The Costa Rican Ecological Corridor and Wildlife Connectivity Project Part III:

Understanding Animal Movement

Prepared for Tannaz Zargarian and Justin Podur

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Introduction:

The Alexander Skutch Biological Corridor located in Costa Rica is home to a region possessing one of the "richest concentrations of species and ecosystem diversity in the world" (Miller, Chang & Johnson 2001, p.7). The area, once teeming with wildlife and greenery, has been subjected to human encroachment and development. The increasing presence of human beings within the corridor has fragmented the area and made it difficult for wildlife to function naturally in their habitats. Because there is so much importance placed on species biodiversity, especially in an area as unique as the biological corridor, conservation measures are being taken to maintain the land. The corridor includes many "fragmentation-sensitive species for which corridors are likely" (Beier & Noss, 1998, p. 1242), necessary for their survival. However, since protection of the corridor has not been completely successful, our research will study what effect fragmentation has had on the wildlife currently residing in the area and how human development has affected their movement and home ranges.

The Alexander Skutch Biological Corridor acts as a passageway for wildlife to move from Las Nubes to Los Cusingos. With the construction of roads and modification of the land for agriculture and human development, the connectivity of the landscape has been disrupted. Our research focuses on how animal home ranges within the corridor are affected by human activity. By mapping the photographs of wildlife taken by 9 camera traps within the corridor, we can infer if human impact of land use and roads have affected the ease of animal movement.

With roads passing throughout the corridor and increased human land-use, we hypothesize that ease of animal movement is decreased. The roads may act as a barrier, as the sound of human activity and the threat of vehicles may deter animals from crossing a road. Furthermore, much of the once-rich rainforest within the corridor has been cleared for coffee farming and human settlement. This poses a threat to some of the native fauna species, as they may be more exposed to predation by leaving the protection of the dense rainforest cover. This may impact their home range, as well.

Methods:

Camera Trap Data Layer:

The data acquired from Felipe Montoya contained approximately 1000 wildlife pictures from 9 camera traps within the Alexander Skutch Biological Corridor for the years 2012, 2013, 2014. Each camera trap had corresponding GPS coordinates. These camera trap images were analyzed and wildlife species identified using two Costa Rica mammal field guides by Henderson (2002) and Wainwright (2007). There were certain limitations with the camera trap data and subsequent wildlife identification. In some instances, due to the swift movement of animals across the camera lens, the camera was only able to capture a blurry image of the animal. Other times, the resulting camera trap images only revealed certain portions or angles of the animals captured. In addition, the majority of camera trap data were captured at night resulting in black and white images. This posed further challenges when identifying species owing to the inability of discerning animal colouration. In certain cases, as a result of the limitations of the camera trap data, educated assumptions had to be made when identifying the animal species.

Out of the total species detected at the Alexander Skutch Biological Corridor between 2012 and 2014, only a few of the captured images were bird species. Most bird species images were indecipherable (due to night vision and/or blurry images), thus we chose to focus our analysis on mammal species which made up the vast majority of the animal species detected. There were sixteen mammal species detected in total: common opossum (Didelphis marsupialis), common gray four-eyed opossum (Philander opossum), lowland paca (Cuniculus paca), Central American agouti (Dasyprocta punctata), nine-banded armadillo (Dasypus novemcinctus), Tayra (Eira barbara), ocelot (Leopardus pardalis), white-nosed coati (Nasua narica), collared peccary (Pecari tajacu), puma (Puma concolor), striped hog-nosed skunk (Conepatus semistriatus), northern raccoon (Procyon lotor), coyote (Canis latrans), tapeti (Sylvilagus brasiliensis), northern tamandua (Tamandua mexicana), and red-tailed squirrel (Sciurus granatensis).

The camera trap data were organized in an excel spreadsheet by image number, date, camera name and animal species. After identifying the animal species displayed in the camera trap images, the data was further organized by creating an additional excel spreadsheet. Separate columns were created for each animal species, with the corresponding species count data and camera trap name assigned to it. Each camera name had its coordinates in an adjacent column. This resulting excel spreadsheet was then imported in ArcGIS and used to plot the coordinates of the camera traps within the Alexander Skutch Biological Corridor.

Camera Point Data Layer:

Spatial information which was provided along with Felipe's camera trap images allowed for the creation on an excel spreadsheet which contained camera coordinate points. The latitude and longitude (x and y) data for each camera was recorded in the sheet columns. The image data

was then added to this spreadsheet to function as an attribute data. Each individual camera contains information on the types of species captured by the camera and how many of each species was present at the location. The file was saved and imported into AcrGIS. After right clicking on the file and prompting the show x, y data option, the point data for the separate cameras appeared within the Alexander Skutch Biological Corridor. This newly created layer contains spatial and aspatial information. By accessing the tabular data for each point; location information, camera name, animal species and abundance of animal data can all be acquired.

Road Network Data Layer:

The road network layer was manually created using ArcGIS tools to digitize the paths. First the road networks were located through Google Maps and Google Earth. Next the paths that could be identified were copied from Google onto the Alexander Skutch Biological Corridor base map in ArcGIS. Only the paths that intersected with the Corridor were digitized onto the base map. The road networks all ended before entering the protected forests however still ran through the focal area. The purpose of the road networks layer is to provide information on the movement of species. It will be possible to identify if vehicular and pedestrian traffic affect the movement and range of animal species within the corridor.

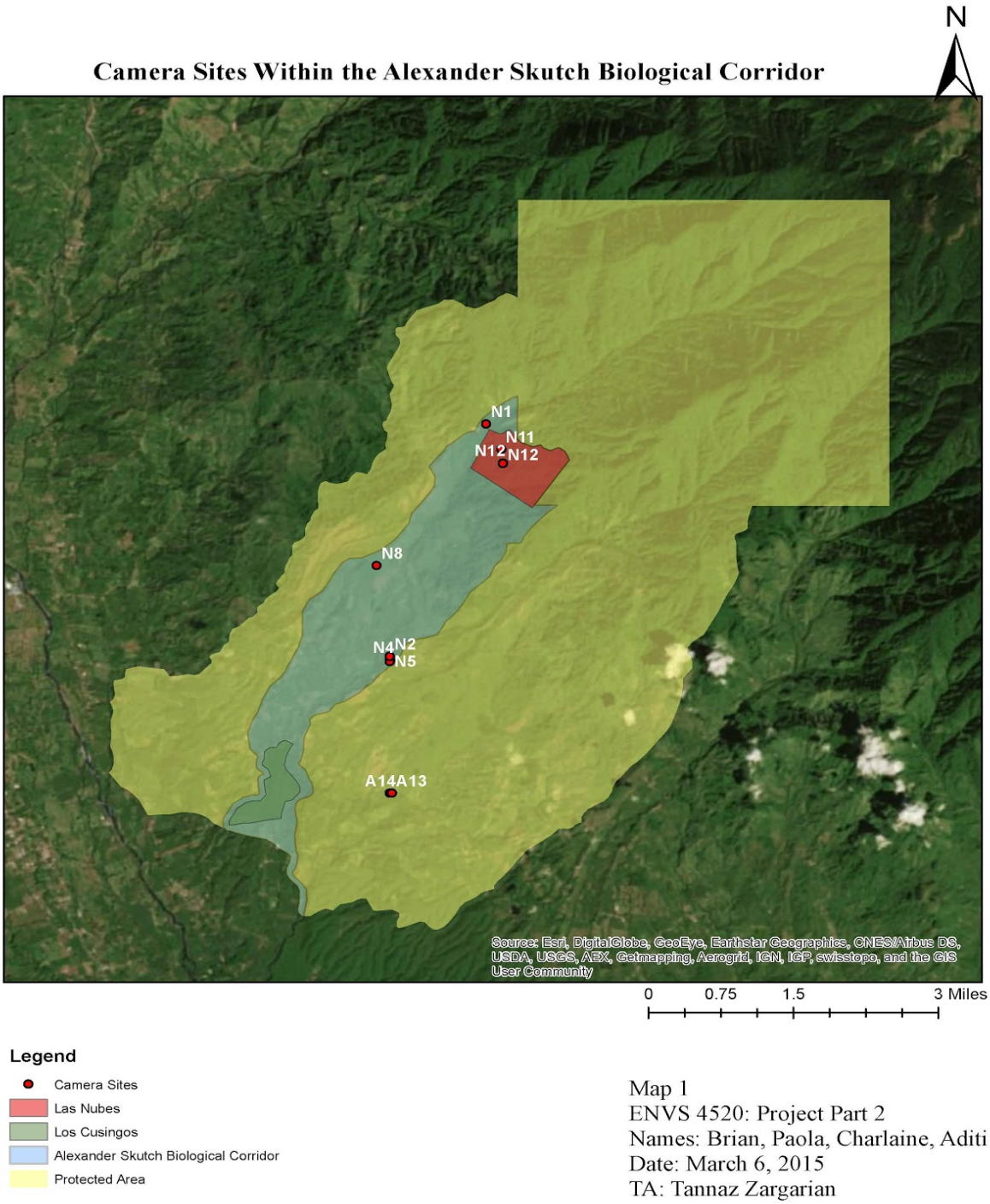
Land Use Data Layer:

The land use information was provided by the data obtained from Felipe. The data already had weighted values for each of the separate land uses however, it was written in Spanish and the land uses were all displayed in a single colour. The group translated the existent data and altered the land use colours so that the uses were more easily identifiable and distinguishable. This allowed for the land use variations to become more apparent for further analysis. The

purpose of this layer will be to provide information on species range, type and inhabitancy on separate lands. It will be possible to recognize if varying terrains have significant, moderate or no impacts on the movement of animals within the corridor.

The following are a set of maps depicting separate data layers created. After each map, there is a page containing meta data for the above layer.

Map 1

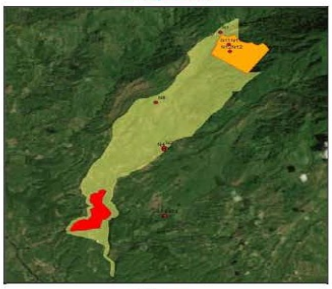


Map 1
ENVS 4520: Project Part 2
Names: Brian, Paola, Charlaine, Aditi
Date: March 6, 2015
TA: Tannaz Zargarian

Meta Data 1

camera_sites

Shapefile



Tags

wildlife, camera traps, costa rica, corridor, alexander skutch, las nubes, los cusingos

Summary

These camera traps took photographs of the wildlife roaming in the corridor between 2012-2014.
They aquired more than 1000 images.
The traps will provide data on animal home ranges and how far each animal travels for various resources.

Description

This is point data representing the camera traps located within the biological corridor.

Credits

Felipe Montoya - York University

Use limitations
There are no access and use limitations for this item.

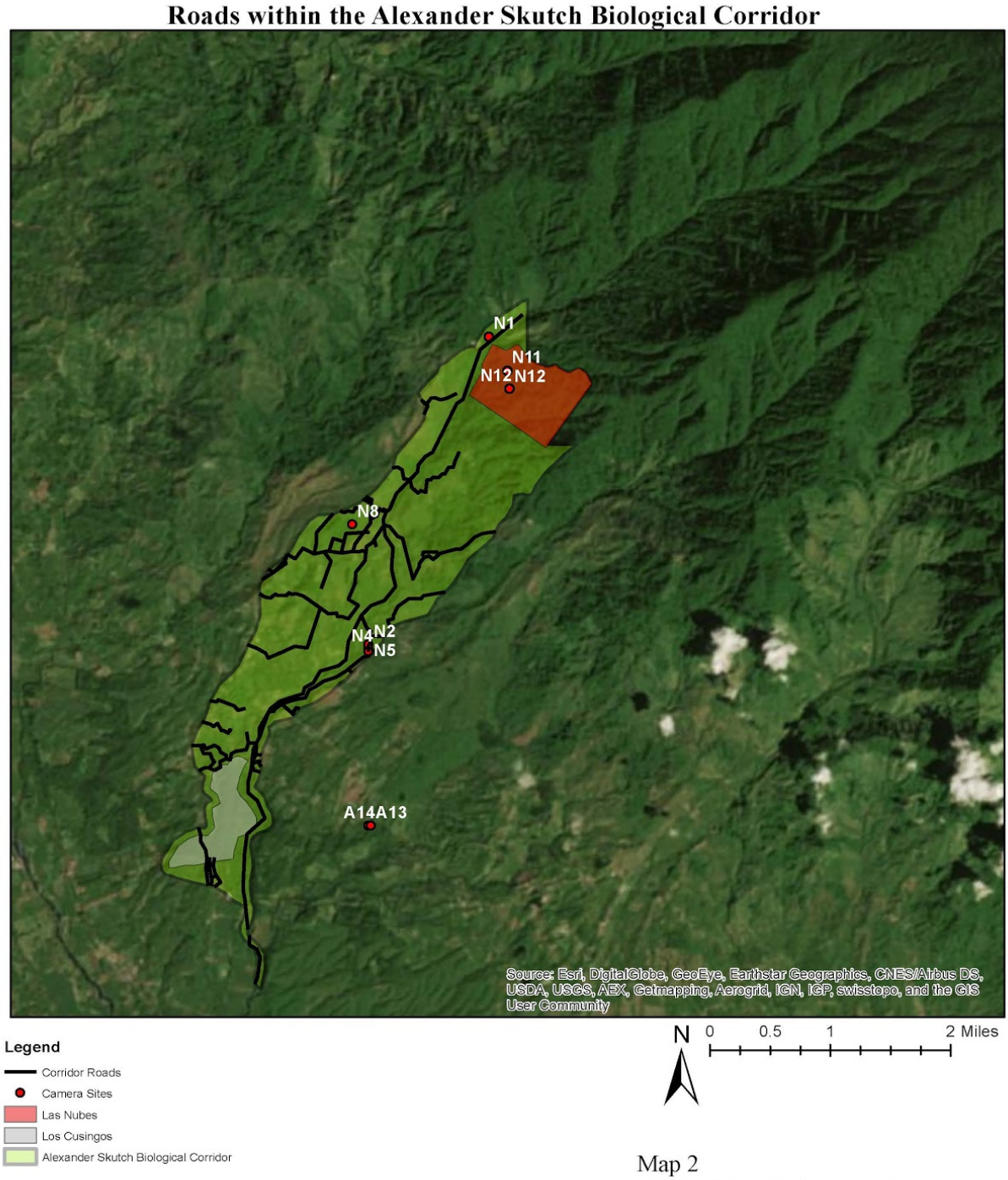
Extent
There is no extent for this item.

Scale Range
Maximum (zoomed in) 1:5,000
Minimum (zoomed out) 1:150,000,000

You are currently using the Item Description metadata style. Change your metadata style in the Options dialog box to see additional metadata content.

Description: The *Camera Sites Within the Alexander Skutch Biological Corridor* map displays the location and relative distances of the cameras within the corridor. This shows the range that is covered by the cameras, as well as illustrating animal movement from one camera location to the next.

Map 2

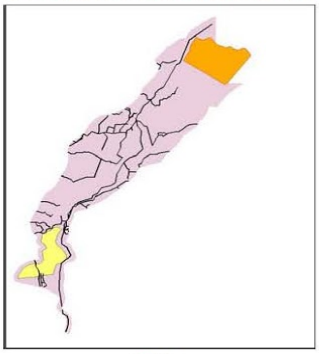


Map 2
ENVS 4520: Project Part 2
Names: Brian, Paola, Charlaine, Aditi
Date: March 6, 2015
TA: Tannaz Zargarian

Meta Data 2

CorridorRoads

File Geodatabase Feature Class



Tags

costa rica, corridor, roads, pathways. transport, connectivity

Summary

The roads file produces a layer that reveals the movement of humans and vehicles through the corridor.
Though they facilitate human travel, they create barriers for wildlife movement.

Description

This is a line segment that provides spatial data on roads within the Biological Corridor.

Credits

https://www.google.ca/maps/dir/Las+Nubes,+Costa+Rica/Refugio+de+Aves+Dr+Alexander+Skutch+%E2%80%9CLos+Cusingos%22,+Costa+Rica/@9.4388199,-83.7542311,13z/am=t/data=!4m14!4m13!1m5!1m1!1s0x8fa0e7a5dbd6308b:0x7d3df77873bc4b1e!2m2!1d-83.962052!2d9.98733!1m5!1m1!1s0x8fa14d0e8797daef:0xeed2ff3a5c59fc8f!2m2!1d-83.627611!2d9.333127!3e0

Use limitations
There are no access and use limitations for this item.

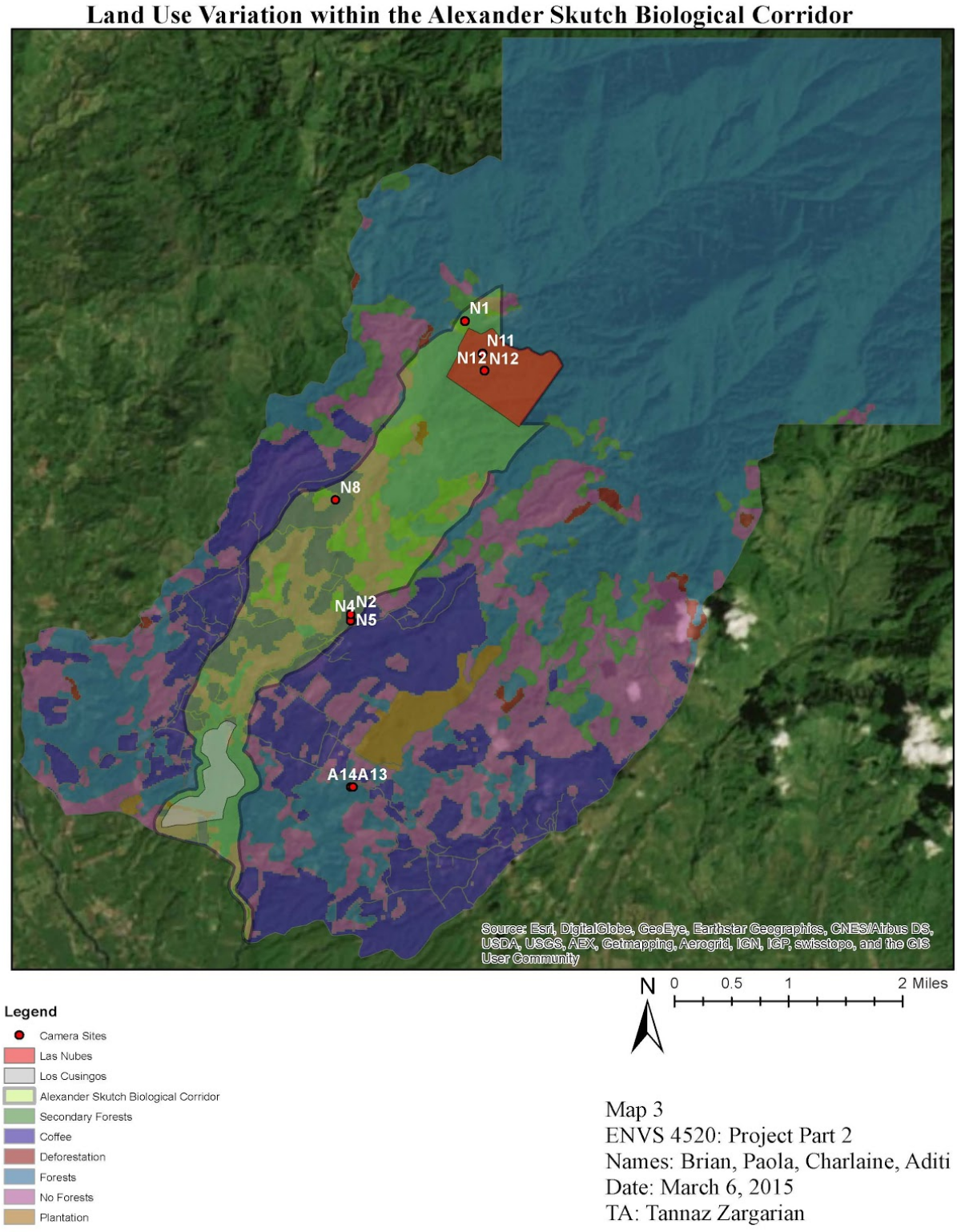
Extent
West -83.632461 **East** -83.592648
North 9.394660 **South** 9.312576

Scale Range
Maximum (zoomed in) 1:5,000
Minimum (zoomed out) 1:150,000,000

You are currently using the Item Description metadata style. Change your metadata style in the Options dialog box to see additional metadata content.

Description: The *Roads within the Biological Corridor* map present the major roads in the corridor. This is important to take into consideration, as roads may act as human-made barriers that obstruct ease of animal movement throughout the corridor.

Map 3

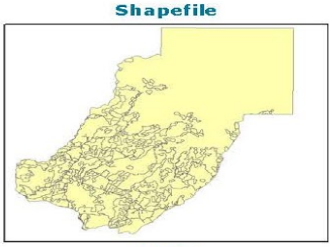


Map 3
ENVS 4520: Project Part 2
Names: Brian, Paola, Charlaine, Aditi
Date: March 6, 2015
TA: Tannaz Zargarian

Meta Data 3

land_use

Shapefile



Tags

land use, coffee, plantations, secondary forest, deforestation

Summary

The landuse layer allows for better analysis of how the Biological Corridor area is being used. The seperate uses show how much land within the corridor is affected by human activity and how this activity may affect wildlife movement within the area.

Description

This is polygon coverage which provides information on the separate land uses within the Biological Corridor.

Credits

http://cobas.juturna.ca/en/drupal/?host=cobas.odd.ucr.ac.cr&locale=en&map=species#map=12/9.3742/-83.5967

Use limitations

There are no access and use limitations for this item.

Extent

There is no extent for this item.

Scale Range

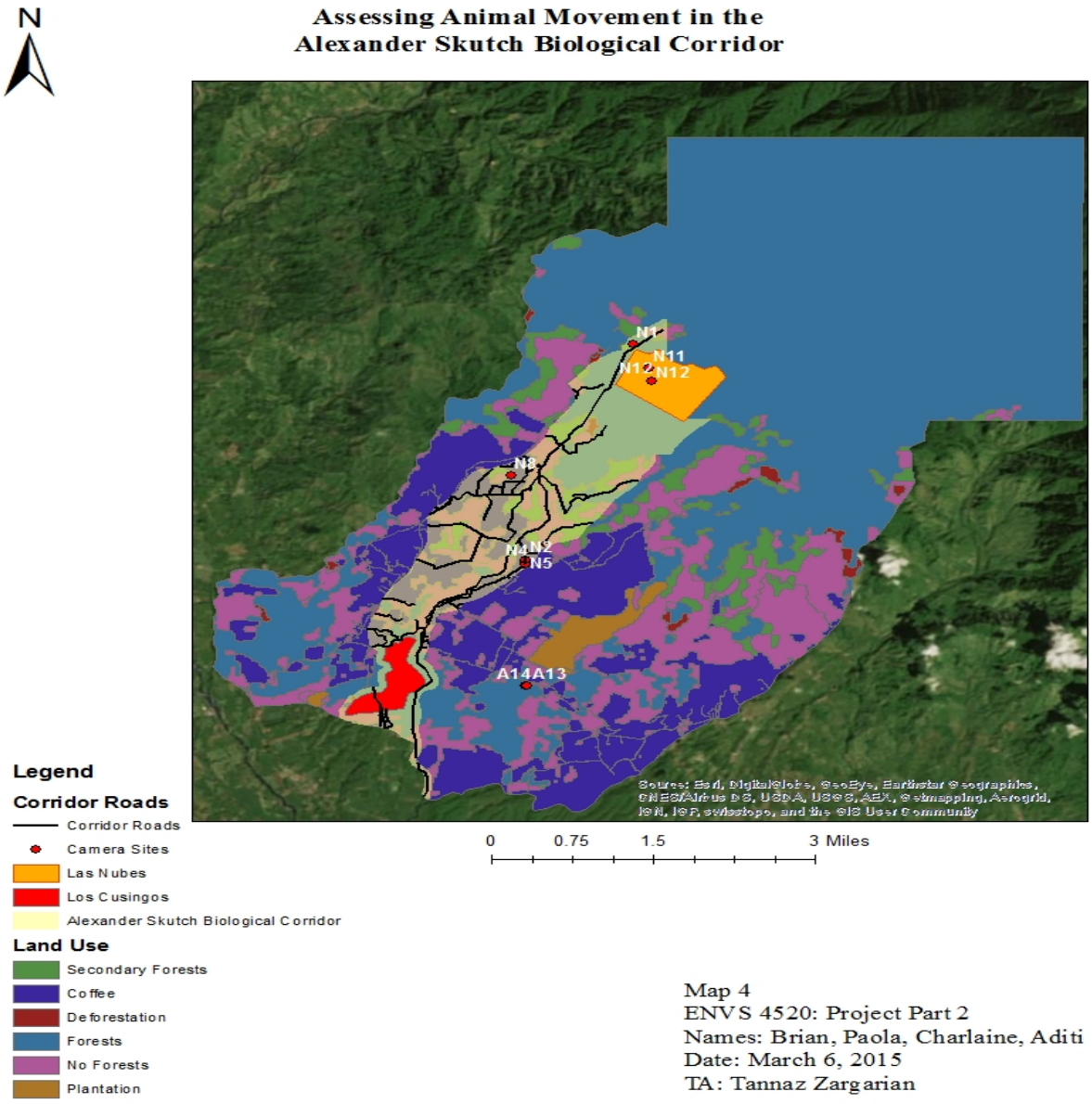
Maximum (zoomed in) 1:5,000

Minimum (zoomed out) 1:150,000,000

You are currently using the Item Description metadata style. Change your metadata style in the Options dialog box to see additional metadata content.

Description: The *Land Use Variation within the Biological Corridor* map illustrates the different physical land cover within the corridor, as well as illustrating the areas of the corridor that have been altered by human activity. Mapping the land use is important because it clearly displays landscape connectivity, as deforestation or coffee farms may deter certain animals from moving throughout the corridor.

Map 4: Animal Movement Assessment



Description: In our fourth map, we include the following layers: Camera Sites, Corridor Roads, Land Use, as well as outlining Las Nubes, Los Cusingos, and the Alexander Skutch Biological Corridor. With these layers included on one map, it allows for the analysis of each camera location in terms of land use and relative distance to major roads within the corridor.

Data Analysis and Results

Camera Data Analysis and Results

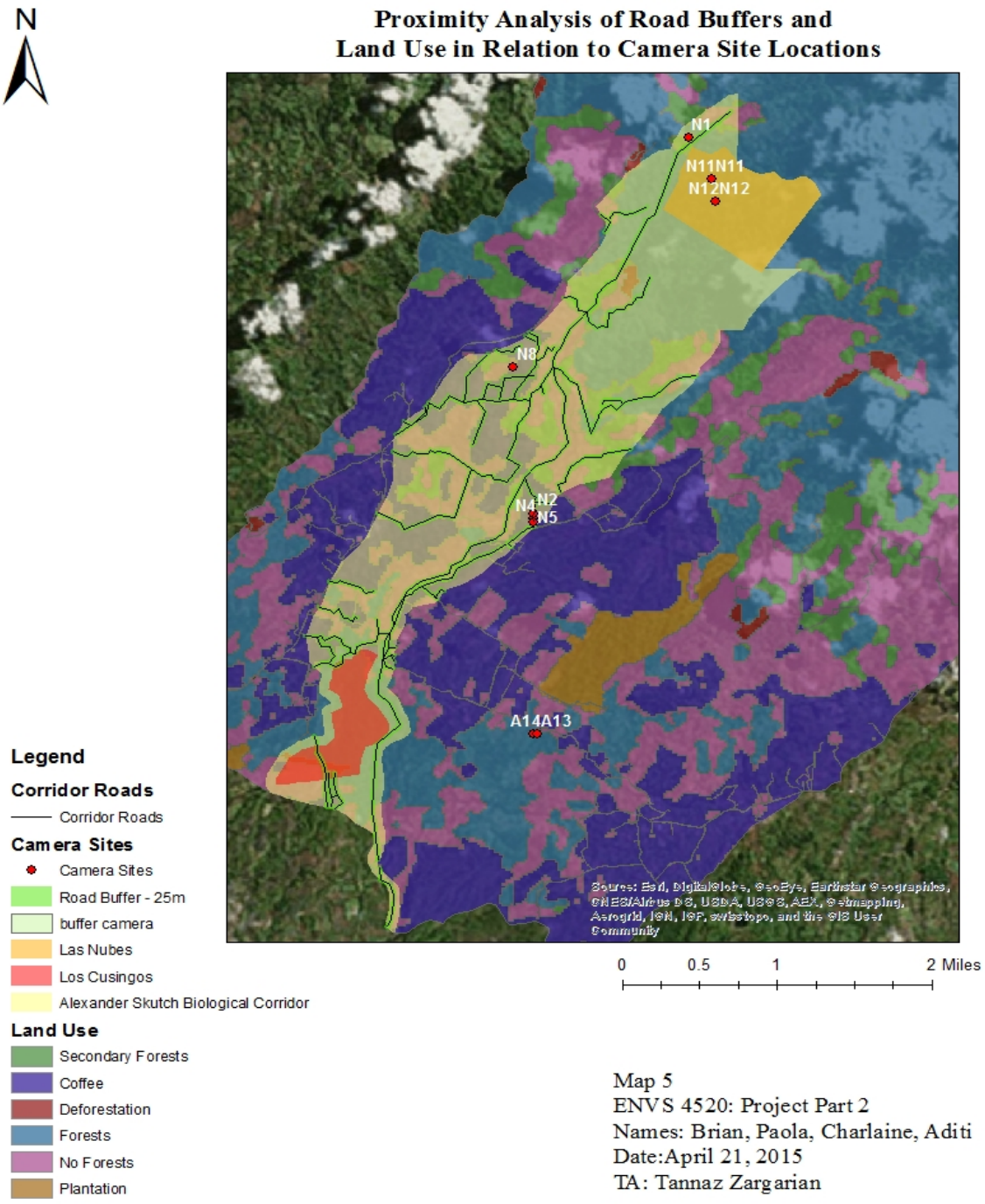
- Cameras sites N11 and N12 are located within Las Nubes. Las Nubes is a rich rainforest ecosystem connecting Chirripó National Park to the northeast and the Alexander Skutch Biological Corridor to the southwest. N11 and N12 are located in the forest, remote from any major road. These camera sites are the only ones located within Las Nubes.
- Camera site N1 is located to the north of Las Nubes, in a secondary forest. A secondary forest is a forest that has regrown following a disturbance, such as the altering effects of human activity. Located about a half mile from N11 and N12, a road also separates N1 from N11 and N12.
- Camera site N8 is situated on the border of a coffee plantation and a deforested region, it is also close to a secondary forest. There are also roads to the north, south, and east of this camera location.
- Camera sites N2, N4, and N5 are located on a coffee plantation, as well as in very close proximity to a road. They are the only camera sites located within a coffee plantation besides N11 and N12.
- Finally, camera sites A13 and A14 are located in the corridor buffer zone in a forest.

Animal Species Data Analysis and Results

The common opossum (Didelphis marsupialis), nine-banded armadillo (Dasypus novemcinctus) and white-nosed coati (Nasua narica) were detected most frequently at camera sites compared to the other mammal species. The common opossum was detected the most frequently at 6 camera sites including N4, N5, N8, A13, N11, and N2. This illustrates that the

common opossum was present at various land uses including coffee plantations, borders adjacent to coffee plantations, forests and the Las Nubes rainforest. Though further research may be required, we can assume that the common opossum's home range spans these six camera locations and corresponding land uses. The white-nosed coati was detected at four camera sites including N8, A13, N11, and N2. This demonstrates that the white-nosed coati was identified at similar land use locations as the common opossum including coffee plantations, borders adjacent to coffee plantations, forests and the Las Nubes rainforest. We can discern that the common opossum and the white-nosed coati have a similar range that spans a variety of land uses. The nine-banded armadillo was detected at 5 camera sites including N12, N4, N5, N8 and N2. This shows that the nine-banded armadillo was detected mainly at coffee plantations. We can assume that the nine-banded armadillo has a home range spanning these five camera locations. Other animal sightings were significantly less than the common opossum, white nosed coati and nine-banded armadillo. The puma, for example was only sighted at N1 which is in the secondary forest and closest to Las Nubes and the National Park. There is reduced noise pollution and no roads which travel into that region. This may be why the puma is less represented through the corridor, as it prefers to maintain its home range in the quiet protected areas of Costa Rica. The ocelot was sighted at camera traps N12, N2 and A14 which were within the areas of Las Nubes, coffee plantations and forests. The home range of this species spans the entire length of the corridor however it was one of the least sighted species. This may be because the ocelot is aware of abnormalities in the landscape, such as camera traps. Ocelots are also nocturnal and hunt in the dark. This reduces the cameras visibility of the animal while it is moving in the night.

Map 5: Road Buffer Proximity Analysis

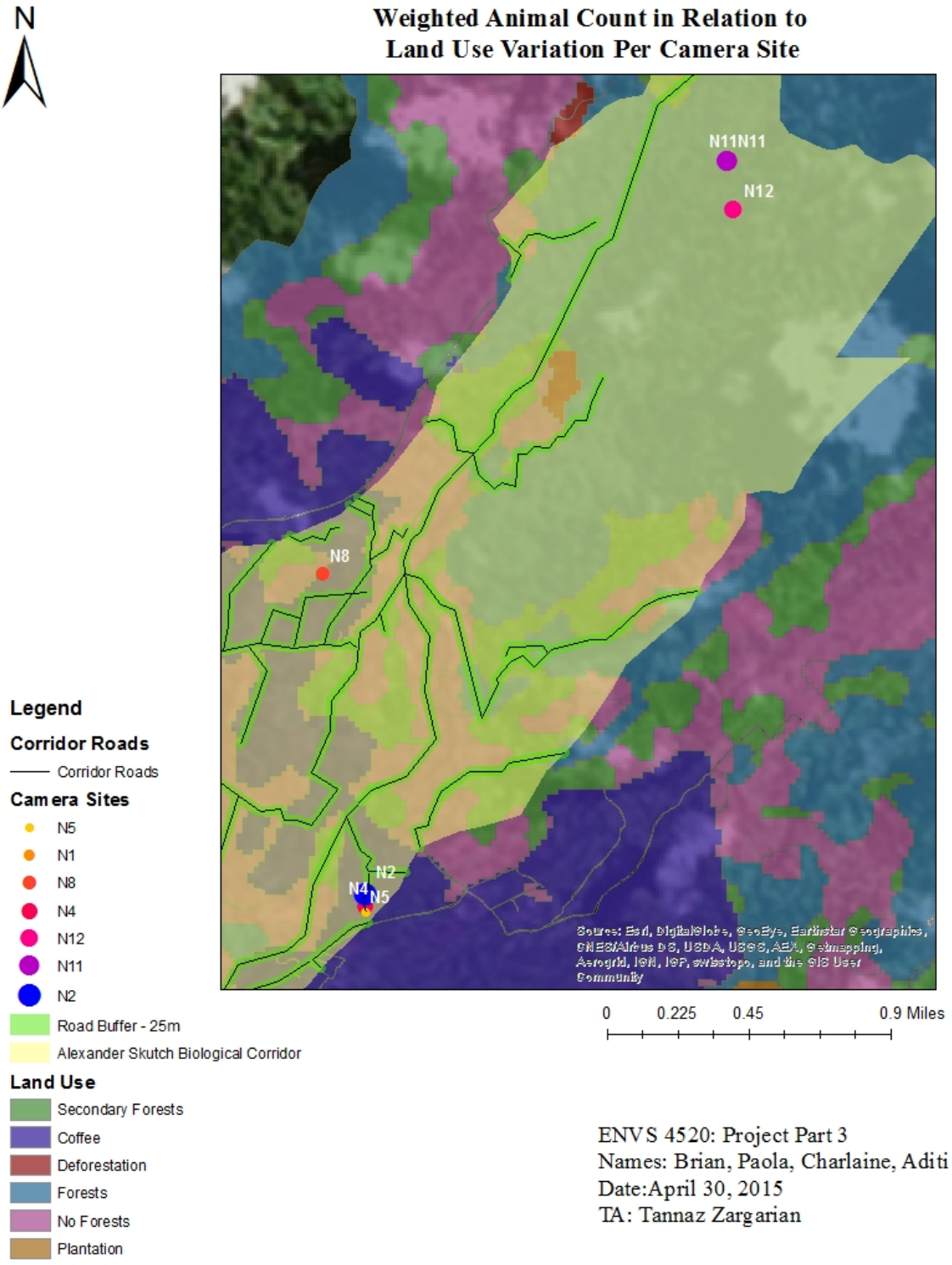


Description: Map 5 shows how many ameras are located within 25 m of the road

Road Buffer Proximity Analysis and Results

The map above (Map 5) has a 25 m buffer around the roads located within the corridor. We used this type of spatial analysis to develop a better understanding of how wildlife may be impacted by human activity and traffic. Since noise pollution can deter animal movement through an area, we assumed that majority of animals were distancing themselves from the road in fear of the unknown and in order to avoid human contact. We created a 25 m buffer around the roads to see which camera traps were most near roadsides. We hypothesized that the roads would limit animal movement and those cameras closest would capture the least amount of pictures. This was true for cameras, N1 and N5 which has the least amount of pictures. However, the results were inconsistent as cameras N2 and N4 had a significant amount of photographs captured. In fact, camera trap N2 has the most pictures throughout all the traps in the corridor. Camera traps N2 and N4 are located in the shaded coffee plantations which uses an agroforestry approach within the fields. This is very important in understanding animal movement and home ranges near those areas. The concept of agroforestry is further elaborated upon under graph 4. Camera trap N5 falls within the 25m road buffer and is also located in the same shaded coffee plantation. Nevertheless, it is positioned at an intersection, meaning there may be more traffic than usual when compared to the road near traps N2 and N4. Though animal movement does not seem to be significantly impacted by roads, it is important to consider those animals that are run over or are more fearful of noise than those crossing. Animals that are avoiding movement, are limiting their gene flow by moving on the boundaries of roads instead of across the roads. Other animals which are not used to human presence and do not know to fear such things as moving vehicles are more susceptible to injury and death.

Map 6: Weighted Animal Count



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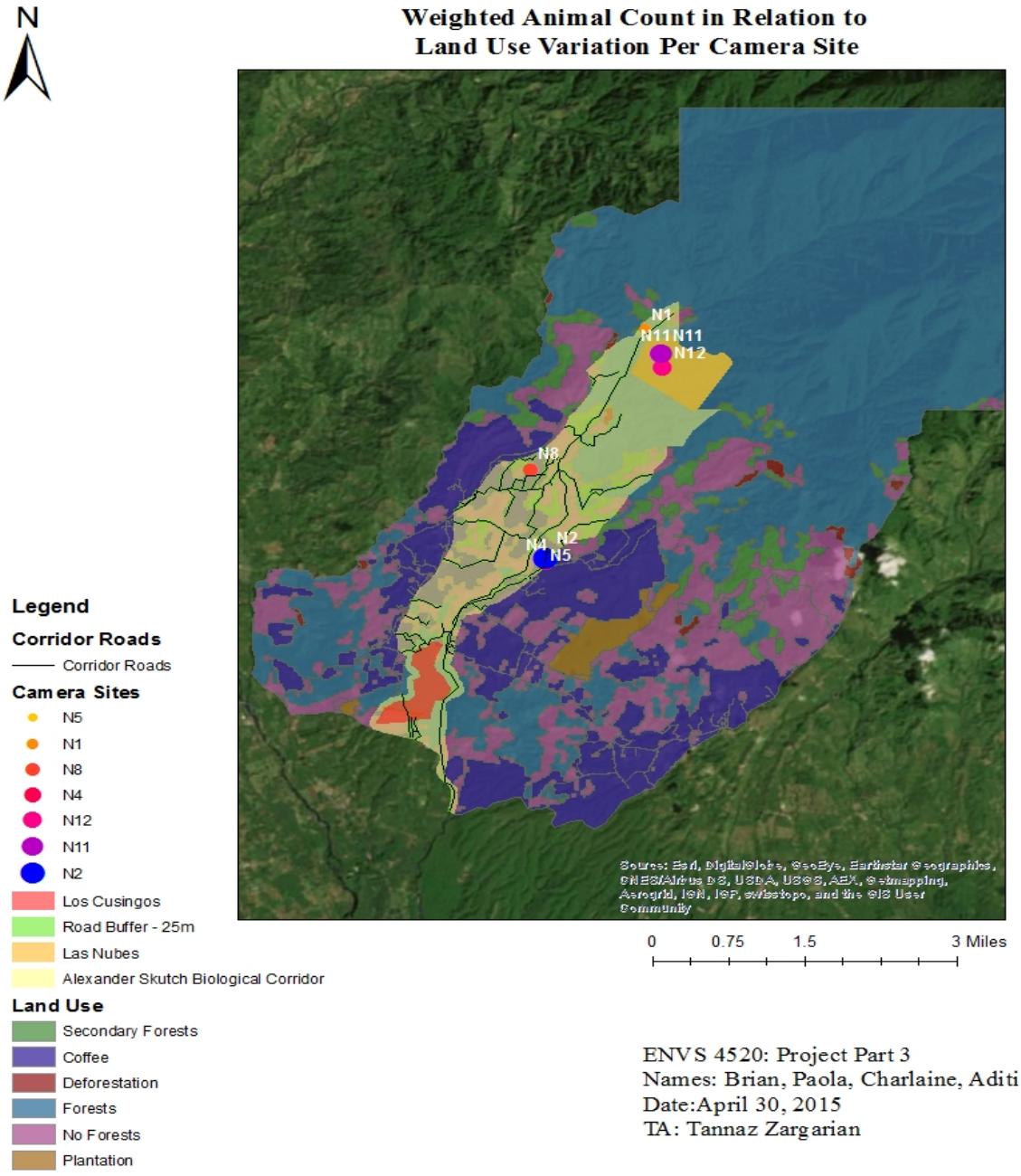
Date:April 30, 2015
TA: Tannaz Zargarian

Map 6: Overview



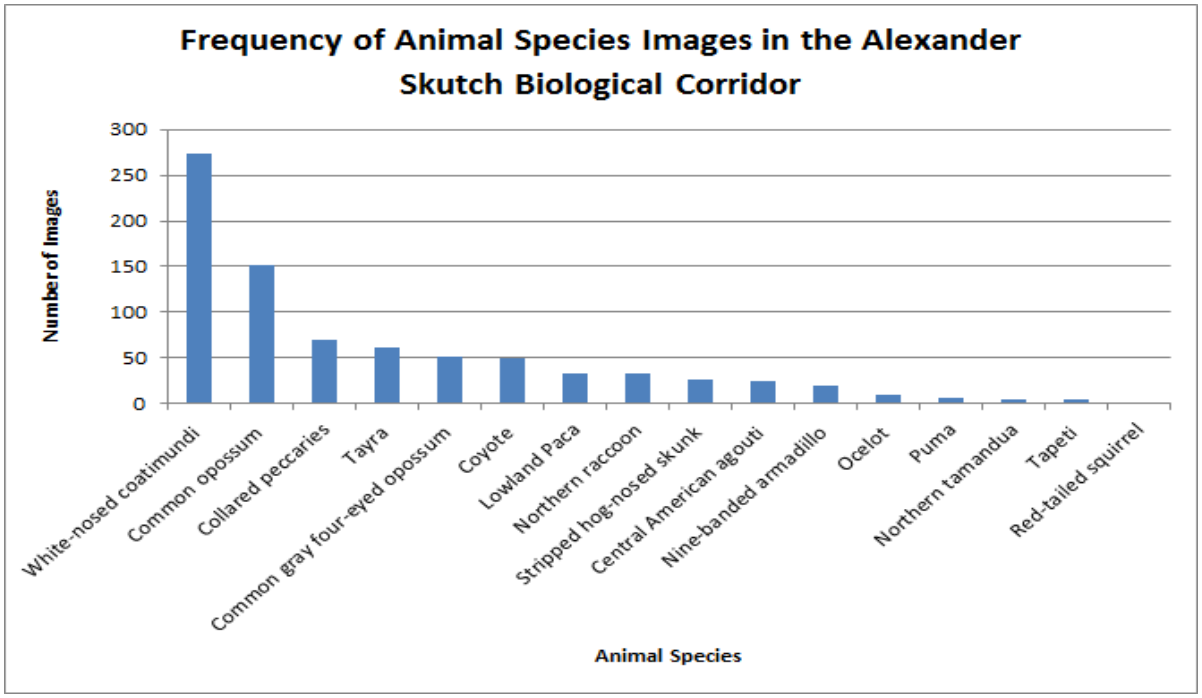
Description: Map 6 illustrates the total animal species counts for each camera trap site.

Weighted Animal Count Analysis and Results

We used the weighted animal count to develop a better understanding of where the most animal species were located and where the most movement took place. Camera traps N4, N2, N11 and N 12 were the traps with the most images captured. Interestingly enough, all four cameras are located in coffee plantations. Camera traps N11 and N12 are located in Las Nubes and N2 and N4 are in the middle of the corridor. Trap N5 had the least amount of data but as discussed prior, it was closest to an intersecting road which may have deterred species movement. N1 is located in a secondary forest in between Las Nubes and a deforested area. The secondary forest may not be well developed just yet meaning that shelter is limited. If the trees and growth in this area is not developed then food supplies may also fall short and limit the amount of species located or moving through that area. N8 is located in what look like a separating border between a plantation and a deforested region. The limited shelter of the vicinity may have been the reason for such minimal data collection. This map does show proof of limited species density, and movement in areas which have been negatively altered (deforestation) by humans. Conversely, it also illustrates animal adaptation and movement in areas which have been altered by humans but have maintained certain aspects of the natural space such as the coffee plantations. This map also gathers no data on the absolute south end of the corridor where Los Cusingos is located. The analysis would be much improved if in the preceding years camera traps are added to the southern region.

Graph Analysis and Results

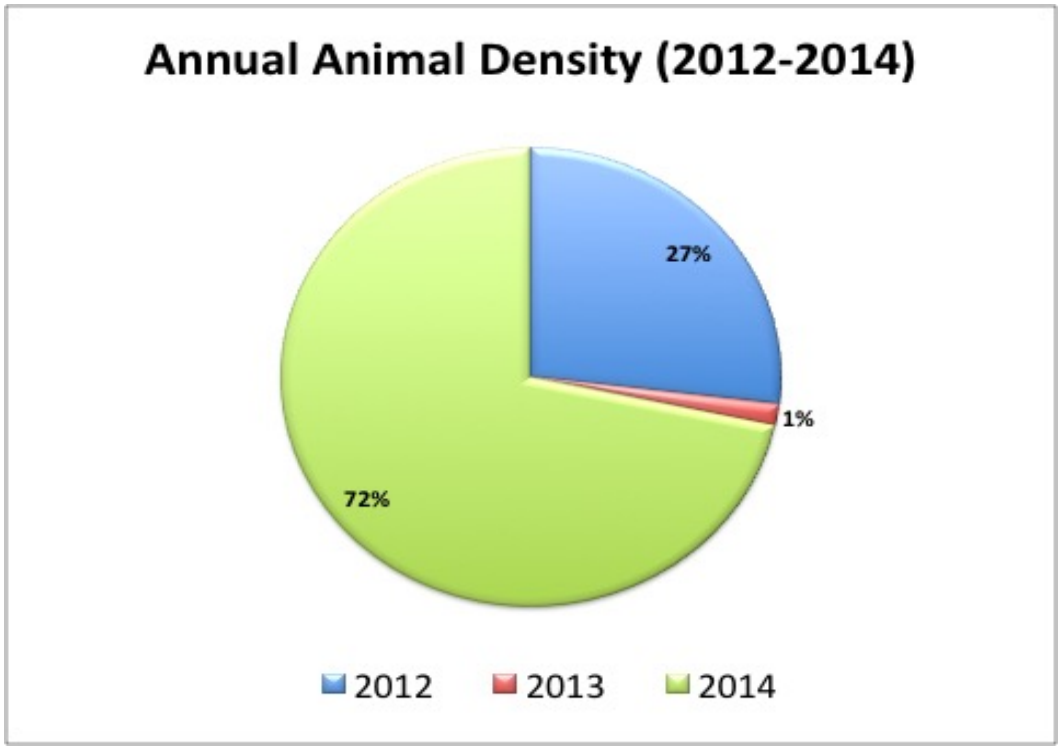
Graph 1: The Frequency of Animal Species Images in the Alexander Skutch Biological Corridor. The graph shows how many of each species is captured in the camera traps.



Graph 1 Analysis/ Results: The graph above illustrates which species were captured by the camera traps within the corridor. The number of sightings for each species is documented in order to develop a better understanding of which species are most prevalent in the area. The data shows a large population of coatimundi and opossum living in the area followed by collared peccaries. This may be because these animals are generalist and will consume a variation of plants, animals and insects. Thier species range may therefore be large as they are not limited or constrained by specific dietary requirements or habitats requirements. Furthermore, "various energetic constituents are correlated with body size, resting metabolism, exis-tence metabolism birth and weaning masses. birth weight and gestation length" (Gittleman and Thompson, 1988,

p.865). The larger the animal is, the more energy it consumes in its reproduction. Therefore, large mammals such as the ocelot and puma are not breeding as rapidly as the coatimundi and opossum. However, there are other small mammals such as the red tailed squirrel and tapeti which are not well represented in the camera trap data. This may be because they are higher in the trees (red-tailed squirrel) and not at the camera lens level or may be much lower than the trap lens height (tapeti).

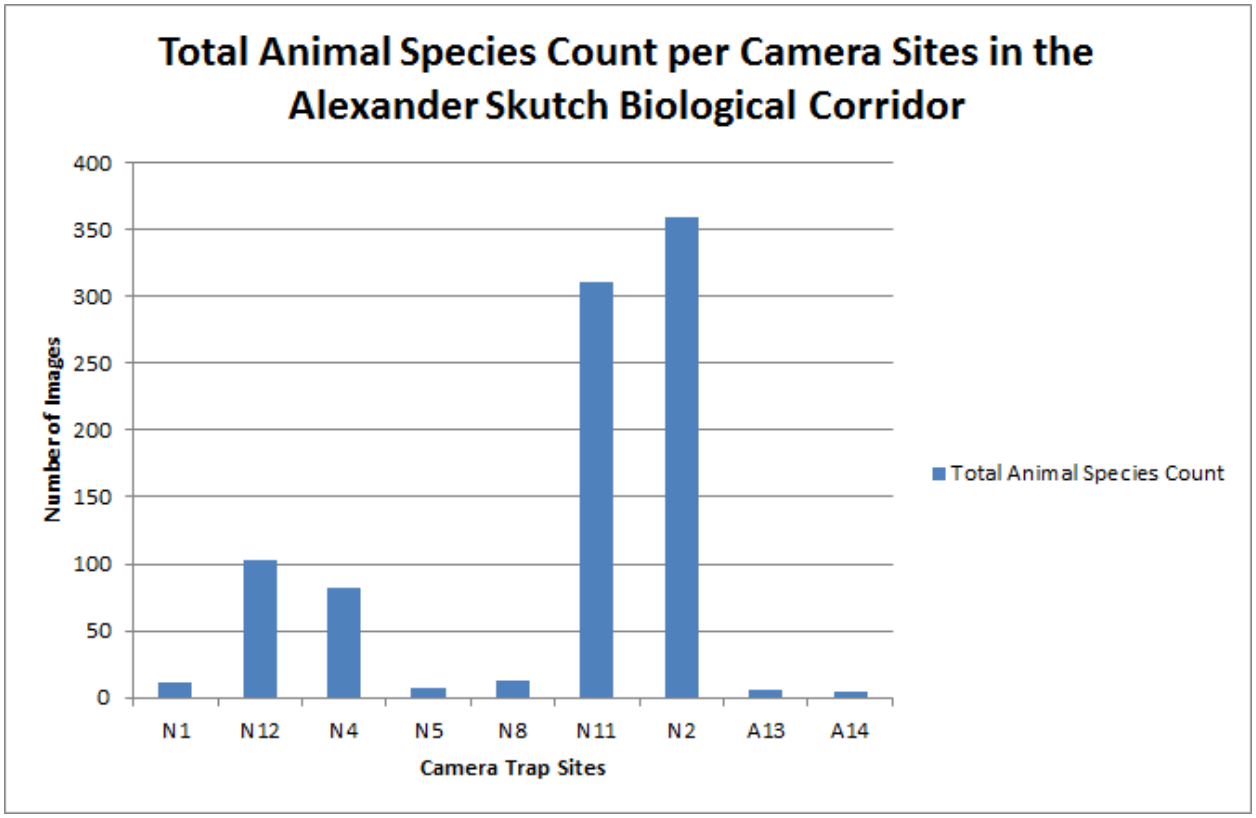
Graph 2: The Annual Animal Density chart shows the quantity of data provided for each year.



Graph 2 Analysis/ Results: There was a significant increase in the amount of data collected for 2014 compared to 2012, however the opposite is true for 2013. This decrease in data may be a result of the cameras that were reported stolen or malfunctioning by Felipe Montoya. We hypothesize that cameras were added in 2014 to aid in research. The newer cameras may have been better placed, better baited, improved by technology, had fewer glitches and were not

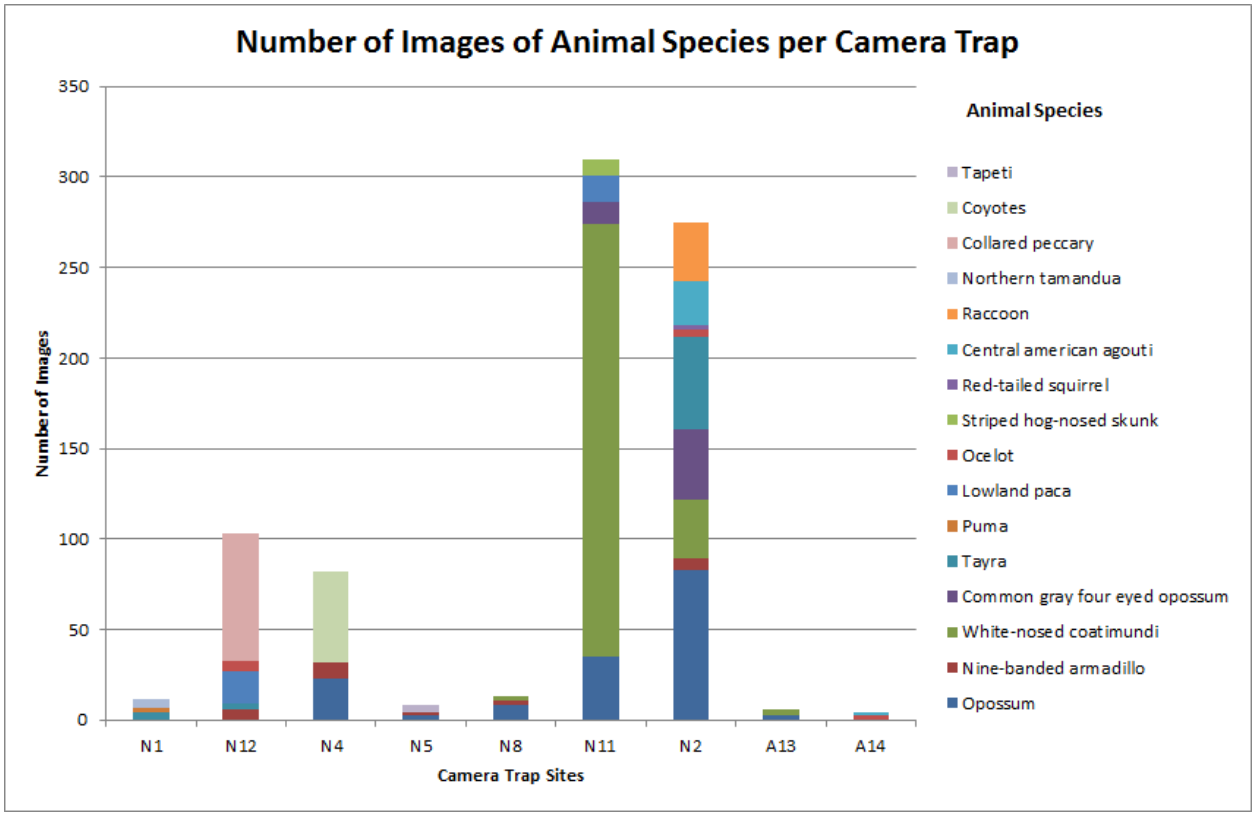
stolen. This ensured that the lens of the camera maintained its position throughout and was able to capture reliable data compared to the 2012 and 2013 camera traps.

Graph 3: This graph illustrates the total number of animal species images per camera trap site.



Graph 3 Analysis/ Results: The camera traps N11 and N2 have the greatest total animal species counts with N11 located in the rainforest and N2 located within a coffee plantation. The camera traps with the lowest total number of animal species images is A14 which is located in the forest. This may have been due to a malfunctioning of the camera trap which prevented it from collecting more data.

Graph 4: This graph illustrates the kinds of animal species according to the number of images per camera trap.



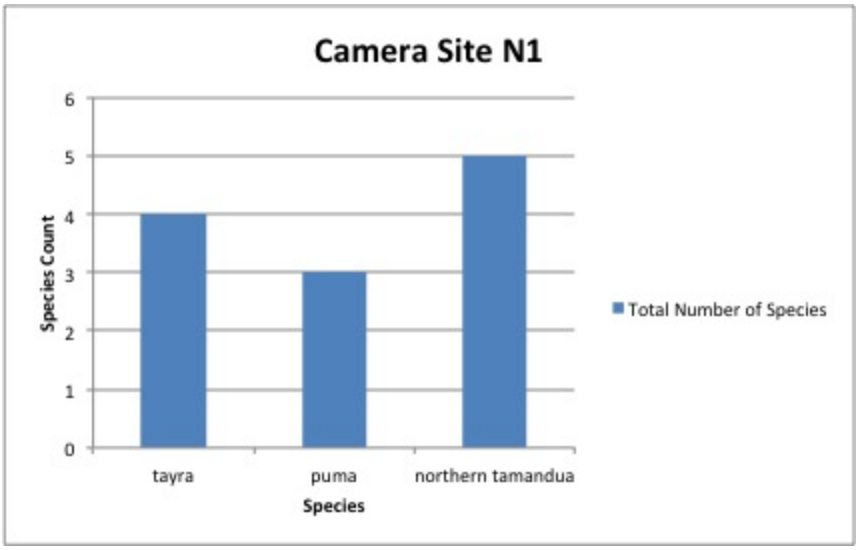
Graph 4 Analysis/ Results: Camera trap N11 has the highest amount of images which may be due to the fact that this camera is located in the rainforest as illustrated in Map 6 , which is majority of the animals' natural habitat. Camera trap N2 has the second highest number of images and is located on a coffee plantation as illustrated in Map 6. Furthermore, camera trap N2 has the highest number of animal species compared to the other camera traps with a total of nine different animals' species. Our results show that these species consisting of the common opossum, nine-banded armadillo, white-nosed coatimundi, common gray four-eyed opossum, tayra, ocelot, red-tailed squirrel, Central American agouti and raccoon have adapted to the altered landscape of a coffee plantation. These animal species are small to medium size and this

may be a contributing factor in their successful adaptation to coffee plantations which have reduced forest cover compared to the rainforest habitat.

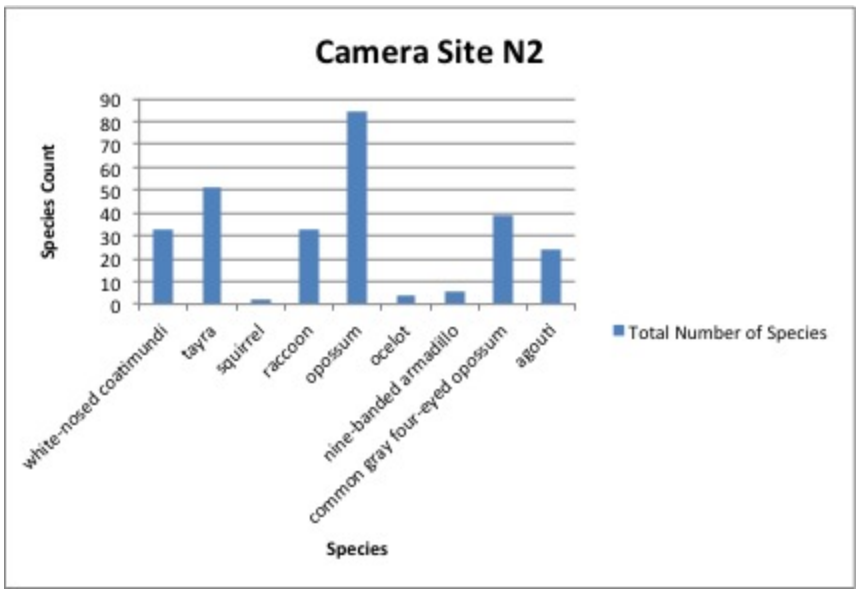
The coffee plantations within the Alexander Skutch Biological Corridor are shade grown coffee plantations (Rapson, Bunch, & Daugherty, 2012, p. 37). Shade-grown coffee plantations are also known as coffee agroforestry which involves managing shade trees within coffee farms to provide habitat for wildlife, act as a buffer zone to reduce edge effects, and increase connectivity between forest fragments (Caudill, DeClerck, & Husband, 2015, p. 85). According to Rapson, Bunch & Daugherty (2012) the Alexander Skutch Biological Corridor shade-grown coffee plantations have been shown to support higher species richness compared to other plantations such as sun coffee plantations, sugar cane and pineapple plantations. Shade grown coffee plantations can demonstrate some ecological value to species (Rapson, Bunch, & Daugherty, 2012, p. 43). This is consistent with Caudill, DeClerck, & Husband (2015) whose study in Turrialba, Costa Rica found that there was greater species richness and abundance in forest habitats and shade coffee compared to sun coffee plantations. This indicates that shade coffee plantations provide increased canopy cover and vegetation complexity which is beneficial to mammals. Though shade coffee plantations are not substitutes for rainforests they do provide habitat for small to medium mammals (Caudill, DeClerck, & Husband, 2015, p. 91). The provision of habitat by shade coffee plantations supports our results of camera trap N2 having the highest number of species.

The following graphs depict the types of animal species photographed at each trap location and the quantity of each species at the separate trap locations.

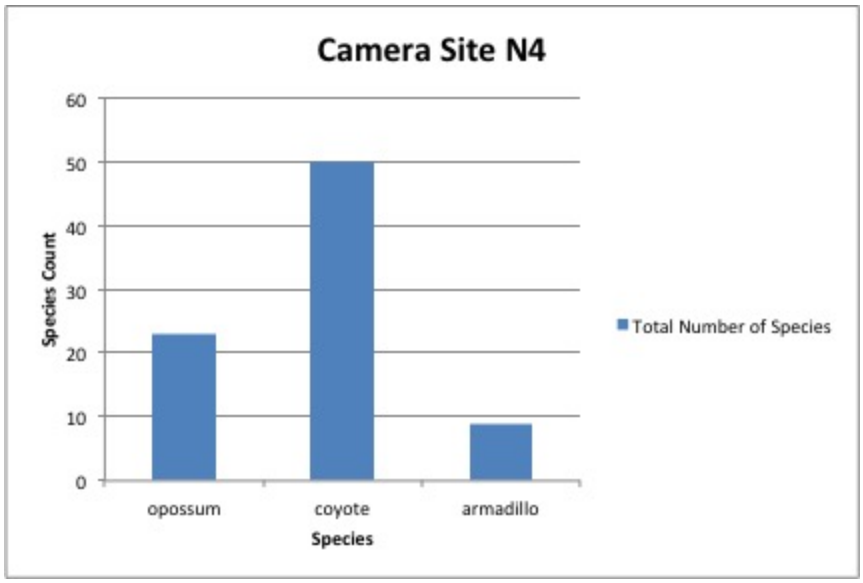
Camera Trap N1: Trap N1 is located in a secondary forest close to Las Nubes. The animals photographed in descending quantity are the northern tamandua, tayra and puma.



Camera Trap N2: Trap N2 is located in a shaded coffee plantation. It photographed the most animals and most animal species out of all the other traps throughout the corridor. The animals photographed in descending quantity are opossum, tayra, common gray four-eyed opossum, white nosed coatimundi, racoon, agouti nine banded armadillo, ocelot and squirrel.



Camera Trap N4: Trap N4 is located beside trap N2 and is within a secondary coffee plantation as well. The animals photographed in descending quantity are coyote, opossum and armadillo.



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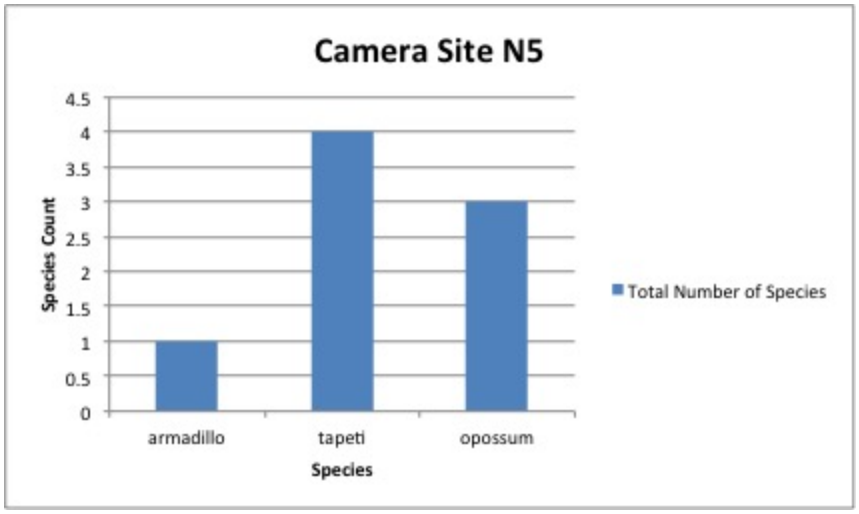
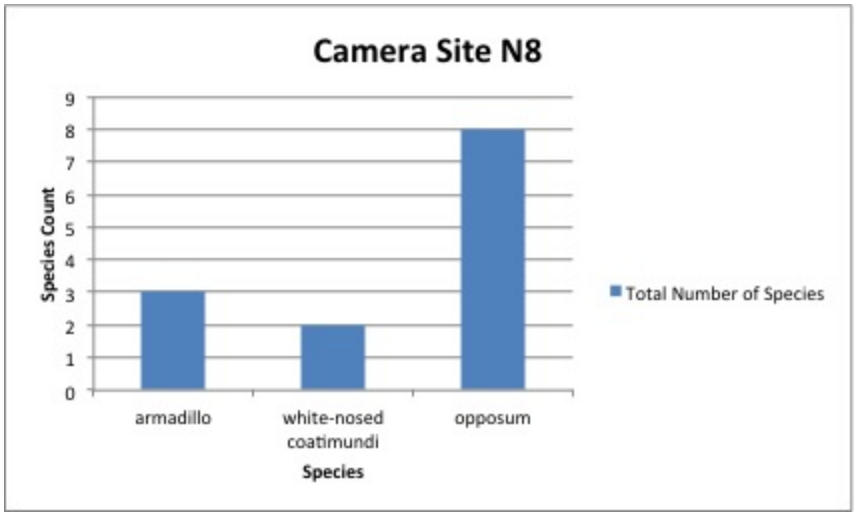
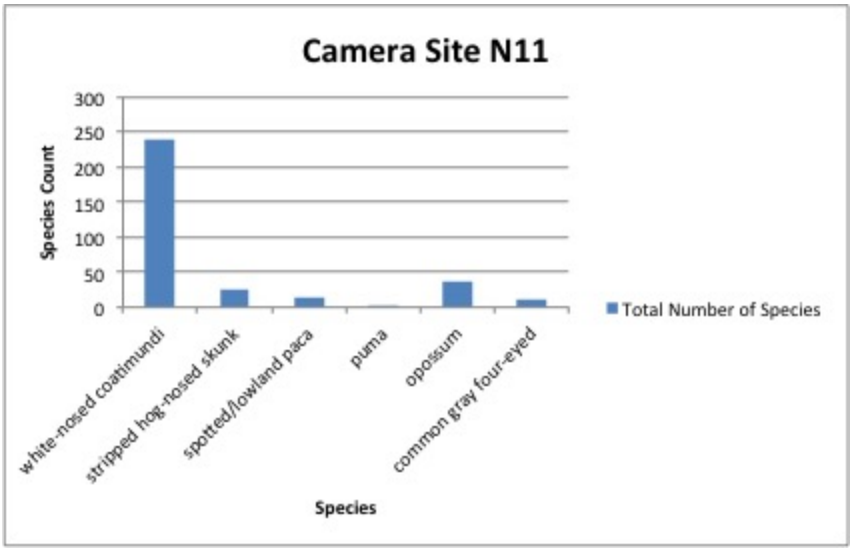
Camera Trap N5: Trap N5 is located at a road intersection in a coffee plantation. It is beside traps N2 and N4 which conversely had the most image data. The animals photographed in descending quantity are the tapeti, opossum and armadillo.



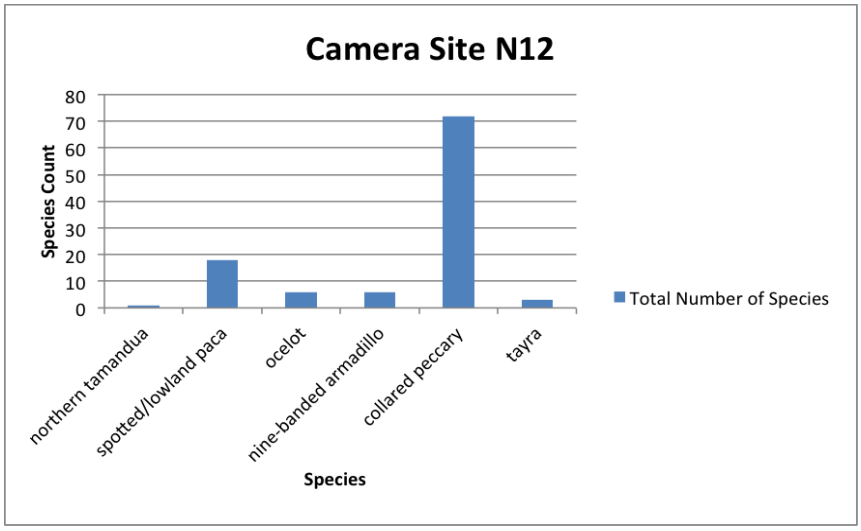
Camera Trap N8: Trap N8 is located in the separating border of a plantation and a deforested region. The animals photographed in descending quantity are the opossum, armadillo and white nosed coatimundi.



Camera Trap N11: Trap N11 is located within Las Nubes. This trap captured the most data after trap N2. The animals photographed in descending quantity are the white nosed coatimundi, opossum, striped hog-nosed skunk, spotted/lowland paca, common gray four eyed opossum and the puma.



Camera Trap N12: Trap N12 is also located within Las Nubes. Like traps N2 and N11 it also captured many images of various species. The animals photographed in descending quantity are the collared peccary, spotted/lowland paca, nine-banded armadillo, ocelot, tayra and northern tamandua.



Limitation of Data

The camera trap data that was acquired had many captured images of various animal species for each separate camera. The information was used as tabular data to develop a better understanding of which type of species inhabited a particular area and the abundance of each species in the area. The limitation of this information is that the same animal may have passed a single camera several times moving back and forth across the lens. This would have caused the camera to capture several images of the same individual. Therefore, the tally of each separate species at the various camera locations may not be representative of true figures.

Furthermore, the cameras are set so that many of them are facing each other. The cameras are placed near each other, most often in pairs of two. They then capture similar information and limit the scope of the analysis with repetitions in information.

Conclusion:

In conclusion, this project has provided a significant amount of data regarding animal movement through the Costa Rican Ecological Corridor. Through the analysis of the data, it was possible to see that human activity and animal movement/ species prosperity are able to coincide if the correct measure are taken to protect the interests and habitats of both parties. The shaded coffee plantations within the corridor maintain many aspects of animals natural habitats while simultaneously generating income and capital for the coffee farmers in the region. Certain areas of the corridor could afford to be improved as they neglect the wildlife's need for natural and untouched spaces. The development of infrastructure and roads create the possibility of animal and habitat fragmentation and increases dangers for the animals. Development can destroy species' habitats, food chains and migratory routes. These negative effects may create a chain reaction and have severe implications for the whole environment. To better support our finding, the data could be improved by placing additional camera traps, especially in the southern region of the corridor. It would also be beneficial to track or tag some species so that their movement is better documented and the image documentations are not repeated.

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