The Rufford Small Grants Foundation

Final Report

Congratulations on the completion of your project that was supported by The Rufford Small Grants 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	Gopalasamy Reuben Clements
Project title	Mitigating the impacts of roads on tigers and their prey in Malaysia
RSG reference	8320-1
Reporting period	22 July 2010 – 21 July 2011
Amount of grant	£5,880
Your email address	neovicarius@gmail.com; reuben@myrimba.org
Date of this report	17th July 2011

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
Objective 1: To determine deforestation risk within tiger habitats under different road expansion scenarios	*			Conclusion: Undetermined. This objective was not completed on time as a longer time than expected was needed to obtain and process satellite images for three tiger landscapes. Logistical constraints were the main factors affecting the completion of this objective (e.g., poor internet connection speed for downloading satellite images from US server, frequent power outages in field house that disrupted analyses).
Objective 2: To determine whether human disturbance is greater at viaduct access routes			*	Conclusion: Among routes 500m from either side of the highway, humans are more likely to camp at routes originating from viaducts than those originating from logging road entrances. This objective is scheduled for completion in July 2012, so this objective was achieved earlier than expected.
Objective 3: To determine whether viaducts facilitate movement of tigers and their prey			*	Conclusion: Seven out of 10 viaducts are utilised by three species of tiger prey, although no tigers have used them so far. One particular viaduct is a 'wildlife crossing hotspot' for tiger prey and should be better protected. This objective is scheduled for completion in July 2012, so this objective was achieved earlier than expected.

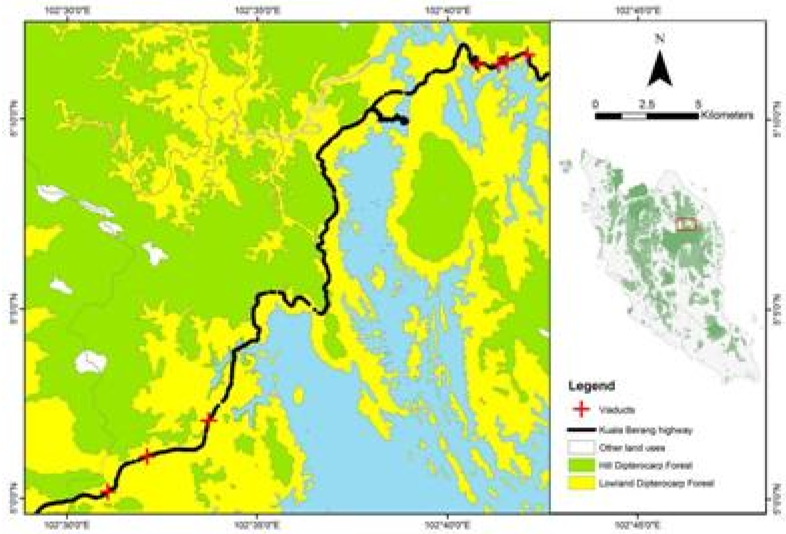
2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

Unforeseen difficulties hampered the completion of Objective 1. A larger than expected amount of time was needed to identify the most suitable classification combination for the LANDSAT images (see appendix 1 for an explanation). Another problem was the frequent power outages at our field station, which disrupted the classification of our LANDSAT images. Each classification combination took around 2-3 days to run, but some would be cut short by power outages that could sometimes occur at least five times a day. Purchasing an uninterrupted power supply did not help as the power outages were sometimes too long. Finally, I decided to move our remote sensing desktop to the town where there are no power outages. In this new location, we created an automatic queue of classification combinations to be run on the desktop to be run automatically. However, we have to commute every 2-3 days to town to retrieve the processed images for further analyses.

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

Objective 1: To date, publicly available deforestation rates for Malaysia have only been determined recently using coarse-grained MODIS satellite images. We have now compiled a comprehensive LANDSAT satellite image bank (346 LANDSAT 4,5 and 7 images over seven scenes across three tiger landscapes) to help calculate relatively more accurate deforestation rates for three tiger landscapes Malaysia between 1985 and 2010. This database, which is open for use by other researchers upon request, will also serve as an important platform from which we can model deforestation risk in tiger landscapes when new roads are being built. We are in the process of exploring different layer combinations for accurate satellite image classification (see appendix 1).

Objective 2: Prior to this study, the levels of human disturbance in the forests adjacent to the highway bisecting the Kenyir Wildlife Corridor (see map below) were unknown.



Conservation outcomes

- This project has now characterised the levels of human disturbance in this corridor for the first time and identified routes that require greater attention by enforcement patrols. As we are working in Permanent Forest Reserves where access is only permitted to forestry personnel and indigenous people, all other signs not related to these groups were considered a signs of human disturbance as a member of the public would require a permit to enter these forests. A total of 83 signs of human disturbance were recorded during 19 of 43 routes spanning 98.8 km in this corridor.
- Of the 43 routes, route PEL08, an old logging road, had the highest levels of human disturbance. Next, I investigated whether humans left more signs of disturbance on routes that originated from certain types of entrances (e.g., from a viaduct or old logging road entrance), or whether more signs of human disturbance could only be detected further in forests than areas near the highway. I conducted binomial logistic regression to investigate whether these two metrics, route origin (ori) or route segment no. (seg), could predict the probability of finding signs of human disturbance (see Appendix 2 for methods). Our generalised linear mixed-effect models showed that human disturbance signs have a slightly

higher probability of being detected on route segments (seg) further from the highway (Table 1). However, this 'distance to highway' proxy was probably not a good enough on its own to predict signs of human disturbance (hum); the percentage deviance (%DE) explained by the model with this predictor was very low despite being included in the top ranked model (Table 1). Therefore, I have to find new metrics that can better predict the occurrence of human disturbance signs to guide future patrols.

Table 1. Generalized linear mixed-effect models used to examine the probability of detecting signs of human disturbance (hum) among 100-m segments (n=755) from the highway.

	-LL	k	AICc	ΔAICc	wAICc	%DE
hum ~ seg + (1|*route*)	-172.856	3	351.743	0.251	0.4344	1.99
hum ~ 1 + (1|*route*)	-176.359	2	356.734	5.242	0.0358	0
hum ~ ori + seg + (1|*route*)	-171.719	4	351.492	0	0.4925	2.63
hum ~ ori + (1|*route*)	-175.312	3	356.655	5.163	0.0373	0.59

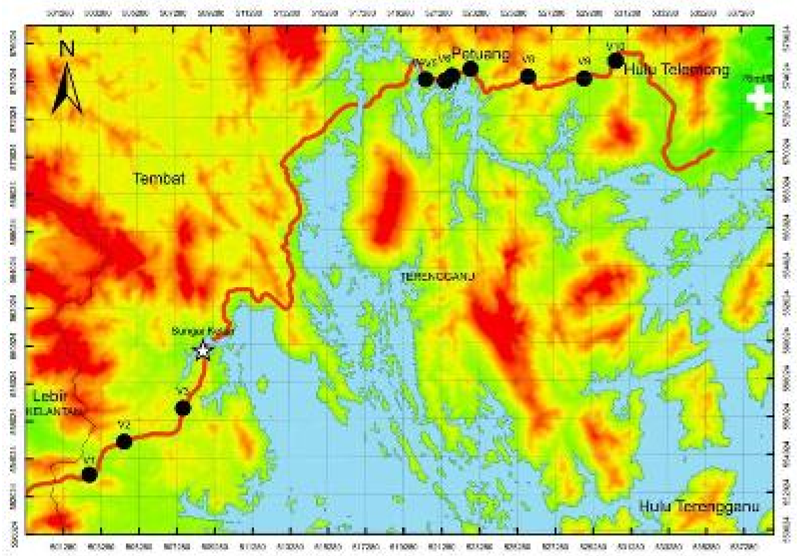
Notes: The analytical theme represented by each model, hum (human disturbance sign), seg (route segment no.), orig (origin of route), the intercept-only model, and *route* as a random effect), and the information-theoretic ranking of models investigating the predictors of mammal IUCN threat categories according to Akaike's information criterion corrected for small sample size (AIC_c) are shown. k = number of parameters, –LL = maximum log-likelihood, ΔAIC_c = difference in AIC_c for each model from the most parsimonious model, $wAIC_c$ = AIC_c weight, and %DE = percent deviance explained in the response variable by the model under consideration.

- Examining route segments (n=165) within 500m from the highway, those originating from viaducts were more likely to have human camps than those originating from logging road entrances. Of 15 old camps found within 500m from the highway, 67% were recorded along routes originating from viaducts and most were probably established by local campers. Our binomial logistic regression showed that route segment no. (seg) and origin of route (ori) was included top-ranked information-theoretic model (AIC_c weight = 0.93), with both metrics contributing to 23.3% of the variance explained. Patrols along routes from viaducts spanning 500m could therefore be useful at deterring unauthorized human access. However, longer-term data from our project is needed to investigate whether such camps at viaducts affect movement of tiger prey.

Caveats and future directions

- Future analyses will be conducted to account for detection probability (using data from our resampled routes) in human disturbance encounter rates and spatial autocorrelation. I will also explore better predictors of human disturbance signs (e.g., no. of access points in each transect) and increase our replicates to obtain better predictive results.

Objective 3: In Malaysia, NGOs have calling for the creation of viaducts in wildlife corridors to facilitate the movement of tigers and their prey, but never had prior knowledge of whether viaducts are actually utilized by these mammals. Ten viaducts (black circles in map below) have been built along the Kuala Berang Highway in the State of Terengganu. The first three viaducts were intentionally built to facilitate the movement of mammals such as tigers and tiger prey – this study aims to assess whether all ten viaducts serves this purpose.



Conservation outcomes

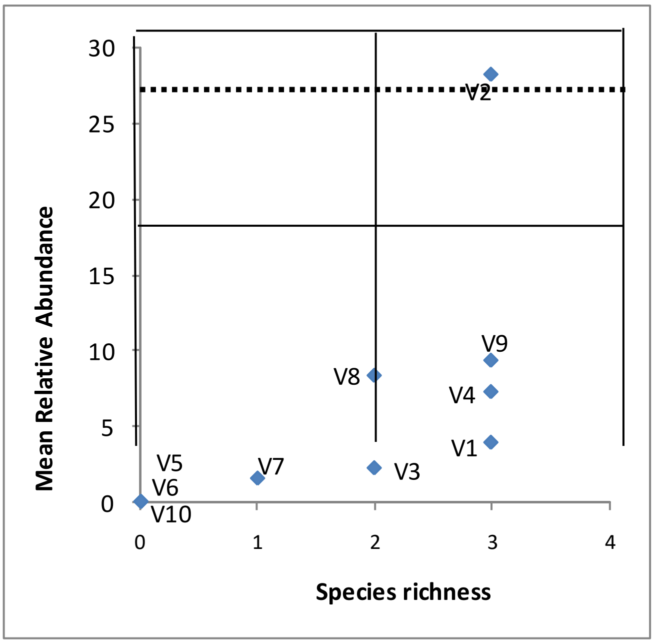
- Our project determined that seven mammal species utilise the viaducts in the Kenyir Wildlife Corridor. Of these species, three potential tiger prey utilise 7 of the 10 viaducts (see below).

(Barking deer (Muntiacus muntjak)

Asian tapir (Tapirus indicus)

Wild pig (Sus scrofa)

- From 40 camera traps deployed at the dry columns of 10 viaducts over a total of 2323 camera-trap nights, viaduct no. 2 was considered the most effective wildlife crossing structure for tiger prey as it came out on the top right quadrant (see below) of a species richness vs. mean relative abundance map (see Appendix 3 for methods). It is recommend that enforcement authorities prioritise viaduct 2 for patrols due to this viaduct being a ‘wildlife crossing hotspot’, followed by viaducts 1, 3, 4, 8 and 9 as secondary priorities.



- Vegetation improvement activities could also be prioritised at viaduct no. 1, 2, 3, 4, 8 and 9 to facilitate greater movement among mammals. At secondary viaducts with high amounts of human activity (e.g., viaducts 4, 8 and 9), ‘no camping’ signs could be erected to minimise the effects of human disturbance on tiger prey utilising these viaducts.
- Despite the presence of tiger prey at seven viaducts, tigers have yet to be recorded at the viaducts, although six pugmarks (see below) have been found in forests near to the highway.


Caveats and future directions

- As relative abundance indices fail to account for imperfect detection, I will reanalyze our data to account for detection probability (using detections delimited by fixed sampling occasions).

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

This project has employed two local research assistants and four indigenous field assistants. During this project, two research assistants, William Yap and Paul Henry, have undergone capacity building. The former attend a GIS/remote sensing course, while the latter is applying for a field biology course. One of the indigenous field assistants has also been trained to conduct surveys after having learnt navigation and camera trapping skills. The local community around the field house has also expressed interest in our research. As such, we have printed interesting wildlife photos taken from the forests and made short captions in Malay. These photos were put up at the village committee head's shop to raise public awareness of wildlife found in our project site (see below).


5. Are there any plans to continue this work?

Yes, I have plans source for funds to complete Objective 1 and continue with the field surveys to get more comprehensive datasets for Objective 2 and 3.

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

The management recommendations resulting from this project will be socialised with government partners once the project objectives are complete. I also believe that the results from our project should be shared with researchers and members of the public. As such, we have set up a research group called Rimba (http://myrimba.org), through which have been regularly disseminating updates from each objective in our project.

Objective 1: Once we have determined the best classification method, we will also share our methods on our webpage (http://myrimba.org/category/biologists-toolbox) to allow other conservation scientists to replicate our methods for their own projects.

Objective 3: We regularly update the public on the mammal species recorded from the forests and the viaducts in the Kenyir Wildlife Corridor. We have set up a photo update section on the webpage (http://myrimba.org/2011/07/14/photo_update_4/) for this purpose.

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

The RSG was used between Nov 2010 and April 2011. The funds were used up by April 2011 before the project completion date (21 Jul 2011) as money was needed to support salaries of additional field assistants.

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 assistant salaries	1751	5299	3548	Due to the large spatial scale of this project, two additional research assistants were hired to help with the remote sensing in Objective 1 and camera trapping in Objective 2 and 3. As such, funds had to be diverted from the other two items.
Field camping equipment and rations	2917	0		I received a research grant from Univerisiti Malaya to cover expenses for this item.
Vehicle running and maintenance costs	1212	581	631	Part of the field vehicle running costs were covered by the Universiti Malaya Research Grant
Total	5880	5880		1.00 MYR = 0.203220 GBP

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

The next most important step would be to convince government authorities to take up our recommendation of focusing *forest* patrols at one old logging road (PEL08). *Highway* patrols should focus at viaducts 1, 2, 3, 4, 8 and 9 as they are more important viaducts to facilitate movement of tiger prey and the routes (~500m) originating from these viaducts may have a higher probability of detecting human disturbance. The next most important step would be to identify the most suitable classification method needed to process satellite images to obtain accurate deforestation rates for tiger landscapes for our modelling in Objective 1. Finally, it is important that we continue to collect long-term temporal data of viaduct usage by tiger prey and other mammals, as well as habitat use of nearby forests by mammals in order to be sure of the effectiveness of viaducts as wildlife crossing structures.

10. Did you use the RSGF logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

Yes, I used the RSGF logo in my presentations to government stakeholders such as the Department of Works. I have also placed the logo on our website to thank the Rufford Small Grants Foundation for their generous donation (http://myrimba.org/donors/).

RSGF was also acknowledged my recent article published in an international peer-reviewed journal, Frontiers in Ecology and the Environment (ISI impact factor: 8.820).

Clements RG, Bradshaw CJA, Brook BW and Laurance WF. The SAFE index: using a threshold population target to measure relative species threat. FRONTIERS IN ECOLOGY AND THE ENVIRONMENT (online early) DOI PDF

11. Any other comments?

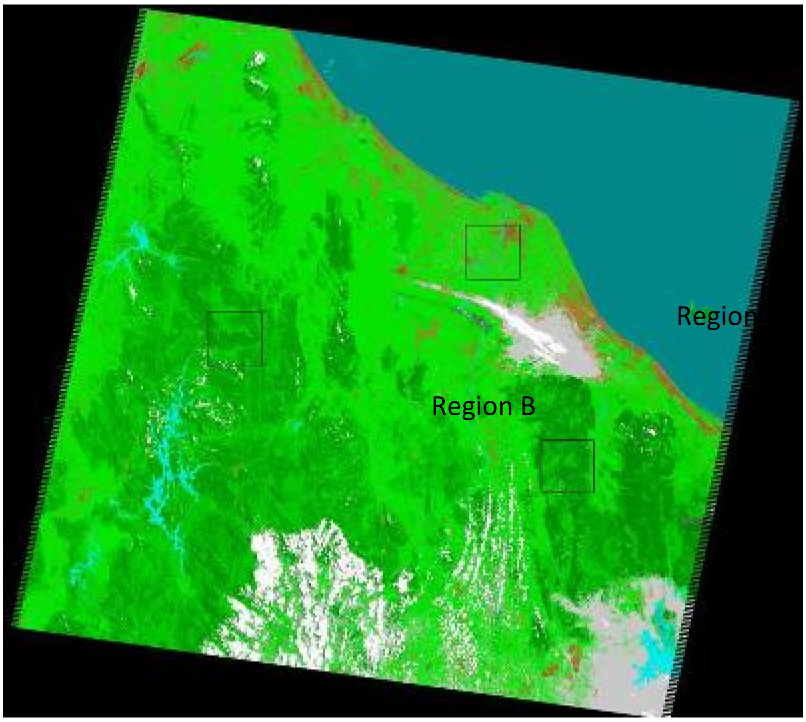
I am very grateful for the funds provided by the Rufford Small Grant Foundation for my project. I thank William Yap and Paul Henry for their assistance on the research and field work, as well as Acik, Dahar, Puyee, Param and Uda for their keen sense of direction and observational prowess in the forest. This research was conducted under an Economic Planning Unit research permit no. 2653, in collaboration with the Department of Wildlife and National Parks, Terengganu State Forestry Department, Universiti Malaya and the Department of Works.

I also thank these people for their donations (e.g., money, time, data, equipment, accommodation, food, advice, permits, logistics, etc) for the Kenyir Wildlife Corridor Project (in alphabetical order): Ahimsa Campos-Arceiz, Aida Elyana, Azrina Abdullah, Boyd Simpson, Burhanuddin Mohd Nor, Carl Traeholt, Cheong Pui Keng, Christopher Wong, Dylan Jefri Ong, Elangkumaran Sagtia Siwan, Kae Kawanishi, The Lau Family (Auntie, Uncle Bo Ang, Ah Gu, and Ching Fong), Goh Suz Suz, Liew Thor-Seng, Jeff and Nicole Ronner, Mark Rayan Darmaraj, Miriam Goosem, Mohd Nawayai Yasak, Mom & Dad, Puan Munirah, Radzi, Ramy Bulan, River Foo, Sara Sukor, Shariff Mohamed, Sheema Abdul Aziz, Steven Lim, Surin Suksuwan, Susan F. Laurance, Suzalinur Manja Bidin, Tang Fook Leong, Wan Noor Shahida, William F. Laurance, Wong Pui May, The Yap Family, Yong Chiu Mei, Yusoff Shariff, Zul and Zulkifli Ayob.

APPENDIX 1

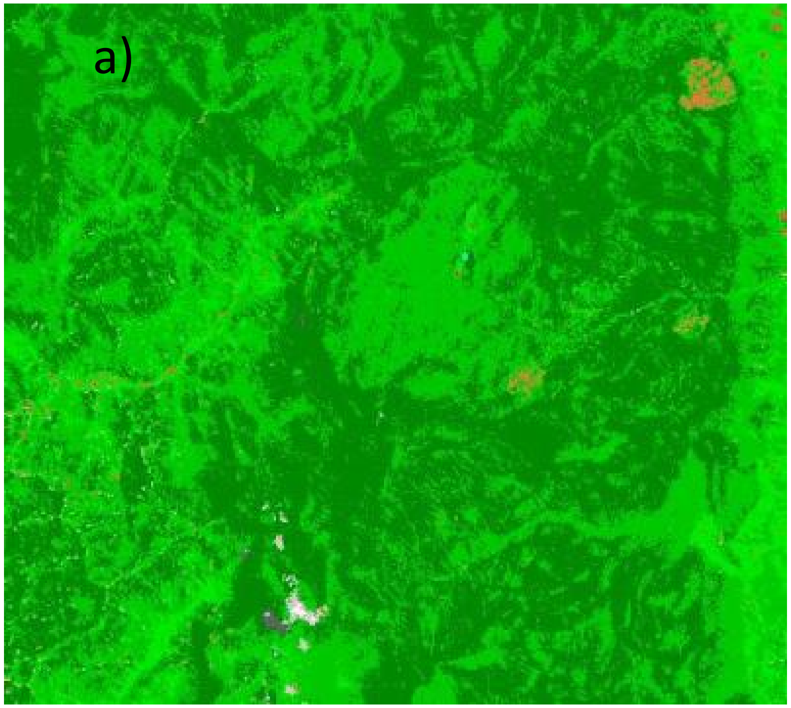
Why we need to experiment with different layer combinations for accurate satellite image classification?

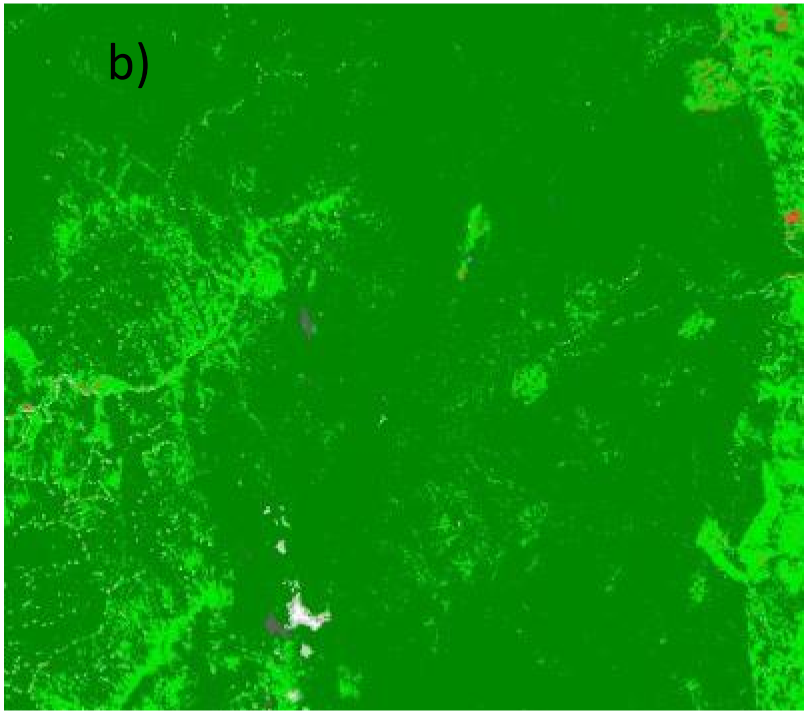
One of the main problems in remote sensing is the lack of standardized methodology from which a trained analyst could create a thematic map of an area that gives a fair representation of what is truly on the ground. The 'best' thematic maps are usually landscape-specific and they take a lot of time and effort to determine the most suitable classification methods, especially over large spatial scales. The main purpose of experimenting with different layer combinations is to obtain a standardized method, which could be used to create accurate thematic maps for Malaysia's tiger landscapes using publicly available satellite data. Success would make remote monitoring of tiger landscapes on a regional scale highly feasible and this would be a great asset to conservationists worldwide. Let us examine three regions (i.e., A, B and C) in one of our scenes from the Greater Taman Negara tiger landscape to get a better idea of our issues.



Region A

Region A (selectively logged forest)

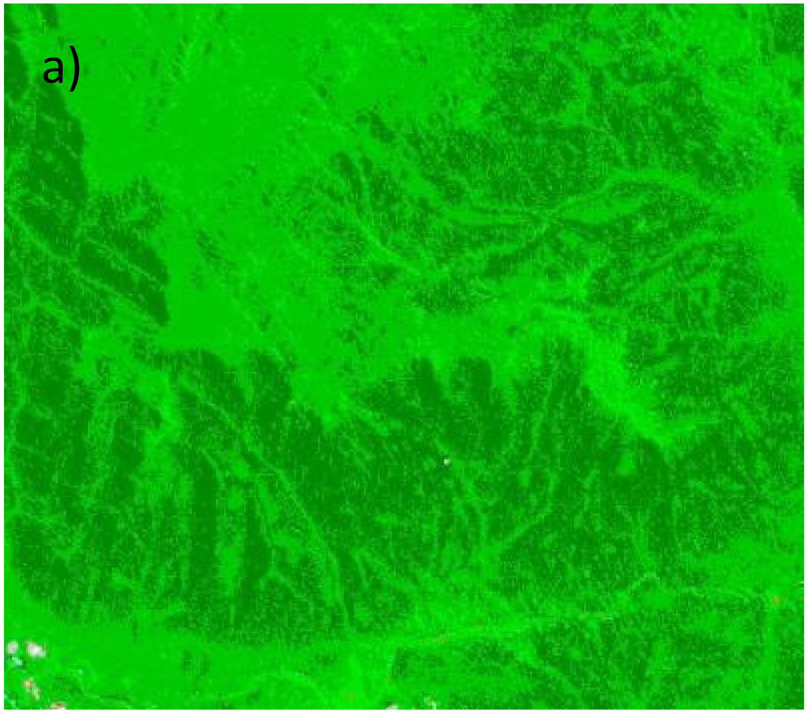


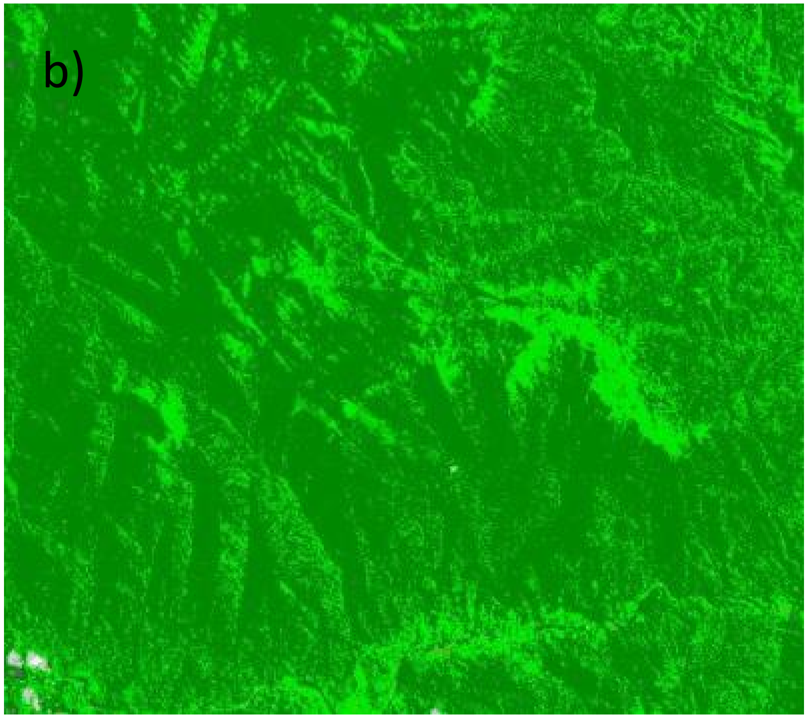


a) the thematic map with slope layer provided too much detail in terms of the terrain; this extra detail was unnecessary and will affect the results as the secondary forest area (light green) will be overestimated.

b) the thematic map with no additional information layers did a good job classifying this area, highlighting only the secondary forest area (light green).

Region B (primary forest)

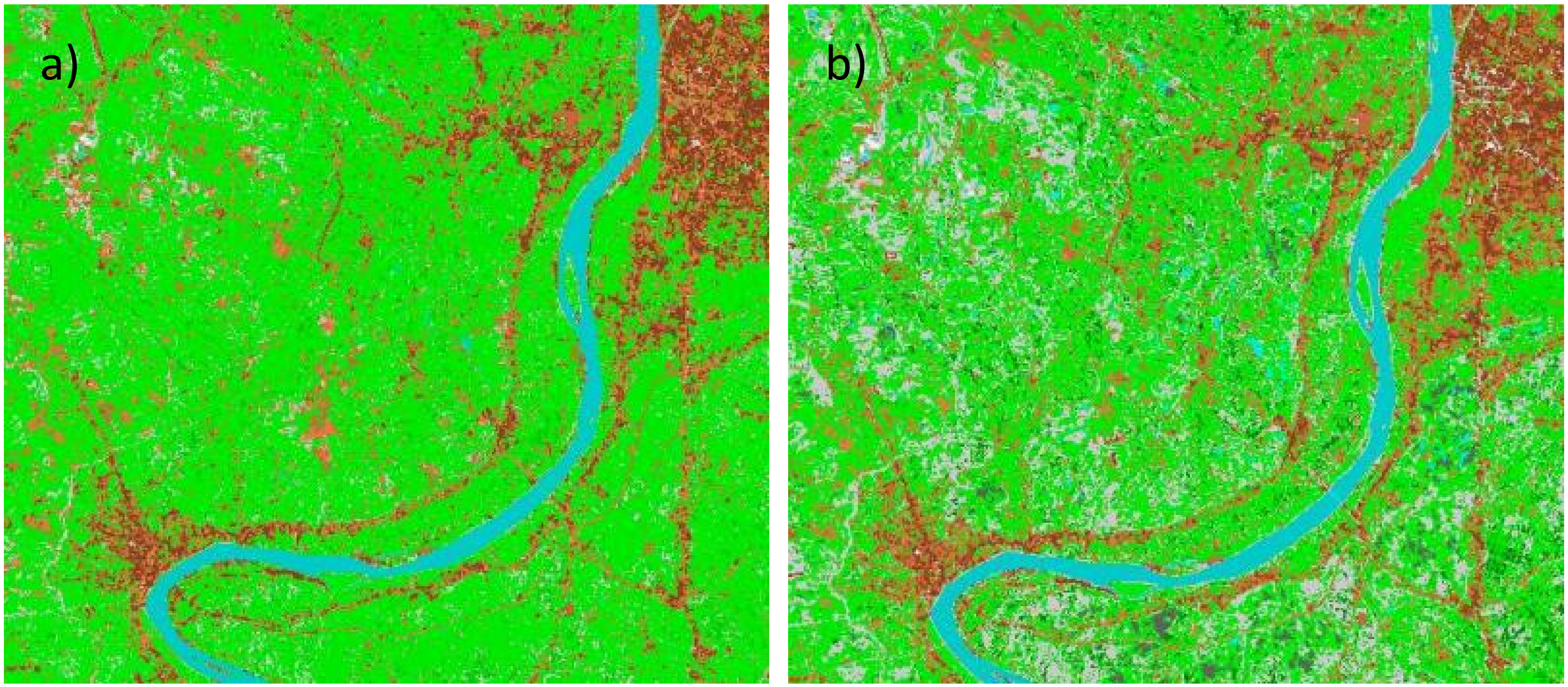




a) the thematic map with slope layer gave too much detail and resulted in a whole plateau classified as secondary forest (light green), when it is in fact part of a primary forest.

b) the thematic map with no additional information layers highlighted areas (light green)that probably represent a true gap in the forest canopy.

Region C (urban and suburban area)



a) the thematic map with slope map gave the best separation between man-made features and vegetation (in this case, they are mostly paddy fields).

b) the thematic map with no additional information layers included a lot of grey areas, which is actually a misclassification of paddy fields as cloud cover.

APPENDIX 2

What predicts the probability of detecting signs of human disturbance in the Kenyir Wildlife Corridor?

Two metrics that could possibly predict the occurrence of human disturbance were investigated: 1) route origin (i.e., whether route originated from a viaduct or old logging road entrance); and 2) route segment distance from highway (i.e, routes were divided into 100m segments. Binary logistic regression was conducted to determine which of the two metrics, route origin or route segment distance from highway, better predicted the probability of finding a human disturbance sign. Our binary response consisted of 'detection' or 'non-detection' of a human disturbance sign. Generalized linear mixed-effect models (GLMMs) were fitted to the data using *transect* as a random effect to account for spatial autocorrelation to some degree. Relative likelihoods and weights of models were calculated using Akaike's information criterion corrected for small sample sizes (AIC_c). For each model, the percentage deviance explained (%DE) as a measure of goodness-of-fit was also calculated, and compared each model's %DE to determine the proportion of variance in the response that was attributable to each predictor.

APPENDIX 3

How do we measure the effectiveness of a viaduct in facilitating the movement of tigers and their prey?

A species richness vs. relative abundance map was developed to quantify the effectiveness of a viaduct as a wildlife crossing structure for tiger prey. Species richness is defined as the total number of species detected (max species richness = 4; the Malayan tiger and three potential tiger prey species – wild pig, barking deer and Asian Tapir) at each viaduct over the entire camera trap duration; while relative abundance was defined as the mean relative abundance indices (RAI) of all cameras at each viaduct. RAI is calculated by the formula:

$$RAI = 100 * \frac{\sum detections}{\sum trapnights}$$

For successive photocaptures of the same species over a long duration, a 30-min interval was used to delimit a new detection of the same species; this can help provide some degree of independence to the species detections.