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CORRESPONDENCE

Analysis of stable states in global savannas – a response to Staver and Hansen

ABSTRACT

Staver & Hansen (2015, *Global Ecology and Biogeography*, doi: 10.1111/geb.12285) comment on our recent paper (Hanan *et al.*, *Global Ecology and Biogeography*, 2014, **23**, 259–263) in which we argue that classification and regression tree methods used with remote sensing data to predict tree cover may bias inference of bifurcations in savanna vegetation communities. While we agree with several of their comments, we remain unconvinced that a remote sensing product based on an inherently discontinuous statistical approach can, or should, be used to test for discontinuities.

Keywords

Alternative stable states, forest, frequency distribution, MODIS VCF, remote sensing, savanna, tree cover.

We appreciate the points raised by Staver & Hansen (2015) on the potential relationship between underlying statistical approaches (i.e. classification and regression trees, or CARTs) and our ability to detect discontinuities in satellite-derived tree-cover data. While we agree with some of the points they raise, we remain unconvinced that the analysis they present provides strong evidence for the absence of statistical artefacts in the vegetation continuous fields (VCF) tree-cover data.

First, we would like to emphasize our points of agreement: (1) we agree that theory and empirical evidence support the hypothesis that forest and savanna may be alternative stable states via an amplifying feedback between herbaceous fuel load, fire and tree mortality; (2) we agree that remote sensing data, and the VCF dataset in particular, provide unique information on the state and function of terrestrial vegetation that has contributed immensely to regional- and global-scale ecological and biogeographical research; and (3) we understand that derivation of global tree-cover estimates is a complex and difficult task, requiring some trade-off between the approaches needed to achieve such a huge undertaking and the acceptable errors.

Our point of disagreement relates to whether the Moderate Resolution Imaging Spectroradiometer (MODIS) VCF dataset can be used to detect unbiased signals of alternative states given the discontinuity inherent in CART methods. Staver and Hansen question our use of simulated data ('pseudo-data') to support our argument. We would point out that there is a rich history in the statistical and ecological sciences of using simulated data with known properties to ensure that statistical methods or models accurately reproduce the 'truth'. For example, Dakos *et al.* (2012) recently used simulated data to test proposed indicators of critical transitions. In our analysis, we used simulated data not to represent the true structure of woody vegetation in African savannas, but because they afforded us full control of the underlying distributions with which to test how CART methods may affect model predictions.

We found the new analysis presented by Staver & Hansen (2015), purporting to provide evidence that VCF predictions are not biased by the underlying CART nodes, to be unconvincing. On the contrary, the discontinuities in VCF tree-cover estimates (i.e. the horizontal regions of low point-density) shown in their Fig. 1 (e.g. Fig. 1b for Africa) should surely be accompanied by similar discontinuities in validation data (vertical regions of low point-density at similar tree cover) for us to conclude that these are not reflections of CART methods. Staver & Hansen (2015) recognize this discrepancy, stating that 'MODIS VCF introduces sharp discontinuity between *c.* 38–43% tree cover that is not present in validation data . . .', adding 'However, the aggregate of these data suggests that the MODIS data represent real tree cover relatively well, at least at large scales'. Our point is that while the 'aggregate' VCF relationship is impressive, we cannot ignore the detail in the detection of discontinuities and inference of alternative states in savannas. Staver & Hansen's Fig. 1(b, c) proves our point. Aggregation into 10% bins (in their Fig. 1d–f) obscures, but does not remove, the underlying bias.

In conclusion, we stress again that we do not disagree with the hypothesis that savanna and forest may in some situations be alternative states maintained by a fire feedback. We applaud the efforts of Staver *et al.* 2011, Hirota *et al.* 2011, Favier *et al.* 2012 and others to detect these patterns at continental and global scales. We remain convinced, however, that the potential statistical artefacts in the VCF tree-cover product make it unsuitable for this particular purpose.

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REFERENCES

Dakos, V., Carpenter, S.R., Brock, W.A., Ellison, A.M., Guttal, V., Ives, A.R., Kéfi, S., Livina, V., Seekell, D.A., Van Nes, E.H. & Scheffer, M. (2012) Methods for detecting early warnings of critical transitions in time series illustrated using simulated ecological data. *PLOS One*, **7**, e41010.

Favier, C., Aleman, J., Bremond, L., Dubois, M.A., Freycon, V. & Yangakola, J.-M. (2012) Abrupt shifts in African savanna tree cover along a climatic gradient. *Global Ecology and Biogeography*, **21**, 787–797.

Hanan, N.P., Tredennick, A.T., Prihodko, L., Bucini, G. & Dohn, J. (2014) Analysis of stable states in global savannas: is the CART pulling the horse? *Global Ecology and Biogeography*, **23**, 259–263.

Hirota, M., Holmgren, M., Nes, E.H.V. & Scheffer, M. (2011) Global resilience of tropical forest and savanna to critical transitions. *Science*, **334**, 232–235.

Staver, A.C. & Hansen, M.C. (2015) Analysis of stable states in global savannas: is the CART pulling the horse? – a comment. *Global Ecology and Biogeography*, doi: 10.1111/geb.12285.

Staver, A.C., Archibald, S. & Levin, S.A. (2011) The global extent and determinants of savanna and forest as alternative biome states. *Science*, **334**, 230–232.

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