The Rufford Small Grants 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	Sidhanand Kukrety
Project title	Ecological Restoration of Red Sanders (*Pterocarpus Santalinus L.*) Forests – an Adaptive Collaborative Modelling Supported Approach
RSG reference	5756-1
Reporting period	July 2010 to Dec 2011
Amount of grant	£4800
Your email address	sid.forester@gmail.com
Date of this report	December 29th 2011

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
Species Distribution Modelling (SDM)			Yes	1. Red sanders (RS, *Pterocarpus santalinus*) is an endemic and endangered timber tree species of southern India. Continued biotic pressure and illegal logging has severely impacted its distribution and growth. The true historic distribution of the species and the areas from where it has become extinct are not known. 2. Species distribution modelling can be used to identify the historic distribution of a species with reasonable accuracy. By comparing the predicted distribution with the known, the priority areas for restoration can be identified. 3. Data from various sources was imported into file GDB in ArcGIS and then processed to prepare ASCII files with model builder. All the data layers were projected to WGS1984, resampled to same cell size and clipped to the study area. The Digital Elevation Models (DEM) of different regions were mosaicked to Study area and processed to remove sinks. Slope and Aspect layers were developed from the final DEM layer. The variable files and sample data was imported into MaxEnt (Maximum Entropy: Phillips et al. 2004) for developing a distribution model. The results (ascii files) from MaxEnt were then imported into ArcGIS and reclassified. Further analysis was completed by incorporating presence data and the present known extent of red sanders. 4. For modelling species distribution of red sanders 25 variables were used. Out of 19 WorldClim variables, only eight were found to be significant. The land cover, aspect and slope variables were not significant. Soil data was found to be too coarse to be used; hence rejected. The distribution of red sanders was found to be dependent on temperature and precipitation variables. Results show that the variables were able to predict the distribution of species in southern India to a significant extent. 5. The species distribution model predicted shrinkage in the overall extent and area under red sanders. The model predicts historic presence of red sanders in northern Tamil Nadu and north-eastern Karnataka. 6. With the help of the historic distribution map, the restoration of this endangered species can be done in

				the areas where from the species has become locally extinct. For details please see Figure 1 in Annexure 1.
Facilitating Red sanders regeneration - Identification of Best Restoration Technique			Yes	1. This objective evaluated the effect of silvicultural treatments on survival and growth of red sanders seedlings in an effort to enhance the overstory establishment. 2. Using randomised complete block design, this study evaluates the effect of silvicultural treatments involving prescribed fire (PB), in combination with disking (DPB), singling (SPB), and singling plus disking (SDPB) and control (NT) on survival and growth on young regeneration. 3. Data collected were analysed for seedling survival and height, root collar diameter (RCD) and volume growth. Results indicate significantly positive effect of silvicultural treatments on survival and growth. Seedlings with fewer coppice shoots showed better survival and DPB treatment resulted in maximum overall (96%) survival. 4. Seedlings accrued maximum RCD (0.68 cm) and volume (42 cm^3) growth with SDPB treatment which was 85% and 97% more than the control. Seedlings with SPB treatment gained a maximum 42% (21 cm) height relative to control. 5. Tall and larger stump size seedlings experienced better height and volume growth with SPB and SDPB treatments respectively. 6. The number of coppice shoots did not have any clear impact on growth. However, number and height of neighbouring seedlings and trees also influenced seedling survival and growth. 7. Although, DPB and SDPB treatments showed similar performance, SDPB treatment was identified as a better option for improving establishment of advance regeneration. In dense regeneration areas preferential treatment of the taller and larger stump-sized seedlings and, in limited regeneration areas that of smaller seedlings may yield better results. 8. Additionally, removal of congestion and canopy opening may also help establishment of young regeneration. For details please see Table 1 and Table 2 in Annexure 1.
Stakeholder's perception Analysis			Yes	1. In this study, I applied Analytic Hierarchy Process (AHP) to elicit stakeholders' preference for the most appropriate restoration management strategy in Andhra Pradesh (AP). 2. Amongst stakeholder groups, I used Analytic Hierarchy Process to analyse perceptions of four key stakeholder

				groups i.e., Administrators, Field Officers, Community, and NGO and Academia to identify the most suitable management option from Government Management (GM), Quasi-Government Management (QGM), Community Forest Management (CFM) and Private Management (PM). 3. Results indicate that stakeholder groups' preferences for management options were not homogeneous. While the Administrators (35%) and Field Officers (36%) favoured GM, the Community (36%) and Knowledgeable Sources (50%) preferred CFM. 4. Consolidated priorities of all stakeholder groups indicate CFM as the most preferred choice (34%), followed by GM (31%). With an average weight of 56%, Ecological criterion was chosen as the most important criteria followed by economic (25%). 5. The ability of the management in Reducing Disturbances (23%), Improving RS Density (18%), Improving Ecosystem Services (15%), and Improving Livelihoods (15%) were considered important. 6. The preference of Administrators and Field Officers for GM reflects their support for top-down approach of management and scepticism about CFM, a bottom-up approach. Compared to Administrators, the Field officers' lack of support for CFM was surprisingly more pronounced. 7. The NGO and academia's preferences indicated high social and ecological awareness. Incorporation of stakeholders' preferences in restoration planning can help in improving coordination among the stakeholder groups and management, thereby improving the success of the endeavour. For details please see Figure 2 and Figure 3 in Annexure 1

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

None.

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

The three most important outcomes of the projects are:

a. Our results indicate the shrinkage in area under red sanders distribution. The resource managers can use this information for initiating restoration of this species in its erstwhile distribution areas.

b. Other than restoring the area under red sanders distribution, there is an identified need to restore the degraded red sanders forests. The techniques identified can be successfully used for restoration. Our results indicate that the survival and growth of young red sanders seedlings can be successfully improved by using singling with prescribed burn treatment.
c. Red sanders is an endangered species and the management of these forests is entirely under the control of government agencies. The other management options for these forests are often ignored. Stakeholder analysis results indicate that Community Forest Management (CFM) is a more acceptable option as compared to government management.

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

This study is exploratory in nature and there were no direct benefits for the communities from this project. However, the study results indicate that managing these forests through community participation can create opportunities for local livelihoods. The future restoration if taken up under community forest management has potential of improving economic and ecological benefits for the communities and therefore community ownership.

5. Are there any plans to continue this work?

Yes. I plan to extend this study with actual restoration of red sanders forests in Andhra Pradesh. Restoration of these forests is essential for the economic well-being of the community on one hand and for ecological biodiversity on the other. Towards this I would like to submit second small grant proposal in due course.

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

The results of this study are available on public domain as part of my doctoral dissertation and are also submitted to reputed international journals which will be available to the resource managers and restoration practitioners worldwide.

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

This RSG was used for 18 months from July 2010 to December 2011. The actual study period for one part of the project; ecological objective takes a longer duration (36 months or more) due to treatment effects.

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
Field Trial	1500.00	1510.20	+10.20	Minor difference due to change in exchange and wage rates
Equipment	940.00	861.45	-78.55	Savings; as per actual
Local transport	895.00	930.00	+35.00	Minor increase due to increased fuel prices

Books, Printing, Stationary and misc.	300.00	340.00	+40.00	Minor increase in incidentals
Conference/ Student activity fee	225.00	304.35	+79.35	As per actual
Subsistence allowance	940.00	854.00	-86.00	Saved for attending conference
TOTAL	**4800.00**	**4800.00**	**0.00**	* All figures in £ sterling; Exchange Rate used (1 £ sterling = USD 1.29 = INR 73)

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

The next logical step is to take appropriate steps to improve community ownership of the red sanders forests. Towards this in addition to improving the use value of the public forests, appropriate steps towards promotion of non-destructive harvest of non-timber forest produce are needed. Besides, there is need to research seed ecology and expansion of the species in its erstwhile areas.

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

Yes. I used the RSGF logo in my doctoral dissertation defence presentation and at the International Symposium on Society and Resource Management, Madison, Wisconsin, USA held on 4-8 June 20, 2011. Besides, I have acknowledged the RSGF in the research papers submitted to the following journals.

1. Kukrety, S., Gezan, S., Jose, S., Alavalapati, J.R.R., 2011. Facilitating regeneration of *Pterocarpus santalinus L.* - An Endangered Tree Species from India, Restoration Ecology (under review)

2. Kukrety, S., Dwivedi, P., Alavalapati, J. R. R., 2011. Red Sanders *(Pterocarpus santalinus L.)* Restoration in India: Exploring Stakeholders' Perceptions about Management Options. Restoration Ecology (under review)

3. Kukrety, S., Jose, S., 2011. Status of Endangered Red Sanders *(Pterocarpus santalinus L.)* – Species Distributional Modeling approach (under preparation)

11. Any other comments?

I have enclosed the results of the study as tables and figures in Annexure 1. Further details on red sanders and on objective 2 of the study are available at http://gradworks.umi.com/34/67/3467629.html

ANNEXURE 1.

Table 1. Results for survival and growth study analyses

Source[#]	Degrees of Freedom	Variable (P > F)			
		Survival*	D_Ht	D_RCD	D_VOL
Block	3	-	0.009	< 0.001	0.003
N_Cop	1	0.056	< 0.001	-	0.007
RCD0	1	-	< 0.001	-	-
Ht0	1	-	-	< 0.001	< 0.001
N_Trees	1	-	< 0.001	0.006	0.084
N_Others	1	-	0.002	-	-
Ht_Others	1	0.039	0.042	-	0.322
Trt	4	0.008	< 0.001	< 0.001	< 0.001
Ht0*Trt	4	-	-	< 0.001	0.027
Ht_Others*Trt	4	0.007			
N_Trees*Trt	4	-	0.003	-	-
Block*Trt	(15[†]) 12	0.397	0.004	0.237	0.255

[#] Only the variables in the final model are displayed. The blank (-) denotes absence from the model. [†]Degrees of freedom for the survival study. * Survival variables are plot level averages. D_Ht = Height growth, D_RCD = root collar diameter growth, D_VOL = Volume growth, N_Cop = number of coppice shoots, RCD0 = initial root collar diameter, Ht0 = initial height, N_Trees = number of trees in the plot, DBH_trees = diameter at breast height for trees, N_Others = number of other seedlings in the plot, Ht_Others = height of other seedlings, and Trt = Treatment factor.

Table 2. Mean (± SE) results for survival and growth with different treatments

Treatments	Survival proportion	D_Ht (cm)	D_RCD (cm)	D_Vol (cm^3)
NT	0.82 ± 0.04	14.65 ± 0.73	0.37 ± 0.02	21.43 ± 1.49
PB	0.87 ± 0.03	16.59 ± 0.73	0.46 ± 0.02	24.23 ± 1.63
DPB	0.96 ± 0.02	17.92 ± 0.76	0.66 ± 0.03	40.03 ± 2.66
SPB	0.81 ± 0.04	20.87 ± 1.09	0.61 ± 0.03	36.73 ± 2.62
SDPB	0.94 ± 0.02	19.21 ± 0.86	0.68 ± 0.03	42.30 ± 2.82

D_Ht = Height growth, D_RCD = root collar diameter growth, D_VOL = Volume growth, NT = no treatment, PB = prescribed burn, DPB = disking with prescribed burn, SPB = singling with prescribed burn, and SDPB = singling plus disking with prescribed burn.

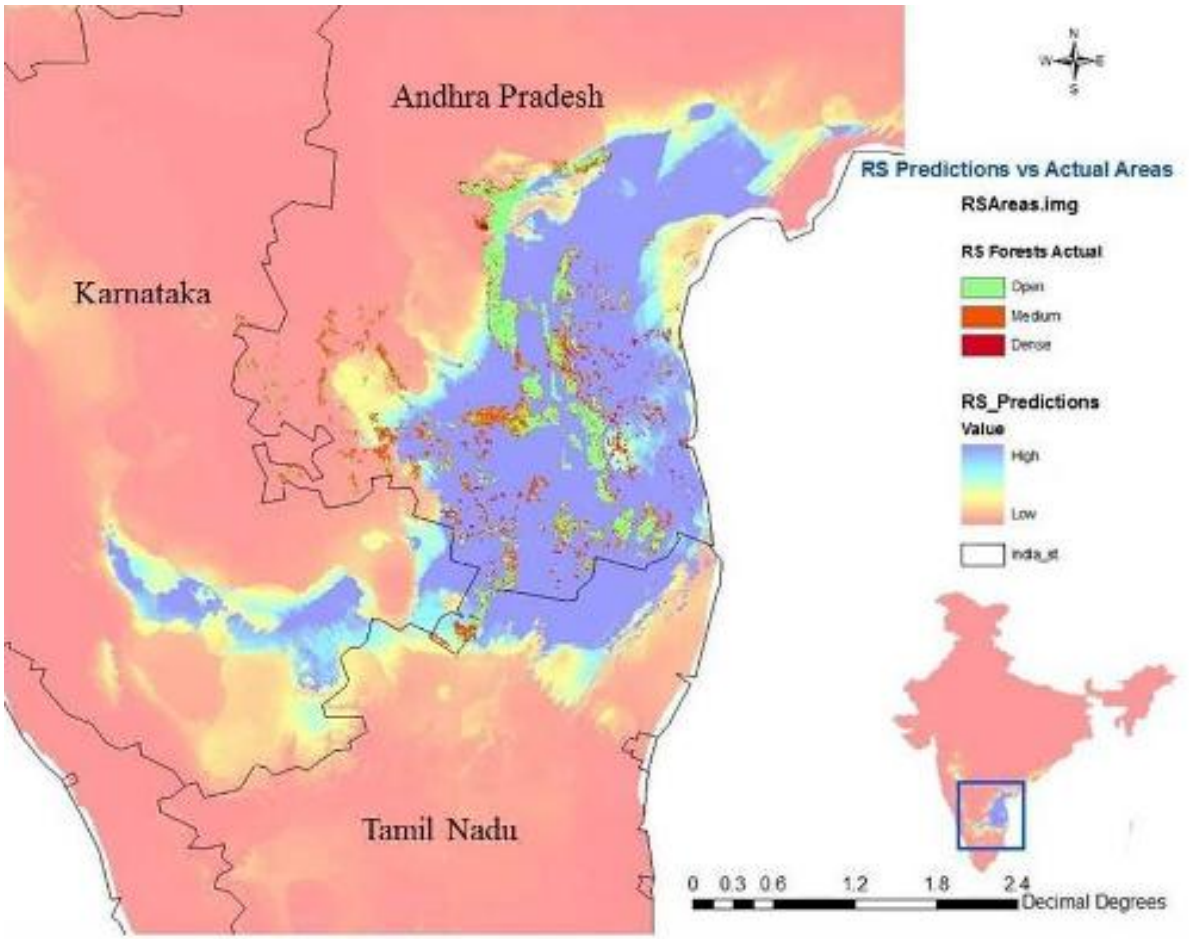

Figure 1. Historical areas predicted by MaxEnt Model. The darker blue areas are areas with high probability, whereas the pink refers to areas with low probability of Red sanders occurrence. The actual area under Red sanders is overlaid on the model result.

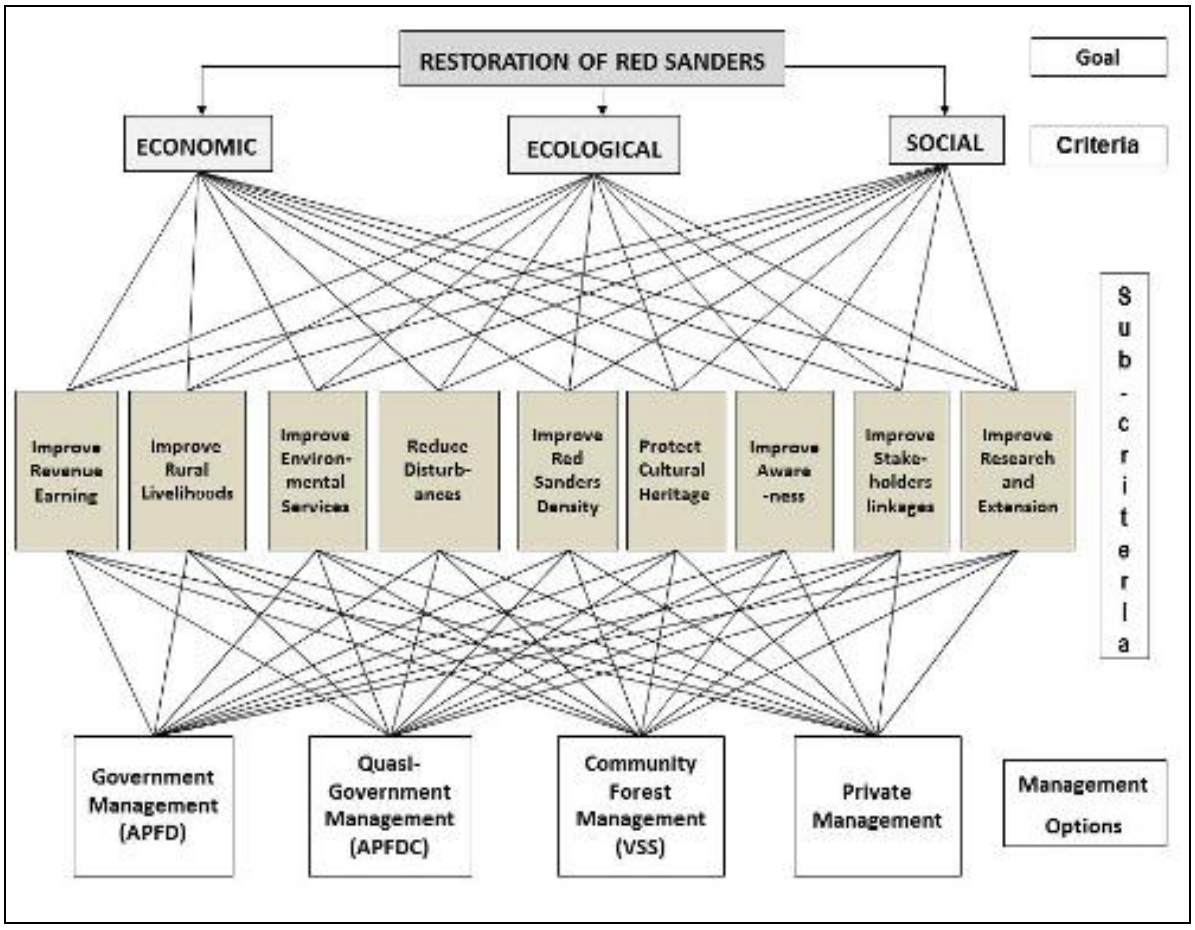

Figure 2. Analytic Hierarchy Process – Hierarchy used for identification of best management option

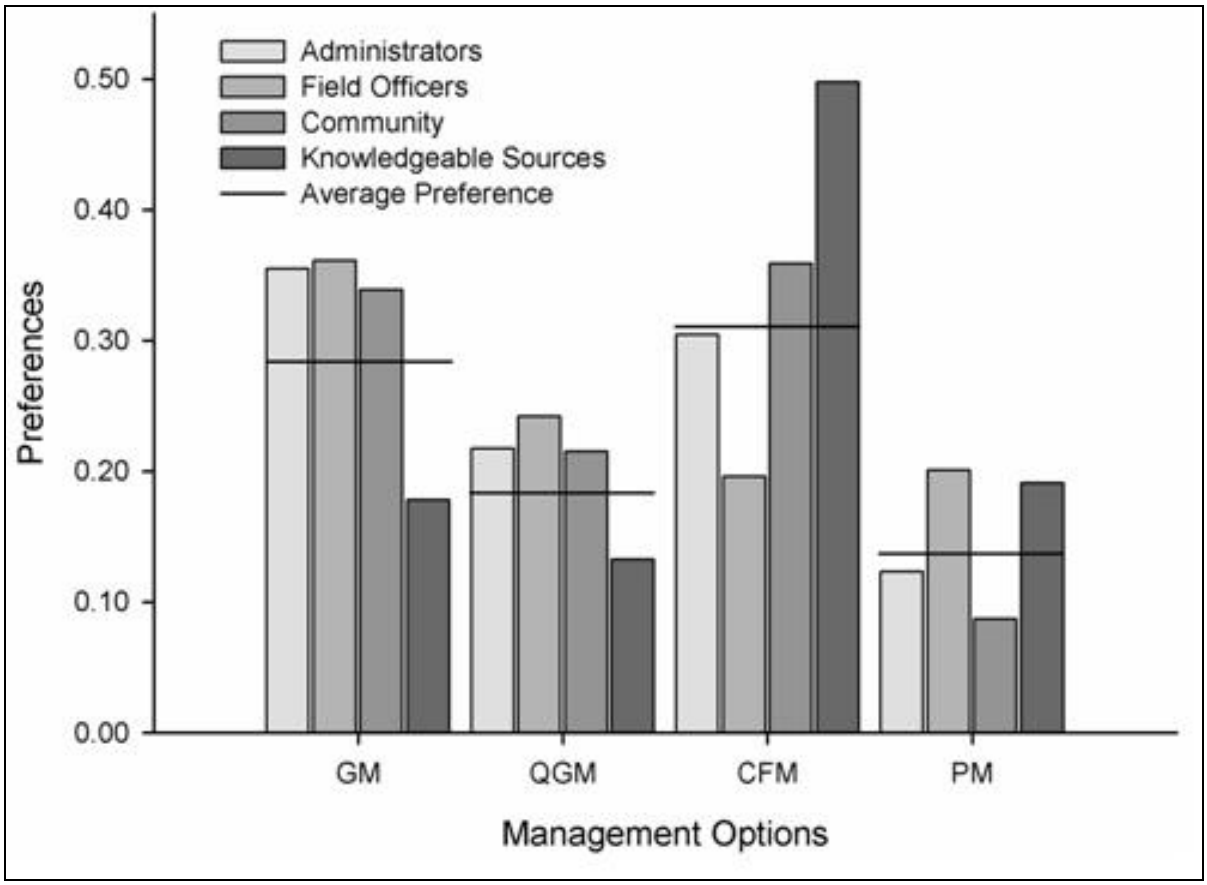

Figure 3. Stakeholders preference for management options (GM: Government Management, QGM: Quasi-Government Management, CFM: Community Forest Management, PM: Private Management, Knowledgement sources = NGOs and Academia)