Towards Methodologies for Global Monitoring of Forest Cover with Coarse Resolution Data

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Objective: To support GOFC goals to develop and demonstrate operational forest cover monitoring at regional and global scales

Approach: Apply MODIS data, in conjunction with high-resolution and *in-situ* data, to derive periodic, consistent, automated estimates of fractional tree cover

Methodology for creating continuous fields of percent tree cover

- **Inputs**
  - Global satellite data (AVHRR/MODIS/VIIRS)
 - A global network of training sites depicting percent tree cover
- **Algorithm**
  - Regression tree used to estimate percent cover per pixel
- **Strengths of approach**
  - Synoptic, internally consistent estimate of global percent tree cover
  - Per pixel estimates of percent cover allow for improved depictions of heterogeneous regions
  - Direct comparisons with subsequent maps for monitoring change in forest cover
  - Approach is fully operational where no post-processing is involved
  - Use field data to improve calibration of algorithm as well as in validating/evaluating initial products

MODIS 500 meter percent tree cover map 2001

Percent
Tree Canopy
Cover

0

100
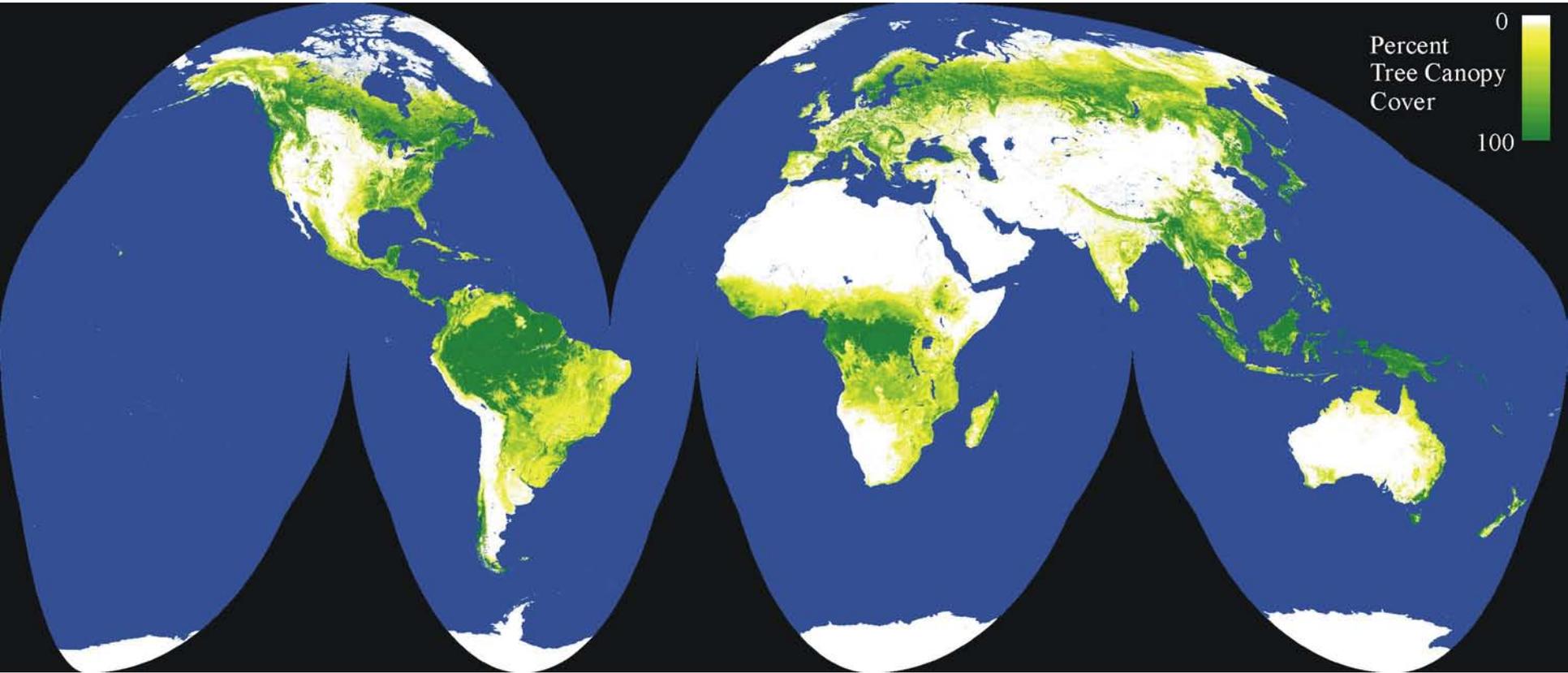
AREA OF FOREST DEPENDS ON DEFINITION

FAO definition of forest = 10%, other definitions abound
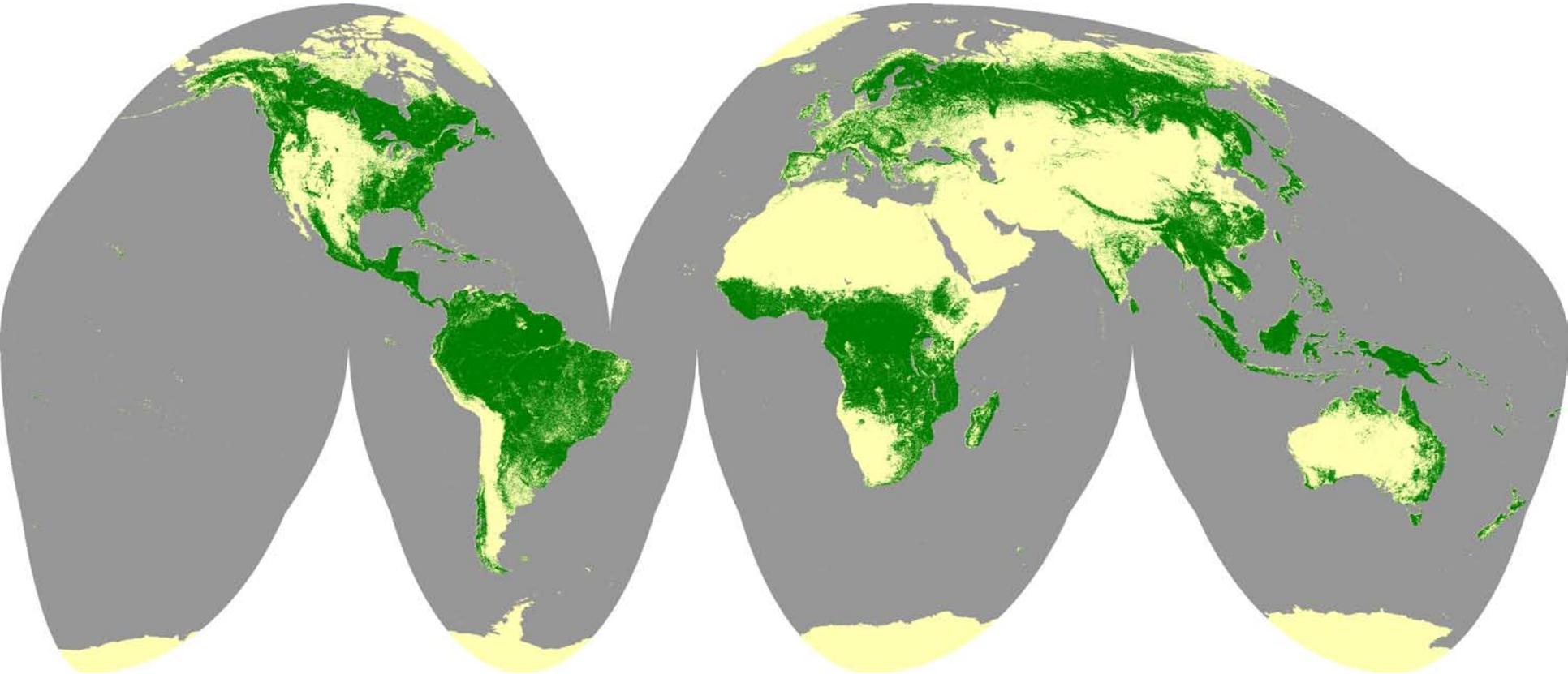
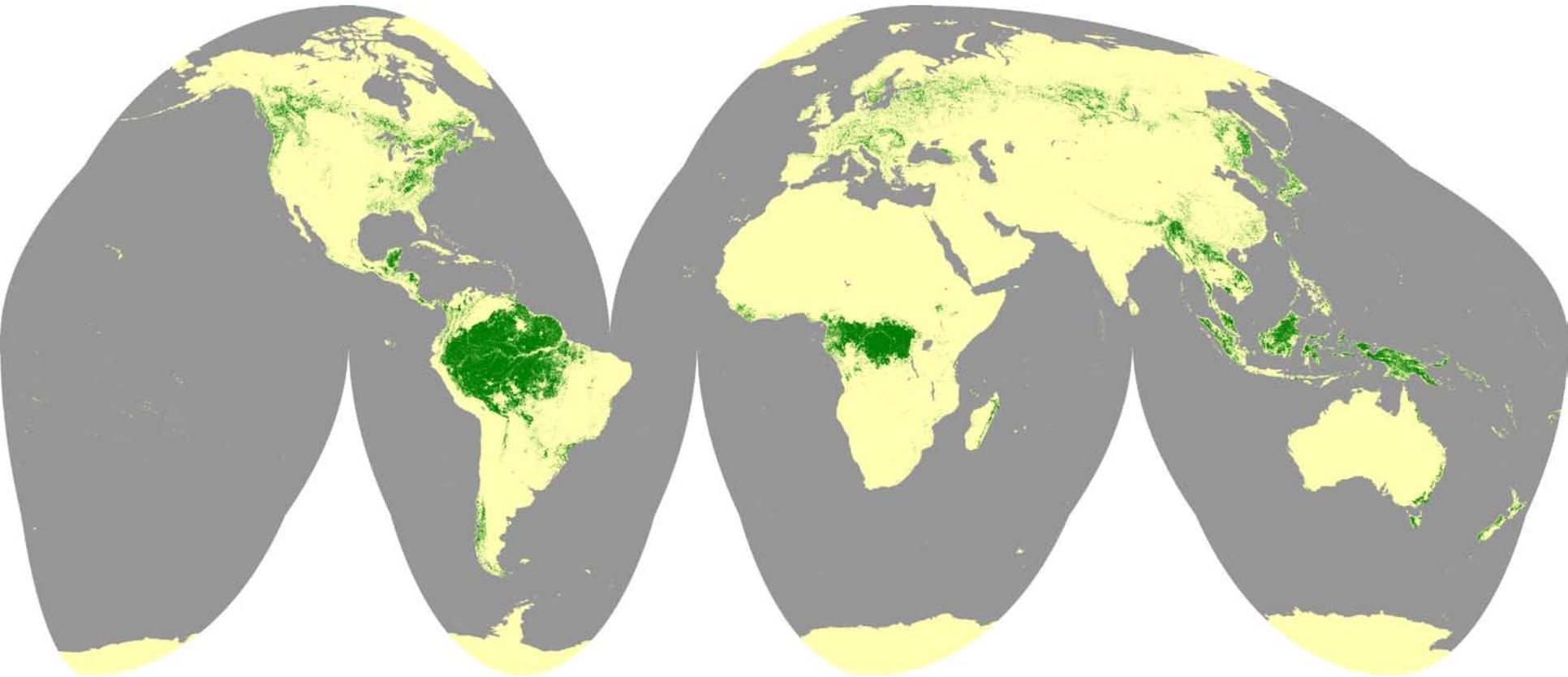0%   100%

Applied tree cover threshold
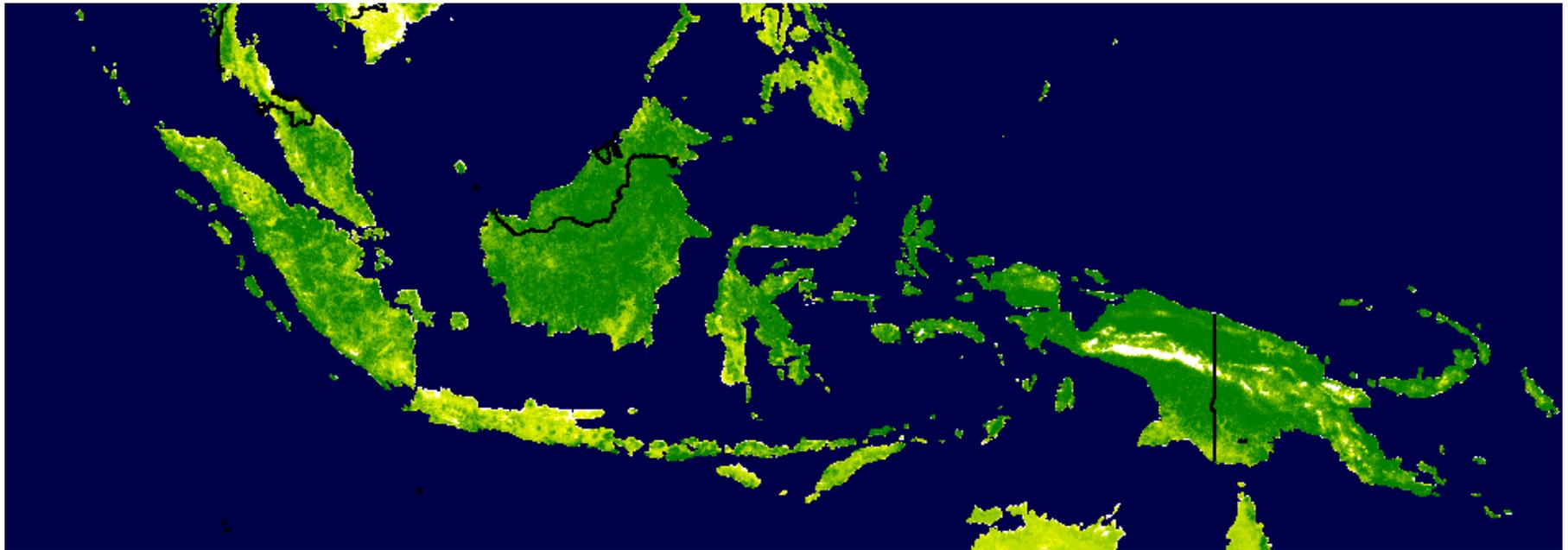
Variable definition of forest cover from MODIS data

0% 100%

Applied tree cover threshold

PERCENT TREE COVER TO DETECT CHANGE

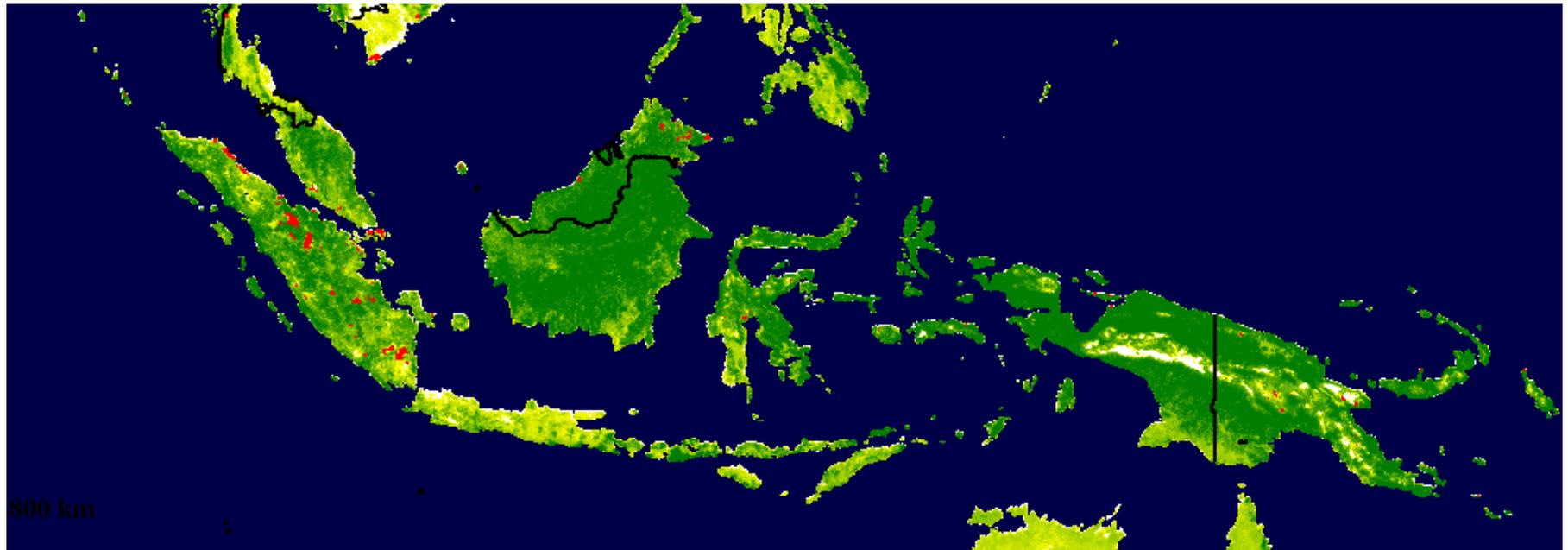## Insular Southeast Asia Percent Tree Cover 1984 from 8km AVHRR data

Tree cover

0%

1000 km

100%

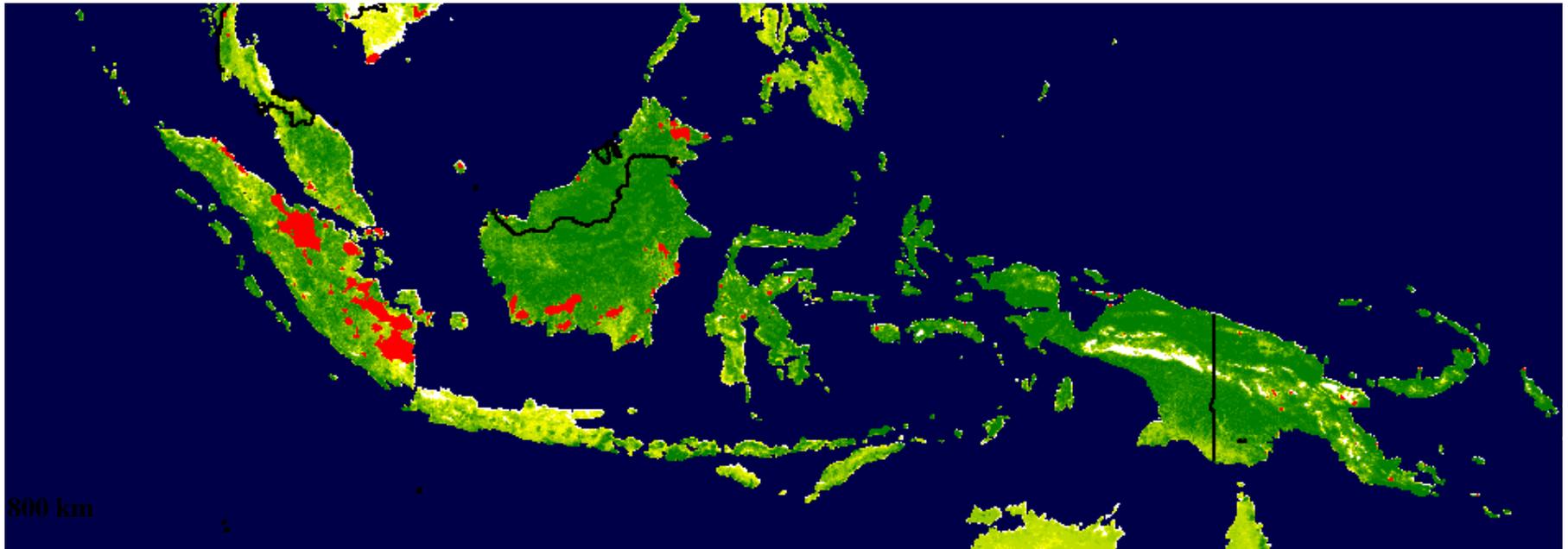# Insular Southeast Asia Percent Tree Cover 1990
from 8km AVHRR data

Tree cover

0%

800 km

1000 km

100%

Insular Southeast Asia Percent Tree Cover 1997
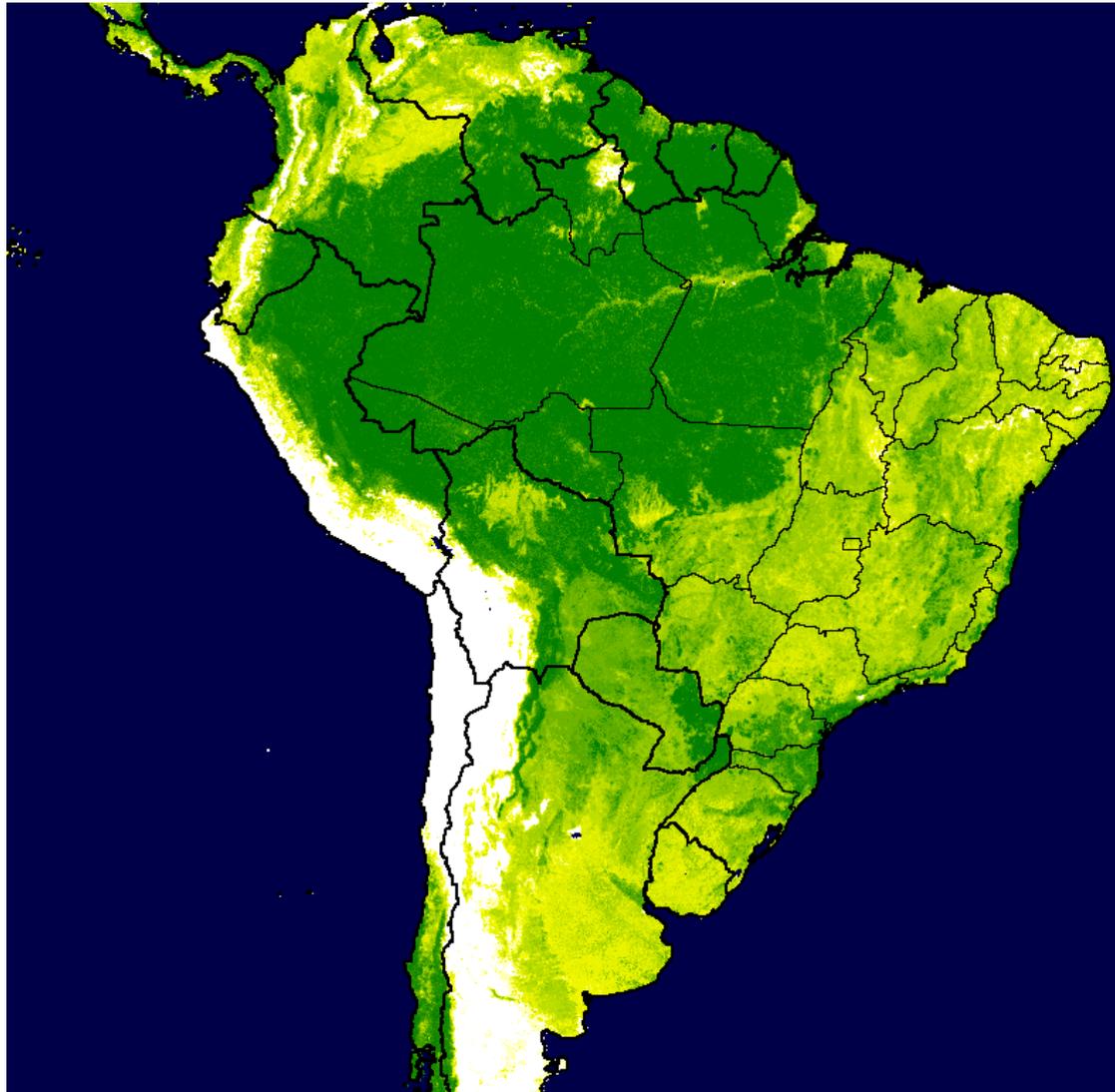# from 8km AVHRR data

800 km

Tree cover

0%

1000 km

100%

For Tropical Asia, a 58% increase in the rate of forest loss from the 80's to 90's, from 14000 to 23000 km²/yr

South America Percent Tree Cover 1984 from 8km AVHRR data
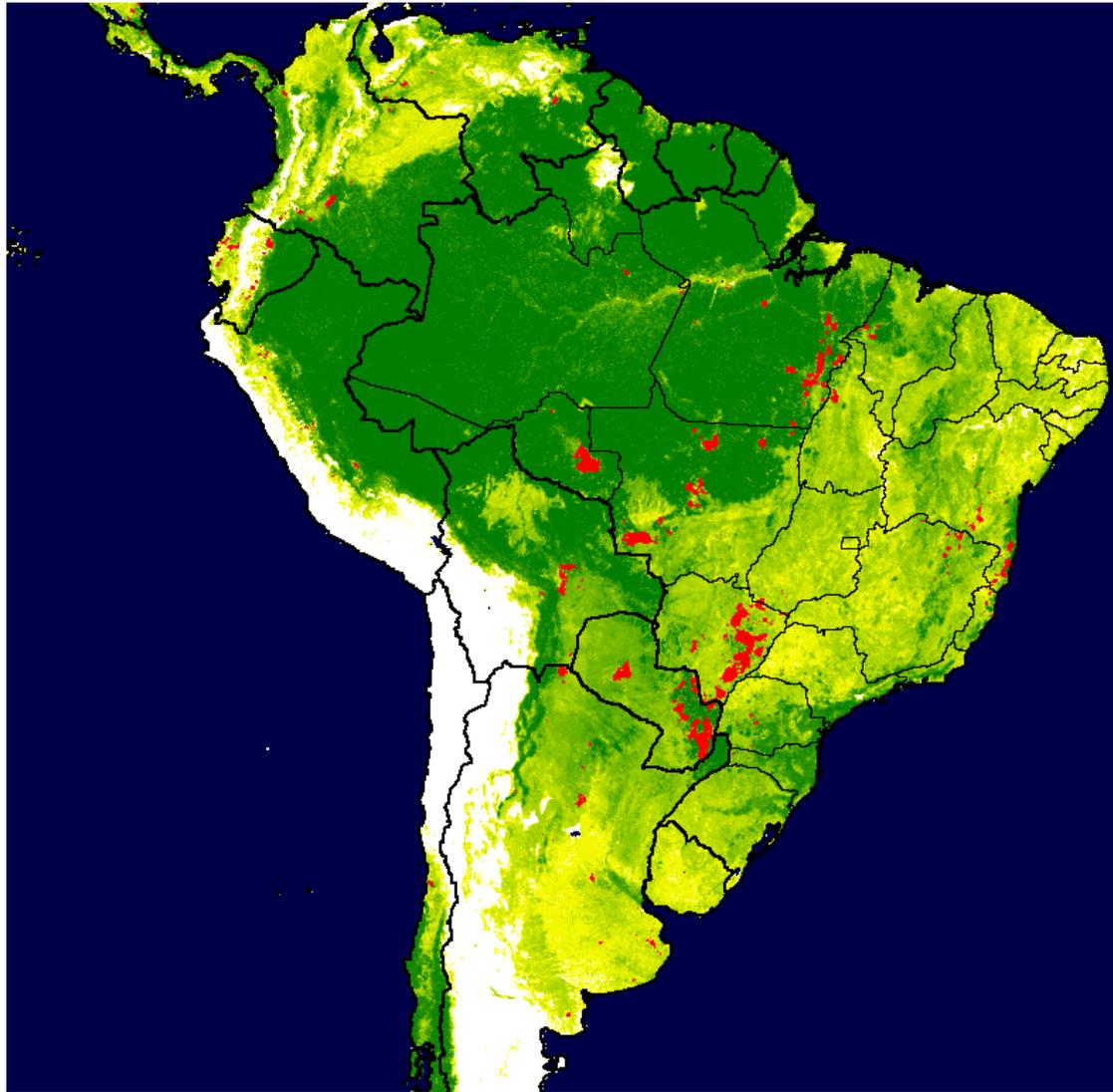

800 km

Tree cover

0%

100%

South America Percent Tree Cover 1990
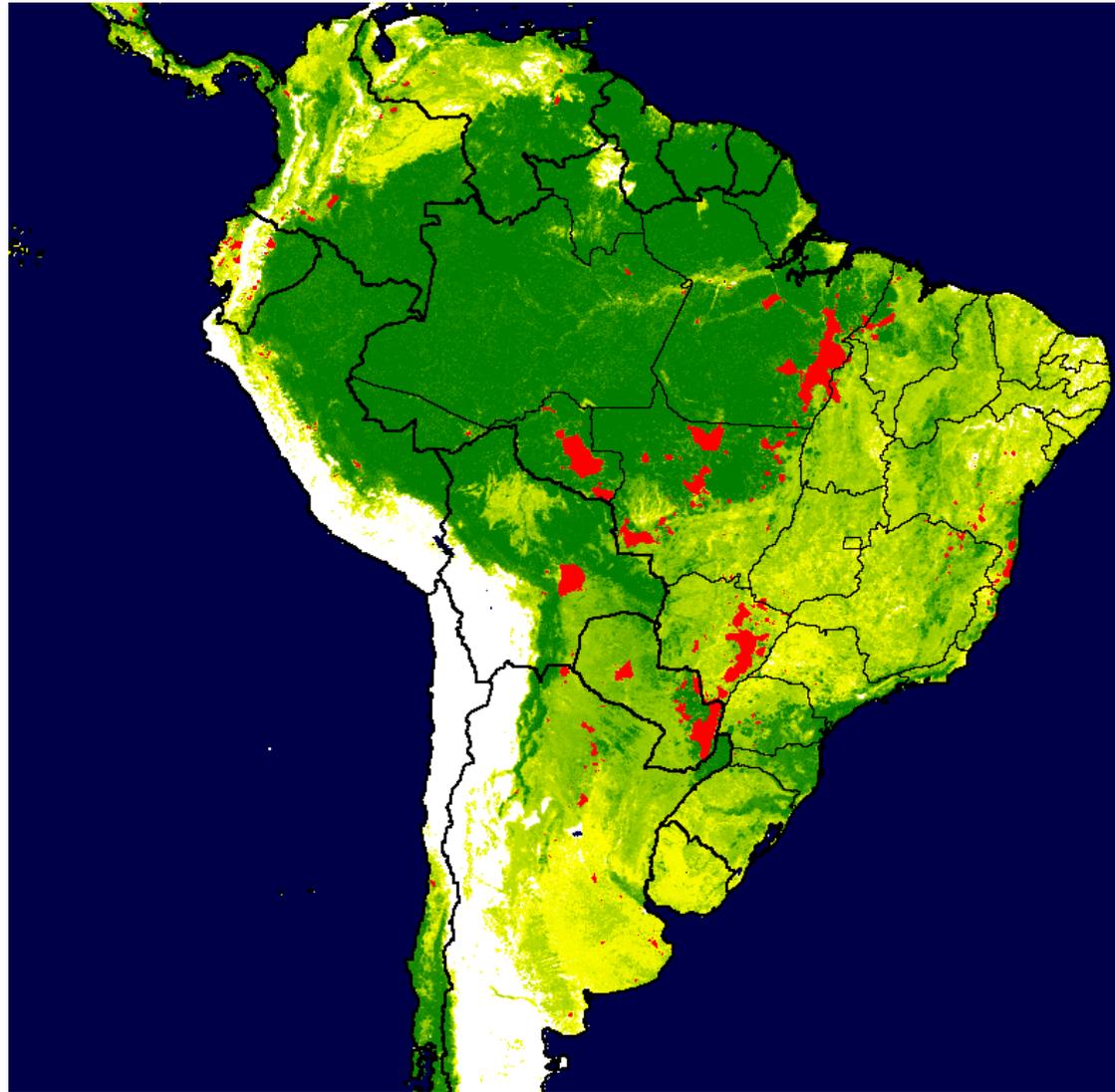# from 8km AVHRR data

800 km

Tree cover

0%

100%

= deforestation 1984-1990

South America Percent Tree Cover 1997
## from 8km AVHRR data

800 km

Tree cover

0%

100%

For Latin America, no change in rate of clearing from 80's to 90's, rate = ~40000km²/yr

= deforestation 1984-1997

UNIVERSITY OF MARYLAND

Comparison of net tree cover change from AVHRR and FAO Forest Resource Assessment data for 1980-2000.

	8km annual change estimate in 1000's of ha/yr		FRA annual change estimate in 1000's of ha/yr	
	80-90	90-00	80-90	90-00
Latin America	-4033 (-3746 to -4497)	-3909 (-3924 to -3883)	-7407	-4669
Tropical Africa	131 (-11 to 838)	53 (-4 to 450)	-4164	-5296
Tropical Asia	-1459 (-1450 to -1099)	-2307 (-2219 to -1913)	-1926	-2347
Developed Pacific	-64 (-28 to 1)	-13 (-2 to -74)	-126	-367
North America	-160 (-123 to -565)	-616 (-301 to -1054)	317	388
Europe	1106 (345 to 2259)	878 (225 to 1857)	191	427
North Africa & Middle East	25 (-7 to 116)	7 (-25 to 105)	-115	60
Former Soviet Union	-951 (-1176 to 571)	-1188 (-1185 to -252)	51	740
China and Mongolia	-257 (-101 to -966)	-342 (-159 to -774)	-400	1746
Total change	-5662 (-6296 to -3342)	-7437 (-7597 to -5539)	-13579	-9318
Percent difference in rate of change in forest cover	+31% (+21% to +66%)		-31%	

Amazon Basin Percent Tree Cover from 500m MODIS data
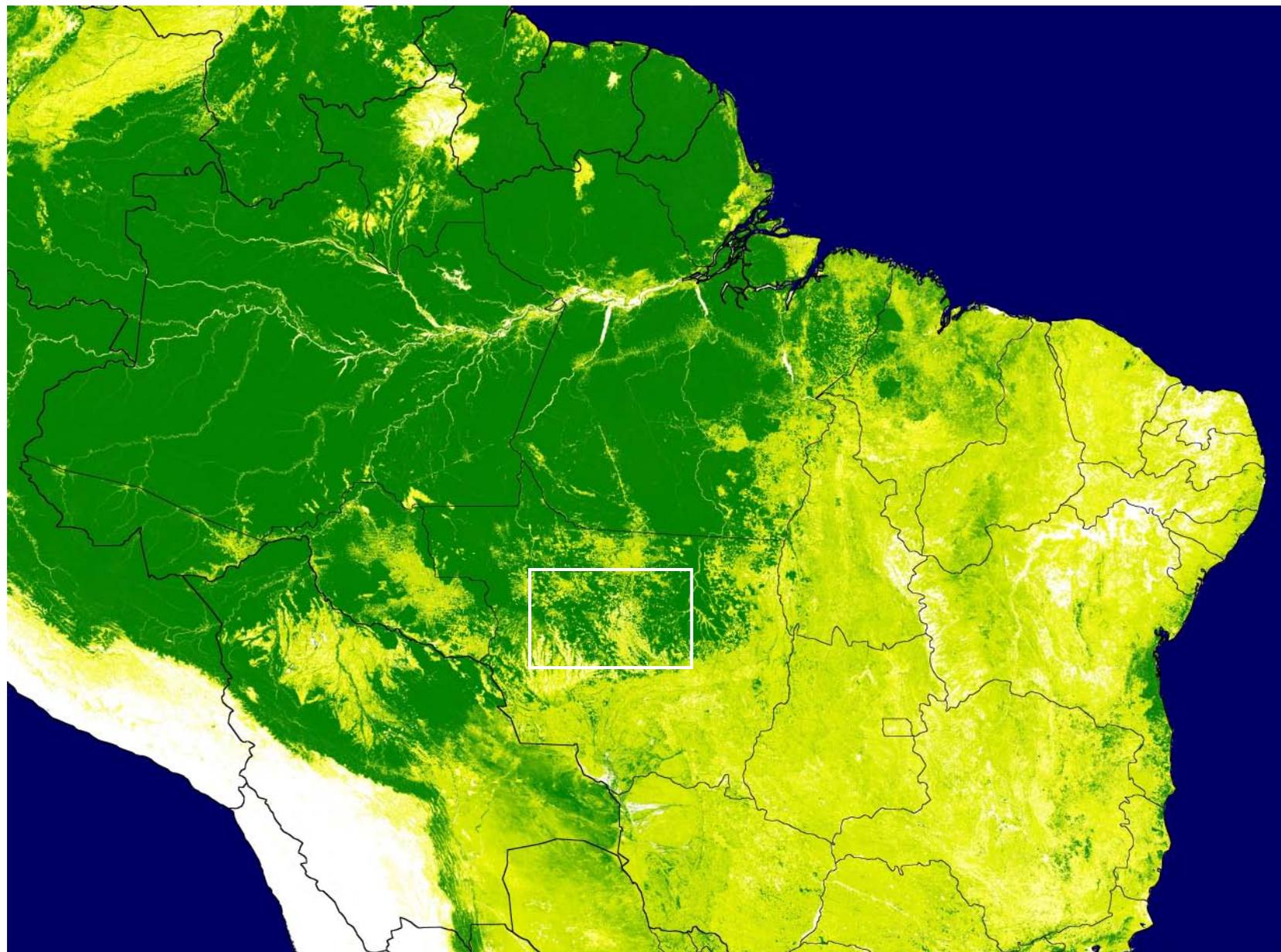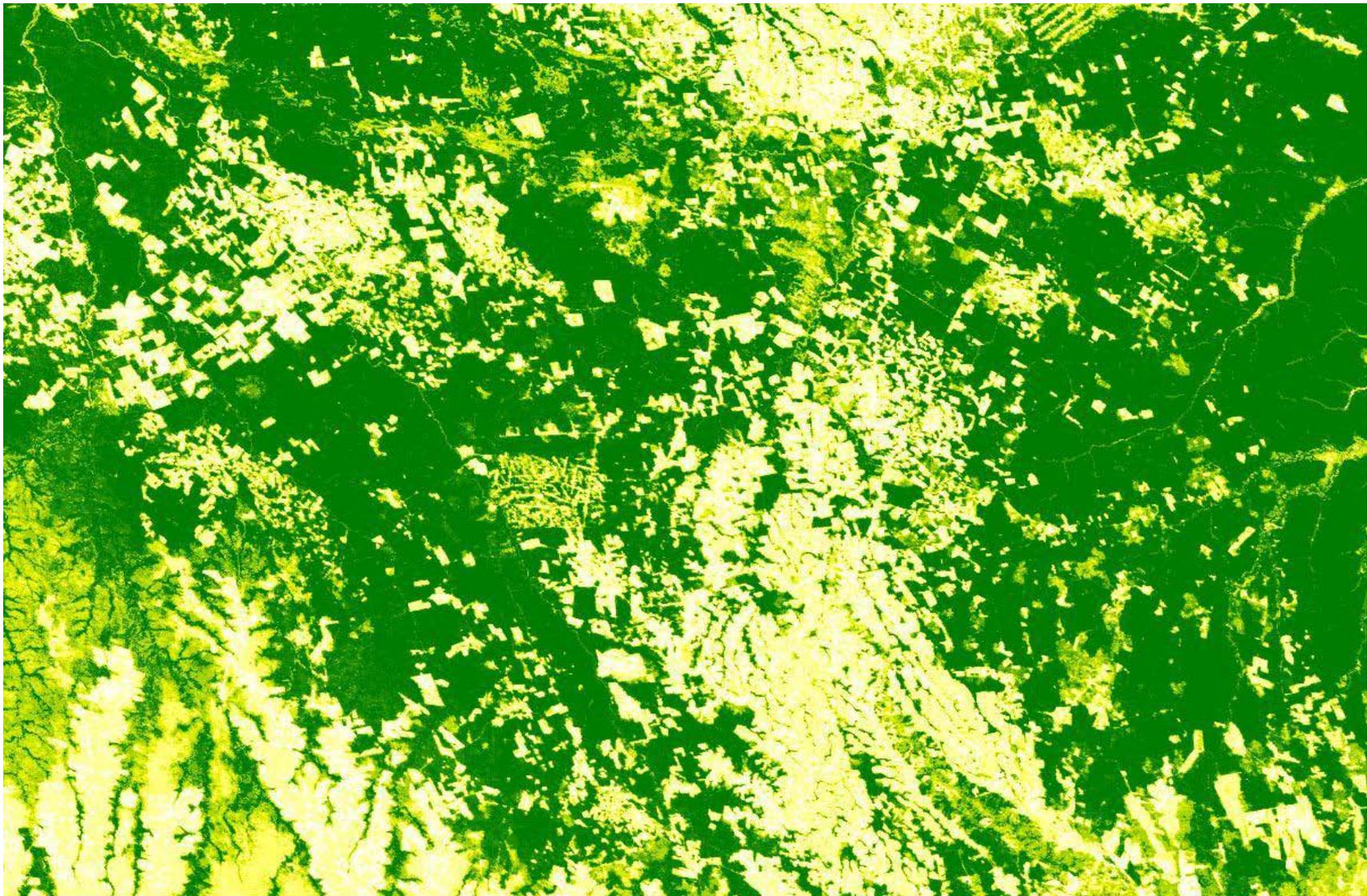
Tree cover

0%

100%

600 km

2000

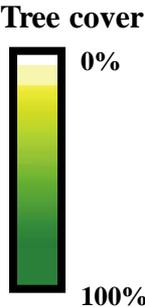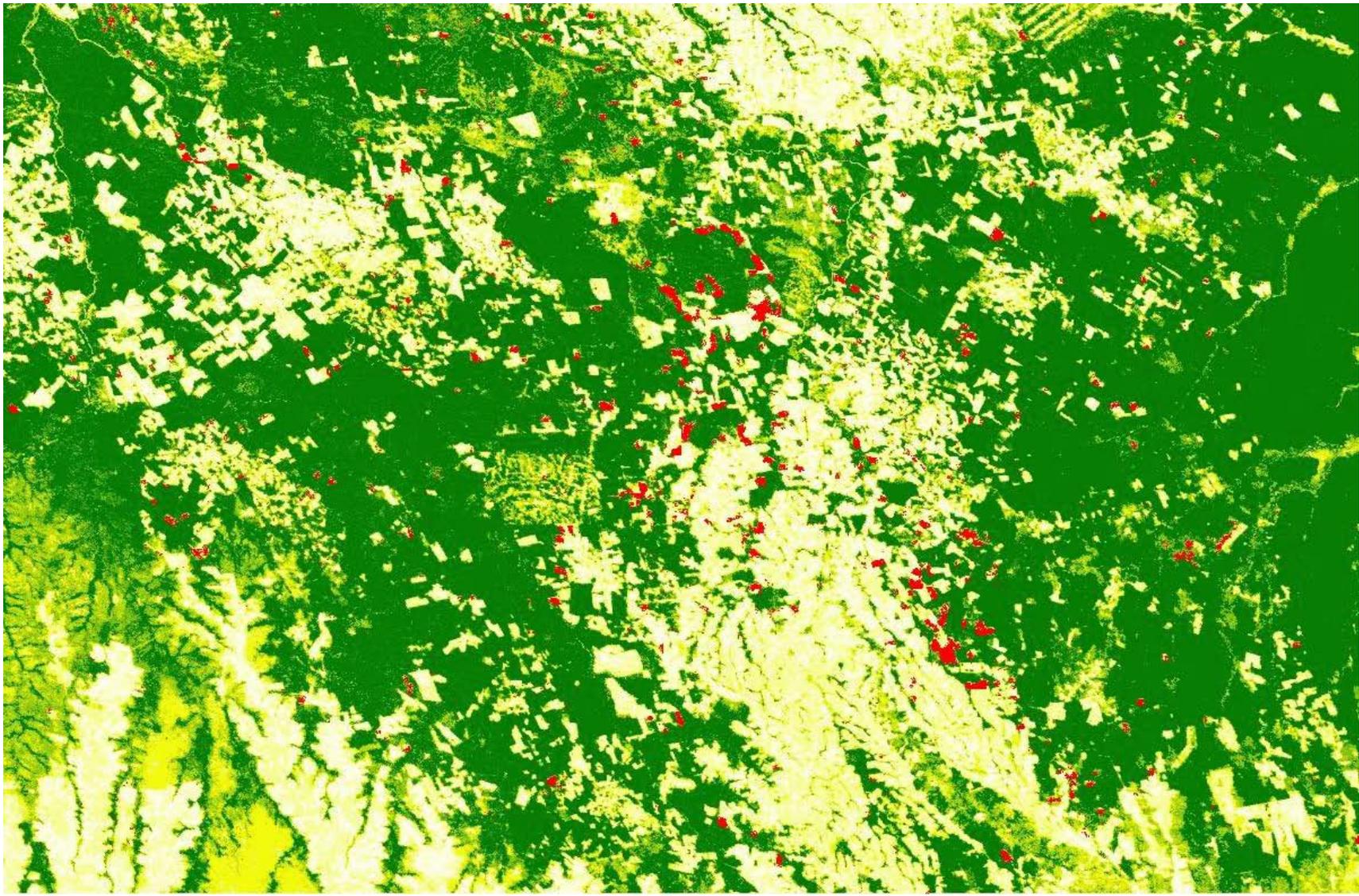# Central Mato Grosso State Percent Tree Cover from MODIS Data

Tree cover

0%

100%

75 km

2000

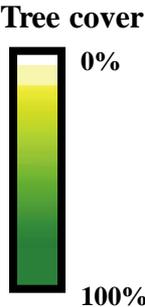**Central Mato Grosso State Percent Tree Cover from MODIS Data**

Tree cover
0%

100%

75 km

2001

■ = deforestation 2000-2001

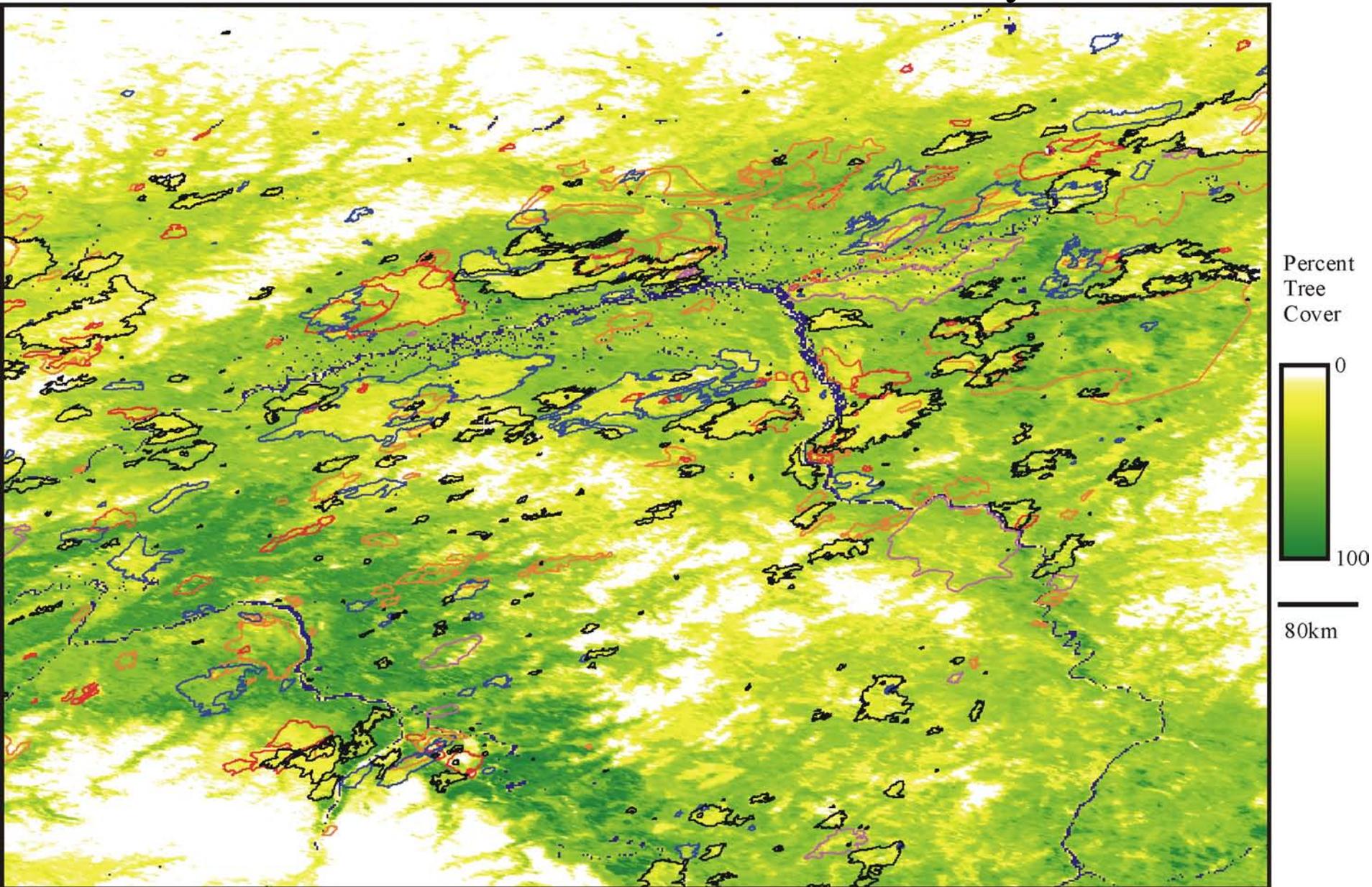# Central Mato Grosso State Percent Tree Cover from MODIS Data
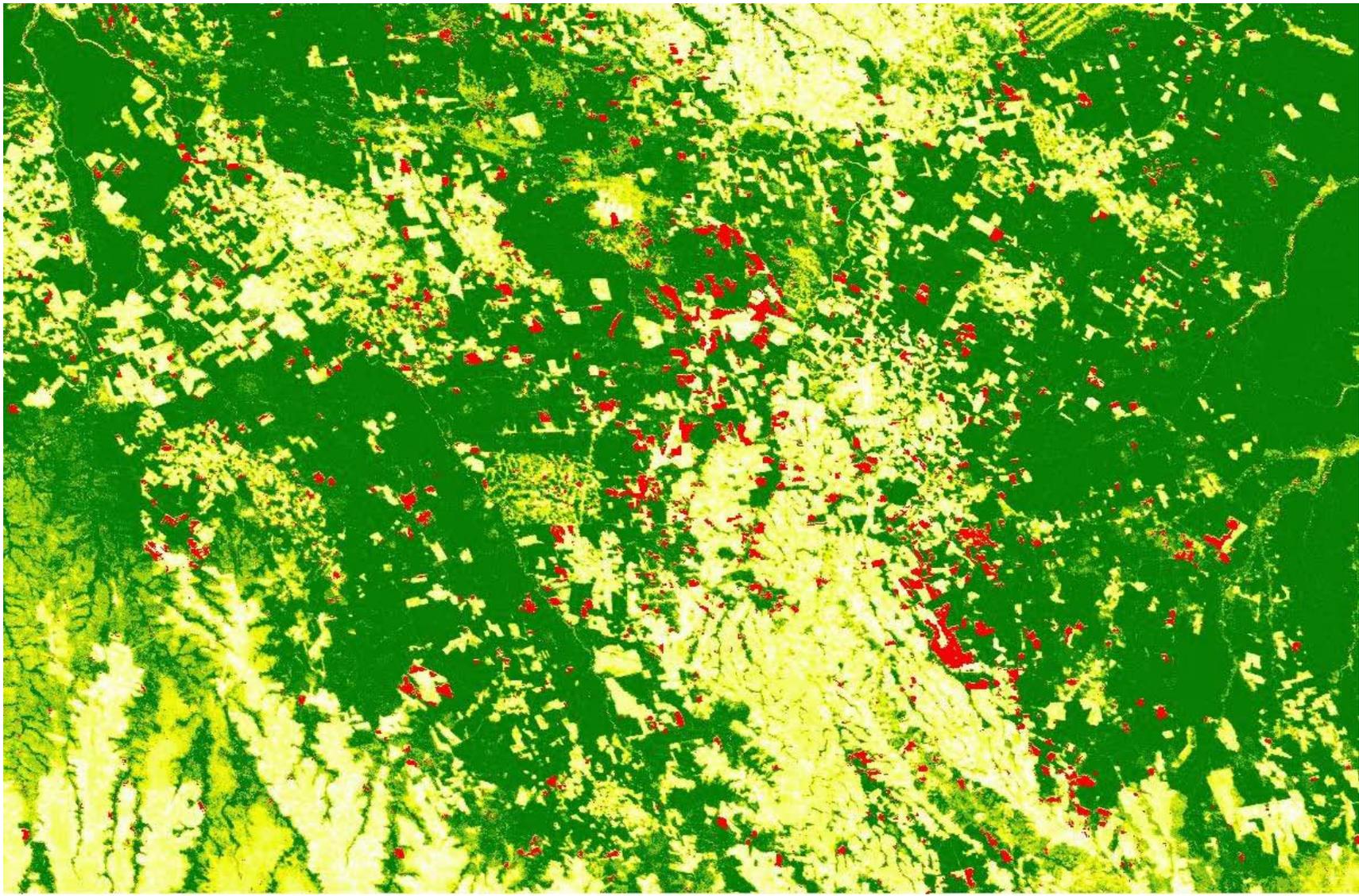
Tree cover
0%
100%

75 km

2002

= deforestation 2000-2002

Two year change=
2.8% or 6671 km²
out of ¼ million km²

MODIS tree cover data and fire history in Alaska

154.5W,68.8N

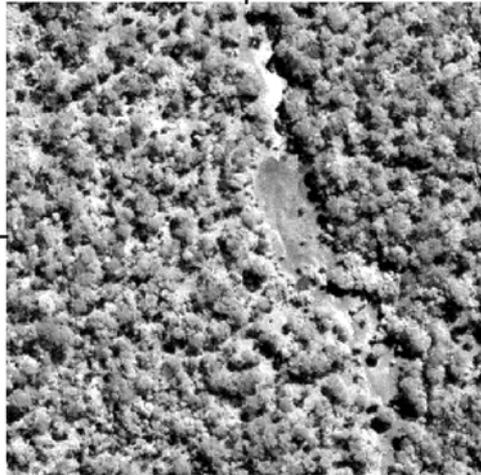Percent
Tree
Cover

0

100

80km

137.8N,63.2W

Historical burn scars shown in vector overlay
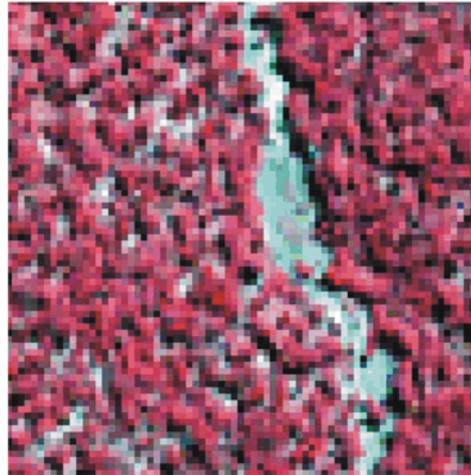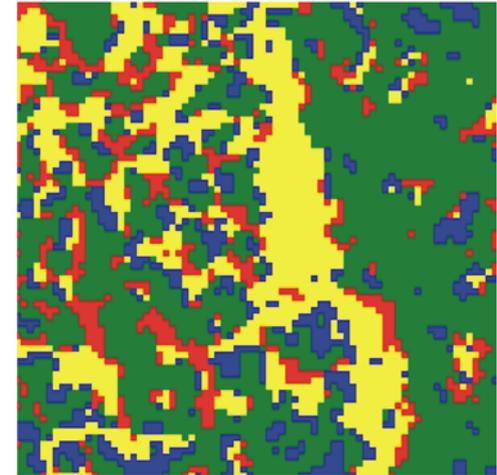Black vectors = 1990-2000, blue = 1980-90, red = 1970-80, magenta = 1960-70, orange = 1950-60

a) IKONOS pan-chromatic 1 meter data
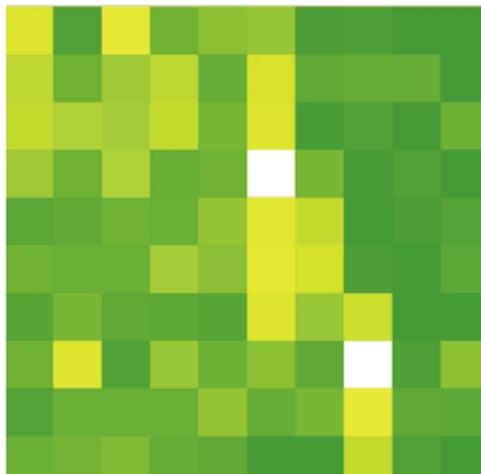
b) IKONOS false-color composite 4 meter data

c) Classified crowns,
green=crown agreement
yellow=no crown agreement
red=commission error
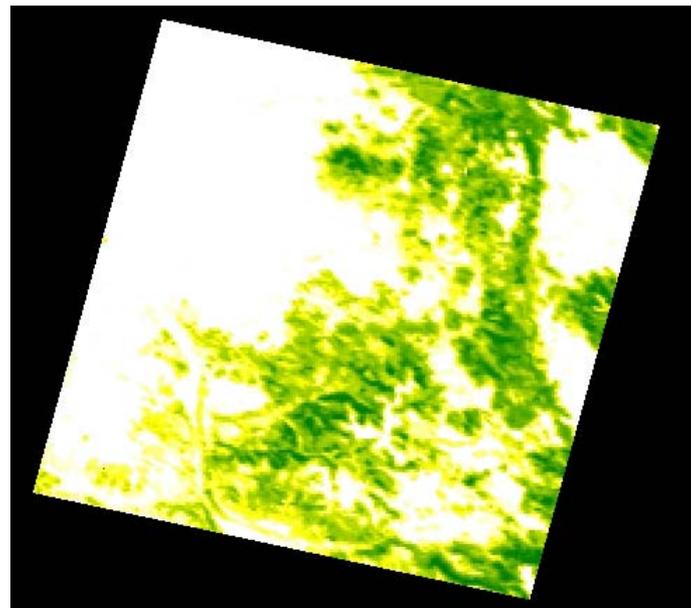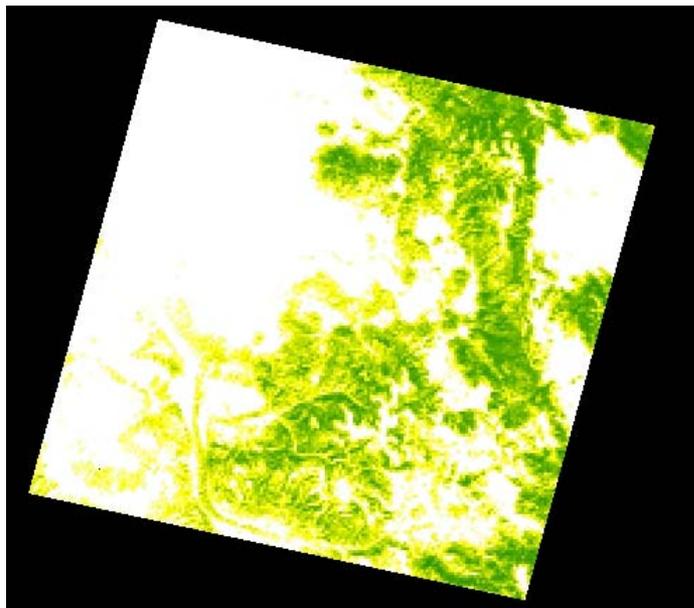blue=omission error

Tree crown cover
0%
100%

d) IKONOS training labels aggregated to 30 meters

VALIDATION:
nested field, IKONOS and ETM+ to calibrate/validate MODIS percent tree cover maps
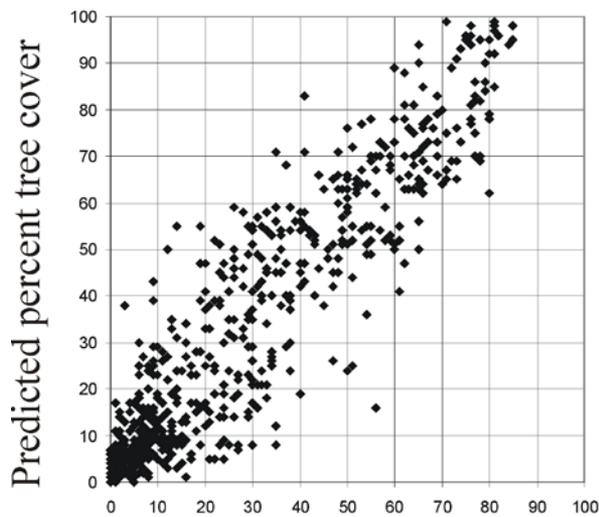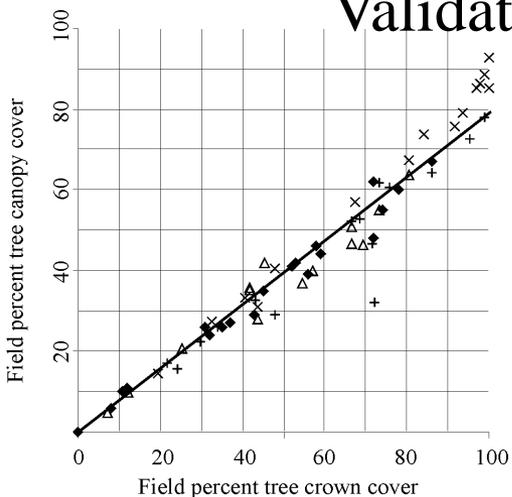
Example from Colorado, USA

path/row 035/032

Validation data

MODIS 500 meter map

30 km

Field percent tree canopy cover vs. Field percent tree crown cover
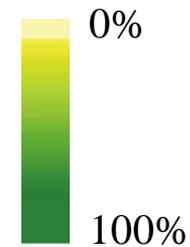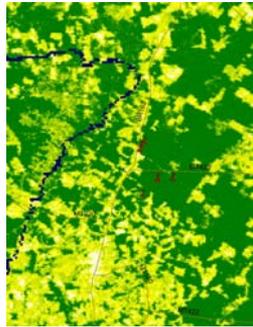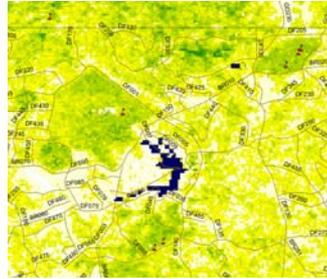
◆ WRS 035/032 Colorado, USA
+ WRS 042/034-36 California, USA
△ WRS 175/070-71 Western Province, Zambia
✕ WRS 046/027-29 Pacific Northwest, USA

Predicted percent tree cover vs. Validation percent tree cover

Tree cover

0%

100%

Mato Grosso

Federal District
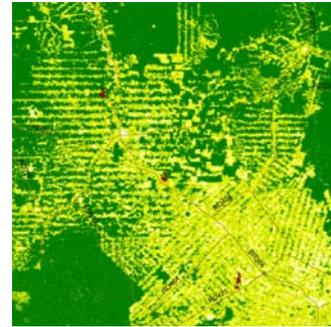
Rondônia

2003 Field Sites for VCF calibration in Amazonia

MODIS VCF 2001 and Field Data Comparison

$y = 0.687x + 13.628$

$R^2 = 0.7329$

MODIS VCF 2001 % Tree Cover

Field Measurements % Tree Cover
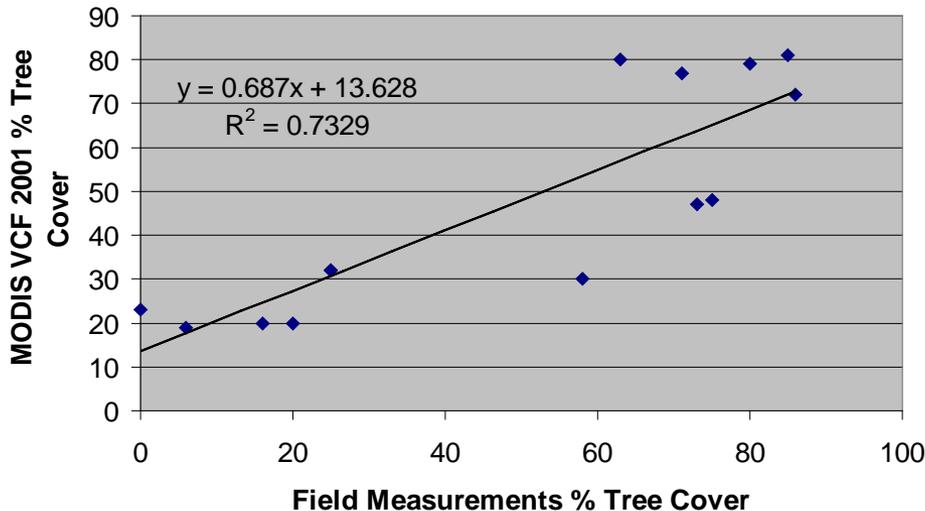
Example of field-derived cover compared directly with 500 meter MODIS percent tree cover estimate

# Evaluation of MODIS 500 meter percent tree canopy cover map

Standard error of estimate as a function of percent tree cover strata

	<=10%	11-40%	41-60%	>60%	Overall
Training data	10.3	17.6	18.3	14.5	15.6
Validation sites	8.1	13.1	13.8	11.9	11.5

Tree canopy cover is defined as the percent of skylight intercepted by vegetation greater than or equal to 5 meters in height.

Results indicate higher accuracies in areas of extreme low and high cover. Training accuracies may overstate error due to reliance on ancillary data of widely ranging reliability in creating the global percent cover training data set.

What do we know now that we didn't know before?
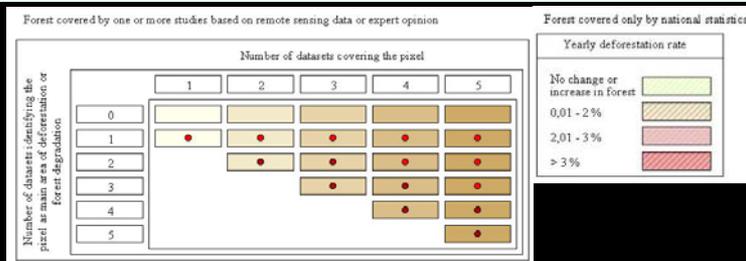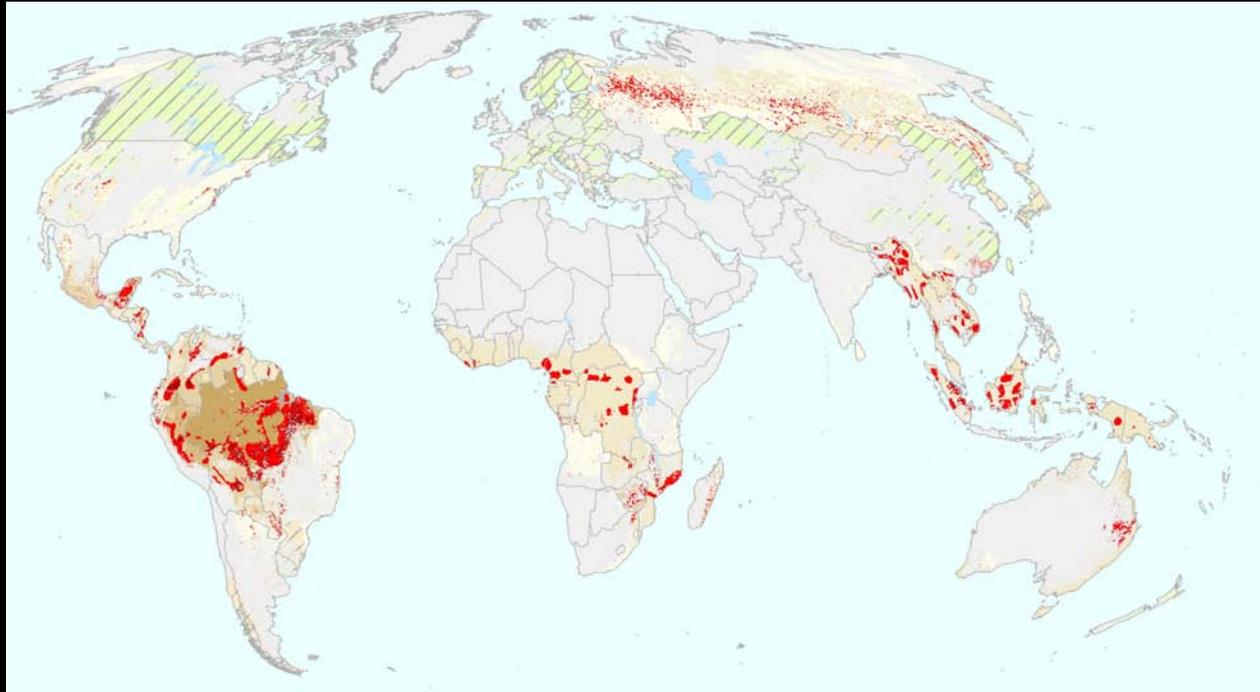
Main areas of deforestation 1980-2000: Synthesis for Millennium Ecosystem Assessment

# What do we know now that we didn't know before?

Science magazine

ECOLOGY:
U.N. Report Suggests Slowed Forest Losses

Erik Stokstad

A comprehensive survey of the world's forests, released last week by the United Nations (U.N.), suggests that global rates of forest loss decreased in the 1990s. But the ink was barely dry on the report before the World Resources Institute (WRI), a think tank in Washington, D.C., disputed that conclusion. "We need good news about the world's forests," says Dirk Bryant, who directs WRI's forest program. "But this is definitely not it."
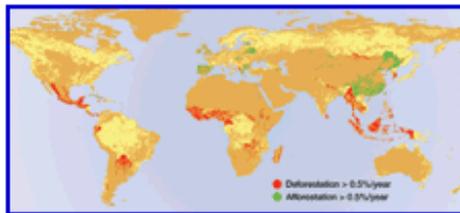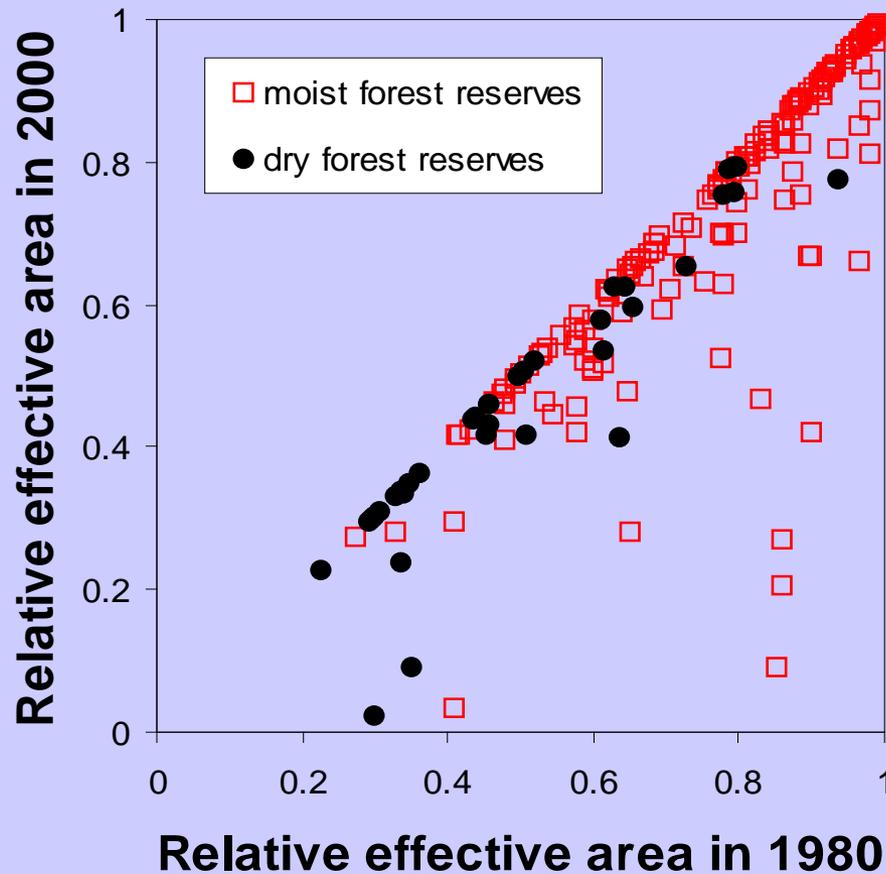
Extremes. Forests (yellow) are colored red where deforestation was especially high during the 1990s.

23 March 2001, p. 2294.

Satellite-derived estimates indicate increase in deforestation rates from 80s to 90s rather than decrease

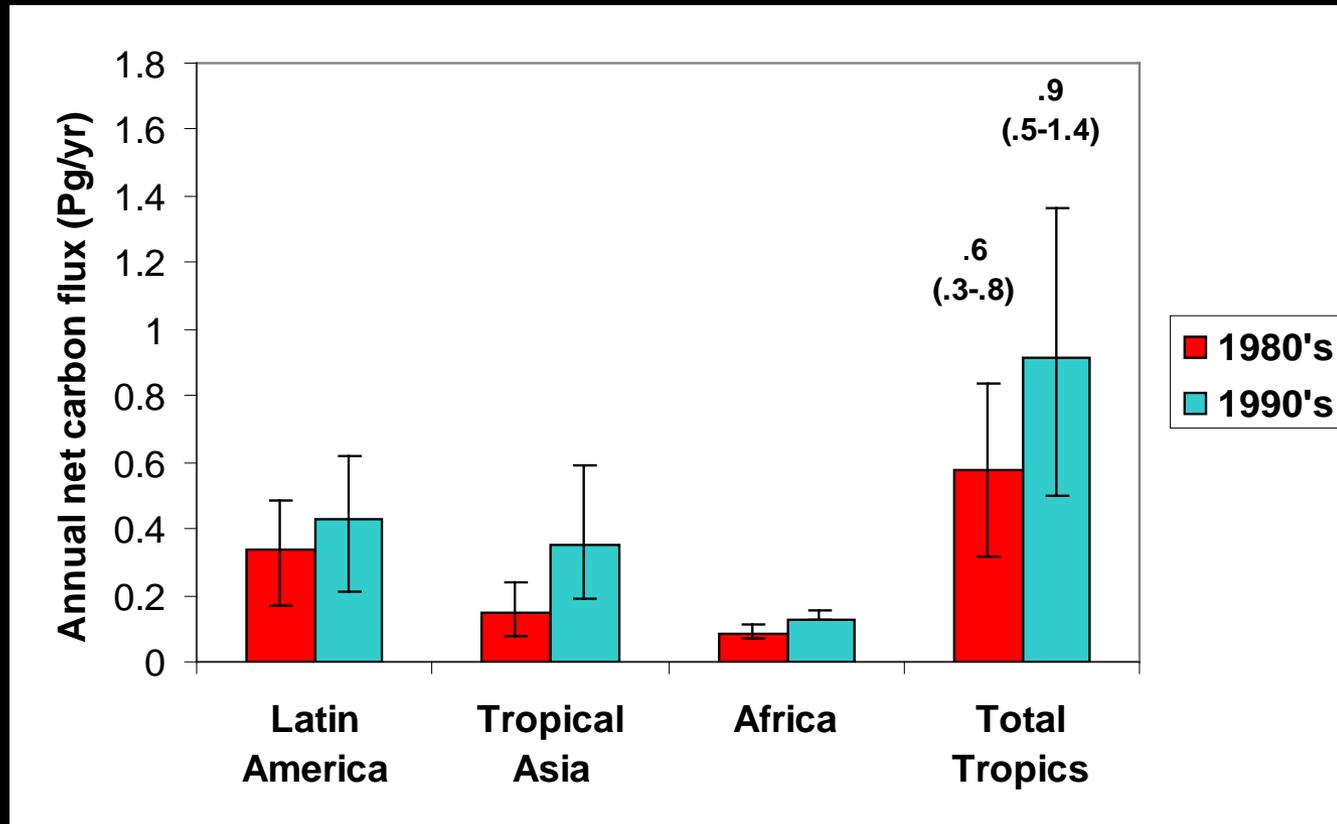# What do we know now that we didn't know before?

Relative effective area = forest area inside and in 50 km buffer around reserve at time t relative to area of intact forest
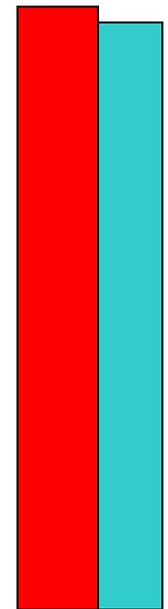
DeFries et al., submitted

~70% of highly protected areas throughout tropical forests lost surrounding forest habitat in last 20 years

What do we know now that we didn't know before?
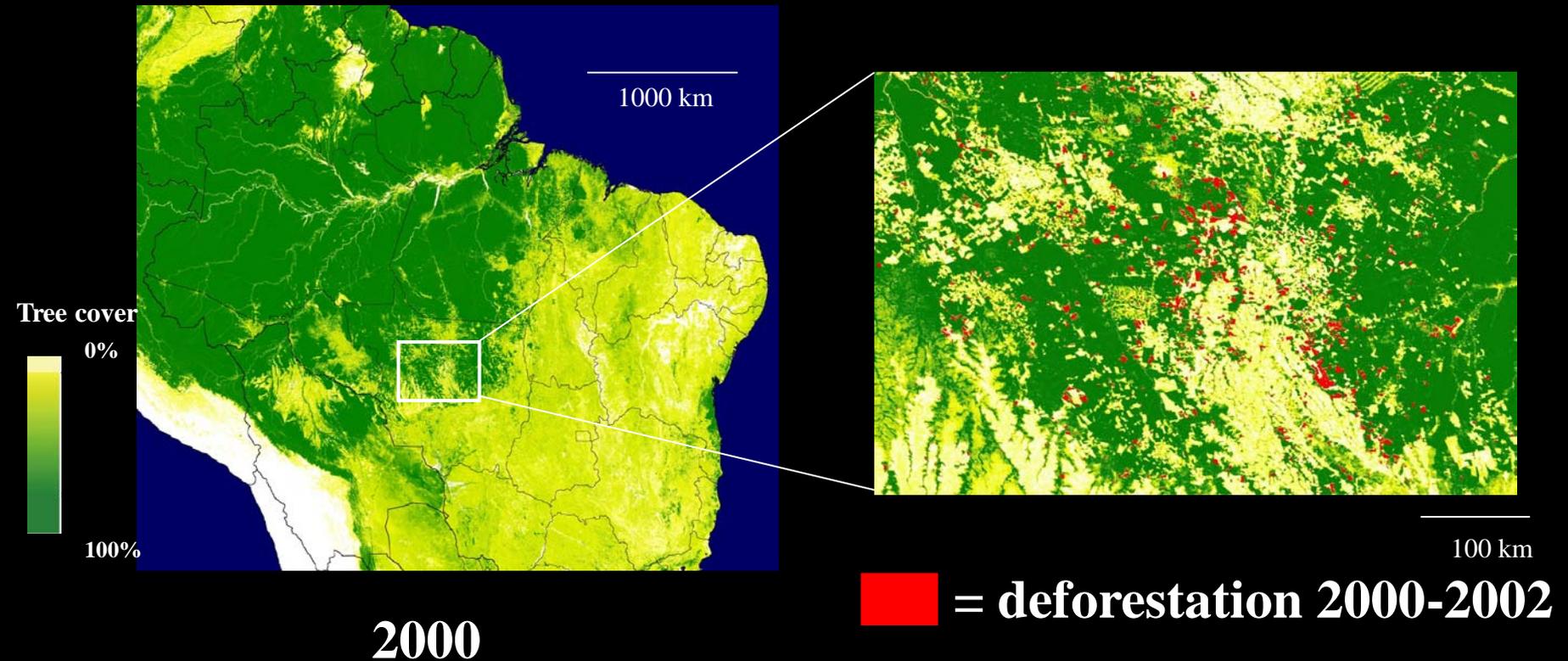

(DeFries, et al., 2002)

Alternative estimates of carbon flux from tropical deforestation and regrowth based on satellite observations rather than FAO national statistics

What do we know now that we didn't know before?

Tree cover
0%
100%

1000 km

100 km

2000

■ = deforestation 2000-2002

Developing ability for automated monitoring of changes in forest cover at regional scale

What else?

- Regionally-specific automated algorithms for monitoring changes in forest cover
- Linkages of monitoring capabilities with conservation and carbon applications
- What institution is responsible for globally-consistent, repeated assessments of forest cover?