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	Leandro Alécio dos Santos Abade
Project title	Informing conservation planning and conflict mitigation strategies by assessing determinants of large carnivore presence across Tanzania's Ruaha landscape
RSG reference	19515-1
Reporting period	2016-2017
Amount of grant	£4,970
Your email address	leandro.abade@zoo.ox.ac.uk
Date of this report	

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
Identify carnivore habitat use and its variations according to land-use classes and influence of human disturbance, and the most important landscape variables influencing on large carnivore habitat use				The study was the first to assess and quantify the influence of landscape and anthropogenic variables on lion, leopard and mesocarnivores occurrence patterns in a multiple land-use area including Ruaha National Park and surrounding village land. We used camera-trapping data and hierarchical occupancy modelling to provide the first assessment of the potential role of habitats bordering protected areas for carnivore distribution and conservation in this landscape. We showed that high rates of anthropogenic disturbance adjacent to Ruaha National Park create a "hard edge" for all these carnivore species, compromising their persistence in the village lands around Ruaha National Park. We demonstrated that even in systems with robust carnivore populations, high rates of anthropogenic disturbance, represented by proximity to human households and livestock presence, coupled with the intense underlying prey depletion, habitat changes and carnivore persecution and killing can significantly limit their occurrence patterns. Interestingly, the occupancy analyses performed in this study identified important heterogeneity in carnivore responses to anthropogenic and landscape variables across the gradient of human occupation. For each species, the model outputs identified a particular set of ecological and

				human-related factors that determined carnivore occurrence, which provided interesting insights into carnivore spatial ecology. For instance, site occupancy for lions was largely influenced by large prey biomass, whereas for leopards and civets, it was mostly limited by proximity to human households and high number of livestock detections at the camera-trap station level. Black-backed jackals, bat-eared foxes and aardwolves, on the other hand, were mostly influenced by proximity to the Great Ruaha River. Despite the observed variation in carnivore responses to environmental traits, there was a consistent and steady decline in carnivore detections with increasing distance from Ruaha National Park, especially in those areas of increased anthropogenic pressure closer to human households. These findings could be indicating low carnivore abundance in the village lands, as low detections have been shown to often correlate with low population densities. The Ruaha landscape has undergone substantial changes over the past decades following rapid increases in human and livestock populations around the national park. The increased populations of herders and farmers has led to intensification of agropastoral practices in the village lands, and caused major habitat conversion and degradation. Increased human populations have been associated with increased threats to carnivores, such as bushmeat hunting and poaching, logging, livestock encroachment, and human-wildlife conflict. Therefore, these anthropogenic pressures associated with rapidly growing human populations are likely to be a limiting

				factor for both carnivore and wild prey occurrence around Ruaha National Park, as observed in other areas across Africa.
Map areas with increased potential for carnivore habitat use and that represent key habitat patches for their conservation outside the protected area				These areas have been mapped combining information derived from the camera-trapping survey and other methodologies, and predicted key conservation areas for carnivore conservation for the Ruaha landscape and beyond, using the lion as a key carnivore species. In addition, we identified that highly suitable habitats were associated with low human population density (<10 people/km^2) and rainfall, and over 75% of these habitats were limited to protected areas, with the remainder patchily distributed across village lands. The results suggested limited potential for landscape connectivity between Ruaha and adjacent areas. The digital information the digital and printed maps and geographic information system (GIS) material will be made publically, as well as shared with the Tanzania environmental agency upon peer-reviewed publication.
Identify and map areas with increased overlapping between carnivores and humans, and with increased potential for human-carnivore conflict;				See point below.
Produce evidence-based management recommendations for consideration by the Wildlife Division at Ruaha National Park and other regional stakeholders that will help inform future conservation recommendations				The study results and the evidence-based management recommendations have been written and prepared for consideration for publication in peer-reviewed international conservation journals, and will be shared with local authorities and stakeholders after been accepted for publication in international peer-reviewed conservation journals. Currently, four

				manuscripts have been prepared for peer-reviewed publication: 1. The importance of the wildland-human interface for carnivore ecology: a case study of leopard (*Panthera pardus*) site use in Tanzania. Leandro Abade et al. Status: In preparation to submission to Biodiversity and Distribution 2. Examining patterns of lion (*Panthera leo*) occurrence across a gradient of anthropogenic pressure in southern Tanzania Leandro Abade et al. Status: In preparation to re-submission to Ecology and Evolution 3. Evaluating the spatial ecology of a carnivore guild across a gradient of anthropogenic pressure using camera-trapping and multispecies occupancy models. Leandro Abade et al. Status: Under review, Journal of Animal Ecology 4. Mapping the suitability of habitat for lions across two stronghold populations in southern Tanzania. Leandro Abade et al. Status: In preparation for submission to PNAS

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

We adjusted the approach of our work and focused our analysis on those large carnivore species of conservation concern and with higher number of detections across the study area. Thus, we report mainly on lions and leopards, and also on mesocarnivore species that were commonly photographed during the study, namely African civets, aardwolves, bat-eared foxes and black-backed jackals. Even though we could not report on African wild dogs and cheetahs (as previously expected), this study is the first to assess and report on the occurrence patterns and spatial distribution of a carnivore guild in the Ruaha landscape, and on their potential to overlap and create conflict with humans in this area.

Due to unusually high rainfall and serious flooding of the study area over the wet season, we were not able to collect data for the period between November 2016 – March 2017. This has limited our ability to make inferences about the rainy season in the study, and the results from the study are related to the dry seasons.

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

This study is the first to systematically investigate and report on carnivore site occupancy and interspecific interactions across a gradient of anthropogenic pressure in the Ruaha landscape. The database generated on this study is an asset and substantially contribute to revert the current knowledge dearth about carnivore distribution in this landscape. In addition, the rigorous methodological framework developed during this study can be used to help informing carnivore conservation planning in Ruaha, with applications elsewhere where carnivores and humans overlap.

2. Development of a distribution map (using lions as a key species) that can be used to inform conservation strategies that could intend to protect those areas with higher suitability for carnivores and to safeguard their conservation.

3. This study is the first to identify and quantify the landscape and human-related variables influencing and likely limiting the spatial distribution of a carnivore guild across areas exposed to varying levels of human disturbance in one of the most important and hitherto poorly studied landscapes for carnivore conservation globally. On a local level, the results of this study (i.e. low carnivore detection and probability of occupancy in the village land) highlight the importance of addressing the threats imposed by people and livestock immediately adjacent to protected areas, as our findings suggest that intense human activities (represented by proximity to human households and increased livestock numbers), likely coupled with underlying high levels of human-induced carnivore mortality due to conflict likely represent key-limiting factors to carnivore spatial distribution in the human-dominated non-protected areas around Ruaha National Park. On a landscape level, the findings of the study can help support the development of integrated management strategies such as adaptive livestock and wildlife foraging systems, as this could help to limit the impact of habitat conversion, overgrazing and prey depletion associated with livestock herding on rangeland habitats.

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

The work has been developed in close collaboration with the local communities, and during the field work, part of the results from the camera-trapping survey have been shared through the Ruaha Carnivore Project DVD nights, which helped to broadcast the preliminary findings of the study. These DVD nights, are part of an educational outreach project for sharing scientific data with local communities through presentations about the project and educational wildlife documentaries in Swahili. These DVD nights have so far visited over 15 villages surrounding Ruaha National Park, and reached an estimate of over 30,000 people. During these events the villagers gather around a mobile cinema-screen and have the opportunity to learn, understand and interact with project team members, as well as to ask questions and participate in discussions about the project as a whole, and the importance of conserving large carnivores in their lands. Thus, the results of this study has helped to raise awareness, and discussions about potentially dangerous areas

for livestock owners to graze their herds, and about the importance of using improved husbandry practices, which has been shown to contribute for minimising livestock predation by carnivores locally. Moreover, some of the villagers are closely involved in the checking of the cameras used in this study as they are hired and work as village scouts for RCP, helping with camera-trapping monitoring. Additionally, it is worth mentioning that all those involved with the survey have benefited from training on the use of field equipment such as GPS and camera-traps, and had the opportunity to learn more about wildlife conservation and carnivore ecology. I have also provided informal training on the use of statistical analysis (R language) and QGIS to the Ruaha Carnivore Project members.

5. Are there any plans to continue this work?

Yes. Even though the camera-trapping survey has been finalised, and the information on carnivore and primary prey occurrence has been recorded (for the purposes of the current study; i.e. occupancy modelling), the data derived from this study is integrating a Pan-African citizen-science platform on Zooniverse - comprising several conservation projects that rely on camera-trapping methodology - that will help to investigate how different land-use classes influence predator and prey distribution and densities across several study sites in Africa, and could help on the development of conservation strategies. In addition, this data will enable to estimate wild prey densities for the first time in the study area.

The information collected in this study is also being used by two ongoing research projects in the study area that are using different methods (interview and spoor-survey) to estimate carnivore density and use of habitat in the village lands surrounding Ruaha National Park. These analyses will provide a robust understanding of how carnivores are affected by diverse sources of anthropogenic pressure (such as habitat conversion; livestock overgrazing) and mortality (such as poaching; prey depletion; retaliatory killing) in this multiple use landscape. Secondly, the combination of these studies will shed light on how distinct and complementary methodologies can help to assess carnivore and prey spatial ecology in different scales, and that can be used to inform conservation practices in a more targeted and effective manner, for instance, on reducing carnivore depredation risk. Thirdly, the data collected in the study will also be used to help estimating leopard density based on coat patterns for the first time in this area.

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

As described above, the results and the evidence-based management recommendations derived from the study have been written and are in preparation or under consideration for publication in peer-reviewed international conservation journals. Besides the scientific contribution to the field of carnivore conservation in Tanzania, the results will be shared with the Wildlife Division at the Ruaha National Park, the Ruaha Carnivore Project, and regional stakeholders during a workshop for explaining the findings of this study and the management recommendations that could help preventing conflict and carnivore killing in the study site. This output has been postponed as a result of the delayed completion of the study, but there is a

current plan for presenting the workshop next July, during my next field trip to Tanzania. In addition, and as mentioned above, all the digital information resulting from this study, including any maps and GIS material will be made publically, and will be shared with the Tanzania environmental agency upon peer-reviewed publication.

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 funds were used to sponsor field activities between the 12 months anticipated on the original grant proposal.

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**
Producing material for workshop (printing and lamination)	50	124	**-74**	Printing and lamination costs higher than anticipated
Eneloop rechargeable batteries	1,170	1,668	**-498**	I needed to purchase extra 380 batteries (@1.36/unit) and also two battery charges and battery cases to transport them to Tanzania
Additional SD Cards - 50 units at £3/unit	150	206	**-56**	The SD cards costed 4.12/unit
Mileage (gas, vehicle maintenance, accommodation and subsistence for research and field assistant, ranger costs for checking camera-trapping in the National Park)	3,600	2,972	628	The difference is relative to the moths where field work was limited due to the flooding and inaccessibility to field sites.
TOTAL	**4,970**	**4,970**	**0**	

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

There are many aspects that could build on this research to improve further understanding of the determinants of carnivore occurrence in anthropogenic landscapes, and how to promote their conservation in those areas where they are more vulnerable. For example, using complementary survey protocols such as track counts could be used, especially in the village lands around Ruaha National Park, to further investigate the determinants of carnivore occupancy in these areas, especially to clarify what determines mesocarnivore occurrence in village lands. Furthermore, unstructured spatial capture-recapture sampling of carnivore sightings could be used for evaluating carnivore spatial ecology and demography, as there is an urgent need to assess the population status for large carnivores in this area. Additionally, information on movement analyses from GPS-collaring of carnivores could provide finer-scale spatiotemporal data about site use and livestock depredation risk, and this is much needed to better inform livestock owners about fine-scale movements of carnivores. This is currently under implementation by The Ruaha Carnivore Project.

Lastly, the successful conservation of carnivores in the study area ultimately hinges on the implementation of measures aiming at improving human tolerance towards carnivores to reduce carnivore mortality and incentivise wider wildlife conservation in the village lands. The expansion of community-based conservation approaches such as the adoption of schemes that would enable local people to directly engage and profit from wildlife presence, and to receive tangible and commensurable benefits from carnivore conservation in their land could help to minimise carnivore mortality, and enhance tolerance to their presence in village lands. Thus, conservation funding is much needed to enable implementing such strategies across the villages that surround Ruaha National Park.

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?

I used the logo and acknowledged the Rufford Small Grants and The Rufford Foundation in all the written material derived from this study, including the thesis and manuscripts derived from this project, and used the logo in presentations that used any data related to this study.

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 would like to thank the Rufford Small Grants and The Rufford Foundation for recognising the value of this project, committing to support the study, and understanding the challenges that delayed the original schedule of activities and limited fully achieving the original proposed deliverables.