Surveys of a High-Diversity Primate Community in a Forestry Concession, Ucayali, Peru

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Abstract: The western Amazon has the highest levels of primate sympatry in the Neotropics. These important primate communities are increasingly threatened by anthropogenic activities of hunting and habitat loss and disturbance. Sustainably managed forestry has been suggested as an economic activity that can generate income for local communities, contribute to national economies, and aid in long-term conservation of wildlife and habitats. At the request of the company LUSH, we carried out two rapid surveys (2019 and 2021) of the primate community at a forestry concession managed by the company in the Ucayali Region, Peru. We also noted threats to primates and habitat in areas surrounding the concession *ad libitum*. We found 12 primate taxa living in sympatry. They included threatened species such as *Cacajao ucayalii*, *Lagothrix lagothricha*, and *Ateles chamek.* Harvesting of Palo Rosa (*Aniba rosaeodora*: Lauraceae) in the concession has been suspended since 2016 due to a Peruvian government moratorium on the export of the species. The company has since maintained a skeleton staff to ensure the integrity of the concession. Illegal logging and other prohibited activities are common in the area surrounding the concession, and in downstream communities we found many primates hunted for food and for pets. Within the concession, the habitats are intact, and we found evidence of only historic logging and rare instances of hunting. The high diversity of primates at the site makes the continued implementation of sustainable logging practices of great importance, particularly in view of the current situation in the surrounding area.

Keywords: Management, distributions, logging, abundance, hunting

Resumen: La Amazonía occidental tiene los mas altos niveles de simpatría de primates en el Neotrópico. Estas comunidades de primates tan diversas están cada vez más amenazadas por las actividades antropogénicas de caza y pérdida y alteración del hábitat. La silvicultura gestionada de forma sostenible ha sido sugerida como una actividad económica que puede generar ingresos para las comunidades locales, contribuir a las economías nacionales y ayudar a la conservación a largo plazo de la vida silvestre y los hábitats. A pedido de la empresa LUSH, realizamos dos censos rápidos (2019 y 2021) de la comunidad de primates en una concesión forestal administrada por esta empresa en la Región Ucayali, Perú. Encontramos 12 taxones de primates viviendo en simpatría. Éstas incluían especies amenazadas como *Cacajao ucayalii*, *Lagothrix lagothricha* y *Ateles chamek*. La cosecha de Palo Rosa (*Aniba rosaeodora*) en la concesión se suspendió en 2016 debido a una moratoria del gobierno peruano sobre la exportación de la especie. Desde entonces, la empresa ha mantenido personal para garantizar la integridad de la concesión. En el área que rodea la concesión, la tala ilegal y otras actividades prohibidas son muy comunes, y en las comunidades río abajo encontramos muchos primates usados como mascotas o carne de monte. Dentro de la concesión, los hábitats están intactos con evidencia únicamente de tala histórica y raros casos de caza. La alta diversidad de primates en el sitio hace que la continua implementación de prácticas sostenibles de tala sea de gran importancia, particularmente en vista de la situación actual en el área circundante.

Palabras clave: Manejo, distribuciones, tala, abundancia, caza

Introduction

Primate species diversity varies widely across the Neotropics and is highest in the western Amazon (Rylands 1987; Peres 1988, 1993; Haugaasen and Peres 2005). This natural variation depends on factors such as current and historic site-specific habitat characteristics, climatic variation, and physical barriers to range boundaries (Reed and Fleagle 1995; Boubli *et al*. 2015; Lynch Alfaro *et al*. 2015). On the broadest scale in the Amazon, unflooded terra firma forests generally have higher primate species diversity than seasonally flooded *igapó* and *várzea* sites (Haugaasen and Peres 2005), although primate community densities, abundance, and biomass in seasonally flooded sites can equal or exceed that in unflooded terra firma forests (Haugaasen and Peres 2005). At the local scale, it is the area of suitable habitat available, variety of microhabitats, and local climate that determine natural species richness (Reed and Fleagle 1995; Haugaasen and Peres 2005; Calle-Rendón *et al*. 2020). At sites with notable levels of anthropogenic disturbance and hunting, species richness is generally lower (larger species are extirpated), but primate community density and biomass as a whole can equal those at unhunted sites through density compensation of smaller species replacing larger species (Peres and Dolman 2000).

Anthropogenic activities, principally changes in land use, are the main cause of local primate extinctions and the main threat to tropical species globally (Estrada *et al*. 2017), with deforestation rates set to increase in the near future (Carvalho *et al*. 2019). The search for alternative land uses and income streams compatible with conservation has become a major issue for governments, NGOs and researchers (Sears and Pinedo-Vasquez 2011; Rico *et al*. 2018). Sustainably managed timber harvesting has been suggested as a mechanism to mitigate the loss and degradation of natural areas in the tropics while aiding local and national economic development (Pearce *et al*. 2003). Of Peru's ~1.29 million km², approximately 142,050 km² (11% of the country) are in areas demarcated as Permanent Production Forests (Bosques de Producción Permanente), of which just over half (73,285 km²) are in active or proposed forestry concessions for timber extraction (Fines Maderables) (Authors' calculations from government data downloaded 05/05/2022, source: <https://geo.serfor.gob.pe/visor/>).

The efficacy and actual conservation impact of sustainable forestry practices in much of the world's tropics, including Peru, are still under debate (Pearce *et al*. 2003; Sears and Pinedo-Vasquez 2011; Putz *et al*. 2012). Under the current forestry and wildlife law, extractive timber concessionaires in Peru must contribute to local economies and work under a management plan to promote, among other things, the sustainability of timber harvests and the conservation of biodiversity. Sustainably managed forestry concessions have been shown to reduce clearcutting of forests in parts of the Peruvian Amazon (Oliveira *et al*. 2007). However, sustainability and management of forestry concessions depend on the completion of management plans and on legislation. Poorly managed forestry concessions across Indonesia have been converted to oil palm plantations, with disastrous consequences for local primate populations (Supriatna *et al*. 2017). The implementation of extractive forestry operations in remote areas can also lead to increased hunting of primates due to increases in human presence and the construction of new roads allowing for easier access (Bowler 2007; Haurez *et al*. 2013).

Peru has the fifth highest primate diversity of any country (59 taxa), the majority being found in the country's extensive Amazonian lowlands which cover ~60% of Peru's land surface (Aquino *et al*. 2015; Pacheco *et al.* 2009; Shanee *et al*. 2017). Sixteen (27%) of Peru's primates are threatened with extinction (IUCN 2021), primarily due to habitat loss and hunting. From 2001 to 2014 Peru lost almost 120,000 ha of Amazonian forest per year (Perú, Programa Bosques 2015), with an additional 1.43 million ha between 2014 and 2019 (Global Forest Watch 2020). The best current estimates on hunting offtake rates suggest that many primate species are threatened by hunting for bushmeat, sport, belief-based use, and the illegal pet trade, and that for many species and in many areas this has become unsustainable (Shanee 2012; Shanee *et al.* 2015; Mendoza *et al*. 2022). Any program to conserve primates needs to be based on up-to-date information on the diversity and distribution of the target taxa, particularly considering anthropogenic habitat destruction and climate change (Hansen *et al*. 2001; Newbold *et al*. 2014; Sales *et al*. 2020). In Peru, many areas and several primate species have yet to be the focus of detailed field studies. The recently launched *Plan Nacional de Conservación de los Primates Amenazados del Perú* aims to rectify this (Peru, SERFOR 2020).

At the request of the cosmetics company LUSH UK, we carried out rapid biological inventories of mammals, birds, reptiles, amphibians, and plants at a forestry concession in Peru's central Amazon, which is managed by the company's Peruvian arm (LUSH Peru S.A.C.). We also carried out socioeconomic surveys in indigenous communities surrounding the concession. These surveys aimed to evaluate the conservation importance of the area in order to aid the company in deciding whether or not to maintain the area as a concession. Here we report the results of these surveys focused on primates.

Methods

Study site

We carried out surveys in a ~5,955 ha forestry concession (contract number No 25-PUC/C-J-061-03, permanent plot No 158) run by LUSH Peru S.A.C. The southern portion of the concession is in the Ipiria District, with the northern portion in the Masisea District, both in Coronel Portillo Province, Ucayali Region (9°10'53.96"S, 74°2'48.10"W). The site lies approximately 100 km southeast of the city of Pucallpa, the regional capital (Fig 1).

The concession is surrounded by four other active forestry concessions which are used for timber extraction by the legal concessionaries, and are also heavily and illegally logged by third parties. By river, the area is approximately 10 km east of the indigenous community of Pueblo Nuevo del Caco, the nearest community to the site. Communities in the area are of predominantly Shipibo-Conibo origin. Forestry concessions and indigenous communities are the only major land-ownership types in the wider area. The concession had previously been used for commercial timber extraction but was awarded to LUSH in 2012 for the harvesting of resin from Palo Rosa (*Aniba rosaeodora*: Lauraceae), an Endangered tree (IUCN 2021), and listed on Appendix II of CITES (CITES 2022). The oil extracted from Palo Rosa is a common ingredient in many cosmetics. The Peruvian government imposed a moratorium on the extraction of Palo Rosa in 2016 due to uncertainty over the species' conservation status. LUSH has maintained the concession without harvesting any products since, while waiting for permission to renew extraction. During this time, they have also actively prohibited the entrance of illegal loggers or hunters to the area. At the start of the pandemic, those workers who were at the site were not able to leave due to enforced restrictions on movements, and after this LUSH maintained a skeleton staff of minimum 2–3 people on a rotational basis to ensure the integrity of the concession and security of the installations during the COVID-19 pandemic period.

Forests in the area belong to the Southwest Amazon moist forest ecoregion, with small patches of Iquitos *várzea* (Fig. 1, Dinerstein *et al*. 2017). The site includes lowland terra firma and seasonally flooded *várzea* forests typical of the western Amazon. The only access to the concession is by motor canoe along the Río Sismaya, a tributary of the Río Caco, itself a tributary of the Río Ucayali. According to the *Servicio Nacional de Meterología e Hidrología del Perú* (SENAMHI), mean annual daytime temperatures at the site vary between 19.7 and 30.6°C. The heavy rainy season lasts from November until April, with average annual rainfall of 1,753 mm. but with sporadic showers and storms possible throughout the year. Soils in the area are Entisols, Inceptisols and Ultisols. The seasonal flooding regime in much of

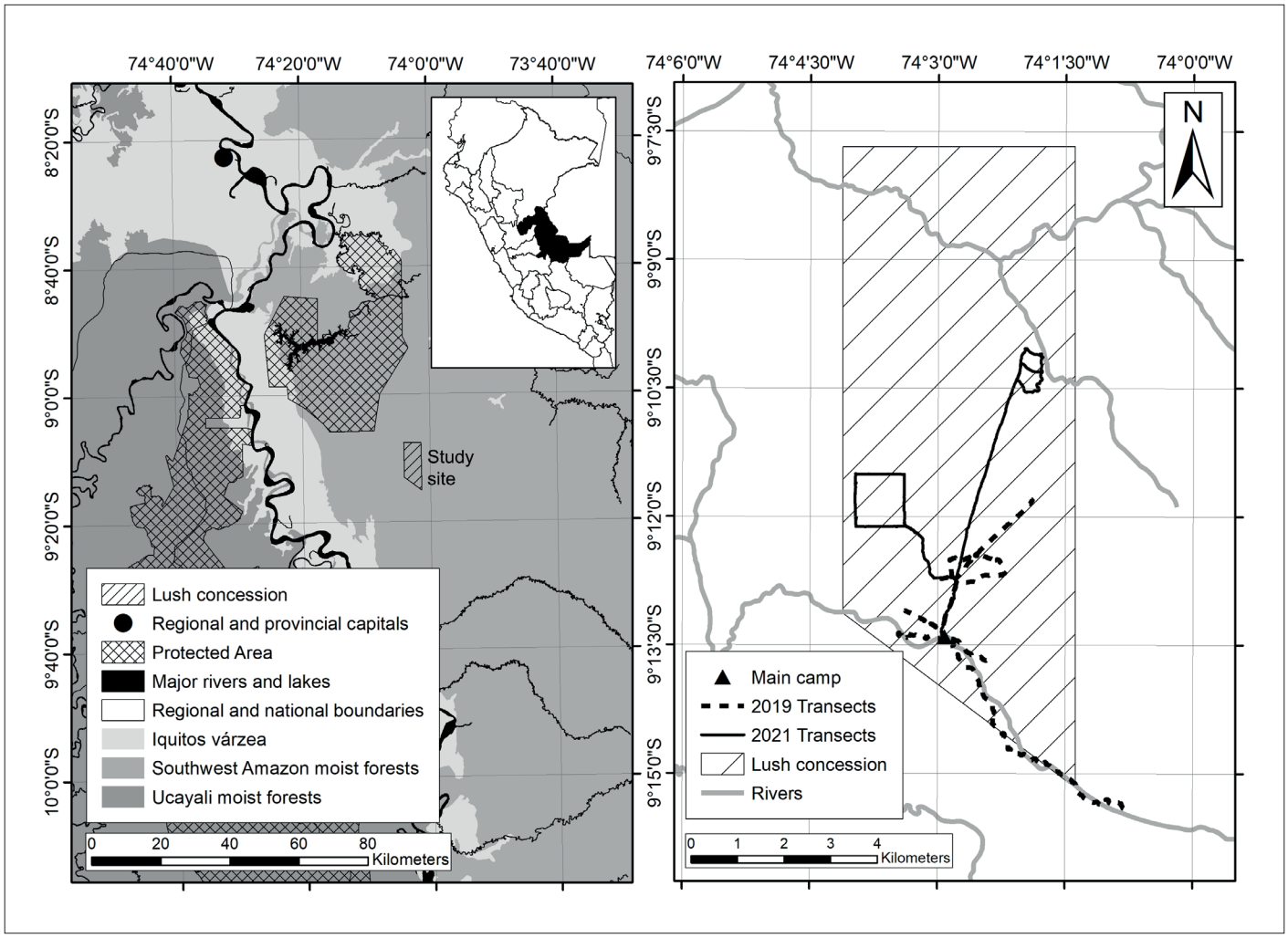

Figure 1. Survey site location in Peru, showing major geographic features (left) and detail map of concession site and (right) showing transects used in the two surveys.

the area keeps the lower strata and forest floor relatively free of plant growth.

Surveys

Our fieldwork was carried out during two survey periods, one between the 28 January and 6 February 2019 and the second from 17–25 November 2021. The first survey took place during the rainy season, and the second towards the end of the dry season. The COVID-19 pandemic made it impossible to conduct the second survey earlier. We conducted field surveys using rapid biological inventory methods, following standardized linear transect methods as closely as possible (Peres 1999; Pitman *et al.* 2014; Allgas *et al*. 2018). Researchers walked in pairs accompanied by concession staff as field guides. The guides were essential in trail finding and entering new areas, and in spotting and identifying species. All staff members who accompanied us were from local indigenous communities. We walked the existing trail system and entered new areas, being careful to keep disturbance to a minimum. Existing trails were those used for extraction of timber prior to the awarding of the concession to LUSH. These trails are maintained and periodically cleaned for censusing Palo Rosa for potential future extractive activity. Trails were walked at all times of day, including some nocturnal surveys, at a pace ~1 km/h, stopping approximately every 50–100 m to observe the surroundings. We recorded evidence of the presence of non-primate mammals, both terrestrial and arboreal but with particular emphasis on primates. When detected, we recorded the species and location with a handheld GPS (Garmin GPSMap 60CSx), and recorded date, time, activity, and any interspecific associations and interactions. We did not record survey effort during the 2019 visit. As such, we only calculated abundance for the 2021 survey. We estimated simple abundance (number of detections/10 km) based on primate detections during large mammal survey walks. Additional presence records of species from detections during non-mammal surveys were not considered in abundance calculations, but were included when determining diversity, here defined as the number of different taxa present at the site.

As part of the surveys requested by LUSH, we also surveyed trees, shrubs, and lianas that were identified in interviews and by local guides as being of possible interest for commercial development, and to characterize habitat. Species were identified in the field by local name, and samples collected for identification using published keys and comparison with specimens held at the herbarium of the Forestry Sciences Faculty of La Molina National Agricultural University, Lima. Although we do not analyse our findings in relation to habitat surveys, we nonetheless include the plant list here for completeness and as it may aid in future research and conservation work.

Conservation assessment

While carrying out survey work, we qualitatively examined the condition of the forest and levels of anthropogenic disturbance, looking for signs of logging, hunting, or other disturbance that could impact primate populations. Through conversation with staff, we were also able to gauge the pressures facing the concession and neighbouring areas. Also, we noted river traffic along the ríos Sismaya and Caco, recording instances of timber and wildlife being transported, as well as the legality or illegality of these activities, and noted instances of the consumption and keeping of wildlife in the neighboring indigenous communities we visited during the survey periods.

Results

Surveys

Survey effort and the areas surveyed varied between years and were highly dependent on weather conditions and water levels in flooded forest areas. During the 2019 wet season survey, we were restricted to surveying only the southern portion of the concession due to seasonal flooding. In 2021, we were able to access more distant northern areas of the concession (Fig. 1). Total mammal survey effort was 111.7 km (52.2 km in 2019 and 59.5 km in 2021) for diurnal surveys. This was divided between six trails or trail portions, which varied in length from 1.1 to 4.8 km, one river-based transect of 7.2 km in 2019, and seven trails or trail portions, which varied in length from 0.4 to 5.3 km in 2021 (Fig. 1). Some trails were surveyed during both survey periods.

Between both surveys, we recorded the presence of 12 primates (Table 1, Fig. 2). All species were recorded during both years except for the coppery titi monkey (*Plecturocebus cupreus*) and the Peruvian black-faced spider monkey (*Ateles chamek*), which were recorded only in 2021, with *P. cupreus* only recorded in riparian habitat. No titi monkey calls were heard during the 2019 survey, nor in the forest interior during the 2021 survey. *Aotus* cf. *nigriceps* was only detected during nocturnal surveys. The most commonly detected species were the moustached tamarin (*Tamarinus mystax*), Weddell's saddle-back tamarin (*Leontocebus weddelli*), and the Bolivian squirrel monkey (*Saimiri boliviensis*) (Table 1). We observed several instances of mixed-species groups of *L. weddelli* and *T. mystax,* and of *Cebus unicolor* and *S. boliviensis*.

Species of conservation interest observed included the black-faced spider monkey (*Ateles chamek*) EN, Humboldt's woolly monkey (*Lagothrix lagothricha*) VU, and the Ucayali bald uakari (*Cacajao ucayalii*) VU (Table 1). We found no direct evidence of either the southern pygmy marmoset (*Cebuella niveiventris*) or Goeldi's monkey (*Callimico goeldii*), although the IUCN Red List includes estimated distributions for both species that would overlap the area (IUCN 2021). Interviews with concession staff and local informants provided conflicting information on the possible presence of these species in or around the area.

Of the 107 plants sampled, 103 were identified to genus and 93 to species level. Plants identified came from 51 families, and 82 genera. The most diverse families were

Table 1. Primate species recorded during surveys, and details of detections and abundance for 2021 survey.

Species	2019 survey	2021 survey	Number of detections (2021 only)	Encounter rate group detections/10 km* (2021 only)	Conservation status IUCN/ Peru	Observations
Aotus cf. *nigriceps***	X	X	1	-	LC	Only detected on night surveys
Tamarinus mystax	X	X	7	1.2	LC	
Leontocebus weddelli	X	X	6	1.0	LC	
Saimiri boliviensis	X	X	6	1.0	LC	
*Plecturocebus cupreus***	-	X	4	0.7	LC	Only detected in riverine forest
Cebus unicolor	X	X	5	0.8	NT	
Sapajus apella	X	X	3	0.5	LC	
Pithecia inusta	X	X	2	0.3	LC	
*Cacajao ucayalii****	X	X	-	-	VU	Not recorded on transects
*Alouatta seniculus****	X	X	1	-	LC	
*Lagothrix lagothricha****	X	X	1	-	VU/EN	
Ateles chamek	-	X	2	0.3	EN/EN	
Primates			37	6.2		

*Survey effort 59.5 km ** *P. cupreus* detection rate not included in overall encounter rate as only detected in riverine forest. ***Encounter rate not calculated as number of detections too low.

Rubiaceae, with eight species, and Bignoniaceae, Fabaceae, and Moraceae, with six species each. The most diverse genera were *Ficus* (Moraceae), *Fridericia* (Bignoniaceae) and *Palicourea* (Rubiaceae), with four species each. The full plant list and the estimated abundance of each species is given in an appendix.

Conservation assessment

During the surveys, local staff informed us about illegal activities occurring in the wider area, including logging, hunting, and coca farming (for cocaine production). We saw constant evidence of illegal logging in the area outside the concession, including logging camps along the Río Sismaya above and below the concession. We visited and spoke with the loggers at one of the camps, and noticed the transport of tree trunks down the river during both survey periods. Although the neighboring areas are legally concessioned to logging companies, local informants told how these are generally overrun by illegal operations, which do not work within the stipulated management plans for long-term sustainability. At the illegal loggers' camp that we visited in 2019, we observed the consumption of bushmeat, including armadillo, deer, and primates, as the main staple of the diet, aside from rice and fish. We were able to observe the transport of several live animals, including primates, in one of the logger's canoes, as they escorted harvested timber being floated downstream until being collected at the confluence of the ríos Caco and Ucayali (Fig. 3). Presumably, the animals were for sale in markets downriver either for bushmeat or as pets. During our visits to local communities, we observed several young primates kept as pets that had been obtained after the mother had been caught and eaten. They included *Ateles chamek*, *Cacajao ucayalii*, and *Sapajus apella* (Fig. 3).

In the LUSH concession, we found no evidence of logging during either survey. We did find evidence of low levels of hunting, including three instances of shotgun cartridges on the trails. During the 2021 survey, at least one *Sapajus apella* was killed by another visiting research team's indigenous guide (Fig. 3). The company subsequently notified the research team and took steps to ensure anti-hunting rules would be respected in the future.

Discussion

Our access to parts of the concession was limited during the 2019 survey because much of the area was underwater and, even with greater access in 2021, much of the concession remains unexplored by researchers (Fig. 1). Primates were the mammals most often seen during surveys, with 12 species living in sympatry. This places the concession as one of the most primate-rich sites in Peru, equal to the diversity found in the 1.7 million-ha Pacaya-Samiria National Park (Allgas *et al*. 2018), and just below that of the Tamshiyacu-Tahuayo Regional Conservation Area (Puertas and Bodmer 1993), and the globally recognized 2 million-ha Manu National Park (Terborgh 1983), with 13 species each. This last site has an altitudinal gradient in the thousands of meters,

Figure 2. Primates photographed during surveys; (**a**) *Cacajao ucayalii* (**b**) *Leontocebus weddelli* (**c**) *Lagothrix lagothricha* (**d**) *Saimiri boliviensis* (**e**) *Ateles chamek* (**f**) *Aotus* cf. *nigriceps* (**g**) *Pithecia inusta* (**h**) *Tamarinus mystax*.

Figure 3. (**a**) and (**b**) illegally logged timber being floated downstream past the LUSH concession (**b**) a captive *Cacajao ucayalii* in a local indigenous village and (**c**) *Sapajus apella* being prepared for consumption.

meaning not all primate species are found in sympatry. This is also on par with global hotspots of primate diversity such as Ranomafana National Park, Madagascar, which is home to at least 13 species (Wright *et al*. 2012). The primate community composition and detection rates that we found are within the ranges of those for similar primate communities found in previous studies at other sites in Peru (Table 2).

The diversity and abundance of primates in the area suggests that it is well conserved. Our observations of non-primate mammals at the site (Table 3), such as jaguar (*Panthera onca*), white-lipped peccary (*Tayassu peccari*), and giant armadillo (*Priodontes maximus*), further suggest that disturbance and hunting pressure is low. The seemingly healthy mammal assemblage in the area is important considering the many indigenous communities in the surrounding area, with the concession possibly providing a source and refuge for species traditionally used by the Shipibo (Anca 2022). Notwithstanding the key role which indigenous communities and the recognition of traditional territorial rights play in the conservation and persistence of primates across the globe (Estrada *et al*. 2022), hunting by local people, including indigenous groups, can cause the local extirpation of prey species at hunted sites (Peres and Dolman 2000). A study at the nearby Shipibo community of Pueblo Nuevo del Caco found much lower abundance and the absence of many of the larger mammals, with local Shipibo attributing this to hunting and forest disturbance driving species away from their villages (Anca 2022).

The diversity and abundance of primates at the site means that the community may have recovered from previous disturbance when the concession was being actively logged for timber. Although inactive, and with plans for future sustainable management, the site still faces pressures from legal and illegal logging in the surrounding area, as well as hunting from loggers. The effects of selective logging and harvesting of non-timber forest products on wildlife can vary. Some arboreal mammals, including primates, are greatly affected by forest disturbance, more than their terrestrial counterparts. A study in the Manu Biosphere Reserve found a 64% decrease in mean occupancy of the arboreal mammal community, with decreases in populations of primates including *Ateles*, *Lagothrix*, and *Alouatta* (Whitworth *et al*. 2019). Another meta-analysis of published literature found that birds were negatively affected, whereas species richness of plants, mammals, and invertebrates, showed no significant difference in harvested and non-harvested forest areas (Putz *et al*. 2012). To reduce the impact of future commercial extraction, LUSH plans to process Palo Rosa on-site

Table 2. Comparative abundance (group detections/10 km) from seven studies across Peru. Species names given follow those in the original publication.

	This Study	Lower ríos Urubamba and Tambo (Aquino *et al*. 2013)	Rio Curaray (Kolowski & Alonso 2012)	Río Tapiche * (Bennett *et al*. 2001)	Parque Nacional Manu (Endo *et al*. 2010)	Lower Urubamba (Gregory *et al*. 2017)	South Peru** (Palminteri *et al*. 2011)
Alouatta	-	0.6 *A. seniculus*	0.2 *A. seniculus*	1.5/2.1 *A. seniculus*	1.01 *A. seniculus*	0.14 *A. seniculus*	0.6 *A. sara*
Ateles	0.3	0.3 *A. chamek*	2. 7 *A. belzebuth*	-	-	-	1.7 *A. chamek*
Cebus	0.8	0.4 *C. albifrons*	0.3 *C. albifrons*	0.1/0.3 *C. albifrons*	1.94 *C. albifrons*	0.43 *C. albifrons*	0.4 *C. albifrons*
Lagothrix	-	0.2 *L. cana*	4.7 *L. poeppigii*	-	-	-	0.4 *L. cana*
Leontocebus	1.0	-	1.9 *S. fuscicollis*	2.0/1.7 *S. fuscicollis*	0.5 *S. fuscicollis*	1.62 *S. fuscicollis*	1.4 *S. fuscicollis*
Pithecia	0.3	-	0.85 *P. aequatorialis*	1.4/0.1 *P. monachus*	0.09 *P. irrorata*	0.1 *P. irrorata*	0.3 *P. irrorata*
Plecturocebus	0.7	1.3 *C. brunneus*	0.8 *C. discolor*	0.1/0.11 *C. cupreus*	0.25 *C. brunneus*	0.1 *C. brunneus*	0.8 *C. brunneus*
Saimiri	1.0	0.3 *S. boliviensis*	0.5 *S. sciureus*	1.7/0.27 *S. boliviensis*	-	-	0.5 *S. boliviensis*
Sapajus	0.5	0.4 *C. apella*	0.9 *C. apella*	0.9/1 *C. apella*	2.03 *C. apella*	0.48 *S. apella*	1.5 *C. apella*
Tamarinus	1.2	1.2 *S. imperator*	-	-	0.25 *S. imperator*	0.52 *S. imperator*	0.2 *S. imperator*
Primates	**6.2**	**-**	**12.8**	**6.5/9.9**	**-**	**2.24**	**-**

* Values given for east and west side of river, ** Average group abundance across 37 sites in southern Peru.

through the processing of coppiced tree limbs, rather than the felling and transport of whole trees. We also noted a small tree nursery of Palo Rosa saplings for supplementing the current population at the site.

In the Congo Basin, the growing timber industry has had negative impacts on western lowland gorilla populations (*Gorilla gorilla gorilla*), and new roads leading into gorilla habitat have led to increased levels of hunting along with rising demand for bushmeat (Haurez *et al*. 2013). Similar trends have been reported from forestry concessions in the Peruvian Amazon, where influxes of forestry workers result in higher hunting levels (Bodmer *et al*. 2006; Bowler 2007; Bowler *et al*. 2013). The opening of a new gas pipeline in Cuzco Region, Peru, led to a drop in abundance of primates during and after construction (Gregory *et al*. 2017) and in northern Loreto, Peru, seismic oil exploration led to a drop in the number of individuals counted, although not in group counts (Kolowski and Alonso 2012). Although hunting by forestry concession workers is not legally permitted, increased consumption of wild meat, including primates, was recorded in communities in a logging concession along the Río Yavarí, Peru (Bodmer *et al*. 2006; Bowler *et al*. 2013). Even abandoned or disused logging concessions present problems, with hunters making use of old logging camps and routes even after logging operations have ceased.

Globally, crop expansion is expected to replace a significant amount of primate habitat, and undisturbed habitat is expected to be reduced in 98% of primate ranges (Isabirye-Basuta and Lwanga 2008; Estrada *et al*. 2019, 2020). As such, alternative land uses and the implementation of sustainable harvests are needed to slow the loss of forest habitats. Whilst some primate species may be able to adapt, larger and specialist species rarely persist in heavily disturbed environments (Cardillo *et al*. 2005). Finding a balance between the needs of local and national economies and conservation is a difficult but necessary task. The use of Reduced Impact Logging and other mechanisms to increase sustainability can lead to reductions in the impact of logging and forestry when compared to traditional logging practices (Carvalho Jr *et al*. 2021). The implementation of sustainable forestry practices, while still rare, can also provide long-term economic benefits over intensive extraction through sustained yields. One study found that intensive logging practices can lead to reductions in timber harvest levels of 45% between the first and second harvest, and up to 65% if the same species is repeatedly extracted (Putz *et al*. 2012), thus the implementation of sustainable harvests is necessary.

From our surveys, we found clear evidence for the presence of 12 primates at the concession site. If *Cebuella*

Table 3. Non-primate mammal species recorded through direct detection during surveys.

Order	Species	Common name	Conservation status (IUCN)
Carnivora	*Bassaricyon alleni*	Eastern lowland olingo	LC
	Leopardus pardalis	Ocelot	LC
	Lontra longicaudis	Neotropical otter	NT
	Panthera onca	Jaguar	NT
Cetartiodactyla	*Odocoileus virginianus*	White tailed deer	LC
	Tayassu peccari	White lipped peccary	VU
Cingulata	*Priodontes maximus*	Giant armadillo	VU
	Dasypus novemcinctus	Nine-banded armadillo	LC
Didelphimorphia	*Marmosops noctivagus*	White-bellied slender mouse opossum	LC
Perissodactyla	*Tapirus terrestris*	Lowland tapir	VU
Pilosa	*Tamandua tetradactyla*	Southern tamandua	LC
Rodentia	*Cuniculus paca*	Lowland paca	LC
	Dasyprocta fuliginosa	Black agouti	LC
	Sciurus ignitus	Bolivian squirrel	LC

niveiventris and *Callimico goeldii* are also present at the concession, as suggested by some local informants, then this is a remarkable site for its levels of primate sympatry. Only a handful of sites in the western Amazon are known to have 14 and 15 primate species living in sympatry (Rylands 1987; Peres 1988, 1993; Haugaasen and Peres 2005), which is possibly the highest primate diversity globally. Palminteri *et al*. (2011) did not find evidence of *C. goeldii* or *C. niveiventris* during surveys of 37 sites across Madre de Dios in southern Peru and, as with the LUSH concession, many of the sites surveyed were within the predicted distributions of both species. If they are absent from these areas, and not just as yet undetected, it provides evidence that the species' restricted diets and habitat specializations means that current estimates of their distributions may significantly overestimate the area actually occupied by these species (de la Torre *et al*. 2020).

The small size of the LUSH concession and level of threat from hunting, logging, and deforestation in other areas in the vicinity, mean that, without true sustainable management and protection, the local primate community may be lost in the near future. The nearest protected area, Imiría Regional Conservation Area, ~10 km north, which was declared in 2010, harbors the same primate species diversity (Peru, Gobierno Regional de Ucayali 2014), but is already facing extreme pressures due to the construction of a road through the park and illegal economic activities (Ibisch and Hobson 2015). The El Sira Communal Reserve lies ~50 km west of the area, but on the other side of the Río Ucayali, and the Sierra del Divisor and Alto Purus national parks are 100 km and 200 km to the north and south of the area, respectively, meaning there is no real protection in the nearby area.

Other concessions or non-protected areas in the Amazon, sites that generally face higher pressures from hunting and deforestation, could also host similar levels of biodiversity. Unfortunately logging concessions and other land use rights are often granted without prior surveys of biodiversity value. The LUSH concession is well-maintained and appears to provide an oasis for local wildlife. The high diversity of primates, and the possibility of additional primate species not yet recorded, warrants more study. The current level of protection afforded to the area may not be sufficient to ensure persistence of the primate community, and the lack of well-managed protected areas in the vicinity adds urgency to the need for proper enforcement of current forestry and wildlife laws. Such protection is necessary to ensure that neighbouring logging concessions provide the conservation benefits purported by the promise of sustainable forestry.

Conflict of interest and ethics statement

The surveys were funded by LUSH UK and organized together with LUSH Peru S.A.C. to determine the conservation status and value of the concession. The authors state that this has not influenced our findings, which are reported here honestly and in their entirety.

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Appendix

Plant species and abundance at the survey site.

Family	Species	Common name*	Abundance
Acanthaceae	*Mendoncia aspera* Ruiz & Pav.	Nariz de pinsho	Low
Achariaceae	*Mayna odorata* Aubl.	Sol del oriente	Medium
Annonaceae	*Annona hypoglauca* Mart.	Guanabana del monte	Medium
Annonaceae	*Duguetia odorata* (Diels) J.F. Macbr.	Tortuga	Medium
Annonaceae	*Oxandra sphaerocarpa* R.E. Fr.	Lagrimas de matatao	Medium
Annonaceae	*Xylopia parviflora* Spruce	Carahuasca de altura	Medium
Apocynaceae	Indeterminate	Retanrau	-
Apocynaceae	*Himatanthus sucuuba* (Spruce ex Müll. Arg.) Woodson	Ojé	Low
Araceae	*Monstera dubia* (Kunth) Engl. & K. Krause	Princesa	High
Araceae	*Dracontium spruceanum* (Schott) G.H. Zhu	Jergón sacha	Low
Araliaceae	*Dendropanax tessmannii* (Harms) Harms	Flor de la rosa	Medium
Arecaceae	*Iriartea deltoidea* Ruiz & Pav.	Pona	Medium
Asteraceae	Indeterminate	Amasisa de altura	-
Bignoniaceae	*Jacaranda copaia* subsp. *spectabilis* (Mart. ex DC.) A.H. Gentry	Planta acido	High
Bignoniaceae	*Fridericia aff. candicans* (Rich.) L.G. Lohmann	Paloma	Medium
Bignoniaceae	*Fridericia bracteolata* (DC.) L.G. Lohmann	Rosita	Medium
Bignoniaceae	*Fridericia japurensis* (DC.) L.G. Lohmann	Locrero	Medium
Bignoniaceae	*Fridericia pearcei* (Rusby) L.G. Lohmann	Cornetin	Medium
Bignoniaceae	*Tynanthus polyanthus* (Bureau) Sandwith	Dos compañeros	Medium
Burseraceae	*Protium sp*.	Grepes	High
Cannabaceae	*Celtis schippii* Standl.	Princesa	Medium
Chrysobalanaceae	*Hirtella bicornis* Mart. & Zucc.	Zimpzim	Low
Chrysobalanaceae	*Hirtella racemosa* Lam.	Sacha sanango	Low
Clusiaceae	*Clusia aff. hammeliana* Pipoly	Chiquech	High
Clusiaceae	*Dystovomita* sp.	Huaringa	Low
Costaceae	*Costus* aff. *erythrocoryne* K. Schum.	Shacha pion	High
Costaceae	*Goeppertia aff. legrelleana* (Linden) Borchs. & S. Suárez	Mani	High
Cucurbitaceae	*Gurania acuminata* Cogn.	Moquete de lobo	High
Cucurbitaceae	*Gurania bignoniacea* (Poepp. & Endl.) C. Jeffrey	Flor de paujil	High
Dilleniaceae	*Doliocarpus* sp.	Soga paujil	Low
Dryopteridaceae	*Mickelia guianensis* (Aubl.) R.C. Moran, Sundue & Labiak	Nobiumrau	Low
Ebenaceae	*Diospyros aff. nanay* B. Walln.	Cocona de árbol	Low
Fabaceae	Indeterminate	Papazo	-
Fabaceae	*Inga edulis* Mart.	Guaba	(Cultivated)
Fabaceae	*Copaifera* aff. *paupera* (Herzog) Dwyer	Copaiba	Low
Fabaceae	*Dipteryx micrantha* Harms	Shihuahuaco	Low
Fabaceae	*Lonchocarpus* sp.	Barbasco	Medium
Fabaceae	*Ormosia* sp.	Rabo de picaflor	Medium
Gesneriaceae	Indeterminate	Huallanchy	-
Gnetaceae	*Gnetum nodiflorum* Brongn.	Critz	Low
Heliconiaceae	*Heliconia schumanniana* Loes.	Lengua de pinshra	High
Hypericaceae	*Vismia glabra* Ruiz & Pav.	Palo sangre	High
Hypericaceae	*Vismia macrophylla* Kunth	Árbol del mentol	High
Lauraceae	*Nectandra* sp.	Moena	Medium
Lauraceae	*Ocotea* sp.	Palta moena	Medium

Family	Species	Common name*	Abundance
Linaceae	*Hebepetalum humiriifolium* (Planch.) Benth.	Choro huayo	Medium
Linaceae	*Roucheria columbiana* Hallier f.	Mentol	Medium
Linaceae	*Roucheria schomburgkii* Planch.	Camu camu huayo	Medium
Linderniaceae	*Lindernia crustacea* (L.) F. Muell.	Tiri tiri	High
Loganiaceae	*Strychnos aff. jobertiana* Baill.	Compañero de cocona de monte	Low
Loranthaceae	*Passovia pyrifolia* (Kunth) Tiegh.	Suelda con suelda	Low
Malpighiaceae	*Banisteriopsis caapi* (Spruce ex Griseb.) C.V. Morton	Ayahuasca	Medium
Malpighiaceae	*Banisteriopsis martiniana var. subenervia* Cuatrec.	Nariz de tuqui tuqui	Medium
Malvaceae	*Ochroma pyramidale* (Cav. ex Lam.) Urb.	Topa	High
Malvaceae	*Apeiba membranacea* Spruce ex Benth.	Toé de monte	Medium
Malvaceae	*Ceiba samauma* (Mart.) K. Schum.	Lupuna	Medium
Malvaceae	*Pseudobombax septenatum* (Jacq.) Dugand	Punga	Medium
Melastomataceae	*Aciotis acuminifolia* (Mart. ex DC.) Triana	Tabu	High
Melastomataceae	*Adelobotrys aff. adscendens* (Sw.) Triana	Maquisapa pusanga	Low
Melastomataceae	*Bellucia pentamera* Naudin	Frente de mono	Medium
Melastomataceae	*Graffenrieda miconioides* Naudin	Renaquillo de altura	Medium
Meliaceae	*Guarea macrophylla* Vahl	Casho	Medium
Meliaceae	*Trichilia inaequilatera* T.D. Penn.	Nariz de paujil	Medium
Meliaceae	*Trichilia pallida* Sw.	Gavilan	Medium
Moraceae	*Ficus trigona* L. f.	Renaquillo	High
Moraceae	*Ficus americana* Aubl.	Renaquillo	Low
Moraceae	*Ficus caballina* Standl.	Renaco	Low
Moraceae	*Ficus* sp.	Papá macho	Low
Moraceae	*Naucleopsis krukovii* (Standl.) C.C. Berg	Caimitillo de altura	Medium
Moraceae	*Sorocea muriculata* Miq.	Mueské	Medium
Myristicaceae	*Otoba parvifolia* (Markgr.) A.H. Gentry	Camu camu de altura	High
Myristicaceae	*Virola pavonis* (A. DC.) A.C. Sm.	Cumala	High
Myrtaceae	*Psidium guajava* L.	Guayaba	(Cultivated)
Myrtaceae	*Eugenia discreta* McVaugh	Gavilan macho	Medium
Myrtaceae	*Myrcia guianensis* (Aubl.) DC.	Flor de rosa	Medium
Ochnaceae	*Cespedesia spathulata* (Ruiz & Pav.) Planch.	Almendra	Medium
Phyllanthaceae	*Hieronyma alchorneoides* Allemão	Gallinazo ajos	High
Piperaceae	*Piper conispicum* Trel.	Santa maría	High
Piperaceae	*Piper gratum* Trel.	Riouco	High
Polypodiaceae	*Phlebodium decumanum* (Willd.) J. Sm.	Coto remedio	Low
Proteaceae	*Panopsis rubescens* (Pohl) Pittier	Cocona de árbol	Low
Pteridaceae	*Adiantum tetraphyllum* Humb. & Bonpl. ex Willd.	Nobiumrau	High
Rubiaceae	*Palicourea cymosa* (Ruiz & Pav.) Standl.	Pion colorado del monte	High
Rubiaceae	*Palicourea nigricans* K. Krause	Planta paloma macho	High
Rubiaceae	*Palicourea paulina* (Standl.) C.M. Taylor	Sanango	High
Rubiaceae	*Palicourea* sp.	Sigueme sigueme	High
Rubiaceae	*Palicourea tomentosa* (Aubl.) Borhidi	Planta paloma hembra	High
Rubiaceae	*Psychotria marginata* Sw.	Yacuruna de altura	High
Rubiaceae	*Calycophyllum megistocaulum* (K. Krause) C.M. Taylor	Capirona de altura	Medium
Rubiaceae	*Uncaria guianensis* (Aubl.) J.F. Gmel.	Uña de gato de altura	Medium
Rutaceae	*Ertela trifolia* (L.) Kuntze	Paico de altura	High
Salicaceae	*Banara guianensis* Aubl.	Cashma	High
Salicaceae	*Tetrathylacium macrophyllum* Poepp.	Tangarana de hoja grande	High
Salicaceae	*Xylosma benthamii* (Tul.) Triana & Planch.	Panguana	Low

Family	Species	Common name*	Abundance
Selaginellaceae	*Selaginella flexuosa* Spring	Frente de carachama	High
Siparunaceae	*Siparuna guianensis* Aubl.	Ardilla huayo	High
Siparunaceae	*Siparuna thecaphora* (Poepp. & Endl.) A. DC.	Ardilla huayo colorado	High
Solanaceae	*Solanum sessiliflorum* Dunal	Cocona	(Cultivated)
Solanaceae	*Solanum* sp.	Toé hembra	High
Solanaceae	*Solanum leucopogon* Huber	Sacha ishanga	Medium
Urticaceae	*Cecropia ficifolia* Warb. ex Snethl.	Shiary	High
Urticaceae	*Coussapoa villosa* Poepp. & Endl.	Toé de monte	High
Urticaceae	*Pourouma cecropiifolia* Mart.	Shiari	High
Violaceae	*Rinorea lindeniana* (Tul.) Kuntze	Pashmaco	High
Violaceae	*Rinorea racemosa* (Mart.) Kuntze	Picaflor pusanga	High
Vochysiaceae	*Qualea acuminata* Spruce ex Warm.	Chuchuhuasia	Medium
Zingiberaceae	*Renealmia breviscapa* Poepp. & Endl.	Bumzamrau	High

* Spanish or local Spanish common name, or transcription of local name as given verbally.