THE FUTURE CLIMATE OF AMAZONIA

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LBA ECO

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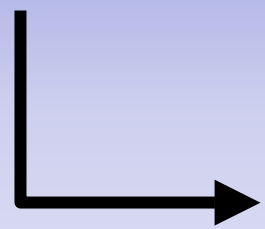
Vegetation-Climate Interactions

Climate  **Vegetation**



Bidirectional on what times scales?

Introduction I

Biosphere-Atmosphere Interactions occur across a range of timescales:

On short timescales (seconds to hours): the coupled system is dominated by the rapid biophysical and biogeochemical processes that exchange energy, water, carbon dioxide, and momentum between the atmosphere and the land surface.

Intermediate-timescale (days to months) processes include changes in the store of soil moisture, changes in carbon allocation, and vegetation phenology (e.g., budburst, leaf-out, senescence, dormancy).

On longer timescales (i.e., seasons, years, and decades), there can be fundamental changes in the vegetation structure itself (disturbance, land use, stand growth).”

Foley et al., 2000.

Introduction II

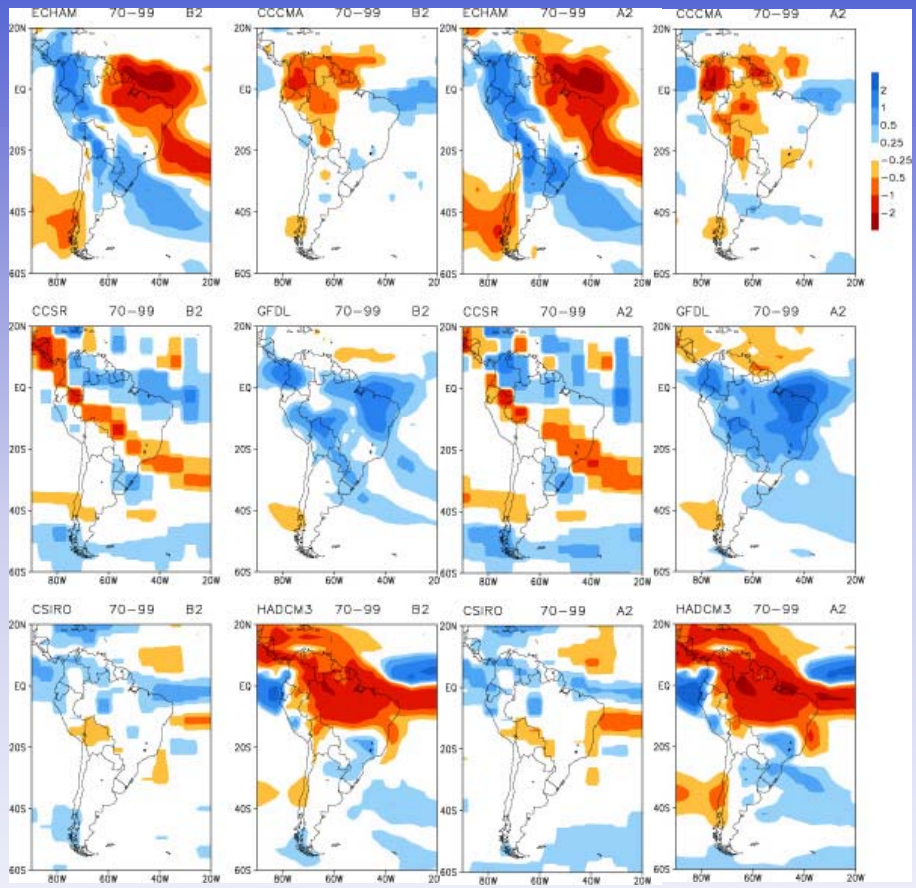
Biome-Climate interactions are complex, non-linear. Therefore, they can, in theory, present multiple equilibria, that is, for the same global climate, there can be more than one stable biome in equilibrium with that climate. We will see an illustration of such possible ‘bi-stability- for South America.

Global climate change is real. How Amazonia rainforest will respond to climate change? We will show results that indicate that areas of savanna may expand into the future and forest areas may decrease.

Future climate change could cause warming ! And about rainfall ?

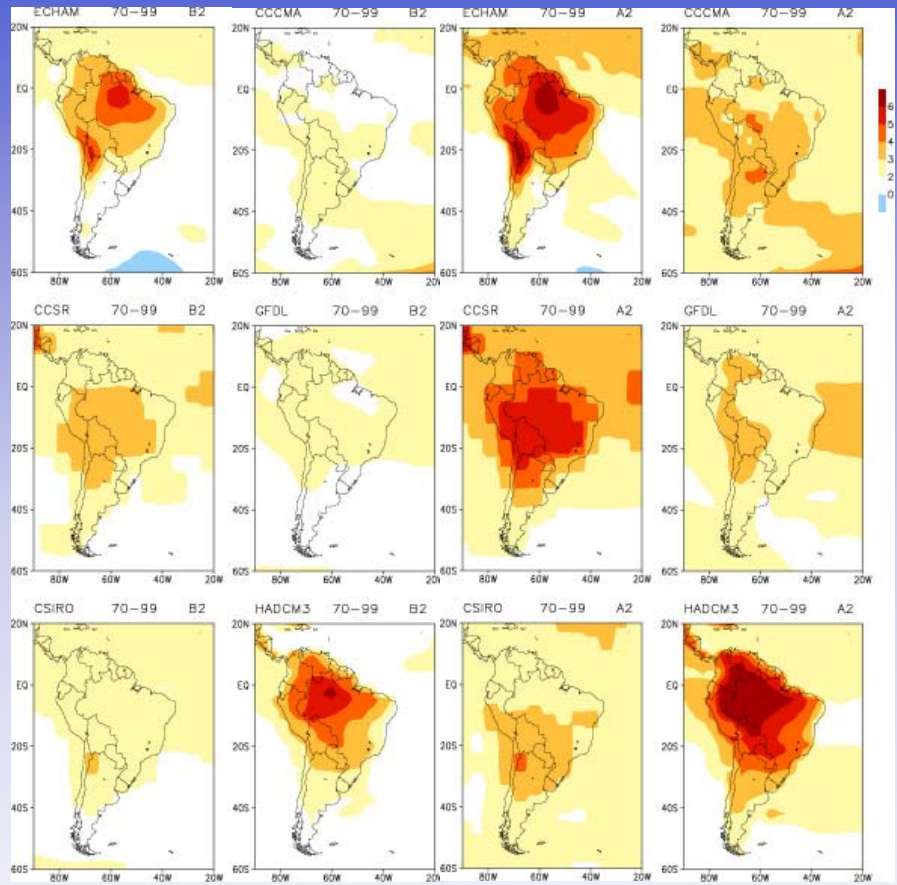
Precipitation Anomalies (mm/day) for 2070-2099

B2 Scenario - Low GHG Emissions **A2 Scenario -** High GHG Emissions



Temperature Anomalies (°C) for 2070-2099

B2 Scenario - Low GHG Emissions **A2 Scenario -** High GHG Emissions



CPTEC Potential Biome Model – CPTEC/PBM

- A Potential Vegetation Model that uses 5 climate parameters to represent the (SSiB – Dorman & Seller, 1989) biome classification was developed (CPTEC-PBM).

- CPTEC-PBM is able to represent quite well the world's biome distribution. A dynamical vegetation model (DVM) was constructed by coupling CPTEC-PBM to the CPTEC Atmospheric GCM (CPTEC-DVM).

Five climate parameters drive the potential vegetation model – CPTEC/PBM

Monthly values of precipitation and temperature

P_i , T_i , i = 1...12

Water Balance Model

MODELO DE BALANÇO HÍDRICO

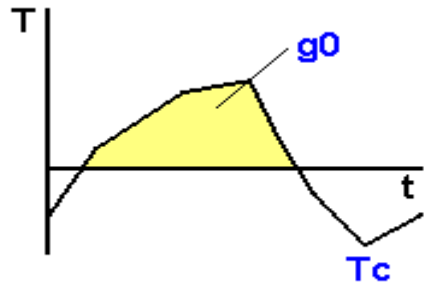
g5 , g0 , Tc , s , h

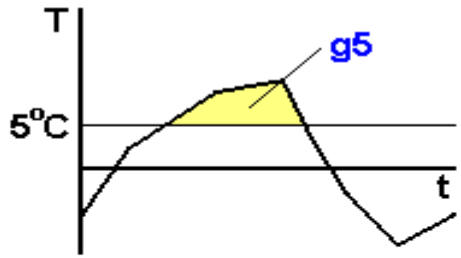
Potential Vegetation Model

MODELO DE VEGETAÇÃO POTENCIAL

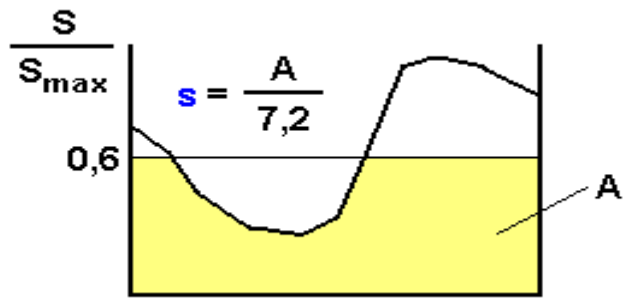
bioma do SSiB

SSiB Biomes





$$h = \frac{ET}{ET_{max}}$$



Biome = f (climate variables)
= f (g_0, g_5, Tc, h, s)

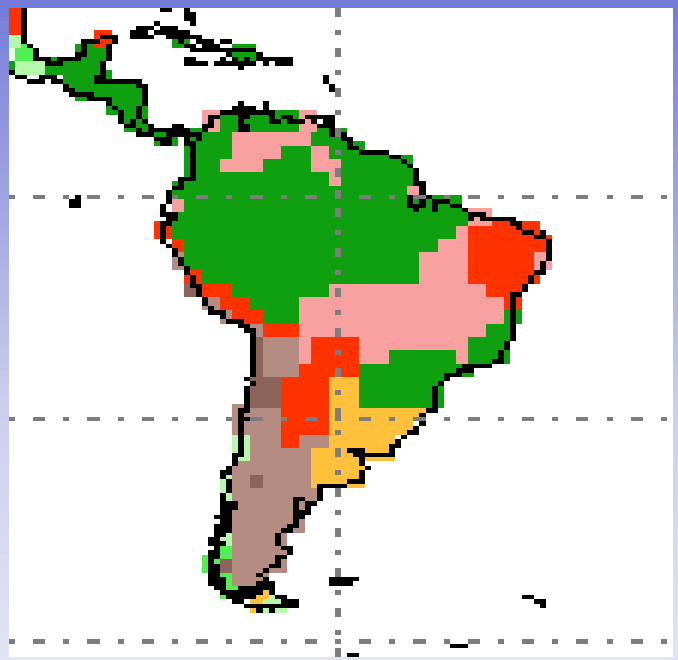
g_0 = degree-days above 0°C
g_5 = degree-days above 5°C
Tc = mean temperature of the coldest month
h = aridity index
s = sesonality index

Oyama and Nobre, 2002

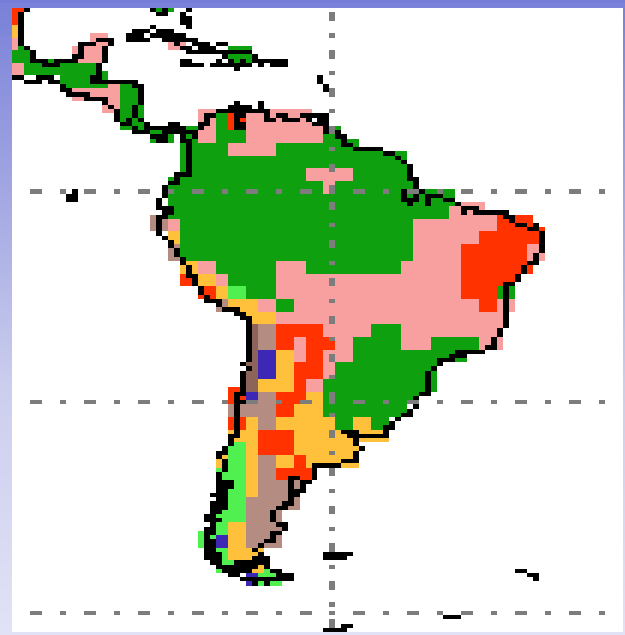
Visual Comparison of CPTEC-PBM versus Natural Vegetation Map

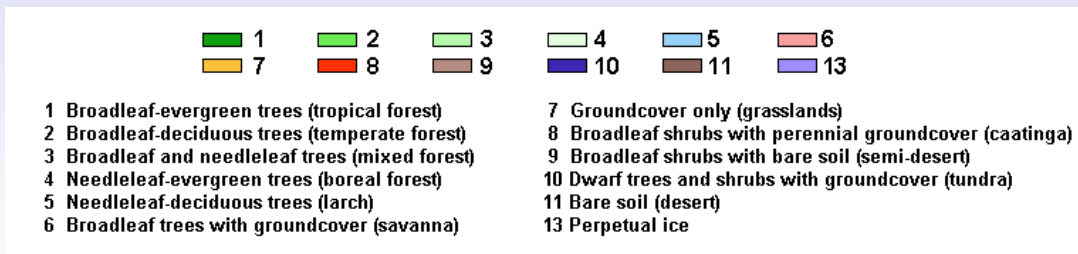
62% agreement on a GLOBAL 2 deg x 2 deg grid

NATURAL VEGETATION



POTENTIAL VEGETATION



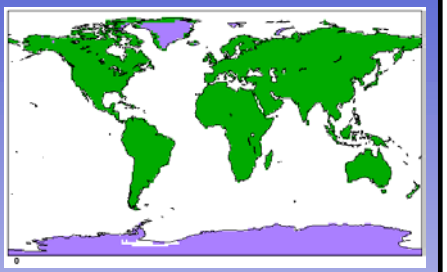


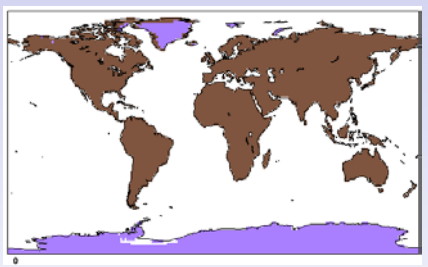
SiB Biome Classification

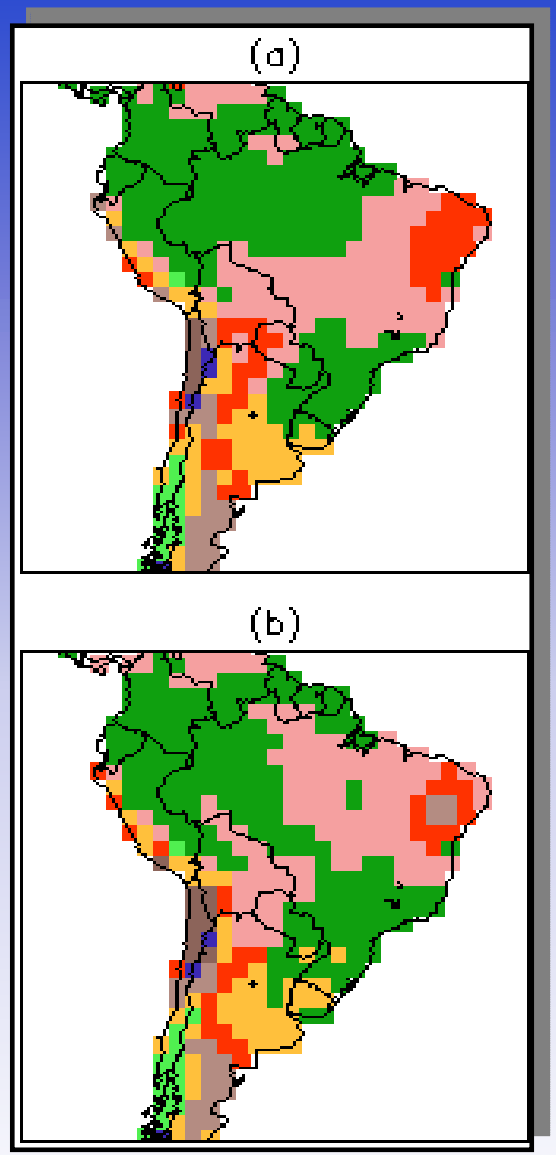
Oyama and Nobre, 2002

Searching for Multiple Biome-Climate Equilibria

Two Biome-Climate Equilibrium States found for South America!







(a) First State - Biome-climate equilibrium starting from forest land cover as initial condition for the Dynamic Vegetation Model. These results are similiar to current natural vegetation.

(b) Second State - Biome-climate equilibrium starting from desert land cover as Initial Condition for the Dynamic Vegetation Model

b) 'Savannization' of Amazonia and 'desertification' in NE Brazil

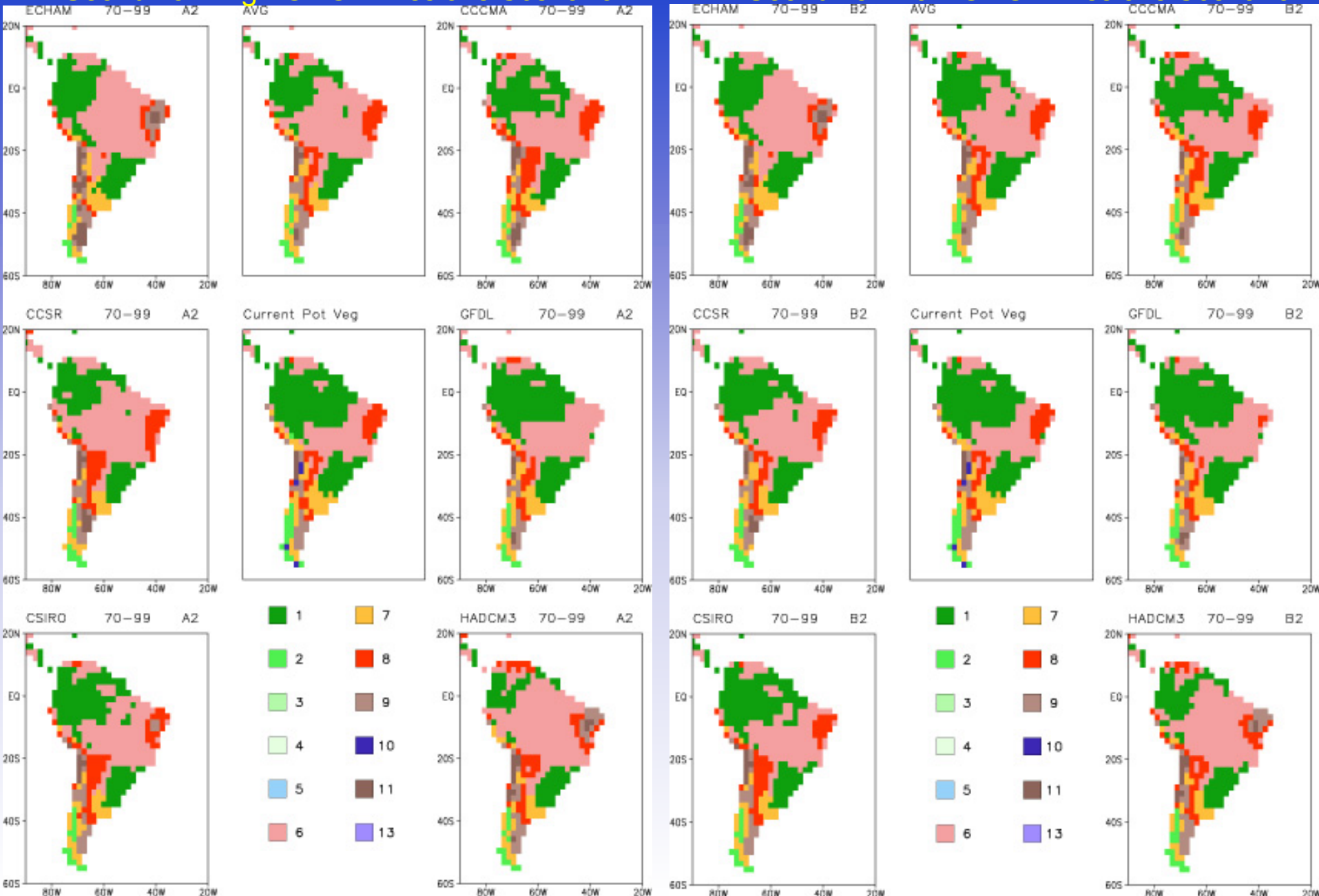
Oyama and Nobre, 2003

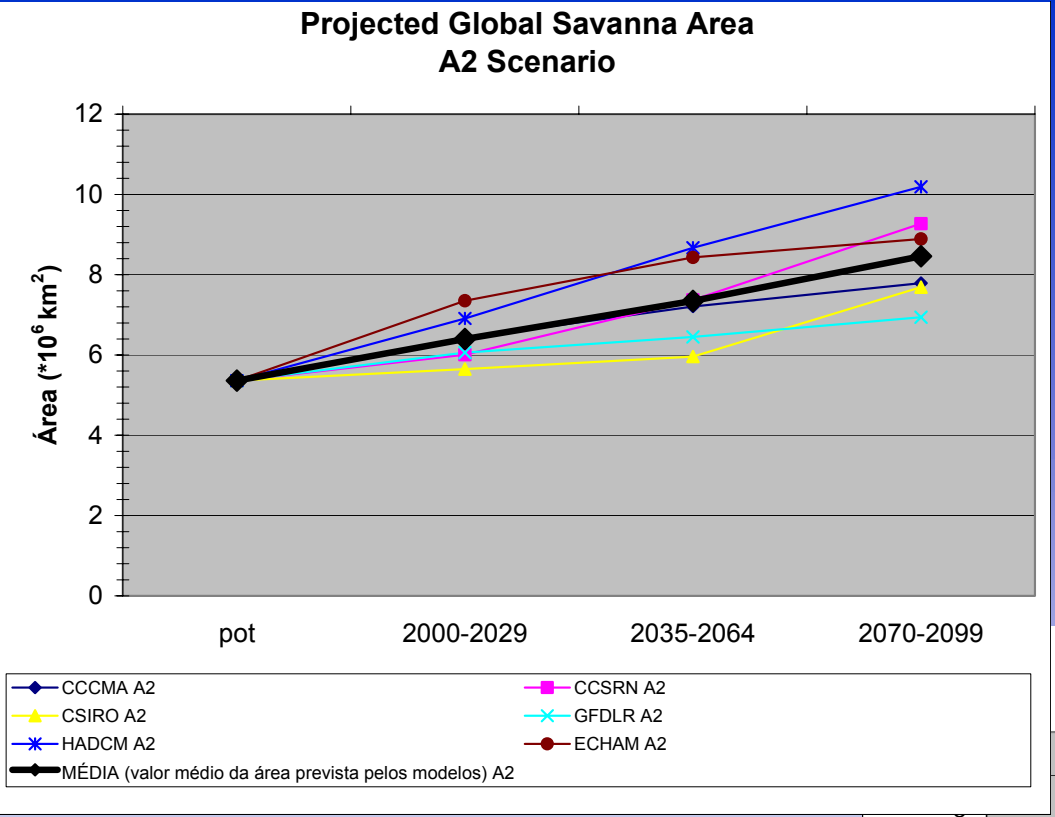
Application of the Potential Vegetation Model (CPTEC-PBM) for Scenarios of Future Climate Change from six Global Climate Models (GCM)

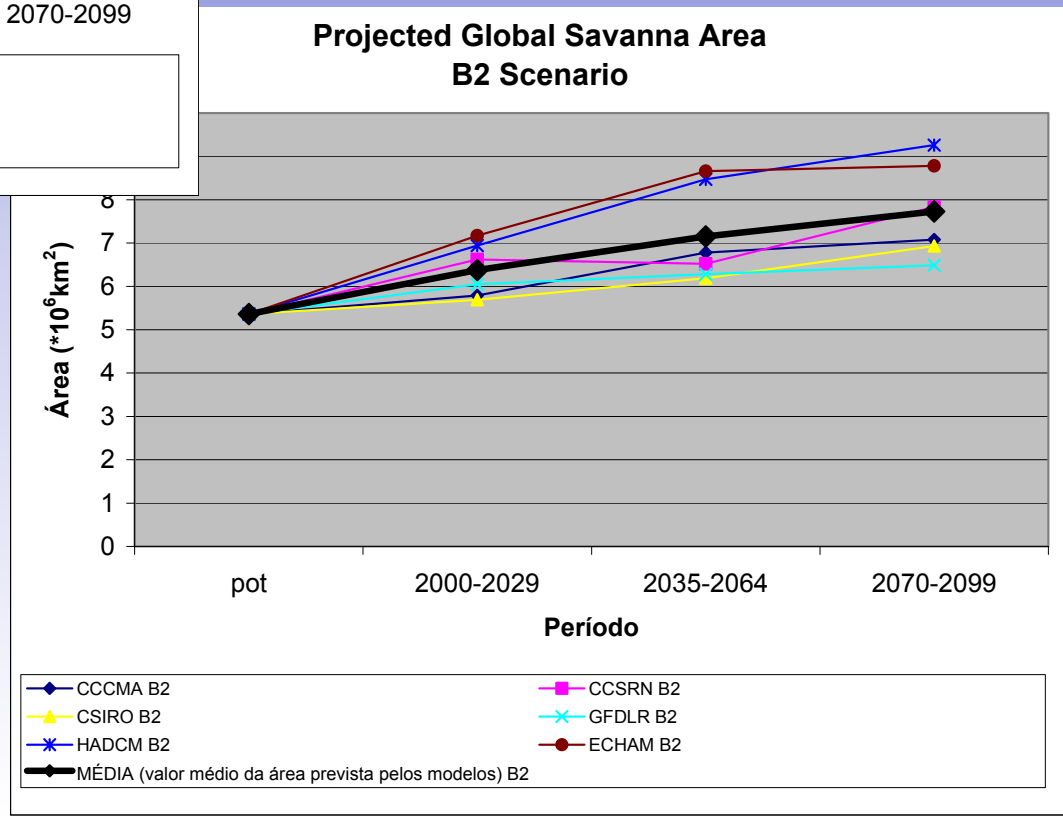
Projected Biome Distributions for South America for 2070-2099

A2 Scenario - High GHG Emissions Scenario

B2 Scenario - Low GHG Emissions Scenario

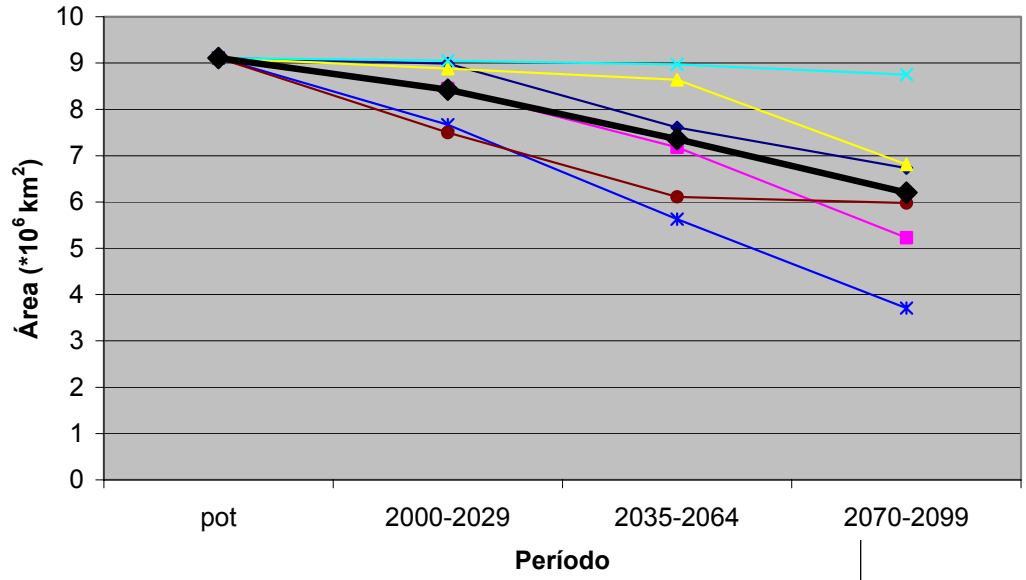






Projected climate changes indicate an increased global savanna cover !

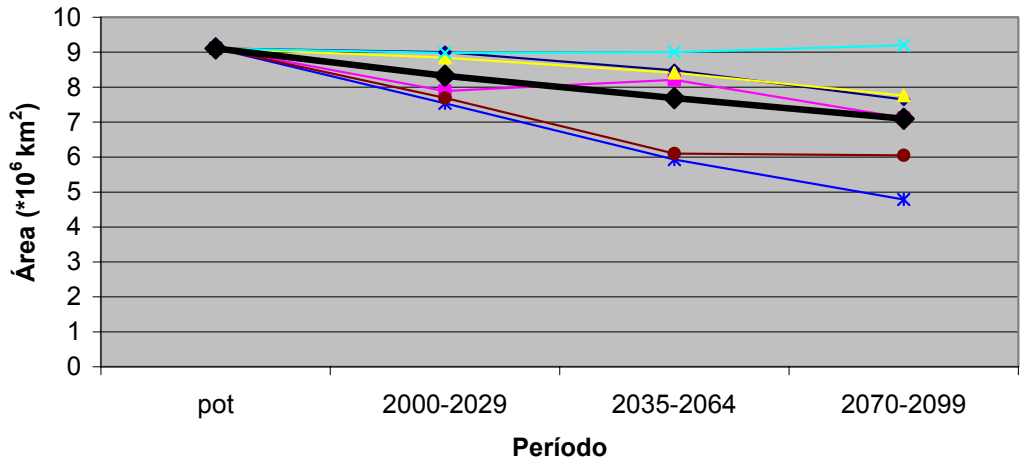
Projected Global Forest Area
A2 Scenario



CCCMA — CCSRN
CSIRO — GFDLR
HADCM — ECHAM
MÉDIA (valor médio da área prevista pelos modelos)

Projected climate changes indicate a decreased global forest cover !

Projected Global Forest Area
B2 Scenario



CCCMA — CCSRN
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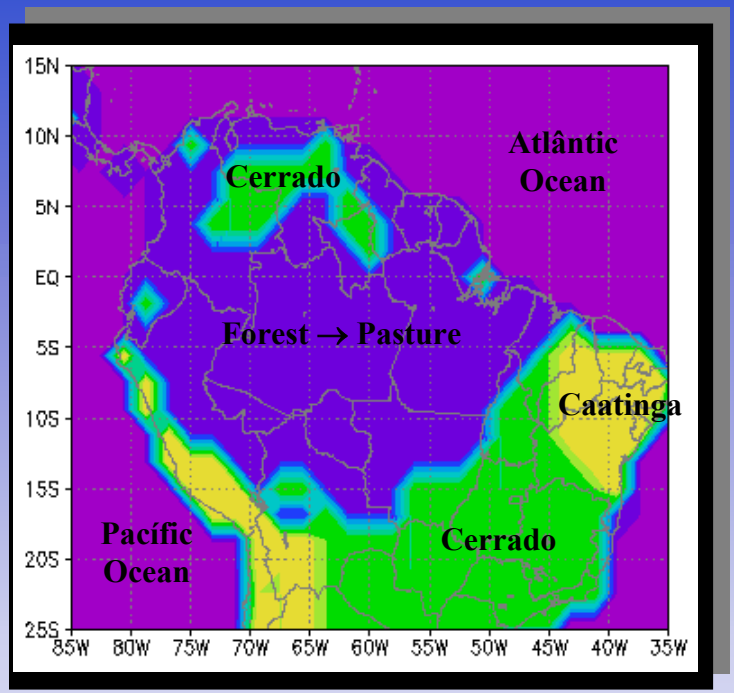
MÉDIA (valor médio da área prevista pelos modelos)

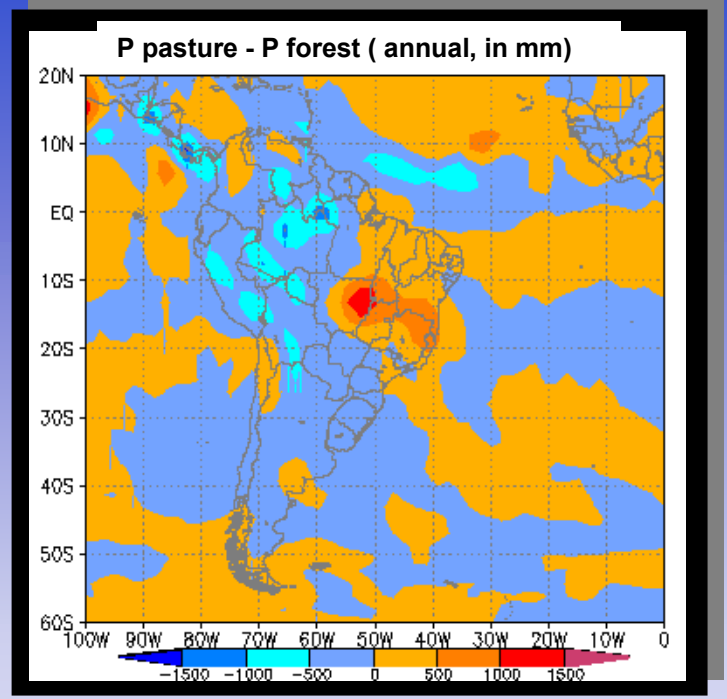
Changes in vegetation structure may also significantly influence the climate (Pielke and Avissar, 1990).

From forest to pasture...

Simulating the impacts of deforestation

EFFECTS OF LARGE SCALE DEFORESTTION



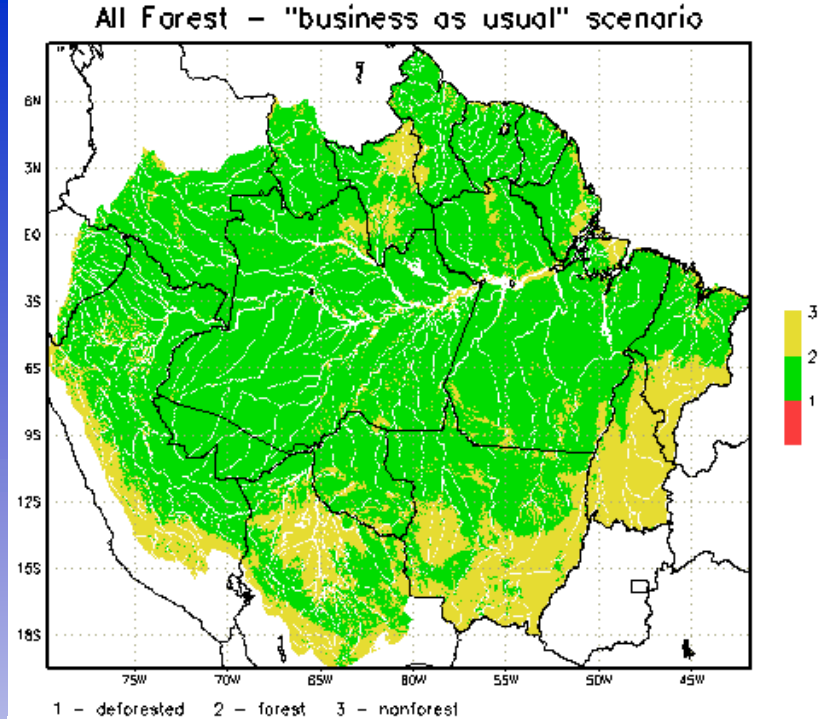


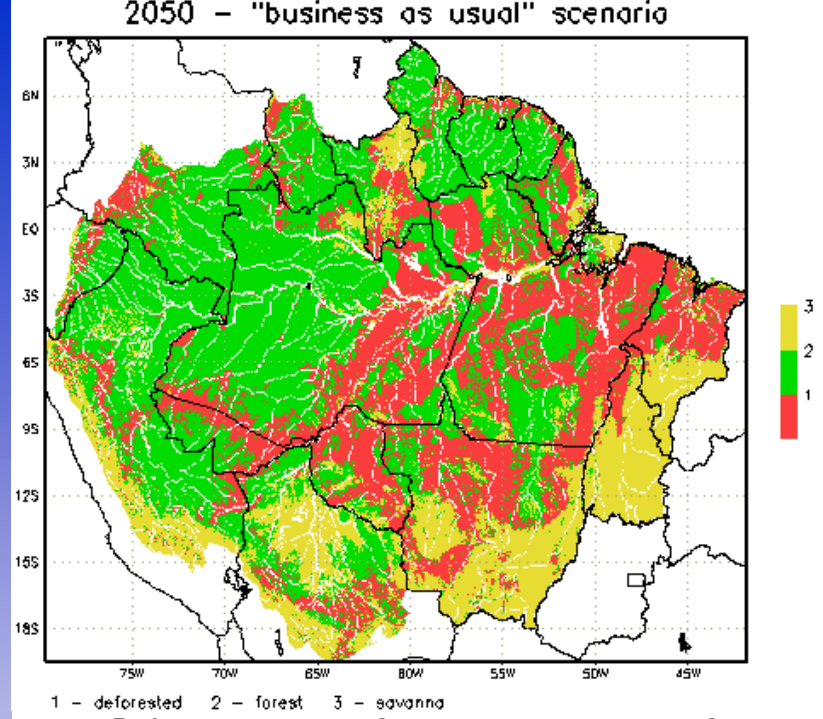
Rocha, 2001.

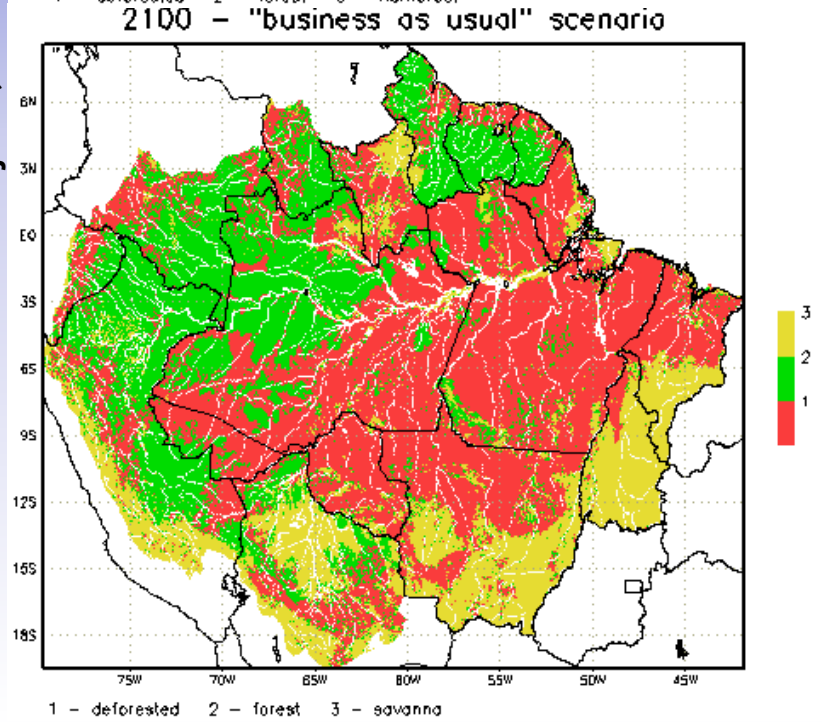
Summary of Numerical Simulations of deforestation

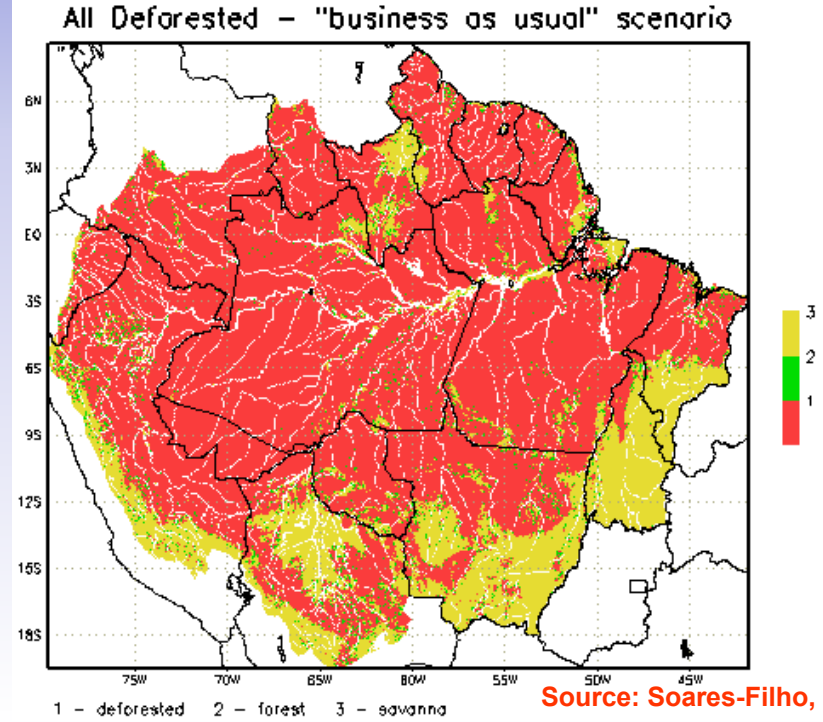
- 1 to 2.5 C surface temperature increase (verified by observations!)
- 15% to 30% evapotranspiration decrease (verified by observations!)
- 5% to 20% rainfall decrease (still inconclusive observations!)

Amazon Scenarios Project, LBA

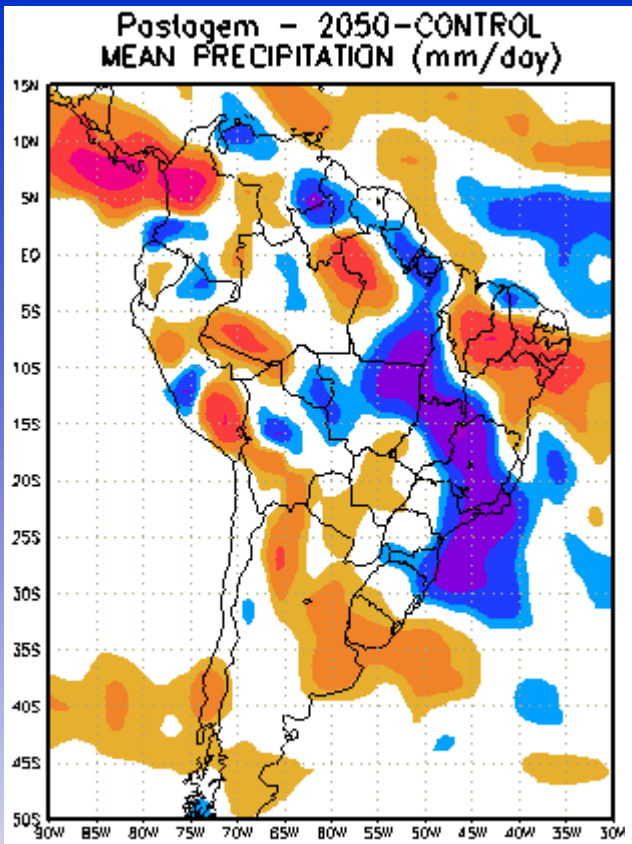


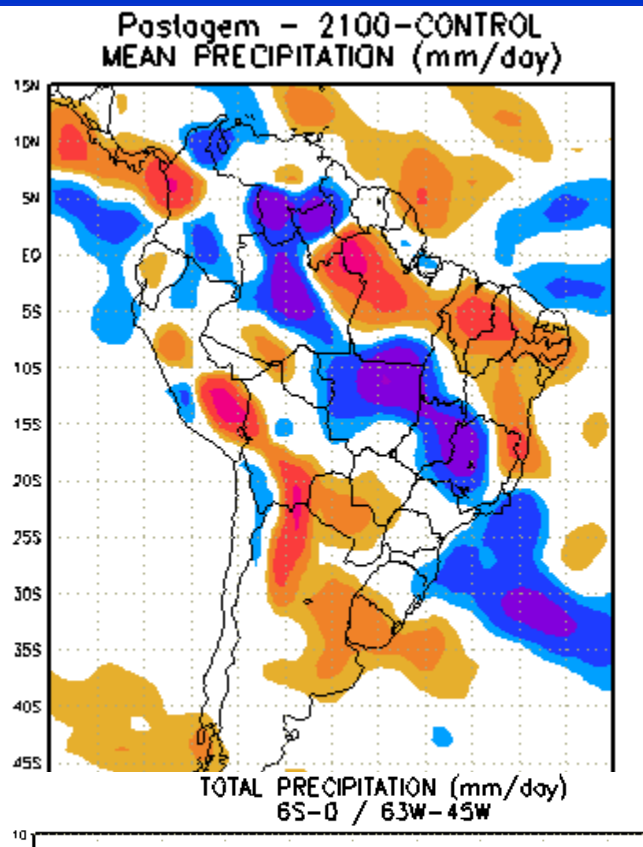


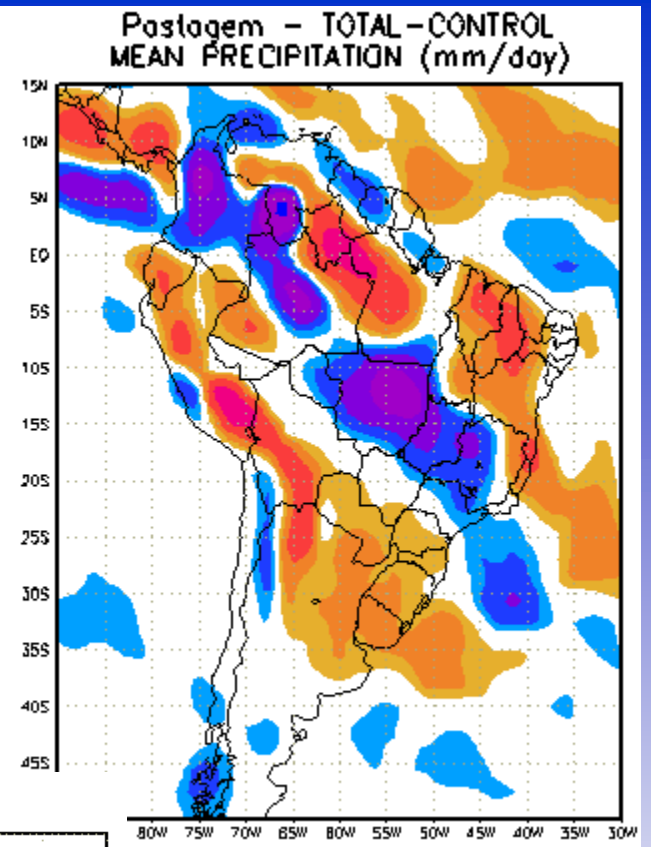


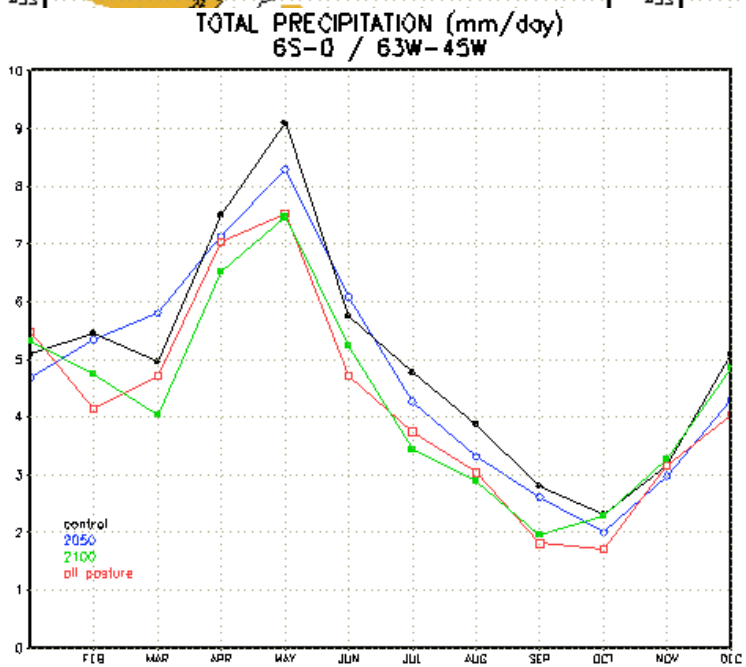


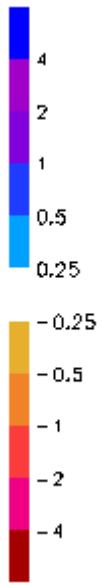
Source: Soares-Filho, 2005



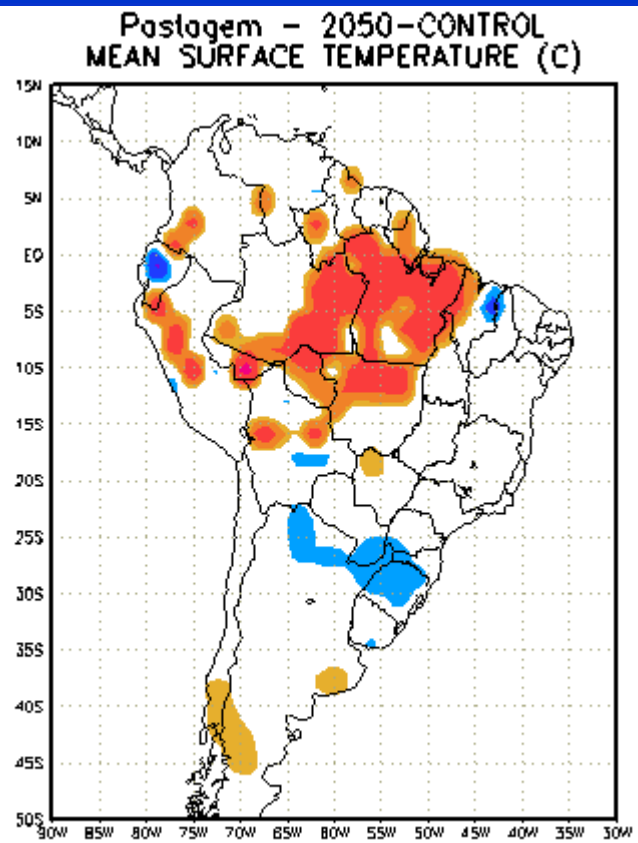


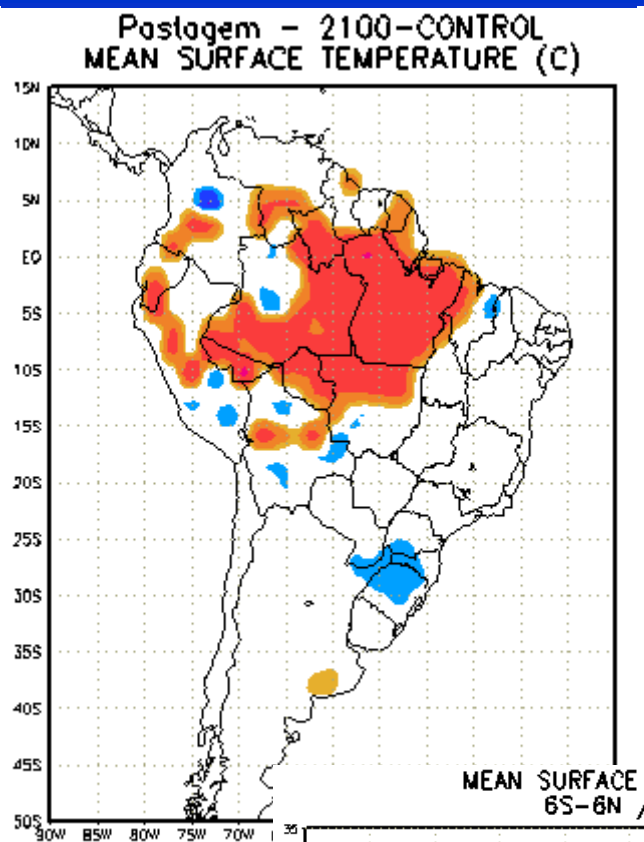


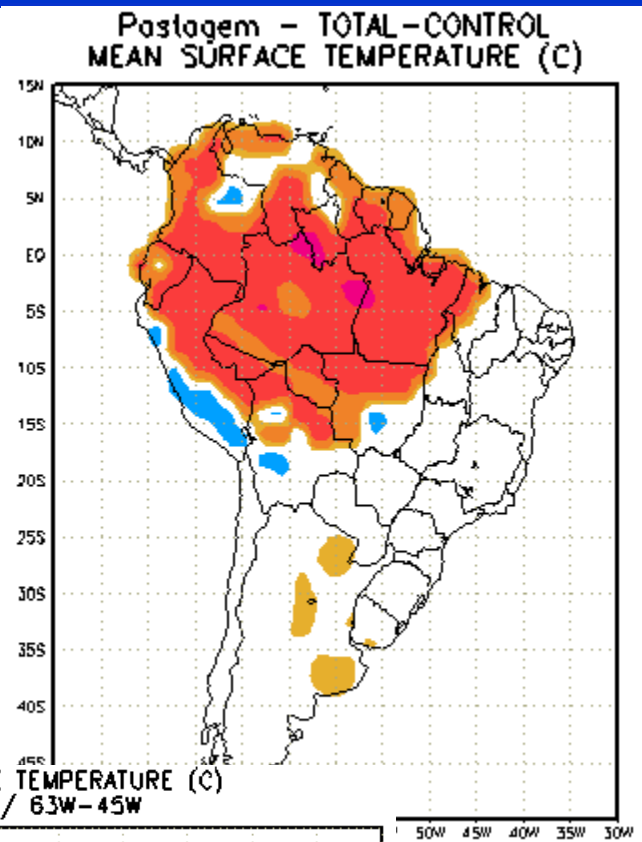


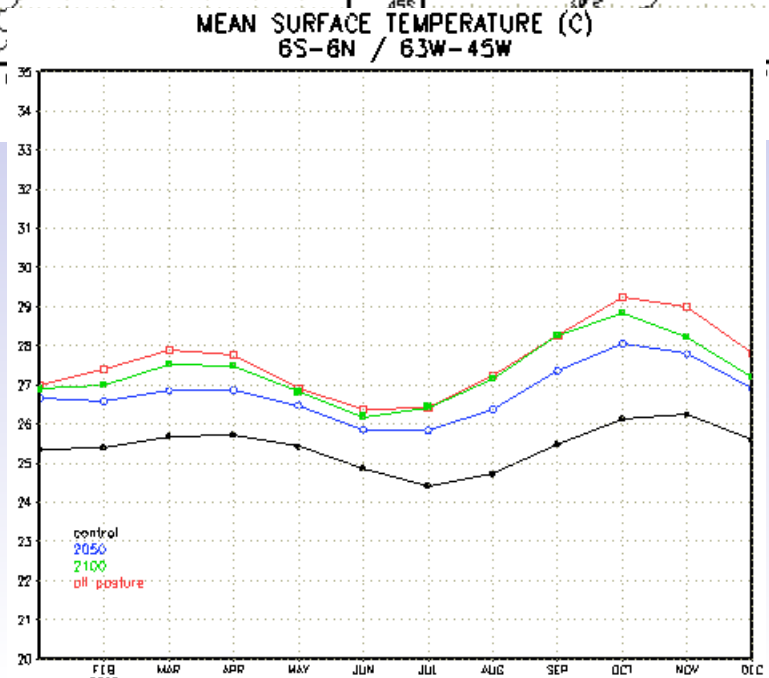


Reduction of precipitation !

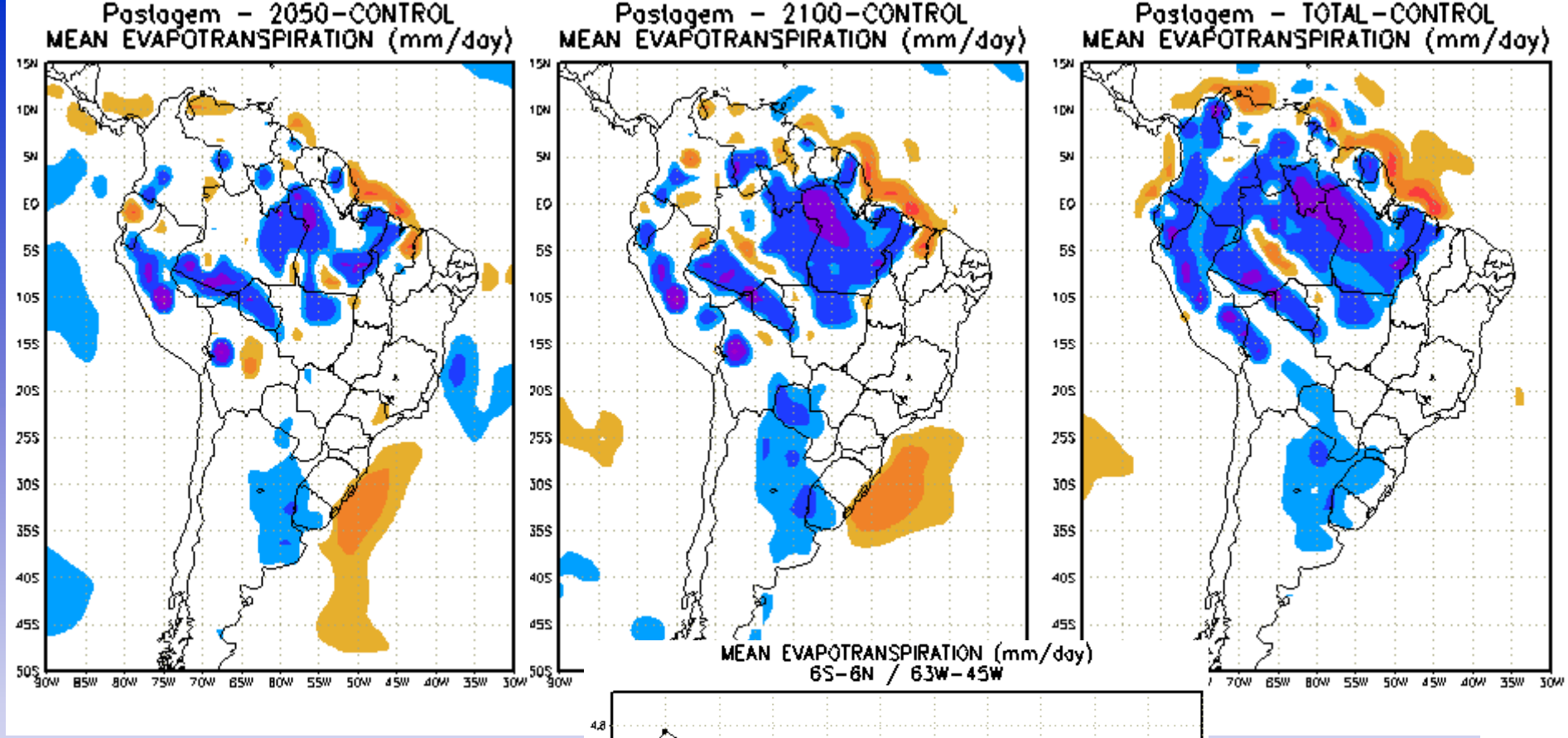




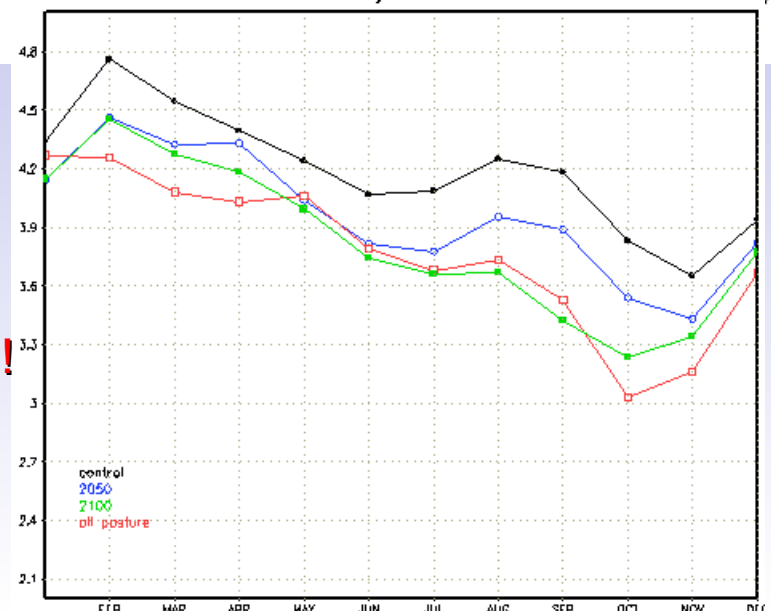


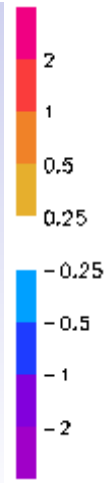


1°C to 3°C warming of air temperatures



MEAN EVAPOTRANSPIRATION (mm/day)
6S-6N / 63W-45W





Reduction of evapotranspiration !

Conclusions
The future of biome distribution in Amazonia in face of land cover and climate changes

- Natural ecosystems in Amazonia have been under increasing land use change pressure.These large-scale land cover changes could cause warming and a reduction of rainfall by themselves in Amazonia.

- Projected climate changes for Amazonia indicate a much warmer climate at the end of the Century and decreased forest cover and increased savanna cover.

- The synergistic combination of regional climate changes caused by both global warming and land cover change over the next several decades could tip the biome-climate state to a new stable equilibrium with '*savannazation*' of parts of Amazonia (and 'desertification' in Northeast Brazil) and catastrophic species losses.