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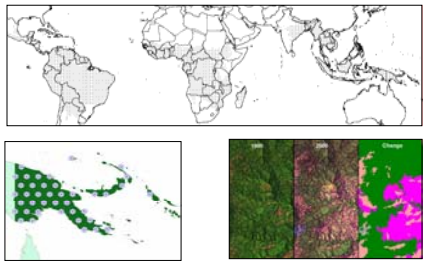
Reducing emissions from deforestation

Estimating forest conversion rates from national to global scales using the TREES-3 method



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Introduction - Importance of methodological issues

Dr. Antonio Lumicisi, Ministry for the Environment, Land and Sea, Italy

The TREES-3 approach - The potential of Earth Observation data for monitoring forest areas at global to regional levels

Dr. Frédéric Achard & Dr. Hugh Eva, JRC

TREES-3 Case studies – Congo basin, Costa Rica & Papua New Guinea

Dr. Hugh Eva, JRC & Dr. Danilo Mollicone, MPI

Forest monitoring – A ground based approach for PNG

Dr. Edward Nir, Forest Research Institute of PNG & Dr. Danilo Mollicone, MPI

Side-event of the 12th Conference of Parties of the UN Framework Convention on Climate Change 9th November 2006

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TREES-3 (2007 – 2013)

A project of the European Commission's Joint Research Centre

Goal:
- **To reduce uncertainties in global/regional estimates of forest area changes**
  and related biosphere-atmosphere processes
  With focus on the Tropics and boreal Eurasia

Heritage:
- **Follows on from TREES-I / TREES-II** fifteen years expertise in mapping and monitoring of the world's forests

Methods:
- **Extensive use of Earth observing satellite data**

Implementation:
- **Collaborative partnership with FAO FRA 2010 programme and national or regional agencies**

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JRC role: Scientific support to EC services

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TREES-3 main objective:

Updating and improving forest change estimates at global to regional levels for the periods: (mid 1975)-1990-2000-2005(-2010)

Approach:

Intensive use of Earth Observation data: a sample of 20-30m resolution satellite imagery

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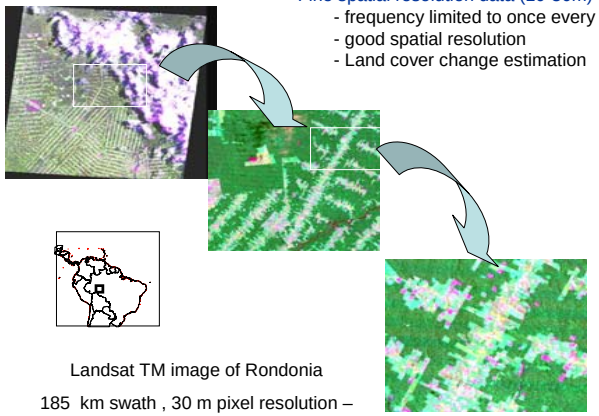
Fine spatial resolution data (10-30m)
- frequency limited to once every 20 days
- good spatial resolution
- Land cover change estimation



Landsat TM image of Rondonia

185 km swath , 30 m pixel resolution –

i.e. 0.08 ha

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Cost of current satellite imagery

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Sensor resolution	Current sensors	Utility for monitoring	Cost	Cost for PNG *450,000 km²*
Medium (250m - 1km)	AVHRR, SPOT-VGT, MODIS, MERIS	**Monitoring of** large clearings **/ "hotspots"**	**Low or free**	
High (**10 - 60m**)	Landsat-TM, ASTER, SPOT-HRV, AWiFs, DMC,	**Primary tool to identify /measure deforestation**	**Recent: 0.02 €/km² Historical: Low or free**	**Country: > 10,000 € Sample: > 3,000 €**
Very high (< 5m)	SPOT (2.5m), IKONOS, QuickBird	Validation over small areas	**2 to 33 €/km²**	**Country: 1 - 15 M€ Sample: ~ 250,000 €**

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Availability of high resolution satellite imagery

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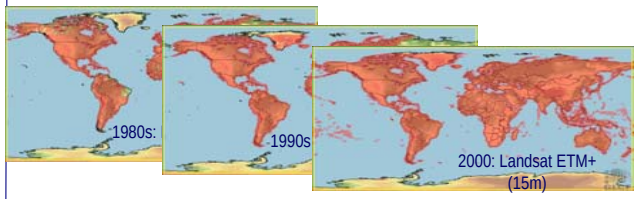
1. Historical datasets: free Global Landsat coverage for 1980s, 1990s and 2000

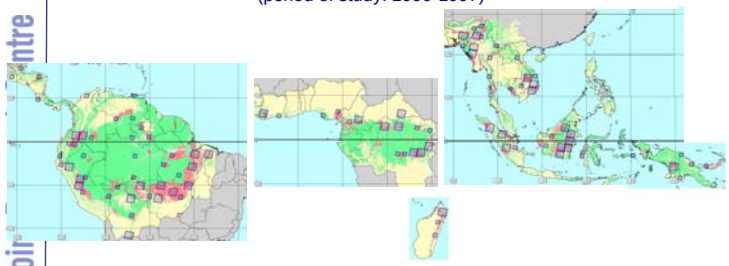
- Global Landsat mosaics produced from NASA
  - **around-years 1990 and 2000**
  - **in production for 2005/2006**
  - available at: https://zulu.ssc.nasa.gov/mrsid/mrsid.pl
- 27,841 images are available at Global Land Cover Facility



2. Recent data: availability is good where sufficient cloud-free periods or 'dry seasons'

Distribution of sampling units in the TREES-II survey

For measuring forest cover change at continental scale
within a stratified systematic sample
(period of study: 1990-1997)



Each square represents one sample (90x90 km or 180x180 km)

These 102 observation units cover 6.5% of the humid tropical domain

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Estimates of tropical forest change at regional & global levels

	Latin America (10^6 ha)	Africa (10^6 ha)	Southeast Asia (10^6 ha)	Global (10^6 ha)
Total study area	1,155	337	446	1,937
Forest cover in 1990	669 ±57	198 ±13	283 ±31	1,150 ±54
Forest cover in 1997	653 ±56	193 ±13	270 ±30	1,116 ±53
Annual deforested area	2.5 ±1.4	0.85 ±0.30	2.5 ±0.8	5.8 ±1.4
rate	0.38%	0.43%	0.91%	0.52%
Annual regrowth area	0.28 ±0.22	0.14 ±0.11	0.53 ±0.25	1.0 ±0.32
rate	0.04%	0.07%	0.19%	0.08%
Annual net cover change	- 2.2 ±1.2	- 0.71 ±0.31	- 2.0 ±0.8	- 4.9 ±1.3
rate	0.33%	0.36%	0.71%	0.43%
Annual degraded area	0.83 ±0.67	0.39 ±0.19	1.1 ±0.44	2.3 ±0.71
rate	0.13%	0.21%	0.42%	0.20%

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Options for an improved TREES-3 sampling scheme

Requirements for a global scheme:

- Samples across the world
- Intensification when required (ecosystem, hotspot, regional)
- For each sample a box interpretation

Potential Sampling Schemes:

- Random
- Stratified
- Systematic :
  - Triangles based on Hexagonal Tessellation
  - Geographic co-ordinates

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Selection of a robust sampling scheme
-
Highlights from a statistical expert meeting held at JRC on 28/29 September 2006 in collaboration with FAO FRA

1. **The systematic geographical grid at 1-degree (full coverage) as main sample frame is considered by FAO and JRC as the most practical and appropriate sampling approach for global monitoring with high resolution satellite data**
2. **Sample units size is suggested to be 10km x 10km for the core interpretation with an additional 5km buffer zone for contextual information**
3. The unequal probability associated with this grid will have to be taken into account during the estimation phase as usual variance estimators (that assume simple random sampling) typically overestimate variance of sampling errors

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Selection of a robust sampling scheme
Highlights from the statistical expert meeting

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4. **Ancillary information derived from full coverage coarse-resolution satellite data** (e.g. MODIS, VGT) **can be used to improve efficiency**, either through pre-stratification (to intensify the sampling rate in sub-regions of particular interest such as hot spot areas or specific ecosystems), or through regression estimators (during the estimation phase)

5. **For missing data (in particular cloudy regions) two solutions are possible:**
   - **to use a pre-stratification** and design a separate plan with a co-variable,
   - **to provide information** for missing sample units **through expert opinion**

6. **Independent accuracy assessment** should be ideally based on very high resolution satellite imagery (secondary sampling units) but such scheme would be difficult to achieve due to the absence of historical imagery and cost of recent imagery. The consistency of the survey could be evaluated by repeating the exercise on a sub-sample with independent interpreters.

Systematic sampling using the geographical grid (lat /long)

With distance between sample units = 1 degree
→
Number of sampling units in the tropics: ~ 3000

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Options for sampling from geographical grid

50x50 km @ 1°

10x10 km @ 1°

10x10 km @ 0.25 °

10x10 km @ 1°

10x10 km @ 1°

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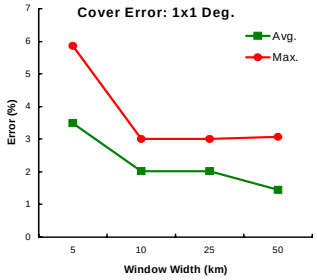
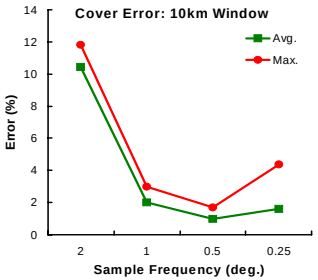
Example of error from systematic sampling

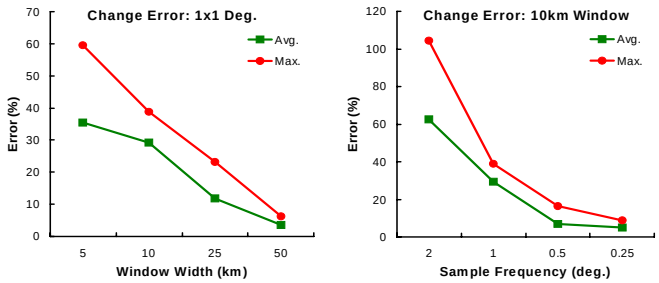
Maximum (3 countries) error for **area** = 3% with 10x10 km @ 1°





Example of error from systematic sampling

Maximum error for **area change** = 40% with 10x10 km @ 1°



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Options for satellite image interpretation

-

Highlights from FAO-UNEP technical meeting *(18 October 2006)*
on methodology and implementation aspects
of the planned FRA 2010 Remote Sensing Survey

- Traditional (aerial photography)
- Visual interpretation
- Pixel based image processing
- Segmentation

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Area estimates over large areas / large samples from remote sensing data :
A few examples of existing projects

- Initial assessment of land cover done by dot-grid approach – a direct application of aerial photo-interpretation (FAO 1980s)

- Overlay of tracing paper on 1:200,000 Landsat printouts – manual digitising to vectors (INPE / FAO)

- On-screen digitising of False Colour Composite (Corine Land Cover / TREES)

- Pixel based classification of multi-spectral image – expert interpretation (Landsat Pathfinder / INPE)

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Requirement for processing large numbers of Sample Units

- Rapid processing of large numbers (‘000’s) of small sample units
- use all multi-spectral data and contextual information in the process
- Retain the land parcel as the unit of analysis
- Inter-active classification (i.e. historical and recent)
- Consistent precision in the delineation of features
- obtain first pass classifications and change matrices from automatic process
- allow expert visual validation and re-interpretation of all scenes and dates

Implementation of TREES-3 / FAO FRA 2010 project:
- Minimum mapping unit at global scale : < 5-7 ha
- Legend: levels of details in phase of elaboration

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TREES-3 Next steps (2007-2008)

- Develop case studies
- Work in collaborative partnership with FAO FRA 2010 programme (Remote sensing survey component)
- Finalize TREES-3 / FAO FRA 2010 RS methodology
- Acquire and pre-process the satellite data
- Implement the sampling scheme through a network of national or regional agencies
- Produce statistical estimates at regional levels

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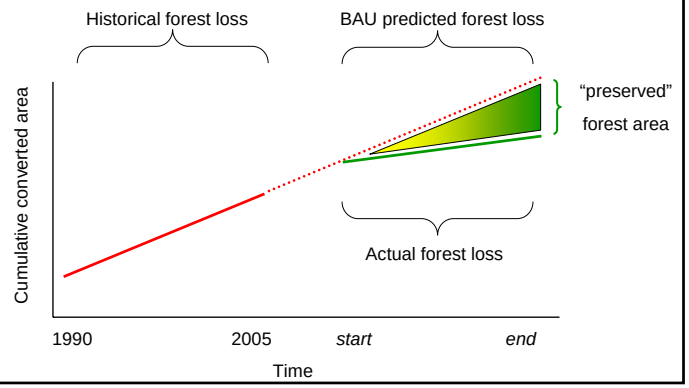
Potential contribution of TREES-3 / FAO FRA 2010 to the "avoided deforestation" item



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Potential contribution of TREES-3 / FAO FRA 2010 to the "avoided deforestation" item: Activity data

Activity data :

Global and regional forest conversion rates

Methods for national forest conversion rates

Constant data :

National carbon stock estimate per forest type