Title: Comment on "The extent of forest in dryland biomes"

Authors: Daniel M. Griffith[1]*, Caroline E.R. Lehmann[2,3], Caroline A.E. Strömberg[4], Catherine L. Parr[5,6,7], R. Toby Pennington[8,9], Mahesh Sankaran[10,11], Jayashree Ratnam[10], Christopher J. Still[1], Rebecca L. Powell[12], Niall P. Hanan[13], Jesse B. Nippert[14], Colin P. Osborne[15,16], Stephen Good[17], T. Michael Anderson[18], Ricardo M. Holdo[19], Joseph W. Veldman[20,21], Giselda Durigan[22], Kyle W. Tomlinson[23], William A. Hoffmann[24], Sally Archibald[3,25], and William J. Bond[26,27]

Affiliations:

[1]Forest Ecosystems and Society, Oregon State University, Corvallis, Oregon, U.S.A.

[2]School of GeoSciences, University of Edinburgh, Edinburgh EH9 EFF, U.K.

[3]Centre for African Ecology, School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg, Private Bag X3, WITS, 2050, South Africa

[4]Department of Biology & Burke Museum of Natural History & Culture, University of Washington, Seattle, Washington, U.S.A.

[5]Department of Earth, Ocean and Ecological Sciences, School of Environmental Sciences, University of Liverpool, Liverpool

[6]School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa

[7]Department of Zoology & Entomology, University of Pretoria, Pretoria 0002, South Africa

[8]Royal Botanic Garden Edinburgh, Edinburgh EH3 5LR, UK

[9]Department of Geography, University of Exeter, EX4 4RJ, UK

[10]National Centre for Biological Sciences, Tata Institute of Fundamental Research, GKVK Campus, Bellary Road, Bangalore, India.

[11]School of Biology, University of Leeds, Leeds LS29JT, UK.

[12]Department of Geography and the Environment, University of Denver, Denver, Colorado, U.S.A.

[13]Plant and Environmental Sciences, New Mexico State University, Las Cruces, New Mexico, U.S.A.

[14]Division of Biology, Kansas State University, Manhattan, Kansas, U.S.A

[15]Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, U.K.

[16]Grantham Centre for Sustainable Futures, University of Sheffield, Sheffield S10 2TN, U.K.

[17]Department of Biological & Ecological Engineering, Oregon State University, Corvallis, Oregon, U.S.A.

[18]Department of Biology, Wake Forest University, Winston-Salem, North Carolina, U.S.A.

[19]Odum School of Ecology, University of Georgia, Athens, Georgia, U.S.A.

[20]Department of Ecosystem Science and Management, Texas A&M University, College Station

Texas, USA
[21]Instituto Boliviano de Investigación Forestal, Casilla 6204, Santa Cruz, Bolivia
[22]Assis State Forest, Forestry Institute of São Paulo State, Assis, SP, Brazil
[23]Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun 666303, Yunnan, People's Republic of China
[24]Department of Plant and Microbial Biology, North Carolina State University, Raleigh, North Carolina, U.S.A.
[25]Natural Resources and the Environment, Council for Scientific and Industrial Research, Pretoria, South Africa
[26]South African Environmental Observation Network, National Research Foundation, Claremont, South Africa
[27]Department of Biological Sciences, University of Cape Town, Rondebosch, South Africa
*To whom correspondence should be addressed: griffith.dan@gmail.com

Abstract (60/60 words):

Bastin et al (Reports, 12 May 2017, p. 635) infer forest as more globally extensive than previously estimated using tree cover data. However, their forest definition does not reflect ecosystem function or biotic composition. These structural and climatic definitions inflate forest estimates across the tropics and undermine conservation goals leading to inappropriate management policies and practices in tropical grassy ecosystems.

Main text (824/1000 words; 15/15 references; 2/2 Figures):

Bastin *et al* (*1*) used high-resolution Google Earth images to estimate tree canopy cover in 213,795 (0.5 ha) globally distributed plots. Extrapolation of these plot-level data produced a forest cover classification where they concluded “dry forests” cover ~ 40% more of the global land area than previously estimated, increasing global forest cover estimates by 9%. However, their calculation of forest extent is based on a structural definition adopted by the Food and Agriculture Organization of the United Nations (FAO), where areas greater than 0.5 hectares and with more than 10% tree cover are considered forest (*1*). As a consequence of applying the FAO forest definition, Bastin *et al* (*1*) misclassify as dry forest many tropical regions that are in fact savannas. Savannas differ from forests in having a continuous grassy ground layer which supports fire and grazing mammals. These disturbances select for functionally distinct plant traits and species that are different from forests in their biodiversity and ecosystem services (*2*, *3*).

Bastin *et al* (*1*) refer to plots with 10-40% tree cover as open forest and over 40% as closed forest. These "forest" classes clearly overlap with savannas which can range in tree cover from 0 – 80% (*4*). Tree cover has been previously demonstrated as an unreliable metric by which to differentiate forest and savanna (*3*), and sites classified by Bastin *et al* (*1*) as forest include iconic savannas such as Kruger National Park (Fig 1). Additionally, the FAO "forest" definition applied by Bastin *et al* (*1*) includes sites where tree cover is "temporarily under 10% but is expected to recover," an unclear guideline implying degradation rather than accounting for known temporal variability in savanna tree cover (*5*–*7*). Consequently, the majority of "new" forest identified here resulted from the misclassification of tropical savannas as "forests" (Bastin *et al* Fig S12)(*8*).

Implications of misclassification of savanna as forest include support for afforestation, modification of mammalian grazer and browser regimes, and fire suppression policies (*9*), as fire and large herbivores are generally considered to be at odds with the integrity of forest ecosystems (*2*, *10*, *11*). In contrast, it is the loss of these processes in many savannas that results in their degradation (*8*). Over millions of years, fires and herbivores have driven the evolution of herbaceous plants with belowground buds, underground trees and trees with thick insulating bark, traits which make savanna species functionally distinct from forest species (*5*, *9*). Afforestation and fire suppression policies in savannas risk destroying a wealth of specialized and endemic savanna biodiversity that underpin unique ecological processes, and compromising ecosystem functions such as carbon cycling and water and energy exchange (*5*, *6*, *9*, *11*, *12*). Further, afforestation strategies negatively impact grassy ecosystem function by altering the hydrology and/or trophic structure (*2*, *8*) of entire landscapes. Many of the sites identified by Bastin *et al* (*1*) as forest fall within areas identified as opportunities for "forest and landscape restoration" (*6*), increasing the very real risk that misclassification could misdirect afforestation policies (*8*).

Further underlying the misclassification of savanna is an assumption that biomes can be delineated using a single simple metric of climate (*i.e.*, aridity index). Using a threshold aridity index (0.65) belies the rich ecological complexity in identification and characterization of biomes, the subject of debate for a century (reviewed in *11*). Historical contingencies in the distribution and evolution of plant lineages and their associated functional traits generate critical biogeographic variation in the limits of biomes and their dynamics in response to climate (*e.g.*, savannas across continents) (*14*). Because of this complexity, the climate threshold in Bastin *et al* (*1*) also misclassifies some wet Neotropical forests (in Amazonian Ecuador and Peru, and on the Pacific coast of Ecuador and Colombia) as dry forest (*15*). Recent evidence overwhelmingly shows that definitions of forest based solely on tree cover or climate thresholds ignores key functional difference between closed and open canopy vegetation types (*2*, *3*, *6*, *8*).

Many of the ecosystems identified by Bastin *et al* (*1*) are not forest but savannas (*3*, *5*) where low tree cover is the result of natural processes (*4*, *5*, *8*, *9*). Their aim was "to accurately determine how much forest and tree cover remains in dryland biomes" (p.635). This aim implies that dryland systems were once widely forested, which is incorrect. In Figure 2, we map locations derived from (*5*) providing fossil evidence that many "forest" sites in Bastin *et al* (*1*) have supported tree-grass mosaic vegetation over millennia. Conservation policies should reflect savanna antiquity and not equate low tree cover with degradation. Moreover, although we have focused on savannas, the inflation of forest extent could equally hamper conservation in other threatened forests. An example is the dry forests of Latin America, which lack adequate protected areas to safeguard their unique and geographically heterogeneous flora (*15*). While the data collected by Bastin *et al* (*1*) are impressive and potentially useful, the use of the FAO forest definition is damaging to conservation goals across the tropics.

Acknowledgments: CJS and DMG were supported by National Science Foundation award 1342703; CAES by NSF award 1253713. CLP is funded by a Royal Society-DFID Africa Capacity Building Research grant. RTP acknowledges funding from the Scottish Government's Rural and Environmental Science and Analytical Services (RESAS) Division, NERC NE/I028122/1 and NERC/CONFAP NE/N000587/1. DMG and CERL led the drafting of the manuscript with contributions from all authors. CAES created the fossil map. NPH, JR, CLP, and JWV provided images.

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Figures:

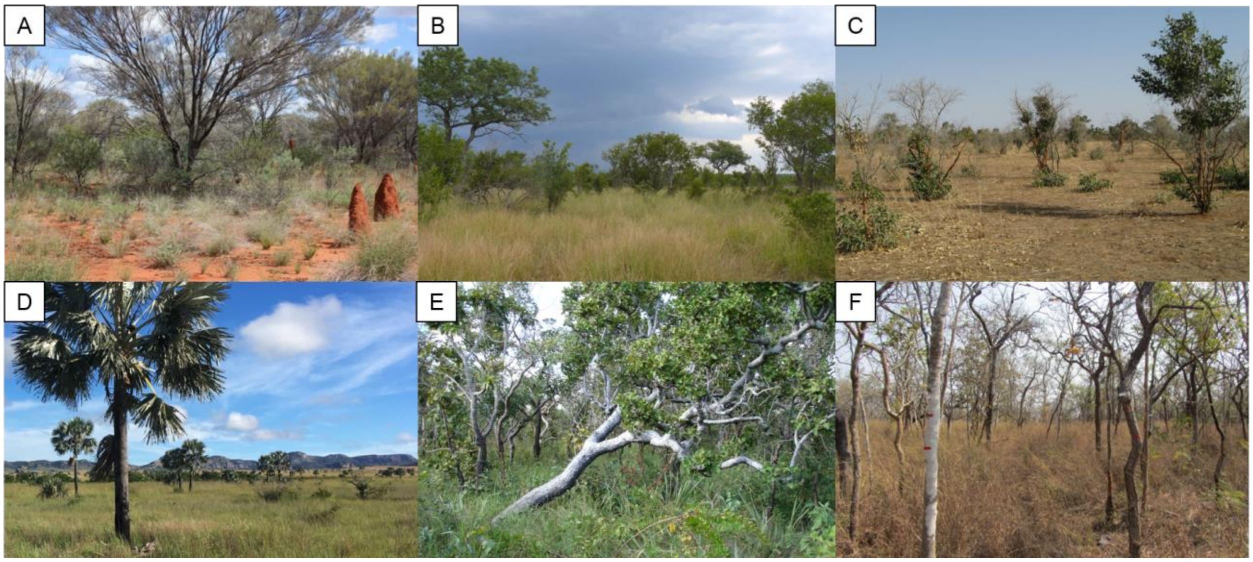

Figure 1. Examples of savannas, with continuous grass layers and discontinuous tree canopies, that are misclassified as forests by the FAO 10% tree cover threshold in Bastin *et al* (*1*). (A) *Acacia*-grass mixture from Australia, functionally a savanna according to contemporary ecological understanding. This is Fig S3 from Bastin *et al* (*1*). (B) *Combretum* savanna in Kruger National Park, South Africa. Photo credit: CLP. (C) South-Sahel site in Lakamané, Mali. This site has ~12.4% tree cover, is heavily grazed and experiences frequent fires. Photo credit: NPH. (D) Savanna from Isalo National Park, Madagascar. Photo credit: CERL. (E) Savanna (cerrado) in eastern lowland Bolivia. This site is within the “dry subhumid” zone in Bastin *et al* and experiences frequent fires. Photo credit: JWV. (F) Long-term monitoring plot in an *Anogeissus*-*Terminalia*-*Chloroxylon* savanna in Amrabad Tiger Reserve, southern India. Photo credit: JR.

Figure 2. Forest distribution in "drylands," from Bastin *et al* (2017), where points (red dots) highlight areas where fossil evidence (*e.g.*, fossil floras and faunas, stable carbon isotopes) has demonstrated past occurrence (>0.5 million years ago, but mainly 4-22 million years ago) of grass-dominated habitats and their faunas across continents (*5*). Although savanna extent has shifted with changing climates and disturbance regimes and exact compositions have changed during the last 22 million years, it is abundantly clear these regions have deep evolutionary roots as mixed tree-grass systems (*5*). Note: ocean points represent paleovegetation data reconstructed from marine cores.