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	Bhanu Sridharan
Project title	Taking back the land: Factors aiding or constraining regeneration of damaged mangrove forests in the South Andaman Island
RSG reference	13037-1
Reporting period	
Amount of grant	£4936
Your email address	Bhanu.sridharan@gmail.com
Date of this report	December 15, 2014

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
Review of literature to identify major geological effects of the 2004 tsunami and earthquake				Using seismological studies published on the effects of the 2004 earthquake we have identified to major physical effects to mangroves in different parts of the Andaman Islands
Mapping of damaged mangrove forests in the South Andaman Region			X	We have mapped two major effects of the 2004 tsunami and earthquake 1) Subsidence in the South Andaman region in the Lohabarak Crocodile Sanctuary (PA), and the Wandoor region (non PA). Plots were set up in the Lohabarak Sanctuary to examine natural regeneration patterns in damaged mangrove forests 2) Upliftment and the Mayabunder area in Middle Andaman. This was not part of the original project plan but has yielded useful insights. Plots were set up in the Panighat creek region to examine natural regeneration patterns of damaged mangroves in the area. 3) We have also mapped areas in South Andaman region where mangroves historically existed but were cleared for agriculture during the 1970-1990 period. These areas now appear to have natural mangrove regeneration and could be important areas for mangrove restoration
Identifying regeneration patterns for different species			X	We set up a total of 45 circular plots (10 m radius) covering a total 14,130 m^2 area in the South and Middle Andaman Islands. Within these plots we counted the number of adult trees, saplings and seedlings of all true mangrove species, mangrove associates and littoral forest species. We have also measure canopy cover, tidal

				inundation, salinity and soil pH to understand which factors may influence regeneration of different mangrove plant species.
History of mangrove vegetation pre-tsunami			X	Using a census of dead tree species (by looking for standing dead trees) and interviews with local communities (supported by the Ravi Sankaran Inlaks Fellowship) we also created a history of dominant mangrove species before the tsunami and changes to regeneration patterns after. We are using this to create a before/after scenario to understand the effect of major natural disturbances to mangrove forests.
Monitoring sapling and seedling survival		X		We have also tagged over 300 individual seedlings and saplings of mangrove plants to understand their survival probability over a year (comprising different seasons) and to understand the effect of herbivory on different species. We are continuing to follow the survival of these tagged seedlings and saplings. We have recorded the mortality of over 100 individuals so far (~90% *Avicennia* seedlings). We are analysing this data now in the hope of finding useful information for improving nursery techniques for different species for afforestation.
Permanent plots for monitoring			X	Since natural plant regeneration is a long term process, we have also set up permanent plots in the Lohabarak Crocodile Sanctuary, where we hope to continue monitoring regeneration in order to understand what factors will be truly important to ensure successful restoration of mangrove vegetation.
Nursery experiments	X			As mentioned in our project update, nursery experiments to look at germination of different species had to be shelved until we had more information from the survival data and regeneration data. We hope to do this from monsoon season starting from April 2015 onwards with additional funding raised.

Outreach: workshops		X		We have engaged in the following outreach activities at the Andaman and Nicobar Environmental Team base: 1) Workshops for local public school children on the natural history of mangroves and their importance, including field trips to mangrove forest patches in the Wandoor area with the help of the Education Officer, ANET. 2) Workshops for Teacher's Training Institute, Port Blair on the importance of mangrove forests, natural history and techniques for teaching school children about local ecosystems.
Outreach: documentary film				A short film on the mangrove ecosystem in collaboration with ANET's scientific communication team, focussing on natural history to be translated into Hindi and Bengali for local school children to watch.

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

A major issue during the project was obtaining permits to work in the protected areas in the Andaman Islands. The local forest department was appeared to be going through some shift in personnel, leading to severe delays in permits. This was however overcome eventually, with permits now to work in two areas in the South and two in Middle/North Andaman islands. However this led to inordinate delays but we worked around it by sampling non-protected areas. But we hope to finish work in the protected areas by August 2015, as a comparison of human-influenced mangrove patches with relatively isolated patches (i.e. the PAs) will give us better understanding of what affects regeneration patterns.

Another issue we faced was that plot markers and tags used to follow seedlings and saplings on field were frequently tampered with, perhaps by local people passing through the mangrove patches. While we talked to people living adjacent to the mangrove patch, it was impossible to discuss the issue with the several people who visited the mangrove forest for fishing, or crab collection from other villages. Our only solution was to visit the sites regularly and check on plot markers and seedling tags.

One part of the project was to set up a long term monitoring programme with clear protocols designed, so that the local Forest Department as well as local NGOs like ANET would be able to continue monitoring mangrove forests in the Andamans. This took substantial time, as it was challenging to develop field methods which were both robust in

design as well as simple enough to be followed by non-field biologists (such as Forest Department ground staff). We dealt with this with a lot of trial and error and testing methods using volunteers who visited ANET.

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

The three most important outcomes of the project were:

1) Mapping changes caused by the 2004 earthquake and tsunami: We found that the 2004 earthquake had completely changed the topography of the region. North and Middle Andamans had undergone upliftment of land with drying out of large parts of the creeks and mangrove patches. South Andamans had undergone subsidence of land, leading to increased inundation in several parts of the mangrove forests which were drier earlier. In South Andamans, subsidence had also led to salt water inundation of several agricultural fields which were then abandoned. This has obvious implications for which mangrove species would die out and which would come back. Surprisingly although geological studies and surveys on mangrove plants in tsunami affected areas exist, no information on the effect of these topographic changes on vegetation has been available so far. Major consequences of change in sea-water inundation are: 1) areas that are more frequently inundated (South Andaman) are likely to be dominated by one or two mangrove species that are salt tolerant; and 2) in areas that have dried out due to upliftment mangrove plants are likely to be out-competed by freshwater littoral species.

2) Regeneration patterns in affected areas: In the context of the changes mentioned above, we assessed regeneration patterns in two distinct zones, Lohabarak in South Andamans, where mangroves have experienced subsidence and Mayabunder, in Middle/North Andamans where mangroves have experienced upliftment.

Lohabarak: Through local interviews and Google Earth images we found that several areas (of the Lohabarak and adjoining Wandoor region) that were dry pre-tsunami, had now subsided leading to greater sea water inundation. We counted and measured (girth and height) of 2000 plants belonging to 21 species of mangroves and mangrove associates, excluding ferns and creepers, in 30 plots in the Lohabarak Crocodile Sanctuary. A major difference since the 2004 event was that in areas close to the landward edge, which were previously dominated by littoral forest species such as *Exoceria alogacha, Heritiera littoralis* are now seeing:

1) Greater sea-water influx because of subsidence.
2) Primarily regeneration of *Rhizophora mucronata, R. apiculata* and *Avicennia officials. Rhizophora species* comprised ~30% of plant species measured, while *Avicennia* species comprised ~42% of all plants in Lohabarak.
3) *Rhizophora* and *Avicennia* species are believed to be typically highly tolerant of salt water and frequent inundation and appear to be dominating the South Andaman affected regions.

4) Conversely, *Bruguiera gymnorrhiza* a true mangrove species that is believed to be less tolerant to salt water and frequent inundation appears to have faced the most mortality in the region (~ 90% of the dead trees surveyed). Ninety-five percent of standing dead trees surveyed in Lohabarak comprised *Bruguiera gymnorrhiza.* We found only 11 adult *Bruguiera* trees in the 30 plots (9420 m^2) in the Lohabarak sanctuary and only 41 saplings in all.
5) This preliminary analysis indicates that in areas of South Andamans where sea-water influx is high, mangroves may be dominated by plants tolerant of frequent flushing and greater salinity, mainly *Avicennia officials and Rhizophora spp.* This could lead to a reduction in floral diversity in these parts.

Mayabunder: In North Andamans, we found the opposite:

1) Uplifted areas were completely dry, receiving no salt water.
2) Standing dead trees comprised of a mix of *Rhizophora species, Bruguiera gymnorrhiza* and *Ceriops tagal.*
3) Littoral forest species such *Exoceria alogacha* dominated new regeneration and appear to be replacing true mangrove species. This coupled with lack of sea water could be of significance to nutrient cycling and marine biodiversity in the area and also influence how local communities use mangrove forests.
4) *Bruguiera gymnorrhiza* was the dominant true mangrove species in the area and had the maximum regeneration in affected areas of North Andamans. *Rhizophora* species were restricted to the creeks while *Avicennia* species were rare (one adult individual in the sampled area).
5) The major finding from this North Andaman site is likely to be that affected mangrove areas are slowly shifting to a littoral forest ecosystem dominated by plants that compete better in freshwater and low salinity conditions. This could mean a reduction in mangrove area in the North.

The effect of environmental factors such as light/canopy cover, inundation and soil pH are likely to be nested within these broad patterns. We are conducting further analysis to tease these factors apart.

3) Setting up a long-term Mangrove Monitoring Programme: We also developed a long-term monitoring programme to track changes in the mangrove forests of Lohabarak Sanctuary with the help of visitors, volunteers and local field assistants in ANET. In order to do this we set up 21 permanent plots (a subset of the plots sampled for the project) and produced a user-friendly manual with the field methods for monitoring adult tree populations, survival of tagged saplings and seedlings as well as phenology patterns such as fruiting and flowering. We also hope to through this programme collect information on human use in this landscape over the next two years and hope to replicate this in North Andaman. [Soft copy of the Protocol is attached]

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

A part of our project involved interviews with local communities (jointly funded by the Ravi Sankaran Inlaks Fellowship). This involved talking to villagers of the Karen community (in Mayabunder), Ranchi community in Wandoor and Rutland and Bengali community in Wandoor. These discussions were immensely useful in helping create a historical profile of mangrove vegetation in Andamans pre-tsunami. In such regions where baseline data is scarce, local ecological knowledge has thus proven to be an ideal way of re-creating information on what past topography of the region, the dominant tree species pre-tsunami and changes post-tsunami. We also began a preliminary discussion with the Karen community in Mayabunder, about potentially setting up a monitoring programme in that region as well.

Apart from this we also conducted field based educational programmes for children from two local government schools in the region: the Bal Niketan School and Manglutan Municipality School to introduce them to mangrove ecosystems and natural history.

The project also depended heavily on local field assistants, particularly from the Karen and Ranchi community. Our primary field assistant Vishal Kujur, a young Ranchi from Rutland Island has now been trained to identify mangrove plants (including scientific names), use a GPS and camera and can conduct field work in most aspects of this study including measuring plant populations, soil salinity and soil pH. We believe that with continued involvement in the Mangrove Monitoring Programme, Vishal will become instrumental in training volunteers and other local assistants in the future.

5. Are there any plans to continue this work?

Yes we plan to continue this work by monitoring plots set up in Lohabarak and following tagged saplings and seedlings for a minimum of 2 years. We also hope to set up a similar monitoring programme in North Andamans in order to create complete baseline on natural regeneration patterns. We have also been identifying agricultural fields that were formed by clearing off mangrove forests. These fields now have natural regeneration happening and we hope to monitor these sites and test some planting and restoration techniques here from 2015. We also hope to study mangrove plantations set up by the local Forest Department as part of their restoration policies to identify their successes and failures. We hope raise funding for this part of the project through collaborations with the Forest Department and additional external funding.

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

The data collected over the past 13 months is currently being analysed and will be presented in the form of:

1) Manuscript to be submitted to an international scientific journal for the larger scientific community.
2) Power point presentations and a written report for the Forest Department.
3) Online portal (managed by ANET) where current information and data from further monitoring will be uploaded for other researchers and managers to use.
4) Presentations for student groups visiting ANET.
5) Popular articles highlighting the role of the mangrove ecosystems as well as the importance of scientifically tested restoration practices.

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

I received the Rufford Small Grant in February 2013, for a period of 18 months. I conducted my first recce in April 2013 and as notified previously, I started work in September 2013 in order to start after the monsoon period (May-August 2013). The project has been running from September 2013- November 2014. While we have been collecting data throughout this period on various aspects of the study; main regeneration plots were delayed by permit issues. However, as my proposed project period was for 18 months, the project duration has been more or less consistent. We hope to complete final analysis and detailed final report by February 2015, completing 18 months.

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
Airfare (To and from Bangalore- Port Blair)	182	340	158	Airfare prices went up considerably; also had to travel to mainland twice in the field period for personal reasons
Food and stay	1512	1528	-16	Food costs increased while traveling to the North Andaman region which was not part of the original field plan.
Local Travel (incl. bus fare, jeep, taxi and motorbike)	79	77	2	We travelled to field sites in North Andaman by hiring bikes (@ approx. £1 a day). Travel from base (ANET) to North Andaman by bus, travel from airport to base by taxi.
Field Assistant Wages	817	2045	-1235	Field assistant salary was originally budgeted for £45/month for one person. We had to however hire two

				field assistants; the wages also increased to £68/month since time of budgeting. However we made up for this by cutting out personal living expenses as I got a second grant from the Ravi Sankaran Inlaks Fellowship where I budgeted by living expenses.
Personal Expenses	1620	0	1620	See explanation above; £1235 from this item was spent on field assistant wages, while the remaining £125 were spent on education and outreach.
Equipment	526	190	336	We borrowed a GPS, salinometer and clinometer from ANET which were the major costs of the equipment list. We also found inexpensive models of pH meter which cut down on costs.
Medical expenses	200	**0**	200	No medical emergencies arose
Educational Workshops	0	340	-340	The workshops for school children from Bal Niketan School and Manglutan Municipality School– major costs were travel to the base at ANET and filed site of Lohabarak from Port Blair in a bus and food for the day for 25 participants (15 from Bal Niketan and 20 students' incl. two teachers from Manglutan Municipality School.
Documentary Film	0	380	-380	Expenses were to pay a film maker interning at ANET for working on the film for 4 months (@£56/month) and additional expenses such as travel costs, food and local assistants @ £ 150
Total	4936	4900	36	We have approximately £36 pounds remaining from the original budget, which we would like to give our field assistant Vishal Kujur as bonus for his excellent work.

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

As the primary goal of this study was to understand how natural regeneration of different species may inform restoration practices, the next step is to focus on current restoration practices.

1) One of our future goals is to document the methods used by the local Forest Department in mangrove restoration practices and determine if they are effective. As we build on the baseline data we have collected, we hope to also use information on current restoration practices to understand how human interventions can best mimic nature.
2) We also plan to conduct more practical restoration experiments to test the best methods for planting and ensuring survival of mangrove saplings and seedlings, specifically by trying planting techniques in the abandoned agricultural fields adjacent to the mangrove forests.
3) So far much of our work has focussed on South Andaman. We plan to survey more areas in the North Andaman region, particularly protected areas such as Interview Island which according to available remote sensing data has been badly affected. This might be even more important as, in affected areas in the north mangrove forests seem to be shifting to a littoral forest system. This change in ecosystem could be detrimental to local communities, especially in areas where mangroves have already undergone degradation caused by logging and encroachment.

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?

We used the Rufford Foundation logo in the protocol we designed to continue monitoring work with ANET. We also used the logo in the documentary film we made about the mangrove ecosystems [link provided separately]. In the future, we plan to use the logo for forest department presentations and all presentations to be made regarding the information generated by the project and for the online portals.

11. Any other comments?

We would like to thank the Rufford Foundation for supporting this project and helping us create some much needed baseline data on the effect of the 2004 tsunami and earthquake on mangrove forests in the remote Andaman Islands. We are also grateful for the leeway we have had with project timelines and delays in fieldwork.

ANNEX I

Tsunami affected areas in the Lohabarak Crocodile Sanctuary, South Andaman. Earthquake caused subsidence, led to increased inundation and mortality of mangrove trees like *Bruguiera gymnorrhiza* seen here.

Tsunami affected areas in the Panighat Creek, Mayabunder, North Andaman. Earthquake caused upliftment, led to creeks drying out, decreased inundation and mortality of species like *Rhizophora.* The area is now dominated by freshwater grass and littoral species like *Exoceria alogacha. Bruguiera gymnorrhiza* seen in the background, a mangrove plant with relatively low salt tolerance appears to have survived.

Paddy fields in South Andaman, submerged by the tsunami, now showing mangrove regeneration. Saplings of *Rhizophora sp.* can be seen.

ANNEX II

Local field assistants, Vishal Kujur (left hand side picture) measuring plant height in South Andaman Islands; Saw Thomas and Saw Isaac in Mayabunder.

ANNEX III

Permanent plots marked in Lohabarak; A *Ceriops tagal* sapling tagged and being followed in Lohabarak.

ANNEX IV

While *Bruguiera gymnorrhiza* seems to be facing the most mortality in South Andamans, in the Mayabunder area in North Andamans *B. gymnorrhiza* seems to be the only species surviving in affected areas.