

Where do we draw the line?
Conserving biodiversity in the Amazon through transboundary
protected areas

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Abstract

The concept of borders brings up many complex issues, especially in regard to the creation of protected areas. International boundaries are not consistent with ecosystem borders, and conservation needs to be targeted at protecting ecoregions rather than areas ending at arbitrary international borders. When assessing the creation of a protected area, it is necessary to use an ecological approach in addition to a social perspective. Home ranges and locations of keystone species are important, as well as the use of a protected area as an ecological corridor. Buffer zones are also imperative for protected areas. This paper shows that Peru's Sierra del Divisor Reserved Zone needs to receive formal protection immediately, as it contains rich biodiversity, threatened species, and will serve as an ecological corridor and a buffer zone to Brazil's Serra do Divisor. The large binational park in Peru and Brazil is necessary to conserve important biodiversity in the Amazon.

I. Introduction

This paper focuses on a biodiversity hotspot in the Amazon and the conservation requirements for survival of key species in the ecosystem. The paper will adopt an ecological approach to the assessment of the Sierra del Divisor region of Peru, which has recently been designated a Reserved Zone. The literature review will provide background on transboundary protected areas and the importance of an ecological approach. The methods will describe the importance of the study species as well as the geographic location and significance of the potential protected area. The results section will present findings on the current status of important wildlife species as well as the home range habitat they require for survival.

I will argue the Sierra del Divisor Reserved Zone deserves formal protection, as an important habitat for endangered, rare, and important species in the Amazon. The Reserved Zone should also have a connection with Brazil's Serra do Divisor National Park to provide an ecological corridor for species with large ranges. Further, the proposed road extending from Pucallpa, Peru, to Cruzeiro do Sul, Brazil, should not be constructed as it would have devastating consequences on the landscape.

II. Literature Review

This paper will provide an ecological approach to the assessment of a potential transboundary protected area, based on multiple perspectives including biology and geography. This ecological approach to creating protected areas is criticized by many scholars in the field of political ecology. These scholars write of their concern for

ecological concerns taking precedence over social issues in the creation of protected areas (West et al. 2006, Ali 2007). The goal of this paper is not to ignore social issues, but rather to provide an ecological approach that can add to studies that provide information on the social issues of the study area (Vriesendorp et al. 2006). An ecological approach is a necessary part of assessing protected areas, as the field of political ecology may become 'politics without ecology' if research keeps drifting from an ecological focus, and therefore not contribute to important environmental issues (Walker 2005). The arguments provided in this paper do not ignore the ecological primacy/political expediency dilemma (Ali 2007), but rather provide strong ecological arguments that should add to other support for the creation of a transboundary protected area. To start the discussion of transboundary protected areas, we need to start with an overview of borders in general.

Borders are complex and impact the daily lives of people who live near them, whether or not they are conscious of the fact. Borders have long been thought to only create barriers, but should be reconsidered as potential bridges and points of contact (Newman 2006). There are endless types of borders, ranging from continental to minute scales. One type of border that resonates is that between countries, as these international borders tend to limit much movement between sides. An important implication of these borders is limited conservation, as protected areas are usually contained within a country's borders. This compartmentalization is inconsistent for animals and plants, as international borders don't mean anything to any species other than humans. Conserving biodiversity is imperative, as species are the end products of evolution and are prone to extinction (Terborgh 1999). Such conservation requires

conditions at least suitable enough for the survival of species (Terborgh 1999).

Currently, the formation of protected areas is not consistent with the preservation of the world's biodiversity.

Perhaps a better way to think about conservation of species and biodiversity is in terms of ecoregions. Ecoregions are delineated by biological grounds and tend to transcend international borders (Terborgh 1999). This approach makes border issues even more complex when formulating conservation management plans. In small protected areas targeting conservation of different specific species around the world, species are highly vulnerable to extinction (Terborgh 1999). In order to achieve long-term preservation of biodiversity, large protected areas must be created and managed properly (Terborgh 1999).

More than 12% of the Earth's surface is currently included in formally constituted protected areas. Is this enough? Should conservationists be satisfied with this number? To conserve biodiversity in the long run, it is necessary to have far more protected areas than exist in the world currently, especially in endangered biomes and biodiversity hotspots (Laurance and Peres 2006). Many existing protected areas are also not sufficient in conserving biodiversity or ecosystem function (Laurance and Peres 2006).

In order to create protected areas of sufficient scale to protect biodiversity, these areas may need to cross international boundaries. Analysis of a game theory model based on the opportunity cost and the conservation benefit of a reserve and a strategic interaction between countries demonstrates that transboundary protected areas are necessary "to promote the survival of endangered species with long life spans, large area requirements, or potential for conflict with humans" (Busch 2008).

Large protected areas are especially imperative in the Amazon, as forests are increasingly fragmented by agriculture, deforestation, and other destructive human activities. In a 3 million hectare area of Atlantic Forest in Bahia, Brazil, many fragmented patches have lost important ungulates and primates, such as tapirs, white-lipped peccaries, howler monkeys, and spider monkeys (Laurance and Peres 2006). As fragmentation increases, the size of protected areas needs to keep increasing in order to preserve important species (Laurance and Peres 2006).

Most species vulnerable to extinction are top predators and medium and large-sized species favored by hunters (Laurance and Peres 2006). The declines and extinctions of these species have many deleterious consequences for ecosystems (Laurance and Peres 2006). Many large vertebrates act as seed vectors for plants, so their disappearance results in poor dispersal of seeds causing a decline of animal-dispersed plants and therefore increasing abiotically dispersed species (Laurance and Peres 2006). For example, primate-dependent plants can suffer a 40% to 50% reduction in overhunted forests due to lack of gut dispersal (Peres and Roosmalen 2002 as cited in Laurance and Peres 2006).

Peres' 2001 study of the population density of 46 large vertebrate species in 13 nonhunted and 17 hunted areas of the Amazon focused on extinction as a function of fragment area. Results revealed that fragments of >10,000 hectares were fairly resilient to extinctions, especially when faced with low hunting pressure. Smaller areas could retain species if adequately protected. To preserve over half of the study species, at least 600 hectares would be required if species were lightly hunted, but 2,000 hectares would be necessary in the presence of high hunting pressure. To preserve 90% of the

46 species, 11,000 hectares would be required in the presence of hunting. In reality, even larger areas are required for species persistence in the Amazon, as forest fragments are typically separated by unsuitable habitat for animals to cross (Peres 2001).

Even without data on home ranges of species, forest patches of any size are important to conserve because they serve as “sources of large-seeded plant species, stepping stones for animal dispersal, buffer strips for riparian corridors, fire-breaks to deter pasture fires, and regulators of local and mesoclimate” (Laurance and Peres 2006). However, large, pristine patches of forest are also imperative to conserve as they act as “refugia and sources of emigrants for many disturbance- and area-sensitive species” (Laurance and Peres 2006). The best general strategy for protecting tropical forests is the “bigger is better” paramount. Large reserves can reduce many of the threats to tropical forests including fragmentation effects, edge effects, and illegal encroachment (Laurance and Peres 2006). Unfortunately, large reserves are still prone to some threats, such as climatic and atmospheric changes, exotic pathogens, and surface fires (Laurance and Peres 2006). However, these threats cannot be avoided in any type of protected area, so the best strategy is the creation of mega-reserves that can protect tropical forests from many of their significant threats (Laurance and Peres 2006). The best size of a particular reserve depends on a variety of factors specific to the area, but Laurance and Peres (2006) believe protected areas cannot be too large. They argue that many reserves are too small, and even reserves of 2 million hectares can be affected by encroachment and isolation effects if surrounded by areas of human destruction (Laurance and Peres 2006).

Beyond size, it is imperative to reduce fragmentation and provide conservation corridors. As described by the island biogeography model, animals from surrounding populations can help rebuild populations facing extinction (Peres 2001). Dispersal from healthy source populations can be decreased by fragmentation, so corridors of suitable habitat need to be maintained between patches for animal movement (Peres 2001). In lowland Amazonia, the landscape usually consists of many small patches of suitable habitat surrounded by degraded pastures (Peres 2001). This results in low vertebrate diversity in the Amazon even in the absence of hunting (Peres 2001). Therefore, the chance of extinction for vertebrates in this region is higher than most areas, and requires even larger areas to protect any given species (Peres 2001). The larger the reserve area, the less prone species are to extinction, so the best strategy is to create the largest protected areas possible and “tying them together with corridors to make them effectively, even larger” (Laurance and Peres 2006).

III. Methods

Study Species:

To assess ecological boundaries in the study area, this paper will provide a literature review of home ranges of keystone species in the Amazon ecosystem, as well as their endangered/threatened status. The CITES Appendices provided describe different levels of protection for species from overexploitation. Appendix I includes the most endangered species among CITES species listings and international trade of these species is prohibited. Appendix II lists species that are not immediately threatened by extinction but will become endangered if current trade practices are

continued, so the trade of these species sometimes requires permits (CITES 2010). The other species status listing used in this paper is the IUCN Red List of Threatened Species, which provides taxonomic, conservation status, and distribution of listed species based on their categories and criteria (IUCN 2010).

The species chosen for the study are five primates: Goeldi's marmoset (*Callimico goeldii*), common woolly monkey (*Lagothrix* sp.), red howler monkey (*Alouatta seniculus*), spider monkey (*Ateles* sp.), and the red uakari monkey (*Cacajao calvus*), and two ungulate species: white-lipped peccary (*Tayassu pecari*) and the South American tapir (*Tapirus terrestris*). These species have been identified as important ecosystem indicators along the Sierra del Divisor (The Nature Conservancy 2007), as they are game species targeted by hunters, which are more prone to extinction caused by habitat fragmentation than other forest specialist animals due to their low fecundity and large spatial requirements (Laurance and Peres 2006). The extinction of the large bodied primates, woolly monkeys (*Lagothrix* sp.), and spider monkeys (*Ateles* sp.), is detrimental to many large-seeded tree species that rely on the animals for dispersal and germination (Laurance and Peres 2006). The white-lipped peccary, woolly monkey, and red uakari monkey are social species and exist at low densities in large, spread out groups (Peres 2001). Many of these species are rare and listed as vulnerable or threatened by different indices.

Study Area:

The area in question is the Sierra del Divisor Reserved Zone, located on the Peruvian border, adjacent to the Serra do Divisor National Park in Acre, Brazil (Figure 1).



Figure 1: Peru/Brazil border showing the areas of the Sierra del Divisor in Peru and the Serra do Divisor in Brazil.

The Sierra del Divisor region, officially announced a Reserved Zone on April 33rd, 2006 (The Nature Conservancy 2006), covers a million and a half hectares (Salisbury 2007) while the adjacent Serra do Divisor covers 1.49 million hectares (Vriesendorp et al. 2006). The reserved zone classification was a small victory, as it shows that the

Peruvian government recognizes the importance of protecting the area, although the designation does not currently grant the area any formal protection.

The Sierra del Divisor/Serra do Divisor region encompasses almost 3 million hectares and contains high cultural and biological diversity. The Sierra del Divisor has one of the largest estimates of biological diversity in the world (Scarcello et al. 2008 as cited in Salisbury 2007) and contains 18 primate species, the highest amount in South America and possibly the world (The Nature Conservancy 2006). The area is also important as a conservation corridor for other protected areas in Peru and Brazil (Salisbury 2007). Currently, the Serra do Divisor does not have a buffer zone past its edge on the Peruvian border for protection from logging and other human disturbances, and needs the Sierra del Divisor to act as its buffer. The main threats to the Sierra del Divisor area include logging and over-exploitation of wildlife through commercial fishing and bird and mammal hunting (Vriesendorp et al. 2006, Figure 2). Hunting in tropical forests results in a gradient of decreasing animal densities toward the human settlement (Siren et al. 2004).

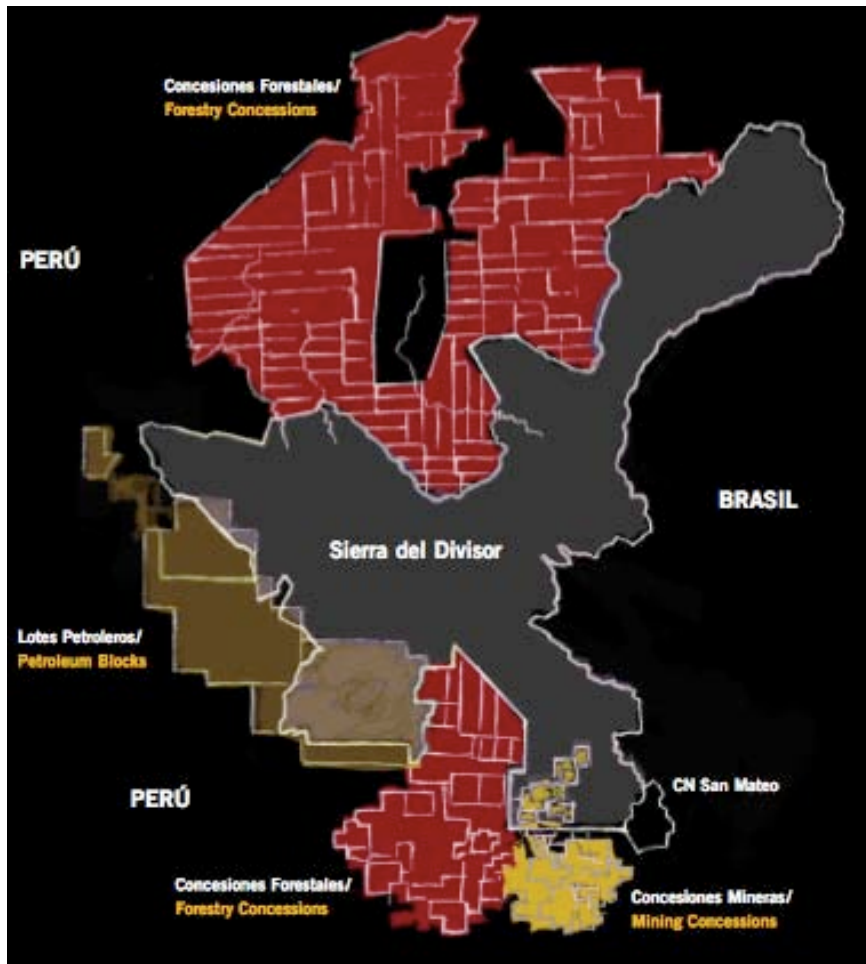


Figure 2: Granted and proposed concessions highlight the multiple threats to the Sierra del Divisor region (Vriesendorp et al. 2006).

An additional serious threat to the Sierra del Divisor/Serra do Divisor region is a proposed road stretching from Pucallpa, Peru, to Cruzeiro do Sul, Brazil (Amigos da Terra 2009). The presidents of the two countries decided to invest in a road providing Acre, Brazil with a link to the Pacific coast, an interoceanic highway (Amigos da Terra 2009). This is not surprising, as the Brazilian government has been planning road and highway networks throughout the country (Laurance and Peres 2006). Roads are a significant threat to tropical forests, fragmenting plant and animal populations and increasing human disturbance in the area. Roads can be the first step in the process of

frontier-colonization of an area (Laurance and Peres 2006). Also, once roads are installed, they often result in an onslaught of human activities, such as “unplanned colonization, predatory logging, incursions of hunters and miners, land speculation-that are nearly impossible for governments of developing nations to control” (Laurance and Peres 2006). The lesson to be learned here is to create protected areas before human interference in an area, as it is more difficult and expensive to manage and protect reserve in areas already suffering degradation (Laurance and Peres 2006). Efforts need to be made immediately to protect pristine areas in the Amazon before it becomes completely fragmented by roads and overrun by resource-hungry humans.

IV. Results

This section will provide data on the importance of the species studied as well as their home range requirements and the area required for survival of important wildlife species.

Primates

Goeldi's marmoset (*Callimico goeldii*) is patchily distributed in western Amazonia. It is listed in Appendix I of CITES (CITES 2010), Vulnerable in Peru (Vriesendorp et al. 2006), and considered Vulnerable by the World Conservation Union (IUCN 2010). It has been observed in the Serra do Divisor (Aparecida de Oliveira Azevedo Lopes and Rehg 2003), as well as the Sierra del Divisor (Vriesendorp et al. 2006: 199). In the Sierra del Divisor, small mammals are threatened by habitat loss, especially species like the *Callimico goeldii*, which have a very restricted geographic distribution. This species is a rare habitat specialist, so the rare habitats it occupies must be conserved (Vriesendorp

et al. 2006). This matter is even more pressing as its preferred habitat, riverine forests, may be especially susceptible to human degradation due to their proximity to large rivers (Vriesendorp et al. 2006).

The common woolly monkey, *Lagothrix* sp., is commonly hunted throughout its range and is prone to local extinction (Vriesendorp 2006). Both species in the area, *L. lagotricha* and *L. poeppigii*, are listed in CITES Appendix II (CITES 2010) and considered Vulnerable by the World Conservation Union (IUCN 2010). Healthy populations of *Lagothrix poeppigii* have been observed in the Sierra del Divisor Reserved Zone (Vriesendorp 2006: 145). The common woolly monkey *L. lagotricha* has been shown to have a home range of approximately 268 hectares and adjacent species did not overlap (Nishimura 2002). Other estimates of home range have varied from approximately 170 to 860 hectares (Siren et al. 2004). A study conducted approximately 130 kilometers from the Sierra del Divisor near the Tapiche River reported an observed decline of the species (Bennett et al. 2001).

The red howler monkey, *Alouatta seniculus*, is a primate species relatively resistant to habitat disturbance even in the presence of hunting, but has been found to be absent from many sites in the Amazon (Iwanaga and Ferrari 2002). It is listed in CITES Appendix II (CITES 2010). The monkeys have been documented to exist near the Tapiche River, 130 kilometers from the Sierra del Divisor (Bennett et al. 2001) and within the Sierra del Divisor (Vriesendorp et al. 2006). The home range of a red howler troop has been estimated at 180 hectares (Siren et al. 2004). One study observed a decline in the populations of red howlers since past studies, reporting a density of 58% fewer howlers as well as fewer estimated animals per group. The authors suggest

hunting as the cause of the decline (Bennett et al. 2001). Another study reporting an observed decline in red howlers suggest that it is not due to human disturbance, but rather a complex of ecological factors such as the availability of nutrient-rich flooded forest habitats (Iwanaga and Ferrari 2002).

The two spider monkeys in the area, *Ateles belzebuth* and *chamek*, are listed in Appendix II of CITES (CITES 2010) and is considered Endangered by the World Conservation Union (IUCN 2010). *Ateles chamek* is commonly hunted throughout its range and is prone to local extinction (Vriesendorp et al. 2006). At a site along the Tapiche River, approximately 130 kilometers from the Sierra del Divisor, spider monkeys had been recorded in the past but were not present during a recent study (Bennett et al. 2001). The white-bellied spider monkey, *Ateles belzebuth*, has a home range of 120-150 hectares, about half that of woolly monkeys. Each group exhibited an exclusive area with little overlap between groups. The results of the study suggest territoriality in spider monkeys (Nishimura 2002). The home range of *Ateles belzebuth* has been recorded as 280 hectares (Siren et al. 2004). The black spider monkey, *Ateles chamek*, is heavily hunted and faces local extinction, however healthy populations have been observed within the Sierra del Divisor region (Vriesendorp et al. 2006).

The red uakari monkey, *Cacajao calvus*, is rare and poorly known (Vriesendorp et al. 2006). It is a rare habitat specialist and exhibits a patchy distribution, preferring palm swamps near large rivers (Vriesendorp et al. 2006). Like Goeldi's marmoset, the species is threatened by habitat loss due to a very restricted geographic distribution. The Sierra del Divisor is the first protected area in which the red uakari and Goeldi's marmoset have both been observed (Vriesendorp et al. 2006). The red uakari is

considered Vulnerable by the World Conservation Union (IUCN 2010), Vulnerable in Peru (Vriesendorp et al. 2006), and is listed in Appendix I of CITES (CITES 2010).

Ungulates

The white-lipped peccary, *Tayassu pecari*, is a large ungulate of the Neotropics. The species is considered Near Threatened by the World Conservation Union and populations are decreasing (IUCN 2010) and listed in Appendix II of CITES (CITES 2010). A management plan for the Serra do Divisor included the white-lipped peccary in its list of most hunted species by inhabitants of the Parque Nacional (SOS Amazonia 1998). A study in the Northern Brazilian Amazon observed a 10,960 hectare home range for a herd of 130 animals and 2,180 hectares for a herd of 53 animals. The two herds showed site fidelity, and therefore no signs of migration. The study also reported reduced densities of white-lipped peccaries in Amazonia compared to past studies (Fragoso 1998). Other studies have reported home ranges from 2,180 hectares to 10,960 hectares (Siren et al. 2004). In a rapid biological inventory, the white-lipped peccary was only found at one out of three survey sites (Vriesendorp et al. 2006). The species was observed near the Tapiche River, suggesting high dependence on water resources (Vriesendorp et al. 2006: 201).

The lowland or South American tapir, *Tapirus terrestris*, is an ungulate that experiences high hunting pressure in Amazonia (Vriesendorp et al. 2006: 236). A management plan for the Serra do Divisor included the tapir in its list of most hunted species by inhabitants of the Parque Nacional (SOS Amazonia 1998). It is listed in CITES Appendix II (CITES 2010) and considered Vulnerable by the World Conservation Union. However, many healthy populations have been observed recently within the

Sierra del Divisor (Vriesendorp et al. 2006: 199). Home range estimates for the species have varied from 590 to 3,900 hectares (Siren et al. 2004).

Table 1: Home range and known locations of study species.

Species	Home Range	Known locations
<i>Callimico goeldii</i>		<ul style="list-style-type: none"> • Serra do Divisor, near the Rio Ouro Preto and near the Rio Jurua-Mirim (Aparecida de Oliveira Azevedo Lopes and Rehg 2003) • Sierra del Divisor, Tapiche, several encounters in dense riverine forest with some bamboo (Vriesendorp et al. 2006)
<i>Lagothrix</i> sp.	<p><i>L. lagotricha</i>: 268 ha (Nishimura 2002) 170-860 ha (Siren et al. 2004)</p>	<ul style="list-style-type: none"> • <i>Lagothrix poeppigii</i>: Sierra del Divisor, Ojo de Contaya (less common), Tapiche (most common), Divisor (most common) (Vriesendorp et al. 2006) • <i>Lagothrix lagotricha</i>: Serra do Divisor, near the Rio Ouro Preto and near the Rio Jurua-Mirim (Aparecida de Oliveira Azevedo Lopes and Rehg 2003) • ~130 km from Sierra del Divisor near Tapiche (Bennett et al. 2001)
<i>Alouatta seniculus</i>	22-180 ha (Siren et al. 2004)	<ul style="list-style-type: none"> • Sierra del Divisor, Tapiche (Vriesendorp et al. 2006) • Serra do Divisor, near the Rio Ouro Preto and near the Rio Jurua-Mirim (Aparecida de Oliveira Azevedo Lopes and Rehg 2003) • ~130 km from Sierra del Divisor near Tapiche (Bennett et al. 2001) • Sites in Rondonia, Brazil (Iwanaga and Ferrari 2002)
<i>Ateles</i> sp.	<p><i>A. belzebuth</i>: 120-150 ha (Nishimura 2002) 280 ha (Siren et al. 2004)</p>	<ul style="list-style-type: none"> • <i>Ateles chamek</i>: Sierra del Divisor, Ojo de Contaya (most common), Tapiche (one sighting) (Vriesendorp et al. 2006) • <i>Ateles chamek</i>: Serra do Divisor, near the Rio Ouro Preto and near the Rio Jurua-Mirim (Aparecida de Oliveira Azevedo Lopes and Rehg 2003)
<i>Cacajao calvus</i>		<ul style="list-style-type: none"> • Sierra del Divisor, Ojo de Contaya (one group, top of a ridge), Tapiche (one large group) (Vriesendorp et al. 2006) • Serra do Divisor, near the Rio Ouro Preto and near the Rio Jurua-Mirim (Aparecida de Oliveira Azevedo Lopes and Rehg 2003) • ~130 km from Sierra del Divisor near Tapiche (Bennett et al. 2001)
<i>Tayassu pecari</i>	<p>10,960 ha (130 animals) 2,180 ha (53 animals) (Fragoso 1998)</p>	<ul style="list-style-type: none"> • Sierra del Divisor: Tapiche (common) (Vriesendorp et al. 2006) • Maraca Island Ecological Reserve, Roraima, Brazil (Fragoso 1998) • In the Serra do Divisor near the intersection of the Rio Azul and Rio Moa (SOS Amazonia 1998)
<i>Tapirus terrestris</i>	590-3,900 ha (Siren et al. 2004)	<ul style="list-style-type: none"> • Sierra del Divisor: Ojo de Contaya (common), Tapiche (common), Divisor (most common) (Vriesendorp et al. 2006) • In the Serra do Divisor near the Rio Azul and the intersection of the Rio Jurua and Jurua-Mirim (SOS Amazonia 1998)

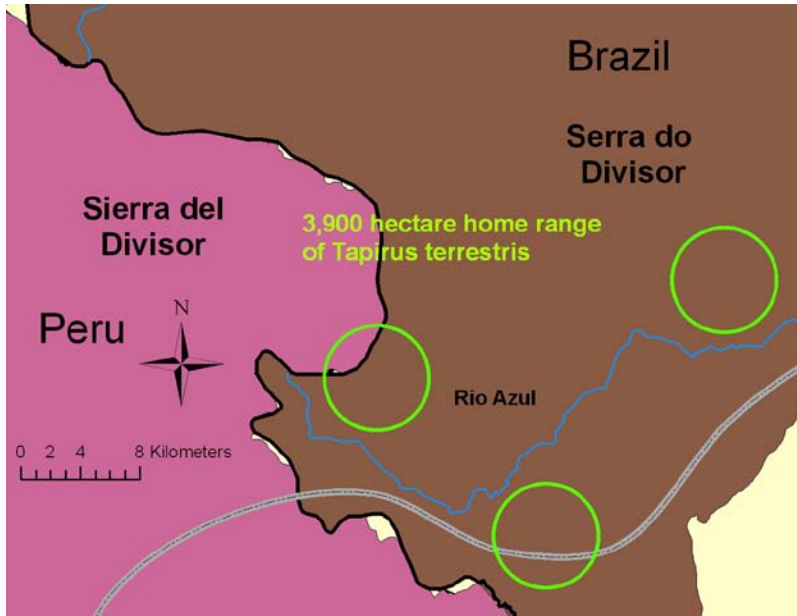


Figure 3: The *Tapirus terrestris* has been observed in the Serra do Divisor near the Rio Azul (SOS Amazonia 1998). Potential locations of the species are surrounded by 3,900 ha circles, the area of the species' largest estimated home range (Siren et al. 2004).

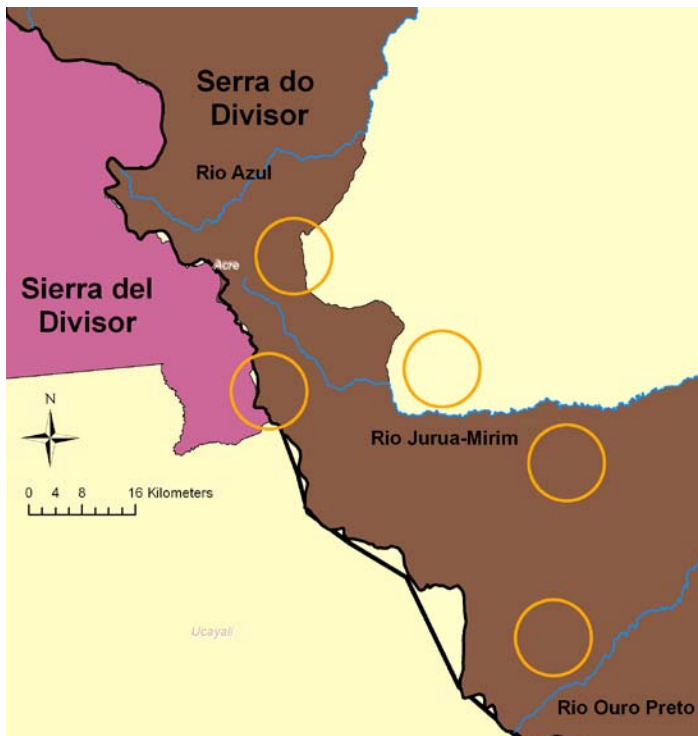


Figure 4: The *Callimico goeldii*, *Cacajao calvus*, *Alouatta seniculus*, *Lagothrix lagotricha*, and *Ateles chamek* have been observed in the Serra do Divisor near the Rio Ouro Preto and near the Rio Jurua-Mirim (Aparecida de Oliveira Azevedo Lopes and Rehg 2003). Potential locations of these species near the rivers are surrounded by 10,000 ha circles, as areas of >10,000 hectares are fairly resilient to primate extinctions (Peres 2001).



Figure 5: Three inventory sites where a many primate species were recorded (Vriesendorp et al. 2006). Circles denote a 10,000 ha area around each site, as areas of >10,000 hectares are fairly resilient to primate extinctions (Peres 2001).

V. Discussion

The results above provide an overview of keystone species in the Amazonian ecosystem: their threatened status, estimated home range, and locations where populations have been observed. These are not the only locations where the species exist, but places where researchers have observed their presence. The home range and location of species data made it possible to create maps showing whether the species' ranges might cross the international border and the proposed road. For example, tapir populations have been sighted in the Sierra del Divisor near the Rio Azul (SOS Amazonia 1998), and have an estimated home range of up to 3,900 ha. Making a 3,900 ha circle around potential locations of populations near the Rio Azul shows that the range could easily cross the international border as well as the proposed road (Figure 3). A transboundary population could be devastated by hunting across the border if the area is not protected. Another tapir population could be fragmented by the construction of the road. Even if the home range of the species was smaller, the home

range area could still cross either of the lines. Five of the keystone species studied in this paper have been observed near the Rio Ouro Preto and the Rio Jurua-Mirim (Aparecida de Oliveira Azevedo Lopes and Rehg 2003). Surrounding potential locations of the species near the rivers with 10,000 ha circles, the area necessary for vertebrate resilience to extinction (Peres 2001), shows that this area could easily cross the international border (Figure 4). Even if a species' small home range or a large range assumed to protect many species does not cross a border, the location of the populations can still be important. If a species' range even comes close to a border that does not have a buffer zone on the other side, the species can be threatened by any disturbance just across the border. For example, if there are many hunters across the border in Peru, they could easily wander across the poorly marked border and kill species in the national park. Also, pollution from resource extraction can travel large distances, harming environments many kilometers away.

Some of the results may seem to be insignificant to the argument of protecting the border area, such as some of the species having relatively small home ranges as well as home ranges not crossing the international border. The Rapid Biological Inventory provided interesting results, yet some species found at the inventory sites may not be affected at all by the international border. Even assuming a large range of 10,000 ha, the range would not come close to the border (Figure 5). However, it is important that many species populations do come close to the border (Figure 3,4) and can be affected by human activities across the boundary, such as hunting. Also, *C. goeldii* does not even have an estimated home range, but it has only been observed in riverine forests. However, it is suggested to be a rare habitat specialist, so no matter

what its home range might be, riverine forests need to be protected for its survival. Other species have relatively small home ranges, such as *Lagothrix* sp., *A. seniculus*, and *Ateles* sp (Table 1). However, the location of the animal population is more important than the size. Even a small population's home range can straddle the international border or the potential road, as shown for the larger tapir populations (Figure 3). Also, the locations of species in this paper are just some of the known locations, there is a very large possibility they are present elsewhere, maybe even closer to the border. It also stands to reason that even if a single species has a small home range, it is even more important to conserve a primate and ungulate community rather than just one species, and a large community range may have an even greater chance of crossing the border. Further, if a species or community range does not cross the border, the Sierra del Divisor region is still imperative as a buffer zone for the Serra do Divisor to make its effective protection area larger. Overall, the information provided here supports large protected areas with buffer zones, and transboundary conservation in the Sierra del Divisor/Serra do Divisor region.

VI. Conclusion

The Sierra del Divisor contains a high concentration of rare and range-restricted species, some only known from this region and occurring in restricted habitats (Vriesendorp et al. 2006). This Peruvian reserved zone could act as a binational conservation corridor with other protected areas in the Amazon. Currently, the Serra do Divisor National Park of Brazil does not have a buffer zone across the Peruvian border, making its area of protection effectively smaller. Laurance and Peres (2006) point out

even large protected areas exceeding 2 million hectares can suffer from encroachment and isolation effects if surrounded by areas of human destruction. To prevent these effects in the Serra do Divisor, its Peruvian border needs to be protected, and the Sierra del Divisor could act as its buffer zone.

In order to protect biodiversity, and mainly the large vertebrates that are important for ecosystems, large protected areas are necessary. Political boundaries are static, but ecological boundaries and species ranges are dynamic. No matter how large a protected area is, bigger will always be better assuming equal levels of quality for enforcement and management. Absence of large vertebrates has been recorded in small fragments <300 hectares near Acre, Brazil, where the Serra do Divisor is located (Peres 2001). As human destruction is causing increased fragmentation in the Amazon, as many large protected areas as possible need to be created. The Sierra del Divisor has some of the highest biodiversity in the world and an abundance of primates that have been hunted to extinction elsewhere. If the area is not protected immediately, we may lose these important species forever, whether or not we know their importance at this moment.

The Sierra del Divisor should receive formal protection immediately, as well as strict protection for palm swamp and riverine habitats, as these areas are imperative for the survival of two rare species that only exist there, *C. goeldii* and *C. calvus* (Vriesendorp et al. 2006). It will also be necessary to create a plan to manage to manage the preferred game species described in this paper. Further, the plans for the proposed road from Pucallpa to Cruzeiro do Sul should be abolished, as the

construction of this road would cause habitat fragmentation as well as open the doors to massive human destruction in the area.

Further research should be done on species presence, habitat preference, and home ranges, but the Sierra del Divisor should still receive protection immediately before key species in the Amazonian ecosystem are lost forever. A similar approach should be taken in assessing potential protected areas in all types of ecosystems; large protected areas are better at conserving biodiversity, while small protected areas trying to protect a specific species are not sufficient. Protected areas should also be examined in terms of providing ecological corridors, and the roles of fragmentation and buffer zones impact the effective size of a reserve. Before creating any protected area, it is critically important to consider the boundary areas to ensure optimal protection of keystone species in the ecosystem and ultimately biodiversity.

VII. References

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