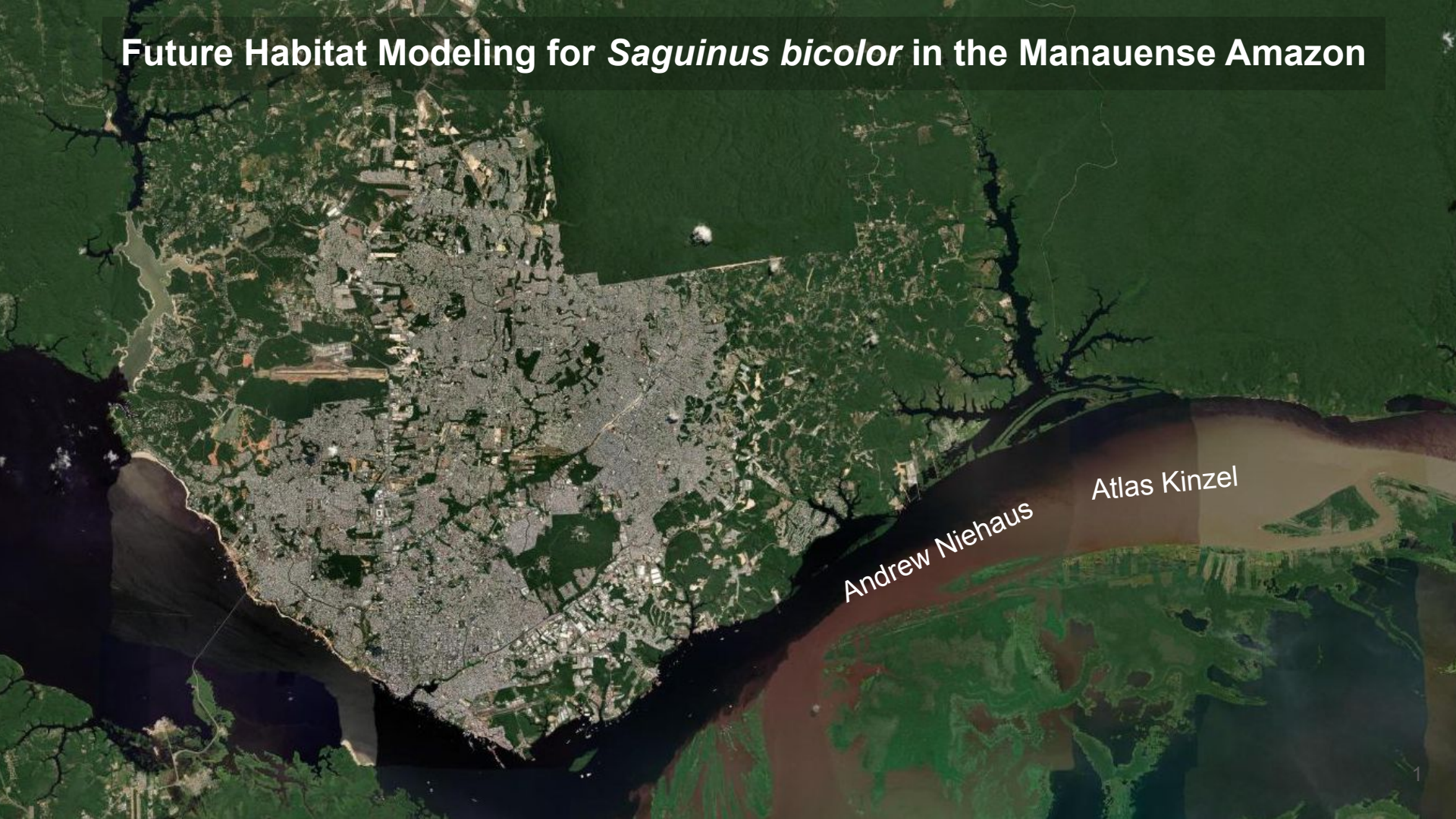
Future Habitat Modeling for *Saguinus bicolor* in the Manauense Amazon



Andrew Niehaus

Atlas Kinzel

Literature Review

- Terra Firme forests and the Northern Amazonia eco region
- Future land use and the Manaus free trade zone
- Pied Tamarin as the flagship species of the region
- Ecotourism and mining

Pied Tamarin

- Critically Endangered (IUCN)
- Range limited to 7500 km^2 area around Manaus in Northern Amazonia
- Range intersects with 7 other primate species
- Population expected to be nearly decimated in the next decade
- 20 cm body length, many natural predators

Pied Tamarin

Black Capped Capuchin

Gold-faced Saki

Guianan Red Howler

Research Question

This project aims to assess the threat of habitat destruction via deforestation to the habitat of the Pied Tamarin in addition to exploring the Habitat and Biodiversity Modeler in Terrset. Our analysis considered habitat in the context of three driver variables: elevation, biomass, and evapotranspiration.

Pied Tamarin

Saguinus bicolor

Taxonomic Notes

Hershkovitz (1977) considered *Saguinus bicolor* to have three subspecies: the nominate, *S. b. ochraceus* and *S. b. martinsi*. Groves (2001, 2005) and Rylands *et al.* (1993, 2000) listed the forms *ochraceus* and *martinsi* as subspecies of *S. martinsi*.

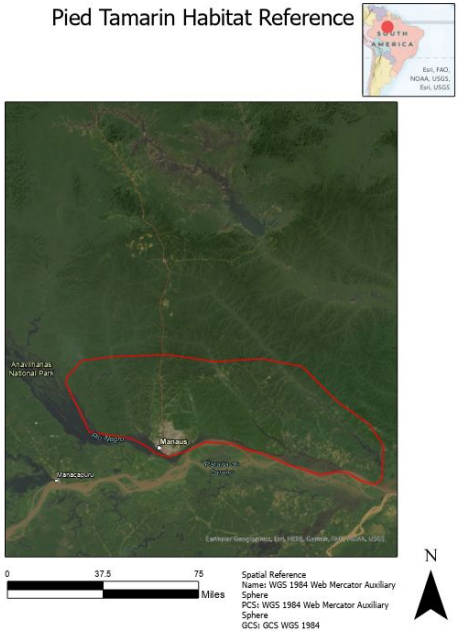
Justification

Saguinus bicolor is considered Critically Endangered due to a projected population reduction of 80% or more in the next 18 years (three generations) due to serious multiple threats suffered within a very concentrated range in and around the city of Manaus: deforestation and habitat fragmentation related to expanding rural settlements and agriculture, livestock production, urban development, an expanding energy matrix and road network, routine collection for the pet trade, competition with the Golden-handed Tamarin (*Saguinus midas*), and high mortality due to predation by dogs and cats, disease, and electrocution on transmission lines.

Geographic Range Information

Saguinus bicolor occurs north of the Rio Amazonas, east of the Rio Negro, in the vicinity of Manaus, the capital of the Amazonas State, Brazil. Surveys by Ayres *et al.* (1980, 1982) reported that its range extended only 30-45 km to the North of Manaus and to the East as far as the town of Itacoatiara, approximately 100 km from the capital. Localities beyond these points indicate only the presence of *S. midas*. Ayres *et al.* (1980, 1982) and Hershkovitz (1966) suggested that it might occur to the Rio Jauaperi, a left bank tributary of the Rio Negro. However, Subirá (1998a, b) considered this to be unlikely. Subirá (1998b) found *Saguinus bicolor* only as far as 35 km from Manaus on the BR174 highway. North of the highway, she found only *S. midas*.

In a more recent study, Subirá (1998b) and Röhe (2006) found *Saguinus midas* much closer to Manaus City and restricted to the West of the Urubu River. Röhe (2006) estimated *S. bicolor*'s distribution in an area of 5,540 km², limited by the Cuieiras River in the West, Urubu River in the East, the Negro and Amazonas Rivers in the South and its contact with *S. midas* in the North. The same study (Röhe *et al.* unpl. data) shows a deforestation rate around 200 km²/year additional to the loss to *Saguinus midas*, which amounts to 55 km²/year. In the next 18 years the species will lose around 83% of its current distribution.



Introducing the Study Area

Notable Regional Features

City of Manaus

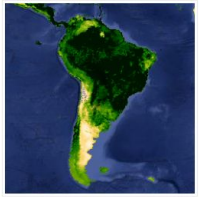
Amazon River

Balbina Dam

Data Sources

- MapBiomas and Google Earth Engine landcover mosaics
  - Eight Brazilian regions in Amazonia (near Manaus)
- IUCN species range shapefile (vector)
- DEM (SRTM)
- WCMC Biomass
- MODIS Terra Net Evapotranspiration

MOD16A2.006: Terra Net Evapotranspiration 8-Day Global 500m



Dataset Availability

2001-01-01T00:00:00Z–2022-11-09T00:00:00

Dataset Provider

NASA LP DAAC at the USGS EROS Center

Earth Engine Snippet

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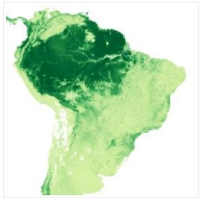
Tags

8-day evapotranspiration global mod16a2 modis nasa

WCMC Above and Below Ground Biomass Carbon Density



Dataset Availability

2010-01-01T00:00:00Z–2010-12-31T00:00:00

Dataset Provider

UNEP-WCMC (UN Environment Programme World Conservation Monitoring Centre)

Earth Engine Snippet

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```

Tags

SRTM Digital Elevation Data Version 4

Dataset Availability

2000-02-11T00:00:00Z–2000-02-22T00:00:00

Dataset Provider

NASA/CGIAR

Earth Engine Snippet

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Tags

dem elevation geophysical srtm topography cgiar

Preprocessing

- MapBiomas data was downloaded by target region (8 total), imported to Terrset, mosaicked into one image, and reclassified into a broad selection of land covers (forest, agriculture, built, and water)
- IUCN shapefile was converted into a TIFF and imported into Terrset
- Google Earth Engine sources were downloaded, converted to raster+imported to Terrset, and windowed to MapBiomas data dimensions

```
var image_clip = image.clip(geometry);
Map.addLayer(image_clip, {}, 'image_clip');

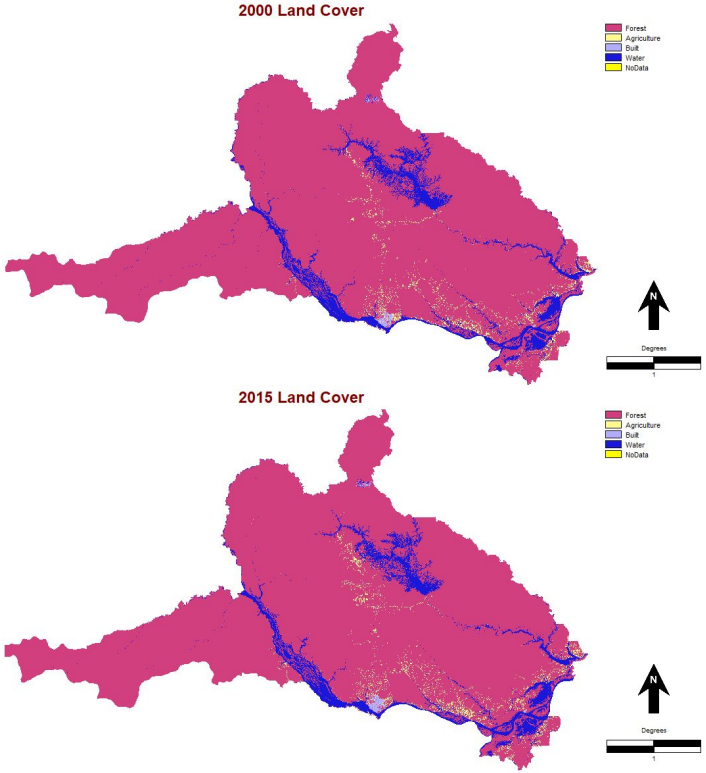
Export.image.toDrive({
  image: image_clip,
  description: 'Biomass',
  region: geometry,
  folder: 'earthengine',
  scale: 300,
  maxPixels:1e12,
})
```

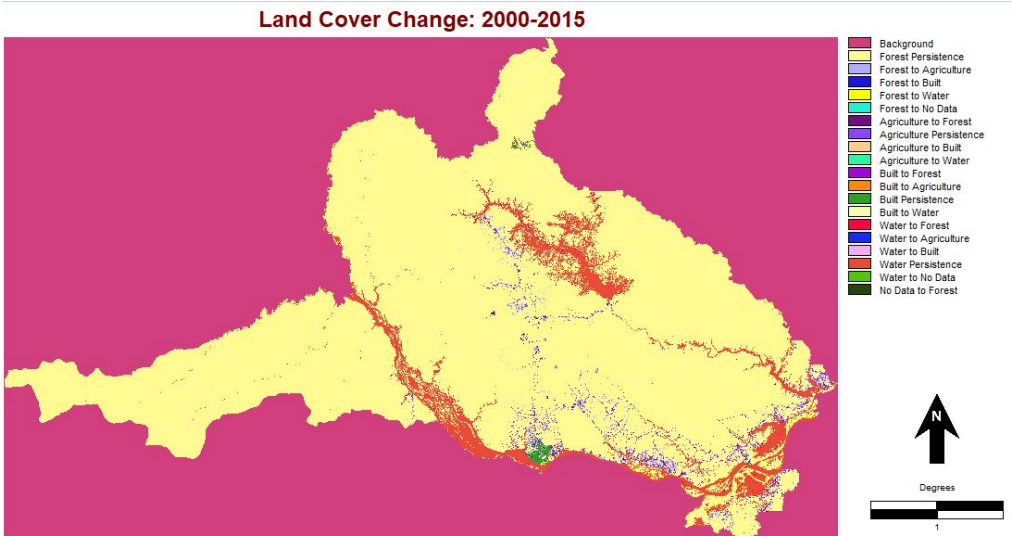
Classification

1. Forest (combination forest/non forest natural)
2. Agriculture (pasture/agriculture)
3. Built (mining/urban)
4. Water (river)
5. Other (unclassified, kept for continuity of the extent but ignored)

COLEÇÃO 4 - PORTUGUÊS	COLLECTION 4 - ENGLISH	NEW ID
1. Floresta	**1. Forest**	1
1.1. Floresta Natural	1.1. Natural Forest	2
1.1.1. Formação Florestal	1.1.1. Forest Formation	3
1.1.2. Formação Savanica	1.1.2. Savanna Formation	4
1.1.3. Mangue	1.1.3. Mangrove	5
1.2. Floresta Plantada	1.2. Forest Plantation	9
2. Formação Natural não Florestal	**2. Non Forest Natural Formation**	10
2.1. Área Úmida Natural não Florestal	2.1. Wetland	11
2.2. Formação Campestre	2.2. Grassland	12
2.3. Apicum	2.3. Salt flat	32
2.4. Afloramento Rochoso	2.4. Rocky outcrop	29
2.5. Outra Formação Natural não Florestal	2.5. Other non forest natural formation	13
3. Agropecuária	**3. Farming**	14
3.1. Pastagem	3.1. Pasture	15
3.2. Agricultura	3.2. Agriculture	18
3.2.1. Cultura Anual e Perene	3.2.1. Annual and Perennial Crop	19
3.2.2. Cultura Semi-Perene	3.2.2. Semi-perennial Crop	20
3.3. Mosaico de Agricultura e Pastagem	3.3. Mosaic of Agriculture and Pasture	21
4. Área não vegetada	**4. Non vegetated area**	22
4.1. Praia e Duna	4.1. Beach and Dune	23
4.2. Infraestrutura Urbana	4.2. Urban Infrastructure	24
4.3. Mineração	4.3. Mining	30
4.4. Outra Área não Vegetada	4.4. Other non vegetated area	25
5. Corpos D'água	**5. Water**	26
5.1 Rio, Lago e Oceano	5.1. River, Lake and Ocean	33
5.2 Aquicultura	5.2. Aquaculture	31
6. Não observado	6. Non Observed	27

Introductory Analysis



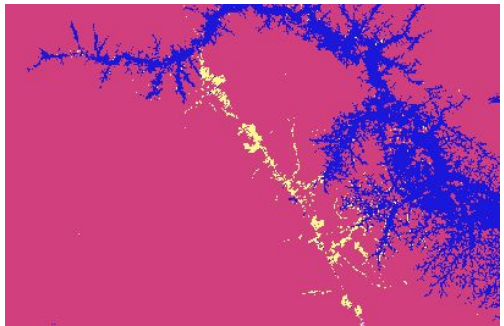


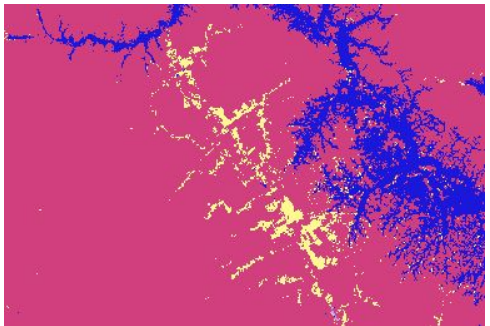
Category	Background	Forest	Agricultu re	Built	Water	No Data	Total
Backgound	204051896	0	0	0	0	0	204051896
Forest	0	108745956	940706	34946	236200	3	109957811
Agriculture	0	741238	929115	32443	3199	0	1705995
Built	0	366	147	274504	3211	0	278228
Water	0	635668	11391	8353	8393648	1	9049061
No Data	0	1	0	0	0	0	1
Total	204051896	110123229	1881359	350246	8636258	4	325042992

Introductory Analysis Discussed

Simple land cover change analysis shows an approximately 10% increase in agricultural area from 2000 to 2015.

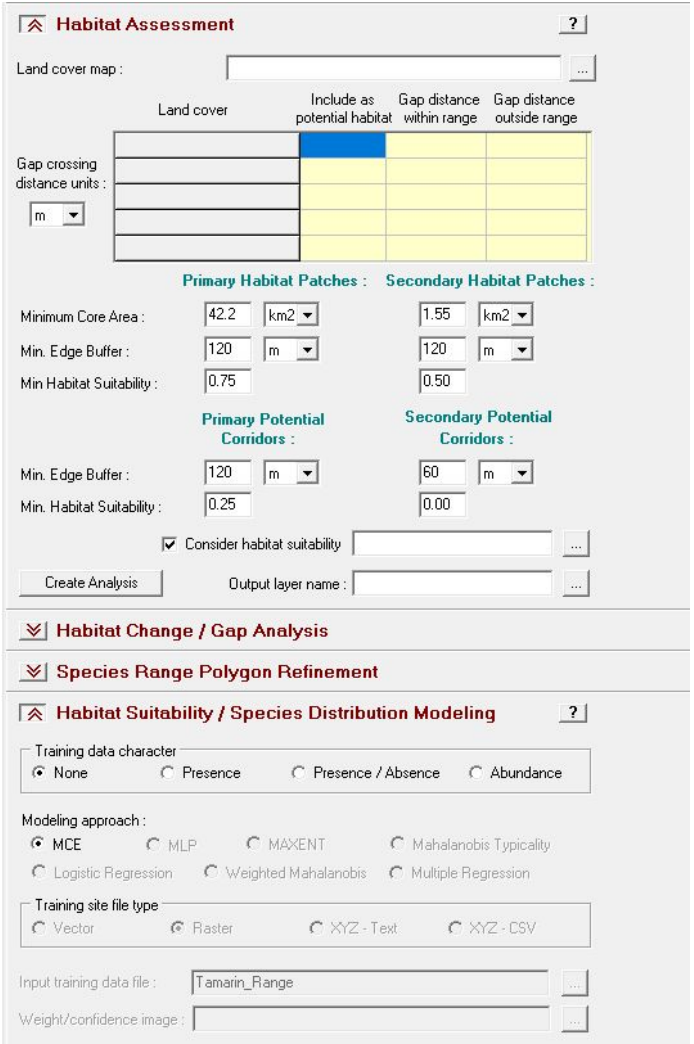
Transition to agriculture appears to be most concentrated just below the Balbina Dam, which shows to be a node of land change through changing water levels and agricultural development.



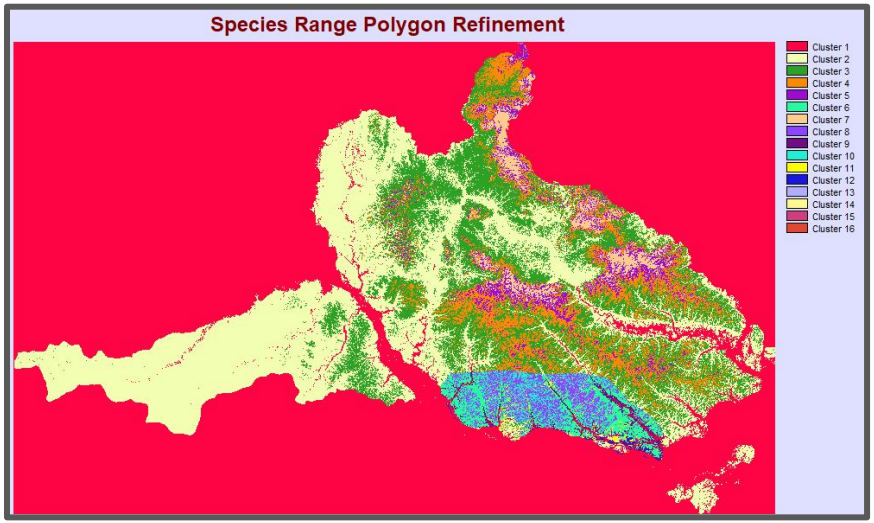


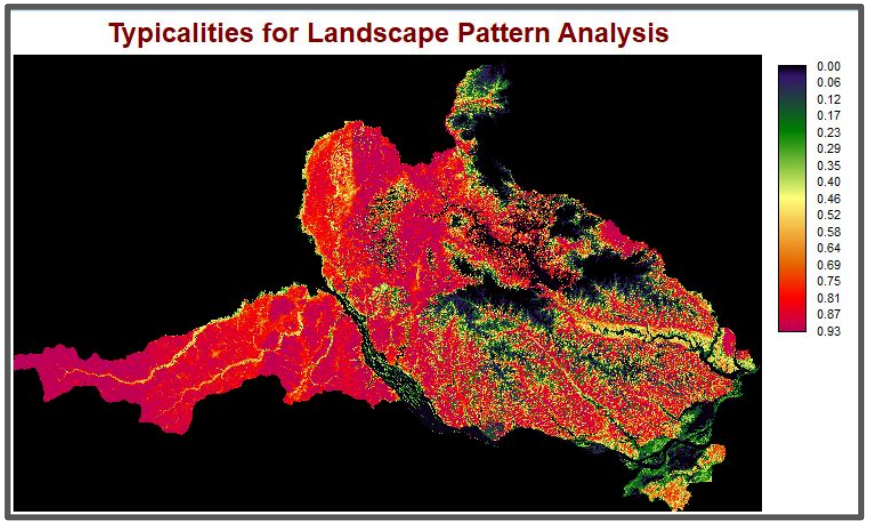
Habitat and Biodiversity Modeler

A primary focus of this project was to explore functions of the Habitat and Biodiversity Modeler in Terrset in the lens of the Pied Tamarin species habitat. The module proved quite laborious to maneuver, and we did not make any revealing conclusions. In our attempted work, we focused primarily on the habitat suitability modeling and landscape pattern analysis. The next slide displays a few outputs we found which we were not sure how to interpret, but found interesting.



HBM Figures


Species Range Polygon Refinement
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6
Cluster 7
Cluster 8
Cluster 9
Cluster 10
Cluster 11
Cluster 12
Cluster 13
Cluster 14
Cluster 15
Cluster 16


Typicalities for Landscape Pattern Analysis
0.00
0.06
0.12
0.17
0.23
0.29
0.35
0.40
0.46
0.52
0.58
0.64
0.69
0.75
0.81
0.87
0.93

Conclusion

- While the Pied Tamarin’s range is somewhat restricted by ecological predictors, there are clearly areas that the primate should be able to thrive in and that are geographically within reach.
- Increase in agriculture, overall gain in forest, but losses in water, and the classification of land covers confuse this relationship
- Habitat Modeling is a complex analysis that relies on a large amount of preprocessing and the existence of various data related to a specific ecological region and/or species.

References

Egler, S. G. (1992). Feeding Ecology of Saguinus bicolor bicolor (Callitrichidae: Primates) in a Relict Forest in Manaus, Brazilian Amazonia. *Folia Primatologica*, *59*(2), 61–76. https://doi.org/10.1159/000156644

Hilário, R. R., Silvestre, S. M., Abreu, F., Beltrão-Mendes, R., de Castro, C. S. S., Chagas, R. R. D., De la Fuente, M. F., Duarte, M. H. L., Ferrari, S. F., Passamani, M., Schiel, N., Souto, A., Young, R. J., & Souza-Alves, J. P. (2022). Temperature and exudativory as drivers of the marmoset (*Callithrix* spp.) daily activity period. *American Journal of Primatology*, *84*(6). https://doi.org/10.1002/ajp.23341

Márcio Ayres, J., Mittermeier, R. A., & Constable, I. D. (1982). Brazilian Tamarins on the Way to Extinction? *Oryx*, *16*(4), 329–333. https://doi.org/10.1017/S0030605300017786

Marsh, L. K., & Chapman, C. A. (Eds.). (2013). *Primates in Fragments: Complexity and Resilience*. Springer New York. https://doi.org/10.1007/978-1-4614-8839-2

Vidal, M. D., & Cintra, R. (2006). Effects of forest structure components on the occurence, group size and density of groups of bare-face tamarin (Saguinus bicolor - primates: Callitrichinae) in Central Amazonia. *Acta Amazonica*, *36*(2), 237–248. https://doi.org/10.1590/S0044-59672006000200014

Vidal, M. D., Gordo, M., Jerusalinsky, L., Boubli, J. P., Röhe, F., Institute (ICMBio)), R. S. (Chico M., & International), R. A. M. (Conservation. (2015). IUCN Red List of Threatened Species: Saguinus bicolor. *IUCN Red List of Threatened Species*. https://www.iucnredlist.org/en