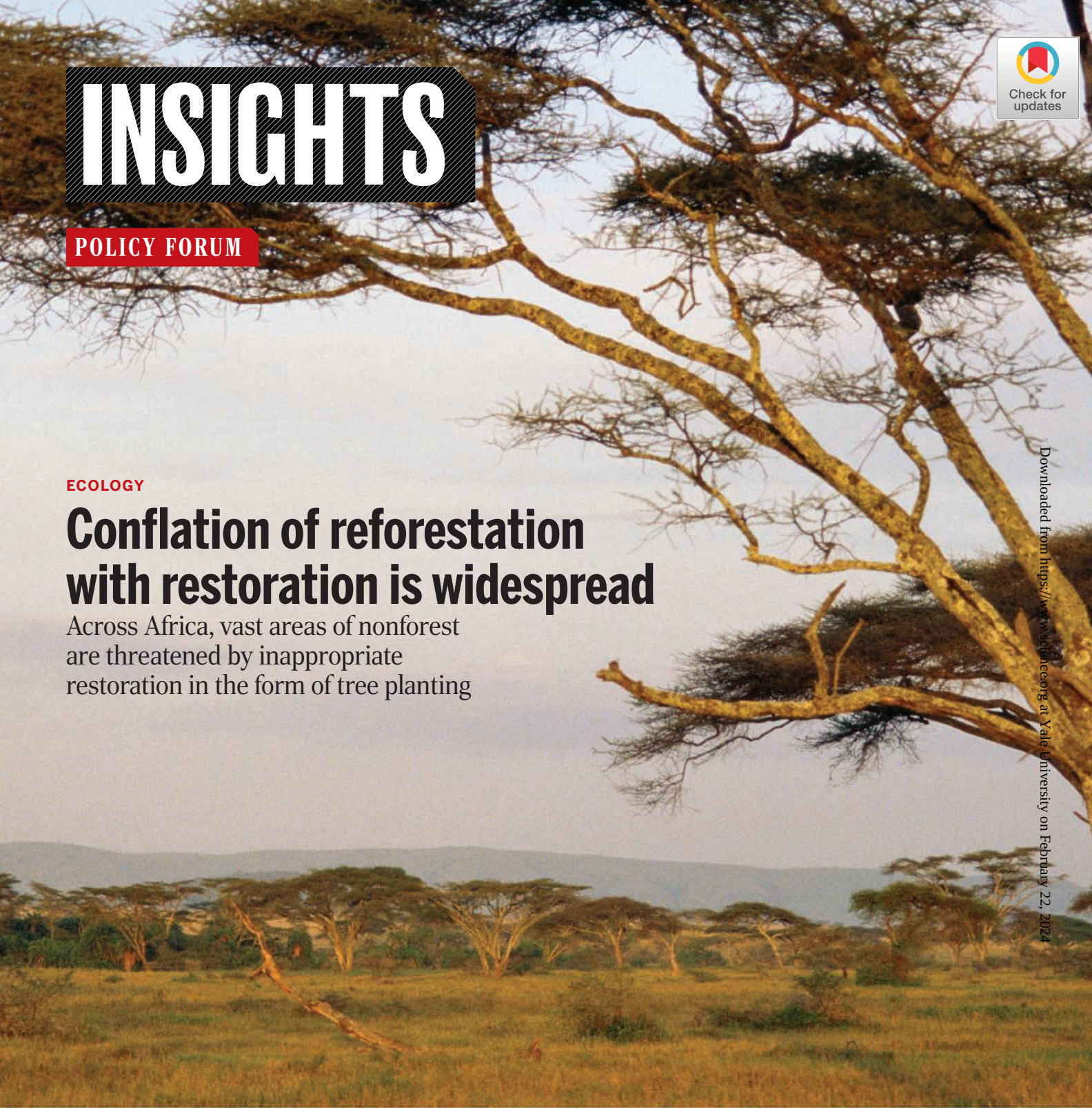
INSIGHTS

POLICY FORUM



ECOLOGY

Conflation of reforestation with restoration is widespread

Across Africa, vast areas of nonforest are threatened by inappropriate restoration in the form of tree planting

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The Bonn Challenge was launched by the German government and the International Union for Conservation of Nature (IUCN) in 2011 with the goal of restoring 350 million ha of degraded and deforested landscapes by 2030. Although there is acknowledgment that forest landscape restoration (FLR) promoting tree planting should not cause the loss or conversion of open, nonforested ecosystems (i.e., they should not be afforested) (*1*), concerns have been raised that the focus on tree-based restoration combined with misclassification of grassy ecosystems could lead to misplaced restoration and destruction of intact, ancient ecosystems (*2*). Yet, the potential scale of the issue, or whether concerns are playing out in practice, are unknown. To understand the potential scale of tree planting in savannas and grasslands, we examined restoration pledges under the African Forest Restoration Initiative (AFR100) and on-the-ground projects,

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Trees dot the savannah in Tanzania's Serengeti National Park.

finding that tree planting is widespread across nonforest systems.

FLR, which aims to restore ecological functionality and enhance human well-being across deforested or degraded landscapes (*3*), underpins the Bonn Challenge goal. The FLR approach is applied widely, with locations for restoration guided by the Atlas for FLR Opportunities produced by the World Resources Institute (WRI). In practice, the principal restoration activities focus on increasing tree cover (*1*, *3*), whether by seedling planting, natural regeneration, agroforestry (incorporation of trees into agricultural systems), or management plantations, and therefore broadly assume that degradation can be remedied by increasing tree cover. Drawing on the definition used by the Food and Agriculture Organization (FAO) of the United Nations (UN), WRI and the IUCN (among others) define forests as areas that are covered in trees with canopy cover of at least 10% (*1*). But this definition has been criticized (*4*, *5*) because it can be used to erroneously classify open systems with trees, such as savanna, as forest.

There is, therefore, the potential for tree planting to occur in nonforested systems, such as tropical grasslands and savannas, because they are frequently misclassified as forest (*4*, *6*) or tree cover levels are deemed below potential given the climate and soils (*1*). FLR considers increases in woody cover as desirable with a focus on the regrowth of trees on the landscape (*1*), and seldom as something undesirable. Yet, restoration actions that increase tree cover in nonforested systems can be problematic because high tree cover can degrade them (*4*). Planting trees in grassy systems increases canopy cover and reduces light with consequent structural, compositional, and functional changes to the understory; in some grassy systems, this can result in wholesale biodiversity loss, notably of shade-intolerant species associated with open habitats (*7*), as well as changes in ecosystem functioning, declines in critical ecosystem services (e.g., reduced water availability, restricted access to food and medicinal resources), and even unintended climate warming due to reduced albedo (*4*, *6*). Degradation by tree planting results in the permanent transformation of grassy systems with low likelihood, and/or extremely slow rate, of recovery (*8*). In nonforest systems (e.g., savannas), degradation is often better characterized by the loss of ground cover (e.g., grass), soil erosion, loss of ecosystem processes (e.g., fire, herbivory), and conversely, an increase in tree cover (*9*).

As an example of a major restoration initiative, we focus on the AFR100, which aims to restore 100 million ha across Africa by 2030 through planting and natural regeneration of trees, and assess the extent to which nonforest systems may be targeted for tree-planting restoration initiatives. At a broad scale, the WRI Atlas of FLR Opportunities maps restoration opportunities. However, to calculate the area available for restoration in forest (broadleaved and dry forest) relative to commitments for each AFR100 country, we used the RESOLVE Ecoregions (*10*) [see supplementary materials (SM)]. Although RESOLVE underestimates the area of nonforest in some locations (e.g., Madagascar), it is a widely accepted global biome map. We examined the area pledged for forest restoration in each country in light of the total area of forest available for restoration to calculate the scope for restoration in forest versus nonforest habitats. We assumed, if there was no forest habitat or the forest was intact (i.e., not needing restoration), that the area for restoration would be displaced to nonforest habitat.

Then, using the Mongabay Reforestation database (https://reforestation.app), we examined restoration projects taking place in AFR100 countries to determine whether savannas and other nonforest ecosystems are the target of on-the-ground tree-planting restoration projects, and, if so, examine the characteristics of the restoration projects. Not all reforestation projects are included here, but this is one of the most comprehensive portals (see SM). Information was extracted from the database and project websites, and where a location was provided, we classified this according to biome.

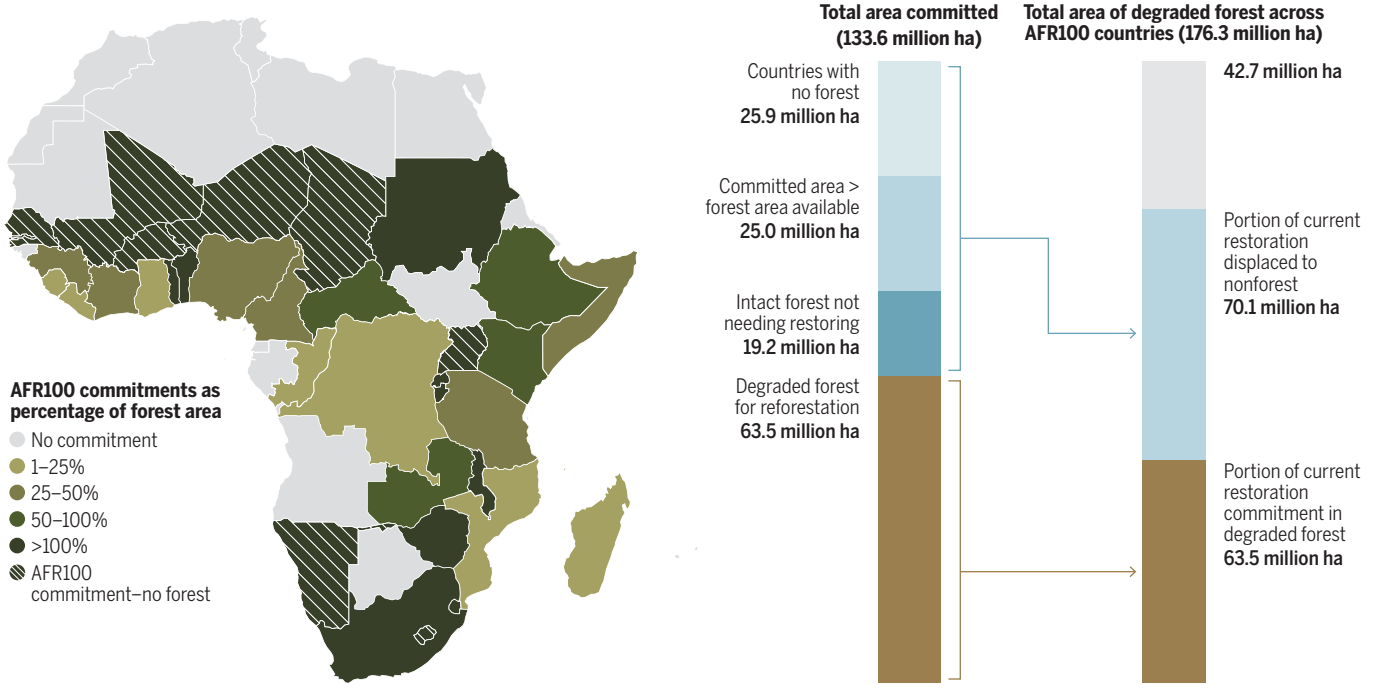
Across Africa, a total of 133.6 million ha has been pledged toward AFR100 in 35 countries, exceeding the original target of 100 million ha by a third. The median land area pledged per country is 8% (mean 14.6%), but this hides considerable variation. Some countries have a large proportion of their total area pledged for restoration, particularly Rwanda (85.6%), Burundi (76.2%), and Malawi (40.5%), whereas others, known to be undergoing considerable degradation of nonforest areas through woody encroachment (*6*), are also pledging to "restore" substantial areas by increasing tree cover (e.g., Eswatini, 27.6%).

Our analysis revealed that for 18 out of 35 countries, the pledged area exceeds that of forest area (see the figure). Indeed, nearly a fifth of the total area pledged for forest landscape restoration (25.9 million ha) covers eight countries with no forest cover (Burkino Faso, Chad, Lesotho, Mali, Namibia, Niger, Senegal, The Gambia) (see the figure). Many countries that have forest cover have pledged an area greater than forest area available, meaning that a further 25.0 million ha is earmarked for restoration in nonforest systems (e.g., Republic of Sudan, Malawi, Zimbabwe, Burundi) (see the figure).

Recognizing that not all forest is degraded and in need of restoration, we assessed to

Mismatched reforestation commitments

Countries' African Forest Landscape Restoration Initiative (ARF100) commitments to reforestation are shown as a percentage of their national forested area (including countries having committed despite having no forested area) (map). Area committed for AFR100 reforestation by vegetation type and degradation is shown (left bar graph). Bars show the portion of current AFR100 restoration commitment in degraded forest, and the maximum potential degraded forest restoration (i.e., if total committed area was focused solely in degraded forest in AFR100 countries), which would total 133.6 million ha of the total 176.3 million ha of degraded forest across Africa (right bar graph).



what extent the forest area available for restoration actually requires restoration: That is, for each country, how much forest is degraded versus intact (i.e., not in need of restoration)? We estimated this using the Forest Landscape Integrity Index (FLII) (*11*) assuming that forests of low and medium integrity, but not high integrity, need restoration. Taking into consideration the extent of forest requiring restoration (i.e., sum of area classified as low and medium forest integrity; see SM), an additional 19.2 million ha of forest has been pledged that exceeds the area of degraded forested habitat (e.g., Ethiopia, Kenya, Somalia) (see the figure). Overall, a total of 70.1 million ha, or 52.5% of the total area committed, is in nonforest ecosystems, principally savannas and grasslands (see the figure); this is greater than the area of France, indicating that tree-based restoration in Africa could cover vast areas of nonforest habitat. Conversely, the area for true forest restoration in AFR100 countries covers less than half of the area pledged (47.5%).

Across the 35 countries signed up to AFR100, our analysis based on FLII indicates that total degraded forest habitat covers 176.3 million ha (see the figure). In countries with degraded forest, once the area of degraded forest restoration is accounted for from their total commitment, 112.8 million ha of degraded forest across Africa still requires restoration; this means that a third of low- and medium-integrity forest (63.5 million ha) is earmarked for restoration currently under AFR100. Furthermore, if the total committed area for restoration were focused on truly degraded forest, instead of nonforest systems, three-quarters (75.8%) of degraded forests in AFR100 countries could be restored (see the figure) and extensive afforestation avoided.

Examining on-the-ground restoration projects across AFR100 countries in the reforestation.app database (n = 99) with known locations (n = 67), 52% are in savanna or grasslands [with most variously inaccurately classified in the database as Tropical dry forest, Tropical rainforests, or Tropical moist forest; see (*10*)]. Despite the AFR100 initiative purporting to support restoration of grasslands and savannas with native grasses (not tree planting), we could only find evidence of one project actively restoring the grass layer (Moilo Grass Seedbank and Maasai Wilderness Conservation Trust, Kenya); all other projects are focused on increasing the number of trees. These data from on-the-ground restoration projects illustrate that the large areas committed to restoration in nonforest systems are the principal target of restoration by tree-planting programs involving seedling planting (76% of projects) or agroforestry (49% of projects). Furthermore, almost 60% of agroforestry projects use non-native species; introduced species can be particularly problematic when they are invasive (e.g., *Grevillea robusta*). Of the UN Restoration Principles (*12*), it is questionable whether two are being met in nonforest ecosystems ("Benefits to Nature and People" and "Addresses Causes of Degradation") as biodiversity outcomes can be poor, and increasing woody cover in open ecosystems is itself a cause of degradation (*4–7*).

Most projects have as their aim improving livelihoods and restoring degraded

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and/or deforested areas, but critical information on what aspects of degradation are being restored (*9*), as well as monitoring and performance indicators, are seldom openly available, and finding information on these aspects of projects is challenging. Given that these projects received considerable funding (>$1 billion in development finance and $148 million from private sector commitments) from Global North governments (e.g., German Federal Ministry for the Environment), IUCN, UN, the FAO, Global Environmental Facility, and local and international nongovernmental organizations (e.g., Nature Conservancy), it is essential that the projects are transparent and accountable, or they will be at risk of greenwashing. There are likely a combination of drivers underlying our findings, including lack of ecological awareness among the public and policy-makers (*13*), large financial incentives, forest definitions, and poor program management.

We argue that although FLR allows for multiple benefits of tree-based restoration, the widespread use of agroforestry for restoration should receive greater scrutiny, especially in nonforested ecosystems. Although agroforestry can enhance biodiversity (particularly when starting from a low baseline) and increase ecosystem health (e.g., increasing soil fertility, reducing soil erosion), and therefore assist with recovery of degraded land, this is not always the same as restoration because agroforests support fewer species than forests (*14*). Agroforestry, particularly with non-native species, in grassy systems is problematic because ecosystem processes such as fire and grazing, which are critical to the functioning of tropical grassy systems, often conflict with agroforestry. Therefore, although agroforestry can offer considerable benefit to human well-being, ecological integrity and functionality are not automatically enhanced. Instead, in grassy systems, other land uses may be more appropriate and compatible with restoration across large areas—these include, for example, sustainable livestock and wildlife farming.

Of course, nonforested systems also require restoration when degraded (through soil erosion, loss of herbaceous layer from over-grazing and woody plant encroachment, suppression of fire, and overharvesting of trees) (*6*, *9*). However, it is essential to identify nonforest ecosystems correctly so that they receive appropriate restoration interventions (e.g., resting land from grazing, seeding with grasses, clearance of woody encroachment). The dominant focus on trees to "regain ecological functionality" (*1*) rather than restoration of the ground layer is not helpful for most of these degradation examples. Although here we demonstrate the scale of inappropriate restoration across Africa, nonforest systems are threatened globally (e.g., the rich grasslands of Chapada dos Veadeiros National Park, Brazil, with up to 400 species of plants/ha, are being planted with trees).

Our analyses indicate that tree planting is widespread across nonforest systems, and highlight the hegemony of trees and forests (*13*) within global restoration efforts. At the root of the problem is that the grassy biomes remain fundamentally misunderstood and consequently are misclassified as forest (*4*, *6*). Guidelines for FLR based on the FAO definition of forest consider any area with a minimum of >0.1 ha in size, a minimum of 10% tree cover, and a minimum tree height of 2 m as forest. The definition has been criticized (*4*, *5*, *15*) because it may not adequately differentiate natural and plantation forest (which differ in carbon and biodiversity values) and is based solely on vegetation structure, meaning that open systems with trees, such as savanna, can be misclassified. Yet the definition persists, in part because the focus is on trees and canopy cover is easily measured with remote sensing. FLR targets areas with low tree cover in climates that can support forest, often erroneously assuming that these areas are deforested and degraded and therefore represent opportunities for restoration (*1*, *2*).

"...vegetation definitions that only consider tree cover are problematic for tropical grassy biomes..."

But vegetation definitions that only consider tree cover are problematic for tropical grassy biomes because they fail to recognize the grassy layer under the canopy that is a defining feature of these systems and means they are structurally, functionally, and compositionally distinct from forests (*4*). Although FLR states that tree cover should not exceed that considered "ecologically appropriate for a particular location" (*1*), it is unclear who decides what is appropriate. Grassy systems vary hugely in woody cover in space and time [e.g., 5 to 80% cover (*4*)], and such a vague approach with no consideration of the inherent ecological differences between forest and open ecosystems is fraught with problems.

Increasing tree cover in open ecosystems globally represents a major threat, not only for the ecosystems themselves but ultimately for society as a whole (*4*, *6*), and tree-planting actions will exacerbate already problematic woody encroachment. We urge a paradigm shift away from the structural focus on trees to include the distinctive and important characteristics and ecology of grassy, nonforest systems. Although not perfect, an improvement would be the use of biome maps, such as RESOLVE ecoregions, which would enable large areas of nonforest to be masked and true forests to be identified more accurately (*5*).

It is essential that the differing characteristics of forest and nonforest degradation are recognized because this will determine restoration actions and enable genuinely degraded systems to be restored with greater sensitivity. Ultimately, the right trees and the right number need to be planted in the right place. But, until the definition of forest is revised, there will always be the double jeopardy of afforestation of ancient grasslands and deforestation of virgin forest. We must act to avoid a situation where we cannot see the savanna for the trees, and these precious grassy systems are lost irrevocably. ■

REFERENCES AND NOTES

1. C. Hanson, K. Buckingham, S. DeWitt, L. Laestadius, *The Restoration Diagnostic* (World Resources Institute, 2015).
2. W. J. Bond, N. Stevens, G. F. Midgley, C. E. R. Lehmann, *Trends Ecol. Evol.* **34**, 963 (2019).
3. S. Maginnis, J. Rietbergen-McCracken, W. Jackson, "Restoring forest landscapes: An introduction to the art and science of forest landscape restoration," ITTO Technical Series no. 23 (2005); http://www.itto.int/direct/topics/topics_pdf_download/topics_id=10640000&no=1&file_ext=.pdf.
4. C. L. Parr, C. E. R. Lehmann, W. J. Bond, W. A. Hoffmann, A. N. Andersen, *Trends Ecol. Evol.* **29**, 205 (2014).
5. P. F. Scogings, *For. Ecol. Manage.* **546**, 121381 (2023).
6. N. Stevens, W. J. Bond, A. Feurdean, C. E. R. Lehmann, *Annu. Rev. Environ. Resour.* **47**, 261 (2022).
7. J. D. Wieczorkowski, C. E. R. Lehmann, *Glob. Change Biol.* **28**, 5532 (2022).
8. E. Buisson, S. Archibald, A. Fidelis, K. N. Suding, *Science* **377**, 594 (2022).
9. E. Buisson *et al.*, *Biol. Rev. Camb. Philos. Soc.* **94**, 590 (2019).
10. E. Dinerstein *et al.*, *Bioscience* **67**, 534 (2017).
11. H. S. Grantham *et al.*, *Nat. Commun.* **11**, 5978 (2020).
12. FAO, IUCN CEM and SER, "Principles for ecosystem restoration to guide the United Nations Decade 2021-2030" (2021); https://www.fao.org/documents/card/en/c/CB6591EN.
13. F. A. O. Silveira *et al.*, *J. Appl. Ecol.* **59**, 1967 (2022).
14. A. Wurz *et al.*, *Nat. Commun.* **13**, 4127 (2022).
15. N. Sasaki, F. E. Putz, *Conserv. Lett.* **2**, 226 (2009).

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SUPPLEMENTARY MATERIALS

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