



High jaguar densities and large population sizes in the core habitat of the southwestern Amazon



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ABSTRACT

Over 80% of the currently occupied range of the jaguar (*Panthera onca*) lies in the Amazon. However, few density estimates exist for this habitat. Between 2005 and 2010 we carried out six camera trap surveys at three different sites in the department of Madre de Dios in the Peruvian Amazon. We analyzed our data using a Bayesian spatially explicit capture recapture model (SECR) with sex covariates to account for differences in home range size and detection probabilities of male and female jaguars. As several of our camera grids were too small for reliable density estimates, we used estimates for the σ parameter from the largest camera grid to correct for the bias. Density estimates for our surveys were similar with an average density of 4.4 ± 0.7 jaguar 100 km^{-2} . Both home range size and encounter rates varied significantly between sexes with males having a larger home range and higher encounter rate than females. Our estimated sex ratio was 1:1.5 compared to an observed ratio of 1.9:1. Not accounting for sex would have resulted in an underestimation of the true density. The densities found in this study are among the highest documented and show that the Amazon is indeed a core habitat for the jaguar. We estimate that three jaguar conservation units in our study region (areas defined by experts as having a high conservation priority) could harbor as many as 6000 jaguars (CI: 4278–8142).

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1. Introduction

The jaguar (*Panthera onca*) has a wide distribution ranging from northern Mexico to northern Argentina, but has disappeared from over 40% of its original range over the last century largely due to habitat loss (Sanderson et al., 2002; Zeller, 2007). It is currently classified as near threatened by the IUCN with populations in Central America and Mexico, the Atlantic forest, the Cerrado of Brazil, the Chaco in northern Argentina and savannas of Venezuela and the Guianas being most threatened (Caso et al., 2008). The Amazon remains the largest continuous block of habitat within the jaguar's range and is considered a stronghold for the species with a very high probability of long term survival (Sanderson et al., 2002; Zeller, 2007). Within the Amazon the upper Amazon tropical lowland moist forest makes up the largest ecoregion, spanning five countries including Brazil, Bolivia, Columbia, Ecuador and Peru.

In Peru the jaguar is found throughout the lowlands of the Amazon basin east of the Andes up to an elevation of about 1500–2000 m and about 23% of its range falls within protected areas (Carrillo-Percestequi and Maffei, in press). During a recent reclassification of the Peruvian red list of threatened species the jaguar was

classified as near threatened (Carrillo-Percestequi and Maffei, in press). The major threats to the species are hunting and deforestation due to the expansion of agriculture and a surge of gold mining in the Amazon over the recent years (Swenson et al., 2011). With an increase of cattle ranching and small scale agriculture we also expect more conflicts between jaguar and ranchers with more jaguars being shot as retaliation to livestock loss. While the Peruvian law prohibits any killing of jaguars and all trade with jaguar parts, there is little enforcement and teeth, claws, skin parts and even whole skins are often seen for sale in local markets.

The southern part of the Peruvian Amazon in the department of Madre de Dios still consists of largely continuous forest (Asner et al., 2010). The region includes three protected areas of more than 1 million hectares each: Alto Purus, Manu, and Bauhuja-Sonene National Parks; as well as the Tambopata National Reserve; several large indigenous reserves and a number of private conservation concessions. The landscape connects to Manirupi-Heath Amazonian Wildlife Reserve and Madidi National Park in Bolivia to the east. Based on the large expanse of these forests and the assumed health of jaguar populations in the region, experts defined three jaguar conservation units (JCU) of high priority that together cover an area of 138,000 km^2 , 55,014 km^2 of which are within existing protected areas (Zeller, 2007). Despite the importance of the Amazon lowland moist forest as jaguar habitat, only

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a few studies have been carried out in this ecoregion and as of today no reliable density estimates exist. The goal of our study therefore was to evaluate the density of jaguars in different types of management units in the Madre de Dios basin; government protected areas, a private conservation area, and a forestry concession (one of the first in the Amazon basin to receive FSC certification) in order to obtain a better understanding of their population status across the landscape, and ultimately to estimate the size of the population in the whole region.

Camera traps in combination with capture–recapture models have become the most widely used method for estimating jaguar densities (Maffei et al., 2011; Silver et al., 2004). However, a recent simulation study showed that results can be highly biased when camera grids used are smaller than the home range of the study species (Tobler and Powell, in press; but see Sollmann et al., 2012). Since our surveys were affected by this problem we evaluated a new method of data sharing and borrowing across surveys in combination with spatially explicit capture recapture (SECR) models (Borchers and Efford, 2008; Efford et al., 2009; Royle and Gardner, 2011; Sollmann et al., 2011) in order to obtain unbiased results from three different sites in two of the JCU proposed by Zeller (#75 and #76, 2007) in the south-eastern Peruvian Amazon.

2. Materials and methods

2.1. Study area

This study was carried out at three different sites in the department of Madre de Dios, Peru (Fig. 1). The first site, the Los Amigos

Conservation Concession, is a 1400 km² private protected area, established in 2001 (12°19′–12°36′S, 70°02′–70°17′W, 200–320 m asl) that is bordered in the south by the Madre de Dios River, in the north and east by forest concessions, and in the west by a large indigenous area that protects uncontacted groups that are living in voluntary isolation. Our second site was located along the Tambopata river in the Bahuaja Sonene National Park, 5 km south of the Malinowsky guard post (12°57′–13°01′S, 69°25′–69°30′W, 200–250 m asl). The third site was within the Espinoza Forestry Concession in the northern part of Madre de Dios south of the Tahuamanu river (11°25′–11°44′S, 69°42′–69°57′W, 300–380 m asl). This forest concession is FSC certified for sustainable management and has been selectively logged since 2003. A network of logging roads has been established that allows access for workers and trucks hauling supplies, logs, and lumber but guarded gates prevent outsiders from using the roads. Hunting at all three sites is prohibited but there is some hunting in surrounding areas. We are not aware of any killing of jaguars within our study areas during the time of our surveys.

The climate in the region is divided into a dry season from June to October and a rainy season from November until May with a mean annual rainfall between 2500 and 3500 mm. Mean annual temperature is 24 °C with a range from 10 to 38 °C.

All three sites are in lowland Amazonian moist forest. Los Amigos and Tambopata contain both *terra firma* and floodplain forest while Espinoza is mainly *terra firme* forest. The floodplain forest in the region is never completely inundated, even at the peak of the rainy season except for a narrow fringe of less than 1 km along the main river.

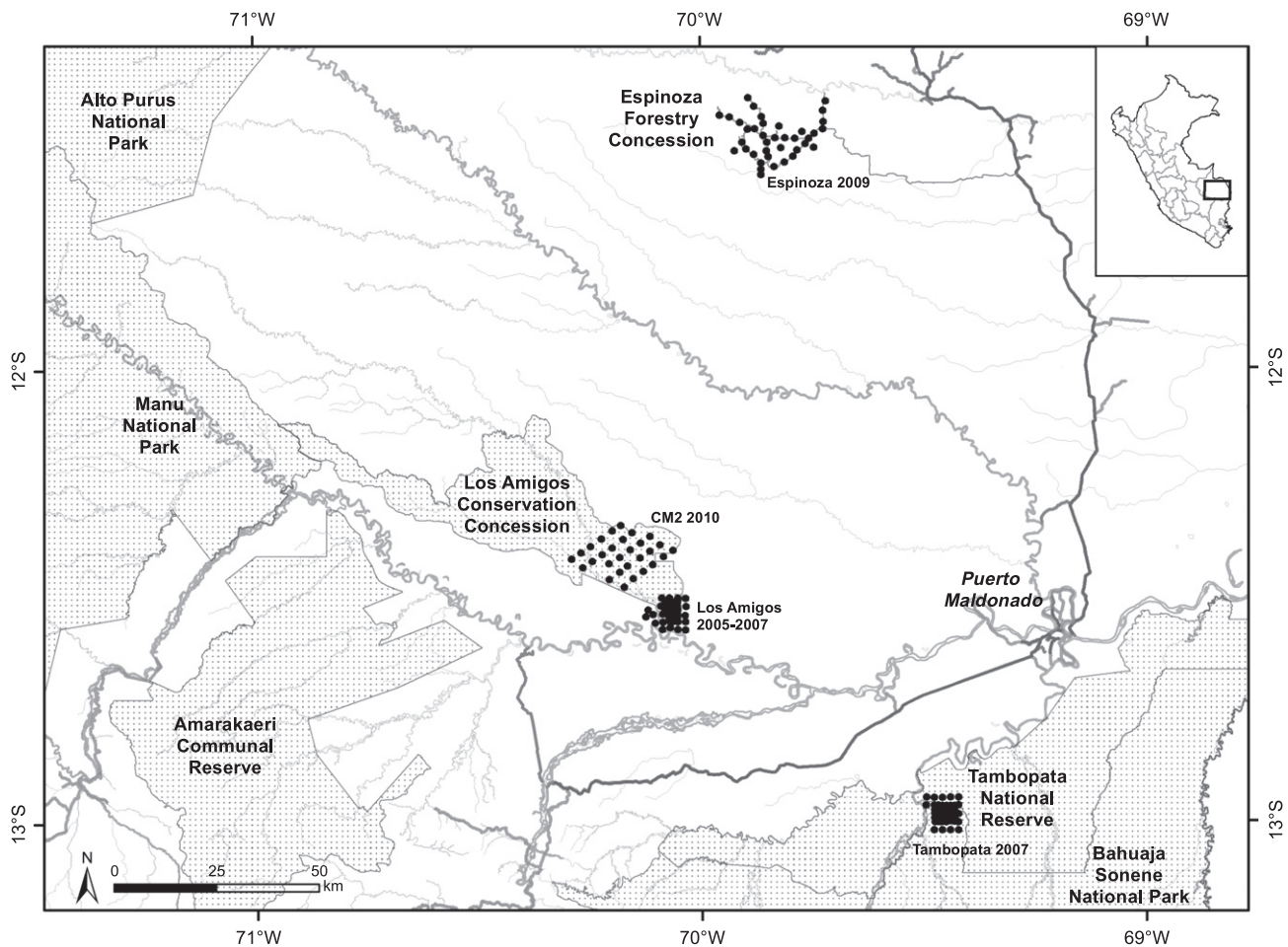


Fig. 1. Map showing the location of six camera trap surveys in Madre de Dios, Peru. Shaded areas are protected areas; the dark line shows the interoceanic highway.

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