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1ST BIOFUELS INTERNATIONAL CONFERENCE

How to Measure the Impact of Biofuels on Climate Change

Andre Nassar

Sao Paulo
27 May 2010

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Outline

- The “state of the art” on land use change debate (direct and indirect effects methodologies)
- Methodological challenges
- Advances and evidences
- Research agenda

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Methodologies under development to calculate land use change

- Projections based on economic models and scenarios of ethanol demand (ILUC is measured at the margin) => projections;
  - General Equilibrium:
    - GTAP (Purdue University) actually being integrated with SAGE - Global Land Use Data (University of Wisconsin-Madison) => used in CARB/LCFS
    - MIRAGE (CEPII and IFPRI), with FAO land use database => used in by the European Commission, for the Directive on Biofuels;
    - LEITAP (economic model) and IMAGE (land use, yield and CO2 emissions model), developed by the Wagenigen University.
  - Partial equilibrium:
    - FAPRI/CARD => used for EPA/RFS
    - Aglink/OECD e FAO => used in by the European Commission, for the directive on biofuels
    - Regional /country models:
      - US: FASOM (optimization model that distributes land use by county)
      - Europe: CAPRI
      - Brazil: BLUM (integrated with the FAPRI/CARD world models)
- Allocation methodologies based on historical patterns (ILUC is measured at the average) => deterministic methodologies.
  - Greenergy (Technical Paper - TP-080212-A), Ensus
- The lack of acceptable methodology yields to the precautionary approach: pre-established criteria that guaranties ILUC zero.
  - RCA (responsible cultivation areas methodology), Ecofys

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Key Issues on Land Use Change

- 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: Ag. Census, IBGE Surveys (PAM, PPM, LSPA), Conab crop assessments and spatial information

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Advances

ICONE Advances on ILUC Calculation (CGEE and FAPESP Projects)

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- What happens if one activity expands one hectare?
- Historical pattern on land use change using cause-effect approach, based on the definition of allocation factors due to land expansion:
  - Expansion coefficient: contribution of each economic activity on natural vegetation conversion into different productive uses;
  - Substitution coefficient: competition pattern between one activity and other productive uses.
- How to measure?
  - Using secondary data by micro region and establish expansion patterns (CGEE project):
    - IBGE planted area from PAM;
    - Commercial forests calculated using IBGE production on wood based products;
    - Deforestation data from INPE, LAPIG, SOS Mata Atlantica;
    - Pasture area as an adjustment of total agricultural area;
  - Using satellite images in order to confirm and re-calibrate the coefficients:
    - Cerrados' substitution and expansion patterns will be estimated by LAPIG using FAPESP funding;
    - INPE might calculate substitution and expansion patterns for all the Brazilian biomes and for different agricultural activities;
      - Considering expansion patterns only for sugarcane is not enough to measure ILUC

ICONE Advances on ILUC Calculation (CGEE and FAPESP Projects)

- Why is that important?
  - Calibrate elasticities in the BLUM: combining area expansion coefficients and prices (profitabilities) in order to calculate agricultural land supply elasticities and substitution elasticities;
    - Importance on combining GIS and economic modeling in order to measure land use changes;
    - Establish empirical patterns in order to calibrate elasticities for each activity;
  - GHG emissions calculated considering land use changes in different types of natural vegetation
    - Reduce the lack of information on natural vegetation conversion for agricultural purposes, under or overestimating GHG emissions;
    - Avoid assumptions on land use change patterns over different natural vegetation types and, also, over pasture areas;
- Are these advances enough to reduce uncertainties on measuring ILUC?
  - Uncertainties related to GHG coefficients:
    - IPCC default has to be revised considering scientific advances in Brazil
  - Inserting economic modeling into spatial explicit models
    - Supply and demand from economic model considered in a down-scale modeling, considering land use changes patterns regionally;
      - GHG emissions calculation for a country might consider regional dynamics

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Evidences

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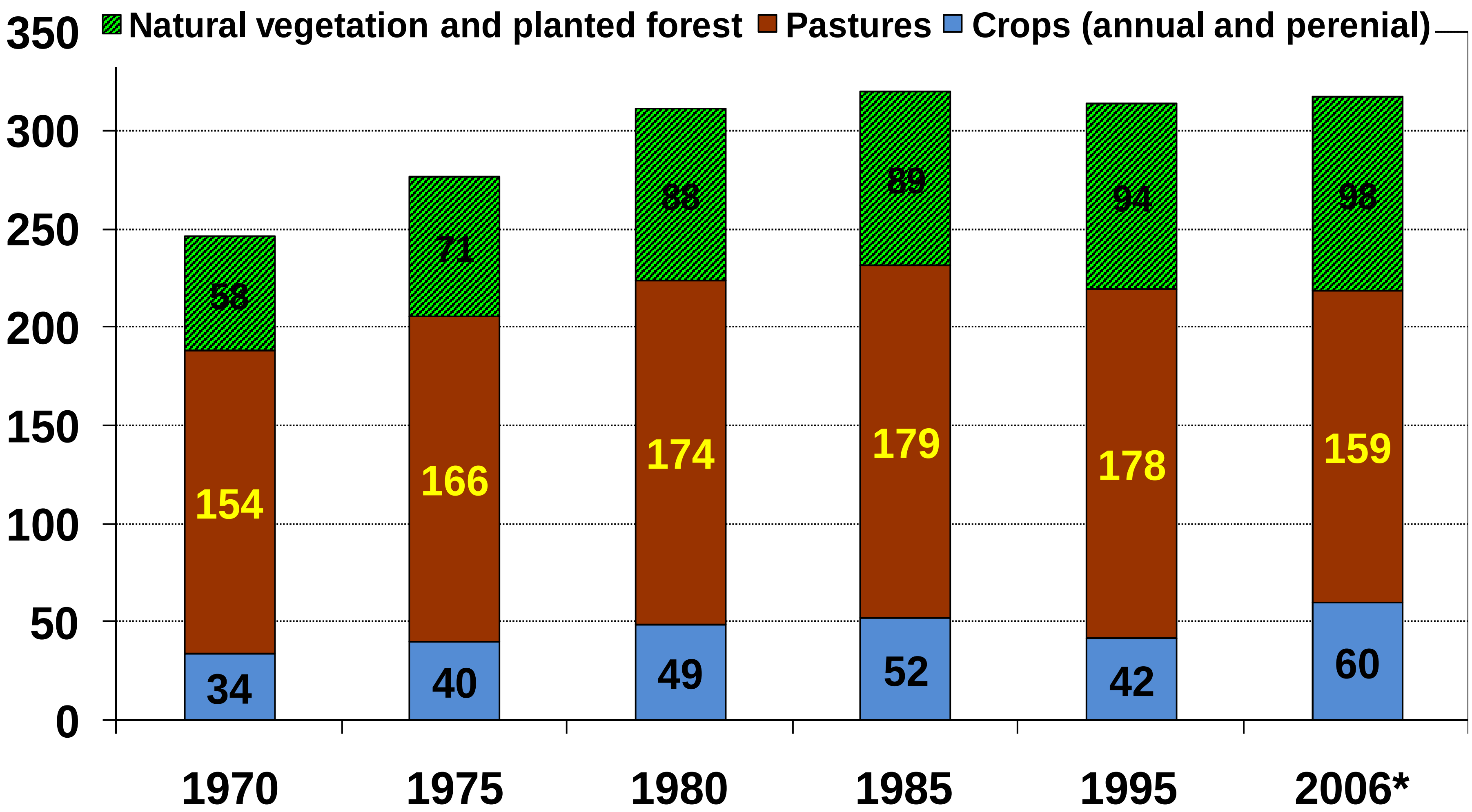
Brazil: Agricultural Land Use

(Agricultural Census, million ha)



Source: IBGE (Agricultural Census).
* Crops: it includes silage for animal feeding.

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

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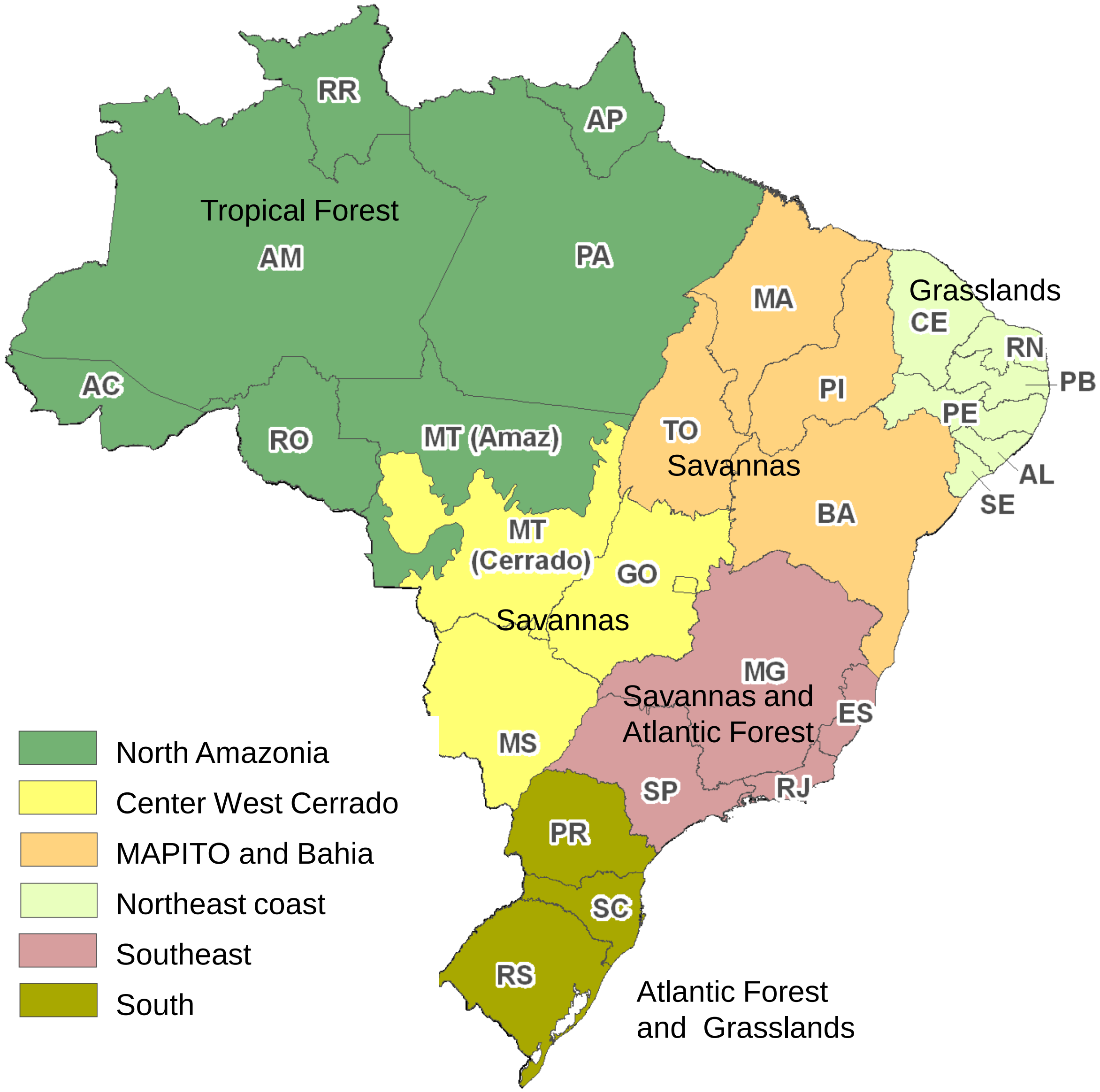
- Substitution and Expansion coefficients were calculated by micro-region
- Coefficients' matrices presented by BLUM macro-regions



Source: ICONE.

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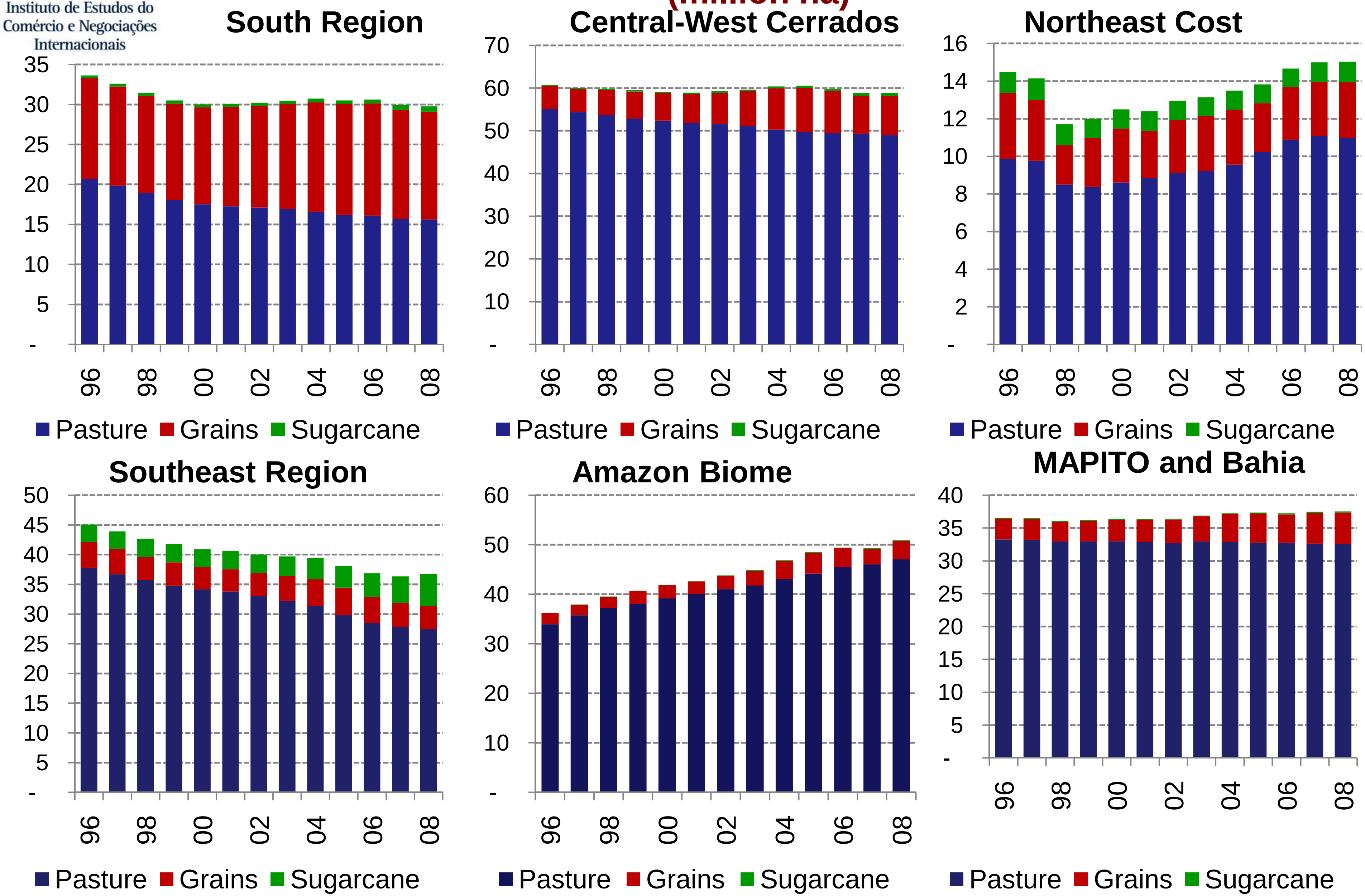
Evolution of Sugarcane, Grains and Pasture Area in Agricultural Regions (million ha)



Source: data combination (Agricultural Census/IBGE, Producao Agricola Municipal/IBGE; Producao Pecuaria Municipal/IBGE, CONAB, spatial information.

Example of Direct Substitution: Remote Sensing

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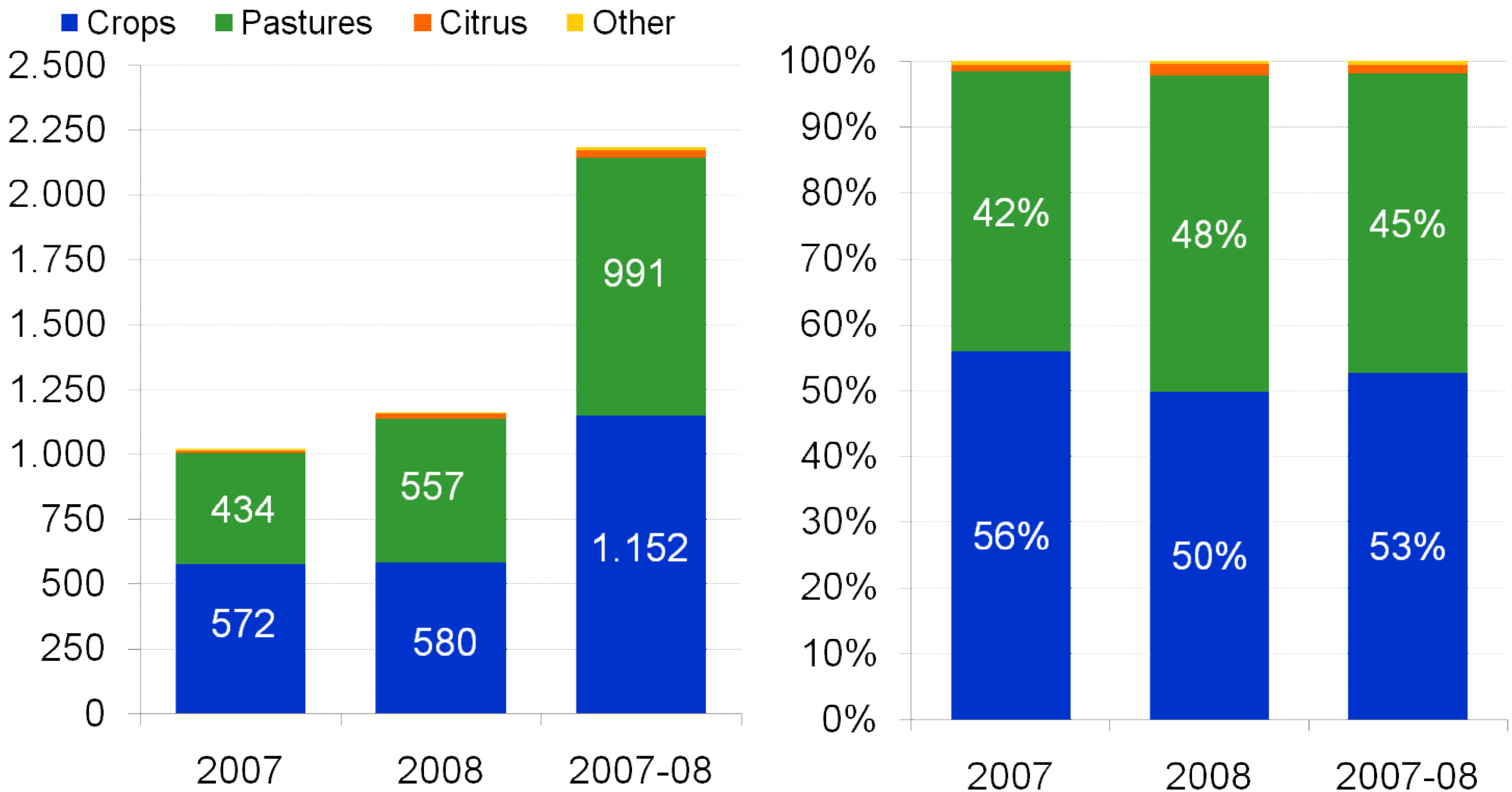
South-Central Region: Classes of Land Use Converted to Sugarcane, 2007 and 2008 (1,000 ha)



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.

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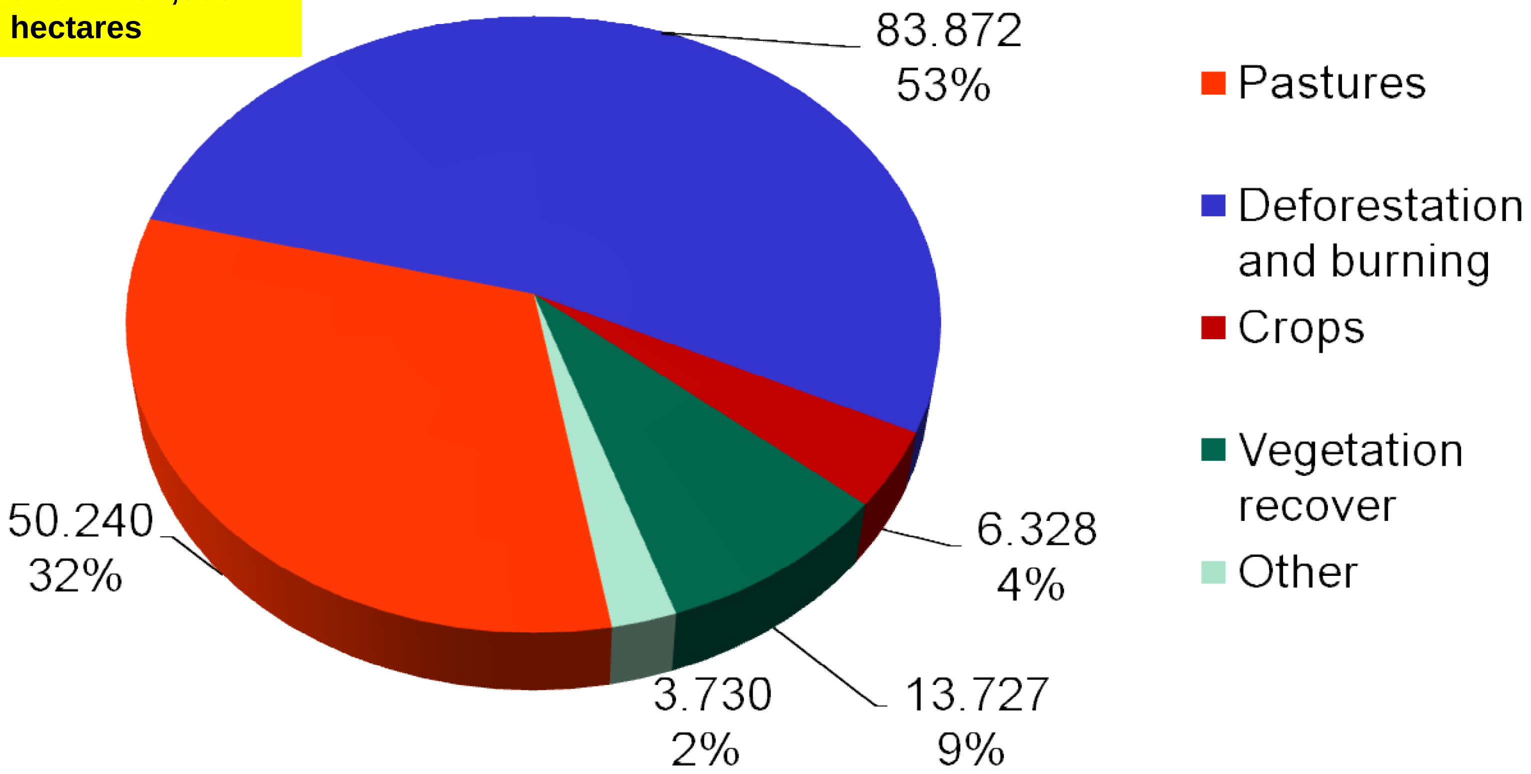
Example of Expansion in the Amazon: Data from Soybean Moratorium Project

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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Methodology Used to Calculate Allocation Coefficients

- Secondary data form IBGE using planted area database starting on 2002 and average from 2006 to 2008:
  - PAM planted area for soybeans, sugarcane, rice, cotton, corn (first season harvested area); drybeans, other temporary crops (excluding winter crops); permanent crops;
  - Commercial forest by micro-region was estimated using IBGE production database for wood based products (not yet implemented).
- Satellite images for deforestation:
  - Amazon: Prodes-INPE
  - Cerrado: LAPIG
  - Atlantic Forest: SOS Mata Atlantica (not yet implemented)
- Pasture area as a residual:
  - Variation of pasture area is calculated by the difference between deforestated area and total area used by permanent and temporary crops;
    - Assumption: all anthropized area is used for agricultural activities

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Methodology Used to Calculate Allocation Coefficients

Cases	Δ Deforesta-tion	Δ Crops	Δ Pasture	Methodological Approach
Crops and pasture expansion	(+)	(+)	(+)	Proportional allocation of pasture and crops over natural vegetation.
Only crops expansion	(+) or 0	(+)	(-)	Proportional allocation of crops over pasture and natural vegetation.
Only pasture expansion	(+) or 0	(-)	(+)	Proportional allocation of pasture over crops and natural vegetation.

Source: ICONE.

- Special cases for sugarcane: since satellite images shows that there is no expansion of sugarcane over natural vegetation, other decision criteria were used;
- Results are in terms of estimated matrices for 1 hectare expansion of each activity considered;
  - Special attention for sugarcane expansion and its direct and indirect impacts – base for calculating ILUC factor.

Allocation Coefficients Results: South Region

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	Sugar-cane	Soybean	Corn	Cotton	Rice	Drybeans	Perma-nent	Other temp.	Pasture	Defores-tation
Sugarcane	1,00	0,00	0,02	0,01	0,01	0,00	0,02	0,00	0,00	0,00
Soybean	0,05	1,00	0,10	0,00	0,00	0,04	0,03	0,07	0,20	0,00
Corn	0,06	0,15	1,00	0,00	0,05	0,37	0,21	0,18	0,55	0,00
Cotton	0,05	0,01	0,01	1,00	0,00	0,00	0,00	0,00	0,00	0,00
Rice	0,02	0,03	0,02	0,02	1,00	0,02	0,01	0,02	0,05	0,00
Drybeans	0,06	0,05	0,04	0,01	0,03	1,00	0,08	0,06	0,13	0,00
Permanent	0,10	0,02	0,02	0,07	0,04	0,01	1,00	0,03	0,04	0,00
Other temp.	0,01	0,01	0,00	0,00	0,04	0,01	0,07	1,00	0,03	0,00
Pasture	0,65	0,73	0,79	0,89	0,84	0,54	0,59	0,64	1,00	0,00
Deforestation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00

Source: ICONE.

- Since almost all crops expands in the South region, and due to no deforestation in this previous analysis, more than 60% of crops expansion occurs over pasture areas.
  - Small amount of land available in the South.

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Allocation Coefficients Results: Southeast Region

	Sugar-cane	Soybean	Corn	Cotton	Rice	Drybeans	Perma-nent	Other temp.	Pasture	Defores-tation
Sugarcane	1,00	0,00	0,01	0,00	0,02	0,01	0,01	0,01	0,09	0,00
Soybean	0,06	1,00	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,00
Corn	0,07	0,01	1,00	0,04	0,05	0,03	0,04	0,03	0,14	0,00
Cotton	0,02	0,01	0,02	1,00	0,05	0,05	0,02	0,02	0,01	0,00
Rice	0,01	0,01	0,01	0,04	1,00	0,01	0,02	0,01	0,04	0,00
Drybeans	0,01	0,04	0,03	0,03	0,03	1,00	0,03	0,03	0,07	0,00
Permanent	0,06	0,04	0,08	0,03	0,08	0,09	1,00	0,03	0,32	0,00
Other temp.	0,02	0,00	0,02	0,00	0,02	0,02	0,02	1,00	0,04	0,00
Pasture	0,74	0,61	0,73	0,43	0,63	0,68	0,69	0,70	1,00	0,00
Deforestation	0,01	0,28	0,10	0,43	0,13	0,12	0,16	0,17	0,28	1,00

Source: ICONE.

- Most important region for sugarcane and ethanol production;
  - Sugarcane increased 1.6 million hectares;
  - 74% of sugarcane expansion was over pasture areas;
  - 28% of pasture expansion was over Cerrado;

Allocation Coefficients Results: Center-West Cerrado Region

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	Sugar-cane	Soybean	Corn	Cotton	Rice	Drybeans	Perma-nent	Other temp.	Pasture	Defores-tation
Sugarcane	1,00	0,00	0,01	0,00	0,00	0,00	0,04	0,01	0,00	0,00
Soybean	0,06	1,00	0,04	0,08	0,00	0,07	0,01	0,01	0,01	0,00
Corn	0,09	0,01	1,00	0,00	0,02	0,02	0,02	0,07	0,00	0,00
Cotton	0,08	0,01	0,03	1,00	0,02	0,00	0,02	0,00	0,00	0,00
Rice	0,09	0,05	0,06	0,05	1,00	0,02	0,08	0,04	0,01	0,00
Drybeans	0,01	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00
Permanent	0,01	0,00	0,00	0,00	0,01	0,00	1,00	0,01	0,01	0,00
Other temp.	0,06	0,01	0,02	0,02	0,04	0,00	0,02	1,00	0,00	0,00
Pasture	0,48	0,32	0,24	0,20	0,23	0,49	0,06	0,35	1,00	0,00
Deforestation	0,11	0,59	0,59	0,65	0,68	0,40	0,75	0,50	0,96	1,00

Source: ICONE.

- Most dynamic region for agricultural production;
  - Soybean increased 2.7 million hectares, mostly over Cerrado;
  - Sugarcane expanded 262 thousand ha, mostly over pasture, rice, corn and cotton;
  - Important region for corn as a second crop.

Allocation Coefficients Results: North-Amazon Region

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	Sugar-cane	Soybean	Corn	Cotton	Rice	Drybeans	Perma-nent	Other temp.	Pasture	Defores-tation
Sugarcane	1,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00
Soybean	0,00	1,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00
Corn	0,12	0,02	1,00	0,00	0,06	0,05	0,09	0,04	0,01	0,00
Cotton	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00
Rice	0,26	0,05	0,08	0,05	1,00	0,02	0,15	0,06	0,01	0,00
Drybeans	0,01	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00
Permanent	0,09	0,00	0,04	0,00	0,08	0,34	1,00	0,03	0,00	0,00
Other temp.	0,01	0,00	0,00	0,00	0,02	0,00	0,02	1,00	0,01	0,00
Pasture	0,21	0,07	0,05	0,16	0,00	0,04	0,00	0,06	1,00	0,00
Deforestation	0,30	0,86	0,82	0,79	0,84	0,54	0,72	0,80	0,98	1,00

Source: ICONE.

- In the Amazon, pasture is the most important land user;
  - Pasture increased 7 million ha, 98% over natural vegetation;
  - Soybean increased 1 million ha, mostly over pasture;
  - Sugarcane growth was only 32 thousand ha.

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Allocation Coefficients Results: Northeast Coast Region

	Sugar-cane	Soybean	Corn	Cotton	Rice	Drybeans	Perma-nent	Other temp.	Pasture	Defores-tation
Sugarcane	1,00	0,00	0,01	0,01	0,00	0,00	0,02	0,01	0,26	0,00
Soybean	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Corn	0,06	0,02	1,00	0,18	0,01	0,04	0,07	0,12	0,35	0,00
Cotton	0,02	0,28	0,03	1,00	0,07	0,02	0,05	0,05	0,04	0,00
Rice	0,02	0,00	0,01	0,02	1,00	0,00	0,01	0,01	0,03	0,00
Drybeans	0,01	0,16	0,04	0,07	0,10	1,00	0,11	0,16	0,23	0,00
Permanent	0,06	0,00	0,02	0,03	0,00	0,05	1,00	0,06	0,04	0,00
Other temp.	0,02	0,11	0,01	0,00	0,02	0,03	0,04	1,00	0,04	0,00
Pasture	0,82	0,43	0,87	0,69	0,79	0,85	0,70	0,58	1,00	0,00
Deforestation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00

Source: ICONE.

- Land use “stable” over time;
  - Climate and soil conditions not suitable for agriculture expansion;
  - Sugarcane area increased 86 thousand ha from 2002 to 2008, mostly over pasture areas.

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Allocation Coefficients Results: MAPITO and Bahia Region

	Sugar-cane	Soybean	Corn	Cotton	Rice	Drybeans	Perma-nent	Other temp.	Pasture	Defores-tation
Sugarcane	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Soybean	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Corn	0,09	0,01	1,00	0,00	0,00	0,02	0,13	0,13	0,17	0,00
Cotton	0,01	0,00	0,00	1,00	0,00	0,02	0,01	0,00	0,00	0,00
Rice	0,16	0,04	0,01	0,03	1,00	0,06	0,03	0,01	0,01	0,00
Drybeans	0,18	0,00	0,10	0,03	0,00	1,00	0,27	0,28	0,24	0,00
Permanent	0,03	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00
Other temp.	0,08	0,00	0,01	0,00	0,00	0,00	0,01	1,00	0,01	0,00
Pasture	0,42	0,10	0,30	0,01	0,24	0,64	0,53	0,23	1,00	0,00
Deforestation	0,04	0,84	0,57	0,92	0,75	0,25	0,03	0,35	0,56	1,00

Source: ICONE.

- Potential land for crops expansion
  - Soybean expansion (600 thousand ha) was mostly over Cerrado;
  - Pasture increased 1.5 million hectares, 56% over Cerrado.

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Research Agenda

- Improve our 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.)

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