1st Brazil-US Biofuels Short Course

THE POTENTIAL FOR 1st GENERATION ETHANOL PRODUCTION FROM SUGARCANE

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- **Ethanol production from sugarcane (mainly in Brazil) on the basis of "1st generation technology" (22.5 billion liters per year in 3.4 million hectares) replaces today 1% of the gasoline in use in the world and is highly competitive in economic terms with ethanol produced from other crops in the US and Europe.**

- **Characteristics of Ethanol from sugarcane**

  - **On a life cycle basis it reduces greenhouse gas emissions (GHG) by 84% (on a volume basis) while ethanol from corn reduces GHG emissions by 30% and ethanol from sugar beets by 40%;**

  - **Production cost is smaller than production cost from corn by 60% and 75% smaller from sugar beets;**

  - **The yield in liters of ethanol per hectare (6,470l/ha) is significantly higher than the yield from corn (4,180 l/ha) or sugar beets (5,500 l/ha).**

CHARACTERISTICS OF DIFFERENT CROPS FOR ETHANOL PRODUCTION

	Sugar cane (in Brazil)	Corn (in the USA)	Sugar beet (in Europe)
Energy balance (a)	8.1 - 10	1.4	2.0
Production cost (€/100 liters) (b)	14.48	24.83	52.37
CO_2 reduction compared to gasoline (c)	84%	30%	40%
Total production (billion liters) (D)	22.5	34	733.6
Area cultivated (million hectare) (E)	3.4	8.13	133.4
Yield (liter/hectare) (D/E)	6,471	4,182	5,500*

(a) Defined as energy output in a liter of ethanol over fossil fuel energy needed to produce. Sources: Macedo et al, 2008; World Watch Institute, 2006.
(b) Henniges, O., and Zeddies, J., Competitiveness of Brazilian ethanol in the EU. 2004
(c) Doornbosh and Steenblik, 2007. * theoretical yield, as presented by Word Watch Institute, 2006.

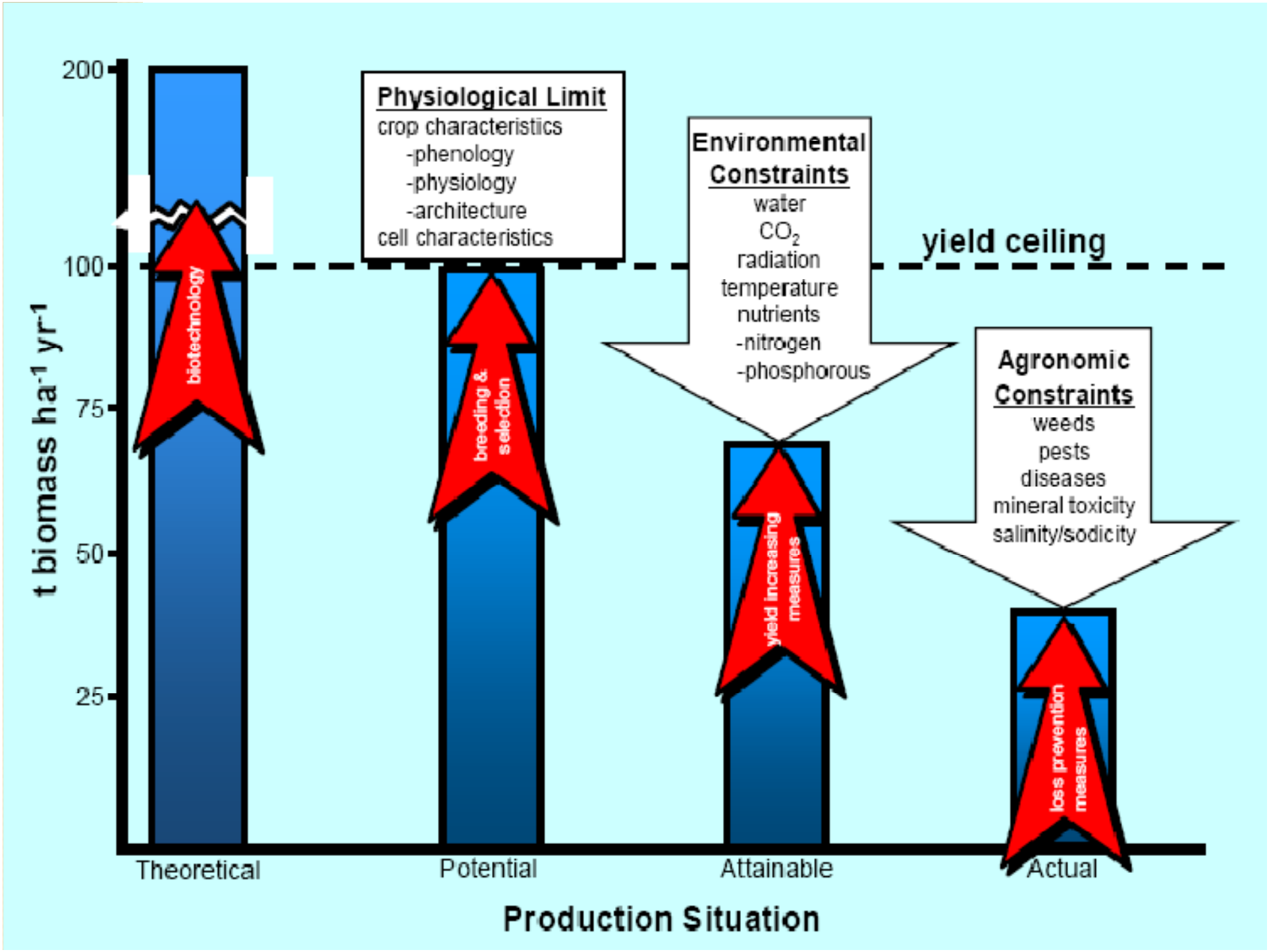
- **Sugarcane is the most successful raw material in use today. The potential for its expansion comes from.**
  - **Productivity gains which would allow greater production in the same area and**
  - **Geographical expansion to larger areas.**

- **Sugarcane is an important tropical crop having C4 carbohydrate metabolism which allied with its perennial nature, makes it one of the most productive cultivated plants (D'Hont et al, 2008). Such crops capture 6% of the solar energy incident in them, which corresponds to a theoretical cane yield of 472 tc/ha or 219 tons of dry biomass per ha (Table II).**

AVERAGE, MAXIMUM AND THEORETICAL SUGARCANE YIELD AND TOTAL DRY MATTER PRODUCTION

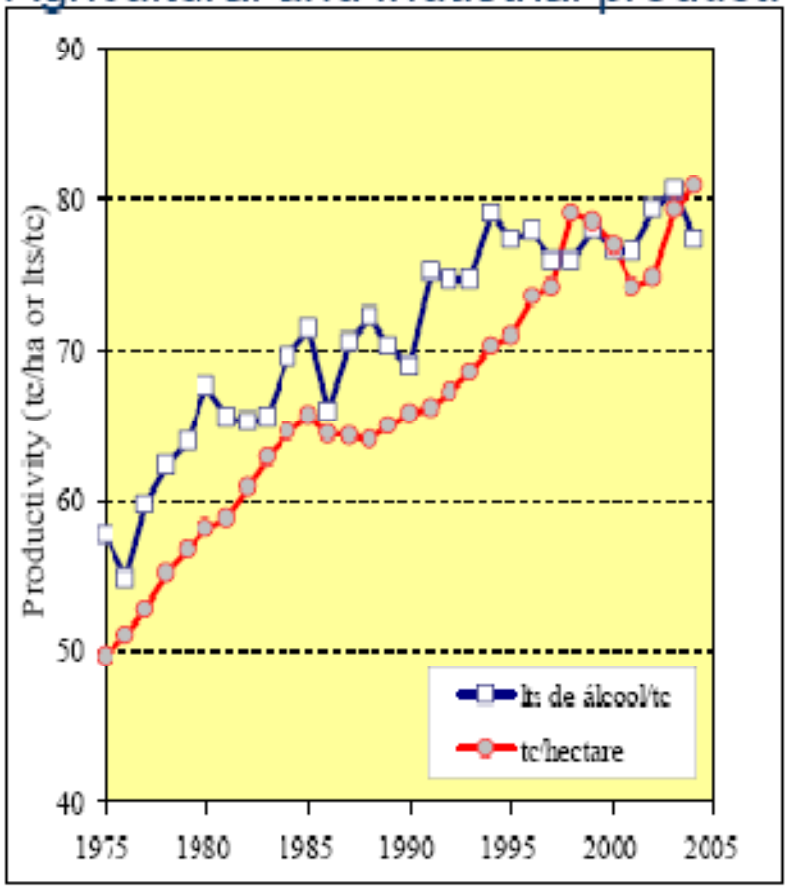
Type (Australia, Colombia, South Africa)	Cane yield (t/ha yr)	Biomass	
		(t/ha yr)	(g/m^2 d)
Average	84	39	10.7
Commercial maximum	148	69	18.8
Experimental maximum	212	98	27
Theoretical maximum	472	219	72.4

Source: Moore, 2009

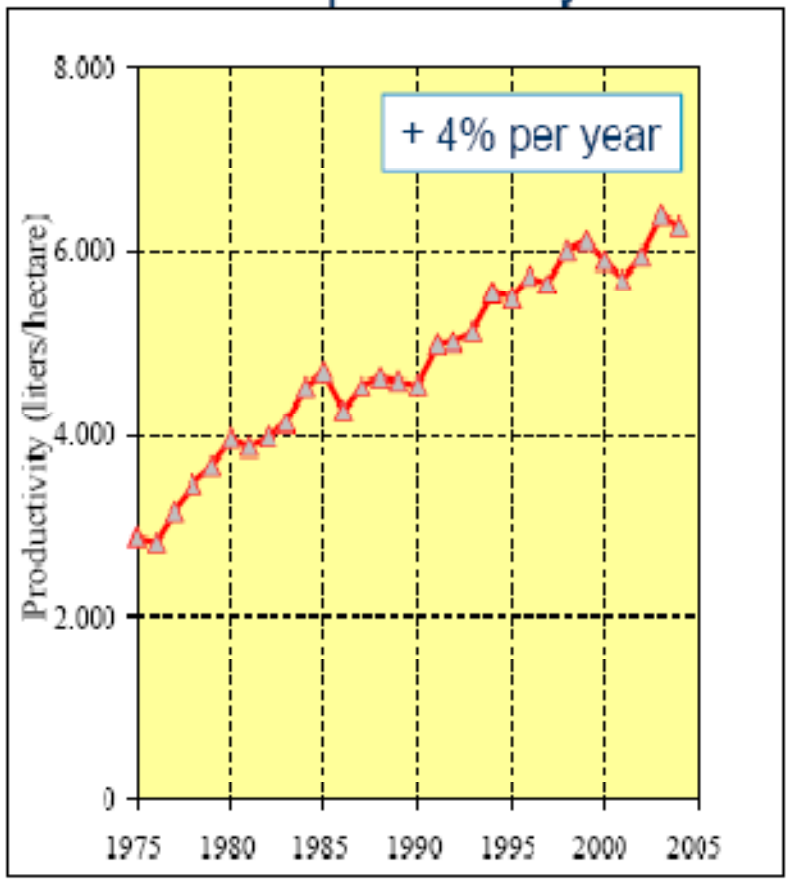

200
100
75
50
25
t biomass ha-1 yr-1
Physiological Limit
crop characteristics
-phenology
-physiology
-architecture
cell characteristics
Environmental Constraints
water
CO2
radiation
temperature
nutrients
-nitrogen
-phosphorous
Agronomic Constraints
weeds
pests
diseases
mineral toxicity
salinity/sodicity
yield ceiling
biotechnology
breeding & selection
yield increasing measures
loss prevention measures
Theoretical
Potential
Attainable
Actual
Production Situation

INCREASE IN PRODUCTIVITY THROUGH R&D

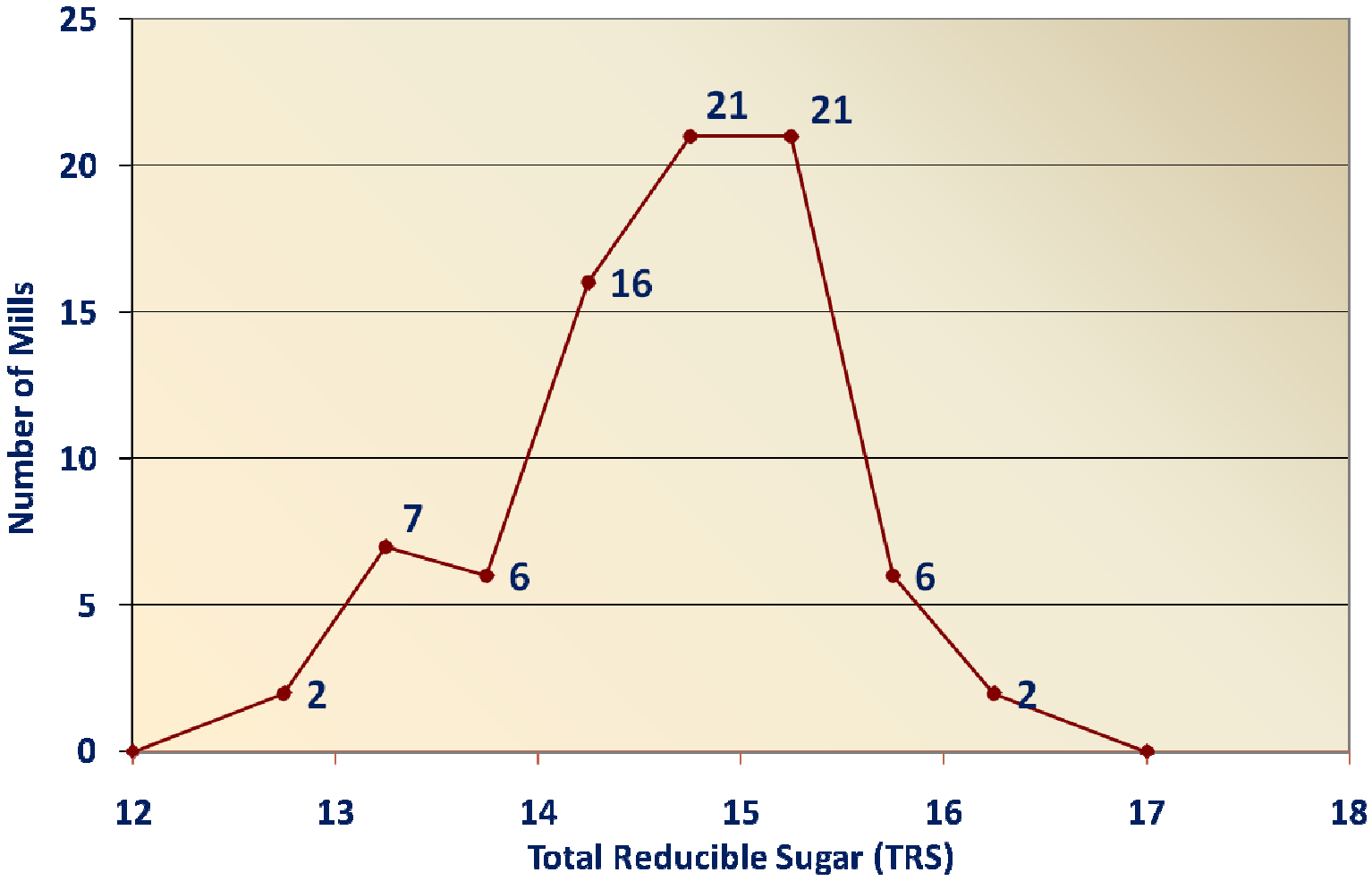
Agricultural and Industrial product.



Total productivity



DISTRIBUTION OF TRS AMONG MILLS



BRAZIL: 1% OF ARABLE LAND DISPLACES 50%+ OF THE GASOLINE

Millions of Hectares (2007)		% total land	% arable land
BRAZIL	**851**		
TOTAL ARABLE LAND	**354.8**		
1. Total Crop Land	**76.7**	***9.0%***	***21.6%***
Soybean	20.6	*2.4%*	*5.8%*
Corn	14.0	*1.6%*	*3.9%*
Sugarcane	7.8	*0.9%*	*2.2%*
Sugarcane for ethanol	**3.4**	***0.4%***	***1.0%***
Orange	0.9	*0.1%*	*0.3%*
2. Pastures	**172.3**	***20%***	***49%***
3. Available area **Total arable land – (crop land + pastures)**	**105.8**	***12%***	***30%***

PERSPECTIVES FOR THE REPLICATION OF BRAZILIAN ETHANOL PROGRAM IN OTHER DEVELOPING COUNTRIES

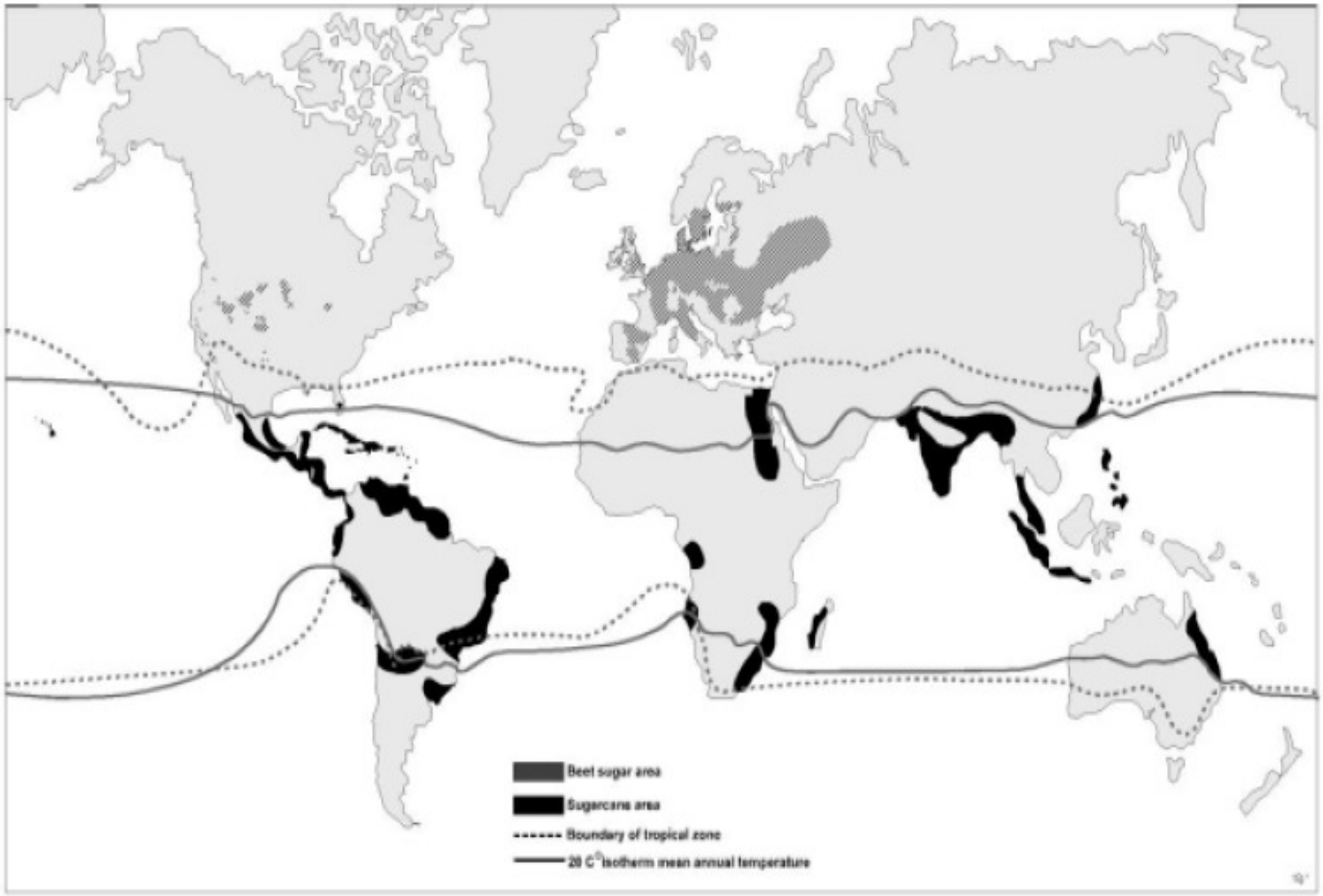
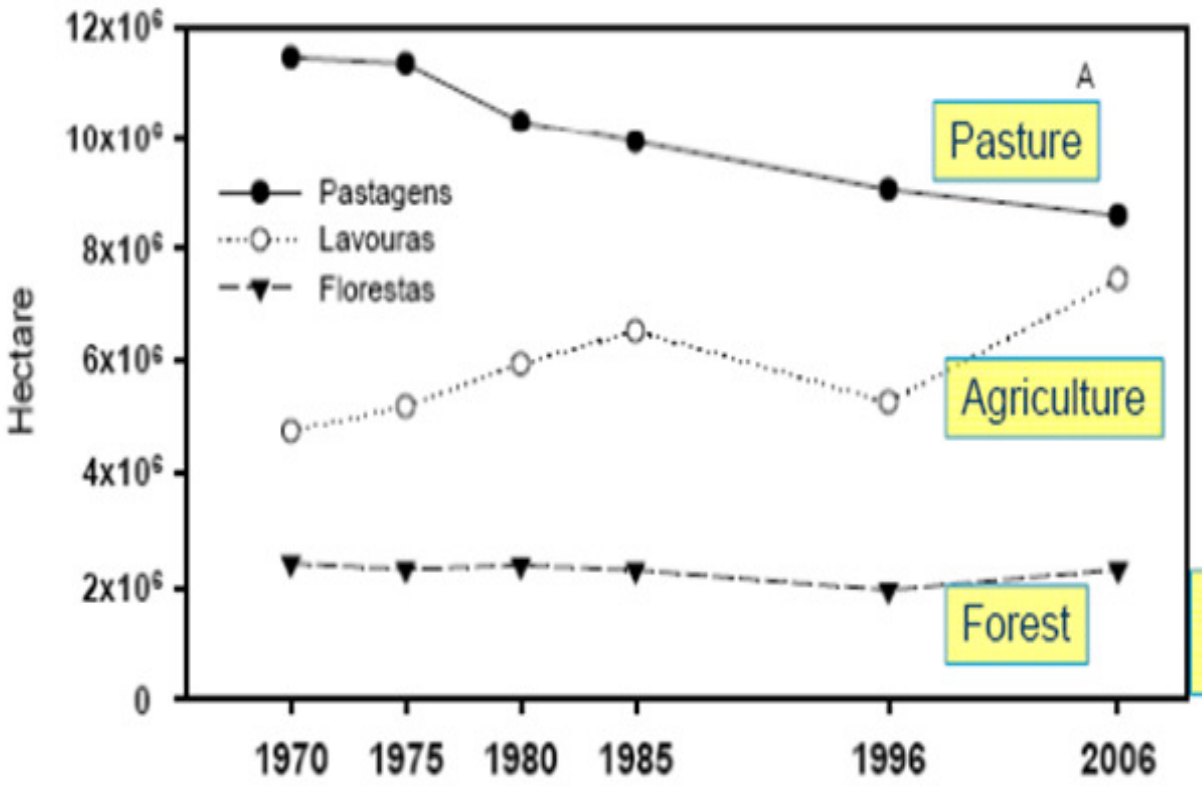


Figure 3.5. Global Distribution of Sugar Beet and Sugarcane Production. Redrawn from Helmut Blume, *Geography of Sugar Cane* (Berlin,1985), 22.

São Paulo: Land Use Change, 1970-2006



Sugarcane x Pasture: fixation of 0,5 Mg C/ha.yr

Source: Boddey, R.M, "GHG Emission Mitigation Though Ethanol from Sugarcane in Brazil", Circular Técnica Embrapa 27 (04/2009)

TOP 15 SUGARCANE PRODUCERS (2007 FAO ESTIMATES)

Country	Area Harvested (million ha)
Brazil	6.71
India	4.90
China	1.24
Pakistan	1.03
Thailand	1.01
Mexico	0.68
Colombia	0.45
Australia	0.42
South Africa	0.42
Cuba	0.40
Philippines	0.40
United States of America	0.36
Indonesia	0.35
Argentina	0.29
Vietnam	0.29
Total	18.95

- **The potential of "1st generation technology" for the production of ethanol from sugarcane is far from being exhausted. There are gains in productivity of approximately a factor of two from genetically modified strands and a geographical expansion by a factor of 10 of the present level of production in many sugar producing countries.**

- **The replacement of 10% of the gasoline used in the world by ethanol from sugarcane seems possible before "2nd generation technologies" reach technological maturity and possibly economic competitiveness.**

ZONEAMENTO AGROAMBIENTAL PARA O SETOR SUCROALCOOLEIRO DO ESTADO DE SÃO PAULO

SECRETARIA DE AGRICULTURA E ABASTECIMENTO

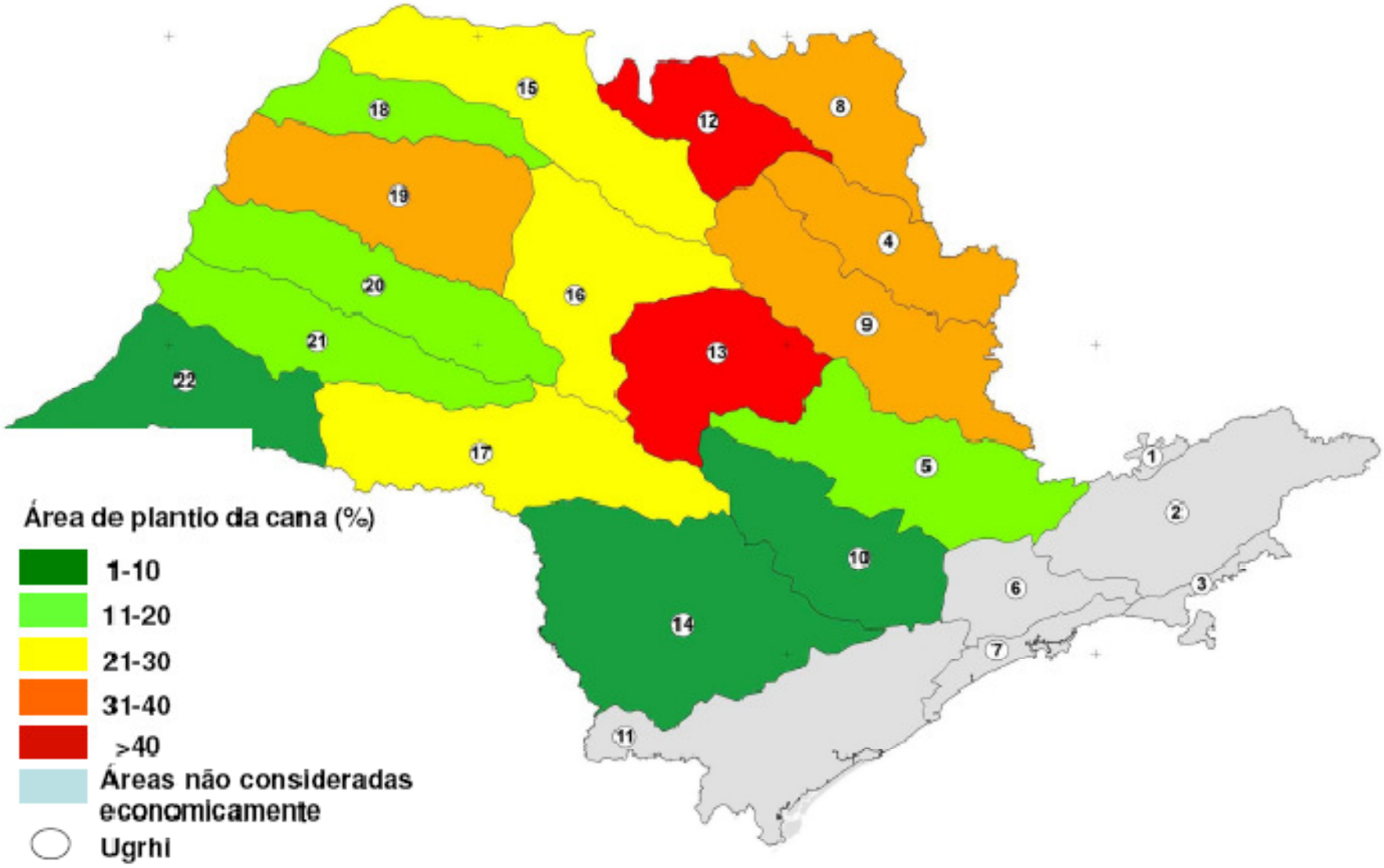
SECRETARIA DO MEIO AMBIENTE

GOVERNO DO ESTADO DE SÃO PAULO

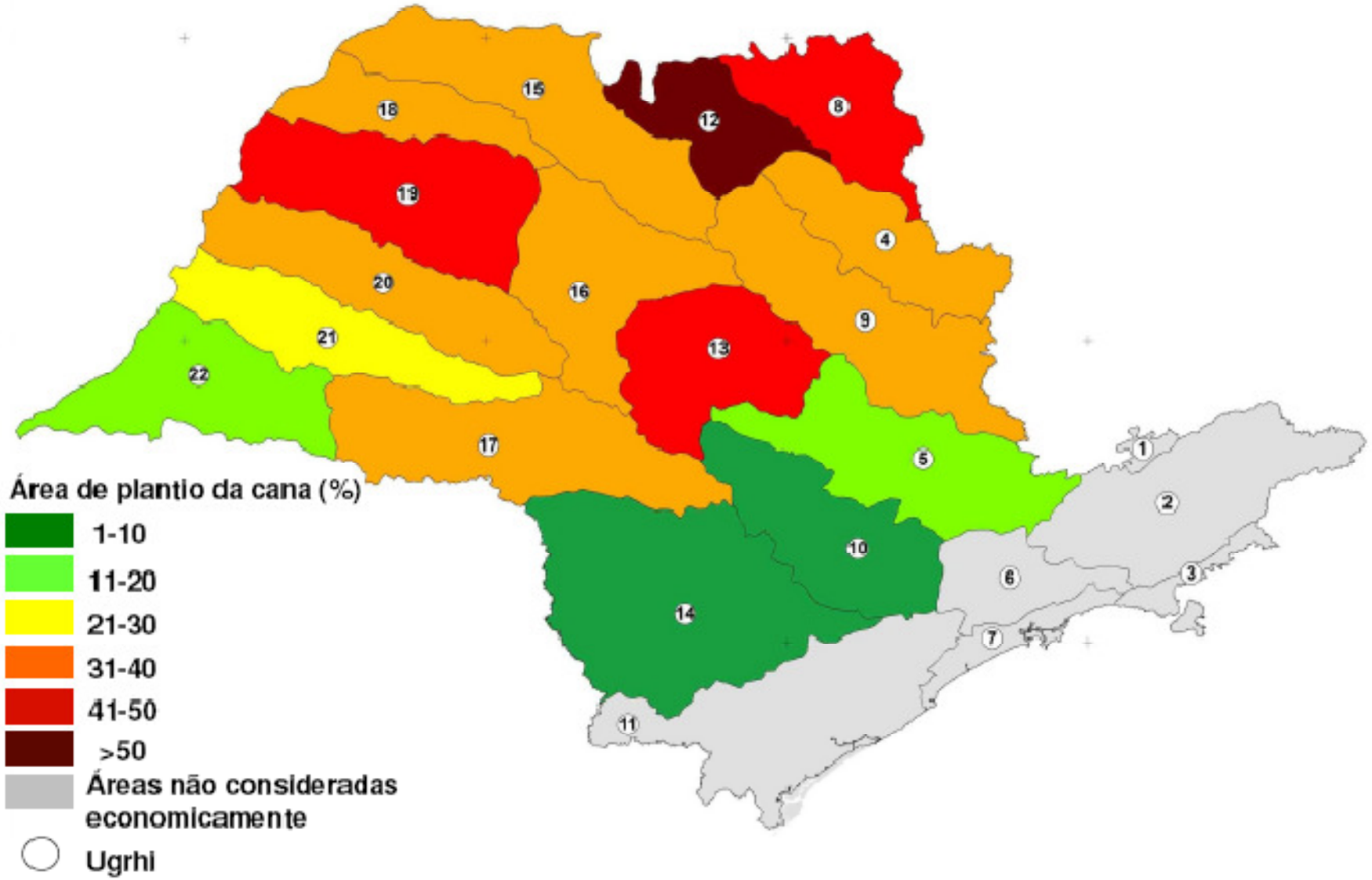
TRABALHANDO POR VOCÊ

Ocupação das terras pela cultura da cana-de-açúcar

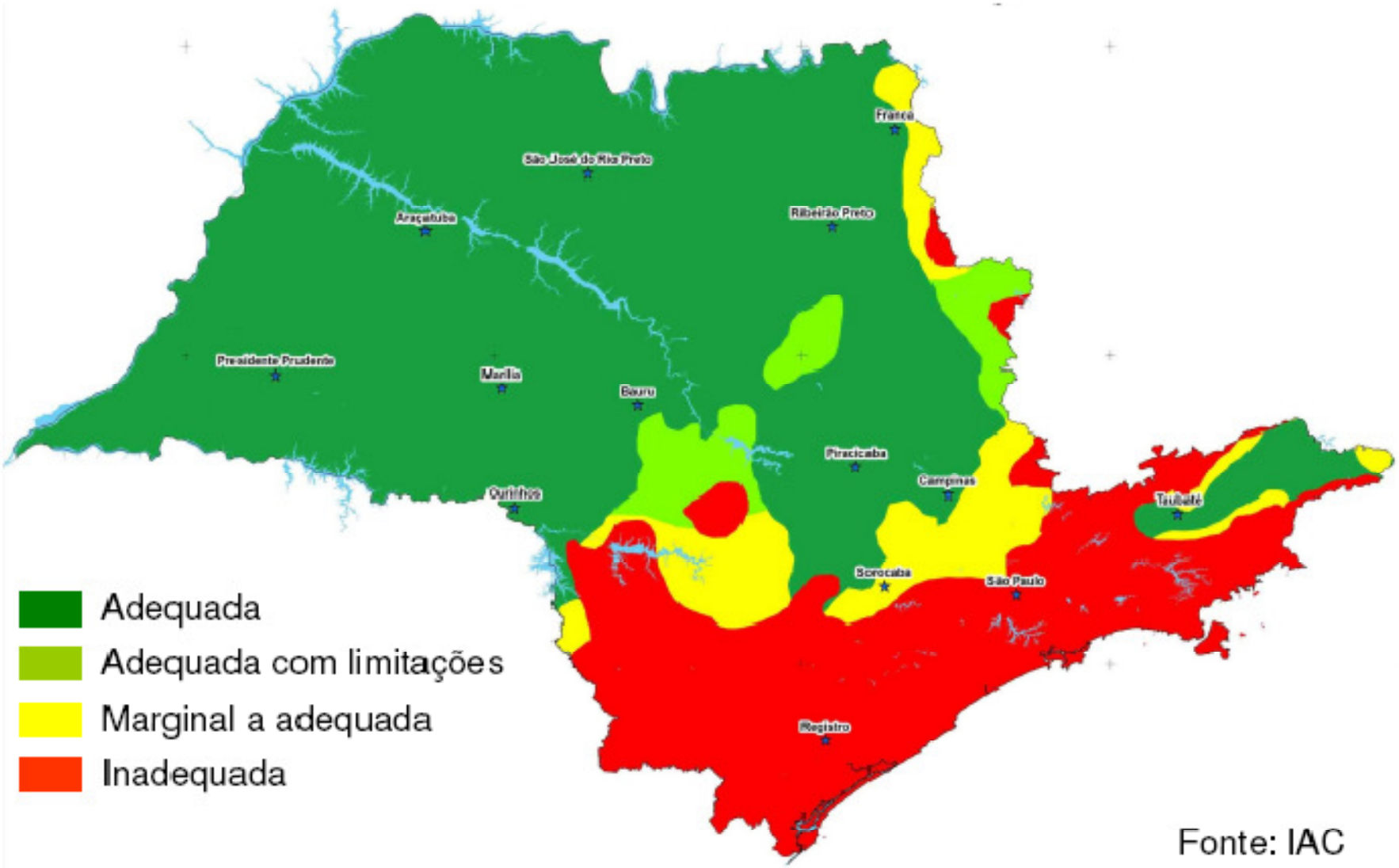
Situação Atual



Ocupação das terras pela cultura da cana-de-açúcar – Projeção 2010



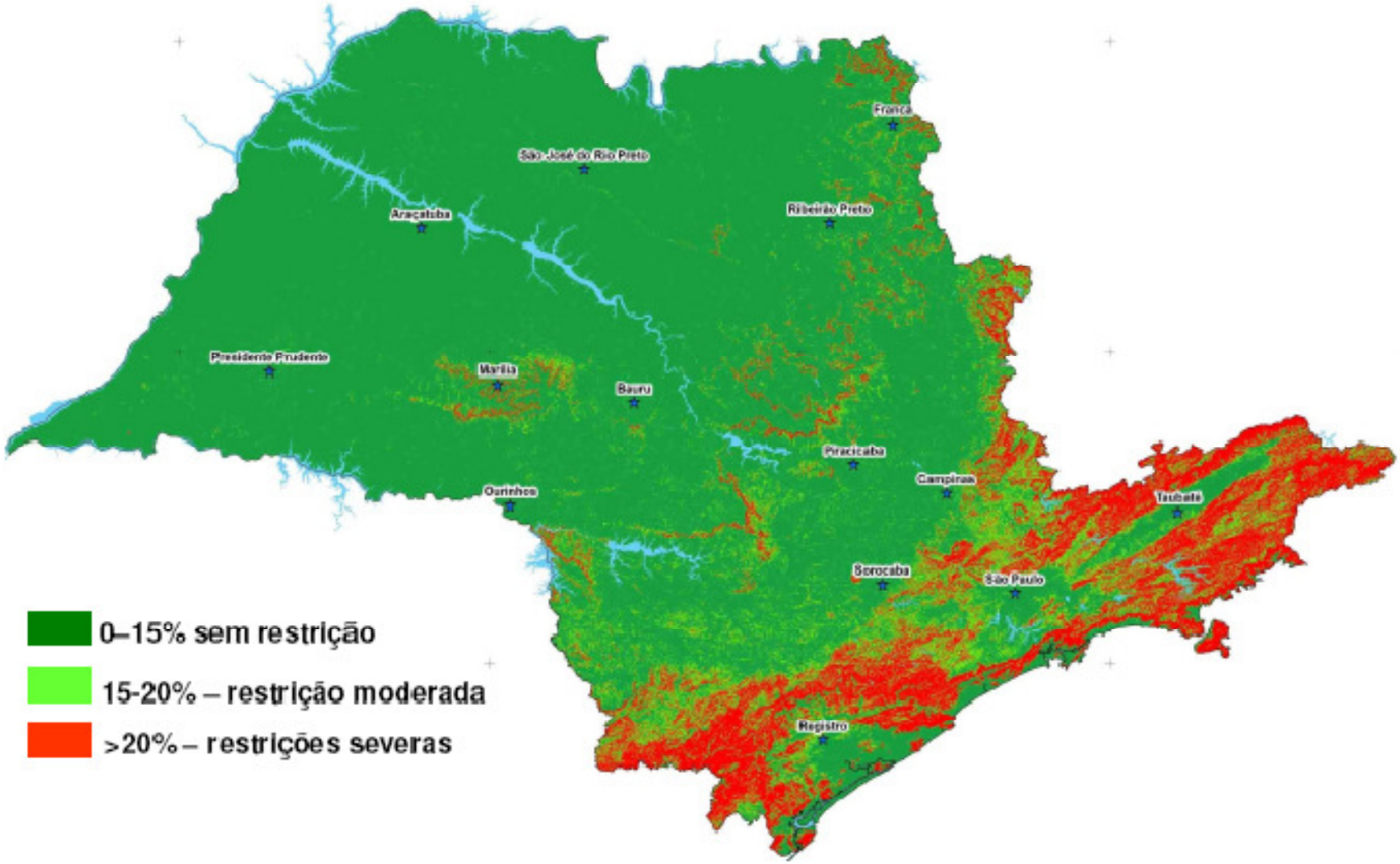
Aptidão edafoclimática para cultura da cana-de-açúcar
(restrição de solo e/ou clima)



Fonte: IAC

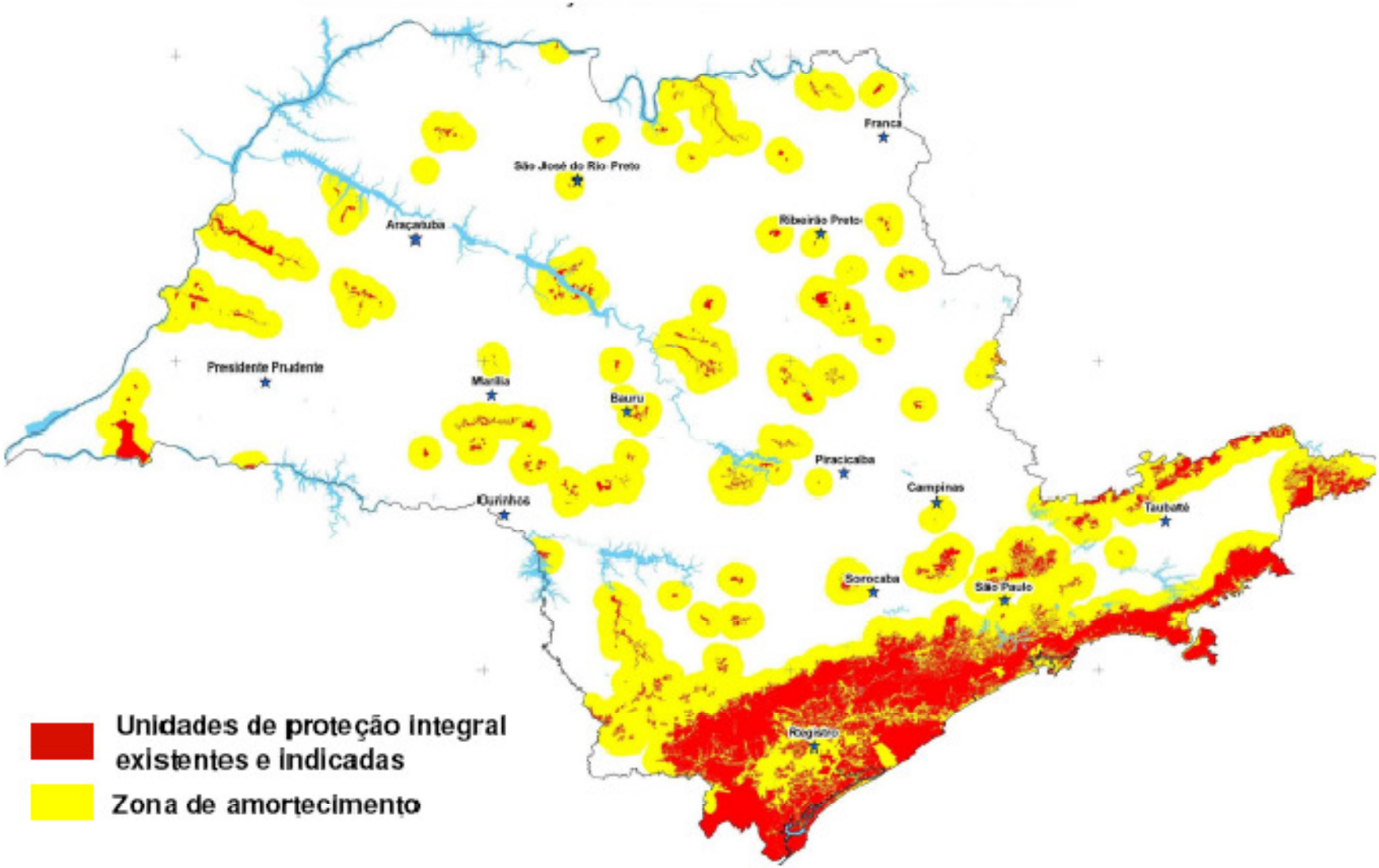
Áreas de restrição à colheita mecânica

(restrição pela declividade)

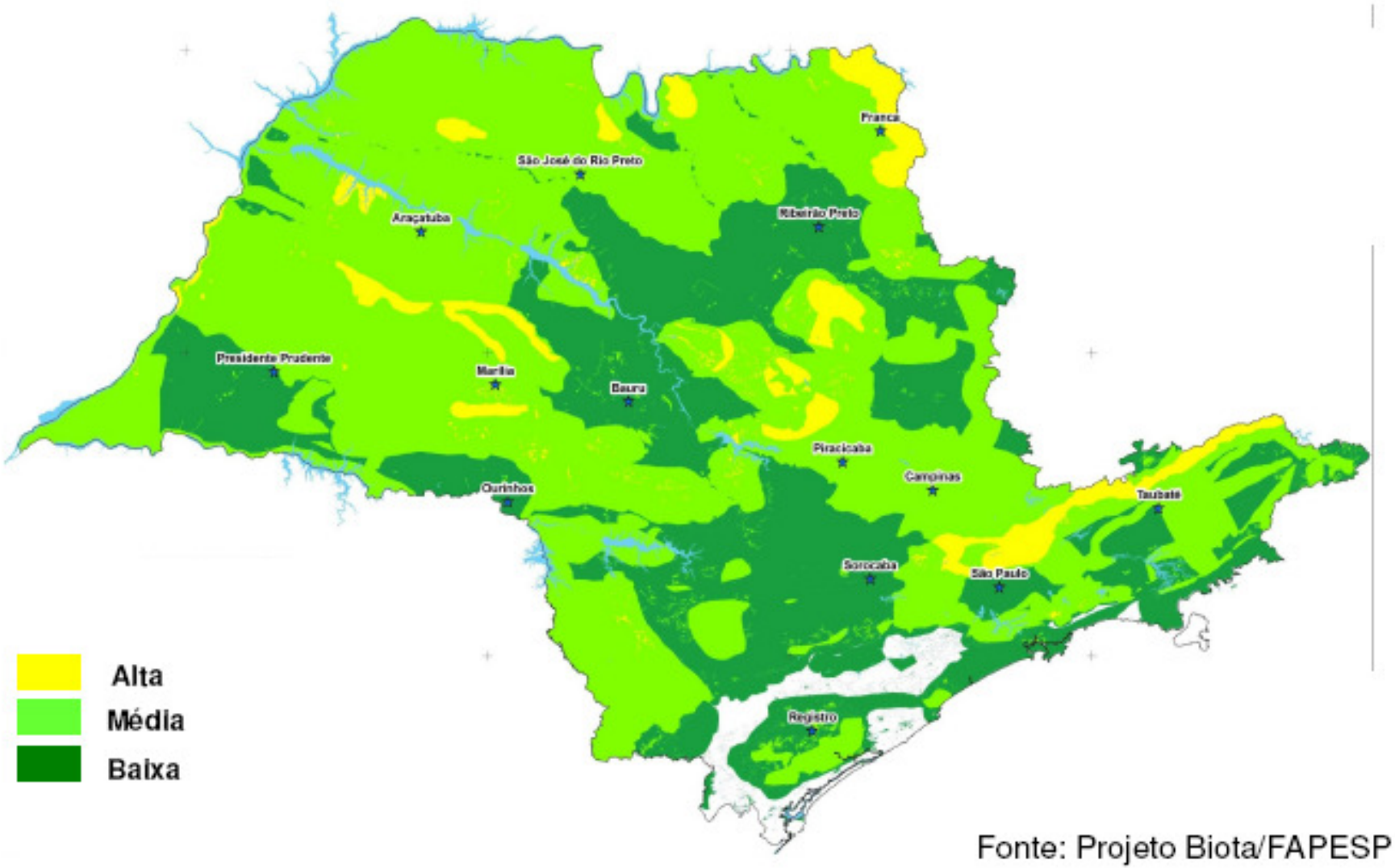


Disponibilidade de Águas Superficiais e Vulnerabilidade das Águas Subterrâneas

Unidades de Conservação de Proteção Integral (existentes e indicadas/BIOTA)



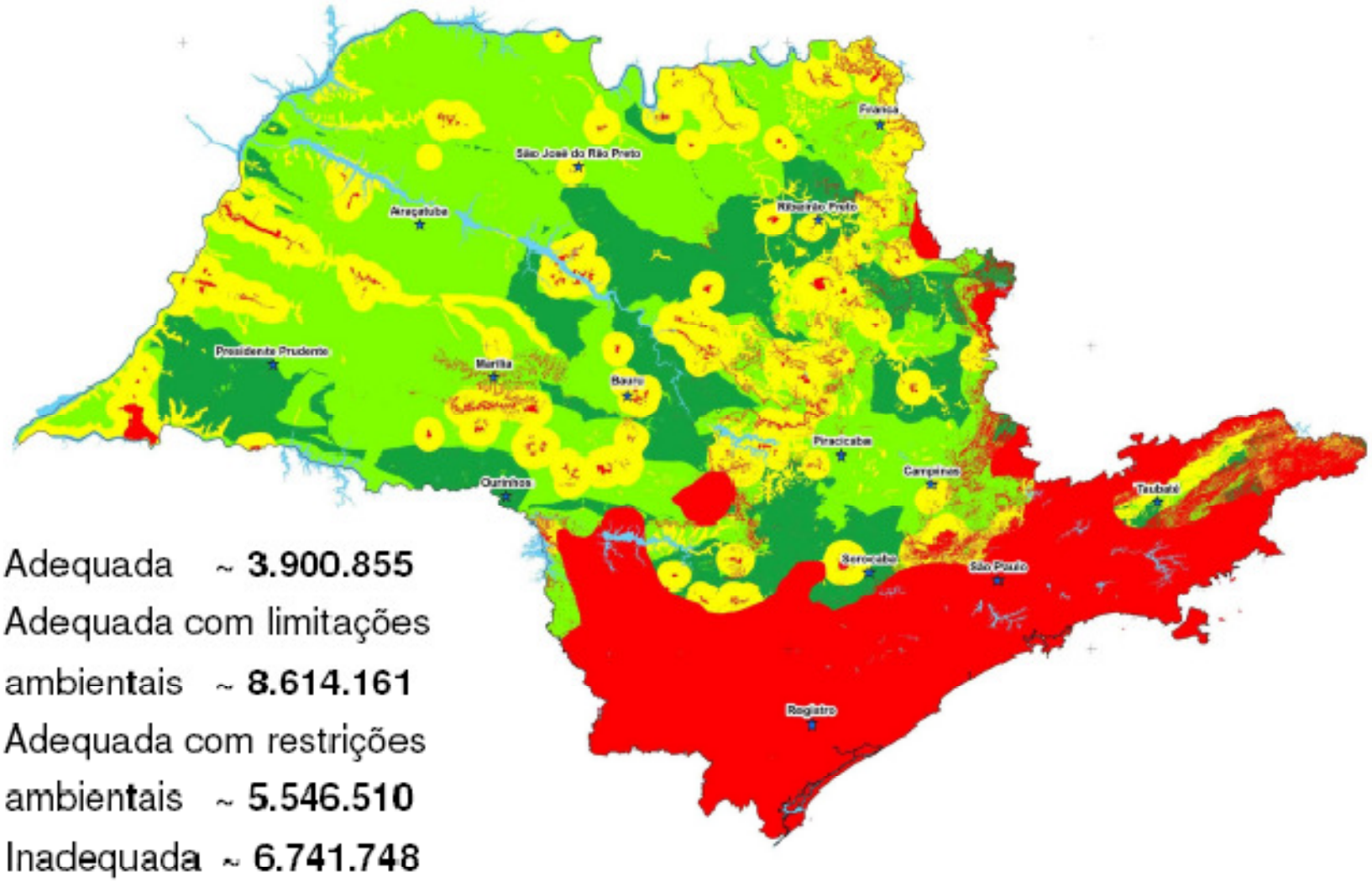
Prioridade para Incremento da Biodiversidade (conectividade/BIOTA)



Fonte: Projeto Biota/FAPESP

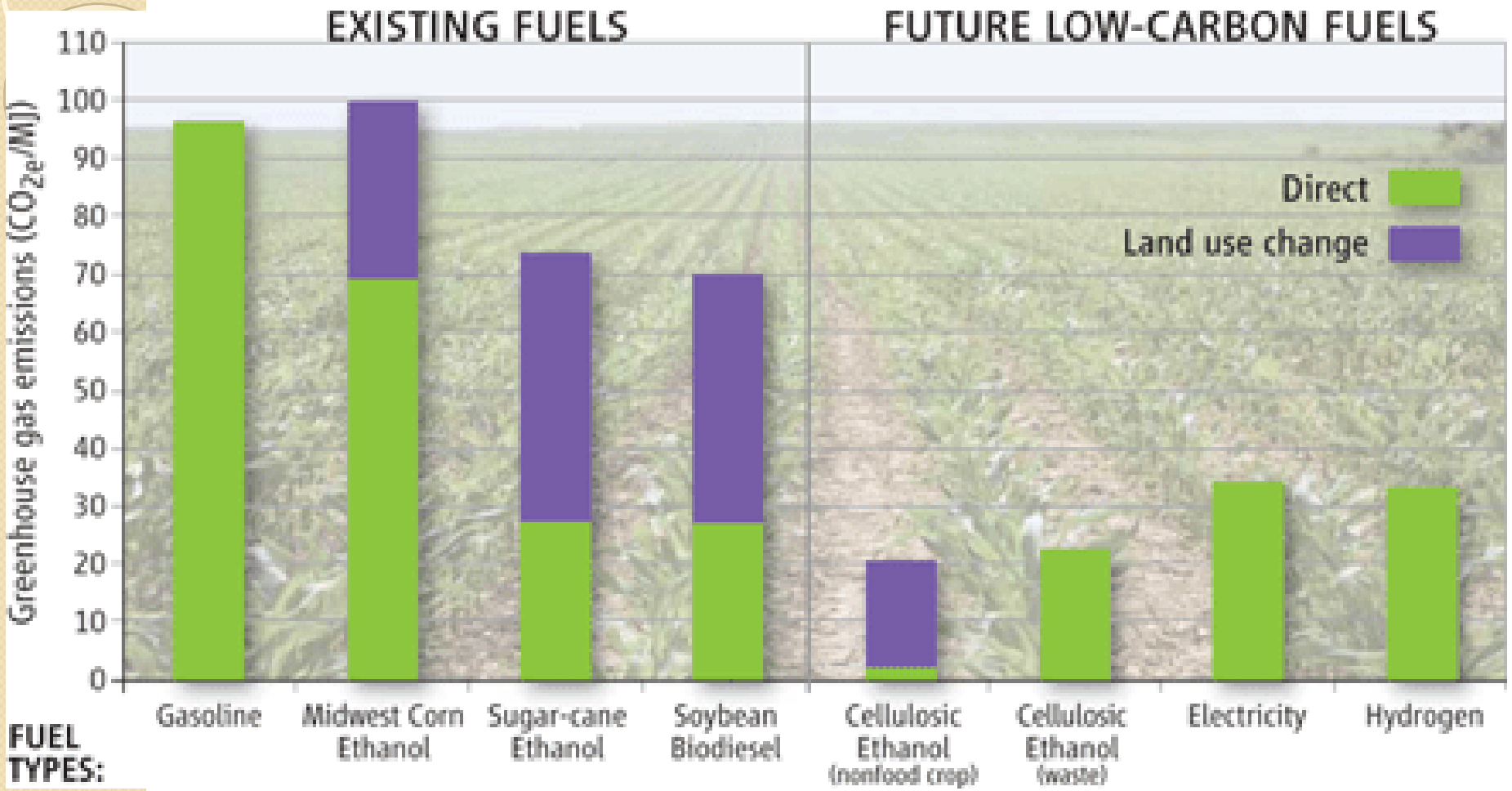
Qualidade do Ar nas Bacias Aéreas

Zoneamento Agroambiental para o Setor Sucroalcooleiro do Estado de São Paulo



ZONEAMENTO ECOLÓGICO-ECONÔMICO (ZEE) SAA E SMA

1. Zoneamento e Monitoramento Ecológico-Econômico
2. Logística de Escoamento de Etanol
3.Certificação de Qualidade dos Biocombustíveis
4. Co-geração de Eletricidade
5. Pesquisa e Desenvolvimento (*)


EXISTING FUELS
FUTURE LOW-CARBON FUELS
Greenhouse gas emissions (CO_{2e}/MJ)
110
100
90
80
70
60
50
40
30
20
10
0
Direct
Land use change
FUEL TYPES:
Gasoline
Midwest Corn Ethanol
Sugar-cane Ethanol
Soybean Biodiesel
Cellulosic Ethanol (nonfood crop)
Cellulosic Ethanol (waste)
Electricity
Hydrogen