Dr. Alan Belward, Knowledge for Sustainable Development and Food Security Unit
European Commission, Joint Research Centre, Directorate for Natural Resources

SDG 15: sustainably manage forests

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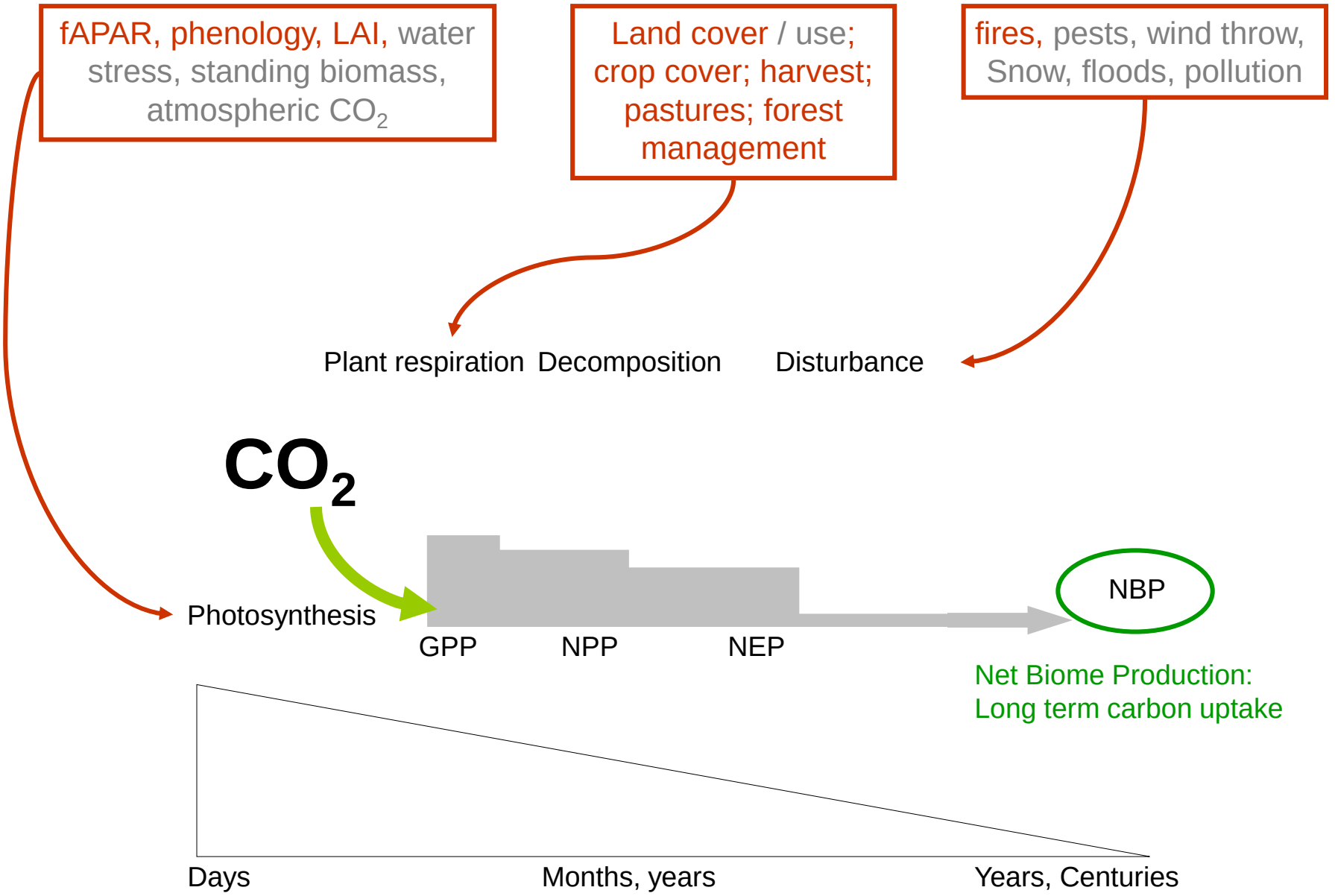
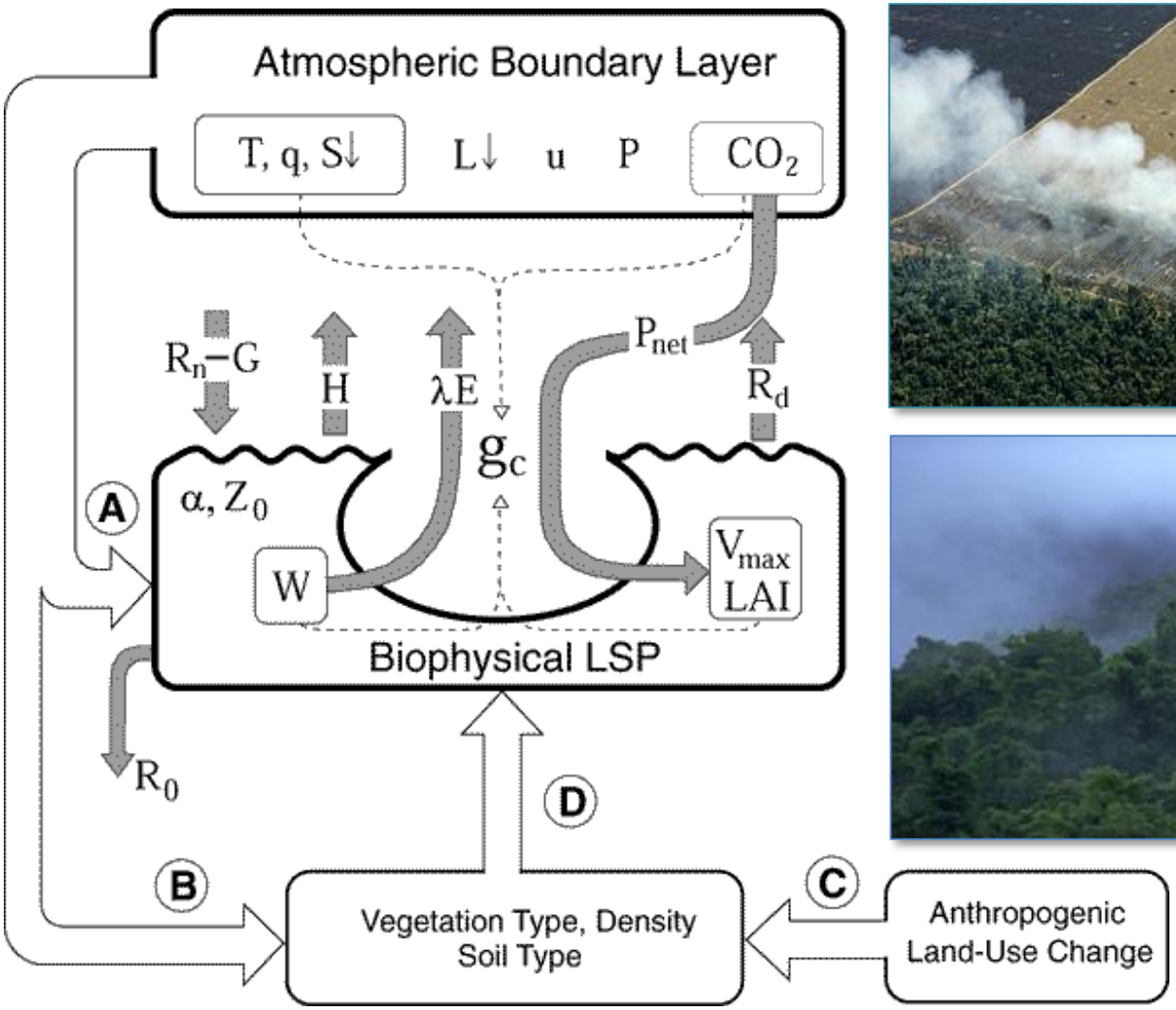


After D. Mollicone after Buchmann and Schulze, 1999

31% of land surface covered by forest (4 bn ha)



Source IPCC TAR, 2001, FAO FRA 2010 Picture credits, crisisobserver.com, bioblog

UNITED NATIONS

UNFCCC Framework Convention on Climate Change

Distr.
GENERAL

FCCC/CP/2009/11/Add.1
30 March 2010

Original: ENGLISH

Decision 4/CP.15

Methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

Decision 4/CP.15

(d) To establish, according to national circumstances and capabilities, robust and transparent national forest[1] monitoring systems and, if appropriate, sub-national systems as part of national monitoring systems that:

(i) Use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes;

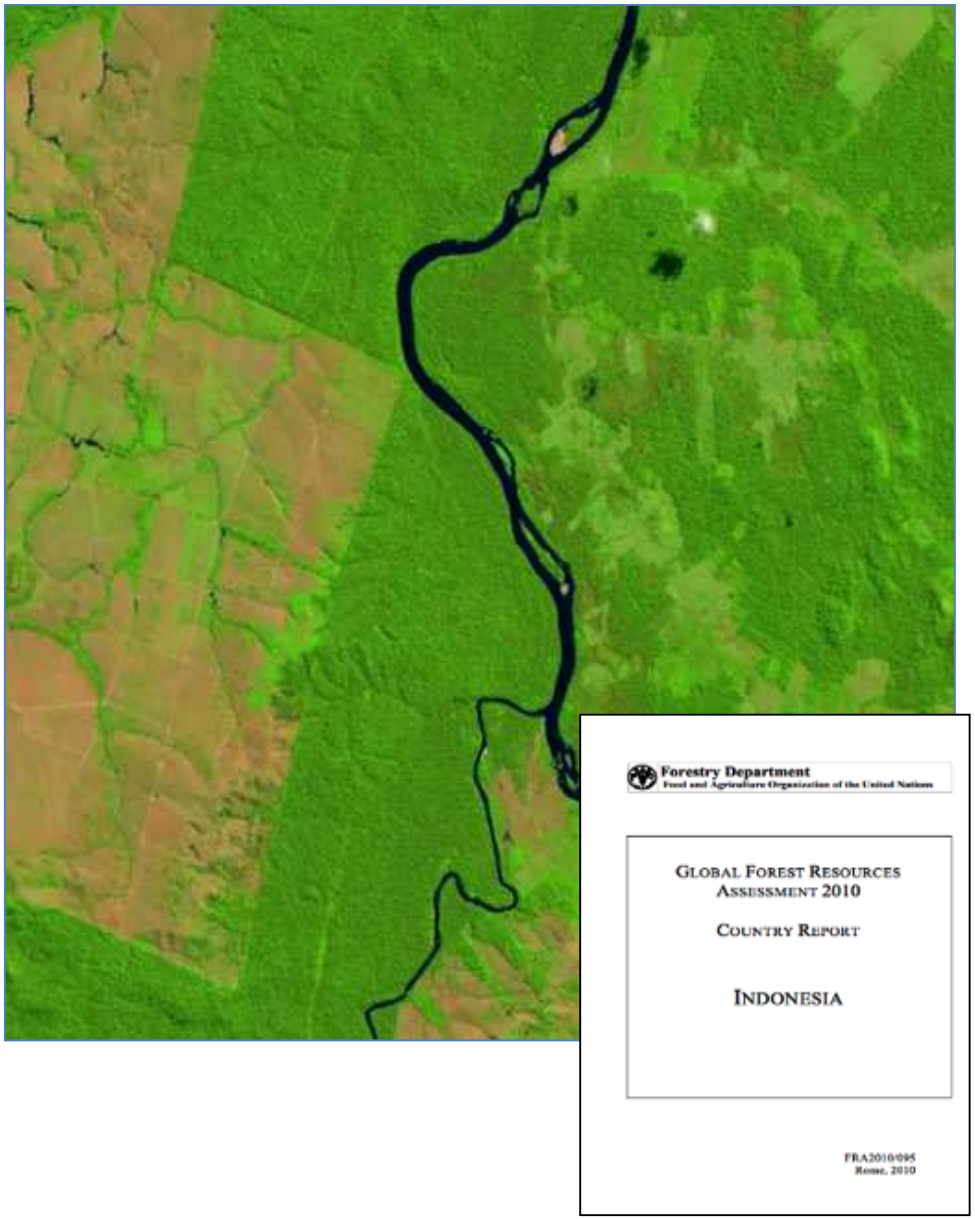
(ii) Provide estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account national capabilities and capacities;

(iii) Are transparent and their results are available and suitable for review as agreed by the Conference of the Parties;

Accurate reporting of global forest resources – the Forest Resource Assessments

- Country reports; Essential basis for global reporting if more than land cover are desired

- Remote sensing; Systematic, uniform, independent, neutral, verifiable



Picture credits FAO FRA 2010 Key findings
USGS Landsat 5 P231 R 67 22nd July 2011

A role for Earth Observation technologies

- Satellite Observations can provide
  a) uniform coverage of any given country (and indeed the globe)
  b) consistent international georeferenced databases
  c) annual measures of land cover areas and changes
  d) measurements of biomass (albeit not directly)
  e) measurements of areas of disturbance (fire, wind throw, insects)
  f) observations going back to 1972 (and even beyond with the declassification of early military satellite imagery)
  g) potential for independent verification

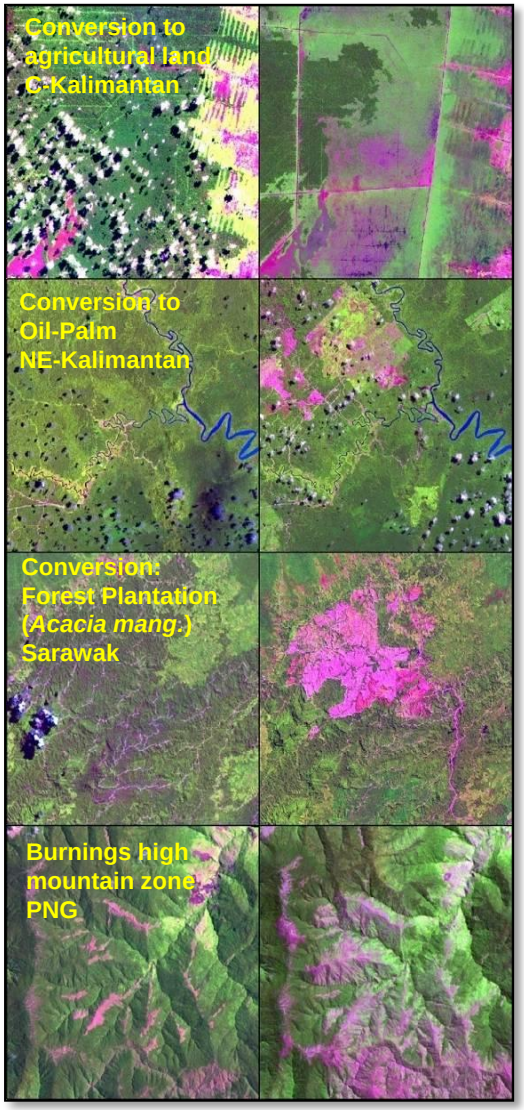


Image and interpretation H-J. Stibig JRC

Published by: EUROPEAN COMMISSION Joint Research Centre
In association with: UNEP
On behalf of:
The Global Land Cover Partnership:

Global Land Cover for the Year 2000

Land cover classification produced with data acquired in 2000 from the VEGETATION instrument, onboard the SPOT4 satellite.

Developed by the European Commission's Joint Research Centre, in association with the United Nations Environmental Programme and the Food and Agriculture Organization, on behalf of the Global Land Cover 2000 partnership.

Edited by:
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Digital datasets can be downloaded from www.gvm.jrc.it/glc2000

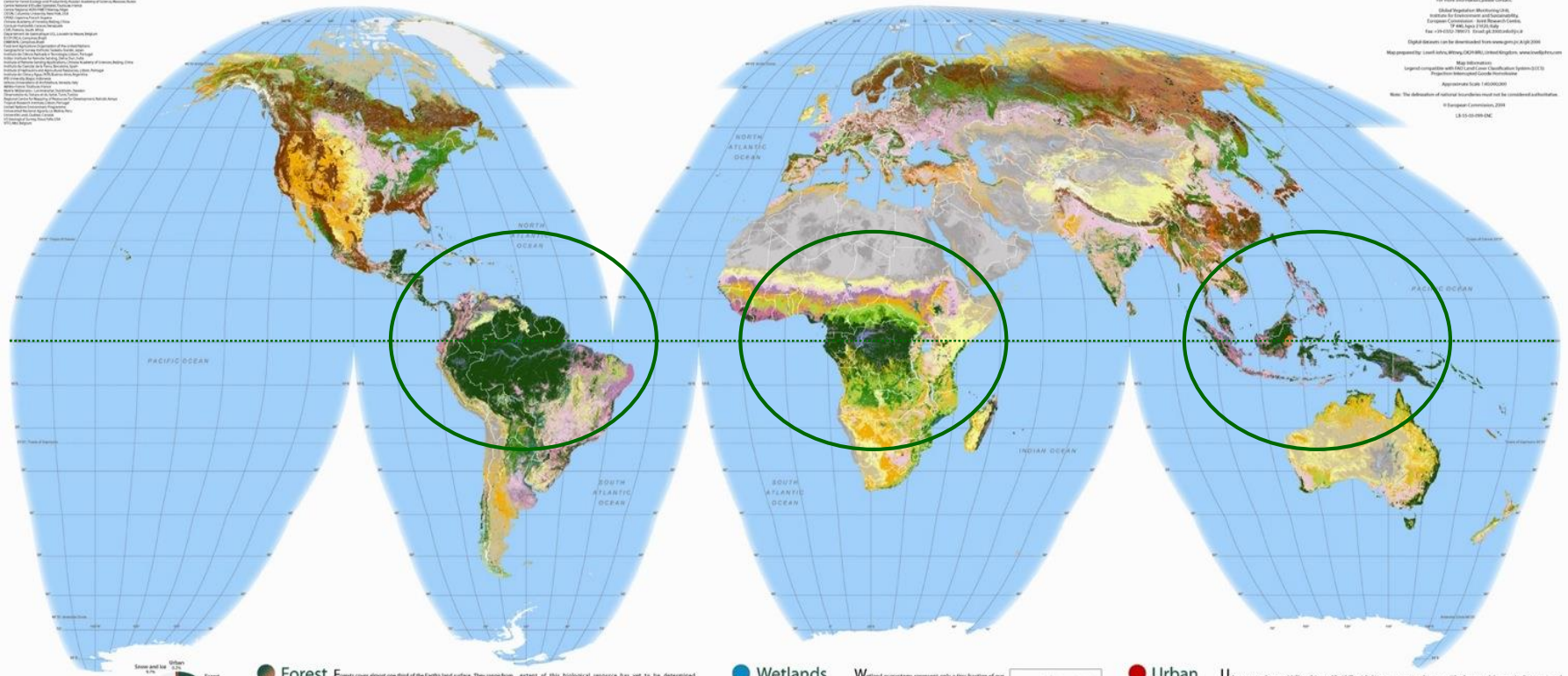
Map prepared by: Lovell Johns, Witney, OX29 0RU, United Kingdom. www.lovelljohns.com

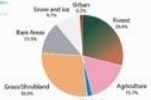
Map Information:
Legend compatible with FAO Land Cover Classification System (LCCS)
Projection: Interrupted Goode Homolosine

Approximate Scale: 1:40.000.000

Note: The delineation of national boundaries must not be considered authoritative.

LB-55-03-099-ENC





Land Cover Themes

GLC2000 Global Legend

Forest

Forests cover almost one third of the Earth's land surface. They range from the broadleaved evergreen tropical rainforests in the equatorial belt, to the boreal forests of Russia and Canada. Forests play an important role in regulating our climate through their influence on energy, water and gas exchanges with the atmosphere, and through acting as a source and sink in biogeochemical cycles. They play a key part in our social, cultural and economic lives and are home to tens of millions of people. In recent times, all our forests have come under threat from agricultural expansion, commercial logging, urban and industrial development, mining, and energy production.

The world's largest tropical humid rainforests are found in the Amazon basin of South America, the Congo basin of Central Africa, and on the continent and islands of South East Asia. They cover an area approximately 1.5 times the size of Australia (1.5 million km²). The tropical rainforest biome contains the most diverse life forms on Earth, providing habitats for at least half of the world's plant and animal species. In one hectare alone, hundreds of tree species can be found, an amount considerably larger than found in the whole of Europe. One quarter of our world's medicines used today come from tropical rainforests, and the full extent of this biological resource has yet to be determined.

Boreal forests are the largest continuous forest area on Earth. They are located in North America and Northern Eurasia in areas where the summer temperatures rarely, if ever, rise above 10°C. They contain mostly needle-leaved evergreen forest types, such as spruce and pine in Canada and Scandinavia, or needle-leaved deciduous forest types, such as larch in Siberia. The boreal forests contain some of the most remote, inaccessible and largely "untouched" forests of our planet, yet these regions are increasingly a focus for many economic activities.

Broadleaved deciduous and needle-leaved evergreen types largely make up the temperate forests of the world. The history of human presence in these regions means that only fragments of natural forest remain, and the majority of temperate forests are heavily managed. The temperate forests are the backbone of modern industry and at the same time provide a valuable recreational and wildlife resource.

Wetlands

Wetland ecosystems represent only a tiny fraction of our planet's surface. The map shows how sparsely distributed they are. The vegetation of wetlands varies greatly across the globe embracing grasslands, shrublands, forests (freshwater and mangrove) and bogs. They can be freshwater or saline. They not only provide a habitat for rich plant and animal life, but also hold great importance in terms of regulation of the water cycle, and the global climate as the world's largest emitter of methane (an important greenhouse gas). Wetlands are hot spots of biodiversity, providing nesting grounds for migrating birds, and a home for reptiles and amphibians. Wetlands cover a large range of landscape conditions. They can be inundated grasslands, such as the flooded savannahs of the Pantanal in South America and the Georgina-Diamantina river catchment of Australia, flooded sedges of the palsa bogs of northern Russia, or flooded shrublands, such as the Hadejia-Nguru wetlands of Southern Sudan. Mangroves, like the Sundarbans of Bangladesh are dense coastal forests, inundated by sea water. Swamp forests, such as in the Congo basin of Central Africa, or Amazon basin of South America, are created by regular freshwater flooding.

Urban

Urban areas are home to 3 billion of the world's 6 billion inhabitants, but they only cover 0.2 % of our planet's land surface. Urban areas have experienced almost a 15-fold increase in population over the last century. In comparison, rural populations have only doubled. Africa and Asia have the world's lowest urban population (approximately 37%), whereas in the urban sprawl of Europe and North America, about 76% of the population live in urban areas. According to UN predictions however, the urban populations of Africa and Asia will significantly increase from 37% to 55% by the year 2030, whilst the situation in Europe and North America will remain much as it is today.

The process of urbanisation is usually related to economic growth, and it typically goes hand in hand with large changes in social, political and demographic conditions. Improvements in communications and infrastructure have connected urban centres around the world, creating command and control centres for global and regional economies. In the developing world, people continue to move to urban areas either because of the perceived economic, and social benefits (pull factors), or to escape hardship in rural areas (push factors). Due to the migration of people into urban areas and out of the countryside, the demand for Food, fuel, and shelter in the urban area increases. This has a profound impact on the way in which the surrounding land cover is managed and maintained.

In addition to the effects on the world's economic and social life, urban areas directly influence the planet's climate system. Each day, urban areas are literally hot spots for energy consumption, and thus emission of pollutants and greenhouse gases. The thermal properties of artificial surfaces, such as buildings or roads, create higher temperatures in urban landscapes, by acting as a store of solar energy. Furthermore, the removal of natural vegetation eliminates the natural cooling effects of evapotranspiration and shading.

The inset map shows the location of the 32 urban areas with a population greater than 8 million inhabitants. It is notable that Asia, which has around 60% of the global population, accounts for half of these large cities.

Grass/Shrubland

Grasslands and shrublands cover almost the same land area of our planet as is covered by forest. The grasslands of the world can be found in hot and cold climates, over all continents. Extensive areas of grasslands can be seen on the map in sub-Saharan Africa, the prairies of North America, the Llanos and Pampas of South America, the outback of Australia, and the steppe grasslands of Central Asia, extending into Central Europe. In many cases, the world's shrublands are part of an environmental gradation from desert to grass and shrublands, to forest. This gradation can be clearly seen in the Sahel region of Africa, south of the Sahara desert, which contains a component of grassland underneath the shrub layer, as well as scattered shrubs within grassland. These landcover types make up the savannahs of Africa and South America, which are maintained by regular annual burning. It is estimated that more than 2.5 million km² of Grasslands and Shrublands burn each year. Much of the carbon released from these fires is recovered by new plant growth in subsequent years. Nevertheless the scale of these fires is such that they play an important role in the global climate system. Both of these land cover types are also an important part of the social life of many nomadic peoples and have been used throughout human history for grazing and hunting.

Agriculture

15.7% of the Earth's land surface is responsible for feeding most of the people most of the time. Human ingenuity has overcome natural limitations to grow food crops in almost all conditions. Agriculture is thus found across all continents, the grain belt of North America, the agricultural belt stretching from Europe across central Asia to Kazakhstan, the large areas in northern India, eastern China, and central Brazil are particularly evident.

Agricultural land is used for both subsistence farming, where the farmer produces food for his or her own family, and commercial agriculture, where the food is produced for national or international markets. Subsistence agriculture, in which traditional methods such as long fallows are practiced, is still dominant in Africa, and South East Asia.

Large commercial agricultural areas are found in the Americas, and Europe. These serve the urban food markets. The global import and export of food to the consumer markets of the developed world means that nearly any type of food product is available, during any season. This has been made possible, for example, by the use of 85% of the world's freshwater for irrigation. On the other hand inappropriate agricultural practices can have catastrophic environmental consequences such as desertification, soil erosion, and affecting the quality of our water in the ground, in rivers, in lakes, and in the sea.

Bare Areas

23% of our planet's land surface has little or no vegetation (desert, snow and ice). Deserts are areas that experience small amounts of rainfall. The Sahara is the world's largest desert followed by the Gobi desert of the south of Mongolia and the north of China. Because of the hostile conditions and very low population densities, the deserts are amongst the least well surveyed and monitored land cover types, yet they play an important part in our climate. Deserts can also impact surrounding areas for example, the desert fraost can cause severe damage to agriculture and vegetation in neighbouring regions.

They are home to globally important minerals, as well as specialist plants, animals, and even humans, which have adapted to the lack of water and the extreme hot or cold. Plants have adapted by having very brief, but remarkably fast growing periods on the rare event of rain in the desert. The dominant animal life in a hot desert is usually nocturnal, carnivorous, small animals, which hide themselves from the sun by burrowing into the ground.

Snow & Ice

Around a third of the Earths land surface can be covered seasonally by snow, and 10% of the land is permanently covered. The largest expanse of ice in the world is found in the ice sheets of Antarctica. As well as in polar ice caps, ice and snow are also found in the mountainous regions of the world. Ice and snow, like deserts, not only play an important role in the global climate system, by affecting solar energy and influencing surface temperatures, but are also the largest store of freshwater in the world and affect soil moisture and run-off. Whilst only 2% of the world's water is stored in ice, the freeze/thaw cycles are very important in the global hydrological cycle and are a regionally important source of water for crop irrigation. The snow cover also plays an important role in determining permafrost zones and rates of glacier advance and retreat. The advance and retreat of polar and high mountain glaciers is also a vivid indicator of climate change.

EVA HD, et al. 2004, A land cover map of South America, *Global Change Biology*, **10** (5), 731-744

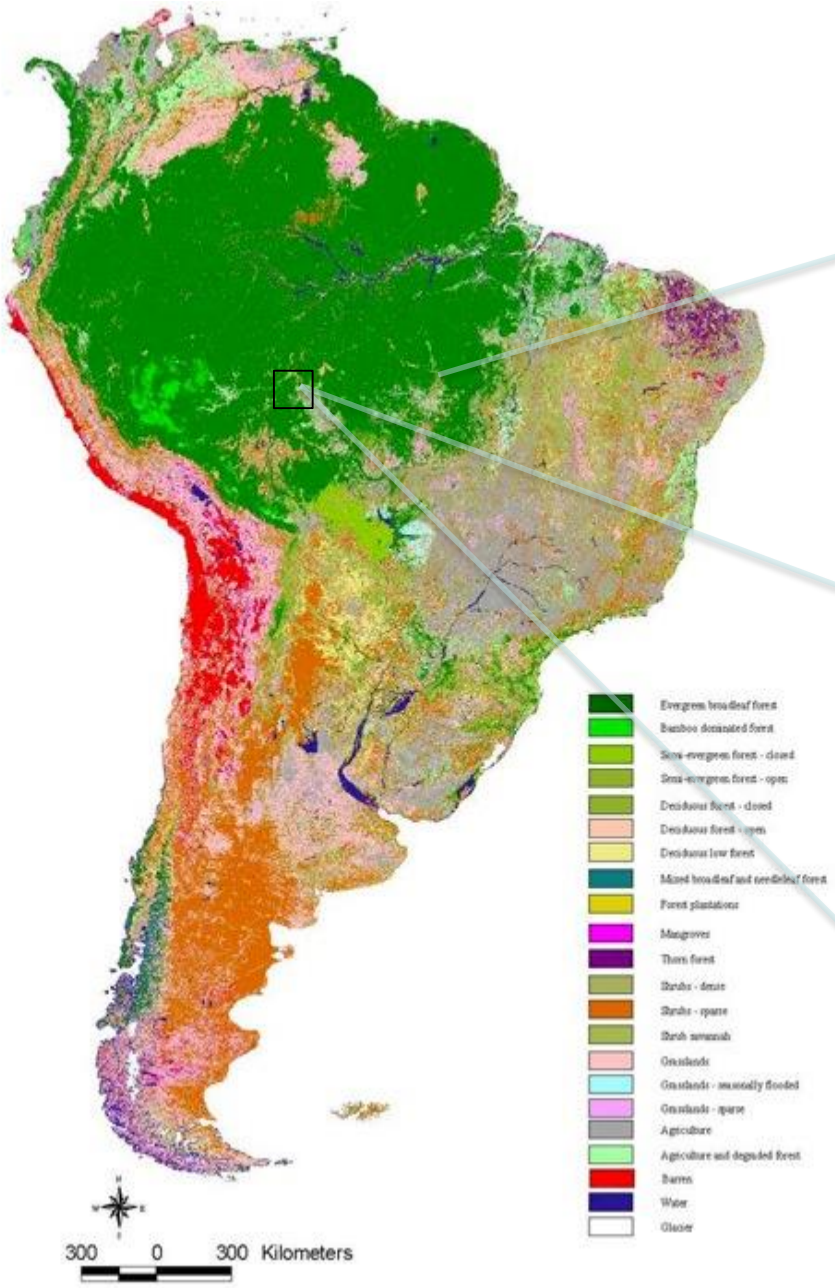
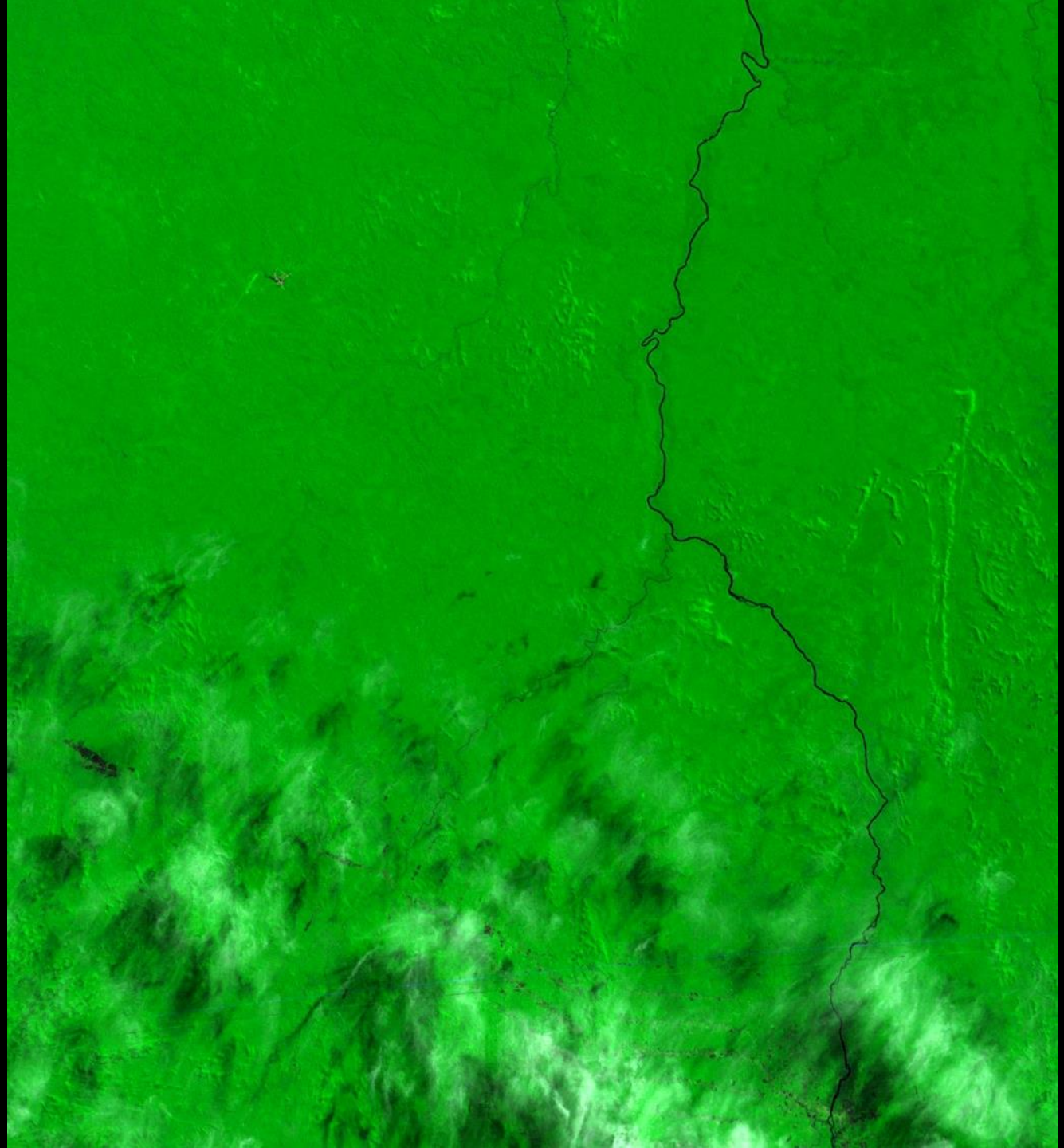


Photo credits H. D. Eva, ronet.com.br, skyscapercity.com

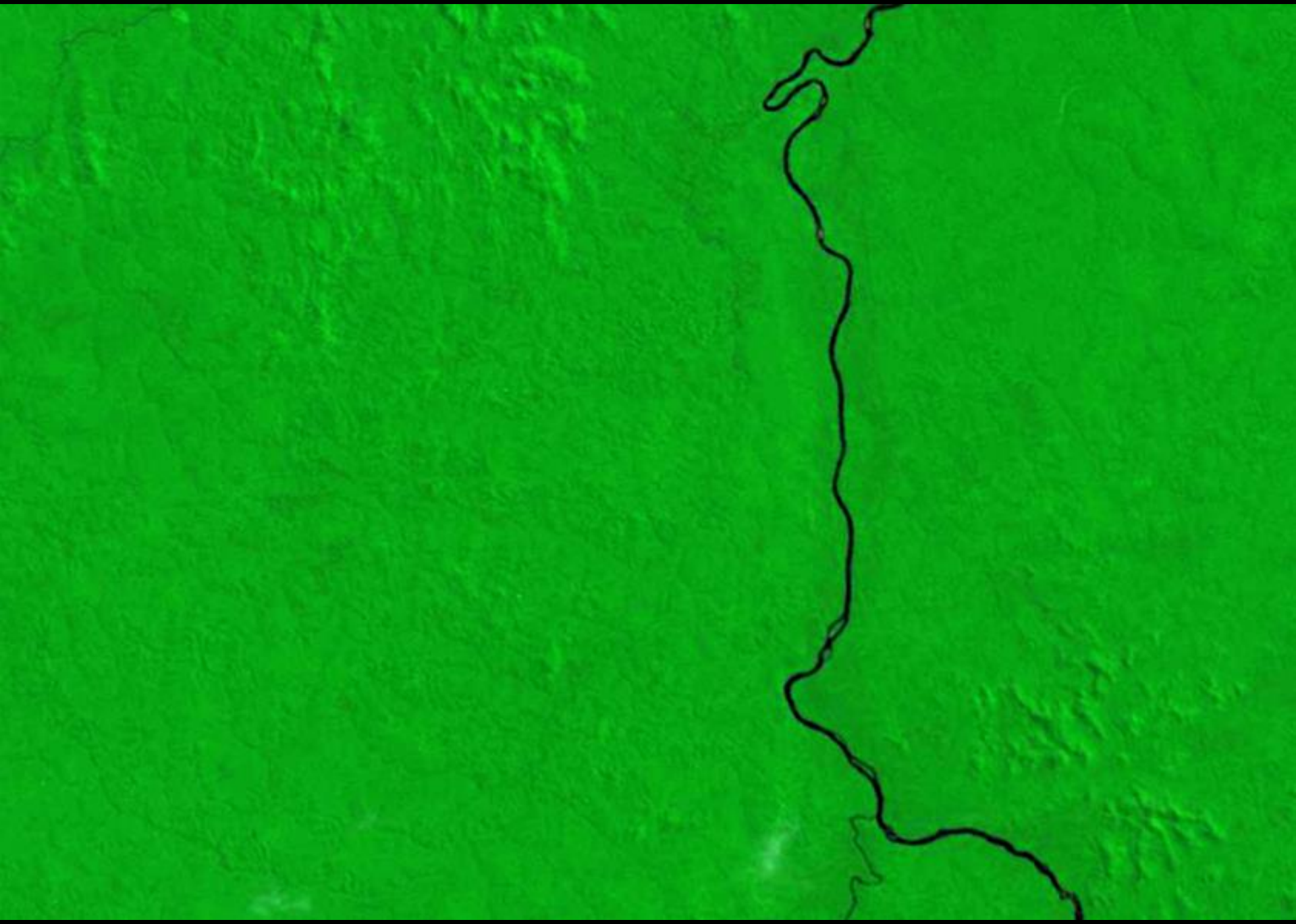
Landsat courtesy
USGS and NASA

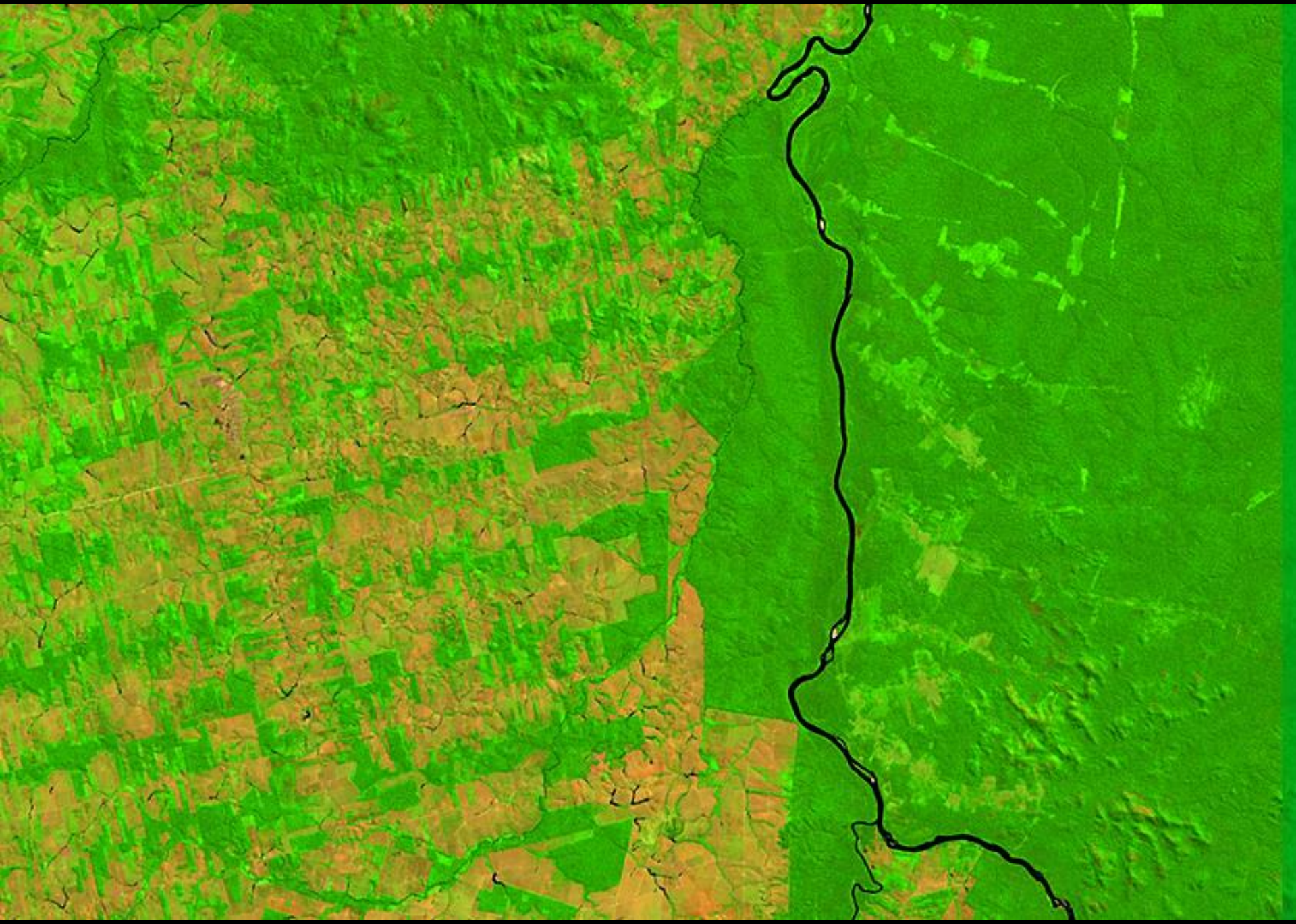


180 km

30 August 1973


Landsat courtesy
USGS and NASA
180 km
04 August 2013





EVA HD, et al. 2004, A land cover map of South America, *Global Change Biology*, **10** (5), 731-744

Carajas Iron Ore mine, Para state

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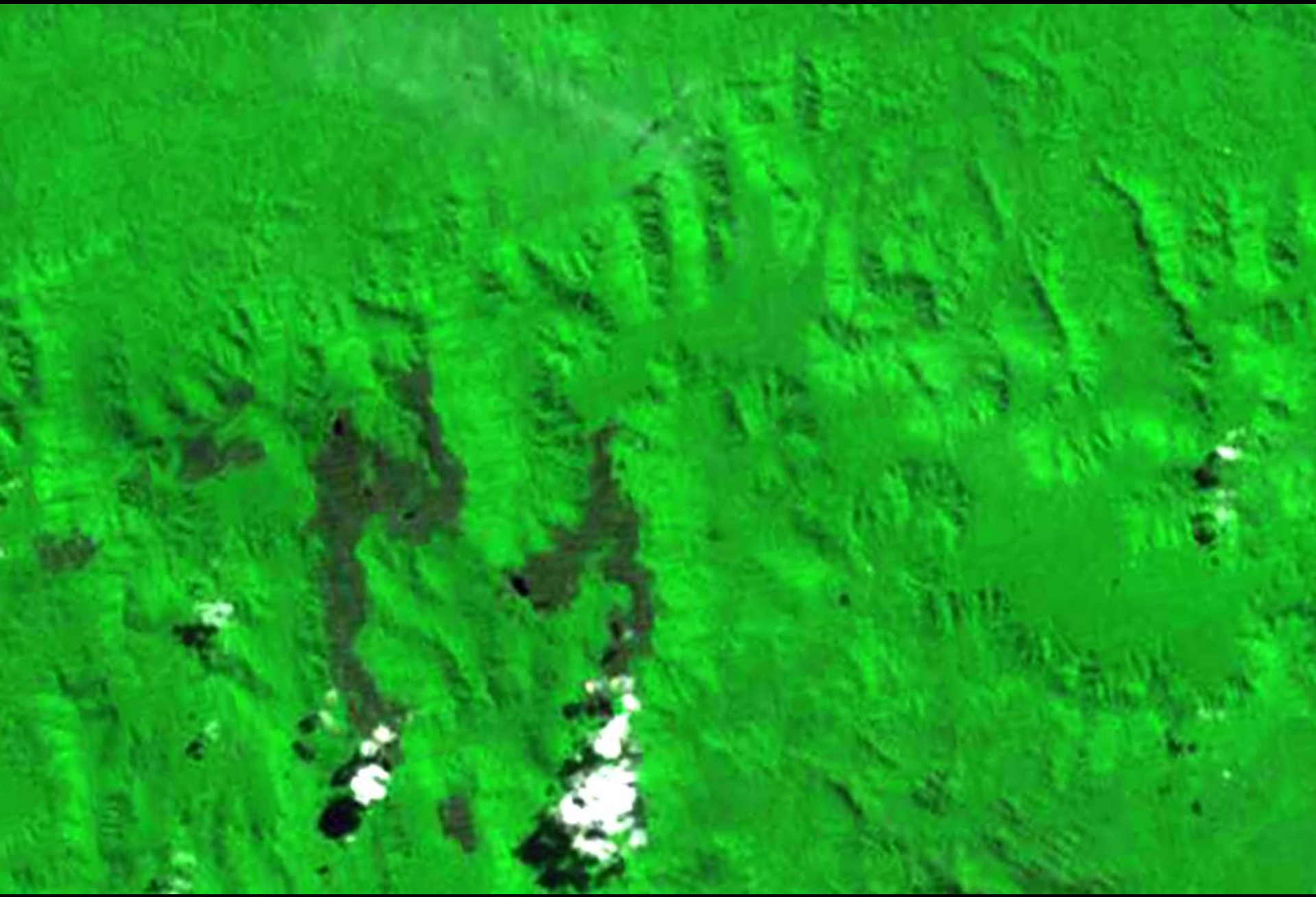

Carajas Para 4th August 1973

Carajas Para 3rd August 2013

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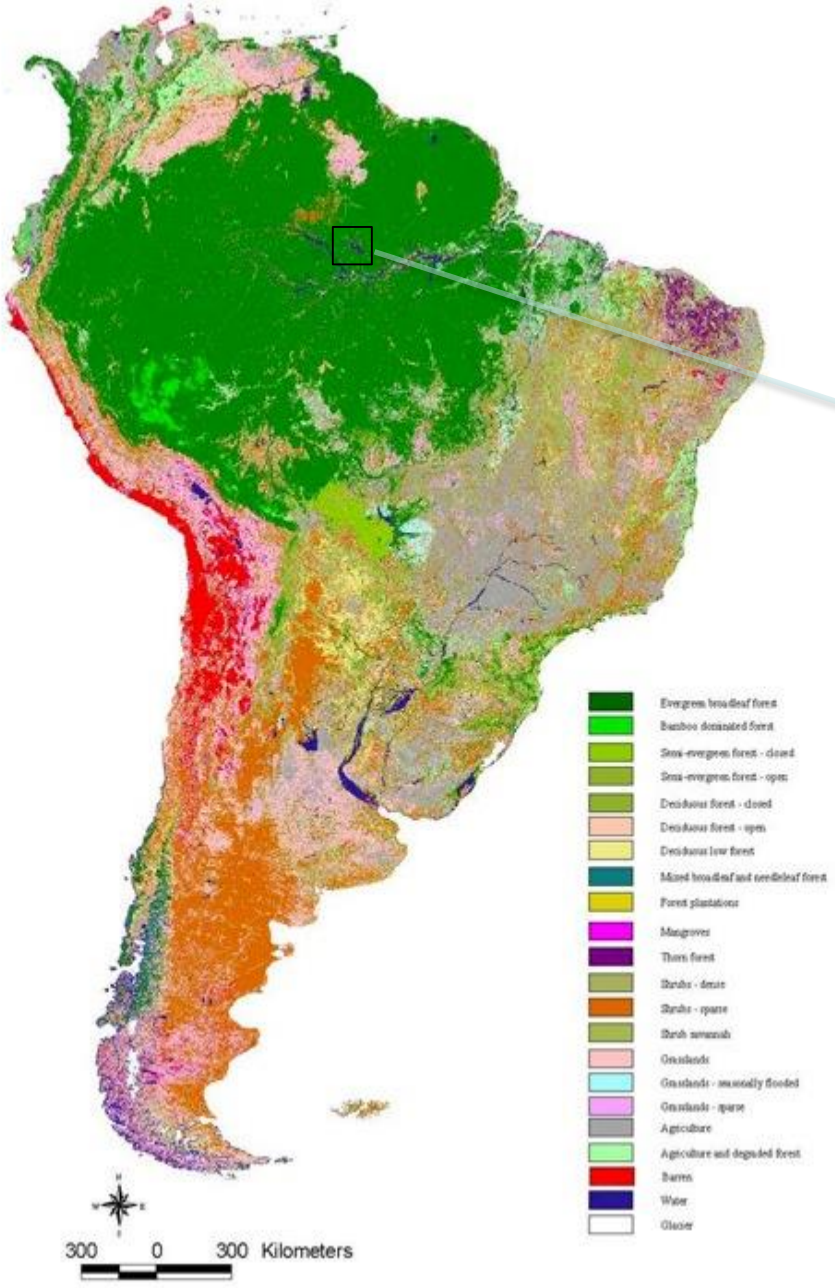
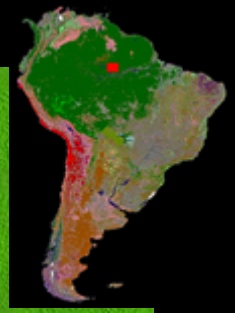


Balbina Dam

Photo credits H. D. Eva, ronet.com.br, skyscapercity.com

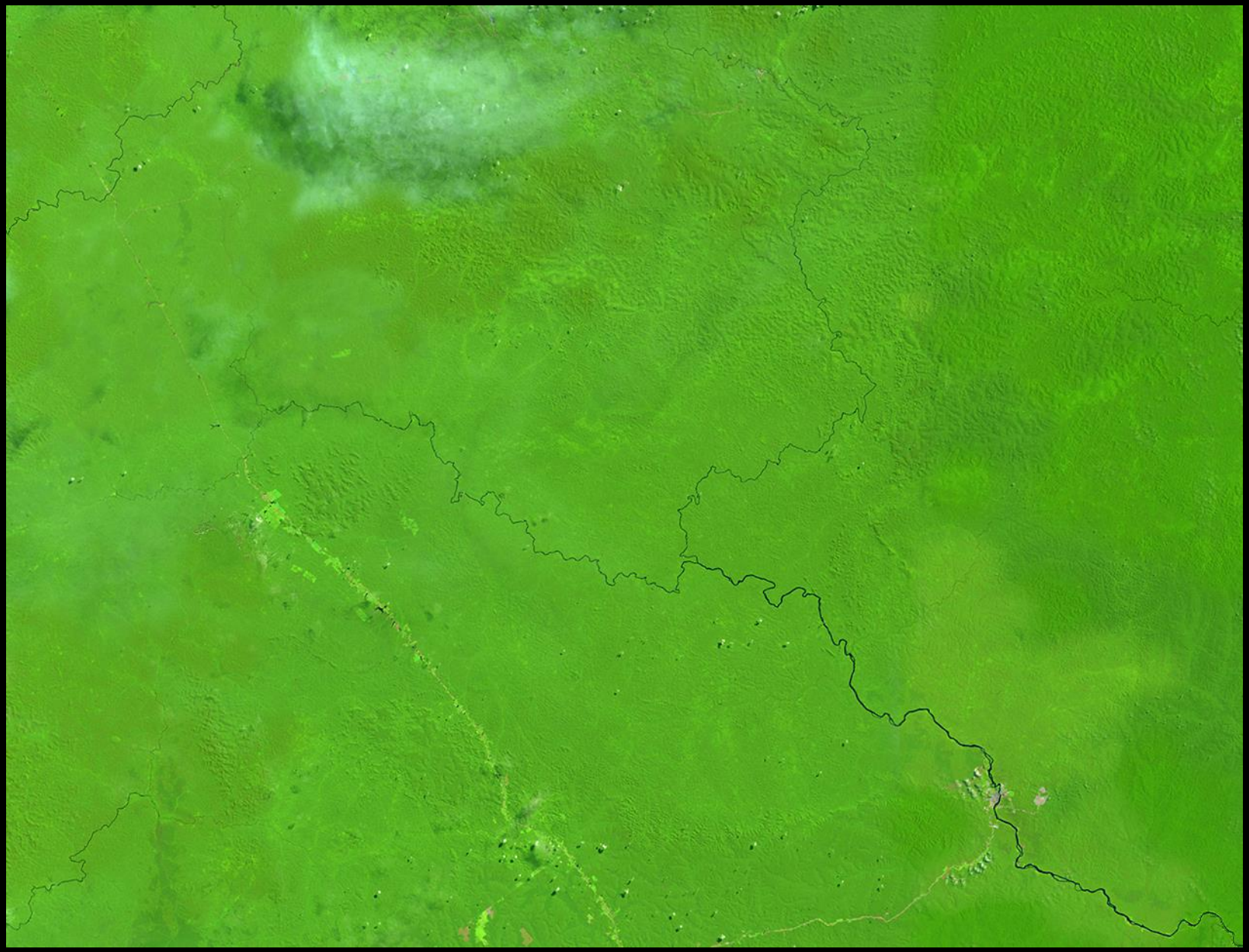
http://2amazonsintheamazon.files.wordpress.com/2013/09/img_5679.j

Landsat courtesy USGS and NASA



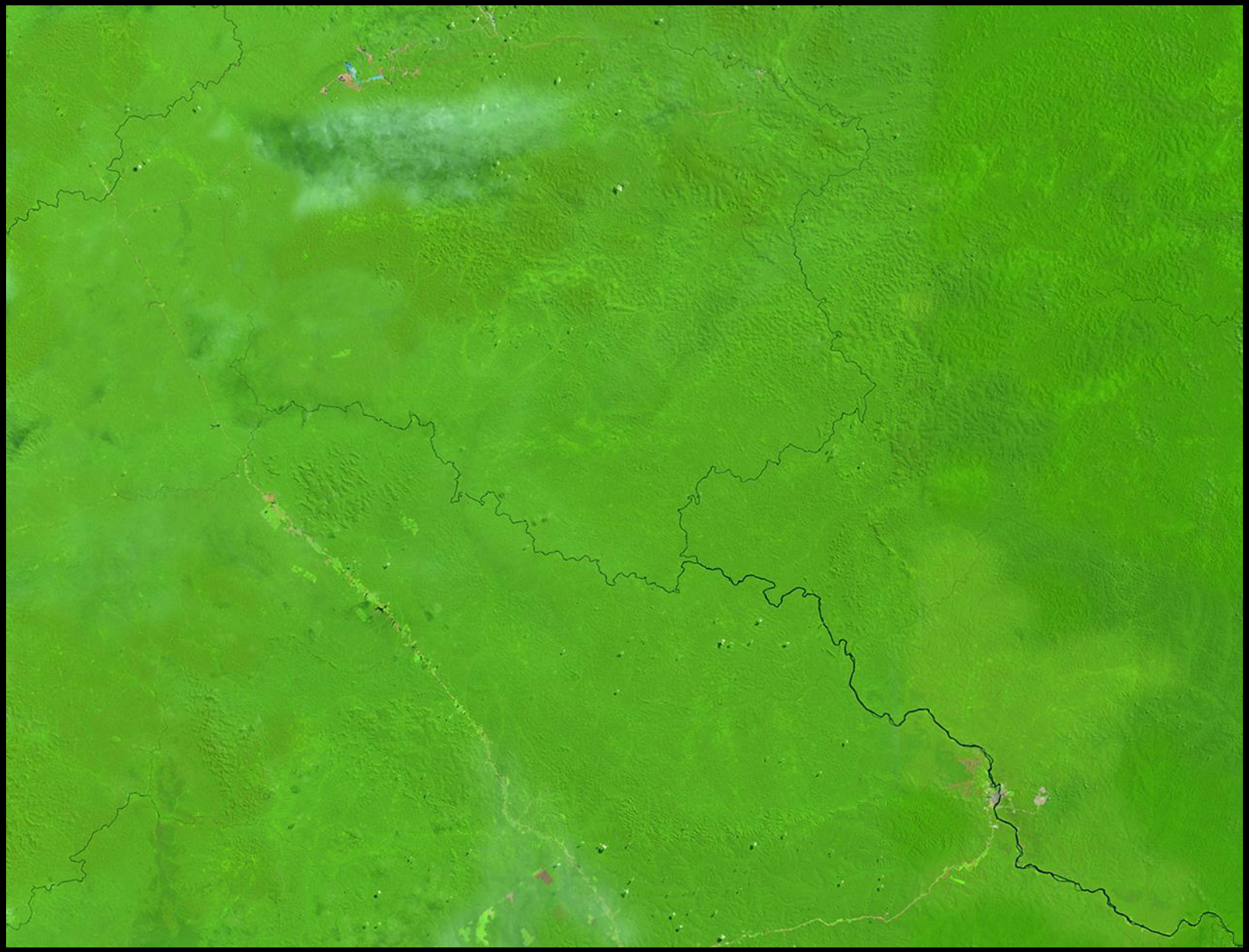
July 1972

Landsat courtesy USGS and NASA



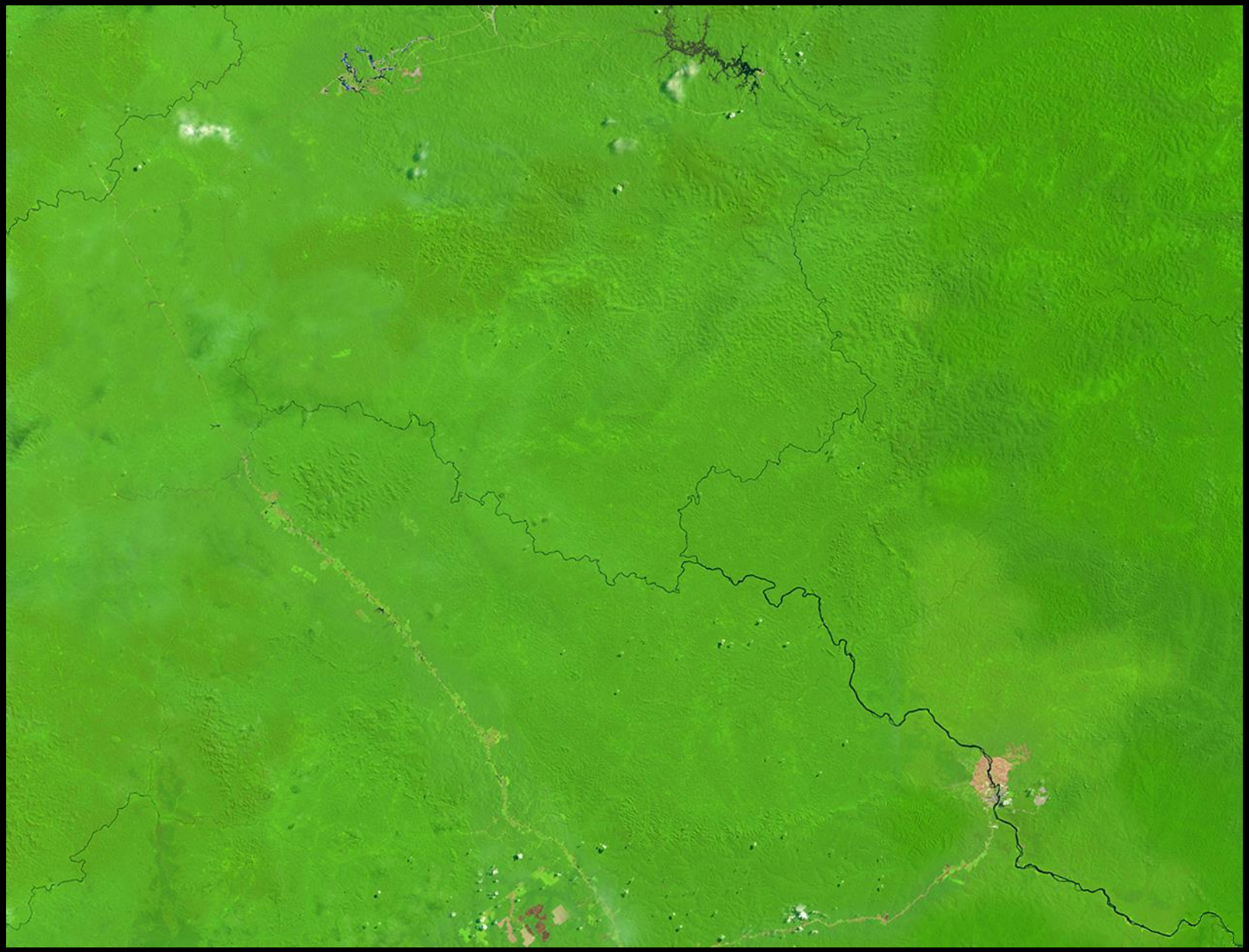
August 1984

Landsat ourtesy USGS and NASA



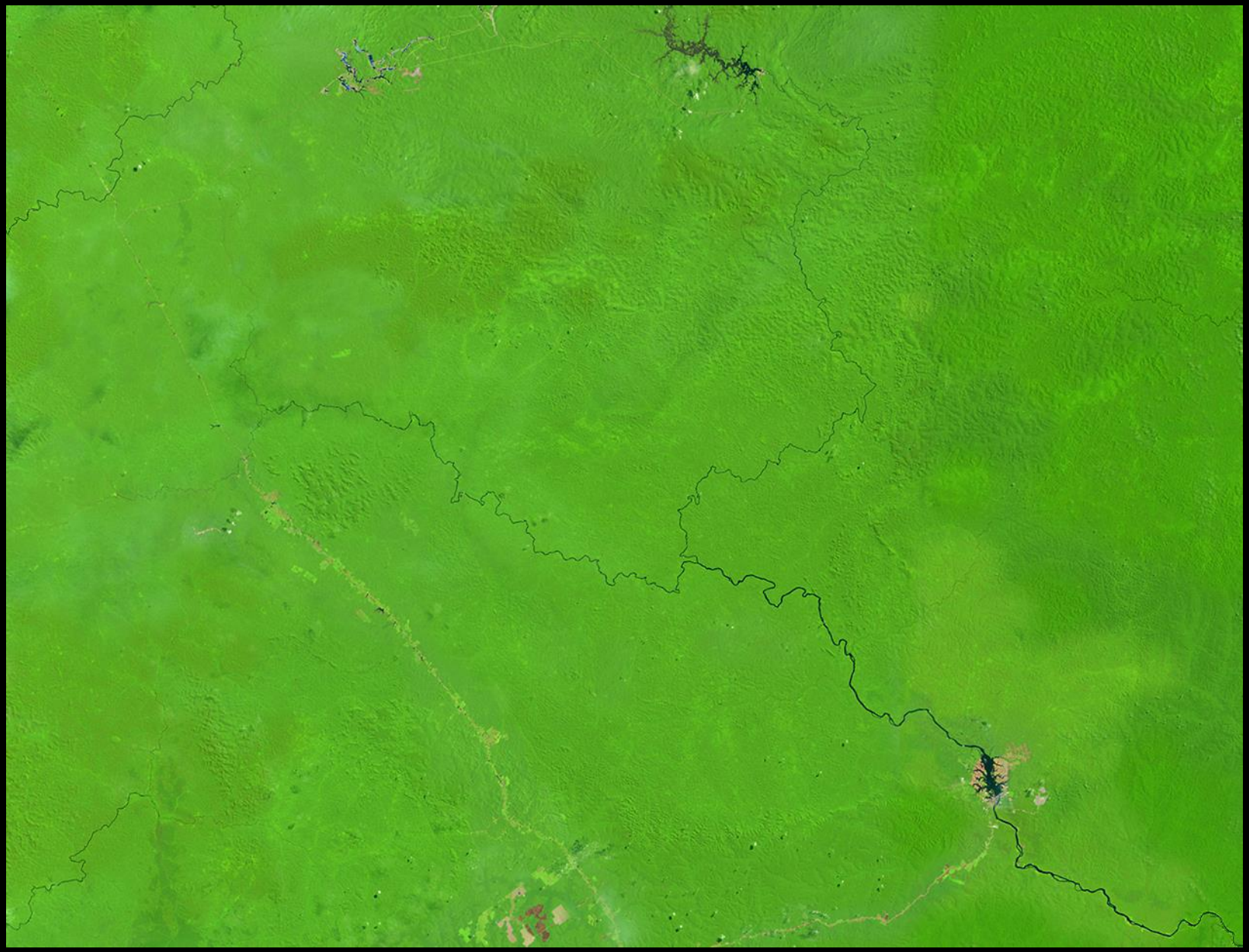
September 1985

Landsat courtesy USGS and NASA



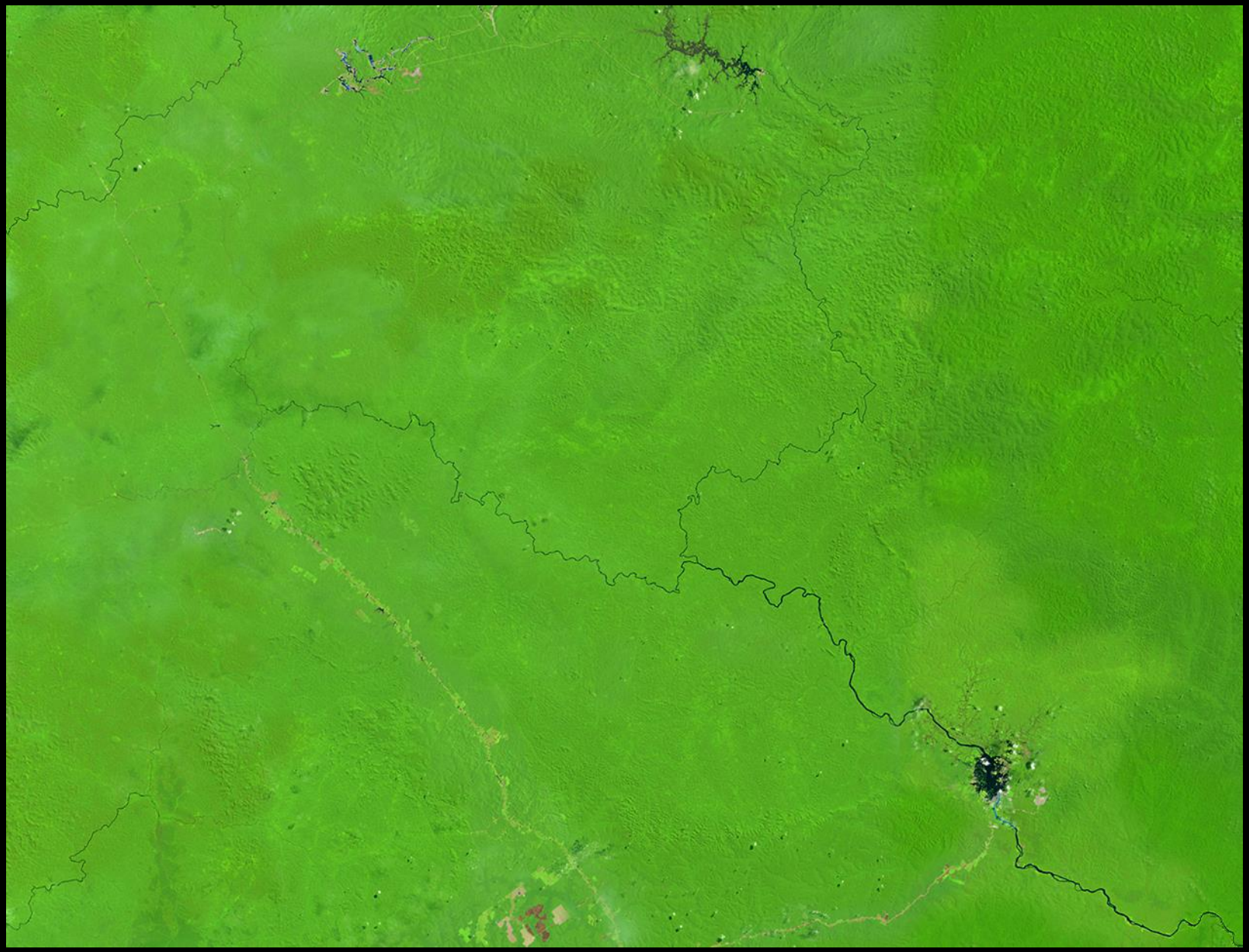
September 1987

Landsat courtesy USGS and NASA



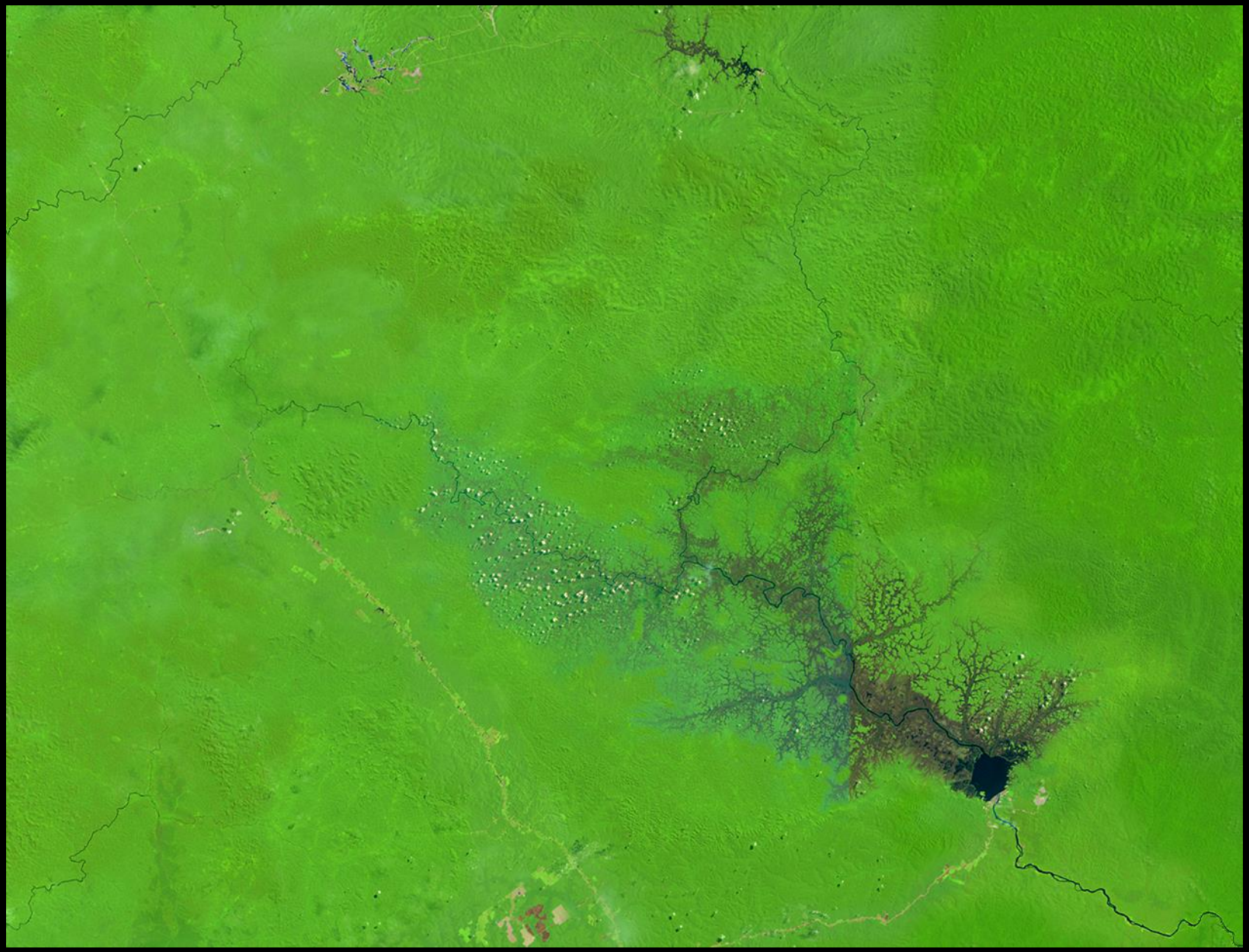
December 1987

Landsat courtesy USGS and NASA



February 1988

Landsat courtesy USGS and NASA



September 1988

Landsat courtesy USGS and NASA

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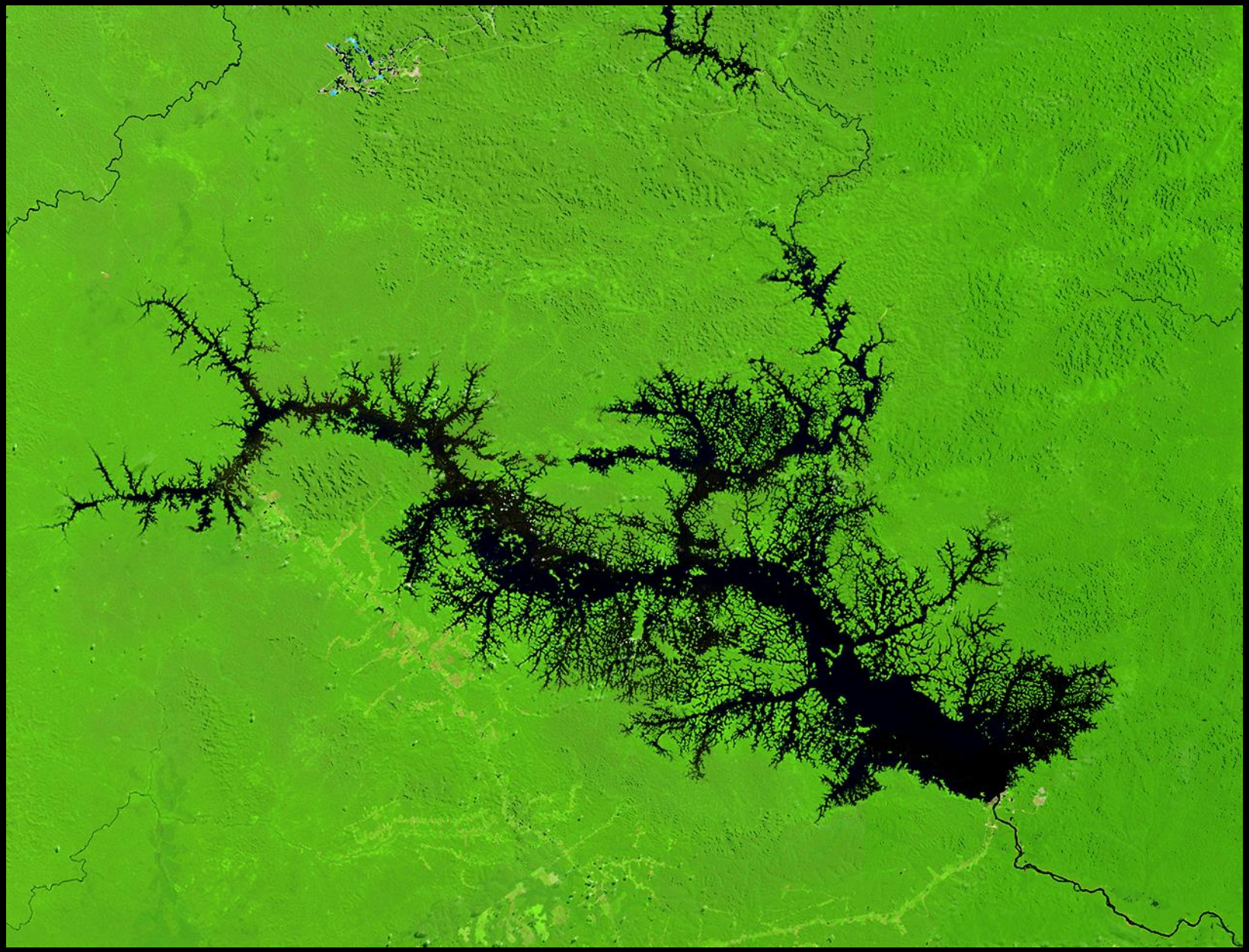


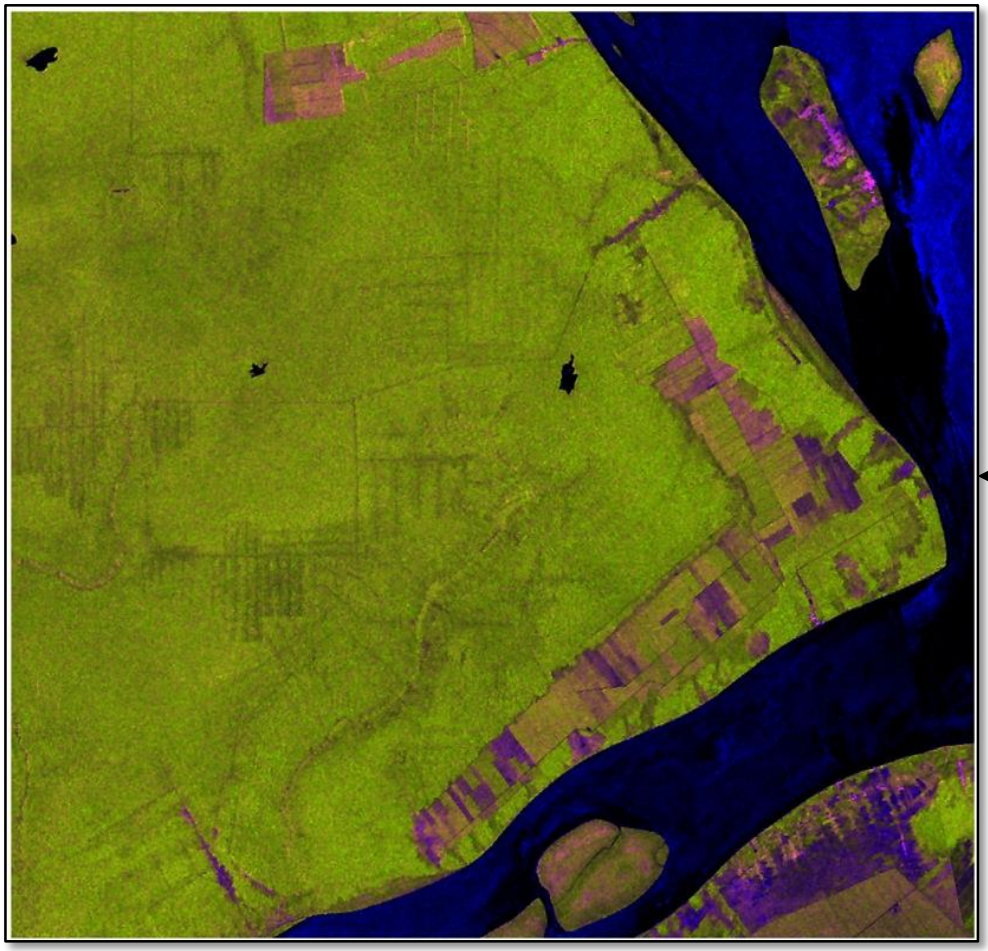
July 2013

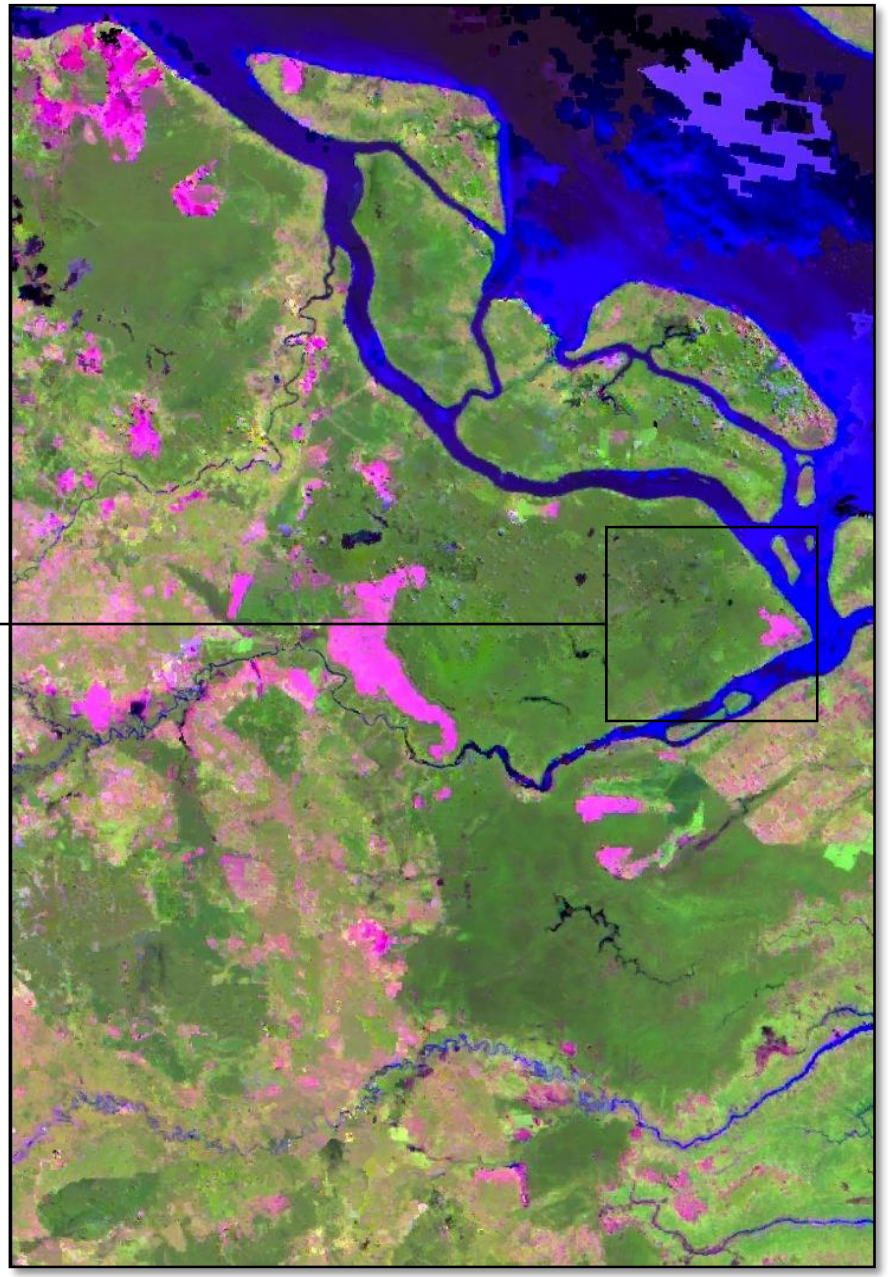
STIBIG H-J.et al., 2007. A land cover map for South and Southeast Asia derived from SPOT-4 VEGETATION data. *Journal of Biogeography,* **34**, 625 - 637

Photo credits AFP/AFP, Dita Alangkara

Images MODIS (2004) and ALOS (2007)

Indonesia: Central Sumatra - Riau province *Window size: 190 x 275 km*





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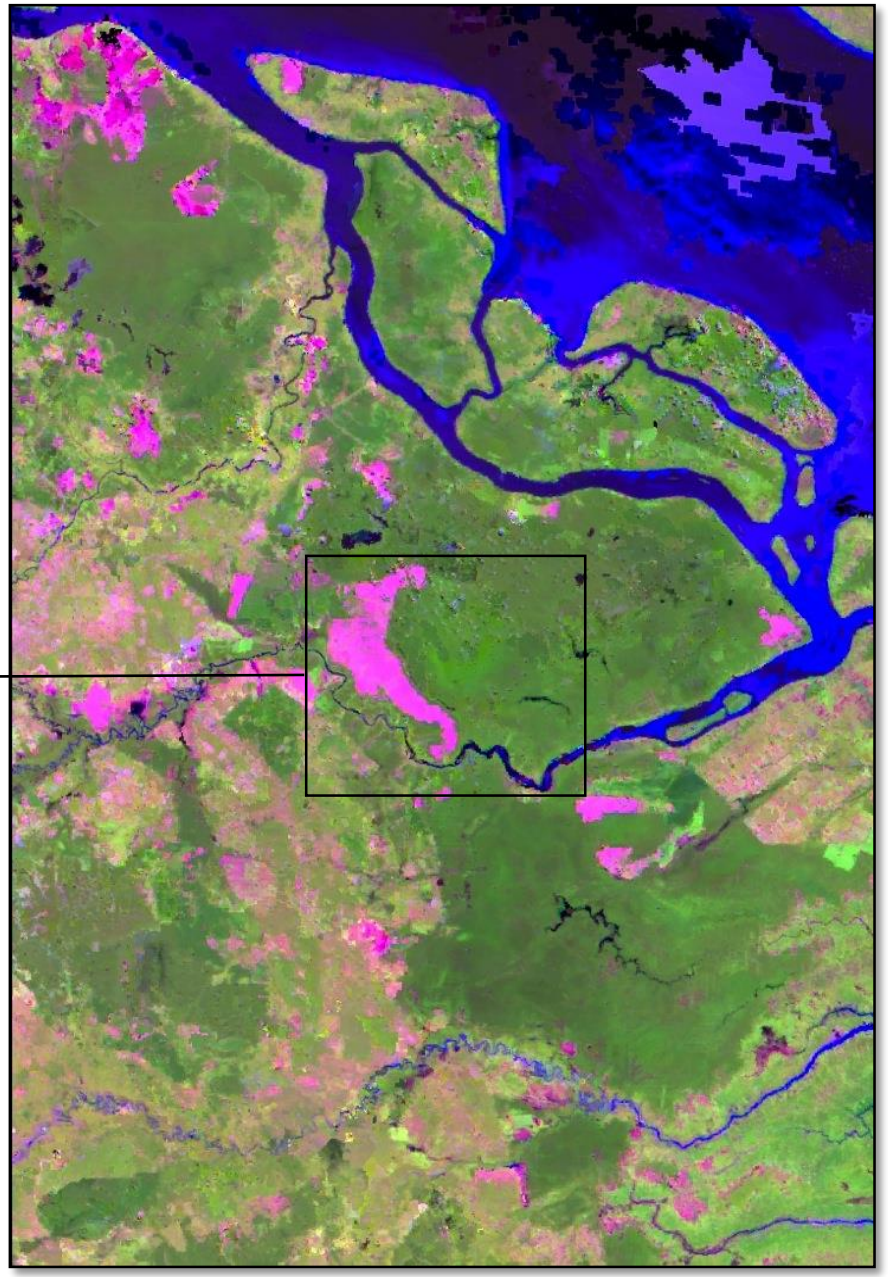


MAYAUX, P., *et al*., 2004, Journal of Biogeography 31 (6), 861-877

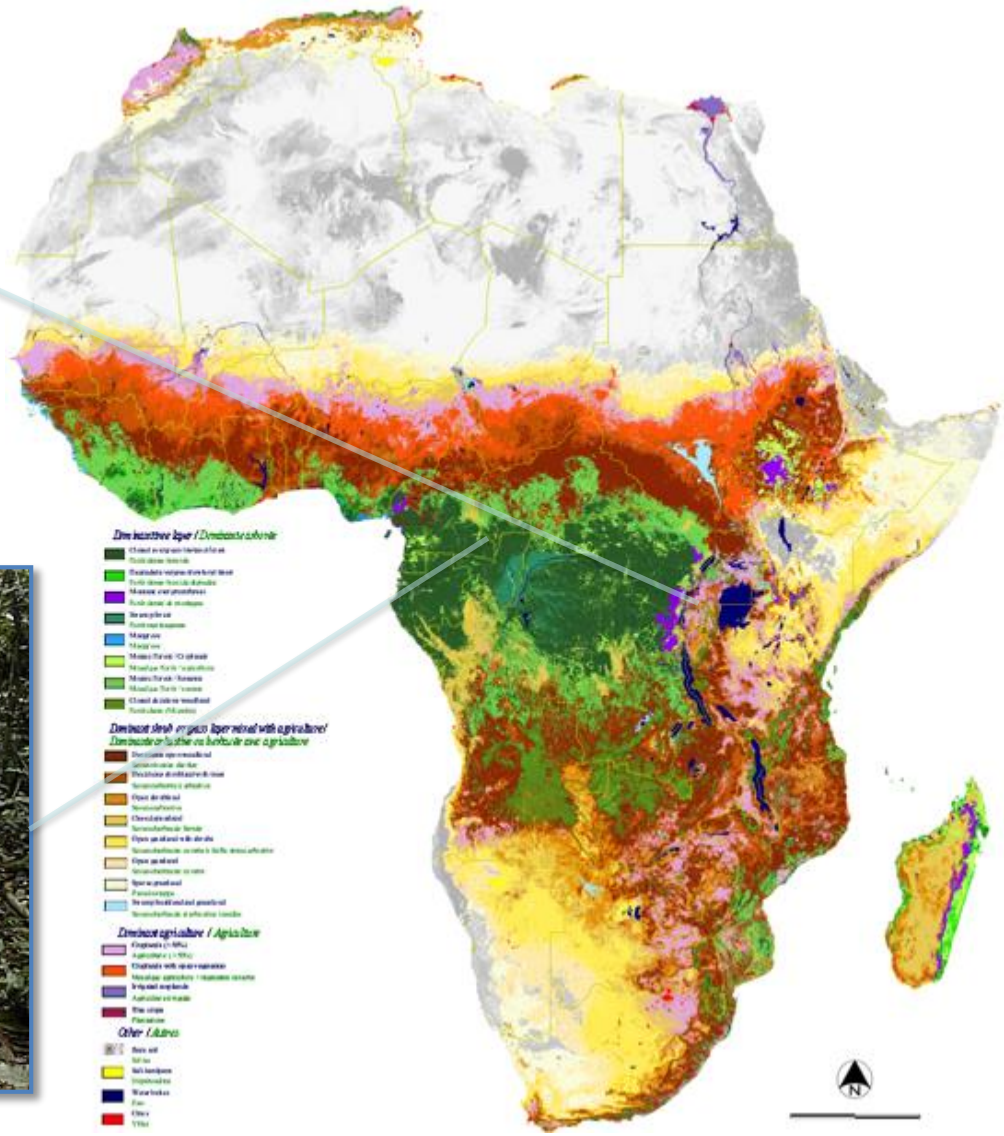
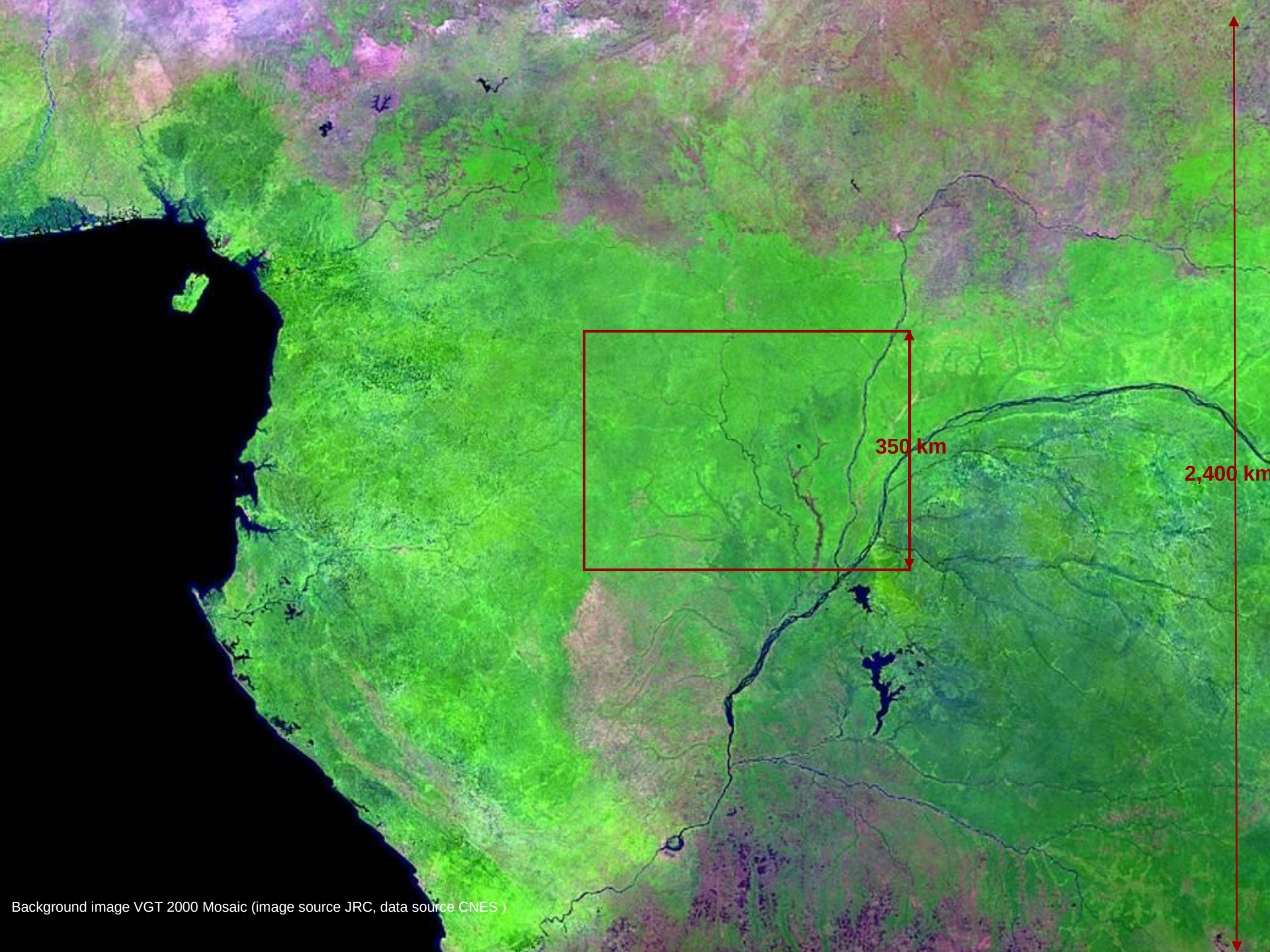
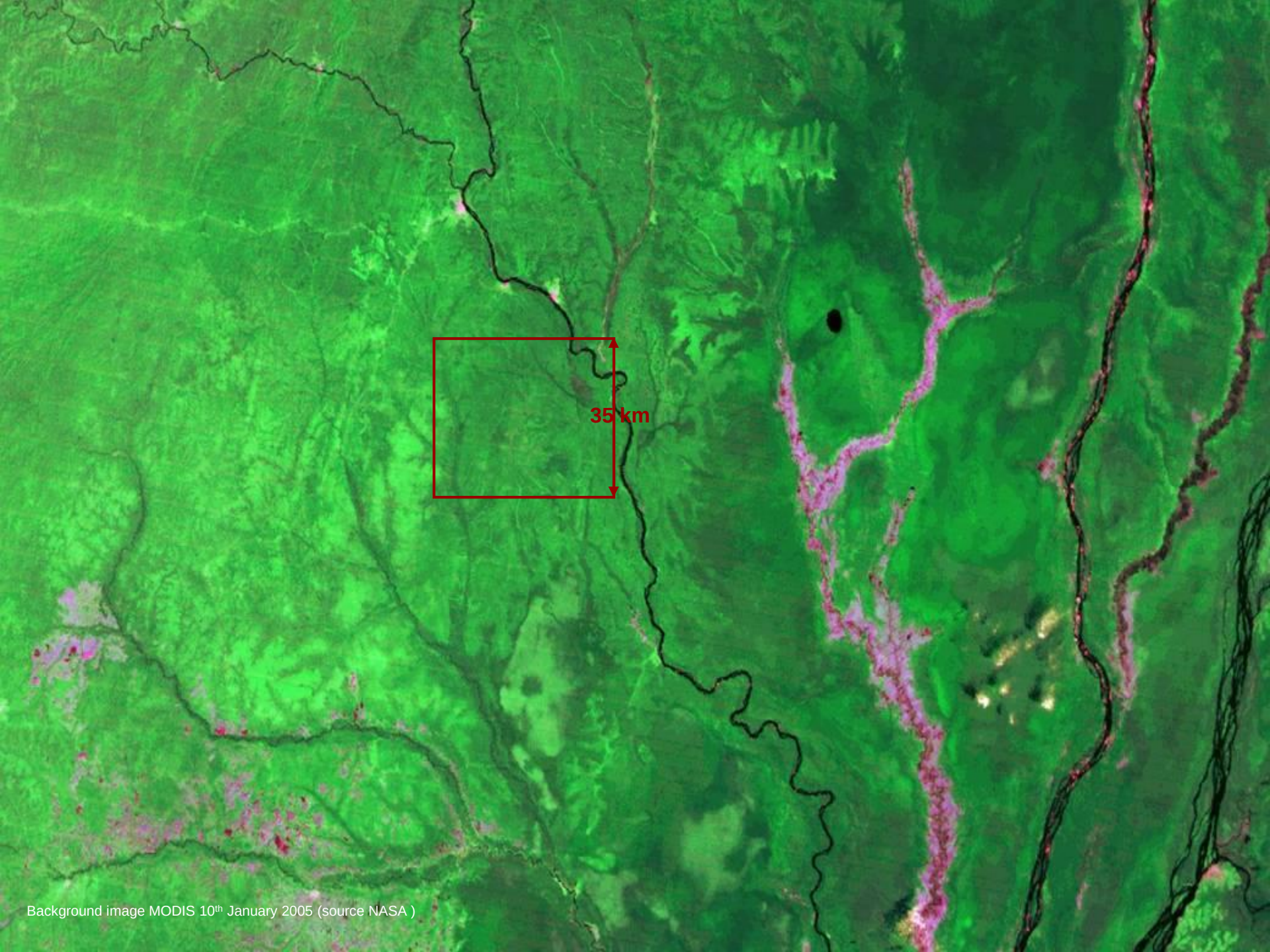
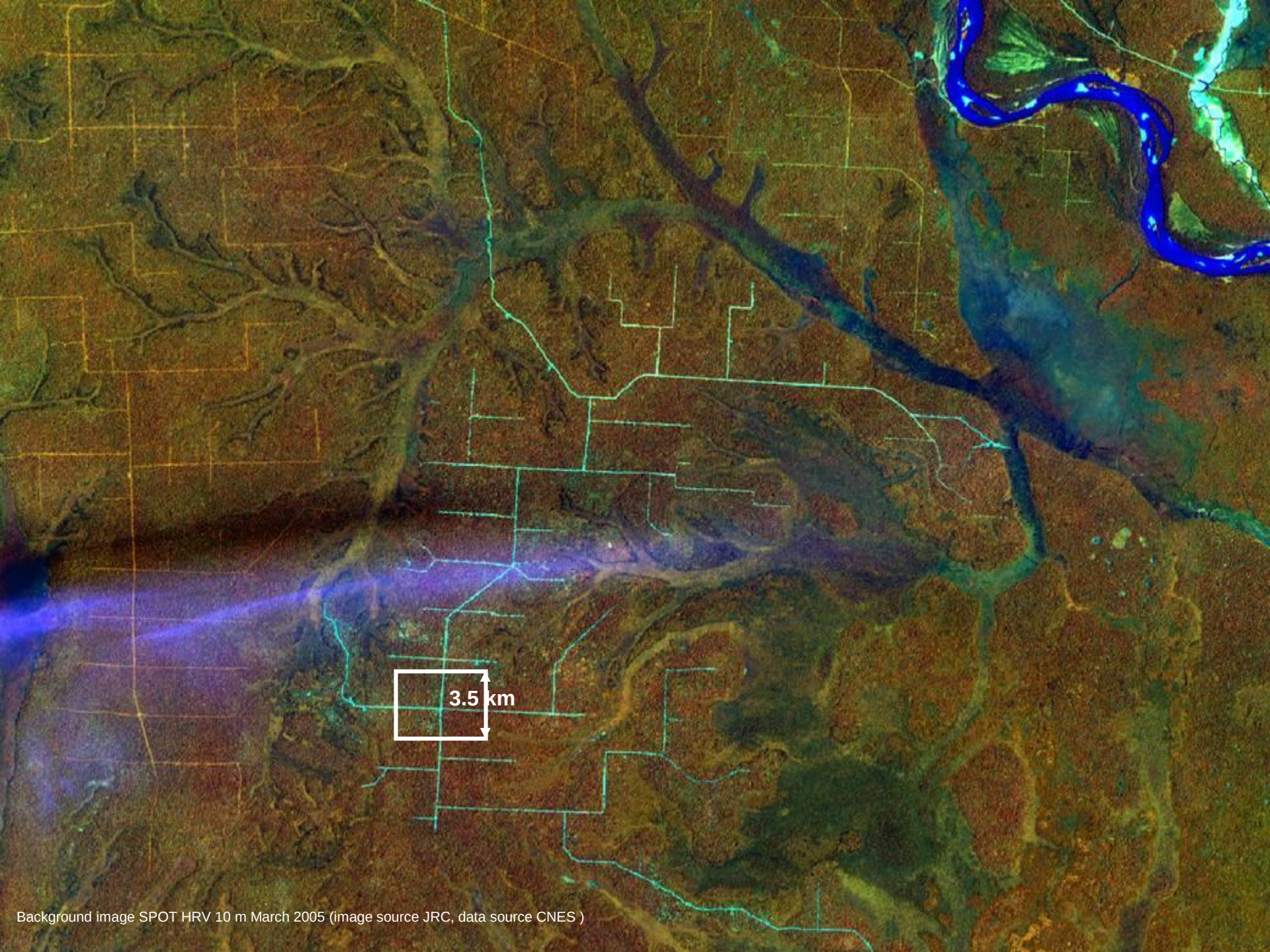


Photo credit: Reuters, and *Paulin Ngobobo, WildlifeDirect*

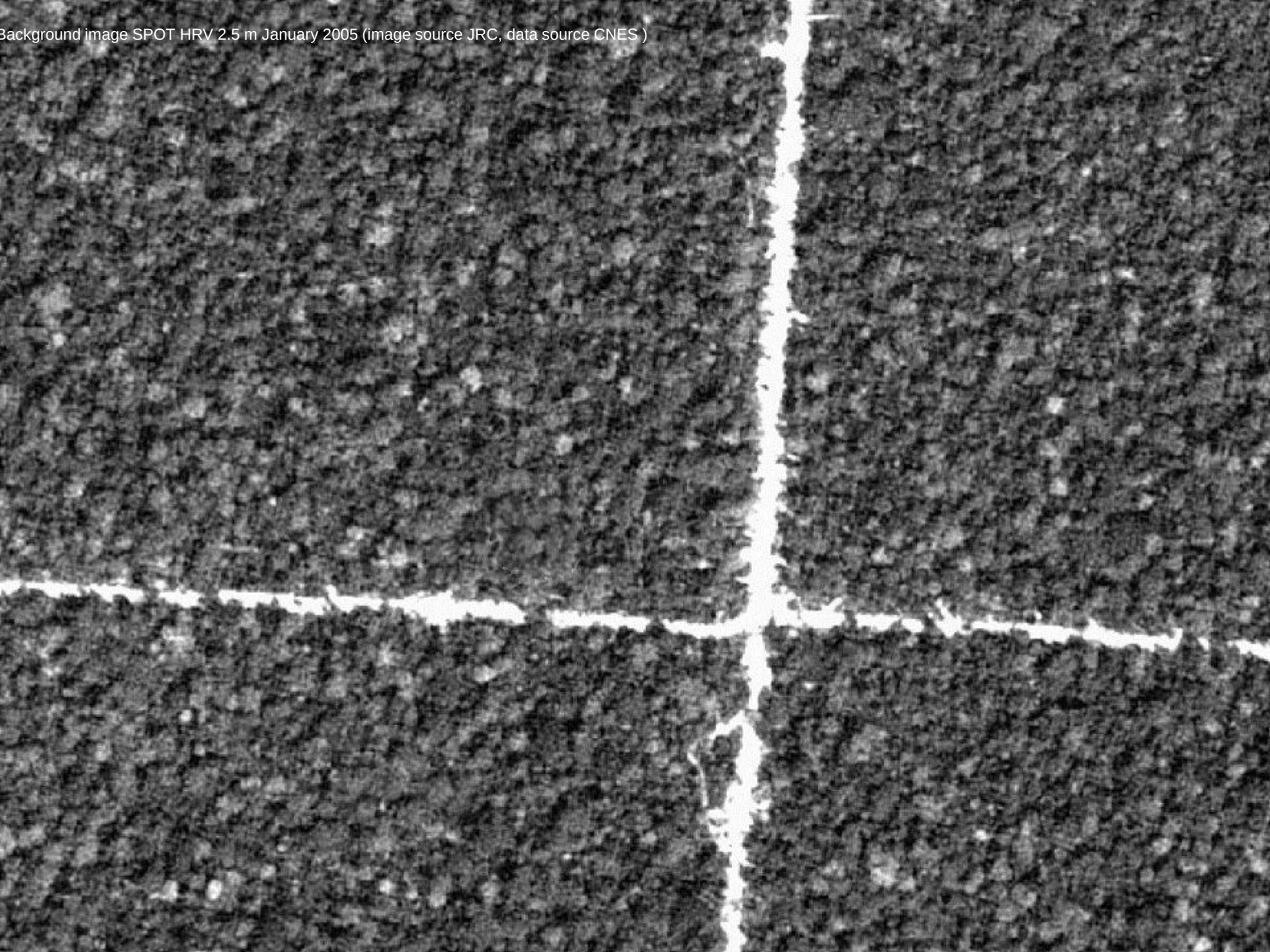

350 km
2,400 km
Background image VGT 2000 Mosaic (image source JRC, data source CNES)



Background image MODIS 10th January 2005 (source NASA)



Background image SPOT HRV 10 m March 2005 (image source JRC, data source CNES)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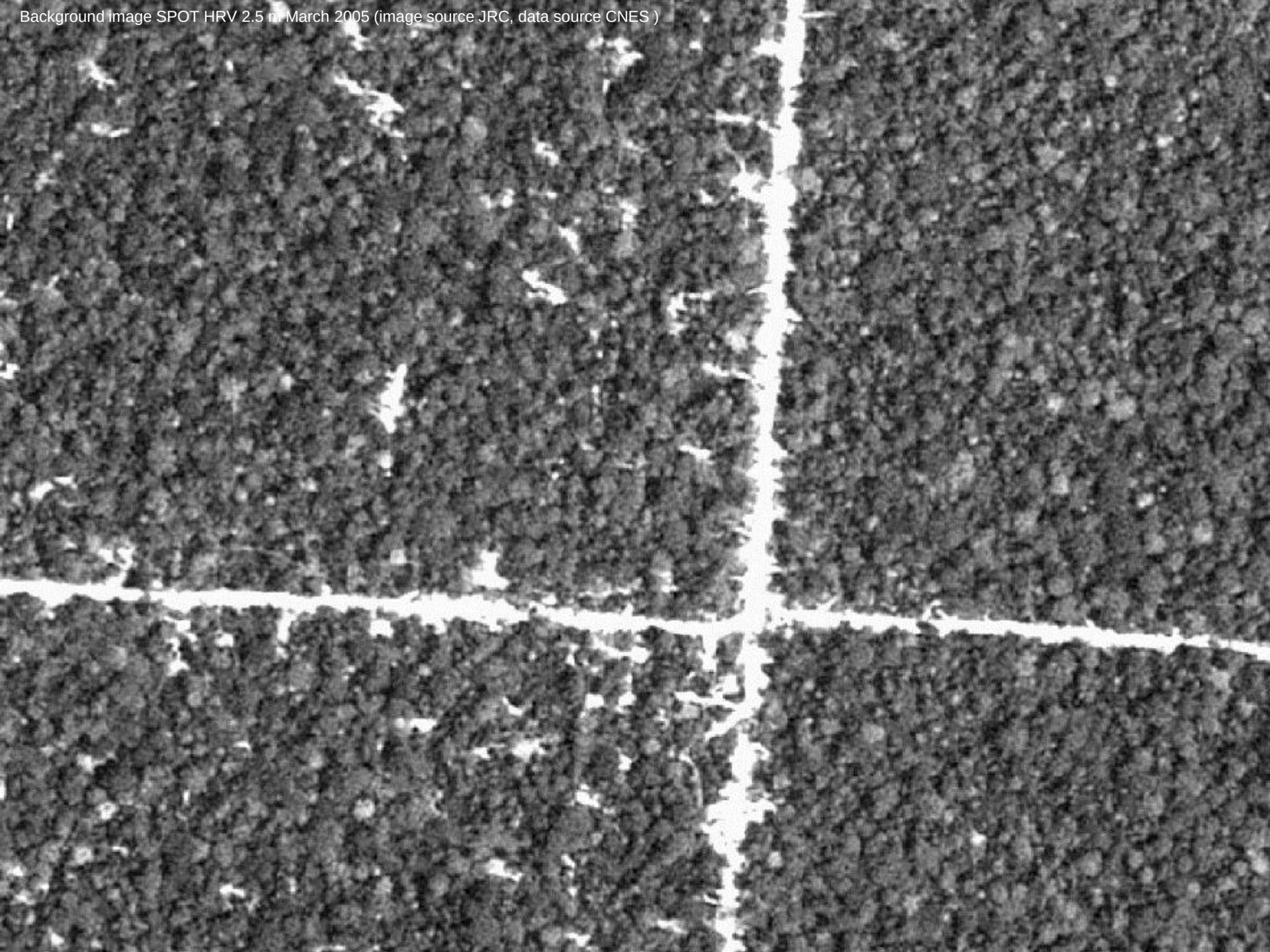
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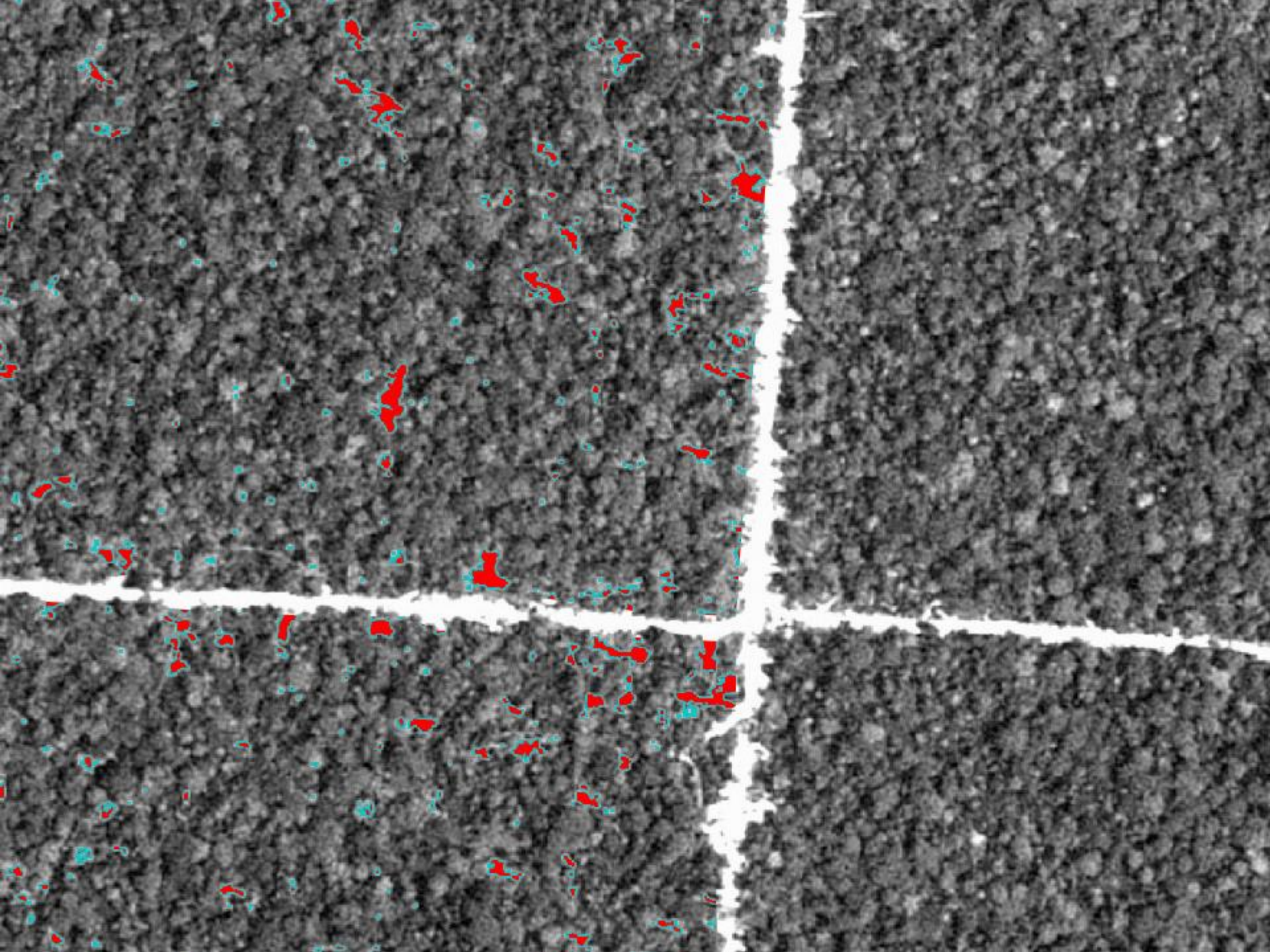
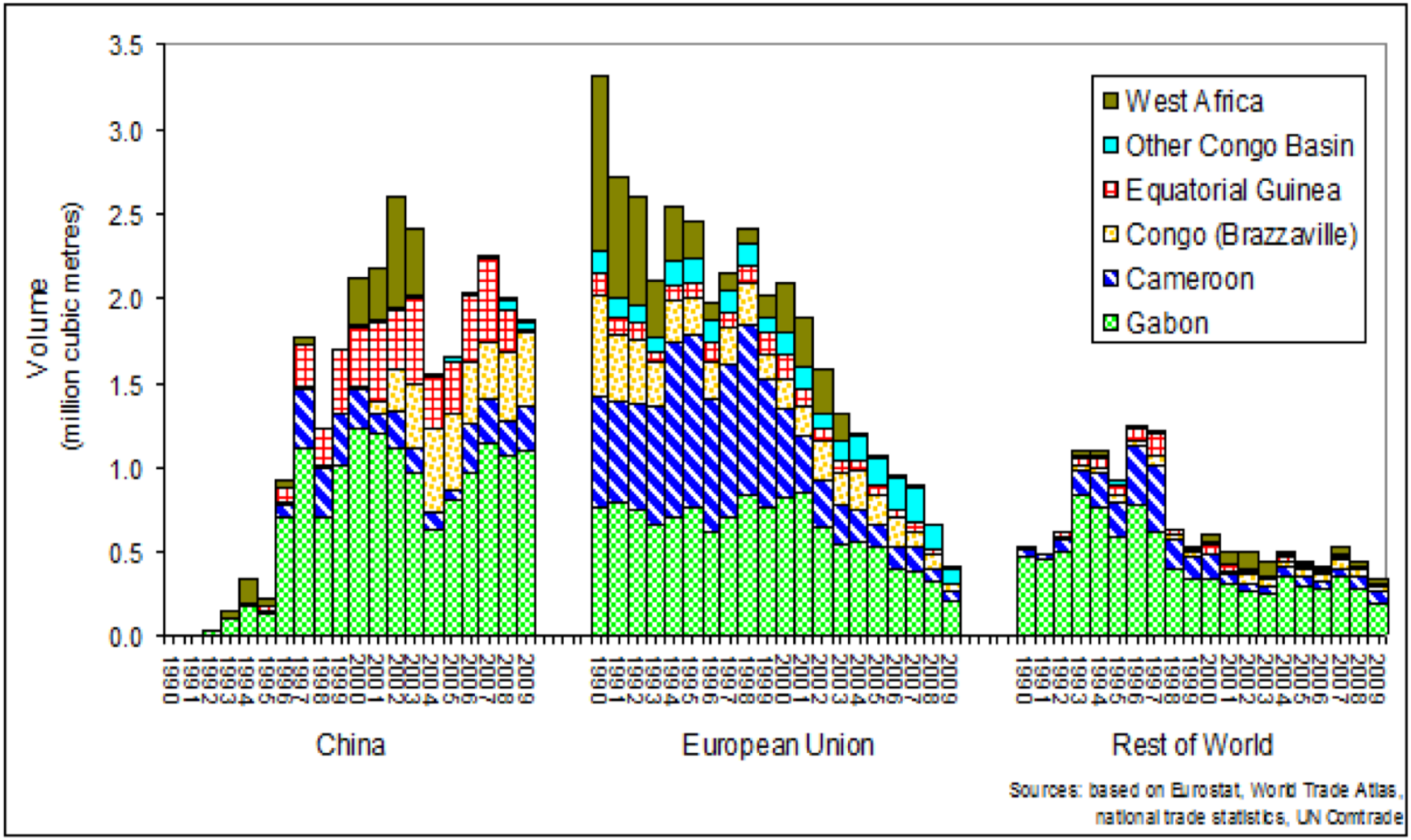


West Africa and the Congo Basin - exports of logs* to China, the EU and elsewhere (excludes plantation logs)



* excludes timber (including teak) which derived from plantations

Forest Law Enforcement, Governance and Trade

- Control of illegal logging in Cameroon and Indonesia avoided tax losses of $4 billion between 2001 and 2006
- Forest reforms in Cameroon since 1994 saw tax revenues go from zero to $50 m/yr in 2004

Source: Statistics - Illegal Logging and Related Trade: 2008 Assessment of the Global Response (Pilot Study), Chatham House, August 2008, http://www.illegal-logging.info/indicators

Photo: http://www.africanews.com/ Cameroon introduces wood tracking system, posted 17th June 2010

http://awsassets.wwf.org.au/img/fl_illegal_logging_riau_sumatra_5178.

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Illegal logging makes billions for gangs, report says

By Richard Black
Environment correspondent

Illegal logging generates $10-15bn (£7.5-11bn) around the world, according to new analysis from the World Bank.

Its report, Justice for Forests, says that most illegal logging operations are run by organised crime, and much of the profit goes to corrupt officials.

Countries affected include Indonesia, Madagascar and several in West Africa.

Illegal logging has been blamed for a number of flooding incidents, notably in the Philippines

The bank says that pursuing loggers through the criminal justice system has made a major impact in some nations, and urges others to do the same.

It also recommends that aid donors should fund programmes that strengthen the capacity of law enforcement and legal authorities to tackle

Related Stories

Logging blamed for Philippine flood deaths

http://www.bbc.co.uk/news/science-environment-17448581

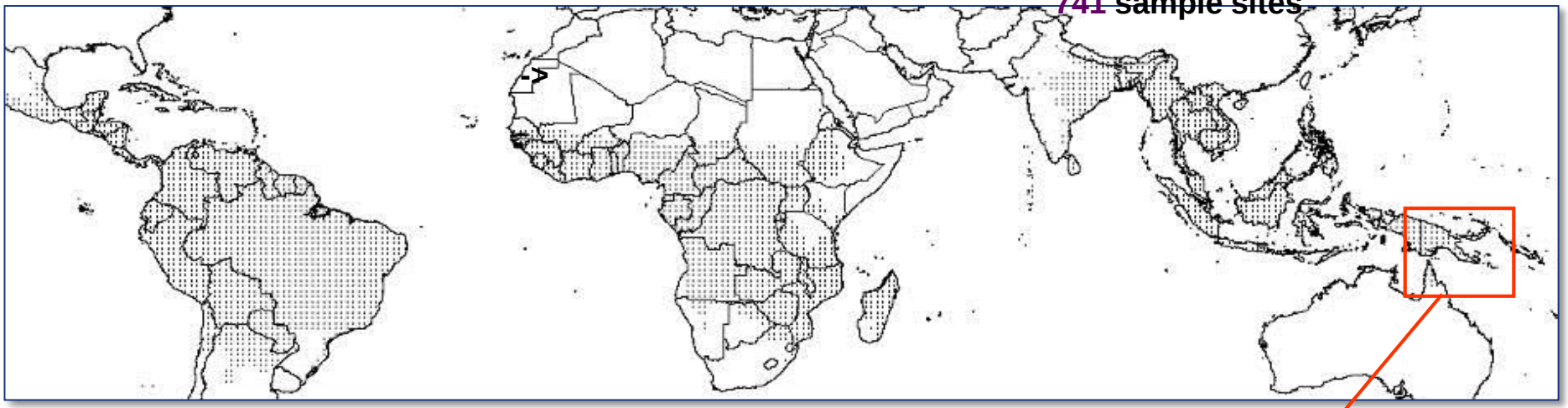
http://newswatch.nationalgeographic.com/files/2010/07/logging-photo-4-thumb-425x320

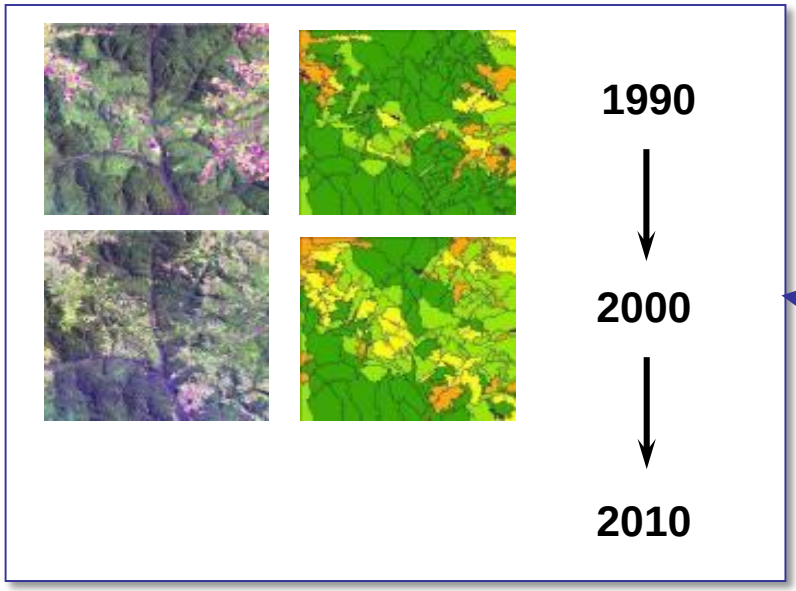
Systematic sampling - 4016 sample sites

Tropical Latin America & Caribbean (LAC): 1230 sample sites

Sub-Saharan Africa (AFR):2045 sample sites

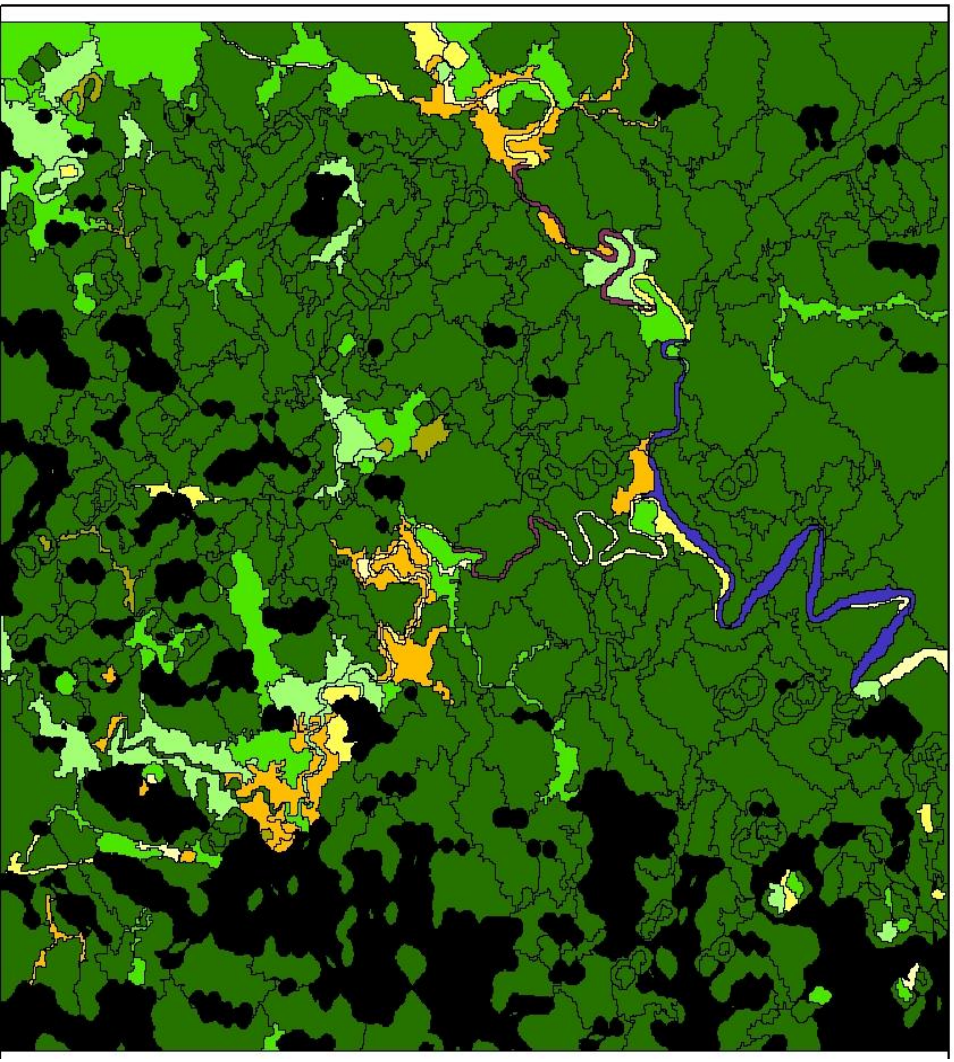
South and Southeast Asia plus PNG and the Solomon Islands (SEA): 741 sample sites

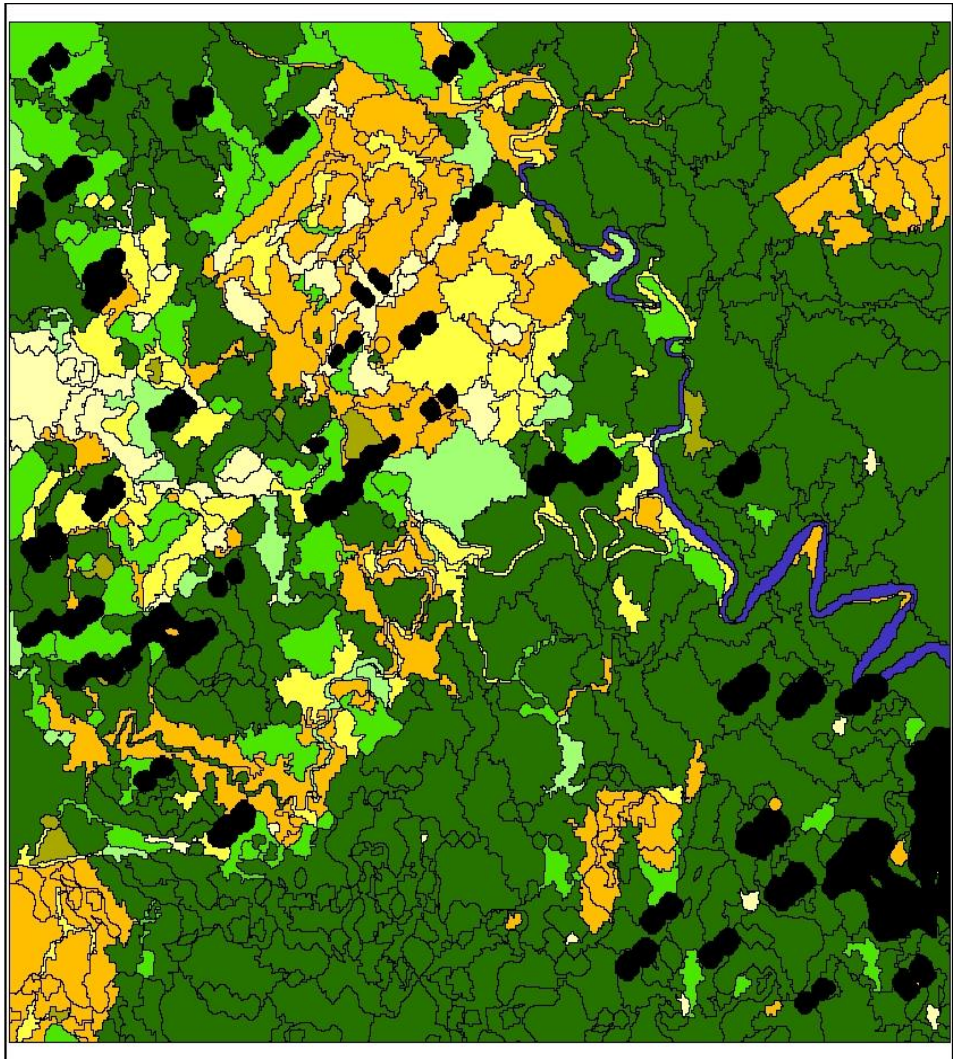




Samples are 20km x 20km size

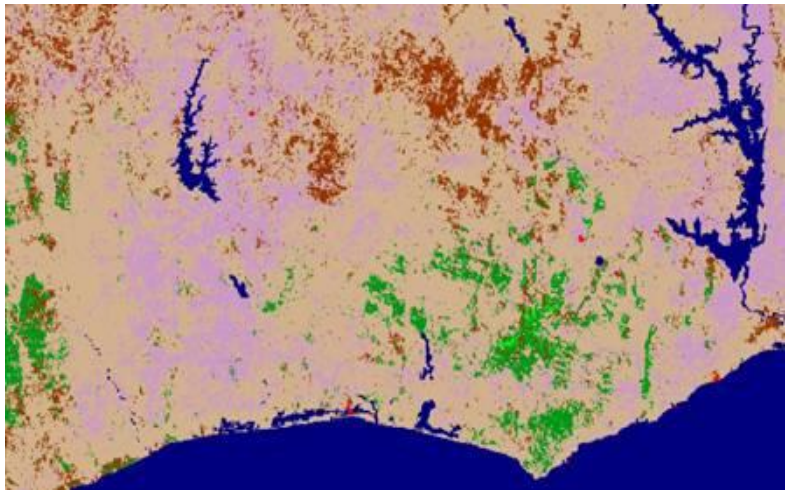
N4 E117 Borneo / E-Kalimantan-North



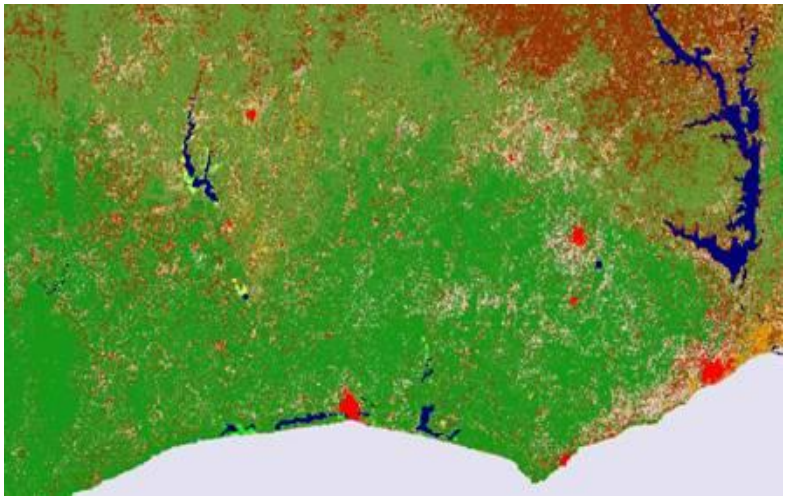


N4 E117 Borneo / E-Kalimantan-North (Mentarang): Inland Swamp Forests / Oil Palm

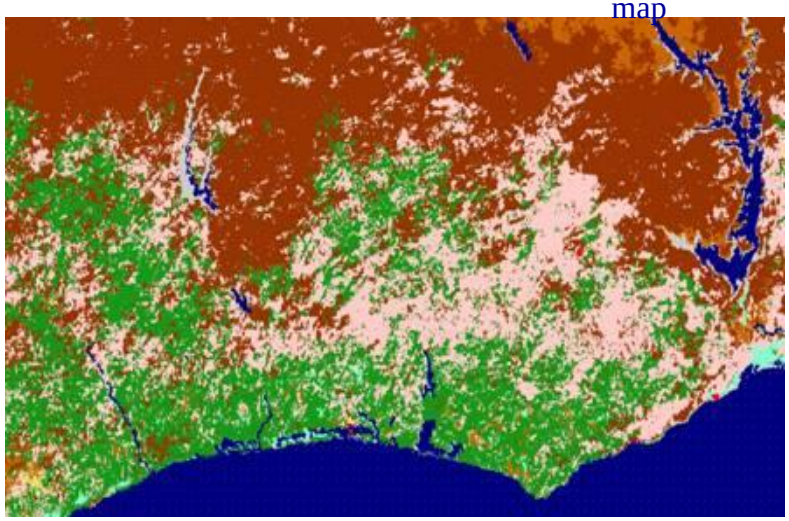
Don’t always believe the map…



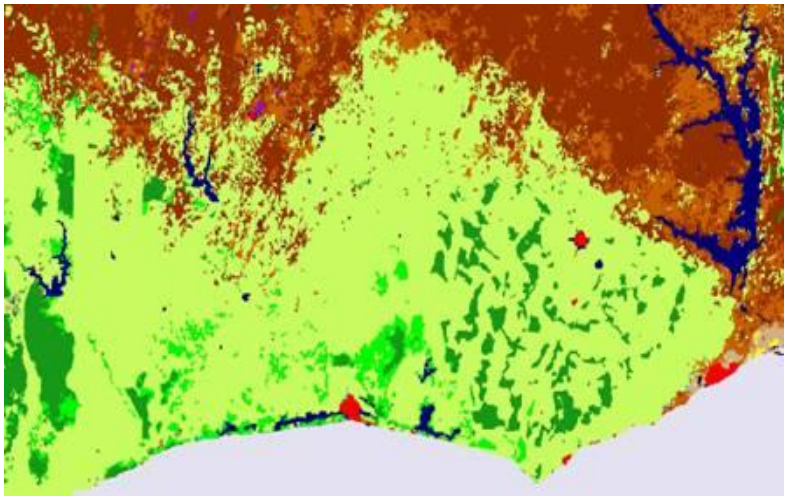
UMd map



MODIS Land Cover map



IGBP DIS-cover map



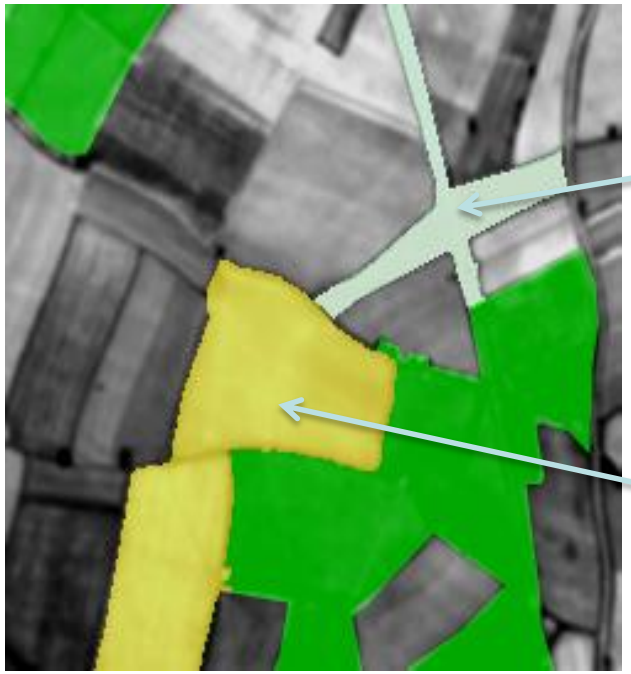
GLC2000 map

Examples of Error

- Geolocation; absolute and relative
- Thematic content - misclassification
  - Errors of omission; where the thematic class represented in the final map is incomplete, i.e some areas of the target feature are not mapped – the map fails to depict the target feature
  - Errors of commission; where the thematic class represented in the final map contains elements from different target features, i.e. some areas of the thematic class do not correspond to the associated target feature – the map depicts target features incorrectly
- Omission leads to under-estimation, commission to over-estimation… by chance these errors could cancel each other out in terms of area, and still leave you with an inaccurate map

Validation and reference data (“ground-truth”)

- In situ observations and measurements
  - Species, populations and biome composition
  - Population densities and spatial distribution
  - Landscape characteristics
  - Soil characteristics
  - Biomass
- In situ has high cost, time constraints, access restrictions – both physical and legal, nor are they error free
- Surrogates are often used (air photo, VHR imagery)
  - Suitability, selection, preparation and analysis
  - Own errors to be considered


Omission
Commission

Interpreting the confusion matrix

n = 295		Predicted (Mapped Data)		
		Not-Harvested	**Harvested**	**Row Total**
Actual (Reference Data)	**Not-Harvested**	84	9	93
	Harvested	22	180	202
	Column Total	106	189	295

Omission (Not-Harvested) = 84/93 90%

Commission (Not-Harvested) = 84/106 79%

Commission (Harvested) = 180/189 95%

Omission (Harvested) = 180 / 202 89%

Overall accuracy = 264 / 295 89%

Interpreting the confusion matrix

n = 295		Predicted (Mapped Data)		
		Not-Harvested	**Harvested**	**Row Total**
Actual (Reference Data)	**Not-Harvested**	84	9	93
	Harvested	22	180	202
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User's accuracy

Producer's accuracy

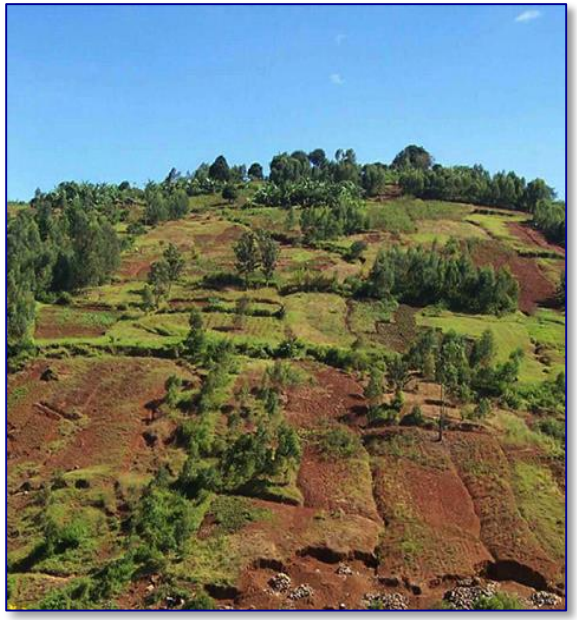
Errors may not all have equal Importance…

Forest area estimates for year 2010 and annual deforestation 1990-2000 & 2000-2010 (million ha & million ha per year)

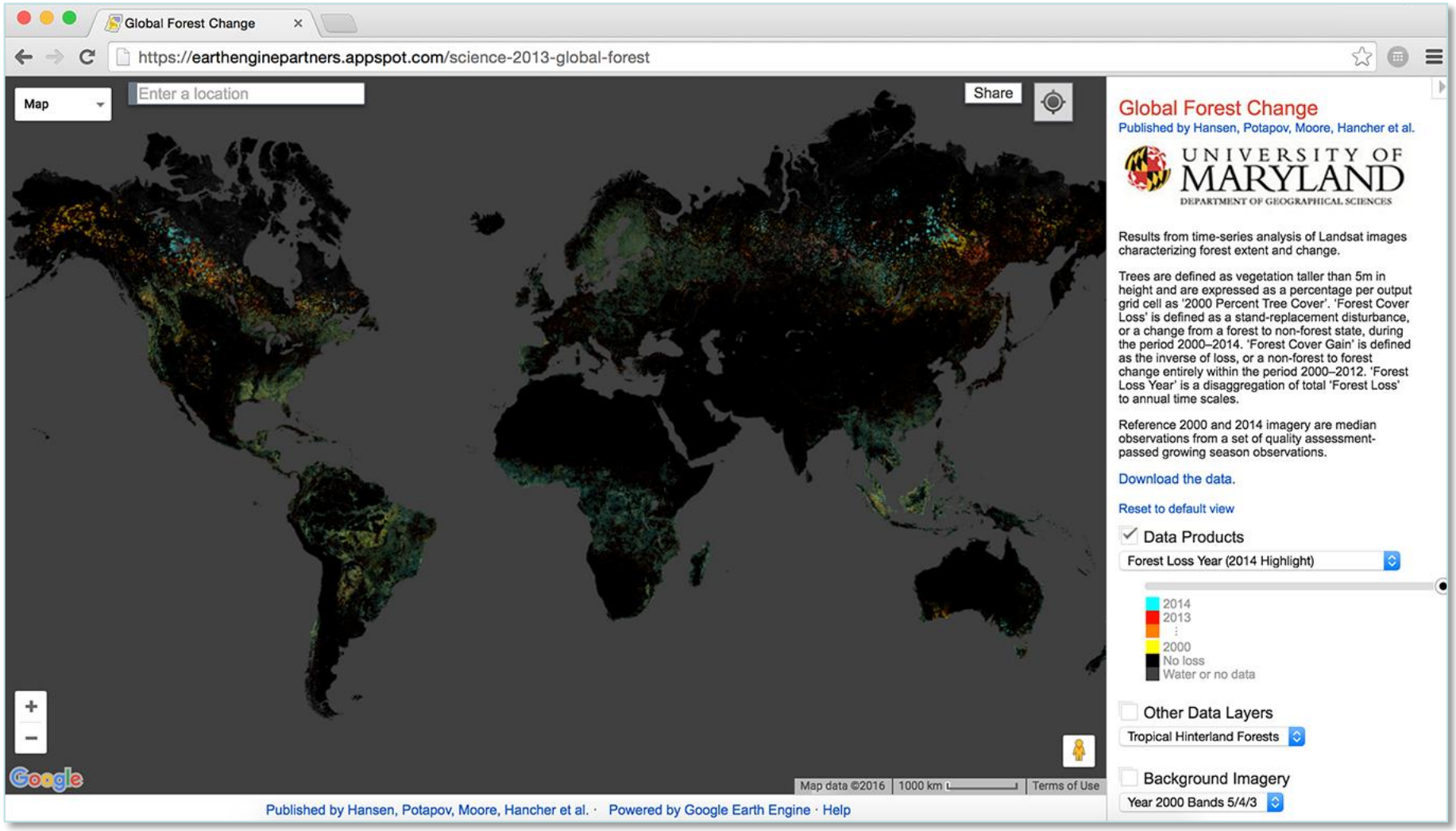
Source	FAO Country Survey			JRC RSS		
Region	Forest 2010	Net loss 1990-2000	Net loss 2000-2010	Forest 2010	Net loss 1990-2000	Net loss 2000-2010
South America	**843**	**4.30**	**4.07**	**743**	**2.85**	**2.84**
Africa	**666**	**4.08**	**3.44**	**485**	**1.42**	**1.65**
Southeast Asia	**324**	**2.53**	**0.78**	**286**	**1.78**	**1.44**

Afforestation
India Photo: K. Ramesh Babu The Hindu

Reforestation
Brazil Photo: Reserva Ecologica De Guapi Assul



Deforestation
South Kivu DRC Photo: CIRAD S. Bouderbala



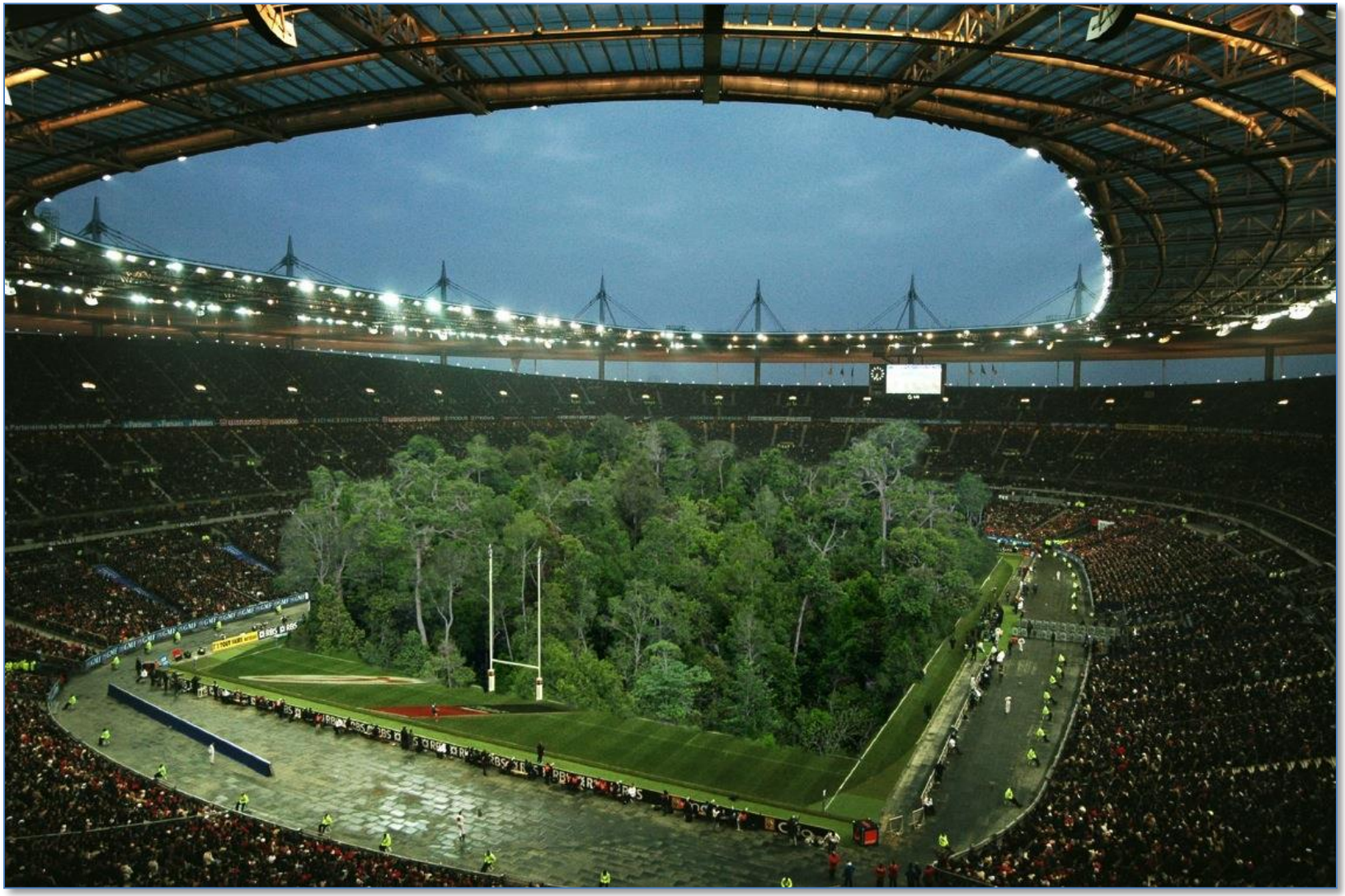
https://earthenginepartners.appspot.com/science-2013-global-forest

European Commission

Joint Research Centre

Photo credit Thomas Faivre-Duboz

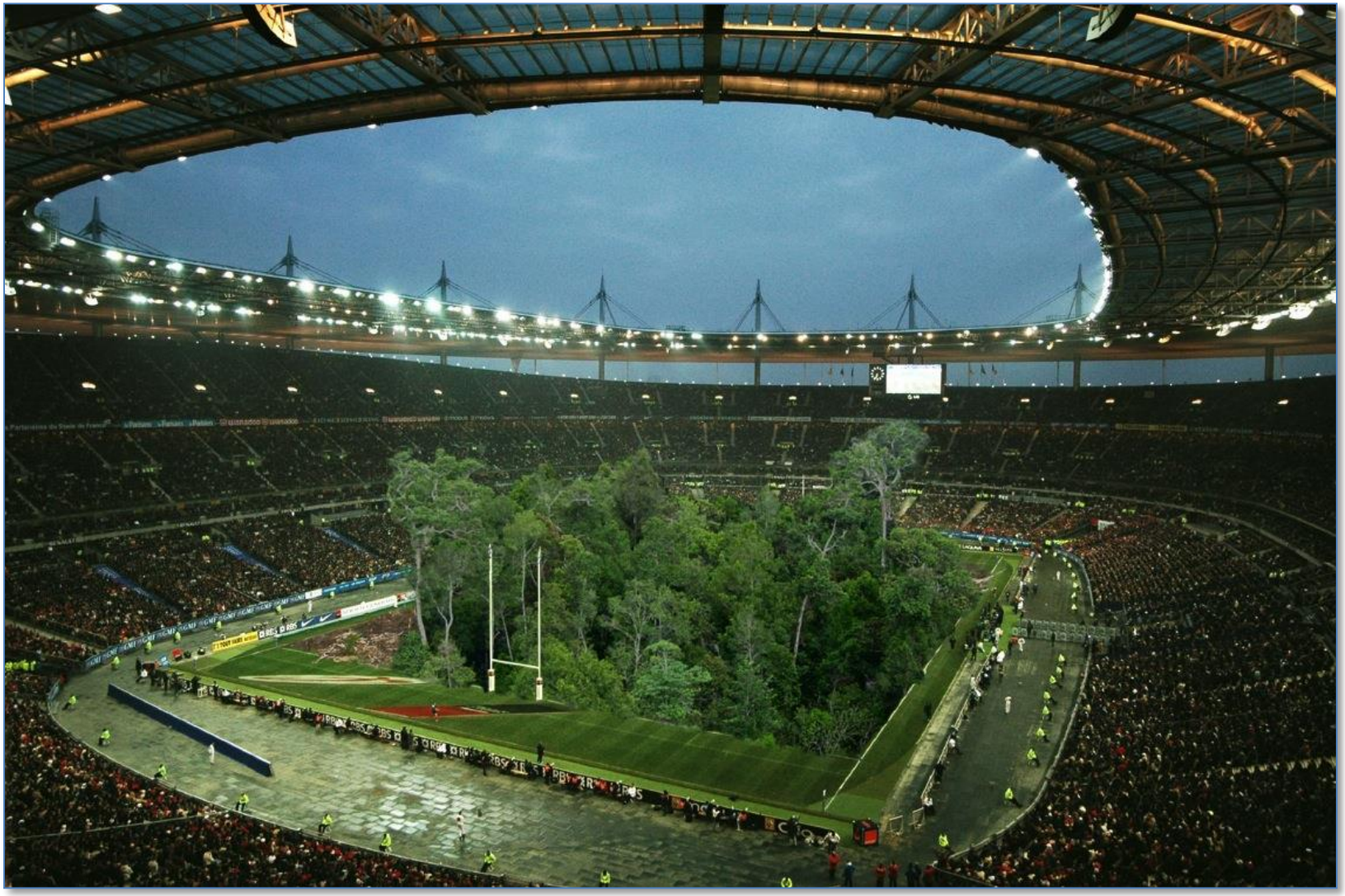
European Commission



Joint Research Centre

Photo credit Thomas Faivre-Duboz, modified by Alan Belward

European Commission



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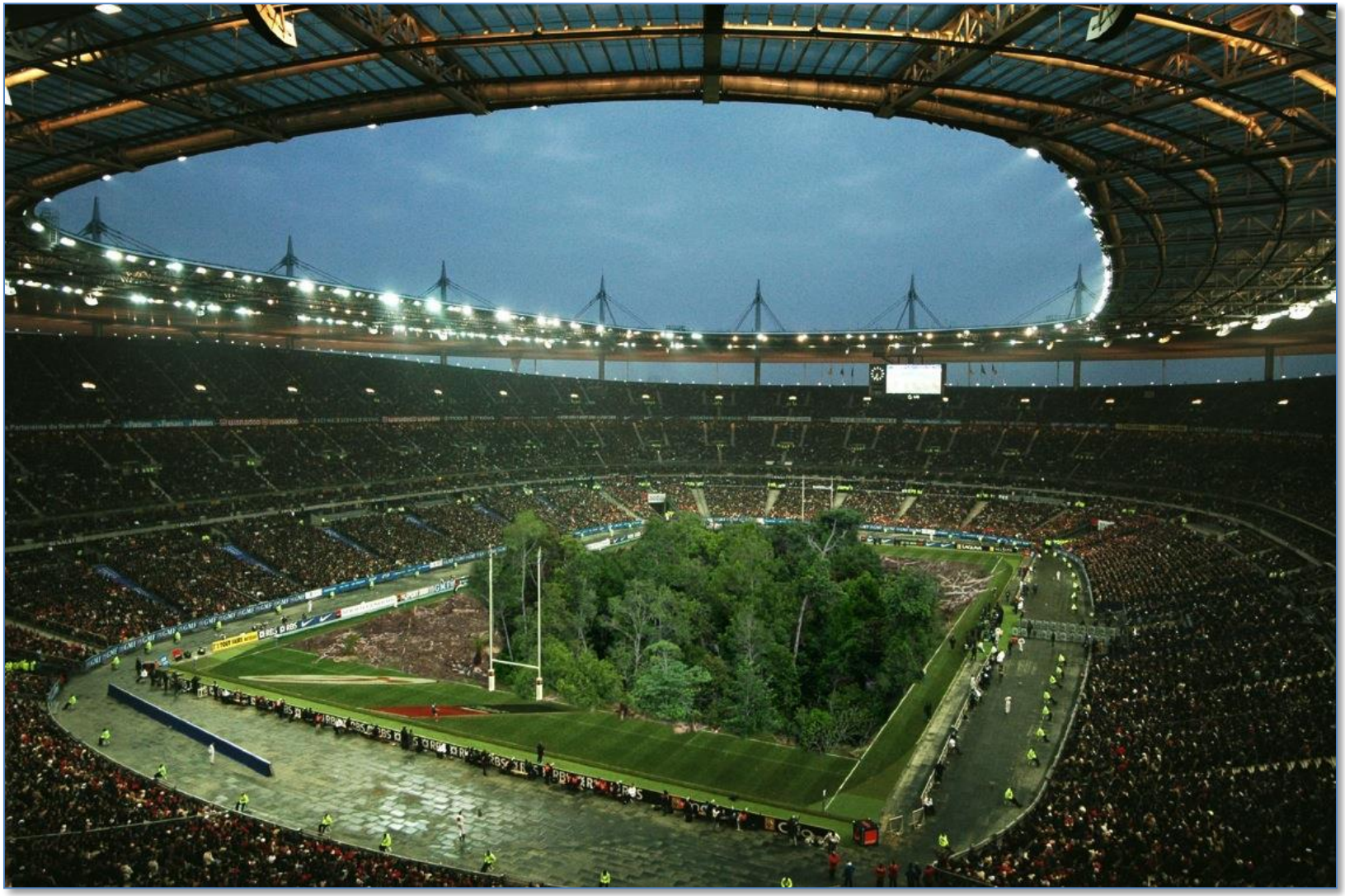

Joint Research Centre

Photo credit Thomas Faivre-Duboz, modified by Alan Belward

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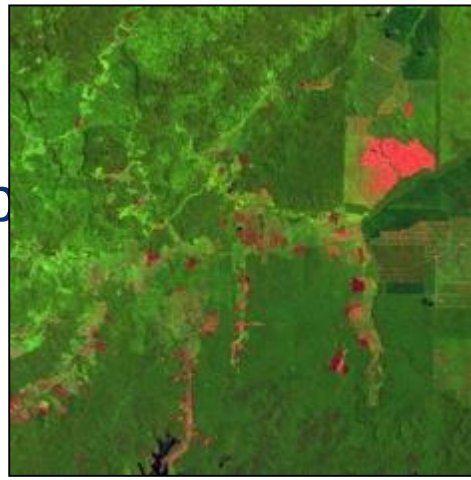
Summary

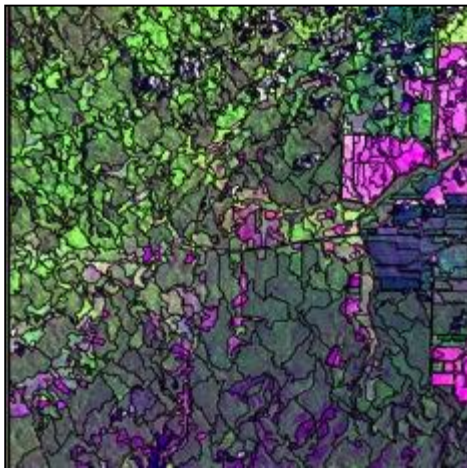
① Where are the world's forests found?

② Where is forest cover changing?

③ What are the reasons for this change?

④ EO is able to quantify these changes and help attribute causes.





Source; USGS S01_W053_tm_226-061_23081986
S01_W053_etm_226-061_08042003; segmentation JRC