VEGETATION AND ECOSYSYTEM PROCESS RESPONSES TO GLOBAL WARMING IN THE MONTANE GRASSLAND ECOSYSTEM IN THE NILGIRIS

Submitted to:
Nilgiri South Division, Tamil Nadu Forest Department,
and other interested citizens

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Introduction

Global warming is a major threat to ecosystems around the world. Temperature rise can mediate changes in plant productivity and vegetation composition through changes in rates of processes like photosynthesis, and the availability of resources like water and nutrients, and can affect ecosystem processes such as soil respiration and carbon storage as well. Though many studies have been done to understand global warming effects on vegetation and ecosystem processes, majority of them have been done in temperate regions (Aronson & McNulty, 2009), and there is a paucity of empirical data from tropical regions. Our project primarily is aimed at addressing this lacuna.

The Western Ghats are one of the most biodiverse regions of India, and the montane grasslands in the upper reaches of the Ghats, such as in the Nilgiris, are an integral part of the unique shola-grassland mosaic. The shola-grasslands host a variety of endemic plants such as the ground orchid *Satyrium nepalense* and Rhododendrons, and the grasslands are essential for the survival of herbivores such as the sambar deer (*Rusa unicolor*), which has been categorized as Vulnerable in the IUCN Red List, and the endangered Nilgiri Tahr (*Nilgiritragus hylocrius*) (Robin, V. V & Nandini R, 2012).

In the last century, many invasive plants such as wattle (*Acacia mearnsii*), Scotchbroom (*Cytisus scoparius*) and *Ulex europeaus* have been introduced into the grasslands. These species, perhaps because of their fast growth rates and

profusion of seeds, have already replaced much of the grasslands – maybe even up to 83% (Sukumar, R. *et al*., 1995). Montane grasslands in the Nilgiris are vulnerable to global warming; but the level of threat in terms of species loss, community shifts and invasion, are not quantified. To appropriately manage and conserve the remaining tracts of this critical ecosystem, long term empirical data of global warming effects on the vegetation and dynamics of this system is imperative.

Montane grasslands in the Nilgirs form a unique mosaic ecosystem with *shola* forests, and are threatened by invasive plants such as wattle and scotchbroom.

In our project, we primarily address the following questions: (a) How does warming affect species richness in the montane grasslands of the Nilgiris? (b) How do grasses, sedges and herbs in the grasslands respond to warming? (c) Does warming affect green, brown and bare ground cover in these grasslands? and (d) How is soil respiration affected by warming? Our project also aims to contribute to long term monitoring of ecosystem responses of the montane grasslands in the Nilgiris to warming.

In this report, I give a brief overview of of our experiment in the Nilgiris, and a summary of our findings to date.

One of our experimental plots in the Nilgiris

Our experiment

A number of warming experiments worldwide use open top chambers (OTCs) to study ecosystem responses to temperature rise. We modified the OTC design from Godfree *et al.* (2011), after some setbacks, we have, we believe, a design that is can withstand the high winds at our field site during the monsoon despite the slopey terrain they are built on. The OTCs are hexagonal structures, ~3m in diameter and ~50cm tall. An iron frame supports the pyramidal structure made of polycarbonate that retains IR radiation within it, thus warming it. The photograph shows us setting up one of the OTCs in the montane grasslands of the Nilgiris. We have now set up 30 OTCs and paired 1m x 1m control plots, enclosed in 10 fences to protect them from herbivores in the area.

We also set up collars in the soil within OTCs and in the control plots to measure soil CO_2 efflux, partitioned by root, arbuscular mycorrhizal and other soil microbial contributions (Protocol adapted from RAINFOR-GEM; http://gem.tropicalforests.ox.ac.uk/files/rainfor-gemmanual.v3.0.pdf). Pictured above are the three kinds of pipes used to allow roots (with holes for the roots to grow in), keep out roots but allow AMF (with holes closed with nylon meshes with 40u pore size) and pores that keep out both roots and AMF (with no holes to let either of them grow in). Pictured below are members of our team setting collars up at our experiment site.

Vegetation cover and composition, soil chemistry, abiotic factors like soil moisture and temperature, and soil respiration are being monitored periodically. The photo above shows a grid that we use to measure vegetation cover. The Environmental Gas Monitor (EGM; pictured below) is an IR absorption based machine used widely by researchers around the world to measure CO_2 efflux *in situ*. We use the EGM machine to measure soil respiration at 15 day intervals.

Preliminary findings

Species richness was measured in October 2015, after 6 – 9 months of warming. The richness in both the OTCs and controls was found to be ~7 on average. There was no statistical difference between the OTCs and control plots. This is perhaps because change in species richness is typically a process that is discernible at longer timescales. It is also possible that vegetation in the region is highly adapted to temperature changes and can therefore withstand fluctuations in temperature imposed by our treatment. Further, our analysis at the moment cannot detect species replacement, and can only detect any changes in gross species richness.
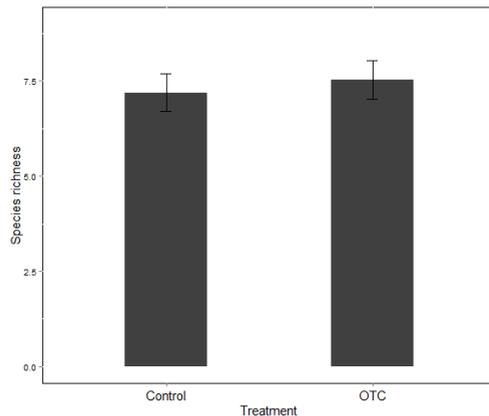

After 6 – 9 months of warming, species richness in the OTCs is not different from the control.

We also measured **plant functional group cover (grasses, sedges and herbs)** at quarterly intervals. We had expected some change in the performance of these plant groups since previous literature suggests that C_3 plants (such as herbs) and C_4 plants (such as grasses) may differ in their competitive abilities, and be differently affected by a rise in temperature and consequent decreases in soil moisture. So far, there are no significant changes in the cover of these functional groups in our experiment.
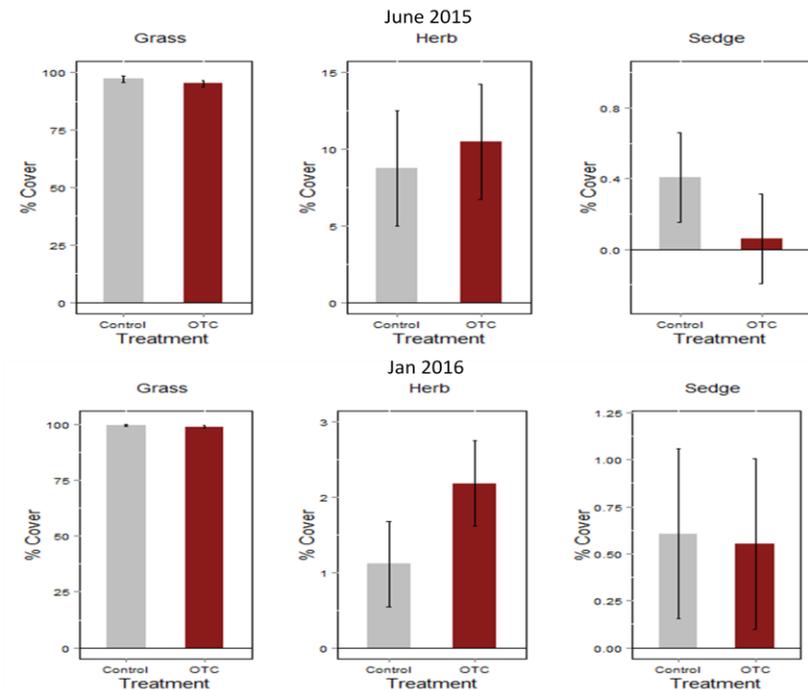
Green, brown and bare ground cover measured over quarterly intervals shows a significant change after about a year of warming. There is more green cover in the control plots than the OTCs, and the warmed plots also have more brown and bare ground cover. These results, if they persist over longer timescales, might lead to species richness changes due to shading of herbs by standing dead grass biomass, or even a decline in forage quality for the herbivores since brown biomass is associated with lower nutrient content than green.
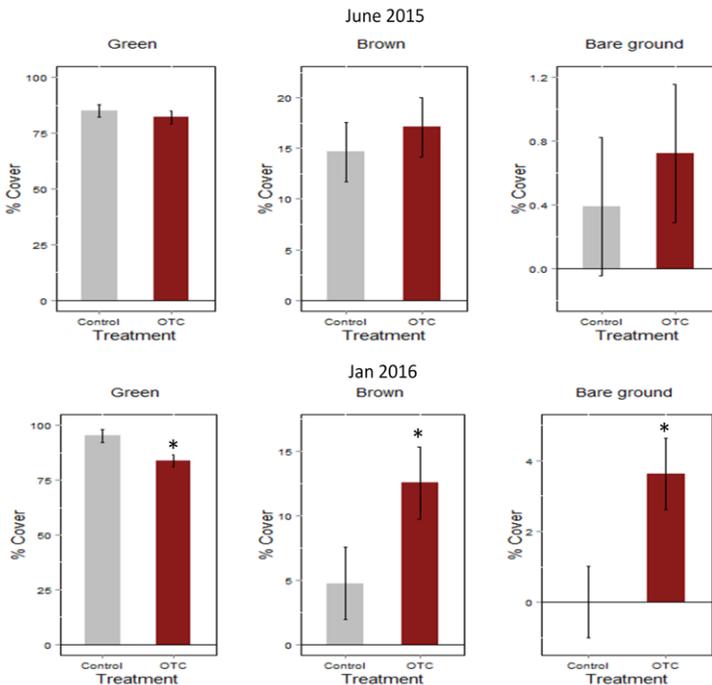
We also measured **CO_2 efflux** changes due to warming. Preliminary analysis suggests that the warmed plots have higher soil respiration than the control plots under all treatments (with roots, without roots, without roots and AMF). This could suggest that in the longer term, the grasslands could become a larger source of CO_2.
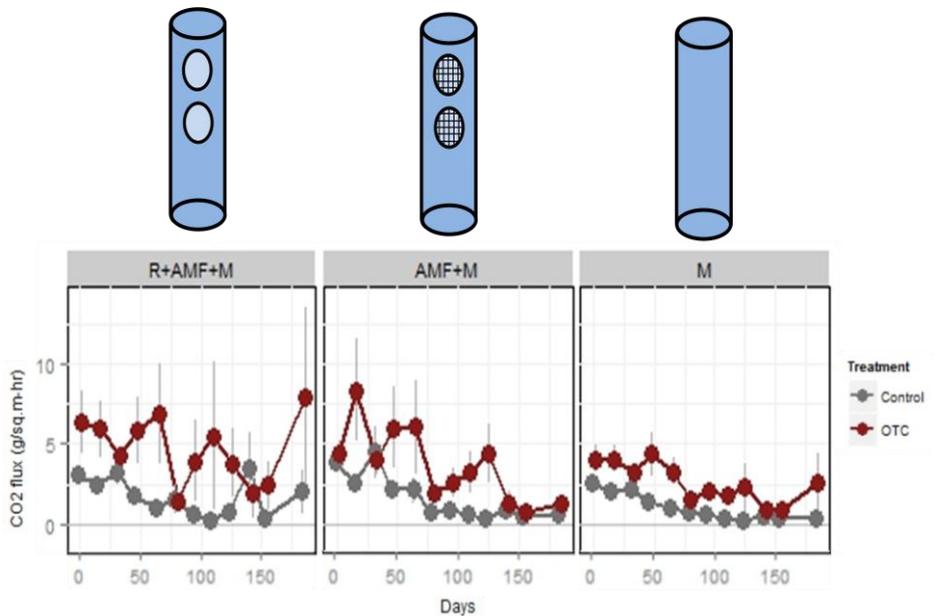
Conclusions

Over the last year, we have set up in situ warming experiments in the montane grasslands of the Upper Nilgiri landscape, and have monitored vegetation and ecosystem process changes over time. So far, while species richness and functional group level performance has not changed due to the warming treatment, we have been able to detect increases in brown cover and CO_2 efflux due to warming. It is however important to generate long term data before we can understand the grasslands' responses to warming and use this knowledge to inform management decisions for the region.

Acknowledgements

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