Sugarcane Ethanol:
Contributions to Climate Change Mitigation and the Environment

Prospects of the Sugarcane Expansion in Brazil: Impacts on Land Use Allocation and Changes

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  - Remote sensing images
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Objectives

- To analyze the dynamics of the sugarcane expansion in Brazil and it's relation to land use changes (LUC).

- To evaluate if there is direct changes of land use due to sugarcane expansion:
  - Past and future expansion are analyzed;
  - LUC is measured in terms of other land uses area displaced by the sugarcane expansion.

- To assess the sugarcane expansion under the indirect LUC approach:
  - Effect-cause relations between sugarcane, crops and pastures expansion;
  - Comparison of areas displaced by the sugarcane expansion and the net growth of land allocated to crops and pasture.

The Dynamics of Sugarcane Expansion in Brazil

Agricultural Land Use in Brazil

| Millions of hectares (2007$_e$)		% of total	% of arable land
BRAZIL	**851**		
TOTAL ARABLE LAND	**354,8**		
1 - 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**	*20,2%*	*48,6%*
3 - Available area [Available area - (crop land + pastures)]	**105,8**	*12,4%*	*29,8%*

Source: IBGE, Elaboration: UNICA,

Agricultural Land Use in Brazil
(Agricultural Census)
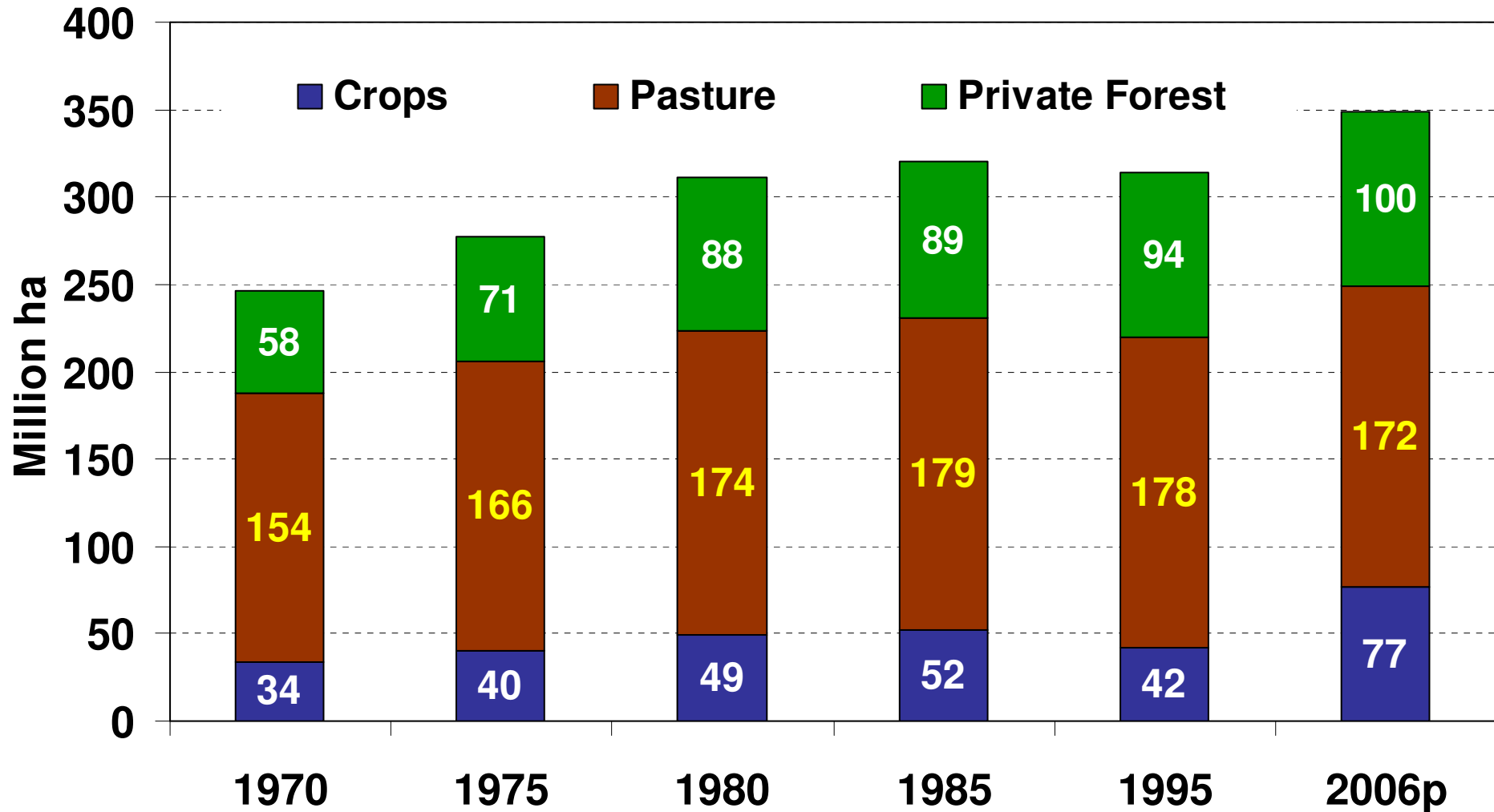
Source: IBGE
P = Preliminary

Overview of Sugarcane in Brazil

Land Allocated in 2006 (million ha)

70.8

6.2

172.0

3.1

3.1 (1%)

- Pastures
- Other crops
- Sugarcane (sugar)
- Sugarcane (ethanol)
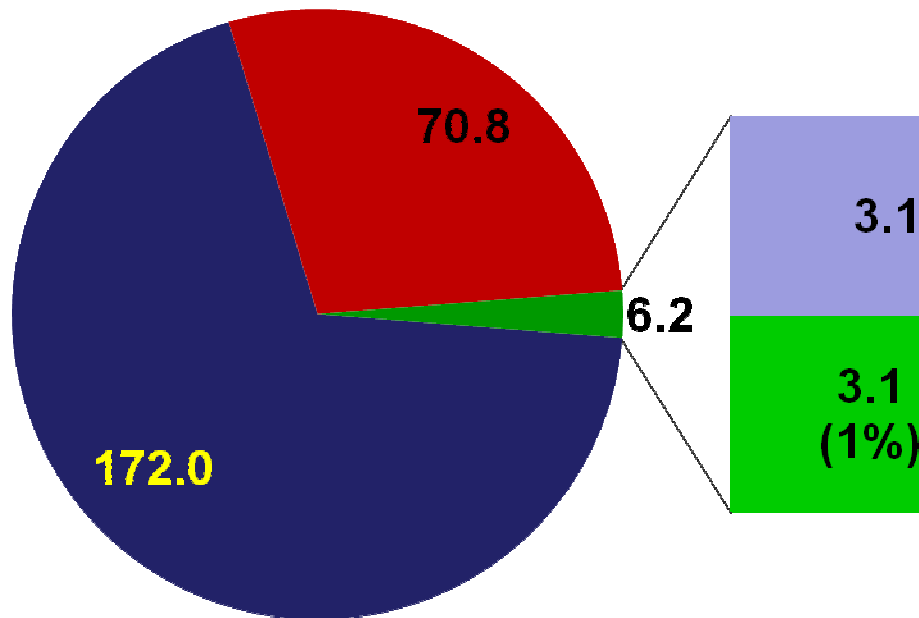
Land Allocated 2018(p) (million ha)
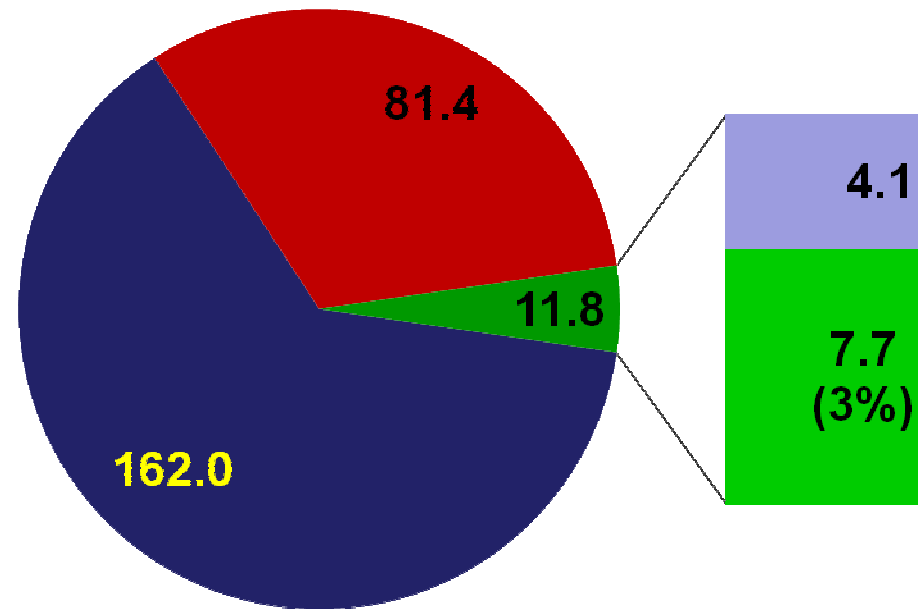
81.4

11.8

162.0

4.1

7.7 (3%)

- Pastures
- Other crops
- Sugarcane (sugar)
- Sugarcane (ethanol)

Ethanol Situation (million liters)	2006	2018
Consumption	12,295	40,908
Percentage Otto Market	(40%)	(54%)
Exports	3,502	13,700

Source: ICONE´s Projections
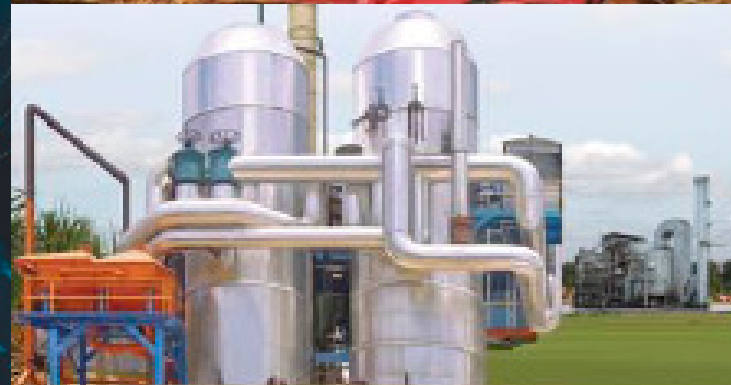
Brazilian Biomes and States

Legal Reserve 80%

Legal Reserve 35%

Legal Reserve 20%

- Amazon Forest
- Atlantic
- Savanna
- Steppe
- Pantanal wetland
- South Grassland
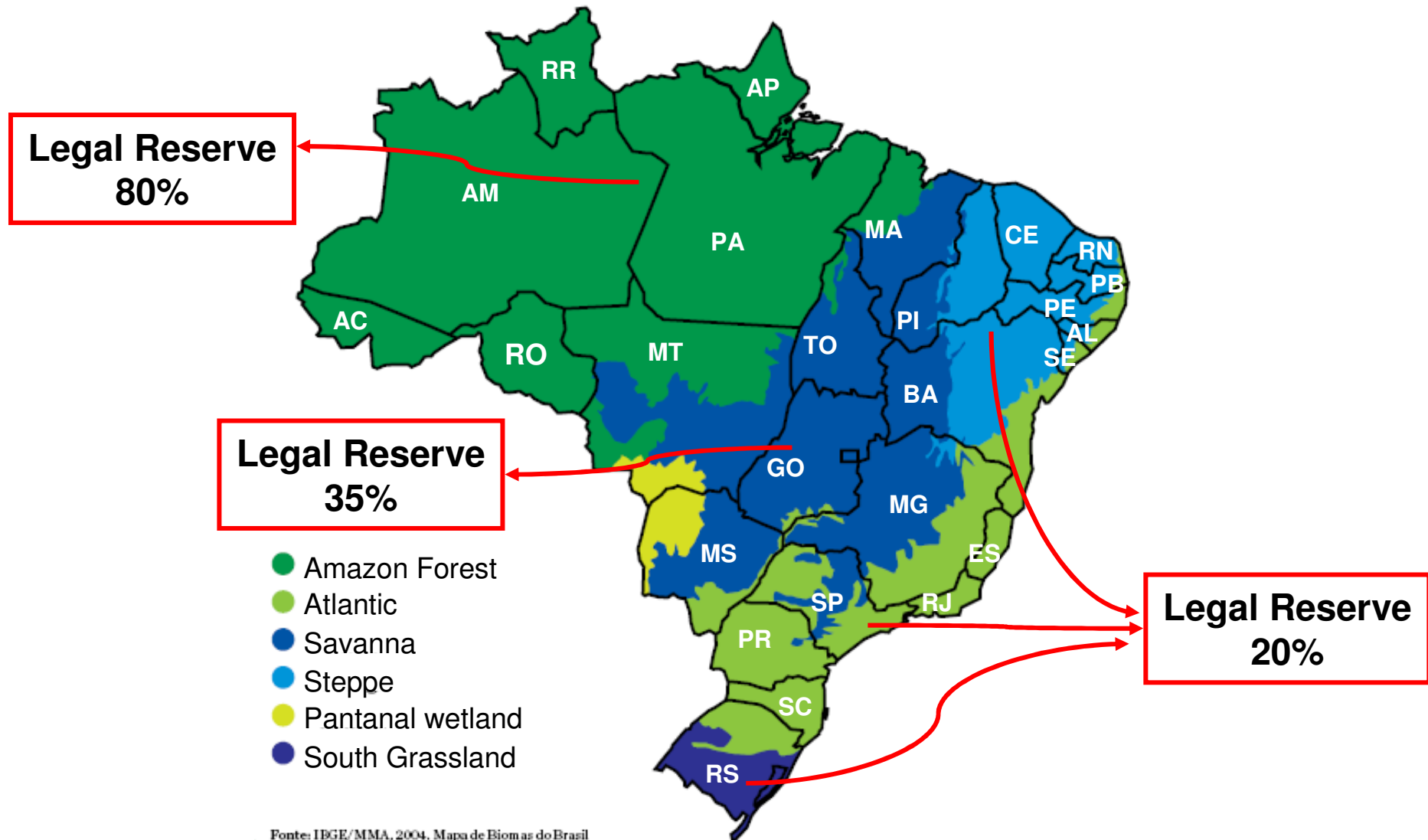
Fonte: IBGE/MMA, 2004. Mapa de Biomas do Brasil

Source: IBGE/MMA.

South-Central Region: Spatial Distribution of Sugarcane Crop in 2007

87% of the Brazilian sugarcane production

50% of gasoline consumption is replaced by sugarcane ethanol produced on nearly 1% of Brazilian arable land (3,4 million hectares).
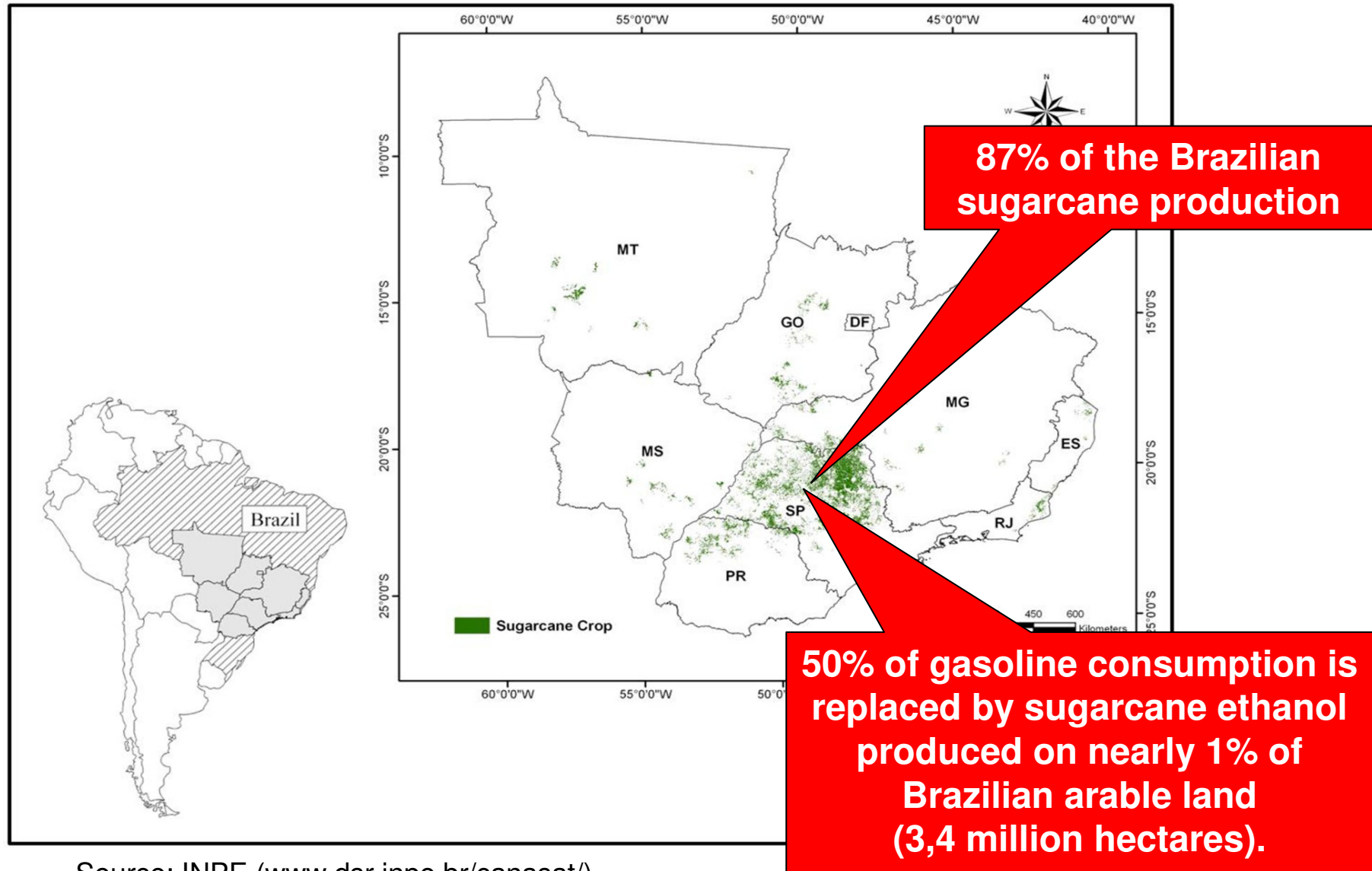
Source: INPE (www.dsr.inpe.br/canasat/).

Sugarcane Planted Area According to Production Regions, 2005 to 2008

Annual growth rate (2005 to 2008)	
South-Central	16% p.a.
Northeast	2% p.a.
Other	2% p.a.
Brazil	**13% p.a.**

1,000 ha

2005
- Other: 444
- Northeast: 1,041
- South-Central: 4,633

2006
- Other: 461
- Northeast: 1,068
- South-Central: 5,116

2007
- Other: 447
- Northeast: 1,099
- South-Central: 6,067

2008
- Other: 469
- Northeast: 1,121
- South-Central: 7,157

■ South-Central (1) ■ Northeast (2) ■ Other (2)
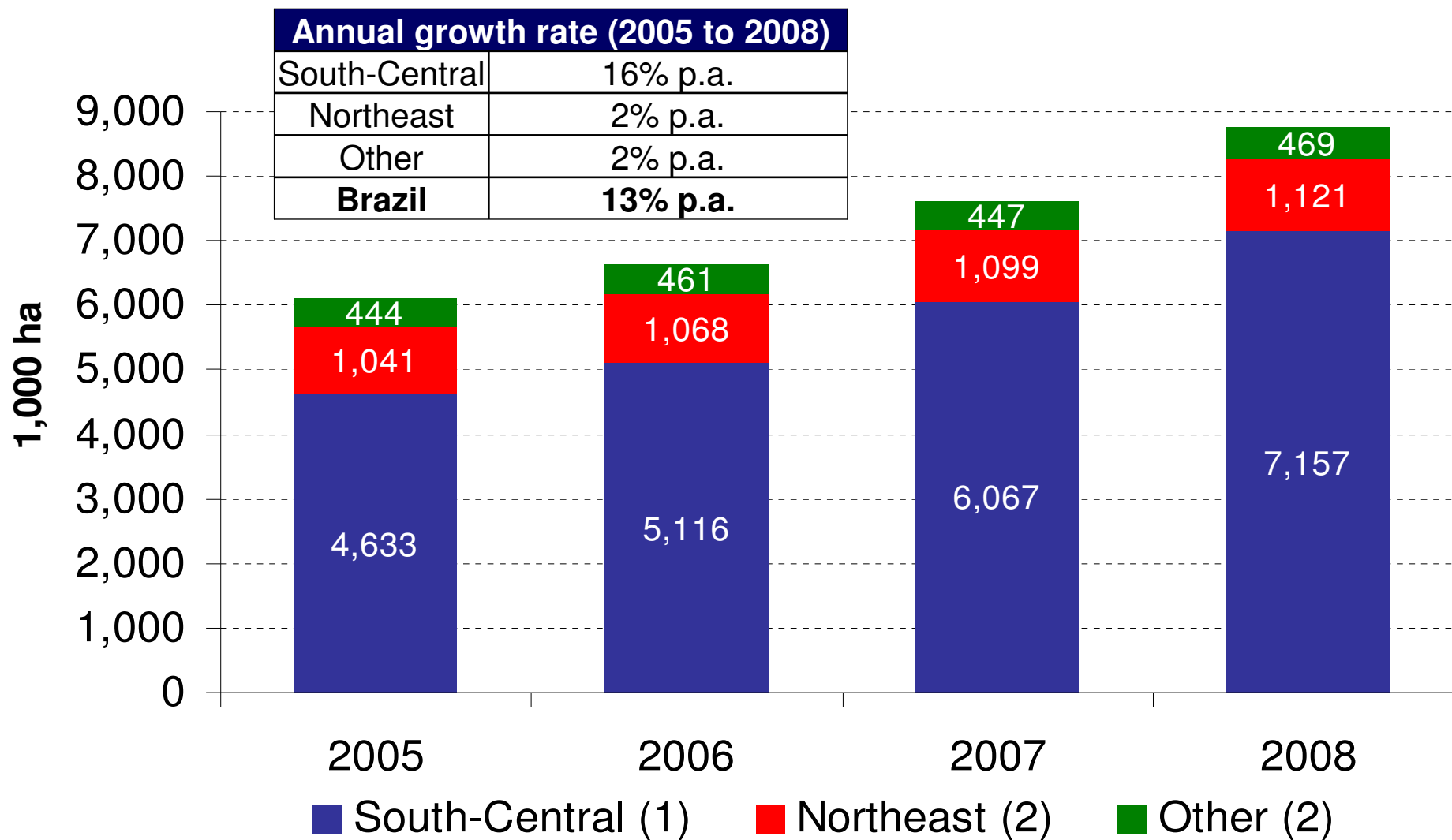
Notes: (1) Source: Canasat/INPE, comprising São Paulo, Minas Gerais, Paraná, Goiás, Mato Grosso and Mato Grosso do Sul.
Sources: PAM/IBGE (2005 and 2006); LSPA/IBGE (2007 and 2008).

Methodology

Methodology

Past Trend

- Mapping sugarcane expansion using remote sensing from the Canasat Project (www.dsr.inpe.br/canasat).

    o Displacement measured in an yearly basis and using planted areas.

- Micro-regional secondary data, using adapted Shift-share model.

    o Displacement measured as the absolute variation of the harvested areas.

- Case studies through environmental licensing reports.

Future Trend

- Partial equilibrium model to project land allocation for agricultural activities in a macro-regional level;

    o Adapted Shift-share to breakdown macro-regional projections in micro-regional data.

    o Projections based on harvested areas.

Remote Sensing Analysis: Classes of Land Use and Occupation Identified Prior to the Sugarcane
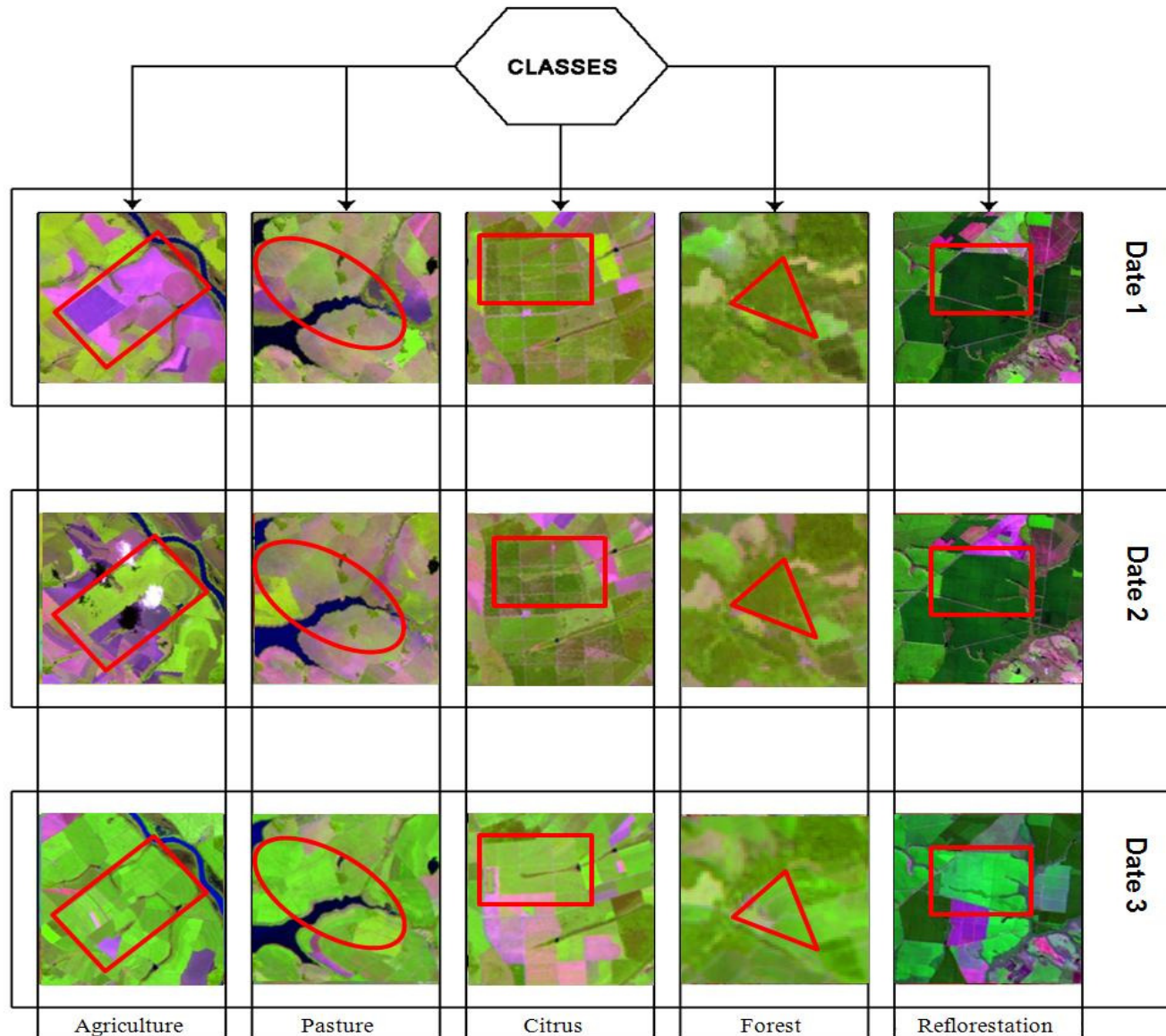
Source: INPE (www.dsr.inpe.br/canasat/). Notes: March of 2003 (date 1), May of 2003 (date 2) and April of 2008 (date 3).

Results for Direct Land Use Changes

Land Use Classes Converted to Sugarcane: Compared Results in the South-Central Region (1,000 ha)

|	Period/Measurement Method		
	Secondary Data 2002 - 06 (1) (harvested area)	Remote Sensing 2007 - 08 (2) (planted area)	Projection Model 2008 -18 (3) (harvested area)
Sugarcane expansion	1,030	2,184	3,848
Agriculture	122 (12%)	1,152 (53%)	1,594 (41%)
Pasture	793 (77%)	991 (45%)	2,369 (62%)
Other	114 (4) (11%)	42 (2%)	24 (1%)

Source (1): Secondary data from IBGE; (2): Satellite images; (3): Projection model; (4) 3 percent of the total agricultural expansion.

Remote Sensing
South-Central Region: Land Use Classes Converted to Sugarcane, 2007 and 2008 (1,000 ha)
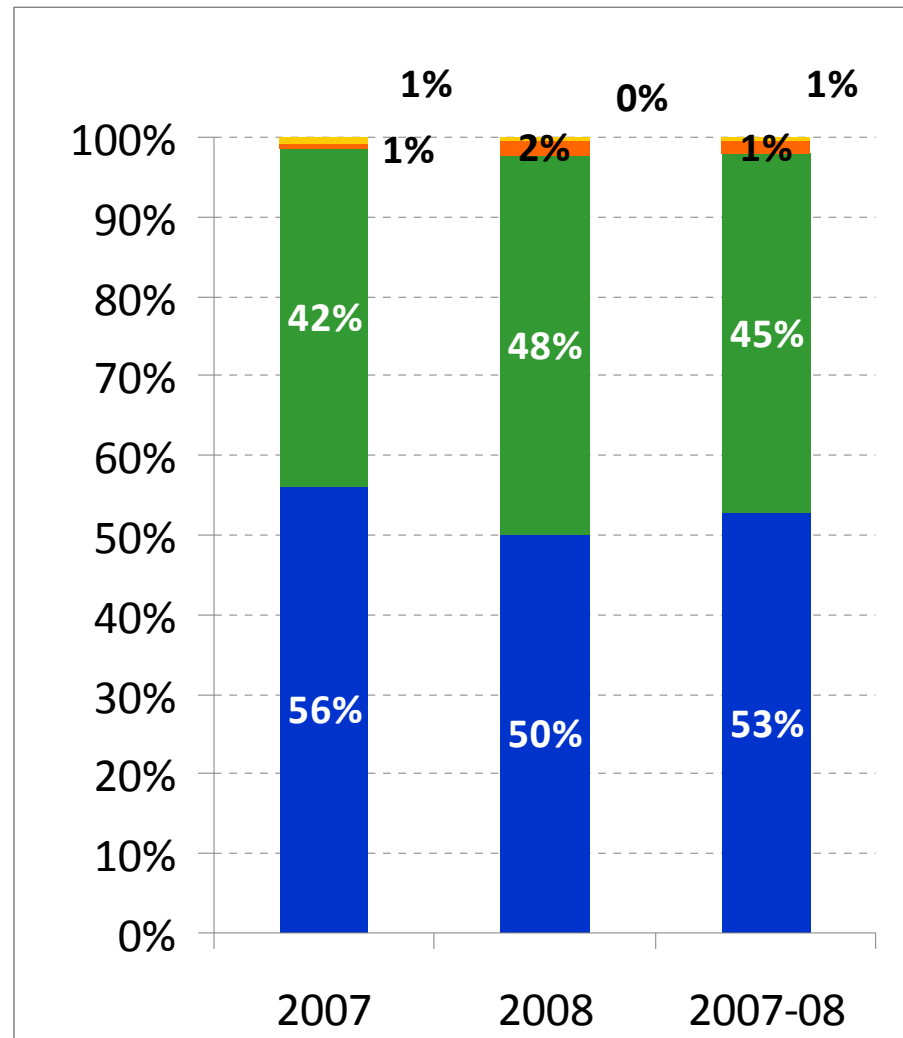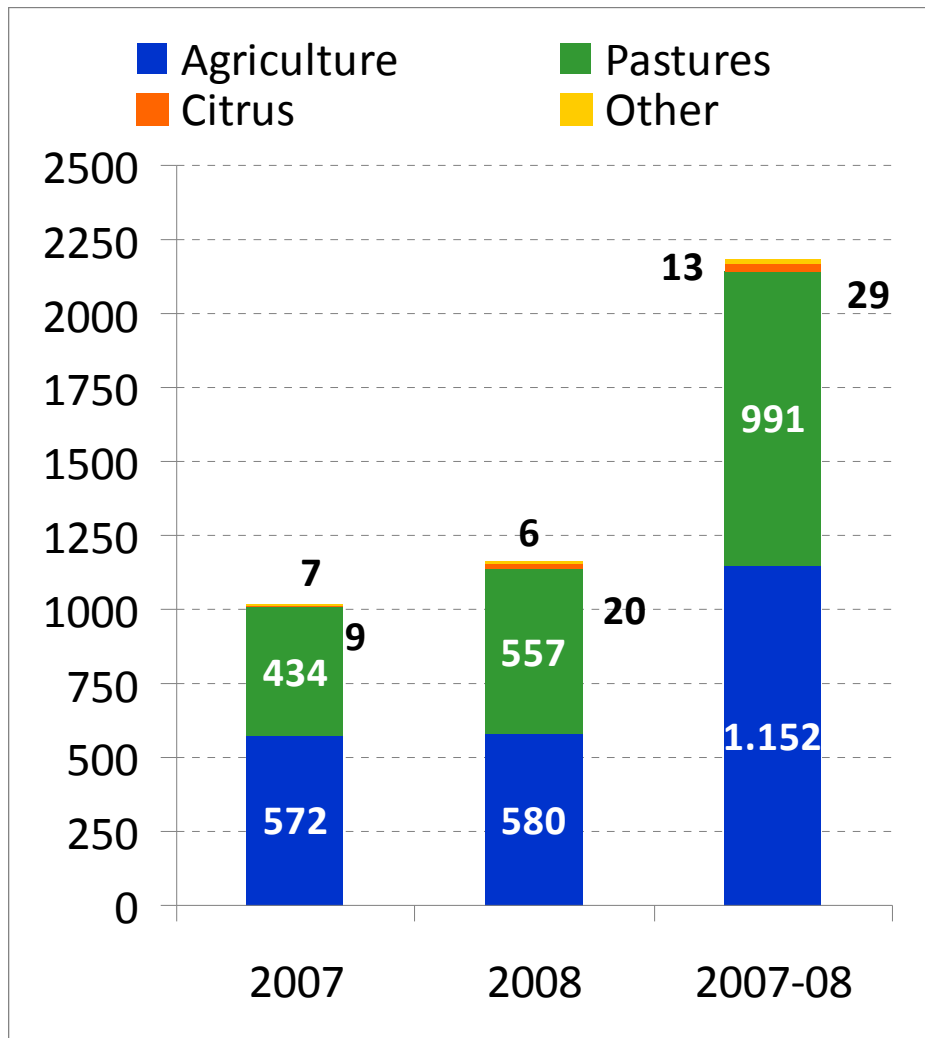
Projections 2008 – 2018
South-Centre: Expected Land Allocation for Sugarcane, Crops and Pastures

(1,000 ha and heads)

	2008	2018	Absolute growth
Sugarcane (ha)	6,359	9,654	3,295
Grains (ha)	26,332	29,529	3,198
Pasture (ha)	92,328	86,215	-6,113
Total (ha)	125,018	125,398	380
Cattle Herd (hd)	119,399	125,501	6,102

Grains: soybean, corn, cotton, rice and dry beans.

Results for Indirect Land Use Changes

Net Growth of Agricultural Land Uses Area and Cattle Herd 2002-06 (1,000 ha and heads)

| State	Sugarcane (ha)	Other crops (ha)	Pasture (ha)	Total used area (ha)	Cattle Herd (hd)
São Paulo	622	-224	-882	-484	-909
Minas Gerais	153	389	-625	-82	1,644
Paraná	74	850	-1	287	-284
Mato Grosso do Sul	41	1	-985	-210	558
Goiás	34	576	-2,041	-1,431	545
Bahia	26	492	143	661	912
Mato Grosso	25	1,634	-1,437	0	3,881
Maranhão	16	298	-463	-148	1.835
Pará	3	115	2,502	2,620	5,311
Piauí	3	206	-112	97	34
Rondônia	1	124	-363	-239	3,444
Tocantins	1	0	-595	-355	1
Acre	1	13	109	123	635
South-Centre	949	3,226	-5,971	-1,920	5,435
Total	1,000	5,446	-5,385	1,061	18,383

Source: PAM/IBGE, Agricultural Census/IBGE and PPM/IBGE.

Brazil: Cattle Herd Evolution
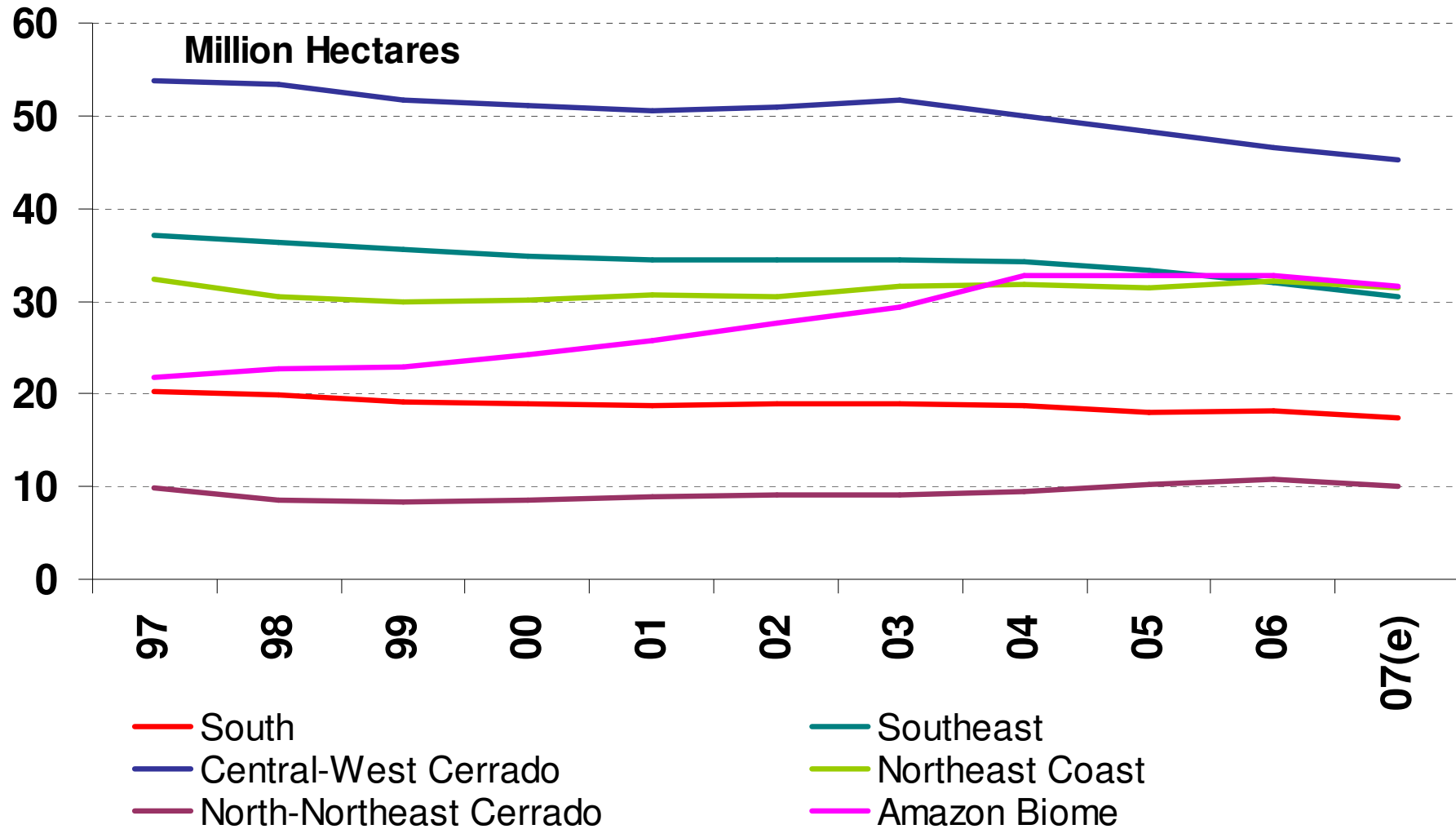## (data from PPM/IBGE)
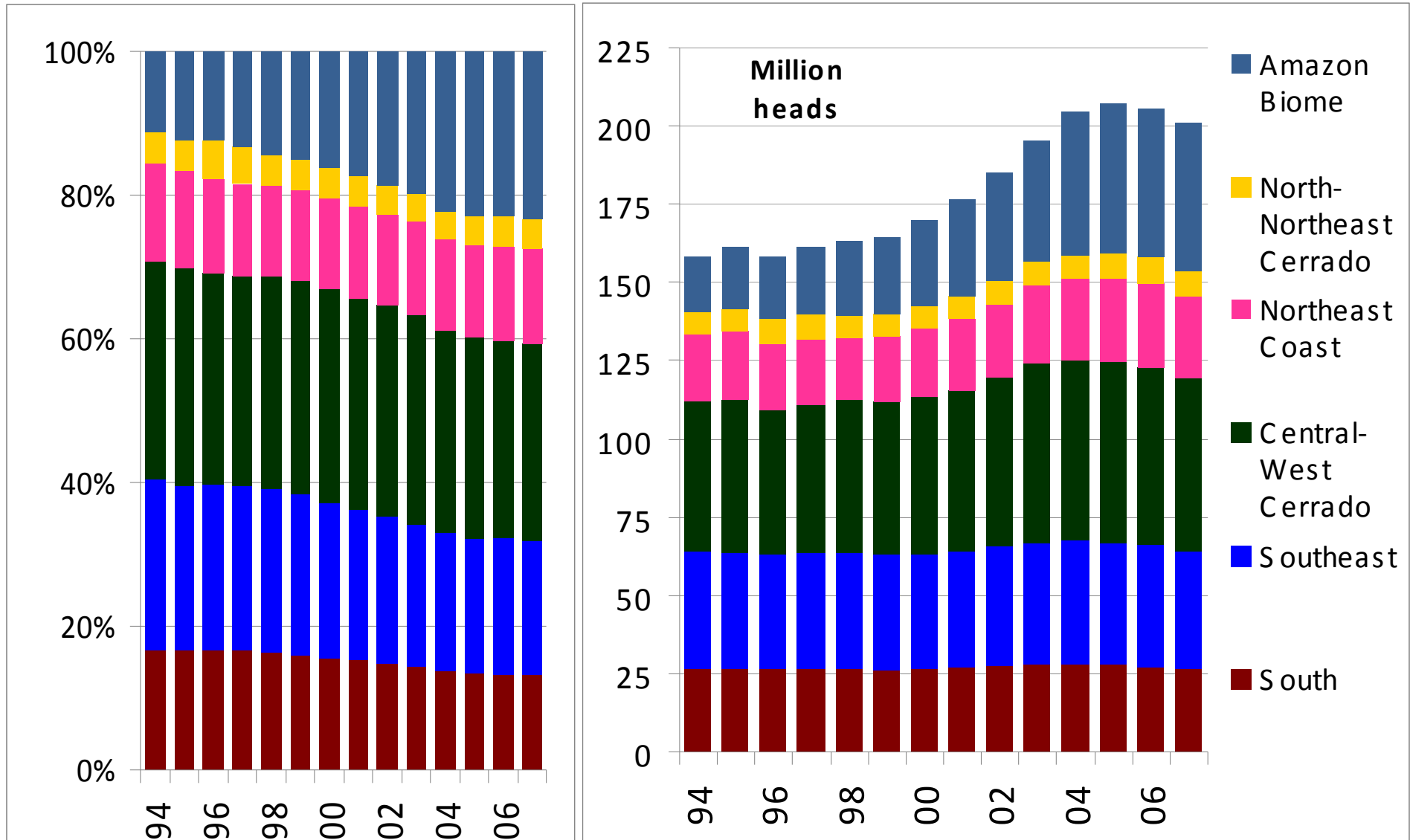
Source: IBGE (Agricultural Census 1996 and 2006; Livestock Municipal Survey); Scot Consultancy.

Cattle raising: animals per ha
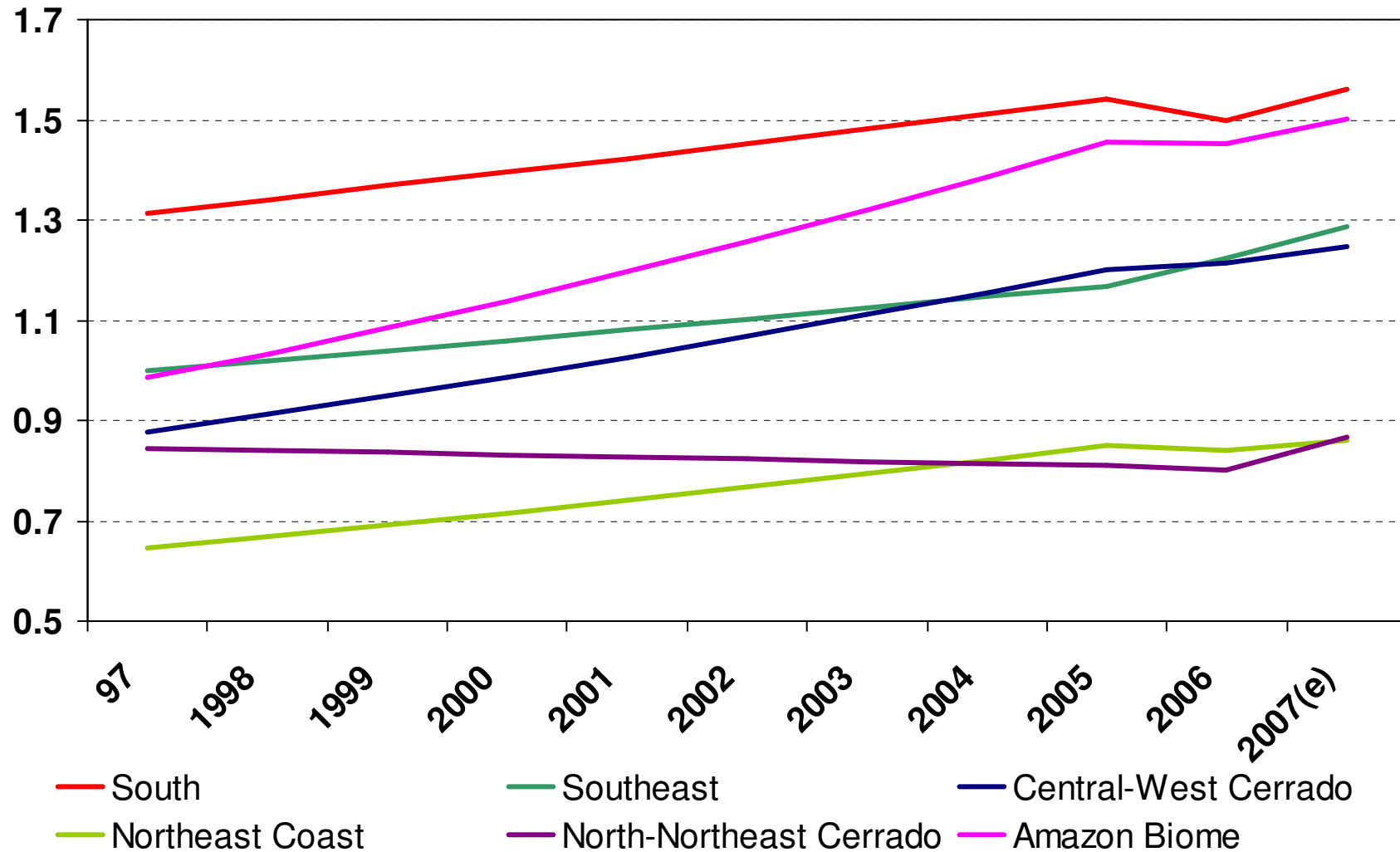
Source: IBGE (Agricultural Census 1996 and 2006; Livestock Municipal Survey); Scot Consultancy.
Note: (e) estimated.

Brazil: Pastureland Area

Million Hectares

Legend:
- South (red)
- Central-West Cerrado (dark blue)
- North-Northeast Cerrado (dark red/maroon)
- Southeast (teal)
- Northeast Coast (green)
- Amazon Biome (magenta)

X-axis: 97, 98, 99, 00, 01, 02, 03, 04, 05, 06, 07(e)

Conclusions

Direct land use change

- There is no significant sugarcane impact on natural landscapes, considering all methods used. Sugarcane has been expanding over anthropized areas;

- Methods presented different participation of crops and pasture in displacement areas:
  - Satellite images: more importance for crops.
  - Secondary data, case studies and projections: more importance of pastures.

Conclusions

Indirect land use change

- There is no clear link between sugarcane expansion and crops and pasture expansion (agriculture and cattle are expanding despite of sugarcane):
  - New areas of crops and pasture are larger than sugarcane's and have their own dynamics.

- Yield improvements, especially in pasturelands, are essential in order to analyze possible iLUC effects: the cattle intensification taking place in Brazil is a reality that must be considered.

Conclusions

- The land use dynamics of the sugarcane in Brazil shows that the GHG benefits from using sugarcane ethanol must be highlighted;

- The Agroecological Sugarcane Zoning made by the Environmental Ministry and the Agricultural Ministry will set the basis for the sugarcane expansion:

  - No go areas (Amazon forest), incentive the occupation of degraded land and pastures;

- LUC and iLUC spillover effetcs: the methodologies concerns needs to be carefully addressed in order to allow reasonable and reliable data;

- Regional aspects plays an essential role in analyzing the dynamics of land use change: the pasture case in Brazil is a unique-example.

Thank you for your attention

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