



MINISTÉRIO DA CIÊNCIA E TECNOLOGIA  
**INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS**

# **Combined deforestation and fire occurrence in long-term models of forests and savannas in the Brazilian Amazonia**

**Manoel Cardoso, Gilvan Sampaio and Carlos Nobre**

**Instituto Nacional de Pesquisas Espaciais – INPE  
Centro de Ciências do Sistema Terrestre - CCST**

AGU Meeting of the Americas - August 2010, Foz do Iguaçu, Brazil



# Topics in the talk:

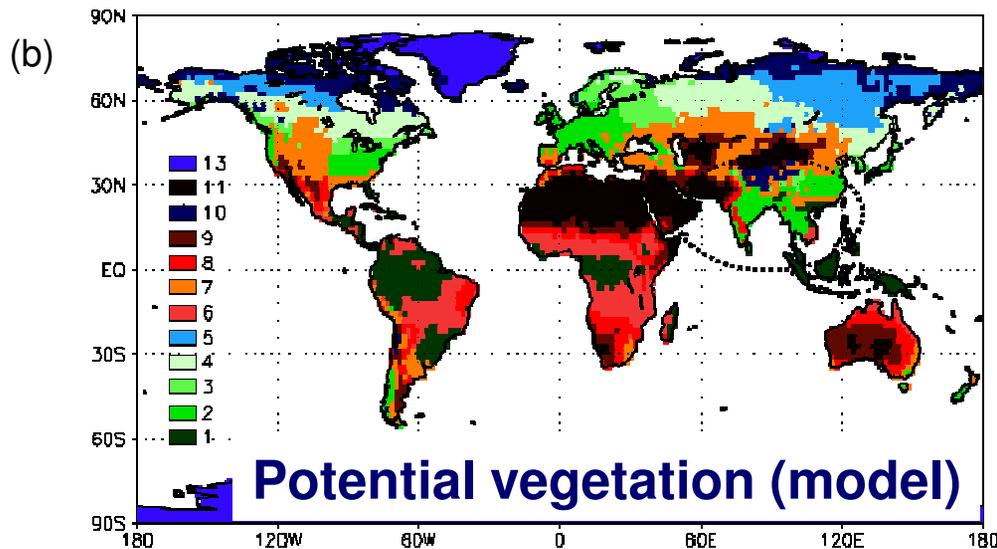
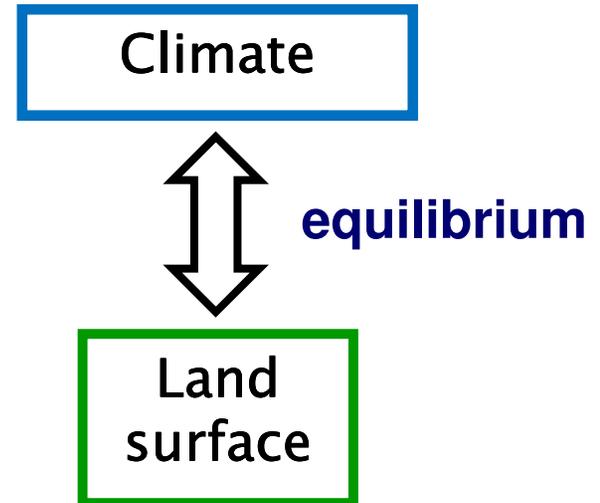
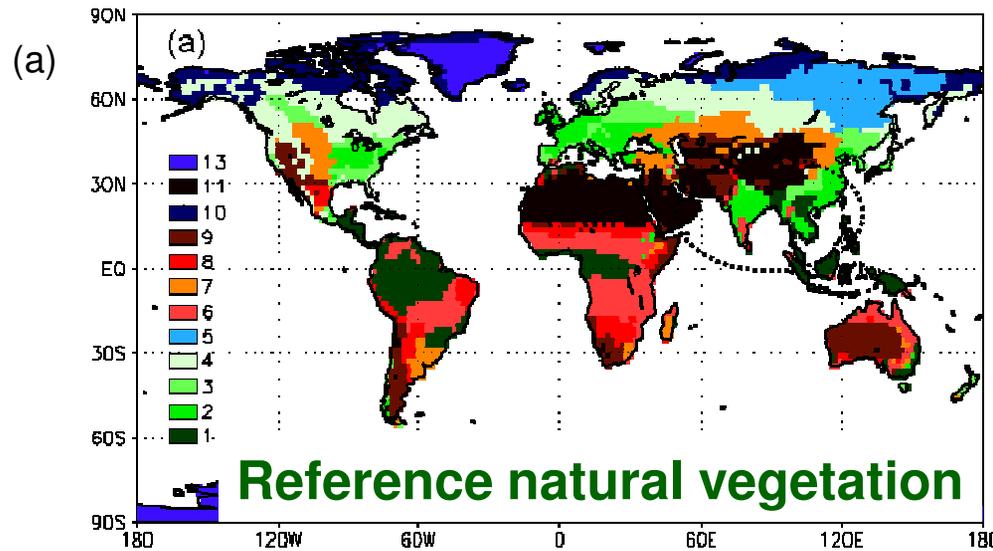
**1. Overview**

**2. Data and method**

**3. Perspectives for applying the results**



# CPTEC - Potential Vegetation Model



- (1) broadleaf-evergreen trees (tropical forest)
- (2) broadleaf-deciduous trees (temperate forest)
- (3) broadleaf and needleleaf trees (mixed forest)
- (4) needleleaf-evergreen trees (boreal forest)
- (5) needleleaf-deciduous trees (larch)
- (6) broadleaf trees with groundcover (savanna)
- (7) groundcover only (prairie, steppes)
- (8) broadleaf shrubs with perennial groundcover (caatinga)
- (9) broadleaf shrubs with bare soil (semi-desert)
- (10) dwarf trees and shrubs with groundcover (tundra)
- (11) bare soil (desert)
- (13) ice



## Example of tropical-forest areas in the Brazilian Amazon progressively declining due to deforestation and fire



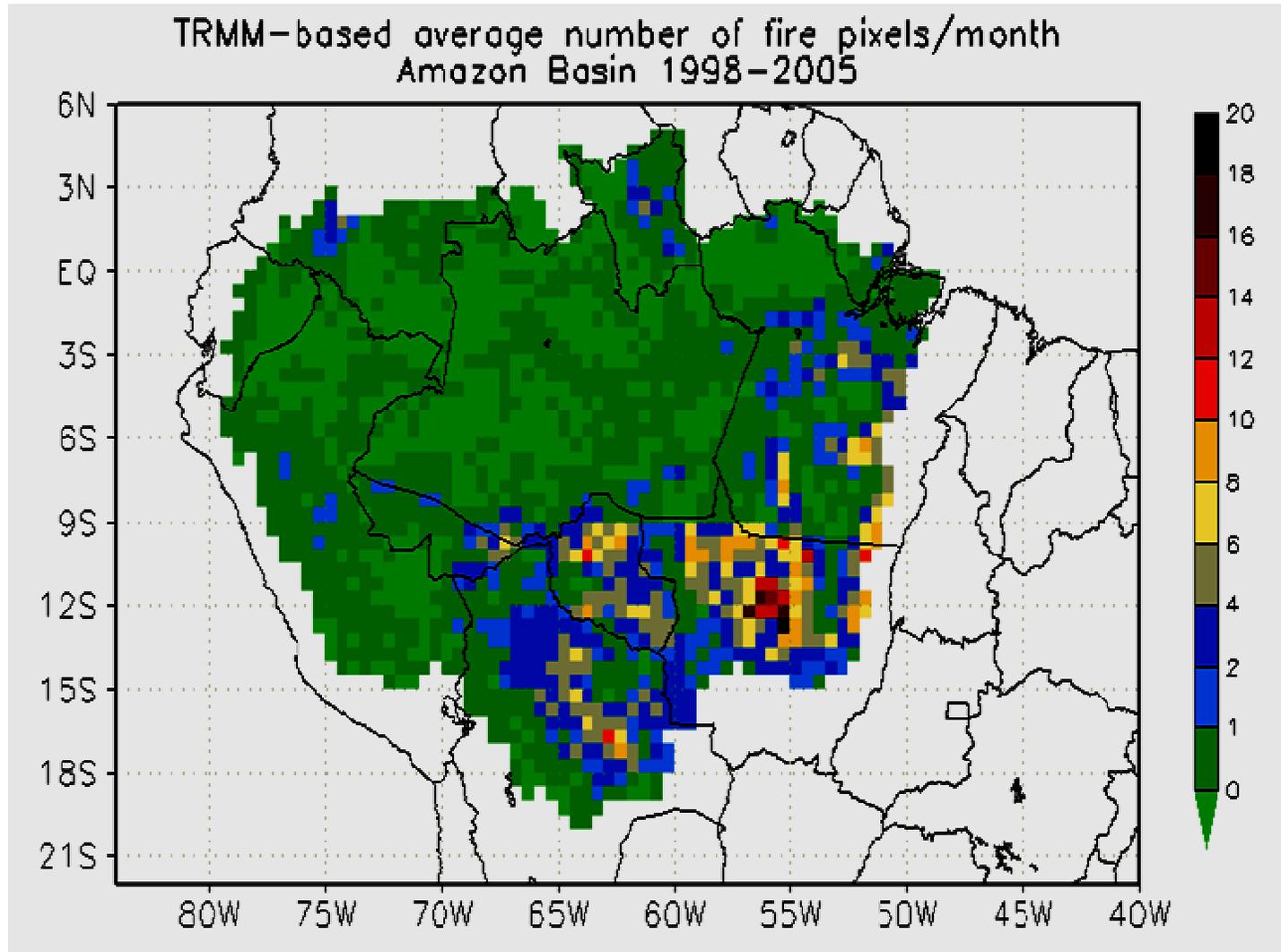
The process usually starts with **(a)** selective logging, followed by **(b)** progressive openings in the understory, which cause plant mortality, fuel build up, increase of flammability and the **(c)** occurrence of fires. In **(d)**, an area where surface species are recovering while trees present fire scars and absence of most of canopy, indicating substantial damage to native vegetation. Persistence of fires in these areas can rapidly decrease resilience leading to replacement of primary forests by degraded/secondary vegetation and savannas.



## **2. Data and method**



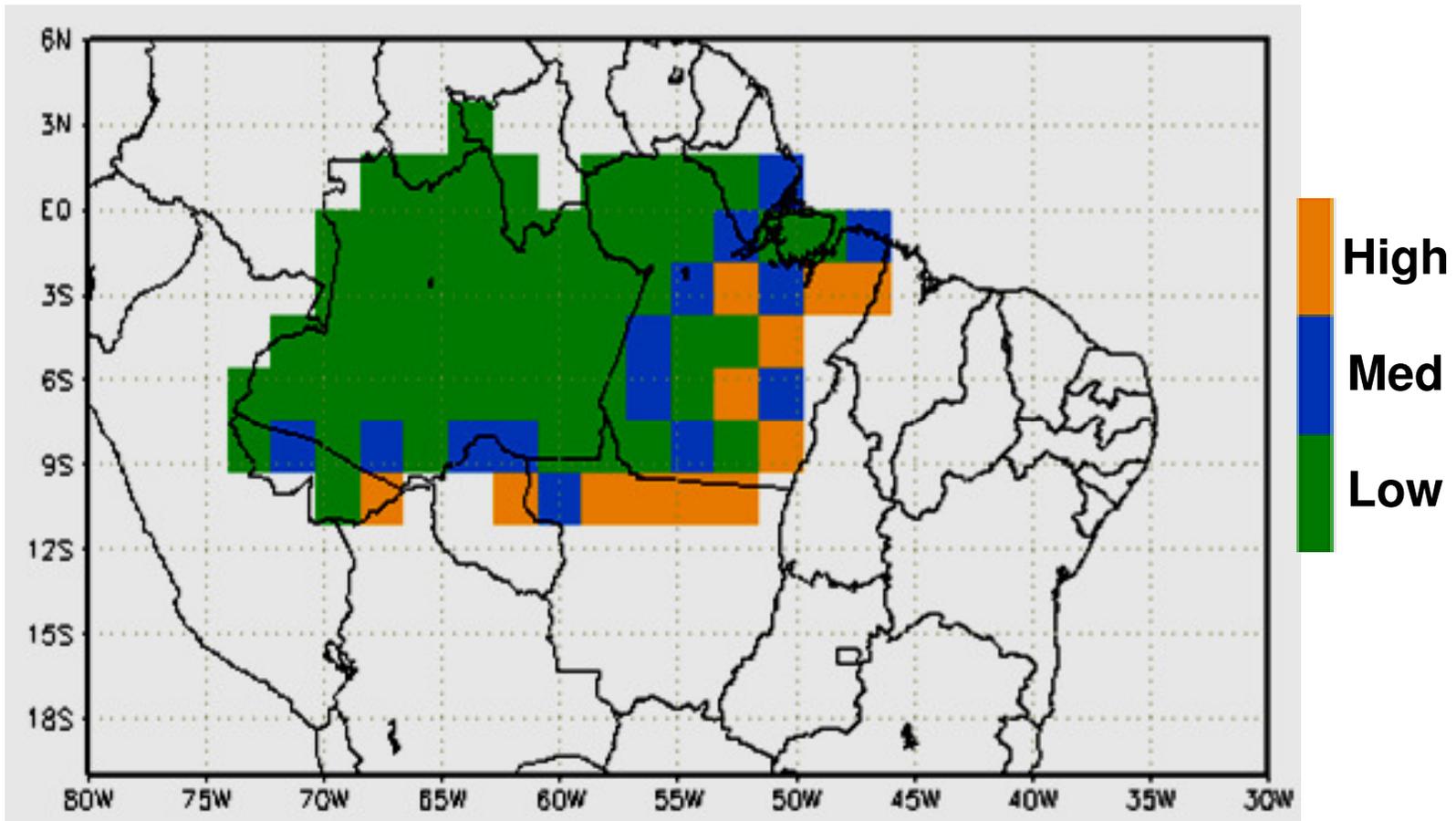
# TRMM-based Active Fire Data



(Giglio et al. 2003)



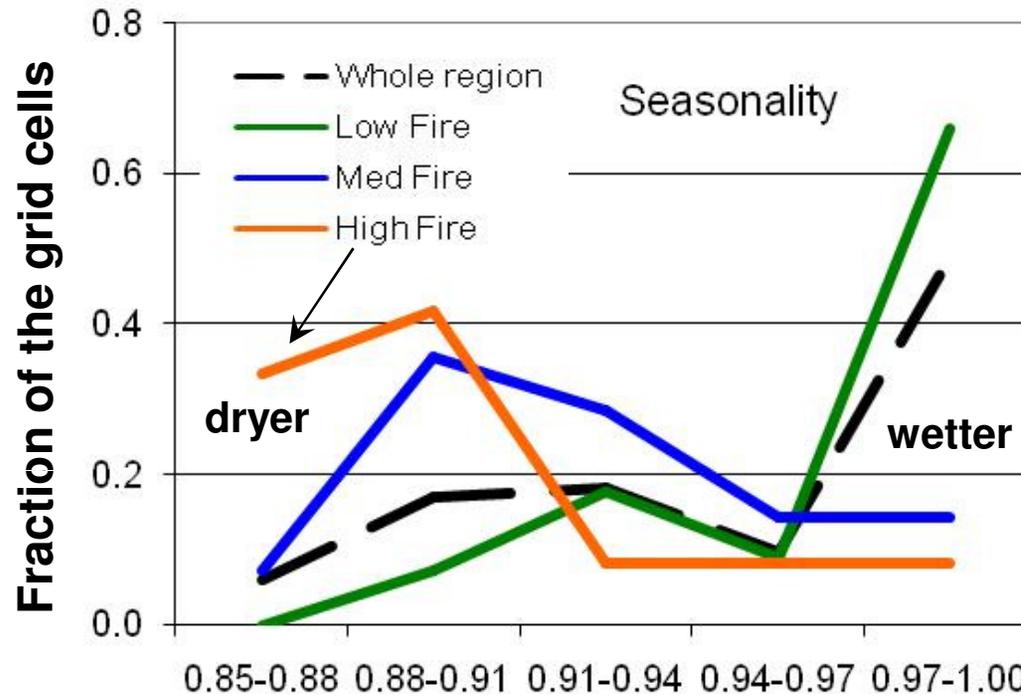
## Fire activity in areas of potential tropical forests in the Brazilian Amazon



Color cells are areas of natural (not considering land use) tropical forests as determined by the CPTEC-PVM (Oyama and Nobre 2004) in the Brazilian Amazon. Fire occurrence during 1998-2005 detected with TRMM-VIRS (Giglio et al. 2003) was classified in three levels: **Low**: active-fire detections were  $\leq 50$  (green), **Medium**: 50-250 (blue), and **High**:  $\geq 250$  (orange). Fire levels determined based on 5% and 25% of the maximum number of detections in the study region.



# Distribution of values of the soil-moisture seasonality index under different fire frequencies



## Soil-moisture seasonality D

$$D = 1 - \frac{\sum_{i=1}^{12} F(0.5 - w_i)}{6}$$

$w$  = soil water degree of saturation

$$F(x) = \begin{cases} x, & x \geq 0 \\ 0, & x < 0 \end{cases}$$

wetter

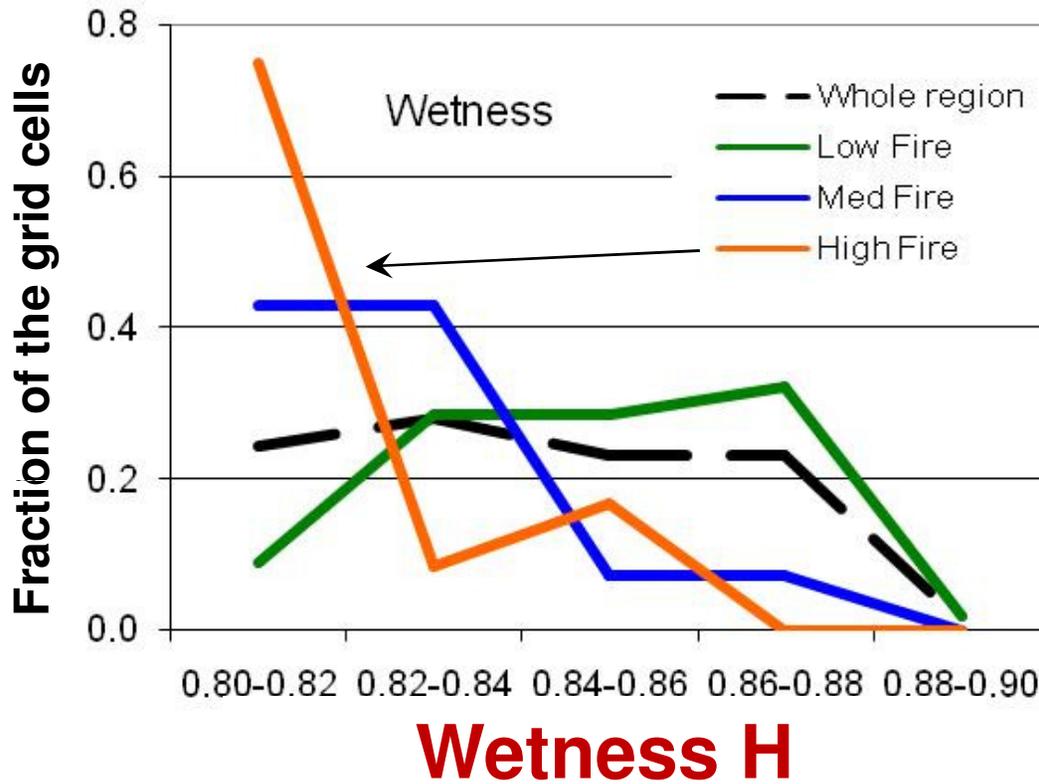


dryer

From Oyama and Nobre (2004)



# Distribution of values of the wetness index under different fire frequencies



$$H = \frac{\sum_{i=1}^{12} g_i E_i}{\sum_{i=1}^{12} g_i E_{m_i}}$$

$$g = \begin{cases} 1, & \text{unfrozen} \\ 0, & \text{frozen} \end{cases}$$

$E$  = actual evapotranspiration  
 $E_m$  = max evapotranspiration  
 $i$  = month index

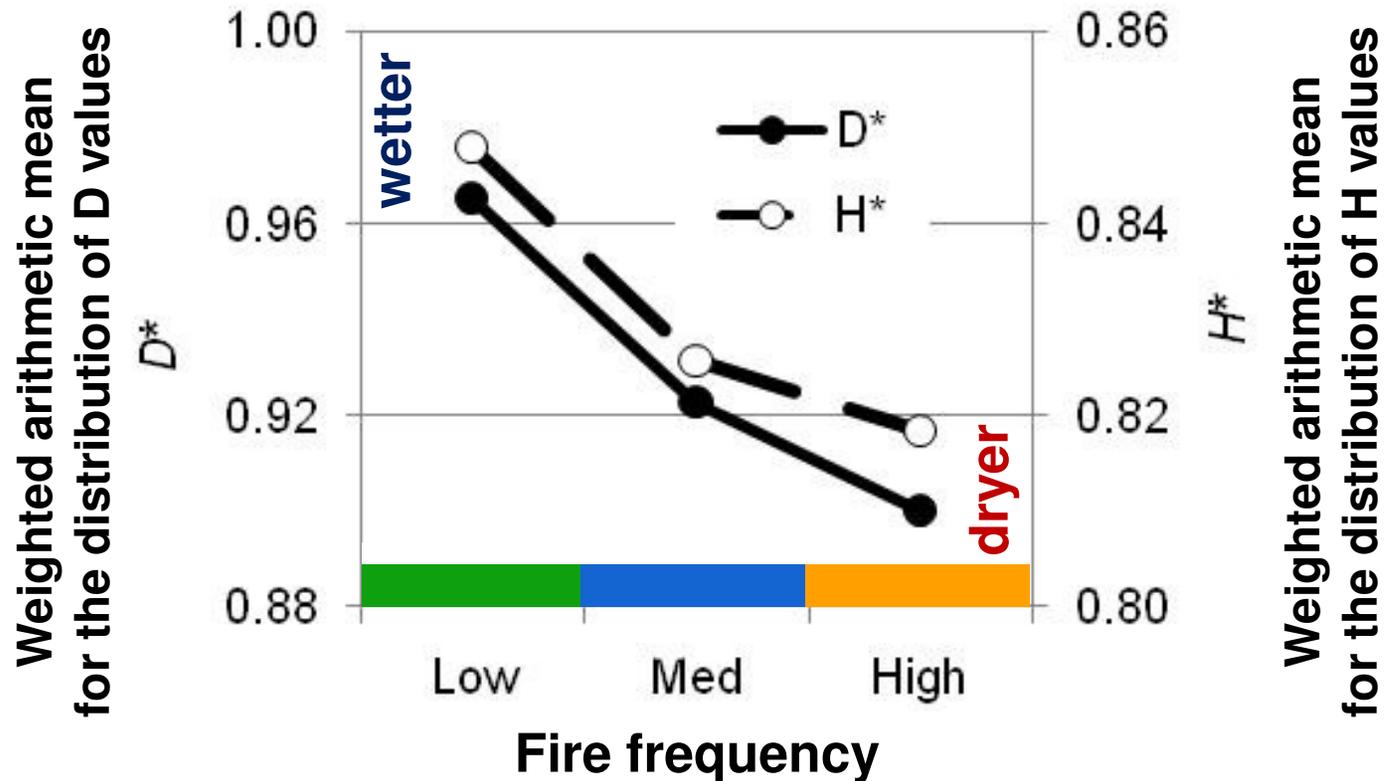
wetter



dryer



## Summary statistics for the distributions of the wetness and soil-moisture seasonality indexes



Our analyses show that most-common values of H and D were progressively lower in places with relatively higher fire frequencies. These results can be used for estimating future conditions of forest areas by checking if future D and H values would support projected fire frequencies. For example, future values of D smaller than 0.9 combined with projected fire frequencies greater than medium indicate substantial risk to nearby forests.



### **3. Perspectives and plans for applying these results**



# **Accounting for deforestation and fires in projections of the spatial distribution of the major biomes in the region**

## **Major assumptions:**

- 1- Land-use dynamics and policy currently observed in the Brazilian Amazon will remain in the future.**
- 2- Deforestation/fires will affect forests only in grid cells of tropical and seasonal forests that are located adjacent (<150km) to savannas**



## **Application:**

- 1- If a place projected to be covered by tropical or seasonal forest presents both indexes  $H$  and  $D$  below certain thresholds, and**
- 2- the area is adjacent to a savanna, then:**
- 3- tropical forest will be adjusted to seasonal forest, or seasonal forest will be adjusted to savanna**



Method is fully described in  
**Biologia 64/3: 433-437**

“Long-term potential for tropical-forest degradation due to deforestation and fires in the Brazilian Amazon”



Biologia 64/2: 1—, 2009  
Section Botany  
DOI: 10.2478/s11756-009-0076-9

**Long-term potential for tropical-forest degradation  
due to deforestation and fires in the Brazilian Amazon**

Manoel CARDOSO, Carlos NOBRE, Gilvan SAMPAIO, Marina HIROTA, Dalton VALERIANO & Gilberto CÂMARA

*Instituto Nacional de Pesquisas Espaciais – INPE, Cachoeira Paulista, 12630-000 SP – Brasil;  
e-mail: mcardoso@cptec.inpe.br.*

**Thank you!**