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Physical Environment Aspects as Subsidy to Occupation in Southwest Amazon Conservation Units – A Case Study Relating the Jamari National Forest and its Surrounding Areas

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Abstract

This research had as its objective the understanding of physical environment dynamics and its association with land occupation in the Jamari National Forest and its surrounding areas. Geoprocessing and the adaptation of thematic maps were used during the research. Field activities were carried out in order to verify the adapted maps, interpret the actual land occupation dynamics and to collect and analyze soil/sediment samples. Most of the soils were shown to be physically fragile with low nutrients bioavailabile. They cannot support agricultural activities, even with the use of fertilizers. Research showed the presence of soils with a high content of sand fraction grains, presenting high levels of quartz mineral, which vary from 76 to 93% in the west, where the greatest anthrop interference in the area can be found. Cattle rearing is the prevailing activity in the region. This occupies around 95% of deforested areas. The pastures have lost approximately half of their productive biomass capacity in 10 years forcing either the clearing of previously forested areas or the acquisition of lands by cattle ranchers. The settlers that sell their lands purchase others that are cheaper, forested, so continuing the cycle of settlement and clearance. However, research shows that the fine balance between vegetation, soil and dissected relief is fragile. Thus, the breaking of this balance by altering any of these elements can accelerate the erosion process and nutrient loss to the depth of the water table. The structural and mineralogical characteristics of the soils show marked limitations for agricultural use due to the reduced volume of weathered material available to physically support crop cultivation and humidity retention.

Keywords: *Conservation unit; occupation dynamic; physical environment dynamic; environmental service*

Introduction

Planning policy for the use of space in the Amazon has always been based on political policy (Fearnside and Laurance, 2012; Mello, 2006; Thery, 2005), leaving both technicians and scientists to take into consideration.

From the 1960's until the present day this has become a common format. It succeeded in legitimizing government policy. However, another characteristic of these programs is that plan after plan progressively exacerbates environmental

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issues in Amazonia, such as poverty and illegal deforestation (Santos, 2002), social inequality (MMA, 2006; Esterci and Schweickardt, 2010), the destruction of valuable resources, such as biodiversity and carbon storage together with the promotion of extended production, such as livestock and soybean production, which do not require high levels of labor. These in turn transform into social and environmental issues.

Environmental issues arising from damage caused by activities in inappropriate spaces in the Amazon raise the need to rethink the capacity of the environment in order to avoid problems such as erosion in cropland (Li and Yeh, 2001). Current governmental spending in Brazil on issues related to erosion is around US$9.3 billion annually (SBPC, 2011). There is a concern in society today regarding sustainable development (Sachs, 2008). Sustainable development is based on the premise that conservation of the environment is a way to ensure maximum and sustainable use of natural resources with minimal negative environmental impact.

Multidisciplinary studies of the physical environment concerning environmental fragility (Crepani et al., 2001; ROSS, 2009) are carried out as a means for understanding environmental phenomena, thus providing planners with information related to vulnerabilities caused through human intervention (Silva, 2000; Mattos and Peres Filho, 2004). This permits the determination of parameters that can modify ecosystems without destroying them (Tricart, 1977).

The occupation around the Jamari National Forest (Flona) in Rondônia is an example of one of these studies, and the issues surrounding the occupation around protected areas together with the relationship with natural erosion vulnerability. A lack of planning policy aimed at protecting environmental resources and their services has resulted in an incompatible relationship with the environment.

This article aims to understand the dynamics of the physical environment and its association with methods of occupation around the Jamari National Forest. The article also proposes a classification of natural vulnerability to erosion associated with specific attention to the characteristics of occupation. The identification of critical areas and potential erosion measures that require specific planning and management has also been attempted.

1. Area and Location of Collection Points

The study includes the Jamari National Forest (Flona) together with a buffer area of 10 kilometers around it starting from the official line of demarcation laid down by the Brazilian federal government (MMA, 2000). The Jamari National Forest is located in the north of Rondônia (Figure 1) and is between 62º 44’ 05” and 63º 16’ 54” meridians and parallels 9º 00’ 00” and 9º 00’ 00”south latitude. The forest consists of 223.086,27 hectares and was established by Decree Number 90.224 on 25/09/1984. It is located in socioeconomic and ecological zoning of Rondônia subarea 3.1, a region consisting of protected areas for sustainable use (Batista and Matricardi, 2002), and is bordered to the north by the Ecological Station (ESEC) Samuel (covering the municipalities of Itapuã do Oeste and Candeias do Jamari). The municipality of Cujubim is to the southwest and to the west, Candeias do Jamari, Itapuã d’oeste and ESEC Samuel. The Jamari National Forest lies within the municipality of Itapuã do Oeste and 5% within Cujubim. The main access to the Flona can be gained by travelling 110km along the BR-364 highway from Porto Velho and to Cujubim by travelling along the RO-452 highway.

2. Material and Methods

For a generation, the SPRING (System Georeferenced Information Progressing) was used in order to attain numerical modelling of land at a scale of 1:250.000 to construct thematic maps of geology, geomorphology, vegetation, and soil types together with climate and geoprocessed.

This system allows the visualization of data to the application of techniques in order to create a numerical terrain model/NTM of the area.

Thus, the analysis of natural erosion vulnerability was carried out as proposed by Crepani et al., (2001), which has recently been applied in other areas of Rondônia (Silva and Maniesi, 2005) and Acre (Chelly and Maniesi, 2008), classifying the degree of vulnerability of each territorial unit based on the principles of ecodynamics of Tricart (1977), which refer to the processes of pedogenesis and morphogenesis. The natural vulnerability to erosion is expressed as a score ranging from 1 to 3.

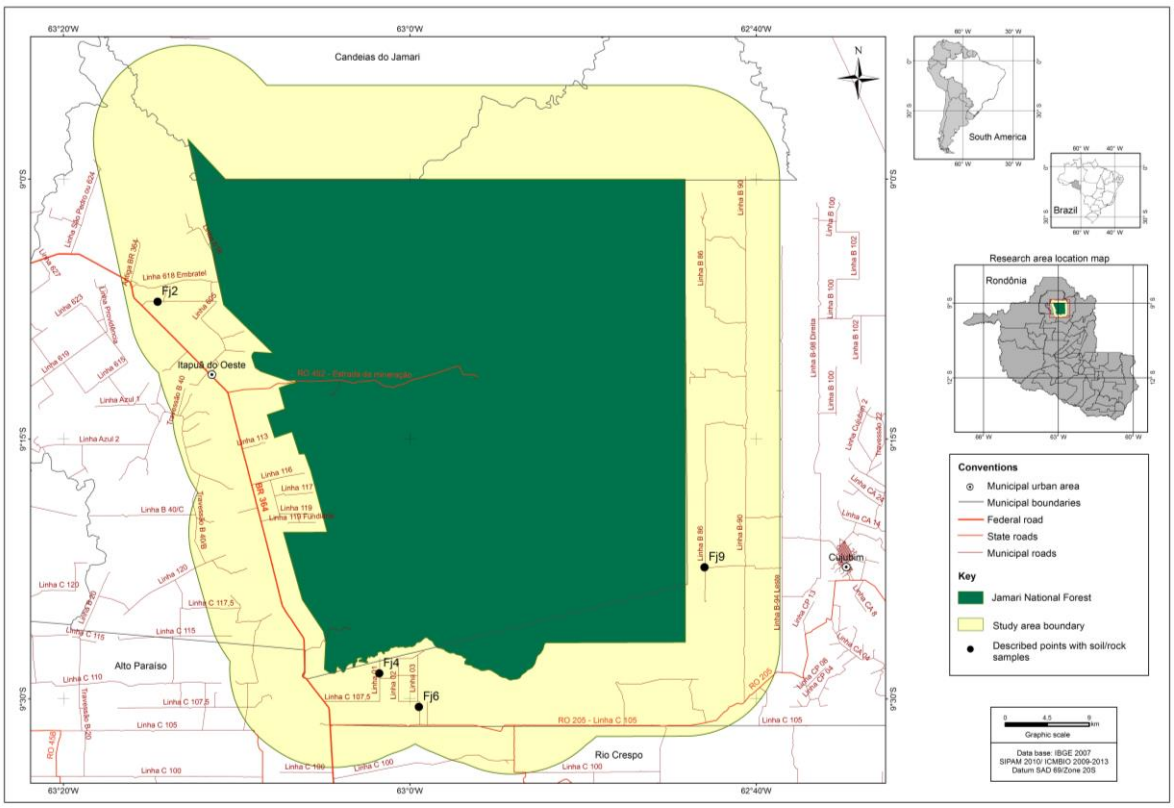


Figure 1: Map Showing Localization of the Area and Collection Points of Soil and Sediments.

Table 1

Assigning Criteria for Natural Erosion Vulnerability Values in the Jamari National Forest and its Surrounding Areas according to Crepani et al. (1996, 2001)

Theme	Assigned criteria for natural erosion vulnerability values
Geology	Rock cohesion
Geomorfology	Releif dissection
Pedology	Soil stage of development
Vegetation	Vegetation cover density
Climate	Total rainfall and seasonal distribution

The closer the score is to 1, the greater the system stability, and the closer to 3, the more vulnerable to erosion the system is.

Values of natural erosion for each unit of each subject were assigned considering the characteristics that influence the soil loss processes as shown in Tables 1 and 2.

These values include the processes that influence the pedogenesis and/or morphogenesis development according to the following classes: stable, moderately stable, moderately stable/ vulnerable, moderately vulnerable, and vulnerable (Figure 2).

After the elaboration of the numerical terrain model/NTM, field activities were carried out in order to validate the natural erosion vulnerability map and to interpret the induced erosion dynamics facing the present occupation modes.

2.1 Granulometric and Mineralogical Studies

2.1.1 Granulometric Analysis

Particle size analysis identified the various proportions of sand, silt, and clay material collected in four selected samples (FJ-2, FJ-4, FJ-6, FJ-9) as shown in Table 3. In order to enable the separation of fractions, a shaker table was used for grains of sand, silt, pipette, and clay (Dourado et al., 2012; Souza et al., 2003; Sanchez et al., 2009). Samples were worked through by wet sieving.

Table 2

Assigned Values to Each Natural Erosion Vulnerability Topic Related

Vegetation	VS	Geomorfology	VS	Soils	VS	Geology	VS	Climate mm/yr	VS
Open Ombrophilous Forest	1.0	Planning surfaces	1.6	Latosoils	1.6	Unconsolidated sediments	3.0	2100	2.05
Dense Ombrophilous Forest	1.3	Cluster of hills and small dome-like hills	2.4	Podzols	1.7	Laterite	2.1	2200	2.10
Contact savannah/ forest	2.0	Floodplains	3.0	Concretionary Soils	3.0	Granites	1.1	2300	2.15
Pionner formations	2.0	Fluvial Terraces	1.2	Inceptsol	2.65	Gneisses	1.3	2400	2.20
Savannahs	2.4			Regosols	2.9			2500	2.25
Secondary Vegetation	3.0			Gley Soil	3.0			2600	2.30
				Quartz Sands	3.0				

*VS – Vulnerability Scale

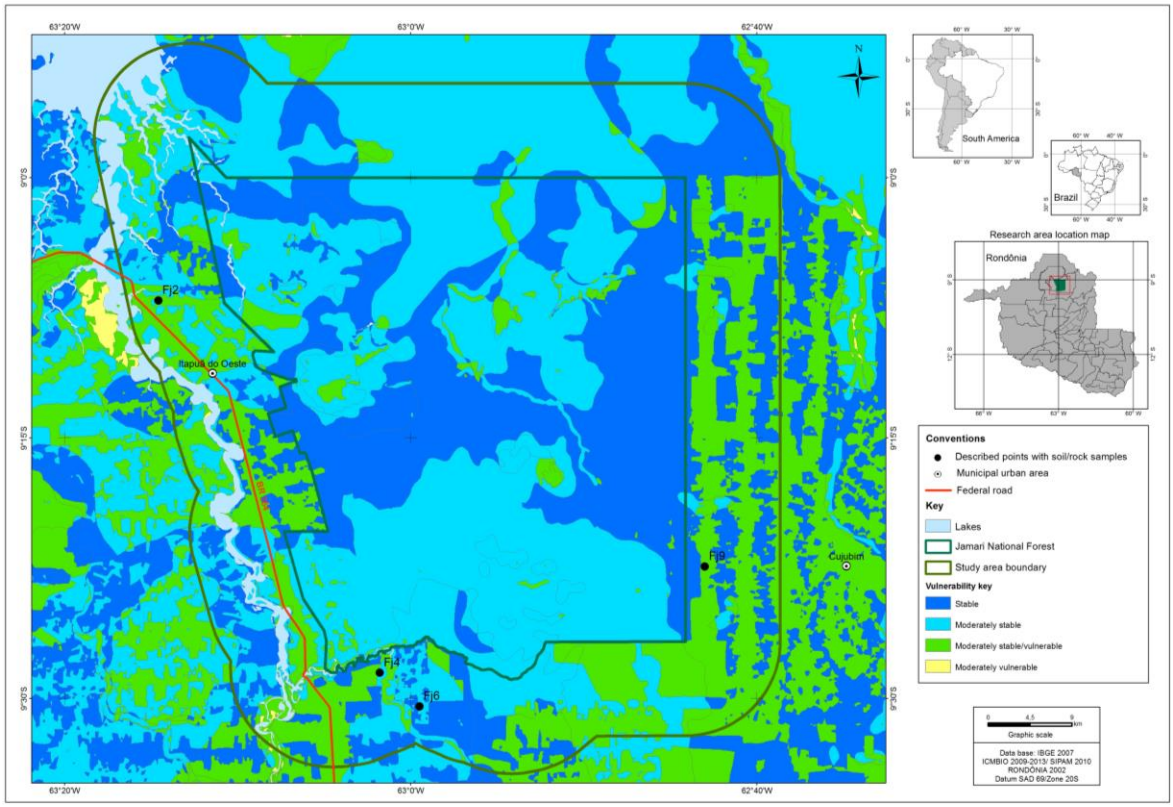


Figure 2: Map of Natural Erosion Vulnerability of the Jamari National Forest and Surrounding Areas

Table 3

Granularity of Samples FJ-2, FJ-4, FJ-6, and FJ-9 in Percentage by Weight of Sand and Silt Fractions + Clay Test

Sample	Sand (g)	Silt + Clay (g)	Sand (% by weight)	Silt + Argila (% by weight)
FJ-2	231,6	428,1	35,1	64,9
FJ-4	420,5	479,9	46,7	53,3
FJ-6	335,9	383,5	46,7	53,3
FJ-9	321,1	167,7	65,7	34,3

A standardized series of superimposed sleeves with a mesh aperture, diameters of 6, 10, 20, 40, 60,100, and 150 mesh, was used for fractions of sand grains.

Results show the relative frequency at various sizes between an upper limit and lower limit are present within the population of particles. After screening, particles were oven dried with compressed air in order to define the weights and representation in each sample, as in the work of Nascimento et al. (2012), Santos (2010), and Gomes (2009). The Wentworth (1922) method was used for the screening of sand fraction with mesh opening diameters, including classes of sand 2mm to 0.0062 mm and silt and clay (0.062 mm). Pipette was used for silt and clay fractions (Souza et al., 2003; Sanchez et al., 2009).

2.1.2 Mineralogical Analysis

Analysis was carried out in the laboratory of Geosciences at The Federal University of Rondônia with the aid of a binocular microscope to determine grain size of sand fraction intervals in four previously selected samples (FJ-2, FJ-4, FJ-6, FJ-9). For each particle size class, from very course to very fine, the characteristics of grain, together with the degree of rounding, was taken into account as well as other properties, such as color, luster, cleavage, magnetism, trace, hardness, and transparency. The data obtained is shown in Table 4.

2.2 Digital Elevation Model – Map of Natural Erosion Vulnerability

From the weight values attributed to each theme (climate, soils, geology, geomorphology, and vegetation), it was possible to determine the values of vulnerability of each thematic unit using map algebra.

The map of natural erosion vulnerability of the national forest and its surrounding areas was classified into 21 categories of analysis with the objective of determining their vulnerability, as proposed by Crepani et al., (1996), and later reclassified into five categories for the purpose of visual analysis.

As can be seen in the natural erosion vulnerability map of the Jamari Natural Forest and its surrounding areas, after reclassification into five categories, only four of them were clearly identified. No area was found to be vulnerable to erosion. The areas that presented themselves as moderately vulnerable to erosion are located in the sites that have already been deforested, as can be seen in the western, southern, and eastern portions of the map. It can be observed that in the east, changing environments caused by deforestation are responsible for the change in pattern from stable to moderately vulnerable.

Table 4

Mineral Percentage Volume of Sand Fraction Samples FJ-2, FJ-4, FJ-6, and FJ-9

Sample	Minerals (% in volume)					
	Quartz	Feldspato	Mica	Opaque	Zircone	Lateritic Fragments
FJ-2	76	-	-	19	1	4
FJ-4	93	-	-	5	1	2
FJ-6	76	1	< 1	10	< 1	13
FJ-9	20	-	2	< 1	< 1	78

There is an area that can be identified as moderately vulnerable to erosion in the southwestern area, close to the bed of the Jamari River. This can probably be associated with areas of alluvial deposition. The remaining area consists of both moderately stable and stable areas to erosion.

It can be observed that a change in values of natural erosion susceptibility varies significantly across the area. This indicates an increased risk related to the appearance of erosive processes. Apart from the deforestation factor, this may be associated with decreased soil cohesion due to the occurrence of undifferentiated sediments with markedly sandy and quartz (Tables 3 and 4) characteristics.

There is a predominance of cattle ranching in the region (Almeida Silva et al., 2009). Such activity requires deforestation of large areas and the creation of pasture, which is used to feed herds. The areas of greatest vulnerability can be found in the southwestern region of the map and are associated with alluvial deposits devoid of vegetation and caused by anthropogenic activities associated with roads and the removal of riparian forests (Lima and Zaika, 2000), rivers in the region, use of land without maintenance of riparian vegetation, and on hilltops may change the rating for vulnerability where laws are not adhered to.

Data related to field samples corroborates the numerical terrain map indicating a significant presence of quartzose sand and material, as shown in Tables 3 and 4, but primarily to FJ-2 and FJ-4 points, both connected to potentially unstable areas.

The opening of roads and/or removal of forest cover for pasture may change the classification of stable polygons to moderately vulnerable, which in turn requires greater care in handling. Cattle ranching and the removal of riparian and hilltop forests together with the associated mass movement of people has led to the siltation of rivers across the studied area.

3. The Physical Environment of the Jamari National Forest and its Regional Context

3.1 Geology

The Jamari National Forest is inserted within the South American Amazon Platform Cratonic Structural Unit (Quadros, 2011) in a geotectonicamently stabilized region (Pires, 2009) in Paleoproterozoic. In virtue of age, the morphology expresses flattened surfaces derived from the reworking of pre-existing rocks, with a special configuration marked by low dissection morphoclimatic events (Adamy, 2002; Radam, 1978). Geological data, Scandolara et al., (1999) and Quadros (2010) show that the whole area is built upon Paleoproterozoic rocks of the Jamari Complex.

3.2 Geomorphology

Two of the three main geomorphological environments can be found within the study area (Adamy, 2002). They are (a) areas of regional planning surfaces and (b) the area of the Madeira River system.

a) Areas of regional planning surfaces: This is present in a large part of the state, being characterized by areas of leveling in ancient rocks and sedimentary structures covered by Tertiary – Quaternary. There is a high quantity of iselbergs on these surfaces indicating stronger weathering action over a considerable geological time.

b) Madeira river system: This is characterized by high geomorphological complexity which is formed by alluvial plains, alluvial terraces, wetlands, and inactive ranges of obstructed run off.

3.3 Climate

The climate of Rondônia is characterized by a spatial and temporal homogeneity of average air temperature. Within the study area, there is a difference of only 2ºC between maximum and minimum temperature ranges of 25-26ºC, while in the southern parts, the temperature ranges from 24-25ºC (Gama, 2002). However, this is not the case with respect to rainfall, which presents seasonal variability, and to a lesser extent, spatial variability. Flona and its surrounding areas show some of the highest rainfall levels in the state with

annual averages between 2.400 and 2.600mm (Gama, 2002). These characteristics can be defined as a tropical, rainy climate, Aw type, hot and humid according to the Koppen classification.

The period of highest rainfall is between November and May, with less intense levels (less than 20mm per month) in the months of June, July, and August. Humidity levels range from 80% to 90% in summer and around 75% in winter (Gama, 2002).

3.4 Soil

Maps for the state generally agree regarding soil type, independent of scale within the study area. Radam (1978) and Cprm (2010) 1.000.000 and Rondônia (2002) 1:250.000 show a near total dominance of latosoils that are present, including the largest area of yellow dystrophic latosoil and a secondary area of red-yellow dystrophic latosoil (Radam, 1978; Rondônia, 2002; Sipam, 2000).

Exceptions are Radam (1978), which points to the existence of hydromorphic podzols rich in allelic quartz sands located in the central western part of the study area, and Rondônia (2002), which describes patches of dystrophic regosoils in the centre of UC.

3.5 Vegetation

Rondônia is located between two of the richest areas of morphoclimatic life on the planet, the Amazon and the Cerrado, and represents the southwestern portion of the largest system of rivers and rainforests in the world (Bartherm and Goulding, 1977).

This position gives Rondônia and, consequently, the Jamari National Forest, a rich biodiversity. Phytophysignomies of open evergreen forest, tropical rain forest, and alluvial formation (MMA, 2005) can all be found within the Jamari National Forest.

Open rain forest is the dominant vegetation in the state, occupying approximately 55% of its area (Silva and Vinha, 1978) and 95% of the unit, and, until recently, was known as an "area of climatic transition." It can, by physiognomy, structure, and frequent gregariousness of certain species with some endemic genera, be classified as a new phytoecological Brazilian Amazon region.

According to Rondônia (2002), dense tropical rain forest represents only a small proportion of vegetation type of the northwestern part of the unit, and there are parts that are of high economic value (Silva and Vinha, 2002). This dense vegetation has a multistratification characteristic.

The management plan of the unit (MMA, 2005) also records the presence of alluvial formations, or 'Buritizal', located in shallow sheets close to river sources and waterlogged depressions. Buritizal is located along a 16 km length of the southern portion of the western boundary.

4. The Physical Environment and its Relation to the Method of Occupancy in the Jamari National Forest and Surrounding Areas

Laboratory data was obtained from treatment of four samples collected around the vicinity of the Jamari National Forest and was represented by undifferentiated Cenozoic sediments (FJ-2) and soils FJ-4, FJ-6, and FJ-9. Amounts related to percentages of sand fractions (particle diameter of between 2 and 0,062 mm) and silt + clay (diameter of particles smaller than 0,062mm) selected constituents of sand fraction in Table 3.

An initial evaluation of the data set (Tables 3 and 4) showed a prevalence of quartz grains in samples FJ-2, FJ-4, and FJ-6 samples, ranging from 76% to 93%. Fragments of laterites are most commonly found in sample FJ-9 (78,2%), indicating that the original granite rock has undergone supergene enrichment, contributing to the continuing evolution of eluvial soil.

An outcrop on the eastern edge of a minor road is known as line 6/6 and is located in the northwestern area of the Jamari National Forest. This is an area of intense cattle trampling due to a semicircular excavated area, with a diameter of approximately 10 meters and a depth of approximately 1.5 meters, used for the capture of rainwater for livestock.

There are cracks in the compacted material due to the heavy trampling of cattle; however, there is no significant linear erosion action. The sedimentary material consists of quartz grains milimeter to submillimeter faceted and sub-rounded, sur-

rounded by a matrix of silty, medium-gray clay with portions of an ochre colour.

Sediment represents the plio-Pleistocene period and a fluvial environment primarily of alluvial fans, channels, and floodplains (Scandolara et al., 1999). The sediment is identified as Undifferentiated Sedimentary Covers and Frames by Rizzotto (2007). It is a stratigraphic unit with a thickness generally less than 40 meters.

Evaluation along the binocular loupe revealed a sedimentary material consisting of a higher proportion of silt and clay (64.9%) compared to the sand fraction (35.1%). Sand predominates in fine sand fractions + very fine (61.3%) compared to medium sand (10.6%) and thick + very coarse (27.1%).

Grains in the sand fraction with a degree of angular rounding (47%), sub angular (33%), sub rounded (20%), consisting of quartz (76%), laterite (4%), opaque (19%), and zircon (1%) are identified in Table 5.

Transparent grains of quartz outnumber those of a milky nature. Its low degree of roundness and flattered grains suggests its original form of autigene filling is now disaggregated. Reddish spots are undespread, and there are powdery aggravates associated with laterite grains of course sand fractions and course persistent transport.

The opaques are represented in a higher proportion by ilmenite and magnetite by subordinate mode. Isolated grains are present in fractions smaller than 0,5mm, as fine rounded grains of quartz. Muscovite occurs in fraction finer than 0,25mm as clear angular sub angular laminar particles.

FJ-4 is located in the southwestern region of the Jamari National Forest and is composed of weathered granite rock. It is the only material of chemical weathering to be found is angular quartz crystals, corresponding to 93% of the mineral component of the sand fraction (Table 6). The lateritic fragments (2%) and opaque fragments (5%) are part of mineralogy of fractions with grain diameters less than that of medium sand.

The original granitic rocks belong to the Santa Clara Intrusive Suite, an outcrop in the southeastern area of the Jamari National Forest, and are intrusive within the Jamari Complex. The specific area of syenogranite with phenocrysts of potassium feldspar. Rocks are light gray in colour with SiO_2 content between 63% and 75% K_2O + Na_2O from 7,32 to 9,16%, FeO + MgO from 0,88% to 0,99%, representing metaluminous subalkaline granites to weakly peraluminous (Bettencourt et al., 1997).

Table 5

Estimated Percentage by Volume of Mineral Sand Fraction FJ Sample 2. % Sand + Silt + Clay = 100%; % Course Sand + % Medium Sand + % Fine Sand + % Very Fine Sand = % Sand

Classification Of Material	Weight %	Minerals (% in volume) Quartz	Feldspato	Mica	Opaque	Zircone	Lateritic Fragments
SAND	35,1	76	-	-	19	1	4
– Very course sand	7,6	8	-	-	-	-	47
– Course sand	19,5	25	-		1		6
– Medium sand	11,6	13	-	-	5	-	10
– Fine sand	27,5	30	-	-	22	-	23
– Very fine sand	33,8	24	-	-	72	100	14
SILT + CLAY	64,9						

Table 6

Estimated Percentage by Volume of Mineral Sand Fraction Sample FJ-4% Sand + Silt + Clay = 100%; % Course Sand + Medium Sand + Fine Sand + % Very Fine Sand = Sand

Classification Of Material	Weight %	Minerals (% in volume) Quartz	Feldspato	Mica	Opaque	Zircone	Lateritic Fragments
SAND	46,7	93	-	-	5	< 1	2
– Very course sand	14,2	15	-	-	-	-	14
– Course sand	37,9	40	-	-	-	-	40
– Medium sand	15,2	16	-	-	-	-	8
– Fine sand	20	19	-	-	35	-	21
– Very fine sand	12,7	10	-	-	65	-	20
SILT + CLAY	53,3						

Point FJ-6

At the FJ-6 sampling point, intermediate laterites are found between columnars structures and concretionary soils that support hilly relief. Close to these hills, recessed reliefs that consist exclusively of concretionary laterites can be identified with eluvial soil and low density (less than 1 meter thick) with ferruginous concretions.

The lateritic crust is of an immature type, developed on Cenozoic undifferentiated sediments. There are concretions of black hematite and a rigid shell that serves to support the hilly relief where an Embratel tower is built. Line 618 in the western area of the Jamari National Forest.

The material exhibits a predominance of quartz crystals (76%) in the sand fraction and feldspar weathering processes (1%) distributed in the different sand fractions. The presence of laterite fragments found in fractions with a grain diameter above that of course sand (43%) and other fractions of sand distributed in percentages of between 13% and 16% (Table 7).

Fragments are reddish with a powdery quality and dotted with a fine, clear, powdery scoring of sub rounded quartz in straight and conchoidal fractures in quartz. There is often a presence of oxides/ hidroxides of iron red/yellow colour. They are monocrystaline, predominantly transparent, and sub rounded grains.

Point FJ-9

On both sides of the secondary road, identified as B Line 86 on the western edge of the Jamari National Forest, eluvial soil of varying thickness (often more than 3 meters) occurs. It is of a reddish colour and often contains widespread angular centimetric quartz crystals. The soil shows a predominance of particles in the sand fraction (65.7%) compared to the silt clay (34.3%) with the following mineralogical properties (Table 8): quartz (20%), lateritic fragments (18%), mica (2%), and opaque (1%). The decrease in particle size of the grains in the range of the sand fraction has meant a decrease of laterite fragments, gradually enriching the contents of quartz 11%-29% and the very fine sand fraction as well as opaque, mica, and zircon (Table 8).

Even with a considerable quantity of particles in the sand fraction, the presence of materials in the silt + clay favours the development of a soil with a horizon B thickness, configuring to a red latosoil.

The geological base consists of porphyirtic monzogranite with phenocrysts of potash feldspar in a fine matrix consisting of quartz, hornblende, biotite, and plagioclase. Rocks contain SiO_2 between 68% and 72% and K_2O + Na_2O greater than 8%, constituting a sub-alkaline, geochemical affinity, metalumia to lightly peraluminous (Rizzotto et al., 1995).

Table 7

Estimated Percentage by Volume of Mineral Sand Fraction Sample FJ-6 % Sand + Silt + Clay = 100%. Course Sand + % Medium Sand + % Fine Sand + % Very Fine Sand = Sand.

Classification Of Material	Weight %	Minerals (% in volume) Quartz	Feldspato	Mica	Opaque	Zircone	Lateritic Fragments
SAND	46,7	76	1	< 1	10	< 1	13
– Very course sand	37,9	41	22	-	-	-	43
– Course sand	31,6	36	48	-	16	-	13
– Medium sand	8,9	7	13	-	18	-	14
– Fine sand	11,5	9	17	-	31	-	14
– Very fine sand	10,1	7	< 1	100	35	100	16
SILT + CLAY	53,3						

Table 8

Estimated Percentage by Volume of Mineral Sand Fraction Sample FJ-9 % Sand + Silt + Clay = 100%; % Course Sand + % Medium Sand + % Fine Sand + % Fine Sand + % Very Fine Sand = Sand.

Classification Of Material	Weight %	Minerals (% in volume) Quartz	Feldspato	Mica	Opaque	Zircone	Lateritic Fragments
SAND	65,7	20	-	2	< 1	< 1	78
– Very course sand	79	28	-	-	-	-	93
– Course sand	3,5	11	-	6	-	-	2
– Medium sand	2,7	10	-	13	-	-	1
– Fine sand	6,7	22	-	40	-	-	2
– Very fine sand	8,1	29	-	41	100	100	2
SILT + CLAY	34,3						

The Jamari National Forest is a regional, geological basement gneisses of the Jamari Complex, configurating reliefs cringraded to below 200m, even when displaying coverage of undifferentiated Cenozoic sediments (FJ-2 point). Low hills occur, supported by columnar laterites (FJ-6 point). Hills associated with intrusive granites also occur with modelling related to weathering along subhorizonal fractures, which cause exfoliation of the rock, configurating rocks with millimeter or even centimetres thick. Its peeling tends to form rounded, hilly surfaces. (Points FJ-4 and FJ-9).

Essential nutrients and consistently high luminosity are associated with poor soils, temperature and humanity reflect effectiveness of natural vegetation. Particle size, distribution and mineralogical data, soils, and sediments show that most of the nutrients are stored in the vegetation itself. The soil consists of a number of nutrients that result from the pedoenvironmental bioavailable conditions under which they are formed, and are constantly being modified in order to adapt to the prevailing environmental conditions. Nutrients are only sufficient to adapt to conform to the so-called law of the minimum, which conforms to efficient cycling, a rapid decomposition of crop residues, the release of nutrients, and the absorption of nutrients by the root.

When there is replacement by pasture and/or crop, as is the case around the Jamari National Forest, nutrients can become lost in the depths of the water table or through erosion (Lepsch, 2011). Thus,

there are few areas for the implementation of productive, sustainable agriculture. Exceptions to this are places with gentle slopes and good drainage where relatively well developed soils occur. There are possible areas of point FJ-6 with latosoils associated with granitic rocks (FJ-9), young soils, or neosoils, or rather without B horizon diagnostic that occur in Indifferential Cenozoical Sediment.

4.1 Causes and Consequences of Anthropogenic Procedures

The beginning of problems related to reforestation in the Jamari National Forest can be seen as a result of policies implemented by the federal government and typified by programs such as POLONOROESTE and PLANAFLORO.

According to Fearnside (1983, 1989), deforestation occurred in the 1980's and increased at a rate of 24.8% per year. According to the author, this sharp increase in deforestation rates was the result of migration boosted by the paving of the BR-364. Several settlement projects (PAs) proposed by INCRA were situated on the edges of protected areas (Mello, 2006). The colonization projects close to the south area, respectively as Americo Ventura and Cujubim, presented problems due to a lack of planning. These PAs were designed in soils with low prospects for agricultural activity due to low levels of essential nutrients and reduced volume of weathered material available to support this activity (Fearnside, 1989). It is a tendency to occupy the Amazon, discussed by Fearnside (1989, 1993, 2004), Mello (2006), Mello-Thery (2011), that leads to the opening of roads, as well as the expansion of new frontiers, which puts intense pressure on natural resources (Fearnside and Ferreira, 1985).

Settlements were intended to be structured production units, served by technical assistance with training of families on how to manage their areas. As they have been, and continue to be, created, families have little prospect for success because of the political and economic structure that traps them in the same social conditions (Esterci and Schweickardt, 2010) causing the abandonment of lots and, consequently, the rise of huge estates (Andrade, 1987; Amaral, 2004; Carvalho Filho, 2010).

The situation in the south-southwestern area of the Jamari National Forest is the most worrying, as here can be found the highest number of land pointed polygons that are susceptible to erosion. The conversion of forest to pasture is associated with a low fertility soil together with high permoperosity with values close to 50% for the sand fraction and 100% for the mineral quartz (point FJ-4).

A high number of forms within the vicinity of the Jamari National Forest do not have water available for livestock due to the heavy sitting of water-courses. This problem is exacerbated in times of drought and many rivers have become intermittent due to degradation of areas for livestock activity.

Maintenance of natural landscapes it of utmost importance in order to ensure natural processes can be preserved and continue to be self regulating.

Conclusion

Research carried out in the Jamari National Forest and surrounding areas demonstrates definite low levels of essential nutrients and a reduced volume of weathered material available for the necessary logistical support for agricultural and/or livestock production activities.

Planning for the use and occupation of land has not taken into account issues related to regional characteristics, the intensive use of natural resources, or legal issues. All of these factors have led to environmental problems, such as land degradation and silting up of rivers.

With respect to erosion, no accelerated erosive processes were observed in any significant level. However, the methods of environmental use change patterns of stability making them more vulnerable.

The Amazon as a whole, not just protected areas, should be supported by the creation of buffer zones and supervised forms of land use consistent with regional characteristics, thus enabling socio-economic development and ensuring the maintenance of the environmental services that these areas provide to society.

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