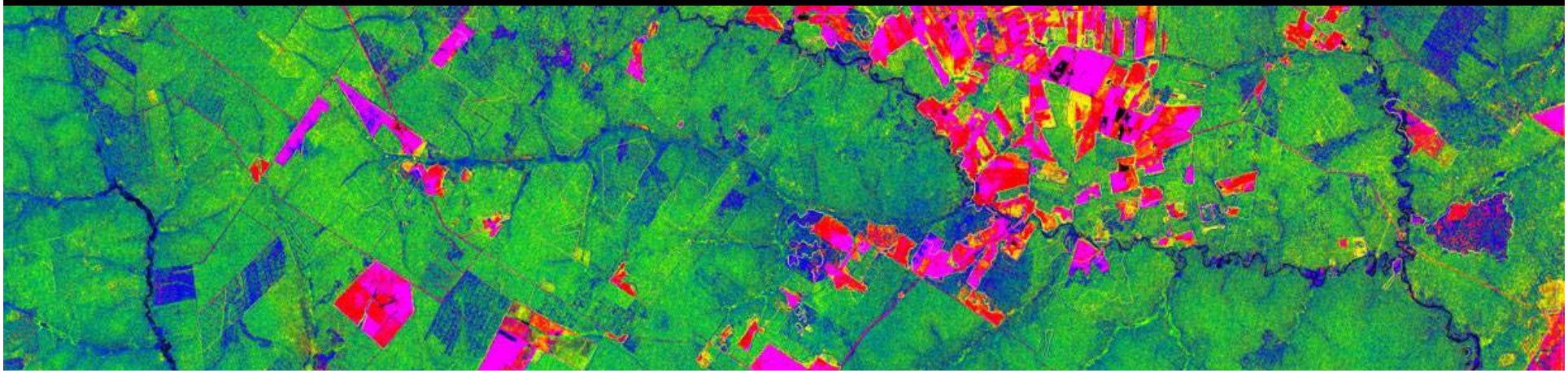
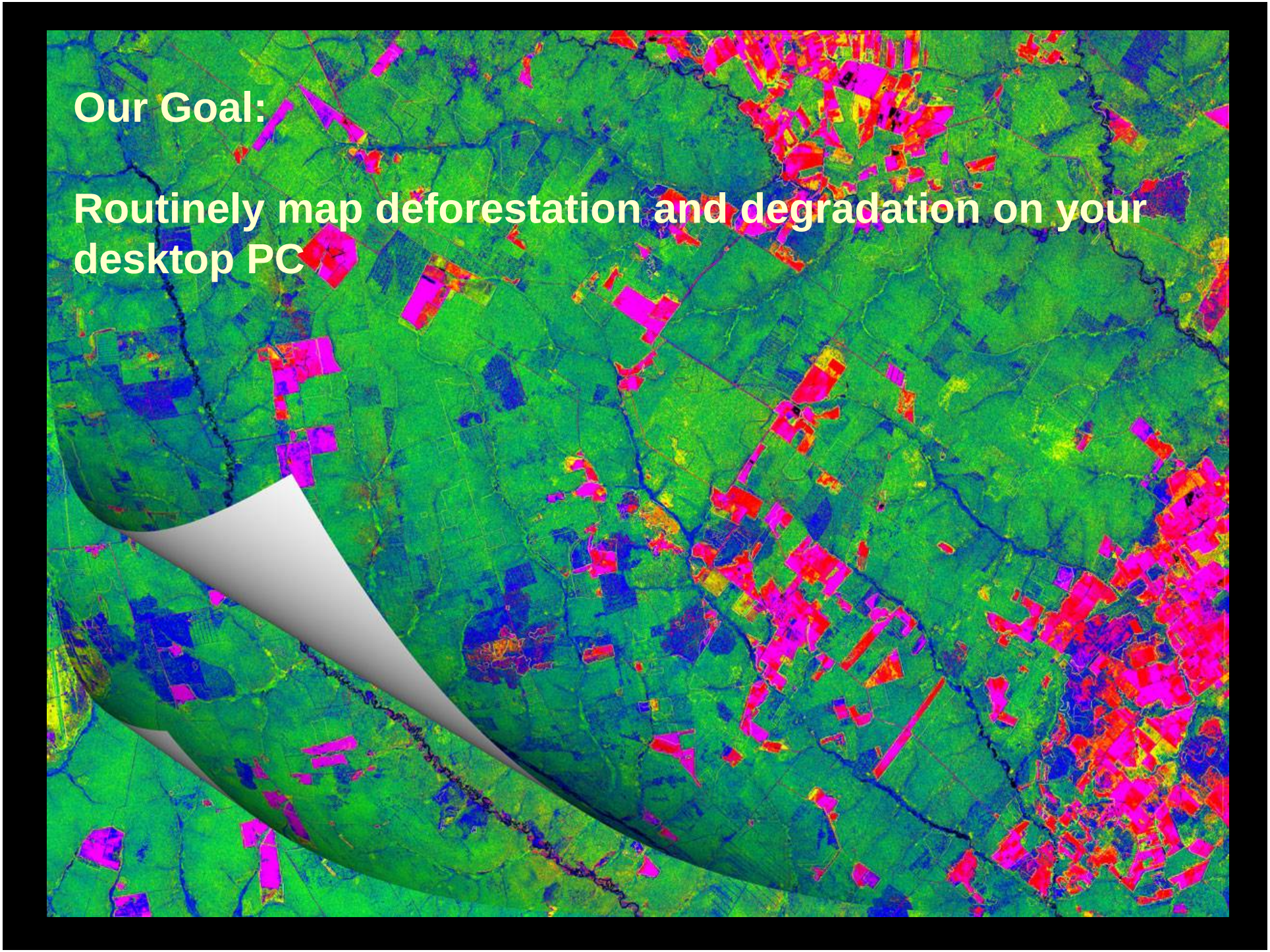
Carnegie Landsat Analysis System – Lite (CLASlite)

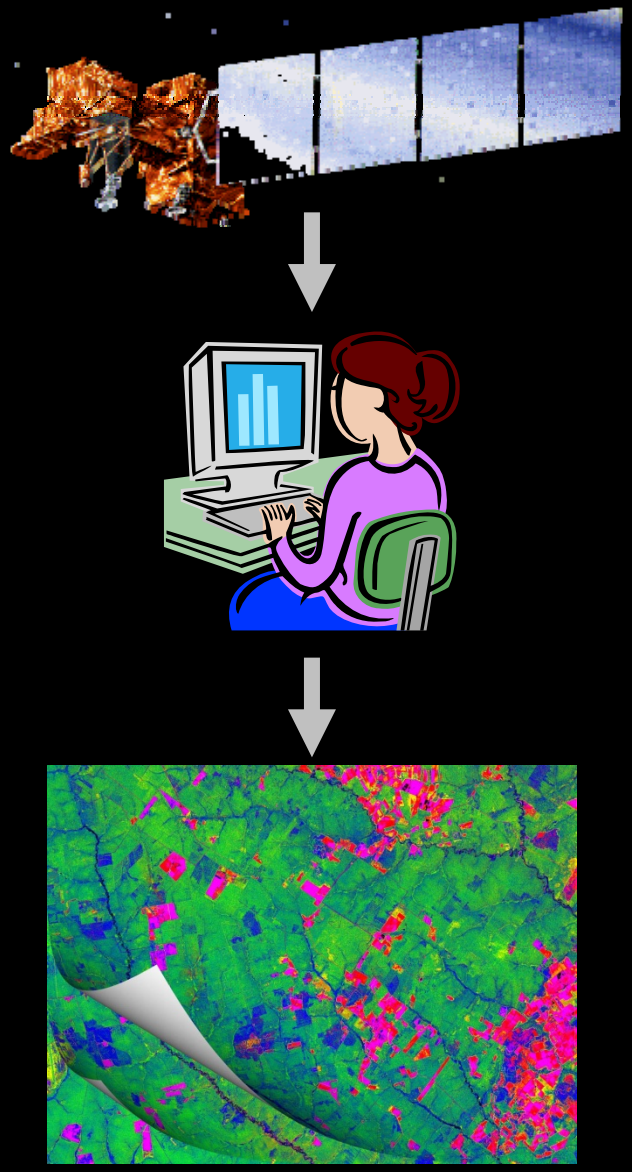
Greg Asner
Carnegie Institution




Our Goal:
Routinely map deforestation and degradation on your desktop PC

Two major challenges in mapping deforestation and disturbance with satellites

- Satellite data availability (cost, access, cloud cover)
  - Tropical forests are cloudy places
- Processing unfriendly images to maps that can be interpreted by people
  - Analyzing the data in a way that allows comparisons between images



Before CLASlite, there was CLAS

Carnegie Landsat Analysis System

In 2005, we deployed CLAS for the first time, analyzing more than 480 Landsat images taken from 1999-2002 over the Brazilian Amazon. We mapped selective logging with uncertainties of 11-14%, and produced the first large-scale, high-resolution maps of logging in the tropics.

Brasil y Perú

In 2007, we expanded CLAS to include deforestation, and mapped the Peruvian Amazon. Errors in mapping deforestation and degradation were 0.5% and 9.5%, respectively. We showed that land-use allocation can protect forests, but poorly managed logging can lead to forest degradation over large areas.

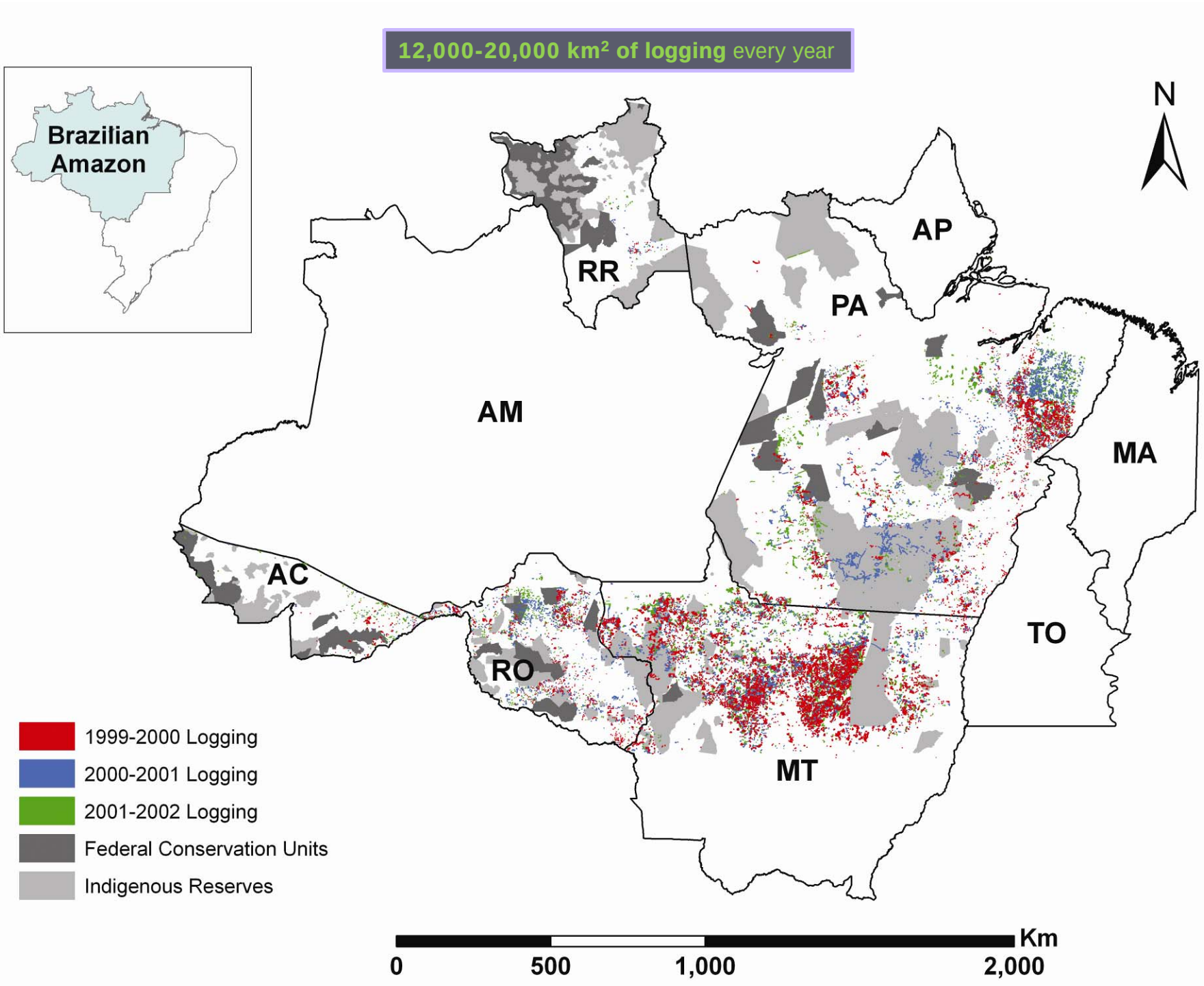
Since 2007 G1

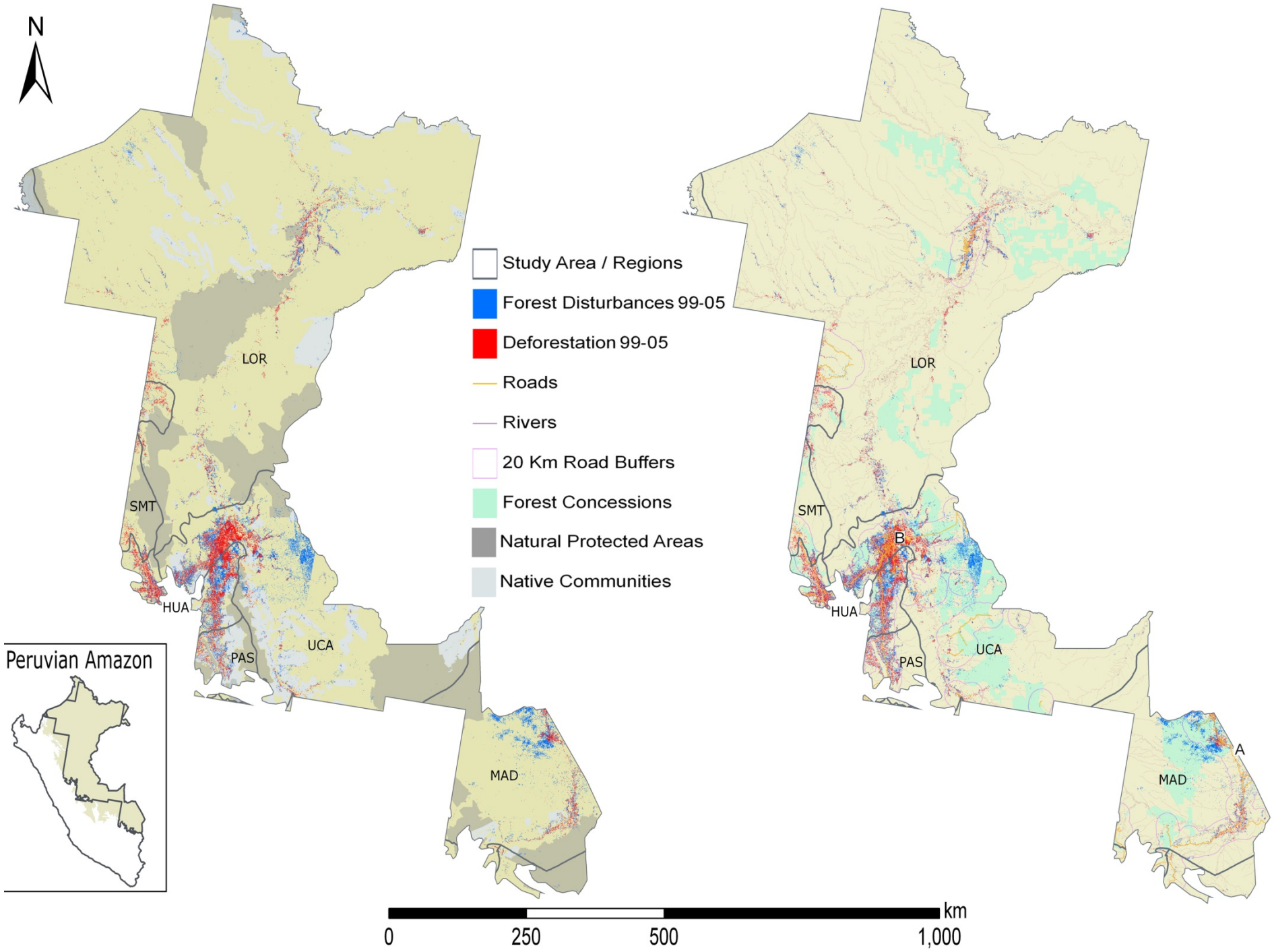
- Borneo, Indonesia, Asia
- Hawaii, Madagascar, Mozambique, and other regions

Slide 4

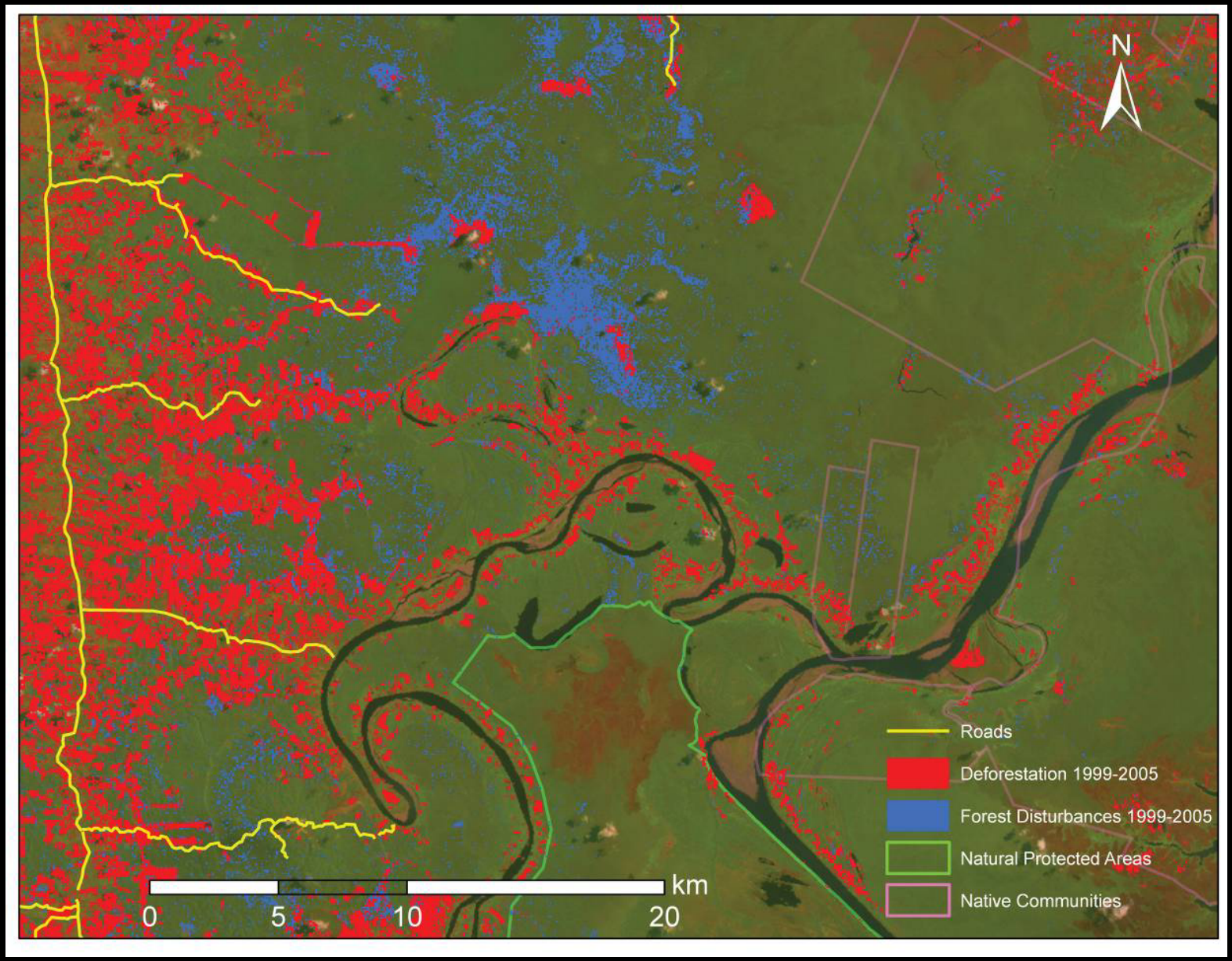
G1 Where else?

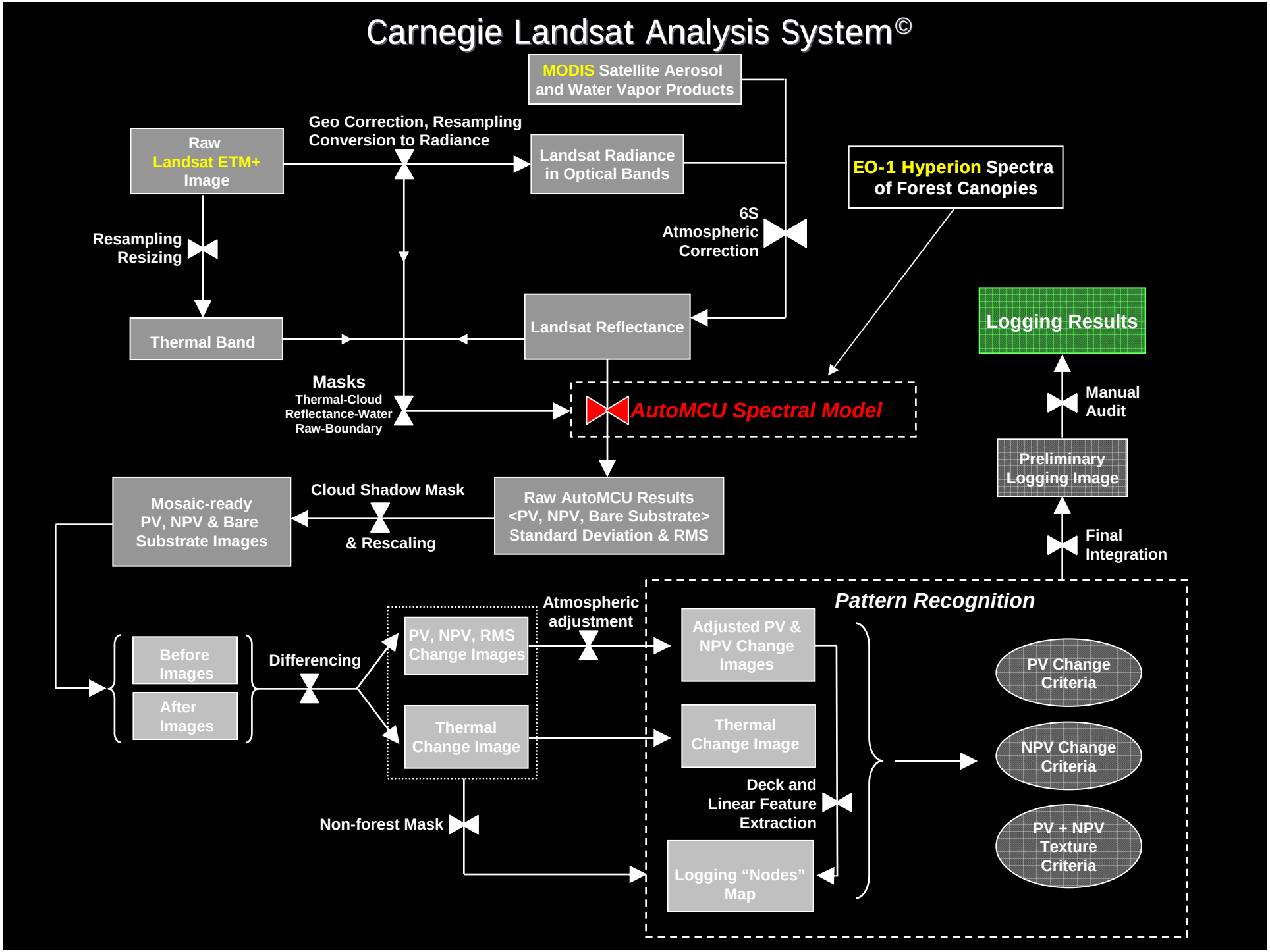
Guayana , 7/16/2009


12,000-20,000 km² of logging every year
Brazilian Amazon
N
RR
AP
PA
AM
MA
AC
RO
TO
MT
1999-2000 Logging
2000-2001 Logging
2001-2002 Logging
Federal Conservation Units
Indigenous Reserves
0
500
1,000
2,000
Km

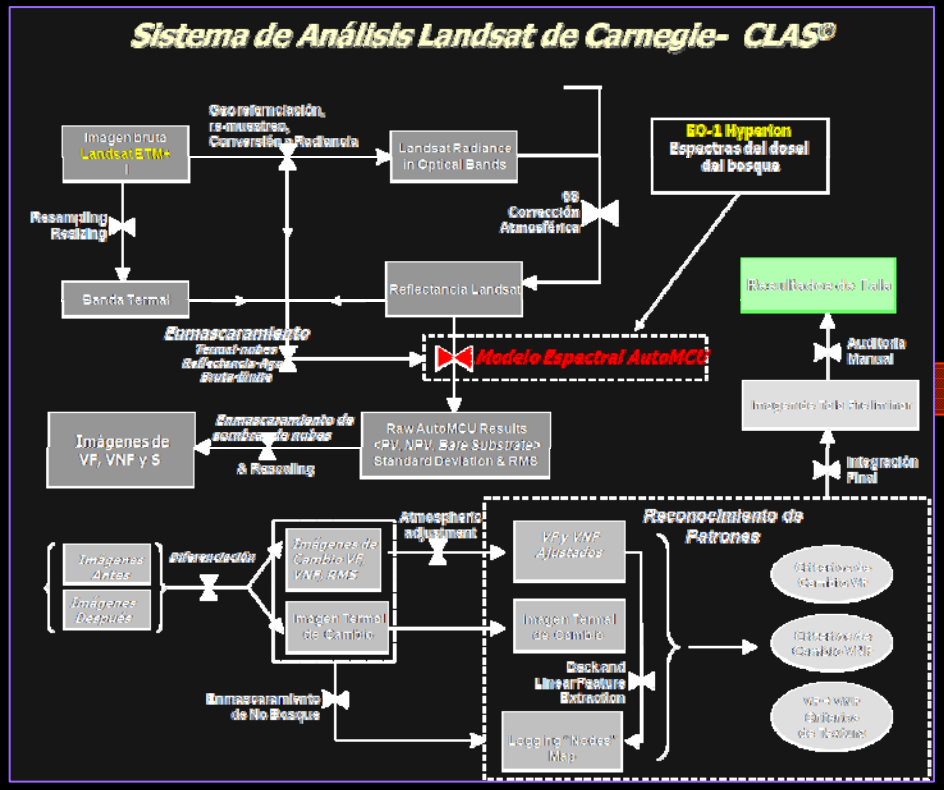

N
Study Area / Regions
Forest Disturbances 99-05
Deforestation 99-05
Roads
Rivers
20 Km Road Buffers
Forest Concessions
Natural Protected Areas
Native Communities
LOR
SMT
HUA
PAS
UCA
MAD
B
A
Peruvian Amazon
0
250
500
1,000
km

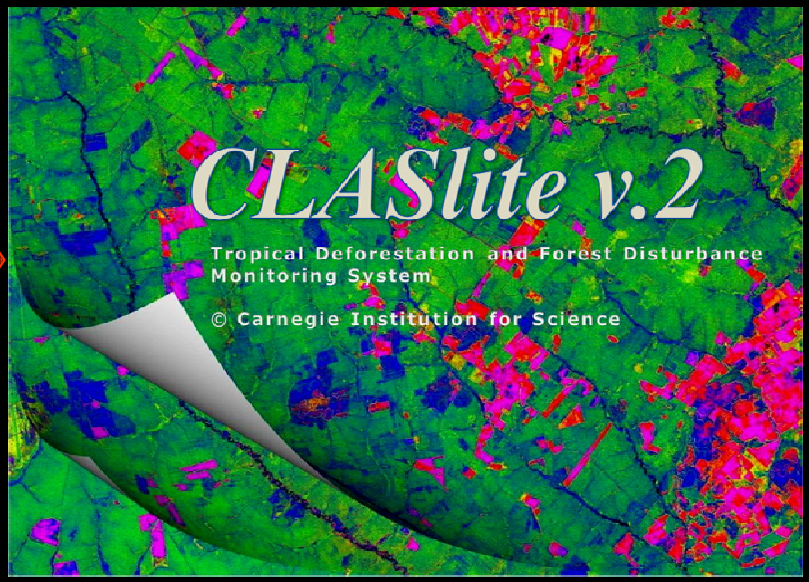
High-resolution example of forest disturbance and deforestation in Peru




Carnegie Landsat Analysis System©
MODIS Satellite Aerosol and Water Vapor Products
Geo Correction, Resampling Conversion to Radiance
Raw Landsat ETM+ Image
Landsat Radiance in Optical Bands
EO-1 Hyperion Spectra of Forest Canopies
6S Atmospheric Correction
Resampling Resizing
Thermal Band
Landsat Reflectance
Logging Results
Masks
Thermal-Cloud
Reflectance-Water
Raw-Boundary
AutoMCU Spectral Model
Manual Audit
Preliminary Logging Image
Mosaic-ready PV, NPV & Bare Substrate Images
Cloud Shadow Mask
& Rescaling
Raw AutoMCU Results <PV, NPV, Bare Substrate> Standard Deviation & RMS
Final Integration
Pattern Recognition
Atmospheric adjustment
Before Images
After Images
Differencing
PV, NPV, RMS Change Images
Thermal Change Image
Adjusted PV & NPV Change Images
Thermal Change Image
PV Change Criteria
NPV Change Criteria
PV + NPV Texture Criteria
Deck and Linear Feature Extraction
Non-forest Mask
Logging "Nodes" Map

From *CLAS* to *CLASlite*



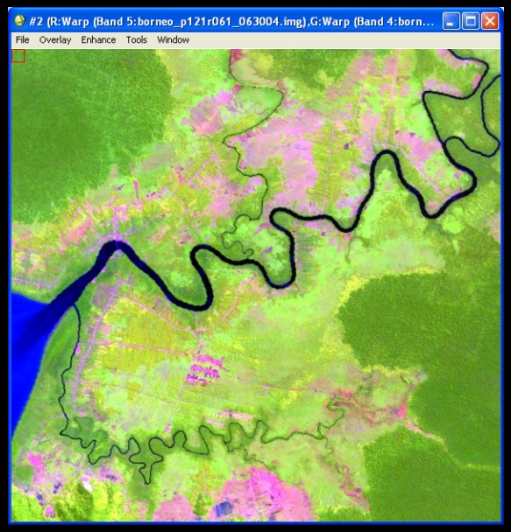


CLASlite vs. CLAS

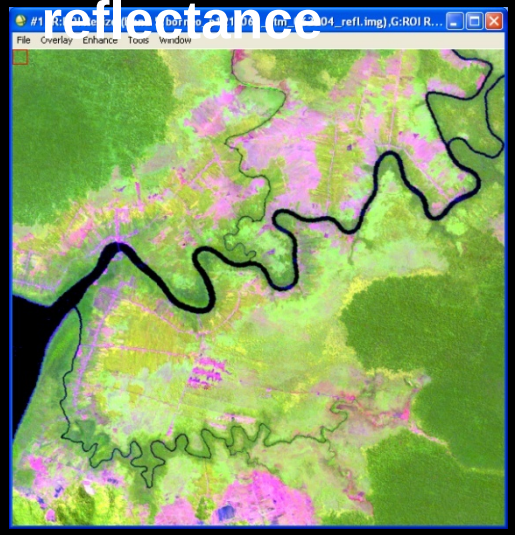
System requirements	CLASlite v2.0	CLASlite v1.0	CLAS
Remote sensing expertise of user	Low	Low	High
Frequency of time-series for analysis	Selectable	Single image	Annual time-series of images
Satellite images processed per use	Several	One	Hundreds
Satellites supported	LANDSAT 4, 5, 7, ASTER, ALI, MODIS, SPOT-4, SPOT-5	LANDSAT 4, 5, 7, ASTER, ALI	LANDSAT 5, 7
Processing time	Hours	Hours	Days-to-Weeks
Operating system	PC (processor x86 (32 bits)), Windows XP and , 4 GB hard disc, 1 GB RAM).	PC (processor x86 (32 bits)), Windows XP, 2 GB hard disc, 1 GB RAM)	Super computers
System functionalities			
Image calibration and pre-processing	Full implementation	Full implementation	Full implementation
Image atmospheric correction	Full implementation	Full implementation	Full implementation
Analysis of forest cover at sub-pixel resolution	Full implementation	Full implementation	Full implementation
Analysis of live vs. dead vegetation cover	Full implementation	Full implementation	Full implementation
Cloud and cloud shadow masking	Partial implementation	Partial implementation	Full implementation
Deforestation maps	Yes	No	Yes
Forest disturbance (degradation) maps	Yes	No	Yes

What is *CLASlite*?

Raw Image



Auto-reflectance



Fractional Cover

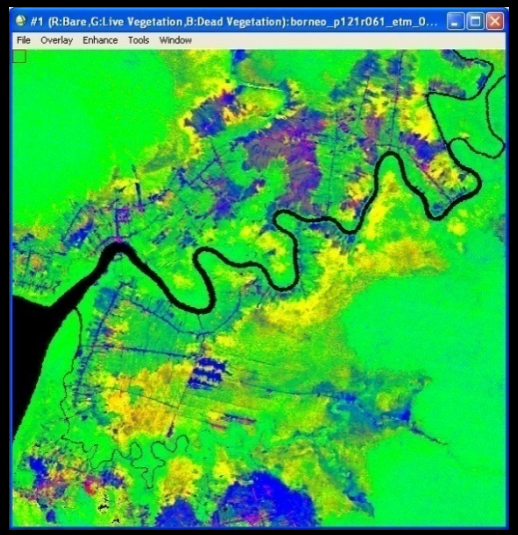
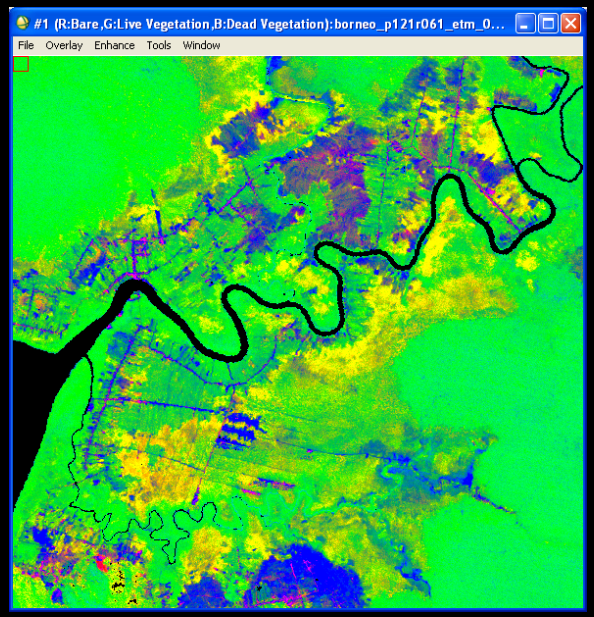


Image Calibration

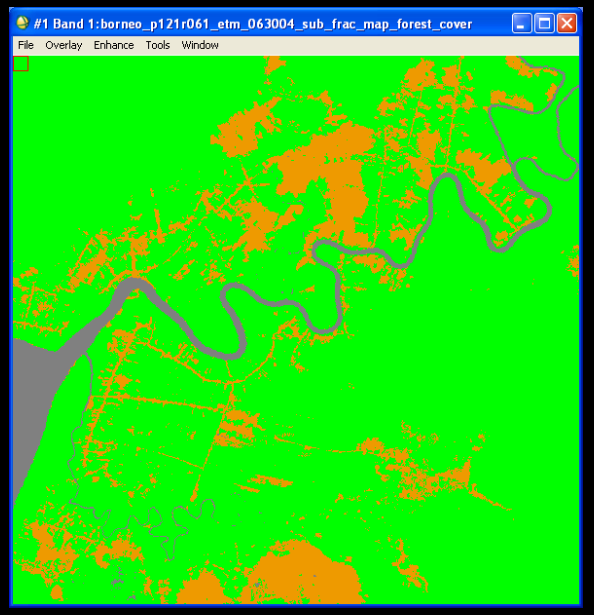
Monte Carlo Unmixing

What is *CLASlite*?

Fractional Cover



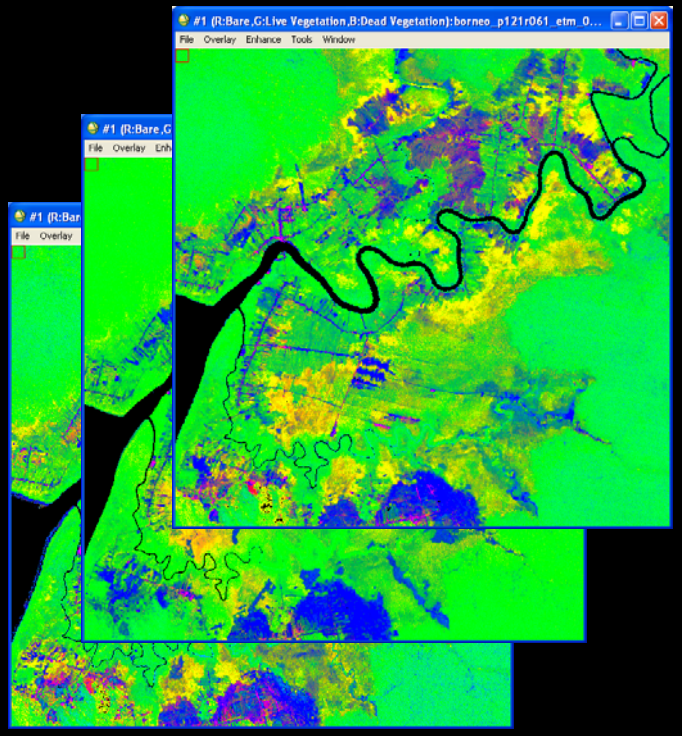
Forest Cover



Auto-Mapping

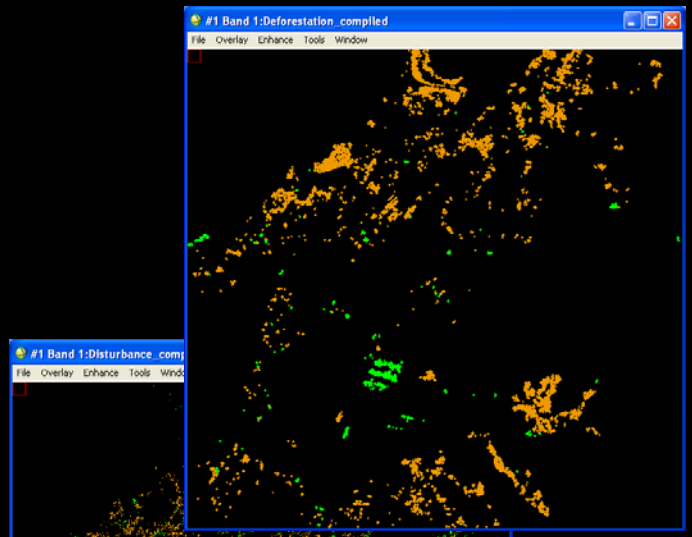
What is *CLASlite*?

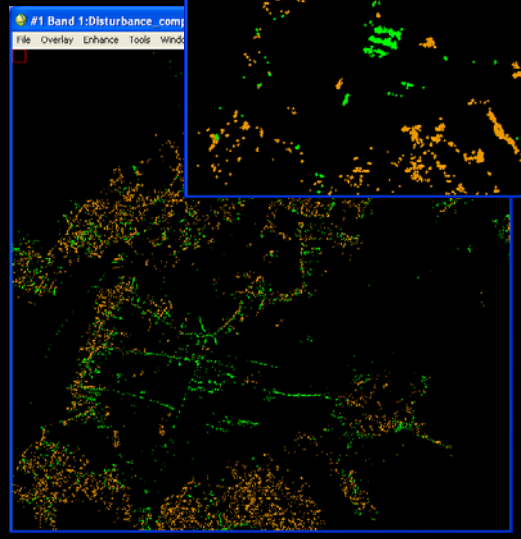
Multi-image Analysis



Auto-analysis

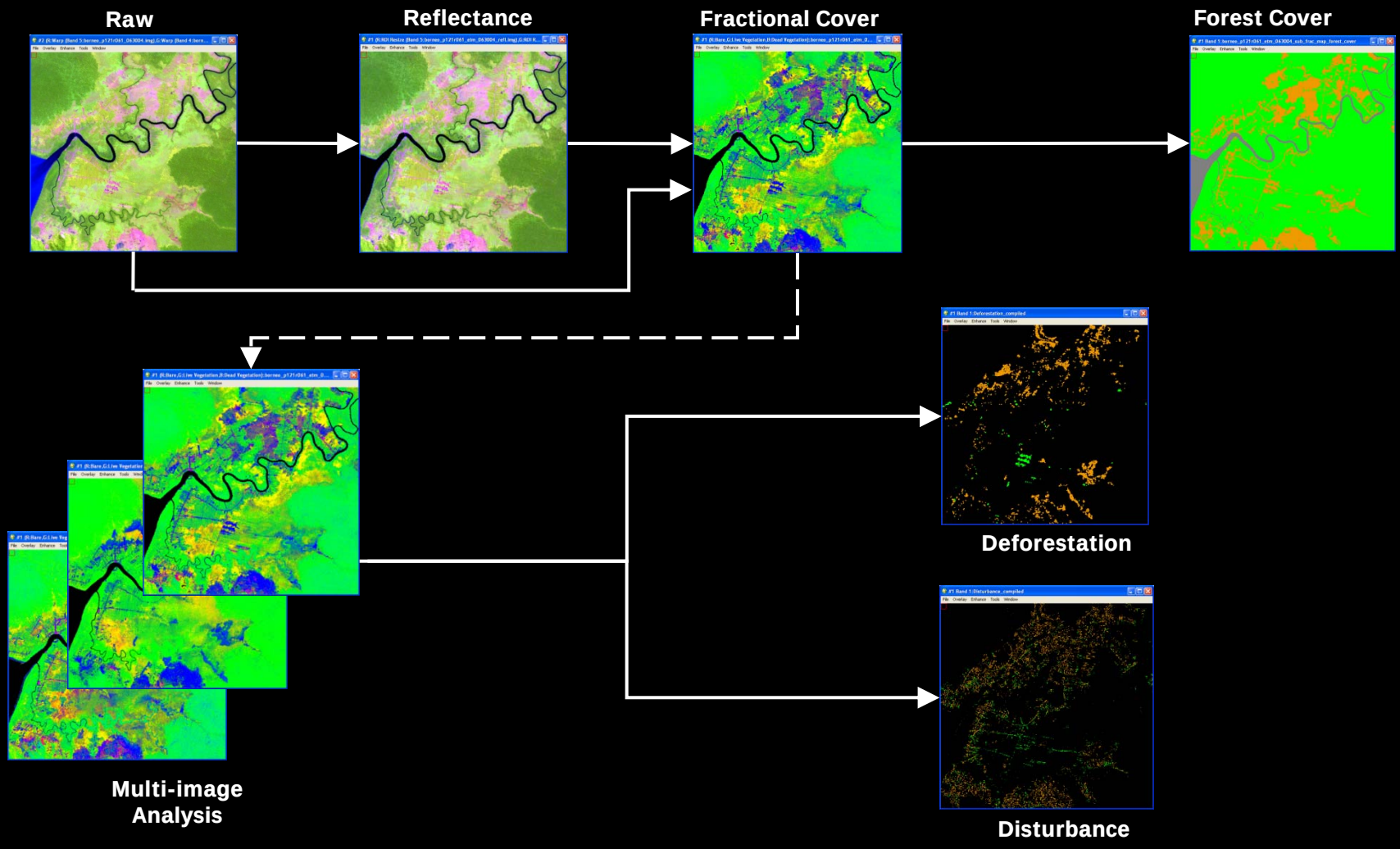
Deforestation



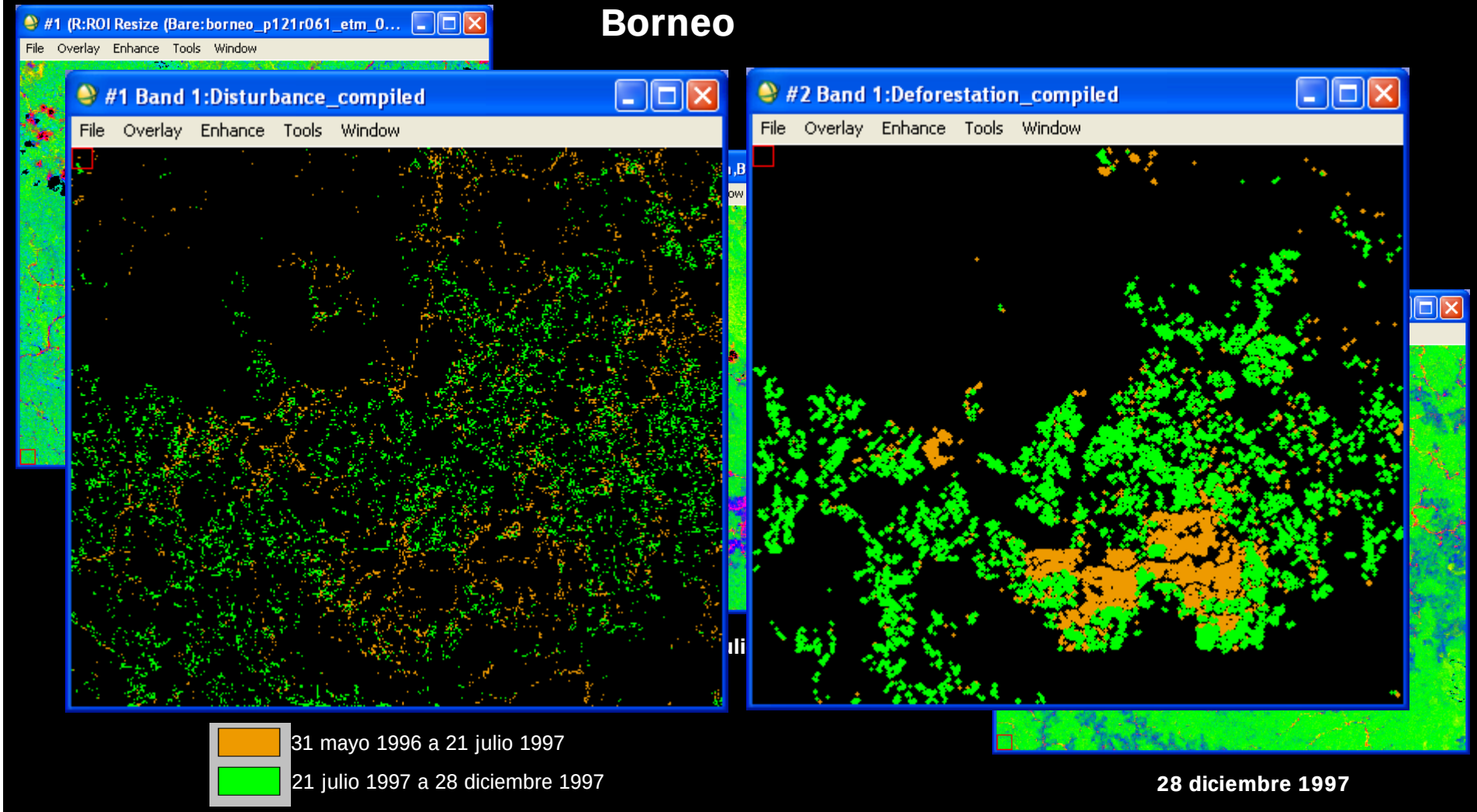


Forest Disturbance

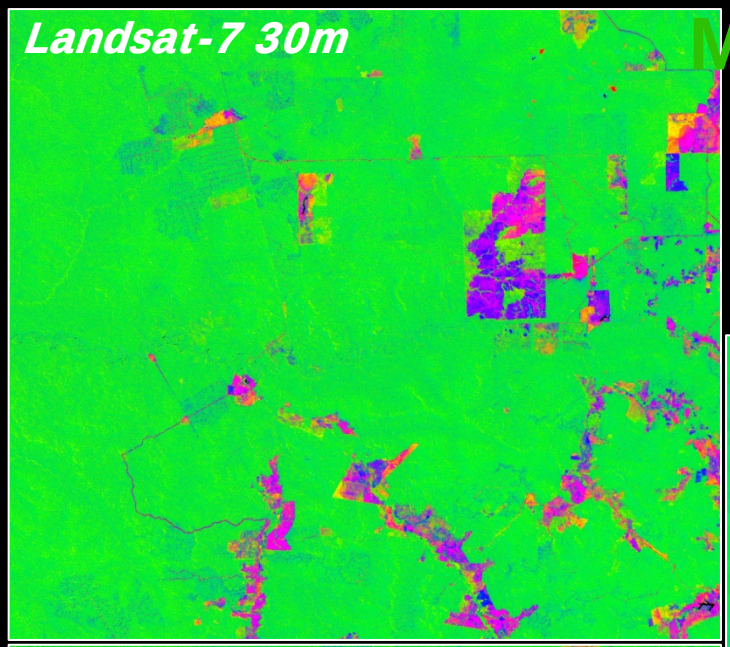
What is *CLASlite*?

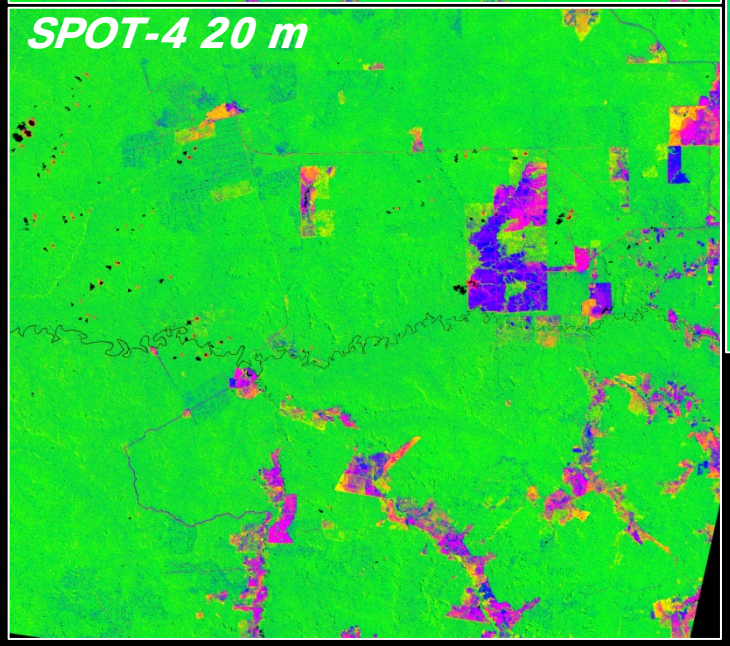


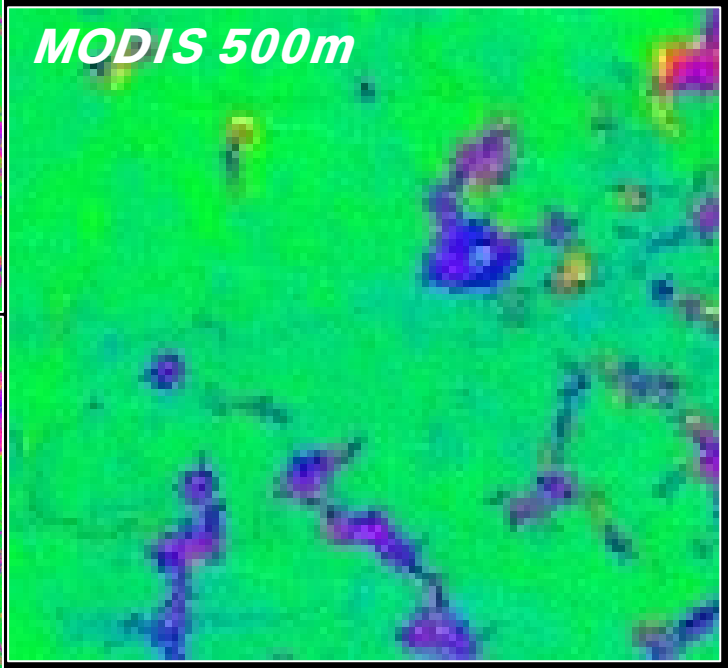
Multiple Image Analysis

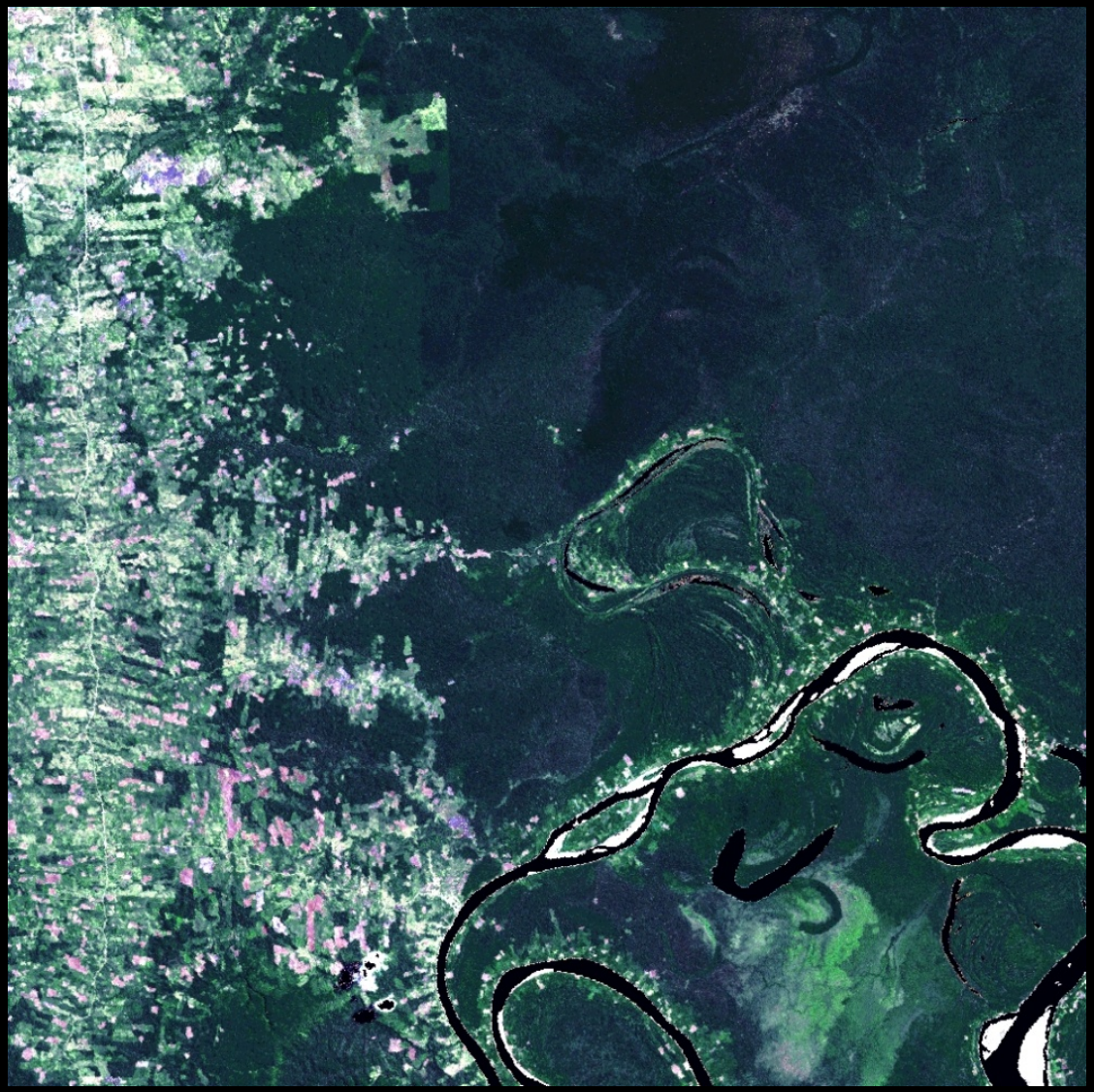


Mixing of Image Sources

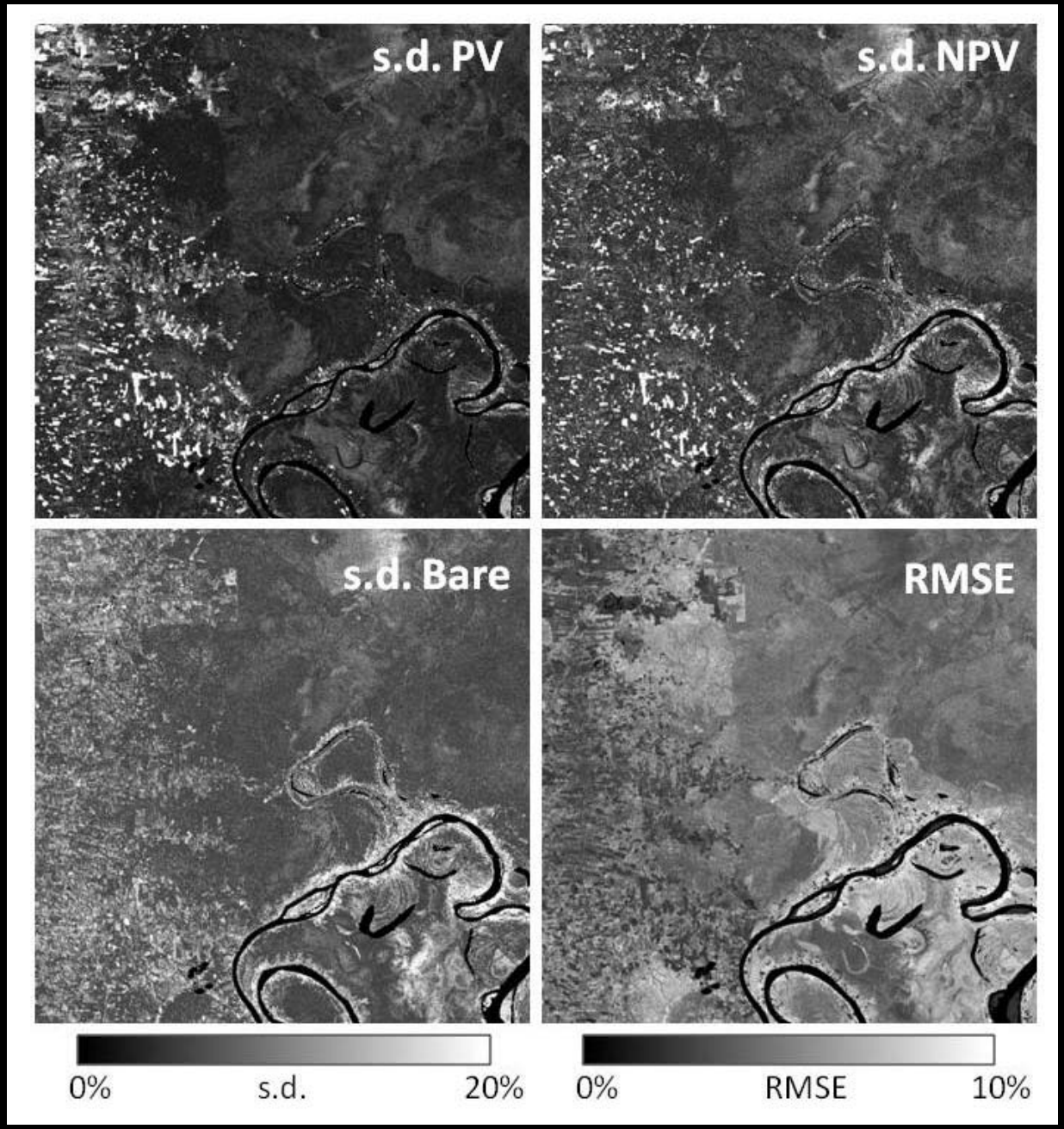


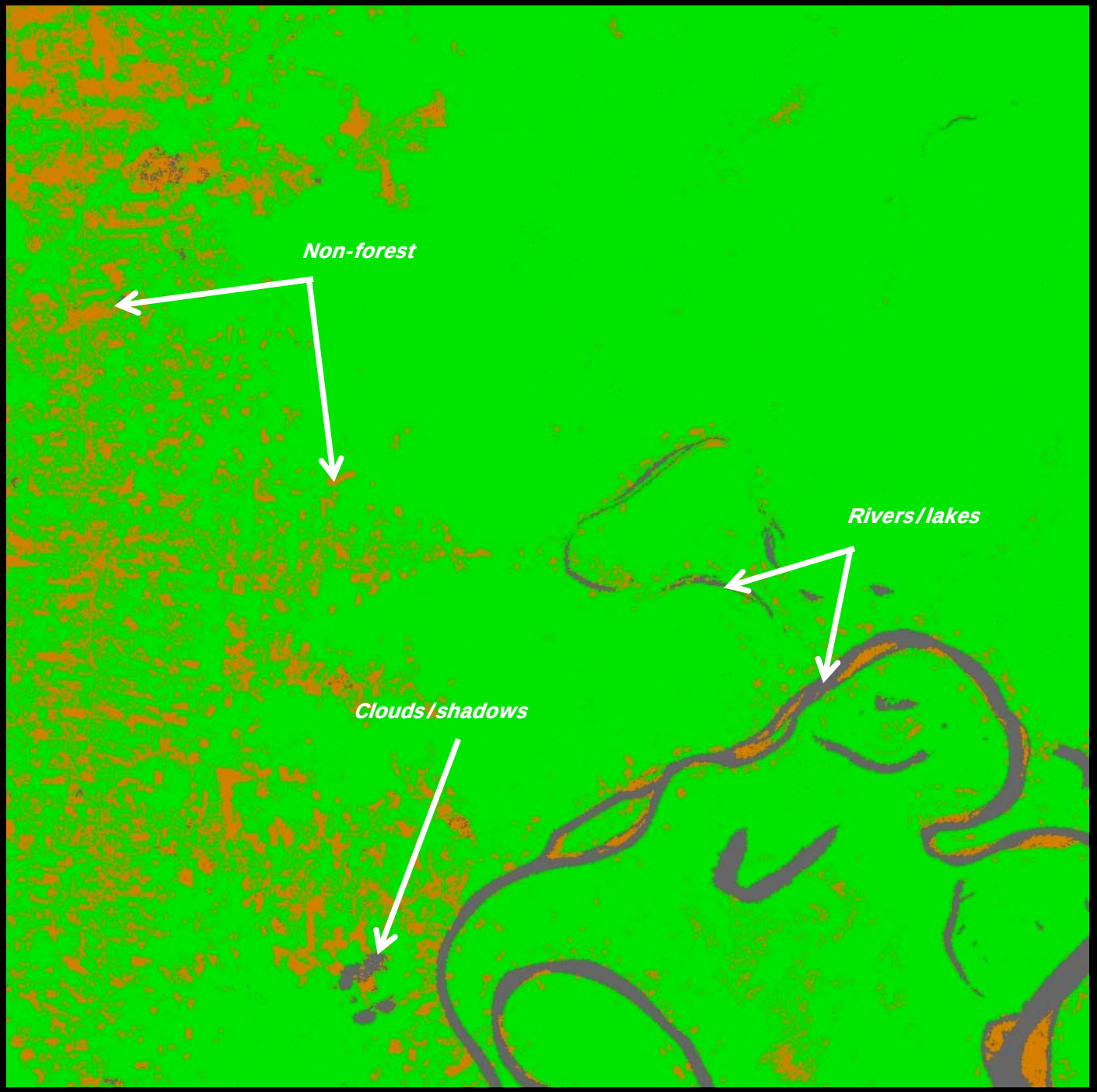


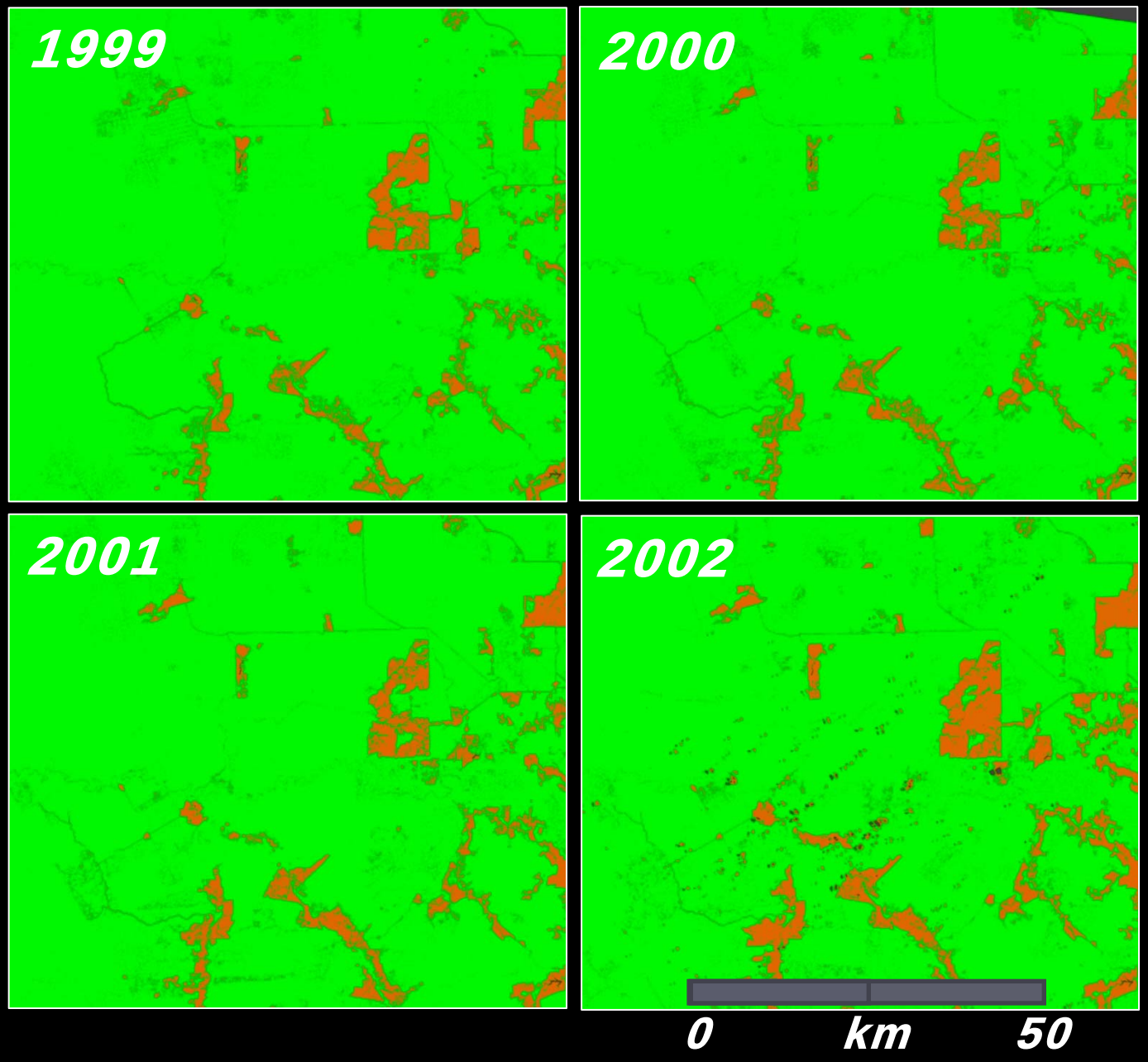




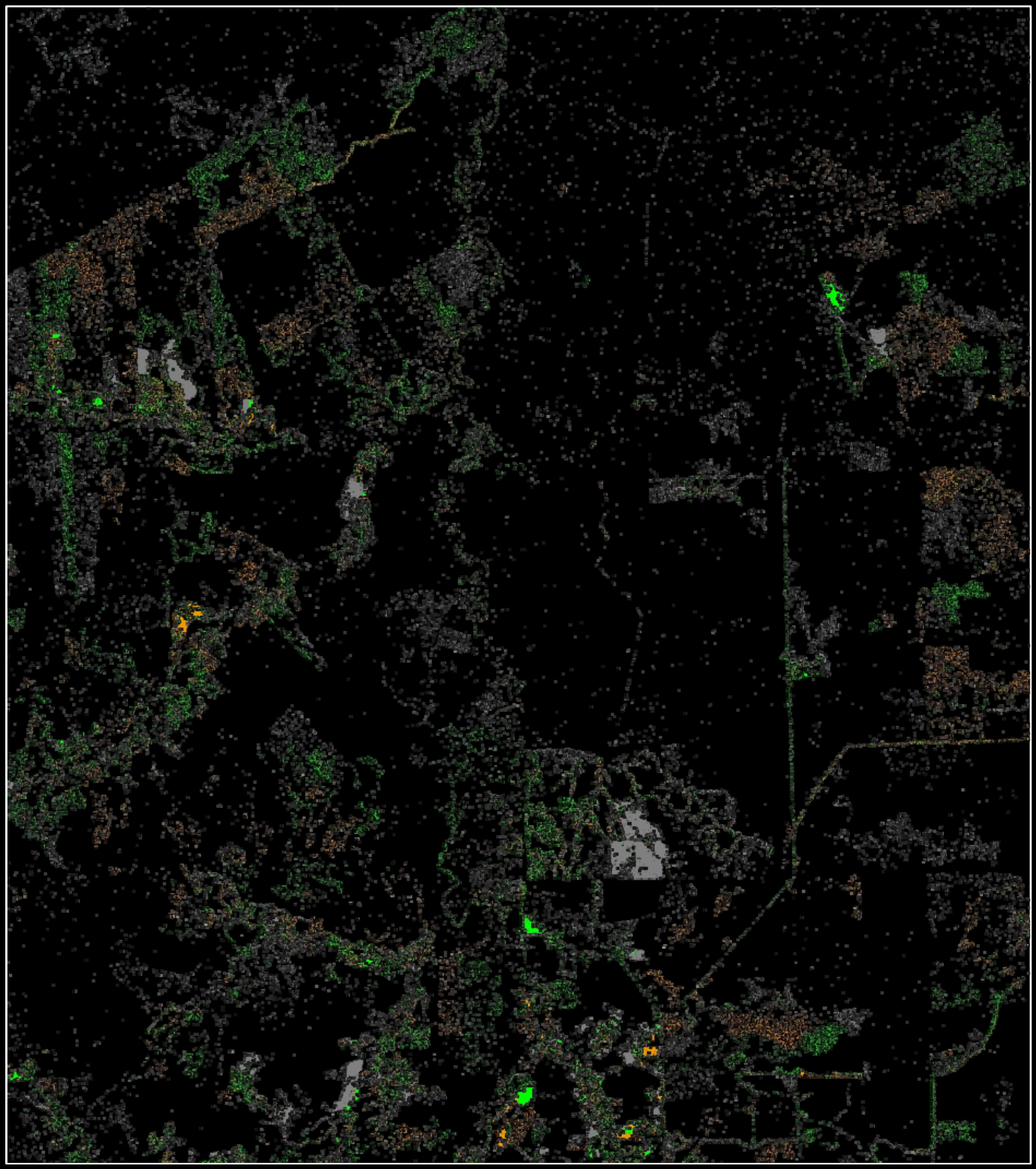
NPV
PV
BARE


s.d. PV
s.d. NPV
s.d. Bare
RMSE
0%
s.d.
20%
0%
RMSE
10%


Non-forest
Rivers/lakes
Clouds/shadows


1999
2000
2001
2002
0
km
50

Deforestation



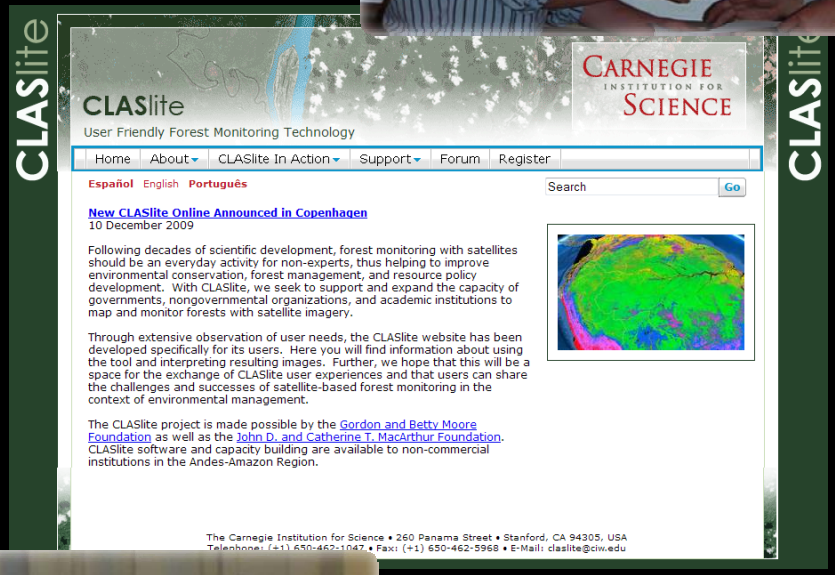
Disturbance

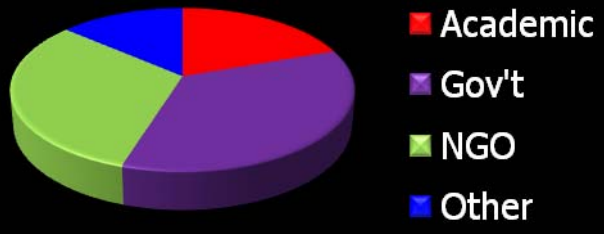
Giving It Away:
CLASlite Dissemination and Capacity Building Project

We are providing CLASlite training and sustained technical support to key government, NGO and academic institutions in the Andes-Amazon region.

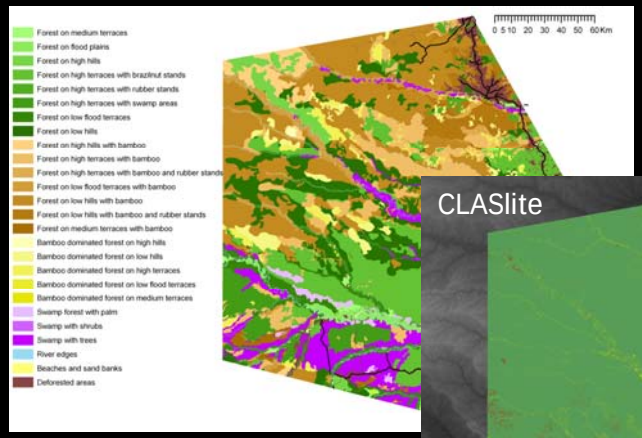
To date, we have trained more than 240 users from more than 70 agencies in 6 countries.

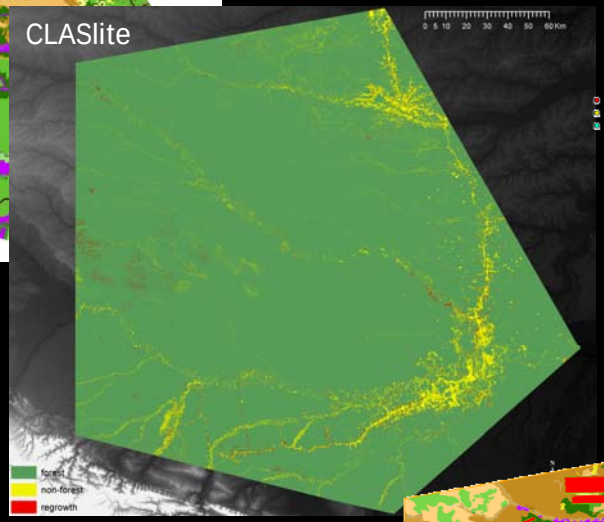
http://claslite.ciw.edu

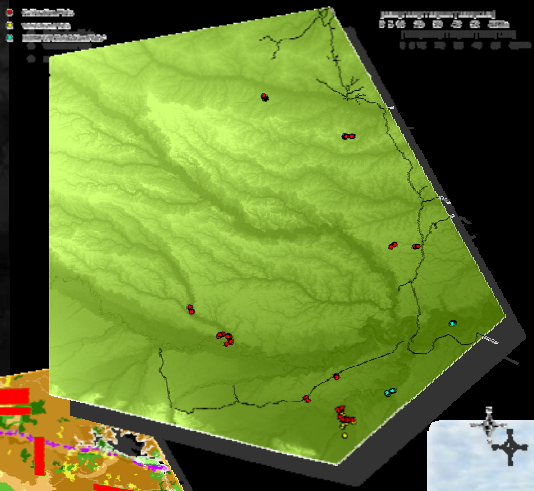


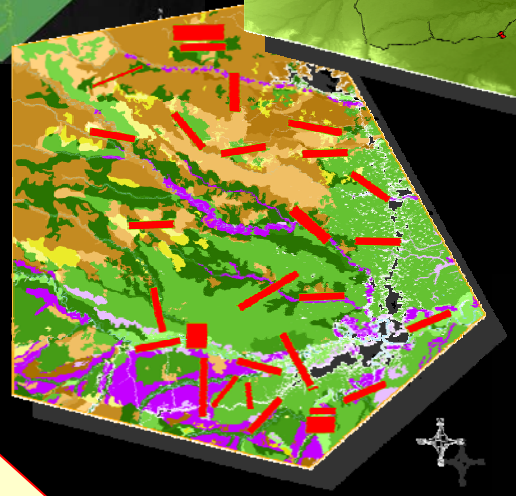


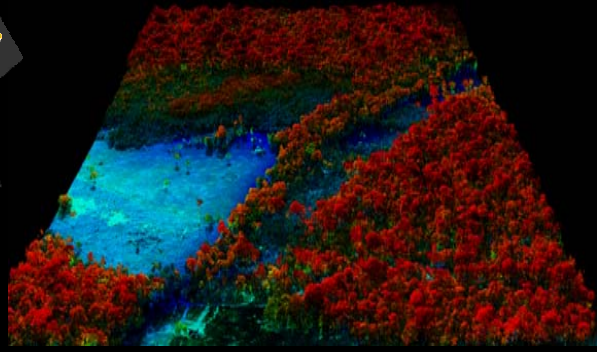
Carnegie REDDlite Integration Software

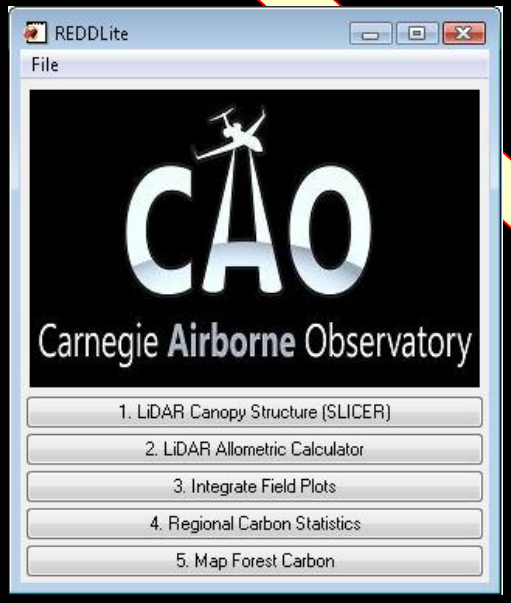












CAO

Carnegie **Airborne** Observatory — Remote Measurement of Biospheric Structure and Function

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Our Mission

The Carnegie Airborne Observatory combines advanced spectroscopic imaging and waveform laser remote sensing technologies to study ecosystems anywhere in the world. The CAO mission is to understand how changes in land use, climate, and natural disturbances affect the structure, composition and functioning of ecosystems, and how these changes alter the services provided by ecosystems to people.

Our Sponsors

The Carnegie Airborne Observatory is made possible by the generous support of the W. M. Keck Foundation, the Gordon and Betty Moore Foundation, and William R. Hearst III. CAO research applications are supported by the Andrew W. Mellon Foundation, the John D. and Catherine T. MacArthur Foundation, NASA's Terrestrial Ecology Program, and the Carnegie Institution.

CAO Status

The CAO is operating in Hawaii, South Africa and the Amazon Basin in 2009-2010.

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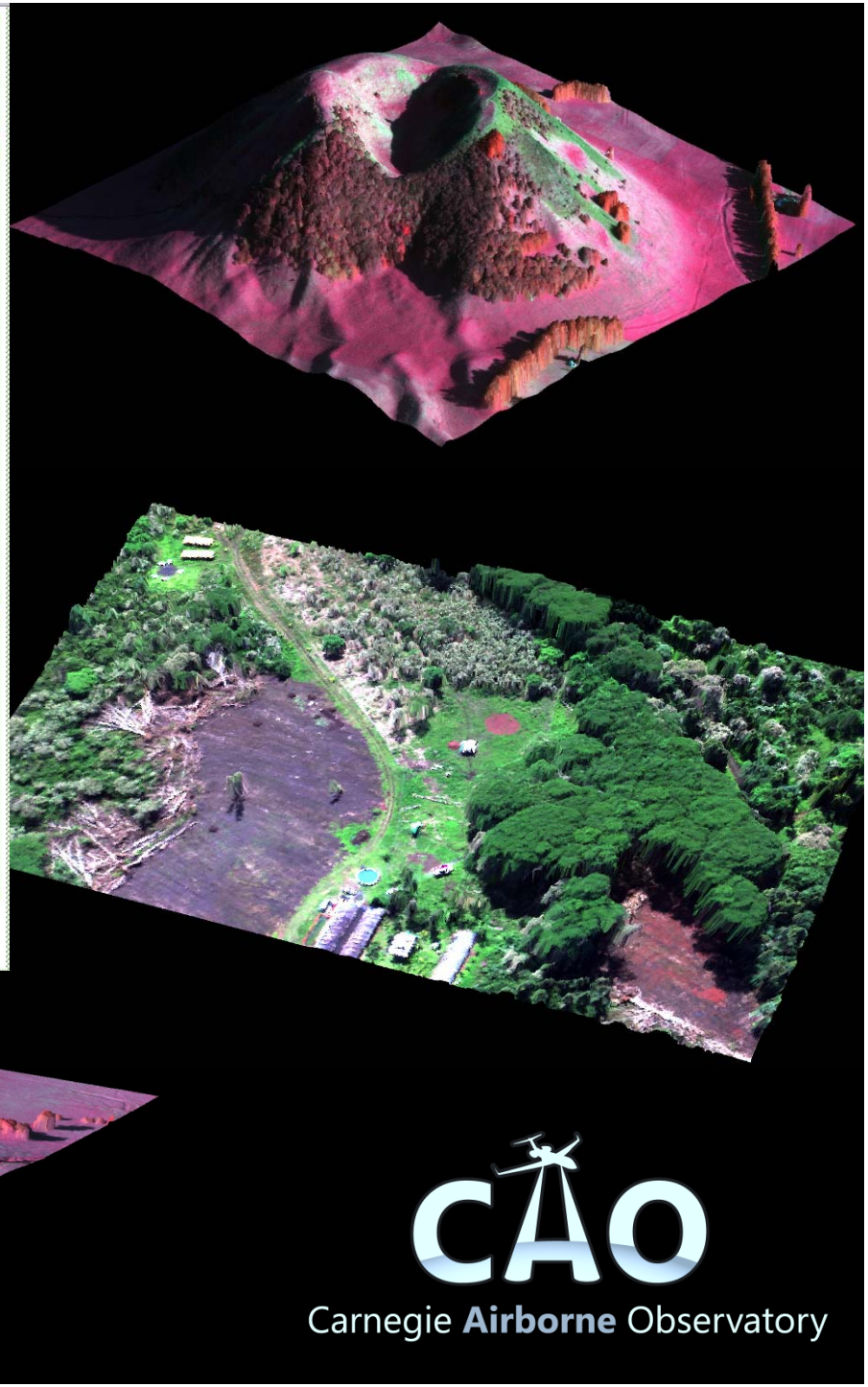
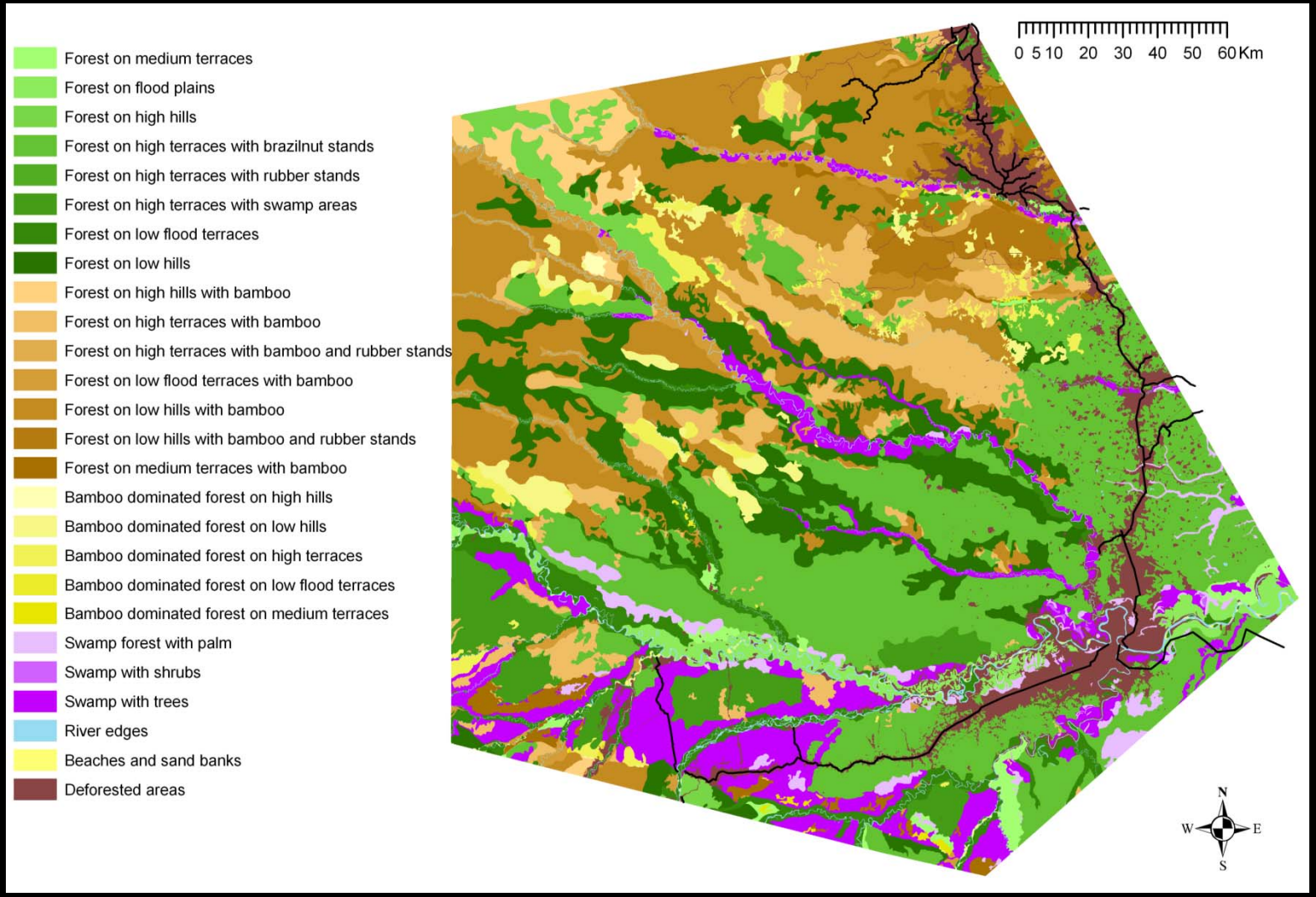
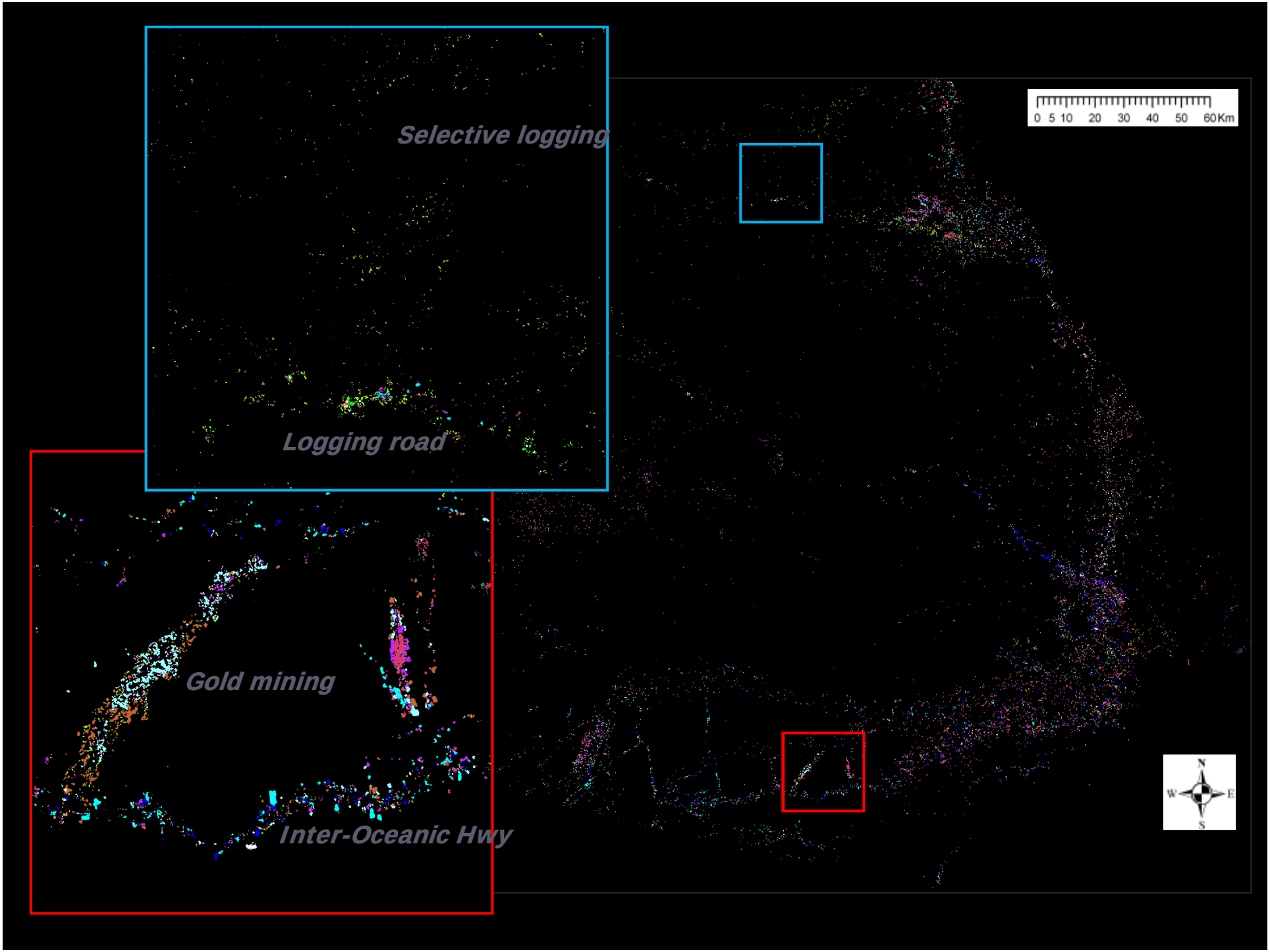


CAO

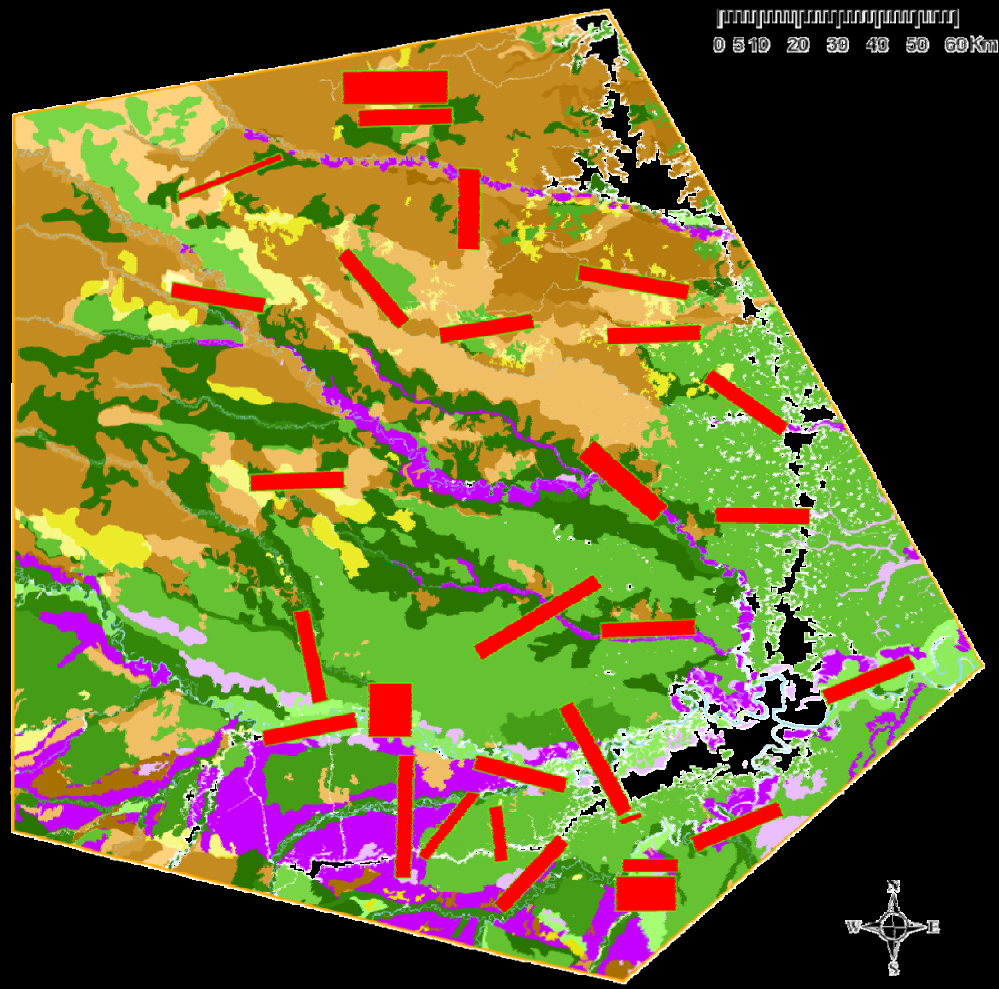
Carnegie **Airborne** Observatory

Habitat Mapping by the Peruvian Ministry of Environment

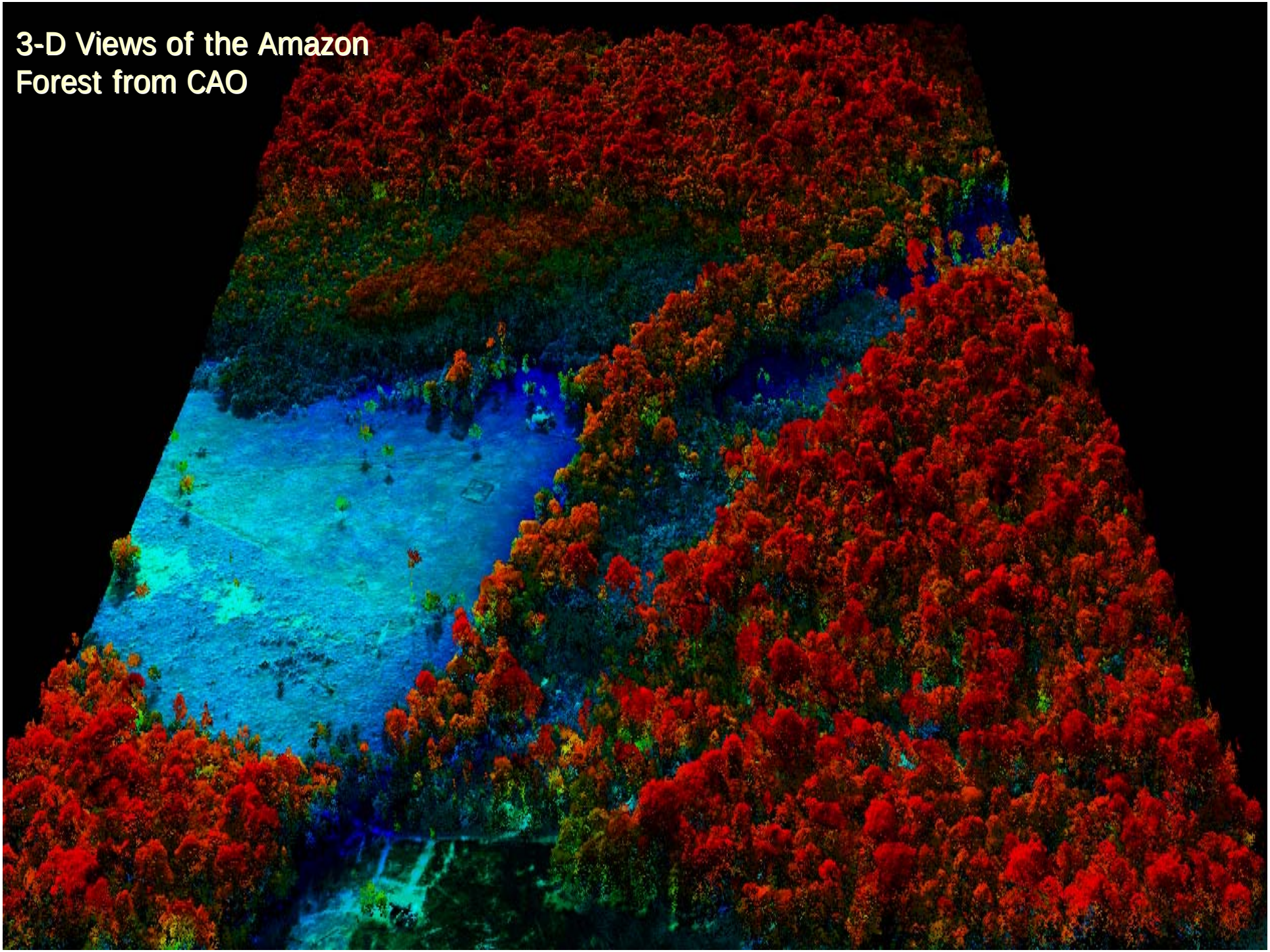



Selective logging
Logging road
Gold mining
Inter-Oceanic Hwy
0 5 10 20 30 40 50 60 Km
N
W
E
S

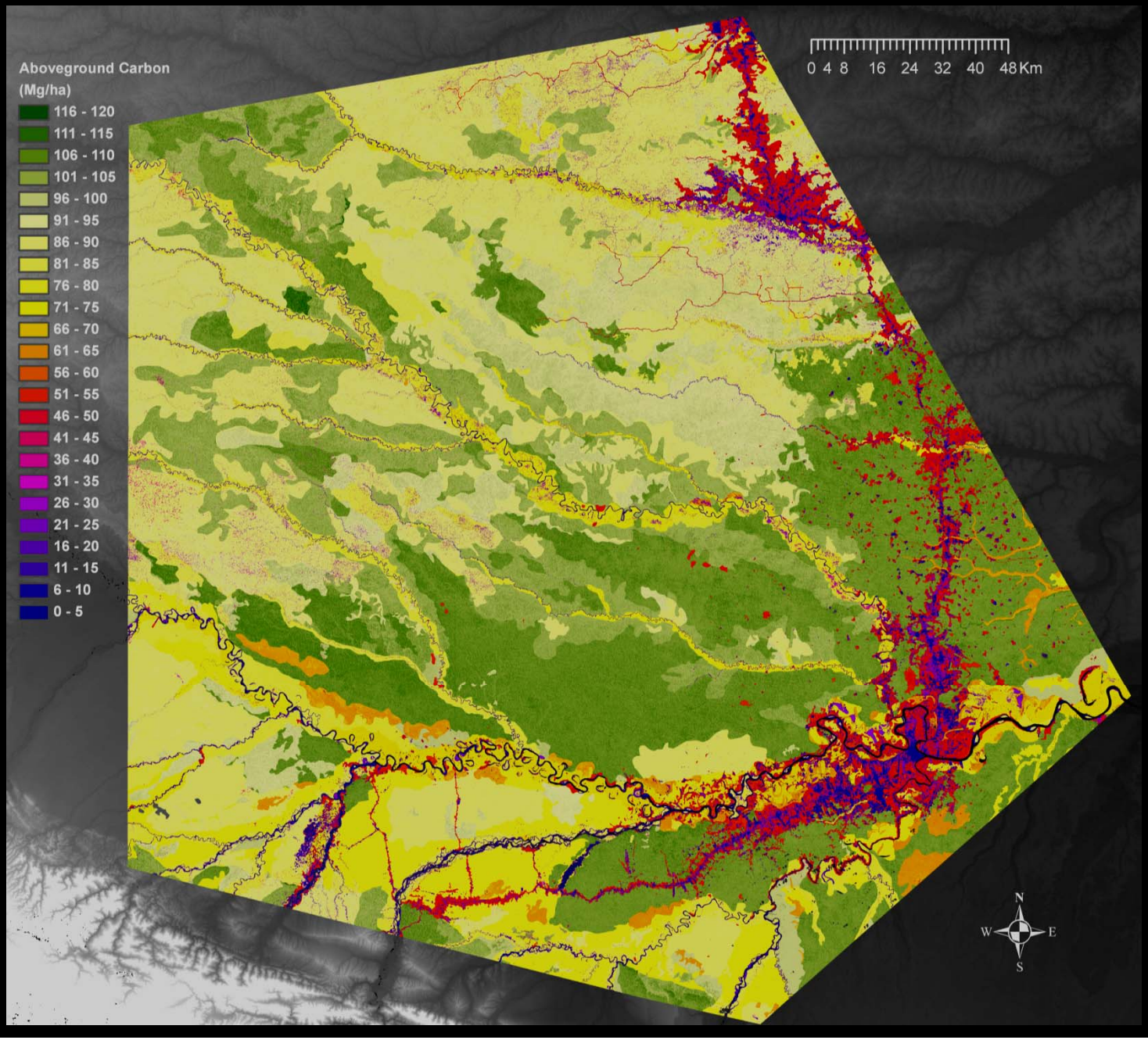
Regional Mega-sampling of Forest 3-D Structure and Biomass using Airborne LiDAR



3-D Views of the Amazon Forest from CAO

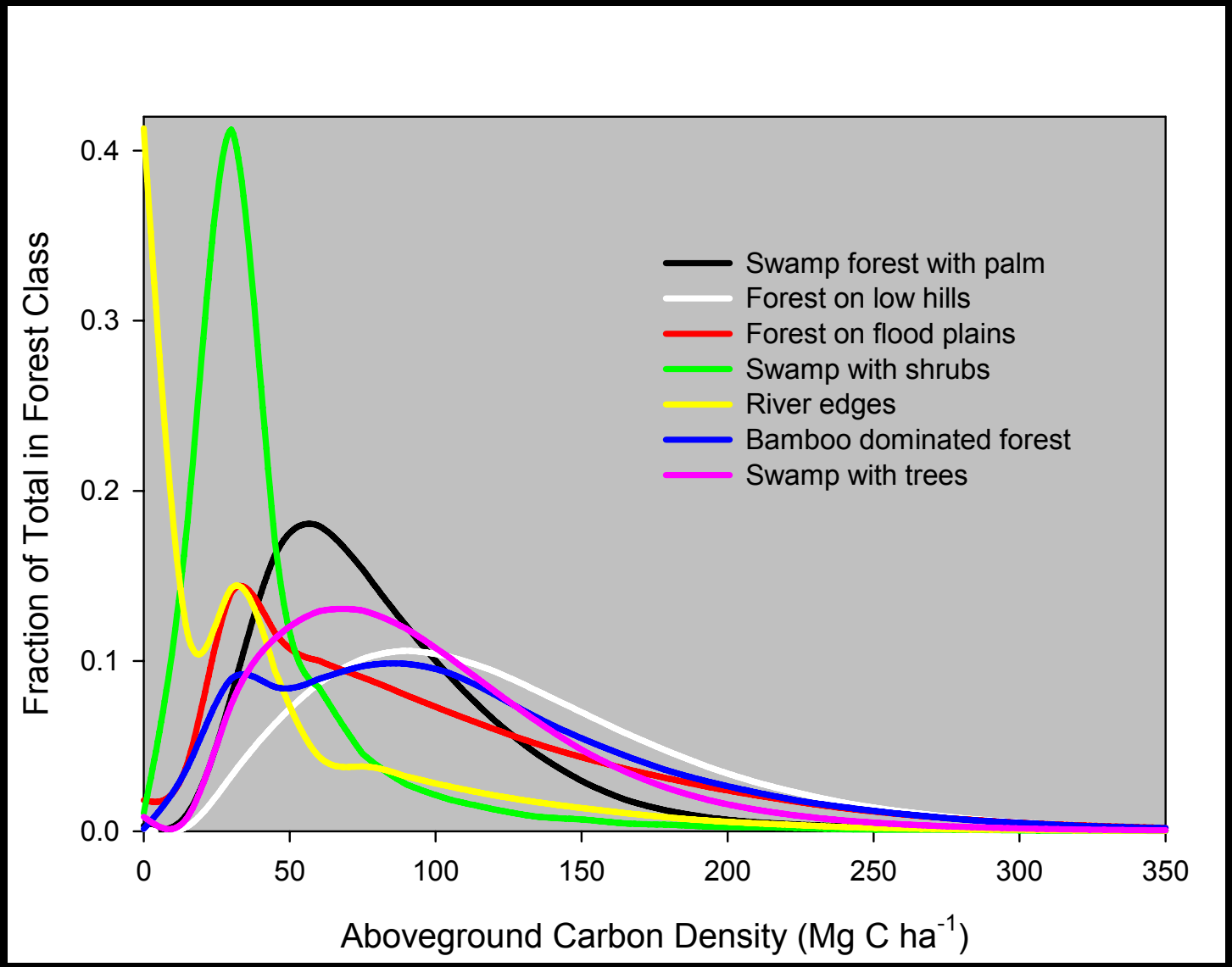


Forest Aboveground Carbon Storage in 4,300,500 ha at 0.1 ha Resolution



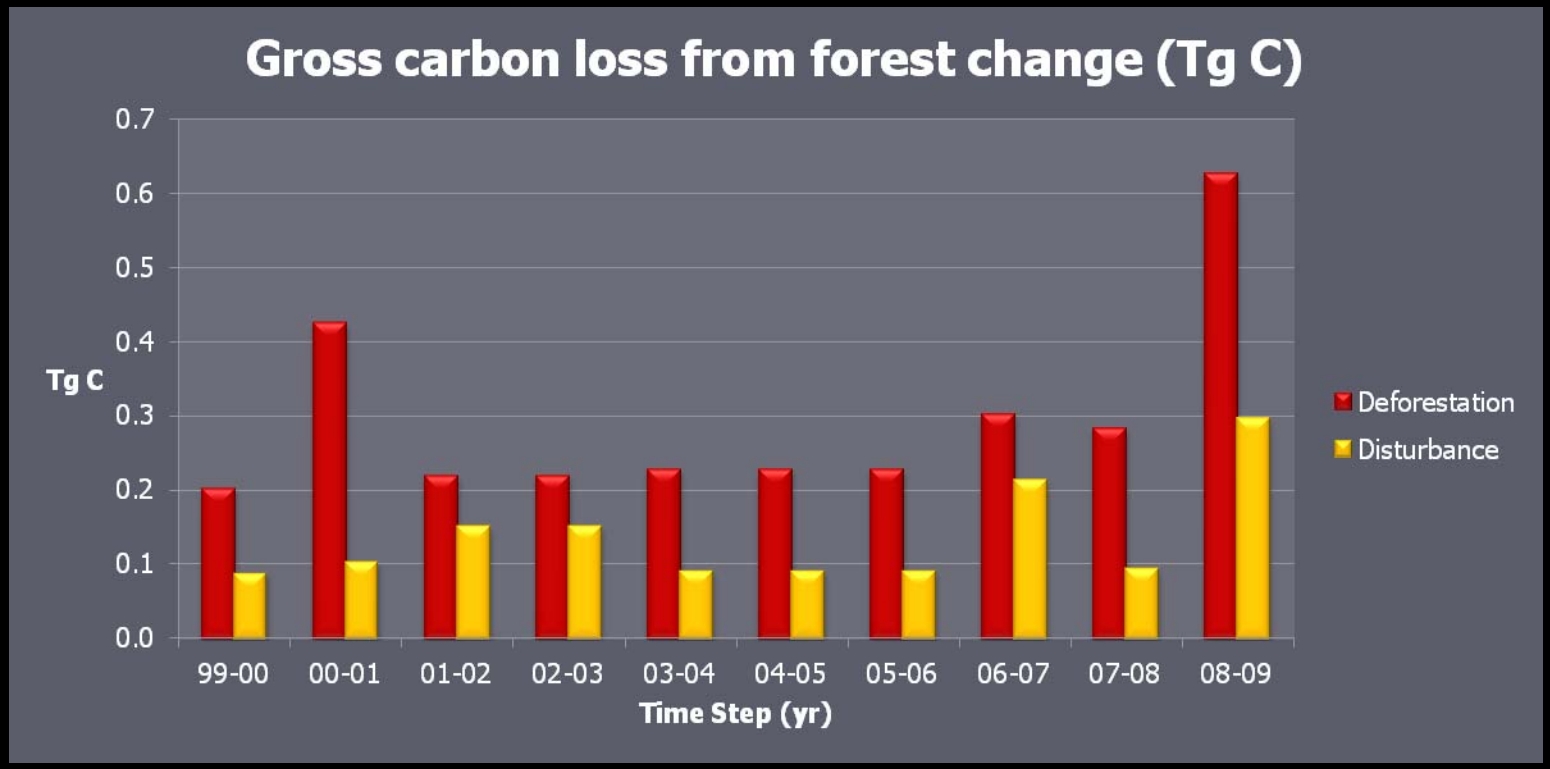
How much carbon is stored in Amazon forest?

REDDlite v.0



Gross Carbon Emissions from Deforestation and Degradation

REDDlite v.0



- 1 Tg = 1 million metric tonnes
- Carbon emissions from forest disturbance average 47% of deforestation.

“CLASlite Online” running on Google Earth Engine

Information
http://claslite.ciw.edu

Technical Assistance
claslite_support@ciw.edu