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The jaguar in the Atlantic Forest

Jaguars *Panthera onca* are Critically Endangered (A4 b c d; C2 a i) in the Atlantic Forest because a population reduction of 50-90% was estimated in the past 10-15 years in the largest subpopulations of jaguars at the Upper Paraná and is suspected at the Coastal Atlantic Forest. The causes of reduction have not ceased since there is a continuous decrease in the Extent of Occurrence EOO, Area of Occupancy AOO and habitat quality, plus retaliatory and sport killing. The total number of mature individuals is less than 250 and the number of mature individuals is less than 50 in almost all subpopulations. The most serious threats to jaguars in the Atlantic Forest are habitat loss and degradation, loss of prey base and jaguar hunting. Legal protection has been ineffective in stopping Atlantic Forest deforestation and most protected areas have human settlements, causing direct habitat loss, habitat degradation and loss of prey base; other forms of habitat degradation are caused by illegal palm *Euterpe edulis* harvesters and poachers, as well as through natural and criminal fires that occur throughout the Atlantic Forest. Conservation measures most needed are the legal and effective protection of all the remaining large fragments of the Atlantic Forest through new restrictive Conservation Units, restoration of connectivity between the extant protected areas with known jaguar populations, effective protection of the extant Conservation Units in the form of intensive patrolling and an increase in ecological and genetic research to allow population management, which may be a necessity in some areas.

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Assessment

Critically Endangered A4 b c d; C2 a (i)

– A population reduction of at least 50%, probably closer to 87-90%, was estimated in the past 10-15 years in the largest subpopulations of jaguars at the Upper Paraná. The main cause of reduction of this subpopulation in the past 25 years may have been habitat loss which has intensified in the region in the last 60 years; therefore, a similar trend

of subpopulation reduction may be suspected to have occurred in the last 25 years. The causes of reduction have not ceased since there is a continuous decrease in the extent of occurrence EOO, area of occupancy AOO and habitat quality, plus retaliatory and sport killing; therefore the trend of reduction of the subpopulation in the Upper Paraná is likely to continue for the next 25 years and the species may become extinct in 88 years. There is no



Fig. 1. Extent of occurrence EOO of jaguar in the Atlantic forest. The numbers refer to the polygons described in Table 1.

long-term information for subpopulations in the coastal Atlantic Forest, but the reduction of the EOO to 43% at the south of the Serra do Mar range which occurred over the last 50 years, the ongoing habitat loss and the habitat quality degradation which is increasing throughout the Atlantic Forest support the supposition that population losses and trends are similar to those on Upper Paraná or worse. The total number of mature individuals is less than 250 and the number of mature individuals is less than 50 in almost all subpopulations with the exception of one subpopulation estimated at 52 mature individuals.

Geographic range information

Extent of occurrence EOO

The Atlantic Forest originally occupied 1,315,460 km² (IBGE 2008) and jaguars were historically distributed throughout the biome (Sanderson et al. 2002). The present extent of occurrence EOO of jaguars in the Atlantic Forest is 44,487 km². It comprises both the protected areas with known or inferred recent (last 10 years) jaguar presence (Table 1) and points of jaguar presence reported by researchers and in the literature. This EOO represents 44% of the remaining 102,012 km² (INPE & SOS Mata Atlântica 2008) of the Atlantic Forest and is divided in eight polygons which also represent present jaguar subpopulations (Fig. 1). A single Minimum Convex Polygon is not adequate to represent jaguar EOO because the areas with jaguar presence in the Atlantic Forest are isolated by large areas unsuitable for jaguar presence (Ferraz et al. 2012, this issue) which occupy ca. 80% of the EOO.

The Atlantic Forest may be divided in 15 ecological regions (Di Bitetti et al. 2003). In regard to jaguar distribution, the Upper Paraná Forest Ecological Region located west of meridian 51 represented by polygons 1 and 2 in Figure 1 differs from the remaining Atlantic Forest not only by ecological but also socio-economic characteristics and threats to the conservation of the species.

Area of occupancy AOO

Jaguars use mainly good quality habitat (Cullen et al. 2005) which is almost totally confined to the interior of protected areas (Fig. 2). Thus, the area of occupancy AOO of jaguars in the Atlantic forest is 30,382 km², which is the sum of the Conservation Units with known or inferred recent jaguar presence (Supporting Online Material SOM Appendix 1).

Severe fragmentation

The massive destruction of the Atlantic Forest began with the European colonization (Dean 1996) and has greatly accelerated in the last three decades (INPE & SOS Mata Atlântica 2008) with a mapped destruction of 11% of the remaining forest from 1985 to 1995 (Câmara 2005), allowing a projection of roughly 27% loss in the past 25 years. Despite legal protection, Atlantic Forest deforestation continues at an average rate of 350 km²/year (INPE & SOS Mata Atlântica 2008), which projects to a loss of 8.5% of the remaining forest in the next 25 years.

The smallest of the isolated forest fragments with recently confirmed jaguar presence is the 360 km² PE Rio Doce (Viana 2006). According to Ribeiro et al. (2009) only around 20% of the remaining forest exists in fragments larger than 250 km². The Atlantic Forest is the most densely populated area of Brazil and the areas between the subpopulations are intensely occupied by human activities. Although jaguars have good dispersal ability (Quigley & Crawshaw 2002), most of these occupied areas are totally unsuitable for jaguar use; therefore, the eight subpopulations are isolated from one another.

In the Upper Paraná only 2.7% of the original forest area remains (7,712.76 km², Di Bitetti et al. 2003). The occupation of the region was intensified around 60 years ago initially by coffee and cotton plantations and subsequently by cattle farms and the cultivation of other crops (Godoy 2001).

The marshland areas of the Paraná River which represent 40% of the habitat suitable for jaguars available in the Upper Paraná are being destroyed by hydroelectric dams. Presently only 30% of the Paraná River in Brazil is free of dams and the marshlands of the River Paraná have been reduced to 230 km² (Agostinho & Zalewski 1996).

Ecology and population information

Population size

Population estimates for the Upper Paraná have been obtained by radio telemetry and camera trapping in different environments and areas. In PE Morro do Diabo population density was 2.22 ind./100 km² (Cullen et al. 2005); in PN de Iguaçu, Brazil, 15 years ago population density was 3.7 ind./100 km² (Crawshaw Jr 1995); in PN Iguazú, Argentina, contiguous to PN Iguaçu in Brazil, population densities were 0.49 ind./100 km² and 0.93 ind./100 km² when this Park is added to private contiguous areas (Paviolo et al. 2008). Preliminary data from the “Projeto Carnívoros do Iguazú” corroborate the low population density found by Paviolo et al. (2008) in the Iguaçu region. In marshland areas such as the PE das Várzeas do Rio Ivinhema a population density of 0.72 to 0.84 ind./100 km² was estimated (D. Sana, unpubl. data). Except for the PE Morro do Diabo, the recent studies have estimated low population densities - smaller than 1 ind./100 km² in all regions.

Cullen (2006) estimated a carrying capacity of around 82 animals for the region of PE Morro

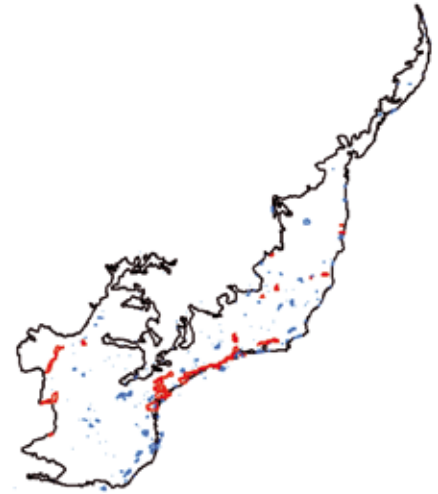


Fig. 2. Area of occupancy AOO of jaguar in the Atlantic Forest, estimated as the protected areas (red lines) with known or inferred presence of the species.

do Diabo, PE das Várzeas do Rio Ivinhema and PN de Ilha Grande. From PE Morro do Diabo to PN de Iguazú along a 50 km strip of each side of the rivers Paranapanema and Paraná, there are around 13,000 km² of adequate habitat for jaguars consisting of forests and marshlands. When marshland and forest areas with different population densities were separated, a carrying capacity of 94 individuals was estimated for this region (Programa “Onças do Alto Paraná” unpublished data). However, there are important contiguous areas at Paraguai and Argentina (Misiones) at the Green Corridor which add protected areas

Table 1. Estimated extent of occurrence EOO of jaguar and population size (mature individuals) estimated for the 8 subpopulations of the species in the Atlantic Forest.

Polygon	Polygon #/ Subpopulation	States	area (km ²)	# mature individuals	References and methods
PN Iguaçu to PE do Turvo	1	RS, SC, PR, Misiones (Argentina)	4,542	32	Paviolo et al. 2008, camera-traps
Pontal do Paranapanema to PN Ilha Grande	2	PR, MS, SP	9,517	52	Cullen et al. 2005, camera traps; Sana, unpubl. data, radio telemetry and camera traps
Serra do Mar	3	PR, SP, RJ	25,609	31-51	Beisiegel & Oliveira, unpubl. data, camera-traps
Sooretama/Reserva Vale	4	ES	2,514	<20	Srbek-Araujo, unpubl. data, camera- traps
Mantiqueira	5	MG	828	6	Amorin Jr., unpubl. data, camera traps
Rio Doce	6	MG	365	13	Viana 2006, camera traps
Espinhaço	7	MG	154	1	Amorin Jr., unpubl. data, camera traps
Monte Pascoal/Pau Brasil	8	BA	958	1 - 5	Leite et al. 2002
Total			44,487	156 - 180	



Fig. 3. View of Parque Estadual Carlos Botelho PECB, inside the best preserved forest in the Serra do Mar polygon (Photo B. Beisiegel).

suitable for the species. These areas must also be considered for the conservation of jaguars (Paviolo et al. 2006). The population densities cited above allow the estimate of 32 mature animals for the polygon of PN Iguçu to PE do Turvo and 52 mature individuals for the polygon of Pontal do Paranapanema to PN Ilha Grande.

The core area population of the Serra do Mar polygon lies within the southwestern portion of São Paulo state and adjacent areas of Paraná state where due to low socio-economic development human pressure on the forest is less accentuated than in the remaining Atlantic forest. At the

fragment including the Parques Estaduais Carlos Botelho, Intervalos and PETAR, which is the best preserved portion of this forest, jaguar population density is 0.23-0.39 mature individuals/100 km² (B.M. Beisiegel & E.N.C. Oliveira, unpub. data). The Area of Occurrence of jaguars in this polygon is 13,147.79 km²; if jaguar population density was uniform through all the area, the Serra do Mar polygon would have a total population of 30 - 51 mature individuals. However, most of the Area of Occurrence in this polygon is not so well preserved as in the Park. Tracks and reports suggest that in most of its areas jaguar population density is much



Fig. 4. Interior of the Atlantic forest in Parque Estadual Carlos Botelho PECB (Photo B. Beisiegel).

lower than at PECB; therefore, the best estimate for this polygon would be less than 51 individuals.

The Reserva Vale area has a population of less than 20 mature individuals (A.C.S. Araujo unpublished data); and although there are no data from Reserva Biológica Sooretama, the same individuals probably use both areas. The best population density estimate for the polygons of the Minas Gerais state (Parque Estadual do Rio Doce, Mantiqueira and Espinhaço) are 0.02 ind/100 km² in suitable areas of, respectively, 1,253.65, 605.86 and 139.42 km² (Viana 2006; E.M. Amorin Jr., unpubl. data). Leite et al. (2002) estimated the population of south Bahia state to be 3-9 jaguars of which 1-5 would be mature individuals; but there is no present information on its status or persistence.

The total jaguar population for the Atlantic Forest is therefore no greater than 156-180 mature individuals. Table 1 summarizes sub-population estimates.

Population trends

Jaguar subpopulations are declining throughout the Atlantic Forest. At the Green Corridor including the Iguçu National Park in Argentina and Brazil jaguar population densities decreased 2-7.5 times over 10 years (Paviolo et al. 2008) indicating a 50% to 87% population reduction in this period. Preliminary studies of the Project "Carnívoros do Iguçu" indicate that the population density at PN do Iguçu may be 10 times lower than the density estimated by Crawshaw (1995) 15 years earlier and that implies a 90% population reduction over this period. If the present trends of reduction and isolation of subpopulations continue, the average time for the extinction of the jaguar at the Upper Paraná is estimated to be 88 years (Cullen et al. 2005).

The species disappeared from the Coastal Atlantic Forest of the States of Rio Grande do Sul and Santa Catarina between the years 1960 and 1990 (Mazzolli 2008) which means a loss of more than 20,000 km² and a reduction of 43% of the EOO of jaguars at the southern portion of Serra do Mar over 30 years.

Human occupation of the areas surrounding the AOO of jaguars and human pressure inside the Conservation Units are increasing. Consequently habitat quality and capacity for the support for jaguar subpopulations is decreasing.

Subpopulations

In the Upper Paraná (polygon 1 and 2 in Fig. 1) jaguar subpopulations are restricted to semi-connected areas in a metapopulation structure (Cullen et al. 2005). Genetic studies denote 4 groups: Morro do Diabo; Porto Primavera; Ivinhema and Green Corridor (PN de Iguaçu to PE do Turvo, connected by forest area in Misiones, Argentina (Haag 2009). Loss of genetic variability and isolation between these areas may be occurring, with the Green Corridor being isolated from the subpopulations in the north (Haag 2009).

There are at least six subpopulations within the Coastal Atlantic Forest (Table 1). Since there is no evidence of connectivity between PN Serra da Bocaina and REBIO Tinguá (RJ), the Serra do Mar subpopulation may also be separated in two.

Other life history information

Inside any remnant of the Atlantic Forest, 12 km is the maximum distance from any non-forested area (Ribeiro et al. 2009); and this distance, which is similar to the average jaguar home range diameters (8.55 km², Crawshaw 1995) occurs only within the largest remnants. Therefore, probably only a few jaguars in all the Atlantic Forest have home ranges free from edges with non-forested, populated areas.

Threat information

Being the top terrestrial predator throughout its range, the jaguar is affected by all threats that decrease the populations of their prey in addition to the threats specific to their own survival. SOM Appendix II presents these threats according to the IUCN classification scheme and the most serious of them are discussed here.

Habitat loss

Legal protection of the Atlantic Forest has been ineffective in stopping deforestation. Moreover, most protected areas including the most restrictive categories have human settlements, causing both direct habitat loss and habitat degradation.

Habitat degradation

This is one of the most serious threats faced by the species since carrying capacity determines the impact of small population sizes on population growth, long term persistence, genetic diversity and mean time to extinction (Desbiez et al. 2012, this volume). All the protected areas of the Atlantic Forest suffer from



Fig. 5. Large scale habitat loss in the Parque Estadual do Turvo to gain land for agriculture (Photo B. Beisiegel).

some form of habitat degradation, mainly the activities of illegal palm *Euterpe edulis* harvesters and poachers which cause loss of prey base and alteration of the forest ecology. The marshland areas of Upper Paraná are annually affected by natural and criminal fires.

Loss of prey base

Subsistence and sport hunting occurs throughout the Atlantic Forest. In some localities jaguar prey, mainly tapirs *Tapirus terrestris*, white lipped peccaries *Tayassu pecari*, different deer species *Mazama spp.* and collared peccaries *Pecari tajacu* have been overhunted to scarcity or extinction (Crawshaw 1995, Cullen et al. 2000, Azevedo & Conforti 2008).

Jaguar hunting

In some parts of the Atlantic forest the rarity of the jaguar today is probably due to elimination of the species in the past. Such is the case in the Serra do Mar from southern RJ (PN Serra da Bocaina; P. Crawshaw, pers. comm.) to the PE da Serra do Mar where there is plenty of the preferred jaguar prey and continuous forest cover (A. Rossi, pers. comm.).

Retaliatory killing occurs throughout the Upper Paraná where there is a predominance of cattle farms (D. Sana, unpubl. data, IBAMA, unpubl. reports, Crawshaw Jr. 1995, Azevedo & Conforti 1999) and in the southwestern São Paulo state (e.g. Palmeira & Barreira 2007). Sport hunting is not cited in the literature but is reported by researchers and by the staff of some protected areas (APA de Guaraqueçaba, EE Xitué, PE Intervales).

Conservation information

Conservation measures

SOM Appendix III presents current projects on jaguar conservation. Here we list the most pressing conservation actions needed to conserve the jaguar in the Atlantic Forest.

1. The jaguar needs legal protection in the form of restrictive Conservation Units for all the remaining large fragments of the Atlantic Forest, and restoration of connectivity between the extant protected areas with known jaguar populations.
2. The species needs effective protection of the extant Conservation Units in the form of intensive patrolling. This is regarded as one of the most important conservation measures by the collaborators of this account and by the literature (e.g. Mazzolli 2008).
3. There is a need to increase ecological and genetic research to allow population management. Translocations to increase depleted populations or to reduce inbreeding may be a necessity in some areas (e.g. Sooretama/Reserva Vale complex, A. C. Srbeck-Araujo, pers. comm., north coast of São Paulo, A. Rossi, pers. comm.).

Contributors

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Supporting Online Material SOM Appendices I to III are available at www.catsg.org/catnews

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