

5.2.2

Biological Environment

Regional Setting

The region of the Arraias municipality, where the present study areas are located, is in the Cerrado biome dominion, and as the Atlantic rainforest, it is one of the world's hot spots, according to the environmental organization Conservation International. The Cerrado is the second largest biome in area in Brazil, occupying 23% of the national territory (two million square kilometers), and is basically located in the Brazilian Central Highlands (Planalto Central), spreading to the States of Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Tocantins, Bahia, Piauí, Maranhão and Federal District, apart from some separate portions of the States of Roraima, Pará, Amazonas, Rondônia, Amapá, São Paulo and Paraná. It is considered as a vegetation group of great phytophysognomic heterogeneity (RIBEIRO & WALTER, 2008).

The term Cerrado designates a type of vegetation with its own physiognomy and flora, classified as a savanna according to worldwide vegetation classification standards (EITEN, 1994). The savanna (Cerrado) is conceived as a xeromorphic vegetation, most often defined by a seasonal climate (with more or less six dry months). However, it may also be encountered in ombrophilous climate. The Cerrado regions are located in aluminized, leached soils and present hemicriptophytes synusiae, small sized geophytes, chamaephytes and oligotrophic phanerophytes, occurring throughout the Neotropical zone, and mainly in Central Brazil. In other parts of the country, it is designated by local names, such as: “*tabuleiro*”, “*agreste*” and “*chapada*” in the northeast region; “*campina*” or “*gerais*” in the north of the States of Minas Gerais, Tocantins and Bahia, among other denominations (DAMBRÓS & CONSÓRCIO IMAGEM-WWF, 2004).

The main factors determining the predominance of formations with savanna phytophysionomies which characterize the biome are climate, soils and fire. This biome is characterized by average annual temperatures that vary from 22°C to 27°C, with a dominating tropical hot sub-humid climate, remarkably seasonal and characterized by a great quantity of annual rainfall (between 1,100 and 1,600 mm), mainly concentrated in a period of 6 to 7 months, between October and April, while the rest of the year is characterized by a strong dry season. The Cerrado region's geology is one of Brazil's most complex and diversified and its relief presents a broad scope of morphological features, especially depressions, plains and plateaus. The latter constitute a predominating feature and are characterized by flat extensive tabletops with very few drainage networks.

Apart from the climate, which according to Eiten (1994) produces indirect effects on vegetation, interfering in the soils' chemical and physical characteristics, in water and nutrient availability and in geomorphology and topography, flora distribution is also conditioned by latitude, frequency of burns, depth of the water table, pastures and several anthropic factors.

As a consequence of the environmental characteristics described above, this biome's vegetation presents a very diverse physiognomy throughout its extension, varying from the Cerrado open grasslands (grassy-woody savanna) to relatively dense forests as the cerradões (forest / wooded savanna) (RIBEIRO & WALTER, 2008).

According to Eiten (1994), the most common form of savanna in Central Brazil is the “trees and shrubs vegetation”, denominated as Cerrado *sensu stricto* (s.s) or Cerrado *sentido restrito*, which is a physiognomy characterized by well defined tree and shrub strata and tree cover varying from 10 to 60%. This form of Cerrado may vary according to density, being sparser or denser. A denser and higher forest formation, with trees up to 7 m or more (reaching up to 15 or 18 m, depending on the species), thus forming a practically closed canopy cover, is known as Cerradão.

Riparian vegetation along rivers, humid fields or *buriti veredas* can be found amidst the extensive savanna formations where the water table is superficial, and cloud or mesophyle forests are found on more fertile soils. Field formations present smaller tree covers than the Cerrado *sensu stricto* (s.s) and more sparse bushes; those are known as *campo* Cerrado and *campo sujo* (meaning “dirty” grasslands, with a scattering of shrubs and small trees). The most extreme form of field is the *campo limpo*, (meaning open grasslands) mainly with predominance of grassy herbaceous vegetation, with rare presence of bushes and complete absence of trees.

The different existing physiognomies in the Cerrado domain play a fundamental role for fauna, as they provide both shelter and food. In this context, forests, mainly gallery forests or riparian vegetation, act as important corridors, where significant genetic exchanges occur. This is considered as the richest flora in world savannas, as it is very rich from the floristic point of view (KLINK, 1996). Estimates consider the flora is composed of about 1,000 to 2,000 tree-shrub species and 2,000 to 5,250 herbaceous sub-shrub species (CASTRO *et al.*, 1999).

However, the decrease in diversity of vegetation formations constitutes a common fact in Cerrado areas subject to development projects. Several degrading events result from environmental modifications induced by human utilization of natural resources. The main interferences are: forest clearing, burns, replacement of flora by crop or cattle, introduction of machinery, supplies, pesticides, water exploitation, construction of dams and roads, among others. The main consequences are: extraction of flora species and chasing away of native fauna, erosion, soil compaction, loss of water and nutrients, soil, water and air pollution, silting and turbidity of rivers, destruction of aquatic fauna and flora, etc. In the case of soil, degrading effects are more extensive if soil is utilized not taking its resilience into consideration.

Floristic knowledge of the southern part of the State of Tocantins and the northern part of the State of Goiás is still very scarce, in spite of the remarkable representativeness of the Cerrado *strictu sensu* which is encountered in the remaining vegetation. Academic works were developed in the Chapada dos Veadeiros region and will be further detailed below (FELFILI & FAGG, 2007; MUNHOZ & PROENÇA, 1998; SOUZA, 1999; SILVA *et al.*, 2002). A survey executed by Munhoz & Proença (1998) mentions 1,310 flora phanerogam species in several phytophysionomies of the Chapada dos Veadeiros region. Souza (1999) executed a floristic survey at a farm in the municipality of Cavalcante, State of Goiás, in the surrounding area of the Chapada dos Veadeiros National Park, having sampled several phytophysionomies. Soares & Silva (2005) sampled 136 tree species in a gallery forest segment of Couros River.

5.2.2.1

Protected Areas

Assessment of Conservation Units (Unidades de Conservação – UC) or areas of relevant interest in the study area were undertaken using Federal databases for the State of Tocantins available at the Ministry of Environment (Ministério do Meio Ambiente – MMA), and databases at a State level, available at the Planning Secretariat of the State of Tocantins (Secretaria de Planejamento do Estado do Tocantins – SEPLAN). Both databases are available in the websites of the respective abovementioned governmental authorities.

Currently, the State of Tocantins has 14 Conservation Units (UCs): 12 are state-owned (4 total protection conservation units and 8 sustainable use conservation units); 2 are Federal: the Serra Geral Ecological Station (Estação Ecológica Serra Geral) and the Araguaia National Park (Parque Nacional do Araguaia).

The municipality of Arraias does not comprise any Federal, state or municipal UC in its territory. However, the municipality has potential preservation areas which have been mapped by SEPLAN – one is located in the center of the municipality, comprising the Serra de Arraias, with 101,960.77 ha, and another, located in the southwest region, comprising the Serra do Bom Despacho, with 34,021.59 ha.

Both of the abovementioned areas are within the class known as “priority areas for conservation”, which is a class that does not pose the same obligations and care as those stated in the SNUC (National System of Conservation Units, acronym in Portuguese, Law N° 9.985 of June 18, 2000). These “priority areas” were initially defined by legislation in the Decree No. 5092 of May, 21, 2004 and Ordinance n° 126 of May, 27, 2004 of the MMA (Brazilian Ministry of the Environment) and later reviewed in MMA Ordinance n°9 of January, 23, 2007, and are defined as areas which should receive priority for the creation of new Conservation Units, biodiversity research, recovery of degraded areas and populations of overexploited or threatened species, among other sustainable uses. This legislation does not prevent the destination of such areas for other uses, however.

The priority areas for conservation in the municipality of Arraias, State of Tocantins are within an approximate distance from the Project of 8.8 km and 50 km, respectively, for the area located in the center of the municipality and for the southwestern area.

Indigenous lands

According to the database made available by the National Foundation for the Indigenous Population (Fundação Nacional do Índio - FUNAI), the municipality of Arraias has no register of indigenous lands. The municipality of Arraias is characterized by the influence of the colonial period's historical mining context, when the indigenous populations were migrating to regions opposite to those that were being exploited for gold in the State of Tocantins. This fact explains the existence of indigenous communities in the northern and western regions of the State.

5.2.2.2

Vegetation

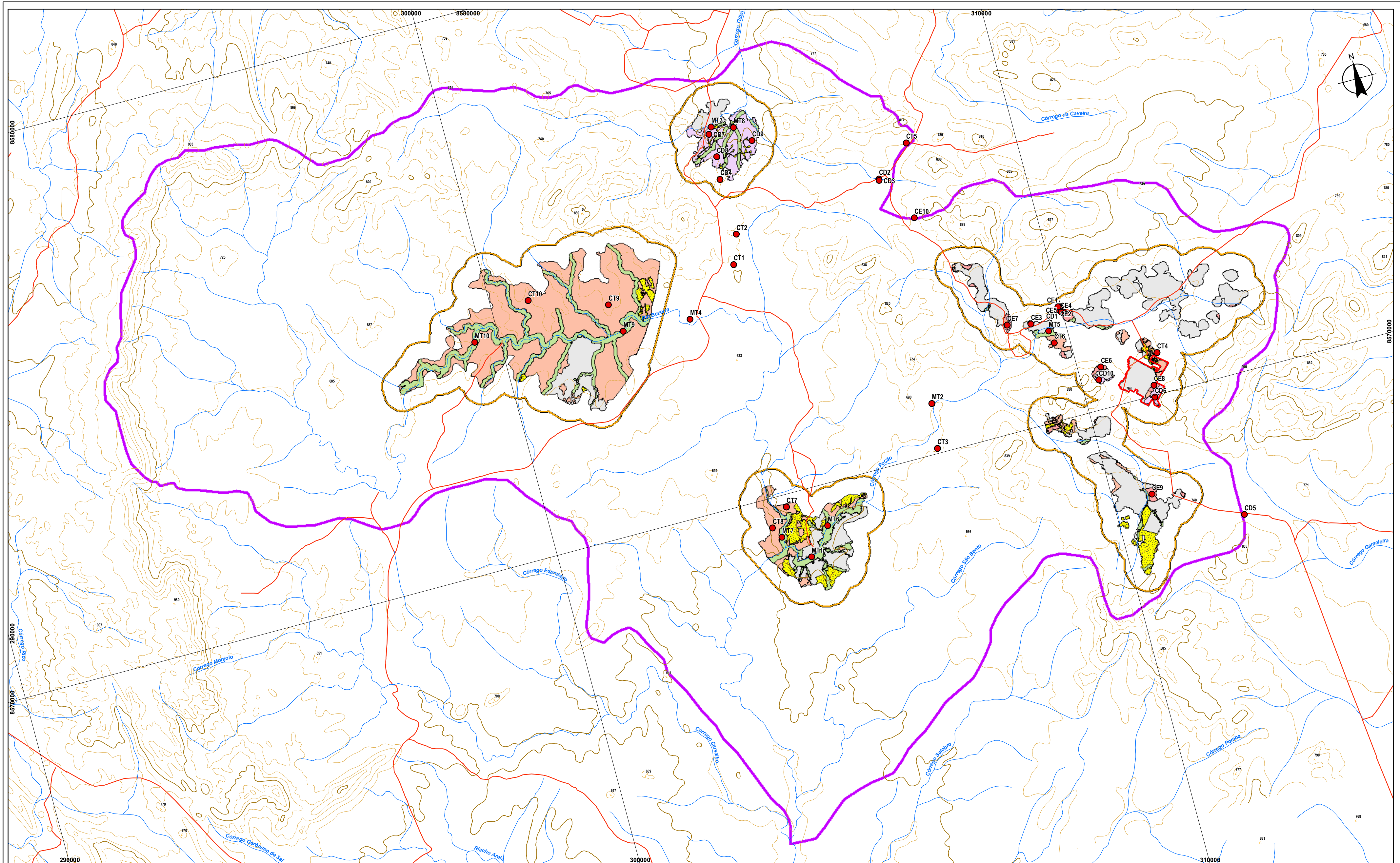
Methodology

Determination of vegetation cover in the Project area was initially executed using Worldview 2 high resolution satellite imagery, performed on March 28, 2010, and was also based on previous knowledge of typical vegetation formations of the region.

Following this stage, field work was executed in order to characterize flora occurring within the study area, comprising the planned mining areas and the construction areas of the industrial units, construction of water catchment and tailing dams and the sanitary landfill, as well as the Project's surrounding area in order to:

- Determine native vegetation areas to be cleared due to the Project's construction;
- Characterize native vegetation physiognomies found in the study area and in its surrounding area;
- Assist in the Project's planning activities in order to reduce or avoid negative impacts on native vegetation;
- Characterize land use and occupation in the study area and in the Directly Affected Area (DAA);
- Suggest mitigation and compensation measures for impacts affecting these locations.

Therefore, a floristic and phytosociological inventory was conducted to identify species during fieldwork and acquire knowledge about their quantities to establish the natural vegetation baseline in the area planned for the Project's construction and in the respective surrounding area. Field survey has made possible the establishment of boundaries and characterization of the vegetation physiognomies in aerial imagery, later incorporated on a land use and occupation map presented below (**Figure 5.2.2.2.a**).



- Legenda**
- Proposed Monitoring Points
 - Elevation Points
 - Master Curves
 - Industrial Plant
 - Intermediate Curves
 - Hydrography
 - Roadways
 - Directly Affected Area (Physical Environment)
 - Direct Area of Influence (Physical Environment)

- Vegetation and Land Use Class**
- Dense Cerrado
 - Typical Cerrado
 - Cerradão
 - Raparian Vegetation
 - Pasture Areas
 - Degraded Land



Source: Information obtained from environmental Impact Assessment - July 2010

0 0,2250,45 0,9 1,35 1,8 km

Scale: 1:45.000

Projection - Universal Transverse Mercator - UTM
Geodesic Reference System - South American Datum - SAD 69
Date: 06/04/2011 Fig. JGP: Figure Vegetation Map.mxd

CLIENT:

ItaFós
mineração

PROJECT: **PROJECT ARRAIAS**

FIGURE 5.2.2.2.a:
VEGETATION AND LAND USE MAP

JGP Consultoria e Participações Ltda.

Characterization of Physiognomies

Characterization of native vegetation (Cerrado) physiognomies aimed at identifying all existing vegetation typologies, and was executed by means of random walks within all the area of direct influence and area directly affected by PROJECT ARRAIAS. All characteristics referring to general aspects of the vegetation structure were registered, and identification was executed based on Ribeiro & Walter (2008).

Floristic Survey

Determination of the floristic composition of the area was conducted by the walking method, considering the different existing phytophysionomies. Identification was executed at the collection site when possible during fieldwork. Whenever taxonomic uncertainties arised, material from the species was collected and sent to the Tocantins Herbarium (HTO) of the Federal University of Tocantins in order to be identified by comparison with reference material, and the material collected was later deposited at the Herbarium. The registered individuals were identified according to the classification system based on the Angiosperm Phylogeny Group - APG II (SOUZA & LORENZZI, 2008).

Threatened species and species of conservation interest

Species conservation status was determined based on IBAMA threatened species list (Normative Instruction N° 6 of September 23, 2008), State Decree N° 838, of October 13, 1999, and Article N° 112 of the State of Tocantins Constitution. Species were also classified according to the following criteria: bio-indicator, endemic, economic importance, rare, exotic and threatened species.

Phytosociological analysis

Four phytosociological inventories were also executed in each one of the physiognomies encountered in the study area (Cerrado, dense Cerrado, cerradão and riparian vegetation) (**Table 5.2.2.2.a**). The most significant forest fragments of each physiognomy were sampled, focusing on the locations which will be affected by the construction phase of PROJECT ARRAIAS. The objective of this sampling is to provide quantitative relations between taxons, their horizontal structure and the community's diversity, assisting in the baseline study and the current characterization of the local native vegetation. **Table 5.2.2.2.a** shows the locations of parcels utilized for the phytosociological survey, according to each physiognomy studied.

Table 5.2.2.2.a
Parcel coordinates of the phytosociological survey according to physiognomy studied

Physiognomy	Coordinates				
	Parcel 1	Parcel 2	Parcel 3	Parcel 4	Parcel 5
Area 1: Cerradão	23 L 0309954 UTM 8572005	23 L 0309992 UTM 8571997	23 L 0309398 UTM 8571830	23 L 0310024 UTM 8571888	23 L 0309989 UTM 8571898
Area 2: Riparian vegetation	23 L 0304458 UTM 8568778	23 L 0307286 UTM 8570901	23 L 0304716 UTM 8576788	23 L 0303444 UTM 8573514	23 L 0309677 UTM 8571622
Area 3: Dense Cerrado	23 L 0309935 UTM 8571964	23 L 0304653 UTM 8574791	23 L 0307413 UTM 8575060	23 L 0304628 UTM 8575826	23 L 307680 UTM 8574042
Area 4: Cerrado (Typical)	23 L 0304465 UTM 8574269	23 L 0304482 UTM 8574268	23 L 0307174 UTM 8570088	23 L 0311477 UTM 8570738	23 L 0308061 UTM 8575591

Data referring to the phytosociological inventory of the tree-shrub strata (community) were obtained during fieldwork utilizing the parcels method (MUELLER-DOMBOIS & ELLENBERG, 1974). The parcels location was determined by random points within forest fragments, avoiding edge effects. From each point, a 20-m long and 50-m wide parcel was set up, totaling 1,000 m² parcels. Five equal parcels were assembled, comprising a total sampling area of 5,000 m².

In each parcel, all individuals were recorded, except for lianas and dead individuals, with Circumference at Breast Height (CAP, measured at 1.30 m from the ground) equal to or more than 10 cm. Data for each sampled individual was registered on the field worksheet with its total height estimate and its CAP measures obtained with a metric tape. In case of trees bifurcating below 1.30 m height, all trunks within the established inclusion limits were measured.

In order to execute calculations of the phytosociological inventory, field work data were processed utilizing Mata Nativa 2.0® (CIENITEC, 2006), an unbiased software. The following phytosociological parameters were calculated: frequency; density; dominance in absolute and relative values; Cover Value Index and Importance Value Index – IVI; and wood output.

A complementary phytosociological study will be undertaken, inventorying five new parcels for each physiognomy and using the same inclusion size utilized in the inventory previously presented in this report. Therefore, as sampling effort is increased, a higher floristic diversity and alteration in the phytosociological parameters is expected for the sampled species. Results obtained from the five new parcels will be analyzed together with data from sampling already obtained for each physiognomy. This means that phytosociological analysis for each physiognomy will be carried out based on the data from the 10 1,000 m² parcels.

The new parcels suggested for the complementary phytosociological survey include a larger spatial territory, comprising mining areas, according to the following Table (Table 5.2.2.2.b):

Table 5.2.2.2.b

Parcel coordinates for the new parcels suggested for the complementary phytosociological survey according to physiognomy studied

Physionomies	Coordinates				
	Parcel 6	Parcel 7	Parcel 8	Parcel 9	Parcel 10
Area1: Cerradão	23L 310417 UTM 8570748	23L 308973 UTM 8571922	23L 311265 UTM 8570178	23L 310718 UTM 8568278	23L 307860 UTM 8574257
Area2: RiparianVegetation	23L 304883 UTM 8569249	23L 304027 UTM 8569258	23L 305102 UTM 8576672	23L 302209 UTM 8573618	23L 299557 UTM 8574121
Area3: Dense Cerrado	23L 311224 UTM 8569965	23L 304640 UTM 8576669	23L 304670 UTM 8576238	23L 305365 UTM 8576356	23L 310324 UTM 8570533
Area4: Typical Cerrado	23L 309715 UTM 8571389	23L 304246 UTM 8569770	23L 303906 UTM 8569468	23L 302075 UTM 8574151	23L 300684 UTM 8574604

Results and discussion

Characterization of native vegetation physiognomies

The Cerrado biome is presented as a mosaic of physiognomy forms and, in the study area, the dominant physiognomy is the Cerrado *sensu stricto* (typical) with a high anthropic level, resulting from forest clearings and burns. Apart from this physiognomy, the region is characterized by Cerrado *sensu stricto* (dense), cerradão and riparian vegetation associated to water courses.

Typical Cerrado

Cerrado *sensu stricto* (typical) is characterized by bent and crooked trees, with irregular branches. The Cerrado *sensu stricto* occupies about 70% of the total Brazilian Cerrado area, and is composed by a continuous stratum of grass formations and other strata of tree and shrub woody vegetation covering about 50% of land surface (EITEN, 1972). Shrubs and sub-shrubs are spread and some species present perennial underground organs.

The floristic composition, despite being similar to the cerradão, has predominant ecotypes which characterize the environments according to the occupied geographical area. The most common tree species in the area are: *Astronium fraxinifolium* (gonçalo alves), *Annona coriacea* (bruto), *Byrsonima crassifolia* (murici), *Callisthene fasciculata* (capitão do campo), *Caryocar brasiliense* (piqui), *Curatela americana* (sambaíba), *Eugenia dysenterica* (cagaita), *Guetarda virbunoides* (angélica), *Luehea divaricata* (açoita cavalo), *Magonia pubescens* (timbó), *Psidium myrsinoides* (araçá) and *Qualea grandiflora* (pau terra).

Dense Cerrado

This is a subtype of predominantly arboreal vegetation, with 50% to 70% of cover and an average height of 5 to 8 meters. It represents the most dense and highest form of Cerrado *sensu stricto*. In some areas, this vegetation presents a continuous canopy cover, and arborous strata of straight and crooked individuals. Basically, it contains two strata: a tree-shrub stratum, formed by trees and shrubs with deep roots allowing them to reach the water table, and an herbaceous stratum composed by a grass formation of scrubland with shallow roots and high light intensity when spacing is considered.

The most frequent species registered which belong to this physiognomy are: *Alibertia edulis* (marmeladinha), *Astronium fraxinifolium* (gonçalo-alves), *Byrsonima crassifolia* (murici), *Callisthene fasciculata* (capitão do campo), *Caryocar brasiliense* (piqui), *Eugenia dysenterica* (cagaita), *Luehea divaricata* (açoita cavalo), *Machaerium acutifolium* (jacarandá), *Magonia pubescens* (tingui, timbó), *Pseudobombax tomentosum* (imbirucu), *Rhamnidium elaeocarpum* (bosta de cabrito) and *Terminalia argentea* (garroteiro).

Cerradão

Cerradão is characterized as a forest formation, although from a floristic point of view it has greater similarity with the Cerrado itself (RIBEIRO & WALTER, 2008). It presents a predominantly continuous canopy cover and an arboreal cover varying from 50 to 90%, and height varying from 8 to 15 meters. The physiognomy is in a good state of conservation; however, its surrounding area has little structural connectivity.

This formation has a renowned biological importance due to the fact it shelters a great number of threatened species, which are protected by the IBAMA Normative Instruction N° 6, of September 23, 2008, by State Decree N° 838, of October 13, 1999, which defines the Forestry Policy of the State of Tocantins and of Article N° 112 of the State of Tocantins Constitution. Several areas are crossed or limited by highways, which poses a risk to fauna and increases risk of fire.

The most frequent species in this physiognomy are: *Alibertia edulis*, *Aspidosperma subincanum*, *Brosimum gaudichaudii*, *Callisthene fasciculata*, *Callisthene mollissima*, *Dilodendron bipinnatum*, *Erythroxylum suberosus*, *Myracrodruon urundeuva*, *Myrcia rostrata*, *Piptadenia gonoacantha*, *Copaifera langsdorffii* and *Tabebuia roseo-alba*.

Riparian Vegetation

Riparian vegetation is indispensable to harmonize productive systems and the lifestyle of human populations, and mainly to provide for water quality and the maintenance of genetic flow between flora and fauna species. Its importance has been legally supported by Federal Law N° 4.771/1965 – Brazilian Forestry Code (Código Florestal Brasileiro), which defines that the environmental function of riparian vegetation is to preserve water resources, landscape, geological stability, biodiversity, and the genetic flow of fauna and flora, as well as to protect the soil and assure well-being of human populations (ANDRADE *et al.*, 2005).

In the Tocantins region, riparian vegetation presents a high level of human disturbance, mainly in urbanized areas, being frequently disturbed by forest clearing, burns, opening of roads and implementation of plantations. In the study area, likewise, the most serious threats to conservation of the riparian vegetations of Bezerra River and Poção Creek are related to land use in the surrounding areas, mainly those related to cattle breeding. Cattle grazing controls biomass of invasive grasses, thus decreasing negative impacts of competition and risk of fires. However, cattle may also act as a disperser of invading grass, aggravating invasions, apart from impacting the ecosystem due to trampling.

Therefore, the area of the riparian vegetation of these two water courses is inferior to the permanent preservation area, characterized by less crooked trees and many palm trees. In general, trees are predominantly straight and vary in height from 20 to 25 meters, with some few emerging individuals reaching 30 meters or more in height. The most frequent tree species found in the study area are: *Anadenanthera colubrina*, *Aspidosperma subincanum*, *Brosimum gaudichaudii*, *Byrsonima sericea*, *Coccoloba mollis*, *Myracrodruon urundeuva*, *Protium heptaphyllum* and *Attalea speciosa*.

Floristic Survey

Floristic

The survey encountered 136 species belonging to 45 families. The richest family was Fabaceae (Leguminosae) with 27 species, divided in three sub-families: Caesalpinoideae (9 species), Mimosoideae (7 species), Faboideae (11 species). Following come the Malvaceae and Myrtaceae families (9 species each), Vochysiaceae, Bignoniaceae (6 species each), Anacardiaceae and Sapindaceae (5 species each). The Malpighiaceae, Combretaceae and Apocynaceae families were represented by four species each, whereas the other families presented less than three representatives. The highest abundance was presented by *Rhamnidium elaeocarpum* (272 individuals), *Qualea grandiflora* (252 individuals) and *Magonia pubescens* (210 individuals).

The Fabaceae family has a broad distribution, including about 650 genera and approximately 18,000 species, representing one of the largest Angiosperm families, and also one of the most important from an economic point of view. In Brazil, Fabaceae presents about 175 genera and 1,500 species (SOUZA & LORENZI, 2008). The great richness of this family's vegetation formations in the Cerrado biome is mentioned by several authors with regards to its broad distribution and ecological plasticity (FELFILI, 1994; SILVA JÚNIOR, 1999; NÓBREGA *et al.*, 2001, SILVA *et al.*, 2002).

The Malvaceae family includes the former Sterculiaceae, Tiliaceae and Bombacaceae, as phylogeny works have evidenced that distinctions between these families are unsustainable (JUDD & MACHESTER, 1997; ALVERSON *et al.*, 1999 *apud* SOUZA & LORENZI, 2008). Therefore, the genera they comprised are now treated as Malvaceae, which in turn makes this family one of the richest in the Cerrado, from a floristic point of view.

The Myrtaceae family is renowned for its high richness throughout the Neotropical region (GENTRY 1995). The Vochysiaceae family has a high incidence on soils with high acidity and low nutrient availability, as those which are predominant in the Cerrado *stricto sensu*, including several species that store aluminum without suffering apparent damage (HARIDASAN, 2000).

The most representative genera in number of species was *Tabebuia*, with five species; followed by *Myrcia* and *Byrsonima*, with four species; *Diospyros*, *Andira*, and *Qualea* with three; and *Anacardium*, *Psidium*, *Alibertia*, *Casearia*, *Pouteria*, *Simarouba*, *Callisthene*, *Erytheca*, *Luehea*, *Pseudobombax*, *Brosimum*, *Eugenia*, *Aspidosperma*, *Machaerium*, *Licania*, *Terminalia*, *Bauhinia*, *Hymenaea* and *Sclerolobium*, with two species each.

Species largely dispersed in the Brazilian Cerrado *sensu stricto* are: *Qualea parviflora*, *Q. grandiflora*, *Q. multiflora*, *Curatella americana*, *Annona crassiflora*, *Dimorphandra mollis*, *Salvertia convallariaeodora* and *Psidium myrsinoides* (RATTER *et al.*, 2003). On the other hand, species with limited geographic distribution were found, such as: *Callisthene mollissima*, which is abundant in the Cerrados area of southwestern Tocantins and northern Goiás (FELFILI *et al.*, 2007, FELFILI & FAGG, 2007), although it is rare in other regions of the Cerrado biome.

With regards to floristic species in the Cerrados *sensu stricto* of the study area, the following forest species which commonly occur in the transition area between the Cerrado and forest environments were found, such as: *Anadenanthera peregrina*, *Dilodendron bipinnatum*, *Terminalia argentea*, *Callisthene fasciculata*, *Cordia glabrata*, *Guazuma ulmifolia*, *Magonia pubescens* and *Myracrodruon urundeuva*, which indicate soil patches that are more fertile (RATTER *et al.*, 1978).

The following species are indicators of mesotrophic soils: *Tabebuia roseo-alba*, *Pseudobombax tomentosum*, *Terminalia argentea*, *Rhamnidium elaeocarpum*, *Magonia pubescens*, *Luehea divaricata*, *Dipteryx alata*, *Astronium fraxinifolium* and *Callisthene fasciculata* (RATTER *et al.* 1996). Floristic surveys and phytosociological studies have evidenced that environmental and soil factors, as mentioned in this study, can be responsible for the vegetation's floristic and structural variability.

5.2.2.3

Forestry Resources

Threatened Species and Conservation Interest Species

Utilization of flora species by human population is as ancient as the human species itself. Since the early days of mankind, plants have been used as food, as raw material for construction of houses, as treatment for various diseases, among others. Several Cerrado wood species can potentially be utilized by man and many of these produce edible fruit (ALMEIDA *et al.*, 1987; FONSECA & MUNIZ, 1992). Native species with phytotherapeutic value are equally important and are being utilized in popular medicine (MARTINS & CALDAS, 2000). There are some with high wood output and others with potential for ornamental and landscape activities.

However, many of the species have suffered constant anthropic interventions which have resulted in environmental degradation. In face of this problem, studies in areas which have suffered some type of degradation are very important since they allow identification of environmental impacts and management techniques to reinstate initial environmental conditions. The existence of several populations of tree species with wood output, as *Tabebuia roseo-alba*, *Myracrodruon urundeuva* and *Astronium fraxinifolium* qualify the project area as an important source of vegetation material (seeds, pollen and wood products) and the maintenance of arboreal diversity of these communities on a regional scale should be considered a priority. These two latter species are found in Brazil's List of Threatened Flora, developed by IBAMA (2008).

Article N° 112 of the Constitution of the State of Tocantins (1989) states the obligation of preserving natural and planted vegetation areas including fruit-bearing tree species used by communities and by the wild fauna. Among the plant species listed in this legislation, the following are found at the project area according to the surveys undertaken: *Attalea speciosa* (babaçu), *Caryocar brasiliense* (pequi), *Hymenaea stigonocarpa* (jatobá do Cerrado) and *Hymenaea courbaril* (jatobá). Other fruit-bearing species registered at the project area which may also be considered as included within the scope of this legislation are: *Copaifera langsdorffii*, *Hancornia speciosa* (mangaba), *Buchenavia tomentosa* (mirindiba), *Xylopia aromatica* (pimenta de macaco), *Byrsonima* spp. (murici), *Anacardium humile* and *Anacardium occidentale* (cashew).

Federal Decree N° 838, which establishes the Forestry Policy of the State of Tocantins, defines that the management or exploitation of all species covered by Article N° 112, described above, and also of a number of other species, depends on approval of a sustainable forestry management plan and authorization by NATURATINS. Species registered at the project area included within the scope of this Decree are all those mentioned in the paragraph above, as well as: *Myracrodruon urundeuva* (aroeira), *Astronium fraxinifolium* (Gonçalo-alves), *Tabebuia aurea* (ipê-caraíba), *Tabebuia impetiginosa* (ipê roxo), *Tabebuia roseo-alba* (ipê branco), *Tabebuia ochracea* (ipê amarelo), *Tabebuia serratifolia* (ipê-amarelo), *Piptadenia gonoacantha* and *Acrocomia aculeata*.

According to the IBAMA threatened species list (MMA Normative instruction N°6 of September 23rd, 2008) two species are considered threatened: *Myracrodruon urundeuva* (aroeira) and *Ocotea odorifera* (louro) and one species is considered data deficient (*Astronium fraxinifolium*, gonçalo-alves). Additionally, one subspecies of a species registered at the project area but not identified to the subspecies level is also considered data deficient according to IBAMA's list: *Protium heptaphyllum* ssp. *cordatum*.

The potential for medicinal use is also attributed to part of the abovementioned species, as well as others encountered in the Cerrado *sensu stricto* of the study area, thus reinforcing the economic potential of these areas, which, in turn, may be strengthened by the establishment of sustainable extractivism management plans. Apart from their economic potential, such species present a high potential for attracting local fauna and bird fauna of the Cerrado biome, and, for this reason, they are essential for environmental reinstatement projects which aim at the genetic linkage between remaining fragments of the region's native vegetation.

Due to the species' qualities, the resulting demand for them has led to a reduction in the size of natural populations and, in some areas, has reduced them drastically. Intense utilization of Cerrado species is further evidence that the richness of its biodiversity can generate differentiated products to create market niches or expand products' offer in less explored markets. It is important to note that several vegetation species of the Cerrado biome have an economic potential and multiple usages.

Utilization of native species is an economic alternative of the region's sustainable development. There are several species utilized regionally, and many of them may be used for more than one end. However, the end user is still represented by the regional population whose activity is essentially based on extractivism.

Several species registered in this study may be utilized as food for fauna, considering both direct fruit supply and flowers, which in turn, rely on several animals as pollination and dispersion agents (**Table 5.2.2.3.a**).

Table 5.2.2.3.a**Utilization of Cerrado native plants registered in the Project's vegetation surveys.**

Scientific Name	Common Name	Potential Use
<i>Acosmium dasycarpum</i> (Vogel) Yakovle	Para tudo	me, or, ta.
<i>Acrocomia aculeata</i> (Jacq.) Lodd	Macaúba	al, ar, or, ol, ml.
<i>Alibertia edulis</i> (L. C. Rich.) A. Rich.	Marmelada	al, or, me.
<i>Alibertia verrucosa</i> S. Moore	Marmeladinha	al, or, me.
<i>Anacardium humile</i> Saint Hill	Cajuí	al, ml, me, ta.
<i>Anacardium occidentale</i> L.	Caju	al, ml, me, ta.
<i>Anadenanthera colubrina</i> (Vell.) Brenan	Angico branco	al, ml, me, ta.
<i>Andira cuyabensis</i> Benth.	Angelim	al, ar, or, ol, ml.
<i>Andira legalis</i> (Vell.) Toledo	Angelim verdadeiro	al, ar, or, ol, ml.
<i>Andira vermifuga</i> Benth	Angelim	al, ar, or, ol, ml.
<i>Annona coriacea</i> Mart.	Bruto	al, ar, or, ml.
<i>Apeiba tibourbou</i> Aubl	Pente de macaco	ar, ma, ml, or, ta.
<i>Apuleia leiocarpa</i> Vog. Macbride	Garapa, grapiá	ma, me, or, ti, ml.
<i>Aspidosperma macrocarpa</i> Mart	Pereira	al, ar, or, ol, ml.
<i>Aspidosperma subincanum</i> Martius	Pau pereira	al, ar, or, ol, ml.
<i>Astronium fraxinifolium</i> Schott.	Gonçalo alves	ma, me, or, ta, ti.
<i>Attalea speciosa</i> Mart. ex. Spreng	Babaçu	al, ar, or, ol, ml.
<i>Bauhinia rufa</i> (Bong.) Steud	Pata de vaca	ar, me, or,
<i>Bowdichia virgilioides</i> Kunth	Sucupira preta	al, ar, or, ol, ml.
<i>Brosimum gaudichaudii</i> Trécul.	Mama-cadela	ma, me, or, ta, ti.
<i>Brosimum lactescens</i> (S. Moore) C. C. Berg	Inharé	ma, me, or, ta, ti.
<i>Buchenavia tomentosa</i> Eichler.	Mirindiba	al, or.
<i>Byrsonima crassa</i> Niedenzu	Murici vermelho	al, or.
<i>Byrsonima crassifolia</i> L. Rich	Murici	al, or.
<i>Byrsonima sericea</i> DC	Murici grande	al, or.
<i>Byrsonima verbascifolia</i> (L.) Rich	Murici cascudo	al, or.
<i>Callisthene fasciculata</i> Mart.	Capitão do campo, Jacaré	ar, ma, me, ml, or, ti.
<i>Callisthene mollissima</i> Warm	João farinha	ar, ma, me, ml, or, ti.
<i>Caryocar brasiliense</i> Cambess	Piqui	al, or, me, ml, ol, ta.
<i>Casearia arborea</i> (Rich.) Urb	Folha de carne	ma, me,
<i>Casearia sylvestres</i> SW.	Guaçatonga	ma, me,
<i>Cenostigma macrophyllum</i> Tul.	Pau ferro	ma, me, ml, or, ta.
<i>Copaifera langsdorffii</i> Desf	Pau d'oleo, copaiba	ml, ma, me, or, ol, ti.
<i>Curatella americana</i> L.	Sambaíba	ma, me, ml, or, ta.
<i>Davilla elliptica</i> St. Hil.	Sambaibinha	ma, me, ml, or, ta.
<i>Dilodendron bipinnatum</i> Radlk.	Mamoninha	ml, ma, me, or, ol, ti.
<i>Diospyros brasiliensis</i> Mart. ex Mig.	Olho de boi da mata	al, or, me.
<i>Diospyros burchellii</i> DC	Olho de boi da mata	al, or, me.
<i>Diospyros hispida</i> A. DC	Olho de boi	al, or, me.

Scientific Name	Common Name	Potential Use
<i>Emmotum nitens</i> (Benth.) Miers	Sobre	al, ma, or.
<i>Enterolobium contortisiliquum</i> (Vell.) Morong	Orelha de negro	ar, al, ma, me, or.
<i>Eriotheca gracilipes</i> (K. Schum.) A. Robyns	Painera do campo	ar, al, ma, me, or.
<i>Eriotheca pubescens</i> (Mart. & Zucc.) Schott. & Endl.	Imbiruçu	ar, al, ma, me, or.
<i>Erythroxylum suberosus</i> St. Hil	Mercúrio do campo	al, me, or.
<i>Eugenia aurata</i> Berg	Maria Preta	ar, al, ma, me, or.
<i>Eugenia dysenterica</i> DC	Cagaíta	al, ar, or, ol, ml.
<i>Ficus</i> sp.	Gameleira	ml, ma, me, or, ol, ti.
<i>Genipa americana</i> L	Genipapo	al, me, or.
<i>Guazuma ulmifolia</i> Lam	Mutamba	ar, al, ma, me, or, ti.
<i>Guettarda viburnoides</i> Cham. & Schltdl	Angélica	ar, ma, ml, or, ol, ta.
<i>Hancornia speciosa</i> Gomez.	Mangaba	al, or, ol, ta
<i>Himatanthus obovatus</i> (Müll. Arg.) Woodson	Tiborna	al, me, or.
<i>Hymenaea courbaril</i> L.	Jatobá da mata	al, ma, me, ti.
<i>Hymenaea stigonocarpa</i> Mart.	Jatobá	al, ma, me, ti.
<i>Jacaranda brasiliana</i> (Lam.) Pers. N	Jacarandá	ar, ma, ml, or, ol, ta.
<i>Kielmeyera coriacea</i> Mart.	Pau santo	ar, or, ml
<i>Lafoensia pacari</i> Saint-Hilaire	Mangabeira	ol, ml, me
<i>Licania humilis</i> Cham. & Schltdl.	Farinha seca	ar, ma, ml, or, ol, ta.
<i>Luehea divaricata</i> Martus et Zuccarini	Açoita cavalo	ar, ma, ml, or, ol, ta.
<i>Luehea paniculata</i> Mart. & Zucc.	Açoita cavalo graúdo	ar, ma, ml, or, ol, ta.
<i>Machaerium acutifolium</i> Vogel	Jacarandá do campo	ma, me, or.
<i>Machaerium opacum</i> Vogel	Jacarandá cascudo	ma, me, or.
<i>Magonia pubescens</i> A. St. Hill	Tingui, timbó	ar, ma, ml, or, ol, ta.
<i>Mapronea guianensis</i> Aubl. P. C	Pau pobre	ml, ma, me, or, ol, ti.
<i>Myracrodruon urundeuva</i> Fr. All.	Aroeira	ma, me, or, ta, ml.
<i>Myrcia rostrata</i> DC	Goiabinha	al, ma, me, ti.
<i>Myrcia sellowiana</i> Berg	Goiaba míuda	al, ma, me, ti.
<i>Myrcia tomentosa</i> Glaz	Araça largo	al, ma, me, ti.
<i>Myrtaceae</i> sp.	Goiabinha araça	al, ma, me, ti.
<i>Ocotea odorifera</i> (Vellozo) Rohwer	Louro	ar, ma, ml, or, ol, ta.
<i>Ocotea</i> sp.	Canela	ar, ma, ml, or, ol, ta.
<i>Ouratea castaneifolia</i> (DC.) Engl.	Serrinha	ar, ma, ml, or, ol, ta.
<i>Physocalymma scaberrimum</i> Pohl	Cega machado	ar, ma, ml, or, ol, ta.
<i>Piptadenia gonoacantha</i> (Mart.) Macbr.	Angico	al, ml, me, ta.
<i>Platymenia reticulata</i> Benth	Candeia, vinhático	al, ma, me, ti.
<i>Pouteria gardnerii</i> (Mart. & Miq.) Baehn	Fruta de viado	al, ml, me, or, ol, ti.
<i>Pouteria</i> sp.	Abiu	al, ml, me, or, ol, ti.
<i>Protium heptaphyllum</i> March	Almecega	al, ml, me, or, ol, ti.
<i>Pseudobombax longiflorum</i> (Mart. & Zucc.) A. Robyns.	Paineira	ar, ml, or, ol, ta.
<i>Pseudobombax tomentosum</i> (Mart. & Zucc.) A. Robyns.	Embiruçu	ar, ml, or, ol, ta.

Scientific Name	Common Name	Potential Use
<i>Psidium myrsinoides</i> O.Berg	Araça	al, ma, me, ti.
<i>Pterodon emarginatus</i> Voge	Sucupira branca	ar, ma, me, ml, or, ti.
<i>Qualea grandiflora</i> Mart	Pau terra da folha larga	ar, ma, me, ml, or, ti.
<i>Qualea multiflora</i> Mart.	Pau-terra do campo	ar, ma, me, ml, or, ti.
<i>Qualea parviflora</i> Mart.	Pau terra da folha miúda	ar, ma, me, ml, or, ti.
<i>Rhamnidium elaeocarpum</i> Reissek	Bosta de cabrito	
<i>Roupala montana</i> Aubl	Mijo de guará	ar, ml, or.
<i>Salvertia convalariaeodora</i> St.Hill	Folha larga	ar, ma, me, ml, or, ti.
<i>Sclerolobium aureum</i> (Tul.) Benth	Tatarema	ma, ml, ti.
<i>Sclerolobium paniculatum</i> Vogel	Cachamorra, carvoeiro	ma, ml, ti.
<i>Simarouba amara</i> Aub	—	ma, me, or, ta, ti.
<i>Simarouba versicolor</i> St. Hil	Mata cachorro	ma, me, or, ta, ti.
<i>Siparuna guianensis</i> Aublet	Negramina	me, or ol, ta, ti.
<i>Sterculia striata</i> A.St.-Hil. & Naudin	Chichá	ma, me, or, ta, ti.
<i>Strychnos pseudoquina</i> St. Hil.	Quina	me, or ol, ta, ti.
<i>Styrax ferrugineus</i> Nees & Mart.	Laranjinha do campo	ma, me, or, ta, ti.
<i>Tabebuia aurea</i> (Manso) Benth. & Hook.	Ipê caraíba	ma, me, or, ti, ml.
<i>Tabebuia impetiginosa</i> (Mart. ex DC.) Standl	Ipê roxo	ma, me, or, ti, ml.
<i>Tabebuia ochracea</i> (Cham.) Standl.	Ipê amarelo	ma, me, or, ti, ml.
<i>Tabebuia roseo-alba</i> (Ridl.) Sand.	Taipoca	ma, me, or, ti, ml.
<i>Tabebuia serratifolia</i> (Vahl) Nichols.	Ipê-amarelo	ma, me, or, ti, ml.
<i>Talisia sculenta</i> Radlk	Pitomba	ma, me, or, ti, ml.
<i>Tapirira guianenses</i>	Pau-pombo	al, ml, me, or, ol, ti.
<i>Terminalia argentea</i> Mart. & Zucc.	Capitãozinho	ml, me, or, ol, ti.
<i>Terminalia lucida</i> Hoffmanns	Pubeiro	ml, me, or, ol, ti.
<i>Tocoyena formosa</i> (Schum. & Schlecht) Schum.	Genipapo bravo	ma, me, or, ti, ml.
<i>Triplaris gardneriana</i> Wedd.	Pajeú	ar, ml, or, ol, ta.
<i>Vatairea macrocarpa</i> (Benth.) Ducke.	Amargoso	al, ma, me, ti.
<i>Xylopia aromatica</i> (Lam.) Mart.	Pindaíba	al, ar, me, re.
<i>Zanthoxylum rhoifolium</i> Lam.	Mamica de porca	ml, ol, ta

Legend: al: food; ar: artisanal/handicraft; ma: wood; ml: honey; me: medicinal; ol: oil; or: ornamental; ta: tanning; ti: dyeing
 Fonte: AMBIENGER, 2010.

Phytosociological Analysis

Surveys which are exclusively floristic allow relatively simple and efficient comparisons between a great number of areas. However, differences and similarities between areas which are geographically close and/or similar from a floristic point of view may be approached considering quantitative data supplied by phytosociological surveys, due to the fact that quantitative differences between the areas may be much more striking than floristic differences (CAUSTON, 1988). Measures of species abundance and distribution are essential when the objective is to acquire knowledge about vegetation structure and build a theoretical basis in order to subsidize management, conservation and/or recovery of similar areas (VILELA *et al.*, 1993).

Quantification of solid wood volume is essential for the implementation of forest sustainable management plans. In order to quantify this volume, a forest inventory was carried out, consisting in the measuring of part of the population, i.e., measuring sampling units or parcels, and further extrapolating of these results for the total area. Therefore, an estimate of the available quantity and distribution of wood is obtained in order to plan forest operations.

The wood stock volume is low when compared to other forest biomes, implying that any clear-cutting of wood is not economically justified. However, the development of a forest product management plan may become interesting when the presence of highly diverse characteristics and of several forest products, such as bark, resins, seeds, and some wood species, are considered.

Typical Cerrado

A total of 952 individuals distributed in 68 species were sampled. The main species according to their Importance Value Index (IVI) are, in descending order: *Curatella americana*, *Eugenia dysenterica* and *Rhamnidium elaeocarpum*, representing together 42.88% of the identified individuals; followed by: *Qualea grandiflora*, *Magonia pubescens*, *Byrsonima crassifolia*, *Luehea divaricata*, *Astronium fraxinifolium*, *Psidium myrsinoides* and *Kielmeyera coriacea*, which together represent 52.4% of total.

The four species with the highest IVI have a broad distribution in the Cerrados dominium. Ratter *et al.* (1996), when analyzing the floristic composition of 98 Cerrado areas and the Amazon savannas verified that these species were present in 71% and 60% of the study areas, respectively. Furley *et al.* (1988) considered these species as generalists, while Felfili *et al.* (1994) have observed that *Curatella americana* is most abundant in lower altitude Cerrado areas, which seems to be the case in the present study.

Species with the lowest incidence are: *Aspidosperma macrocarpa*, *Bauhinia rufa*, *Diospyros burchellii*, *Erytheca pubescens*, *Eugenia aurata*, *Lafoensia pacari*, *Luehea paniculata*, *Matayba guianensis*, *Myrtaceae* sp., *Pseudobombax tomentosum*, *Pterodon emarginatus*, *Rourea induta*, *Salacia campestris*, *Simarouba versicolor*, *Tabebuia ochracea*, *Zanthoxylum rhoifolium*, with only one individual, adding up 2.78% of collected individuals.

Total wood stock volume calculated for this physiognomy was of 28.20 m³/ha. As expected from its defining characteristics, this was the lowest value found among all four surveyed physiognomies.

Cerradão

The Cerradão was sampled in three vegetation fragments which were close to each other. The low representativeness of cerradão has been reported for the entire region of the Cerrado biome, resulting from its naturally fragmented distribution, which occurs in mosaics with areas of Cerrado *sensu stricto*, and from the high level of replacement of this phytogeography by agricultural and livestock activities. As in other regions of the Cerrado biome, the Cerradão of the study area is characterized by the great importance of species common in the riparian vegetation, the semideciduous forests and the Cerrado *sensu stricto*.

A total of 830 individuals distributed in 88 species were registered; eight species were identified only at genera level, whereas four species did not have their identification confirmed. Species with the highest Importance Value Index (IVI) were, in descending order: *Myracrodruon urundeuva*, *Dilodendron bipinnatum*, *Piptadenia gonoacantha*, *Tabebuia roseo-alba* and *Astronium fraxinifolium*.

The study area shows a considerable level of balance, presenting a high floristic richness and a considerable level of conservation, attributes which comprise key information for development of studies and projects. The design of management and sustainable extractivism strategies relies fundamentally on the information gathered for future assessment of impact, conservation and planning of regional production.

Total wood stock volume calculated for this physiognomy was of 77.72 m³/ha. This value was higher than those for both Typical and Dense Cerrado, but lower than that for Riparian Vegetation. This is consonant with expectations due to the formations's characteristics as a forest formation, albeit less dense than other forest physiognomies.

Dense Cerrado

A total of 1,120 individuals distributed in 65 species were sampled. *Callisthene fasciculata* presented the highest Importance Value Index (IVI), representing 10.24% of the total sample. The second highest IVI was presented by *Magonia pubescens*, which also obtained the highest density values. A high frequency value was obtained by *Terminalia argentea*.

The most frequent species among the main species collected were: *Magonia pubescens* with 133 individuals, *Callisthene fasciculata* with 112 individuals, *Rhamnidium elaeocarpum* with 89 individuals, *Qualea grandiflora* with 88 individuals and *Terminalia argentea* with 73 individuals. These five species represent 44.19% of the total species collected. Species with lower incidence were: *Brosimum gaudichaudii*, *Byrsonima verbascifolia*, *Himatanthus obovatus*, *Jacaranda brasiliensis*, *Machaerium opacum*, *Protium heptaphyllum* and *Zanthoxylum reipholium*, with only one individual each.

On the other hand, species presenting a single individual in the sampling, considered as rare in the study area of the Dense Cerrado, were: *Machaerium opacum*, *Jacaranda brasiliense*, *Byrsonima verbascifolia*, *Himatanthus obovatus*, *Protium heptaphyllum*, *Brosimum gaudichaudi*, *Zanthoxylum reipholium* and one individual which was not identified.

In the dense Cerrado area, species presenting the largest volumes also presented the largest number of individuals, such as: *Callisthene fasciculata* (112 individuals), *Magonia pubescens* (133 individuals), *Terminalia argentea* (73 individuals) and *Rhamnidium elaeocarpum* (89 individuals). It is also important to note that *Callisthene mollissima* with 19 individuals and *Caryocar brasiliense* with 18 individuals presented, respectively, the fifth and sixth largest volumes.

Total wood stock volume calculated for this physiognomy was 42.56 m³/ha. This is much lower than the values for the studied forest physiognomies (Cerradão and Riparian Vegetation), but still more than 50% higher than the wood stock volume for the Typical Cerrado formation.

Riparian Vegetation

The present study observed that these riverine formations are not in a good state of conservation, showing signs of degradation. In general, the fragments which were not replaced by pastures and agricultural activities show the signs of previous fire events. The best preserved fragments have developed in rugged terrains. A total of 701 individuals belonging to 89 species were registered during the phytosociological survey in the riparian vegetation fragments. Out of these, ten species were identified at the genus level, whereas three remained without confirmed identification.

Species presenting the highest Importance Value Index (IVI) are: *Attalea speciosa*, *Dilodendron bipinnatum*, *Myracrodruon urundeuva*, *Rhamnidium elaeocarpum*, *Brosimum gaudichaudii*, *Astronium fraxinifolium* and *Guazuma ulmifolia*.

Estimates of species richness and density are within the values found for riparian vegetation in different localities of the State of Tocantins. Richness of species per hectare and values for the basal area (represented by dominance of boles per hectare) although slightly smaller than the ones found for other samplings, are considered to be within typical values for this type of vegetation.

In the riparian vegetation area, species presenting the highest wood stock volumes were: *Attalea speciosa* (12.37 m³ with 11 individuals), *Dilodendron bipinnatum* (3.1072 m³ with 38 individuals), *Myracrodruon urundeuva* (2.99 m³ with 34 individuals) and *Hymenaea courbaril* (2.64 m³ with 15 individuals). Total wood stock volume calculated for this physiognomy was of 86.81 m³/ha, the highest value among all formations surveys, as expected due to its characteristics as a typical forest formation.

Characterization of land use and occupation in the Directly Affected Areas

The Directly Affected Areas – DAA – relate to the structures to be built after approval of PROJECT ARRAIAS. The structures considered are: tailings dam, water catchment dam, phosphate mining areas, industrial facilities and sanitary landfill. The structures comprise a total area of 1,492.56 ha, representing 8,62% of the Project's study area established for the Physical and Biotic environment. Cultivated areas are present especially in the São Bento block, the Near-mine blocks and in parts of the Tailings Reservoir, although some are also present in the Water Catchment Reservoir. Most of these consist of cultures for complementation of the families' own consumption; subsistence cultures are present in two cases, within the Tailings reservoir and the São Bento Mining area.

The presentation of each area comprised in the construction of PROJECT ARRAIAS is further detailed below. **Table 2.6.2.a** presents a quantification of the Directly Affected Areas – DAA – according to land coverage criteria. Total DAA land coverage reveals that 62.18% refers to areas with natural vegetation. The most significant coverage is the typical Cerrado, with 39.50% followed by riparian vegetation with 16.33%, dense Cerrado with 4.96%, and cerradão with a total of 1.39%. The DAA's anthropic areas total 37,80%, pastures and degraded land represent 28.20% and 9.60%, respectively, and built areas represent 0.02%.

Industrial facilities

The planned area for construction of the industrial facilities or industrial units comprises a total area of 44.67 ha. The area is composed by: pasture areas, 43.19 %; degraded land, 25.12%; typical Cerrado, 13.53%; dense Cerrado, 13.84%; and Cerradão, 4.32%. The pasture areas show some isolated and scattered native trees. The Cerrado *sensu stricto* (typical) is part of one of the greatest remaining portions of natural vegetation in the study area. Nonetheless, only a minor part of the edge of this remaining portion of natural vegetation will be cleared.

Water Catchment Dam

The area planned for construction of the water catchment dam is composed by natural vegetation in 47.80% of its total area (216.77 ha). Natural vegetation cover is represented by typical Cerrado with 23.99% followed by riparian vegetation with 23.81%. Pasture areas and degraded land represent the remaining 52.20%.

The dam will affect Poção Creek and Bezerra River. However, this intervention will not result in significant impacts to native vegetation. This is due to the fact that these two water courses have been thoroughly affected by human intervention in the past and as a result are generally non-characteristic, showing signs of constant degradation in view of the presence of cattle in the surrounding area. The construction of the water catchment dam will also affect areas of the Cerrado *sensu stricto* (typical), which is highly degraded, most probably due to constant trampling.

Tailings Dam

The tailings dam design has planned a 20-year lifespan, being the largest structure in the continuous area of the PROJECT ARRAIAS, and consequently generating the greatest environmental impact. Comprising a total area of 741.26 ha, the tailings dam area has a natural vegetation cover of 89.66%. The typical Cerrado represents 68.35% and the riparian vegetation, 21.31%. The remaining 10.44% are represented by anthropic areas, where 8.78% are pasture, 1.65% is degraded land and 0.01% represents built areas.

The tailings dam will interfere in the course of the Bezerra River; however, its riparian vegetation is highly altered and thus shows characteristics different from those of the original vegetation, presenting low forest height and individuals with an average diameter below 10 cm. The tailings reservoir will also clear of an area superior to 500 ha of Cerrado *sensu stricto* (typical). However, this vegetation is also significantly degraded, most probably due to the fact that the area suffers constant interferences caused by agriculture and livestock activities and by fires. These are used by the region's land owners to manage pasture areas and "clean" road edges, and end up interfering in the native vegetation's state of conservation.

Mining Areas

Mining areas planned for the Project are distributed in five DNPM (National Department for Mineral Production, acronym in Portuguese) Polygonal Areas (864.113/2003, 864.173/2004, 864.174/2004, 864.175/2004 and 864.176/2004). The mining areas correspond to 30.14% of the PROJECT ARRAIAS' DAA, with a total area of 488.85 ha. Anthropogenic areas are the most representative, comprising 70.17% of the area. Pasture and degraded land areas total 70.13%, whereas built areas total 0.04%. Areas covered by natural vegetation occupy only 29.83%, (145.82 ha) distributed as: typical Cerrado (5.26%, 25.71 ha), dense Cerrado (13.88%, 67.85 ha), cerrado (3.85%, 18.82 ha) and riparian vegetation (6.84%, 33.44 ha).

Final Considerations

The implementation of PROJECT ARRAIAS will result in impacts to the native vegetation due to the clearing of 928.04 ha of native vegetation, including 145.81 ha in mining areas (15.71%), 14.15 ha in the Industrial site (1.52%), 664.47 ha in the Tailings Reservoir (71.60%) and 51.60 ha in the Water Catchment Reservoir (11.16%). Cerrado *sensu stricto* (typical) and riparian vegetation areas, despite being in a rather degraded state when compared to the original vegetation, will be the physiognomies to suffer the greatest interventions (590.30 and 242.96 ha, respectively). Apart from this, riparian vegetation is also known for forming natural ecological corridors.

The areas of native vegetation to be cleared during the Project's implementation and operation represent 62.18% of the total area of the Project's Directly Affected Areas (DAAs). Native vegetation comprises 29.83% of the area of mining sites, 31.68% of the Industrial site, 89.64% of the Tailings Reservoir and 47.80% of the Water Catchment Reservoir. Endangered flora species are also present within these areas, as described above and mentioned below.

The Project's impacts in the Cerrado *sensu stricto* areas (dense) (74.02 ha) and in the Cerradão (20.77 ha) will be of great significance due to the good state of these physiognomies' conservation in this area and to the fact that these areas are being considered for conservation purposes. The floristic and phytosociological survey has allowed a good acknowledgement of the floristic composition of the physiognomies encountered in the study area, especially the registry of endemic, rare and threatened species. The complementary phytosociological survey is expected to further increase the number of species in the study area.

Important species encountered in the study area were *Myracrodruon urundeuva* and *Ocotea odorifera*, listed as threatened in Brazil's Threatened Flora List (MMA, 2008), *Astronium fraxinifolium*, referenced in the same list as Data Deficient, and to a lesser degree *Protium heptaphyllum*, whose subspecies *P. heptaphyllum cordatum* is also listed in the Brazilian list as Data Deficient. Also relevant are the fruit-bearing species used by human communities

and fauna, whose preservation is entailed in Article nº 112 of the Constitution of the State of Tocantins: *Attalea speciosa*, *Caryocar brasiliense*, *Hymenaea stigonocarpa* and *Hymenaea courbaril* (directly cited in the article) and also *Copaifera langsdorffii*, *Hancornia speciosa*, *Buchenavia tomentosa*, *Xylopia aromatic*, *Byrsonima* spp., *Anacardium humile* and *Anacardium occidentale* (whose fruit is also used and also arguably included within the scope of this legislation). Additionally, the following species are listed in Decree Nº838 of the Forestry Policy of the State of Tocantins, and can from a legal standpoint only be managed or exploited with authorization from NATIRATINS: *Tabebuia aurea* (ipê-caraíba), *Tabebuia impetiginosa* (ipê-roxo), *Tabebuia roseo-alba* (ipê-branco), *Tabebuia ochracea* (ipê-amarelo), *Tabebuia serratifolia* (ipê-amarelo), *Myracrodruon urundeuva* (aroeira), *Piptadenia gonoacantha*, *Acrocomia aculeata* and also all those included above under Article nº112 of the Constitution of the State of Tocantins. The results presented reinforce the need for broader biodiversity studies in order to define priority areas for the creation of Conservation Units and thus the strengthening of the Conservation Units system of the State of Tocantins.

5.2.2.4

Terrestrial and Semi-Aquatic Fauna

A preliminary study about the terrestrial fauna in the Project's region analyzed secondary data from previous environment-related reports and documents from other projects in nearby localities and various other sources including books and catalogues with species distribution for the groups included. The reports and documents consulted were: Basic Environmental Program (PBA, acronym in Portuguese) for the Lajeado Hydropower Project (THEMAG/INVESTCO, 1998); Final Inventory Report for the Serra da Mesa Hydropower Project (NATURAE, 1996); and data from the area of implantation of the Axis XVI Dam in Arraias –TO (SRHMA/BIOFÍSICA, 3rd Fauna monitoring report, 2009). Species distribution data was obtained from: EMMONS (1990) and REIS *et al* (2006) (Mammals); SICK (1997) (Birds); PETERS and OREJAS-MIRANDA (1970) and FROST (1985) (Herpetofauna). This bibliographic survey will be posteriorly complemented and shall allow a general assessment of the fauna of known and expected occurrence in the area in a regional scale, including the Project's indirect area of influence (IAI).

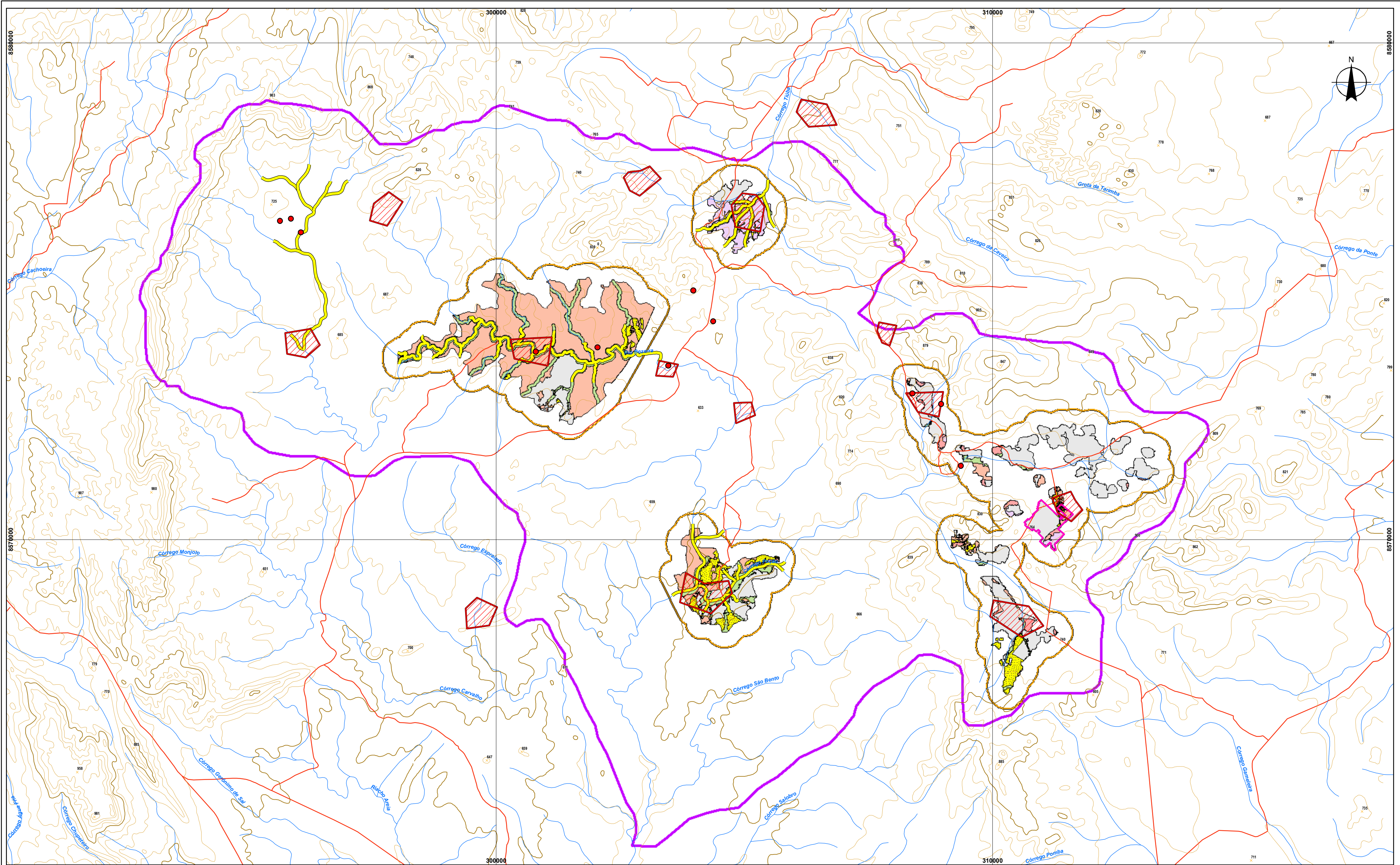
Field surveys were also undertaken for the various fauna groups for the elaboration of the Project's Environmental Baseline. Two 10 (ten)-day campaigns were carried out in different times of the year to take the region's seasonal differences into account: one from February 19th to February 28th, 2010 (rainy season) and another from June 6th to June 15th, 2010 (dry season). Both campaigns included 6 main sampling areas, including parts of the Project's Directly Affected Areas (DAAs) and of its Direct Area of Influence (DAI) and encompassing different physiognomies ("Cerrado *lato sensu*" and "*strictu sensu*", with areas of transition to closed-canopy "Cerradão" and areas with preserved riparian vegetation), as well as different degrees of human alteration.

Complementary fauna surveys will be carried out as a complement to these studies, as indicated in **Section 5.2.5**. These have two main goals: the first is to complement the baseline in terms of spatial coverage of the Project's area of influence, broadening the area covered by adding sampling points in other parts of the DAAs and the DAI including areas not considered in the previous studies, in terms of methodology (e.g. complementing the cave fauna sampling with the use of additional sampling methods) and also in terms of taxonomic representativeness (through the inclusion of specific surveys for the semi-aquatic fauna); the second is to support the impact assessment for several vertebrate and invertebrate groups through the development of a more complete baseline survey and the inclusion of marginal sampling which will serve as control areas which can be compared with the ones situated inside the DAAs and the DAI.

Specifically, the area affected by the proposed tailings reservoir and the western part of the DAI will be included in the sampling, two additional sampling areas outside the DAI will be added for use as control points, and specific surveys for semi-aquatic fauna will be carried out, as described in **Section 5.2.5**. The map with all areas to be covered in the terrestrial and semi-aquatic complementary surveys is presented in **Figure 5.2.2.4.a**. The same points and areas should be used for future monitoring activities for all fauna groups. The locations for terrestrial fauna sampling (except insects) are shown in **Table 5.2.2.4.a**; locations for insects are shown in **Table 5.2.2.4.b**. The six main sampling areas for the surveys carried out to date correspond to five of the areas proposed for the complementary surveys: DAA Canabrava (2 areas), DAA Water Catchment, DAA Industrial Unit, DAA Coité and DAI 1.

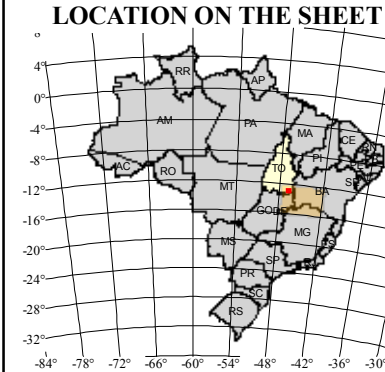
Table 5.2.2.4.a
Sampling locations for terrestrial fauna sampling (except insects).

Area	x	y
DAA Canabrava	305078,0	8576590,5
DAA Water Catchment	304196,0	8568904,7
DAA Industrial Unit	311505,3	8570672,6
DAA Domingos	310467,1	8568427,3
DAA Coité	308680,4	8572763,3
DAA Tailings	300727,7	8573818,2
DAI 1	303428,9	8573429,3
DAI 2	307857,7	8574164,6
DAI 3	304983,6	8572582,4
DAI 4	296070,2	8573958,3
DAI 5	297764,5	8576651,3
DAI 6	302923,3	8577231,4
IAI 1	306432,2	8578569,6
IAI 2	299666,1	8568503,7



- Legend**
- Bio- indicator Insects
 - Elevation Points
 - Semi-aquatic Fauna Sampling Locations
 - Master Curves
 - Intermediate Curves
 - Hydrography
 - Roadways
 - Industrial Plant
 - Directly Affected Area (Physical Environment)
 - Direct Area of Influence (Physical Environment)

- Vegetation and Land Use Class**
- Dense Cerrado
 - Typical Cerrado
 - Cerradão
 - Riparian Vegetation
 - Pasture Areas
 - Degraded Land
- Land Wildlife Sampling Locations**
- Bio- indicator Insects
 - Semi-aquatic Fauna Sampling Locations
 - Terrestrial Fauna Sampling Locations



Source: Information obtained from environmental Impact Assessment - July 2010

0 0,225 0,45 0,9 1,35 1,8 km

Scale: 1:50.000

Projection - Universal Transverse de Mercator - UTM
Geodesic Reference System - South American Datum - SAD 69

Date: 06/04/2011 Fig. JGP: Figure Land Wildlife.mxd

CLIENTE:

PROJECT: **PROJECT ARRAIAS**

FIGURE 5.2.2.4.a:
LAND WILDLIFE SAMPLE LOCATIONS

 **JGP** Consultoria e Participações Ltda.

Table 5.2.2.4.b
Sampling locations for insects

Area	x	y
Poção Creek Riparian vegetation	309366,0	8571482,0
Poção Creek Cerradão	308967,0	8572726,0
Poção Creek Cerrado	308389,0	8572938,0
Bezerra River Riparian vegetation 1	303469,0	8573500,0
Bezerra River Cerradão 1	303972,0	8575012,0
Bezerra River Cerrado 1	304376,0	8574392,0
Bezerra River Riparian vegetation 2	300796,8	8573780,4
Bezerra River Cerrado 2	302042,7	8573865,1
Control Riparian vegetation	296063,1	8576180,4
Control Cerrado	295868,0	8576457,1
Control Cerradão	295645,8	8576416,3

Specimens collected during the complementary surveys will be used to set up reference collections of the area for all groups for which the methodology used includes captures (small terrestrial mammals, bats, birds, herpetofauna, aquatic herpetofauna, entomofauna and cavernicolous fauna). The collections of voucher specimens attesting the presence of the species registered will be later deposited in recognized scientific institutions.

Mammals

This group comprises three subgroups which are traditionally treated separately in ecological studies: small terrestrial mammals, bats and medium- and large-sized mammals. Mammal surveys therefore included a combination of direct and indirect methods and techniques to allow sampling for all three subgroups composing this faunistic component, as follows:

- For medium- and large-sized mammals: interviews with locals, active search for tracks or other indirect signs of species occurrence (feces, hair, territorial marks), visual and auditory census and camera traps;
- For small terrestrial mammals: captures with live-traps (*Sherman* and *Tomahawk* models) set in transects at the sampling areas and with *pitfall* traps, meant primarily for herpetofauna sampling but which also result in small mammal captures;
- For bats: captures with mist-nets in localities specific to the group's sampling, including two natural cave entrances, the surroundings of one of these caves and points over streams.

Specific methods, sampling effort and the results obtained for each of the three subgroups of mammals are presented below along with the additional procedures to complement the current sampling.

Small Terrestrial Mammals

Methodology

The main method used for sampling of this group was the setting up of live-traps in transects in each of the six main sampling areas, with small variations in the number of traps at each area. Considering all six sampling areas, a total of 212 traps were installed per campaign (106 *Sherman*, 106 *Tomahawk*; trap types were alternated in each transect); all traps were baited daily and verified during the mornings.

The sampling also included small mammal registers obtained in *pitfall traps* set up for herpetofauna sampling. Nine (9) of the 12 (12) *pitfall* stations were considered for the small mammals survey, totaling 36 buckets.

Considering both methodologies, total sampling effort for the small mammal survey was 2.238 trapnights.

Results

The field surveys registered 134 specimens including representatives of the 2 orders (Didelphimorphia and Rodentia) and 3 families traditionally included in this faunal group (Didelphidae, 23,1% total records; Echimyidae, 9,7% of records; and Cricetidae, 67,2% of records).

The records included 11 species of different genera, among which the cricetid *Oecomys bicolor* was the most widespread, occurring in 5 of the 6 sampling sites. Other registered cricetids were *Necomys lasiurus*, *Holochilus sciureus* and *Hylaeamys megacephalus*. Among didelphid marsupials, the records include *Gracilinanus agilis*, *Didelphis albiventris*, *Marmosa murina* and *Cryptonanus agricolai*; the echimyid *Thrichomys* sp. was also recorded.

The richness in each sampling area varied between 3 species (in areas 3 and 4, corresponding to the DAI and to the DAA of the water catchment dam, respectively) and 6 species (in area 2, located in the DAA of a mining area).

None of the recorded species is considered threatened according to the Brazilian list of threatened species (MMA, 2003) and to IUCN (IUCN, 2011) or included in any CITES appendices. One species, however, is classified by IUCN as data deficient, i.e. having insufficient data for a precise assessment of its current conservation status: the marsupial *Cryptonanus agricolai*, for which ecological information beyond distribution range and population data is virtually inexistent. According to IUCN's status assessment report (PIRES COSTA & PATTERSON, 2008), the species might be currently under pressure due to habitat loss in the Cerrado, but no exact information exists about the degree and importance of this threat.

Another interesting register obtained during the field studies is the echimyid *Thrichomys* sp. BONVICINO *et al* (2008) refer to the species present in most of Tocantins and in the state of Goiás as *Thrichomys* sp., suggesting that it is a form not clearly included in one of the genus' known species. These authors also report the occurrence of *T. inermis* in eastern Tocantins, close to the border with the state of Bahia. No additional information exists about the *Thrichomys* from Goiás and Tocantins; *T. inermis*, on the other hand, is described by BONVICINO & GEISE (2008) as common in the areas where it occurs.

Analyses of sampling sufficiency, richness estimates, diversity calculations for the sampling areas and similarity analyses between sampling areas and between field campaigns will be performed later and provide more detailed information about the representativeness of the surveys, as well as allow a more comprehensive characterization of the areas as to their importance for the small mammal fauna.

Moreover, the comparison of the results of field campaigns with a list of species of expected occurrence obtained from current and future bibliographic surveys will enable inferences about the representativeness of the fauna in sampled areas in relation to the regional fauna and allow the recognition of non-recorded species of expected occurrence at the area which, due to their characteristics, may present particular relevance concerning conservation issues, thus deserving special attention.

Complementary sampling

Further field sampling for small terrestrial mammals will be carried out to complement the results obtained during the campaigns carried out to date as indicated in Section 5.2.5. These shall include additional sampling points distributed throughout the DAAs and the DAI, as well as points outside the DAI for use as control points during monitoring activities, in the areas presented in **Figure 5.2.2.4.a**.

Two supplementary campaigns will be carried out, encompassing the dry and rainy seasons, employing the same methods described above. Each transect shall have a minimum of 50 (fifty) live-traps and a minimum of 20 (twenty) 60-liter buckets set up in lines to compose the *pitfall traps*. Traps shall remain open for 5 consecutive nights at each sampling site.

The procedures described above will allow a complete characterization of the area and an improved assessment of the existing fauna, its importance and use of the various habitat types at the area.

Medium-and Large-sized Mammals

Methodology

Medium- and Large-sized mammal surveys included interviews with locals, active search for visual contact, vocalizations, tracks and other signs of species' presence, as well as the recording of road-kill, encompassing both vegetation-covered areas and roads close to the sampling areas and transects defined in and around each of the six fauna sampling areas; additionally, camera trapping was carried out in different parts of the Project area.

The field biologists travelled through roads and transects slowly at two different times of the day (6h30 to 12h00 and 15h00 to 21h00) looking out for sightings and vocalizations and indirect signs of species presence such as tracks. Ten (10) night censuses were also carried out, traversing a total of 72km.

Additional sampling through camera trapping used 23 traps during the first field campaign (wet season), and 17 traps during the second (dry season campaign). Most cameras were positioned around the six main terrestrial fauna sampling areas, but further cameras were also set up in other areas of potential relevance or interest for the group.

Semi-aquatic medium- and large-mammals (the mustelids *Lontra longicaudis*, Neotropical otter, and *Pteronura brasiliensis*, Giant otter) will be the focus of future specific surveys, as indicated in **Section 5.2.5** and as presented below under *Aquatic and semi-aquatic fauna (Herpetofauna and mammals)*. Should these species be detected at the area, supplementary studies may also be carried out during the monitoring period, concerning their local distribution and use of the area, as well as the area's relevance for these species.

Results

Records were obtained for 19 species belonging to 18 genera, 14 families and 8 orders. The orders with the greatest number of representatives were Carnivora (6 species) and Artiodactyla (5 species). Four (4) of the species were only mentioned in interviews with locals: Maned wolf (*Chrysocyon brachyurus*), Pampas deer (*Ozotoceros bezoarticus*), Southern Tamandua (*Tamandua tetradactylus*) and Agouti (*Dasyprocta* sp.). All other species were also recorded through sightings, tracks, other signs or photographs from camera traps.

Some among the species recorded have particular relevance due to being included in lists of threatened species (IUCN, 2011; MMA, 2003) or in CITES appendices: the Maned wolf (*Chrysocyon brachyurus*) is included in Brazil's threatened species list and CITES appendix II, and assessed by IUCN as NT ("near-threatened"); the Oncilla (*Leopardus tigrinus*) is included in CITES appendix I and Brazil's threatened species list, and is assessed by IUCN as VU ("vulnerable"); the Tapir (*Tapirus terrestris*) is included in CITES appendix II and considered VU by IUCN; the Pampas deer (*Ozotoceros bezoarticus*) is included in CITES appendix I and listed by IUCN as NT. Additionally, a number of other species are listed in CITES appendices II and III.

The Oncilla (*Leopardus tigrinus*) is a widely distributed species, but occurs in many areas at low population densities. The main currently recognized threats to the species are habitat loss and fragmentation; it suffers likewise with the effects of road mortality, retaliatory killing and hunting for the illegal pelt trade or for the pet trade (OLIVEIRA *et al*, 2008a).

Chrysocyon brachyurus (Maned wolf) is also widely distributed and present in low densities throughout its range, showing a preference for grassland (including seasonally flooded fields), shrubland or open-canopy forests, but also occurring in pastures or agricultural areas. The main threat mentioned for the species is habitat loss and fragmentation through conversion to cultivated lands (FONSECA *et al*, 1994), especially in the Cerrado.

The Tapir (*Tapirus terrestris*) has a wide distribution and may occupy various habitat types, especially in more humid or seasonally flooded areas (BROOKS *et al*, 1997). The species' tolerance to degraded habitat seems to be variable, curiously, differing between regions. The Tapir is at any rate considered sensitive to hunting activities, however, due to its low reproduction rate.

The Pampas deer (*Ozotoceros bezoarticus*) has a highly fragmented distribution through South America; its distribution has greatly shrunk since the XIX century and is currently comprised of small, generally isolated populations (JACKSON & LANGGUTH, 1987; GONZÁLEZ *et al*, 1998, 2002). As reported by PINDER (1994), the largest current populations are located in Brazil in northeastern Cerrado and Pantanal. The largest current threats to the species are habitat loss to agricultural activities and competition with livestock.

Future sampling sufficiency and similarity analyses between sampled areas and field campaigns will improve the comprehension of the sampling's representativeness and allow more detailed characterization of the areas in relation to their importance to the medium- and large-mammal fauna. Besides, comparisons between the field results and lists of species of expected occurrence obtained from bibliography shall allow inferences about the representativeness of the recorded data in relation to the regional fauna and the recognition of eventual unrecorded species of particular conservation relevance.

Complementary sampling

As for other terrestrial fauna groups, complementary sampling will be carried out for medium- and large-sized mammals including additional sampling points so as to include the whole of the DAAs and DAI and points outside the DAI to serve as control points in the monitoring phase, as mentioned in **Section 5.2.5**. The areas to be covered in large-mammal sampling are presented in **Figure 5.2.2.4.a**. Two 10-day campaigns shall be executed to encompass seasonal differences, using the same methodologies of previous campaigns: active search for sightings, vocalizations, tracks and other signs of presence, interviews and camera trapping; additional specific techniques for semi-aquatic mammals will include interviews, visual surveys and searches for tracks and communal latrines along river margins.

Chiropterans (Bats)

Methodology

Bat sampling at the study area included two campaigns, carried out from February 20 to February 25, 2010 and from June 7 to June 10, 2010 (rainy and dry seasons, respectively), and included 8 capture sessions in different localities (4 during the rainy season and 4 during the wet season). The method used was captures with mist-nets, and the areas surveyed differed from those for other terrestrial fauna groups, including two natural caves (one near the future industrial area and one in a hilly area at the mines' DAA), the area near one of these caves and points over streams in Poção Creek (corresponding to the area DAI Water Catchment in **Figure 5.2.2.4.a**) and Bezerra River (area DAI Tailings in **Figure 5.2.2.4.a**). The duration of capture sessions at the points over streams and around the cave was 5 hours, starting shortly after sunset, and sampling at those areas used seven mist nets with widths of seven and eleven meters; sampling at cave entrances started at the end of the afternoon (at approximately 16h30), in an attempt to capture individuals leaving their roosts, and finished after a long period of inactivity (at approximately 21h30).

The summed sampling effort for bats at all sampling areas, considering both campaigns, was approximately 190 hours x nets.

Results

Sampling for bats resulted in the capture of 133 specimens representing 17 (seventeen) species at the different sampling sites, belonging in turn to 16 genera and 3 families. The most abundant species in both seasons was *Carollia perspicillata* (40,6% of records during the rainy season; 52,5% during the dry season; 49,6% in total), similarly to the results of other surveys (e.g. BERNARD & FENTON, 2002; SIMMONS & VOSS, 1998).

Frugivorous bats, which may act in seed dispersal and thus constitute essential elements to forest ecosystems' regeneration (CHARLES-DOMINIQUE, 1986), represented 71,4% of all captured specimens considering both field campaigns (59,4% of records during the rainy season and 75,3% during the dry season).

Considerable disparity was observed in the representativeness of different guilds between seasons: during the dry season campaign, the number of insectivores (approximately 35% of the total) was expressively higher than that seen in the dry season campaign (under 5% of the total), while all other guilds' representativeness increased during the dry season.

Eight of the 17 species recorded were captured in nets set up at cave entrances, indicating their use as roosting sites. Six species were registered at the cave in the hilly area: *Desmodus rotundus*, *Carollia perspicillata*, *Glossophaga soricina*, *Lonchophylla mordax*, *Micronycteris minuta* and *Mimon bennettii*; five species were recorded in the cave at the industrial area: *Diphylla ecaudata*, *Desmodus rotundus*, *Phyllostomus hastatus*, *Carollia perspicillata* and *Glossophaga soricina*. The existence of at least six bat species with different alimentary habits in the region's caves illustrates their relevance for local chiropterans and indicates the importance of their conservation.

None of the recorded species is considered threatened according to IUCN and Brazilian threatened species lists, and all species present wide to very wide distribution. Nevertheless, one species is assessed by IUCN as DD ("data deficient"), i.e. as possessing insufficient data for an assessment about its current situation (*Vampyressa pusilla* and one (*Platyrrhinus lineata*) is included in CITES appendix III, although it is common and widely distributed in Brazil.

Sampling sufficiency, richness estimates and comparisons of sampling areas through diversity and similarity analyses shall be performed to enrich area characterization and comparisons between sampling sites. Moreover, an analysis of similarity of bat fauna composition between both sampling seasons will also be done for a more thorough understanding of the seasonality effects on the group at the study area. Furthermore, data obtained in supplementary field and bibliographic surveys will allow both a more detailed analysis of the representativeness of the sampled areas in relation to the regional fauna and the identification of species of expected occurrence that may be of particular relevance due to their characteristics.

Complementary sampling

As with other mammal groups and indicated in **Section 5.2.5**, complementary sampling will be done for chiropterans in order to include samples from all the DAAs and the DAI and sampling areas outside the DAI for use as control points, in the areas presented in **Figure 5.2.2.4.a**. This sampling will use mist nets of different sizes set up in areas used by bats for travel such as the borders of gallery forests, the area over streams or cave entrances. Fifteen (15) mist nets will be set up at each sampling point, and sampling will occur for 4 (four) consecutive nights at each point. Additionally, mist-net sampling will be supplemented by active searches to detect bats in their roosting sites. Two complementary campaigns will be carried out, one during the dry and another during the rainy season.

Avifauna

Birds are recognized as important bioindicators of environmental quality due to a number of factors, including the ease of detecting bird species through sightings or the identification of each species' distinctive calls, the relatively well-known fauna, the comprehension of the group's ecosystem roles and the existence of standardized work systems and methodologies, enabling comparison of results obtained in different areas. The group's inclusion in environmental baseline studies is therefore traditional, helping in the assessment of areas' environmental quality and relevance with the obtainment of ecologically significant data within relatively brief periods.

Methodology

Field surveys for birds were carried out in two campaigns (rainy season and dry season campaigns) and encompassed seven points representing different phytophysionomies at the Project area: Cerrado *strictu sensu* (grassland with varying density of low trees, DAA Industrial Area), Rocky Outcrops (DAI 3), Cerradão (closed canopy, DAA Canabrava), Campo Sujo (woody grassland, near DAI 3), Floodable (DAA Domingos) and Non-Floodable Gallery Forests (DAI 1, DAI 2).

Surveys were done in a 10-day period in each campaign, encompassing a total sampling effort of 10 hours per day, with surveying activities concentrated in the morning and late afternoon. Records were obtained through direct sighting using binoculars and registering of vocalizations. A total 16 hours effort of night censuses was also carried out to complement samplings.

Additionally, mist-net sampling was carried out in each sampling site from sunrise to approximately 11h00 and from 14h00 until shortly before sunset.

Results

192 species distributed over 26 orders and 48 families were registered in the survey. The non-passeriformes families with the largest species counts were Trochilidae (11 species), Psittacidae (10 species) and Columbidae (8 species), while within the Passeriformes order, the most represented family was Tyrannidae (23 species), followed by Thraupidae (10 species). The majority of the birds registered occurred in the canopy or understory (51 species in each), while 29 used the middle stratum and a smaller quantity the ground stratum or water areas.

110 of the species registered (57% of the total) were common in the humid and dry season campaigns, while 51 species (27% of the total) were registered only in the rainy season, and 31 (16% of the total) only in the dry season, indicating a relative seasonal disparity in comparison to local avifauna.

The results of the field studies found an occurrence of a migratory species (the White-faced Whistling Duck, *Dendrocygna viduata*) and the occurrence of 6 species endemic of the region: the Passeriformes *Melanopareia torquata* (Collared Crescentchest), *Herpsilochmus atricapillus* (Black-capped Antwren), *Antilophia galeata* (Helmeted Manakin), *Cyanocorax cristatellus* (Curl-crested Jay) and *Saltatricula atricollis* (Black-throated Saltator) and the parrot *Pyrrhura pfrimeri* (Pfrimer's Parakeet). *Pyrrhura pfrimeri* is also considered vulnerable according to the IUCN and BirdLife International and considered endangered according to the Brazilian list of endangered species.

Another parrot, the Hyacinth Macaw (*Anodorhynchus hyacinthinus*), is also considered endangered by the IUCN/BirdLife International and also the national list of endangered species, and is included in CITES appendix I. 11 species are considered “near threatened” according to IUCN/BirdLife International: *Rhea americana* (Greater Rhea), *Crypturellus undulatus* (Undulated Tinamou), *Pilherodius pileatus* (Capped Heron), *Eurypyga helias* (Sunbittern), *Ara ararauna* (Blue-and-yellow Macaw), *Hylocryptus rectirostris* (Chestnut-capped Foliage-gleaner), *Xenops rutilans* (Streaked Xenops), *Cyanocorax cristatellus* (Curl-crested Jay), *Cyanocorax cyanopogon* (White-naped Jay), *Piranga flava* (Hepatic Tanager) and *Sporophila angolensis* (Chestnut-bellied Seed-Finch). There are still more species included in CITES appendices, as is the case for all of the parrots (appendix II).

The Hyacinth Macaw (*Anodorhynchus hyacinthinus*) is principally found in Brazil in Eastern Amazônia, the Pantanal and in Cerrado, Caatinga and Babaçu forest areas called “Gerais”. The main threat to this species is illegal commercial activities; an estimated 10.000 individuals have been taken from the wild during the 1980s. In the “Gerais” area, the conversion of habitat in agrarian areas also presents a threat.

The Pfrimer's Parakeet (*Pyrrhura pfrimeri*) is one of the species whose distribution is extremely limited, restricted to the belt of semi-deciduous forest (analogous to the Caatinga) in soils or calcareous outcroppings in the Serra Geral between the states of Tocantins and Goiás, an area continuously affected by deforestation. Habitat loss in its limited area of distribution represents the principal threat to the species, which could also be a target for hunting for illegal trade (BIRDLIFE INTERNATIONAL, 2008). Given the great sensitivity of species and the IUCN proposition for studies on remaining habitats as a primary activity for conservation, new surveys in the area before the beginning of the installation of the Project will be done to determine the usage level and relevance of the areas of each species and to infer population data of the species in the area as indicated in **Section 5.2.5**.

Eleven registered species in the area are traditionally hunted, potentially suffering from hunting pressure in the region: the tinamous *Crypturellus undulatus* (Undulated tinamou), *Crypturellus parvirostris* (Small-billed tinamou), *Rhynchotus rufescens* (Red-winged tinamou) and *Nothura maculosa* (Spotted nothura), the anatidae *Dendrocygna viduata* (White-faced whistling duck), *Dendrocygna autumnalis* (Black-bellied whistling duck) and *Amazonetta brasiliensis* (Brazilian teal), the cracid *Penelope supercilialis* (Rusty-margined guan) and the columbids *Patagioenas picazuro* (Picazuro pigeon), *Patagioenas cayennensis* (Band tailed pigeon) and *Leptotila verreauxi* (White-tipped dove). Other species that are potential victims of bio-pirating for illegal trade as pets or to raise privately: the parrots *Ara ararauna* (Blue-and-yellow macaw), *Diopsittaca nobilis* (Red-shouldered macaw), *Aratinga leucophthalma* (White-eyed parakeet), *Aratinga aurea* (Peach-fronted parakeet), *Forpus xanthopterygyus* (Blue-winged parrotlet), *Brotogeris chiriri* (Yellow-chevroned parakeet), *Amazona aestiva* (Blue-fronted parrot) and *Amazona amazonica* (Orange-winged parrot), the emberizidae *Sicalus flaveola* (Saffron finch) and *Sporophila angolensis* (Chestnut-bellied seed-finch) and the icteridae *Cacicus cela* (Yellow-rumped cacique), *Icterus croconotus* (Orange-backed troupial) and *Gnorimopsar chopi* (Chopi blackbird).

Future analyses of sample sufficiency, richness estimates and diversity analyses in the areas sampled and similarity between sampled areas will allow for detailed characterization of avifauna. Similarity composition analyses and other characteristics between the campaigns, on the other hand, will allow for deeper analysis of local seasonality for the group. Finally, comparisons between the data obtained in the field campaigns and bibliographic research will allow verification of regional avifauna representation and the identification of species that might have special relevance given their characteristics.

Complementary Sampling

Complementary avifauna samples, as mentioned in **Section 5.2.5**, will extend the number of sample points to distribute them throughout all the DAA and DAI and at some areas outside the DAI for use as control points, using the same techniques already used. Areas to be covered by the sampling are shown in **Figure 5.2.2.4.a**. At each sample point, 15 mist nets will be set up for 4 days. The point-count methodology will also be used (BLONDEL

et al, 1970; VIELLIARD & SILVA, 1990) in at least 3 points per sample point, recording species identified through their calls or visualization for 10 minutes at each point. The use of this method will give support to qualitative and quantitative analyses with respect to the local avifauna. Two sampling campaigns will be carried out, one in the dry season and another in the rainy season.

Herpetofauna

The Cerrado has a large number of herpetofauna species and a considerable degree of endemism. Reptiles have a significant number of herpetofauna species and a considerable degree of endemism in the Cerrado, principally among some groups. Reptiles in the Cerrado are strongly associated with physiognomy, the majority living in open environments in fields and Cerrados, while others are restricted to forest environments. This caused high indices of heterogeneity in the composition between areas, resulting in communities with high total richness and diversity. The strong association of certain species with the habitat structure, for reptiles, and water dependency in the case of amphibians make the herpetofauna group a good indicator of habitat conservation.

Methodology

The herpetofauna survey primarily used the Pitfall traps method. These consisted in two stations in each of the six herpetofauna sampling points, equivalent to the small mammal sampling locations. At each sampling point, one station was composed of one central and three peripheral buckets set radially in a Y shape, and another has buckets installed linearly. Each station was built with four 20-liter pails placed 5 meters apart from one another and tarpaulin screens 40 centimeters tall held down by eight stakes about 50 centimeters long each.

Additionally, the Time-Limited Visual Search (TLVS) methodology was adopted, consisting of active searches through the leaf litter, fallen tree trunks and lotic environments in waterbodies at the different sampling points carried out three times on each sampling day (morning, afternoon and night). During the search, amphibian calls and tracks from medium and large-sized lizards were also registered. Finally, interviews with locals were also done.

Results

For the herpetofauna group, the results of the wet season and dry season campaigns were fairly different, as is common in seasonal environments such as the Cerrado. In the sample from the wet season campaign, 68 individuals were identified belonging to 24 species distributed among lizards (Iguanidae, Tropiduridae, Teiidae and Scincidae families), snakes (Dipsadidae, Elapidae, Viperidae and Amphysbaenidae families), anurans (Bufonidae, Hylidae, Leptodactylidae families) and gymnophiona. Additionally, 5 species of snakes were registered on interviews with locals: *Drymarchon* sp., *Chironius* sp., *Boa constrictor*, *Hydrodynastes* sp. and *Eunectes* sp.

On both campaigns, the number of reptiles registered was greater than the number of amphibians, differently from what normally occurs on herpetofauna campaigns, at least during the wet season. The number of amphibians registered was greater during the wet season than during the dry season, as expected for the group due to their dependence on water and/or humidity, which causes it to be more active during the wet season. The predominance of reptiles in the area is an indicator of the dry nature of the environment at the Project area. Similarity analysis between the herpetofauna present in both seasons will be carried out later and help characterize the effects of seasonality on the group.

Diversity analysis and richness estimates were done for the herpetofauna group considering all of the sampled areas and the data of both survey campaigns together. The result obtained for the Shannon index ($H' = 1.5973$) can be considered intermediate in value. Equitability species distribution ($J = 0.984$) was fairly high, indicating relatively low species dominance in the area. Total estimated richness for the area (using the 1st order Jackknife estimator, HELTSHE & FORRESTER, 1983) was 42 species, 6 beyond the total obtained during the surveys. Future sample sufficiency analyses, diversity analyses for each of the sampled areas and similarity analyses between the sampled areas will be done to further characterize the local herpetofauna.

No endangered species according to the national list of endangered species (MMA, 2003) and IUCN (IUCN, 2011) was registered during the survey. The registers include generalist species and others exclusive to the Cerrado. No register was specifically endemic to the region studied.

A comparison between the data obtained in the field campaigns and secondary data obtained from the literature will be done to help characterize the local fauna in relation to what is known about the fauna on a regional scale. The comparison will also enable eventual identification of non-registered species that could possibly occur in the area and merit special attention.

Complementary Sampling

Complementary sampling will be done for the herpetofauna using the same areas selected for the complementary surveys of small mammals, distributed over the whole DAAs and DAI and in areas at the limits of the DAI, as shown in **Figure 5.2.2.4.a** and indicated in **Section 5.2.5**. The methodology used in these samples will be the same used in other surveys, with a combination of pitfall traps and active search. Two campaigns will be carried out, one in the dry season and another in the wet season, and in each section at least 20 60-liter buckets will be mounted in a line to create pitfall traps, which shall remain open for 5 consecutive nights. Active searches in the local rivers will also be carried out to look for reptiles in aquatic habitats, including crocodiles, chelonians, for 10 days on each campaign. Hoop traps will be installed in the main rivers in an attempt to capture aquatic chelonians and amphibians.

Insects

Insects are considered good indicators of the level of environmental impact due to the group's diversity (they represent nearly 70% of all animal species), the variety of habitats they occupy, their importance in biological ecosystem processes and their relatively easy sampling. Beyond that, the richness of orders, families and species of insects in an environment decreases with the increase in human influence (BRAGANÇA *et al*, 1998, 2000).

The Hymenoptera order (wasps, bees and ants) includes a large variety of insects, many of large ecological and economical importance, and is considered one of the most useful bio-indicators of environmental alterations caused by man. The diversity of hymenopteran families in the Project region was analyzed comparing different environments and verifying the composition of fauna in terms of functional groups (phytophagous, predators, parasitoids or pollinators), to give support to the analysis of the environmental situation of the area.

Methodology

Sampling of Hymenopteran insects happened in two campaigns respecting local seasonality: from February 19 to February 28, 2010 (rainy season) and from 06 to 15 of June, 2010 (dry season). Two sample sites were selected (Poção Creek and the Bezerra River), with one Malaise trap installed in each of three environments in each sample site: Riparian vegetation, Cerradão and Cerrado.

In each campaign, the traps were active for seven consecutive days. Later, the material was transferred to specific bottles and transported to the lab for sorting, separation of the hymenoptera and their identification at the family level. Richness and abundance comparisons were done between collecting seasons (dry and rainy) and between environments.

Both Hymenopterans and other collected material were stored in the entomological collection in the Biological Sciences Course at the Federal University of Tocantins, in Porto Nacional, TO.

Results

A total of 2,124 individuals were collected, distributed among 27 Hymenoptera families. The 11 most abundant families with at least 40 individuals each corresponded to nearly 85% of the species found. These were: Apidae, Bethylidae, Formicidae, Mutillidae, Pompilidae, Vespidae, Ichneumonidae, Braconidae, Mymaridae, Scelionidae and Eulophidae. The least common families, with just one or two specimens, were Pergidae, Tenthredinidae, Anthophoridae, Tiphiidae, Ceraphronidae, Mymarommatidae and Proctotrupidae.

The number of families registered in the rainy season (34) was a little greater than in the dry season (31), as was the number of individuals collected (1,182 in the rainy season, 922 in the dry season), indicating the existence of light seasonal influence on the group. Considering the sample sites, the total number of families (36) and individuals present (1,264) in the environments of Poção Creek were expressively greater than those obtained at the Bezerra River (27 families, 840 individuals).

With respect to environments, the areas of Riparian Vegetation showed a high number of individuals and families in both seasons, while the number of records in the Cerradão and the Cerrado were reduced during the rainy and dry seasons, respectively. In both seasons, the sampling site and environment with the largest number of individuals (wet 337, dry 330) and families (wet 25, dry 28) was the Riparian Vegetation of Poção Creek. At the Bezerra River Site, the area with the largest number of individuals in both campaigns was the Cerrado (wet: 415; dry: 242), which also showed the greatest number of families during the wet campaign (23). In the dry campaign, it had the same number of families as the Cerradão (19).

Four of the families registered during the field surveys are pollen collectors, one of which also uses nectar; four are composed of predator species; nine families are egg parasitoids; 20 are larva parasitoids; 3 families have pupa parasitoid species; finally, three families are composed of phytophagous.

The variations in the number of families and individuals found are possibly related to the variations in the diversity and structural complexity of the vegetation (ALTIERE & LETOURNEAU, 1984; BRAGANÇA, 1995; BRAGANÇA *et al*, 1998b, AZEVEDO & SANTOS, 2000). Environments with greater diversity and complexity in the microclimate and vegetation tend to possess greater Hymenoptera diversity, due to greater diversity in food items and shelter availability. That increases the number of ecological niches for phytophagous and also for their predators, among which are various Hymenoptera (ALTIERE & LETOURNEAU, 1984; BRAGANÇA *et al*, 1998).

Complementary Sampling

Complementary sampling will also be done for the entomofauna group, using additional sampling points near Bezerra River upstream from the area of the planned tailings reservoir for use as control points in monitoring, as shown in **Figure 5.2.2.4.a** and indicated in **Section 5.2.5**. The methodology used will be the same as that from surveys already done, using Malaise traps. The sample will include two campaigns, one in the dry season and another in the wet season.

Aquatic and semi-aquatic fauna (Herpetofauna and mastofauna)

Complementary surveys will be done for the sampling of aquatic and semi-aquatic mastofauna and herpetofauna, as described above, to complement the results obtained in the field campaigns already carried out.

The aquatic and semi-aquatic fauna surveys (herpetofauna and mastofauna) will include active search for aquatic turtles and crocodiles and employ hoop traps to capture turtles and amphibians from the Pipidae family. Semi-aquatic mammals (otters and giant-otters) will be detected, if present at the area, through active searches of the river banks, looking for tracks and communal latrines, and also through interviews with locals. These additional surveys will be done in two 10-day campaigns, including both seasons (dry and rainy), at waterbodies situated in four areas, including streams at the DAA for the Canabrava mining area and the water catchment and tailings reservoir and the Bezerra River upstream from the latter for use as a control point during monitoring activities.

The data obtained will be discussed in light of information already available and incorporated in the analysis of impacts on the different elements of the fauna.

Cave fauna

Specific problems are attributed to subterranean ecosystems regarding conservation, including the high rate of endemic species found in these environments and the different behaviors of troglophilic organisms (CULVER, 1986). These environments are highly fragile due to the low biodiversity, resulting mainly from the lack of light and photosynthetic organisms and the resulting scarcity of food sources. Maintaining cave

environments depends on the availability of nutrients in the substrate and on the climatic fluctuations to which cave-dwelling species are susceptible, so these ecosystems are strongly influenced by epigeal (non-cave) environmental characteristics.

Three main categories are recognized among the cave fauna according to their relationship with the hypogeal environment (caves): troglobites (species restricted to cave environments); troglophytes (optional cave dwellers, able to live and reproduce in both hypogean environments and epigeal environments) and Trogloxenes (species which use caves, but need to return outside to complete their lifecycle).

Many cave species have a low dispersion ability and low population density, resulting in small populations. They most often produce a small number of descendents and dedicate great effort to their survival. These factors result in a low reproduction rate and consequently a low rate of recovery after population losses. For these reasons, cave-dwellers can generally be considered vulnerable species (TRAJANO, 2000).

During the geological field campaign between February, 18-22, 2010, several caves were found in the Project region. Later, between June, 02-07, 2010, a field campaign was done with results evidencing the existence of 12 caves and significant karst features in the study area, pointing to the need for surveys on the cave fauna as part of the study and the characterization of the relevance of the caves found. Additional surveys of the cave fauna will be carried out in all caves found in the Project area as part of the Complementary Biospeleological Survey Plan as indicated in **Section 5.2.5**, and also during monitoring activities.

Cave fauna - Invertebrate

Methodology

The invertebrate cave fauna study occurred on two trips to the field from 3-7 October, and 14-20 November, 2011 (wet season), with work conducted between 8h00 and 20h00. Studies involved surveys of invertebrates present in each cavity with the active search method, going over the substrates while looking for specimens.

The organisms were collected and packaged in receptacles with 70% alcohol for fixing and conservation, and later sent to the Zoological Museum of the University of São Paulo (MZUSP) and to the Insect Collection of the zoology department of UNESP/Botucatu (UBTU). There, they underwent sorting and preliminary identification and were forwarded to specialists whenever possible for confirmation and/or detailing of the identification.

More detailed identification of the obtained material at the taxon level will be presented in the future along with the results from the cave fauna complementary surveys.

Results

The most diversified group found in the study in the 12 cavities were insects, with various morphospecies sampled pertaining to 18 different families. Among the insects registered, two troglophyles are known: a cricket (*Eidmanacris* sp., Phalangopsidae family) and the Heteroptera from the Reduviidae family. Troglomorphism (adaptations to the cave environment) was observed in two groups: Collembola from the Family Entomobryidae, frequently found in caves in the Ribeira Valley, including troglomorphic and troglophilic species; and trogiomorpha psocoptera, a group uncommon in the caves in the region and whose specimens are not commonly troglomorphic, such that they should be better studied before the species found may be classified as troglomorphic. Crickets similar to representatives of the genus *Endecous* occurred in 7 caves, showing some distinct characteristics and some fossorial characteristics. However, these species were also collected in the leaf litter close to the entrance of the caves.

The Araneae group presented large richness, with 176 species distributed among 17 families. The Sicariidae family (e.g. *Loxosceles* sp.) was very well represented in the caves, being found in large quantities in all of the cave environments. Among the families found, Ctenidae are spiders that prey mainly on crickets, some of which are errant troglophiles which use all regions of the caves. Pholcidae (e.g. *Mesabolivar* sp.) and Theridiosomatidae are also troglophiles which construct their nets on the walls of the caves, where they catch small flying insects, using mainly the entrance and the twilight zone, while Theridiosomatidae uses humid areas and/or water routes.

Three caves were considered the most relevant biologically due to the following characteristics: high organic substrate diversity (in two of the caves), high richness of invertebrate species (in two cavities), troglomorphic species (in three caves), high abundance of invertebrate species (in one of the caves) and the presence of species unknown to science (in two caves).

Complementary Sampling

Complementary samples will be taken in the caves through additional surveys including both the dry season (June, July, August and September) and the wet season, in all of the caves mapped in the DAI and ADA. As indicated in **Section 5.2.5**, surveys shall include the active search methodology as described above, and additionally use Winkler sampling and pitfall traps with baits and formaline for a better representation of different groups.

Cave-dwelling Fauna - Bats

Methodology

Two field campaigns were done in the rainy season (October 04–07, 2010, and November 14–18, 2010). On each one, one or two mist-nets were set up at the entrance of each cave in order to cover the area used by bats to exit. The nets were placed in the afternoon (around 16h00) and taken down around 22h00 or when bats stopped leaving the cave. The nets were inspected every 15 minutes and any bats found were removed, had their biological data taken, and were then let free at the same location.

Two of the caves present in the Project area were also studied beforehand, during the bat campaigns.

Results

A total of 137 individuals from 11 species were captured indicating that the caves were used as shelter and/or roosting sites by the majority of the bat species whose presence was evidenced in the Project's area of influence. The species found were distributed among 3 families: Phyllostomidae, Emballonuridae and Furipteridae, the last registered in the cave bat survey, but not during the general bat field campaigns.

The majority of species found in the study area were from the Phyllostomidae family, which is generally the case for surveys in the neotropical region. They also show a large diversity of food habits. In this study, 82.4% of individuals caught were fructivores or nectarivores, while insectivores were the second most common (11.7% of the total). The species *Glossophaga soricina*, nectarivore, represented more than 70% of the total number of registered individuals .

Complementary Sampling

As for cave-dwelling invertebrates, complementary sampling for bats will be taken through additional campaigns during the dry season (in the months of June, July, August or September) and the wet season, employing mist-nets and preserving individuals collected as voucher specimens for a reference collection as indicated in **Section 5.2.5**. The dry and wet season campaigns should have a minimum interval of 4 month between them, and the sampling activities should include all of the natural cavities mapped in the DAI and DAAs.

5.2.2.5 Aquatic Fauna

Ichthyofauna

The damming of a river and consequent reservoir formation creates a new environment with characteristics different from the original river conditions. With the intent of studying the ichthyic community, six ichthyofauna points were sampled in the direct and indirect areas of influence of the Project, of which two represent future dam areas: Point 1 (tailings dam) and Point 6 (water catchment dam). Point 3, located in Carvalho Creek's watershed, will serve as a control point for comparisons with the other points on the sampling grid because it is outside the limits of the Project's DAI. However, in order for future effects of the dam to be monitored with regard to ichthyofauna composition, one new sample collection point (Point 7) will be included, located upstream of the confluence of the Bezerra River with the Carvalho Creek. Thus, the sampling grid for the monitoring phase will have 7 points (**Table 5.2.2.5.a**) distributed among the ADA, DAI and IAI.

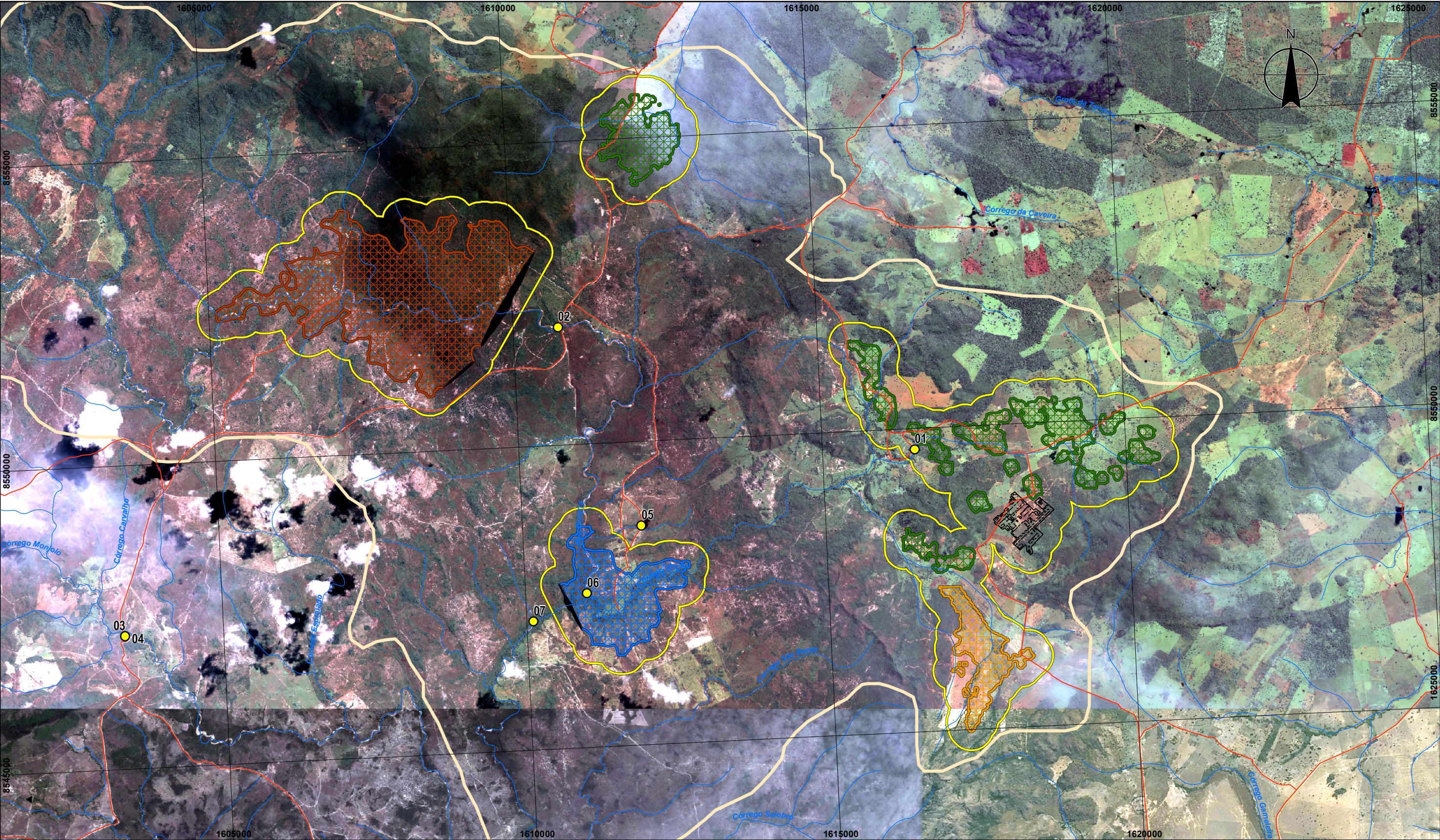
The map with the locations of the ichthyofauna sampling points is shown in **Figure 5.2.2.5.a**.

Table 5.2.2.5.a
Description of ichthyofauna sampling points

Sampling points	Description
Point1	Poção Creek (located in mining areas)
Point2	Bezerra River
Point3	Carvalho Creek
Point4	Bezerra River, in the tailings dam area
Point5	Lake with macrophytes in the Bezerra River watershed
Point6	Bezerra River, downstream of the future dams in the water catchment dam area
Point7	Bezerra River, upstream of the confluence of the Bezerra River with the Carvalho Creek

Sampling Collection and Analysis

Fishing gear, such as gillnets (meshes 3, 5 and 7), sieves and casting nets, was used to capture representative samples at the selected collection points. Capture efforts using fishing gear were not standardized; however, during the monitoring campaigns, time of gillnet use and frequency of casts using sieves and casting nets will be established to standardize sampling for all collection points. These capture efforts will be presented indicating the different methods for the lotic and lentic environments. If a method is found to be inefficient, the methodology may be improved during the campaigns.



LEGEND: ● Ichthyofauna — Hydrography — Roadways - Industrial Plant - Dams - Directly Affected Area (Physical Environment) - Direct Area of Influence (Physical Environment) - Water- Catchment Dam - Tailings Dam (3-20 anos) - Mining Areas (0-5 anos) - Mining Areas (>5 anos)	LOCATION ON THE SHEET	INFORMATION Scale: 1:60.000 0 0,3 0,6 1,2 1,8 2,4 3 3,6 km Projection - Universal Transverse de Mercator - UTM Geodesic Reference System: South American Datum - SAD 69 Date: 01/04/2011 Fig. JGP: Figure Ichthyofauna.mxd	CLIENT:
			PROJECT: PROJECT ARRAIAS
			FIGURE 5.2.2.5.a: ICHTHYOFAUNA MONITORING POINTS
			Consultoria e Participações Ltda.

The species captured in the Baseline study were identified and immediately released. During the monitoring campaigns, the specimens will be sent to a reference collection to confirm the taxonomy of fish species, enriching the fauna inventory of the regional watersheds.

The community of sampled fish at the 06 collection points was analyzed according to species richness, the Shannon Diversity Index and Pielou (1975) equitability Index, and to abundance data expressed in CPUE (Catch-Per-Unit-Effort). The Collector's Curve will also be incorporated in the monitoring reports.

In the inventory phase, the collected species were also characterized by feeding habits, according to theoretical models of six food categories: plankton eating, detritus eating, ichthyophagous / piscivores, omnivores, iliophagous and insectivores. To confirm these data, the stomach contents of a subsample that includes all fish species collected from at least one campaign during the dry season and one during the wet season were analyzed.

The physical and chemical properties of the air and water (transparency, depth, temperature, dissolved oxygen and pH) were recorded at all of the points. Measurements of electrical conductivity and turbidity *in situ* will also be recorded in the monitoring stage. A Horiba U50 multiparametric probe will test temperature, dissolved oxygen, pH, conductivity and turbidity, and a Secchi disk will be used to test transparency.

All field procedures and species caught will be included in the photographic record in the monitoring reports.

The composition of the fish community in terms of the number of migratory, rare, endemic, endangered and new species was observed in the first surveys.

Results

During the surveys performed in February and June, 147 individuals were sampled, distributed among 15 species belonging to three orders: Characiformes (Families: Anostomidae, Characidae and Erythrinidae), Perciformes (Family: Cichlidae) and Siluriformes (Families: Heptapteridae and Loricariidae).

Among the orders captured, the Characiformes and Siluriformes were the most representative in terms of number of species, with 46.66% each. The Perciformes were represented by only one species. The collection point with the greatest species richness was Point 2 with 7 species, whereas the one with the greatest diversity and equitability indices was Point 3 during the dry season.

With respect to catch data by Catch-Per-Unit-Effort (CPUE), the highest registered value was 29.33 fish/m² at Points 3 and 6 during the rainy season.

Among the species sampled, 40% are detritivore, 13% were insectivores, 20% omnivores, and 20% are piscivores. The plankton-eater and iliophagous categories did not have any identified specimen in the sampling. Statistical analyses comparing the survey campaign results will be presented to test for the existence of any significant seasonal difference or lack thereof for local species.

Only the species *Leporinus friderici* and *Rhamdia quelen* are considered migratory, but are not long distance migrators. Both species directly depend on river migration upstream to complete the development of their gonads, undergo the process of fertilization and spawn.

Although there are some fish species of the Loricariidae family which are notably dependent on environments with rapids, the habitat in the Project area cannot be considered critical since the species identified are not exclusive to the study area. The species *Ancistrus aguaboensis* could be considered endemic to the region of the High Tocantins River (Bertaco et al, 2010), but not only to the Project area.

During the surveys, species new to science were not found, and the same goes for rare or endangered species. However, secondary data from the IAI can help identify rare, endemic and endangered species which could be present in the Bezerra River basin.

Considering the *in situ* parameters evaluated, the values of dissolved oxygen varied from 5.64mg/L at point 5 during the dry season to 9.78mg/L at point 1 in the wet season. According to Esteves (1988), values below 3 mg/L are considered insufficient for local ichthyofauna. A recommended value in Resolution CONAMA 357/05 is 5 mg/L.

The pH, a parameter that represents the concentration of hydrogen H⁺ ions, indicates whether the water is acidic (pH<7), neutral (pH=7) or alkaline (pH>7). For the *in situ* samples, the values vary from 5.21 at point 06 (rainy season) to 7.84 at point 1 (dry season).

The water temperature varied from 20.8 °C (dry season) to 36.9 °C (rainy season), compatible to the air temperature (20.7°C to 34.8°C), both characteristic values for the region.

To guarantee that the proposed ecological flow of 30% is sufficient to support aquatic fauna, measurements of the water flow during the monitoring phase will be included. These data will help the detailed study of the ecological flows from the Bezerra River to be conducted before starting the construction of the dams, as indicated in **Section 5.2.5**.

Plankton Populations

Phytoplankton, zooplankton and benthonic populations were analyzed qualitatively at the same points where the surface water quality analyses were performed, the map of which is presented in **Section 5.2.1.9 – Figure 5.2.1.9 (Surface water)**.

Phytoplankton

Phytoplankton samples were collected below the surface (10 cm) with collection bottles and afterward put in acetic Lugol solution. The points sampled were the same chosen to evaluate water quality. Collections with plankton nets with 25µm mesh were also performed, according to the methodology proposed by Bicudo & Menezes (2005).

The phytoplankton population in the sampled points was qualitatively evaluated by number of species found (composition/descriptive species) and quantitatively by density (number of individuals per milliliter), relative abundance, Shannon-Wiener diversity indices and equitability index.

Results

Qualitative analysis of the phytoplankton population carried out during the rainy season (Feb. 2010) found 66 genera with 127 species, distributed among *Bacillariophyta* (*Bacillariophyceae*, *Coscinodiscophyceae* and *Fragillariophyceae*), *Chlorophyceae*, *Cryptophyceae*, *Cyanophyceae*, *Dinophyceae*, *Euglenophyceae*, *Oedogoniophyceae*, *Xanthophyceae* and *Zygnemaphyceae*. The *Bacillariophyta* division (42 species) was the most representative group, followed by the classes *Zygnemaphyceae* (29 species), *Chlorophyceae* and *Cyanobacteria* (both with 18 species).

The group with highest density in all points was *Bacillariophyta* (diatoms), common algae in lotic environments. Phytoplankton population density was highest at station P8 with 1,039 ind.ml⁻¹ composed mainly of *Chlorophyceae* and *Cyanobacteria*, and lowest in P05 (111 ind.ml⁻¹).

The *Bacillariophyta* division was the main representative of algae in terms of relative abundance at most sampled sites. The *Chlorophyceae* class was especially significant at stations P08, P09 and P11 and *Cyanobacteria* was fairly representative at P08 and P10.

In the period evaluated, the population showed little change with respect to the equitability index, constant at most points. That could indicate certain stability in their structure in the face of environmental influxes. The equitability index varied from 0.49(P12) to 0.66 (P05 and P11).

The values of the Shannon diversity index for Phytoplankton varied between 1.71 bits.ind⁻¹ at P12 to 3.30 bits.ind⁻¹ at P08. Station P08 showed several classes in its quantitative analysis, differing from the other points whose densities were mainly associated with the presence of *Bacillariophyta*.

In the dry season (June 2010), qualitative analysis registered 67 genera with 113 species distributed among Bacillariophyta (Bacillariophyceae, Coscinodiscophyceae and Fragillariophyceae), Chlorophyceae, Crysothricaceae, Cryptophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae, Oedogoniophyceae, Xanthophyceae and Zygnemaphyceae. The Zygnemaphyceae class was the most well-represented (35 species), followed by the Bacillariophyta division (29 species), Chlorophyceae (17 species) and Cyanobacteria (13 species).

The phytoplankton population density was highest at P8 (849 ind.ml⁻¹) and lowest at P05 (36 ind.ml⁻¹). These results corroborated with those found in the rainy season, but with smaller density values at these points.

Bacillariophyta was the main representative at most points in terms of relative abundance. The *Chlorophyceae* class was especially important at stations P08, P09, P10 and P11. *Cyanobacteria* was fairly representative at P05 and P08.

In the period evaluated, the population showed little change with respect to the equitability index, keeping similar values at most points. The values varied between 0.45(P08) and 0.69 (P05). Diversity index values applied to Phytoplankton density varied between 1.09 bits.ind⁻¹ at station P05 to 2.78 bits.ind⁻¹ at station P08.

Generally, the water bodies assessed had similar behavior during the two periods (rainy and dry). There was a small decrease in richness and density values during the dry season, probably because there was periphyton influence on the phytoplankton population.

Zooplankton

In the rainy season (March, 2010), 10 rotifer species were identified, along with some Copepoda of the Cyclopoida order (nauplii and copepodites). The Rotifers included the Bdelloidea order (1 species) and the families Brachionidae (3 species), Lecanidae (2 species), Colurellidae, Collothecidae, Conochilidae and Synchaetidae, with 1 species each.

In relation to richness, point P8 showed the greatest number of species (6 species), followed by points P9 and P11 (3 species), P12 (2 species), P5, P6, and P10 (1 species each). At station P7, no species were registered.

In general, sample points had low density. Point P5 had the highest number with 53.01 ind./m³, followed by P11 with 27.73 ind./m³. In terms of abundance, the most abundant species were *Lecane monostyla* spI, *Collotheca ornata* and *Keratella americana*, all belonging to the group Rotifera.

In the dry season (June, 2010), a total of 8 taxa were identified, of which 7 belonged to Rotifera and 1 to Cladocera. Specimens of the Copepoda group from the Cyclopoida order in the first stage of development (nauplius) were also collected.

The Rotifera was composed of the order Bdelloidea (1 species) and the families Brachionidae (2 species), Lecanidae, Colurellidae, Collothecidae and Synchatidae, with 1 species each. Among the Cladocera, only the Bosminidae family was registered (1 species).

For rotifers and cladocerans, richness varied from 0 to 6 taxons. Sample point P8 had the greatest number of species (6), followed by points P9 and P10 with 2 species each. There was no record of any species at sample points P6 and P7. Zooplankton population density was low in all of the sample points. Station P8 had the highest representation with 256.89 ind./m³, followed by P5 with 114.17 ind./m³. Regarding abundance, rotifers *Keratella americana*, *Polyarthra vulgaris* and *Lecane monostyla* spI were the most abundant.

The group Rotifera dominated the zooplankton population in almost all of the sample points in the two collection periods (dry and wet season).

Benthos

Three sediment samples were collected with a net-like catcher in eight sampling points and put in plastic bags for biological analysis. In the laboratory, the material was washed with running water in a series of sieves with 1.00, 0.50, and 0.25 mm mesh. The animals removed from the upper sieves were removed and preserved in 70% alcohol. After washing, the samples were sorted, identified with use of a stereomicroscope down to the smallest taxonomy level possible with the help of specialized literature (MERRIT & CUMMINS, 1996) and preserved in 70% alcohol.

The results gathered were interpreted descriptively (including identification of the organisms and numerical density) and quantitatively through diversity and richness indices.

Results

During the rainy season campaign, 1,611 specimens were caught, representing 5 different taxa. The Thiariidae family was classified as the eudominant group in relative abundance, representing 88.58% of the total species caught, followed by Planorbidae (Gastropoda), with 7.26%, Chironomidae (Diptera), with 3.54%, Baetidae (Ephemeroptera) with 0.56% and Pyralidae (Lepidoptera) with 0.06%. With respect to abundance, considering all of the aquatic insects collected, the Gastropoda (Thiariidae) order was most abundant.

Water quality based on the Hilsenhoff Family Biotic Index results indicated that the environment has the best water quality at point SP-11, followed in decrescent order by: SP-12, SP-9, SP-5, SP-6, SP-10, SP-8 and SP-7, which had the worst water quality, not offering sufficient conditions to supply the needs of the different benthic populations.

During the dry season, a total of 168 specimens were captured, representing 08 different taxa. The greatest richness of organisms was observed at point SP-6, with 48 organisms, followed by points SP-7 with 42, SP-10 with 31, SP-8 with 22, SP-5 with 12, SP-9 and SP-11 with 5 and SP-12 with 3. The Chironomidae (Diptera) family was the group that had the highest relative abundance, making up 61.90% of the total specimens caught, followed by the order Gastropoda, families Planorbidae and Hydrobiidae with (5.95%), Odonata, Gomphidae family with (5.36%), Hemiptera, Naucoridae family with (2.38%) and Gastropoda, Pleuroceridae family and Ephemeroptera, Baetidae family with (0.60%), the families with the lowest representation in the sample.

The results for the Hilsenhoff Family Biotic Index were the same as those obtained for the rainy season. Point SP-11 was classified as having the best water quality, then in order: SP-12, SP-9, SP-5, SP-6, SP-10, SP-8 and SP-7, which had the worst water quality.

5.2.2.6

Vectors and Human Health

The possible environmental changes caused by the Project may have effects on local medically important fauna, resulting in adverse effects to local public health. In the state of Tocantins, 166 positive cases of autochthonous and imported malaria were recorded in 2008. In addition to malaria, other diseases transmitted by insects are reported in the region, such as dengue, which in 2008 in the state of Tocantins infected more than 11,200 people (MS, 2009) and that only in January 2010 had more than 9,100 cases in the state of Goiás (MORENO, 2010), of which 327 were in the municipality of Campos Belos, near Arraias. Additionally, leishmaniasis is mentioned as an important disease in the region, as in 2008 more than 390 cases of tegumentary leishmaniasis and another 430 of visceral leishmaniasis were registered in Tocantins (MS, 2009). Costa (2005) points out Tocantins as one of the four Brazilian states with largest concentration of cities hosting the vector *Lutzomyia* (*Nyssomyia*) *whitmani* s. l. and Carvalho *et al* (2010) identified a new

phlebotomine species in the city of Arraias, which indicates the potential of the municipality for the transmission of leishmaniasis in both of its forms.

Therefore, a health impact assessment to identify the medically important entomological fauna (vectors) will be conducted in the project area, prioritizing potential transmitters of malaria, a highly transmissible disease which is frequently lethal and other key vectors affecting human health, as indicated in **Section 5.2.5**. This will comply with Ordinance No. 45, of December 13, 2007, which establishes issuance of the Technical Opinion on Assessment of Malaria Potential and of the Certificate of Sanitary Condition by the Health State Secretariats belonging to the Legal Amazon Region, Ordinance No. 47, of December 29, 2006, which deals with assessments of potential for malaria transmission in malaria endemic regions and Technical Notes No 16/2009 and No 12/2007 (CGPNM/DIGES/SVS/MS) as well as WBG PS 4.

The fauna survey of medical interest will include collection of material in terrestrial environment, utilizing the Shannon trap methodology, and collection of larvae by dippings (as recommended by Technical Note No.12/2007 -CGPNM/DIGES/SVS/MS) during daytime. The surveys should include two campaigns, covering the dry and humid seasons, and should include mainly localities within the directly affected area – DAA (water catchment and tailings reservoirs and the industrial unit), as depicted in **Figure 5.2.2.6.a**. The sampling areas are shown in **Table 5.2.2.6.a**.

Table 5.2.2.6.a
Sampling areas for medically important fauna.

Area	Centroid	
	x	y
Water Catchment Reservoir	303932,6	8569059,8
Tailings Reservoir	301977,9	8573256,5
Industrial Unit	311221,5	8570045,5

Data obtained will be discussed and compared with SINAN(Information System on Notifiable Diseases)'s epidemiological data on relevant diseases in the Project's area (municipality of Arraias – State of Tocantins) and the surrounding localities (municipality of Campos Belos – state of Goiás and other surrounding areas) and with scientific publications regarding the epidemiological situation within the region.

