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	Md Abdul Halim
Project title	Tree species diversity as a driver of above ground tree carbon and soil carbon fluxes in the tropics: Implications for REDD+ in Bangladesh
RSG reference	19533-1
Reporting period	May 2017
Amount of grant	£4965
Your email address	abdul.halim@mail.utoronto.ca
Date of this report	25 May 2017

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
Measurement of tree species diversity				I have successfully measured species richness as an index of tree species diversity from the sample plots. We had to develop herbaria for some species, which were difficult to identify in field. Local experts were a key resource for in-field identification.
Measurement of above ground tree carbon				I have found a total of 26 tree species in the surveyed plots at LNP. Allometric equation for each species was developed using DBH and wood density as the predictors of above ground tree carbon, more specifically above ground stem carbon.
Measurement of soil carbon flux				Using a soil respiration chamber (home brewed) and an Ultraportable Greenhouse Gas Analyser (from Los Gatos Inc.), I have successfully measured soil CO_2 and CH_4 fluxes from each sample plot.
Find out how tree species diversity controls above ground tree carbon and soil carbon flux				After calculating above ground tree carbon and soil carbon fluxes, I was able to establish a significant relationship with tree diversity.
Disseminate the knowledge to the local community, policy makers, and scientific community				I have shared preliminary findings to the local community and to the policy makers. Next step is to share with scientific community by publishing the findings in a peer reviewed journal.

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

Major difficulties were to work during rainy season. It rained almost every day and the terrain was very slippery. In some cases, I could not reach places with the heavy

equipment where I intended. Leeches during rainy season and ticks during winter were other two major challenges we faced. We, however, learnt indigenous tricks (spaying Gul: tobacco powder on feet) to deter them.

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

Outcome 1: Initially I thought the soils of LNP would be a source of CH_4, as the forests in Bangladesh in general have gone through a lot of anthropogenic disturbances and the microorganisms (methanotrophs) responsible for breaking down CH_4 into CO_2 might have destroyed. I was surprised to see that none of the sample points (in all plots) was a source of CH_4. The methanotroph recovery rate presumed to be quite high in the study area. It, however, demands further detailed study to understand the underlying mechanism.

In any Bangladeshi forest, for the first time, I have measured soil carbon fluxes. Our policy makers, thus, did not have any clear idea of how our forest soils are truly performing in terms of carbon storage. This finding has significant implications for calculating REDD+ carbon budget for the country. We now have scientific evidences that our forest soils are actually storing more carbon than we previously thought. We however need to conduct studies in other forests of the country to ascertain full potential.

Outcome 2: Another key finding is that the soil organic carbon is positively related to tree diversity. This relationship is statistically significant and tree diversity alone can explain more than 65% of the variation in soil organic carbon (0-30 cm depth) (the rest could be from shrubs and herbs). This result implies that if we can maintain high tree diversity than just focusing on fast growing species, forest soils be able to store more carbon. This finding will be a key determinant to how we choose species for afforestation and deforestation in forest areas.

Outcome 3: Another interesting outcome of the study is that the soil CO_2 efflux was positively correlated to tree diversity but CH_4 influx was indifferent. This is partly because high tree diversity usually increases productivity and thus root respiration. I only measured daytime CO_2 fluxes, so it's not possible to differentiate root respiration (plant do not respire at night) from that of microorganisms (respire both day and night). I also did not measure net productivity, which also makes it difficult to give a clear explanation of the process driving the fluxes. Studying tree photosynthesis rate along with above ground carbon might be a good proxy of ecosystem productivity.

Relationship between plant diversity and productivity (and soil respiration) is still poorly understood. This study might shed some lights to the general scientific understanding.

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

Local communities were involved both directly and indirectly. Direct involvements include hiring them as guides, field assistants, and local experts for tree identification.

I also hired one family for cooking meals for us. By indirect involvement, I mean, the key findings were shared with the communities through a focus group discussion. The key topic of this discussion was why we should plant variety of trees rather than just single fast growing species. This discussion generated tremendous interests regarding the project. We had a long fruitful discussion on the findings. I strongly believe this project helped them understand how and why biodiversity is important for them.

I have also arranged two seminars with local experts and policy makers: one at the beginning to get their inputs in the project and, the other, in the end to share key findings.

Last but not least, I was able to fund one Forestry undergraduate student from this grant who is studying how land use (land sharing vs. sparing) affect bird and reptiles diversity in and around the study area (Lawachara National Park).

5. Are there any plans to continue this work?

Certainly. From this study, we have learnt tree diversity affects carbon (soil and above ground) positively but we don't know how and why. I have set the sample plots as permanent plots. In the next phase, I want to measure tree photosynthesis rate as a proxy to productivity to accurately explain what drives the carbon and tree diversity relationship.

Another part of the next phase would be to develop a method to monitor plant/tree diversity rapidly, reliably, and cost effectively for the forested areas of Bangladesh. Surveying tree diversity is slow and satellite remote sensing is not always a reliable method to monitor tree diversity. UAV (Unmanned Aerial Vehicle), such as low cost drones, could be a potential route to explore in this regard.

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

As I mentioned earlier, I have already shared the key findings with the local communities and policy makers. Now I'm preparing a manuscript for Global Change Biology (John Wiley & Sons, Inc.) journal to share the key findings to the scientific community. I will send a copy to RSG Foundation once published.

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 RSG was used over the period of little over 1 year (May 2016 to May 2017). One of my instruments was malfunctioning for a few weeks or so; otherwise I could have finished the project within one year. However, the project is successfully finished with some key findings.

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
Stationaries (Field book, pencil, marker, clipboard, paper, tag etc.)	50	50	0	There was no difference for this item.
Rite in the rain paper (For printing field references and data sheet)	86	86	0	Do
Printing/Photocopying	50	50	0	There was no difference for this item.
Purchase of reference books (Field guides for plant identification)	100	160	- 60	This was adjusted from Food item. Field guides are donated to the Department of Forestry and Environmental Science (DFES), Shahjalal University of Science and Technology (SUST), Bangladesh
Generator (Honda EU1000i)	799	799	0	There was no difference for this item. The generator was donated to DFES, SUST, Bangladesh
PVC Pipes for Gas Collar	250	250	0	There was no difference for this item.
3 Field Assistants	900	900	0	There was no difference for this item.
Local Guide	300	300	0	There was no difference for this item.
Food	750	640	+110	Using local cook and doing grocery from local market, we are able to save some fund which was used to buy some more reference books and for onsite transportation.
Accommodations	360	360	0	There was no difference for this item.
First Aid Kit	50	50	0	There was no difference for this item. Kits were donated to DFES, SUST, Bangladesh

On site transpiration	450	500	-50	We had to hire some day labours to assist in carrying instruments since some of our plots were too far away from road. The difference was adjusted from Food.
Transportation (Dhaka/Sylhet to study area)	220	220	0	There was no difference for this item.
Organizing workshops/seminars	600	600	0	There was no difference for this item.
TOTAL	**4965**	**4965**		

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

This project has set the starting point for studying the important relationship between tree diversity and carbon. The next immediate step would be to conduct similar research in other forest areas of Bangladesh to ascertain full potential of carbon storage of the forests. Another important step would be to conduct research to understand how ecosystem productivity is related to plant diversity in the forests of the country.

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

The RSG Foundation logo was displayed during the seminars (both at the beginning and at the end of the project) held at Shahjalal University of Science and Technology and the foundation was highly acknowledged for its support.

I will also use the logo for the formal outreach material sent to the policy makers, which is expected done in near future.

11. Please provide a full list of all the members of your team and briefly what was their role in the project.

12. Any other comments?

I sincerely thank The Rufford Foundation for its generous support. The project is very important for my country and an important achievement in my career. Apart from this, it gave me the opportunity to bring high-tech instruments from University of Toronto to Bangladesh and I was able to show my students at home institution how to use them. It was really an eye-opening experience for them. I am really thankful to RSGF for giving me this opportunity.