Final Evaluation Report

Your Details	
Full Name	Rubin Sagar
Project Title	Tropical Forest Conservation: Evaluating the impact of anthropogenic disturbance in the canopies of tropical forests in southern Western Ghats, India
Application ID	29821-1
Date of this Report	23-08-2022

1. 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
Study and highlight sensitivity of canopy biodiversity to physiological changes arising from forest disturbance			■	
Deriving a critical light factor	■			Within the tight budget and timelines, we faced a trade-off of collecting data for more trees and covering a greater area vs studying fewer trees over a smaller area. We chose the former based on the objectives presented in the project proposal. Hence, the density and amount of light data per tree we could collect was insufficient to notice a particular light/disturbance level beyond which species communities are negatively affected. We underestimated the amount of data required to achieve this objective.
Publishing plan			■	The work was published in Frontiers in Forests and Global Change, a leading international journal in the subject. The work was also presented in the Association for Tropical Biology and Conservation (ATBC) conference in 2021.
Training local youth and government staff		■		We trained two local early career professionals in conducting the fieldwork, using equipment, identifying local epiphyte and beetle species, etc. We are working on liaising with the State Forest Department to train their staff. It is unlikely that this will happen anytime soon, owing to changes in the Forest Department's policies and functioning post-Covid 19.

2. Describe the three most important outcomes of your project.

a). 1. The canopy microclimate differs between primary forests and secondary forests.

The mean daily canopy temperature of all the trees from the sites in each forest type, was significantly higher in the disturbed forest (mean ± SD: 19.4°C ± 2.58°C vs 20.5°C ± 3.04°C; t-test $p < 0.01$; df = 34). The mean hourly canopy temperature was consistently higher for the disturbed forest (Figure 1). The mean daily canopy light intensity was also higher in the disturbed forest, but not significant (mean ± SD: 7670 ± 12424 Lux in the primary forest vs 8862 ± 11686 Lux in the secondary forest; t-test $p > 0.05$, df = 33). Unlike temperature, the light intensity of the disturbed forest was not higher for all hours of the day (Figure 2).

The frequency of temperatures and light intensity for each sampled tree were consistent with the above findings (Figure 3). Lower temperatures were more frequent in the primary forest, as compared to the secondary forest (Figure 3a). The difference in the frequency of the hourly mean temperatures was significant (Fisher's exact test p-value = 1e-04, based on 9999 Monte-Carlo replicates). Although the light intensity does not vary as dramatically, the difference in the frequency of the hourly mean light intensities was also significant (Fisher's exact test p-value = 0.0324, based on 9999 Monte-Carlo replicates).

b). 2. Beetle and epiphyte communities differed between primary and secondary forest canopies.

We obtained 175 beetle individuals (mean ± SD: 2.6 ± 2.3 individuals per crown-tree in the primary forest; 7.1 ± 5.7 individuals per crown-tree in the secondary forest). 161 individuals were identified in 18 families, however, the family for 14 individuals could not be identified. Also, a total of 66 beetle morphospecies were identified. We collected 28 beetle morphospecies from the primary forest and 49 beetle morphospecies from the secondary forest in our samples. Of the 66 morphospecies, 47 beetle morphospecies were singletons. 11 (16.67%) beetle morphospecies were found in both forest types, whereas 17 (25.75%) were unique to the primary forest and 38 (57.57%) were unique to the secondary forest. The five most abundant families (abundance, relative abundance), with a relative abundance greater than 5% were Mordellidae (63, 36%), Nitidulidae (31, 17.7%), Staphylinidae (13, 7.4%), Elateridae (10, 5.7%) and Chrysomelidae (9, 5.14%). There was one morphospecies in the Mordellidae family, with 56 individuals found in the secondary forest, and seven individuals in the primary forest. Similarly, we found more Elateridae and Chrysomelidae individuals in the secondary forest. Nitidulidae and Staphylinidae abundances were similar in both forest types.

We also found approximately 2720 vascular epiphyte individuals (mean ± SD: 104.5 ± 241.05 individuals per crown-tree in the primary forest; 46.83 ± 104.42 individuals per crown-tree in the secondary forest). The most abundant epiphyte genera (abundance, relative abundance) were *Eria* sp. (Orchidaceae) (1320, 48.45%), *Bulbophyllum* sp.1 (Orchidaceae) (980, 35.97%) and *Bulbophyllum* sp.2 (Orchidaceae) (265, 9.72%). Among these, *Eria* sp. and *Bulbophyllum* sp.2 were largely absent from the secondary forest, except for one tree (D3T1). Whereas

Bulbophyllum sp.1 was more abundant in the secondary forest, but their abundance was exceptionally high in one tree.

c). 3. The differential microclimatic conditions (light, temperature or the combination of light and temperature) are not the factors that explain the differences in the beetle or epiphyte communities.

Beetle communities showed a significant level of dissimilarity between the forest types, but the epiphyte communities did not differ significantly.

The Bray Curtis dissimilarity index was 0.76 for beetle communities and 0.69 for the epiphyte communities between the primary and secondary forest. The NMDS analysis divided the beetle communities in the primary and secondary forests into distinct clusters (Figure 4A) with a stress value less than 0.01. Further analysis performed using an ANOSIM test resulted in a statistically significant, but with a low level of dissimilarity (ANOSIM statistic R: 0.3169, $p = 2e{-}04$). The Betadisper analysis followed by ANOVA showed significant differences in the dispersion of beetles ($F = 9.239$, $P = 0.0049$) indicating greater heterogeneity in beetle communities between the forest types. For the vascular epiphyte communities, the NMDS analysis showed a high degree of overlap with a stress value of less than 0.01. The ANOSIM test resulted in values indicating similar vascular epiphyte communities in the primary and secondary forest (ANOSIM statistic R: 0.0163, $p = 0.2804$). Additionally, the Betadisper analysis followed by ANOVA did not show significant differences in the dispersion of epiphytes in the two forest types ($F = 1.7289$, $P = 0.201$) also indicating similar communities.

The temperature and light may be contributing factors to explain the differences in beetle communities, but in combination other factors such as forest structure and relative humidity. Our design limited the observations to light and temperature.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

The most significant unforeseen difficulty was the onset and rise of Covid-19. Restrictions due to Covid-19 were enforced in March 2020, which was soon after the receipt of the award. As discussed via email with the administration and trustees of The Rufford Foundation, we had to postpone the commencement of fieldwork by 9-10 months due to travel restrictions, as well as restrictions to access the field site, being a protected area.

Nonetheless, we were determined and saw an opportunity to travel and commence work in February 2020. We began data collection in early March 2020. However, the drastic rise in Covid-19 cases in April 2020 forced us to cease the data collection and continue with the data we had. June – August is the monsoon season, and fieldwork was not possible during those months.

4. Describe the involvement of local communities and how they have benefitted from the project.

The role of local communities is very important in conservation, particularly when they are dependent on the forest area and/or reside within the forest, protecting key species or areas which are not protected by the government, providing incentives for forest management, inclusion of traditional ecological knowledge, etc. However, the communities residing in the vicinity of ATREE's sites primarily work in the tea estates within KMTR. There is little dependence on the forests, and certain areas of the forest are formally protected by the government, which has prevented access by the few remnant communities that reside in the forest. Also, most communities were relocated a few decades ago. Hence, most villages are situated outside the reserve.

The approach of this project was based on conservation physiology, which used research as an evidence base primarily for conservation action and management. There was no focus on a particular species, monetary benefits for incentivising community-based conservation, or dependence on traditional knowledge. Hence, the proposal did not specify engagement with local communities at this stage to achieve conservation. However, we recruited two local early career professionals as research assistants for the project, which has contributed to their training and education.

5. Are there any plans to continue this work?

There are no immediate plans to continue this work.

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

The research and findings were presented as a talk at the Association for Tropical Biology and Conservation (ATBC) Virtual Conference 2021. It is one of the most prominent international bodies concerned with science, conservation, development, and environmental policy in the tropics.

The talk can be found here: https://youtu.be/caMtHb7ZiQc

Further, the research has led to a manuscript published by "Frontiers in Forests and Global Change" and can be found here:
https://www.frontiersin.org/articles/10.3389/ffgc.2022.734448/full

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

Our short-term study provides an insight into the microclimatic differences between primary and secondary tropical wet forest canopies, a first for the southern Western Ghats. Further, we provide an important baseline for future research on beetles in the region. Looking ahead, long-term studies on seasonal fluctuations in beetle communities, comparisons with trends in canopy tree phenology and the role of crown structure should reveal much more about the ecology of beetles in tropical wet forests.

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

Yes, the logo was used in the presentation for the ATBC 2021 conference (as a recorded video) and has been uploaded to YouTube.com.

9. Provide a full list of all the members of your team and their role in the project.

Dr M. Soubadra Devy – Advised and supervised the entire project and led liaisons with the Forest Department.

Mr Tamizhazhagan – Field expert employed by ATREE who trained us and provided his invaluable assistance throughout the project owing to his deep knowledge of the local biodiversity, techniques, walking routes and much more.

Mr Satheesh and **Mr Mahesh Poomani –** Field Assistants who immensely contributed with the data collection.

10. Any other comments?