THE LAST SURVIVING POPULATION OF *CACAJAO OUAKARY* (SPIX, 1823) (PITHECIIDAE, PRIMATES) IN AN *IGAPÓ* FOREST IN THE MANAUS METROPOLITAN REGION, CENTRAL AMAZONIA, BRAZIL

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Abstract

The golden-backed uacari (*Cacajao ouakary*) has a broad geographic range across Colombia, Venezuela, and Brazil, but its distribution is patchy due to its reliance on specific *igapó* floodplain habitats adjacent to *terra firme* forest. Despite this wide range, the species occurs only in fragmented pockets of suitable habitat and has previously been studied only in minimally disturbed areas. In this study, we investigated the presence and conservation status of the golden-backed uacari in anthropogenically impacted *igapó* near Manaus, Amazonas, Brazil. Over a period of 16 months, we used semi-structured interviews and linear transect surveys to assess threats and population status. The species is not hunted, and only 5% of respondents (n = 3 out of 60) confirmed its presence in the region. During extensive fieldwork, only two sightings were recorded, both in the 1,840 ha fragment of *igapó* forest that lacks substantial adjacent *terra firme*, limiting seasonal movements. These individuals appear to represent an isolated remnant population, likely the last of their kind in the area. Given the ongoing loss and fragmentation of habitat, this population faces a high risk of local extinction unless urgent conservation measures are implemented.

Keywords: conservation, fragmentation, landscape ecology, Pitheciidae, uacaris

Resumo

O uacari-de-costas-douradas (*Cacajao ouakary*) possui uma ampla distribuição geográfica, sendo encontrado na Colômbia, Venezuela e Brasil. No entanto, sua ocorrência é restrita a bolsões de habitat de igapó adequados, adjacentes à terra firme, o que resulta em uma distribuição não uniforme ao longo de sua área de ocorrência. Até o momento, a espécie havia sido estudada apenas em áreas pouco impactadas. Neste estudo, investigamos a presença do uacari-de-costas-douradas em igapós impactados por atividades humanas, nas proximidades da cidade de Manaus, Amazonas, Brasil. Durante 16 meses, utilizamos entrevistas semiestruturadas e transectos lineares para estabelecer um perfil de ameaças à conservação da espécie. O uacari não foi considerado alvo de caça, e apenas 5% dos entrevistados (n = 3 de 60 entrevistas válidas) relataram sua presença regional. Ao longo da pesquisa de campo, obtivemos apenas dois registros visuais da espécie. As observações ocorreram em um fragmento de igapó de 1.840 ha com pouca terra firme adjacente para migração sazonal. Esses indivíduos encontram-se isolados em escala da paisagem, sendo provavelmente os últimos sobreviventes locais da espécie. Diante da contínua perda e fragmentação do habitat, essa população corre sério risco de extinção local em um futuro próximo, caso não seja implementado nenhum plano de conservação da espécie.

Palavras chave: conservação, ecologia da paisagem, fragmentação, Pitheciidae, uacaris

Introduction

Landscape Ecology has two central dimensions: an ecological one, emphasizing the spatial context of ecological processes and their importance for biological conservation, and a geographical one, which studies the impact of human activities on regional landscapes (Metzger, 2001). For primate conservation, knowledge of the ecological and geographical themes of landscape ecology is invaluable. These elements can be especially important when species have broad geographical ranges but are not evenly distributed within them, being instead restricted to pockets of suitable habitat (Pita et al., 2013).

The golden-backed uacari (*Cacajao ouakary*) has a wide geographic distribution, being found in Colombia, Venezuela, and Brazil. However, its occurrence is restricted to seasonally flooded riparian forests (*igapó*) with adjacent

areas of *terra firme* (never-flooded forest) and therefore does not occur uniformly throughout its range. Accessibility to these habitats also plays a critical role in its presence. For instance, the golden-backed uacari appears to be absent from all river islands in Anavilhanas National Park, despite the presence of extensive *igapó* formations (Ferreira Neto et al., 2021). These islands are separated from the continental riverbanks by large areas of open water.

The lack of homogeneity in the distribution of a species hinders conservation strategies and increases the risk of local extinctions (Michalski and Peres, 2005). Furthermore, although the human impacts of selective logging and habitat fragmentation have been well documented for primates in non-flooded Amazonian forests (Marsh, 2013), these aspects have been little studied in *igapó* forests, where uacaris are found (Myster, 2018).

For the present study, we focused specifically on *igapó*, a habitat of fundamental importance for the golden-backed uacari (Barnett et al., 2015). *Igapó* is a forest seasonally flooded by rivers with waters poor in inorganic nutrients but rich in tannins and organic acids (Junk et al., 2015), with marked seasonal pulses in fruit availability (Parolin et al., 2002). In *igapó* forests, many tree species are water-dispersed (Correa et al., 2015a), and these seeds tend to accumulate in large floating mats (Antunes et al., 2019). They are subject to intense predation both while floating (Correa et al., 2015b) and later, when they germinate and sprout during the dry season (Antunes et al., 2019). Although it is primarily a seed predator, *Cacajao ouakary* also plays an important role as a seed disperser for species such as *Escheweilera tenuifolia* (Lecythidaceae), *Duroia velutina* (Rubiaceae), *Inga rhynchocalyx* (Fabaceae) and *Macrolobium acaccifolium* (Fabaceae) (Barnett et al., 2012), which are dominant in regional *igapó* forests, along with species of the genera *Micropholis* and *Pouteria* (Sapotaceae) (Barnett et al., 2015).

The specialized diet of *Cacajao ouakary*, consisting of hard-shelled fruits (Barnett et al., 2013), together with its seasonal movements between habitats in search of resources (Barnett, 2010), make the species particularly vulnerable to anthropogenic impacts, hinder conservation strategies and increase the risk of local extinctions (Michalski and Peres, 2005).

In Brazil, the area inhabited by *Cacajao ouakary* is bounded to the south by the Solimões and Japurá rivers. The western extension of its range is bounded by the Apaporis River and the La Macarena Mountains in Colombia, while the northern limits occur near the Guaviare River in Colombia, the Negro River, the Cassiquiare Canal, and the Orinoco River in Brazil and Venezuela (Boubli et al., 2008; Bertuol, 2015) (see Fig. 1). The taxonomic nomenclature has varied over time, but recent biogeographic, morphological, and molecular evidence supports the use of *C. ouakary* for populations south of the Negro River (Ferrari et al. 2014; Dias da Silva et al., 2020; Tomanek et al., 2020).

Cacajao ouakary is strongly associated with flooded forests (*igapó* and *várzea*—its equivalent in white waters: Junk et al., 2015) and has never been recorded in dry forests more than 5 km away from flooded forests (Defler, 2001). However, *terra firme* forest is a fundamental resource for the species, as it is phenologically distinct from *igapó*, thus providing complementary food resources at times of the year when these are scarcer in *igapó* (Barnett, 2010; Barnett and Jucá, 2018). Due to its wide distribution, the species is listed by the IUCN, as well as in Brazil (MMA/ICMBio, 2018), as Least Concern (Boubli et al., 2021), but highly vulnerable to anthropogenic action. Until now, this species has only been studied in areas with little impact. Identifying the factors that drive regional extinctions in areas most affected by anthropogenic change is essential. For this reason, we studied *C. ouakary* in anthropogenically impacted *igapó*.

To assess the impacts of human disturbance on a population of uacaris, in this study: (i) we estimated the extent of recent habitat fragmentation at the landscape scale (over the last 40 years); (ii) we interviewed local informants about the presence and hunting of uacaris; (iii) we surveyed the *igapó* habitat to assess uacari densities; and (iv) we assessed the presence of threats and habitat modifications that compromise the species' long-term survival. This allowed us to estimate the degree of current human influence and the effects of management on the regional landscape, as well as the extent of uacari population isolation at the local and regional spatial levels.

Materials and Methods

Study area

The study was conducted in the locality of Açutuba (3°05'S, 60°18'W), an area of approximately 1,840 ha of *igapó* forest in the municipality of Iranduba, 25 km west of Manaus, in the state of Amazonas, Brazil. The area is situated on the right (south) bank of the Rio Negro (Fig. 1), in the easternmost portion of the Negro/Solimões interfluve. Açutuba is an *igapó* area impacted by humans, located in the Manaus Metropolitan Region (RMM) and lying at the easternmost point of the known distribution of *Cacaajo ouakari* (Fig. 1). In general, as in Açutuba, the *igapó* has three main forms: 1) Low *igapó*, characterized by herbaceous and shrubby species, usually present at the edges of the forest, in natural clearings, and in impacted areas; 2) Medium *igapó*, with tree species up to 20 m in height; and 3) High *igapó*, with trees > 20 m in height and DBH ≥ 5 m (Rocha, 2017).

The study area is one of only three remaining forest fragments larger than 1,000 ha in the southern half of the municipality of Iranduba and is part of the Environmental

Protection Area of the Right Bank of the Rio Negro (APAMDRN), a region covering 461,740.67 ha that was created in 1995 (Braga, 2016). An Environmental Protection Area (APA) allows for human occupation, but only in a sustainable manner (MMA, 2000), which has not been the case in the Açutuba *igapó*, an area that has been intensively exploited for decades, a situation that worsened after the construction of the Rio Negro Bridge at the end of 2011 (Ramos, 2015). Deforestation has been increasing due to real estate speculation and tourism, both of which are unplanned and disregard the impacts on the landscape, biota, and ecosystem services (FVA, 2014; Ramos et al., 2018), including the *igapó* (Kanai and Schindler, 2019).

The municipality of Iranduba is a ceramics-producing region (Pinheiro, 2015), where human occupation dates back to at least the 7th and 8th centuries (Torres and Pereira, 2007), representing 14 centuries of natural resource exploitation by humans, as illustrated by the fifteen archaeological sites at Lago Limão (Moraes, 2006). This includes potential evidence of non-human primate hunting by indigenous inhabitants (Roosevelt et al., 2002), as well as deforestation to provide charcoal for kilns.

In the last two decades, government-supported development projects in the area have included the Urucu-Coari-Manaus gas pipeline (Menezes, 2011) and the Rio Negro Bridge (Ramos, 2015), with powerful impacts on the socioeconomic and environmental dynamics of the municipality (Ribeiro et al., 2012; FVA, 2014; Kanai and Schindler, 2019). Economic development has brought with it environmental degradation, including an increase in deforestation (FVA, 2014). By March 2014, 605,000 ha of forests had been lost in the MMR, equal to 6% of the total area. While 81% of Iranduba municipality is officially listed as protected land (the highest percentage in the MMR), some 21% of its area was deforested by 2013 (FVA, 2014). This means that at least 2% of deforestation occurred within protected areas.

Census

Primate censuses were conducted using linear transects (Peres and Cunha, 2011), consisting of six trails ranging from 1.1 to 3.5 km in length, with a total coverage of 14 km (Fig. 2). To include as many microhabitats and flood durations as possible, and thus maximize representativeness, these were distributed at distances from the mainland ranging from 0 to 1000 m. To minimize the effects of sampling dependency, the transects were at least 1 km apart or separated by a river (a likely geographical barrier; Mourthé et al., 2022). The transects were surveyed in the morning (7 a.m. to 12 noon) and afternoon (12 noon to 5 p.m.) for 16 months between January 2015 and April 2016. The effort per transect was varied to standardize coverage per km, and the order was varied to avoid temporal bias. Research activities were interrupted during rainfall. No night censuses were conducted. As the habitat is seasonally flooded, the methodology varied according to the flood pulse; during the low water season, censuses were conducted on foot, but by canoe during flooded periods, following Barnett (2010). The transects were conducted with two samples per month of trails during the flood season and one sample per month of trails during the non-flood season, and 1-2 trails per day, for a total of 240 km during the study. Whenever there was visual or auditory contact with primates, we recorded the type of detection, species, abundance, date and time, meteorological data, perpendicular distance from the center of the group or subgroup (using a Bushnell 6x24 rangefinder), behavioral activity (*ad libitum*), and food resource.

Ethnoprimatology

Following previous ethnoprimatology studies (Fuentes, 2010, 2012), we used the snowball method to select informants by reference groups, a method widely used to document local ecological knowledge (dos Santos et al., 2020) that uses recommendations from one informant to select the next interviewee. The net result is a series of well-connected informants in the community and community leaders with strong communication skills and local knowledge about their territory (Davis and Wagner, 2003). In this study, the informants were residents of the *igapó*, people who fish, hunters, and gatherers who use and have daily contact with the flooded forest. We conducted semi-structured interviews with informants from the riverside community, using a combination of questions and images of primates to confirm species recognition and, at the same time, test the informant's knowledge of Amazonian primates. Of the 63 interviews, 60 were considered valid. Three were excluded because the interviewees provided unrealistic information (confirmation of the occurrence of primate groups from another biome), demonstrating a lack of knowledge about local primates.

Land-use changes

Data on land use changes were obtained from a study conducted by the Vitória Amazônica Foundation on deforestation in the municipality of Iranduba (FVA, 2014), located in the eastern part of the Negro-Solimões interflux and including the study site (Fig. 3).

Historical landscape data analysis revealed a drastic reduction in the forest over the past four decades; with natural vegetation decreasing from 77.3% to only 21.4% between 1980 to 2021 (Fig. 3), so that only 13,209 ha of forest remains in the south of Iranduba municipality (Fig. 4). This mostly occurs in isolated fragments, of which only three were larger than 1000 ha, including our study area (2286 ha, 1840 ha of which was *igapó*). All habitat on the southern bank of the Rio Negro was *igapó* (Fig. 4).

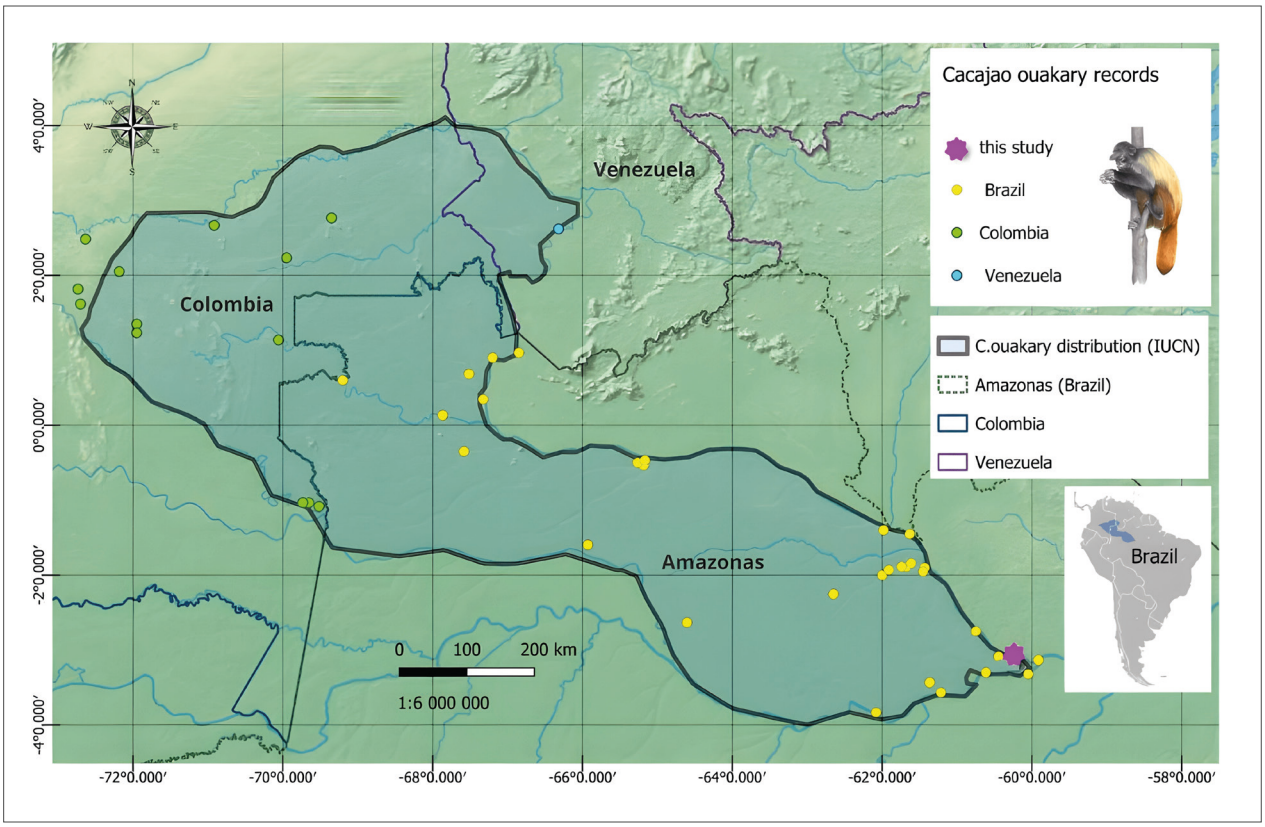

Figure 1. Geographical distribution map for *Cacajao ouakary*, showing this study's record in the context of other historical records in the Brazil, Colombia and Venezuela.

Results

The current study involved 960 census hours of fieldwork over a period of 16 months. During this period, we had 204 encounters with primate groups of seven species: *Alouatta juara*, *Aotus vociferans*, *Cacajao ouakary*, *Cebus unicolor*, *Sapajus macrocephalus*, *Saimiri cassiquiarensis*, and *Pithecia chrysocephala*. Of these, only two of the groups observed were of uacaris (0.98% of all primate encounters). In both cases individuals were seen within the lower canopy of an *igapó* tree, approximately 150 m from the interface between the *igapó* with *terra firme* forest (Fig. 1). The first record (3°06'18"S, 60°17'36"W) was of a single individual resting in a 5m-tall *Eschweilera tenuifolia* tree, and the second (3°05'54"S, 60°16'32"W) was of a group of four individuals foraging in an 8m-tall *Swartzia laevicarpa* (Fabaceae) tree, on pods containing immature seeds (Table 1).

Of a total of 60 interviews, 5% (n = 3) reported the presence of uacaris in the region. However, while 43% (n = 26 records) of respondents reported hunting, or having hunted primates (mainly *Alouatta juara*), uacaris were not cited as a food or hunting resource. In relation to the forest tree species most used and felled in the *igapó* for wood, interviewees cited: *Calophyllum brasiliense* (Calophyllaceae), *Couratari guianensis* (Lecythidaceae) and *Ocotea cymbarum* (Lauraceae) (Table 1).

Discussion and Conclusions

Considering all known records of *Cacajao ouakary* to date, our observations are among the easternmost documented and also among the closest to the city of Manaus. Notably, these are the only records from a fragmented and anthropogenically disturbed area. The proximity to Manaus makes this study the first to report the presence of uacaris in a heavily impacted *igapó* forest, in contrast to previous studies (e.g., Barnett, 2010), which were conducted in relatively undisturbed habitats. A specimen was collected in the municipality of Manacapuru in 1932 (Hershkovitz, 1987), but by the late 1980s, the species was considered extinct in the Lower Rio Negro region (Barnett and da Cunha, 1989). Our findings, however, indicate that while the species is rare in the region, it is not extinct. According to field evidence and ethnobotanical interviews, deforestation in the study region is a daily activity, with selective cutting of large species of high economic value (Table 1). As a result, the uacari population at Açutuba appears to have become extremely reduced, compared to reports of transect-based surveys elsewhere in the interfluve; for example, while the current study made two sightings of this primate in a 16-month period (960 hours), studies at Jaú National Park, a site with low human impact, recorded five groups in 25.5 hours and nine groups in 168 hours (Barnett et al., 2005). Moreover, at Jaú groups commonly varied between 7-40 individuals,

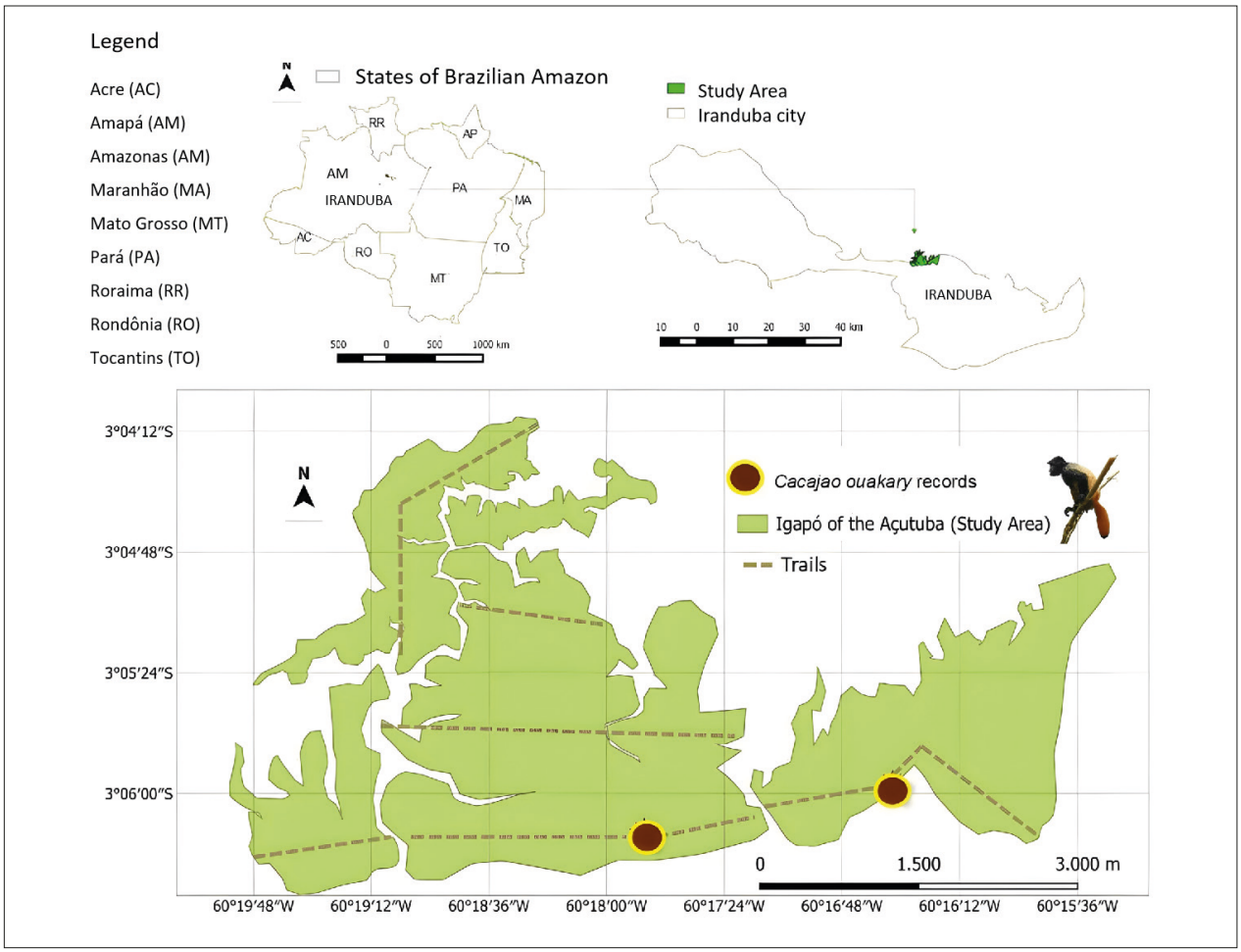

Figure 2. Study area at *Igapó* of Açutuba, Iranduba Municipality, Amazonas state, Brazil, showing the system of six trails used during field surveys. Circles indicate locations where golden-backed uacaris (*Cacajao ouakary*) were visually recorded.

Table 1. Botanical species used by humans (for wood) and uacaris (for food).

Family	Botanical Species	Local name	Wood use	Food resource used by uacaris	
			(interviews, this study)	This study	Barnett (2010) [includes other species within these families]
Calophyllaceae	*Calophyllum brasiliense*	Jacareúba	x		x
Fabaceae	*Swartzia laevicarpa*	Saboarana	x	x	x
Lauraceae	*Ocotea cymbarum*	Louro-Ina-muí	x		*Endlicheria chalisa*
Lecythidaceae	*Couratari guianensis*	Tauarí	x		*Couratari* cf. *stellata* *Couratari* cf. *tenuicarpa*
	Eschweilera tenuifolia	Macacarecuia		x	x
Sapotaceae	*Manilkara* spp.	Maçaranduba	x		*Manilkara bidentata*

with over 100 animals being recorded together on occasions (Barnett et al., 2005), while in this study no more than four animals were seen together. Additionally, in Jaú, uacaris are one of the most common primates, often constituting some 50% of group sightings (Barnett et al., 2002), whereas in the current study, they represented less than 1% of total primate encounters. At Jáu National Park, a site some 220 km upriver from Açutuba, uacaris had a density of 10 ind/km^2 (Barnett et al., 2002; Barnett, 2010), values similar to populations on the Río Apaporis in Colombia (Defler, 2001; Barnett et al., 2013). The lower encounter rates and smaller group sizes recorded in Açutuba indicate a sharply declining population. This may be due to hunting pressure in the past, as well as

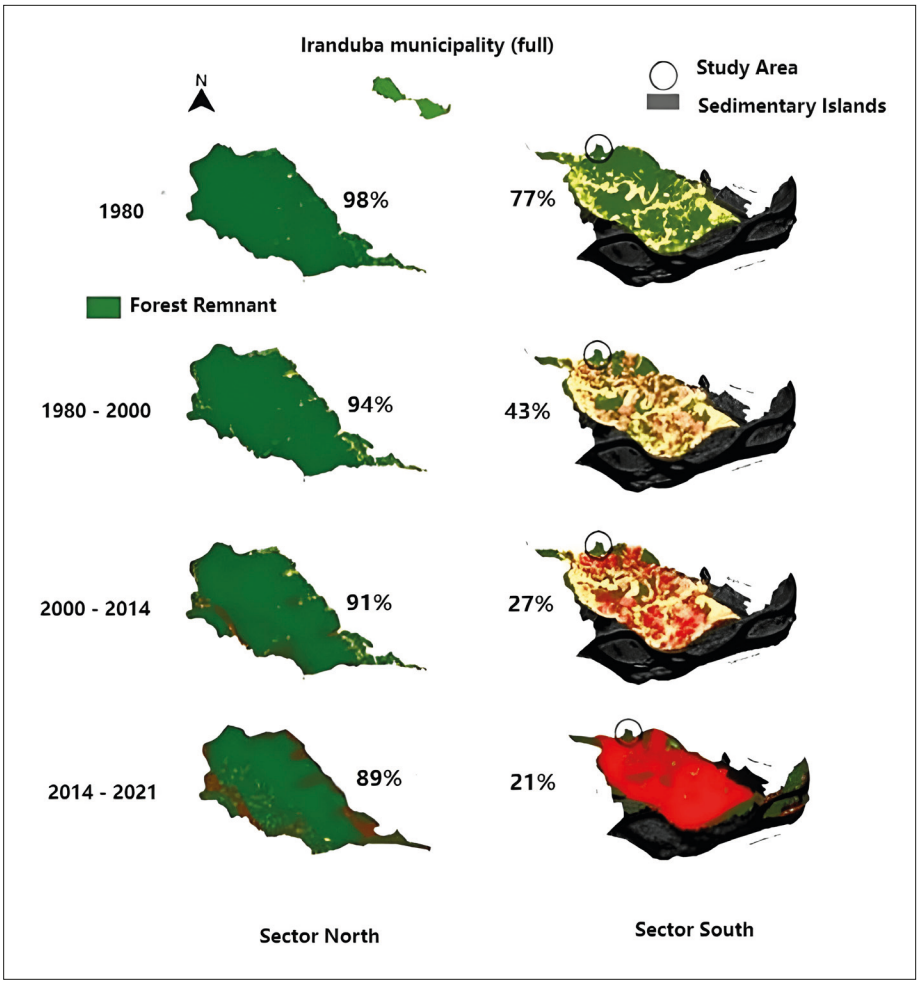

Figure 3. Forest remnants of the municipality of Iranduba (divided into North and South sectors) between 1980 and 2021 (FVA, 2014). The study area is in the South Sector (study site circled in black), the municipal portion that borders Manaus, therefore the most anthropized area.

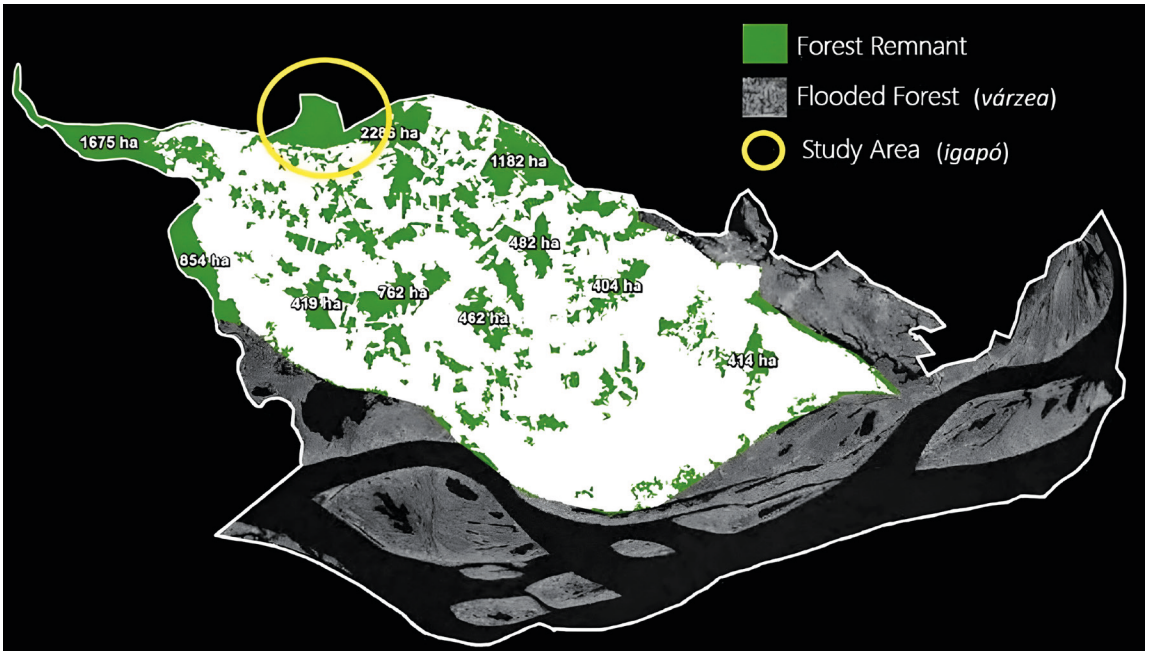

Figure 4. Forest remnants of the municipality of Iranduba sector South (FVA, 2014), showing the size of the study area (2286 ha) and the other largest forest remnants in the region.

current deforestation of the *igapó* and fragmentation of the adjacent *terra firme* forest. Therefore, protecting not only the flooded forest but also its interconnectivity with the *terra firme* forest appears to be critical for the survival of this primate.

Indeed, habitat loss may have an especially acute impact on uacaris as groups are known to migrate between *terra firme* and *igapó* forests seasonally, tracking fruit availability (Barnett et al., 2018; Barnett and Jucá, 2018). An inability to do this, combined with the removal of favoured fruit species (e.g. Maçaranduba, *Manilkara* spp., Sapotaceae) via selective logging, may greatly restrict the capacity of remaining *igapó* to support this primate in viable populations (Barnett, 2010). Additionally, habitat fragmentation of *igapó* impacts both emigration of survivors and immigration of new individuals. The occurrence of circumscribed areas of *igapó* and no access to *terra firme* to offset seasonal dearth in fruit availability in *igapó*, may account for the absence of uacaris on the seasonally-flooded river islands that comprise the Anavilhanas Archipelago upstream of Manaus on the Rio Negro (Ferreira Neto et al., 2021). This form of complex dependency underscores the vulnerability of migratory species, even when the movements occur at a local level (McLeman and Hunter, 2010). Recently criminal forest fires in the region have also impacted and aggravated this scenario (personal observation).

The presence of these multiple drivers leading to the decline of the regional uacari (*Cacajao ouakary*) population, means that the individuals at Açutuba are likely the last survivors of the species locally. Accordingly, we recommend that the study area should be reassessed and recategorized as a conservation unit of a more restricted category, forming a zone of ecological corridors connected to the Jaú National Park to guarantee the conservation of uacaris and other species seasonally or permanently dependent on the regional *igapó* forest ecosystem. This reassessment and recategorization would include the remaining forests in the APAMDRN protected area which form part of the Central Amazon Corridor and are also a core area of the Central Amazon Biosphere Reserve (Queiroz, 2005) and the core area of the Biosphere Reserve (Almeida, 2014). We must intensify faunal and floristic surveys and impact assessments of existing protected areas, as well as currently unprotected flooded forest remnants in the lower Rio Negro. In addition, these areas are a vital source of fisheries protection (Araujo-Lima et al., 1998), reinforcing the importance these areas for wildlife conservation and the self-sufficiency of regional riverine communities.

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References

Almeida, C. A. 2014. O mosaico do baixo Rio Negro: conservação da biodiversidade e sustentabilidade na Amazônia. Master's thesis in Sustainable Development, University of Brasília, Brasília, Brazil.

Antunes, A. C., Baccaro, F., Caetano Andrade, V. L., Ramos, J. F., Da Silva Moreira, R. and Barnett, A. A. 2019. *Igapó* seed patches: a potentially key resource for terrestrial vertebrates in a seasonally flooded forest of central Amazonia. *Biol. J. Linn. Soc.* 128(2): 460–472. https://doi.org/10.1093/biolinnean/blz101

Araujo-Lima, C. A. R. M., Goulding, M., Forsberg, B., Victoria, R. and Martinelli, L. 1998. The economic value of the Amazonian flooded forest from a fisheries perspective. *Internat. Vereinig. für theoret. Undangew. Limnol: Verhandlungen* 26(5): 2177–2179. https://doi.org/10.1080/03680770.1995.11901131

Barnett, A. A., Borges, S., de Castilho, C. V. Neri, F. and Shapley, R. L. 2002. Primates of Jaú National Park, Amazonas, Brazil. *Neotrop. Primates* 10(1): 65–70. https://doi.org/10.62015/np.2002.v10.505

Barnett A. A., de Castilho C. V., Shapley R. L. and Anicácio A. 2005. Diet, habitat selection, and natural history of the golden-backed uacari, *Cacajao melanocephalus ouakary*, in Jaú National Park, Brazil. *Int. J. Primatol.* 26: 949–961. https://doi.org/10.1007/s10764-005-5331-5

Barnett, A. A. 2010. Diet, habitat use and conservation ecology of the golden-backed uacari, *Cacajao melanocephalus ouakary*, in Jaú National Park, Amazonian Brazil. Doctoral thesis in Center for Research in Evolutionary Anthropology, Roehampton University, London, UK.

Barnett, A. A., Boyle, S. A., Pinto, L. P., Lourenço, W. C., Almeida, T., Silva, W. S. and Spironello, W. R. 2012. Primary seed dispersal by three Neotropicals seed-predating primates (*Cacajao melanocephalus ouakary*, *Chiropotes chiropotes* and *Chiropotes albinasus*). *J. Trop. Ecology* 28(6): 543–555. https://doi.org/10.1017/S0266467412000600

Barnett, A. A., Bezerra, B. M., Oliveira, M., Queiroz, H. and Defler, T.R. 2013. *Cacajao ouakary* in Brazil and Colombia: patterns, puzzles and predictions. In: *Evolutionary Biology and Conservation of Titis, Sakis and Uacaris*, L. Veiga, A. Barnett, S. Ferrari and M. Norconk (eds.), pp.179–195. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781139034210.022

Barnett, A. A., Silva, W. S., Shaw, P. J. A. and Ramsay, R. M. 2015. Inundation duration and vertical vegetation stratification: a preliminary description of the vegetation and structuring factors in Borokotóh (hummock *igapó*), an overlooked, high-diversity, Amazonian habitat. *Nordic J. Botany* 33: 601–614. https://doi.org/10.1111/njb.00744

Barnett, A. A. and Jucá, T. 2018. Primates of *igapó* forests. In: Igapó *(Black-water flooded forests) of the Amazon Basin*, R. W. Myster (ed.), pp.121–133. Springer, Switzerland. https://doi.org/10.1007/978-3-319-90122-0

Barnett, A. A., Todd, L. M. and Tomanek, P. 2018. A ecologia do uacari-de-costas-douradas (*Cacajao ouakary*) (Pitheciidae) na bacia Amazônica. In: *La Primatología en Latinoamérica 2*, B. Urbani, M. Kowalewski, R. G., Teixeira da Cunha, S. de la Torre and L. Cortés-Ortiz (eds.), pp.219–228. Instituto Venezolano del Investigaciones Científicas, Caracas.

Bertuol, F. 2015. Testando limites específicos dos Uacaris pretos sensu Hershkovitz (1987) (Pitheciidae: Primates). Master's thesis, INPA, Manaus, Brazil.

Boubli, J. P., da Silva, M. N. F., Amado, M. V., Hrbek, T., Pontual, F. B. and Farias, I. P. 2008. A taxonomic reassessment of *Cacajao melanocephalus* Humboldt (1811), with the description of two new species. *Int. J. Primatol.* 29: 723–741. https://doi.org/10.1007/s10764-008-9248-7

Boubli, J. P., Palacios, E., Urbani, B., Mittermeier, R. A. and Bezerra, B. M. 2021. *Cacajao melanocephalus* (amended version of 2020 assessment). The IUCN Red List of Threatened Species 2021: e.T160875418A191697842. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T160875418A191697842.en. Accessed 22 June 2021.

Braga, A. R. O. 2016. Estrutura da paisagem e a conectividade entre os fragmentos florestais do entorno da Cidade Universitária do Estado do Amazonas. Master's thesis, Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Brazil.

Carwardine, J., Martin, T. G., Firn, J., Reyes, R. P., Nicol, S., Reeson, A., Grantham, H. S., Stratford D., Kehoe L. and Chadès, I. 2019. Priority Threat Management for biodiversity conservation: A handbook. *J. Applied Ecology* 56: 481–490. https://doi.org/10.1111/1365-2664.13268

Correa, D. F., Álvarez, E. and Stevenson, P. R. 2015a. Plant dispersal systems in Neotropical forests: availability of dispersal agents or availability of resources for constructing zoochorous fruits? *Global Ecol. and Biogeog*. 24: 203–214. https://doi.org/10.1111/geb.12248

Correa, S. B., Costa-Pereira, R., Fleming, T., Goulding, M. and Anderson, J. T. 2015b. Neotropical fish–fruit interactions: eco-evolutionary dynamics and conservation. *Biol. Reviews* 90(4): 1263–1278. https://doi.org/10.1111/brv.12153

Davis, A. and Wagner, J. R. 2003. Who knows? On the importance of identifying "experts" when researching Local Ecological Knowledge. *Human Ecology* 31: 463–489. https://doi.org/10.1023/A:1025075923297

Defler, T. R. 1999. Fission-fusion behaviour in *Cacajao melanocephalus ouakary*. *Neotrop. Primates* 7: 5–8. https://doi.org/10.62015/np.1999.v7.412

Defler, T. R. 2001. *Cacajao melanocephalus ouakary* densities on the lower Apaporis River, Colombian Amazon. *Primate Report* 61: 31–36.

Dias da Silva, R. H. P., Castro-Sá, M., Baccaro, F., Tomanek, P. and Barnett, A. A. 2020. Juggling options: optimal selection of size-weight combinations of *Aldina latifolia* (Fabaceae) pods by *Cacajao ouakary* (Pitheciidae). *Biotropica* 52: 1275–1285. https://doi.org/10.1111/btp.12835

dos Santos, J. S., dos Santos Teixeira, J. V., Guanaes, D. H. A., da Rocha, W. D. and Schiavetti, A. 2020. Conflicts between humans and wild animals in and surrounding protected area (Bahia, Brazil): an ethnozoological approach. *Ethnobio. Conserv.* 9. https://doi.org/10.15451/10.15451/ec2020-02-9.05-1-22

Ferrari, S. F., Guedes, P. G., Figueiredo-Ready, W. M. B. and Barnett, A. A. 2014. Reconsidering the taxonomy of the Black-faced Uacaris *Cacajao melanocephalus* group (Mammalia: Pitheciidae) from the northern Amazon Basin. *Zootaxa* 3866: 353–370. https://doi.org/10.11646/zootaxa.3866.3.3

Ferreira Neto, G. S., Baccaro, F. B., Spironello, W. R., Gonçalves, A. L. S., Quesada, C. A. and Barnett, A. A. 2021. Soil fertility and anthropogenic disturbances drive mammal species richness and assemblage composition on tropical fluvial islands. *Austral Ecol.* 46: 792–801. https://doi.org/10.1111/aec.13023

Fuentes, A. 2010. Natural/cultural encounters in Bali: Monkeys, temples, tourists, and ethnoprimatology. *Cultural Anthrop.* 25: 600–624. https://doi.org/10.1111/j.1548-1360.2010.01071.x

Fuentes, A. 2012. Ethnoprimatology and the anthropology of the human-primate interface. *Ann. Rev. Anthrop.* (41): 101–117. https://doi.org/10.1146/annurev-anthro-092611-145808

FVA. 2014. Iranduba: características socioambientais de um município em transformação, M. S. Rodrigues, C. T. Pedrollo, S. H. Borges, Y. R. Camargo, M. P. Moreira, G. S. Amaral, D. O. Brandão and S. Iwanaga (eds.), Manaus Série Documentos Técnicos FVA 2.

Hernández-Camacho, J. and Cooper, R. W. 1976. The nonhuman primates of Colombia. In: *Neotropical Primates: Field Studies and Conservation*. R. W. Thorington Jr. and P. G. Heltne (eds.), pp.35–69. National Academy of Science, Washington DC.

Hershkovitz P. 1987. Uacaries, New World monkeys of the genus *Cacajao* (Cebidae, Platyrrhini): a preliminary taxonomic review with the description of a new subspecies. *Am. J. Primatol.* 12: 1–53. https://doi.org/10.1002/ajp.1350120102

Junk, W. J., Piedade, M. T. F., Schöngart, J., Cohn-Haft, M., Adeney, J. M. and Wittmann, F. 2011. A classification of major naturally-occurring Amazonian lowland wetlands. *Wetlands* 31(4): 623–640. https://doi.org/10.1007/s13157-011-0190-7

Junk, W. J., Wittmann, F., Schöngart, J. and Piedade, M. T. 2015. A classification of the major habitats of Amazonian black-water river floodplains and a comparison with their white-water counterparts. *Wetl. Ecol. Manag.* 23: 677–693. https://doi.org/10.1007/s11273-015-9412-8

Kanai, J. M. and Schindler, S. 2019. Peri-urban promises of connectivity: linking project-led polycentrism to the infrastructure scramble. *Environ. Plann.* A 51: 302–322. https://doi.org/10.1177/0308518X18763370

Marsh, L. K. 2013. *Primates in Fragments: Ecology and Conservation*. Springer Science and Business Media. https://doi.org/10.1007/978-1-4757-3770-7

McLeman, R. A. and Hunter, L. M. 2010. Migration in the context of vulnerability and adaptation to climate change: insights from analogues. *Climate Change* 1: 450–461. https://doi.org/10.1002/wcc.51

Menezes, A. L. D. 2011. Gasoduto Urucu-Coari-Manaus: impacto ambiental e socioeconômico na cidade de Manacapuru/AM. Doctoral thesis, Universidade de São Paulo, São Paulo, Brazil.

Metzger, J. P. 2001. O que é ecologia de paisagens? *Biota Neotrop.* 1: 1–9. https://doi.org/10.1590/S1676-06032001000100006

Michalski, F., and Peres, C. A. 2005. Anthropogenic determinants of primate and carnivore local extinctions in a fragmented forest landscape of southern Amazonia. *Biol. Conserv*. 124(3): 383–396. https://doi.org/10.1016/j.biocon.2005.01.045

MMA. 2000. Sistema Nacional de Unidades de Conservação da Natureza. Ministério do Meio Ambiente. Brasília, DF, Brazil.

MMA/ICMBio. 2018. *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Volume II – Mamíferos*, 1a. ed., Brasília, DF.

Moraes, C. P. 2006. Arqueologia na Amazônia Central vista de uma perspectiva da região do Lago do Limão. Master's thesis, Museu de Arqueologia e Etnologia, Universidade de São Paulo, São Paulo, Brazil.

Myster, R. W. 2018. Igapó *(Black-water flooded forests) of the Amazon Basin*, Springer. https://doi.org/10.1007/978-3-319-90122-0

Nowak K., Barnett, A. A. and Matsuda, I. 2020. *Primates in Flooded Habitats: Ecology and Conservation*, Cambridge University Press. https://doi.org/10.1017/9781316466780

Mourthé, Í., Hilário, R. R., Carvalho, W. D. and Boubli, J. P. 2022. Filtering effect of large rivers on primate distribution in the Brazilian Amazonia. *Frontiers Ecol. Evol.* 10: 857920. https://doi.org/10.3389/fevo.2022.857920

Palacios, E. and Peres, C. A. 2005. Primate population densities in three nutrient-poor Amazonian *terra firme* forests of south-eastern Colombia. *Folia Primatol.* 76: 135–145. http://dx.doi.org/10.1159/000084376

Parolin, P., Armbruester, N., Wittmann, F., Piedade, M. T. F. and Junk, W. J. 2002. A review of tree phenology in central Amazonian floodplains. *Publ. Inst. Nac. Pesq. Amazonia Bot.* 52: 195–222.

Peres, C. A. and Cunha, A. 2011. *Line-Transect Censuses of Large-Bodied Tropical Forest Vertebrates: A Handbook*. Wildlife Conservation Society, Brasília. https://ueaeprints.uea.ac.uk/id/eprint/38569

Pinheiro, H. A. 2015. Oleiros da vida: trabalho, ambiente e o futuro dos trabalhadores do barro em Iranduba/AM. Doctoral thesis in Environmental Science and Sustainability, Universidade Federal do Amazonas, Manaus, Brazil.

Pita, R., Mira, A. and Beja, P. 2013. Influence of land mosaic composition and structure on patchy populations: the case of the water vole (*Arvicola sapidus*) in Mediterranean farmland. *Plos One* 8(7): e69976. https://doi.org/10.1371/journal.pone.0069976

Queiroz, H. L. 2005. A criação da Reserva Amanã: um importante estágio para a consolidação do embrião do Corredor da Amazônia Central. In: *Os Corredores Ecológicos das Florestas Tropicais do Brasil*, J. M. Ayres, G. A. B. da Fonseca, A. B. Rylands, H. L.Queiroz, L. P. Pinto, D. Masterson et al. (eds.), pp.246–249. Sociedade Civil Mamirauá, Belém.

Ramos, C. J. P. 2015. Simulação da dinâmica espacial do desmatamento na área dos municípios sob influência direta da ponte do Rio Negro, Amazonas. Master's thesis, Instituto Nacional de Pesquisas da Amazonia, Manaus, Brazil.

Ramos, C. J. P., de Alencastro Graça, P. M. L. and Fearnside, P. M. 2018. Deforestation dynamics on an Amazonian peri-urban frontier: simulating the influence of the Rio Negro Bridge in Manaus, Brazil. *Environm. Manag.* 62(6): 1134–1149. https://doi.org/10.1007/s00267-018-1097-3

Ribeiro, E. M., Machado, A. L. S., Oliveira, E. C. and do Nascimento, E. P. 2012. Comunidades à margem da sustentabilidade: um olhar sobre o Polo Ecoturístico de Iranduba (AM). *Rev. Bras. Ecotur.* 5(1): 11–26.

Rocha, A. 2017. Disponibilidade de recursos e antropização estruturando a assembleia de primatas na floresta de *igapó*. Master's thesis in Ecology, Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Brazil.

Roosevelt, A. C., Douglas, J. and Brown L. 2002. The migrations and adaptations of the first Americans: Clovis and pre-Clovis viewed from South America. In: *The First Americans: The Pleistocene Colonization of the New World*, N. G. Jablonski (ed.), pp.159–236. Wattis Symposium Series in Anthropology, California.

Spix, J. B. 1823. *Simiarum et vespertilionum Brasiliensium species novae, ou Histoire naturelle des espèces nouvelles de singes et de chauves-souris, observées et recueillies pendant le voyage dans l'intérieur du Brésil.* Typis Francisci Seraphici Hübschmanni, Monaco.

Tomanek, P., Mourthé, I. and Barnett, A. A. 2020. Calls for concern: matching alarm response levels to threat intensities in three Neotropical primates. *Acta Oecol.* 109: 103646. https://doi.org/10.1016/j.actao.2020.103646

Torres, I. and Pereira, H. 2007. A vida à beira da cidade–história e etnografia do Cacau Pirêra/Iranduba (AM), *Somanlu* 7(2): 59.