Sustainable Biomass production for the World Market - IEA Bioenergy, Task 40

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Sustainability of sugar cane, sugar and ethanol production in Brazil

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Data from a study by UNICA (2004-2005), with participation of 22 Brazilian scientists / technicians.

- The principles in Rio Declaration and the actions / responsibilities detailed in the Agenda 21 have added to the conditions for human development (until then, social and economic) the environmental protection.
- The sugar cane agro-industry in Brazil (with important perspectives of growth and diversification) has started a comprehensive analysis of its sustainability, for the next 15 years.

Main topics

- Impacts on natural resources

  Energy; materials; water
- Environmental impacts

  Air quality: cities and rural areas; global climate; soil occupation and bio-diversity; agricultural soil preservation; utilization of agro-toxics and fertilizers
- Sustainability of the agricultural production base
- Production impacts in commercial actions
- Socio-economic impacts

Impacts on energy utilization

World context: oil depletion; increasing demand; increased local and global pollution

- The sugar cane industry is self sufficient and produces energy surpluses; totals are:

  9,7 TWh electric + mech. energy (3% of Brazil's electricity)
  17,5 M toe of bagasse (equivalent to all NG + fuel oil)
  Ethanol (~ 40% of the Otto cycle)

- Potentials, with commercial technologies and the same cane production: more 30 TWh electricity or 40% more ethanol (from residues)
- For each additional 100 M t cane: + 3,8% of today's electricity demand, and + 4,9 M m^3 ethanol (with 52% of cane going to ethanol).

Impacts on materials utilization

Context: world per capita materials utilization is growing, as well as the consequent environmental impacts

- Agriculture: source of renewable materials
- Sugar cane, Brazil, 2004: 55 M t sucrose; 100 M t cellulosic material (50% “lost”)
- Sucrose derived products: may use 1.5 M t sucrose, next years (amino acids, organic acids, sorbitol, yeast extracts, plastics)
- Ethanol derived products: in the 80’s: + 30 products

→ *Great possibilities; still small implementation.*

Impacts on global climate (GHG emissions)

Context: growing consensus on the need to prevent an increase of ~2 °C on the planet's surface till 2050 (it has been + 0.6°C, since pre-industrial times); consequences.

- The ratio of the renewable energy produced (with ethanol) to the fossil energy used in its production is 8.3. *This outstanding performance leads to avoiding GHG emissions equivalent to 13% of the total emissions from the energy sector in Brazil (basis: 1994).*

  Avoided GHG emissions in 2003:
  ethanol substituting for gasoline: 27.5 M t CO_2 eq.
  bagasse in sugar production: 5.7 M t CO_2 eq.

- Each additional 100 M t cane will avoid 12.6 M t CO_2 eq. (ethanol,bagasse and surplus electricity)

Air pollution: urban and rural areas

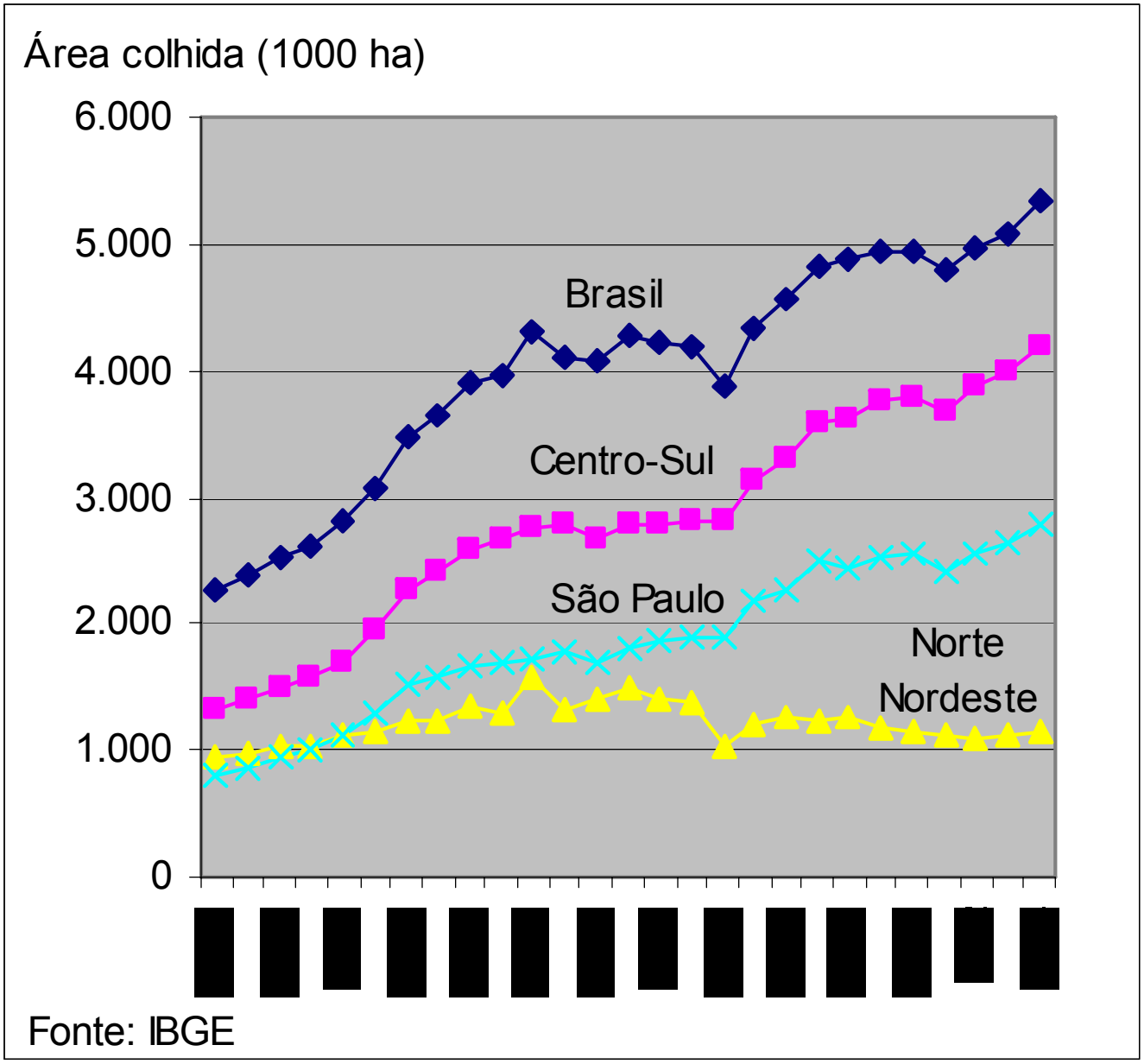
- Effects of ethanol use as motor fuel in urban areas were the elimination of lead compounds in gasoline; reduction of CO emissions; elimination of S and particulate matter; and less toxic and photochemically reactive organic compounds emissions.
- The burning of cane trash has not been associated with chronic diseases; it had to be controlled due to risks (electric systems, road traffic, forests) and dust. The São Paulo State legislation (gradually reducing the areas with cane burning) considered technology availability, employment, and high risk areas.

Impacts on water supply and quality

- The use of water for agricultural irrigation is very small in Brazil (~3,3 M ha, against 227 M ha worldwide). *Sugar cane in Brazil uses no irrigation.*
- Water uptake was reduced from 5 m3 / t cane (1990 to 1997) to 1,83 m3 / t cane (2004), in São Paulo. Water re-utilization is high (total use is 21 m3 / t cane); the treatment for discharge reached efficiencies above 98%.
- Embrapa classifies sugar cane in Level 1 (no impact in water quality).
- The APP (Permanent Protected Areas) close to rivers and lakes correspond to 8,1% of the sugar cane area in São Paulo; 3,4% have natural forest cover and 0,8% were re-forested.
  Implementation of programs for recuperation may be important to preservation of plant biodiversity.

Soil Utilization

- From an area of 850 M ha, Brazil uses 7% for agriculture; 35% as “pasture land”, and 55% have forests.
- Sugar cane uses 0,6% of Brazil area (half to ethanol); the areas considered adequate for its expansion correspond to at least 12% of the country’s area.
- In the last decades sugar cane areas grew in the Center - South; from 1992 to 2003, 94% of the expansion was around the existing production units. Utilization of the Cerrados (25% of the territory) was relatively small.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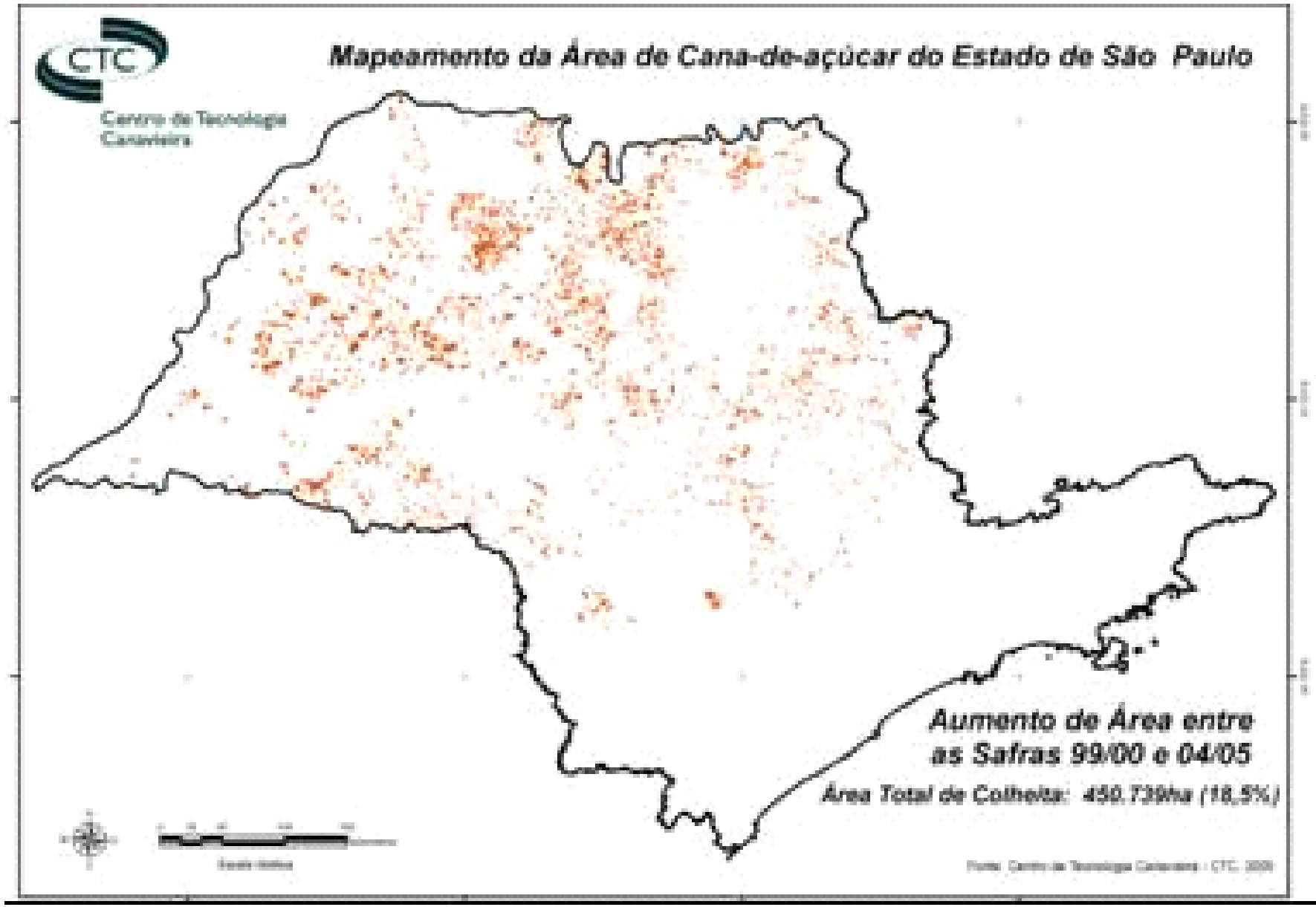
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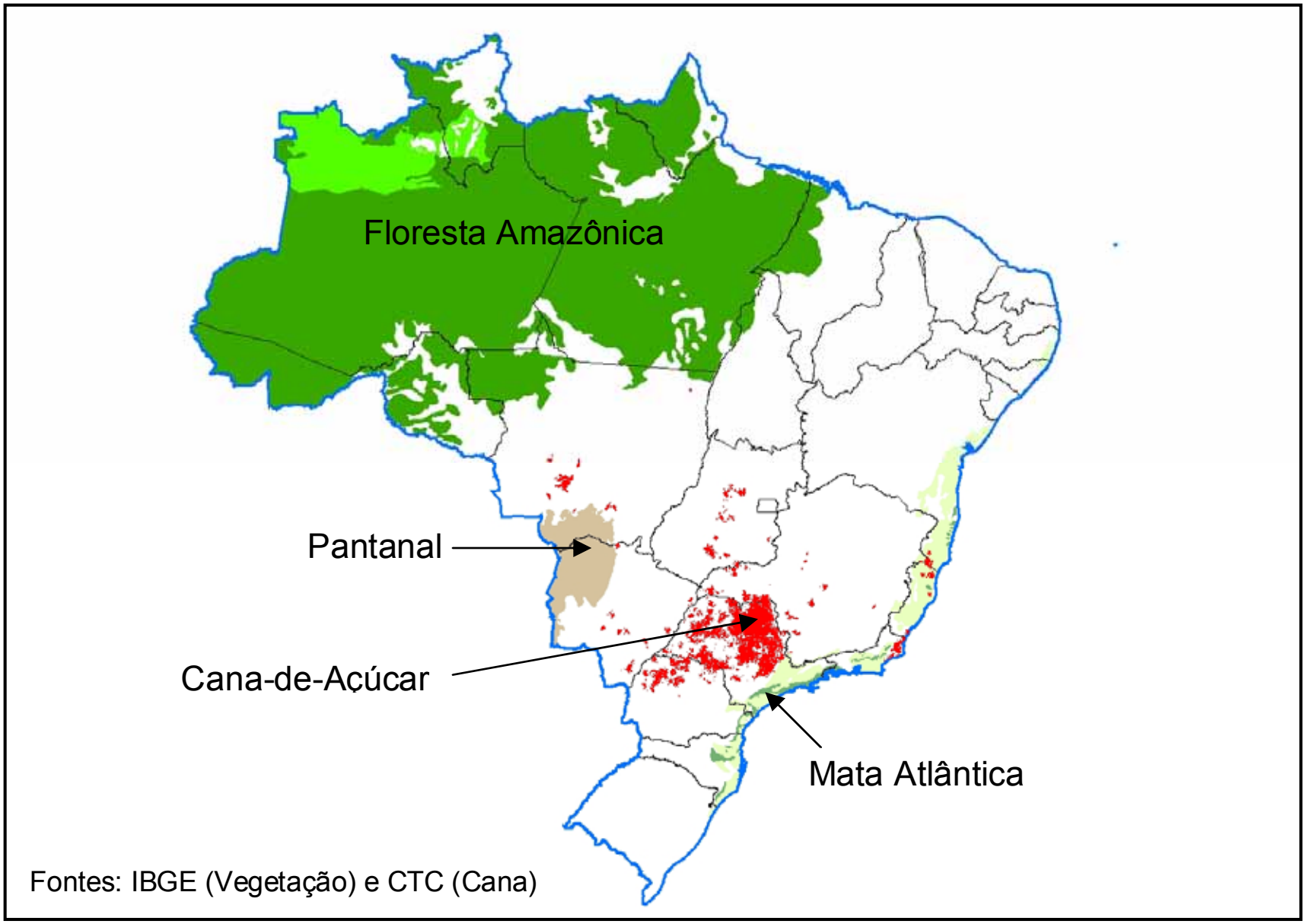
Mapeamento da Área de Cana-de-açúcar do Estado de São Paulo
Aumento de Área entre as Safras 99/00 e 04/05
Área Total de Colheita: 450.739ha (16,5%)

Soil Utilization and bio-diversity

- Brazil has the world's largest biological diversity; conservation priorities and protected areas were established mainly in 1995-2000.
- The Atlantic Forest has been largely replaced for centuries (much before the conservation considerations); the Cerrados utilization is more recent, and agricultural expansion must be carefully planned to preserve biodiversity and water resources.



Fontes: IBGE (Vegetação) e CTC (Cana)

Impacts from soil utilization

Sugar cane recent expansion happens in relatively poor soils (mostly pastureland, or some highly anthropized Cerrados). It helps recovering soil quality by adding organic matter and fertilizers, improving soil conditions.

Sugar-cane in Brazil presents relatively small soil erosion losses; this situation is improving as harvesting without burning expands and reduced preparation techniques are introduced, leading to very low loss rates, comparable to those for direct planting in annual cultures.

Annual crop	Losses	
	Soil	Water
	ton/ha/year	% Rain
Castor	41,5	12,0
Beans	38,1	11,2
Manioc	33,9	11,4
Peanut	26,7	9,2
Rice	25,1	11,2
Cotton	24,8	9,7
Soybean	20,1	6,9
English potato	18,4	6,6
Sugar-cane	12,4	4,2
Corn	12,0	5,2
Corn + Bean	10,1	4,6
Sweet potato	6,6	4,2

Use of Agrochemicals - 1

Context: the Brazilian legislation covers all important areas. The use of more biological controls (and some practices of "organic" agriculture) is sought; and cane genetic modification is a promise.

- Pesticide consumption in sugar-cane crops is lower than in citric, corn, coffee and soybean crops; the use of insecticides is low, and that of fungicides is virtually zero.
- The sugar-cane beetle is the subject of the country's largest biological control program. It also has been possible to substantially reduce the use of pesticides through selective application.
- Sugar cane still uses more herbicides than coffee or corn; less than orange, and the same as soy beans.

Use of Agrochemicals - 2

- Sugar-cane diseases are fought against with the selection of disease-resistant varieties. They have been sufficient to address occurrences as the mosaic virus (1920), the sugar-cane smut and rust (1980's), and the SCYLV (1990's), through replacement of varieties.
- Genetic modifications (at field test stage) have produced plants resistant to herbicides, smut, the mosaic virus, the SCYLV and the sugar-cane beetle.

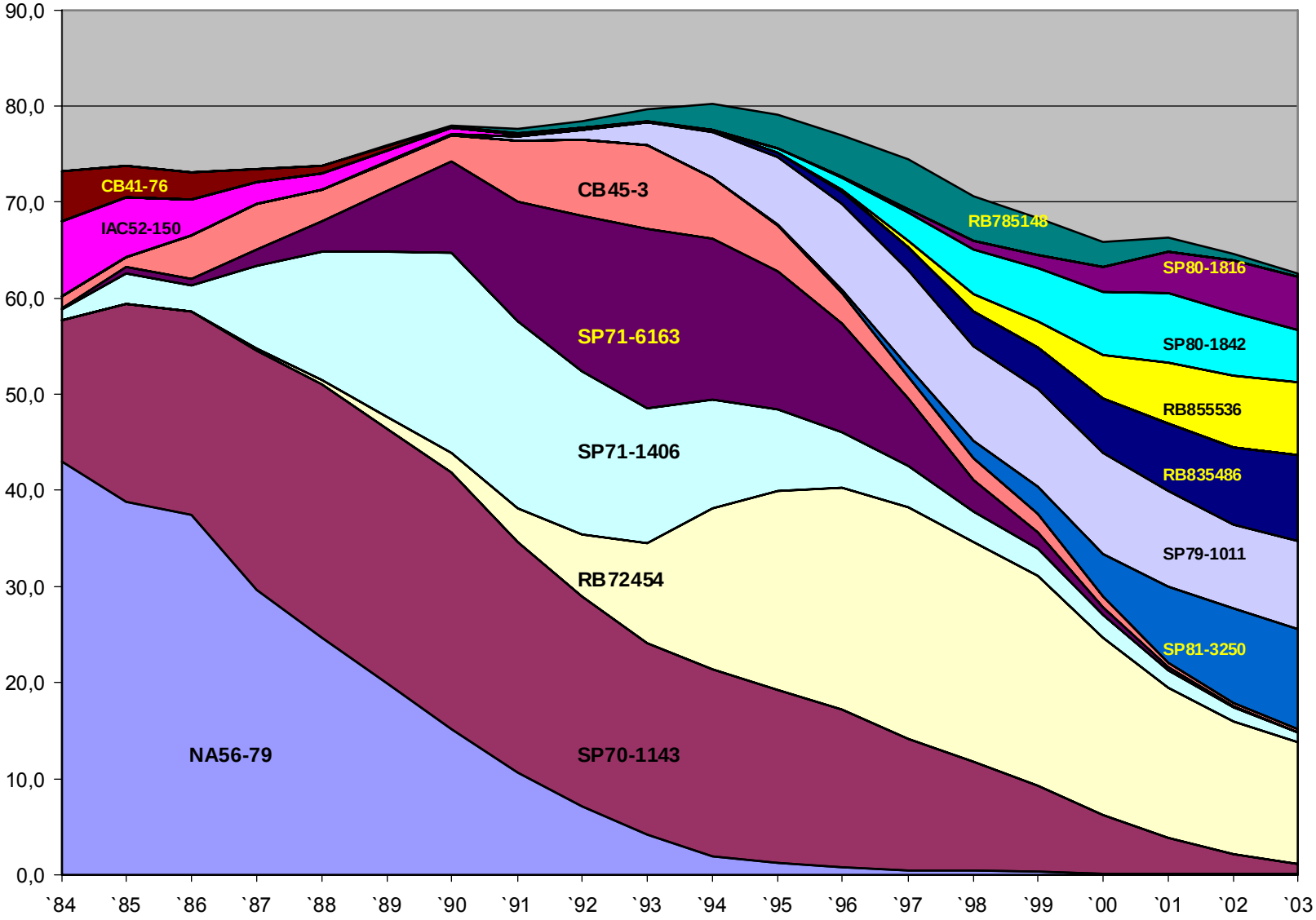
Fertilizer Utilization

- Among Brazil's crops (area larger than 1 M ha), *sugar-cane uses less fertilizers than cotton, coffee and orange, and is equivalent to soybean*. The use of fertilizers is also small compared to sugar-cane crops in other countries (48% more is used in Australia).
- A very important factor is the nutrient (mainly K) recycling with full utilization of wastes (vinasse and filtercake), considering the limiting topographic, soil and environmental control conditions.
- Soil leaching and underground water contamination with vinasse are controlled limiting application rates; a Technical Standard by the Office of the Secretary of Environment (S. Paulo) regulates all relevant aspects: risk areas (prohibition); permitted rates; and technologies.

Sustainability of the agricultural production base

Ability to resist pests, diseases and periodic climate variations.

- *Protection from pests and diseases is a strength of Brazil's production: it is based on a continued supply of resistant sugar-cane varieties and not much on phytosanitary barriers*
- The four sugar-cane genetic improvement programs in Brazil (the two leading programs are private) work with more than 2 million seedlings per year; 51 varieties have been released over the past ten years. The twenty most important varieties occupy 80 percent of the crop area, but the most widely used occupies just 12.6 percent.
- Brazil has (non-commercial) transgenic varieties since the 1990's. Commercial results may arise over the next five years.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RB855536
RB835486
SP79-1011
SP81-3250

Production impacts on commercial actions

Does the production need subsidies?

- The sugar cane products (Brazilian Center South) do not have any price support mechanism; there are no subsidies to sugar production or trade today.
- Ethanol production costs are competitive with gasoline at oil prices US$ 25-30/bbl. They are much lower than ethanol costs from corn (USA) or beets / grain (EU), or for prospective costs for cellulose based ethanol.
- Sugar costs are much lower than for any other producer worldwide; production/export cost is 65% of the average for other exporters.
- There are important possibilities for cost reduction through diversification (energy / co-products)

Some economic impacts

- Substitution of ethanol for gasoline from 1976 to 2004 corresponded to saving US$60.7 billion (or US$ 121.3 billion, with interest rates) in currency.
- The Brazilian equipment industry had a significant development; the larger manufacturer supplied 726 distilleries and 106 complete sugar mils, including the co-generation plants.
- Jobs were created for a large range of manpower capacities.

Jobs and Income -1

- Compared to the Brazilian 45-percent mean rate of formal jobs, the sugar-cane production has a rate of 68.5 percent (from the 53.6% of 1992). In the Center-South, this rate reaches 82.8 percent, and 88.4 percent in São Paulo (2003).
- *Poorer regions are characterized by lower salaries and a much larger use of labor, consistent with technology levels (automation, mechanization).*
- The seasonal index for the job (sugar cane production) was 2.2 in São Paulo in the early 1980's, 1.8 in the late 1980's, and 1.3 in the mid 1990's.

Jobs and Income - 2

- In the late 1990's, with 650,000 direct jobs and 940,000 indirect jobs (plus around 1,800,000 induced jobs), the number of jobs per product unit in the Center-South region was 3.5 times higher than in the North-Northeast.
- The *formal, direct jobs* in the industry are now increasing (more 18% from 2000 to 2002), and reached 764,000 in 2002. Jobs in agriculture decrease, while industrial jobs increase in number.
- In the Center-South, the income of people working in sugar-cane crops is higher than in coffee, citrus and corn crops, but lower than in soybean crops. In the North-Northeast, the income in sugar-cane crops is higher than in coffee, rice, banana, manioc and corn crops, equivalent to citrus crops, and lower than in soybean crops.

Observations

All the relevant aspects (social, economic, environmental) for sustainability must be evaluated, from source to end use, when considering the future (and today's) energy supply systems. Externalities (positive or negative) must be clearly identified.

The sugar cane industry (essentialy a food producer, now with a growing participation as an energy supplier) presents some important sustainability characteristics.

It has progressed towards more sustainable conditions, and still shows significant improvement potential.