Resolving the limitations on plant growth and biomass

Dr. Tom Bennett (School of Biology; t.a.bennett@leeds.ac.uk)
www.tombennettlab.org

Dr. Sarah Batterman (School of Geography; s.a.batterman@leeds.ac.uk)
https://www.geog.leeds.ac.uk/people/s.batterman

What limits primary productivity in plants remains a major question relevant across scales and biological systems. Agronomists and farmers have long sought the factors that support efficient accumulation of biomass in order to maximize crop production. Ecologists have identified environmental conditions as critical determinants of plant productivity across biomes globally (e.g., Whittaker). Within natural tropical forest systems, resolving these factors is particularly relevant since tropical forests have the potential to mitigate climate change by serving as a carbon sink in the future, unless biomass carbon accumulation becomes limited by another factor (e.g., Hungate et al. 2003, Science).

In addition to climate, it is clear that deficiency in light or mineral nutrients can inhibit plant growth. However, the extent to which light and nutrients are practical limiting factors for biomass formation remains unclear. For instance, in mature tropical forests, fertiliser application has little apparent effect on net forest biomass accumulation (Wright et al. 2011, Ecology). In experimental greenhouse conditions, plants often do not maximize their growth, even under ideal growth conditions (Poorter et al. 2012, Functional Plant Biology). This result may be due to root restriction, crowding, or inherent genetic constraints that prevent the plants from taking full advantage of available resources.

This project aims to dissect the contribution of these factors (light, nutrients, crowding and genetics) to the limitation of plant growth. It will consider plants grown in a range of environmental systems, including greenhouse, natural tropical forests and large-scale field experiments, and a range of species, including both agricultural crops and tropical trees. We will pay particular attention to the new hypothesis that root restriction acts as the practical limit on biomass accumulation under many conditions.

The student will have the opportunity to develop a range of approaches in order to address this question. We will perform experiments in controlled environments to precisely dissect the relative effects of root restriction (e.g. through manipulating pot size), nutrient application and light levels on growth and biomass formation. We will identify what conditions are needed for any given factor to act as limitation of plant growth. We will also test the effect of these limiting factors in agricultural contexts, using crop trials (for instance, of seed drilling rate versus fertilizer application) at the University of Leeds experimental farm. Finally, we will assess the effect of fertiliser application and plant density on biomass formation in long-running field sites in the Panamanian tropical forest.


This project will help to establish the best strategies for improving plant productivity and biomass formation in both agricultural and forestry contexts and will improve our understanding of the role of nutrient limitation on the carbon sink in tropical forests.