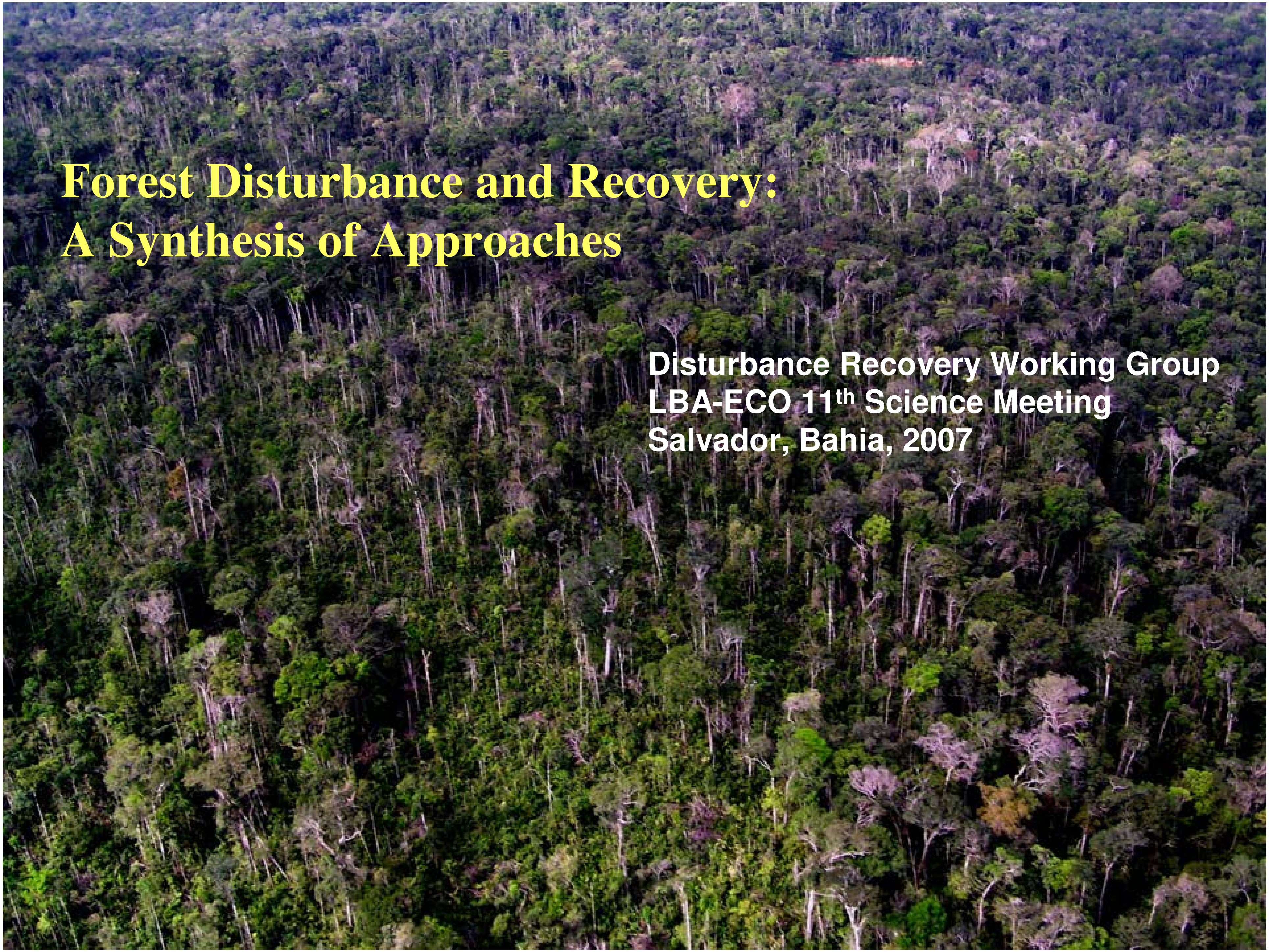
Forest Disturbance and Recovery: A Synthesis of Approaches



Disturbance Recovery Working Group
LBA-ECO 11th Science Meeting
Salvador, Bahia, 2007

Review
TRENDS in Ecology and Evolution Vol.22 No.8
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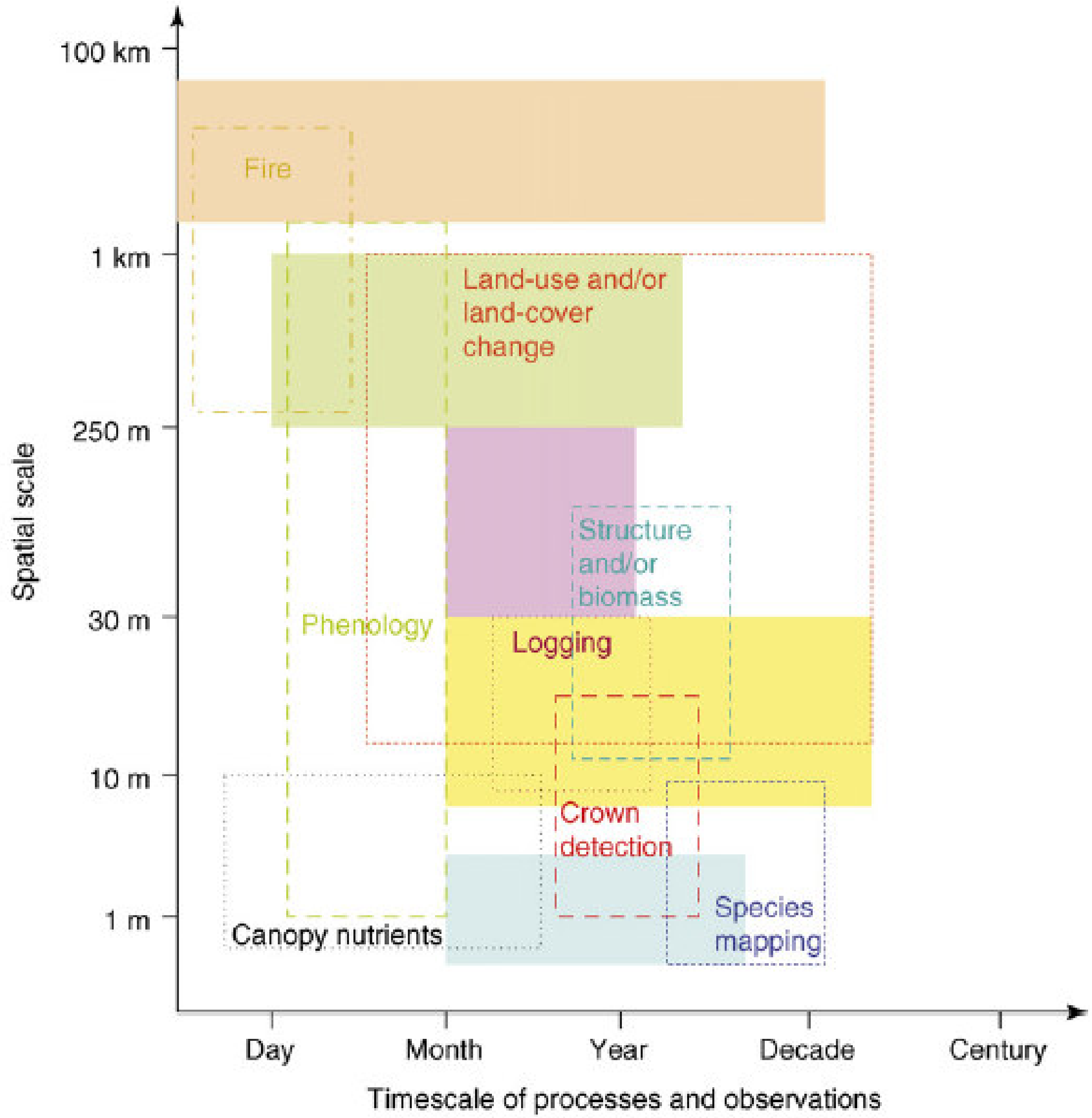
Regional ecosystem structure and function: ecological insights from remote sensing of tropical forests

Jeffrey Q. Chambers[1], Gregory P. Asner[2], Douglas C. Morton[3], Liana O. Anderson[4], Sassan S. Saatchi[5], Fernando D.B. Espírito-Santo[6], Michael Palace[6] and Carlos Souza Jr[7]

Ecological studies in tropical forests have long been plagued by difficulties associated with sampling the crowns of large canopy trees and large inaccessible regions, such as the Amazon basin. Recent advances in remote sensing have overcome some of these obstacles, enabling progress towards tackling difficult ecological problems. Breakthroughs have helped transform the dialog between ecology and remote sensing, generating new regional perspectives on key environmental gradients and species assemblages with ecologically relevant measures such as canopy nutrient and moisture content, crown area, leaf-level drought responses, woody tissue and surface litter abundance, phenological patterns, and land-cover transitions. Issues that we address here include forest response to altered precipitation regimes, regional disturbance and land-use patterns, invasive species and landscape carbon balance.



TRENDS in Ecology & Evolution

Figure 1. Scales and sensors. Recent advances in remote sensing of tropical forests have improved our understanding of a range of ecological processes that operate at varying spatial and temporal scales. Colored boxes show the spatial and temporal range of coverage from different satellite and airborne sensors (red, GOES; green, MODIS; pink, LiDAR, Radar; yellow, Landsat, EO-1; blue, IKONOS, Quickbird, Airborne). Suitable overlap between the scales of ecological processes, human actions and remote-sensing technology is denoted by dash and dot boxes.

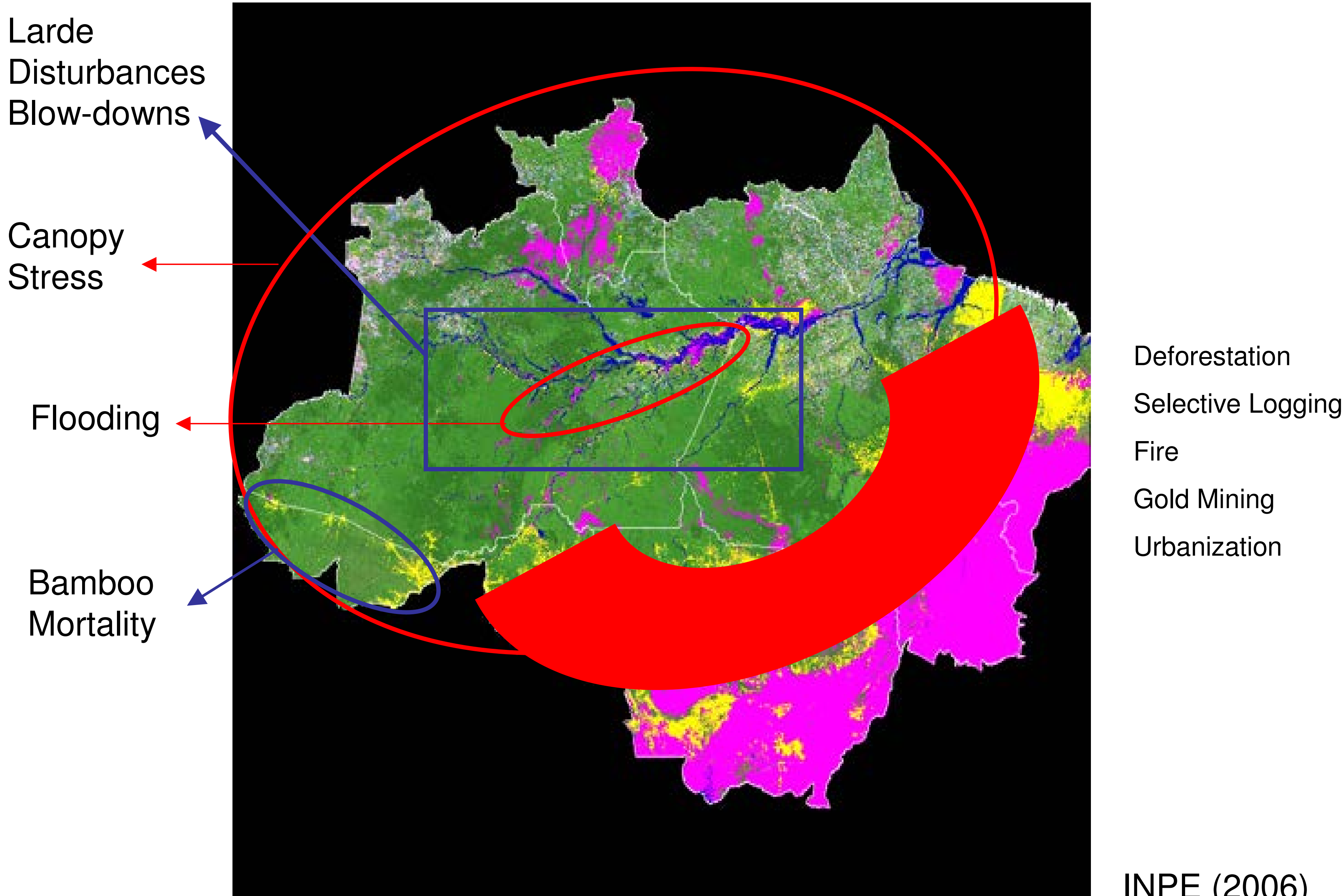
General Framework for Forest Disturbance/Recovery

Following some ideas of Bruce Nelson from INPA, the natural disturbance in the Amazon we can be organized as:

Biotic – synchronous mortality of bamboo forest, tree mortality caused by lianas, and babaçu palm forest;

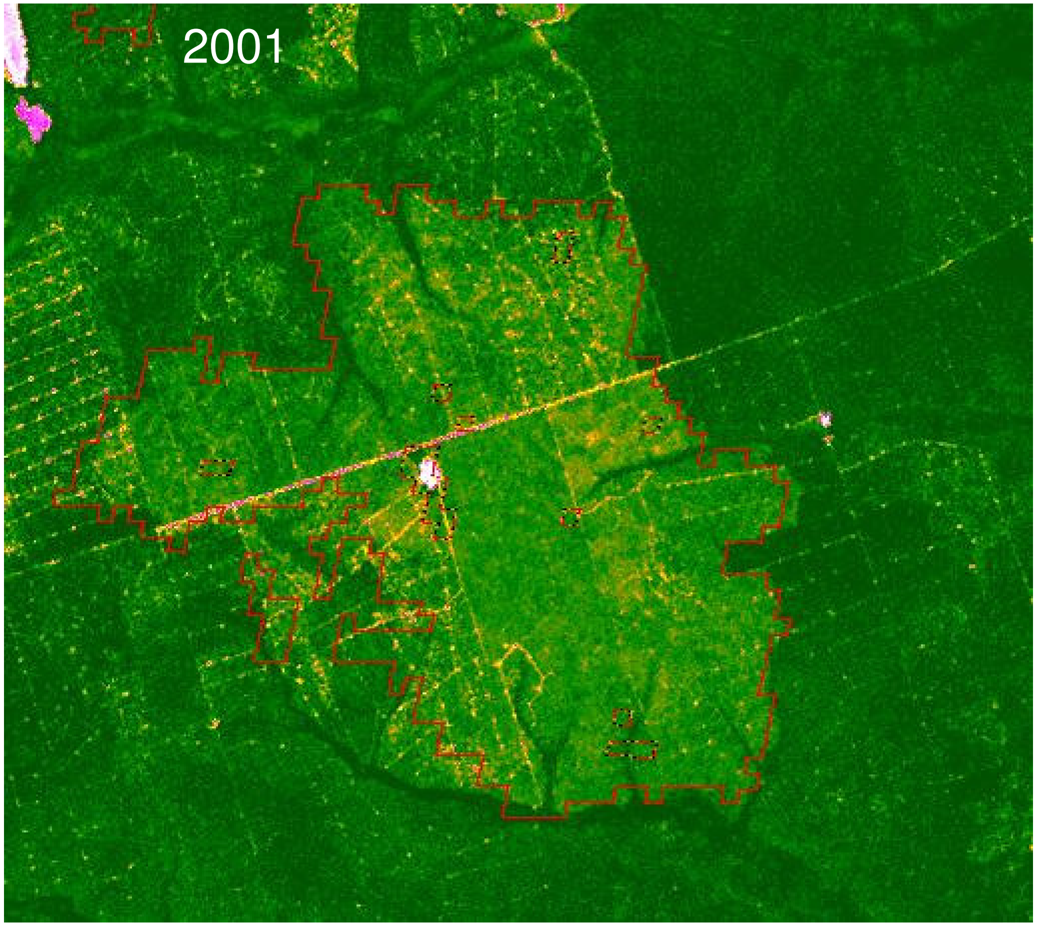
Abiotic – caused by destructive wind (blow-downs), long period of dry season and flooding;

Human-Indigenous – caused by fire and old areas of field plantation;

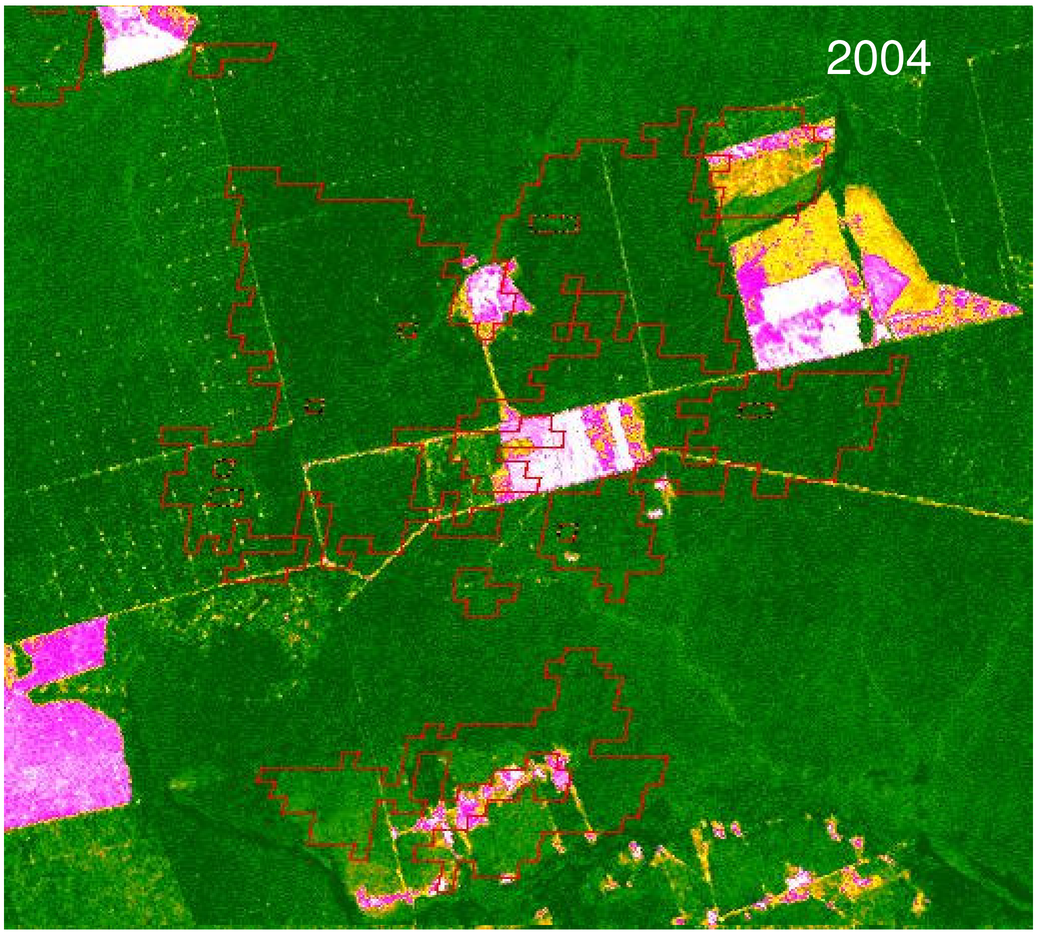

Larde
Disturbances
Blow-downs
Canopy
Stress
Flooding
Bamboo
Mortality
Deforestation
Selective Logging
Fire
Gold Mining
Urbanization

INPE (2006)

Logged 1992-2001, burned in 1995 and 1999.



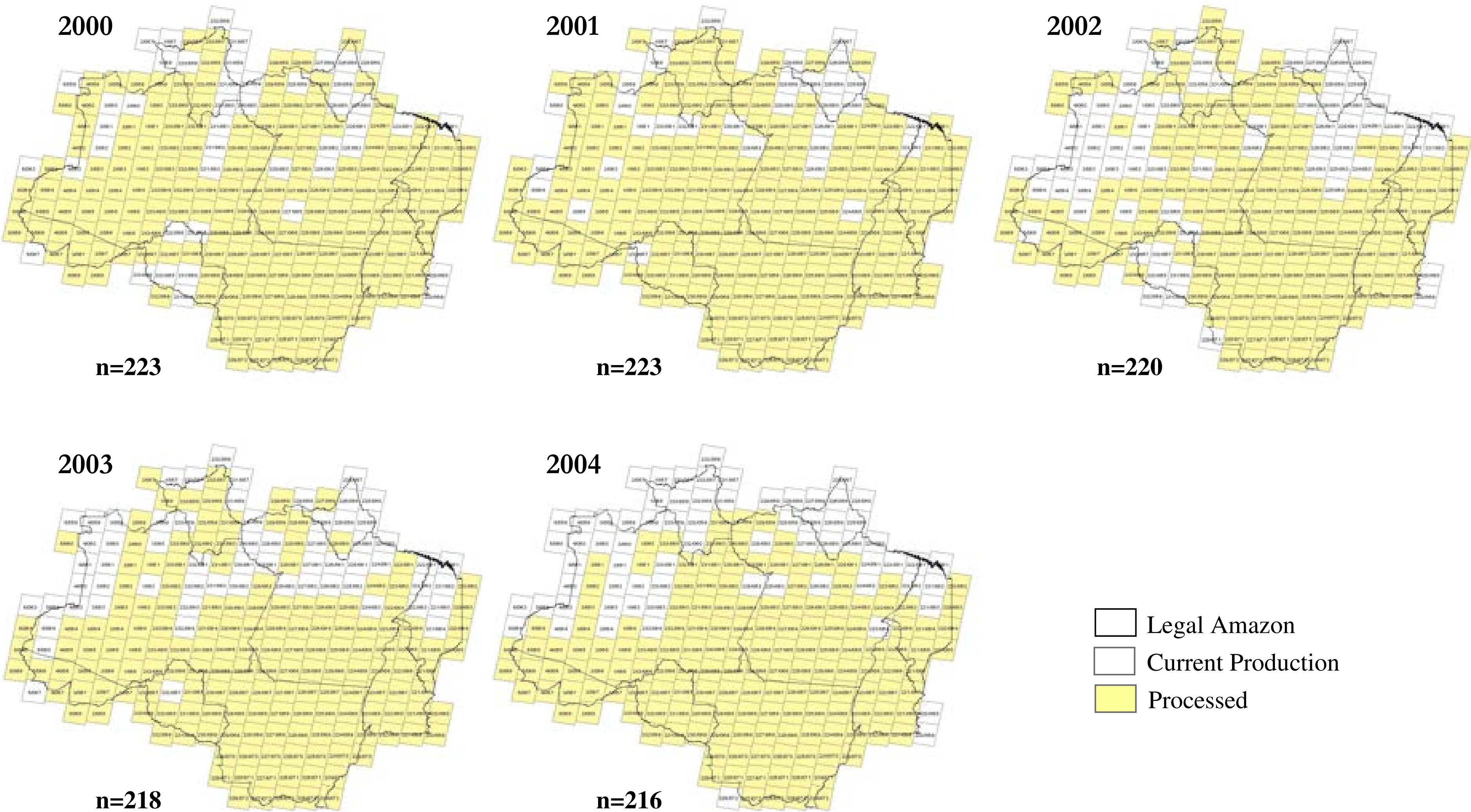
Great example of multiple burns, top section logged over many years, bottom burn Scar never logged, but burned twice in 3 years (99, 02)

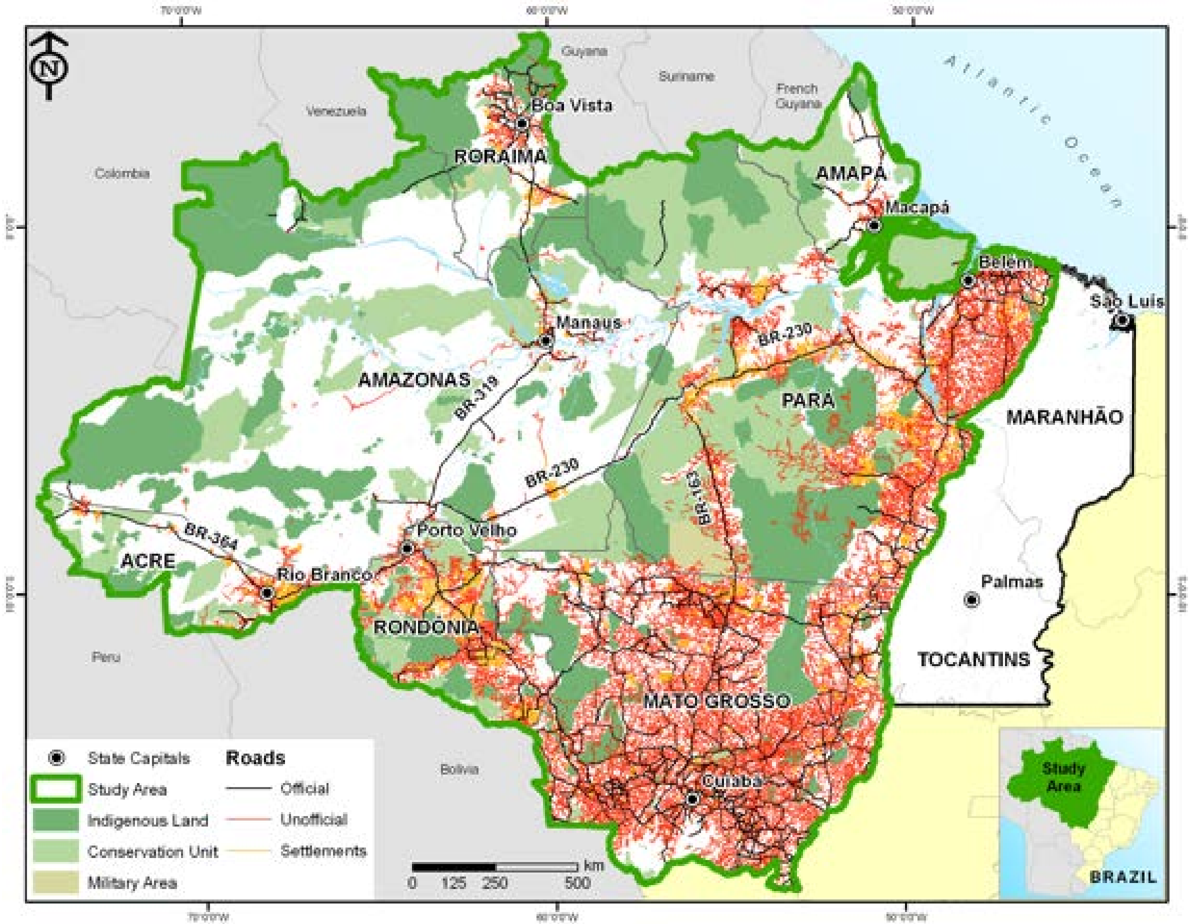


Logged in the late 1980s - mid 1990s
Burned in 1999

Not logged during 1984-2000
Burned 1999, 2002

Cenas Processadas da Amazônia Legal (Total=1100 cenas)

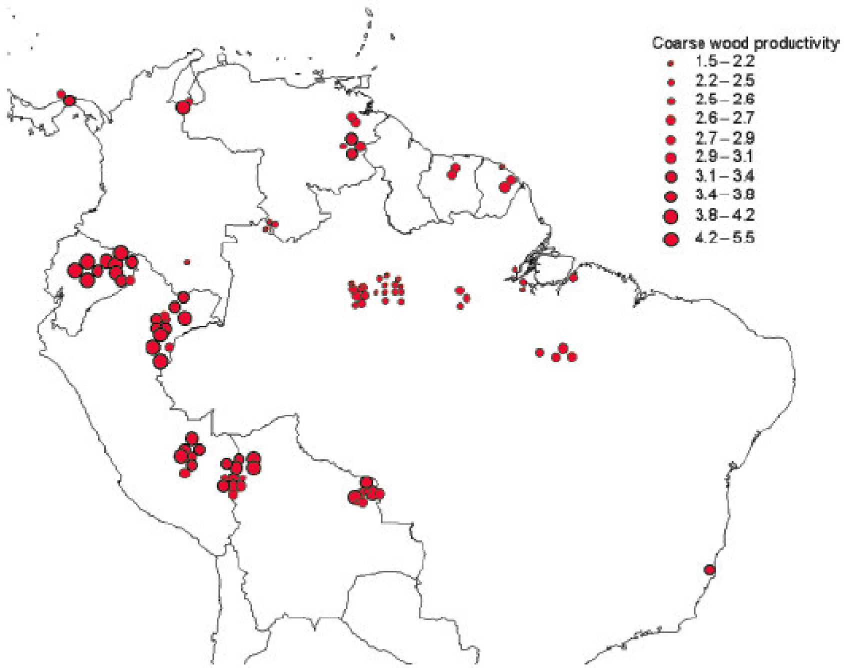


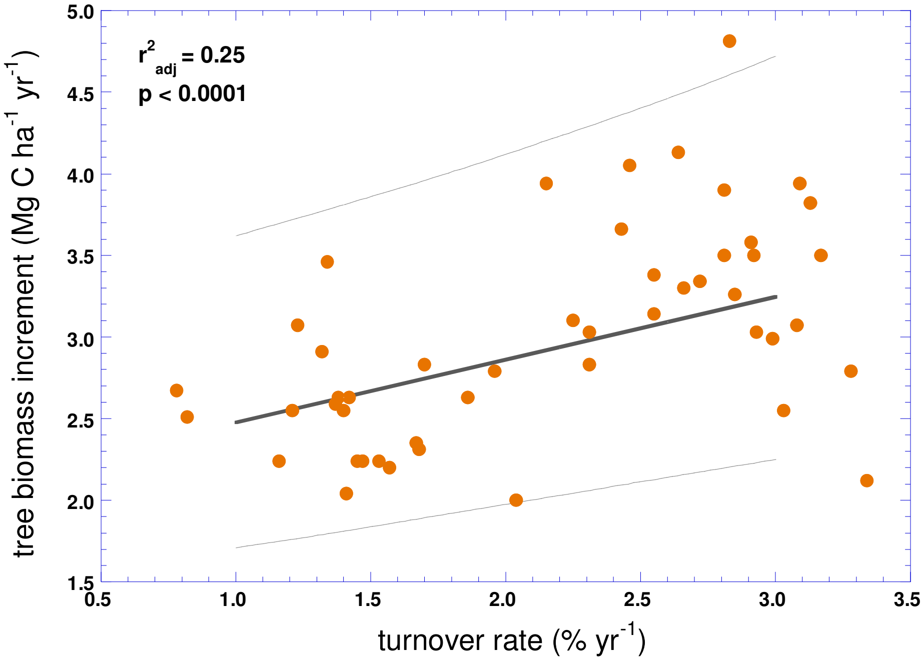


With a frequency/intensity maps of forest disturbance, you could show the time-Integrated signal of forest disturbance and recovery across the basin. The map would highlight a very intense, frequent band of disturbance at the frontier, a wider zone of logging and logging+fire beyond that (following roads), with UC having only frequent, low-intensity natural disturbances, and landslides along the Andes showing infrequent, high-intensity disturbances.

Souza Jr., *et al.*, não publicado

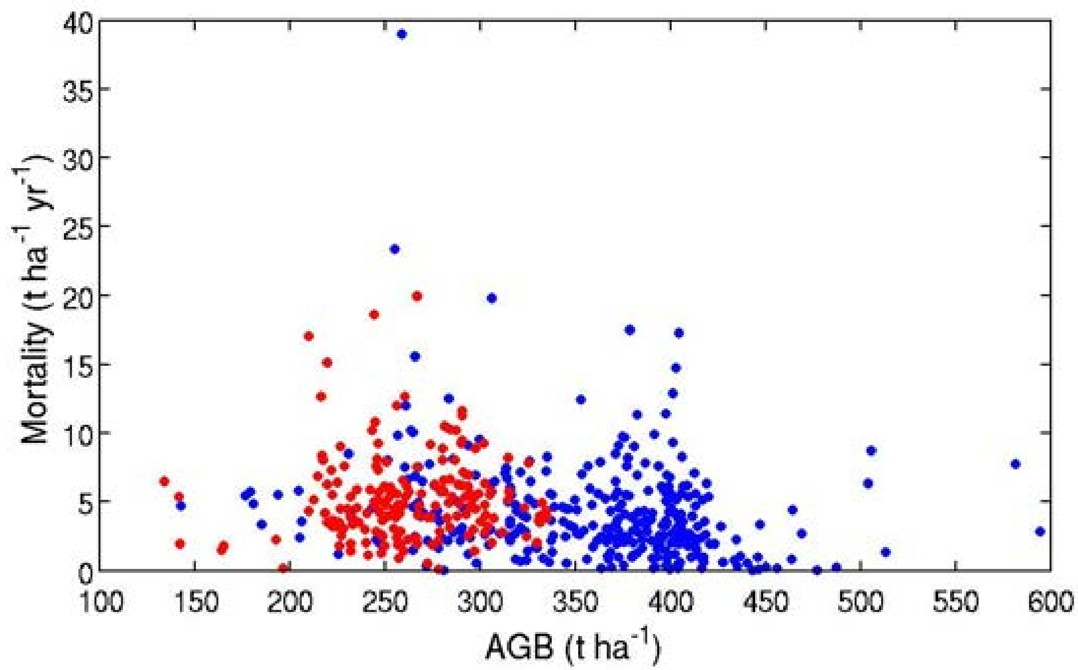
Modeling Carbon Cycling Dynamics Across the Basin

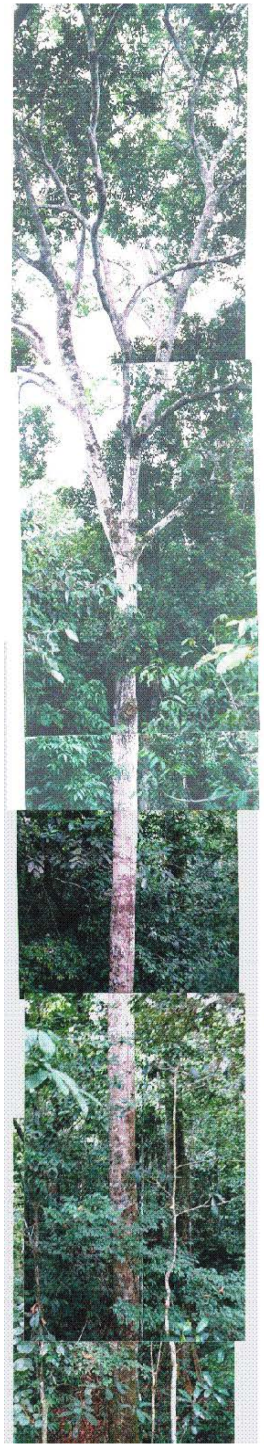




Malhi, Y.et al. 2004. The above-ground wood productivity and net primary productivity of 100 neotropical forests. Global Change Biology **10**:563-591.

West: biomass low, turnover fast
East: biomass high: turnover slow





Blow-down in the Amazon

Ecology, 75(3), 1994, pp. 853–858

FOREST DISTURBANCE BY LARGE BLOWDOWNS IN THE BRAZILIAN AMAZON

Bruce W. Nelson,[1] Valerie Kapos,[2] John B. Adams,[3,5] Wilson J. Oliveira,[4] Oscar P. G. Braun,[4] and Iêda L. do Amaral[1]

Wind defoliation and large blowdowns are important and frequent disturbances for tropical forests of islands and coastal areas in the hurricane belts 10°–20° north and south of the equator (Sousa 1984, Whitmore 1984). In the Caribbean, hurricane repeat cycles may be ≤15–20 yr and effects on the forest can range from

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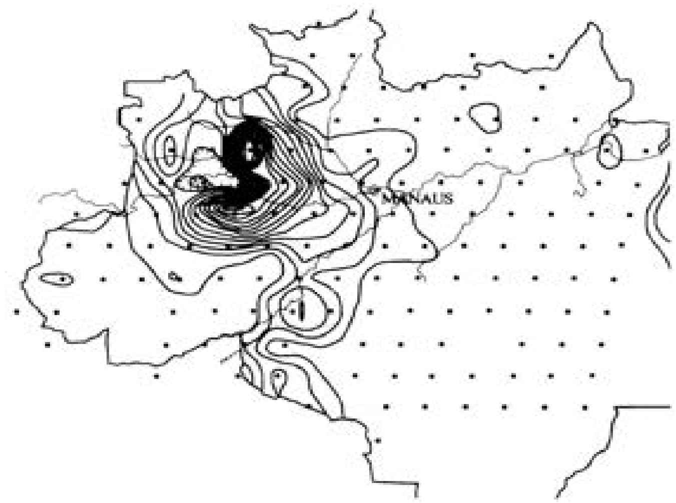
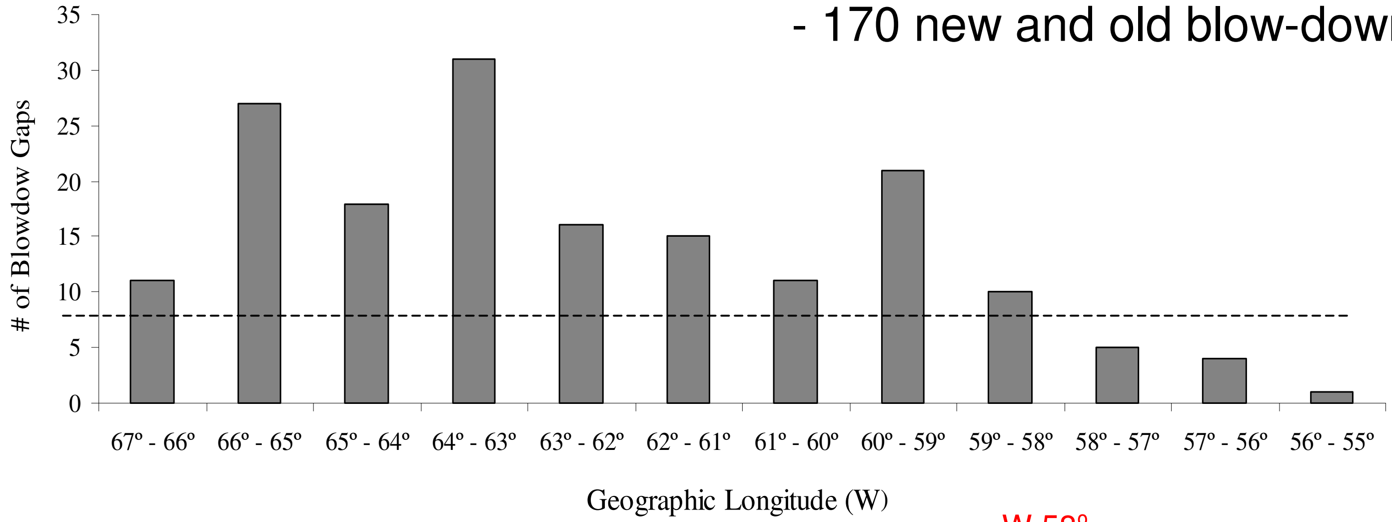
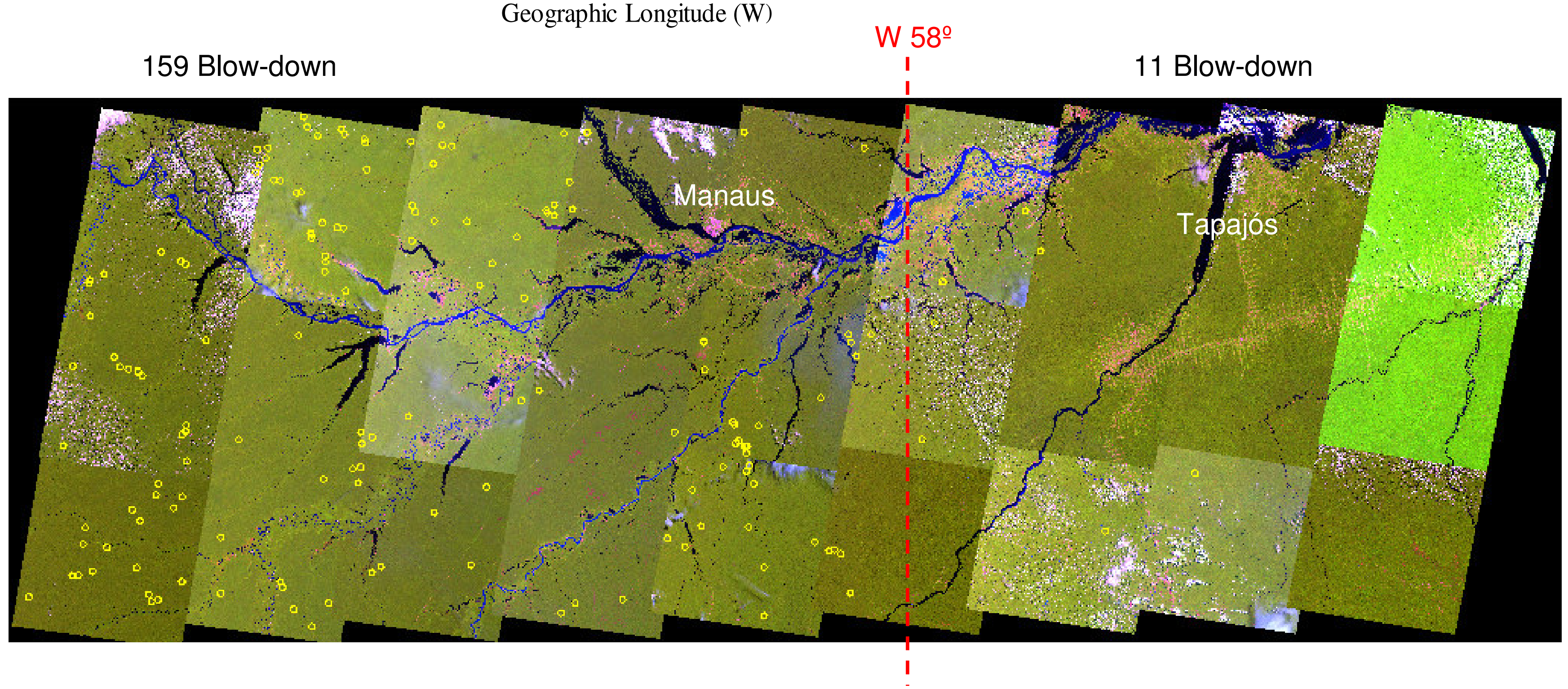
[4] DEPEX-SEBINT, Petrobrás, Avenida Chile 65-Centro, 20035 Rio de Janeiro, RJ, Brazil.
[5] Send reprint requests to this author.



Geographic Distribution

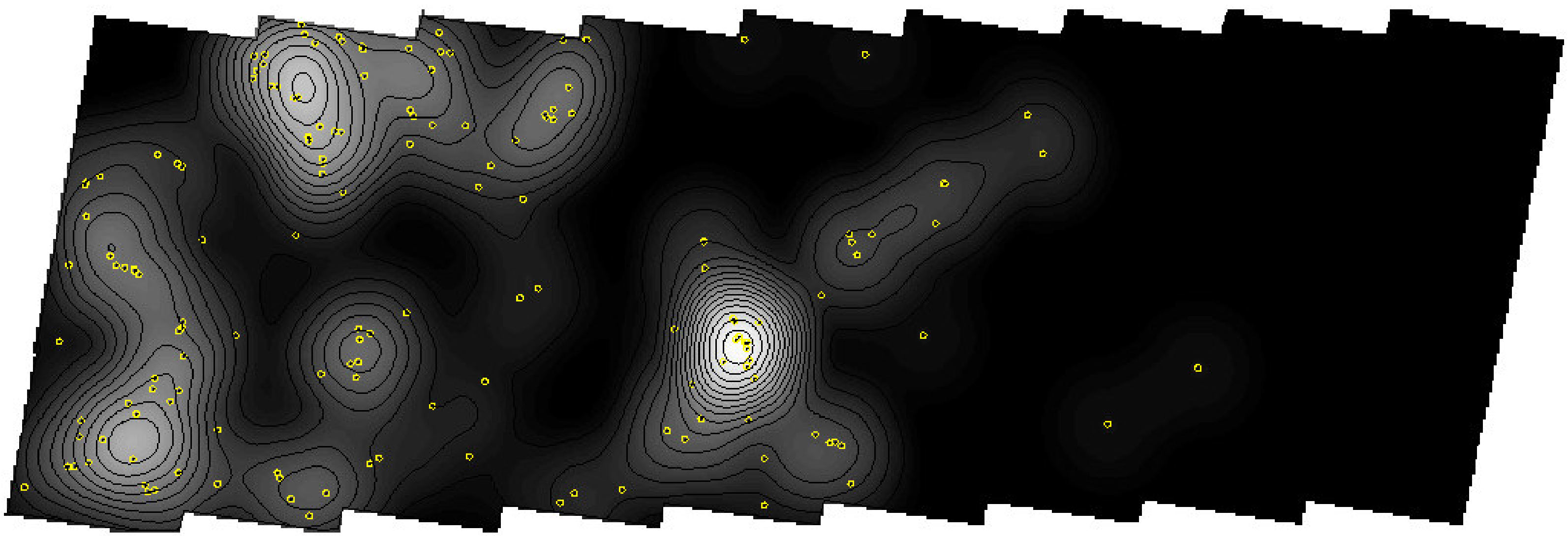
- 170 new and old blow-downs were found;

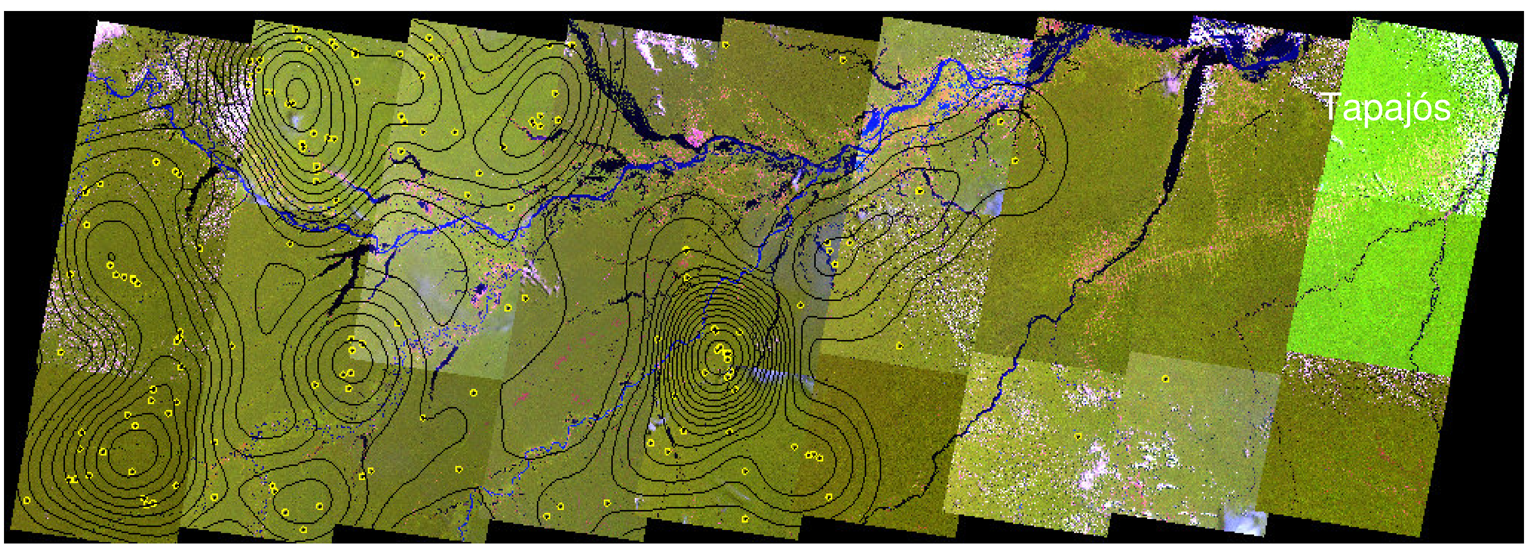


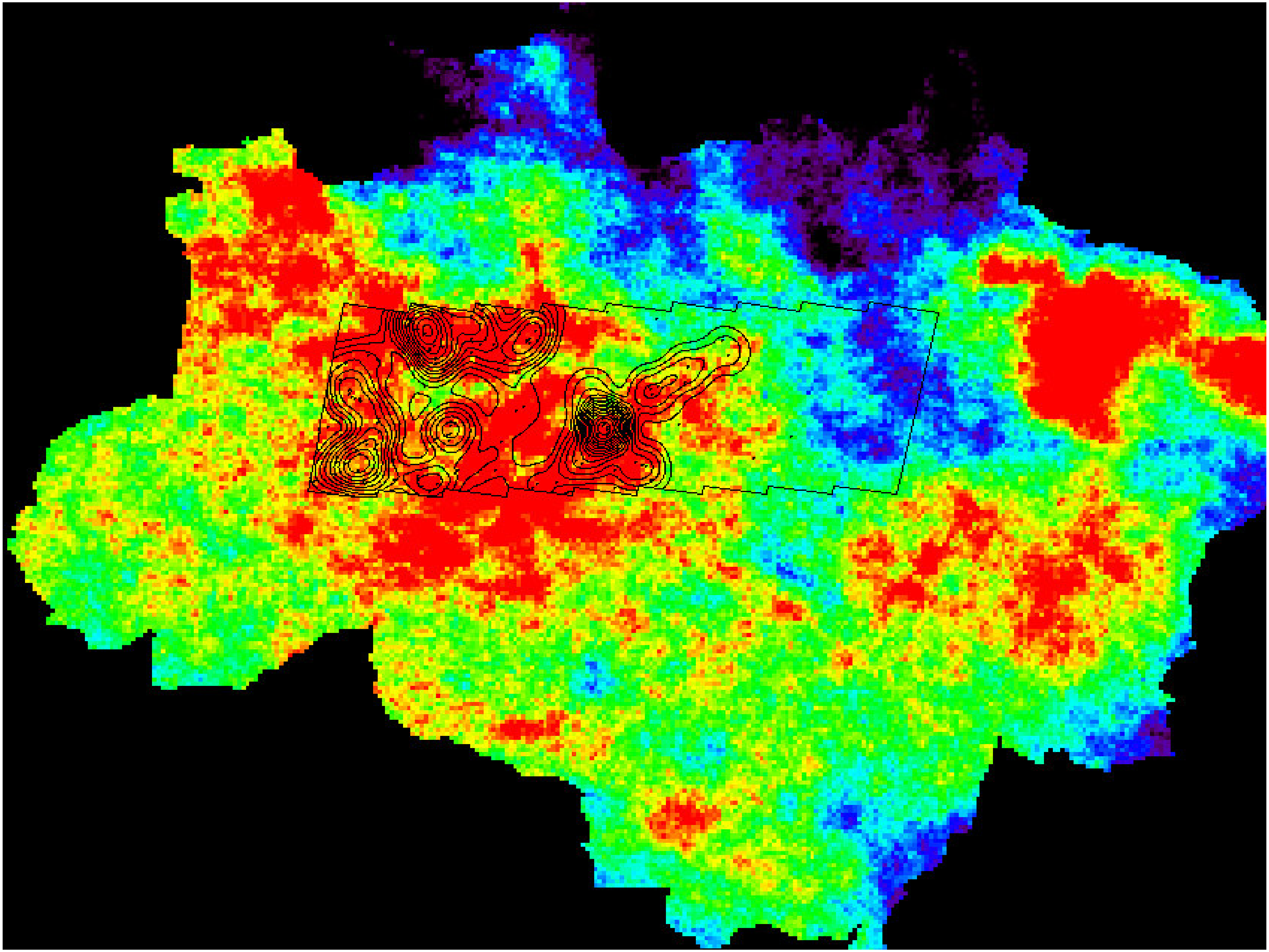


Cluster Analysis

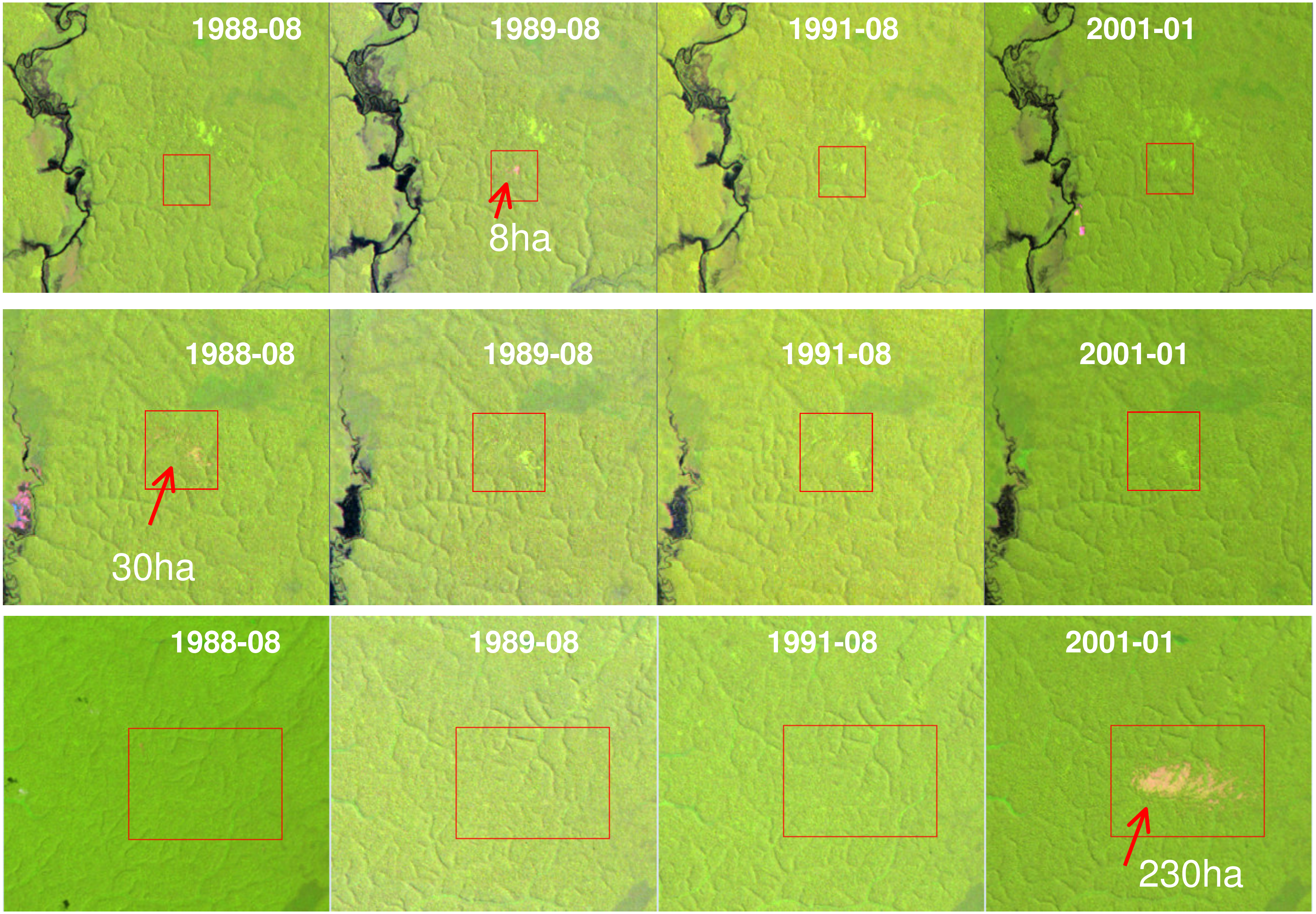
- 8 clusters;
- 100 km was used into a spatial dependency process



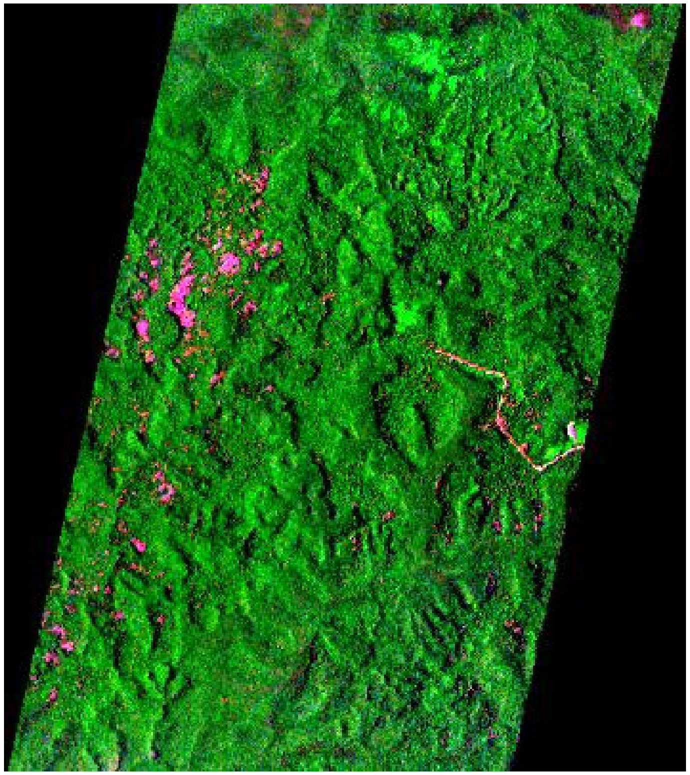


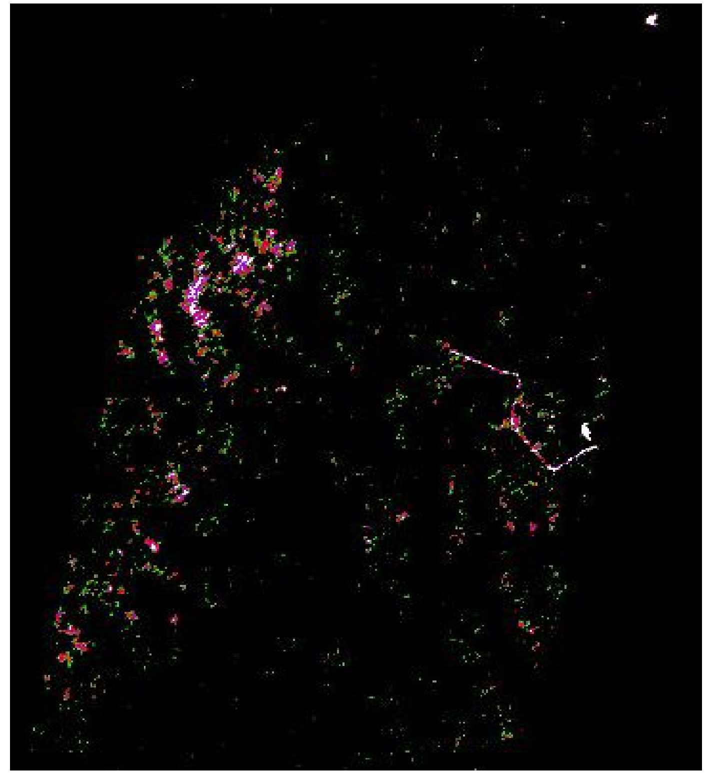


Central Amazon blowdown Landsat time series for > 20 years



Sampling the Disturbance Gradient Employing RS Metrics

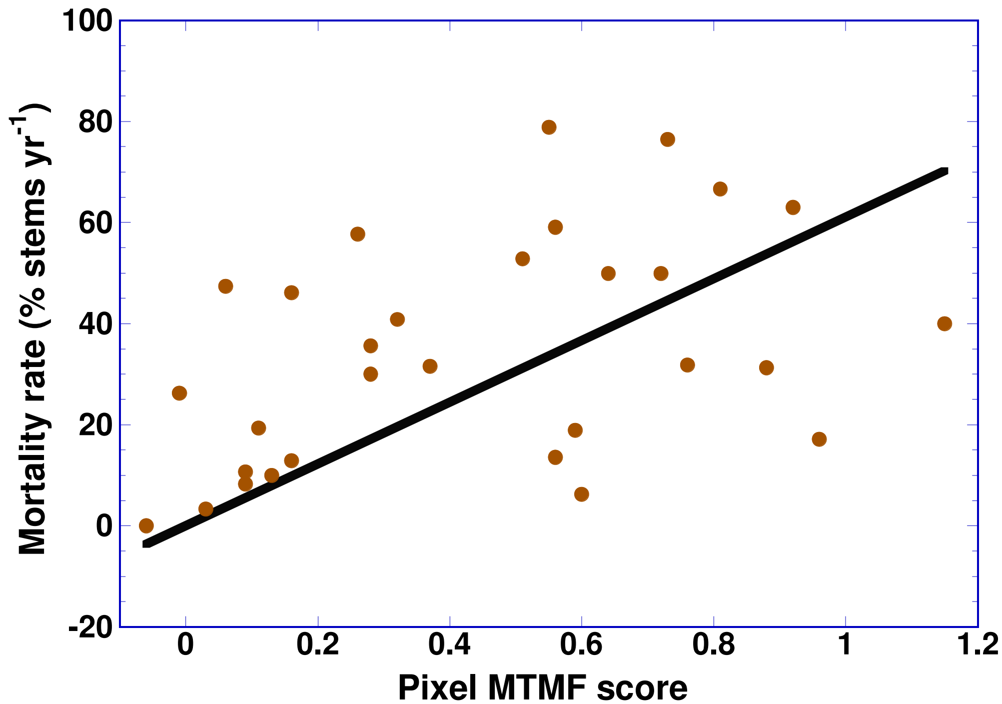




SITE 1

disturbance class	MTFM range	Lat	Long	pixel value	mortality rate
1	> 0.80	2° 35' 10.56"	60° 13' 33.15"	0.81	0.67
2	0.61 - 0.80	2° 35' 8.60"	60° 13' 37.03"	0.64	0.50
3	0.41 - 0.60	2° 35' 9.57"	60° 13' 37.03"	0.56	0.59
4	0.21 - 0.40	2° 35' 10.54"	60° 13' 39.94"	0.28	0.36
5	0.11 - 0.20	2° 35' 13.47"	60° 13' 40.92"	0.09	0.11
6	< 0.10	2° 35' 13.41"	60° 13' 41.88"	0.06	0.47

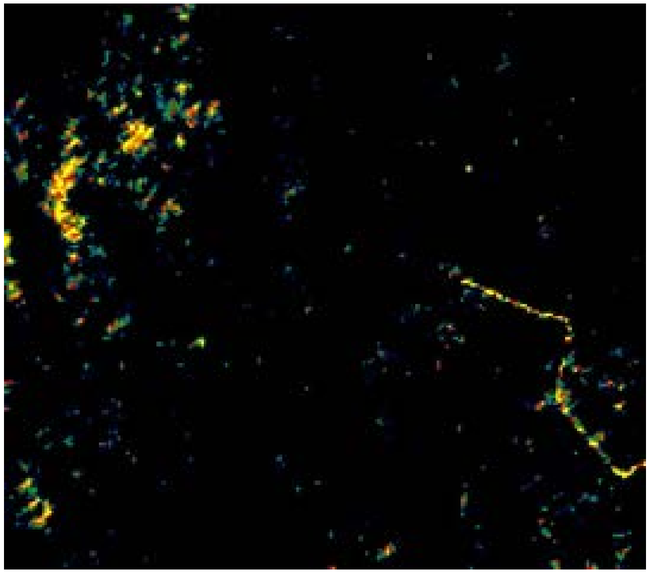
Developing relationships between remote sensing metrics and field-based mortality/damage rates

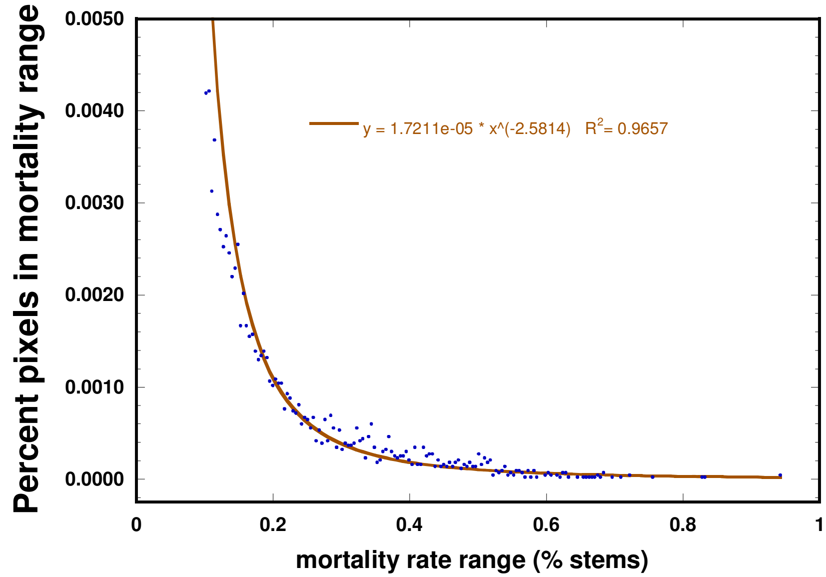


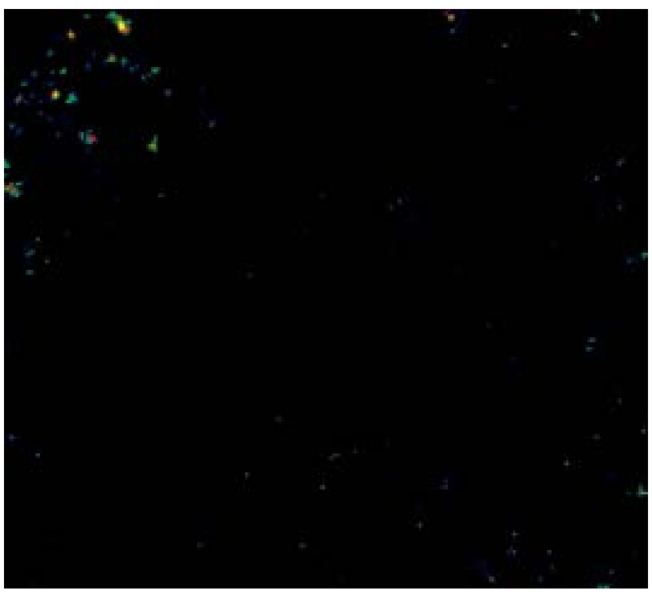
Each point from a randomly placed 400 m^2 inventory plot over a 25 km^2 area

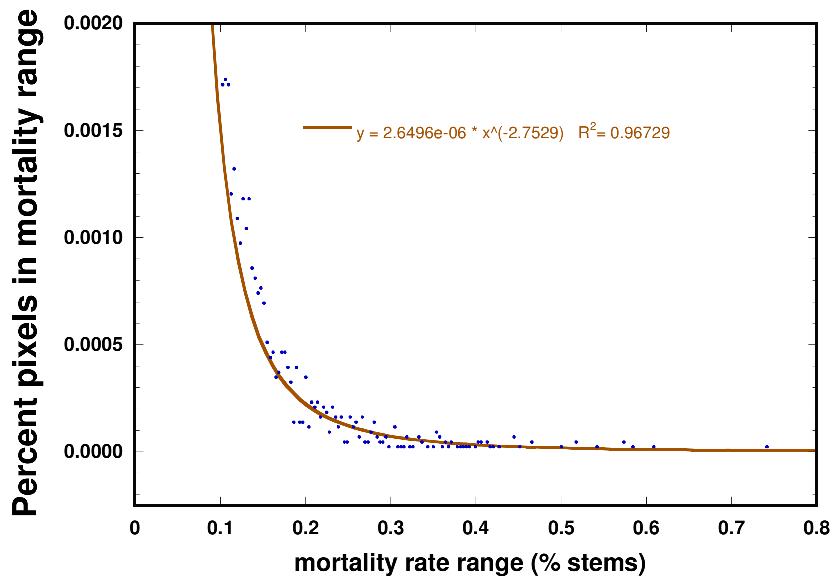
G. Guimarães
INPA Masters thesis

Frequency plot of Tree Mortality Rate Distribution at Landscape (> 1000 ha) Scale

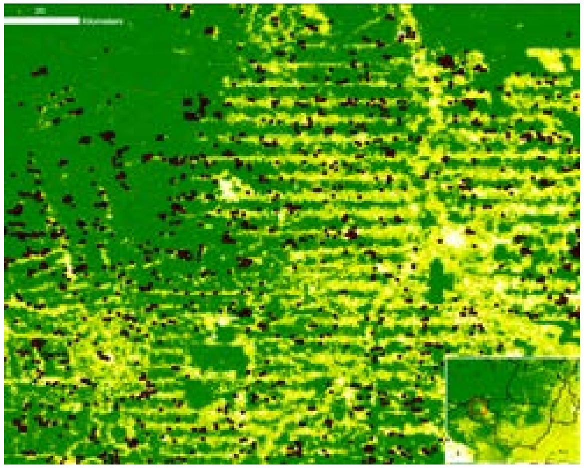








CHANGING DYNAMICS REFLECTED IN SPATIAL PATTERNS OF MODIS-DERIVED % TREE COVER AND FIRE EVENTS

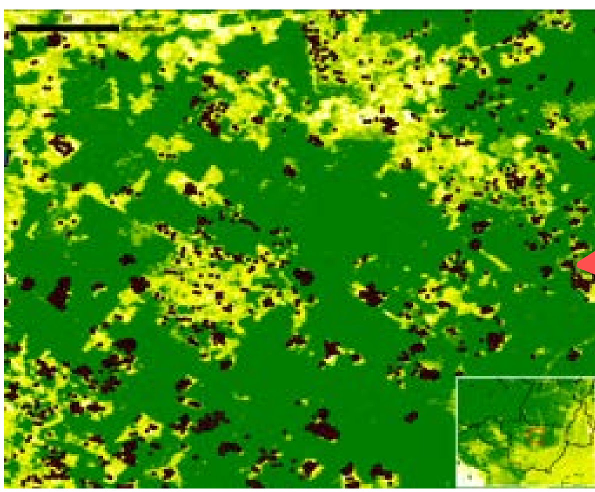


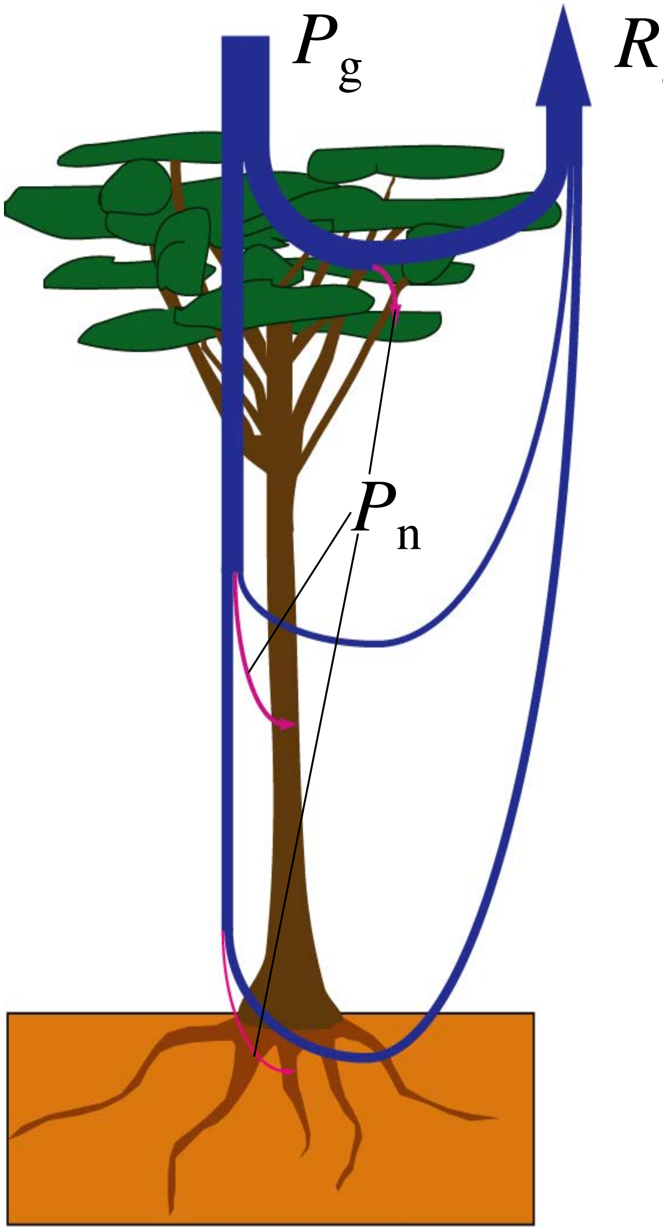
2001 Tree cover

0%

100%

2001-03 active fire





Ecological Applications, 14(4) Supplement, 2004, pp. S72–S88

RESPIRATION FROM A TROPICAL FOREST ECOSYSTEM: PARTITIONING OF SOURCES AND LOW CARBON USE EFFICIENCY

Jeffrey Q. Chambers,[1,2,4] Edgard S. Tribuzy,[2] Ligia C. Toledo,[2] Bianca F. Crispim,[2] Niro Higuchi,[2] Joaquim dos Santos,[2] Alessandro C. Araújo,[2] Bart Kruijt,[3] Antonio D. Nobre,[2] and Susan E. Trumbore[1]

$CUE = P_n/(R_a + P_n)$

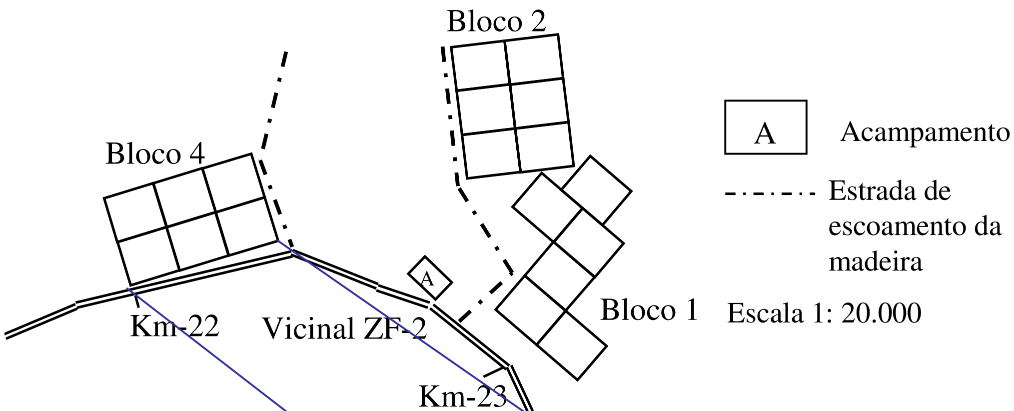
CUE = 30%

Only about 30% of carbon assimilated in photosynthesis was used to construct new tissues, with 70% being respired back to the atmosphere as autotrophic respiration.

Temperate forest and suggested global constant:

CUE = 50%

Overview of the BIONTE Logging Experiment



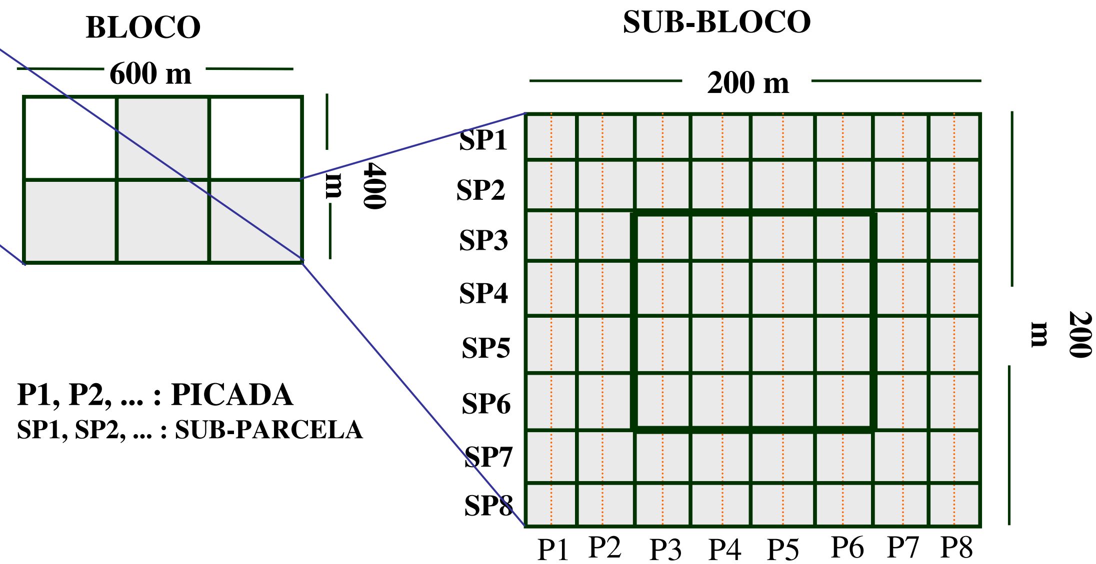
Treatments: % of commercial species basal area removed:

T0: Control (3 ha)

T1: 32% (3 ha)

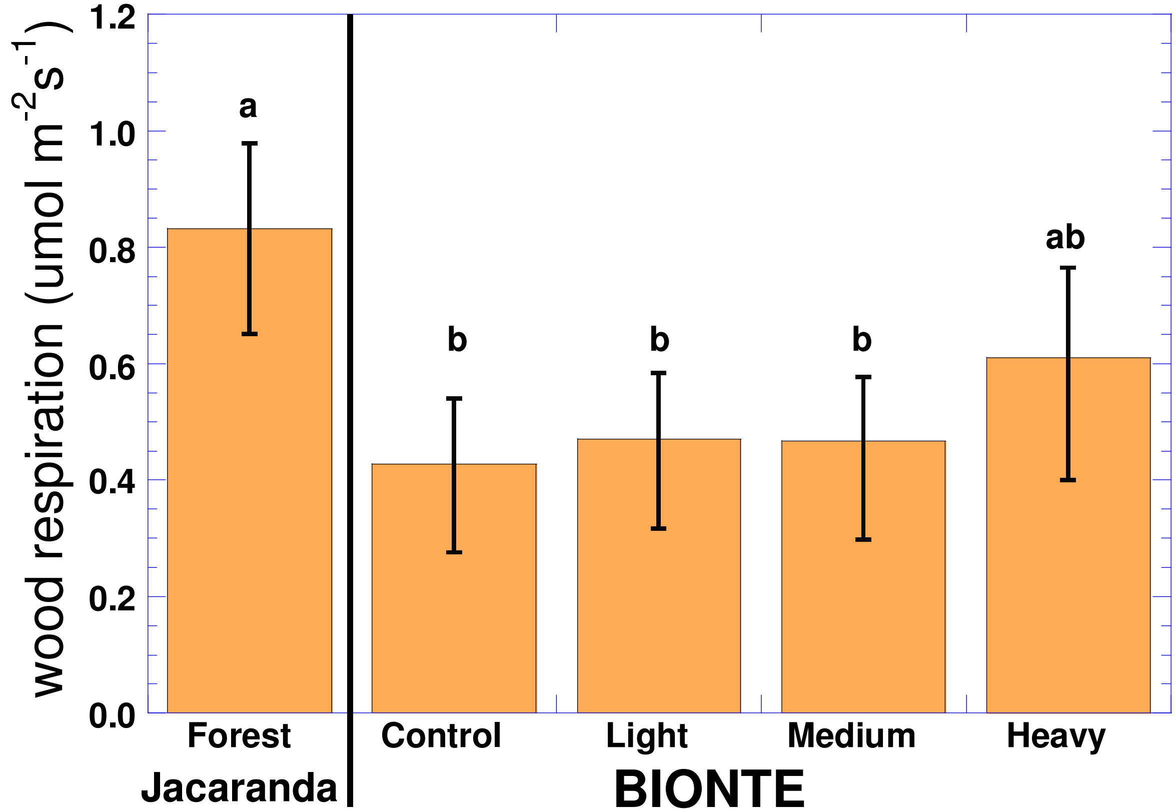
T2: 42% (3 ha)

T3: 69% (3 ha)



How does growth and woody tissue respiration of surviving trees respond to this disturbance?

Average Respiratory Flux for Statistically Equivalent Tree Size and Growth Rate



Plots accumulating (recovering) biomass had lower respiratory flux per unit growth and higher carbon use efficiencies.

L. Teixeira (2001) INPA Masters thesis

Potential Explanations for Low CUE

1. **Higher respiratory costs in tropical forests**

2. **CUE increases with mean annual temperature**

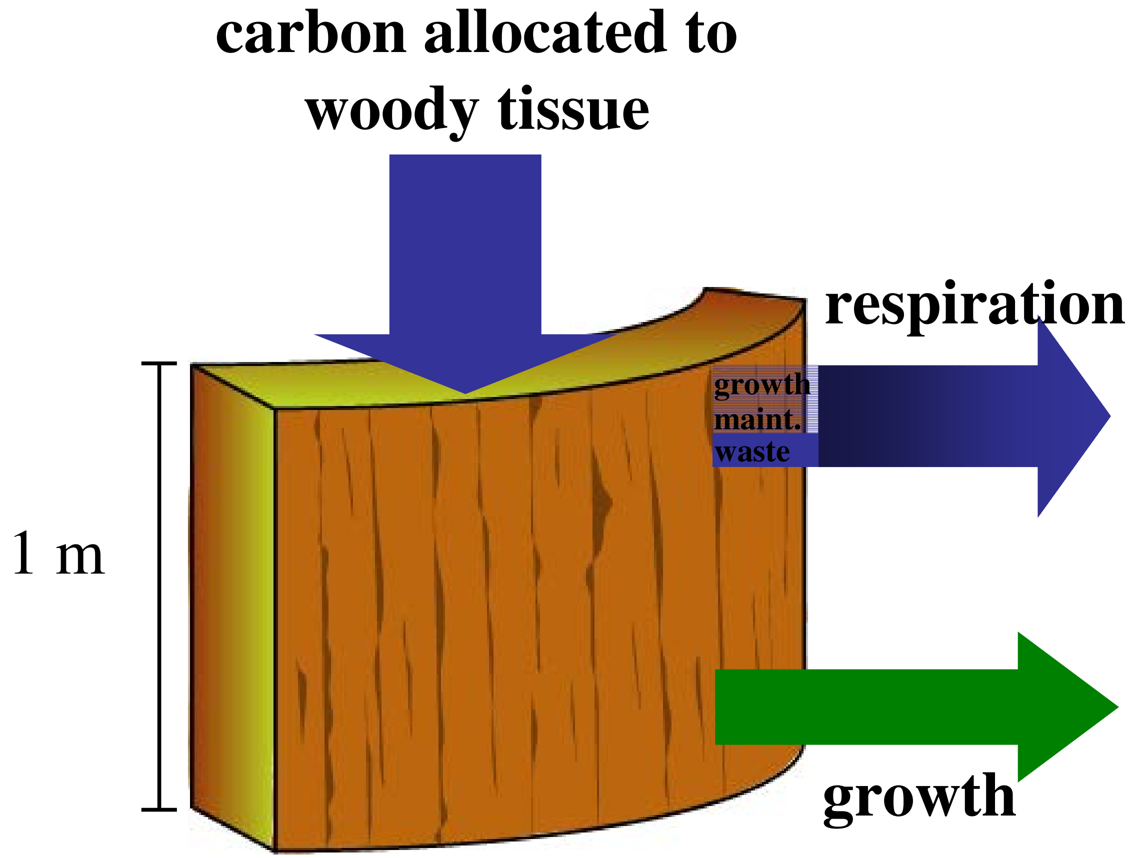
3. **Not carbon limited: many trees are assimilating more carbon than needed for construction and maintenance respiration**

$$CH_2\text{-} + O_2 \xrightarrow{\text{cytochrome oxidase}} CO_2 + H_2O + ATP$$

$$CH_2\text{-} + O_2 \xrightarrow{\text{alternate oxidase}} CO_2 + H_2O + \text{heat}$$

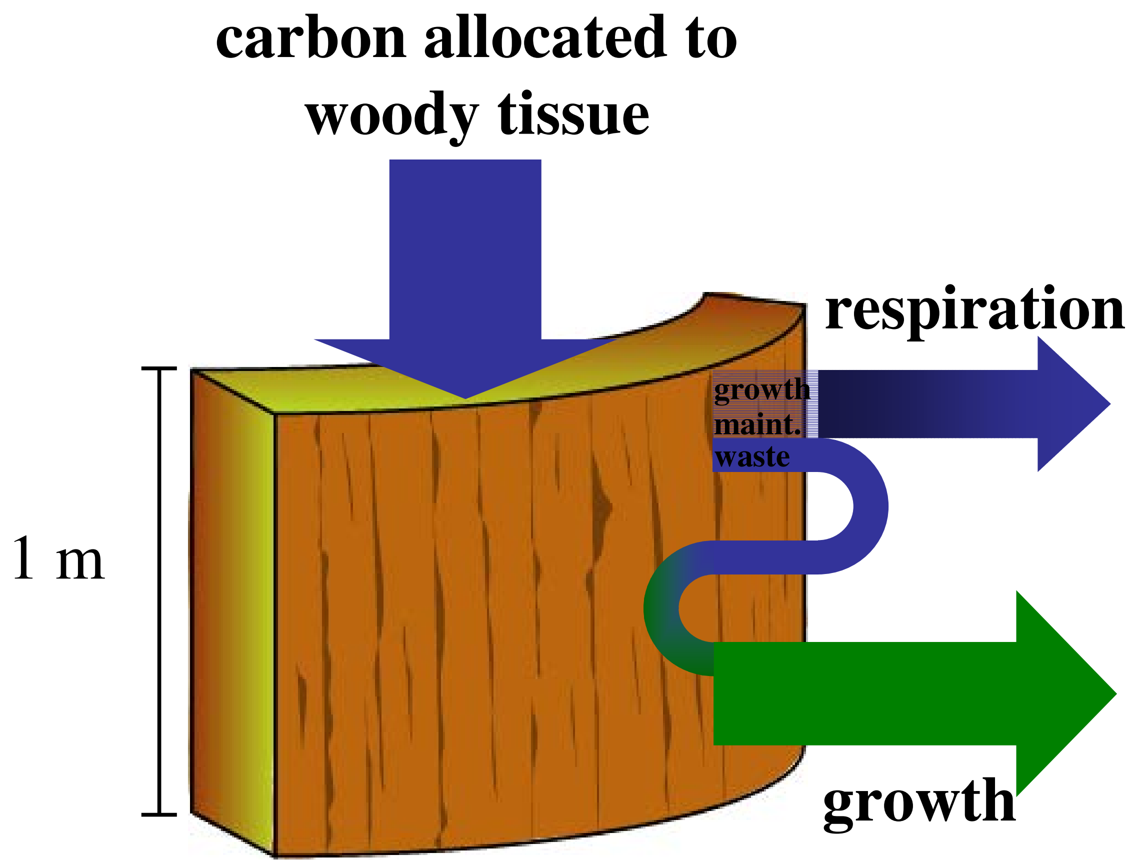
Hypothesis: Trees are carbon primed to rapidly respond to an increase in non-carbon resources.

Carbon Overflow Hypothesis



Carbon Partitioning in Woody Tissues: Resources Limited

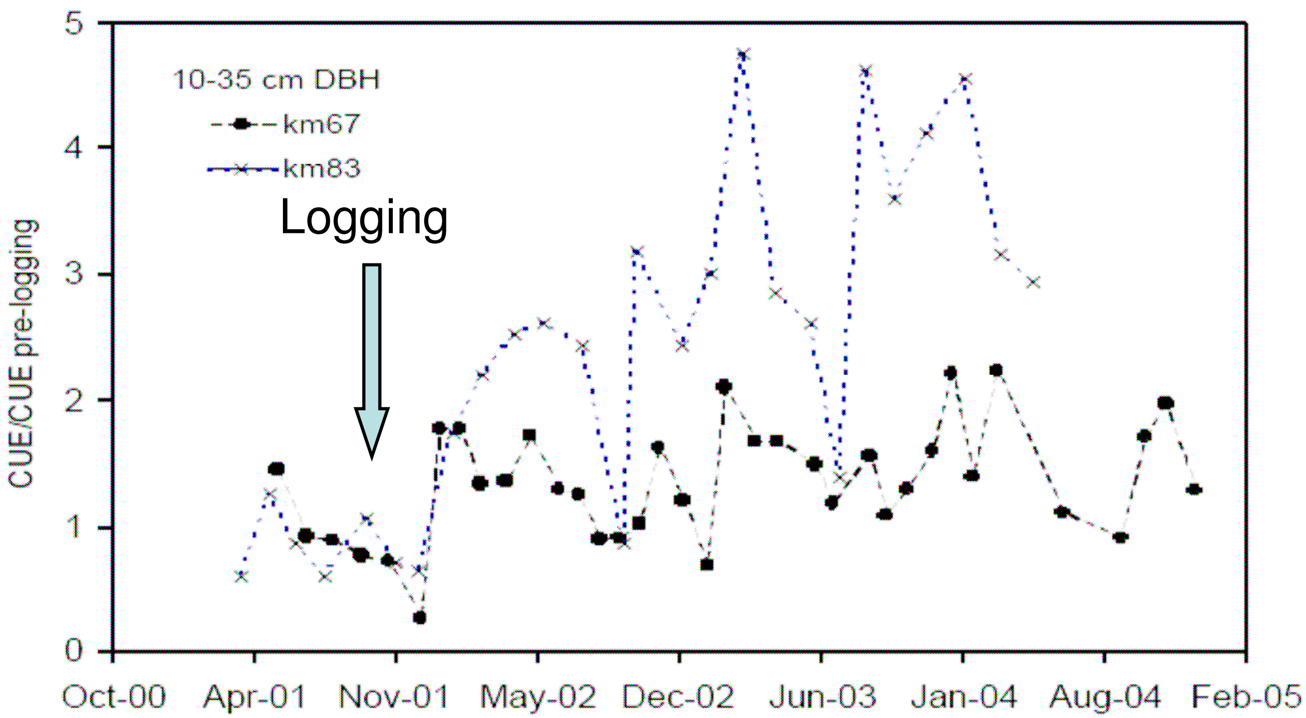
Carbon Overflow Hypothesis



Carbon Partitioning in Woody Tissues: Resources Increased

Tapajos Selective Logging Experiment

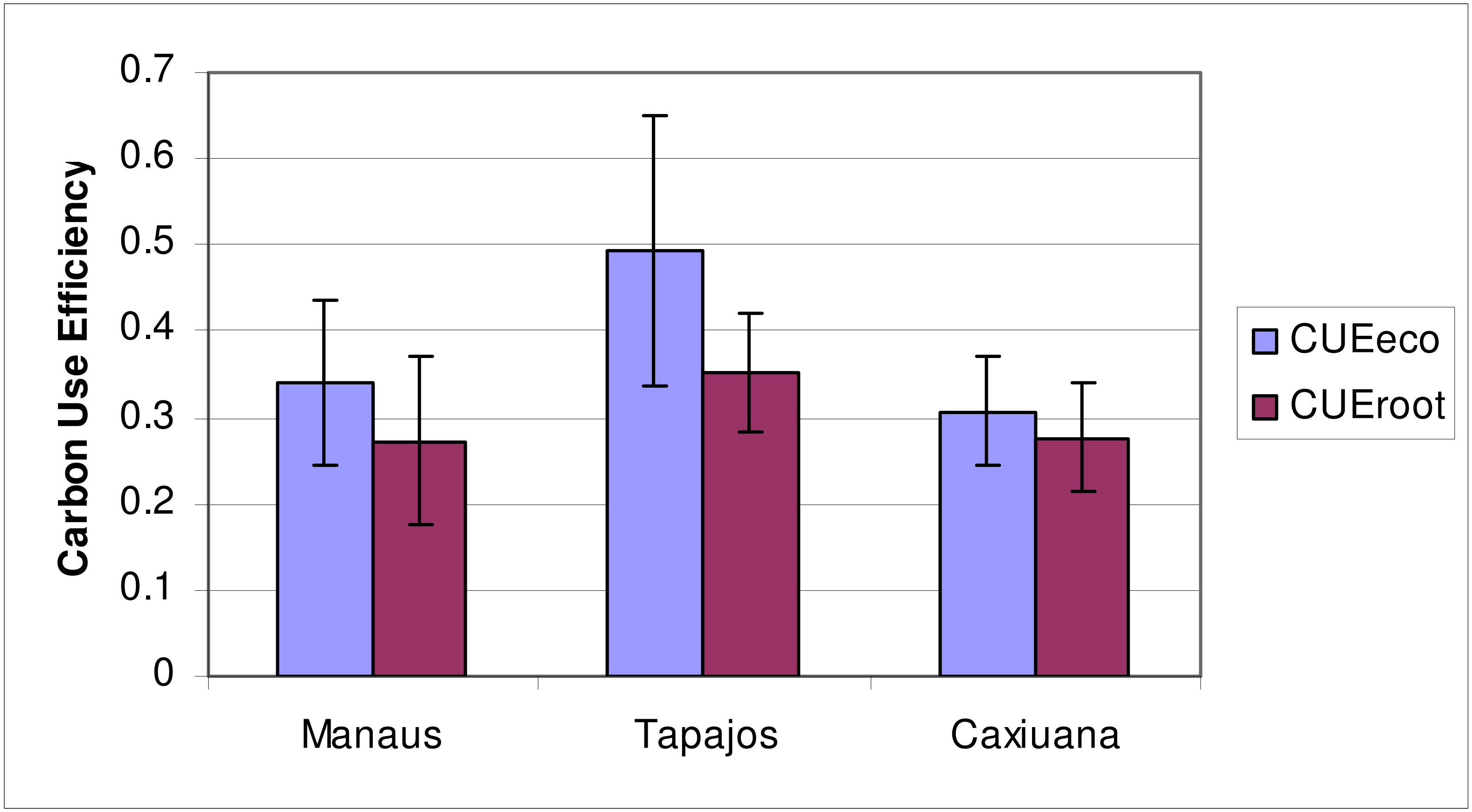
Wood Carbon Use Efficiency (CUE) = (Coarse Wood NPP) / GPP

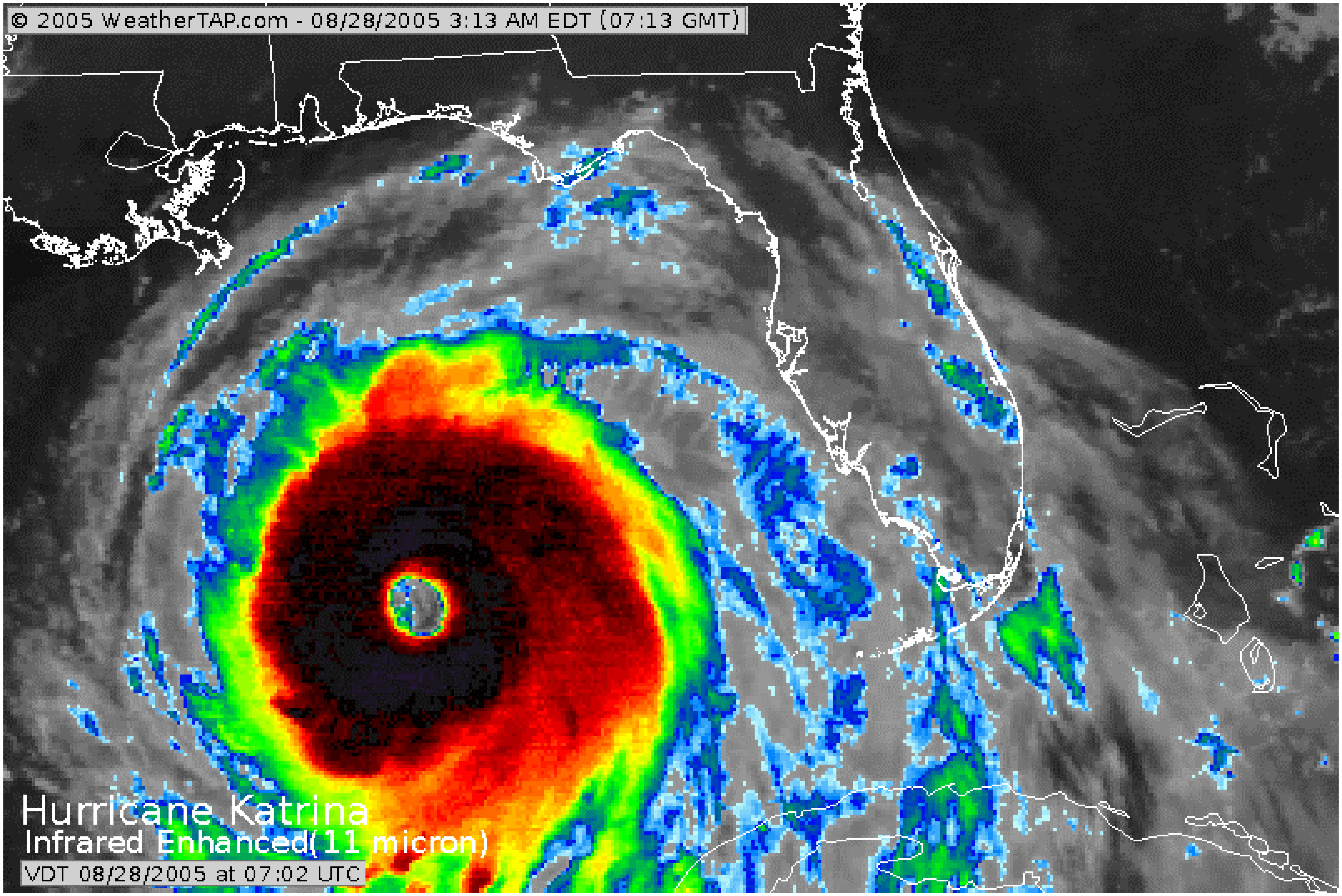


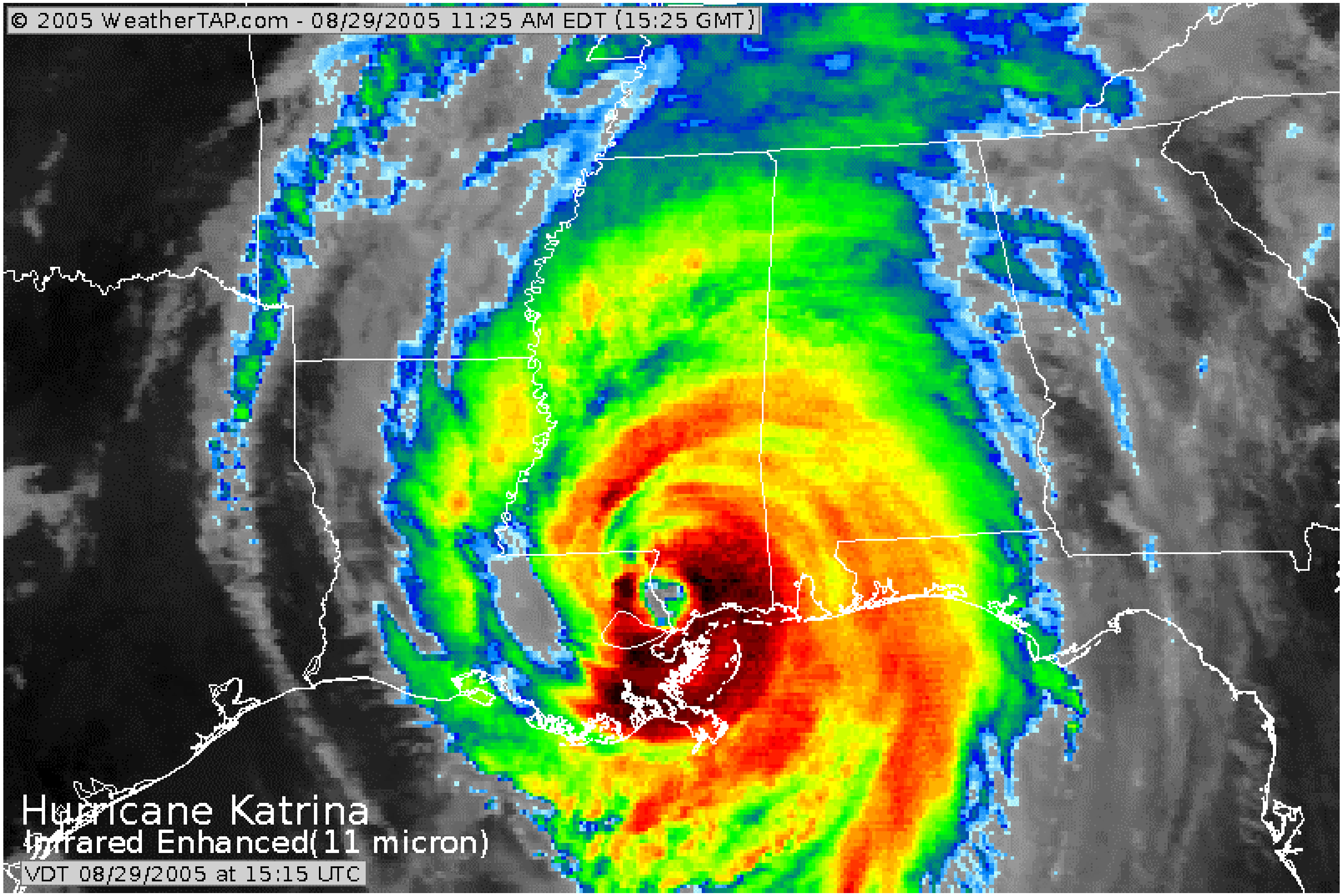
Selective logging promotes forest recovery by increasing allocation of photosynthate to wood production (increased CUE)

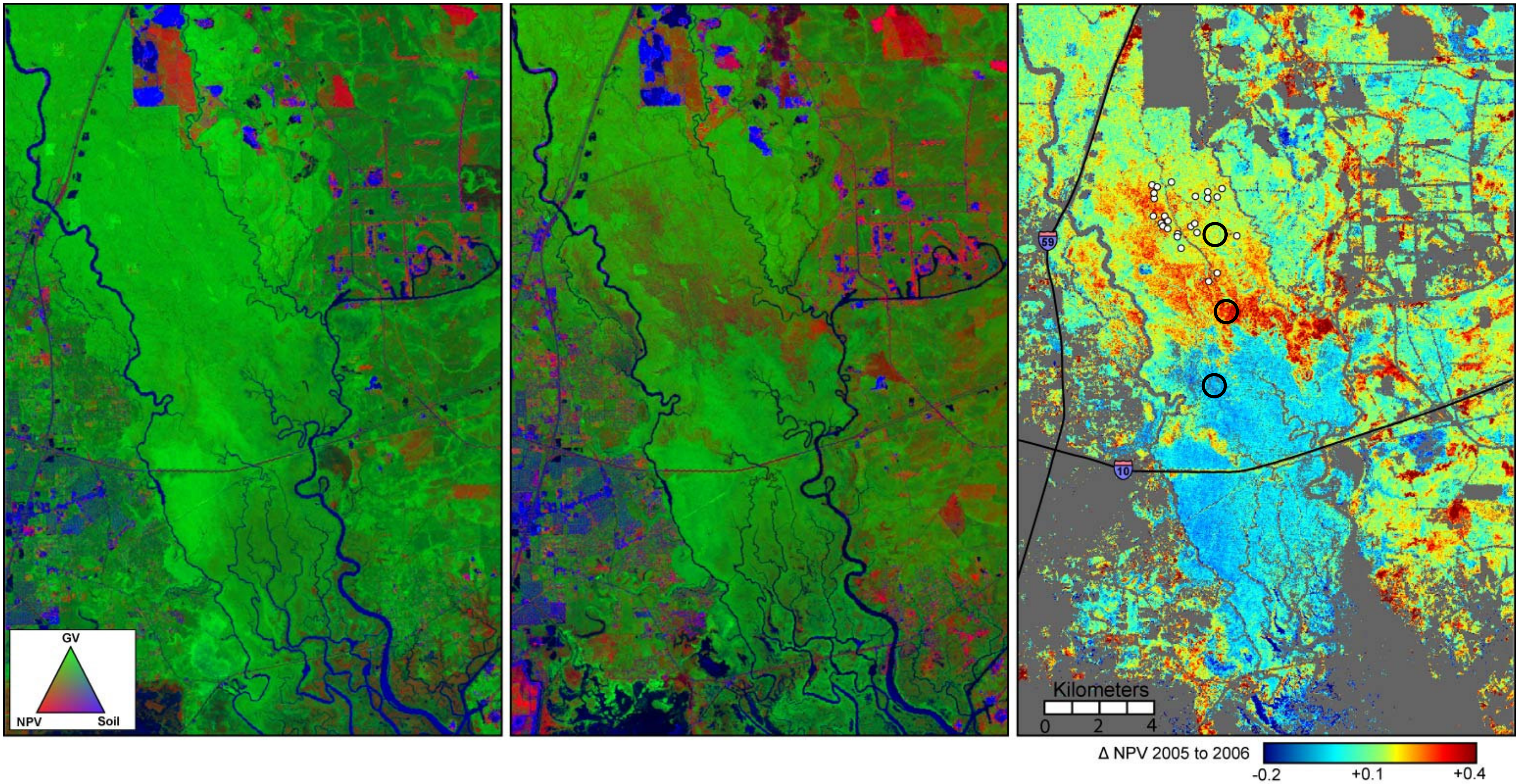
See Scott Miller talk on Friday's session on Carbon and Energy fluxes

Carbon use efficiencies

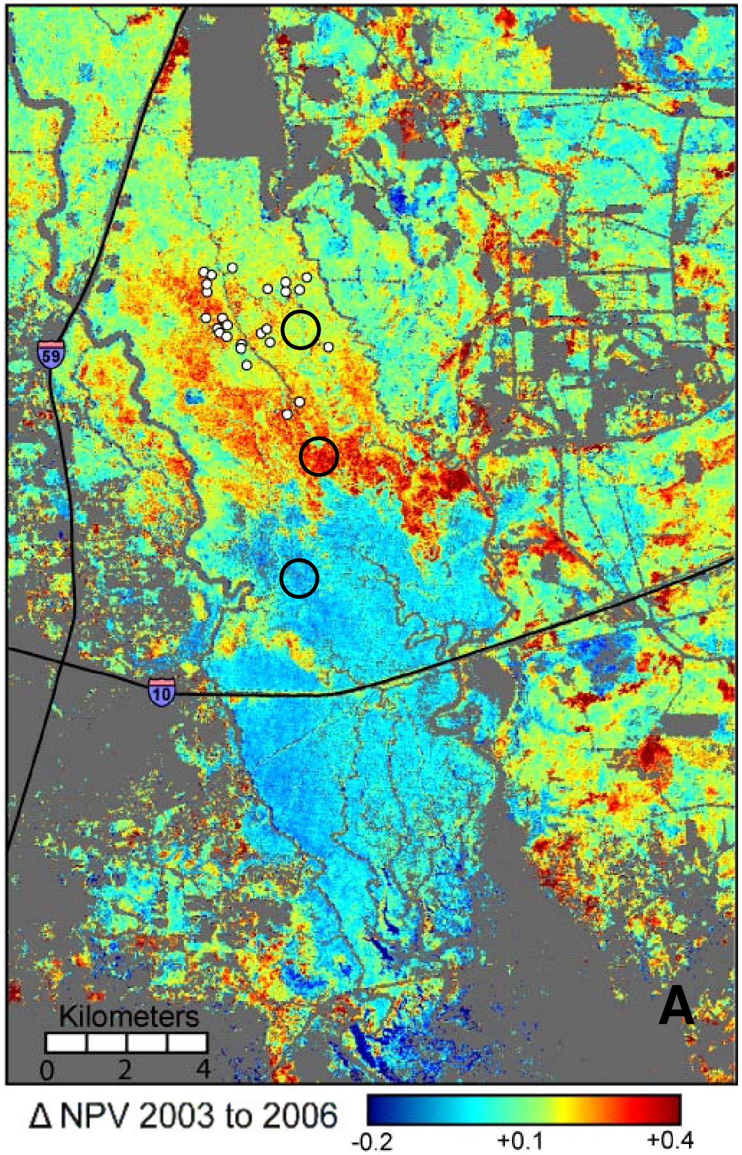


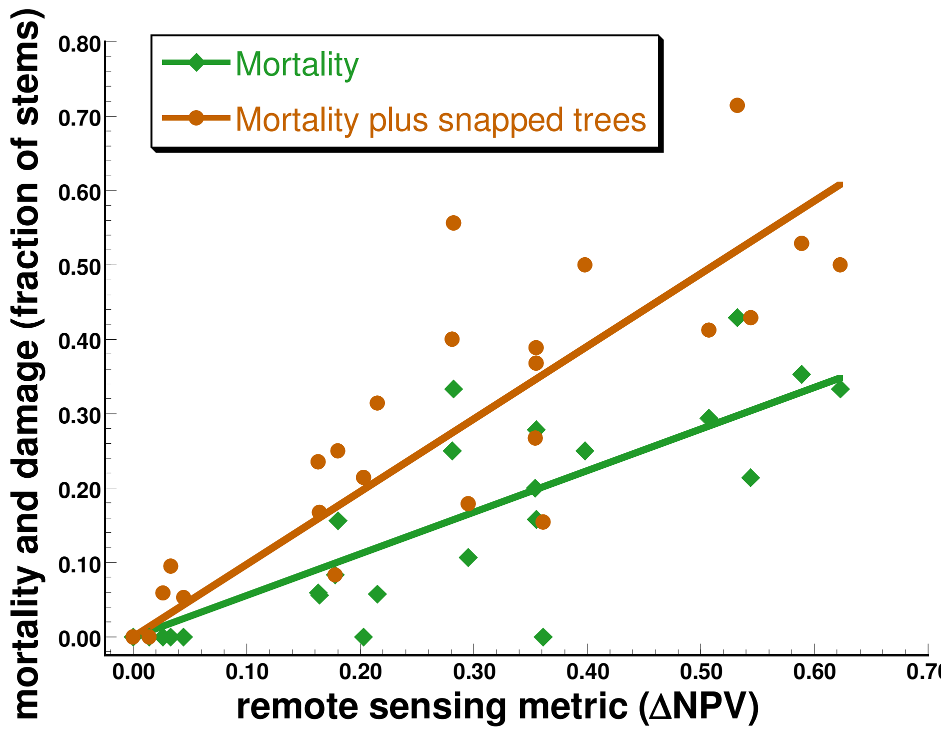

© 2005 WeatherTAP.com - 08/28/2005 3:13 AM EDT (07:13 GMT)
Hurricane Katrina
Infrared Enhanced(11 micron)
VDT 08/28/2005 at 07:02 UTC


© 2005 WeatherTAP.com - 08/29/2005 11:25 AM EDT (15:25 GMT)
Hurricane Katrina
Infrared Enhanced(11 micron)
VDT 08/29/2005 at 15:15 UTC

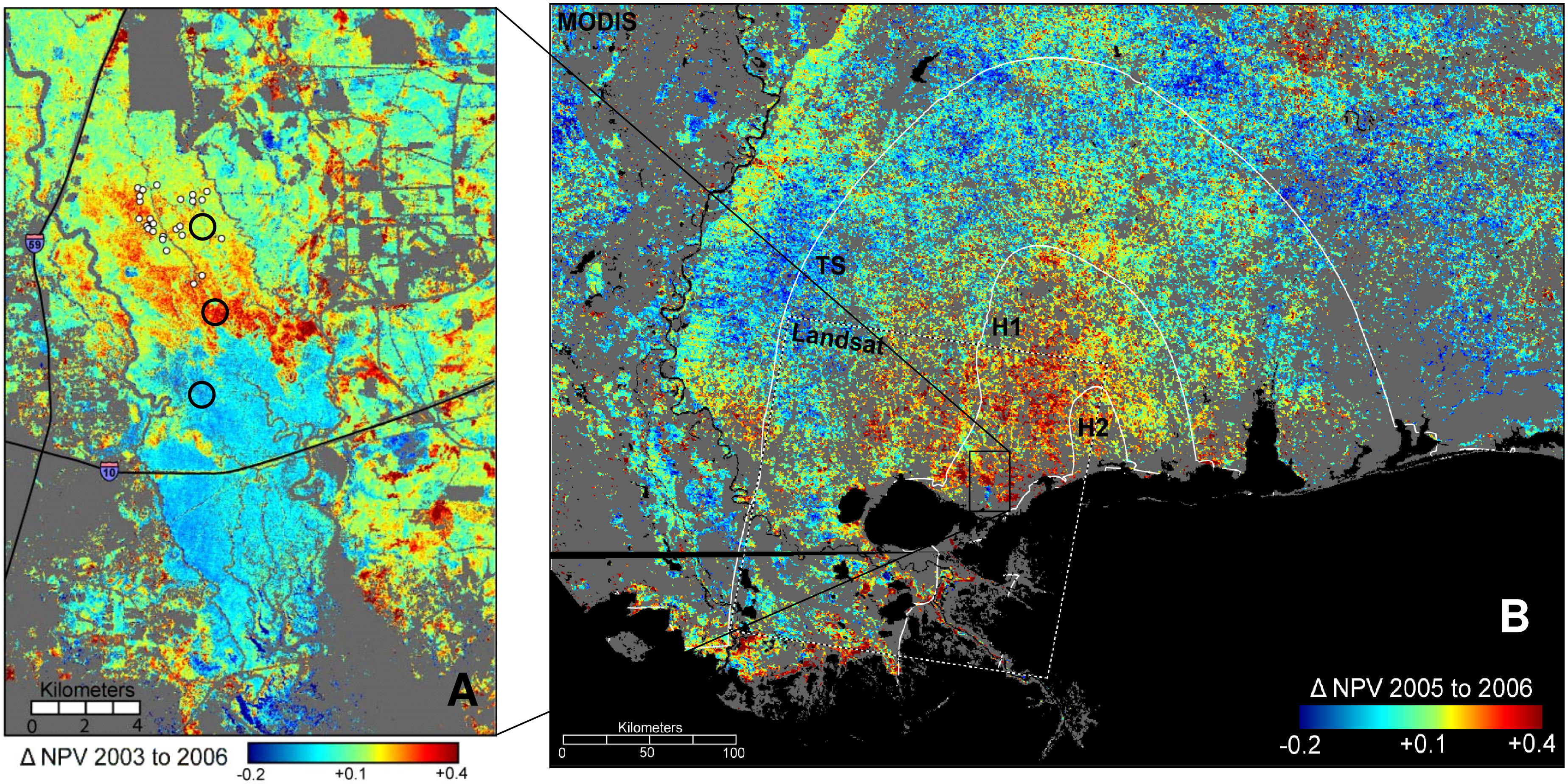

GV
NPV
Soil
59
10
Kilometers
0
2
4
Δ NPV 2005 to 2006
-0.2
+0.1
+0.4

Mapping hurricane Katrina impact at a regional scale: linking field ecology and remote sensing





Hurricane Katrina's Footprint on Gulf Coast Forests



Disturbance/Recovery Group Summary

- ***Trends in Ecology and Evolution*** **paper our current crowning achievement**
- **Ideas generated for grand synthesis across biotic, abiotic and anthropogenic disturbance/recovery gradients**
- **Number of projects working on filling gaps in our understanding of the distribution of tree mortality events: (1) size, (2) intensity, and (3) return interval**
- **Emerging synthesis on variability in carbon use efficiency (CUE) across sites and with varying methods – excellent basic science achievement of LBA-ECO**
- **Tools and methods developed in the Amazon now being employed to quantify forest impacts elsewhere (e.g. hurricane Katrina)**


Luiz Aragao, Vilany Carneiro, Elise Chapman, Marcos Costa, Ruth DeFries, Jeremy Fisher, Niro Higuchi, George Hurtt, Michael Keller, Steve Klooster, Mark Kramer, Paul Moorcroft, Lucie Plourde, Amanda Robertson, Sami Rifai, Marie-Louise Smith, Liliane Teixiera, Yadvinder Malhi, Greg Asner, Doug Morton, Liana Anderson, Sassan Saatchi, Fernando Espırito-Santo, Michael Palace, Carlos Souza,

This has been a Disturbance Synthesis Working Group production.

Tulane University

DOE National Institute for Climatic Change Research

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