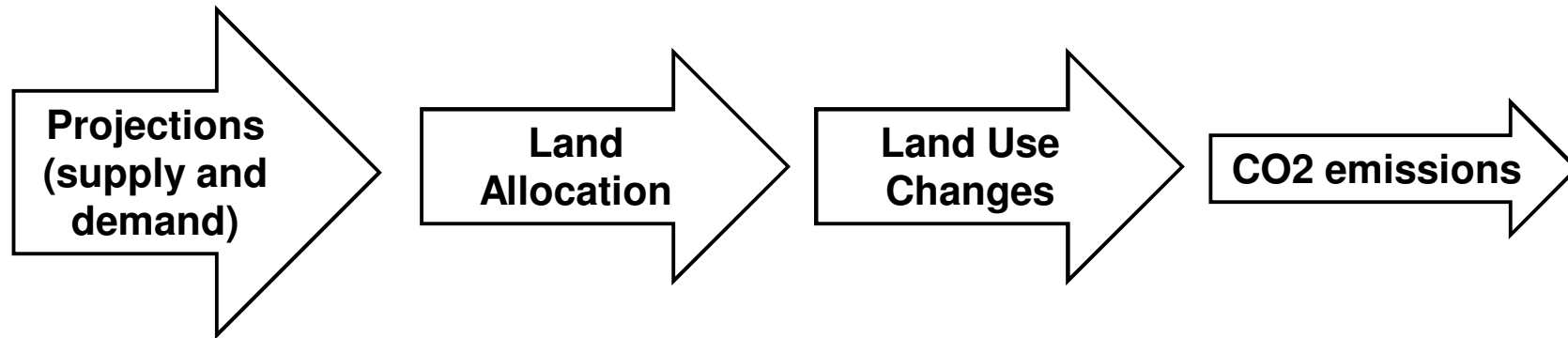# 1st Brazil-U.S. Biofuels Short Course: Providing Interdisciplinary Education in Biofuels Technology

Measuring Agricultural-Based Biofuels Indirect Effects on Land Use

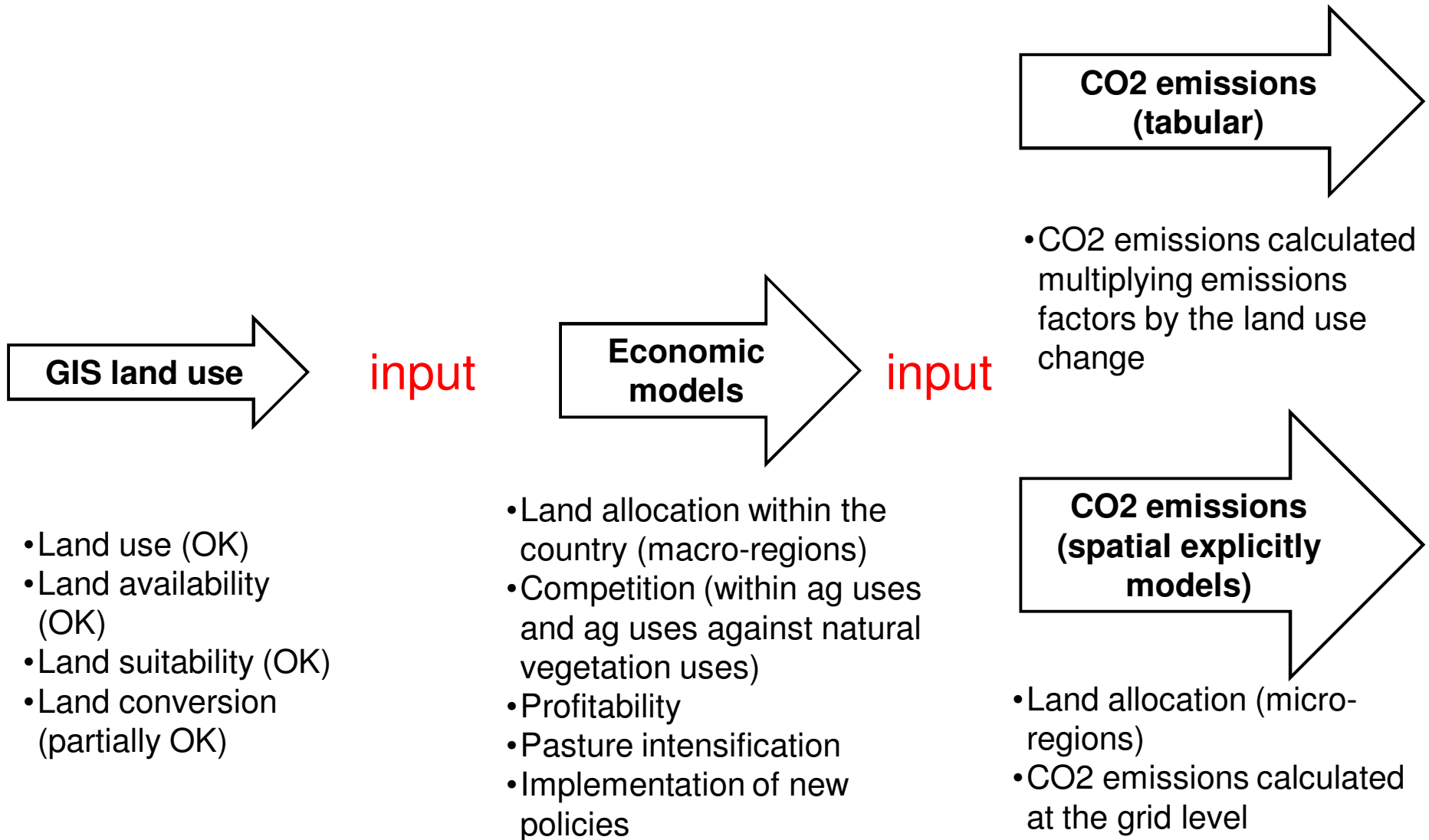## Andre M. Nassar

Managing Director, ICONE

Sao Paulo

7 August 2009

ICONE
Institute for International
Trade Negotiations

Measuring ILUC : Flow of Activities

Projections (supply and demand) → Land Allocation → Land Use Changes → CO_2 emissions

- Worldwide
- General and partial equilibrium
- Projections
- Baseline and alternatives scenarios
- Supply and demand => land allocation
- Conversion of land allocation into land use changes
- Calculation of CO_2 emissions (carbon stocks, emission factors, time horizon, discounting rate, carbon uptake)
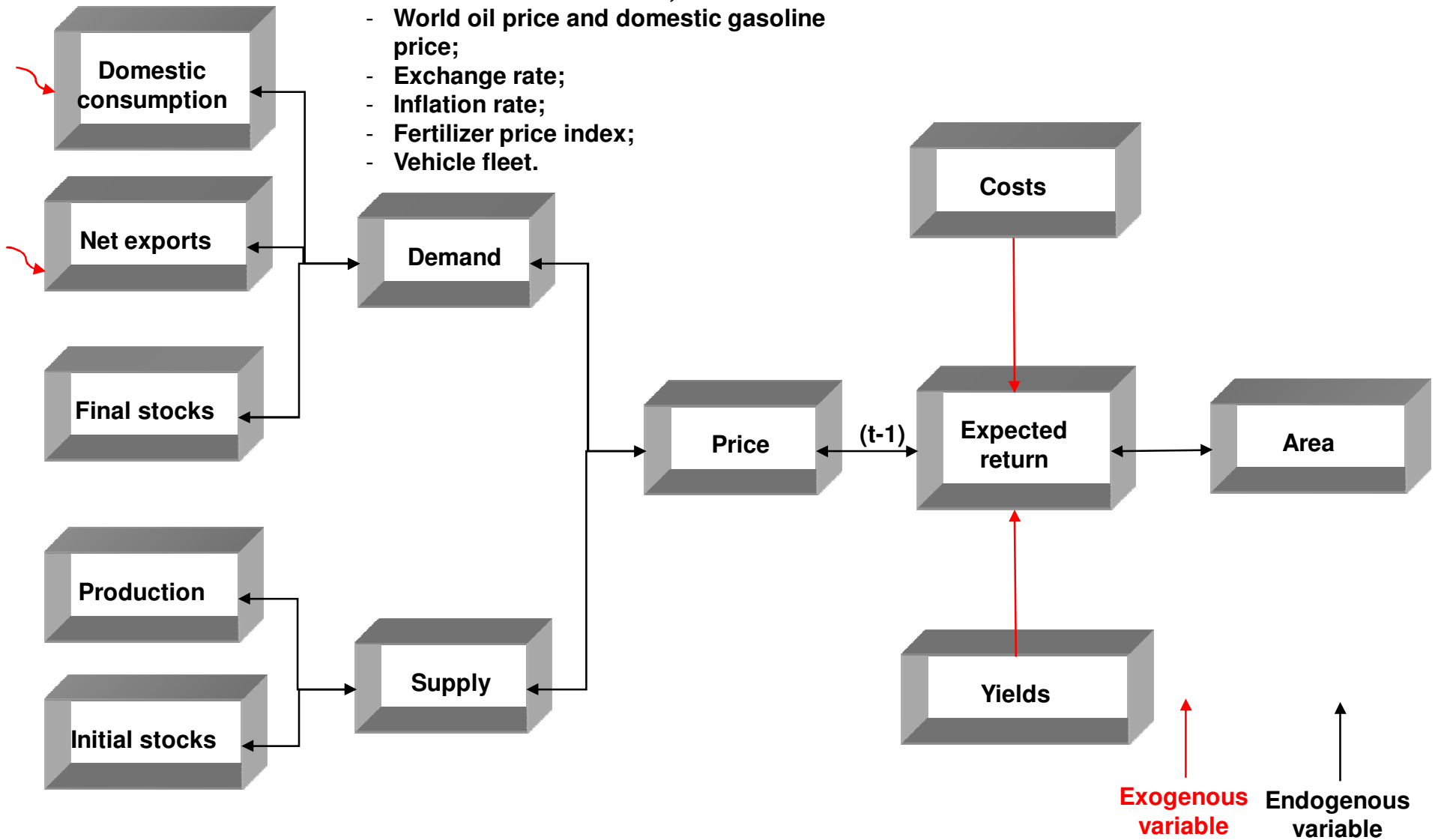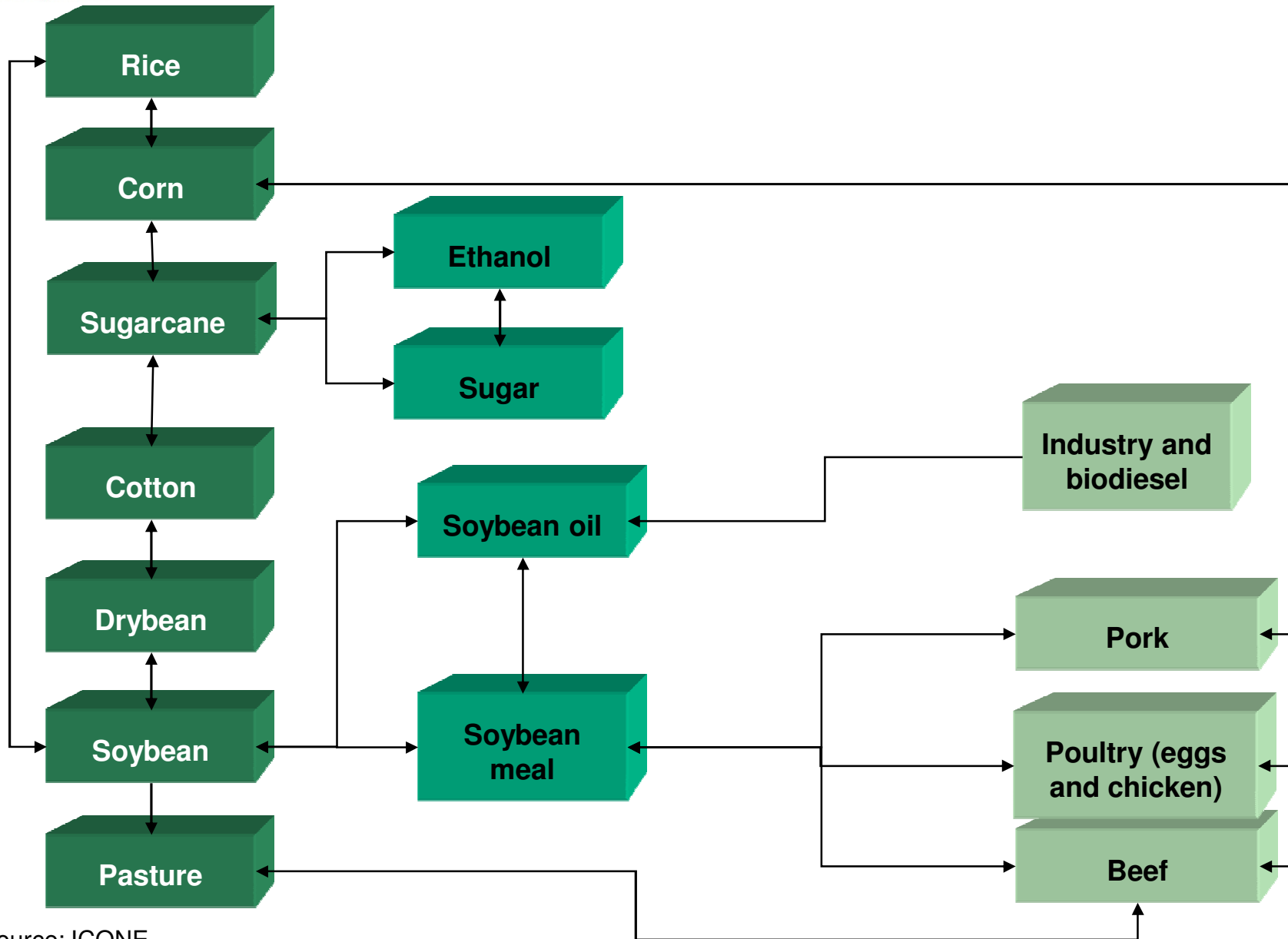
Measuring ILUC : Tools

GIS land use →

input

• Land use (OK)
• Land availability (OK)
• Land suitability (OK)
• Land conversion (partially OK)

Economic models →

input

• Land allocation within the country (macro-regions)
• Competition (within ag uses and ag uses against natural vegetation uses)
• Profitability
• Pasture intensification
• Implementation of new policies

CO2 emissions (tabular) →

• CO_2 emissions calculated multiplying emissions factors by the land use change

CO2 emissions (spatial explicitly models) →

• Land allocation (micro-regions)
• CO_2 emissions calculated at the grid level

Structure of the Supply and Demand Section
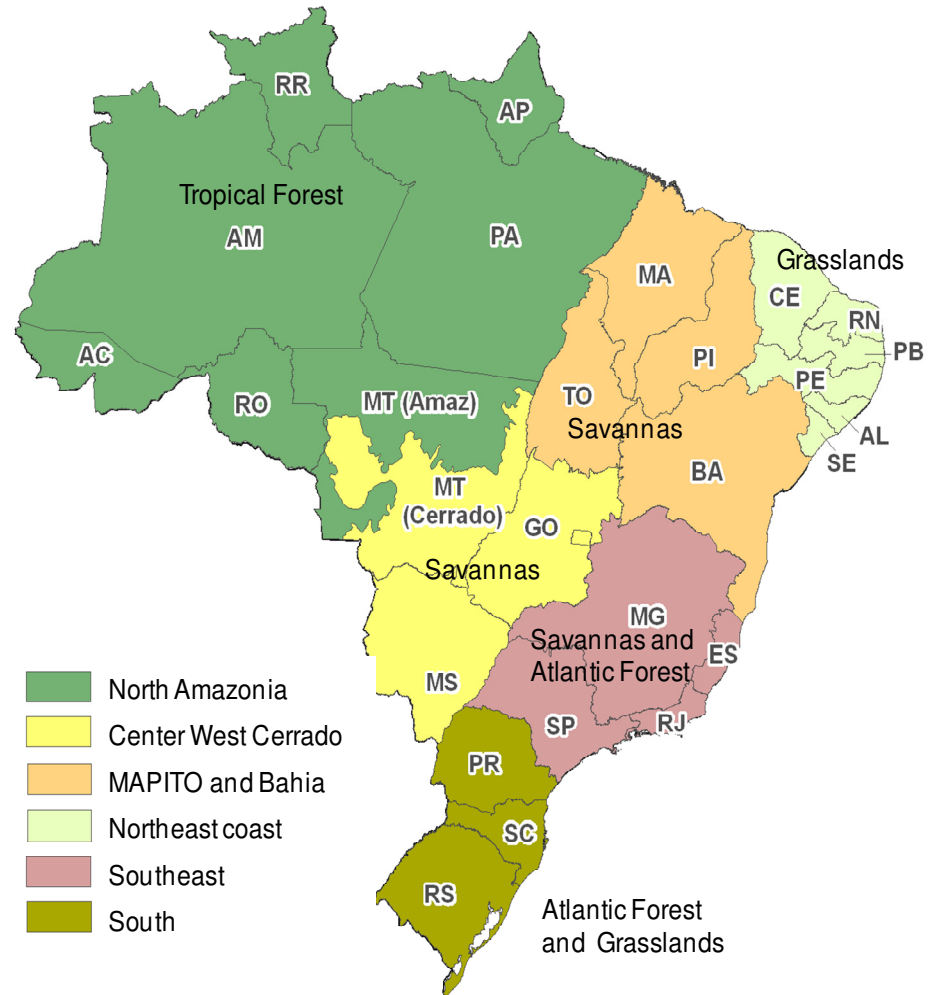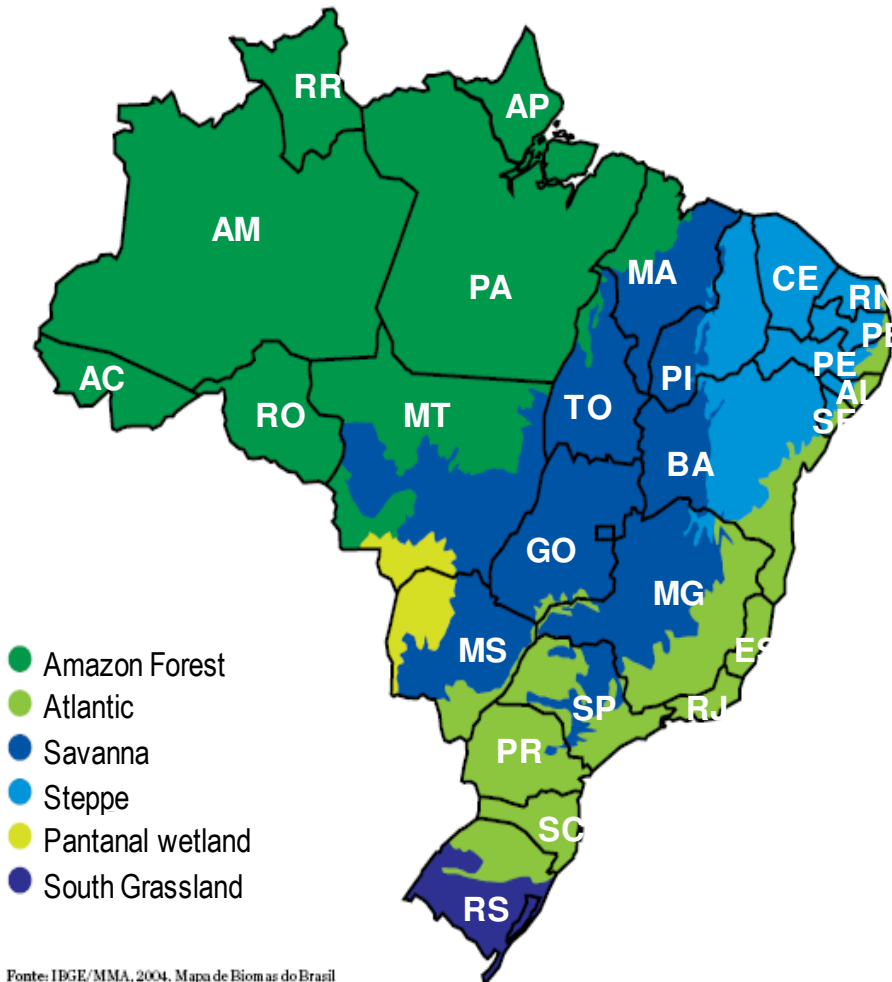
Exogenous macroeconomic data
- **Population;**
- **World and national GDP;**
- **World oil price and domestic gasoline price;**
- **Exchange rate;**
- **Inflation rate;**
- **Fertilizer price index;**
- **Vehicle fleet.**

Domestic consumption

Net exports

Final stocks

Demand

Price

(t-1)

Costs

Expected return

Area

Production

Initial stocks

Supply

Yields

Exogenous variable   **Endogenous variable**

Source: ICONE.

Activities Covered by the Model

Source: ICONE

Brazilian Biomes and BLUM Regions

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Legend (left map):
- Amazon Forest
- Atlantic
- Savanna
- Steppe
- Pantanal wetland
- South Grassland

Fonte: IBGE/MMA, 2004. Mapa de Biomas do Brasil

Legend (right map):
- North Amazonia
- Center West Cerrado
- MAPITO and Bahia
- Northeast coast
- Southeast
- South

Brazilian Biomes and Legal Reserve (preservation rate)

Amazon Forest
Atlantic Forest
Savanna
Steppe
Pantanal wetland
South Grassland

Legal reserve 20%

Fonte: IBGE/MMA, 2004. Mapa de Biomas do Brasil

Brazilian Biomes and Legal Reserve (preservation rate)

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Legal reserve 35%

MA

TO

MT

- Amazon Forest
- Atlantic Forest
- Savanna
- Steppe
- Pantanal wetland
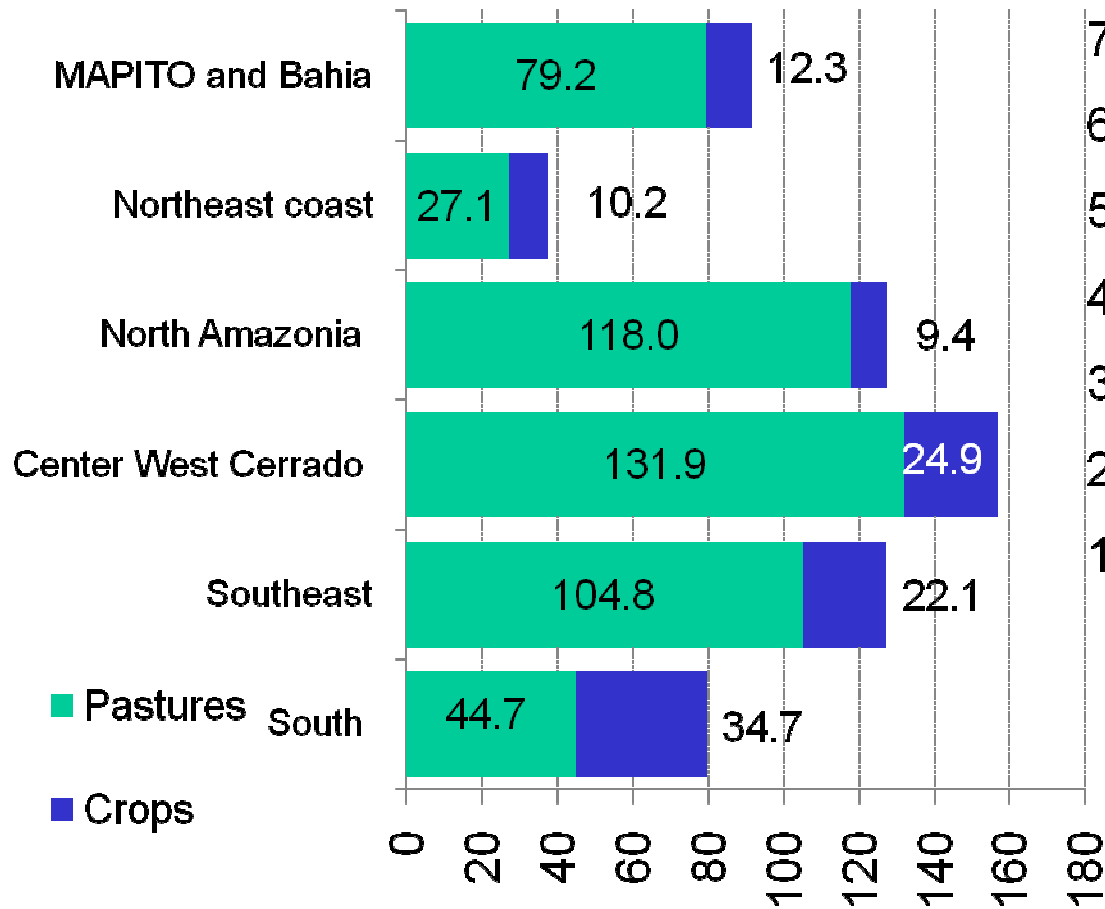- South Grassland

Fonte: IBGE/MMA, 2004. Mapa de Biomas do Brasil

Brazilian Biomes and Legal Reserve (preservation rate)

Legal reserve 80% (50% with Economic and Ecological Zoning)

AP
AP
AM
MA
PA
AC
RO
MT

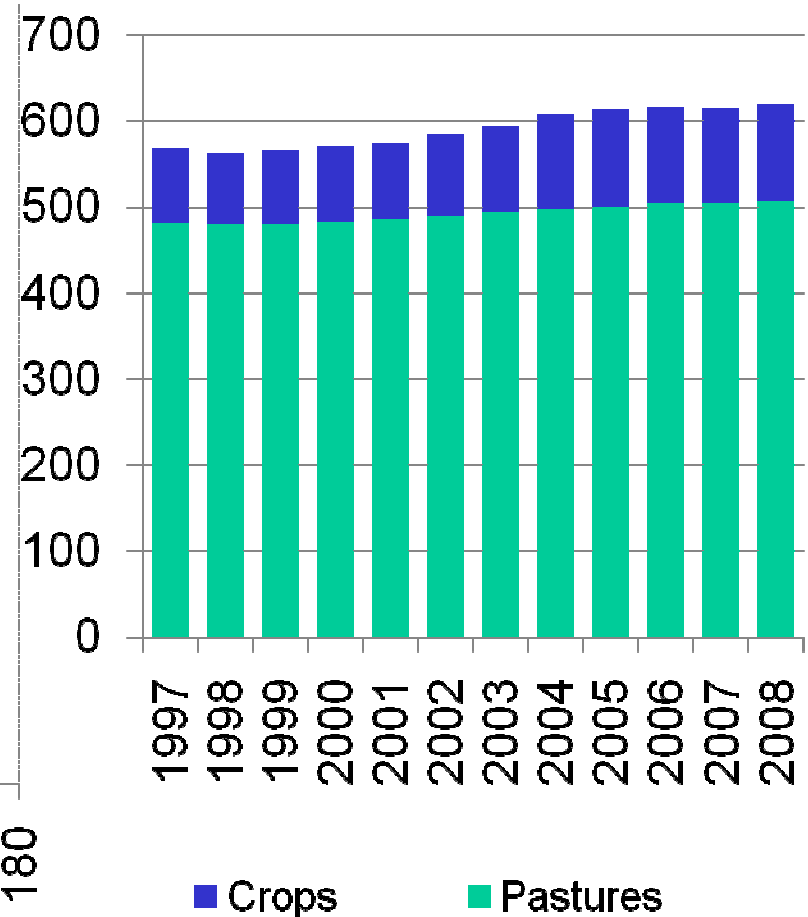- Amazon Forest
- Atlantic Forest
- Savanna
- Steppe
- Pantanal wetland
- South Grassland

Fonte: IBGE/MMA, 2004. Mapa de Biomas do Brasil
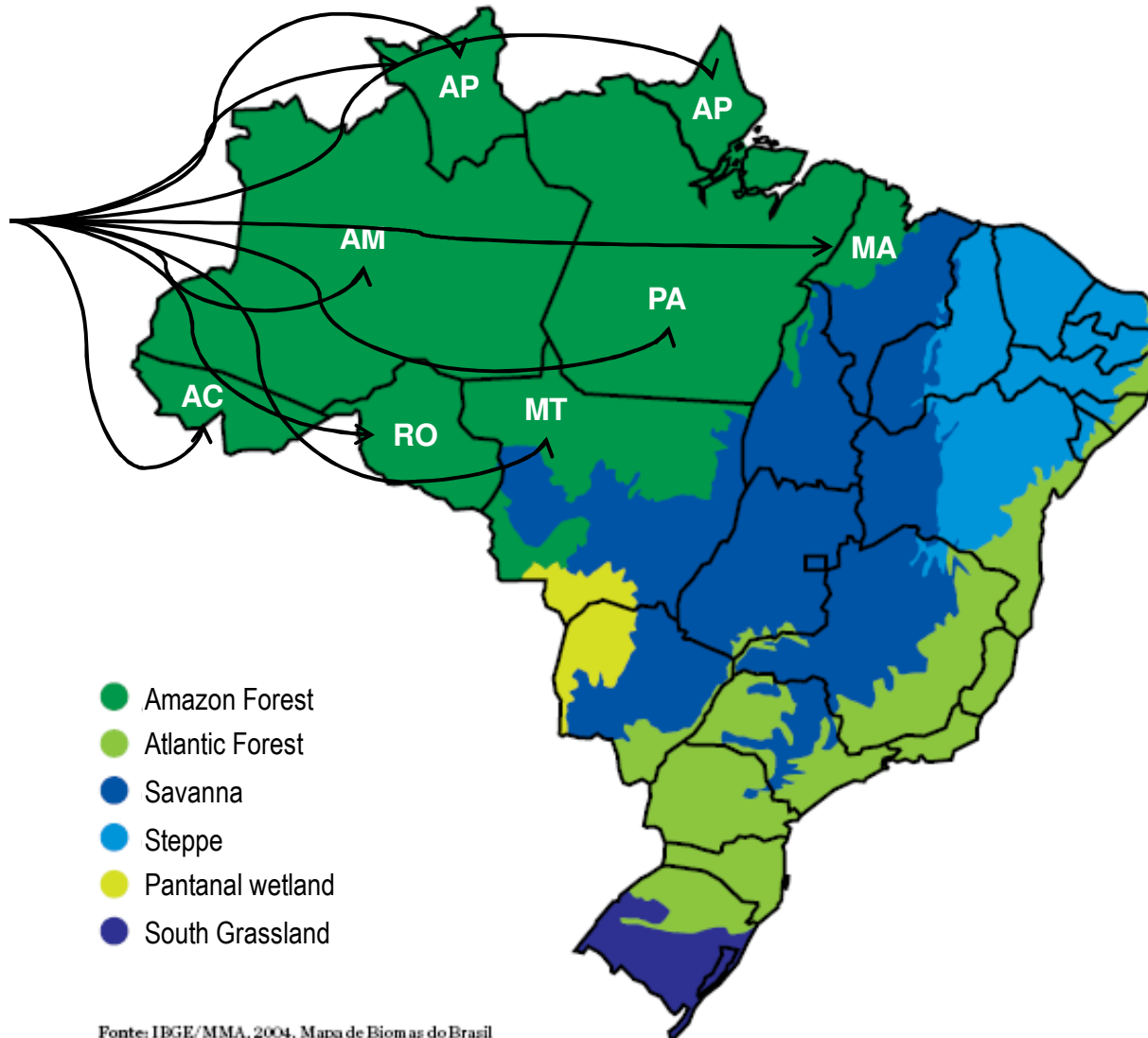
Brazil: Land Allocated to Agriculture According to the BLUM Regions
(million acres)

Macro-regions, 2008

Region	Pastures	Crops
MAPITO and Bahia	79.2	12.3
Northeast coast	27.1	10.2
North Amazonia	118.0	9.4
Center West Cerrado	131.9	24.9
Southeast	104.8	22.1
South	44.7	34.7

■ Pastures
■ Crops

Brazil, 1997 to 2008

■ Crops ■ Pastures

Crops: Soybean, Corn (1st crop), rice, cotton, dry bean and sugarcane

Source: IBGE/CONAB. Elaboration: ICONE.

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Criteria Used for the Calculation of Land Allocated to Pastures

| Region | Sources for 1996 and 2006 | | Criteria for time series construction |
	1996	2006	1997 to 2005, 2007 and 2008
South	Ag Census 1996	Ag Census 2006	Regression lagged pasture and cattle herd
Southeast	Ag Census 1996 except Sao Paulo and Minas Gerais states	Ag Census 2006 except Sao Paulo and Minas Gerais states	Regression lagged pasture and cattle herd
Sao Paulo	IEA	IEA	
Minas Gerais	Ag Census 1996 corrected using high slopes pasture from GIS 2006	GIS 2006	
Center West	Ag Census 1996	GIS 2006 except Mato Grosso and Mato Grosso do Sul states	Regression lagged pasture and cattle herd
Mato Grosso	Ag Census 1996 using 50% of pasture area in municipalities which are both in the Amazon and Cerrado Biomes	Ag Census 2006 using 50% of pasture area in municipalities which are both in the Amazon and Cerrado Biomes	
Mato Grosso do Sul	Ag Census 1996	GIS 2006 using Census 2006 for Pantanal's municipalities	
Amazon	Deforestations correction from GIS 2006 to 1996	GIS 2006	Deforestation discounting crops expansion
Northeast	Ag Census 1996	Ag Census 2006	Regression lagged pasture and cattle herd
MAPITO and Bahia	Ag Census 1996	Ag Census 2006	Regression lagged pasture and cattle herd

Source: ICONE

Source: IBGE/CONAB. Elaboration: ICONE.

Land Availability

Total Brazilian land, by municipality, was mapped and classified, using GIS into the following categories:

- Protected areas (for conservation and indian reserves)

- Antropic areas and natural vegetation areas

- Protected areas within private properties: APP (riparian areas) and Legal Reserve required (RL – a % of the property, depending on the biome). Since the RL is a more subjetive requirement, results are presented with and without this complience.

- Slope: 1, 2 (till 12% - suitable for agriculture), 3, 4 (12-45% - not suitable for agriculture), 5, 6 (more than 45% - protected area)

Land Suitability

Total Brazilian land, by municipality, was mapped and classified, using GIS into the following categories:

1. Low suitability

2. Medium suitability

3. High suitability

4. Very high suitability
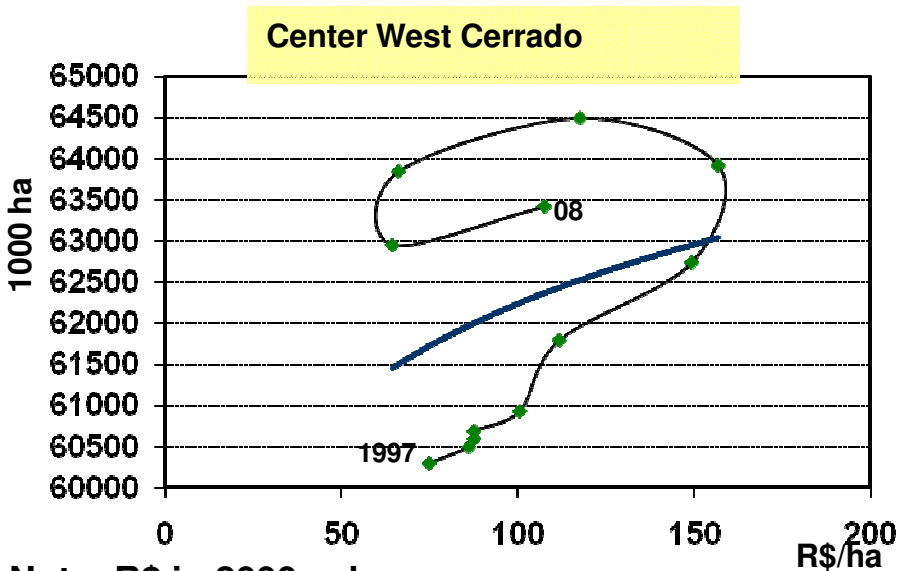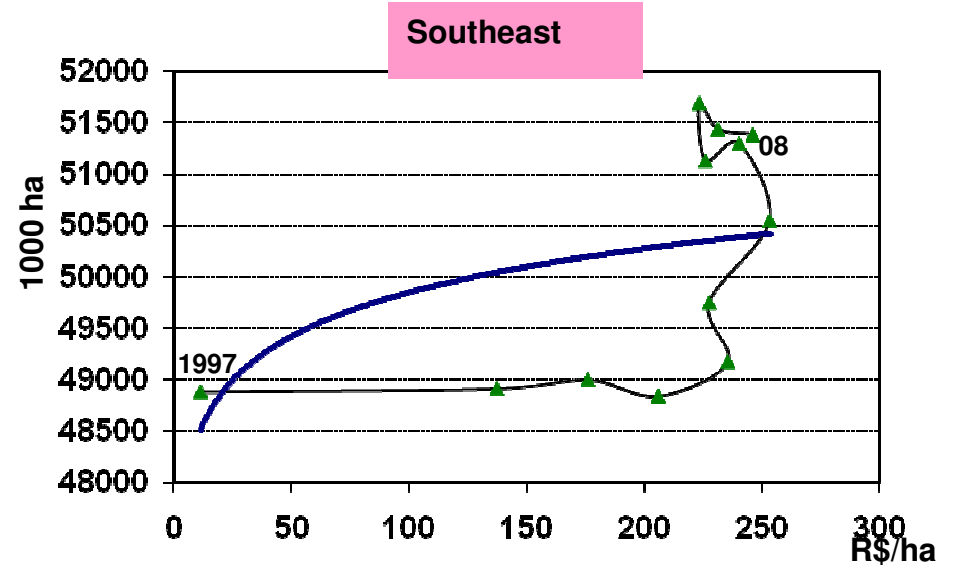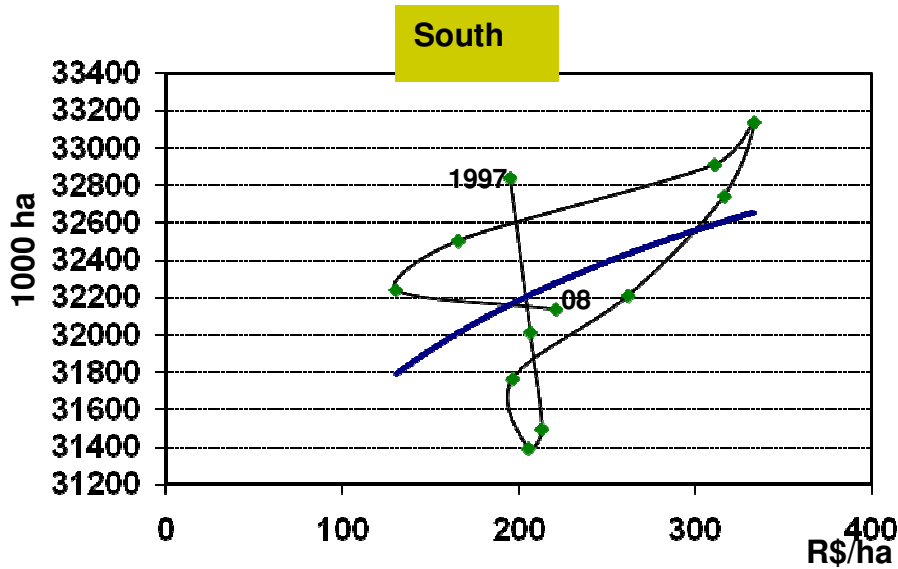
(Urban areas and water was excluded)

The criteria used for classification are:

- Soils (depth, drainage, and fertility)

- Climate (temperature and radiation, basal temperature, and evapotranspiration – ET)

- Topography (<6; 6-12%; 12-16%; >16%)

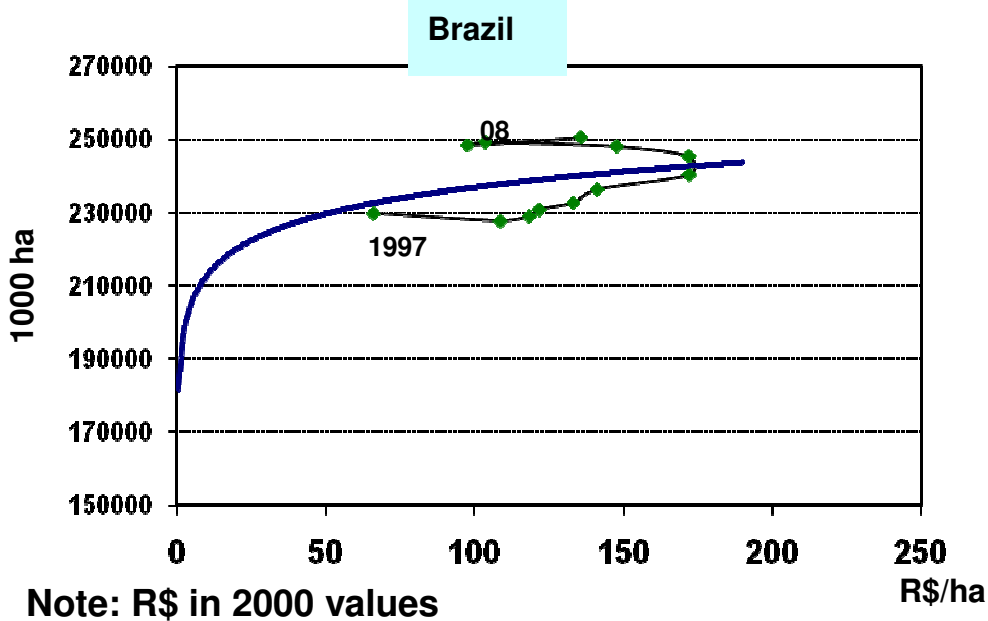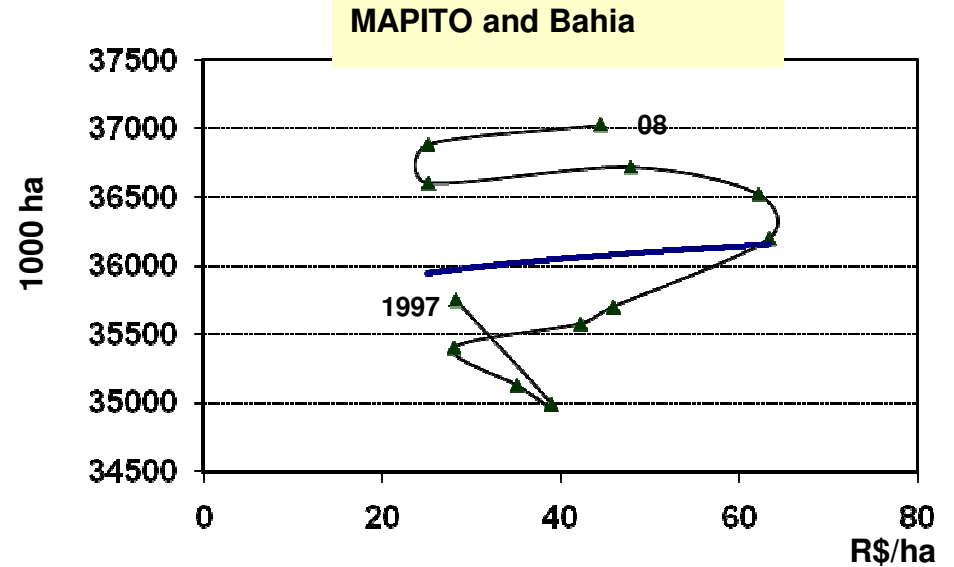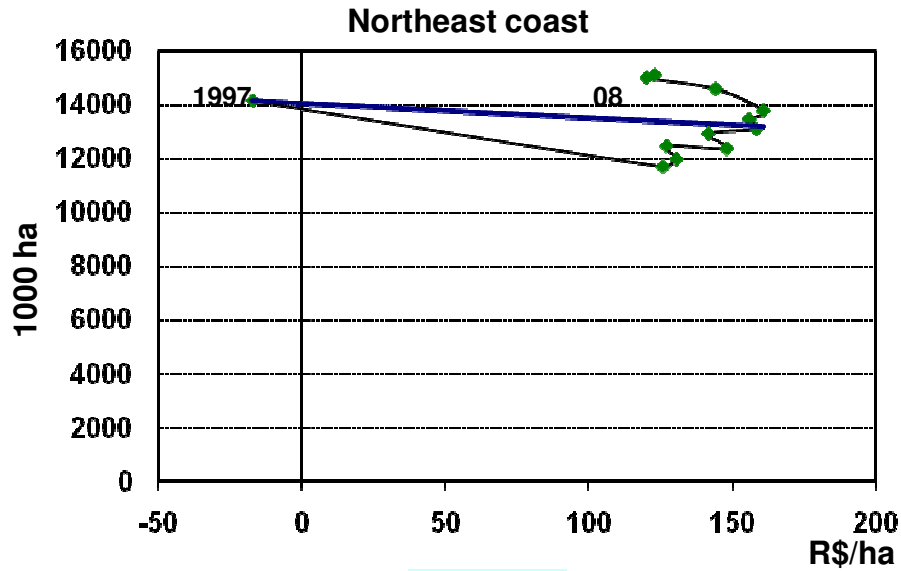Then, these three dimensions are integrated.

Both analysis was conducted by a SIG specialized team from University of São Paulo (ESALQ-USP), and they will be published soon.

# Total agricultural area and average return
(1st crops)

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South

Southeast

Center West Cerrado

North Amazon
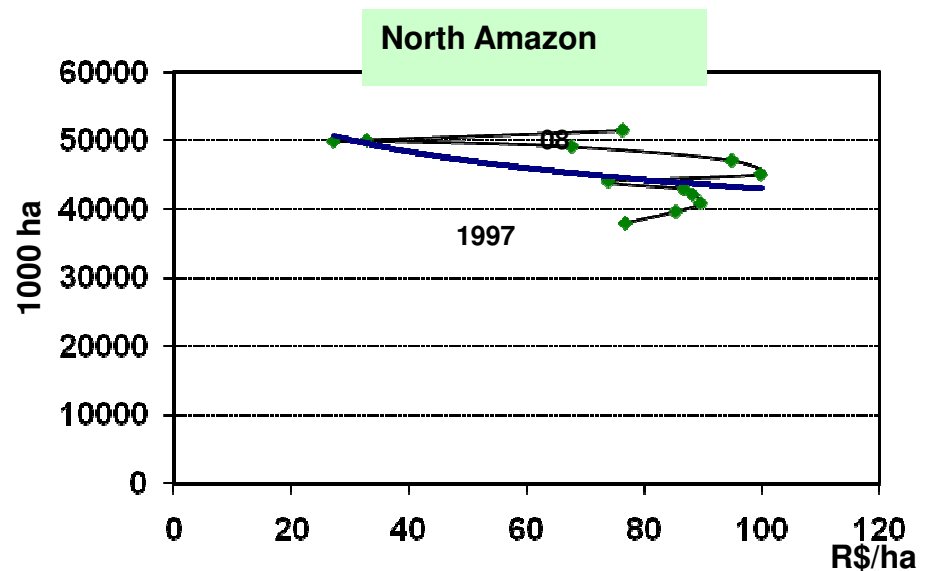
Note: R$ in 2000 values

Total agricultural area and average return
(1st crops)

Northeast coast

MAPITO and Bahia

Brazil

Note: R$ in 2000 values

Validating the Projections
Total Herd (1,000 heads) and Stocking Rate (animals/ha)

Elaboração: ICONE.
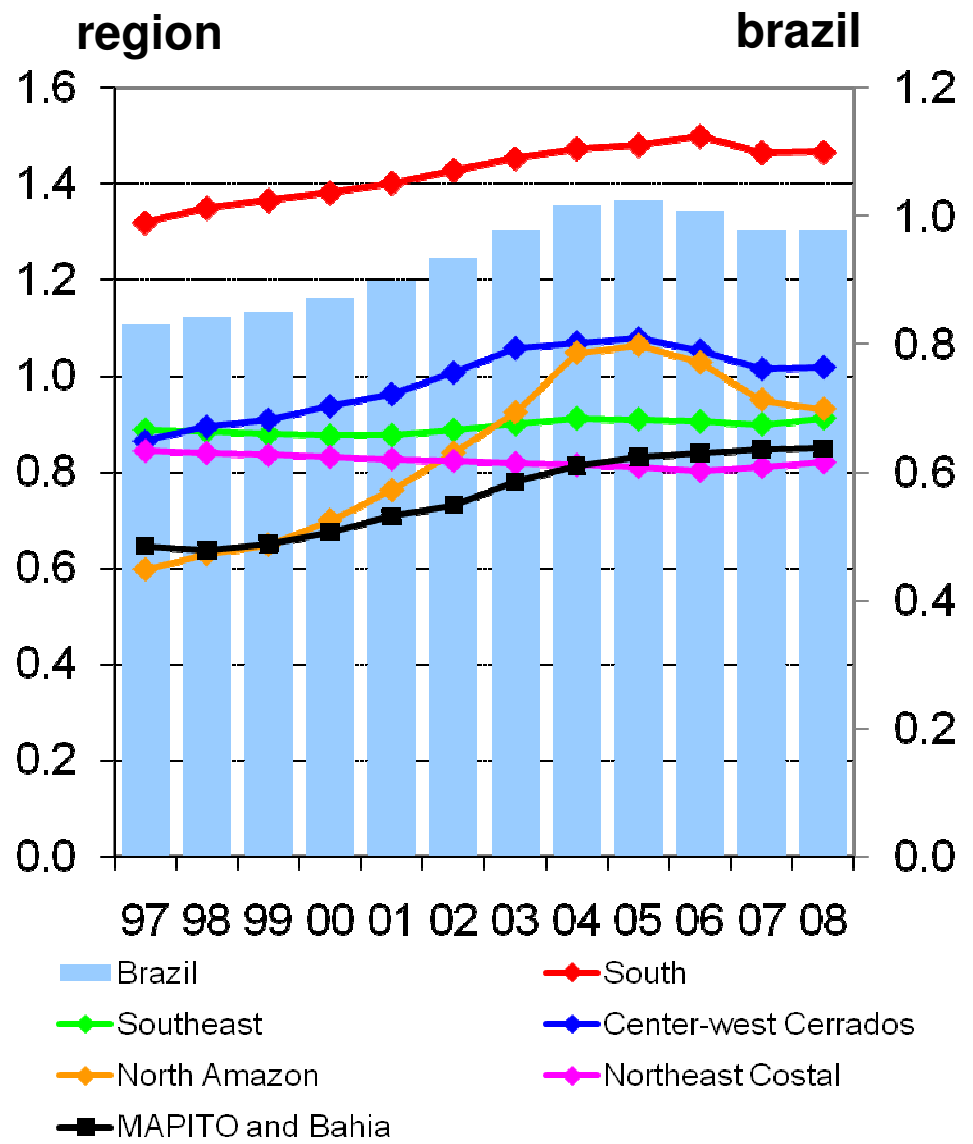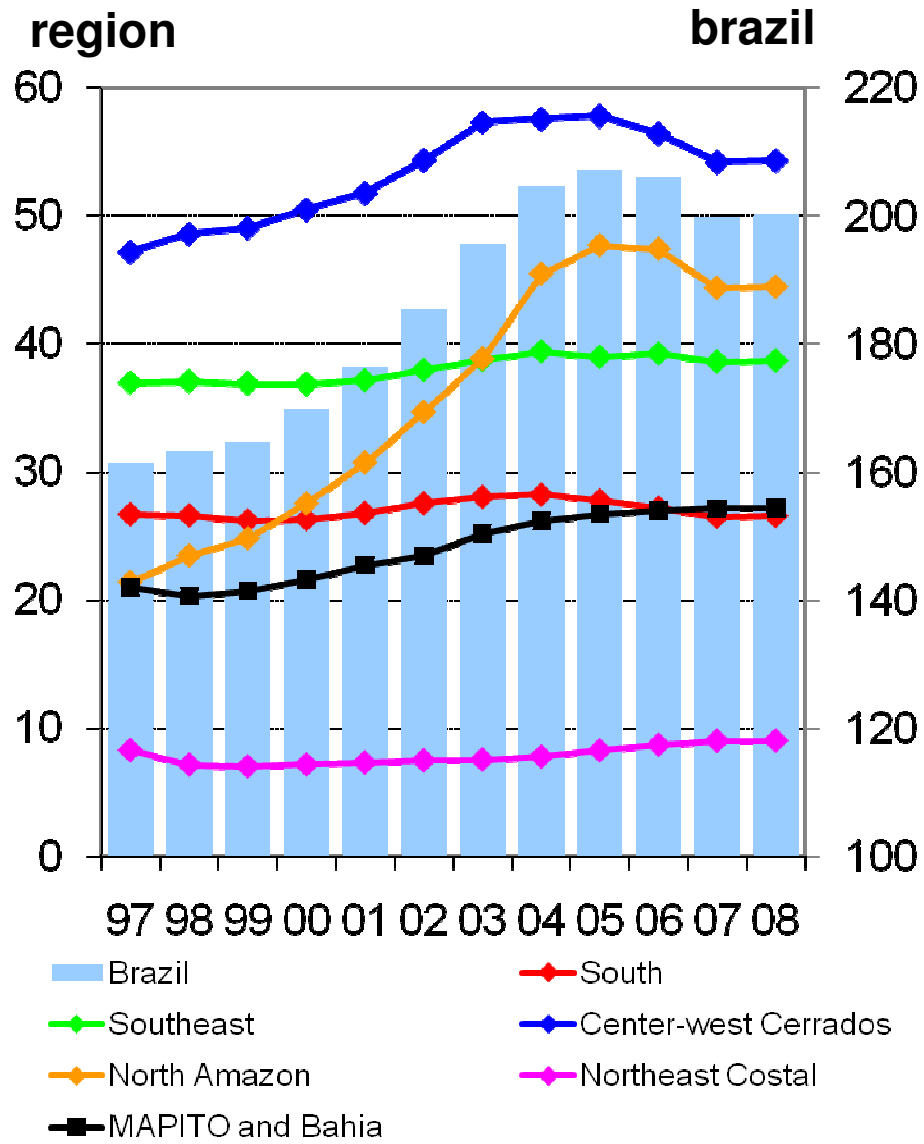
Support Spatial Information
Example of Direct Substitution: Remote Sensing

South-Central Region: Classes of Land Use Converted to Sugarcane,, 2007 and 2008 (1,000 ha)
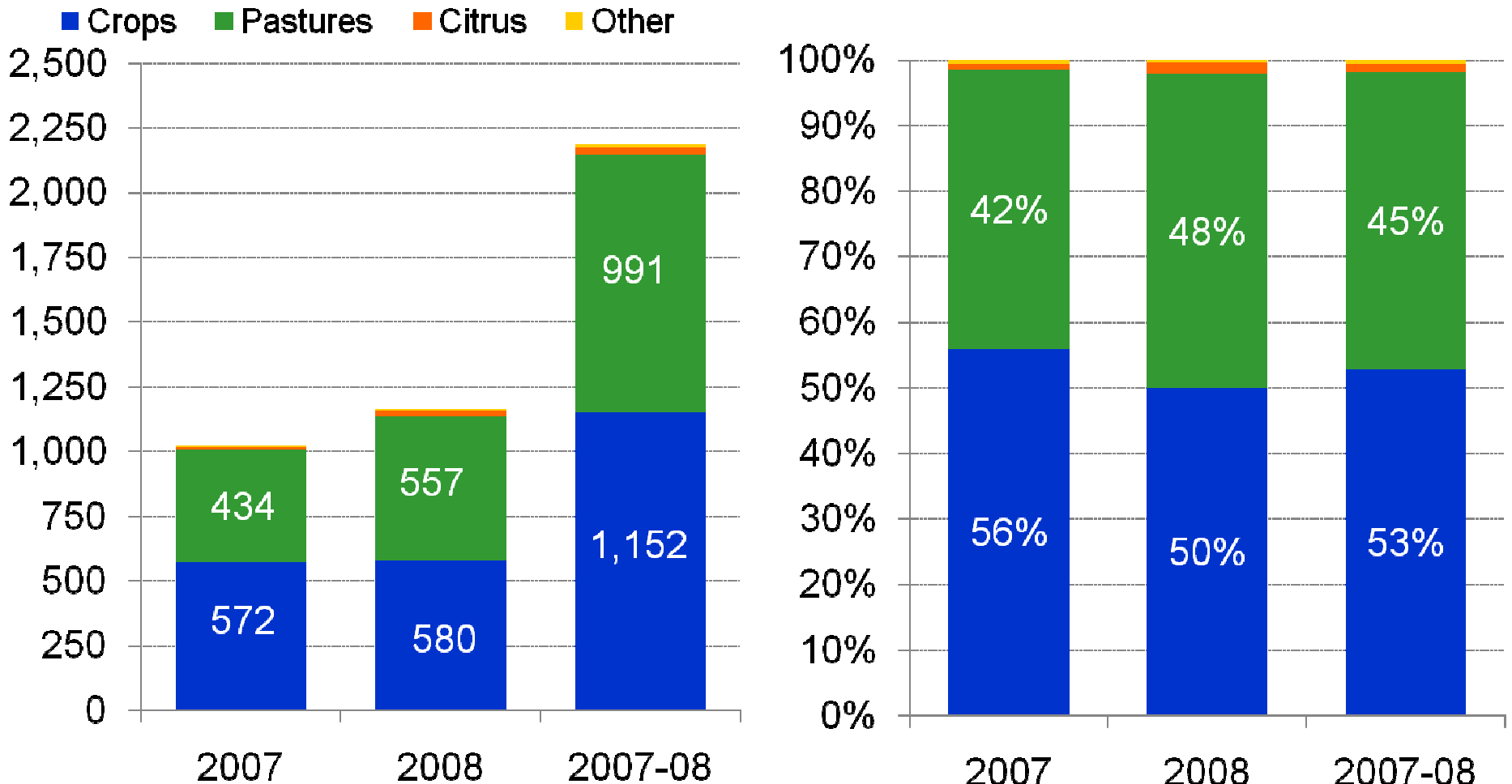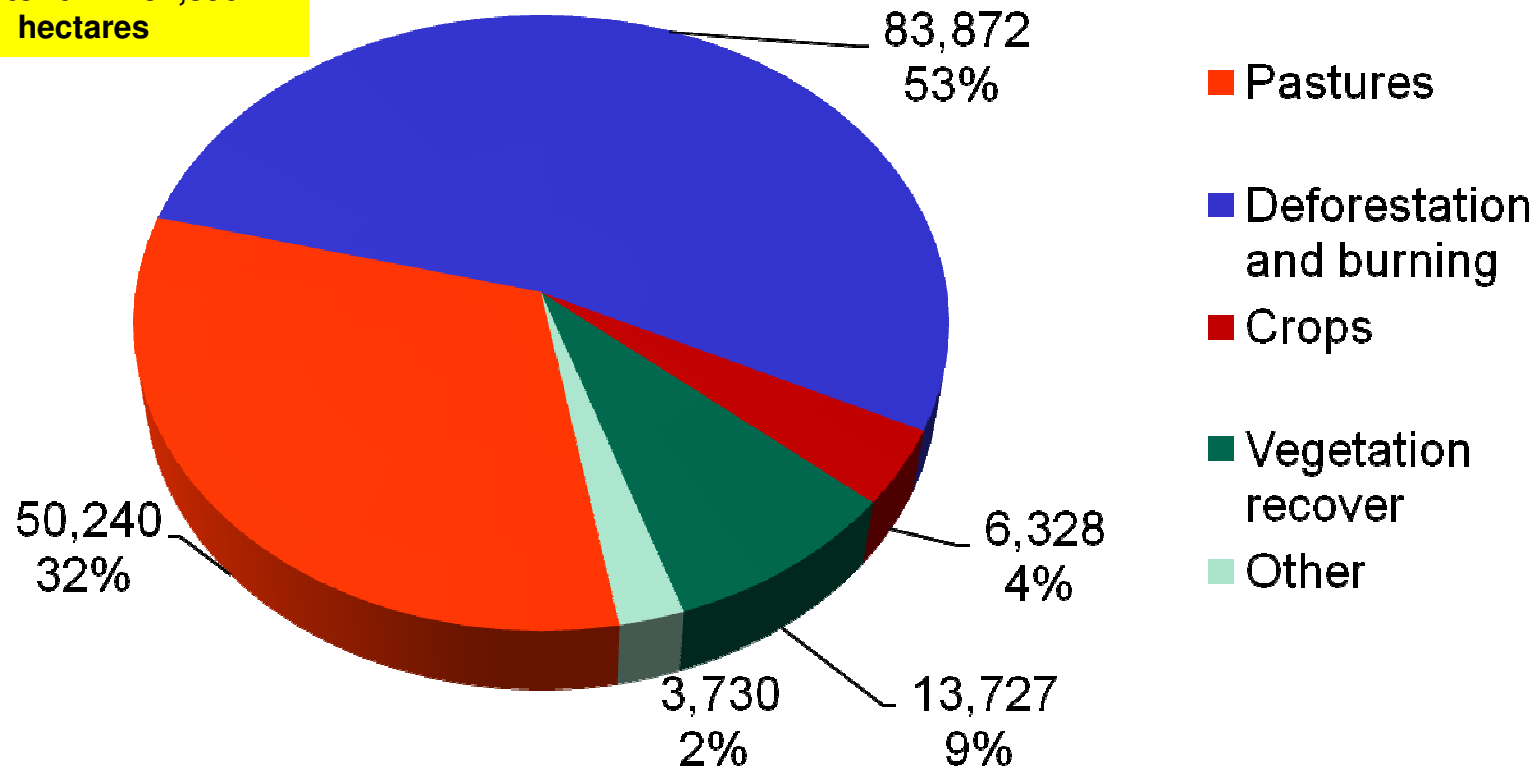

Source: CANASAT/INPE, published in Nassar, A.M., Rudorff, B. F. T., Antoniazzi, L. B., Aguiar, D. A., Bacchi, M. R. P. and Adami, M, 2008. Prospects of the Sugarcane Expansion in Brazil: Impacts on Direct and Indirect Land Use Changes. In: <u>Sugarcane Ethanol: Contributions to Climate Change Mitigation and the Environment</u>. Zuurbier, P, Vooren, J (eds). Wageningen: Wageningen Academic Publishers.

Support Spatial Information
Example of Expansion in the Amazon: Data from Soybean Moratorium Project

Amazon Biome: Deforestated Area under Monitoring from 2006 to 2008 by Land Use Classes (hectares)

Total area cleared monitored by the moratorium: 157,896 hectares

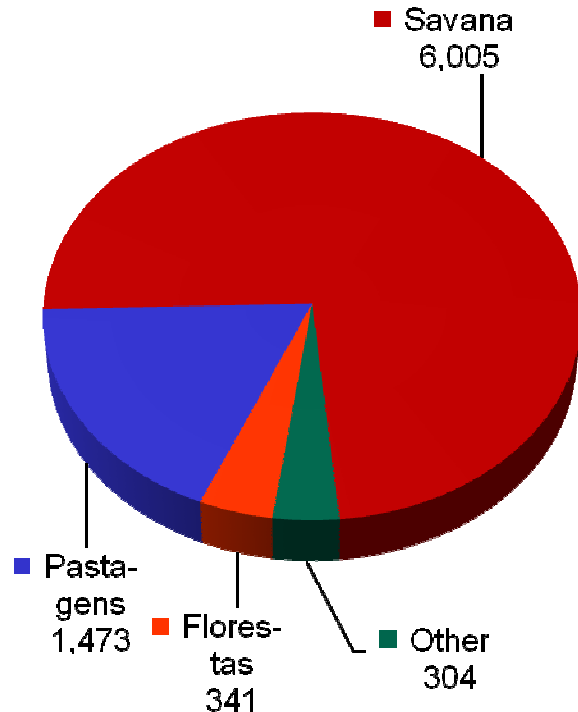- 83,872 53%
- 50,240 32%
- 6,328 4%
- 3,730 2%
- 13,727 9%

Legend:
- Pastures
- Deforestation and burning
- Crops
- Vegetation recover
- Other

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Source: Abiove e Globalsat (www.abiove.com.br).
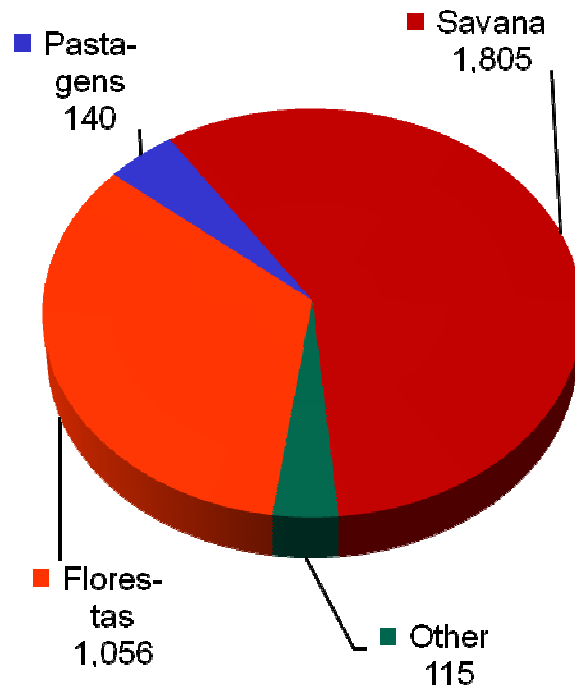
Support Spatial Information
Example of Expansion over Natural Vegetation and Pastures:
Winrock International Analysis to EPA

Land Use Changes Resulting from Crops Expansion (2001 to 2004)

Brazil (8.1 million ha)

- Savana 6,005
- Pasta-gens 1,473
- Flores-tas 341
- Other 304

Indonesia (3.1 million ha)

- Pasta-gens 140
- Savana 1,805
- Flores-tas 1,056
- Other 115

U.S. (14.6 million ha)

- Pasta-gens 8,974
- Savana 3,098
- Other 1,510
- Flores-tas 1,076

Fonte: Winrock International.
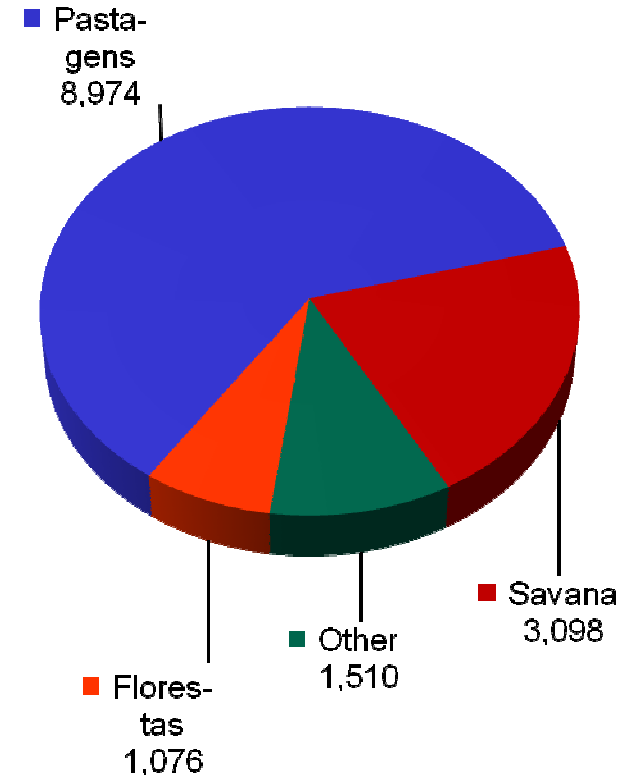
Support Spatial Information
Deforestation and Land Conversion (1,000 ha)

Amazon Deforestation

	Deter		Prodes
	jan-dez	jan-mai	
2005	2,323		1,885
2006	935		1,411
2007	693	129	1,153
2008	733	373	1,197
2009		54	

Source: http://www.obt.inpe.br/prodes/prodes_1988_2008.htm

Cerrados: Deforestation Alerts (modifications in the natural vegetation) from 2003 to 2007

State	Deforestation Alerts (thousand ha, from 2003 to 2007)	Cerrados Area within the State (original area) (thousand ha)
MT	669	35,883
BA	281	15,135
PI	240	9,344
TO	215	25,280
MA	207	21,255
GO	111	32,959
MG	92	33,371
MS	79	21,637
PR	3	374
SP	2	8,114
DF	1	580
Total	1,898	203,933
Region 1	3	374
Region 2	93	41,485
Region 3	859	91,060
Region 4	0	0
Region 5	0	0
Region 6	943	71,014

Source:
http://www.lapig.iesa.ufg.br/lapig/alerta/notas_tecnicas.pdf