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OPINION ARTICLE

Urgent need for updating the slogan of global climate actions from "tree planting" to "restore native vegetation"

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The prevailing nature-based solution to tackle climate change is tree planting. However, there is growing evidence that it has serious contraindications in many regions. The main shortcoming of global tree planting is its awareness disparity to alternative ecosystem types, mainly grasslands. Grasslands, where they constitute the natural vegetation, may support higher biodiversity and a safer, soil-locked carbon stock than plantations and other forests. We suggest replacing "tree planting" by "restore native vegetation." This improved action terminology reduces the risks of inappropriate afforestation and, by diversifying target ecosystem types, does not reduce but increases potential land area for nature-based climate mitigation.

Key words: afforestation, biodiversity loss, Bonn Challenge, climate mitigation, EU Biodiversity Strategy, forest restoration, grassland restoration, tree planting, Trillion Trees

Implications for Practice

- Reforestation and afforestation are heavily supported by most climate strategies and are often limited to planting monocultures of exotic tree species.
- There is growing concern that afforestation targets open habitats, mostly grasslands and savannas, despite strong evidence that these biodiverse habitats can store large quantities of carbon belowground, are less exposed to devastating fires, and absorb less solar radiation than closed-canopy forests due to their higher albedo.
- "Tree planting" as a general slogan of climate strategies should thus be replaced with "restore native vegetation," which can be forest, grassland, or combinations thereof, depending on the habitat conditions of an area.

Introduction

Nature-based climate strategies, such as the Bonn Challenge or the Trillion Tree Campaign, have become exceedingly popular to counteract anthropogenic carbon emissions. The first and foremost method of these strategies is planting trees worldwide (Bastin et al. 2019; Cook-Patton et al. 2020; Fleischman et al. 2020; Holl & Brancalion 2020), which is often limited to planting monocultures of exotic tree species (Lewis et al. 2019; Heilmayr et al. 2020). However, there is growing concern that global afforestation, that is, the establishment of woody vegetation in historically or naturally non-forested areas, may have critical side effects in many regions. Such inappropriately chosen target areas include temperate and tropical grasslands and savannas, despite strong evidence that these habitats can store large quantities of carbon belowground, are less exposed to devastating fires, and absorb less solar radiation than closed-canopy forests (Carvalhais et al. 2014; Dass et al. 2018; Temperton et al. 2019). Many of these ecosystems are also very biodiverse (Murphy et al. 2016; Zhao et al. 2020), and their afforestation is not only a missed opportunity to truly mitigate climate change but also increases biodiversity loss (Veldman et al. 2019).

Global afforestation programs may thus generate conflict with local to regional restoration, conservation, and climate targets (see also Suding et al. 2015). They might have limited effect not only on climate mitigation but also on livelihood goals (Coleman et al. 2021). There seems little progress toward a prompt solution for this issue as even its recognition is largely lacking among pro-afforestation groups. As a reinforcement of this global deficiency of climate strategies, the recently declared EU Biodiversity Strategy for 2030 also ignores the climate benefit of grasslands by setting the plantation of 3 billion trees as a major action, which is not counterbalanced by any other

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proposed form of major habitat restoration (Gómez-González et al. 2020; Selva et al. 2020). Why is this?

Grassland Awareness Disparity

We believe that the mismatch between the ultimate goal of global climate strategies and their tree planting action is mainly due to grassland awareness disparity, that is, a general undervaluation of the diverse flora, fauna, and ecosystem services of grasslands (and other non-forested vegetation types) compared to those of forests, leading to an ignorance of grasslands as possible alternatives for forest-based solutions. For centuries, the western world has considered forests the climax of ecological organization; hence, nature tends to equal forests for many people (Pausas & Bond 2019). In colonial times, this notion was spread all across developing countries, where it continues to persist until the present (Davis & Robbins 2018). Tropical grasslands and savannas have traditionally been mistaken for degraded forests with little biodiversity conservation value (Veldman 2016); therefore, it is no surprise that climate actions have not embraced them yet. In contrast, the biodiversity of temperate grasslands in the northern hemisphere has long been acknowledged but, to date, no global climate strategy considers them as targets. Grasslands lack large and obvious above-ground carbon stores such as massive tree trunks and their microclimate is generally more hostile (i.e. warmer and drier) compared to that of forests (Tölgyesi et al. 2020), hindering their appreciation as efficient climate solutions by the general public and policy makers. However, grasslands may sometimes represent larger and more stable carbon sinks belowground than forests below- and aboveground combined (Dass et al. 2018). The attention of the scientific community is also biased for forests, as a recent synthesis highlighted that nearly three times more papers are available in the Web of Science portal on the restoration of forests than grasslands (Török et al. 2021). This bias is particularly expressed in the Global South, where grassland restoration is still in its infancy (Buisson et al. 2021). Nevertheless, the number of studies emphasizing the importance of grassland restoration (e.g. Török et al. 2011; Buisson et al. 2019) and the inclusion of this action in large-scale biodiversity conservation programs, such as the UN Decade on Ecosystem Restoration (Dudley et al. 2020), is increasing, especially in the Global North. As long as climate actions do not embrace grasslands and handle them equally to forests, though, the conflict between afforestation and the conservation or restoration of non-forested ecosystems will persist and hinder activities on both sides (see also Silveira et al. 2021).

Where to Plant What?

Ecological theory predicting whether forest or grassland (or other non-forested vegetation types) should occur under natural conditions in a specific location is well-founded. Where climate, soil, and/or topography are restrictive for closed-canopy natural forests, the restoration of alternative ecosystems, such as grasslands and other open habitats, should be encouraged. The success rate of afforestation in areas that are too arid for trees would be low and hence the carbon targets are unlikely to be met. Intensive forestry techniques may decrease the mortality of trees but entail heavy soil disturbance (Yildiz et al. 2018), compromising soil carbon stocks and questioning the net effect on carbon storage. Moreover, afforestation in arid areas can have detrimental regional side effects, including soil salinization and negative water balance (Jackson et al. 2005; Wang et al. 2020; Li et al. 2021).

Afforested arid lands are also more prone to fire, and when burnt, exhibit a heavier overall land degradation, including soil erosion, than non-forested sites (Nunes et al. 2018). In contrast, grasslands in arid areas preserve native biodiversity and safely store carbon in the soil, even when fires sweep through (Dass et al. 2018). The amount of carbon potentially stored in the soil of arid grasslands, such as the prairie and steppe grasslands, is well indicated by their typical, black chernozemic soil, which is among the most carbon-rich soils on the Earth (Mikhailova & Post 2006). Similarly, open habitats with water-logged conditions, such as peatlands, are also advised against for afforestation, as it changes their carbon-rich soil from sink to source, preventing a net gain in ecosystem carbon stocks (Friggens et al. 2020).

On the other hand, historically forested regions, located mostly in humid but not water-logged tropical, temperate, or boreal areas, should be reforested if currently cleared. However, monocultures should be avoided and the natural diversity of the forests should be restored, since plantations harbor little biodiversity and store little more carbon, on average, than the land cleared to plant them (Lewis et al. 2019; Martin et al. 2021). Furthermore, care should be taken in that indiscriminate reforestation of agriculturally utilized land may lead to deforestation or the destruction of grasslands elsewhere to meet the demand for food and feed products (Fleischman et al. 2020; Holl & Brancalion 2020).

In a broad zone between these two extremes, that is, historically treeless grasslands or closed-canopy forests, savannas and forest-steppes can be found, featured by a mosaic of woody vegetation and grassland (Staver et al. 2011). Here, environmental conditions are within the tolerance limit of closed-canopy forests; therefore, these ecosystems are among the major targets of afforestation plans (e.g. Bastin et al. 2019). Historically, wildfires, wild herbivores, and/or millennia-long traditional land use have partially or temporarily suppressed woody species in this zone, thereby making room for grassy vegetation (Sankaran et al. 2008; Erdős et al. 2018). The mosaic structure of these ecosystems allows for exceptionally high species diversity and large capacity for ecosystem service provisioning (Archer et al. 2017). Grasslands within these regions are among the globally most threatened habitats due to conversion to cropland or land abandonment and subsequent woody species encroachment, and will be further decimated if they fall victim to a tree planting frenzy (Bond 2019). A key concern about the afforestation of savannas and forest-steppes lies in the fact that ongoing climate change has already shown an increase in the frequency of droughts and other extreme weather conditions,

compromising the sustainability of forests (Mátyás & Sun 2014; Anderegg et al. 2020) and their capacity to efficiently capture atmospheric carbon dioxide (Anderegg et al. 2015). Another important aspect to consider is that increasing atmospheric carbon dioxide tends to increase soil organic carbon in grasslands but not in forests (Terrer et al. 2021). Restoration in these transitional areas, whether for carbon storage or biodiversity conservation, should thus focus on the reestablishment of both woody and grassy vegetation in appropriate proportions and spatial configuration. Implementation of new concepts such as rewilding and creation of multifunctional landscapes could be promising ways forward (Manning et al. 2018; Svenning 2020).

Conclusions

Considering the high number of situations where tree planting is disadvantageous, its use as an action or a general slogan to address policy makers and the general public is highly problematic. As catchy as it may sound, the fact that well-established science does not back it up in many cases may confuse target groups (i.e. benevolent policy makers, non-governmental organizations [NGOs], and the general public), thus, threatening the credibility of climate mitigation strategies and generating conflicts between climate mitigation and biodiversity conservation. We recommend that global climate strategies should include grasslands and replace the slogan "tree planting" by "restoring native vegetation" as a nature-based solution, which can be forest, grassland, or combinations thereof, depending on present or projected future conditions of an area. This general approach fully includes reforestation if the trees are planted in the right places, but also grants equal consideration to alternative vegetation types, mostly grasslands or grassy ecosystems. Thus, the first step in all localities would be, using comprehensive ecological knowledge, to assess what the target ecosystems should be. This approach is more advanced than a simple call to plant trees and requires the involvement of more expert knowledge to aid policy makers and NGOs, but would

(1) remove the current dangerous mismatch between actions and goals imposed by the risks of inappropriate afforestation (Anderegg et al. 2020) and the loss of benefits from non-forested vegetation types,
(2) provide reconciliation between actions of climate mitigation and biodiversity conservation, and, most importantly,
(3) expand the potential land area that can be considered for nature-based climate solutions.

"Restoring native vegetation" in climate strategies would be an action with a self-sustaining outcome that has no critical adverse effects, so the reliability of promoting organizations will not be undermined. The use of "restoring native vegetation" applied at whole landscape and watershed scales would pave the way for a more efficient global consensus on the activities to mitigate climate change and the biodiversity crisis.

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