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► To cite this version:

Csaba Tölgyesi, Elise Buisson, Aveliina Helm, Vicky Temperton, Péter Török. Urgent need for updating the slogan of global climate actions from “tree planting” to “restore native vegetation”. *Restoration Ecology*, 2022, 30 (3), pp.e13594. 10.1111/rec.13594 . hal-03454170

HAL Id: hal-03454170

<https://hal.science/hal-03454170v1>

Submitted on 26 Jan 2022

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1 Urgent need for updating the slogan of global
2 climate actions from “tree planting” to “restore
3 native vegetation”

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16

17 **Running head:** Restore self-sustaining native vegetation

18

19

20 **Abstract**

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

30
31 **Keywords:** afforestation, biodiversity loss, Bonn Challenge, climate mitigation, EU
32 Biodiversity Strategy, forest restoration, grassland restoration, tree planting, Trillion Trees
33

34 **Author contributions:** CT and PT developed the idea, and all authors contributed to the
35 writing and revision of the text.

36

37 **Implications for practice**

- 38
- 39 • Reforestation and afforestation are heavily supported by most climate strategies and
40 are often limited to planting monocultures of exotic tree species.
 - 41 • There is growing concern that afforestation targets open habitats, mostly grasslands
42 and savannas, despite strong evidence that these biodiverse habitats can store large
43 quantities of carbon belowground, are less exposed to devastating fires, and absorb
44 less solar radiation than closed-canopy forests due to their higher albedo.
 - 45 • “Tree planting” as a general slogan of climate strategies should thus be replaced with
46 “restore native vegetation,” which can be forest, grassland, or combinations thereof,
47 depending on the habitat conditions of an area.

48

49 **Introduction**

50 Nature-based climate strategies, such as the Bonn Challenge or the Trillion Tree Campaign,
51 have become exceedingly popular to counteract anthropogenic carbon emissions. The first and
52 foremost method of these strategies is planting trees worldwide (Bastin et al. 2019; Cook-
53 Patton et al. 2020; Fleischman et al. 2020; Holl & Brancalion 2020), which is often limited to
54 planting monocultures of exotic tree species (Lewis et al. 2019; Heilmayr et al. 2020).
55 However, there is growing concern that global afforestation, that is, the establishment of
56 woody vegetation in historically or naturally non-forested areas, may have critical side effects
57 in many regions. Such inappropriately chosen target areas include temperate and tropical
58 grasslands and savannas, despite strong evidence that these habitats can store large quantities
59 of carbon belowground, are less exposed to devastating fires, and absorb less solar radiation
60 than closed-canopy forests (Carvalho et al. 2014; Dass et al. 2018; Temperton et al. 2019).
61 Many of these ecosystems are also very biodiverse (Murphy et al. 2016; Zhao et al. 2020),
62 and their afforestation is not only a missed opportunity to truly mitigate climate change but
63 also increases biodiversity loss (Veldman et al. 2019).
64 Global afforestation programs may thus generate conflict with local to regional restoration,
65 conservation, and climate targets (see also Suding et al. 2015). They might have limited effect
66 not only on climate mitigation but also on livelihood goals (Coleman et al. 2021). There
67 seems little progress toward a prompt solution for this issue as even its recognition is largely
68 lacking among pro-afforestation groups. As a reinforcement of this global deficiency of
69 climate strategies, the recently declared EU Biodiversity Strategy for 2030 also ignores the
70 climate benefit of grasslands by setting the plantation of 3 billion trees as a major action,
71 which is not counterbalanced by any other proposed form of major habitat restoration
72 (Gomez-Gonzalez et al. 2020; Selva et al. 2020). Why is this?
73

74 **Grassland awareness disparity**

75 We believe that the mismatch between the ultimate goal of global climate strategies and their
76 tree planting action is mainly due to grassland awareness disparity, i.e. a general
77 undervaluation of the diverse flora, fauna and ecosystem services of grasslands (and other
78 non-forested vegetation types) compared to those of forests, leading to an ignorance of
79 grasslands as possible alternatives for forest-based solutions. For centuries, the western world
80 has considered forests the climax of ecological organization; hence, nature tends to equal
81 forests for many people (Pausas and Bond 2019). In colonial times, this notion was spread all
82 across developing countries, where it continues to persist until present days (Davies and
83 Robbins 2018). Tropical grasslands and savannas have traditionally been mistaken for
84 degraded forests with little biodiversity conservation value (Veldman 2016); therefore, it is no
85 surprise that climate actions have not embraced them yet. In contrast, the biodiversity of
86 temperate grasslands in the northern hemisphere has long been acknowledged but, to date, no
87 global climate strategy considers them as targets. Grasslands lack large and obvious above-
88 ground carbon stores such as massive tree trunks and their microclimate is generally more
89 hostile (i.e., warmer and drier) compared to that of forests (Tölgyesi et al. 2020), hindering
90 their appreciation as efficient climate solutions by the general public and policy makers.
91 However, grasslands may sometimes represent larger and more stable carbon sinks
92 belowground than forests below- and aboveground combined (Dass et al. 2018). The attention
93 of the scientific community is also biased for forests, as a recent synthesis highlighted that
94 nearly three times more papers are available in the Web of Science portal on the restoration of
95 forests than grasslands (Török et al. 2021). This bias is particularly expressed in the Global
96 South, where grassland restoration is still in its infancy (Buisson et al. 2021). Nevertheless,
97 the number of studies emphasizing the importance of grassland restoration (e.g. Török et al.
98 2011; Buisson et al. 2019) and the inclusion of this action in large-scale biodiversity

99 conservation programs, such as the UN Decade on Ecosystem Restoration (Dudley et al.
100 2020) is increasing, especially in the Global North. As long as climate actions do not embrace
101 grasslands and handle them equally to forests, though, the conflict between afforestation and
102 the conservation or restoration of non-forested ecosystems will persist and hinder activities on
103 both sides (see also Silveira et al. 2021).

104

105 **Where to plant what?**

106

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

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

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

134

135 In a broad zone between these two extremes, i.e. historically treeless grasslands or
136 closed canopy forests, savannas and forest-steppes can be found, featured by a mosaic of
137 woody vegetation and grassland (Staver et al. 2011). Here, environmental conditions are
138 within the tolerance limit of closed-canopy forests; therefore these ecosystems are among the
139 major targets of afforestation plans (e.g. Bastin et al. 2019). Historically, wildfires, herbivores
140 and/or millennia-long traditional land-use have partially or temporarily suppressed woody
141 species in this zone, thereby making room for grassy vegetation (Sankaran et al. 2008; Erdős
142 et al. 2018). The mosaic structure of these ecosystems allows for exceptionally high species
143 diversity and large capacity for ecosystem service provisioning (Archer et al. 2017).

144 Grasslands within these regions are among the globally most threatened habitats due to
145 conversion to cropland or land abandonment and subsequent woody species encroachment,
146 and will be further decimated if they fall victim to a tree planting frenzy (Bond 2019). A key
147 concern about the afforestation of savannas and forest-steppes lies in the fact that ongoing
148 climate change has already shown an increase in the frequency of droughts and other extreme

149 weather conditions, compromising the sustainability of forests (Mátyás & Sun 2014;
150 Anderegg et al. 2020) and their capacity to efficiently capture atmospheric carbon dioxide
151 (Anderegg et al. 2015). Another important aspect to consider is that increasing atmospheric
152 carbon dioxide tends to increase soil organic carbon in grasslands but not in forests (Terrer et
153 al. 2021). Restoration in these transitional areas, whether for carbon storage or biodiversity
154 conservation, should thus focus on the re-establishment of both woody and grassy vegetation
155 in appropriate proportions and spatial configuration. Implementation of new concepts for
156 multifunctional landscapes could be a promising way forward (Manning et al. 2018; Svenning
157 2020).

158

159 **Conclusions**

160

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

176

177 (1) remove the current dangerous mismatch between actions and goals imposed by the risks of
178 inappropriate afforestation (Anderegg et al. 2020) and the loss of benefits from non-forested
179 vegetation types,

180 (2) provide reconciliation between actions of climate mitigation and biodiversity
181 conservation, and, most importantly,

182 (3) expand the potential land area that can be considered for nature-based climate solutions.
183 ‘Restoring native vegetation’ in climate strategies would be an action with a self-sustaining
184 outcome that has no critical adverse effects, so the reliability of promoting organizations will
185 not be undermined. The use of ‘restoring native vegetation’ applied at whole landscape and
186 watershed scales would pave the way for a more efficient global consensus on the activities to
187 mitigate climate change and the biodiversity crisis.

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191 watershed scales would pave the way for a more efficient global consensus on the activities to
192 mitigate climate change and the biodiversity crisis.

193

194 **Acknowledgements**

195 The authors were supported by the National Research, Development and Innovation Office of
196 Hungary (PD132131 – CT, K119225 – PT) and the Hungarian Academy of Sciences
197 (Momentum Program) during manuscript writing. CT was also supported by the Bolyai János
198 Research Scholarship of the Hungarian Academy of Sciences. The help of Gerhardt

199 Overbeck, Fernando A. O. Silveira and four anonymous reviewers improving the former
200 manuscript drafts are greatly acknowledged.

201

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