Remote Sensing and Forest Degradation

an organic, free-range presentation...

Erik Lindquist
Forestry Officer – UN Food and Agriculture Organization
Ciudad de Panama, 3 Septiembre, 2014

Today's Presentation

- Why is it important??
- What is degradation??
- MODIS-based, global, hot-spot approach
- Landsat-based, local, experimental
- Time-series approach...
- Ancillary datasets

Why is degradation important?

- Deforestation and degradation contribute between 6 and 18 percent of annual CO2 emissions (between 4 and 14 deforestation alone)...

- Locally...degradation can contribute much more
- Doubles the rate of deforestation alone (DRC...)

Van der Werf et al., 2009, Zhuravleva et al., 2013

What is forest degradation?

Pick a definition that can be measured/monitored with available instruments

We chose to define degradation as a measureable decrease in canopy cover that is not complete overstory removal (deforestation)

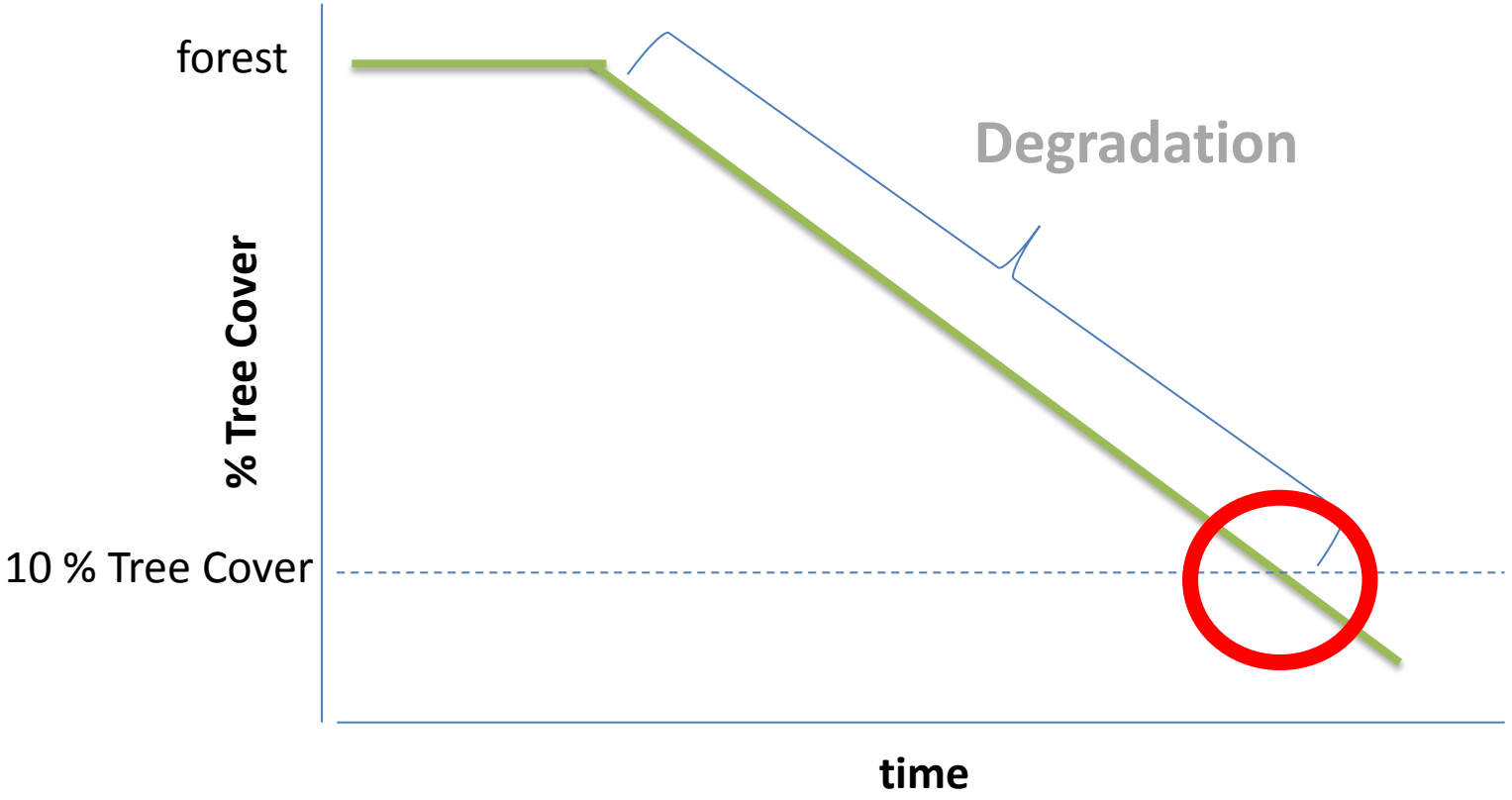
What is forest degradation?

Can also signify sustainable forest management (selective harvest), etc…depends on interpreter to know precisely the cause

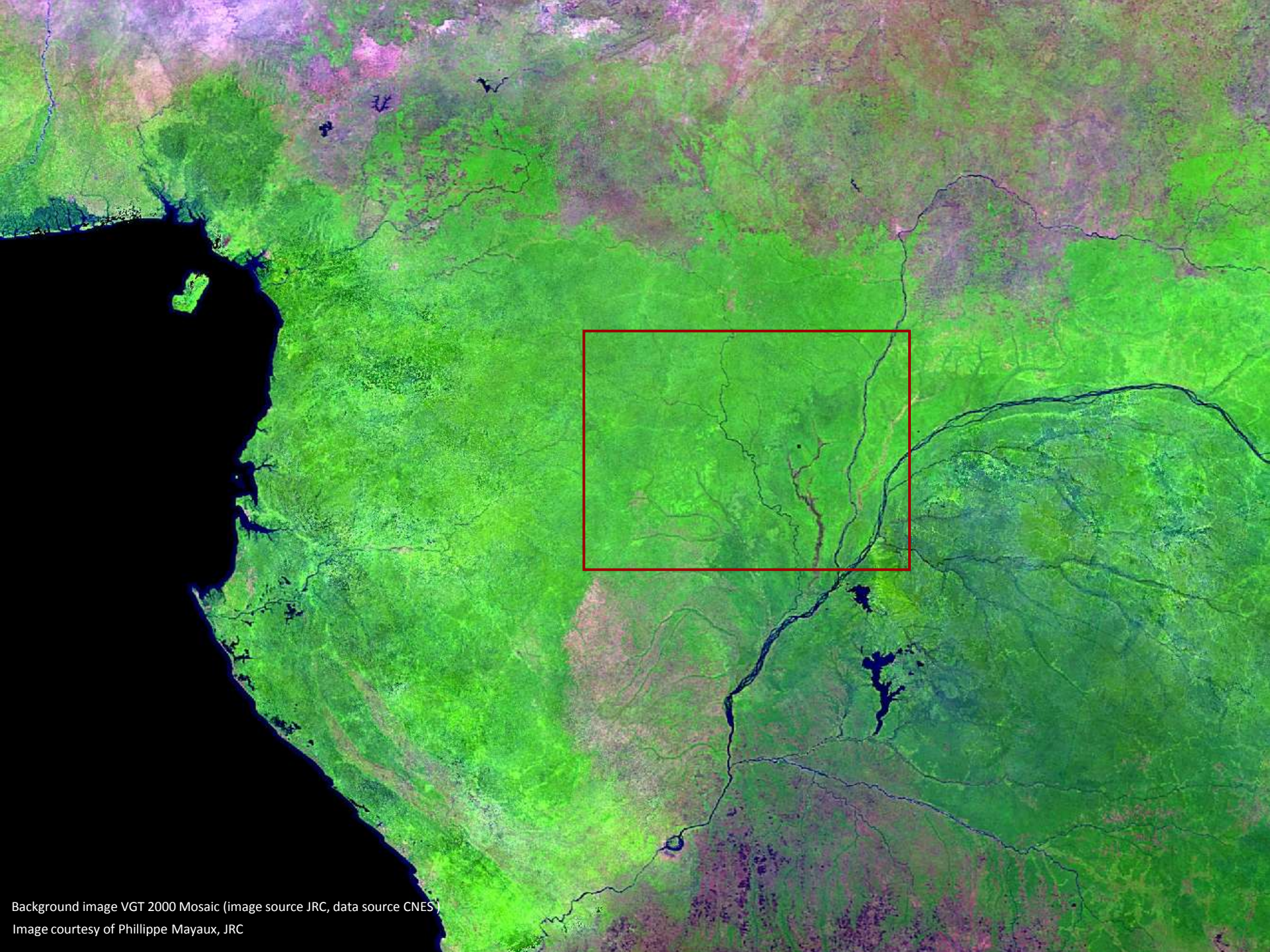
Begin by eliminating areas where degradation is not likely (using distance from development metrics, Intact Forest Landscapes)…focus search for degradation only in these zones

Land Cover and Land Use Change:

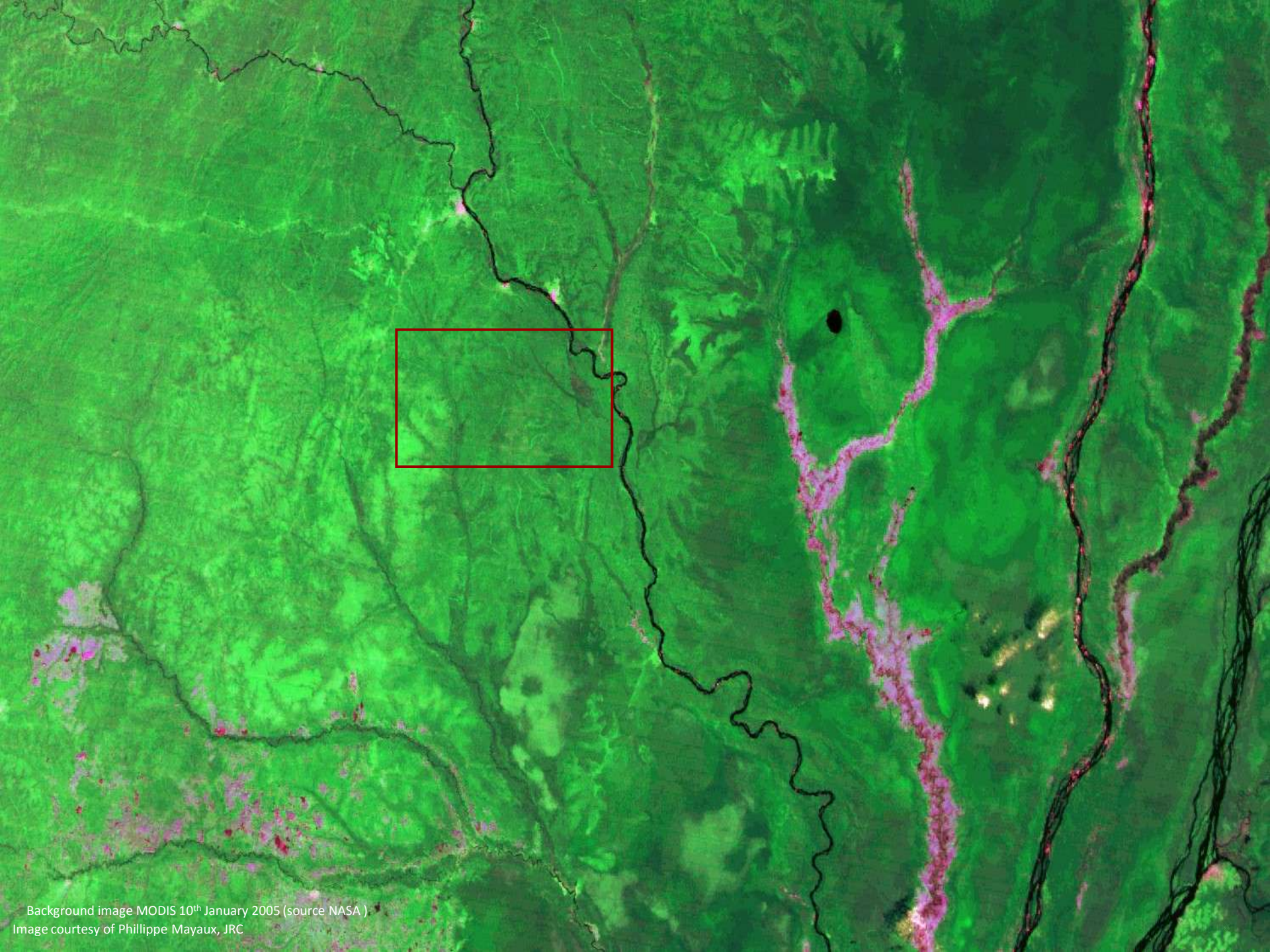
Degradation and Deforestation (FAO forest definition)



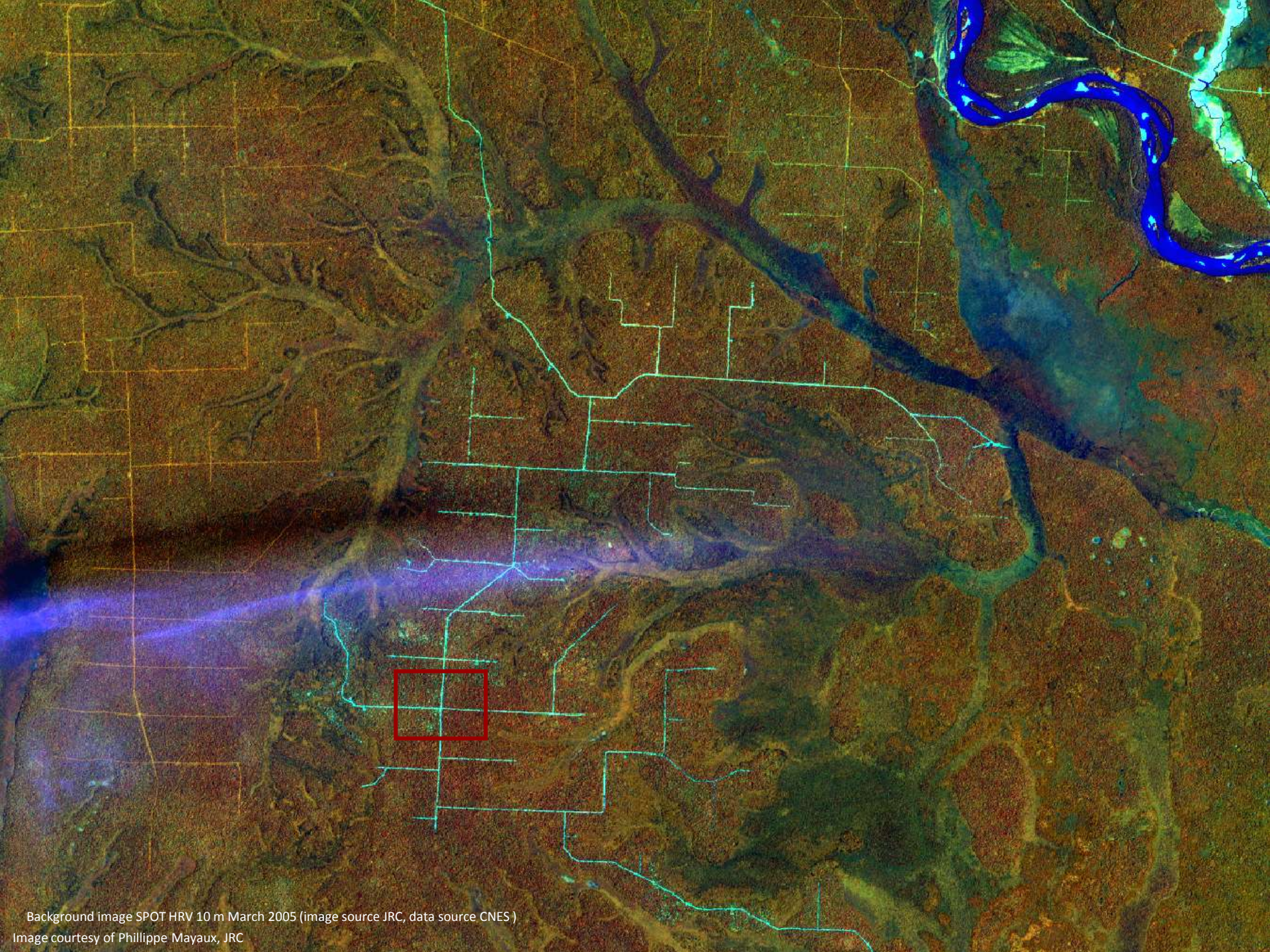
Potential Land Use Change



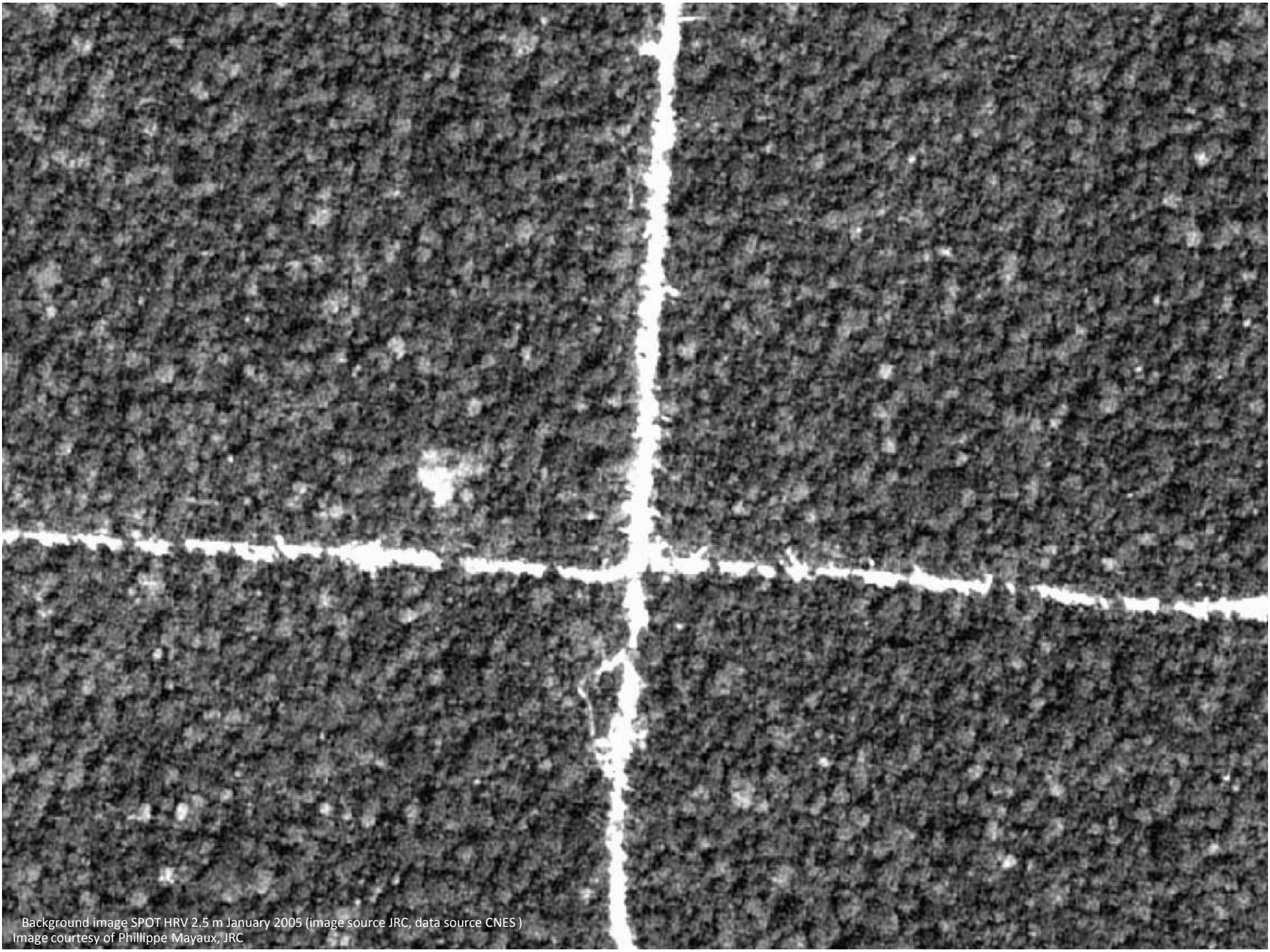
Background image VGT 2000 Mosaic (image source JRC, data source CNES)
Image courtesy of Phillippe Mayaux, JRC



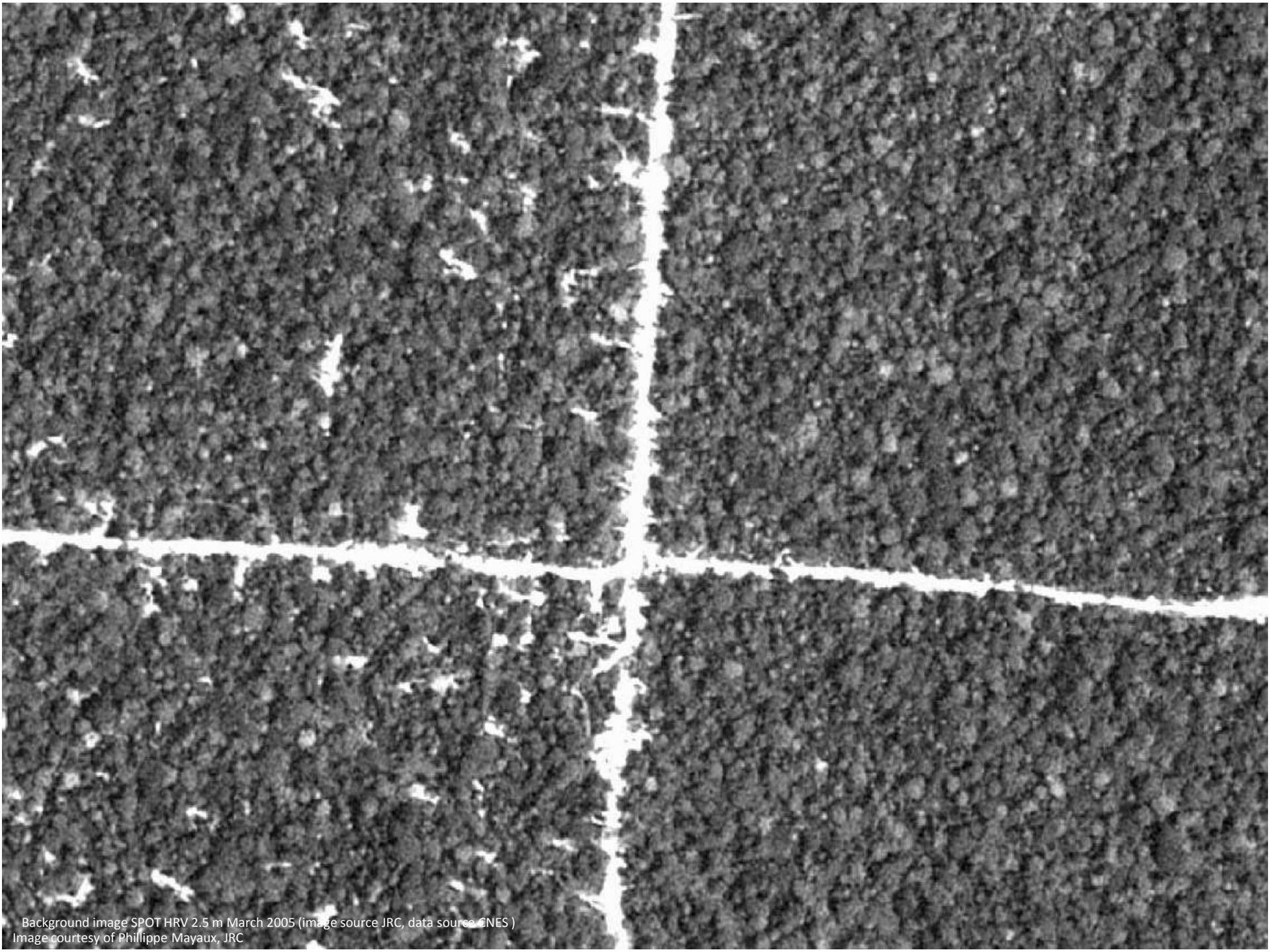
Background image MODIS 10th January 2005 (source NASA)
Image courtesy of Phillippe Mayaux, JRC



Background image SPOT HRV 10 m March 2005 (image source JRC, data source CNES)
Image courtesy of Phillippe Mayaux, JRC



Background image SPOT HRV 2.5 m January 2005 (image source JRC, data source CNES)
Image courtesy of Phillippe Mayaux, JRC



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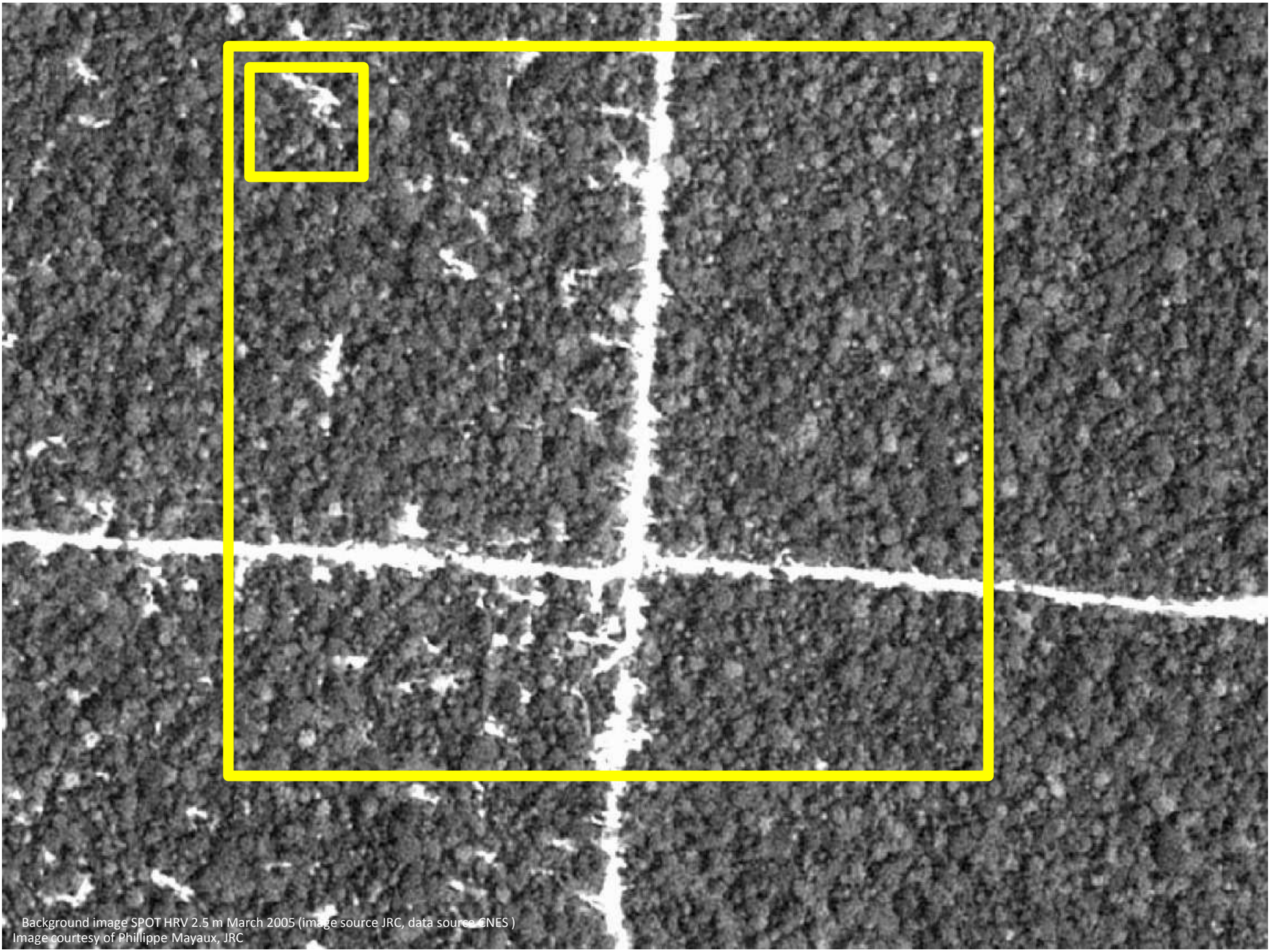

Background image SPOT HRV 2.5 m March 2005 (image source JRC, data source CNES)
Image courtesy of Phillippe Mayaux, JRC

How many kinds of value-laded forest degradation are there?

- Many, many
- These fit into four general categories:
  - Lack of ability to sustain production
  - Reduction in biodiversity
  - Soil erosion
  - Carbon stocks
- Clearly what is one man's degradation is another man's sustainable forest management
- There is no single way to properly address each of these at the same time (at least not yet)

Looking for an indicator.....

- We evaluate many approaches, including:
  - Do nothing, it is too difficult
  - Seek the perfect solution
  - Do something, recognizing it is a first step and will need refinement over time
    - This is what we chose
- We want an indicator that is above all of the general categories of degradation, but could be used by all

- A reduction in canopy area density was chosen because:
  - It relates to all categories of degradatation
  - It can be measured, albeit crudely, from space
  - We can argue about it!!

The method with MODIS

- Time-series MODIS 250m VCF from 2000 – 2011
- 2 main criteria
  - linear trend of time-series < -1
  - range between VCF crown cover in 2000 and 2011 > 20
- Can be further constrained by Intact Forest Landscapes and Wetlands databases
- MODIS canopy cover loss product (VCC)

The method with MODIS

- 62 MODIS VCF annual phenologic metrics

For bands 1-7

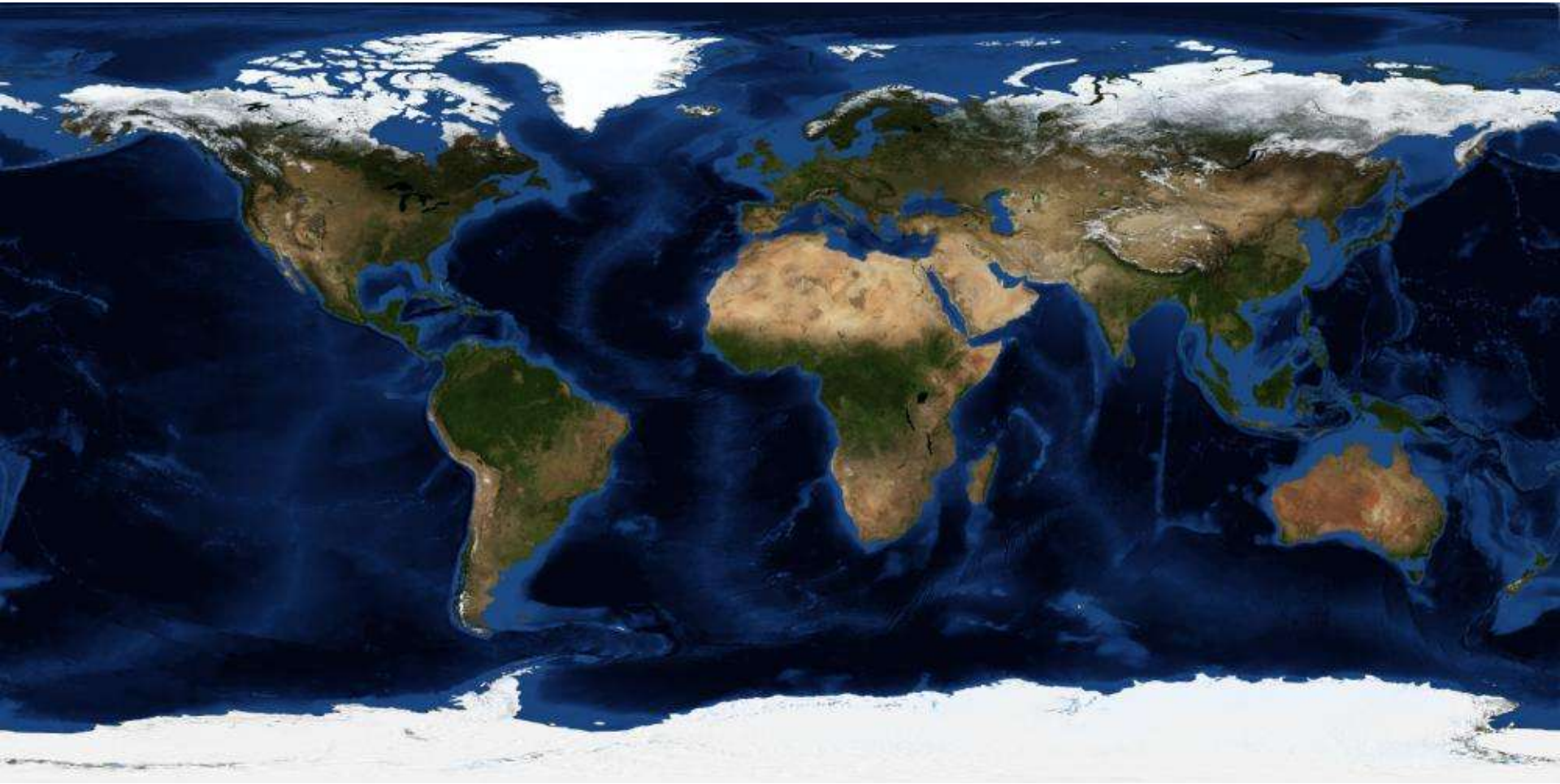
Minimum reflectance
Eighth darkest reflectance
Amplitude of minimum and 5th darkest reflectance
Mean 3 darkest reflectances
Mean 5 darkest reflectances
Mean 8 darkest reflectance
Reflectance at peak NDVI
Mean reflectance of values corresponding to 3 greenest composites

For NDVI –

Maximum NDVI
Eighth highest NDVI
Amplitude of minimum and 5th highest NDVI
Mean of 3 highest NDVI values
Mean of 5 highest NDVI values
Mean of 8 highest NDVI values

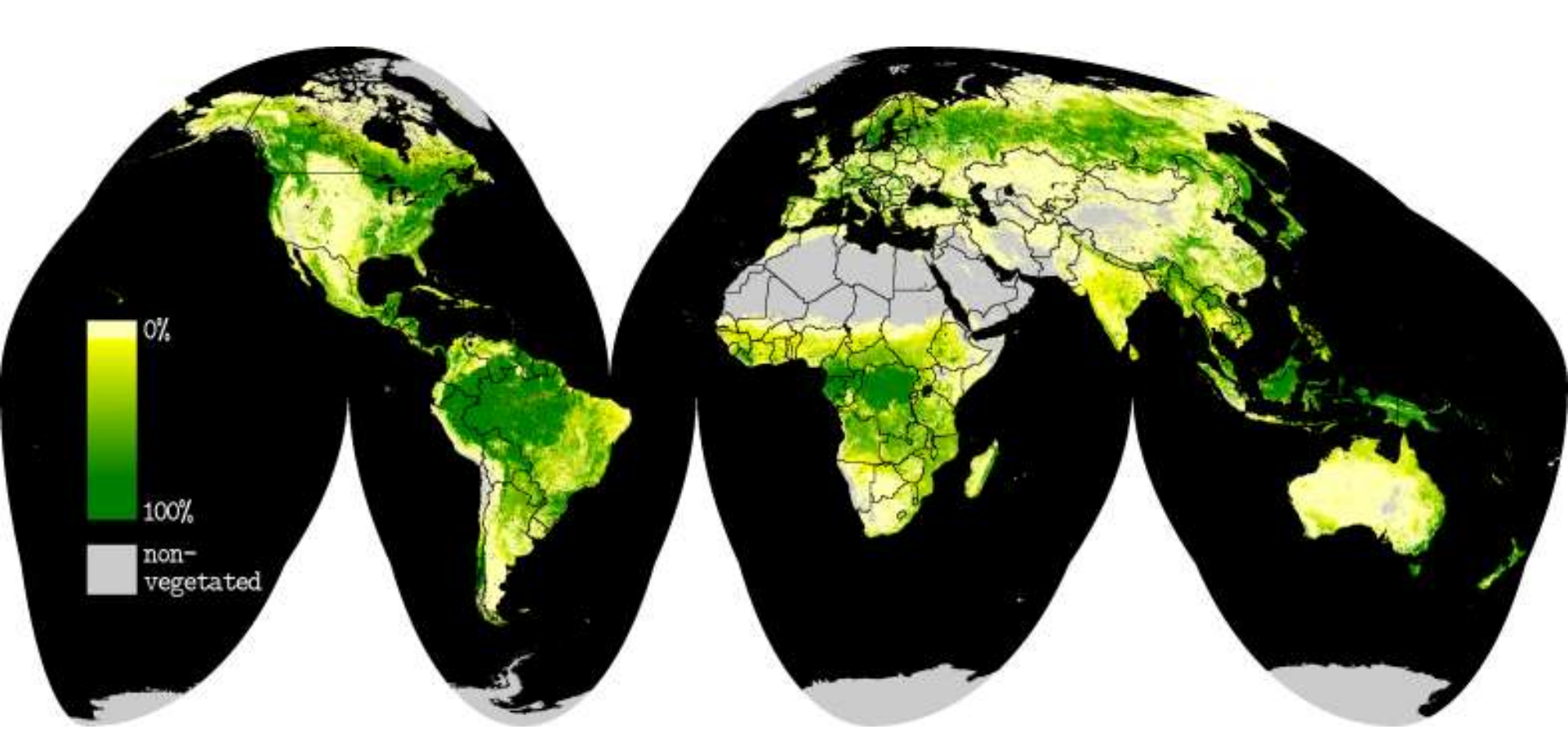
Hansen et al., 2003, Global percent tree cover at a spatial resolution of 500 meters: First results of the MODIS vegetation continuous fields algorithm, Earth Interactions Vol.7, No 10, pp1-15.

Global Imagery Inputs...



MODIS

MODIS Global Percent Tree Cover



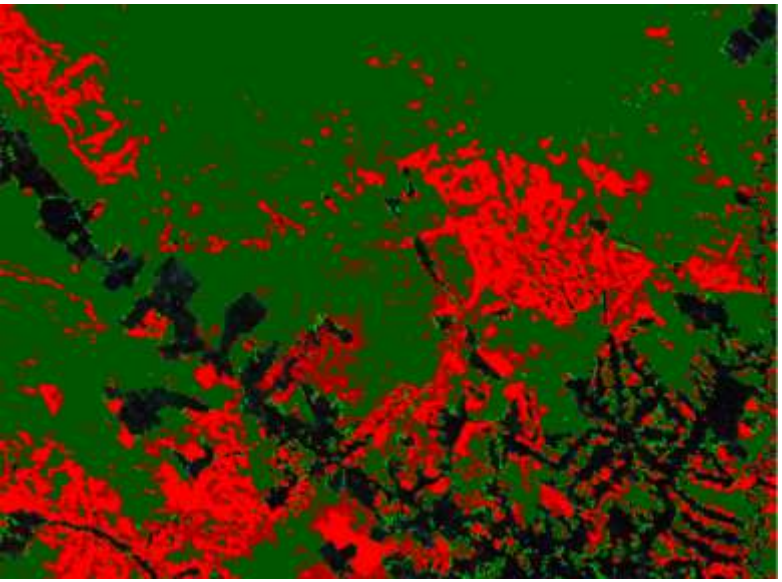
from Hansen et al., 2003

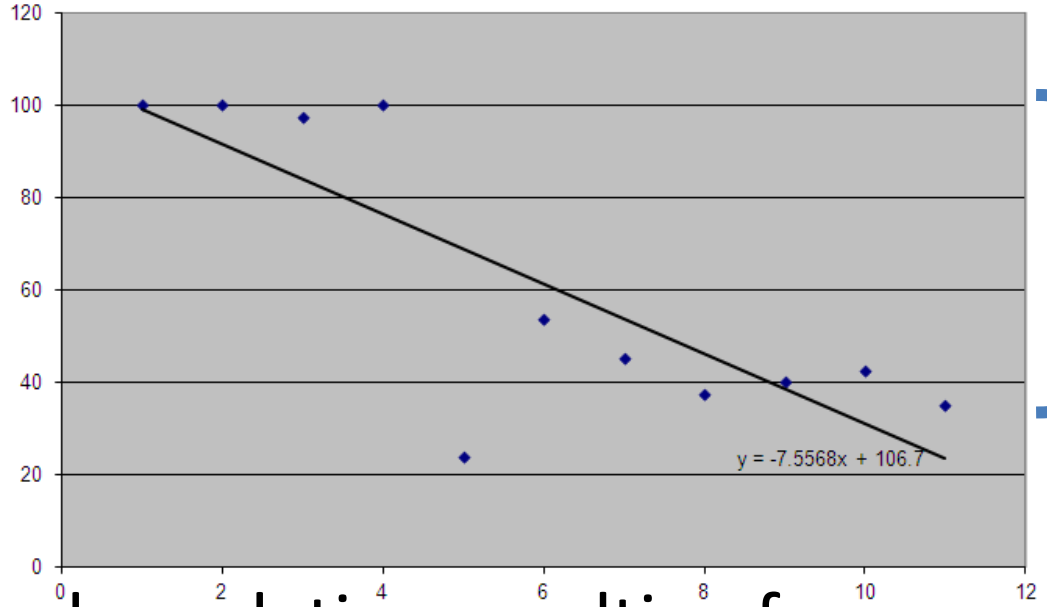
TREE COVER

The method – basic principles

- Vegetation composition changes affect metrics
- Deforestation
  - Unambiguous signal
  - Low VCF values (< 30) and
  - Constant
- Partial overstory removal
  - Ambiguous
  - High to low VCF values
  - Decreasing trend over time

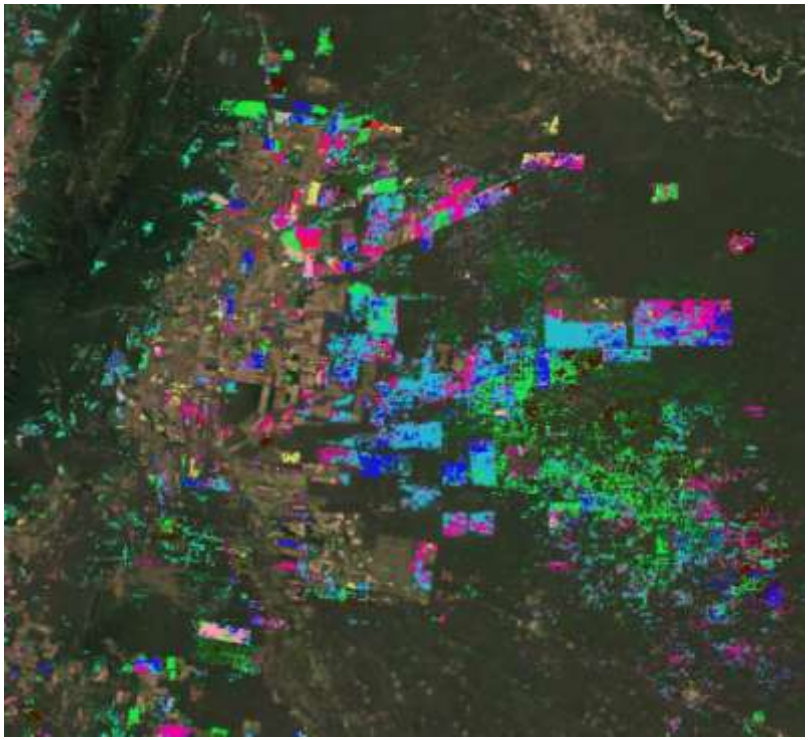
Degradation from Remote Sensing

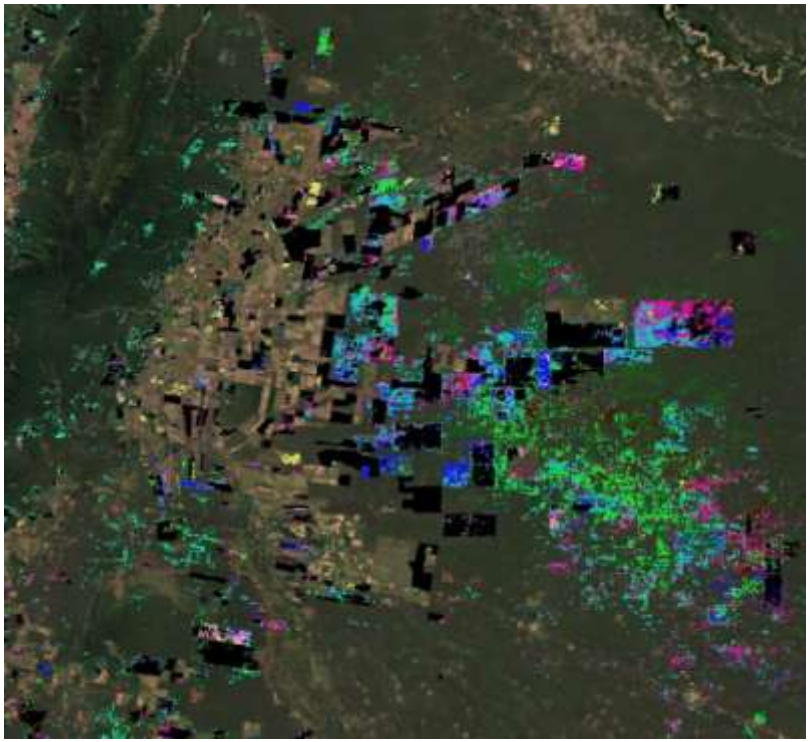




- Example of likely degradation resulting from nearly complete overstory removal in 2004
- If pixel detected as degraded meets definition of non-forest, will be labeled as deforestation and year

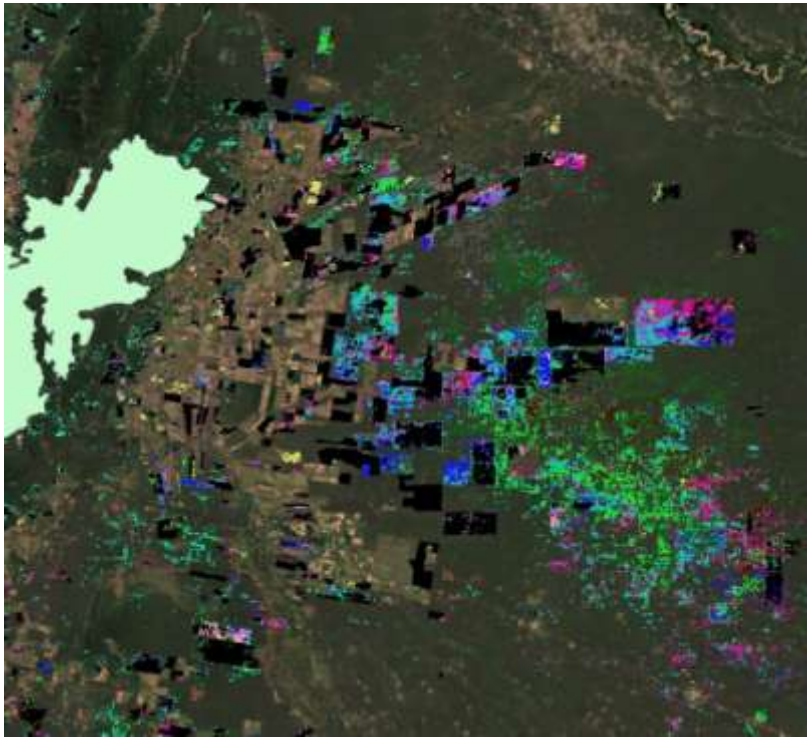
Degradation from Remote Sensing

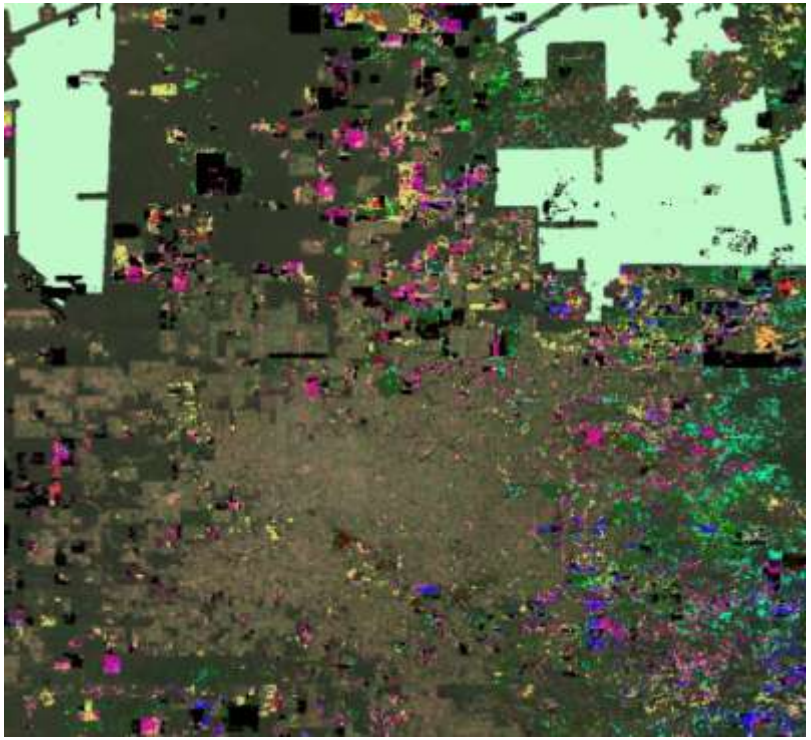




- Canopy cover removal by year of first disturbance
- Masked with MODIS-derived forest cover loss

Degradation from Remote Sensing

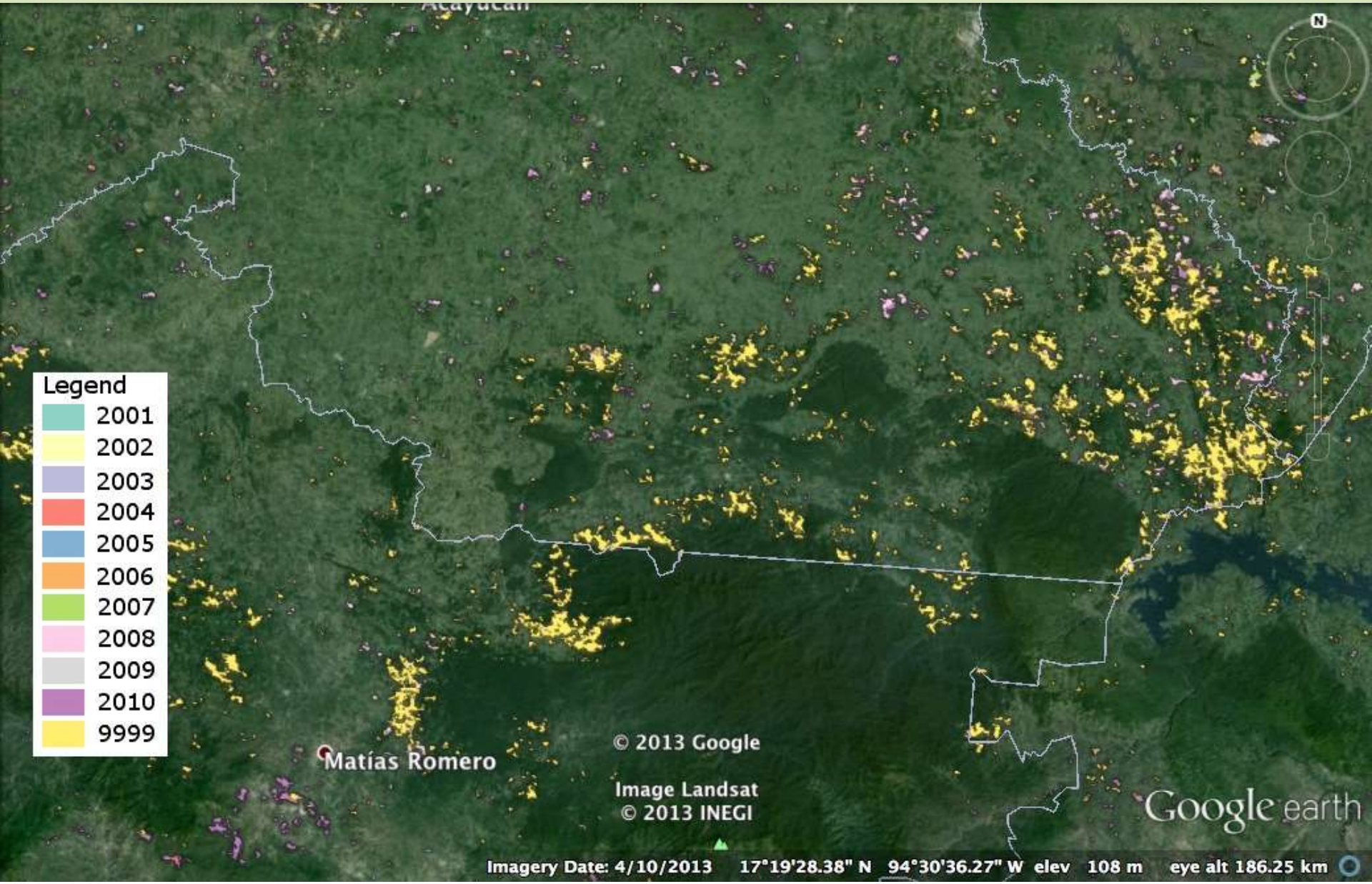




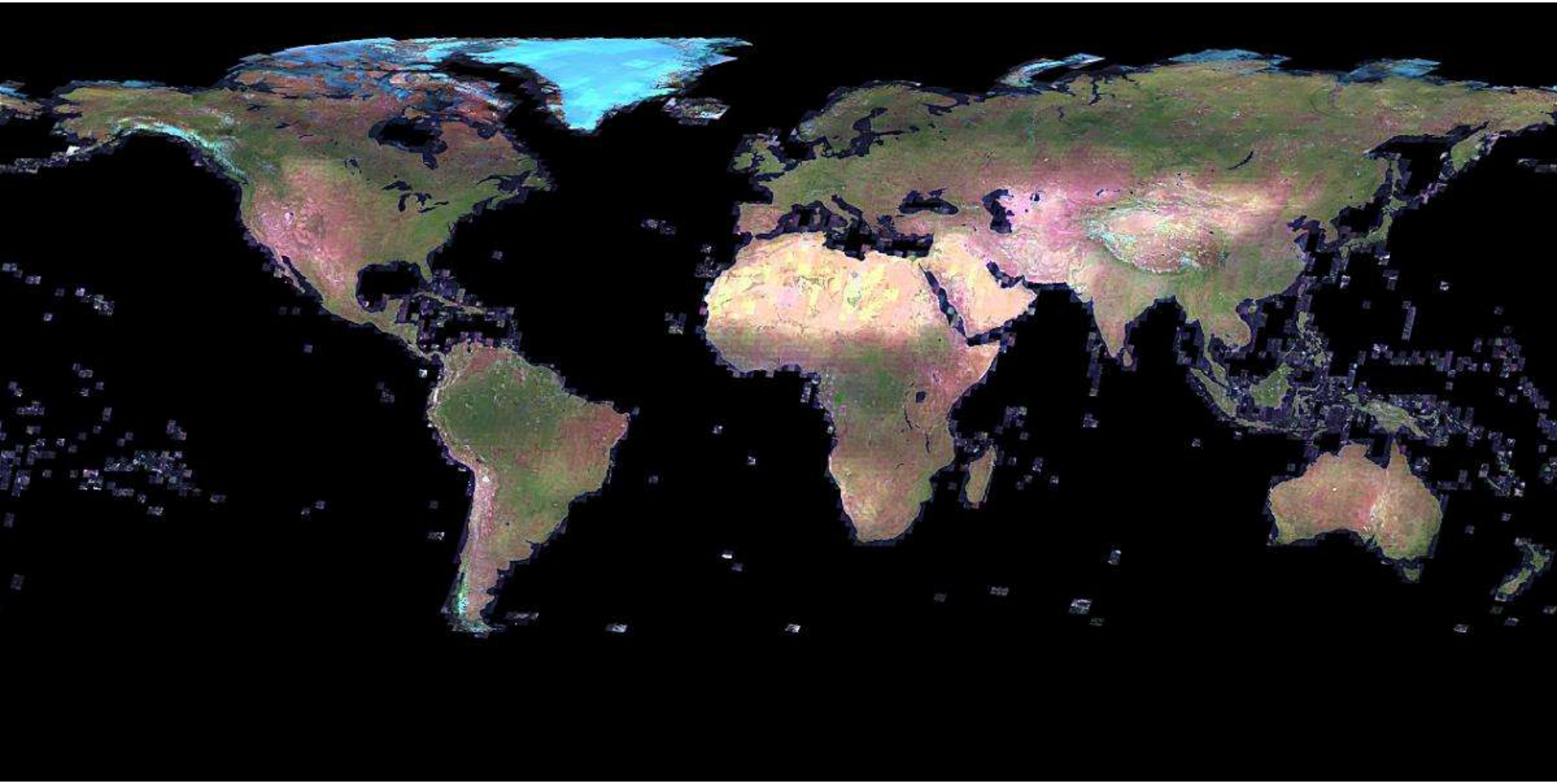
- Example of partial canopy cover removal with MODIS forest cover loss and Intact Forest Landscape mask

Partial Canopy Cover Reduction

Partial Canopy Cover Reduction



Global Imagery Inputs...



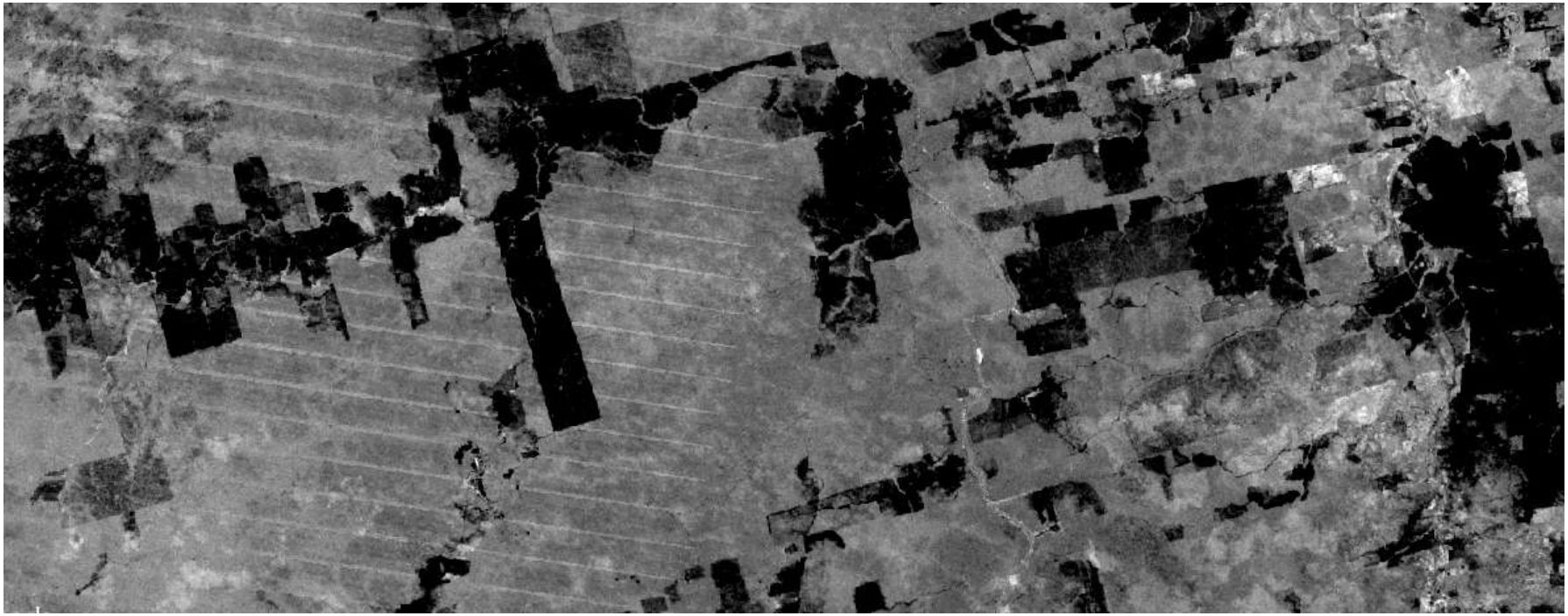
Landsat

Landsat Time-Series Analysis

10 years of Landsat...every cloud-free pixel

Landsat Time-Series Analysis

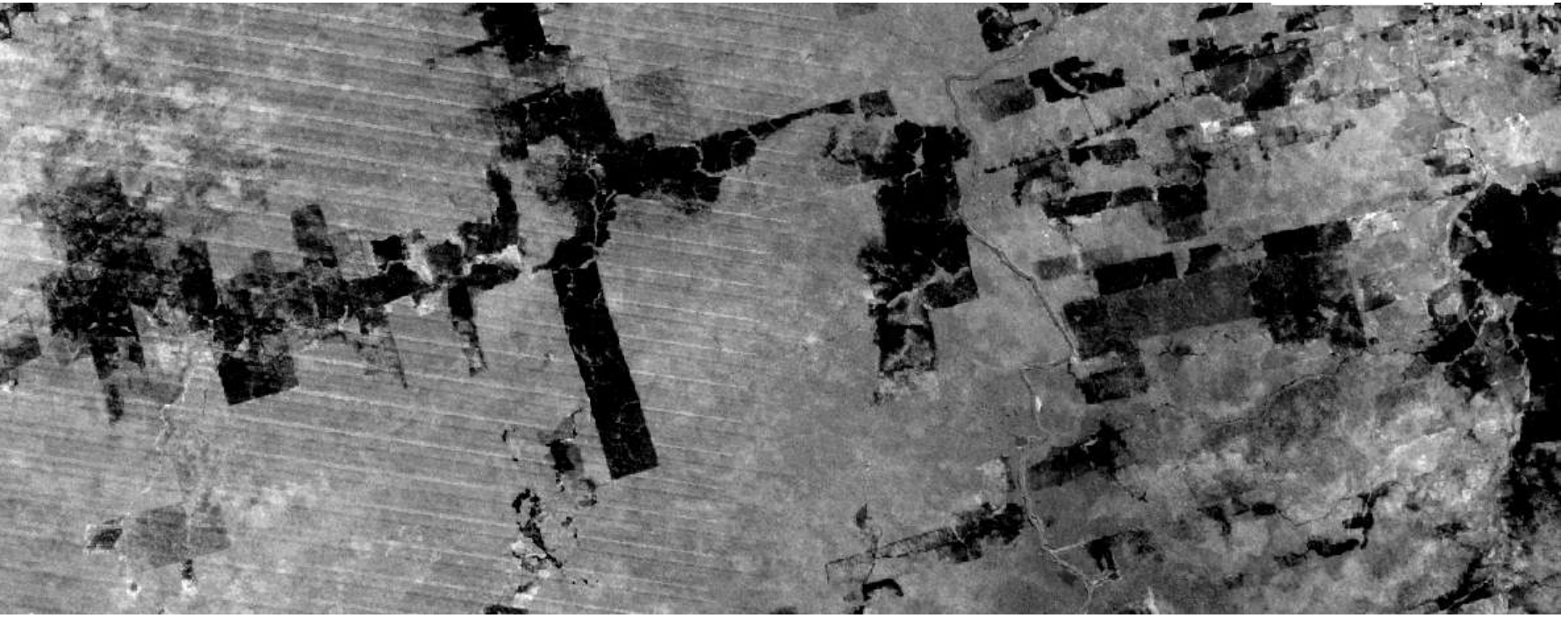
Slope of the linear regression



10 years of Normalized Burn Ratio

Landsat Time-Series Analysis

10 years of Landsat...every cloud-free pixel



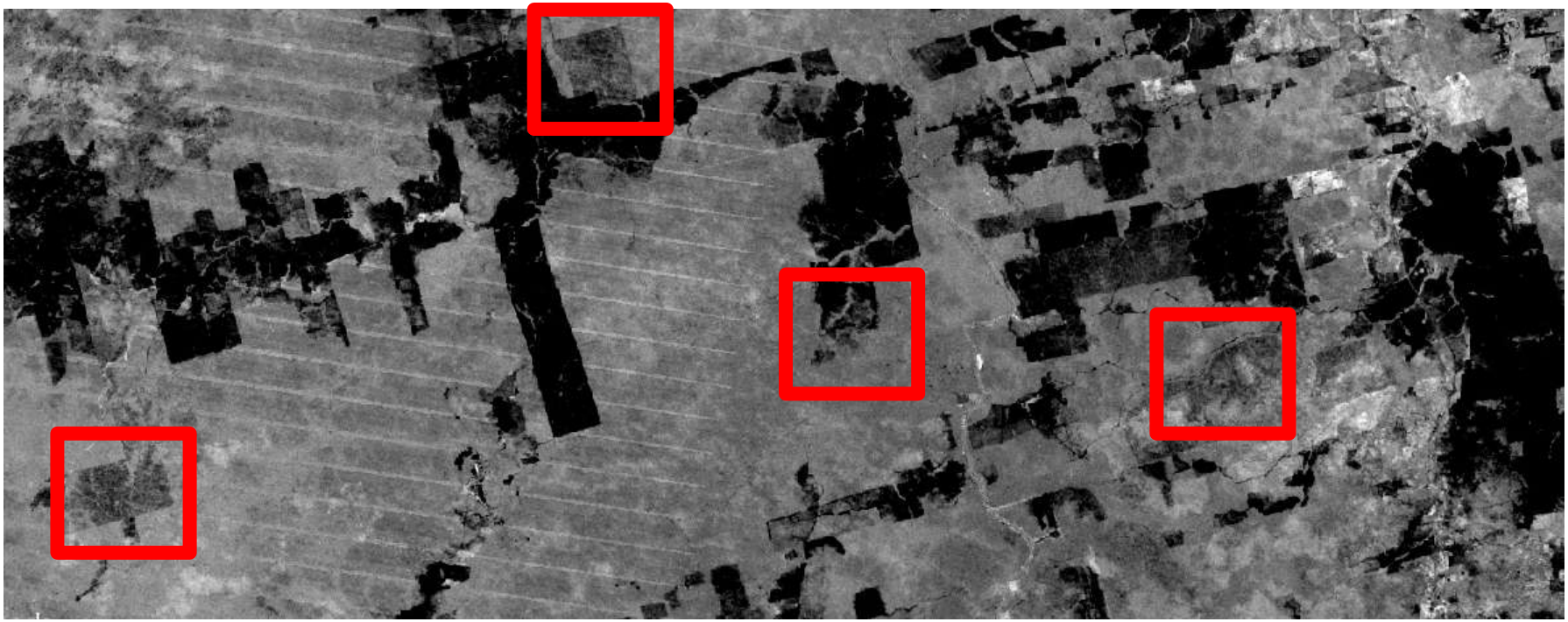
10 years of NDVI

Landsat Time-Series Analysis

10 years of Landsat...every cloud-free pixel

Landsat Time-Series Analysis

Slope of the linear regression



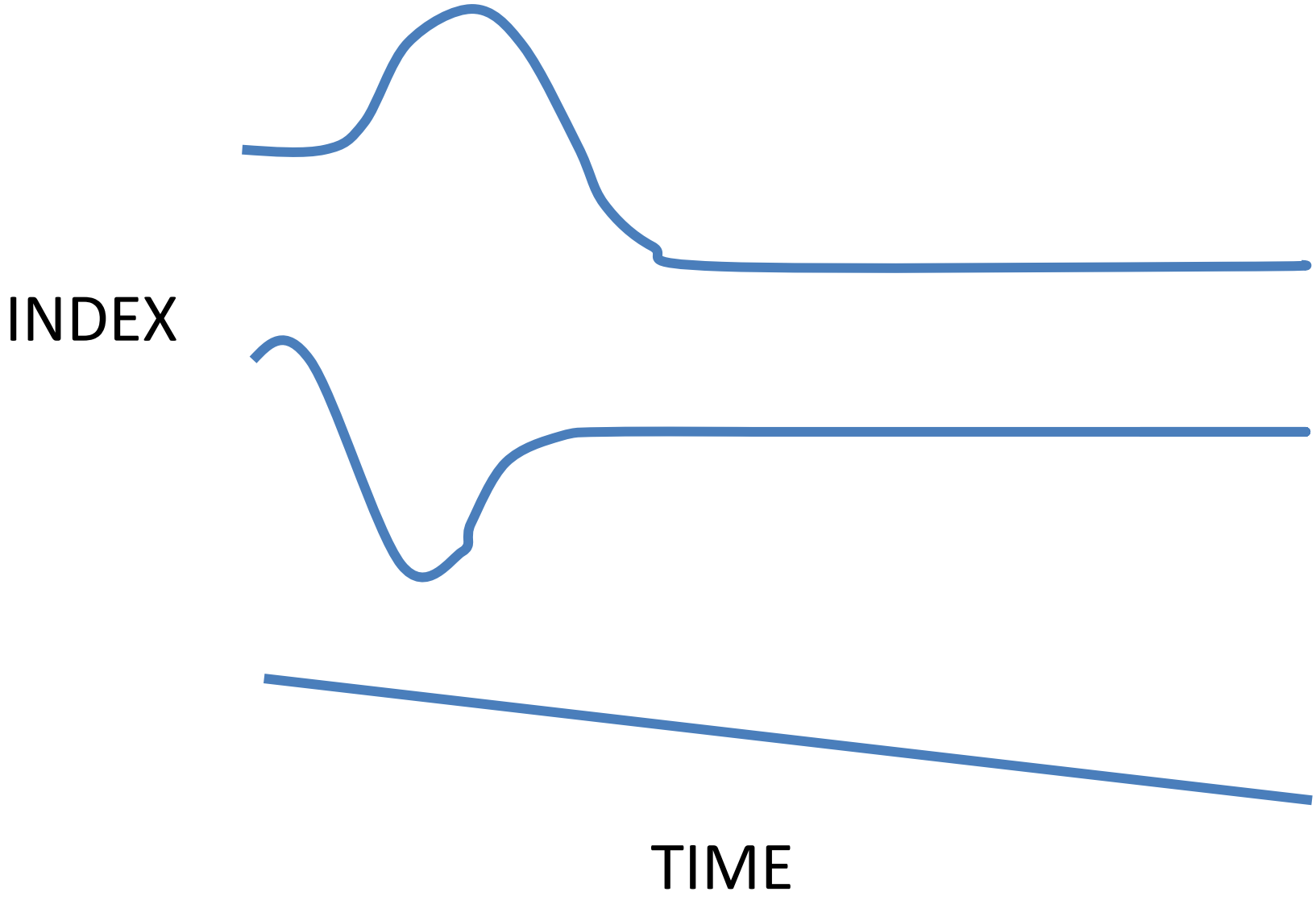
10 years of Normalized Burn Ratio

Landsat Time-Series Analysis

10 years of Landsat...every cloud-free pixel

10 years of NDVI

Landsat...time series signatures

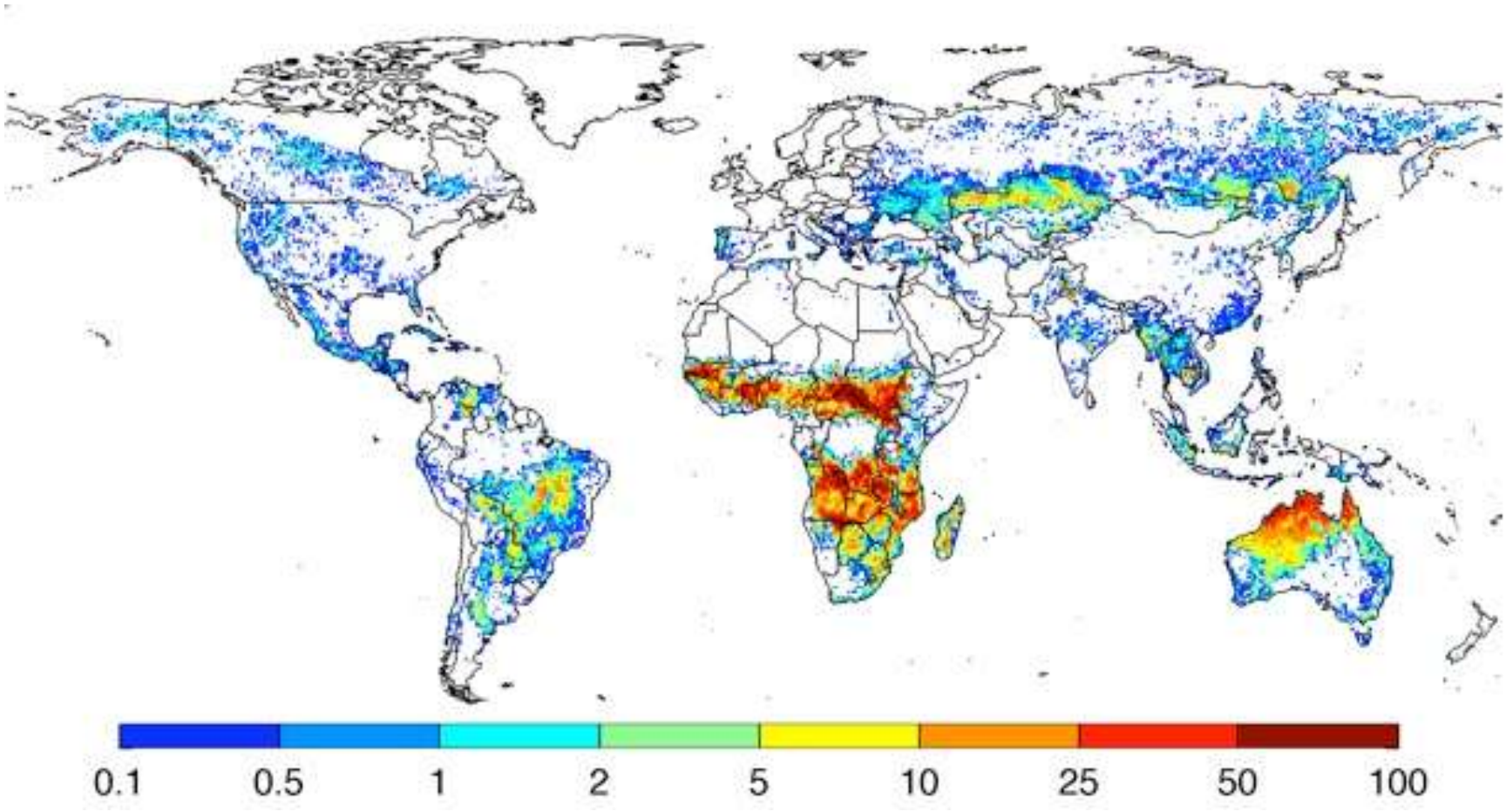


Ancillary Datasets

- MODIS Burned Area (MCD45A1)
- Intact Forest Landscapes
- MODIS Land Cover Change (LCC) (MOD12)

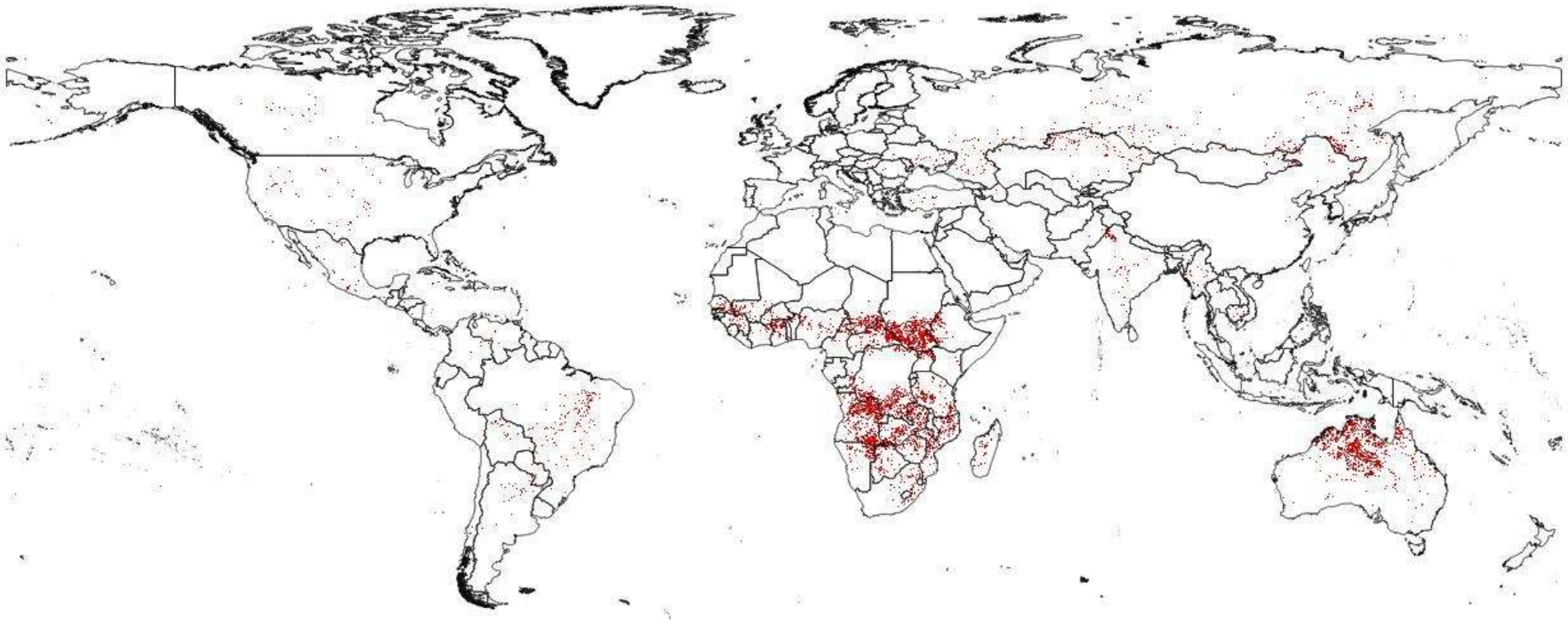
- Others....

Burned Area, 2000 - 2012



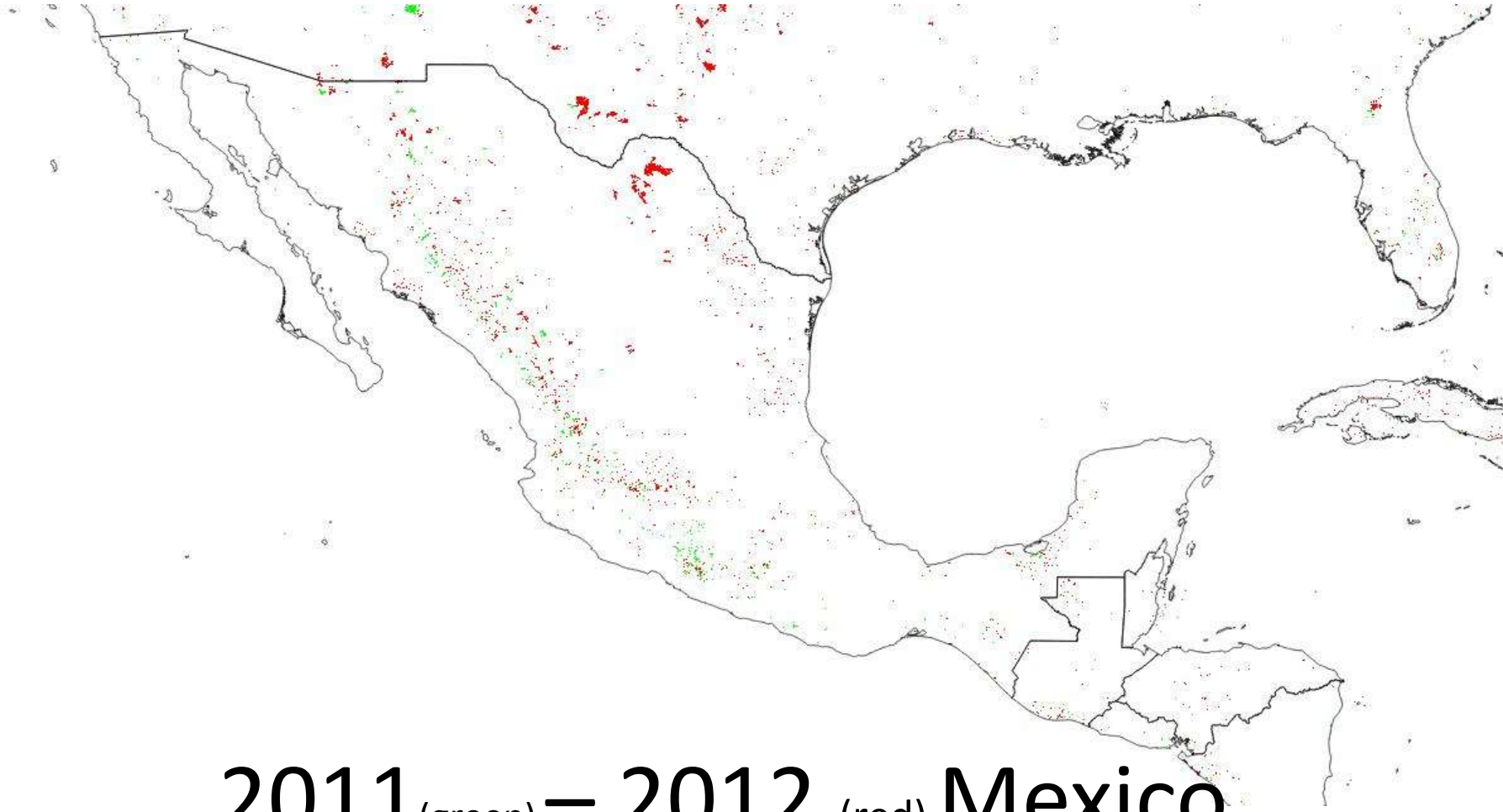
Roy, D.P., Jin, Y., Lewis, P.E., Justice, C.O., 2005, Prototyping a global algorithm for systematic fire-affected area mapping using MODIS time series data, *Remote Sensing of Environment,* 97: 137-162

Burned Area



2011 – 2012 Global

Burned Area



2011(green) – 2012 (red) Mexico

The end – Forest Degradation from RS

- Serve as an indicator…maybe not for precise area calculations
- Big pixels are limited by their nature and cannot detect all fine-scale changes
- Method depends on relatively large areas of change
- ….but it’s something at least….a start.

forest ?

picture from FAO forestry photo database: http://www.fao.org/forestry/iyf2011/69191/en/


forest ?
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forest ?

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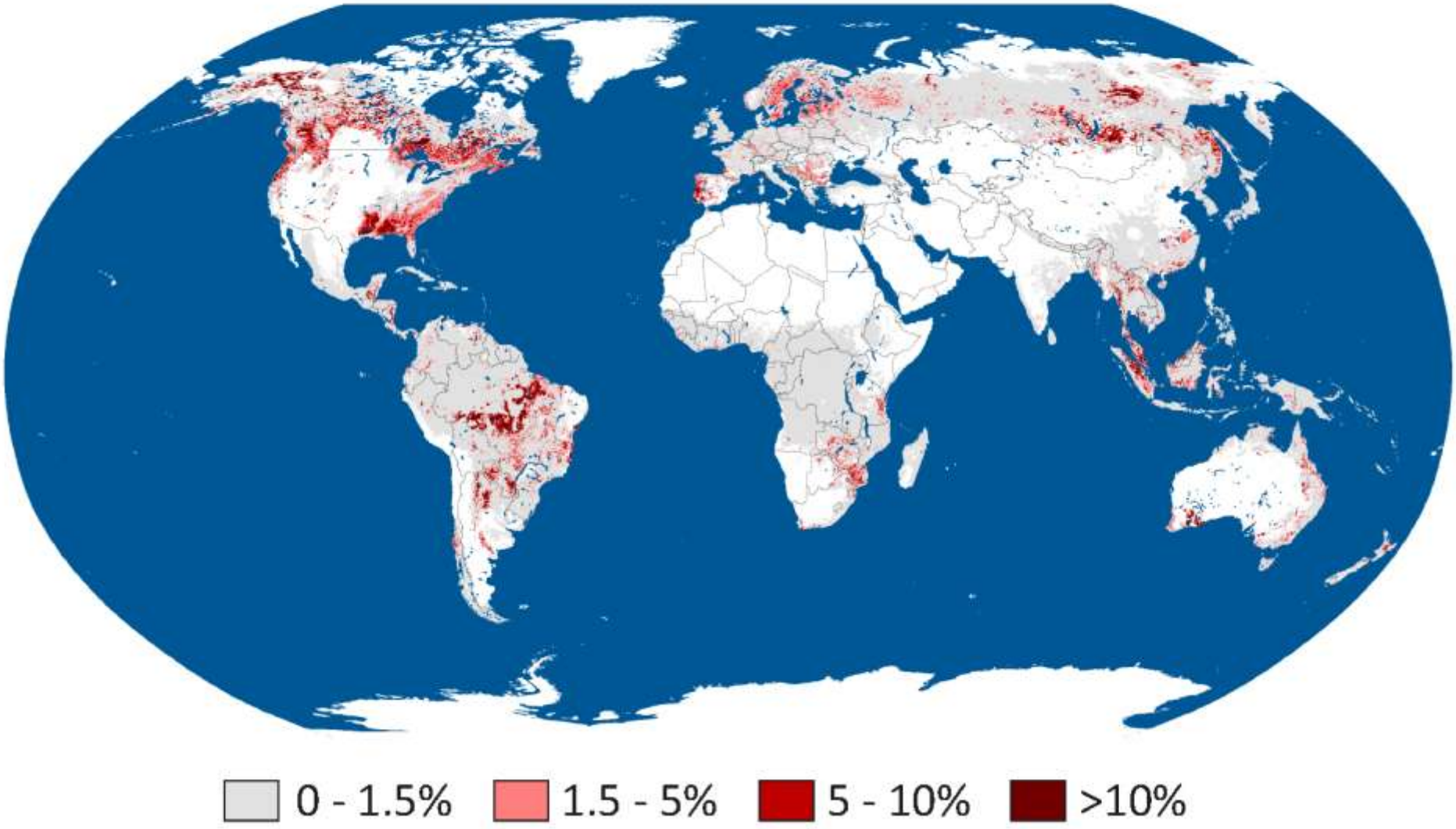
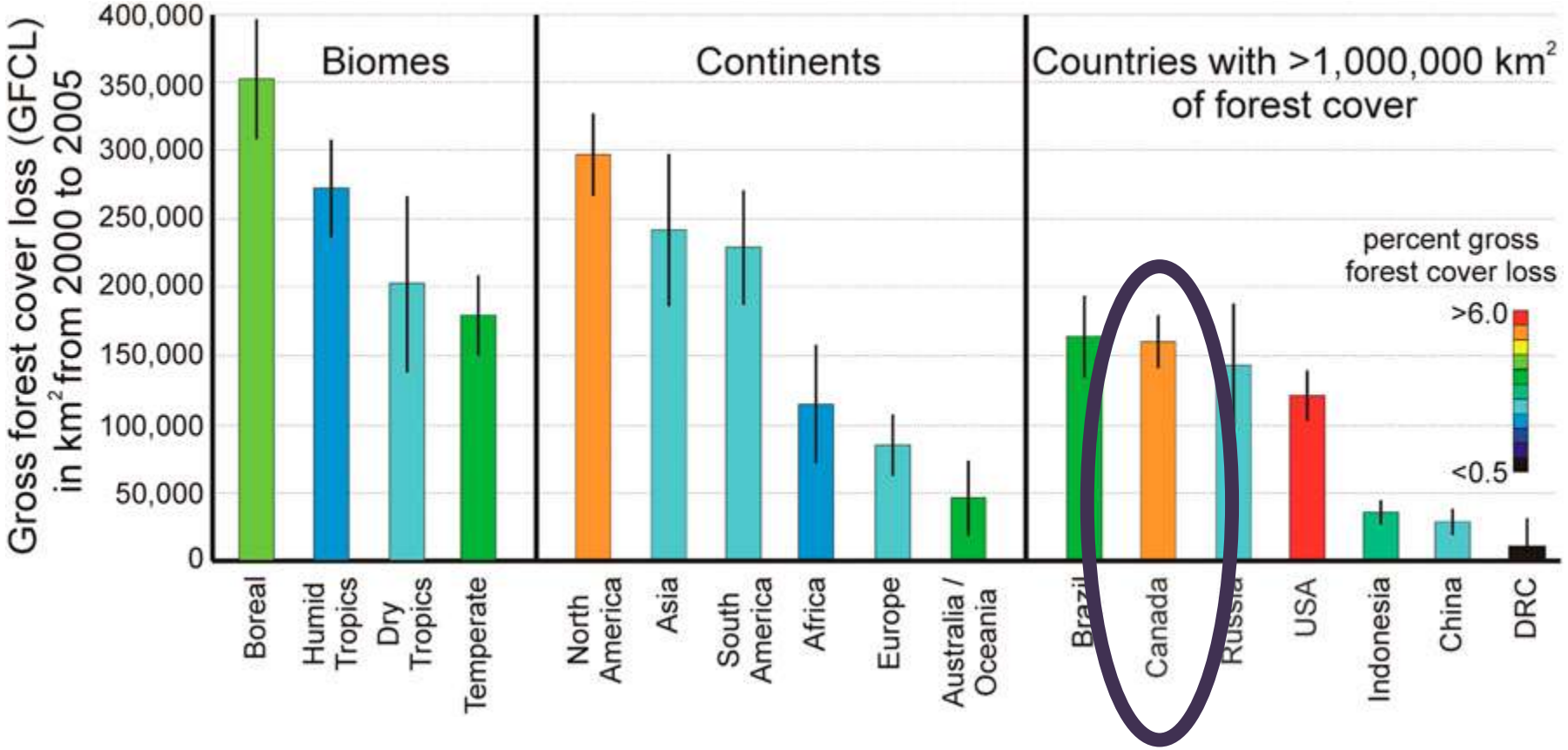
Percent forest cover loss, 2000 to 2005



from Hansen et al., 2010 PNAS



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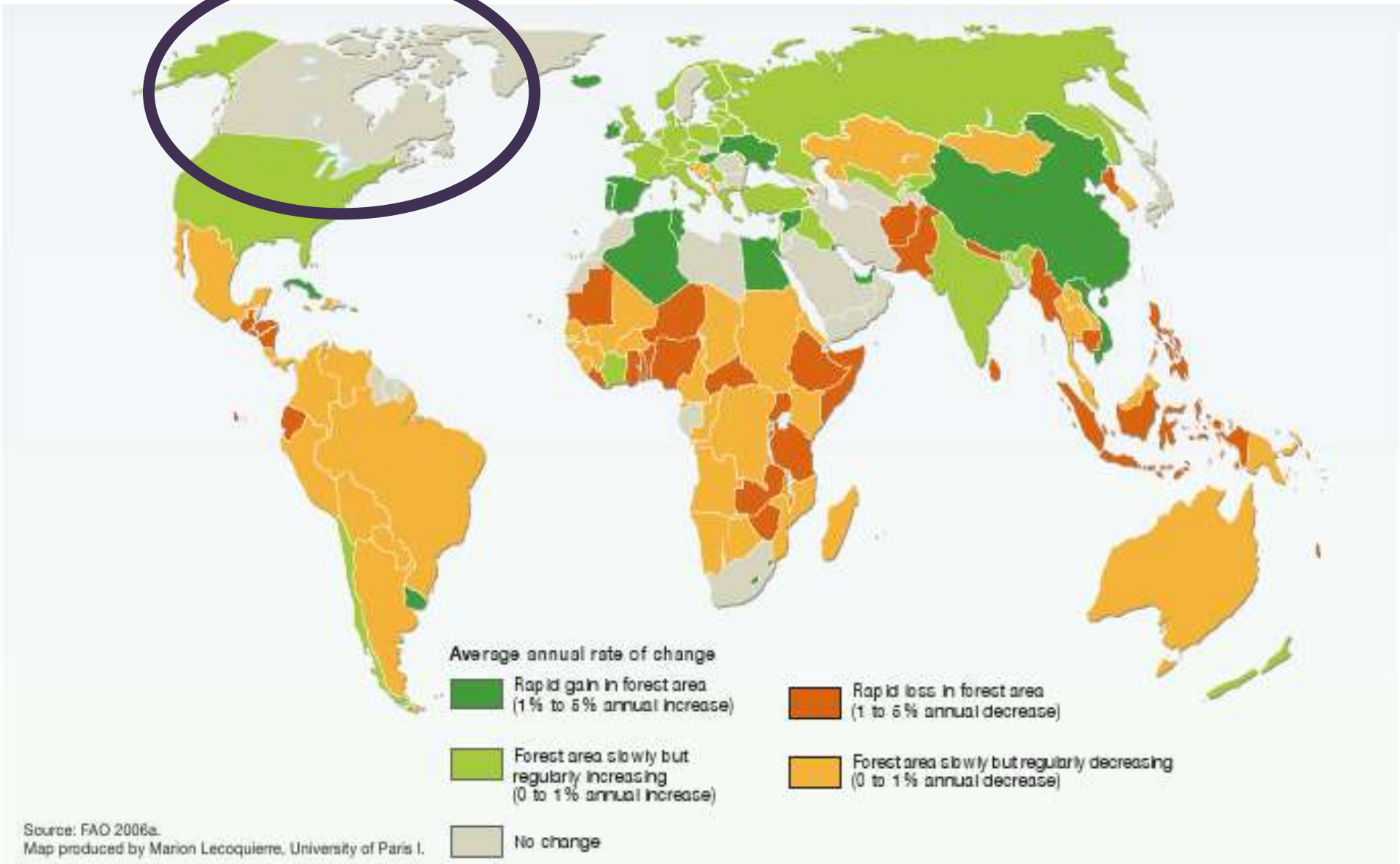
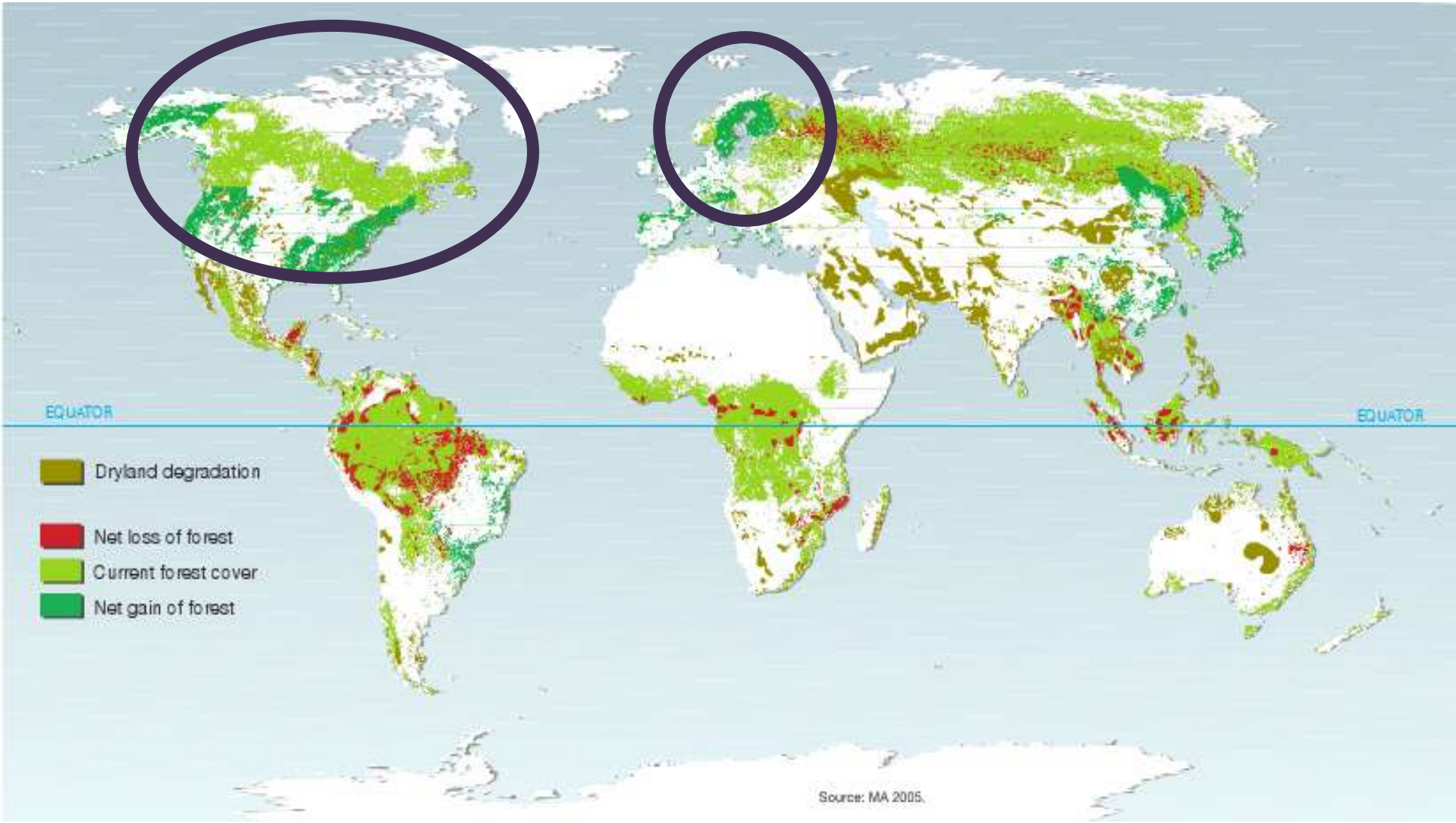


http://www.unep.org/vitalforest/graphics.asp



http://www.unep.org/vitalforest/graphics.asp

openforis
COLLECT EARTH

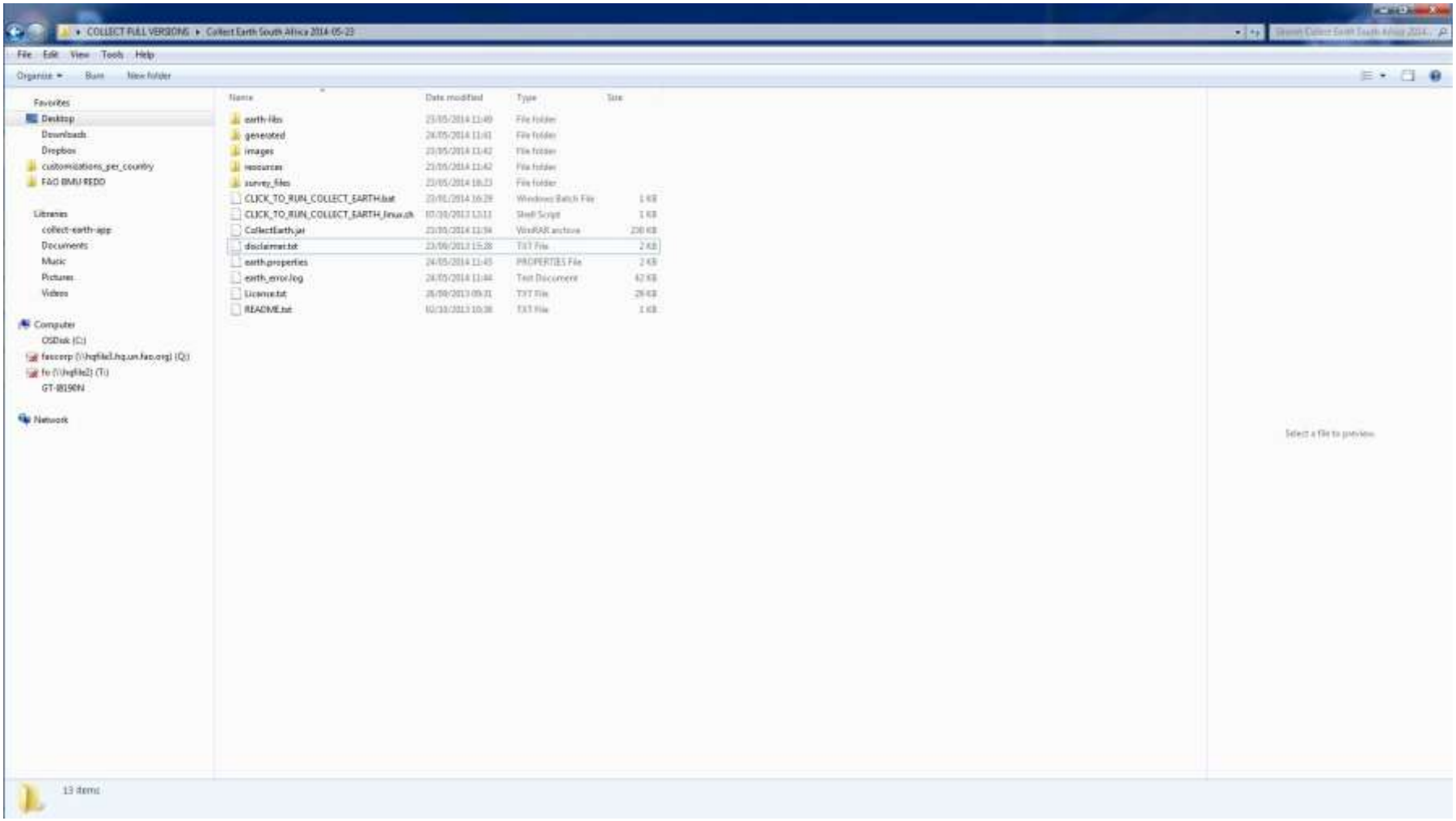
Visual interpretation tool for land use/cover classification

Collect Earth in a nutshell

- User friendly data collection tool based on standard Java technology
- Google Earth used as data entry interface
- Zero-configuration necessary, runs out of the box on most PCs
- Fast learning curve, only limited computer skills necessary
- Internet connectivity not required if other data sources are provided
- Individual or team based data collection


Java
openforis
Google Earth
COLLECT EARTH
Google earth engine
a google.org project
Google fusion tables
beta
bing maps
saiku
CUTTING EDGE OPEN SOURCE ANALYTICS
PostgreSQL
SQLite

Demonstration: Start-up and assessment of one plot



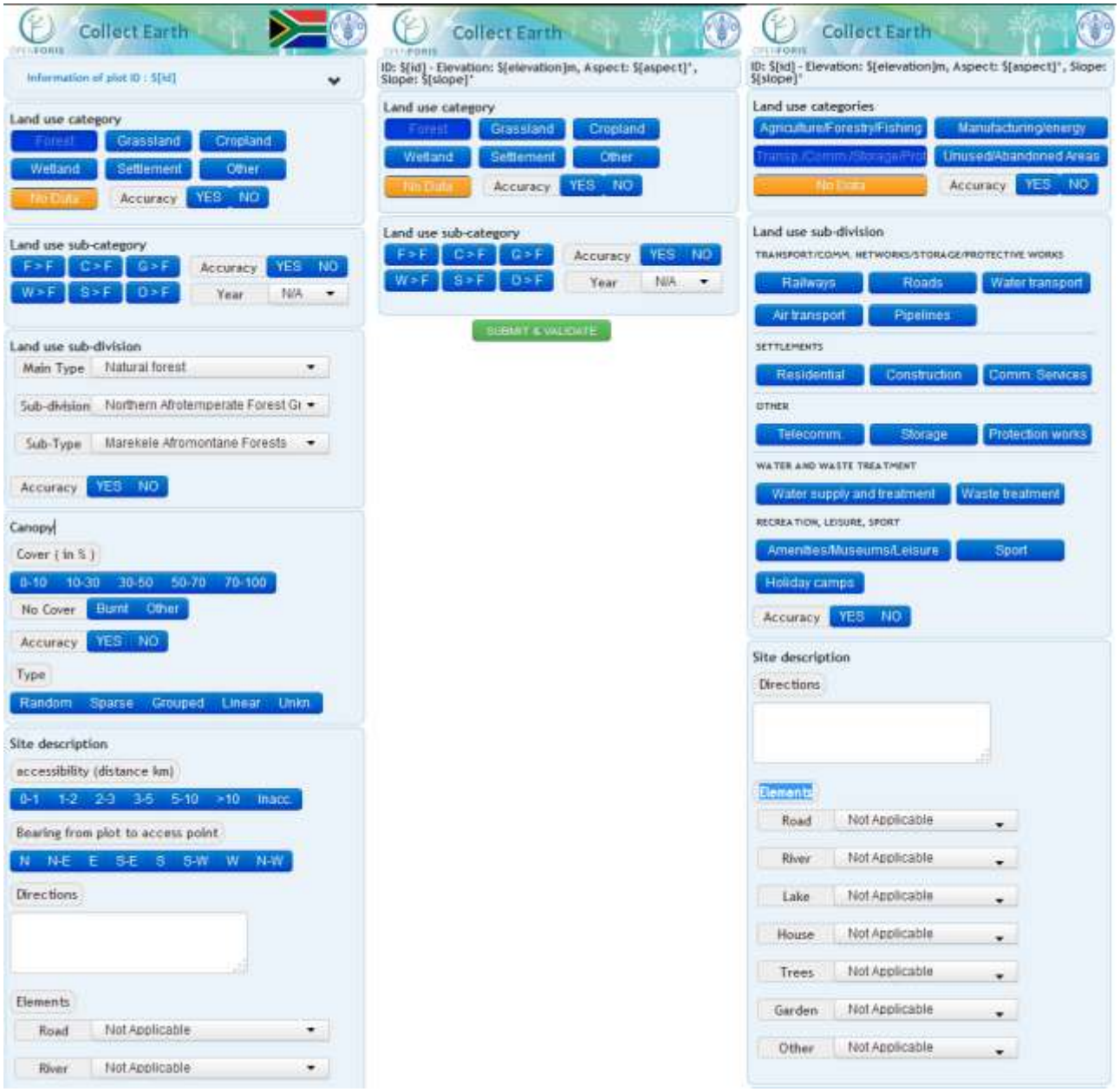
Use cases

- Land Use and Land Use Change (LULUCF) assessment in Papua New Guinea and Mongolia
  - Reporting to to the UNFCCC in an IPCC compliant manner (Land Use Change matrix)
    - Training in 18 more countries during 2014 (including Algeria and Morocco) as a part of a REDD project funded by BMU (International Climate Initiative)
    - PNG and Mongolia assessments already carried out successfully
- First phase of a two-phased National Forest Inventory
- Validation of maps or other spatial data (DRC, UN-REDD/Hanssen data)
- Collection of socioeconomic data (Vietnam)

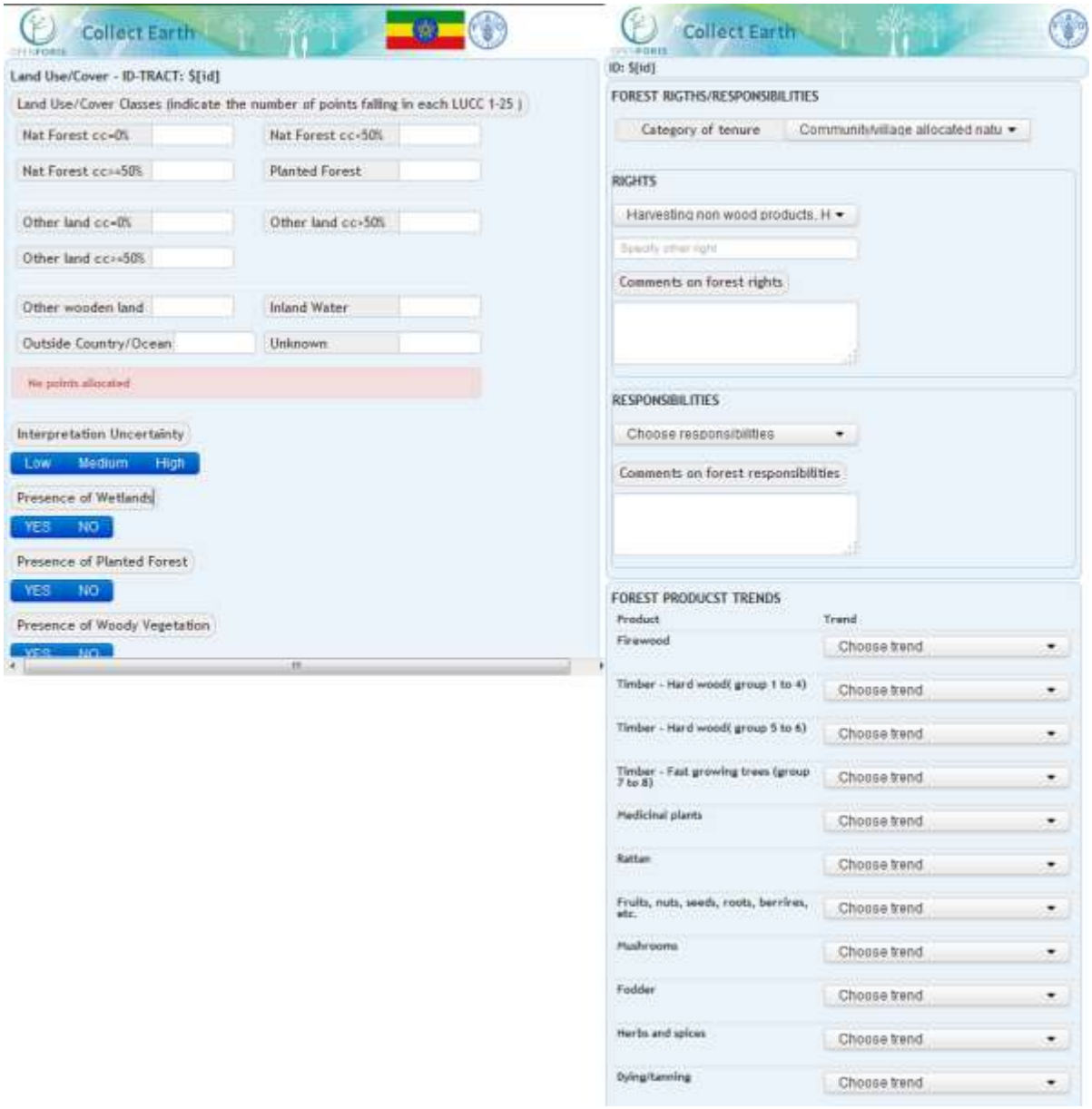
Customization

- Structure of the data stored by Collect Earth is only dependent of the user requisites
- Google Earth pop-up is fully customizable HTML (web-page)
- Grid design can be produced with any GIS software like ArcGIS or QuantumGIS. Extra data like elevation or strata can be added
- Open-source project. Free to extend and modify

Examples of South Africa, simple LULUC survey and LUCAS

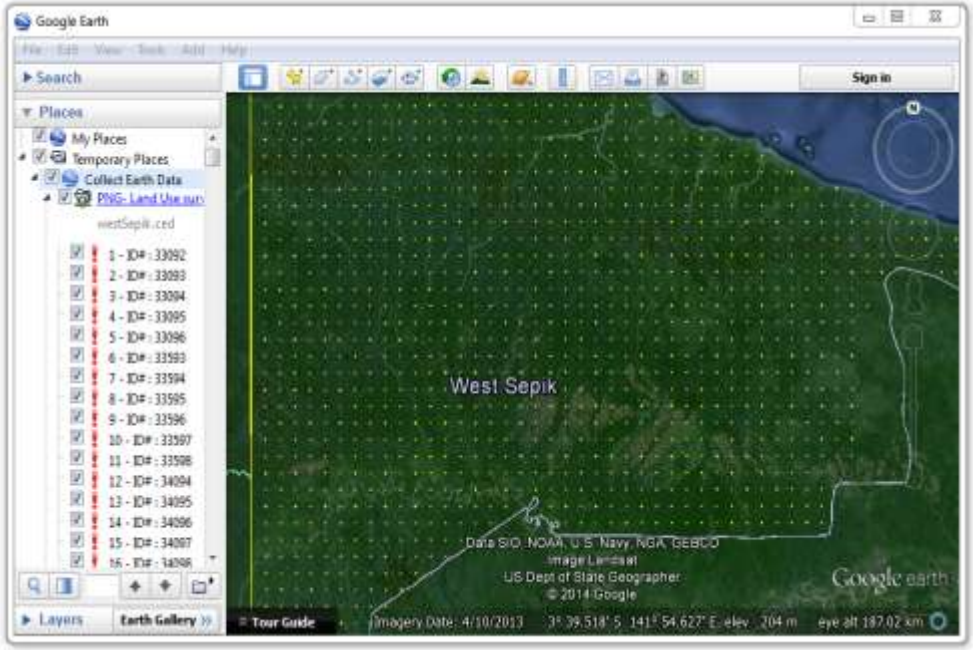


Examples of Ethiopian NFI and a socioeconomic survey in Vietnam



Sampling design

- Systematic sampling
  - Densities by strata/region
- Plot locations from previous studies
- Limitation of 5000 plots per region/strata (Google Earth)



Ancillary data

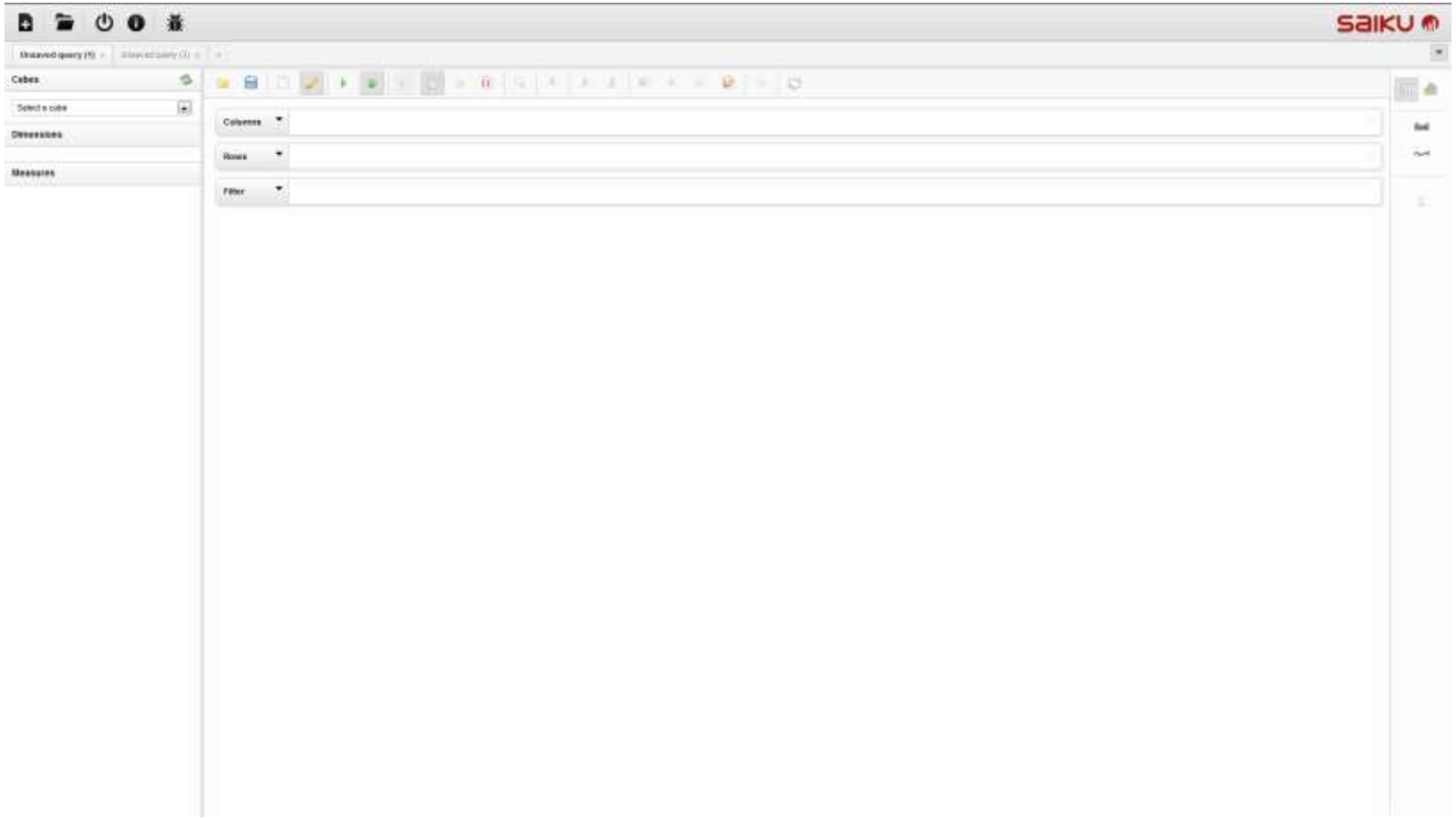
- Data that comes from other sources can be added
- Any data that can be referenced to the plot
- Invisible while collecting data
- Used in the analysis phase

- Examples
  - Vegetation or soil maps
  - Population data
  - Precipitation data
  - Lithological data
  - DEM

Analysis through Saiku

- Fast and intuitive
- Flexible query combination
- Powerful tool for data analysis and cleansing
- Data export to Excel, CSV and PDF
- Graphics generated on the fly

- Data can be analyzed as it is collected
- Data can be shared and analysis performed in computer with no internet access.
- Open source Business Intelligence application developed by MeteoriteBI
- Possible to add **ancillary data** to complete analysis (land cover, soil, population datasets)



Google Earth Engine (GEE)

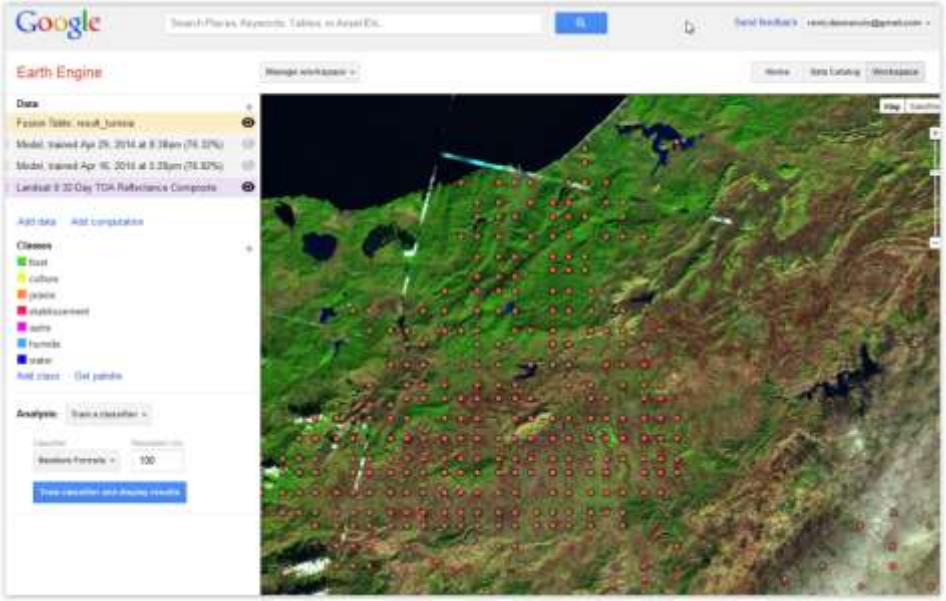
- Used for the land use change analysis.
  - Multiple data sources available:
    - Landsat 5 from 1984 to 2013, Landsat 7 from 1999 and Landsat 8 from 2013.
    - Greenest-pixel layers provide cloud-free imagery
  - Image processing in the cloud
  - Provides classification functionalities using the collected data as training set (Fusion tables)

Land Use change with Bing and GEE

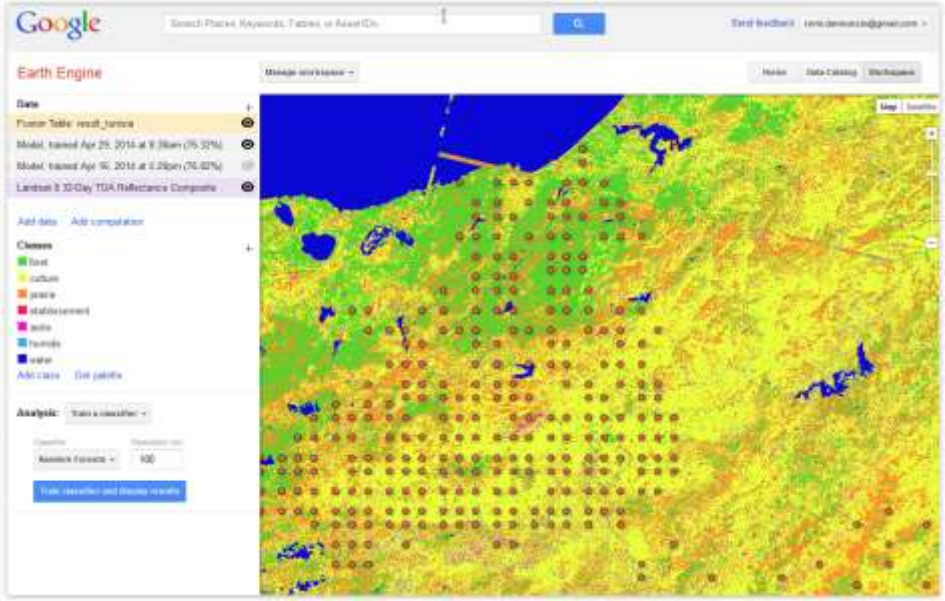
GEE & Fusion tables

The data collected can be exported to a Fusion table format, then uploaded to Google Drive and accessed through GEE to be used as a training set to produce a land-use/cover map

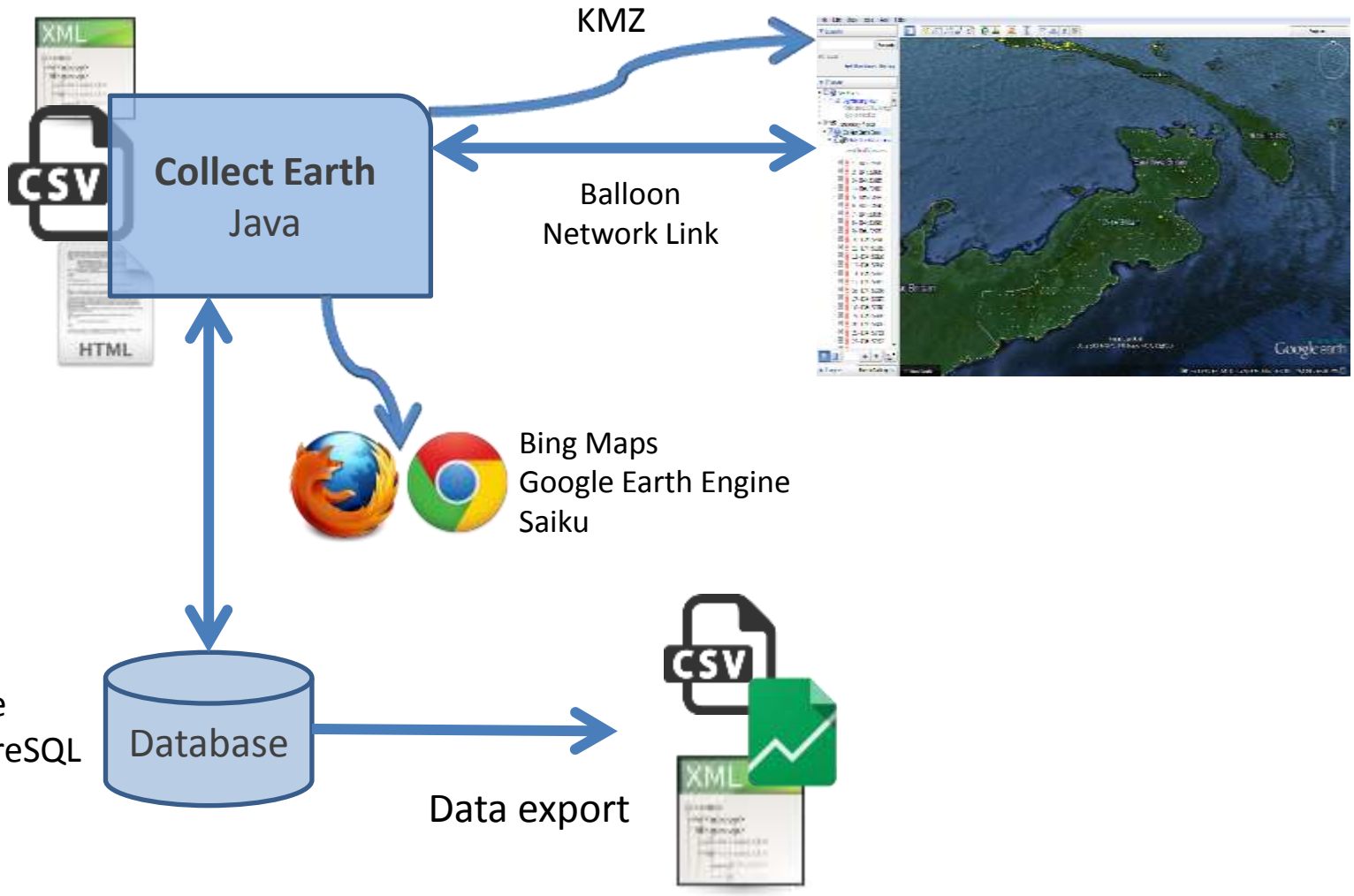
Data from Collect Earth embedded in Google Earth Engine



Results of the random-forests classifier using the collected data as a training set



Collect Earth basic architecture



- SQLite
- PostgreSQL

Stand-alone or server based

- Stand-alone
  - Collect Earth uses a single-file database (SQLite) to store/fetch the data.
  - The data can be exported into XML
  - A user can gather data from several operators (through the XML files) and import it into his Collect Earth instance to combine it
- Server-based
  - Collect Earth uses a server database (PostgreSQL)
  - All operators connect to the same database
  - Collected data available to all operators.

How can I get it?

- Future version fully customizable by user.
  - Ready by September-October 2014
- Currently support for the OpenForis workgroup (or an expert) necessary to set up new surveys.
  - Support offered to all the projects interested
  - Contact: alfonso.sanchezpausdiaz@fao.org
- Open-source approach
  - Collaboration is a plus!

Ecuador
Metodología y desarrollo del Mapa de Carbono Nacional

Pablo Moncayo – MAE
Néstor Veas – FAO
Paula Lima – FAO

9th GFOI Americas Workshop

December 2 – 7, 2013

Colombia

Instructions for Authors: These are the Main Presentation Questions for your Countries, Please use this template as a guide for your 20 minute presentation

Country Information

1.What are you country's National priorities for monitoring forest for carbon accounting purposes in the country? Provide a brief description of the national policy context

2.Which are the National ministries or government agencies responsible for implementation of MRV in your country

3.Are there any Existing national monitoring systems, capabilities and other supporting international partnerships already in operation?

Mapping Status in Country

1. Remote Sensing for forest and carbon monitoring – status of the national monitoring system
2. Status of Biomass maps in country
3. Future plans

Antecedentes

Antes del 2008

Información no oficial, dispersa y con objetivos particulares y puntuales

Metodologías diferentes y no compatibles

Debilidad institucional para generar y proveer información

Vacios de información para la toma de decisión

Tema ambiental secundario en la política pública

2008

Nueva Constitución

Plan Nacional del Buen Vivir

Incentivos para la conservación

Prioridad en temas de mitigación y adaptación al cambio climático

Priorización de temas de planificación y ordenamiento del territorio

2009 – 2013

Nueva Gobernanza Forestal

Implementación de incentivos para la conservación (SocioBosque, REDD+)

Estrategia Nacional de Cambio Climático

Generación y gestión de la información (por proyectos)

Prioridades del Ecuador

- Reducción de la deforestación
- Aumento de la cobertura forestal (Incentivos)
- MRV (monitoreo, reporte y verificación) respecto al Cambio Climático (Subsecretaría de Patrimonio Natural)
- Multipropósitos (Mejorar cobertura, gestión de riesgos, energía, riego)
- Sociobosque

Implementación de MRV

- MAE
  - Cambio Climático
  - REDD+

- Mapa de Deforestación
- Mapa de Vegetación
- Evaluación Nacional Forestal

Sensores Remotos para el monitoreo de los Bosques y Carbono

9 estratos de Bosque

- MVE:

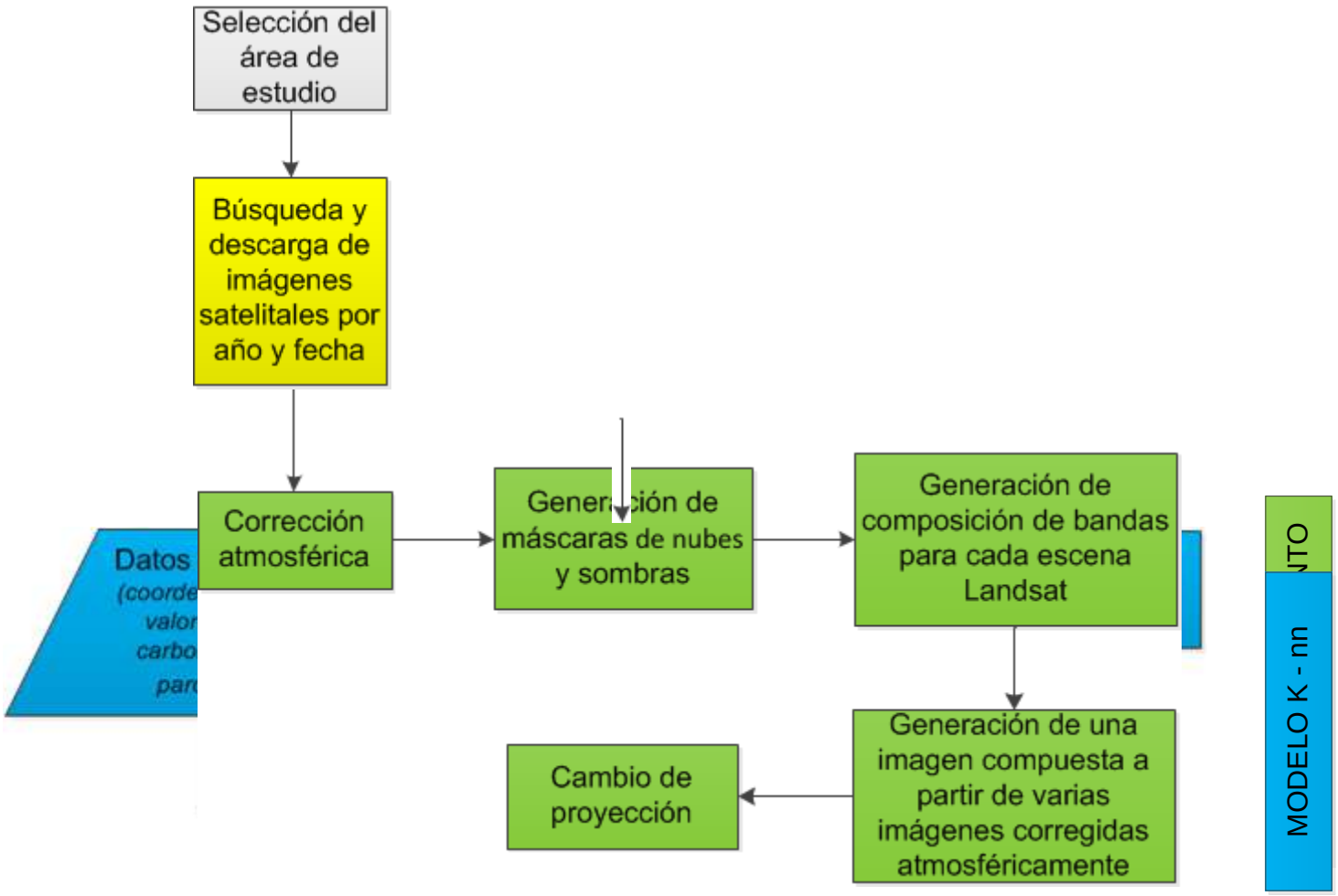
  91 Ecosistemas, 65 en Bosque

- MD:

  1990-2000: -0,71% (89.944 Ha/año)

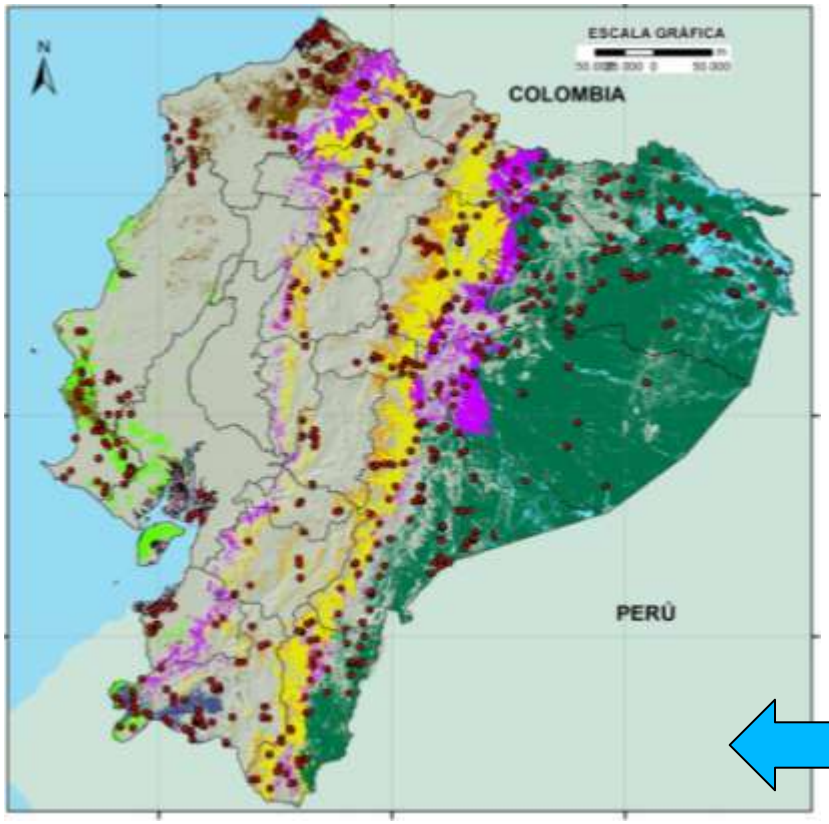
  2000-2008: -0,66% (77.647 Ha/año)

Obtención del Mapa de Carbono con imágenes LANDSAT

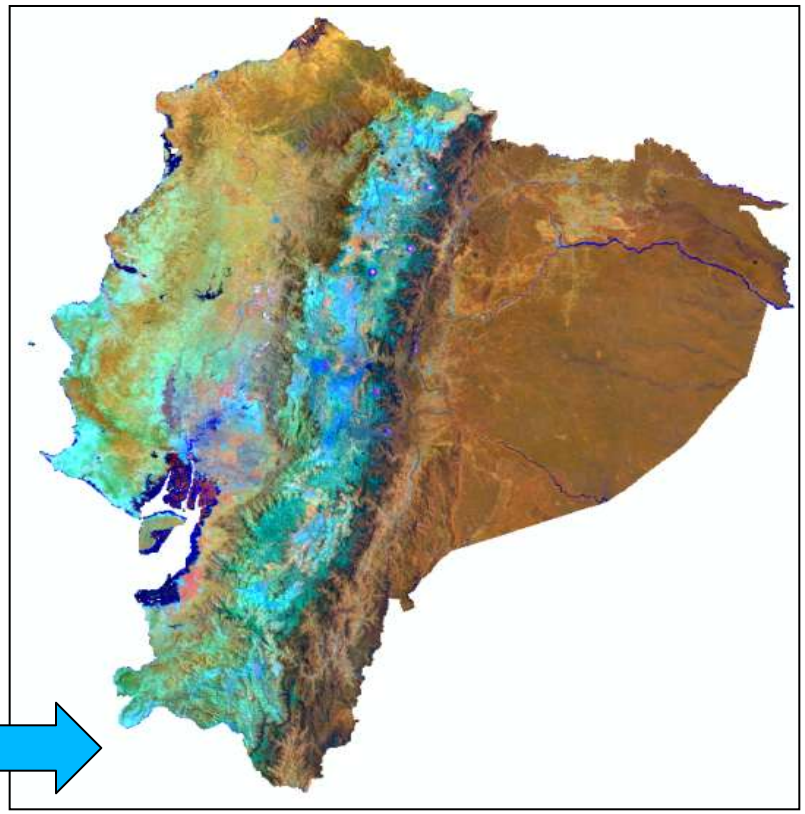


Componentes

Estratos y parcelas de la ENF

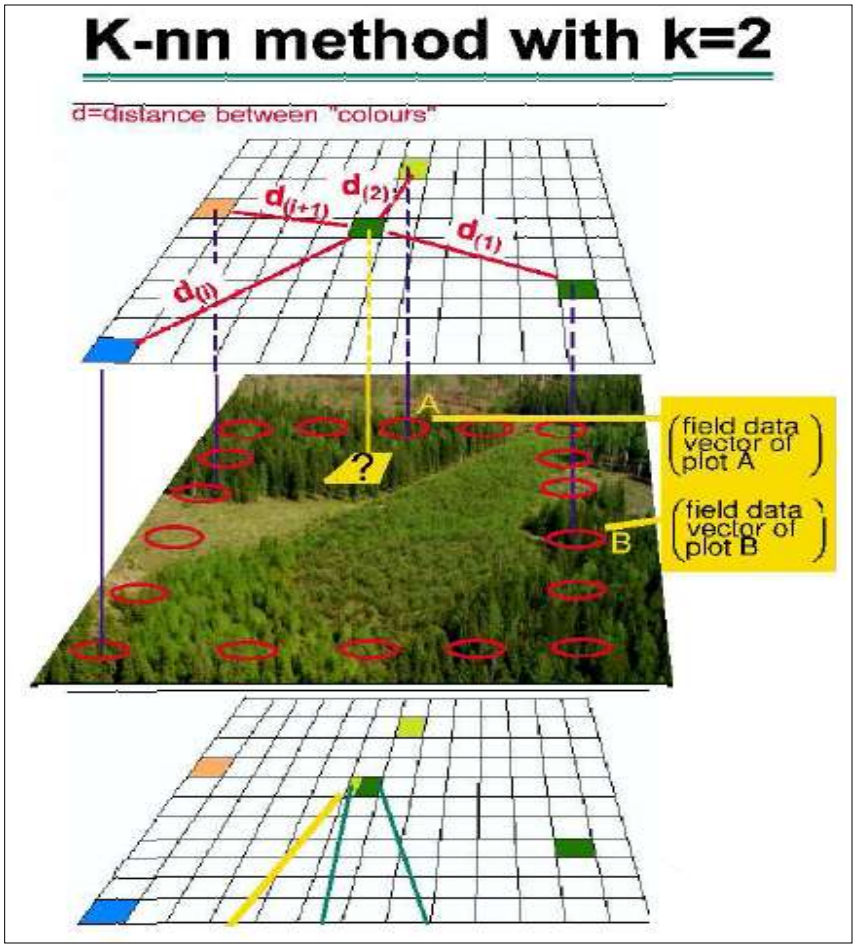


Mosaico LANDSAT (Hansen *et al.* 2008)

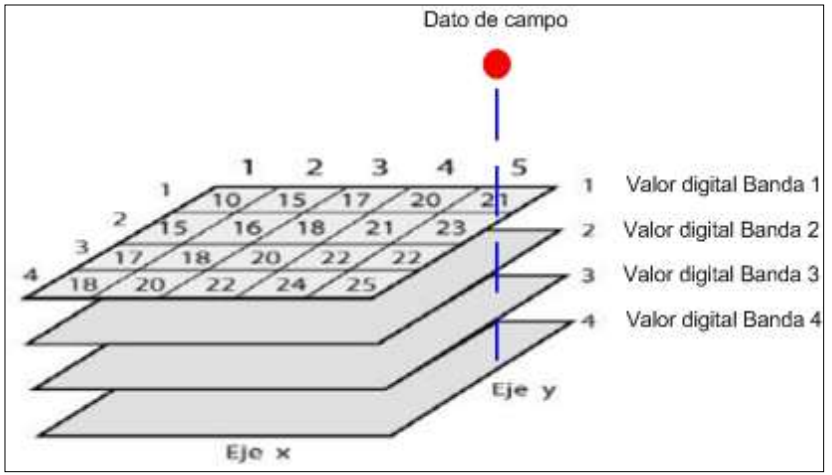


Algoritmo K-nn

Algoritmo K-nn



Fuente: Centro de Investigación de Bosques de Finlandia, 1996



Cada imagen tiene una cuadrícula de píxeles con un valor digital asociado.

K-nn calcula y correlaciona las coordenadas, distancias y valores de las parcelas de campo (realidad) con cada píxel de la cuadrícula , asignándoles un valor estimado de la realidad (modelo).

El modelado permite tener datos del estrato sin tener que muestrear e inventariar exhaustivamente toda el área.

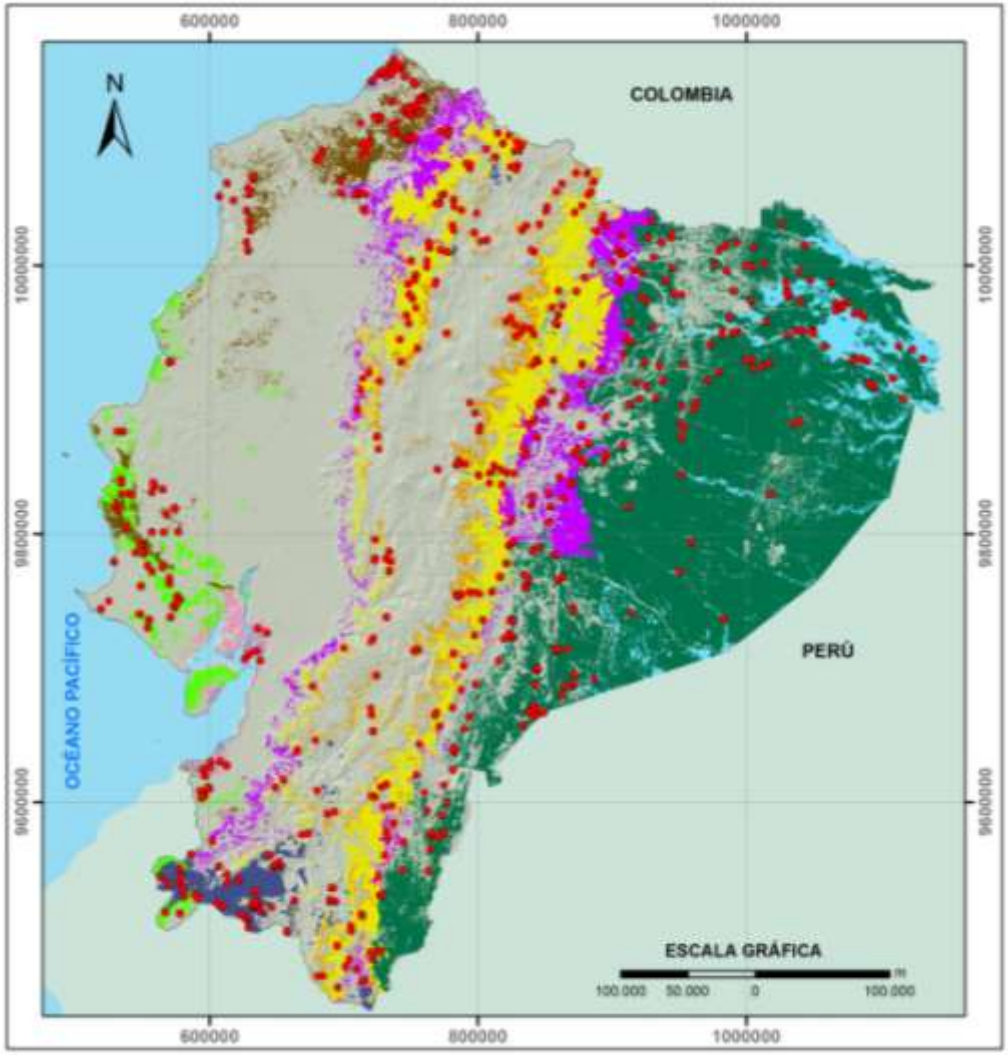
Estratos y Parcelas

Simbología

(Parcelas

Estratos

- Bosque Seco Andino
- Bosque Seco Pluviestacional
- Bosque Siempre Verde Andino Montano
- Bosque Siempre Verde Andino Pie de Monte
- Bosque Siempre Verde Andino de Ceja Andina
- Bosque Siempre Verde de Tierras Bajas de la Amazonia
- Bosque Siempre Verde de Tierras Bajas del Choco
- Manglar
- Moretales



ESTRATOS DE BOSQUE (ENF)	Superficie de Bosque (Ha)	Precipitación Anual (mm)	Unidades de muestreo	Número de Parcelas
BSA	162986,85	841	30	90
BSP	399322,53	724	70	210
BSVAM	1888674,12	2416	119	349
BSVAPM	1079697,24	3406	76	223
BSVCA	502770,24	1559	84	252
BSVTBA	6293513,34	2835	112	330
BSVTBCH	465706,17	2389	80	207
M	104572,17	1028	30	90
Mo	466068,87	2799	30	89
TOTAL	**11363311,53**	**2148**	**631**	**1840**

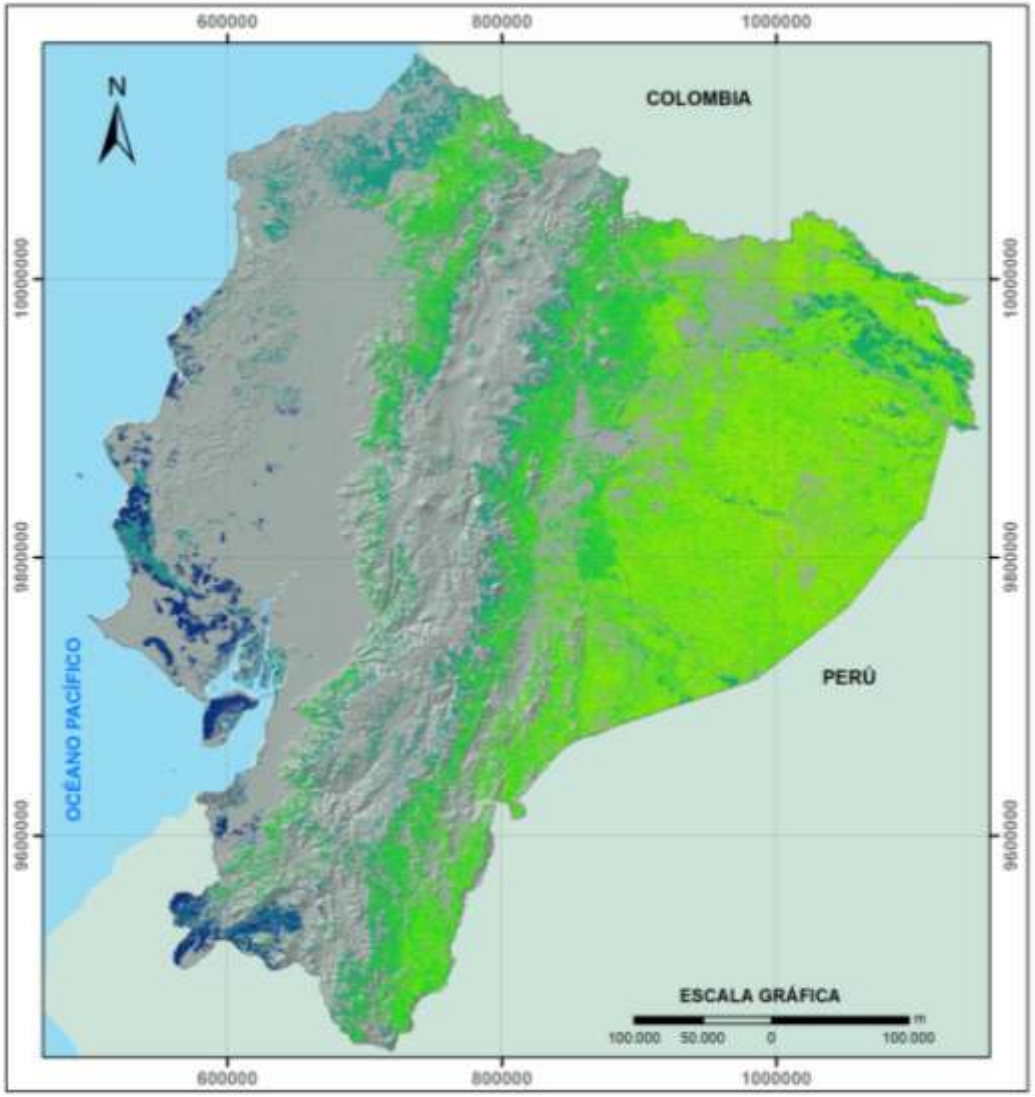
MAPA DE CARBONO

1.600.526.432
Ton. Carbono

5.896.130.426
Ton CO_2 equivalente

Es igual a 14 veces las emisiones netas de CO_2 Equivalente (CO_2, NH_4, N_2O) del Ecuador en 2006*

*Segunda Comunicación Nacional sobre Cambio Climático – MAE,2011



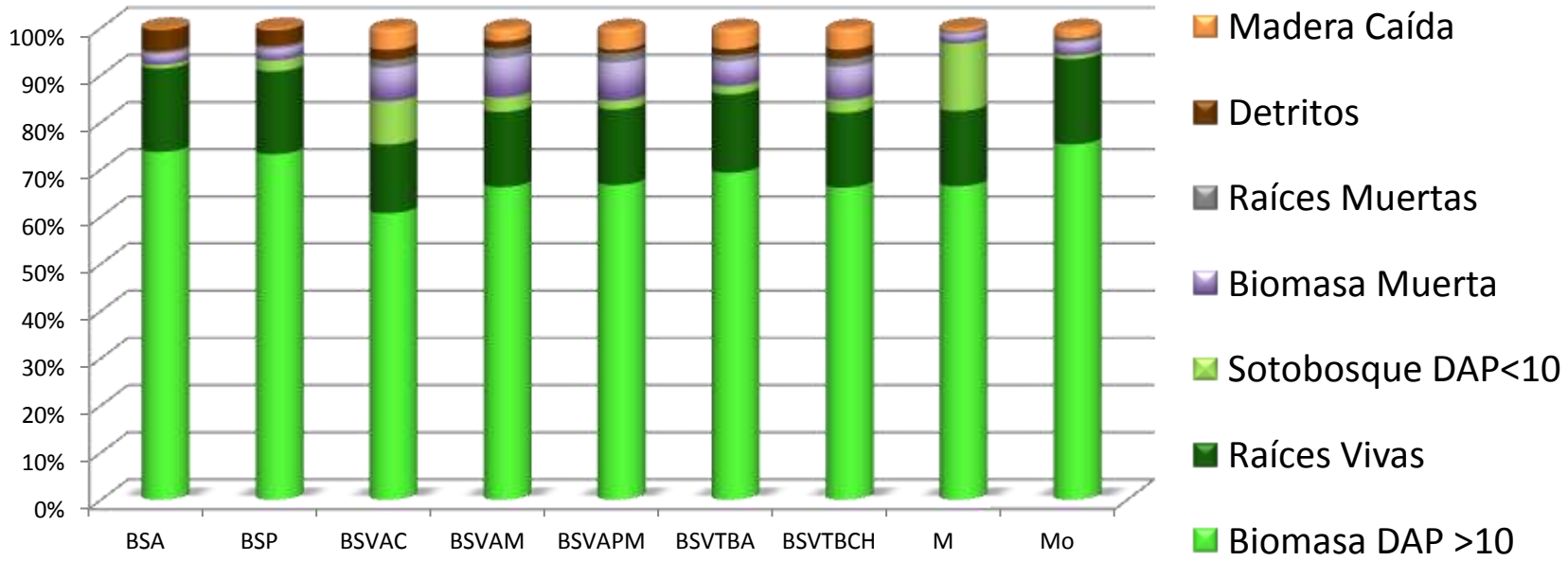
DISTRIBUCIÓN TOTAL DE CABONO POR ESTRATO

- BSA (0.51%)
- BSP (0.91%)
- BSVAC (2.90%)
- BSVAM (14.84%)
- BSVAPM (9.28%)
- BSVTBA (65.71%)
- BSVTBCH (2.36)
- M (0.40%)
- Mo (3.11)

Carbono Total
8105549,40
14609870,85
46358709,78
237473320,60
148463312,27
1051736995,21
37695538,09
6348447,08
49734689,17

Comparación entre resultados LANDSAT Y MODIS

	% LANDSAT (3 pools)	% MODIS (Fuste)
BSA	0,51	0,53
BSP	0,91	0,88
BSVAC	2,90	4,36
BSVAM	14,84	13,49
BSVAPM	9,28	9,63
BSVTBA	65,71	62,13
BSVTBCH	2,36	2,88
M	0,40	0,68
Mo	3,11	5,43


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
BSA
BSP
BSVAC
BSVAM
BSVAPM
BSVTBA
BSVTBCH
M
Mo
Madera Caída
Detritos
Raíces Muertas
Biomasa Muerta
Sotobosque DAP<10
Raíces Vivas
Biomasa DAP >10


BSVTA
167.11 T/Ha
1.051.736.995 Ton


BSP
36.59 T/Ha
14.609.870 Ton

El Futuro…

- Consolidación de la Unidad de Monitoreo Forestal del Ecuador (2014)
- Inventario Nacional en áreas no boscosas (II trimestre 2014)
- Consolidación del Sistema Nacional de Parcelas Permanentes (2014)

Monitoreo Espacial

PROCESOS	TEMPORALIDAD (años)	ESCALA
Actualización de la tasa de deforestación	2	1:100.000
Cobertura y uso - *Coordinación Interinstitucional MAE-MAGAP (2014)	4	1:100.000
Desarrollo de líneas base para degradación	por Definir	por definir
Monitoreo en áreas críticas (por definir)	1	1:50.000
Actualización de ecosistemas y estado de los mismos (incluye insumos de: bioclima, fenología, geoformas, ecosistemas y servicios ecosistémicos)	4	1:100.000
Escenarios de Referencia	6*	1:100.000
Monitoreo de emisiones por deforestación	por definir	1:100.000

*A partir del 2020 se adopta la temporalidad propuesta por la CMNUCC