A Camera Trap Inventory of Terrestrial Mammals in a Selectively Logged Forest, Southeastern Peru

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Abstract

This study provides the first inventory of terrestrial mammal presence and abundance at Finca Las Piedras, a biological station located in the Madre de Dios Department, Southeastern Perú, through camera trap monitoring of human and mammal pathways. Finca Las Piedras is located on the edge of a continuous forest that stretches toward the Bolivian border, composed mainly of Brazil nut concessions and selectively logged forest on one side, and agricultural fields and cattle pasture on the other. Ongoing threats of deforestation and fragmentation in the area represents an ecological pressure on faunal community that may lead to population decline or local extinction. Documenting the use of human and mammal-made trials provides insight into mammalian diversity, abundance, and distribution levels in Finca Las Piedras, and with further monitoring will help document the faunal recovery of the disturbed forest. Through our study we recorded 137 videos of terrestrial mammals belonging to 14 species, 13 families, and 7 orders. Upon review of the station's camera trap records an additional 7 species and 2 families were added, bringing the total to 21 species, 15 families, and 7 orders. This data will further conservation efforts by helping us monitor mammal diversity in areas with human disturbances such as deforestation and highway construction, and in a broader scope help to promote effective wildlife management.

Introduction

The Amazon Basin is the most biologically diverse place on Earth; it contains millions of species - many remain unknown. It extends across eight countries: Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana, and Suriname, and is Earth's largest rainforest and river system. The Amazon rainforest is often called the "lungs of the Earth" because it plays a vital role in regulating the Earth's climate and CO_2 sequestration, especially considering the increasing threats of climate change. There is a clear link between the health of the planet and the health of the Amazon, making this a vital biome to protect**.** Unfortunately, the Amazon rainforest is currently at risk with threats from both climate change and deforestation - "Since the year 2000, rainfall has declined across 69% of the Amazon Forest. WWF estimates that 27% of the Amazon biome will be without trees by 2030 if the current rate of deforestation continues"(World Wildlife Fund).

Studying mammal diversity in disturbed forests generates insights into the overall health of the forest and indicates recoverability. Many mammals play the role of forest gardeners, dispersing seeds throughout their range. Both the inhabitants and the habitat play an interconnected role in the overall ecological health and have evolved to fit a specific realized niche. Diversity and abundance of mammals of a certain place can be a comparable measurement utilized as a baseline for conservation efforts.

Perú alone is home to 559 species of terrestrial mammals, and Southeastern Perú has some of the highest diversity of plant and animal species in the world (Peruvian Ministry, 2020). However, many species have experienced huge declines due to hunting, deforestation, pollution, and poaching for the international fur trade. Mammals are specifically at risk with 21% possibly facing extinction and 61% of carnivores facing extinction (Ripple et al. 2014, IUCN 2018). Medium and large sized animals in forest biomes are facing the largest threat (Ripple et al. 2014, IUCN 2018), making the protection of their habits essential for wildlife conservation efforts on both international and local levels.

In Alliance for a Sustainable Amazon's Finca Las Piedras biological station, wildlife and habitat conservation are among the most vital objectives, and given its location, research in faunal communities could provide information on how resilient and dynamic disturbed forests could be after a regrowth period. Although some mammals are very charismatic and well-studied across the Amazonia, few studies focus on non-protected areas, forest fragments, and forest remnants in human-dominated environments. To that aim, we set up seven cameras divided into two primary locations: human made trails and animal made trails, for a period of 6 weeks.

Camera traps are now a standard method for monitoring a variety of species that may not be seen on transect studies or through eyewitness data recording. They are an excellent noninvasive method of monitoring local fauna, especially those that are cryptic and/or nocturnal (Tobler et al. 2018). Selective placement of camera traps along animal trails and natural paths maximizes encounter rates (Melo et al. 2012); furthermore, mammals have been informally documented using human trails at Finca Las Piedras since the station's founding in 2017.

The objective of this research project was to provide an initial terrestrial mammal assessment for Fincas Las Piedras by analyzing diversity, abundance, and distribution of commonly used pathways – human-made and mammal-made trials. With these two location types, we were also able to compare the frequency of use and differences in species composition between the two pathways. This information allows us to understand the broader mammal abundance in the disturbed forests of unprotected land in the Madre de Dios region. Understanding the number of species in an area is critical to predicting future impacts and monitoring current human impacts. By understanding the species abundances and interactions we can get a broader picture of the whole ecological structure of the area.

Methods

Study Site

Finca Las Piedras (FLP) is a research station in the Tambopata region of Madre de Dios, Perú (Lat.: -12.22789; Long.: -69.11119). The station is located 3km away from the Interoceanic highway and encompasses an area of 54 ha. FLP is composed of palm (*Mauritia*) swamp, new and regenerating farmland, and terra firme forest –

a moist forest with a pronounced dry season that peaks between August and October. The region's Köppen-Geiger climate classification is Af, Equatorial fully humid (Kottek et al. 2006). Located less than an hour outside of the regional capital of Puerto Maldonado, FLP's land features areas that were commercially logged and used as agricultural fields in recent decades, and as such is mostly new and second growth forest.

Data Collection

We deployed seven camera traps for a total of 280 camera trap days to nine different locations surrounding Finca Las Piedras. Traps remained in the field between 7 July 2021 and 16 August 2021 and were checked once weekly to maintain memory card space. The camera traps, Browning Model BTC-5HDPX, were programmed to record for 30 seconds when motion was detected and operated 24 hours a day, using infrared light to record data in low light/night conditions. Sightings of the same mammal were considered independent if they occurred within greater than one hour of each other (Tobler 2008).

Our camera trap array covered a minimum convex polygon of 29 hectares, an area equivalent to 52% of the FLP property. Camera trap locations were divided into two categories – human and mammal trails. Three camera traps were placed at the intersections of human trails to maximize encounter rates for approximately three weeks. For the rest of the data collection time, animal trails were identified based on the presence of animal signs (e.g. tracks, scat, and evident pathways) and proximity to water.

Upon camera collection, videos were reviewed and non-targeted species (e.g. birds, bats) were filtered out. All terrestrial mammals were then identified down to the species level using photo guides compiled by Alliance for a Sustainable Amazon and consultations with mammal experts, with the exception being small rodents that were unidentifiable without physical specimens. Our data collection also involved a review of the camera trap records

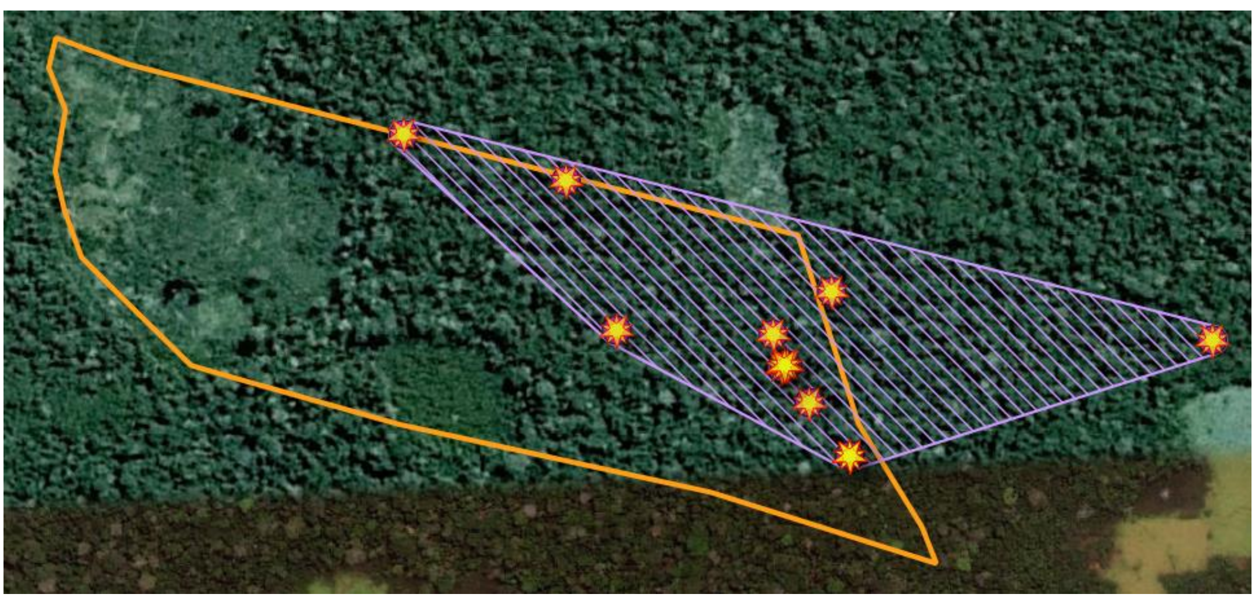

Figure 1: Camera trap locations. Purple: Minimum convex polygon area. Solid orange line: Finca Las Piedras property. Star: Camera trap location.

from the previous five years of FLP's operation. The station's previous camera trapping efforts have not followed specific research aims or recorded location data, so solely presence/absence data was able to be collected from these records (see Table 1).

Results

From 137 videos of terrestrial mammals, we detected 14 species belonging to 13 families and 7 orders; with the inclusion of FLP records an additional 7 species and 2 families were added, bringing the total to 21 species, 15 families, and 7 orders.

The number of sightings for each species ranged from 1 to 38, with the most common sighting being agoutis (*Dasyprocta variegata*). Our camera traps detected 12 of the 22 terrestrial mammal species previously documented at FLP in a field guide produced by Alliance for a Sustainable Amazon (Hendus 2019). Including FLP videos, 18 of the 22 terrestrial mammals were represented.

Additionally, five species were recorded that were not present in the species guide: Margay (*L. wiedii)*, Short-eared Dog (*A. microtis*), Crab-eating Raccoon (*P. cancrivorus*), Green Acouchi (*M. pratti*), and

Table 1: Terrestrial mammal species detected in the present study and previously at Finca Las Piedras. For IUCN status: LC: Least Concern, NT: Near Threatened, VU: Vulnerable, DD: Data Deficient.

Order/Family	Scientific name	Common Name	IUCN Status	Locations Seen	Sightings Recorded	From Past Recordings?
Order Carnivora						
Canidae	*Atelocynus microtis*	Short-eared Dog	NT	M	1	
Felidae	*Leopardus pardalis*	Ocelot	LC	M	2	
	Leopardus wiedii	Margay	NT		1	X
	Puma concolor	Puma	LC		2	X
	Panthera onca	Jaguar	NT		1	X
Mustelidae	*Eira barbara*	Tayra	LC	M	1	
Procyonidae	*Procyon cancrivorus*	Crab-eating Raccoon	LC	H	2	
	Nasua nasua	White-nosed Coati	LC		1	X
Order Rodentia						
Dasyproctidae	*Dasyproctidae variegata*	Central American Agouti	LC	H, M	38	
	Myoprocta pratti	Green Acouchi	LC	H, M	2	
Cuniculidae	*Cuniculus paca*	Lowland Paca	LC	M, H	16	
Sciuridae	*Sciurus spadiceus*	Southern Amazon Red Squirrel	LC	H	1	
Muridae	*Mus sp.*	unidentified mouse species		M, H	28	
Order Perissodactyla						
Tapiridae	*Tapirus terrestris*	South American Tapir	VU	M	8	
Order Artiodactyla						
Cervidae	*Mazama americana*	Red Brocket	DD	M, H	15	
Tayassuidae	*Pecari tajacu*	Collared Peccary	LC		6	X
Order Pilosa						
Myrmecophagidae	*Tamandua tetradactyla*	Collared Anteater	LC	M	1	
Order Didelphimorphia						
Didelphidae	*Didelphis marsupialis*	Common Opossum	LC		1	X
	Philander opossum	Gray Four-Eyed Opossum	LC	M	1	
Order Cingulata						
Dasypodidae	*Cabassous unicinctus*	Southern Naked-tailed Armadillo	LC		1	X
Chlamyphoridae	*Priodontes maximus*	Giant Armadillo	VU	H	1	

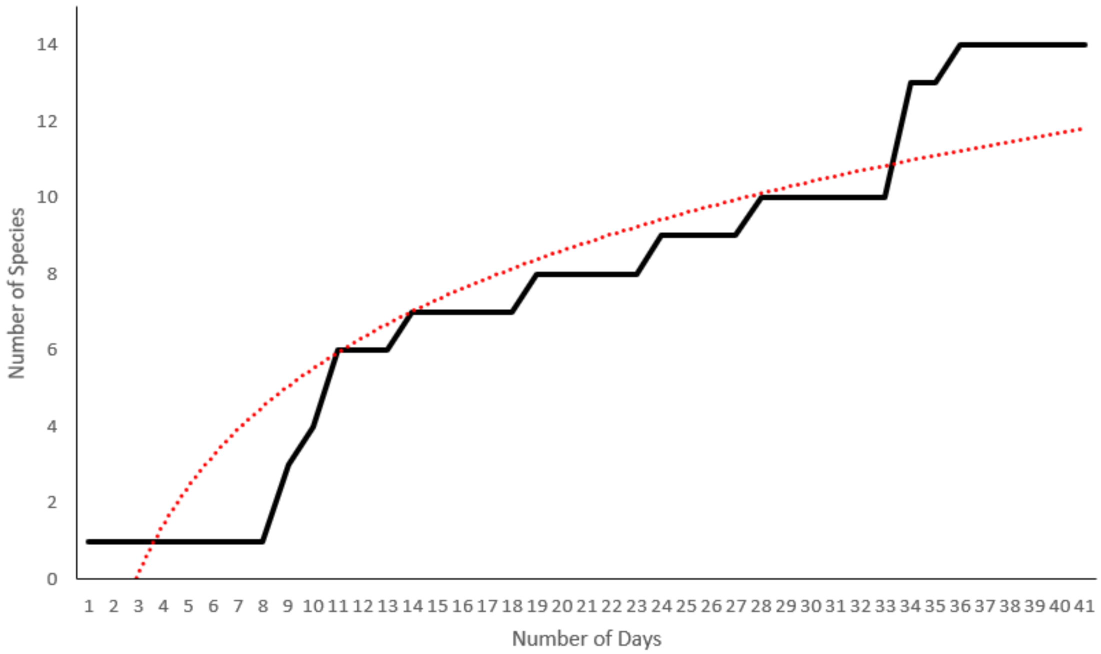

Figure 2: Species accumulation curve for 41 days of camera trap activity.

the Gray Four-eyed Opossum (*P. opossum*). This is the first documentation of any form of the Crab-eating Raccoon, Green Acouchi, and Gray Four-Eyed Opossum since the establishment of FLP in 2017.

The camera trap results from human trails and mammal trails differed in species composition and number. Unique to human trails were the Giant Armadillo (*P. maximus*), Crab-eating Raccoon (*P. cancrivorus*), and the Southern Amazon Red Squirrel (S. spadiceus); unique to mammal trails were the Tayra (E. barbara), South American Tapir (*T. terrestris*), Gray Four-Eyed Opossum (*P. opossum*), Collared Anteater (*T. tetradactyla*), Ocelot (*L. pardalis*), and Short-eared Dog (*A. microtis*). The Shannon-Weiner index for the mammal trail community was 1.432, while for the mammal trail community the Shannon-Weiner index was 1.805. While the mammal trail community was somewhat more diverse, the differences between these groups were not significant (P=0.679, t Stat = -.421, df = 16).

Discussion

Several factors potentially impacting our study results include overall sampling time, single season sampling, and uneven sampling effort between mammal and human trails. Given the number of camera traps at our disposal, assessing the complete terrestrial mammal diversity of Finca Las Piedras requires more time than the duration of our stay allowed. This is evidenced in our species accumulation curve, which did not approach an asymptote after 41 days of sampling; we attempted to mitigate this shortcoming (find better word) via the inclusion of FLP's previous data. We had 7 camera traps with one unable to collect dates and times, limiting the accuracy of activity pattern data. As our time of residence was July – August, only the dry season was sampled; this seasonal bias means that the same sampling locations could produce different results during the wet season. The uneven sampling effort of camera trap sites was due to reframing the structure of our study,

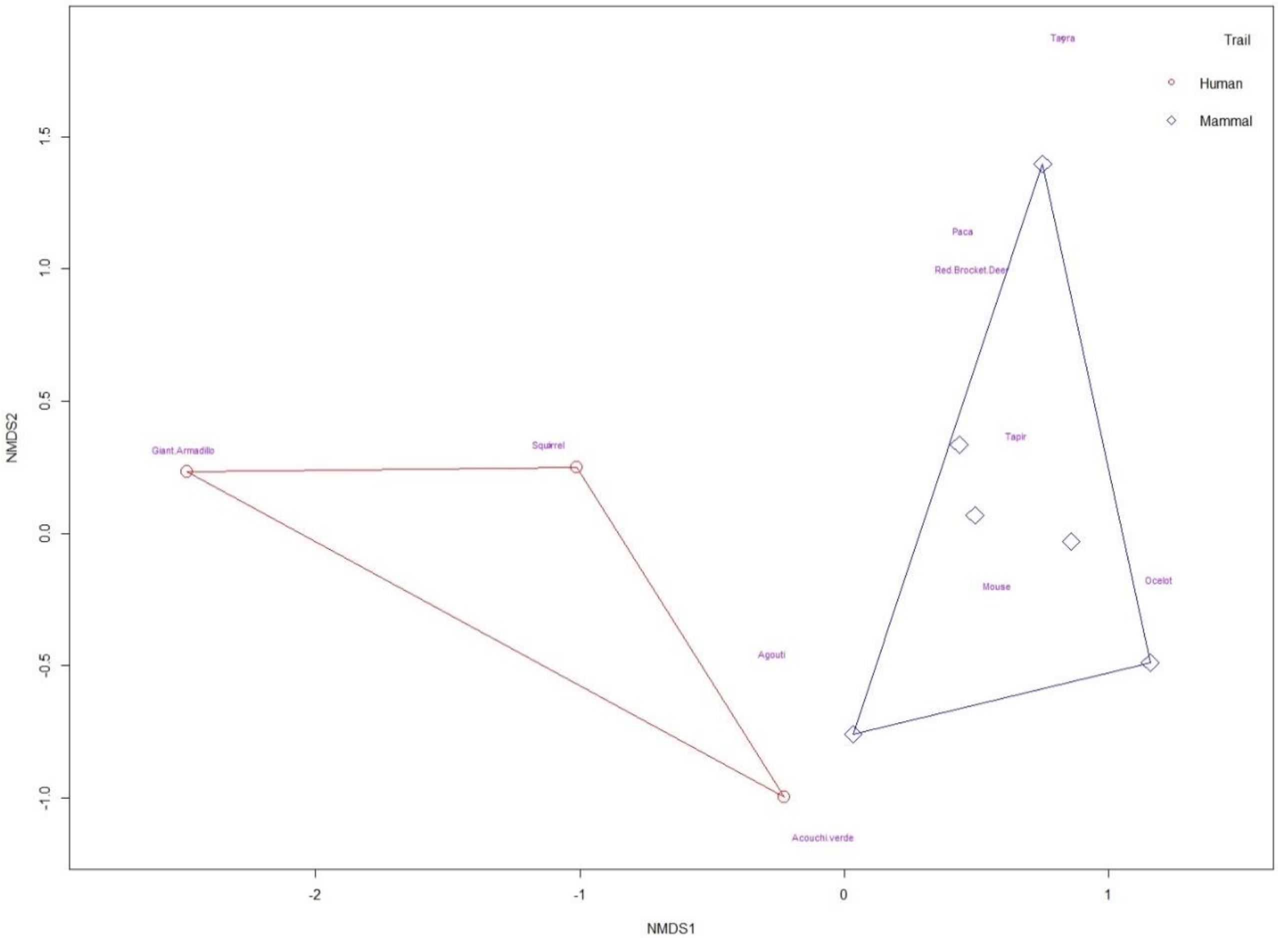

Figure 3: Nonmetric multidimensional scaling plot comparing human trail (red) and mammal trail (blue) communities.

transitioning from comparing water source utilization to mammal vs. human trail utilization.

Further research

A way to enhance our study further is through pairing camera traps with acoustic recorders, enabling access to a broader range of data and insights into human disturbances (Buxton, 2018). For studies focused on terrestrial mammals using both methods will allow us to collect data on multiple trophic levels by providing sound data to the areas out of the camera's range (Buxton, 2018). While terrestrial camera traps have very little chance of capturing monkeys, acoustic sound recorders would also be a good addition if we wanted to expand the study to include monkeys, allowing for a more holistic picture of the ecosystem to be collected.

Another possible addition to the study is adding camera traps to the road leading to FLP. We have often seen paw prints, potentially belonging to a cougar or other large cat, on informal walks along the road. Large animals may utilize the pathways at night and the open space allows for clear photos. In logging areas, large animals have been detected at the greatest rates on old logging roads making these a potential hot spot for large felids (Tobler 2018). The Jaguars use of road networks for travel was noted in Tobler's research and could be a motivating factor in placing camera traps to monitor movement on the road leading to Finca. Adding additional cameras on the roads would also show what mammals cross between these different regions, from the secondary forests to aguajal and this could provide more insight on forest fragmentation.

Implications for forest health

The terrestrial mammal population of Finca Las Piedras is a promising indicator of disturbed and edge forest health. Our assessment showcases 21 species, including rare top predators such as jaguars and pumas. In addition, there have been unofficial observations made of seven additional species: *Sylvilagus brasiliensis*, *Coendou bicolor*, *Marmosops sp*., *Dasypus novemcinctus*, *Potos flavus*, *Galictis vittata*, and *Puma yagouaroundi*. This species inventory is remarkably similar to those of larger, ecologically intact areas such as Machalilla National Park in Ecuador, which recorded 29 species over nearly 6,500 camera trap days (Cervera 2016). With continued monitoring and additional assessments in future years, FLP's mammal inventory will become more diverse and accurate, as well as a way to monitor human impacts on wildlife. Some human disturbances that could be especially prevalent in this region are fires, the Interoceanic highway, logging, and deforestation due to cattle farming. The resilience of this degraded forest is a promising sign for Amazonian conservation efforts, and one that can hopefully be applied to many Brazil nut concessions in the region as well.

By establishing a baseline of data on terrestrial mammal presence using camera traps, we can begin to see the "unseen" creatures of the forest and get a small glimpse of how much life there is to protect; this is especially important for the unprotected areas which make up much of the Amazon. Even unprotected lands can be managed responsibly and in a way that protects its inhabitants, and our hope for this study is to provide an initial step towards this large goal.

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