

Final Evaluation Report

We ask all grant recipients to complete a project evaluation that helps us to gauge the success of your project. This must be sent in **MS Word and not PDF 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 – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please DO NOT fill in and submit this form until the project has been completed.

Complete the form in English. Note that the information may be edited before posting on our website.

Please email this report to jane@rufford.org.

Your Details	
Full Name	Lim Wing Shen
Project Title	Impact Assessment on The Establishment of Artificial Salt-Licks for Wildlife Monitoring and Management at Kawang Forest
Application ID	33917-1
Date of this Report	24 th September, 2025

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
<p>Provide data on terrestrial mammals in the Kawang Forest Reserve to Sabah Forestry Department.</p>				<p>A total of 60 sampling points were created across the five selected study sites, which recorded 607 independent detections of native terrestrial mammals, including 1,821 photographs and 607 videos. A total of 27 native species were found along and near forest access routes across five study sites, with 14 species sighted at Kawang Forest Reserve (KFR), 10 recorded at Kinarut Eco Forest Park (KEFP), 8 observed at Universiti Malaysia Sabah (UMS), 13 documented at Tenghilan Community Forest (TCF), and 22 detected at the Inobong Substation of the Crocker Range Biosphere Reserve (CRBR).</p> <p>This data served to provide a list of native terrestrial mammal species, along with the information on their species traits, present within KFR and the other four study sites. As a result, this information could be shared with the Sabah Forestry Department.</p>
<p>Determine whether existing conservation efforts at KFR are ample to protect local native species, particularly the elusive and threatened large-sized species from risk of extinction.</p>				<p>Among the various elusive native species observed in the five sites, six species were classified as threatened. Nonetheless, only the bearded pig (<i>Sus barbatus</i>) was large-sized (> 45.0 kg), and only the vulnerable Whiteheadi's Sundaic maxomys (<i>Maxomys whiteheadi</i>) was small-sized (< 1.0 kg), while the other four species were medium-sized (1.0 kg to 45.0 kg). These 4 species were the endangered long-tailed macaque (<i>Macaca fascicularis</i>), critically endangered Sunda pangolin (<i>Manis javanica</i>), endangered southern pig-tailed macaque (<i>M. nemestrina</i>), and the vulnerable Smooth-coated otter (<i>Lutrogale perspicillata</i>).</p> <p>Among these six threatened species, both the large-sized bearded pig and medium-sized smooth-coated otter were not found</p>

			<p>in KFR. Hence, the present results suggest that either the existing conservation efforts are insufficient to protect these 2 species or they were not present in the sampling areas of KFR during the sampling period.</p> <p>Both the long-tailed macaque and Sunda pangolin were sighted at UMS, KEFP, and TCF. However, the bearded pig was found only at TCF, while the smooth-coated otter was detected at KEFP. Moreover, at CRBR, Whitehead's Sundaic maxomys, smooth-coated otter, and both macaque species were observed. As a result, 4 out of these 6 species were sighted at CRBR, followed by 3 species at both TCF and KEFP, and 2 species at UMS. These results suggest that areas along and near forest access routes within the five study sites were mainly used by non-threatened species and those that were not large-sized.</p> <p>The findings and recommendations from this project have not yet been delivered towards the five respective management authorities. Instead, this information will be shared with them as part of my doctoral thesis, following its review and approval by my examiners, supervisors, and university in the near future.</p>
<p>Investigate the influence of creating artificial saltlicks onto wildlife community at KFR, in terms of changes in their activity patterns and interactions with other species sharing the same habitat areas.</p>			<p>Blocked artificial saltlicks were established at half of the sampling points within each study site, including 5 saltlicks each at KFR and CRBR, 4 at TCF, 10 at KEFP, and 6 at UMS. In total, 30 saltlicks were established across the five study sites, while the other 30 sampling points served as control points (without adding mineral blocks).</p> <p>During the sampling period, local native terrestrial mammals did not ingest mineral blocks at KFR, TCF, and KEFP, while this behaviour was observed twice at UMS and seven times at CRBR. Usually, local native species mainly passed through or foraged close to mineral blocks at all five sites. This emphasizes that their visits to the artificial saltlicks were not resulted by the presence of the blocks, but instead by the sampling point areas being parts of their movement corridors for daily activities.</p>

			As a result, the differences in mammalian detection frequency, species evenness, and species richness between the artificial saltlicks and control points, as well as over time at the saltlicks, were found to have no significant association with the presence of artificial saltlicks across these five sites.
Verify whether the creation of artificial saltlicks for long-term wildlife monitoring and management can be a suitable and sustainable approach.			<p>The blocked artificial saltlick design used in this project showed low effectiveness in drawing native terrestrial mammals to the designated spots within the five study sites. However, this assessment was conducted right after the saltlicks were created, over a period of only 9 to 12 weeks. Conversely, prior studies investigated artificial saltlicks years after their establishment, in which a wide range of native species was sighted actively utilizing these saltlicks for mineral intake, instead of just passing by. Actually, these saltlicks were used significantly more frequently by specific native species than the adjacent non-saltlick areas within the study sites.</p> <p>Henceforth, the limited usage of artificial saltlicks by native terrestrial mammals for mineral intake in this study was likely due to the fact that these species had not yet become habituated to regularly using the saltlicks. This was supported by the several sightings of native species sniffing mineral blocks up close without physical contact across the five study sites. This emphasizes that although these species recognize the blocks, they remain wary of these blocks during the sampling period. In short, the present findings merely highlight that the proposed artificial saltlick design was not viable for their long-term monitoring at the five sites, instead of denoting that artificial saltlicks, in general, were ineffective for such monitoring.</p>
Determine the explanatory factors that significantly affect the activity patterns of wildlife at the artificial saltlicks in KFR, in terms of their group sizes, detection frequencies, and absences or presences at any given			This assessment was conducted on native terrestrial mammals at KFR and four other study sites within the West Coast Division of Sabah (Western Sabah). The focus was on their utilization patterns in areas along and near local forest access routes, instead of solely on artificial saltlicks. These patterns were examined at both the species and

<p>time or saltlick.</p>			<p>community levels, in terms of their species count, group sizes, detection frequencies, and detection durations.</p> <p>While accounting for the effects of study site traits (e.g., site management practice and authority, function, forest type, forest size, and forest connectivity), their usage patterns were validated to be influenced by various explanatory factors, at both the community and species levels. Significant drivers of their use patterns included the groundcover density, precipitation, terrain ruggedness, topographic position, human disturbance intensity, elevation, presence of water body, and distances to human environment and forest access route.</p> <p>Generally, the way a species uses specific areas within a habitat at particular times is influenced by factors such as vegetation, topography, anthropogenic disturbance, and weather conditions. The given factors impact the species' ability to regular body temperature, access resources, engage in specific activities, and avoid disturbance and predation at given areas and times. As difference species demonstrate distinct morphological, identity, and behavioural traits, they respond varyingly to the same environmental conditions.</p> <p>Henceforth, the combined use patterns of different species dictate how the native mammalian community using given areas at specific times. In turn, combining these patterns across different areas would help reveal how they utilize spaces along and near forest access routes within a habitat. However, these patterns are consistently influenced by the population size of each native species, which is dictated by the existing habitat conditions.</p>
<p>Investigate the long-term influences of prey-predator relationship, interspecific competition, and human disturbance onto wildlife in Kawang Forest Reserve.</p>			<p>Both the invasive free-ranging dog (<i>Canis familiaris</i>) and domestic cat (<i>Felis catus</i>), as well as humans, were observed at the sampling points across all five study sites. Nevertheless, sightings of the two invasive species were infrequent ($n \leq 10$ per study site). In contrast, human activity was more prominent ($n > 10$ at all sites), with higher activity recorded at TCF ($n = 89$), UMS ($n =$</p>

			<p>96), and KEFP (n = 302), and lower activity at CRBR (n = 23) and KFR (n = 25). Humans and the given two invasive species were mainly sighted passing through the areas, with no clear evidence of hunting for local native wildlife. Henceforth, human activity was determined as the primary source of anthropogenic disturbance at all five sites.</p> <p>Temporal niche partitioning was detected among specific species pairs at each site, majorly due to differences in diel activity hours related to their distinct species traits. Moreover, most native species, as well as humans and these two species, exhibited consistent diel activity patterns across the five sites, with only several native species revealing notable deviations. As a result, species occupying similar temporal niches exhibited similar diel activity patterns, but reached their activity peaks at different times. This likely occurred as a strategy to reduce risks of predation and competition with other sympatric species at each site.</p> <p>The present findings underscore that high human activity at KEFP and TCF may have triggered both the diurnal plantain squirrel (<i>Callosciurus notatus</i>) and the crepuscular mousedeer (<i>Tragulus</i> spp.) to adjust their natural diel activity patterns in response to anthropogenic disturbance. On the other hand, at CRBR, the crepuscular southern red muntjac (<i>Muntiacus muntjak</i>) shifted to diurnality, probably to avoid predation by the nocturnal Sunda clouded leopard (<i>Neofelis diardi</i>). Both the common palm civet (<i>Paradoxurus hermaphroditus</i>) and Malay civet (<i>Viverra zangalunga</i>) showed peak activity hours overlapping with that of the Whitehead's Sundaic maxomys (<i>Maxomys whiteheadi</i>) as well, suggesting an adaptive strategy to improve hunting success at CRBR. In short, anthropogenic disturbance and interspecific interactions were validated to have long-term impacts on diel activity patterns of native terrestrial mammals at KFR and the other four study sites within Western Sabah.</p>
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2. Describe the three most important outcomes of your project.

- a). The findings of this project suggest that the spatio-temporal utilization patterns of native terrestrial mammals within a habitat are influenced by a combination of biotic and abiotic factors (e.g., anthropogenic disturbance, weather conditions, and bio-physiochemical properties), along with species-specific morphological, identity, and behavioural traits. These species-specific use patterns collectively shape broader, community-level utilization patterns at specific areas, and in turn, along and near forest access routes within a habitat at certain times. However, these patterns are also defined by the existing population sizes of each species, which are dictated by current habitat conditions (e.g., forest connectivity, type, and size, degree of habitat degradation, and the type and intensity of human disturbance and activity). Ultimately, the present findings validate the existence of complex spatio-temporal interactions between the mammalian use patterns and environmental conditions within a habitat in Western Sabah.
- b). This project primarily focused on areas along and within 50.0 m of forest access routes across five forest habitats in Western Sabah. Because of their proximity to human settlements and vehicle roads, these sites are easily accessible to both humans and exotic wildlife from nearby human environments, either illegally or legally. However, during the sampling period, neither direct field observations or the deployed camera traps detected any sign of hunting activity. Detections of invasive species such as domestic cats and free-ranging dogs were also seldom, indicating that humans were the primary sources of anthropogenic disturbance (predominantly sighted either passing through or conducting research activities) across all five study sites. However, as this project was limited to local routes and nearby areas, it could not account for potential activities occurring outside local sampling areas (e.g., within interior forest areas, around site boundaries, or along inaccessible routes). Therefore, the present findings can only verify the absence of observed hunting activity along and near the surveyed routes. The data also suggest that local native species might be exhibiting spatial and temporal niche partitioning when using these areas, in response to the presence of humans and the two recorded invasive species across the five study sites.
- c). This project validated that native terrestrial mammals exhibited a preference for habitat areas with specific environmental conditions for regular navigation and resource acquisition, both at the species and community levels. These preferred areas were generally found along slopes and within valleys, featured taller tree canopies, and situated farther from forest access routes and water bodies. Such locations likely provide higher food and shelter availability, better concealment, lower forest degradation level, and reduced risks of competition, predation, and disturbance, despite being less easily accessible. Remarkably, these areas were frequented by a diverse array of native species, including several threatened species, thereby underscoring their role as important movement corridors across all five sites. Consequently, these results highlight key sensitive areas that support the routine activity of native terrestrial mammals, while still remaining accessible to humans, across these five study sites.

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

This project was originally designed to cover the entire Kawang Forest Reserve. Yet, it soon became evident that most of the area was inaccessible, due to harsh terrain (steep slopes and undulating hills) and poorly maintained trails, which were seldom utilized by visitors. Local staff also revealed that only a few native terrestrial mammal species inhabited the reserve, with low population densities making sightings rare, an observation later verified during a preliminary assessment conducted along the only accessible trail. Therefore, I expanded the project scope to include additional forest habitats in Western Sabah, ultimately covering four more study sites. However, some of these areas had limited forest cover, and access beyond local established trails and gravel roads remained difficult. Consequently, the study was confined to areas located along or within 50.0 m of accessible forest access routes (gravel roads and forest trails) across all five study sites.

Secondly, this project originally planned to use a weather station to collect various weather factors (e.g., illumination, precipitation, and wind). The station was installed near the basecamp at Kawang Forest Reserve, with similar placements intended for the other four study sites to allow easier access for maintenance, data retrieval, and monitoring. However, all five sites experienced frequent human activity (illegally or legally) and visits from long-tailed macaques (might tamper with field equipment in human-modified environments). These conditions made the weather station highly vulnerable to damage and theft. As a result, I retrieved the station just a month after deployment, and its use was cancelled across all sites, despite being purchased with project funds. Instead, I revised the project objectives to focus only on precipitation, using site-specific data purchased from the Malaysia Meteorological Department.

Thirdly, this project used Ka Shi H7 camera traps (Zhen Shi Jie Ke Ji Co., Ltd.), due to their affordability compared to branded models such as Reconyx and Bushnell, as well as their ability to operate for more than 30 days in the field while capturing high-quality photos and videos. However, during deployment across the five sites, several units faced technical problems, including water damage from prolonged exposure to humidity, battery failures, and data corruptions. Hence, faulty units were replaced with new ones, which necessitated extending the sampling period at specific sites to make sure a minimum of 60 days of data collection per sampling point. Furthermore, camera traps were installed at each point by utilizing a standardized setup intended to capture clear footage of terrestrial mammals of various sizes. However, in practice, the footage mainly enabled species-level identification of large and most medium-sized mammals. Conversely, most small and some medium-sized species were either missed entirely or captured in footage of insufficient quality for reliable species-level identification. Ultimately, many small mammal species remained unidentified, and both the lesser mousedeer (*Tragulus kanchil*) and greater mousedeer (*T. napu*) were collectively classified as “mousedeer” in this project.

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

Local community involvement in this project primarily involved individuals employed as staff under the management authorities of the five study sites. Since this project focused upon native terrestrial mammals and treated human activity as a predictor factor, direct engagement with the wider local community was limited, with support majorly given by site management staff. However, the selection of suitable locations for creating sampling points along and near local forest access routes was informed by the knowledge shared by local staff members. Their extensive experience and familiarity with the terrain were instrumental in identifying areas commonly utilized by local native terrestrial mammals. Consequently, many of the selected areas showed clear signs of regular mammalian activity throughout the sampling period.

Notably, Tenghilan Community Forest is divided among different local landowners, resulting in frequent movement by community members through the local sampling points, both during and outside of my field work. These encounters offered chances to share information about the project and its potential implications for future forest management with local community members. Actually, the present findings provide valuable insights that can inform pragmatic strategies for managing native terrestrial mammals and their habitats, both in this forest and across the other four sites. These strategies intend to promote the long-term sustainable use of local natural resources and may comprise initiatives such as promoting wildlife-watching tourism, as well as regular monitoring, protection, and conservation efforts integrated into existing local management plans. While there are currently no in-person initiatives (e.g., training or awareness programmes) planned to directly share the results of this project with the local community, these findings will to be published and made publicly accessible in the future.

During the implementation of this project, three postgraduate students from Universiti Malaysia Sabah were engaged as enumerators to assist with data collection. Their primary tasks involved conducting forest inventory activities, such as measuring tree heights, DBH, and canopy openness within the 10 m radius circular plot established at each sampling point. While all the students were Malaysian, only two were from Sabah, and none originated from the communities surrounding the five study sites.

5. Are there any plans to continue this work?

Yes, I intend to continue with this project. At present, my surveys have focused only on native terrestrial mammals sighted along and around accessible forest trails and gravel roads, applying camera traps deployed for up to 12 weeks at each sampling point across five study sites in Western Sabah. After working with these native species for nearly 7 years, I have come to understand that using a combination of sampling techniques can significantly enhance species detection. Therefore, it is vital to carry out further surveys at these five sites using multiple techniques to minimize the risk of species miss-detection. Furthermore, additional surveys are needed in interior forest regions, near site boundaries, and along routes that were previously inaccessible, as these areas might harbour species not observed in this project. Ultimately, including

such areas would provide a more comprehensive understanding of local biodiversity and mammalian habitat usage patterns at each site.

Conducting repeated surveys in the same areas within these five sites is essential for monitoring potential changes in mammalian use patterns over time. Extending the sampling duration at each point can further enhance data accuracy and reliability, thus offering a more detailed understanding of site-specific temporal usage patterns for each native species compared to those noted in this project. Since the present findings indicate a clear need to refine existing management plans at the five sites, commencing regular surveys would enable the assessment of temporal shifts in their use patterns under both existing and revised management strategies. Furthermore, many threatened native species continue to inhabit these fragile habitats with high accessibility to humans, thereby underscoring the necessity for long-term monitoring to support their conservation. Continuing this project may also help raise awareness of the threats local native species face, while involving local communities in future research efforts may further enhance the impact and long-term sustainability of this initiative.

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

I mainly share the results of my work through publications in peer-reviewed scientific journals, as well as presentation at university seminars and international conferences. For instances, findings on native terrestrial mammal species sighted along and near forest access routes at Universiti Malaysia Sabah, Tenghilan Community Forest, and Kawang Forest Reserve were published in a Scopus-indexed journal, "HAYATI Journal of Bioscience" (Vol. 31, No. 2, March 2024, pp. 404–413). Furthermore, at the Inobong Substation within the Crocker Range Biosphere Reserve, camera traps recorded two vulnerable pheasant species, which were the crested partridge (*Rollulus rouloul*) and great argus (*Argusianus argus*). Subsequently, data from these unexpected sightings were analysed, and the findings were presented at the International Conference on Borneo Sustainability 2025 (ICBS 2025), held at Universiti Malaysia Sabah from 9th to 12th September 2025. Several other findings from this project have also been used to prepare manuscripts, which have been submitted to various research journals and are currently undergoing peer review.

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

Native terrestrial mammals are vital contributors to ecosystem services that underpin the long-term sustainability of natural ecosystems and human well-being. However, their survival is under growing threats from habitat loss driven by logging, land cover changes, hunting for their meat, body parts, or live capture for illegal trade and the pet industry, and unchecked encroachment of invasive wildlife from nearby human settlements. To ensure the continued existence of these native species across Sabah, it is critical to protect them and conserve their natural habitats. With this in mind, the next key steps are recommended:

- i. Engage with the management authorities of the five sites to offer suggestions based on the project's findings, for improving existing site management plans to support the long-term sustainable usage of natural resources.
- ii. Collaborate with site management authorities to initiate regular research and monitoring activities at each study site. This should comprise ongoing wildlife surveys, the identification of potential illegal entry points used by humans and invasive species from outside the site boundaries, and investigations into the long-term impacts of both human and invasive species activities upon local native terrestrial mammals and their habitats.
- iii. Encourage site management authorities to develop wildlife-watching tourism initiatives based on the findings of this project. This could help raise awareness among key stakeholders (e.g., management personnels, visitors, and nearby communities) of both the monetary and non-monetary values of conserving local native terrestrial mammals and their habitats. Nonetheless, these tourism activities must be carefully managed to ensure long-term sustainability and to minimize potential recreational impacts on local ecosystems.

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?

Although the published research articles, as well as the slides and posters presented in the university seminars and international conferences, did not feature The Rufford Foundation logo, all materials clearly acknowledged the support of the Rufford Small Grant in the implementation of this project, both verbally during presentations and in the written acknowledgement sections.

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

i. Mr. Lim Wing Shen (Project leader)

I was majorly responsible for selecting the study sites and determining suitable locations for establishing sampling points. In addition, I conducted field data collection, performed data analysis, and utilized the project results to prepare manuscripts for publication, and also presentations for university seminars and international conferences. While I was the sole active member of the project, I occasionally enlisted the assistance of postgraduate students from Universiti Malaysia Sabah for short-term data collection when necessary.

ii. Assoc. Prof. Dr. Andy Russel Mojiol (Supervisor)

As my doctoral supervisor at Universiti Malaysia Sabah, Dr. Andy played a vital role in supporting the overall implementation of the project. His contributions comprised coordinating transportation from the university to all five study sites, plus offering valuable insight on experimental design, wildlife survey sampling techniques, and the selection of study sites. While he was not directly involved in fieldwork, he actively provided academic guidance and logistical support throughout the sampling period of this project.

iii. Mdm. Marlisa Maksin (Collaborator)

As a staff member of the Sabah Forestry Department based at Kawang Forest Reserve, Mdm. Marlisa offered crucial support during my visits to the site. Her assistance included offering background information about this forest reserve, arranging for a forest ranger to accompany me during my initial forest surveys, and coordinating accommodation for each visit to the site. In this capacity, she served as a local collaborators for this project.

iv. Mdm. Fiona Evelyn Anthony (Collaborator)

Stationed at Kinarut Eco Forest Park under the Sabah Forestry Development Authority, Mdm. Fiona offered valuable assistance during my data collection period at the site. Her support involved sharing background information about the park, and arranging transport to sampling points and accommodation for each site visit. Therefore, she served as a local collaborator on this project.

v. Mr. Pius Kandaung (Collaborator)

As a staff member of Sabah Parks based at the Inobong Substation within the Crocker Range Biosphere Reserve, Mr. Pius provided significant support during data collection at this site. His contributions comprised providing background information about both the reserve and the substation, arranging for a forest ranger to accompany me on the forest trails when staff availability permitted, and coordinating accommodation for each site visit. Therefore, he served as a local collaborator on this project as well.

10. Any other comments?

The implementation of this project was delayed by the COVID-19 pandemic, as well as several unforeseen challenges encountered during the initial phase of field data collection at Kawang Forest Reserve. Nonetheless, with the dedicated support of my supervisor and the collaboration of local partners at each site, the project gradually improved and progressed toward successful completion. I would also like to take this opportunity to express my heartfelt gratitude to The Rufford Foundation for awarding me the Rufford Small Grant, as this project would not have been possible without this generous financial support. Furthermore, I sincerely acknowledge the Foundation's ongoing commitment to conservation efforts, not only at the five study sites involved in this project in Western Sabah, but also in many other regions around the world.

ANNEX – Financial Report
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