

Tapirus terrestris in Espírito Santo, Brasil

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Abstract

We investigated the conservation status of *Tapirus terrestris* in Espírito Santo by interviewing scientists and reserve managers working there and by visiting forests ≥ 1000 ha. Whereas tapirs inhabited the entire state at the beginning of the 20th century, their populations were reduced to three, or possibly four, isolated populations by the time of the study (2006). Widespread deforestation, escaped fires, and excessive hunting were the principal causes of the tapirs decline. Although hunting pressure has decreased in the past decades and does not appear to be an imminent threat to the extant populations, the populations in the two smaller reserves (Córrego Grande and Córrego do Veado) are vulnerable to escaped fires and the deleterious consequences of inbreeding depression. The larger population (Sooretama and Linhares reserves) has good prospects for long-term persistence. Each population is isolated from the others by inhospitable landscapes and due to the intensive use of these lands it is unlikely that it will be possible to create movement corridors. Conservationists are active in the state and as the reserve managers are supportive of conservation and research programs and there is suitable habitat for tapir re-introductions, the future for tapirs in the state is hopeful.

Key words: Espírito Santo, fire, isolation, persistence, *Tapirus terrestris*

Introduction

This study is part of the “Projeto Antas da Mata Atlântica” project of the IUCN/SSC Tapir Specialist Group with the aim of creating an updated biogeography of *Tapirus terrestris* in the Atlantic forest biome. Specific objectives include identifying all of the remaining populations and their geographical limits, assessing the conservation status of each population and of the landscapes/reserves they inhabit, identify the principal threats to these populations, to describe the types of habitats, both natural and anthropogenic, that these

animals use, to identify areas of potential habitat where tapirs no longer exist, and to eventually synthesize this information in order to devise conservation action strategies to help guarantee the species persistence in the biome. In this first article we present our assessment of the Espírito Santo populations with subsequent reports to follow in the coming years.

Geography

Esírito Santo (46,077 km²) is divided between two distinct geological regions: the tabuleiro sand plain lowlands north of the Rio Doce; and the highlands areas mostly to the south of the Rio Doce with granite outcrops and peaks exceeding 1,000 m (Figure 1). The entire state falls within the Atlantic forest biome, with evergreen broadleaf forests dominating, semi-deciduous forests along the southern border, restinga forests along the coast, and alpine vegetation on the rocky outcrops of the high peaks. The principal river is the Rio Doce, smaller rivers and streams are abundant, especially in the highlands, and the lakes near Linhares are some of the largest natural lakes in Brazil.

The state was the domain of several indigenous groups, but it was the Botocudos who controlled much of the hinterlands that prevented the Portuguese and later the Brazilians from occupying this area, and human settlements remained concentrated along the coast until the late 19th century. Only then did European immigrants begin to colonize the interior. German and Italian immigrants scaled the coastal palisade to farm the highland region, clearing much of the forest by the first decades of the 20th century, while the tabuleiro lowlands suffered large-scale clearing after the 1940s with most of the forests cleared by the early 1960s (Garay *et al.*, 2003).

Brown & Brown (1992) and Viana *et al.* (1996) calculate that only 10 % of the state remains under forest cover, but SOS Mata Atlântica/INPE (2002) estimate that approximately 30 % remains. While forest cover is increasing in the highland area as a result of agricultural intensification, farm abandonment, and an out-migration of the rural youth, the tabuleiro landscape is an intensively cultivated agricultural region and

forest is still being cleared and/or destroyed by fire. Today the landscapes of the highland areas are mosaics of cattle pastures, coffee and eucalyptus plantations, and yam, vegetable, fruit, and maize fields interspersed with closely spaced (mostly < 400 m) forest fragments. The vast majority of the forests consist of small (mostly < 10 ha) fragments growing on previously cleared land with tracts of mature forest widely scattered on the higher slopes and in some of the reserves. Eucalyptus plantations (especially east of BR-001), cattle pastures, and sugarcane fields dominate the tabuleiro landscapes, with lesser amounts of coffee and some large plantations of passion fruit, papaya, and rubber near Linhares. The lower course of the Rio Doce between Linhares and the ocean is flanked by old cabruca cacao groves and cattle pastures. Forest cover throughout the tabuleiros is much reduced and completely lacking in some areas or limited to degraded scraps of bush along the main rivers and streams. The majority of the fragments are small (1-4 ha, with fragments as large as 20 ha rare), widely spaced (500-1000+ m), and severely degraded.

Methods

We used a combination of field visits and interviews to determine the distribution and status of the lowland tapir *T. terrestris* in Espírito Santo. During these interviews with biologists, reserve officials, and people working in NGOs we asked specific questions about tapir population(s) (e.g. size, distribution, habitat use, extra-reserve use, etc.) in the regions they are familiar with. When possible we had the interviewees explain the distribution on maps. If there were no tapirs present, we asked about the history of tapir extinctions. We used these interviews as the principal basis for deciding which sites to visit.

Interviews with country people were semi-structured conversations during which we would introduce ourselves as biologists conducting a survey and ask what types of wildlife were found in the region. We would then ask what was the largest animal found in the region, and if they still did not mention tapirs, we would specifically seek information on tapirs asking if they knew when the species was extirpated. When they claimed that tapirs were present, we tested their knowledge of the species by asking questions about the natural history of tapirs and accepted or rejected the interview based on our assessment of their knowledge. We also asked if tapirs leave the forest and what types of agricultural lands they use. In some cases we were able to ask about hunting pressure and timber extraction.

In addition to the reserves with confirmed tapir populations, we visited sites that should have the potential to support tapir populations. We defined these sites as large (minimum ca. 1,000 ha) forests and landsca-

pes with a high percentage of forest cover (ca. $\geq 25\%$) based on the supposition that these would most likely contain habitat for tapirs. We visited as many of these areas as possible and also the areas between the main forest blocks.

As we traveled through the state we kept detailed notes of the landscape, using towns, natural landscape features (e.g. hill ranges, rivers and roads), and GPS points as references, recording human land uses, forest cover, and the state of the forests.

Results

Areas Visited

In November 2006 we spent 15 days in Espírito Santo traveling throughout the central highlands, coastal region, and tabuleiro landscape and visiting 10 forest areas $\geq 1,000$ ha. We did not visit the area south of Vitoria and Pedra Azul, but interviewed several scientists who work and/or live there. We interviewed 36 people including 7 scientists who between them had visited almost all of the forest reserves in the state, 20 park officials including the heads of the Córrego Grande, Córrego do Veadó, Sooretama, Caparaó, Augusto Ruschi, Itaúnas, and Rio Preto reserves, and 11 other people who live near and work in forest reserves. Chiarello's (1999) and Lorenzutti and Padua Almeida's (2006) publications on the large mammals of the state were helpful references.

History of *Tapirus terrestris* in Espírito Santo

Tapirs inhabited all of Espírito Santo until the end of the 19th century and persisted in much of the state into the mid-20th century including the Vitoria area (the mountain by Serra) until the 1940s. The decline of the tapirs began with the invasion of the highland areas by German and Italian immigrants in the late 19th century (first families arrived in the Pedra Azul region in 1888 and in the Santa Teresa region in 1875).

Angelo Bellon, now 80 years old, explained that when his family arrived the region was completely forested and that the settlers first cleared forest to plant maize and beans and raise hogs for subsistence. Subsequently they cleared larger tracts of forest to create cattle pastures which became the principal economic activity for much of the following 100 years. They also selectively harvested trees from the forests throughout this period. In the 1970-80s charcoal producers moved throughout the highlands buying the rights to forest lots and burned many of the remaining forest fragments.

The immigrants throughout the highlands were avid hunters and killed everything, from small birds to tapirs, causing a precipitous decline in wildlife populations. Tapirs were especially valued for their hides as the leather was used to make whips and for hitching

the mule trains that were the principal means of transporting goods to the coast. The skin of highland tapirs (where temperatures drop to 0-3° C during the winter) was reportedly thicker than that of the lowland (tabuleiro) tapirs, and so more procured for these purposes.

Tapirs were mainly run with dogs and killed by hunters waiting at pools of water known as *poço das antas*. At one of these *poços* on Angelo Bellon's farm at the foot of Pedra Azul (it is a clear cool pool of water some 5-6 m wide and up to 2 m deep) hunters killed more than 20 tapirs. Hunters also killed tapirs in *forro* pit fall traps. These same methods were used throughout the highlands and tapirs were extirpated in the Pedra Azul region some 60-70 years ago (1940s), at which point they had been reduced to remnant populations inhabiting the forests of the highest slopes, having been extirpated from the farm areas early on (no reports of tapirs raiding crops during this time).

In the Alfredo Chaves highlands and to the north in the Santa Teresa and Colatina/Bananal regions hunters extirpated tapirs in the 1930/40s with some populations persisting into the early 1950s in some mountain strongholds. Recent reports of tapirs in the Caparaó National Park on the border with Minas Gerais still need to be verified. They disappeared in the coastal area around Vitória by the mid-20th century. In the tabuleiro landscape to the north, the decline of tapirs followed the massive loss of forest cover in the decades following World War II cleared to make way for industrial plantations of eucalyptus, sugarcane, coffee and cattle pastures. By the 1960s most of these forests had been cleared and tapirs reduced to three isolated populations in four reserves.

Tapir Populations

Córrego Grande Biological Reserve: 80 % of this 1,540 ha reserve located on the border with Bahia (some 14km east of highway BR-101) was destroyed in a fire in 1987 and now consists of dense secondary forest with an upper canopy of 8-12+ m. Brejauba palms (*Astrocaryum aculeatissimum*) and bamboo are common in the understory. The 20 % of the reserve that did not burn supports a mature forest with spaced old trees reaching 20-30+ m and a fairly open understory. The terrain is flat and the soils are sandy as is typical of the tabuleiro region. The main stream is the Córrego Grande (that passes along the western and southern sides of the reserve) but it is no more than 2-3 m wide and 1m deep, and other streams are smaller with small ponds along their courses where they pass under the perimeter road. There is also a 20 ha lake with a dense growth of cattails to 1-2 m, surrounded by a dense thicket of thin vines, palms, bushes and young trees reaching 7-10 m. Eucalyptus monocultures dominate the surrounding landscape with forest cover reduced to the barest scraps of pioneer vegetation along the waterways.

None of the three people working in Córrego Grande Biological Reserve have seen a tapir, but have recorded tracks occasionally, especially along the perimeter road in the southern part of the reserve where tapirs appear to visit a jackfruit tree and along the lake where the tapirs wallow in small pools in the dense thickets of the lake edge. Tapirs are attracted to oiti (*Chrysobalanaceae*) trees during the fruiting season and the guards find tracks under these trees in the southern part of the reserve, but they do not appear to visit the mature forests along the western side of the reserve despite the abundance of oitis, and our guide (who has patrolled this forest for 5 years) has never seen tapir tracks in this area. He told us that sometimes they do not see tapir tracks for several months and he believes that the animals prefer the interior of the reserve where no one visits.

Hunters use the reserve, mostly visiting from neighboring properties, and sometimes arm rifle traps, but hunting pressure is not heavy and the last record of a tapir killed was in 2001. The largest threat to the tapirs appears to be wildfires and given that no contingency measures are in place to protect the reserve for these events, it is probable that fires will burn into the forest again in the future.

While tapirs could easily pass through the 5 strands of loose wire that fence in the reserve, there is no indication that they are doing so and this populations appears to have been isolated for several decades. The Rio Preto National Forest and properties neighboring it together preserve 5,000ha of forest only 8-10 km south of Córrego Grande and considering tapirs dispersal capacities it is conceivable that they would be able to recolonize these forests by following the Córrego Grande stream south to the Rio Itaúnas and then moving up that river for a kilometer, but there is no record of any individuals doing so.

We found a track of one large tapir by small shaded pools along the north side of the lake (S18° 14.815'; W39° 48.608') in an area of dense thicket of brejauba palms, *Heliconia*, *Piper* plants, and bamboo backed by a dense secondary forest reaching 7-12 m.

Córrego do Veado Biological Reserve: The reserve is several kilometers north of Pinheiros in northern Espírito Santo, some 20km west of BR-101, in an area that was largely deforested by the 1960s. 80 % of this 2,400 ha reserve burned in a fire started in a neighboring pasture in 1987 and now consists of a dense secondary forest similar to that of Córrego Grande. The remaining 20% of the reserve supports a mature forest with a diverse flora. The main stream is the Córrego do Veado that flows along the eastern side of the reserve and forms part of the upper Itaúnas River watershed. The surrounding landscape is largely deforested and only widely spaced scraps of degraded forest generally

<10 ha remain. Cattle pastures dominate the agricultural landscape with lesser amounts of land dedicated to sugarcane, manioc, coffee, papaya, and pumpkins.

The reserve personnel regularly see tapir tracks along the reserve road near the headquarters, especially in the dry season when the animals visit the two large streams there. Tapirs wander throughout the forest and there is a large and well-used tapir trail in the center of the reserve. There is also a curve on the perimeter road known as the *curva da anta* where the guards occasionally see a tapir resting.

Tapirs do occasionally leave the reserve to raid maize and manioc fields in neighboring farms, but there are no records of them traveling far beyond the forest edge and the population is considered isolated. The region sustains significant hunting pressure, but none of these appear to target tapirs and there are no recent reports of tapir killings. Consequently, hunting does not appear

to pose an immediate threat to this population. Wildfires could pose a more imminent threat.

We found fresh and old tapir tracks, scats and a well used trail near the headquarters in the southeastern part of the forest in an area of dense secondary growth to 6-10 m.

Sooretama Biological Reserve and the Linhares Forest Reserve:

At 24,000 ha Sooretama is the largest federal reserve in the state and is contiguous with the 22,000 ha Linhares Forest Reserve of the Vale do Rio Doce company together forming one of the largest blocks of Atlantic forest remaining in Brazil (46,000 ha). These reserves protect a large area of mature tabuleiro forest with old growth trees and a highly diverse fauna and flora. The forest profile in general is one of dense growth to 6-15 m with spaced larger trees to 20-30+ m and some giants passing 40 m. Thin lianas and vines are abundant in the

dense lower stratum as are palms, especially brejauba and buri (*Polyandrococos caudensis*). The terrain is flat with steep shallow ravines along the waterways where the water cuts through the sandy soils. The largest river is the Barra Seca that runs along the northern boundary, but several other large streams/small rivers traverse the reserve from west to east. Waterways are choked with dense vegetation creating nearly impenetrable thickets. Cattle pastures, coffee farms, eucalyptus plantations, and sugarcane fields dominate the surrounding landscapes, with forest cover reduced to small widely spaced degraded fragments. We only visited the Sooretama reserve.

Tapirs are rarely recorded around the headquarters on the central southern side of the Sooretama reserve, but elsewhere it seems fairly common and the five park officials interviewed had all seen tapirs in the past two years. The two areas in Sooretama where the guards most frequently find tapir signs are the Córrego Quirino and the Córrego d'Abóbora.

The Córrego Quirino is located in the center of the reserve (S 19° 00.679'; W 40° 06.019') in an area of mature forest with a profile of 6-10 m of dense growth with abundant brejauba palms and spaced taller trees to 20-30+m. It is a wide stream hidden in a dense thicket of

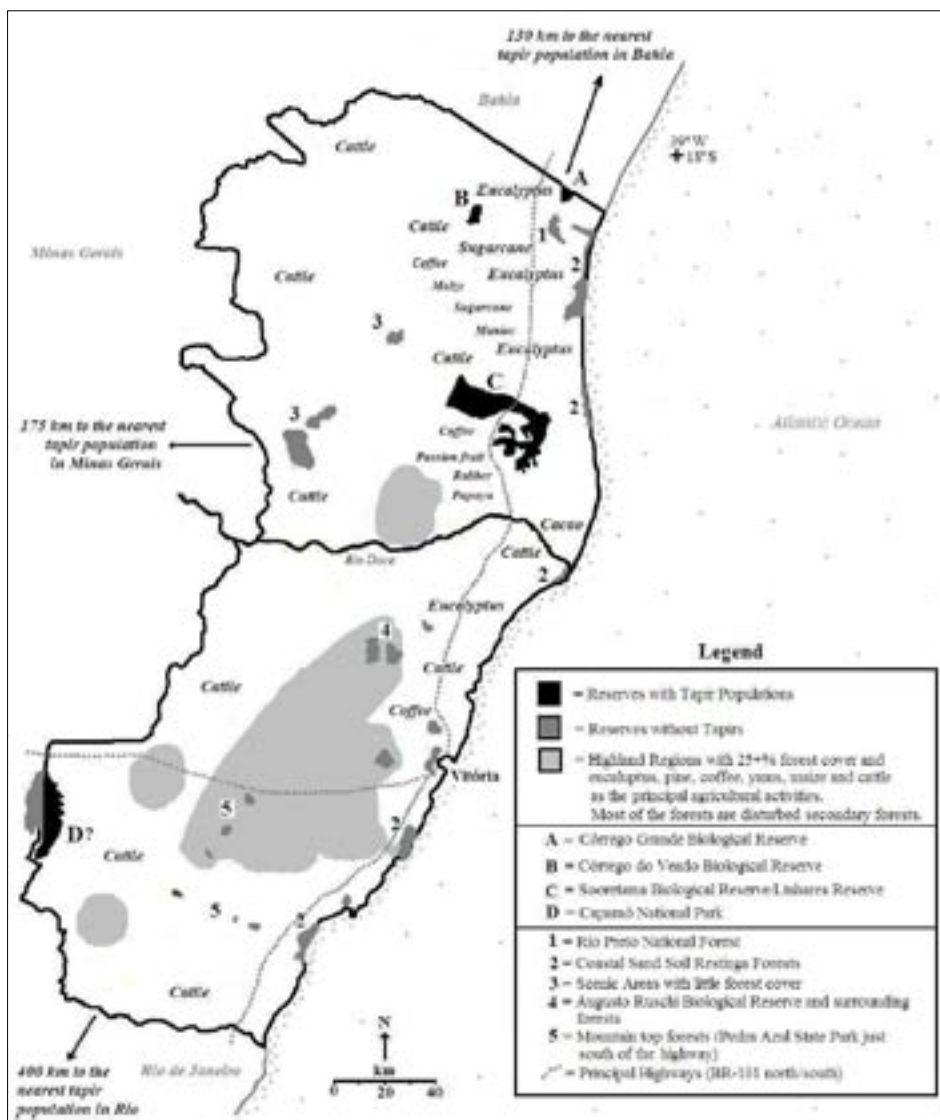


Figure 1. *Tapirus terrestris* populations in Espírito Santo.

tall grasses, heliconias and scattered thin trees and palm clumps. A camera trap along the access road near the stream has photographed several tapirs there.

The Córrego d'Abobora lies in the northeastern sector of the park (S 18° 59.833'; W 40° 00.993'), feeding into the Rio Barra Seca 1km west of BR-101. In this section of its course it is a dense wetland of reeds some 50-70m wide flanked by a steep sided forested ravine. Where it joins the Barra Seca, the river opens into a large open channel in the middle of an extensive reed wetland up to 1 km wide with widely spaced hummocks supporting a few *Cecropia* and palm clumps. The forest in this area was burned in a large fire that entered the park from neighboring cattle pastures in 1987 and now consists of a dense secondary forest to 6-12+ m with few large mature forest trees. The security guard along the highway saw a tapir behind the guard post a few days before we arrived.

People occasionally see tapirs crossing the busy BR-101 highway that traverses the forest from north to south suggesting that the populations of the two reserves are still contiguous, and although the highway is a death trap for other wildlife, there were no tapir deaths registered during a year-long study (2005) of road kill. Given the large size of this forest block and the fact that tapirs use most or all of the forest area, the potential population could be large (100+ animals).

Tapirs rarely leave the forest, but recently an individual raided a passion fruit crop planted along the southern reserve edge, destroying 500 of the 1,200 plants before being captured and released in the Linhares reserve. Interviews with several people who live in Juncado 4.5 km south of the Sooretama reserve have never heard of tapirs anywhere beyond the forest edge. A man who works in the Lorenzutti museum used to see tapirs in properties (Fazendas Cupido & Refúgio) near the Lagoa Macuco in the Linhares reserve where tapirs are common and frequently found tracks along a dam trail above a wetland. In this area they sometimes raid pumpkin, cacao, and coconut crops (eating the young leaves of the latter) along the forest edge.

A tapir was killed in a collision with a school bus near Córrego Farias south of the Linhares reserve close to the city of Linhares in 1997 (now on display in the Lorenzutti Museum in that city) and one appeared on the south side of the Rio Doce 15 km west of Regência in a time of heavy flooding 15 years ago. These events indicate that tapirs do occasionally try to move away from the reserves, but that these are rare dispersal attempts and the population remains isolated from others in the state.

While hunting pressure was intense in Sooretama in the past, it has dropped since 9-12 guards from the Linhares reserve began helping with the Sooretama patrols. Local people mostly hunt as a leisure activity and although some do hunt for commercial purposes

and sport hunters occasionally come from as far as Rio de Janeiro to hunt there, tapirs are rarely the game of choice. The guards believe that this is due to a decrease in the use of hunting dogs (people fear attracting the attention of the guards), and without dogs it is much more difficult to hunt tapirs. Also, they claim that tapirs are too heavy to carry out of the forest discreetly and for this reason are now rarely hunted. The Linhares reserve has been effectively patrolled for many years and by all accounts the tapirs there are well protected.

Caparaó National Park: This 31,800 ha park protects mountain forest and alpine vegetation on a rugged range on the border of Espírito Santo and Minas Gerais, with 70 % of the reserve in the former. The forests of the region have been disturbed for a long time, cleared to make way for cattle pastures and coffee plantations, burned by charcoal makers and wildfires from neighboring pastures. Today the situation has improved and the forest is recovering in the heavily impacted areas. The most intact forests have large trees with an upper canopy of 20-30 m and understory with bamboo as a dominant plant. More disturbed forests, especially those on the higher slopes (>1000 m), consist of secondary growth to 2-5 m with some trees reaching 10-15 m and scattered trees as tall as 20m. Tree ferns are common and mosses and lichens cover most surfaces. Above 2000 m the forest gives way to alpine vegetation (*campos rupestres*). The best preserved forests lie on the steep slopes of the Espírito Santo segment of the park and it is here that tapirs reportedly persist today.

Tapirs were extirpated from the Minas Gerais segment of the park more than 50 years ago and the species was believed to be extinct on the Espírito Santo side as well until scientists found tracks there in 2006 (Edsel Amorim Moraes Jr. pers. com.). The reserve director at first told us that guards have confirmed the species presence there, but later retracted saying that they may have been capybara tracks (*Hydrochoerus hydrochaeris* Linnaeus, 1766). Even if confirmed present, the fact that the animals have remained undetected to the point of people believing they were extinct suggests that the population is small. However, the large size of the reserve gives hope that if the tapirs indeed do exist there, that the population has room to grow. The reserve is surrounded by intensively cultivated and grazed lands and the hunting tradition is strong, so it is unlikely that tapirs will re-colonized or disperse across these landscapes in the future.

Areas of potentially suitable Habitat where Tapirs are absent

Rio Preto National Forest: This national forest (2,830 ha) and contiguous legal reserves of neighboring properties protect 5,000 ha of forest along the Itaúnas River in northern Espírito Santo several kilometers east of BR-

101 in a landscape dominated by eucalyptus plantations and cattle pastures. While this forest suffered selective logging for decades and a fire in 1987 that burned 870 ha, it still retains good stands of mature forest. The forest has few springs and streams apart from the Rio Itaúnas however, and the *mussununga* wetlands are seasonal ponds, so it may not be an ideal site for tapirs. Hunting pressure is still fairly intense but appears to be declining, although it has become a fashion amongst some people in nearby cities (São Mateus) to order game meat from local hunters. The director of the reserve has worked in the reserve for 17 years and has never received any notice and/or record of tapirs in the area.

Santa Teresa region: The two principal reserves in this region are the Augusto Ruschi Biological Reserve (3,600 ha) and the Santa Lúcia Biological Station of the Museu de Biologia Prof. Mello Leitão (460 ha), but there is much forest cover outside of these reserves. A recent GIS analysis by Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) showed that the 36,000 ha landscape surrounding the Augusto Ruschi reserve retains 24,000 ha of mostly contiguous forest and that 70 % of the inter-fragment distances are ≤ 50 m. The highland forests extend south to the Duas Bocas and Pedra Azul reserves and while most of these forests are clearly secondary forests growing on previously cleared land, they occupy an extensive area and forest cover is increasing (mainly due to the dual processes of agriculture intensification and land abandonment). Wildlife populations appear to be recovering in the region, and while hunting is still common, it has decreased greatly in comparison to former times.

According to local people who have lived in the region for decades tapirs were extirpated some 50-60 years ago as in the rest of the highland region. The principal guide of the Mello Leitão museum grew up hunting in these mountains with his father and uncle and never heard of tapirs anywhere near here. Old timers informed Sr. Molina, who has looked after the Santa Lúcia Biological Station for the past 26 years, that tapirs were killed off some 60 years ago. There are several other similar narrations but none has seen any evidence of tapirs or heard of any in the region. There were several recent reports of tapirs but none of the people we spoke with who have experience in the forest believed them to be true. We imagine that these supposed sightings are of capybaras by people from outside the region who are unfamiliar with the fauna.

Duas Bocas Biological Reserve: This 2,900 ha forest near the western edge of the greater Vitoria urban area no longer has tapirs. We interviewed a scientist working there with aquatic animals who spends a great deal of time along the waterways in the reserve and he has never seen any evidence of tapirs or heard of any nearby.

Pedra Azul State Park and other highland areas: As described above, tapirs were extirpated by the mid-20th century throughout this region.

Goytacazes National Forest: The 1,350 ha Goytacazes forest lies along BR-101 just south of Linhares on the Rio Doce in the cacao zone. There is no living memory of tapirs inhabiting the area and as the forest lies on the outskirts of town along a busy highway, it is unlikely that it would make a good site for tapir re-introductions.

Coastal restinga reserves: The Itaúnas State Park protects 3,000 ha of restinga forest and sand dunes at the mouth of the Rio Itaúnas on the northern coast of Espírito Santo in a region dominated by eucalyptus plantations. There is no memory of tapirs there in recent decades. The staff the 833 ha Comboios Biological Reserve, several men in their 50s who were born nearby, have never heard of tapirs in the region. A. Gatti found no evidence of tapirs while working with mammals in the 1,500 ha Paulo Cesar Viana State Park along the southern coast.

Discussion

Movement Barriers isolate the extant Populations

Other than the two cases listed above of tapirs appearing 10+ km south of the Linhares Reserve, there are no reports of tapirs moving any further than a few hundred meters from the forest edge and it is clear that each population is isolated from the other and from the nearest populations in the neighboring states. The landscapes between the three tabuleiro tapir populations are overwhelmingly dominated by cattle pastures and eucalyptus plantations and other agricultural lands that offer little in the way of food or shelter for tapirs. The small, degraded fragments that characterize the forests of these landscapes are not large enough to sustain tapirs even if they did move out of the reserve and the animals would have to constantly be moving between fragments to find the resources necessary to survive. Tapirs can and do eat agricultural crops in northern Espírito Santo (maize, manioc, passion fruit, pumpkins, cacao, young coconut trees, and jackfruit), and the damage they cause can be considerable. Consequently, it is unlikely that they could survive by raiding these crops without coming into conflict with farmers. As hunting is still common in northern Espírito Santo, animals would be vulnerable when they moved between forest patches. The extensive network of barbed wire fences would further impede travel, and a tapir moving between the populations would have to pass hundreds of fences to reach the next population. Highway BR-101 is one of the principal roads of Brazil and traffic is likely to increase in the future, and even though tapirs are still crossing between the Sooretama

and Linhares reserves, these do not appear to be common events and could become rarer in the future if traffic increases and/or the highway is widened. Agricultural land is highly valued in northern Espírito Santo and as this is unlikely to change, the prospects of creating movement corridors to link these disparate populations in the coming decades are slim.

While there is more forest cover in the highlands and several wildlife species are making strong comebacks (e.g. collared peccaries and capybaras), there are no tapirs left nearby to re-colonize these areas. Even if the Caparaó population does exist, it is unlikely to expand beyond the reserve boundaries any time soon, mainly because there is still ample empty habitat within the reserve and because the surrounding landscapes are not conducive to tapir movements being that several busy highways traverse the landscape and the small forest fragments, albeit closely spaced, are unlikely to provide sufficient refuge from hunters.

The Threat of Fire

The main immediate threat to tapirs of the two smaller reserves is catastrophic fires like those that burned much of the forest in 1987. Tapirs survived the 1987 fires presumably by fleeing into the 20 % of the forest that did not burn and then re-colonizing the burned areas as the vegetation recovered. In the event that the entire reserve burns, the tapirs will have no place to seek refuge. Cattle pastures, eucalyptus groves, and sugarcane fields on the edge of the reserve are hazards that should be avoided by creating agroforestry buffer zones that are less likely to catch fire (Cullen *et al.*, 2004) but this is unlikely to happen in the near future because there are no economic incentives for landowners to do so. While fires are also a threat to Sooretama and Linhares reserves, the sheer size of these forests makes it less likely that they will be completely destroyed in the event of a catastrophic fire.

The impact of fire on the persistence of the Espírito Santo tapirs was modeled by Arnaud Desbiez using a Population Viability Analysis (Vortex) with various estimates of population sizes and catastrophic fire frequencies provided from information collected during this study. The results indicate that catastrophic fires are unlikely to directly cause tapir extinctions when population have approximately 200 individuals (probably the upper size limit of the Sooretama/Linhares population), but might cause fluctuations in the number of individuals in the population that would make it more vulnerable to stochastic variables such as disease, hunting pressure and road kill and could increase the chance of erosion of genetic diversity in the long run. In small populations, such as those found in the Córrego do Veado and Córrego Grande reserves, the model exercise indicates that there is a good chance that fires will drive these populations to extinction within 100 years.

The modeling results suggest that conservation action to protect the tapirs needs to include strategies to protect these areas from catastrophic fires that are likely to re-occur. This is a real threat that should be addressed as soon as possible.

The Threat of Hunting

Hunting does not appear to be an imminent threat to the Espírito Santo tapirs and as hunting pressure appears to decrease throughout the state, there is hope that the situation will continue to improve and tapir populations will grow in the future. However, animals that raid crops will always be susceptible to retaliation and it is probable that tapirs will occasionally be killed in these circumstances. For the small tabuleiro populations even the loss of one animal could be catastrophic. If hunting pressure decreases further and wildlife protection legislation becomes more effectively enforced, the highland region may be a viable site for tapir re-introductions. The total forest cover in the highland region is already > 100,000 ha and although most of the fragments are small, they are closely spaced and occupy a large percentage of the area and without hunting pressure these landscapes would probably be suitable for tapirs.

Genetic Considerations

The probable large size of the Sooretama/Linhares population and the short time it has been isolated suggests that the deleterious consequences of inbreeding are not an imminent concern. However, the small populations in Córrego Grande and Córrego do Veado suggest that they are unlikely to be viable in the long-term without genetic intervention. While it is likely that the translocation of individuals between populations *could* make these small populations more genetically robust, funding shortage makes it unlikely that translocations will occur in the near future.

Conclusions

- Tapirs are reduced to at least three and possibly four isolated populations, two with probably < 20 animals each, and the other with a potentially robust population of > 100 individuals.
- The persistent threat of escaped fires could eliminate the two small populations, but is unlikely to destroy the Sooretama/Linhares (and Caparaó) populations.
- The deleterious genetic effects of isolation are a long-term threat to the two small populations and it may be that we will have to intervene by translocating animals or genetic material between populations if they are to persist. The large population is unlikely to need genetic intervention in the near future.

- The extent of deforestation and forest degradation in the tabuleiro landscape and the high economic value of the land make it unlikely that the low quality matrix that is currently isolating tapirs in reserves will change in any way to improve its permeability for tapirs. Increasing traffic in Brazil and the importance of BR-101 for the national economy suggest that in the future this highway will become even more of a barrier than it is today, especially if it is improved by adding additional lanes (which will eventually happen), and this could impede tapir movements between the Linhares and Sooretama reserves.
- Hunting pressure appears to be declining in the state and this coupled with an increase in forest cover in the highlands gives hope that one day this region will be an appropriate site for tapir re-introductions.

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References

- Brown, K.S. Jr. & Brown, G.G. 1992. Habitat alteration and species loss in Brazilian forests. In: T. C. Whitmore & J. A. Sayer (eds.) *Tropical Deforestation and Species Extinction*, pp. 119-142. Chapman Hall, London.
- Chiarello, A.G. 1999. Effects of fragmentation of the Atlantic forest on mammal communities in south-eastern Brazil. *Biological Conservation* 89:71-82.
- Cullen, L., Ferreira, L.L. & Pavane, T.B. 2004. Agroforestry Buffer Zones and Stepping Stones: Tools for Conservation of Fragmented Landscapes in the Brazilian Atlantic Forest. In: G. Schroth, G.A.B. da Fonseca, C.A. Harvey, C. Gascon, H.L. Vasconcelos & A.M.N. Izac (eds.) *Agroforestry and Biodiversity Conservation in Tropical Landscapes*, pp. 415-430. Island Press, Washington D.C.
- Dean, W. (1995) *With Broadax and Firebrand - The Destruction of the Brazilian Atlantic Forest*. University of California Press, Berkeley.
- Garay, I., Rizzini, C.M., Kindel, A., Agarez, F.V., Passos, M.A.L., Santos, dos R.D. & Sanchez, V.R. 2003. *A Floresta Atlântica de Tabuleiros: Diversidade Funcional da Cobertura Arbórea*. Editora Vozes, Petrópolis, Rio de Janeiro.
- Lorenzutti, R. & Almeida, A. de P. 2006. A Coleção de Mamíferos do Museu Elias Lorenzutti em Linhares, Estado do Espírito Santo, Brasil. *Boletim do Museu de Biologia Prof. Mello Leitão* 19: 59-74.
- SOS Mata Atlântica/INPE. 2002. Atlas dos remanescentes florestais e ecossistemas associados no domínio da Mata Atlântica. Fundação SOS Mata Atlântica, São Paulo.
- Viana, V.M. & Tabanez, A.A.J. 1996. Biology and conservation of forest fragments in the Brazilian Atlantic moist forest. In: J. Schelhas & R. Greenberg (eds.) *Forest Patches in Tropical Landscapes*, pp. 151-167. Island Press, Washington, D.C.

Appendix I: Spatial relationship of the tapir populations.

Population	Distances between tapir populations	Landscape mosaic between the populations	Evidence of tapir movements
Córrego Grande	50 km to Córrego do Veado; 130 km to the Descobrimento National Park population in Bahia.	Eucalyptus and sugarcane plantations and cattle pastures. Fences with barbed wire and in the direction of the Córrego do Veado population the busy BR-101. Forest cover throughout is sparse and reduce to small (mostly 1-4 ha) widely spaced (500-1000+ m) fragments, with few fragments >20 ha.	No
Córrego do Veado	50 km to Córrego Grande; 60 km to the Sooretama/ Linhares population.	The landscape between this reserve and Sooretama is dominated by cattle pastures, with lesser amounts of eucalyptus, coffee, sugarcane, maize, and black pepper. Many barbed wire fences and several fairly busy highways. Forest cover is reduced to widely spaced (500-1000+ m) degraded fragments (1-10 ha).	No
Sooretama and Linhares	60 km to Córrego do Veado; 175 km to Caparaó.	Eucalyptus, cattle, coffee, cities, highways and heavily fragmented forest reduced to small, degraded fragments. Highlands of highly contiguous fragments of secondary forest.	No
Caparaó	100 km from Rio Doce State Park in Minas Gerais; 175 km to Sooretama.	Coffee, cattle, and small highly degraded forest fragments.	No