Final Evaluation Report

Your Details	
Full Name	Hector Alexis Luque Machaca
Project Title	Impacts of Logging on Terrestrial Mammals in the Tropical Forests of Sarapiquí, Costa Rica
Application ID	28321-1
Grant Amount	£ 5000
Email Address	Hectorluque02@gmail.com
Date of this Report	March 2, 2021

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
Estimate the species richness of the assemblage of large and medium-sized terrestrial mammals in forests subjected to logging with different post-harvest regeneration times.				With a sampling effort of 4,634 trap nights, we detected a total of 20 native species of large and medium-sized mammals, and one non-native species (*Canis lupus familiaris*; Appendix 1). Wild mammals were distributed in 14 families distributed in eight taxonomic orders, of which Carnivora had the highest number of families and species, followed by the Didelphimorphia, Rodentia and Artiodactyla (Appendix 2). Initially we wanted to estimate the species richness for each forest individually. However, we were forced to group the forests into three regeneration categories (7-14 years, 18-24 years, and 25-45 years), due to the low number of records in some of the sampling units. In all three clusters, the richness estimates were higher, but not significantly greater, than the observed naive richness (Appendix 3). In forests with 7-14 years of regeneration, rarity and vulnerability to hunting were part of the best richness model, while in forests with 18-24 years and 25-45 years of regeneration, the rarity models had a greater effect on estimated richness (Appendix 3).
Quantify the species occupancy of the assemblage of large and medium-sized terrestrial mammals and its relationship with local habitat attributes in forests subjected to logging.				We estimated occupancy of the 20 wild species within seven trophic guilds: omnivorous predators, meso-predators, apex predators, large herbivores, medium herbivores, insectivores, and omnivores (Appendix 4). No top-ranking model emerged for any of the guilds; that is, $\omega i>$ 0.90 of the Akaike weight. Alternatively, we used the delta Akaike ($\Delta AICc$) values in the models of all the guilds (Appendix 5). **Omnivorous predators:** The covariates were included in the top-ranking models were quantity of 1m saplings, proportion of forest canopy closure, percentage of leaf litter and presence of dogs. The non-

				transformed beta coefficients of the first three covariates showed positive relationships with the occupancy of the guild. On the other hand, the presence of dogs had a negative effect. For all cases, the results coincided with our *a priori* predictions. **Meso-predators:** The top-ranking models included the following covariates: proportion of basal area, proportion of forest canopy closure, proportion of vertical light closure of the forest, number of 2m saplings, number of seedlings, regeneration time, and number of 1m saplings. All of the covariates, except number of seedlings and regeneration time, showed positive relationships with the occupancy of the guild. **Apex predators:** The top-ranking occupancy models were the constant models. However, we included proportion of forest canopy closure as a covariate in the 90% confidence sets and found that it was positively correlated to the occupancy of this guild. **Large herbivores:** The top-ranking occupancy models were the constant models. However, we included proportion of forest canopy closure as a covariate in the 90% confidence sets and found that it was positively correlated to the occupancy of this guild. **Medium herbivores:** The top-ranking occupancy models were the constant models. However, we included proportion of forest canopy closure as a covariate in the 90% confidence sets and found that it was positively correlated to the occupancy of this guild. **Omnivores:** We found proportion of vertical forest light closure, number of 1m saplings, percentage of leaf litter, and proportion of forest canopy closure in the top-ranking models. For this guild, only the forest's vertical light closure ratio matched our *a priori* predictions. **Insectivores:** Percentage of leaf litter, proportion of basal area, regeneration time, number of seedlings, and number of

				1m saplings were part of the top-ranking models. All were positively related to the occupancy of the guild except regeneration time.
Quantify the species occupancy of the assemblage of large and medium-sized terrestrial mammals and its relationship with habitat attributes at the landscape scale in forests subject to logging.				We estimated occupancy of the trophic guilds described above at the landscape scale. No top-ranking model emerged for any of the guilds; that is, ωi> 0.90 of the Akaike weight. Rather, the models from all guilds had low ΔAICc values (Appendix 6). **Omnivorous predators:** Percentage of forest cover and density of roads were part of the top-ranking models. Only the non-transformed beta coefficient of the first covariate coincided with our *a priori* prediction, showing a positive relationship with the occupancy of the guild. **Meso-predators:** Percentage of forest cover, regeneration time, presence of dogs, and distance to national parks were included in the top-ranking models. All covariates except forest regeneration time coincided with our *a priori* predictions. **Apex predators:** Density of roads, presence of dogs, and distance to towns were part of the top-ranking models. The non-transformed beta coefficients of these covariates showed negative relationships with the occupancy of this guild, coinciding with our *a priori* predictions. **Large herbivores:** Density of roads, presence of dogs, percentage of forest cover, and regeneration time were part of the top-ranking models. The beta coefficients were variable and generally did not coincide to our *a priori* predictions. **Medium herbivores:** The percentage of forest cover and the regeneration time of the forest were located within the top-ranking models. Both variables were positively related to the occupancy of this guild. **Omnivores:** The distance to national parks, the distance to towns and the presence of dogs were part of the top-ranking models. Of these variables, only distance to towns did not coincide with our *a priori* predictions. **Insectivores:** Percentage of forest cover,

				density of roads, and distance to national parks were found within the top-ranking models. All covariates coincided with our *a priori* predictions.

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

During data collection, the main unforeseen difficulties were the SARS-CoV2 pandemic and adverse weather conditions. These issues caused a delay in data collection of approximately 3 months.

In the systematisation and digitisation phase of the camera trap data, I analysed a total of 38,996 photographs using Colorado Parks and Wildlife's CPW programme. During the process of extracting results for occupancy analyses, a programme error forced me to reanalyse 32,442 photos, causing a significant delay at this stage. However, this problem allowed us to identify two species that were not detected in the first review: *Puma yaguaroundi* and *Procyon lotor*. Due to these new findings, we reanalysed the remaining photographs but did not identify any other new species. This unexpected error contributed to the double revision of our data, decreasing the observer detection bias.

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

- Coinciding with other studies in tropical forests, we found a greater number of species in forests with longer post-harvest regeneration times (25 years or more). In these forests we recorded rare species such as *Leopardus tigrinus* and *Puma yaguaroundi*. This suggests that a longer regeneration time is essential for the persistence of rare species in forests subjected to logging.

- The structure of the forests we evaluated (local scale of habitat) had a differential influence on the occupancy of trophic guilds. In general terms, the occupancy of large and medium mammal trophic guilds was higher in mature forests (for example, forests with less light under the canopy, higher proportion of basal area and higher percentage of leaf litter). At the landscape scale, anthropic disturbances (e.g., higher road density, distance to towns) negatively influenced guilds' occupancy. Conversely, a higher percentage of forest cover and closer proximity to national parks had a positive effect on the occupancy of the guilds. Additionally, we noted a worrying presence of dogs, both free-roaming and hunting dogs, in eight of the sites evaluated in this study (Appendix 7). We suggest that this observation be considered in order to determine how hunting and the presence of this non-native species influence biodiversity, and therefore, forest sustainability.

- In Costa Rica, forest permits are granted considering the forests' dendrological, structural, and temporal characteristics. Our interpretation of our results shows that when granting these permits to private parties, parameters that take into account the configuration of the landscape must also be considered. This can be achieved through community strategies that focus on connecting forest patches by increasing forest connectivity, as well as vegetation cover allowing greater transit of key forest species such as mammals and other vertebrates.

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

In this study, the participation of human communities within the rural landscape of our study area was carried out through the Foundation for the Development of the Central Volcanic Mountain Range (FUNDECOR). This institution coordinated the necessary authorisation to start data collection on private properties. The owners of the properties where our sampling units were located were informed about the importance of this research for the sustainability of their forests. Additionally, they participated in a telephone interview in which they were asked whether hunting took place on their land. If they confirmed this practice, they were asked about their perceptions of the intensity of hunting in the forests on their land.

5. Are there any plans to continue this work?

Yes. The next step involves human communities within the area of influence of our research. This consists of coordinating workshops (held virtually, due to the pandemic) to present the results of this work and the factors (characteristics of the forest structure and habitat characteristics at the landscape scale) that influenced the persistence of large and medium-sized terrestrial mammals in their forests. In this fashion, we intend to sensitise the population with respect to the fauna associated with the forests subjected to human use.

I also believe that it is important to continue collecting data in the field to obtain estimates that are ever closer to the reality of the status of large and medium-sized terrestrial mammals in forests subjected to logging. We are currently working to obtain research permits to continue collecting data in the study area. This will also allow us to answer other questions that arose during this first stage of the project.

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

Taking into account the importance of sharing these results with various stakeholders at the local, national, and international level, my thesis supervisor and I consider it important to disseminate the results through four types of media: scientific articles in indexed journals, participation in congresses and symposia, articles in national newspapers, and audiovisual production.

We will submit two scientific articles with our results to indexed journals for review, as well as an additional article based on a literature review that we carried out to determine the current knowledge about the responses of mammals to forest harvesting. We also intend to present our results in upcoming conferences on conservation of biodiversity. Regarding publication in national newspapers, we will write notes in the college newspapers of the National University of Costa Rica (UNA) and the University of Costa Rica (UCR) to disseminate our results with the university community and the local population. Lastly, with the support of FUNDECOR, we will continue the audiovisual production of our work, producing videos that show our results and recommendations. This will complement the first video we made in which we showed the data collection process: https://www.youtube.com/watch?v=doiRYTKveqM&t=50s

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

We utilised the RSG throughout the project. Although the expected time of use of the funds was 1 year, I was forced to extend the use of the funds for an additional 3 months due to poor weather conditions in January and the closure of FUNDECOR activities for 2 months (April and May) due to the pandemic. During these additional months, I readjusted the funds to use them for food (36 days)

8. Budget: 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. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Camera traps	1577	1365	+212	
GPS	474	442	+32	
GAS	582	0,00	+582	The motorcycle could not be purchased. This amount was used for food.
Food	2367	3447	-1080	The sampling period was extended. Difference for camera traps, GPS and GAS redirected to food (£ 826).
Total	5000	5254	-254	The leader of the project covered the difference.
Exchange rate used				1 GBP = 722.35 CRC

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

Considering the importance of carrying out similar studies in other regions of Costa Rica, as well as in Central America, the next step should be to organise public and private inter-institutional cooperation to collect information on the responses of the assemblage of terrestrial mammals and other taxonomic groups to forest use on wider spatial scales. This would allow focusing and highlighting of the importance of this type of study for the sustainability of the neotropical forests of Central America and the effective conservation of biodiversity.

10. 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?

Yes, the Rufford Foundation logo was used to present the progress of the project through a video presenting the data collection procedure to the various interest groups interested in this topic. This first advance was disseminated by various institutions, including the National University of Costa Rica.

11. Please provide a full list of all the members of your team and briefly what was their role in the project.

Hector Alexis Luque Machaca: I conducted the field samplings, the organization and analysis of the data, the writing of reports, and the presentation of the results of this work.

Joel Sáenz Méndez: Contributed substantially to the conceptualization of the project, as well as the methodological design of the field sampling. He accompanied the team during field samplings and advised the project in all its stages.

Manuel Spinola Parallada: Contributed to the design of the statistical, theoretical, and methodological analyses of the project.

Bernal Herrera Fernández: Served as an advisor to the project and will made recommendations for the applicability of our ecological results to sustainable forest management strategies.

12. Any other comments?

I would like to thank the Rufford Foundation for supporting the idea of conserving large and medium-sized land mammals in forest landscapes subject to logging. The generation of this knowledge allowed us to have a better understanding of how this assemblage adapts to forest landscapes designated for logging. The development was a success because we managed to meet the proposed objectives, and the information generated can now be used to make recommendations to contribute to sustainable management of the tropical forests of Costa Rica.

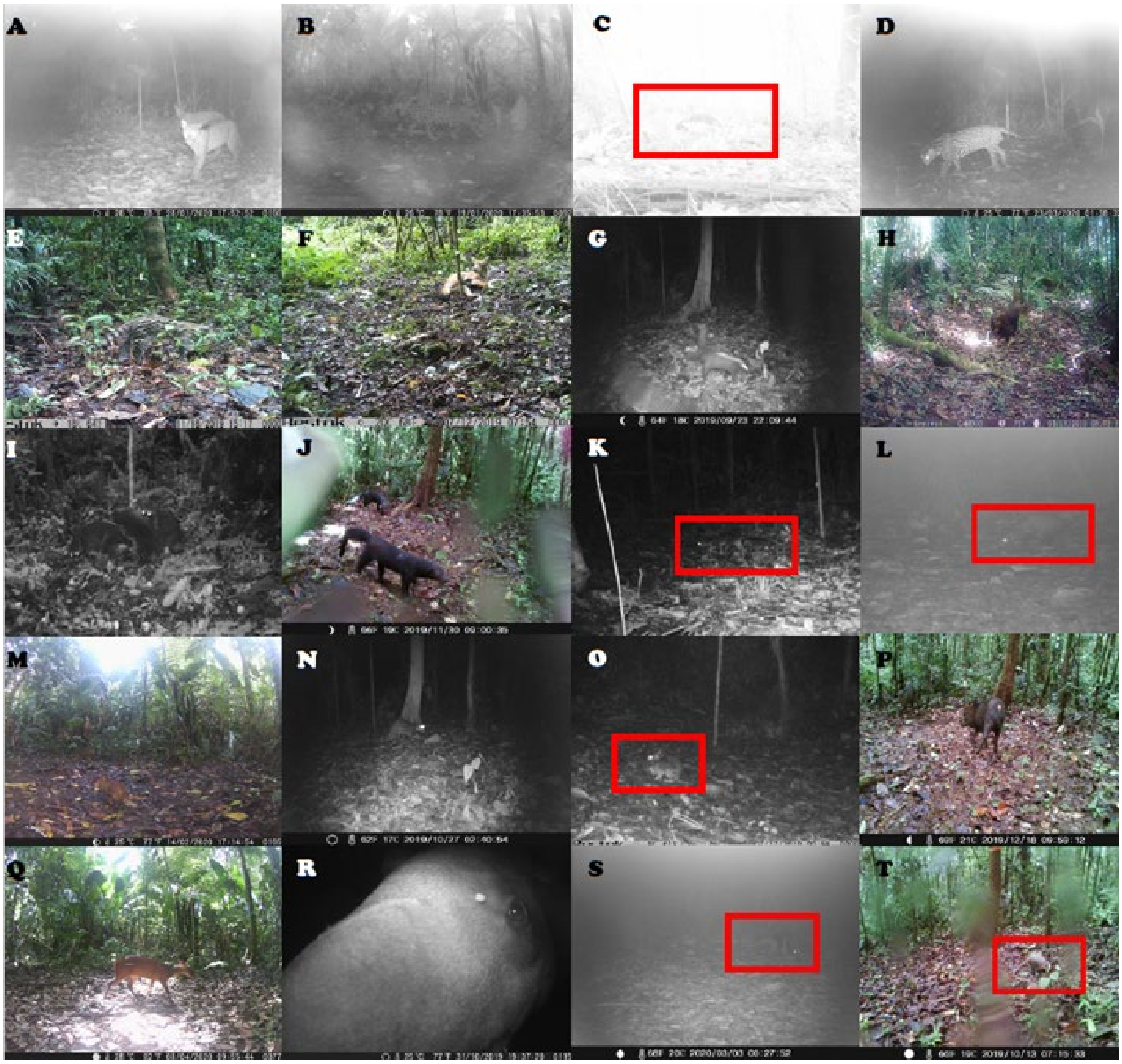
Additionally, during the development of this project, important new research questions arose relating to the conservation of biodiversity in the tropical forests of our study area. For example, we documented the presence of hunting dogs and stray dogs. In natural areas, stray, wild, or hunting dogs interact with native fauna as prey, competitors, or predators, posing a great threat to biodiversity. For this reason, we recommend conducting studies to determine which factors promote the presence of this domestic predator in the forests of our study area and how it impacts native species.

Finally, I would like to comment that executing the last stage of this research in the midst of the humanitarian crisis that we are going through as a society was a massive challenge that I had to face as a foreign student in Costa Rica. On some occasions, social distancing, confinement, and concern for my family in Peru caused me to feel overwhelmed and emotionally exhausted. I managed to cope with these issues thanks to the professional assistance provided by the Costa Rican Government. I submit this very personal testimony so that it can be documented and serve as a precedent for the design and implementation of professional assistance plans for students outside their countries of origin during times of crisis.

*Below 7 Appendices

Appendices

Appendix 1. Large and medium-sized terrestrial mammals detected in forests with different years of post-harvest regeneration, Costa Rica, 2020.



A) *Puma concolor*	**F)** *Canis latrans*	**K)** *Philander opossum*	**P)** *Pecari tajacu*
B) *Panthera onca*	**G)** *Conepatus semistriatus*	**L)** *Didelphis marsupialis*	**Q)** *Mazama temama*
C) *Puma yaguaroundi*	**H)** *Nasua narica*	**M)** *Dasyprocta punctata*	**R)** *Tapirella bairdii*
D) *Leopardus pardalis*	**I)** *Procyon lotor*	**N)** *Cuniculus paca*	**S)** *Tamandua mexicana*
E) *Leopardus tigrinus*	**J)** *Eira barbara*	**O)** *Sylvilagus brasiliensis*	**T)** *Dasypus novemcinctus*

Order	Family	Species
Carnivora	Felidae	*Panthera onca* (Linnaeus, 1758)
		Puma concolor (Linnaeus, 1771)
		Puma yaguaroundi (É. Geoffroy Saint-Hilaire, 1817)
		Leopardus pardalis (Linnaeus, 1758)
		Leopardus tigrinus (Schreber, 1775)
	Canidae	**Canis lupus familiaris* Linnaeus, 1758
		Canis latrans Say, 1823
	Mephitidae	*Conepatus semistriatus* (Boddaert, 1785)
	Procyonidae	*Nasua narica* (Linnaeus, 1766)
		Procyon lotor (Linnaeus, 1758)
	Mustelidae	*Eira barbara* (Linnaeus, 1758)
Didelphimorphia	Didelphidae	*Philander opossum* (Linnaeus, 1758)
		Didelphis marsupialis Linnaeus, 1758
Rodentia	Dasyproctidae	*Dasyprocta punctata* Gray, 1842
	Cuniculidae	*Cuniculus paca* (Linnaeus, 1766)
Lagomorpha	Leporidae	*Sylvilagus brasiliensis (*Linnaeus, 1758)
Artiodactyla	Tayassudidae	*Pecari tajacu* (Linnaeus, 1758)
	Cervidae	*Mazama temama* (Erxleben, 1777)
Perissodactyla	Tapiridae	*Tapirella bairdii* (Gill, 1865)
Pilosa	Myrmecophagidae	*Tamandua mexicana* (Saussure, 1860)
Cingulata	Dasypodidae	*Dasypus novemcinctus* Linnaeus, 1758

*Non-native predator

Appendix 3. Statistics of model selection, observed naive richness, and richness estimates derived from the analysis of occupancy in forests with different years of post-harvest regeneration, Costa Rica, 2020.

Model	**K**	(7-14 years of regeneration)	(18-24 years of regeneration)	(25-45 years of regeneration)
		ΔAIC$_c$	ΔAIC$_c$	ΔAIC$_c$
p(.), Ψ (.)	2	2.84	2.39	1.61
p(.), Ψ (rarity)	3	0.45	**0.00**	**0.00**
p(.), Ψ (diet)	3	4.10	3.65	3.39
p(.), Ψ (hunting)	3	3.03	4.46	4.08
p(.), Ψ (habitat)	3	4.70	2.49	1.22
p(.), Ψ (size)	3	3.29	4.43	4.02
p(.), Ψ (vulnerability)	3	2.06	3.77	3.84
p(.), Ψ (home range)	3	5.31	4.12	4.02
p(.), Ψ (rarity + hunting)	4	0.94	2.40	2.68
p(.), Ψ (rarity + vulnerability)	4	**0.00**	1.79	2.55
p(.), Ψ (global)	9	16.77	18.21	15.83
Observed richness	–	14	14	20
Estimated richness (Ψ±SE)	–	16(0.87)	16(0.88)	23(1.08)

Appendix 4. Large and medium-sized land mammals grouped into trophic guilds, Costa Rica, 2020.

Trophic guild	Species
Apex predators	*Panthera onca* (Linnaeus, 1758)
	Puma concolor (Linnaeus, 1771)
Mesopredators	*Puma yaguaroundi* (É. Geoffroy Saint-Hilaire, 1817)
	Leopardus pardalis (Linnaeus, 1758)
	Leopardus tigrinus (Schreber, 1775)
Omnivorous predators	*Procyon lotor* (Linnaeus, 1758)
	Nasua narica (Linnaeus, 1766)
	Eira barbara (Linnaeus, 1758)
	Conepatus semistriatus (Boddaert, 1785)
	Canis latrans (Say, 1823)
Large herbivores	*Tapirus bairdii* (Gill, 1865)
	Mazama temama (Erxleben, 1777)
Medium herbivores	*Cuniculus paca* (Linnaeus, 1766)
	Sylvilagus brasiliensis (Linnaeus, 1758)
Insectivores	*Tamandua mexicana* (Saussure, 1860)
	Dasypus novemcinctus (Linnaeus, 1758)
Omnivores	*Pecari tajacu* (Linnaeus, 1758)
	Philander opossum (Linnaeus, 1758)
	Didelphis marsupialis (Linnaeus, 1758)

Appendix 5. Model selection statistics and effects of habitat covariates at the local scale, estimated (β) for models of occupancy of the assemblage of large and medium-sized terrestrial mammals in forests subjected to logging, Costa Rica, 2020.

Model	k	ΔAICc	ωi	β1	SE	β2	SE
Apex predators							
Ψ(.), p(.)	2	**0.00**	0.26				
Ψ(canopy), p(.)	3	1.37	0.13	1.39	1.01		
Ψ(saplings), p(.)	3	1.73	0.11	1.23	0.97		
Ψ(vertical canopy), p(.)	3	1.81	0.11	1.19	0.95		
Ψ(leaf litter), p(.)	3	2.00	0.10	1.19	1		
Ψ(basal area), p(.)	3	3.06	0.06	0.73	0.85		
Ψ(dogs), p(.)	3	3.17	0.05	-1.21	1.44		
Ψ(years), p(.)	3	3.76	0.04	0.29	0.70		
Ψ(saplings2), p(.)	3	3.80	0.04	0.25	0.69		
Ψ(seedlings), p(.)	3	3.92	0.04	-0.05	0.72		
Ψ(canopy + vertical canopy), p(.)	4	4.01	0.04	2.33	1.77	1.79	1.37
Ψ(basal area + saplings), p(.)	4	4.59	0.03	1.88	1.60	2.05	1.32
$\hat{\psi}$(SE)	0.24 (0.92)						
Obligate carnivorous mesopredators							
Ψ(basal area), p(days)	4	**0.00**	0.23	1.76	1.23		
Ψ(.), p(.)	2	0.46	0.18				
Ψ(canopy), p(days)	4	1.01	0.14	1.17	0.85		
Ψ(vertical canopy), p(days)	4	1.32	0.12	1.47	1.14		
Ψ(saplings2), p(days)	4	2.39	0.07	0.75	0.80		
Ψ(seedlings), p(days)	4	2.59	0.06	-0.72	0.85		
Ψ(years), p(days)	4	2.75	0.06	-0.57	0.71		
Ψ(saplings), p(days)	4	2.97	0.05	0.53	0.77		
Ψ(leaf litter), p(days)	4	3.23	0.05	0.32	0.67		
Ψ(dogs), p(days)	4	3.36	0.04	0.41	1.33		
$\hat{\psi}$(SE)	0.51 (0.79)						
Omnivorous predators							
Ψ(saplings), p(.)	3	**0.00**	0.29	2.19	1.32		
Ψ(canopy), p(.)	3	1.26	0.16	1.66	1.04		
Ψ(.), p(.)	2	1.50	0.14				
Ψ(canopy + saplings), p(.)	4	1.80	0.12	2.44	2.18	2.85	1.99
Ψ(leaf litter), p(.)	3	2.87	0.07	1.20	0.87		
Ψ(dogs), p(.)	3	2.92	0.07	-2.19	1.55		
Ψ(saplings2), p(.)	3	4.07	0.04	0.88	0.86		
Ψ(canopy + vertical canopy), p(.)	4	4.31	0.03	2.87	1.88	-1.92	1.74
Ψ(basal area), p(.)	3	4.37	0.03	0.71	0.72		
Ψ(seedlings + saplings), p(.)	4	4.81	0.03	-0.62	0.98	2.87	1.97
Ψ(years), p(.)	3	4.97	0.02	0.47	0.72		
$\hat{\psi}$(SE)	0.54 (1.09)						
Large herbivores							

Ψ(.), p(.)	2	**0.00**	0.26				
Ψ(canopy), p(.)	3	0.21	0.23	2.62	2.34		
Ψ(years), p(.)	3	0.36	0.22	-2.31	2.01		
Ψ(saplings), p(.)	3	1.86	0.10	1.26	1.05		
Ψ(saplings2), p(.)	3	2.29	0.08	0.99	0.87		
Ψ(dogs), p(.)	3	3.88	0.04	-0.36	1.60		
Ψ(leaf litter), p(.)	3	3.90	0.04	0.12	0.80		
Ψ(seedlings), p(.)	3	3.93	0.04	-0.04	0.96		
$\hat{\psi}$(SE)	0.45 (1.16)						
Medium herbivores							
Ψ(.), p(.)	2	**0.00**	0.33				
Ψ(vertical canopy), p(.)	3	1.55	0.15	1.31	0.99		
Ψ(years), p(.)	3	1.86	0.13	1.44	1.34		
Ψ(seedlings), p(.)	3	3.19	0.07	0.69	0.89		
Ψ(canopy), p(.)	3	3.59	0.05	0.42	0.73		
Ψ(dogs), p(.)	3	3.68	0.05	-0.70	1.42		
Ψ(saplings2), p(.)	3	3.73	0.05	-0.31	0.67		
Ψ(saplings), p(.)	3	3.83	0.05	-0.22	0.72		
Ψ(basal area), p(.)	3	3.88	0.05	0.15	0.71		
Ψ(leaf litter), p(.)	3	3.93	0.05	-0.04	0.72		
Ψ(years + seedlings), p(.)	4	5.53	0.02	2.22	2.12	1.23	1.31
$\hat{\psi}$(SE)	0.76 (0.85)						

Omnivores							
Ψ(saplings), p(days)	4	**0.00**	0.28	-1.47	1.06		
Ψ(vertical canopy), p(days)	4	1.53	0.13	0.89	0.76		
Ψ(leaf litter), p(days)	4	2.22	0.09	-0.85	0.96		
Ψ(canopy), p(days)	4	2.47	0.08	-0.56	0.70		
Ψ(.), p(.)	2	2.50	0.08				
Ψ(basal area), p(days)	4	2.60	0.08	0.53	0.73		
Ψ(saplings2), p(days)	4	2.72	0.07	-0.53	0.82		
Ψ(dogs), p(days)	4	2.75	0.07	0.87	1.40		
Ψ(seedlings), p(days)	4	2.97	0.06	-0.28	0.68		
Ψ(years), p(days)	4	3.00	0.06	-0.28	0.71		
$\hat{\psi}$(SE)	0.50 (0.76)						
Insectivores							
Ψ(leaf litter), p(days)	4	**0.00**	0.34	1.63	1.11		
Ψ(basal area), p(days)	4	1.25	0.18	1.08	1.01		
Ψ(years), p(days)	4	2.30	0.11	-0.37	0.79		
Ψ(saplings), p(days)	4	2.35	0.11	0.52	1.15		
Ψ(seedlings), p(days)	4	2.40	0.10	-0.32	0.93		
Ψ(canopy), p(days)	4	2.46	0.10	0.18	0.72		
Ψ(leaf litter + basal area), p(days)	5	3.74	0.05	4.71	5.83	4.93	6.23
$\hat{\psi}$(SE)	0.70 (1.27)						

Appendix 6. Statistics of model selection and effects of habitat covariates at landscape scale, estimated (β) for occupancy models of assemblage of large and medium-sized terrestrial mammals in forests subjected to forestry, Costa Rica, 2020.

Model	k	ΔAICc	ωi	β1	SE	β2	SE	β3	SE
Apex predators									
Ψ(roads), p(.)	3	**0.00**	0.38	-1.61	0.95				
Ψ(dogs + roads), p(.)	4	1.52	0.18	-2.05	1.81	-1.91	1.16		
Ψ(.), p(.)	2	2.13	0.13						
Ψ(towns + roads), p(.)	4	2.98	0.09	-0.80	1.30	-1.78	1.03		
Ψ(coverage), p(.)	3	3.25	0.08	0.85	0.73				
Ψ(dogs), p(.)	3	3.50	0.07	-1.43	1.26				
Ψ(years), p(.)	3	4.58	0.04	0.33	0.53				
Ψ(parks), p(.)	3	4.81	0.03	0.52	1.28				
$\hat{\psi}$(SE)	0.25 (0.86)								
Obligate carnivorous mesopredators									
Ψ(coverage), p(days)	4	**0.00**	0.47	1.09	0.76				
Ψ(years), p(.)	4	2.08	0.17	-0.35	0.58				
Ψ(dogs), p(days)	4	2.36	0.15	-0.40	1.14				
Ψ(parks), p(days)	4	2.46	0.14	0.20	1.21				
Ψ(coverage + parks), p(days)	5	3.71	0.07	1.11	0.76	0.29	1.26		
$\hat{\psi}$(SE)	0.65 (0.74)								
Omnivorous predators									
Ψ(coverage), p(.)	3	**0.00**	0.29	1.26	0.70				
Ψ(roads), p(.)	3	0.41	0.24	-1.20	0.66				
Ψ(.), p(.)	2	1.85	0.12						
Ψ(dogs + roads), p(.)	4	2.22	0.10	-1.43	1.22	-1.11	0.66		
Ψ(dogs), p(.)	3	2.50	0.08	-1.55	1.08				
Ψ(years), p(.)	3	3.07	0.06	0.78	0.72				
Ψ(coverage + years), p(.)	4	3.17	0.06	1.13	0.77	0.22	0.76		
Ψ(towns + roads + dogs), p(.)	5	3.68	0.05	-2.92	2.23	-2.05	1.22	-0.83	1.31
$\hat{\psi}$(SE)	0.77 (0.99)								
Omnivores									
Ψ(parks), p(days)	4	**0.00**	0.27	2.03	1.28				
Ψ(towns), p(days)	4	0.07	0.26	2.01	1.28				
Ψ(dogs), p(days)	4	1.90	0.10	-1.04	0.99				
Ψ(.), p(.)	2	2.58	0.07						
Ψ(coverage), p(.)	4	2.85	0.06	0.19	0.48				
Ψ(years), p(days)	4	3.00	0.06	-0.07	0.48				
Ψ(roads), p(days)	4	3.02	0.06	0.02	0.48				
Ψ(towns + roads), p(days)	5	3.15	0.06	2.51	1.49	0.48	0.61		
Ψ(towns + roads + dogs), p(days)	6	3.27	0.05	4.07	1.91	0.88	0.70	-2.70	1.50

$\hat{\psi}$(SE)	0.31 (1.29)								
Insectivores									
Ψ(coverage), p(days)	4	**0.00**	0.69	1.94	0.93				
Ψ(roads), p(days)	4	2.80	0.17	-1.53	0.85				
Ψ(coverage + parks), p(days)	5	3.17	0.14	1.99	0.93	1.08	1.43		
$\hat{\psi}$(SE)	0.74 (0.82)								
Large herbivores									
Ψ(roads), p(days)	4	**0.00**	0.43	-1.35	0.90				
Ψ(dogs+ roads), p(days)	5	2.58	0.12	1.60	1.61	-1.78	1.03		
Ψ(coverage), p(days)	4	2.85	0.10	0.40	0.54				
Ψ(years), p(days)	4	2.96	0.10	-0.56	0.78				
Ψ(.), p(.)	2	3.16	0.9						
Ψ(parks), p(days)	4	3.32	0.8	-0.45	1.34				
Ψ(dogs), p(days)	4	3.38	0.8	0.28	1.11				
$\hat{\psi}$(SE)	0.45 (0.76)								
Medium herbivores									
Ψ(coverage), p(.)	3	**0.00**	0.37	1.61	0.91				
Ψ(coverage + years), p(.)	4	0.58	0.28	3.88	3.13	2.84	2.21		
Ψ(years), p(.)	3	1.52	0.17	1.12	0.72				
Ψ(.), p(.)	2	2.48	0.11						
Ψ(dogs), p(.)	3	4.44	0.04	-0.96	1.04				
Ψ(towns), p(.)	3	5.31	0.03	-0.18	1.09				
$\hat{\psi}$(SE)	0.28 (1.11)								

Appendix 7. Free-roaming and hunting dogs in forests subject to logging. Costa Rica, 2020. (Hunters cover the lens of the trap camera to avoid detection).