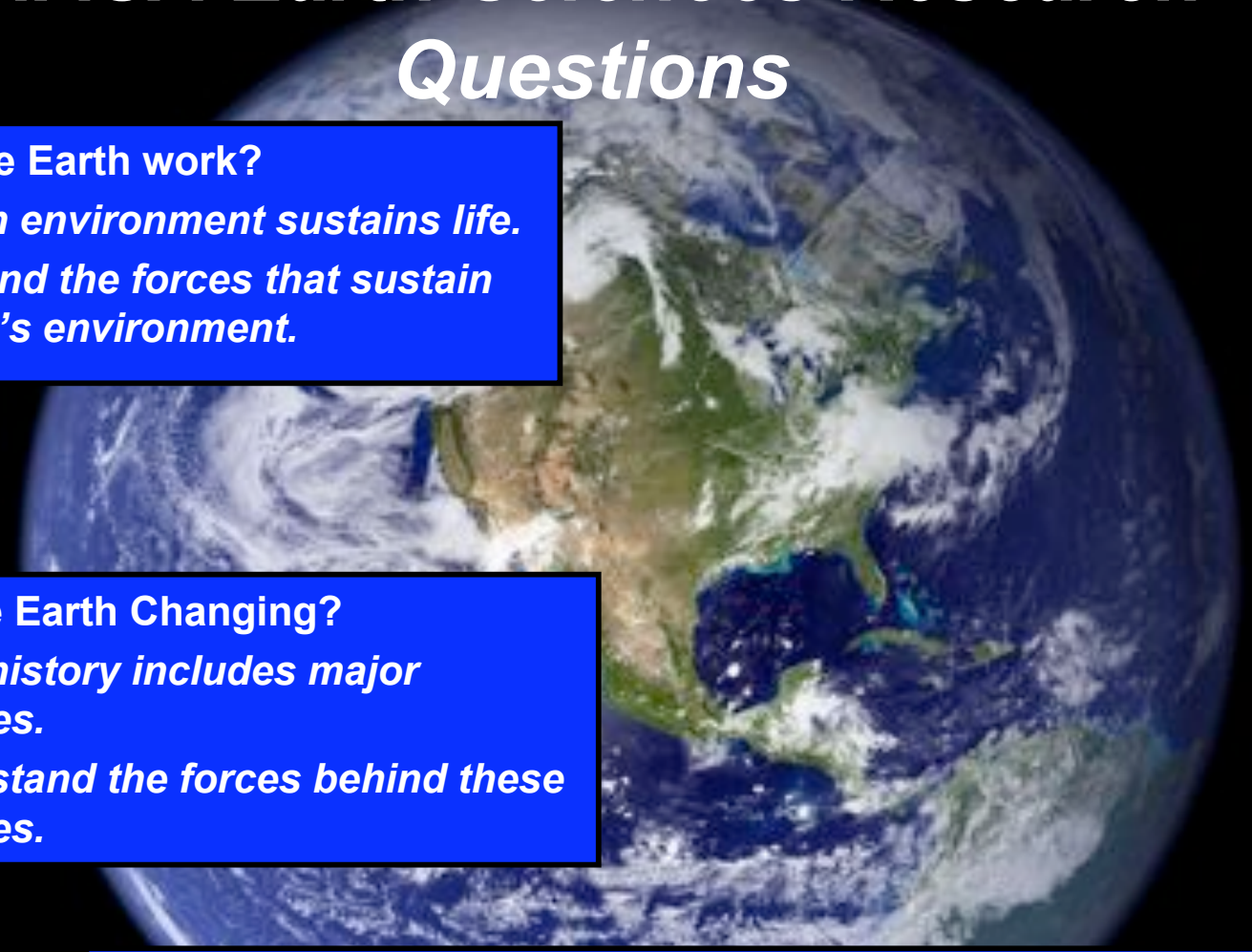

NASA
Jason-1
Landsat 7
QuikSCAT
ERBS
ACRIMSAT
Aqua
Terra
TOPEX/Poseidon
TRMM
SAGE III/METEOR-3M
UARS
SORCE
GRACE
SeaWiFS
EP-TOMS
NMP/EO-1
ICESat
Aura

NASA Earth Sciences Research Questions



How does the Earth work?

- *The Earth environment sustains life.*
- *Understand the forces that sustain the Earth's environment.*

Why is the Earth Changing?

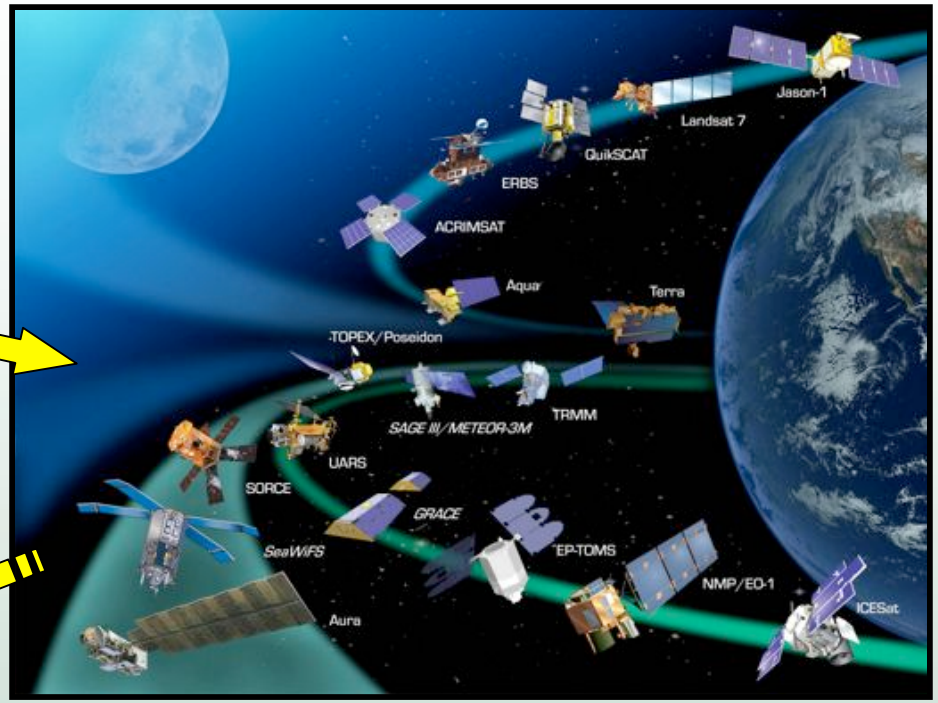
- *Earth history includes major changes.*
- *Understand the forces behind these changes.*

What do these changes mean for life on Earth?

- *Changing Earth conditions change ecosystems and habitability.*
- *Understand the forces that change Earth habitability.*

The NASA Role in Earth Sciences Research

- Develop satellite Earth observation systems
  - *for Weather and Climate Research*
  - *for Operational Transition (e.g. to NOAA)*



- Utilization of satellite climate data
  - *Develop highly accurate climate data records*
  - *Develop and provide data analysis algorithms*
  - *Provide access to climate data*

- Satellite data applications
  - *Provide Earth observations tuned to user's needs*
  - *Hand off data access to users*
  - *Collect and provide unique data sets*

Fire Disturbance and Man

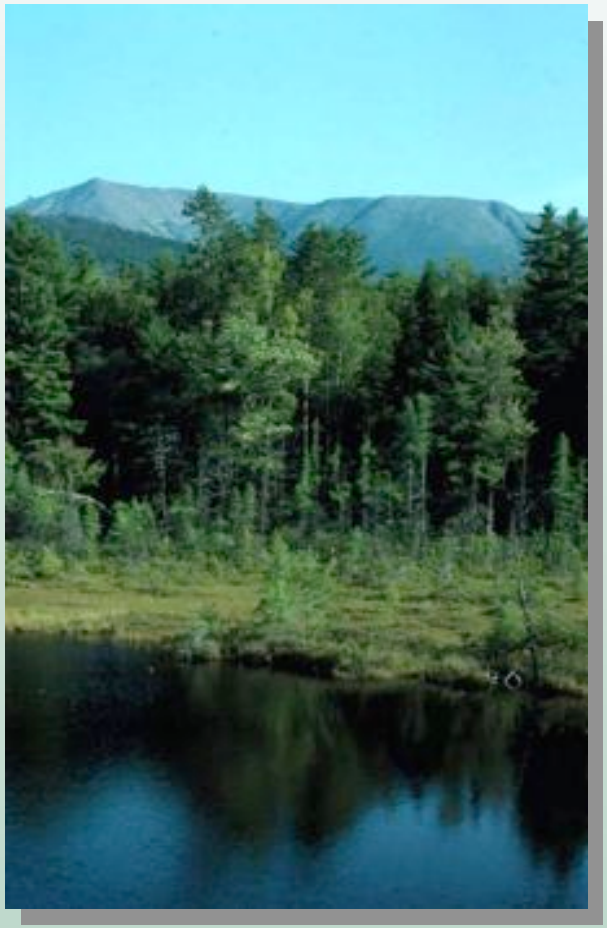
Using Satellite Data to Track the World's Forests

Dr. Jeffrey G. Masek
Biospheric Sciences Branch
NASA Goddard Space Flight Center

What's a Forest?

•Over 240 definitions of "forest" used globally (Lund, 1999)

•Generally related to canopy cover (typically >10%) and tree height (> 2m)

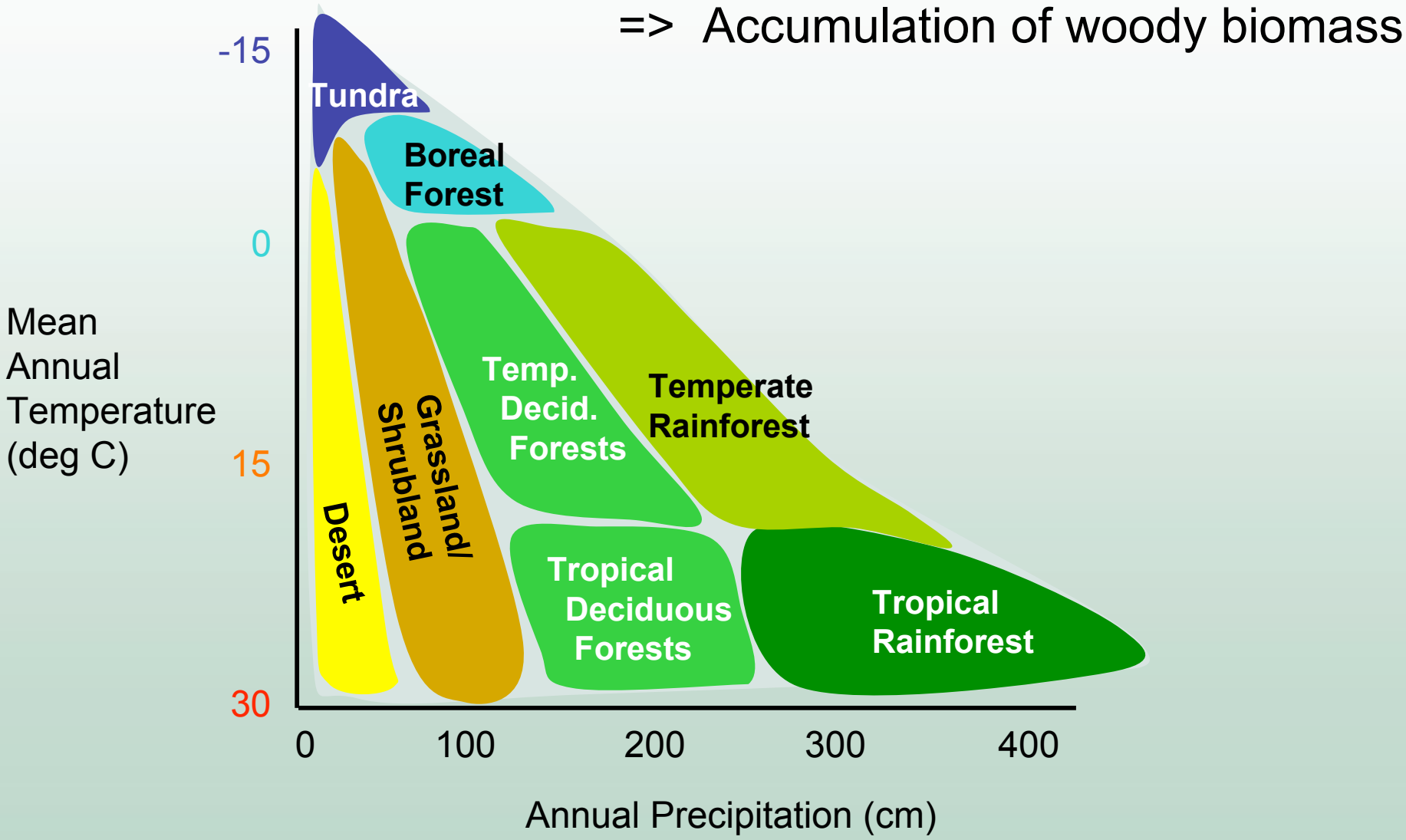


Forests and Climate

Favorable growth conditions

=> Competition for light

=> Accumulation of woody biomass



http://www.inforain.org/maparchive/world_biomes_graph.gif

Why are Forests Important? …

Carbon & H_2O Cycles

- Forests store ~600 Gt carbon– about the same the atmosphere

- Changes in land vegetation (mainly deforestation) account for ~20% of human-induced carbon flux to atmosphere

Biodiversity

- tropical forests contain 2-10x as many plant species per area as mid-latitude

Economics

- Forestry accounts for ~1.3% of US GDP, 1.3 million jobs

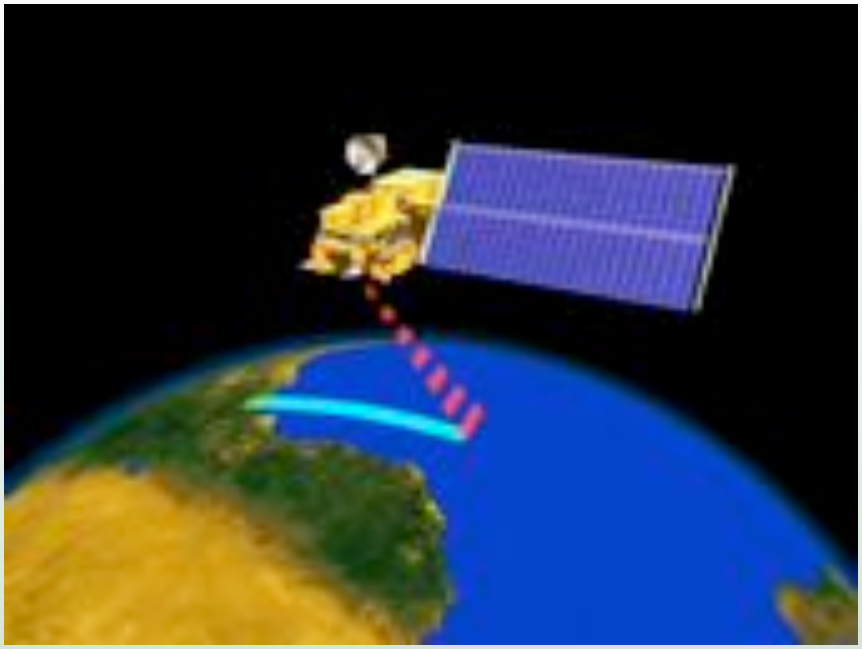
Remote Sensing Technologies for Monitoring Forests

MODIS – Moderate Resolution Spectroradiometer

Daily, global images w/ 36 spectral bands

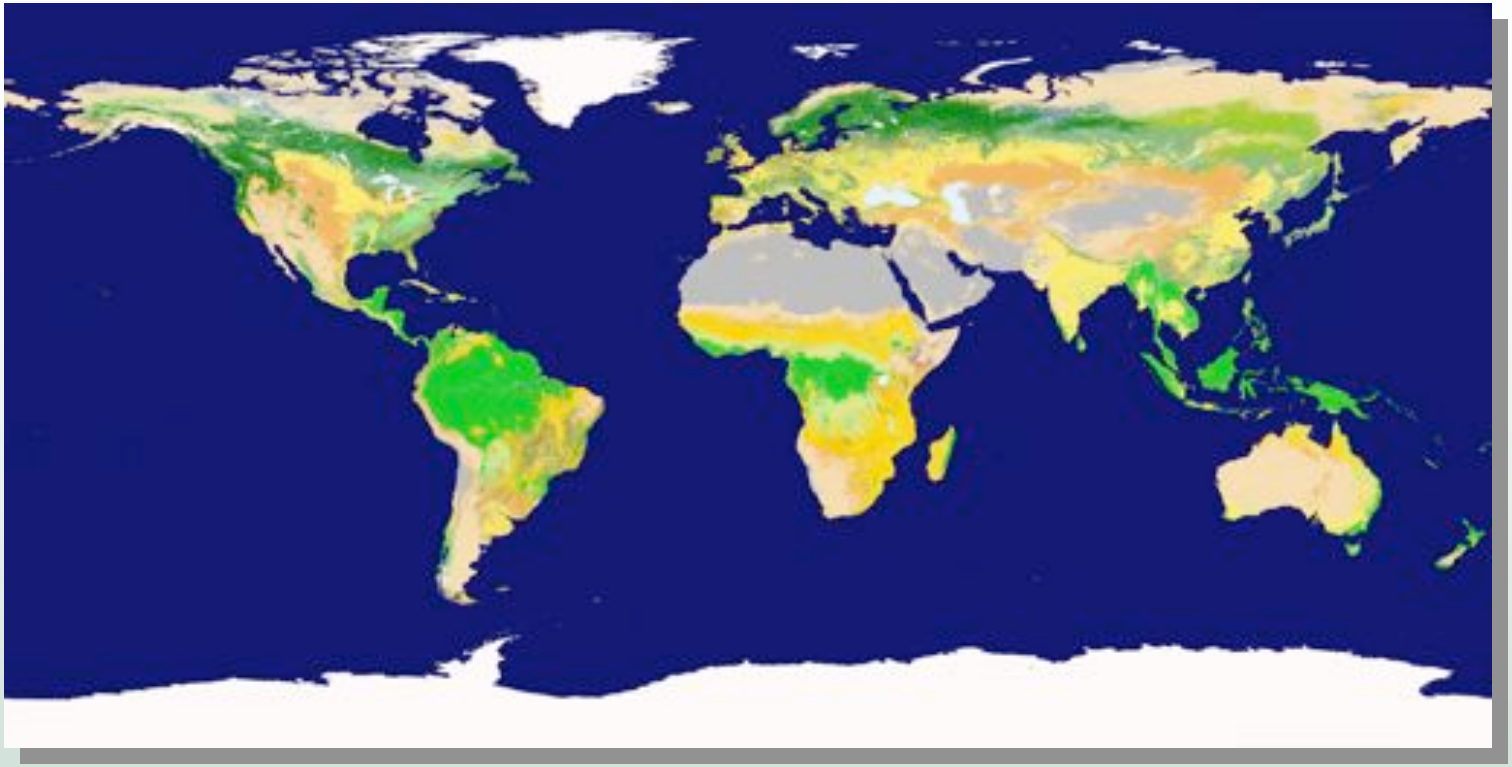
250m – 1km resolution

Launched in 1999



- **Mapping global land cover**
- **Vegetation photosynthesis / productivity**
- **Fire location, area, temperature**

MODIS Land Cover Type



How much forest is there?

34% of Land Area is Forest

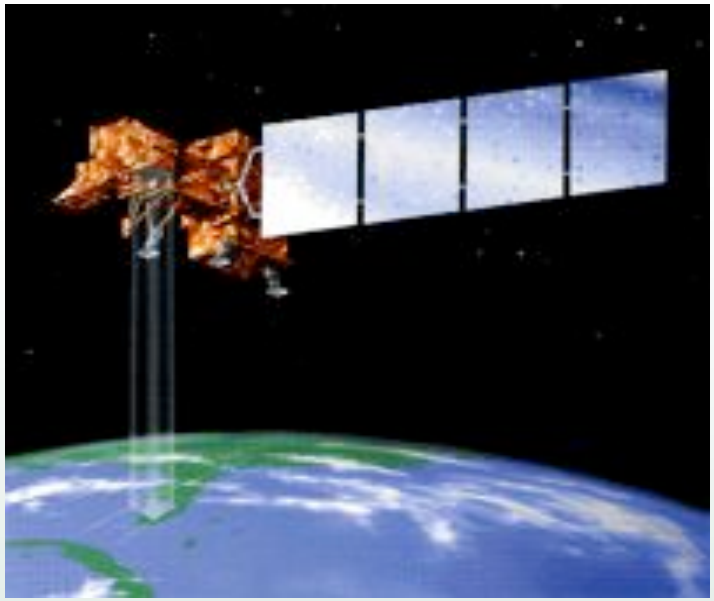
7% conifer 15% bdleaf evgreen 3% bdleaf decid

3% larch 6% mixed

20% Savannah

12% Agricultural/Natural “Mosaic”

Landsat (USGS/NASA)



- Continuous operation since 1972
- 7 Spectral bands, 30m resolution
- Seasonal global coverage (16-day repeat)

- **Detailed mapping of land cover type**
- **Monitoring land cover change**
  Deforestation
  Urbanization
  Natural Disturbances
- **Consistent, Objective, Global View of Forest Change**

How are Forests Changing Around the Globe?

Changes in Forest Cover: the Global View

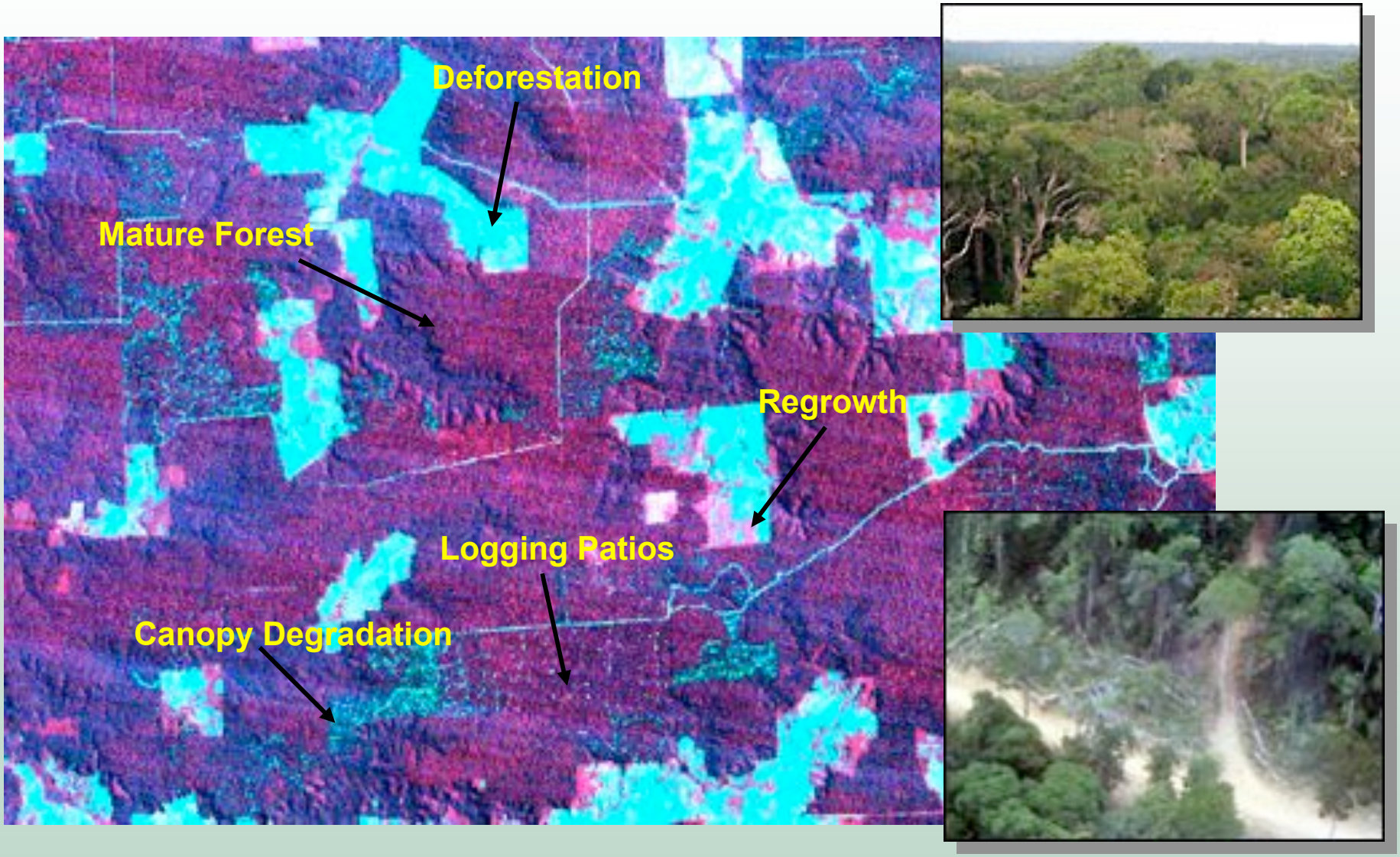
	2000 Forest Area (k Ha)	% Change/Yr 1990-2000
D R Congo	135,207	-0.4
Tanzania	38,811	-0.2
Thailand	14,762	-0.7
Peru	65,215	-0.4
Brazil	543,905	-0.4
China	163,480	1.2
Russia	851,392	0
Finland	21,935	0
United States	225,993	0.2
Canada	244,571	0
Globe	3,869,455	-0.22

Source: UNEP FRA2000

Tropical Deforestation

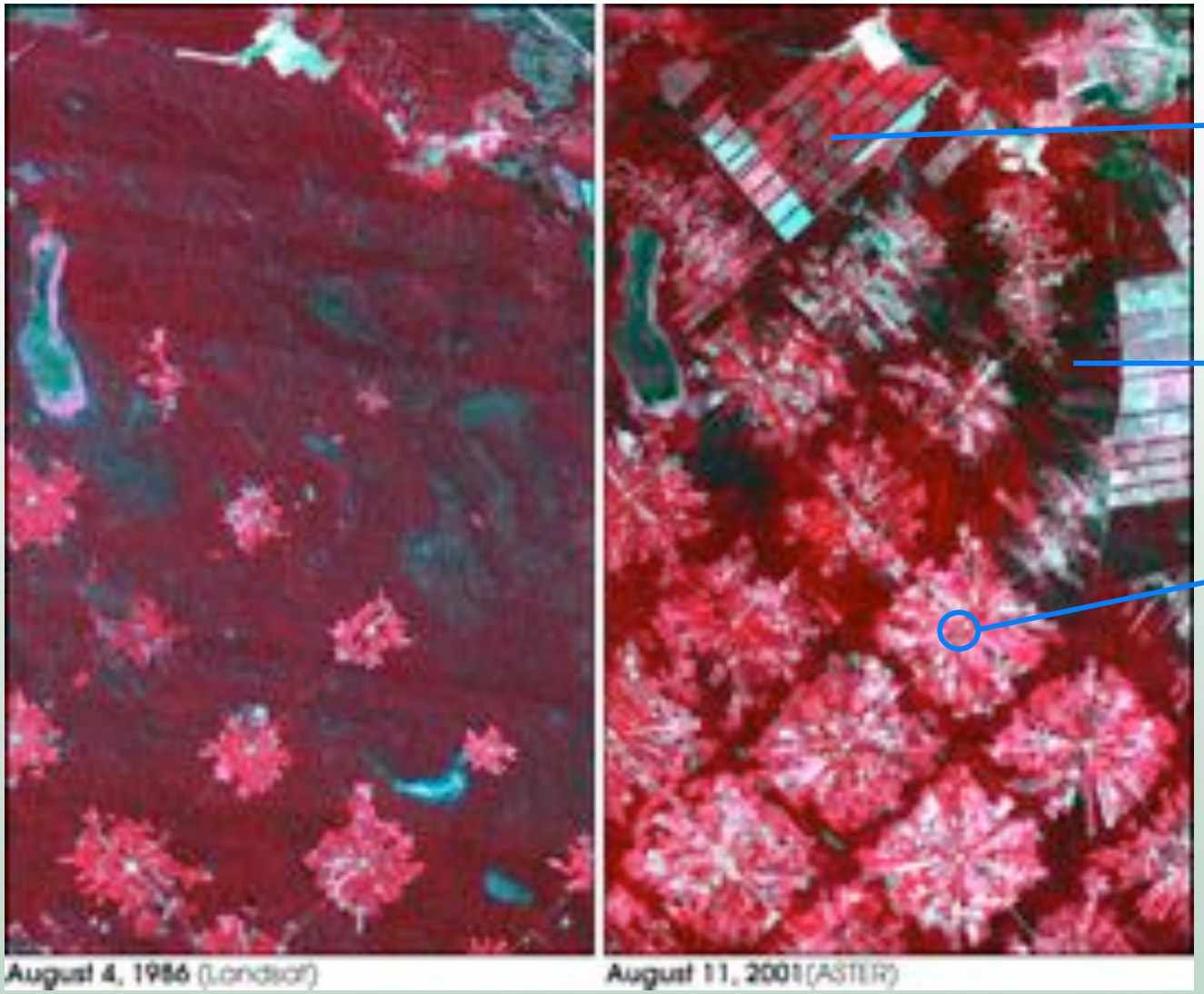
September, 1989

Example: Amazonian Forest Change



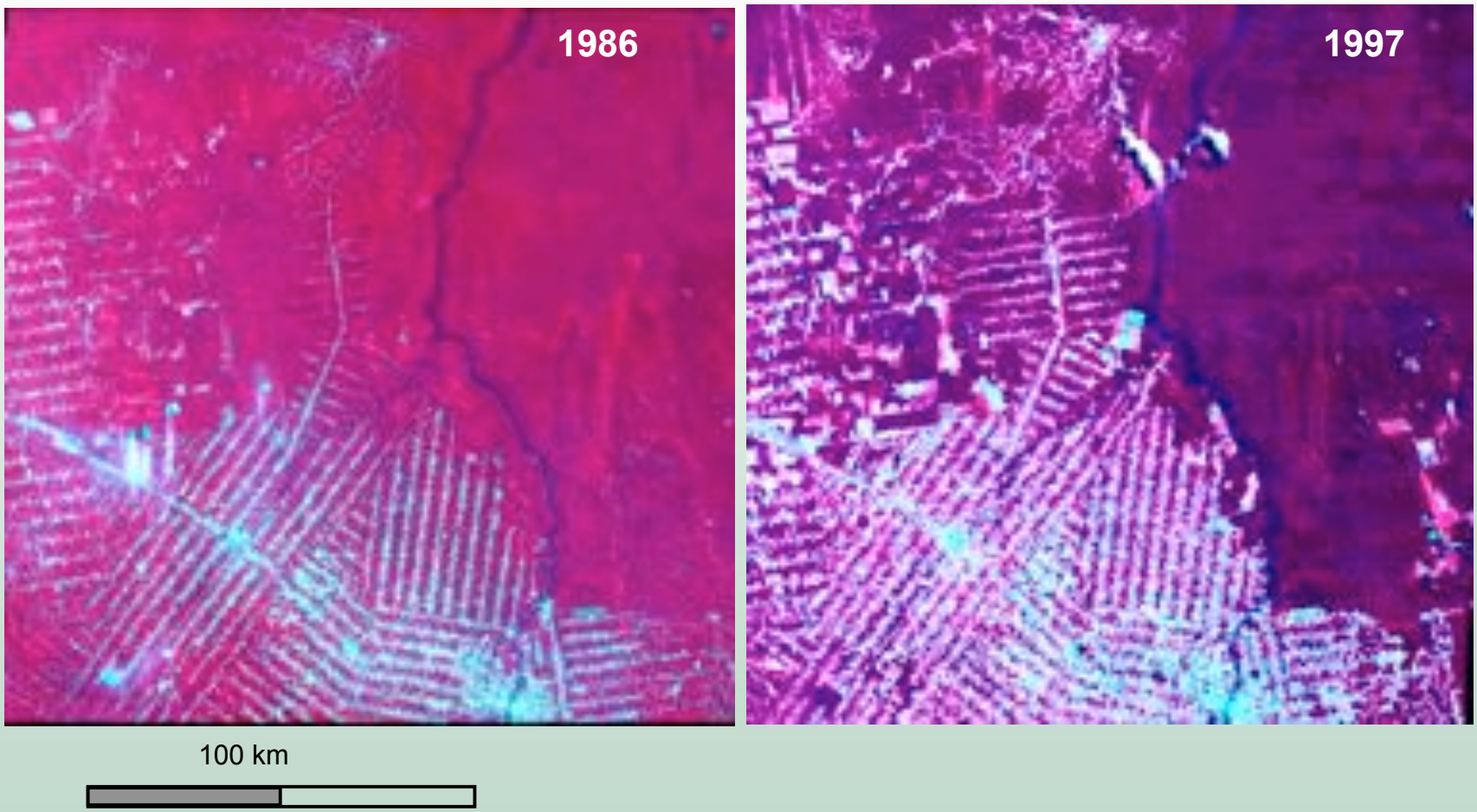
Courtesy David Skole, MSU

Tierras Bajas resettlement project, Santa Cruz Bolivia



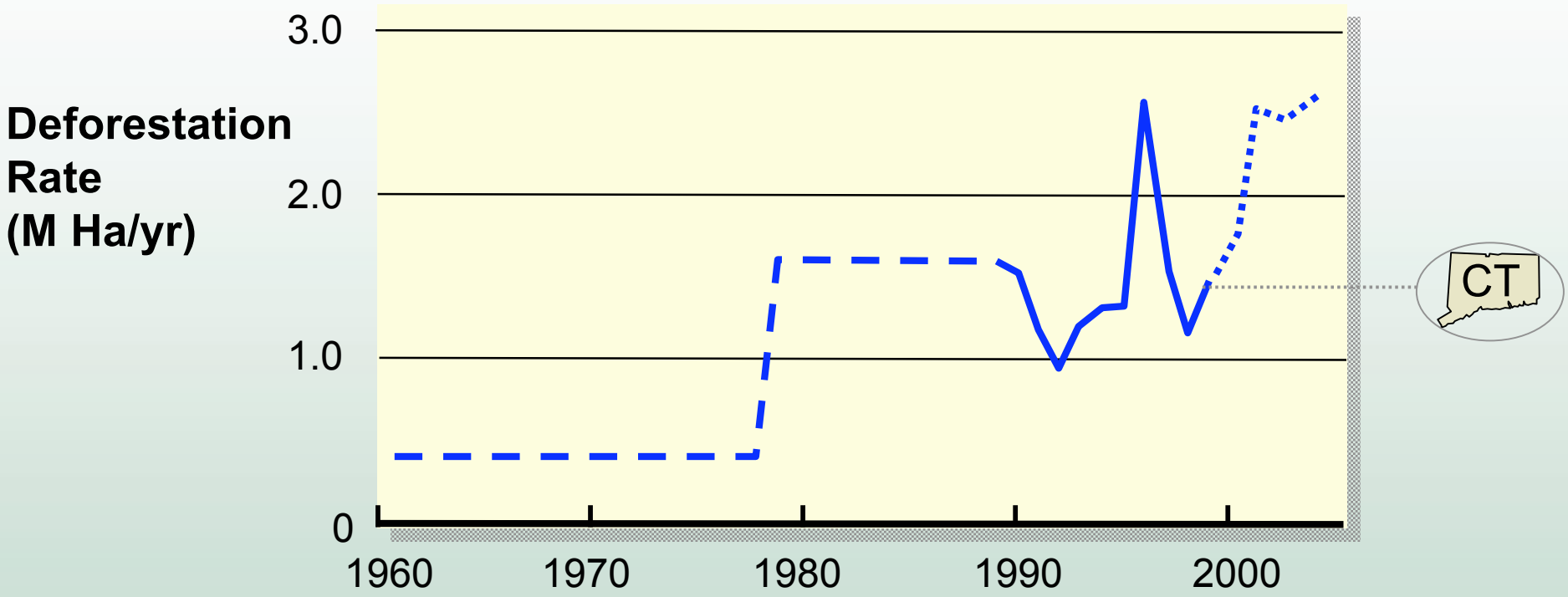
1986 2001

“Herringbone” Deforestation Pattern, Rondonia Brazil



Courtesy TRFIC–MSU, Houghton et al, 2000.

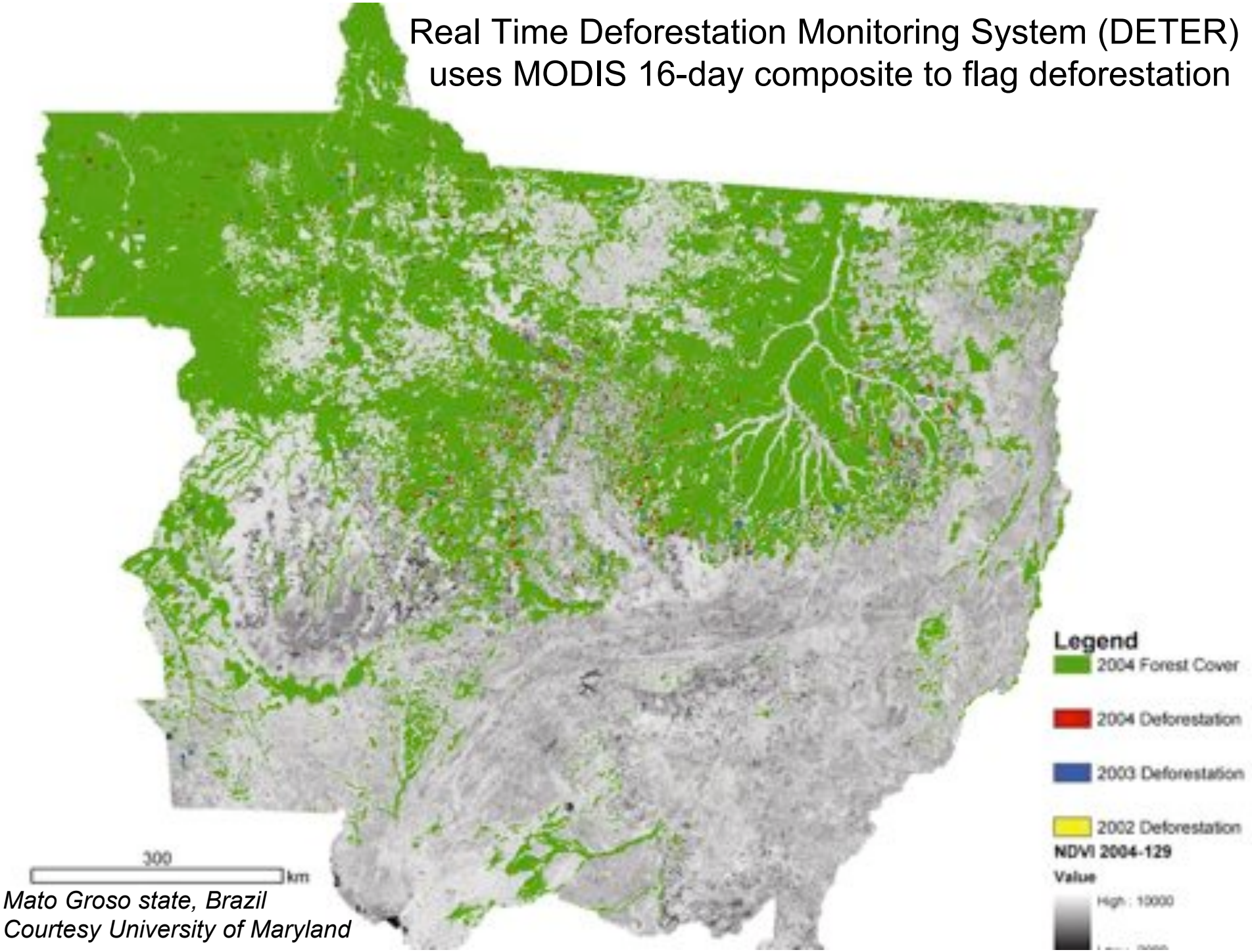
Deforestation Rates in the Brazilian Amazon



Total Area Deforested:
648,000 km2 (~90% since 1970)
= ~12% of original area

Sources: Houghton et al, 2000
INPE/Brazil ; Fearnside 2005

Real Time Deforestation Monitoring System (DETER) uses MODIS 16-day composite to flag deforestation



Mato Groso state, Brazil
Courtesy University of Maryland

Aspects of Tropical Deforestation

- Importance of industrial agriculture (e.g. soybeans, cattle) vs. subsistence farming and homesteading

- Fluctuations in deforestation rate linked to commodity prices and other macroeconomic indicators

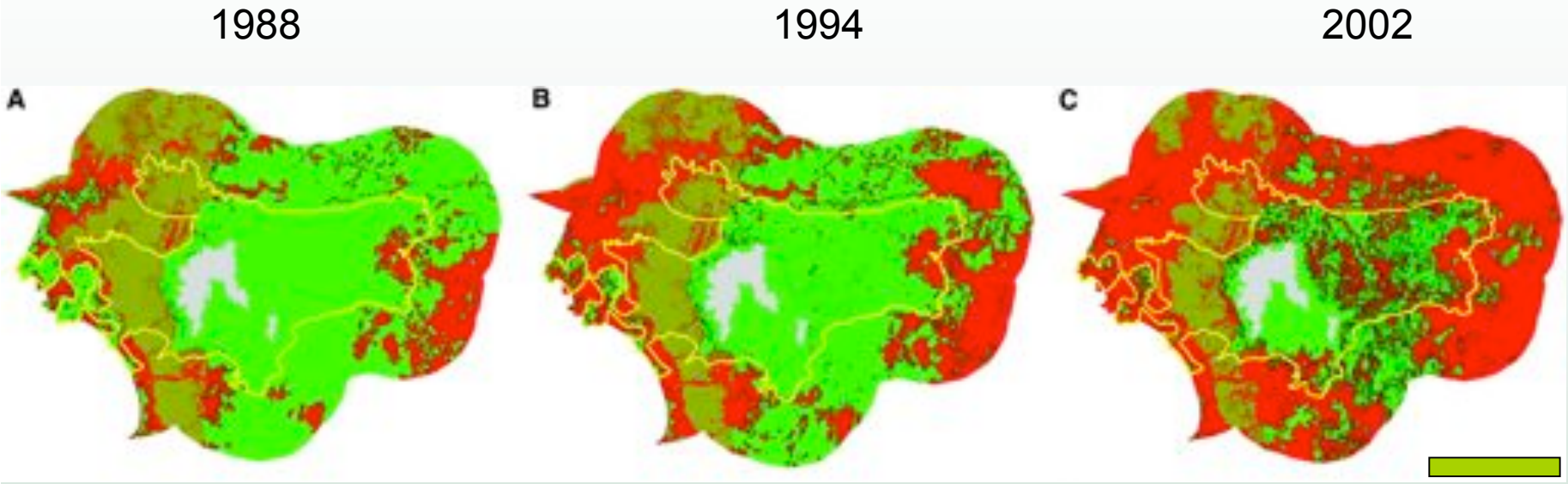
- National policy and enforcement plays an important secondary role

- Ecological roles of selective logging and forest "degradation" may be critical (and hard to monitor)


5km

Gulung Palung National Park, Borneo, Indonesia

Images from Gunung Palung web site



- Forest clearing in Gunung Palung National Park (yellow line), 1988-2002, from Landsat imagery
- Since the mid-1980's, 56% loss of lowland forests across Indonesian Borneo

Lowland forest

Non-forest

Peat forest

Montane Forest

Courtesy Curran et al., Science, 2004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Sonya Kahlenberg


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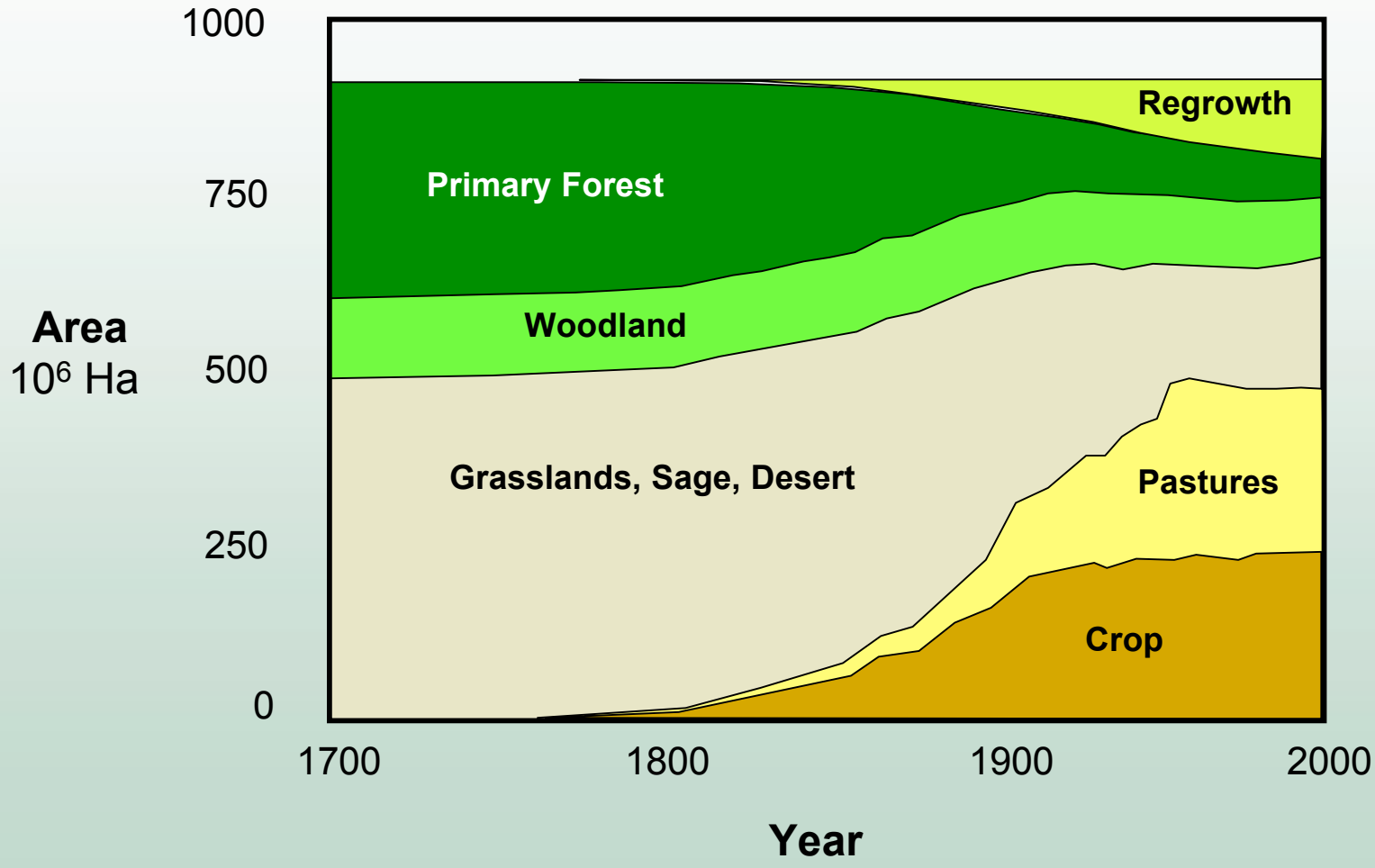
History of US Land Cover: 1700-2000



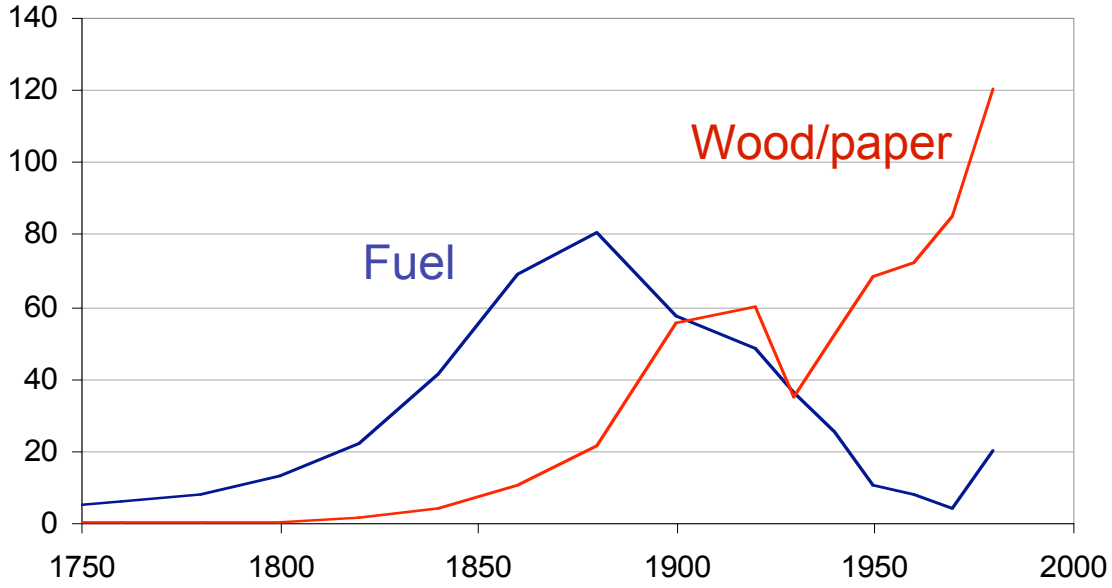
From Houghton and Hackler, 2000

Mohican State Forest, Ohio

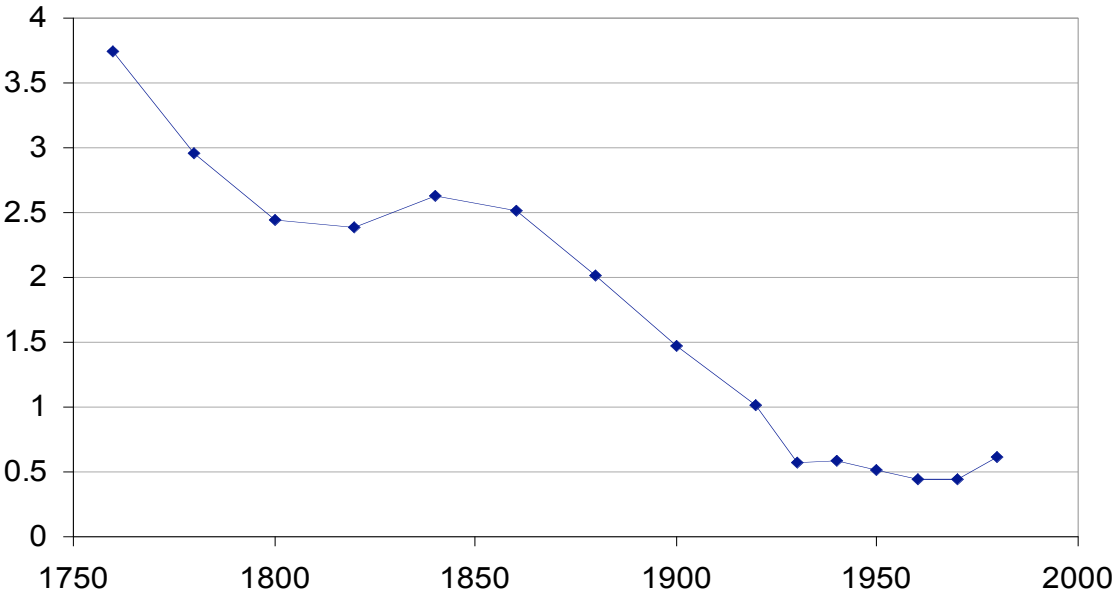
Courtesy Ohio Division of Forestry

US Harvest Patterns: 1750 - 1980

Annual wood harvest (TgC)



Per-capita wood harvest (TgC / 10^6 persons)



Data from Houghton and Hackler, 2000)

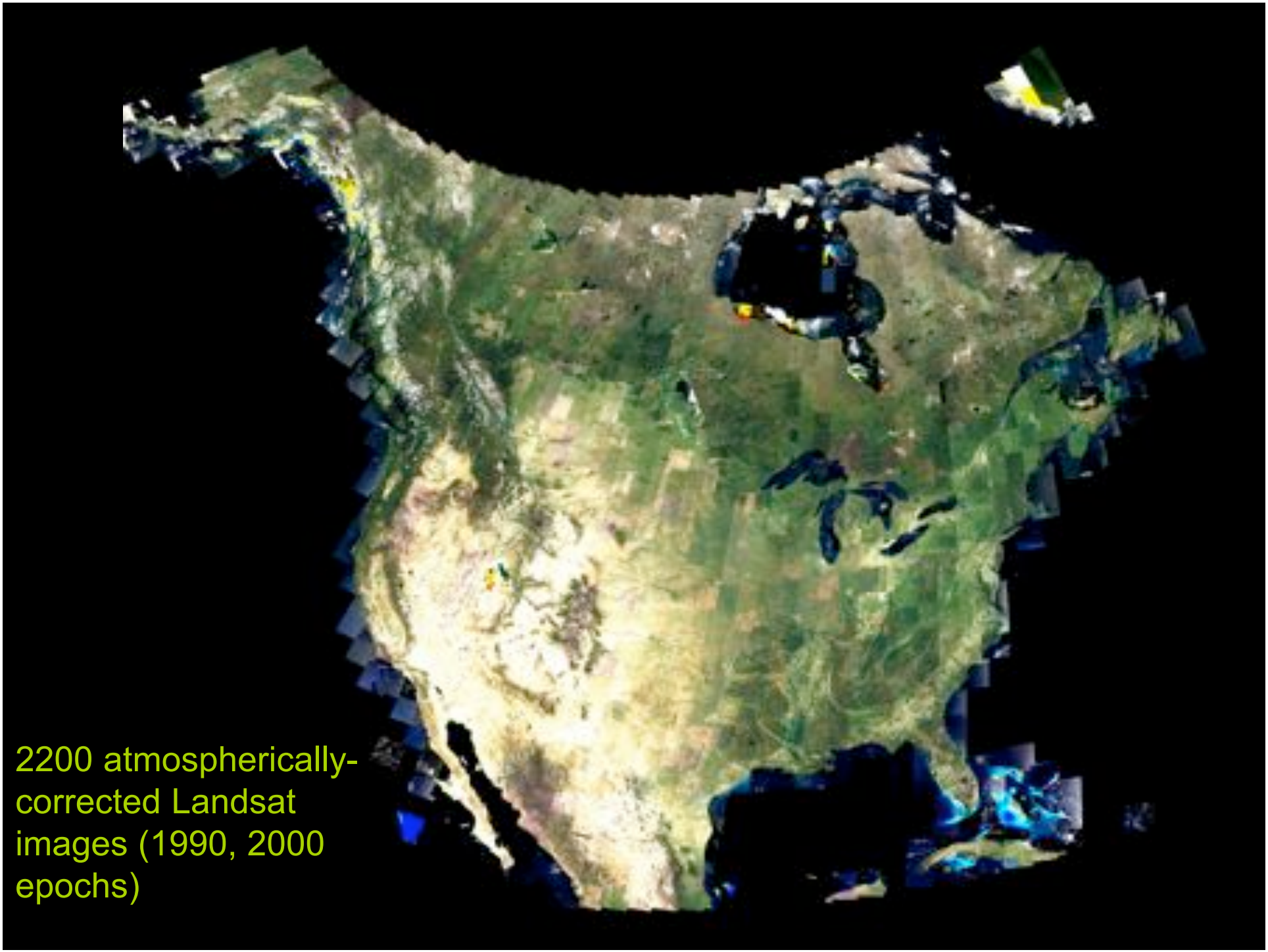
LEDAPS

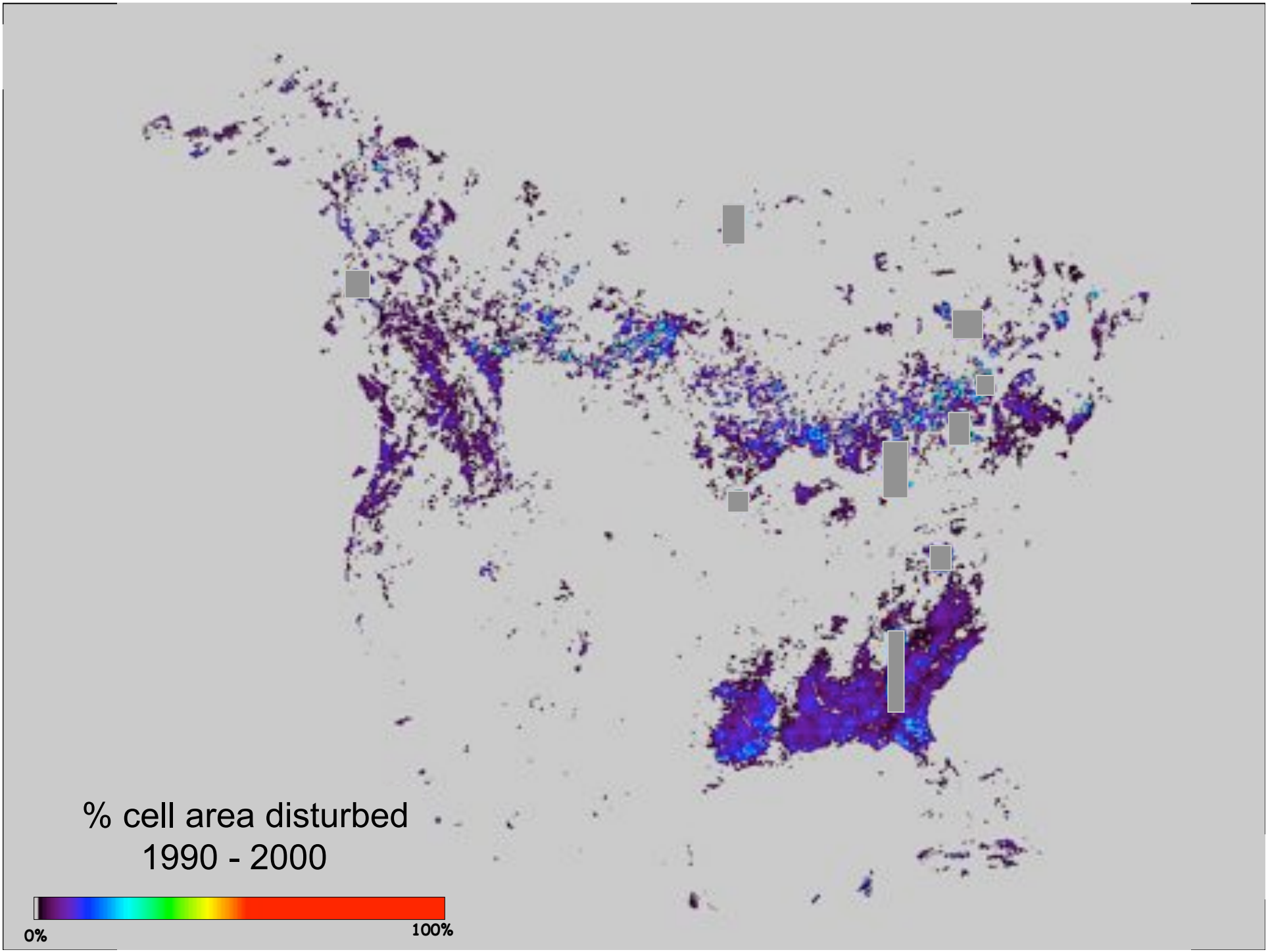
Landsat Ecosystem Disturbance Adaptive Processing System

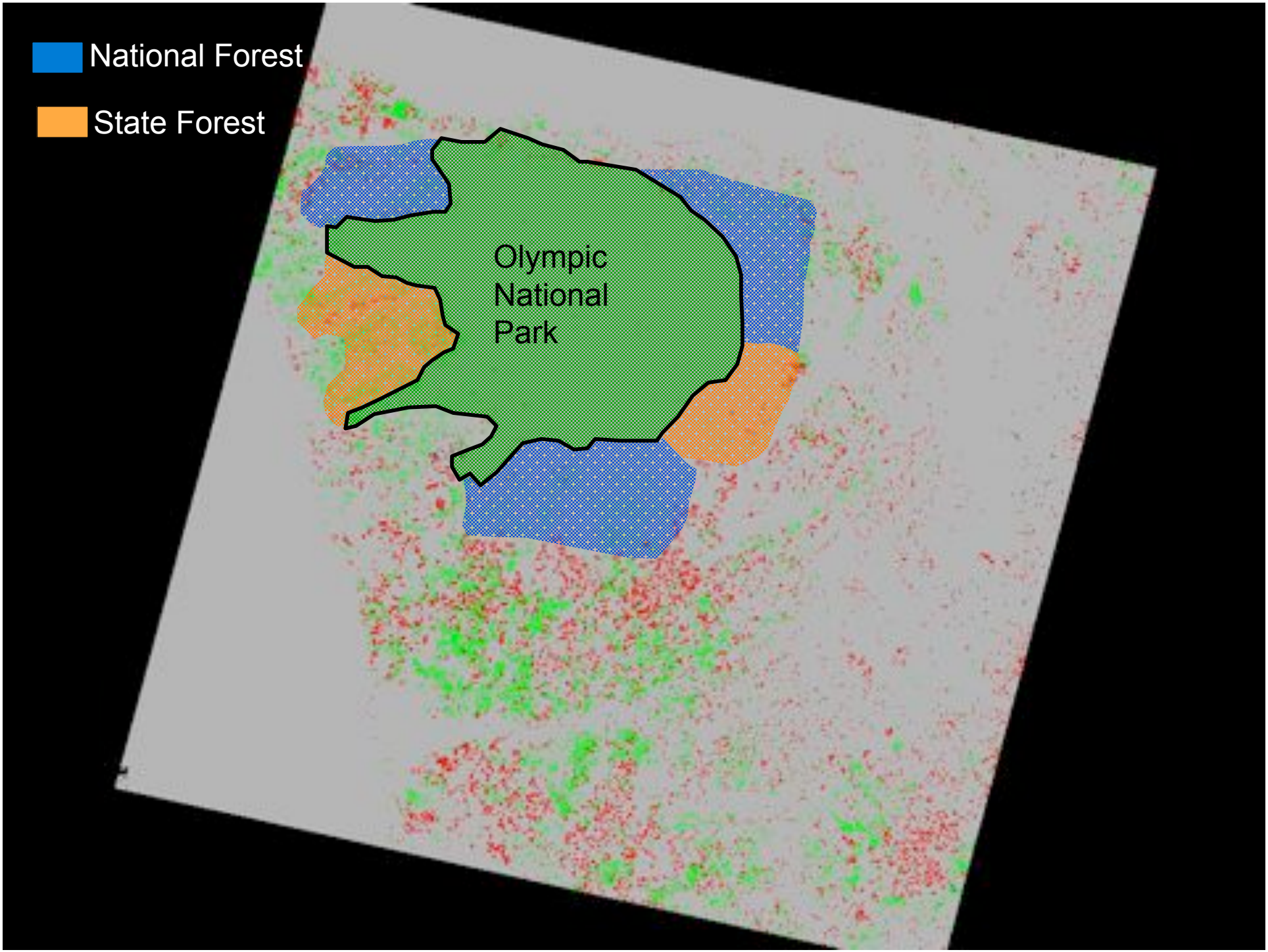
- To date, we have no detailed maps of forest cover change and disturbance for North America

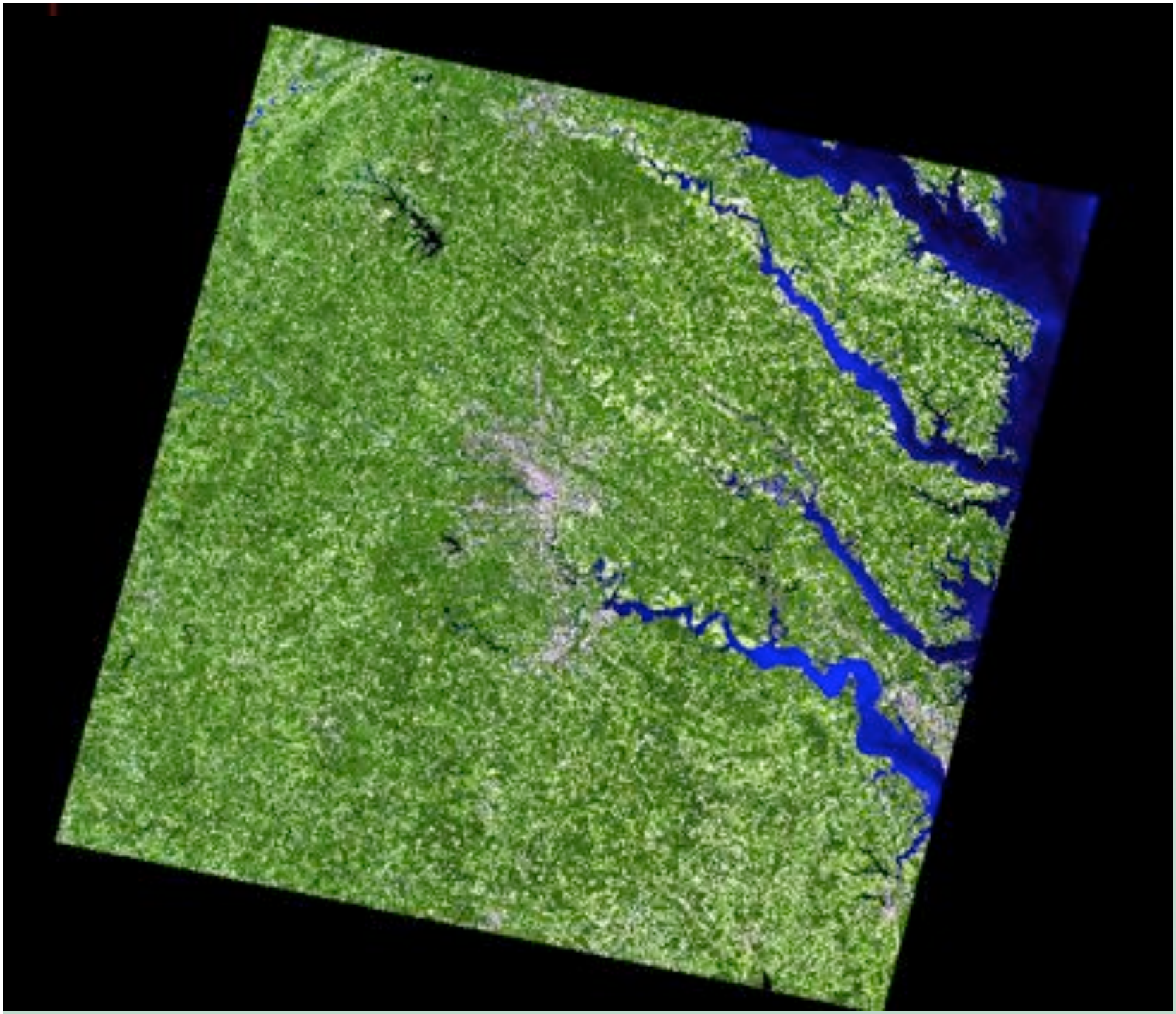
- LEDAPS seeks to produce **decadal** views of forest change from wall-to-wall analysis of Landsat imagery (1975-2000)

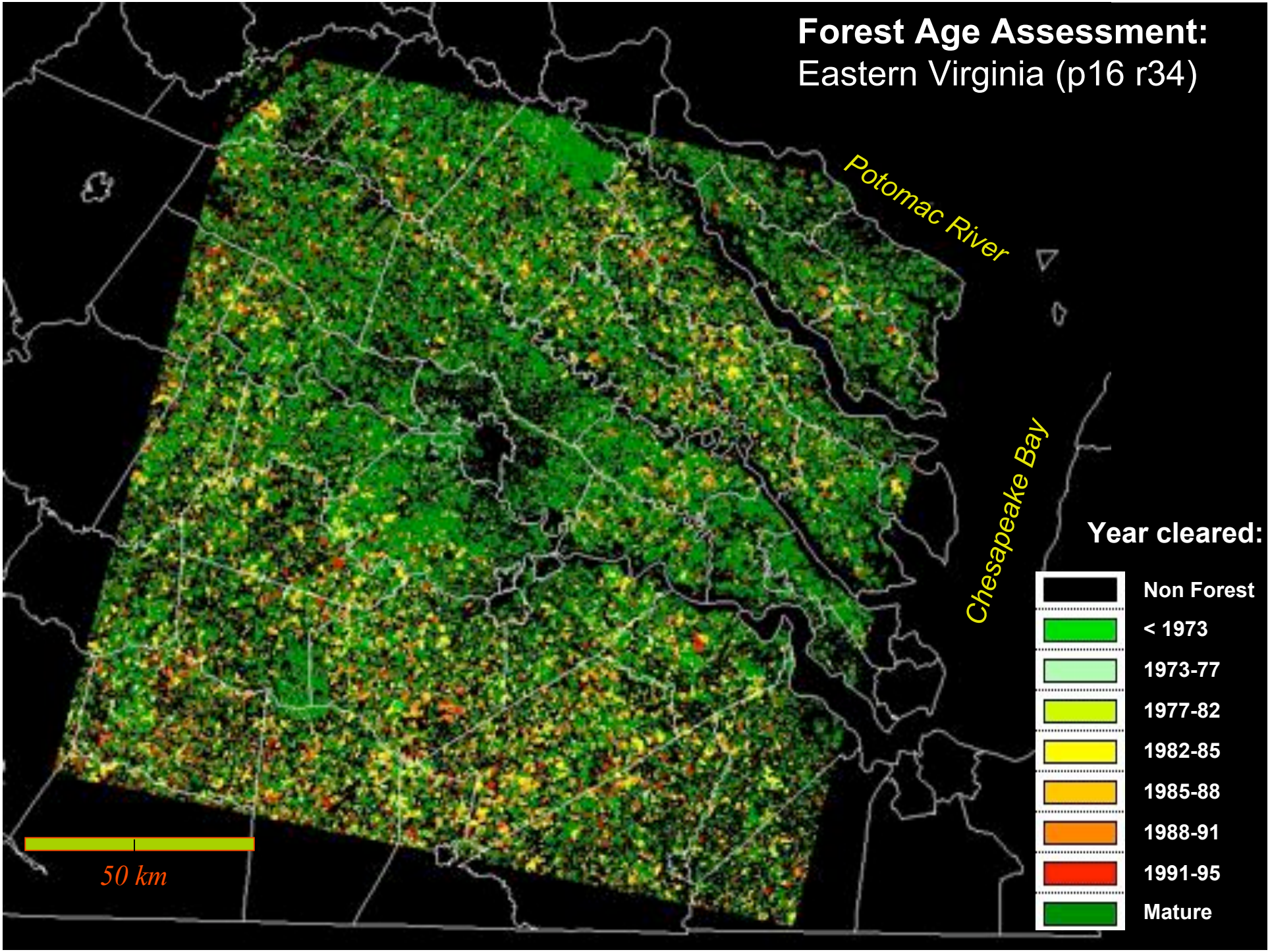
- Supported by NASA and US Forest Service


2200 atmospherically-corrected Landsat images (1990, 2000 epochs)


% cell area disturbed
1990 - 2000
0%
100%


National Forest
State Forest
Olympic
National
Park




Forest Age Assessment:
Eastern Virginia (p16 r34)
Potomac River
Chesapeake Bay
Year cleared:
Non Forest
< 1973
1973-77
1977-82
1982-85
1985-88
1988-91
1991-95
Mature
50 km

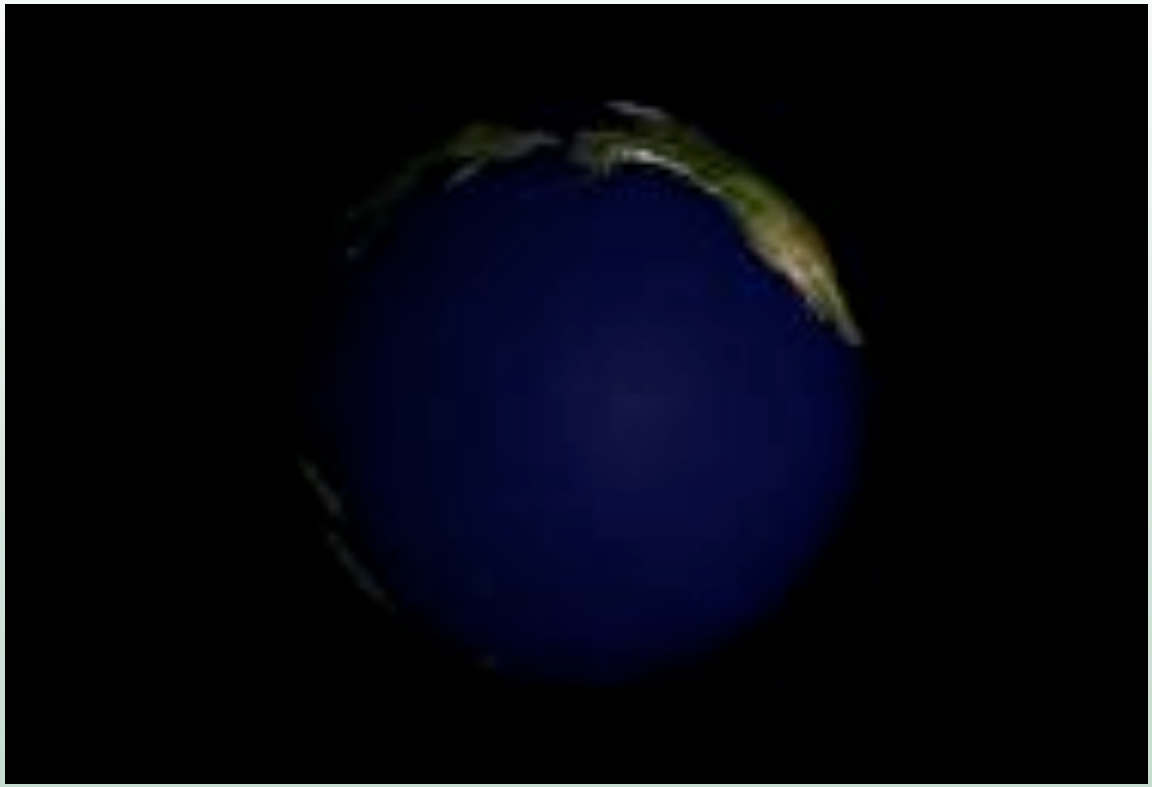
“Natural” Disturbances

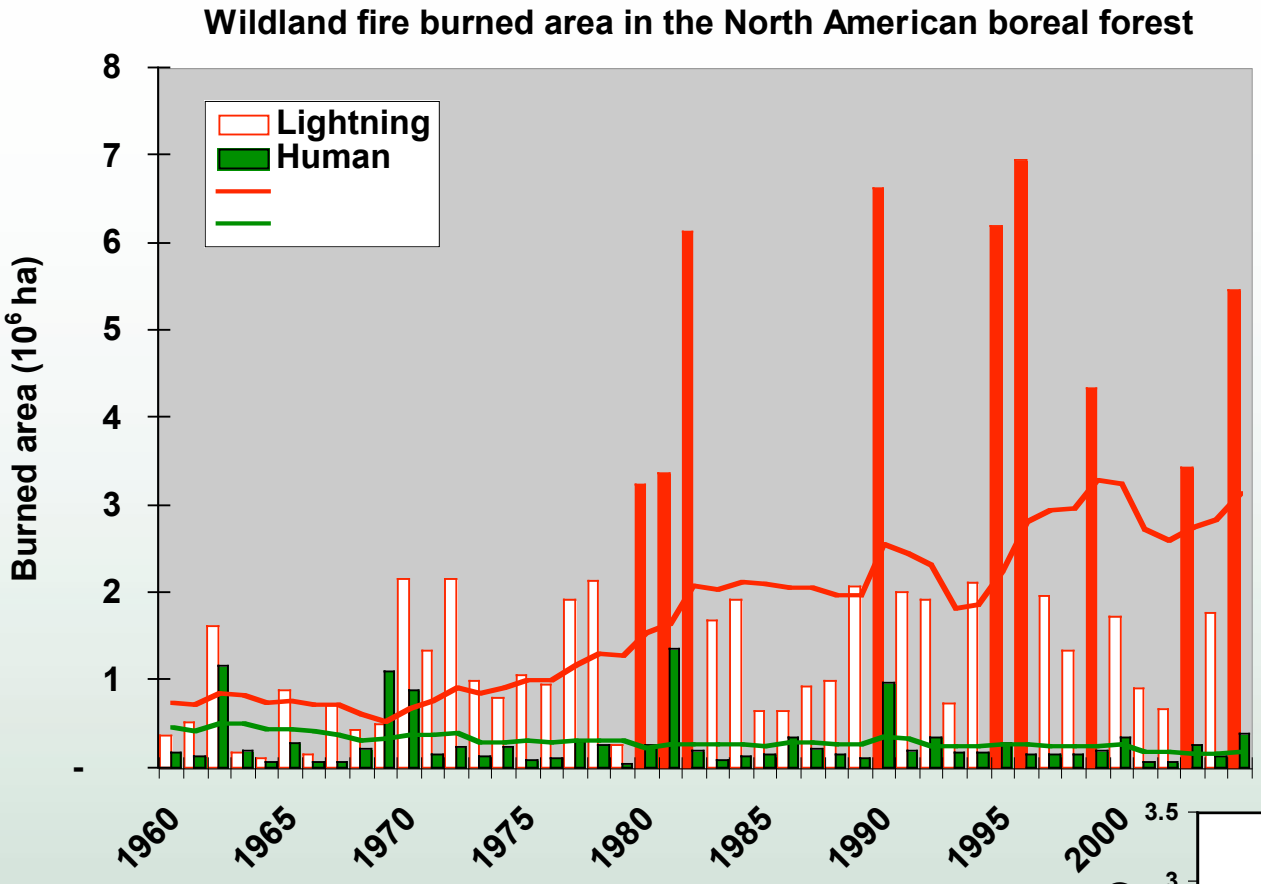
•Fire, Insect Outbreaks, Floods, Wind

•Interaction between human activities and disturbance frequency
- fire suppression in managed forests
- increased fire in unmanaged forests
- insect outbreaks in climatically “stressed” stands
- increased hurricane frequency

Active Fires from MODIS (February – August, 2002)

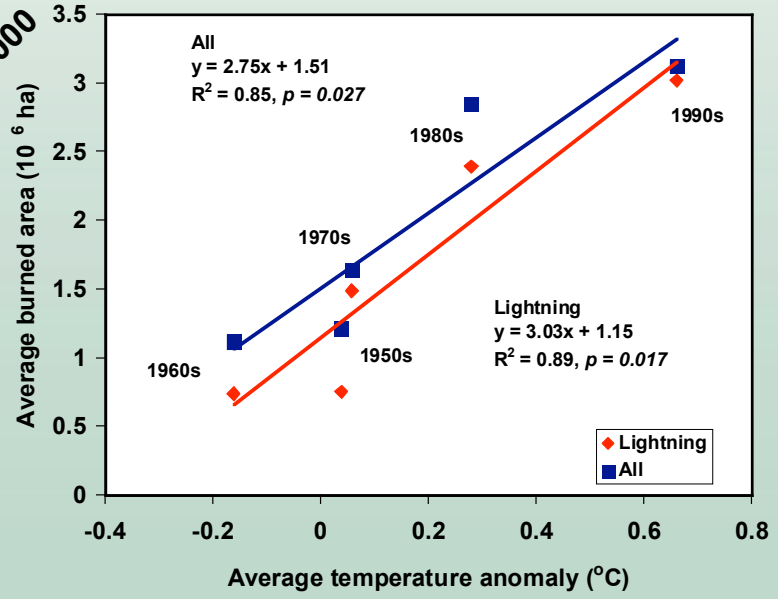
+ zoom to Rodeo-Chediski Fire, Arizona





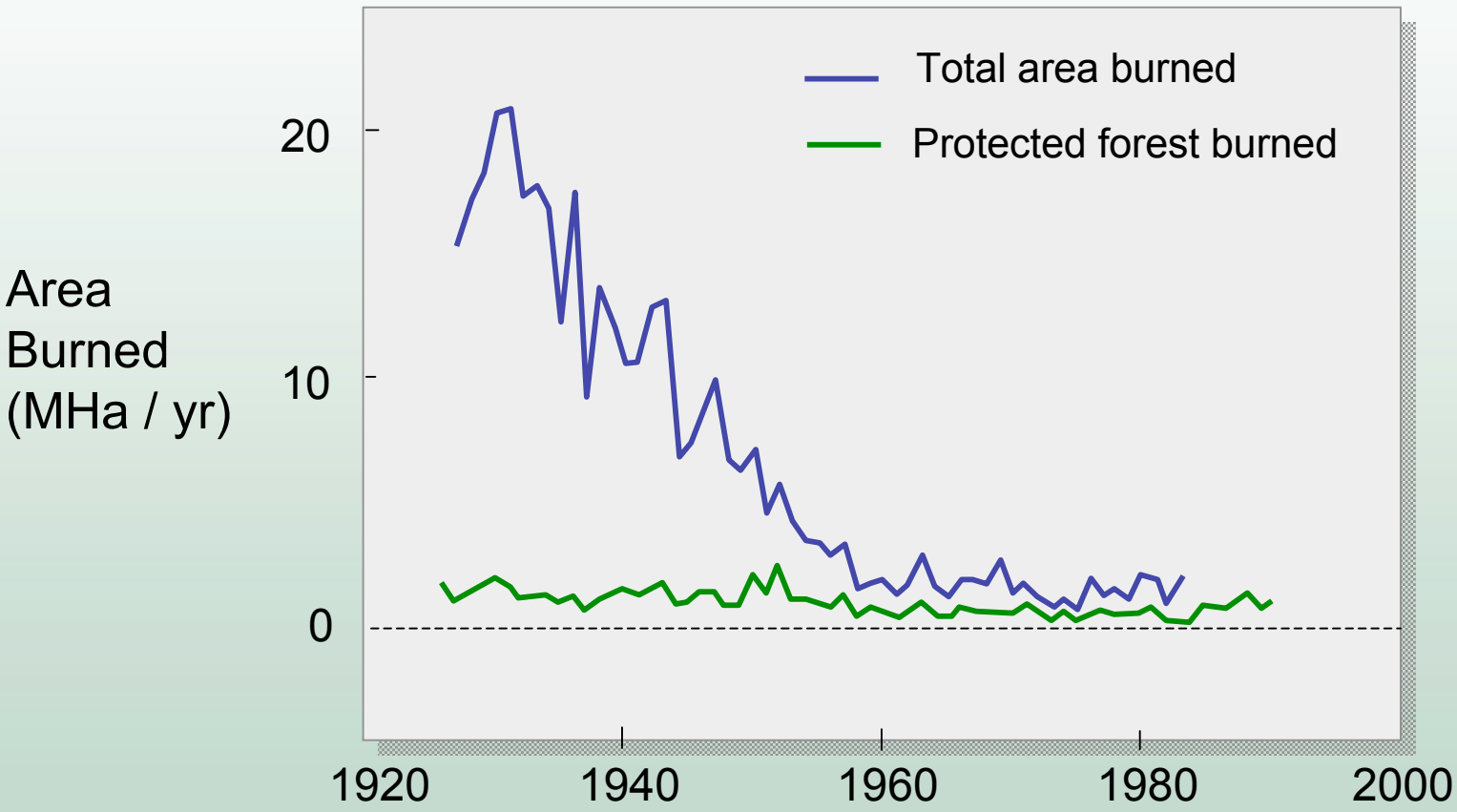
Increasing frequency of lightning induced fires

Tied to increasing temperature?



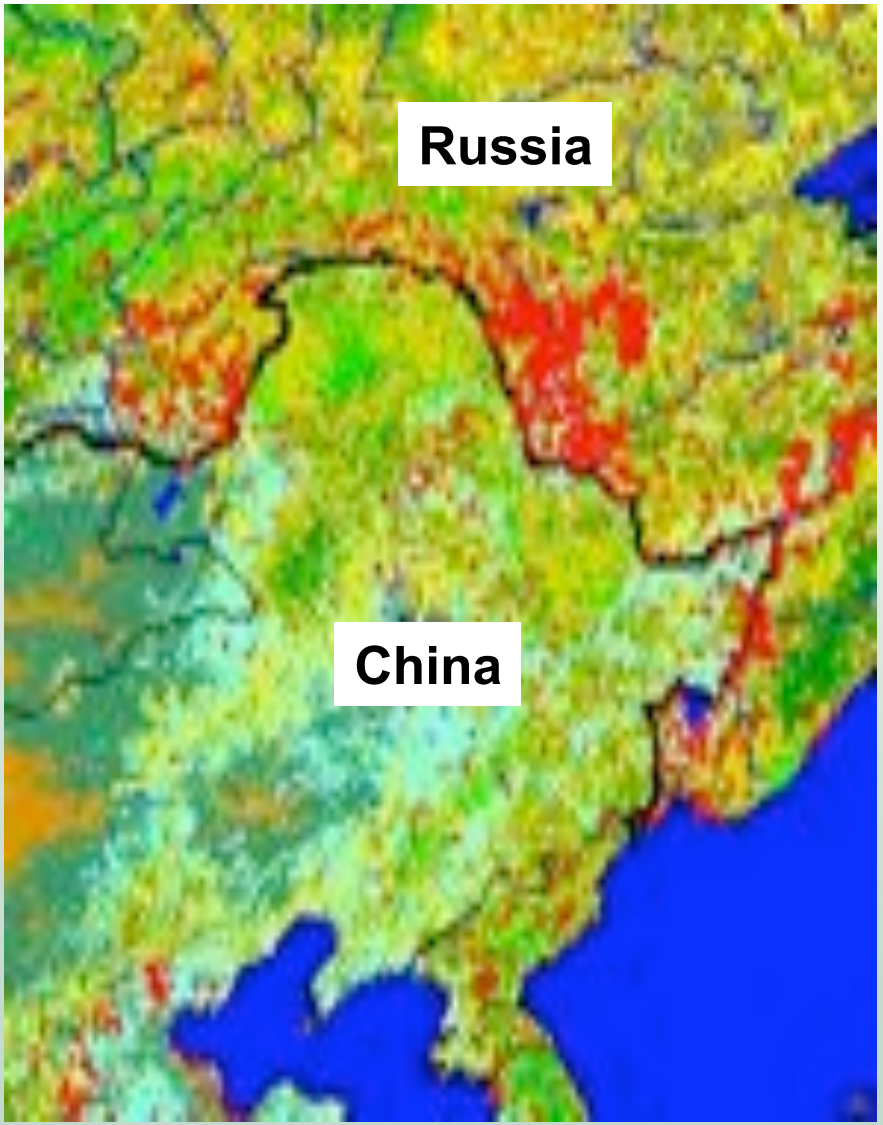
Courtesy E. Kashischke, UMD

Fire Suppression in the United States



Effects of Fire Suppression in China

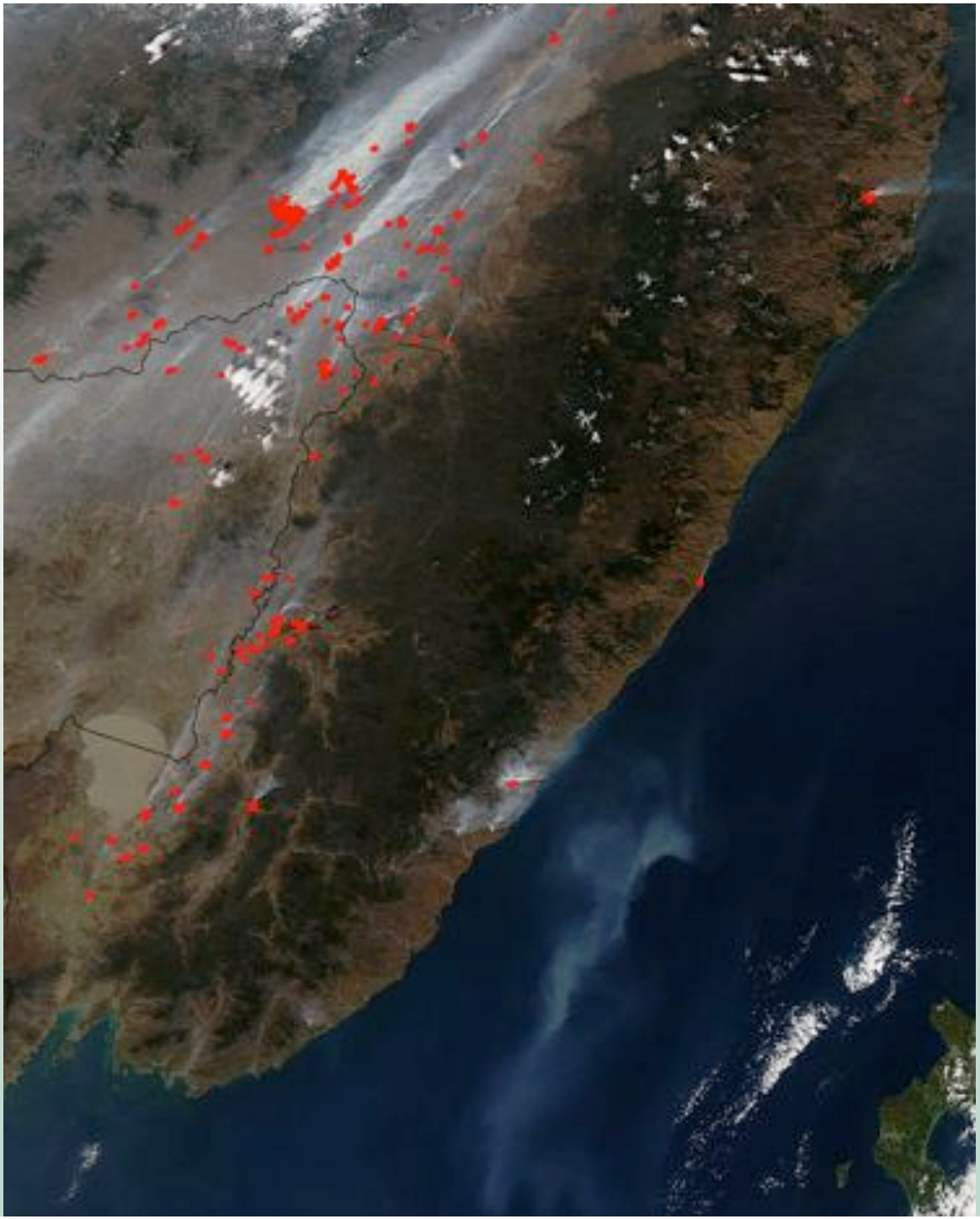
MODIS thermal anomalies mapped April – June, 2002



MODIS Rapid Response Active Fire Detections

Collaboration between USFS – UMD - GSFC

3pm PST September, 29 2005



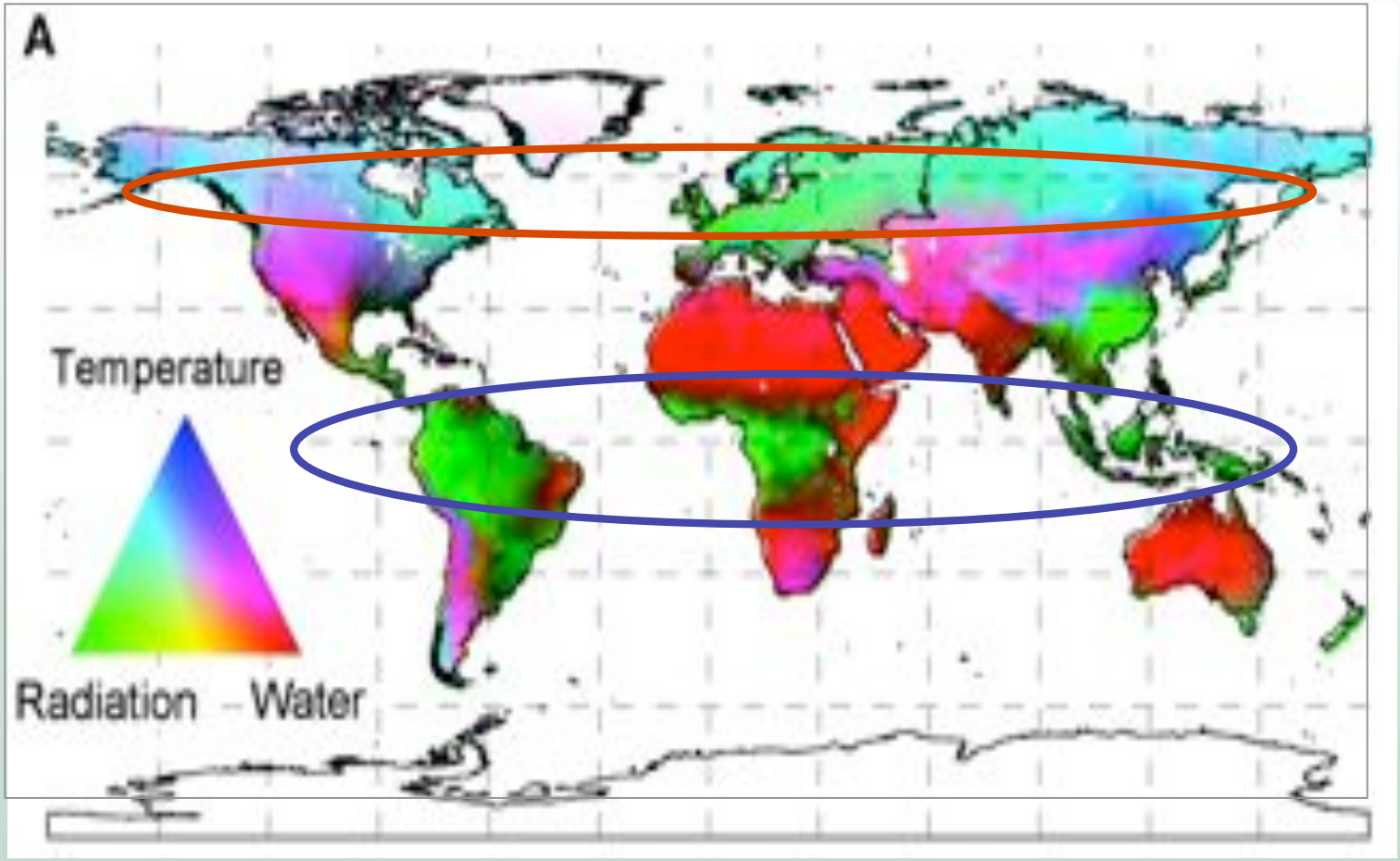
Fires and smoke
Plumes, Russian Far East

10/19/2005 (Yesterday)

What will the future bring for Earth's forests?

End of presentation; beginning of additional slides

Limiting Factors for Global Vegetation



From Nemani et al., Science, 2002

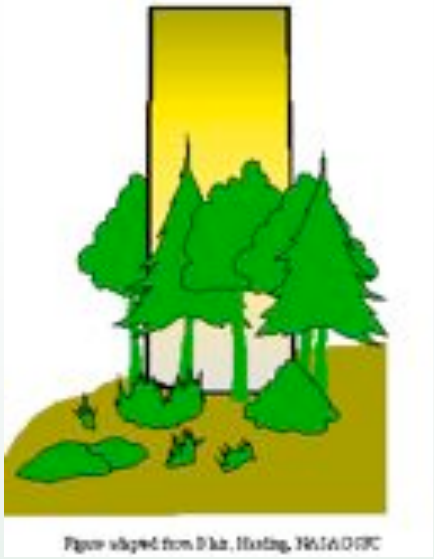
Lidar Techniques for Forest Structure

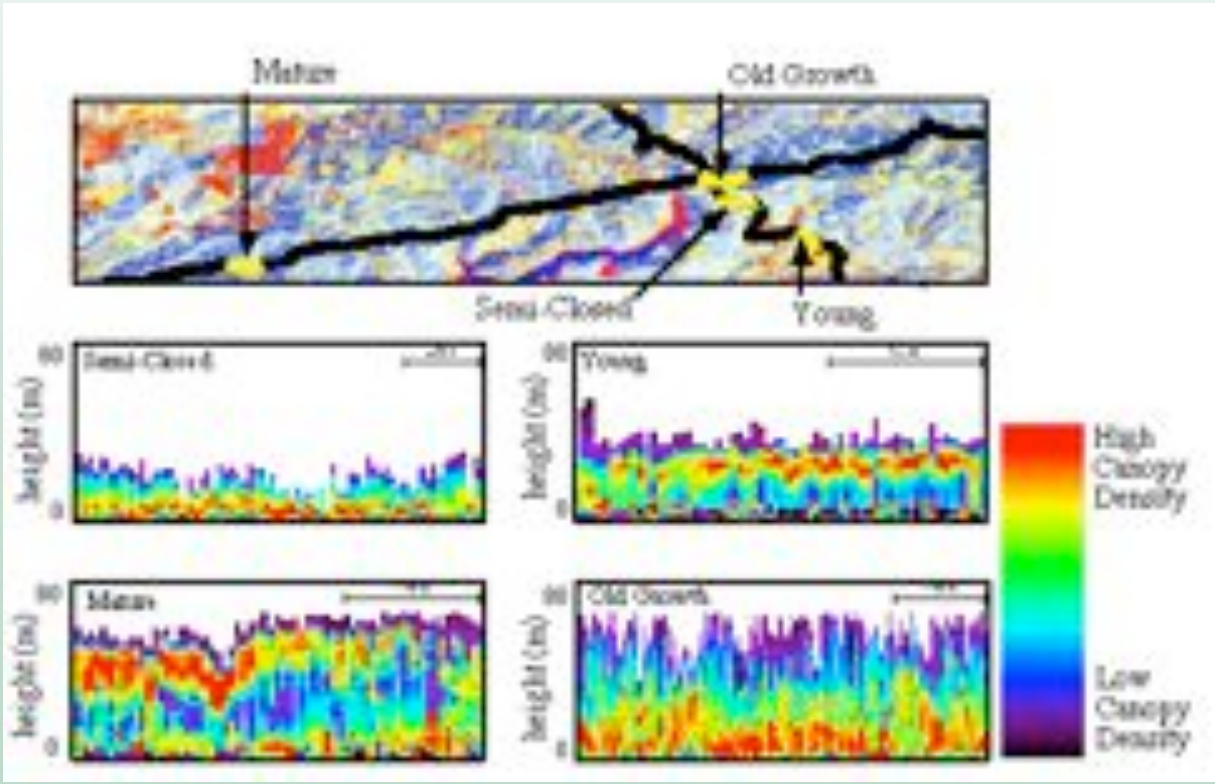
Laser profiling of forest canopies for
- Stand height (~ biomass)
- 3-d canopy architecture

Time delay between 1st and last return gives height

Mostly airborne, although IceSat GLAS launched in 2003

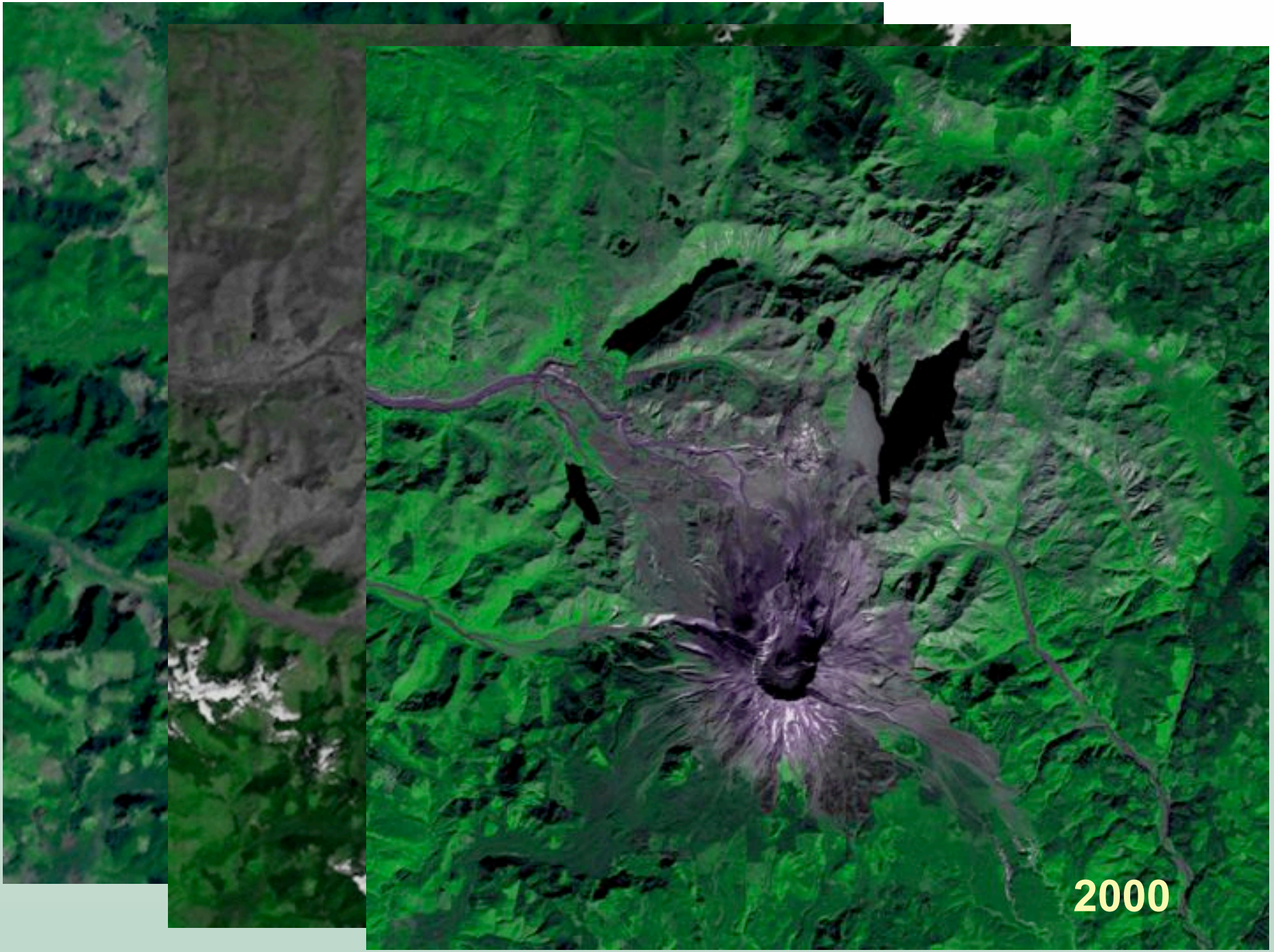
Also, radar and multi-angle technologies for examining forest structure



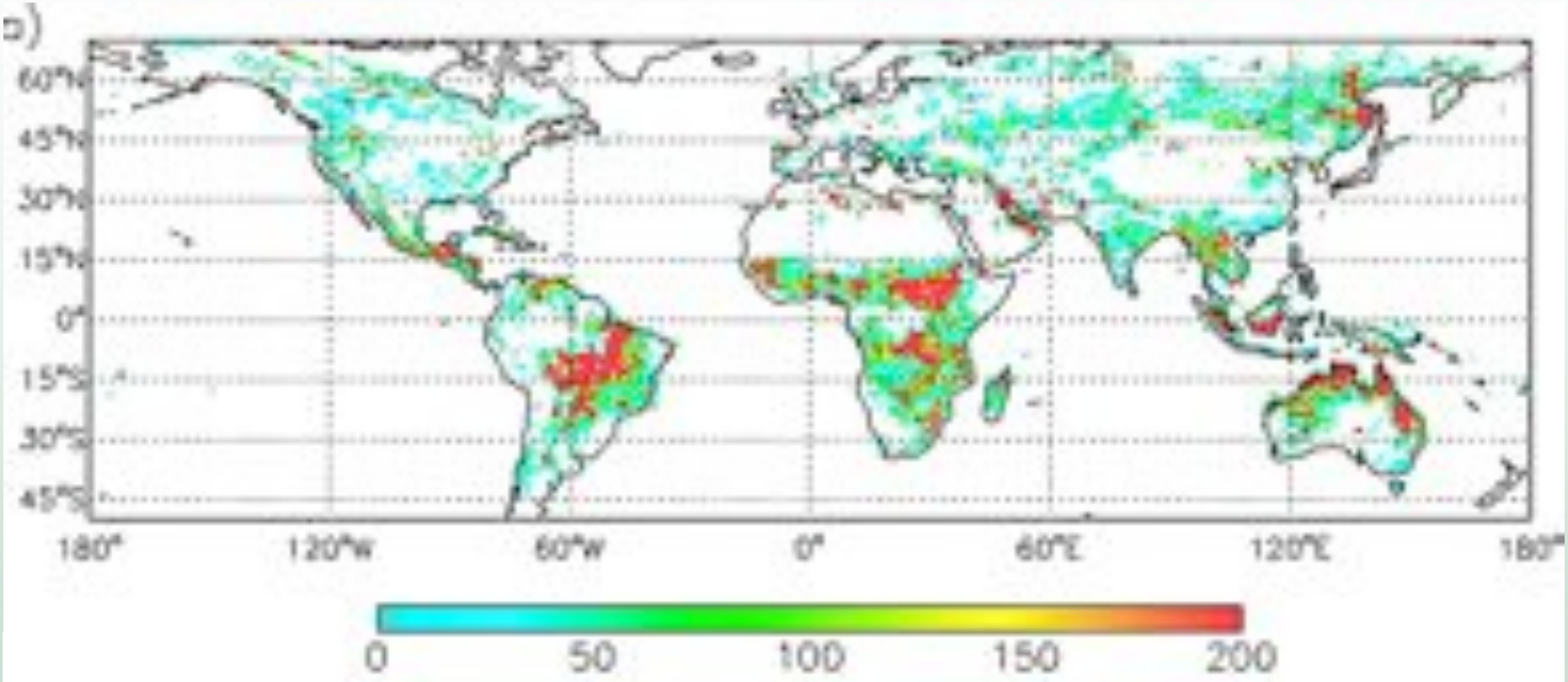


Example: Siberian Silkworm Outbreak


21 3:32

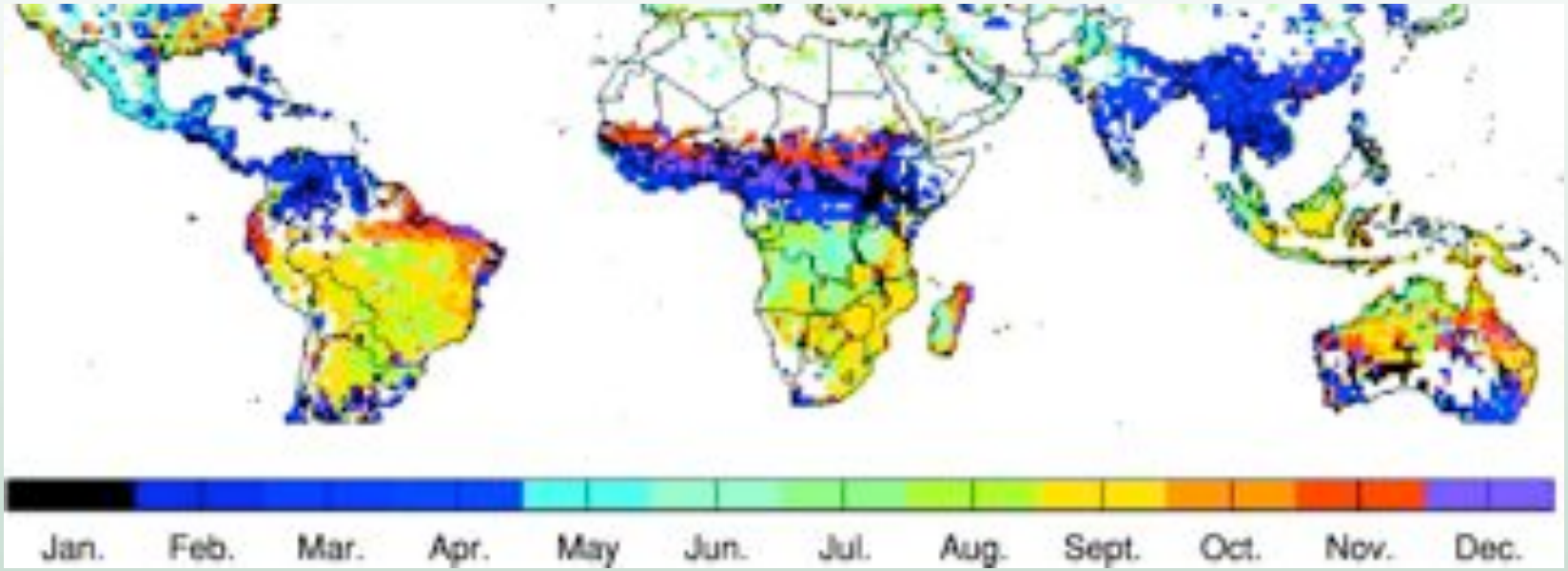

2000

Global Fire Activity from ATSR (1996-2000)



from Duncan et al, 2003

Peak of fire season determined by fire counts (TRMM)



From Van der Werf et al, Global Change Biology, 2003

Landsat Maps of Insect Damage in Priangar'e