how a monocultural approach risks subordinating local sovereignty to the demands of global carbon accounting.

I argue that the success of the global tree-planting agenda relies on rendering certain species legible, governable and investible to state and market forces while simultaneously making biodiverse smallholder agroforestry systems illegible. In Rwanda, this asymmetric legibility derives not only from the discursive engine and political economy of NBS, but also from eucalyptus’s unique, agentic materiality. While their fast growth and hard wood entice proponents, eucalypts can also impede groundwater flows, decrease the productivity of adjacent crops and deplete soil fertility (Belachew and Minale 2025).

To analyse these dynamics, this article brings together insights from the geographies of infrastructure (Nelson and Bigger 2021; Birkenholtz 2022; Lawhon et al. 2022) and vegetal geographies (Lawrence 2022; Jakobsen and Westengen 2022) to develop the concept of *vegetal infrastructure*. While broader concepts such

as ‘living infrastructure’ (Amin 2014) are used to describe the engineering of ecological systems for human benefit, I offer vegetal infrastructure as an analytic that foregrounds the unique materiality of plants. This supports the examination of plant life as a specific kind of infrastructure that co-produces social and political outcomes. It helps move beyond treating tree-planting as a technical solution to reveal it as an emergent socio-material assemblage (cf. Barua 2021), one where living elements (trees, soils) and non-living ones (policies, markets) are bound together. The following section reviews the literature that informs this approach. I then describe my methods and present my analytical narrative of Rwanda’s eucalyptus boom.

## 2 | Vegetal Infrastructure

Political ecologists have critiqued NBS and afforestation as depoliticised technical fixes co-opted by powerful interests (Erbaugh et al. 2020; Elias et al. 2021; Fagan et al. 2020). Recent writing on NBS highlights how its ‘win–win’ rhetoric hides environmental injustices (Woroniecki et al. 2020; Cousins 2021; Grabowski et al. 2022; Singhal and Gupta 2024). And work on afforestation shows how contemporary initiatives reanimate colonial forestry paradigms in ways that impinge on rural livelihoods (Davis and Robbins 2018; Elkin 2022). For example, monoculture tree plantations in India decrease fodder availability and disrupt pastoralists’ migratory routes (Ramprasad et al. 2020). I build on this political ecology work by developing the concept of *vegetal infrastructure* to consider how trees are materially and semiotically enrolled as NBS.

To begin, analysing tree-planting as a NBS requires shifting focus from infrastructure as a fixed object to ‘infrastructuring’ as a dynamic process (Anand et al. 2018; Karasti and Syrjänen 2004). As Star and Ruhleder (1996) suggest, infrastructure is fundamentally relational, only gaining function through its integration into specific contexts, practices and social worlds. Amin (2014) further contends that infrastructure is ‘lively,’ demonstrating how pipes and blueprints organise social life. Applying this perspective, geographers have revealed the labour—often unseen, feminised and undervalued—required to maintain infrastructural services (Lawhon et al. 2018; Kanoi et al. 2022). For instance, drip irrigation efficiency relies on underpaid women performing the additional weeding and harvesting necessary for higher yields (Birkenholtz 2022). In this article, I show how the concept of infrastructuring offers a powerful lens for analysing tree planting as a NBS because it shifts our attention from static woodlots to the contested processes of their creation and maintenance.

Because NBS initiatives explicitly enrol plants and animals as infrastructure, it is crucial to explore their relations with humans (Nelson and Bigger 2021). However, attention to more-than-human actors has been limited in existing work on the geographies of infrastructure (Barua 2021). There are, of course, exceptions, which I build upon in this article. Wakefield (2020) shows how oyster-reef breakwaters require continuous upkeep by engineers, ecologists and oysters. As a second example, Ernwein and Palmer (2025) explore moss air-filtration devices that enrol plants into digital sensor systems to optimise

performance. These cases underscore how NBS hinge on rendering non-human life legible, consistent and calculable. Yet, they have done less to account for the dynamics of uneven development and environmental justice, which remain paramount concerns for political ecology.

To further train infrastructural inquiry towards the vegetal realm of tree planting, we can look to scholarship on human-plant relations, which takes plant agency and material capacities seriously (Lawrence 2022). This ‘vegetal turn’ (Di Paola 2024) defines agency as relational and distributed rather than conscious intent (Galvin 2018; Flachs et al. 2024). Plants have agency because their distinct qualities and life processes shape landscapes and social worlds (Head et al. 2014). Work on human-plant relations highlights how power operates through the vegetal (Bastos 2024; Fleming 2017; Flachs et al. 2024). James Scott’s (2017) distinction between ‘political crops’ (legible, storable) and ‘escape crops’ (hidden) offers a key example, inspiring research on plants like onions, maize and tea, whose material properties both conform with and contest agrarian political economies (Jakobsen and Westengen 2022; Karlsson 2022; Matthan 2022). The surprising exclusion of trees from such analyses leaves questions about their own ‘political’ or ‘escape’ tendencies.

This article leverages two specific analytical strengths of human-plant relations to evaluate tree planting as a form of vegetal infrastructure. First, I engage with the ‘work that plants do’ (Ernwein et al. 2021) to sustain the social institutions undergirding Rwanda’s eucalyptus boom. Second, I examine how specific arboreal capacities are enrolled in political projects—much as tea plant properties facilitate extractive labour (Besky and Padwe 2016). I ask: how do the material properties of eucalyptus enable its enrolment into state and market projects of rural modernisation, and how does this render alternative human-plant relations illegible in ways that negatively impact marginalised actors? This approach aligns with scholarship on ‘infrastructural ecological citizenship’ (Hope 2022), where environmental rights are negotiated through the material assembly of infrastructure.

In summary, weaving together work on the geographies of infrastructure and human-plant relations offers a complementary theoretical approach. An infrastructural lens reveals hidden human labour and political economy but often overlooks more-than-human agency, while human-plant relations scholarship often neglects wider political-economic structures. Combining them supports the analysis of tree-planting as a socio-material assemblage. It helps highlight how tree materiality enables legibility for powerful actors while rendering alternative human-plant relations illegible.

The concept of vegetal infrastructure has practical relevance for examining ‘trees outside forests,’ which are increasingly recognised as vital for rural livelihoods and carbon sequestration (Skole et al. 2021; Choksi et al. 2025). Geospatial analyses reveal a substantial share of global trees within smallholder agricultural landscapes (Brandt et al. 2020; Duguma et al. 2020). This is true in Rwanda, where 72% of trees grow in farmlands and savannas, accounting for 48% of the nation’s carbon stocks (Mugabowindekwe et al. 2023). In fragmented spaces—farm

boundaries, small woodlots, contested commons and agroforestry systems—the daily work of infrastructuring and the intimate politics of human-plant relations are especially palpable.

### 3 | Methods

The findings presented below draw from mixed-methods research conducted during 20 months with four rural communities in Kibirizi sector, Southwest Rwanda. When I began fieldwork, I did not intend to study eucalyptus, afforestation or NBS. My focus was climate change adaptation in the context of agricultural modernisation associated with the African Green Revolution (Clay 2023). After several months in the field, the rising importance of trees relative to crops and the gendered and classed nature of this shift became evident. As did the relationship between agricultural intensification and tree-planting, which for wealthier households can be synergistic, their profits from surplus crop sales invested into woodlots (Clay and King 2019). This prompted attention to the social lives of tree-planting initiatives.

The study began with two months of participant observation, open-ended interviews and five focus group interviews (with 7–16 participants) to understand trajectories of environmental governance, land use and livelihoods. This informed a structured survey on livelihoods, resource access and land-use practices, which research assistants administered to 428 households (90% of total). A second survey involved visiting these households’ 3017 parcels to consider soil fertility, crop yields and decision making. Parcel visits also facilitated a more-than-human ethnography that sought to notice the active role of the vegetal. I documented the physical interactions between eucalyptus and neighbouring crops—for example, noting root spread, shade impacts and the visible allelopathic stunting of beans and maize—while observing the specific labour practices (such as trench-digging or intensive pruning) that farmers employed to manage these biological agents. I also conducted in-depth interviews with 80 individuals who were randomly selected from the 428 surveyed households (in Kinyarwanda or French with a Rwandan research assistant). Interviews averaged 1 h and 20 min and focused on resource access, livelihoods, gendered responsibilities and tree planting. Finally, I interviewed 42 local and regional individuals in leadership roles, including mayors, agronomists, tree nursery operators and others.

### 4 | Political Trees: Assembling Vegetal Infrastructure

I first arrived to Kibirizi during Rwanda’s worst drought in 60 years. The landscape was eerily quiet. It was late September and planting for the upcoming long rainy season should have been underway. But the rains that farmers rely on to loosen southwest Rwanda’s notoriously dense clay soils were months late. Instead, grey smoke wafted from a half-dozen small kilns in clear-cut eucalyptus woodlots. Charcoal production, I would learn, had become an economic lifeline, particularly during drought. The reverence for eucalyptus is anchored in the trauma of the 2001 *Ruchamakara* (‘charcoal making

hunger’) famine. Its name stems from the fact that, following three failed harvests, residents cut down virtually all trees to produce charcoal that they could sell to buy food. Frequently described as the worst famine in memory, elders recounted *Ruchamakara* as a landscape liquidation where even buried roots were unearthed to make charcoal. This collective memory has rendered the fast-growing eucalyptus legible as the ultimate insurance policy against a climate-induced return to such precarity. Study participants emphasised how tree planting has accelerated ever since.

This boom is mirrored across Rwanda. As of 2015, 40% of households maintained eucalyptus on their farms (Mukuralinda et al. 2016). By 2020, eucalyptus species accounted for an estimated 80% of the country’s total forest cover (Karangwa 2018). This is orders of magnitude beyond nearby countries. In 2009, eucalypts covered 8% of Rwanda’s total land, compared to only 0.4% in Ethiopia, 0.1% in Kenya and 0.05% in Uganda (FAO 2009). Not only are they viewed locally as climate-resilient investments, but eucalyptus species are heavily subsidised by government and development actors. In 2011, Rwanda became the first African nation to join the Bonn Challenge, pledging to bring two million hectares of land under restoration by 2030. This expansion has thus far relied strongly on eucalyptus, with over 400,000 ha planted countrywide from 2011 to 2018 (IUCN 2020).

Understanding this boom requires attention to the material agency of eucalyptus, which strongly aligned with colonial, state and market logics, allowing the species to be assembled into a legible, governable and investible vegetal infrastructure. The contemporary eucalyptus boom is the latest chapter in a much older colonial experiment reaching back to the 1890s. German colonial administrators first framed tree planting as a technical fix for fuelwood deficiency and erosion (Everaerts 1939). In the 1930s, the Belgian colonial government introduced eucalyptus, compelling Rwandans to plant the trees through forced communal labour (Harroy 1944). A quota of one hectare of woodlot per 100 people was imposed (Biroli 1980). Following multiple famines in Rwanda, further large-scale eucalyptus planting commenced to counteract irregular rainfall and erosion (Harroy 1944; Jacovelli 2002). These colonial impositions often met with resistance, with Rwandans uprooting the trees in protest (Olson 1995).

Eucalyptus’s role in colonial land management and its subsequent ascent as Rwanda’s dominant tree species is no accident. It is a ‘political tree’ (cf. Scott 2017) because its distinct material qualities facilitate the construction of vegetal infrastructure that does specific ecological work and that can also be circulated efficiently as lumber, charcoal and quantitative figures on hectares planted and carbon sequestered. The enrolment of eucalyptus into infrastructural assemblages is driven by how perfectly it aligns with the state’s need for systems that are legible, governable and investible: fast growth, dense wood that makes excellent charcoal, leaves with a colour signature that is highly visible via satellite, deep and extensive root systems, ease of reproduction by seed or coppicing, suitability across soil and climate types, tolerance of climatic extremes and minimal care requirements. These traits align with standardised sets of tools, policies and paradigms to propel eucalyptus across Rwanda as a

solution to environmental and economic goals. I briefly explore each in turn.

In environmental terms, planting trees is at the centre of Rwanda’s effort to achieve net zero carbon emissions while preventing flooding and erosion. Rwanda became the first African nation to submit a ‘nationally determined contribution’ plan (Republic of Rwanda 2020), outlining ambitious goals to reduce greenhouse gas emissions 38% by 2030. As such, the Rwandan government and development partners strongly position tree planting as a ‘climate smart’ action. For example, the One Acre Fund distributes eucalyptus seedlings to farmers along with its hybrid maize seed. It describes tree planting as a primary tool for building climate resilience, framing trees as a climate-resilient asset that helps farmers cope with income shocks from unpredictable weather.

Eucalypts possess a unique, shimmering blue-green colour signature that is highly visible via satellite. This biological trait exerts a form of material agency by rendering the trees legible to global carbon accounting and state monitoring in a way that complex, biodiverse agroforestry systems—which appear as muddled green signatures—do not. Eucalypts are digitally compatible with the state’s desire for quantifiable, standardised data. This material legibility makes the tree a preferred ally for state planners seeking quantifiable reforestation targets.

Economically, eucalyptus has become a pillar of emerging ‘non-farm’ rural livelihoods, its charcoal destined for rapidly growing urban centres where households desire dense fuel. The tree’s excellent fit for the charcoal industry owes to a unique combination of rapid growth, hard wood and the capacity of eucalyptus to grow back from the same roots after being cut. These features make eucalyptus highly investible, creating a state-sanctioned pathway for capital accumulation in rural areas. Indeed, for many of the households in this study, charcoal production remains a literal economic lifeline—especially during drought—and serves as a pillar of the emerging non-farm rural economy that fuels rapidly growing urban centres. These economic and environmental rationales collide in the tree’s role as a solution to erosion, a long-standing threat to the country’s agricultural productivity (Bizoza 2014), which is governed through a law requiring woodlots on slopes greater than 45 degrees.

By providing a solution to ecological and economic goals, eucalyptus has become Rwanda’s dominant tree. While state and development actors acknowledge the importance of planting diverse tree species on Rwandan farms (Karangwa 2018), this aspiration confronts entrenched structural constraints. In practice, there has been strong inertia around eucalyptus species given the seeds that are available in nurseries. In Rwanda, around two-thirds of the seeds supplied by the National Tree Seed Centre over the past decade have been eucalyptus species (544,613,265 of 820,906,727) (Lillesø et al. 2023). Because eucalyptus seedlings are subsidised, they cost only 20 RWF a piece (around 0.03 USD) in community nurseries, while other species often cost ten times as much. According to interviewees who work in nurseries, these features have made eucalyptus an incumbent tree that is difficult to dislodge, particularly given the need to meet global reforestation commitments.

Eucalyptus can thus be viewed as a ‘political tree.’ This extends Scott’s (2017) concept of ‘political crops’ to consider how the tree’s material properties make it particularly amenable to state and market logics. Like tea, maize and onion (Besky and Padwe 2016; Jakobsen and Westengen 2022; Matthan 2022), eucalyptus enables surveillance, investment and extraction. As a ‘political tree,’ its agentic qualities align with the goals of a modernising state. Propped up by contemporary regimes of climate change mitigation, the provision of a coveted fuel source that drives urbanisation and the capacity to reduce erosion, eucalyptus carries forward the colonial rationale of environmental control that originally brought it to Rwanda.

Through these mechanisms, state and market forces have enrolled eucalyptus as the material of a new vegetal infrastructure. The following section highlights the ground-level realities, tracing how that infrastructure is built and sustained through human and more-than-human labour—and the uneven social worlds it generates. The same biophysical characteristics that make eucalyptus a political tree (fast growth, deep and extensive root systems, ease of production) also enable it to perform land enclosure.

## 5 | The Dilemma of Vegetal Infrastructure

We could hear the argument before we arrived. As we rounded the bend, we noticed a middle-aged woman yelling. Her fury was aimed at the eucalyptus trees bordering her field. An older man and a government administrator listened while she condemned the trees for poisoning her crops and stealing their water. Pointing to her stunted bean plants, she repeated several times: ‘Before the trees these were my best fields,’ asking ‘How will I feed my family now?’. Conflicts like this were far from unique. They spurred local norms dictating that anyone planting eucalyptus must maintain a buffer between their woodlot and their neighbours’ crops. In this case, there was a clear gap between the bean plants and the trees’ trunks. But their branches reached out over the crops and their roots, she insisted, reached under. Though sympathetic to the farmer, the administrator eventually sided with the woodlot owner.

This conflict represents a visceral, quotidian manifestation of what has long been known in forestry and development circles as the ‘eucalyptus dilemma’ (Teketay 2000). The trees’ tendency to outcompete crops for water and nutrients is well documented (Mugunga 2016), occurring not only mechanically through deep roots and shade, but through toxic allelochemicals in their leaves and roots that inhibit the growth of other plants (Chapuis-Lardy et al. 2002; Rahman et al. 2024). Citing these concerns, Rwanda’s former Director of Forestry called for a moratorium on planting eucalyptus and for the uprooting of existing trees back in 2006 (Gahigana 2006). This scepticism is not isolated to Rwanda. Vigorous debate persists globally about whether the tree’s high productivity in dry, infertile areas outweighs steep costs to crop yields (FAO 2009; Madalcho et al. 2019; Rahman et al. 2024; Belachew and Minale 2025).

This is the core tension of eucalyptus as vegetal infrastructure. Its celebrated utility for commodity production and environmental management is inseparable from its antagonistic material

agency. The eucalyptus dilemma raises a crucial question: why, despite its well-documented antagonism to arable crops, was eucalyptus so thoroughly enrolled as the vegetal infrastructure of choice in Rwanda, where over 80% of people depend on agriculture? This section answers that question by turning to the local political ecologies of Kibirizi. It details the on-the-ground process of infrastructuring eucalyptus and demonstrates how this produces and entrenches gender and class inequalities through an asymmetric legibility. I first explore what this vegetal infrastructure makes *legible*: the rationales for planting that align with state modernisation, climate resilience and financial accumulation. I then turn to what this same process renders *illegible*: diverse agroforestry systems, the devalued labour of women and the coping strategies of the landless poor. Finally, I reflect on this vegetal infrastructure as a form of slow violence that transforms the social-ecological landscape.

### 5.1 | Legibility: Infrastructuring Eucalyptus

Beyond state initiatives, the eucalyptus boom is driven locally by interlocking livelihood logics, particularly among wealthier men. More than just individual preferences, these are land-use strategies that animate tree planting and stabilise eucalyptus as vegetal infrastructure. They converge around two themes: (1) the tree as a resilient, low-labour and flexible financial asset; and (2) its role in a gendered vision of rural modernisation. Unpacking these themes shows that the boom is not simply compliance with top-down policy but is part of situated processes of agrarian change. It is through becoming part of this social-ecological fabric that the trees become vegetal infrastructure—durable fixtures that actively produce and enforce social order.

First, eucalyptus is legible as a uniquely climate-resilient and low-labour financial asset. The *Ruchamakara* famine of 2001 solidified the tree’s reputation as a lifeline during climate shocks, a perception reinforced amidst recent droughts that dramatically reduced crop yields during this study. This narrative strongly aligns with the framing of tree planting as ‘climate smart’ by development actors discussed in Section 4. Moreover, unlike labour-intensive annual crops on steep, unmechanised hills, eucalyptus requires minimal maintenance. Parcel-level survey data indicates a stark labour divide: while staple crops like beans and maize require intensive biannual tilling and multiple weeding cycles, woodlot owners reported that eucalyptus requires almost no labour after the initial year of establishment.

In interviews, respondents frequently contrasted the ‘exhausting’ daily requirements of subsistence agriculture with the ‘passive’ growth of woodlots, with one male respondent noting that once the seedlings take root, the tree ‘does the work of growing itself’ while he pursues non-farm income. This is a key material property that enables its legibility to wealthier residents as a modern, financial asset. Respondents likened woodlots to a ‘bank account’—a flexible asset that can be liquidated whenever cash is needed, but one with far less labour than livestock. This financial legibility is anchored by the booming urban charcoal market, which provides a stable and consistently rising price for the wood, insulating investors from the volatility of commodity crops.

Given the need for surplus land or stable income, woodlots are widely viewed as an indicator of class, signifying a household's capacity to go beyond meeting everyday food needs. As shown in Table 1 and Figure 1, ownership is starkly classed: 93.8% of the wealthiest quartile operate woodlots (averaging > 0.5 ha) compared to just 26.7% of the poorest, whose 'woodlots' are often mere boundary trees.tiny parcels (average of 0.03 ha) that only supply firewood. And it is well known that many of the woodlots are owned by people who live outside of the community. Some resented this incursion of external privilege. Others viewed it as partly a result of Rwanda's aggressive land-use consolidation program, which compels farmers to cultivate state-approved crops (Clay 2017). Amidst this program, woodlots offer vital flexibility, enabling autonomy from government decisions about which crop should be planted from one season to the next.

Eucalyptus also functions as a legible pathway to a modern, masculine identity. The woodlot has become a symbol of an entrepreneurial rural man who is no longer tied to the soil, reinforcing a gendered division of labour where farming is increasingly cast as women's work. Across demographics, respondents described men's aspiration to transition away from agriculture, which many, in alignment with the state's own

development narrative, view as antiquated and unprofitable. Male respondents frequently claimed that they now lack time for agriculture. Women corroborated this widely, sometimes noting sardonically that men 'send their female servants to farm subsistence crops for them.' Eucalyptus enables men to escape agriculture through woodlot ownership and labour in the charcoal value chain. Selling seedlings, cutting wood and firing kilns provide vital cash income in a sector that is now strictly gendered.

This gendered reordering is especially visible in the charcoal sector. Historically, charcoal was produced on a smaller scale through household labour, frequently involving women. However, driven by urbanisation and a desire for tax revenue, the state has sought to modernise the sector (World Bank 2012). The cultural understanding of eucalyptus as a man's domain is so embedded that respondents laughed at the idea of a woman participating in the charcoal industry, upholding the narrative with cautionary tales, such as one about a woman who cut her own leg with an axe while trying to make charcoal. Men now control every stage of the value chain, while women's only eucalyptus work is the unremunerated daily collection of branches for cooking.

**TABLE 1** | Woodlot operation by socio-economic class (represented by income quartile).

Income quartile	Mean woodlot (ha)	Proportion of total land (%)	Expanded woodlots in past ten years (% of group)
Low	0.001	7.6	8.2
Medium low	0.043	11.8	16.8
Medium high	0.225	29.2	26
High	0.911	46.6	51
All	—	20.5	21.3
Sig.	0	0	0



**FIGURE 1** | Woodlot operation by socio-economic class (represented by income quartile).

The political economic and cultural restructuring of the charcoal industry produces and maintains this gendered vision of tree planting. Regulation, such as requiring cutting permits from local authorities, makes the industry legible to the state and formalises it as a masculine economic sphere. It also restricts participation to well-connected men, who then hire other men in communal gathering space—typically bars. According to many men, the need to secure such contracts is why they spend little time labouring in their household's fields (see also Clay and Yurco 2024). As a vegetal infrastructure, eucalyptus nurtures these gendered social transformations and codifies them onto the landscape. While both trees and annual crops are products of the soil, their materialities lend to distinct social temporalities. Agriculture in Kibirizi is tethered to the hunger of the seasons and the immediate, manual labour required to loosen dense clay soils. In contrast, eucalyptus represents a shift from seasonal labour to a multi-decadal investment.

Survey data reinforces this distinction: while 93.8% of the wealthiest households own woodlots, they are managed not through the intensive feminised labour of weeding, but through the masculine-coded work of charcoal value chains. It is this material detachment from the daily, surface-level labour of the soil, rather than a detachment from the land itself, that differentiates the woodlot from the field in the eyes of rural residents. Taken together, these legible rationales reveal how wealthier households are not passive recipients of state policy but are active agents building vegetal infrastructure. By investing their capital and land, they co-produce an infrastructure that secures their own wealth and aligns with a state-backed vision of (environmentally friendly) rural modernisation. This process materially embeds their class and gender advantages into the landscape, creating a system that is legible and profitable for them—a dynamic whose exclusionary consequences become clear when we turn to what, and who, is rendered illegible.

## 5.2 | Enclosure Through Illegibility

A primary consequence of infrastructuring eucalyptus is that it actively devalues and displaces long-standing human-plant relations, rendering the complex, socio-ecological dependencies of smallholders illegible to the state's modernisation project. This is not merely a case of one species physically replacing another. The expansion of eucalyptus woodlots erodes the specific human-plant intimacies and labour regimes—primarily managed by women—that sustained dozens of native tree species for food, fodder and medicine (cf. Bastos 2024; Di Paola 2024). When these native species are uprooted or fail to be replanted because they lack 'investible' seeds in nurseries, the cultural knowledge and food security strategies tied to them are displaced alongside the physical biomass.

The food security needs of the poor are also made illegible by policies requiring fields steeper than 45 degrees to be planted with trees—a rule that disproportionately affects poorer households who most commonly farm marginal land on steep slopes. For many of these households, eucalyptus is often seen not as an investment but as an imposition. These households lack the

crucial element of time, and many are forced to make distress sales of their land at a low cost.

For those cultivating crops adjacent to woodlots, the trees are not just an imposition but an active antagonist. Here, the material agency of the eucalyptus becomes the primary mechanism through which the vegetal infrastructure performs its work of enclosure. Land-poor respondents discussed how eucalyptus trees crowd out their parcels. One respondent described the trees as 'selfish and greedy,' showing how that their roots desiccated her bean crop several meters from the trunk. In these instances, the tree's allelopathic leaves and deep taproots actively suppresses the growth of food crops, physically policing the boundary between the monoculture woodlot and the biodiverse plots tended by women. This is the vegetal infrastructure in operation: a more-than-human assemblage where the work of the tree is harnessed as a physical proxy for state-led land consolidation.

The daily operation of this infrastructure generates poignant feelings of injustice. Female respondents expressed this as they watched their own harvests decline during drought while their neighbours with woodlots weathered the climate shocks. For the landless, whose livelihoods depend on labouring in others' fields, eucalyptus also symbolises dissipating opportunities. While many viewed woodlots as a sensible investment that they too would make if given the choice, they also expressed a sense of lost sovereignty brought on by the incursion of eucalyptus. In a landscape marked by drastically uneven access to land and other resources, the trees serve to restrict the capacities of women and the poor to define and control land use in line with their needs.

This focus on the quotidian and the intimate reveals how the relationship with eucalyptus is deeply differentiated by gender and class. For wealthier men, the tree is an ally in a project of rural modernisation, a low-labour investment that generates cash and facilitates a move away from antiquated subsistence agriculture. The human-plant relationship engenders commodity production and capital accumulation. For many women and the poor, the trees are experienced more by what they displace. The eucalyptus is an aggressive neighbour whose thirsty roots and toxic leaves inhibit the food crops they cultivate for household subsistence. These gendered relationships with the tree are co-produced through everyday labour and struggle. In this way eucalyptus can be viewed as a participant in the vegetal infrastructuring, its visibility and agentic qualities intersecting with state power and labour dynamics to make inequality a durable fixture on the landscape.

## 6 | The Slow Violence of a Solution

Afforestation has become a highly visible expression of the global turn towards NBS. By strategically deploying trees as infrastructure, NBS proponents seek to harness ecological processes to address social-environmental challenges (IUCN 2020). The eucalyptus boom in Rwanda exemplifies how the global tree-planting agenda makes certain human-plant relations legible and investible while obscuring and compromising others. This article has demonstrated how external afforestation ambitions

synergised with local livelihood and land-use dynamics to propel eucalyptus monocultures across rural landscapes previously devoted to agri-biodiverse food security crops and trees (see also Robbins 2001). This nuances the political ecological critique of afforestation as a purely top-down directive isolated in large plantations. It shows how NBS can involve micro-scale processes of enclosure, further undermining the livelihoods and food sovereignty of the marginalised, including women and the landless poor. These findings resonate with the mounting evidence that tree planting is far from a simple solution (Holl and Brancalion 2020; Choksi et al. 2025).

The uneven, gendered livelihood dynamics are systematically missed by the satellite assessments and national targets that measure the success of afforestation in terms of trees planted, carbon stored or hectares reforested. This oversight itself speaks to powerful imaginary of trees as a positive social-environmental force (Bäckstrand and Lövbrand 2006). In Rwanda, eucalyptus became a ‘political tree’ (cf. Scott 2017) because its material properties dovetailed with the nation’s rural modernisation development campaign. It is highly legible to state planners and rural elites even as it creates new forms of precarity on the ground. Those unable to benefit from eucalyptus experience their livelihoods and landscapes being unmade by this vegetal infrastructure. This lens reveals the intimate, embodied politics of infrastructuring nature, where the slow violence of ecological competition erodes women’s labour, knowledge and right to the landscape. This echoes broader feminist political ecology insight on how inequity materially infuses the spaces of everyday life (Nightingale 2011; Birkenholtz 2022).

The concept of vegetal infrastructure helps show how the win-win promises of NBS often rely on a simplified view of nature as a neutral technology, ignoring the agentic capacities of non-human life and how these can be enrolled in ways that deepen social inequity. By making these struggles visible, this article adds fodder to arguments for the urgent need to diversify global tree-planting mandates beyond monocultures of introduced species (Fleischman et al. 2020). The concept of vegetal infrastructure is offered as a vital diagnostic tool to assess the justice implications of NBS and afforestation globally.

Future research could use this lens to critically examine other initiatives, from mangrove restoration to urban greening projects, considering how these supposedly universal solutions intersect with local political ecological dynamics to reproduce and harden social inequities. By unsettling the perceived neutrality of green technologies, we can begin to cultivate more pluralistic reforestation agendas that prioritise the situated needs of the landscapes and communities they are intended to serve. Interrogating vegetal infrastructures is an important step towards generating a more ‘modest imaginary’ (Lawhon et al. 2022) about what NBS and afforestation can and ought to do.

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#### Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

#### Endnotes

<sup>1</sup> Bastin et al. (2019) and Strassburg et al. (2020) faced immediate and significant scientific pushback for overestimating carbon sequestration potential through idealised modelling that overlooks local land tenure, existing soil carbon and the albedo effects of expanding forest cover in specific biomes.

#### References

- Amin, A. 2014. “Lively Infrastructure.” *Theory, Culture and Society* 31, no. 7–8: 137–161. <https://doi.org/10.1177/0263276414548490>.
- Anand, N., A. Gupta, and H. Appel, eds. 2018. *The Promise of Infrastructure*. Duke University Press. ISBN 9781478002031.
- Bäckstrand, K., and E. Lövbrand. 2006. “Planting Trees to Mitigate Climate Change: Contested Discourses of Ecological Modernization, Green Governmentality and Civic Environmentalism.” *Global Environmental Politics* 6, no. 1: 50–75. <https://doi.org/10.1162/glep.2006.6.1.50>.
- Barua, M. 2021. “Infrastructure and Non-Human Life: A Wider Ontology.” *Progress in Human Geography* 45, no. 6: 1467–1489. <https://doi.org/10.1177/0309132521991220>.
- Bastin, J. F., Y. Finegold, C. Garcia, et al. 2019. “The Global Tree Restoration Potential.” *Science* 365, no. 6448: 76–79. <https://doi.org/10.1126/science.aax0848>.
- Bastos, C. 2024. “Plant-People Intimacies: Sugar Canes, Pineapples and the Memory of Migration in Hawai’i.” *Journal of Ethnobiology* 44, no. 1: 11–22. <https://doi.org/10.1177/02780771231221643>.
- Belachew, K. G., and W. K. Minale. 2025. “Socioeconomic and Environmental Impacts of Eucalyptus Plantations in Ethiopia: An Evaluation of Benefits, Challenges, and Sustainable Practices.” *Scientific World Journal* 2025, no. 1: 1780293. <https://doi.org/10.1155/tswj/1780293>.
- Besky, S., and J. Padwe. 2016. “Placing Plants in Territory.” *Environment and Society* 7, no. 1: 9–28. <https://doi.org/10.3167/ares.2016.070102>.
- Birkenholtz, T. 2022. “Infrastructuring Drip Irrigation: The Gendered Assembly of Farmers, Laborers and State Subsidy Programs.” *Environment and Planning E: Nature and Space* 6, no. 1: 132–152. <https://doi.org/10.1177/25148486221100386>.
- Biroli, P. 1980. “Effort de Reboisement au Rwanda.” *Bulletin Agricole du Rwanda* 13: 24–29.

- Bizoza, A. R. 2014. "Institutions and the Adoption of Technologies: Bench Terraces in Rwanda." In *Challenges and Opportunities for Agricultural Intensification of the Humid Highland Systems of Sub-Saharan Africa*, edited by B. Vanlauwe, P. van Asten, and G. Blomme. Springer. [https://doi.org/10.1007/978-3-319-07662-1\\_26](https://doi.org/10.1007/978-3-319-07662-1_26).
- Brandt, M., C. J. Tucker, A. Kariryaa, et al. 2020. "An Unexpectedly Large Count of Trees in the West African Sahara and Sahel." *Nature* 587: 78–82. <https://doi.org/10.1038/s41586-020-2824-5>.
- Chapuis-Lardy, L., D. Contour-Ansel, and F. Bernhard-Reversat. 2002. "High-Performance Liquid Chromatography of Water-Soluble Phenolics in Leaf Litter of Three Eucalyptus Hybrids (Congo)." *Plant Science* 163, no. 2: 217–222. [https://doi.org/10.1016/S0168-9452\(02\)00099-7](https://doi.org/10.1016/S0168-9452(02)00099-7).
- Choksi, P., D. Lalai, A. Menon, et al. 2025. "How Do Trees Outside Forests Contribute to Human Wellbeing? A Systematic Review From South Asia." *Environmental Research Letters* 20: 034040. <https://doi.org/10.1088/1748-9326/adb7f4>.
- Clay, N. 2017. "Agro-Environmental Change in African Mountains: Shifting Socio-Spatial Practices Amid State-Led Commercialization in Rwanda." *Annals of the American Association of Geographers* 107, no. 2: 360–370. <https://doi.org/10.1080/24694452.2016.1254019>.
- Clay, N. 2023. "Uneven Resilience and Everyday Adaptation: Making Rwanda's Green Revolution Climate Smart." *Journal of Peasant Studies* 50, no. 1: 240–261. <https://doi.org/10.1080/03066150.2022.2112673>.
- Clay, N., and B. King. 2019. "Smallholders' Uneven Capacities to Adapt to Climate Change Amid Africa's Green Revolution: Case Study of Rwanda's Crop Intensification Program." *World Development* 116: 1–14. <https://doi.org/10.1016/j.worlddev.2018.11.022>.
- Clay, N., and K. Yurco. 2024. "Beyond the 'Gender Gap' in Agriculture: Africa's Green Revolution and Gendered Rural Transformation in Rwanda." *Journal of Rural Studies* 112: 103444. <https://doi.org/10.1016/j.jrurstud.2024.103444>.
- Cousins, J. J. 2021. "Justice in Nature-Based Solutions: Research and Pathways." *Ecological Economics* 180: 106874. <https://doi.org/10.1016/j.ecolecon.2020.106874>.
- Davis, D. K., and P. Robbins. 2018. "Ecologies of the Colonial Present: Pathological Forestry From the Taux de Boisement to Civilized Plantations." *Environment and Planning E: Nature and Space* 1, no. 4: 447–469. <https://doi.org/10.1177/2514848618812029>.
- Di Paola, M., ed. 2024. *The Vegetal Turn: History, Concepts, Applications*. Vol. 38. *The International Library of Environmental, Agricultural and Food Ethics*. Springer Nature Switzerland. <https://doi.org/10.1007/978-3-031-68671-9>.
- Duguma, L. A., P. A. Minang, B. E. Aynekulu, et al. 2020. "From Tree Planting to Tree Growing: Rethinking Ecosystem Restoration." World Agroforestry Working Paper. <https://doi.org/10.5716/wp20001.pdf>.
- Einhorn, C. 2022. "Tree Planting Is Booming. Here's How That Could Help, or Harm, the Planet." Climate. The New York Times, March 14. <https://www.nytimes.com/2022/03/14/climate/tree-planting-reforestation-climate.html>.
- Elias, M., D. Joshi, and R. Meinzen-Dick. 2021. "Restoration for Whom, by Whom? A Feminist Political Ecology of Restoration." *Ecological Restoration* 39, no. 1–2: 3–15. <https://doi.org/10.3368/er.39.1-2.3>.
- Elkin, R. S. 2022. *Plant Life: The Entangled Politics of Afforestation*. University of Minnesota Press. ISBN: 9781517912628.
- Erbaugh, J. T., N. Pradhan, J. Adams, et al. 2020. "Global Forest Restoration and the Importance of Prioritizing Local Communities." *Nature Ecology & Evolution* 4, no. 11: 1472–1476. <https://doi.org/10.1038/s41559-020-01282-2>.
- Ernwein, M., F. Ginn, and J. Palmer. 2021. *The Work That Plants Do: Life, Labour and the Future of Vegetal Economies*. Vol. 45. Transcript Verlag. <https://doi.org/10.1515/9783839455340>.
- Ernwein, M., and J. Palmer. 2025. "Making the Mos(s) of Nature? Cleantech, Smart Nature-Based Solutions, and the 'Rendering Investable' of Urban Moss." *Environment and Planning E: Nature and Space* 8, no. 1: 306–324. <https://doi.org/10.1177/25148486241295950>.
- Everaerts, E. 1939. "Monographie Agricole du Ruanda-Urundi." *Bulletin Agricole du Congo Belge* 30, no. 3: 343–396.
- Fagan, M. E., J. L. Reid, M. B. Holland, J. G. Drew, and R. A. Zahawi. 2020. "How Feasible Are Global Forest Restoration Commitments?" *Conservation Letters* 13, no. 3: e12700.
- FAO. 2009. "Eucalyptus in East Africa: The Socio-Economic and Environmental Issues." Addis Ababa: FAO.
- Flachs, A., C. Bastos, D. Heath, and S. Venkateswar. 2024. "Introduction to Special Collection: Plant-Anthropo-Genesis: The co-Production of Plant–People Lifeworlds." *Journal of Ethnobiology* 44, no. 1: 3–10. <https://doi.org/10.1177/02780771241228068>.
- Fleischman, F., S. Basant, A. Chhatre, et al. 2020. "Pitfalls of Tree Planting Show Why We Need People-Centered Natural Climate Solutions." *Bioscience* 70, no. 11: 947–950. <https://doi.org/10.1093/biosci/biaa094>.
- Fleming, J. 2017. "Toward Vegetal Political Ecology: Kyrgyzstan's Walnut–Fruit Forest and the Politics of Graftability." *Geoforum* 79: 26–35. <https://doi.org/10.1016/j.geoforum.2016.12.009>.
- Gahigana, I. 2006. "No More Eucalyptus Trees, Says Official." The New Times, Kigali.
- Galvin, S. 2018. "Interspecies Relations and Agrarian Worlds." *Annual Review of Anthropology* 47, no. 1: 233–249. <https://doi.org/10.1146/annurev-anthro-102317-050232>.
- Grabowski, Z. J., K. Wijsman, C. Tomateo, and T. McPhearson. 2022. "How Deep Does Justice Go? Addressing Ecological, Indigenous, and Infrastructural Justice Through Nature-Based Solutions in New York City." *Environmental Science & Policy* 138: 171–181. <https://doi.org/10.1016/j.envsci.2022.09.022>.
- Harroy, J.-P. 1944. *Afrique, Terre Qui Meurt: La Degradation des Sols Africains sous l'influence de la Colonisation*. Academie Royale de Belgique.
- Head, L., J. Atchison, C. Phillips, and K. Buckingham. 2014. "Vegetal Politics: Belonging, Practices and Places." *Social & Cultural Geography* 15, no. 8: 861–870. <https://doi.org/10.1080/14649365.2014.973900>.
- Holl, K. D., and P. H. Brancalion. 2020. "Tree Planting Is Not a Simple Solution." *Science* 368, no. 6491: 580–581. <https://doi.org/10.1126/science.aba823>.
- Hope, J. 2022. "Driving Development in the Amazon: Extending Infrastructural Citizenship With Political Ecology in Bolivia." *Environment and Planning E: Nature and Space* 5, no. 2: 520–542. <https://doi.org/10.1177/2514848621989611>.
- International Union for Conservation of Nature (IUCN). 2020. "IUCN Global Standard for Nature-Based Solutions." 1st ed. Gland, Switzerland: IUCN. <https://portals.iucn.org/library/sites/library/files/documents/2020-020-En.pdf>.
- Jacovelli, P. A. 2002. "Cultivation and Production of Eucalypts in Africa." In *Chapter 9 in Eucalyptus: The Genus Eucalyptus*, edited by J. W. Coppen, vol. 216. CRC Press. <https://doi.org/10.1201/9780203219430>.
- Jakobsen, J., and O. T. Westengen. 2022. "The Imperial Maize Assemblage: Maize Dialectics in Malawi and India." *Journal of Peasant Studies* 49, no. 3: 536–560. <https://doi.org/10.1080/03066150.2021.1890042>.

- Kanoi, L., V. Koh, A. Lim, S. Yamada, and M. R. Dove. 2022. "What Is Infrastructure? What Does It Do?": Anthropological Perspectives on the Workings of Infrastructure(s)." *Environmental Research: Infrastructure and Sustainability* 2, no. 1: 012002. <https://doi.org/10.1088/2634-4505/ac4429>.
- Karangwa, C. 2018. "Delivery of Quality and Diverse Planting Material is a Major Constraint for Restoration: What Solutions, What Emerging Needs? [Panel Discussion]." Global Landscapes Forum, Bonn, Germany.
- Karasti, H., and A.-L. Syrjänen. 2004. "Artful Infrastructuring in Two Cases of Community PD." In Proceedings of the Eighth Conference on Participatory Design: Artful Integration: Interweaving Media, Materials and Practices – Volume 1 (New York, NY, USA), PDC 04, July 27, 20–30. <https://doi.org/10.1145/1011870.1011874>.
- Karlsson, B. G. 2022. "The Imperial Weight of Tea: On the Politics of Plants, Plantations and Science." *Geoforum* 130: 105–114. <https://doi.org/10.1016/j.geoforum.2021.07.017>.
- Lawhon, M., D. Nilsson, J. Silver, H. Ernstson, and S. Lwasa. 2018. "Thinking Through Heterogeneous Infrastructure Configurations." *Urban Studies* 55, no. 4: 720–732. <https://doi.org/10.1177/0042098017720149>.
- Lawhon, M., G. Nsangi Nakyagaba, and T. Karpouzoglou. 2022. "Towards a Modest Imaginary? Sanitation in Kampala Beyond the Modern Infrastructure Ideal." *Urban Studies* 60, no. 1: 146–165. <https://doi.org/10.1177/00420980211064519>.
- Lawrence, A. M. 2022. "Listening to Plants: Conversations Between Critical Plant Studies and Vegetal Geography." *Progress in Human Geography* 46, no. 2: 629–651. <https://doi.org/10.1177/03091325211062167>.
- Levien, M., and K. Paprocki. 2026. "Against the Planetary: Carbon Fetishism and the Politics of False Solutions." *Journal of Peasant Studies* 53: 443–473. <https://doi.org/10.1080/03066150.2026.2616321>.
- Lillesø, J.-P. B., F. Pedercini, and E. Ngethe. 2023. "Tree Seed-Seedling Demand, and Certification of Seed Sources Rwanda; Special Focus on the Eastern Province." CIFOR-ICRAF. <https://www.cifor-icraf.org/trepa/wp-content/uploads/sites/54/2024/02/Final-Draft-Interim-report-Seed-Sector-Review-for-TREPA-Rwanda.pdf>.
- Lotspeich, J. 2023. "Why Planting and Growing Trees Matters for Climate, People and Biodiversity." World Economic Forum, October 10. <https://www.weforum.org/stories/2023/10/planting-growing-trees-climate-people-and-biodiversity/>.
- Madalcho, A. B., B. Lemma, M. M. Mena, and B. B. Badesso. 2019. "Is the Expansion of Eucalyptus Tree a Curse or an Opportunity? Implications From a Dispute on the Tree's Ecological and Economic Impact in Ethiopia: A Review." *Journal of Ecology and the Natural Environment* 11, no. 6: 75–83. <https://doi.org/10.5897/JENE2019.0765>.
- Matthan, T. 2022. "Speculative Crops: Gambling on the Onion in Rural India." *Geoforum* 130: 115–122. <https://doi.org/10.1016/j.geoforum.2021.10.014>.
- Mugabowindekwe, M., M. Brandt, J. Chave, et al. 2023. "Nation-Wide Mapping of Tree-Level Aboveground Carbon Stocks in Rwanda." *Nature Climate Change* 13: 91–97. <https://doi.org/10.1038/s41558-022-01544-w>.
- Mugunga, C. P. 2016. "The Use of Eucalyptus in Agroforestry Systems of Southern Rwanda: To Integrate or Segregate." Doctoral diss., Wageningen University and Research. <https://doi.org/10.18174/375484>.
- Mukuralinda, A., J. D. Ndayambaje, M. Liyama, et al. 2016. "Taking to Scale Tree-Based Systems in Rwanda to Enhance Food Security, Restore Degraded Land, Improve Resilience to Climate Change and Sequester Carbon." PROFOR, Washington, D.C.
- Nelson, S. H., and P. Bigger. 2021. "Infrastructural Nature." *Progress in Human Geography* 46, no. 1: 86–107. <https://doi.org/10.1177/0309132521993916>.
- Neumayr, M. B. 2020. "President Trump Signs One Trillion Trees Executive Order, Promoting Conservation and Regeneration of Our Nation's Forests." October 16. Accessed 5/12/2024. <https://trump.whitehouse.archives.gov/articles/president-trump-signs-one-trillion-trees-executive-order-promoting-conservation-regeneration-nations-forests/>.
- Nightingale, A. J. 2011. "Bounding Difference: Intersectionality and the Material Production of Gender, Caste, Class and Environment in Nepal." *Geoforum* 42, no. 2: 153–162. <https://doi.org/10.1016/j.geoforum.2010.03.004>.
- Olson, J. 1995. "Farmer Responses to Land Degradation in Gikongoro, Rwanda." PhD thesis, Michigan State University, East Lansing.
- Osborne, T., S. Brock, R. Chazdon, et al. 2021. "The Political Ecology Playbook for Ecosystem Restoration: Principles for Effective, Equitable, and Transformative Landscapes." *Global Environmental Change* 70: 102320. <https://doi.org/10.1016/j.gloenvcha.2021.102320>.
- Rahman, M. A., A. K. Das, Z. Al Riyadh, M. Suhag, and M. M. Rahman. 2024. "Eucalyptus in Agriculture: Friend or Foe? Analyzing Its Impact on Crop Yields, Soil Dynamics, and Farmers' Perceptions in Bangladesh." *Agroforestry Systems* 98: 3109–3128. <https://doi.org/10.1007/s10457-024-01077-5>.
- Ramprasad, V., A. Joglekar, and F. Fleischman. 2020. "Plantations and Pastoralists: Afforestation Activities Make Pastoralists in the Indian Himalaya Vulnerable." *Ecology and Society* 25, no. 4. <https://doi.org/10.5751/ES-11810-250401>.
- Republic of Rwanda. 2020. "Updated Nationally Determined Contribution." UNFCCC. [https://unfccc.int/sites/default/files/NDC/202206/Rwanda\\_Updated\\_NDC\\_May\\_2020.pdf](https://unfccc.int/sites/default/files/NDC/202206/Rwanda_Updated_NDC_May_2020.pdf).
- Robbins, P. 2001. "Fixed Categories in a Portable Landscape: The Causes and Consequences of Land-Cover Categorization." *Environment and Planning A* 33, no. 1: 161–179. <https://doi.org/10.1068/a3379>.
- Schultz, B., D. Brockington, E. A. Coleman, et al. 2022. "Recognizing the Equity Implications of Restoration Priority Maps." *Environmental Research Letters* 17, no. 11: 114019. <https://doi.org/10.1088/1748-9326/ac9918>.
- Schwab, N. 2022. "2 Years of Growth in the Trillion Trees Movement." World Economic Forum August 28. <https://www.weforum.org/stories/2022/08/two-years-of-trillion-trees/>.
- Scott, J. C. 2017. *Against the Grain: A Deep History of the Earliest States*. Yale University Press. ISBN 9780300182910.
- Singhal, S., and M. Gupta. 2024. "Critically Analyzing Nature-Based Solutions: A Political Ecology Framework of Planning for the Yamuna River Floodplains, Delhi." *Journal of Urban Affairs*: 1–21. <https://doi.org/10.1080/07352166.2024.2413587>.
- Skole, D. L., C. Mbow, M. Mugabowindekwe, M. S. Brandt, and J. H. Samek. 2021. "Trees Outside of Forests as Natural Climate Solutions." *Nature Climate Change* 11: 1013–1016. <https://doi.org/10.1038/s41558-021-01230-3>.
- Star, S. L., and K. Ruhleder. 1996. "Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces." *Information Systems Research* 7, no. 1: 111–134. <https://doi.org/10.1287/isre.7.1.111>.
- Strassburg, B. B. N., A. Iribarrem, H. L. Beyer, et al. 2020. "Global Priority Areas for Ecosystem Restoration." *Nature* 586: 724–729. <https://doi.org/10.1038/s41586-020-2784-9>.
- Teketay, D. 2000. "Facts and Experience on Eucalyptus in Ethiopia and Elsewhere: Ground for Making Wise and Informed Decision." Workshop on Eucalyptus Dilemma held on 15 November 2000 at Ghion Hotel, Addis Ababa.
- United States Congress. 2020. "H.R. 5859–Trillion Trees Act." <https://cdrlaw.org/resources/h-r-5859-trillion-trees-act/>.

Wakefield, S. 2020. "Making Nature Into Infrastructure: The Construction of Oysters as a Risk Management Solution in New York City." *Environment and Planning E: Nature and Space* 3: 761–785. <https://doi.org/10.1177/2514848619888746>.

Wallace-Wells, D. 2023. "Forests Are No Longer Our Climate Friends." *New York Times*. September 6. <https://www.nytimes.com/2023/09/06/opinion/columnists/forest-fires-climate-change.html>.

World Bank. 2012. "Establishing a Green Charcoal Value Chain in Rwanda: A Feasibility Study (Vol. 2): Main Report (English)." Washington, D.C.: World Bank Group. <http://documents.worldbank.org/curated/en/603321468026133861/Main-report>.

Woroniecki, S., H. Wendo, E. Brink, et al. 2020. "Nature Unsettled: How Knowledge and Power Shape 'Nature-Based' Approaches to Societal Challenges." *Global Environmental Change* 65: 102132. <https://doi.org/10.1016/j.gloenvcha.2020.102132>.