

## Science & Society

### Grassy trees: the neglected hybrids for sustainability

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**Grassy trees – large forest-adapted monocots such as bamboo, palm, and bananas – combine grass-like rapid growth with tree-like canopy dominance. Their ambiguous status between woody and herbaceous plants has led to research neglect. Recognizing them as a distinct growth form is key to harnessing their potential as nature-based solutions for sustainability.**

#### Grassy trees: the unique hybrids of grasses and trees

A hybrid growth form between grasses and trees

'Grassy trees' are defined here as a growth form of large forest-adapted monocots (bamboos, palms, and bananas) that reach tree-like stature and canopy dominance despite lacking secondary growth and true wood. Functionally, they combine monocot constraints with tree-like ecological roles in competition, disturbance response, and succession.

This unique position becomes clearer in contrast to the two dominant plant strategies:

trees invest in long-lived woody structures via secondary growth to compete for light in stable forests, whereas grasses, lacking secondary growth, forgo wood and instead prioritize belowground storage and clonal spread in frequently disturbed, open habitats. Between these strategies lies a less-explored growth form: grassy trees. Grassy trees thus occupy an

intermediate position, defying a simple woody–herbaceous dichotomy and warranting recognition as a distinct growth form that integrates strategies from both ends of the spectrum.

#### Their hybrid power: fast growth and abundance under human impact

Grassy trees overcome monocot constraints by producing dense, rapidly formed tissues for structural stability and, in many species, resprouting clonally via rhizomes to resprout quickly into canopy gaps after disturbance. These hybrid traits – combining the structural presence of trees with the regenerative flexibility of grasses – give grassy trees a competitive edge in high-disturbance or transitional environments, where short-term productivity is favored over long-term persistence (Figure 1A). For instance, bamboo can maintain canopy dominance across extensive forest areas (e.g., >20% of southwestern Amazonian forests) [1]. In the Americas, palms constitute up to 60% of all large tree stems (>10 cm diameter) in some forests [2]. Wild banana species (*Musa* spp.) frequently dominate canopy gaps for years as pioneer species, especially in northern India and Southeast Asia [3]. These examples together suggest that high-disturbance regimes combined with grassy tree traits can create a self-reinforcing feedback that favors the persistence of grassy trees.

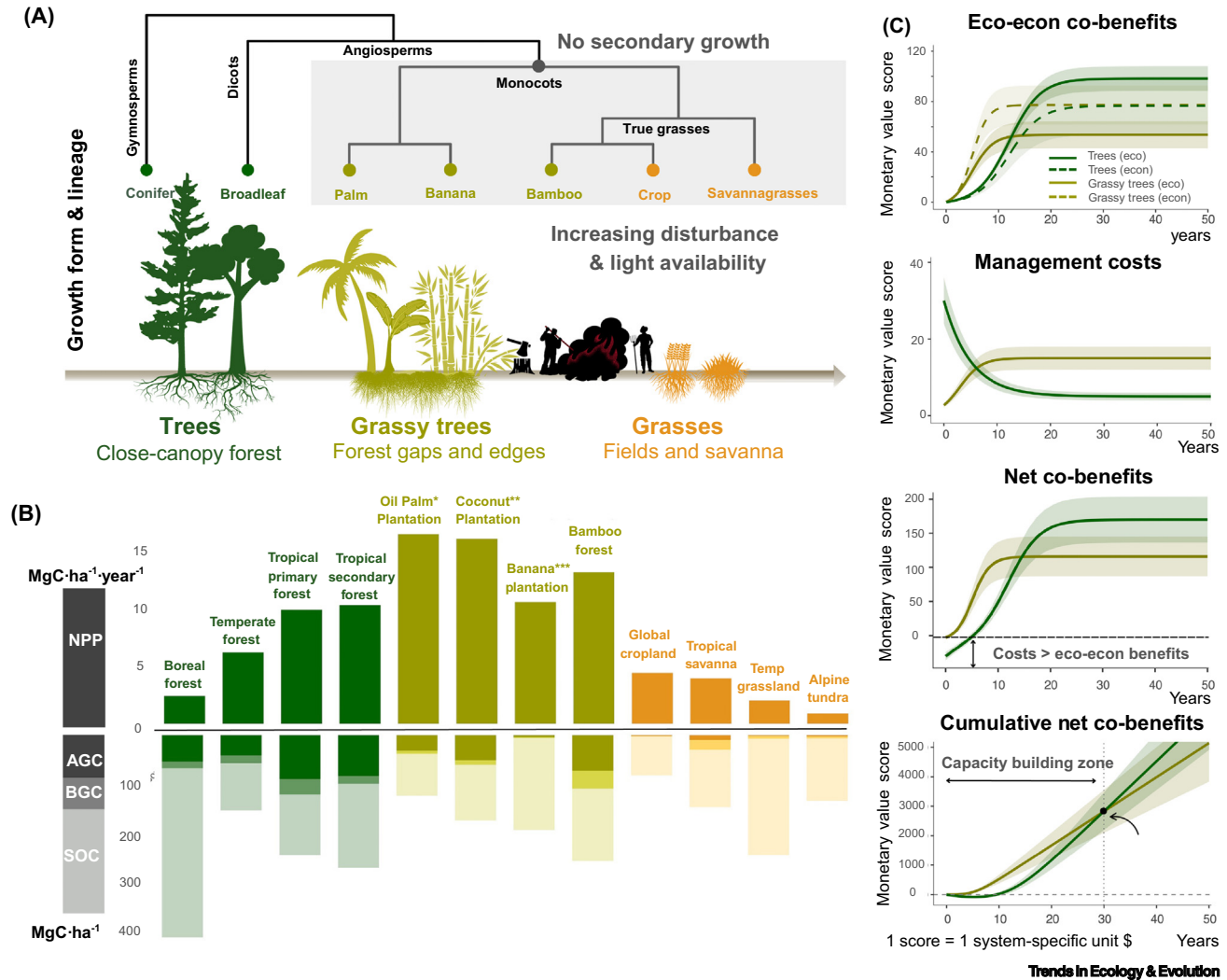
Humans both create the disturbances that favor grassy trees and have long cultivated them for their hybrid traits. Their herbaceous yet lignified tissues are easier and cheaper to process than wood, and clonal growth yields dependable shoots and fruits. Crucially, grassy trees grow far faster than typical trees, supplying timber, fruit, fiber, and fuel within years rather than decades – yet they offer more structure, shade, wind shelter, and permanence than grasses [4]. This utility has driven their widespread cultivation and reinforced their dominance in disturbed

landscapes, where human actions serve as both a disturbance and a selective force.

As a result, grassy trees exhibit hybrid vigor in exceptionally high net primary productivity (NPP) – surpassing both trees and grasses – despite having intermediate biomass and carbon storage (Figure 1B). They can be more productive than tropical secondary forests, which drive today's persistent forest carbon sink [5]. For example, bamboo can sequester carbon at rates up to four times higher than typical tropical regrowth forests [6]. While comprehensive carbon sequestration data for grassy trees remain limited – often biased toward fast-growing plantations and lacking consistent methodology or long-term monitoring – available estimates still indicate significantly higher sequestration rates compared to typical tropical regrowth forests (see Table S3 in the supplemental information online). The fast productivity of grassy trees positions them as valuable agents in climate mitigation and restoration, offering quick carbon returns and the capacity to stabilize disturbed and degraded landscapes, laying a foundation for the recovery of slower-growing trees serving as longer-term carbon storage.

#### Research neglect rooted in ambiguous hybridity

The hybrid nature that makes grassy trees ecologically competitive – combining adaptive traits from both grasses and trees – has also contributed to their neglect in ecological research. They are long excluded from forest inventories due to inconsistent protocols [7], or misclassified either as weeds or indistinct canopy trees. Such exclusion and misclassification introduce significant biases: ground-based surveys that overlook grassy trees underestimate their ecological contributions, while remote sensing methods that conflate them with dicot trees in heterogeneous canopies overestimate forest biomass and carbon storage, since grassy trees often have



**Figure 1. The hybrid nature and power of grassy trees to accelerate sustainable development.** (A) Grassy trees have a hybrid nature derived from their unique evolutionary lineage and adaptations to human-impacted forest environments. As large forest-adapted monocots with tree-like structures and canopy-forming capabilities lacking secondary growth, they exhibit distinct ecological functions that set them apart from conventional growth forms of trees and grasses. Visual elements were created in Canva Pro (<https://www.canva.com>). (B) Ecosystem-level carbon stocks of grassy trees fall between those of systems dominated by trees and grasses. However, their hybrid vigor drives productivity that surpasses both, enabling rapid carbon stock accumulation and making them ideal for carbon sequestration. Data used to produce panel B and their references are summarized in Table S1 in the supplemental information online. Abbreviations: AGC, aboveground carbon; BGC, belowground carbon; NPP, net primary production; SOC, soil organic carbon 0–30 cm. \*Oil palm (*Elaeis* spp.), \*\*Coconut (*Cocos nucifera*), \*\*\*Banana (*Musa* spp.). (C) A generalized cost–benefit analysis framework for planting and using grassy trees versus trees in sustainable development initiatives. The monetary value score is an idealized, arbitrary scale for easier comparisons on costs and benefits at a particular time since project initiation. Grassy trees will offer immediate ecological and economical net benefits in the first decade due to the long history of their subsistence use and management in their habitats, while trees require higher start-up costs. However, grassy trees – such as bamboo, fruit palms, and bananas – require intensive and consistent management. The uncertainty of their carbon dynamics and their impact on ecosystem service in the long term also draws down their net benefits over time compared to tree plantations or tree-dominated natural forests. In general, we expect a shift in service for sustainability to be led by grassy trees to trees after a few decades, largely dependent on management and conservation policies (such uncertainty is represented by the shades in the diagrams).

hollow stems [4]. Moreover, grassy trees also differ in their belowground carbon allocation and soil organic carbon from forest trees (Figure 1B).

This carbon discrepancy underscores the need for accurate assessments of grassy trees' global abundance and ecological impact, yet the continued absence of

standardized survey data hampers carbon modeling and monitoring efforts. This data scarcity exacerbates their exclusion from research and reporting frameworks,

reinforcing a vicious cycle of scientific neglect of grassy trees.

Breaking this cycle requires recognizing grassy trees as a distinct growth form – separate from both trees and grasses – with unique physiology, evolutionary origins, ecological functions, and interactions with human socioeconomic systems. Promoting research on these 'hybrids' not only improves carbon assessments by incorporating disturbances and shifting species composition, it also highlights how plant communities and human societies have coevolved – offering nature-based solutions that are grounded in community knowledge and practice to support both climate action and human resilience.

### Accessible nature-based solutions go beyond carbon

While tree-based restoration can deliver enduring ecosystem services and carbon-finance benefits, many large-scale afforestation efforts falter when top-down governmental or market-driven programs overlook local ecology, land-use history, stakeholder inequities, and ongoing maintenance needs [8]. Such initiatives often require complex management systems and substantial initial investments, frequently exceeding community capacity (Figure 1C). Natural regeneration, a lower-cost alternative, typically requires decades to restore forest resilience – during which income loss and limited resource access may drive further deforestation.

Grassy-tree interventions, in contrast, rapidly deliver ecological and socioeconomic benefits during the slower recovery of tree-dominated forests (Figure 1C). Grassy tree species with known resilience to drought and cyclones can be particularly useful for short-term biomass recovery [9]. Grassy trees also provide essential resources (fiber, fuel, food, and construction materials), generating stable income streams and low-impact alternatives to plastics and fossil fuels.

Although grassy-tree systems ultimately store less carbon and offer fewer ecosystem services than mature forests (Figure 1B) – while requiring consistent, intensive management to sustain their carbon benefits [10] – their strong initial 'kick-off' (~10 years in Figure 1C) supports community adaptation without compromising ecological integrity or human wellbeing. Importantly, grassy trees complement rather than exclude tree-based restoration, as natural regeneration or afforestation can simultaneously occur or strategically follow grassy-tree interventions after reaching peak community capacity (~30 years, Figure 1C).

### Harnessing the hybrid power of grassy trees for sustainability

Across the pantropical world, particularly in developing regions of South and Southeast Asia, Africa, and South America facing urgent climate challenges, underrecognized grassy trees present a powerful opportunity to accelerate progress toward the sustainable development goals (SDGs) [11] (Figure 2A). We highlight three cases of utilizing grassy trees as accessible nature-based solutions to prioritize different SDGs and the ecological, socioeconomic, and cultural dimensions of co-benefits (Figure 2B).

#### Palm (*Mauritia flexuosa*)

This is a keystone palm species thriving in the peatlands of tropical South America where it forms extensive swampy ecosystems [12]. Ecologically, these palm stands play a vital role in carbon sequestration by storing carbon within waterlogged soils while providing essential habitats for wildlife to conserve biodiversity. Wild and cultivated *M. flexuosa* supports the livelihoods of local communities through the harvest and sale of its vitamin-rich fruits and oil, contributing to poverty reduction and economic growth while enhancing food security and wellbeing [12].

#### Bamboo

African Lowland Bamboo, *Oxytenanthera abyssinica*, is native to the dry woodlands

of East Africa. This drought-resistant bamboo offers significant ecological benefits by providing vegetation cover in drylands, aiding in land restoration efforts, and improving soil health [13]. This bamboo species holds substantial cultural and economic importance in East Africa, especially as a green business opportunity in bamboo-rich Ethiopia [14]. Its stems are utilized for construction, furniture making, and crafting, providing income opportunities and subsistence as a fuel and food source.

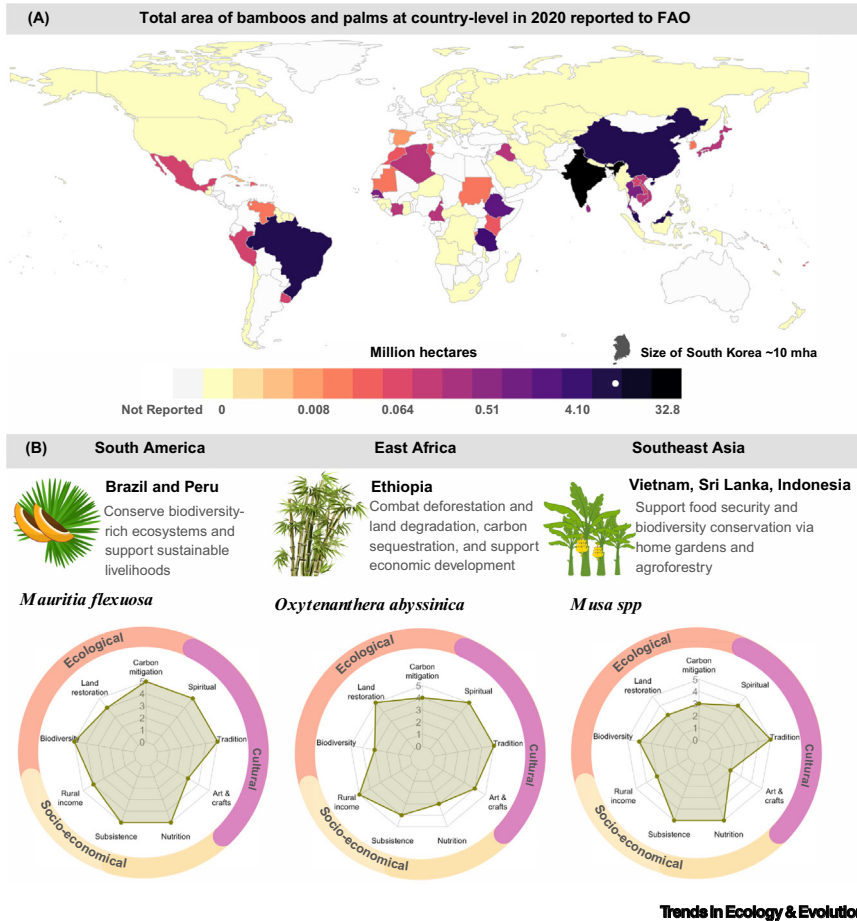
#### Banana

In Southeast Asia, various species of banana and plantains (*Musa* spp.) are widely cultivated in home gardens. These plants contribute to species and structural biodiversity within the home garden systems while preventing soil erosion [15]. As the cornerstone of food security in Southeast Asia, bananas provide essential nutrients and calories and a vital source of income for families, supporting poverty reduction and economic activity.

All three of these grassy tree species have deep cultural significance in rituals, arts, and spiritual life beyond monetization. By rapidly delivering co-benefits across ecological, socioeconomic, and cultural dimensions, grassy trees can accelerate the adoption of nature-based solutions and strengthen capacity for long-term sustainable development.

### Caveats and future directions for grassy trees as nature-based solutions

Despite their promise, comparing grassy trees to conventional tree-based approaches in delivering ecological and economic benefits requires more systematic investigation. Large-scale monocultures of species like oil palm and bamboo have demonstrably contributed to deforestation and biodiversity loss. Furthermore, the carbon sequestration potential of grassy trees needs long-term monitoring and



**Figure 2.** Grassy trees are truly accessible nature-based solutions for sustainable development with diverse co-benefits. (A) The global distribution of grassy trees (bamboos and palms), highlighting their abundance in developing nations in South and Southeast Asia, South America, and Africa. Country- or region-level areas are based on the Food and Agricultural Organization’s (FAO’s) Forest Resource Assessment (<https://fra-data.fao.org/assessments/fra/2020/>) [13] and are detailed in Table S3 in the supplemental information online. South Korea (~10 million hectares) serves as a reference point on the logarithmic scale. (B) **Three examples of grassy trees as nature-based solutions with their unique benefit profile in ecological, socioeconomic, and cultural dimensions.** The use and management of the moriche palm (*Mauritia flexuosa*) – common in swamps and wet areas of tropical South America – highlights how an ecological keystone species can sustain local livelihoods while contributing to biodiversity conservation and carbon mitigation [12]. The adoption and promotion of local lowland bamboo (*Oxytenanthera abyssinica*) in Ethiopia shows how bamboo’s rapid growth and propagation contributes rapidly to soil and water restoration in arid conditions with carbon benefits [13], while delivering developmental benefits to local economies as bamboo-product industry expands in the country [14]. The widespread cultivation of bananas and plantains (*Musa spp.*) forming canopy structure for cultivating diverse understory species in home gardens of Southeast Asia demonstrates the potential of tackling food security, rural income, and empowering small holders to build capacity towards environmental-friendly agroforestry practices [15]. Figure 2B was created with Canva Pro (<http://www.canva.com/>). Open research statement. The code used to generate the figures in this publication is available on Figshare at <https://doi.org/10.6084/m9.figshare.28905758>. This private reviewer link will be made public upon publication.

careful evaluation across product life cycles, as their biomass is often rapidly converted into short-lived items. These impacts necessitate a nuanced perspective

urging us not to dismiss grassy trees outright but to acknowledge their ecological uniqueness. Future research should quantify their relative benefits and management

costs (generalized in Figure 1C) in place-specific strategies for sustainable development, while also addressing the considerable uncertainties arising from varied management practices and land-use histories across tropical regions.

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**Declaration of interests**

The authors declare no competing interests.

**Declaration of generative AI and AI-assisted technologies in the writing process**

During the preparation of this work the authors used ChatGPT4-o to identify grammar errors. After using this service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

**Supplemental information**

Supplemental information associated with this article can be found online at <https://doi.org/10.1016/j.tree.2025.10.002>.

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