

# The social and environmental impacts of industrial agriculture in the Legal Amazon

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**Abstract.** The current study aims at analysing how the dynamics of deforestation are related to the expansion of agriculture into the Amazon frontier. This paper presents results of combined spatial analysis and socio-economic census for the state of Mato Grosso, equally the leader in production of soybean in Brazil and the highest deforestation rate in the Amazon region. Maps were produced for geographic analysis using GIS and remote sensing techniques. Dataset were collected from socio-economic census provided by the Brazilian Statistic and Geography Institute (IBGE [9]), and satellite remote sensing imagery (CBERS and Landsat) were provided by the National Institute for Space Research (INPE [5]), for the period of 2000-2006. INPE's associate projects DETER and PRODES provided spatially referenced data for deforestation, whereas data in shapefile formats were acquired from the Institute of Environment and Renewable Natural Resources (IBAMA [13]). The data gathered were integrated in a GIS for analysis using ArcGIS 9.2 software and colour composite remotely sensed image generated using image processing software system IDRISI. The results show that expansion of large scale agriculture has indirectly become an important actor in the process of deforestation and the creation of new agricultural frontiers.

**Keywords:** Deforestation, agricultural frontier, arc of deforestation, soybeans, Mato Grosso.

## 1. Introduction

The Amazon region retains 40 per cent of the world's remaining tropical rainforests [16], which provide environmental services that are important both locally and globally including the conservation of biodiversity, carbon storage and regional regulation of hydrological cycles. It is estimated that 14 per cent of the Legal Amazon's original area has been cleared since the arrival of its first non-indigenous inhabitants [3], during the 16th century. The environmental loss due to deforestation is difficult to quantify. Concerns on the damaging effects on biodiversity, regional hydrology and climate, have been aggravated by the alarming potential of atmospheric concentration of greenhouse gases, such as carbon dioxide, released by deforestation and fire in these forests.

The spatial patterns of deforestation have changed over the last decades and so have the rate in which they occur. However, current deforestation has concentrated in what has been defined as the Arc of Deforestation (Fig 1), where clearing of forests has been stimulated by land speculation, and more recently, increased by the production of export commodities such as soybeans and beef. Brazil is one of the few countries in the world to possess large areas of unoccupied land that could be farmed [4], making it the world's last agricultural frontier. With the growing participation in the globalized world market, the expansion of these agricultural frontiers has become inevitable.

This paper attempts to present a review of recent literature of the main drives of deforestation in the Amazon, focusing on the advance of cultivation of soybeans and transport infrastructure in the region.

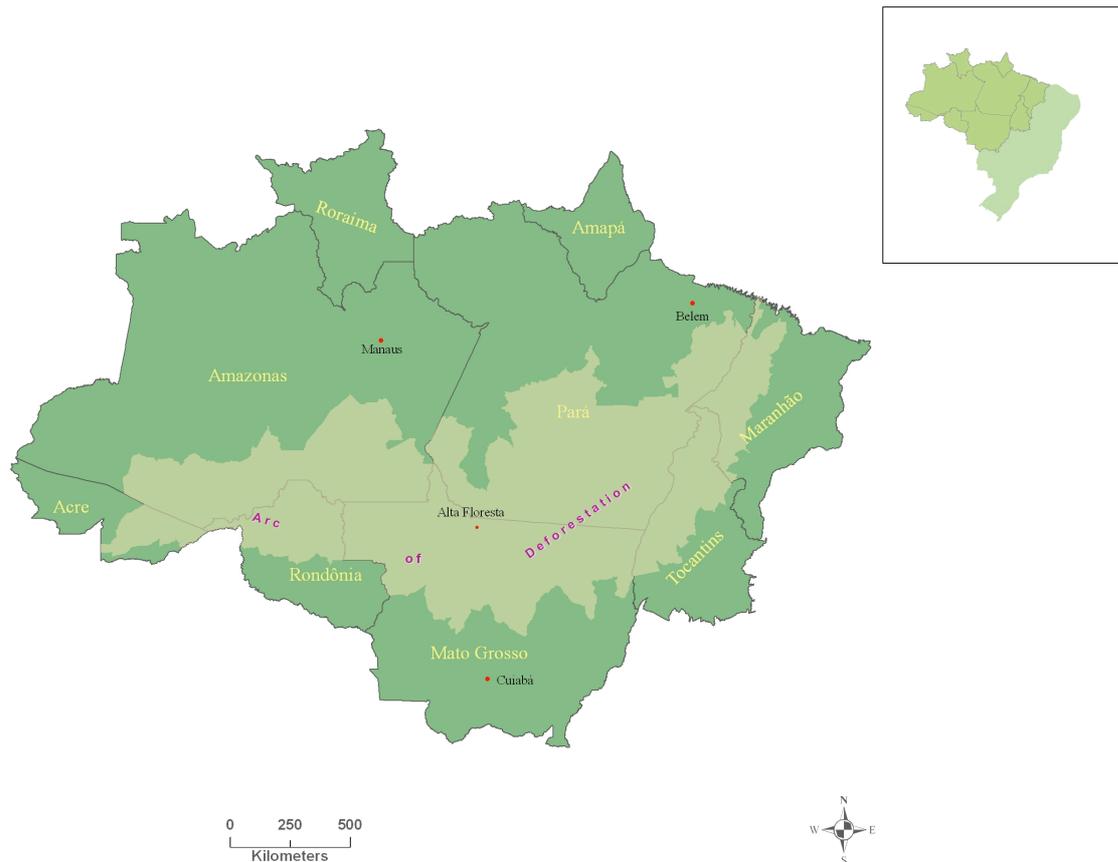


Figure 1 – The Brazilian Legal Amazon and the Arc of Deforestation - areas on the southern and eastern edges of the Amazon where primary forest has been converted to pasture and agriculture. Source: IBAMA SISCOM [13]

## 2. The current dynamics of deforestation

The indiscriminate deforestation of the Amazon rainforest is undoubtedly a great contributor to the alarming figures of global high rate net forest lost, mostly to conversion to agricultural land. The process of deforestation in the Amazon has been shaped by past settlement patterns and driven by several different actors. There are, however, temporal and spatial variations in deforestation [1] and the causes and dynamics are very distinctive in different locations, thus making it difficult to generalize what drives it, or predict precisely how extensive it will be.

Recent literature has demonstrated different variables, such as demographic, infrastructural or biophysical attributes, thought to be responsible to the rates in which deforestation will occur. Overall, most studies agree that poor environmental law enforcement, predatory exploitation of natural resources, pressure from increasing population, cattle ranching, agricultural expansion and infrastructure development projects are the main contributors to current deforestation in the Amazon and these variables interact in complex way.

The Amazonian population has increased considerably from 2.5 million in 1960 to over 20 million in 2000 [9] in a rate nearly twice that of the rest of Brazil [1], further increasing the pressures on forests. It is clear that economic development is vital for the region and its inhabitants, which puts the Brazilian government in a conservation-versus-development dilemma and raises the challenge of balancing its Amazonian development plans with new conservation policies, and most importantly, their implementation.

The expansion of cattle ranching into the Amazon and, more recently, soybean production in the agriculture frontier has not contributed to reduce social and economic inequality in the population. The consolidation of large farms and ranches means that small farmers do not stand a chance in the share on the appropriation of the increasing values of these lands [15]. Their options are either to try a new life in rapidly growing urban centres throughout the Amazon, or invade new lands and prepare them for more profitable investments [2].

The present study focus on the idea that, in contrast to other land-use conversions in recent years (e.g. land speculation, tenure or domestic markets), one of the main factors indirectly driving deforestation today is the advance of soybeans into the agriculture frontier of the Amazon, which has been regulated by the international market. Soybean planters might not cut the forest themselves, but they increased the pressure on small farmers to sell their land and move to frontiers areas and clear more [14].

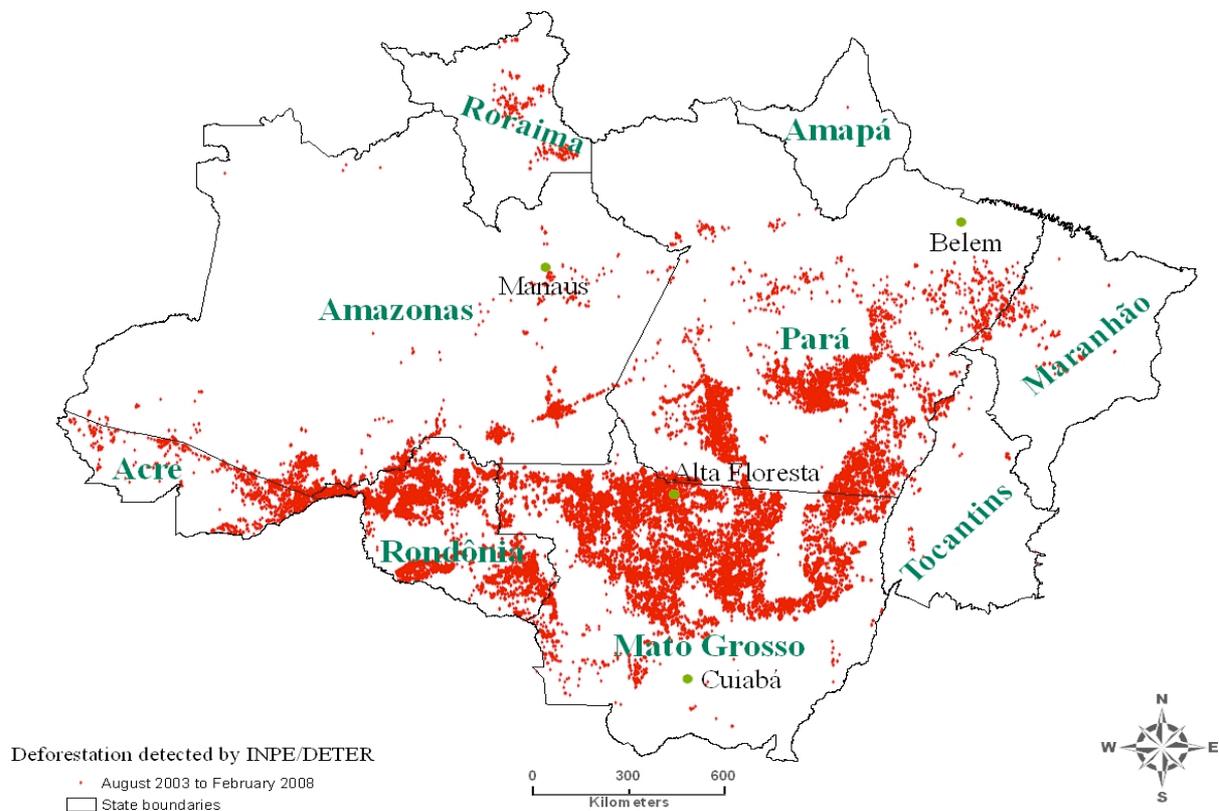


Figure 2 – Deforestation in the Legal Amazon. The map shows focus of deforestation collected by INPE’s DETER [6] project in the period of August 2003 to February 2008. The state of Mato Grosso is the biggest contributor to deforestation in the region, according to INPE [5], followed by Pará and Rondônia. Source: INPE/DETER[6] and IBAMA SISCOM [13].

### 3. Impacts of large scale agriculture: the case of Mato Grosso

Helped by government’s rural subsidies, transport facilitations for the outputs and intensive agricultural research to overcome low fertility of tropical soils [17], the agricultural production expanded from the south towards the vast Brazilian *Cerrado*. It is estimated that out of the 86 million tons of soy produced in Brazil (harvest 2006/2007, EMBRAPA [8]) over 15 per cent comes from the crop barren soils of the Legal Amazon region [9], with the state of Mato Grosso as the biggest producer in Brazil. However, in order to strengthen their activities,

large-scale farmers have induced smaller farmers to sell their land and move to new frontiers deeper into the forest and clear more land; a dynamic that has also led to the displacement of small farmers to urban areas, worsening the social problems, such as unemployment, crime and segregation [38].

Land use in Mato Grosso has been characterized by a dominant pattern of forest conversion that started with small scale exploration for timber, mining and subsistence agriculture [17]. The consolidation of land use into large-scale ranching soon followed, and although cropland expansion has occurred mostly in areas already cleared in previous activities, this new configuration of land use in Mato Grosso has had important effects both socially and environmentally in the region. At the southern tip of the Legal Amazon, deforestation has intensified (Fig. 3) as a result of the arrival of small farmers, displaced from their land now occupied by large-scale croplands, and the dominance of cattle ranching. Although extensive cropland does not contribute directly to most deforestation itself, it seems to be the driving force behind the process.

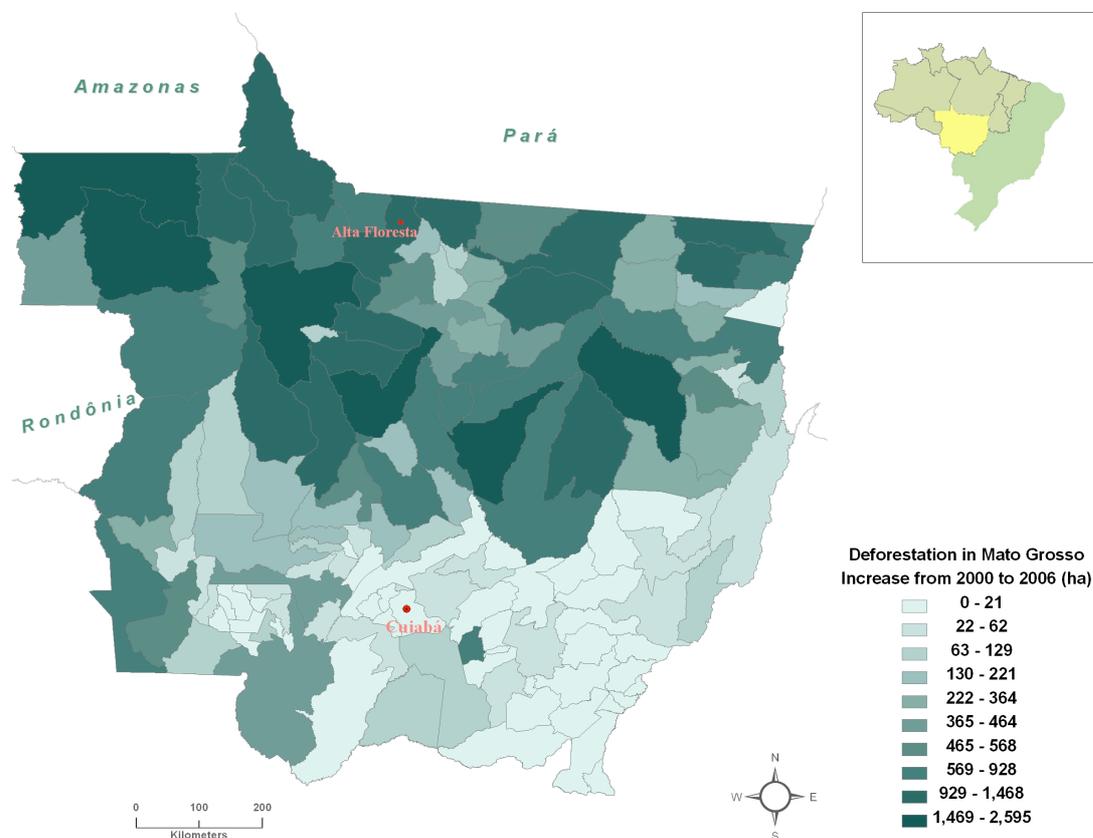


Figure 3 – Deforestation in the state of Mato Grosso, at a municipality level. The map shows the concentration of deforestation in the north of the state, at the Amazon frontier. Data on deforestation collected from INPE's PRODES project shows the increase (in hectares) of areas deforested in the region from 2000 to 2006. Source: IBAMA/SISCOM [13] and INPE/PRODES [7].

The maps presented on Figure 4 (below) shows the reconfiguration of agriculture and ranching in Mato Grosso over time, presented separately at a municipality level. The production of soybean has intensified and concentrated particularly in the central and southern parts of the state, as a result of consolidation of large agricultural enterprises. However, the map on bottom left shows how soybean production has intensified in those regions. As a consequence, cattle ranching, which was concentrated at southern Mato Grosso in 1990 (top right map) has rapidly expanded to the Amazon frontier in the north (bottom right map).

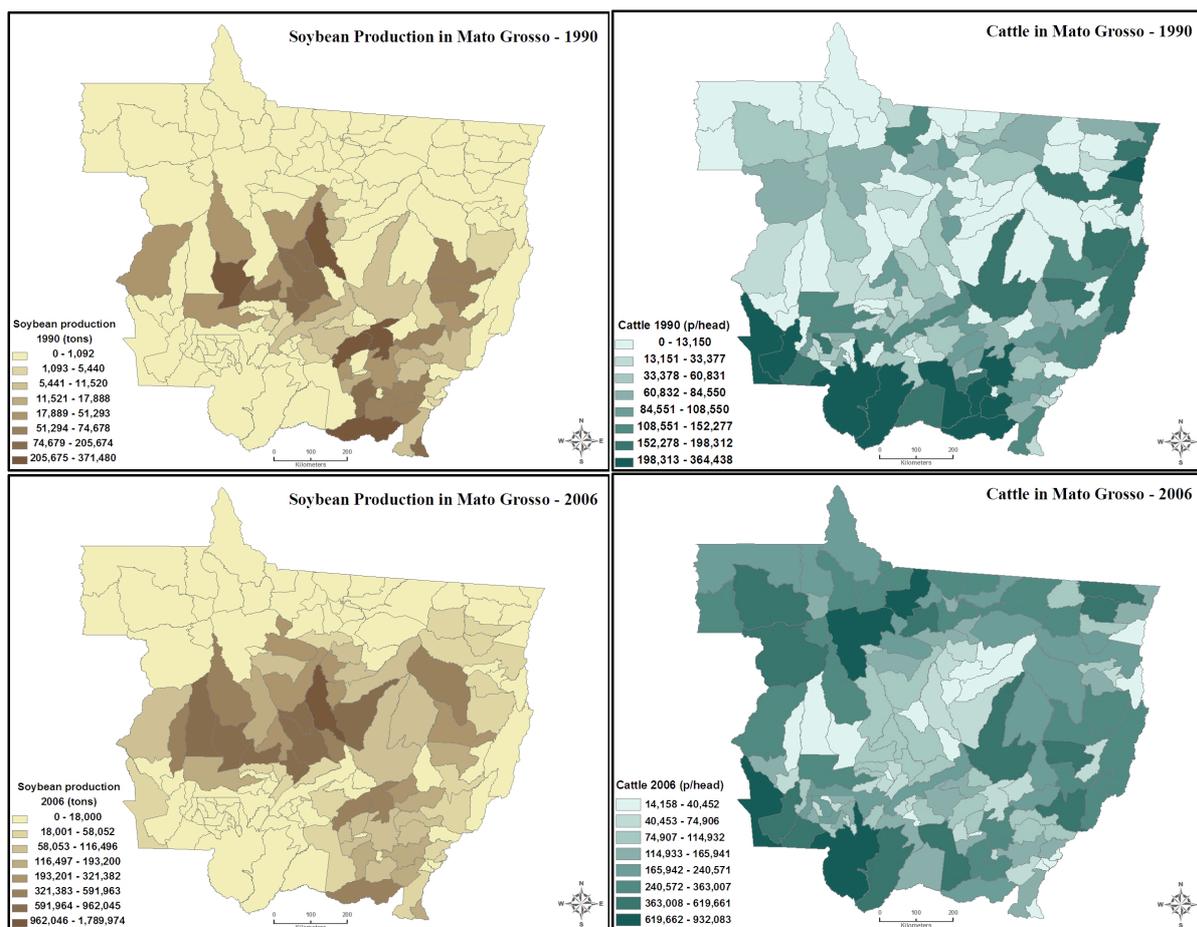


Figure 4 – Land use change in Mato Grosso state due to cattle and soybean productions in 1990 and 2006. Source: IBGE [9] and IBAMA SISCOM [13].

### 3.1 Case study: Alta Floresta

Located at the border with Pará state, 830 km north from Cuiabá (capital of Mato Grosso state), Alta Floresta is situated at 09°52' S; 56°06' W, with 8,947 km<sup>2</sup> [9]. Out of the 36 municipalities that most contributed to the deforestation in the Amazon region in 2007, 19 of them are in the Mato Grosso state, including Alta Floresta [5 and 12]. INPE [5] estimates that 38 per cent of total Amazonia deforestation over 1999-2003 occurred in Mato Grosso, and that 5.6 per cent of remaining Mato Grosso cerrado were deforested between 1998 and 2002 [15].

Logging and deforestation in Alta Floresta, as a by-product of ranching, have intensified as a result of the dominance of technically advanced and highly mechanized cultivation of soybeans that today occupies 5,125 million hectares [8] of land use in other parts of Mato Grosso – around 25 per cent of the Brazil's total soy planted area [8]. Conservation efforts, such as the creation of the State Parks Cristalino I and II proved to be an efficient way to protect the remaining fragmented forests. But even areas of conservation have been overwhelmed by the destructive trends of ranching-agriculture [18].

The reduction is a setback in the regional conservation strategy, built on the conventional emphasis on parks, indigenous or extractivist reserves. Under funded and understaffed conservation areas also suffer from weak implementation of environmental legislation and law enforcement. Moreover, in Brazil it is not unusual for illegal deforestation to involve public servants, such as environmental agents in massive corruption schemes with timber companies or traders [15].

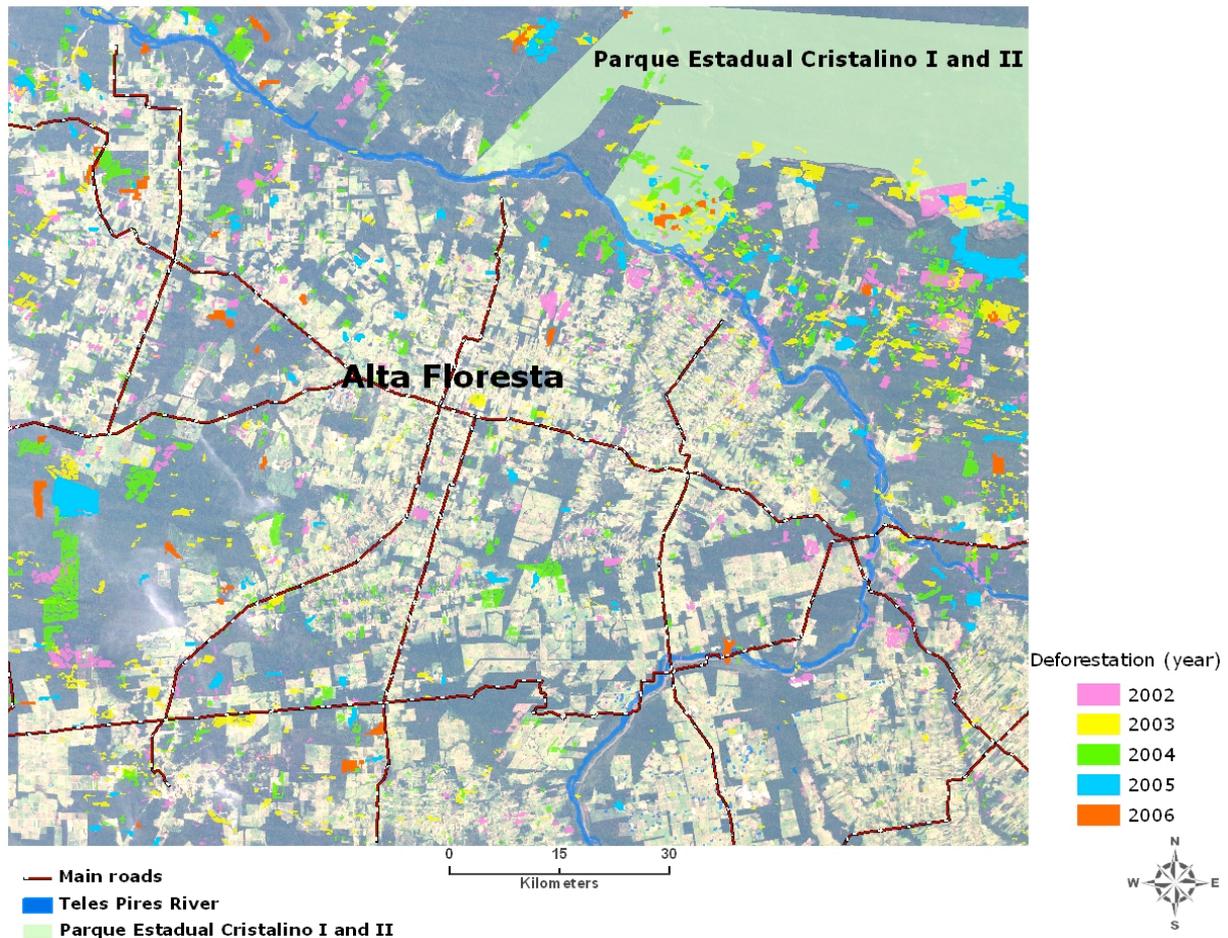


Figure 5 – The region of Alta Floresta, where only fragmented forests (dark green) now remain. The satellite image was obtained by Landsat 5 TM in 30/04/2000. In the same year the Cristalino State Park I was declared area of conservation. The data for deforestation from INPE’s DETER [6] project from the years 2002 to 2006 shows where deforestation occurred in the area, which included patches within Cristalino Park. The map also shows the patterns of deforestation along the main roads of the area. Source: INPE [5], DETER [6] and IBAMA SISCOM [13].

## 5. Conclusion

This study has focused in both expansion of the agriculture frontier as one of the main ultimate factors contributing to the current rates of deforestation in the Legal Amazon. The state of Mato Grosso, and more specifically the region of Alta Floresta, has been chosen as areas of interests, because of factors that make this region on of the most dynamic agricultural frontiers in the Amazon. These factors include a whole reconfiguration of the agriculture in Mato Grosso, which has led to the movement of both urban and rural populations to the Amazon frontier.

The social, economic and environmental effects this movement has brought about have been analysed combining social-economic census, satellite based and spatially referenced data, as well as extensive review of the literature available. I found that, even though the expansion of large scale agriculture is not directly a factor of deforestation itself, it has become an important additional actor in the process, for inducing smaller farmers into new forested agricultural frontiers.

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