1 **It's Time to Assign Non-forested, Non-agricultural Lands a Global Designation**

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3 David D. Briske[1*], Lynn Huntsinger[2], Nathan F. Sayre[3], Peter F. Scogings[4], Mark Stafford-

4 Smith[5], Tungalag Ulambayar[6]

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6 [1] Ecology & Conservation Biology, Texas A&M University, College Station, Texas USA

7 [2] Rangeland & Wildlife Management, University of California-Berkeley, USA

8 [3] Geography Department, University of California-Berkeley, USA

9 [4] Centre for Functional Biodiversity, School of Life Sciences, University of KwaZulu-Natal,

10 Scottsville, South Africa

11 [5] CSIRO, Land & Water, Canberra, Australia

12 [6] Zoological Society Luujin, Ulaanbaatar, Mongolia

13 * Corresponding author: dbriske@tamu.edu

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15 **Abstract**

16 Earth's land cover consists of forests, agricultural land, urban settlements, and a large,

17 heterogeneous category that includes deserts, grasslands, savannas, shrublands and tundra.

18 This heterogeneous category has eluded a collective designation comparable to that of forests,

19 which has contributed to its omission from multilateral programs and critical global initiatives.

20 Potential designations for this land category—drylands, grasslands, grassy biomes, open

21 ecosystems and rangelands—were evaluated for their relative advantages and disadvantages.

22 Grassy biome is recommended as the most appropriate designation because it conveys a meaning

23 that is distinct from forests, emphasizes that grasses often coexist with other plant growth forms,

24 and has great utility for use by multilateral organizations. However, the criteria of tree canopy

25 cover $\geq 10\%$ used by the Food and Agriculture Organization (FAO) to define forests represents a

26 major obstacle to implementation of the grassy biome designation. This minimal canopy cover

27 infringes on global savannas that occupy 20-25% of global land area. An assessment of the

28 functional plant traits determining the shade and fire tolerance of savanna and forest trees

29 indicate that a minimal tree canopy cover of 45% represents an ecologically appropriate

30 demarcation between savannas and forests.

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Impact Statement

Declaration of 2026 as the International Year of Rangelands and Pastoralists by the United
Nations General Assembly provides an opportune occasion to promote a global designation for
the non-forested, non-agricultural land category. We respectfully urge multilateral organizations
and partner nations to adopt 'grassy biomes' as a formal designation for this heterogeneous land
category. The defining feature of this designation is a consistent cover of annual or perennial
grasses throughout much of the year, including coexistence of other plant growth forms e.g.,
forbs, shrubs, succulents and scattered trees. The grassy biome designation would provide a more
ecologically accurate distinction from forests than the one which is currently utilized. This would
establish the foundation for development and implementation of a grassy biome resource
assessment comparable to that of forest resource assessments that have been conducted by FAO
for the past 70 years. Collectively, these resource assessments would provide valuable inventory
data for approximately 75% of the Earth's land surface and effectively support the aspirations
and futures of its many peoples. Continued prioritization of forest assessments over those of the
grassy biome can no longer be justified given the pressing challenges confronting Earth
stewardship.

Introduction

Earth's land cover broadly consists of forests, agricultural land, urban settlements, and a large,
heterogeneous category that includes deserts, grasslands, savannas, shrublands and tundra. This
land category represents approximately 50% of the Earth's land surface, which is 1.5 and 2.8
times greater than that of forests and agricultural land, respectively (Reid et al. 2008; UNCCD
2024). Various terms are used to describe these lands, including drylands, grasslands, grassy
biomes, open ecosystems, grazing lands and rangelands. These are overlapping but non-identical
terms, and each has multiple definitions that vary by author and application, specifically with
reference to land use and land type. For example, a recent report by the UN Convention to
Combat Desertification (UNCCD) used three terms—drylands, grasslands and rangelands—to
describe this heterogeneous land category, with rangelands defined as a land use, rather than a
land cover type (UNCCD 2024). Moreover, these lands occur on all continents except

61 Antarctica, spanning numerous cultures and languages which further contributes to this varied

62 nomenclature (Fig. 1).

63

64 The absence of a single, globally recognized designation for these lands creates a major obstacle

65 to their recognition, perceived value, and stewardship (Johnsen et al. 2019; Parr et al. 2024). For

66 example, numerous multilateral organizations specifically attend to forests and agricultural land,

67 and the Food and Agriculture Organization (FAO) has conducted regular global forest resource

68 assessments for 70 years (Garzuglia 2018). In contrast, comparable assessments have not been

69 conducted for the heterogenous land category, and a substantial fraction is routinely

70 misclassified as forest or degraded forest (Parr et al. 2024; Scogings 2023). In addition, this land

71 category is not explicitly referenced in the U.N. Sustainable Development Goals, whereas two

72 targets specifically invoke forests in Goal 15 – Life on Land. The limited recognition and value

73 assigned to these lands has been described as a 'case of benign neglect' in a U.N. report (Johnsen

74 et al. 2019). Insufficient emphasis on these lands by multilateral organizations and member states

75 obscures the value of 50% of the Earth's land area to society and Earth stewardship (Stafford-

76 Smith and Metternicht 2021; Zhang et al. 2023).

77

78 Declaration of 2026 as the International Year of Rangelands and Pastoralists by the United

79 Nations General Assembly provides an opportune occasion to promote a global designation for

80 this land category (IYRP). Adoption of a common designation by multilateral organizations and

81 member states would promote recognition and stewardship at a level comparable to that of

82 forests. Such a designation is not intended to replace the established names of ecological

83 biomes—large geographical regions characterized by a distinct climate and biota that possess

84 similar adaptations to that environment e.g., desert, grassland or forest—or regional

85 nomenclature for specific vegetation types within this land category.

86

87 **Potential Land Category Designations**

88 The heterogeneous land category, excluding agricultural lands and human settlements, represents

89 the conceptual reciprocal of forests. Forests comprise diverse tree growth forms, including

90 evergreen and deciduous species of varying stature, density and proportion, but they share a

91 common appearance because the tree growth form remains dominant. In contrast, the

3

92 heterogeneous land category is comprised of multiple plant growth forms, including grasses,

93 forbs, shrubs, succulents and trees, in various combinations and proportions, but are not forests.

94 The heterogeneous composition of vegetation in this land category has eluded a collective

95 designation, so that specific vegetation types—grasslands, savannas, shrublands, deserts and

96 tundra—are individually referenced.

97

98 We have chosen to use land cover, rather than land use, to assess land category designations

99 because it implicitly acknowledges the diverse ecosystem services supplied and is most easily

100 evaluated by multiple assessment procedures. However, functional plant traits are referenced to

101 identify critical distinctions between land cover categories when information is available.

102

103 The definitions and relative advantages and disadvantages of dryland, grassland, grassy biome,

104 open ecosystem and rangeland as appropriate designations for this land category are presented in

105 Table 1. Grassland is the only designation that represents an ecological biome. Each of the

106 designations has numerous and varied definitions so those that identify the most common

107 descriptors and are referenced most frequently have been selected. Although some commonality

108 exists among the five broad designations associated with this land category, they do not express

109 synonymous meanings, and they all possess various advantages and disadvantages. Drylands,

110 grasslands and rangelands received careful consideration given their extensive prior usage and

111 recognition, but they were all determined to have major limitations as an effective designation.

112

113 **Drylands** are exclusively based on climatic criteria— an aridity index (annual

114 precipitation/evapotranspiration) less than 0.65—without specific reference to land cover. This

115 designation is ecologically appropriate insofar as the representative biomes occur in drier

116 climates than do forests, but the wettest portions of grassland, savanna, and shrubland biomes

117 exceed this aridity index with a mean annual precipitation of 1,000 mm (Whittaker 1975) (Fig.

118 2). Moreover, drylands represent the domain of the UNCCD, which includes arable lands.

119

120 **Grasslands** are widely envisioned as expansive treeless plains, which are most prominent in

121 Asia, North America and South America. However, globally, grasses often coexist with shrubs,

122 trees, and succulent plants in various combinations and proportions. These heterogeneous

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123   vegetation types— shrub-steppe, shrublands, and savannas—are not effectively represented by

124   the grassland designation and grasslands are frequently misinterpreted as degraded forests, rather

125   than having evolved with unique climates and natural disturbance regimes (Bond et al. 2005;

126   Davis 2016).

127

128   The term *rangelands* have been extensively used in western range science for over a century,

129   primarily in Australia, South Africa and the U.S., but global usage has been limited. Two notable

130   exceptions are the use of rangelands by the International Year of Rangelands and Pastoralists

131   (IYRP), which adopted terminology developed by the International Rangeland Congress (IRC).

132   Adoption of the term rangelands was strongly influenced by members of the U.S. rangeland

133   community, which convened the inaugural rangeland congress in Denver, Colorado in 1978.

134

135   Broad international usage of rangelands has been limited by several major challenges. First, it

136   has a negative connotation relative to forests, which dates to the mid-19th century when western

137   European scholarship erroneously interpreted rangelands as degraded forests (Davis 2016;

138   Kumar et al. 2020). In this context, rangeland is a social classification that emphasizes marginal

139   land, rather than an ecological classification based on land cover (Sayre 2017). Second,

140   rangeland is often understood as a land use, emphasizing forage and livestock production, rather

141   than a land cover type (UNCCD 2024). Range livestock production is vital to pastoral

142   livelihoods, but rangelands also hold great value to Earth stewardship for climate regulation,

143   biodiversity conservation, and numerous cultural values (Briske and Coppock 2023; Zhang et al.

144   2023). Third, the rangelands designation carries colonial implications derived from its European

145   origins and imposition on indigenous lands (Davis 2016). Finally, a comparable term for

146   rangelands does not exist in most languages, so translation presents a major challenge.

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148   *Open ecosystems* were also considered inappropriate because they were introduced to identify a

149   specific portion of this land category—grasslands, and savannas that occur in climates warm and

150   wet enough to support closed forests but are not forests or anthropogenically degraded forests

151   (Bond 2019). In these cases, the natural disturbance regimes of fire and grazing prevent the

152   climatic potential from being expressed as forest (Fig. 2). The term "open" may further

153   marginalize this land category by suggesting that it has minimal value and that it is well suited

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154   for alternative land uses, e.g., afforestation, agriculture and renewable energy (Briske and

155   Coppock 2023). Open ecosystems have several alternative meanings in ecology and information

156   networking.

157

158   A multi-term designation was also considered—grassland-rangeland-savanna—but its value for

159   further promoting global recognition of this land category is questionable. The composite term

160   "grasslands and rangelands" has several supporting arguments: (a) "grasslands" is

161   familiar/recognizable across places and languages, and many people value them; (b) and

162   "rangelands" encompass the various land cover types that aren't grasslands; (c) the two together

163   allow for the presence or the absence of livestock grazing; (d) they both have recognized bodies

164   of scholarship (grassland ecology, rangeland ecology). However, the existing ambiguity and

165   inconsistency of each term is potentially compounded by their combined use (Table 1).

166

167   **Selected Land Category Designation**

168   ***Grassy biome*** was selected as the most appropriate designation for this land cover category. It is

169   characterized by a grass cover that varies from open grasslands to savannas with up to 60% tree

170   cover that is maintained by natural disturbance regimes of grazing, drought and fire (Bond 2005;

171   Parr et al. 2014). Original usage of the term was similar to that of open ecosystems in that it was

172   intended to establish tropical grasslands and savannas as being distinct from forests (Bond 2019)

173   (Fig. 2). However, recent usage of grassy biome indicates that it is more comprehensive than

174   those of the topical systems originally identified.

175

176   We recommend that grassy biome be used to broaden the scope of the grassland biome, both

177   tropical and temperate, by recognizing that grasses frequently coexist with other plant growth

178   forms e.g., forbs, shrubs, succulents and scattered trees. The defining feature of this designation

179   is a consistent cover of annual or perennial grasses throughout much of the year. In this context,

180   grassy biomes also include tundra because grasses and grass-like sedges are an important land

181   cover. The functional plant traits supporting high tolerance to drought, grazing and fire and low

182   tolerance to prolonged shade make deserts, grasslands, savannas, and shrublands more similar to

183   each other than to forests (Bond 2005; Parr et al. 2014).

184

185 The evolutionary history of the grassy biome has been well established in the palaeoecological

186 record (Jacobs et al. 1999). They initially became widespread in the early to mid-Tertiary Period

187 30 to 60 MYA. Savannas and grasslands further expanded in the late Miocene Epoch 15 MYA as

188 forests began to open in response to a drier and more seasonal climate. Herbivores coevolved

189 with expanding grass-dominated biomes by adapting functional traits that facilitated grazing

190 rather browsing strategies.

191

192 A proposed definition for the grassy biome designation follows along with the **current** FAO

193 definition for forests.

194 *Grassy biome* – Land spanning more than 0.5 ha with a minimum of 10% cover of annual or

195 perennial grass for at least 2 months of the year (Lund 2007) and a canopy cover of trees greater

196 than 5 m that does not exceed 45%. This land category includes grasslands, savannas,

197 shrublands, deserts, and tundra while cultivated, irrigated and agroforestry lands are excluded.

198 *Forest* – Land spanning more than 0.5 ha with trees higher than 5 m and canopy cover more than

199 10%, or trees able to reach these thresholds *in situ*. It includes young natural stands and forest

200 nurseries, but not forests on agricultural or urban lands (FAO 2020).

201

202 We acknowledge that entirely unique designations may exist for this heterogeneous land

203 category. A novel term that emerged from our deliberations was 'terravista'. It is derived from

204 the Latin word's *terra* ("land") and *vista* ("view"). 'Terravista' expresses a feature common to

205 all the biomes in this land category: namely, open visibility over long distances for a human on

206 the ground. This effectively captures the reciprocal relation of 'terravista' to forests because even

207 though savannas have trees, the sparse densities permit ready visibility. While this may suggest a

208 purely structural definition, we intend 'terravista' to encompass the functional attributes

209 associated with the grassy biome.

210

211 **Forest-Grassy Biome Demarcation**

212 The recommended grassy biome category exhibits vast overlap with forest land based on FAO's

213 criterion of tree canopy cover $\geq$ 10% (Garzuglia 2018; Scogings 2023). This criterion was

214 originally derived from the UNESCO report 'International Classification and Mapping of

215 Vegetation' (UNESCO 1973), which defined 'closed' forest as having interlocking canopies and

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216 'woodlands' as having a canopy cover >40%. The 1980 FAO forest resources assessment also

217 referenced 'open' and 'closed' forests as having canopy covers of 10-40% and >40%,

218 respectively (Garzuglia 2018). However, the 2000 forest resources assessment eliminated the

219 open and closed forest classifications and applied the minimum 10% canopy cover criterion to all

220 forests. Modification of this important criterion appears to have been arbitrarily made without

221 clear ecological or socioeconomic justification and it has received substantial criticism (Scogings

222 2023; Veldman et al. 2015).

223

224 This canopy cover criterion greatly infringes on savannas, which occupy 20-25% of global land

225 area (Scogings 2023). Savannas are characterized by a continuous cover of C4 grasses that are

226 interspersed with trees of varying density and canopy cover. Savannas typically occur in tropical

227 and subtropical regions characterized by mean annual temperature >10° C and mean annual

228 precipitation of 200-2700 mm, which is distributed in distinct wet-dry seasons (Stevens et al.

229 2022). However, most savannas occur in a narrower range of mean annual precipitation of 400-

230 1600 mm (Scogings 2023). Savannas are of ancient origin and are maintained by interactions

231 among climate, fire and grazing (Bond et al. 2005). These disturbances enable grassy biomes to

232 extend into climatic zones capable of supporting forests and long-term variation among these

233 variables is known to have modified grassy biome-forest boundaries (Staver et al. 2011;

234 Whittaker 1975) (Fig. 2). However, this does not imply that forests can occupy major portions of

235 these grassy biomes when these disturbances are lessened.

236

237 The distinction between savannas and forests is dependent upon the functional plant traits that

238 determine shade and fire tolerance, in addition to structural criteria (Ratnam et al. 2011). The

239 amount of canopy shade at which sun tolerant savanna tree seedlings are replaced by shade

240 tolerant forest trees is considered a 'deep shade' threshold (Charles-Dominique et al. 2018; Pilon

241 et al. 2021). This threshold occurs at a leaf area ratio (LAR, leaf area/ground area) of 1.0 - 1.5,

242 which coincides with a tree canopy cover of approximately 40-45% (Duursma and Mäkelä 2007;

243 Martens et al. 2000). A second critical threshold, the 'fire suppression' threshold, occurs when

244 grass cover and production is insufficient to support frequent ground fires that are necessary to

245 minimize tree establishment and maintain grass dominance (Ratnam et al. 2011). This threshold

246 occurs at a LAR of 1.0 and C4 grasses that are characteristic of tropical savannas are greatly

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247   suppressed at a LAR > 1.5 (Charles-Dominique et al. 2018; Pilon et al. 2021). These critical

248   thresholds occur at a minimal tree canopy cover of approximately 40-45% which directly

249   challenges the validity of the 10% canopy cover criterion used by FAO to define forests.

250

251   The adverse consequences of the 10% tree canopy cover criterion are highlighted in the FAO

252   report entitled the 'first global assessment of trees and forests in drylands', which provides a

253   forest-centric representation of drylands (FAO 2019). The assessment indicates that 18% of

254   drylands are forested, with 50 and 66% having a canopy cover > 70% and 40%, respectively.

255   However, savannas, which were not acknowledged in the assessment, likely comprise much of

256   these dryland forests (Scogings 2023). The assessment further indicated that woodlands,

257   including shrublands, comprise 10% of drylands and that 'other lands', including barren lands

258   and grasslands represent 28% and 25%, respectively (FAO 2019). In contrast, the 'thematic

259   report on rangelands and pastoralists' conducted by the UNCCD describes rangelands as being

260   comprised of deserts (35%), tropical grasslands and savannas (26%) temperate grasslands and

261   savannas (13%), and three other minor vegetation types, in addition to tundra (15%) (UNCCD

262   2024). The recommended grassy biome designation is intended to minimize these inconsistencies

263   among multilateral organizations by collectively representing all major vegetation types with a

264   grass cover (Fig. 2).

265

266   We acknowledge that the grassy biome designation possesses limitations and ecological

267   exceptions, but it is intended to serve as a critical administrative instrument more than an

268   ecological concept. Consider that 'forest' serves as an effective land cover designation even

269   though forests differ greatly in structure, function, management and value. Therefore, we suggest

270   that the grassy biome designation be interpreted in a similar manner to preclude ecological

271   limitations and exceptions from obscuring the critical need for greater recognition and

272   assessment of this land category.

273

274   **Recommendations**

275   We respectfully urge multilateral organizations, specifically FAO and UNCCD, to adopt the

276   following two recommendations in support of IYRP. First, adopt 'grassy biomes' as a formal and

277   universal designation for heterogeneous lands not included in forests, agricultural land, and

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278   urban settlements to ensure that they receive comparable recognition and value to that of forests.

279   Second, revise the 10% tree cover criterion for the definition of forests to a minimal value of

280   45% so that global savannas and shrublands are appropriately assigned to the grassy biome

281   category. Establishment of an appropriate tree cover criterion will require careful evaluation of

282   ecological, socioeconomic, and land classification considerations.

283

284   Adoption of these recommendations would establish the foundation for development and

285   implementation of a grassy biome resource assessment that would be comparable to that of forest

286   assessments, which have been conducted for the past 70 years. These combined assessments

287   would encompass 75% of the Earth's land surface and provide valuable inventory data in support

288   of Earth stewardship. For example, a more comprehensive and quantitative inventory of grassy

289   biomes would directly support the recent initiative launched by UNCCD to address the complex

290   challenges confronting conservation, management, and restoration of this land category and to

291   better support the aspirations and futures of its many peoples (Herrera Calvo and Alexander

292   2024). Continued prioritization of forest assessments over those of grassy biomes can no longer

293   be justified given the pressing challenges confronting Earth stewardship and human well-being

294   (FAO 2019; Lewin et al. 2024).

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References

Bond WJ (2019) *Open Ecosystems: ecology and evolution beyond the forest edge*. Oxford U.K.: Oxford University Press

Bond WJ, Woodward FI and Midgley GF (2005) The global distribution of ecosystems in a world without fire. *New Phytologist* **165**(2)**,** 525-538. https://doi.org/https://doi.org/10.1111/j.1469-8137.2004.01252.x.

Briske DD and Coppock DL (2023) Rangeland stewardship envisioned through a planetary lens. *Trends in Ecology & Evolution* **38**(2)**,** 109-112. https://doi.org/10.1016/j.tree.2022.09.012.

Charles-Dominique T, Midgley GF, Tomlinson KW and Bond WJ (2018) Steal the light: shade vs fire adapted vegetation in forest-savanna mosaics. *New Phytologist* **218**(4)**,** 1419-1429. https://doi.org/10.1111/nph.15117.

Davis DK (2016) *The Arid Lands: History, Power and Knowledge.* Cambridge, Massachusetts, U.S.A: MIT Press.

Duursma RA and Mäkelä A (2007) Summary models for light interception and light-use efficiency of non-homogeneous canopies. *Tree Physiology* **27,** 859-870.

FAO (2019) Trees, forests and land use in drylands: the first global assessment. Available at https://openknowledge.fao.org/server/api/core/bitstreams/4db91cfa-6a0d-4e40-82ce-a7d2297c6a6c/content (accessed July 24).

FAO (2020) Global forest resources assessment 2020: terms and definitions. Available at https://openknowledge.fao.org/server/api/core/bitstreams/531a9e1b-596d-4b07-b9fd-3103fb4d0e72/content (accessed July 2024).

Garzuglia M (2018) Seventy years of FAO's forest resources assessment. Available at https://openknowledge.fao.org/server/api/core/bitstreams/52036a6c-3e50-43dc-84de-1efc94d9e89c/content (accessed August 2024).

Herrera Calvo PM and Alexander S (2024) A new perspective on rangelands and pastoralists to reverse their silent demise, which is impacting climate and food supply for billions. *Global Change Biology* **30**(6)**,** e17377. https://doi.org/10.1111/gcb.17377.

IRC International Rangeland Congress. Available at https://rangelandcongress.org/ (accessed July 2024).

IYRP International Year of Rangelands and Pastoralists. Available at https://iyrp.info/ (accessed July 2024).

Jacobs BF, Kingston JD and Jacobs LL. (1999) The origin of grass-dominated ecosystems. *Annals of the Missouri Botanical Garden* **86**, 590-643.

Johnsen KI, Niamir-Fuller M, Bensada A and A. W-B (2019) A case of benign neglect: knowledge gaps about sustainability in pastoralism and rangelands. Available at https://www.unep.org/resources/report/case-benign-neglect-knowledge-gaps-about-sustainability-pastoralism-and-rangelands. (accessed June 2024).

Kumar D, Pfeiffer M, Gaillard C, Langan L, Martens C and Scheiter S (2020) Misinterpretation of Asian savannas as degraded forest can mislead management and conservation policy under climate change. *Biological Conservation* **241,** 108293. https://doi.org/https://doi.org/10.1016/j.biocon.2019.108293.

Lewin A, Murali G, Rachmilevitch S and Roll U (2024) Global evaluation of current and future threats to drylands and their vertebrate biodiversity. *Nature Ecology & Evolution*. https://doi.org/10.1038/s41559-024-02450-4.

Lund GH (2007) Accounting for the World's Rangelands. *Rangelands* **29**(1)**,** 3-10.

11

Martens SN, Breshears DD and Meyer CW (2000) Spatial distribution of understory light along the grassland/forest continuum: effects of cover, height, and spatial pattern of tree canopies. *Ecological Modelling* **126,** 79-93.

Olson DM, Dinerstein E, Wikramanayake ED, Burgess ND, Powell GVN, Underwood EC, D'amico JA, Itoua I, Strand HE, Morrison JC, Loucks CJ, Allnutt TF, Ricketts TH, Kura Y, Lamoreux JF, Wettengel WW, Hedao P and Kassem KR (2001) Terrestrial Ecoregions of the World: A New Map of Life on Earth: A new global map of terrestrial ecoregions provides an innovative tool for conserving biodiversity. *BioScience* **51**(11)**,** 933-938. https://doi.org/10.1641/0006-3568(2001)051[0933:Teotwa]2.0.Co;2.

Parr CL, Lehmann CE, Bond WJ, Hoffmann WA and Andersen AN (2014) Tropical grassy biomes: misunderstood, neglected, and under threat. *Trends in Ecology & Evolution* **29**(4)**,** 205-213. https://doi.org/10.1016/j.tree.2014.02.004.

Parr CL, te Beest M and Stevens N (2024) Conflation of reforestation with restoration is widespread. *Science* **383**(6684)**,** 698-701. https://doi.org/doi:10.1126/science.adj0899.

Pilon NAL, Durigan G, Rickenback J, Pennington RT, Dexter KG, Hoffmann WA, Abreu RCR and Lehmann CER (2021) Shade alters savanna grass layer structure and function along a gradient of canopy cover. *Journal of Vegetation Science* **32**(1)**,** e12959. https://doi.org/https://doi.org/10.1111/jvs.12959.

Ratnam J, Bond WJ, Fensham RJ, Hoffmann WA, Archibald S, Lehmann CER, Anderson MT, Higgins SI and Sankaran M (2011) When is a 'forest' a savanna, and why does it matter? *Global Ecology and Biogeography* **20**(5)**,** 653-660. https://doi.org/10.1111/j.1466-8238.2010.00634.x.

Reid RS, Galvin KA and Kruska RS (2008) Global significance of extensive grazing lands and pastoral socities: An introduction. In Galvin KA, Reid RS, Behnke RH and Hobbs NT (eds), *Fragmentation in Semi-arid and Arid Landscapes: Consequences for Human and Natural Systems.* Dordrecht, Netherlands: Springer, 1-24.

Sayre NF (2017) *The Politics of Scale: A History of Rangeland Science*. Chicago, Illinois, USA. University of Chicago Press.

Scogings PF (2023) Perspective: Monitoring global forests using only structural metrics – problems and solutions from a savanna viewpoint. *Forest Ecology and Management* **546**, 121381. https://doi.org/10.1016/j.foreco.2023.121381.

Stafford-Smith M and Metternicht G (2021) Governing drylands as global environmental commons. *Current Opinion in Environmental Sustainability* **48,** 115-124. https://doi.org/10.1016/j.cosust.2020.12.006.

Staver AC, Archibald S and Levin SA (2011) The global extent and determinants of savanna and forest as alternative biome states. *Science* **334**(6053)**,** 230-232. https://doi.org/10.1126/science.1210465.

Stevens N, Bond W, Feurdean A and Lehmann CER (2022) Grassy Ecosystems in the Anthropocene. *Annual Review of Environment and Resources* **47**(1)**,** 261-289. https://doi.org/10.1146/annurev-environ-112420-015211.

UNCCD (2024) Global Land Outlook: Thematic Report on Rangelands and Pastoralists. Available at https://www.unccd.int/sites/default/files/2024-05/GLO%20rangelands%20full.pdf. (accessed August 2024).

UNESCO (1973) International classification and mapping of vegetation. Available at https://wiki.met.no/_media/polarprofile/products/metadatavocab/icmv.pdf. (accessed August 2024).

389 **Veldman JW, Overbeck GE, Negreiros D, Mahy G, Le Stradic S, Fernandes GW, Durigan**
390   **G, Buisson E, Putz FE and Bond WJ** (2015) Where Tree Planting and Forest
391   Expansion are Bad for Biodiversity and Ecosystem Services. *BioScience* **65**(10)**,** 1011-
392   1018. https://doi.org/10.1093/biosci/biv118.
393 **Whittaker RH** (1975) *Communities and Ecosystems*. London, UK: Collier MacMillan.
394 **Zhang Y, Tariq A, Hughes AC, Hong D, Wei F, Sun H, Sardans J, Penuelas J, Perry G,**
395   **Qiao J, Kurban A, Jia X, Raimondo D, Pan B, Yang W, Zhang D, Li W, Ahmed Z,**
396   **Beierkuhnlein C, Lazkov G, Toderich K, Karryeva S, Dehkonov D, Hisoriev H,**
397   **Dimeyeva L, Milko D, Soule A, Suska-Malawska M, Saparmuradov J, Bekzod A,**
398   **Allin P, Dieye S, Cissse B, Whibesilassie W and Ma K** (2023) Challenges and solutions
399   to biodiversity conservation in arid lands. *Science of the Total Environment* **857**(Pt 3)**,**
400   159695. https://doi.org/10.1016/j.scitotenv.2022.159695.
401

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413 **Figure Titles**
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415 **Figure 1**. Map illustrating spatial coverage of the proposed grassy biome category, including its
416 representative biomes, in comparison to forests. Inset illustrates the aggregate coverage of the
417 proposed grassy biome category (beige) relative to that of forest land category (green) (modified
418 from Olson et al. 2001).

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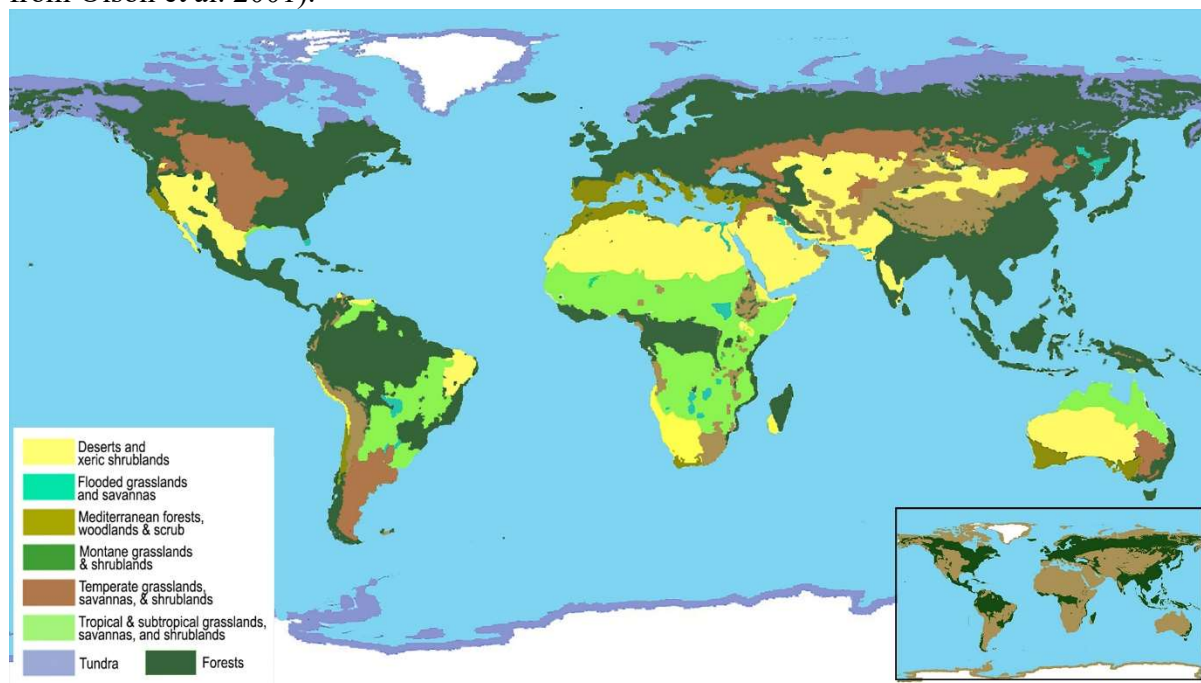
421   **Figure 2**. Correlation between biomes and mean annual temperature and precipitation across the
422   globe. Area within the dotted lines represents a zone of biome uncertainty in which natural
423   disturbance regimes may prevent the climatic potential from being realized (modified from
424   Whittaker 1975).
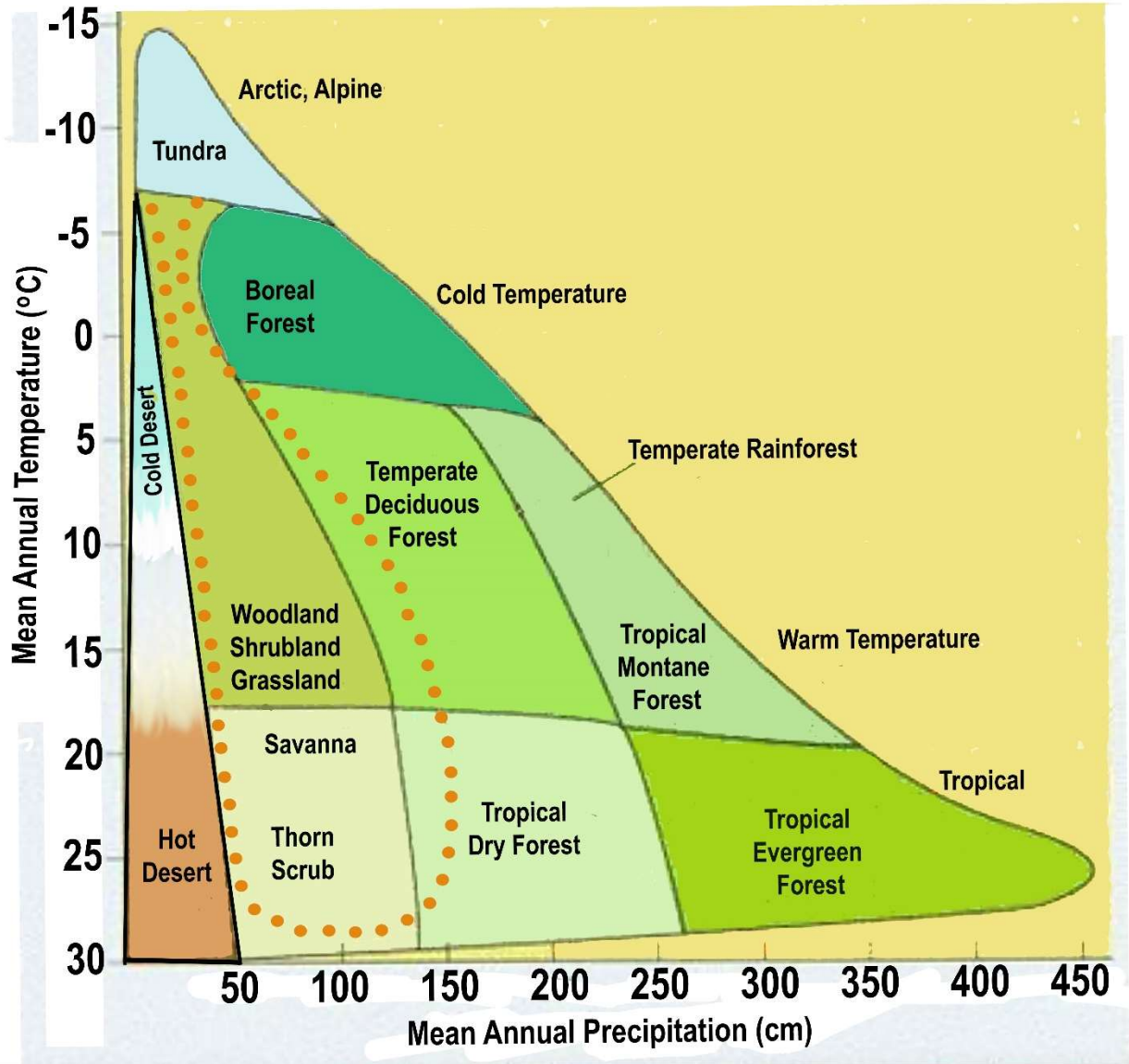
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428 **Table 1**. Definitions, and advantages and disadvantages of five broad designations considered for the
429 heterogeneous land category.

Designation	Definition	Advantages	Disadvantages
Drylands	Land where average annual rainfall is less than potential water losses through evaporation and transpiration; an aridity index (annual precipitation/evapotranspiration) less than 0.65.	Established designation based on quantitative climatic variables; annual precipitation and temperature are broadly correlated with biome distribution; and it is recognized in multiple languages.	Derived from climatic variables without specific reference to land cover, wetter portions of grasslands and savannas may exceed an aridity index of 0.65. Drylands are recognized as the domain of the UNCCD, which includes arable lands.
Grasslands	Land with sufficient precipitation for grass growth, but environmental conditions, both climatic and anthropogenic, prevent tree growth. Occurrence correlates with rainfall intensity between desert and forest, and it is extended by grazing and/or fire in many areas that were previously forested.	Globally recognized land cover based on grass dominance, valued by numerous cultures and the term exists in multiple languages. This land category is supported by an extensive body of scholarship.	Entire land category is not represented; it becomes ambiguous when woody plants (e.g., shrublands and savannas) and non-native species are present, and it may be incorrectly interpreted as degraded forest.
Grassy Biomes	Land characterized by continuous cover of annual or perennial grasses and sedges that varies from open grasslands to savannas with up to 60% tree canopy cover. They are maintained by natural disturbance regimes of grazing, drought and fire.	Designation expands upon the grassland biome to encompass the entire land category. It is characterized by a grass cover and functional plant traits of drought, grazing and fire tolerance and shade intolerance. It conveys few alternative meanings.	Limited recognition and usage based on recent introduction; similar limitations as the grassland biome, and it has been widely applied to tropical grasslands and savannas.
Open Ecosystems	Grasslands, savannas and shrublands that occur in climates warm and wet enough to support closed forests, but are not forests or anthropogenically degraded forests.	Broad designation that coincides with much of the land category and it suggests the absence of trees.	Ambiguous term with limited recognition and context based on recent introduction; "open" may suggest minimal value and availability for alternative land uses; alternative meanings exist in ecology and information networking.
Rangelands	Land occupied by native herbaceous or shrubby vegetation grazed by domestic or wild herbivores. May include tallgrass prairies, steppes, desert shrublands, shrub woodlands, savannas, chaparral, and tundra.	Coincides closely with the entire land category, depending upon the specific definition and usage, and they have been extensively investigated in western science.	References land use and land cover, with livestock grazing being dominant, which minimizes their diverse ecological and societal value. It has failed to attain broad international adoption following a century of use and it possesses colonial implications.

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