Norwegian University
of Life Sciences

Distribution and habitat change of the critically endangered Kaapori capuchin (*Cebus kaapori)*

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Preface

This thesis is the final part of my two-year master's degree in Urban Agriculture at the faculty of Biosciences, under the Norwegian University of Life Sciences (NMBU).

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Abstract

The Kaapori Capuchin (*Cebus kaapori)* is endemic to the eastern Brazilian Amazon and is considered one of the world's most threatened primates. As the Amazon is shrinking due to human activities and climate change the habitat of the Kaapori is gradually disappearing and- the Kaapori is more vulnerable than ever. By analyzing published, unpublished, and field data I explore the distribution of the Kaapori and how their habitat has changed from the year they were observed until 2022 within an estimated home range. The results show that most of the observations of the Kaapori are within the IUCN distribution, but there are some notable observations outside of this distribution. Observations within the Xingu endemic area and on Marajó island-, suggest that the distribution suggested by the IUCN does not span the full actual distribution of the Kaapori. The calculated home ranges show only small changes in the composition and coverage of the habitat, with the majority still having some forest cover. Even if there still is forest cover in the home ranges of the Kaapori, we do not know the condition of the forest and if it is highly disturbed it may spell the end of the Kaapori capuchin.

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1 Introduction

The Amazon rainforest is considered one of Earths greatest biological treasures, hosting a quarter of the world's terrestrial species and accounting for 15% of global terrestrial photosynthesis (Malhi et al., 2008). The Amazon biome covers 5.4 million km^2 and the forest plays a crucial role in the global atmospheric circulation with its high contribution of evaporation (Malhi et al., 2008). Despite its immense importance, the Amazon is shrinking at an alarming rate. Major threats faced by the Amazon include deforestation and climate change (Pacheco & Meyer, 2022).

The current accumulated deforestation in the Brazilian Amazon stands at about 25% of its total area, with the most significant losses concentrated in the southern and eastern regions due to urban expansion, agriculture, and livestock farming (da Silva et al., 2022; Vieira et al., 2008). This deforestation driven by international demand for tropical timber, beef, and biofuels, poses a grave threat towards the region's biodiversity and ecosystem functionality (Malhi et al., 2008).

Deforestation leads to habitat degradation, fragmentation, and loss of biodiversity (Almeida-Rocha et al., 2017; Paiva et al., 2020). The creation of forest edges exacerbates these effects by creating edge effects that alter ecological dynamics and species distribution (Lenz et al., 2014). These edge effects are typically caused by activities such as ranching, farming, logging, and road construction (Lenz et al., 2014).

Climate change compounds these challenges, further imperiling species with its potential to alter vegetation patterns and precipitation regimes (Bellard et al., 2012). These double threats threatens species living in the Amazon, especially those with a low dispersal capacity (Paiva et al., 2020). Models predict a large-scale substitution of the Amazon Forest by savanna-like vegetation by the end of the twenty-first century, threatening endemic species in particular (Nepstad et al., 2008; Ribeiro et al., 2016).

Increases in greenhouse gas emissions has contributed to the increase in global temperatures and causes increasing pressure on species to adapt *in situ* or shift their distributions (Peters et al., 2013; Virkkala et al., 2004). Human activities, including deforestation and land use, interact with climate change to change environmental degradation in the Amazon (Malhi et al., 2008). Thinning forests and increased susceptibility to fire exacerbate the impacts of droughts, leading to extensive forest degradation and loss of forest cover (Nepstad et al., 2008). As burning continues to contribute to the deforestation, the added climatic changes of the region increase

the risk of droughts and flooding,- and signal a potentially drier and hotter biome (Paiva et al., 2020)

Intensive deforestation and projected climate change will severely impact the biodiversity in the Amazon, and forest-dependent species are particularly vulnerable (Paiva et al., 2020; Ribeiro et al., 2016). Many mammal species are especially at risk, and species such as primates are expected to suffer severe population declines within their natural distribution (Miles et al., 2004). Potential impacts of climate change on the natural distribution of species in the Amazon suggest that 43% of species may go extinct by 2095 due to climatic changes (Miles et al., 2004). Even slight anomalies in rainfall and temperature could expose a large percentage of species to adverse conditions. By 2070, an average of 85% of mammals may experience exposure to deforestation and climate change in more than 80% of their ranges, highlighting the vulnerability of endemic species of the region (Ribeiro et al., 2016).

As deforestation and climate changes continue to reduce taxonomic and functional diversity, forest ecosystems could collapse before reaching full deforestation (Paiva et al., 2020). Under changing conditions species must either adapt, move towards preferred environments, or suffer population declines and possible local extinction (Urban, 2015). Among the species that suffer from these threats are primates. Primates play a particularly important role in maintaining ecosystem stability and biodiversity (Paglia et al., 2012). With over 500 species distributed across the world, primates contribute to forest regeneration, aid seed dispersal, and influence the overall health and resilience of tropical ecosystems (Estrada et al., 2017; Paglia et al., 2012).

Currently, nearly 70% of primate species are threatened and are facing an imminent extinction crisis due to anthropogenic pressures such as habitat loss, illegal trade, and hunting(Estrada et al., 2017; Torres-Romero et al., 2023). These threats often act synergistically, exacerbating the already high population declines (Estrada et al., 2017). In 2017, 82% of threatened primate species were showing population declines, especially in areas with human-induced habitat disturbance (Estrada et al., 2017). Human-induced disturbances such as mining, development of tree plantations, cattle pastures and forest conversion to annual crops has severely impacted primate populations and communities (Almeida-Rocha et al., 2017). The predicted expansion of agriculture in the coming century is particularly concerning, as it overlaps with over two thirds of the global primate area, leading to further habitat loss and fragmentation (Estrada et al., 2017). This overlap could lead to a significant range contraction and puts primates at increased risk of infection from human and domesticated animal pathogens, through activities such as hunting, pet trade, ecotourism, and research activities (Estrada et al., 2017). Retaining

connectivity across remnants of undisturbed forest within human-modified landscapes is crucial for the conservation of primate populations, as rapid habitat degradation alters species' population viability and occupancy patterns in tropical forests (Almeida-Rocha et al., 2017). Furthermore, edge effects significantly influence primate distribution, even after decades of regeneration and the impacts on primate communities have great implications for conservation efforts and the maintenance of biodiversity, especially in fragmented forest habitats (Lenz et al., 2014).

The Amazon biome harbors one of the highest primate diversities globally, with species adapted to a wide range of habitats, ranging from lowland rainforests to high-altitude cloud forests (O. de Carvalho Jr, 2003; Paglia et al., 2012). The region hosts over 150 species of primates, with the Brazilian Amazon being particularly critical for conservation efforts due to its high species richness and endemism (Paiva et al., 2020; Rylands et al., 2012). Of the 92 primate species found in the Brazilian Amazon, 87 are endemic to the region (Paiva et al., 2020). Primates are highly sensitive to habitat loss and modification, since they are essentially arboreal (Ferrari & Lopes, 1996; Hershkovitz, 1977). In the Neotropics agricultural expansion, habitat loss and human-induced disturbances are among the biggest threats to primates. Agricultural activities, including livestock farming and crop cultivation, pose major challenges to primate conservation, with 59% of primate species in the Neotropics negatively affected by livestock farming alone (Estrada et al., 2017).

One of the species suffering from habitat loss in the Amazon is the Kaapori capuchin (*Cebus kaapori*), a species endemic to the eastern Amazon and restricted to the states of Pará and Maranhão (Queiroz, 1992). They usually occur in groups of 1-7 individuals but have been observed in groups up to 10 individuals (O. Carvalho et al., 1999) . They can also be found in groups with other species such as *Chiropotes stanas* and the *Sapajus apella* (de Oliveira et al., 2014; Ferrari & Lopes, 1996; personal observation, 2023). The Kaapori has one of the smallest geographical distributions of its genus and this distribution coincides with the region with the longest history of human occupation (Fialho et al., 2021). This region therefore has the highest level of habitat degradation and deforestation in Amazonia, with more than 70% of the forest already destroyed or converted to farmland (Almeida & Vieira, 2010; da Silva et al., 2022; O. de Carvalho Jr, 2003). Due to climate change and deforestation, a species distribution model predicts that the Kaapori capuchin could lose all its remaining habitat over the next 30 years (da Silva et al., 2022) .

The Kaapori Capuchin was first described by Queiroz (1992). It was discovered during field work among the Ka'por indigenous people in the Marahão region of Brazil (Queiroz, 1992). The first specimen was observed after being hunted by the community and its skin and skull was preserved as a paratype (Queiroz, 1992). The discovery of this new species was significant as it was previously considered to be outside the range of the untufted capuchins (Queiroz, 1992). The Kaapori is distinguished by its longer body and less robust appearance compared to other capuchins, with external and cranial measurements further distinguishing the Kaapori as an untufted capuchin (Masterson, 1995).

Understanding the taxonomy of the capuchin monkeys is crucial for comprehending the classification of the Kaapori capuchin. The taxonomic structure of the capuchin monkeys is complex and ever-changing. For a while, all capuchins were included in the genus *Cebus*, but in 2012 it was proposed to split the genus between tufted/robust (*Sapajus)* and untufted/gracile (*Cebus)* (Lynch Alfaro et al., 2012). Within the genus *Cebus*, the taxonomic history presents many controversies and the location of the Kaapori within the phylogenetic tree is still debated. Until 2001 the Kaapori was classified as a subspecies of the *Cebus olivaceus*, but current taxonomic classification considers the Kaapori a distinct species (Groves, 2001; Lynch Alfaro et al., 2014).

Just two years after its discovery the Kaapori capuchin was classified as an endangered species (Ferrari & Queiroz, 1994). This designation persists, with the IUCN listing it as a critically endangered species, with a declining population (Fialho et al., 2021). In 2016, it was included in the IUCN list over the most endangered primates of the world, further underlining the critical condition of the Kaapori Capuchin (Schwitzer et al., 2016). It is believed that the Kaapori are not tolerant to habitat change (Fialho et al., 2021). Already in 1994, habitat degradation as a result of illegal gold prospecting, ranching activities and invasive and indigenous hunting, were highlighted as the main threats to the Kaapori, and these threats still persist today (Ferrari & Queiroz, 1994). With current rates of deforestation and climate change projections, the predicted loss of habitat for the Kaapori is 100% of its current known range by 2050 (Paiva et al., 2020). Studies on the abundance of the Kaapori in the Gurupi Biological Reserve and the Fazenda Cauxi in Paragominas found results that suggest that the Kaapori is naturally rare (Lopes, 1993). Lopes (1993) suggests that because of its natural rarity and hunting pressure it is susceptible to all disturbance and degradation of its habitat, and even selective logging can pose a considerable threat .

Despite its status as critically endangered few studies have focused on Kaapori capuchin ecology. One study used scan sampling to analyze the behavior of nine Kaapori capuchins during the dry season and it showed that the Kaapori are highly frugivorous (de Oliveira et al., 2014). The study involved a comparison of plants consumed by other *Cebus* and *Sapajus* species, revealing a significant dietary overlap with robust capuchins (de Oliveira et al., 2014). The Kaapori is not restricted to primary habitats and displays habitat variety, utilizing various forest types, including terra firme forest, secondary forest, and flooded areas dominated by acai palms (de Oliveira et al., 2014). Records from areas close to the coast in Pará state suggest that the Kaapori also uses stretches of mangroves and estuarine floodplain (Fialho et al., 2021). They usually utilize the top of the trees, with records of feeding 6 to 20 meters above ground (de Oliveira et al., 2014). Recent camera-trap observations from the Hydro Paragominas bauxite mine area showed Kaaporis visiting the ground, suggesting that they might also utilize the forest floor (Wiig et al., 2023) .

Due to a lack of studies focusing on the Kaapori, there still a lack of knowledge of its biology, behavior, and ecology. Which makes it difficult to develop effective conservation strategies. With this thesis, I aim to fill some of these gaps by exploring the Kaapori capuchin distribution. It is speculated that the distribution was larger before the age of deforestation, but it is unknown whether all the Kaapori have disappeared from their presumed historical range. The distribution suggested by the IUCN with an endemic center in Belém center of endemism is limited, and with this thesis I aim to test this by compiling and mapping all known Kaapori capuchin observations.

Additionally, I explore how the Kaapori's habitat has changed over time, particularly as a result of deforestation and climate change, through a comprehensive review of existing literature and field work conducted in a large forest fragment in the Paragominas municipality, Pará. A better understanding of its distribution and habitat will facilitate more targeted and effective conservation efforts. By pinpointing where they occur and the status of the Kaapori habitat, we can develop conservation strategies that are both informed and impactful.

2 Methods

2.1 Study area

The fieldwork for this study was conducted in the Rio Capim Complex in the municipality of Paragominas, in the state of Pará (Figure 1). The area is considered an area of continuous forest and is one of the largest remnants of primary forest in northeastern Pará (Carbon Footprint, n.d.). The area consists of 119,927 hectares of legal reserve, 14,050 hectares of forest plantation and 474 hectares of infrastructure (Figure 1). The area is owned by the Cikel Brasil-Verde Group and made up of CBNS Company farms owned by the Kellia Group (da Silva Ferreira, 2023). The Rio Capim area has had managed logging since 2000 and in 2001 it was certified by the Forest Stewardship Council (FSC). The FSC only certifies logging that does not significantly affect the ecosystem in all the stages of the production chain (FSC, 2024).
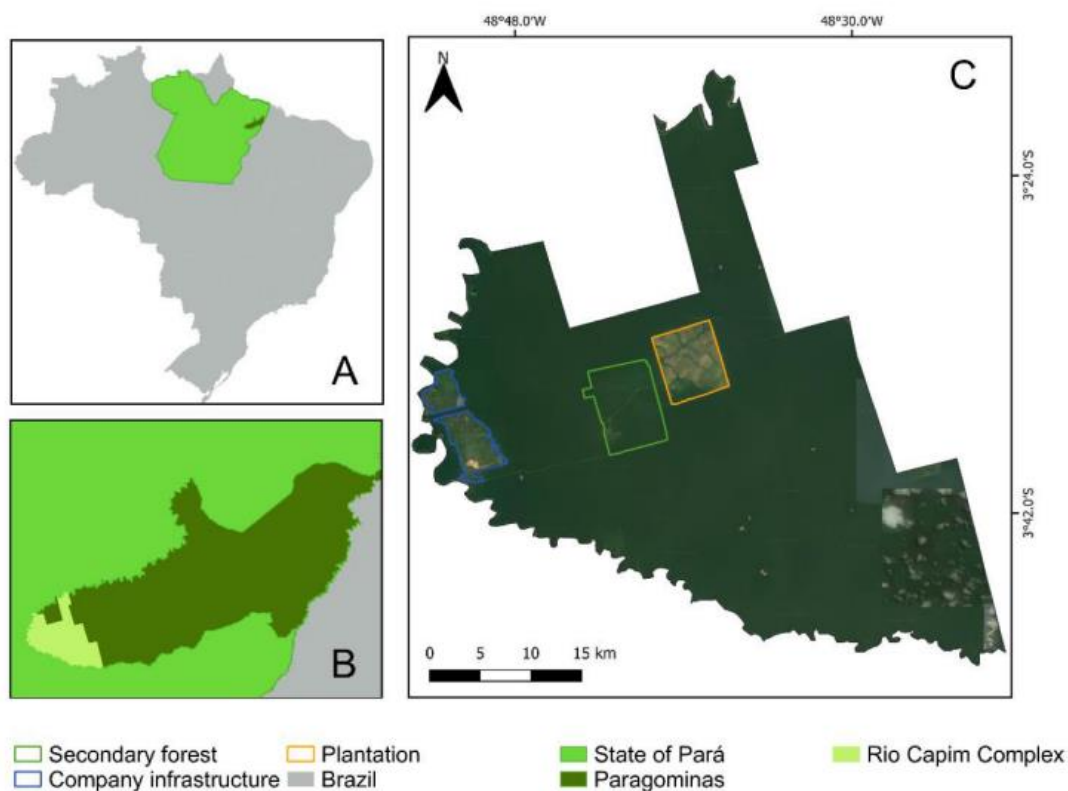
Figure 1: Map of the study area. (A) Map of Brazil picturing Pará. (B) Map of the municipality of Paragominas showing Rio Capim Complex (light green). (C) Satellite image of Rio Capim Complex. The dark green shows the cover of Ombrophylous Forest and the light green contour an area of secondary forest. The blue contour shows company infrastructure for processing harvested wood and the orange contour shows a plantation area. (Map provided by the Kellia Group)

The total logging concession (UMF) is divided into smaller sections called Annual Production Units (UPAs). The UPAs range in size from 2000 to 5000 hectares and have a cutting cycle of 35 years to ensure regeneration of the forest (Prudente et al., 2017). Each year, Fazenda Rio Capim explore 5000 hectares of forest, the UPAs are mapped before the logging is carried out and a Sustainable Forest Management Plan and Annual Operational Plan (POA) are created (da Silva Ferreira, 2023). These plans contain detailed descriptions of the activities that will be carried out that year, such as risk management, directional cutting, roads, and storage. In each UPA, two to five trees are harvested per hectare and these plans include a description of each tree that will be explored within each UPA. To minimize damage to the forest floor the logging is done during the dry season (da Silva Ferreira, 2023).

The native vegetation in the area is mainly dense Ombrophylous Forest, characterized by a continuous canopy between 25 and 30 meters high (Prudente et al., 2017). The climate is classified as Humid Tropical based on the Koppen classification with an annual temperature of 26.3°C and an annual relative humidity of 81% (Prudente et al., 2017). The annual average rainfall is 1800 mm/year, and the driest period is between July and October (Prudente et al., 2017).

2.2 Data collection

The data used in this thesis is a combination of published data, unpublished data, and field data collected at Rio Capim from October to November in 2023.

Published data utilized here was compiled by Gomes (2018), creating an online database of known Kaapori observations from published articles, reports, theses, dissertations, and museum collections. Any observations within the same square kilometer were considered as one occurrence (Gomes, 2018).

The unpublished data were observations of the Kaapori obtained from other projects that did not aim to collect data on the Kaapori. For example, during an ongoing camera-trap study at the Hydro Paragominas bauxite mine area there have been observations of the Kaapori capuchin (Wiig et al., 2023). Other observations have been made during an ongoing project at Agropalma, an Oil Palm plantation in Paragominas, Pará.

 The fieldwork for this study was part of a larger study on primate assemblage structure and composition at the Rio Capim Complex in Paragominas. During this study, all primates in the logging concession, including Kaapori capuchin, were surveyed using standardized transect

methods as described by Peres (1999). Each transect was walked once in the morning, and after a break at the end of the transect the same transect was surveyed in the afternoon (Peres, 1999).

Six 5km transects were sampled and these were located throughout the Rio Capim logging concession (Figure 2), where four transects (1, 2, 3, and 6) were placed in areas that had never been logged. Transect 4 and 5 were logged in 2000 and 2003, respectively. Each transect was accessible by car due to the logging road network with three transects being accessed at one end (1, 4, and 5) and three transects being accessed in the middle (2, 3, and 6).
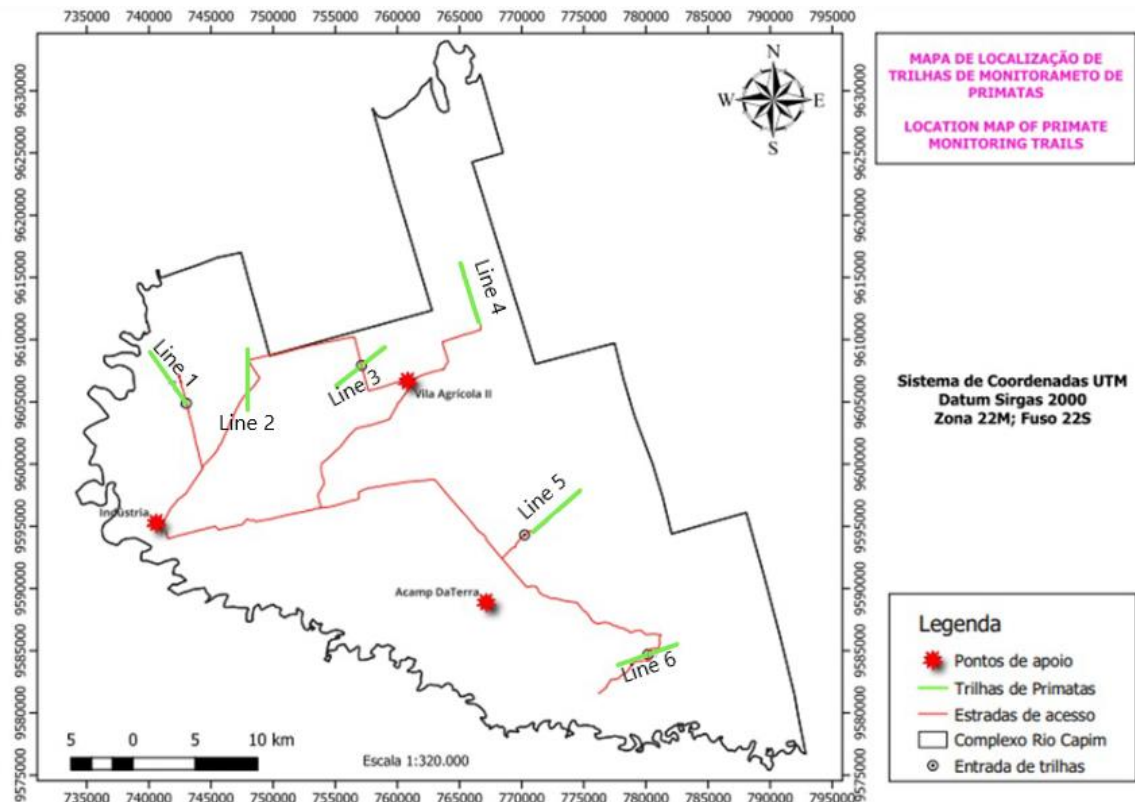
Figure 2: Map of the six transects (green lines) within the Rio Capim Complex. Trail access points are indicated by black circles and the road network are indicated by the red lines. Red stars are support stations within the concession. (Map provided by Cikel)

For each observation, time of observation, group size, perpendicular distance from the trail and the primate's height above ground in the vegetation was noted. In addition, exact coordinates were logged using the Avenza Maps app (Avenza Systems Inc., 2023).

Total two-way census effort for each transect was 80km for transect 1, 90km for transects 2-4 and 60km for transects 5 and 6.

2.3 Data Processing

2.3.1 Kaapori capuchin distribution

Kaapori capuchin data were divided into "old data" (published data) and "new data" (unpublished data). The observations of the Kaapori capuchin were processed in WGS 1984 Zone 22 and plotted in QGIS (QGIS.org, 2023). They were then laid over the estimated distribution of the Kaapori capuchin from the IUCN to create a distribution map.

2.3.2 Habitat change

To assess Kaapori capuchin habitat cover, I created a buffer around each observation of the primate to represent its home range. Only one study has estimated home range size of the Kaapori capuchin, but they suggested that the observed home range was likely too small since it was obtained from a highly fragmented forest area and during a short sampling period (de Oliveira et al., 2014). Because of this uncertainty, I chose to estimate the Kaapori capuchin home range size by averaging the home range of similar species (Table 1). I assumed that the estimated home ranges were circles and calculated the radians manually for all the home ranges. I then used the average of these as an estimate for Kaapori home range size. This gave a diameter between 1490m (with *C. kaapori*) and 1550m (without *C. kaapori*), which I decided to average to 1500 meters. The observations were processed in WGS 1984 UTM Zone 22 in ArcGIS (ESRI, 2016). By using the buffer function, I created buffers with a diameter of 1.5km around each observation. If a buffer overlapped more than 50% with one or more buffers, I assumed that this observation was either the same individual or part of the same group and discarded the point.

Table 1: Home range sizes for different capuchin species, converted into radian lengths. Since the home range size provided for the C. kaapori has a high likelihood of being too small, the average radius length is provided with and without this species.

Species	Home range	Calculations	Radian	Source
Cebus albifrons	240 ha	$\sqrt{240ha * 100000/\pi}$	874m	(Matthews, 2009)
Cebus apella nigritus	161±77ha	$\sqrt{116ha * 100000/\pi}$	726.9m	(Di Bitetti, 2001)
Cebus capucinus	Yearly: 197.768ha Monthly:108.76ha	$\sqrt{197ha * 100000/\pi}$ $\sqrt{108ha * 100000/\pi}$	791.9m 586.3m	(Campos et al., 2014)
Cebus kaapori	62.4 ha	$\sqrt{62.4ha * 100000/\pi}$	445.7m	(de Oliveira et al., 2014)
Cebus olivaceus	243-275 ha	$\sqrt{245ha * 100000/\pi}$ $\sqrt{275ha * 100000/\pi}$	883.1m 935.6m	(Robinson, 1986)
Sapajus apella	429ha (250-850)	$\sqrt{429ha * 100000/\pi}$	1168.6m	(Lenz et al., 2014)
Sapajus robustus	120 ha Wet season: 102 ha Dry season: 111.5ha	$\sqrt{120ha * 100000/\pi}$ $\sqrt{102ha * 100000/\pi}$ $\sqrt{111.5ha * 100000/\pi}$	618.2m 569.8m 595.7m	(Martins et al., 2022)
Average Radian length		745m (Excluding *C. kaapori:*775m)		

To extract habitat data, a land use and cover map from the year of observation was retrieved from MapBiomas (MapBiomas, 2023) and buffers were projected onto the map. To extract the coverage of each land cover type, I used the clip function to extract the coverage from the underlying map. To read the data, I converted the raster to a polygon and changed the symbology to gridcode. I then used the calculate geometry function to calculate the area of each land cover type within the buffer in square meters. The data was then exported to Microsoft Excel, where I calculated the percentage coverage of each land cover type within each buffer.

I repeated this process with the land use and cover map from 2022, to assess potential habitat loss or gain over time. This process was performed for every observation except the observations from 2023 as the only available map was from 2022 and there was nothing to compare to.

2.3.3 Habitat change data analysis

I sorted the land cover data based on the MapBiomas classification system, which places all the land cover types into 6 classes and 20 categories. Using Microsoft Excel, I counted the occurrences of each category within the buffers, for both the year of observation and 2022. These occurrences were then visualized using R Studio (v4.2.2; R Core team, 2022) with the packages ggplot2 (Wicham, 2016), dplyr (Wickham et al., 2023) and reshape2 (Wickham, 2007). To assess the significance of changes in occurrence within the land cover types I used chi-square tests in R Studio. Chi-squared tests were performed individually for each land cover type to determine if there was a significant difference in occurrences over time.

I calculated the average coverage of each land cover type in the buffers where they were present using Microsoft Excel. The average coverages of the different land cover types where they were presented where visualized using R Studio (v4.2.2; R Core team, 2022) with the packages ggplot2 (Wicham, 2016), dplyr (Wickham et al., 2023) and reshape2 (Wickham, 2007). A paired t-test were performed on the entire dataset to test for significant differences in the coverage of each land cover type between the year of observation and 2022.

For each of the observations I calculated the difference in each land cover type from the year of observation and 2022 in Microsoft Excel. I then sorted them based on the value of the biggest change in coverage and calculated the percentage of the total number of buffers which had the same level of change.

3 Results

3.1 Kaapori capuchin distribution

The distribution data consists of 192 data points, with 40 points in the unpublished category and 152 points in the published category.

Most observations are located within the distribution area suggested by the IUCN (Figure 3). However, a few observations lie outside this polygon. For example, there are three observations between 200 to 230 kilometers northwest, as well as six observations between 50 to 80 kilometers west, and three observations between 20 to 50km south.
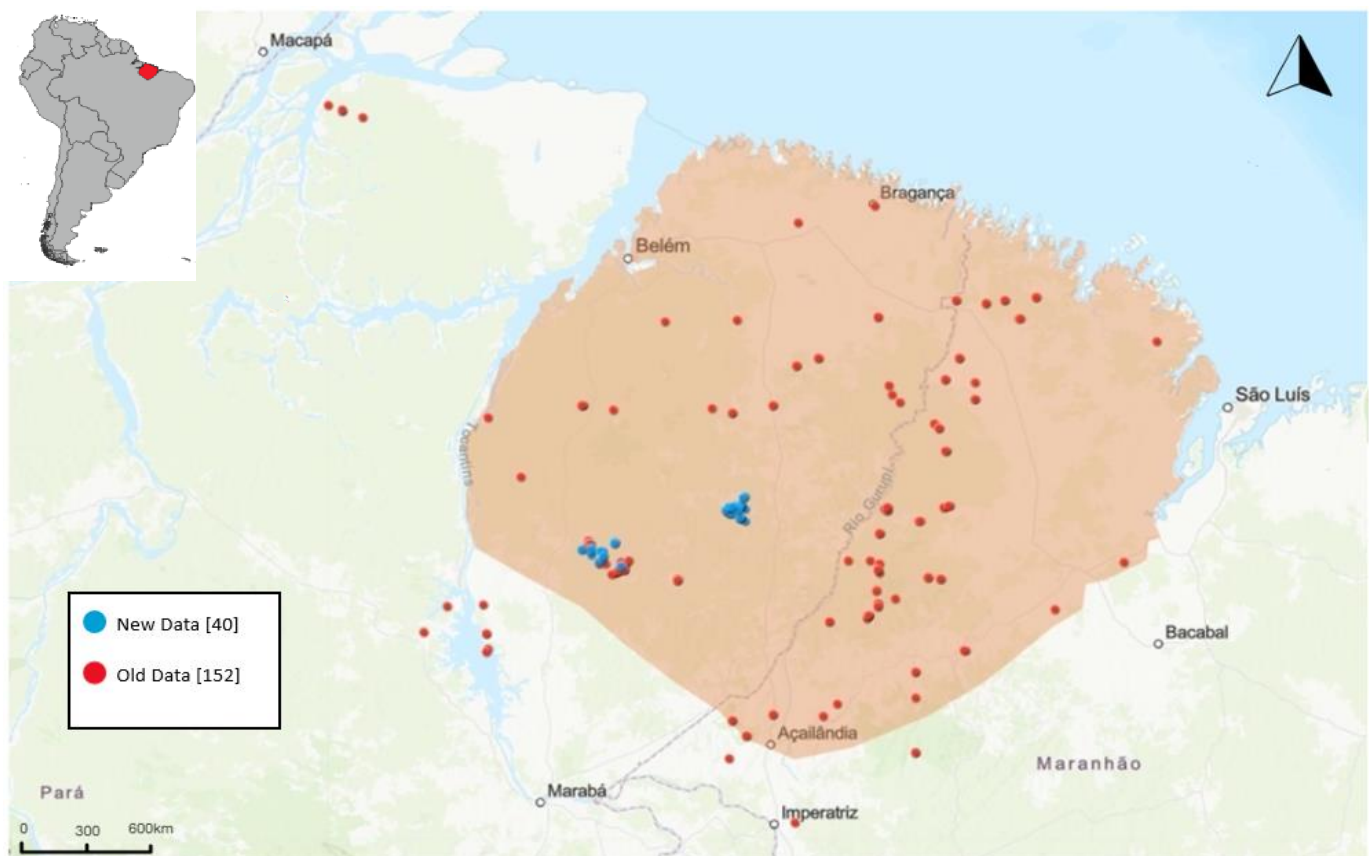

Figure 3: The distribution of all known Kaapori capuchin (Cebus kaapori) observations since 1990. Published data points (Old data) are marked in red and unpublished data points (New data) are marked in blue.

3.2 Kaapori capuchin habitat change

3.2.1 Habitat occurrence

In the 129 buffers analyzed, there were 11 different land cover types present in the year the observations were made. In 2022 there were 13 land cover types present in the same buffers. The new land cover types were Savanna Formation and Soybean, with one and two occurrences, respectively. The most common land cover type within the buffers are Forest Formation and Pasture, which occurs in 129 and 61 buffers in the year of observation and 125 and 64 times in 2022, respectively (Figure 4). The least common land cover types were Urban Areas, with one occurrence in the year of observation and two in 2022.

Overall, there are few changes in the occurrence of each land cover type over time. The biggest increases were Pasture and Palm oil which increased with 3 occurrences each. The biggest decrease was Wetland, which decreased with 4 occurrences, followed by Forest Formation which decreased with 3 occurrences (Figure 4).
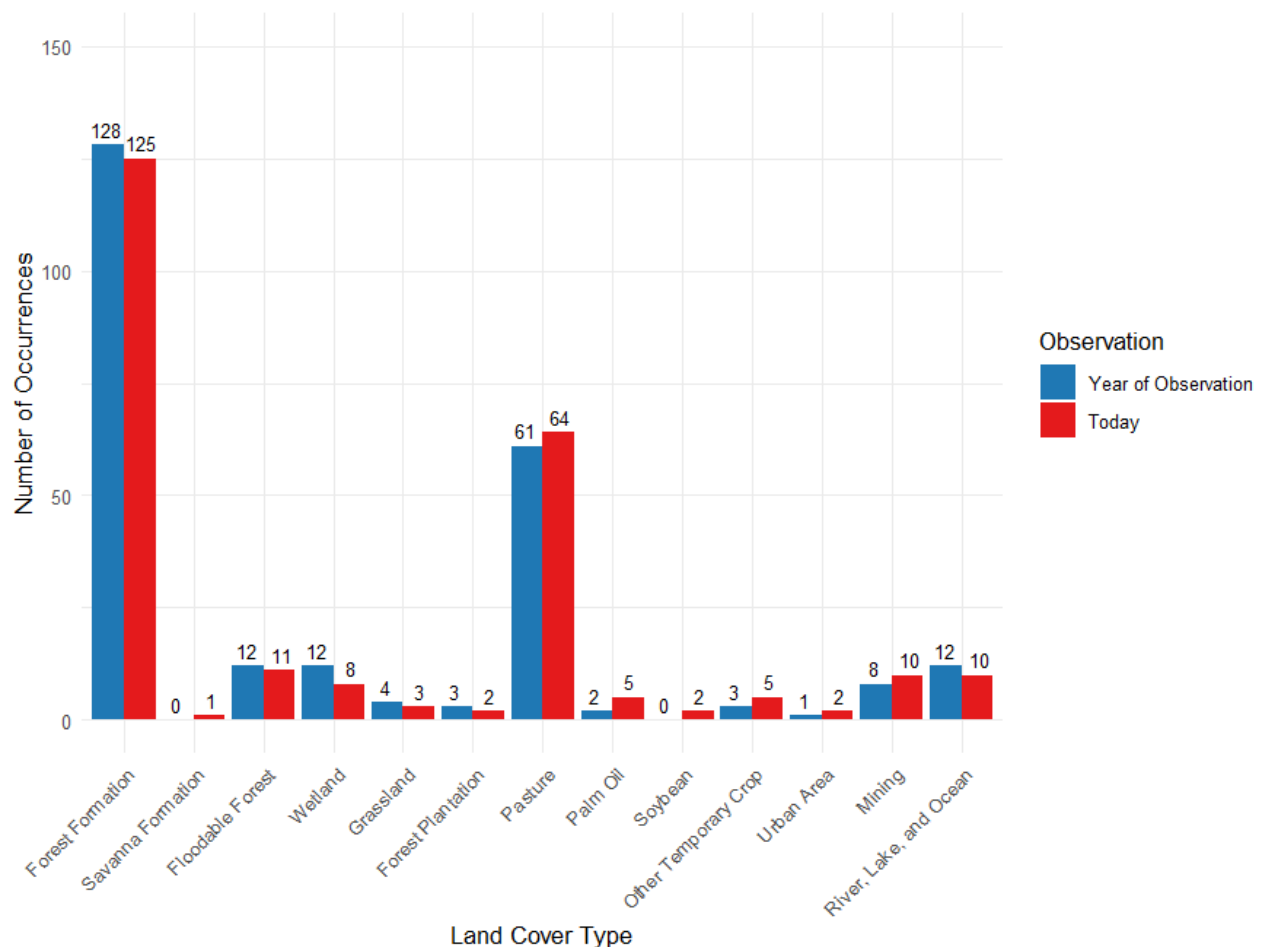

Figure 4: The occurrences of each land cover type recorded within the buffers in the year of observation (blue) and 2022 (red).

Chi-squared tests revealed that there were no significant differences in occurrences between the year of observation and 2022 for any of the land cover types examined (Table 2). Across each land cover type the p-values were greater than the chosen significance level of 0.05, indicating that there was insufficient evidence to reject the null hypothesis of no significant difference (Table 2).

Table 2: Results of chi-square tests for the occurrence of each land cover type observed in each Kaapori capuchin buffer (calculated home range) in the year of observation and today.

Land cover type	χ-squared	df	p-value
Forest Formation	0.074104	1	0.7855
Savanna Formation	1.5164e-32	1	1
Floodable Forest	0.00039541	1	0.9841
Wetland	0.49465	1	0.4819
Grassland	0.00011639	1	0.9914
Forest Plantation	8.2794e-05	1	0.9927
Pasture	0.023903	1	0.8771
Palm Oil	0.56334	1	0.4529
Soybean	0.49394	1	0.4822
Other Temporary Crop	0.11896	1	0.7302
Urban Area	7.8727e-32	1	1
Mining	0.04956	1	0.8238
River, Lake, and Ocean	0.056426	1	0.8122

3.2.2 Average habitat coverage

The land cover type with the greatest area of coverage was Forest Formation in both the year of observation and 2022, with an average coverage of 75.48% and 70.23% within the buffers these were present respectively. In the year of observation, the next greatest coverage was Urban Area and Pasture with 34.66% and 29.72% coverage, respectively. In 2022 the second largest land cover type by area was Palm Oil, that included this land cover type, had an average coverage of 55.01%. Following this were Mining and Pasture, with 36.60% and 34.05%

coverage, respectively (Figure 5). In the year of observation, 57 of the buffers had 100% coverage of Forest Formation, which decreased to 53 in 2022.

There were only three land cover types that decreased in average coverage from the year of observation until today. Forest Formation had the biggest decrease with 5.07% within the buffers these were present, Floodable Forest with 4.67% and Forest plantation with 1.13%. The biggest increase in average coverage is found in Palm oil, where the average coverage increased with 44.06%, followed by Soybean and Mining, with an increase of 22.00% and 21.22% respectively. The other categories had a more moderate increase between 12.14% and 0.27% in the buffers these were present (Figure 5).
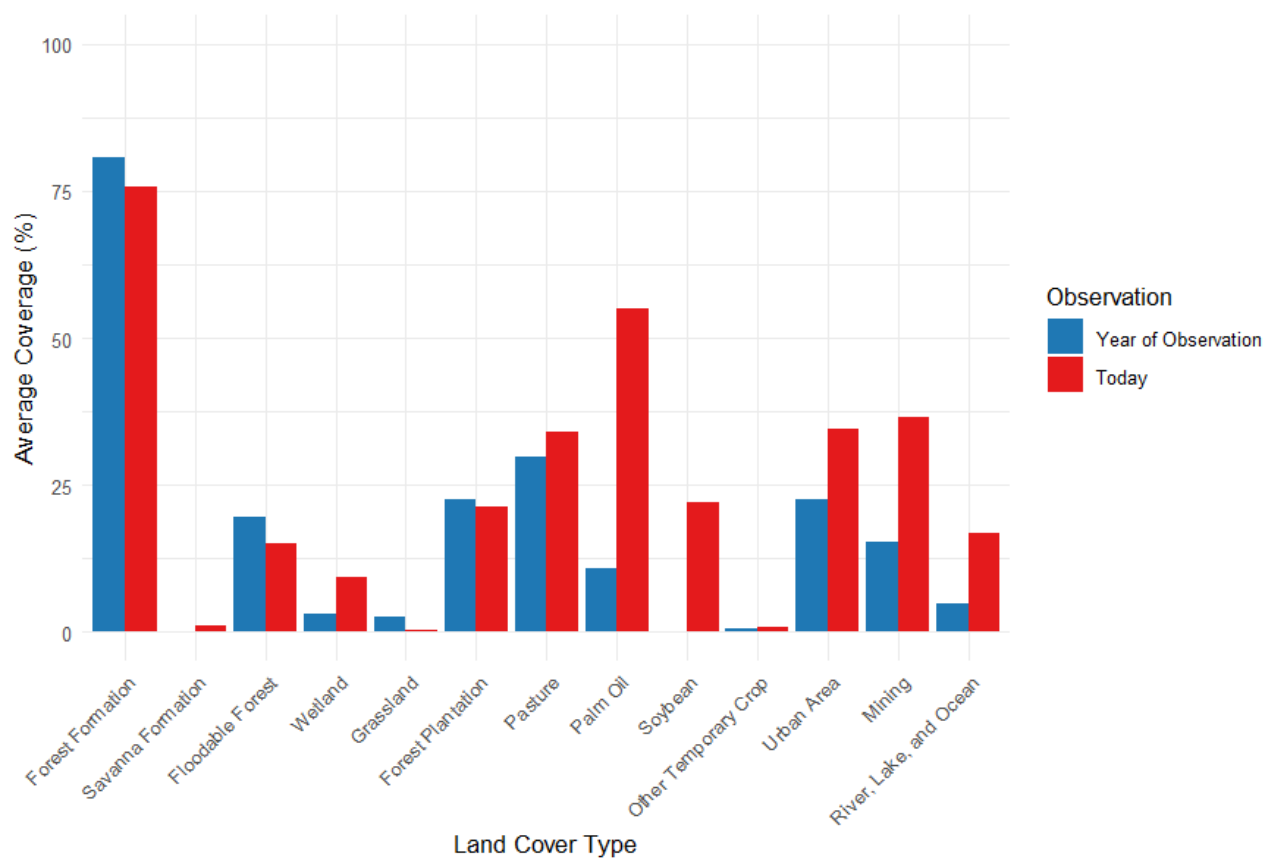
Figure 5: The average coverage of each land cover type recorded within the buffers in the year of observation (blue) and 2022 (red).

Based on the paired t-test there was no significant difference in the average coverage between the year of observation (M= 17.28%, SD= 22.36) and 2022 (M=23.90%, SD= 22.12) conditions; $t(12)= -1.59$, $p=0.069$. These results suggests that there is no difference in the average coverage of the different land cover types between the year they were first observed and today, suggesting a relatively stable environment.

3.2.3 Change in habitat coverage

Of the 129 buffers, 118 had comparable data. The greatest change in coverage revealed that 76 of these 118 buffers had little to no change in coverage. The remaining 42 buffers had more than 5% change in coverage from the year of observation until 2022. Eight of these buffers had less than 10% change in coverage and only seven buffers had more than 70% change in coverage.

Table 3: The largest change in the area of coverage in the individual buffers from the year of observation until 2022.

Change	Number of home ranges	Percent of home ranges
0%- <5%	76	64.40%
5%- <10%	8	6.78%
10%- <30%	13	11.01%
30%- <70%	14	11,86%
70%- 100%	7	5.93%

4 Discussion

The Amazon is experiencing significant threats from human disturbances and climate change, with strong implications for its many endemic and valuable species. The Kaapori capuchin is a critically endangered primate endemic to Belém and Maranhão, and severely understudied. My study looks into whether the current known distribution of the Kaapori as provided by the IUCN is too limited, as well as how the habitat of the Kaapori has changed over time from 1990 until 2022.

4.1 Kaapori capuchin distribution

Most of the observations of the Kaapori are within the suggested range provided by the IUCN (Figure 3). However, there are also several observations outside the distribution polygon. For example, there are several observations around the Tucurui hydroelectric reservoir on the Tocantins river- which is more than 50 kilometers outside the portrayed IUCN distribution (Figure 3). Interestingly there are observations on the west bank of the Tocantins and Tucurui dam. The Tocantins River is the division between the Belém and Xingu endemic areas, suggesting that this species in fact occurs outside the Belém endemic area (José et al., 2005). This river barrier hypothesis was first described by Wallace (1852), where he noted that the large rivers of the Amazon limited primate species range and different species therefore occur on different sides. Since most primates, including capuchins do not swim, rivers act as natural barrier (Kempf, 2009). The presence of the Kaapori in these areas might suggest that the range of the Kaapori extends further into the Xingu endemic area, but this demands further investigation. Whether these observations are misidentifications, escaped pet primates or naturally occurring Kaapori capuchins, but clearly demands further research.

In addition, there were three observations on Marajó island, 200 kilometers northwest of the suggested IUCN distribution (Figure 3). In contrast to the observations near Tocantins and Tucurui, these observations have been confirmed. Marajó island is a fluvial island created by sediments from the Amazon River and is separated from the mainland by an estuary in the south creating a peninsula-like formation (Britannica, 2021). This means that the primates either had to cross the river or go around and cross the estuary to get to the island. The island may be a part of the historical range of the Kaapori, and if so, could potentially be an old population without separated from other Kaapori (Ferrari & Queiroz, 1994). A study from 1995 mapped the primates of the islands of the Amazon estuary, and claimed the Kaapori were not present on Marajó, but suggested that the Kaapori might have been present on the island previously

(Fernandes et al., 1995). Based on current primate distributions and the general area cladogram they found that the homoplasies found did not perfectly fit, suggesting local extinctions on the islands (Fernandes et al., 1995). More studies are needed to explore the Kaapori on Marajó, and if this is a well-established population separate from the larger Kaapori population, it will be especially important to consider in future conservation plans.

The observational data included in this thesis, is currently the most comprehensive record for this species, but there is still a possibility that there exist more observations than what has been recorded here. The species remains understudied, and it may have been overlooked, simply because people are unaware of its existence and importance to research. It may also have been missed or incorrectly identified in primate censuses, as it appears to form groups with other capuchin species and therefore been hidden in plain sight. Moreover, a lot of literature is only available in Portuguese. Such literature is hard to find (e.g. on Google Scholar and Web of Sciences) and the language barrier may have led to observations not being registered, further complicating our understanding of the Kaapori. I therefore strongly advise everyone with information on the Kaapori to make this available to the scientific community in English.

Yet, the observations included in this thesis clearly suggests that the current and historical distribution of the Kaapori capuchin is larger than that presented by the IUCN. Further studies should be conducted to understand the extent of Kaapori capuchin distribution, and the IUCN distribution should likely be revised.

The observations within the IUCN distribution are scattered across the entire polygon (Figure 3). Interestingly, many of the observations are located along the Gurupi river, and by the river there are two continuous areas that are suitable for the Kaapori, the Gurupi Biological Reserve and two indigenous areas. The Gurupi Biological Reserve is in Marahão, and it is the only reserve of its type, east of the Xingu river (Lima et al., 2014; Mendonça et al., 2021). It covers 271,000 hectares and is a part of a mosaic of protected areas forming the main remaining Amazon forest in Marahão. On paper, the area seems to be well suited for Kaaporis as it a large area of continuous forest, and there have been several studies on the Kaapori within the reserve (Buss et al., 2017; Lopes, 1993).

In 1993 Lopes calculated the density of the Kaapori within the reserve and the study was repeated in 2017 by Buss and colleagues and it showed that the density had gone down (Buss et al., 2017; Lopes, 1993). This can be due to illegal activities within the reserve. Since its creation in 1988 the reserve has been heavily affected by illegal timber extraction and over the

last 30 years the reserve has lost 30% of its forest cover due to illegal logging, human occupation, and livestock farming (Mendonça et al., 2021). In addition, frequent fires due to human activities have affected nearly 50% of the reserve (Mendonça et al., 2021). Suggesting that the reserve may not be a suitable as first assumed, and contribution to the loss of habitat for the Kaapori.

Northeast of the reserve are the indigenous lands of Alto Rio Guamá in Pará and Alto Turiaçu in Maranhão, with many observations of the Kaapori (Figure 3). This is also a continuous forest area, and as with the reserve this area also suffers from deforestation. Greenpeace did aerial studies of these areas in 2020 and they uncovered an increase in deforestation, forest fires, and agribusiness within the indigenous lands (Greenpeace, 2020). Even with the degradation of the lands, these areas are important in the survival of the Kaapori. Indigenous peoples' land is considered the most important factor in predicting higher numbers of primate species richness and they play an important role in the long-term persistence of all primate species on both a regional and global scale (Torres-Romero et al., 2023). Even degraded indigenous land are crucial for the survival of many primates, potentially also the Kaapori.

Most of the new observations were located in either the Rio Capim Complex in Paragominas or the Hydro Paragominas bauxite mine area (Figure 3). The Rio Capim complex is considered the largest forest patch in the region, but it highly disturbed as it is a logging concession. Although reduced impact logging conforming to FSC is used, the disturbance may be detrimental to the Kaapori in the area. The primary forest within the Hydro Paragominas bauxite mine area is not as disturbed, but it is destined to be removed for mining, which will likely mean the end of the Kaapori in that area. The rest of the observations are located in areas with no obvious suitable habitat for the Kaapori (Figure 3). These observations are mostly in areas of highly fragmented forest and that does not bode well for these individuals.

4.2 Kaapori capuchin habitat change

In the calculated home ranges, there were no significant differences in the occurrence of the different land cover types in the 30-year period (1990-2022) analyzed. These findings suggest that the occurrences of various land cover types have remained relatively stable over time but there are still some notable differences. Firstly, from the year of observation until 2022 two land cover types were added (Savanna Formation and Soybean) (Figure 4). Savanna Formation had one occurrence and Soybean had two occurrences, but even if these are not very high numbers, they are new additions to the home ranges suggesting that they may have replaced other more

suitable land cover types. These new additions only cover a small part of calculated home ranges and the Kaapori may not use this land type. Since the assumed home range is a circle, it automatically captures all the land cover types within the area and may not be an accurate projection of the area that the Kaapori uses. The home range used in this study is only an assumption and the actual home range might be larger or smaller. More studies are needed to develop a more accurate home range. So, even if a land cover type is registered within the home range it does not mean the Kaapori uses it as a part of its habitat.

Water sources appear to be important for the Kaapori, as 12 home ranges had water present in the year of observation. However, this went down to 10 in 2022 (Figure 4). Additionally, the distribution shows many observations close to rivers. It may suggest that the Kaapori prefer to have water close to or within their home range. The future of the water availability in the eastern Amazon is uncertain, as future scenarios predict a hotter and drier climate in the region, with more severe drought and more frequent El Niño events (Berenguer et al., 2021; Wang et al., 2019). In fact, the 2023 dry season was unusually dry, due to an El Niño event, and this might be a preview of what the future holds for this part of Amazonia.

Overall, the land cover type increase in occurrences seem to be mostly in the types of habitats that the Kaapori would avoid, such as pasture and mining. Land cover types that have decreased in occurrence are typically land cover types the Kaapori would prefer, such as forest. This might suggest that some of the preferred habitat of the Kaapori have been replaced by non-suitable habitats.

This change in occurrence does not necessarily correlate with the average coverage of the different land cover types. There has been an increase in the occurrence of Floodable Forest, but a decrease in coverage (Figure 4&5). This means that even if the land cover type occur within more home ranges, it covers less area in each home range. The opposite is the case for Wetland, Grassland, and River, Lake, and Ocean where the occurrence has decreased but the coverage has increased (Figure 4&5). Even if these land cover types occur in fewer home ranges, they cover more area in the home ranges where they do occur.

Even if there were no significant changes in the occurrence of the land cover types there were some changes in the coverage of each of the land cover types. Notably, the Forest Formation cover type had decreased with 5.07% and went from 128 to 125 occurrences (Figure 4&5). Since the Kaapori are known to dwell high in the canopy, one would expect that the majority of the observations were made in areas with forest cover (de Oliveira et al., 2014). According to my results, there were 57 home ranges with 100% Forest Formation coverage in the year of

observation. This decreased to 53 home ranges in 2022. This suggests that forest conversion is happening within areas that support Kaapori capuchins, and this is worrying trend. However, a large portion of the buffers still have a complete coverage of forest and maintaining this forest cover is therefore a major conservation priority as this is likely important habitat for the Kaapori.

These seemingly small changes in the forest coverage of the home ranges do not represent the quality of the forest coverage that remains. The forest might have been degraded by factors such as selective logging, which is a common practice in the eastern Amazon. Selective logging can have a significant ecological impact on the forest as it can deplete resources such as seeds and fruits over a large area (E. A. R. Carvalho et al., 2022; Uhl et al., 1989). As this loss of secondary production may be detrimental to species, a well-managed reduced-impact logging is shown not drive species to extinction at a landscape level, suggesting that reduced-impact logging could be a compromise between species conservation and economic interests (E. A. R. Carvalho Jr et al., 2021). A case-study from the Yavari-Mirin basin in the Peruvian Amazon showed that populations of primates did not decline in response to logging activities, suggesting that despite primate's slow reproduction rates and low population densities they respond well to logging activities (Mayor et al., 2015). Even with these seemingly positive results for primates, the response of the Kaapori capuchin is not known, but it is suggested that the Kaapori might not tolerate changes such as selective logging (Lopes, 1993). If the Kaapori still remain in these degraded forests, it is likely more vulnerable compared to before the forest was logged.

 The coverage of land cover types the Kaapori would avoid, such as farming areas, have increased, though the change was not significant. The creation of farmlands creates a fragmented forest landscape with little opportunities for movements and habitat with sharp edges. It has been shown that the distribution of primates becomes altered following the creation of sharp forest edges, even after years of regeneration (Lenz et al., 2014). However, a study of forest fragments in eastern Brazil found that fragments still support 79% of the expected diversity predicted in the area (Stone et al., 2009). This suggests that fragments may be able to preserve most diversity, but the fate of any single species within these fragments remain uncertain.

The biggest increase in land cover type coverage was Palm oil, with coverage increasing with 44.06% (Figure 5). In the home ranges where Palm Oil was present it covered half of the home range, suggesting a loss of approximately half the suitable Kaapori habitat in these areas. In addition, coverage of Soybean and Pasture also increased leading to further loss of suitable

habitat for the Kaapori (Figure 5). Mining has also increased (21.22%), which further suggests the loss of suitable habitat for the Kaapori (Figure 5). This might increase even more as the Hydro area is destined to be removed for mining as well. When species lose their habitat, they must adapt or face local extinction. Some adaptive responses in primates include migration to more suitable habitat, acclimation to new conditions, and tolerance of changing environmental conditions (Sales et al., 2020). Since the Kaapori is vulnerable to habitat change, the total loss of habitat might mean extension of the Kaapori in the area.

The changes in occurrence and average coverage can indicate the state of the habitat of the Kaapori as a whole. Looking at the changes in the individual home ranges many of the same patterns emerge. In the individual home ranges only 36% of the home ranges had changed more than 5% in the land cover type with the greatest change. This is further broken down to 8 home ranges with a change between 5% and <10% change and 13 home ranges with a change between 10% and <30% in coverage (Table 3). This shows that these home ranges have had some change in coverage, but as the estimations of home range are rough these land cover changes may not be detrimental to the groups in these observations. Their actual home range may be in an elongated forest fragment that is not captured in the home range estimates and therefore these small changes in the circular home range might not affect the Kaapori.

14 of the home ranges had a change between 30 and <70% and 7 home ranges had changed up to 100% (Table 3). This shows that 21 of the buffers have changed in more than 30% of their area, which could be negative for the Kaapori. The Kaapori may have adjusted their home range to a more suitable habitat, but as 7 home ranges have had what seems like a total transformation of the home range, the Kaapori may have been lost from these locations. The changes in land cover type are mostly from forest to less desirable land cover types such as Pasture and Mining. Suggesting that the preferred habitat of the Kaapori is lost form the location, but further studies are needed to verify that they are truly gone from these locations.

The rest of the home ranges had experienced essentially no change. This might be explained by the fact that most of these observations were done inside protected areas or indigenous lands and have therefore been protected against activities that would have changed the habitat significantly.

The above trends show that the habitat has changed over time, but perhaps not as dramatically as one might expect. Eastern Amazonia is considered the most heavily deforested region of the Amazon, and the literature paints a bleak picture of the future of the forest in the region (Laurance et al., 2001; Marengo et al., 2018). The lower than expected habitat change may be

due to incentives for conserving Amazonian forest. The protected areas of the Amazon cover around 43% of its biome, and these areas have played a decisive role in conserving extensive forest areas and reducing regional deforestation. The protected areas have restrictions on the use of the natural resources so that they are able to protect well-preserved forest remnants (Kere et al., 2017; Nolte et al., 2013).

Protected areas are crucial for the conservation of primates, as these areas serve as potential refuges and provide a stable habitat that buffer populations against the impact of anthropogenic pressures (Torres-Romero et al., 2023). It has been shown that the most effective strategy to contain deforestation and protect biodiversity are protected areas (Paiva et al., 2020). Protected areas, including Indigenous Territories are directly associated with primate richness. The presence of these areas is positively associated with all primate species, including both threatened and non-threatened species (Torres-Romero et al., 2023).

This highlights the importance of both protected areas and Indigenous Territories in conserving primates, as their range play an important role in maintaining connectivity across forests, which is crucial in the long-term persistence of species (Fernández-Llamazares et al., 2021; Torres-Romero et al., 2023). In addition to protected areas, the local and indigenous people's contribution to conservation complements the regional and state efforts, as they through millennia have managed these areas and know how to sustainably manage them. They play an important part in conserving biodiversity and could mean the difference between survival and extinction of local species(Corrigan et al., 2018).

The future of the Kaapori is uncertain, but predicted scenarios does not provide a positive outlook for the species. Gomes (2018) evaluated the impacts of climate change and deforestation on the Kaapori within the IUCN distribution. The study found that within the IUCN distribution the Kaapori are in danger of losing 97% of its suitable habitat due to deforestation and climate change (Gomes, 2018). Groups registered outside the projected IUCN distribution are also in peril, as the Xingu endemic area are the endemic area have a high deforestation rate (José et al., 2005). Incentives to save the Amazon appear to have some effect, but many protected areas are often used for economic profit, rather than species conservation, reducing their effectiveness in safeguarding biodiversity (Paiva et al., 2020).

6 Conclusion

The Kaapori capuchin distribution range may be larger than the distribution portrayed by the IUCN. This suggests that the IUCN range map likely needs a careful revision based on the available observations of the species across the region.

Based on all the known observations of the Kaapori it does not appear to have lost much of their habitat over time, which is good news for this threatened species. Both the occurrences and average coverage of the different land cover types had experienced no significant changes across time. However, it is important to remember that even if there is still forest cover in the points where the Kaapori has been observed that does not necessarily mean that they still dwell in these areas. With fragmentation and increasing habitat changes due to climate change and human activities species may have been lost from certain areas. A more targeted effort to understand the current distribution, habitat use, and group sizes of the Kaapori is therefore needed. Without this information it is difficult to provide meaningful conservation strategies and I fear that the Kaapori will disappear before we understand its importance in the ecosystem.

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8 Appendices

S1: *The counted number of occurrences of each land cover type across the 129 buffers and the average coverage of these in both year of observation and 2022. In addition, the average coverage of each land cover type adjusted for the occurrence in the year of observation and 2022 is provided. To show how much each land cover type cover on average in the buffers they are present. After occurrences, average coverage and average coverage adjusted for occurrences the difference is listed from year of observation till 2022, where increases are marked in green, and decreases are marked in red.*

Type	Number of occurrences	Number of occurrences 2022	Change occurrence	Average coverage	Average coverage 2022	Change Average coverage	Average coverage adjusted for occurrences	Average coverage adjusted for occurrences 2022	Change adjusted average coverage
Forest	**140**	**137**	**-3**	**81.91%**	**74.59%**	**-7.32%**	**75.48%**	**70.23%**	**-5.25%**
3: Forest Formation	128	125	-3	80.08%	73.30 %	-6.78%	80.71%	75.64 %	-5.07%
4: Savanna Formation	0	1	1	0	0.01 %	0.01%	0	1.00 %	1.00%
6: Floodable Forest	12	11	1	1.83%	1,28%	-0.55%	19.67%	15.00%	-4.67%
Non-Forest Natural Formation	**16**	**11**	**-5**	**0.37%**	**0.59%**	**0.22%**	**3%**	**6.93%**	**3.93%**
11: Wetland	12	8	-4	0.29%	0.58%	0.29%	3.12%	9.42%	6.30%
12: Grassland	4	3	-1	0.08%	0.01%	-0.07%	2.63%	0.27%	2.36%
Farming	**69**	**78**	**9**	**14.76%**	**19.73%**	**4.97%**	**27.6%**	**32.63%**	**5.03%**
9: Forest Plantation	3	2	-1	0.52%	0.33%	-0.19%	22.47%	21.34%	-1.13%
15: Pasture	61	64	3	14.06%	16.89%	2.83%	29.72%	34.05%	4.33%
35: Palm Oil	2	5	3	0.17%	2.13%	1.96%	10.95%	55.01%	44.06%
39: Soybean	0	2	2	0	0.34%	0.34%	0	22.00%	22.00%
41: Other Temporary Crop	3	5	2	0.01%	0.03%	0.02%	0.59%	0.86%	0.27%
Non-Vegetated Area	**9**	**12**	**3**	**1.22%**	**3.19%**	**1.97%**	**17.52%**	**34.27%**	**16.75%**
24: Urban Area	1	2	1	0.27%	0.35%	0.08%	22.60%	34.66%	12.06%
30: Mining	8	10	2	0.95%	2.84%	1.89%	15.38%	36.60%	21.22%
Water	**12**	**10**	**-2**	**0.44%**	**1.31%**	**0.87%**	**4.76%**	**16.90%**	**12.14%**
33: River, Lake, and Ocean	12	10	-2	0.44%	1.31%	0.87%	4.76%	16.90%	12.14%

S2: *The greatest change in coverage in the individual observations of the Kaapori from year of observation till 2022. Included in this table is only the comparable data.*

Longitude	Latitude	Year	Greatest change in coverage in percent
-46,37	-2,63	1990	0
-46,08	-2,33	1991	68,22
-48,833333	-2,5	1992	92,93
-47,181667	-2,163611	1992	4,66
-46,75	-3,4166667	1992	52,93
-47,333333	-2,2166667	1992	0
-47,783333	-2,55	1992	16,1
-47,05	-4,65	1992	1,13
-48,83	-2,5	1996	88,91
-46,75	-3,42	1996	69,6
-46,404681	-3,7334346	1996	0
-47,316667	-1,1833333	1996	2,7
-46,759722	-1,865	1998	5,44
-47,75	-1,8833333	1998	67,14
-47,783333	-2,55	1998	7,89
-46,75	-3,4166667	1998	65,22
-45,032082	-3,6269543	1998	64,38
-46,5	-4,6	1998	60,23
-48,25	-1,9	1998	54,43
-49,5	-2,5833333	1998	8,65
-46,333333	-2,6666667	1998	0
-48,166667	-3,75	1998	26,51
-46,404681	-3,7334346	1998	3,91
-45,516667	-3,9666667	1998	16,68
-47,5	-2,5	1998	87,38
-46,18456	-2,154115	1998	52,05
-47,181667	-2,163611	1998	52,05
-48,833333	-2,5	1998	73,34
-48,17	-3,76	1999	11,62
-46,759722	-1,865	2000	6,15
-48,78	-3,52	2002	0
-48,78	-3,5	2002	0
-49,506667	-4,273611	2002	2,82
-48,78	-3,52	2003	0
-48,58	-3,7	2003	0
-48,79	-3,52	2004	0
-48,58	-3,7	2004	0
-48,56	-3,63	2004	0
-48,51	-3,62	2004	0
-48,54	-3,68	2004	0
-48,78	-3,5	2005	0
-48,56	-3,63	2005	0

-48,54	-3,68	2005	0
-46,078333	-2,456111	2005	4,05
-45,865833	-1,739444	2005	2,72
-46	-1,764167	2005	21,21
-46,293889	-3,234444	2005	27,41
-47,684444	-4,878611	2005	46,1
-46,212778	-1,742778	2005	4,16
-46,498889	-4,415	2005	16,43
-45,649444	-1,7227778	2005	0,37
-46,766667	-3,833333	2005	0
-50,521965	-0,375024	2005	0
-47,778333	-4,771389	2005	31,34
-49,529709	-3,940786	2005	75,15
-46,291389	-2,313056	2005	55,37
-46,316667	-3,75	2005	0
-47,096389	-4,056667	2005	0,78
-47,496667	-4,721944	2005	20,13
-46,262222	-3,223889	2005	7
-46,5	-5	2005	0
-45,763611	-1,868333	2005	0,06
-46,466667	-3,333333	2005	8,54
-46,152778	-4,264444	2005	13,28
-46,660209	-2,422666	2005	0
-46,283333	-2,833333	2005	0
-48,58	-3,7	2006	0
-48,53	-3,64	2006	0,69
-48,61	-3,71	2006	0
-49,27	-3,02	2006	10,72
-48,82	-3,53	2006	0
-49,95	-4,13	2006	18,45
-49,5	-4,25	2007	3
-48,78	-3,5	2008	0
-48,79	-3,48	2008	0
-48,58	-3,7	2008	0
-48,56	-3,66	2008	0
-48,55	-3,65	2009	0
-48,54	-3,68	2010	0
-48,61	-3,71	2010	0
-48,67	-3,64	2010	0,31
-48,72	-3,64	2011	0,5
-49,512167	-4,1416111	2011	26,86
-50,62	-0,34	2013	0
-50,38	-0,42	2013	0
-48,78	-3,5	2013	0
-48,53	-3,64	2013	0,3
-46,764972	-3,921528	2013	0

-46,826667	-4,012417	2013	0
-46,757194	-3,944583	2013	0,32
-46,758444	-3,685222	2013	0
-46,696583	-3,251222	2013	0
-49,51	-4,14	2014	22,88
-46,61	-2,48	2014	0,31
-46,75	-3,71	2014	0
-46,72	-3,25	2014	0
-47,822	-3,254	2014	2,27
-47,741	-3,23	2014	1,05
-46,749044	-3,638129	2015	0
-47,698	-3,157	2015	9,58
-47,755	-3,225	2015	6,09
-47,8	-3,28	2016	0
-47,697	-3,24	2016	0,07
-47,69	-3,335	2016	37,96
-47,732	-3,306	2016	96,44
-47,815	-3,267	2016	0,2
-47,797	-3,277	2016	0
-48,62	-2,53	2017	0
-46,810944	-3,622392	2017	1,22
-47,768	-3,277	2017	2,15
-47,78	-3,243	2017	1,23
-47,718	-3,214	2017	0,7
-47,729	-3,235	2017	0,24
-47,822	-3,254	2018	1,29
-47,741	-3,23	2018	0,93
-47,732	-3,306	2018	90,12
-47,804	-3,23	2019	0
-46,968469	-3,61434	2019	5,92
-47,71052	-3,17118	2020	0,51
-47,7365	-3,25433	2021	4