Chapter 6:
Soil occupation: new production areas and biodiversity

Agriculture uses only 7% of Brazilian territory (0.7% for sugar cane): most of the country's soil is occupied by pastures (around 35%) and forests (55%). The expansion of sugar cane crops has essentially replaced other agricultural exploitations or cattle-breeding. In the next few years expansion will take place in western São Paulo State and its borders, in areas that are very far from the currrent biomes of the Amazon Rain Forest, the Pantanal or the remaining Atlantic Forest. Occupation of the cerrado must be planned to protect biodiversity and water resources.

6.1 Introduction

The growth of the sugar cane culture (and even more, that of Brazilian agriculture, taken as a whole) raises questions about the availability and limitations of suitable areas. It also raises questions about areas and locations used over the past few years and trends for the years to come, as well as the knowledge of the biodiversity in Brazil's main biomes, as the context for possible implications and caution.

In 2004, Brazil's environmental preservation and conservation areas reached 95 Mha, which represents around 11 percent of the Brazilian territory. Brazil's entire crop area corresponded to ~60 Mha.

Biodiversity preservation practices include preserving important samples of biodiversity for the future, prospecting for the unexploited biodiversity in a non-intrusive manner, and fostering an environmentally compliant use of land and natural resources.

The Convention on Biological Diversity proposed in Rio (1992) seeks to ensure the preservation and sustainable use of the biodiversity. In fact, it implies a balance between sustainable exploitation and preservation of biodiversity resources. The setting of very different objetives in this single concept still causes implementation difficulties. Generally speaking, the understanding is that "it is our duty to preserve this asset for the future generations". The Convention has provided a legal basis that did not exist in most countries, and still does not exist in many. The Convention was never ratified by the United States, for example; and, in many cases, a Biological Inventory has either yet to be prepared or remains incomplete.

Steps for the implementation of this Convention (and Agenda 21, in this topic) to be taken by the countries include the preparation of a biodiversity

inventory and monitoring of important biodiversity resources, the creation of reserves, the creation of seed, germoplasm and zoological banks, and the conduct of Environmental Impact Assessments covering activities that could affect the biodiversity. We have witnessed the rise of a biodiversity measurement and preservation "science" over the past few years.[1]

1 TARLOCK, D.: "Biodiversity and endangered species", *in*: DERNBACH, J.C. (Ed.): *Stumbling toward sustainability*, Washington DC, Environmental Law Institute, 2002

In the following paragraphs we will address the use of agricultural soil in Brazil, its evolution, and the position of agriculture; including a certain emphasis on the current "agricultural border", i.e. the *cerrado*, or savannah. We will also address the reality of Brazil's plant biodiversity: the present knowledge; the situation in the main biomes; and preservation. In conclusion, we will specifically consider the sugar cane culture in this context: the crop areas, their location, and their recent and expected expansion. The impact of sugar cane crops on the fauna will not be covered being less relevant. An assessment conducted by EMBRAPA[2] (for sugar cane) rates almost all impacts on mamals, birds, amphibians and invertebrates as level 2 and 1 (low or no impact), and level 3 (medium impact) on reptiles.

2 "Agroecologia da cana-de-açúcar", EMBRAPA, 2003; www.cana.cnpm.embrapa.br (Nov 2003)

6.2 Use of agricultural soil in Brazil

The Brazilian territory covers an area of 850 Mha, between 5 ºN and 33 ºS of lattitude, 34 ºW and 73 ºW of longitude. The topography is characterized by extensive flat regions and some mountain ranges with altitude of up to 3,000 m. A large portion of the territory has the conditions to economically sustain agricultural production, while huge areas covered by forests with different biomes are preserved.

Brazil's vegetal cover was mapped by EMBRAPA[3] in 2002, based on daily information provided by the vegetation sensor of satellite Spot IV. The study was conducted within the scope of the Global Land Cover 2000 program (GLC 2000) through an initiative coordinated by the IES – Institute for Environment and Sustainability. **Table 1** shows the distribution of soil use.

3 EMBRAPA, "Mapa da cobertura vegetal do Brasil", www.cobveget.cnpm.embrapa.br/resulta

Table 1: Distribution of Brazil's vegetal cover (2002)

Area	Area (Mha)	Distribution
Agriculture and pasture	297	35%
Forests	464	55%
Fields and savannahs	73	9%
Cities, rivers and others	17	2%
Total	851	100%

According to IBGE[4] – Brazilian Institute of Geography and Statistics, annual and permanent crop areas have developed regionally as shown in **Table 2:**

4 IBGE: "Levantamento sistemático da produção agrícola para 2003-2004", site www.sidra.ibge.gov.br (June 2004)

Table 2: Crop areas in Brazil, million ha

Region	N-NE	S-SE	CW	Brazil
1994	16.0	28.8	8.0	52.8
2004	14.4	30.9	15.1	60.4
Variation	-10.0%	7.3%	88.7%	14.4%

While the crop areas located in the N-NE and S-SE regions showed little variation, it is clear that the agricultural border is in the Center-West region, where the production area has doubled within ten years' time.

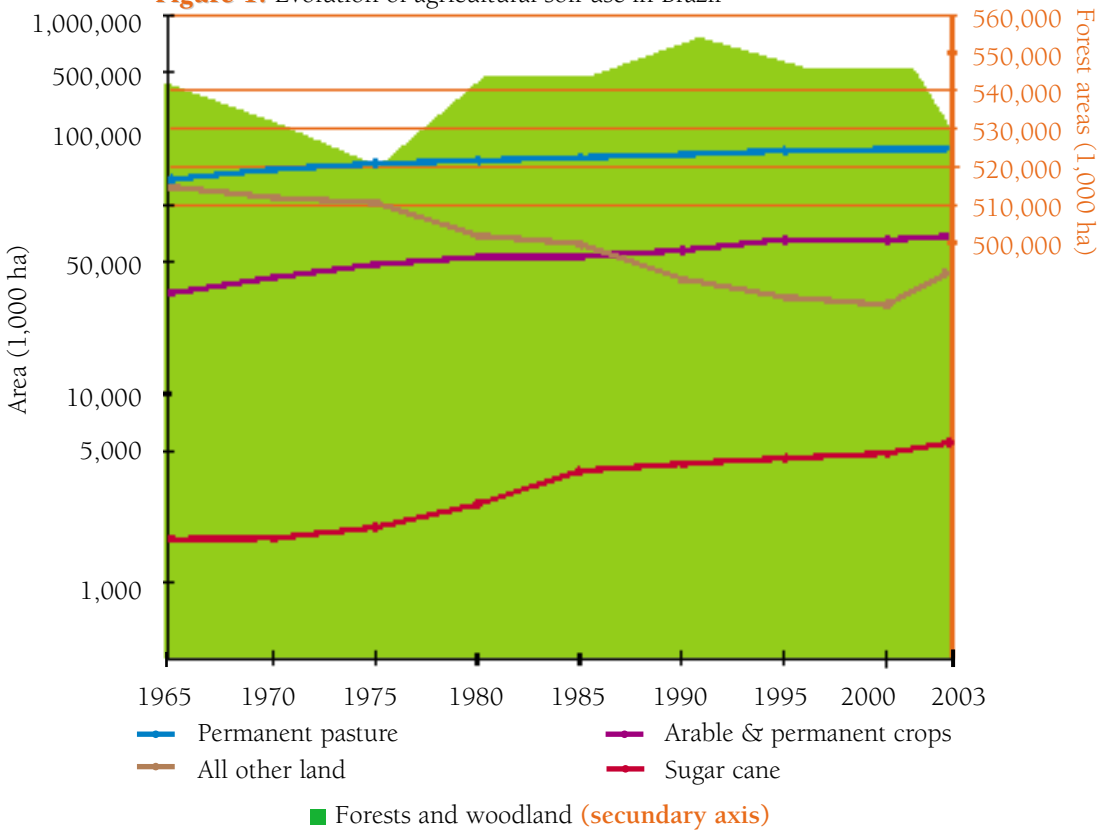
Crop areas currently total 60 Mha (around 21 Mha of which with soybean, and 12 Mha with corn). The "pasture" areas correspond to around 227 Mha, including a portion featuring a certain degree of degradation. Forest areas (including those used for forestry) total 464 Mha. An estimation by EMBRAPA[5] (analyzing the soybean crop expansion situation) indicates that there are still approximately 100 million hectares to support the expansion of cultures of annual-cycle species. In addition, the area to be potentially released as a result of technological development in the livestock business is estimated at 20 million hectars. Veja Magazine,[6] with some help from technicians of the Ministry of Agriculture and IBGE – Brazilian Institute of Geography and Statistics, reports that around 30 percent of this territory is occupied by crops and livestock, resulting in 106 million hectares, one of the world's largest agricultural reserves, with fertile soil that is almost all located in savannah areas.

5 CASTIGLIONI, V.B.R.: *Avaliação da expansão da produção de etanol no Brasil*, Brasilia, EMBRAPA, CGEE-NAE, 2004

6 Revista Veja, "Agricultura – O tamanho do Brasil que põe a mesa", Edition 1843, March 3 2004

A simplified description of the evolution of soil use over the past few decades is shown in **Figure 1**:

Figure 1: Evolution of agricultural soil use in Brazil



Source: FAO - Food and Agriculture Organization of The United Nations, http://faostat.fao.org/faostat

This information provided by the FAO – Food and Agriculture Organization of the United Nations with respect to Brazil, indicates that the expansion of crops and livestock area over the past few years has coincided with the decrease in degraded pasture areas and grassland with some shrubs, rather than forest areas. A study conducted by IPEA – Institute of Applied Economic Research[7] to analyze the rapid growth of soybean crop areas in Brazil confirms that the rise of such culture in areas has basically consisted of occupation of degraded pastures, rather than "virgin areas".

A particularly important case is the use of the *cerrado*. The three paragraphs below sum up the remarks contained in a report prepared by EMBRAPA[8] in 2000.

The cerrado is a Brazilian ecosystem that covers an area of 204 Mha (24% of the territory). It contains the second largest biodiversity in South America (with ~6,500 plant species, three hundred vertebrate species, and one thousand genera of fungi), and the sources of five major river basins. Virtually ignored until 1960, today it is in a prominent position for the country's crops and livestock. Following the construction of Brasília back in the 1970's, a more technologically advanced crops and livestock economy started to

7 O Estado de São Paulo Newspaper, Caderno Economia, January 11 2005, p. 4

8 Information provided by BRESSAN, A.,M.: "Agriculture", from EMBRAPA reports, 2000

replace the shifting agriculture, extractivism and extensive cattle-breeding. As early as 2000, the cerrado *accounted for 41 percent of the country's cattle and 46 percent of the Brazilian soybean, corn, rice and coffee crops. Fifty Mha of it was occupied by cultivated pastures, 12 Mha by annual cultures, and 2 Mha by permanent cultures. The activities of* EMBRAPA Cerrados *since 1975 have been essential to that development. Today, the* cerrado *continue to be the natural agricutural border of the country's South and Southeast regions, with a huge potential for development.*

The cerrado *has a savannah vegetation pervaded by gallery forests, with several "grades" between* campo limpo *(clean grass fields) and gallery forests. The soil is highly weathered, deep, and well-drained, but has a low natural fertility and high acidity. However, there is plenty of limestone in the* cerrado*, and the topography favors mechanization.*

In 2000, the main production systems included:

Cattle-breeding (for slaughter), with cultivated pastures (~50 Mha, in 2002, variable stages of degradation);

Agricultural production: grains (rice, beans, corn and soybeans), coffee and manioc are the most important crops, having a considerable share in Brazil's agricultural production. Also reforestation (1970's) and fruit culture growing, currently expanding.

The *cerrados* are located in extensive, non-continuous areas, which are shown in **Figure 2**. It is important to consider their location together with the country's main forest biomes: the Amazon Rain Forest, the Atlantic Forest and the *Pantanal* (grasslands and wetlands), as shown in **Figure 5**, where there are severe environmental restrictions on the use of soil, which is considered in the EIA/RIMA analysis for any undertaking.

Figure 2: Areas where the cerrados are located

Source: EMPRABA information (2004)

The expansion of sugar cane crops in areas that were originally taken up by *cerrados* has been relatively small. In most cases, it seems to have taken place by replacing other covers that had already subsituted for the *cerrado* (usually pastures). The current trends seem to be towards the continuation of such a situation: expansion of sugar cane crops in the west of São Paulo, replacing pasture areas. **Table 2** shows that the total sugar cane crop area that was added between 1993 and 2003 in all states where there were extensive *cerrado* regions (Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais) reached only around 300,000 ha (the expansion of the sugar cane crop area in the Center-South region represented 1.4 Mha in the same period, and the expansion of the entire crop area in the region between 1994 and 2004 amounted to 7 Mha). However, because sugar cane may play a role of increasing importance in the agribusiness development within these regions, it will be necessary to consider specific sustainability aspects of sugar cane growing in these region. This obviously applies to all other crops considered (some of which, such as soybean, being already used on a large scale) for the *cerrados* as well. Also, it must be noted that the occupation of *cerrado* areas or, alternatively, areas orginally covered by the *cerrados* but currently used as pastures, for example, may have very different consequences (sometimes opposing consequences) to such factors as soil quality, erosion and others.

Analyses are now being conducted on this early occupation stage of the *cerrados*, including the perspective of environmental preservation and the search for profitable and socially fair production systems. A lot more attention shall be given to the combination of irrigated systems with the use of pesticides and fertilizers, improper soil preparation and conservation practices, inefficient use of water, and the effects of the great and rapid urbanization, with deficient waste treatment systems.

6.3 Plant biodiversity in Brazil: knowledge, situation in the main Biomas; preservation

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Brazil, a mega-diverse country

Brazil is regarded as the country that has the world's largest biological diversity for having a large portion of the Amazon Rain Forest, the largest green area on the planet, the Atlantic Forest and the *Cerrado*. These are ecosystems considered to be hotspots because of the threat to, and the wide diversity of, related endemic species.[9] Brazil has one of the world's richest floras, estimated at 50,000 to 60,000 angiosperm species (plants with flowers).

In Brazil, the main effort to set biodiversity preservation priorities (hotspots and wilderness areas) was developed within the scope of the "Priority Actions for Preservation of the Biodiversity of Brazilian Biomes" project.[10] This project, coordinated by the Ministry of the Environment, was carried out in conjunction with Conservation International, Funatura, and the Biodiversitas Foundation. In the period between 1995 and 2000, workshops were held in order to discuss and set the preservation priorities for the *Cerrado* and the *Pantanal*, the Coastal and Marine Zone, the Amazon Rain Forest, the Atlantic Forest, the Southern Fields, and the *Caatinga*. Over a thousand experts (in ecology, botanics, zoology and related disciplines) contributed to setting the preservation priorities for Brazil's main biomes. Base maps were drafted for the inclusion of information on natural areas, existing preservation areas, physical and political subdivisions, demographic and economic statistics, and fauna and flora gathered by experts. The setting of priorities was based on the knowledge and opinions of the experts who were consulted. Because the initiative did not take into consideration any future scenarios, including the impact of agricultural expansion and vulnerability to climate changes, it is important to review the preservation priorities by incorporating advances in methodology, aiming at building new impact and vulnerability scenarios.[11]

Present situation of, and threats to, Brazilian biomes

Of the areas originally taken up by the different biomes in Brazil (**Table 3**), variable and not always known portions remain, given the imprecision of existing estimations. The areas protected as preservation units are also variable from biome to biome, showing disproportionate efforts in search of representativeness in the National Preservation Units System.

9 MITTERMEYER, R.A.; MYERS, N.; MITTERMEYER, C.G: "Hotspots Earth's biologically richest and most endangered terrestrial ecoregions", New York, CEMEX, Conservation International, 1999

10 www.mma.gov.br/biodiversidade/probio/sub.html

11 CANHOS, V.P.C; SIQUEIRA, M.F: "D.A.L. 2004 – Mudanças climáticas globais: conseqüências para a biodiversidade", Nota Técnica elaborada para o Núcleo de Assuntos Estratégicos da Presidência da República, Centro de Gestão e Estudos Estratégicos, Contrato no. 083/2004

Table 3: Brazilian biomes: original area, current cover (2005), and percentage contained in preservation units

Biome	Original coverage (% of the country)[1]	Current cover (% of the original)[2]	Protected areas (% of the original)[3]
Amazon Rain Forest	49.29	85	4.83
Cerrado	23.92	20[4]	1.71
Atlantic Forest	13.04	7	0.72
Caatinga	9.92	32[4]	0.69
Campos Sulinos	2.02	1.98[4]	0.27
Pantanal	1.76	?	0.57

1 http://www.ibge.gov.br
2 http://ebape.fgv.br
3 http://www.ibama.gov.br
4 Areas where the ecosystem can be considered untouched

In addition to the regional differences in preservation conditions, the causes and pace of degradation of Brazil's different biomes have been historically distinct.

The Atlantic Forest was the first biome to be devastated by a slow process of wood exploitation and replacement with agriculture and cattle-breeding throughout the Brazilian seashore. There are now significant remains only on the steep bluffs of *Serra do Mar*, which cover less than 8 percent of the original area. The area currently taken up by sugar cane crops is almost all located in lands that were originally covered by this biome. The agricultural occupation process in the Atlantic Forest preceded any concerns about preservation, such that no areas capable of representing the original biodiversity of the biome were preserved. Even hillside areas and river banks, which are now protected by law, were not spared. For these regions, the current adaptation of soil use for the environmental legislation will necessarily required forest restoration planting.

The *Cerrado* was spared by agricultural occupation until very recent times. Not long ago, extensive cattle-breeding and firewood and coal exploitation were the only major economic activities within the huge territory of the *Cerrado*. Those activites, in spite of having an adverse impact, did not result in a significant reduction of the area covered by the biome. Over the past few decades, however, with the technological advance in crops and livestock, the *Cerrado* area has been decreasing at a fast pace, estimated at 3

percent a year. At least 50 percent of the original *Cerrado* has been totally destroyed.[12] Extensive areas have been highly modified by the invading African grass varieties and very frequent fires, and only 20 percent of the original area is untouched.[13] The recent agricultural expansion on the *Cerrado* has been taking place without so much as complying with the environmental legislation in force. Since 1965, when the Forest Code took effect, the *Cerrado* vegetation should have been preserved in at least 20 percent of the area of each property (50% in the Amazon), not to mention the permanent preservation areas (hilltops, hillsides, and water body banks). Even in São Paulo State, where the *Cerrado* vegetation currently covers less than 1 percent of the territory, cases of deforestation for the expansion of agriculture and cattle-breeding have been reported, and the area covered by the biome in that state has decreased by 26 percent since 1990 (data provided by *Instituto Florestal*).

Unlike the Atlantic Forest, however, for a large portion of the region covered by the *Cerrado* it is still possible to plan the occupation in a sustainable manner, harmonizing the exploitation of crops and livestock with preservation of biodiversity and water resources. Special attention is required in some areas in Goiás (GO), Mato Grosso do Sul (MS) and Mato Grosso (MT) where lie the springs of the rivers that flow to the *Pantanal*. If poorly planned, the agricultural occupation of these areas undermine the stability of the entire Pantanal ecosystem. Likewise, the charging areas of the Guarani aquifer, in the Southeast region, which are usually covered by the *Cerrado* vegetation, need to be preserved.

Building impact and vulnerability scenarios

Harmonizing socioeconomic development with environmental preservation is no easy task. The development and implementation of appropriate sustainable development strategies will be increasingly based on knowledge management, and the incorporation of recent developments in information technologies and communications. There is a growing demand for quick answers with a view to solving the problems relating to the occurrence and distribution of biological species, such as impact studies linked with the release of transgenic organisms in the environment and the implementation of invading species and crop pest restraining and controlling measures. Systemic approaches to support an educated decision-making process will depend more and more on access to and integration of information available from information distributing sources. They will also depend on the use of advanced computer-based data analysis and space viewing tools, as well as the building of impact and vulnerability scenarios.

12 Felfili, J.M.; Haridasan, M.; Mendonça, R.C.; Filgueiras, T.S.; Silva Junior, M.C.: "Projeto Biogeografia do bioma cerrado: vegetação e solos", Cadernos de Geociências, 12, Rio de Janeiro, 1994, pp. 75-165

13 www.ibama.gov.br/

The *Instituto Virtual da Biodiversidade*, (Virtual Institute of Biodiversity), related to the FAPESP Biota Program,[14] incorporates the latest breakthroughs in information technology for biodiversity. That initiative integrates the information from more than 50 research projects (fauna, flora and microbiota) through interoperated information systems, including *Sin*Biota[15] and *species*Link.[16] These systems have been designed in line with internationally accepted standards and protocols, as well as free software with open protocols. *Sin*Biota supports the integration, summarization and space viewing of data from field observations. *Sin*Biota is a centralized system that dynamically integrates data from projects related to the program with those from external information sources (national and international) via the Internet. The use of the standard data sheet and the geo-coding (lattitude and longitude) for the collection site are compulsory for projects related to the program. The digital map base of São Paulo State, with associated environmental layers, including river basins, vegetal cover, highways, city limits and preservation areas, make up the *Atlas Biota*. The *species*Link network integrates primaty data on specimens from distributed biological collection in real time, and uses computer-based tools for correcting and viewing more than one million records of collections related to system (data obtained in Nov 10, 2006).

Geo-referenced information is of paramount importance to the setting of biodiversity preservation and sustainable use strategies. However, there are still significant gaps in the knowledge of species distribution in the main Brazilian biomes. Computer-based tools to model the distribution of species help the direction field research and the identification of biologically richer areas, as well as the delimitation of potentialy rich in threatened or endemic species. It also helps identifying species that could be used in environmental recovery efforts, assessing potential threats posed by invading species and evaluating the possible impact of climate changes on biodiversity. The most commonly used predictive modeling system for species are based on the species ecological niche concept. These methods use a sub-set of conditions for the ecological niche, combining species occurrence data with the environmental characteristics of the occurrence spot, seeking to define places having similar environmental characteristics through algorithms. The niche modeling sets the enviromental limitations on the dimensions where the model is developed, thereby allowing the distribution of a given species to be projected in a geographic space with a view to anticipating where the species can or cannot keep viable populations.[17] In order to assess the impact of climate changes on 162 tree species of the Brazilian *Cerrado*, Siqueira &

14 www.biota.org.br

15 http://sinbiota.cria.org.br/atlas

16 http://splink.cria.org.br

17 PETERSON, A.T.: "Predicting species' geographic distributions based on ecological niche modeling", Condor 103, 2001, pp.599-605

Peterson[18] used modeling methodologies to generate potential geographic distribution maps for such species based on the fundamental ecological niche concept. The analysis shows a loss of the potential distribution area in excess of 50 percent for essentially all of the species under analysis within a period of 50 years. These results demonstrate the urgent need to put together and apply consistent preservation and sustainable use policies for the *Cerrado* biodiversity, while improving handling and monitoring techniques. It must also take into account the impact of climate changes and of the expansion of agriculture and cattle-breeding, as well as the vulnerability of that biodiversity to such changes. If this scenario is confirmed, the tree species diversity hotspots of the *Cerrado* that are now located in the country's central plateau may migrate to the south and overlap degraded landscapes of the *Cerrado* vegetation in São Paulo State, which are predominantly used for agricultural purposes. It is important to review preservation actions focusing on the southeast of Minas Gerais, Mato Grosso do Sul and São Paulo, with a view to ensuring the expansion of protected conservation areas and establishing ecological and riverside wood restoration corridors, while integrating high-priority areas.

18 SIQUEIRA, M.F.; PETERSON, A.T.: "Consequences of global climate change for geographic distributions of cerrado tree species", Biota Neotropica 3(2), 2003, www.biotaneotropica.org.br/v3n2/pt/download?article+BN00803022003+item

6.4 Sugar cane growing expansion areas

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Brazil's sugar cane crops covered an area of 1.0 million hectares in 1955, reaching 1.5 million hectares in 1962.[19] That area remained virtually stable for the ten subsequent years.[20] The period in which the crop area grew more rapidly began in the second half of the seventies, upon implementation of the Proalcool program in 1976. The area stabilized as of the 1987/1988 crop at around 4.2 million hectares (**Figure 3**). Another growth stage was observed during the period between the 1994/1995 and 1997/1998 crops (motivated by sugar exports). After a short stabilization period, a new expansion cycle has begun. The areas increased to 5.9 million hectares for the 2005/2006 crop, 4.7 million ha (80%) of which in the Center-South region.

The expansion has been occurring in the country's Center-South region for the last 25 years, while the sugar cane crop area has remained practically stable in the Northeast region, covering approximately 1.0 million hectares.

19 JUNQUEIRA, A.A.B.; DANTAS, B.: "A cana-de-açúcar no Brasil", *in*: *Cultura e adubação da cana-de-açúcar*, Ed. Instit. Brasil. de Potassa, 27-60, 1964

20 FERNANDES, A.C.: "Produção e produtividades da cana-de-açúcar no Brasil", Centro de Tecnologia Canavieira, internal report

Figure 3: Evolution of the harvested area in Brazil; Center-South, North-Northeast, and São Paulo

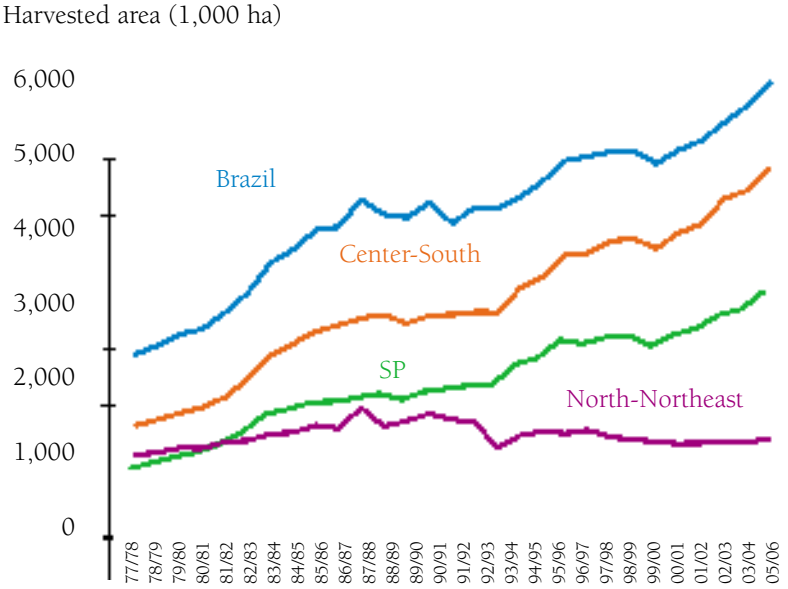
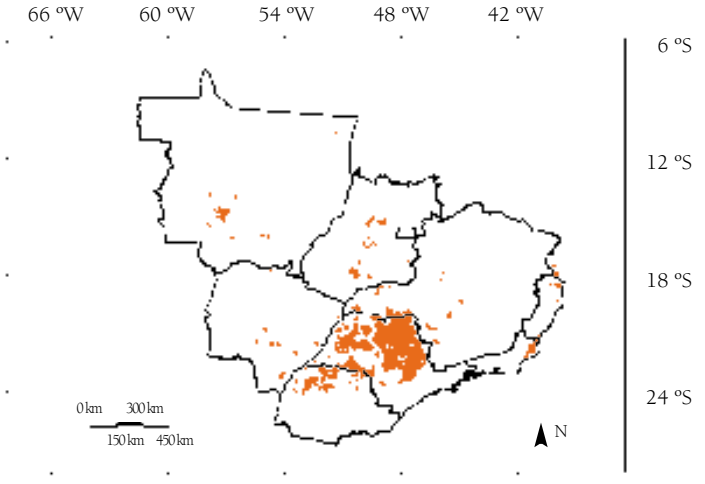


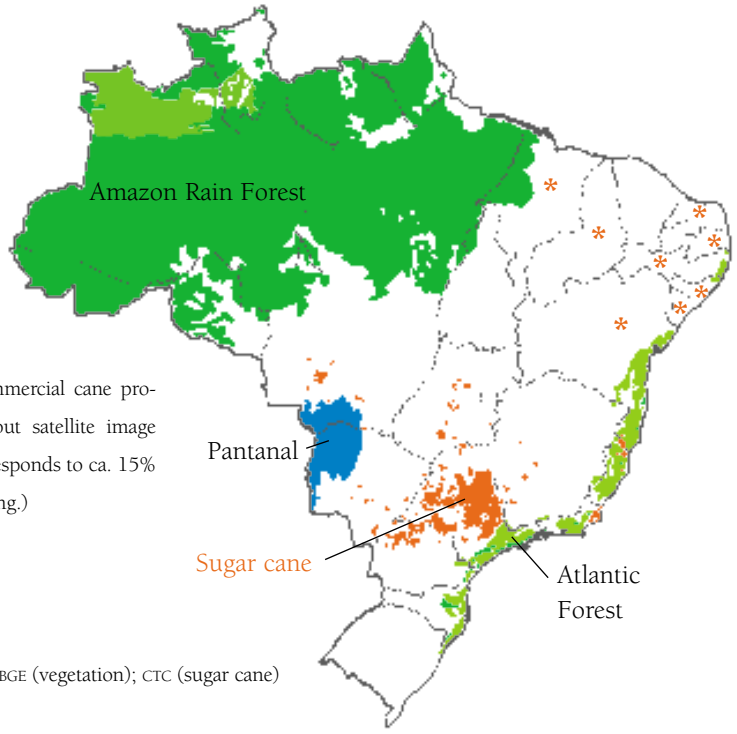
Figure 4: Sugar cane map in the Center-South region of Brazil, 2004/05 Crop



2004/05 Crop
Source: CTC, 2006

Figure 4 shows the sugar cane harvesting area in the Center-South region for the 2005/06 crop, which was mapped through remote sensing by the Sugar Cane Technology Center (CTC) and the National Institute of Space Research (INPE). **Figure 5** shows the same area and the position of Brazil's main biomes (Amazon Rain Forest, Atlantic Forest, and the Pantanal), demonstrating that the areas having the highest concentration of sugar cane crops are far from those vegetation units.

Figure 5: Sugar cane areas in the Center-South region and Brazil's main biomes



*: States with commercial cane production, but without satellite image survey. (N-NE corresponds to ca. 15% of national harvesting.)

Sources: IBGE (vegetation); CTC (sugar cane)

For the past 10 crop seasons (1991/92-2005/06), the sugar cane crop area in the Center-South region increased by 1.9 million hectares (69%), distributed as shown in **Table 4**. São Paulo State accounts for most of that increase (70% of the total).

With the regional differences in productivity, the Center-South region produced around 85 percent of Brazil's sugar cane in 2005, distributed among 238 units. It is important to note that the Center-South region's sugar

cane production increased from 176.2 to 281.5 Mt (53%, or 5% per year) from 1992/93 to 2002/03. However, the very units already in existence in 1992 accounted for almost all of that increase with some reduction in the number of producing units in the period (from 248 to 216). Actually, the great expansion at new agricultural frontiers occurs only in the last crop seasons, with average growth of 10% per year from 2003/04 to 2005/06.

Table 4: Variation of the sugar cane harvesting area in Center-Southern states for the last 15 crops; ha

State	1993	2003	Variation
São Paulo	1,852,400	3,141,777	70%
Paraná	172,296	406,989	136%
Mato Grosso	51,293	206,849	303%
Goiás	101,919	196,586	93%
Mato Grosso do Sul	65,358	135,427	107%
Minas Gerais	275,709	349,394	27%
Espírito Santo	34,157	64,373	88%
Rio de Janeiro	195,352	169,139	-13%
Others	75,347	49,153	-35%
Center-South	2,823,831	4,719,687	67%

Source: IBGE – Anuários Estatísticos

The great importance of São Paulo's production and its growth rate require the context of this growth to be considered with respect to its connection with total agricultural soil occupation. Table 5 is very significant in this respect.

Table 5: Evolution of crop areas in São Paulo, 1990-2004, Mha

	1990	2004
Total crop area	**6.27**	**6.05**
Sugar cane	1.81	2.80
Coffee	0.57	0.22
Orange	0.72	0.58
Other crops	3.17	2.46

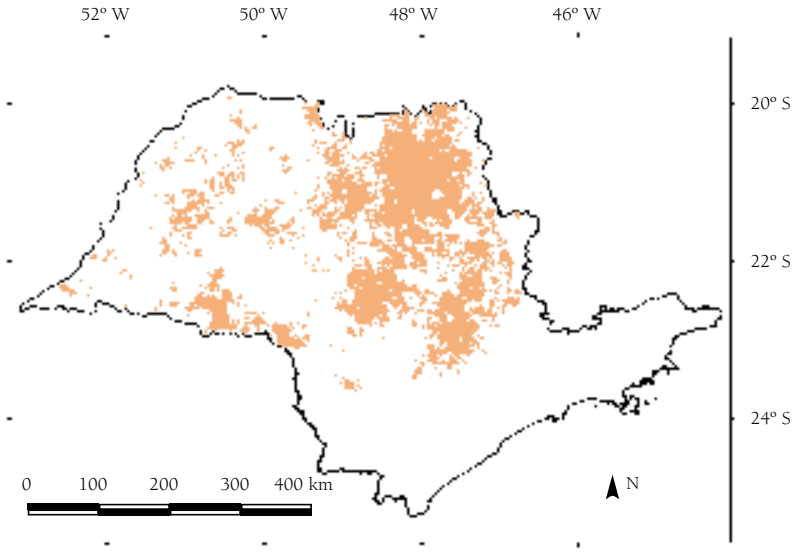
The tables show that the total crop area has been practically constant during a period (since 1990) in which sugar cane crops have been growing rapidly. What has happened is crop substitution. In this specific case, sugar cane has mostly been replacing orange and other crops, while also occupying pasture areas. The system, in fact, is known to be very dynamic, responding to prices (international prices in the case of oranges and coffee), and the crops are changed (and reversed, in some cases) after only a few years.

Accordingly, an analysis of the expansion of sugar cane crops for the next few years should consider which crops could be replaced in order to assess the impacts of changes in soil occupation. The trends are shown below.

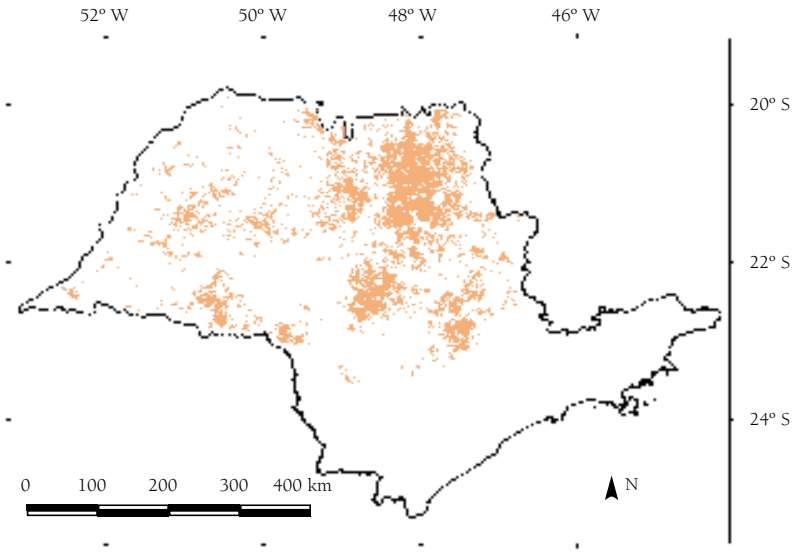
For São Paulo State, CTC has been mapping the growth of the sugar cane crop area for the past 8 crops (1999-2006) by remote sensing, using images provided by the Landsat satellite. **Figure 6** shows that mapping, as well as the evolution of the harvesting area during the period. The fastest-growing area is the west of the state, which is a traditional cattle-breeding region where sugar cane crops have mainly started taking up pasture areas.

For the most part, the identified trend is towards an increase in the sugar cane growing area in the Center-South region's current production areas. The emphasis is on western São Paulo, the areas by the borders with Mato Grosso, and some areas in the states of Goiás and Minas Gerais.

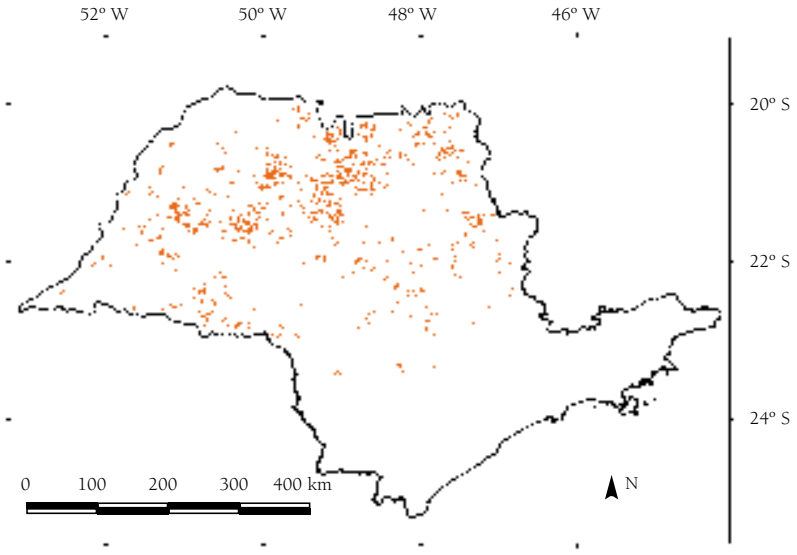
Figure 6: Mapping of the São Paulo State's sugar cane areas for the 99/00 and 06/07 crops, and area increase for the period



Source: CTC



2006/07 Crop
Source: INPE, CTC

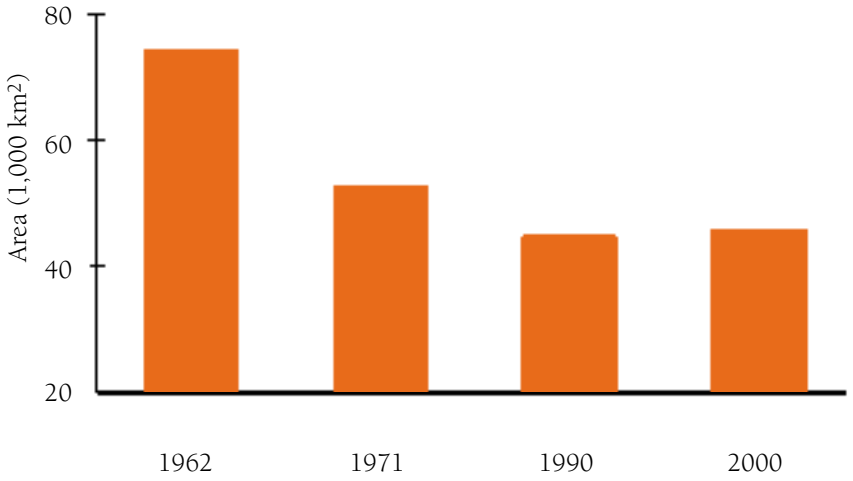


Increase in area from 1999/2000 to 2006/07 crops
Source: CTC

The forest areas once covered 82 percent of the territory in São Paulo State back when Brazil was discovered.[21] Since the beginning of the country's colonization in the 16th century, they have systematically decreased. The evolution of coffee crops was one of the main causes. In the last decade, however, this trend has reversed. The latest forest inventory has reported a rise of 3.8 percent in the area with natural vegetation. **Figure 7** shows the remaining natural vegetation area of the state, indicating that the recent sugar cane expansion periods in the state (starting in 1994) coincide with the forest area recovery period. In part, the restoration of riverside woods has contributed to this process (see **item 5.4**). This trend may be enhanced.

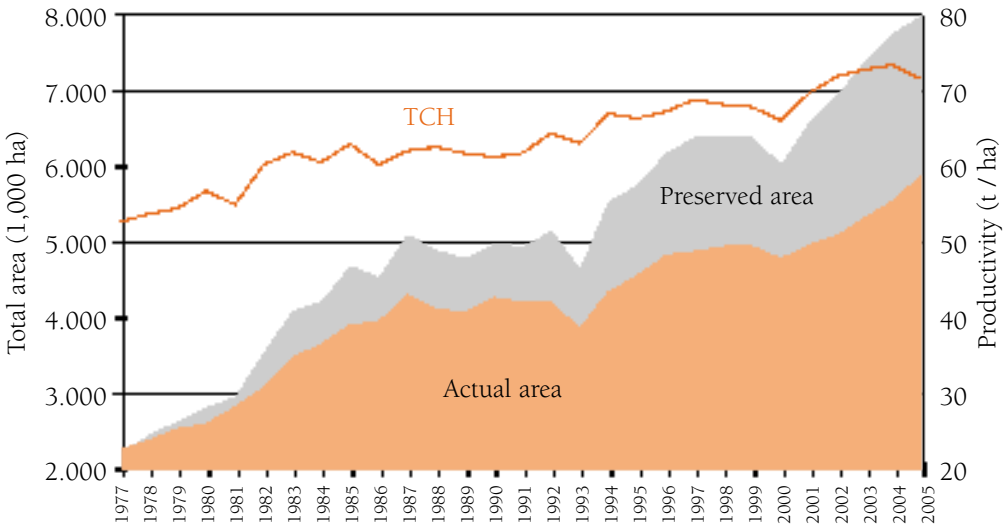
21 ZORZETTO; R. *et al.*: "A floresta renasce", Revista Pesquisa FAPESP, n.º 91, Sep. 2003, pp. 48-52

Figure 7: Remaining natural vegetation area in São Paulo State
Source: Note **21**



The great rise in productivity resulting from technology developments in sugar cane production has been responsible not only for the industry's increased productivity, but also for the decrease in the crop area that needs to be occupied to support the increase in production. **Figure 8** shows that if there had been no productivity gain, the area to be used for growing the same amount of sugar cane would have had to be 2.0 million hectares larger than that used for the 2005/2006 crop.

Figure 8: Actual production area and area saved by the introduction of technology



6.5 Summary and conclusions

• With 850 Mha, Brazil has a large portion of its territory able to meet the conditions to economically support agricultural production, while preserving vast forest areas within different biomes. Today, agriculture uses only 7 percent (half of which being taken up by soybean and corn crops), pastures use around 35 percent, and forests 55 percent. The expansion of agriculture over the past 40 years has taken place mostly in degraded pasture areas and *campos* (grassland with some shrubs), rather than forest areas. The area currently occupied by sugar cane crops represents only 0.7 percent of the territory, and the areas currently able to support the expansion of this kind of crop represent at least 12 percent.

• The *Cerrado* (24% of the territory) has been extensively utilized for agriculture and cattle-breeding over the past 40 years. The expansion of sugar cane crops in areas covered by the *Cerrado* vegetation has thus far been relatively small, and has replaced other covers that had previously replaced the *Cerrado* (usually pastures).

• The expansion of sugar cane crops has taken place essentially in Brazil's Center-South region over the past 25 years, in areas that are very far from the current biomes of the Amazon Rain Forest, the Atlantic Forest and the Pantanal. From 1992 until 2003, almost all of the expansion in the

Center-South region occurred in existing units; new agricultural borders were involved very slightly. In São Paulo, the growth has occurred through the substitution of pastures and other crops.

• For the next few years, there shall be growth in the Center-South region, with an emphasis on the west of São Paulo, regions by the borders with Mato Grosso, and in some areas within the states of Goiás and Minas Gerais.

• Brazil concentrates the world's largest biological diversity (including the Amazon Rain Forest, the Atlantic Forest, and the *Cerrado*), and a flora estimated at 50,000 to 60,000 angiosperm species. The biodiversity preservation priorities were set mainly between 1995 and 2000, with the contribution of hundreds of experts. Protected areas were established for the six major biomes in the National Preservation Units System. This important initiative shall be undergoing some reviews, so as to incorporate methodology advances and to consider the expansion of agriculture and the vulnerability to climate changes.

• Since the discovery of Brazil, the Atlantic Forest has been the first biome to be partially replaced through the exploitation of wood, agriculture and cattle-breeding along Brazil's entire coast. Among many others, the sugar cane culture (Center-South and Northeast) is now in areas originally covered by that biome. This process by far preceded any concern for preservation, and consequently, preservation requires the restoration of areas protected by law (riverside woods, hillsides).

• The occupation of the *Cerrado* by agriculture is very recent, and includes areas occupied by cattle-breeding, as well as firewood and coal exploitation. Its growth should be planned taking into consideration the preservation of biodiversity and water resources, especially in sensitive areas (sources of rivers that flow to the Pantanal, and recharge areas of the Guarani aquifer).

• Harmonizing socioeconomic development with environmental preservation requires up-to-date information and appropriate tools for analyzing impact and vulnerability. Programs like that of the IVB (São Paulo) and advances in the survey of geo-referenced data (in progress) are therefore highly important in this context.