

TRABAJOS ORIGINALES

Population density and primate conservation in the Noroeste Biosphere Reserve, Tumbes, Peru

Densidad poblacional y conservación de los primates de la Reserva de Biosfera del Noroeste, Tumbes, Perú

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Abstract

The Noroeste Biosphere Reserve (NBR) is home to at least 22 species of medium and large mammals including the primates *Alouatta palliata aequatorialis* and *Cebus albifrons aequatorialis*. Previous estimates of *A. p. aequatorialis* population density vary from 2.3–8.6 ind/km² in 1983 to 17–19 ind/km² in 2005 and 2006, respectively. While for *C. a. aequatorialis* there are no estimates of population density in the NBR. In order to calculate the population density estimates for both species we installed six transects in 10.5 km² within the Cerros de Amotape National Park (belonging to the NBR) from August 2012 to March 2013. Based on 112.3 km of transects we obtained a population density of 8.3 ± 3.6 ind/km² for *A. p. aequatorialis*. However, for the reduced number of *Cebus albifrons aequatorialis* sightings we were only able to calculate a group size from three to 12 individuals and an encounter rate of 0.3 ind/km. Even though *A. p. aequatorialis* has potentially increased in population density, it is not feasible to make comparisons with previous estimates in the same area because of the different employed methodologies and the lack of randomness in the data collection. We recommend a long-term monitoring plan, including *C. a. aequatorialis* which makes it a conservation priority for the NBR, this monitoring plan should include mitigation of potential threats such as illegal hunting and trapping for the pet trade.

Keywords: *Alouatta palliata aequatorialis*; *Cebus albifrons aequatorialis*; distance sampling; line transect; Noroeste Biosphere Reserve.

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Resumen

La Reserva de Biósfera del Noroeste (RBN) alberga por lo menos 22 especies de mamíferos medianos y grandes entre las cuales se encuentran los primates *Alouatta palliata aequatorialis* y *Cebus albifrons aequatorialis*. Los estimados previos de la densidad poblacional de *A. p. aequatorialis* varían de 2.3–8.6 ind/km² en 1983 a 17–19 ind/km² en 2005 y 2006, respectivamente. Mientras que para *C. a. aequatorialis* no existen estimados poblacionales para la RBN. Para calcular la densidad poblacional de estas dos especies instalamos seis transectos lineales en 10.5 km² dentro del Parque Nacional Cerros de Amotape (perteneciente a la RBN) de agosto del 2012 a marzo del 2013. En base a 112.3 km de transectos se obtuvo una densidad poblacional de 8.3 ± 3.6 ind/km² para *A. p. aequatorialis*; sin embargo, por el reducido número de avistamientos de *Cebus albifrons aequatorialis* solo se pudo calcular el tamaño de grupo que varió de tres a 12 individuos y la tasa de encuentro de 0.3 ind/km. A pesar que la población del *A. p. aequatorialis* aparentemente ha aumentado, no es factible hacer comparaciones con los estimados anteriores debido a las diferentes metodologías empleadas y a la falta de aleatoriedad en la toma de datos. Recomendamos un plan de monitoreo a largo plazo, que incluya a *C. a. aequatorialis* como objeto y prioridad de conservación para la RBN, el cual debería incluir la mitigación de posibles amenazas como caza y captura para comercio de mascotas.

Palabras clave: *Alouatta palliata aequatorialis*; *Cebus albifrons aequatorialis*; monitoreo; transecto lineal; Reserva de Biosfera del Noroeste

Introduction

The Noroeste Biosphere Reserve (NBR) was established by the UNESCO in 1977 (INRENA 2001) and includes three natural protected areas: El Angolo Hunting Reserve, Cerros de Amotape National Park (CANP) and Tumbes National Reserve. It protects the Equatorial dry forest (Brack-Egg 1986) and the Pacific Tropical Rainforest, the last found nowhere else in Peru (Chapman 1926, Brack-Egg 1986). The NBR holds fauna of Amazonian origin and biota similar to Central American forests (Lamas 1976, Cabrera & Willink 1980, Brack-Egg 1986, Cadenillas 2010). Unfortunately, the area adjacent to the Cerros de Amotape National Park and the Tumbes National Reserve: El Oro and Loja Provinces, in Ecuador, are highly fragmented for farming and agriculture (Dodson & Gentry 1991, Wunder 2001).

One of the NBR main objectives is the protection of the fauna and flora within its boundaries. In this area, the Primate Order is only represented by two confirmed species: *Alouatta palliata aequatorialis* Festa, 1903 (Ecuadorian mantled howler monkey) and *Cebus albifrons aequatorialis* Allen, 1914 (Ecuadorian capuchin monkey). However, Encarnación and Cook (1998), also registered, *Saimiri sciureus*, for the reserve but the current presence of a population is doubtful (Hurtado & Pacheco 2015).

The known distribution range for the Ecuadorian mantled howler monkey extends from Panama to Peru (Crockett 1998, Cuarón et al. 2008). Even though its southern known locality has been confirmed to be the Noroeste Biosphere Reserve; its northern limit range is not yet determined (Cortés-Ortiz et al. 2015). It is also categorized as Vulnerable by the International Union for Conservation of Nature (Cuarón et al. 2008); and as Endangered by Peruvian legislation (Decreto Supremo N° 004-2014-MINAGRI).

The Ecuadorian capuchins monkey's distribution range is restricted to western Ecuador and northwestern Peru (Jack &

Campos 2012); unfortunately by 1988 the western forest of Ecuador had lost 95% of its original cover (Dodson & Gentry 1991). With such a restricted distribution, Campos and Jack (2013) made a potential distribution assessment, identifying three priority areas for Ecuadorian capuchins conservation, one of them, the Noroeste Biosphere Reserve. Moreover, *Cebus a. aequatorialis* is now considered critically endangered by the IUCN (Cornejo & de la Torre 2015) while Peruvian legislation does not list it at-any risk category.

The aims of this work were to i) provide new density estimates for the Ecuadorian mantled howler monkey in the NBR, and ii) provide the first information on group sizes and relative abundance of the Ecuadorian capuchin monkeys in the NBR. This assessment is basic for a better conservation plan for these highly endangered species and to encourage further research questions.

Material and methods

Study species.- Mantled howler monkeys (Fig. 1A) are facultative folivorous species (Milton 1982) and even though their vocalizations can be heard up to 1 km depending on the vegetation, they are cryptic animals hard to register (Dechner 2011). To the best of our knowledge, there is not a complete taxonomic revision nor diagnosis of the *Alouatta palliata* populations distributed in Central and South America, but *A. p. aequatorialis* is restricted to this area and its distribution is imprecise (Cortés-Ortiz et al. 2015). For this reason, Cortés-Ortiz et al. (2015) suggested studies with a larger number of samples to determine the current taxonomic status of the populations distributed in the NBR and Southern Ecuador.

The taxonomic status of the Ecuadorian white-fronted capuchin, *Cebus albifrons*, is now debatable. In the only comprehensive taxonomic revision of the genus *Cebus* (currently divided into the genera *Sapajus* and *Cebus*), Hershkovitz (1949) considered that the *Cebus aequatorialis* of Allen (1914) actually represents a subspecies of *Cebus albifrons*, considered as *C. a. aequatorialis*.



Figure 1. Primate species present in the Noroeste Biosphere Reserve (NBR) (A) *Alouatta palliata aequatorialis* and (B) *Cebus albifrons aequatorialis*.

Cornejo and de la Torre (2015), based on Lynch Alfaro et al. (2010) and Boubli et al. (2012), considered *C. a. aequatorialis* as originally proposed by Allen (1914), *Cebus aequatorialis*. However, upon a detailed review of the literature, several concerns for the validity of this species arose. Lynch Alfaro et al.'s (2010) publication lacks detailed information such as origin, number of specimens used, and detailed methods. In addition, Boubli et al. (2012), performed a molecular phylogenetic analysis of 50 samples of untufted capuchins (genus *Cebus*), where they could not obtain samples of *C. a. aequatorialis* (see Boubli et al. 2012; p. 383). We do not deny that the populations of *C. a. aequatorialis* in the NBR may represent an isolated taxon; nevertheless, we considered that there is still not enough evidence to elevate it to the full species rank. Therefore, in this paper, we will treat the populations of the Ecuadorian white-fronted capuchin as proposed by Hershkovitz (1949), *Cebus albifrons aequatorialis* (Fig 1B).

In reference to the only report of *Saimiri* sp. (considered as *Saimiri* cf. *sciureus*) observed by Encarnación and Cook (1998); there is evidence of only one additional sighting of one individual in 2008 near the NBR (3.79°S, 80.26°W) (Renzo Piana comm. pers.). This sighting could be a result of trafficking in wildlife, or a remnant of the groups mentioned by Encarnación and Cook (1998) since the distribution of the genus *Saimiri* does not extend to the western side of the Andes (Hershkovitz 1949). For these reasons, Hurtado and Pacheco (2015) considered that if the species was truly present in the NBR, it is probably already locally extinct.

Study area.- The CANP is located in the northeastern region of the NBR in the Tumbes Province, Peru (03°50'S, 80°16' W). Three major forest types can be distinguished in the Park: Equatorial Dry Forest (EDF), Pacific Tropical Rainforest (PTR), and a Transitional Forest (TF) (Brack-Egg 1986). We selected one locality in the TF (El Caucho Biological Station) and one in the

PTR (Campo Verde) because no previous sightings or reports were obtained in the EDF. The Pacific Tropical Rainforest is characterized by marked seasonality, the rainy season (January – March) and dry season (April-December) where precipitation is up to 1537 mm/year and temperature fluctuates from 19 to 35 °C (INRENA 2001).

El Caucho Biological Station (03°50'S, 80°16'W, 355 m.), represents the Transition Forest, characterized by *Ceiba trichistandra*, *Cavanillesia platanifolia*, *Ficus jacobii*, *Triplaris cumingiana*, *Bougainvillea peruviana*, *Tessaria integrifolia*, *Inga feuillei*, and *Cecropia peltata* (Ponte 1998, Pacheco et al. 2007).

Campo Verde (03°50'S, 80°10'W, 750 m), is characterized by a dense perennial forest, hilly terrain and high humidity (Ponte 1998). The characteristic species of this area are *Centrolobium ochroxylum*, *Cordia eriostigma*, *Tabebuia chrysantha*, *Triplaris cumingiana*, *Gallesia integrifolia*, *Ficus jacobii*, and *Cedrela fissilis* (Ponte 1998, Pacheco et al. 2007).

Data collection.- We surveyed six transects in 10.5 km², each transect of 4 km and three per locality. We were not able to randomly select transects because of logistics and park protection constraints. However, we tried stratification by selecting existing trails that cross several vegetation types and considered straightening of the trails and distance between them (Buckland et al. 2001). Furthermore, transects along streams or flooded areas were avoided to account for overestimation when the abundance of high-quality resources yield higher detection probability or encounter rate (Peres 1997, Bravo & Sallénave 2003). Instead we selected trails that only crossed streams.

Between August 2012 and February 2013, following Peres and Cunha's (2011) methodology, two people walked each of the six transect at approximately 1.2 km/hour, starting between 6:00 and 7:30 am (Fig. 2). We did not census the return transect. We only census primates during the day, accumulating 37 sampling

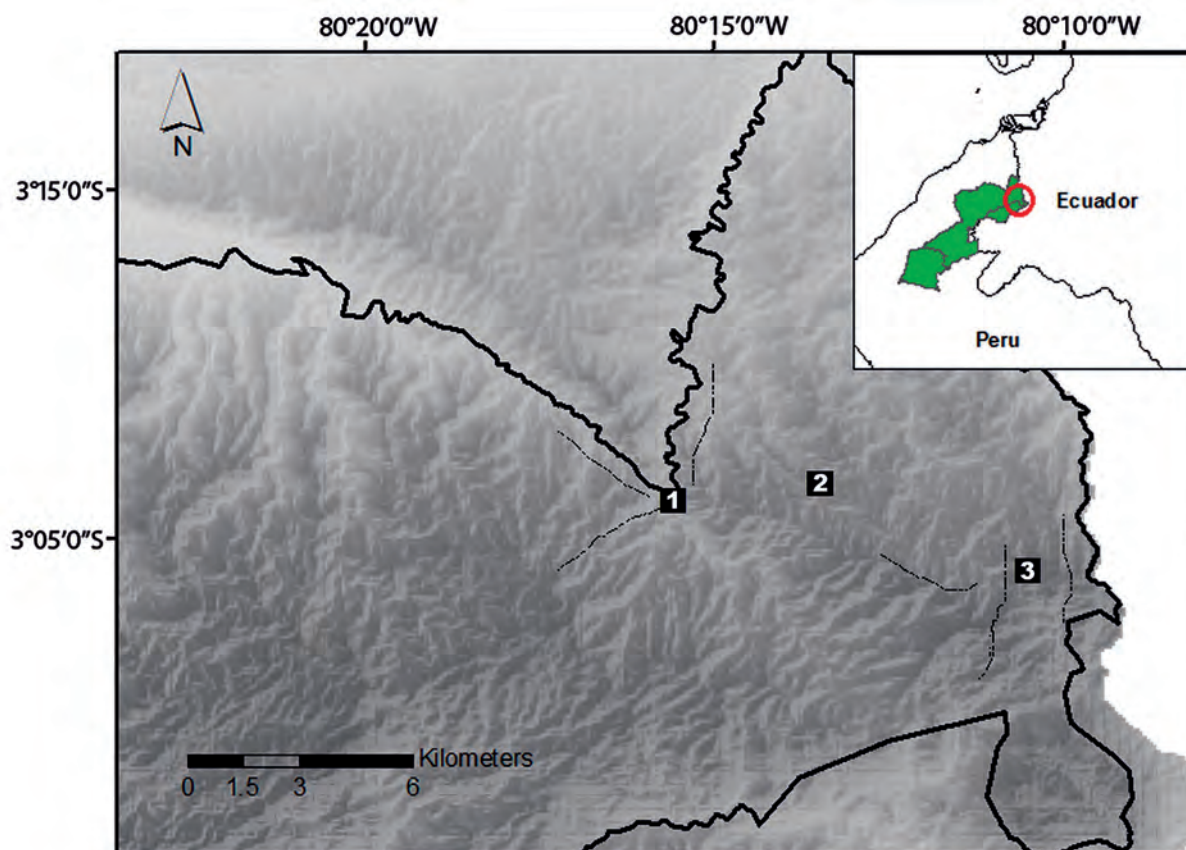


Figure 2. Line transects for *Alouatta palliata aequatorialis* and *Cebus albifrons aequatorialis* in dotted lines. (1) El Caucho Biological Station, (2) La Vaca stream, (3) Campo Verde localities. Green area and black continuous line represent the Noroeste Biosphere Reserve Limits.

Table 1. Records obtained during 2012 and 2013 census in the Noroeste Biosphere Reserve. (*) indicates other sightings outside the transects PTR: Pacific Tropical Rainforest, TF: Transitional Forest.

Species	Habitat	Number of individuals	Latitud	Longitud	Elevation (m)
<i>Cebus albifrons aequatorialis</i>	TF	12	-3.82989	-80.2685	420
<i>Cebus albifrons aequatorialis</i>	TF	4	-3.81555	-80.2697	354
<i>Cebus albifrons aequatorialis</i>	TF	8	-3.82415	-80.2441	579
<i>Cebus albifrons aequatorialis</i>	TF	3	-3.82515	-80.2422	598
<i>Cebus albifrons aequatorialis</i>	PTR	3	-3.84117	-80.1649	745
<i>Cebus albifrons aequatorialis</i>	PTR	8	-3.84339	-80.1644	745
<i>Cebus albifrons aequatorialis</i>	TF	*	-3.84831	-80.269	498
<i>Alouatta palliata aequatorialis</i>		*	-3.66174	-80.1639	723
<i>Alouatta palliata aequatorialis</i>	TF	7	-3.81392	-80.2718	353
<i>Alouatta palliata aequatorialis</i>	TF	3	-3.81247	-80.2739	318
<i>Alouatta palliata aequatorialis</i>	TF	3	-3.81554	-80.2696	355
<i>Alouatta palliata aequatorialis</i>	TF	3	-3.82393	-80.2536	508
<i>Alouatta palliata aequatorialis</i>	TF	1	-3.82925	-80.2317	597
<i>Alouatta palliata aequatorialis</i>	TF	1	-	-	-
<i>Alouatta palliata aequatorialis</i>	PTR	3	-3.84018	-80.1687	754
<i>Alouatta palliata aequatorialis</i>	PTR	5	-3.8475	-80.1781	750
<i>Alouatta palliata aequatorialis</i>	PTR	5	-3.84752	-80.1784	-
<i>Alouatta palliata aequatorialis</i>	PTR	3	-3.83174	-80.2266	618
<i>Alouatta palliata aequatorialis</i>	TF	4	-	-	-
<i>Alouatta palliata aequatorialis</i>	TF	9	-3.81194	-80.2742	324
<i>Alouatta palliata aequatorialis</i>	TF	7	-3.81341	-80.2719	356

days. The data collected per census were: the transect number, date, time, and the total distance walked. For each sighting, we recorded time, species, the number of individuals, perpendicular distance to the first individual detected, coordinates, and behavior (Marshall et al., 2008); to calculate perpendicular distance we used a rangefinder (Bushnell Yardage Pro, 5 – 100 yards).

Data analyses.- Data Analyses consisted in calculating density estimates for species with more than 12 sightings (*A. p. aequatorialis*) and encounter rates for species with fewer records (*C. a. aequatorialis*), we only used data collected during the transect census and did not include occasional sightings to avoid overestimation. To calculate population density we used the Distance sampling method with Distance 6.0 software (Thomas et al. 2010). For the selection of the best model we used the Akaike Information Criterion (AIC) and a coefficient of variation lower than 30% (Buckland et al. 2001). Distance sampling is commonly employed in tropical forests (Peres 1999, Jathanna et al. 2003, Araldi et al. 2014) and should provide a baseline for future monitoring plans with comparable data in the NBR.

For species with a lower quantity of records (<12) we calculated encounter rates as the number of individuals observed per distance walked (Marshall et al. 2008).

Results and discussion

We obtained 19 primate independent observations of two species of primates, *Cebus albifrons aequatorialis* and *Alouatta palliata aequatorialis* in 112.3 km of sampling effort. For *A. p. aequatorialis* we registered 13 independent observations (Table 1) with group sizes from one (male) to nine individuals (\bar{x} = 4.15). Moreover, we calculated a population density of 8.3 ± 3.6 ind/km² (AIC= 96.5) (Table 2).

For *C. a. aequatorialis* we obtained six independent observations (Table 1). Group sizes ranged from 3 to 12 individuals (\bar{x} = 6.3) and the encounter rate was 0.3 ind/km.

Alouatta palliata aequatorialis

The scenario for the population in Tumbes has potentially improved since the 1980's. One of the first primate assessments and population density estimates in the NBR for *A. p. aequatorialis* were based on a few sightings (Pulido & Yockteng 1986, Encarnación & Cook 1998).

In 1986, Pulido and Yockteng's expedition had difficulty registering howler monkeys, which could be attributed to the lack of protection, hunting pressure in the area, and the shy behavior of the individuals. However, after 41.1 km in 2.58 km² they registered five vocalizations and no direct observation; and calculated a population density of 4.19 ind/km². Furthermore, after two sightings in the Cabo Inga sector, they adjusted their density estimate to 2.3 to 8.6 ind/km² (Table 2).

These low population estimates had potentially increased when Encarnación and Cook (1998) found two troops of *A. p. aequatorialis* consisting of 20 and ten individuals, plus one solitary monkey which was associated to the riparian forest, in the surrounding area of la Vaca and el Ciruelo streams. Moreover, between November 2003 and June 2004, Alzamora (2005) surveyed two streams within the NBR and calculated a population density of 17.1 ind/km². In 2006, the same author counted 142 mantled howler monkeys near el Caucho Biological Station and Campo Verde (localities surveyed in this research) and obtained a population density of 19.1 ind/km² (Table 2).

Our estimate of 8.3 ± 3.6 ind/km² for almost the same localities surveys do not represent a decline in howlers populations, but a difference in the methodology employed. Previous estimates made by Alzamora (2005, 2006) could represent an overestimation due to sampling near streams which according to Encarnación and Cook (1998) is the preferred habitat of this species within the NBR. This tendency towards riverine areas was also noted by Stoner (1996), who determined the selection of black howlers in Costa Rica was linked to rivers and streams as well as primary forest.

Table 2. Population density estimates for *Alouatta palliata aequatorialis* and *Cebus albifrons aequatorialis* across its distribution range.

Species	Method used	Locality	Habitat type	Density estimate	Reference
<i>A. p. aequatorialis</i>	Line transect	El Amargal -Colombia	Tropical moist forest	0.83 groups/10 km ²	Ramirez-Orjuela & Sanchez-Dueñas 2005
<i>A. p. aequatorialis</i>	Triangulation survey	Cerro Blanco -Ecuador	Tropical dry forest	47 ind/km ²	Papworth & Mejia 2015
<i>A. p. aequatorialis</i>	Distance sampling	Pacocha Marine and Wildlife refuge -Ecuador	Tropical dry forest	12.4 ind/km ²	Cervera et al. 2015
<i>A. p. aequatorialis</i>	Vocalizations	NBR - Peru	Tropical dry forest	2-8 ind/km ²	Pulido & Yockeng 1986
<i>A. p. aequatorialis</i>	Line transect	NBR - Peru	Tropical dry forest	17.1 ind/km ²	Alzamora 2005
<i>A. p. aequatorialis</i>	Line transect	NBR - Peru	Tropical dry forest	19.1 ind/km ²	Alzamora 2006
<i>A. p. aequatorialis</i>	Distance sampling	NBR - Peru	Tropical dry forest	8.3 ind/km ²	This research
<i>C. a. aequatorialis</i>	Line transect	El Palmar & Cordillera de la Jama - Ecuador	Desciduos and semi-desciduos forest	3.5 - 3.9 ind/km ²	Albuja & Arcos 2007

Even though our density estimate was non-randomized and to some degree could represent an underestimation of the howler's population size, we covered streams (preferred habitats) as well as transects in the middle of the forest (less preferred habitats). These distinct methodologies and survey design make these studies harder to compare and could explain the different results. However, our results confirm that populations of *A. p. aequatorialis* are recovering.

Mantled Howler monkey's population density varied across its distribution range, representing low estimates in Colombia, 0.83 groups/10 km² (Ramirez-Orjuela & Sanchez-Dueñas 2005) and contrasting estimates in Tropical Dry Forest of Ecuador, from 47 ind/km² (Papworth & Mejia 2015) to 12.4 ind/km² (Cervera et al. 2015). Again, these estimate differences can be attributed to the different methods used such as Triangulation surveys (Papworth and Mejia 2015), playback calls (Salcedo et al. 2014), line transects and survey duration (Ramirez-Orjuela & Sanchez-Dueñas 2015, Cervera et al. 2015), which makes difficult comparisons among areas and time. We recommend using line transects and distance sampling across this primate distribution to assess population changes and dynamics.

Cebus albifrons aequatorialis

Previous information for the NBR reported group sizes of three to five individuals in two different years 1980 and 1994 (Cook & Encarnacion 1998); however no population density was estimated. Additionally, in western Ecuador, after surveying 28 localities and only confirming the presence of *C. a. aequatorialis* in eight, density was calculated as 3.5 and 3.9 ind/km² (Albuja & Arcos 2007). In the Pácoche Marine and Wildlife Refuge, in the coast of Ecuador, Cervera et al. (2015) recorded only three observations of *C. a. aequatorialis* outside 90 km of transects census, indicating a low population size and immediate need for conservation in Ecuadorian populations. With the low encounter rate we obtained added to the low-density estimates obtained through their distribution, this subspecies should be considered for priority conservation within the NBR.

Because of the several different data analyzes and methodologies (different localities and seasons), it is hard to quantify population trends and dynamics of both primates within the NBR. However, primate populations can vary depending on several factors: population growth rates, hunting pressure, diseases, increase in predation rate, and the decrease in habitat suitability, among others (Chapman & Balcomb 1998, Carrera-Sánchez et al. 2003). Moreover, ENSO events affect the NBR every few years, altering rainfall patterns and plant productivity (Holmgren et al. 2006, Holmgren et al. 2001), and these changes should be considered in future assessments.

In order to elucidate current population trends of *Alouatta palliata aequatorialis* and *Cebus albifrons aequatorialis* in the NBR, it is imperative to implement a long-term monitoring plan, with detailed and uniform methodology. An assessment of the primate capture for pet trade is also needed. In the adjacent forest in Ecuador, *C. albifrons* represents 27% of illegal mammal captures and 50% of primate captures which makes this species a common target (de la Torre 2012). Considering the NBR is located in the limit of Ecuador and previous hunting attempts

from Ecuadorians in the area of Campo Verde, an increased and continuous monitoring of this area is necessary to reduce the effects of illegal hunting. Furthermore, the lack of information about this species in Peru added to the low population density and connectivity of the remnant suitable areas in Ecuador (Albuja & Arcos 2007, Campos & Jack 2013, Cervera et al. 2015) should give this species the higher legal protection by the Ministerio del Ambiente in Peru.

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