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	Xavier Arnan
Project title	Chronic anthropogenic disturbance in the Caatinga: effects on ant-mediated ecosystem services and their vulnerability to climate change
RSG reference	17372-1
Reporting period	June 2015 – December 2016
Amount of grant	£4985
Your email address	x.arnan@creaf.uab.es; xavi.arnan@gmail.com
Date of this report	13/01/2017

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
To characterise chronic anthropogenic disturbance (CAD) along the Park and summarise disturbance information in a global disturbance index				
To measure the diversity of ecosystem services provided by ants in relation to seed dispersal and anti-herbivory plant protection as well as their vulnerability (measured as functional redundancy and response diversity) to climate change				
To contribute to the global understanding of the effects of CAD on: a) the ecosystem services provided by ants (seed dispersal, plant protection); and b) the vulnerability of these ecosystem services to future disturbances related to climate change.				
To contribute to fill up the gap in knowledge on the effects of CAD on biodiversity and the associated ecosystem services in semiarid ecosystems (particularly the Caatinga)				
To educate local communities about the importance of insects, and particularly ants, for ecosystem processes, and how human activity can compromise them				I say partially because although we made a great effort in this direction and we try to reach as many people as possible, the Park is huge and we could not get everyone
To generate a public debate between researchers, local managers and local				

communities about what is the best sustainable way to exploit the Caatinga, so that people can continue to live in, without damaging its diversity and associated functions				

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

We were not able to establish 30 plots due to logistic problems. Instead, we established 20 plots. This was offset by characterising disturbance very intensively in these plots which were very well distributed throughout the disturbance gradient.

We could not sample interactions between ants and domatias as well as between plants, ants and sap-feeding Homoptera because they were very rare in the study area, which did not allow to perform robust statistical analyses. So, we only analysed data in relation to ant-seed and ant-extra-floral nectaries bearing plants interactions; however, the scarcity of ant-domatia and plant-sap-feeding Hompotera-ants interactions in the Park is already a relevant finding.

We could not measure thermal tolerance (at least with a good replication) for all ant species involved in seed dispersal or plant protection services. Alternatively, we properly characterised the thermal tolerance for 21 ant species, and from them we build a predictive model (from the relationship between physiological thermal tolerance and morphological traits) that help predicting thermal tolerance for the remaining ant species

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

We have intensively characterised the chronic anthropogenic disturbance regime in the park. This information was of great value for this project, and for sure it will be for other related projects that are (or will be) conducted in the Catimbau National Park. Thus, by means of remote sensing techniques, interviews with local communities, and direct measurements of the factors causing disturbance in the field, we identified and characterised the three main sources of disturbance in the park: 1) Grazing pressure (goats and cattle herbivory); 2) Wood extraction (alive wood and coarse woody debris extraction); and 3) Extraction of non-timber forest products (medicinal plants, animal and human foods, and hunting). We then summarised all disturbance data in different indices from different levels of data integration, from single disturbance metrics, to multi-metric indices accounting for each source of disturbance, and finally, a global multi-metric index that integrates all sources of disturbance. We can highlight that the different disturbance sources are heterogeneously distributed across the Park, in the manner that some of them spatially overlap while others do not. It is worth noting that virtually conserved areas were not found.

In general, anthropogenic chronic disturbance did not affect the number of ant species that perform important ecosystem services, such as seed dispersal and anti-herbivory plant protection, nor the diversity of ant functional groups related to these services. However, disturbance modified the identity of the species that provided these functions along the disturbance gradient. Interestingly, we found that disturbance altered the vulnerability of these ant-mediated ecosystem services to future disturbances related to climate change. But surprisingly, we found opposite effects: disturbance increased and reduced vulnerability of seed dispersal and plant protection services, respectively. However, we must be cautious before drawing wrong conclusions in terms of conservation for plant protection services. Since there is an important species turnover from less to more disturbed areas, we still need to know how is the quality of the service provided by ant disturbance-winner and disturbance-loser species (which was out of the scope of this project). Such a replacement of ant species would assure or even improve functionality, although they might not guarantee the quality of the service. As a rule, the most disturbed areas are dominated by generalist species, and we know from literature they usually perform the worst quality services. We also found that the most relevant sources of disturbance were grazing pressure and wood extraction. Particularly, the vulnerability of seed dispersal services was mainly affected by goat herbivory, while the vulnerability of plant protection services was mainly affected by cattle herbivory. As regards wood extraction, the extraction of coarse wood debris was not relevant, and only the extraction of alive wood by humans affected plant community vulnerability to future disturbances related to climate change.

Creation of educational materials in non-technical language to get closer to local communities of the area. Particularly, we made the following educational materials: a) a comic about leaf-cutting ants and their importance for ecosystem functionality; b) a nice poster that showed our main results; c) a mock-up about the Caatinga that was an exact replica in miniature of the park, which local people can feel identified with, and which reproduce the main ecological processes that take place in relation to human disturbance; and d) a giant board game (called 'A Fortuna da Caatinga') where participants must answer questions and pass tests related to chronic anthropogenic disturbances and biodiversity conservation in the Caatinga, paying special attention to ants and their mediated ecosystem services.

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

Local communities were directly involved in this project in different ways. On the one hand, their help in our field work was essential: a) interviews with them were crucial to properly characterise the disturbance regime in our plots; b) they gave to us permission to work in their lands; and c) they were our guides to get some remote plots. The fact of involving them in our work it was already a first step to introduce them the importance of biodiversity conservation in the caatinga for their persistence and welfare. On the other hand, we organized two activities with local communities that had the dual role of dissemination of our research in the park and preliminary results as well as raising awareness and mobilise people for biodiversity conservation. The first activity was conducted in the school 'Escola Municipal

Antônio Sampaio' in Buíque (the main town within the Park), on 6th December 2016. Throughout the whole day there were activities that involved more than 50 students from 10 to 14 years. These activities consist in listening songs that refer to the biodiversity of the caatinga, playing a board game about biodiversity conservation in the caatinga, and interpreting a mock-up that symbolised the park and the most important ecological processes that take place in relation to human actions. With these activities, together with some educational materials we distributed, we stimulated students to a) identify the caatinga as an endemic ecosystem and recognize the main physical characteristics as well as the typical fauna and flora; and b) understand how anthropogenic activities modify the semi-arid environment, and how organisms respond to these modifications. We aimed to raise awareness about the importance of biodiversity and ecological interactions for the maintenance of life, paying special attention to ants which are important for the maintenance and functioning of many basic ecosystem services. The next day, we organized a public debate open to everyone in the same school that was attended by about 30 people, among whom there were researchers, park managers, park guides and park residents (highlighting the leaders of the main indigenous communities of the area). In this event, we first presented the research we are doing in the park and some preliminary results; and second, we generated an interesting debate involving all participants about the importance of our research in the park and the benefits they can get from it, as well as on what is the best sustainable way to use the caatinga, so that people can continue living in there without damaging its diversity and associated functions. We understand the importance of disseminating our knowledge about the park among people living within the conservation unit, and we agree that sharing the information generated by this study with local people may be an effective biodiversity conservation strategy for the park biodiversity. We are very pleased about the inputs received in these activities. For sure that local residents have become aware of the importance of many organisms, at least ants, for the maintenance of a healthy caatinga, which they depend on for persistence. And we hope park managers took note to take the best decisions to guide local conservation policies for mitigating the negative effects of disturbance on biodiversity, ecosystem functioning and stability.

5. Are there any plans to continue this work?

Yes. We are planning to a) quantify the quality of the functions (i.e. seed dispersal and anti-herbivory protection) that different ant species provide; b) sample real controls, i.e. conserved or very few disturbed areas, the closest we can get from our study area. This is important to get more robust conclusions from our study, since the Park is somehow disturbed everywhere; and c) analyse the effects of disturbance on biodiversity and ecosystem services vulnerability with experimental designs that allow us to make more precise predictions. For example, we are planning to perform herbivore exclusion experiments, so we will be able to compare paired plots with and without the effects of herbivory.

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

I plan to share the results of my project by means of: a) One or two scientific publications in SCI conservation biology journals; b) Presentations in national and international conservation meetings; c) Publications of one article in popular journals involved in nature conservation; d) Technical reports for the direct transfer of the results to the land managers at the different levels of administration of the national park and other regional and national authorities; e) Publication of informative material with the main results adapted to a public language (already done); and f) A workshop\meeting where researchers, managers and park residents participated (already done).

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

According to the project proposal, the RSG was used between June 2015 to December 2016. The resources from the RSG started to be used in June 2015 when we established the plots at field and characterised the chronic disturbance intensity, and ended up covering the costs of the activities of results disseminations we performed with local communities in December 2016.

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 work	662	877	+215	We used money we saved from the Heat Bath (see below) to cover the high costs of field work
Field assistant	1030	1230	+200	We used money we saved from the Heat Bath (see below) to cover the high costs of field work
Fuel	1316	1316	0	Fully spent
Sampling and lab materials (ethanol, eppendorfs, others)	386	386	0	Fully spent
1 Notebook HP 14-D030BR Intel Corei 54GB HD500GB, Led 14" DVD-RW Windows 8	460	560	+100	Given the budgeted amount was lower than the actual price of the notebook when we brought it, we also spent some of the money we saved from the Heath Bath
8x6 Thermal-Lok Dry Heat Bath	515	0	-515	This device used to perform the measures of

				maximum thermal tolerance was already bought with money from another project when the project started because we needed it for other related works; this amount was thus used to cover the high costs of field work
8x6 Thermal-Lok Dry Heat Bath	230	230	0	Fully spent
Edition of information material for public use	386	386	0	Fully spent
Total	**4985**	**4985**	**0**	

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

Related to this project, the most important steps are: a) Since our study area (Catimbau National Park) is indeed very disturbed everywhere, we really need to find real controls for our experimental design (that is, caatinga very conserved areas close to our study area) and sample there following the same protocol; b) To quantify the quality of the functions (i.e. seed dispersal and anti-herbivory protection) that different ant species provide; and c) To establish predictive and precise models by integrating all data that allow to establish the disturbance thresholds before the system collapse. This is very important in order to take decisions on which activities can be done and where they can be done without putting the stability of the system in risk. For example, how many goats they can rise? Which are the better areas where they can grace? How do the different sources of human disturbance interact in space and time? How do the different sources of disturbance interact with climate? Are the driest and most disturbed areas the most vulnerable ones?

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?

Yes, I did. The RSGF logo appears in the didactic materials we prepared (i.e. the poster and the ant comic) and distributed among local communities. The RSGF logo was also used in presentations we did in internal seminars in our institution (UFPE) and in a talk I gave at the 'XXII Simpósio de Mirmecología – An International ant meeting' that took place in Ilhéus (Brazil) in October 2016. Finally, we made special mention to the RSGF in the activities we did with local communities, in the way we highlighted that these activities and part of our research would not be possible without the RSGF support.