Understanding the changes in woody cover and leaf dynamics in the Miombo woodlands of southern Africa through plot remeasurement and UAV remote sensing

Primary supervisor: Edward Mitchard; second supervisor: Casey Ryan

Contact: edward.mitchard@ed.ac.uk

CASE partnership – CASE Partner Bioclimate, an Edinburgh-based SME. Web link.

Project background

Miombo woodlands covers about 2.7 million km^2 of southern Africa, spanning much Tanzania, Mozambique, Zimbabwe, Zambia and Angola. These woodlands have comparatively higher biomass than surrounding savannas due to the prevalence of large, long-lived trees, and are rich in biodiversity and endemic species. They are also populated by over a hundred million people, most of whom rely on the ecosystem services of these forests for some or all of their livelihoods.

Miombo Woodland in Nhambita, Mozambique

We know the Miombo forests are changing fast (Ryan *et al.*, 2016) due to climate change and human pressures. Savanna ecosystems are very dynamic, with competing processes of tree growth and fires meaning woody cover levels are constantly changing when considered at any spatial or temporal scale. Most trees in the Miombo are deciduous, and it is likely that the timing of leaf display is changing, in response to a changing climate, changing species composition, and potentially plasticity within the trees themselves.

Researchers at the University of Edinburgh and our collaborators have set up a network of field plots in Mozambique and Tanzania over the past 10 years, and used these to investigate changing carbon storage of the landscape due to human degradation and recovery from past disturbance, as well as fundamentals of the ecology of these forests (Williams *et al.*, 2008; McNicol *et al.*, 2015; Woollen *et al.*, 2016). A global network of researchers are currently collaborating to remeasure these and other savanna plots. The PhD student would take advantage of this momentum to remeasure the plots in Tanzania and Mozambique, and potentially also some older plots in Zimbabwe, providing long-term data on tree growth and mortality rates across a strong gradient of rainfall and across various soil types.

Scaling up this tree growth data using satellite data is limited by a lack of understanding of phenology (the timing of leaf flush and senescence events), and in particular trying to separate the grass and tree phenology. The development of low-cost, highly-capable UAVs (i.e., drones) and analysis software capable of using multi-angle views to create 3D models, allows us to capture aerial photos at the sites and easily separate the greenness signal from trees and grasses. Such data should allow for a leap in understanding as to how tree and grass phenology is related to rates of tree growth and different rainfall/soil regimes.

Key research questions

1. How are Miombo woodlands changing on an annual – decadal timescale, in terms of their growth rates and species composition? How does this rate of change relate to local climate and soil factors?

2. Can UAV data collected through the year be used to unpick grass and tree phenology cycles. If so, how do these relate to site ecology and climate, and can satellite data be used to map these parameters over a wider area and assess change?
3. How resilient is the functioning of Miombo woodlands to current human disturbance and climate change?

Methodology

The student will remeasure trees in about 50 plots located across Mozambique, Tanzania and Zimbabwe, in partnership with local scientists, and with the support of research assistants. In addition to the tree growth data, the student will collect data from Edinburgh-owned quadcopter UAVs at different points in the growth season (e.g. dry season, late dry season, wet season) for a subset of these plots along a rainfall and soil gradient, and use 3D analysis techniques to separate the greenness signal from grasses and trees; the student will join a vibrant group specialising in remote sensing applications and will be trained in this area. Training on use of UAVs is available thought the Airborne GeoScience Facility at the University of Edinburgh. Finally, both datasets will be used to create maps of the whole region from combining optical and radar satellite data, in order to assess how tree growth and phenology are changing due to human and climate drivers.

The fieldwork and data collection will be concentrated in the first 18 months of the project, with the remaining time spent analysing the field and remote sensing (UAV and satellite) data.

Training

A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. Further, specialist training will be provided in tree identification, plot remeasurement, UAV data collection, and remote sensing data analysis.

Requirements

The most important characteristics we are looking for in a student are enthusiasm for the project and challenging tropical fieldwork, and strong quantitative and analytical skills. It is not necessary to have an ecological or environmental background: applicants from a maths, physics or engineering background would be looked on favourably, as long as you have an interest in ecosystem science.

We would expect the applicant to have a 1st class degree at an undergraduate level in a science subject. Some experience of fieldwork in remote locations (not necessarily tropical), coding in R or Python, or GIS/remote sensing would useful, but by no means essential.

References

McNicol IM, Ryan CM, Williams M. **2015**. How resilient are African woodlands to disturbance from shifting cultivation? *Ecological Applications*: 150407011925001.

Ryan CM, Pritchard R, McNicol I, Owen M, Lehmann C. **2016**. Ecosystem services from Southern African woodlands and their future under global change. *Philosophical Transactions of the Royal Society B-Biological Sciences* **in review**.

Williams M, Ryan CM, Rees RM, Sambane E, Fernando J, Grace J. **2008**. Carbon sequestration and biodiversity of re-growing miombo woodlands in Mozambique. *Forest Ecology and Management* **254**: 145–155.

Woollen E, Ryan CM, Baumert S, Vollmer F, Grundy I, Fisher J, Fernando J, Luz A, Ribeiro N, Lisboa SN. **2016**. Charcoal production in the Mopane woodlands of Mozambique: what are the trade-offs with other ecosystem services? *Philosophical Transactions of the Royal Society B: Biological Sciences* **371**: 20150315.

Project summary - (30 words max) which could be used for advertising

Miombo woodlands are undergoing rapid but poorly quantified change. This project would involve remeasuring forest plots in Tanzania, Mozambique and Zimbabwe to quantify this change, and scale up these findings using UAV and then satellite data.