Mapping Ecuadorian mantled howler for conservation

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The steep decline of Ecuadorian mantled howlers (*Alouatta palliata aequatorialis*) perfectly illustrates the threat that hangs over all Ecuadorian primates.[1,2] The main threat they are facing is habitat loss, which is pervasive in coastal Ecuador where less than 10% of the original forest cover remains.[3] Since mapping and analyzing vulnerability is the first step toward planning and developing sound conservation actions,[4] I have built the first vulnerability map for *A. p. aequatorialis* and I have assessed the impact of anthropogenic disturbances on the demography of the species. My results indicate that it has been confined to the last forest fragments, poorly connected between them and most of them without legally protected status. This patchy distribution, combined with ongoing deforestation and negative impacts from ecotourism, threatens long-term persistence of this species; but establishing more "non-paper" protected areas could make a difference.

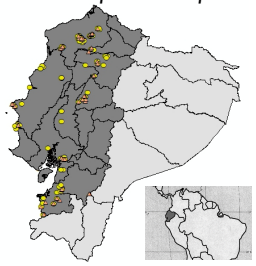
Objectives

i. create the first map of ***A. p. aequatorialis* Environmental Vulnerability** (EV) using the data of the First Primate Census in the coastal region of Ecuador [5]
ii. determine how **human use** of this species affect its presence and group size
iii. seek a pattern of **EV values distribution**
iv. assess the impact of **anthropogenic disturbances** on its EV and group size

Materials and methods

The species

Alouatta palliata aequatorialis Festa 1903 (Atelidae: Primates)



The study area

Coastal Ecuador and western Andean foothills

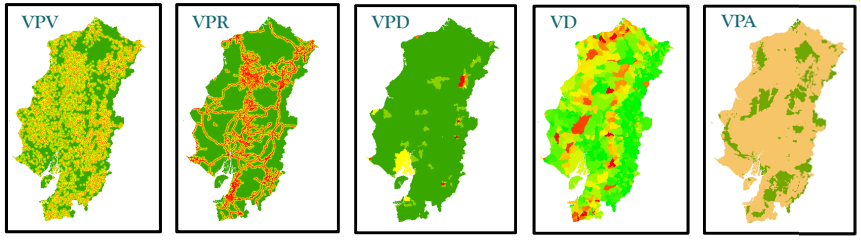
Deforestation rate: 300 000 hectares per year (3%) [3]
Human population density: 55 inhabitants/km² [3,6]
Provinces: Esmeraldas, Guayas, Los Ríos, Manabí, El Oro, Santa Elena, Azuay, Bolívar, Cañar, Carchi, Chimborazo, Cotopaxi, Imbabura, Pichincha, Santo Domingo de los Tsáchilas, and Tungurahua
Census: 81 localities censused during October-November 2016 ● (number of groups and group sizes were reported)

Interviews with local people were conducted in 58 localities to assess *A. p. aequatorialis* use ▲

The vulnerability map

EV = VPV + VPR + VPD + VD + VPA

all factors on a scale of **1-5**, with 5 being maximum vulnerability; except for VPA, on a scale of **1-2**, with 1 being inclusion in protected areas. [7]



Proximity to villages
Euclidean distance from each cell to the closest village

Proximity to roads
Euclidean distance from each cell to primary, secondary and tertiary roads, and railways

Population density
According to the Ecuadorian Population and Housing Census in 2010 [8]

Deforestation
According to data from 1990 to 2014

Protected areas
Considering areas from the Heritage of Natural Areas of the Ecuadorian State (PANE) and Areas of Forest and Protective Vegetation (ABPV) [9]

Statistical analysis

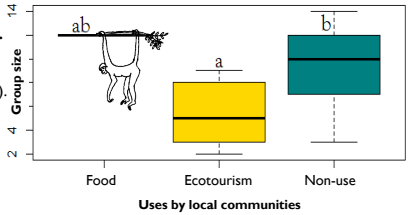
Presence and group size by uses	**Likelihood Ratio test (λ):** Is there a relationship between presence of *A. p. aequatorialis* and the use of this species by local communities? **ANOVA one-way (F) + Tukey HSD:** Human use is responsible for differences in group size?
Vulnerability by location	Looking at **maps**!
Anthropogenic effects on group size	**Pearson correlation tests (r):** Is there a relationship between EV values and group size reported? Is there a relationship between group size and distance to the nearest village, distance to the nearest road and human population density?

Results

Presence and group size by uses

There is a significant relationship between use of *A. p. aequatorialis* and its presence (λ(3)=15.164, p-value=0.020). When howlers were detected, communities use them mainly for ecotourism (37%) or do not use it (44%).

There are differences of group size according to human use (F(2)=4.437, p-value=0.026): size of troops subjected to ecotourism is almost half (58%) the size of non-used troops (p-value=0.037).



Vulnerability by location

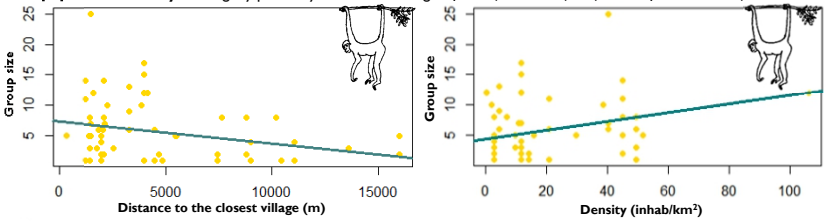
Mean environmental vulnerability (EV) of all census points is **6.9±1.9**.

Northwest Ecuador is the area preferred by most *A. p. aequatorialis* troops. There were 2.3 times more populations in nonprotected areas (N=121) than in protected areas (N=51). However, all private reserves that were included in the census shelter relatively large populations of howlers (group of 5 individuals or more).

Anthropogenic effects on group size

There was no significant relationship between EV and group size (r=0.193, F(1, 58)=2.238, p-value=0.140).

Distance to villages was slightly negatively correlated with group size (r=0.282, F(1,60)=5.167, p-value=0.027), whereas **population density** was slightly positively correlated with group size (r=0.297, F(1,60)=5.794, p-value=0.019).



Discussion

Despite its large body size, **hunting** is not a serious threat to *A. p. aequatorialis* in Ecuador.[2,10] However, **ecotourism** does have a negative impact on its populations. It may be that increased contact between people and monkeys increases the potential for disease transmission,[11] as reflected by the unsolved death of 44 Ecuadorian mantled howlers in Pacoche Reserve during February 2016.[7]

Most groups were located in forest fragments near the **protected areas of north-western Ecuador,** where deforestation have been less pervasive than in the rest of the coastal plain.[12] These results point to the dramatic consequences of deforestation for *A. p. aequatorialis* and to the efficiency, to some degree, of protected areas for its conservation.

Surprisingly, **EV cannot be used to predict troop size**, perhaps for *A. p. aequatorialis* has already gone locally extinct where vulnerability is too high or for group size is limited by social rather than by ecological constraints. Besides, group size increases with proximity to villages and increases with human population density. It could be that these troops, while travelling between fragments of native forests, meet in high resource availability areas (such as river margins and crops), where they survive using exotic trees as food sources. [12]

In spite of this capacity to persist in extreme conditions, the fragmented distribution of *A. p. aequatorialis* in western Ecuador does not bode well for its long-term survival, even more if we consider limited overlap with formally protected areas and current deforestation rates.[3] Although protected areas are not the panacea for achieving biodiversity conservation,[9,14] they seem to buffer *A. p. aequatorialis* from various anthropic disturbances. For this reason, **this species will largely benefit of the establishment of new protected areas and of the legal strengthening of current ones; and also of the construction of protected corridors between forest fragments.**

References: **(1)** de la Torre, S. 2012. *Int Zoo Yearb.*, **46**: 25–35. doi:10.1111/j.1748-1090.2011.00158.x. **(2)** Tirira, D.G. (ed.). 2011. *Libro Rojo de los mamíferos del Ecuador.* Second Edition. Fundación Mamíferos y Conservación, Pontificia Universidad Católica del Ecuador & Ministerio del Ambiente del Ecuador. Publicación especial sobre los mamíferos del Ecuador 8. Quito. **(3)** Dodson, C.H. & Gentry, A.H. 1991. *Ann Mo Bot Gard*, **78**(2): 273-295. **(4)** Wilson, K., Pressey, R.L., Newton, A., Burgman, M., Possingham, H. &, Weston, C. 2005. *Environ Manage*, **35**: 527. doi: 10.1007/s00267-004-0095-9 **(5)** MAE, WCS, USFQ & GEPE, *in prep.* **(6)** de la Torre, S., Yépez, P., Nieto, D. & Payaguaje, H. 2013. In: Marsh, L.K. & Chapman, C.A. (eds). Primates in Fragments. Complexity and Resilience. Developments in Primatology: Progress and Prospects. Chapter 29. Springer, New York. pp 437-445. **(7)** S. de la Torre, personal communication. **(8)** INEC (National Institute of Statistics and Censuses). 2010. *Ecuador Population and Housing Census 2010*. **(9)** López-Rodríguez, F. & Rosado, D. 2017. *Journal of Environ Manage*, **190**(1): 45-52. doi:10.1016/j.jenvman.2016.12.043. **(10)** Crockett, C.M. 1998. *Int J Primat*, **19**: 549-578. doi:10.1023/A:1020316607284. **(11)** McKinney, T., Westin, J.L. & Serio-Silva, J.C. 2015. In: Kowalewski, M.M., Garber, P.A., Cortés-Ortiz, L. & Urbani, B. (eds). Howler Monkeys. Developments in Primatology. Springer, New York. pp 281-311. **(12)** Sierra, R. 1999. *Vegetación Remanente del Ecuador Continental*. Circa 1996, Escala 1:10000.000. Proyecto INEFAN/GEF & Wild-life Conservation Society, Quito. **(14)** Pozo-Montuy, G., Serio-Silva, J.C. & Bonilla-Sánchez, Y.M. 2011. *Primates*, **52**: 139. doi:10.1007/s10329-010-0231-5. **(15)** van der Hoek, Y. 2017. *Environ Cons*, **1-7**. doi:10.1017/S0376892917000115

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