Global trends in savanna tree cover: where are hotspots of change?

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Project Background

Tropical savannas are tree-grass systems widely distributed across the seasonally dry tropics, cover ~ 20% of the global landmass and account for ~30% of terrestrial primary productivity. Research by both Ed Mitchard and Caroline Lehmann has shown rapid change in tree cover across Africa (Mitchard & Flintrop, 2013) and Australia (Lehmann *et al.*, 2009), and though drivers may differ this trend appears to be happening across savanna vegetation globally (Stevens *et al.*, 2016). Further, there is broad evidence of increasing shrub and tree cover across much of the world's arid and semi-arid ecosystems (Eamus & Palmer, 2007; Van Auken, 2009; Eldridge *et al.*, 2012). However, the key hotspots, extent, magnitude and drivers of these changes are all unknown. This is despite the significant environmental, economic and cultural importance of tropical savannas. Regional changes in tree cover have important global consequences, potentially representing a substantial portion of the (poorly quantified) tropical carbon cycle (Grace *et al.*, 2014), influencing the biodiversity and ecosystem services of these landscapes, and instigating positive and negative feedbacks with temperature and precipitation.



The drivers of savanna tree cover are complex and interrelated. As such, increasing atmospheric CO_2 concentrations, fire regimes, mega-herbivory (from livestock and wildlife), and changing climate (especially precipitation) have all been suggested as being responsible for current widespread changes in tree cover. It is clear that different drivers dominate in different locations and at different ends of the precipitation spectrum (Andela *et al.*, 2013). Critically, in order to predict future trends, we must understand the relative role of different environmental controls in driving change.

Change can be observed via optical, passive microwave or radar remote sensing (e.g. Mitchard *et al.*, 2009; Andela *et al.*, 2013; Mitchard & Flintrop, 2013), but there is poor agreement between studies. Today, more remote sensing datasets than ever before are available free of charge, covering greenness, rainfall, soil moisture, fire, aboveground woody biomass, and ground temperature, among other variables. Similarly good and consistent climate data is now widely available, along with improved soil maps. Developments in computing power and data storage have made the co-registration and analysis of multiple high resolution global datasets easier. This project presents an amazing opportunity to combine and compare key global datasets to determine the location of change and magnitude of change in tropical tree cover and unpick the inter-related environmental factors underpinning global changes in savanna tree cover.

The project

The fundamental questions to be addressed in this PhD are: 1) Across tropical savannas globally, where are key hotspots of vegetation change? 2) What is the magnitude of these changes? 3) What underpins these changes? The PhD will have three components:

1. **Fieldwork** – fieldwork will be undertaken to link on-the-ground growth rates to remotely sensed vegetation change. Eight transects established by Mitchard in 2007 in the Mbam Djerem National Park in Cameroon across the forest-savanna boundary will be re-measured. The area is experiencing rapid change and re-measurement will link tree growth and

recruitment with very high resolution optical data from 2007 to 2015 and aerial photographs from the 1950's. A second field season would be undertaken as a comparison to Cameroon, with the location determined based on remote sensing analyses to find a contrasting area.

2. **Remote sensing data analysis** – An omnivorous approach to remote sensing data will be utilised where available datasets relating to woody cover, vegetation function and potential drivers will be co-registered, and analysed, both spatially and using time-series analysis at a pixel and regional scale. These analyses will be three-fold: 1) characterise current tree cover; 2) map changes in tree cover as far back in time as is practical; and, 3) quantify the drivers of this change via statistical modelling detrending data relative to climate.
3. **Modelling –** based on the interests of the student, a conceptual model could be developed based on the remote sensing analysis, field data, and the literature. This could evolve into a quantitative model, which could be used to predict future changes in woody cover derived from climate model ensembles and other assumptions.

Training

A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. Training in remote sensing, geospatial statistics, and the analysis of large datasets will be provided, through attending UoE and NERC courses, MSc courses and 1:1 with the supervisors. Furthermore there will be specific training related to field measurements, involving learning both in Edinburgh and in the field. The PhD student would be well placed to go and work in academic research, environmental policy and conservation.

Requirements

We are looking for an enthusiastic person excited at the prospect of tropical fieldwork and the challenge of producing elegant results from large and complex datasets. The student need not have an ecological background, but should have a 1st class (or equivalent) degree in a science subject. Students with a quantitative background (e.g. degrees in physics, maths or computer science) but a strong interest in ecological science are encouraged to apply. Previous experience of GIS/remote sensing software, and more general programming in R/Python, would be useful but not necessary. Some competence in speaking French would be an advantage.

References

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Project Summary

This projects aims to map where the hotspots of woody encroachment are occurring, and discover what is causing savannas to become woodier across the tropics.