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Session 2: Country and Case Studies *Biodiversity Mapping and Biofuels Development: The Brazilian Experience*

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The Brazilian Alcohol Program

- The second world largest commercial program on biomass
- Started in 1975 by Federal Government
- Decision from Brazilian Federal Government to produce ethanol in addition to sugar (from sugarcane): objective of reducing petroleum imports (Gulf War).
- High-octane fuel in vehicles, replacing lead and/or MTBE.
- 2009: 7 million flex-fuel vehicles (both ethanol and gasoline, any blend)
- all gasoline in Brazil blended with (anhydrous) ethanol: 20 to 26% of ethanol in volume basis
- Nowadays - economically competitive to gasoline
- Sustainability issues??



The Brazilian Sugar Cane Sector

- **2007/2008 season:**
 - Sugar cane harvested area: 7.8 million hectares
 - 3.4 million hectares used for ethanol production and the difference to sugar production
 - Sugar cane processed: 493 million tones
 - Ethanol production: 22.5 billion liters
 - 375 plants (401 plants in 2008/2009 – 60% in Sao Paulo State)
- **Ethanol export (year 2008): 5.12 billion liters**
 - Main importing countries:
 - USA (1.52 billion liters) and
 - The Netherlands (1.33 billion liters)



Projections: Season 2012 / 2013

- Sugar cane production: 728 million ton
- Cultivated area: 10.33 million hectares
- Ethanol production: 38 billion liters

Where?
How?

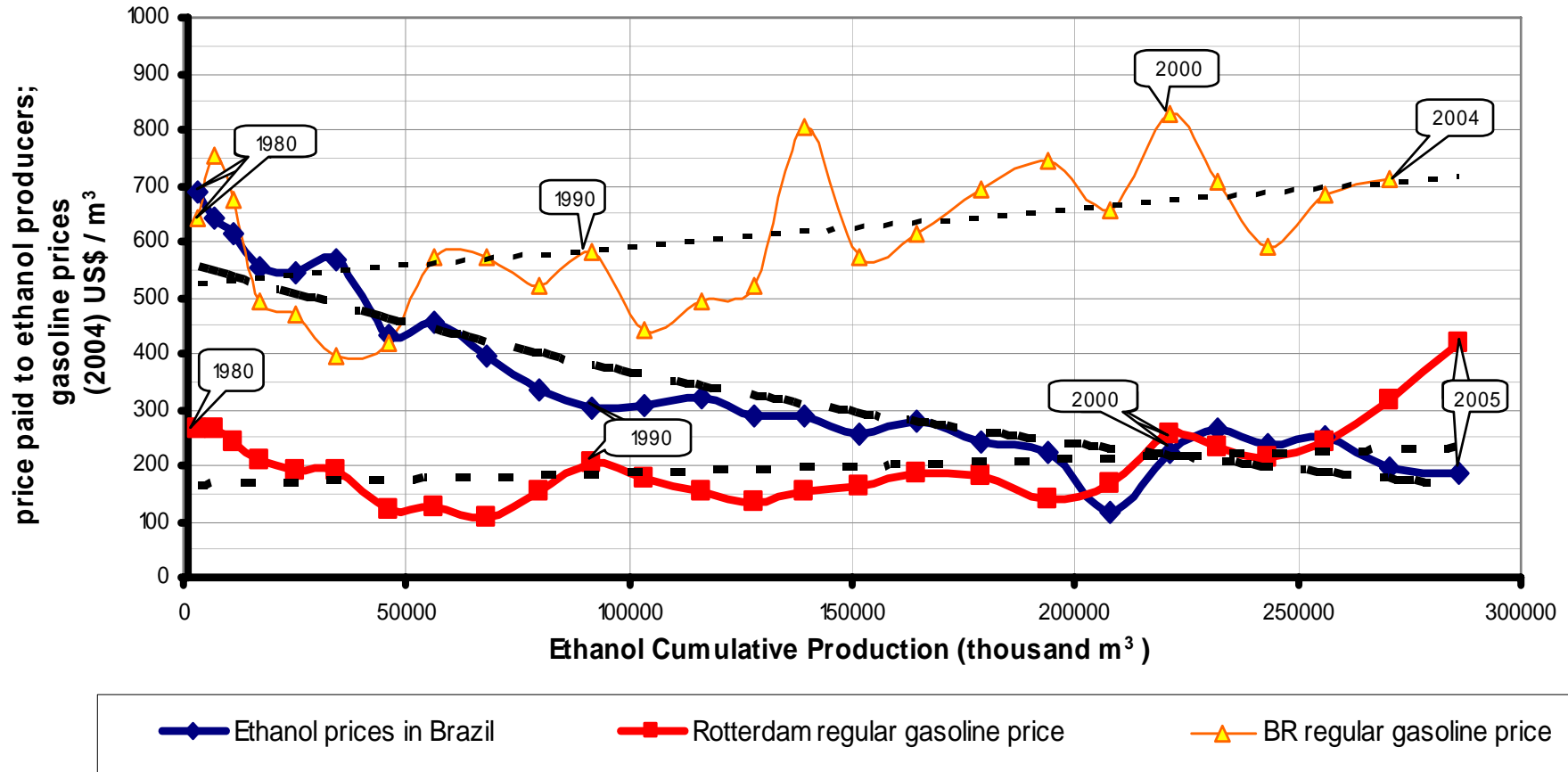


Sugarcane Ethanol Sustainability Issues



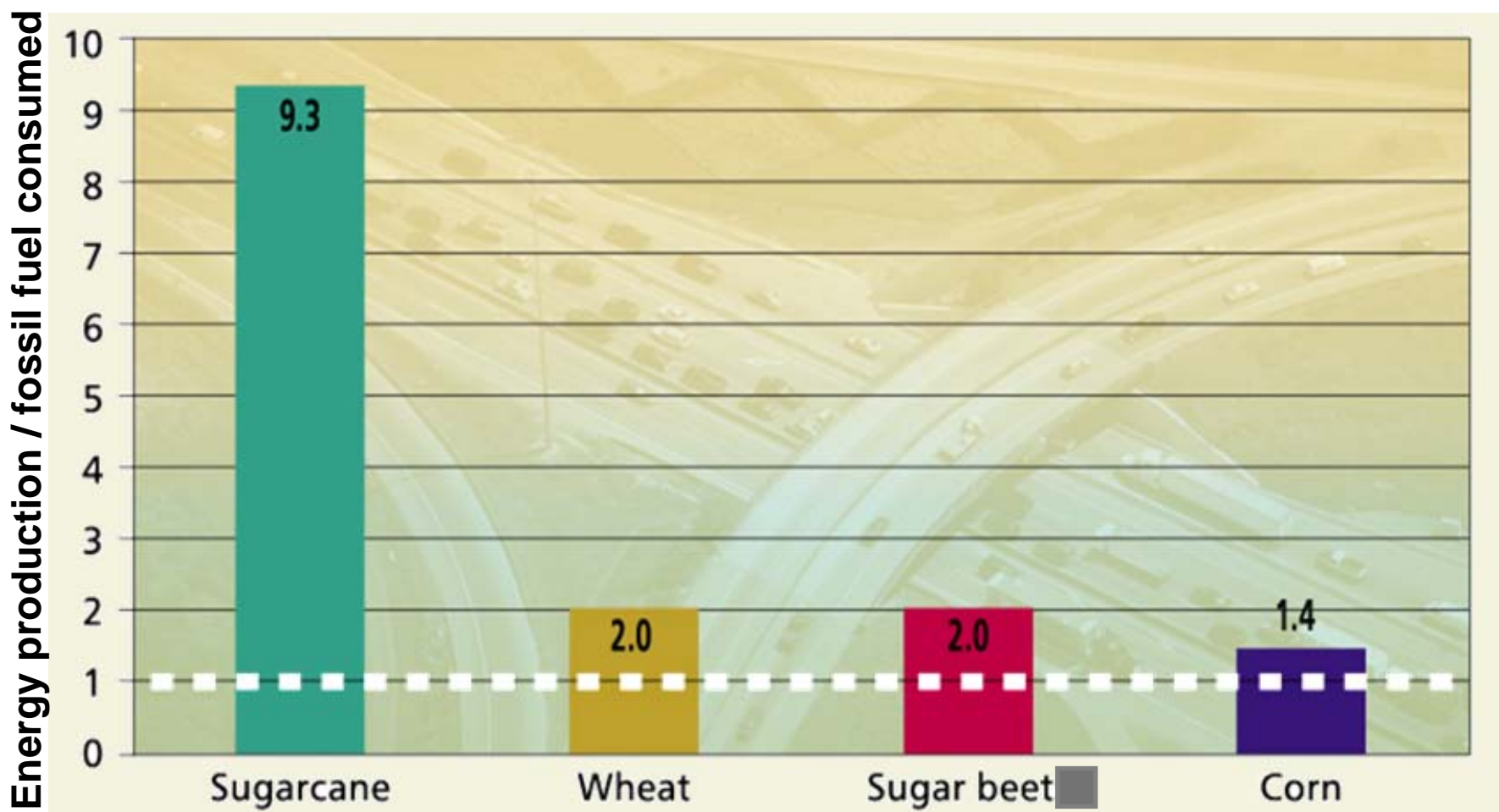
- **Economic Sustainability**
- **Social Sustainability:** existing legislation all over the country – better enforcement needed in some cases.
 - Sugar cane production regions: higher income than others; formal jobs.
- **Environmental sustainability:**
 - Existing adequate legislation (both agricultural and industrial sectors)
 - Adequate enforcement

The Economic Competitiveness of Sugar Cane Alcohol Fuel Compared to Gasoline



Current ethanol prices (ex-taxes) paid to producers: anhydrous US\$ 0.32/liter / hydrated: US\$0.29/liter (March, 2009).

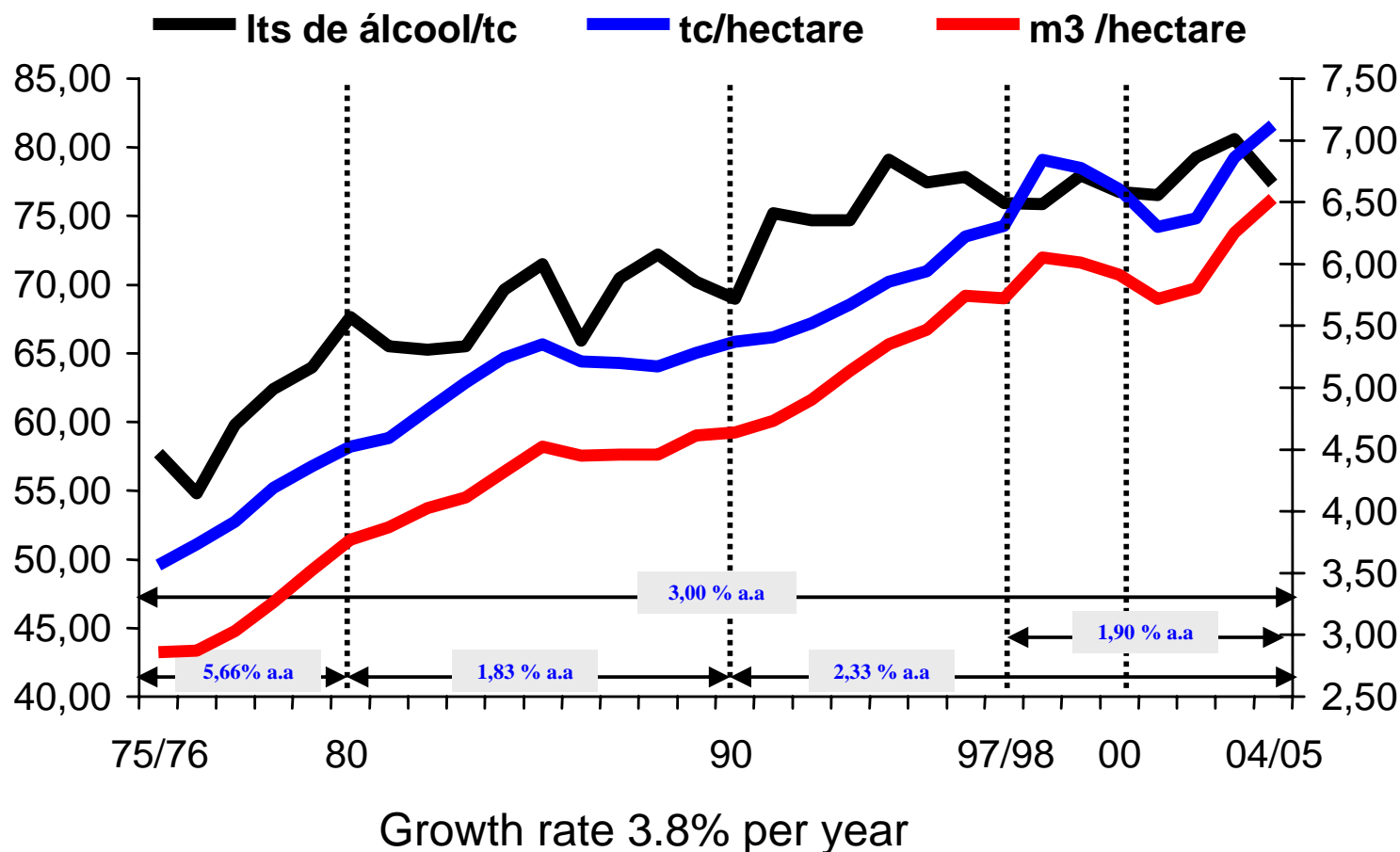
Energy Balance of Ethanol Production from Different Feedstocks



Why so high energy balance?

- All energy needs in industrial phase from sugarcane bagasse (no fossil fuels, only diesel oil in agricultural phase)
- High increases in agricultural and industrial productivity
- Sugarcane as feedstock – 500 varieties adequate to different soils/regions

Sugar Cane Ethanol Productivity in Brazil



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
CO₂ reduction compared to gasoline (c)	84%	30%	40%
Total production (billion liters) (D)	22.5	34	2.7
Area cultivated (million hectare) (E)	3.4	8.13	0.49
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 World Watch Institute, 2006.

Social sustainability

- Existing legislation all over the country – Federal and state laws
- Better enforcement needed in some cases.
- Sugar cane production regions: higher income than others (Ribeirao Preto has the highest ones – Sao Paulo State).
- Most are formal jobs.
- Best social conditions when compared with other sectors in Brazilian agriculture

Environmental Sustainability

- Existing strict environmental legislation
- Enforcement?
- Main issues:
 - Water consumption
 - Land Use – deforestation in Amazon?
 - Biodiversity – impacts on biodiversity?
 - Food vs fuel?
- Zoning

Environmental Sustainability



Table 3. Summary of main environmental laws.

Law	Objective	P.S.
No. 4,771, September 15th, 1965	Forest Code	Permanent preservation areas
No. 997, May 31st, 1976	Environment Pollution Control	Environmental Permission
Portaria do Ministério do Interior No. 323, November 29th, 1981	It prohibits release of vinhoto in the water	
No. 6,938, August 31st, 1981	Environment National Policy	Mechanisms and instruments (environmental zoning, Environmental Impact Assessment)
CONAMA deliberation No.001/7986	General Guidelines for the Evaluation of Environmental Impact	For 'industrial complex and units and agro-industrial'
No. 6,171, July 04th, 1988	The use, conservation and preservation of agricultural soil	
No. 11,241, September 19th, 2002	Gradual elimination of burning the straw of sugarcane	Elimination of the use of fire as a unstraw method and facilitator of cutting the sugarcane
No. 12183/05	Use of water charge	
No. 50,889, June 16th, 2006	Legal Reserve of landed property in the State of São Paulo	Obligation of reserving an area equivalent to 20% of each rural property
SMA deliberation 42, October 14th, 2006	Environmental prior license to distilleries of alcohol, sugar plants and units of production of spirits	It defines criteria and procedures
Deliberation No. 382, December 26th, 2006	It sets the maximum emission of air pollutants to sources.	Annex III: Emission limits for air pollutants from processes of heat generation from the external combustion of sugarcane's mulch
Agricultural and Environmental Protocol of sugar/ethanol industry	Prominence to anticipate the legal period to the end of the harvest of sugarcane with the previous use of fire in the areas cultivated by plants	Government of the State of São Paulo and UNICA
Elimination intentions of burning sugarcane in the ethanol/sugar sector of Minas Gerais protocol	Removal of burnt by 2014	SIAMIG/SINDAÇÚCAR-MG and Government of the State of Minas Gerais

Source: Brazilian and State laws.

Environmental Sustainability



Table 9. Sugarcane agricultural sustainability.

Sugarcane

Less agrochemicals	Low soil loss	Minimal water use
<p>Low use of pesticides. No use of fungicides Biological control to mitigate pests. Advanced genetic enhancement programs that help identify the most resistant varieties of sugarcane. Use of vinasse and filter cake as organic fertilizers.</p>	<p>Brazilian sugarcane fields have relatively low levels of soil loss, thanks to the semi-perennial nature of the sugarcane that is only replanted every 6 years. The trend will be for current losses, to decrease significantly in coming years through the use of sugarcane straw, some of which is left on the fields as organic matters after mechanical harvesting</p>	<p>Brazilian sugarcane fields require practically no irrigation because rainfall is abundant and reliable, particularly in the main South Central production region. Ferti-irrigation: applying vinasse (a water-based residue from sugar and ethanol production). Water use during industrial processing has decreased significantly over the years: from 5 m³/t to 1 m³/t.</p>

Source: Unica (2008).

Source: Zuurbier and van de Vooren, eds, 2008

Environmental Sustainability

Land Use in Brazil

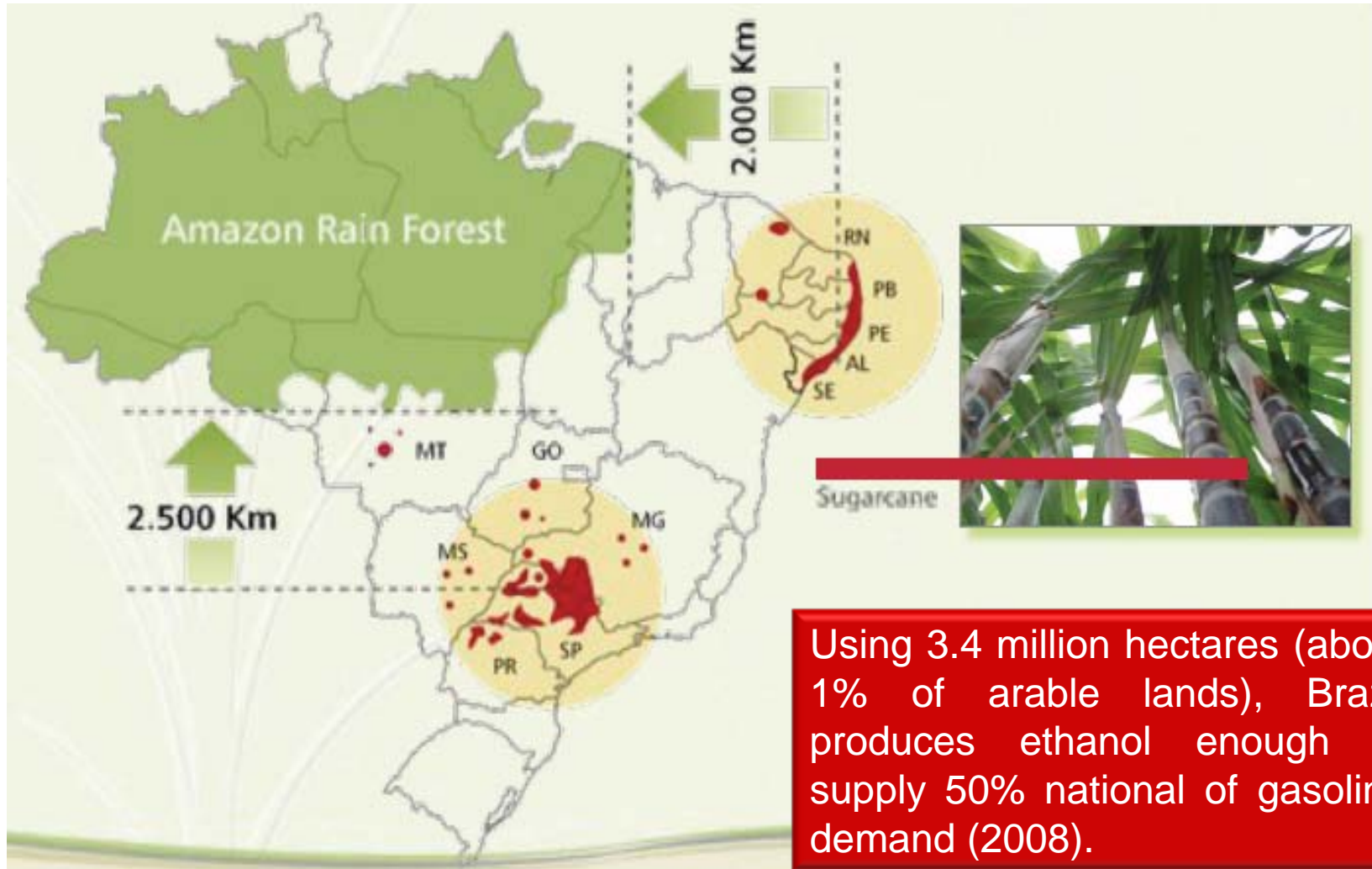


Millions hectares (2007 _e)		TOTAL %	TILABLE LANDS %
BRAZIL	851		
TOTAL OF TILABLE LANDS	354.8		
1. CULTIVATED AREAS	76.7	9.0%	21.6%
SOY	20.6	2.4%	5.8%
CORN	14	1.6%	3.9%
SUGARCANE	7.8	0.9%	2.2%
SUGARCANE FOR ETHANOL	3.4	0.4%	1.0%
ORANGE	0.9	0.1%	0.3%
2. PASTURE	172.3	20.2%	48.6%
3. AVAILABLE AREA (Total tilable - cultivated areas- pasture)	105.8	12.4%	29.8%

Note: 1) "Total of cultivated areas" refers to permanent farmings, temporary farmings and flowers culture, including hydropony and plasticulture, seedlings arboretums, plants greenhouses and vegetation houses and cofoddering for cut; 2) Soybean, corn, sugarcane and orange areas are data from the Municipal Agricultural Production, published by IBGE; 3) Extension of the Brazilian territory, total of tillable lands, cultivated lands and pasture lands consist in preliminary results from the 2006 Farming and Cattle Raising Census; 4) 2007_e- estimation; 5) Sugarcane destined to the ethanol production was estimated from the data from the Ministry of Agriculture, Cattle Breeding and Supply. National Balance of sugarcane and agroenergy, 2007 .

Environmental Sustainability

Expansion of Sugar Cane Crops in Brazil



Environmental Sustainability

Evolution of area dedicated to cattle in São Paulo State

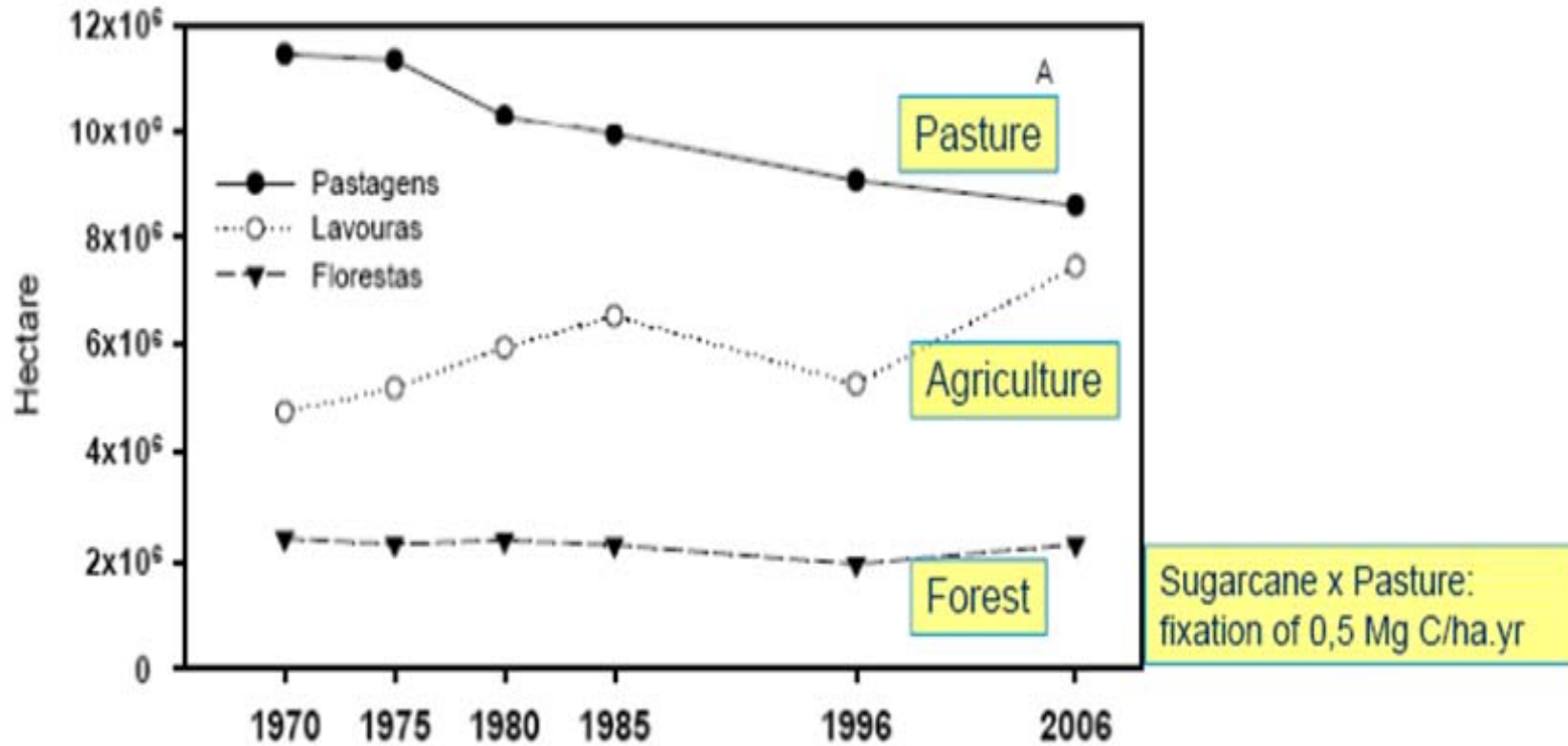


	2001	2002	2003	2004	2005	2006	2007	2008
Cattle (million heads)	13.15	13.46	13.76	13.77	14.07	13.75	12.20	11.95
Pasture (million hectares)	10.29	10.10	10.11	10.12	10.01	9.71	9.12	7.64
Density (heads/ha)	1.28	1.33	1.36	1.36	1.41	1.42	1.34	1.56

Trend to more intensive cattle-breeding

Environmental Sustainability

Sao Paulo: Land Use Change, 1970-2006



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

Environmental Sustainability

Sugarcane expansion in Center-Southeast States from 1996 to 2006 (areas in 1000 ha)

<i>State</i>	<i>Sugarcane</i>	<i>Soybean</i>	<i>Pastures</i>	<i>Forests</i>
São Paulo	792	93	-468	372
Minas	184	538	-4794	1428
Paraná	133	153	-942	378
Goiás	120	1611	3880	1393
Mato Grosso do Sul	71	811	-3389	-927
Mato Grosso	68	1607	1357	-3785

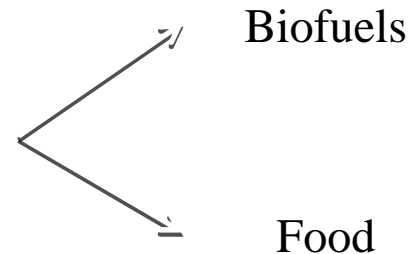
Source: Unicamp 2008

(study funded by UK's Department for Environment, Food and Rural Affairs – DEFRA)

Environmental Sustainability Cattle Breeding in Brazil

Current Situation		
Area	Number of heads	Density (heads/ha)
172 million hectares	169 million heads	0.98
Perspectives		
108 million hectares	169 million heads	1.56 (SP index - 2008)

64 million hectares – degraded land -
available !



Environmental Sustainability

- Carbon avoided emissions with sugarcane replacing pasture:
 - 1 ha pasture changing to 1 ha sugarcane (40% green harvested)
 - 0.64 Mg CO₂ eq/ha.year
 - Considering ethanol replacing gasoline: 13.2 MG CO₂ eq/ha.year

Source: Soares et al, 2009 – Embrapa

Environmental Sustainability

Mechanical Harvesting of Green Sugar Cane

- Mechanical harvesting of green sugar cane in Brazilian States (2007/2008), as a % of total harvested area (reduction on pollutant emissions).
 - São Paulo: 47% (existing Law 11,241/02)
 - Goiás: 40% (requirement for sugar cane licensing)
 - Minas Gerais: 28% (requirement for sugar cane licensing)
 - Paraná: 29.4% (requirement for sugar cane licensing)



Environmental Sustainability

Deforestation in Amazon?

- According to studies (e.g. Smeets et al, 2008, at Fischer G. et al, 2008, Zuurbier and van de Vooren, eds):
 - “Hotspots of deforestation in Amazon are not directly threatened by current sugarcane expansion”
 - “Amazon deforestation caused mainly by cutting illegal log, ... then conversion to pastoral lands and more recently for expansion of soybean production”
 - Moreover: sugarcane crops not adequate for Amazon region

Environmental Sustainability

Biodiversity

- **Existing legislation for Legal Reserve** – mandatory to maintain given percentage of native forest in every rural property (Federal Forest Code)
 - 80% in Amazon
 - 35% in cerrado (Brazilian Savannah/legal Amazon) – also high biodiversity (pressure from pasture and soybean, like Amazon)
 - 20% in other regions (Southeast region, e.g. São Paulo)
 - Difficult to implement in some regions – e.g. 2006 – State decree in São Paulo to incentivate reforestation in such areas
 - **Licensing of new mills - mandatory**
- **Riparian forest mandatory to maintain**
 - Existing lack of reforestation – e.g. São Paulo Environmental Secretariat has special program to recuperate it (World Bank)
- **Need for better enforcement in the rest of the country – *fauna corridors***

Environmental Sustainability

Biodiversity

An example on São Paulo State



- **Recuperation of biodiversity:** recent study conducted by Embrapa (Brazilian Agricultural Research Corporation), in Rio Pardo's Basin (São Paulo state), covering an area equivalent to 16.5% of the state, **where biodiversity was completely absent, identified 209 species** of animals (amphibians, reptiles, birds and mammals) living in agricultural areas (sugar cane, coffee, orange and other fruit crops, planted forests and pasture lands).
- **Mechanical harvesting of green cane (without fire), the small amount of pesticides used and no tillage are pointed as the main drivers to the increase of wild life (fauna corridors).**
- **Possible to have same results in other regions with the introduction of mechanical harvesting in the country...**

Environmental Sustainability

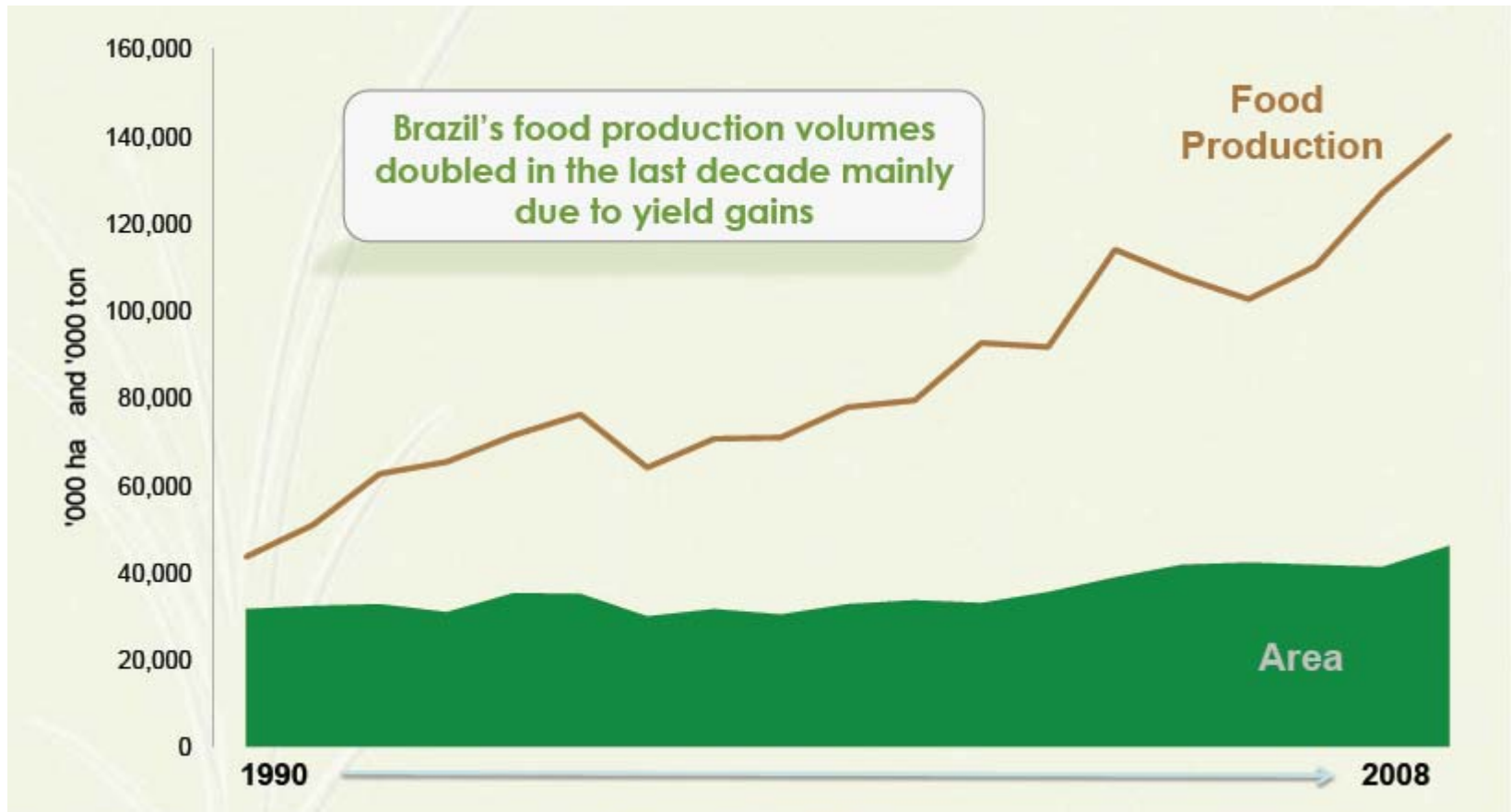
Food vs Fuel ?

- Crop rotation mandatory: 20% of the harvested sugarcane area each year replaced by food crops (peanuts, beans etc)
- Food crops production in the country ?
- Food prices vs biofuels?

Environmental Sustainability

Food vs Fuel ?

Food Production Increase in Brazil



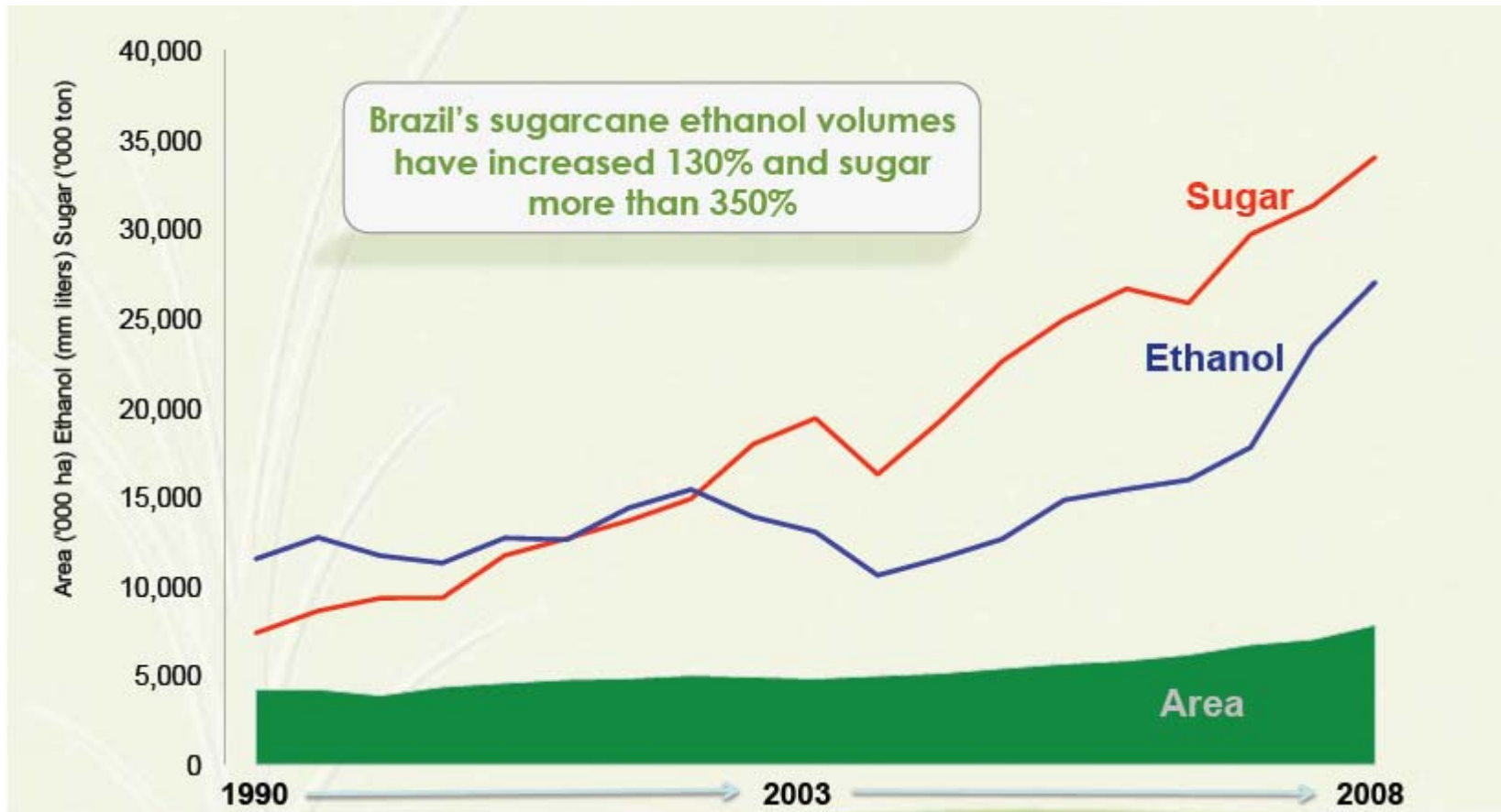
Sources: IBGE and UNICA.

Note: grains include rice, corn, wheat, soybeans etc

Environmental Sustainability

Food vs Fuel ?

Sugar and Ethanol Production Increasing

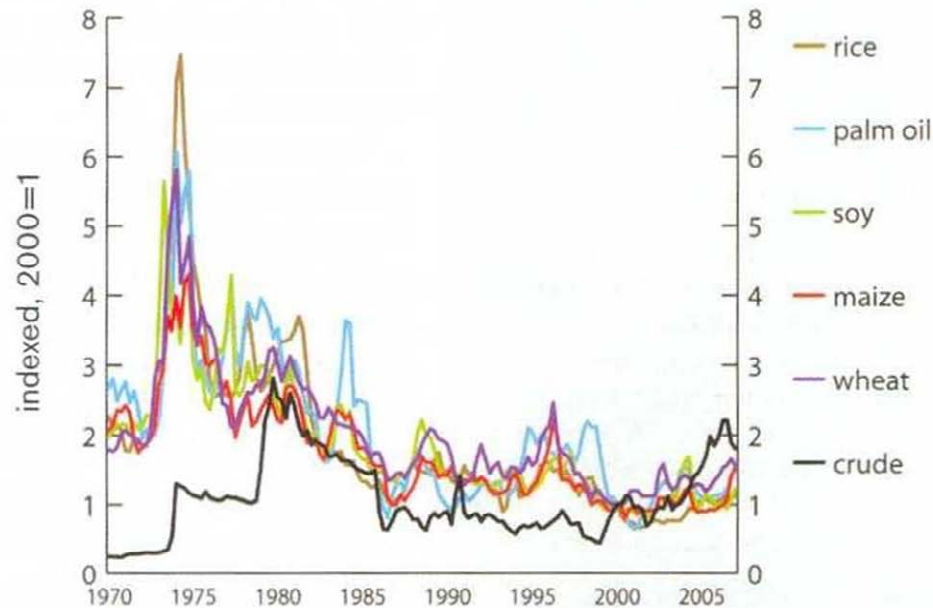


Sources: IBGE and UNICA.

Environmental Sustainability

Food vs Fuel ?

Global trends in prices of food commodities and crude oil 1970–2007



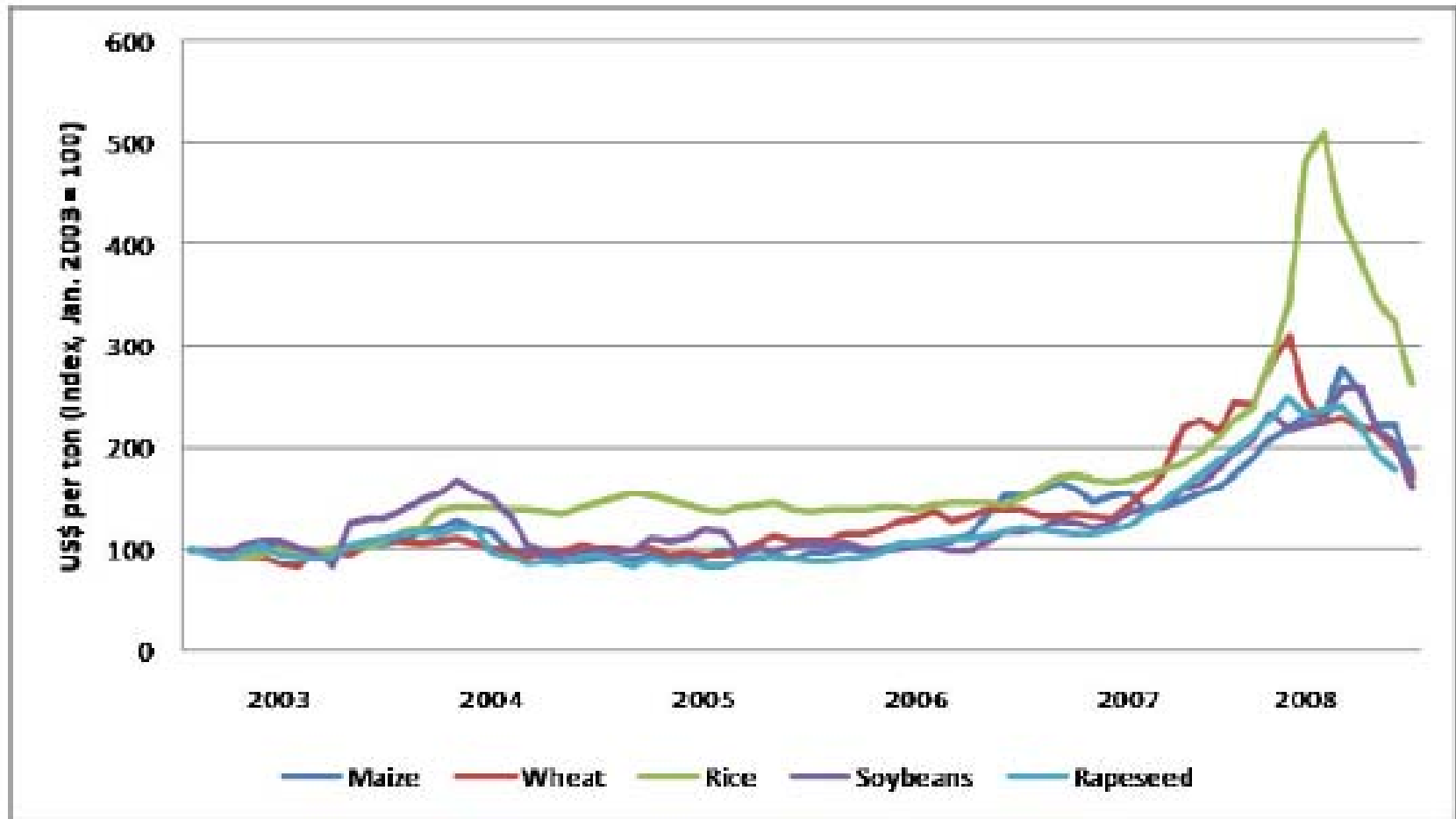
Long-run trends in inflation-corrected prices

NOTE: Crude prices are international averages.

SOURCE: Historical data from International Monetary Fund, *International Financial Statistics*, <http://ifs.apdi.net/imf/>. Futures data from Chicago Board of Trade, <http://cbot.com>; and <http://tradingcharts.com>.

Environmental Sustainability

Food vs Fuel ?



Source: Faaij, A., Berlin 2009

Environmental Sustainability

Food vs Fuel ?



- In Brazil (and maybe in other countries...), the allegation that biofuels production is responsible for the food crisis seems not to be adequate because:
 - Do not distinguish feedstocks for ethanol production
 - Ignores the challenge of global warming mitigation from biofuels
 - Do not consider the impact of oil prices increase on food prices
 - Do not consider the effect of US dollar devaluation and financial speculation over the prices of agricultural commodities
 - Do not consider the impact of food demand growth by emerging economies (India and China)
 - Ignore adverse climate conditions in agricultural countries
 - Underestimates technological evolution

Environmental Sustainability

Ethanol Life Cycle Emissions (2004)

Type	(kg CO ₂ eq./TC)	
	Scenario 1 (average)	Scenario 2 (best values)
Fossil fuels	19.2	17.7
Methane and N ₂ O from trash burning	9.0	9.0
Soil N ₂ O	6.3	6.3
Total emissions	34.5	33.0
Avoided emissions		
Surplus bagasse use	12.5	23.3
Ethanol use	242.5 (A); 169.4 (H)	259.0 (A); 180.8 (H)
Total avoided emissions	255.0 (A); 181.9 (H)	282.3 (A); 204.2 (H)
Net avoided emissions	220.5 (A); 147.4 (H)	249.3 (A); 171.1 (H)

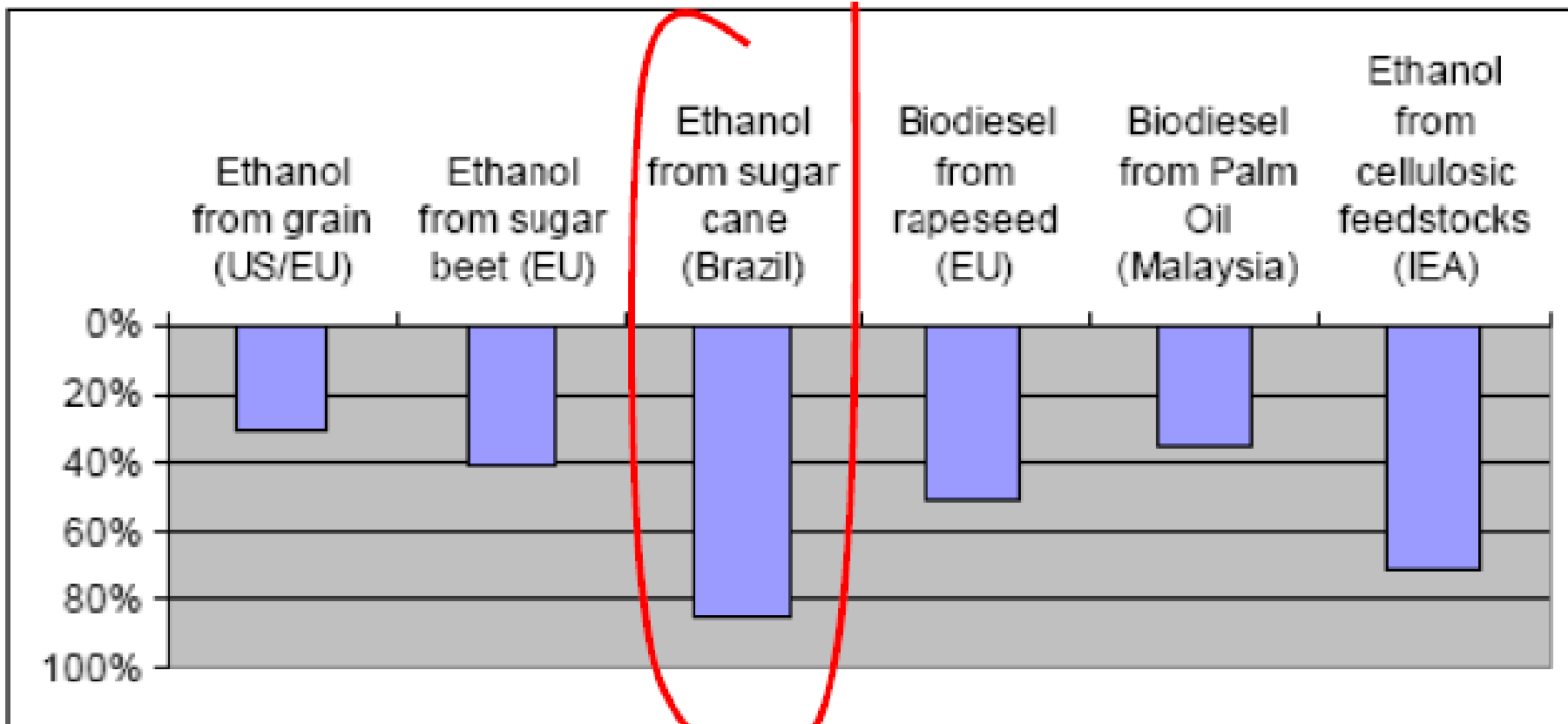
(A): Anhydrous ethanol

(H): Hydrus ethanol

GHG emissions reduction: up to 90%
Average energy balance: up to 8.0 (year 2004) - 9.3 (year 2006)

Environmental Sustainability

Biofuel avoided emissions



Doornbosch and Steenblik, OECD 2007

Environmental Sustainability

Table 6. Carbon balance under different land uses replaced by sugarcane.

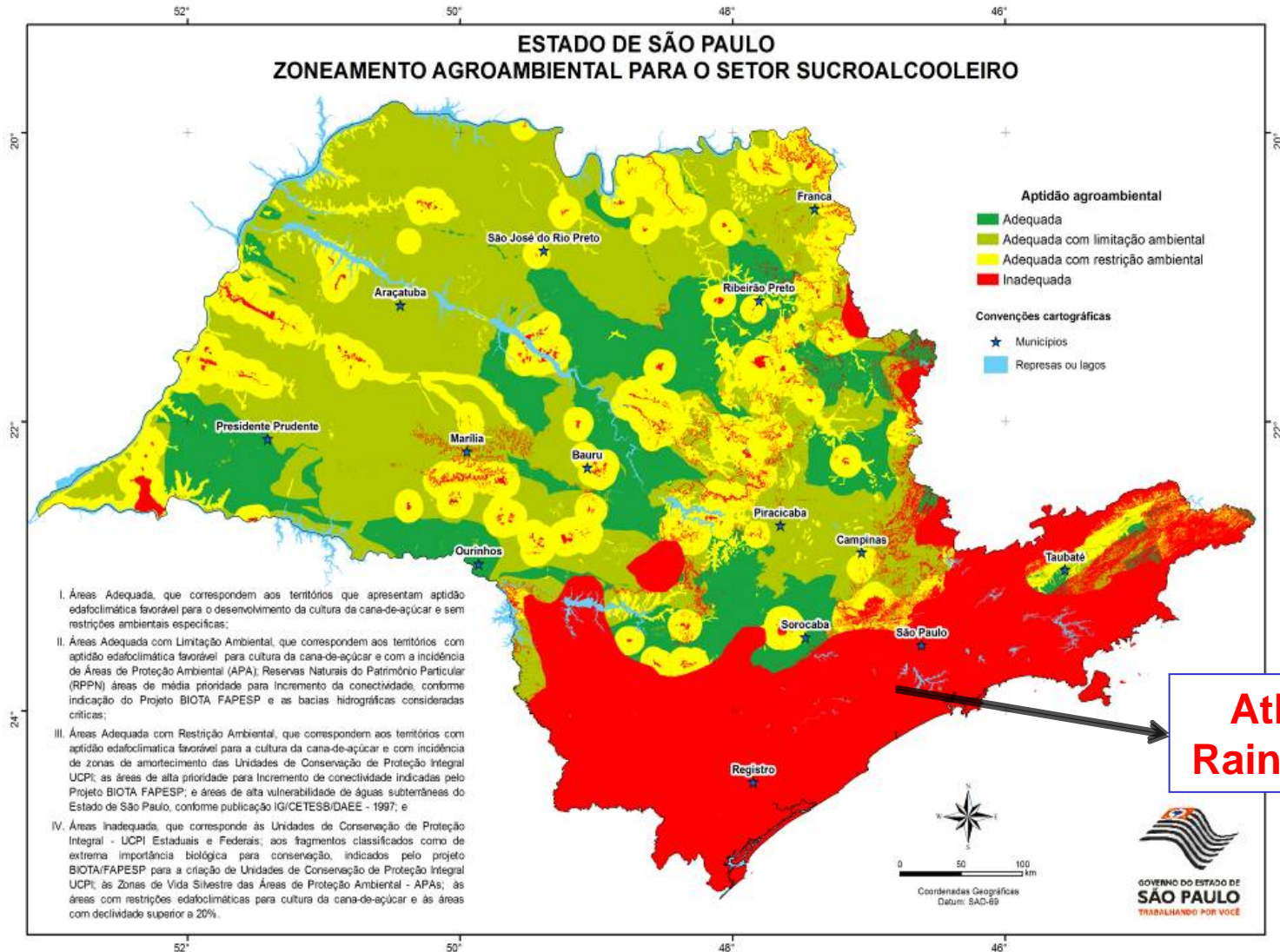
Biomass	Total carbon stocks (Mg/ha)	Carbon balance due to sugarcane replacement (Mg/ha)
Cotton (d)	40.1	21.8
Degraded pasture (b)	42.0	19.8
Maize (h)	44.1	17.7
Sugarcane burned (g)	52.1	9.7
Soybean (e)	54.9	6.9
Managed pasture (f)	58.5	3.3
Cerrado – typical savannah (a)	71.5	-9.7
Campo Limpo – grassland savannah (a)	80.4	-18.6
Cerrado – woody savannah (a)	86.5	-24.7
Tropical forest (c)	271.0	-209.2
Total carbon stocks in sugarcane net burned = 61.8 Mg/ha		

Sources: (a) Lardy *et al.* (2001)/Ottmar *et al.* (2001); (b) d` Andréa *et al.* (2004)/Estimated from Szakács *et al.* (2003); (c) Trumbore *et al.* (1993)/INPE; (d) Neves *et al.* (2005)/Adapted from Fornasieri and Domingos *et al.* (1978); (e) Campos (2006)/Adapted from Campos (2006); (f) Rangel and Silva *et al.* (2007)/Estimated from Szakács *et al.* (2003); (g) Estimated from Galdos (2007)/VPB Estimative; (h) d` Andréa *et al.* (2004)/Estimated from Titon *et al.* (2003).

Source: Zuurbier and van de Vooren, eds, 2008

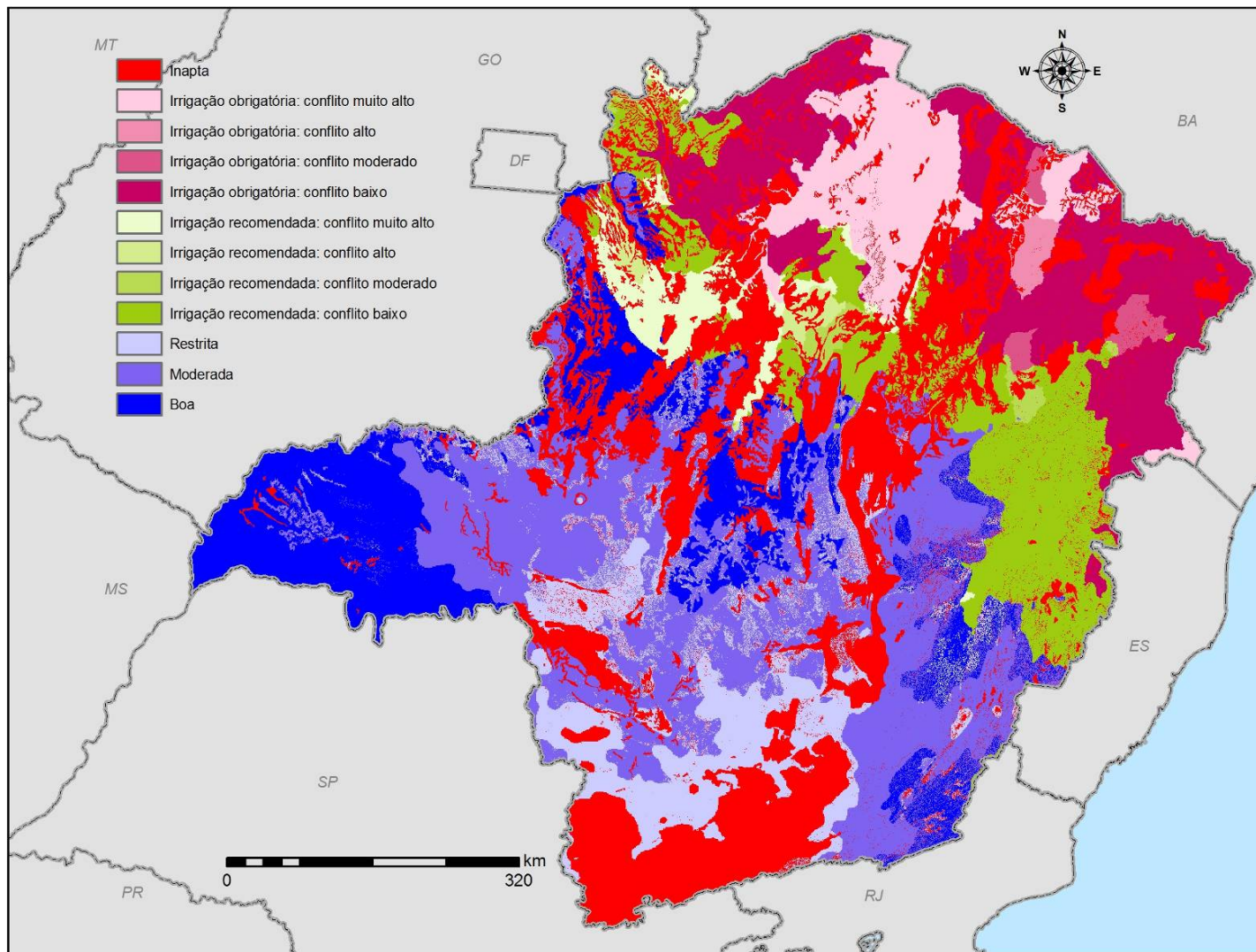
Environmental Sustainability

Sugar Cane Agro-Environmental Zoning in São Paulo state



Environmental Sustainability

Sugar Cane Agro-Environmental Zoning in Minas Gerais state



Environmental Sustainability Sugar Cane Agro-Environmental Zoning

- Other states already introducing sugarcane agro-environmental zoning:
 - Mato Grosso do Sul
 - Mato Grosso
- Current situation: under discussion

Environmental Sustainability

Sugar Cane Agro-Environmental Zoning in Brazil – Federal Government

- It will determine the expansion areas to sugar cane crops.
- It will exclude Amazon Forest, cerrado, Atlantic rain forest and also other sensitive biomes, such Pantanal wetlands (even areas around it)
- The study has identified 65 million hectares which are expected to attend the productivity and environmental criteria imposed by the Ministry of the Environment.
- Discussion with all states involved
- **CURRENT SITUATION – FINAL AGREEMENT BETWEEN MINISTRIES OF AGRICULTURE AND ENVIRONMENT**

Environmental Sustainability

Sugar Cane Agro-Environmental Zoning in Brazil – Federal Government



- Criteria adopted by the study:
 - Using satellite images
 - Timetable for the phase-out of sugar cane burning – cane only green harvested (slopes lower than 12%)
 - Prohibition of vinasse disposal in the rivers, it should be used to produce biogas and for fertirrigation.
 - Land use – only from pasture
 - Adequate conditions on soil and climate (edapho climatic conditions)
 - Sugar cane trash should be used to produce renewable energy
 - Sugar cane will not spread towards food crops.

Environmental Sustainability Ethanol Voluntary Certification Program – Inmetro (Federal Government)



- Objectives:
 - To guarantee that Brazilian ethanol accomplishes sustainability requirements (social, environmental and economic) according to international rules
 - To demonstrate that the use of sugar cane ethanol reduces greenhouse gas emissions
 - To contribute to the increase of Brazilian ethanol competitiveness
- Launch: 2009

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

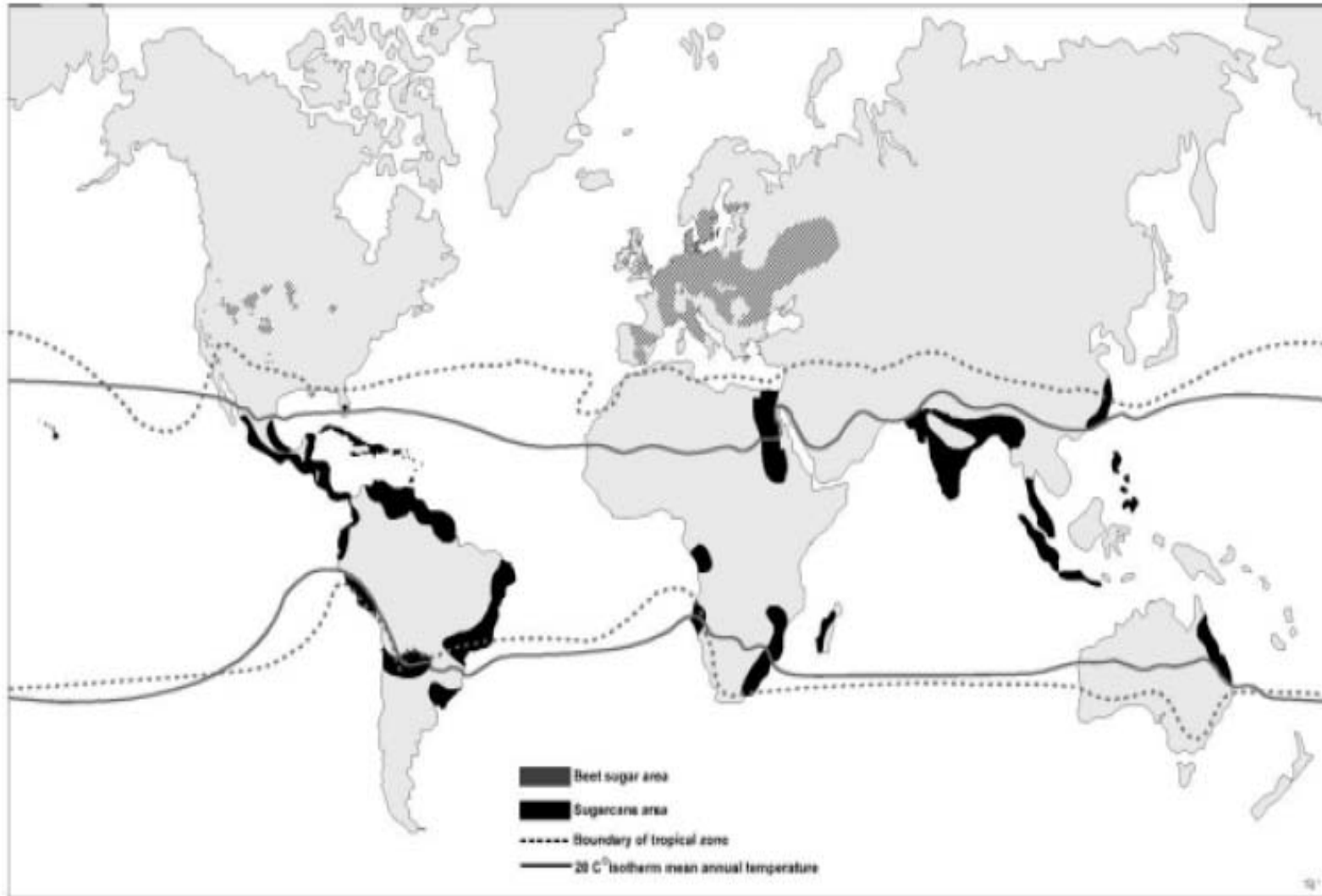


Figure 3.5. Global Distribution of Sugar Beet and Sugarcane Production. Redrawn from Helmut Blume, *Geography of Sugar Cane* (Berlin, 1985), 22.

Final Comments

- Sugar cane ethanol in Brazil → sustainable
- Certification can be introduced in Brazil (transparency and ONE single methodology).
- Real perspectives to replicate the program in other developing countries (already producing sugar cane)
- However, for least developing countries, it is fundamental to establish a waiver on certification criteria, allowing local capacity building and the real local economic development !

10 Myths about Ethanol (?)

1. Brazilian experience is unique
2. incompatible with existing fleets
3. low energy balances of any biofuel
4. high pollutant emissions (cleaner fossil fuels would be preferable)
5. complex logistics
6. competition with food for land, unsustainable practices, deforestation
7. should only be produced domestically by developed countries
8. only subsidized production is possible
9. imports would destroy local agriculture of developed countries
10. energy efficiency alone could preserve oil resources and fulfill Kyoto targets

Thanks!

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<http://cenbio.iee.usp.br>