

LANDSCAPE VALUATION BASED ON THE ECOLOGICAL REQUIREMENTS OF ‘*Tayassu pecari*’ AND ‘*Tapirus terrestris*’ – A FOREST WITH ARAUCARIA, IN PARANÁ STATE, BRAZIL

VALORAÇÃO DA PAISAGEM COM BASE NOS REQUISITOS ECOLÓGICOS DE *Tayassu pecari* E DE *Tapirus terrestris* - FLORESTA COM ARAUCÁRIA, PARANÁ, BRASIL

Gisley Paula Vidolin¹ Daniela Biondi Batista² Adilson Wandembruck³

ABSTRACT

This study valued the landscape of Lageado Grande farm (LGF), an area of 3,136.32 ha, located in General Carneiro, Palmas, and Bituruna, Paraná state, Brazil. The evaluation was based on an integral analysis of the ecological requirements of *Tayassu pecari* and *Tapirus terrestris* and the functional aspects of the LGF landscape. Land use and land cover were mapped, and the map was divided into 335 grids of 10 ha each, which were scored with pre-defined criteria. The scores of each aspect were integrated by multiplying the values and calculating the standard deviation and the mean to establish the classification intervals of the general quality of the landscape. The class gradient for the survival and the preservation of the analyzed species generated was: extremely important, very important, important, and of little importance. It was observed that 61.2% of LGF has environments relevant to the preservation of the species, composed by a forest predominantly of pine, broadleaves, lowlands, and some riparian forest patches of Iratim River. The results show that LGF comprises a mosaic of environments suitable for the occurrence and maintenance of these ungulates.

Keywords: preservation of the species; fragmentation; *Tayassu pecari*; *Tapirus terrestris*.

RESUMO

Este estudo teve como objetivo a avaliação da paisagem da Fazenda Lageado Grande (FLG), área com 3.136,32 ha, localizada em General Carneiro, Palmas e Bituruna no estado do Paraná. A avaliação foi baseada na análise integrada dos requisitos ecológicos do queixada (*Tayassu pecari*) e da anta (*Tapirus terrestris*) com os aspectos funcionais da paisagem que constitui a FLG. Foi elaborado um mapa de uso e cobertura do solo, sobre o qual se aplicou uma malha quadriculada totalizando 335 quadrículas de 10 ha, que foram pontuadas de acordo com critérios pré-estabelecidos. As notas atribuídas para cada aspecto considerado foram integradas por multiplicação dos valores entre si, e calculados o desvio padrão e a média, para estabelecer os intervalos de classificação da qualidade geral da paisagem. O gradiente de classes gerado foi: extremamente importante, muito importante, importante e pouco importante para a sobrevivência e conservação das espécies analisadas. Constatou-se que 61,2% da FLG possuem ambientes relevantes à conservação das espécies, os quais são constituídos por floresta com predomínio de pinheiro, floresta com predomínio de folhosas, várzeas e alguns trechos de vegetação ciliar do Rio Iratim. Com estes resultados pode-se concluir que a área da Fazenda Lageado Grande apresenta um mosaico de ambientes propício à ocorrência e manutenção desses ungulados.

Palavras-chave: preservação de espécies; fragmentação; *Tayassu pecari*; *Tapirus terrestris*.

1. Bióloga, Doutora, Bio situ Projetos e Estudos Ambientais Ltda., Rua Carlos Belão, 45F, Vila Juliana, CEP 83306-120, Piraquara (PR). paula@biositu.com.br
2. Engenheira Florestal, Dr^a., Professora Associada do Curso de Engenharia Florestal, Universidade Federal do Paraná, Rua Lothário Meissner, 900, Jardim Botânico, CEP 80210-170, Curitiba (PR). dbiondi@ufpr.br
3. Engenheiro Florestal, Bio situ Projetos e Estudos Ambientais Ltda., Rua Carlos Belão, 45F, Vila Juliana, CEP 83306-120, Piraquara (PR). adilson@biositu.com.br

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INTRODUCTION

Studies on the effects of landscape fragmentation are not yet common in the evaluation of the biodiversity loss of specific areas. The landscape fragmentation process occurs naturally, but it has been intensified by the anthropic action and has resulted in a large number of environmental problems (MMA, 2003). The continued growth of the human activities has severely reduced and modified natural areas, converting continuous habitats into fragments of different sizes with different degrees of isolation and levels of perturbation (FERNANDEZ, 1997).

This process has, in turn, introduced a series of new factors in the evolution of natural plants and animal populations. These changes affect the demographic mortality and the birth parameters of different species in a distinct manner and, therefore, the ecosystem structure and dynamics (FORMAN and GODRON, 1986; VIANA and PINHEIRO, 1998). Each species responds to environmental modifications in a singular way, increasing its numbers in some environments and decreasing in, or completely avoiding, others (ORTIZ et al., 2002). Thus, the reduction of the primitivity and the diversity of these environments have mostly affected the endemisms, the regional variations, the species with specialized habits, and the species associated with primitive and extensive environments (MMA, 2003).

According to Forman et al. (1976) and Saunders et al. (1991), the species richness decreases as an area becomes smaller than the minimum necessary for the survival of the populations present in it. This minimum area varies as a function of the species and is determined by the size of the territory of one individual (or group of individuals, as a function of the social behavior of the species) and the minimum number of individuals in a genetically viable population (ROSTALTD, 1991). Another relevant factor to the fragment size that determines species the distribution is the area size, as it influences the resource availability. As the area decreases, the resources also decrease, and consequently, the intra- and the interspecies competitions grow (SEAGLE, 1986). Metzger (2001) related an area size with the capacity of movement of species in the landscape, specific habit requirements, and interactions with other species, which affects the landscape perception to a degree. Therefore, species with little capacity for movement or dispersion perceive the landscape

more locally, in contrast to species with a greater capacity for movement, which tends to perceive the landscape more widely. Alternatively, species with highly specialized habitats tend to see the landscape in detail in relation to more generalist species.

The fragment sizes of large-sized mammals, such as some ungulates that need large ranges to meet their ecological requirements, play a fundamental role in both the richness and the abundance of these species. A study performed in the Mid Amazon region (Low Tapajós River) indicated a trend towards loss of diversity for this group combined with the reduction in the fragment size. Thus, in landscapes with advanced fragmentation and few fragments, the isolation of animal populations in fragments and a higher susceptibility to extinction are expected (MMA, 2003).

Araucaria forest areas originally covered 37% of the Paraná state (MAACK, 1968) and are examples of this environmental process. Currently, the combined fragments are distributed in three plateaus in the south of the state, corresponding to less than 1% of the total state area. The few remaining fragments are highly disturbed, isolated, unprotected, small, little known and clearly disappearing, especially in intensely cultured landscapes. In this habitat of loss and fragmentation process, many flora and fauna species associated with this biome have been negatively influenced, undergoing abundance reduction and population isolation; the examples include *Tayassu pecari* and *Tapirus terrestris*, threatened species in Paraná state (MIKICH and BERNILS, 2004). In this context, the present work aimed to evaluate the landscape of a managed area in the araucaria forest biome, regarding to the functional aspects and the ecological requirements of these ungulates as parameters.

METHODS

Area of Study

This investigation was performed in Lageado Grande farm (LGF), in Paraná state, a typical forest estate that produces timber from managed plantations and extracts non-timber products, such as mate herb (*Ilex paraguariensis*), from the forest. The study area is located in the municipalities of 'General Carneiro', 'Palmas', and 'Bituruna', which have geographic coordinates 26°18'11.75" latitude south and 51°35'58.94" longitude west as reference points (Figure 1).

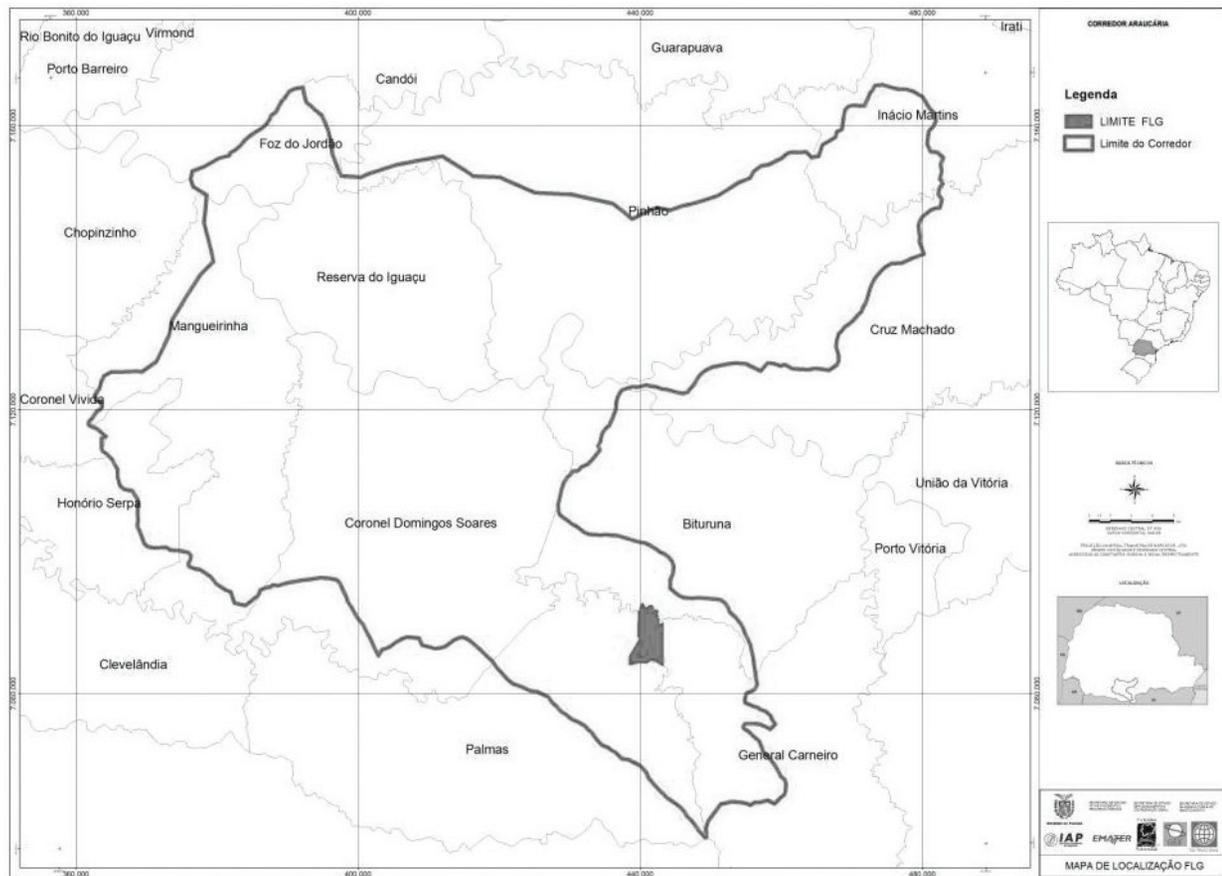


FIGURE 1: Location of Lageado Grande Farm (LGF).

FIGURA 1: Localização da Fazenda Lageado Grande (FLG).

The farm area of 3,136.32 ha is located in the Iguazu basin, a microbasin of Iratim River, and has strongly undulated relief (CASTELLA et al., 2004). Subformations occur as a function of the altitude: Mountain Floresta Ombrófila Mista (400-1000 m snm), High Mountain (over 1000 m snm), and alluvial (old terraces along the rivers) (VELOSO et al., 1991).

The climate is classified as subtropical humid mesothermal (Cfb) and it is characterized by a mild summer and a harsh winter with frequent strong frosts from March to September. It does not present a characteristic dry season. The highest mean temperature is lower than 22 °C, and the lowest mean temperature is below 18 °C. The rainfall is irregular, lower in winter, and higher in summer. The mean annual rainfall is 1500 mm (SMART WOOD PROGRAM, 2002).

One of the main problems in the LGF area is the floristic and structural integrity of the vegetation cover, which has been seriously affected by selective exploitation in the past (RODERJAN, 2004). Furthermore, the LGF surroundings are

characterized by large pine reforestation, agriculture, and small-scale cattle raising areas, “faxinal” (community-based systems of mixed cultivation and wood pasture in araucaria forests), and rural settling, which results in different degrees of impact on the area fauna species, such as the white *Tayassu pecari* and *Tapirus terrestris*.

Methodological procedures

Soil use and cover mapping - the soil use and cover of LGF was mapped by photointerpretation of a satellite image chart of the area with an *ArcMap version 9.2* software. The analysis of the image chart revealed the following characteristics:

- Satellite data: Sensor (IKONOS II), Composition (1, 4, and 3), Spatial resolution (4 m), Acquisition (June 24th, 2003);
- Cartographic parameters: Horizontal datum (SAD 69 ii), Cartographic projection (UTM), M. C. (51° W), Scale (1/10,000);
- Terrain control points obtained with GPS signal receptors RMS: 1.15 m.

A total of eight main soil use and cover

classes were identified in the non-supervised photointerpretation (Figure 2). They were classified into the following habitats:

- a) Forest with predominance of broadleaves (FPB) – rather altered native forest in different succession stages with a continuous canopy dominated by broadleaved species. Sparse pine association occurs in some areas (RODERJAN, 2004);
- b) Forest with the predominance of pine (FPP) – rather altered native forest areas in different stages of regeneration, a continuous canopy dominated by Paraná pine, *Araucaria angustifolia*, without understory or dominated by bamboo (RODERJAN, 2004).
- c) Floodplains (FL) – areas with herbaceous vegetation on hydromorphic soils. Leafy vegetation association occurs in some areas (RODERJAN, 2004);
- d) Secondary vegetation (SV) – area resulting from abandoned soil use or occurring in areas with a time interval between clear-cutting and pine replanting, dominated by bracatinga (*Mimosa scabrella*) and/or ‘vassourinhas’ (*Baccharis* spp.) (RODERJAN, 2004);
- e) Area of permanent preservation (APP) – areas with vegetation located on the watercourse banks;
- f) Water bodies – constituted by rivers, wells, and dams;
- g) Planted forest with exotic species/ Forest plantation (RE) – area planted with *Pinus* sp. for industrial purposes;
- h) Area of anthropic influence (AAI) – industrial areas, roads, exposed soil, gravel.

The interval between APP areas was defined according to Article II of the “Brazilian Forest Code”²², and is directly related to the watercourse width. In the study area, the width of Iratim River ranges from 10 to 50 m, corresponding to 50-m riparian forest corridors on each bank. However, this does not mean that the riparian forest corridors are in the boundaries defined by regulations. There are conflict areas that present with pine, roads, as well as some areas that are without riparian vegetation.

Valuation of the landscape

Plot sizes - a grid with 448 10-ha pixels (316.23 m X 316.23 m) was used. The 335 grids that covered the farm perimeter were scored using

pre-defined functional criteria.

The definition of the species ecological requirements under study - the basic ecological requirements of the species were defined based on the literature (FRAGOSO, 1994; IUCN, 1997; FRAGOSO, 1997; MIKICH and BÉRNILS, 2004) and on the previous knowledge about the ecology species.

Tayassu pecari and *Tapirus terrestris* have basically the same ecological requirements, including abundant hydric resources; availability of humid environments, marshes or waterlogged soils; areas with vegetation formation, preferably with well preserved or dense primitive vegetation; abundance of forage resources; and extensive environments connected to other areas, as they are species with great mobility that need extensive areas with natural corridors. The *Tayassu pecari* does not withstand intense environmental changes, being the first species to disappear from forest fragments.

The selection and the valuation of the landscape attributes - the procedures adopted in the landscape valuation were based on the analysis of the functional aspects of the types of habitats that constitute LGF and their correlation to the ecological requirements of *Tayassu pecari* and *Tapirus terrestris* (Table 1). These aspects refer to the biological responses of the species to the landscape structure (METZGER, 1999) or landscape attributes that were scored according to the variations of their occurrence.

The lowest water resource availability scores were those of sites without watercourse (0% watercourse), the intermediate values were attributed to the pixels partially run by watercourses (50% of extension of watercourse), and the highest scores were those with watercourse in nearly all the pixel area (over 50% of extension of watercourse).

For the pixels with more than one type of habitat (partially filled pixels), we used the weighed mean. In this case, the scores of each attribute were multiplied by the percent pixel area occupied by the habitat. The same procedure was adopted in the analysis of habitat availability during the year.

In the evaluation of the direct influence of the proximity of LGF surroundings, pixels close to the property border were scored the lowest due to the higher susceptibility to the anthropic effects of the surroundings. The direct influence pixels were defined as being located at least 632 m away from the borders, that is, two pixels away from pixels of immediate contact with LGF surroundings. The

pixels with low anthropic influence from LGF surroundings were located over 632 m away from the property borders.

The valuation criterion for the presence of roads considered that the existence of roads fragments the habitats and allows the easy transit of people in the area, which may increase the pressure

on the species. As a result, pixels even partially crossed by roads received a low score, in contrast to pixels without roads, which were scored the highest.

Similar to the valuation of the indirect proximity to the surroundings, the criterion for the proximity to the farmhouse was a distance of at least 623 m from the village; pixels within this distance

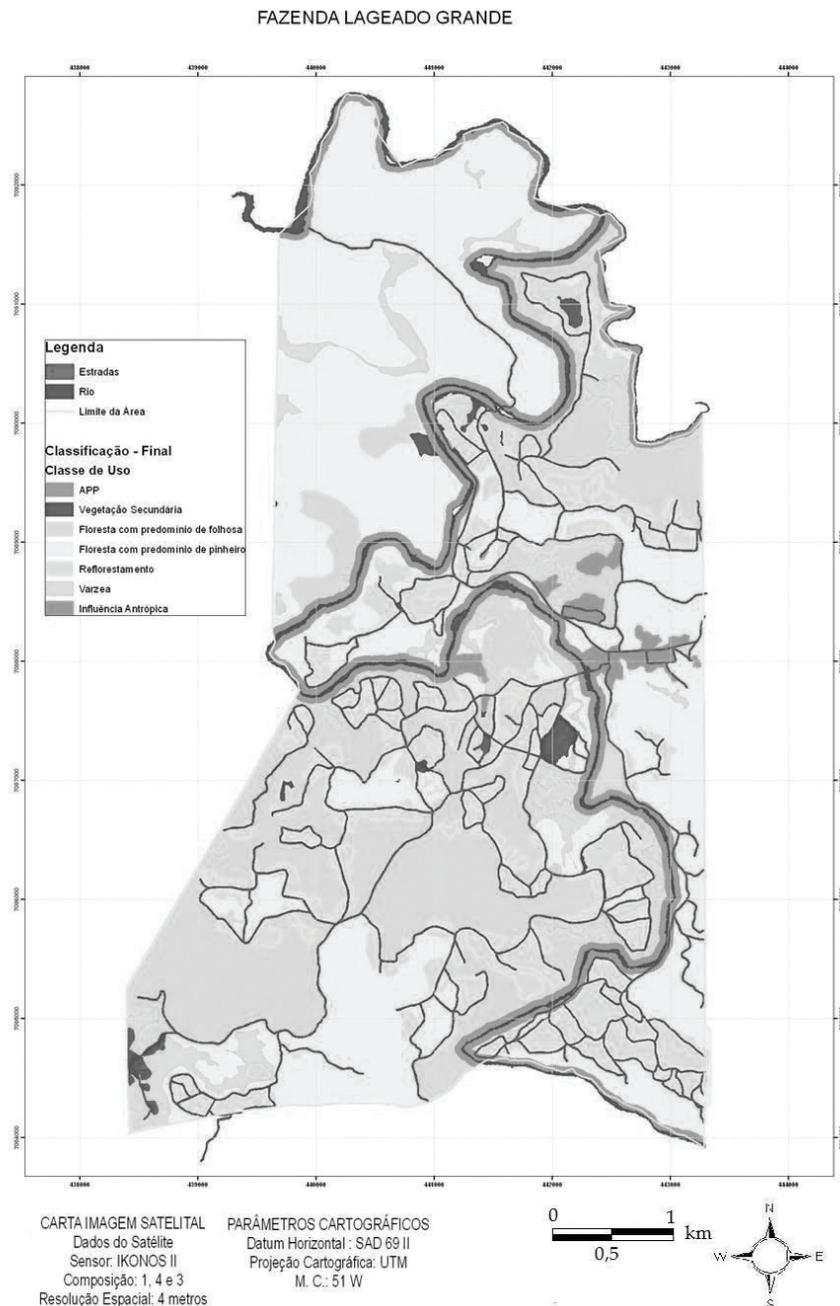


FIGURE 2: Map of soil use and soil cover of Lageado Grande farm, Paraná state (Legend: APP = Area of permanent preservation; Vegetação secundária = Secondary Vegetation; Floresta com predomínio de folhosas = Forest with predominance of leafy species; Floresta com predomínio de pinheiro = Forest with predominance of araucaria; Reflorestamento = Reforestation of *Pinus* sp.; Várzea = Floodplains; Influência antrópica = Anthropic influence).

FIGURA 2: Mapa do uso e cobertura do solo da Fazenda Lageado Grande - PR.

TABLE 1: Valuation of the landscape attributes based on the ecological requirements of the *Tayassu pecari* and *Tapirus terrestris*.

TABELA 1: Valoração dos atributos paisagem baseado nos requisitos ecológicos do queixada e da anta.

Landscape Attributes	Landscape Attribute Variation	Scores
Availability of water recourses	Without watercourse	1
	Partially covered by watercourse	2
	Fully run by watercourse	3
Type of habitat	Anthropic influence	1
	Planted forest with exotic species/forest plantation (<i>Pinus</i> sp.)	2
	Secondary vegetation	2
	Forest with pine predominance	3
	Forest with broadleaved predominance	4
	Area of permanent preservation (APP)/ Riparian forest	5
Habitat availability during the year	Floodplains	5
	Seasonal	1
	Permanent	2
Proximity to LGF surroundings	Area of direct influence (boundary pixels)	0.5
	Area of indirect influence (circumference over 632 m)	1
	Area without influence (inner pixels)	2
Existence of roads	Present	1
	Absent	2
Proximity to the farmhouse	Direct influence area	1
	Indirect or no influence area	2

from the farmhouse were scored the lowest, and the farthest ones from the farmhouse were scored the highest.

Data Processing

For the classification of the ecological importance of each aspect valued, the attributed scores were integrated by multiplying their values. According to Bruschi-Jr. et al. (2002), the multiplicative method stresses the most important functional and landscape elements among the several landscape components of the studied area. If the additive method were used, these aspects might be underestimated because the difference among intervals of classification would be less significant.

After defining the values of each unit, they were inserted in a spreadsheet, and the mean and the standard deviation were calculated to establish the intervals of classification as a function of the general quality of the landscape. Thus, a class score gradient was obtained for the ungulate species studied:

- Extremely important – it comprises more than three ecological requirements;
- Very important – it comprises at least three

ecological requirements;

- Important – it comprises at least two ecological requirements;
- Of little importance – no ecological requirements comprised.

Thus, the key biotopes for the preservation of the species in LGF were identified.

RESULTS AND DISCUSSION

The whole LGF surface was valued, and four levels of importance for environmental sectors were determined for the ungulates studied: extremely important, very important, important, and of little importance (Figure 3); the extremely important class takes an area of 290 ha (8.7% of the landscape), the very important class 420 ha (12.5% of the landscape), the important class 1,340 ha (40% of the landscape), and the little important class 1,300 ha (38.8% of the landscape) (Table 2).

It is worth nothing, however, that the landscape area results for the extremely important and very important classes are proportionally smaller (21.2% = 710 ha, 8.7% = 290 ha for the extremely

important class and 12.5% = 420 ha for the very important class). These two classes correspond to environments located at the center or close to the center of the FLG area, mostly distributed in the higher (northern) part of the farm. This part of the farm, which is the mandatory reserve of the property, has a greater forest density, with a prevalence of pine trees (*Araucaria angustifolia*), and contains the main floodplains areas (farther from the borders and

with lesser anthropic influence).

The floodplains are key habitats for *Tayassu pecari* and *Tapirus terrestris*, as they offer the species wet environments which are often used for foraging (IUCN, 1993; EISENBERG, 1997; BODMER and BROOKS, 1997; PUERTAS, 2006; CORDEIRO and OLIVEIRA, 2006; VIDOLIN et al., 2009). *Tapirus* is highly dependent on these environments for several of the vital functions of its

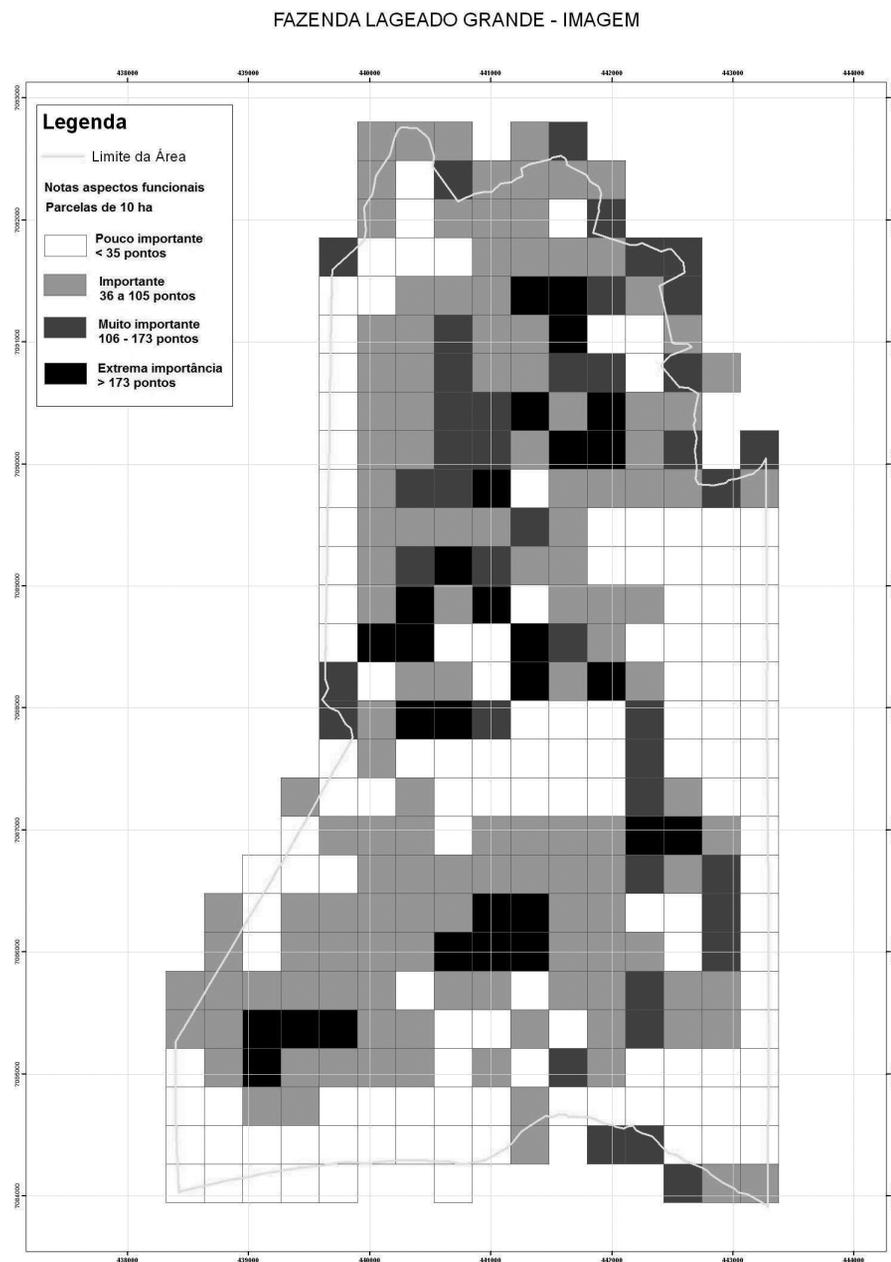


FIGURE 3: Landscape valuation map of Lageado Grande Farm (Legend: Area boundary, Notes: function aspects grids 10-ha plots, Little important, <35 points, Important 36-105 points, Very important 106-173 points, Extremely important >173 points).

FIGURA 3: Mapa de valoração da paisagem da Fazenda Lageado Grande.

TABLE 2: Lageado Grande Farm habitat classification for *Tayassu pecari* and *Tapirus terrestris*.
 TABELA 2: Classificação do habitat para o queixada e para a anta na Fazenda Lageado Grande.

Classification	Area occupied by each class in ha	% occupation of landscape by each class
Extremely important	290	8.7
Very important	420	12.5
Important	1340	40
Of little importance	1300	38.8

life cycle (RICHARD and JULIÁ, 2000), such as regulation of the intestinal tract, thermoregulation, elimination of ectoparasites, and shelter against predators.

The *Tayassu pecari* also has a very close relationship with wet environments, as it is in these environments that they carry out geophagia (dirt eating) to obtain salts and other deposited minerals that are exposed for long periods of time in these non-flooded environments (BODMER, 1990, 1991; DESBIEZ et al., 2004; KEUROGHLIAN et al., 2004; REYNA-HURTADO and TANNER, 2005; KEUROGHLIAN and EATON, 2008; VIDOLIN et al., 2009). Furthermore, the species also finds important food resources in these environments. In the FLG floodplains containing herbaceous vegetation, for example, there are large concentrations of *Baccharis* spp, and it is in the floodplains where the association with leafy species occurs, such as the butiá (*Butia eryospatha*), among many others. Besides these resources, the species also find bamboo (*Bambusa* sp.) sprouts on the borders of these environments. and caratuva (*Chusquea* sp.) (VIDOLIN, 2008).

The areas with a predominance of araucaria, the main arboreal component of the mixed ombrophile forest, are essential environments for the species in the period from March to August, the Brazilian araucaria nut season, when there is a lower production of zoochoric angiosperms (PAISE and VIEIRA, 2005; VIDOLIN, 2008). The araucaria, then, becomes an important source of food during a time of low fruit availability in general (PAISE and VIEIRA, 2005; VIDOLIN, 2008). Brazilian araucaria nut can, therefore, be considered a staple for the animals during the winter.

It is worth pointing out that the Paraná State government passed a decree (Decree no. 4800, Sept. 21st, 1998) that added this part of the farm, about 720 ha, to the Araucaria State Park, thus guaranteeing the interruption of activities such as mate extraction until its expiration in 2004. Currently, this area is not protected and it is no longer a preservation unit,

so it is susceptible to anthropic use (mate extraction, hunting, presence of domesticated animals, and others), the negative impacts of which are unknown.

The environments in the southern portion of the farm comprise extremely important and very important areas, having a large concentration of forest with predominant vegetation. In contrast to the forest with a predominance of pine, the species in this environment generally fructify during the highest rainfall and temperature period (PAISE and VIEIRA, 2005). As this area has the largest variety of vegetation, a larger forage supply and diversity is expected. Some of the forage resources available that are consumed by the lowland tapir and the white-lipped peccary in these environments are guabiroba (*Campomanesia xanthocarpa*), from November to January; ingá (*Inga virescens*), from December to February; pessegueiro-bravo (*Prunus brasiliensis*) from March to June and from September to December; and imbuia (*Nectandra megapotamica*), from December to May.

Some riparian forest patches of Iratim River also belong to these classes, mainly areas with contact with other environments, particularly the lowlands. Butiá (*Butia eryospatha*) is another of the species' forage resources found in these environments. As the river is a natural divider between LGF and other properties, some of the areas analyzed are located at the border of the properties and may be considered dispersion corridors for the species. However, these attributes are affected by the present state of preservation of the riparian forest. Some patches have been completely suppressed over the years or have been altered too much, such that their functions are reduced or no longer effective for this kind of vegetation. Additionally, the conflict areas due to the advancement of pine are extensive and do not meet the minimum requirements established by the "Brazilian Forest Code" which regards to the native vegetation along the rivers.

The environments considered important (40%) are distributed in nearly equal proportions between northern LGF, where the forest with

the predominance of pine is concentrated, and in the southern LGF, where broadleaved forest predominates. The fact that these environments surround those belonging to the extremely important and very important classes stands out; they act as a sort of buffer zone. In the south of the farm, these environments are more vulnerable to anthropic action, as they are located in pine plantation areas with secondary vegetation and an extensive road network that supports the timber production. According to Freitas and Metzger (2007), the extension of the road network subdivides and fragments the whole landscape, and large fragments without roads do not exist.

The environments classified as of little importance (38.8%) have secondary vegetation, pine plantation and they are close to the farmhouse and to LGF surroundings. The secondary vegetation shows that the ecological succession process is in its initial phase of regeneration; this is considered an environment of ephemeral permanence located between the pine clear-cutting and the later plantation of saplings in the same areas.

Concerning *Pinus* sp., based on species records obtained in this study, we can infer that the forest plantation areas are used when they are close to or between natural environments, suggesting the low forage resource availability in these areas limits their use to acting as a passage between native forest fragments. Another factor that restricts the use of this environment by the species is the influence of the farmhouse, and thus the human presence, the vehicle and pedestrian traffic, and the machine and equipment noise. The pressures from the farmhouse surroundings, particularly hunting, are important and pose a greater risk to the survival of the species. Fragoso (1991) cites hunting as one of the main factors for the disappearance of the lowland tapir in some places. For instance, data on hunting in Aripuanã, Mato Grosso State obtained by Ayres and Ayres (1979) indicate that the *Tayassu pecari* and *Tapirus terrestris* were the most-commonly hunted animals, representing 86% and 11% of the total wild animal meat consumption, respectively. This demonstrates the strong pressure of hunting on these ungulates.

The reproductive, ecological, and behavioral aspects of these two mammal species also contribute to make them even more fragile. The reproductive potential of the lowland tapir, for example, is low, bearing only one offspring after a 13-month gestation. They reach sexual maturity only around

the age of two years. In satisfactory environmental conditions, they may bear litters every 14 months; however, in altered habitats, mainly under reduced forage resource availability, the interval between births is larger (EISENBERG, 1997). The birth interval of the lowland tapir in LGF is expected to be even longer. The low productivity of the *Tayassu pecari* is mainly due to its gestation period of about five months, after which two offsprings are born. Furthermore, the herd size, the social organization, and the parental care, along with forage availability, may influence the reproductive success of the species (MARGARIDO, 2001).

In general, although the environmental conditions of the area have been greatly altered as a result of past selective timber extraction and the absence of natural regeneration in most of the area due to the high density of bamboo, LGF presents a mosaic of environments favorable to the occurrence and maintenance of the *Tayassu pecari* and *Tapirus terrestris*. Specifically for the *Tayassu pecari*, which has already disappeared from certain regions of natural distribution (MIKICH and BÉRNILS, 2004), LGF and the surrounding properties constitute some of the last places in Paraná State where the species can still be found; this justifies conservationist measures for this area.

CONCLUSIONS

The valuation results for the entire surface of Lageado Grande Farm leads to the conclusion that over 60% of the area contains environments with ecological requirement indicators considered extremely important, very important, and important for the white-lipped peccary and the lowland tapir. A total environment area of 2,050 ha has the potential to contribute to the maintenance of their populations within the area, where the species find sites with greater forage availability and water sources (rivers and lowlands). Nevertheless, the characteristics of 1,300 ha (41.45%) of the area do not meet the species' requirements for survival, due to low forage availability or intense anthropic pressure.

As this is a preliminary study based on the definition of the species requirements using secondary data, more detailed studies of the area will be need. These studies must preferentially evaluate the selectivity of habitats by these ungulates and verify whether these sectors of the Farm are in fact the most important for the species. In any case, the landscape valuation method in association with

the knowledge of the ecologic requirements of the species can serve as a tool in defining the most important sectors of the area for the preservation of *Tayassu pecari* and *Tapirus terrestris* (in terms of habitat surface).

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