# Characterization of vegetation and land use in rural communities of the Bragantine micro-region, Pará-Brazil

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## ABSTRACT

Accelerated population growth, the velocity and intensity of human activities such as the formation of pastures and slash and burn agriculture developed in the Bragantina micro-region, have provoked marked changes in the vegetation, causing agronomic and environmental problems. Presently, such problems can be seen at the local level, as is the case for the rural communities of the Prata module in the municipality of Igarapé-Açu-Pará. From the supervised technical classification of TM-Landsat images for 1985 and 1995 and geo-processing associated to the field information, characterization of the vegetation and land use of this area was realized. From the analysis made, a predominance of secondary vegetation was observed, corresponding to 63.24% of the total area in 1995. Accentuated conversion of low fallow vegetation (capoeira) to pasture contributed to the expansion of this class during the period considered. Pressure on the areas of younger secondary vegetation, as is the case of low fallow/capoeira, was more intense, due to the tendency for using it for agriculture and pastures, thus an increase from 35.02% in 1985 to 44.65% in 1995 for high fallow/capoeira was verified.

## RESUMO

O crescimento populacional acelerado, a velocidade e a intensidade das atividades antrópicas como a formação de pastagens e a agricultura de corte e queima desenvolvidas na microrregião bragantina, provocaram mudanças acentuadas na cobertura vegetal, ocasionando problemas agronômicos e ambientais. Atualmente, tais problemas refletem-se em nível local como é o caso das comunidades rurais do módulo Prata, município de Igarapé-Açu (PA). Através da classificação supervisionada das imagens TM-Landsat de 1985 e 1995 e geoprocessamento associadas às informações de campo foi realizada a caracterização da cobertura vegetal e do uso da terra nesta área. A partir das análises efetuadas, observou-se o predomínio da vegetação secundária correspondente a 63,24% do total em 1995, bem como uma conversão acentuada das áreas de capoeira baixa para pastagem, contribuindo para a expansão desta classe no período considerado. A pressão nas áreas de florestas secundárias mais jovens como é o caso da capoeira baixa, foi mais intensa, devido a tendência da mesma servir de reserva de uso para agricultura e pastagem, verificando-se assim um acréscimo de 35,02% em 1985 para 44,65% em 1995 da capoeira alta.

## ZUSAMMENFASSUNG

Der zunehmender Bevölkerungszuwachs, die Geschwindigkeit und Intensität anthropogener Aktivitäten, wie z.B. der Übergang zur Weidewirtschaft und die Brandrodung in der Zona Bragantina, haben zu deutlichen Veränderungen der Vegetationsdecke geführt, was Probleme für die Landwirtschaft und die Umwelt mit sich bringt. Gegenwärtig sind derartige Probleme auf lokaler Ebene erkennbar, wie im Fall der ländlichen Kommunen des Prata-Modells im Munizip Igarapé-Açu (PA). Mit Hilfe der Klassifizierung der TM-Landsat Fotos aus den Jahren *1985 und 1995 und Geo-Referenzierungen, die mit Feldinformationen assoziiert* wurden, wurde die Charakterisierung der Vegetationsdecke sowie der Landnutzung in diesem Gebiet vorgenommen. Auf der Grundlage der durchgeführten Analysen zeigte sich 1995 eine Dominanz der Sekundärvegetation in Höhe von 63,24% sowie eine deutliche Umwandlung von niedrigen Sekundärwald- in Weideflächen, die für die Ausweitung dieser Nutzungsform im Untersuchungszeitraum verantwortlich ist. Der Druck auf Flächen mit junger Sekundärvegetation war wie im Fall der niedrigen Sekundärwaldflächen besonders groß, was darauf zurückzuführen ist, daß junge Bracheflächen eher für den Anbau von Feldfrüchten bzw. für Weiden genutzt werden. Daher konnte ein Anstieg des Anteiles alter Sekundärwaldflächen von 35,02% im Jahre 1985 auf 44,65% im Jahre 1995 nachgewiesen werden.

## INTRODUCTION

Occupation of the Bragantina micro-region, unites contrasting forms of organization of the geographical space, resulting from the expansion of the agricultural frontier through appropriation and usage by the pioneer fronts in the colonization process. In this context, the municipality of Igarapé-Açu, stands out as the area with the most compromised environment, where pressure on the natural vegetation, has temporarily or definitively harmed, large parts of the areas under use.

The Prata Module is a part of this reality, characterized by secondary vegetation in various stages of succession, that when incorporated by the traditional system of agriculture at the level of small properties, acts as a reserve of land, as well as fallow and stock of nutrients, which are liberated with the burning of the biomass to re-establish soils that are chemically poor in nutrients.

Such activities have become the stimulus for the occupation of new areas, contributing to the expansion of environmentally damaging effects that result from slash and burn agriculture. In this sense, the relationship between development and the environment, implies the importance of studies that meet the objectives of being applicable to environmental planning capable of minimizing the effects of impacts from the use of the soil.. Thus, this study focuses on the dynamics of the landscape through temporal and spatial analysis of the vegetation and land use patterns, using TM-Landsat images from 1985 and 1995. Keeping in mind the complexity of the spatial transformations which result from land use, field data that are associated to the digital products, through the techniques of geoprocessing was collected to subsidize the evaluations of anthropoid changes in the landscape. Demographic pressure in the socio-economic structures have thus revealed forms of occupation and production of an expressive segment of the small holder producers.

## CHARACTERIZATION OF THE STUDY AREA

The study area covers the Prata Modules, located in the Igarapé-Açu municipality, which pertains to the Bragantine Micro-region, in the northeastern portion of the State of Pará, whose area is about 8,920.7 km$^2$ (IBGE 1995). The coordinates of this module correspond to the latitudes 01°09' and 01°18'S and the longitudes 47°31'and 47°39'WGr., approximately 2km form the main municipal town, covering and area of 12 km by 16 km.

According to Vieira et al. (1981), the Bragantine Micro-region is an area with plain to slightly rolling relief, of the quaternary geology of the Barreiras series. In this context, the Prata module has a relief which is no different from the rest of the micro-region with an altitude no greater than 70m.

The soil type, dominant in the Bragantine Micro-region are yellow Latossoils of medium texture and others with a clay texture, and in a smaller proportion the Concretionary Laterites (Projeto RADAMBRASIL, 1973), that correspond in the present classification to the class of Latossoils and Podzolics, of the rocky phases I, II e III, as a function of the position of the iron concretations in the soil profile. A major part of the latossoil is found in the higher plateaus and areas between river courses, while along the edge of more dissected relief's the podzolics dominate. In the valleys and lower areas, hydro-morphic soils, with strong "gleização", are found.

In relation to climate, the Bragantine micro-region is submitted to a temperature and humidities which in general are high, with some small thermal spatial and temporal variations and considerable temporal fluctuations in rainfall, mainly during the months with less precipitation. (Bastos and Pacheco, 1997). These authors show that the air temperature in the two localities which pertain to this micro-region and that have temperature data (Tracuateua and Igarapé-Açu) show an annual mean oscillating between 25°C and 27°C and, maximum and minimum varying between 30°C and 32°C and between 20°C and 22°C respectively, and fluctuations of mean monthly temperatures lower than 5°C, demonstrating that in the region, as one would expect, there is no occurrence of thermal variation capable to define a seasonal period of winter.

With respect to pluviometric rainfall, in terms of annual means, the micro-region shows a small pluviometric gradient, where it can be said that the region is submitted to a total rainfall in the order of 2500mm and with rainfall concentrated during the months from January to June (Bastos and Pacheco, 1997).

In relation to the vegetation, just like the entire Amazon region, originally northeastern Para State was dominated by Dense Broadleaf forest, which depending on its location in the environment and topographical position, receives the common names of upland forest, and floodplain or stream bed forest. At present, the area under study has a landscape which has resulted from the works of colonizers, such as the old Belem-Bragança Railway Line, with a predominance of secondary vegetation in various stages of succession, utilized as a component of the traditional agriculture system, in different periods of fallow, which according to Denich (1991), vary between three and eight years of age, considering the best hypothesis, in the municipality of Igarapé-Açu.

Considering the low technological level and the predominance of family labor, confronted by the small-holder producers of the Eastern Amazon, this represents the most important segment of agriculture in the region, contributing in a substantial manner to the regional production of basic food goods and the generation of rural employment.

## MATERIAL AND METHODS

For the multi-temporal analysis of vegetation and land use, Orbit/ Point images 223.061, "B" Quadrant "B", TM bands 3, 4 e 5, in digital format, for the dates of 08/06/85 and 08/06/95 were used. For manipulating and analyzing the data a program for treating images (SITIM/INPE), a geographic information system (GIS) and a program for a data base (dBASE IV), were used.

The images were geo-referenced through a pre-processing stage, considering the stage of image X map, using a plain altimetric map of DSG-3ª DL, at a scale of 1:100,000, Castanhal Sheet and then, image X image from the 1995 image and the maps from the DSG, utilizing the digital mapping table (Digigraf, size A0).

Next, the selected TM Bands were submitted to a processing phase for highlighting and the techniques for Amplifying Line Contrast. For the formation of colored compositions, the associated color/band (5R4G3B) obeyed the criteria so that the combination formed would be the most adequate to highlight the features of greatest interest. After this, preliminary, supervised classification was undertaken, considering the Algorithm Maxver. The products resulting from the digital processing were registered on paper at a scale of approximately 1:50,000, in such a way that they give support to the field survey.

The first field visit, aimed to give an overview of the landscape, through co-relationships of the spectral features found in the processed image, as well as an evaluation of the products resulting from the techniques used to highlight and for classifying. At this time control points were collected with the aid of a GPS, referring to the vegetation classes and land use, whose geographic coordinates, serve as support in the definition of training samples.

Based on the criteria for the identification of the diverse tonal patterns, forms and textures observed in the highlighted color composition, as well as the capacity for identifying the thematic images, a final legend for the vegetation classes and land use were defined, corresponding to true field situation.

With the field information of most interest in hand, classification for metrification and refinement for the preliminary classification of the vegetation and land use was made, based upon the final legend composed of vegetation classes for primary vegetation (forest) referring to upland areas ( small fragments) and stream bed vegetation (known as igapó or ciliar forest), two classes of secondary vegetation (high and low fallow vegetation or capoeira),three classes of land use (exposed soil, weedless pasture and weedy pasture), water and one class called interference (clouds and cloud shadows). Next, the areas were quantified, as well as undertaking an analysis of the dynamics of the thematic classes for the characterization of dominant landscapes.

Other field visits, were made for the application of questionnaires together with the small-holder producers about the history of the land use. This information was collected along the highways and main side roads of the Prata module, in the rural communities of Curi, Cumaru, São Jorge and Travessa do Dezesseis. A total of 40 questionnaires were completed, representing a sample which corresponds to 20% of the property owners in each selected community. The samples are representative of the traditional systems of production, those which in some manner have introduced the use of technologies, with the aim of seeking differentiated samples, within the properties, which were based on the following criteria:

- having been occupied for more than 10 years (considering that question related to the traditional forms of land use were included));

- possess an area of up to 100 hectares (characterizing in this way the properties as small-holder's farms);
- develop fallow systems of short or long periods (where capoeira, in various stages of succession, appears as an integral part of the traditional production system).

Such information, stored in a dBASE IV/SGI/INPE system, allowed the elaboration of an up-dated, tabular data base, while keeping in mind the difficulties of manipulating a large quantity of information and the facility of being able to use it in an integrated manner with GIS to carry out consultations on the variables which are of interest.

## RESULTS AND DISCUSSION

The colored TM-Landsat images for 1985 and 1995 of the Prata module, correspond to Figures 1 and 2, while Figures 3 and 4 refer to the thematic images.

The quantification of the areas which relate to the patterns of vegetation and land use in the Prata module for the years considered, can be visualized in Table 1, where it can be verified that secondary vegetation was the dominant pattern, corresponding to approximately, 60.84% of the total area classified in 1985 and 63.24% in 1995, with High Fallow being the vegetation of greatest prominence.

On the other hand, the area of forest which forms part of the productive process, went from 13.93% in 1985 to 7.18% in 1995. these results are related to a series of factors linked to economic needs of the small-holder producer.

1985


**Figure 1:** Colored TM-Landsat Image, Prata module, Igarapé-Açu (PA), Brazil

1995

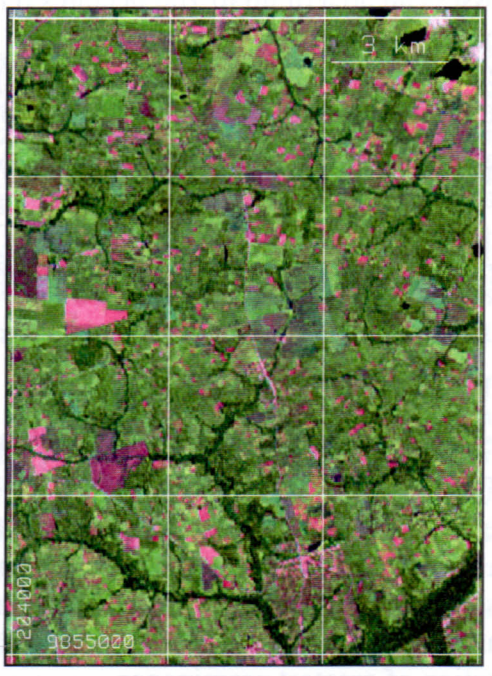


**Figure 2:** Colored TM-Landsat Image, Prata module, Igarapé-Açu (PA), Brazil

1985

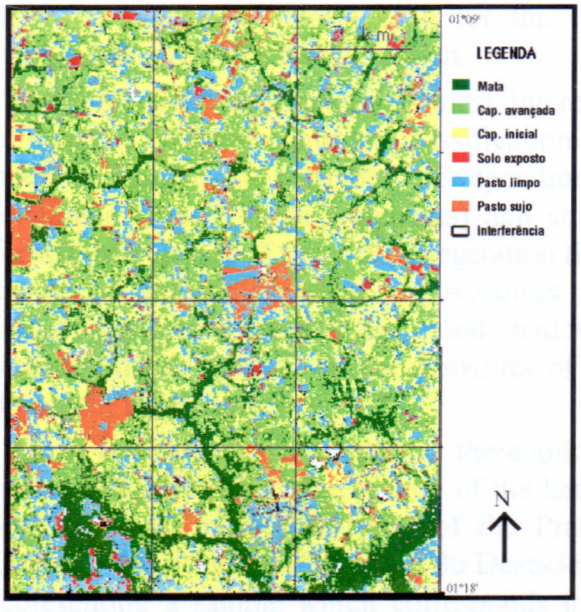


**Figure 3:** Thematic Image, Prata module, Igarapé-Açu (PA), Brazil

1995

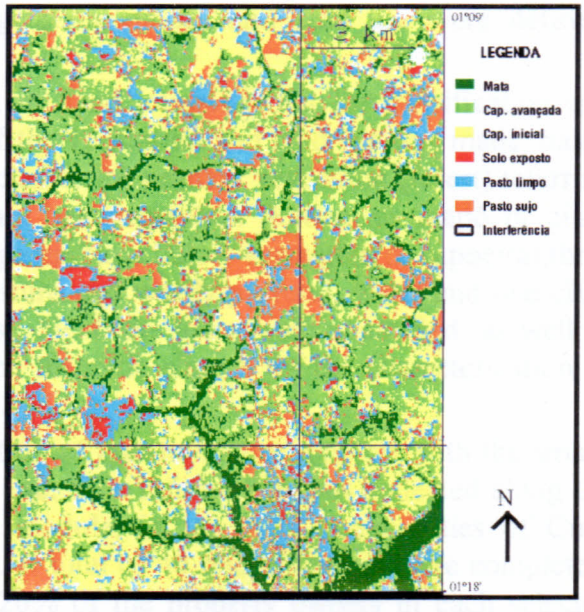


**Figure 4:** Thematic Image, Prata module, Igarapé-Açu (PA), Brazil

**Table 1:** Area and percentage of areas of vegetation and land use types in the Prata Module, Capanema (PA)

| CLASS | 1985 | | 1995 | |
|---|---|---|---|---|
| | ha | % | ha | % |
| **Forest** | 2,673.36 | 13.93 | 1,376.82 | 7.18 |
| **High Fallow** | 6,719.76 | 35.02 | 8,567.91 | 44.65 |
| **Low Fallow** | 4,953.15 | 25.82 | 3,566.43 | 18.59 |
| **Exposed Soil** | 250.83 | 1.31 | 455.76 | 2.38 |
| **Weedless pasture** | 3,003.66 | 15.65 | 1,714.95 | 8.94 |
| **Weedy Pasture** | 1,222.38 | 6.37 | 3,186.81 | 16.60 |
| **Interference** | 80.91 | 0.42 | 179.46 | 0.94 |
| **Water** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Other / Non - class** | 283.26 | 1.48 | 139.17 | 0.72 |
| **TOTAL** | **19,187.31** | **100.00** | **19,187.31** | **100.00** |

Within the areas for land use, the areas of exposed soil include settlements, however, agricultural areas, are more representative of this pattern, which due to the management practices have a significant area of exposed soil. These areas, even though small in area, duplicated from 1.31% in 1985 to 2.38% in 1995. On the other hand, the areas of Weedless Pasture suffered a reduction in area from 15.65% in 1985 to 8.94% in 1995, while Weedy Pasture, practically double in the period considered, going from 6.37% in 1985 to 16.60% in 1995, due to a conversion of Weedless Pasture to this pattern.

The expansion in areas of pasture is mostly related to exhaustion of soil fertility, causing the small-holder to opt for this activity as a means of improving the value of the land, keeping in mind the many land clearings and burnings carried out, which are associated to the fact that the short fallow periods used make the land unprofitable for agriculture.

However, Walker et al. (1997) explain that livestock activities may lead to a form of vegetation dominated by herbaceous plants leading to its degradation. Over the long term pastures may lose their productivity and repeated burning of the pasture causes damage to the structure of the soil, to such a point that the property is only adequate for crops with low nutritional requirements such as cassava.

At the level of the family unit, Homma et al. (1995), explain that as the system of slash and burn doesn't have a stable equilibrium, and keeping in mind the size of the lots where more dense vegetation no longer exists, the fallow vegetation used five or six times starts to present problems, such as the falling productivity of crops. For the author, intensive use, without adequate fallow periods or the introduction of mechanization, applications of lime and chemical fertilizers, means the continued use of fallow isn't possible.

At the level of the communities, whether because of geographic location, or the spaces occupied and physiographic aspects, it was verified that these showed similarities, however, land use, practices and management as a function of the available resources such as labor, as well as food demands, make a difference at the local level. According to Brondízio et al. (1993b), as the patterns of subsistence vary, combining market opportunities to the

management of natural resources, the local population, even neighbors, have a great diversity of land use patterns which can be perceived through the temporal and spatial analysis.

In general, the land use types don't have any homogeneity as to their spatial distribution, even considering that a majority of the small holders develop a kind o agriculture which makes use of an increase in soil fertility from the ashes coming from the burning for the planting of crops such as rice, beans, corn and cassava in this region and one of the factors responsible for these patterns are the kinds of crop consortiums practiced.

**Table 2:** Matrix for the changes in vegetation and land use in rural communities, representative of the Prata module, municipality of Igarapé-Açu (PA) - Brazil

| | Curi | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLASS** | **1 (%)** | **2 (%)** | **3 (%)** | **4 (%)** | **5 (%)** | **6 (%)** | **Total (%)** |
| **(1)Forest** | **28.28** | 45.76 | 12.34 | 1.80 | 6.42 | 5.40 | 100.00 |
| **(2)High Fallow** | 5.47 | **54.84** | 23.00 | 1.25 | 7.52 | 7.92 | 100.00 |
| **(3)Low Fallow** | 2.40 | 45.93 | **27.31** | 1.09 | 9.00 | 14.27 | 100.00 |
| **(4)Exposed soil** | 1.81 | 36.36 | 30.91 | **1.82** | 9.10 | 20.00 | 100.00 |
| **(5)Weedless Pasture** | 1.53 | 35.12 | 25.31 | 1.07 | **12.12** | 24.85 | 100.00 |
| **(6)Weedy pasture** | 1.14 | 10.23 | 10.61 | 3.03 | 29.16 | **45.83** | 100.00 |
| **Cumaru** | | | | | | | |
| **(1)Forest** | **30.30** | 42.42 | 14.14 | 1.01 | 7.07 | 5.05 | 100.00 |
| **(2)High Fallow** | 5.57 | **49.07** | 24.95 | 1.65 | 10.10 | 8.66 | 100.00 |
| **(3)Low Fallow** | 1.65 | 34.82 | **36.71** | 3.53 | 12.00 | 11.29 | 100.00 |
| **(4)Exposed Soil** | 0.00 | 19.23 | 46.15 | **0.00** | 26.92 | 7.70 | 100.00 |
| **(5)Weedless Pasture** | 0.96 | 31.25 | 30.29 | 2.40 | **16.83** | 18.27 | 100.00 |
| **(6)Weedy pasture** | 1.96 | 15.69 | 15.69 | 0.00 | 19.61 | **47.05** | 100.00 |
| **São Jorge** | | | | | | | |
| **(1)Forest** | **48.61** | 32.64 | 7.29 | 1.39 | 6.94 | 3.13 | 100.00 |
| **(2)High Fallow** | 6.70 | **39.87** | 28.39 | 2.71 | 13.88 | 8.45 | 100.00 |
| **(3)Low Fallow** | 1.74 | 35.52 | **36.87** | 2.12 | 14.10 | 9.65 | 100.00 |
| **(4)Exposed Soil** | 0.00 | 30.77 | 46.15 | **0.00** | 15.38 | 7.70 | 100.00 |
| **(5)Weedless Pasture** | 1.42 | 33.65 | 34.12 | 3.32 | **19.43** | 8.06 | 100.00 |
| **(6)Weedy Pasture** | 2.86 | 22.86 | 21.90 | 0.95 | 30.48 | **20.95** | 100.00 |
| **Travessa Dezesseis** | | | | | | | |
| **(1)Forest** | **17.24** | 34.48 | 15.52 | 5.17 | 18.97 | 8.62 | 100.00 |
| **(2)High Fallow** | 3.71 | **38.29** | 24.00 | 4.86 | 19.43 | 9.71 | 100.00 |
| **(3)Low Fallow** | 0.66 | 30.38 | **34.47** | 2.73 | 16.72 | 15.02 | 100.00 |
| **(4)Exposed Soil** | 0.00 | 53.33 | 33.33 | **0.00** | 6.67 | 6.67 | 100.00 |
| **(5)Weedless Pasture** | 0.77 | 31.54 | 34.61 | 1.54 | **18.46** | 13.08 | 100.00 |
| **(6)Weedy Pasture** | 0.00 | 14.28 | 20.00 | 0.00 | 42.86 | **22.86** | 100.00 |

In fact, the maintenance of the productive systems is the greatest concern of the small holder, who tries, through the use of agricultural practices, to guarantee family subsistence and still have some excess to sell. Such practices include such things as planting in the most adequate period, to the use of mechanization to maintain or expand the area being planted, as well as to increase production.

In relation to the mechanization used to prepare the fields for planting, this is certainly linked to the economic conditions of the small-holder, among other variables. In this way, each type of use is subject to constant alterations and unique characteristics for each system, as a result of the natural processes which are specific to each and at the same time, as a function of their interactions.

Table 2 corresponds to the matrix of changes between the thematic classes for each community through a diagonal plan. The remaining percentages are a result of interactions between classes, that is, these correspond to the percentage of one class to another in the period considered. An analysis of the dynamics of these classes of vegetation and land use was undertaken from the matrix for change between the classes of 1985 to the classes of 1995, allowing to verify in this period the landscape suffered a significant temporal and spatial variability.

The percentages of stability, this being, the *pixels* classified in 1985 as Forest, remained practically without any alteration in 1995. The same occurred for High Fallow which had the greatest percentage of stability, through the conversion of Forest and Low Fallow to this pattern, except for the community of São Jorge. This community showed a rate of stability above the rest for the Forest Class, and also showed the greatest stability for Low Fallow in the period considered.

In general, a concentration of the greatest percentages of stability in the matrix related to the Classes of High Fallow, were due to the fact that shifting agriculture is a dynamic activity, making the classes for land use become converted into Fallow areas, resulting in many cases in advanced stages, and the regeneration of areas of pastures, may also take place, contributing to this kind of change.

As Walker et al. (1997) explain, decisions about the use of land are affected by a series of endogenous circumstances, external to the property itself. The market conditions and for soils evolve over time, causing the small holder to choose from a set of dynamic options. In this sense, such factors are reflected in the regeneration of abandoned areas after their use for agriculture, as is the case for Low fallow, converted into High Fallow or in the growth in forest clearings.

On the other hand, due to the tendency toward the expansion of areas of weedy pasture, in the same period that the greatest concentrations for this class are related to the changes which have taken place in the classes for Low Fallow, Weedless Pasture and Exposed soil (Table 2). As Alencar (1996) explains, in general the dynamics of vegetation tends to a greater relation for the use and exchange between areas of younger secondary vegetation and the classes for agriculture and pasture. Among these classes, a high frequency of conversion of the classes Weedless pasture to Weedy pasture occurs, indicating that these were used for the same activity.

## CONCLUSIONS

- For the Development of small-holder agriculture and pasture in the Prata module, areas of secondary vegetation in different stages of succession are deforested, keeping in mind the *diminished stock of primary vegetation where pressure was greatest.*
- A fall in soil fertility resulting from the short fallow period caused an expansion of the areas of Low Fallow, which for the most part were transformed into areas of pasture.
- In the Prata module the dominant socio-economic and cultural characteristics seem to bring about a diversification of production with the introduction of perennial and semi-perennial crops. This internal factor, if well planned, may offer a margin of resources for re-investments in a continuous and progressive manner, as well as avoid the deforestation of the forests which are more distant.
- Access to technologies influenced in the increase in productivity and the generation of surplus for the development of the small-holder. The low level of market integration for inputs and products and the lack of financial resources for the small-holders in the Prate module, make the capacity for investment difficult, inhibiting the search for technologies and consequently diminish improvements in the productive process and increase deforestation.
- Part of these difficulties depend on political decisions that are broader, through credit, productive incentives, commercialization and social organization. The lack of an agrarian policy is a determinant in the isolation of the small-holder, in their poverty and their incapacity and indisposition to assimilate technologies. The absence of basic education influences in decision-making and restricts technological development.

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