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RESEARCH ARTICLE

The potential for large-scale wildlife corridors between protected areas in Brazil using the jaguar as a model species

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Abstract Most large reserves in Brazil do not hold viable populations of jaguars to guarantee the species' long-term survival. Corridors linking populations have been identified as a potential tool to avoid negative effects of isolation, increasing population viability. Here, we performed a Brazil-wide evaluation of potential large scale corridors connecting protected jaguar populations. Six variables (human population size, dam reservoir size, number of dams, roads, railways and cities) expected to negatively impact jaguar movement were analyzed across 180 potential corridors connecting 298 protected jaguar areas. We established overall disturbance scores for the corridors using a principal components analysis and compared them among the Brazilian biomes. We further investigated which variables separated biomes using a canonical variates analysis. The Atlantic Forest and the semi-arid Caatinga have the most impacted potential corridors, whereas the Amazon and Pantanal still have the best potential corridors. Corridor quality in the Cerrado grasslands was intermediate. All variables but human population size and corridor length contributed significantly to differences in corridor variables among biomes. Our conclusions suggest that we need to plan the implementation of large scale corridors in the Amazon, Pantanal and particularly the Cerrado soon, while potential corridors might still be economically viable. In the much more impacted Atlantic Forest and Caatinga, the need for conservation actions is strongest, but logistical difficulties and costs may turn implementation of corridors unfeasible.

Keywords Brazil · Conservation · Corridor · Disturbance · Jaguar · *Panthera onca* · Principal components analysis

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Introduction

Today, the main threat to large and wide ranging mammal species is habitat loss and fragmentation, and the consequent isolation and collapse of local populations (Fahrig 2003; Costa et al. 2005; Fortin and Agrawal 2005). Under the pressure of human population growth and simultaneous conversion of natural habitat (Gardner et al. 2009), the geographical

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distributions of many large mammals have suffered significant reductions (Morrison et al. 2007; Schipper et al. 2008). Reduction of suitable habitat does not occur in a continuous manner, but rather creates disconnected patches in which the species can be found. Habitat converted for anthropogenic use often represents barriers for, or reduces rates of animal dispersion (Bélisle et al. 2001; Gardner et al. 2009), leading to the isolation of populations that occur in suitable habitat patches. Particularly small isolated populations suffer high risks of extinction due to a greater susceptibility to stochastic events (Caughley 1994) and loss of genetic diversity, caused by genetic drift and/or inbreeding (Harrison and Hastings 1996). Genetic diversity is often associated with adaptability to changing or new environmental conditions and pathogens (Lacy 1997; Sih et al. 2000). Especially large-bodied species may suffer from the effects of habitat loss and isolation as they require large tracts of land to maintain viable populations (Fahrig 2003; Fischer and Lindenmayer 2007; Morrison et al. 2007).

Corridors that establish connections between suitable patches of habitat, and thus contribute to the maintenance of gene flow and other ecological processes, are considered one of the main strategies to mitigate or reverse consequences associated with habitat fragmentation/isolation problem, as they allow species to move across the landscape, (e.g., Chetkiewicz et al. 2006; Rocha et al. 2006; Gilbert-Norton et al. 2010). The resulting network of interconnected subpopulations is believed to contribute to the resilience of a species to extinction due to rescue effects (i.e., recolonization of patches where the species has gone extinct) (e.g., Hanski 1991). Corridors can range in scale from a few meters, facilitating the movement of individuals across man-made barriers (e.g., an overpass over a highway), to incorporating entire landscapes with mixed land use types and protection status (Simberloff et al. 1992). While the actual effectiveness of corridors remains controversial, evidence in favor of a positive effect on animal movement between patches is strong (Beier and Noss 1998; Gilbert-Norton et al. 2010).

Against this background, the objective of our study is to identify existing landscape structures in Brazil that can serve as potential large scale wildlife corridors, and evaluate these potential corridors regarding their current degree of human disturbance. Since the definition of a corridor depends largely on the biology (space and habitat requirements, movement ability, etc.) of the focal species (e.g., Haddad and Tewksbury 2006; Gillies and Clair 2008), we chose the jaguar (*Panthera onca*) as a model for our analysis. The jaguar is the largest felid in the Neotropics, and Brazil covers close to 50 % of the species' current range (Zeller 2007). Still, 75 % of the country's protected jaguar populations, when considered isolated, are not viable in the long term (Sollmann et al. 2008). Population isolation, loss of genetic diversity and consequent local extinction events have been observed in several regions of the jaguar's distribution (Cullen 2006; Soares et al. 2006; Mazzolli 2008; Haag et al. 2010). Maintaining or re-establishing connections between jaguar populations has been cited as a priority conservation concern for the species (Silveira and Jácomo 2002; Rabinowitz and Zeller 2010). Jaguars are mobile and wide ranging species with home range requirements of up to several hundred square kilometers (Astete et al. 2008). Thus, corridors for jaguars could provide living space and dispersal opportunities for many other species as the habitat needs for this charismatic umbrella species may encompass the need of other species within the ecosystem (Carroll et al. 2001).

With our analysis we present the first Brazil-wide assessment of large scale potential wildlife corridors. Our results provide guidance as to where to focus future research and conservation efforts aimed towards the implementation of such corridors throughout Brazil.

Methods

Study system

The jaguar occurs in five Brazilian biomes: the Amazon, Pantanal, Cerrado, Atlantic Forest and Caatinga (Table 1), being absent only from the Pampa in the very south of the country. These biomes represent distinct environmental realities, both in terms of habitat and human impact. The Amazon rainforest with its remaining largely undisturbed continuous blocks of forest is the largest stronghold for the jaguar throughout its distribution (Sanderson et al. 2002; Sollmann et al. 2008). With the advancement of the agricultural frontier into the Amazon, however, predictions of future deforestation are high

Table 1 General information about the five Brazilian biomes where jaguar occur, including total area in km^2, % of Brazil area covered by each biome, % of converted area to human use, main natural vegetation and number of protected jaguar areas (PJAs)

Biome	Total area	% of Brazil area	% of converted area	Main vegetation	No. PJAs
Amazon	4,196,943	49,29	12,47	Rain Forest	167
Cerrado	2,036,448	23,92	38,98	Wooded Savannah	60
Atlantic Forest	1,110,182	13,04	73,03	Rain Forest	49
Caatinga	844,453	9,92	36,28	Steppe Savannah	16
Pantanal	150,355	1,76	11,54	Savannah/Chaco	6

Source: IBGE (2004) and Sollmann et al. (2008)

(Costa et al. 2005). The Pantanal is considered a second stronghold for the jaguar (Sanderson et al. 2002). Extensive cattle ranching—the main economic activity in the area—and the seasonal flooding regime have preserved much of its native vegetation, and the high abundance of mammalian prey (Swartz 2000) supports comparatively high jaguar densities (Soisalo and Cavalcanti 2006), even in non-protected areas. The Cerrado, central Brazil's savanna, has been heavily impacted by large scale agriculture (soy bean, cotton, grains, and more recently sugar cane); 80 % of its area is under some degree of human influence (Cavalcanti and Joly 2002). Jaguars occur at low densities and isolation appears to be a predominant threat to the species in this biome (Silveira 2004; Sollmann et al. 2011). The semi-arid climate and poor soils of the Caatinga limit large scale agriculture and cattle ranching, but this biome in the northeast of Brazil suffers from intensive small-scale fragmentation. The poor rural population exerts a strong poaching pressure on the jaguar's prey base (Leal et al. 2005). Home to the major developing centers of Brazil, the coastal Atlantic Forest has lost much of its native vegetation and remaining patches are small (Gascon et al. 2000). Increasing anthropogenic pressures threaten the jaguar and other mammal species in this biome (Canale et al. 2012).

Defining a potential jaguar corridor

We adopt a corridor concept that does not necessarily require an individual to move through the entire length of a corridor to be functional; rather, these large scale corridors should provide living space for the target species outside of established protected populations, so that these maintain some degree of connectivity. This is similar to the concept of "regional corridors" discussed by Simberloff et al. (1992) in the context of allowing range shifts due to climate change. In order to identify potential jaguar corridors it is necessary to identify the populations to be connected in the landscape. We considered the *Protected Jaguar Areas* (PJAs) described in Sollmann et al. (2008) as the jaguar populations in Brazil in need of connection as this study currently represents the broadest assessment of jaguar populations in Brazil. The authors considered protected areas with jaguar presence and larger than 10,000 hectares, since these are, in theory, large enough to sustain a minimum of one resident breeding pair. When these areas were immediately adjacent to each other, they were considered as a single block with a contiguous jaguar population.

In a second step we identified potential connections between these populations. Corridors can be defined according to two aspects: *structural*, considering continuous strips of natural habitats connecting fragments; and *functional*, considering the species' behavioral response to structural elements of a corridor, like the mosaic of different land uses (Chetkiewicz et al. 2006; Fischer and Lindenmayer 2007). While jaguars are able to use anthropogenic habitat, they generally prefer natural habitat (Silveira 2004; Cullen 2006; Conde et al. 2010; Colchero et al. 2011). Riparian vegetation along river courses is among the species' preferred habitats and the species' affinity with water has been demonstrated throughout its distribution (Crawshaw and Quigley 1991; Naiman and Décamps 1997; Cullen 2006; Lees and Peres 2008). Further, in Brazil, environmental legislation requires landowners to protect habitat along water courses in the form of so-called areas of permanent protection (APP) (Brasil and Presidência da República 2012). Thus, river courses provide the highest potential for wildlife corridors in general (legal protection status) and for the jaguar in particular (species specific preferences for riparian habitat and association with water). Therefore, our first choice for potential corridors was the shortest connection between PJAs along river courses, using a database from the National Water Agency (ANA 2006). In the absence of rivers, we also considered strings of natural habitat patches (sequences of native remnants between PJAs). In order for a string of habitat patches to be considered as a potential corridor, maximum distances between subsequent patches had to be below 500 meters. As a third possibility of connection, we chose mountain ranges or foothills, because similar to river courses, steep slopes also have to be protected in the form of APPs (Brasil and Presidência da República 2012). When these mountainous features did not cross the entire distance between two PJAs, we considered a combination of mountains and habitat patches, using the same distance restrictions as outlines above. We used the GIS data base of the Brazilian Institute of Geography and Statistics (IBGE 2004) to identify these landscape structures. Independent of the criteria to define the potential corridor, we considered a strip of 20 km on each side of the main connection as the area of the corridor (including any land use within this strip), assuming that this width would hypothetically cover enough area for a resident or transient jaguar to live in.

To classify the disturbance level of these potential corridors, we considered corridor length and the number of dams (ANA 2008), roads (IBGE 2005), railways (IBGE 2005), cities (IBGE 2010b), total dam reservoir size (ANA 2011) and total human population size of municipalities (IBGE 2010a) along the area encompassed by each corridor. While length is not per se a descriptor of disturbance, on a large spatial scale it is an essential variable determining migration between populations (Kadoya 2009). All other variables are indicators of anthropogenic impacts on the corridor. Jaguars have been shown to avoid roads (Colchero et al. 2011) and so have several other wildlife species (Forman and Alexander 1998). Although there is no information on the effect of the remaining variables on jaguar movement behavior, factors such as human presence and infrastructure have proven to negatively influence the presence and use of corridors by other large mammals (e.g., Shepherd and Whittington 2006).

We analyzed our data separately and comparatively across all five Brazilian biomes where jaguars are known to occur.

Statistical analysis

To reduce the number of parameters describing corridor disturbance, we used a Principal Component Analyzes (PCA) (Manly 1994). The variables *dam reservoir size, human population* along the corridor and *corridor length* were log-transformed prior to the statistical analyses. For further interpretation, we selected principal components axes with eigenvalues larger than 1.0, which also coincided with those selected according to a broken stick criterion (Legendre and Legendre 1998). We used the scores of the selected PCA axis for each corridor as an indication of its degree of disturbance. These scores were categorized into five classes, with the same number of corridors in each class, corresponding to five different disturbance levels (1 = least disturbed, to 5 = most disturbed).

To determine which variables describing corridor disturbance best discriminate the biomes, we further performed a canonical variate analysis (CVA). We used successive removal of roots/canonical functions to determine how many functions to retain in the analysis and built a structure matrix to investigate bivariate correlation of variables with the canonical functions. To see how well these functions separate the different biomes, we plotted the canonical scores of all corridors for the first and second canonical function and visually examined the plot.

Results

From a network of 298 PJAs (Sollmann et al. 2008), we identified 180 potential jaguar corridors connecting 151 PJAs (Fig. 1; Table 2). The majority of potential corridors were along river courses (n = 124, 68.88 %), followed by river courses with natural habitat patches (n = 33, 18.33 %) and only natural habitat patches (n = 10, 5.55 %). Few corridors were identified by mountain ranges and foothills (n = 7, 3.88 %) and by rivers in combination with mountain ranges (n = 6, 3.33 %).

The first axis of the PCA explained approximately 63.5 % of the total variance of the input variables.

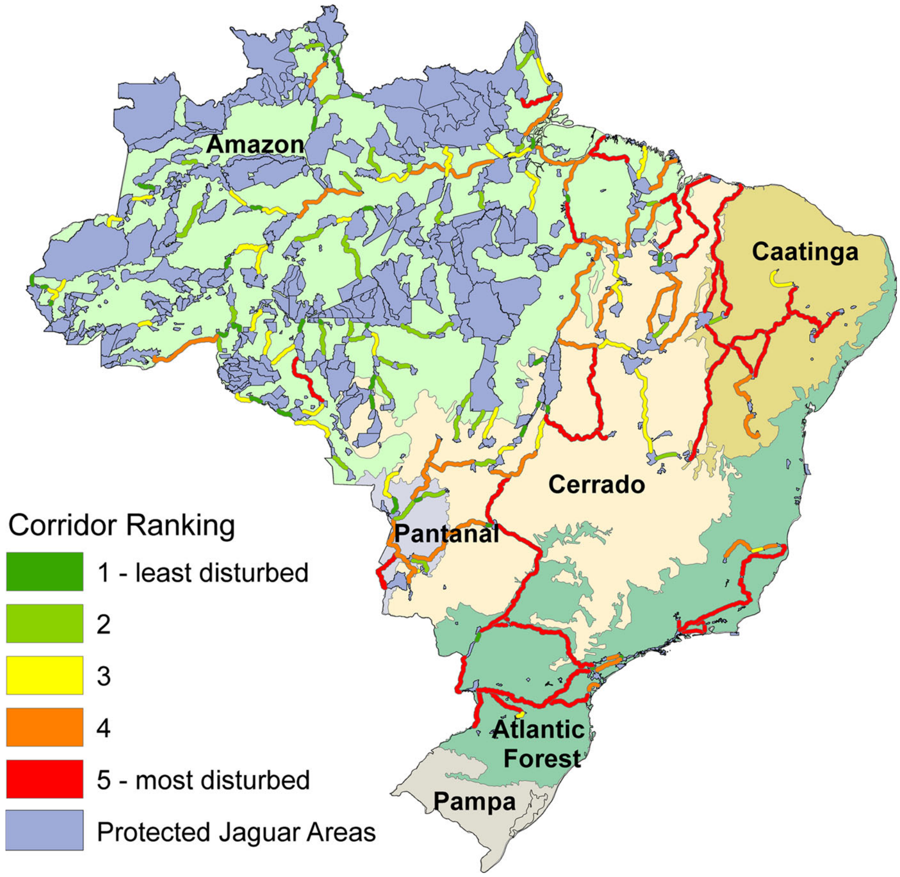

Fig. 1 Map of the potential corridors connecting protected jaguar populations in Brazil and degree of disturbance according to the variables considered in this study (corridor length, number of dams, roads, railways, cities, total dam reservoir size and total human population of municipalities along the area encompassed by each corridor)

Table 2 Characterization of potential jaguar corridors across the five Brazilian biomes where jaguars occur; numbers represent the sum of variables over all identified corridors

Biome	No. corridors	Total length (km)	Total no. dams	Total no. roads	Total no. railways	Total no. cities	Total dam reservoir area (km^2)	Total human population
Amazon	97	12,242	4	116	5	161	3,044.6	10,493,643
Cerrado	33	6,578	12	104	1	115	3,100.69	2,311,506
Caatinga	12	5,294	7	77	3	141	14,203.53	6,312,731
Pantanal	12	2,110	1	24	2	12	0	1,159,767
Atlantic Forest	26	5,551	93	157	25	235	13,474.31	7,686,158
Total	180	31,775	117	478	36	664	33,823.13	27,963,805

With an eigenvalue of 3.808, it was the only axis that fulfilled the criterion of an eigenvalue higher than 1. The eigenvalue was also higher than the one expected by the *Broken-stick* criteria (in this case, for axis $1 = 2.450$) (Legendre and Legendre 1998).

The first principal component axis was positively correlated with all the variables (Table 4), thus indicating that it expresses a general gradient of disturbance. Disturbance varied among the biomes (Table 3): For the Amazon, the majority (>75 %) of corridors fell within the first (i.e. least disturbed) three classes, while for the Caatinga and Atlantic Forest the majority (83 and 80 %, respectively) fell within the two highest disturbance classes (Table 3).

Table 3 Percentage of potential jaguar corridors for each Brazilian biome according to the five disturbance levels (rank 1 = least disturbed, to rank 5 = most disturbed)

Biome	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Amazon	25.77	27.84	24.74	15.46	6.19
Cerrado	18.18	15.15	21.21	30.30	15.15
Caatinga	0.00	8.33	8.33	16.67	66.67
Pantanal	16.67	25.00	16.67	33.33	8.33
AtlanticForest	11.54	0.00	7.69	19.23	61.54

Table 4 Pearson correlation coefficient (r) between each variable used to classify the disturbance level of potential jaguar corridors in Brazil, and axis 1 of the principal components analysis, and variate 1 and 2 of the canonical variate analysis

Variables	r	Variate 1	Variate 2
Corridor length (km)	0.756	0.101	0.425
Hydroelectric dams	0.784	0.663*	−0.207
Roads	0.909	0.641*	0.452
Railways	0.751	0.570*	−0.181
Dam reservoir size (Km^2)	0.720	0.525*	0.312
Sum of human population	0.657	0.339	0.260
Cities	0.882	0.509*	0.429

* Mark strongest correlation between variable and variate 1

In CVA, successive removal of roots indicated that only the first two canonical variates significantly discriminate the biomes (Table 4). All variables showed their strongest correlation with the first canonical variate, apart from corridor length and human population size (Table 4), which showed strongest correlation only with the fifth variate (data not shown). Based on the structure matrix (Table 4), the variables *number of hydroelectric dams* and *number of roads* contributed the most to separating biomes. However, plotting the canonical scores for each corridor from variate 2 against variate 1, it becomes apparent that the separation between groups based on the variables used is not very strong, as point clouds show large overlap among groups (Fig. 2). Observable trends are that (1) Amazon and Pantanal corridors occupy largely overlapping point clouds, shared to some extend by Cerrado corridors; (2) Caatinga corridors are to some degree separated from the other biomes by variate 2, showing overall higher values on the y-axis; (3) Atlantic Forest corridors are largely separated from the Amazon/Pantanal/Cerrado cluster by variate 1, showing higher values on the x-axis.

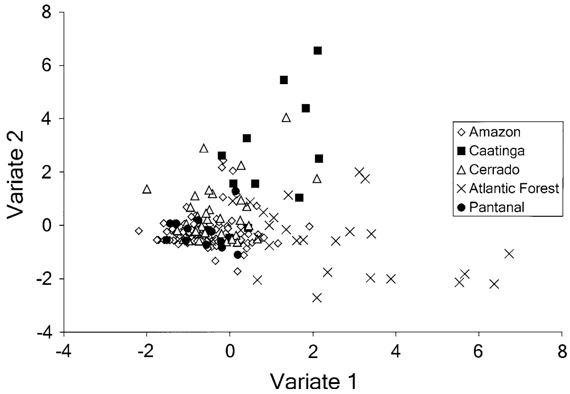

Fig. 2 Plot of scores from a canonical variates analysis of variables describing potential jaguar corridors in five Brazilian biomes; variate 2 is plotted against variate 1

Discussion

A global wildlife conservation problem is that most of the remaining large-bodied animal populations in protected reserves are not large enough to be viable in the long term (e.g., Grumbine 1990). This principle holds true for the jaguar in Brazil, where most protected areas alone are not large enough to sustain long-term viable populations (Sollmann et al. 2008). As a consequence, in order to guarantee long-term viable populations of these species we need to tackle their conservation using a landscape approach that encompasses both protected and non-protected areas. Using the jaguar as a model species, our results indicate that corridors connecting protected areas can still be a key landscape management tool for parts of Brazil.

The canonical variate analysis showed that, to a large degree, corridors of all five Brazilian biomes had similar combinations of variable values. Nevertheless, some trends of separation among biomes were observable. The Caatinga corridors were somewhat separated from the other biomes by variate 2 (Fig. 2). The variable most strongly—positively—correlated with variate 2 is number of roads (Table 4), so Caatinga corridors seem to be more strongly impacted by roads than other biomes. The Atlantic forest corridors were separated from the Amazon/Pantanal/Cerrado cluster by variate 1, again towards the higher values. Here, number of hydroelectric dams was the most strongly and positively correlated variable.

In spite of these similarities, all Brazilian biomes suffer distinct human pressures which reflect directly on corridor quality, implementation costs and potential functionality. Thus, it is not surprising that with 25 % of its corridors in the lowest disturbance class, and over 75 % in the three lowest classes, the Amazon shows an overall better corridor quality than any other biome (Table 3). The Amazon is the least developed region of Brazil with an extremely low human population density and the highest numbers of large protected areas. The Pantanal wetlands appear to be the second most favored in terms of corridor quality. Again, in this biome there is a low human density, and extensive cattle ranching, at least partially on native pastures, is the predominant land use form. This land use pattern favors the species persistence across the biome as well as the maintenance of natural corridors.

Especially for the Amazon, the issue of connecting protected areas might not appear as urgent, considering the higher degree of continuity of natural (or permeable) habitats for the jaguar. But in spite of its sheer size, habitat loss and fragmentation pose a serious threat to the Amazon forest, with estimates of loss of up to 40 % by 2050 (Soares-Filho et al. 2006). Along the southern border of the Amazon, in the so-called Arc of Deforestation, jaguar populations are severely impacted by habitat loss and poaching (de Oliveira et al. 2012), in some cases leading to local extirpation (Michalski et al. 2006).

Large tracts of the Pantanal are unsuitable for intensive development because of the seasonal flooding regime of the area. Consequently, the biome retains much of is natural vegetation cover. Both habitat conversion and intensification of livestock ranching, however, have increased the degree of habitat fragmentation in the Pantanal, and are considered to pose serious threats to wildlife in the future (Fearnside 2005; Harris et al. 2005). Against this background, it seems to be the right time to adopt a proactive approach (Brooks et al. 2006) and plan jaguar corridors for the Amazon and the Pantanal, as long as human impact on suitable landscape structures is still relatively low.

The Atlantic Forest and the Caatinga both have a similar status of overall degradation and human impact. Both biomes were the first to suffer from human pressure since the country's colonization in 1500. According to Ribeiro et al. (2009) 88.3 % of the Atlantic Forest has already been lost. While values for the Caatinga are much lower (40 %, MMA 2007), the remaining habitat is extremely fragmented (Castelletti et al. 2004; Ribeiro et al. 2009), which may explain why both biomes hold the most disturbed, lowest quality corridors.

These high disturbance values suggest that the costs and logistics of implementing a jaguar corridor may already be prohibitive. At the same time, these biomes are likely the ones where jaguars are in most need for conservation intervention in order to persist. Studies in the Atlantic Forest have revealed extremely low population densities (Paviolo et al. 2008), clear genetic signals of population isolation (genetic drift; Haag et al. 2010) and a quickly progressing south-to-north front of local extinction (Mazzolli 2008). Little is known about jaguar populations in the Caatinga, but the fact that only 7 % of this biome is under protection highlights the need for conservation that includes non-protected areas to connect protected populations (de Paula et al. 2012). Roques et al. (2014) report genetic signs of isolation from one of the key jaguar populations in the Caatinga. Nonetheless, in view of the logistical difficulties, for these biomes, the selection of corridors for any investment should follow an extremely careful evaluation, considering if the target populations we wish to connect will in fact benefit from this investment.

The Cerrado is in the process of rapid habitat conversion due to agriculture expansion (Klink and Machado 2005), especially for the recent worldwide demand of ethanol from sugar cane (Rocha 2007). Loyola et al. (2009) indicate the Cerrado as one of the ecoregions in the world demanding urgent intervention for carnivore conservation. The fast conversion of habitat has led to an estimated loss of 50 % of the biome's jaguar population (Moraes Jr. 2012). Genetic studies suggest that recent gene flow connected Cerrado jaguars to those in the Amazon and Pananal (Roques personal communication). Continuing development, however, threatens to impact the remaining potential connections among jaguar populations (Silveira and Jácomo 2002). Considering the intermediate impact level on potential corridors in combination with rapid development, the Cerrado currently appears to be in transition from the low-cost to the high-cost stage of corridor implementation.

The Araguaia river is a graphic example of the pressing need for large scale conservation actions in the Cerrado. With 1,300 miles passing 13 protected areas on its way to the Amazon, this river is one of the largest of central Brazil. It originates in the Cerrado, adjacent to Emas National Park, the largest protected grassland area. The park holds one of the last jaguar population in the southwestern Cerrado, but population density is below 1 individual per 100 km^2 and the park is thought to harbor no more than 10–15 individuals (Sollmann et al. 2011). To maintain the species in this region, connectivity with other populations along the Araguaia river is crucial (Silveira and Jácomo 2002). The area of the Araguaia is still under relatively low human pressure, compared with much of the region, and was identified as holding a key subpopulation of jaguars in the Cerrado (Moraes Jr. 2012). But government-supported infrastructure development, such as the construction of roads and dams, threaten the corridor's functionality (Silveira and Jácomo 2002). The example highlights the need for immediate integration of development and conservation planning in the Cerrado.

We are aware that dispersal behavior of an animal depends largely on its resource requirements (Bélisle 2005; Heinz and Strand 2006). Consequently, the use and movements along corridors by animals are governed by more than the factors considered here, for example the presence and abundance of food resources and other ecological aspects (Johnson 1980). We are also aware that we evaluate corridors based on structural rather than functional aspects, since there are no data about the functional response of jaguars to many of the evaluated characteristics. Further, given the distinct environmental circumstances of the different biomes, and the distinct ecological adaptations of jaguars to these biomes (Astete et al. 2008), it seems unlikely that the species' response to human impacts would be constant across Brazil. We therefore refrain from attempting to develop a single movement model based evaluation of potential corridors (as presented by Rabinowitz and Zeller 2010) throughout Brazil. Rather, we provide an assessment of the degree of disturbance of potential corridors based on existing infrastructure to evaluate the potential for large scale jaguar corridors in Brazil. Functionality is a response to structural aspects of a corridor and we incorporate aspects into our analysis, which, based on what is known about jaguars today, are likely to have a negative impact on corridor functionality. The analysis should be understood as a first step towards actual evaluation of large-scale corridors in Brazil that are potentially viable from the standpoint of existing human infrastructure, and to provide guidance as to where to focus further investigations and conservation efforts.

Future research to determine potential corridors needs to include studies on jaguar dispersal ability and assess the use of designated corridor by the species (Hilty et al. 2006; Noss and Daly 2006; Zeller et al. 2011). In addition, the matrix surrounding a corridor has to be taken into account, since it can contribute significantly to movement between habitat patches (Ricketts 2001; Bender and Fahrig 2005; Vergara 2011). Edge effects of matrix habitat on corridors can cause individuals moving through corridors to have higher mortality due to adverse effects of the matrix (Hobbs 1992), such as increased interactions with humans (Woodroffe and Ginsberg 1998; Kiffner et al. 2012).

All these considerations point towards the fact that the use of corridors as a conservation tool for wide ranging species like the jaguar requires both large scale planning and accounting for regional and local characteristics. Because large scale corridors include anthropogenic land use, political involvement is crucial to the process of implementing such corridors. Human expansion and habitat conversion continue to happen at a fast pace throughout Brazil. If large scale corridors are to play a role in jaguar (and other wildlife) conservation planning, they need to be put on the scientific and political agenda very soon.

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