Towards Methodologies for Global Monitoring of Forest Cover Characteristics with Coarse Resolution Data

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LCLUC Science Team Meeting, Oct 2001, College Park MD

PROJECT ADDRESSES:

GOFC themes

- Forest cover characteristics and monitoring

  periodic mapping at coarse resolution (250-1000m) combined with fine (~25m) resolution

- Forest fire monitoring and mapping
- Forest biophysical properties

LONG TERM GOAL OF LCLUC PROGRAM

"to develop the capability to perform repeated global inventories of land-use and land-cover from space"

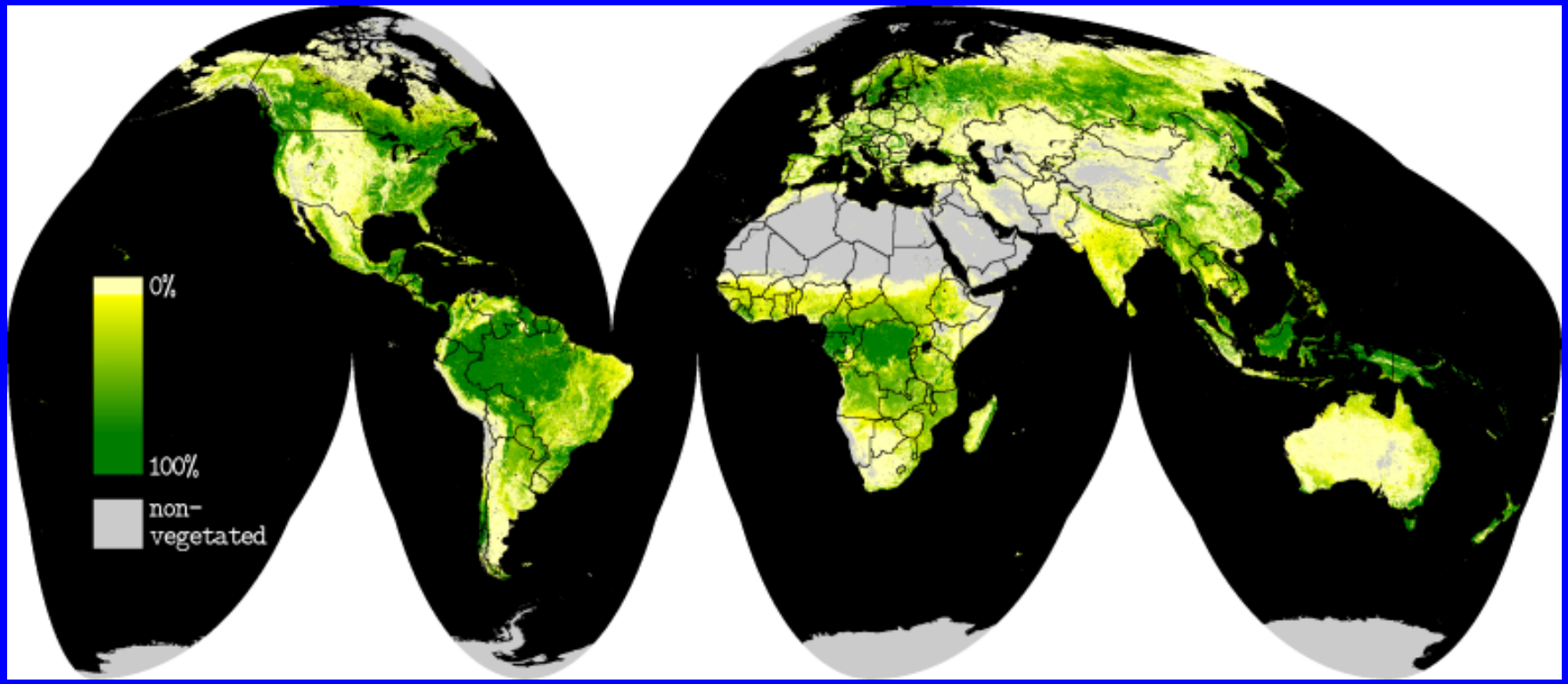
Challenges: Repeated Forest Cover Characteristics and Monitoring

- Baseline for global forest cover?
- Spatial and temporal consistency in definition of "forest"
- Characterizing changes in tree cover through time
- Automated procedure for repeated production
- Combined use of coarse and fine resolution data

Prototype approach: Continuous fields of vegetation properties

- Overcome artificial boundaries inherent in classification approach
- Independent of definition of “forest”
- Possibility to apply temporally to identify changes in % tree cover
- Derived from remote sensing using regression tree with calibration and validation from high resolution data

Continuous fields of vegetation properties to estimate % tree cover

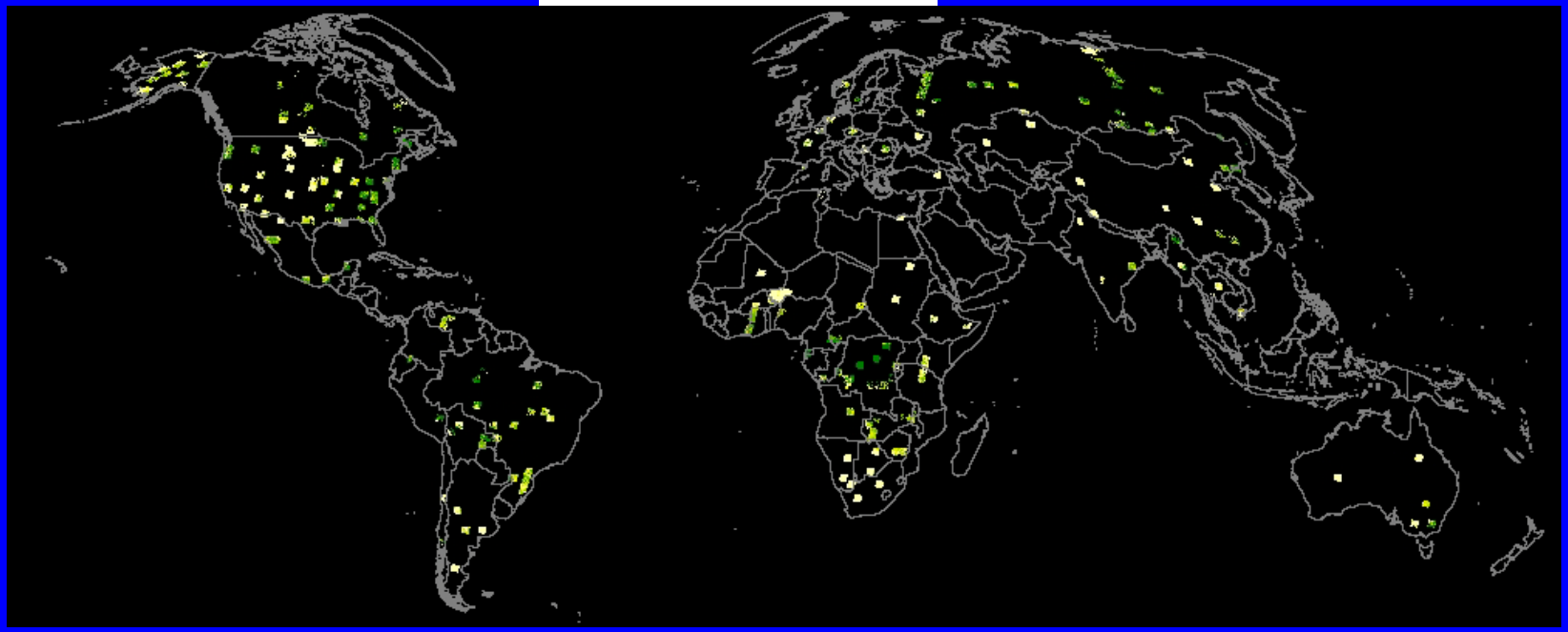


% tree cover derived from 1992-93 1km AVHRR (DeFries et al, 2000)

Algorithm for automatic generation of global tree cover estimates

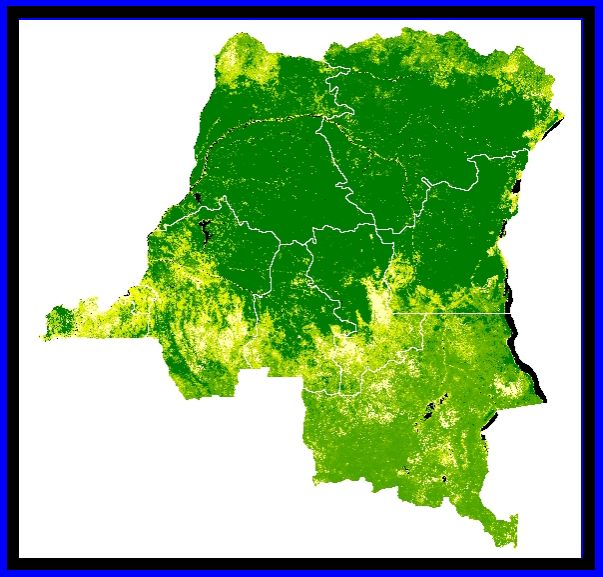
- Regression tree
  - For a given node *i*, all *j* cases of *y* and the mean value of those cases, *u*
- Solution of best split
  - Where *s* is parent node, *t* is left split, u is right split

$$D_i = \sum_{cases(j)} (y_j - u_{[j]})^2$$



Global Network of Training Sites from Landsat Analysis

Possibility of standardizing global forest statistics

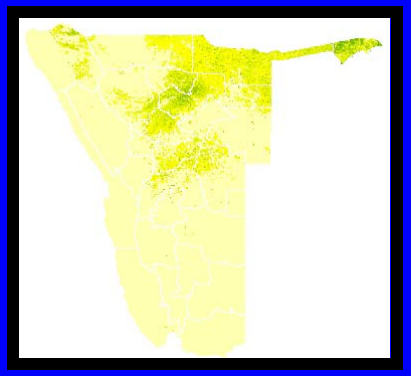


DRC

Tree cover

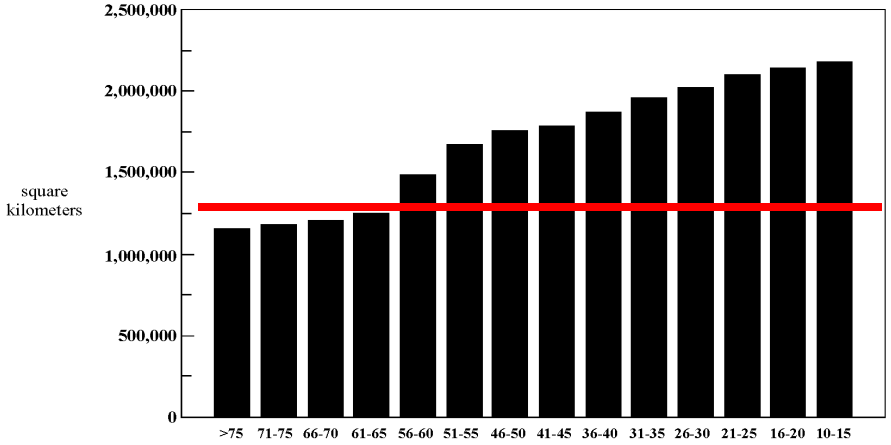
<10%

>80%

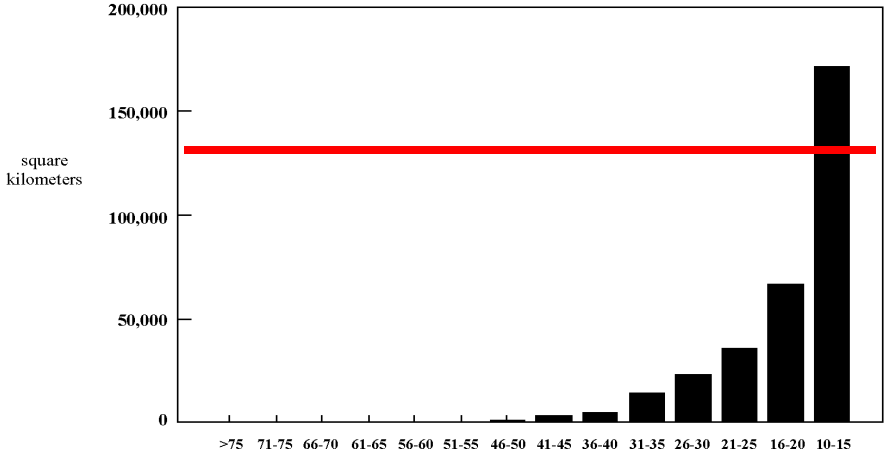


500 km

Namibia



FAO estimate 1995



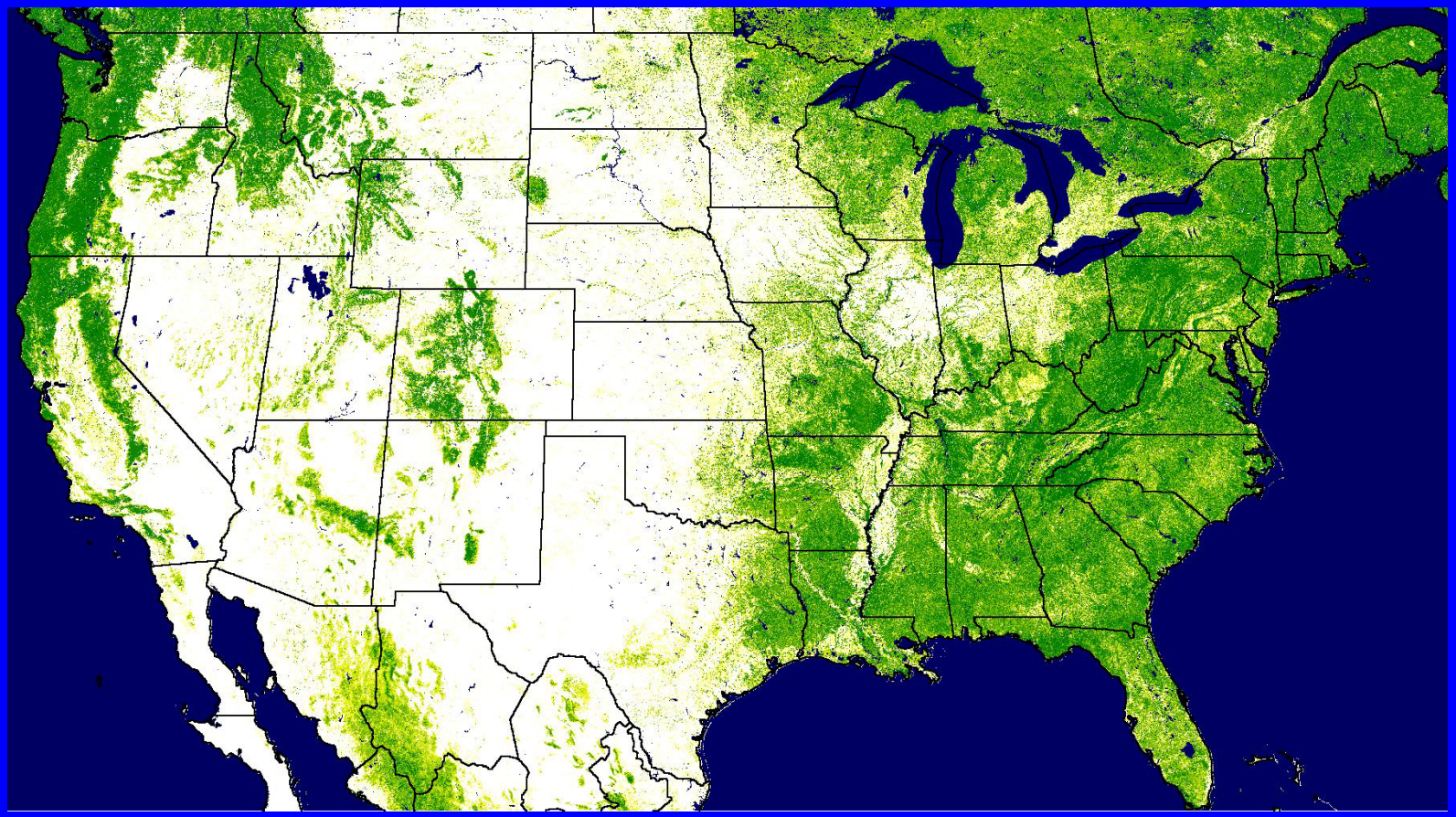
FAO estimate 1995

Objective 1: Establish prototype methodology for characterizing tree cover as proportional coverage with coarse resolution (250-1000m) data based on very-high resolution data and *in situ* measurements

Objective 2: Develop and test automated procedures for mapping tree cover with MODIS data for coterminous US

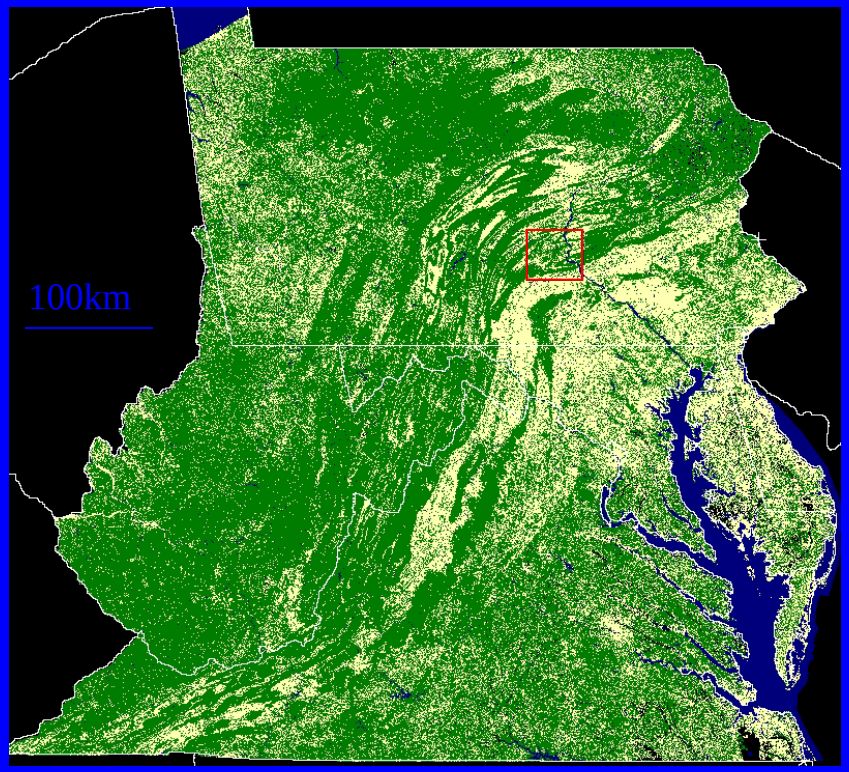
Objective 3: Develop and test the prototype methodology for a number of years to assess capability for identifying locations undergoing rapid change in forest cover

Objective 2: Develop and test automated procedures for mapping tree cover with MODIS data for conterminous US

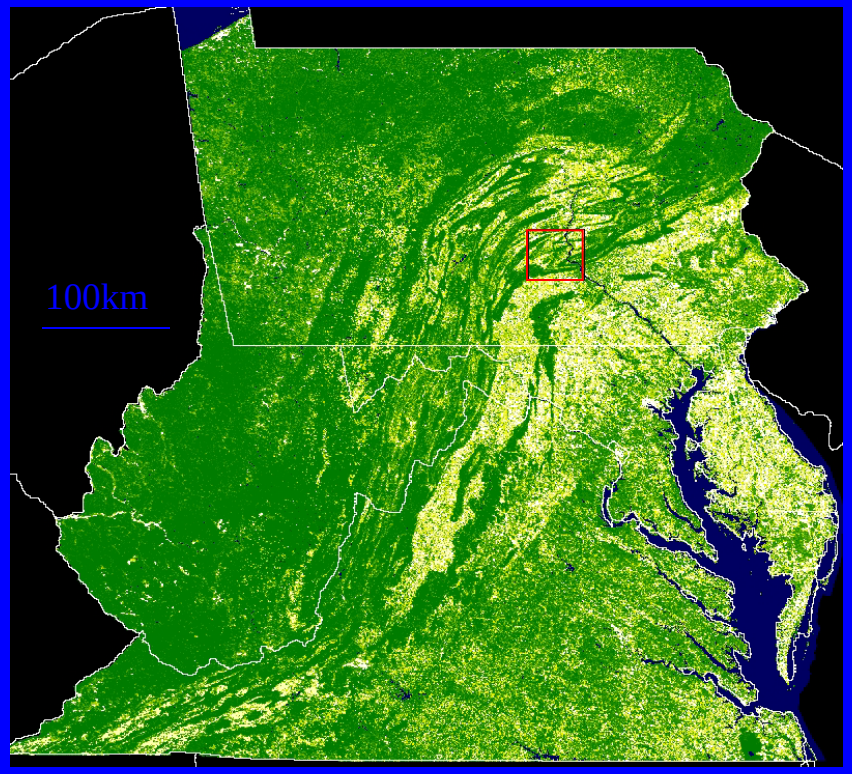


MODIS 250m U.S. Tree Cover Prototype

For details see http://glcf.umiacs.umd.edu

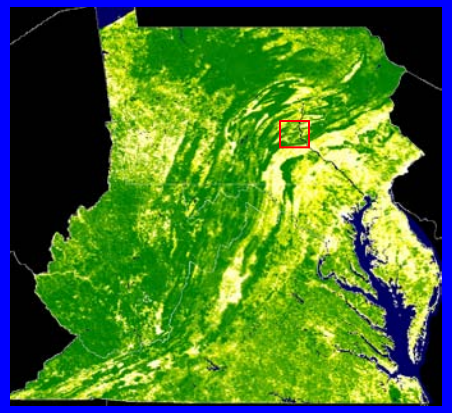


EPA Region 3 MRLC 30 meter map, green is forest, beige non-forest



MODIS 250 meter map

The MODIS result compares quite favorably with the MRLC and is clearly superior to AVHRR heritage products.

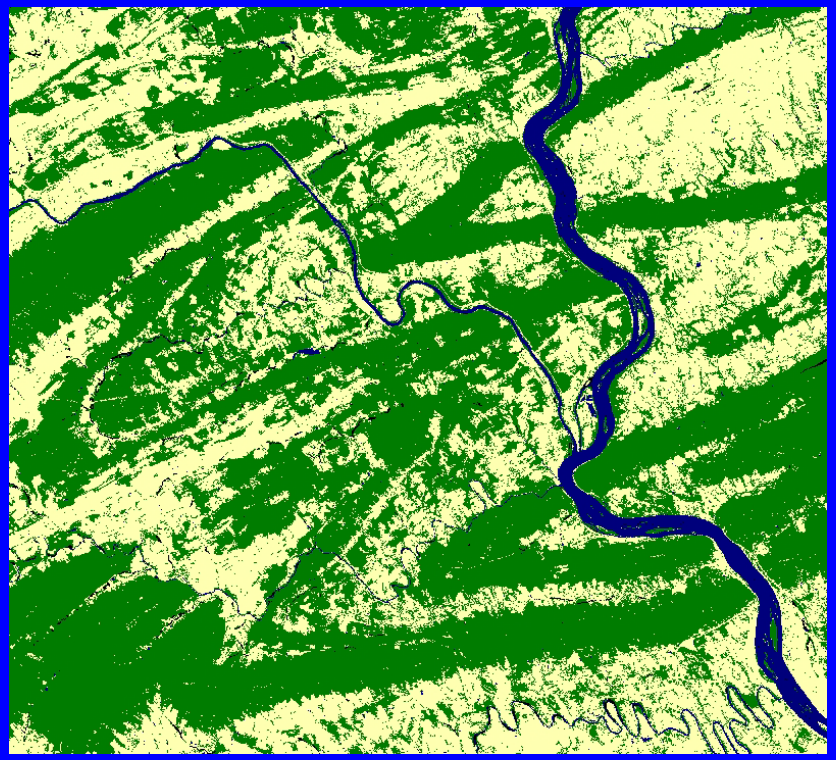


AVHRR 1km, 1995-96

Tree cover

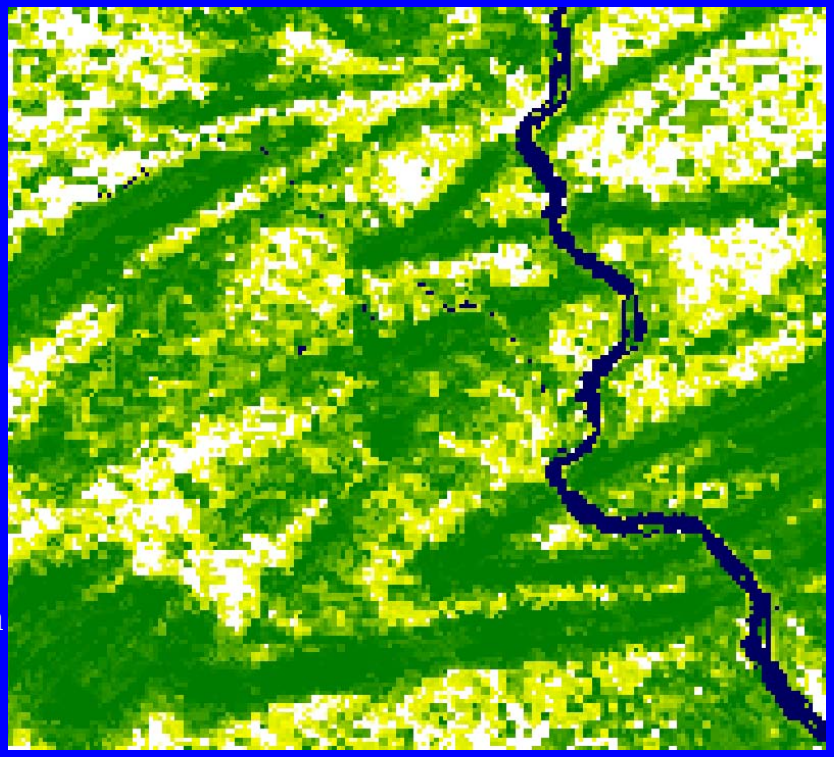
0%

100%



2.5km

EPA Region 3 MRLC 30 meter map, green is forest, beige non-forest



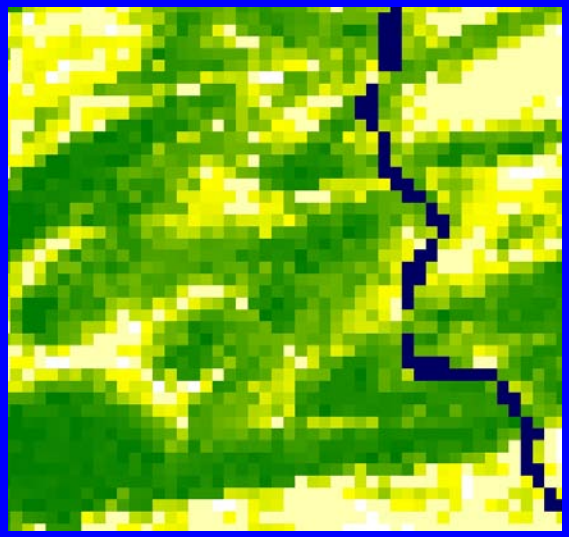
MODIS 250 meter map

Tree cover

0%

100%

AVHRR 1km, 1995-96



10km

Objective 3: Develop and test the prototype methodology for a number of years to assess capability for identifying locations undergoing rapid change in forest cover

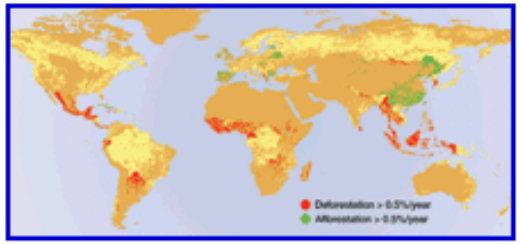
Science magazine

ECOLOGY:

U.N. Report Suggests Slowed Forest Losses

Erik Stokstad

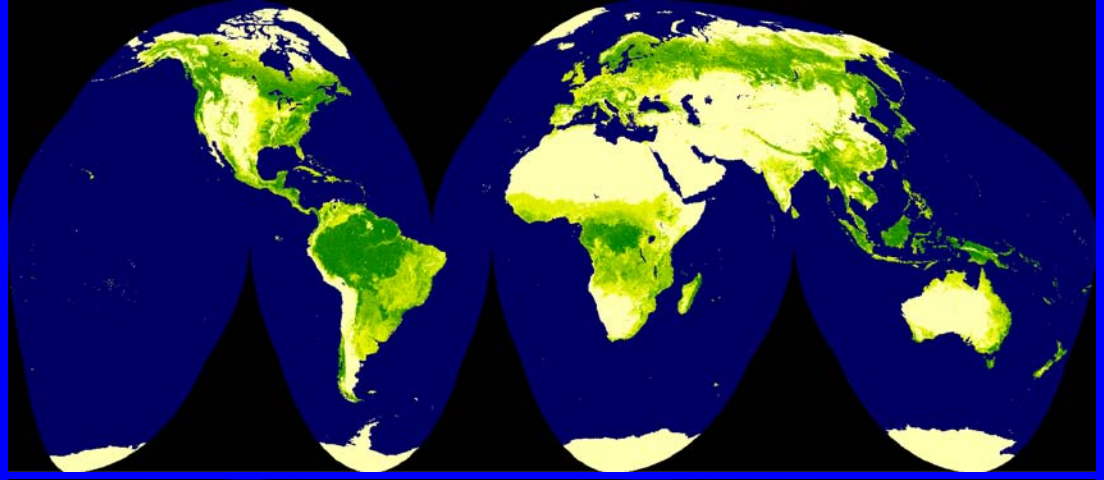
A comprehensive survey of the world's forests, released last week by the United Nations (U.N.), suggests that global rates of forest loss decreased in the 1990s. But the ink was barely dry on the report before the World Resources Institute (WRI), a think tank in Washington, D.C., disputed that conclusion. "We need good news about the world's forests," says Dirk Bryant, who directs WRI's forest program. "But this is definitely not it."



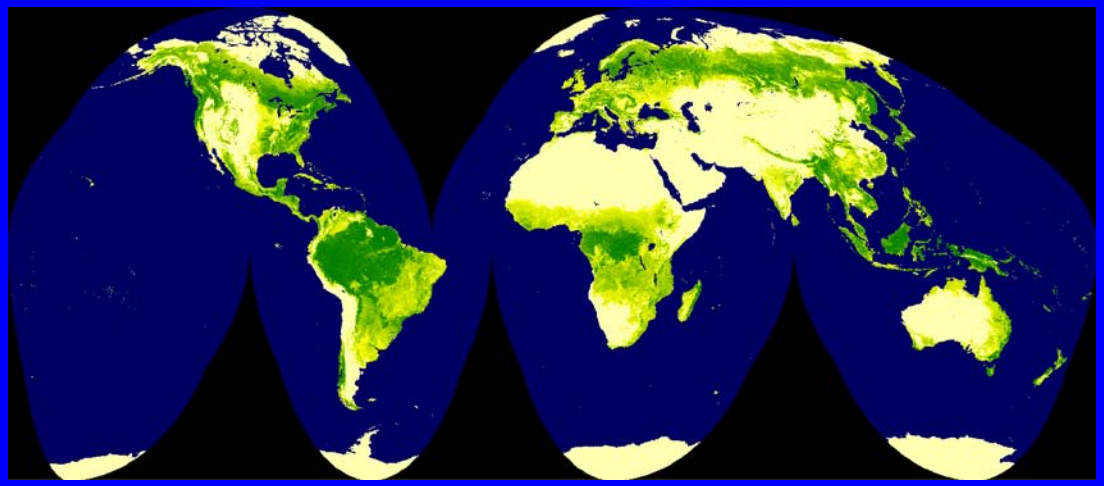
Extremes. Forests (yellow) are colored red where deforestation was especially high during the 1990s.

23 March 2001, p. 2294.

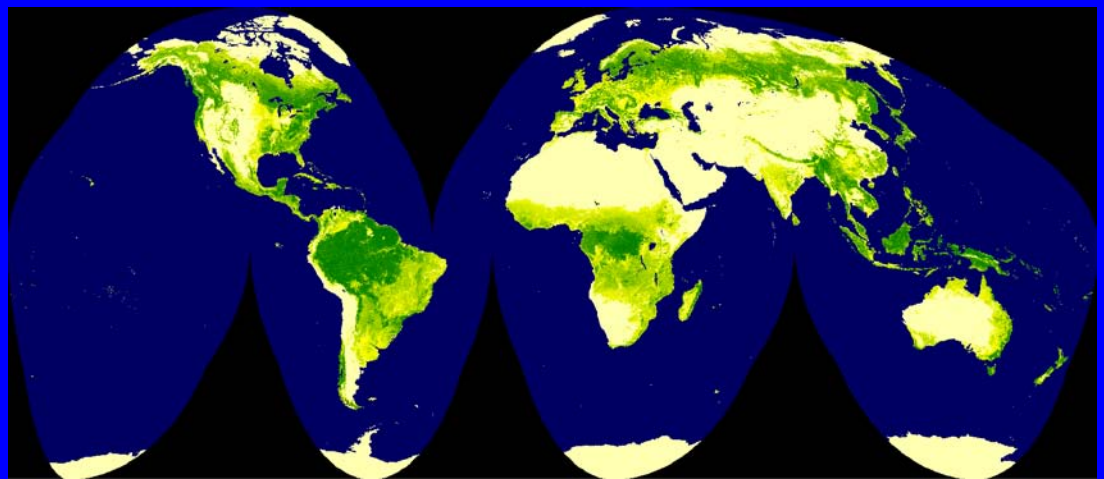
Annual 8km percent tree cover estimates, 1982-2000



1984



1990



1997

Tree cover

0%

100%

1984

1990

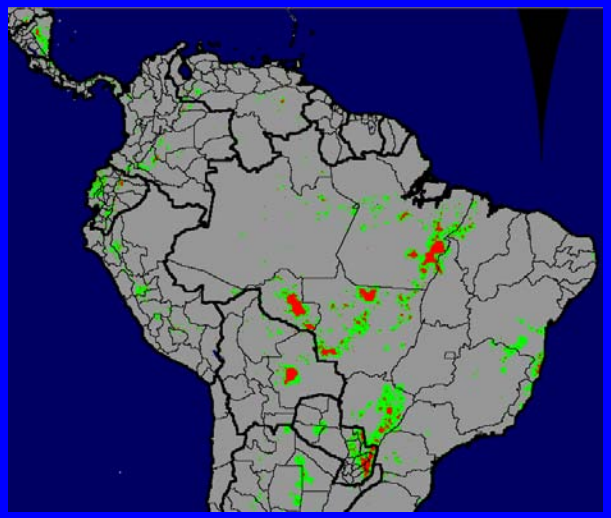
1997

Tree cover

0%

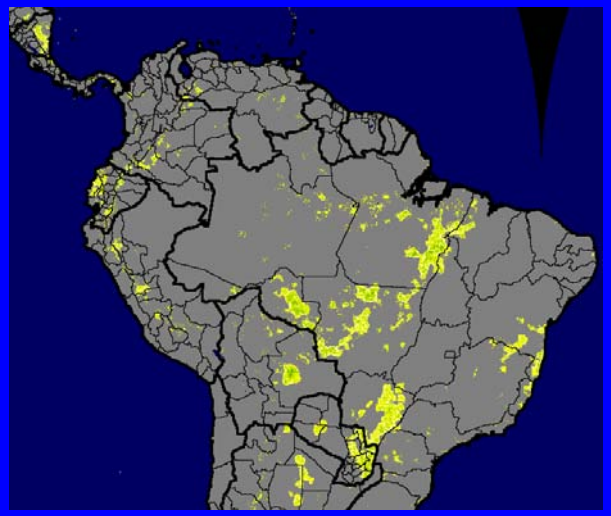
100%

Change pixels

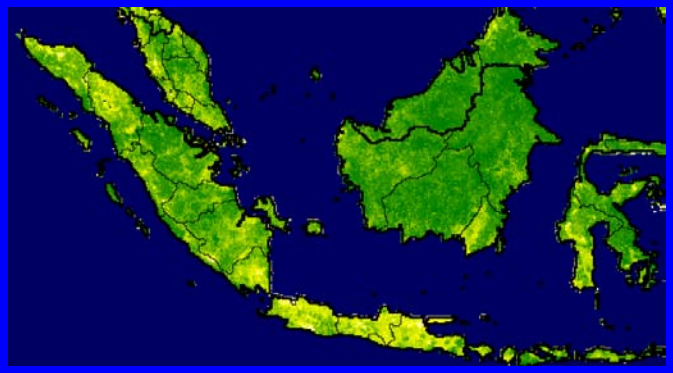


Red=high confidence
Green=low confidence

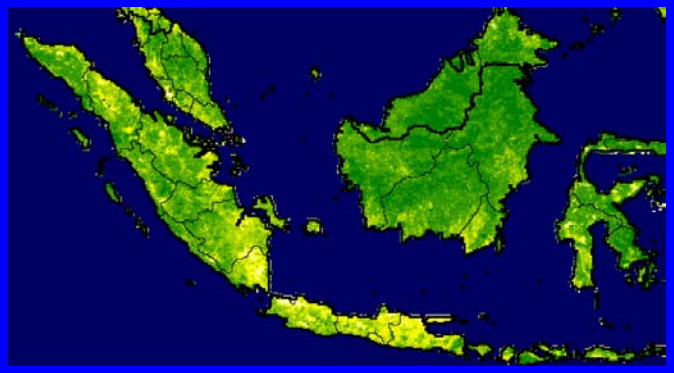
Magnitude of change 84-97



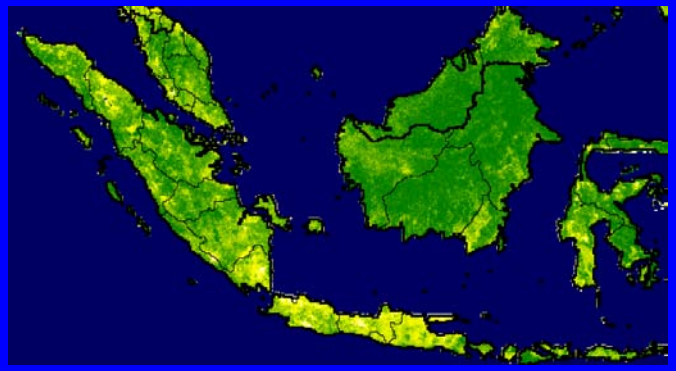
1984



1997



1990

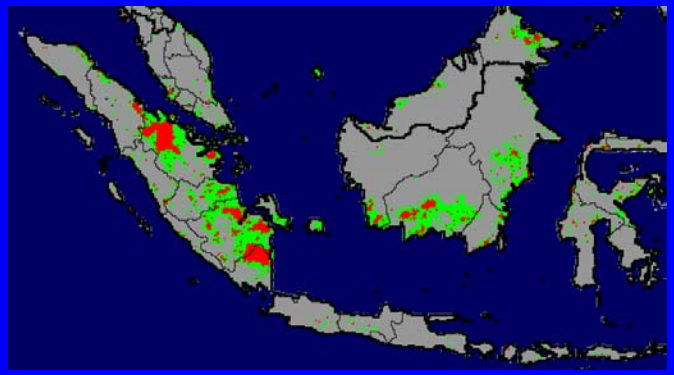


Tree cover

0%

100%

Change pixels



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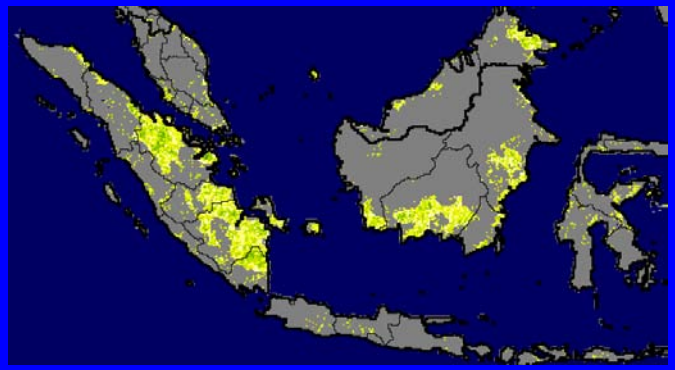
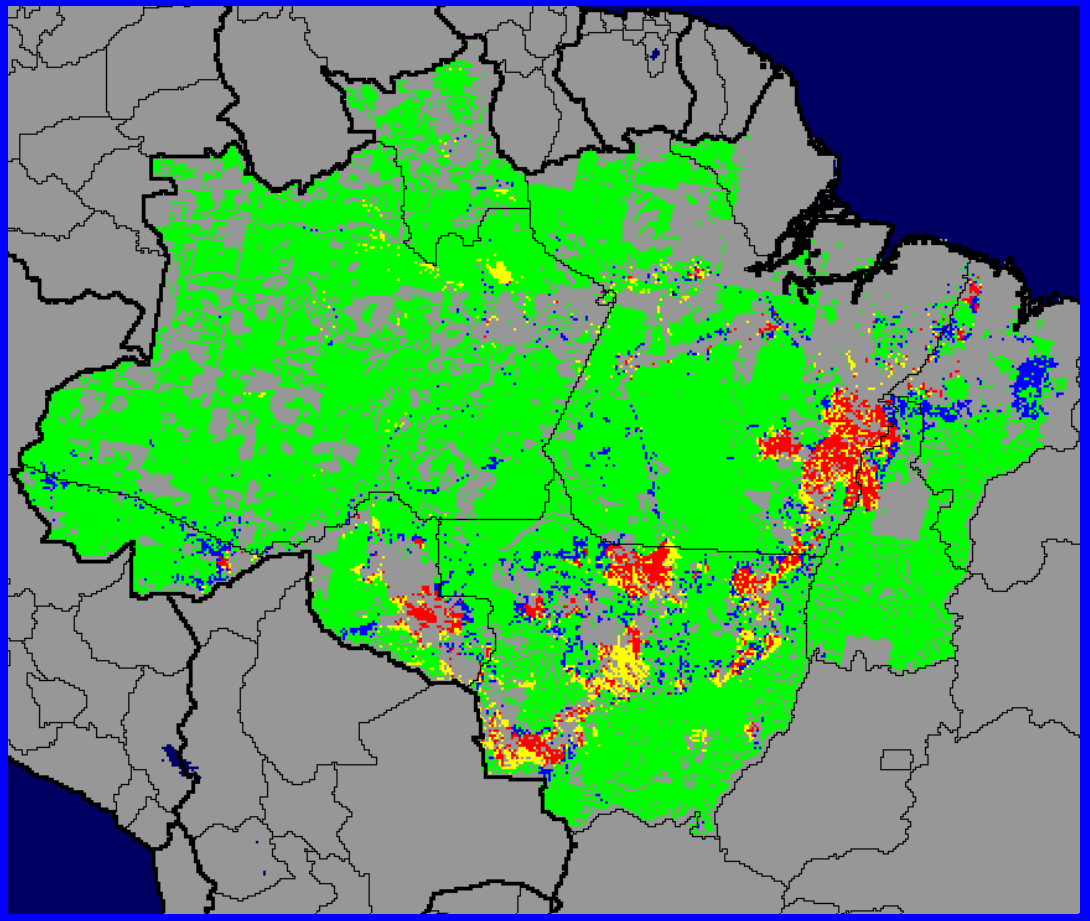
Magnitude of change 84-97



Comparison of 8km change, 1984-1990 to Tropical Rain Forest Information Center estimate, 1986-1992 derived from Landsat Thematic Mapper for the legal Amazon

- TRFIC change bitmap
- TRFIC change pixels
- UMd change pixels
- Area of agreement



TRFIC estimate = 37184 sq. km.
in 4181 8km pixels
UMd estimate = 18178 sq. km.
in 3709 8km pixels
1900 sites in common (~50%)
High confidence UMd = 11008 sq. km.
in 1218 8km pixels, 818 of which
match TRFIC sites

Qualitative comparison of change to TM and ETM+ data

Example from Indonesia, Path 127, Row 59

Tree cover

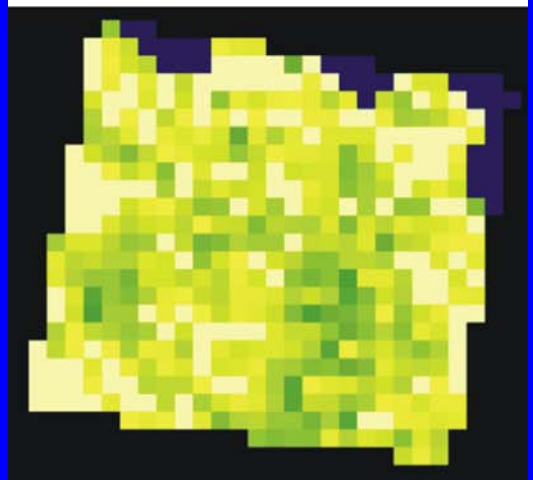
0%

100%

100 km

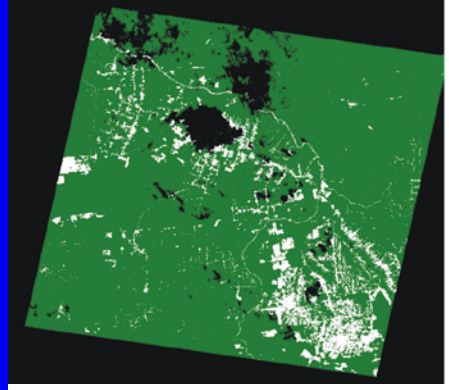
June 1989

April 2000

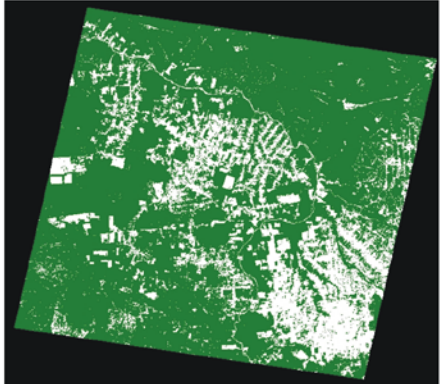


Magnitude of change
From 8km time series

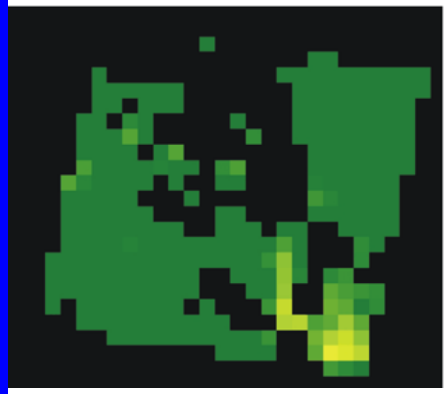
8km continuous field change estimates versus fine resolution change estimates, example from Mato Grosso, Brazil



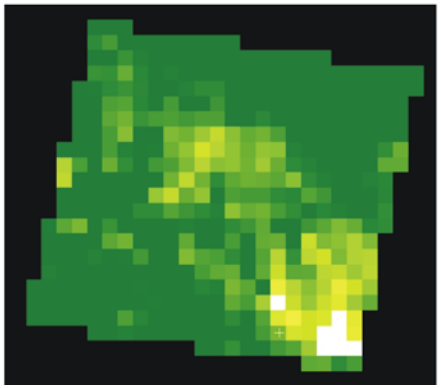
MSS 1986 forest/non-forest



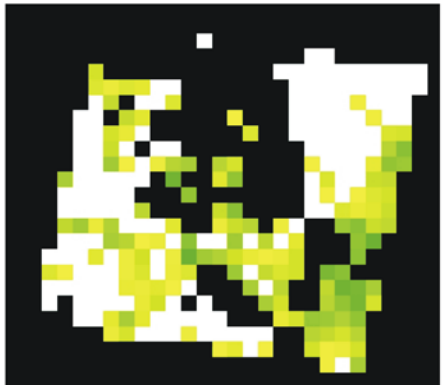
MSS 1992 forest/non-forest



MSS 1986 aggregated to 8km

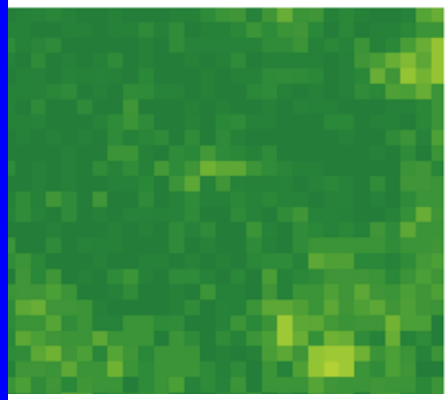


TM 1992 aggregated to 8km

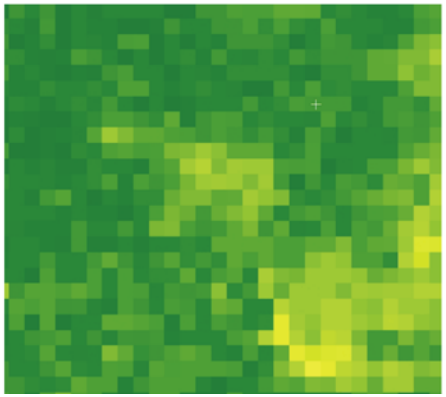


Percent tree cover

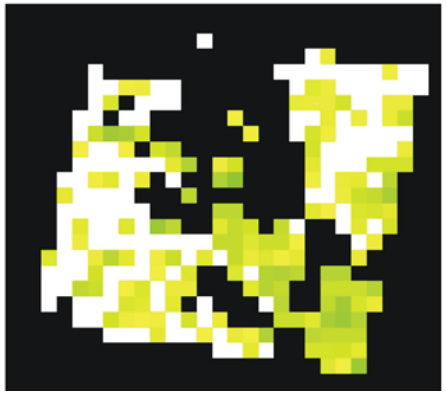
2457 sq. km. cleared



8km 1984 percent tree cover



8km 1990 percent tree cover

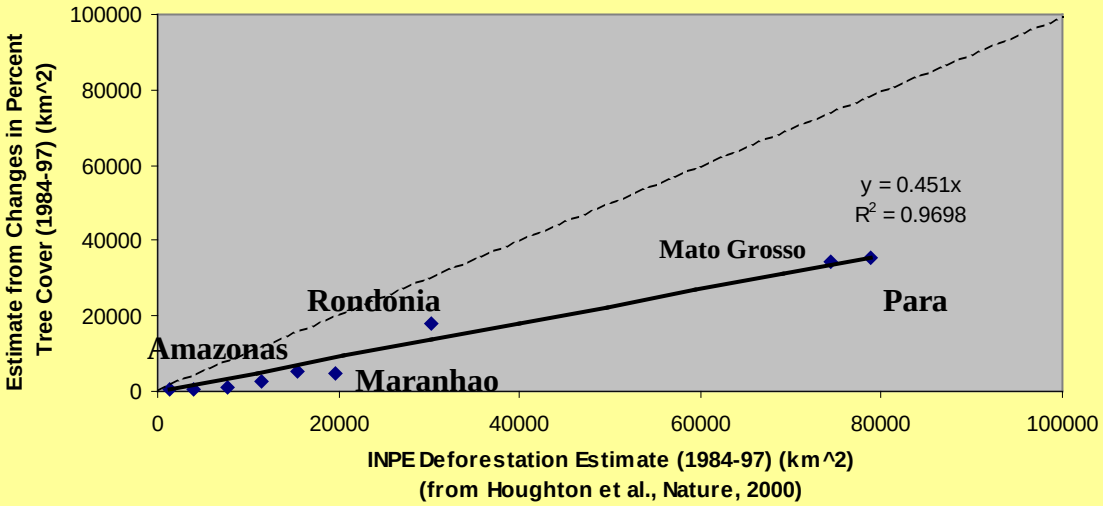


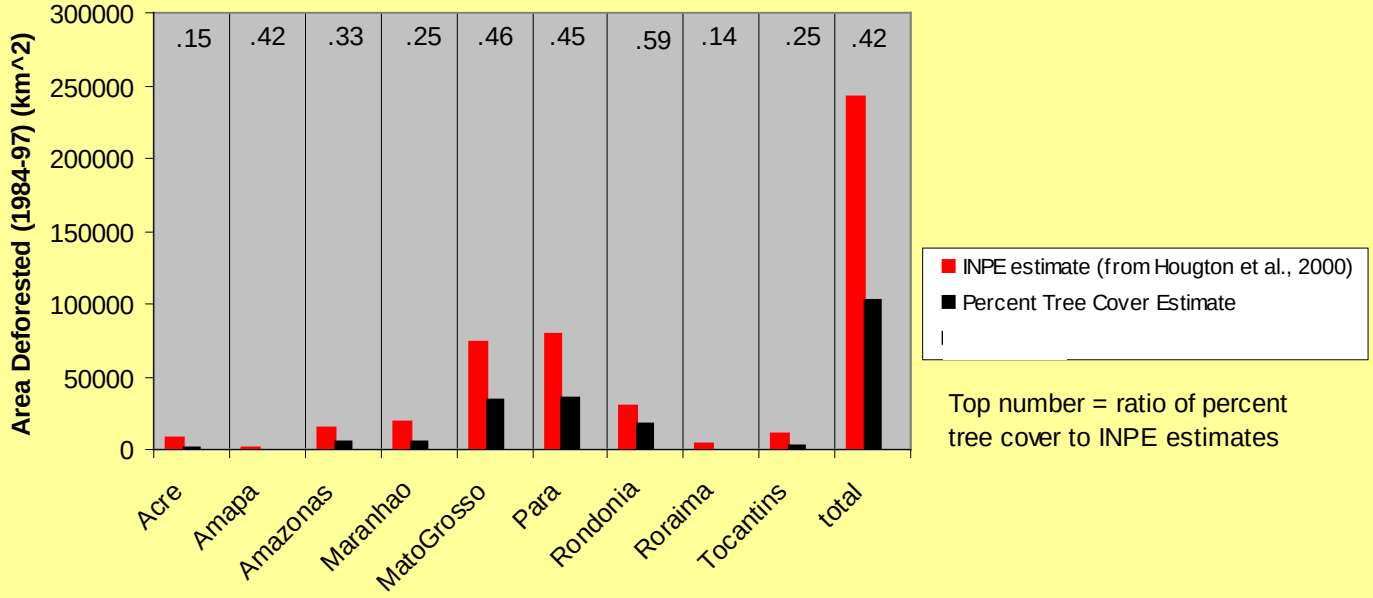
Percent tree cover

1097 sq. km. cleared

*Landsat forest cover from Tropical Rain Forest Information Center

INPE Deforestation Estimates in Amazon Basin vs. Estimates from Percent Tree Cover by State



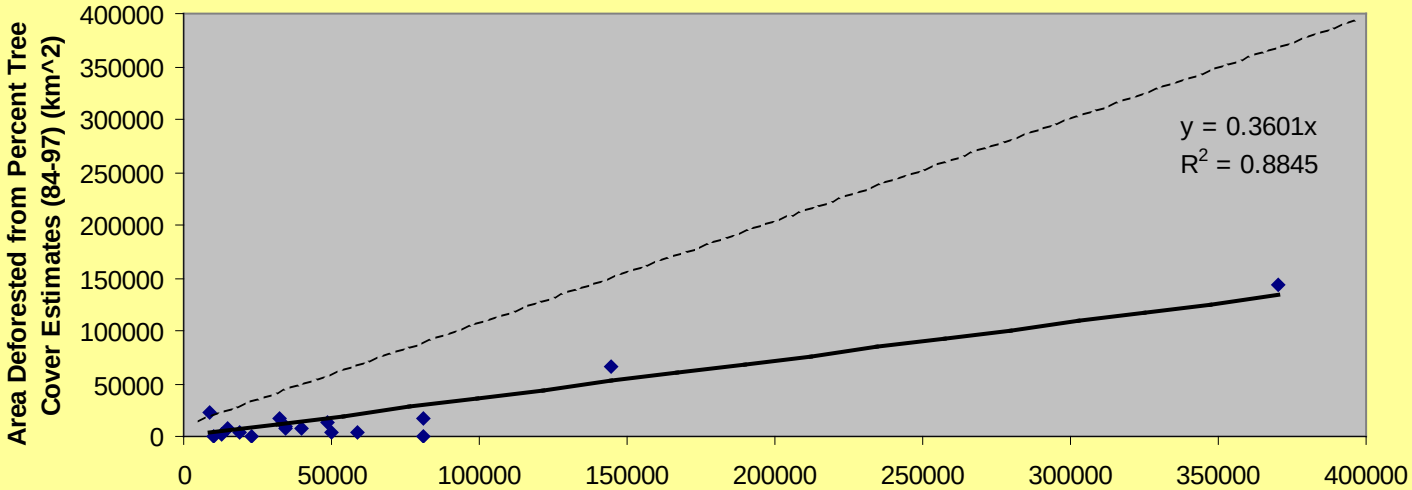


Top number = ratio of percent tree cover to INPE estimates

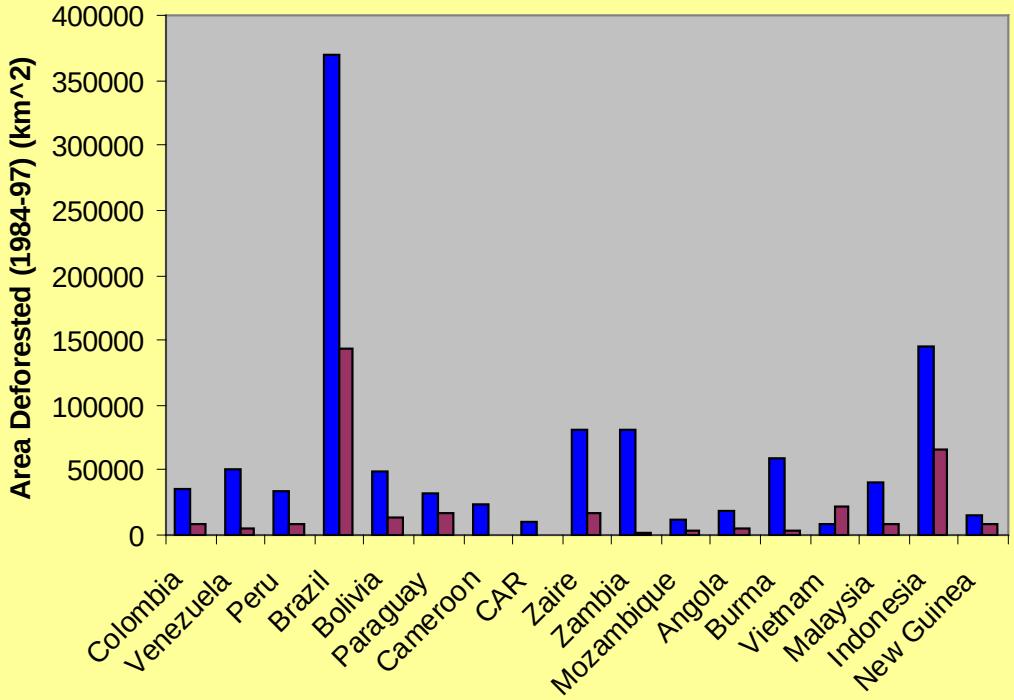
PROPORTION OF AREA DEFORESTED FROM PERCENT TREE COVER ESTIMATE COMPARED WITH ESTIMATES FROM HIGH RESOLUTION LANDSAT DATA

Country	Source	Time period available	Proportion of area detected with percent tree cover estimate
Brazil	INPE (from Houghton et al, 2000)	78-98	.45
Brazil	TRFIC	80s to 90s	.49
Bolivia	Steininger	1987-1993	.67

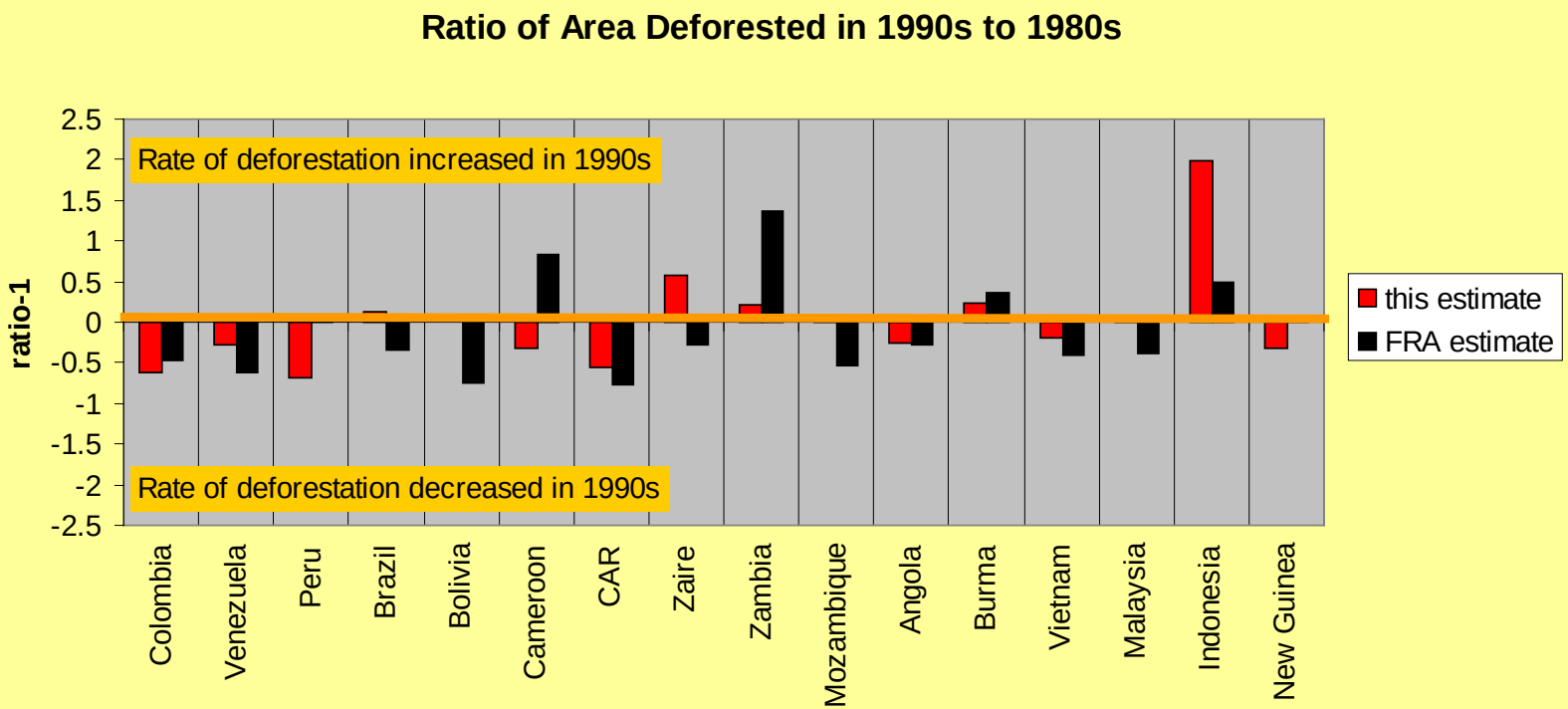
FRA Estimates of Deforested Area vs. Estimates from Percent Tree Cover



For countries in Latin America, Tropical Asia and Africa greater than 5000 km^2 and greater than 50% of area in woodland or forest

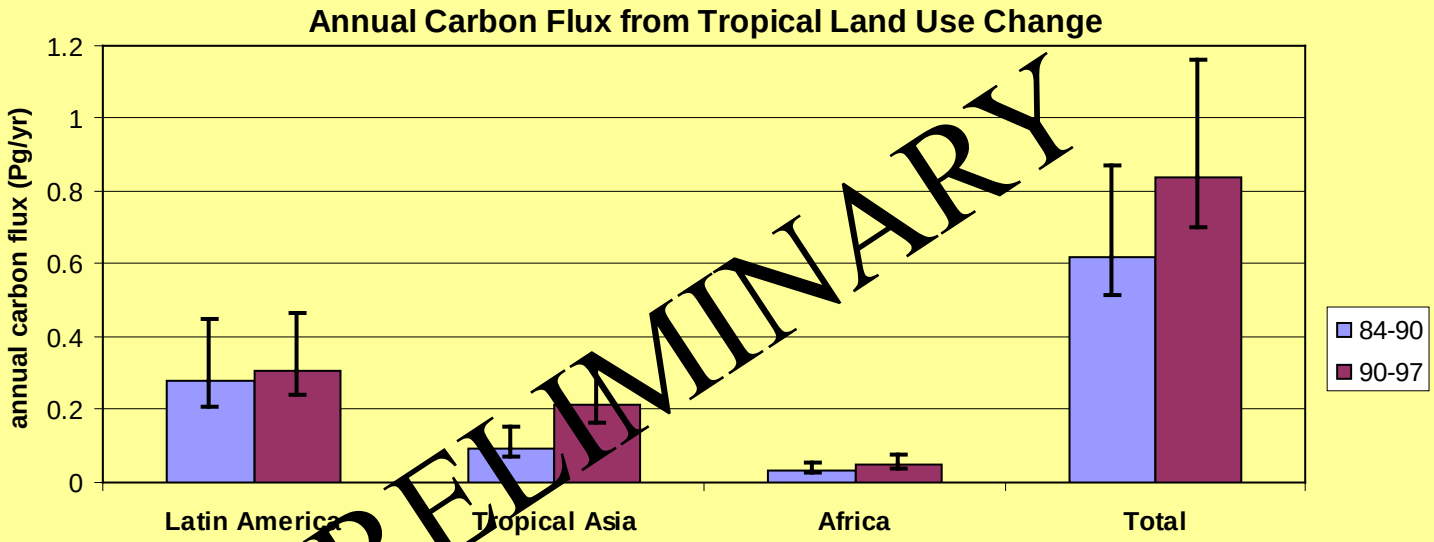


Median ratio for:	
Latin American countries	.26
African countries	.11
Tropical Asian countries	.45



For These Countries, Percent Tree Cover Estimates Suggest Increase in Rates of Deforestation in 1990s from 1980s while FRA Estimates Suggest Decrease

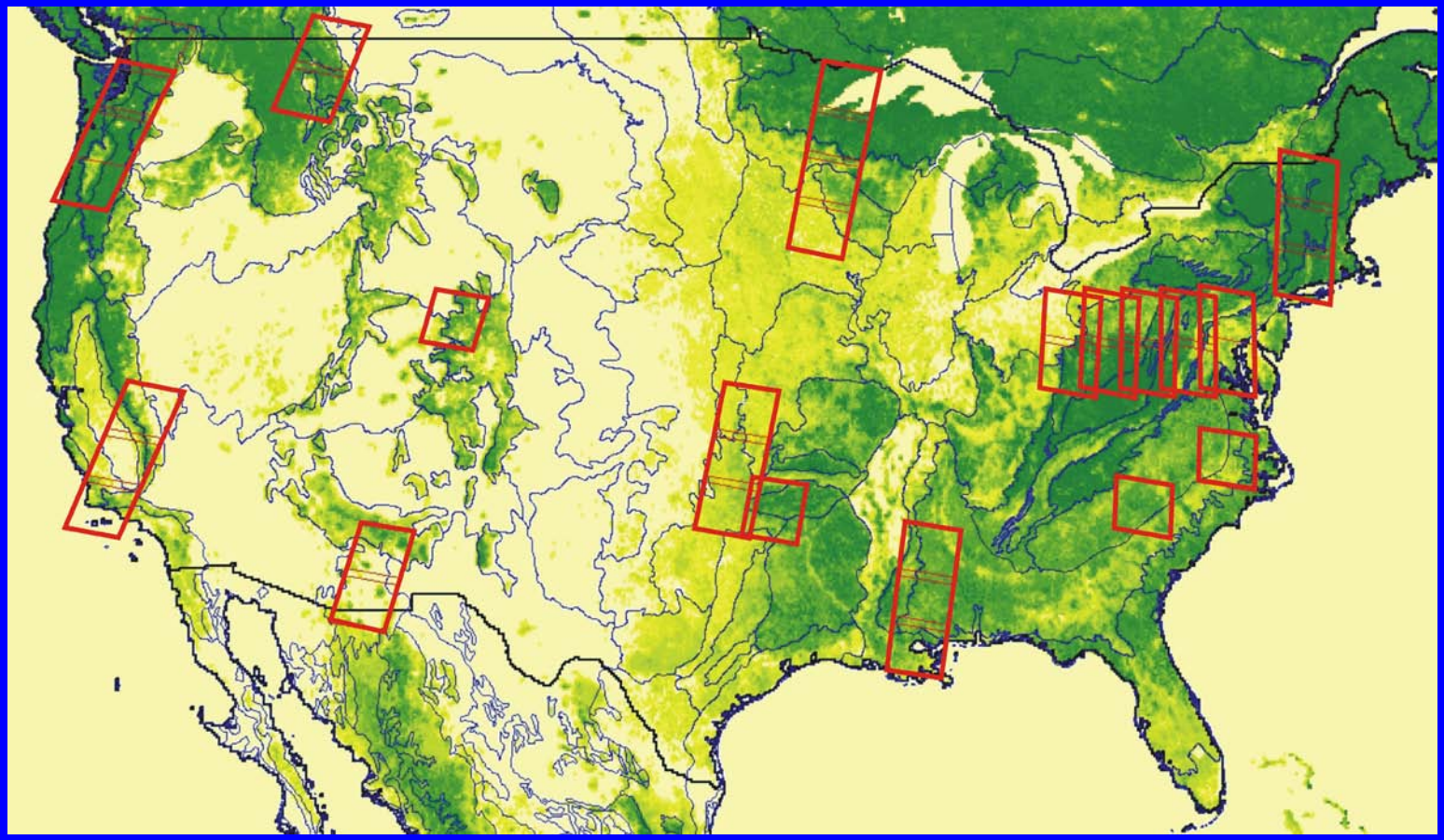
Ultimate aim to estimate carbon fluxes from land use change



Values given are for estimates using 4[illegible]%
Uncertainty ranges from highest and lowest estimates based on 4 and 6 yrs for 84-90 and 5 and 9 yrs for 90-97 in the interval and estimates from 48% and 36% adjustments
Total includes estimates for carbon flux from logging (10%) and shifting cultivation (.21 Gt/yr)

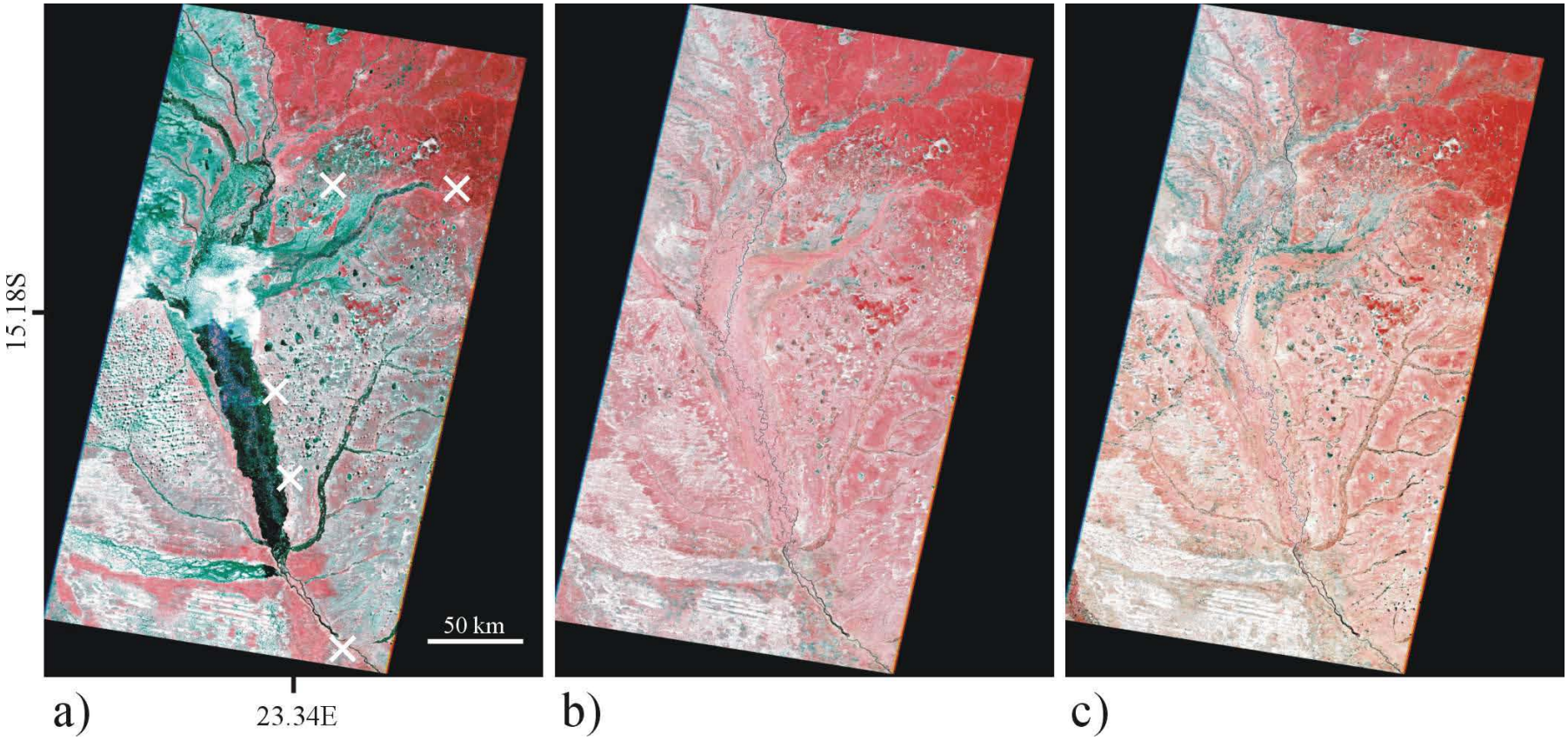
Tentative Results

- Automated analysis of coarse resolution data can identify major, broad-scales changes in forest cover
- Combined use of coarse and fine resolution data offers possibility to monitor changes in forest cover
- MODIS data promising for estimating % tree cover



Sites for MODIS calibration/validation using multi-scale, multi-temporal imagery and *in situ* field measurements

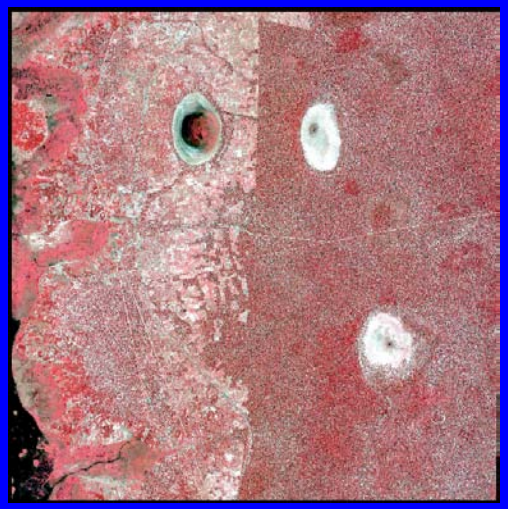
Derivation of MODIS calibration/validation data sets

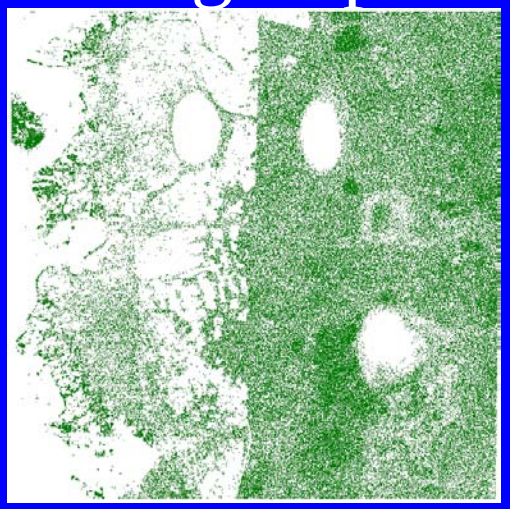


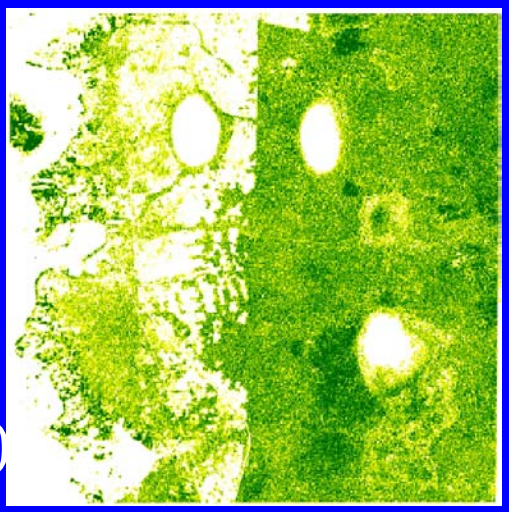
Enhanced Thematic Mapper Plus false-color composites for WRS path/rows 175/070-071, a) April 4, 2000 with crosses marking centers of IKONOS acquistions b) June 29, 2000 c) August 16, 2000.

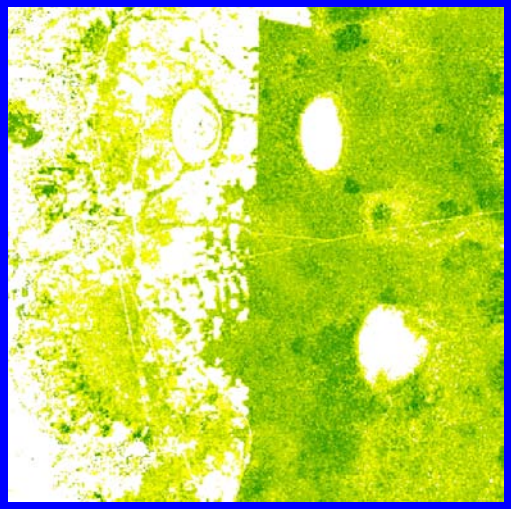
Single date IKONOS allows for mapping of tree crown cover. IKONOS depictions are subsequently scaled to ETM+ resolution for mapping large areas using multi-temporal ETM+ imagery. ETM+ depictions drive the 250-500 m MODIS tree cover mapping.

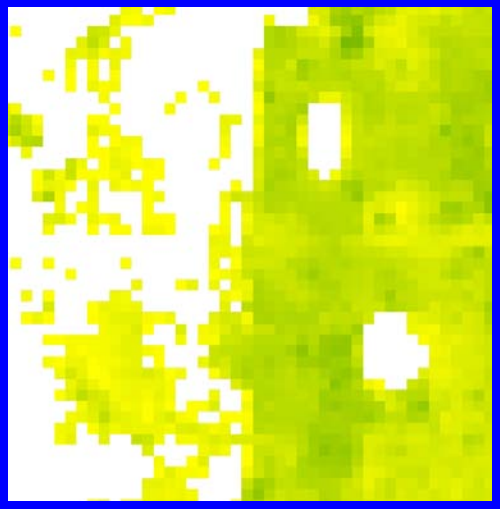
From training to product

a) 

b) 

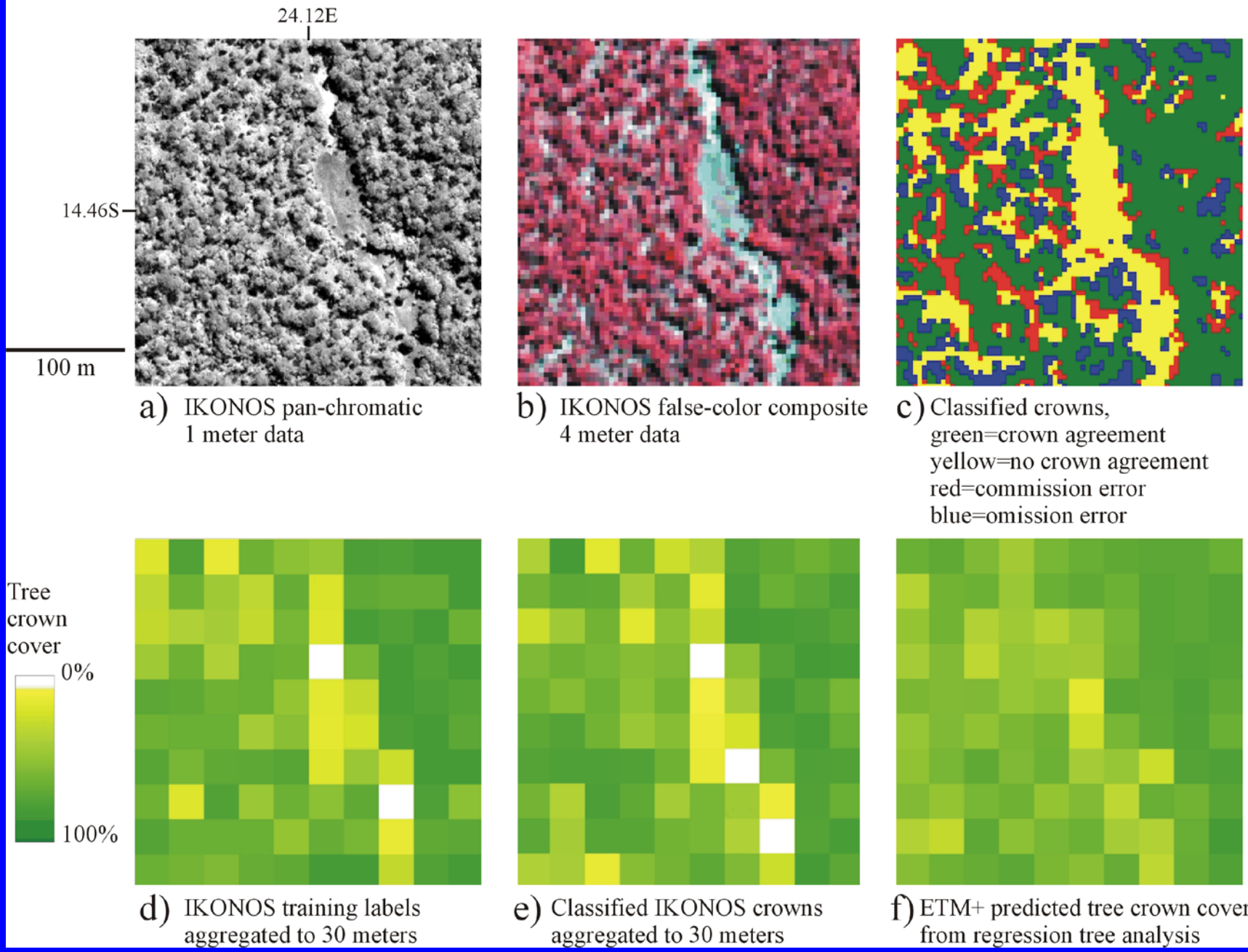
c) 

d) 

e) 

a) 4 m IKONOS 4-3-2 combination, 11km by 11km, b) crown cover interpretation, c) aggregated continuous crown cover training at 30 meter resolution, d) TM canopy cover from IKONOS training, result scaled using field measurements, e) result aggregated to 250 meter for MODIS validation use

Developing a training data set of percent crown cover from IKONOS



a) IKONOS pan-chromatic 1 meter data

b) IKONOS false-color composite 4 meter data

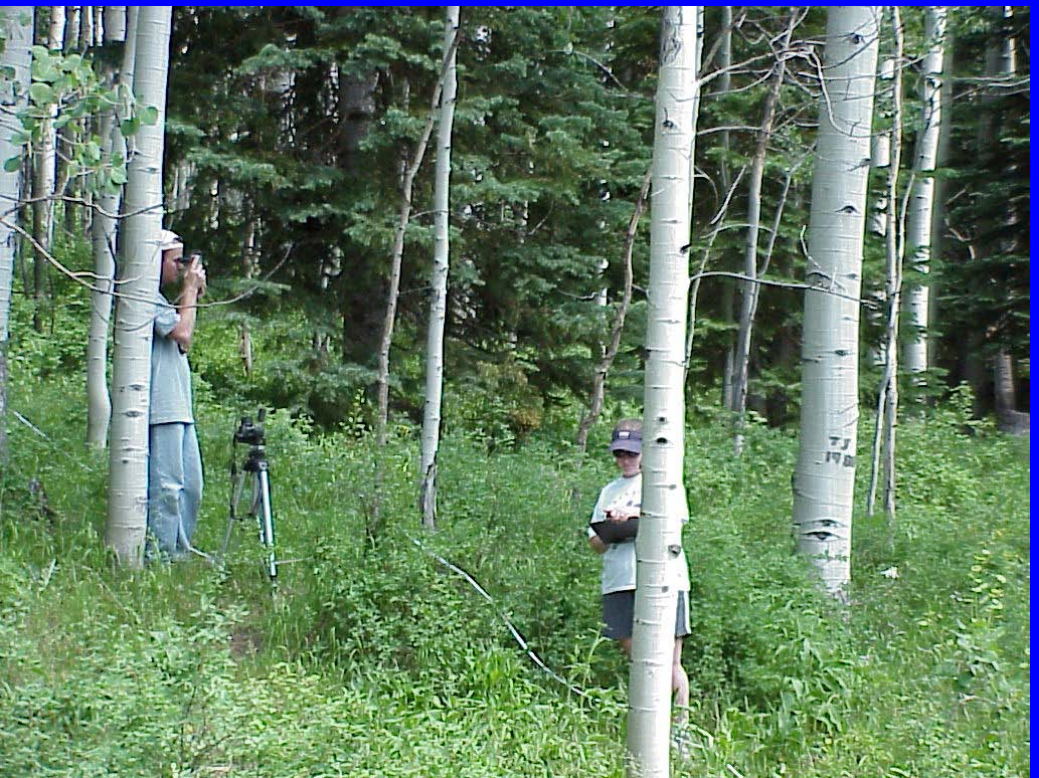
c) Classified crowns,
green=crown agreement
yellow=no crown agreement
red=commission error
blue=omission error

d) IKONOS training labels aggregated to 30 meters

e) Classified IKONOS crowns aggregated to 30 meters

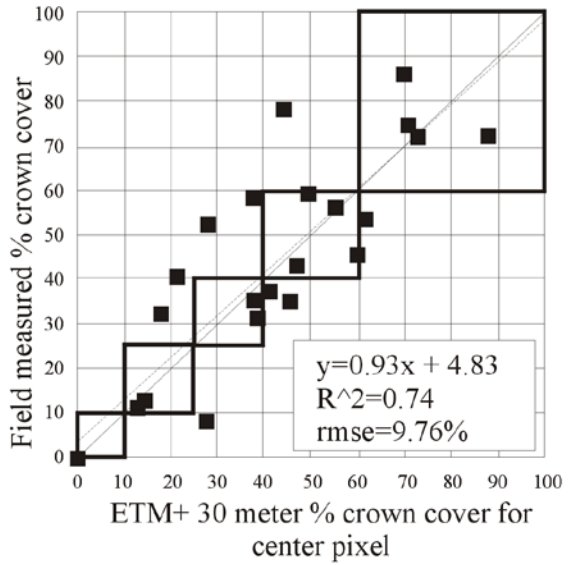
f) ETM+ predicted tree crown cover from regression tree analysis

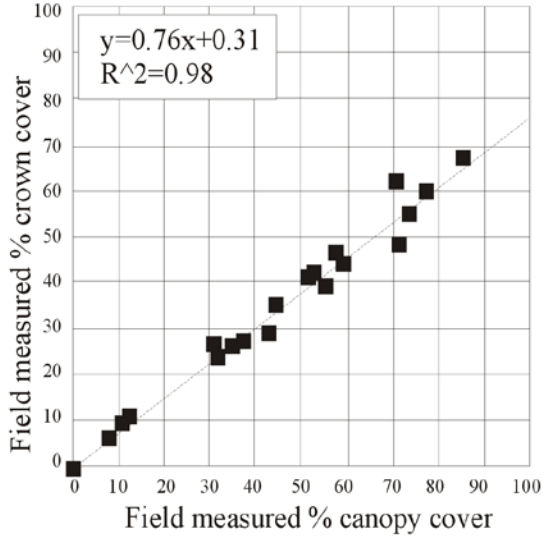
Measuring crown/canopy closure



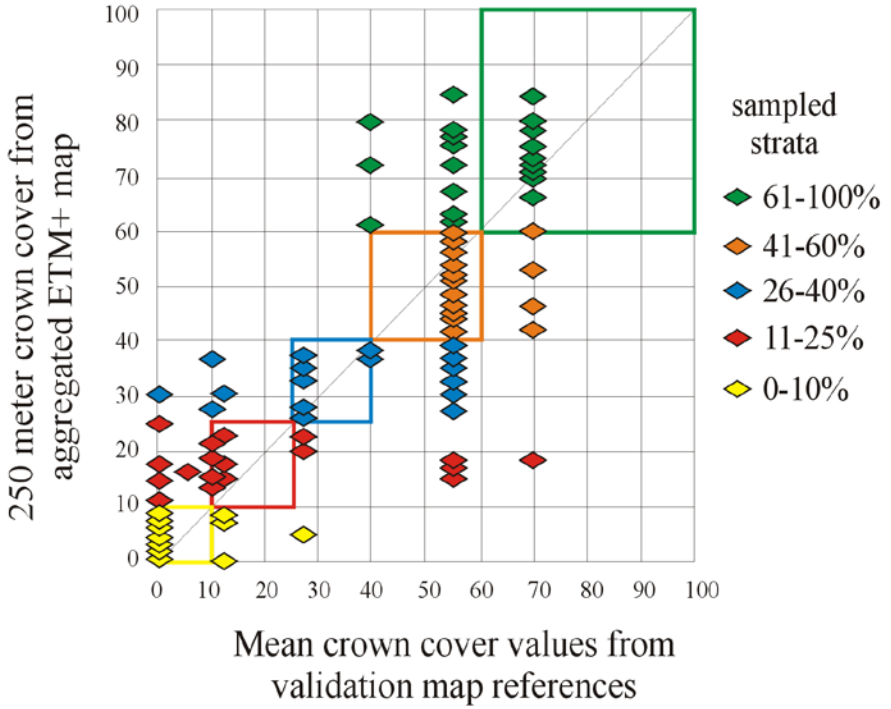
with photography and densitometer

Comparison of ETM+ 30 meter tree cover estimates to field measured validation sites



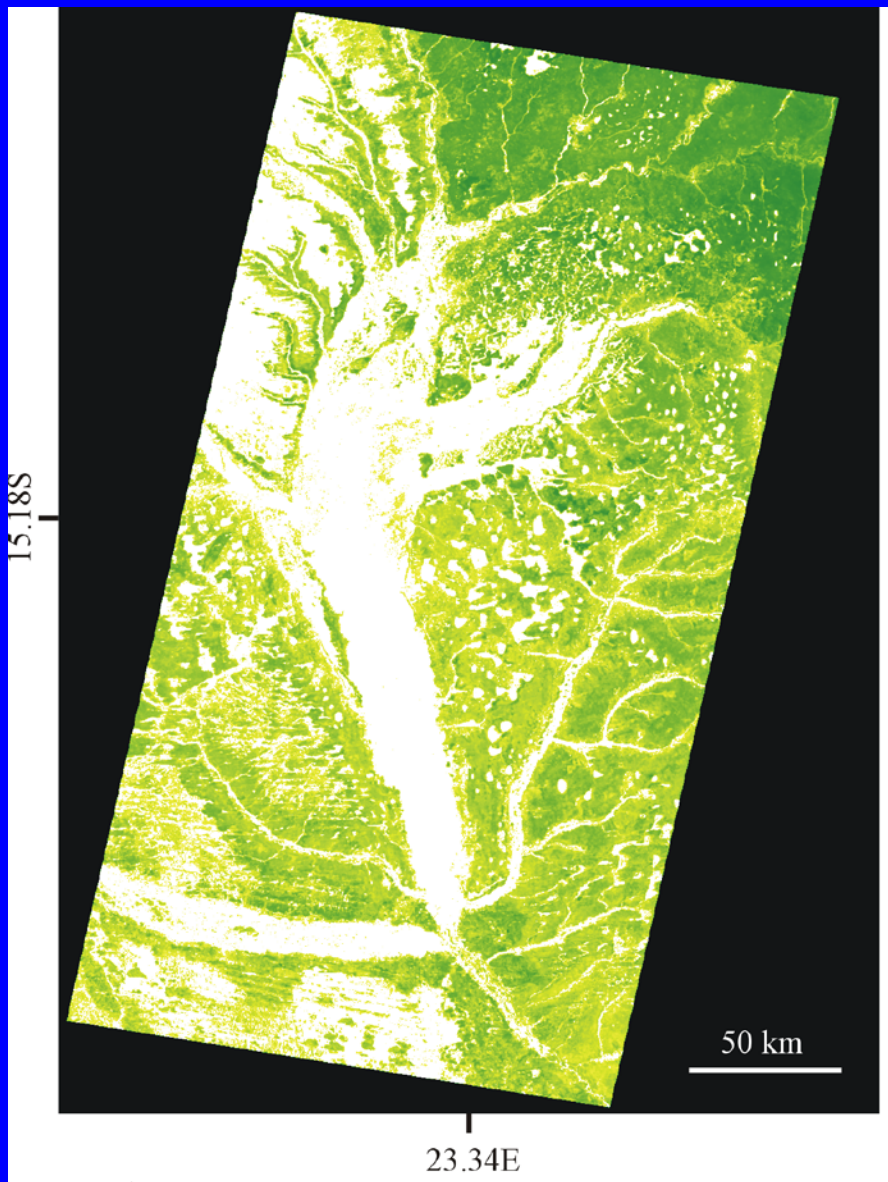


Comparison of "Landscapes and Grasslands of Western Province, Zambia" mean class crown cover values with 250 meter aggregated ETM+ map

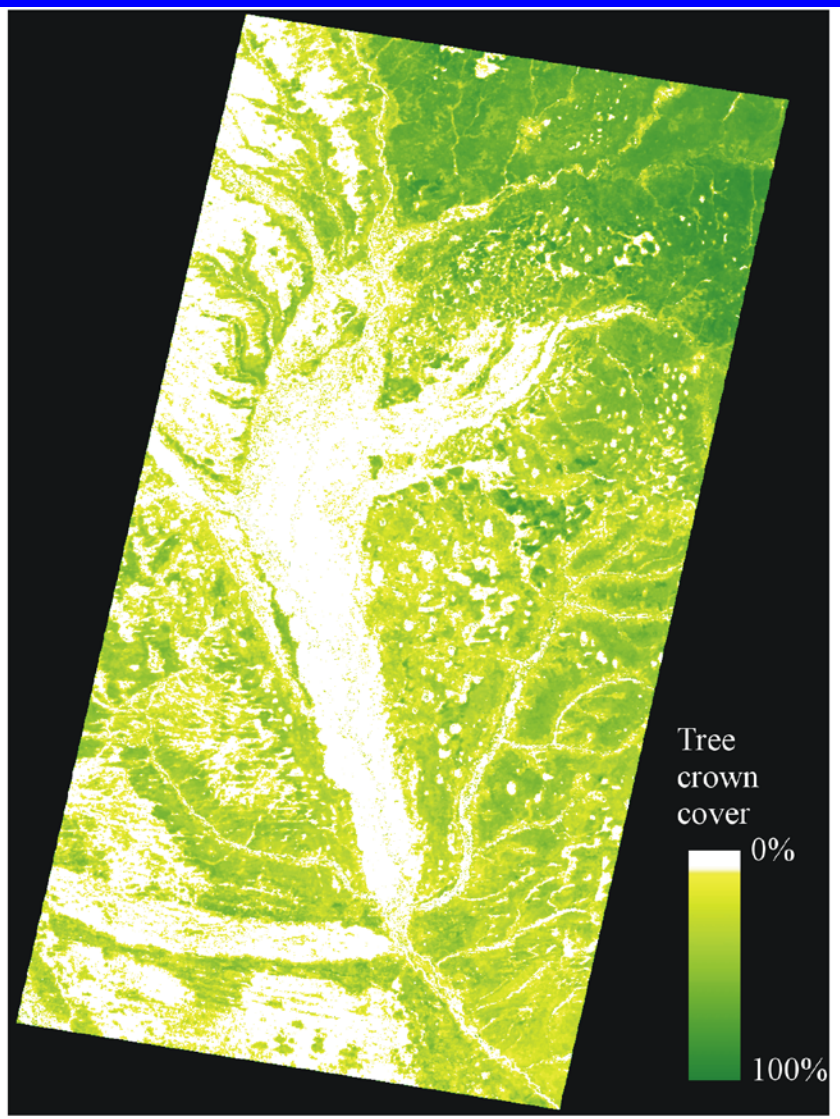


GOFC strata	percent area	rmse
0-10%	35.9	4.16%
11-25%	15.6	10.60%
26-40%	16.5	14.12%
41-60%	18.8	7.16%
61-100%	13.2	12.76%
average rmse		9.8%
area weighted rmse		8.5%

Validation results per strata for the 125 randomly chosen sites



a) ETM+ crown cover aggregated to 250 meters



b) MODIS 250 meter crown cover map made by sampling 20 percent of (a