Final Evaluation Report

Your Details	
Full Name	Cameron Goodhead
Project Title	Evaluating the use of unmanned aerial vehicles (UAVs/drones) for surveying Bornean orangutan populations.
Application ID	29286-1
Date of this Report	07/09/2023

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
Analysing detection rates of orangutan nests from aerial surveys				From 10.2 km of aerial nest surveys within the Sebangau National Park, the drone detected 26.7% of nests detected from the ground surveys, a higher detection rate than previous research in separate locations (Wich et al. 2016, Barrow 2022).
Investigation of factors that affect detection of orangutan nests on drone surveys				Significant effects of nest height, nest age and canopy cover on the detectability of nests were found.
Assessment of aerial nest surveys as a method for surveying orangutan populations				High inter-transect variation in detection rates was found and there was a non-significant relationship between nests detected on ground surveys and nests detected on aerial surveys of the same transects. These results indicate that variation in nest detection from aerial imagery may be too high to produce accurate population estimates for areas. However, the methods may still be useful for assessing rough population estimates for forest areas that are difficult to access, as well as informing presence/absence of orangutan populations. Through the process, other limitations in the methods were also found. We are collaborating with other drone surveyors in the field to surmount these issues and produce best practice guidelines for drone nest surveys. This research was limited by only having access to a single study site for permit reasons. We are working on expanding trials of these methods to other areas to assess differences between sites.
Testing of drone-based thermal cameras for detecting orangutans				Thermal surveys were found to be hugely effective at detecting orangutans, with 17 separate

				detections recorded across 40 km of surveys. The thermal drone could reliably identify orangutans at all tested heights. Calculating densities from detections of orangutans on thermal surveys yielded higher densities than expected for the site, indicating that the method can reliably detect orangutans and could yield more accurate assessments of populations than the nest surveys, although further testing is required.
Testing of drone – based thermal cameras for detecting other arboreal species				In addition to orangutans, the drone thermal surveys reliably detected multiple other species of primates, including Bornean white bearded gibbons, pig-tailed macaques and red langur monkeys. Other arboreal mammal species were also detected, including palm civets, yellow throated martens and plantain squirrels. Furthermore, the thermal camera also made numerous detections of bird species, including black hornbills, Bornean bristleheads, barbet spp., and multiple columbidae spp. This research indicates that thermal drones pose a hugely exciting prospect for biodiversity surveys of arboreal species in tropical forests. 88% of all heat signatures detected could be identified to species level using the accompanying visual telephoto lens on the drone system.
Analysis of detection rates of different taxonomic groups at different drone altitudes				Initial testing demonstrated that lower altitudes of 60 m were optimal for detecting bird and small mammal species, whereas higher altitudes of 80 and 100 m were optimal for detecting primate species due to the higher area covered and no significant changes in detection rates.
Determination of false negative rates of orangutans on thermal surveys				This was unable to be achieved as orangutan follows by the BNF behaviour team were paused during the vast majority of the extent of the research. Thus, we were unable to get a sufficient number of known orangutan locations to assess false negative rates. However, the higher densities of orangutans from

				our planned thermal surveys indicate that the likelihood of missing orangutans is low on thermal surveys. This is backed up by multiple detections of orangutans that were largely obscured by the canopy, indicating that unless the orangutan is fully obscured, the thermal camera will still detect a heat signature.
Surveying areas of the Rungan River Landscape using the developed drone methods				The Indonesian university we were collaborating with could only provide permission for field sites within the Sebangau National Park. We are currently working on connecting with the university responsible for allowing access to study sites within the Rungan River Landscape to allow future surveys to be commenced.
Development of best practice guidelines for drone nest surveys				Throughout the survey, we created optimal methods that worked best for the surveys, including flight guidelines, software, hardware and analysis techniques. Through collaboration with other researchers, we developed an analysis technique for marking and geo-referencing nests in images. We are working at establishing further meetings with these academics to produce a collaborative best practice guidelines for drone nest surveys based off our collective experiences.
Publish results in a master's by Research thesis.				Thesis was submitted in July 2023 and is to be published in Autumn 2023.
Establish workshop to teach both survey methods to local Indonesian researchers and practitioners				This is currently in planning stage. The team decided to postpone the workshop until after the research was completed and best practice guidelines had been developed so that the optimal methods can be taught, and the workshop could be most effective. It is expected to be completed in Summer 2024.
Enhance local research capabilities and collaborate with local institutions.				An undergraduate student from University of Palangka Raya joined the primary researcher for 2 weeks to learn about the methods and assist with data collection. The primary researcher also visited the University of Palangka Raya multiple times, discussing projects with

				other students and meeting lecturers. The primary researcher worked alongside local researchers at Borneo Nature Foundation to develop the methods. The research team are planning on completing a workshop and presentation for the University of Palangka Raya to educate a greater number of students, as well as National Park staff and local conservation practitioners.

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

a). An assessment of the potential for surveying orangutan populations from drone-based nest counts.
From our research, we determined that due to high variation in nest detection rates, drone-based nest counts may not be suitable for accurate population monitoring. Given the high costs of the technology, this is extremely useful in guiding conservation organisations about how to direct funds for orangutan surveys. We are currently working with other researchers to optimise methods that will either account for variation or reduce it, potentially enabling these methods to be used in the future. However, before this is done, considerable further testing of methods across different study sites is needed.

b). An assessment of the potential of thermal drones for surveying arboreal wildlife.
In this research, we demonstrated that thermal drones pose an extremely promising prospect for biodiversity of arboreal species, surpassing our expectations. Orangutans were reliably detected by the thermal camera, but we also detected numerous other species, including small species of birds and mammals. The accompanying telephoto lens on our drone system proved extremely effective at identifying the species of heat signatures in the forest, enabling the species of 88% of heat signatures to be assessed. Based off these results, we are looking at expanding the thermal survey monitoring in Borneo, and seeing if the thermal surveys can be used as an easier way of assessing orangutan densities. Furthermore, once orangutans were spotted, their locations could easily be estimated using simple procedures on the drone software, which proved beneficial to other researchers conducting searches for orangutans in the forest.

c). Development and improvement of optimal methods for drone-based wildlife monitoring.
Through our initial testing periods for both methods, we determined optimal heights for detecting both nests and heat signatures on their respective surveys. We also developed optimal methods for mission planning and data analysis, which prove hugely beneficial to conservation practitioners in the collaborating organisations who wish to continue with the surveys. This will be enhanced through the future meeting with other researchers using drones for nest and thermal surveys to publish

optimal practice guidelines, which will be demonstrated in future workshops with Indonesian collaborating universities, NGOs and national park authorities.

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

The COVID-19 pandemic presented numerous challenges for the project, delaying the onset of it for over 2 years due to strict immigration policy from the Indonesian Government. As a result, the schedule had to be amended and shortened from our original plans. However, we were patient with it and were eventually able to complete the research. Due to the delays caused by the COVID-19 pandemic, the start time for the project coincided with the Indonesian rainy season, limiting the number of days that surveys could be completed.

Initial analysis of photos from the nest surveys took a substantial amount of time due to the initial high overlap used between images of 80% overlap. As a result, a 1 km transect contained over 200 photos, each of which took on average 3 minutes to analyse and would thus often take days of analysis to complete. Methods were amended to reduce overlap between images, which slightly increased the chances nests may be missed but dramatically reduced analysis time. As a result, using our refined analysis methods, transect images could now be analysed within a couple of hours. This makes the method a lot less time-consuming than the ground nest surveys, particularly for areas without permanent ground transects.

Piloting the drone from the forest proved troublesome due to signal issues caused by tall vegetation – we got around this by completing flights either from a 35 m research tower in the forest or from a boardwalk 100 m outside the forest.

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

This research collaborated with locally based NGO, Borneo Nature Foundation (BNF), and a local university, the University of Palangka Raya. Funds raised from this research project contributed to local research assistants' wages for the duration of the project. The primary researcher was heavily involved with both the national park authorities and a local university, meeting with the project's head Indonesian collaborator, Pak Segah, multiple times and discussing research with local students in the university. Furthermore, an Indonesian undergraduate student from the local university assisted with the research for 2 weeks and was taught how to use the methods. Local collaborators will also co-author publications arising from these methods. Lastly, BNF is heavily involved with the local community and the primary researcher had opportunities to interact with and discuss the importance of the rainforest with locals and their children at the 'Anak Sebangau' festival, a festival organised by BNF to encourage local children to interact with and respect nature. I demonstrated my drone piloting for them and discussed my research.

5. Are there any plans to continue this work?

In the future, I plan to return to the location now that I have analysed all the data and assessed the methods to run workshops for local NGOs, conservation practitioners, students and national park Staff. As part of this visit, I will be collaborating with both BNF and the Sebangau National Park to assist with biodiversity surveys in areas of the national park that are rarely surveyed. We will conduct both aerial nest surveys and aerial thermal surveys across different sites within the national park. Lastly, we are establishing communications with the Universitas Muhammadiya PalangkaRaya to permit access to the Rungan River field site so these surveys can be trialled in a completely new area of Central Kalimantan, and a different habitat type to the Sebangau National Park.

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

The results of the thermal surveys are currently in preparation to be published as a paper, which will be distributed with Indonesian language abstracts and feature local collaborators as co-authors.

The results of the aerial nest surveys are likely to be included in the collaborative production of best practice guidelines with other researchers who have tested the methods.

The research from this project is to be presented at multiple conferences over Winter 2023, including Primate Society of Great Britain winter meeting and British Ecological Society 2023 meeting.

Lastly, as discussed in previous sections, the methods will be disseminated to relevant local organisations and individuals through multiple workshops upon my return to Borneo.

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

The next steps are to establish the aforementioned workshops in PalangkaRaya about the methods for local collaborating organisations and relevant individuals, to effectively disseminate the methods. Furthermore, additional surveys will be completed in collaboration with the national park, as these have been requested by the Sebangau National Park team to assist with their monitoring. We also will collaborate with BNF to complete further drone surveys in areas of the Rungan River landscape, an important area for biodiversity that is under threat from development.

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?

The Rufford Foundation logo was used in the acknowledgements section of my Master's by Research thesis. Furthermore, the logo will be used in accompaniment of future publications relating to the research. We are currently working on submitting the results of both the drone nest surveys and the drone thermal surveys in separate

research papers. Once the research is published in research journals, I intend to write blog posts for the journal and for the University of Exeter, both of which will feature the logo. I also intend to present the research as a poster at the British Ecological Society meeting 2023 and a presentation at the Primate Society of Great Britain winter meeting 2023, both of which will feature the logo. Furthermore, upon publication of the research, the Rufford Foundation logo will be used in a social media post to promote the research.

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

Cameron Goodhead – Primary Researcher. Completed the fieldwork, developed methods, analysed results.

Dr Kimberley Hockings – Primary supervisor. Assisted with development of project, methods and writing of results.

Simon Husson – Collaborator at Borneo Nature Foundation, assisted with planning methods, and logistics at field site.

Dr Helen Morrogh-Bernard – Secondary supervisor, assisted with planning methods, and logistics at field site.

Dr Hendrik Segah – Primary collaborator at Universitas Palangka Raya, assisted with logistics, planning of research and establishing connections in Indonesia.

Santi, Adul, Azis, Azis, Hendri, Jali, Twenti, Tomi, Iwan, Galis and Unyil – Nest survey team at Borneo Nature Foundation, completed the ground surveys of nests.

Adit, Restu, Markurius – Drone team at Borneo Nature Foundation, assisted with logistics of field kit, including ordering drones, and planning drone surveys.

Indah Sartika Sari – Organised nest survey teams and ran the camp site. Assisted with bird identifications on thermal surveys.

Dhodi Presetia – Undergraduate student at University of Palangka Raya, accompanied primary researcher for two weeks, assisting with the drone surveys.

10. Any other comments?

Once again, I would like to sincerely thank the Rufford Foundation not only for their support throughout this project, but also for their patience during the tumultuous pandemic eras where the project faced eternal delays. I am waiting until the research is published before doing promotion for it, but all will feature sincere thanks to the Rufford foundation for their support.