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A COMPARISON OF PRIMATE SPECIES ABUNDANCE AND DIVERSITY BETWEEN A PROTECTED AND AN INDIGENOUS-OWNED SITE IN THE SUMACO BIOSPHERE RESERVE, ECUADOR

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Introduction

Fully protected areas surrounded by successive buffer zones are a standard strategy to protect areas of high biodiversity, intended to strike a balance between the necessity to conserve wildlife and the needs of local people. Effective buffer zones should reduce detrimental edge effects caused by abrupt changes in land-use and allow at least some animal and plant species to extend their range beyond the core boundary (Sayer, 1991). However, they should also be places where the traditional land rights and practices of local people are respected, and allow the sustainable use of natural resources. Achieving this equilibrium is difficult; and it is important for our understanding of the success of buffer zones (if success is measured in terms of the presence and abundance of target species) to make regular comparisons of their species assemblages with their associated core areas in order to ascertain their effectiveness and identify which species are most resilient to human presence. In this study we investigate how primate species assemblages and their estimated abundance differ at two sites situated in the protected core area and buffer zone of the Sumaco Biosphere reserve, eastern Ecuador. While human impact in the protected area is very low, our buffer zone site is situated within territory owned by an indigenous Kichwa community that maintains a reasonably traditional lifestyle, where primates are subject to disturbance, hunting, and use as pets. Although these sites are linked by continuous forest cover, they are separated by both distance, altitude,

and climate, which have been shown to affect both the seasonality and floristic composition of neotropical forests (Vázquez & Givnish 1998, Pyke et al. 2001). For these reasons we also present the results of fruiting surveys at both sites, intended to characterize differences in food availability and the intensity of seasonal bottlenecks.

Methods

Study sites and primate surveys

The Sumaco biosphere reserve is located in the northeast of Ecuadorian Amazonia and covers an area of 931,930ha, equivalent to 8% of the country's Amazonian habitat (Valarezo et al. 2001) (Fig. 1). It is subdivided into three zones which vary in their level of protection and in the level and type of activities that can be legally carried out. The core area of the reserve corresponds to the Sumaco-Napo-Galeras National Park, including 190,562ha around the Sumaco volcano and an additional 14,687ha in the Cordillera de Galeras, where human impact has been either very low or non-existent (Valarezo et al. 2001). Surrounding the park is a 178,600ha buffer zone consisting of several protected state forests with low or medium human impact that are used by indigenous communities for subsistence activities, and where timber and non-timber products are extracted. We used three line transects at each of our sites. Our core area transects, located within the boundary of

the Sumaco Galeras National park, were located at an altitude of 2,450m. Average rainfall at the nearest available recording site (the village of Pacto Sumaco) is 4,321mm (climate-data.org). Our buffer zone transects were located within 16,800ha of land owned by San José de Payamino, an indigenous Kichwa community that was granted ancestral land rights over the area in the 1980s. The community currently consists of circa 60 households and still actively hunts game, although meat is rarely sold at markets and alternative protein sources (in the form of chickens owned by each household, fish from the Payamino river, and livestock meat from the nearest market town of Loreto) are readily available. Average rainfall, which is only available for 1982-1984, was 4,290mm (Irvine 1987). There is continuous forest cover between the community's land and the national park, so we would not expect any significant barriers to dispersal from one site to another. Each transect was surveyed a total of 7 to 11 times over a period of 7 months (August 2014 to March 2015), starting at approximately 7am and walking at a pace of circa 1.25km/h. If rainfall occurred prior to starting the transect, we waited until the rain had stopped or lightened considerably before starting. Transects were paused during periods of brief rainfall, or recording discontinued during heavy precipitation. Whenever a group of primates was encountered, we noted the species and number of individuals. Howler monkey

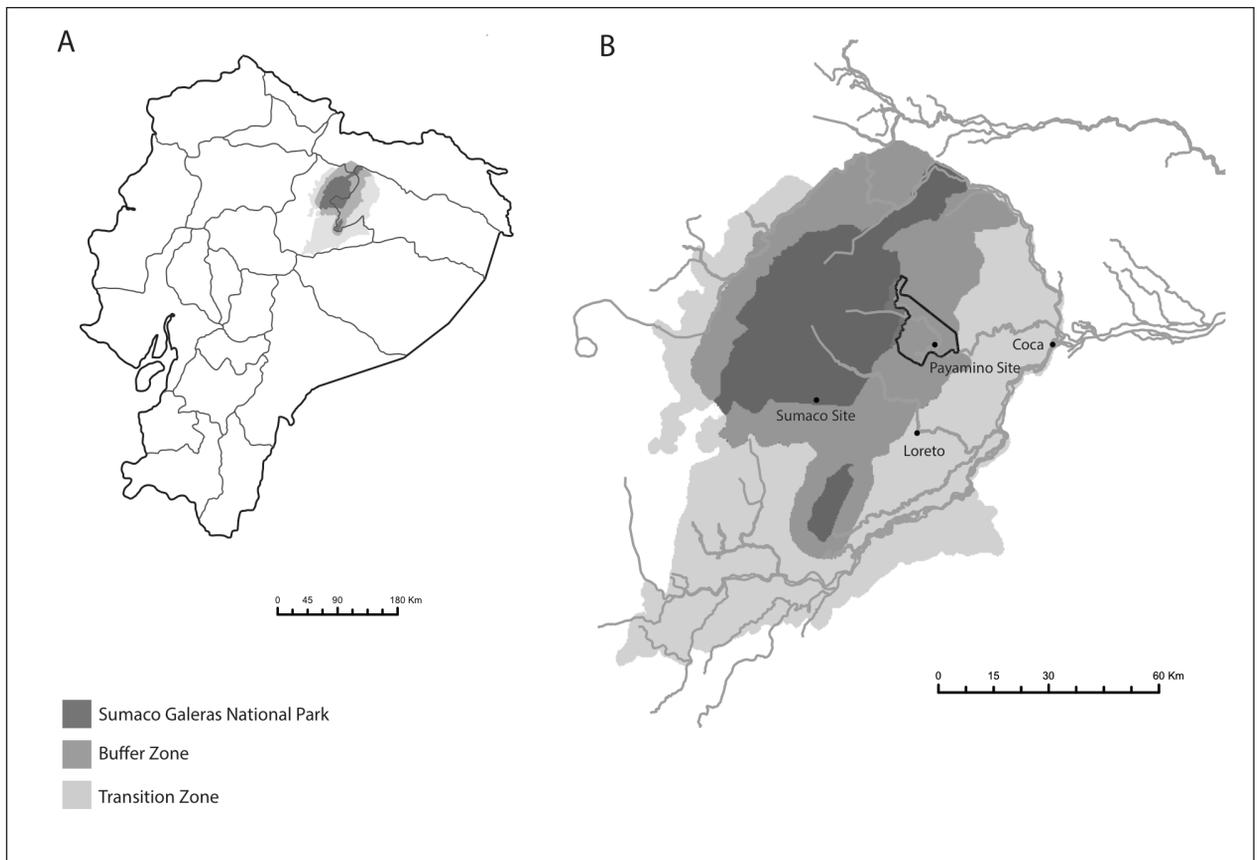


Figure 1. Location of the Sumaco Biosphere Reserve and of our two study sites. The black outline denotes the territory owned by the community of San José de Payamino.

Table 1. Encounter rates of primate species at two study sites in the Sumaco Galeras Biosphere reserve, based on one-way distance. † not recorded on transect, but interviews with locals indicate presence in more remote areas of the community's territory. ‡ Includes encounters that were not sightings. For *Alouatta seniculus* includes five instances of hearing calls but not seeing the group, for *Cebus albifrons* includes one instance of hearing calls and seeing tree movement but not seeing individuals.

			Encounter Rate of Groups/10km (total number of sightings)						
Site	Transect	Km Walked	<i>Lagothrix lagothricha</i>	<i>Ateles belzebuth</i>	<i>Alouatta seniculus</i>	<i>Cebus albifrons</i>	<i>Saimiri sciureus</i>	<i>Saguinus graellsi</i>	Total
Payamino	1	48.9	0	0	0.82 (4)	0.61 (3)	0	0.20 (1)	1.64 (8)
	2	18.4	0	0	0	0	1.08 (2)	0.54 (1)	1.63 (3)
	3	14.5	0	0	2.07 (3)	2.07 (3)	0	0	4.15 (6)
	Total	81.8	0 (0)†	0 (0)†	0.86 (7)‡	0.73 (6‡)	0.24 (2)	0.24 (2)	2.08 (17)
Sumaco	1	7.2	5.53 (4)	0	1.38 (1)	0	0	2.76 (2)	9.67 (7)
	2	10.2	0	0	0	2.96 (3)	0	0.99 (1)	3.94 (4)
	3	12.4	0	0.98 (1)	0	0.81 (1)	0	0.81 (1)	2.42 (3)
	Total	29.8	1.34 (4)	0.36 (1)	0.36 (1)	1.34 (4)	0	1.34 (4)	4.70 (14)

vocalizations were counted as sightings, as the individuals themselves were rarely seen.

Fruiting Surveys

Fruiting surveys took place during the return leg of transect walks every second round of primate surveys. Surveys were conducted using a methodology that merges phenology transects with diameter at breast height (DBH) sampling to measure fruit abundance and seasonal fluctuation in availability, using methods outlined in Parry et al (2007) modified from Wallace and Painter (2002). Whenever patches of fruit were detected on the trail, the parent tree was located and checked with binoculars to see if it was still bearing fruit. In cases where it was, the DBH of the tree was measured and recorded. Any fruit less than 1cm in width was not recorded, and observers of fruit were rotated in order to avoid any potential differences in detection rates. We used two metrics as proxies for fruit availability: cumulative DBH per km (which is assumed to be a reliable indicator of the amount of fruit a tree will produce (Chapman et al. 1994)), and the number of fruiting trees per km.

Results

Primate Survey

We recorded a total of 31 primate encounters with six different species: woolly monkeys (*Lagothrix lagothricha poeppigii* $N=4$), white-bellied spider monkeys (*Ateles belzebuth* $N=1$), red howler monkeys (*Alouatta seniculus* $N=8$), white-fronted capuchin (*Cebus albifrons* $N=10$), common squirrel monkey (*Saimiri sciureus* $N=2$) and Graell's tamarin (*Saguinus graellsi* $N=6$). These figures are inclusive of six 'encounters' where the animals themselves were not seen, but their presence was detected as a result of other cues. For the howler monkey figures, they include five occasions where we heard a group calling close to the transect. Similarly, the capuchin figures include one encounter in Payamino where we saw a rustling of trees and heard the group's calls but

did not make visual contact. Although Payamino's transects covered a greater distance, linear regression showed the number of group encounters was not correlated to the total distance walked ($F=1.497$, $P=0.288$), although this may be more a reflection of the relatively low number of encounters rather than the lack of a relationship.

Our total number of primate sightings ($n=17$ in Payamino, 14 in Sumaco) did not meet the minimum number required for reliable calculation of absolute densities as recommended by Buckland et al. (2001). As a result, we used encounter rates based on one-way distance as a measure of relative group density (Table 1), assuming similar detection rates between both sites. Our data suggest that *Lagothrix* and *Ateles* were completely absent from Payamino, though locals report sightings in more remote areas of the community's territory that were not covered by our surveys. Descriptions of the route taken to see them suggest they are seen in areas very close to the national park boundary. *Saimiri sciureus* were not detected on our Sumaco transects. *Alouatta seniculus* had an encounter rate in Payamino that was over twice that of Sumaco, but *Cebus albifrons* and *Saguinus graellsi* were encountered more frequently in the protected area

Fruiting surveys

Phenology between the two sites differed according to whether cumulative DBH or the number of fruiting trees per km was used as the proxy for fruit availability. We tested for differences between sites using a general linear model with Julian day on which the survey was undertaken as a covariate, using the program car (Fox & Weisberg, 2011) in the statistical package R. Both sites experienced seasonal changes in cumulative fruiting DBH/km ($F_{1,31}=9.55$, $P<0.005$), decreasing at the end of the rainy season (Fig. 2). There was no significant difference between Sumaco and Payamino, indicating that at any given time a similar amount of fruit is available to primates at each site.

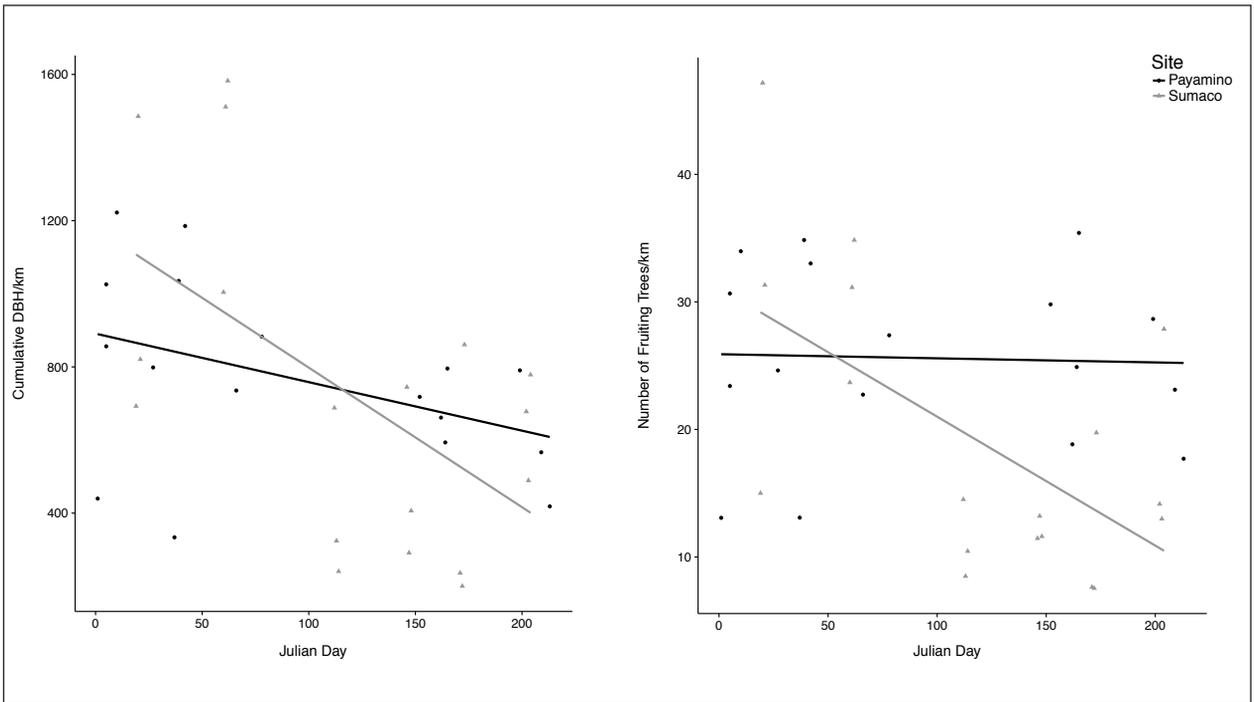


Figure 2. (A) Cumulative DBH/km (B) Number of fruiting trees/km for transects surveyed in Payamino and Sumaco. Julian day 1 corresponds to 25/8/14, when phenology transects were started, and ends on 25/3/15.

However, the same analysis using the number of fruiting trees as the proxy for fruit abundance reveals a clear interaction between site and Julian day ($F_{1,31} = 5.68$, $P = 0.02$). This suggests that Sumaco experiences a seasonal bottleneck whereas the number of trees in fruit in Payamino remains more stable.

Discussion

Primate assemblages between our two study sites differ in terms of the diversity and relative density of species, although our analysis is limited by our low number of encounters and cumulative distance sampled. Although the answer to whether the two sites surveyed differ in terms of fruit availability throughout the year changes depending on the proxy, neither scenario gives a satisfying explanation for our patterns of primate encounters. If both sites have the same availability (as suggested by there being no difference between their cumulative fruiting DBH/km), we would expect species abundance to be the same, or, if Sumaco goes through a more intense seasonal bottleneck than Payamino, the latter would be expected to have a higher abundance. Bearing this in mind we think it unlikely that our observed differences in fruit availability are a major driver behind our differences in primate encounter rates.

Differences in primate species assemblages and encounter rates between the two sites could alternatively be driven by hunting. While some of our data fits this picture, our results do not fully replicate the profile that would be expected under these circumstances. Hunting preferences for primates generally start with large-bodied through to

medium and small-bodied species (Sirén, 2004; Franzen et al. 2006). In this respect the absence of the two largest bodied species of primates from the area inhabited by the Payamino community is typical, as their prestige (Sirén, 2012) as well as several of their life history traits (long inter-birth periods, giving birth to single young, and having group structures where not all females may be reproductively active (Cowlinshaw & Dunbar, 2000)) make them particularly vulnerable to wholesale extirpation (Peres, 1990; Ræz Luna, 1995; Bodmer, 1997). Interviews with members of the community confirm our findings that both species are no longer found near areas that are inhabited (Stafford et al. 2016). In this case the buffer zone is failing to protect two species known to be at high risk of extinction as a result of human activity. As the third largest species, howler monkeys would also be expected to be found at lower densities in Payamino, though as quarry they are generally less preferred than the other atelines (Stafford et al. 2016). Our encounter rates were over twice as high in Payamino than within the boundary of the national park, however encounters were all confined to a small area where we regularly heard a group calling. If our surveys happened to cover a preferred calling site in Payamino (for example, if we happened to place our transect on the border of their home range) but not in Sumaco there is a possibility that our Payamino encounter rates are biased. Data on spatial patterns of calling is absent for *Alouatta seniculus* but varies across other *Alouatta* species (da Cunha & Jalles-Filho, 2007; Holzmann, 2012; Van Belle et al. 2013), so we currently do not know if this could be the case. Sightings of other species were also concentrated on particular transects and areas (see *Lagothrix* and *Saguinus* encounter

rates in Sumaco in Table 1, for example), so in this study we assume *Alouatta* does not have preferences for particular calling sites.

Although our census effort is limited, we found differences in species composition and abundance between a protected area and land contiguous to it that is owned by an indigenous community. These differences appear to be primarily a result of hunting targeting large species with the exception of *Alouatta seniculus*, which was encountered more frequently in the buffer zone than the protected area. Improving our understanding of the additional factors that may be at play, as well as assessing other buffer zones and associated national parks, is important to gain a better understanding of whether buffer zones are an effective tool to help conserve primate diversity.

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