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Red List assessment for the jaguar in the Caatinga Biome

The Caatinga is the only exclusive Brazilian Biome and the jaguar *Panthera onca* is one of the most endangered species in this biome. In this paper we present the status of the species in the Caatinga biome. No specific information on jaguars' biology and ecology is available for the Caatinga. Jaguars are distributed within the Caatinga along 178,579 km², which represents 21% of the biome. This range was estimated based on the confirmed locations, population ranges, and the favourable areas for its presence based on habitat viability models. It seems that the jaguar population in the biome is very fragmented. Five sub-populations were identified and the area of occupancy of jaguars was 87,325.50 km². This area comprises only 10% of the total area of the Caatinga biome. The general average of all the density estimates resulted in a number of 0.3 individuals/100 km², a very low population with estimation of 262 individuals. The status of conservation of jaguar is Critically Endangered C2 a(i). Among the main threats to its populations are stern fragmentation, habitat loss and degradation, loss of prey base, jaguar hunting, and industrialization of the surrounding areas. Some conservations measures like maintenance of the gene flow among jaguar populations by means of ecological corridors and a new protected area are urgent actions.

Assessment

Critically Endangered C2 a (i) – The total number of mature individuals is less than 250 and the number of mature individuals in each subpopulation is less than 50 in the majority of the subpopulations.

Geographic range

Extent of Occurrence (EOO) and Area of Occupancy (AOO)

The Caatinga comprises a total of 844,453 km² throughout ten northeastern States (IBGE 2004). Although the presence of jaguars *Panthera onca* within its boundaries has been controversial, it remains one of the most threatened species in this biome. Until recently the extent of occurrence in the biome was uncertain due to the lack of information and almost the entire Caatinga was indicated as an area of unknown status (Sanderson et al. 2002). Studies over the past ten years by several researchers made the calculation of a distribution range for Caatinga recently possible for the first time. The jaguars are distributed over 178,579 km² which represents 21% of the biome (Fig.1). This range was estimated based on confirmed locations (research projects and specific investigations), population ranges, and favourable areas for its presence based on habitat suitability models (Ferraz et al., in prep.). Within this range 35,668 km² represent 17 protected areas. These areas are key zones for jaguar conservation in this biome since the suggested causes of population decline are directly or indirectly generated by human presence.

Little information on jaguars is available in the Caatinga. Five subpopulations were defined based on location groupings and inferences of suitable habitat. The Area of Occupancy of jaguars in the Caatinga is the sum of the subpopulations. Therefore, the total of the jaguar's area of occupancy is 87,325.50 km² which represents 49% of the jaguar distribution range and only 10% of the total area of the Caatinga biome.

Severe fragmentation

Most of the Caatinga (68%) is disturbed by anthropogenic factors (MMA 2002) and only 31.6% remains intact. Present jaguar distribution is related to the remaining natural habitat quality which depends on reduced human presence and activity. The area along Sao Francisco River in Bahia state represents one of the sectors with the highest human pressure (MMA 2002). Consequently, the human development index increased substantially in the same area (da Silva et al. 2004). Implications for jaguar conservation are clear since they no longer are present in areas of high human development.

Human density in Caatinga generally is very low - averaging 50 to 100 people/km². Within the jaguar range the average is lower than 50 people/km² (da Silva et al. 2004). However, human settlements are abundant; ranging from less than 50 inhabitants to towns with ca. 50,000 people (Fig. 3). Considering that game hunting for food and cultural purposes remains widespread and an important aspect of the local lifestyle, the number of settlements as well as the size of human populations plays an important role in jaguar conservation.

Ecology and population information

Population size

Jaguar population has never been estimated systematically in this biome. The only published information is very recent (Silveira et al. 2010) from research on population estimates in the Serra da Capivara National Park. Since 2005 CENAP has additionally been survey-

Fig. 1. Estimated Extent of Occurrence EOO in the Caatinga.

Fig. 2. Area of Occupancy AOO of jaguar in the Caatinga (polygons of estimated subpopulations).

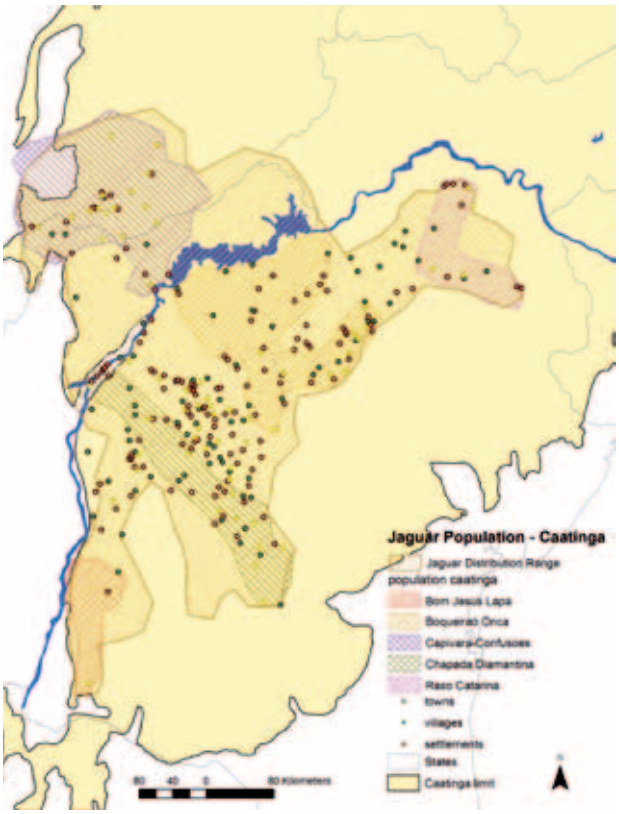

Fig. 3. Human encroachments within the Caatinga's jaguar distribution range.

ing the region of Boqueirão da Onça in Bahia state. Subpopulation estimates (Table 1) were based on the estimates from Boqueirão da Onça associated with researchers' perceptions from field research of sites surveyed for local jaguar abundance and more importantly from the variations of the suitability model (Ferraz et al., in prep.).

The densities were directly calculated for the sites where population information was available from camera trapping. Research conducted by CENAP (unpubl. data) found a density estimate of 0.8 ind./100 km^2 at Boqueirão da Onça (Subpopulation 1). Based on this information and investigations in the rest of the subpopulation area an average of 0.5 ind. /100 km^2 was calculated considering the proximity of highly disturbed adjacent areas with lower jaguar density.

The density estimates reported by Silveira et al. (2010) does not reflect the reality of jaguar populations in the Caatinga; the evaluation at Serra da Capivara National Park (at Subpopulation 2) presented a density estimate of 2.67 ind./100 km^2. The estimate in this particular area cannot be observed in any other site within the jaguar range nor even for the entire Subpopulation 2 itself, but only for the Serra da Capivara National Park due to the specific management activities the area has. The management strategies applied to this protected area, which includes year-round water supplies (through artificial ponds) and increased patrolling and law enforcement to reduce hunting activities, provides a different reality for wild populations of this location, resulting in a higher abundance of prey species for predators. The proper management confers a more suitable area for jaguars. Considering the specificity of estimates for the particular site, we propose for Subpopulation 2 the same average density estimate as we used for Subpopulation 1 (0.5 ind./100 km^2). This estimate was used since the habitat suitability index and numbers of records were very similar (except for the deforestation rates that are higher in the southern portion of this subpopulation). Despite the differences especially in the research protocols and data analysis, the values accounted perhaps are really discrepant (maybe it would not be three times as a standardization in the analysis would reduce the difference). The first site is a National Park that has been managed as described above. Although the second site (Boqueirão da Onça) has a very low human density (in average <1 person/km^2) resulting in one of the most extensively preserved portion of natural habitats in the entire biome, there is still prey hunting and predator persecution on a large scale. However, undoubtedly these two are the main areas (together with the Serra das Confusões National Park) for jaguar conservation in the entire biome.

No research project or specific investigation was conducted in Subpopulation 3 with the exception of CENAP's camera trapping at Chapada Diamantina National Park. From this sampling over 60 days no jaguar was detected. Despite the significance of protected area status, a more conservative density estimate for this subpopulation was considered due to the human occupation in most of its area. Thus we defined it as 0.3 ind. /100 km^2. Although this subpopulation is more isolated than the subpopulations 1 and 2, a connection can be established between it and 1 if changes in land use are applied.

For the Subpopulations 4 Raso da Catarina and 5 Bom Jesus Lapa located in the extremes of the range, the density estimates reflect the worst case scenario and are 0.2 ind./100 km^2 and 0.1 ind./100 km^2, respectively.

The general average of all the density estimates resulted in 0.3 ind./100 km^2, a very low density when compared to other biomes that range from 2 (for Cerrado, Silveira 2004) to approximately 6 individuals/100 km^2 (Pantanal, Soisalo & Cavalcanti 2006).

Table 1. Jaguar subpopulations and density estimates in Caatinga.

Subpopulation	**1**	**2**	**3**	**4**	**5**
	Boqueirão da Onça	**Capivara – Confusões**	**Chapada Diamantina**	**Raso da Catarina**	**Bom Jesus Lapa**
Density (ind/100km^2)	0.5	0.5	0.3	0.2	0.1
Area (km^2)	25,560.4	30,938.5	16,464.6	7,872.3	6,490.7
# of mature individuals	64	78	25	8	3

Subpopulations

The jaguar population in Caatinga is very fragmented. This led us to define the jaguar distribution into five subpopulations (Table 1). If connectivity exists between subpopulations, it will be restricted to only three of them: 1 Boqueirão da Onça with 2 Capivara-Confusões, and 1 with 3 Chapada Diamantina. But the connections between these three subpopulations must be investigated. The Subpopulations 4 Raso da Catarina and 5 Bom Jesus Lapa are definitively isolated from the main block (1, 2, and 3) by human development. There are no records of connectivity between these two and the other subpopulations.

Subpopulation 1 – Boqueirão Onça

This is the second most important area for jaguar in Caatinga. Although it has only three protected areas (the Morro do Chapéu State Park, the Gruta dos Brejões and the Lago do Sobradinho Environmental Protection Areas), it is one of the most continuously preserved areas of the Caatinga. This characteristic made the creation of the Boqueirão da Onça National Park with nearly 8,000 km^2 possible (Fig. 4). This subpopulation was scientifically discovered only in 2005. It was subject to pelt trade for decades until the mid-1990s. Currently animals are persecuted due to livestock losses. The increase in mining activities (Fig. 5) as well as other development related to energy generation and agribusiness pose a major threat to jaguar conservation.

Due to intense human development to the south and east of this subpopulation, there is a strong belief that this subpopulation does not connect with the Subpopulations 3 and 4. On the other hand potential connectivity exists with Subpopulation 2. Although the São Francisco River forms a natural barrier, during the dry season sandbanks exposed in the middle of the river might allow dispersers to cross in the southern end of the subpopulation. The possibility of even a temporary connection between subpopulations would sustain both subpopulations for longer periods since both areas are the most suitable ones for jaguars in the biome and the range.

Subpopulation 2 – Capivara-Confusões

This subpopulation defined by the boundaries of the Serra da Capivara and Serra das Confusões National Parks as well as the Serra Branca Ecological Station between them is the most important for jaguar conservation in Caatinga. This is the subpopulation that will connect with the Cerrado's subpopulations which are not in as critical condition as the Caatinga's. Jaguar records in this area are mainly located in the protected areas and their boundaries. However the species was detected in areas near the São Francisco river (south of Sobradinho lake) which confirms the potential connection with Subpopulation 1.

Fig.4. Aerial view of Boqueirao da Onça habitat during the wet season (Photo R. C. de Paula).

In contrast to the subpopulation across the river, the jaguars in this area are mainly threatened with habitat loss due to deforestation for the supply of the charcoal industry (Fig. 6) and conversion of natural areas into agricultural fields. Approaching the Cerrado biome (2/3 of the Serra das Confusões National Park are within the Cerrado's boundaries), habitat alteration becomes more severe. One of the most threatening factors for this subpopulation is the locally heavy prey base hunting and the persecution of predators due to livestock losses.

Subpopulation 3 – Chapada Diamantina

This subpopulation is sustained mainly by the southern portion where the Chapada Diamantina National Park is located. The subpopulation also encompasses the Lagoa Itaparica and Marimbu-Iraquara Environmental Protected Areas. Little is known about jaguar status in this subpopulation. The known information is restricted to isolated records from livestock conflicts. Persecution due to these conflicts and habitat alteration are the major threats for this subpopulation.

Subpopulations 4 – Raso da Catarina and 5 – Bom Jesus Lapa

These subpopulations are small and totally isolated from the others; jaguar records are rare and most are related to livestock conflicts. Both subpopulations have a high probability to disappear in short time if persecution or habitat loss become more severe.

The three records obtained in 2007 demonstrate the vulnerability of Subpopulation 5: if it becomes totally isolated it will likely disappear in the short-term. However, there are

Fig. 5. Increasing mining activities in the Caatinga are destroying important jaguar habitat (Photo C. Campos).

Fig. 6. Deforestation for charcoal production is an important threat to jaguars in the Caatinga (Photo C. Campos).

records of jaguars in adjacent subpopulations of the Cerrado population to the south and west. If Subpopulation 4 effectively connects with the Cerrado's subpopulations, then it can survive for longer periods. On the other hand the Subpopulation 4 is totally isolated by a barrier of human development from mining companies, federal highway construction and agricultural activity between this subpopulation and the 1.

Population trends

The Caatinga's jaguar stable population was believed to be restricted to Subpopulation 2 (Capivara-Confusões) until records over the past ten years indicated other possible sites (Boqueirão da Onça and Morro do Chapéu regions). The Chapada Diamantina National Park and Raso da Catarina Ecological Station were considered potential areas of occurrence; but specialists doubt whether or not jaguars consistently occupy these areas due to the few recent records of its presence. Little research has been conducted in the Caatinga in general and specially with an elusive mammal such as the jaguar. The only area where jaguars have been studied is the Serra da Capivara National Park. Astete (2008) discussed several aspects of a possible increase in jaguar numbers following an observed increase in prey abundance. The author based his comparisons on research reported by Wolff (2001) in the same area. It looks as if management practices such as increasing park patrols and enforcement have successfully inhibited prey loss due to local hunting activity. Water ponds maintained by the park during the dry season have apparently attracted and possibly increased both predator and prey numbers. Data from the mid-1980s indicate an estimate of 6 jaguars in this same protected area. However past research did not evaluate directly the jaguar population in the same way as Astete (2008). This later scientific data indicated an estimate of at least 21 individuals.

Considering the two decades of improved management and the information available, the park's jaguar population shows an increase of about 200%. Even in the only area with study results, population trend data is not robust. On the other hand, local people's perceptions indicate that there is a decline in the jaguar population in the majority of the subpopulations due to hunting for the pelt trade until the mid-1990s and the persecution due to livestock losses. Scientific information is required in order to have a better understanding of population trends.

Extreme fluctuations

Although apparently no immediate impact causes extreme fluctuations presently, the São Francisco River transposition has been suggested by specialists as one of the main environmental disasters of the century in Brazil since the damage will affect the entire watershed. The vegetation of Caatinga which is adapted to long dry seasons nonetheless depends on the water supplies even if it is in small quantities (Vicente et al. 2003). A detour of the main water body in the entire biome would significantly alter the hydrodynamics in the local watersheds and consequently affect local habitat. By having a drastic impact on vegetation, especially in the composition of forested areas, the suitable habitat for jaguars in the future could be significantly reduced and consequently cause extirpation of smaller subpopulations or extreme fluctuations of Caatinga's populations.

Other life history information

Jaguars apparently show a strong preference for dense vegetation cover in Caatinga and this habitat is restricted to only a few preserved areas throughout the entire biome. Further information is required in order to understand more life history information.

Threats

Jaguar population decline can be caused by habitat loss due to constant disturbance and fragmentation (Sanderson et al. 2002). Conflict with humans due to livestock depredation and the resulting jaguar persecution can also be a cause of decline (Cavalcanti 2003). Both are the main causes affecting jaguar conservation in the Caatinga.

Habitat loss

About 27 million people currently live in the biome, where 70% of the original vegetation has been altered. Human population density is homogeneous, occurring at levels below 100 hab./km^2 (Sampaio & Batista 2004). A large portion of this population bases its survival on natural resources.

About 7% of the biome is covered with PAs. The conservation of these areas is intimately related to efforts that prevent desertification, a serious condition of the semi-arid areas of Caatinga. The deforestation and the maintenance of irrigated cultures accelerate the desertification process by inducing soil salinization. In Brazil 62% of the areas susceptible to desertification are located in the Caatinga, and large portions of these are significantly altered by deforestation or natural habitat conversion into agriculture fields (MMA – SRHPB 2007).

The identification of reserves of iron and other minerals including precious stones in some regions of Caatinga is worrisome because of potentially devastating extraction methods. Charcoal has been extracted quite intensively

in some regions, resulting in large deforested areas due to the lack of sustainable management and law enforcement.

Habitat alteration

Historically, the agriculture practiced in the semi-arid region is nomadic, itinerate or migratory. Farmers in this region remove natural vegetation, use fires and cultivate the soil for a short period. However, due to a lack of planning tradition, agricultural practices end up being a source of disorderly territorial occupation causing highly negative impacts on the environment (MMA 2002). Within the last decades, important changes have remodeled the territorial reality of the northeast, altering the characteristics ot the man-nature relationship of the region (MMA 2005).

New agricultural technologies developed to overcome difficulties such as the low water availability and intense heat characteristics of the Caatinga, have enabled the growth of areas exploited not only for agriculture but also for livestock production. In the western portions of the biome the growth of areas cultivated with soybeans and other monocultures threaten the transition areas of Caatinga-Cerrado.

Loss of prey base

Wildlife hunting for subsistence is culturally significant throughout the Caatinga (Coimbra Filho et al. 2004). This has critical implications for the conservation of many species, since local populations have been decreasing at alarming rates. Several species such as armadillos, peccaries, deer and agoutis among others are targeted by hunters. Although there is a lack of a detailed study on wildlife hunting in the Caatinga, local residents perceive a reduction in abundance of the overhunted species in several areas. Although these prey species are well distributed within the biome, their excessive hunting can drastically reduce populations within a few years, if education and law enforcement strategies are not implemented.

Jaguar hunting

Currently the majority of jaguar hunting incidences in the Caatinga are related to retaliation for livestock depredation. Several individuals are also killed during opportunistic encounters with hunters in search of other species. According to some local residents' accounts jaguar numbers in the region were considerably larger 30-40 years ago than they are now. It was common for hunters to return from their hunting ventures with more than one dead jaguar. At the time the demand for jaguar pelts was high especially for sales to Western Europe (Broad 1988). At present, albeit to a lesser degree, there still exists the demand for jaguar skins (Fig. 7) by large entrepreneurs visiting some of Caatinga's regions.

Locations

The habitat alteration or loss and consequently its fragmentation poses major threats for the jaguar population and their distribution in the Caatinga. The two southern areas of the jaguar range (Subpopulations 3 and 5; Fig. 3) present an accelerated degree of habitat disturbance due to the expansion of agribusinesses. The first doesn't contain any protected area, and it is already being widely exploited for agriculture, cattle ranching, tourism and fishery. The proximity of several mineral deposits increases the underground mining enterprises in the Capada Diamantina area with gold, diamond, emerald and other precious stones, marble and others being extensively extracted. The search for more sources of minerals is attracting more exploration and enterprises to this area with uncontrolled extraction, a constant threat due to ineffective law enforcement. The increasing of mining activities can also be observed in the area of the Subpopulation 1. More recently, the energy companies became interested in this area as well because of its potential for wind power.

The presence of highways with intense traffic to the south and east of Subpopulation 1 can be a threat to the distribution of the species, further isolating this important subpopulation from other potential areas.

In the northwest (Subpopulation 2) there are three nearby protected areas which are however discontinuous. The jaguar dispersal could be guaranteed with the viability of natural corridors that would guarantee individual movement. However, predators moving through human land might cause additional conflict when the scarcity of food leads jaguars to prey upon livestock. Conflicts between jaguars and humans can be found in all the five subpopulations.

The loss of the prey base due to subsistence hunting also is a threat for jaguars in all subpopulations. In some areas the local trade market of wild species for meat use is extensive.

Conservation measures

1. This species needs effective increase in law enforcement to prevent or limit wildlife hunting. Research data points to the lack of this management tool.

Fig. 7. Hunted jaguar discovered in 2008 (Photo C. Campos).

2. Given the need for the maintenance of the gene flow among jaguar populations, the creation of an ecological corridor including the states of Piauí, Pernambuco and Bahia is being evaluated; it would encompass an area of 2 million hectares. With the creation of this corridor the government hopes to direct conservation actions that will allow for the maintenance of jaguar populations in the biome.

3. A new national park with full protection status has been proposed and its creation covering an area of approximately 8,000 km² is in progress.

Research projects

Bahia/Piauí

Conservação da onça-pintada (Panthera onca) no Sub-Médio São Francisco: Estabelecimento do Corredor de Fauna no Nordeste Brasileiro. Coordinators: Ronaldo Morato/Rogério de Paula, CENAP/ICMBio. The goal of the project is to generate ecological information on Caatinga's jaguars and guarantee a minimum viable population through the creation and management of a Caatinga's Protected Area Network system (www.icmbio.gov.br/cenap).

Piauí

Programa de monitoramento de longa duração da população de Onças-Pintadas e suas presas naturais no PN Serra da Capivara, PN Serra das Confusões, PN Nascentes do Rio Parnaíba e ESEC Uruçuí-Una. Coordinator: Leandro Silveira–Instituto para Conservação da Onça-Pintada.

Fig. 8. Camera trap picture from the Caatinga (Photo Archive CENAP).

The goal of the project is to elaborate and start a long-term monitoring program (Fig. 8) of the jaguar population and its natural prey base (www.jaguar.org.br).

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