Survey of Wild Cats (Panthera) and other Mammal Populations at Lowland and Highland Rainforest Elevations in Costa Rica

Authors: Aidan Hallsworth, Molly L. Brooks, Matthew T. Fisher, Wendy L. Welshans

Abstract:

The research paper documents wild cat, and wild cat presence at lowland and highland elevation rainforests. Three questions were used as guidelines for the data analysis comparing the two elevations and their density of wild cats. Field data was collected using Bushnell trail cameras and Havahart traps. Locations of trail cameras and traps were based on biological observations made at both the highland and lowland reserves. Our results indicated a higher density of wild cats at the highland elevation rainforest than in the lowland elevation rainforest. Results also showed little crossover between species that inhabit both elevations. This study was conducted as a foundational study to be used in future monitoring projects either by the Forman Rainforest Project, or other organizations documenting mammal populations.

Introduction:

In March of 2018, The United Nations Environment Program began lobbying for the conservation of wild cats across the world. The United Nations began its initiative to combat the harming of endangered cats due to the rapid decline of populations caused by loss of prey species, habitat degradation, and illegal hunting. Deputy Secretary-General of the United Nations Amina Mohammed claimed conservation, restoration and sustainable use of biological diversity is "*an effective anti-poverty strategy*."[1] In turn, Mohammed stated that "*Protecting ecosystems and ensuring access to ecosystem services by poor and vulnerable groups are therefore essential to eradicating extreme poverty and hunger.*"[2] Human-carnivore coexistence has recently become a much more prevalent global issue with the reintroduction of certain species, as well as successful conservation efforts to restore specific populations. There are 40 wild cat species across the globe[3] with six that can be found across Costa Rica. The wild cats of Costa Rica include Jaguar (*Panthera onca*), Ocelot (*Leopardus pardalis*), Cougar (*Puma concolor*), Margay (*Leopardus wiedii*), Oncilla (*Leopardus tigrinus*), and Jaguarundi (*Puma yagouaroundi*) whom are particularly vulnerable as the majority of communities that must coexistence with these species are impoverished and use these animals as a source of income and food. With the exception of cougars, the habitat where these large cats can be found is almost exclusively either lowland or highland rainforest of central and southern America due to the optimal amount of rainfall, temperature, and biodiversity.[4] Based on observations and past research conducted by the College of Medicine at the University of Florida, the study aimed to answer three questions. The first was which elevation had a higher density of wild cats as this information can be used to

[1] https://news.un.org/en/story/2018/03/1003991
[2] https://news.un.org/en/story/2018/03/1003991
[3] https://www.thewildlifediaries.com/all-wild-cat-species-and-where-to-find-them/
[4] https://rainforests.mongabay.com/03-diversity-of-rainforests.html

determine how species are populating and moving based on human activity in the area. The second question is what landscape linkages can be found in these habitats. This question is particularly important as the majority of rainforests in Costa Rica were deforested within the past half century, and have since regrown. The final question is if different species overlap ranges. This does not just apply to the wild cats of Costa Rica, but to the prey species as well. Determining how species overlap can be used to determine what specific species of wild cats feed on.

To answer these questions, two reserves with different elevations and geographic locations were used throughout the study. Throughout the history of the Forman Rainforest Project, it is common to spend time at two reserves at two different elevations as this allows for a better contrast of habitats and species that inhabit the land. Specifically, a lowland rainforest, and a highland rainforest. This is particularly important with wildcats as their habitat have changed greatly within the past century as the land in Costa Rica went from forested to deforested, and now beginning to reforest. Wild cats have been greatly affected by this change in habitat and are beginning to emerge into lands that have not been inhabited by wild cats for many years.

The first reserve the Forman Rainforest Project was stationed at was Refugio de Vida Silvestre Lapa Verde. Lapa Verde is a private reserve on 1825 hectares of land with 1365 hectares of that land being a tropical rainforest.[5] Lapa Verde is a lowland rainforest in the town of Puerto Viejo at an elevation of 90m (295ft). In total four days were spent at Lapa Verde from February 27, 2023 to March 2, 2023.

The second reserve the Forman Rainforest Project was stationed at was San Gerardo Biological Station. San Gerardo is located in the Children's Eternal Rainforest around Santa Elena. San Gerardo is at an elevation of 1200m (3937ft) making it not only a highland rainforest, but a cloud forest. The Children's Eternal Rainforest privately owns 22500 hectares of land with San Gerardo having direct access to 10km (6mi) of trails. The Children's Eternal Rainforest has issues with "illegal poaching, logging, capture of live animals, and removal of plant material such as orchids and palms.[6]" The knowledge of wild cat populations within the Children's Eternal Rainforest is critical as the knowledge of wild cat populations can be used to better protect the land. 5 days were spent at San Gerardo from March 3, 2023 to March 7, 2023.

[5] https://www.ecovida.ch/naturschutzgebiet-lapa-verde
[6] https://acmcr.org/content/about-us/history/

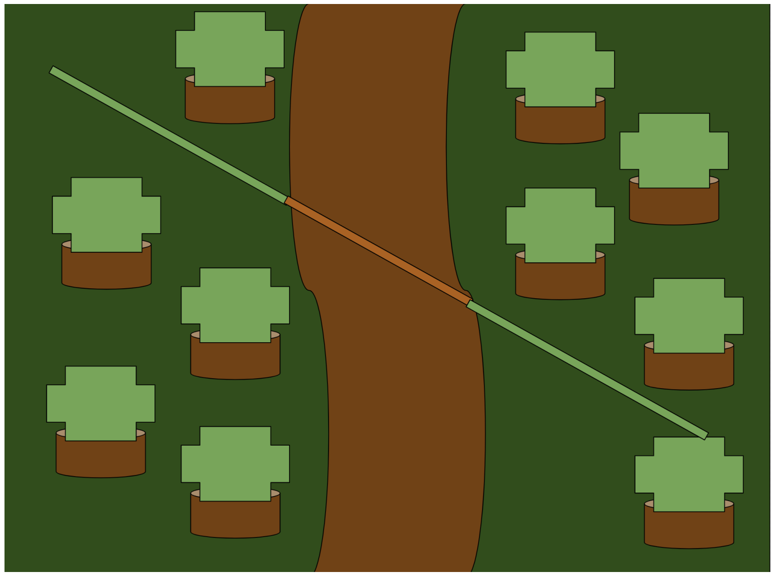
Methodology:
The primary equipment used for recording and documenting wildlife was Bushnell trail cameras. In total, twenty two cameras consisting of the following models were used throughout the study.

- Trophy cam E3 Essential Trail Camera
- Bushnell 14MP Trophy Cam HD Aggressor Brown Low Glow
- Bushnell Trophy Trail Camera Aggressor Low Glow, Camo / 24MP

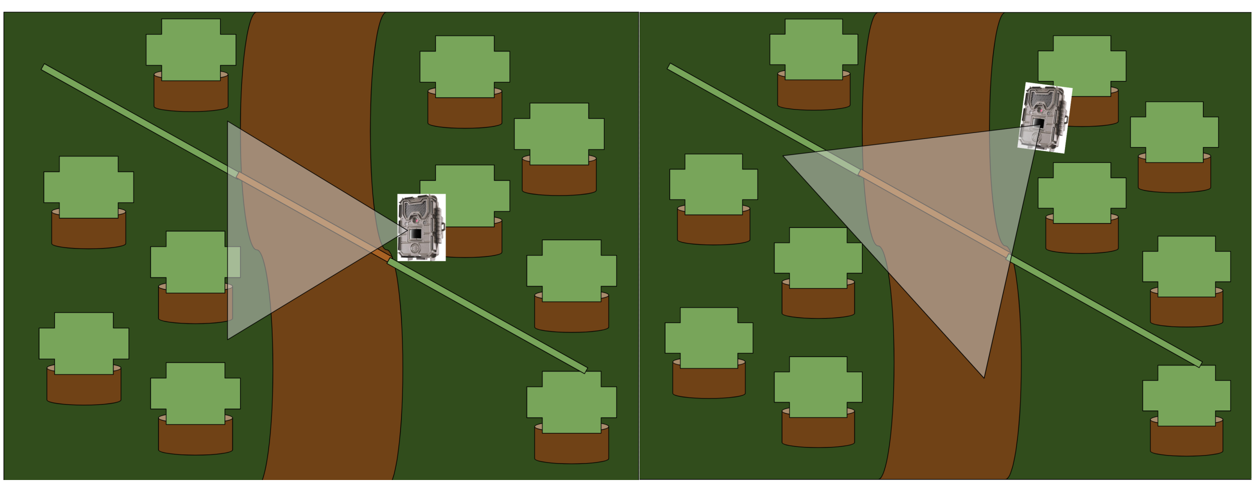
At the beginning of the study all cameras were working at full functionality with some having hybrid capabilities. All cameras with hybrid capabilities were used on this setting due to the higher probability of recording quality footage. All cameras without hybrid capabilities were set to the photo setting. The photo setting was used rather than the video setting because past experience with these cameras has shown that video has short delay from motion activation to recording, increasing the chances of poor quality footage. Regardless of setting, all cameras were set to record three photos in a burst format with 0.8 seconds in between each new burst of photos. The cameras with hybrid capabilities were set to record five second long videos in addition to each burst of three photos. The majority of cameras had the ability to stamp each recording with the date, time (24 hour) and temperature. All cameras with this capability were set to do so. Seen below is a camera with a stamp of the date, time, and temperature.

A select few cameras did not have the ability to record temperature. This was not considered a detriment to the study because all cameras were located within 5 miles of each other in near identical elevations. Temperatures from other cameras at similar times were used in documentation for the recording that did not have temperature stamps. All cameras were formatted uniformly and set to record HD quality footage.

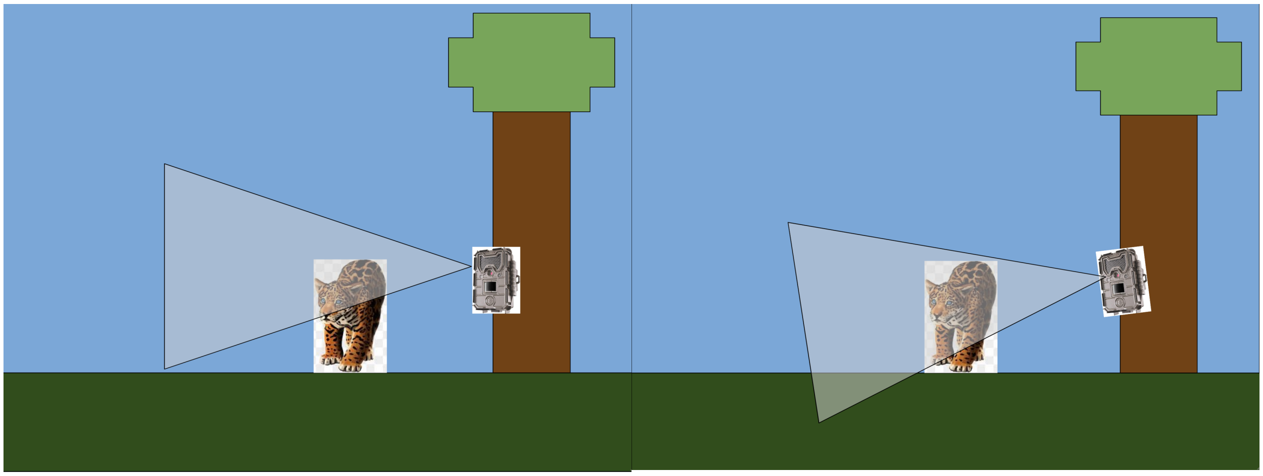
Cameras were located along human maintained trails in areas that showed definite signs of wildlife traffic (tracks, food, broken brush, etc). Almost all cameras were placed in locations that had game trails that bisected the human made trails. Seen below.



Cameras were angled down trails due to the higher chances of recording quality footage. Prior experience has shown that this method yields better results due to a larger portion of the trail being in the camera's field of view. Cameras were angled adjacent to the human made trail and game trail, rather than perpendicular. Seen below is the difference in the field of view of a perpendicular angle and an adjacent angle.



In addition to cameras being angled adjacent to humans and game trails, cameras were angled down from the tree they were attached to. This is done to maximize the view of the forest floor. Prior experience from the Forman Rainforest Project has shown that angling the camera down increases the likelihood of capturing a larger portion of the specimen. Seen below is a diagram representing a camera not angled compared to an angled camera.



The methodology used to angle the camera down involved using sticks from the forest floor as wedges on the upper part of the camera. Each tree and camera was slightly different so stick widths varied. Often multiple sticks were used. Pictured below is a camera angled down from sticks wedged in the upper portion of the camera against the tree.

The majority of cameras were placed around 3 ft above the forest floor as that is the desired height of wild cats and their prey species. Camera's were angled down at this height as it created the ideal field of view required to identify species. The Forman Rainforest Project and outside experience have previously received footage of wildlife that is unidentifiable due to only a small portion of the animal being identified. While setting up camera traps, this was the primary concern that was attempted to avoid. Throughout the survey at both locations, not every wildlife sighting was able to be identified. Not every species was identified due to blurry images on an animal in motion, however no species was unidentifiable due to a camera being improperly angled.

At the majority of camera locations, flagging tape was located in the view of the camera to act as a tool to determine the height of the animals, in turn identifying the animal. An issue with camera trapping the Forman Rainforest Project has come across in prior studies has been determining the approximate height of the specimen as depth perception can be difficult in a photograph or video. Flagging tape was placed at three heights with 1 foot apart between them. This allowed the specimen to be measured against the flagging tape so an approximate height can be determined. All flagging tape was cut and tied in a way that it would not wave or dangle as a brightly colored object waving in the wind can deter wildlife from traversing the area.

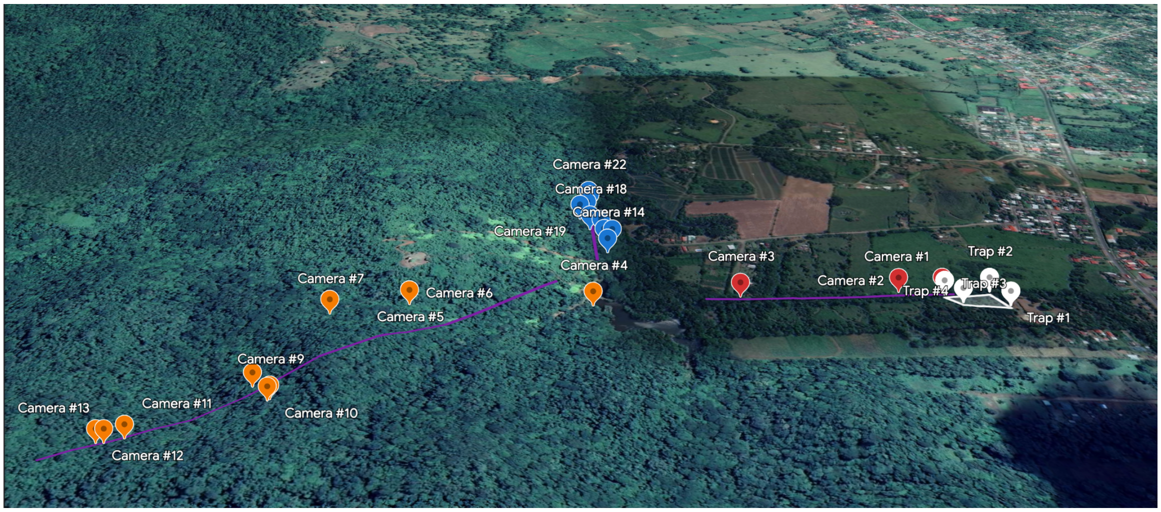
As the camera's were switched from setup mode to on, a white board was displayed in front of the camera consisting of the general location, coordinates, altitude, time, and date. This is a method of backing up camera trapping data. The most critical data points displayed are the coordinates and the date/time. The coordinates are critical as it is easy to confuse camera locations, however if they are documented on each camera, there is always a fail safe to know what coordinates belong to each camera. The date and time are the most critical as human error often leads to cameras being set to the wrong time, date, and year. If the correct measurements are displayed on a camera with incorrect settings, time, date, and year can be calculated based on the correct measurements. Pictured below is an example of a white board with correct measurements.

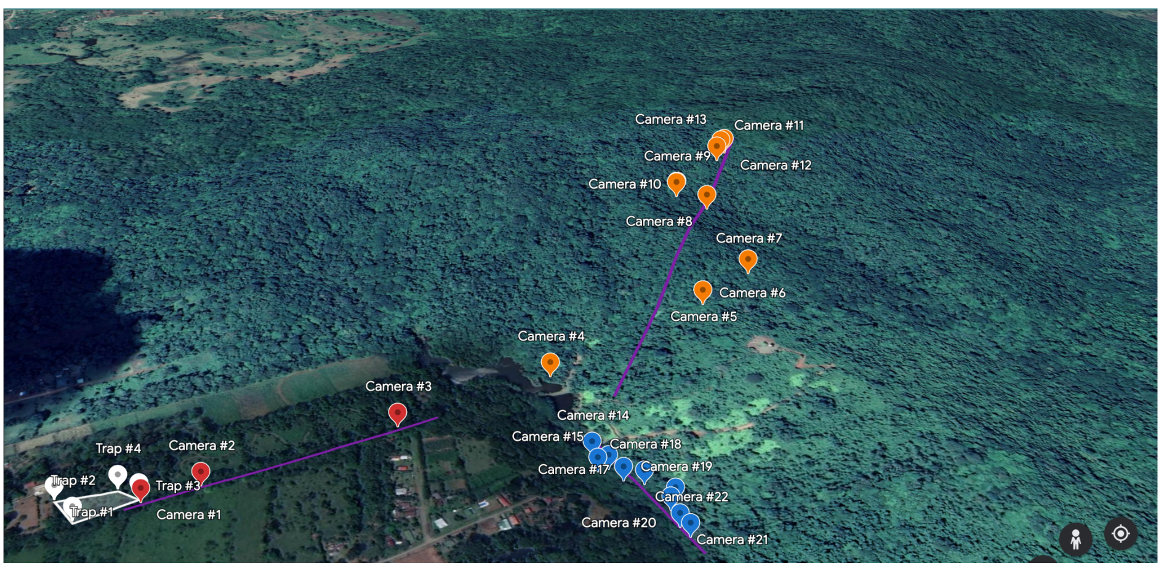
In addition to the camera trapping, physical trapping was used as another method of documenting species. Specifically Havahart-Medium 2-Door were used throughout the study. Four Havahart traps were used at Lapa Verde and two were used at San Gerardo. All Havahart traps were baited with a combination of rice, beans, and bananas/plantains. Pictured below is a Havahart trap used in the study.

At San Gerardo, one of the two Havahart traps was placed in a Strangler Fig (Ficus aurea). This was done by throwing paracord tied to the Havahart trap over a branch. This created a pulley system for the Havahart trap. Two additional strings were tied to either end of the trap to act as guides so the baited and set trap could stay level and not tip over while being pulled up. It was known that the three lines coming off the Havahart trap would likely deter wildlife from being trapped, however, this was still done as physical trapping was a very small part of the population survey so the thought of not documenting any species would not create any discrepancies in the data. Additionally, it was believed that having diversity in the layer of the rainforest the traps were at could potentially trap and record species that are only found in the canopy.

A singular mud trap was used at San Gerardo in an attempt to record and plaster any wildlife tracks. The methodology for creating this mud trap involved pouring approximately 2 gallons of water in a small plot of dirt.

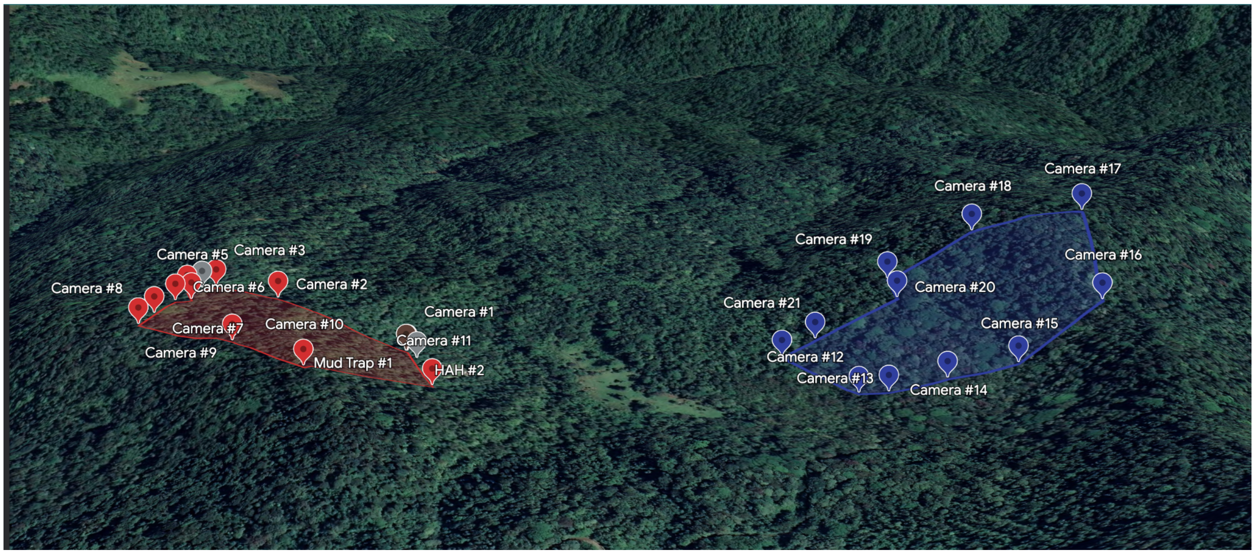
Seen below is a google earth view of the camera trap stations and the physical trap stations at Lapa Verde.

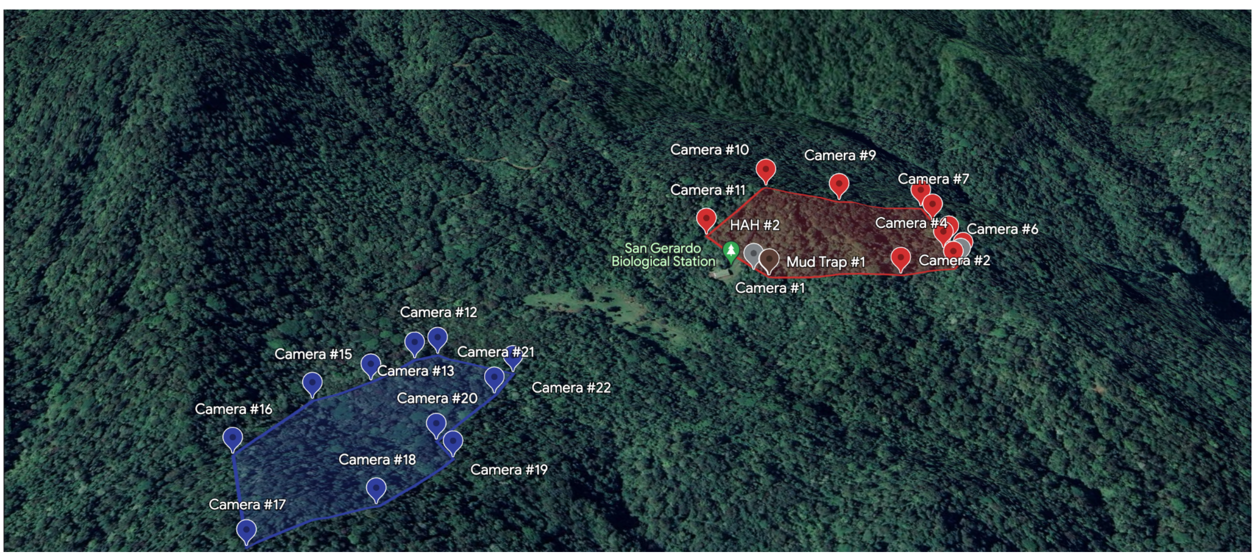




The placemark points in red, orange, and blue represent three transects. Each transect was located on a different trail on Lapa Verde's property. These trails were chosen based on the recommendations and prior knowledge from other biologists familiar with Lapa Verde's landscape and biodiversity. Transects were given the numbers 1, 2, and 3 with cameras 1-3 making up transect 1, cameras 4-13 making up transect 2, and cameras 14-22 making up transect 3. The white shape in the photograph(s) is a study plot of Havahart traps. Based on a random number table, this study plot was given the number 42209. The reserve's proximity to the town of Puerto Viejo can also be seen in the photographs. Motor vehicles could be heard at the reserve from the road. Human interference was a factor as the trails were often used by people of ATV's.

Seen below is a google earth view of the camera trap stations and the physical trap stations at San Gerardo.





The placemark points in red and blue represent the two study plots of camera traps set up at San Gerardo. The study plot in red was given the number 49945 and the study plot in blue was given the number 22404. Both study plots outlined human made trails. The gray placemark points represent the locations of the two Havahart traps with HAH #1 being the location of the Havahart trap in a strangler fig. The brown placemark is the location of the mud trap created at San Gerardo. San Gerardo showed little sign of human intervention and was a much denser and older forest.

Results:

Results from Lapa Verde:

Camera #3 - Northern Racoon (*Procyon lotor*) - March 1, 2023

Camera 6 - Striped Hog-nosed Skunk (*Conepatus semistriatus*) - 2 March, 2023

Camera 7 - Central American Agouti (*Dasyprocta punctata*) - 28 February, 2023

Camera 7 - Great curassow (*Crax rubra*) - 1 March, 2023

Camera 16 - Tayra (*Eira barbara*) - 1 March, 2023

Camera 20 - Nine-banded armadillo (*Dasypus novemcinctus*) - 1 March, 2023

Results from San Gerardo:

Camera 2 - Dice's Cottontail (*Sylvilagus dicei*) - 4 March, 2023

Camera 3 - Red-tailed squirrel (*Sciurus granatensis*) - 7 March, 2023

Camera 5 - Margay (*Leopardus wiedii*) - 6 March, 2023

Camera 6 - Common tapeti (*Sylvilagus brasiliensis*) - 6 March, 2023

Camera 7 - Paca (*Cuniculus*) - 5 March, 2023

Camera 7 - Margay (*Leopardus wiedii*) - 6 March, 2023

Camera 11 - White-nosed coati (*Nasua narica*) - 4 March, 2023

Camera 12 - Ocelot (*Leopardus pardalis*) - 5 March, 2023

Camera 14 - Ocelot (*Leopardus pardalis*) - 6 March, 2023

Camera 16 - Ocelot (*Leopardus pardalis*) - 6 March, 2023

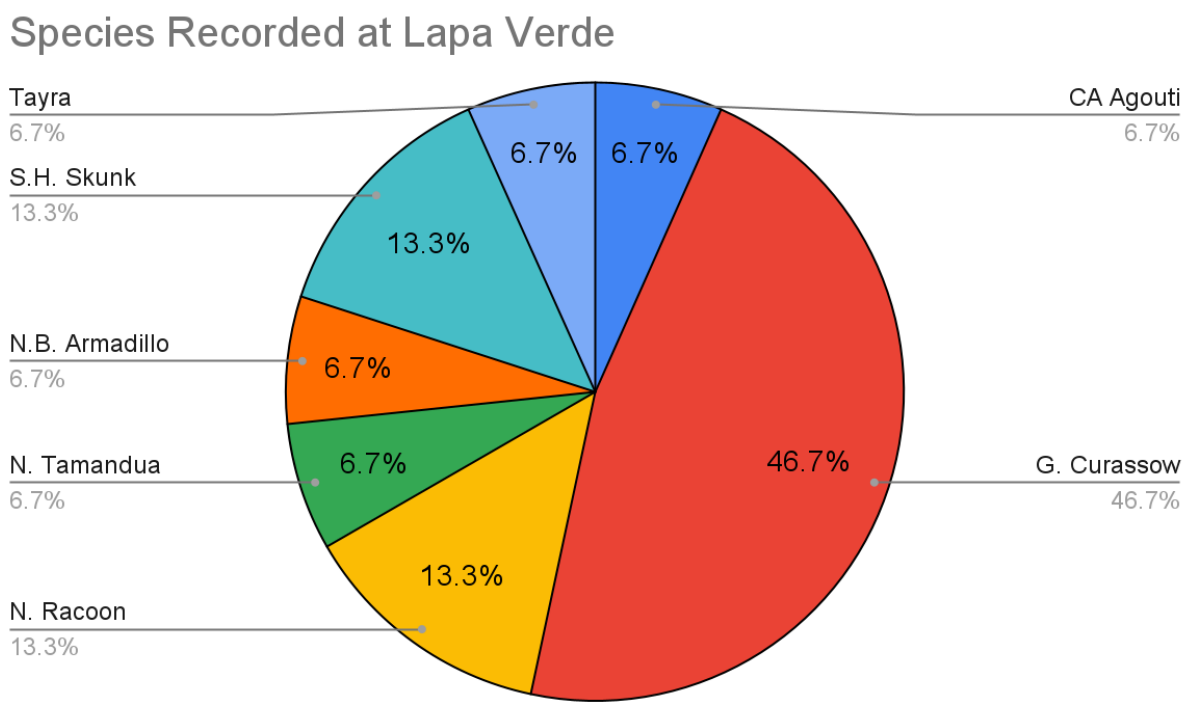
Gray four-eyed opossum (*Philander opossum*) - 6 March, 2023

Analysis:

Lapa Verde Species:

Approximately 1650 camera trapping hours with 15 total documentations.

Capture success rate of approximately 0.9% per camera trapping hour

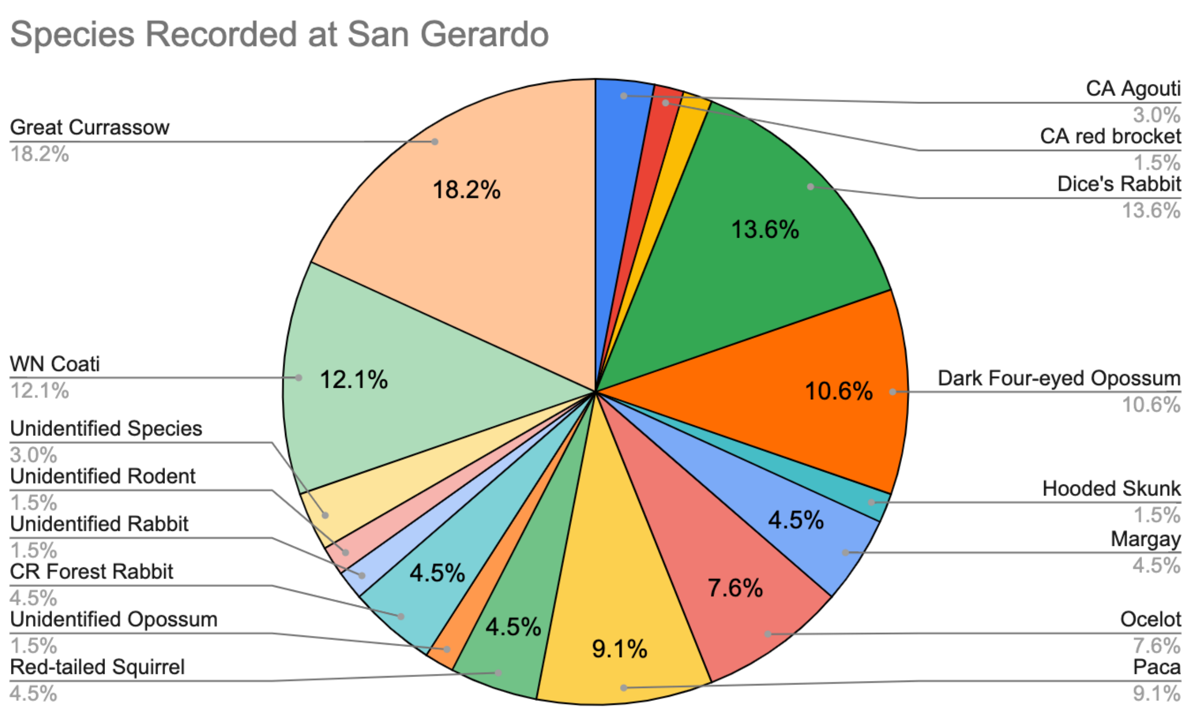


Species	Date	Time	Station #	Temperature °F	ro Pressure (in/I	Wind Direction	Vind Speed (mph	Cloud Type	Juv/Adult
CA Agouti	28 February 2023	14:17	7	84	26.81	East/southeast	14	strato cumulous	Adult
G. Curassow	1 March 2023	10:27	5	73	26.88	East/southeast	16	alto cumulous	Adult
G. Curassow	1 March 2023	10:26	6	71	26.88	East/southeast	16	alto cumulous	N/A
G. Curassow	1 March 2023	10:19	7	77	26.88	East/southeast	16	alto cumulous	Adult
G. Curassow	2 March 2023	8:14	10	75	26.85	East	10	alto cumulous	Adult
G. Curassow	2 March 2023	7:41	11	60	26.85	East	10	alto cumulous	Adult
G. Curassow	2 March 2023	7:28	14	76	26.84	Northeast	8	strato cumulous	Adult
G. Curassow	2 March 2023	7:00	16	71	26.84	Northeast	8	alto cumulous	Adult
N. Racoon	1 March 2023	4:39	3	73	28.86	East	10	alto cumulous	N/A
N. Racoon	1 March 2023	0.09	17	70	26.85	East	15	alto cumulous	Adult
N. Tamandua	28 February 2023	1:39	2	72	26.84	East	12	alto cumulous	N/A
N.B. Armadillo	1 March 2023	2:21	20	68	26.85	East	15	alto cumulous	Adult
S.H. Skunk	1 March 2023	2:42	6	72	26.84	East/Northeast	10	alto cumulous	N/A
S.H. Skunk	2 March 2023	4:39	6	74	26.78	East	18	alto cumulous	Adult
Tayra	1 March 2023	10:27	16	75	26.88	East/southeast	16	alto cumulous	Adult

San Gerardo Species:

Approximately 2650 camera trapping hours with 66 total documentations.

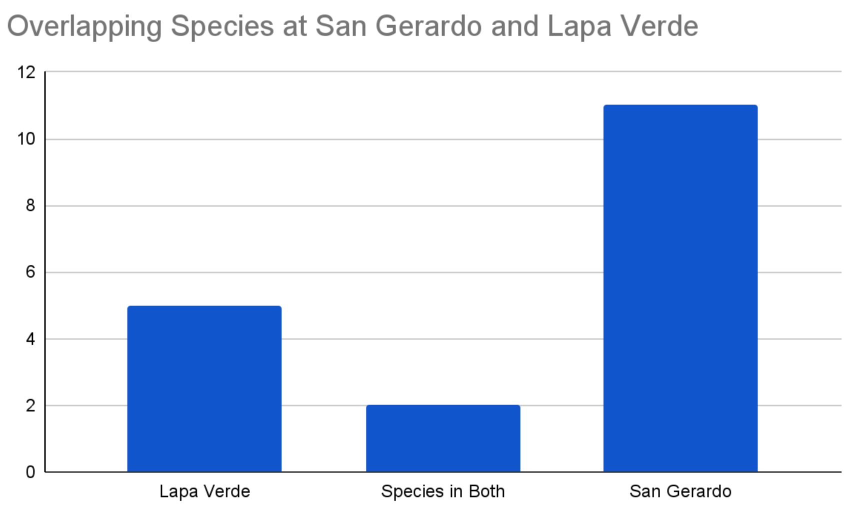
Capture success rate of approximately 2.5% per camera trapping hour



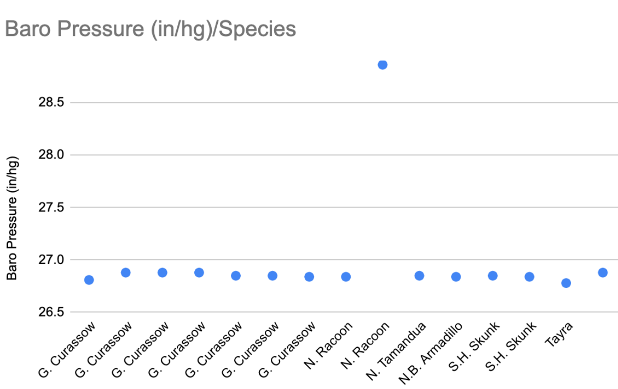
Species	Date	Time	Station #	emperature °	o Pressure (I	Vind Directio	nd Speed (m	Hummidity	Cloud Type	Juv/Adult
CA Agouti	4 March 2023	17:19	9	68	877.3	WNW	2	90.60%	Cumulus	Adult
CA Agouti	5 March 2023	6:44	22	62	879.3	NE	4.4	97.10%	Strato Cumulus	Adult
CA red brocket	6 March 2023	5:39	19	60	880	S	3	97.10%	Strato Cumulus	Adult
Collared Peccary	5 March 2023	20:13	21	44	879.3	E	4.4	97.10%	Strato Cumulus	Adult
Dice's Rabbit	4 March 2023	19:05	16	66	877.3	ENE	2	90.60%	Cumulus	Adult
Four-eyed Opos	4 March 2023	21:12	16	64	877.3	E	2	90.60%	Cumulus	Adult
Four-eyed Opos	4 March 2023	19:06	21	48	877.3	ENE	2	90.60%	Cumulus	Adult
Four-eyed Opos	5 March 2023	5:14	17	66	879.3	ENE	4.4	97.10%	Strato Cumulus	Adult
Four-eyed Opos	6 March 2023	20:56	11	50	880	E	3	97.10%	Stratus	Adult
Four-eyed Opos	6 March 2023	4:36	13	62	880	S	3	97.10%	Strato Cumulus	Adult
Four-eyed Opos	6 March 2023	18:08	13	52	880	E	3	97.10%	Stratus	Adult
Four-eyed Opos	6 March 2023	20:10	20	50	880	E	3	97.10%	Stratus	Adult
Dice's Rabbit	3 March 2023	18:07	5	64	877.3	E	2	90.60%	Cumulus	Adult
Dice's Rabbit	4 March 2023	17:56	2	64	877.3	E	2	90.60%	Cumulus	Adult
Dice's Rabbit	4 March 2023	18:22	6	67	877.3	E	2	90.60%	Cumulus	Adult
Dice's Rabbit	5 March 2023	18:00	1	62	879.3	ENE	4.4	97.10%	Strato Cumulus	Adult
Dice's Rabbit	5 March 2023	19:46	7	64	879.3	E	4.4	97.10%	Strato Cumulus	Adult
Dice's Rabbit	6 March 2023	21:22	2	59	880	E	3	97.10%	Stratus	Adult
Dice's Rabbit	6 March 2023	5:07	14	63	880	SE	3	97.10%	Strato Cumulus	Adult
Dice's Rabbit	7 March 2023	2:57	1	59	880	E	1	92.30%	Cumulus	Adult
Hooded Skunk	5 March 2023	5:27	7	64	879.3	ENE	4.4	97.10%	Strato Cumulus	Adult
Margay	6 March 2023	21:29	5	59	880	E	3	97.10%	Stratus	Adult
Margay	6 March 2023	21:14	7	59	880	E	3	97.10%	Stratus	Adult
Margay	6 March 2023	21:35	7	59	880	E	3	97.10%	Stratus	Adult
Ocelot	5 March 2023	4:38	12	51	879.3	ENE	4.4	97.10%	Strato Cumulus	Adult
Ocelot	5 March 2023	4:48	15	66	879.3	ENE	4.4	97.10%	Strato Cumulus	Adult
Ocelot	6 March 2023	5:15	12	51	880	S	3	97.10%	Strato Cumulus	Adult
Ocelot	6 March 2023	4:44	16	62	880	S	3	97.10%	Strato Cumulus	Both
Ocelot	6 March 2023	21:14	18	42	880	E	3	97.10%	Stratus	Adult
Paca	5 March 2023	0:29	7	64	879.3	NNE	4.4	97.10%	Strato Cumulus	Adult
Paca	5 March 2023	4:25	7	64	879.3	NNE	4.4	97.10%	Strato Cumulus	N/A
Paca	5 March 2023	4:02	9	63	879.3	ENE	4.4	97.10%	Strato Cumulus	Adult
Paca	5 March 2023	19:49	9	63	879.3	E	4.4	97.10%	Strato Cumulus	Adult
Paca	6 March 2023	19:18	12	50	880	E	3	97.10%	Stratus	Adult
Paca	6 March 2023	8:14	21	44	880	E	3	97.10%	Strato Cumulus	Adult
ed-tailed Squirre	4 March 2023	16:25	7	64	877.3	WNW	2	90.60%	Cumulus	Adult
ed-tailed Squirre	7 March 2023	5:56	3	58	880	E	1	92.30%	Cumulus	Adult
ed-tailed Squirre	7 March 2023	8:18	3	61	880	WSW	1	92.30%	Cumulus	Adult
identified Oposs	6 March 2023	21:21	12	50	880	E	3	97.I1%	Stratus	Adult
CR Forest Rabbi	4 March 2023	20:42	6	65	877.3	E	2	90.60%	Cumulus	Adult
CR Forest Rabbi	5 March 2023	19:43	6	63	879.3	E	4.4	97.10%	Strato Cumulus	Adult
Inidentified Rabb	5 March 2023	0:07	22	63	879.3	NNE	4.4	97.10%	Strato Cumulus	Adult
CR Forest Rabbi	6 March 2023	22:34	6	59	880	E	3	97.10%	Stratus	Adult
nidentified Rode	5 March 2023	4:29	7	64	879.3	ENE	4.4	97.10%	Strato Cumulus	N/A
nidentified Speci	5 March 2023	0:09	22	63	879.3	NNE	4.4	97.10%	Strato Cumulus	Adult
nidentified Speci	6 March 2023	16:03	13	54	880	E	3	97.10%	Stratus	N/A
WN Coati	4 March 2023	15:59	11	57	877.3	WNW	2	90.60%	Cumulus	Adult
WN Coati	5 March 2023	7:38	11	51	879.3	E	4.4	97.10%	Strato Cumulus	Adult
WN Coati	6 March 2023	14:57	11	53	880	E	3	97.10%	Stratus	Adult
WN Coati	7 March 2023	5:27	11	48	880	E	1	92.30%	Cumulus	Adult
WN Coati	7 March 2023	8:28	11	51	880	E	1	92.30%	Cumulus	Both
WN Coati	7 March 2023	7:31	14	61	880	WSW	1	92.30%	Cumulus	Adult
WN Coati	7 March 2023	7:23	15	62	880	E	1	92.30%	Cumulus	Adult
WN Coati	7 March 2023	9:25	21	44	880	W	1	92.30%	Cumulus	Adult
Great Currassow	6 March 2023	16:49	3	61	880	E	3	97.10%	Stratus	Adult
Great Currassow	7 March 2023	7:19	3	59	880	E	1	92.30%	Cumulus	Adult
Great Currassow	5 March 2023	22:24	17	64	877.3	E	2	90.60%	Cumulus	Adult
Great Currassow	5 March 2023	11:40	21	46	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	12:03	21	46	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	10:30	22	63	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	11:20	22	63	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	11:34	22	63	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	11:58	22	63	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	12:50	22	64	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	14:25	22	64	879.3	ENE	4.4	97.1	Strato Cumulus	Adult
Great Currassow	5 March 2023	15:40	22	64	879.3	ENE	4.4	97.1	Strato Cumulus	Adult

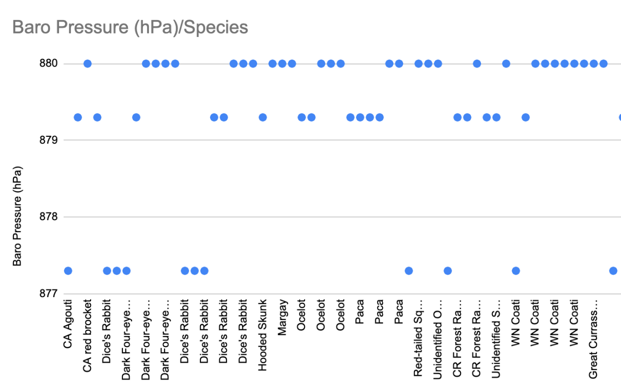
Analysis:

The most significant difference between the results at both reserves is the lack of overlapping species. Only two species were documented at both reserves. At Lapa Verde, only 7 species were documented compared to the 11 at San Gerardo.

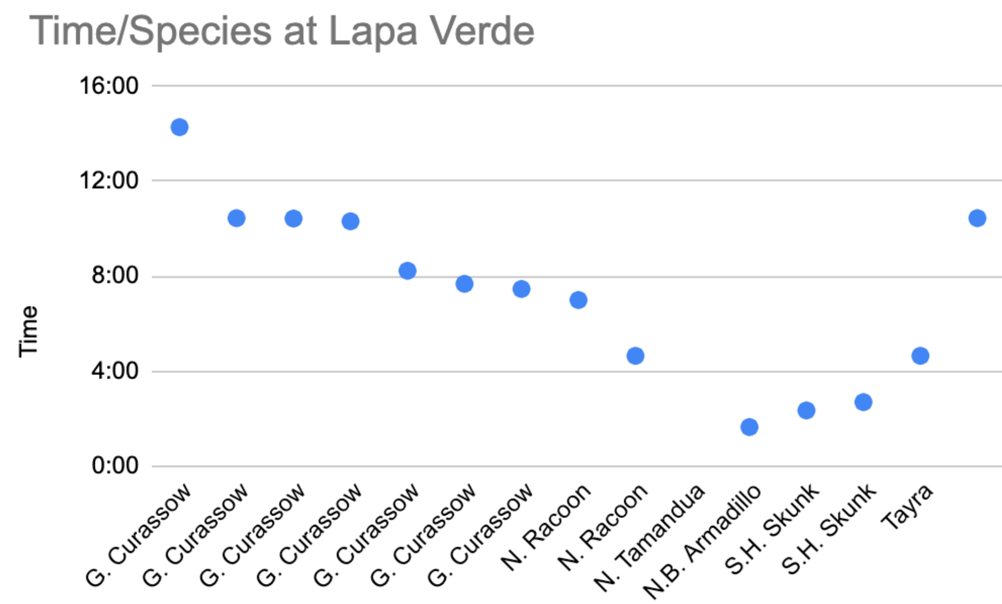


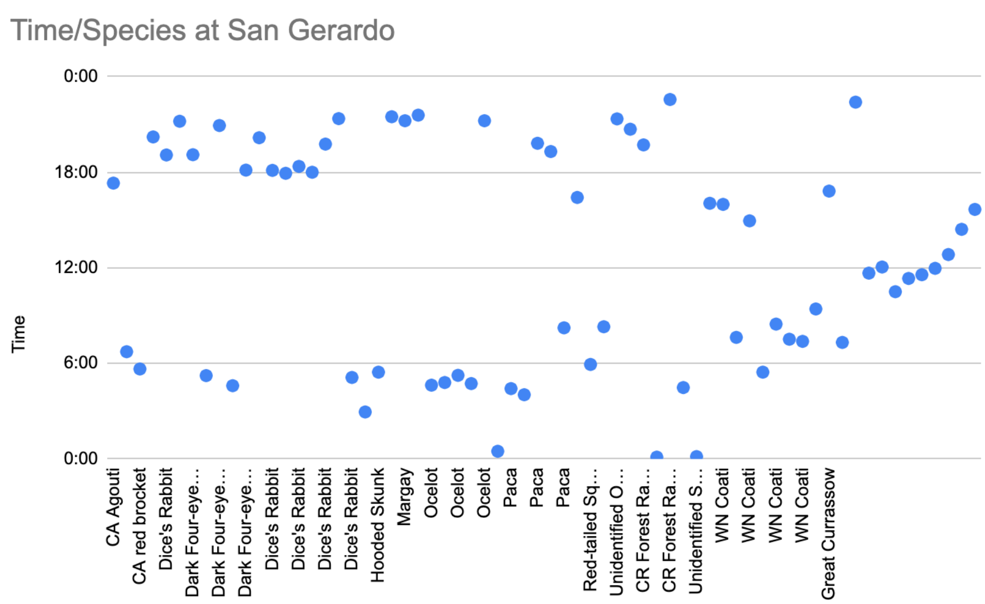
Barometric pressure was observed throughout time at both reserves. Prior research conducted by the Forman Rainforest Project has shown wildlife patterns can be altered significantly as a result of barometric pressure. The 2023 year of field work did not show as there was not enough time at each reserve to properly monitor all barometric pressure. In addition, barometric pressure was normally documented once per day, likely creating discrepancies in the data as the barometric pressure documented is likely not exact. To properly analyze wildlife documentation in relation to barometric pressure, a much longer monitoring project would need to take place at both Lapa Verde and San Gerardo. Below is a scatter chart of barometric pressure readings in relation to species documented at both reserves.

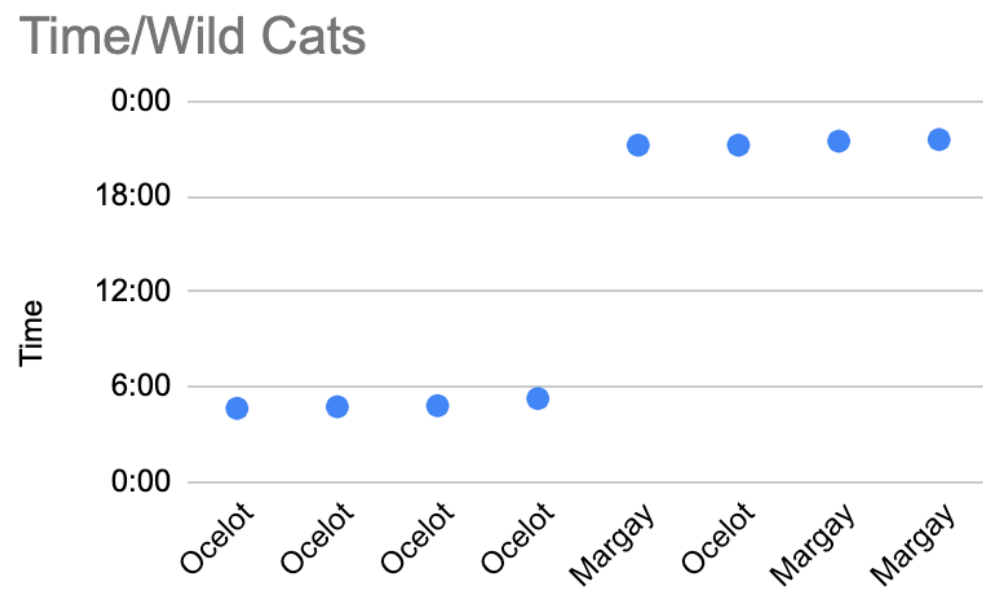




Wildlife was documented periodically throughout the day, however there were distinct patterns in the data. With exceptions, wildlife was documented from dusk to dawn the majority of the time. Wildlife that is not nocturnal was often only documented between dusk and dawn. The best example of this is the Central American Agouti (Dasyprocta punctata) which was only documented between after 17:00 and before 6:44 at San Gerardo. Wild cats were no exception with no documentation before 21:14 or after 5:15. The Great Curassow (Crax rubra) is the only species that was documented the majority of the time between dawn and dusk.







Human error was likely not a factor in the data record during the study. Although there are likely discrepancies in a small portion of the weather recorded, it is highly unlikely that this affected the interpretations made from the results. The solitary instance of human error during the study can be seen in the time and date stamp of camera seventeen. The time and date were not set correctly causing an incorrect reading to be displayed on each recording. The correct time can still be determined as the methodology of recording a series of data points on each camera allows the correct date and time to be calculated.

One instance of equipment failure occurred during field work. Camera #4 did not record any footage at either location. While in the field the specific problem was not able to be identified, however it is likely that it is a result of a hardware malfunction based on an external force such as water damage.

This study was conducted with the three questions in mind. Although continued monitoring is likely needed to further respond to these questions accurately. The results based on the research conducted during 2023 Forman Rainforest Project field work is able to provide an initial response to be used as a bases for future monitoring projects conducted by the Forman Rainforest Project and Lapa Verde, San Gerardo, or reserves in the immediate area.

As outlined in the introduction; the first question the study was themed around involved determining which elevation of rainforest had a higher density of cats. Our research documented eight wild cats at San Gerardo and zero wild cats at Lapa Verde. This results shows an infinite increase in wild cats in the highland population survey compared to the lowland survey. This infinite increase in wild cat population is evidently not standard across all studies regarding wildcats, however it likely shows that the density of wild cats is much higher in highland rainforests compared to lowland rainforests. Highland rainforests have also been documented as the primary elevation for the Oncilla (Leopardus tigrinus) adding to the probability of a higher density of wildcats.

The second question involved identifying landscape linkages or similarities between the two elevations and habitats. Based on observations, recording, and documented weather history in both areas, the linkages between habitats can be seen in the average rainfall per year as well as similar fauna. Lapa Verde averages an annual rainfall amount of 137 inches[7] while San Gerardo averages 118 inches.[8] The primary differences between the two habitats and elevations can be seen in the average temperature, proximity to a human population, and age. The average temperature is much lower at San Gerardo due to lack of air pressure, as well as the low elevation clouds engulfing the rainforest. San Gerardo also showed much less human intervention than Lapa Verde as well as being further a further proximity to a human population. Historically this makes sense as low elevation flat lands provide ideal land for agriculture. Human populations settling in the lowlands deforested much of the rainforests and as a result, many forests in low elevations are often young. San Gerardo was also deforested within the past century but now shows little signs of human intervention. The landscape is much more dense and uneven than Lapa Verde.

The final question involves determining if species overlapped ranges. In this case, range involves a distance where species are still in competition for resources. Our research definitively shows that species do overlap ranges; both Ocelot (Leopardus pardalis) and Margay (Leopardus wiedii) were documented at San Gerardo. These species were documented within a five mile radius which is much smaller than many prey species' home ranges. This can be interpreted as wildcats in San Gerardo are in competition for resources. Only two species were documented at both Lapa Verde and San Gerardo so it is more probable the species overlap ranges only if they share habitats at the same elevation.

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[7] https://en.climate-data.org/north-america/costa-rica/heredia/puerto-viejo-44971/

[8] https://www.monteverdeinfo.com/monteverde-area-maps-facts-and-links#:~:text=Facts%20about%20Monteverde's%20climate.&text=Annual%20rainfall%3A%20118%20inches.,and%205%20hours%20by%20bus.

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Link to Forman Rainforest Project Website: https://formanrainforestproject.wordpress.com/