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12/15/2022

Using Geospatial Analysis Techniques to Assess Habitat Vulnerability in Nine Primate Species

Abstract

This study performs comparative analysis using Geographic Information Systems (GIS) techniques on the vulnerability to anthropogenic disturbance of nine critically endangered primate species: the Blond Titi, Grove's Titi, Vieria's Titi, Buff Headed Capuchin, Ka'8apor Capuchin, Northern Muriqui, Southern Muriqui, Buff Headed Marmoset, and Pied Tamarin (Figure 1). Habitat ranges, as estimated by the International Union for Conservation of Nature (IUCN), are considered in the study area of Brazil and are studied in the lens of population density, proximity to agriculture, and proximity to roadways. Of the nine species studied, geospatial analysis suggests the greatest anthropogenic threat to the Northern and Southern Muriqui and the least anthropogenic threat to the Grove's and Vieria's Titi. The respective variation in vulnerability between these species follow a pattern of direct variation with proximity to the urban coastal areas of Eastern Brazil and inverse variation with proximity to the Amazon Rainforest. From this a two-fold conclusion of reinforcement to known recommendations is made: the Amazon Rainforest is of utmost importance to protect from anthropogenic influence, and proximity to human development must be a primary consideration in the urgency of an endangered species' situation.

Problem statement

This project aims to answer the following question: how vulnerable are the habitats of critically endangered primates in Brazil and how does this compare between species, location, and habitat characteristics? The nine species of interest are made up of three Titi species, two Capuchin species, two Muriqui species, a Marmoset species, and a Tamarin species.

Brazil is a country defined by biodiversity, and in the case of much of its wooded and primate inhabited land, biodensity as well. The density of vegetation in and around the Amazon Rainforest plays a key role in the biological carrying capacity and thus health of resident species. The studied primates, which are all relatively small in size **cite**, commonly find sustenance from foraged nuts and berries, thus increasing reliance on the habitat's stability amd lack of fragmentation. Literature describing the Pied Tamarin suggest a positive correlation between habitat suitability and accessibility to *snags*- referring to limbs or vines hanging to be used in travel by the Tamarins (Vidal et al. 2006, Acta Amazonica pgs. 240-41). Studies of the Capuchin and Muriqui species additionally stress the reliance of groups- particularly those of healthy size- on sufficient habitat area and lack of fragmentation for species survival (De Oliviera et al. 2014 American Journal of Primatology pgs. 921, 926), (Lima et al. 2019 American Journal of Primatology, pgs. 486, 489), (Strier 1992 Oxford University Press, pgs. 3-81).

As is discussed in depth in Karen Strier's book "Faces in the forest: the endangered muriqui monkeys of Brazil", locomotion is a primary aspect of sustenance and survival- allowing for the discovery of appropriate amounts of food, territorial claim, and preservation of safety from attack or ambush. As has been described, many of the threats to habitat autonomy or species survival are shared by all nine species. The most severe of these threats is the immediate destruction of habitat in the process of human development. The Pied Tamarin experiences this pressure perhaps more than any other species in this study. It inhabits a historically small area, pinned by the Amazon river and neighboring primate habitats. In the last century, its habitat has been put in extreme danger by the city of Manaus, the largest city in the Amazonas region. The Pied Tamarin's habitat has been so affected that the species lives in large part in the city limits in parks, gardens, or anywhere else shelter is found (Strier 1992 Oxford University Press, pgs. 3-14)

Data

This study performs distance and density analysis using the GIS programs ArcGIS Pro and Terrset to spatially assess the anthropogenic danger to each species habitat. Data was sourced from the IUCN (habitat range shapefiles), the Humanitarian Data Exchange (administrative boundary shapefiles), the COPERNICUS Data Store (land cover raster), the World Bank Group (state and federal highway system line feature class), and the World Pop Hub (population density). It should be noted that IUCN data varies in age due to the functions of the organization, which releases new updates and classifications for a species as appropriate, making a synchronized habitat extent estimation unrealistic. The World Bank group was additionally used for a national municipality point data shapefile, but this was not included in final analysis. As will be further discussed in the Methodology section. The data studied proved to be quite complicated to work with and difficult to fully complete the planned analysis. Because of this, final interpretation is based on qualitative considerations rather than quantitative measures.

Methodology

The intended methodology of this study led to a final product national scale habitat vulnerability index raster which would then in turn have statistical tests and analyses performed on the behavior of these index values within respective habitats. This index would be calculated simply by rescaling each input raster (distance from highway, distance from agriculture, population density) into ten discrete classes numbered 1-10 (with high values corresponding to small distance from highways/agriculture and large population density). These three inputs would then be combined using the plus tool in ArcGIS Pro, creating an output index with values ranging from 0 to 30 (index values close to 30 suggest high habitat vulnerability while values close to 0 suggest low vulnerability). Due to processing complications, this index was not calculated, though all input variables were visually inspected. In addition to the three layers and subsequent analysis described, geometric centroids were calculated. This was done to measure distance to the nearest municipality from the center of each habitat as a method of measuring proximity to human development in conjunction with a measure of road length density within each habitat (Data visualized numerically in Figure 4 and graphically in Figures 5 and 6) Despite the lack of quantitative results to study, there were key interpretations of habitat vulnerability trends among Brazilian primates visible in a qualitative inspection alone. Final conclusions were reached through exploration of the distance to highway raster and population density along with a larger scale consideration of land cover dynamics throughout the country regarding the Amazon Rainforest, urban coastal regions, and agricultural deforestation.

Results

Habitat vulnerability analysis of the nine specified primate species suggests an inversely correlated relationship between proximity to the Amazon Rainforest and anthropogenic habitat threat. The Northern and Southern Muriqui followed by the Buff Headed Marmoset Ka'apor Capuchin show the greatest vulnerability to anthropogenic disturbance, while the Grove's and Vieria's Titi show the least vulnerability. Provided maps show a concentration of highways and development on the eastern coast of Brazil with a greatest concentration on the southeast coast. Maps conversely show a lack of highways and development in proximity to the Amazon Rainforest. Tabular analysis reinforces these observations, as Figures 5 and 6 display the Northern and Southern Muriqui along with the Buff Headed Marmoset having noticeably higher densities of both highways and municipalities- at times orders of magnitude larger than other studied species. Simultaneously with the demonstrated vulnerability of the Muriqui and Tamarin species, Figures 5 and 6 display the comparative lack of vulnerability to anthropogenic disturbance of the Grove's and Vieria's Titis, which conversely show highway and municipality densities up to an order of magnitude less than other studied species.

Conclusion

In conclusion, the nine studied species of Brazilian primates are all in grave danger of habitat fragmentation, destruction, or even extinction. Threats to habitats and sources of vulnerability stem from countless sources, however this study simplifies this consideration to dynamics between a few key variables- proximity to roads, proximity to agricultural land, and surrounding population density. These three variables summarize many possible paths to habitat disruption: areas of high population density naturally expand into their surrounding area to grow and comfortably support their population, areas of high road density provide opportunity for expansionist development where there may be less inherent population density, and areas close to agricultural land exist in constant danger of disruption at the hands of agricultural deforestation. Brazilian ecosystems provide some of the most biodiverse and ecologically valuable pockets of the world, and this diversity hinges upon comfortable and safe habitats for all species. Monkeys cannot just be given any forest- they must be allowed snags to swing on, space to explore and forage, and territory to safely grow up with family. These habitats cannot be compromised, and thus our efforts in the interest of such species must not be compromised. Ecosystems cannot be forged or manufactured. They cannot be dictated as humans please so they best serve our interests. We must look to species such as the Pied Tamarin, trapped in a wholly unfamiliar setting with waning population numbers, for inspiration to give the fight we must to preserve every habitat we can.

Figures and Tables

Figure 1: Reference map for nine assessed primate species

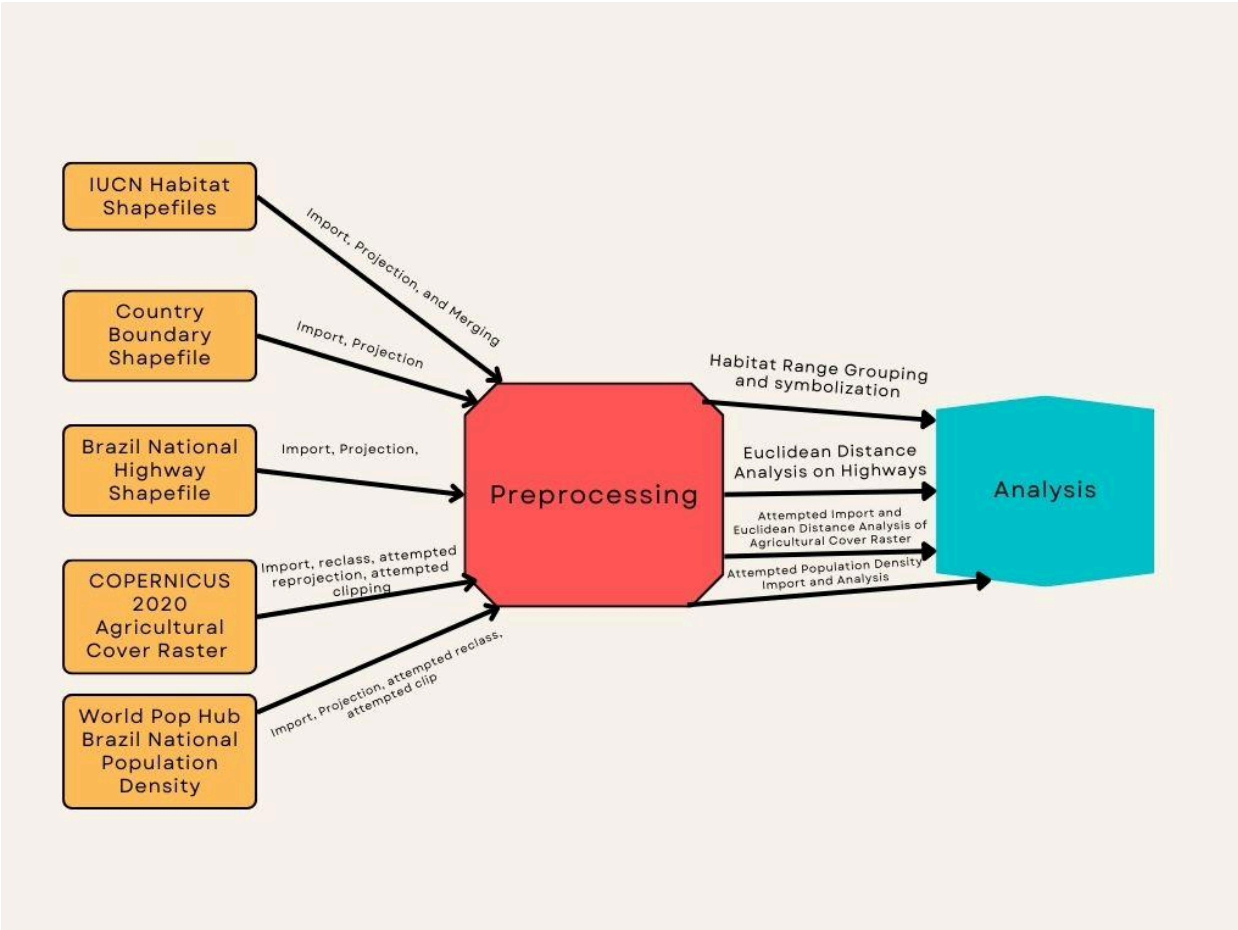

Figure 2: Methodology Flowchart

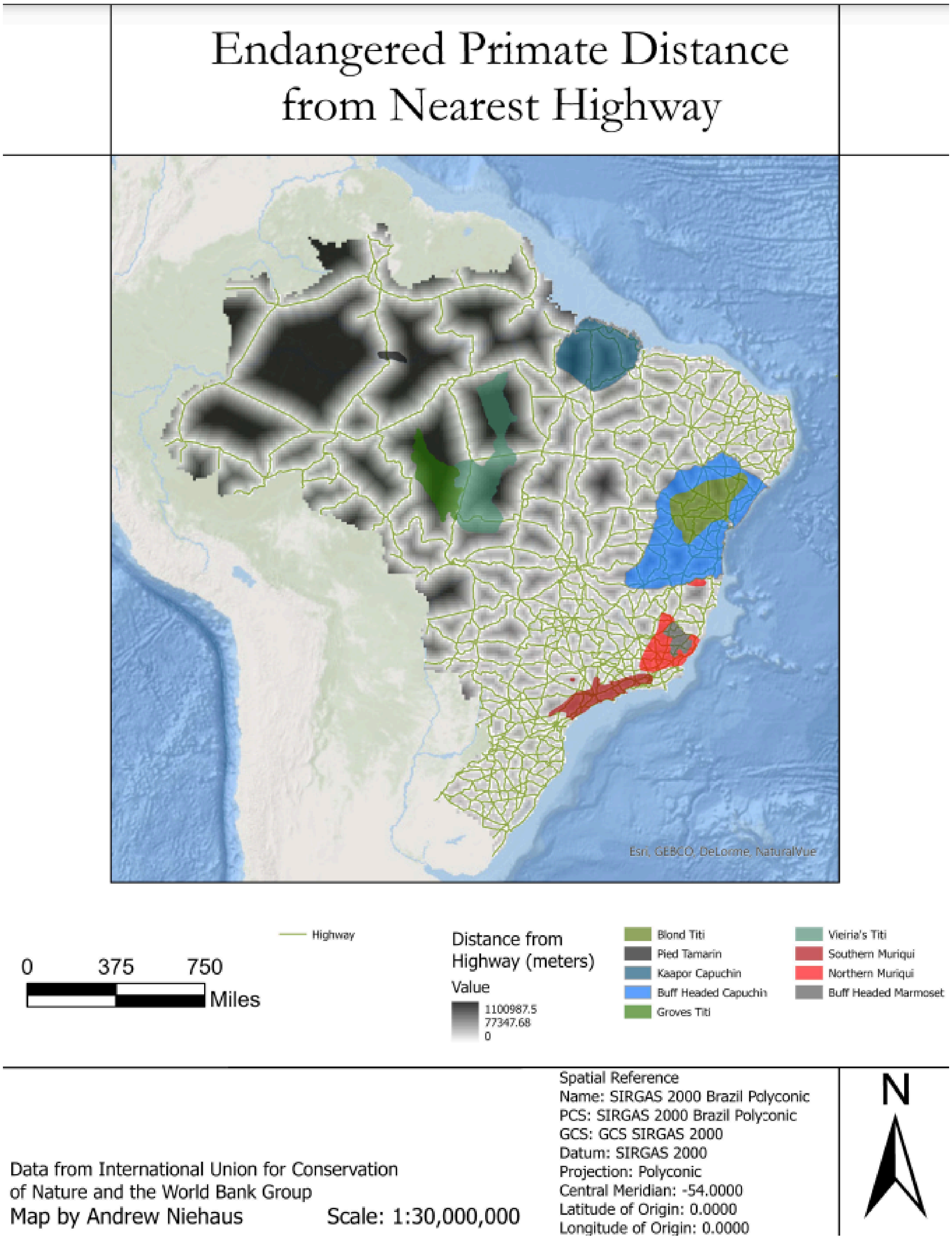

Figure 3: Distance from Federal and State Highways

	Centroid Longitude	Centroid Latitude	Area (square km)	Total Highway Length (km)	Km of Highway per square km	Locality Density (Localities per square km)
Pied Tamarin	-59.6746210	-2.9001700	10128.84	79.00	0.0078	0.001382306
Ka'apor Capuchin	-47.0905650	-2.7748530	190774.1	2223.00	0.0117	0.004895845
Buff_Headed Capuchin	-40.8730760	-12.9014430	466598.3	11074.00	0.0237	0.006581683
Grove's Titi	-57.0091360	-10.4416040	102300.5	40.00	0.0004	0.000322581
Vieiria's Titi	-53.9453670	-9.6494820	222183.6	1018.00	0.0046	0.00031955
Blond Titi	-40.2959510	-11.7298310	129701.2	3334.00	0.0257	0.008118673
Buff-Headed Marmoset	-41.4813970	-19.8737940	24732.7	996.00	0.0403	0.009623161
Southern Muriqui	-46.4297820	-23.5004120	73235.2	3537.00	0.0483	0.01134703
Northern Muriqui	-40.0952110	-16.5740430	96656.92	4378.04	0.0453	0.009632098

Figure 4: Habitat Metadata Table

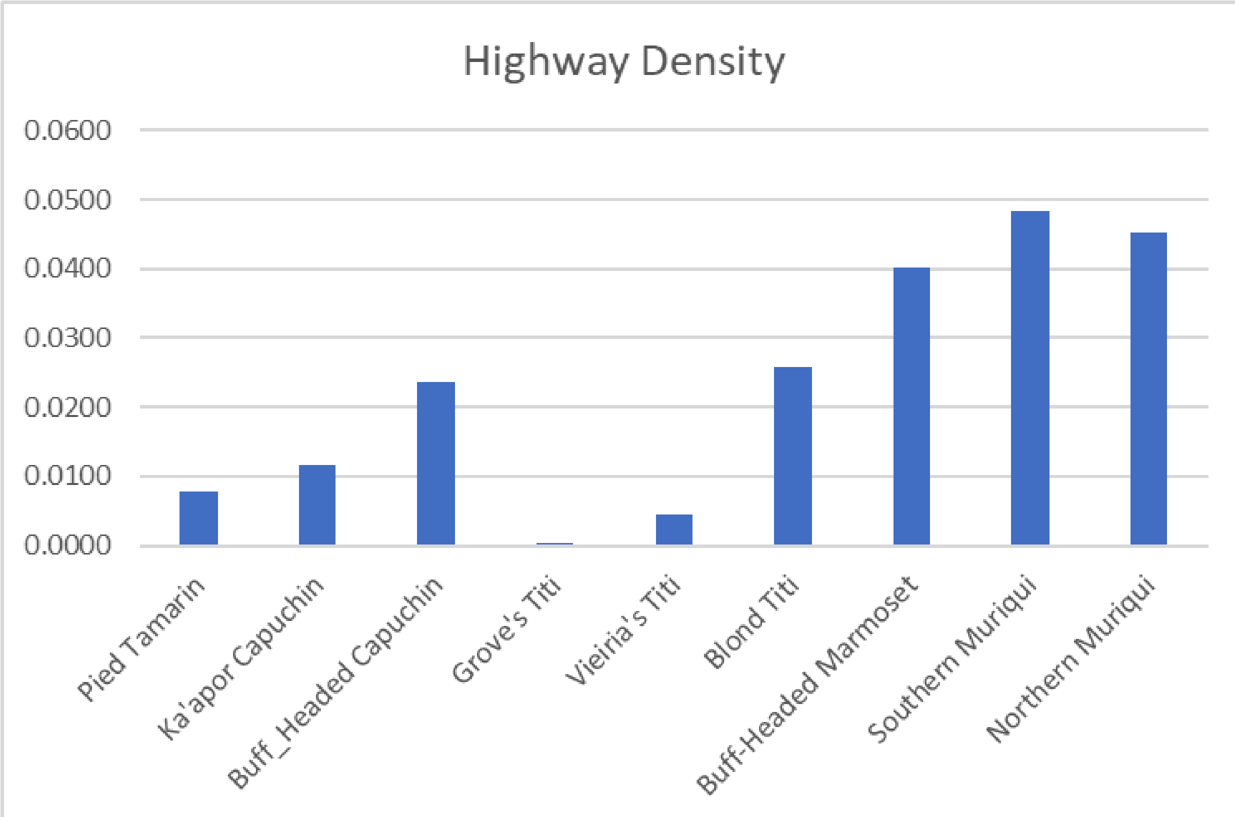

Figure 5: Highway Density Chart

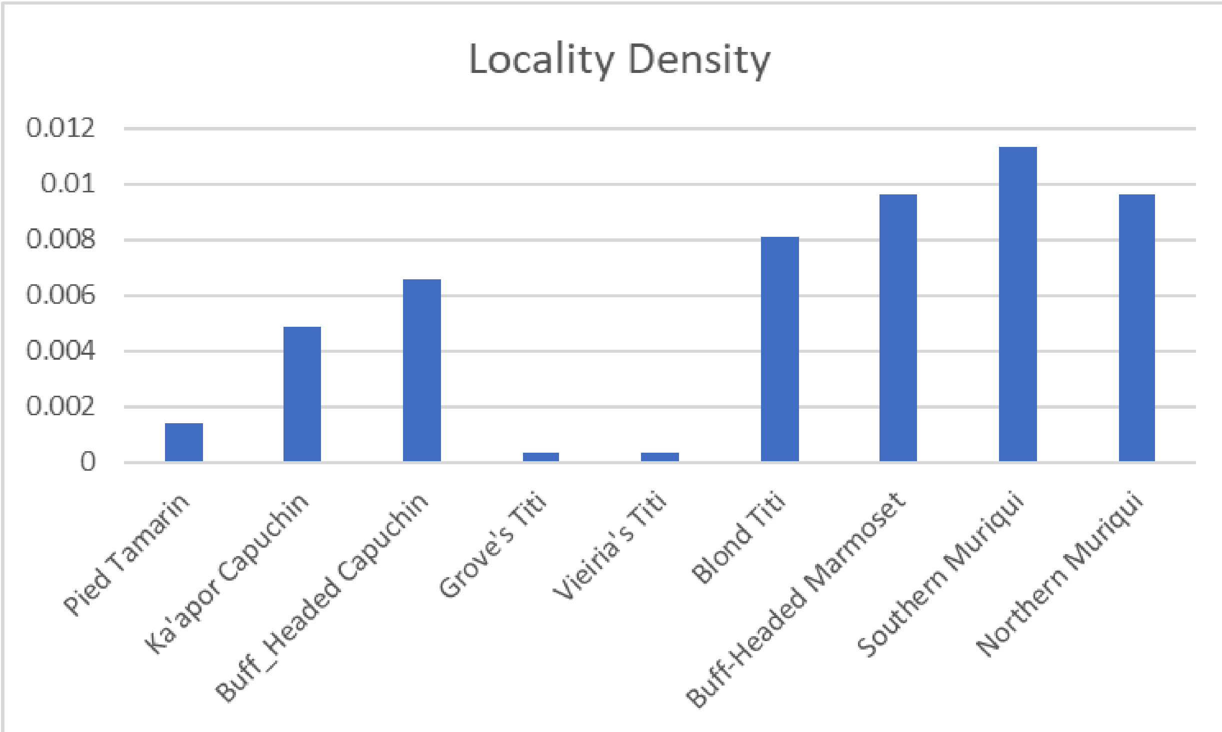

Figure 6: Locality Density Chart

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