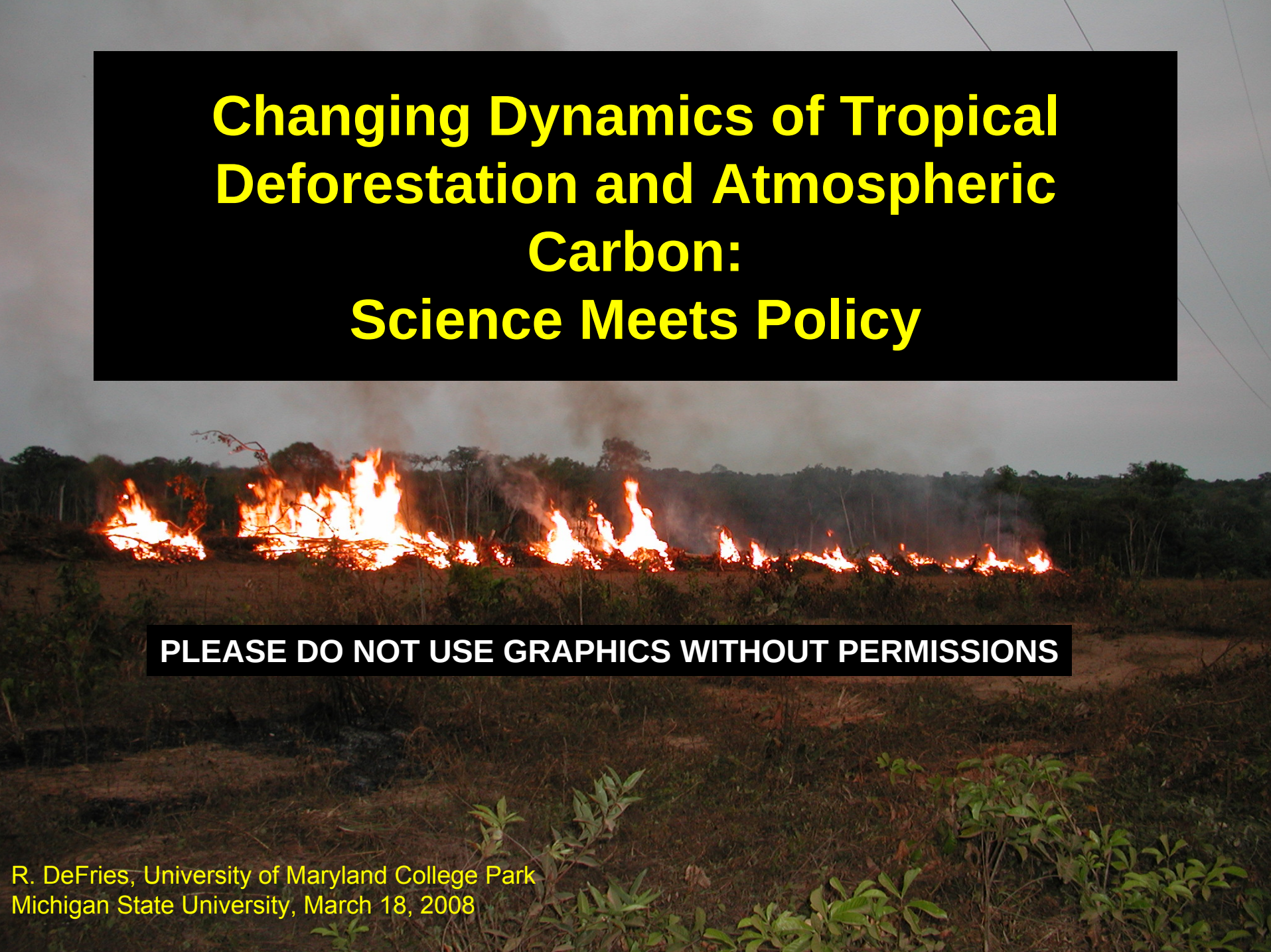
Changing Dynamics of Tropical Deforestation and Atmospheric Carbon: Science Meets Policy



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R. DeFries, University of Maryland College Park
Michigan State University, March 18, 2008

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R. Houghton, Woods Hole Research Institute

With funding from NASA LCLUC, LBA, and TE programs

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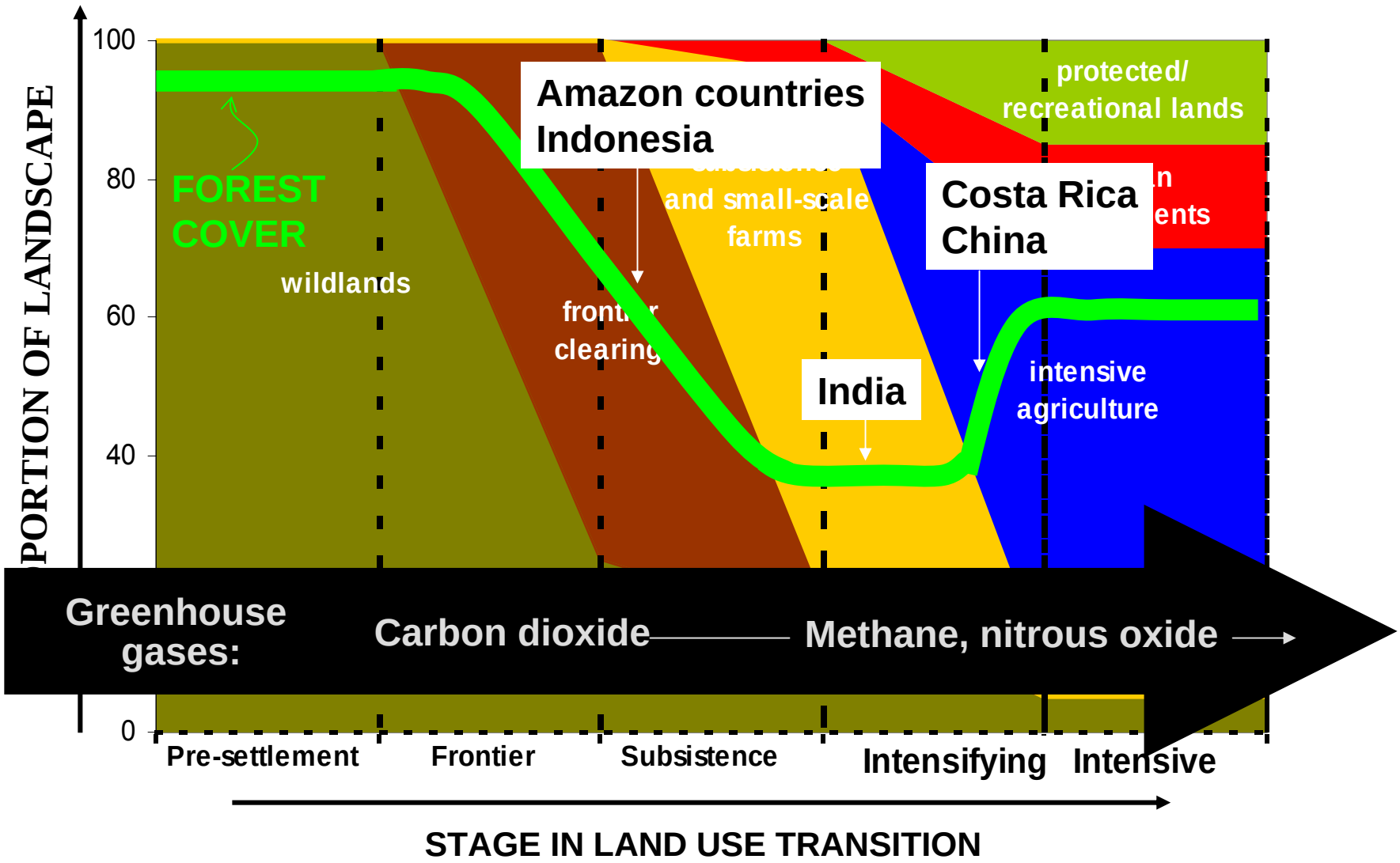

(From Mustard et al., 2004; DeFries et al, 2004; Foley et al., 2006)

Historical Estimates of Carbon Emissions (1850-2000)

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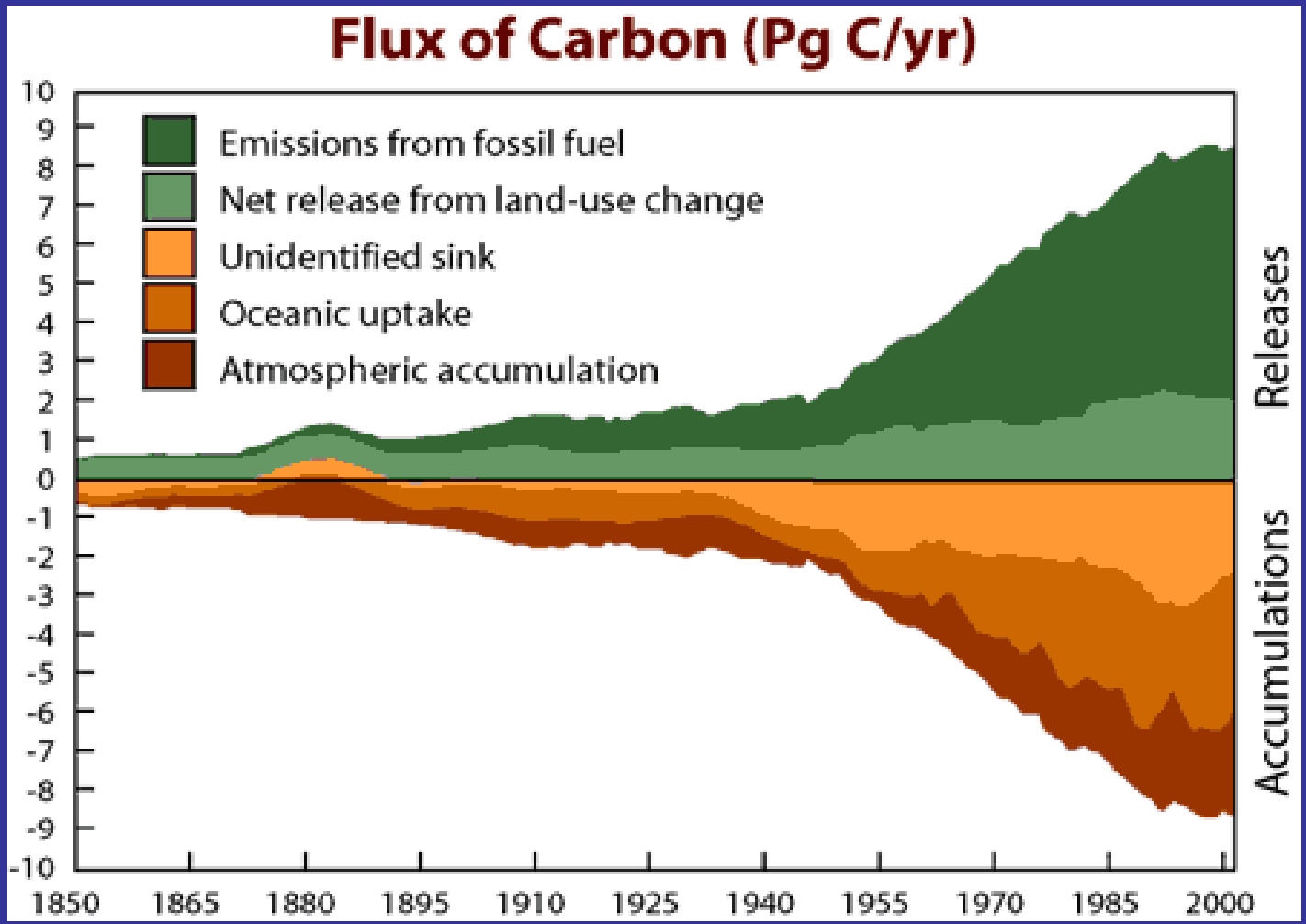

(from Houghton, WHRC)

UN FRAMEWORK CONVENTION ON CLIMATE CHANGE INCLUDED REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION (REDD) IN BALI ROADMAP

Decision -/CP.13

Reducing emissions from deforestation in developing countries: approaches to stimulate action

The Conference of the Parties

Recalling the relevant provisions of the Convention, in particular Article 2, Article 3, paragraphs 1, 3 and 4, and Article 4, paragraphs 1(a)–(d), 3, 5 and 7,

Acknowledging the contribution of the emissions from deforestation to global anthropogenic greenhouse gas emissions,

Acknowledging that forest degradation also leads to emissions, and needs to be addressed when reducing emissions from deforestation,

Recognizing that efforts and actions to reduce deforestation and to maintain and conserve forest carbon stocks in developing countries are already being taken,

Recognizing the complexity of the problem, different national circumstances and the multiple drivers of deforestation and forest degradation,

Recognizing the potential role of further actions to reduce emissions from deforestation and forest degradation in developing countries in helping to meet the ultimate objective of the Convention,

Affirming the urgent need to take further meaningful action to reduce emissions from

developing countries requires stable and predictable availability of resources,

Recognizing that reducing emissions from deforestation and forest degradation in developing countries can promote co-benefits and may complement the aims and objectives of other relevant

Estimates of carbon emissions from deforestation are highly uncertain

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	1980's (PgC/yr)	1990's (PgC/yr)	Spatial coverage	Method for area	Method for carbon flux
Houghton (2003)	2.0	2.2	Global, 9 regions	FAO and inventories	Bookkeeping
Fearnside (2000)	2.4	-	Pan-tropic, 6 regions	FAO and inventories	Bookkeeping
McGuire et al (2001)	0.9-1.6	-	Global	Cropland change	Ecosystem models
DeFries at al (2002)	0.6 (0.3-0.8)	0.9 (0.5-1.4)	Pan-tropics	AVHRR	Bookkeeping
Achard et al (2004)	-	1.1 ± 0.3	Pan-tropics, sample	Landsat	Bookkeeping
Houghton et al (2000)	-	0.2	Amazon	Landsat-derived	Bookkeeping
Fearnside (1997)	-	0.261	Brazilian Amazon	Landsat-derived	Bookkeping, committed flux
Potter et al (2001)	-	0.2-1.2	Legal Amazon	Satellite-derived fire	Fire emission and ecosystem model, gross flux
Van der Werf et al (2003)	-	2.6 fires + 1.2 decomposition (1998-2001)	Tropics and subtropics	Satellite-derived fire	Fire emission and ecosystem model, gross flux

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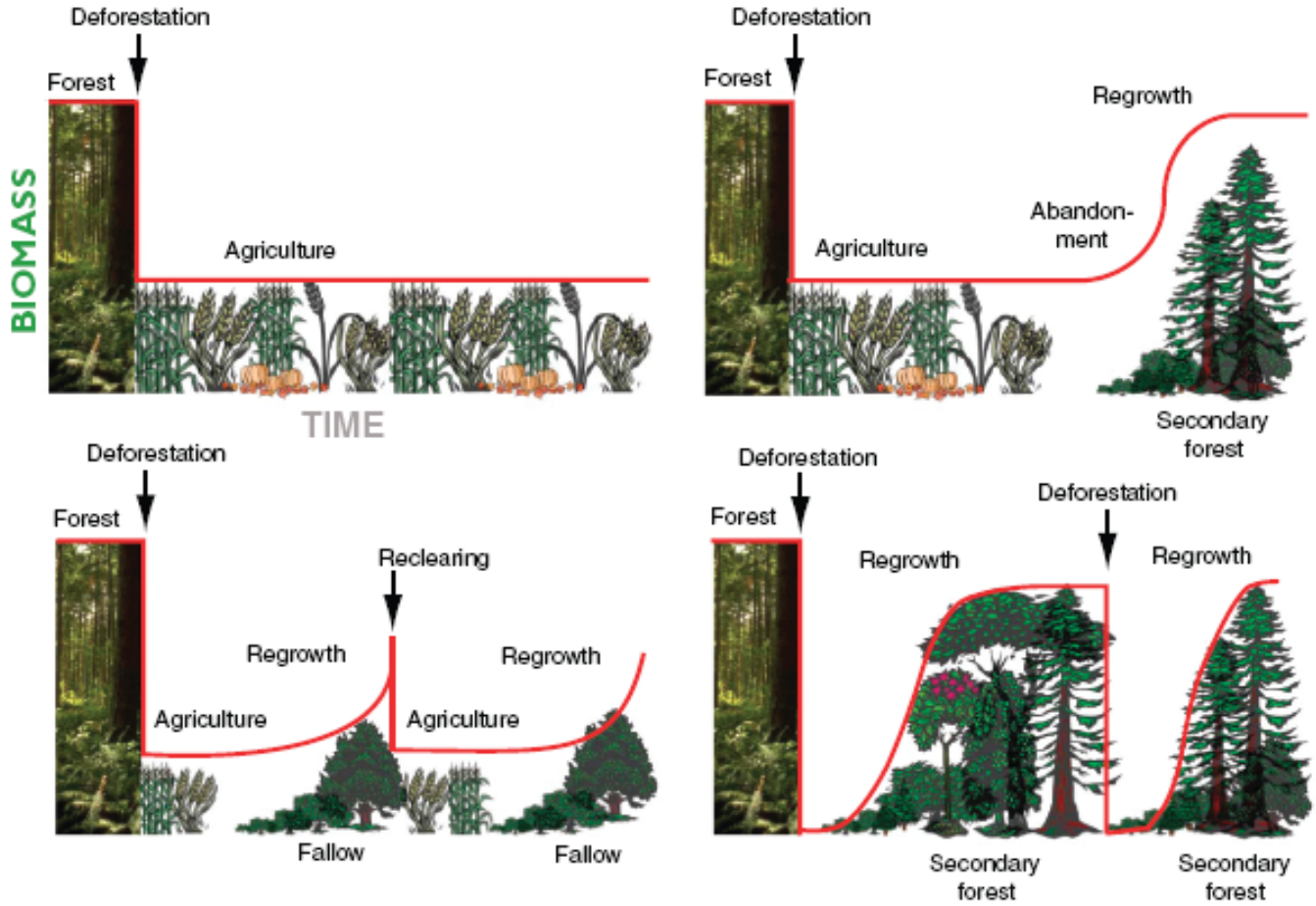

Fig. 3 Different pathways of carbon dynamics following deforestation. Depending on the land-use practices following deforestation, vegetation carbon can either remain at a lower level, or re-accumulate if the land is abandoned and allowed to regrow back into a forest.

C emissions = initial loss + respiration – uptake in regrowth

Annual balance vs committed flux approach

(Ramankutty et al, 2006)

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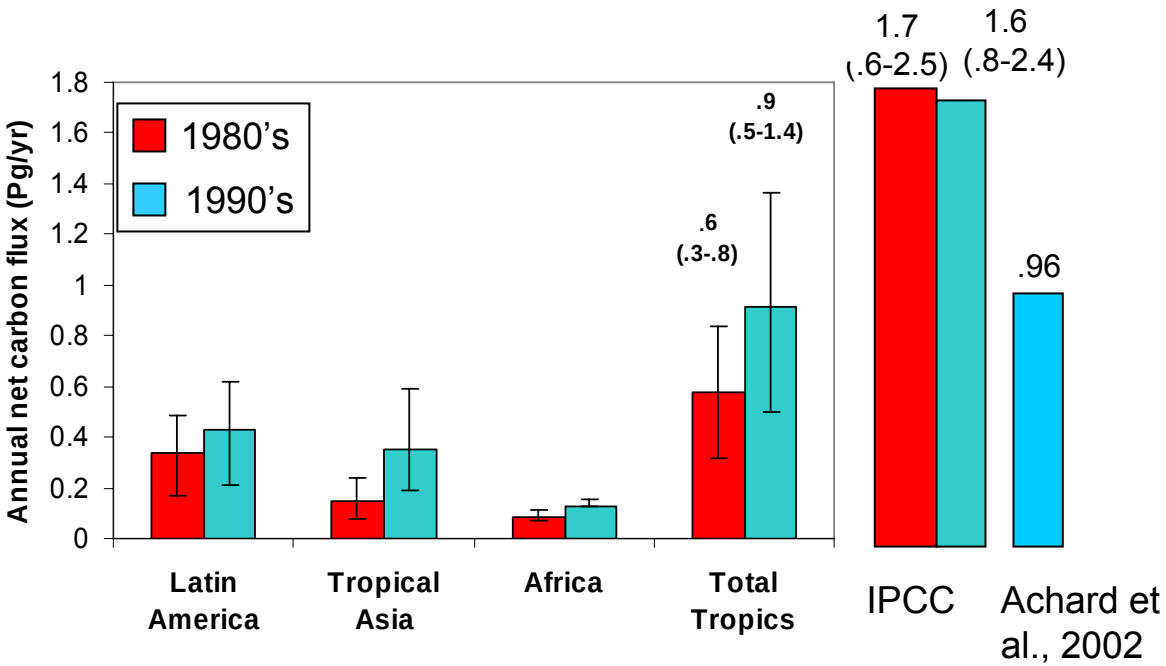
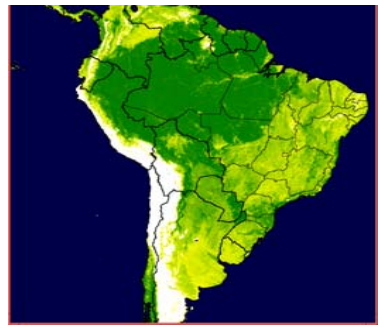
WHAT TOOLS ARE AVAILABLE FOR MONITORING DEFORESTATION AREA?

	LANDSAT –like sensors	*MODIS*	*AVHRR*
Spatial resolution	30m	250m - 1km	8km
Repeat frequency	16 days	daily	daily
Size of scene/tile	185x185 km	1000x1000km	Global and subsets
Length of record	1970's – present? intermittent	2000 - present	1981- present

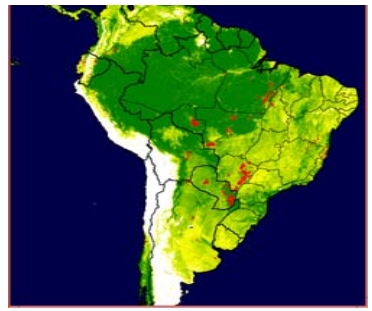
Estimated Carbon Flux from Tropical Deforestation and Regrowth based on Satellite Observations for 1980-2000



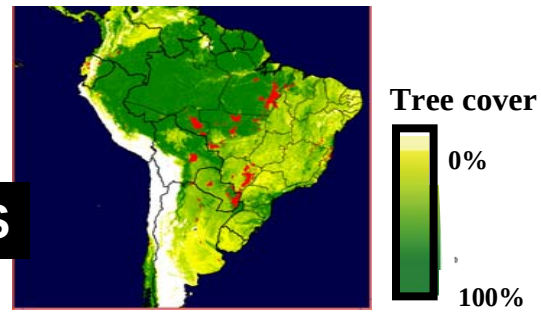
Deforestation in South America derived from AVHRR data (1980-2000)



Circa 1980



Circa 1990



Circa 2000

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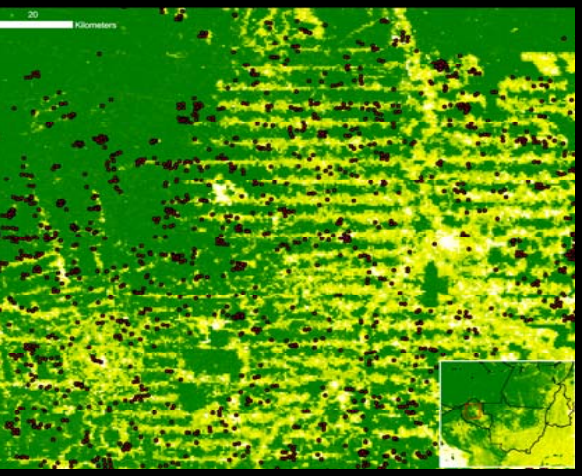
(DeFries et al., *PNAS*, 2002: Hansen and DeFries, *Ecosystems*, 2004)

CHANGING DYNAMICS IN 2000's REFLECTED IN SPATIAL PATTERNS OF MODIS-DERIVED % TREE COVER AND FIRE EVENTS

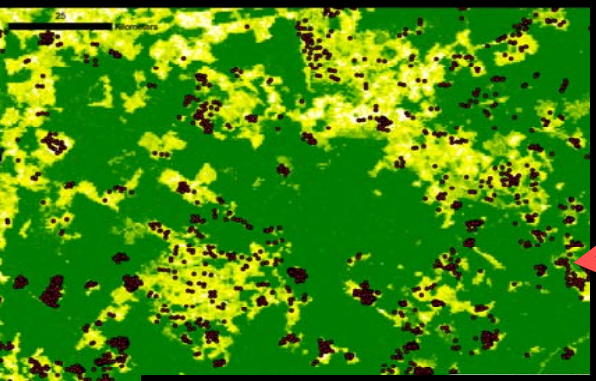


2001 Tree cover

0%

100%

2001-03 active fire



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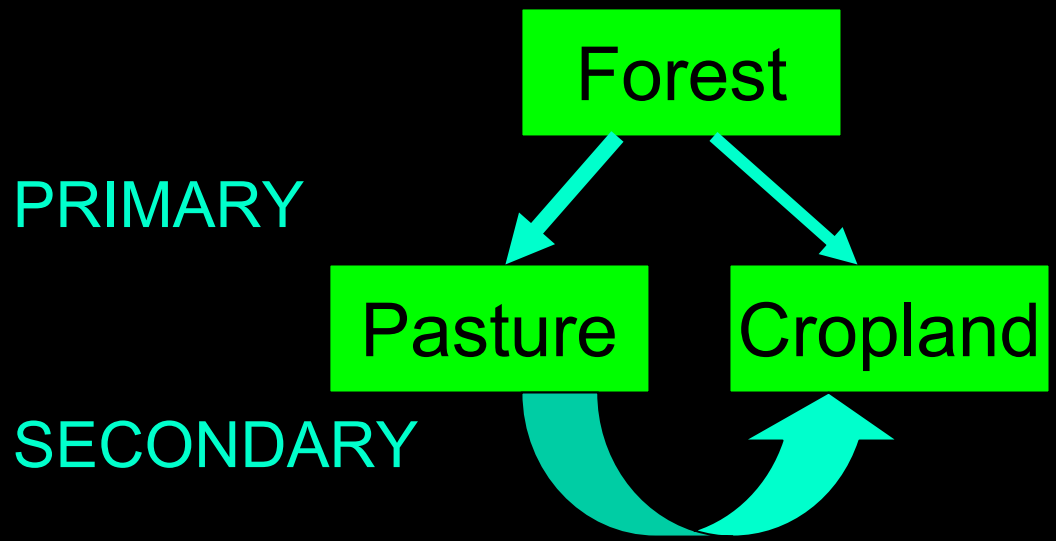
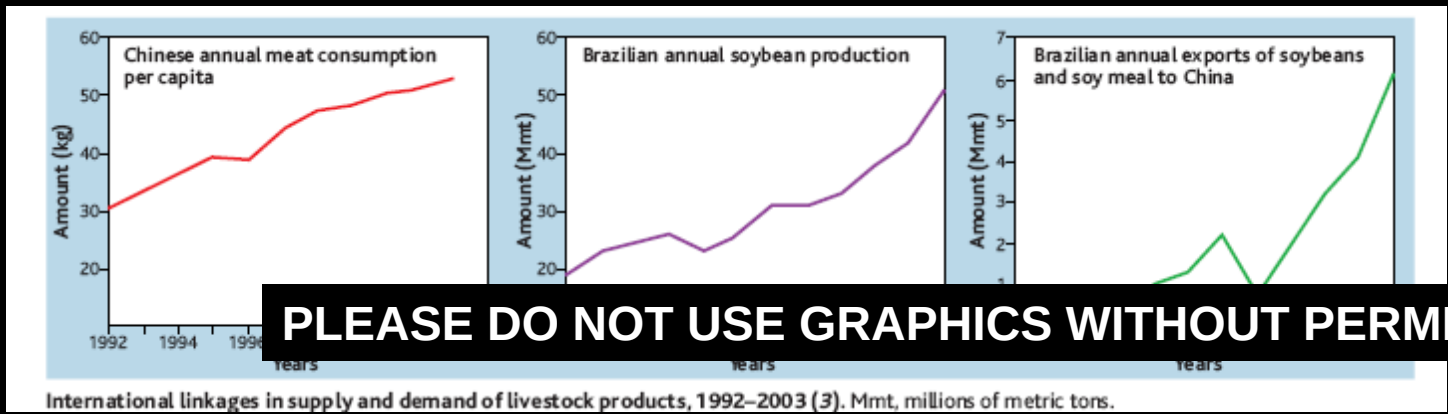
"Brazil could increase its total cultivated land area by 170 million ha if key legal, technical, and financial developments occur…*without any new deforestation in the Amazon basin*." –USDA 2003





International linkages in supply and demand of livestock products, 1992–2003 (*3*). Mmt, millions of metric tons.

(Naylor et al., 2005)

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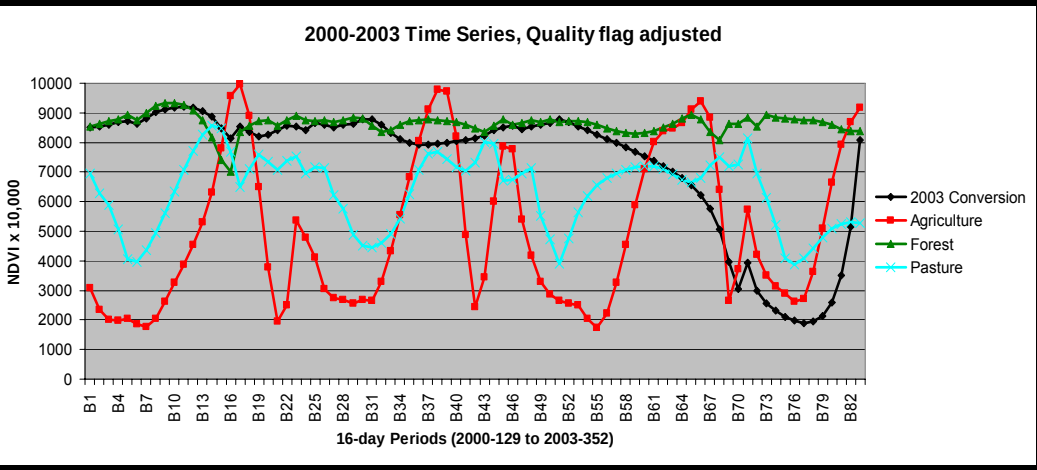
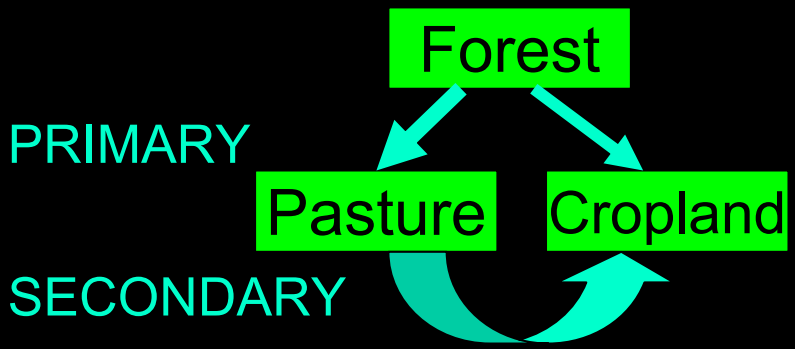
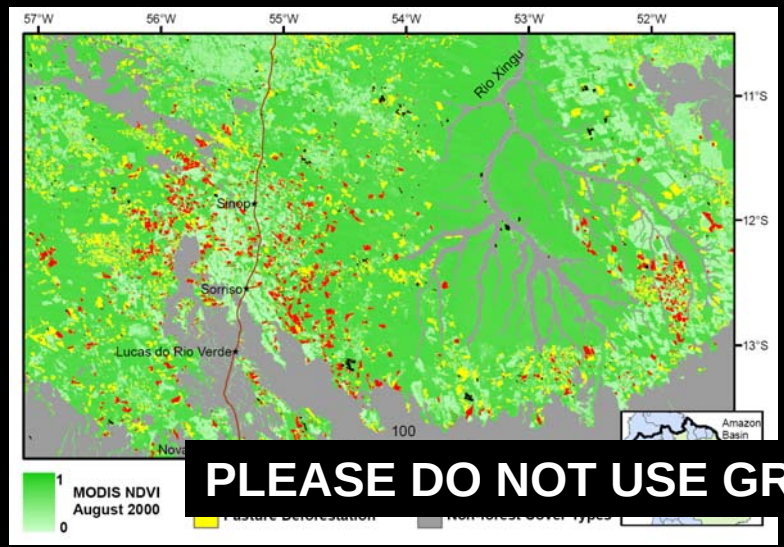
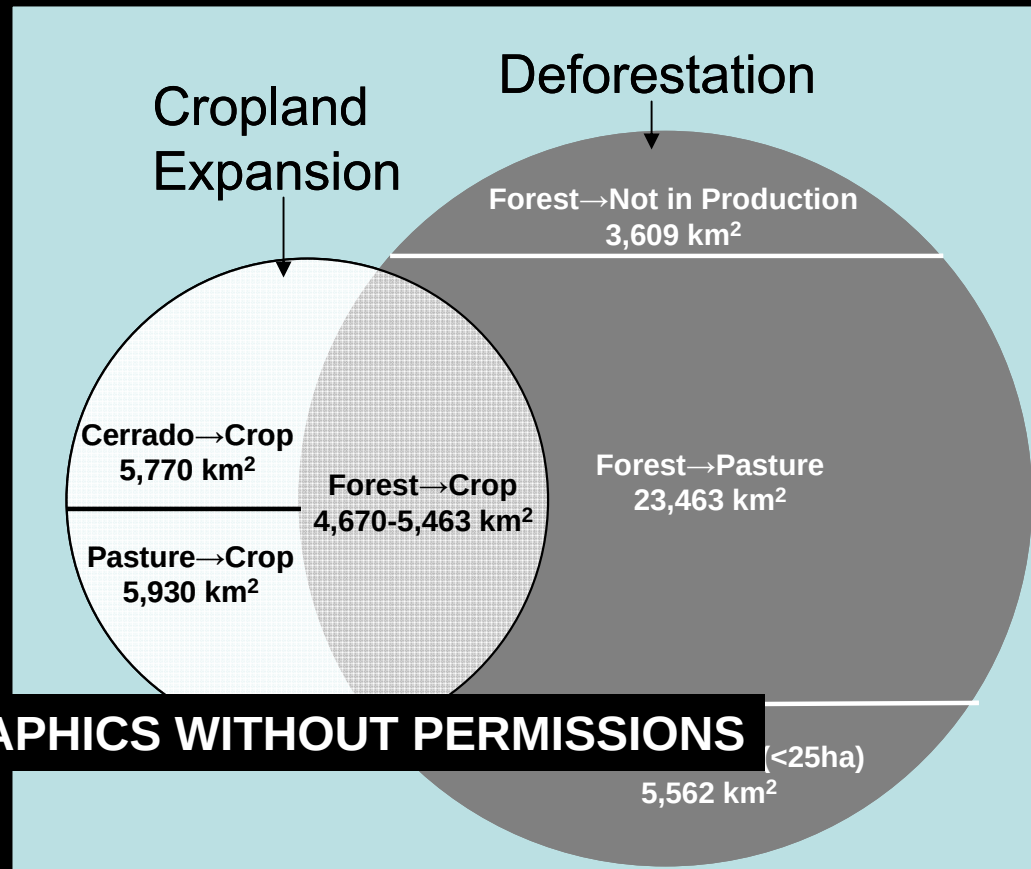
CHANGING LAND USE DYNAMICS IN 2000-05 IN MATO GROSSO: TRACKING WITH MODIS 250m DATA









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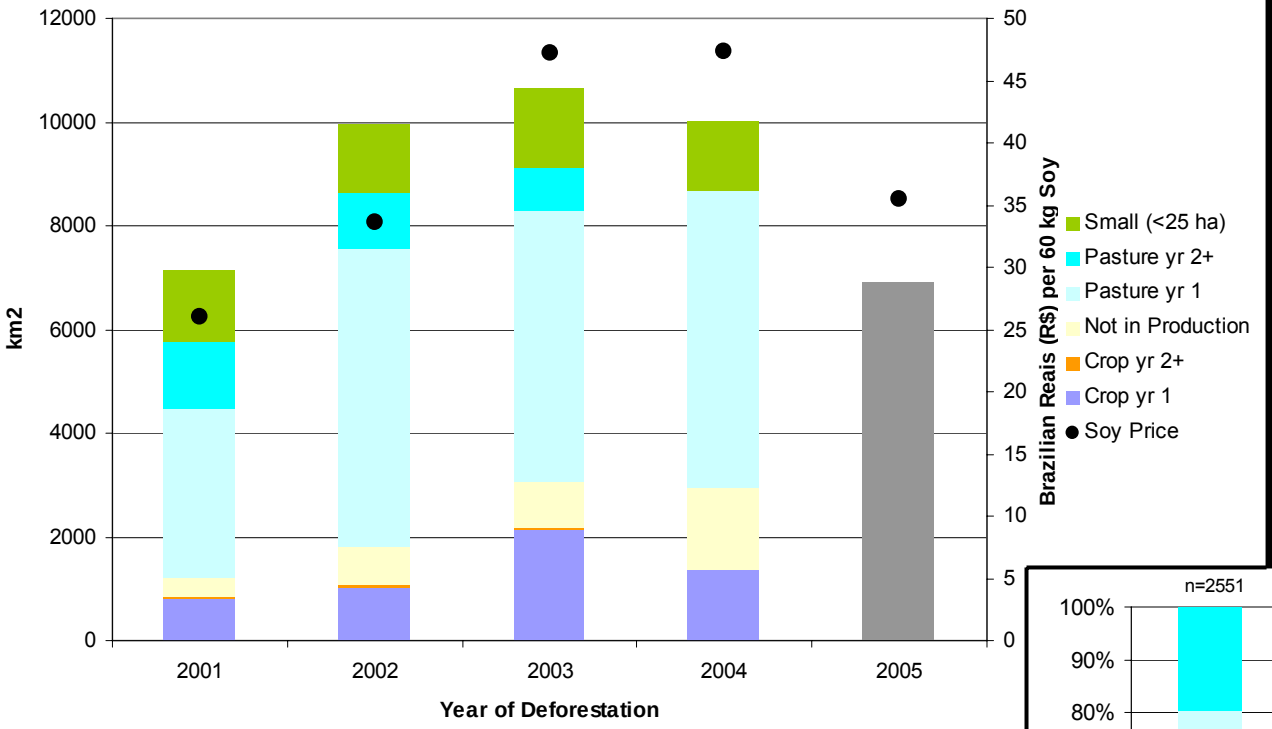
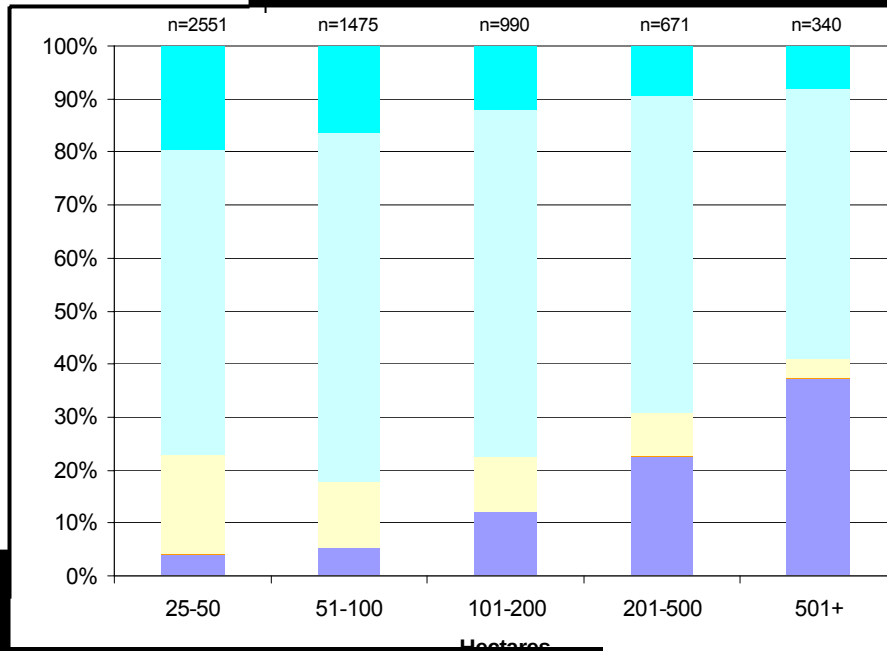
(Morton et al., PNAS, 2006)



POST CLEARING LAND USE IN MATO GROSSO

Conversion dynamics by post-clearing land cover for 2001-2004 deforestation events >25 ha in Mato Grosso State, Brazil from satellite-based phenology information: ***Clearing for mechanized cropland is associated with soy price***



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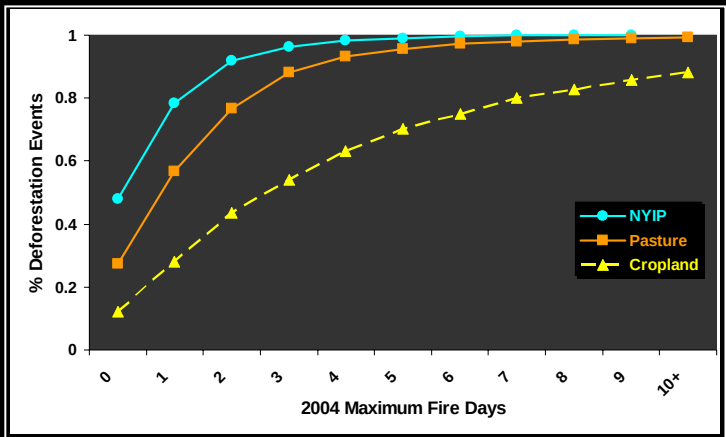
Pate of 2005 deforestation events by clearing size: ***Large clearings are associated with cropland***

(Morton et al., PNAS, 2006)

IMPLICATIONS FOR CARBON EMISSIONS: VARYING AMOUNTS OF REMAINING BIOMASS FROM LAND USES FOLLOWING DEFORESTATION



Conversions of forest to cropland exhibit higher-frequency of MODIS-detected fires than pasture conversions

Forest to pasture

Forest to crop

Pasture to crop

Not in production

(Morton et al., in

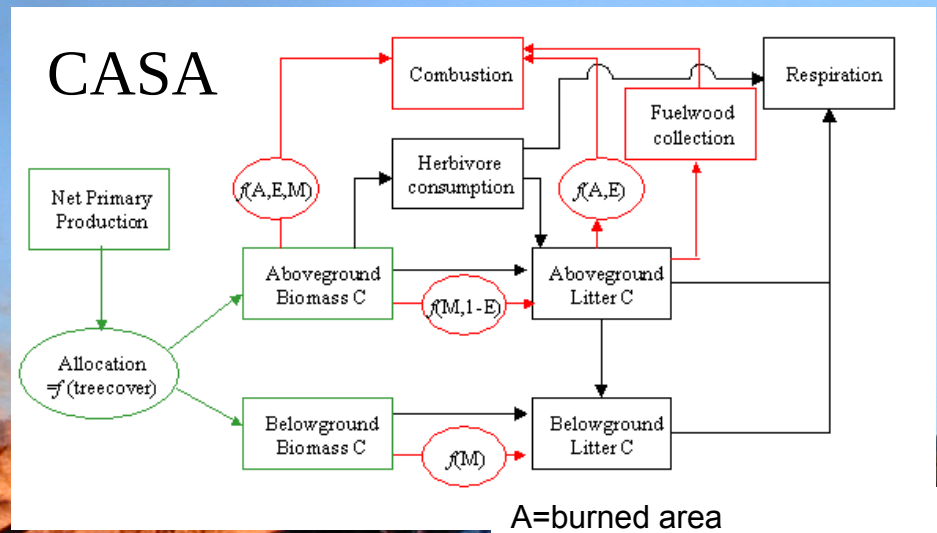
DECAF MODEL TO ESTIMATE GROSS CARBON FLUXES FROM DEFORESTATION FIRES AT 250m MODIS RESOLUTION

LAND USE FOLLOWING DEFORESTATION FROM MODIS

MODIS ACTIVE FIRES

LANDSAT-BASED DEFORESTATION

BURN SCARS FROM PASTURE MAINTENANCE FIRES



A=burned area
E=combustion completeness
M=mortality rate
D=detritus
B=biomass
F=fuelwood

C EMISSIONS FROM FIRE

$$\left[\sum_{d}\sum_{b} B_{t,b}\right]$$

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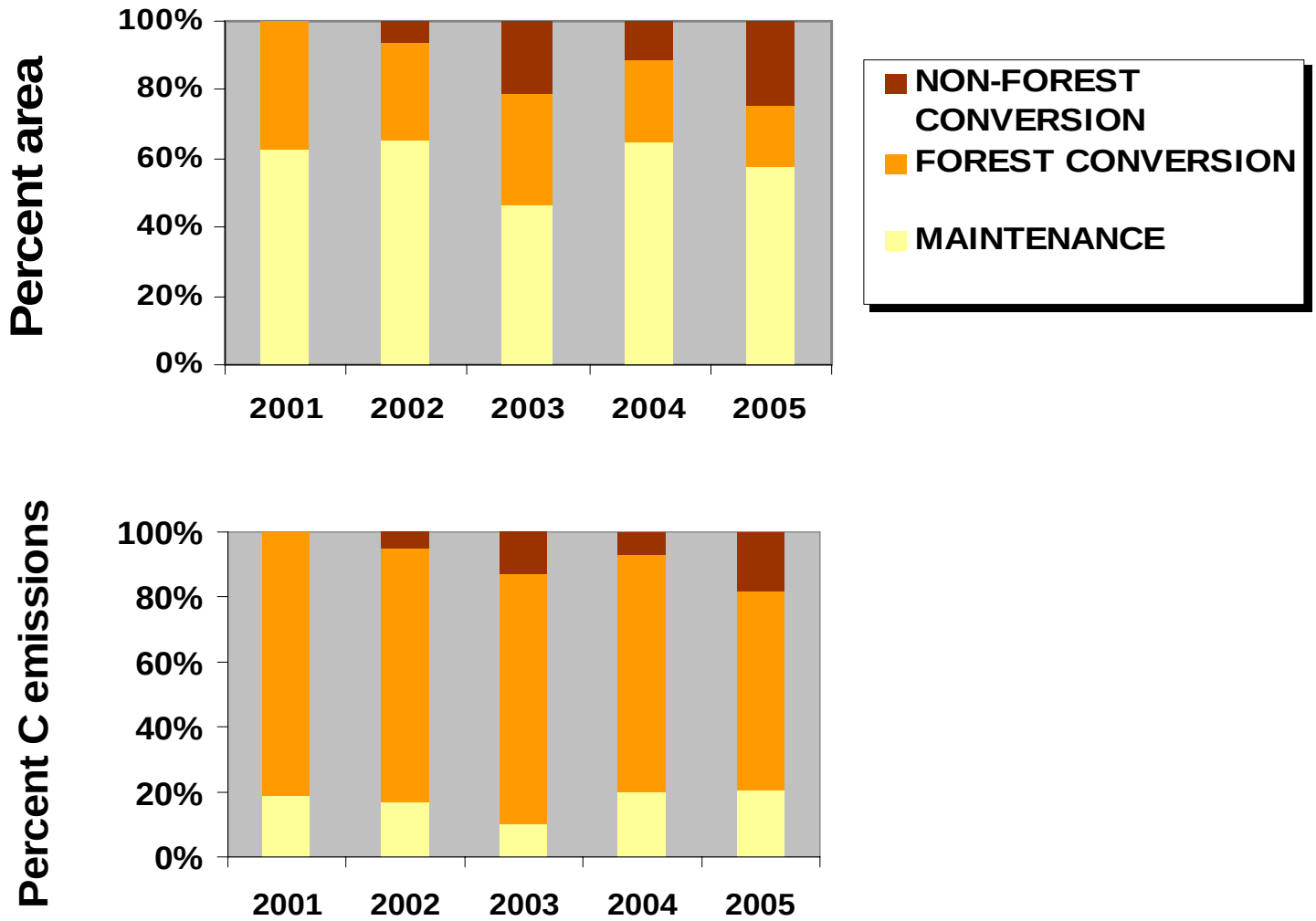
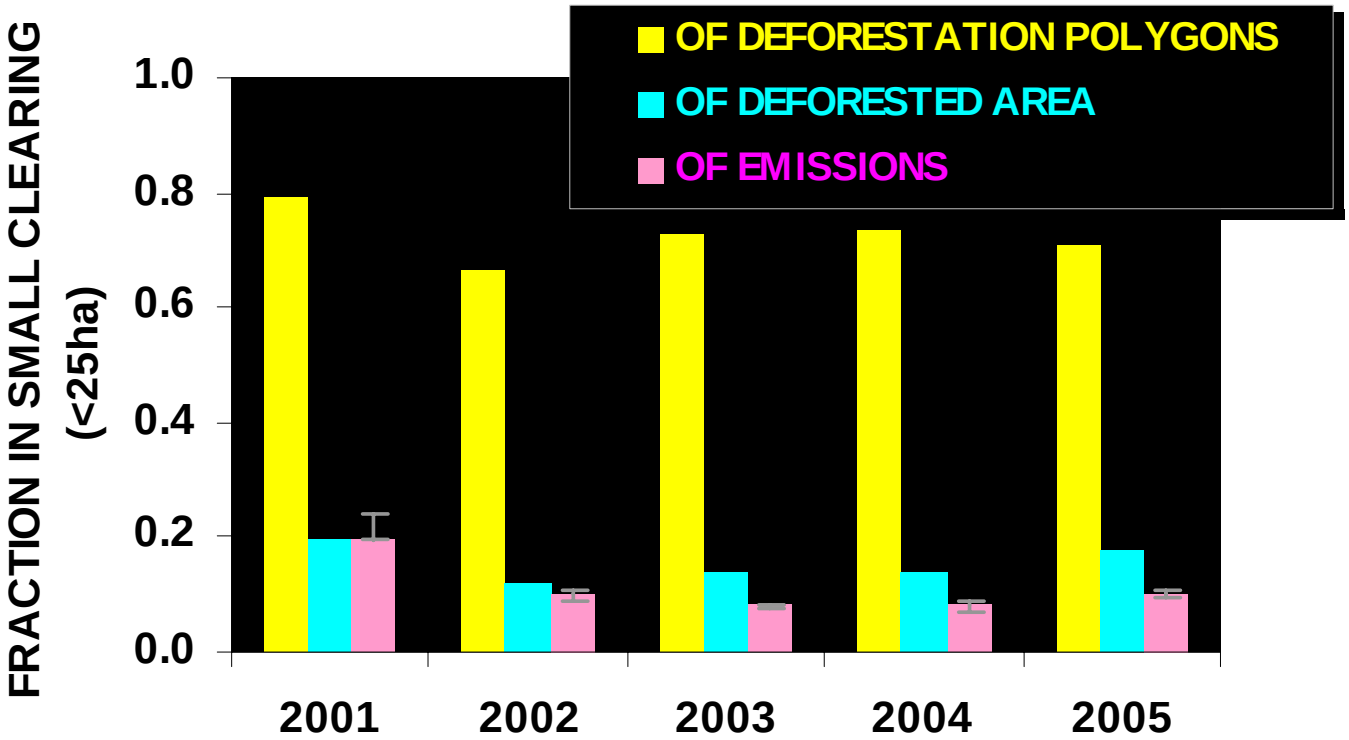
Observation #1: Conversion fires are <50% of area but >80% of emissions

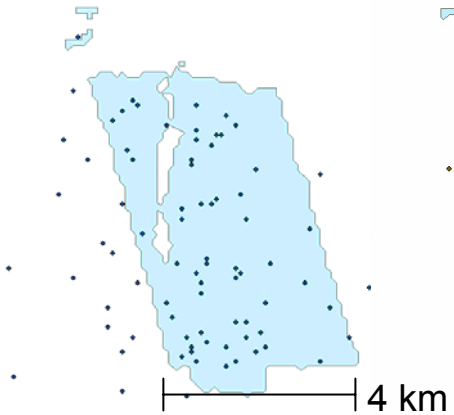


Observation #2: Small deforestation events contribute little to overall emissions

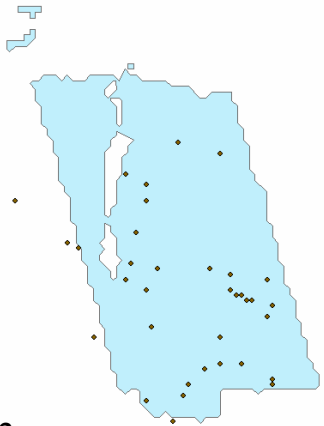


Observation #3: Emissions occur from deforestation fires over multiple years

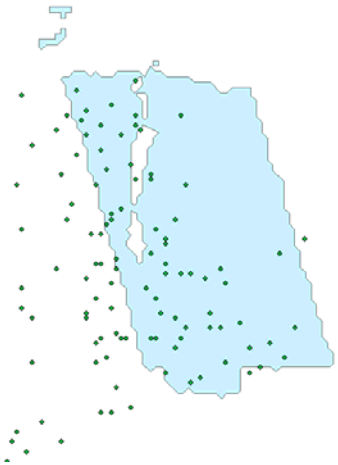
2002 Deforestation
2,500 ha, 79 fire detections



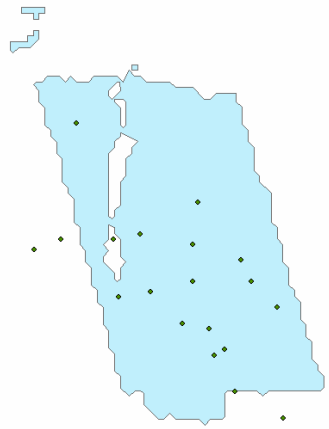
2003
35 detections

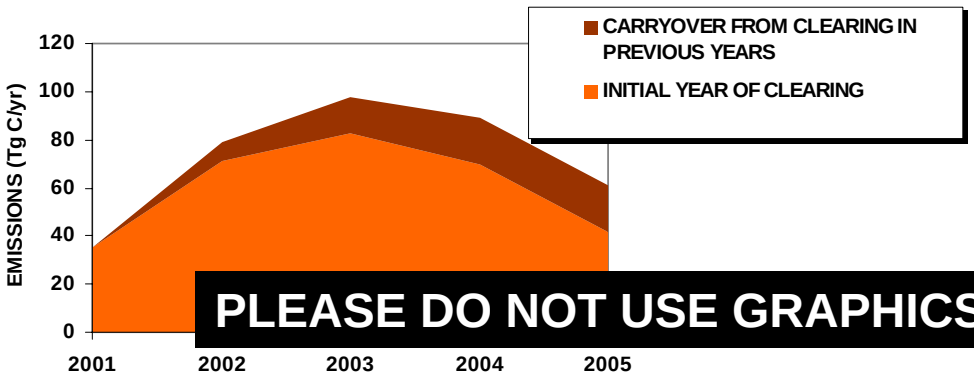


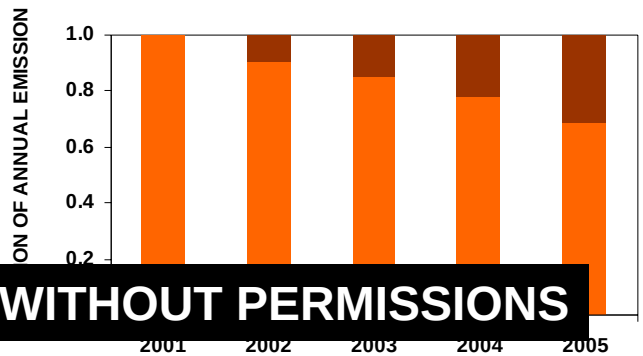
2004
91 detections



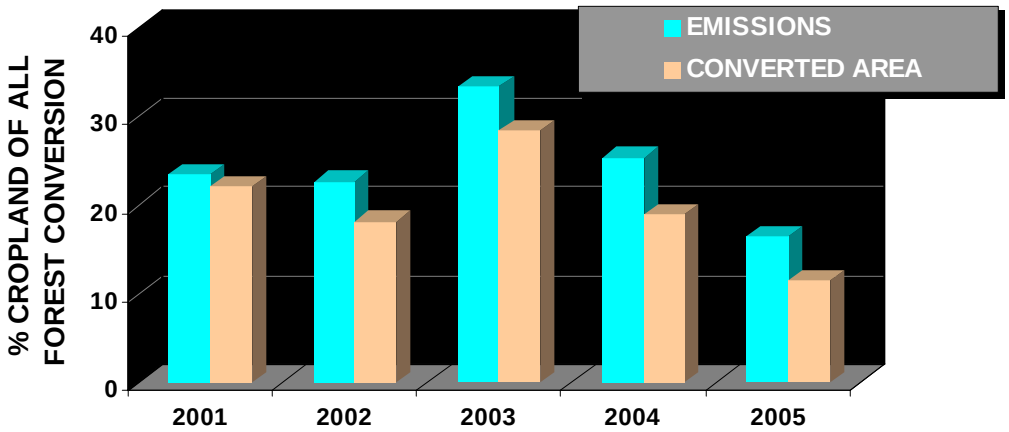
2005
19 detections



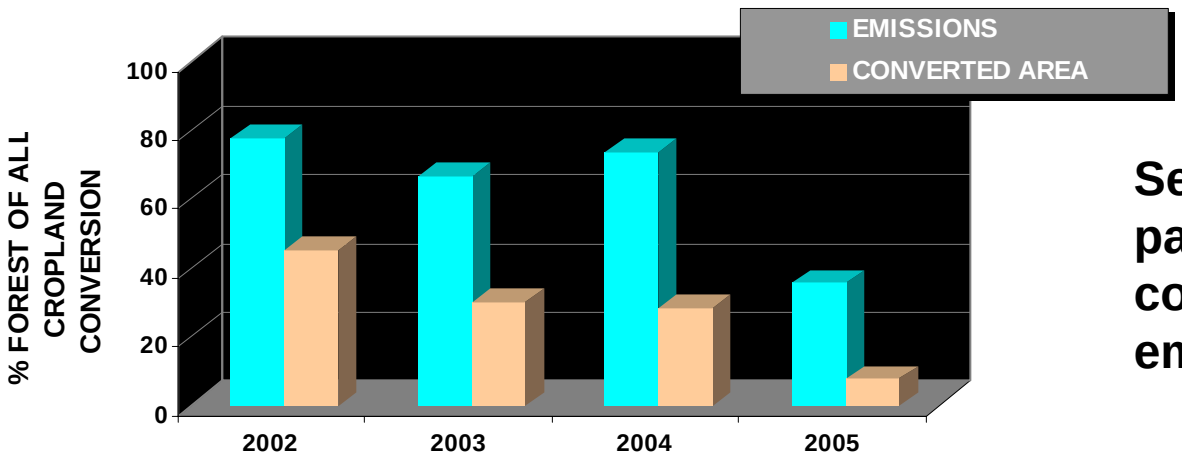




Observation #4: Emissions are not proportional to area and depend on land use transition type

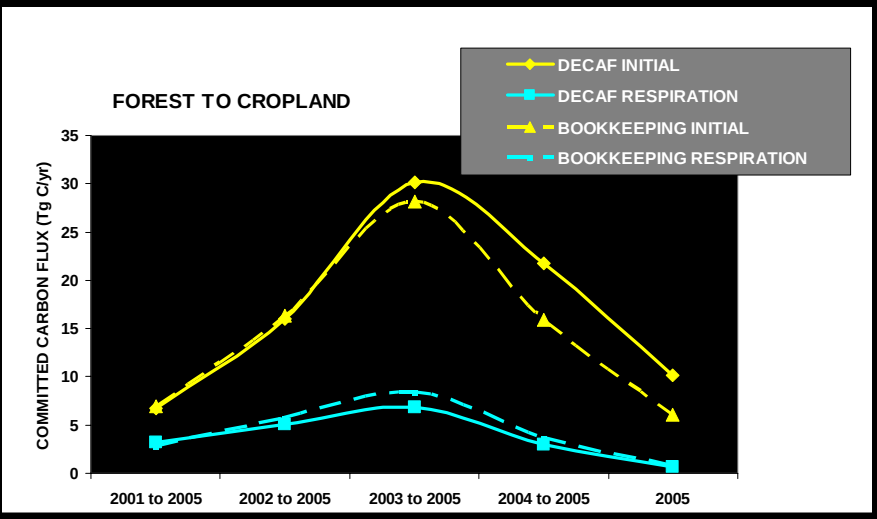


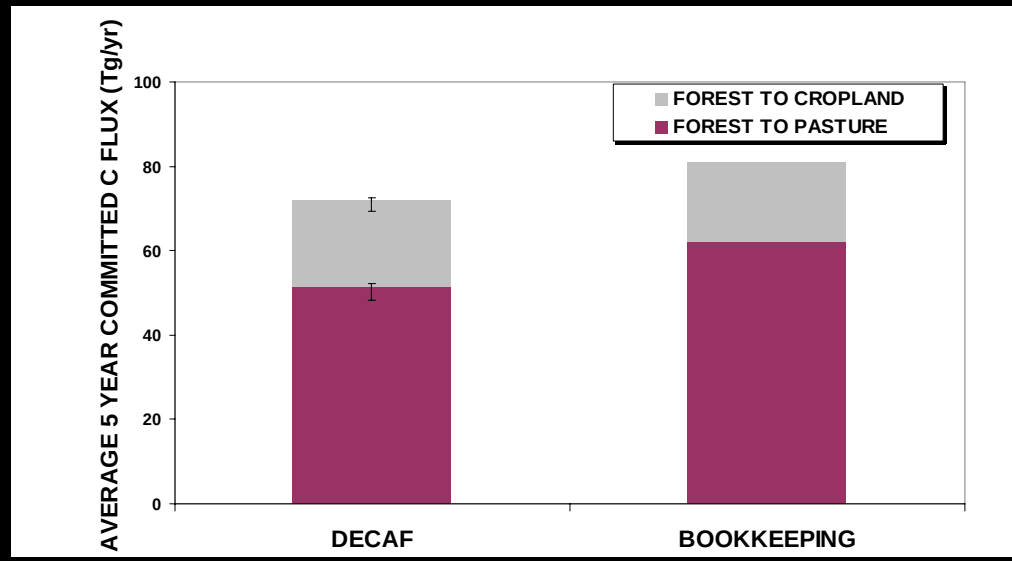
Emissions from forest to cropland transition are in larger proportion than converted area



Secondary transition from pasture to cropland contributes substantial emissions

DECAF COMPARED WITH BOOKKEEPING APPROACH FOR MATO GROSSO





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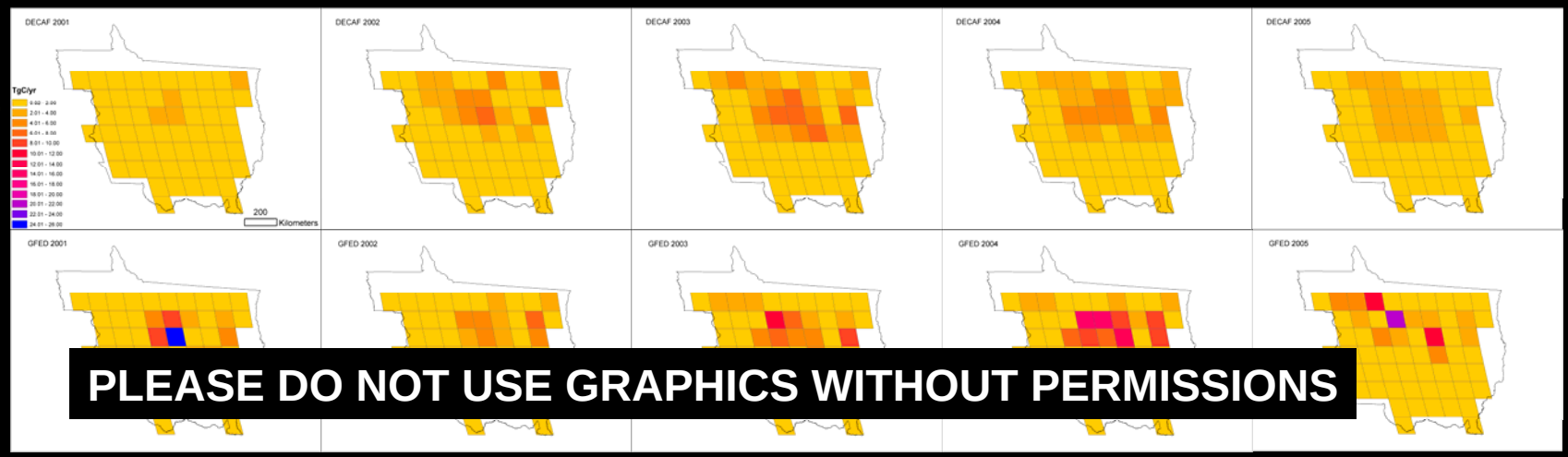
INITIAL DEFORESTATION EMISSIONS + 5-YR COMMITTED RESPIRATION

DECAF COMPARED WITH GLOBAL FIRE EMISSIONS DATA (GFED) FOR MATO GROSSO



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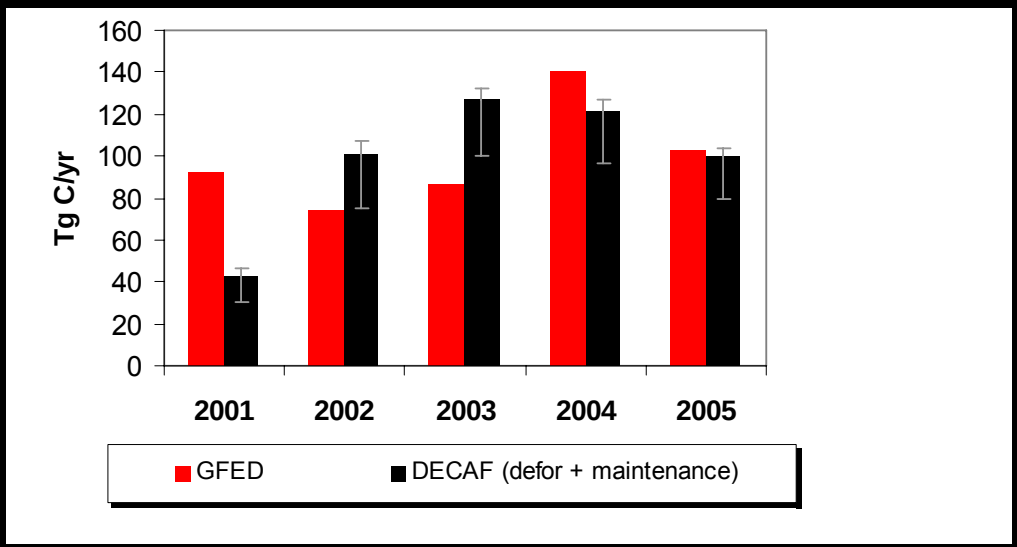
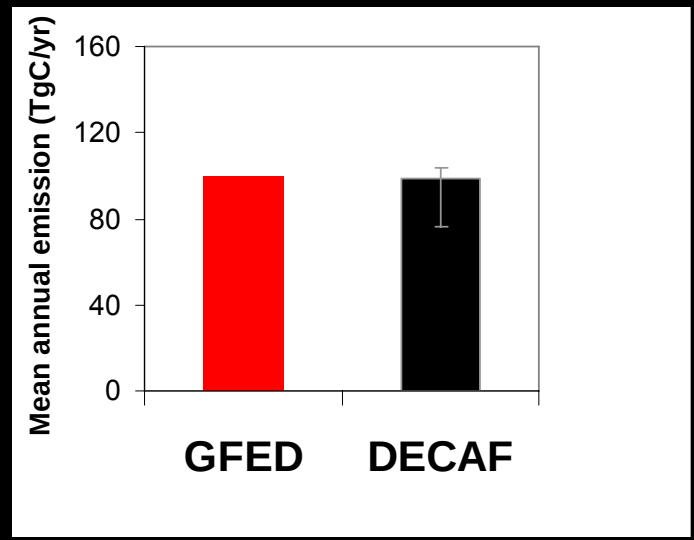




DEFORESTATION FIRE EMISSIONS + PASTURE MAINTENANCE FIRES

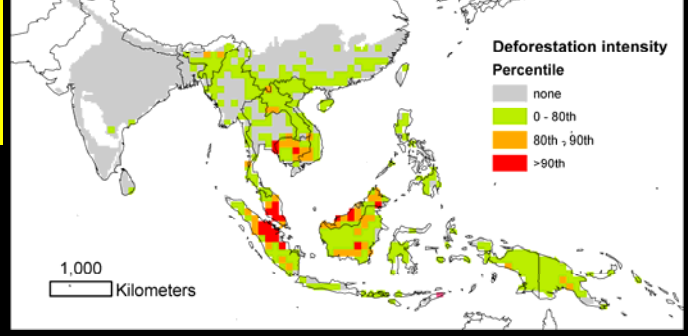
GFED from http://www.ess.uci.edu/~jranders/

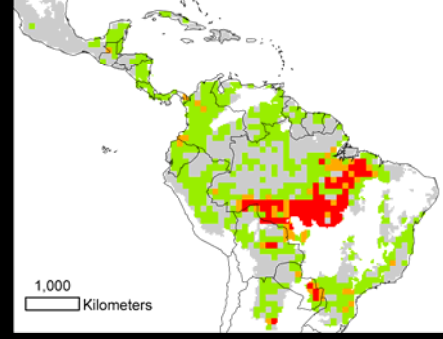
Conclusions from High Resolution Analysis

- Clearing for mechanized production requires new methods for estimating carbon fluxes
- Multiple methods lead to similar estimates for 5-year aggregated emissions
- Need to include land use transitions and multi-year fires for accurate interannual variability and attribution to land use actors
- Scaling up to pan tropics remains a challenge

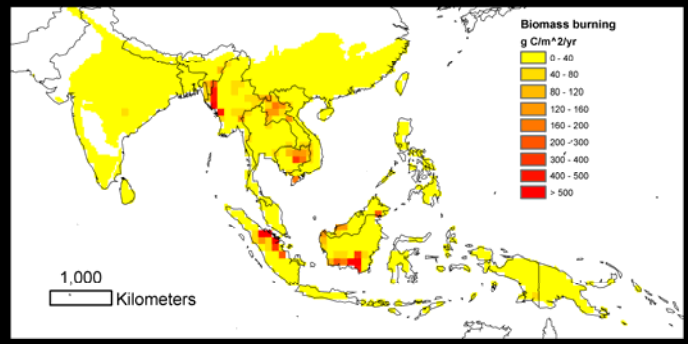
SCALING TO PAN TROPICS FOR 2000's

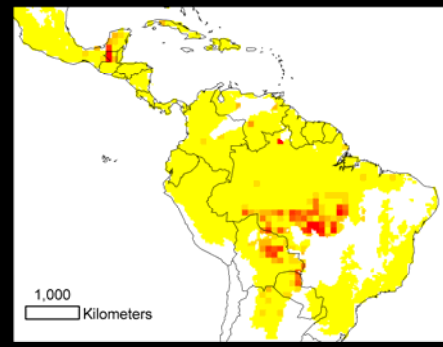
DEFORESTATION HOTSPOTS



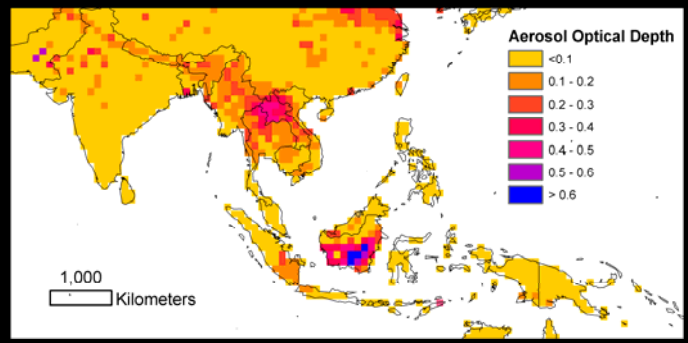


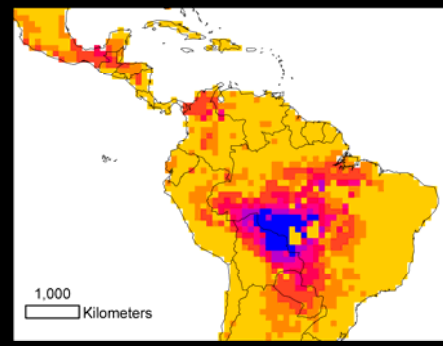
FIRE EMISSIONS





AEROSOL OPTICAL DEPTH





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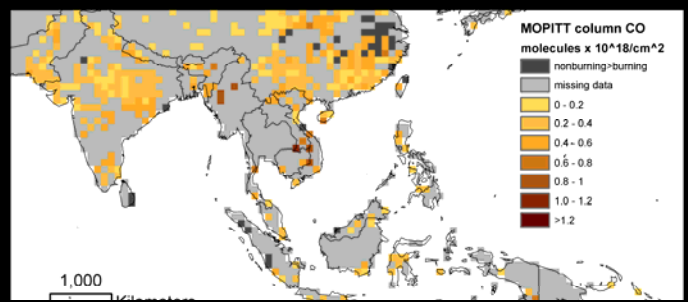

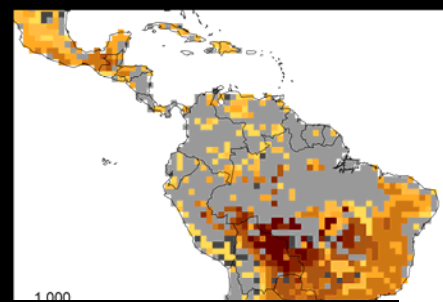

WHICH LAND USE TRANSITION TYPES ARE CONTRIBUTING EMISSIONS?

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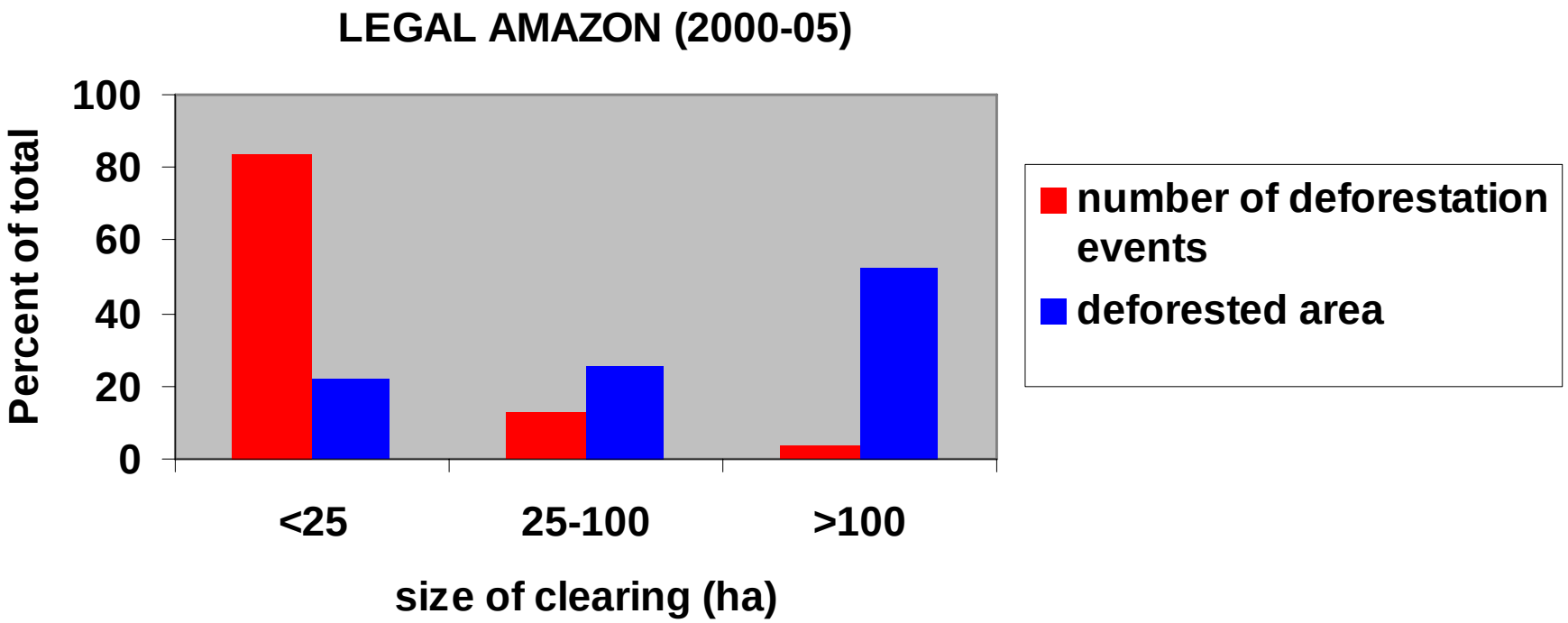
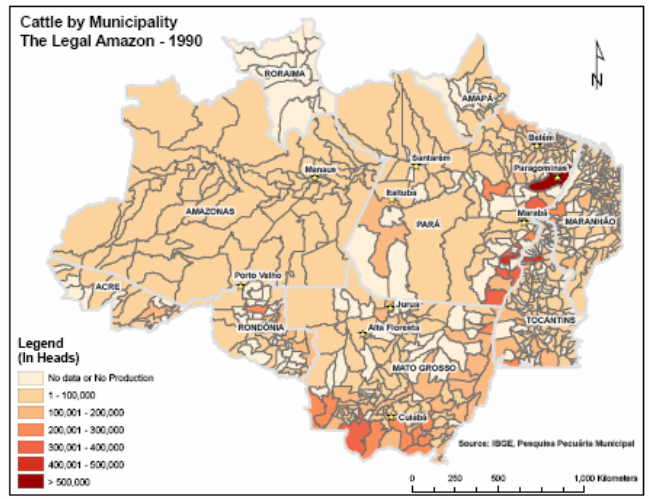
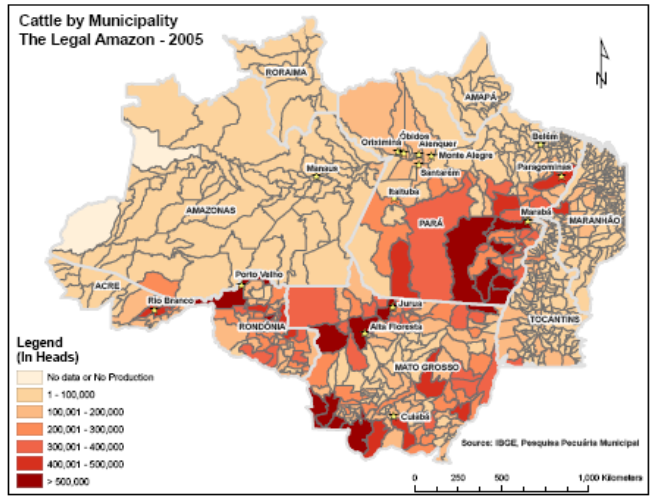
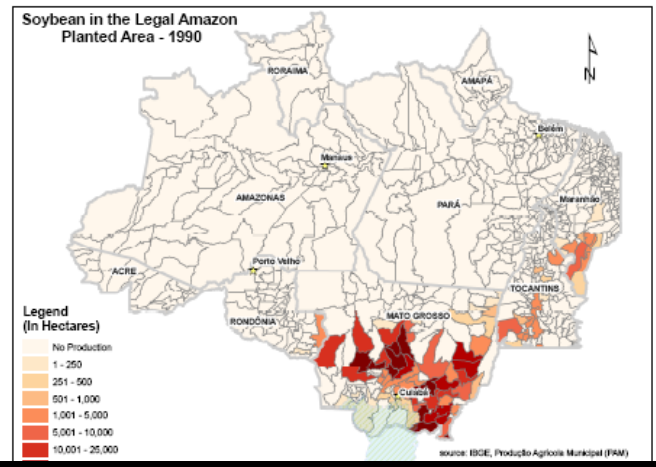
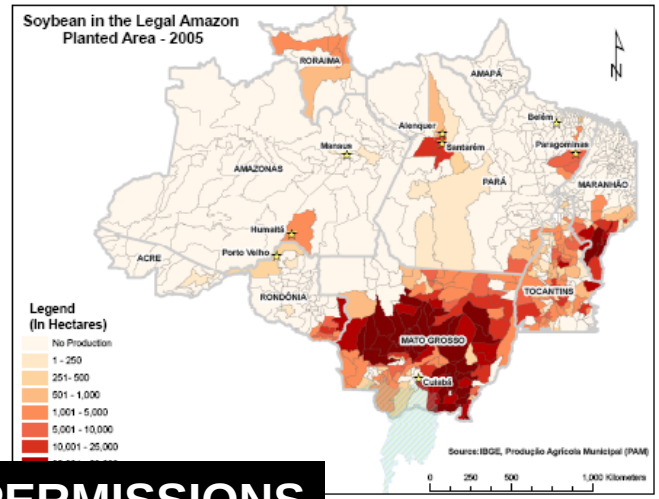


HALF OF AREA DEFORESTED IN BRAZILIAN AMAZON OCCURS IN LESS THAN 5% OF CLEARINGS

(data from INPE)

IS SOY EXPANSION PUSHING CATTLE RANCHING FURTHER INTO FRONTIER?

	1990	2005
PASTURE		
SOY		

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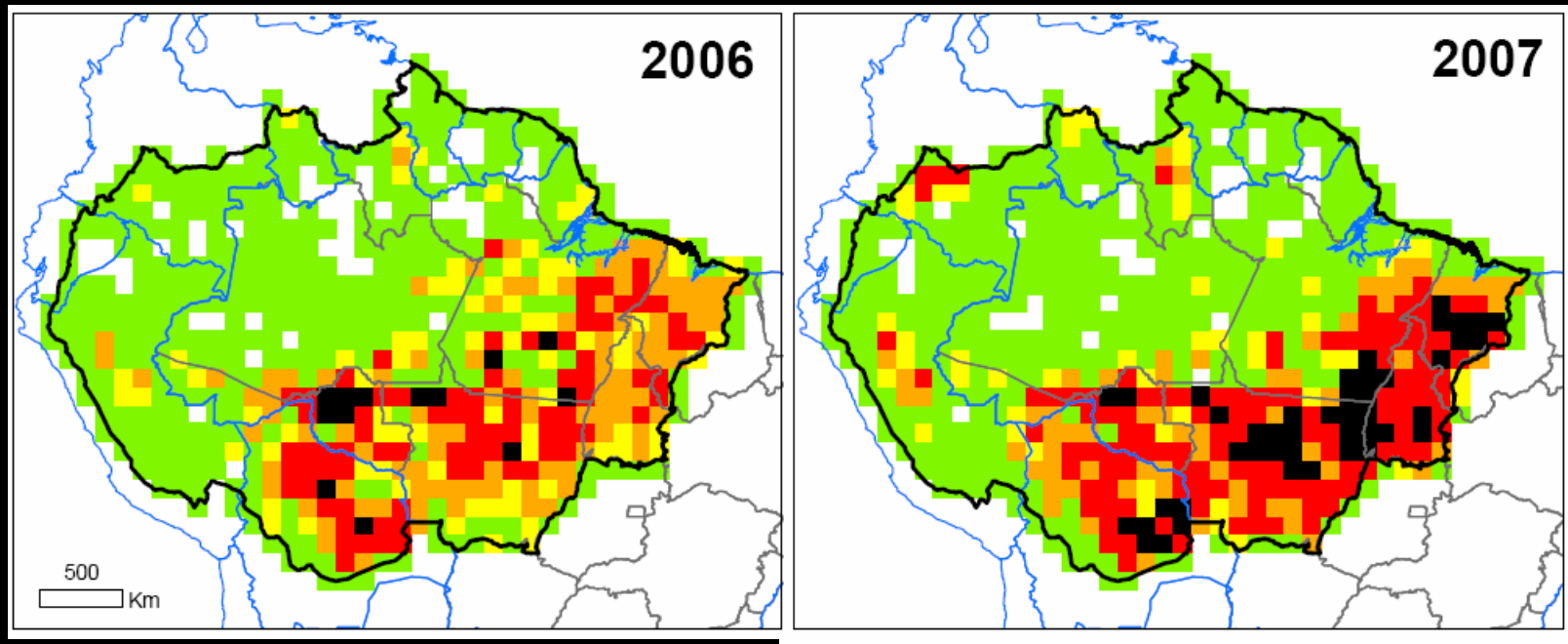
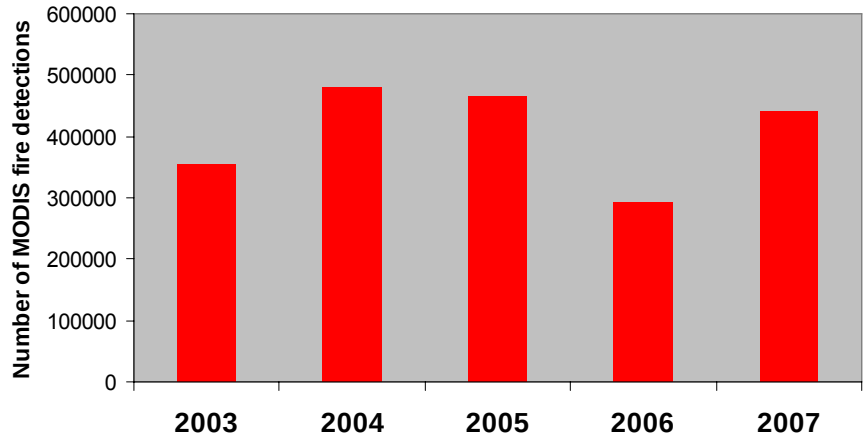
Census data compiled by R. Walker, Michigan State U

IS THERE A POSITIVE FEEDBACK BETWEEN DROUGHT AND CLEARING?



Fires per year
- 0
- 1 - 250
- 251 - 500
- 501 - 1000
- 1000 - 2500
- > 2500



ctive fires through Nov 1, 2007)

Brazil Amazon deforestation soars

The Brazilian government has announced a huge rise in the rate of Amazon deforestation, months after celebrating its success in achieving a reduction.

The Amazon has long been known as the "lungs of the world"

In the last five months of 2007, 3,235 sq km (1,250 sq miles) were lost.

Gilberto Camara, of INPE, an institute that provides satellite imaging of the area, said the rate of loss was unprecedented for the time of year.

Officials say rising commodity prices are encouraging farmers to clear more land to plant crops such as soya.

See map of worst affected areas

The monthly rate of deforestation saw a big rise from 243 sq km (94 sq miles) in August to 948 sq km (366 sq miles) in December.

"We've never before detected such a high deforestation rate at this time of year," Mr Camara said.

His concern, outlined during a news conference in Brasilia on Wednesday, was echoed by Environment Minister Marina Silva.

Expensive soya

Ms Silva said rising prices of raw materials and commodities could be spurring the rate of forest clearing, as more and more farmers saw the Amazon as a source of cheap lan

"The economic reality of these states indicate that these activities impact, without a shadow of a doubt, on the forest," she said.

DEFORESTATION INCREASED IN 2007 IN BRAZIL

BBC News, Jan 24, 2008

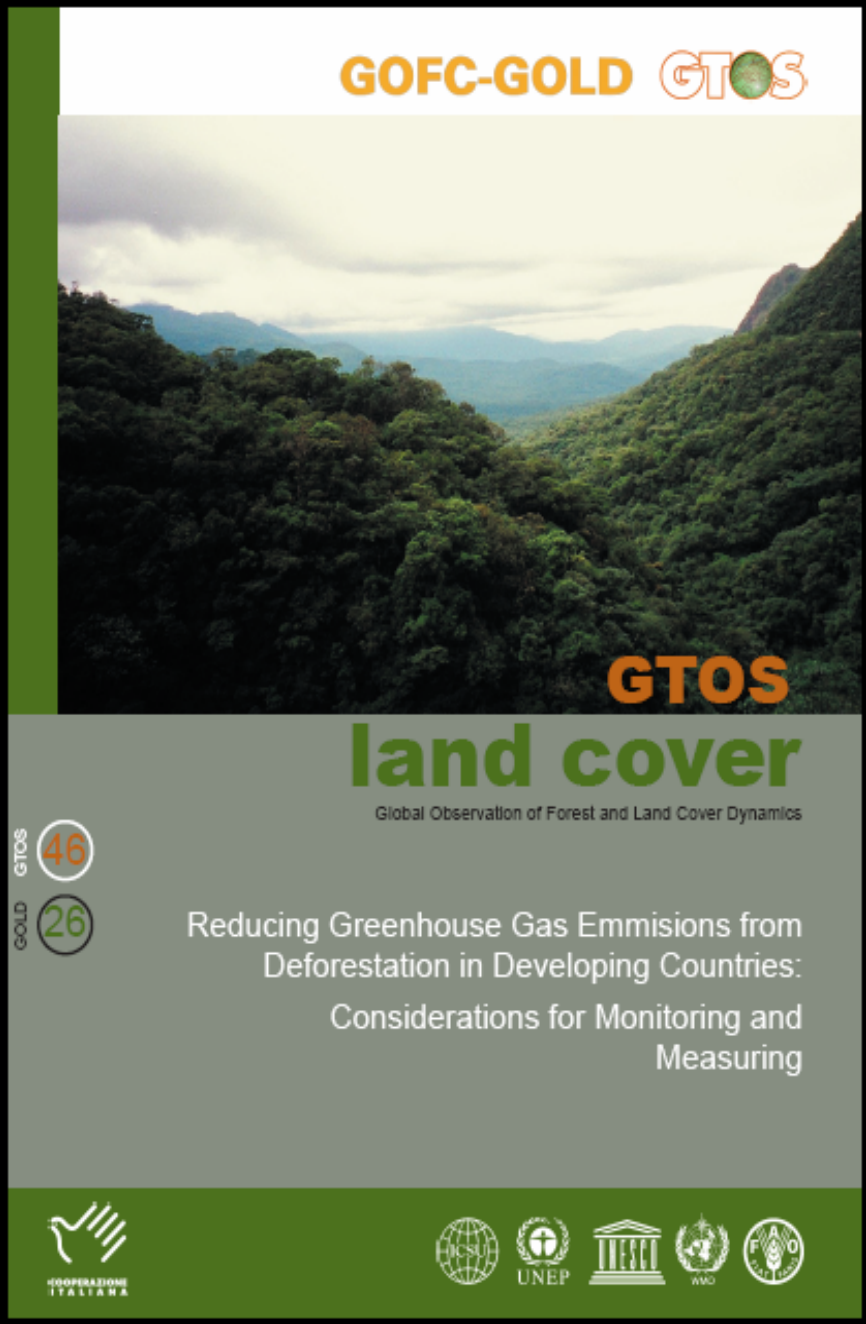
THE POLICY PERSPECTIVE

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE FOURTH ASSESSMENT REPORT

Table 7.2. *Land to atmosphere emissions resulting from land use changes during the 1990s and the 1980s (GtC yr−1). The Fourth Assessment Report (AR4) estimates used in the global carbon budget (Table 7.1) are shown in bold. Positive values indicate carbon losses from land ecosystems. Uncertainties are reported as ±1 standard deviation. Numbers in parentheses are ranges of uncertainty.*

	Tropical Americas	Tropical Africa	Tropical Asia	Pan-Tropical	Non-tropics	Total Globe
1990s						
Houghton (2003a)[a]	0.8 ± 0.3	0.4 ± 0.2	1.1 ± 0.5	2.2 ± 0.6	–0.02 ± 0.5	2.2 ± 0.8
DeFries et al. (2002)[b]	0.5 (0.2 to 0.7)	0.1 (0.1 to 0.2)	0.4 (0.2 to 0.6)	1.0 (0.5 to 1.6)	n.a.	n.a.
Achard et al. (2004)[c]	0.3 (0.3 to 0.4)	0.2 (0.1 to 0.2)	0.4 (0.3 to 0.5)	0.9 (0.5 to 1.4)	n.a.	n.a.
AR4[d]	0.7 (0.4 to 0.9)	0.3 (0.2 to 0.4)	0.8 (0.4 to 1.1)	1.6 (1.0 to 2.2)	–0.02 (–0.5 to +0.5)	1.6 (0.5 to 2.7)

Large range in estimates of carbon flux from tropical land use change



Reference:

DeFries, Achard, Brown, Herold, Murdiyarso, Schlamadinger, De Souza, 2006.

Reducing GHG Emissions from Deforestation in Developing Countries: Considerations for Monitoring and Measuring.

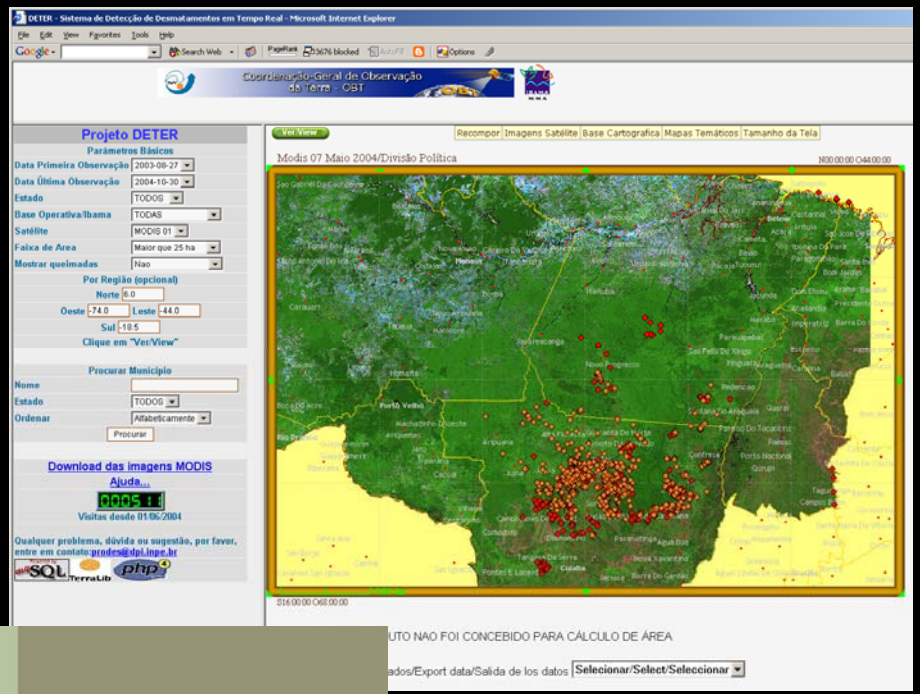
Report of the Global Terrestrial Observing System (GTOS) # 46, 23 p.

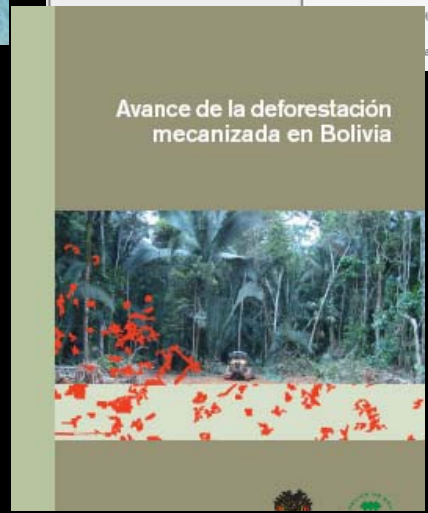
Available at: www.fao.org/gtos/pubs.html

Bottom Line Conclusions on Technical Aspects of REDD

- Various methods are available and appropriate to measure change in forest cover at national level
  - *Caveat: constraint of access to high resolution data and national capacity for analysis*
  - *National examples exist*
- Forest degradation important but more challenging
- Carbon stock estimates and dynamics more uncertain but existing IPCC guidelines can be applied

Some national forest monitoring systems are in place in tropical countries





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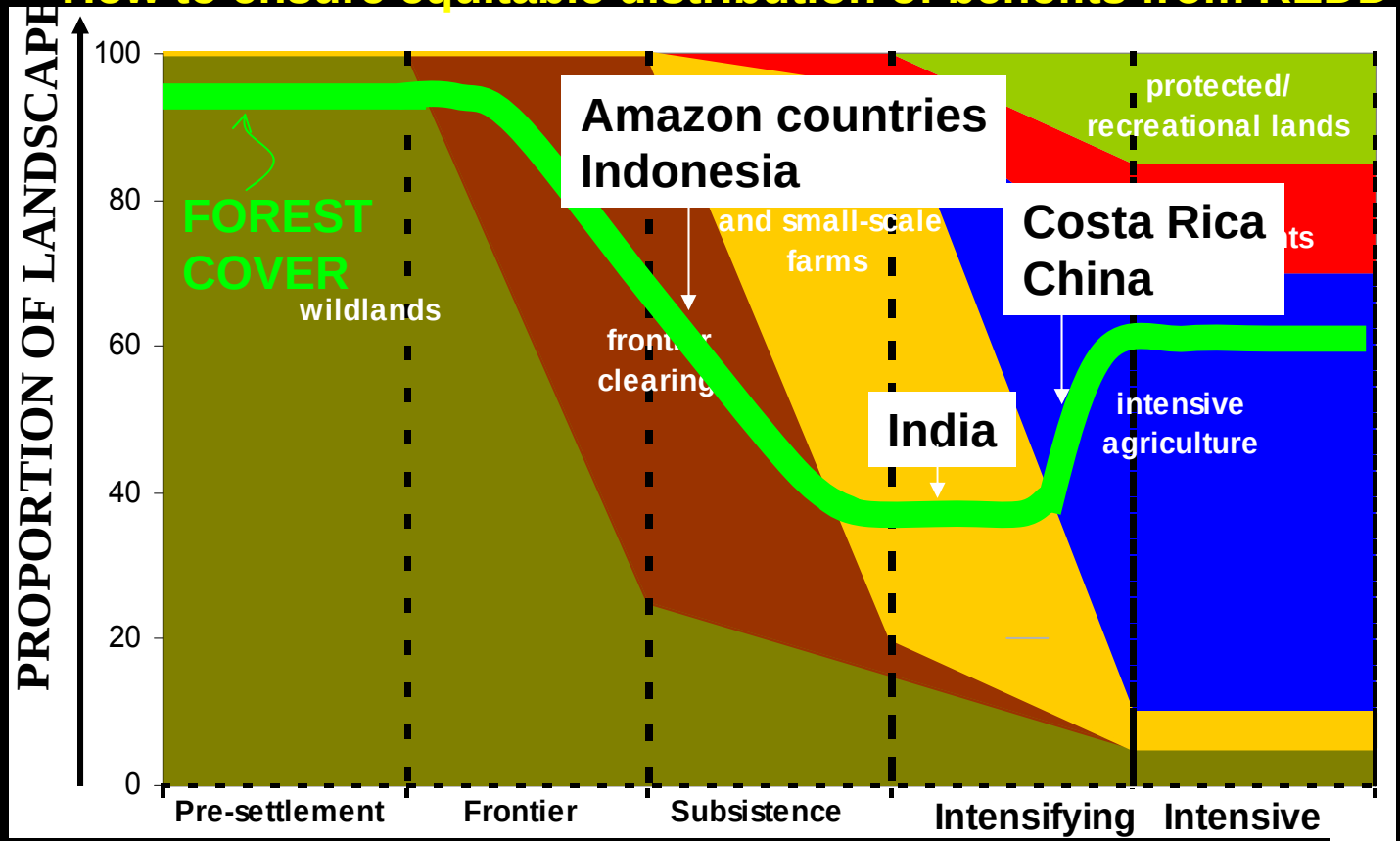
- Should forest degradation be included in REDD?
- Should countries get credit for reforestation and afforestation?
- What is the baseline reference period?
- Market mechanism or fund?
- How to ensure permanence?
- How to ensure against international leakage?
- How to promote co-benefits?
- How to ensure equitable distribution of benefits from REDD?



Conclusions

- **Changing dynamic towards mechanized production increasing per area C emissions from deforestation**
- **Open science questions**
  - ***Feedbacks***
  - ***Relative contributions of deforestation actors***
  - ***Scaling to pan tropics***
- **Policy challenges for REDD but technically feasible**

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THANK YOU
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