Amazon Scenarios: Modeling modeling interactions among land use, climate, and fire

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Co-PIs & Collaborators: Robert Kaufmann (BU), Paulo Moutinho, Ane Alencar (IPAM), Britaldo Soares (UFMG), Carlos Nobre (INPE/CPTEC), Carlos Klink, Heloisa Miranda (UnB), Pedro Silva Dias (USP), Eustaquio Reis (IPEA)

University of Maryland
January 20, 2004

Fire Types

Cleared Areas

Forest

Intentional

Accidental

With: A Alencar, E Mendoza

Question 1:

- What is the contribution of forest understory fires to C emissions?
  - Fire as a fcn of land use, climate, landscape features
  - Forest recovery following fire
  - Conditions that lead to new stable vegetation (savannization)

Question 2:

- What are the most likely trajectories of land use and C emission?
  - Socio-economic variables that determine desirability of landscape units and likelihood of conversion
  - Influence of infra-structure, nat'l economy, int'l economy
  - Interactions between land use change and climate

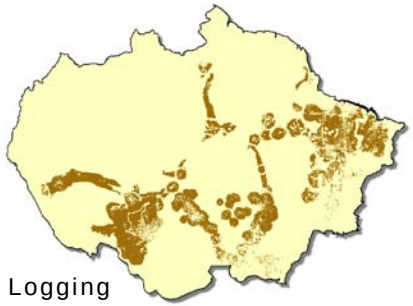
AMAZON SCENARIOS: Model Components

Aquatic Resources/
Watershed Health

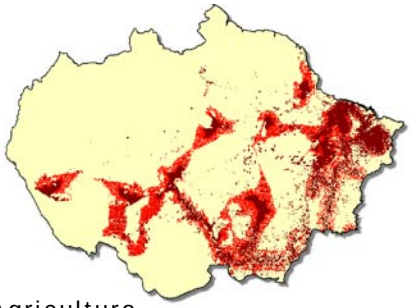
Sediments, toxins

Run-off, carbon

Economics



Logging

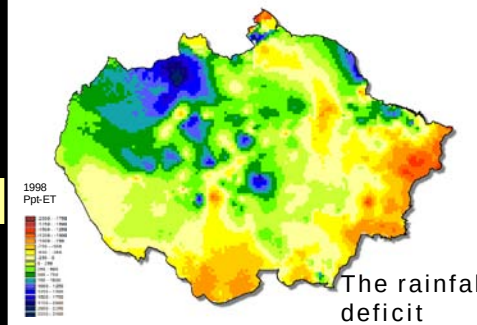


Agriculture

Landcover

Rain, T

Climate



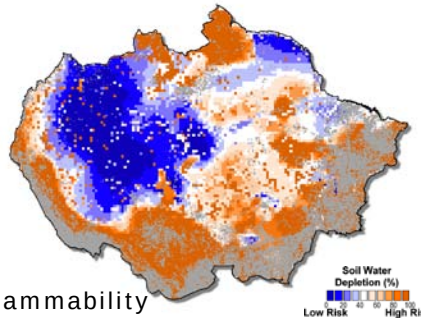
The rainfall deficit

Carbon

Rainfall, T, rad

Ecology

Productivity



Flammability

Landcover

Burned Area, Regrowth

Terrestrial Biodiversity

Habitat, Hunting

Food, r

Amazon Scenarios Institutions

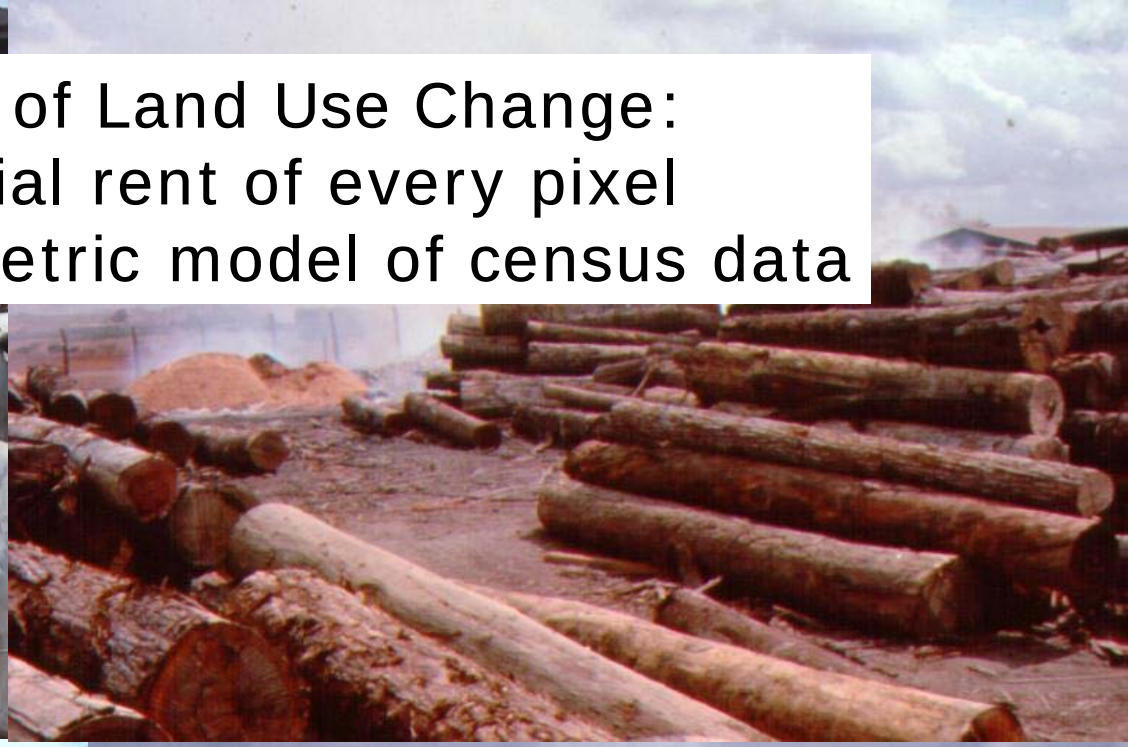
- *Instituto Nacional de Pesquisa Espacial/Centro de Previsao de Tempo e Clima (INPE/CPTEC) (C Nobre)*
- *Instituto de Pesquisa Ambiental da Amazonia (A Alencar)*
- *Instituto de Pesquisa Economica Aplicada (IPEA) (E Reis)*
- *Univ. Federal Minas Gerais (Britaldo Soares Filho)*
- *Univ. Federal Para (D McGrath)*
- *Univ. Federal Acre (F Brown)*
- *Univ. Federal Rondonia (S Rivero)*
- *Univ. Sao Paulo (P Silva Dias)*

- *Boston University (R Kaufmann)*
- *Duke University (R Avissar)*
- *Stanford University (G Asner)*
- *University Virginia (G Amacher)*

Woods Hole Research Center (D Nepstad)

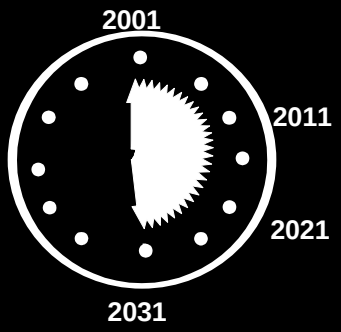
- *Yale University (L Curran)*

The Four Drivers of Land Use Change:
Where: Potential rent of every pixel
How much: Econometric model of census data

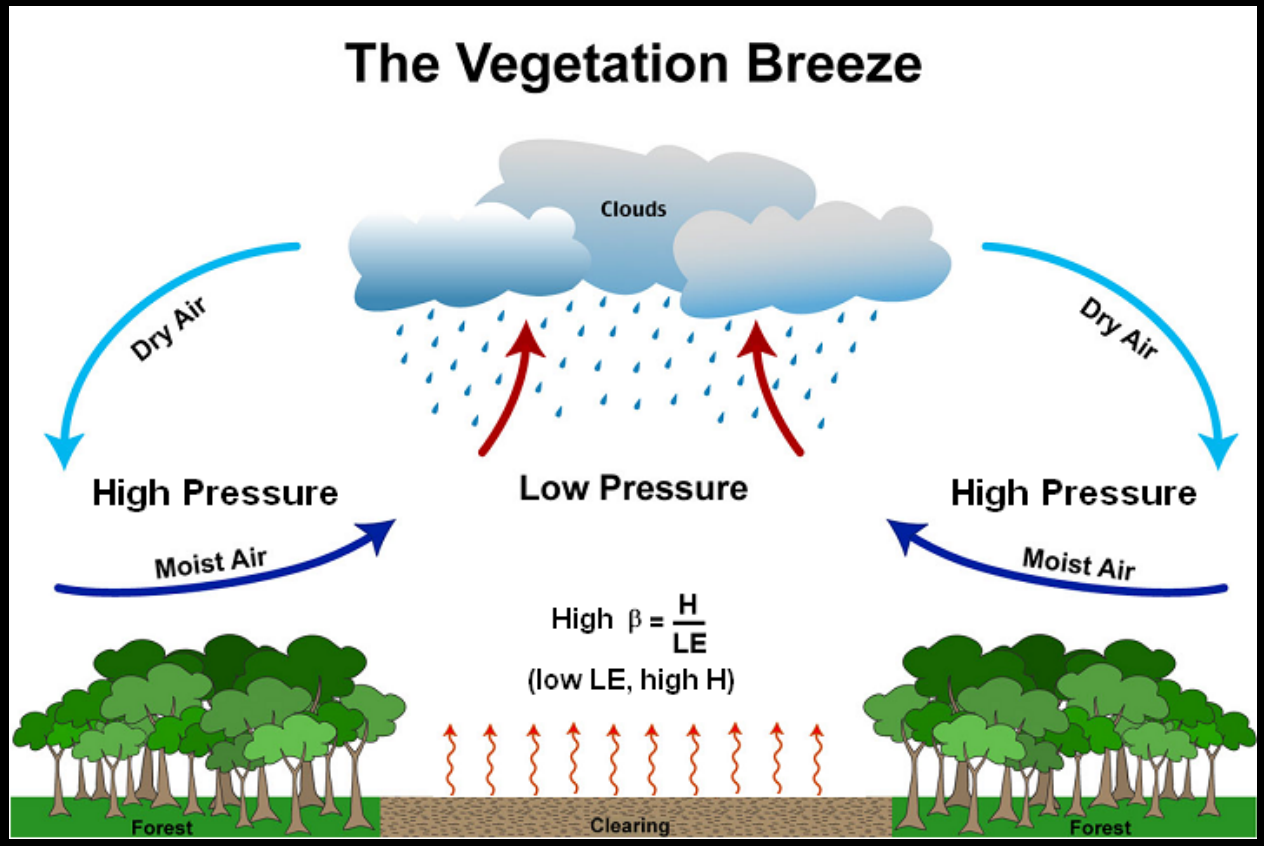



Caracas
The Woods Hole Research Center
IPAM - INSTITUTO DE PESQUISA AMBIENTAL DA AMAZÔNIA
Roads to be paved
Paved roads
Unpaved roads
Waterways
Gas pipelines
Ports
Belém
São Luis
Santarém
Manaus
Iquitos
Novo Progresso
Pucallpa
Porto Velho
Rio Branco
Puerto Maldonado
Lima
Santa Cruz
Cuiabá
Brasília
Ilo
Timber Production (m³/year)
0 - 100,000
100,000 - 300,000
> 300,000

Business as usual scenario



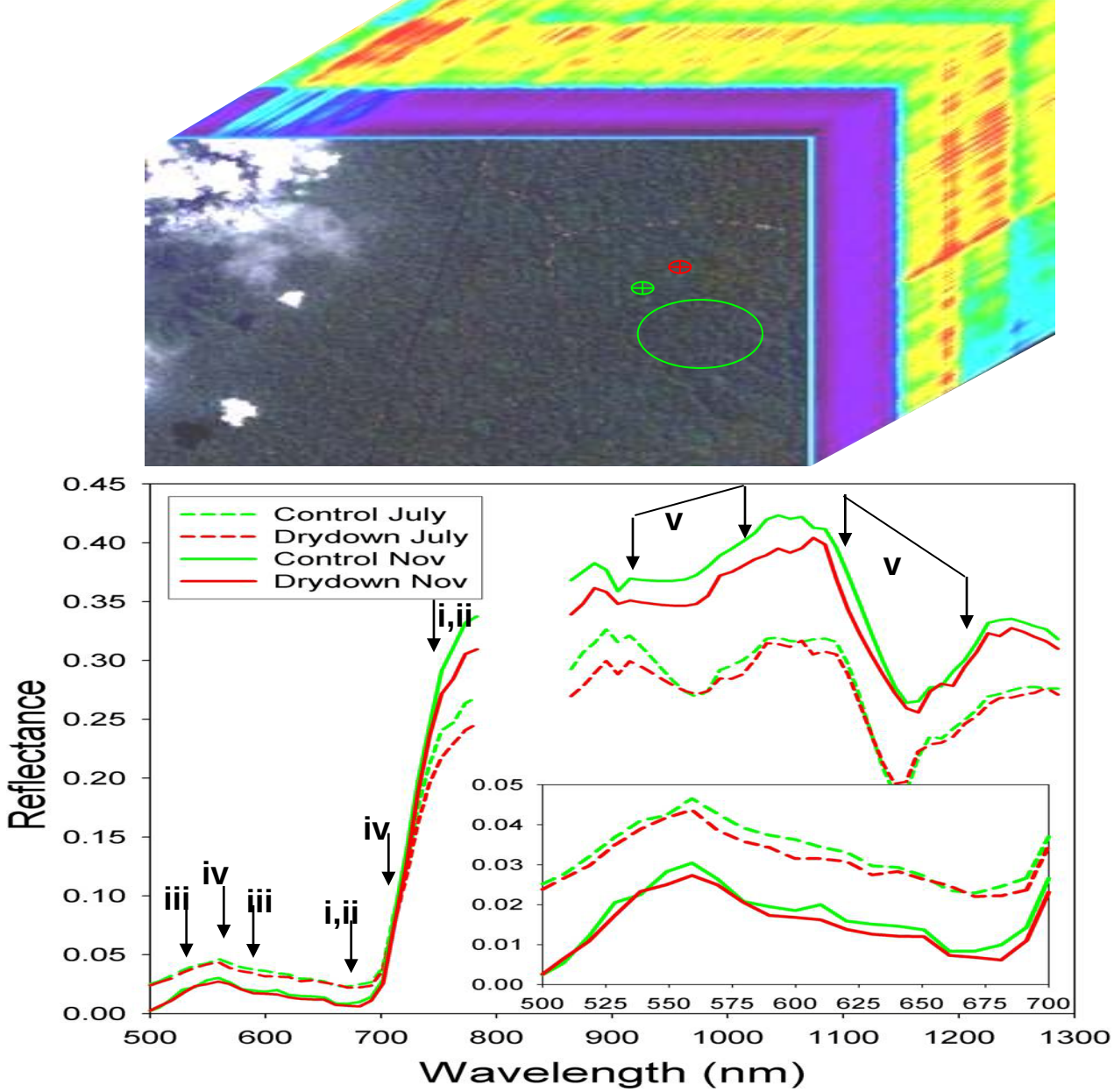
Climate Models: GCM (COLA, CPTEC, C Nobre), RAMS (R Avissar, P Silva Dias)



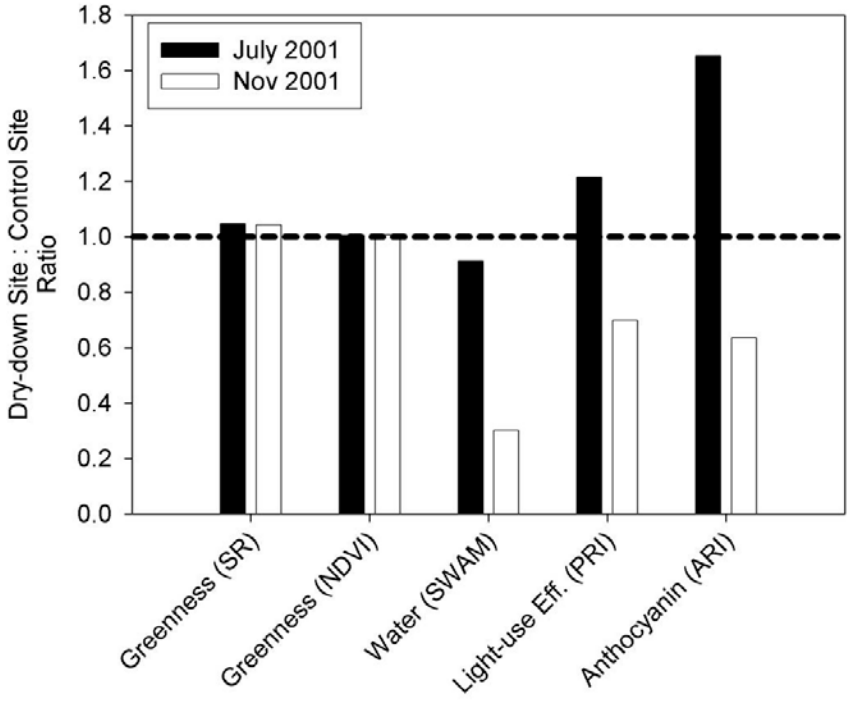
From: R Avissar et al.

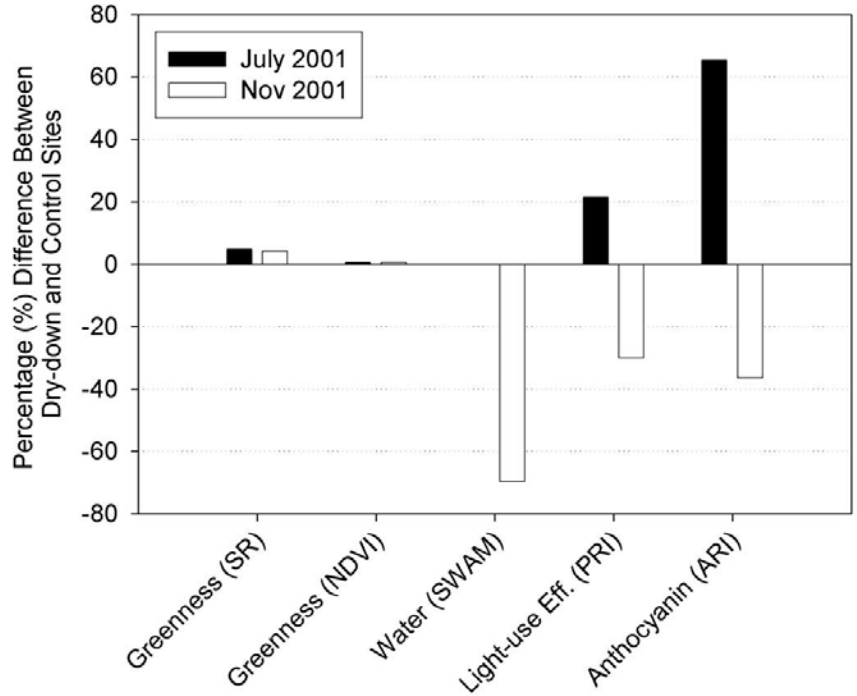
Defining the limits of drought tolerance: A throughfall exclusion experiment

With: P Moutinho, D Ray, G Cardinot, I Tohver, M Dias Filho, M Nascimento, L Solorzano, E Davidson



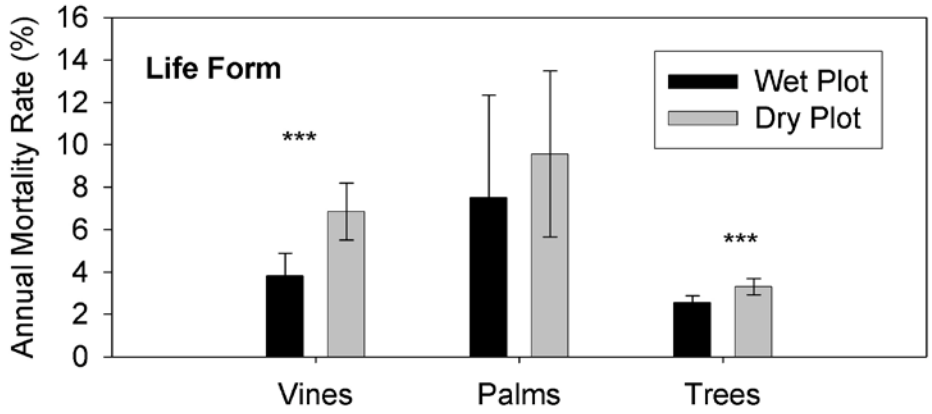
EO-1 Hyperion detection of canopy drought stress

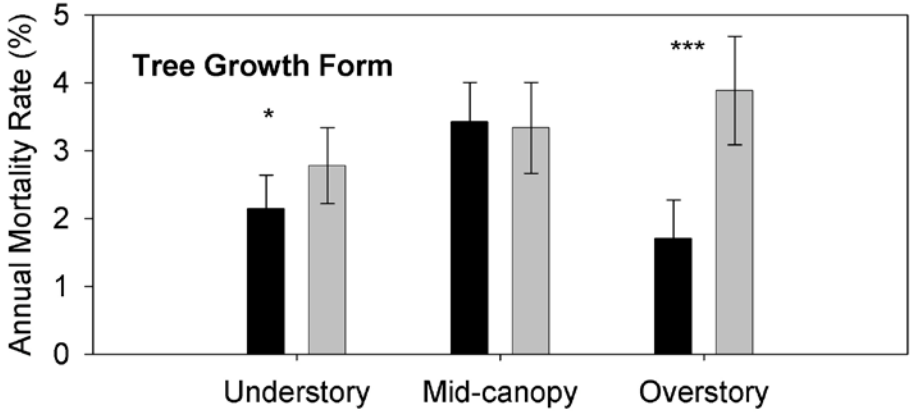


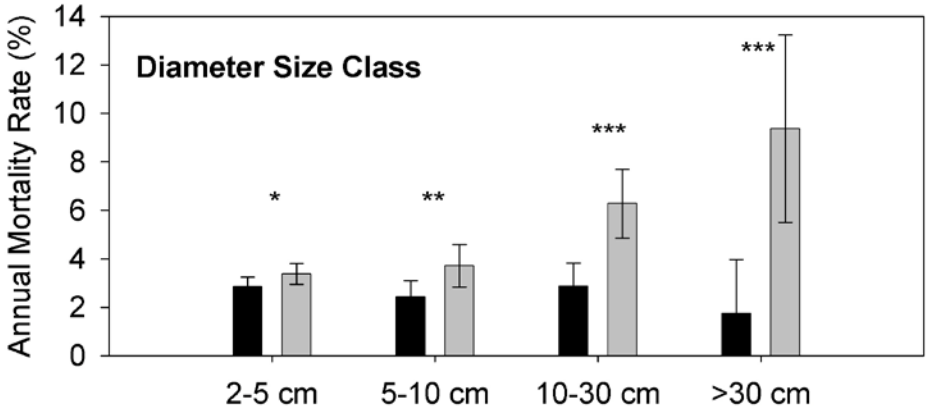


Hyperspectral detection of subtle canopy drought effects: canopy water content and light-use efficiency

With: G. Asner



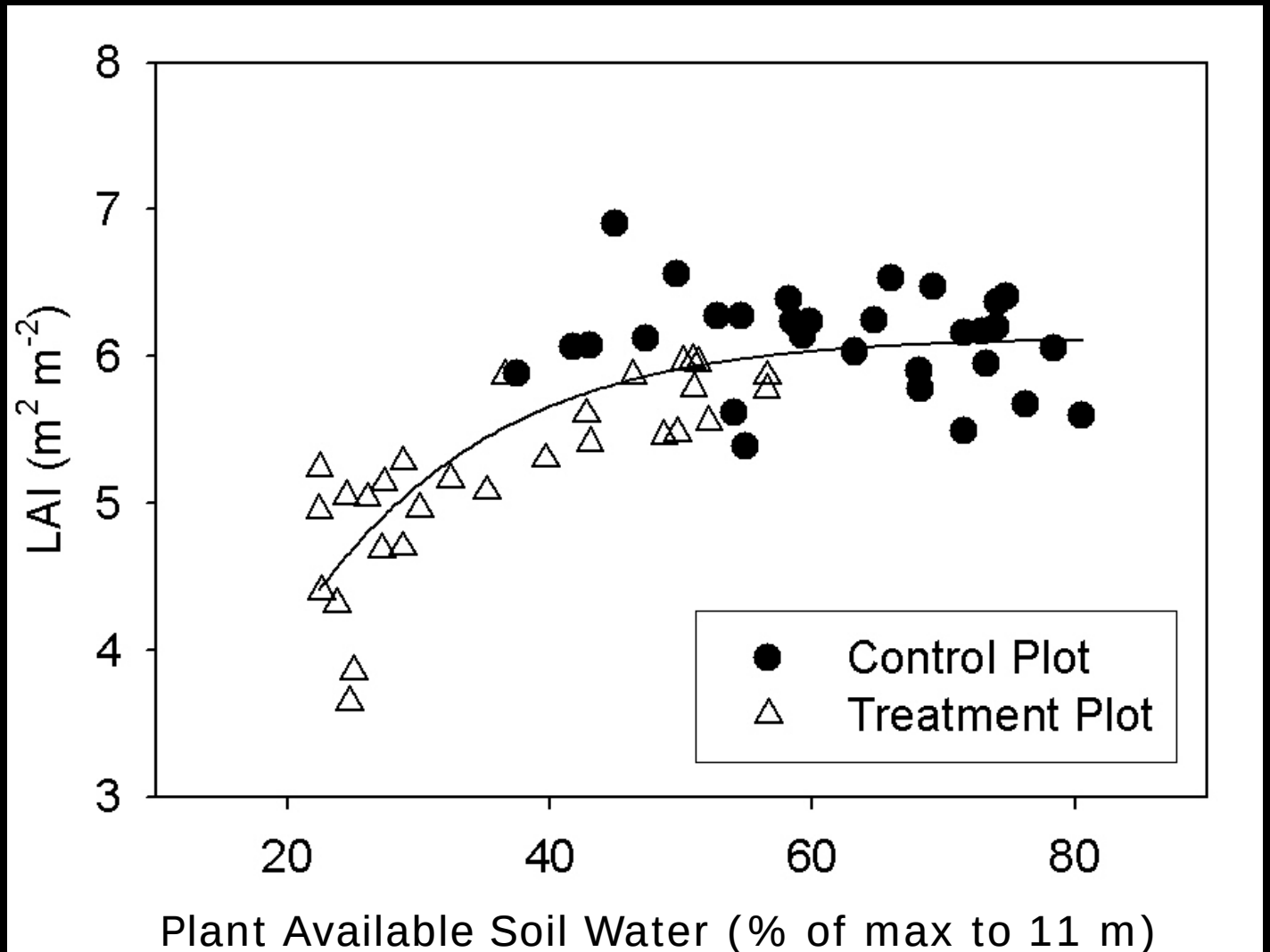


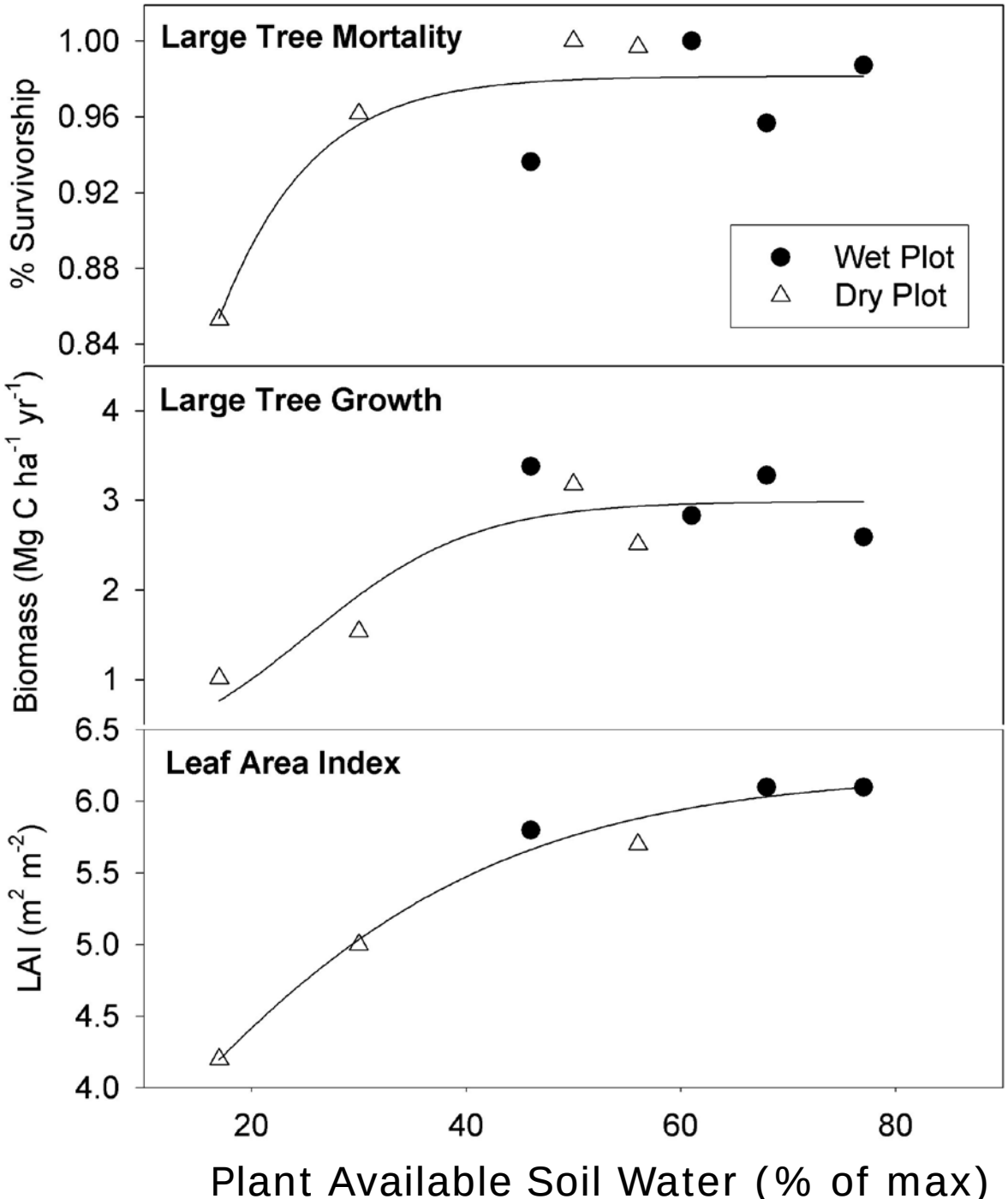


Large, overstory trees die first

Tohver et al., in prep

Canopy thinning only after severe soil moisture depletion





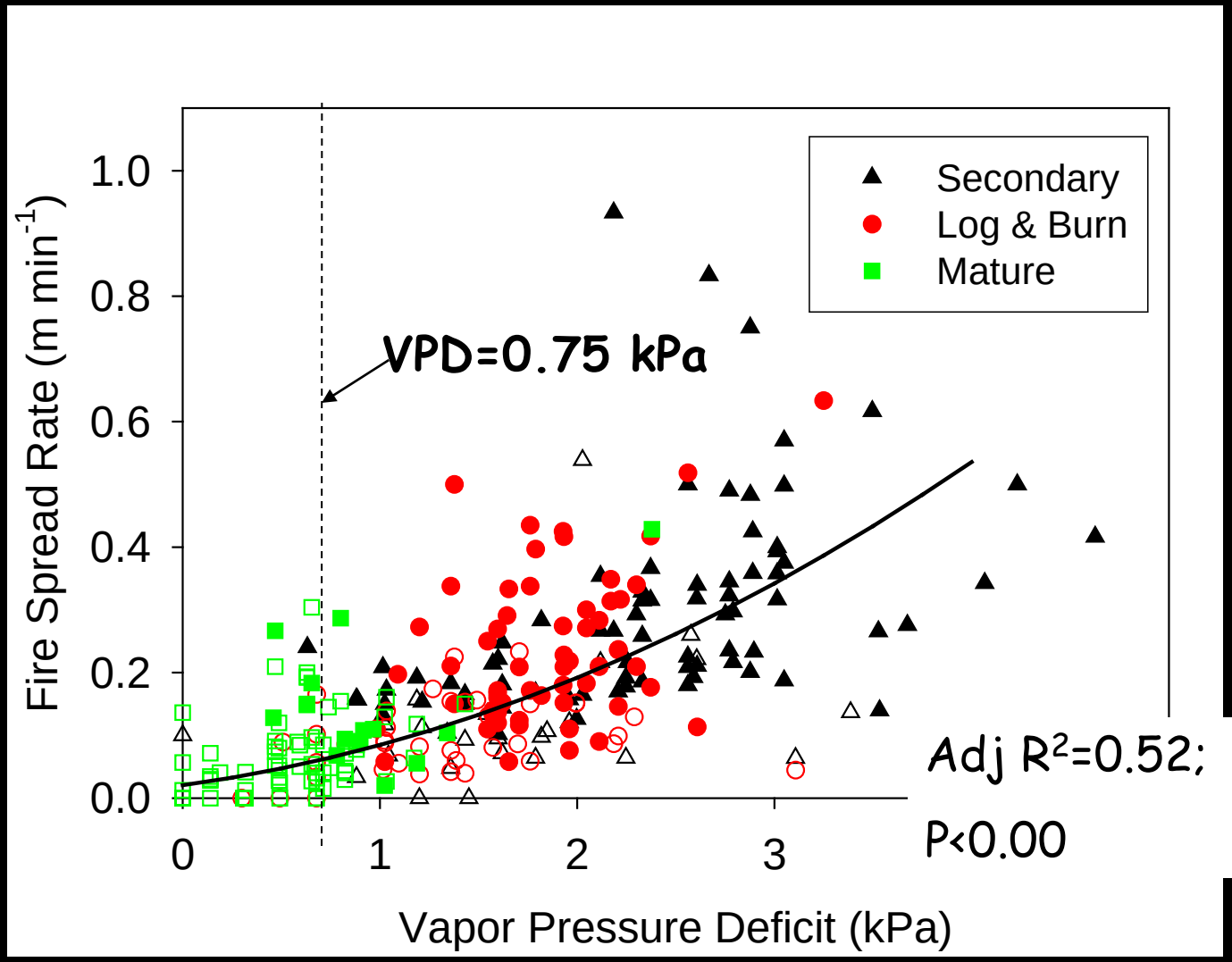
Severe water Depletion to 11 m depth:

- Reduced LAI
- Wood increment most senstive component of NPP
- Increased mortality of large trees.

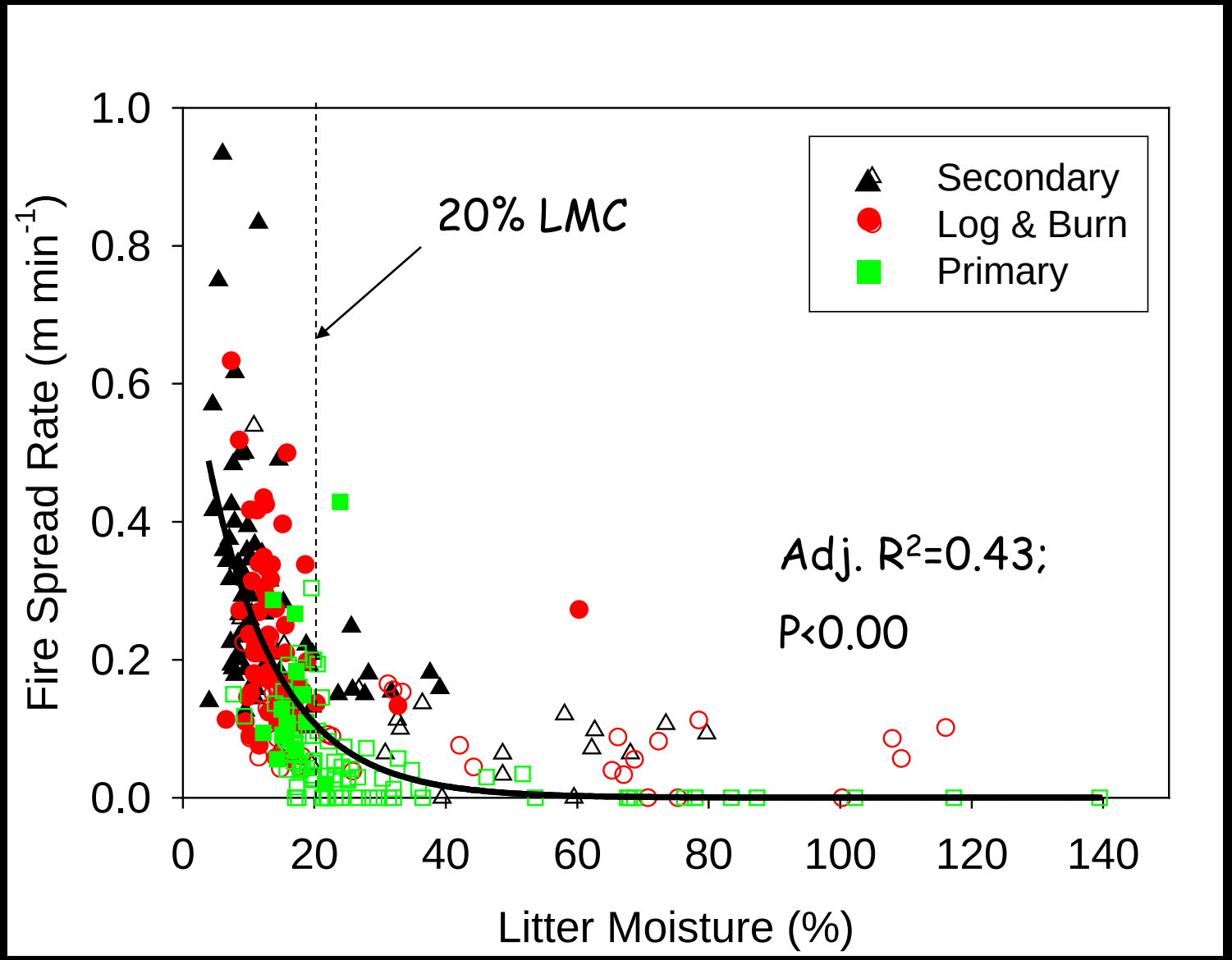
1000 experimental fires in four regions

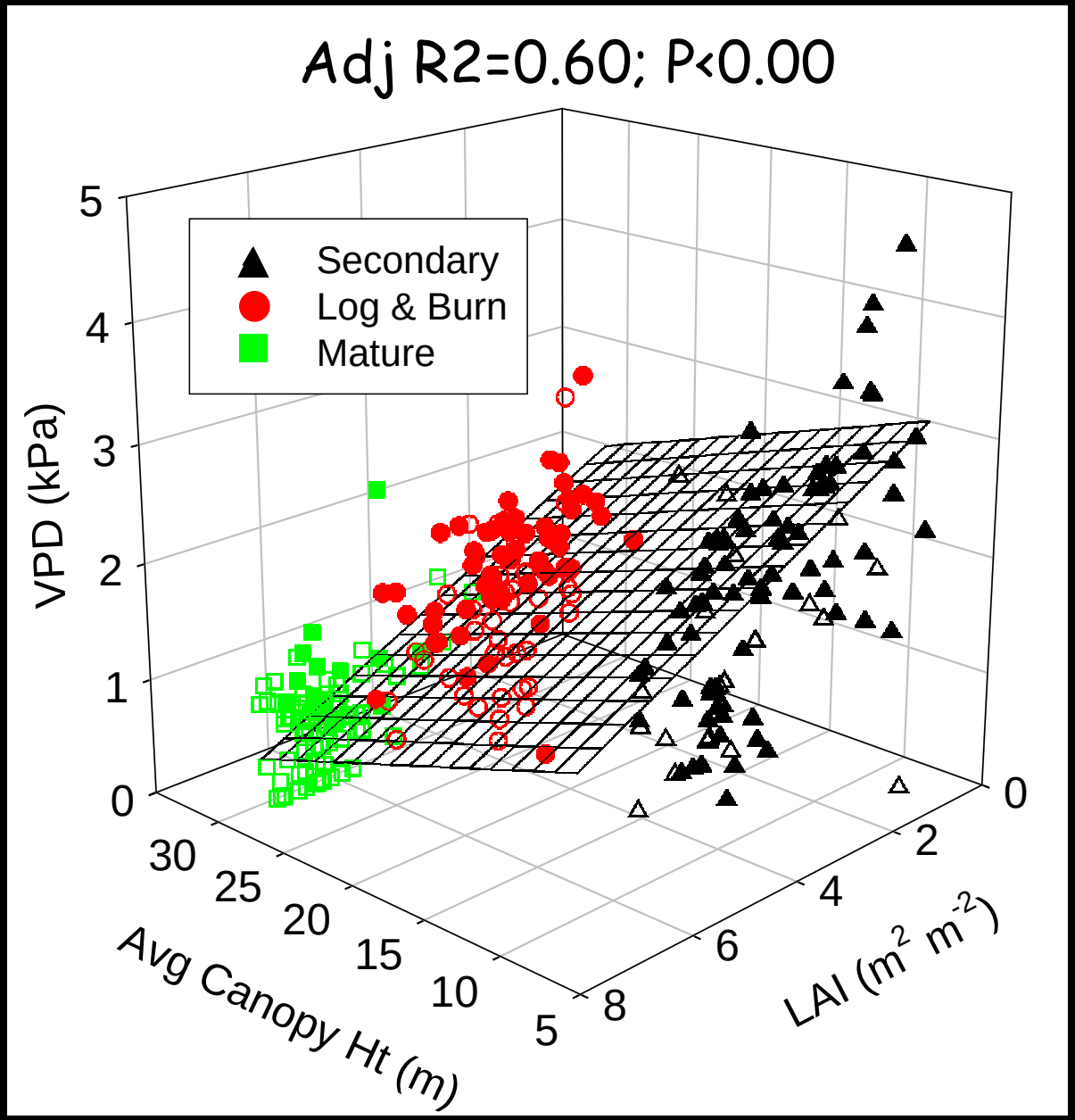
With: D Ray, E Mendoza, F Brown, P Moutinho, B Guerreiros

Vapor pressure deficit is best predictor of fire spread

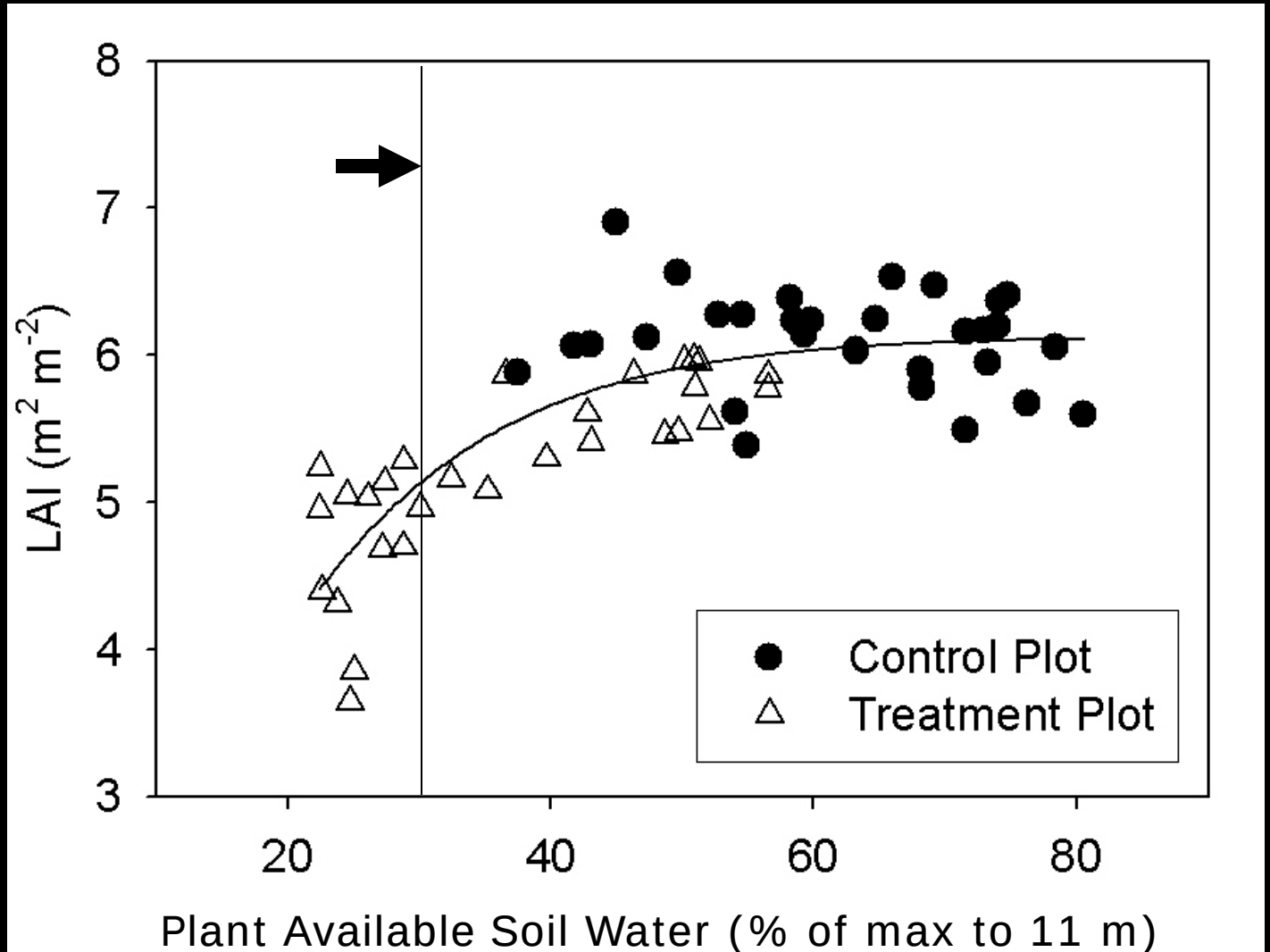


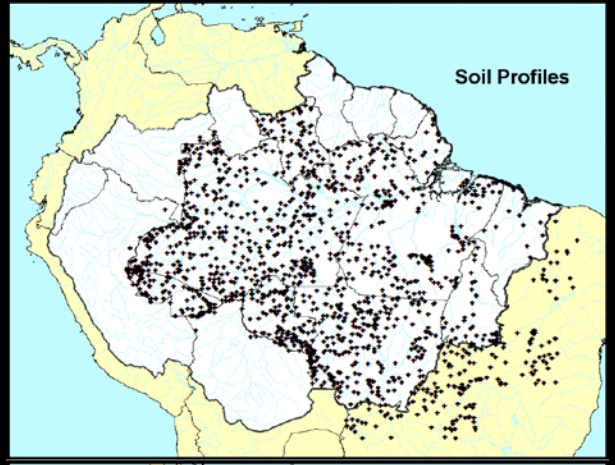
Litter moisture content also good predictor

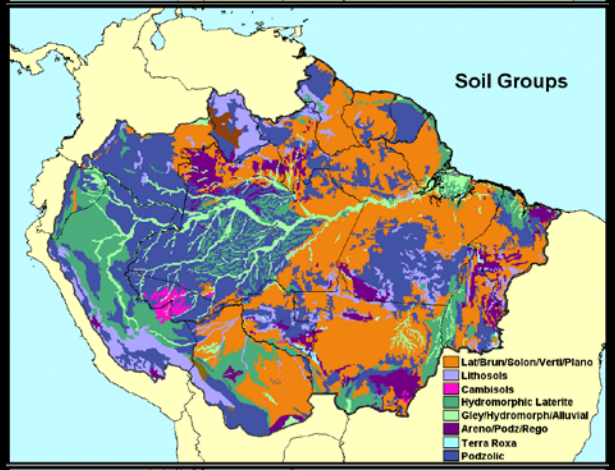


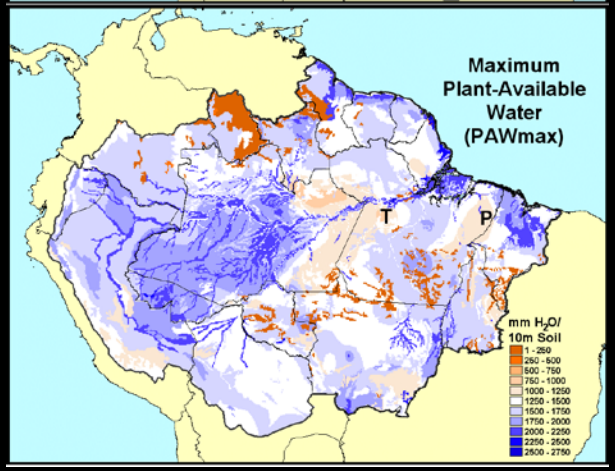

Adj R2=0.60; P<0.00
Secondary
Log & Burn
Mature
VPD (kPa)
0
1
2
3
4
5
Avg Canopy Ht (m)
30
25
20
15
10
5
LAI (m2 m-2)
0
2
4
6
8

Flammability threshold



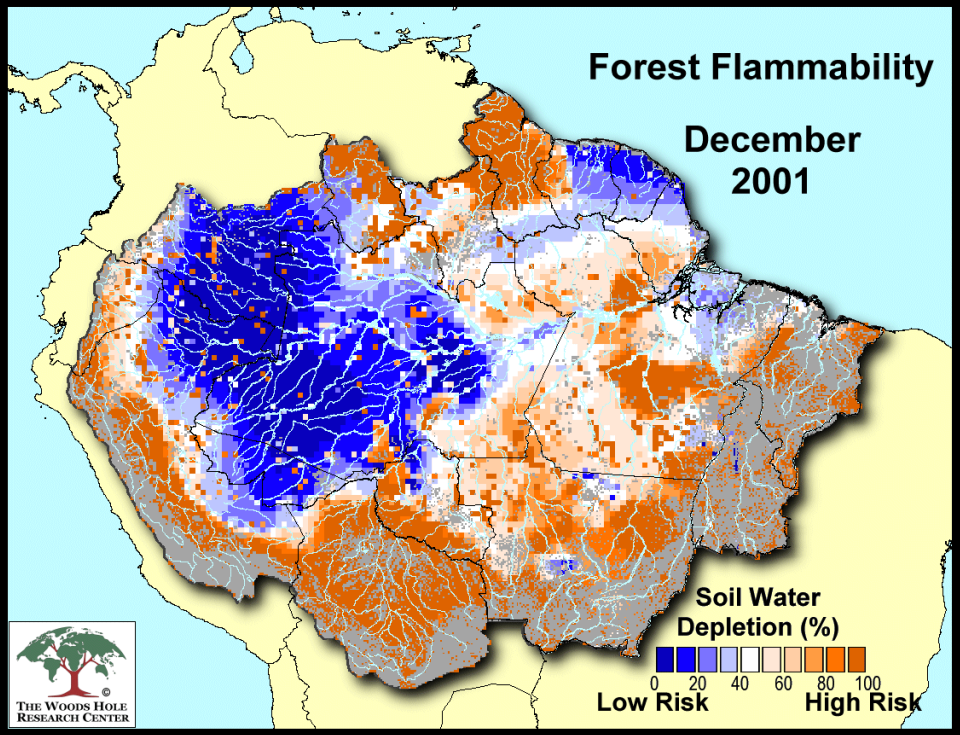






Scaling up: Estimating soil water across the Basin

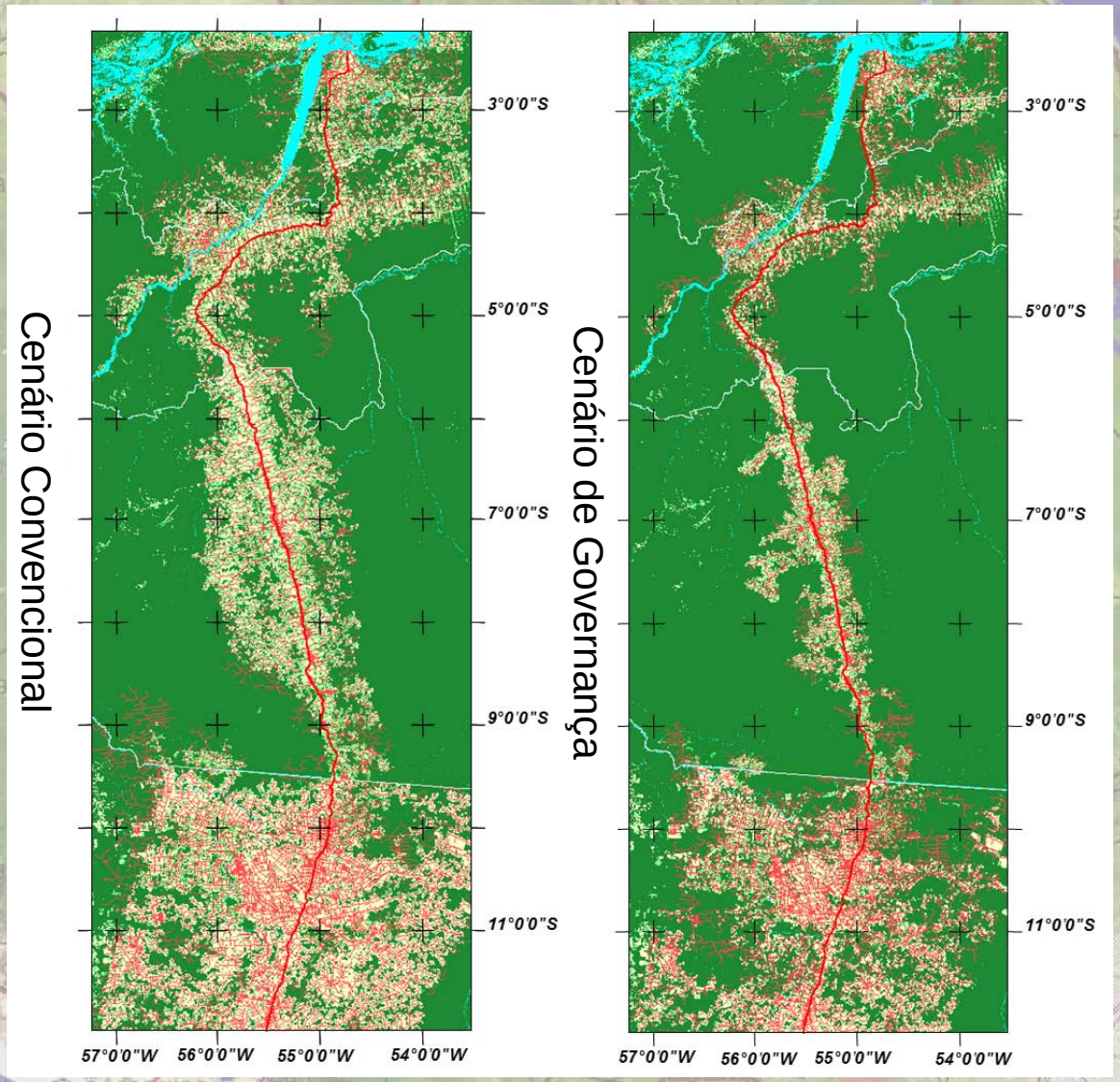
D. Nepstad, P Lefebvre,U Lopes, J Tomasella, A Alencar, et al. In press. Glob Ch Biol



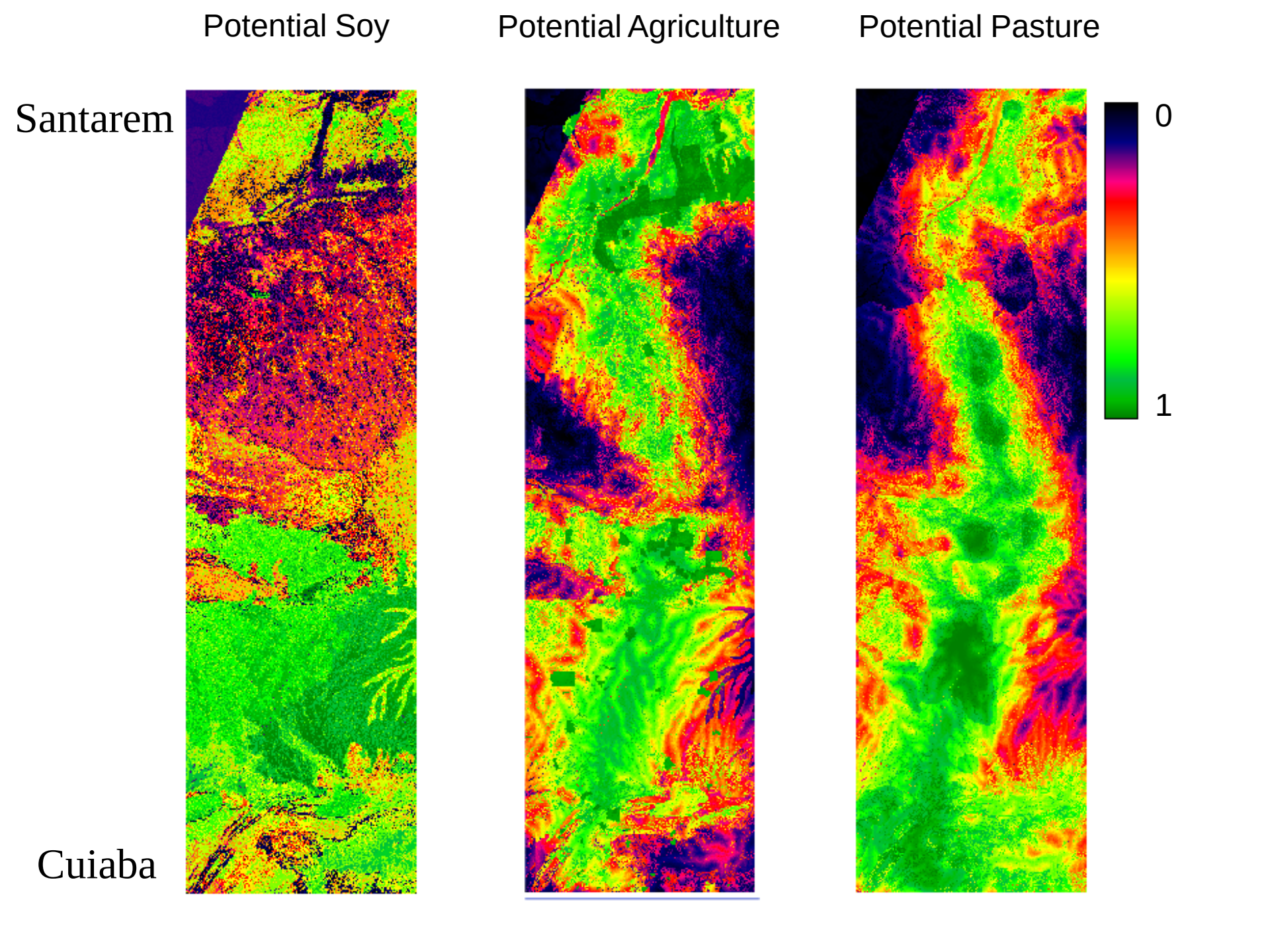
Next Steps in Ecology Model:

- Physiologically-based ecosystem model (CARLUC, with R Houghton & A Hirsch) (carbon pools)
- Gap model (forest structure)

Santarem-Cuiaba Highway



Fonte: IPAM, UFMG, WHRC


Potential Soy
Potential Agriculture
Potential Pasture
Santarem
Cuiaba
0
1


Two Annual Field Courses:
Low-tech Ecosystem Ecology
Frontier Governance

Publications since January 2003 (in press):

- Alencar, A., L. Solórzano and D. Nepstad. Modeling forest understory fire in an eastern Amazon landscape. ***Ecological Applications***
- Nepstad, D., P. Lefebvre, U. L. Silva Jr., et al.. Amazon drought and its implications for forest flammability and tree growth: a basin-wide analysis. **Global Change Biology**
- Nepstad, D., C. Azevedo-Ramos, A.C. Barros, et al. Managing the Amazon timber industry. **Conservation Biology**
- Soares-Filho, B, A. Alencar, D. Nepstad, et al. Simulation of deforestation and forest regrowth along a major Amazon highway: the case of the Santarém-Cuiabá highway. **Global Change Biology**.
- Seroa, R, M del C Diaz, M. J. Silva, D. Nepstad, et al. The social costs of fire in the Brazilian Amazon. Accepted *Ecological Economics*

Publications since January 2003 (submitted):

- Asner, G, D Nepstad, G Cardinot, D Ray. Drought stress and carbon uptake in an Amazon forest measured with spaceborne imaging spectroscopy. Proc Nat. Acad. Science

- Nepstad, D., S. Schwartzman, B. Bamberger, M. Santilli, A. Alencar, D. Ray, P. Schlesinger. Inhibitation of Amazon deforestation and fire by parks and indigenous reserves. Submitted to ***Conservation Biology***.

- Ray, D, D Nepstad, P Moutinho. Canopy and climate controls of forest flammability in the Amazon. Ecology

Conclusions:

- Drought-induced C emissions>land use change emissions
- Remote detection of canopy drought status & productivity
- Forest flammability = f(canopy ht, LAI, days since rain)
- Important role for maps of canopy gap fraction
- Large demand for simulations of land use scenarios