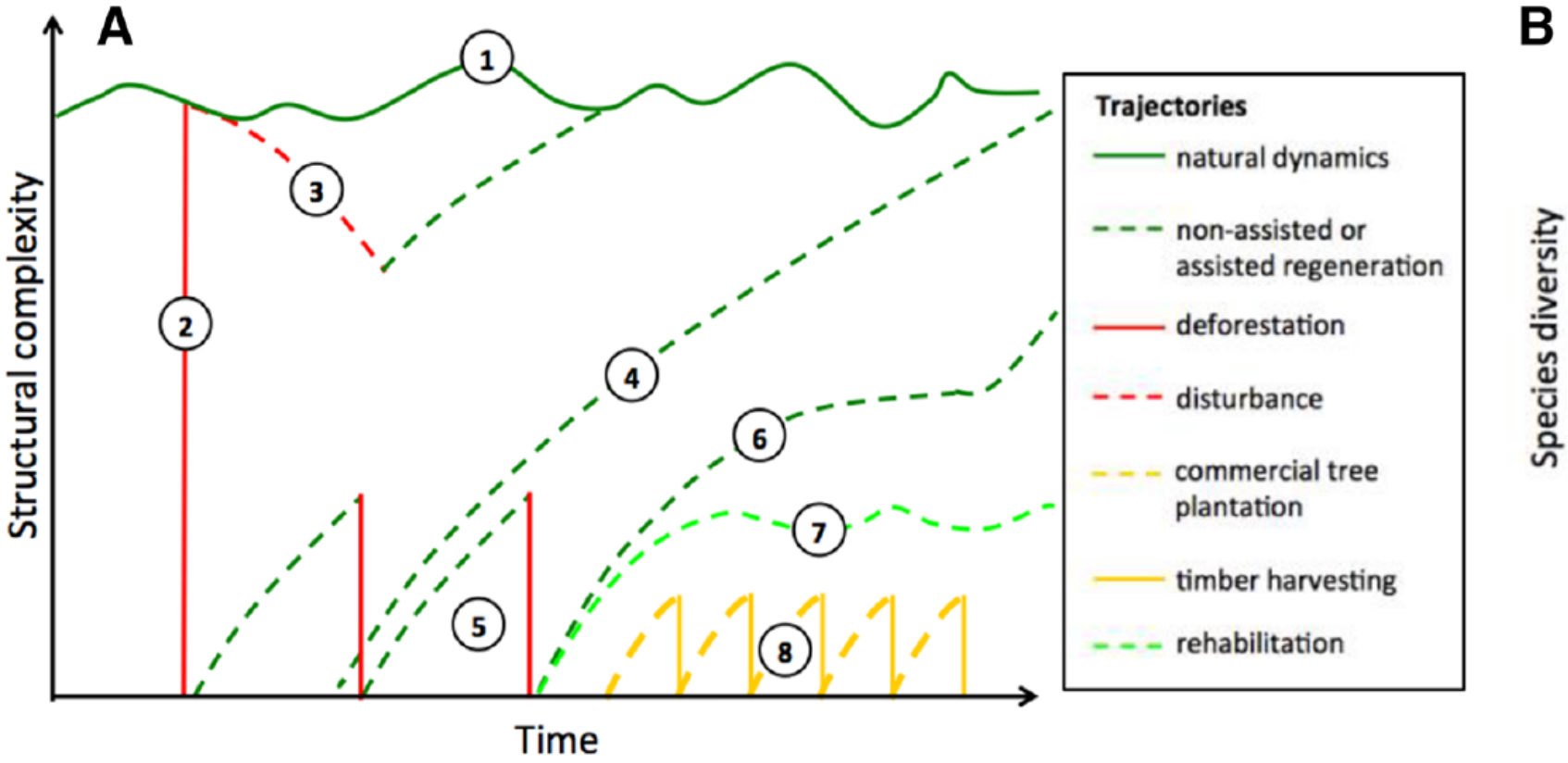
Open Source Big Earth Observation Data Analytics

www.esensing.org

Presented by: Lubia Vinhas


ESTRATÉGIA
DO PROGRAMA
DE MONITORAMENTO AMBIENTAL DOS
BIOMAS BRASILEIROS

Distinguishing forests by temporal evolution



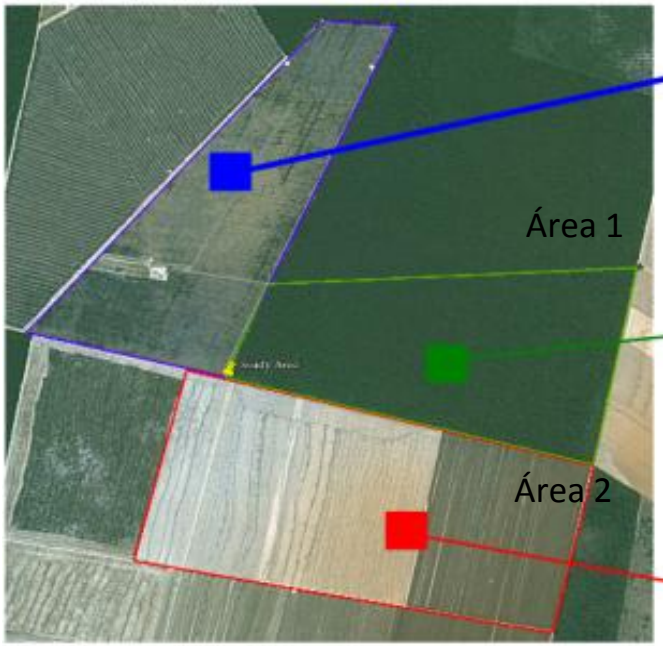
Chadzon et al (2016)

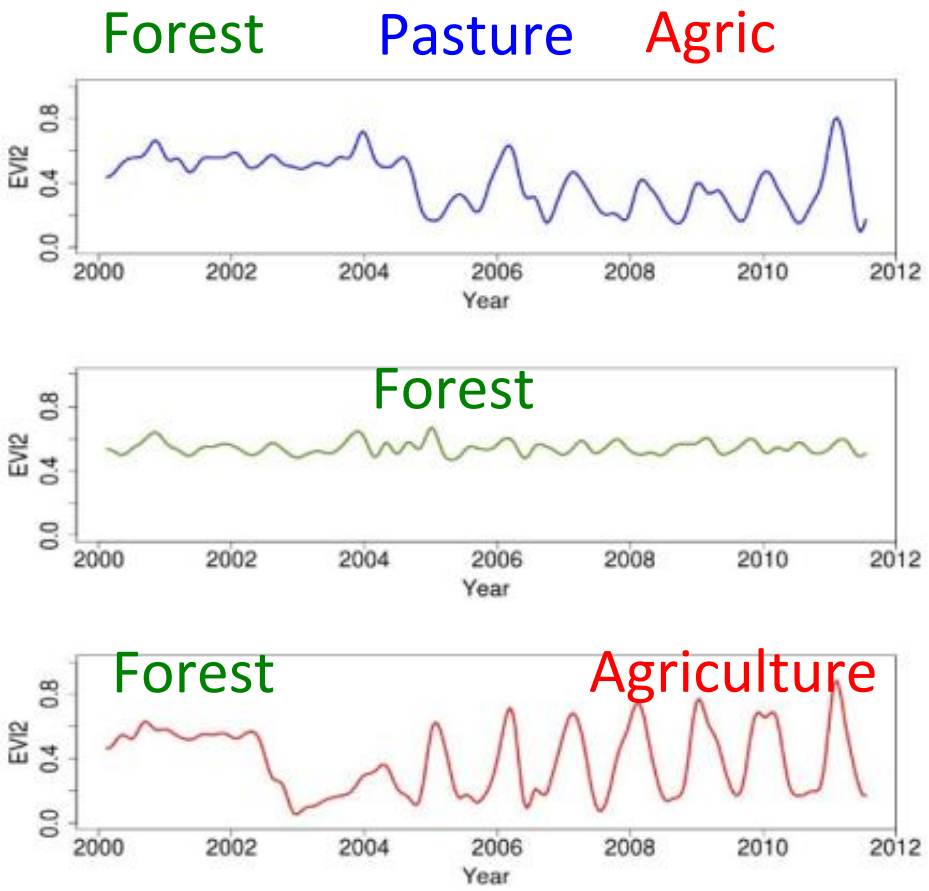
Distinguishing forests by temporal evolution

C

Chadzon et al (2016)

Land trajectories

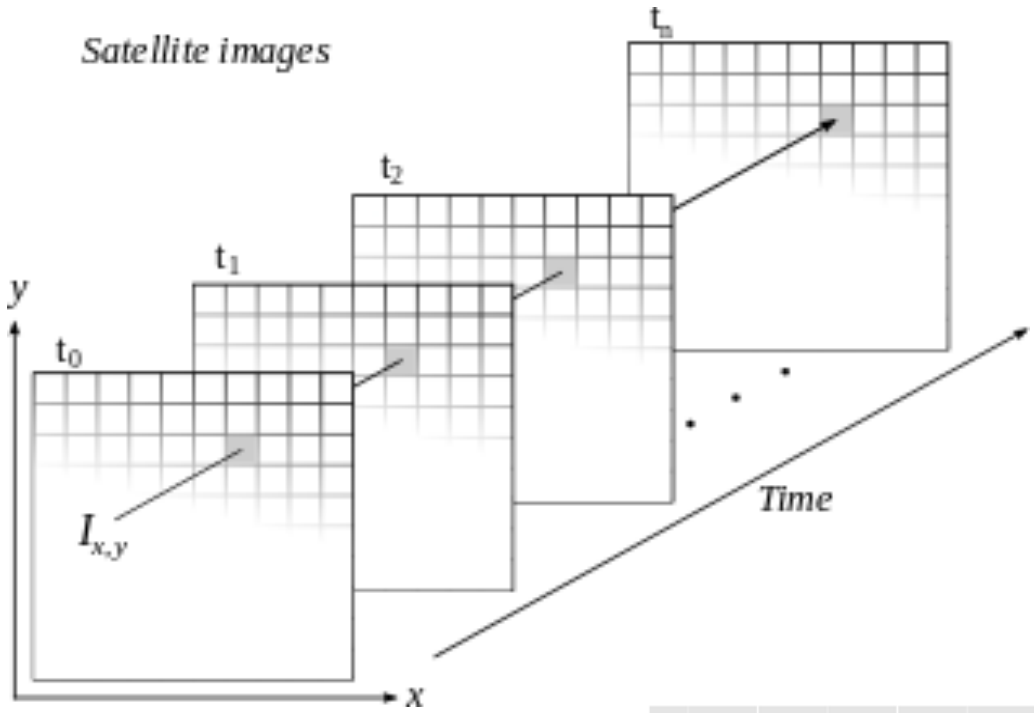




"The transformations of land cover due to actions of land use"

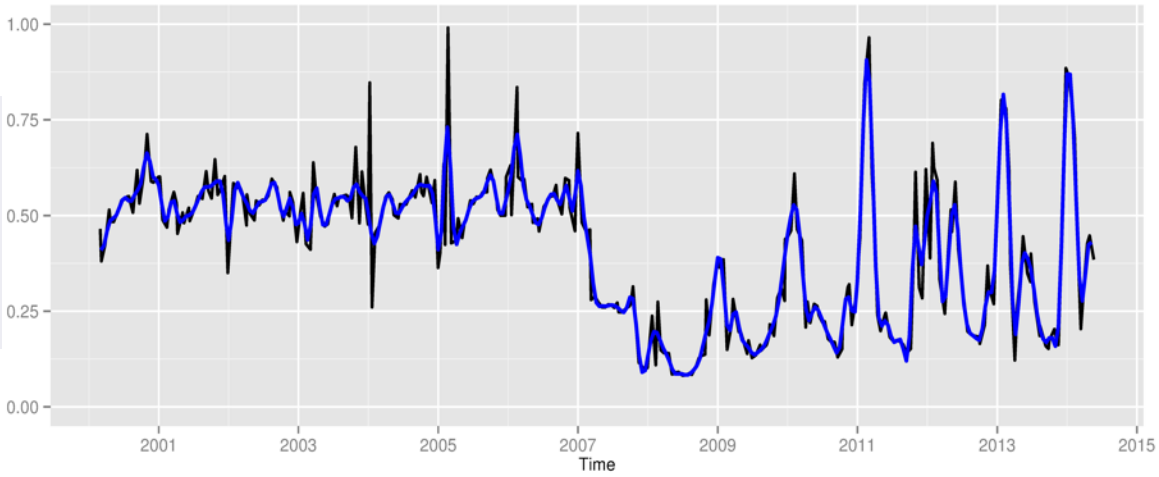
graphics: Victor Maus (INPE, IFGI)

Space first-time later or time first-space later?



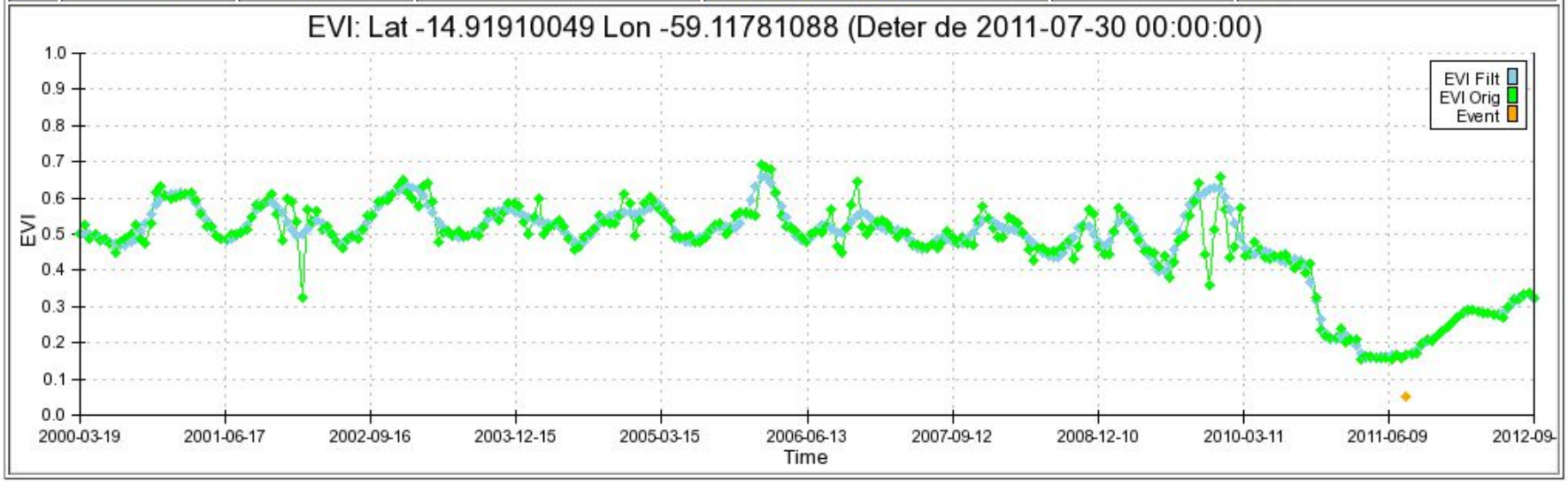
Space first: classify images separately
Compare results in time

Time first: classify time series separately
Join results to get maps

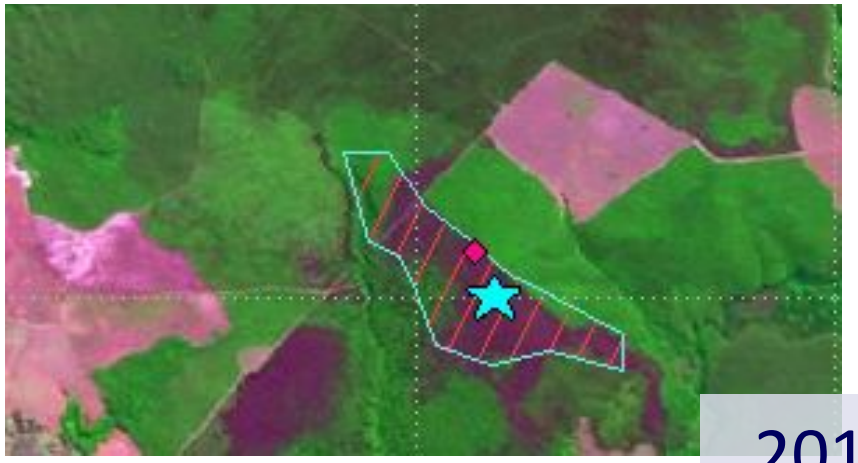


The transition from natural to managed land as seen by remote sensing

Nr	Lat	Long	Mes/Ano Deter	Municipio/UF	Area km2	Classe Avaliacao
3	-14.91910049	-59.11781088	JULHO/2011	Pontes e Lacerda/MT	2.64	Corte_raso

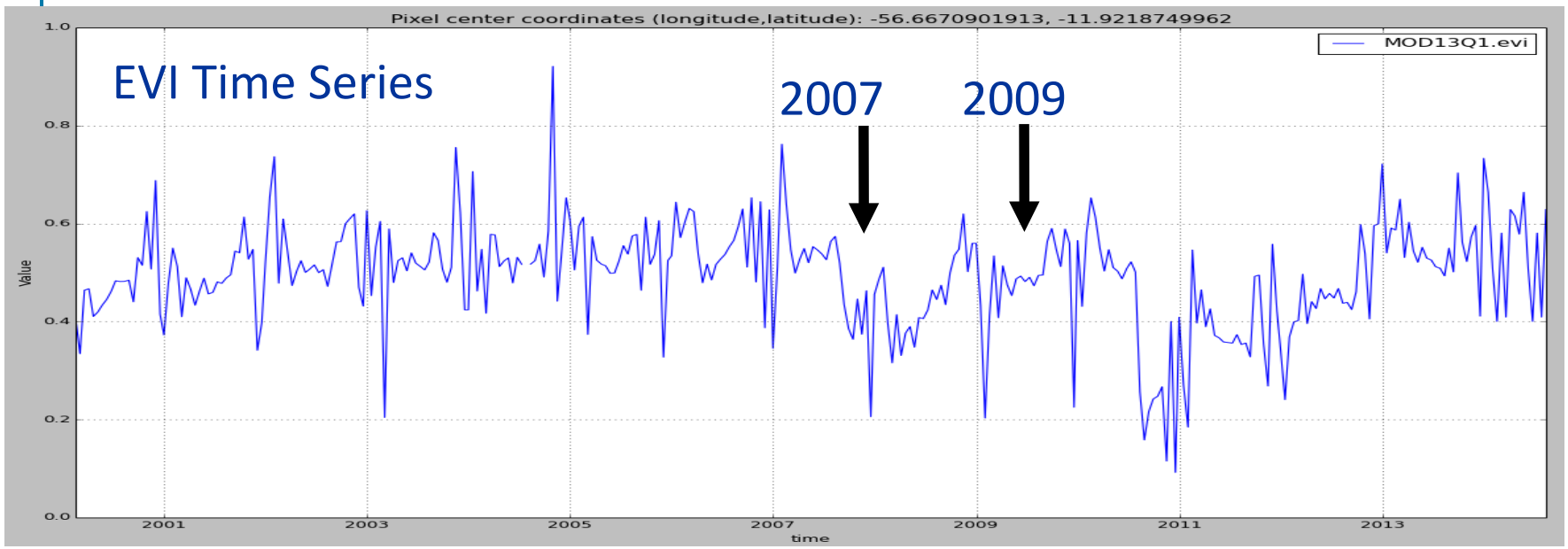


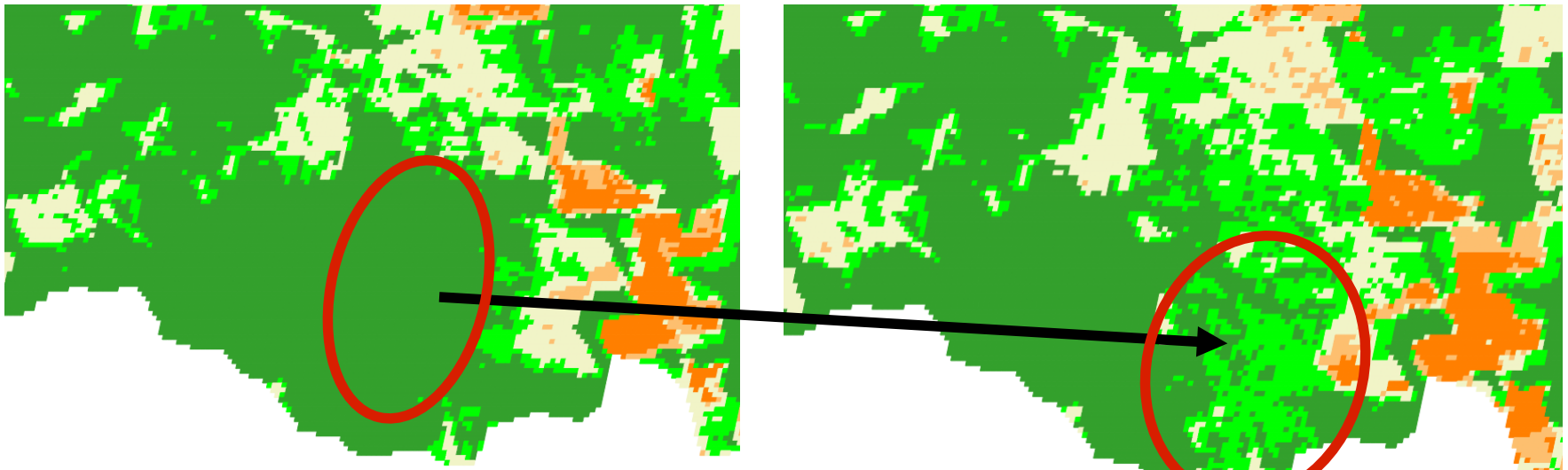
2010



2011

Land trajectories: forest degradation

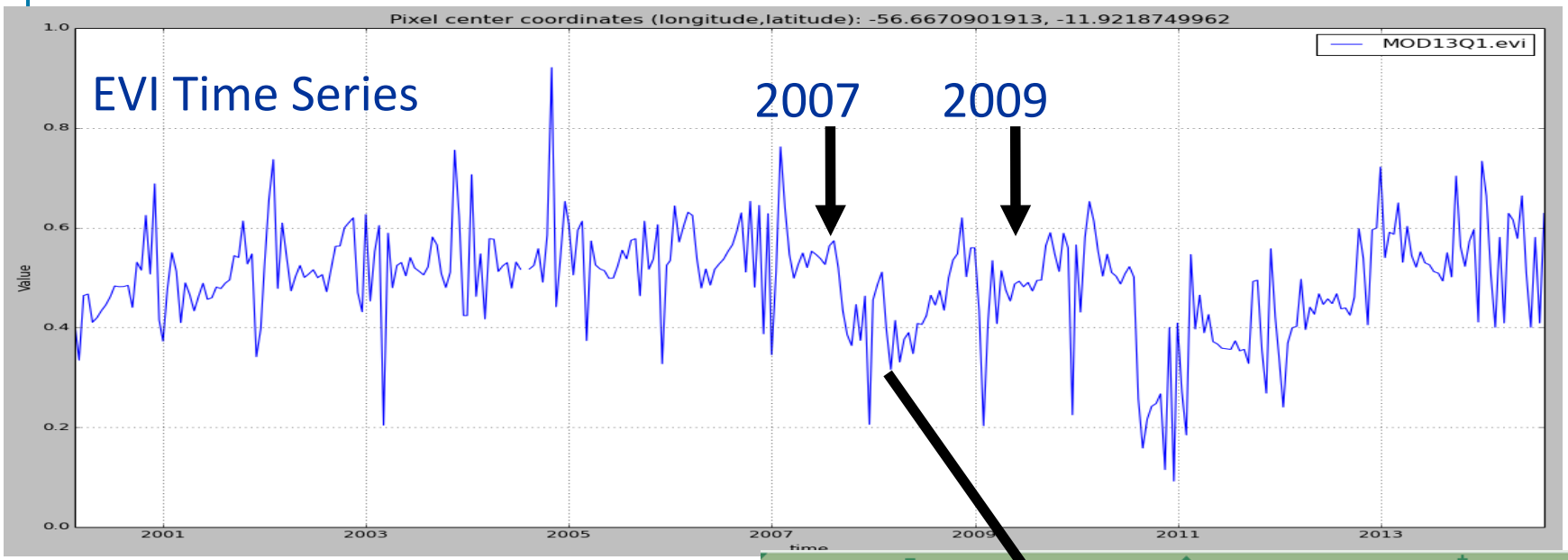


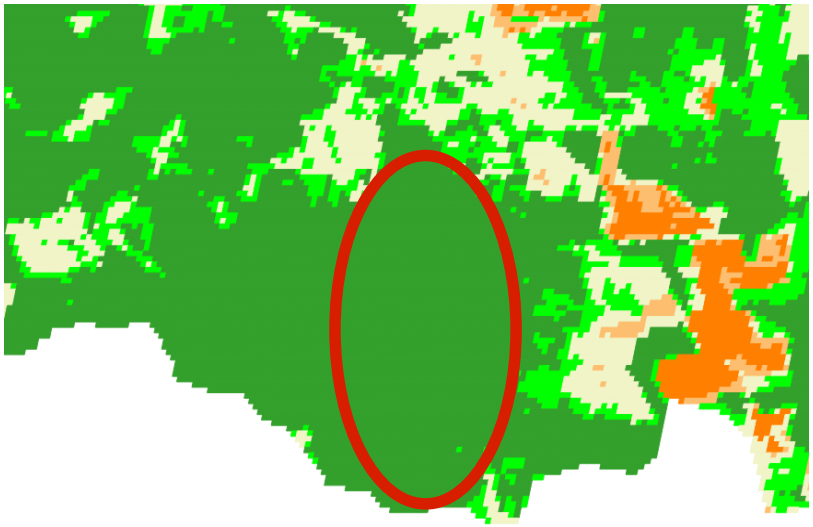


2007

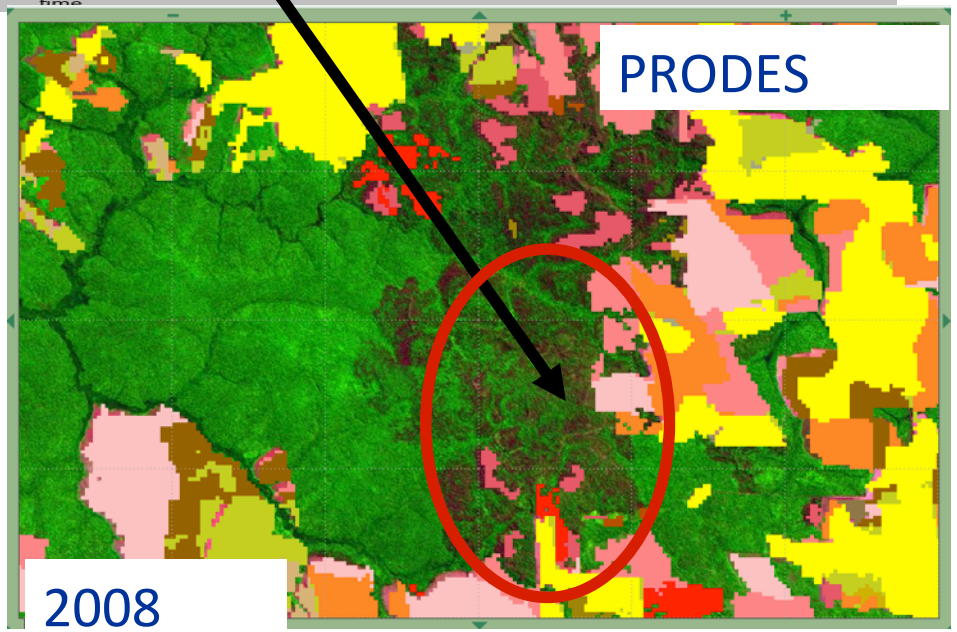
2009

Land trajectories: forest degradation





2007

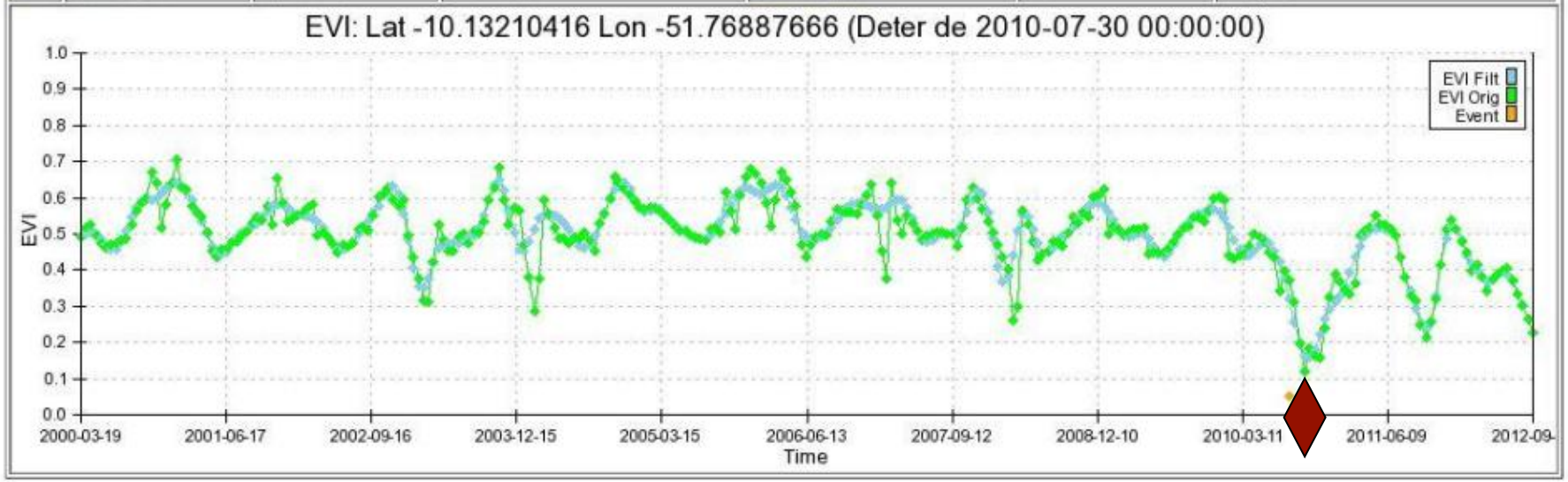


2008

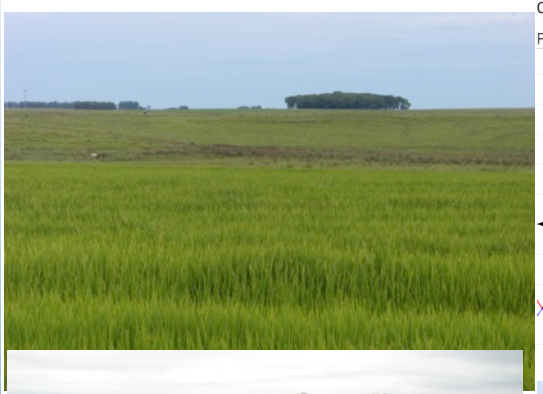
Land trajectories: deforestation events

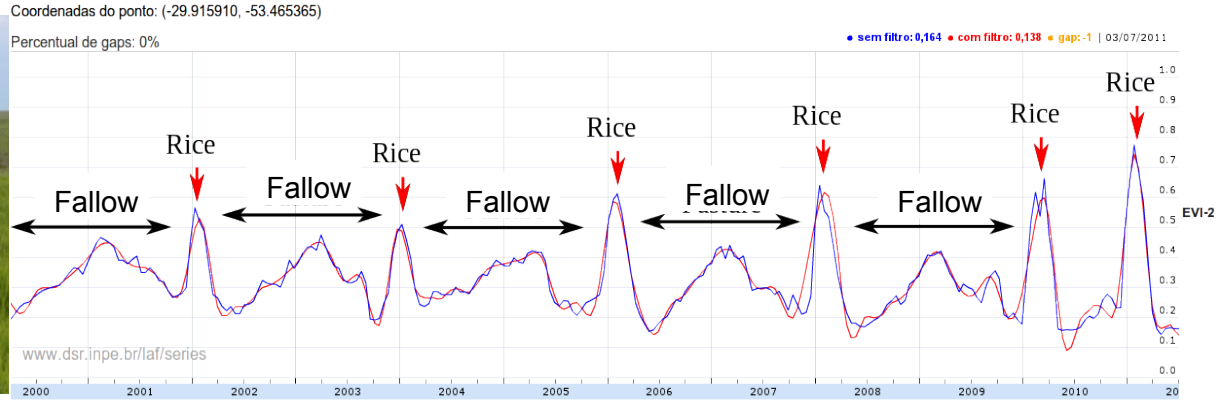
images: INPE

Nr	Lat	Long	Mes/Ano Deter	Municipio/UF	Area km2	Classe Avaliacao
1	-10.13210416	-51.76887666	JULHO/2010	Confresa/MT	1.15	Corte_raso



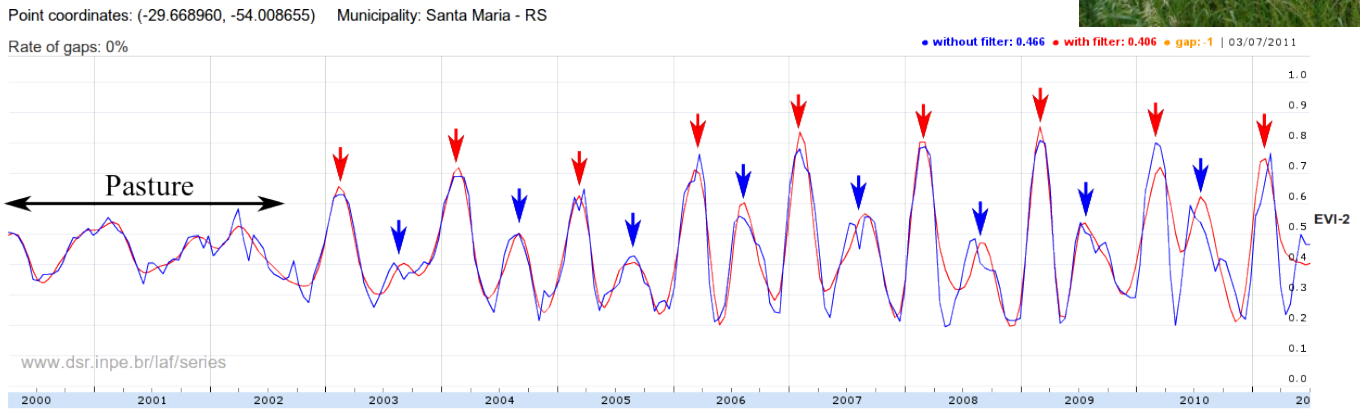
Land trajectories require adequate data





Soybean

Ryegrass



Victor Maus

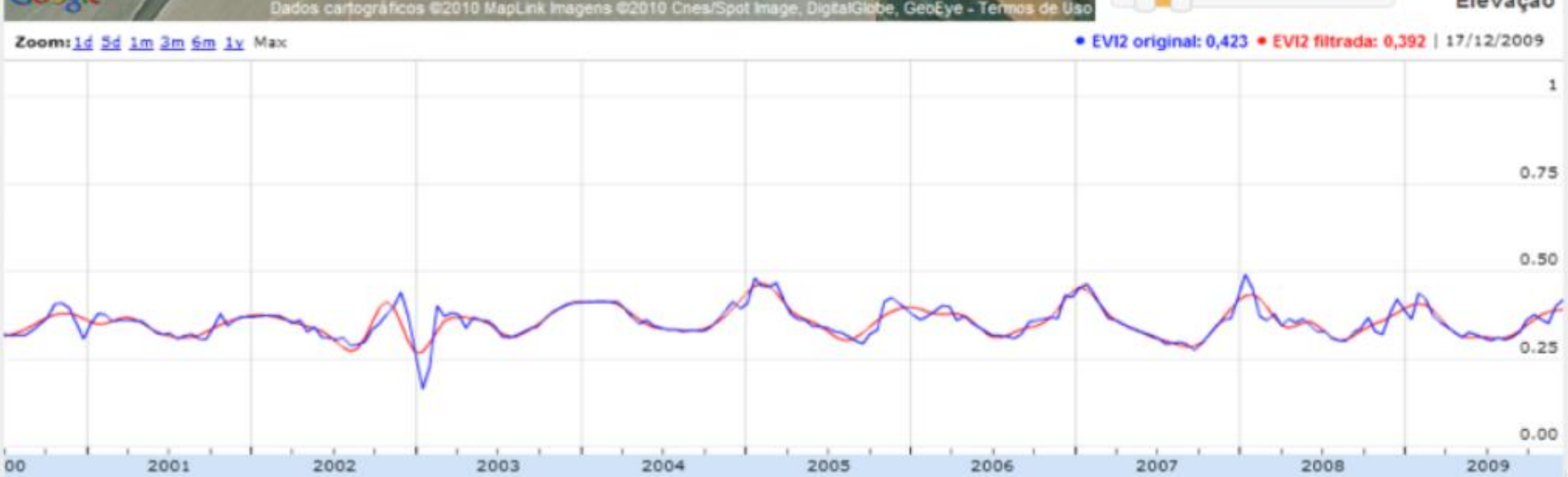
Tropical forest: stable signal + low seasonal change

-17.8697, -45.3993

-17.8710, -45.3992

One sample per year (PRODES)

graphics: LAF/INPE



Double-cropping: soybeans + corn

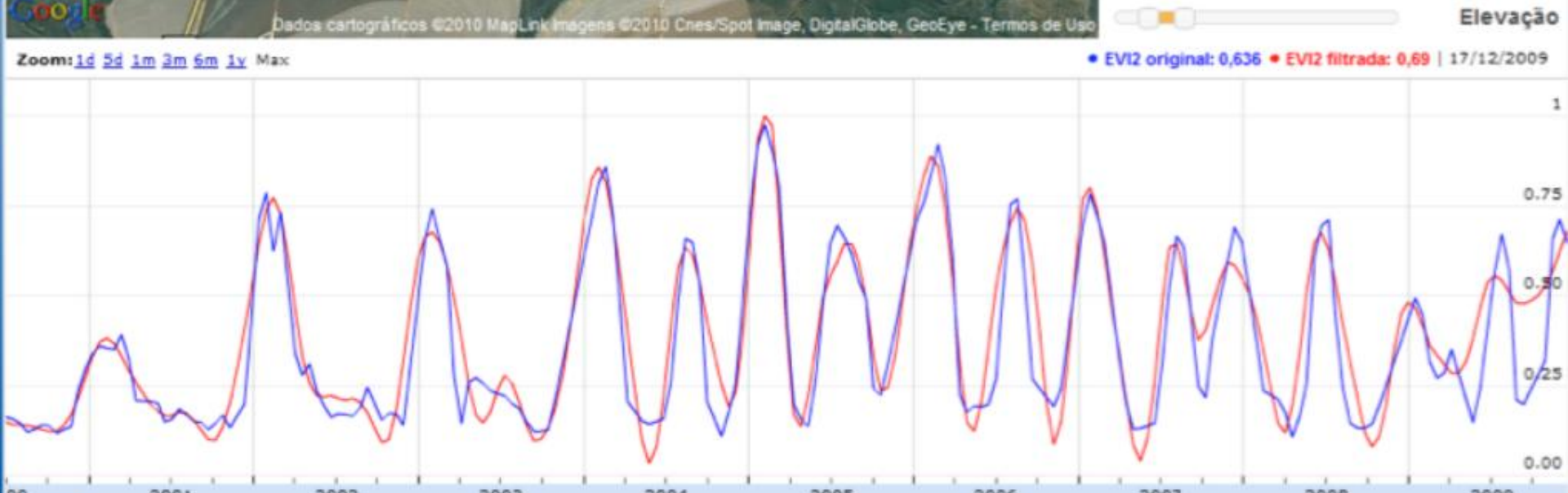
-17.7948, -45.4173

-17.7946, -45.4351

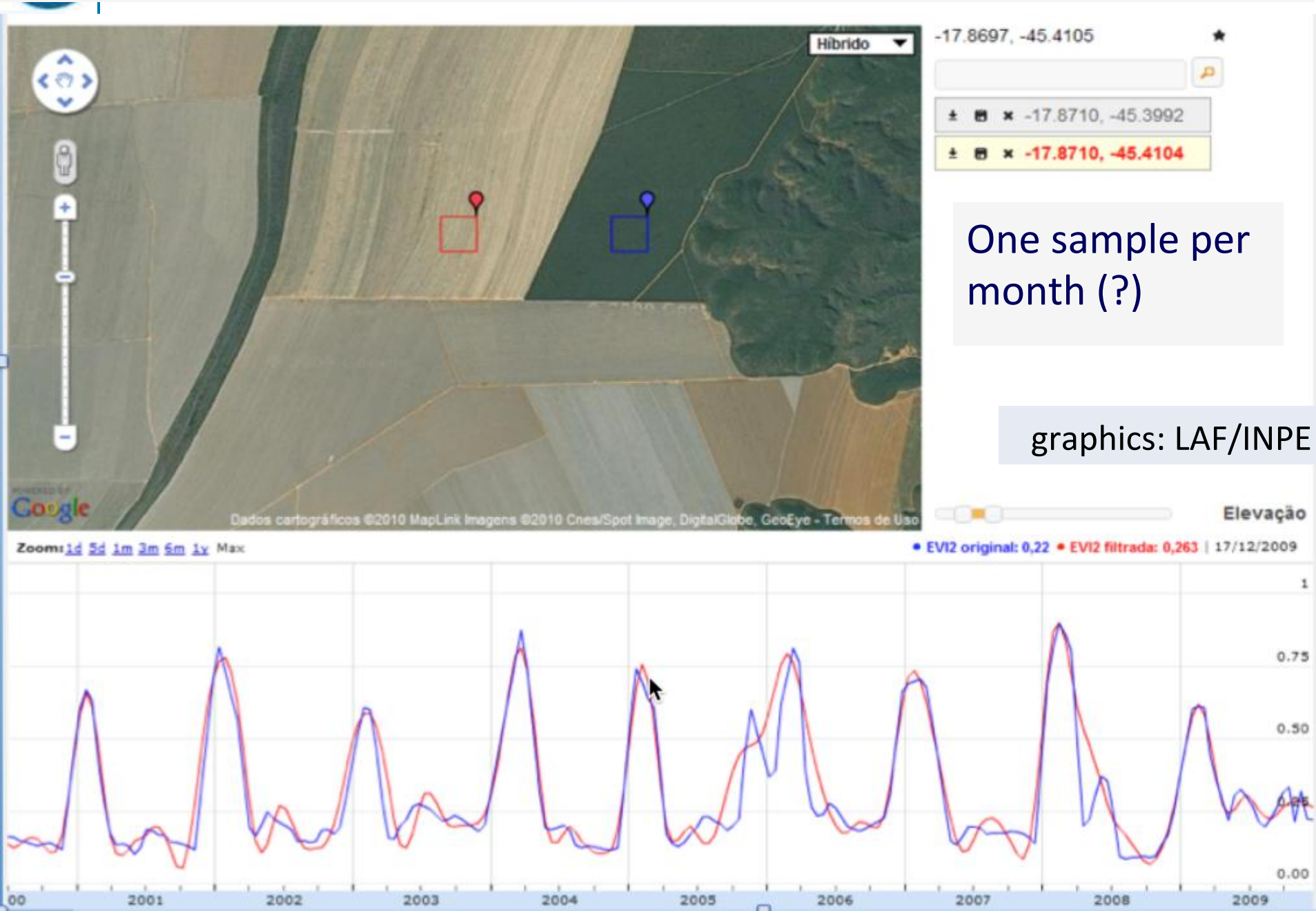
-17.7969, -45.4171

Two samples per month (?)

graphics: LAF/INPE



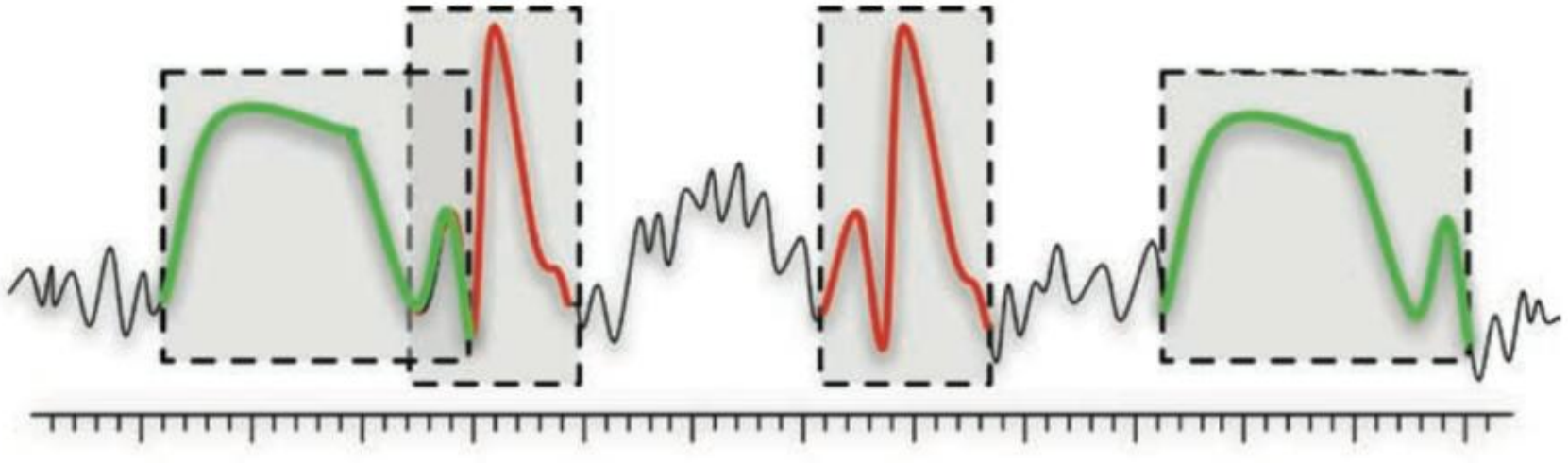
Single-crop grain production: soybeans



One sample per month (?)

graphics: LAF/INPE

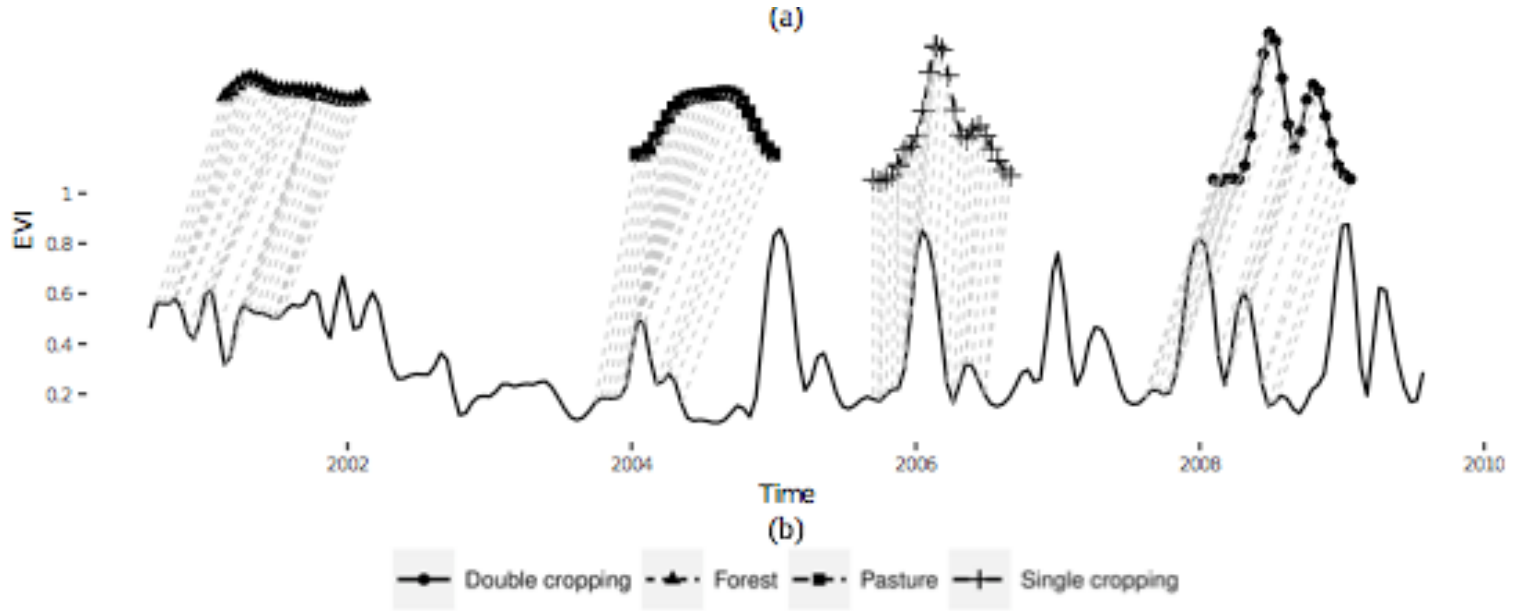
Time series mining: pattern matching



Finding subsequences in a time series
High computational complexity
Patterns are idealized, data is noisy

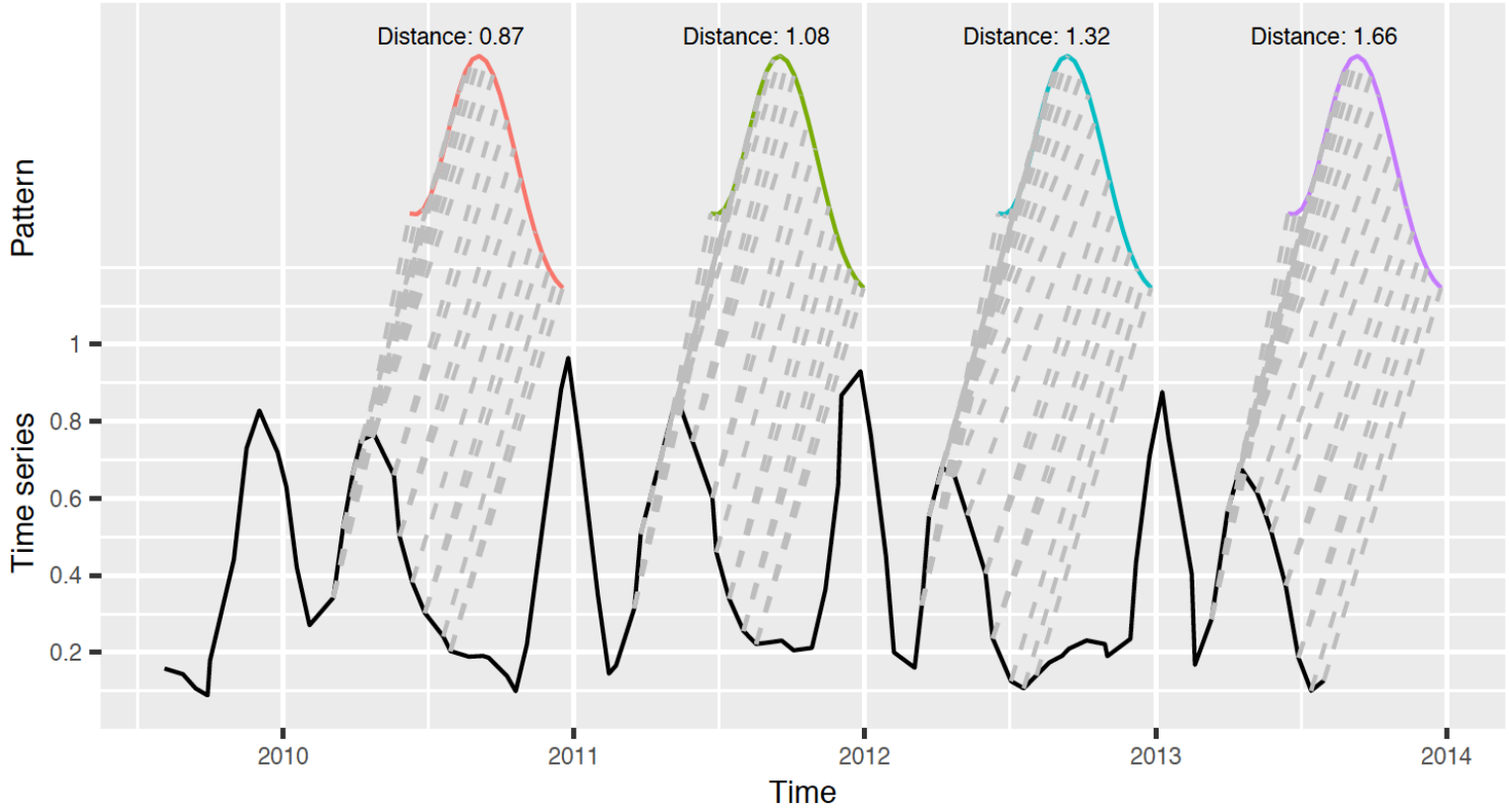
Esling & Agon (2012)

How to match land use patterns in a remote sensing time series?



A good match needs shape similarity and temporal coherence

Data mining for remote sensing time series



Finding alignments of short templates in a long time series considering the agricultural calendar

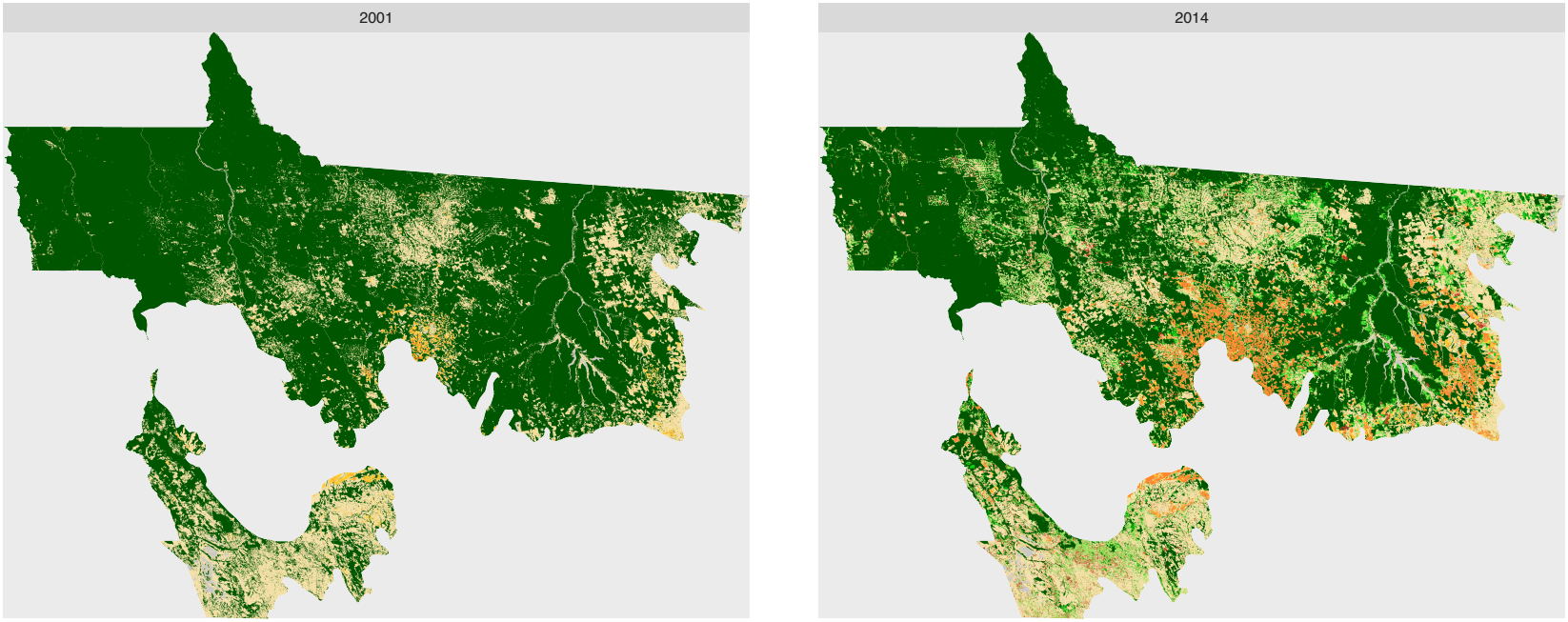
MODIS x Time-weighted DTW

	User (%)		Producer (%)	
Class	MODIS	TWDTW	MODIS	TWDTW
Forest	87.23	94.00	77.36	88.68
Pastureland	67.71	88.41	85.53	85.80
Cropland	89.33	92.00	75.28	96.73

Producer's accuracy: fraction of correctly classified pixels compared to all pixels of that ground truth class

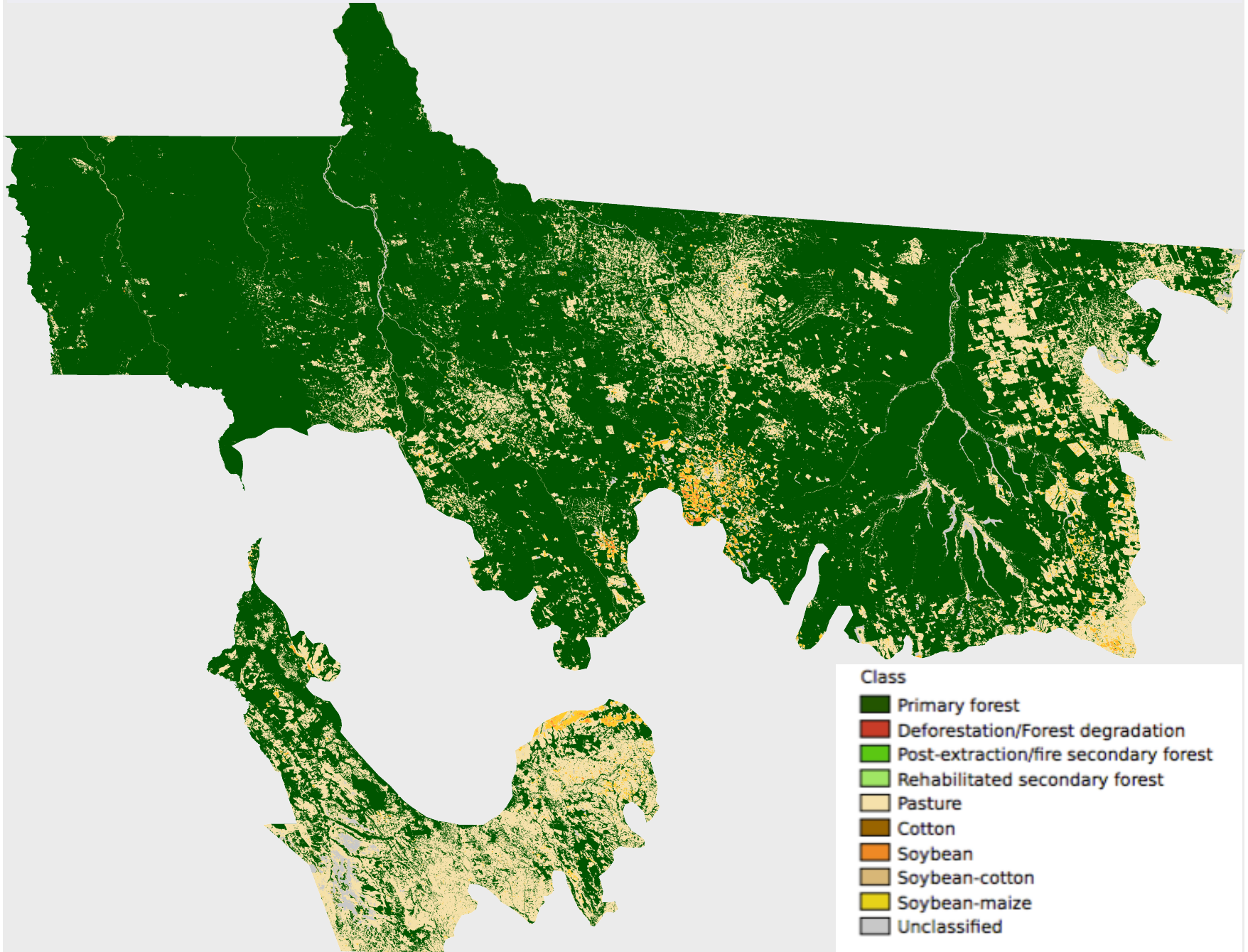
User's accuracy (reliability): fraction of correctly classified pixels of a class compared to all pixels classified as being that class

Land use change trajectories in the Amazonian biome of Mato Grosso state (2001-2014)

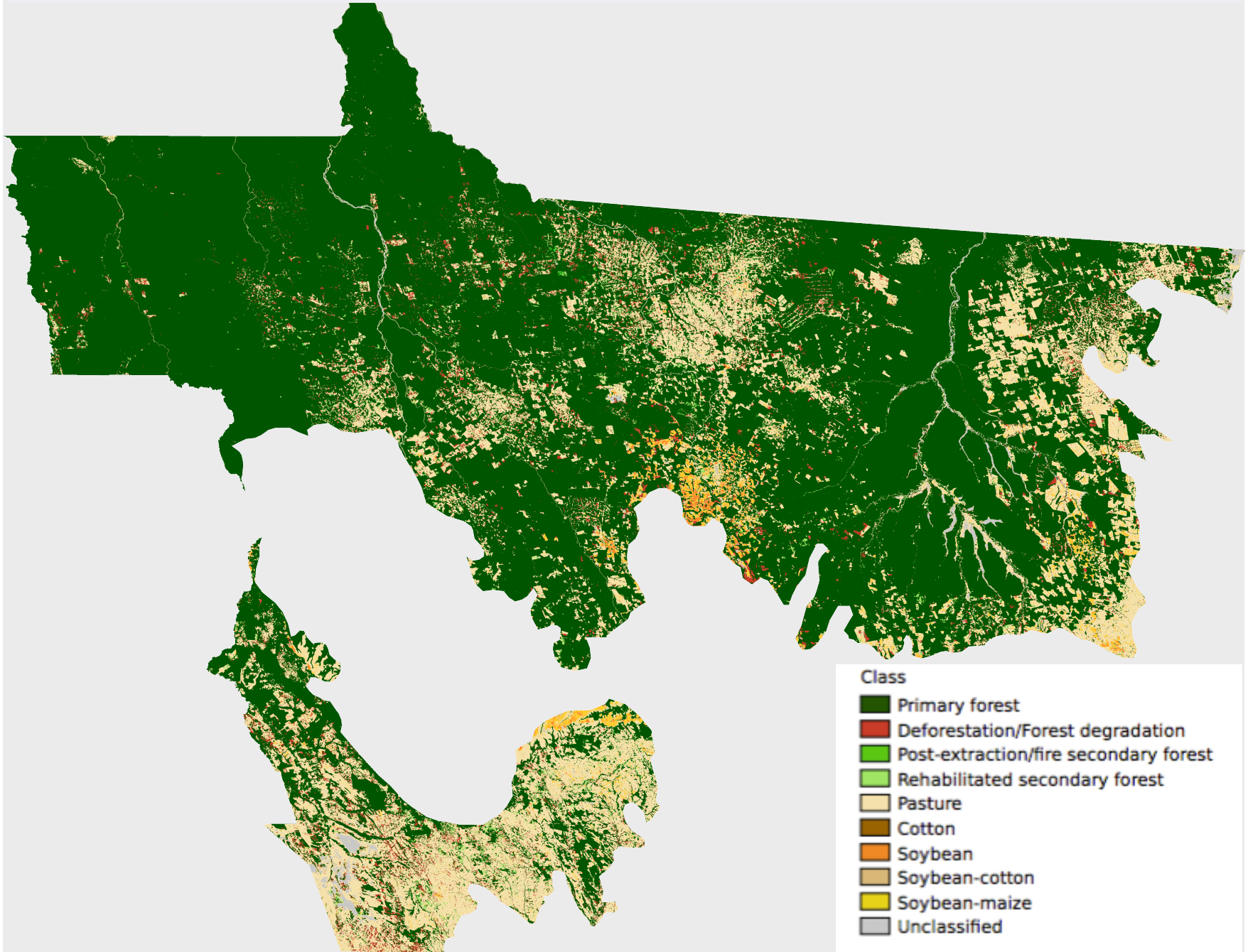


33 million time series

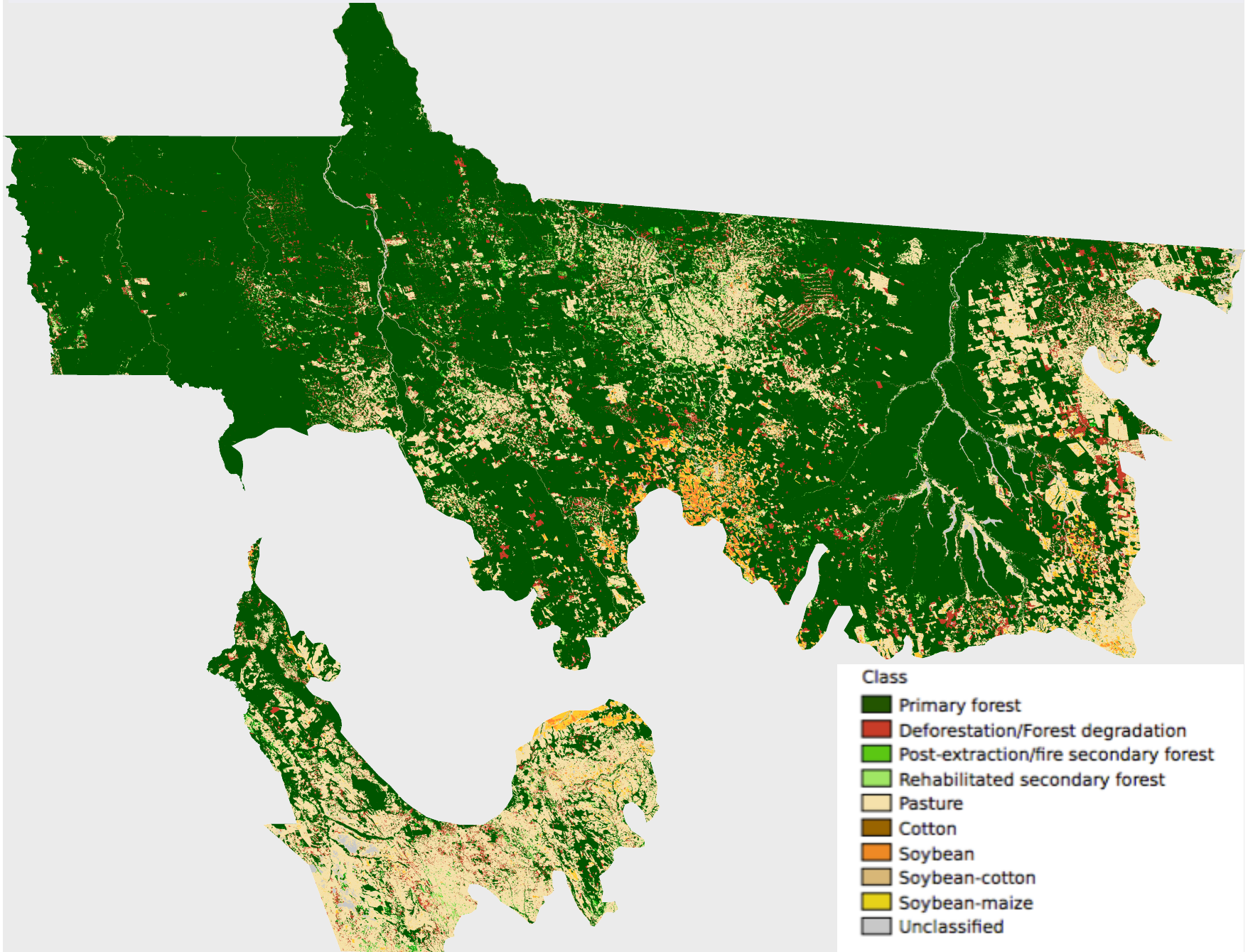
Mato Grosso – Amazonia biome (2001)



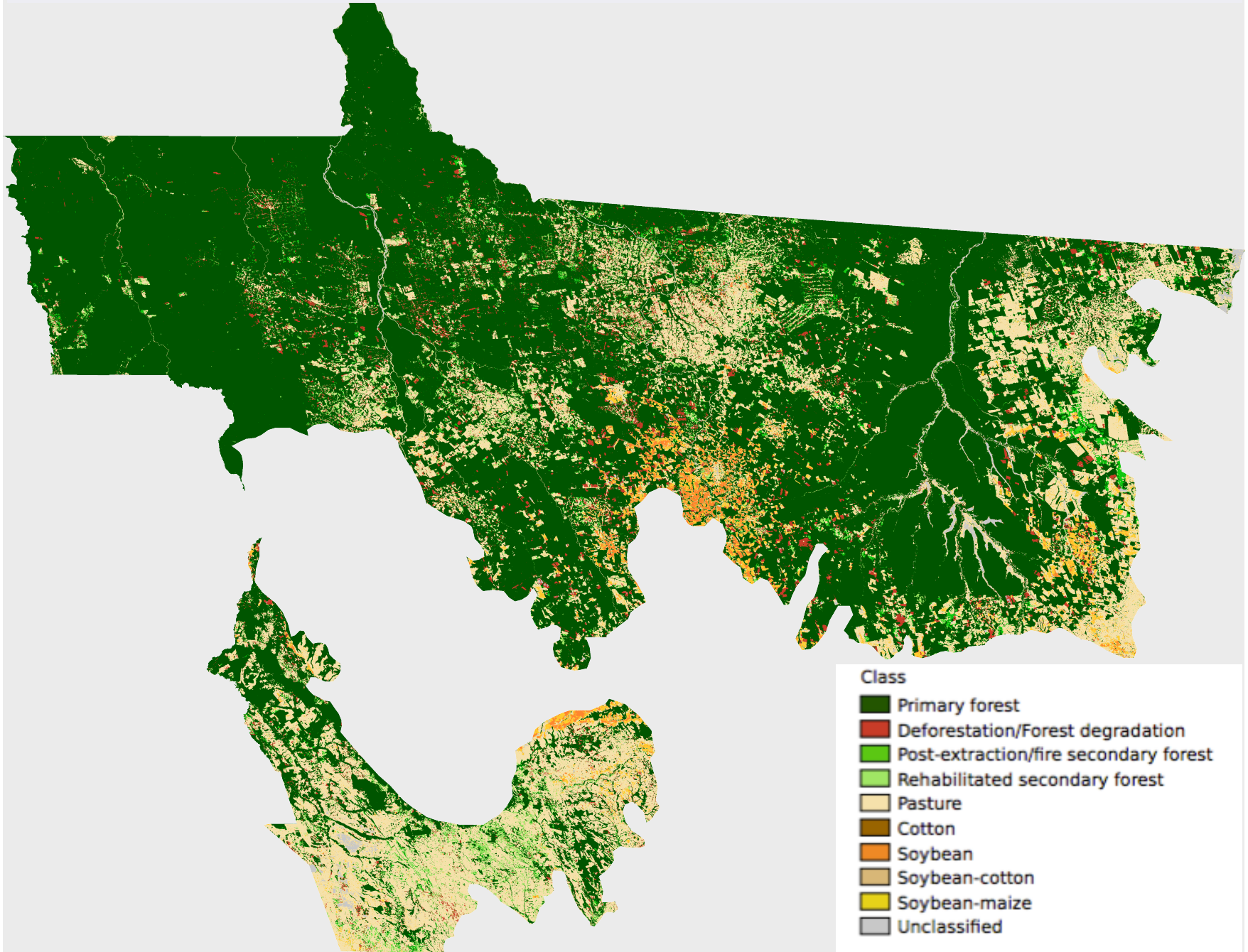
Mato Grosso – Amazonia biome (2002)



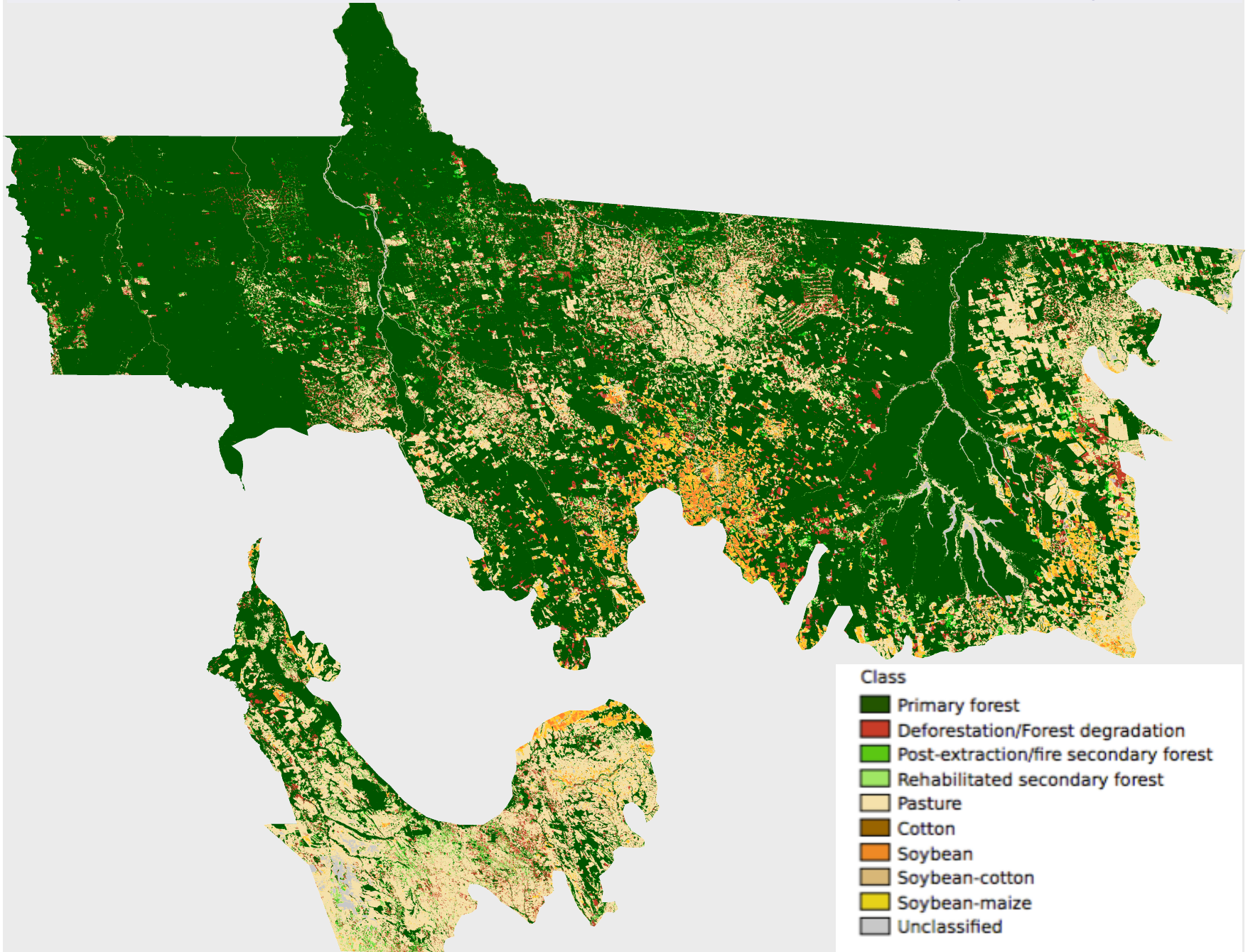
Mato Grosso – Amazonia biome (2003)



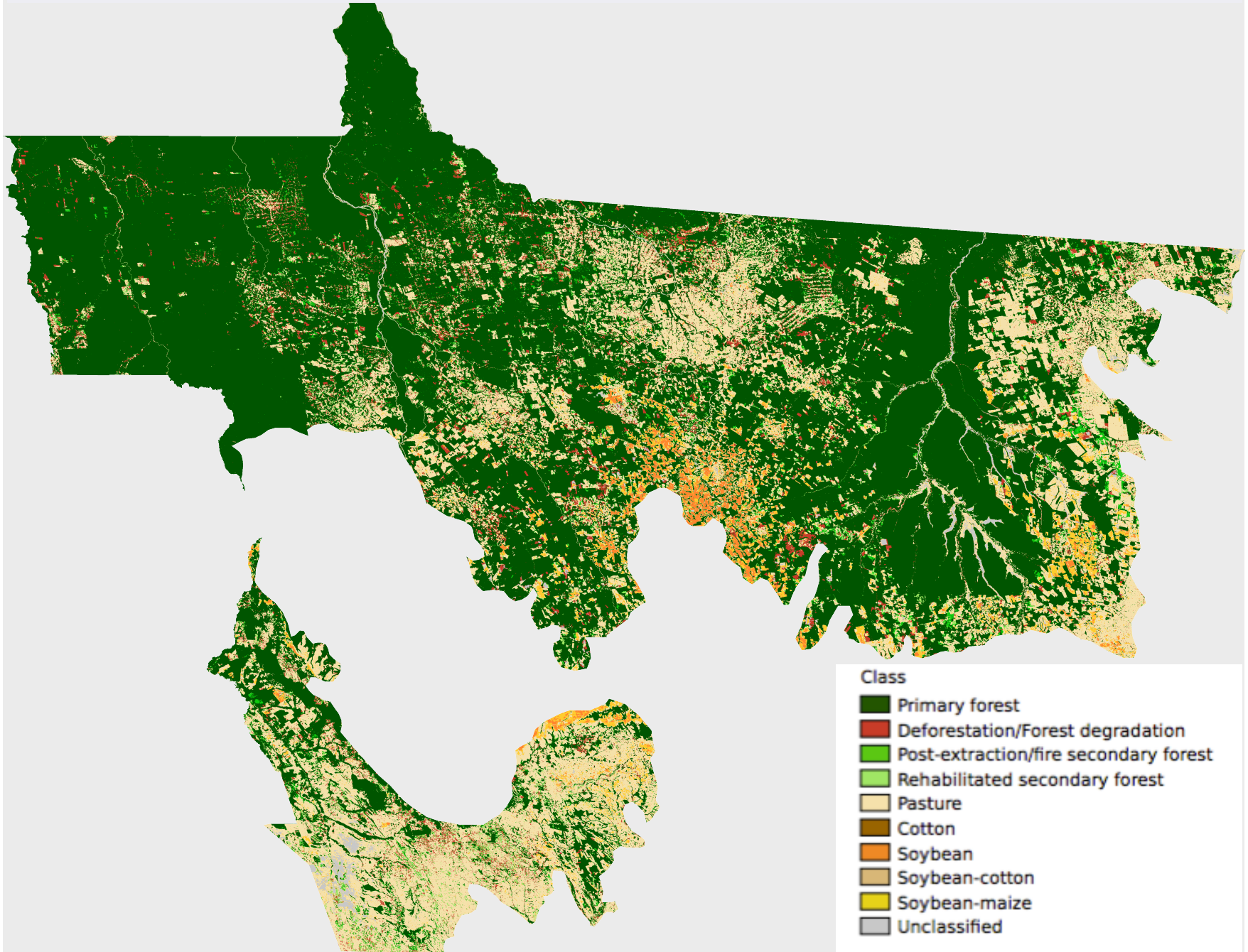
Mato Grosso – Amazonia biome (2004)



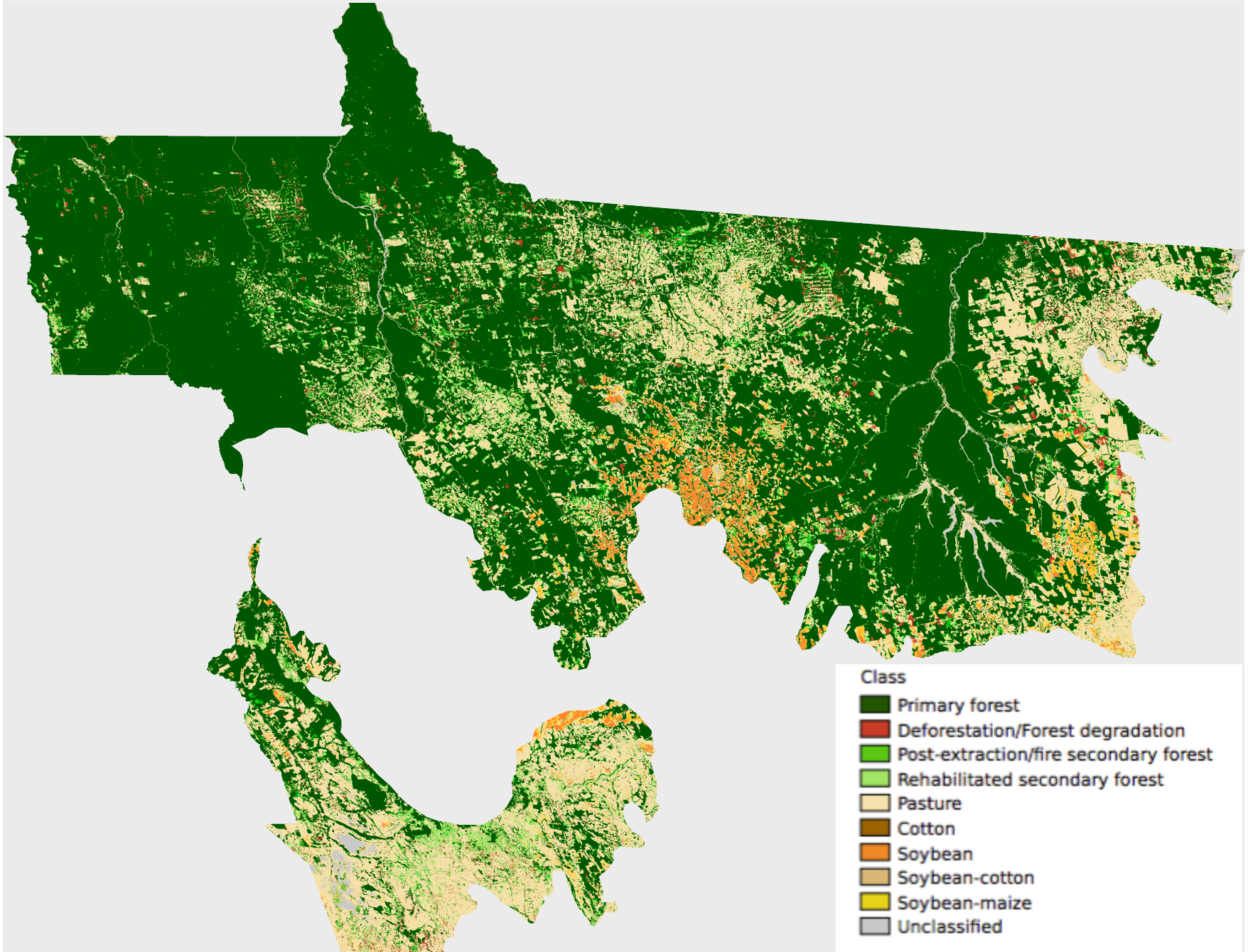
Mato Grosso – Amazonia biome (2005)



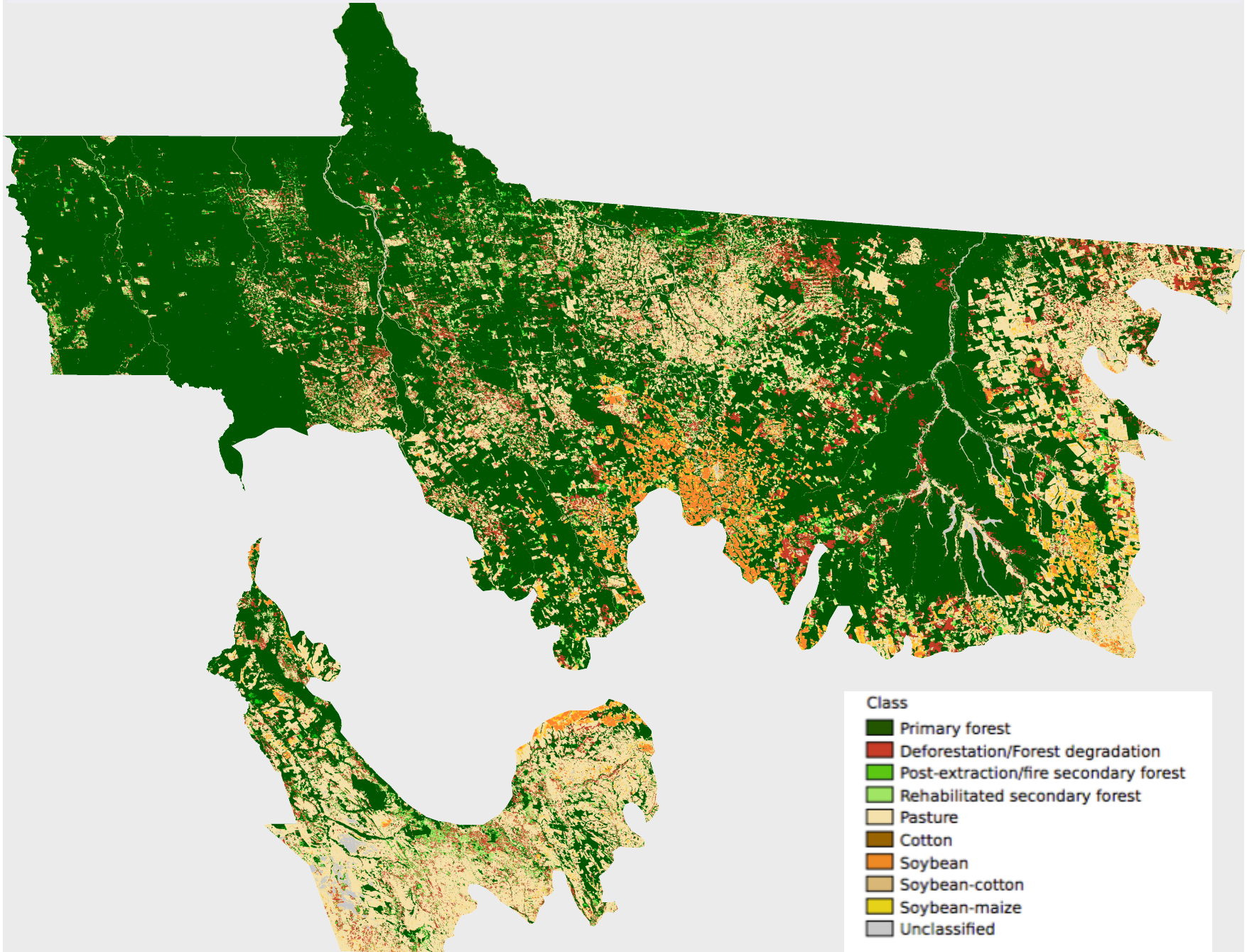
Mato Grosso – Amazonia biome (2006)



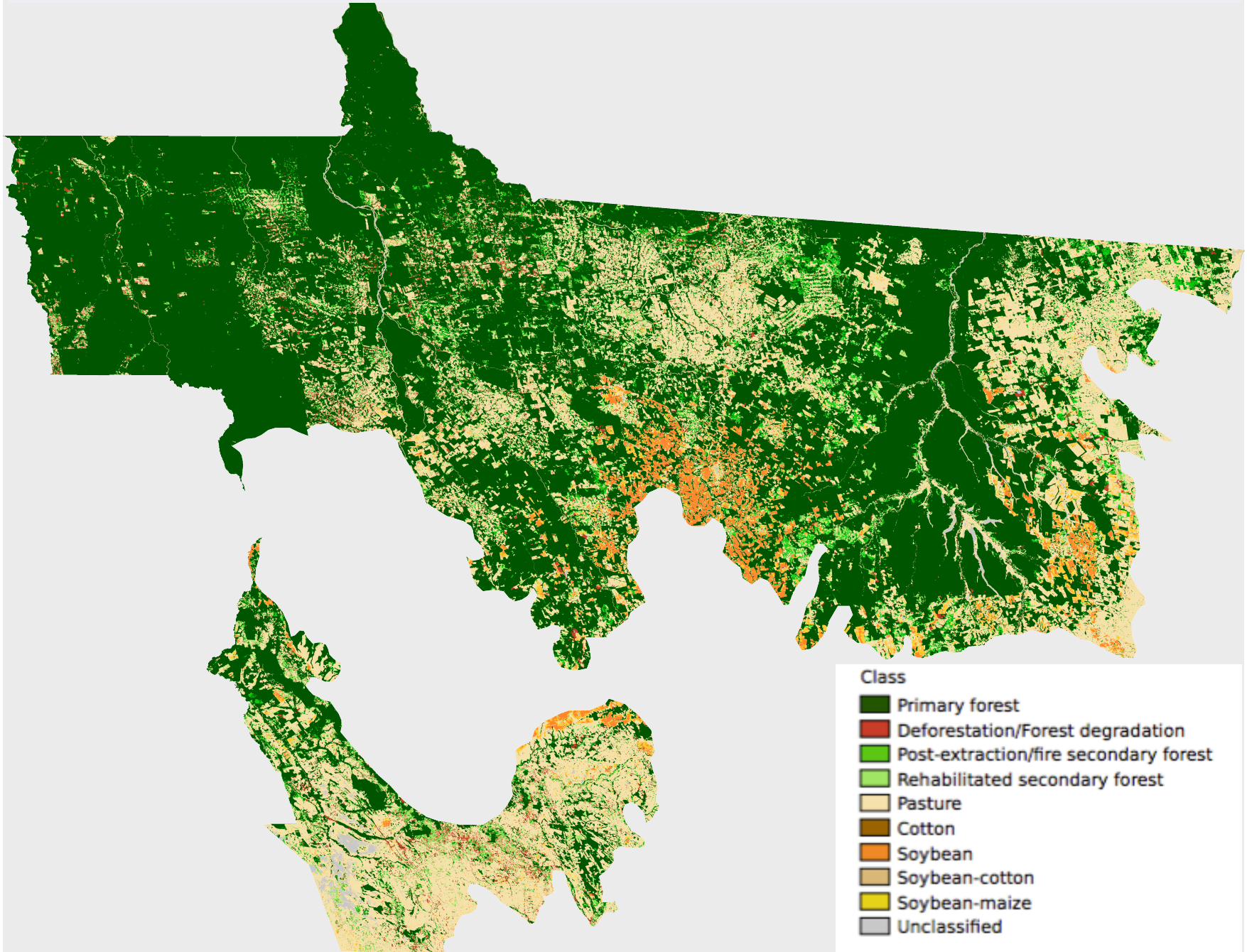
Mato Grosso – Amazonia biome (2007)



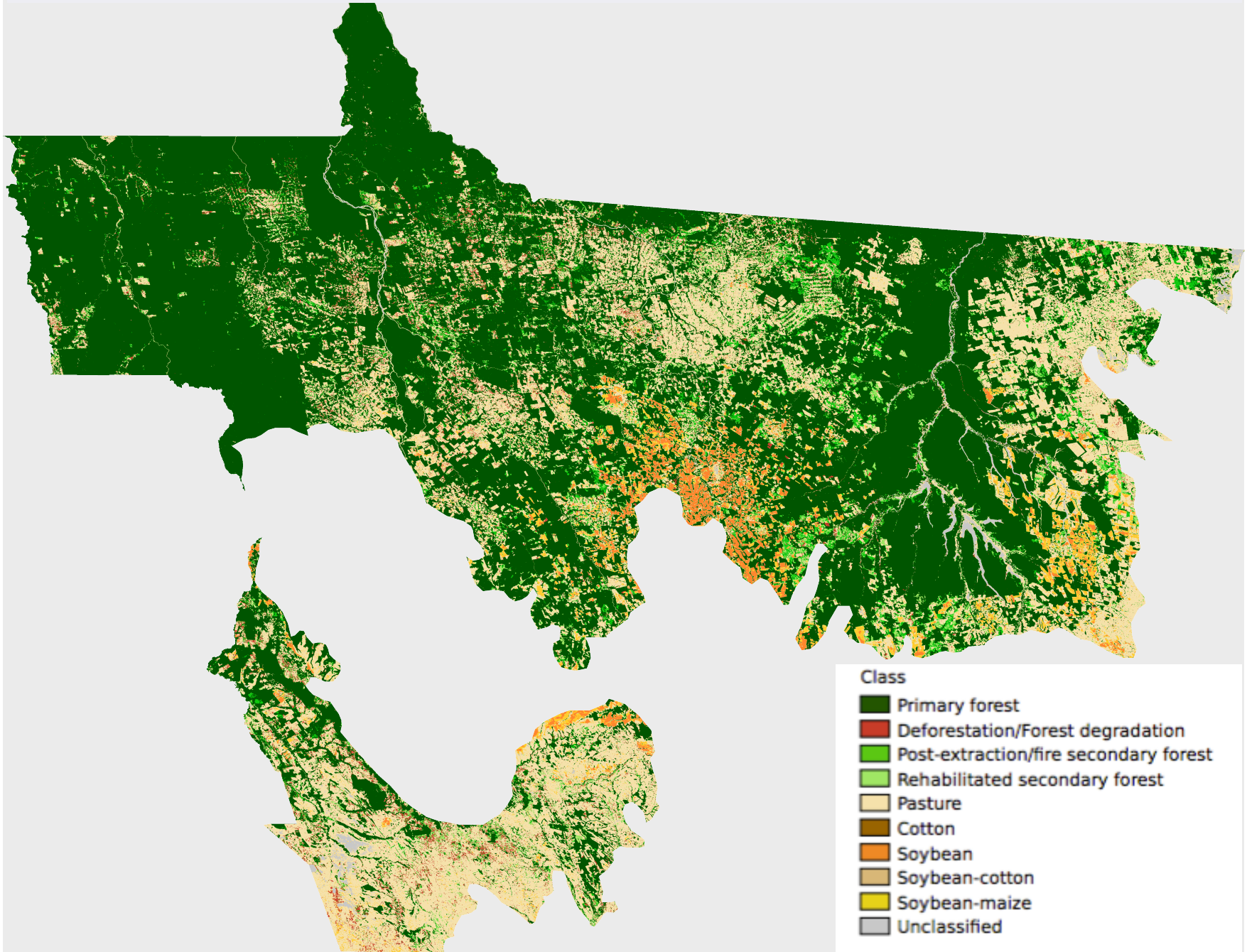
Mato Grosso – Amazonia biome (2008)



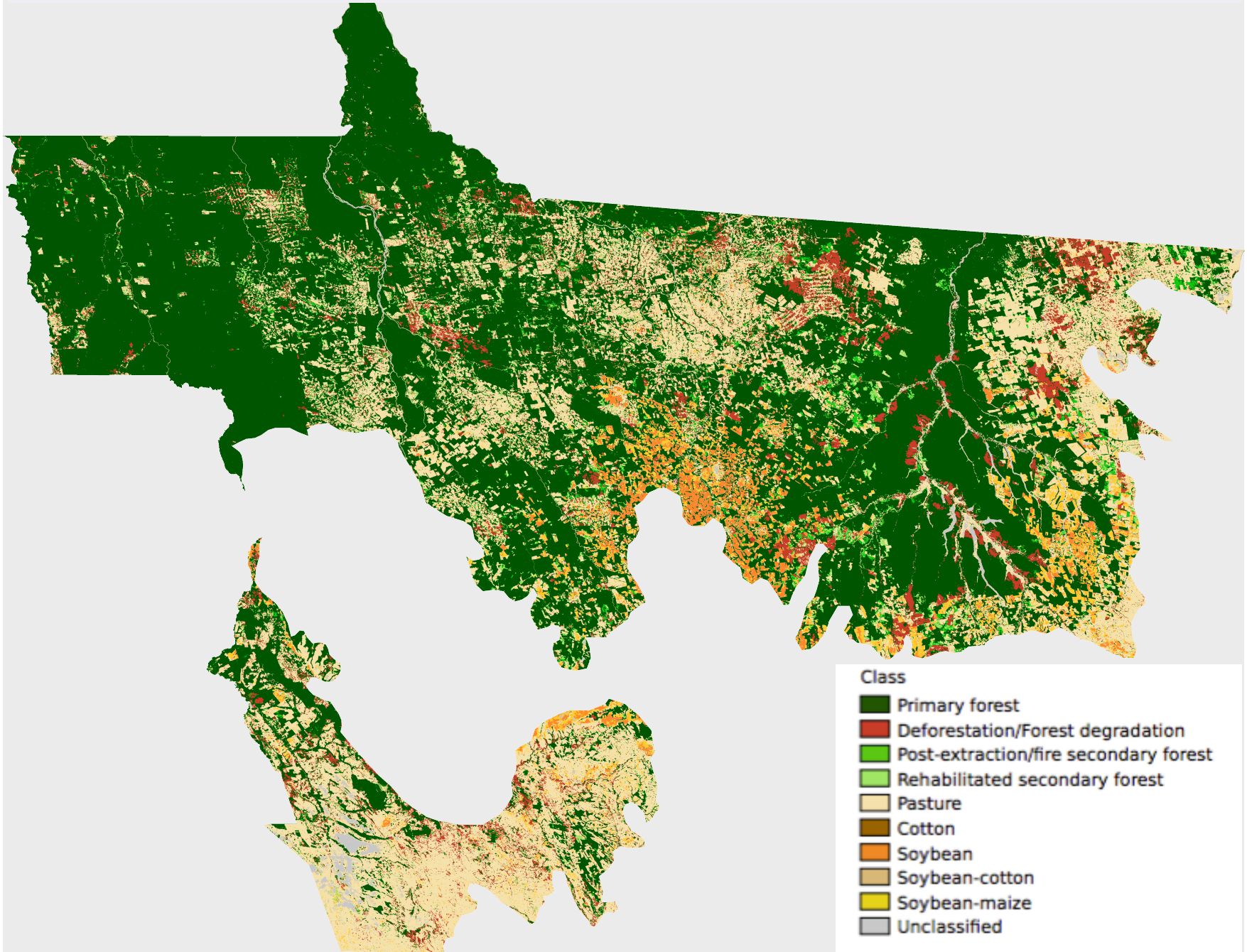
Mato Grosso – Amazonia biome (2009)



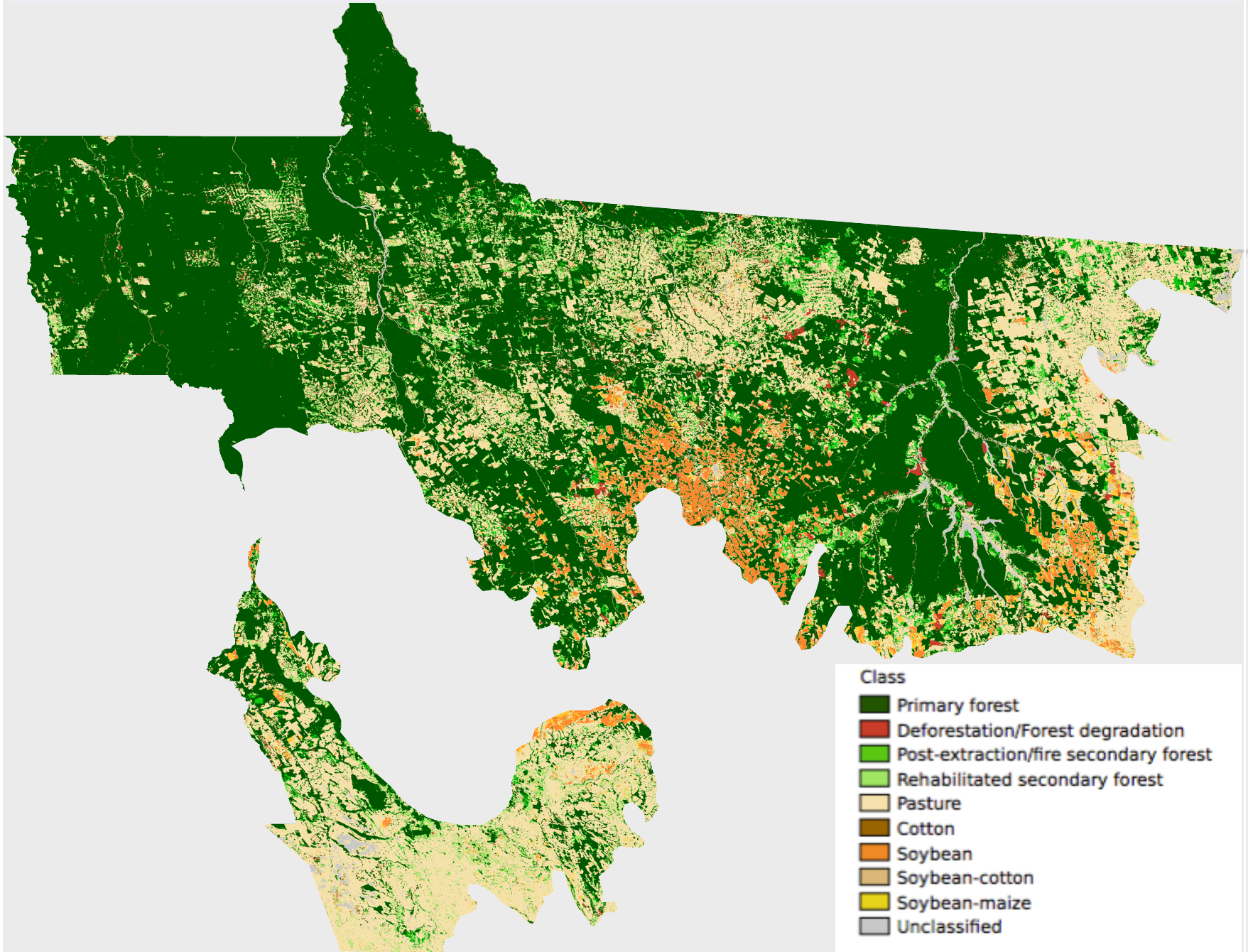
Mato Grosso – Amazonia biome (2010)



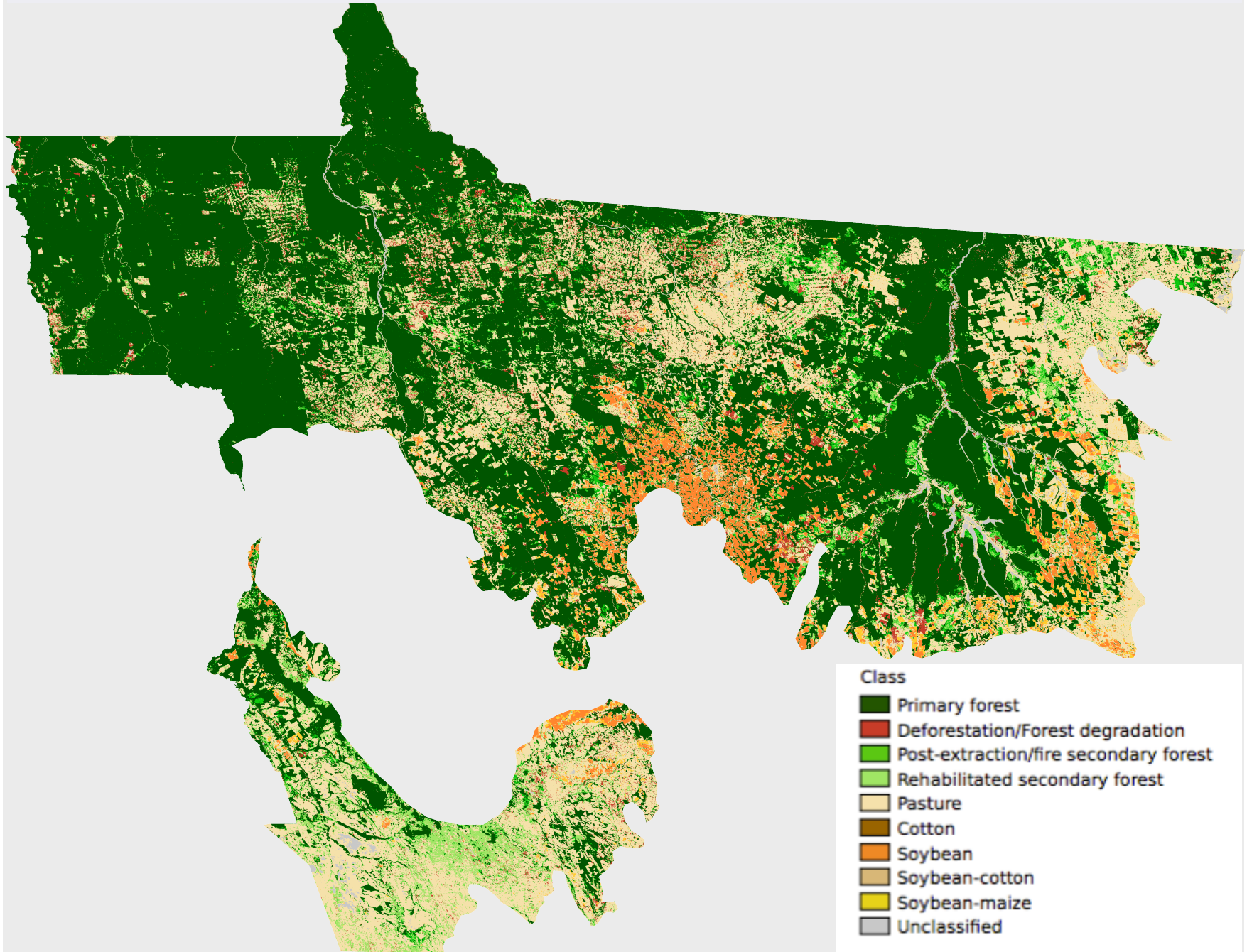
Mato Grosso – Amazonia biome (2011)



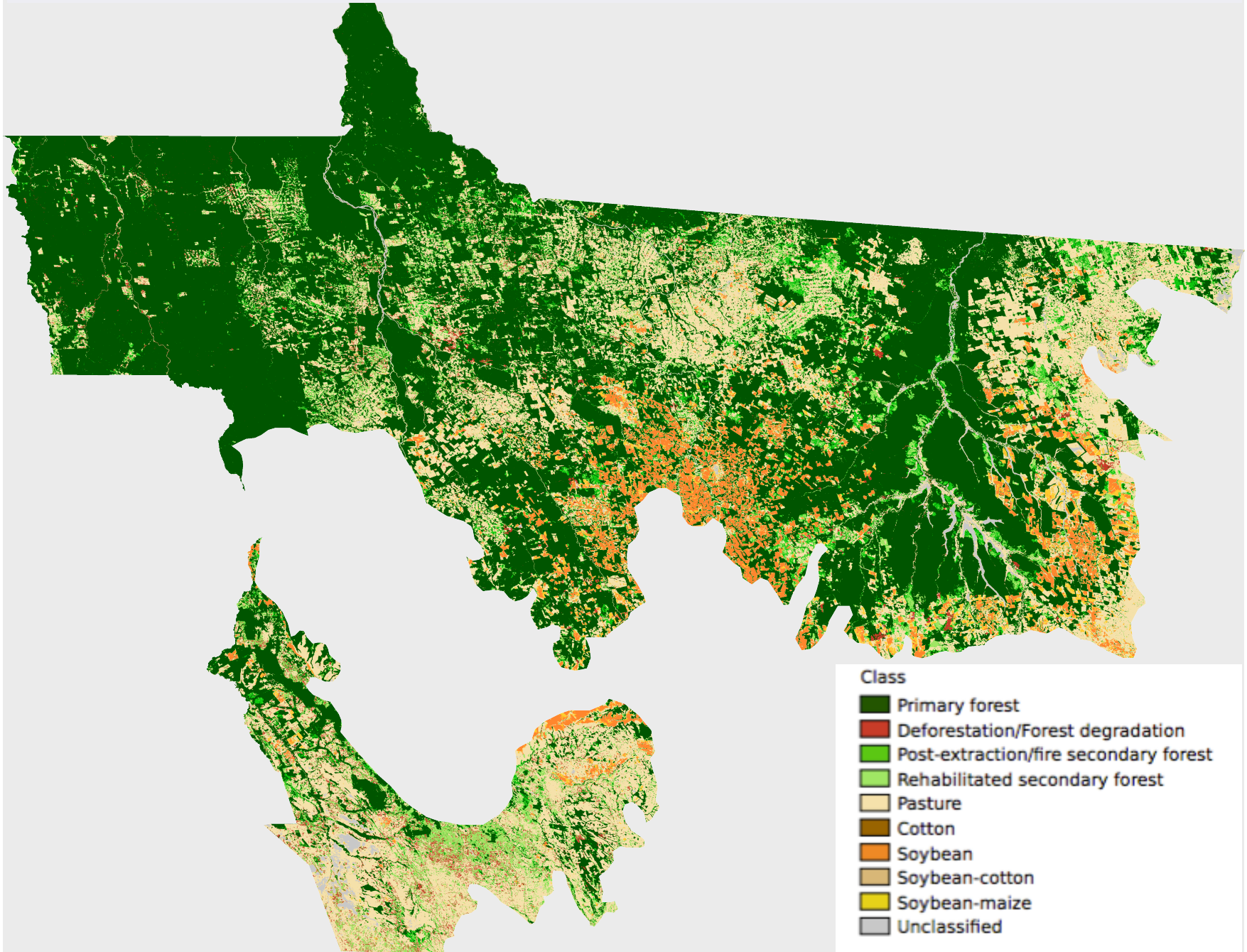
Mato Grosso – Amazonia biome (2012)



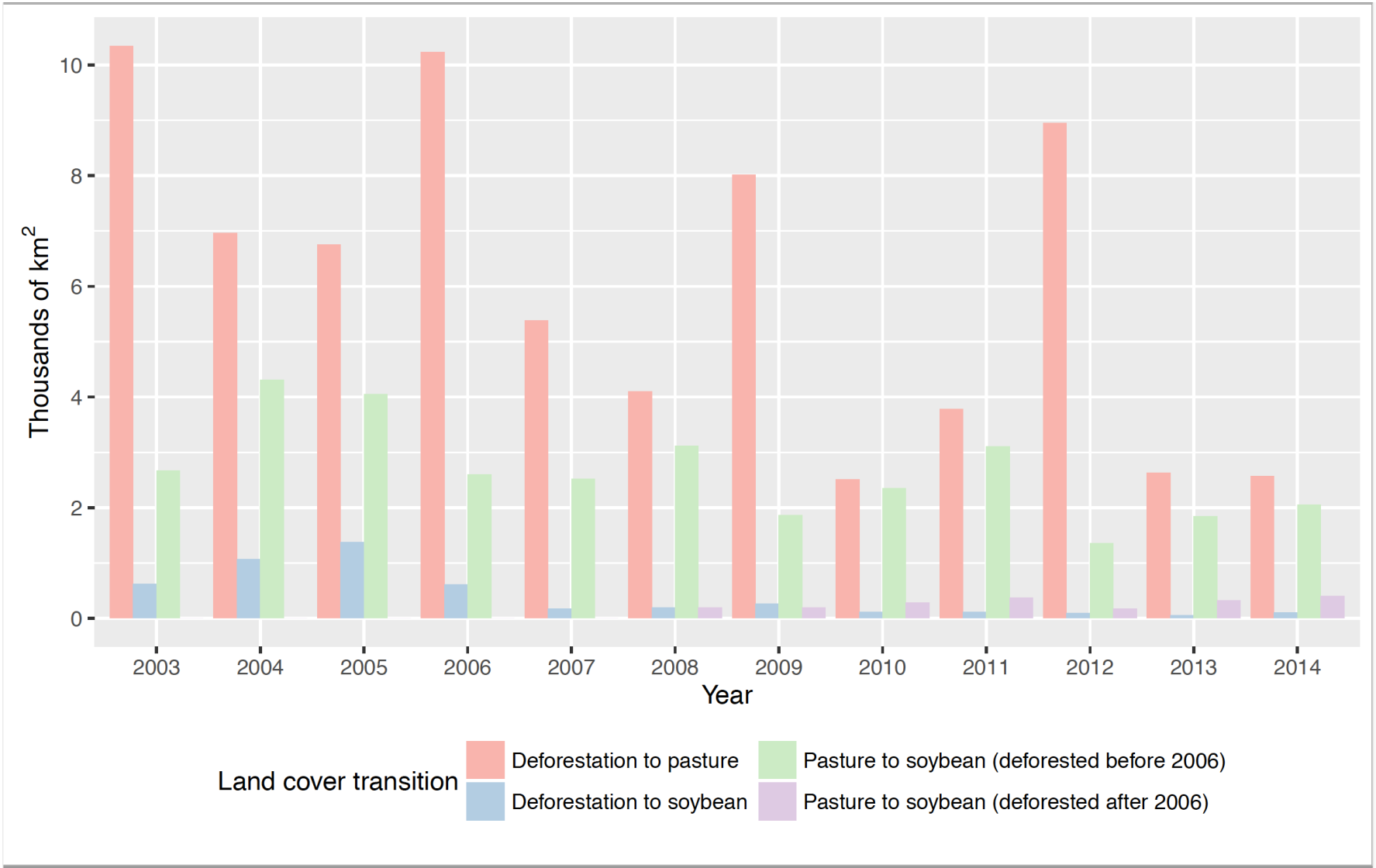
Mato Grosso – Amazonia biome (2013)



Mato Grosso – Amazonia biome (2014)



Using events to understand land transitions



Interval temporal logic (Allen)

Thirteen basic relations

Allen's thirteen basic relations are illustrated in Table 1. This table shows all the possible relations that two definite intervals can have. Each one is defined graphically by a diagram relating two definite intervals a and b, with time running → from left to right. For example, the first diagram shows that "*a* precedes *b*" means that *a* ends before *b* begins, with a gap separating them; the second shows that "*a* meets *b*" means that *b* ends when *a* begins.

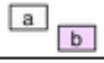
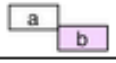
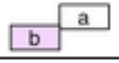
precedes	meets	overlaps	finished by	contains	starts	equals	started by	during	finishes	overlap-ped by	met by	preceded by
												
p	m	o	F	D	s	e	S	d	f	O	M	P

Table 1. Allen's thirteen basic relations

$$\texttt{holds}(p,t) \equiv \forall t'(\texttt{in}(t',t) \Rightarrow \texttt{holds}(p,t'))$$

$$(\texttt{occur}(e,t) \wedge \texttt{in}(t',t)) \Rightarrow \neg\texttt{occur}(e,t')$$

Rules of interval temporal logic

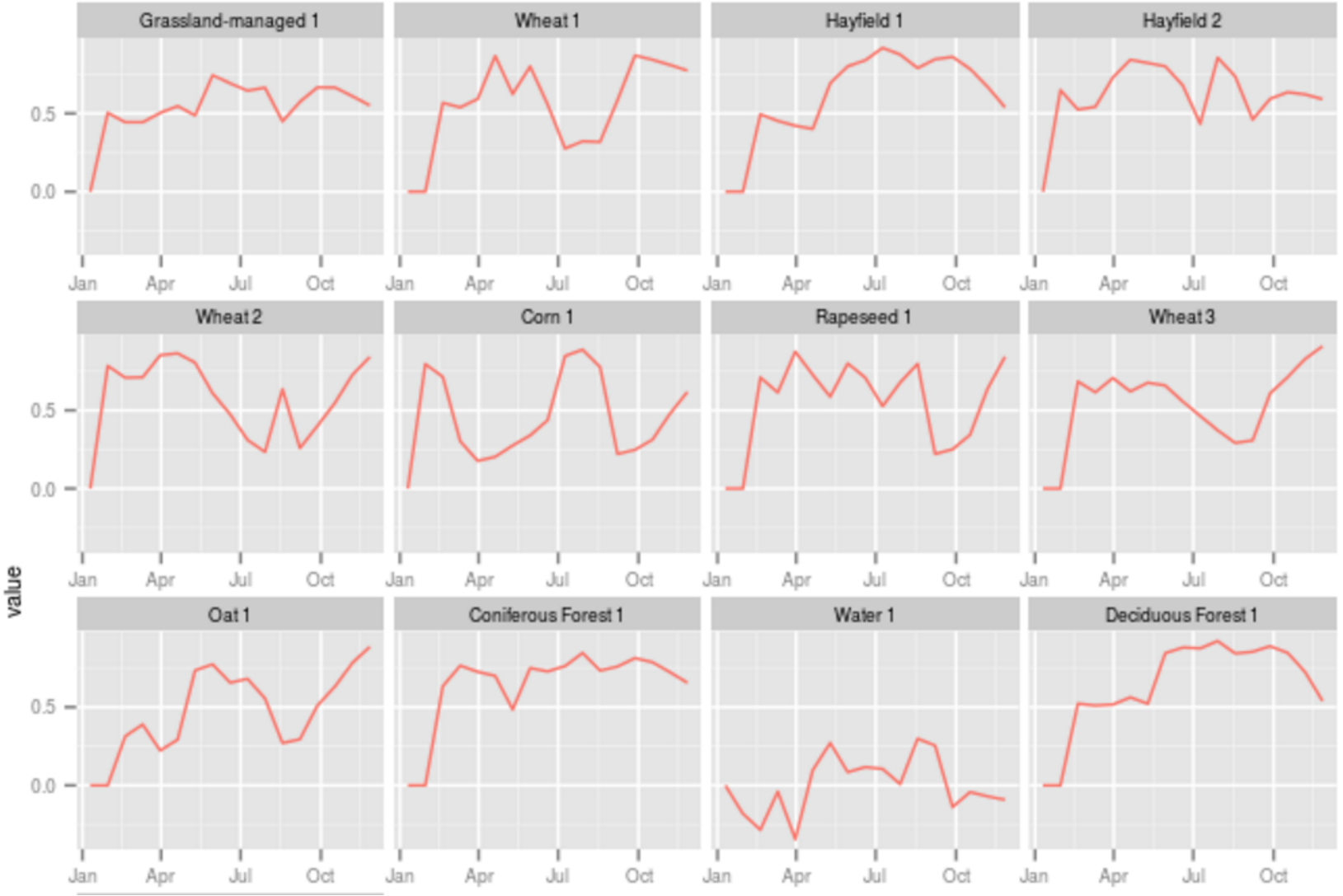
Which forest areas have been replaced by soybeans?

$\forall s \in S,\ occur\ (s, "defor", t\downarrow 1\ ) \cap\ (meets\ (t\downarrow 1\ , t\downarrow 2\ )) \cap occur(s, "soy", t\downarrow 2\ )$

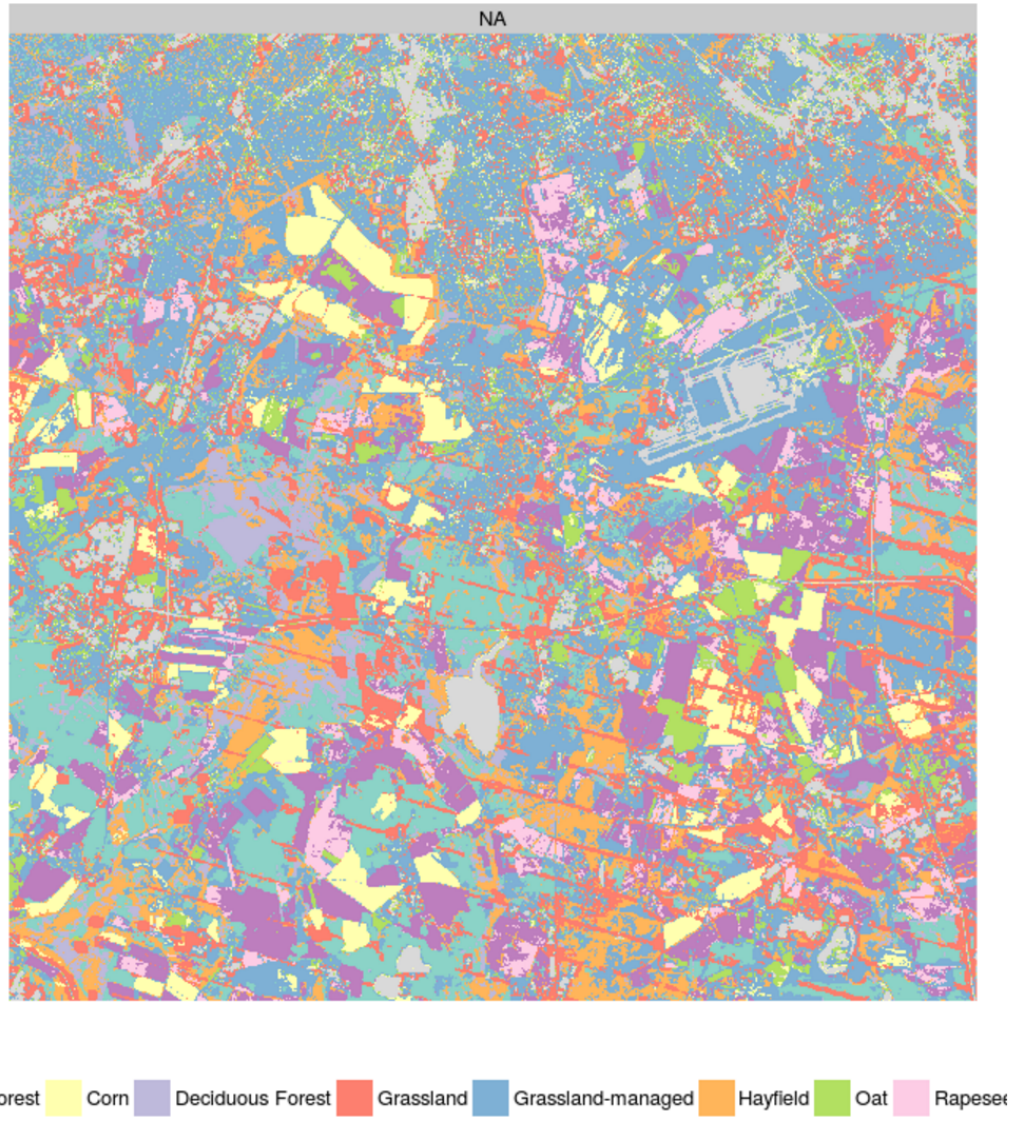
Which forest areas have been replaced by pasture and then turned into soybeans?

$\forall s \in S,\ occur\ (s, "defor", t\downarrow 1\ ) \cap\ (meets\ (t\downarrow 1\ , t\downarrow 2\ )) \cap occur(s, "pasture", t\downarrow 2\ ) \cap\ (preceeds(t\downarrow 1\ , t\downarrow 3\ )) \cap occur(s, "soy", t\downarrow 3\ )$

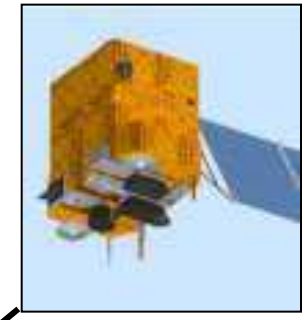
Middle-resolution time series (LANDSAT-8 + Sentinel-2A)

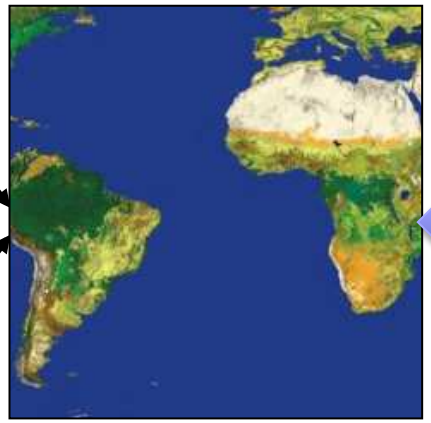


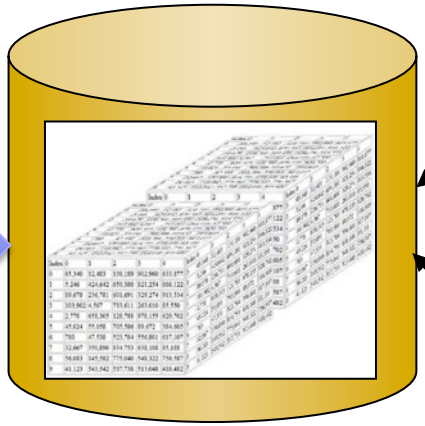
Classificação resultante (mid-resolution)



Open source and open data = knowledge sharing







New insights into land use change

Free satellite imagery

R: New data analysis methods

SciDB: array database for big scientific data

Big EO data analytics: the new frontier on Earth observation

WTSS Client

```
http://www.dpi.inpe.br/wtss/time_series?
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longitude=-54,latitude=-12&start=2000-02-18&end=2000-03-05
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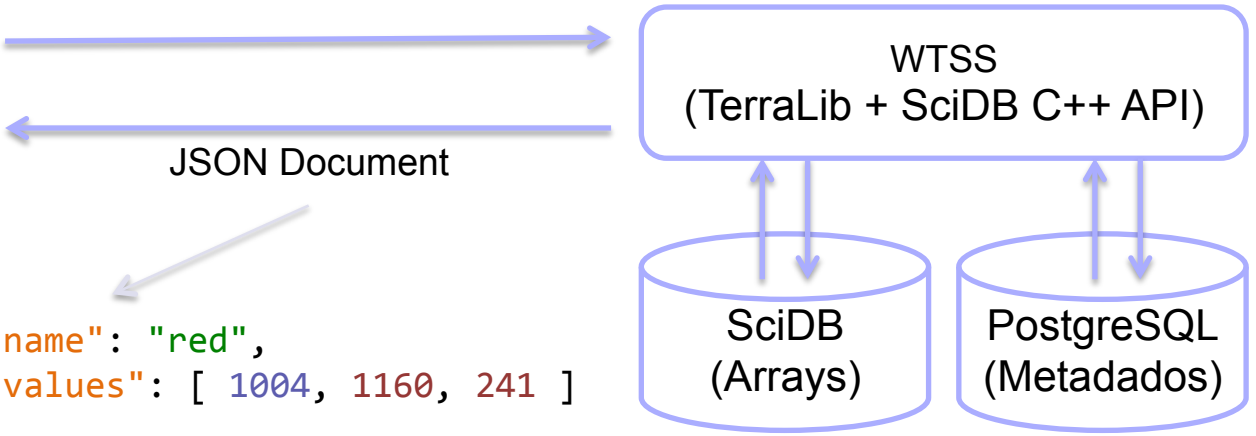


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}
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WTSS – Web Time Series Service: a lightweight service for handling remote sensing imagery as time series

Thesis

- Victor Maus: Land Use / Land Cover change monitoring using remote sensing imagery time series – dtwSat
- Adeline Maciel: Spatiotemporal interval logic for reasoning about land use change using big Earth observation data sets (Março 2017)
- Alber Sanchez: Algorithms for real-time monitoring of deforestation events in big Earth Observation data (March 2018)
- Luiz Fernando Assis: Extraction and analysis of land cover samples for classification of big Earth Observation data (Março 2019)
- Rolf Simões: Land use classification of largescale LANDSAT time series (March 2020)

Articles in Journals

- A Time-Weighted Dynamic Time Warping Method for Land-Use and Land-Cover Mapping, IEEE JSTARS
- dtwSat: Time-Weighted Dynamic Time Warping for remote sensing time series analysis in R, Journal Statistical Software (submitted)
- Long-term land use and land cover change in Brazilian Amazonia using satellite image time series, Remote Sensing (in preparation)
- Spatiotemporal interval logic for reasoning about land use change using big Earth observation data sets, IJGIS (in preparation)

Produção acadêmica: conferencias

- Using dynamic geospatial ontologies to support information extraction from big Earth observation data sets, GIScience 2016 (accepted)
- Big Earth Observation Data Analytics: Matching Requirements to System Architectures, ACM GIS 2016 (submitted)
- Web Services for Big Earth Observation Data, GeoInfo 2016 (submitted)

e-Sensing: project portal

www.esensing.org

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e-sensing: big Earth observation data analytics for LUCC

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E-SENSING: BIG EARTH OBSERVATION DATA ANALYTICS FOR LAND USE AND LAND COVER CHANGE INFORMATION

The **e-sensing** project develops new ways to extract information on land use and land cover change from big Earth Observation data sets, using open Science. Our project is building *a new generation of knowledge platforms for handling big geospatial data.*

The "e-sensing" project is supported by FAPESP (grant 2014/08398-6), under the "e-science" program.

For more information, please see the project overview, the project proposal, or the project presentation.

e-sensing project selects post-doc in geospatial web services

September 2016

PROJECT DEVELOPMENT

DPI Divisão de Processamento de Imagens

Image Processing Division

INSTITUTIONAL SUPPORT

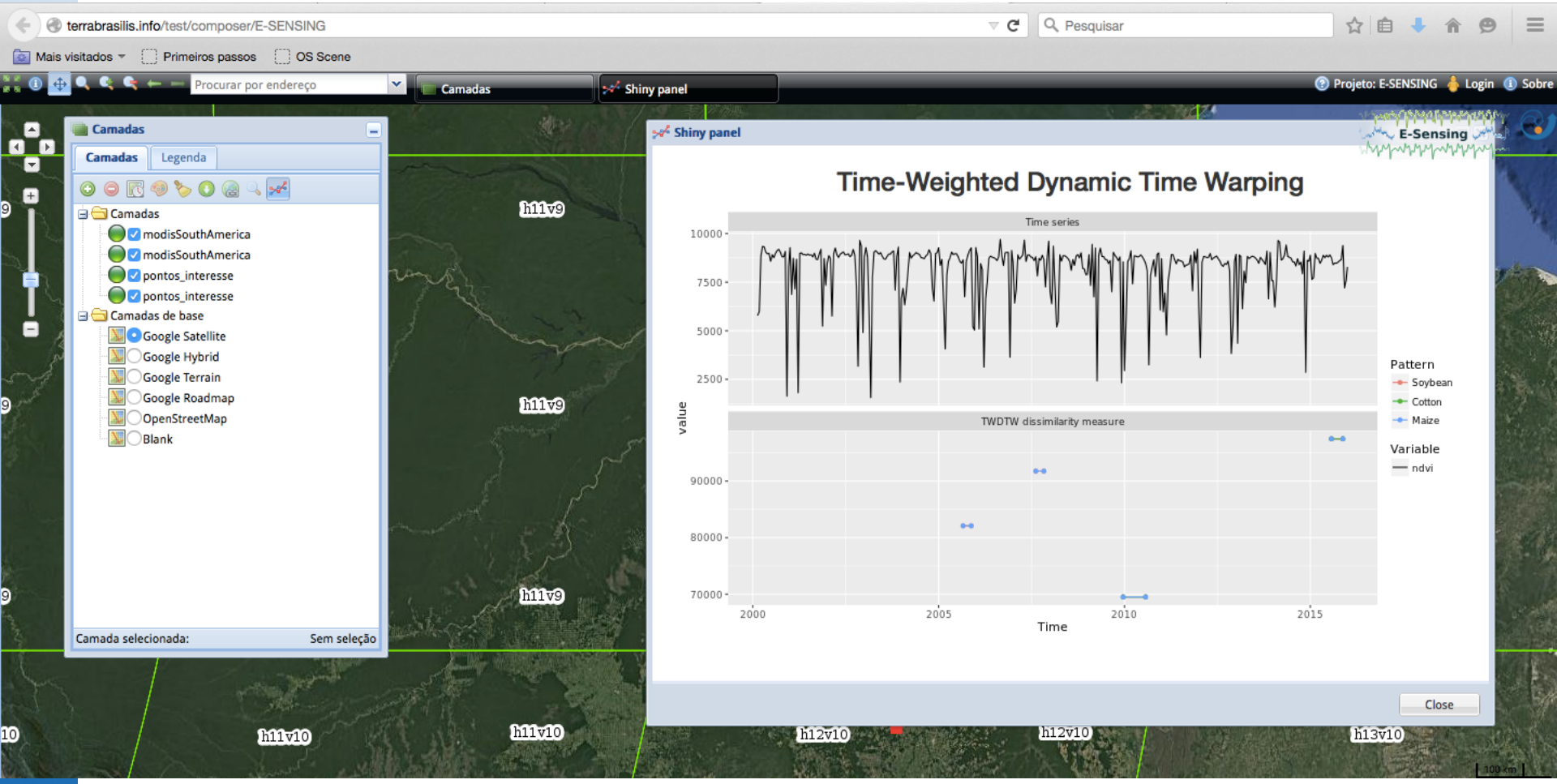
National Institute for Space Research - Brazil

FUNDING ORGANIZATION

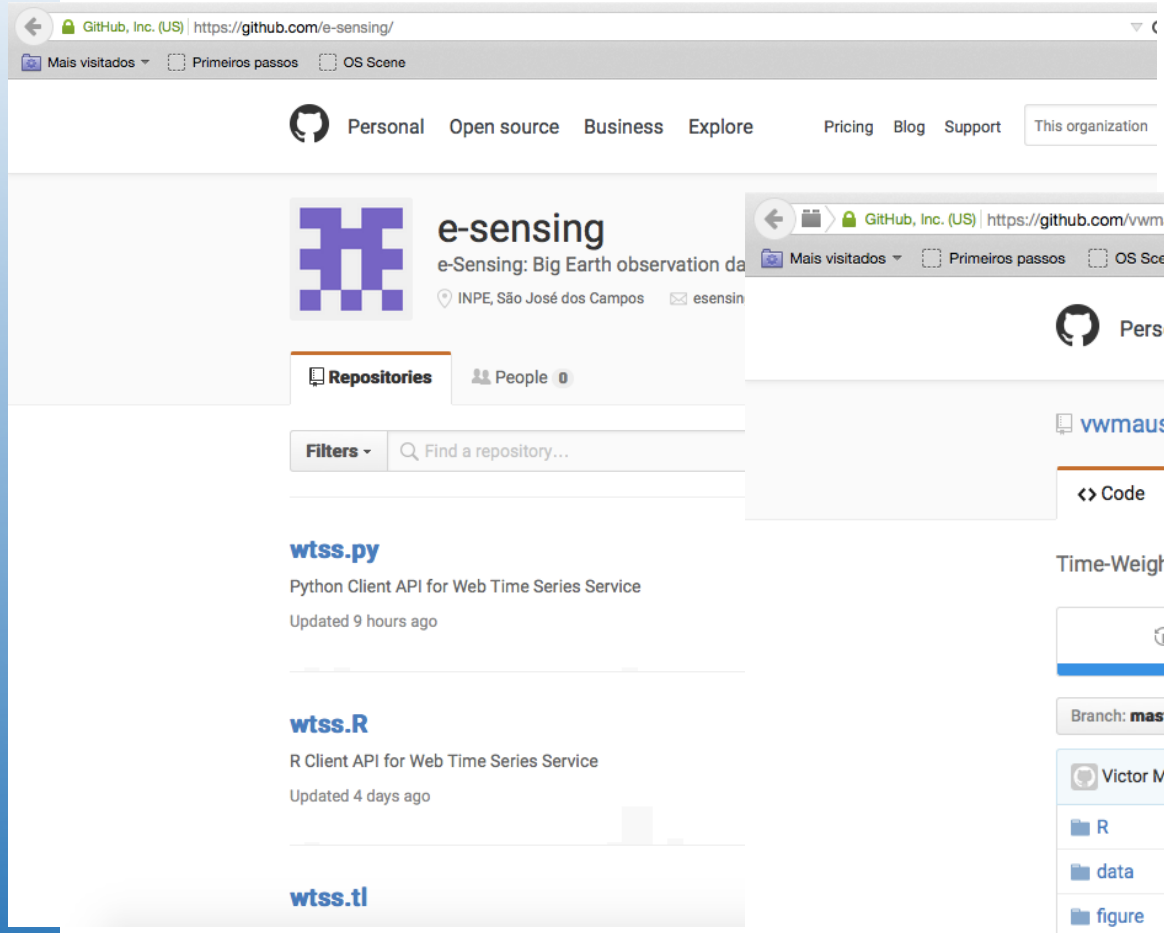
FAPESP

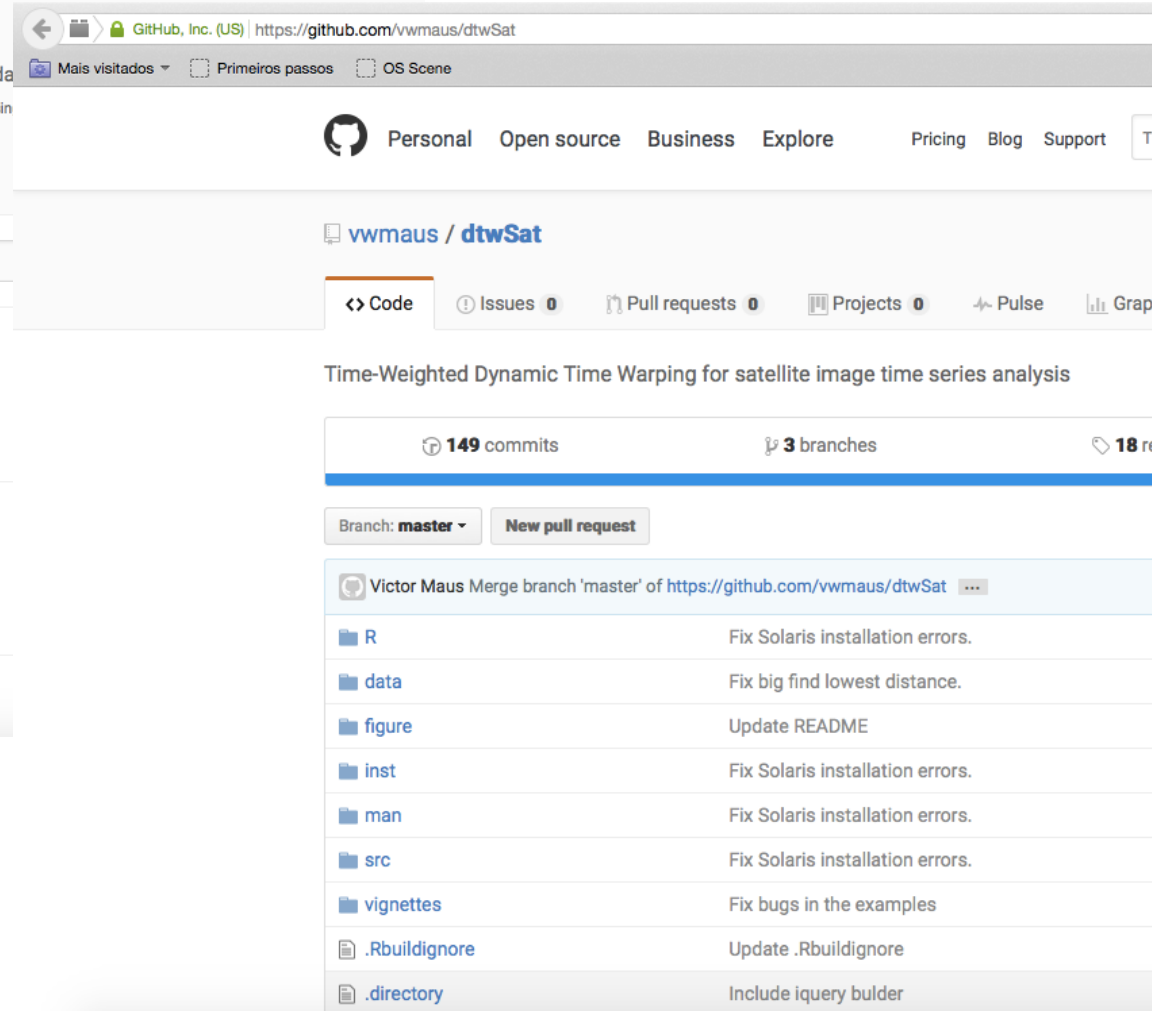
São Paulo Research Foundation

e-Sensing - platform portal (prototype)



e-Sensing: reproducibility





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