

# Landnutzungsänderungen und Bioenergie in Brasilien

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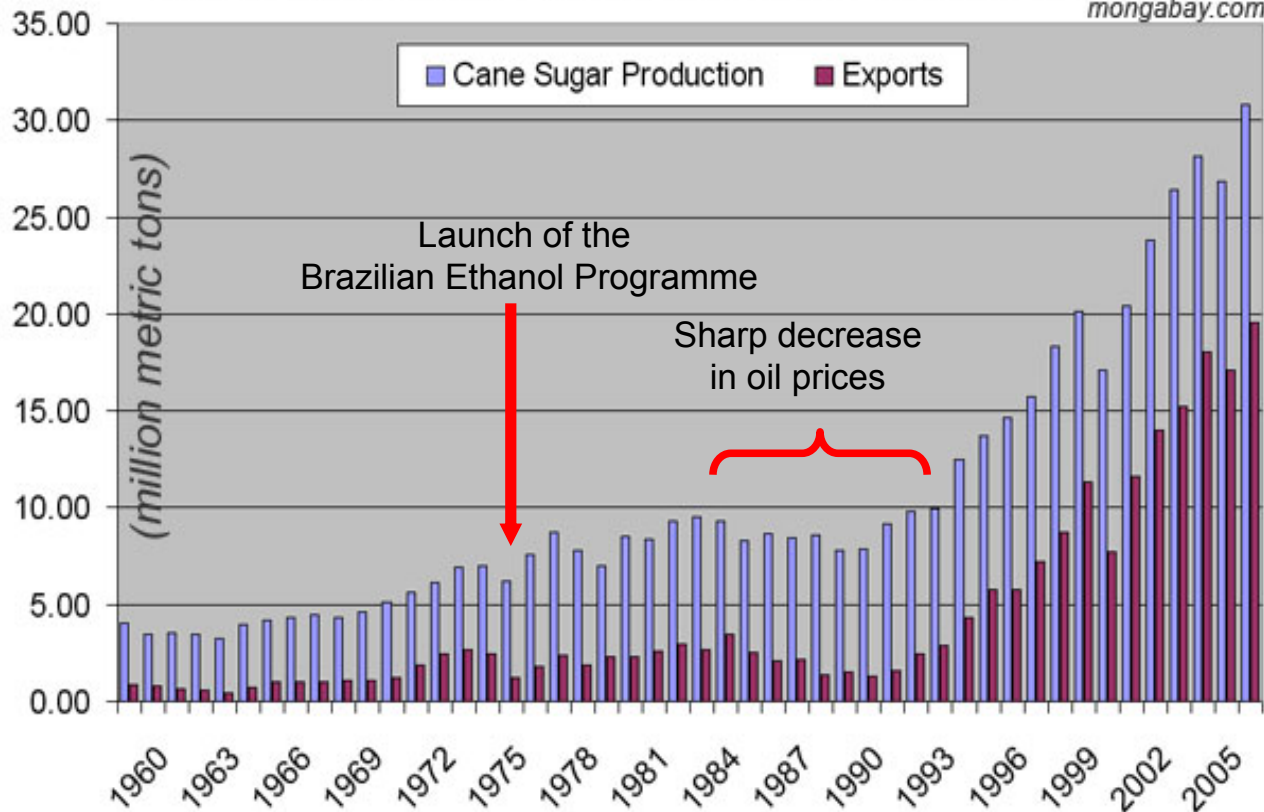
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# Bio-Ethanol and Brazil

Brazil has already launched a national Ethanol Programme following the first oil crisis. Brazil is now the #1 exporter for Bio-Ethanol.

### Cane sugar production & export for Brazil, 1960-2006



Source: USDA & Mongabay.com

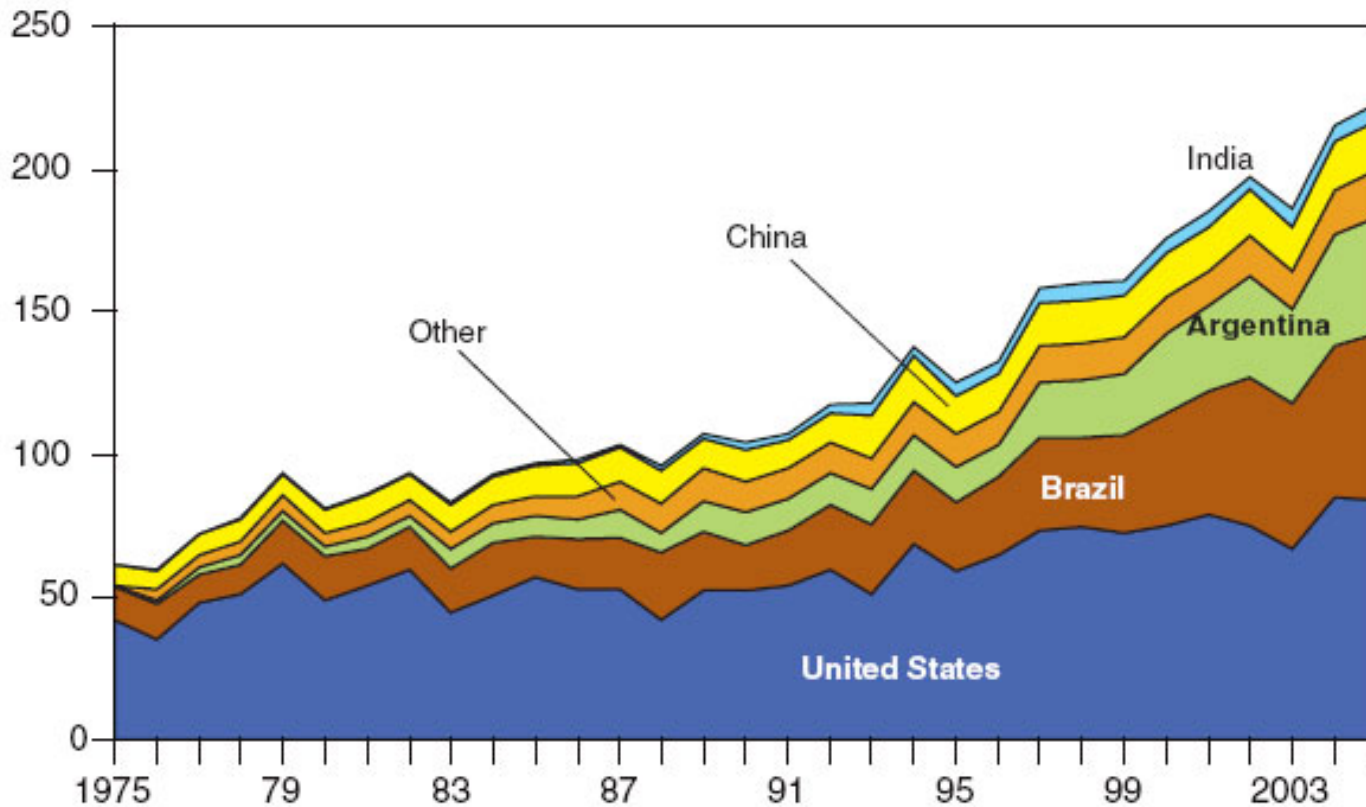
[note 1 ha sugarcane  $\approx$  5800-6500 l ethanol]

# Bio-Diesel and Brazil

Brazil is developing own industries for Biodiesel production. Main crops used for current and future Biodiesel production are soy beans and cotton (seeds).

South American soybean production has grown rapidly since 1980

Mil. metric tons



Source: U.S. Department Agriculture, Foreign Agricultural Service, PS&D database.



## Biofuels and land use change in Brazil

Brazil is largely expanding its cropland on costs of natural rainforest or Savanna (Cerrado) areas or by the conversion of rangelands or other landuses (e.g. coffee plantations) into croplands.

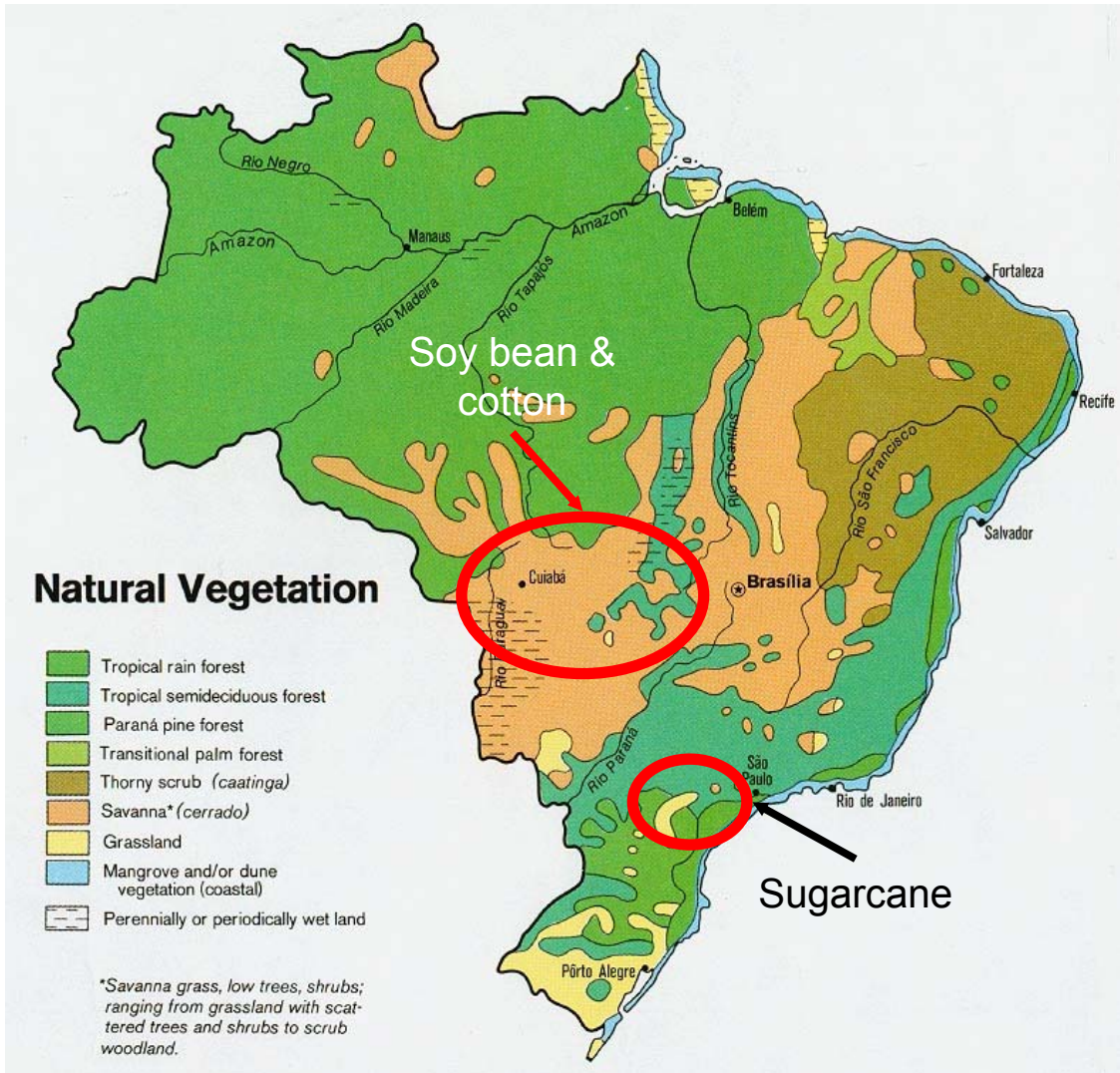
"The primary concern is that the biofuels push will directly or indirectly increase the loss to Brazil's remaining natural high biodiversity areas, such as the Cerrado," (John Buchanan, Conservation International)

„Most of the expansion required will affect the Cerrado ecosystem and the Amazon, which are already being destroyed because of cattle ranching and soybean farming," (Leonardo Lacerda, WWF-Brazil)

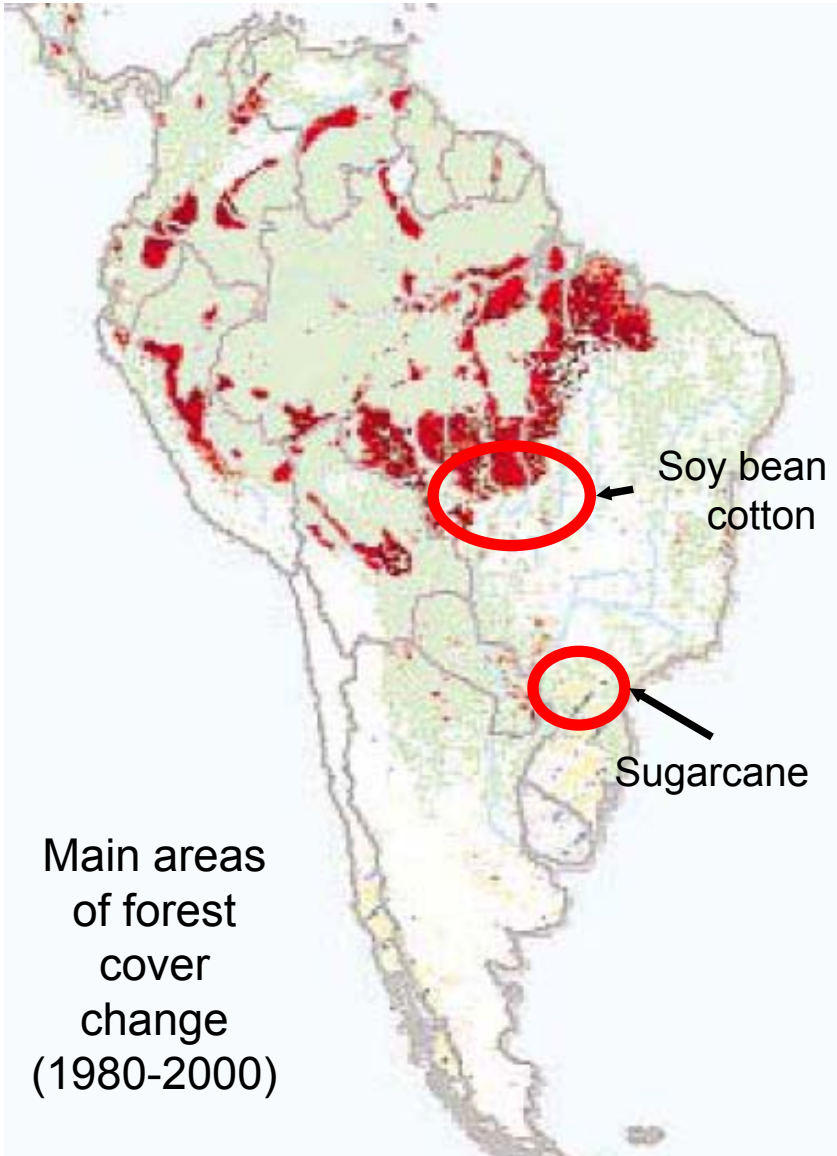
„Growth in Amazon cropland may impact climate and deforestation patterns," (M. Bettwy, Goddard Space Flight Center, Sept 2006)



# Hot spots of land use change in Brazil



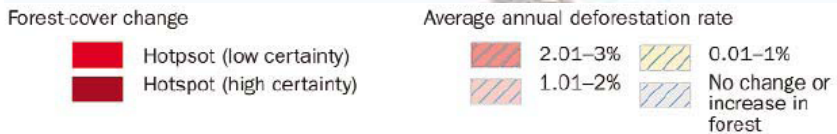
# Recent trends of land use change in South America



Main areas of forest cover change (1980-2000)



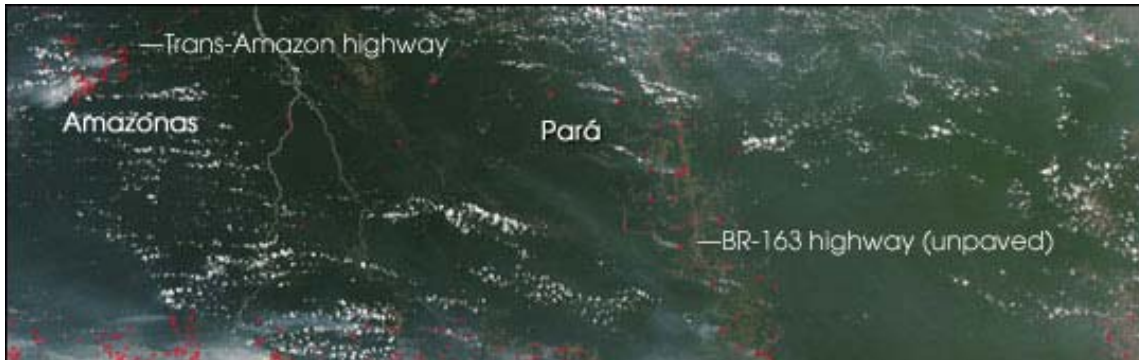
Main areas of change in cropland extent (1980-1990)



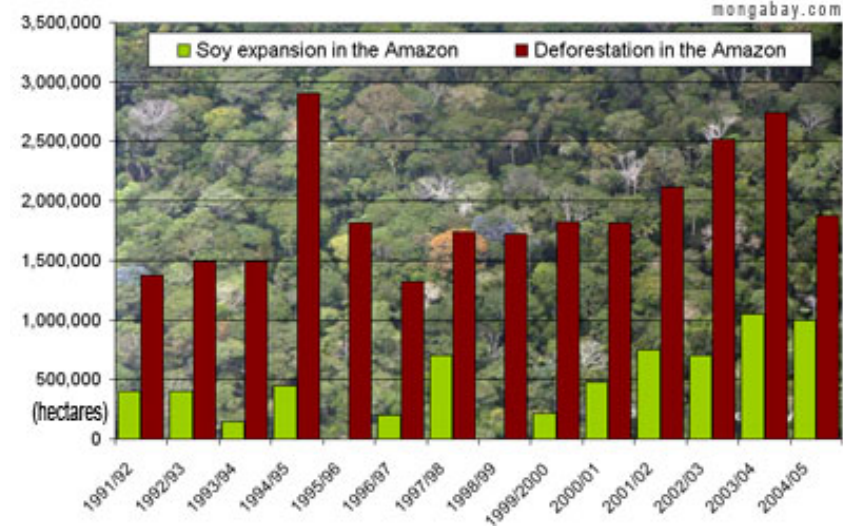
Lepers et al., 2005, BioScience



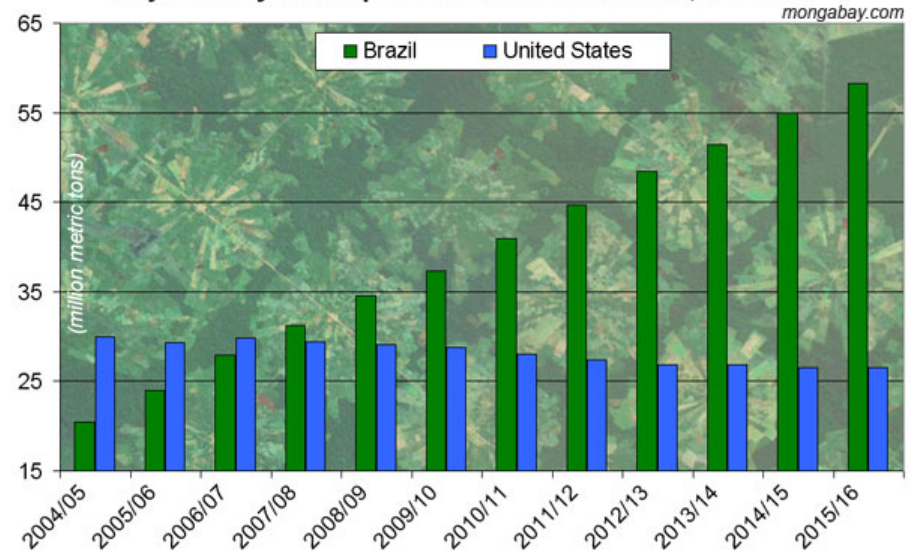
# Biomass burning and land use change, Mato Grosso, Brazil



Soy expansion and deforestation in the Brazilian Amazon, 1990-2005

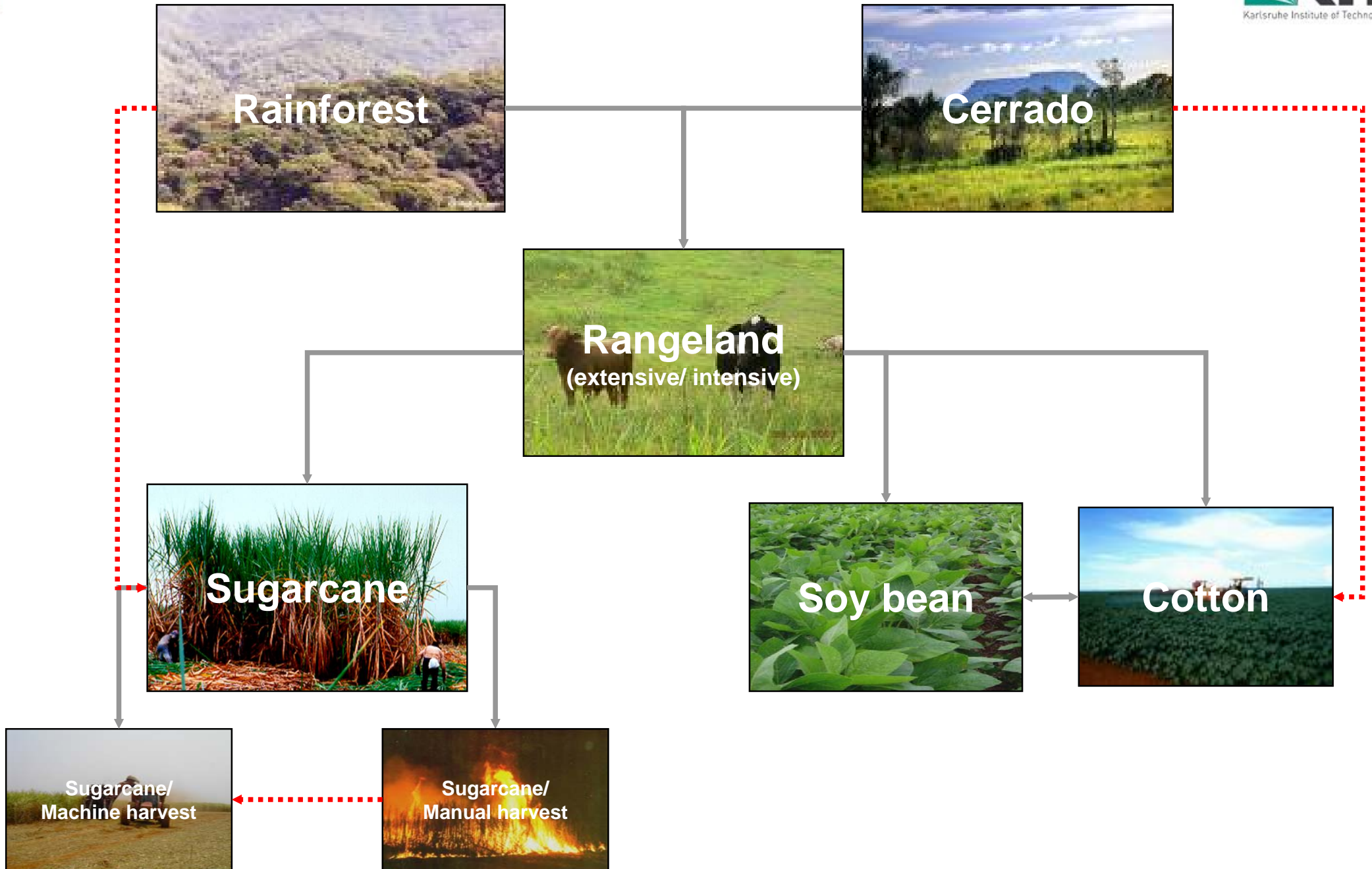


Projected soybean exports for the U.S. and Brazil, 2004-2016





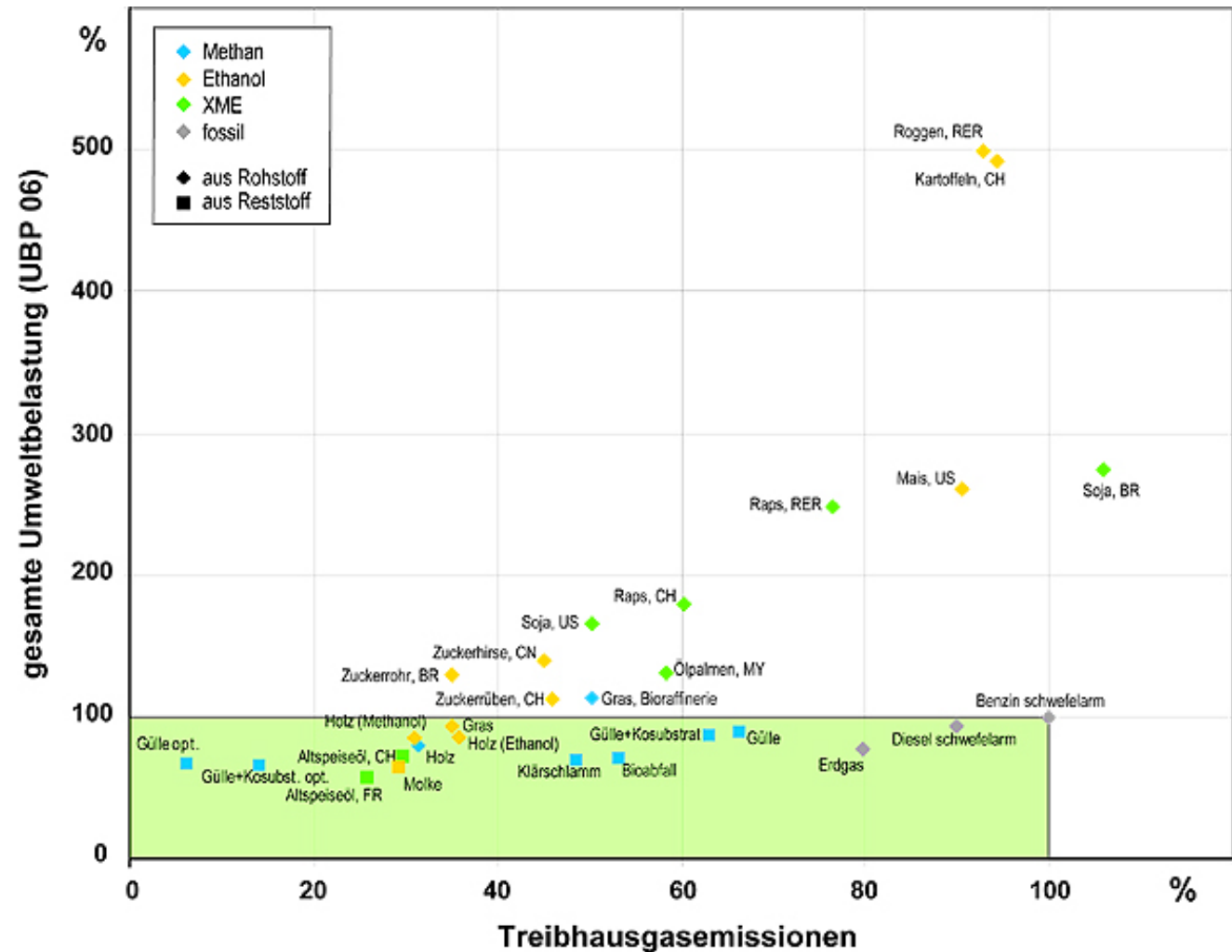
# Current trends in land use change dynamics in Brazil





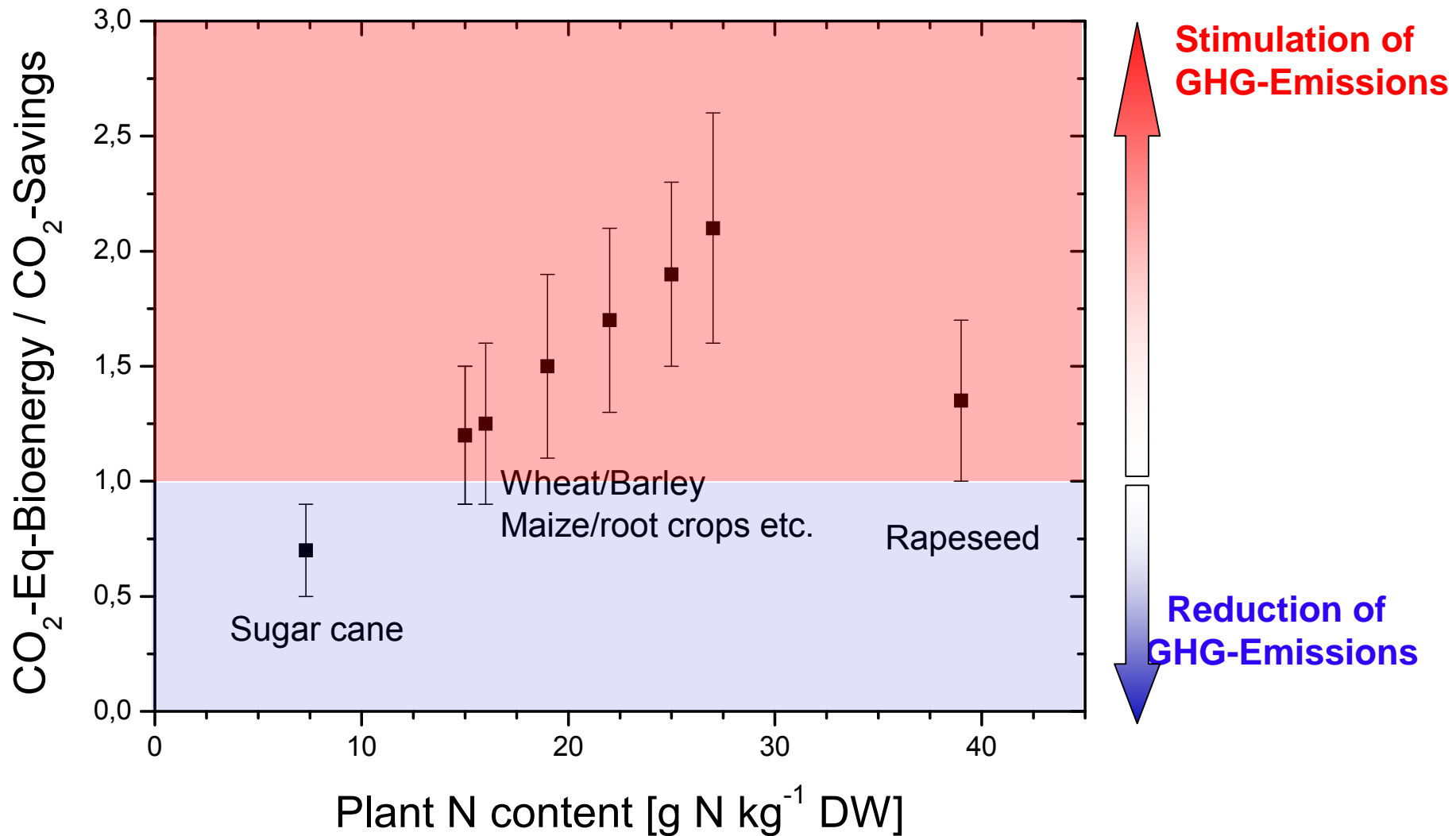
# Hypothesis

Sustainability of ethanol production from sugarcane (net reduction of GHG emissions as compared to fossil fuels, environmental impact [e.g. water quality]) requires improved management



Zah et al. 2007, Ökobilanz von Energieprodukten, empa, CH  
Discussion in Scharlemann and Laurance, Nature 319, 43-44

# C-neutrality of biofuels



Crutzen et al., 2008



# C, N and H<sub>2</sub>O footprint for ethanol production (case study: São Martinho Sugar Mill, São Paulo State, Brazil)



## São Martinho Sugar Mill

- Largest in Brazil
- Modern facility
- Processes 40 kt sugarcane d<sup>-1</sup>
- Pioneer in mechanized
- unburned harvest

# C, N and H<sub>2</sub>O footprint for ethanol production (case study: São Martinho Sugar Mill, São Paulo State, Brazil)

## ***Assessing ecological sustainability:***

- Quantifying major C and N fluxes in the soil-plant system
  - Plant production  
(incl. yield and residue management [filtercake, ash, vinasse])
  - Fertilizer application and biological N<sub>2</sub> fixation
  - Losses in form of N<sub>2</sub>, NO<sub>3</sub>, DOC/ DON
- GHG emissions during sugarcane production from the plant soil system
  - Soil C and N changes on decadal time scales (isotope studies)
  - CO<sub>2</sub> and non-CO<sub>2</sub> (CH<sub>4</sub>/N<sub>2</sub>O) exchange (EC, chamber)
- GHG emissions and nutrient losses during industrial ethanol production
- Changes in regional hydrology and water quality
- Simulation of water, C and N fluxes on regional scales
  - Biogeochemical and hydrological modelling
  - Scenario studies
- Ecological assessment for São Martinho plant



## ***Knowns:***

- Soil and landuse (50 yr retrospective) data (GIS)
- Meteorology for 30 years (longer for other stations in the vicinity)
- Plant production: crop performance, fertilizer use and varieties
- Vinasse application (1l Ethanol = 12-16 l Vinasse) and spatial distribution

## ***Preliminary data:***

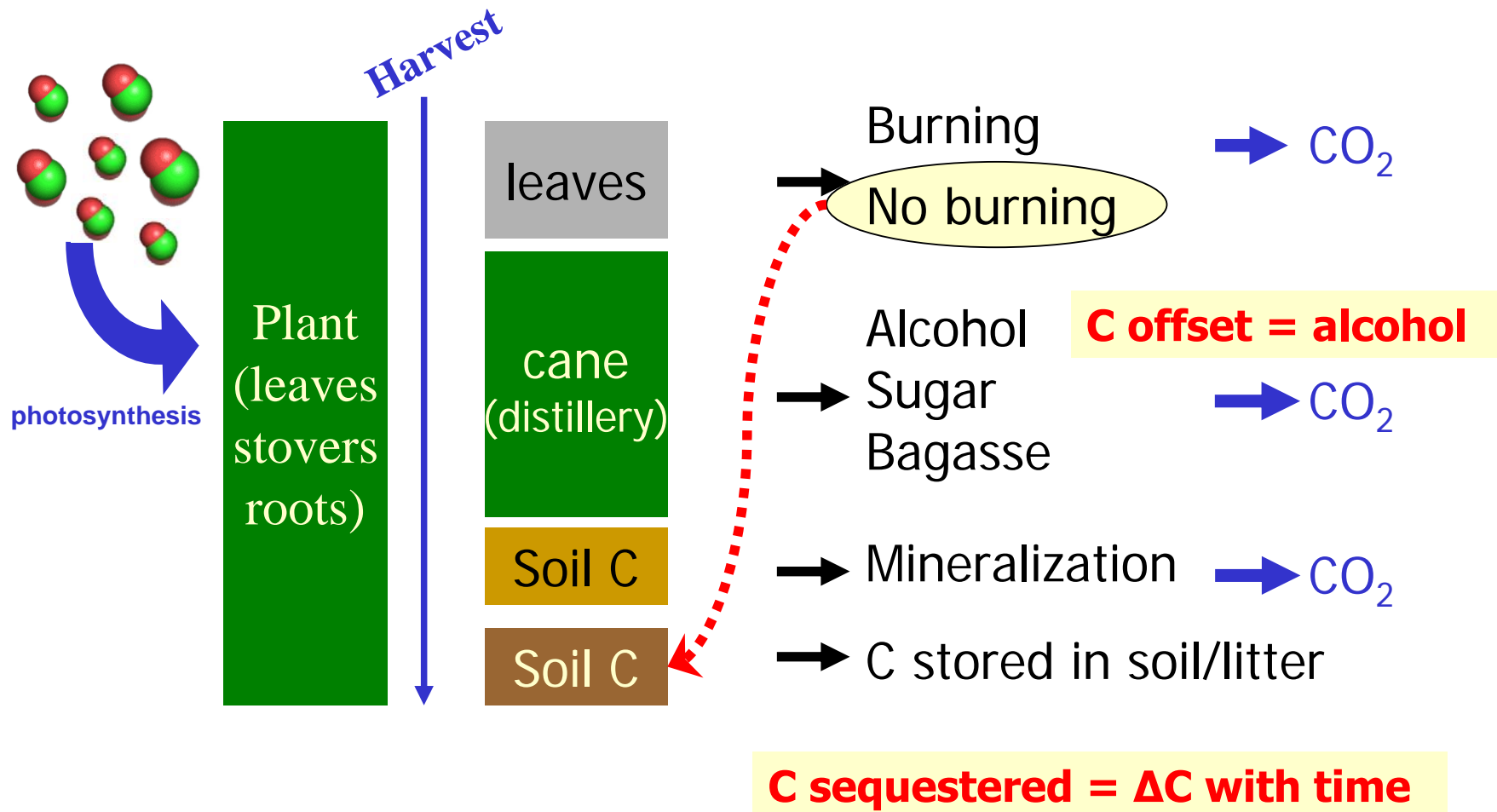
- Soil C/N changes
- N<sub>2</sub>O emissions

## ***Unknowns:***

- Other gaseous N losses and details of GHG fluxes
- Management related losses (Vinasse, filter cake, biogas plant)
- Biological N<sub>2</sub> fixation
- Leaching losses

# São Martinho Sugar Mill: knowns and unknowns

## CO<sub>2</sub> balance for sugarcane agrosystem





# Manual versus mechanized harvesting

## GHG balance [C-CO<sub>2</sub> equivalents]

With burning

No burning



Combustion

Soil mineralization



Soil mineralization

Litter mineralization

# Manual versus mechanized harvesting

## C-exchange [C-CO<sub>2</sub>eq (kg.ha<sup>-1</sup>.yr<sup>-1</sup>)]

With burning



No burning



0	Soil-litter C	-1311
4748	Yield and crop cycle	300
<b>4748</b>	<b>Final balance</b>	<b>-1011</b>

## N<sub>2</sub>O and CH<sub>4</sub> fluxes [C-CO<sub>2</sub>eq (kg.ha<sup>-1</sup>.yr<sup>-1</sup>)]

With burning

No burning



**Yield: Immediate release of GHG (kg C-CO<sub>2</sub> eq.ha<sup>-1</sup>.yr<sup>-1</sup>)**

CH <sub>4</sub>	180	4549	CH <sub>4</sub>	0
N <sub>2</sub> O	4369		N <sub>2</sub> O	

**Crop cycle: fluxes at the soil-litter-atmosphere level (kg Ceq.ha<sup>-1</sup>.yr<sup>-1</sup>)**

CH <sub>4</sub>	- 48.4	CH <sub>4</sub>	31.5	-5 - +3.5 kg CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup>
N <sub>2</sub> O	247.7	N <sub>2</sub> O	268.9	1.8 – 2.2 kg N <sub>2</sub> O-N ha <sup>-1</sup> yr <sup>-1</sup>



# Missing data

## a) Vinasse application



## b) Hotspots & hot moments



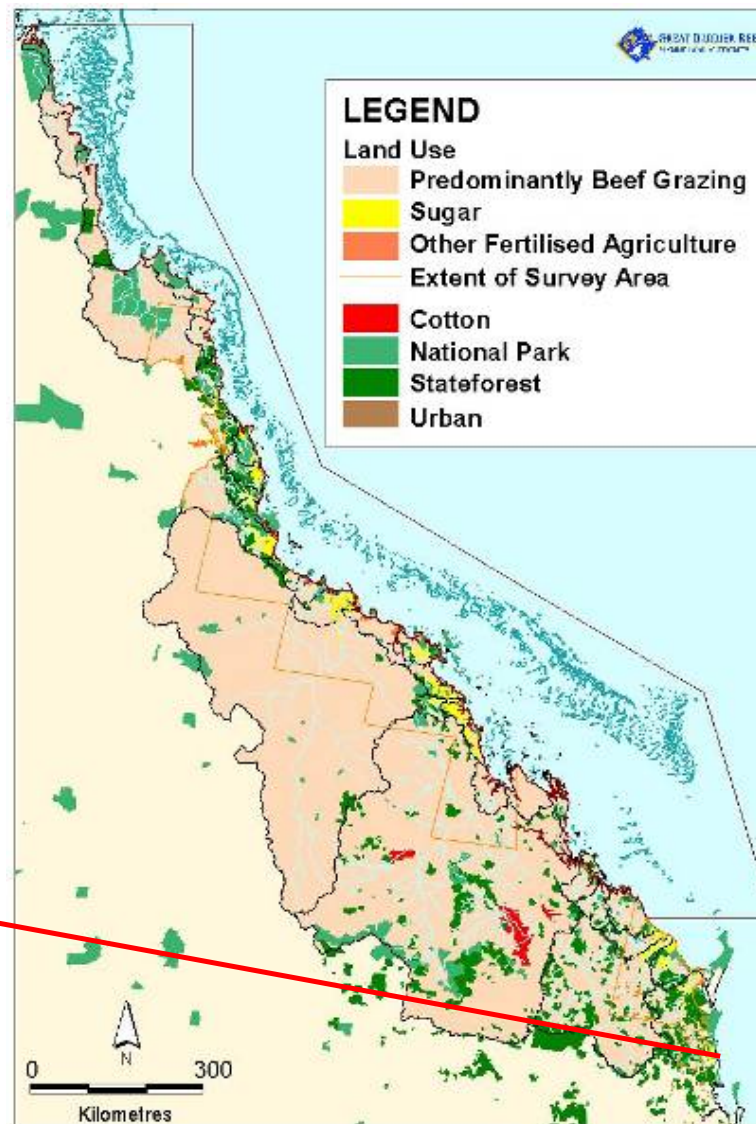
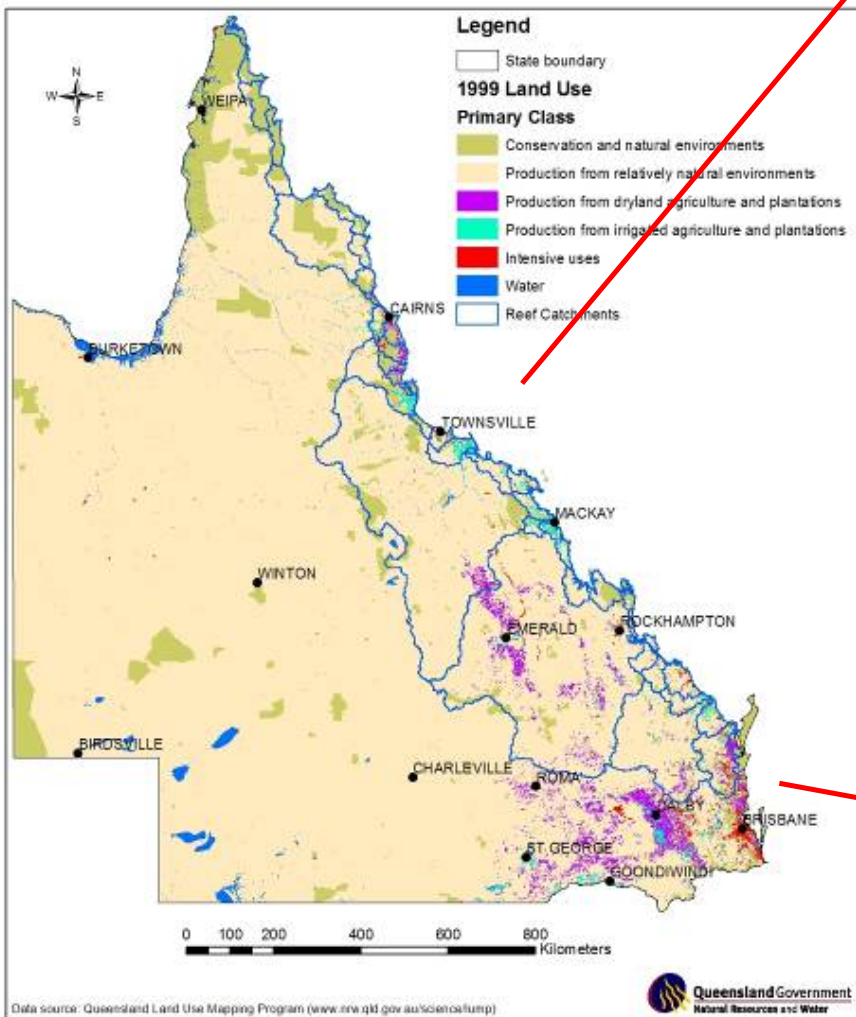
- **Filter cake**
- **Fertilizer application**
- **Rainfall events**

## c) Leaching losses & water quality

# Conclusion: → at least for N<sub>2</sub>O current estimates are too low

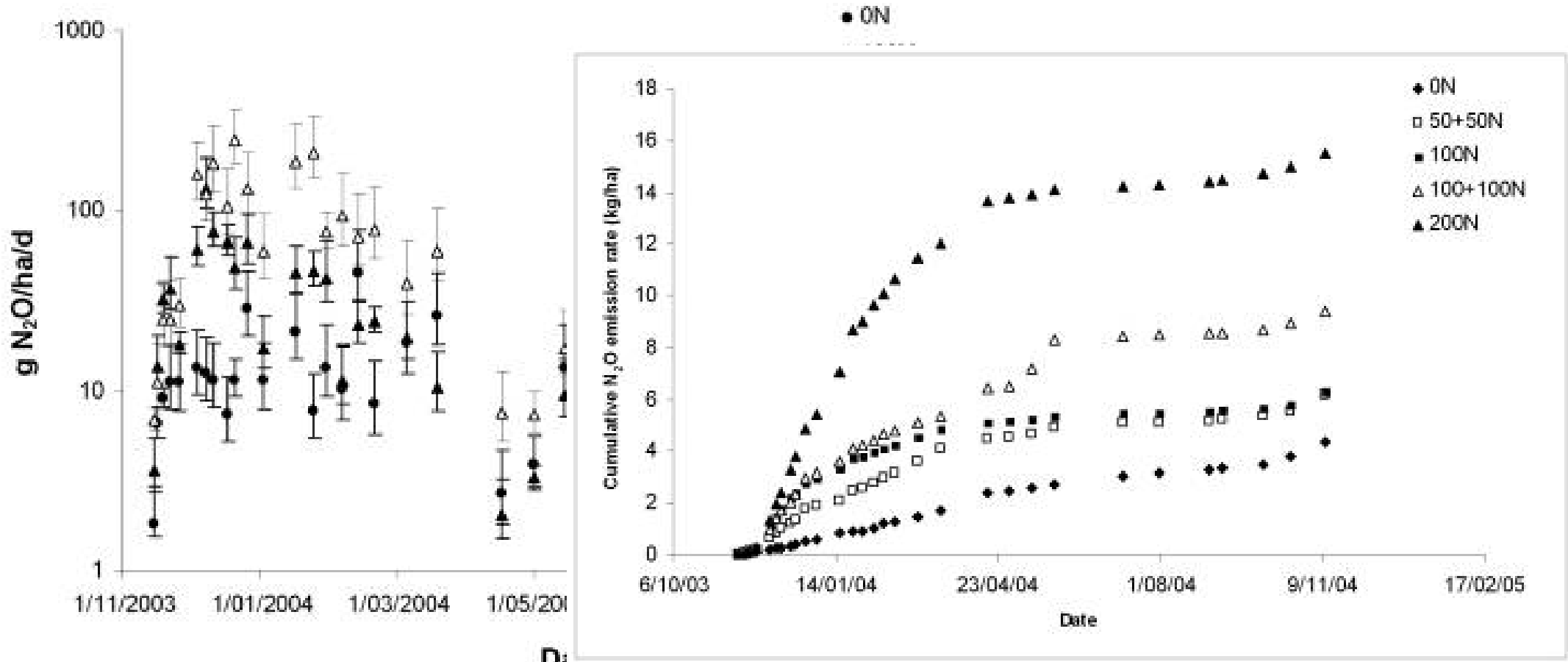
Sugar cane area > 500 000ha, approx 20% of total cropping area

## Australia





# N<sub>2</sub>O losses from sugarcane in Australia 4-16 kg N<sub>2</sub>O-N



Courtesy of Diane Allen, Agric. Departm. Queensland, Australia

Allen, D.E., Kingston, G., Rennenberg, H., Dalal, H., Schmidt, S. 2008. Nitrous oxide emissions from sugarcane soils as influenced by waterlogging and split N fertiliser application. Australian Society for Sugarcane Technologists, (accepted)





## Daimler-Fonds

im Stifterverband für die Deutsche Wissenschaft

**BioForRisk** Evaluierung der Potentiale für energetisch nutzbare Biomasse aus Land- und Forstwirtschaft und der mit der Biomassennutzung verbundenen ökologischen Risiken in Brasilien und Rumänien

International Bureau  
of the Federal Ministry  
of Education and Research



**Full greenhouse gas  
accounting for  
sugarcane production  
systems in Brasil**



- ***Sugarcane (Sao Paulo State)***
  - Urgent need for more detailed measurements spanning entire years
  - No information on N losses by leaching/ water quality
  - Modeling and system analysis is pending
- ***Soy bean/ cotton (Mato Grosso/ Matto Grosso del Sud)***
  - Contacts established
  - Potential sites available
  - Soil sampling has been started/ First measurements 2009
- ***Studies need to include other potential bioenergy crops (e.g. switch grass)***

**Resources and additional partners**