Title: Biodiversity – Ecosystem Function Relationships in Southern African Woodlands

Supervisors: Kyle Dexter (primary), Caroline Lehmann and Casey Ryan; Uni Edinburgh
Contact: kyle.dexter@ed.ac.uk

Summary: The student will assess the relationships between tree species diversity and ecosystem function, measured as wood production, across southern African woodlands, with implications for livelihoods and understanding global change.

Project Background: Understanding the response of southern African woodlands to global change is critical to biodiversity conservation and the livelihoods of >150 million people that live in them (1), but key ecological processes are not well understood. The expansion and 'densification' of the woody component of these woodlands has been proposed as an important global carbon sink (2). However, should these woodlands convert from a more open, savanna-like environment to a more closed, forest-like environment, this 'win' in terms of mitigating global climate change may well be offset by 'losses' in biodiversity and ecosystem services. The survival of many plant species in these woodlands depends on fire disturbances, which would be reduced in a closed forest environment, while many of the large animal species that are the basis of ecotourism revenue require relatively open, grass-rich environments.

Figure 1: Miombo woodland in southern Mozambique, illustrating the current sparsity of trees in southern African woodlands. Even so, woody biomass has increased in this plot over the last 10 years (C Ryan, unpubl. data).

Underpinning the ability of southern African woodlands to become a denser 'carbon-sink', forest-like environment is the biodiversity-ecosystem function relationship (B-EF-R). In tropical forests, a clear positive relationship seems to exist between species richness and carbon sequestration (3-4). More species-rich forests have responded to increased atmospheric CO2 by increasing their growth rates (and soaking up CO2) to a greater degree than species-poor forests. The mechanism put forth by many authors to explain the B-EF-R is niche complementarity, whereby more diverse communities fill more niche space and thus have greater productivity. However, whether a positive B-EF-R relationship exists for the trees of southern African woodlands is uncertain. Previous studies focused primarily on moist forest ecosystems in the Neotropics, but drier woodlands may show different patterns. In moist tropical forests, the abiotic environment is generally favourable for plant growth and reproduction, and competition is intense; in such environments niche partitioning will likely lead to enhanced function. However, in more stressful environments such as woodlands, biotic competition may be less important than stress tolerance in determining which species may be present and/or productive (5). Thus it is possible that in woodlands, a select few species or lineages maintain high productivity, and if a plant community is comprised of these few species, rather than many species, it will have higher productivity.

This PhD project will assess the B-EF-R using plot data from across southern Africa assembled by the project supervisors and collaborators, with additional data generated by the student via field work. The student will analyse the links to tree biodiversity (species richness and phylogenetic diversity) using hierarchical modelling, controlling for direct environmental effects on both diversity and ecosystem function. As environmental factors, the project will incorporate standard variables such as climate and soil type, as well as measures of disturbance, including fire and herbivores.

Key Research Questions:

1) What are the key environmental factors influencing above-ground woody productivity in southern African woodlands?
2) Once environmental factors are controlled for, what influence does tree species diversity, have on above-ground woody productivity?
3) Which woodland types in southern Africa are expected to change the most, and how, under increasing atmospheric CO2, climate change and changing fire regimes?

Methodology and Training: A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The student will acquire skills in **1)** field ecology and tropical botany, **2)** data analysis in the R statistical environment, **3)** scientific writing for both grant applications and journal articles, **4)** scientific presentation skills, and **5)** inter-institutional and inter-cultural collaboration and networking.

The student will gain experience in tropical field ecology and working with collaborators from different countries (Mozambique, South Africa and Angola) during at least one field expedition to southern Africa. During the expedition(s), vegetation plots will be inventoried, herbarium specimens will be collected and plant functional traits may be measured. The student will also gain valuable collaboration skills during a visit to collaborating academic institutions in southern Africa. The student will be trained in scientific presentation in order to give presentations at national and international conferences. Finally, the student will be encouraged to and helped in applying for external grant funding and in publishing his or her work in scholarly journal articles.

Requirements: The student will have an MSc and or an outstanding BSc in natural, environmental, chemical, physical or biological sciences and an ability to undertake (sometimes challenging) tropical field work. The student will ideally have strong quantitative and organizational skills. The student will need to be able to work independently and as part of a larger team.

Supervisors: Dexter has a track record in biodiversity research and large-scale analyses of vegetation composition (6-8), including in southern Africa (9). He has supervised multiple PhD students to completion and regularly publishes with students. Lehmann has a deep track record in savanna and fire ecology research in Australia and Africa (10-11). Ryan has been working in southern African woodlands from his PhD research through to present (1,11-12).

References: (1) Ryan *et al.* 2016. *Philos Trans R Soc* B; (2) Higgins *et al.* 2012. *Nature*; (3) Chisholm *et al.* 2013. *J Ecol*; (4) Poorter *et al.* 2015. *Glob Ecol Biogeogr*; (5) Grime & Pierce. 2012. Wiley-Blackwell; (6) Dexter et al. 2012. *PNAS*; (7) ter Steege, Dexter *et al*. 2013. *Science*; (8) DRYFLOR, Dexter *et al.* 2016. *Science*; (9) Tripp, Dexter *et al.* 2012. *Syst Bot*; (10) Archibald, Lehmann *et al.* 2013. *PNAS*; (11) Lehmann, Ryan *et al*. 2014. *Science*; (12) Ryan *et al*. 2011. *Ecol Appl* (13) Ryan *et al*. 2012. *Glob Change Biol*.