Re-evaluating the Role of Drylands in the Global Carbon Budget

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Introduction

The conventional view of the role of drylands in the global carbon budget in the early 21st Century was best expressed in an Intergovernmental Panel on Climate Change (IPCC) report. This showed that drylands cover 45% of the Earth's land surface but only contain 21% of terrestrial carbon stocks, of which 80% is stored in the soil rather than vegetation (Watson et al., 2000). There has since been much progress in refining estimates of the role played in the global carbon budget by forests in humid areas (e.g. Pan et al., 2011; Baccini et al., 2017), but relatively little progress in improving estimates for dry areas. A major reason for this has been lack of data on tree cover in the drylands, a gap that was only filled last year by the first global survey based on very high (≤ 1 m) resolution (VHR) satellite data. This found that there were 1,327 million ha of drylands with at least 10% tree cover in 2015 (Bastin et al., 2017), increasing fivefold an earlier estimate of the area of tropical dry forest alone, based on lower resolution satellite data (Miles et al., 2006). This new survey offers a fantastic opportunity for a major re-evaluation of the role of drylands in the global carbon budget.

Aims

The aims of this project are to:

1. Produce a new global map of the distribution of carbon stocks and fluxes in vegetation and soil in the world's drylands.

2. Make a new estimate of the contribution of the degradation of dryland vegetation and soil (desertification) to global climate change.

3. Assess the implications of these new estimates for the global carbon budget and the "missing carbon sink".

Materials and Methods

A model will be devised, based on empirical data reported in the literature, that incorporates all possible combinations of grasses, shrubs and trees that constitute the full range of dryland ecosystems, from savanna grasslands to savanna woodlands and closed forests.

This model will then be combined with global empirical data on the distribution of trees, shrubs and land use in the world's drylands, collected in the First Global Drylands Assessment (GDA) of the UN Food and Agriculture Organization (FAO) (Bastin et al., 2017), based on VHR satellite data, and global empirical data on carbon content of trees, shrubs and soils available

in databases (such as ForestPlots (https://www.forestplots.net)) and reported in the literature, to predict the distribution of carbon in vegetation, and by imputation soil too, in these dryland ecosystems. A full survey will be undertaken of te available wood densities and biomass conversion factors for dryland trees and shrubs.

While the first GDA output only reported the distribution of tree cover in 2015, the full GDA database also includes data on the distribution of shrubs, and on changes in tree and shrub cover since 2000 which can be used to estimate carbon fluxes associated with depletion and degradation of vegetation and soil. These data, and FAO's Collect Earth software that was used to analyse VHR satellite data, are openly accessible. Alan Grainger and other Leeds colleagues were trained in the use of Collect Earth.

Fieldwork for additional data collection and validation will be undertaken in sample sites across the drylands in cooperation with research institutes in China, Senegal, the USA and other countries with which Alan Grainger collaborates.

Fit to NERC Science

This project relates to the NERC terrestrial research area, and more specifically to the following sub-areas: (a) biogeochemical cycles; (b) ecosystem-scale processes and land use; (c) land - atmosphere interactions; and (d) soil science.

Potential for High Impact Outcomes

This project will advance previous research published in *Science* as its cover story (Bastin et al., 2017). It should lead to at least three papers in high-impact journals.

Training

The student will be supervised by Alan Grainger and Roel Brienen in the School of Geography, and will also benefit from interactions with scientists in leading drylands research centres in China, Italy, Senegal, the USA and other countries which they will visit. The student will be trained in global change monitoring and mapping, and benefit from a comprehensive PGR skills training programme (https://www.emesskillstraining.leeds.ac.uk) offered by the University of Leeds, which takes advantage of the VITAE Research Development Framework (https://www.vitae.ac.uk). The student's specific training needs will be assessed at the start of the project and then carefully monitored as they meet regularly with their two supervisors and on a six-monthly basis with their Research Support Group.

Student Profile

This project is ideal for a student who wishes to make a career in global change research, specializing in the drylands component which is heavily neglected at present. A strong background in ecology, global biogeography and mathematical modelling is essential, and skills in remote sensing and geographical information systems are desirable.

References

Bastin J.-F. et al., 2017. The extent of forest in dryland biomes. *Science* **356**: 635-638.

Baccini A et al., 2017. Tropical forests are a net carbon source based on aboveground measurements of gain and loss. *Science* **358**: 230-234.
Miles L. et al., 2006. A global overview of the conservation status of tropical dry forests. *Journal of Biogeography* **33**: 491–505.
Pan Y.D. et al., 2011. A large and persistent carbon sink in the world's forests. *Science* **333**: 988–993.
Watson R. et al. (eds), 2000. *Land Use, Land-Use Change and Forestry.* Cambridge University Press, Cambridge.