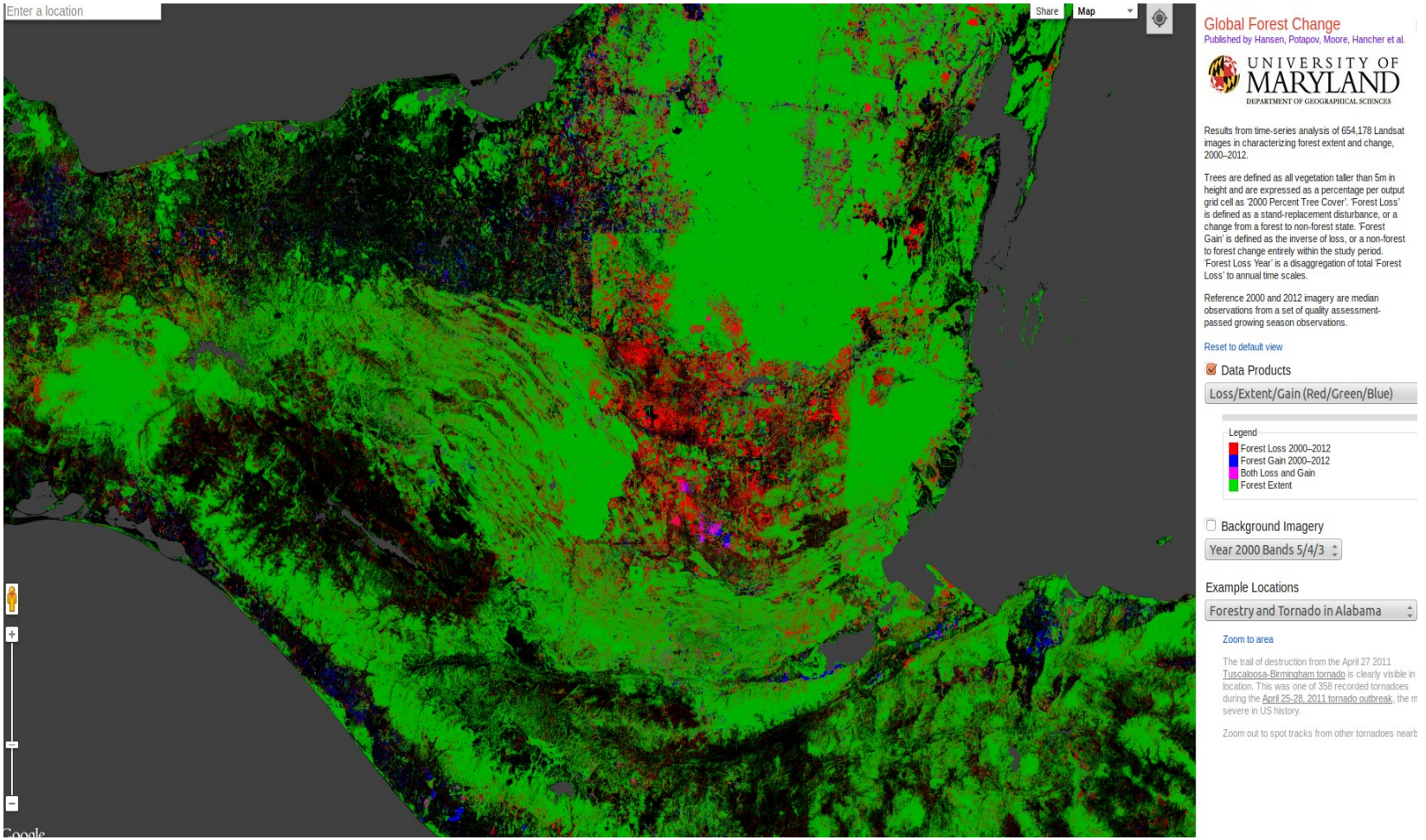
Changes in global forest cover

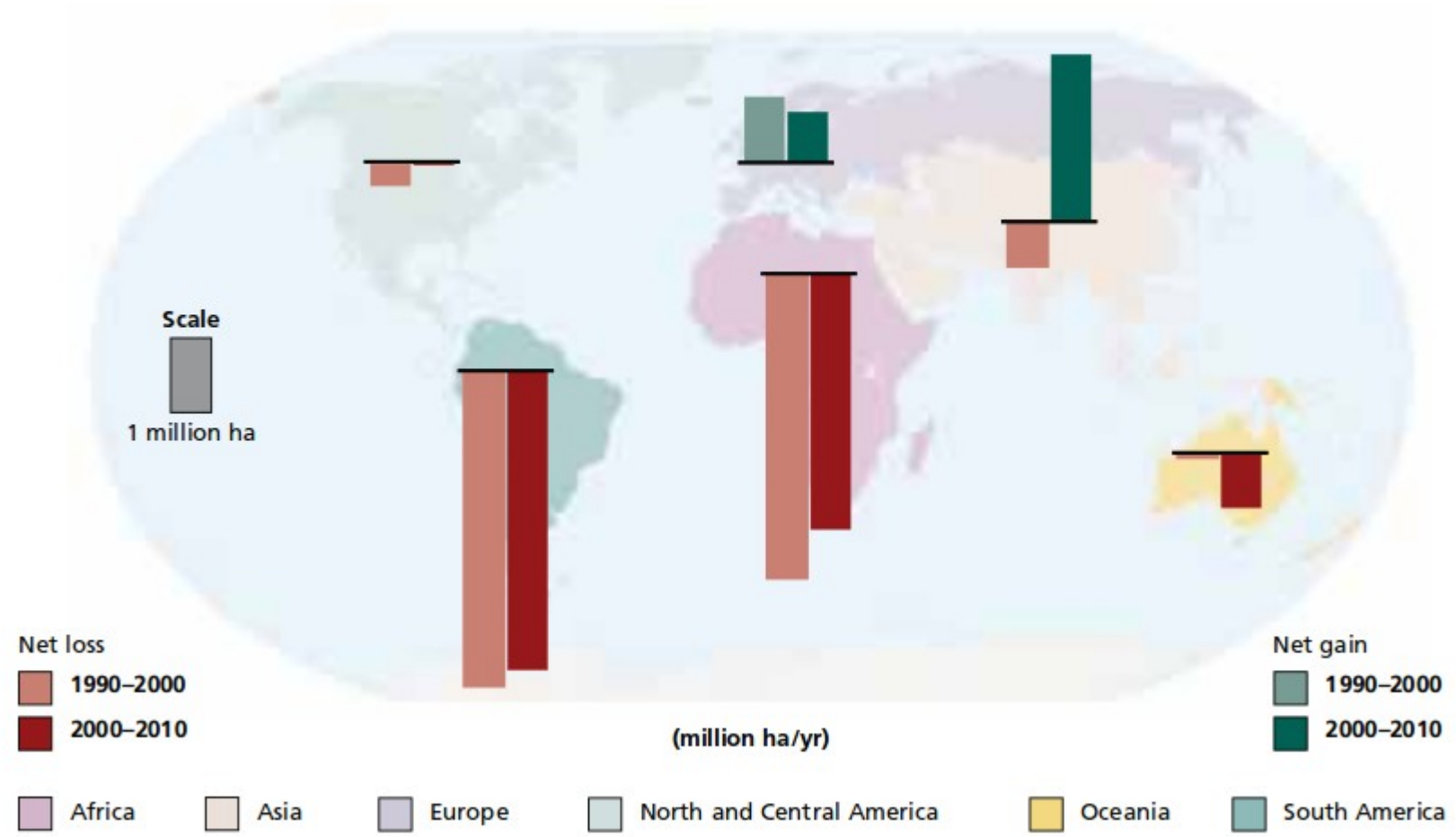


Statistics on deforestation

- UN FAO's Forest Resource Assessment (FRA) produced at decadal intervals. (http://www.fao.org)
- Challenges
  - Inconsistent methods between countries;
  - Defining "forest" based on land use instead of land cover regardless of whether tree cover is present;
  - Forest area changes reported only as net values
  - Forest definitions used in successive reports have changed over time
  - Timber production may not be closely correlated with land use change

FRA global picture

FIGURE 4
Annual change in forest area by region, 1990–2010



FAO FRA summary

- “At a regional level, South America suffered the largest net loss of forests between 2000 and 2010 – about 4.0 million hectares per year – followed by Africa, which lost 3.4 million hectares annually”
- “Asia, which had a net loss of forest of some 600 000 ha annually in the 1990s, reported a net gain of forest of more than 2.2 million hectares per year in the period 2000–2010, primarily due to the large-scale afforestation reported by China”

Improving the picture

- FAO reports based on government figures
- Remote sensing is a more reliable source of information
- Brazil began monitoring Amazonian deforestation at 15 day intervals in 2000 (DETER)
- However, many countries do not have detailed monitoring systems in place

Global monitoring

- Landsat imagery available at 28.5 m resolution
- Landsat 7 completes a full orbit of the earth in about 100 minutes (14 per day).
- Complete coverage of the earth every 16 days
- Most imagery now in public domain. However processing is challenging
- Hansen et al used 650,000 growing season Landsat 7 Enhanced images (total of 1.3 million available at the time of the study)
- Built up a global picture of forest cover change from 2000 to 2014

Hansen et al (2013) methods

- Google Earth Engine: Cloud platform for earth observation data analysis: Public data catalogue + large scale computational facility with parallel processing of geospatial data
  - Image resampling,
  - Conversion of raw digital values to top of atmosphere reflectance,
  - Cloud/shadow/water screening and quality assessment
  - Image normalization

Methods

- Supervised classification
- Image interpretation on screen (based on high resolution imagery) to find change and no change training data for forest cover loss and gain.
- Decision tree algorithm applied
- 20 terapixels of data processed using one million CPU -core hours on 10,000 computers

Results summary

- Global forest cover loss 2.3 million square kilometers
- Global forest cover gain 0.8 million square kilometers
- Context: Land area of the UK is 0.25 million square km
- Land area of Mexico is 2 million square km
- Land area of Brazil 8.5 million square km

Key points

- The tropics were the only climate domain to show a trend (forest loss increasing by 2,000 square kilometers per year)
- Brazil: Rate of forest loss declining
- Indonesia, Malaysia, Paraguay,Bolivia, Zambia, Angola: Increasing
- Boreal forest loss due to fire

Brazil decline

- High point 2003: 40,000 km square per year
- 2010:2011: 20,000 km square per year

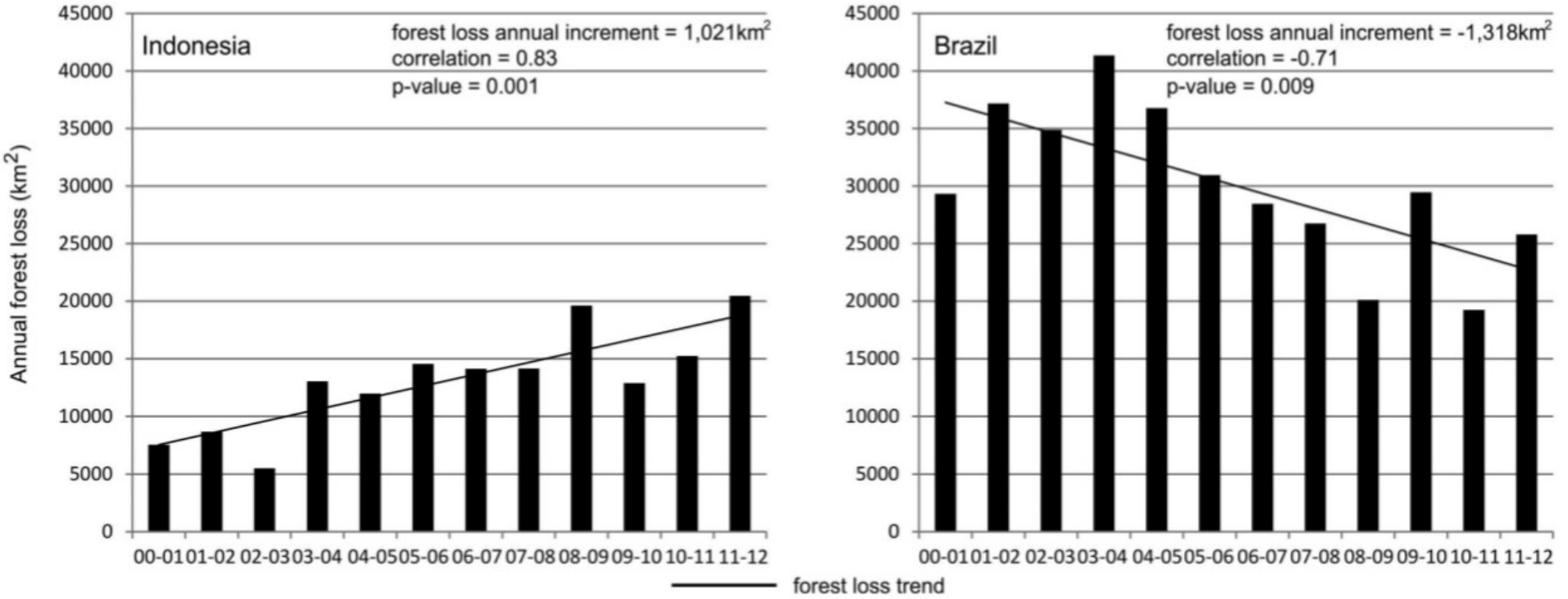


Fig. 3. Annual forest loss totals for Brazil and Indonesia from 2000 to 2012. The forest loss annual increment is the slope of the estimated trend line of change in annual forest loss.

Global patterns

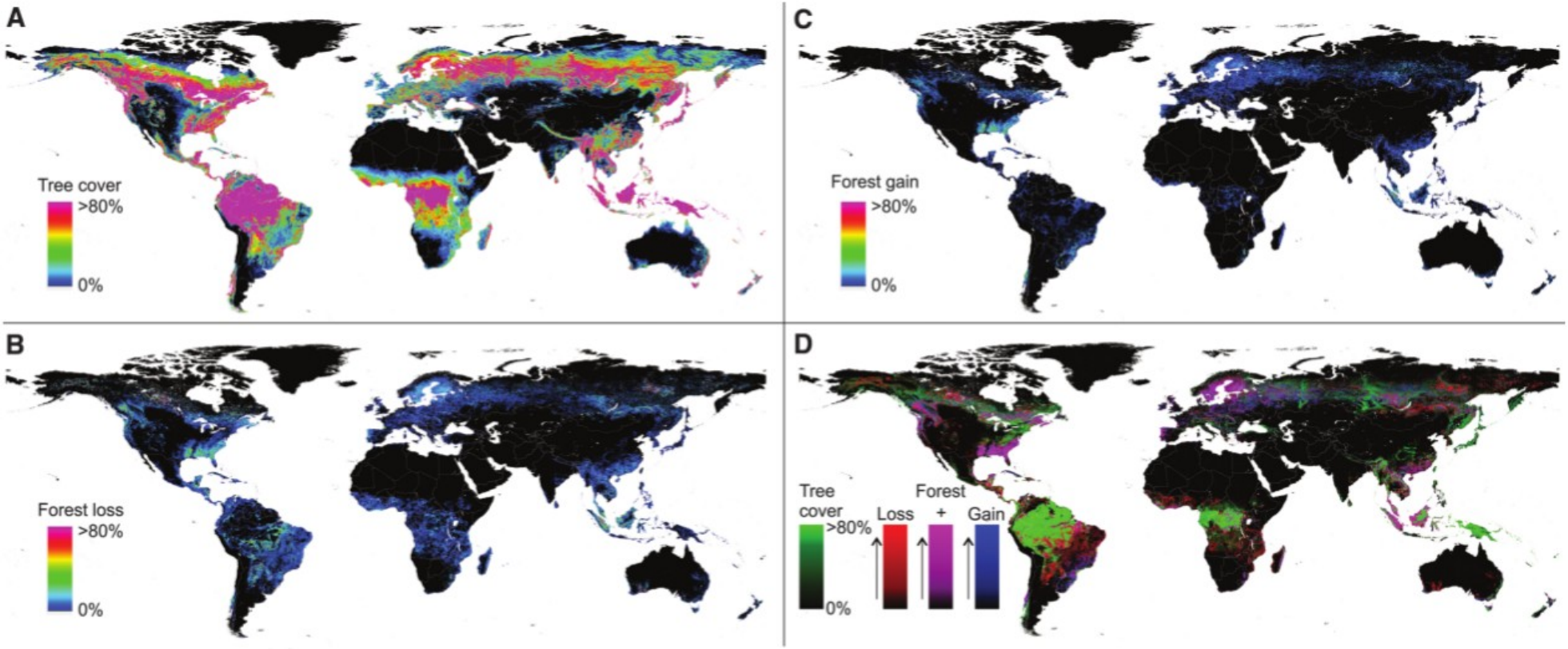
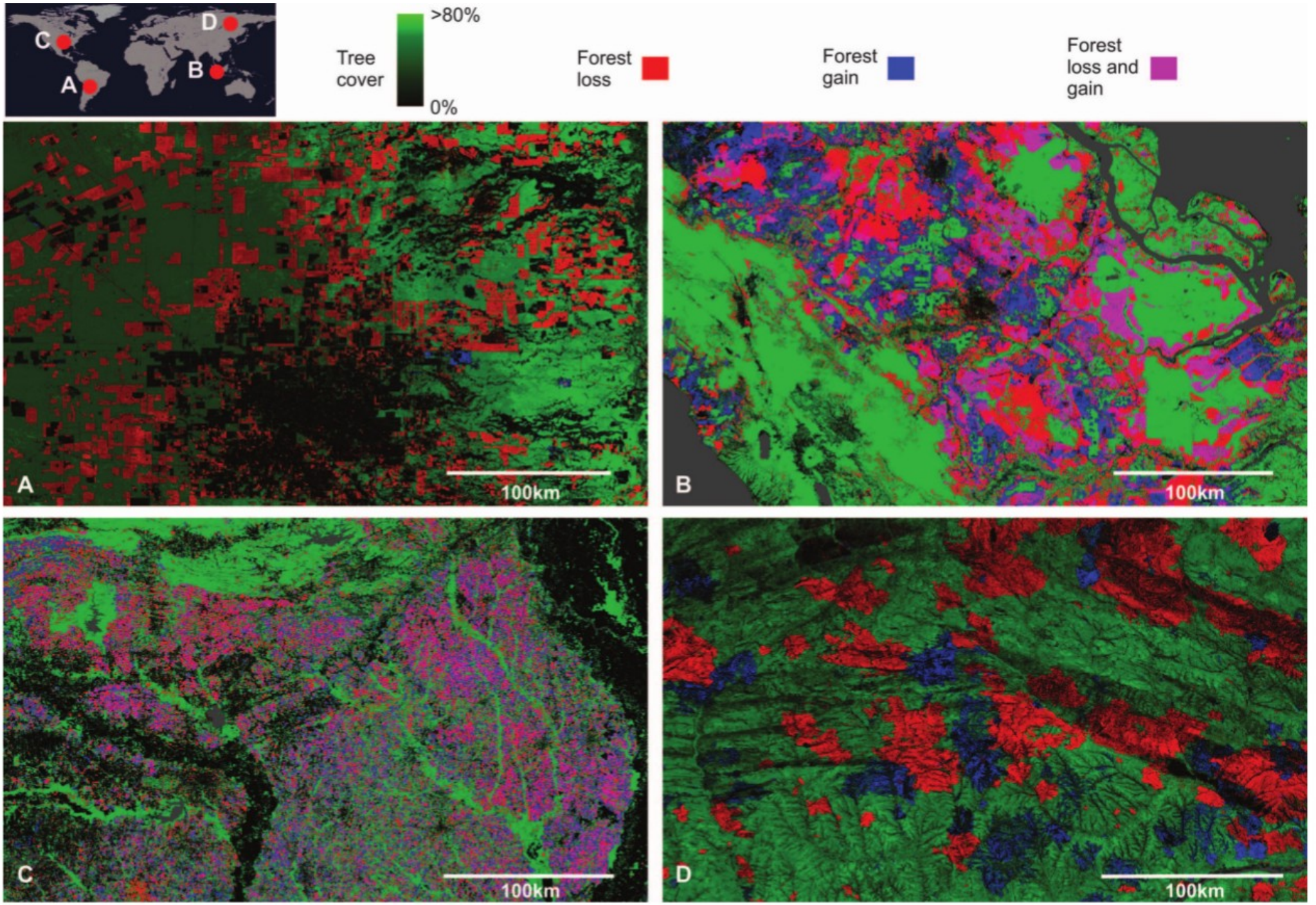
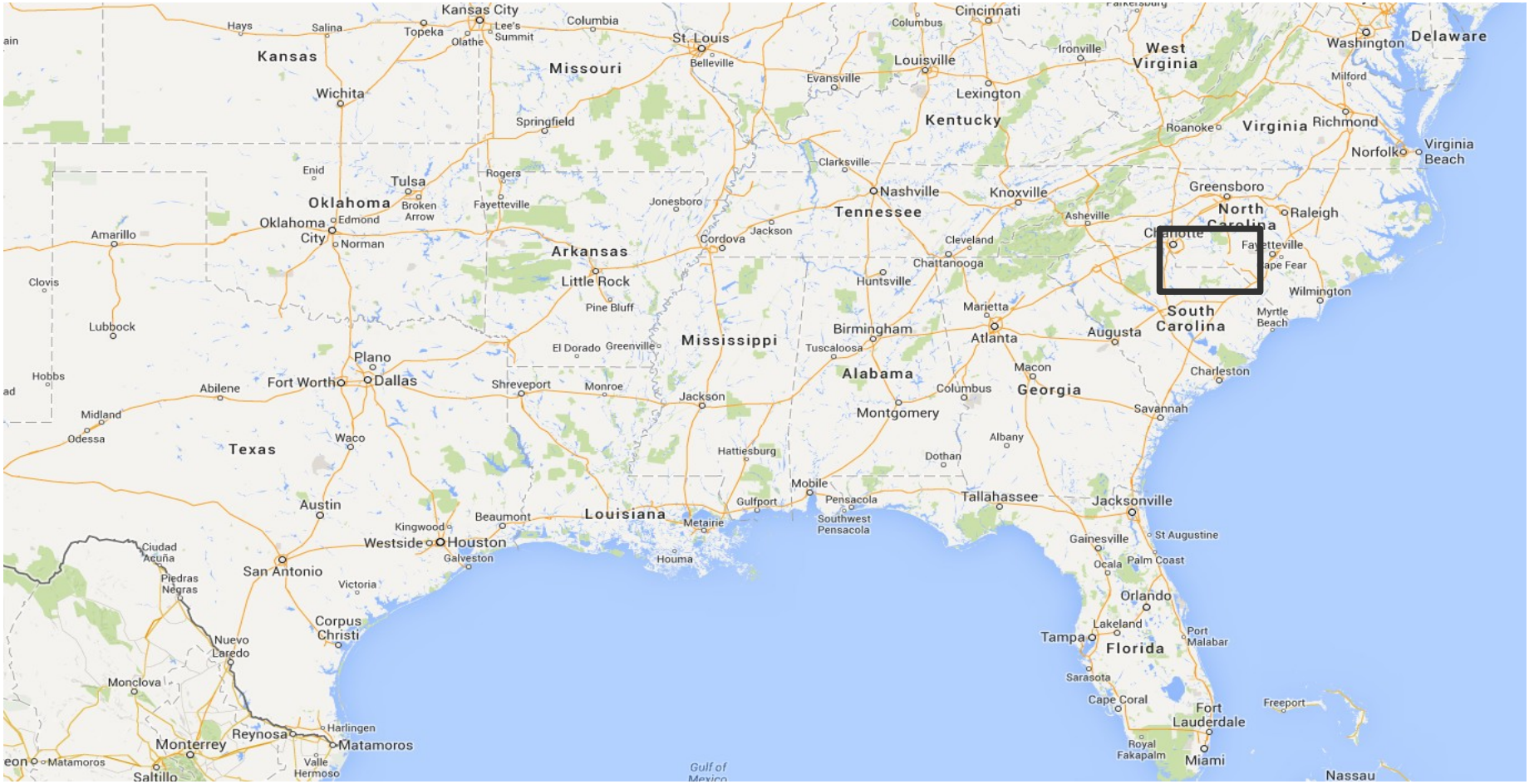


Fig. 1. (A) Tree cover, (B) forest loss, and (C) forest gain. A color composite of tree cover in green, forest loss in red, forest gain in blue, and forest loss and gain in magenta is shown in (**D**), with loss and gain enhanced for improved visualization. All map layers have been resampled for display purposes from the 30-m observation scale to a 0.05° geographic grid.


C
D
A
B
Tree cover
>80%
0%
Forest loss
Forest gain
Forest loss and gain
A
100km
B
100km
C
100km
D
100km

Managed forests

- Forest loss +- = Forest gain



Managed forests

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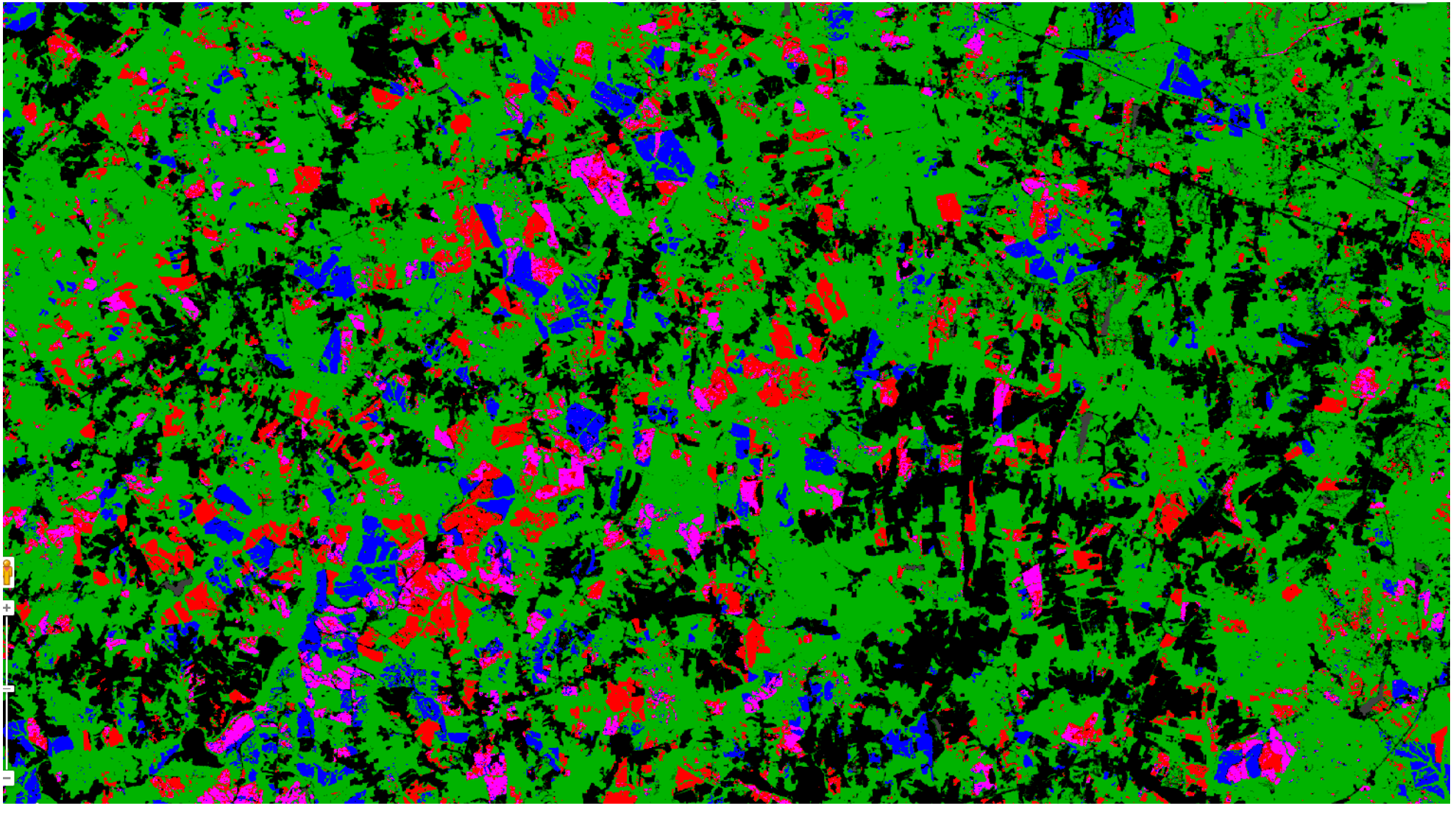


Patterns

- Sharp boundaries and geometrical shapes (rectangles) suggest planned change and management
- Diffuse boundaries and irregular shapes suggest unplanned change (fires, slash and burn, wind throw, disease, natural regeneration)

What is missed?

- Selective logging and other small scale forest disturbance
- Continuous forest regrowth
- Changes in forest composition

Errors

Tropical (n=628)

Loss error matrix expressed as percent of area (selected standard errors are shown in parentheses)

		Reference			
		Loss	No Loss	Total	User's (SE)
Map	Loss	1.50	0.22	1.72	87.0 (4.7)
	No Loss	0.30	97.98	98.28	99.7 (0.1)
	Total	1.80	98.20		
	Producer's	83.1 (5.3)	99.8 (0.1)		

Overall accuracy = 99.5 (0.1)

Drivers of deforestation

- Deforestation is affected by economic forces at a global, national and regional scale
- Deforestation implies land use change
- Land remains deforested permanently if the alternative land use is economically viable
- Land may be deforested and degraded by unsustainable land use change
- Secondary vegetation is usually of less conservation value than the undisturbed forest

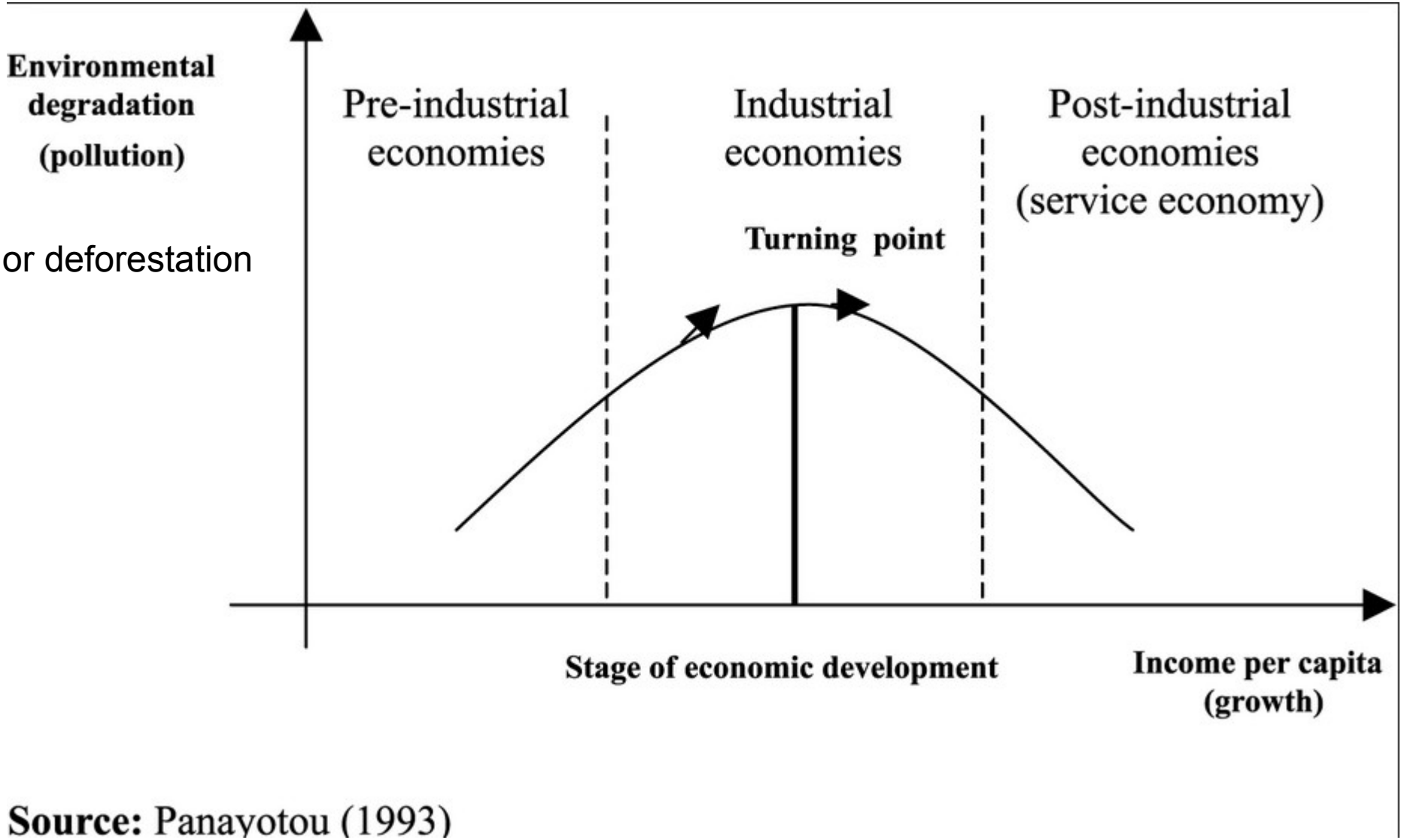
Main drivers of deforestation

- Latin America
  - Subsistence maize production (declining in importance)
  - Cattle
  - Soy bean production (Brazil, Paraguay)
  - Coffee (above 800m)
- South East Asia
  - Clear cut logging
  - Oil palm
- Africa
  - Subsistence agriculture
  - Livestock (Forest savannah border

Reduction in deforestation

- Brazilian law states that landowners in the Amazon MUST retain 80% forest cover on their land
- Costa Rican law prohibits conversion of forest to other uses
- PES schemes in place in many countries
- REDD initiatives for carbon capture
- Mexican laws make legal land conversion complex, costly and time consuming
- But … wider economic forces lie behind the change.

Forest transition



Source: Panayotou (1993)

Example of forest transition

- Puerto Rico
  - When Fields Revert to Forest: Development and Spontaneous Reforestation in Post-War Puerto Rico The Professional Geographer Volume 52, Issue 3, August 2000, Pages: 386–397, Thomas K. Rudel, Marla Perez-Lugo and Heather Zichal
  - Between 1950 and 1990 forest cover increased from 9% to 37% of the island's land area.
  - In proportional terms more land has reverted to forest in Puerto Rico than anywhere else on earth during the second half of the twentieth century.

GDP per capita (PPP)
Source World Factbook

- USA $52,000 (Puerto Rico $17,000)
- UK $36,000
- Russia $17,000
- Mexico $ 15,400
- Brazil $11,700
- Nicaragua, Honduras and Guatemala $4,000 to $6,000
- Indonesia, Philippines, Vietnam $3000 to $5000
- Haiti $1,100
- Madagascar $900
- DR Congo $400

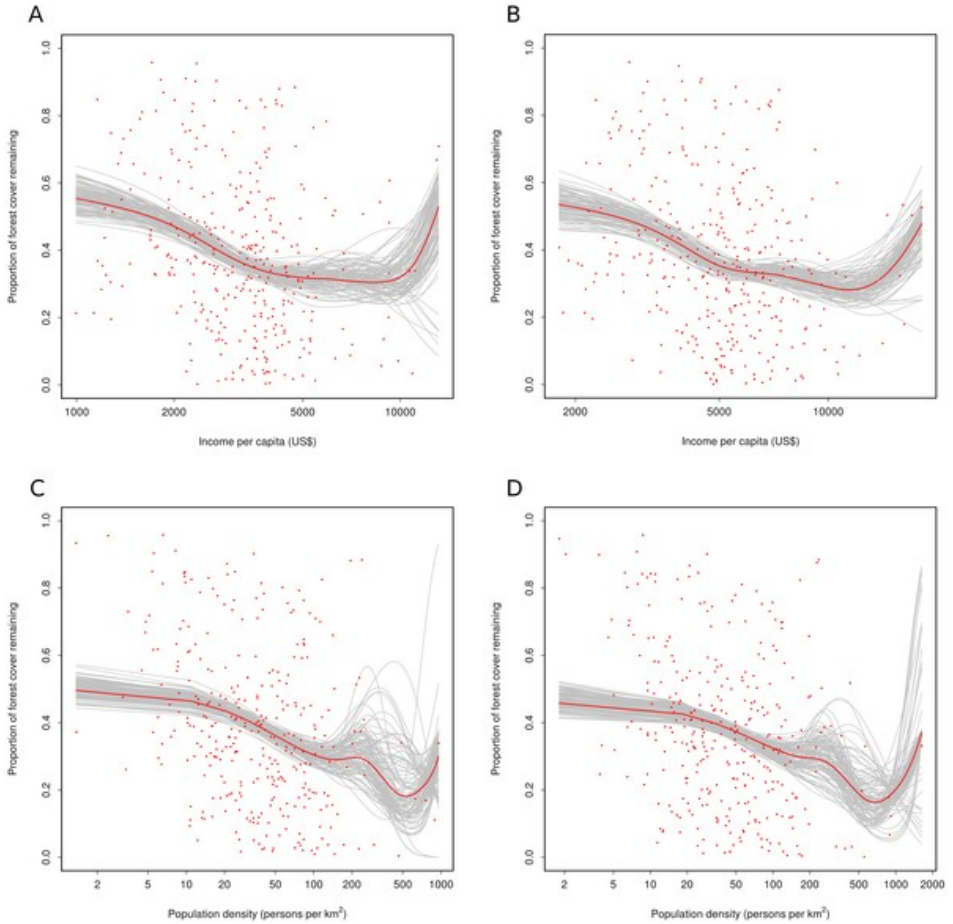
Population growth

- Mexico 1.2% per annum. Should stabilise by 2050
- Brazil 0.9% per annum, declining
- Guatemala 2.5% per annum likely to continue
- Indonesia 1.2% per annum, slowly declining or stable
- Puerto Rico -0.7%

Incipient forest transitions

- Middle income tropical countries may show incipient transition
  - Pressure to deforest for subsistence agriculture is reduced
  - Industrialisation and urbanisation has led to economic growth
  - “Rational” land use change continues where it is profitable
  - Eg. Brazilian law states that only 20% of land in the cerrado (area converted for soya) has to be left forested

Figure 4. Beta GAM modelling on the relationship between the proportion of remaining forest cover at the municipality level and socio-economic factors.



Vaca RA, Golicher DJ, Cayuela L, Hewson J, et al. (2012) Evidence of Incipient Forest Transition in Southern Mexico. PLoS ONE 7(8): e42309. doi:10.1371/journal.pone.0042309
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0042309

Fragmentation

- Deforestation impact on biodiversity may be greater than the figures suggest
- Large areas of tropical forest are now fragmented
- Fragmentation has a wide range of effects on ecological communities and populations of animals and plants