Oxford Environmental Institute
Invited Talk, Jan 2020

Brazilian Amazonia: Governance Issues and Research Challenges

Gilberto Câmara
GEO – Group on Earth Observations
INPE – Brazil's National Institute for Space Research

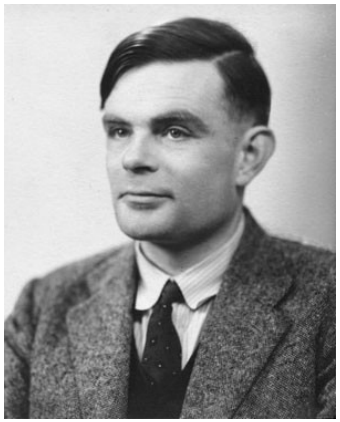
From research to decision-making

Research

problem-based

innovative

objective



Valley of Death

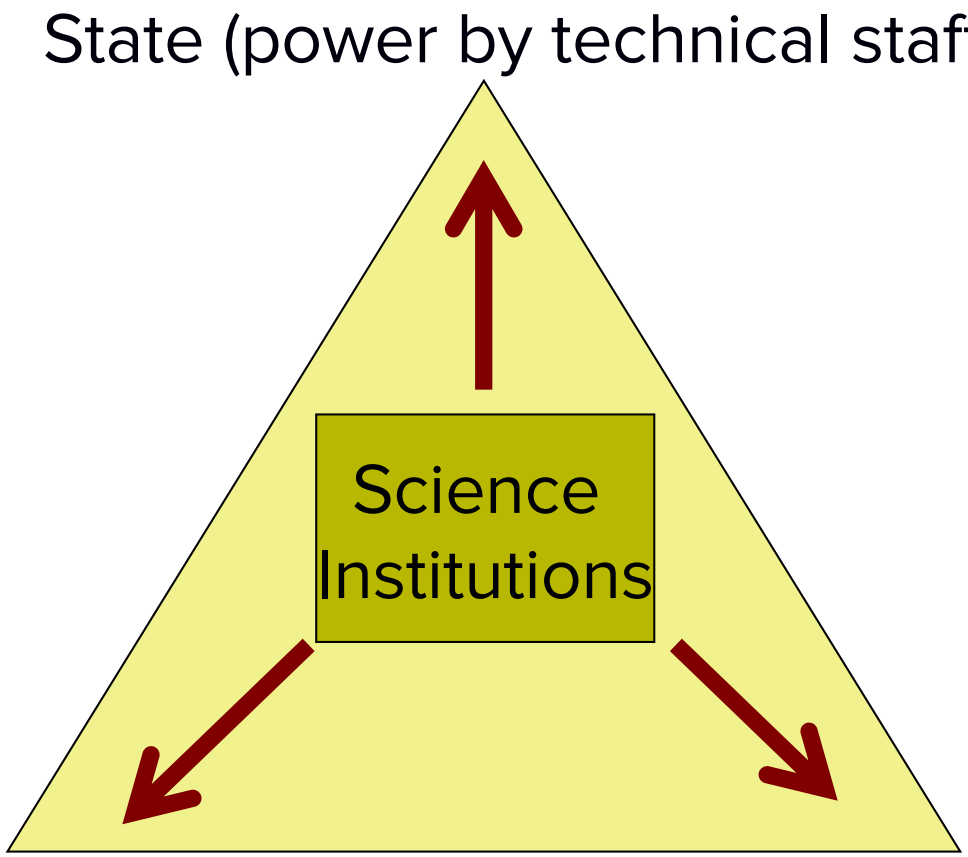
Decision-making

outcome-based

compromise

best guess

Foundations of modern democracies



source: Fukuyama (2011)

Brazil: a natural knowledge economy?

Brazil´s innovation system is in large part built upon its natural and environmental resources, endowments and assets.

The Roots of Brazil

”Being neither Europeans nor North Americans and lacking an original culture, nothing is foreign to us, because everything is.” (Paulo Emilio Salles Gomes)

Amazon deforestation is big news

"Our house is burning"

"Amazon must be protected."

How do they know?

Trust matters!

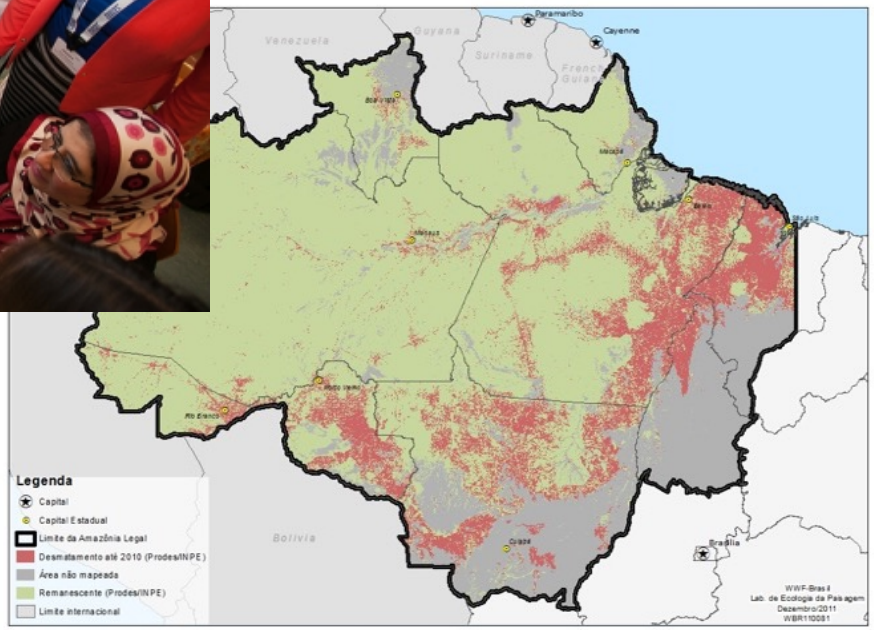
Building institutions for sustainability

Trust is the key!

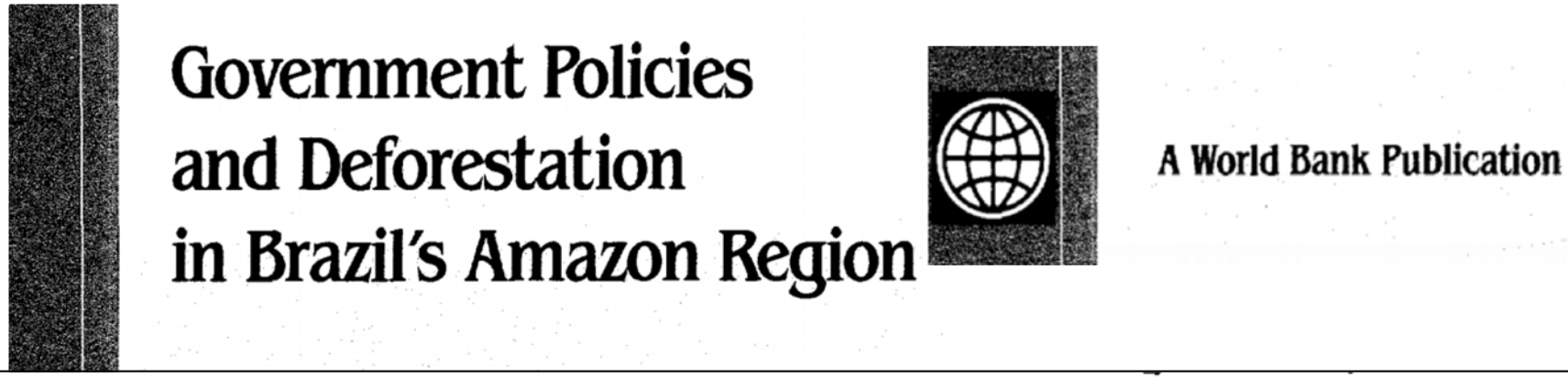
Data

socially robust results

co-design & co-production



Can the World Bank be wrong?



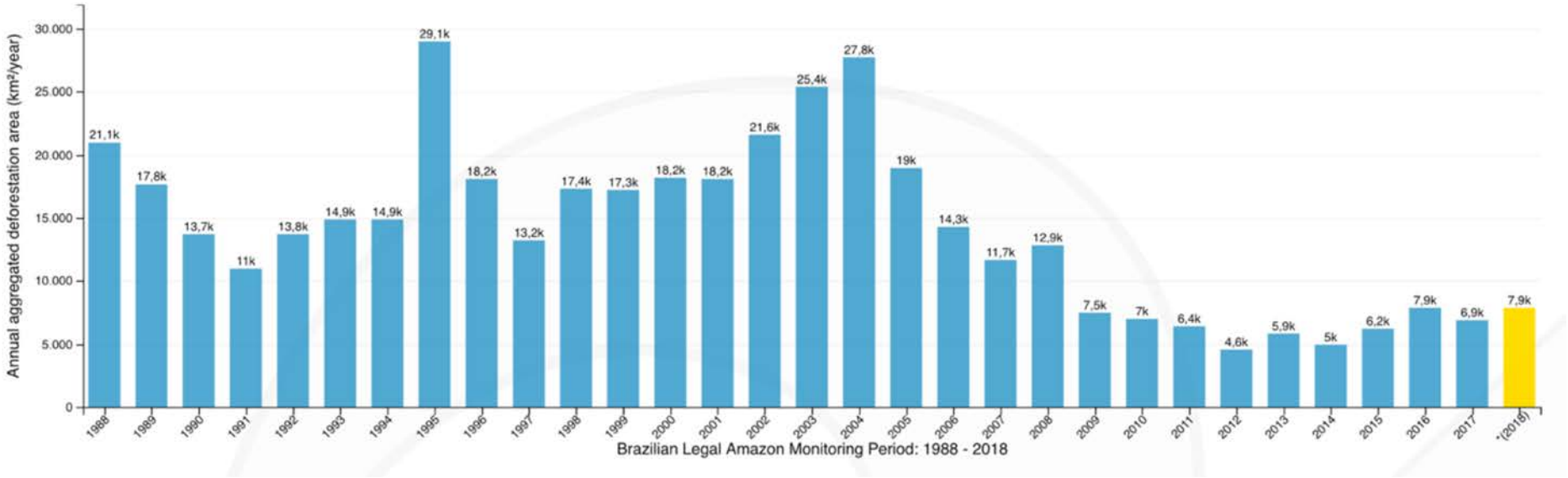
Government Policies
and Deforestation
in Brazil's Amazon Region

A World Bank Publication

Landsat images indicate that deforestation has accelerated sharply since the mid-1970s. As shown in table 1, the deforested area increased to 125,000 square kilometers by 1980 and to almost 600,000 square kilometers by 1988. The 1988 figure is equivalent to 12 percent of Amazonia and is larger than France. As in the

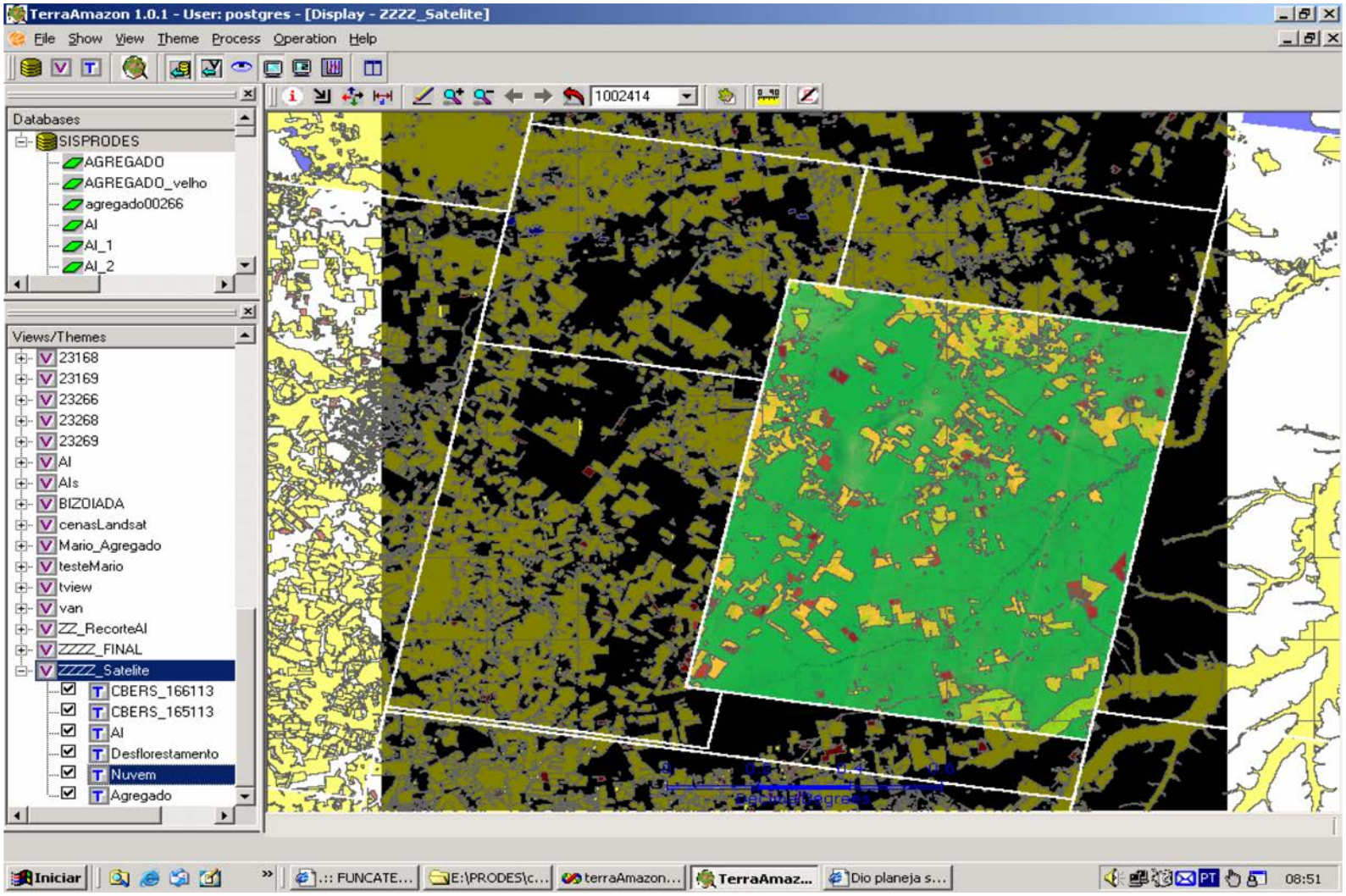
World Bank 1990: Amazonia is losing 60,000 km2 of forest per year!

Deforestation in Brazilian Amazon

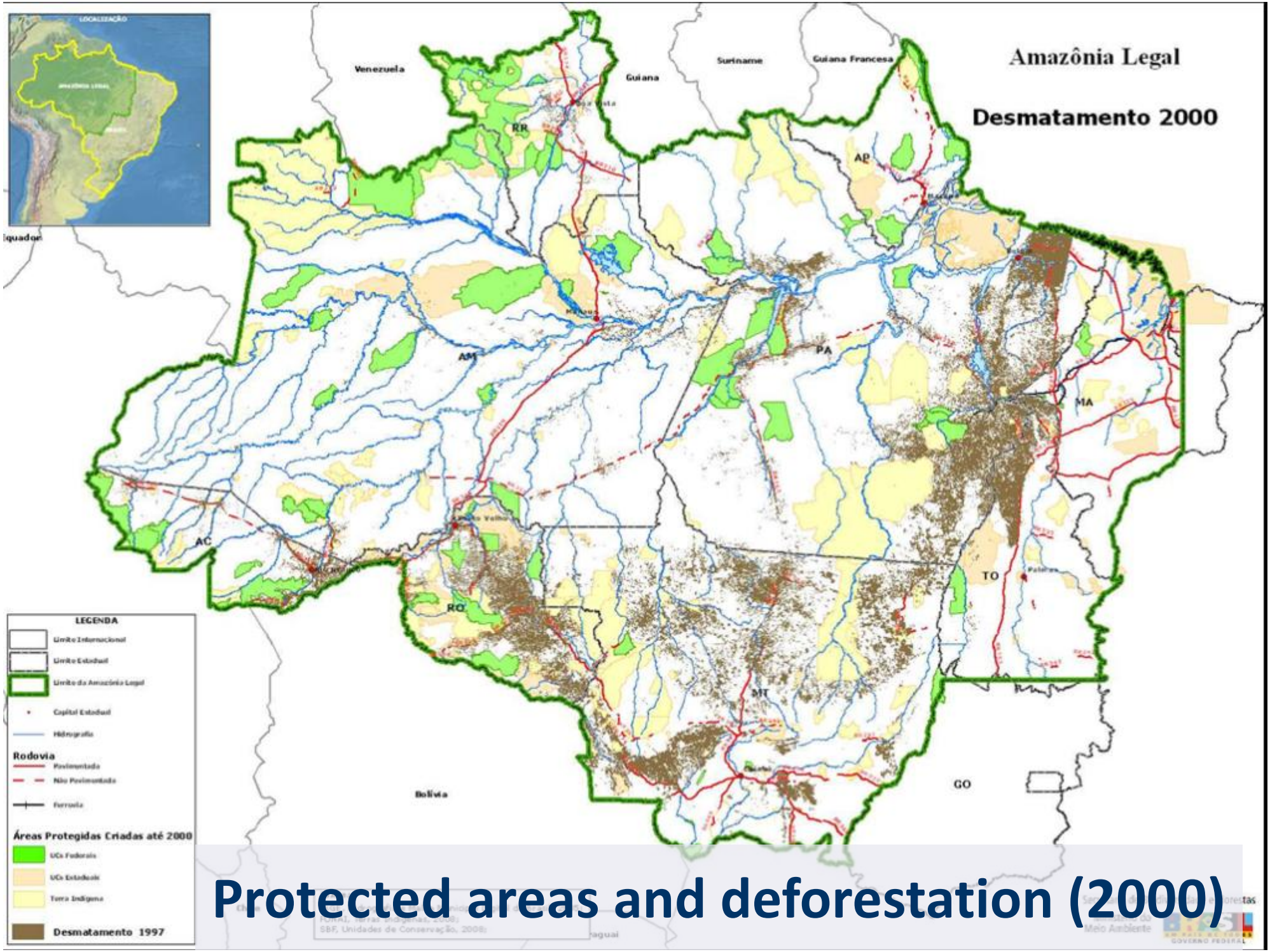


Authoritative data: REDD+ funds (US$ 1,3 billion), decision-makers (Brazil's NDC), researchers (1,000+ papers)

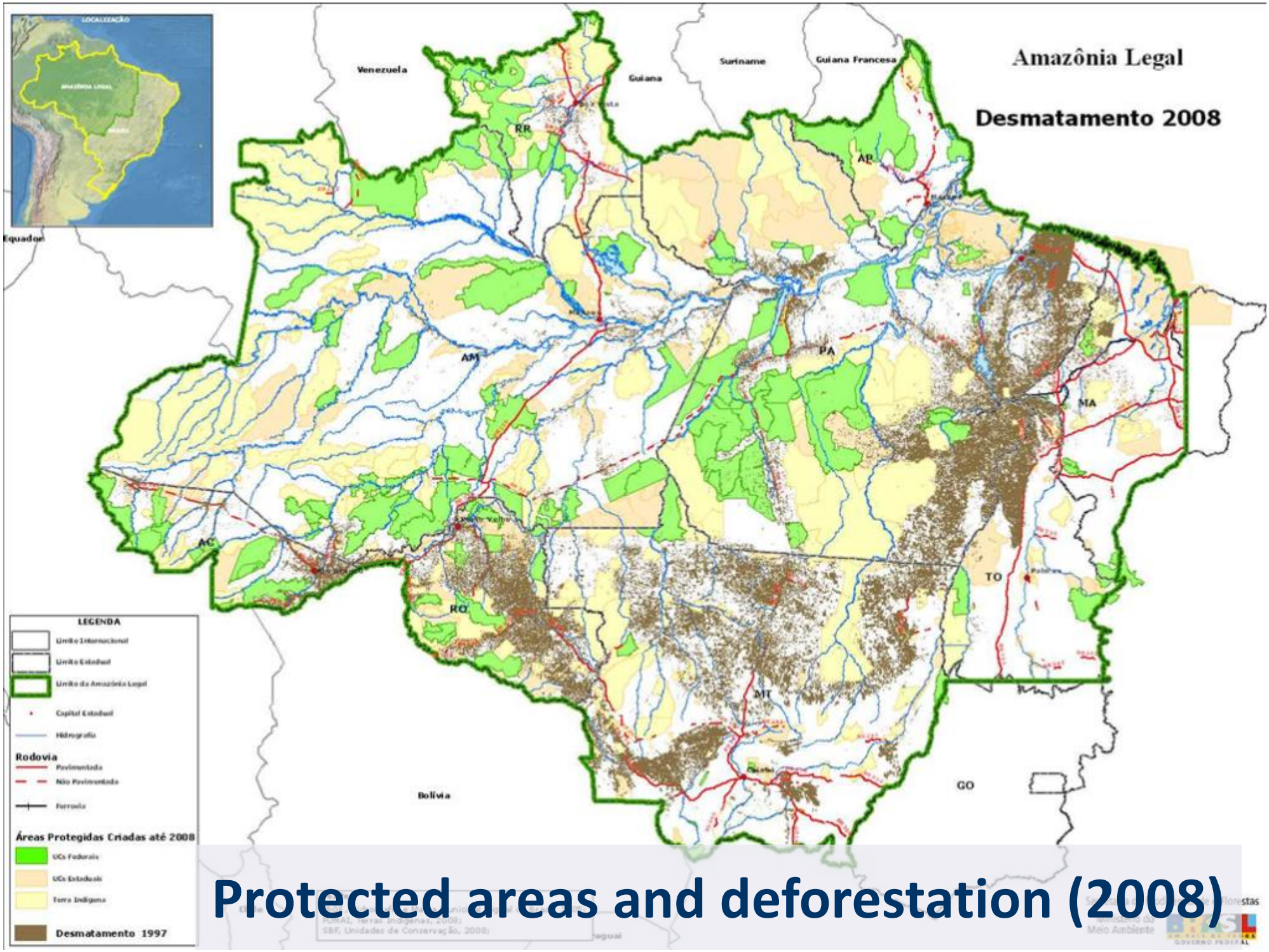
Transparency builds credibility and governance!



"Brazil's monitoring system is the envy of the world.."
(Science, 2007)

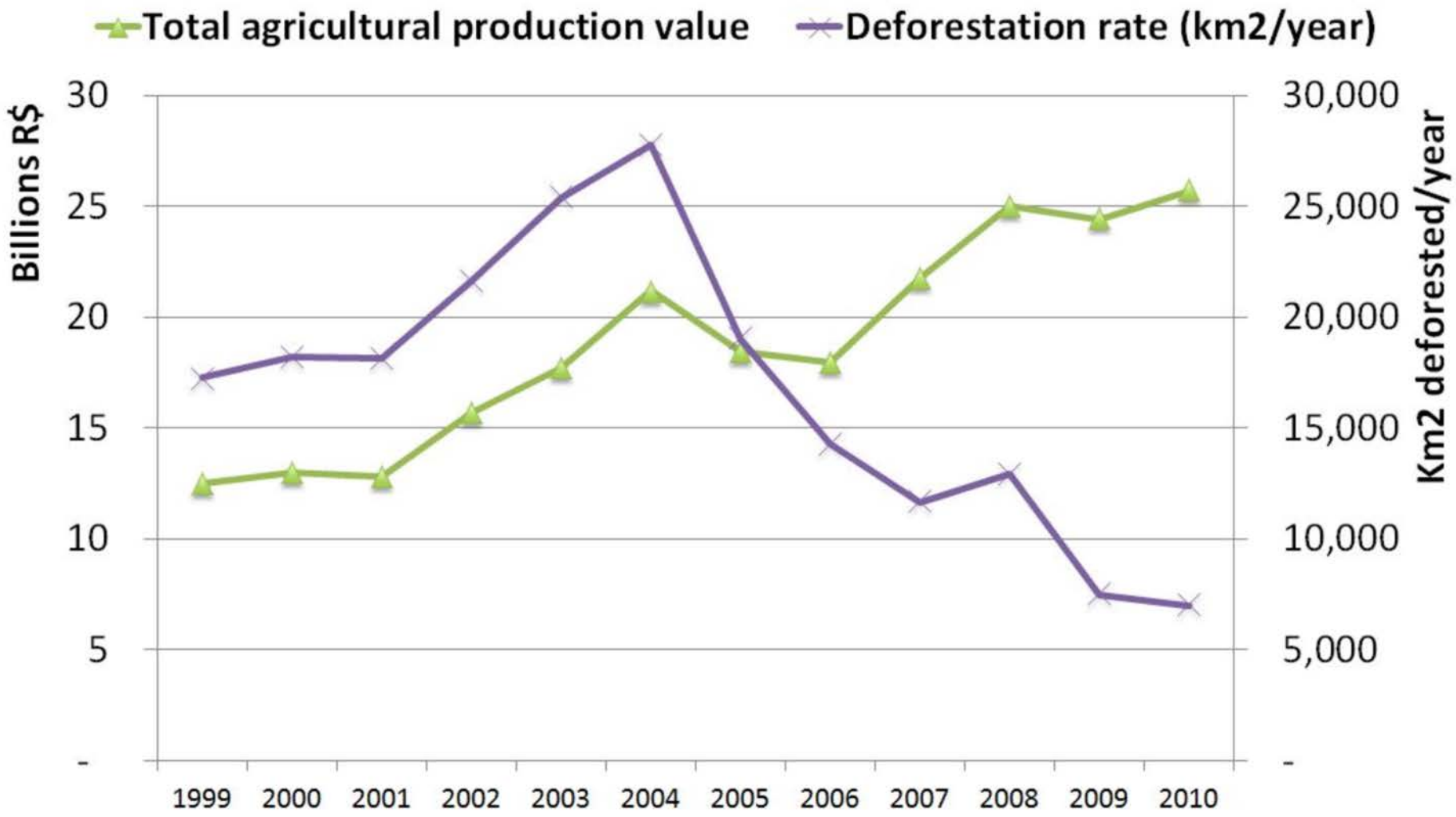


Protected areas and deforestation (2000)



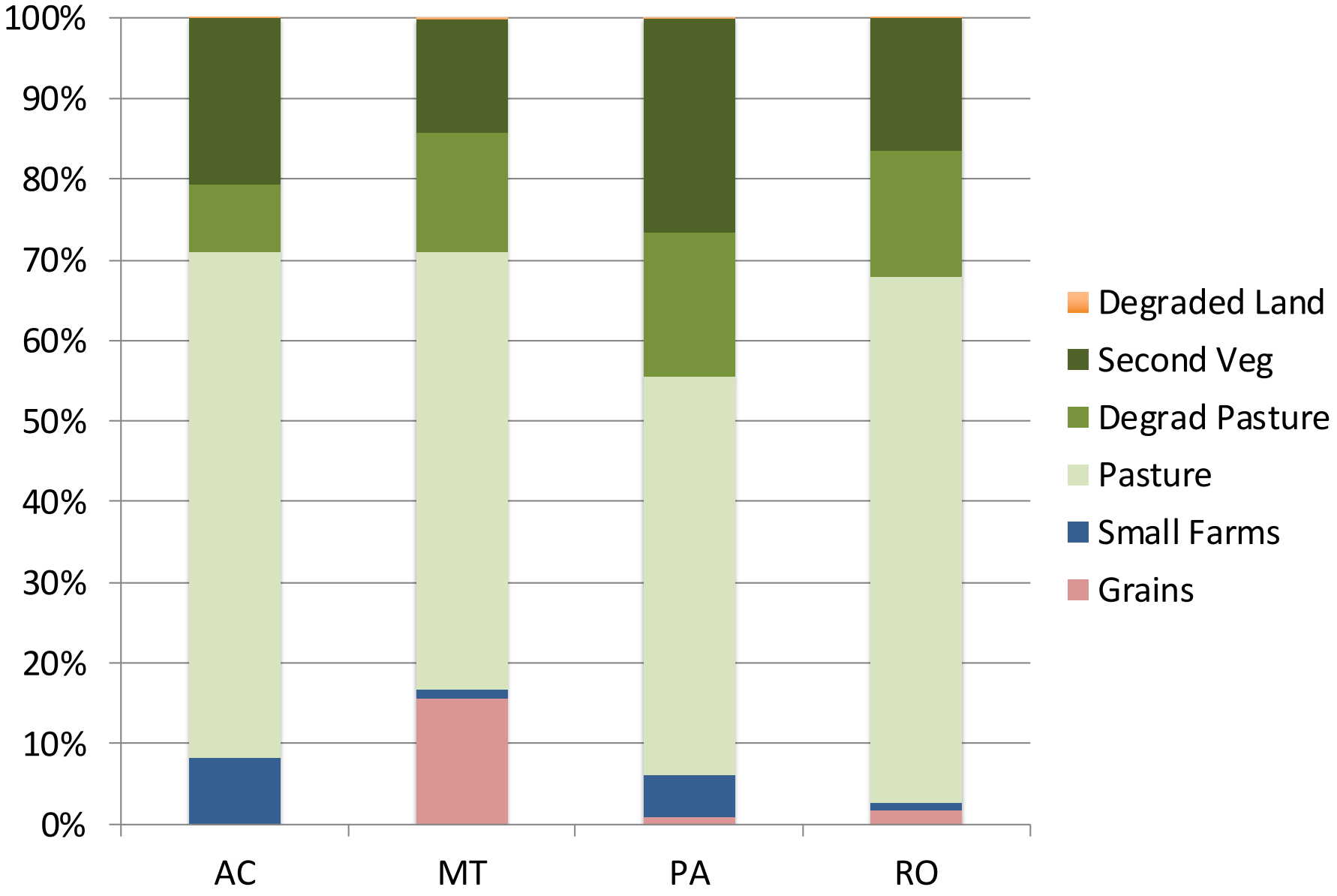
Protected areas and deforestation (2008)

Economic growth and reduction of deforestation in recent years

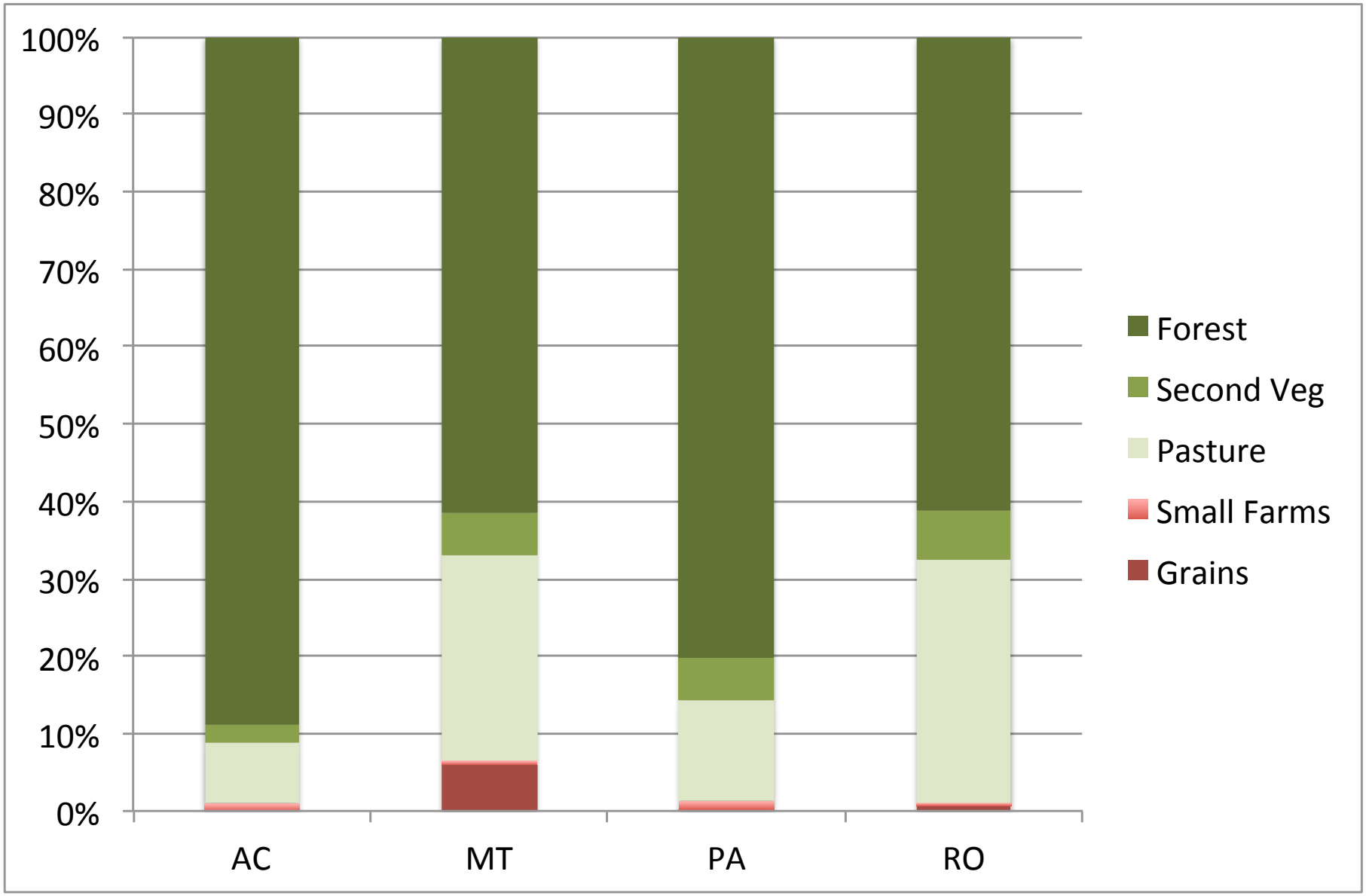


Source: Paulo Barreto (Imazon)

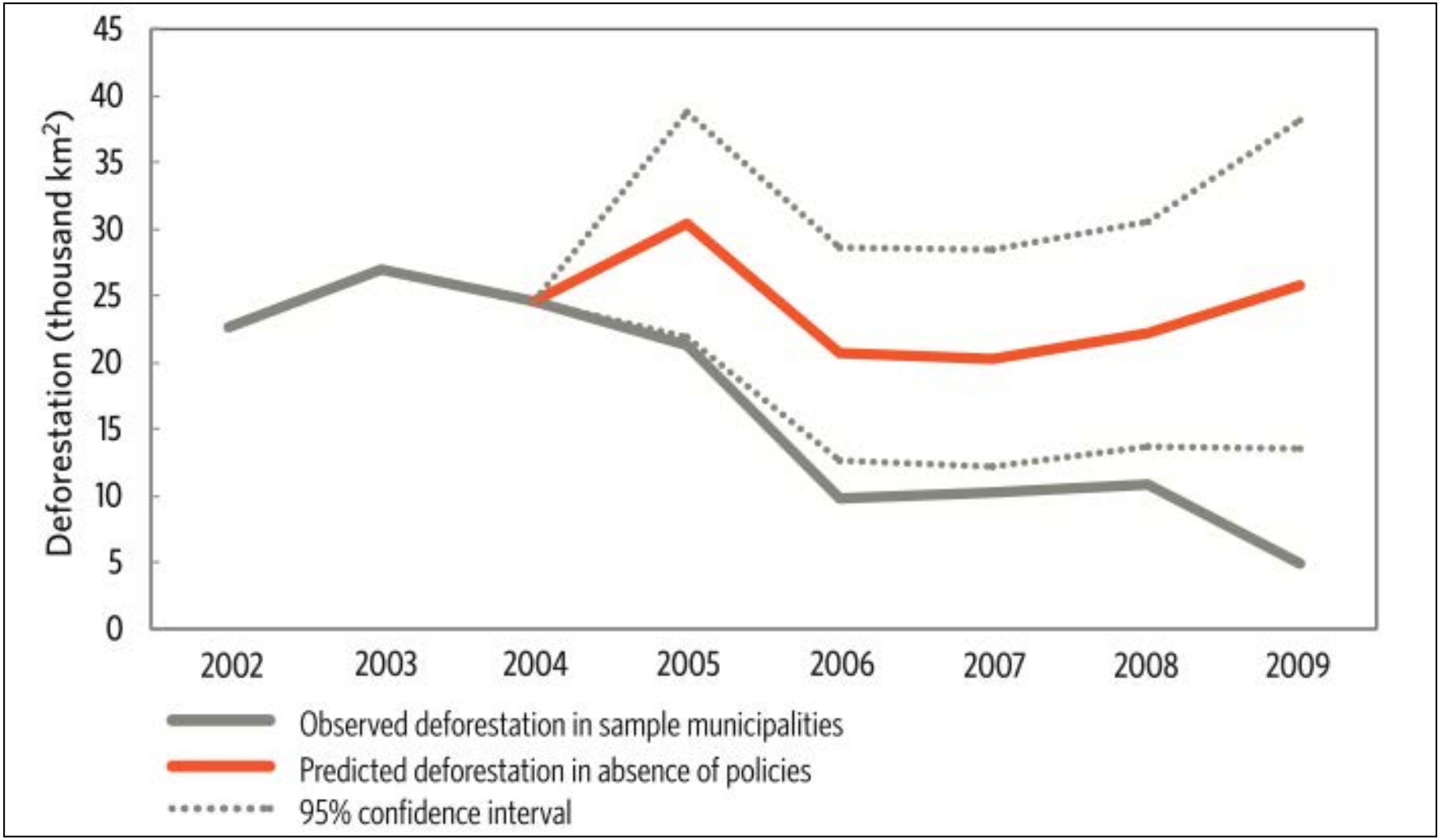
How are we using the forest?



The extent of illegal deforestation

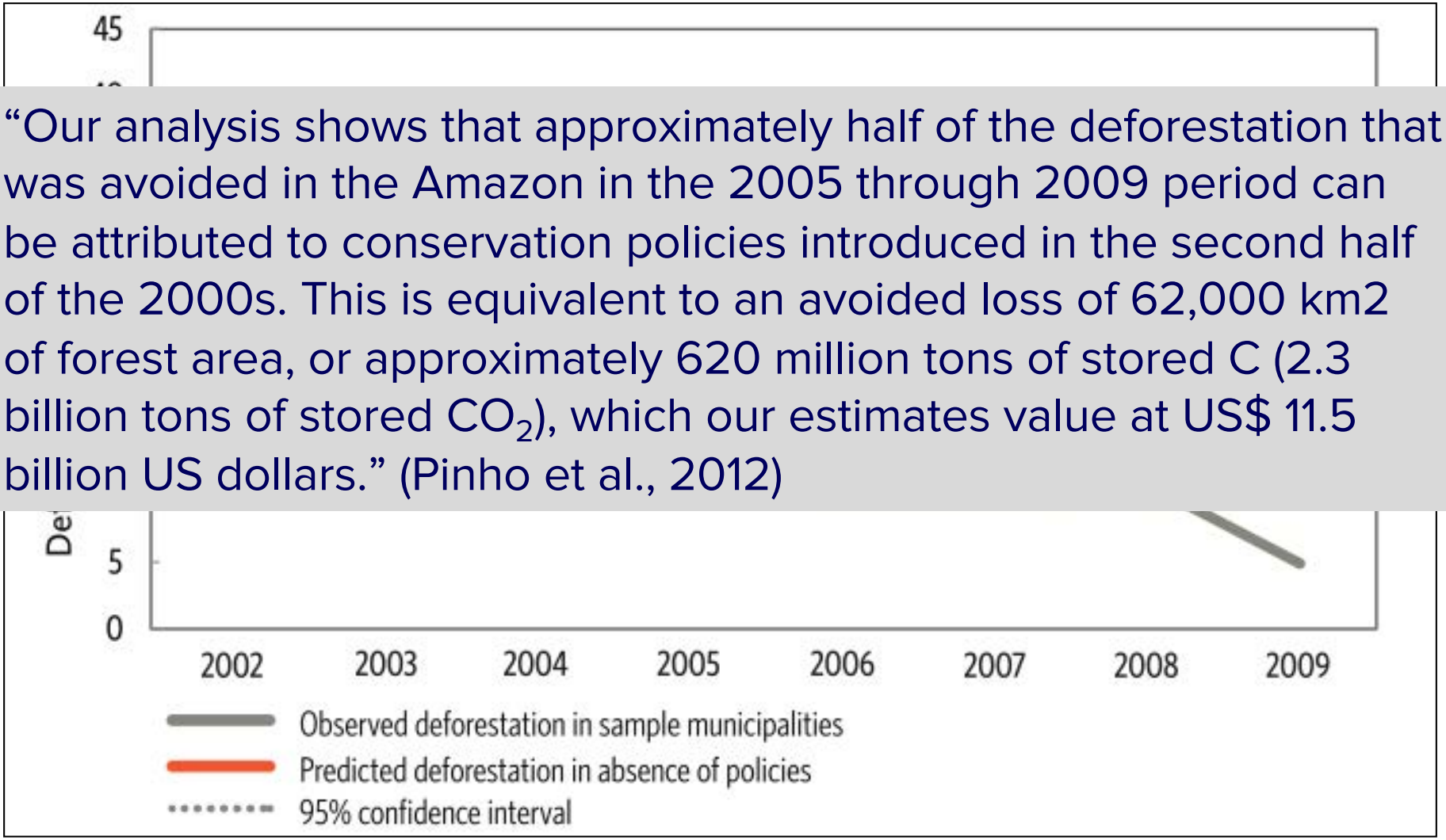


Prices or policies?



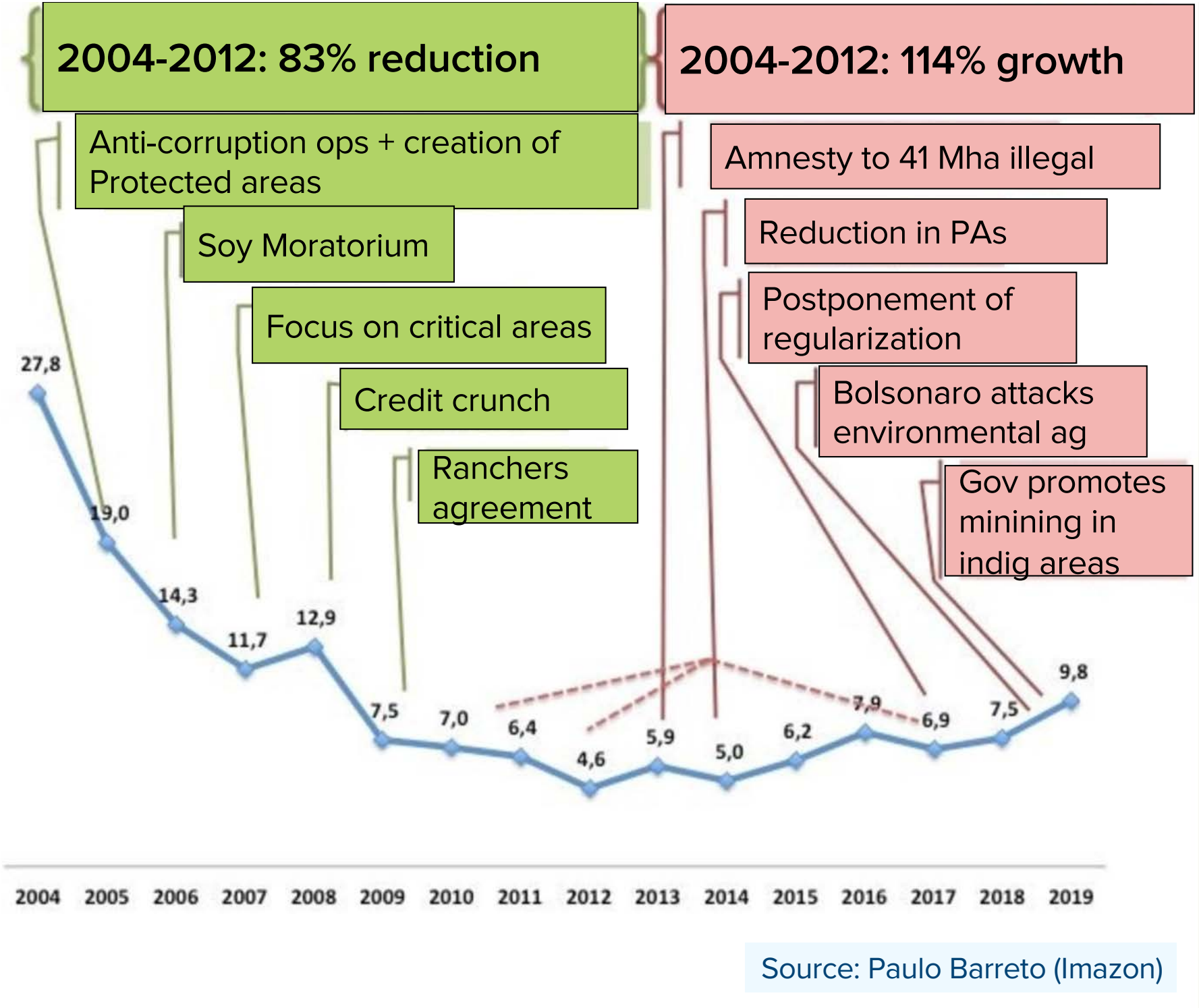
Deforestation Slowdown in the Legal Amazon: Prices or Policies?
http://www. climatepolicyinitiative.org

Prices or policies?



"Our analysis shows that approximately half of the deforestation that was avoided in the Amazon in the 2005 through 2009 period can be attributed to conservation policies introduced in the second half of the 2000s. This is equivalent to an avoided loss of 62,000 km2 of forest area, or approximately 620 million tons of stored C (2.3 billion tons of stored CO_2), which our estimates value at US$ 11.5 billion US dollars." (Pinho et al., 2012)

Deforestation Slowdown in the Legal Amazon: Prices or Policies?
http://www. climatepolicyinitiative.org



Source: Paulo Barreto (Imazon)

The New York Times

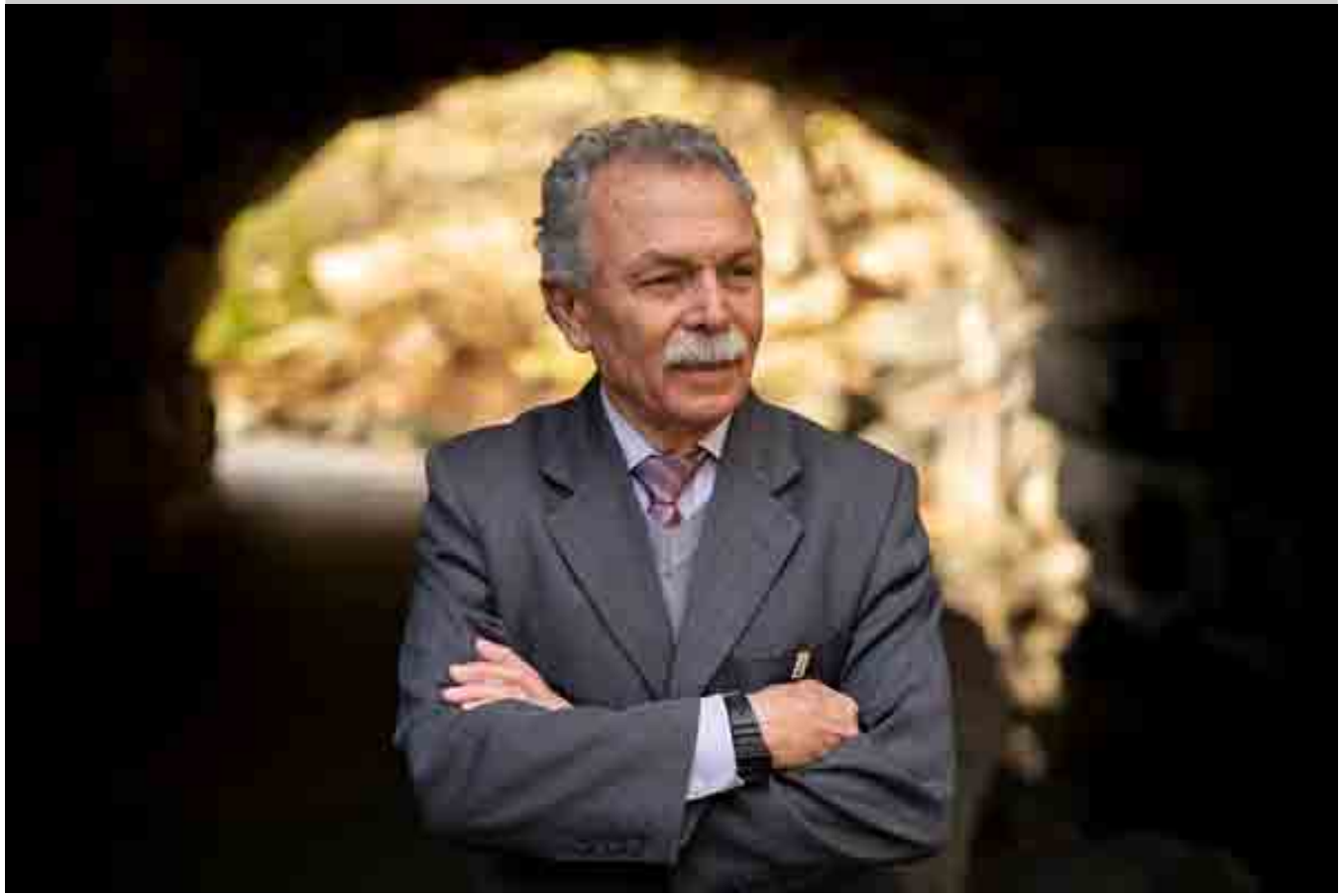
Bolsonaro Fires Head of Agency Tracking Amazon Deforestation in Brazil

Nature's 10

Ten people who mattered in science in 2019.

RICARDO GALVÃO: Science defender

As chaos spiked in the Amazon, the physicist became a national hero by challenging Brazil's government.



Does one size fit all?

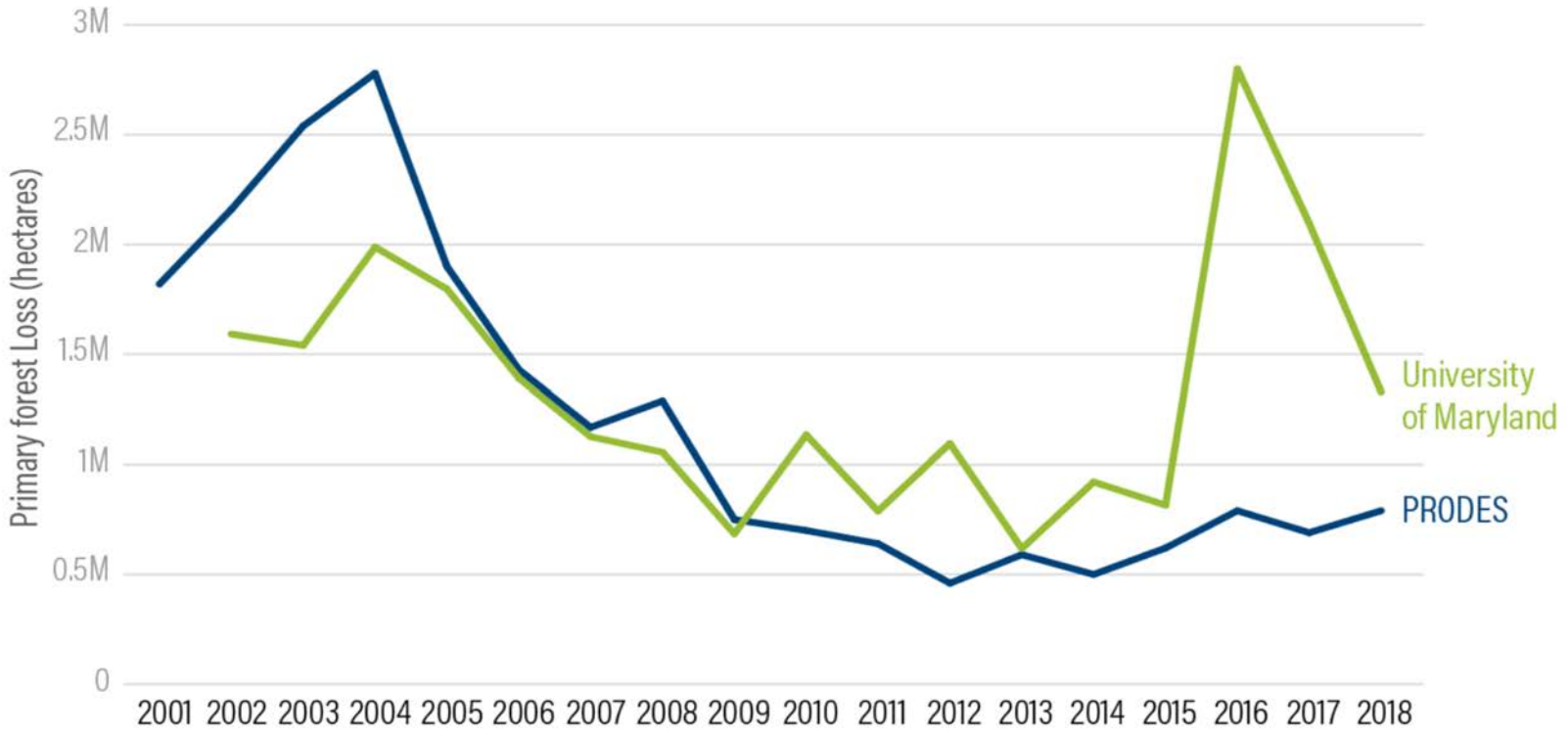
Automated algorithm for tree identification

Should we always report the worst case?

‘Death by a thousand cuts’: vast expanse of rainforest lost in 2018

Search ˅ The Guardian International edition ˅

PRODES vs UMD Primary Forest Loss



GLOBAL FOREST WATCH

WORLD RESOURCES INSTITUTE

PRODES focuses on large clear-cutting of primary forest in the Amazon, while the UMD data captures loss in all tree cover, including loss in secondary forest, forest degradation from fires, and loss as small as 0.1 hectares.

Research questions

- Is there a “tipping point” in Amazonia?
- What are the possible response of Amazonia to climate change?
- What is the extent and trajectories of degradation from fire and logging?
- How resilient is Amazonia to human disturbance?
- What is the best estimate of GHG emissions in Amazonia?
- What are the past trajectories of land use change, degradation, and secondary vegetation?
- What are the future trends of land use change, degradation, and secondary vegetation?
- How to go beyond IPCC reporting on LUCC?
- What are the strenghts and limitations of command-and-control and market-based arrangements?
- How best can Brazil achieve its NDCs?
- How can big EO data analytics support research in Amazonia?

What is the evidence for a “tipping point”?

Science Advances

Amazon Tipping Point

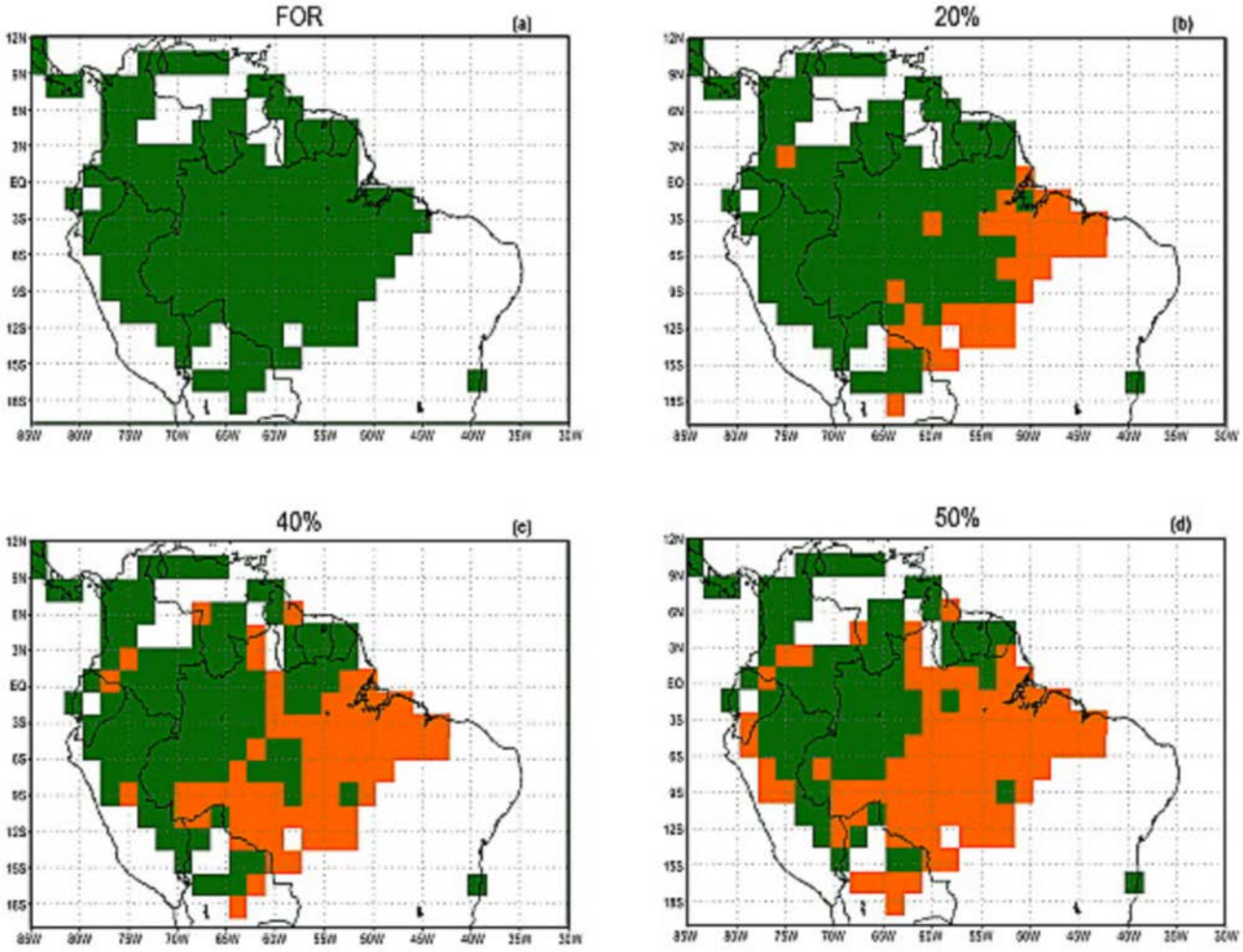
Thomas E. Lovejoy and Carlos Nobre

Geophysical Research Letters

Climate | Free Access

Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion

What is the evidence for a “tipping point”?



Four scenarios of deforestation (are they realistic?)
Use of athmospheric model only

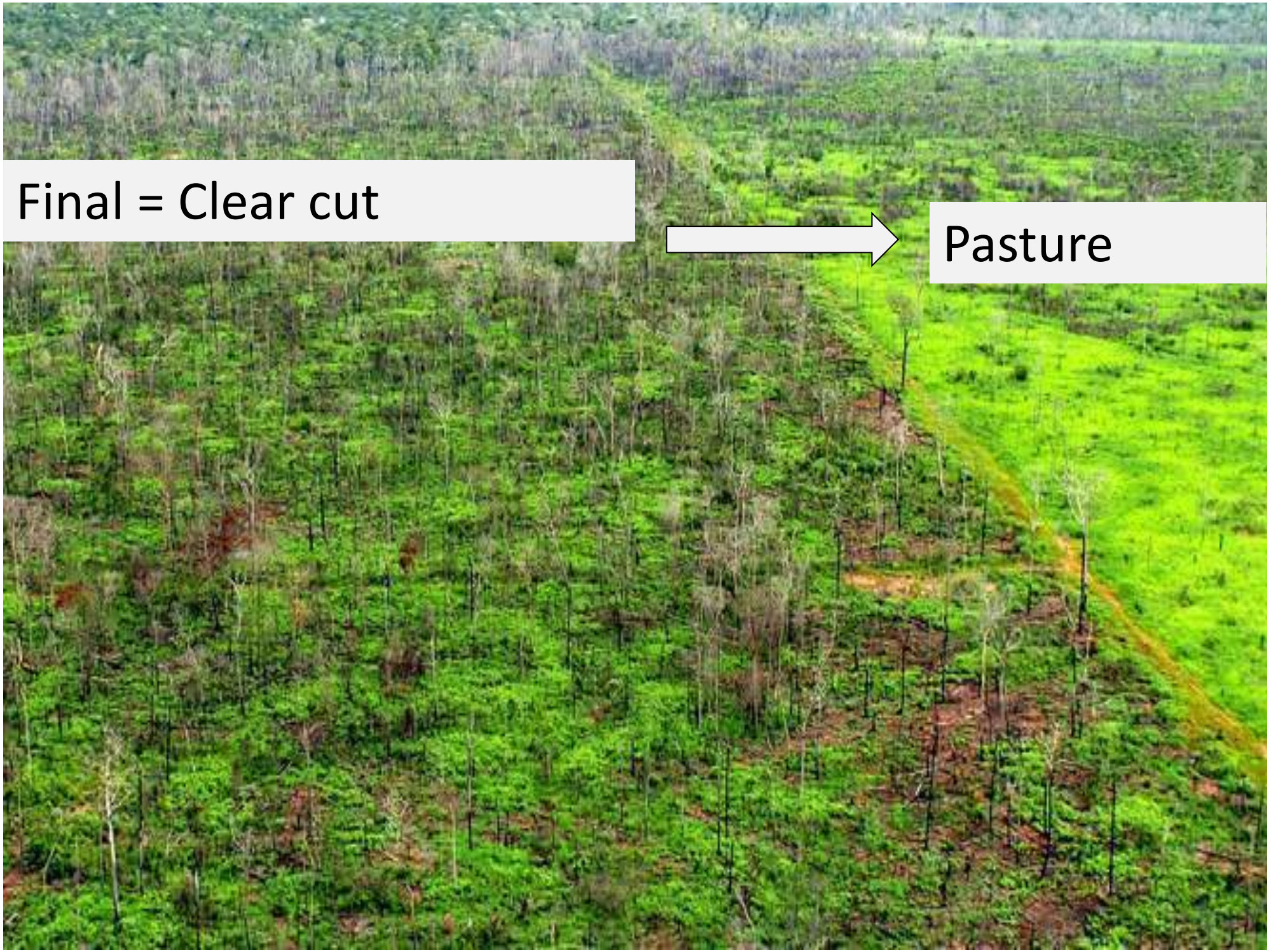
How does deforestation happen?

T1 – Selective logging

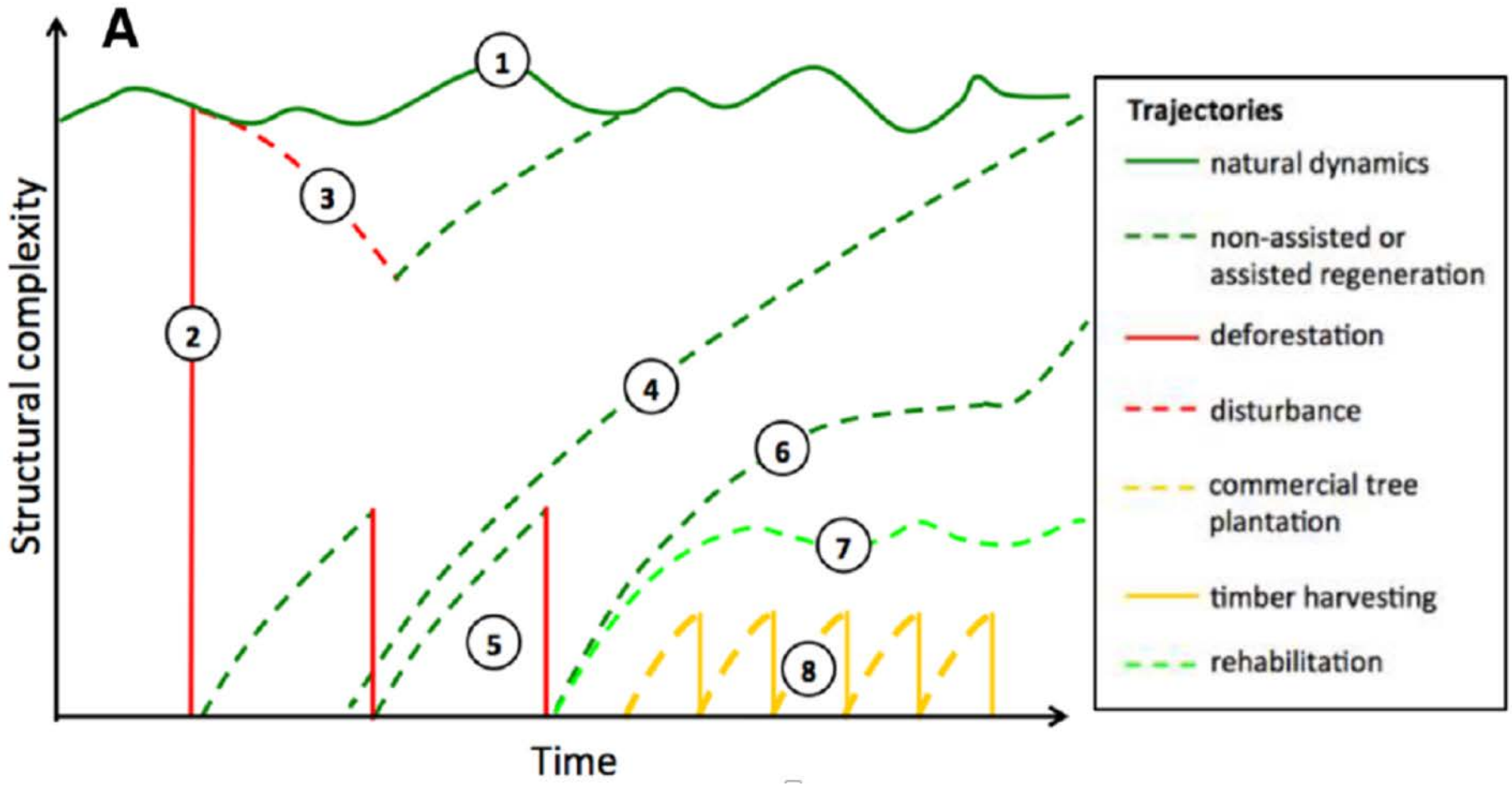
T2 – Loss of smaller trees

T3 – Loss >50% of forest

T4 – Loss >90% of forest


Final = Clear cut
Pasture

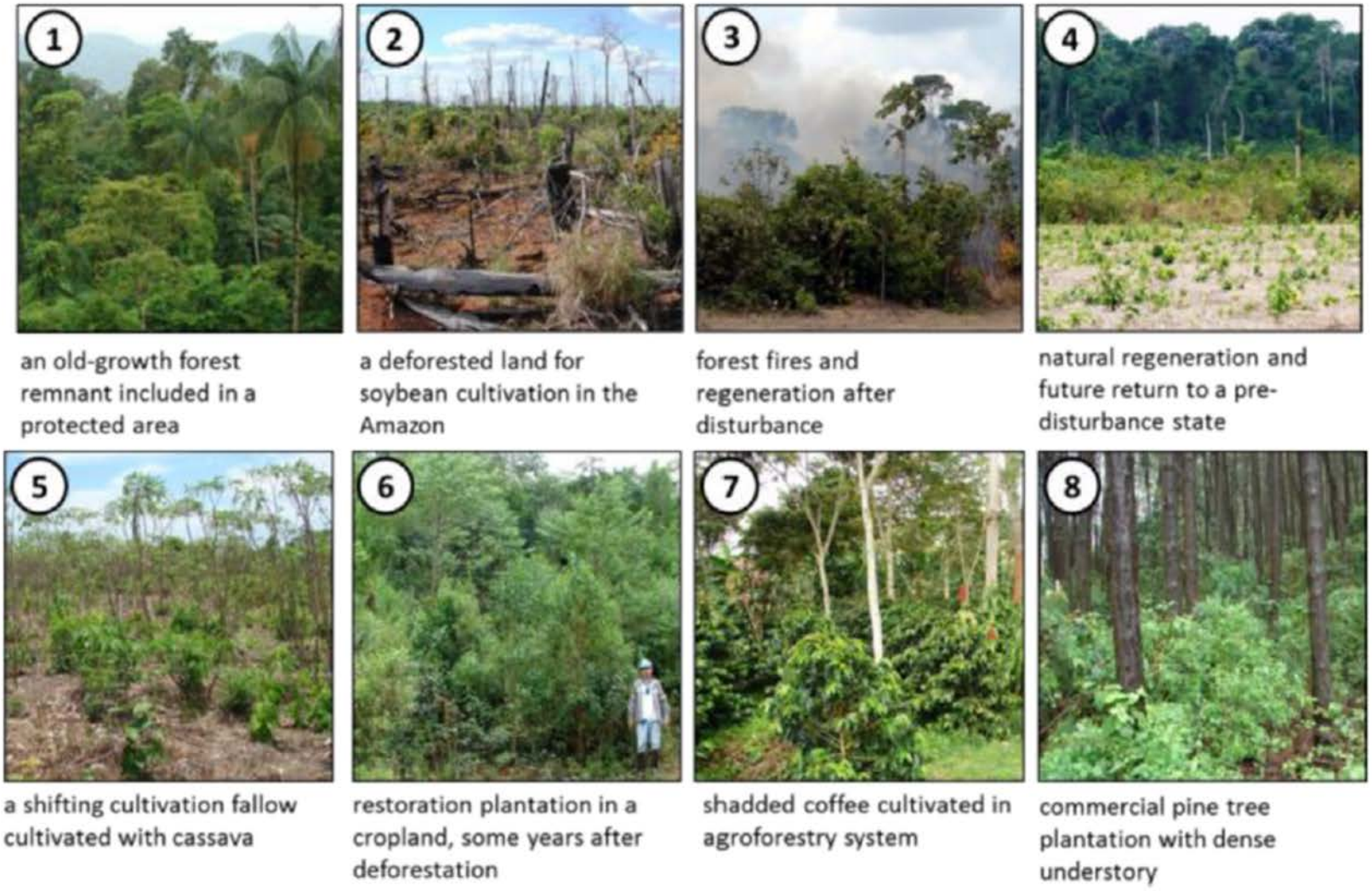
Understanding forest trajectories



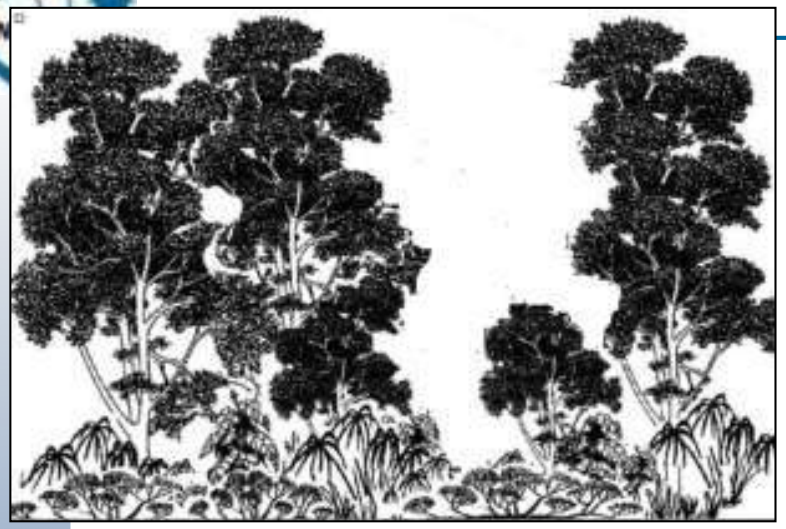
Chadzon et al (2016)

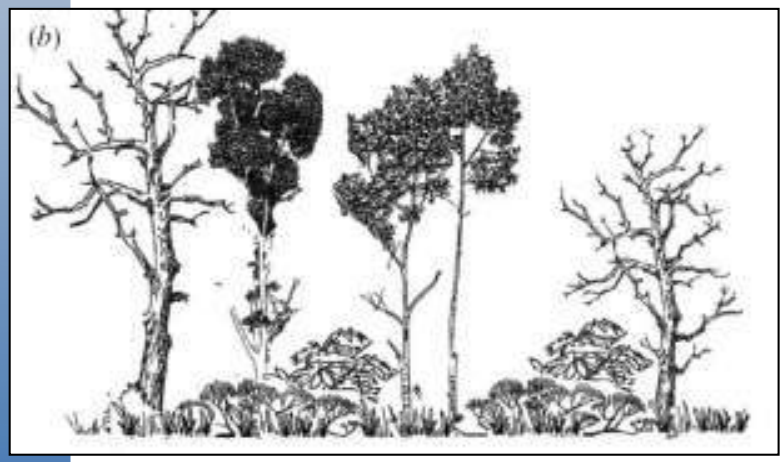
Distinguishing forests by temporal evolution

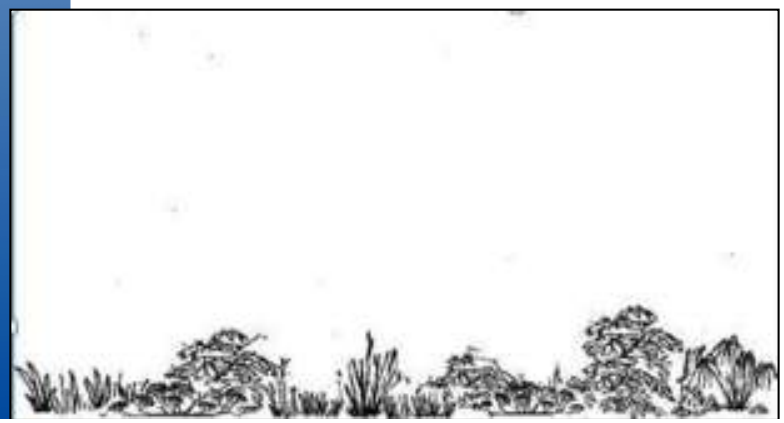
C



Chadzon et al (2016)





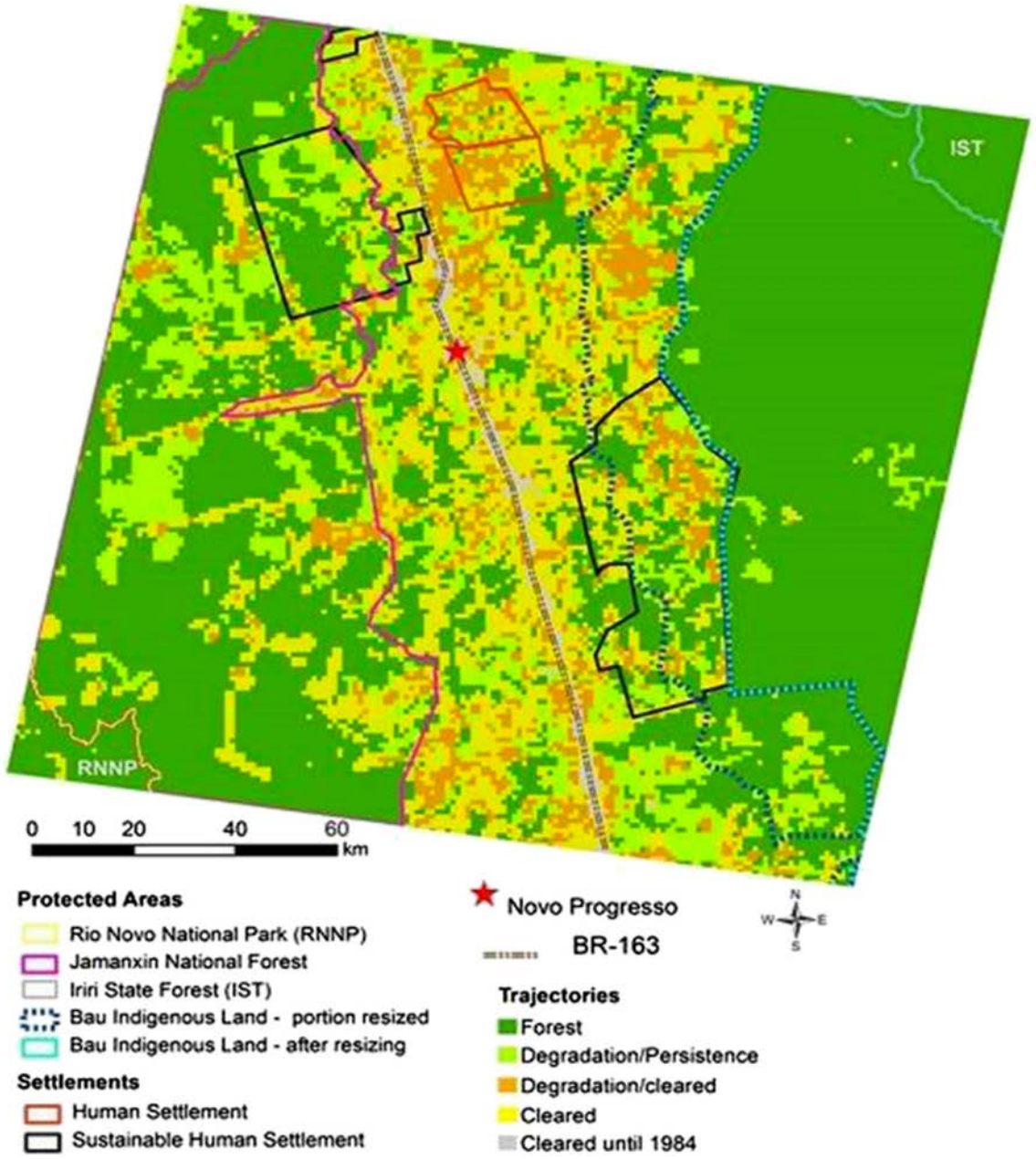


time

INPE's Monitoring Systems

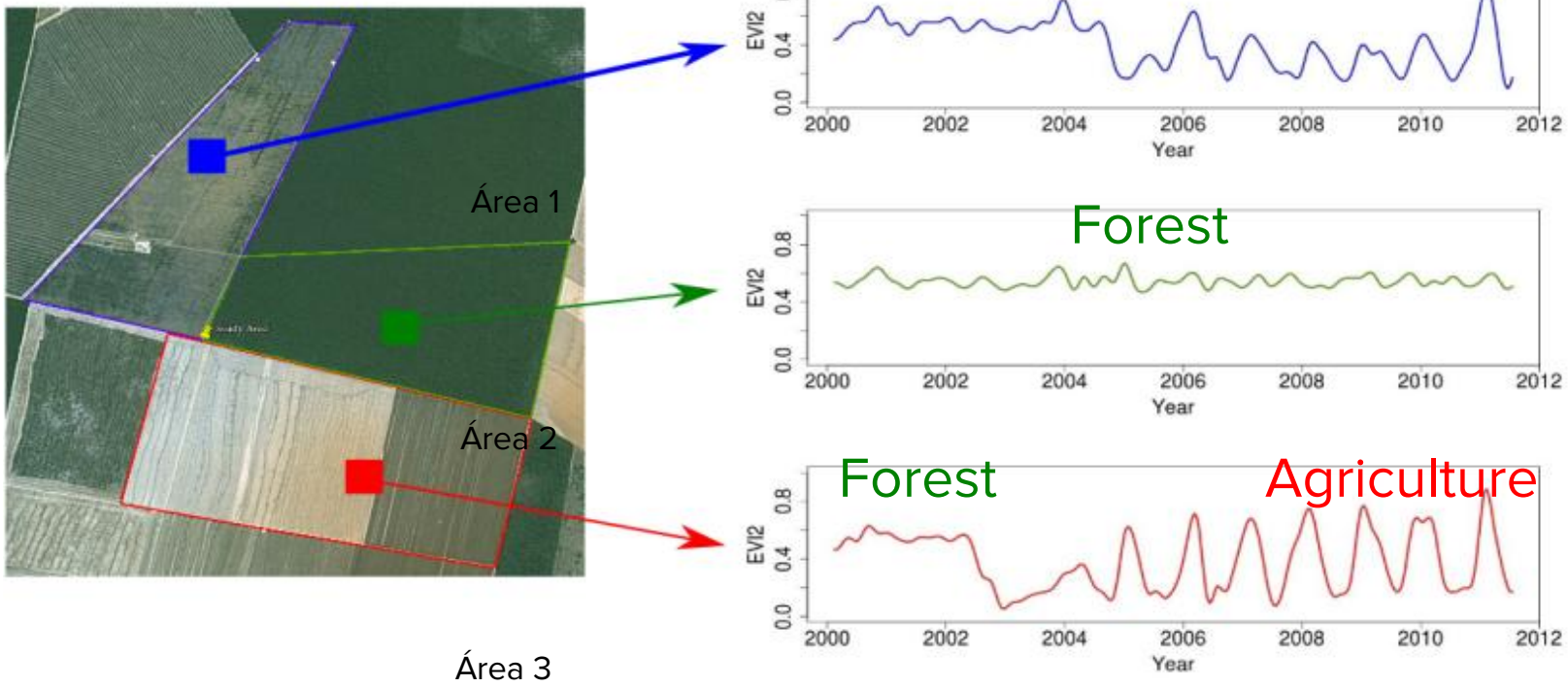
dialy deforestation alerts

Yearly rates of clear cuts



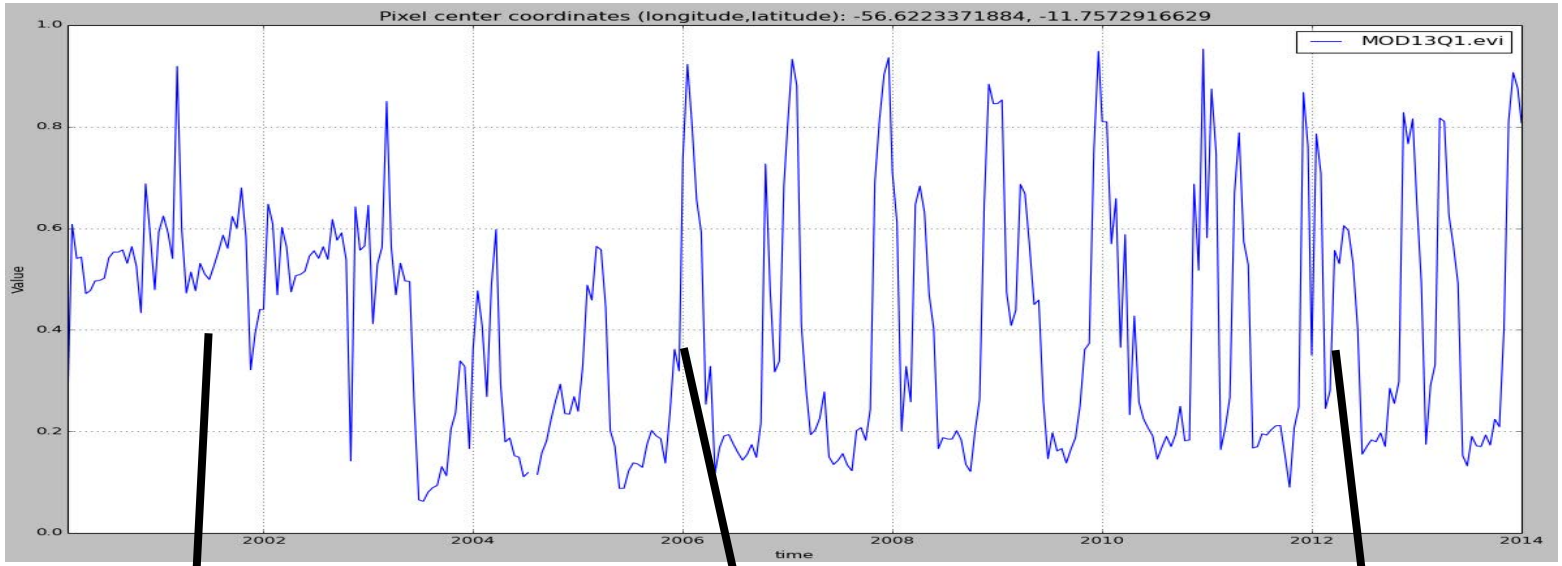
Assessing forest degradation requires looking at land change trajectories (source: Pinheiro et al., 2017)

Land use change trajectories



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

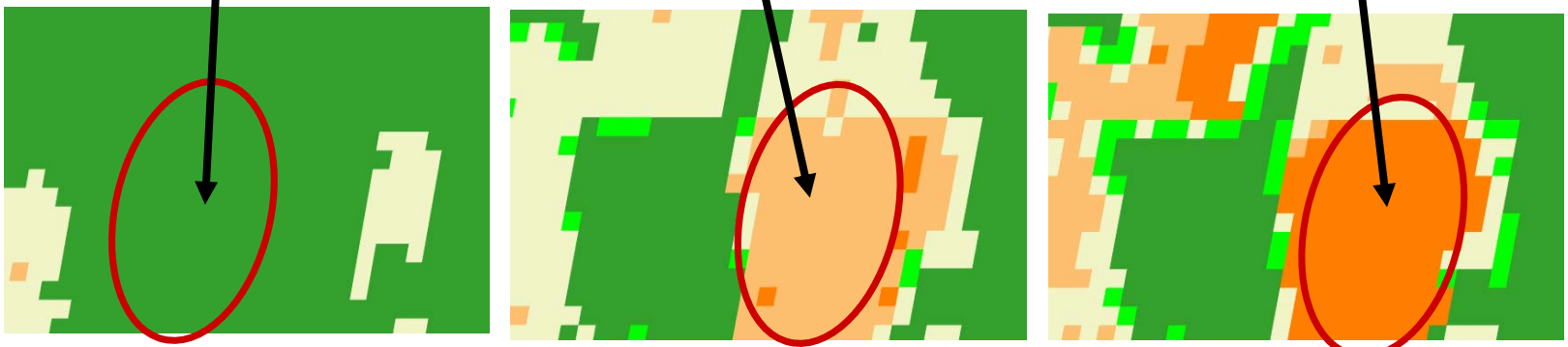
Land trajectories



Forest

Single cropping

Double cropping

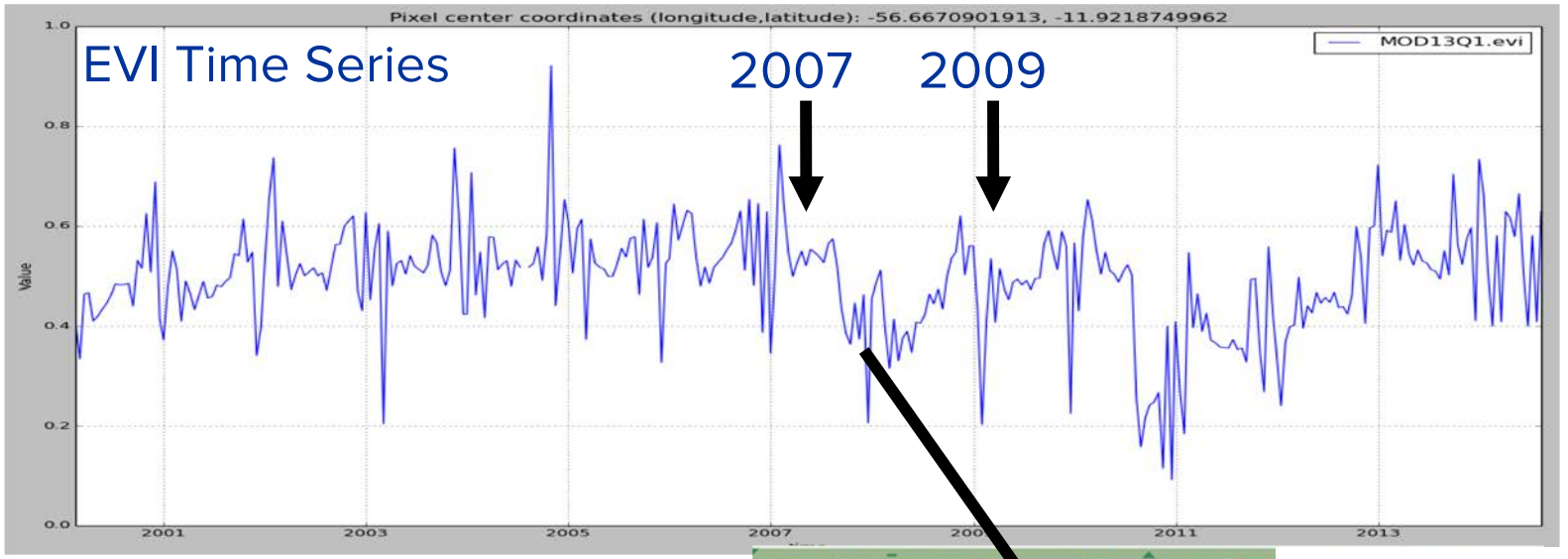


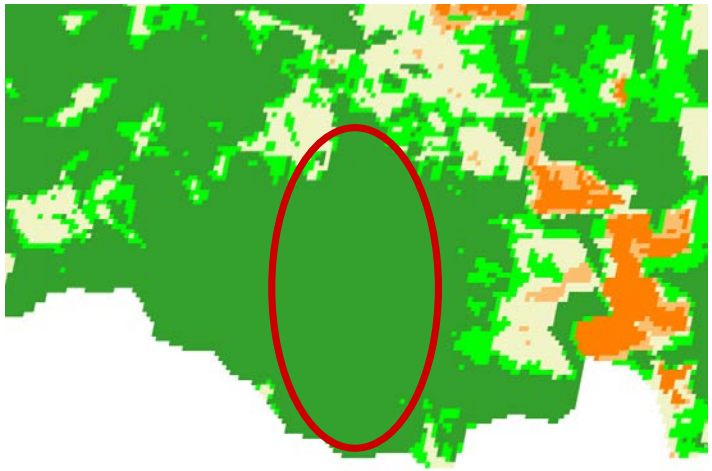
2001

2006

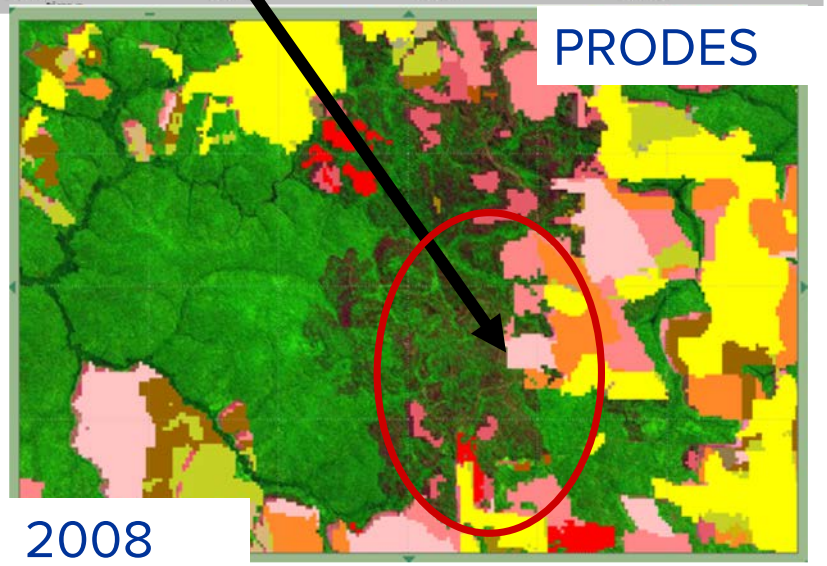
2013

Land trajectories: forest degradation





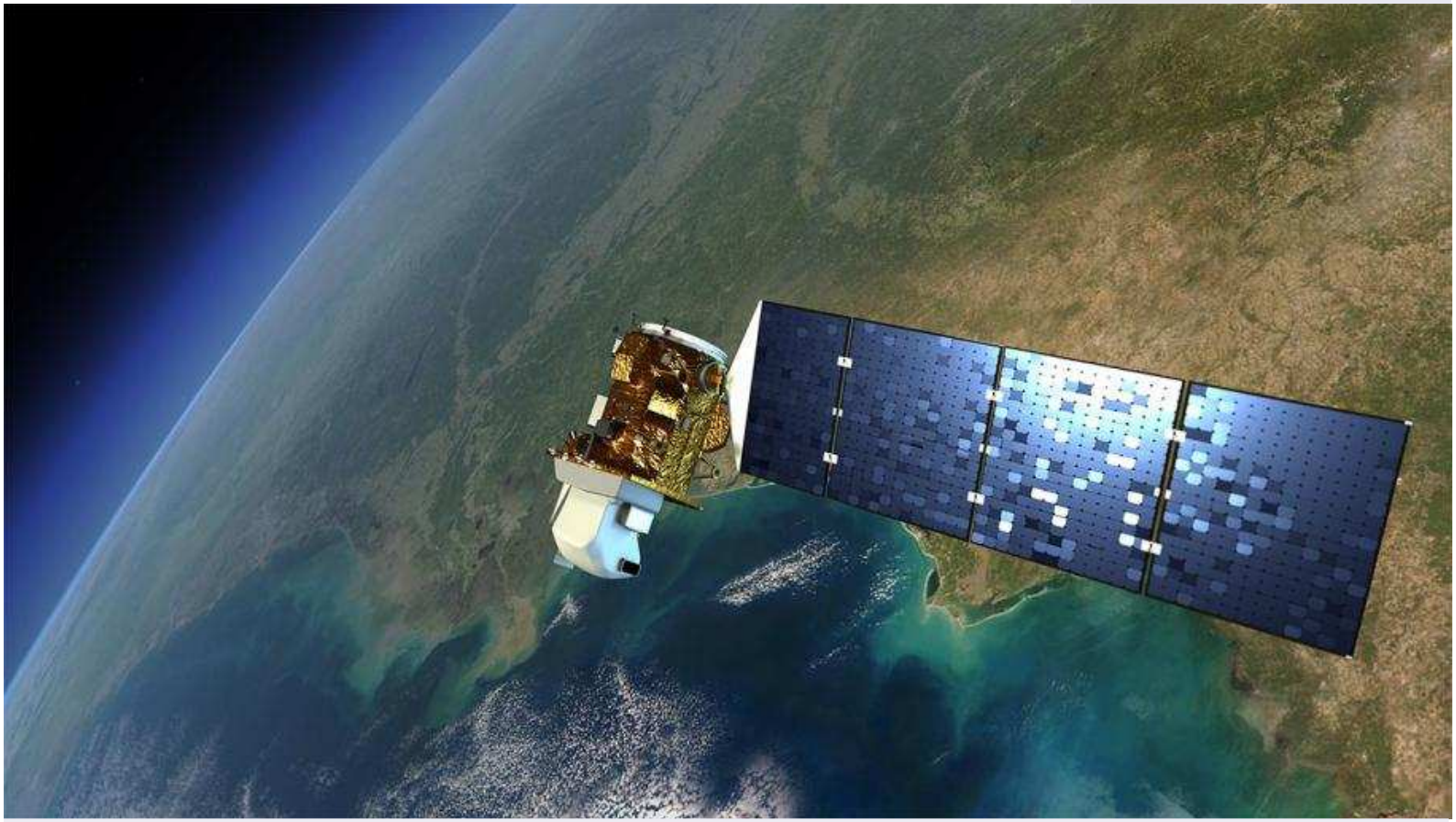
2007



2008

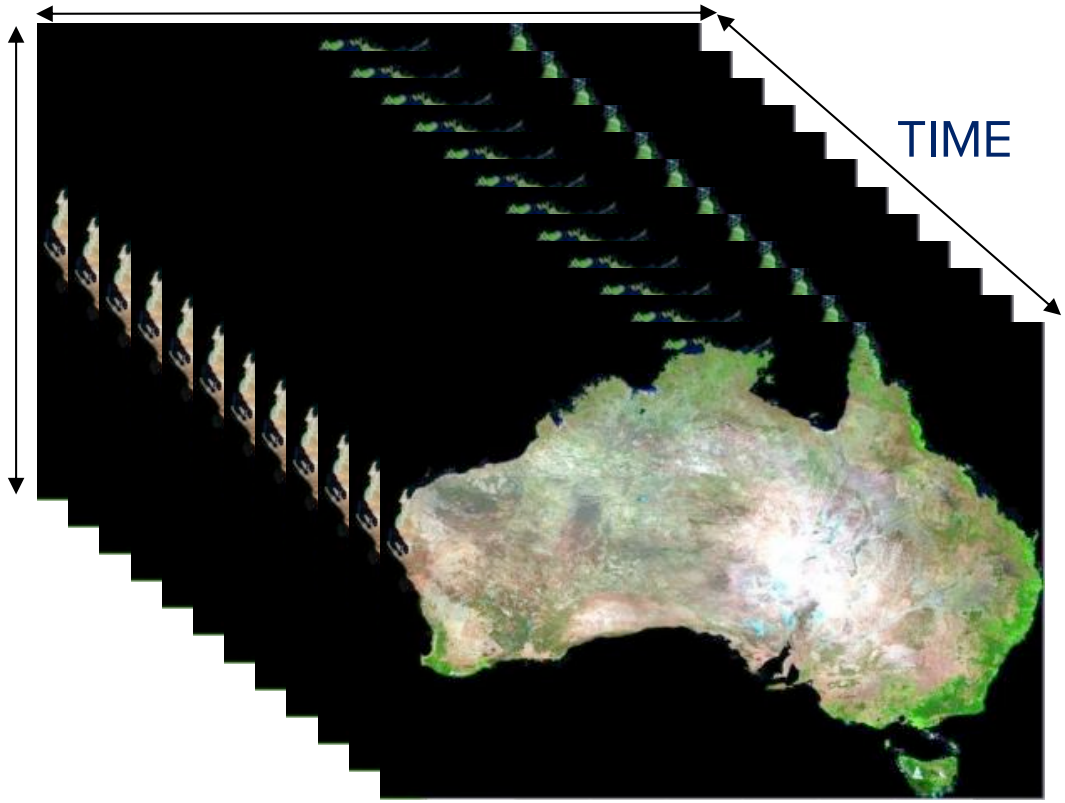
Earth Observation data is now free...and big

graphics: NASA



Sentinels + CBERS + LANDSAT + ...: > 10Tb/day

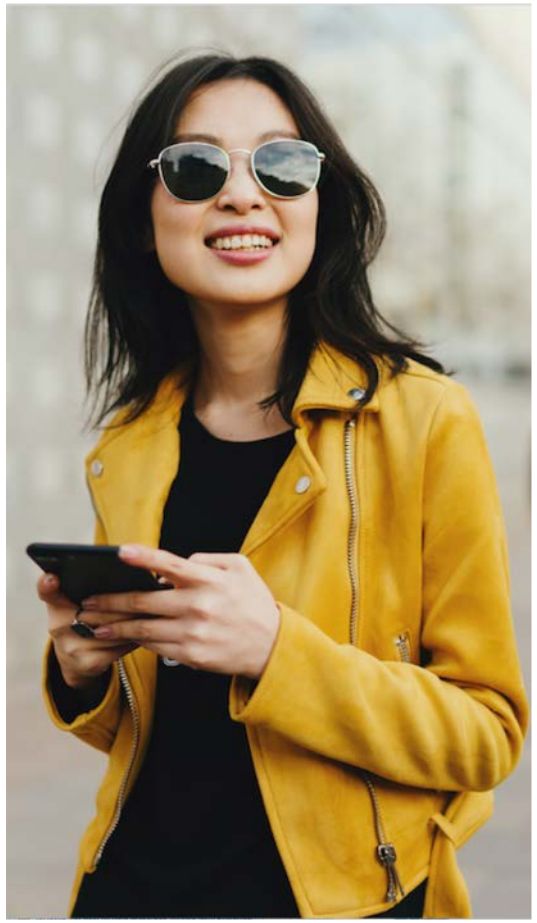
A datacube of remote sensing imagery



Data Cube = Time-series multi-dimensional (space, time, data type) stack of spatially aligned pixels

The new digital economy

Low access cost



big data

public APIs

massive use

images: shutterstock

The zero download model

Space agencies

open data

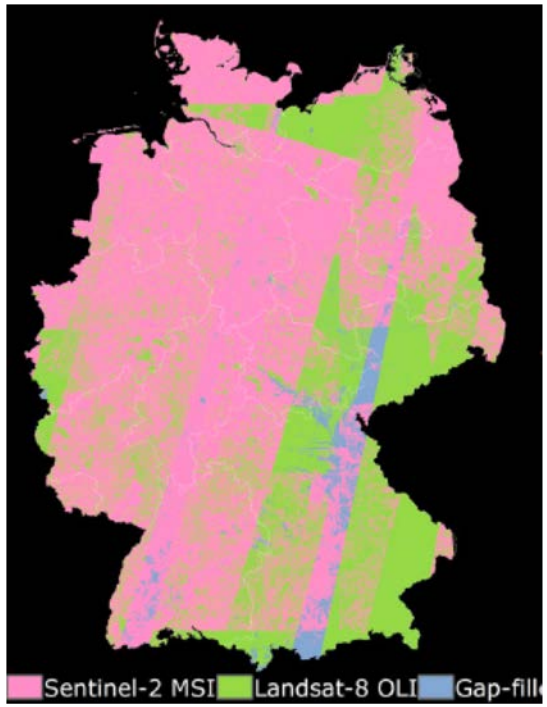
Software

Results

Empowered users

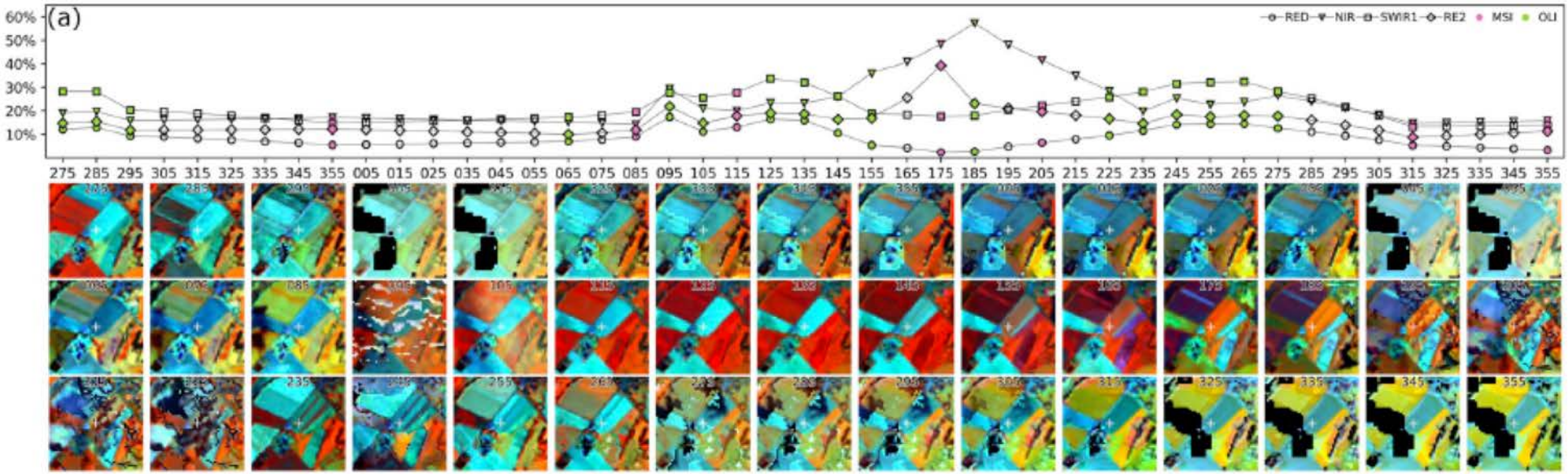
Cloud platforms

Combining Sentinel-2 and Landsat-8 for 10-day periods



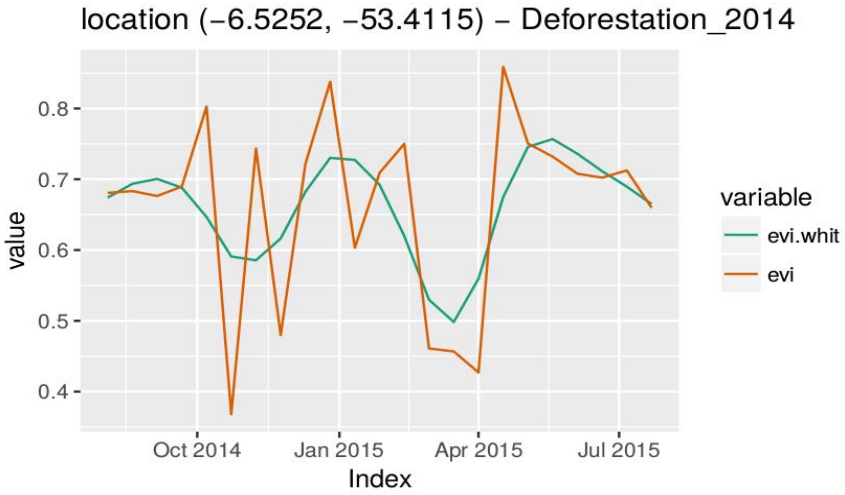
Potato time series

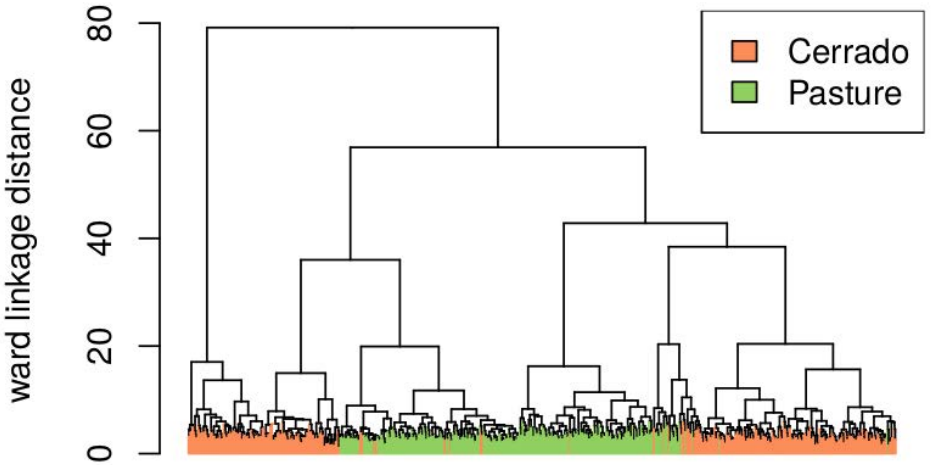
DOY 255 (2016)

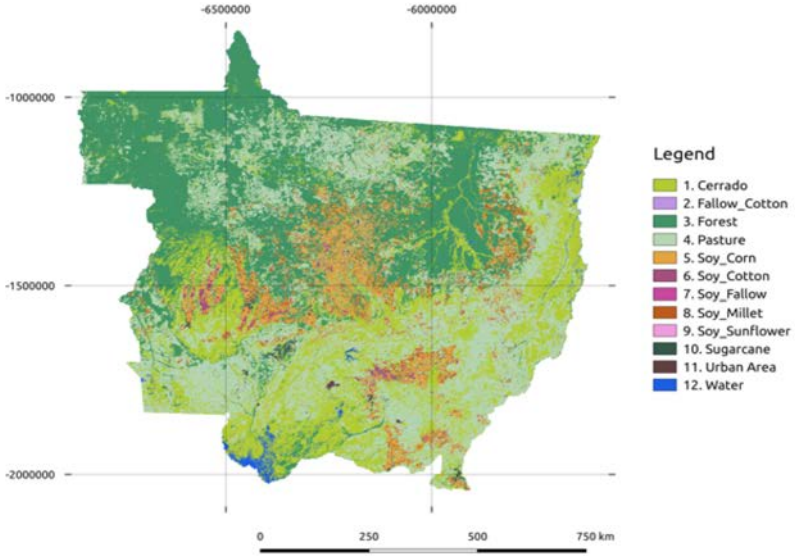


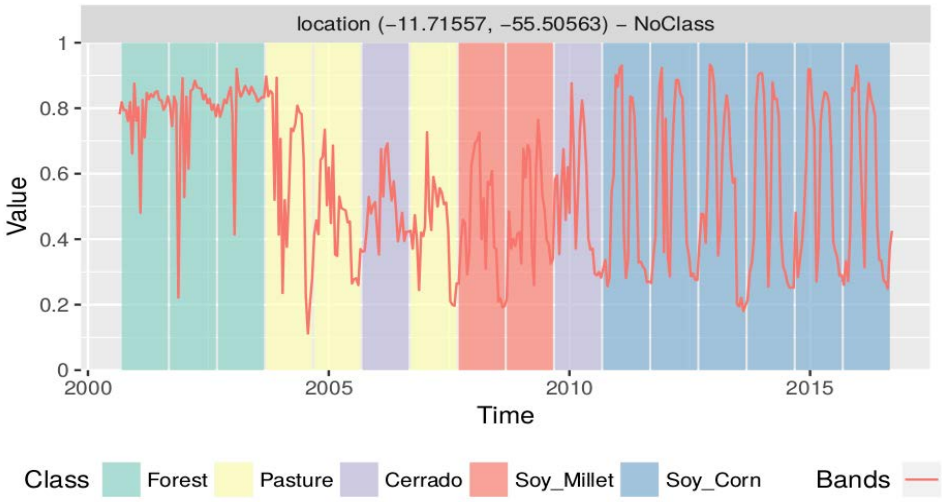
Griffiths et al, RSE (2019)

SITS – an R package for image time series



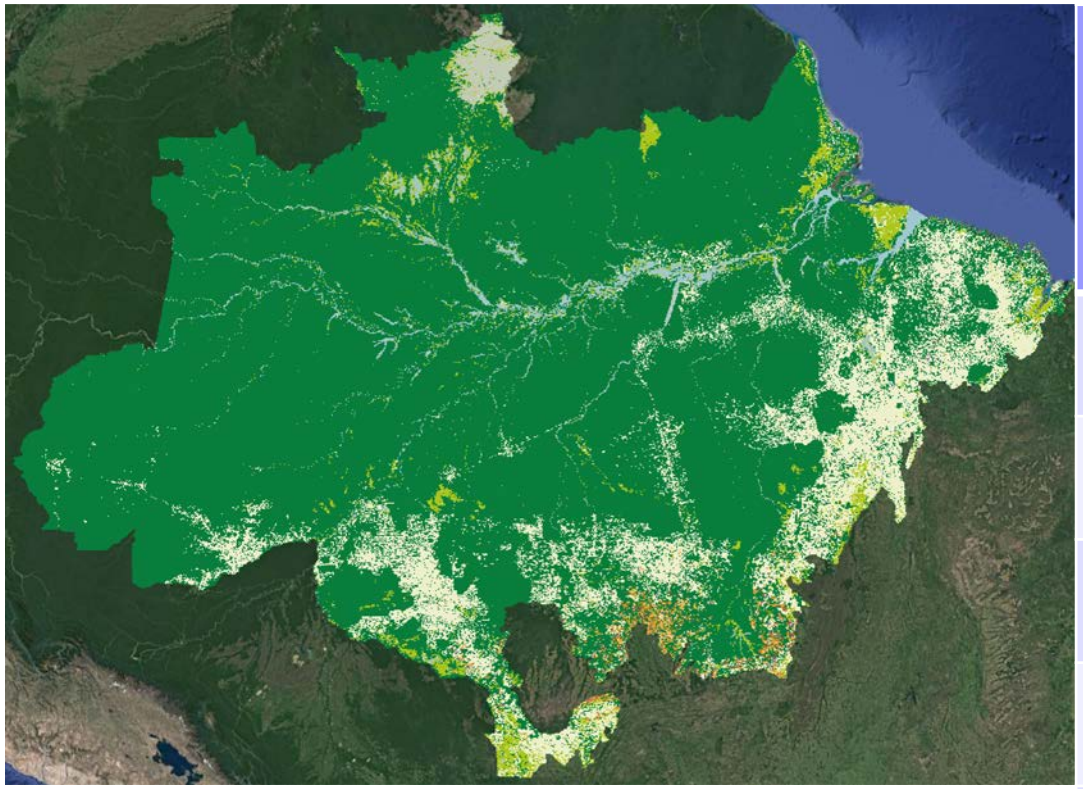






https://github.com/e-sensing/sits

Analytics depend on good in-situ and good quality data cubes



MODIS data cube (MOD13Q1)

33,000 samples

Model	5-fold validation accuracy
SVM	97.6%
Random Forest	98.5%
Perceptron	99.2%
FCNN	98.9%
tempCNN	99.1 %
ResNet	99.0%

INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE
https://doi.org/10.1080/13658816.2018.1520235

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

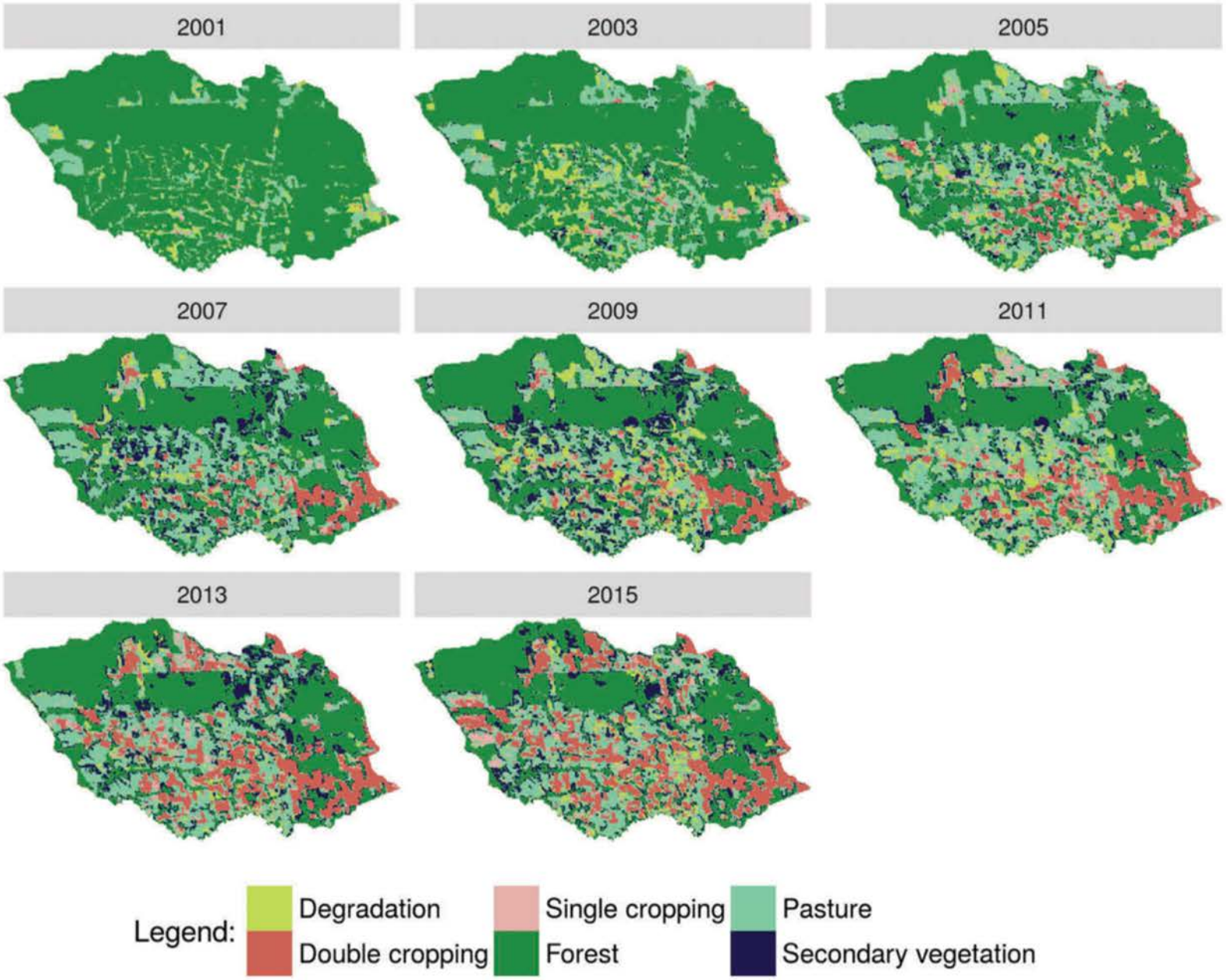
OPEN ACCESS

Check for updates

A spatiotemporal calculus for reasoning about land-use trajectories

Table 3. The predicates RECUR, CONVERT and EVOLVE.

$$\forall\, l \in L, \forall\, c, c_i, c_j \in C, c \neq c_i \neq c_j,\ \forall\, t_i, t_j, t_k \in T, t_i \neq t_j \neq t_k,$$
$$\text{RECUR}\ (l, c, t_i, t_j) \Leftrightarrow\ \text{HOLDS}(l, c, t_i)\ \wedge\ \text{HOLDS}(l, c, t_j)\ \wedge\ \text{BEFORE}(t_i, t_j)$$
$$\wedge\ \neg\ \text{HOLDS}(l, c, t_k)\ \wedge\ \text{MEETS}(t_i, t_k)\ \wedge\ \text{MEETS}(t_k, t_j)$$
$$\text{CONVERT}(l, c_i, t_i, c_j, t_j) \Leftrightarrow\ \text{HOLDS}(l, c_i, t_i)\ \wedge\ \text{HOLDS}(l, c_j, t_j)\ \wedge\ \text{MEETS}(t_i, t_j)$$
$$\text{EVOLVE}(l, c_i, t_i, c_j, t_j) \Leftrightarrow\ \text{HOLDS}(l, c_i, t_i)\ \wedge\ \text{HOLDS}(l, c_j, t_j)\ \wedge\ \text{BEFORE}(t_i, t_j)$$

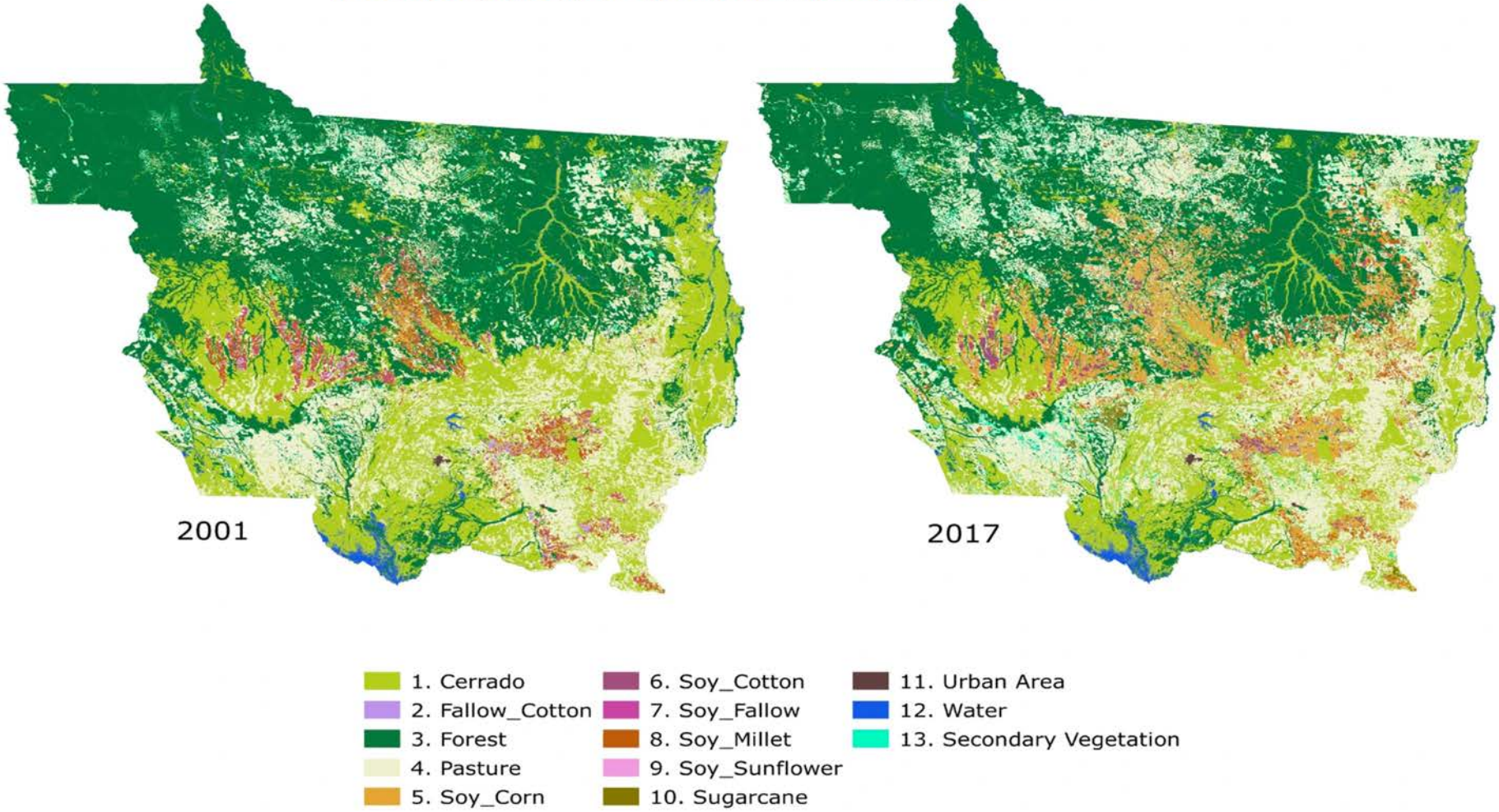

2001
2003
2005
2007
2009
2011
2013
2015
Legend:
Degradation
Double cropping
Single cropping
Forest
Pasture
Secondary vegetation

SCIENTIFIC DATA

Data Descriptor | Open Access | Published: 27 January 2020

Land use and cover maps for Mato Grosso State in Brazil from 2001 to 2017

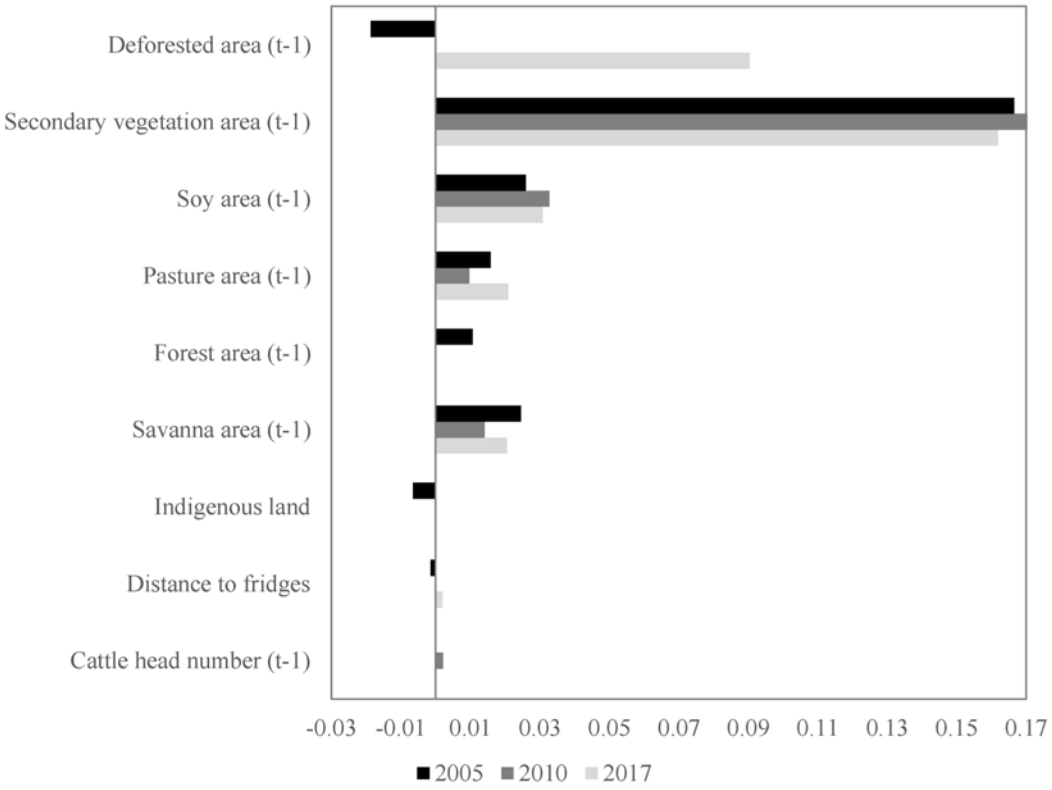
Rolf Simoes ✉, Michelle C. A. Picoli, Gilberto Camara, Adeline Maciel, Lorena Santos,



land

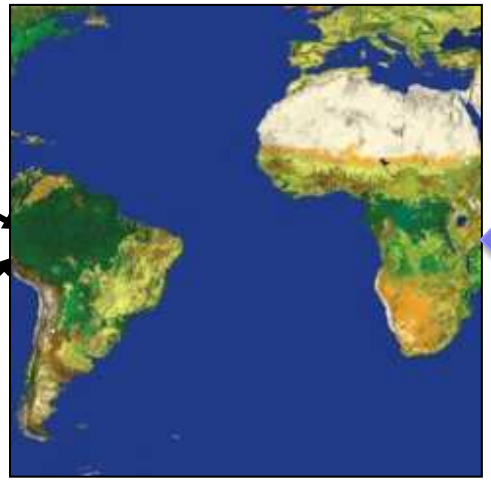
Impacts of Public and Private Sector Policies on Soybean and Pasture Expansion in Mato Grosso—Brazil from 2001 to 2017

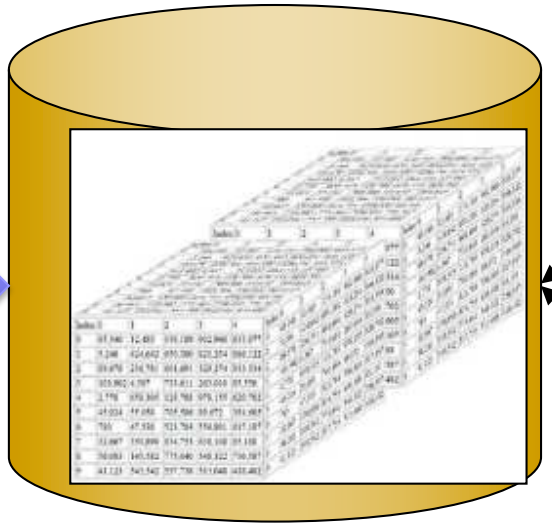
by Michelle C. A. Picoli [1,*,†], Ana Rorato [1,†], Pedro Leitão [2,3,†], Gilberto Camara [1,4,†], Adeline Maciel [1,†], Patrick Hostert [3,5,†] and Ieda Del'Arco Sanches [1]

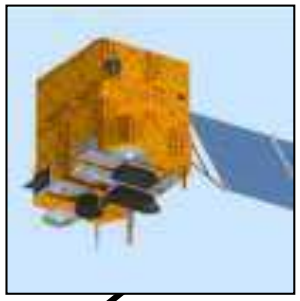


Pasture expansion: more over secondary vegetation than over natural forests

Global Land Observatory: describing change in a connected world





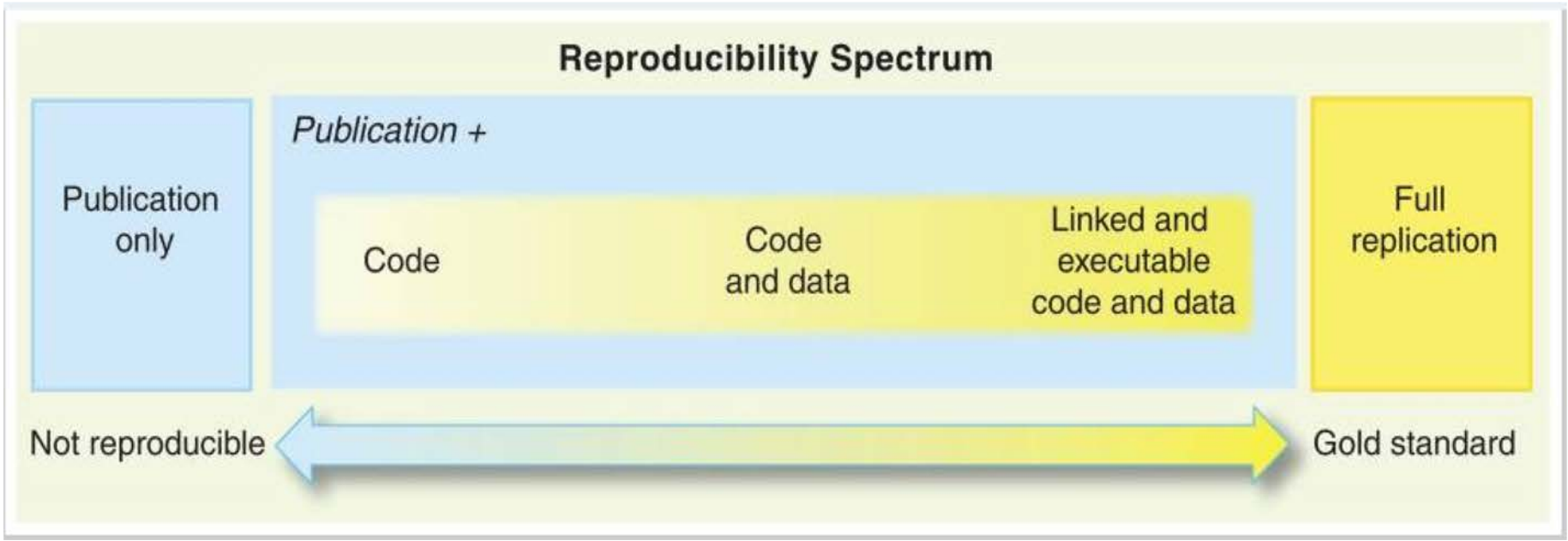


Methods for land change for forestry and agriculture uses

40 years of LANDSAT + 12 years of MODIS + SENTINELs + CBERS

Unique repository of knowledge and data about global land change

Achieving reproducible knowledge



Exposing all parts of an application

image: Peng (Science, 2011)