The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Yadugiri V T
Project title	Understanding plant community responses to future warming in the montane grasslands of the Western Ghats
RSG reference	17009-1
Reporting period	26 February 2015 – 14 April 2016
Amount of grant	£4985
Your email address	vtyadu@gmail.com
Date of this report	14 April 2016

1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Setting up an in-situ warming experiment using open top chambers (OTCs) in the montane grasslands of the Nilgiris.			Y	Thirty OTCs and paired control plots have been set up in the montane grasslands in the Nilgiris, enclosed within 10 fences in carefully selected locations in the landscape. The OTCs have iron frames that support polycarbonate sheets placed at an angle to the ground. Our OTCs achieve a daytime warming of 0.54 ± 0.02^{0}C.
Assessing gross changes in plant species richness, cover and shifts in functional groups of plants due to warming.			Y	**Species richness** was measured immediately after setting up the OTCs and again in October 2015. After 6 – 9 months of warming, there was no statistical difference between the OTCs and control plots in species richness, and the number of species in $1m^2$ in both the OTCs and controls was found to be ~7 on average. 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. 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 have more brown and bare ground cover. The possible reasons and implications of these results are discussed in a detailed report of the project that has been submitted to the local forest administration, a modified version of which will also be submitted to the Rufford Small Grants Foundation.
Estimating ecosystem process changes under warming		Y		Soil cores have been collected at quarterly intervals from the OTCs and the paired control plots. Plant aboveground biomass samples

				were collected towards the end of the growing season, in October 2015. Soil and plant samples are currently being processed for estimating total carbon, nitrogen and phosphorous amounts. While setting up our project, we also set up infrastructure to measure soil respiration, a very important ecosystem process. Preliminary analysis suggests that the warmed plots have higher soil respiration than the control plots. A detailed account of these results is also presented in the project report.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

Working on the design of the open top chambers (OTCs) proved to be more challenging than we anticipated. Our OTCs follow a design that is widely used around the world, and has been proved to be effective in several other sites where in-situ warming experiments have been set up (for instance, in Australia (Godfree *et al*., 2011)). However, the initial OTCs we had set up used acrylic sheets and these broke during the first week of monsoon in June 2015. Discussions with experts and colleagues who have experience setting up OTCs, as well as with other academics at our host institution, NCBS, suggested that our design was not strong enough to withstand heavy winds during the monsoon, given the steep terrain of our field site. We have now set up OTCs that use polycarbonate (a much stronger material) for the walls. These OTCs could withstand the remaining monsoon during July – August 2015, and will hopefully be able to withstand this year's monsoon too.

3. Briefly describe the three most important outcomes of your project.

(a) We have set up an in-situ warming experiment in the montane grasslands of the Western Ghats, and have initiated periodic measurements of several vegetation, soil and ecosystem process parameters. While there are many in-situ warming experiments that have been set up globally, ours is one of the first in the tropics, and in a region that receives an annual rainfall of >2000 mm. Long term data from this experiment would contribute greatly to our understanding of ecosystem responses to warming, and can be very useful for informing management of these grasslands.

(b) **Vegetation responses to warming:** We have measured several vegetation parameters such as species richness and cover responses to warming over the last year. Parameters like species richness are typically measured in most warming experiments and temperature-mediated changes in these might be discernible at longer timescale. However, in our project, we have been able to identify other parameters that could potentially be important to measure as well. For instance, we found that a few months of warming increases brown cover and bare ground cover when compared to the controls. 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.

(c) **Warming effects on ecosystem processes:** We find that there is greater CO_2 efflux under warmer conditions than in the controls. This in the longer term could indicate a greater role of these grasslands as sources of carbon in a warmer world. Our experiment also teases apart the contributions of three major biotic components of the soil that contribute to this CO_2 efflux – plant roots, arbuscular mycorrhizal fungi that form symbioses with these roots, and other soil microorganisms such as bacterial and fungal decomposers.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Our project does not directly impact or involve local communities. However, setting up the OTCs and carrying out measurements entailed a lot of communication with local people who helped us in the work. This gave us an opportunity to discuss our experiment in particular and global change in general with them. Some who have been involved with the project over a longer term have also been trained in basic field ecological methods over the course of our work.

5. Are there any plans to continue this work?

Yes. Global change experiments are most useful in the long term. As our results suggest, some ecological processes such as vegetation composition and cover changes happen slowly. Further, several studies from other parts of the world have suggested that forces acting on plants in the short term change over a period of time. For instance, warming over several years dries up soils and water deficit begins to play a role in shaping vegetation communities. The experiment was designed keeping these factors in mind, and we do plan to continue collecting data for some more years.

6. How do you plan to share the results of your work with others?

Technical papers and reports will be prepared and submitted to peer reviewed journals. This would make results from this project accessible to the global academic community. Analyses are underway for a manuscript about ecosystem process responses to short term warming. Data collection over a few more seasons would allow us to also publish data on vegetation responses to warming.

Non-technical reports are periodically prepared to share the progress of the project and results with the local forest administration. Two such reports have already been submitted, and more will be prepared as and when there are newer findings from the project.

Results from the project will also be presented at various conferences and meetings. This would make the results accessible to the larger academic community as well as practicing conservationists and the interested public. One such talk has already been given at the School of Ecology and Conservation at the University of Agricultural Sciences, Bangalore, India.

7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?

The bulk of the grant was used between March 2015 and April 2016. The project commenced in November 2014. Though the project is essentially long term, the first year is critical, since it involves setting the experiment up and ensuring smooth and accurate functioning of the experiment and

periodic data collection. The Rufford Grant was extremely useful during this critical time of the project.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Polycarbonate sheets for OTC	1387.75	1916.525	-528.7	The number of sheets procured was more; given the harsh field conditions, we decided to procure more sheets to replace panels that might be damaged in the high winds.
Iron pillars for supporting the OTC structure	531.30	0	531.3	We used money from other sources for this, and used this money for field station rent and upkeep and food during field work instead.
ibuttons to record temperature data	1373.50	860	513.5	We got a better deal from the suppliers.
Transport to and from field site, and fuel charges	1026.00	624.8	401.15	Shared costs with other researchers and other projects working in the same area.
Field station rent and upkeep	0.00	681.9	-681.9	Since money budgeted elsewhere for this was used to buy iron pillars, and for lab analyses.
Food during field work	0.00	91.7	-91.7	Since money budgeted elsewhere for this was used to buy iron pillars, and for lab analyses.
Field assistance	486.00	387.2	98.6	Shared costs with other researchers, and also used help from volunteers.
Laboratory analysis for soil elemental composition	667.44	0	667.44	Money from other sources will be used for this. The analyses are still underway.
Communication of findings	121.36	0	121.36	Did not spend money on this, since we presented data from the project in one invited talk, for which there was no expense.
Total	5593.3	4562.4	1030.9	
Amount received	4646.7	**Amount remaining**	84.2	Exchange rate used: 1 GBP = 98.88 INR

9. Looking ahead, what do you feel are the important next steps?

The most important next step is to ensure smooth functioning of the project and regular data collection on vegetation and ecosystem process responses in the coming years. This would involve continuation of regular field visits by the existing team, and also recruiting and training others to carry the work forward.

Over the last year, there have been several opportunities for us to discuss the project with other ecologists and conservationists. These discussions have often led to suggestions for expanding the project scope to include assessing other responses such as phenology, physiological processes such as photosynthesis and so on. It would be wonderful if some of these aspects can also be included in the project in the coming years.

The in-situ experimental setup is a very useful research resource, and can be utilized by other researchers to answer several other questions about ecosystem responses to global change. It can also be a great educational resource, to spread awareness and understanding about global change and its effects on ecosystems among the general public. To ensure the fullest use of the project, we will also explore ways to spread word about the project, especially among researchers, students, the local forest administration and local people, and help them use it for research and learning.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

The Rufford Foundation logo was used, and the funding acknowledged, in the report about the project that was submitted to the local forest administration, as well as in a talk by the PI at the School for Ecology and Conservation, University of Agricultural Sciences, Bangalore, India. The funding will also be acknowledged in all publications, writings, posters and talks that emerge from this project.

11. Any other comments?

Thank you! It has been a wonderful experience working with you, and the support and freedom that the grant allows is incredible. The project was envisaged to help address a severe underrepresentation of the tropics, especially India, in global climate change literature. It also aimed to help initiate long-term data collection and monitoring of one of India's most unique and vulnerable ecosystems – the montane grasslands in the Western Ghats. Thanks to the Rufford grant, it was possible for us to set this experiment up.