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National parks and conservation concessions: a comparison between mammal populations in two types of tropical protected areas in Ucayali, Peru

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Abstract

Peru contains the second largest surface area of the Amazon biome. The Peruvian Amazon is threatened by logging, illegal crops, mining, and agricultural expansion. While a number of national parks exist in the Amazon region, privately managed areas like Conservation Concessions can be an attractive complement to existing parks. We compare medium and large mammal communities in a Conservation Concession in Ucayali with the nearby Parque Nacional Sierra del Divisor National Park and describe species relative abundance and richness of both protected areas. Results suggest that Conservation Concessions can harbour an important diversity of mammal species and could provide connections to larger protected areas. However, they are no substitutes for large protected areas, especially for sensitive and threatened species. Further research is needed to demonstrate their complementarity and improve landscape-level connectivity between conservation models.

Introduction

Peru contains 11.27% of the Amazon rainforest, one of the most biodiverse and important regions of the planet (Charity *et al.* 2016; Garda *et al.* 2010). The Peruvian Amazon is threatened by illegal logging, hunting, cultivation of illegal coca crops, mining, and agricultural expansion (Gutiérrez-Vélez *et al.* 2011; Francesconi *et al.* 2018), all of which proliferate due to insufficient articulation between government institutions to prevent illegal resource extraction and limited efficacy of environmental authorities (Fisher *et al.* 2020; Schleicher 2018). As a result of these threats, biodiversity loss in the Peruvian Amazon is likely high but understudied.

Creating protected areas (PAs) is one of the leading strategies to conserve biodiversity (Garda *et al.* 2010; Chen *et al.* 2022). However, there is little political support for the creation of new, large national parks around the world (McDonald & Boucher 2011); therefore, private PAs are an important complement to national strategies. Peru contains the most areas under private protection among the eight Amazonian countries (Shanee *et al.* 2015; Vuohelainen *et al.* 2012). One such type of private PAs is Conservation Concessions (CCs), which are leased areas granted to a person or organization in order to protect ecosystems and natural resources (Peru 2000). Concession holders are required to submit a management plan within five years of its establishment and to protect the concession from deforestation and other unauthorized resource extraction.

Ucayali, the second largest department in the Peruvian Amazon, has at least 21.4% of its territory under a figure of protection in four different PA models: national parks, communal reserves, regional PAs, and CCs which are in IUCN categories II, V, V, and VI, respectively (Quintana *et al.* 2009; SINIA 2018; IUCN 2021). Conservation Concession Santos Mario Castillo Dominguez (CCSMCD) is one such example of a privately-held CC, while the nearby Sierra del Divisor National Park (PNSD), created in 2015, is one of the most important efforts of the national government to protect a high-priority area of biodiversity due to its location and size in the international conservation corridor (SERNANP 2017).

Despite the variety of conservation models in the region, there are few studies of biodiversity in Ucayali and, to the best of our knowledge, none that assess the value of these two conservation models for terrestrial mammal biodiversity (Schleicher *et al.* 2017). We compare how species composition, richness, and relative abundance differ for medium and large mammals between one CC and a National Park in close proximity. We then discuss implications and benefits of CCs in regional mammal conservation, and we suggest a path for future research.

Material and methods

We conducted the study in the CCSMCD and the Parque Nacional Sierra del Divisor (PNSD) (Figure 1). We chose these two areas due to their similarities in habitats, land covers, and access restrictions, thus enabling a comparison between management types. The CCSMCD is located in the province of Coronel Portillo between the Tamaya and Yucanya rivers (8°55'24" S, 73°43'44" W) and consists of 8,600 hectares of lowland tropical forest with a mean annual temperature of 27°C and 1,667 mm of annual precipitation (SENAMHI 2020). The area is surrounded by major rivers and contains a variety of forest types and numerous oxbow lakes (known locally as *cochas*). The CCSMCD borders the territory of the indigenous Ashaninka community of San Miguel de Chambira. Prior to its declaration as a CC, the area was used for illegal logging of high-valued hardwoods such as mahogany (*Swietenia macrophylla*) and cedar (*Cedrela odorata*) which are no longer found in the area. This logging likely led to forest degradation (Hosonuma *et al.* 2012) and hunting (Mayor *et al.* 2015). Some clandestine selective logging and unauthorized hunting may still occur, as humans were detected, albeit infrequently, in three camera trap stations we placed near the borders of the CCSMCD.

The PNSD consists of 1,354,485 hectares and is located in the province of Coronel Portillo in the department of Ucayali and in the provinces of Ucayali and Requena in the department of Loreto. The park is situated in a warm tropical humid climate with a mean annual temperature of 25°C and annual precipitation between 1,600 to 2,000 mm (SERNANP 2020). Prior to its declaration as a PA, the area experienced some logging and cultivation of illegal coca crops on the park borders. The area that was logged or cultivated has been under reforestation plans since 2018 (personal communication).

We installed cameras (Cuddeback 1279 and 1347, and Bushnell Trophy Cam) following standardized survey techniques for terrestrial mammals (Ahumada *et al.* 2013; Rovero *et al.* 2014) in a grid at intervals of 1000 ± 300 m. We located the cameras along trails where possible to optimize mammal detection. We placed 41 single camera stations in a grid from September to November 2019 (end of the dry season) at CCSMCD, and 48 single camera trap stations divided into three grids from May to August 2019 (beginning of the dry season) at PNSD, covering areas of 61.79 km^2 at CCSMCD and 13.74, 21.55 and 32.20 km^2 (67.49 km^2 in total) in PNSD. The unusual sampling design in PNSD was due to the restrictive nature of the park's management, access restrictions—including the presence of uncontacted indigenous communities in core areas—and the lack of infrastructure within the park. Cameras were secured to trees at a height of 40 cm from the ground to detect medium and large terrestrial mammals (>1 kg) (Carbone *et al.* 2001). Although camera grid designs were distinct, we surveyed similar-sized areas (over 60 km^2 in both the CCSMCD and PNSD) and reached over 1000 trap nights (TN); thus, results can be compared (Kolowski & Forrester 2017).

We used a species accumulation curve with 1,000 randomizations in order to evaluate whether the sampling efforts were adequate to detect the total species richness of the sampled area (Colwell & Coddington 1994). We used R (3.5.1) packages Vegan and Biodiversity to generate richness estimators Chao 1 and Jacknife1 for mammals at each site (Chao *et al.* 2009), which perform realistically under scenarios with several singleton species and are generally used to perform comparisons (Rajakaruna *et al.* 2016). We produced graphs using the ggplot2 R package (Wickham 2016).

We calculated relative abundance indices (RAIs) for each species, each trophic group, threatened species, and all mammals at CCSMCD and PNSD as the average of the total number of independent capture events (C) of that species/group at each camera station divided by the number of TN at that station and expressed as records per 100 TNs (Carbone *et al.* 2001). We considered all consecutive pictures that show different species or different individuals from the same species—where individual identification is possible—as independent events. Pictures taken more than 30 minutes apart were also taken as independent events (O'Brien *et al.* 2003). While there is debate about how accurately RAIs reflect species abundance (Sollmann *et al.* 2013), they are still widely used to compare species capture frequency at different sites because of their useful insights if data are carefully analysed with other ecological variables to improve accuracy such as habitat, community composition, and camera placement (Rovero *et al.* 2014).

Results

The trapping effort was 1,588 and 2,006 camera days for CCSMCD and PNSD respectively. We recorded 19 large and medium (> 1 kg) mammal species for CCSMCD and 21 for PNSD, distributed in eight orders and seven trophic guilds for both areas of study, with an overlap of 17 species (Table S1). Eight species recorded in PNSD have a threatened status according to IUCN, while only four in CCSMCD (Table S1). The species accumulation curves and the richness estimators (Chao 1: 20.39 and Jacknife: 21.16 for PNSD; Chao 1: 18.41 and Jacknife: 19.49 for CCSMCD) suggest that survey effort was adequate to detect the species present in both areas, and richness between the two areas is comparable (overlapping CIs of the species accumulation curves) (Figure S1).

The most frequently detected species were black agouti *Dasyprocta fuliginosa* (RAI CSMCD: 8.694 and RAI PNSD: 9.987), followed by lowland paca *Cuniculus paca* (CCSMCD: 7.381 and PNSD: 9.438). Lowland tapir *Tapirus terrestris* and ocelot *Leopardus pardalis* were recorded more frequently in CCSMCD than PNSD (95% CIs do not overlap – CCSMCD tapir: 7.566; 95% CI: 2.687, 14.798 vs PNSD tapir: 1.200; 95% CI: 0.540, 1.965; CCSMCD ocelot: 1.119; 95% CI: 0.507, 1.894 vs PNSD ocelot: 0.144; 95% CI: 0, 0.447) while red brocket deer *Mazama americana,* Amazonian brown brocket *Mazama nemorivaga,* and collared peccary *Dicotyles tajacu* were detected more frequently in PNSD than in CCSMCD (weak differences in 95% CI, see Table S2). The least detected species was green acouchi *Myoprocta pratti* for CCSMCD and jaguarundi *Herpailurus yagouaroundi* for PNSD (Table S2 and Figure 2). There were no robust differences in RAIs (overlapping 95% CIs) between CCSMCD and PNSD for any of the groups analysed (i.e. different trophic groups, threatened species, and all mammals).

Discussion

While previous research on CCs evaluates their effectiveness for reducing deforestation and mitigating climate change (Vuohelainen *et al.* 2012), their value for biodiversity conservation has little empirical evidence (Magioli *et al.* 2021). This study adds to the knowledge that CCs can have a significant species richness and relative abundance comparable to those of national parks but may not hold the same value for threatened species that are often particularly sensitive to disturbance.

Of the 17 species present in both PAs, the majority displayed comparable RAIs in CCSMCD and PNSD. The case of a higher

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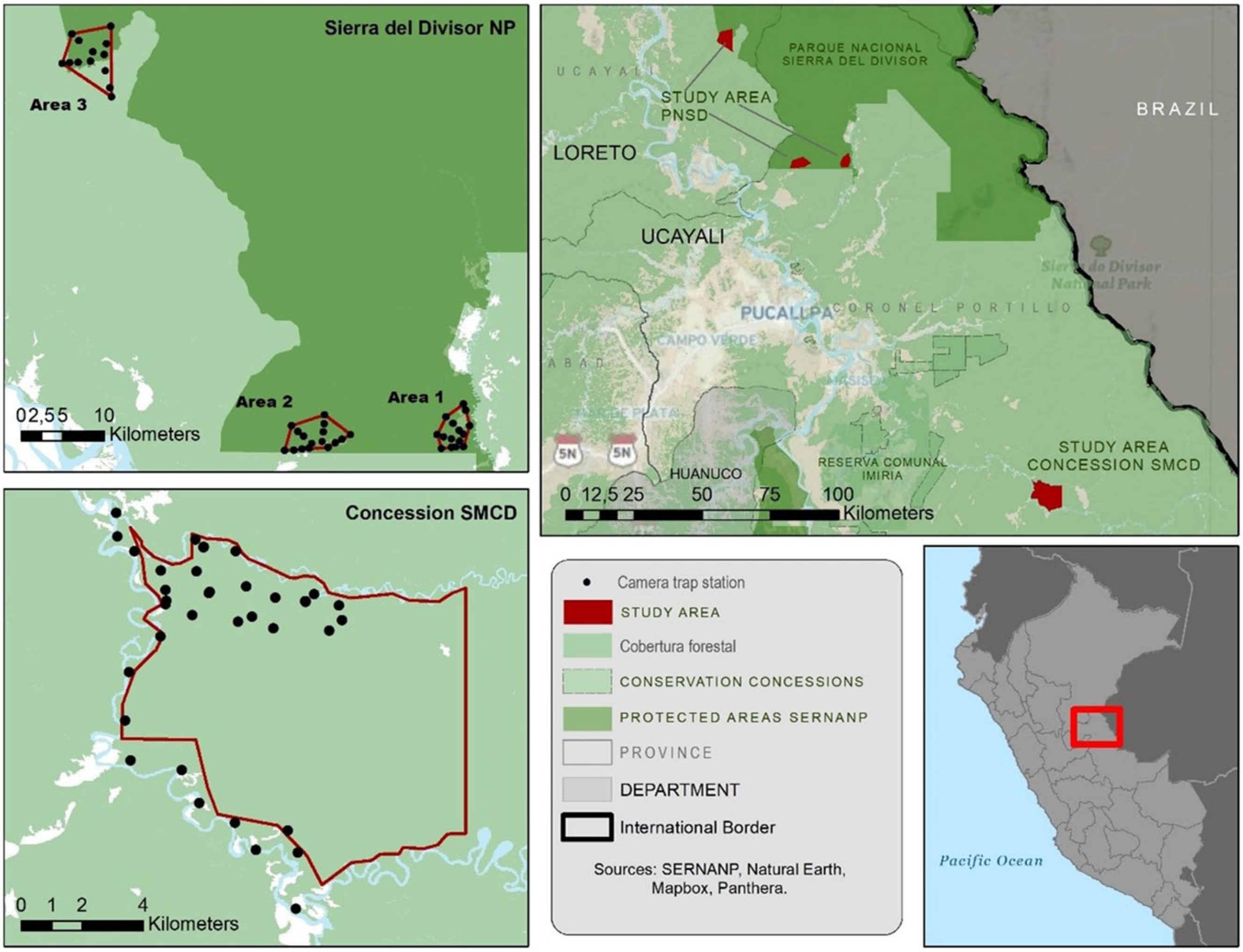

Figure 1. Location of the study areas in Ucayali and Loreto, Peru. (Authors, 2020), sources include Natural Earth, SERNANP, Biored, Mapbox.

relative abundance index for tapirs in CCSMCD may be due to limited hunting by the native communities surrounding the concession since most of their animal protein is obtained from fish (pers, comment), and/or that some cameras were installed near clay licks, which are swampy areas that contain salts that are consumed by many animals, including tapirs and peccaries. Cameras in PNSD could not be placed near clay licks due to accessibility issues. In addition to tapirs, CCSMCD harbours other large mammals that are sensitive to anthropogenic changes like white-lipped peccary (*Tayassu pecari)* (Altrichter *et al.* 2012; Teixeira-Santos *et al.* 2020), indicating the presence of large patches of primary forest with the ecological functionality necessary for white-lipped peccary persistence.

However, the presence of more species classified as threatened on the IUCN Red List in the PNSD than CCSMCD may demonstrate that CCs do not have the same conservation value as large national parks for species that are sensitive to human activity (Semper-Pascual *et al.* 2022). One example is the absence of giant otters (*Pteronura brasiliensis)* from the CCSMCD study area despite the presence of ample suitable habitat and cameras placed near rivers and oxbow lakes. Non-detection or absence may be associated with retaliatory killings related to harvests given the fishing livelihoods of surrounding communities. Similarly, absent in CCSMCD was the short-eared dog (*Atelocynus microtis)*, the only canid endemic to the Amazon. The short-eared dog is distributed throughout most of Ucayali according to the latest habitat suitability projects (Rocha *et al.* 2020). Its absence in the CCSMCD may be due to higher edge density from logging roads previously created, as the species requires highly conserved forests and no human presence (Rocha *et al.* 2020).

Differences in community assemblages may be due to the higher level of habitat degradation and hunting that CCSMCD has suffered in the last decades compared to PNSD. Logging affects biodiversity in different ways; it can alter forest composition and structure, diminishing the natural regeneration of the harvested species (Huth & Ditzer 2001; Putz *et al.* 2012), causing declines in mammal richness and changes in species abundance (Burivalova *et al.* 2014). Also, logging roads increase human access and hunting (Gibson *et al.* 2011; Kleinschroth & Healey 2017). Current presence of humans and related disturbance appears to be minimal in both areas, with less than five records of humans on camera traps in CCSMCD and none in PNSD.

Studies from CCs in the Peruvian Amazon are scarce (Schleicher 2018), but one camera trapping study from the remote Río Novia concession in Southeastern Ucayali (approximately 350 km from CCSMCD) reported a larger number of species than in

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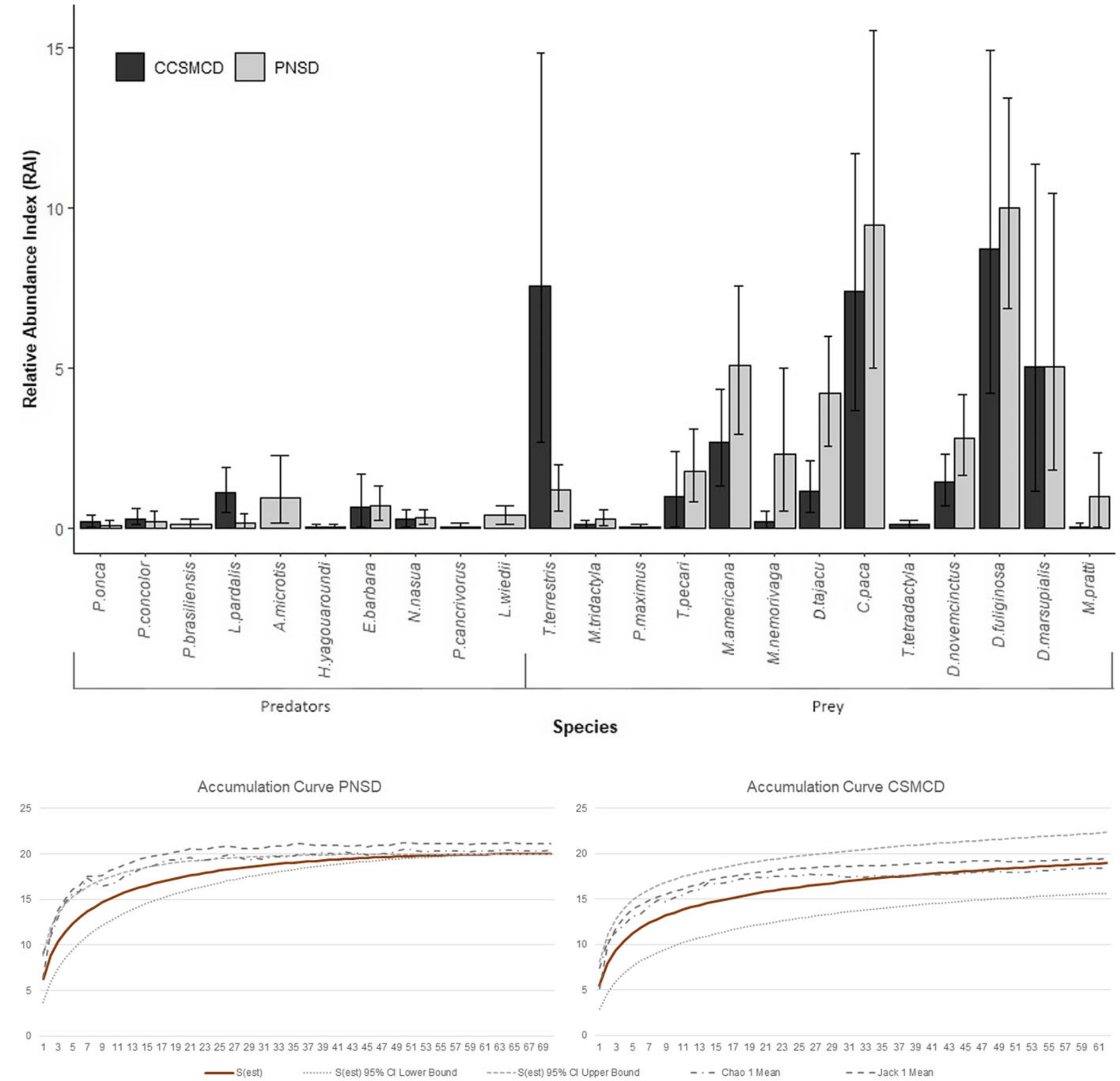

Figure 2. Relative abundance indices of mammals present in CCSMCD (Conservation Concession Santos Mario Castillo Dominguez) and PNSD (Sierra del Divisor National Park), ordered from Predators to Prey and larger to smaller.

CCSMCD in smaller sampling area (36 km^2). Notably, absent were white-lipped peccary, Amazonian brown brocket deer, and crab-eating raccoons (Mena Alvarez *et al.* 2016). Similar to our results in CCSMCD, the study did not detect bush dogs, giant otters, pacaranas, or the great grison *Galictis vittata* (Mena Alvarez *et al.* 2016). Though the two concessions have similar management types and size, direct comparisons between the study in Rio Novia and CCSMCD are difficult because Rio Novia does not have the historic impacts of logging, and there may be other confounding variables in site characteristics, study area size, and species detection probabilities (Voss & Emmons 1996).

Despite the findings of important mammal diversity in CCs, they are unlikely to replace the impact of a large, conserved national parks to protect those species that are more sensitive to human disturbance, such as short-eared dogs and giant otters. Our results suggest that though the mammal composition between areas is not pronounced, mammals are more diverse in a larger area like PNSD. The national park community has a slightly higher species richness, more threatened species, and higher relative abundance of deer species and collared peccaries. Mammal community differences would have likely been more notable if the sampling occurred in core areas of the PNSD, since the

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sampling areas were near the edge of the park and had experienced human disturbance such as hunting and logging before the establishment of the park. Results of other studies in tropical forests show that areas surrounded by large, fragmented habitats have lower species richness and diversity (Ahumada *et al.* 2011).

Management implications and connectivity

Overall, CCs as a model are important for biodiversity conservation, providing connectivity and support in Peru's biodiversity conservation network (Shanee *et al.* 2015; Schleicher 2018). Their smaller size makes them vulnerable to natural and anthropic threats such as floods, fires, and illegal activities but also easier to control and protect them. Since some sustainable activities like tourism or non-timber forest product harvesting are permitted, surrounding communities may benefit from them as well (Vuohelainen *et al.* 2012).

Interest in private PAs is not exclusive to Peru; many countries in South America have looked to this model to return decision-making to local communities and to foster innovation in management (Hora *et al.* 2018). Indeed, little research has been done on the social and environmental contributions of private PAs in Latin America, though further research is expected given that this model is relatively new in many countries.

While the conservation of large areas is important, the connectivity between those areas is just as vital to ensure the genetic viability of large, solitary vertebrates such as jaguars and tapirs (Medici *et al.* 2007; Rabinowitz & Zeller 2010). Currently, CCs in Ucayali are dispersed, and there are no existing efforts to connect them spatially in management plans or government policy. Given that the Peruvian Amazon is among the world's most diverse areas, greater care should be taken in the planning of regional conservation strategies to connect populations of vulnerable and endangered wildlife, which depend on large areas of conserved habitat to survive. Authorities such as SERNANP (Peruvian National Parks Service) and SERFOR (National Forest and Fauna Service) should also undertake landscape-level assessments to determine how different concessions, national and regional PAs, and communally held lands could achieve connectivity for the creation of biological corridors.

Understanding the contribution of different PA models to biodiversity conservation is vital to improving their management. Our study was limited to one national park and one CC. We suggest continued research in Peru's PAs, including other CCs and mammal studies in park buffer areas to understand edge effects on mammal communities. Additionally, research is needed to identify the extent of anthropogenic impacts like hunting and logging in these areas. For CCs, interdisciplinary research on livelihoods and resource access are fundamental to determining that conservation impacts are achieved while also preventing inequities that can result from exclusionary models. As private PAs gain popularity in Latin American countries, understanding their contribution to biodiversity conservation and improving upon their implementation will be crucial for effective national strategies.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S0266467422000414

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Competing interests. The authors declare none.

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