Staquet
Panthera onca

Ten Year Management Plan on Jaguar (*Panthera onca*) Populations in Brazil

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Executive Summary

Jaguars (*Panthera onca*) are the world's third largest big cat and are found throughout Latin America and small parts of the United States of America. They are solitary, elusive carnivores that serves an ecological role as a keystone species throughout their distribution by maintaining populations of herbivorous species which provides more habitat availability and suitability for other wildlife species. Their populations are going through a decline and now 173000 individuals are currently inhabiting about half of their historical range. The factors that endanger jaguar populations are habitat destruction, illegal hunting, and loss of prey. The increase in ranching and the need for more communities for the growing human population are the reasons for the continuation in habitat destruction and the confrontations between people and jaguars. The goal for this management plan is to increase the jaguar populations by 10-15% within 10 years and maintain the populations throughout the country of Brazil. There are currently 86,800 individual jaguars in Brazil and reaching the goals in maintain populations will require improving their habitat and prey availability while reducing the factors that are the direct cause in their decline. The objectives include focusing conservation efforts on certain age classes to increase the survivability of individuals and the chances of reproduction to add individuals to a population. They also include mitigating human and jaguar conflicts, making environmental protections and wildlife management a bigger priority in the public, politics, and laws, and reducing the rate of habitat fragmentation by 20% throughout the country of Brazil. Some actions to make these objectives successful include conducting further research on the life cycle and natural behaviors on jaguars to support conservation efforts needed to benefit the populations and continuing current methods that are used to reduce human and jaguar conflicts. To monitor the success and failures of this management plan, public surveys for the residents' perspective on the jaguars will be conducted yearly along with some population counts on the jaguars in each region of Brazil. Jaguars are currently listed as near threatened by the International Union for Conservation of Nature (IUCN) red list and due to the population declines and the continuation of factors effecting the populations, they will mostly likely be listed as vulnerable in 30 years. If there is an increase in conservation efforts and a reduction in conflicts between jaguars and human communities, then the jaguars will have a smaller chance of reaching extinction.

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Introduction

Jaguars (*Panthera onca*) occur throughout Latin America from Argentina to Mexico and can also be found in southwestern United States of America. While occupying 51% of their historical range, there are currently 173,000 individuals left throughout their distribution and their population is currently declining (Jędrzejewski et al., 2018). They are currently listed as near threatened by the International Union Conservation of Nature (IUCN) red list. With the populations currently declining, the conservation status on the global population is expected to change from near threatened to vulnerable in 30 years (Quigley et al., 2017). The causes of their population decline are mainly habitat fragmentation and degradation along with illegal hunting and loss of prey availability. Due to their current population decline and conservation status, they are currently under the protection of the Endangered Species Act (ESA).

About 50 % of the current jaguar population lives in Brazil, holding 86,800 individuals (Tôrres et al., 2008; Jędrzejewski et al., 2018). In Brazil, the populations are divided by regions in which they are found: Amazon, Atlantic Forest, Cerrado, Pantanal, Pampa, and Caatinga. In each region, jaguars are found where there is dense vegetation and an abundance of water, so their habitat preferences consist of tropical forests, mangrove forests, and swamps and wet savannas. With the differences in habitat and prey base, jaguar ecology should differ widely among these biomes (Astete, Sollmann, and Silveira, 2008). With the different habitat and prey qualities, each region experiences different situations in habitat destruction. As a result, some populations are declining more rapidly than others and some regions are experiencing more human and jaguar conflict throughout the country.

The challenges on focusing conservation efforts on the jaguars include mitigating human

and jaguar conflicts and making environmental and wildlife protections an important priority from the Brazilian government. Currently, authorities have limited access to, and are generally unable to generate data, intelligence, and the means to support law enforcement and prosecutorial agencies during the investigation and prosecution of wildlife crimes (Reuter, Kunen, Roberton, 2018). Other challenges for maintaining jaguar populations is conducting enough research needed to achieve certain conservation management plans because jaguars are solitary, elusive felines that are sensitive to drastic changes to their home range. Jaguars are territorial and when ranchers are entering their home range and prey availability declining, they will most likely target livestock which will interfere with the lifestyle of residents and cause safety concerns. Factors such as competitive hunting of natural prey by humans, fragmentation and loss of habitat may force predators to hunt in modified landscapes for alternative food sources as domestic animals (Tortato et al, 2015). For these reasons are why jaguars are currently being hunted even if it is illegal to hunt jaguars in Brazil and they are under the protections of the ESA. With more efforts in habitat preservation and restoration along with more protections in jaguar populations and public awareness on the conflicts will the populations benefit and avoid extinction.

Natural History

Species identification

Jaguars are the largest cats in the western hemisphere and are can be easily be recognized by their yellowish coat and distinctive spotted pattern. Other than their large spots, they can be identified based on their size with the females' average weight of 42 -76kg and males average

weight from 57-100kg, all depending on the geographic distribution and (Nowell and Jackson, 1996; Mazzolli, 2008).

Fig. 1. The current jaguar population is occupying 51% of their historical range, 173,000 individuals left throughout their distribution (Jędrzejewski et al., 2018).

Image credit: Wildlife Conservation Society

Distribution

Jaguars are currently occupying 51% of their historical range which includes 19 different countries from Argentina to southwestern United States (Fig. 1) (Jędrzejewski et al., 2018). Approximately 50% of the remaining distribution area is within Brazilian territory, making this country extremely important to guarantee long term jaguar conservation (Fig. 2) (Tôrres et al., 2008). The home ranges range may differ between males and females throughout the breeding season. Estimates of year-round home range sizes show 79 km^2 for reproducing females, 103 km^2 for non-reproducing females, and 167 km^2 for males which was obtained with telemetry studies and other spatial analyses (Jędrzejewski et al. 2016).Throughout Brazil, female jaguars' home ranges are consistently smaller than males, reflecting the species' polygamous breeding system. Locations of females suggested a pattern of spatial avoidance among females

during the wet season while home-range overlap among males was extensive, both in the wet and dry seasons and were located <200 m apart more often than expected (Cavalcanti and Gese, 2009).While home range size for a female is determined by her and her offspring's metabolic demands, male ranges are determined by the distribution of reproductive ready females (Fig. 3) (Asete, Sollmann, and Silveira, 2008). While some of the regions in Brazil are heavily impacted by human occupancy, about 80% of the Brazilian jaguar population can be found in the Amazon (Tobler et al., 2013).

Fig. 2 Brazil currently holds half of the entire jaguar population and the subpopulations in regions including the Atlantic Forest and Cerrado being heavily impacted by human occupancy (Tôrres et al., 2008).

Habitat

Jaguars are found mainly in tropical areas where there is dense vegetative cover and an abundance of water at <1,200 m altitude (Dobbins et al., 2017). These habitats will include tropical forests, swamps, mangrove forests, and wet savannas as factors determining the jaguars' occupancy were the presence of wetlands areas (positive effect) (Boron et al., 2018). Dense marshes and forest patches possibly enhance the ability of jaguars to hunt; preference for riparian

areas makes them important potential dispersal paths for jaguars (Fig.3) (Asete, Sollmann, and Silveira, 2008). Studies on jaguar habitat use in Brazil indicate that although they show a trend to use habitats close to water and with denser vegetation cover, the species uses a large variety of habitat forms (Asete, Sollmann, and Silveira, 2008). As Brazil is diverse in different habitats from tropical forests and wetlands to dry deciduous forests, it is possible that jaguars are found in other habitats besides moist areas like the dry areas in the Atlantic Forest. In the Atlantic Forest, the original vegetation is characterized primarily by ombrofilous and semideciduous forests, but human activities have reduced forest cover to 22% of its original extent (Asete, Sollmann, and Silveira, 2008) and that has decreased the jaguar occupancy in the Atlantic Forest by 85% (Fig 2.) (Mcbride et al., 2019).

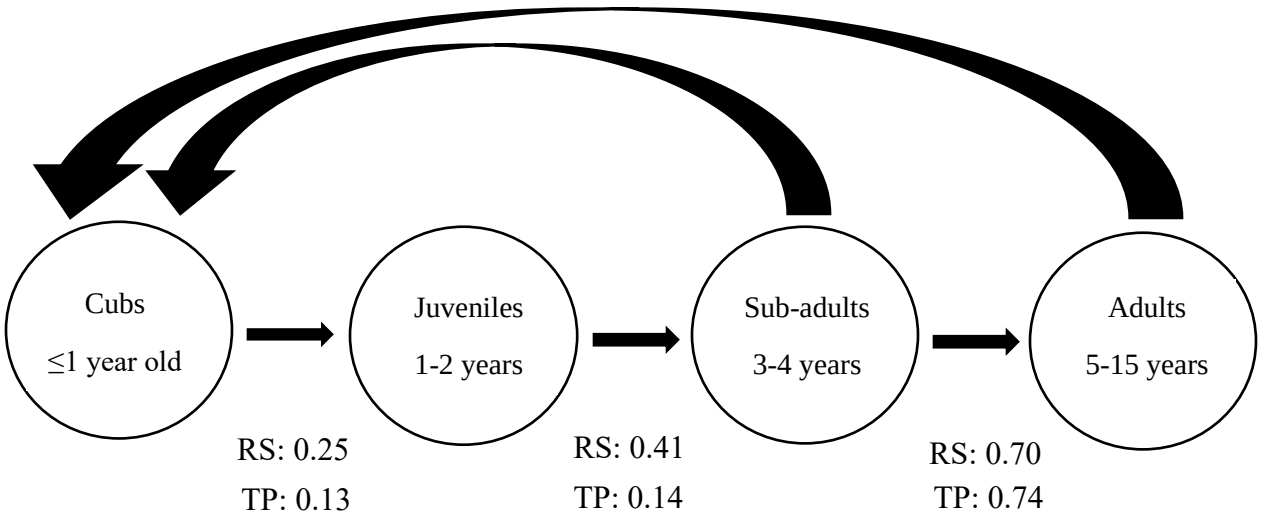
Fig. 3. A male and female jaguar hunting in the swamps of Pantanal. A male jaguar's home range is determined by habitat suitability, prey availability, and number of females in the same area. Males and females can only interact during the wet seasons (December-March) (Asete, Sollmann, and Silveira, 2008). Photo credit: M. Andrews, www.smandrews.com

Diet

Jaguars are opportunistic hunters with prey that varies based on their location. Large cats feeding habits have been studied through two main methods: scat analysis and the carcasses of prey killed by monitored animals (Perilli et al. 2016). Their diet includes deer, fish, turtles, capybara (*Hydrochoerus hydrochaeris),* caiman (*Caiman yacare*), White-lipped peccary (*Tayassu pecari),* and Collared peccary (*Pecari tajacu*). In some cases, when food sources are declining, they will go after Baird's tapir (*Tapirus bairdii*), Brazilian tapir (*Tapirus terrestris*) and cattle (*Bos taurus*). Compared with other large, solitary felids, jaguars have an unusual predator to prey body mass ratio that shows limited effect of prey morphology as a driver of prey selection, lack evidence of optimal foraging beyond their preferred prey, and a lack of preferential hunting on Cetartiodactyla herbivores (Hayward et al., 2016). Since jaguars are opportunistic hunters, their prey preference is based on abundance instead of prey's size and how much time and energy is spent in pursuit of their prey. Generalized linear models showed that jaguars select prey primarily based on socio-ecological and behavioral traits (abundance and herd size), rather than morphological characteristics. Nonetheless, their accessible prey weight range was 6–60 kg, preferred prey weight was 45–85 kg, and mean mass of preferred prey was 32 ± 13 kg leading to a predator to prey body mass ratio of 1:0.53, which is less than that of other solitary felids (although 1:0.84 may be the relationship with the smallest jaguars). (Hayward et al., 2016).

Reproduction

Reproductive parameters such as litter size, cub survival, and interbirth interval correlates with food availability so the reproductive success and survivorship of the jaguar varies across its distribution (Carrillo et al., 2008). The relative local abundance of prey species are good predictors of jaguar habitat use patterns and chances of interactions between individual jaguars (Rabelo et al., 2019). Breeding season takes place when habitats are best suitable for jaguars to be active which is during the wet seasons (December-March) (Astete, Sollmann, and Silveira, 2008). They can start giving birth at 3 years old and can give birth to a rare maximum of four cubs but an average of two cubs per breeding season (Desbiez et al., 2012). A jaguar's gestation period can last for 3 months and the cubs will rely on care for up to 2-3 years before they become sub adults (Fig 4.). The age classification is justified by the long reproductive cycle of female jaguars (i.e.,3 months gestation and 17 months care of cubs) and long (3–4 years) time to first reproduction (Crawshaw and Quigley 1991; De Paula et al. 2013; Jędrzejewski et al. 2016).



TP= Transition probability, RS= Remain in same stage

Fig. 4. Life cycle of the jaguars. The lifespan of jaguars is up to 15 years of age and within those 15 years, cubs will have an average of 50% chance to live to become an adult. They will not sexually mature until they are 3-4 years old and as soon as they reach the 3 or 4 years, they will be able to give birth (Desbiez et al., 2012).

Conservation Needs

Ecological

Loss of prey- Some prey species including the white lipped peccary is currently going through a population decline as well, being listed as nearly threatened by the IUCN red list (Altrichter et al., 2011). The white lipped peccary are important indicators of intact natural landscapes and the status of medium- to large-sized mammals dependent on forest habitats (Keuroghlian et al., 2015). In the Amazon, the Pantanal and other neotropical biomes, white lipped peccary are wide-ranging frugivores and important indicators of forest and landscape conditions because the species play important ecological roles in the ecosystem as a seed predator and disperser, an ecosystem engineer that strongly affects forest soils and plant communities and are important prey for pumas (*Puma concolor*) and jaguars (Keuroghlian et al., 2015). Like the jaguars, the peccaries are going through a population decline due to hunting, and loss of habitat and food sources (Keuroghlian et al., 2015). In certain biomes of Brazil, the impacts of climate change are expected to expand the consequences of ongoing deforestation and fragmentation of natural habitats as models and assessments indicate a relatively large shift in the Pantanal's climatic conditions as they predict overall drier conditions with a 35– 4 5% decrease in rainfall by the end of the century which decreases fruits as food sources for the peccaries (Keuroghlian et al., 2015). As the consequence of loss of habitat and food for the peccaries, jaguars are losing them as food sources within their own territories. Since jaguars are opportunistic hunters, while prey availability is a predominant factor in large felid populations, spacing patterns of the jaguar populations are influenced by a territorial system and will rely on abundance of prey within individual territories (Azevedo and Murray, 2007). In unprotected fragmented lands, jaguar scats rarely contained large wild prey species; rather, a diet of relatively

small wild prey was supplemented with larger domestic species which is evidence that where large prey is scarce, jaguars will target livestock (Foster et al., 2009).

Subpopulations- Jaguars have about 34 subpopulations and they are divided into regions of the countries they are found in. For example, in Brazil, there are currently 86,800 individuals in Brazil and 89% are found in the Amazon region (Jędrzejewski et al, 2018). The jaguar populations are divided into six regions of Brazil which are Amazon, Atlantic Forest, Cerrado, Pantanal, Pampa, and Caatinga. The highest number of jaguars are found in large total areas (almost 9 million km^2) with low human densities (<1 person/km^2) within those areas including the Amazon where the jaguar subpopulations are less affected. (Jędrzejewski et al, 2018). Each region in Brazil, particularly in areas where they are considered endangered, have areas that can only sustain small populations. The rule for defining a small population is having a minimum number of 50 and the maximum of 500 individuals in an area (Mills et al., 2012). Some areas like the Atlantic Forest and Cerrado are areas where jaguar populations are impacted the most with the total number of individuals being less than 250 while there is an estimate of ≤ 80 adults in other regions besides the Amazon with 300 or fewer individuals that are scattered into subpopulations (Paviolo et al., 2016). With these numbers, according to the IUCN Red List, these small populations will be considered as endangered and critically endangered. Through spatial analyses and recapture studies in the Atlantic Forest, there was an estimated abundance of 9 ± SE 1.98 jaguars (95% CI 9–17) and a population density of 3.22 ± SE 1.58 individuals per 100 km^2 (95% CI 1.29–7.98) with annual survival probability over a 5-year interval was 78% (95% CI 58-98) and the recapture probability was 62% (95% CI 42-79) (Srbek-Araujo and Chiarello, 2016). The results were among the highest densities reported for the jaguar in this biome, the future of the population is threatened by local threats, including the expansion of an

existing highway and depletion of the jaguar's native prey base as a result of poaching, and will depend upon urgent implementation of conservation actions (Srbek-Araujo and Chiarello, 2016).

Economic

Impacts on agricultural or ranching value- Jaguars targeting on livestock has become the main reason why they are hunted illegally because it results in economic losses**.** Brazil is the world's largest beef exporter with the largest commercial cattle herd (Vale et al., 2019). There has been an increase in demand for beef which motivates ranchers to expand their production. As a result of pressure for livestock systems to increase yields, feedlots in Brazil grew by 442% in 1990-2017, and by 55% in 2010-2013 alone, having outpaced the growth of cattle herds by 2.3 times since 1990 (Vale et al., 2019). With the growing demand for beef production, ranchers will use up areas there are suitable habitats for jaguars with the dense vegetation and water sources available. Interviewees highlighted their increased vulnerability to attacks during the wet season, when residences are surrounded by water, forcing inhabitants to move to higher areas that are also favoured by jaguars (Porfirio et al., 2014). This influences the jaguars to target the livestock because they will save time and energy from hunting their natural prey and the loss of cattle causes a reduction in beef production. Domesticated animals including horses, donkeys, dogs, and pigs also constitute important prey items.

Many cattle ranches in South America occupy formerly prime jaguar habitat, and therefore livestock has become easy prey for jaguars in Brazil (Zimmerman et al., 2005). Predation on the cattle of the Brazilian Pantanal costs the ranching production US$121, 500 per year (Tortato et al., 2017). The climate shifting is another factor that influences ranchers to move into areas that are suitable habitats for jaguars. It is estimated that there is a decrease in beef cattle productivity due to the increase in air temperature and vulnerability of pasture capacity in

the Cerrado (savannah) mid-west, north and north east regions of Brazil. The increase in cattle production and expansion of pastures for cattle ranching in the north is accompanied by deforestation (McManus et al., 2016). Setting up property zones is one of the strategies used to reduce or prevent loss of cattle. Property zoning is recommended for the Amazon and smaller properties in the Pantanal. For the Caatinga, Atlantic Forest and partially the Cerrado, smaller scale approaches like guard animals or electric fences are applicable. Major conflict zones are in the northwest of Brazil (Silveira et al., 2008). In the northwest sections of Brazil, people are experiencing an abundance of jaguar predation in the Amazon where population is most stable in the country. It is important for ranchers to set boundaries in their properties and change their traditional techniques in caring for their cattle. The traditional husbandry practice in the Pantanal, where cattle are left to roam freely, exacerbates the problem between people and jaguars (Zimmerman et al., 2005).

Tourism value- With jaguars being a charismatic species, they are a productive factor for ecotourism. In the Brazilian Pantanal alone, the jaguar ecotourism represents an annual income of US$6,827, 392 (Tortato et al., 2017). This is what influences the continuation on environmental and wildlife protections because the money made from ecotourism is used to maintain preserves and continue conservation efforts. The protection efforts of the environment and the wildlife of Brazil is highly dependent on the annual profits gained from ecotourism that is achieved. It is challenging to achieve high profits in most of Brazil because it is underexplored and underdeveloped despite its biodiversity (Tortato and Izzo, 2017). Tourism is abundant in the Brazilian Amazon and the Pantanal regions due to the successful conservation efforts in the environment and wildlife, but other regions are still more underdeveloped for tourism and receive less profit.

Partnership situations and solutions- From the observations in costs and benefits on ecotourism and loss of livestock, the gains from ecotourism outweighs the cost in losing cattle which reinforces the continuation for jaguar conservation. The partnership between cattle ranching and ecotourism is a situation because it protects jaguars that are the same area as private ranching properties and little can be done with the change of conservation efforts or ecotourism, mainly due to the fact that jaguar tourism is 25 times greater than the loss of cattle (Tortato and Izzo, 2017). To add factors against the ranchers, most do not receive any financial benefit from the ecotourism. Although the cost of in the loss of cattle and the need to recover for the loss is not ignored. Many ranchers across the country have been surveyed on their perceptions on jaguar conservation and jaguars being around their properties. The results suggest that the ranchers of the northern Pantanal suffer livestock losses that they are mostly not willing to tolerate, and yet they also appreciate the intrinsic natural value of the Pantanal and regard its conservation as important. Ranchers often considered the jaguar to be the most beautiful animal in their environment (survey respondents, pers comm.) but, as reflected by their attitudes, this perception is no guarantee that they will protect it. Their response to the statement 'jaguars deserve protection' was often 'yes, but not on my ranch'. Where ranchers were sympathetic to jaguar conservation, this appeared to originate from personal, pro-conservation attitudes (Zimmerman et al., 2005). The feeling of local people living along the Paraguai River that the jaguar needs to be protected is derived from changes in tourism. Even though the main tourism-related activity in the region is recreational fishing rather than ecotourism, there are several cases where people have spent >1 hour observing a jaguar on the riverbank (Porfirio et al., 2014). Some solutions of maintaining the partnership is have tourism set up donations to the ranching communities. Some surveys showed that 80% of the tourists will be willing to donate during their stay. Some are

willing to donate US$84 for a three day stay in ecotourism rich areas (Tortato et al, 2017). The challenge is to keep the profits and participation rates high enough to maintain conservation efforts hep secure the partnership between tourism and ranching, and to solve the financial problems from loss of livestock with some regions of Brazil being ignored by ecotourism.

Sociocultural

Situations with residents and livestock **-** The main conflict between felines and locals are the predation risk in livestock. The food preference for jaguars are mainly large mammals and if there is low food availability in their areas, they will target livestock which causes human and jaguar conflict. Jaguars have been killed by residents within the boundaries and lands surrounding Iguaçu National Park (INP), Brazil. Both jaguars and pumas occur in the region, however, livestock predation by pumas has rarely been reported (Conforti et al. 2003). To confirm that jaguars are targeting livestock, some surveys were conducted from locals on their perspectives on jaguars and other predators near their properties and the prey preferences were monitored all over Brazil. In the Pantanal region of Brazil, hunting behavior and prey preference was monitored, and the kills were composed of 31.7% cattle (9.8% adults and 21.9% calves), **(**Cavalcanti and Gese, 2010). Even though livestock does not make up most of the jaguar's diet, it still presents a major problem to the locals and their property.

In the Pantanal region of Brazil, most (82%) respondents have suffered cattle losses to jaguars and most (66%) believed that jaguar attacks were becoming more common. There was a positive relationship between cattle lost and both log (ranch size) and log (number of cattle) ($r=0.413$, $P<0.01$, and $r=0.541$, $P<0.001$, respectively) (Zimmerman, Walpole, and Willaims, 2005). Ranchers take up wetland areas as private property to allow cattle to have water sources. The traditional practice of ranching in Latin America is to let the cattle roam free in areas with

little boundaries which gives predators like jaguars and pumas the opportunity to pursue prey that has been introduced into their home ranges.

During the wet seasons, livestock are dispersed over large areas and share the same habitat with jaguars and pumas. Behavioral studies indicate that jaguars usually spend daytime hours in the shade of such forests (Crawshaw & Quigley, 1991). The distance from cattle to the forest has been considered an important factor influencing the probability of depredation and one possible solution of minimizing predation on livestock is for ranchers to limit the space for cattle to roam free or to confine them in a space out of harm's way in the evening (Azevedo and Murray, 2007). Surveys have been conducted all over Brazil to determine the thoughts from locals based on their concern for safety and their lifestyle when living in jaguar territory. About 48% of the responses answer 'dangerous to the question on perceptions, followed by 'dangerous and beautiful' being 28% while the rest simply stated they are not concerned with jaguars and do not see them as a problem (Porfirio et al., 2014). However, the responses may differ during the time surveying takes place with jaguars being more active during the wet season. Other factors that will influence the surveying is the location. Ranches that are set near water sources are most likely to encounter jaguars and other wildlife. In Brazil, perceptions of jaguars were found to differ between riverside communities, where negative perceptions were related to concern for people's safety, and ranching and rural communities, where negative perceptions were related to economic losses associated with jaguar attacks on cattle (Porfirio, 2016 and Fort, 2017). In the past twenty years, people have been hunting over 30 jaguars per year (Carvalho and Pezzuti,

2010) to protect their properties and due to some legal issues, it is challenging to determine which jaguars are legally or illegally killed (Fig. 5).

Fig. 5. Due to loss of habitats and prey, jaguars are entering human communities which leads to residents hunting them to protect their livestock and homes
Photo credit: Silveira et al., 2008.

Legality

Policies and laws on the environment -According to the 1988 Constitution Of The Federative Republic of Brazil, it is a right for the residents to protect and maintain the natural environment. Article 225 calls for the preservation of the environment as an individual right: "Everyone has the right to an ecologically balanced environment" (Rosenn, 2010). This means that many industries and projects proposed must keep the wellbeing of the natural environment in mind for the health of the residents and the environment.

The laws dedicated to protecting and maintaining the natural environment in Brazil include the Brazilian Forest Code (1965). The Brazilian Forest Code states that residents are required to leave 80% of the Amazon as forest habitat and not for human use. The Forest Code was then changed in 2012 which reduced the Amazon preservation limits to 50%. Before the change in the Forest Code 449,600 km^2 of the Amazon was for humans use and the reform of the

Forest Code, considering 50% legal reserve, that number would jump to 1,124.000 km^2 (Castelo, 2015).

Another policy that is dedicated to preserving some regions is the from UNESCO. Some areas where jaguars are found including Pantanal wetlands and the Atlantic Forests are recognized as a "National Heritage" in the 1988 Constitution of Brazil (Harris et al., 2005). With certain areas preserved as cultural heritage sites, they provide well protected habitats for jaguars and other wildlife.

Policies and laws on wildlife management- Hunting is prohibited in Brazil, especially with species that is protected under the Endangered Species Act (ESA). Jaguars are protected under the ESA and are listed as a Near Threatened species with the populations currently declining (Quigley IUCN, 2017). Jaguar killing in the Atlantic Forest, along with other regions in Brazil is frequent, mainly by poachers that consider the species a trophy or by cattle ranchers that eliminate individuals as retaliation for livestock losses (Paviolo et al., 2016). Illegal hunting and fishing activities in combination with habitat loss, deforestation, and the introduction of exotic species contribute to the biodiversity loss in the Brazilian ecosystem (Tabarelli, 2005 ; Chagas, 2015).

The laws in Brazil dedicated to protecting the wildlife includes the Environmental Crimes Law (law nº 9.605/98). According to law 9.605/98 the crimes against wild fauna include killing, hounding, hunting, capturing, or using any fauna species without authorization or license (Rosenn, 2010). The only exceptions of killing wildlife in Brazil are only for the protection of locals and livestock. The penalty is imprisonment from six months to one year, and/or a fine (Rosenn, 2010). The penalty is aggravated for the crimes listed:

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- Against rare species or those considered endangered, even if only at the site of violation.
- In the period in which hunting is prohibited
- During the night
- By abusing the license
- Within a conservation unit
- By using methods or instruments capable of provoking mass destruction

Discussions on the current laws and policies- While the current laws are necessary to protect and manage the wildlife, there may be some changes needed to intensify the current jaguar management procedures. Currently, authorities have limited access to, and are generally unable to generate data, intelligence, and the means to support law enforcement (Reuter, Kunen, Roberton, 2018). Also the Brazilian Forest Code was meant to conserve the rainforests and wetlands in Brazil and reducing the number of acres preserved in the Amazon from 80% to 50% will give access to human use and reduce habitat availability for jaguars and other wildlife. While it is understandable that residents need to meet production demands, it is essential to preserve as much of the Amazon as possible. With the reduction in preservation in the Amazon rainforest and further habitat degradations, there may need to be some changes in the conservation status with some of the subpopulations. The jaguar populations in the Amazon are considered as least concerned but they should be considered as near threatened with the reduction of habitat protections.

Statement of Need

The need for managing jaguar populations of Brazil originates from ecological, sociocultural, economic, and legal issues as described above. Ecological issues include loss of prey including white lipped peccary which has been on decline due to habitat destruction and hunting and some subpopulations are at a greater risk of extinction than others like the populations in the Atlantic Forest and Cerrado region of Brazil. Sociocultural issues include the

human and jaguar conflict. Ranchers often considered the jaguar to be the most beautiful animal in their environment but, as reflected by their attitudes, this perception is no guarantee that they will protect it. Their response to the statement 'jaguars deserve protection' was often 'yes, but not on my ranch'. Where ranchers were sympathetic to jaguar conservation, this appeared to originate from personal, pro-conservation attitudes (Zimmermann, 2005). The economic issue of residents losing livestock reduces production and at the same time people will want jaguars present for the purpose of tourism which sometimes collides with the issues from ranching. Legal issues come from struggles to support law enforcement to ensure protections on wildlife and the environment from the politics of Brazil. With certain successful management scenarios can the jaguar populations benefit and less likely reach extinction.

Management

Goal 1: Increase and maintain the jaguar populations throughout the country of Brazil

Objective 1: Increase the survivorship of the subadult age class by 10% and the cubs by 15% from the current survival rates (i.e., 2020) within the next 10 years (i.e., 2030).

Action 1.1 Conduct additional research on the life cycle, particularly on their reproduction. There has been little research on the jaguar life cycle which sets limits on management options when it comes to focusing conservation efforts on a certain age class to increase and maintain the jaguar populations. More research on the life cycle, behavior on reproduction and hunting and spatial use will give researchers more accurate data and a better understanding on the survival rates for each age class and can be used to closely monitor the target age class to benefit the populations. Understanding their social dynamics and space use is

important for conservation and management strategies to ensure their long-term survival and population persistence (Cavalcanti and Gese, 2009).

Action 1.2 Increase conservation efforts on wildlife species that are considered as prey to jaguars. This can be done by reducing hunting of species including peccary and with habitat preservation. There was an estimate saying the white-lipped peccary has been extirpated in 21% of its historical range over the last 100 years, with reduced abundance and a low to medium probability of long-term survival in another 48% of its current range (Altrichter et al., 2011). The reduction in food availability is one of the main causes for the decline in jaguar populations With population management scenarios on the peccary, including habitat preservation and restoration, then there will be a greater abundance in prey for the jaguars. Conservation efforts in preserving remaining habitat cover and optimizing connectivity between habitat patches will be essential for maintaining white lipped peccary populations and increasing the capacity of future populations (Watson, 2013 and Keuroghlian et al., 2015).

Action 1.3 No action- Lack of conservation efforts and limited research on a certain age class of jaguars will make population management scenarios more challenging. It will also allow the continuation of the populations to decline. Successful conservation efforts will come from research with accurate data and there has been mixed conclusions about the life cycle and behaviors of jaguars. Some researchers felt that females first give birth at 2 years of age and males at 3, while others say females on average start at 3 years of age, as they need to have an established territory and be in good physical condition (Desbiez et al., 2012). There was also considerable debate about whether jaguar reproduction is density dependent. At high densities, some participants thought that animals will compete for prey, territories, and mates, limiting

reproduction. However, others felt that in solitary carnivores' reproduction is not necessarily density dependent (Desbiez et al., 2012).

Final course of action: Action 1.1 stating that additional research needs to be conducted will be implemented immediately. Action 1.2 will be implemented in two years (i.e. 2022) once researchers have a better understanding in the jaguar foraging behavior.

Assessment Protocol: The success can be determined with spatial analyses by monitoring the territory overlaps between male and females during breeding season. The spatial analyses will also be used to monitor the predator and prey interactions and territory overlap. The methods in the spatial analyses will include camera trapping, use of radio collars, and possible mark and recapture methods. The data will also include those from previous research projects to get a better understanding on the jaguar's spatial use. The success can also be determined by monitoring the population density every two years within the decade of the plan's procedure. Habitat corridors serve as areas for transferring individual jaguars and prey species between different populations and will be monitored to determine the frequency of social interactions and predation. This objective can be considered as a success when there is enough resources like food availability to support the jaguar's reproduction and there is an increase in jaguar interactions to increase the population growth rate by 9.5-10% by 2030 (Fig.7). Food sources can increase the survivability of cubs and chances to become adults while the increase in survivability of sub-adults will ensure the expanding fecundity rates in the jaguar population (Fig. 6). To further predict the state of the population, VORTEX population analyses using data on jaguar biology, the current population growth rate and average number of jaguars left in Brazil (Desbiez and Carvalho, 2013) will see if intentions will meet for this objective once the actions are implemented.

The current annual population growth rate is 6% (Cullen et al, 2016) and if the population growth rate does not increase by 7-7.5% by 2025, then there is a small chance the populations will increase by 9.5-10% by 2030 (Fig.7) and there will need to be further research as indicated on Action 1.1 on social interactions between individual jaguars and the possibility of relocating certain individuals to different distributions to support the chances of social interactions. For Action 1.2, options may be capture and relocating prey species including peccary to different forest patches if there is little evidence on home range overlap between predator and prey from spatial analyses. Capturing and relocating of individual jaguars will be the final option since jaguars are territorial and are sensitive to their surroundings and will only be used if all other methods are not successful.

Objective 2: Reduce the human and jaguar conflict in wetland distributions by 30% in five years (i.e. 2025).

Action 2.1 Set yearly surveys for residents to monitor the perspective on the jaguar populations. In areas where human-related mortality is a threat to jaguar populations, identifying which socio-economic factors influence attitudes and perceptions is critical in targeting appropriate resolutions to negative human–wildlife interactions, whether they involve community-based education initiatives, rancher outreach, or improvement of policies (Fort et al., 2017). Various surveys have already been conducted to determine the current state of the human and jaguar conflict including their thoughts on jaguars being in the same areas as human communities. These surveys also include the impacts on economic value of livestock lost from predation and how it impacts their lifestyle. They also include how often people have spotted a jaguar, both local resident and tourists, for better accuracy in population counts. Each year, similar surveys should be conducted to monitor the progress for the management plan and

determine if the jaguar populations and human communities are receiving benefits from the management plan.

Action 2.2 Educate the public on the importance of jaguars based on their ecological roles. In areas where livelihoods have been most affected by livestock losses, and therefore collective experiences over time may negatively influence community perceptions of jaguars, students should be educated at an early age about the importance of carnivores (Fort et al., 2017). Education will spread awareness on how jaguars achieve their roles as a keystone species, this includes stating where jaguars are most abundant and what can be done to avoid confrontations and which safety measures should be practiced so residents can protect themselves and their properties. Some forms of education can include workshops to provide training on techniques to mitigate jaguar predation should be initiated by the government or NGOs and should be tailored to the needs of specific stakeholder groups (Fort et al., 2017). Other topics to educate the public is reasons why jaguars are hunted and what can be done to reduce illegal hunting. Sometimes people know enough about the issue, but do not care about it which is why social marketing approach might be more effective here. Social marketing seeks to develop and integrate marketing concepts with other approaches to influence behaviors that benefit individuals and communities for the greater social good (Marchini and Crawshaw, 2015).

Action 2.3 Continue and intensify the recommended methods to protect private properties and practice proper care for livestock. Each community in a region where jaguars are found has been recommended certain actions based on characteristics of the properties to mitigate the human and jaguar conflict. These methods are also categorized by purpose address conflict at the level of the problem animal, address herd management, a landscape scale and financial compensation for livestock losses (Silveira et al., 2008). Some actions include setting

limits on zoning properties for ranching, setting barriers, or using guard animals to protect private properties. The peak in livestock consumption may reflects on increasing livestock availability during the dry season, as the cattle herds can be found spread in large portions of a ranch. In addition, the dry season also coincides with the livestock calving season, which increases the availability of calves (Perilli et al., 2016).

Action 2.4 No action-No action will allow the continuation of safety risks with people and their property. It will also allow residents to continue struggling with maintain their lifestyle and protect themselves and their properties. Over half of all recorded herd mortality events were caused by large cat predation, resulting in a maximum 2.83% of the average annual herd size and representing an annual financial loss of US$22 400.00 and situations will continue without action (Tortato et al., 2015).

Final course of action: Actions 2.1, and 2.2 stating to set out surveys and educational programs on conservation and predator awareness will be implemented immediately. Action 2.3 stating to intensify methods in reducing livestock predation will be implemented the following year (i.e. 2021). Action 2.1 will be extended towards the deadline stated in Objective 1 to continue monitoring the human and jaguar conflict as management scenarios attempt to increase the jaguar populations.

Assessment Protocol: This objective is to reduce the confrontations between jaguars and people while having people understand the purpose on the conservation efforts taking place. It will be assessed by yearly monitoring on the public's perspective on the jaguars with surveys (Appendix A.) while they are being educated and going through the workshops on the importance of having jaguars in their natural habitats as stated in Actions 2.1 and 2.2. Confrontations between people and jaguars, along with other predators, should decrease once people following methods that are

recommended for each region throughout Brazil as stated in Action 2.3. The regulations of livestock care in some ranching properties should be more strict during the dry season (i.e. May-August) which includes changing practices in letting cattle roam freely to letting them roam for limited times during the day in order to protect the cattle and reduce the chances of calves being targeted. Cattle currently makes up over 34% of the jaguar's diet according to kill rate analysis (Cavalcanti and Gese, 2010) and the actions will be considered as a success if there was a 30% reduction in predation by 2025.

These actions will be considered as a failure if predation on livestock is not reduced by at least 25% in five years and if it is still the highest during the dry season. If the conflict between jaguars and humans continue, even when residents are following the recommended actions in protecting and caring for livestock, then methods that have been recommended but avoided may be used including the use of non-lethal shots. It is always permitted by the law to kill predators to protect properties but one of the intentions of this management plan is to reduce the need for killing carnivores. In some regions, only partial herd management is recommended while others have complete herd management and it is crucial that all regions of full control on managing herds if there is to be a reduction in predation from carnivores (Silveira et al., 2008). Non-lethal shots were considered but never used methods in throughout Brazil (Silveira et al., 2008) and should be used if loss of livestock from carnivores is still a serious situation by 2025.

Objective 3: Reduce the number of harvesting mammals, particularly carnivores, of Brazil by 50% in four years (i.e. 2024). by intensifying laws and policies on wildlife and environmental protections.

Action 3.1 Raise the protection needs of the jaguar populations in the Amazon region. The current conservation status for the populations is least concerned and should be

changed to near threatened (Quigley et al., 2017). Some jaguar subpopulations are at a high risk of reaching extinction mainly due to loss of habitat and food availability in most of the regions they are found in Brazil, but it is not currently considered to be a serious issue in the Amazon region. Raising Amazon subpopulation conservation status from least concerned to near threatened will intensify the needs for environmental law enforcement and conservation efforts as required from the Endangered Species Act.

Action 3.2 Increase laws and penalties on illegally hunting wildlife by making wildlife management a bigger priority. According to the law 9.605/98, the penalty for hunting and harvesting exotic wildlife is imprisonment for six months or a full year with a fine (Rosenn, 2010). It is only legal to hunt jaguars when it comes to self-protection and protection of properties like livestock. However, people are still hunting jaguars outside human community zoned areas. Intensifying penalties for illegally hunting wildlife will cause a decline in illegal hunting. Part of the situation is lack of priority in wildlife management in the judicial system throughout Latin America. Law enforcement and judicial authorities across Latin America, with the exception of those agencies specialized in environmental or wildlife management, lack the understanding, skills, and equipment required to undertake effective investigations that lead to arrests, prosecutions, and convictions of people hunting and trafficking wildlife (Reuter, Kunen, and Roberton, 2018).

Action 3.3 Increase monitoring of illegal trade in wildlife products. Currently, the main challenges to addressing wildlife trafficking in Latin America are the lack of information on the extent, dynamics, and structure of illegal wildlife supply chains (Reuter, Kunen, and Roberton, 2018). Jaguars are hunted for body parts to turn to paste and to sell in black markets. The trade in jaguar parts includes fangs, skulls, claws, and skins, which are sold as trophies and

traditional Chinese medicine across the Americas and in Asia (Fraser, 2018 and Lemieux, 2019). As the black markets in China continue in making profits out of jaguar body parts, the demand for jaguar products increases and the threat to the jaguar populations will increase along with opportunities to access in deep forest habitat.

Action 3.4 No action- The struggles of maintaining law enforcement for wildlife protections makes the conservation efforts in maintaining jaguar populations more challenging. If wildlife management is not made as a bigger priority in the judicial system, then there illegal hunting and wildlife trafficking will continue with little chances of prosecution and conviction (Reuter et al., 2018).

Final course of action: Action 3.2 and 3.3 stating to increase environmental and wildlife protections will be implemented in 1.5-2 years. Action 3.1 will be supplemented in 4 years (i.e. 2024) after monitoring the success and failures of intensifying wildlife protections.

Assessment Protocol: Action 3.1 stating that the Amazon jaguar population should be considered as a near threatened by the IUCN will take place if the struggles in maintaining the environmental and wildlife protections and if wildlife management and habitat preservation being a priority is still a challenge. The objective will be an even greater success if there is a reduction in threats to the jaguar populations and there is no need to use Action 3.1. The conservation law enforcement in Brazil is responsible for monitoring the number of times jaguars are being illegally hunted and harvested and their records can be used to determine the if there is a successful reduction in hunting carnivores. In the past twenty years, people have been hunting around 30 jaguars per year (Carvalho and Pezzuti, 2010) and the about 53.7 % of confiscated illegal carcasses are mammals (Chagas et al., 2015). If there was a 50% reduction in the number of mammals being illegally harvested, then the actions will be a success. The actions

will be considered as a failure if the IUCN are still predicting that the global jaguar population will be considered as vulnerable in 30 years due to overhunting and conflicts between people and carnivores.

Objective 4: Decrease the rate of habitat fragmentation and degradation by 20% in all regions where jaguars are found within 5 years (i.e. 2025).

Action 4.1 Intensify current environmental protection policies. The current exception of acres in the Amazon for human use is 50% according the revised Brazilian Forest Code. (Castelo, 2015). This will increase the rate of habitat fragmentation and degradation and decrease habitat availability. If Amazon preservation were to increase to 65-70%, there will still be enough habitat availability and there will still be access for human use to meet production demands. Increasing the protections with the Brazilian Forest Code will also allow further protections to heavily impacted forests like the Atlantic forest as nearly half of the known forest connector fragments' areas (44.4%) are not under any degree of protection, and 34.8% of them are under the protection of sustainable use protected areas for the use of jaguars and other wildlife (Diniz et al., 2017).

Action 4.2 Decrease the rate road mortality by halting road construction. The current risk for road mortality on jaguars varies from 4% to 33% in various populations (Cullen et al., 2016). Road collisions can easily be avoided and reduced to with more awareness on the jaguars inhabiting areas near roads and certain sections of the roads can be labeled for jaguar crossings. It can also be avoided by reducing habitat fragmentation for road construction. Habitat preservations will be the appropriate actions to decrease road mortality because it will put road construction on hold which can reduce the chances of road collisions to 4-10%.

Action 4.3 No action- The increase in the demand for beef will influence the need for land for ranching. The exponential increase in human populations, combined with the world's demand for food, is creating ever-growing habitat conversion and fragmentation (Timan et al. 2001 and Silveira et al., 2008). It will allow more habitat fragmentation and degradation for human use in the Amazon rainforest. Remaining jaguar populations are becoming increasingly fragmented and isolated throughout the species' range in Brazil, particularly the Pantanal, Atlantic Forest, and Cerrado regions. (Cullen et al., 2016).

Final course of action: Action 4.2 will be implemented immediately as it is needed for residents to be aware of where the wildlife is most abundant to avoid road collisions. Action 4.1 will be implemented in 2 years (i.e. 2022) for the Brazilian government's approval on improving habitat protection policies.

Assessment Protocol: The success of Action 4.1 will depend on the Brazilian government's approval. The need for more land for humans uses increases is understandable but reducing habitat fragmentation and degradation is essential for protecting the tropical forests and wetlands that are suitable habitat for jaguars and other wildlife. If the protections from the Forest Code were to increase by 15-20% by 2022, then more than half of the Amazon will be preserved and habitat destruction in heavily fragmented regions will decrease. The increase in protections from the Brazilian Forest Code should also be able to limit further habitat fragmentations and road construction in protected forests which will assist in reducing jaguar road mortality as stated in Action 4.2. The success will be determined by road mortality, determining if the chances of collision reduced to no more than 10%, with the combination of population density analyses in certain patches. If there is a positive relationship between population growth and the reduction in the number of acres being fragmented, along reduction in road mortality then the actions will be

successful. The actions will fail if the government in Brazil does not expand the number of acres in the Amazon rainforest for preservation and decides to allow 50% of the forest for human use including ranching and residents are still demanding more acres for ranches. Some alternatives will be changes in zoning properties to save up the use of acres and reduce the needs to cut further into forests for ranching.

(a)

***F*(c)**	***F*(*j*)**	***F*(*sa*)**	***F*(*a*)**
0.0702	0.0146	0.0063	0.0020
0.1088	0.0226	0.0097	0.0031
0.6634	0.1378	0.0594	0.0190
2.9516	0.6133	0.2643	0.0845
14.1995	2.9506	1.2717	0.4067

(b)

***F*(c)**	***F*(*j*)**	***F*(*sa*)**	***F*(*a*)**
0	0	0.002362768	0.079970453
0.026466674	0	0	0
0.082333221	0.055513625	0	0
0	0.082333221	0.182014475	0
0	0	0.079970453	0.32670189

Fig. 6. The sensitivity matrix (a) and the elasticity matrix (b) shows that concentrating conservation efforts on cubs to increase the survivability rate by 15% will influence the survivability of the next two life stages. Increasing survivability of sub-adults by 10% will further ensure in expanding the fecundity rates in the jaguar population.

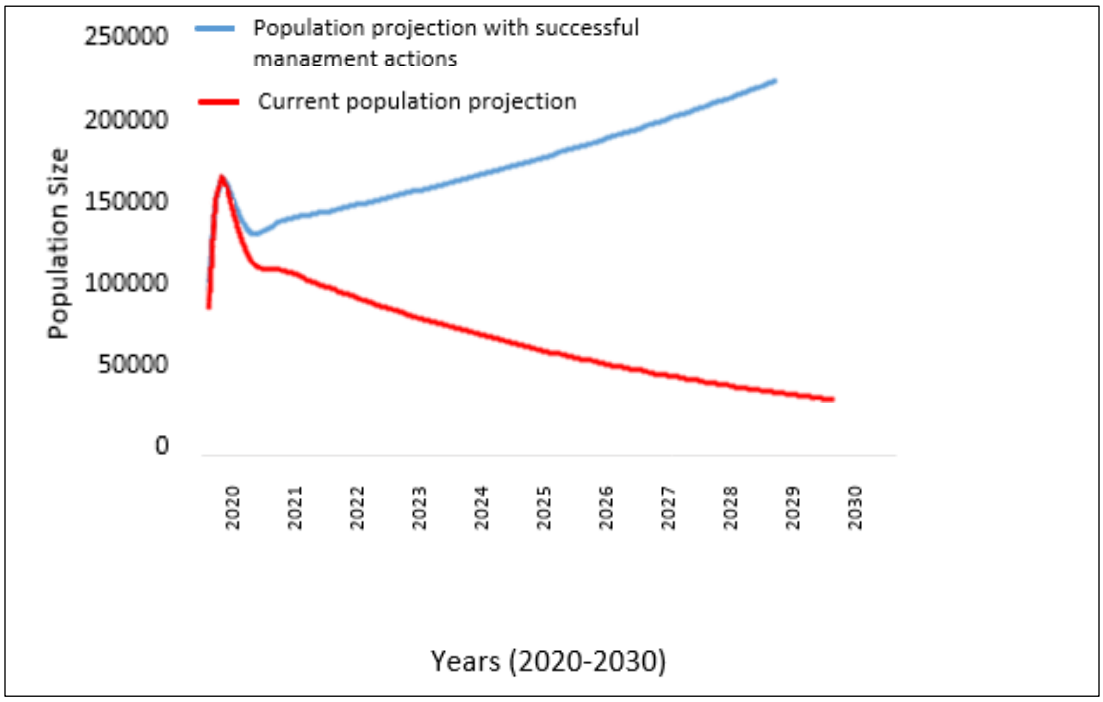

Fig. 7. The jaguar population projection from 2020 to 2030 showing the current population trend (red) and a trend resulting from successful management actions (blue). Management actions include 1.1, and 1.2, as they will focus on age classes that needs an increase in survivability to increase the population growth rate by 10% while actions 3.2, 3.3, 4.1, and 4.2 will further ensure the population increase with wildlife and environmental protections.

Conclusion

Jaguar populations are declining throughout their distribution and this management plan can potentially benefit the jaguar populations and reduce factors that are considered as a risk to a population decline in Brazil. Implementing the final action plans will ensure better environmental protection and wildlife management along with fewer conflicts between people and wildlife. If the proposed actions are successful, then there will be improved jaguar populations with fewer conservation issues. Researchers will have a better understanding in the lifestyle of jaguars including food and habitat preferences along with solving neotropical carnivore conservation issues, all of which can be used for future management scenarios in Brazil as well as in other countries throughout Latin America. With the combination in additional research, awareness to the public to mitigate the human and jaguar conflict, and wildlife management becoming a greater priority in politics, the jaguar populations will benefit and have a smaller chance of reaching extinction.

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Appendix A.

Jaguar (*Panthera onca*) Management Plan Follow up Survey

The jaguar (*Panthera onca*) populations are declining in most regions of Brazil and there are mixed reactions from residents on the jaguar populations. The purpose of this survey is to gain a better understanding on the public's perspective on jaguars and their conservation needs.

1) What best describes your lifestyle?
   a) Ranching
   b) Farming
   c) Tourism
   d) Trade
   e) Other (Please specify): _____
2) Are you a private landowner?
   a) Yes
   b) No
3) Do you believe that jaguars and other predators show a threat to your lifestyle?
   a) Yes
   b) No
   c) Unsure

4) Are you familiar with the jaguar's current conservation status?
   a) Yes
   b) No
5) Do you recognize the ecological benefits that jaguars provide in their distribution?
   a) Yes
   b) No
6) How often do you encounter jaguars in your area in one year?
   a) Often
   b) Fair
   c) Rarely
   d) Never
7) Are you familiar with the current conservation efforts on the jaguar populations in Brazil?
   a) Yes
   b) No
8) Do you approve the current conservation efforts on their populations?
   a) Yes
   b) No
   c) Unsure
9) As a Brazilian resident, do you have any safety concerns about jaguars and other predators? Please explain why.

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10) Do you have any questions or concerns regarding the jaguars and the management plan?