

# **Remote sensing contribution to sustainable sugarcane production**

- Cultivated Area**
- Expansion**
- dLUC**
- Land conversion classes**
- Harvest monitoring**
- Permanent Protected Areas**
- Crop yield**

# Who?



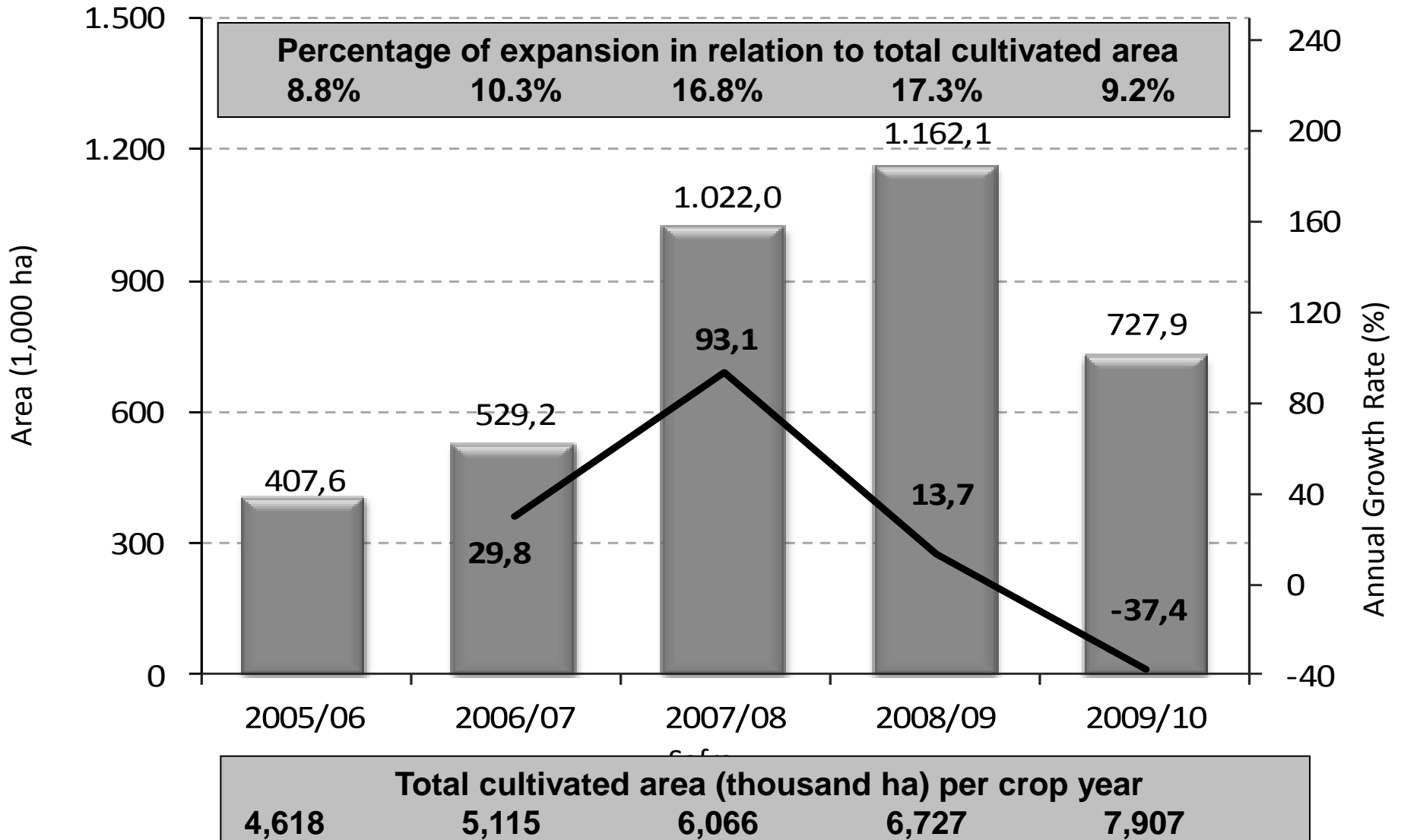
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**Researcher**

**Ph.D Agronomy – Uni. Maryland at  
College Park, 1993**

**Remote sensing applied to agriculture**

# Sugarcane Expansion in South-Central Brazil

## Five Crop Years: 2005/06 to 2009/10



# www.dsr.inpe.br/canasat



**CANASAT**

Sugarcane crop mapping in Brazil  
by Earth observing satellite images



<http://www.dsr.inpe.br/canasat/>



**Introduction**



**Sugarcane Maps**



**Tables**



**Contact**



**Technical Articles**

This site was accessed  
**75399** Since 29 August 2005

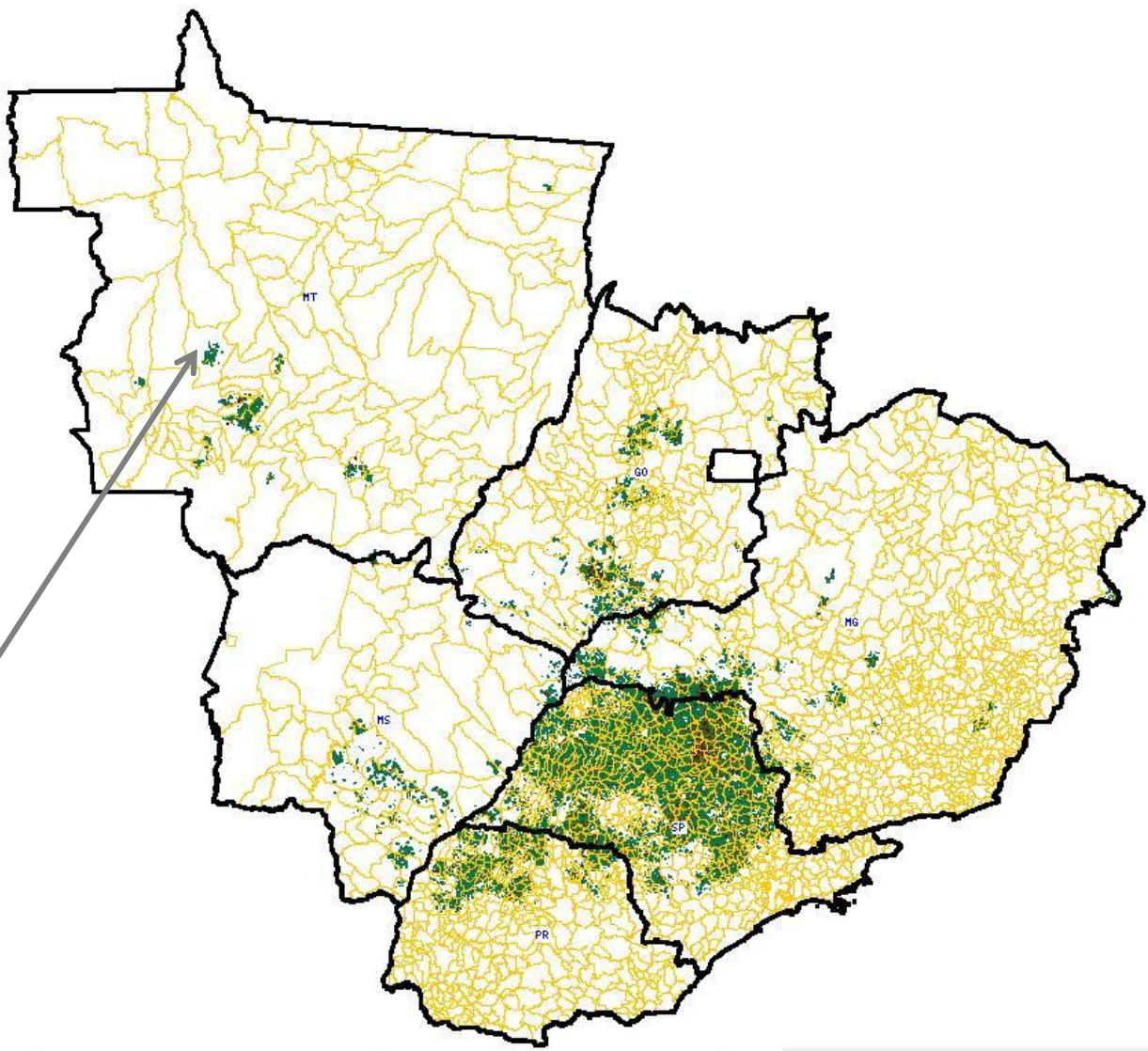


CANASAT

Refresh

Control Panel

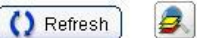
- Sugarcane Maps
  - Crop year 2009/10**
  - Crop year 2008/09
  - Crop year 2007/08
  - Crop year 2006/07
  - Crop year 2005/06
  - Crop year 2004/05
  - Crop year 2003/04
- Cartographic Layers
  - Sugarcane Plants
  - Municipalities
  - States
- Images
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- Sugarcane Area Density M
  - Crop year 2009/10
  - Crop year 2008/09



- Legend
- States
  - Municipalities
  - Ratoon
  - Reformed
  - Expansion
  - Under reform

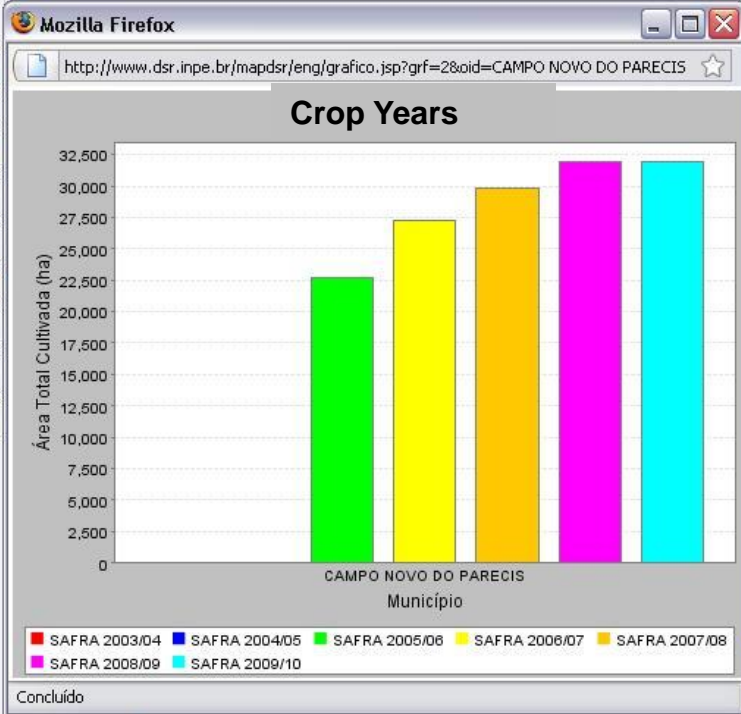
0 718 1420 2130 km

State: go to... Municipality: Mapping year: 2009 Search

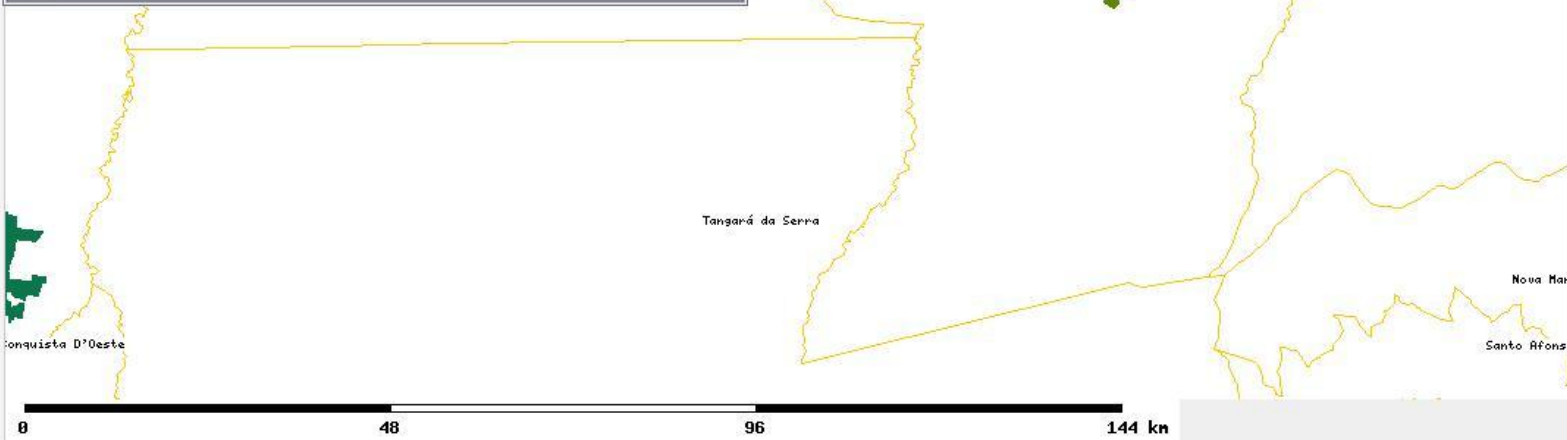


Control Panel

- Sugarcane Maps
  - Crop year 2009/10
  - Crop year 2008/09
  - Crop year 2007/08
  - Crop year 2006/07
  - Crop year 2005/06
  - Crop year 2004/05
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- Cartographic Lays
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  - Mosaic 2007
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- States
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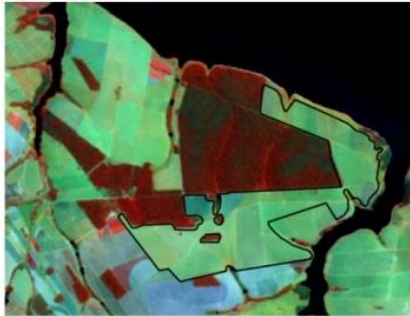




# direct Land Use Change & Sugarcane expansion

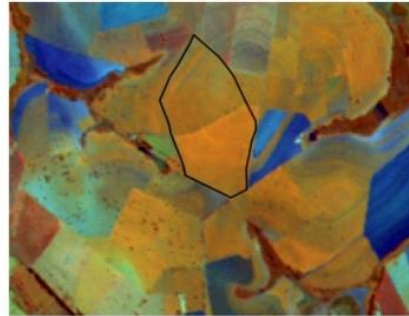
# Land conversion to sugarcane evaluated from satellite images

Pasture



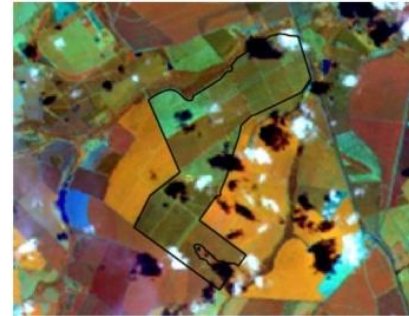
6a) 12/09/06

Soybean



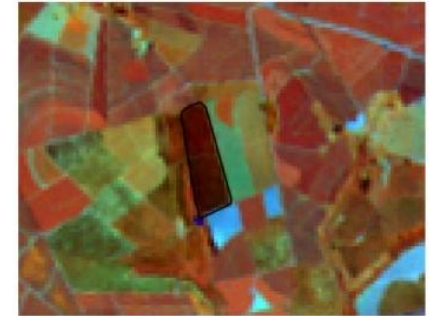
7a) 21/04/06

Citrus

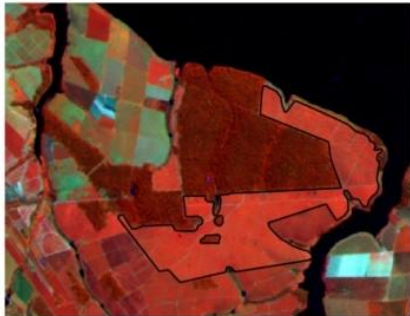


8a) 04/03/06

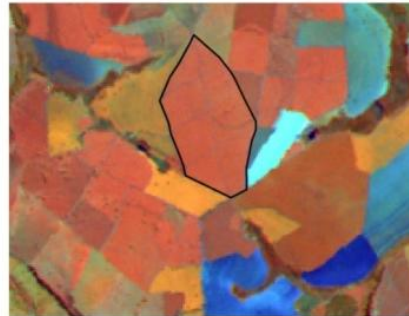
Arboreous Vegetation



9a) 21/04/06



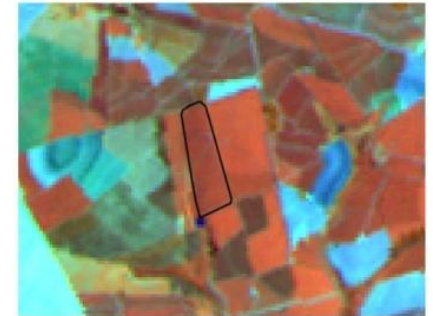
6b) 26/04/08



7b) 26/04/08

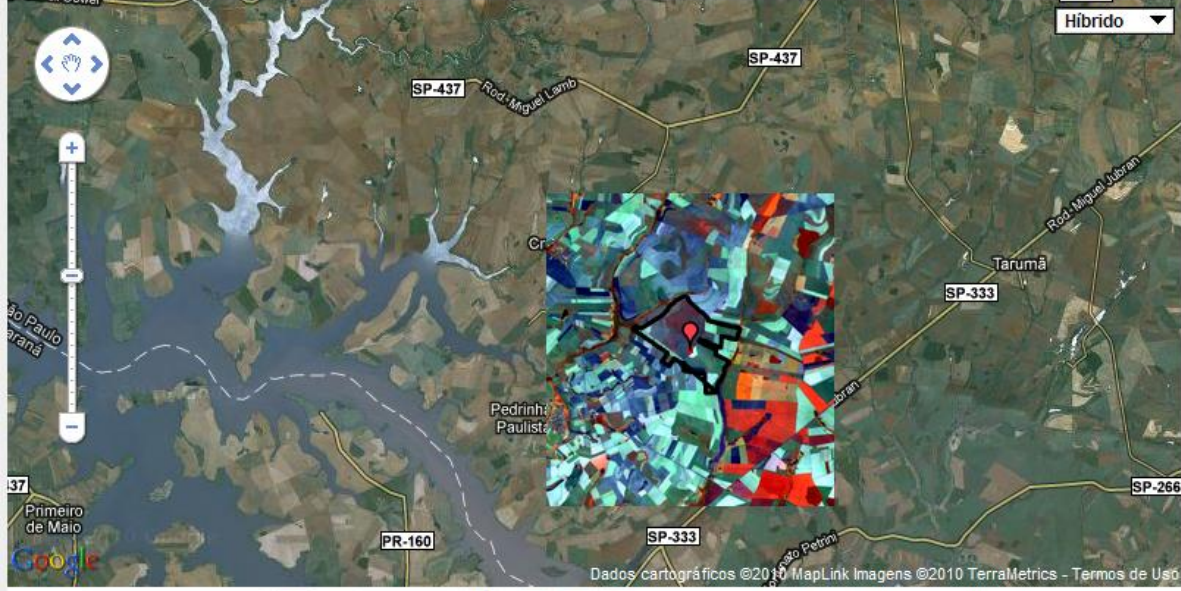


8b) 26/04/08



9b) 26/04/08





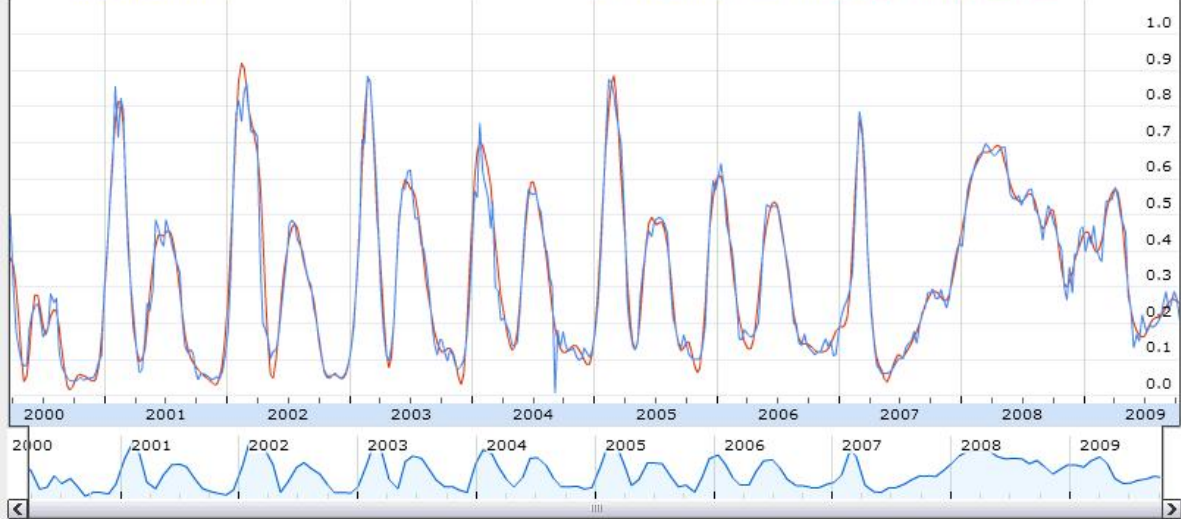
- 01/02
- 02/03
- 03/04
- 04/05
- 05/06
- 06/07
- 07/08
- 08/09
- 09/10

**Curva: 50019**

Safra: 00/01	Uso: Nenhum
Safra: 01/02	Uso: Nenhum
Safra: 02/03	Uso: Nenhum
Safra: 03/04	Uso: Nenhum
Safra: 04/05	Uso: Nenhum
Safra: 05/06	Uso: Nenhum
Safra: 06/07	Uso: Nenhum
Safra: 07/08	Uso: Nenhum
Safra: 08/09	Uso: Nenhum
Safra: 09/10	Uso: Nenhum

Local: Id: 50019 -22.7956, -50.7054 50019 : 12/08/2001

Zoom: 1d 5d 1m 3m 6m 1y Max Curva 50019 original: 0,193 Curva 50019 filtrada: 0,256 | 12/10/2009



“Sustainability criteria for biofuels and other bioliquids”

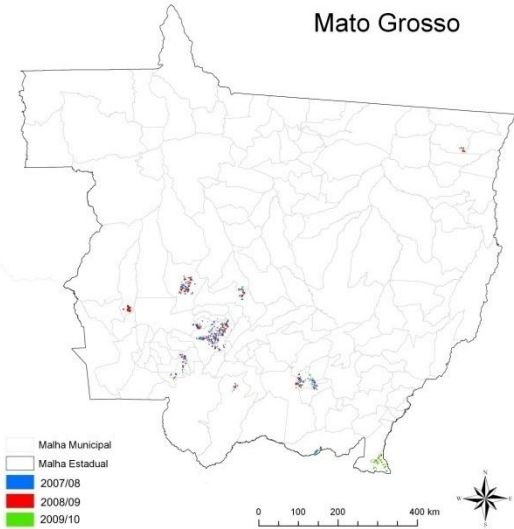
*Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources - Article 17 (§ 3, 4 e 5)*

1<sup>st</sup> January 2008 - no conversion of high biodiversity land to biofuels production

**Area (ha) of high biodiversity land converted to sugarcane after 1<sup>st</sup> January 2008**

	Goiás	Minas Gerais	Mato Grosso do Sul	Mato Grosso	Paraná	São Paulo	Total
Conversion from Pasture or Agricultural Crop to Sugarcane	135,093	96,195	121,468	17,568	35,474	320,394	726,193
Conversion from Natural Vegetation to Sugarcane	-	33	80	-	79	931	1,123 <b>(0.15%)</b>

Mato Grosso



2007/08

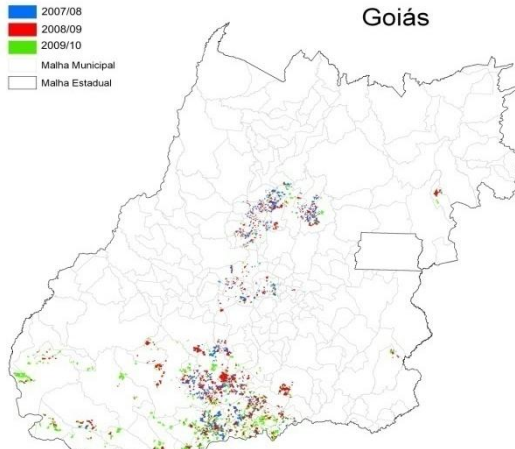
2008/09

2009/10

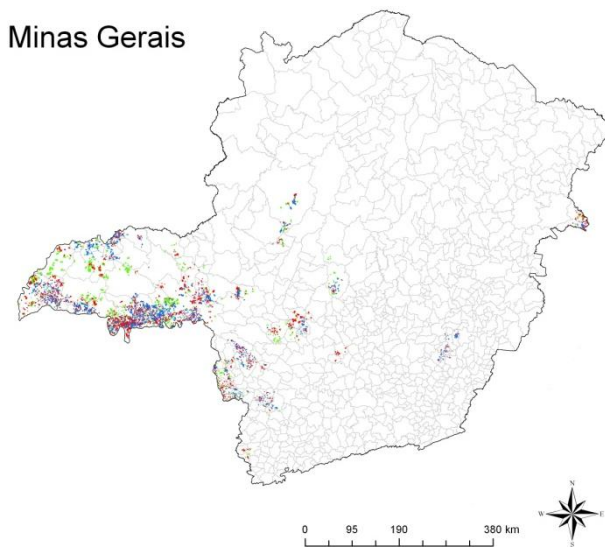
Malha Municipal

Malha Estadual

Goiás



Minas Gerais

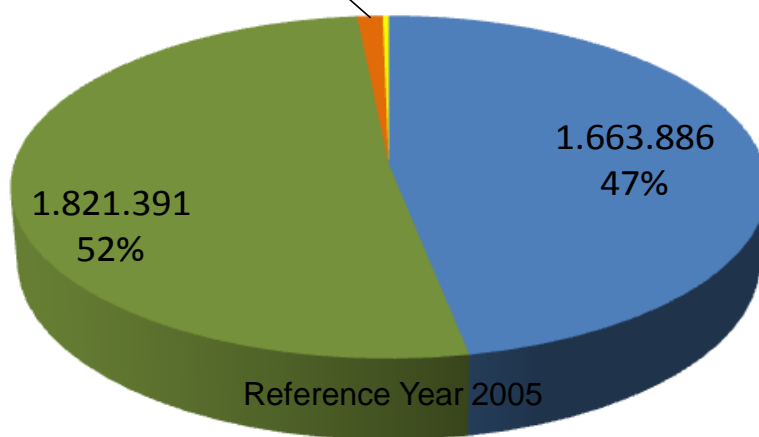


43.869

1%

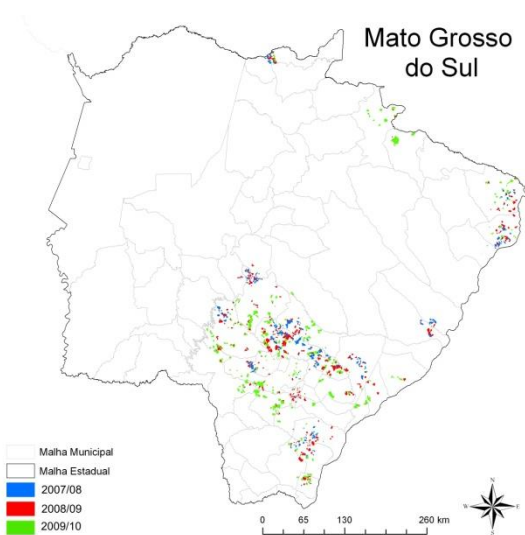
10.208

0%

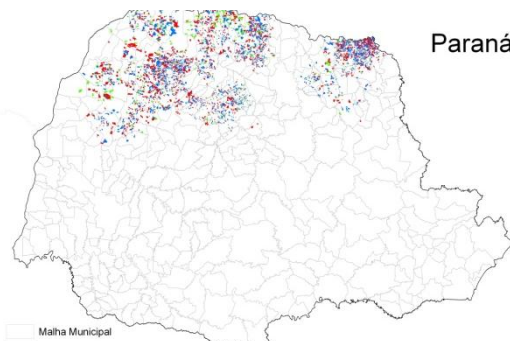


- Crop
- Pasture
- Citrus
- Arboreous Vegetation
- Reforestation

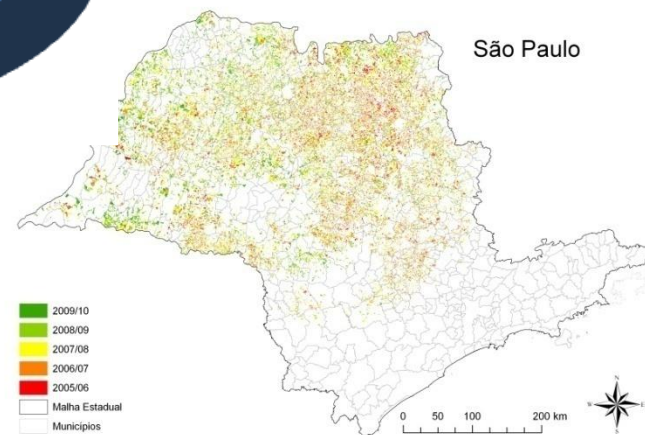
Mato Grosso do Sul



Paraná



São Paulo

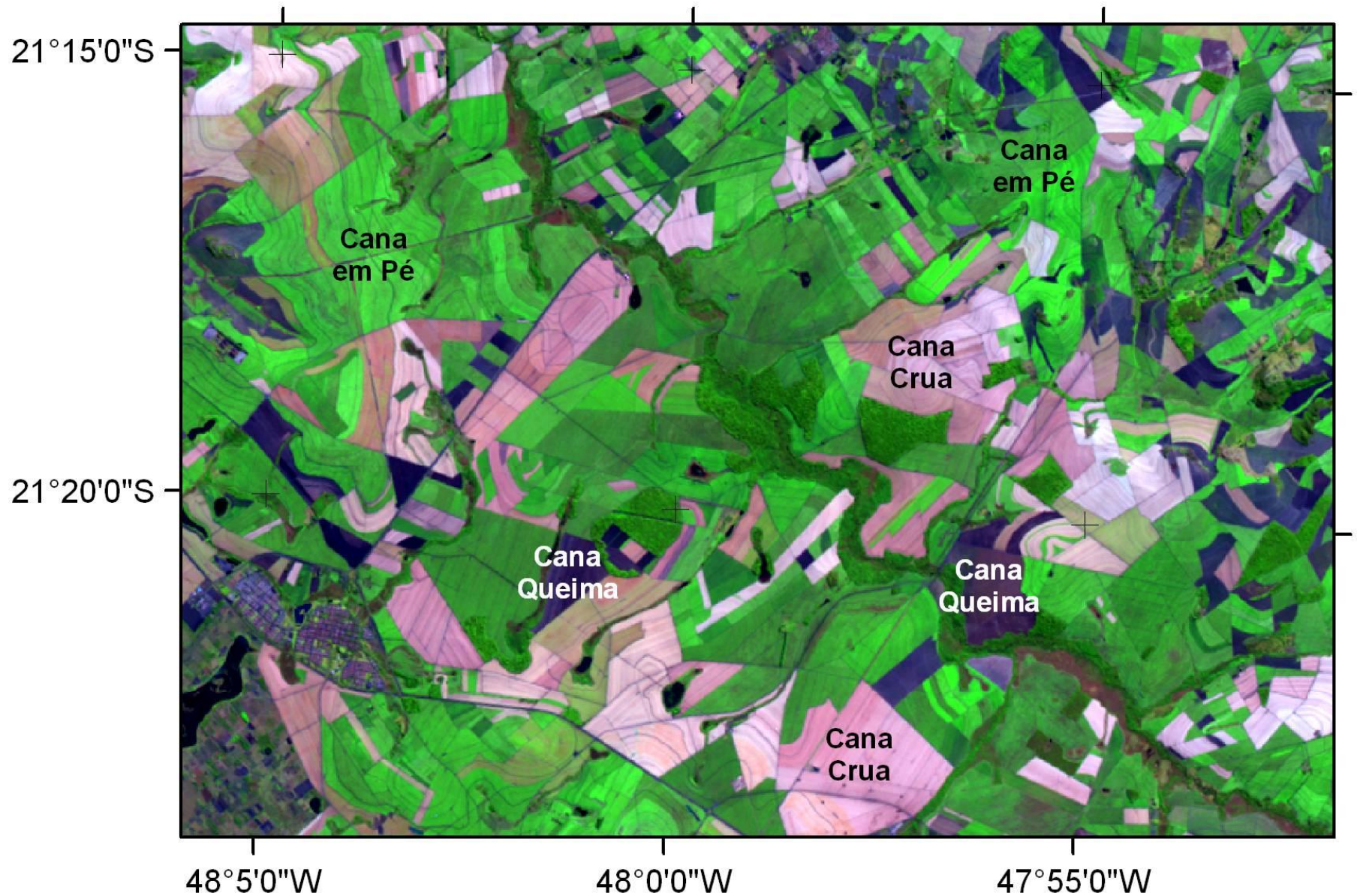


Expansion over the last three crop seasons: 2007/08; 2008/09 and 2009/10

# Harvest type with and without straw burning

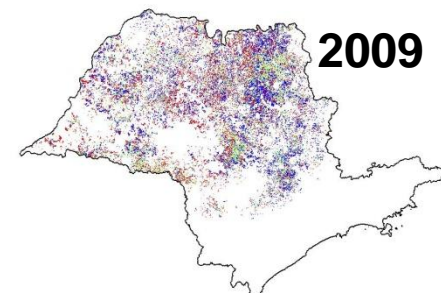
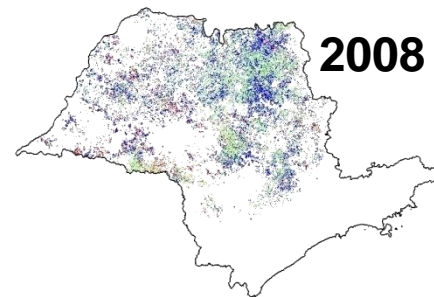
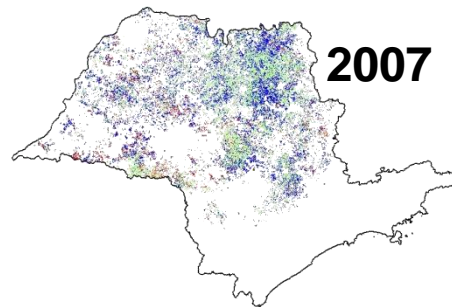
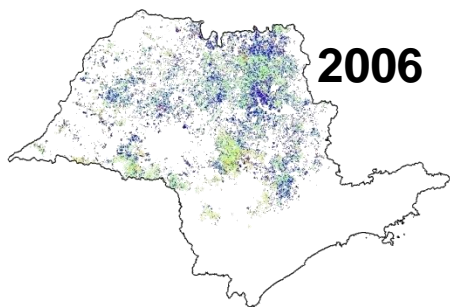


# Sugarcane with and without straw burning

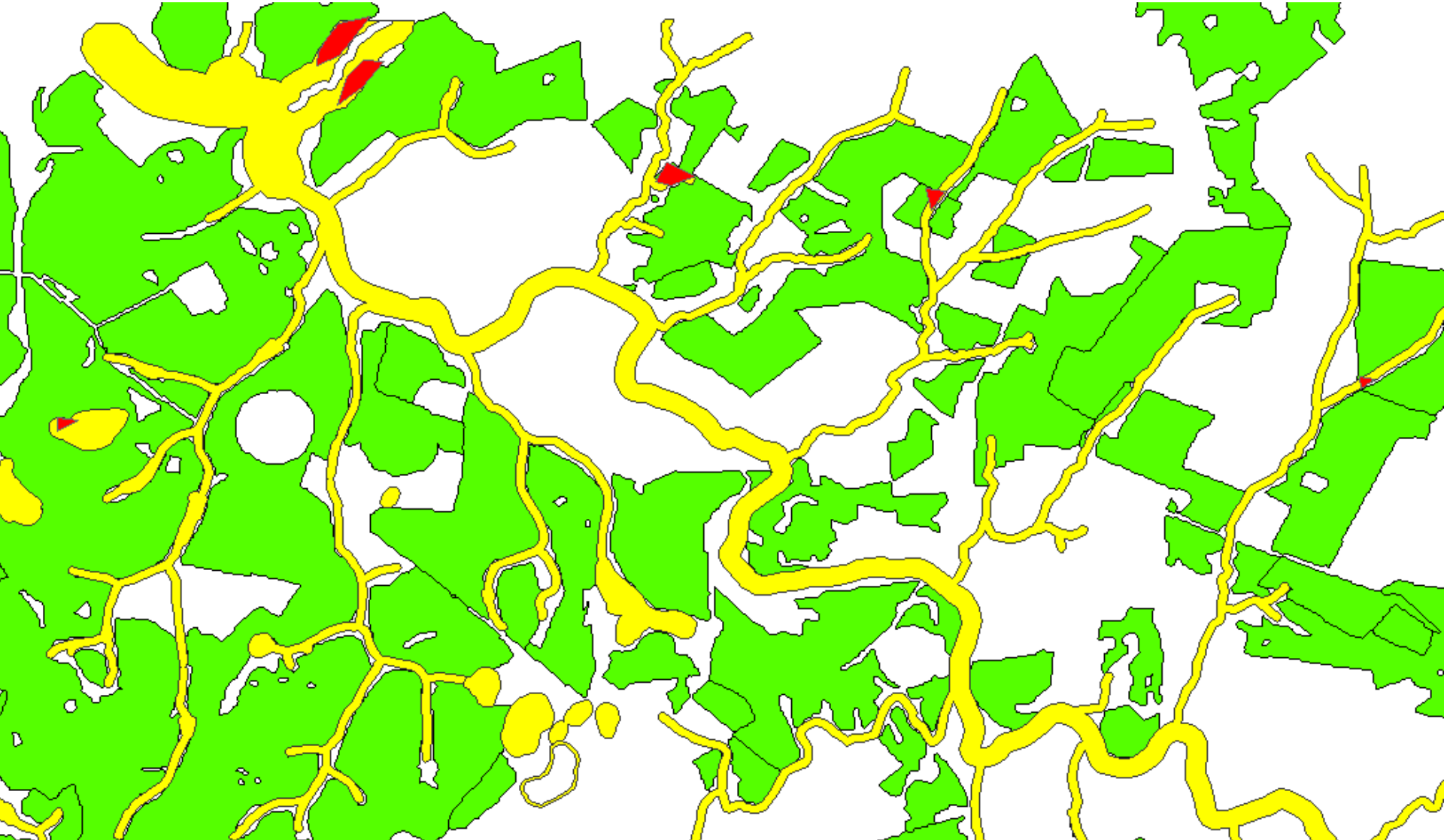


# Percentage of sugarcane area harvested without and with straw burning

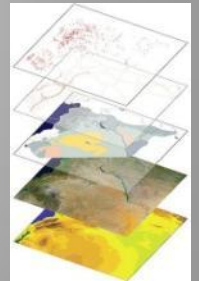
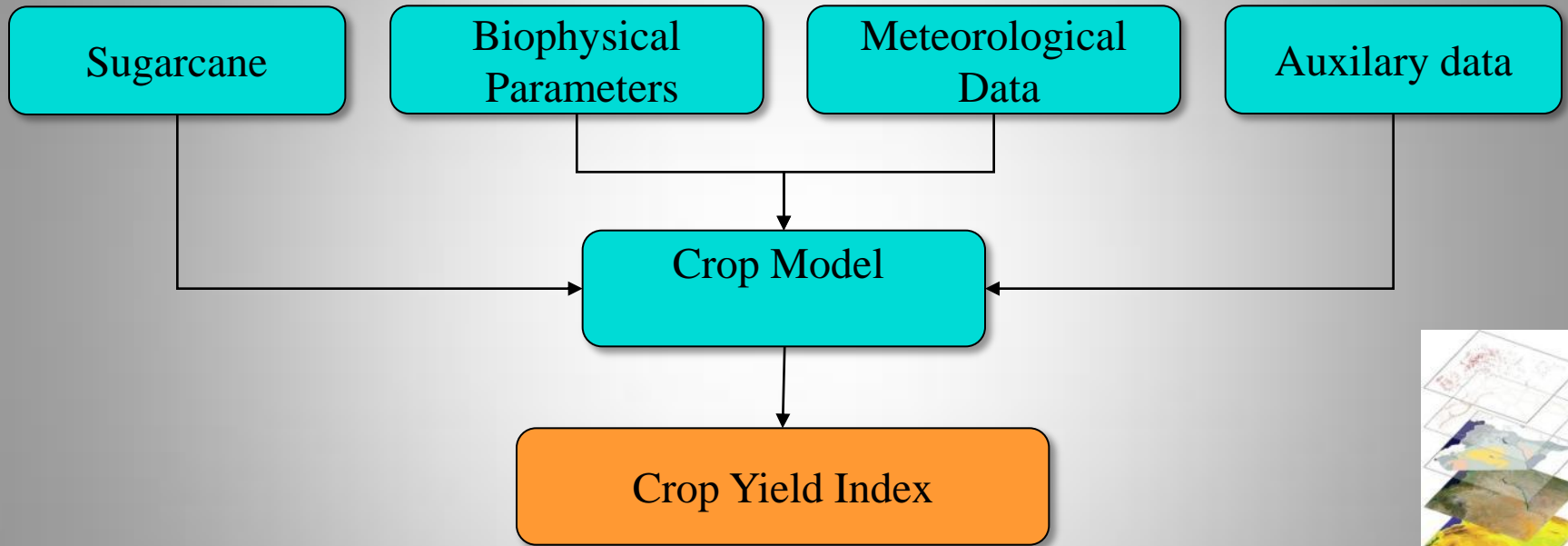
Harvest Season	Harvest Type		
	Without Burning	With Burning	
2006	34.2	65.8	
2007	46.6	53.4	
2008	49.1	50.9	
2009	55.5	44.5	
2010	58.2	41.8	In progress



# Mapping of Permanent Protected Areas



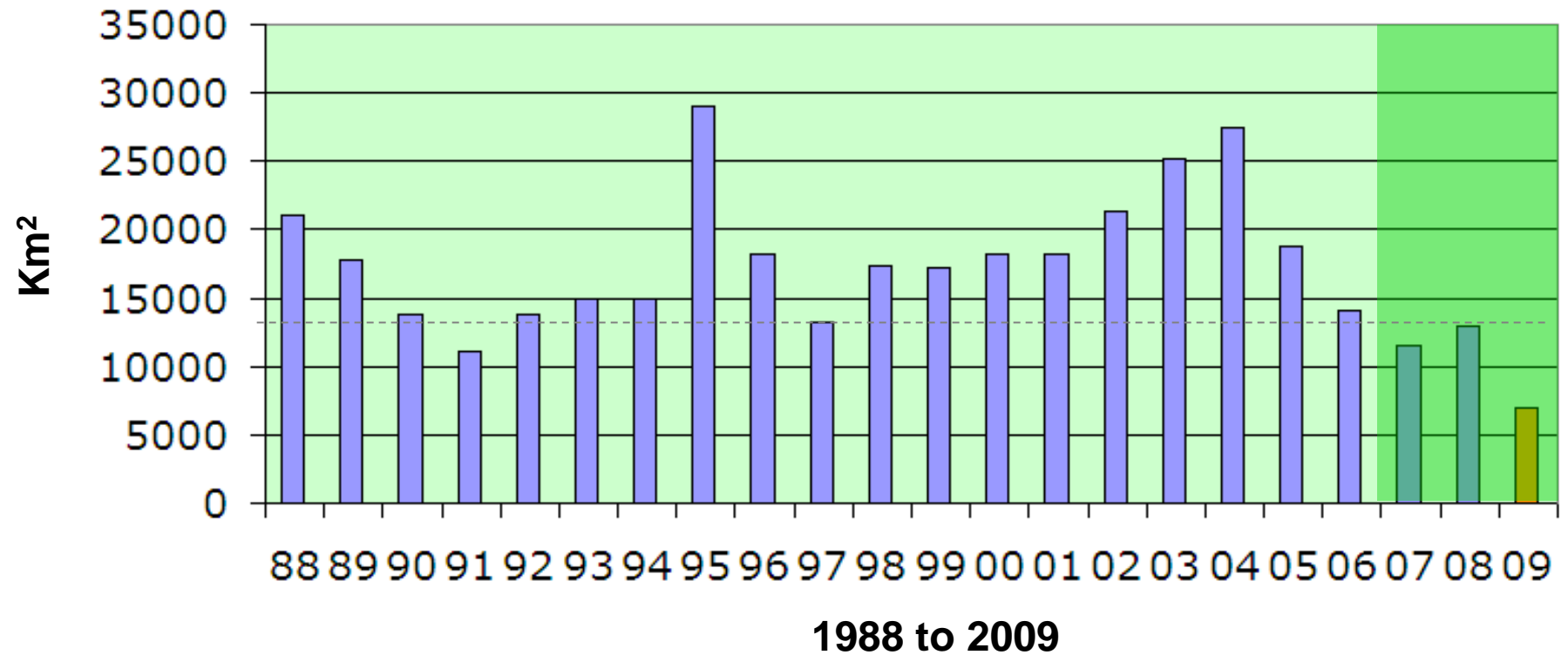
# Yield



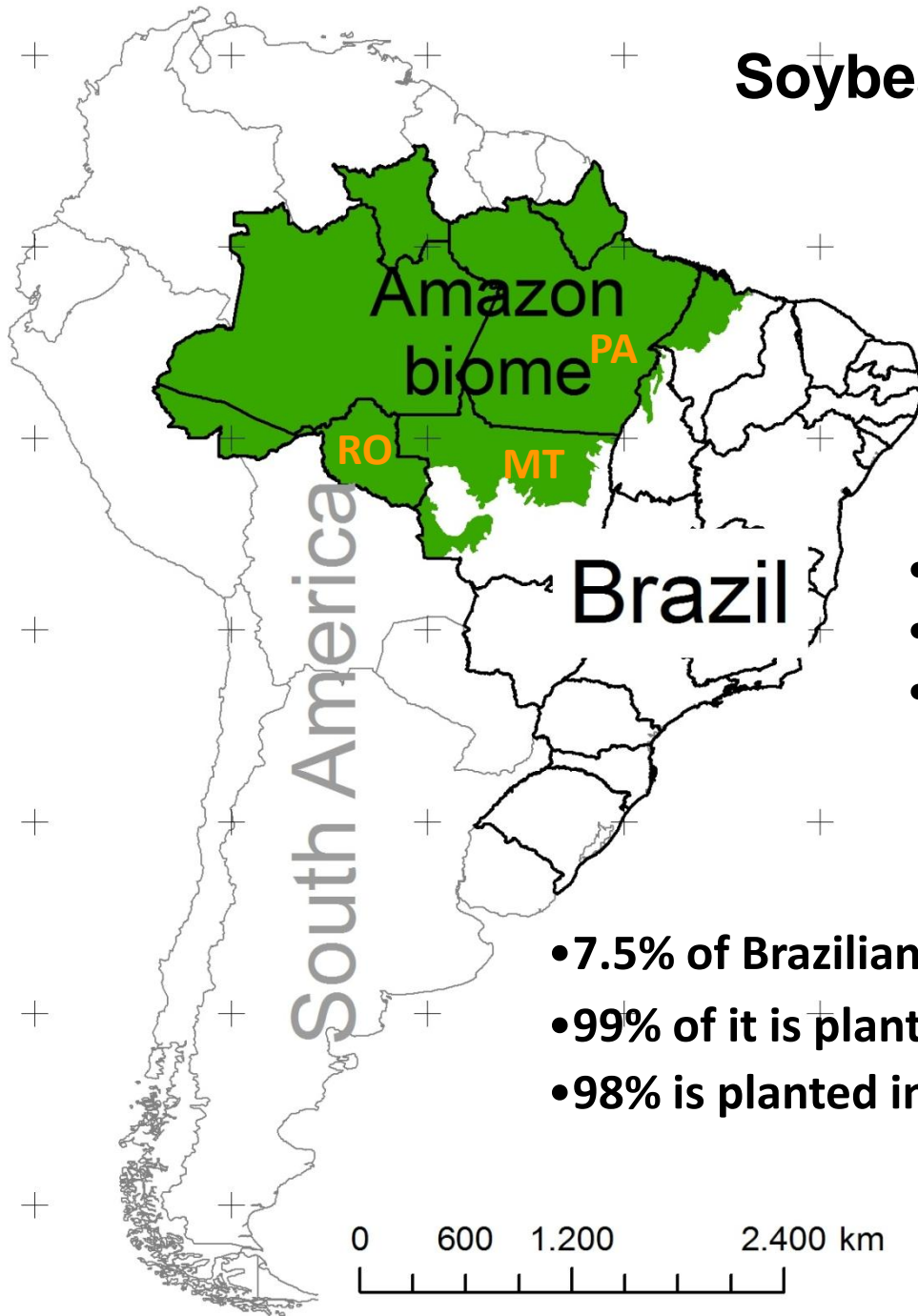


**MONITORING OF SOYBEAN  
MORATORIUM USING REMOTE  
SENSING IMAGES  
Crop Year 2009/10**

# PRODES – Deforestation in the Legal Amazon

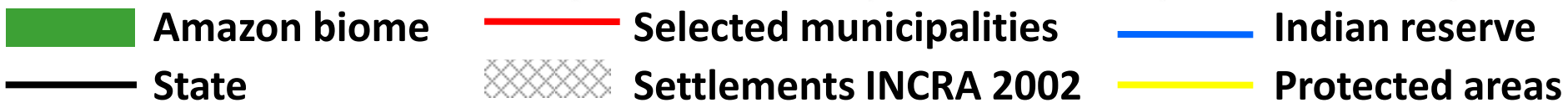
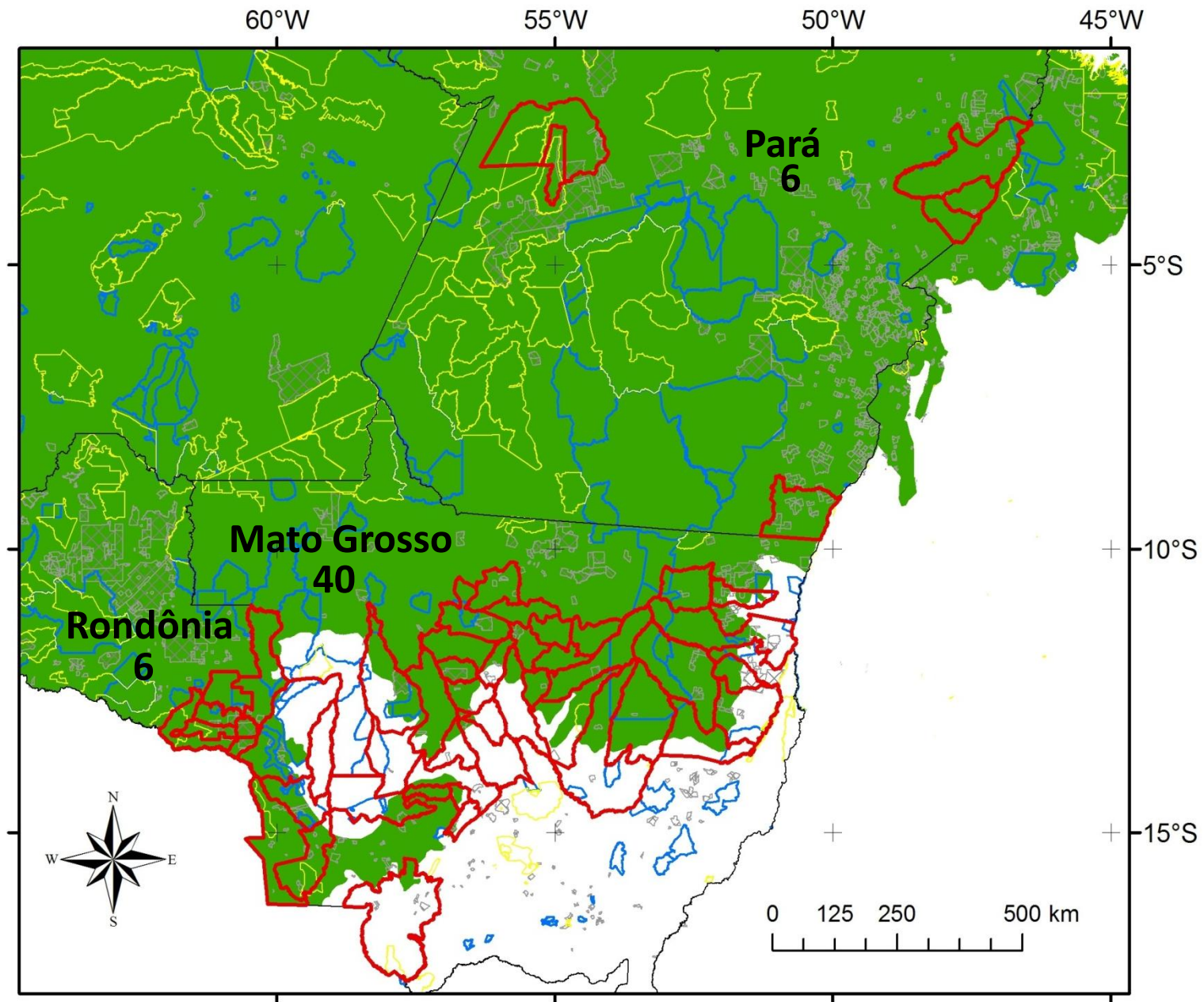


# Soybean in the Amazon biome



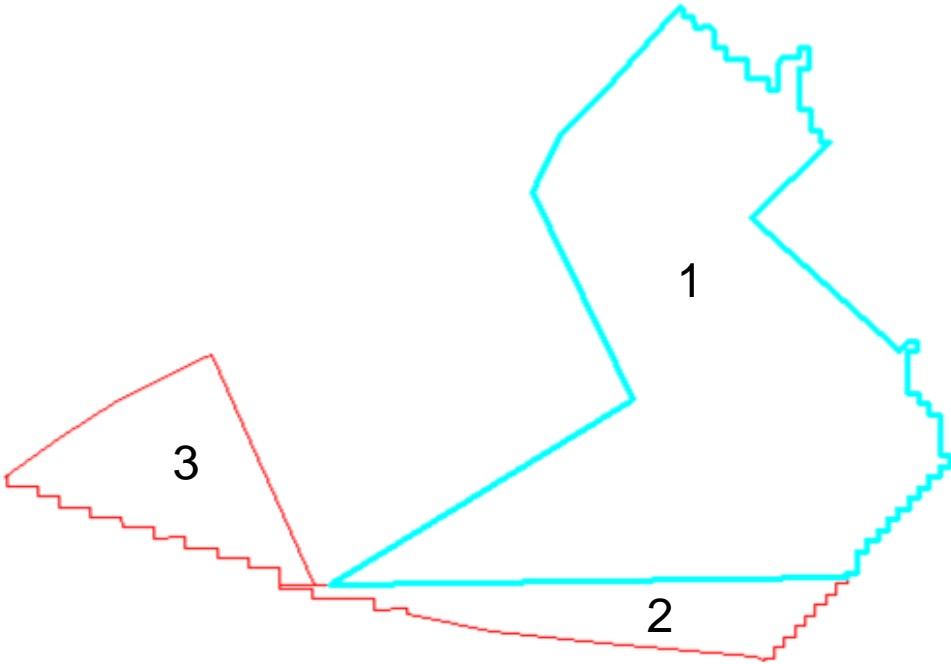
- Brazilian Amazon biome = 4.2 Mkm<sup>2</sup>
- 49.3% of Brazilian Territory
- 9 states and 553 municipalities

- 7.5% of Brazilian soybean is in the Amazon biome
- 99% of it is planted in Mato Grosso, Pará and Rondônia
- 98% is planted in 52 municipalities

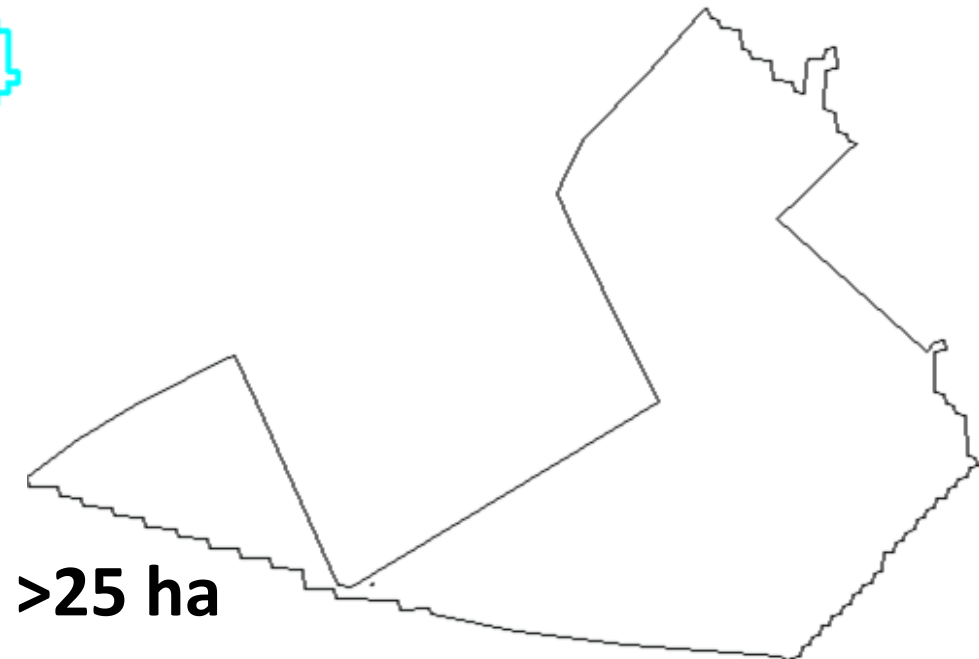


# Fusion of adjacent polygons

Three adjacent polygons

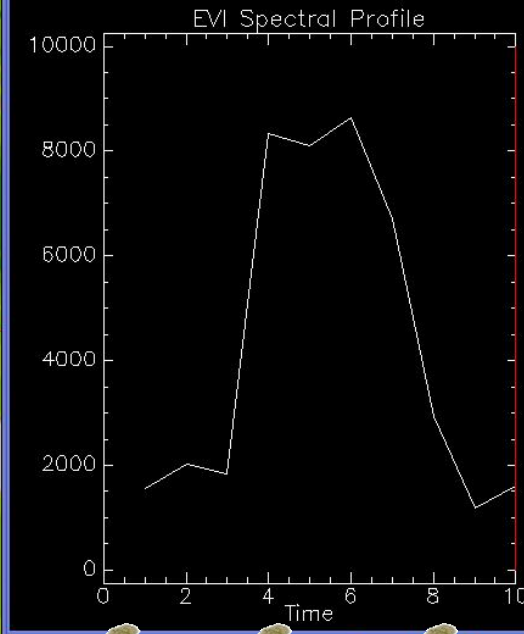
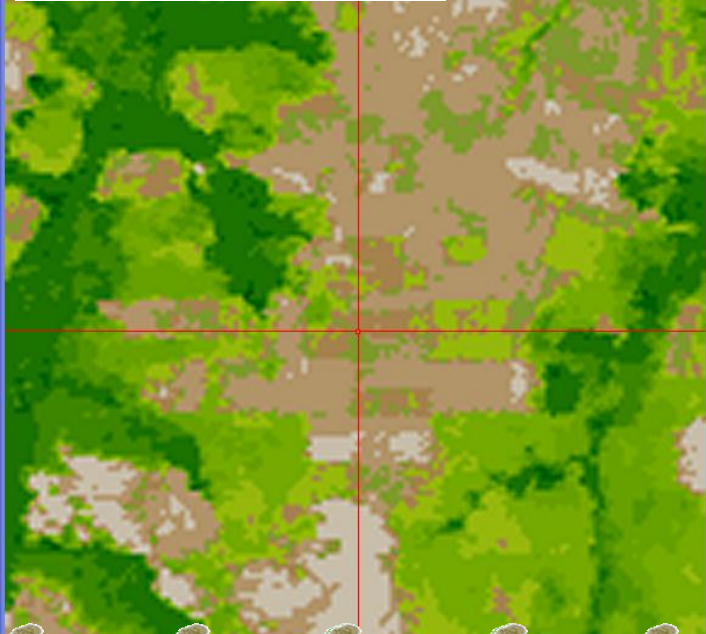
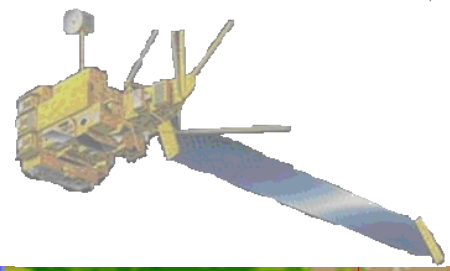


One fused polygon

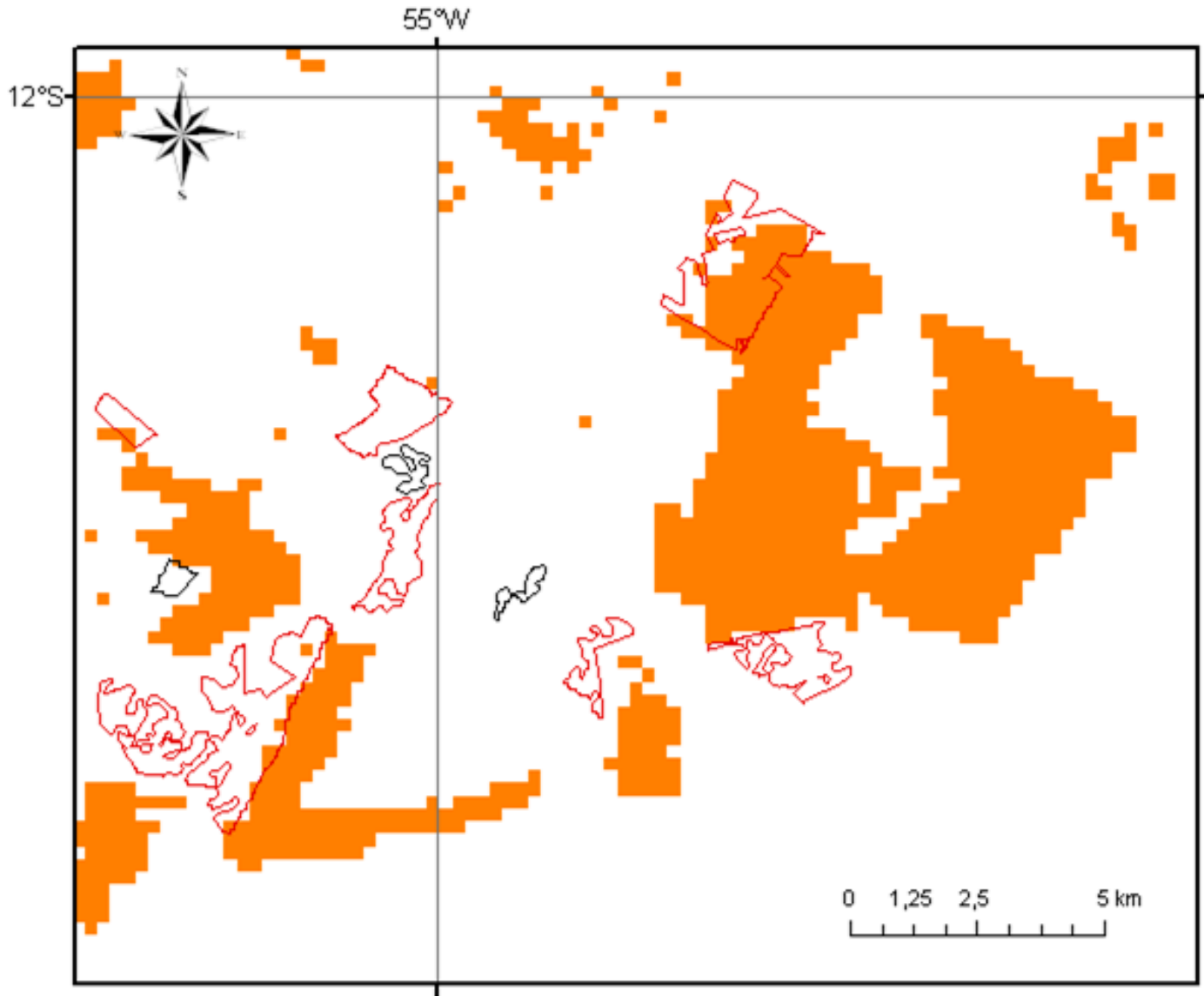


# Number (n) and area (ha) of deforested polygons after the Soybean Moratorium

Classes (ha)	Mato Grosso		Pará		Rondônia		Sub total	
	n	(ha)	n	(ha)	n	(ha)	n	(ha)
25 a 50	878	30,714	498	16,924	90	2,929	1,466	50,557
50 a 100	499	35,307	256	17,790	41	2,915	796	56,011
>100	504	148,542	167	41,781	22	5,256	693	195,581
Sub total	1,881 (63.7%)	214,563 (71.0%)	921 (31.2%)	76,495 (25.3%)	153 (5.1%)	11,100 (3.7%)	2,955 (100%)	302,149 (100%)

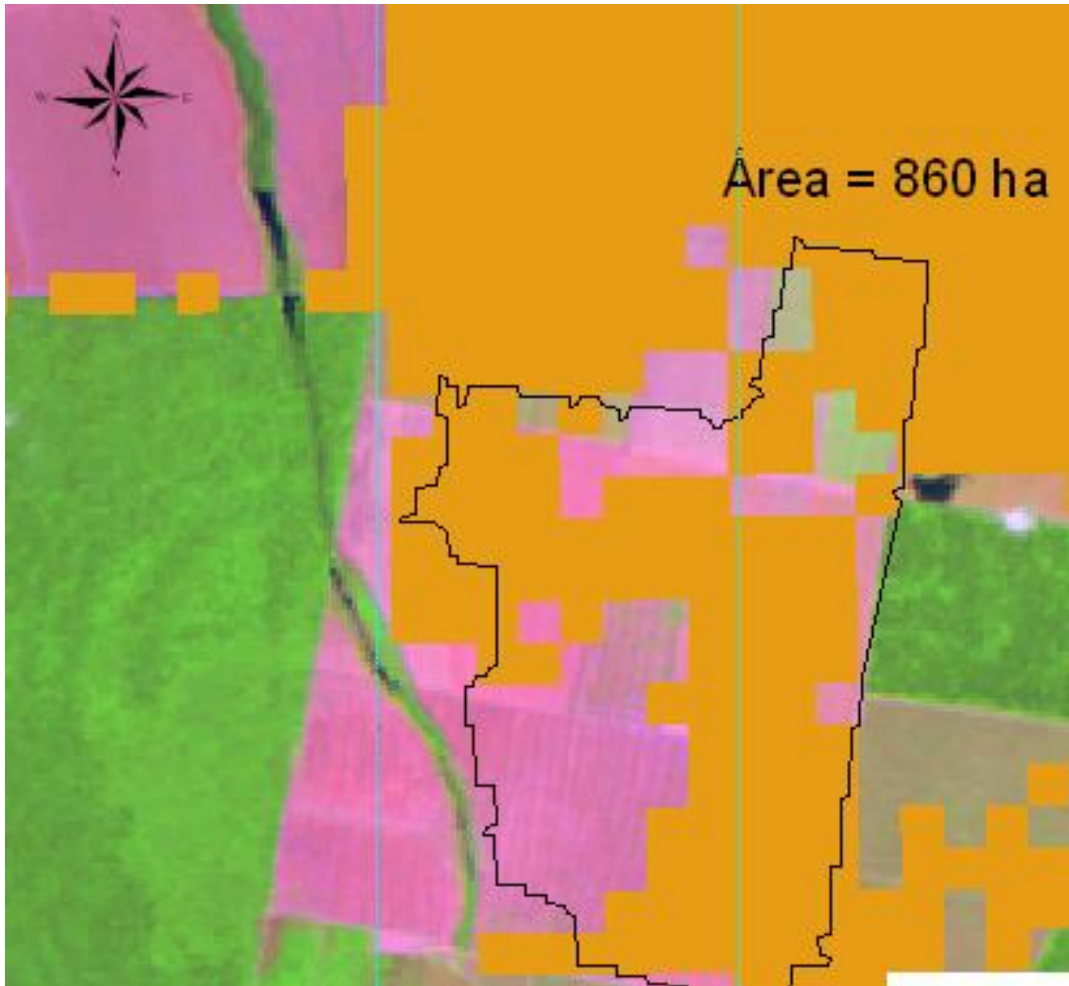


# MODIS image classification to identify annual crops in the 2,955 selected polygons





# Soybean in deforested polygon after 24 July 2006

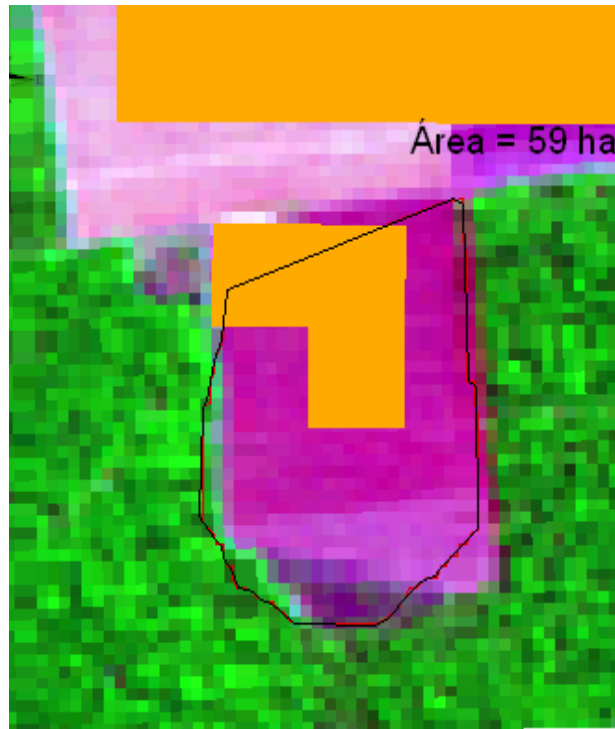


Landsat image in background  
MODIS image classification 



Panoramic aerial photography

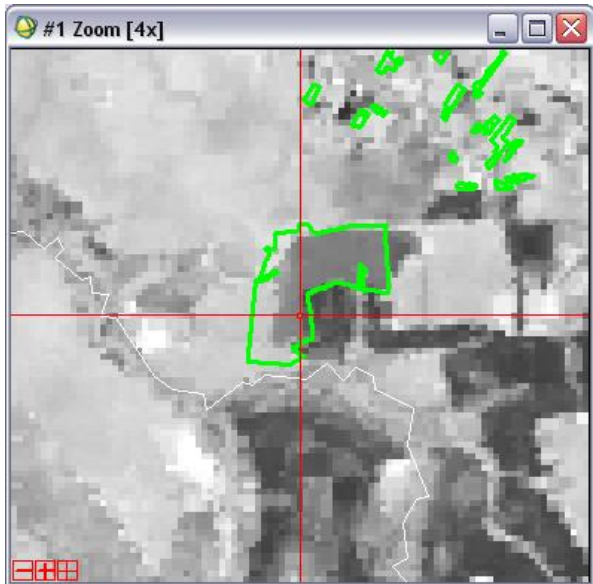
# Soybean in deforested polygon after 24 July 2006



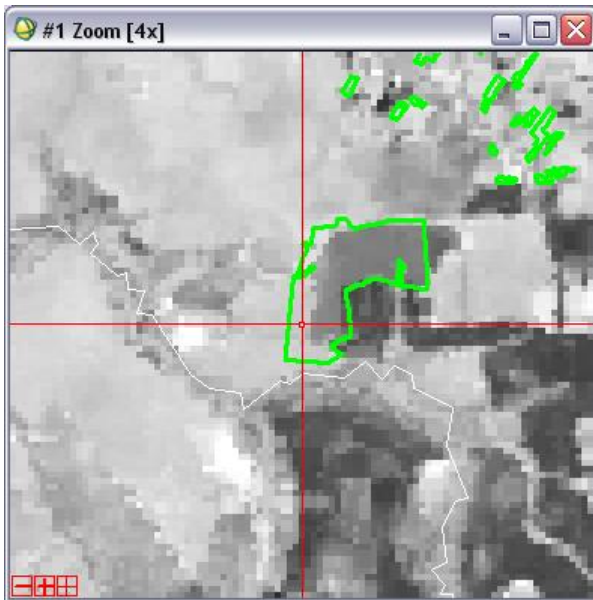
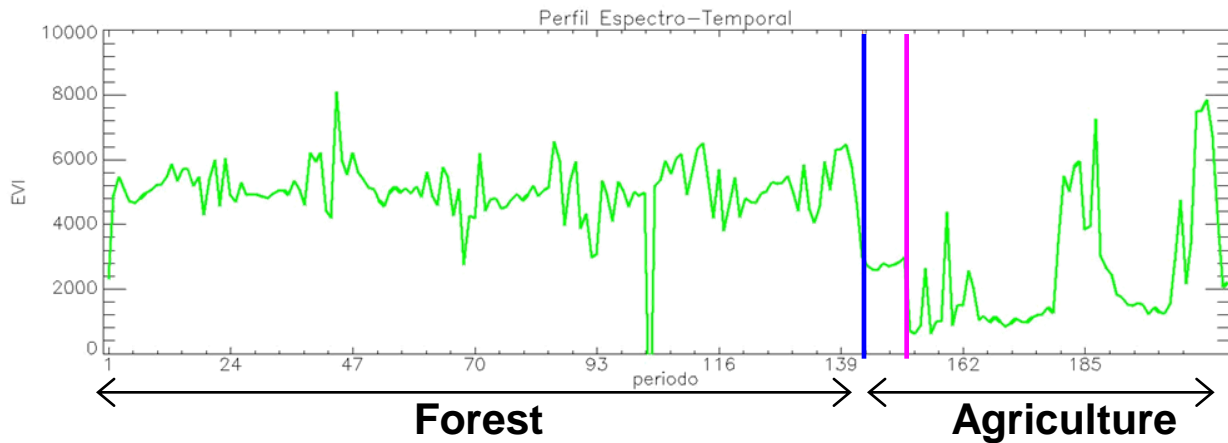
Landsat image in background  
MODIS image classification



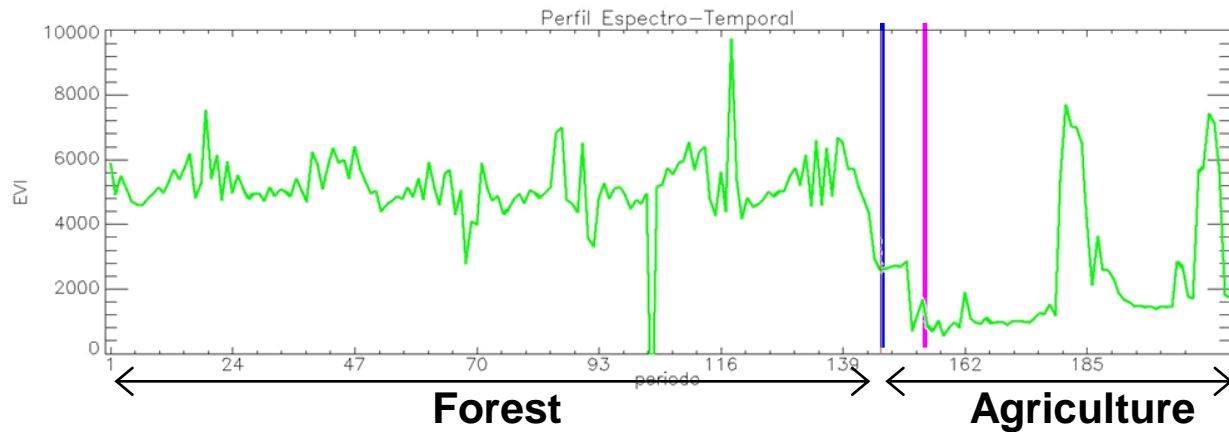
Panoramic aerial photography



## Land Use Change – April 2006



## Land Use Change – April 2006



— 24 de julho de 2006

# Selected polygons as annual crop and soybean

Classes (ha)	Satellite <sup>1</sup>		Aircraft <sup>2</sup>	
	No Annual Crop	Annual Crop	Annual Crop	Soybean
25 to 50	1,374	92	49	28
50 to 100	755	41	22	14
>100	632	61	45	34
<b>Total</b>	<b>2,761</b>	<b>194</b>	<b>116</b>	<b>76</b>

1) Annual crop identification by Terra/MODIS and Landsat/TM images

2) Soybean identification by panoramic aerial photography and field work

# Polygons with soybean

Classes (ha)	Mato Grosso		Pará		Rondônia		Sub total	
	n	(ha)	n	(ha)	n	(ha)	n	(ha)
25 a 50	22	647	6	132			28	780
50 a 100	9	323	5	265			14	588
>100	25	3,701	8	1,198	1	29	34	4,927
Sub total	56	4,670	19	1,596	1	29	76	6,295

# Summary

- **7.5% of the Brazilian soybean is planted in the Amazon biome;**
- **98% of this soybean is planted in 52 municipalities;**
- **2,955 deforested polygons (>25 ha), in these municipalities, were monitored by satellite images;**
- **194 polygons were classified as annual crop using satellite images;**
- **76 polygons were identified as soybean using aircraft;**
- **6,295 ha of soybean were planted in these deforested polygons which corresponds to 0.36% of the soybean area in the Amazon biome.**