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

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GOFC themes

- Forest cover characteristics and monitoring

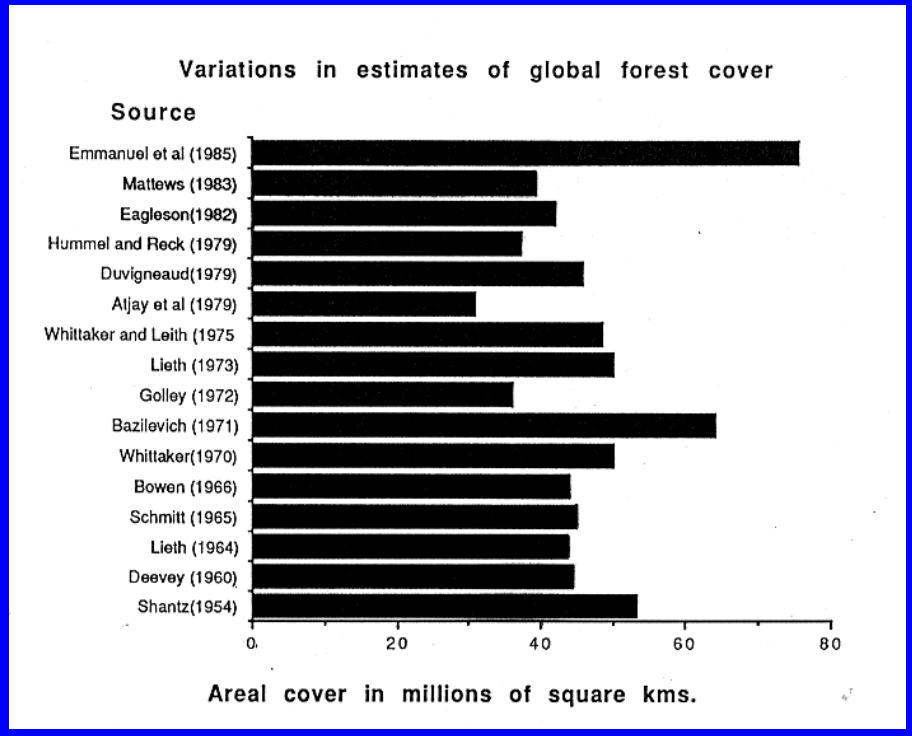
  periodic mapping at coarse resolution (250-1000m) combined with fine (~25m) resolution

- Forest fire monitoring and mapping

- Forest biophysical properties

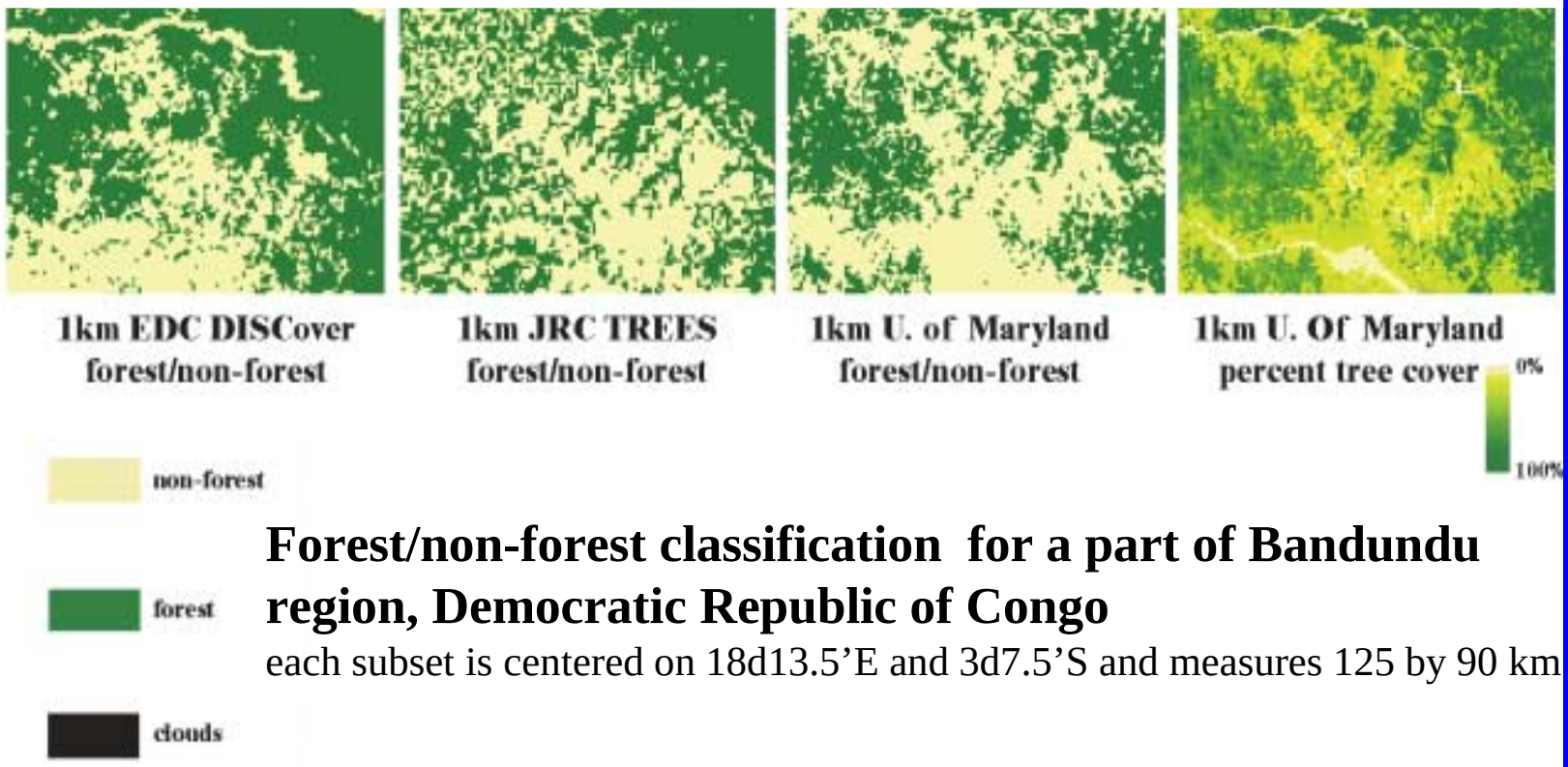
Challenges: Forest Cover Characteristics and Monitoring

- Baseline for global forest cover?



(Townshend et al., 1990)

VARYING ESTIMATES OF FOREST COVER FROM REMOTE SENSING PRODUCTS



Forest/non-forest classification for a part of Bandundu region, Democratic Republic of Congo

each subset is centered on 18d13.5'E and 3d7.5'S and measures 125 by 90 km

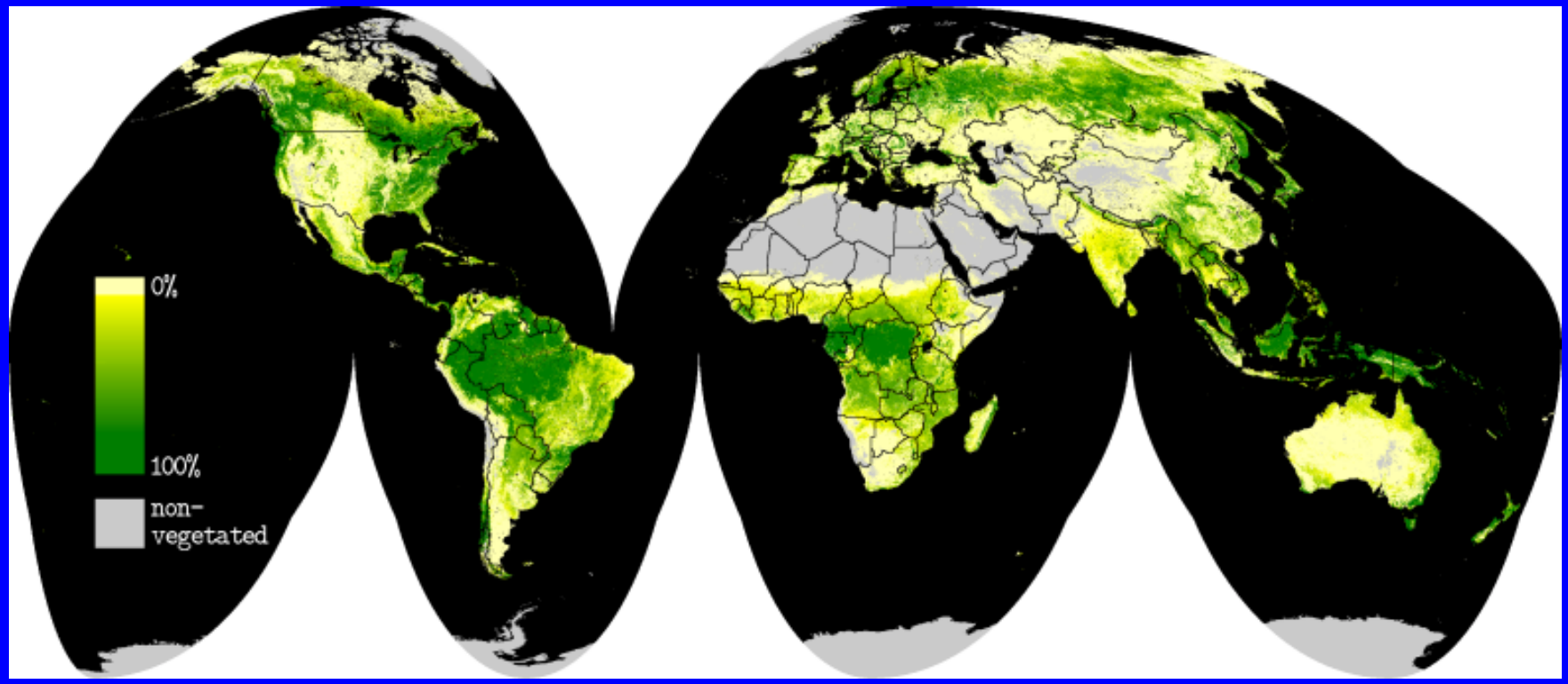
Challenges: Forest Cover Characteristics and Monitoring

- Baseline for global forest cover?
- Spatial and temporal consistency in definition of “forest”
- Characterizing subtle changes in canopy cover
- Automated procedure for repeated production

Prototype approach: Continuous fields of vegetation properties

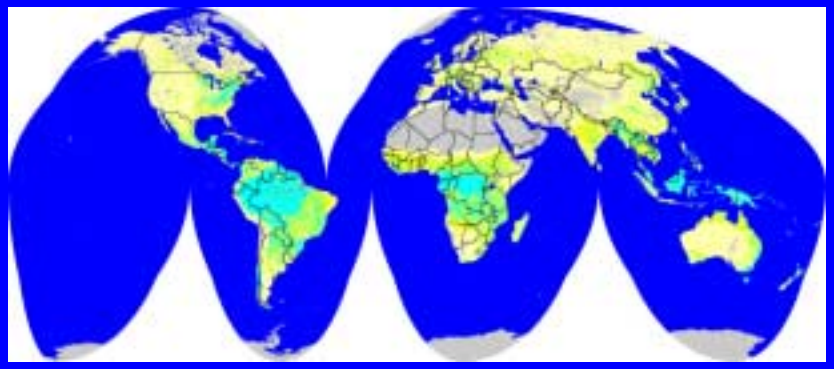
- Overcome artificial boundaries inherent in classification approach
- Independent of definition of “forest”
- Possibility to apply temporally to identify changes in % tree cover
- Derived from remote sensing using linear mixture model with calibration and validation from high resolution data

Continuous fields of vegetation properties to improve depiction of heterogeneity

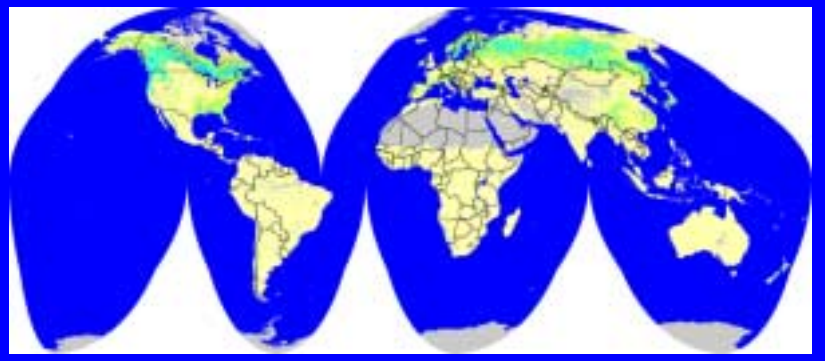


% tree cover derived from 1992-93 1km AVHRR (DeFries et al, 2000)

Leaf type

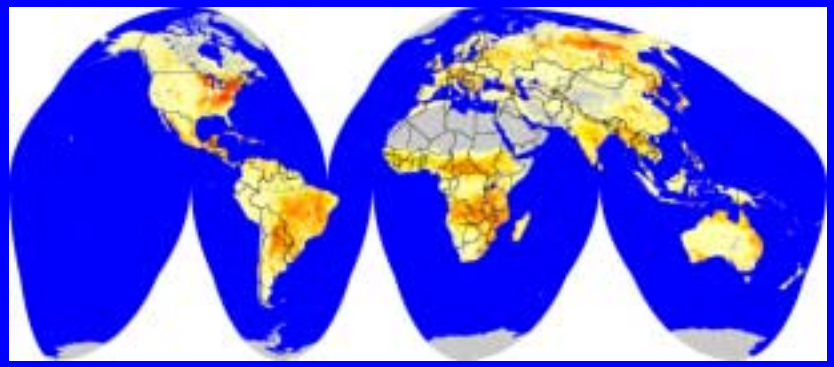


% broadleaf

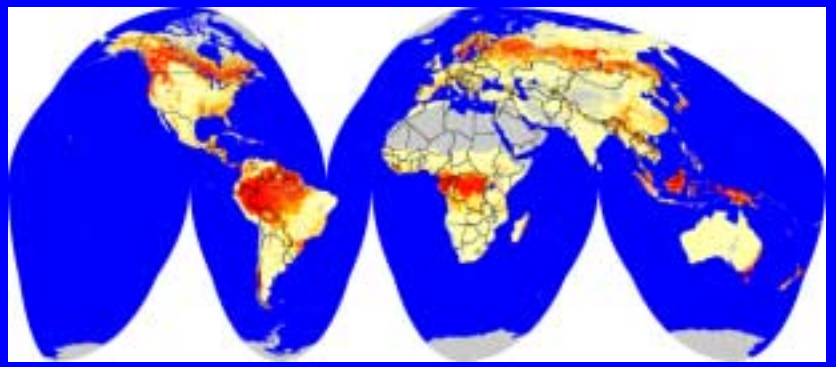


% needleleaf

Leaf longevity



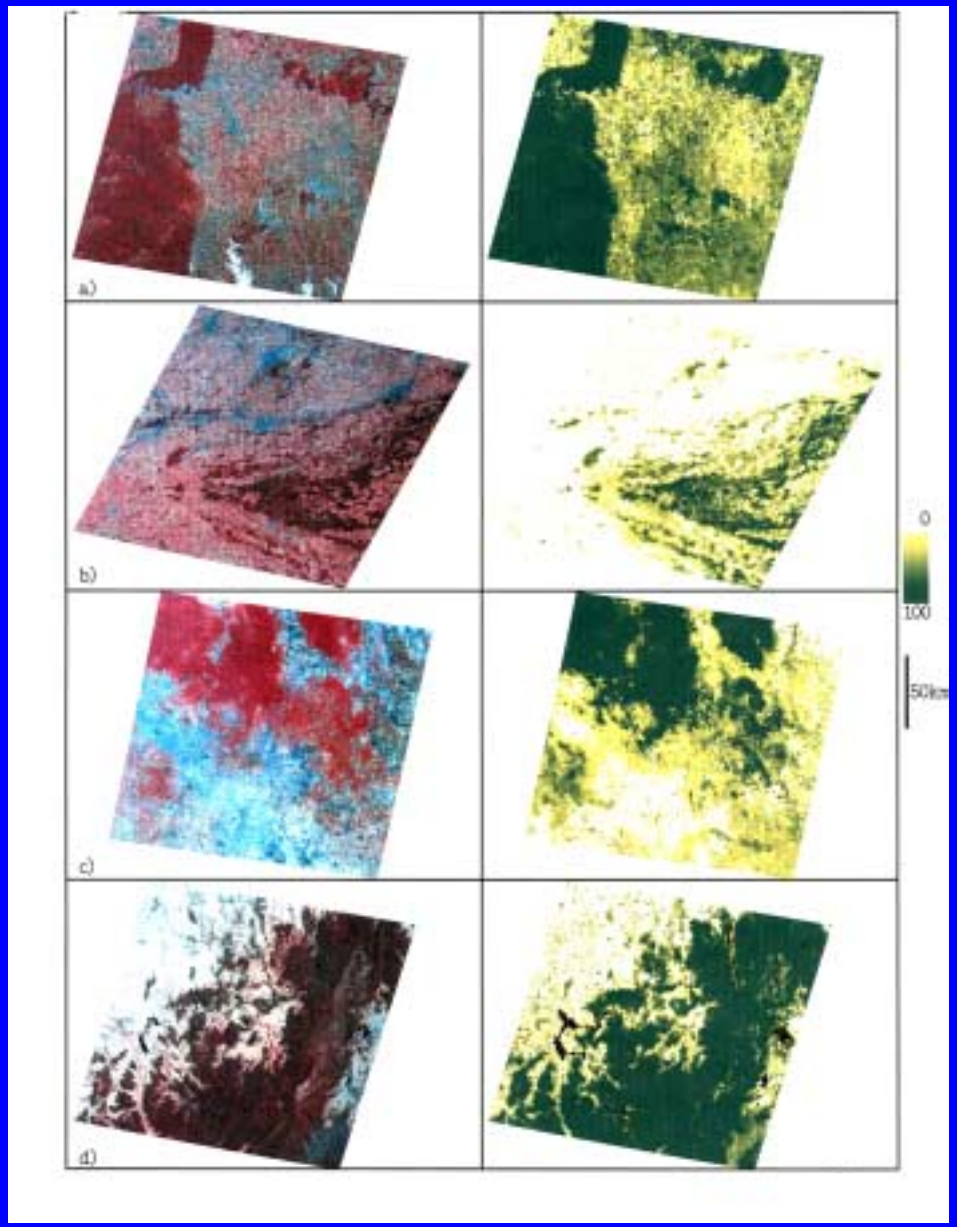
% deciduous



% evergreen

LANDSAT TM

% TREE COVER ESTIMATE

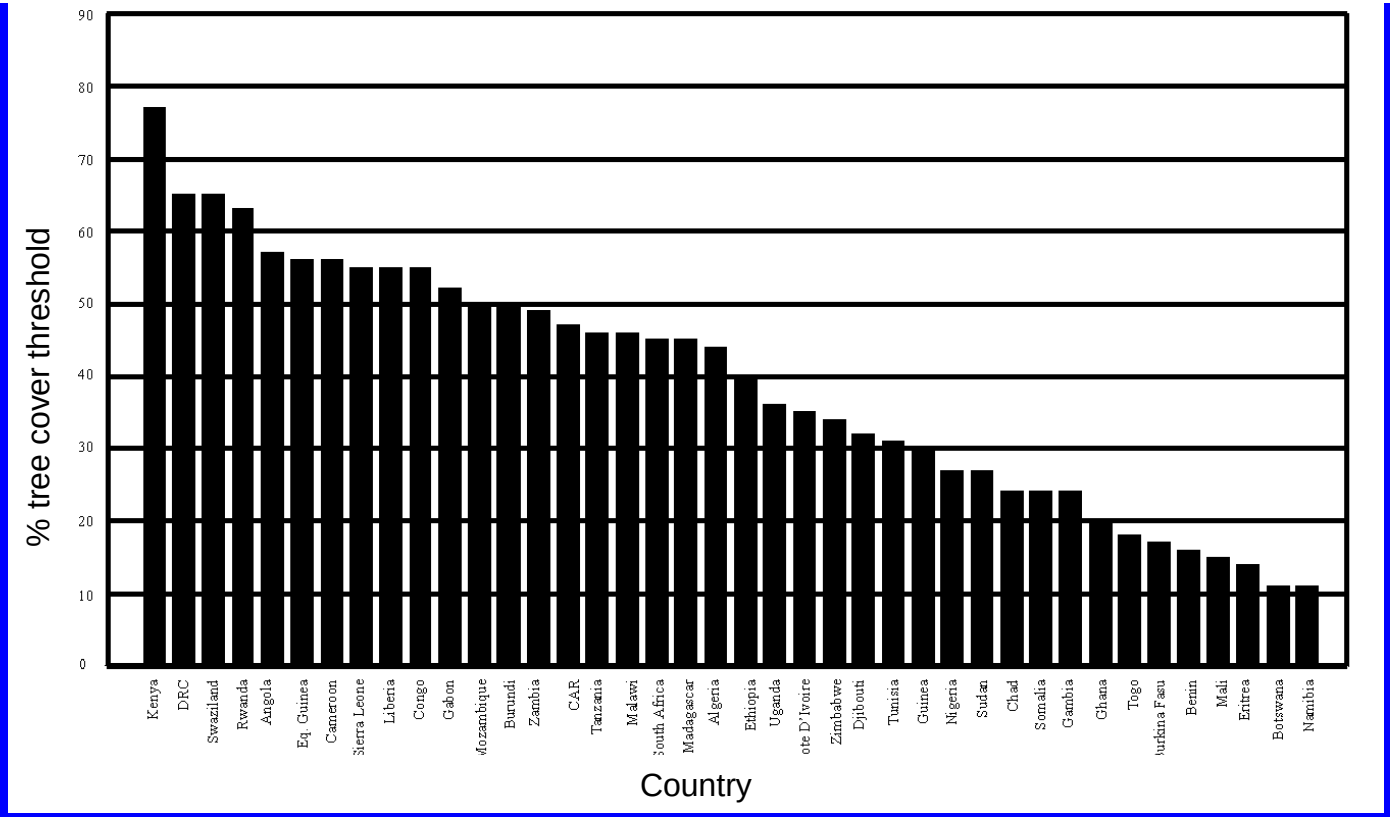


Spatial patterns compare with high resolution data

Next step comparison with in situ data

Continuous fields for spatially consistent estimates of % tree cover

Threshold of tree cover from 1km global data which best matches FAO forest area for African countries



FAO estimates of forested area inconsistent between countries

Possibility of standardizing global forest statistics

DRC

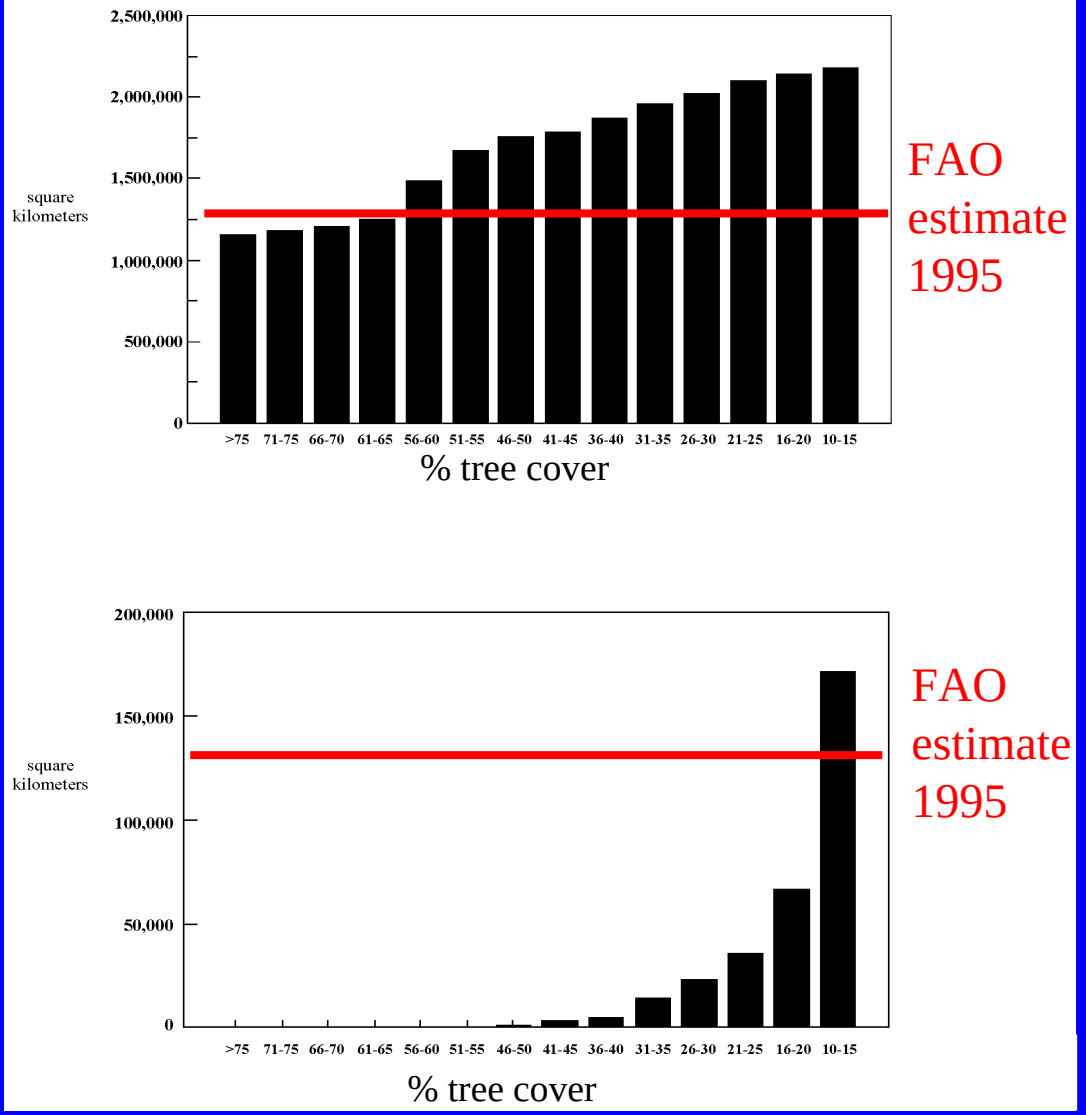
Tree cover

<10%

>80%

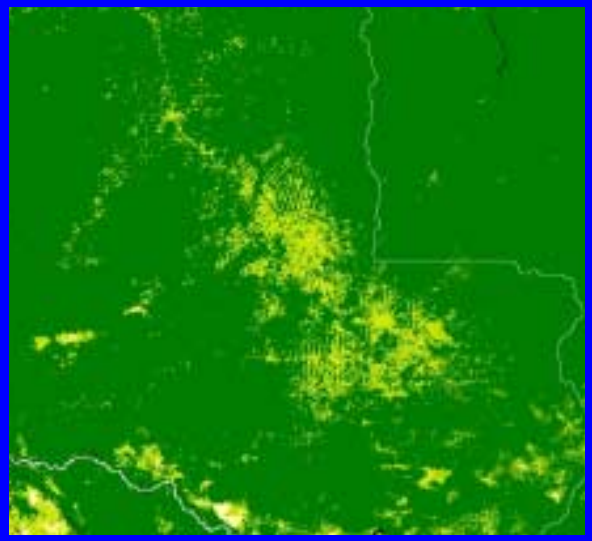
500 km

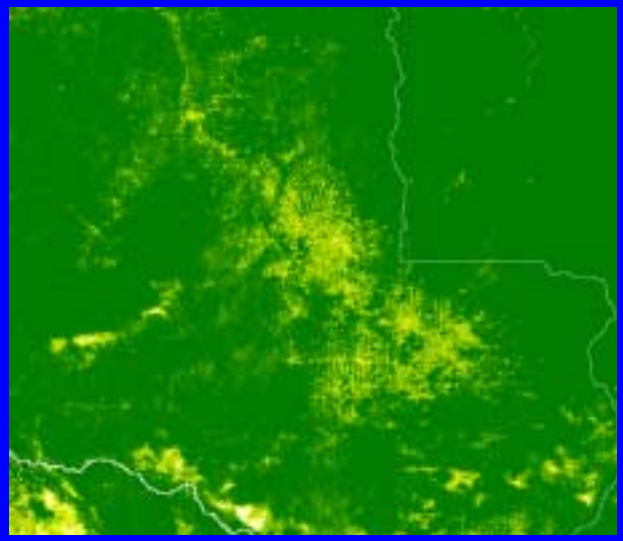
Namibia

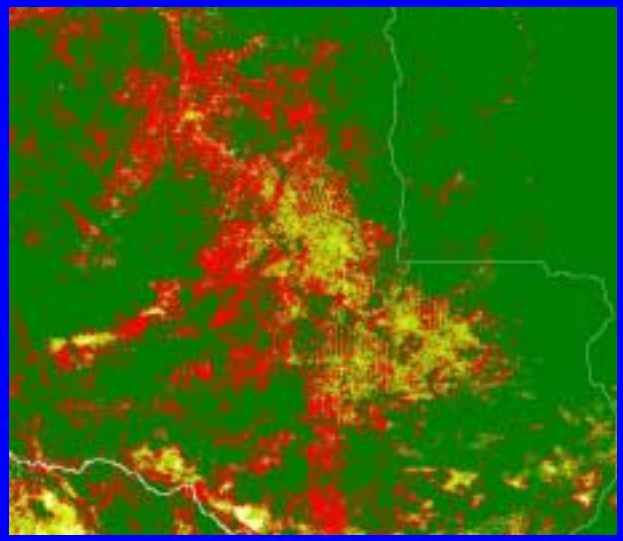


Classification versus continuous field land cover maps

example of Rondonia, Brazil







classification

- herbaceous (<10% tree cover)
- parkland (>=10% and <40%)
- woodland (>=40% and <60%)
- forest (>=60%)

continuous field

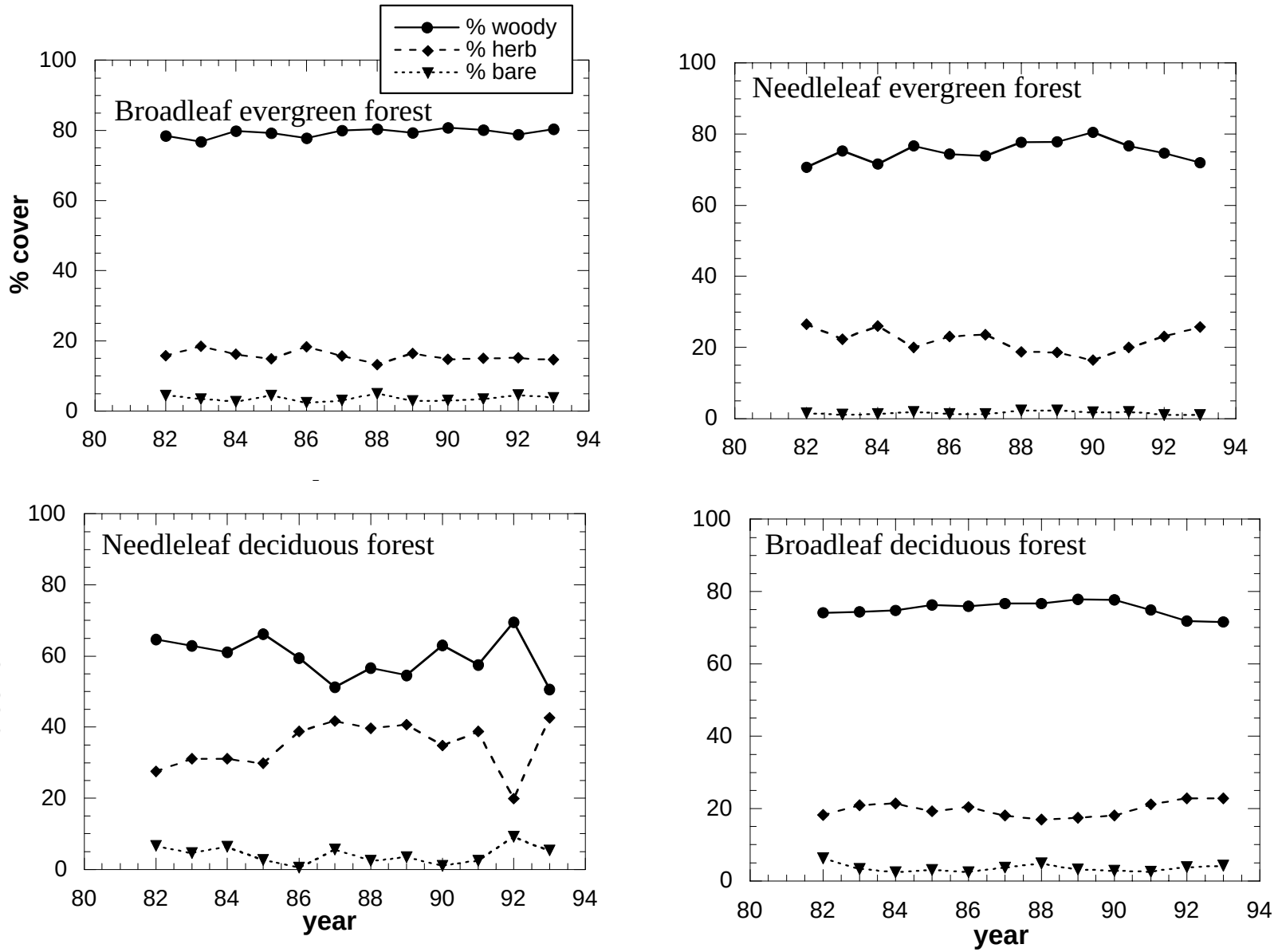
<10% tree cover

>80% tree cover

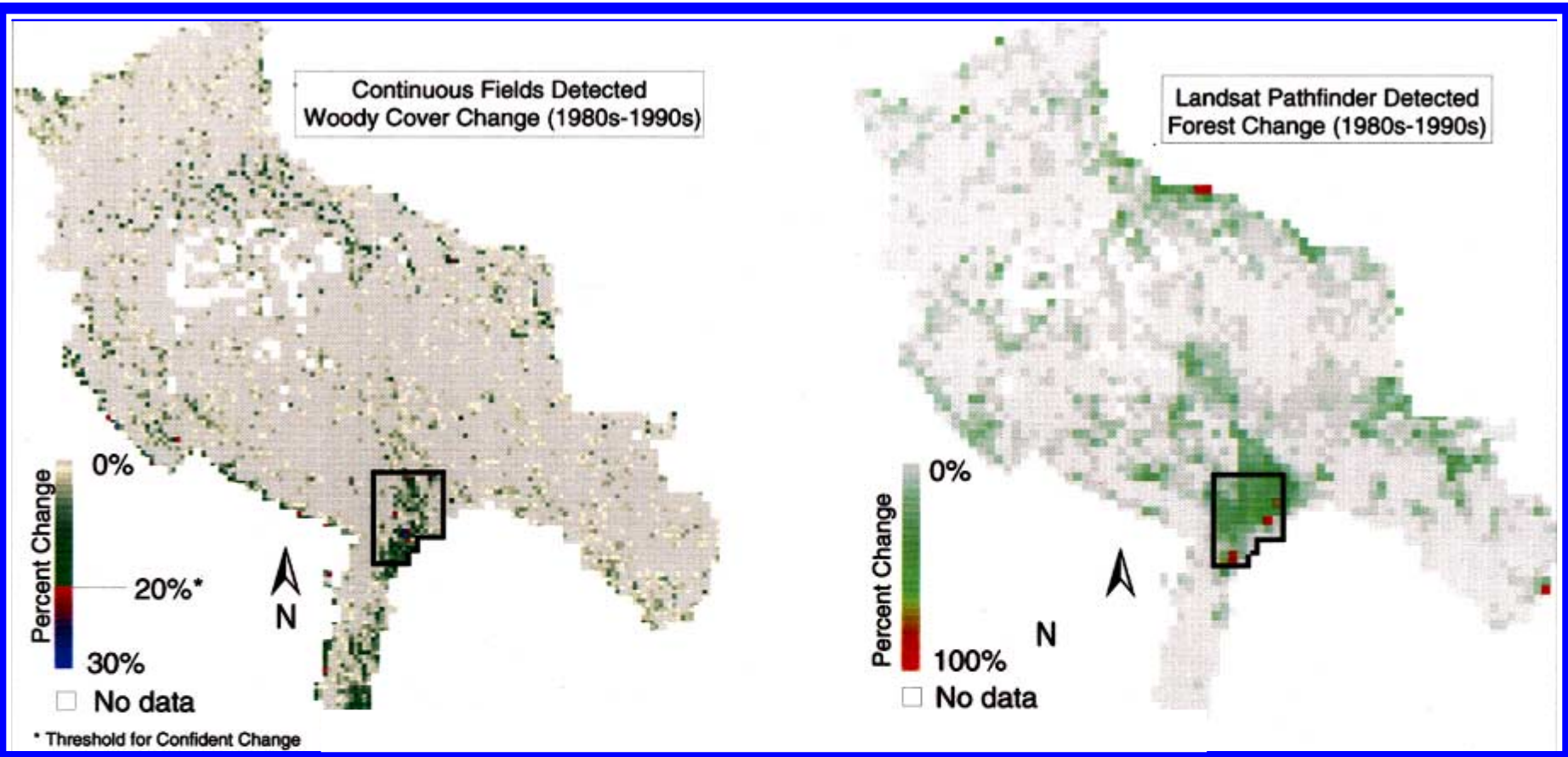
information gain

classified as forest, but less than 80% canopy cover as depicted in the continuous field

TEMPORALLY CONSISTENT ESTIMATES: 8KM TIME SERIES

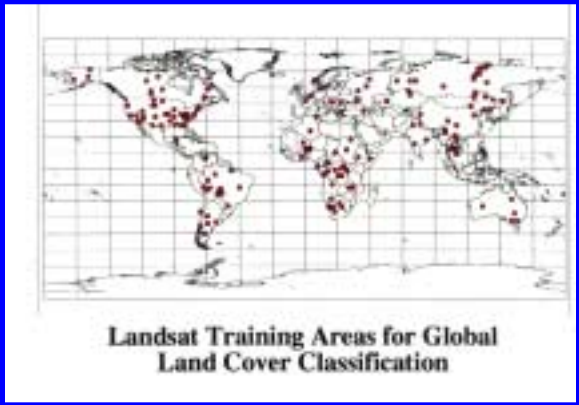


% woody varies up to 20% in stable locations

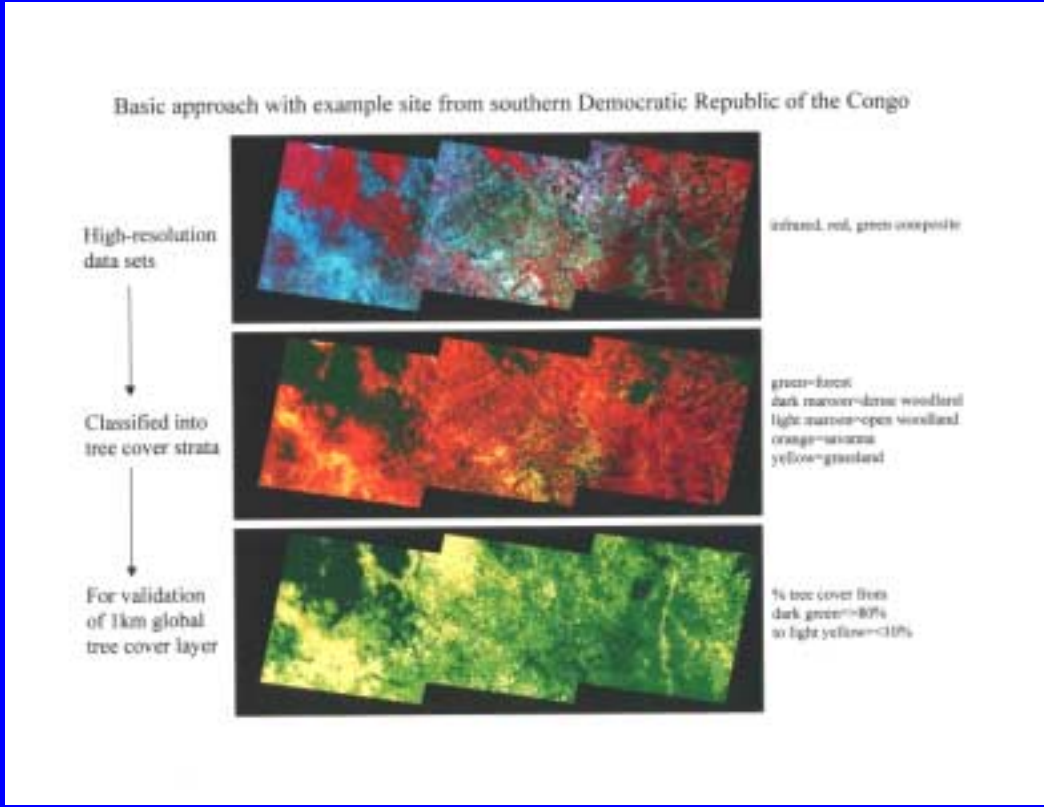


8KM TIME SERIES ONLY PARTIALLY SUCCESSFUL FOR IDENTIFYING CHANGE

TECHNIQUES TOWARD OPERATIONAL LAND COVER MONITORING FROM SATELLITES

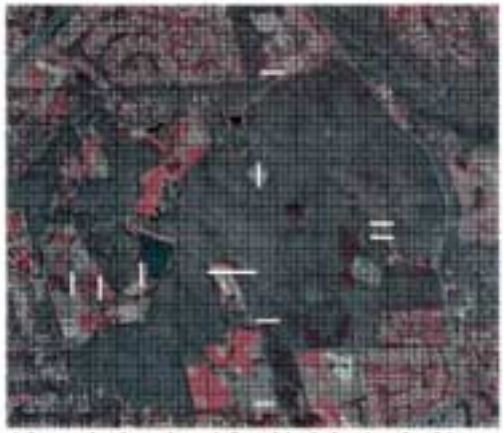


Landsat Training Areas for Global Land Cover Classification

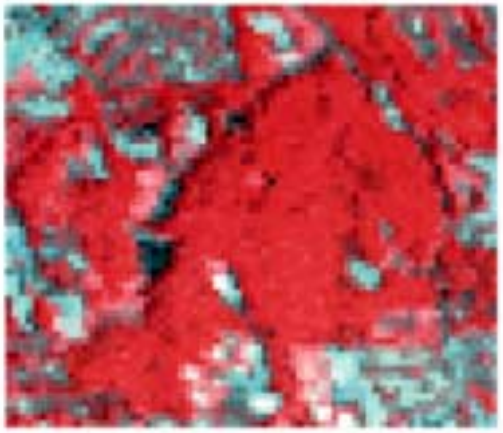


HIGH RESOLUTION DATA TO TRAIN AND VALIDATE COARSE RESOLUTION DATA, NEXT STEP IN SITU DATA

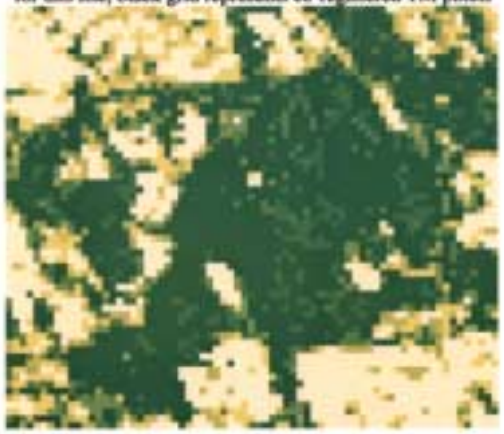
IN SITU MEASUREMENTS TO CALIBRATE AND VALIDATE % TREE COVER



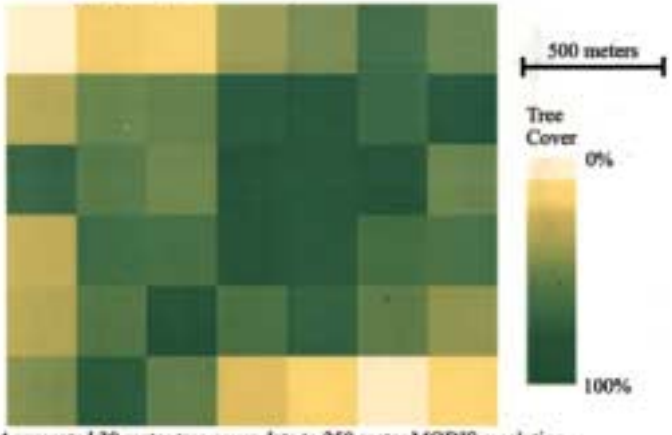
1.2 m orthophoto data, infrared (red plane) and red (cyan plane), spring image, white bands represent field transects for this site, black grid represents co-registered TM pixels



30 m Landsat Thematic Mapper data, infrared (red plane) and red (cyan plane), summer image



30 meter Landsat TM data classified as percent tree strata



Aggregated 30 meter tree cover data to 250 meter MODIS resolution for use in training and validation of coarse resolution products

In-situ measurements aggregated to 250 meters for an area around Wheaton Regional Park, Montgomery County, Maryland

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

- *Use in situ measurements of canopy cover to calibrate and validate algorithm*
- *derive prototype for conterminous US with MODIS 250m data*
- *prior to availability of MODIS data, develop prototypes using AVHRR 1km data*

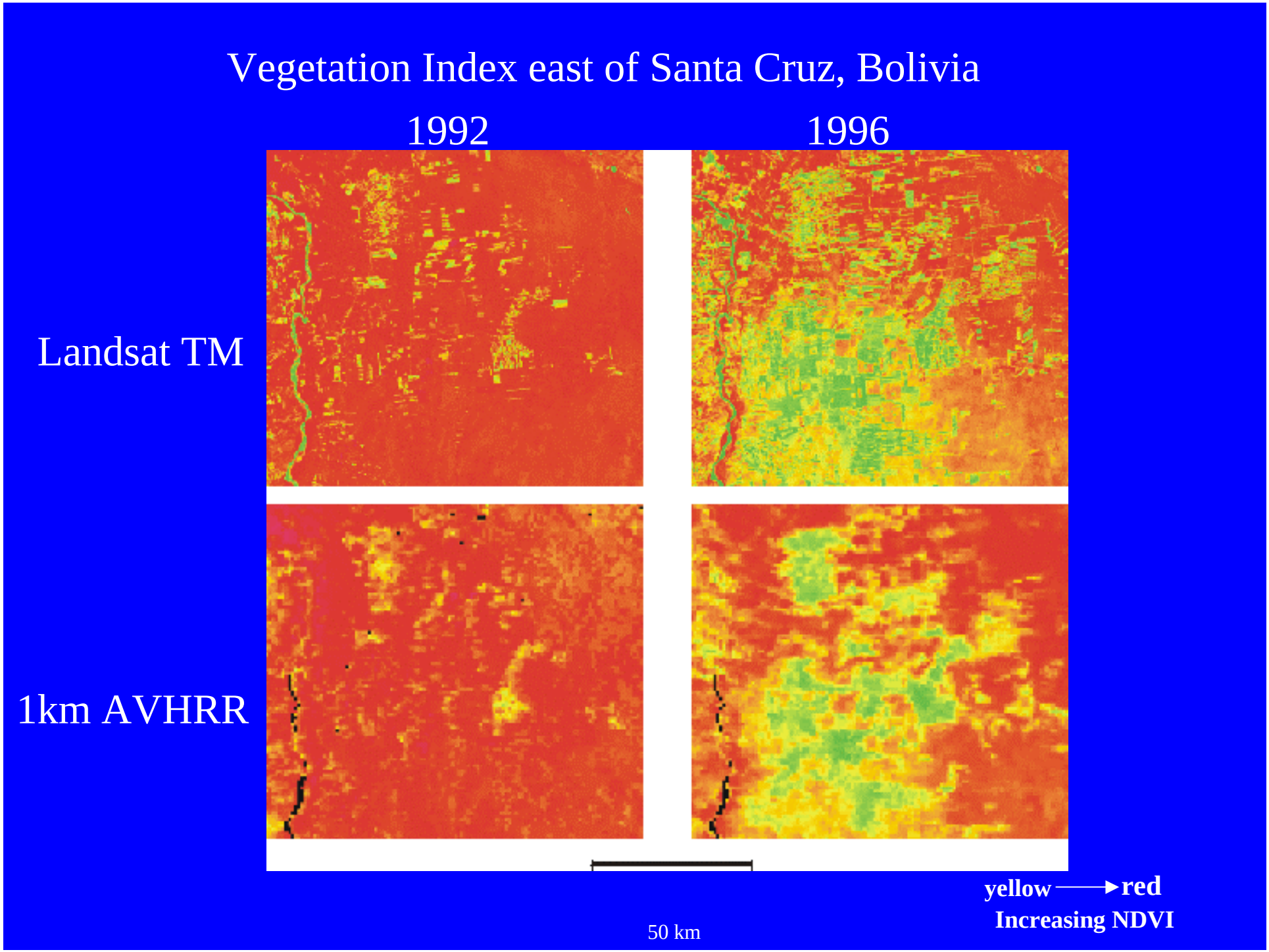
Objective 2: Develop and test automated procedures for mapping tree cover at repeated intervals from coarse resolution data

- *Test techniques combining decision tree with mixture model algorithms*
- *Improve automation through*
  - *-outlier identification for training data*
  - *-automated selection of multitemporal features*
  - *-machine learning techniques for enhanced performance of decision trees*

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

- *Apply methodology to at least 2 years of 1km AVHRR data (1992-93 and 1995-96) until MODIS time series avilable*
- *Compare results with high resolution for areas with both stable and rapidly changing areas*

Vegetation Index east of Santa Cruz, Bolivia

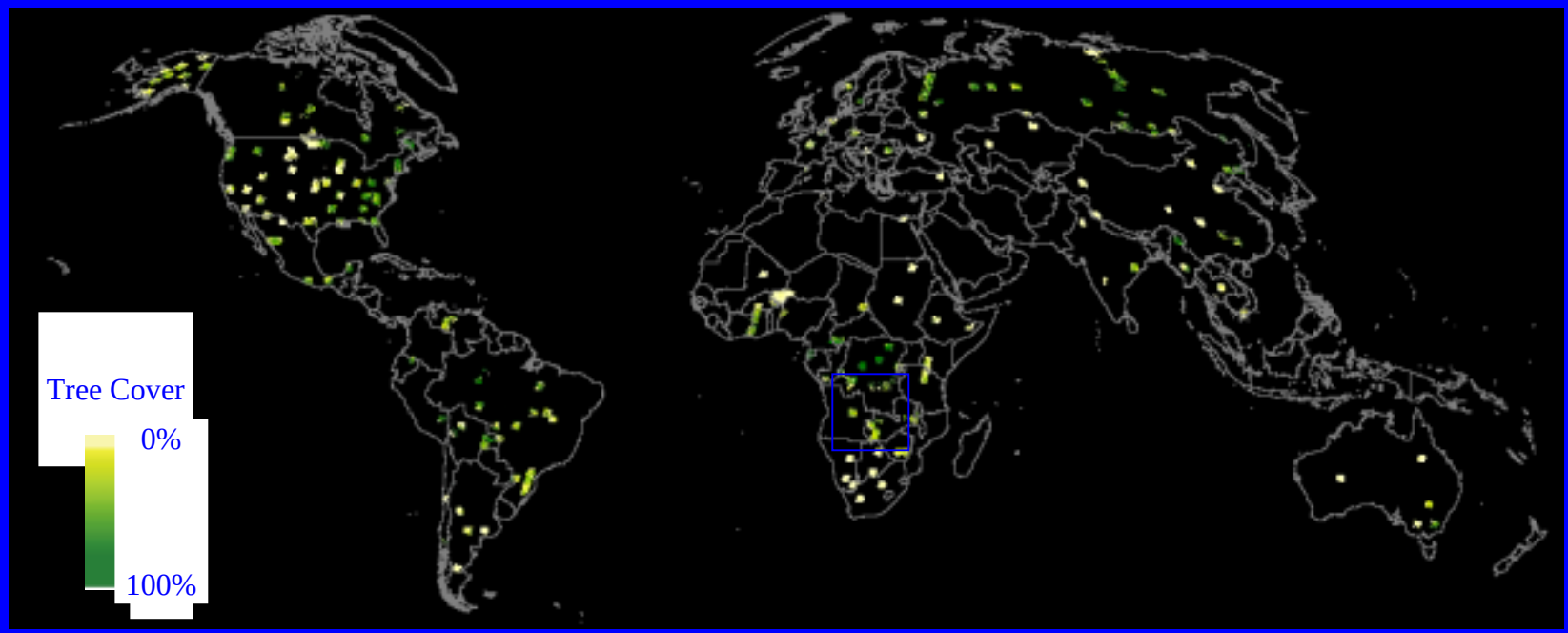


Objective 4: Provide prototype data sets and descriptions of methodologies to GOFC community through UMD Global Land Cover Facility

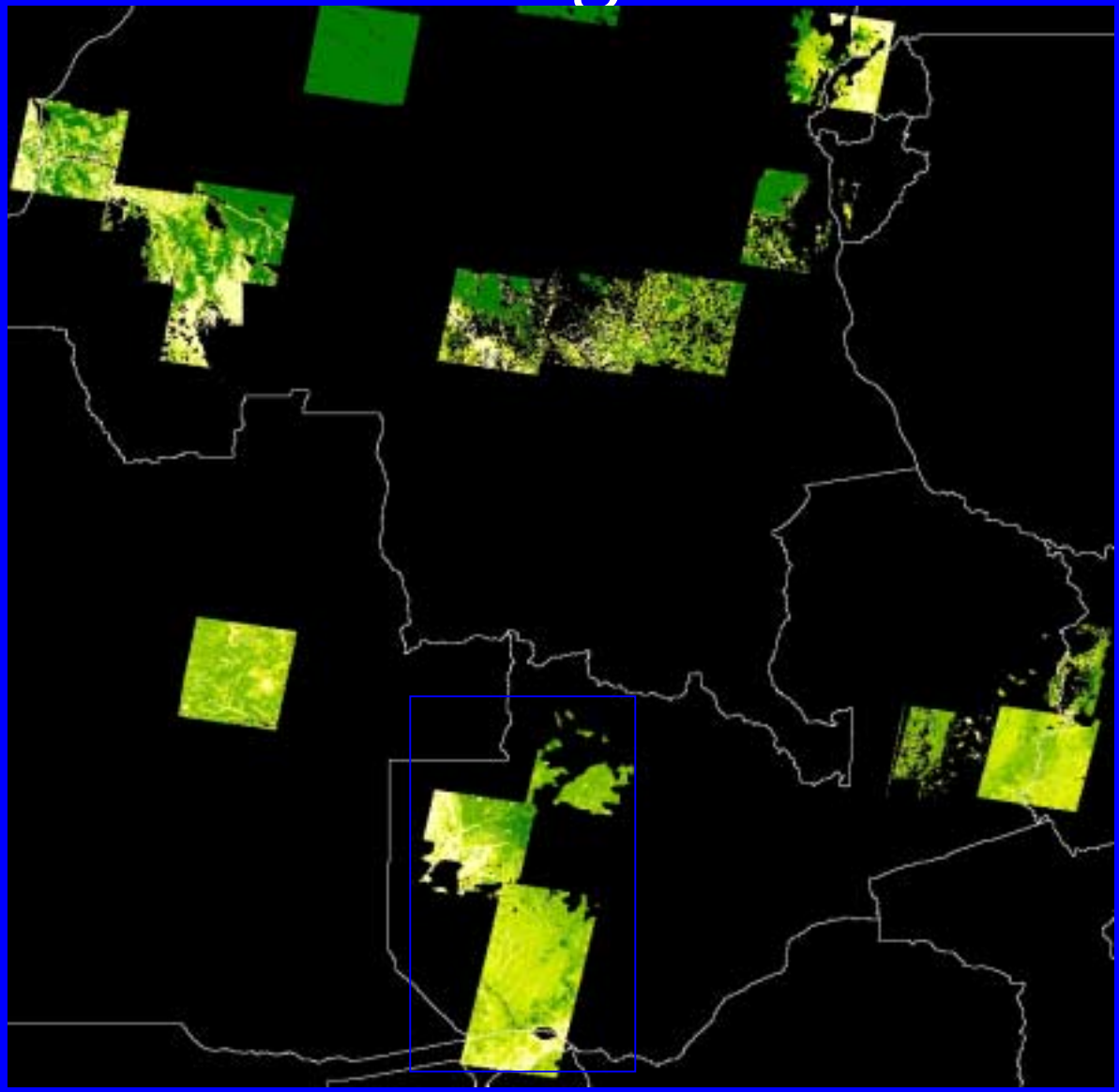
Current Work

- Finalize operational tree cover algorithm
  - Use continuous training data
  - Employ regression tree with mixture model at each node
  - No retouching, use node statistics for informing user on confidence levels
  - Use on 1992-93, 1995-96 global AVHRR data and continental U. S. MODIS data

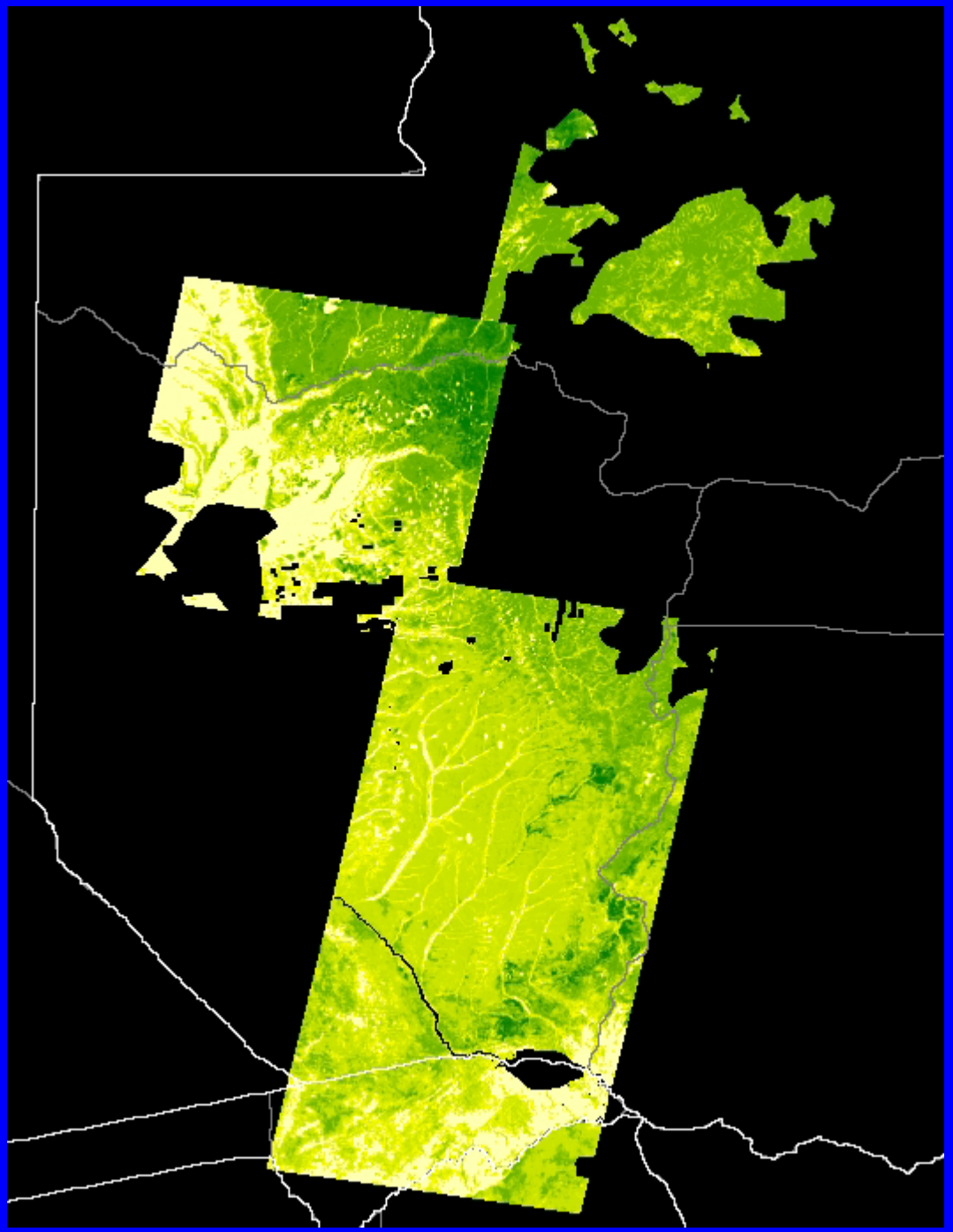
Global continuous fields tree cover training data set



South-central Africa 1km tree cover training data

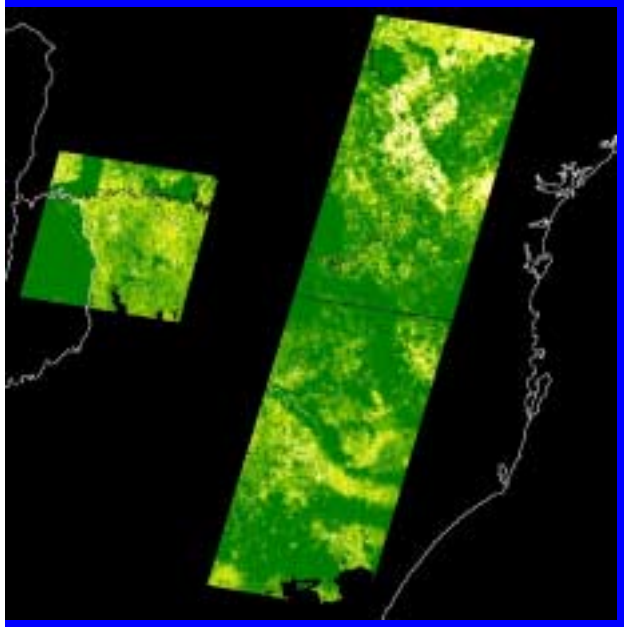


Western Zambia 1km training data

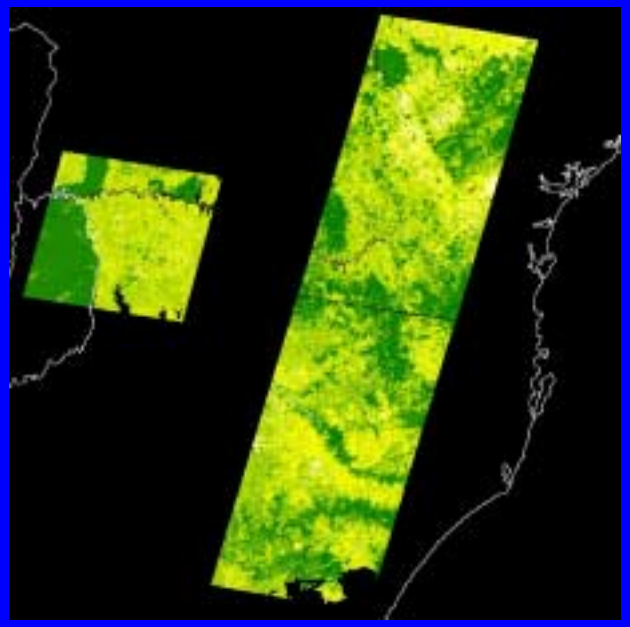


Comparison with training pixels

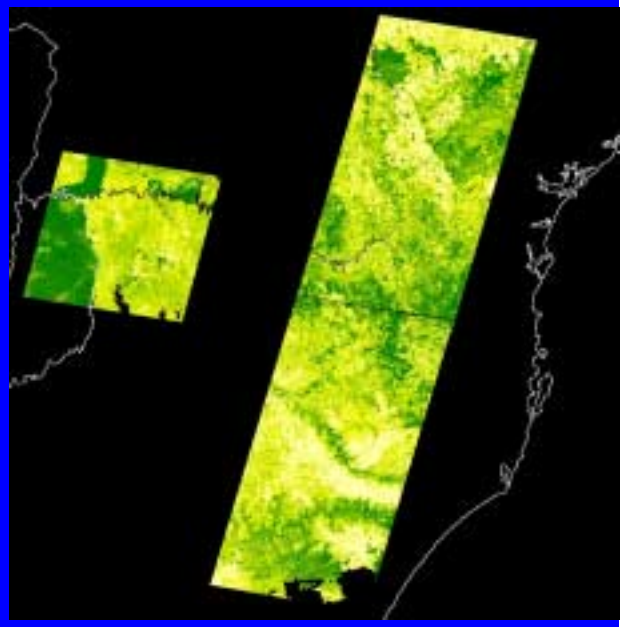
Southern Brazil



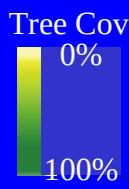
1992-93 prototype



1995-96 prototype

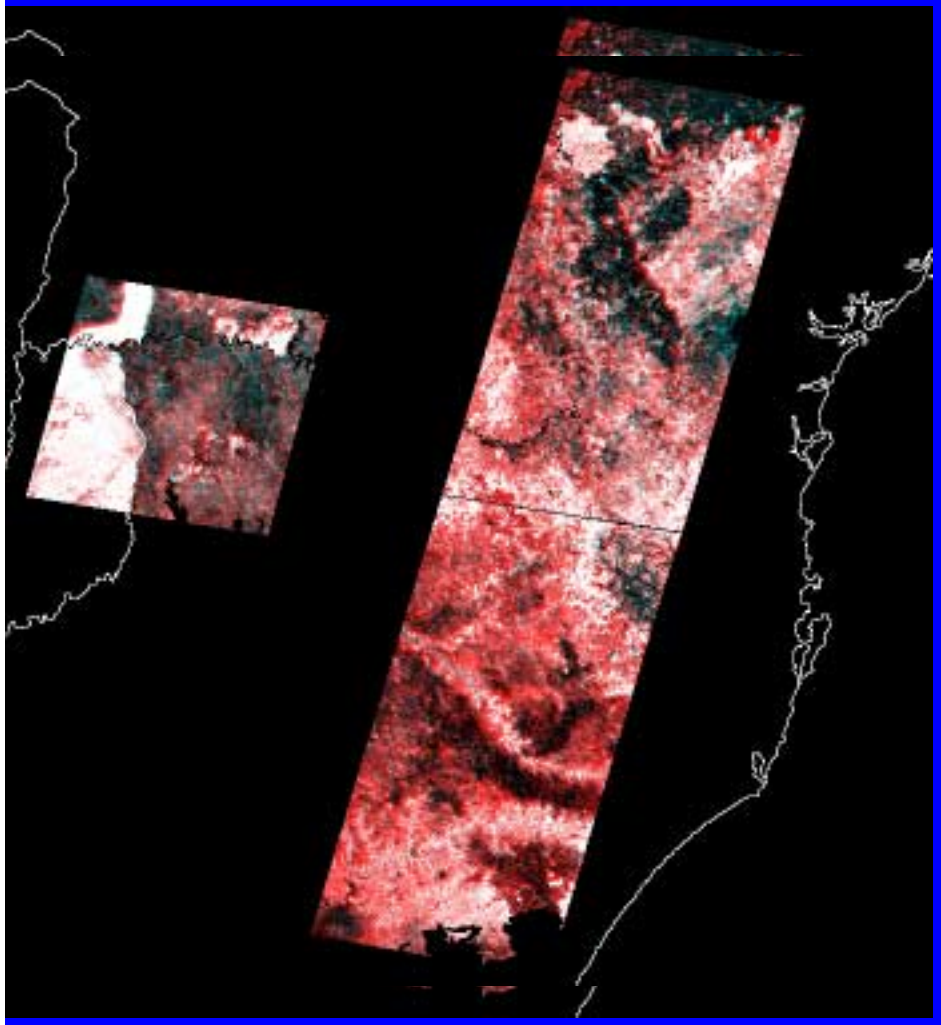


TM-derived 1km training data

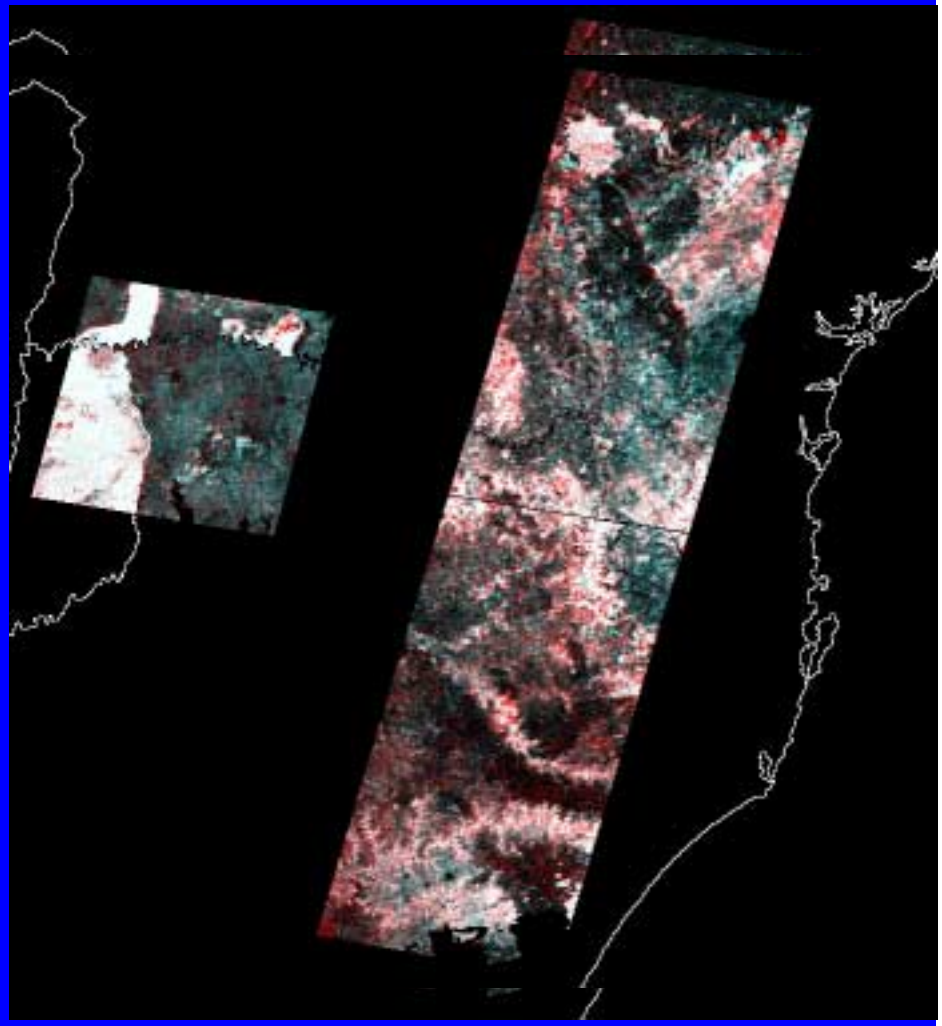


Product vs. training

red=overestimation, cyan=underestimation

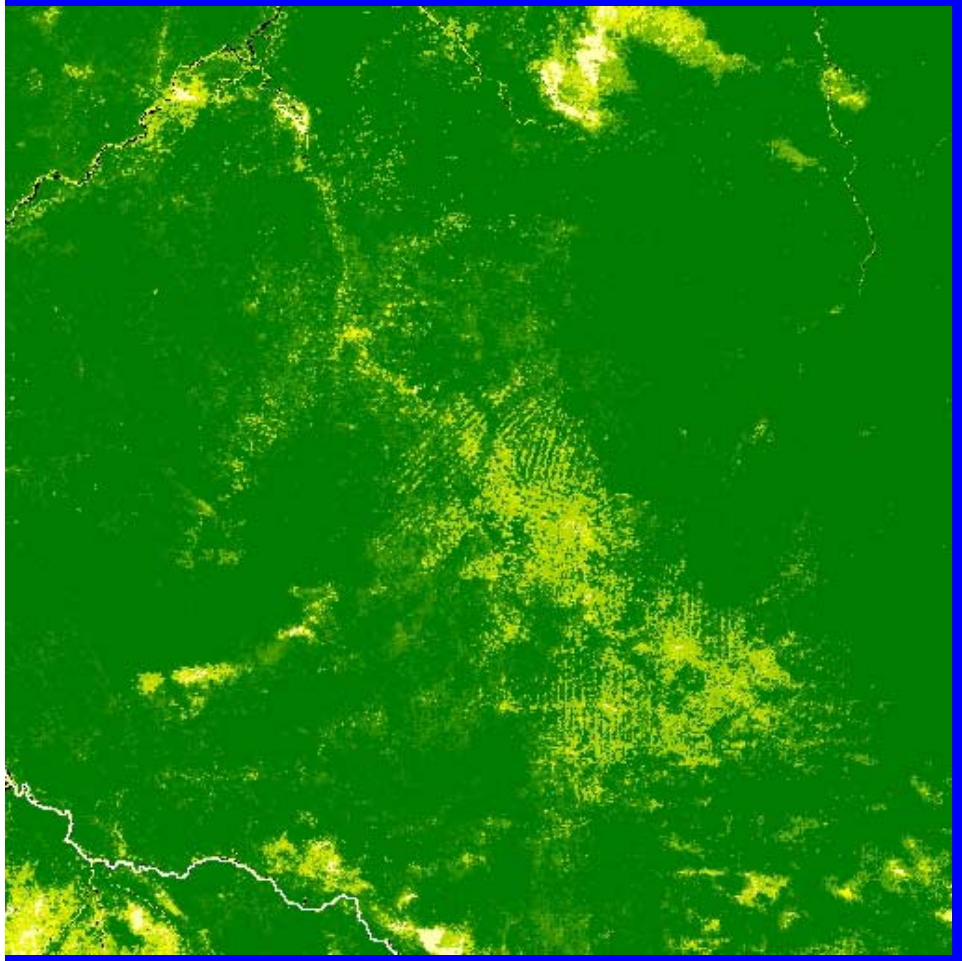


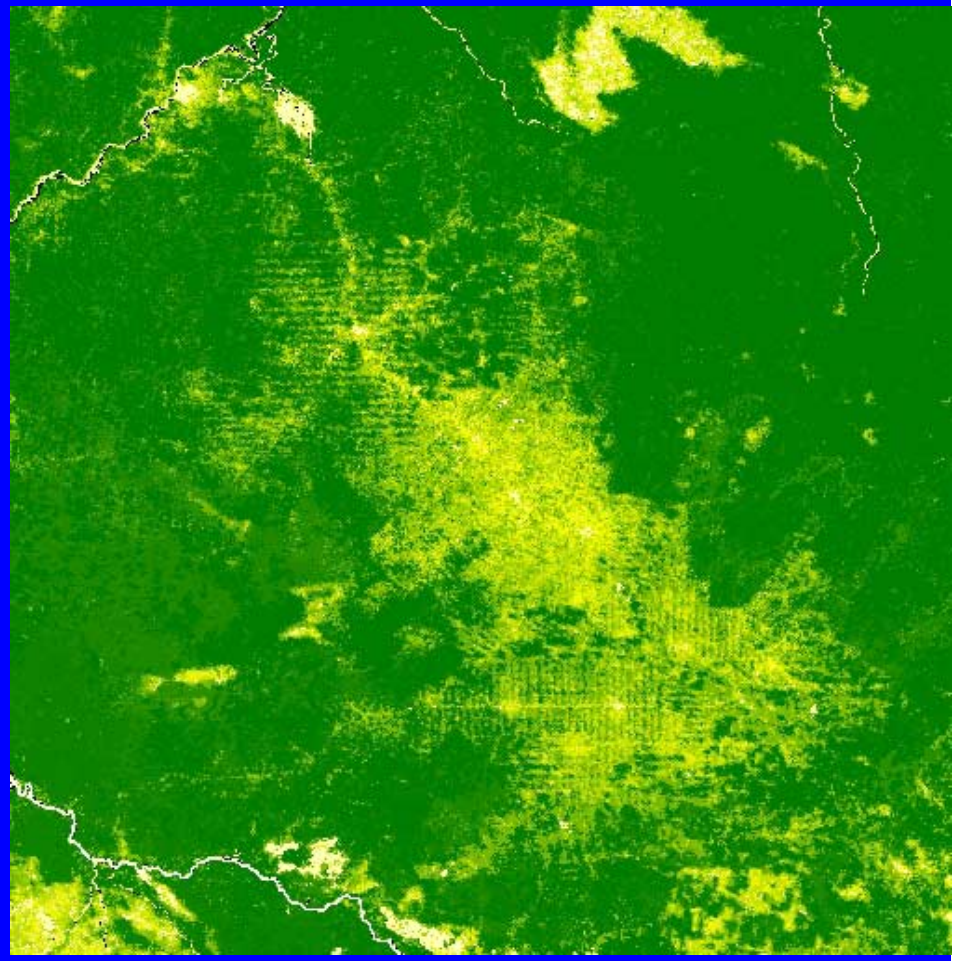
1992-93 prototype



1995-96 prototype

Rondonia, Brazil





Tree Cover
0%
100%

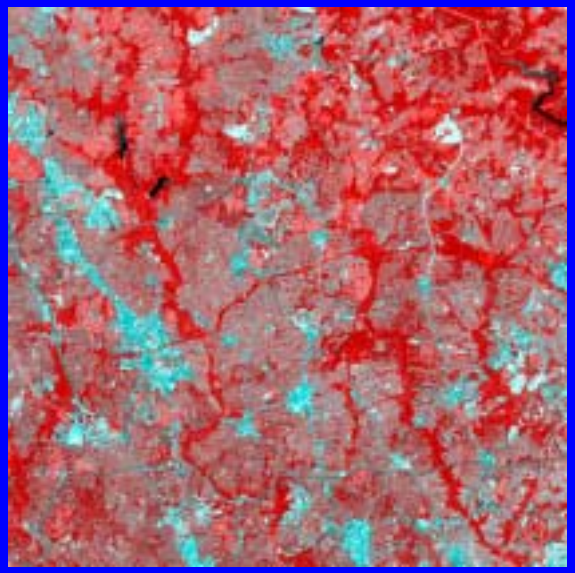
1992-93 prototype

1995-96 prototype

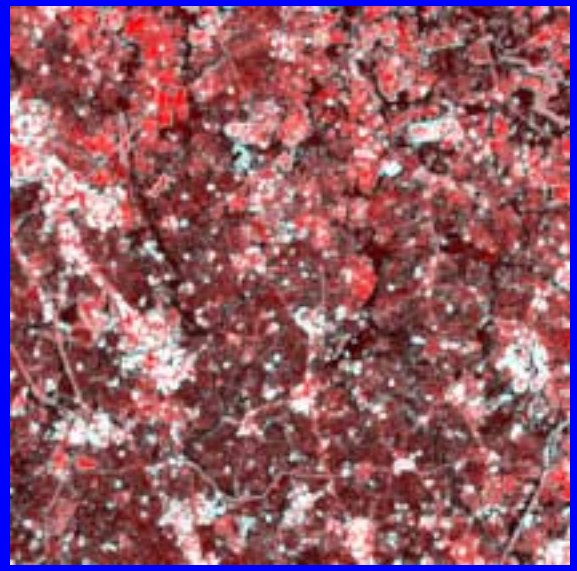
Current Work

- Finalize field work methodology for deriving TM level validation/training data tied to canopy cover variable
  - Sample TM imagery using nested random sampling
  - Sample field sites randomly from spatial and spectral domains
  - Find sampled signatures using filters for access and homogeneity
  - Two-tiered level of intensity for field sites
    - Level 1--using aerial photos, IKONOS availability, drive-by evaluation of broad tree cover categories
    - Level 2--using field intensive measurements of canopy cover

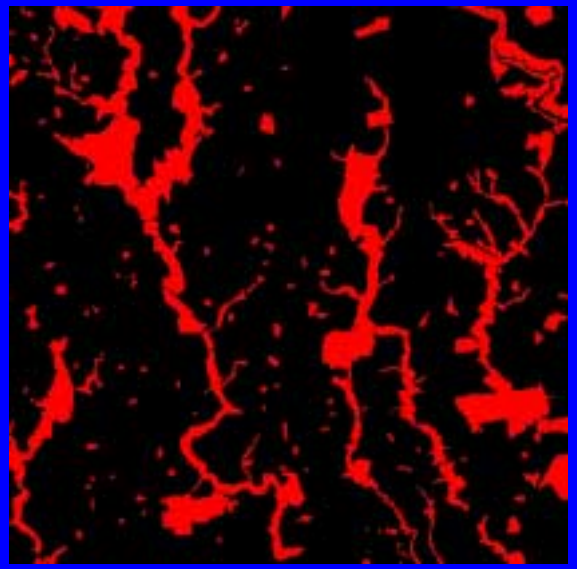
Locating field sites



Bands 4 and 3 of TM for 20 km x 20 km sampling frame

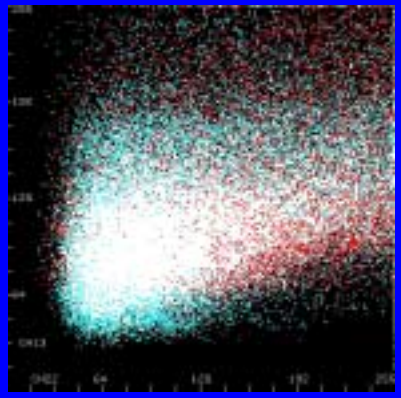


For candidate pixel, red = spectral distance, cyan = local texture



Red = public access land

Texture (heterogeneity)



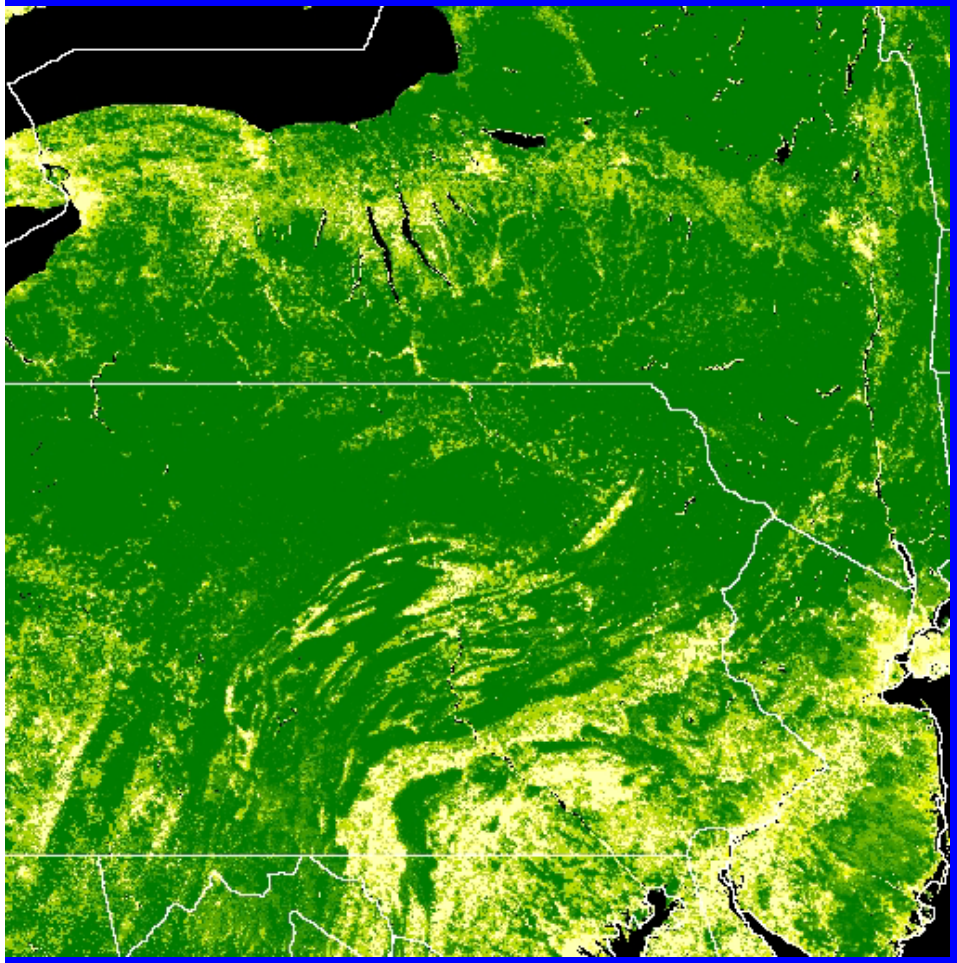
Spectral proximity

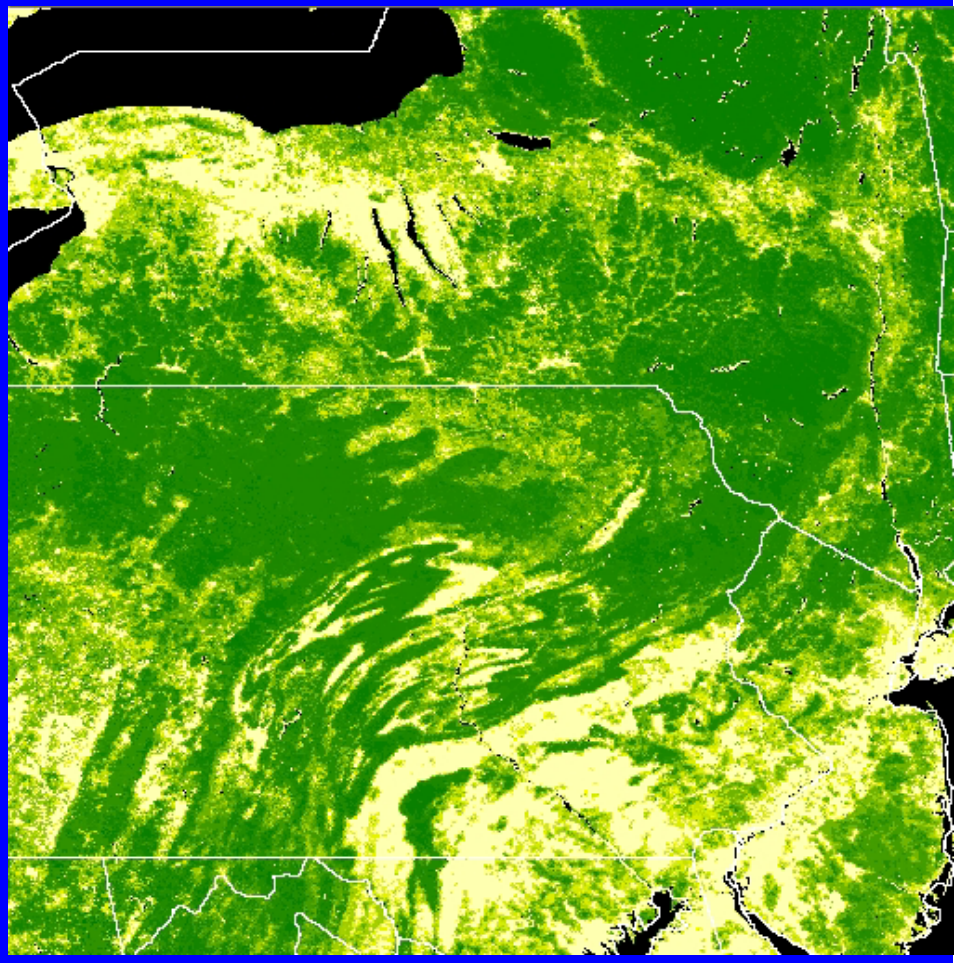
Red=all pixels
Cyan=pixels in public lands

Field measurements of tree canopy cover

Laser instrument reports whether the canopy immediately above is open or closed and the distance from the ground to the first leaf.

Improved characterization with continuous training dataset





Tree Cover

0%

100%

1992-93 prototype

1995-96 prototype