CTBE

2nd Workshop on the Impact of New Technologies on the Sustainability of the Sugarcane/Bioethanol Production Cycle

Research Agenda: Assessing Impacts of Sugarcane Ethanol Production and New Technologies on Land Use Changes

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Key Issues on DLUC/ILUC

- GHG emissions associated to DLUC/ILUC: 2 steps
  - Step 1: Assess the cause-effect relations associated to land use changes
    - Anthropized areas / Frontier (conversion of natural vegetation)
    - Historical patterns / Projections
    - Physical and economic variables
    - No winner methodology: economic-based models (yesterday Mairi's presentation), allocation methodologies (RTFO deterministic approach), precautionary approach
    - **DLUC can be observed (INPE/CANASAT)**
    - **ILUC is measurable but not observable (individual marginal contribution to the ILUC)**
  - Step 2: Converting changes on land use in GHG emissions
    - Spatial explicitly models
    - Carbon stocks and emission coefficients (yesterday Cerri's presentation)

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Key Issues on LUC/ILUC

- Level of aggregation (valid for the 2 steps)
  - Country? Macro-regions? Micro-regions?
  - Flaws of the current methodologies: land use changes and GHG associated emissions calculated in a country level
- National-level or company-level
  - DLUC: okay
  - ILUC: not okay for company level (allocation methodology using coefficients calibrated in national level?)
- Descriptive or normative approach?
  - Descriptive: models representing the future expansion (based on historical patterns) dynamics of the Brazilian agricultural sectors and its impacts in land use changes (direct and indirect)
    - LUC magnitude
  - Normative: policies and actions oriented to minimize DLUC and ILUC (pasture intensification, increasing yields, no tillage systems, zero deforestation, etc.)
    - Recalculate LUC magnitude

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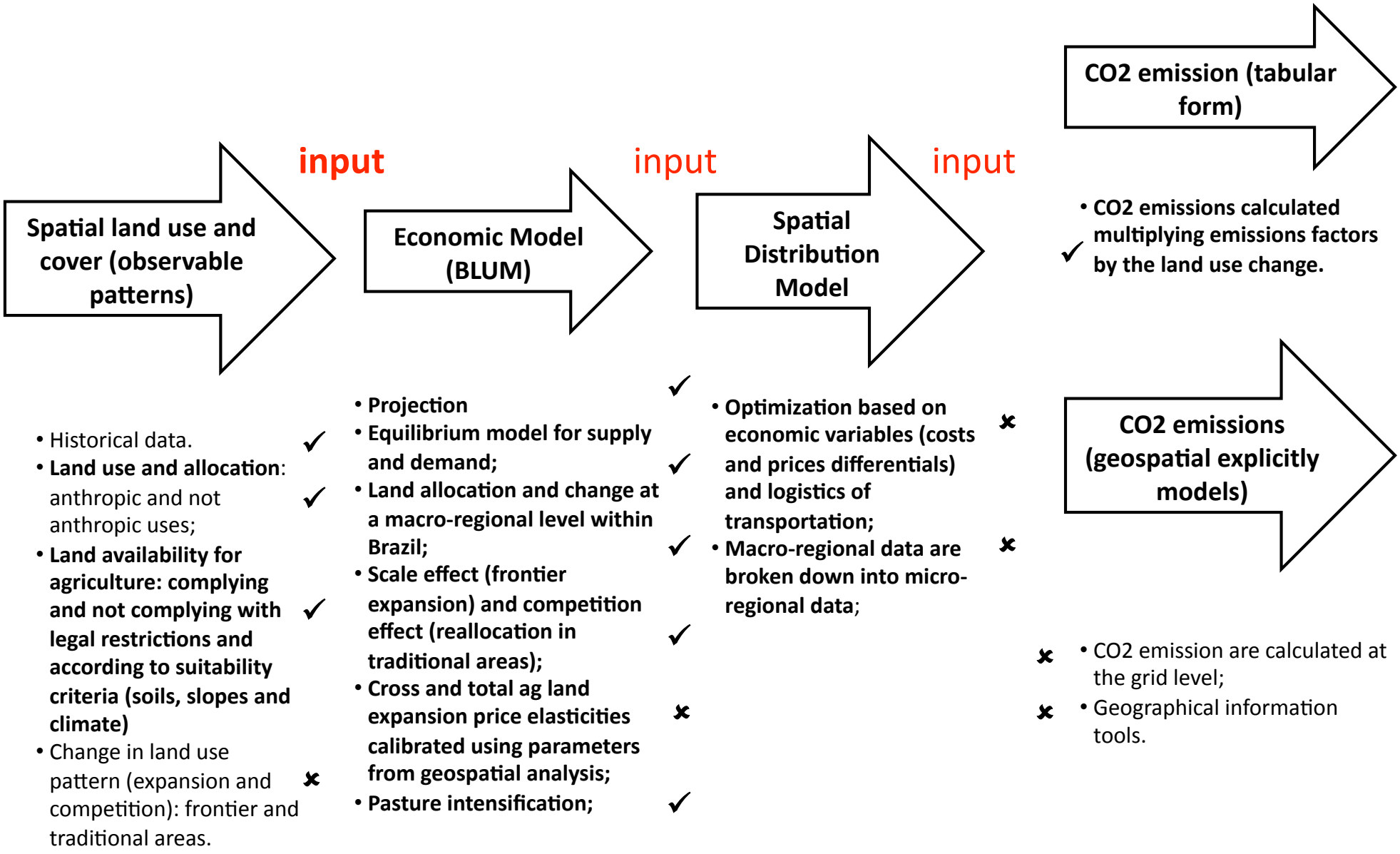
Conceptual Framework for Measuring LUC (using an economic model)



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Fundamental Objective of a Research Agenda

- To establish a pattern (cause-effects relations) of land use change in Brazil as a result of the agricultural and forestry sector dynamics.
  - Data are more important than models/methodologies
  - Gather all data is very difficult
    - Combination of different sources and evidences
    - Incremental accumulation of data and knowledge
  - Two methodological aspects related to the data need
    - Competition effect (substitutions and direct displacement)
    - Scale effect (conversion of natural vegetation)
- Evidences available
  - Canasat (direct effect of sugarcane expansion)
  - Soybean moratorium (grains and pastures in recently cleared land in the Amazon Biome)
  - IBGE municipal agriculture production survey (PAM): shift share (allocation methodology, unfortunately no pasture data)
  - 1996 and 2006 Agriculture Census => pastures
  - Data combination: Census, PAM and spatial information

Example of Direct Substitution: Remote Sensing

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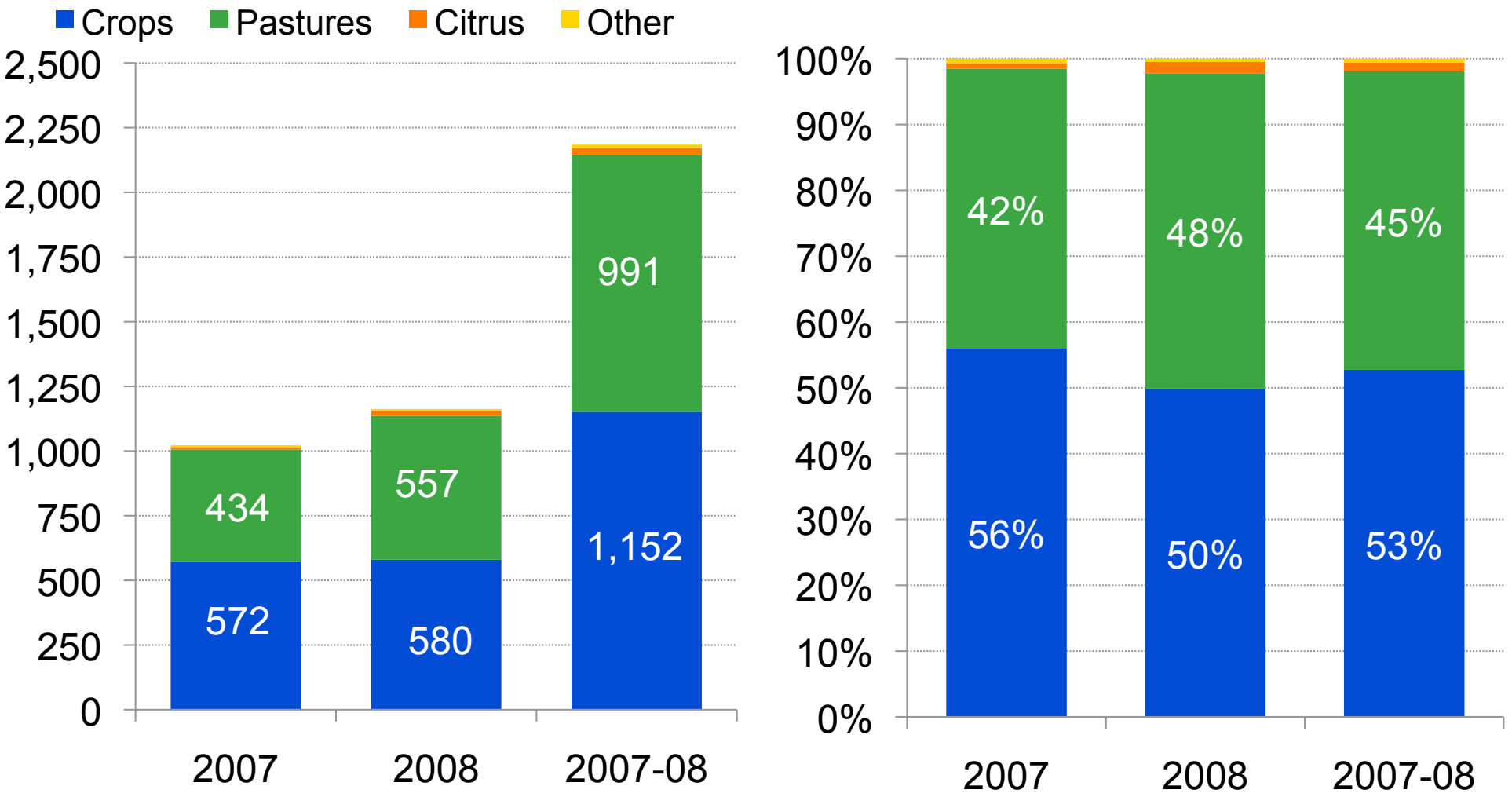
South-Central Region: Classes of Land Use Converted to Sugarcane,, 2007 and 2008 (1,000 ha)

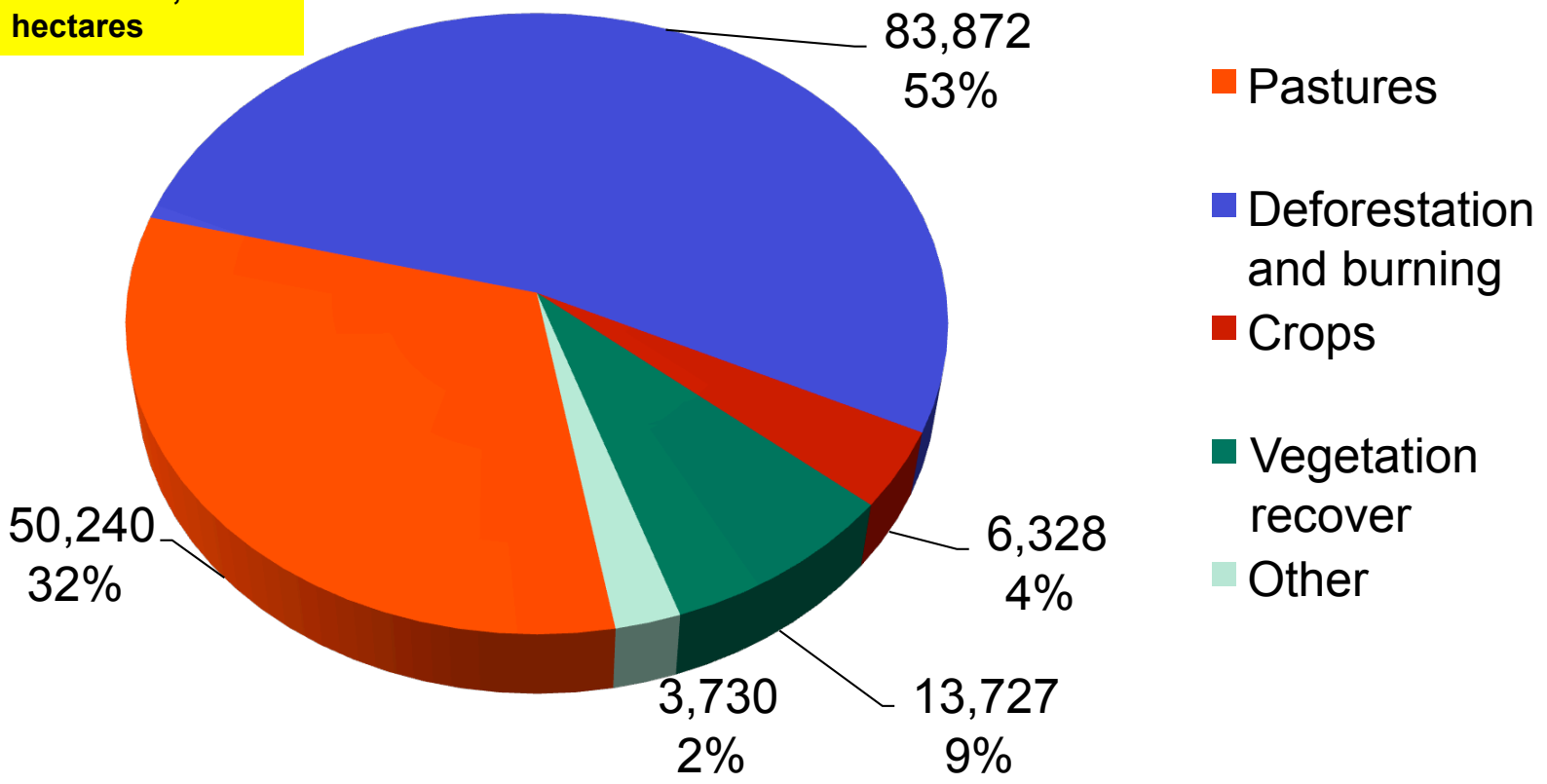


Source: CANASAT/INPE, published in Nassar, A.M., Rudorff, B. F. T., Antoniazzi, L. B., Aguiar, D. A., Bacchi, M. R. P. and Adami, M, 2008. Prospects of the Sugarcane Expansion in Brazil: Impacts on Direct and Indirect Land Use Changes. In: Sugarcane Ethanol: Contributions to Climate Change Mitigation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

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



Source: Abiove e Globalsat (www.abiove.com.br).

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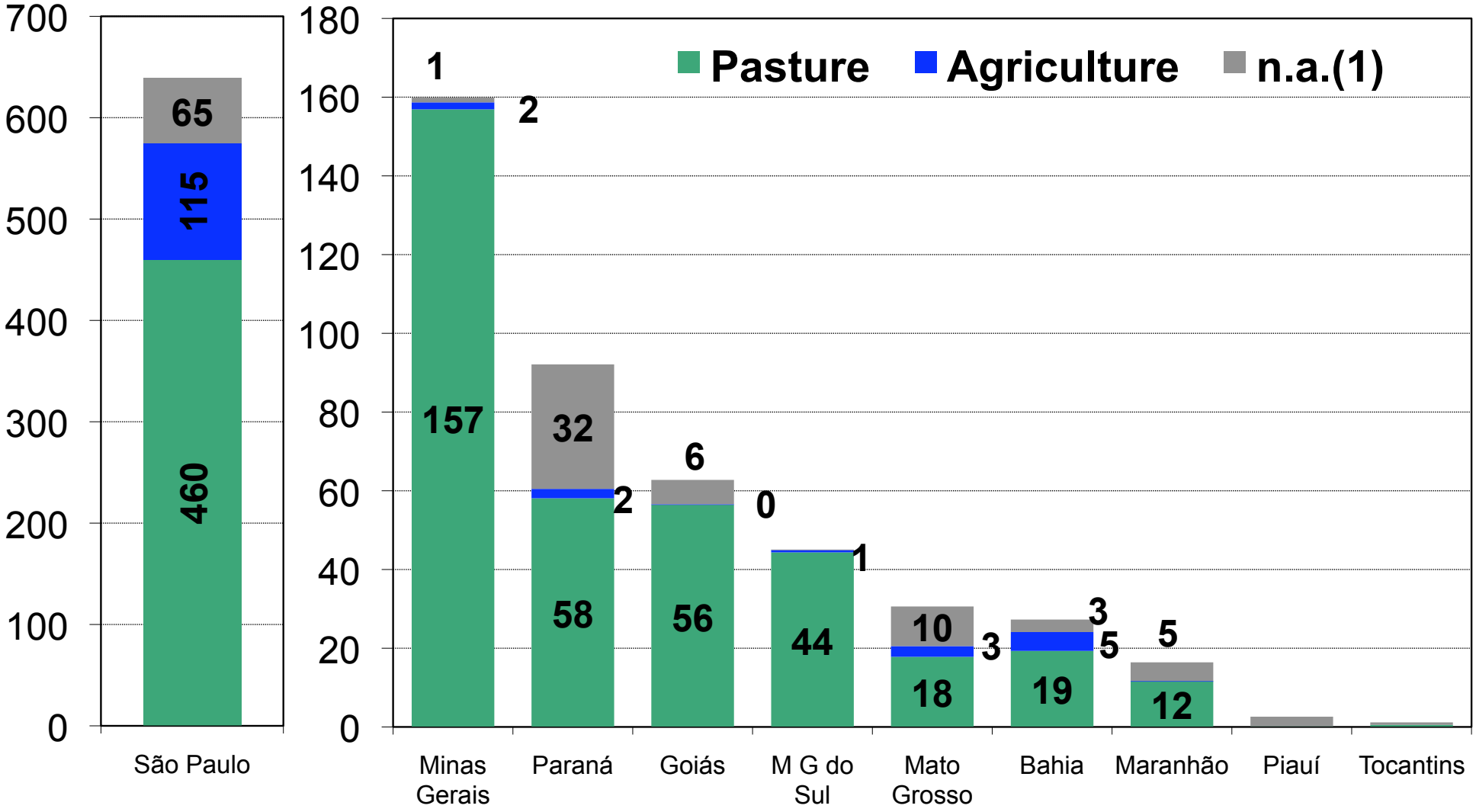
Secondary Data

Expanded South-Central Region: Land Use Classes Allocated to Sugarcane, 2002 to 2006 (1,000 ha)



(1): n.a. (not allocated): means not allocated over previous productive area.

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
Total	1,000	5,446	-5,385	1,061	18,383

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

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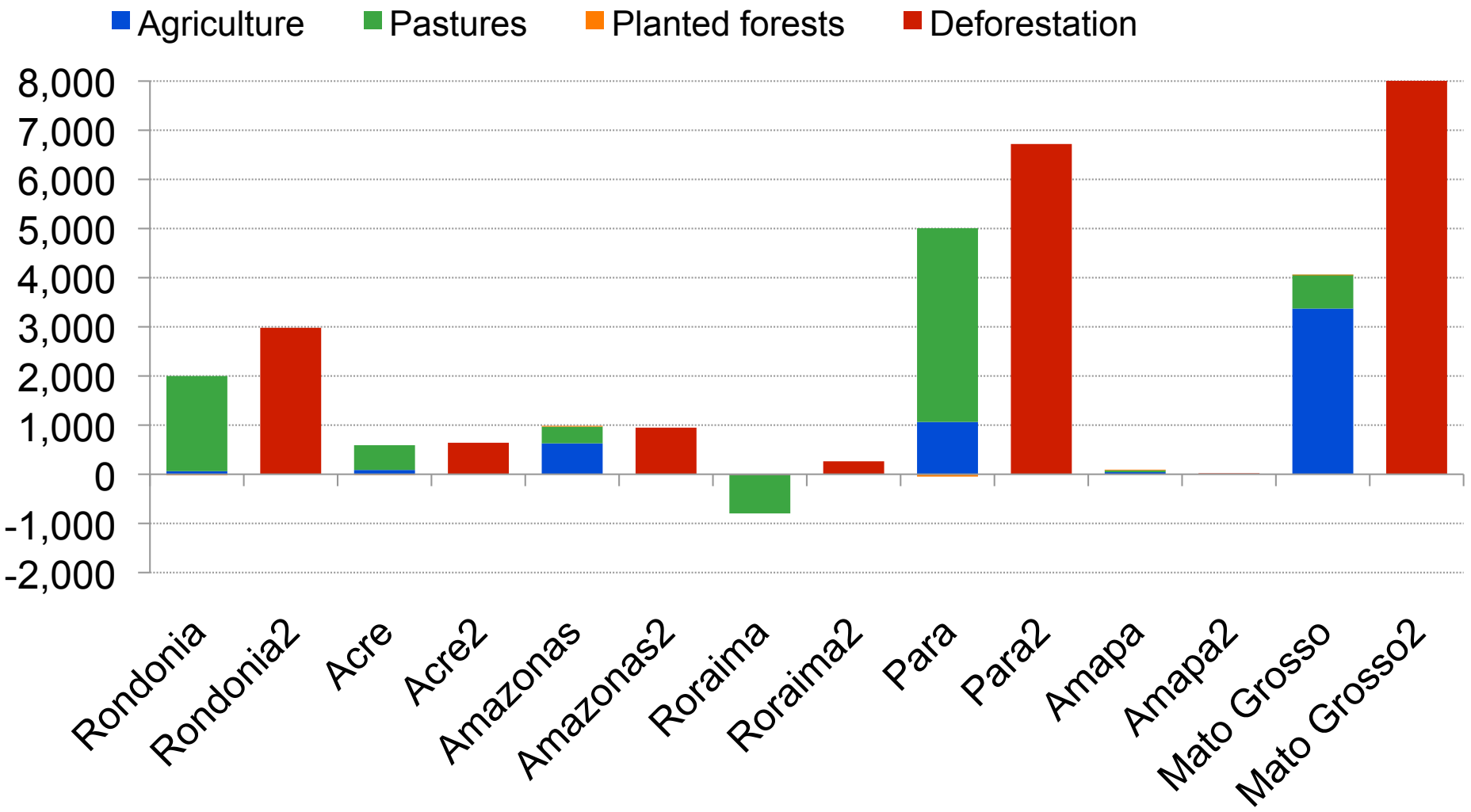
Effects of the Expansion of Agriculture, Forestry and Pasture on Amazon Deforestation

Absolute Variation on Occupied Area with Productive Purposes and Deforestation from 1996 to 2006
Captured by the Agricultural Census and Prodes-INPE



Source: Censo Agropecuário de 2006/IBGE e PRODES/INPE

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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

Sugarcane Expansion: Simulation Using EPA RFS Scenarios (2.5 billion gallon demand shock)

			2008	2022 (baseline)	2022 (shock)
Sugarcane	Production	mil ton	648,848	969,046	1,082,989
	Area	mil ha	8,200	10,525	11,558
Sugar	Production	mil ton	31,947	43,845	43,767
	Domestic Consumption	mil ton	11,006	13,872	13,772
	Exports	mil ton	21,160	29,987	29,987
Ethanol	Production	mil m3	25,720	53,646	63,188
	Domestic Consumption	mil m3	22,778	41,326	41,326
	Exports	mil m3	4,137	12,367	21,816

Fonte: ICONE.

Center-West Cerrados: Land Use Change from 2008 to 2022

		Activity capture land (colunm)						
		Corn	Soybean	Cotton	Rice	Dry bean	Sugarcane	Balance
Activity lose land (row)	Corm	-814.0	285.9	856.6	84.0	-0.4	206.6	1,432.7
	Soybean	205.9	3,484.8	84.8	2.0	-0.1	71.2	363.8
	Cotton	183.0	25.2	599.7	2.1	-0.1	15.8	226.0
	Rice	64.4	2.1	7.7	27.5	-0.1	1.8	76.0
	Dry bean	1.9	0.6	2.3	0.3	13.3	0.7	5.9
	Sugarcane	31.4	15.0	11.3	0.4	0.0	304.7	58.1
	Balance gain	486.6	328.9	962.7	88.8	12.6	296.2	
	Balance gain - loss	-946.1	-34.9	736.7	12.8	6.7	238.1	
	Pasture displacement	132.1	3,519.7	-137.0	14.7	6.5	66.6	3,602.6

Pasture loss	3,602.6
Pasture net expansion	167.9
Total ag land expansion	3,783.8
Crops expansion (net)	3,615.9
Pasture over savana	3,770.5
Crops over savana	13.3

Source: ICONE/BLUM, elaborated using EPA RFS Scenarios

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ILUC Resulting from Sugarcane Expansion: Estimate Using EPA RFS Scenarios (2.5 billion gallons demand shock)

Table 5 – Sugarcane displacement for the shock scenario comparing to baseline scenario

	South	Southeast	Center West	North Amazon	Northeast Coast	MAPITO & Bahia	Brazil
a) Sugarcane Expansion	79.1	708.5	101.5	8.8	118.9	15.7	**1,032.5**
b) Grains to Sugarcane	72.9	470.4	98.7	5.5	0.2	13.6	**661.3**
c) Pasture to Sugarcane	6.2	238.1	2.8	3.3	118.7	2.1	**371.2**
d) Total Ag Land Expansion	21.2	**99.6**	**48.4**	23.2	4.0	9.4	**205.8**
e) Grains Expansion	-39.0	-342.4	-66.3	8.3	12.1	5.5	-421.7
f) Pasture to Grains	34.0	128.0	32.5	13.8	12.3	19.1	239.6
g) Pasture Total Loss	40.1	366.2	35.2	17.1	131.0	21.2	610.8
h) Pasture Net Loss	19.0	266.5	-13.2	-6.1	127.0	11.8	405.0

Fonte: ICONE.

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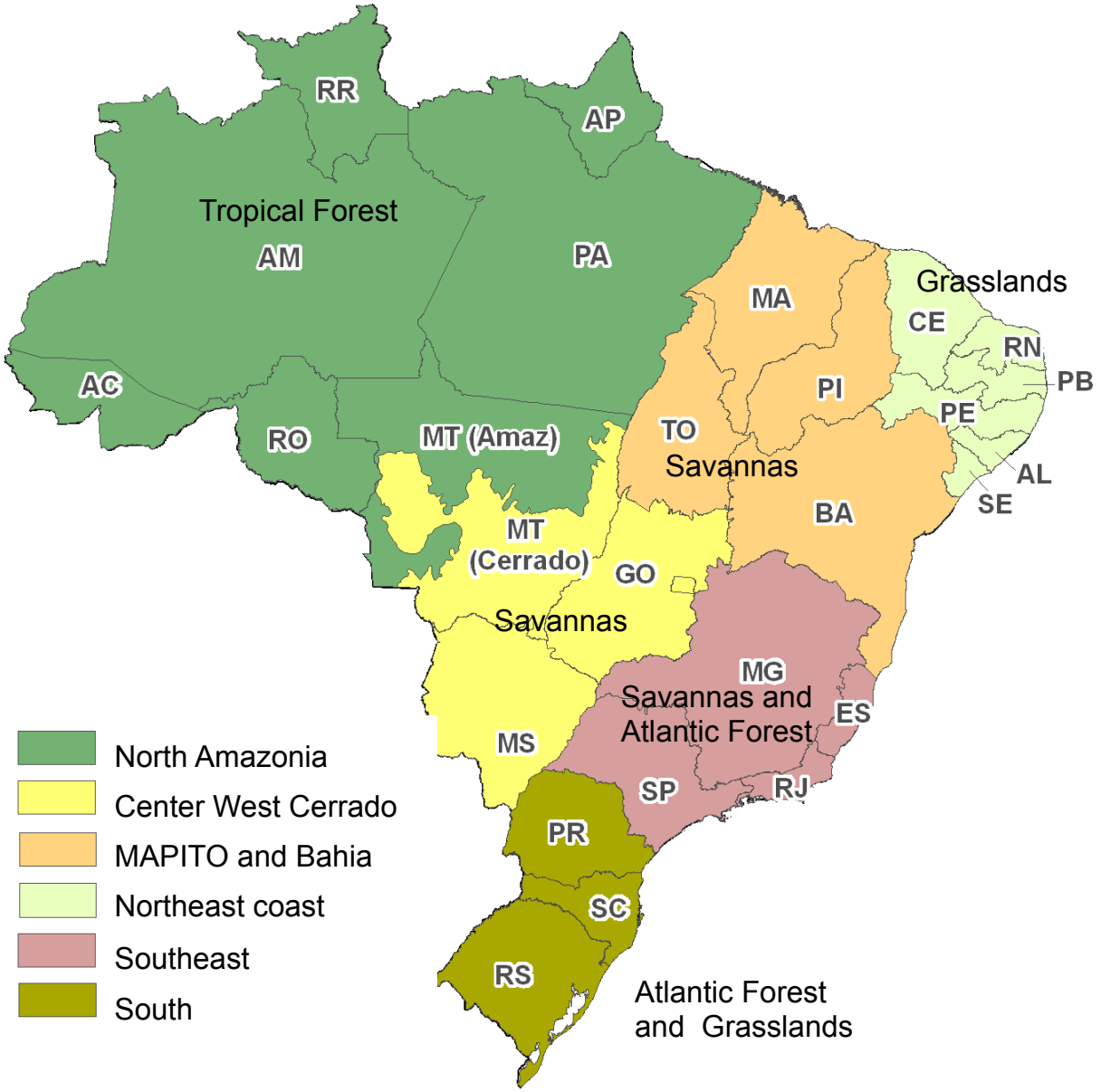
Research Agenda

- Improve your knowledge on the land dynamics of the agricultural and forestry sectors in Brazil
  - Competition and scale processes
  - Satellite images, secondary data
- Establish an routine to combine land use changes and GHG emissions calculations
  - Macro (regions, micro-regions), micro level (industrial unity), spatial analysis
- Improve the economic modeling (BLUM) to capture effects of new technologies on land demand and land allocation
  - To project supply of ethanol, sugar, co-generation replicating a mill behavior (optimizing the use of the sugarcane given an expectative of prices and returns) => number of mills equal to the number of regions
  - To project cattle herd and pastures demand maximizing production factors (land and capital) and different production systems
  - Incorporate market forces that drives productivity up
    - Effects of prices in yields (sugarcane and TRS)
    - Higher efficiency in the industrial process (crushing, fermentation, heating, etc.)

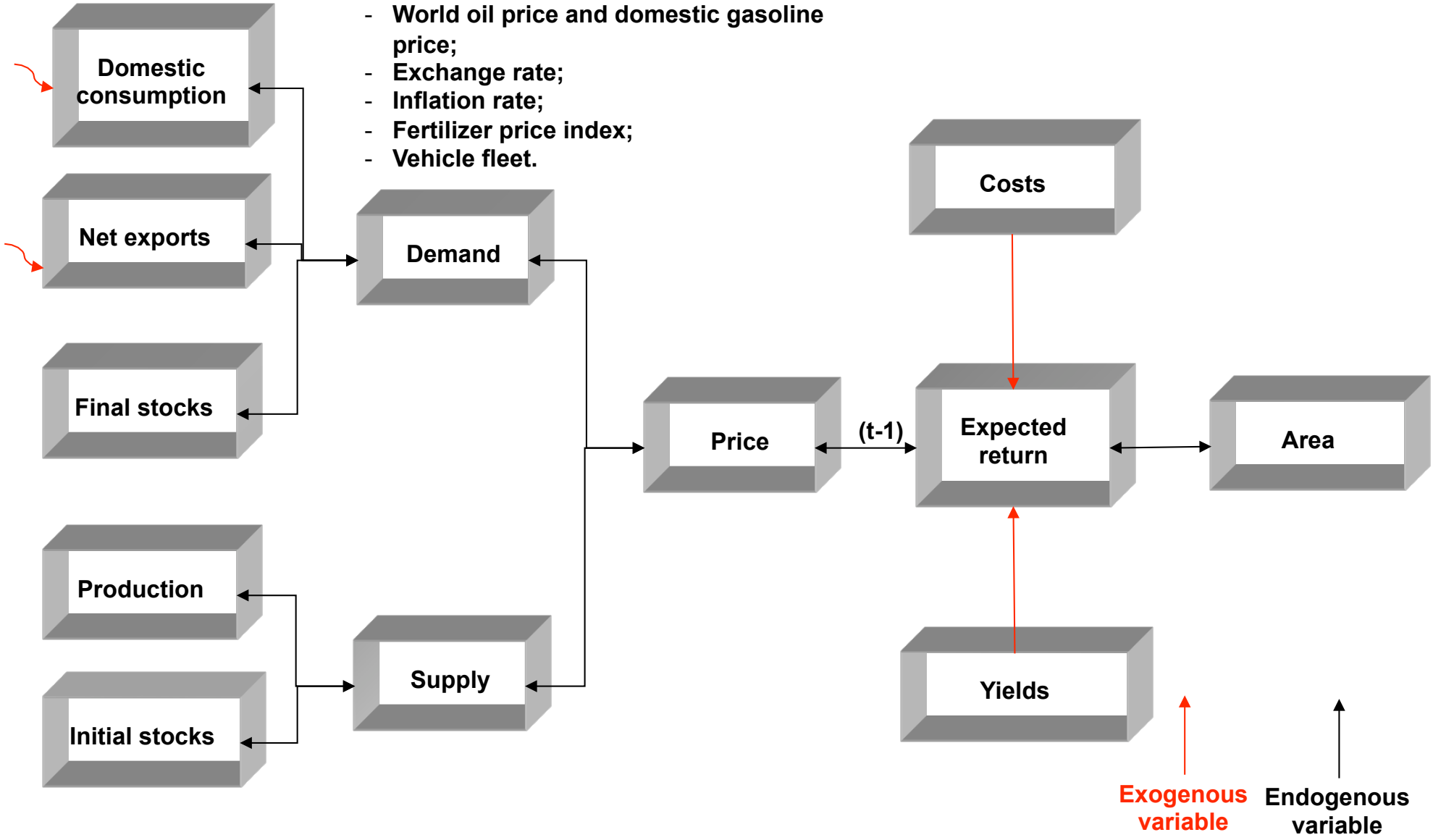
Macro-Regions Used in the Brazilian Land Use Model (BLUM)



Source: ICONE.

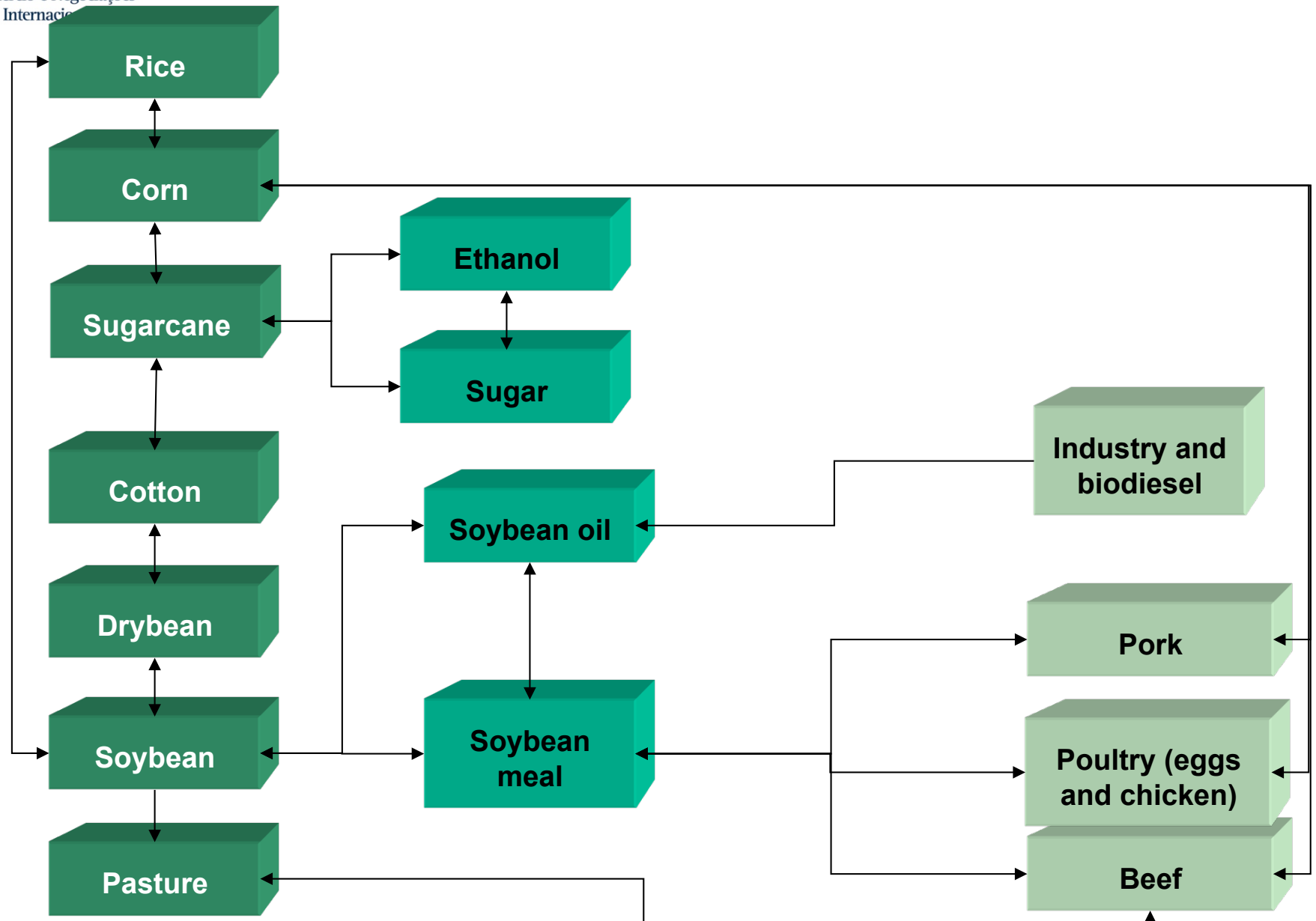
Structure of the Supply and Demand Section

Exogenous macroeconomic data
- **Population;**
- **World and national GDP;**
- **World oil price and domestic gasoline price;**
- **Exchange rate;**
- **Inflation rate;**
- **Fertilizer price index;**
- **Vehicle fleet.**



Source: ICONE.

Activities Covered by the Model



Source: ICONE

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BLUM Formal Description

- The **area of each *i* activity** in region *l* and time *t* (a_{ilt}) is defined as

$$a_{ilt} = A^T m\left(r_{lt}\right) s_{ilt}\left(r_{ilt}, r_{-ilt}\right)$$

A^t is the total land available in the region (estimated from GIS);
m is the share of land in agricultural uses in region
$S_{ilt}(r_{ilt}, r\text{-}_{ilt})$ is the share of the agricultural land devoted to activity *i*, region *l* and time *t*.

- The **share of total area** that is dedicated to agricultural production folows a logistic function such as

$$m_t = \frac{1}{1 + b * \exp(c * r_t)}$$

Where b and c are parameters to be defined, and r_t is the average revenue of the region.

- For the country $A_{it} = \sum_{l=1}^{6} a_{ilt}$

- **Product elasticities:**

Scale Competition

Cross elasticities

$$\varepsilon_{r_{lj}}^{l,i} = \frac{\partial m_l\left(r_{lt}\right)}{\partial r_{lt}} \frac{\partial r_{lt}}{\partial r_{j\,lt}} \frac{r_{j\,lt}}{m_l\left(r_{lt}\right)} + \frac{\partial s_{ilt}\left(r_{ilt}, r_{-ilt}\right)}{\partial r_{j\,lt}} \frac{r_{j\,lt}}{s_{ilt}\left(r_{ilt}, r_{-ilt}\right)}$$

Own elasticities

$$\varepsilon_{r_{li}}^{l,i} = \frac{\partial m_l\left(r_{lt}\right)}{\partial r_{lt}} \frac{\partial r_{lt}}{\partial r_{ilt}} \frac{r_{ilt}}{m_l\left(r_{lt}\right)} + \frac{\partial s_{ilt}\left(r_{ilt}, r_{-ilt}\right)}{\partial r_{ilt}} \frac{r_{ilt}}{s_{ilt}\left(r_{ilt}, r_{-ilt}\right)}$$

Obtaining consistent regional elasticities

Own return elasticities

Homogeneity
$$\sum_j s_{ij} = 0$$
Symmetry
$$s_{ij} = s_{ji}$$
Adding up
$$\sum_i s_{ij} = 0$$

Aditional information:
- Agronomic similarity (GIS)
- level of competition due to investments
- others

Competition elasticities (1st crops) *

	Corn1	Soyb.	Cotton	Rice	beans	Scane	Past.
Corn 1st crop	0,18	-0,26	0,00	0,00	0,00	-0,03	0,00
Soybeans	-0,07	0,40	0,00	0,00	0,00	-0,01	-0,02
Cotton	-0,05	-0,07	0,21	-0,03	0,00	-0,06	0,00
Rice	0,00	-0,02	0,00	0,15	-0,03	0,00	0,00
Dry beans 1	-0,03	-0,01	0,00	-0,22	0,09	-0,01	0,00
Sugarcane	-0,04	-0,04	0,00	0,00	0,00	0,39	0,00
Pasture	0,00	-0,13	0,00	0,00	0,00	0,00	0,01

area

Scale elasticities

Total ag-land elasticity

Returns

External
Estimated
Calculated

(*) Note: elasticities values are preliminary

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Muito obrigado!

Mantenedores

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