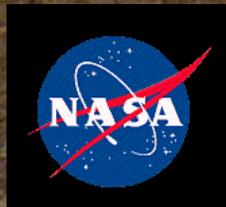


# Deforestation dynamics in Mato Grosso derived from MODIS data

**Yosio Shimabukuro**, INPE  
**Ruth DeFries**, University of Maryland  
**Doug Morton**, University of Maryland  
**Egidio Arai**, INPE  
**Ramon Freitas**, INPE  
**Liana Anderson**, INPE  
**Valdete Duarte**, INPE



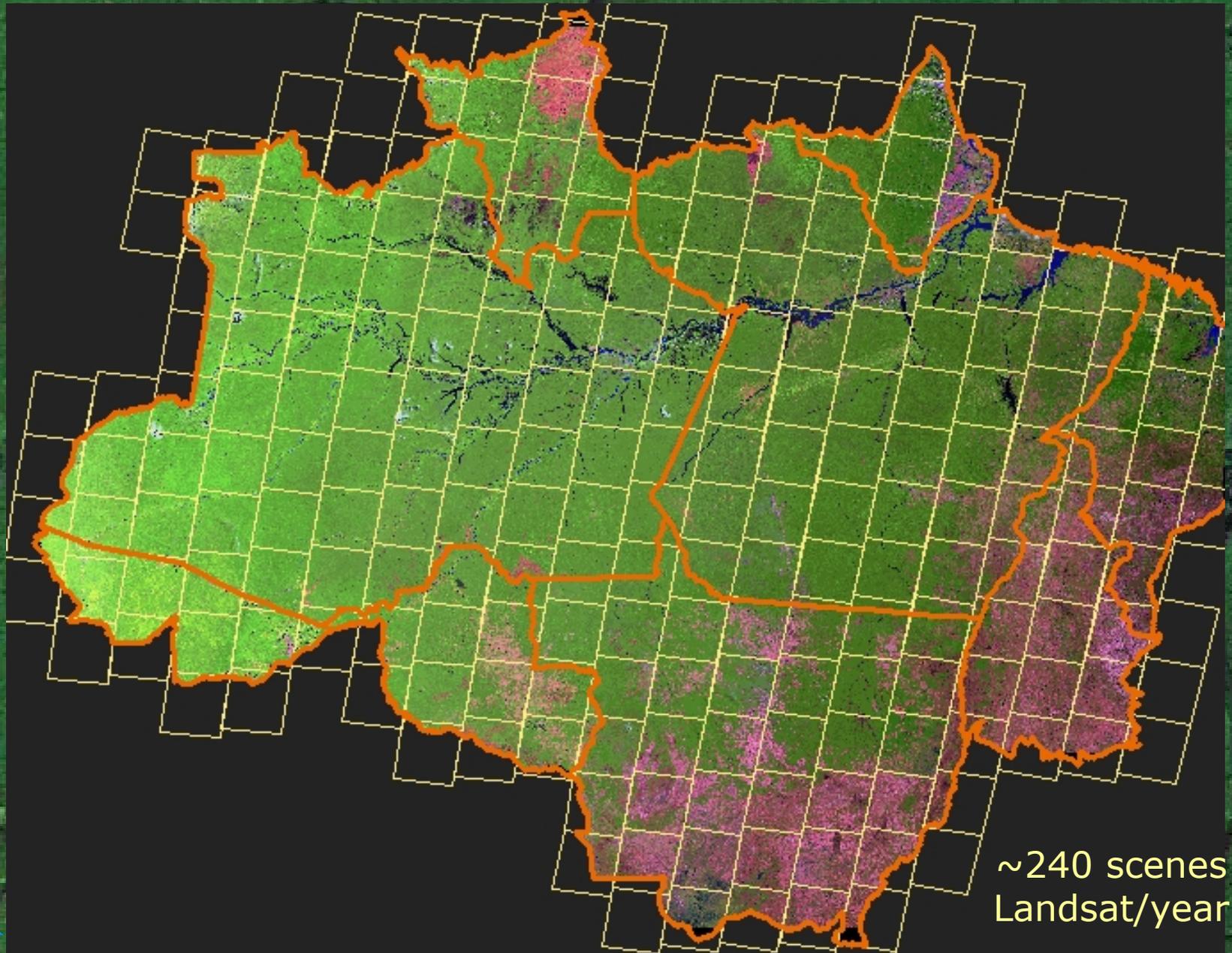
# OPERATIONAL DEFORESTATION MONITORING WITH LANDSAT DATA FROM 1970s TO PRESENT



**MONITORAMENTO DA FLORESTA  
AMAZÔNICA  
BRASILEIRA POR SATÉLITE  
MONITORING OF THE BRAZILIAN  
AMAZON FOREST BY SATELLITE**



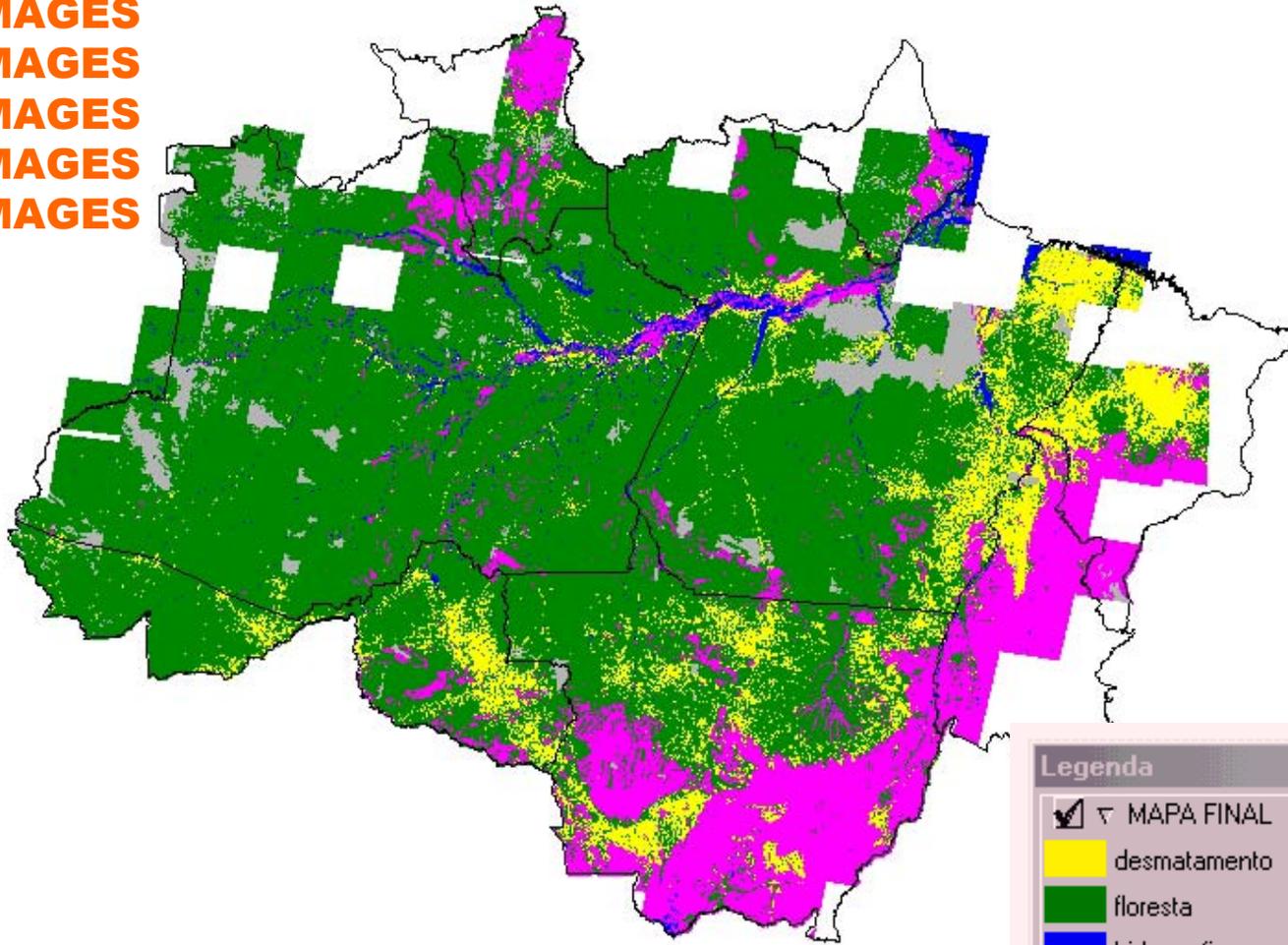
# Landsat TM Images for PRODES



# PRODES Digital - Status

## Landsat TM

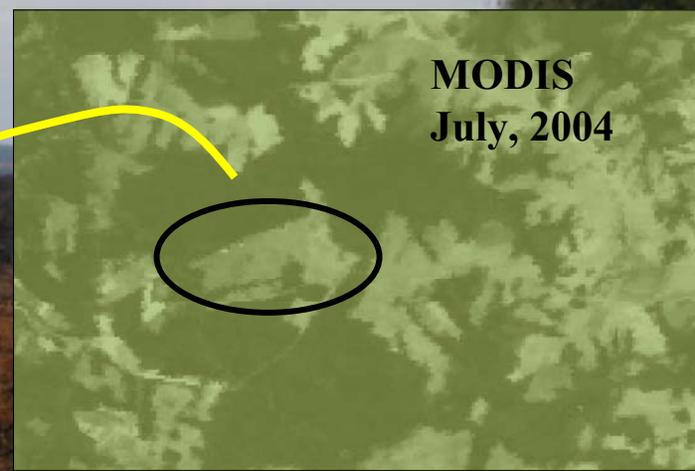
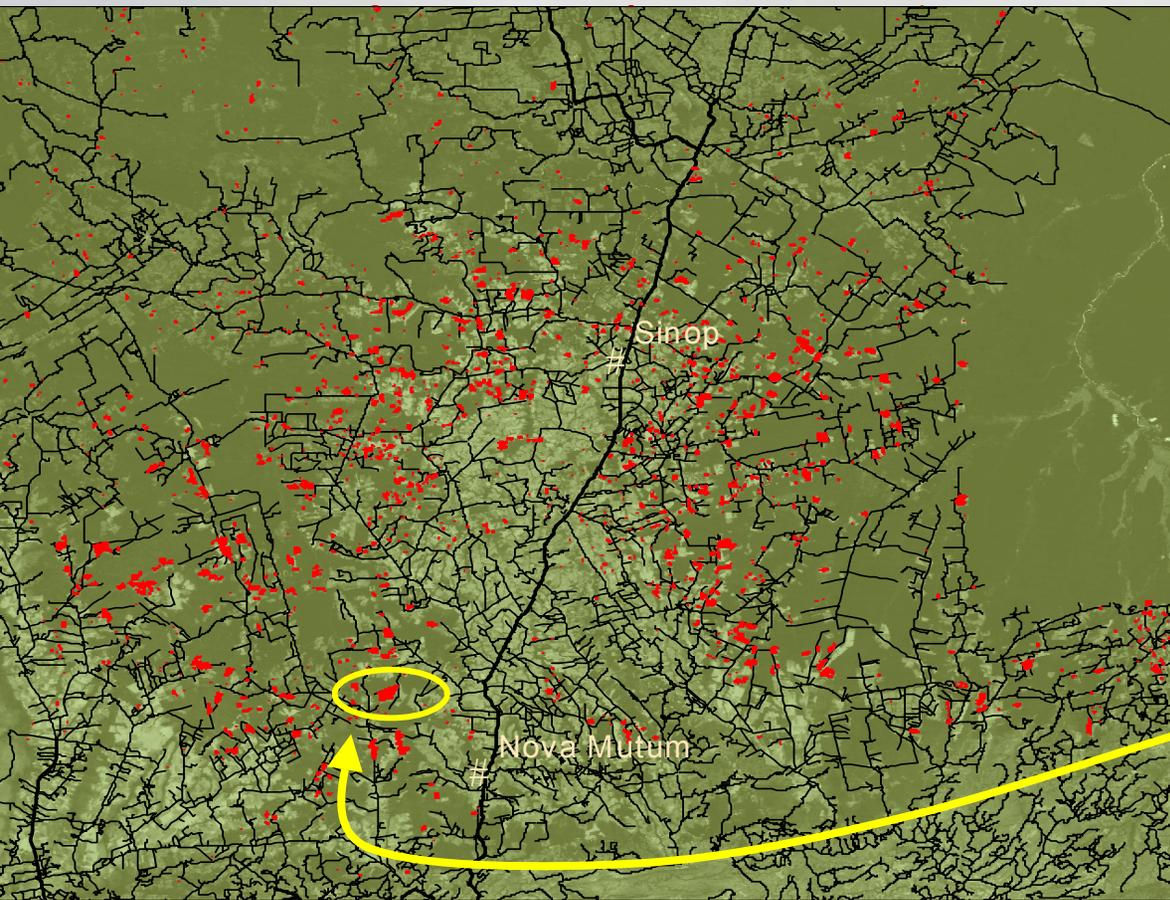
1997 = 181 IMAGES  
2000 = 162 IMAGES  
2001 = 192 IMAGES  
2002 = 205 IMAGES  
2003 = 214 IMAGES



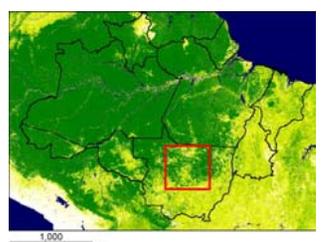
# COMPLEMENTING OPERATIONAL DEFORESTATION MONITORING WITH MODIS DATA

- **Rapid assessment of new deforestation locations on annual time step**
  - **Real-time monitoring (DETER)**
  - **Monitoring secondary land use transitions**
- 
- A photograph of a herd of white cows grazing in a field. The field is filled with dry, brown grass and some green plants. In the background, there are several palm trees and other green trees under a clear blue sky. The cows are of various breeds, some with horns, and are scattered across the field. The overall scene is a rural, agricultural landscape.

# Rapid assessment of new deforestation on annual time step: MODIS VCF Product and MODIS Red band Thresholding



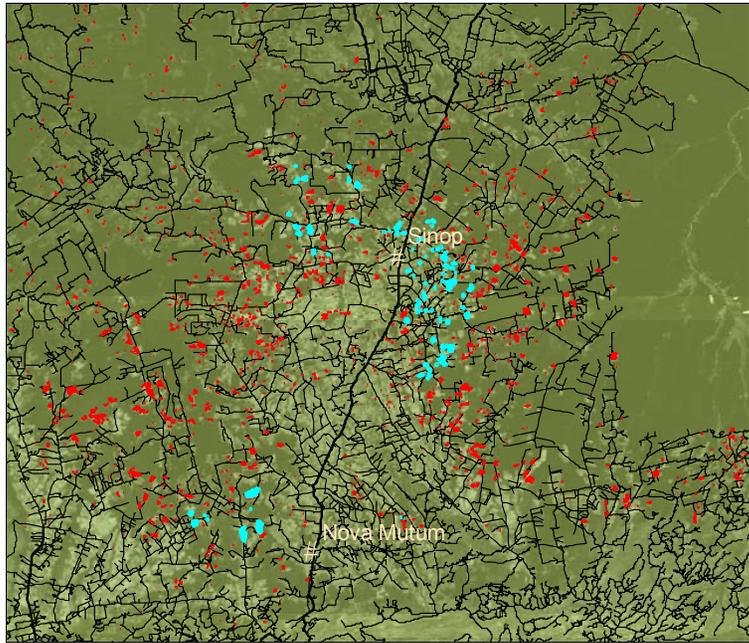
200 Kilometers



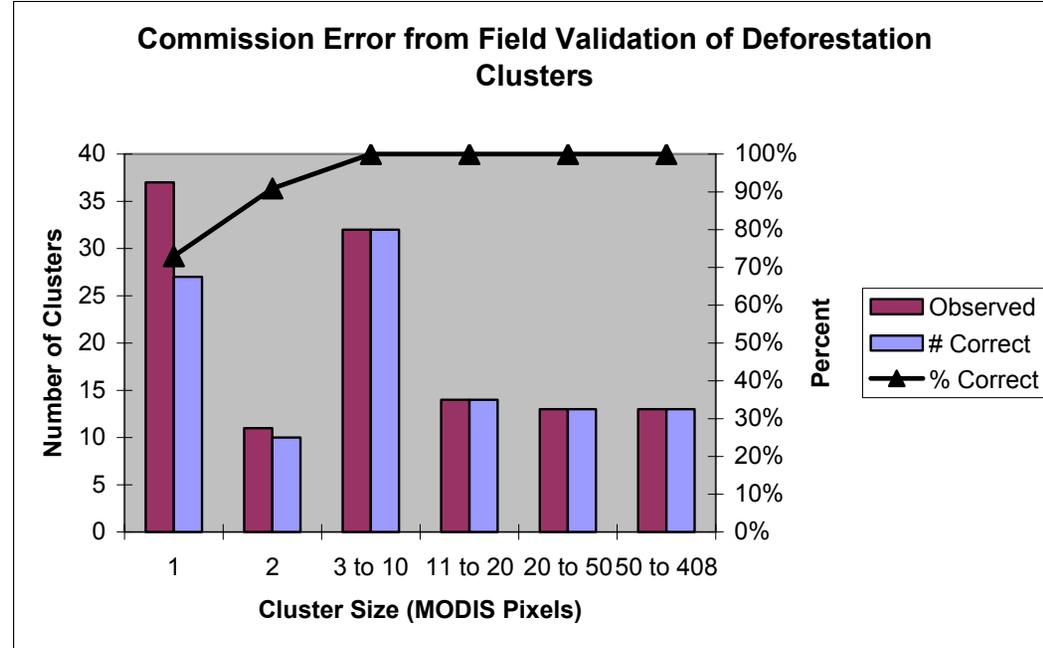
**Legend**  
[Red square] deforestation identified by MODIS  
NDVI 16 day composite through July 6  
Value  
[Green square] High : 9997  
[Light green square] Low : -3000

**Legend**  
NDVI 16 day composite through July 6  
Value  
[Green square] High : 9997  
[Light green square] Low : -3000

# Field Validation in central Mato Grosso—July, 2004

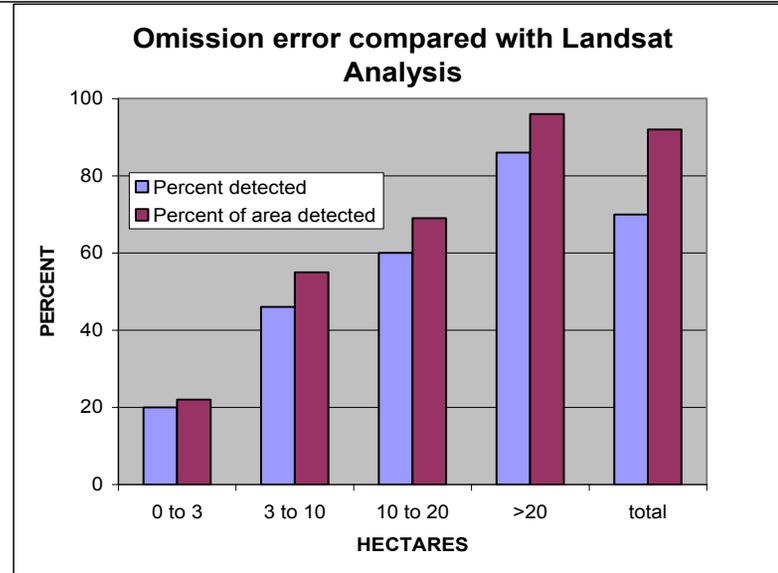


**Legend**  
 ■ deforestation identified by MODIS  
 NDVI 16 day composite through July 6  
 Value  
 ■ High : 9997  
 ■ Low : -3000

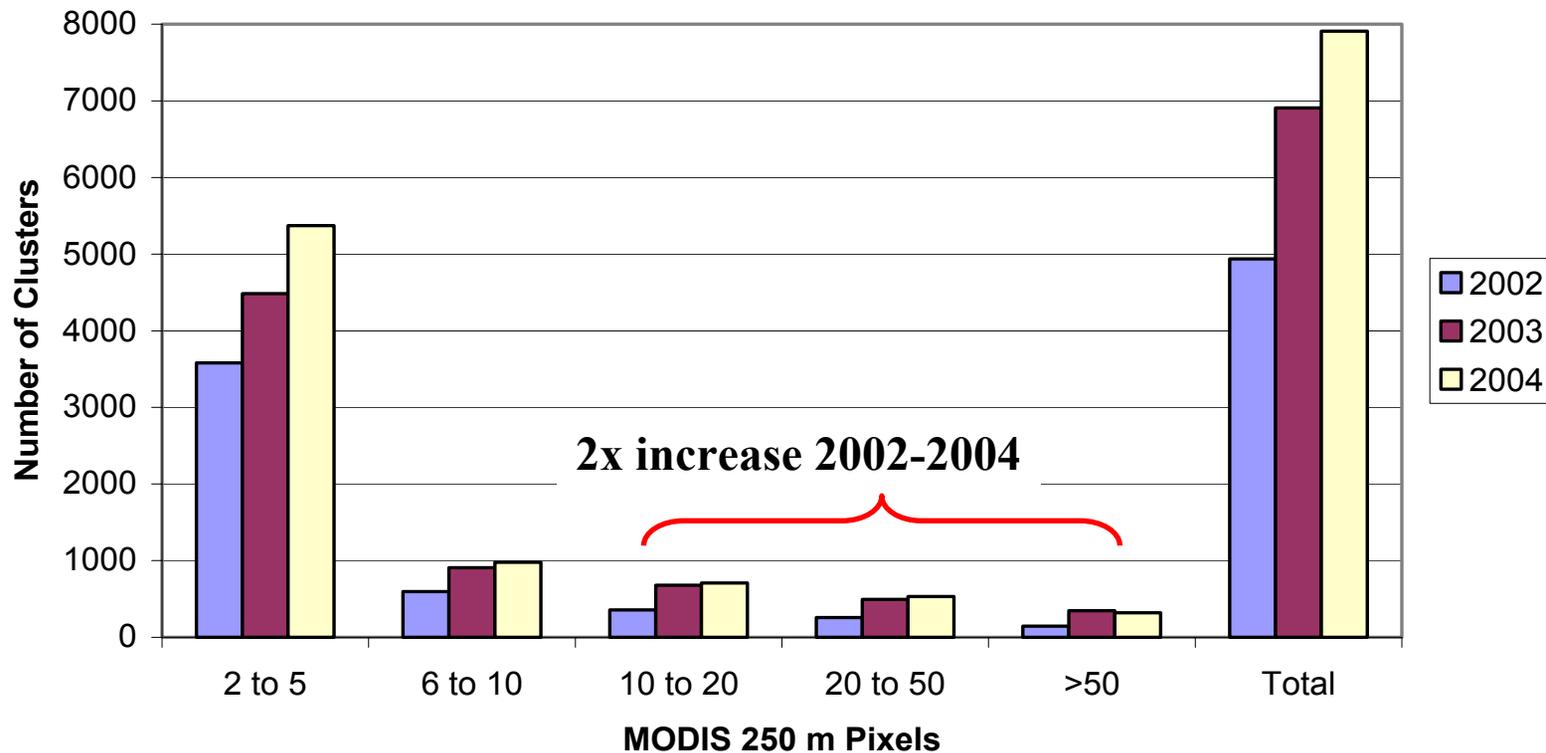


**HIGH ACCURACY IN RAPID IDENTIFICATION OF LARGE DEFORESTATION EVENTS**

(Morton et al., 2005, *Earth Interactions*)

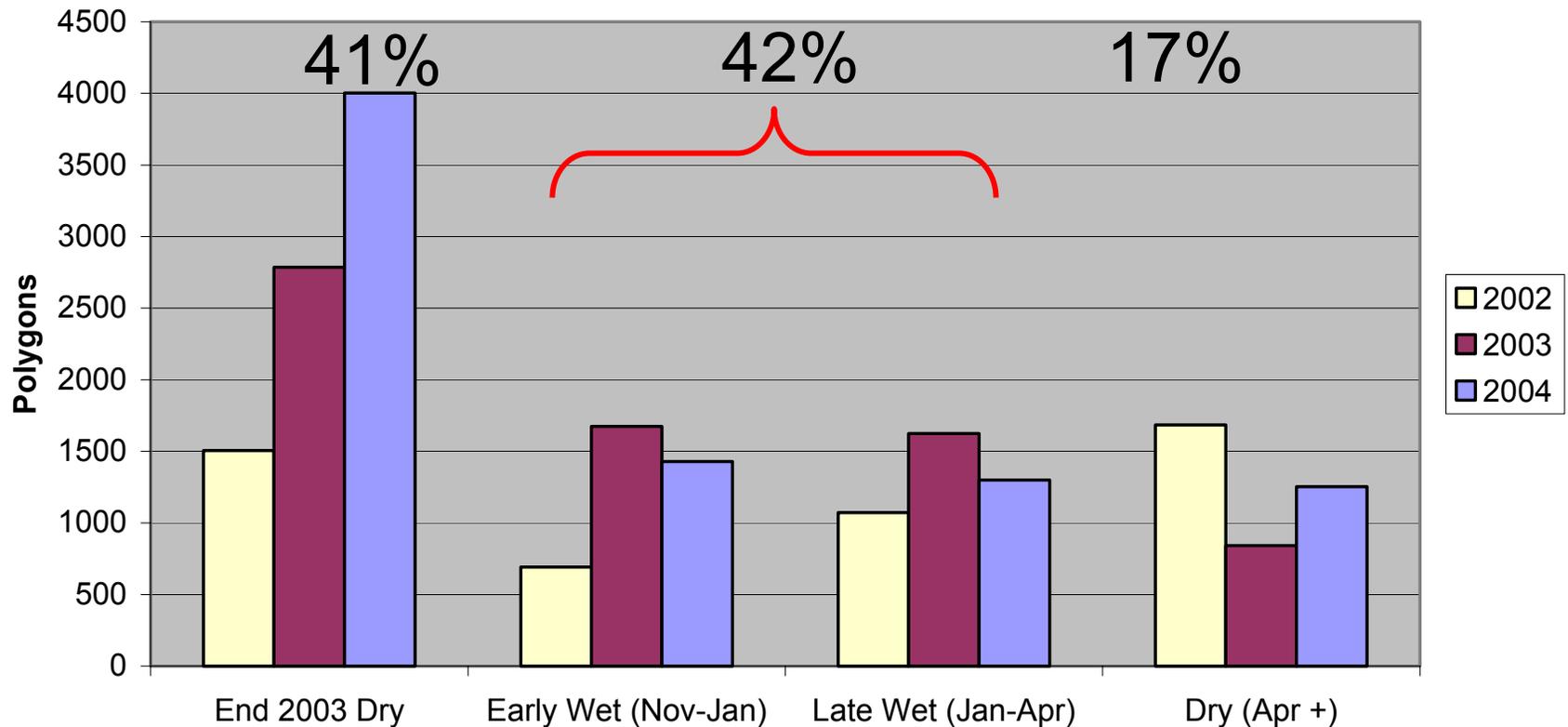


## Deforestation Clusters Detected in Mato Grosso 2001-2004



**MORE AND LARGER DEFORESTATION EVENTS IN MATO GROSSO OVER MODIS TIME SERIES**

## Timing of MODIS-based Deforestation Detections



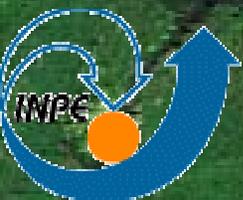
## DEFORESTATION TIMING:

- Critical periods for deforestation monitoring in Mato Grosso are the late dry season and during the wet season.
- 2003 and 2004 show more clearing during wet season than 2002.

# Operational Deforestation Detection in Brazilian Legal Amazon with MODIS

(**DETER** - **DE**teccção em **TE**mpo **Re**al  
do Desmatamento na Amazônia Legal)

[www.obt.inpe.br/deter](http://www.obt.inpe.br/deter)



# DETER: Methodology

- Reference: deforestation map available from PRODES for the previous year
- Monthly detection of changes in forested areas without cloud cover
- Rapid dissemination of the results: internet

# DETER: Feasibility study

Comparing the methodology of PRODES (\*)  
using MODIS data

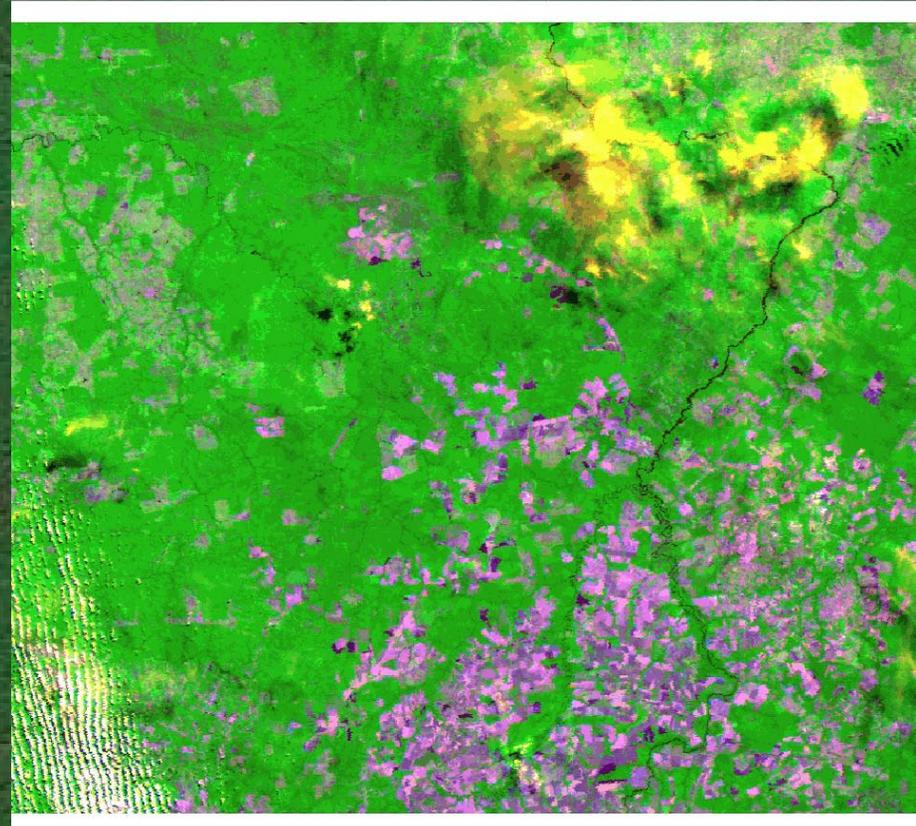
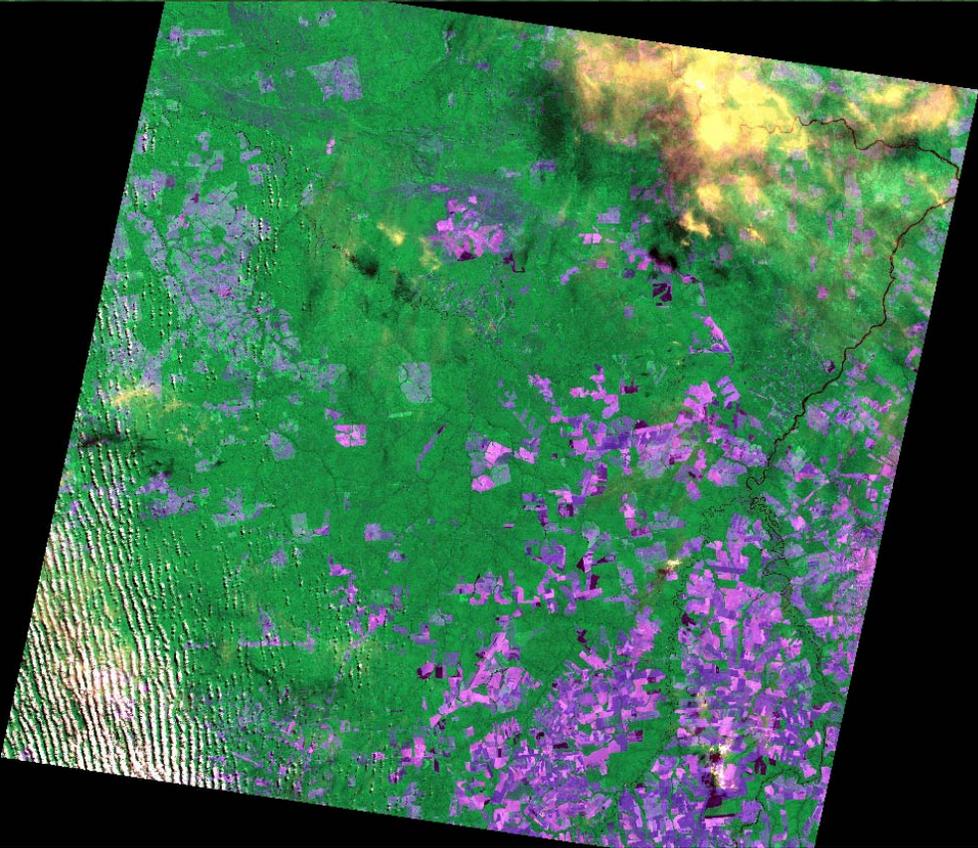
(\*) Transformation of image data using Linear Spectral  
Mixing Model, image segmentation and classification per  
region and pos classification image edition

- 8 sequential Landsat ETM+ scenes acquired in 2002  
(day 166 to day 278)
- 8 Terra/MODIS scenes (the same ETM+ dates)

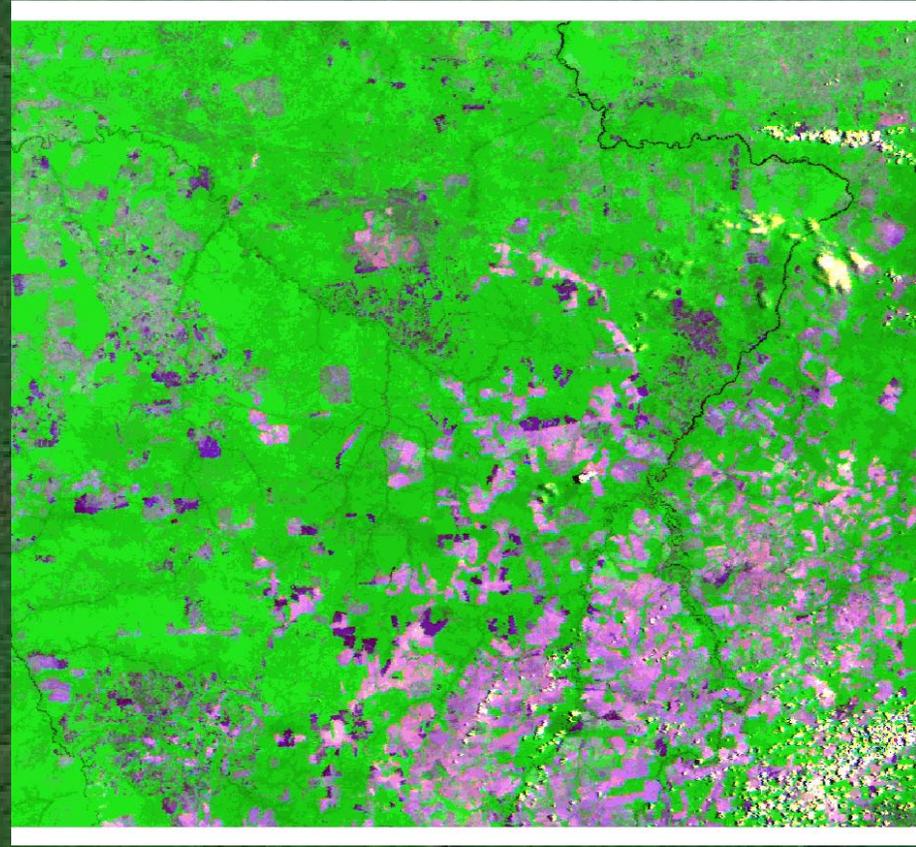
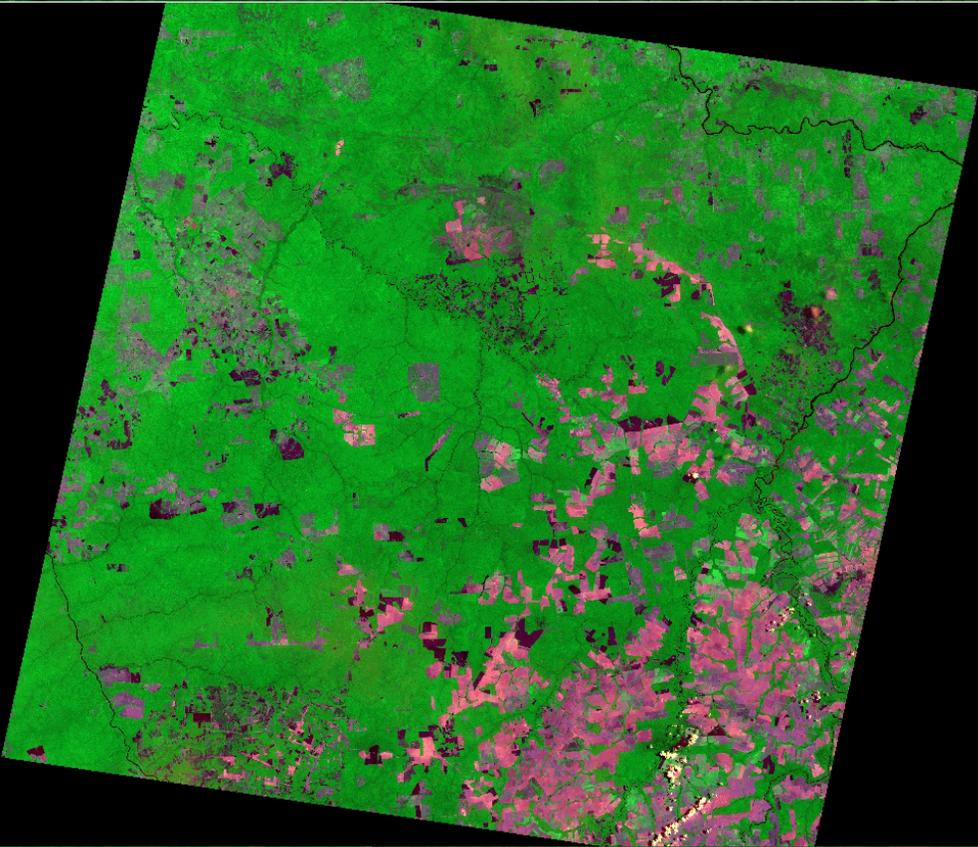
(Anderson, 2003)



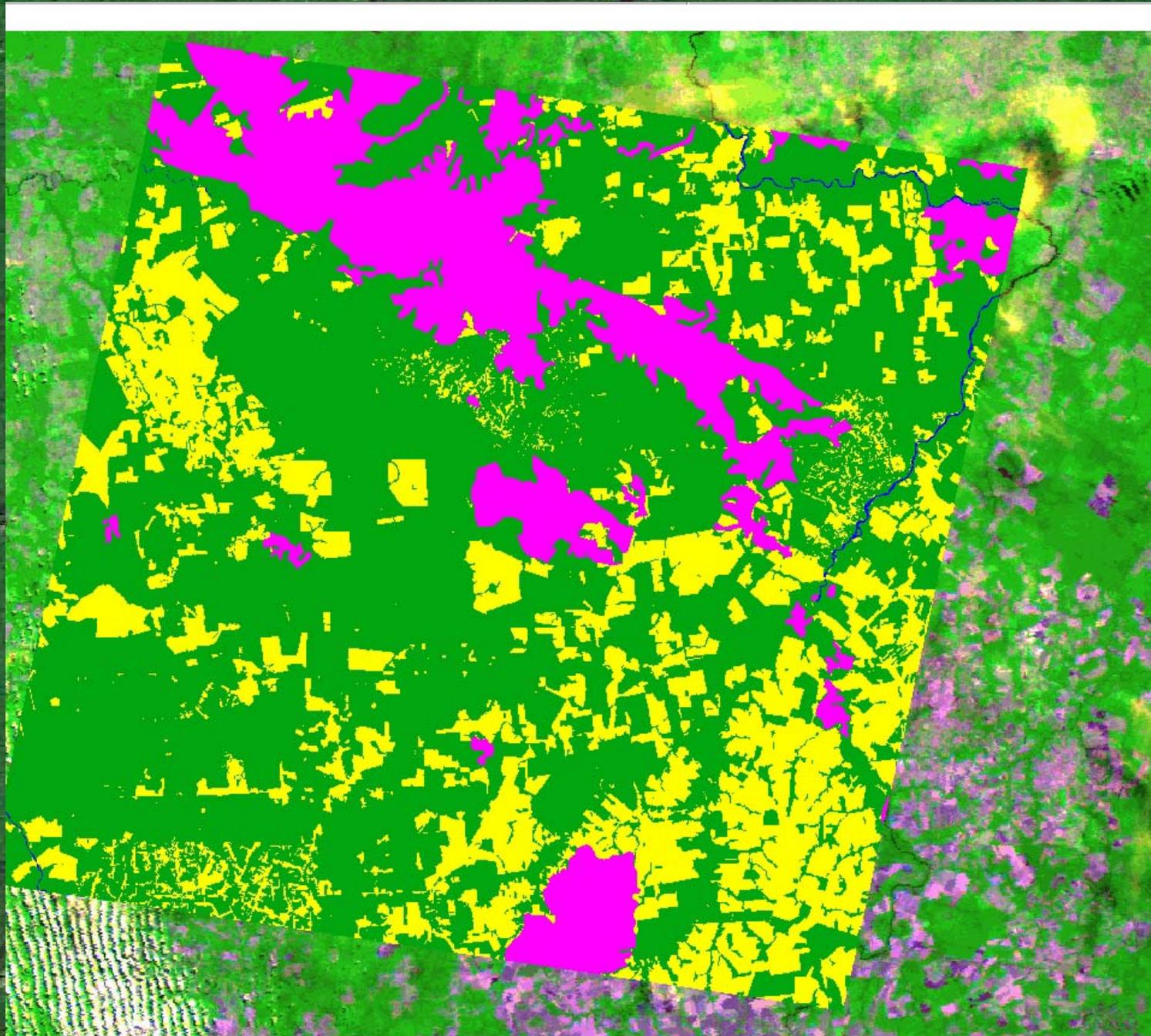
# LANDSAT ETM+ - TERRA MODIS 2002 / 166



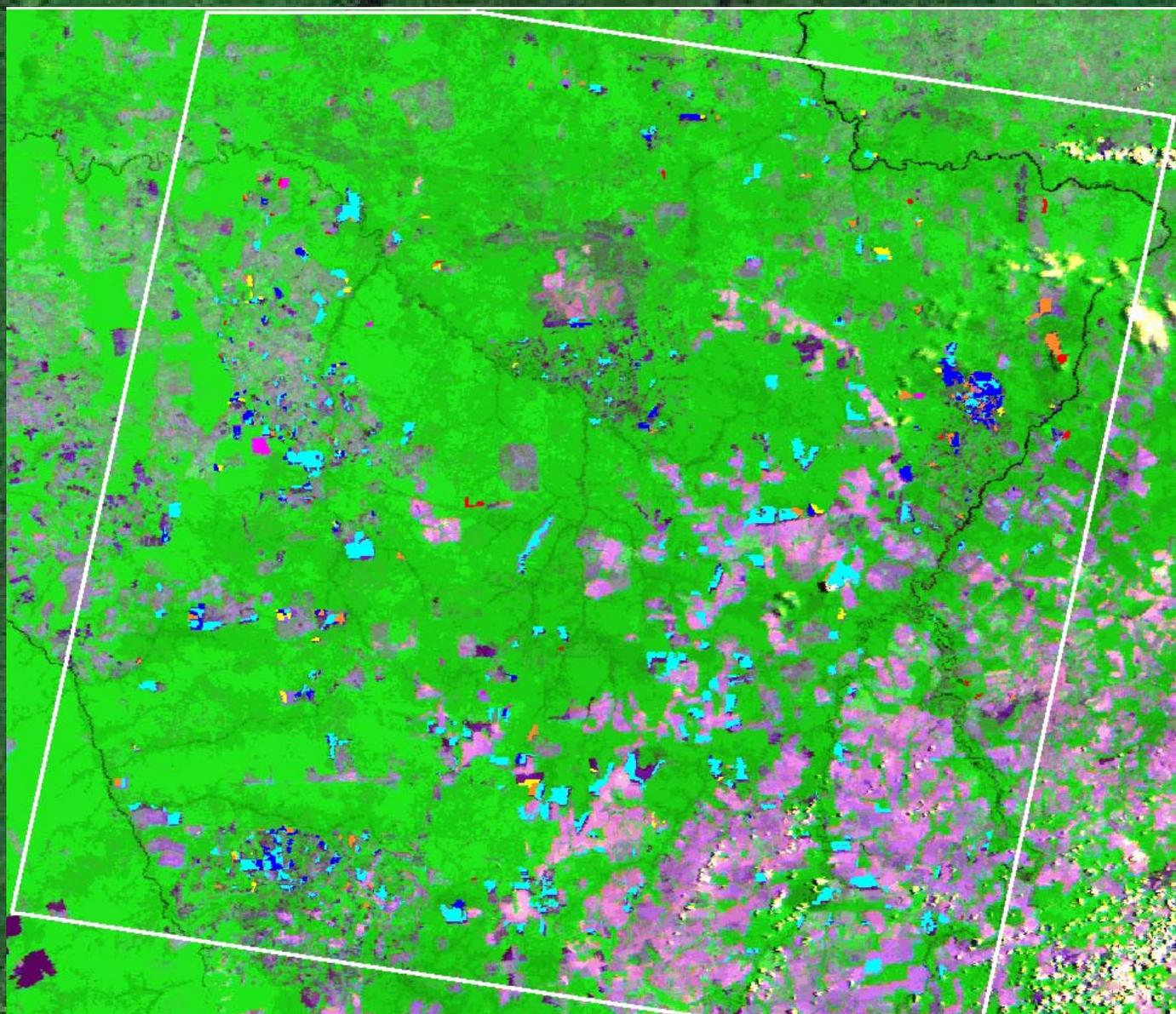
# LANDSAT ETM+ - TERRA MODIS 2002 / 278



# TERRA MODIS 2002/166 ---- PRODES 2001



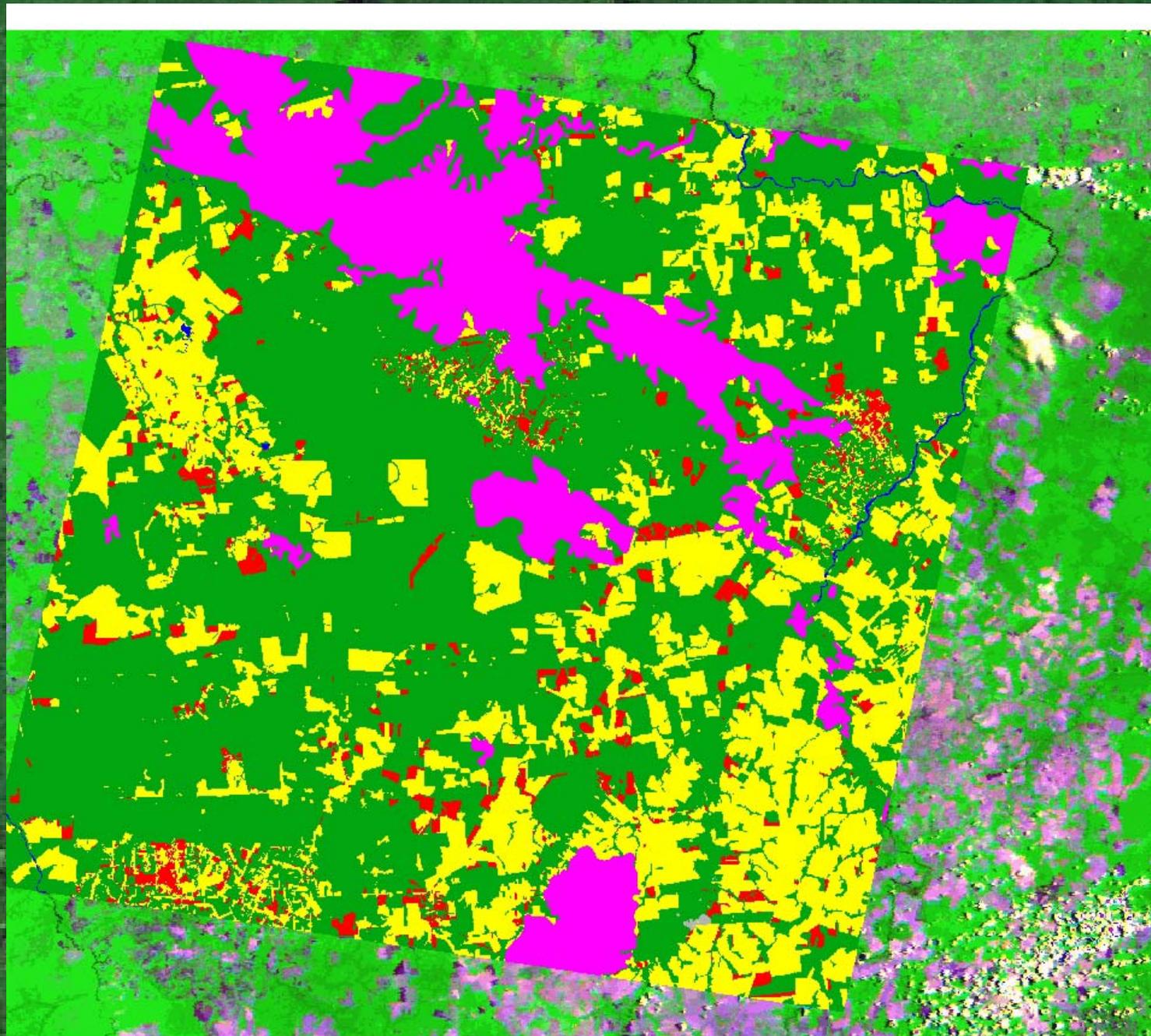
# TERRA MODIS 2002/278: Alert MODIS (166 - 278)



## Legenda

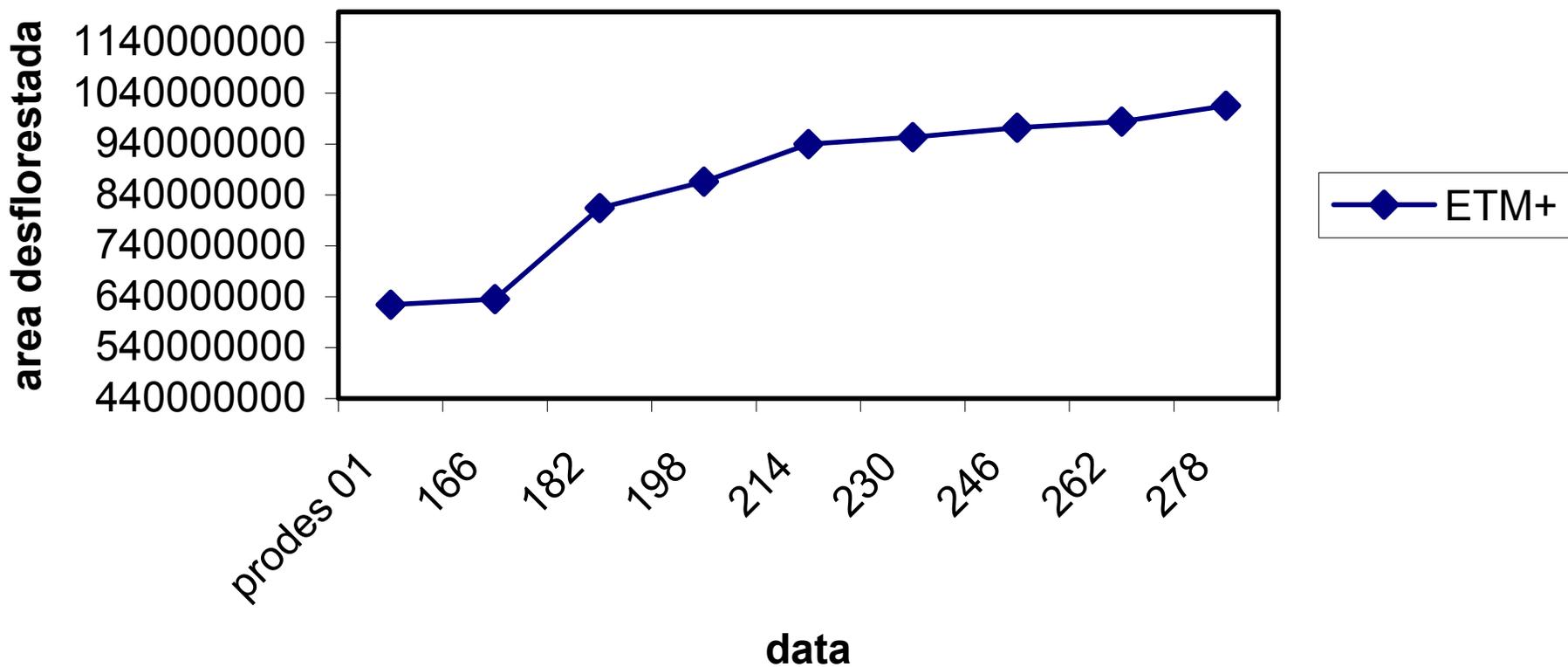
- Alerta\_2002
- Modis\_166
- Modis\_182
- Modis\_198
- Modis\_214
- Modis\_230
- Modis\_246
- Modis\_262
- Modis\_278

# TERRA MODIS 2002/278 / PRODES 2002



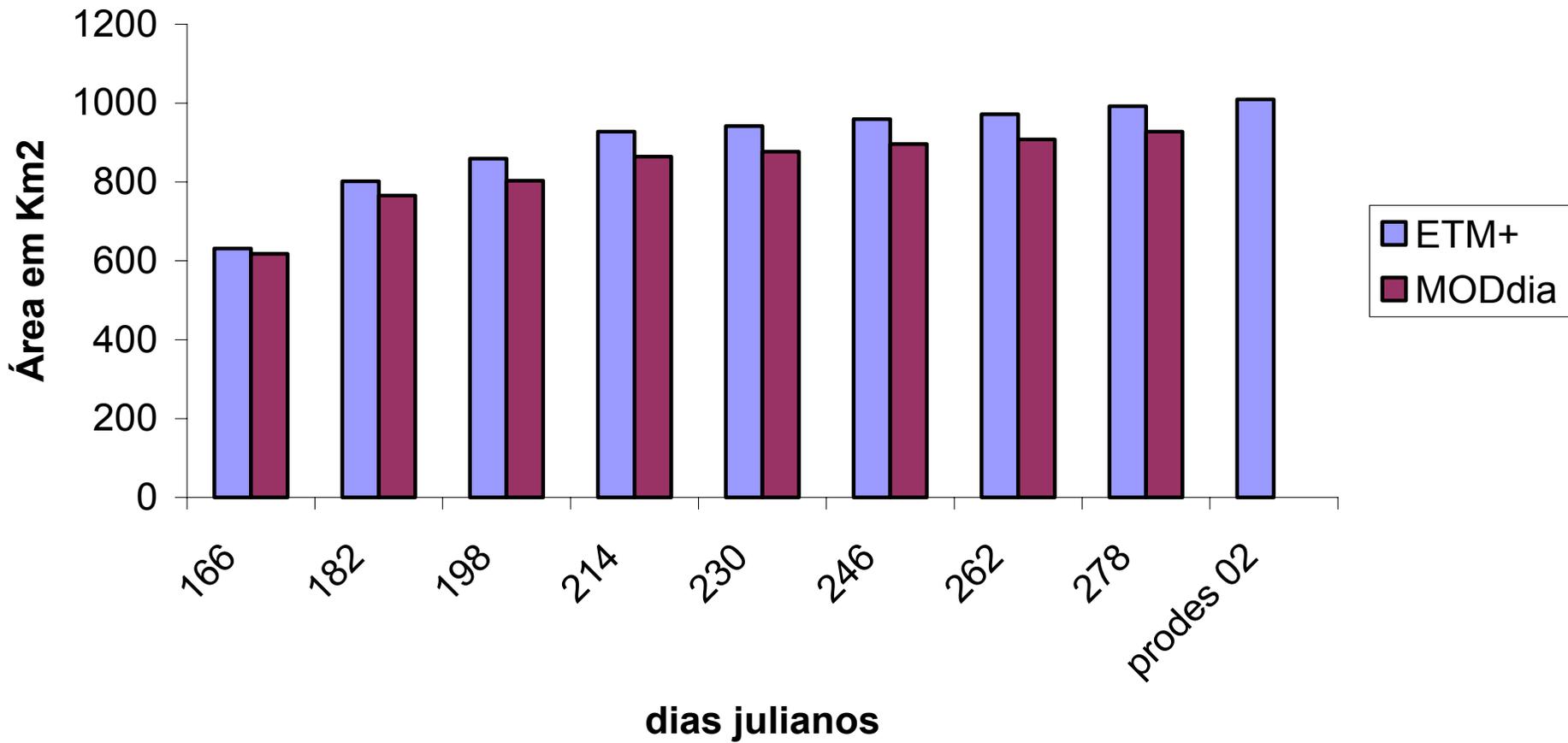
# LANDSAT ETM+ - MAPPED AREAS (M<sup>2</sup>)

## Desmatamento bruto a partir do PRODES 2001

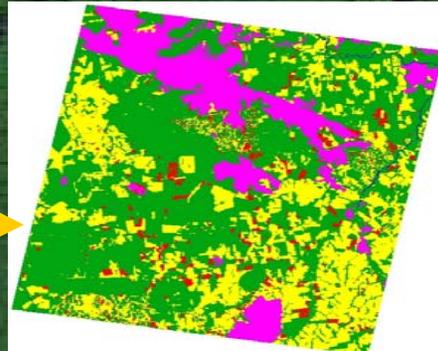


# LANDSAT ETM+ - MAPPED AREAS (KM<sup>2</sup>)

## Área desmatada entre junho e outubro de 2002



# DETER



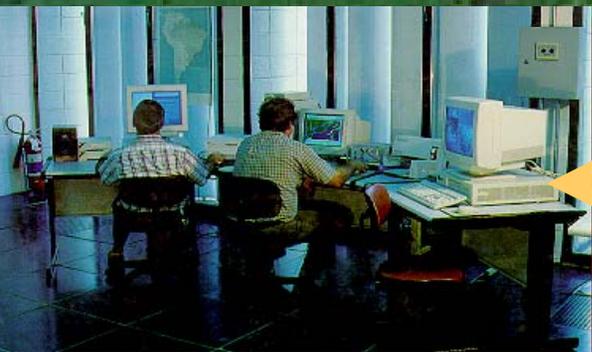
**PRODES Project Deforestation Database for the previous years**

**MODIS image more recent**

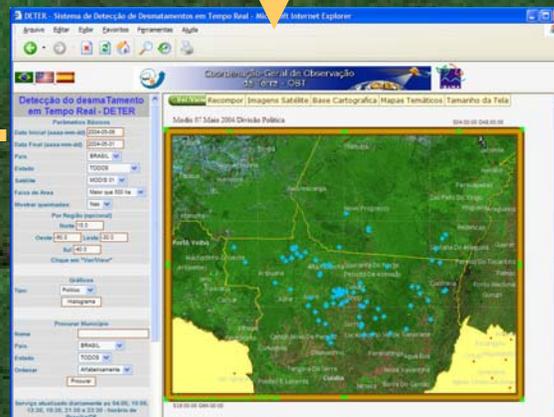
**Ground Station Cuiabá / MT**

**Processing data in S.J. Campos: SPRING – detection of new deforestation areas**

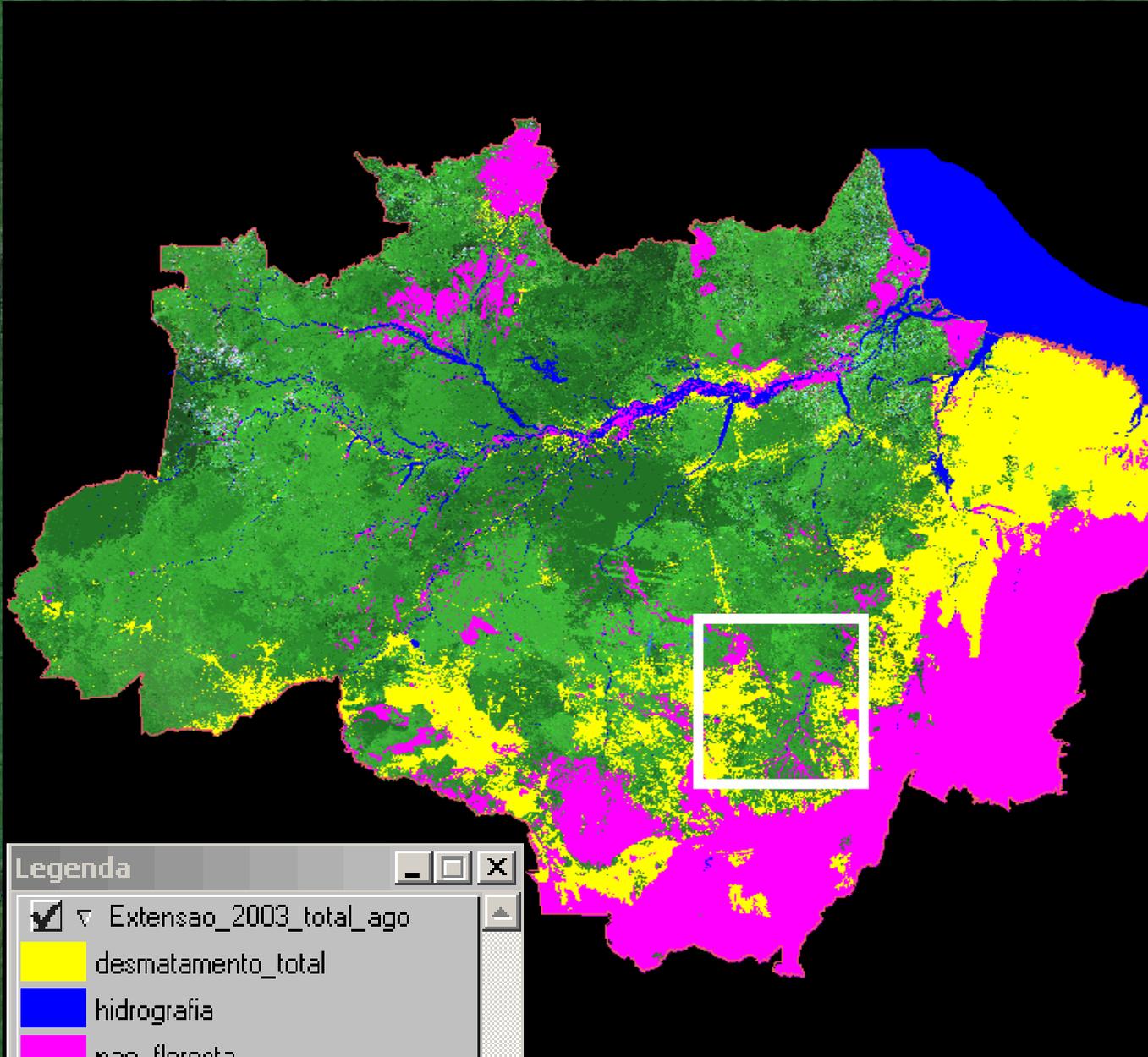
**Products in the Internet**



**Fiscalization: IBAMA and other Institutions**



# 2000 PRODES DIGITAL data complemented for 2003 over MODIS image: 12 to 27 August 2003



# MODIS IMAGE - 22 APR - 07 MAY 2004

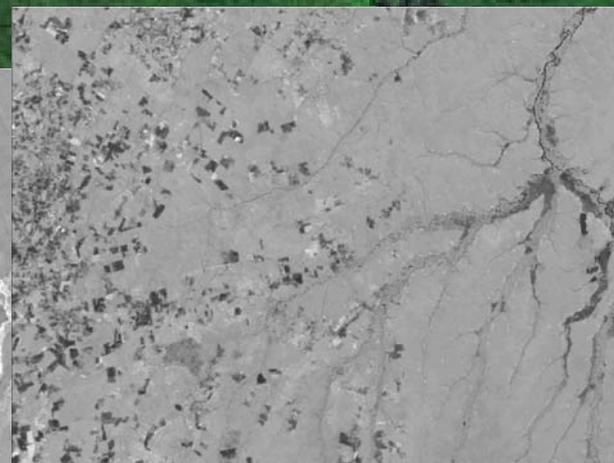
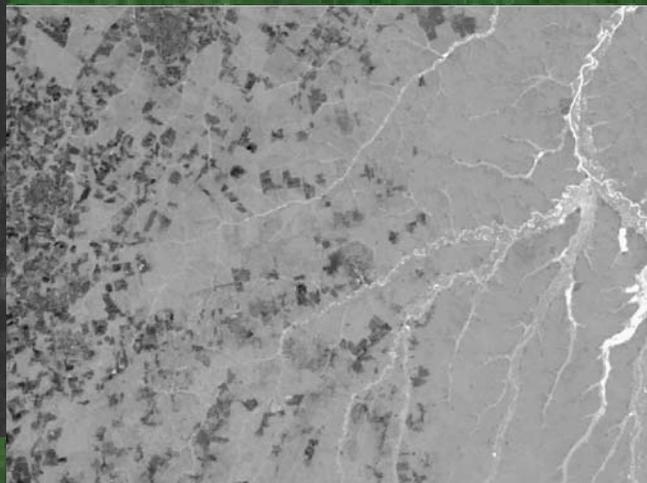


Rio Xingu

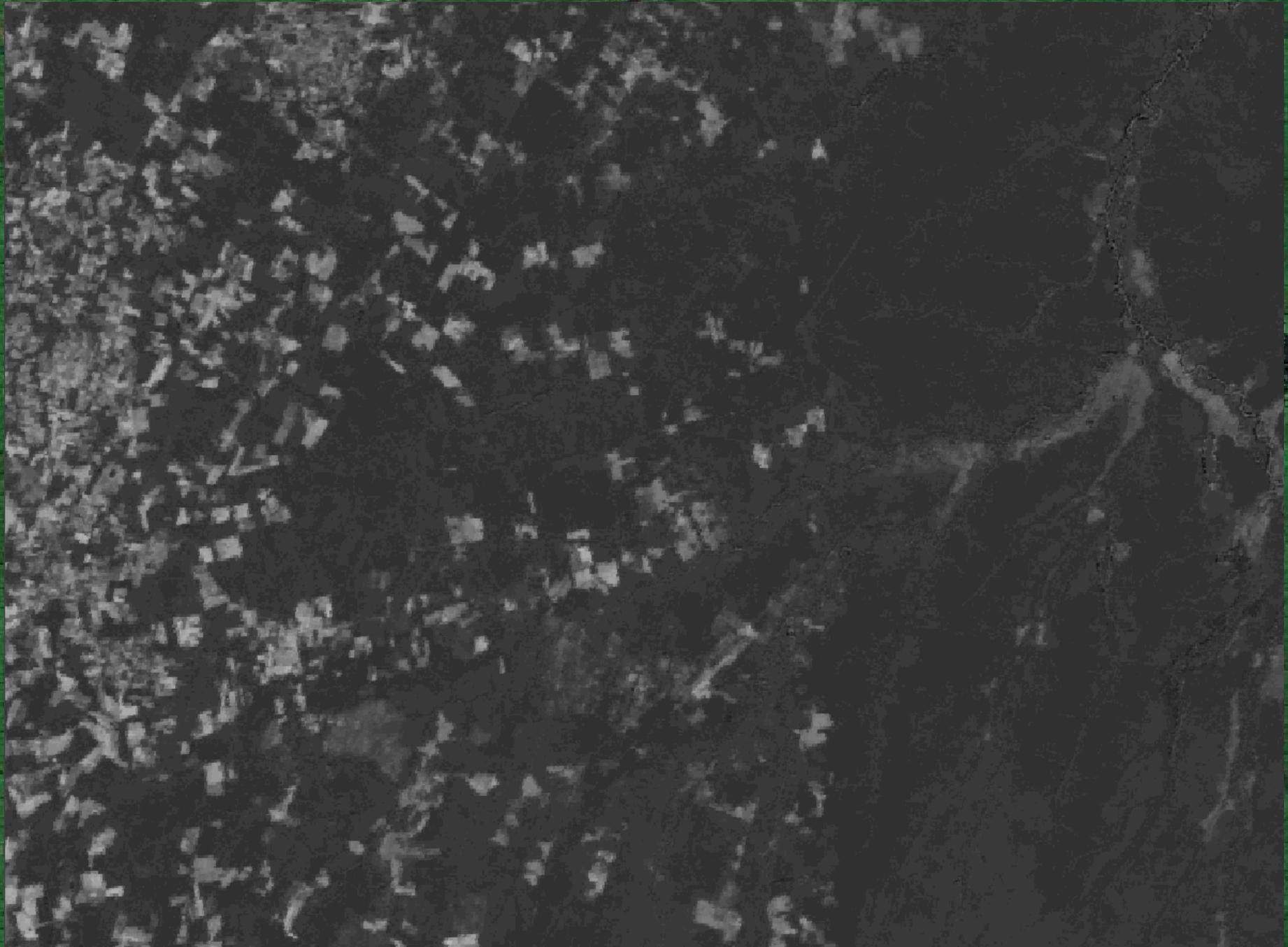
**SOIL FRACTION**

**SHADE FRACTION**

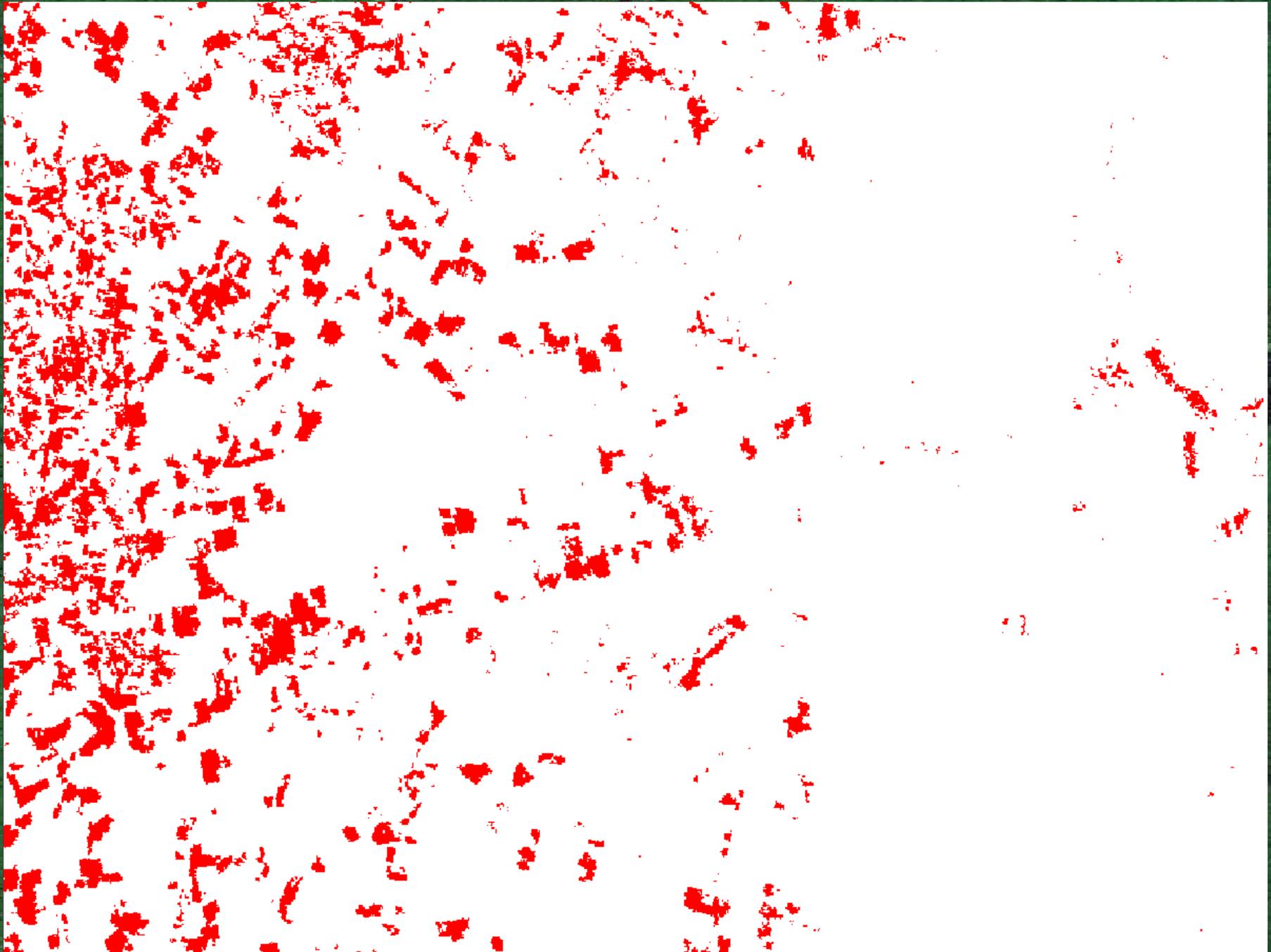
**VEGETATION FRACTION**



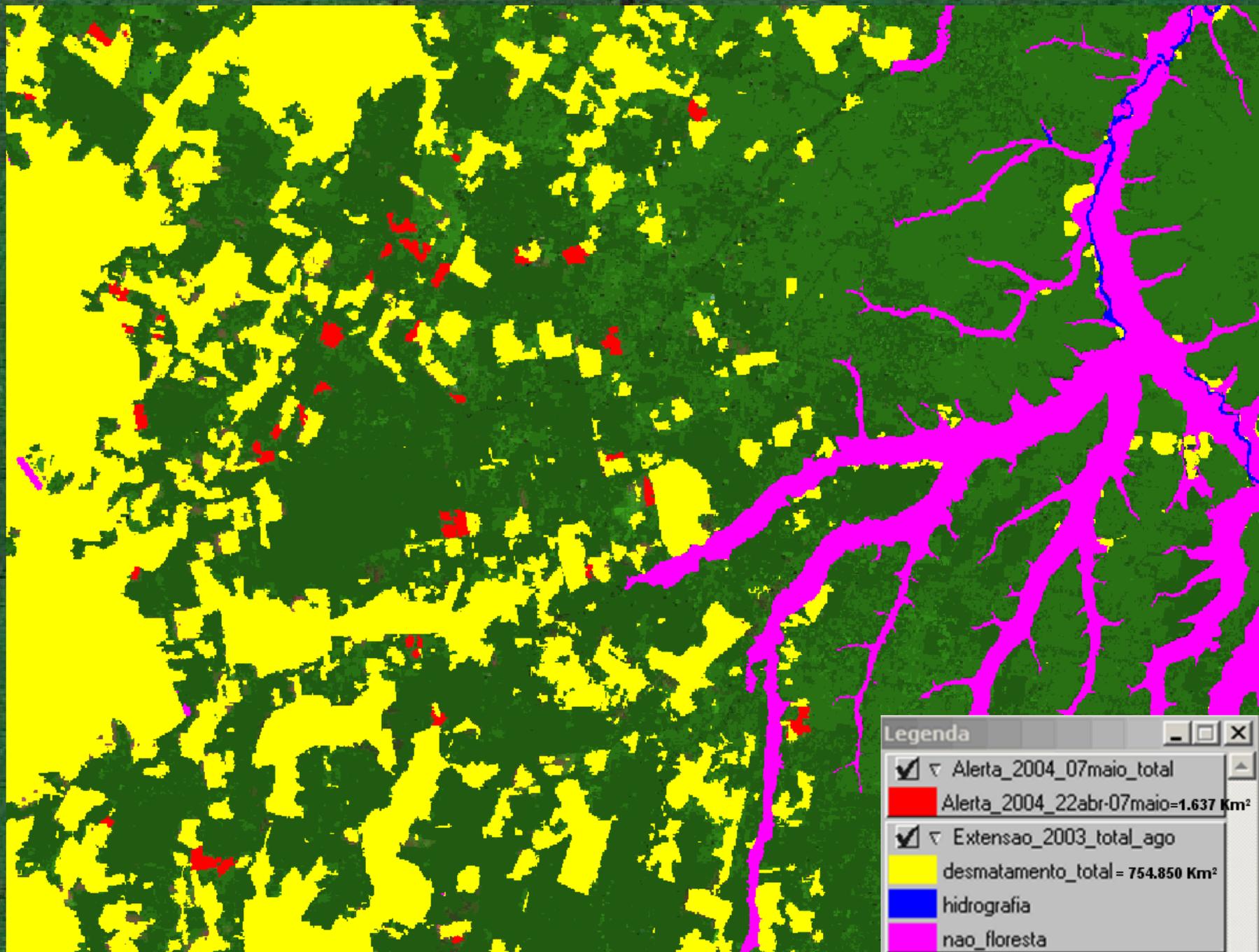
SOIL FRACTION IMAGE ( 22 APRIL to 07 MAY 2004)



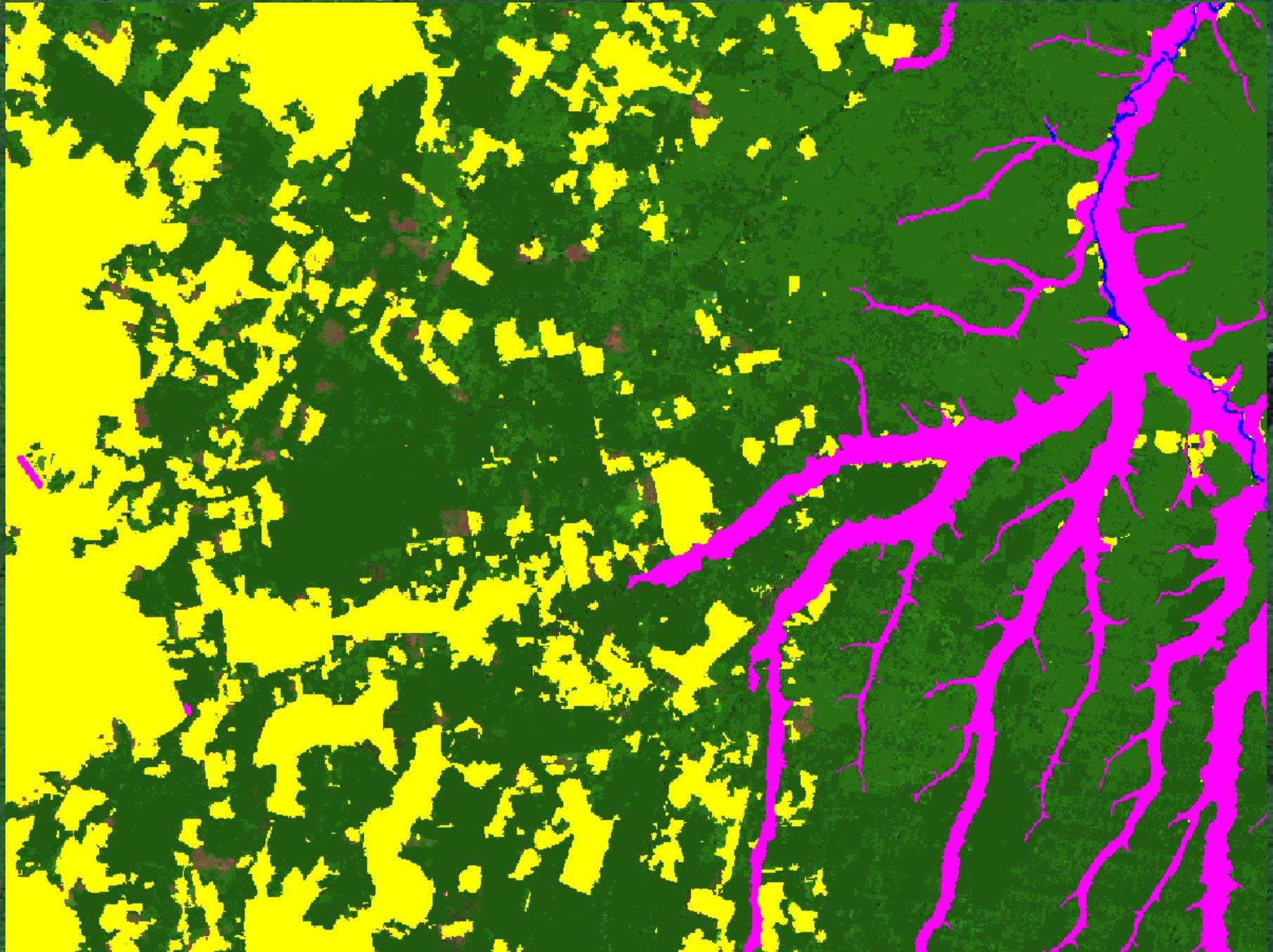
# CLASSIFICATION OF SOIL FRACTION IMAGE



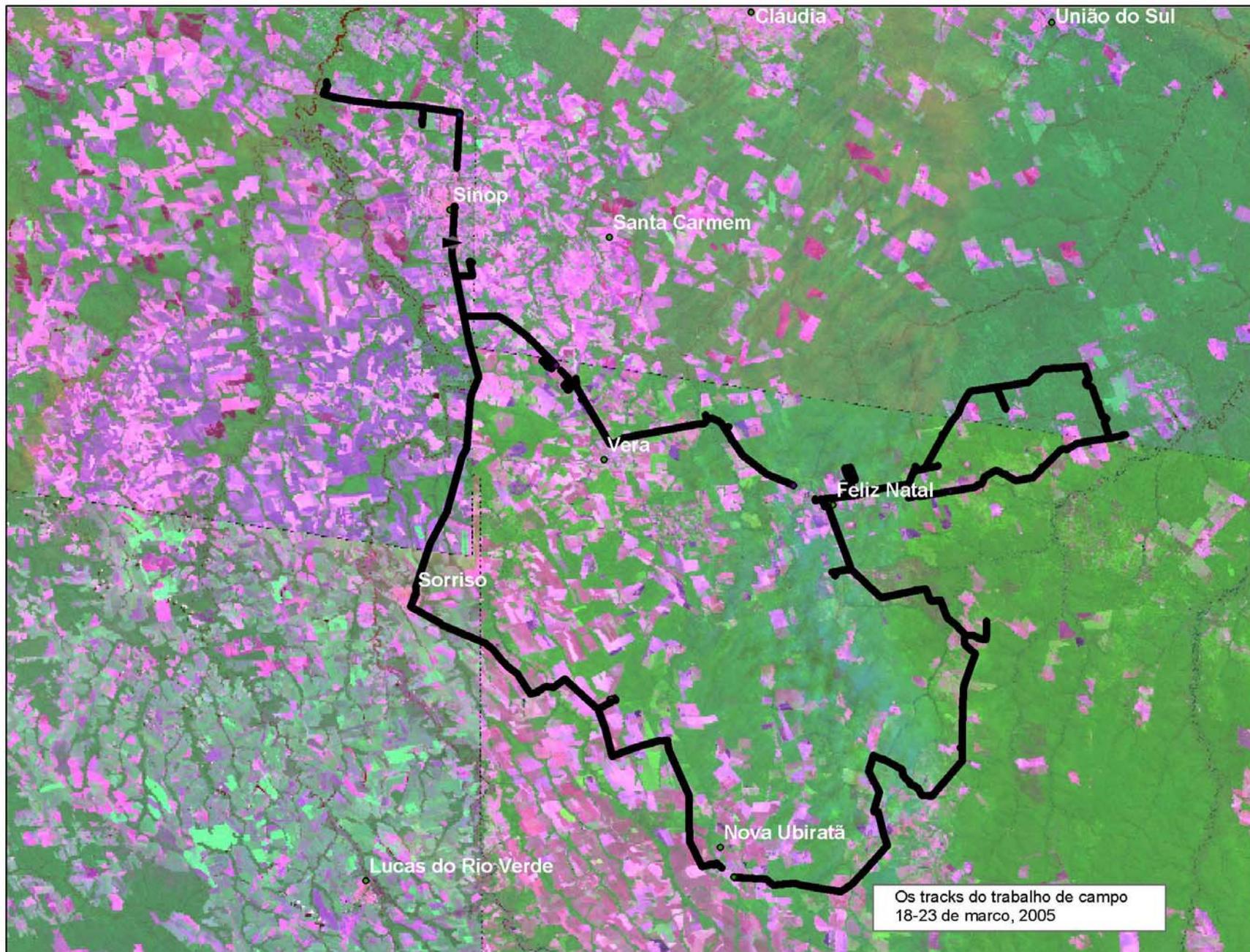
# CLASSIFICATION OF MODIS IMAGE ( 22 APRIL to 07 MAY 2004)



DEFORESTATION UP TO AUGUST 2003 OVER MODIS IMAGE (22 APR - 07 MAY 2004)



# FIELD WORK IN 2005



# BRAND NEW DEFORESTATION

March, 2005





# DETER RESULTS

<http://www.obt.inpe.br/deter>



Coordenação-Geral de Observação da Terra - OBT



DETECÇÃO DO DESMATAMENTO EM TEMPO REAL NA AMAZÔNIA LEGAL - DETER

Parâmetros Básicos

Data Primeira Observação: 2004-05-07  
 Data Última Observação: 2004-08-08  
 Estado: TODOS  
 Base Operativa/IBAMA: TODAS  
 Satélite: MODIS 01  
 Faixa de Área: Maior que 25 ha  
 Mostrar queimadas: Não

Por Região (opcional)

Norte: 5.0  
 Oeste: -74.0 Leste: -44.0  
 Sul: -18.5

Clique em "Ver/View"

Gráficos

Tipo: Político

Procurar Município

Nome:   
 Estado: TODOS  
 Ordenar: Alfabeticamente

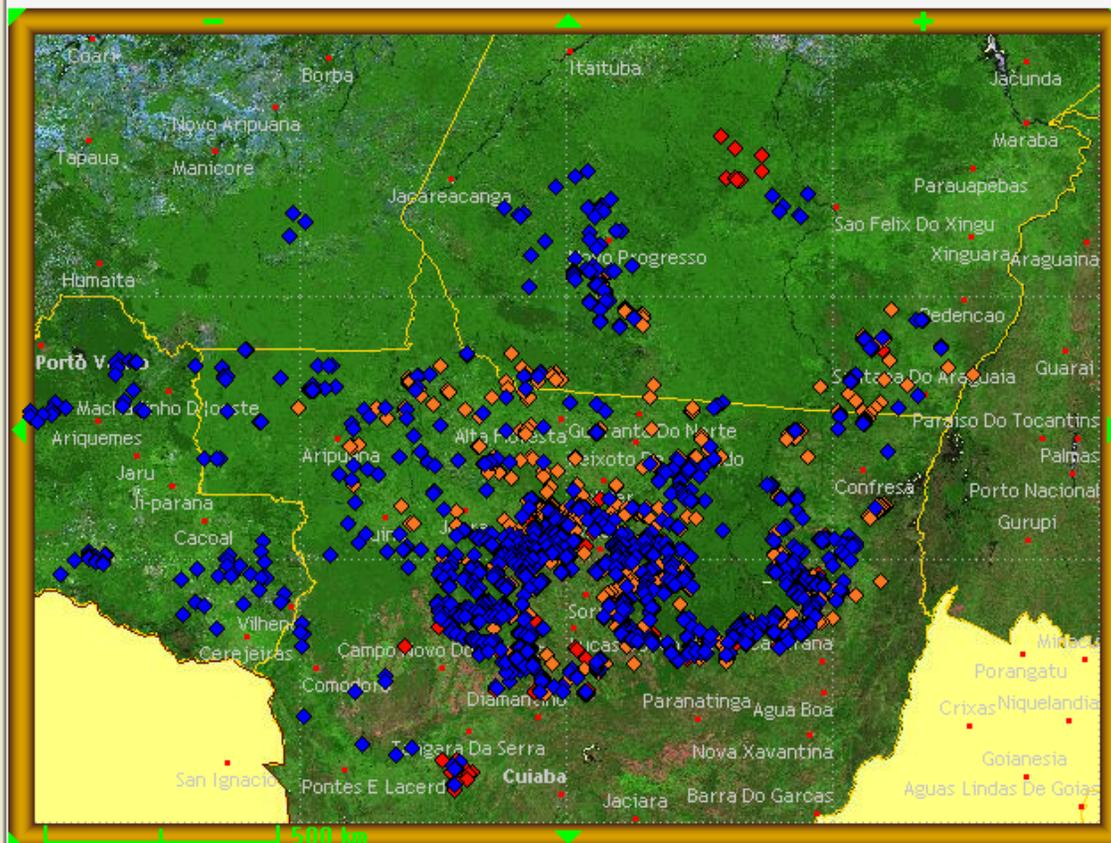
[Ajuda...](#)

Desmatamentos detectados nos Municípios ou Unidades de Conservação...

000043

Modis 07 Maio 2004/Divisão Política

S04:00:00 O48:00:00

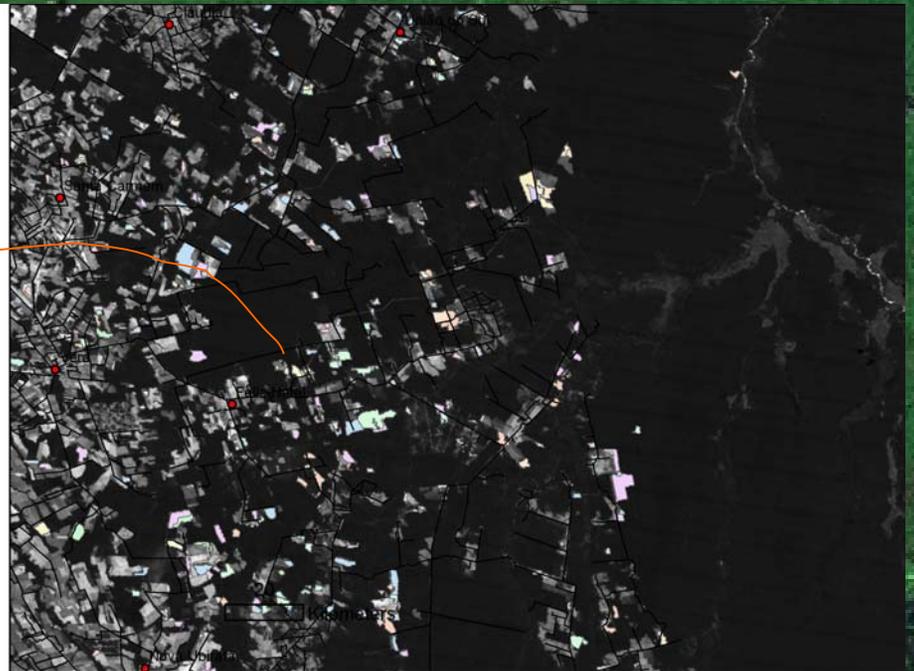


S16:00:00 O64:00:00

Nesta tela existem 2024 de um total de 2069 pontos de alerta no periodo de 2004-05-07 a 2004-08-08

Saída dos dados/Export data/Salida de los datos

**DETER: Publicly-available,  
transparent identification of  
new deforestation locations  
>25 ha every two weeks**



**Legend**

- mt\_sedes
- VIAS\_INTERURBANAS1
  - <all other values>
- COBERTURA
  - Asfalto
  - Terra
  - deter\_20050630\_pol
  - deter\_20050531\_pol\_pol
  - deter\_20050430\_pol
  - Deter\_20050330\_pol
  - Deter\_20050228\_pol
  - Deter\_20050131\_pol
  - deter\_20041231\_pol
  - deter\_20041130\_pol
  - Deter\_20041030\_pol
  - Deter\_20040928\_pol
  - Deter\_20040825\_pol
  - deter\_20040729\_pol
  - Deter\_20040608\_pol
- mod09\_2005\_183\_red\_tiff.tif
  - Value
  - High : 65535
  - Low : 0

80 Kilometers

# Deforestation areas by Municipalities, States or Conservation Areas

## Desmatamento Município e Unid. Conservação

### Parâmetros Básicos

Data Inicial (aaaa-mm-dd)

Data Final (aaaa-mm-dd)

País

Estado

Satélite

Faixa de Área

Agrupar por

Tipo

Nome UC Federal

Nome UC Estadual

Executa

### Gráficos

Tipo

Histograma

5) [S115147055124320040507120000](#) (clique p/ ver)

Município/Estado: Santa Carmem/MT

Nr	Lat	Long	LatGMS	LongGMS	Data	Satelite	Area (Km2/Ha)
1	-11.9335	-55.1459	S 11 56 0.48	O 55 8 45.26	2004-05-07	MODIS-01	1.2611 / 126.1
2	-11.9053	-55.1423	S 11 54 18.94	O 55 8 32.44	2004-05-07	MODIS-01	1.3895 / 138.9
3	-11.8420	-54.7968	S 11 50 31.38	O 54 47 48.41	2004-05-07	MODIS-01	1.5178 / 151.8
4	-11.9197	-55.1963	S 11 55 10.99	O 55 11 46.85	2004-05-07	MODIS-01	2.0321 / 203.2
5	-12.0288	-54.6504	S 12 1 43.84	O 54 39 1.41	2004-05-07	MODIS-01	2.8691 / 286.9
6	-12.0530	-54.9076	S 12 3 10.75	O 54 54 27.36	2004-05-07	MODIS-01	3.1263 / 312.6
7	-11.8026	-54.7692	S 11 48 9.24	O 54 46 8.95	2004-05-07	MODIS-01	3.1878 / 318.8
8	-12.0788	-54.9513	S 12 4 43.78	O 54 57 4.80	2004-05-07	MODIS-01	3.1909 / 319.1
9	-12.0113	-54.8742	S 12 0 40.56	O 54 52 27.13	2004-05-07	MODIS-01	3.7607 / 376.1
10	-11.9270	-54.7236	S 11 55 37.14	O 54 43 24.93	2004-05-07	MODIS-01	4.4747 / 447.5
11	-11.8632	-55.2121	S 11 51 47.47	O 55 12 43.69	2004-05-07	MODIS-01	6.4706 / 647.1
12	-12.1104	-54.9629	S 12 6 37.31	O 54 57 46.31	2004-05-07	MODIS-01	7.7571 / 775.7
13	-11.8412	-54.6775	S 11 50 28.37	O 54 40 38.92	2004-05-07	MODIS-01	7.8785 / 787.9
14	-12.0554	-55.1763	S 12 3 19.31	O 55 10 34.62	2004-05-07	MODIS-01	7.8835 / 788.3
15	-11.7608	-54.7346	S 11 45 38.92	O 54 44 4.71	2004-05-07	MODIS-01	9.2893 / 928.9
16	-11.9412	-54.3954	S 11 56 28.34	O 54 23 43.56	2004-05-07	MODIS-01	10.1314 / 1013.1
17	-11.8038	-54.7198	S 11 48 13.72	O 54 43 11.29	2004-05-07	MODIS-01	10.1899 / 1019.0
18	-11.9322	-54.8579	S 11 55 56.06	O 54 51 28.39	2004-05-07	MODIS-01	12.7008 / 1270.1
Area Total							99.1111 / 9911.1

[Copa arquivo .txt](#) / [Save .txt file](#) / [Copa archive .txt](#)

Serviço atualizado diariamente as 04:00, 10:00, 13:30, 19:30, 21:30 e 23:30 - horário de Brasília/DF

**Receba um relatório resumido dos focos nas UCs em seu email. [Increva-se...](#)**

Visitas desde 01/12/2003

Qualquer problema, dúvida ou sugestão, por favor, entre em contato: [prodes@dpi.inpe.br](mailto:prodes@dpi.inpe.br)



DETER - Sistema de Detecção de Desmatamento em Tempo Real - Microsoft Internet Explorer

Arquivo Editar Exibir Favoritos Ferramentas Ajuda Endereço <http://www.obt.inpe.br/deter/> Ir

  Coord

### DEteção do desmaTamento em Tempo Real na Amazônia Legal - DETER

Parâmetros Básicos

Data Primeira Observação: 2004-06-22  
Data Última Observação: 2004-06-22  
Estado: PA  
Base Operativa/Ibama: TODAS  
Satélite: MODIS 01  
Faixa de Área: Maior que 25 ha  
Mostrar queimadas: Nao

Por Região (opcional)

Norte: 8.0  
Oeste: -74.0 Leste: -44.0  
Sul: -18.5  
Clique em "Ver/View"

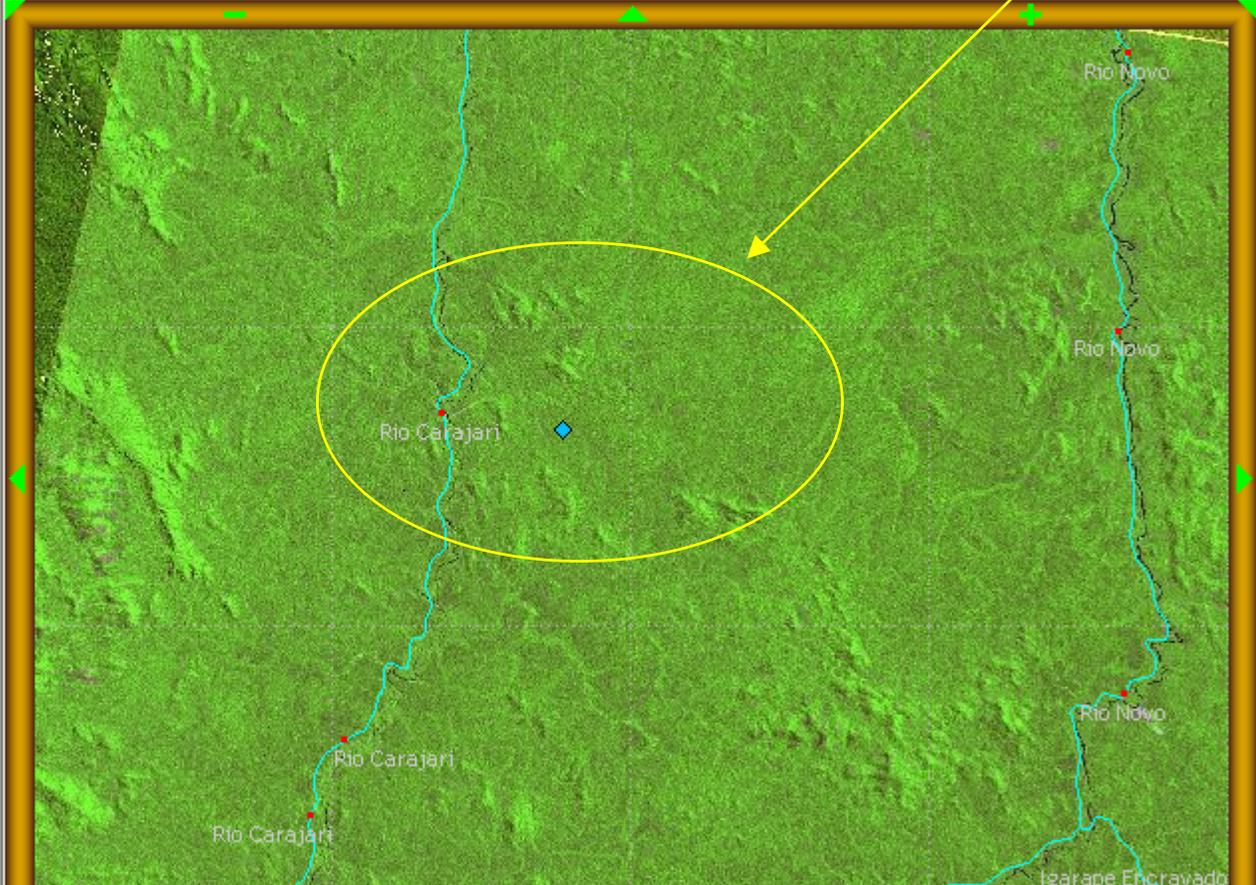
Gráficos

Tipo: Político  
Histograma

Procurar Município

Nome:   
Estado: TODOS  
Ordenar: Alfabeticamente  
Procurar

Mosaico Landsat 2003/Rios Principais S05:00:00 O53:42:00



Landsat 5 TM image (226/64) acquired on 2003-08-22 with no sign of deforestation

Large deforestation area detected by DETER on 22 June 2004 in Altamira, Para State (S 05 08 11.89 - W 53 55 15.73)



### DETECÇÃO do desmatamento em Tempo Real na Amazônia Legal - DETER

#### Parâmetros Básicos

Data Primeira Observação: 2004-06-22

Data Última Observação: 2004-06-22

Estado: PA

Base Operativa/Ibama: TODAS

Satélite: MODIS 01

Faixa de Area: Maior que 25 ha

Mostrar queimadas: Nao

#### Por Região (opcional)

Norte: 8.0

Oeste: -74.0 Leste: -44.0

Sul: -18.5

Clique em "Ver/View"

#### Gráficos

Tipo: Político

Histograma

#### Procurar Município

Nome:

Estado: TODOS

Ordenar: Alfabeticamente

Procurar

[Ajuda...](#)

[Desmatamentos detectados nos Municípios ou Unidades de](#)

Ver/View Recompôr Imagens Satélite Base Cartografica Mapas Temáticos Tamanho da Tela

Modis 08 junho 2004/Rios Principais

S05:00:00 O53:42:00



**MODIS image acquired on 08 JUNE 2004, showing the initial deforestation activity**

S05:18:00 O54:06:00



# DEteção do desmaTamento em Tempo Real na Amazônia Legal - DETER

## Parâmetros Básicos

Data Primeira Observação: 2004-06-22

Data Última Observação: 2004-06-22

Estado: PA

Base Operativa/Ibama: TODAS

Satélite: MODIS 01

Faixa de Area: Maior que 25 ha

Mostrar queimadas: Nao

Por Região (opcional)

Norte: 6.0

Oeste: -74.0 Leste: -44.0

Sul: -18.5

Clique em "Ver/View"

Gráficos

Tipo: Político

Histograma

Procurar Município

Nome:

Estado: TODOS

Ordenar: Alfabeticamente

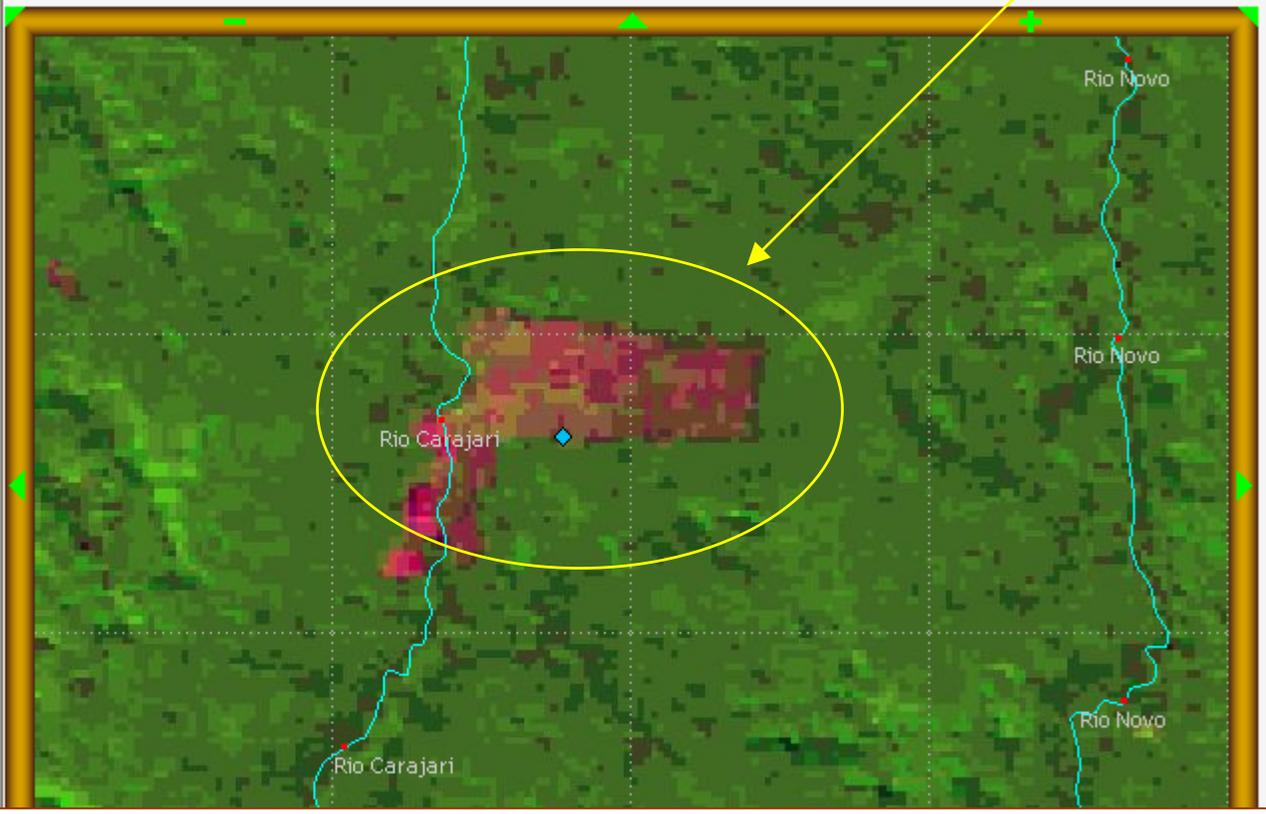
Procurar

[Ajuda...](#)

[Desmatamentos detectados nos Municípios ou Unidades de](#)

Ver/View Recompôr Imagens Satélite Base Cartografica Mapas Temáticos Tamanho da Tela

Modis 22 junho 2004/Rios Principais S05:00:00 O53:42:00



**MODIS image acquired on 22 JUNE 2004, showing the deforestation area very clearly**

Cadastro - Microsoft Internet Expl... em Tempo Real - Microsoft Internet Explorer

Arquivo Editar Exibir Favorit » Endereço

	VALOR
Lat	-5.1366
Long	-53.9210
LatGMS	S 5 8 11.89
LongGMS	O 53 55 15.73
Area Km2 / Ha	62.4 / 6238.5
ra/Date-Time/Fecha-Hora	2004-06-22
Satélite/Satellite/Satélite	MODIS-01
Município/City/Localidad	Altamira
Estado/State/Provincia	PA
Unit/Area de Conservación	
ho arquivo/formato Shape	0.71 MBytes
Download	<a href="#">Deter_20040622_shp.zip</a>

Internet

Coordenação-Geral de Observação da Terra - OBT

Endereço <http://www.obt.inpe.br/deter/> Ir

Recompor In

dis 22 junho 2004/Ri

**MODIS image - 22 JUNE 2004, showing the deforestation polygon and its attributes**

Rio Novo

Rio Novo

Rio Carajari

Rio Carajari

Rio Novo

Igarape Engravado

10 km

S05:18:00 O54:06:00

Internet

Sul

Clique em "Ver/View"

Gráficos

Tipo:

Procurar Município

Nome

Estado

Ordenar

[Ajuda...](#)

*Desmatamentos detectados nos Municípios ou Unidades de*

**DETECÇÃO DO DESMATAMENTO EM TEMPO REAL NA AMAZÔNIA LEGAL - DETER**

**Parâmetros Básicos**

Data Primeira Observação: 2004-05-07  
 Data Última Observação: 2004-07-29  
 Estado: TODOS  
 Base Operativa/Ibama: TODAS  
 Satélite: MODIS 01  
 Faixa de Área: Maior que 25 ha  
 Mostrar queimadas: Não

**Por Região (opcional)**

Norte: 8.0  
 Oeste: -74.0 Leste: -44.0  
 Sul: -18.5

Clique em "Ver/View"

**Gráficos**

Tipo: Político

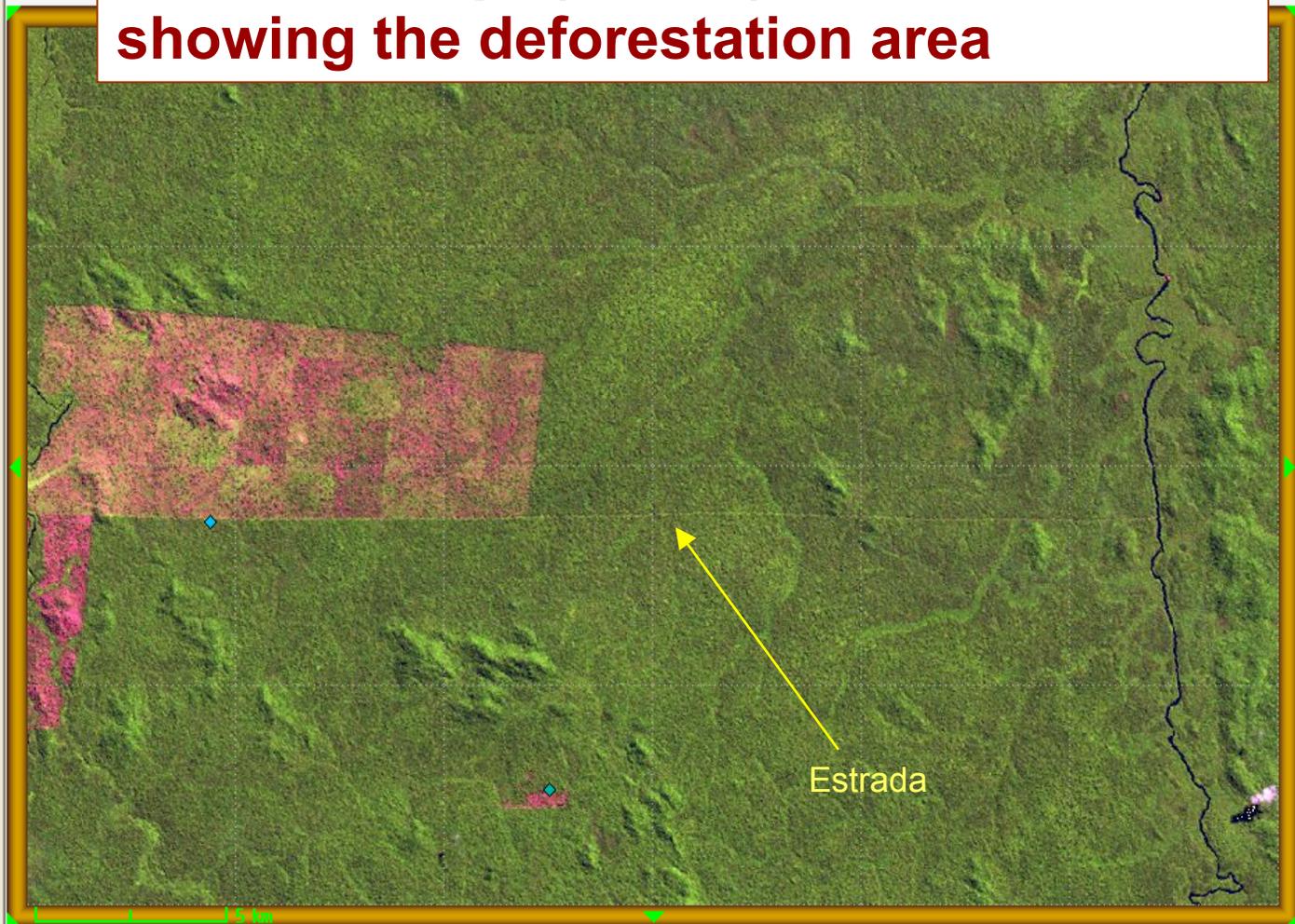
**Procurar Município**

Nome:   
 Estado: TODOS  
 Ordenar: Alfabeticamente

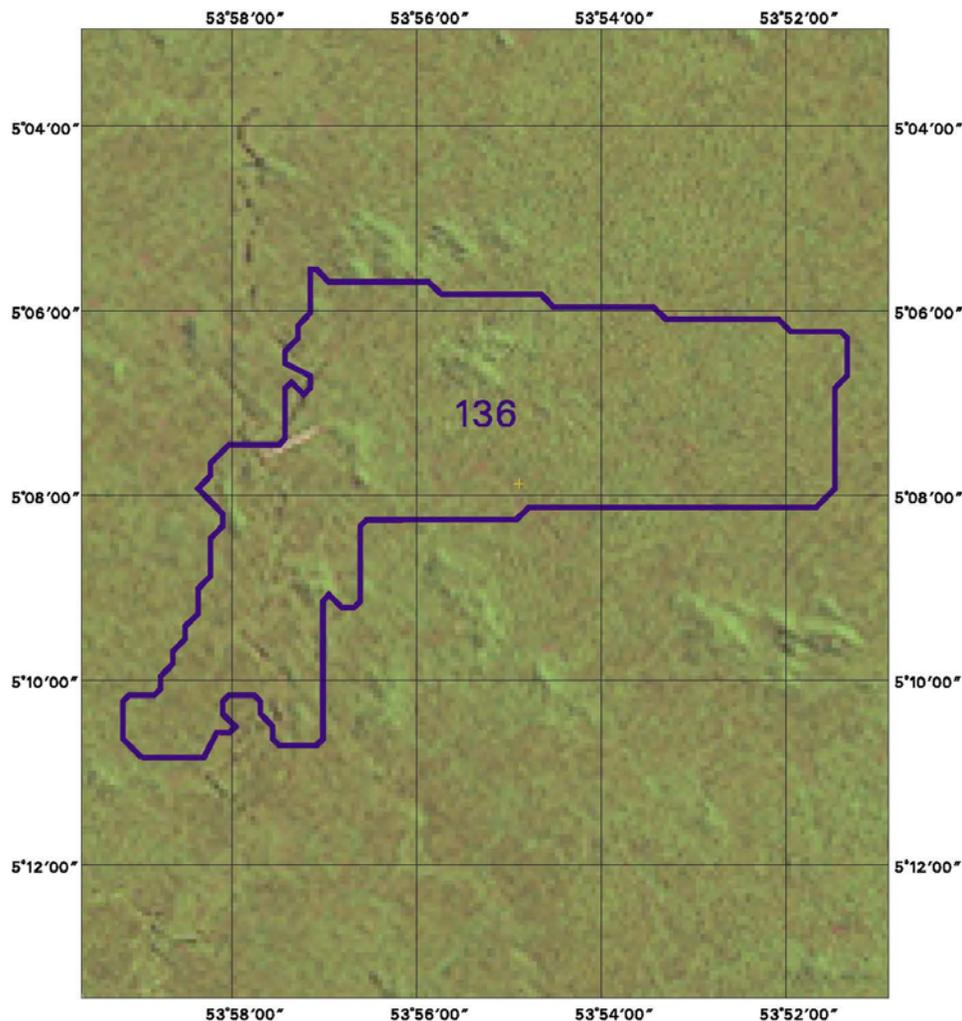
[Download das imagens MODIS](#)  
[Ajuda...](#)  
[Desmatamentos detectados nos Municípios ou Unidades de Conservação...](#)

**000 132**  
 Visitas desde 01/06/2004

**Landsat image (226/64) - 07 JULY 2004, showing the deforestation area**



DOCUMENTO INDICATIVO PARA FISCALIZAÇÃO E CONTROLE DO DESFLORESTAMENTO



**“Document Indicative for Fiscalization and Control of Deforestation”, written by IBAMA/MMA based on DETER information**

Fiscal responsável:

Escala 1:100000

Mosaico Landsat/INPE

Características da área:

Proprietário:

Nota: Este é um documento indicativo de incremento de áreas desflorestadas que possui a finalidade de orientar a fiscalização.

Tipo de desflorestamento:

Uso do solo:

Área licenciada?:

Observações:

COORDENADAS DE APOIO:

Identificador: 136

Longitude: 53°54'54" W

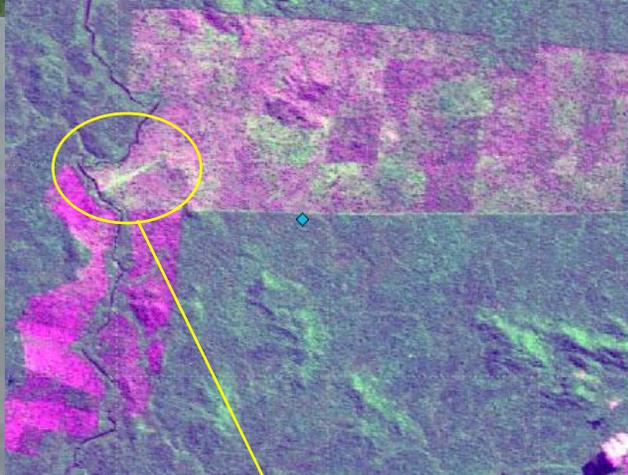
Latitude: 5°07'52" S

Município: ALTAMIRA-PA

Área aproximada: 6185.09 hectares

Fonte: DETER/INPE 22/08/04

**Field verification done by  
IBAMA / MMA on 16 AUGUST 2004  
in Altamira, Para**



16 17:48

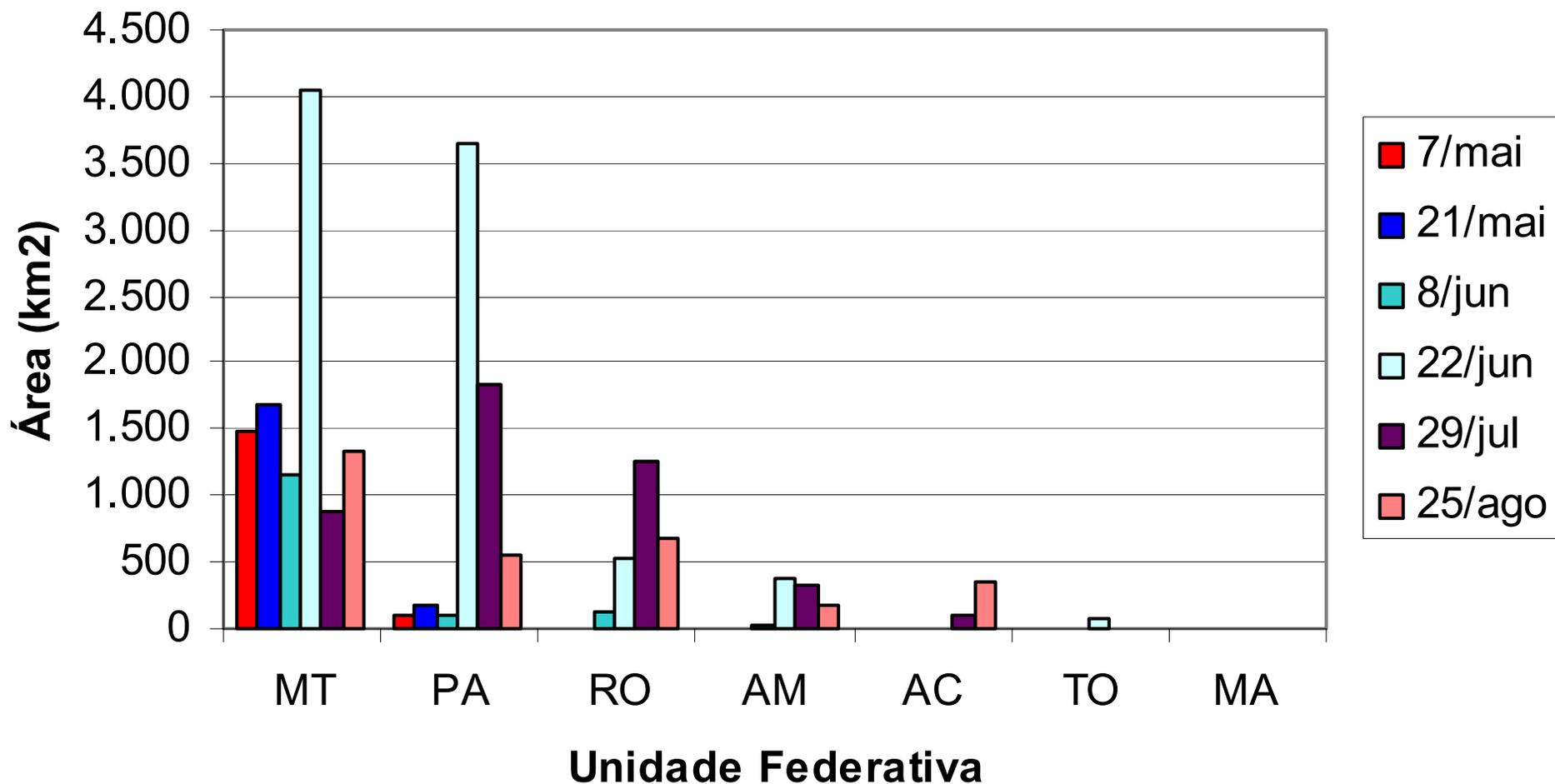


16 17:49



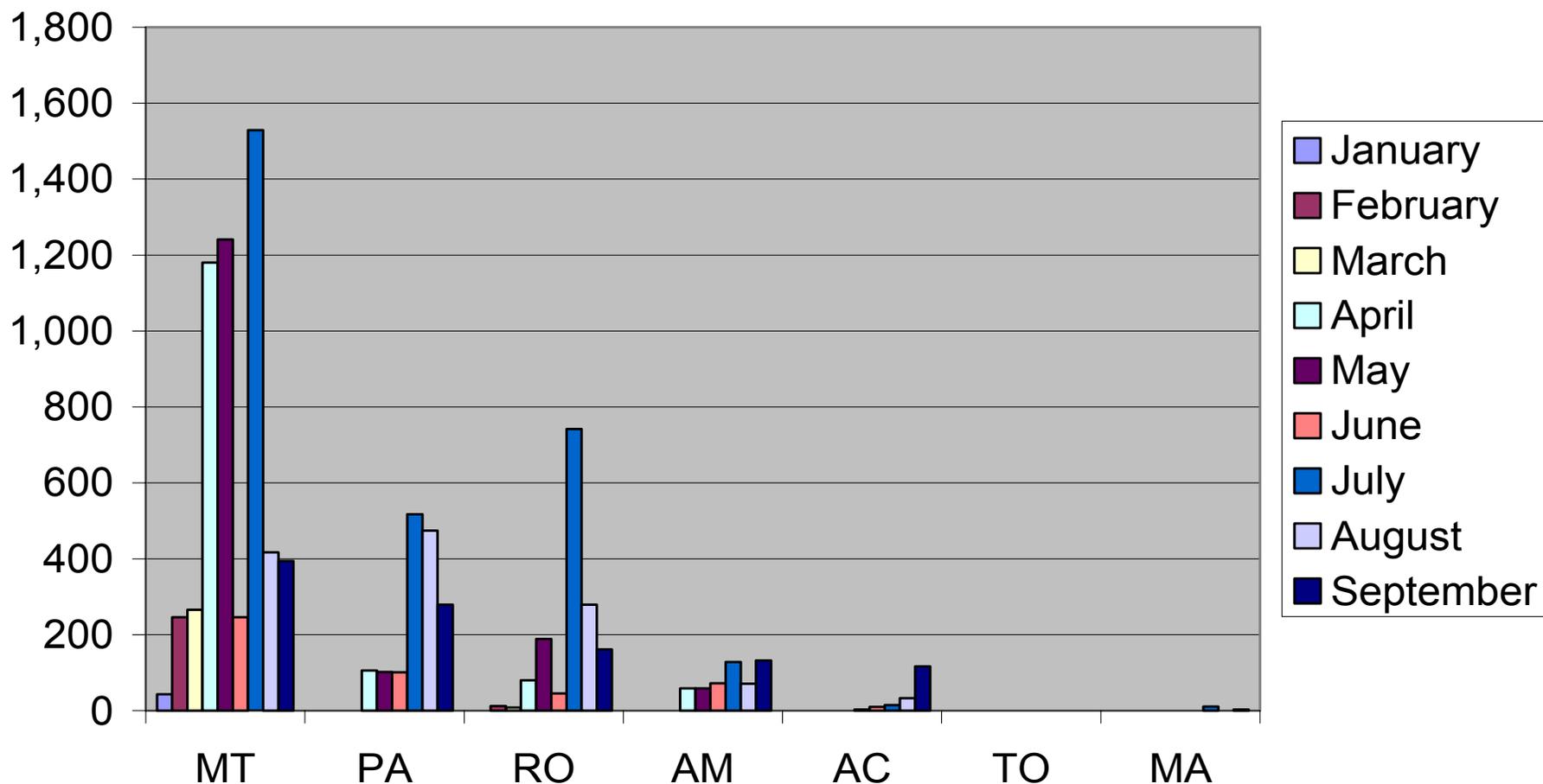
16 18:04

## Dinâmica do Desmatamento por Unidade Federativa (Agosto/2003-Agosto/2004)



# Dinamica do Desmatamento por Unidade Federativa (Janeiro a Setembro de 2005)

Area (km<sup>2</sup>)



Unidade Federativa

# *WHAT TYPES OF LAND USE CHANGE ARE OCCURRING FOLLOWING INITIAL CLEARING?*

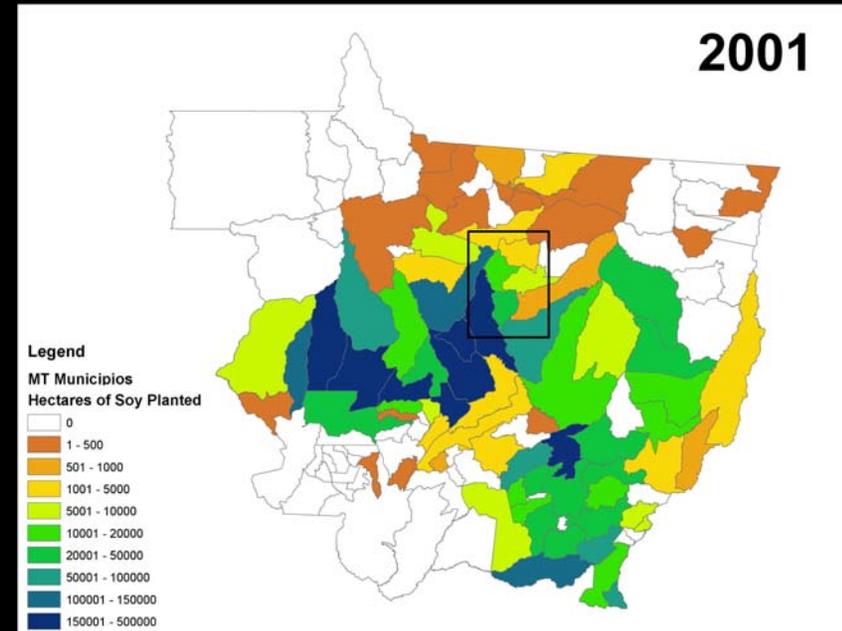
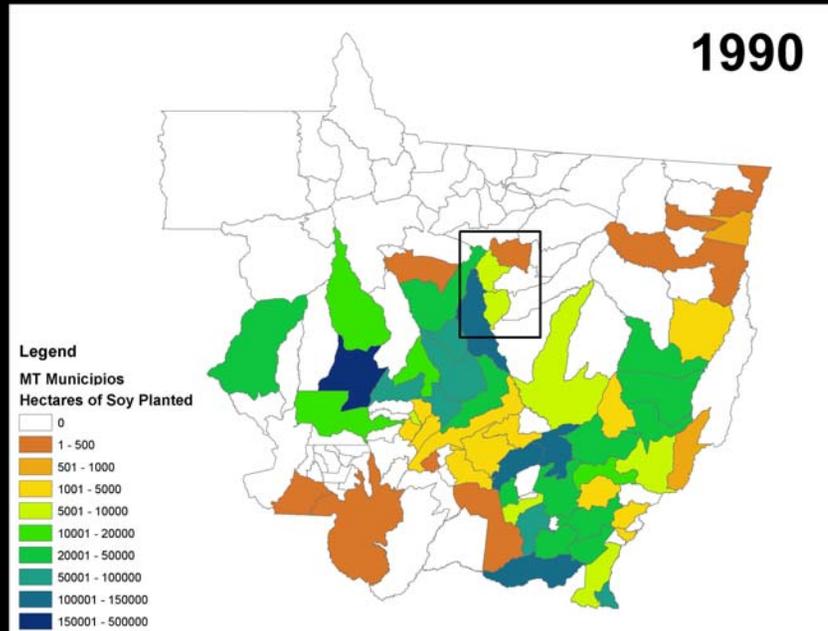
Primary and secondary transitions:

1° Forest → Pasture

1° Forest → Mechanized Agriculture

2° Pasture → Mechanized Agriculture

2° Mechanized Agriculture → Pasture



Data Source: SIDRA

# Utility of MODIS data for monitoring deforestation

- **Not a substitute for higher resolution, Landsat-like observations but allows rapid assessment**
- **Most applicable where large, mechanized clearings**
- **Daily acquisitions and free availability key for operational real-time monitoring**
- **Phenological signal enables monitoring of subsequent land use transitions**

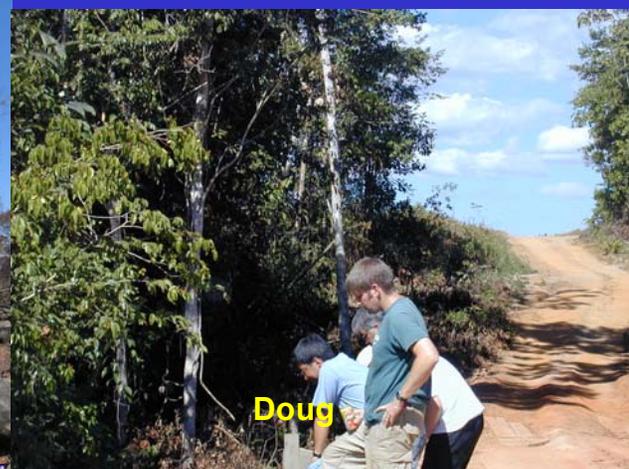


Ramon

Egidio



Liana



Doug



Fernando

Ruth



Ellen

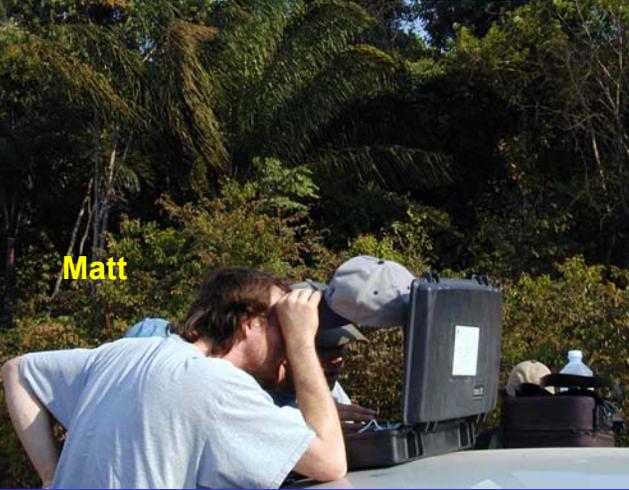


Yosio



Marcelo

**Funding: NASA  
LBA – ECO 2  
Project LC-22**



Matt