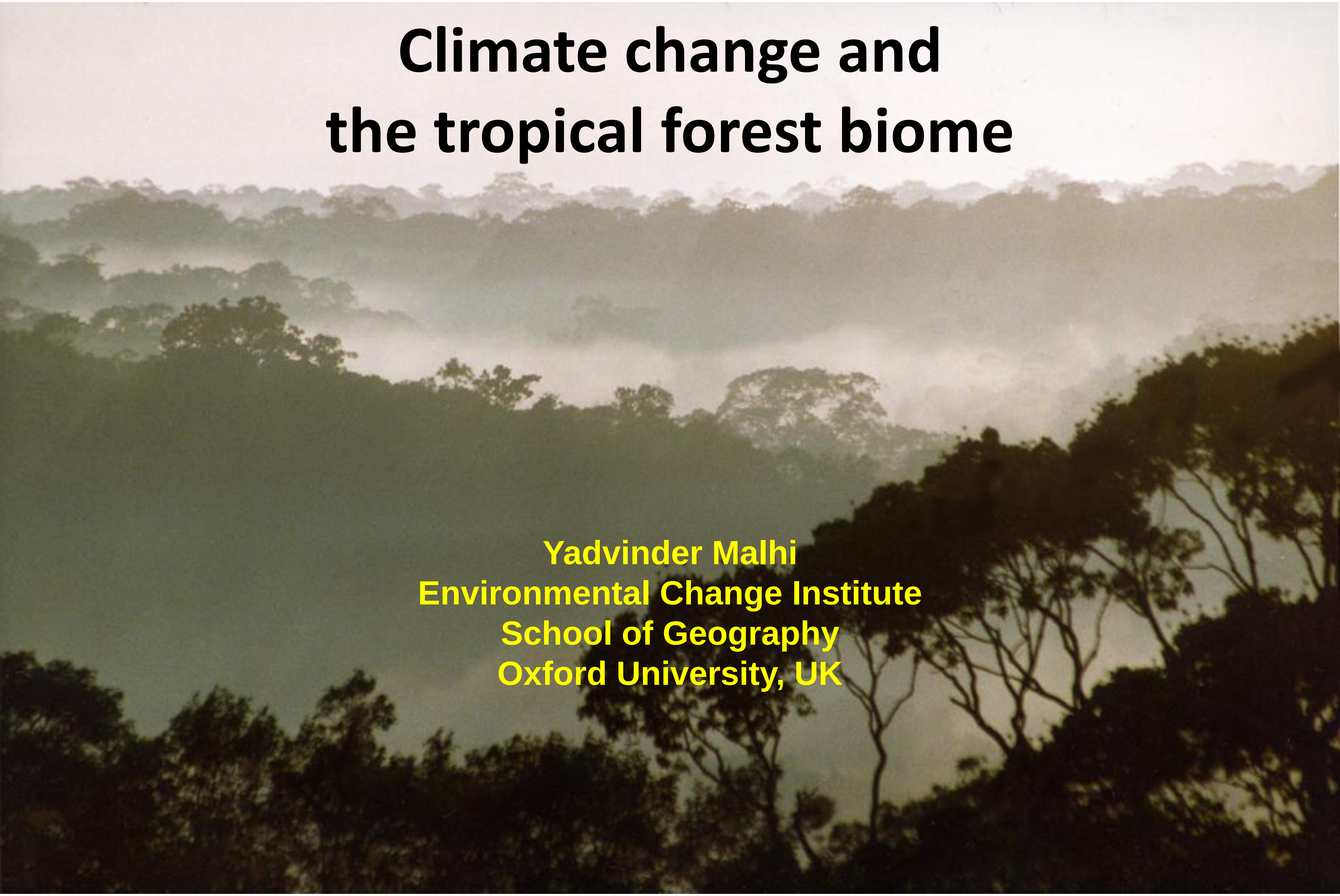
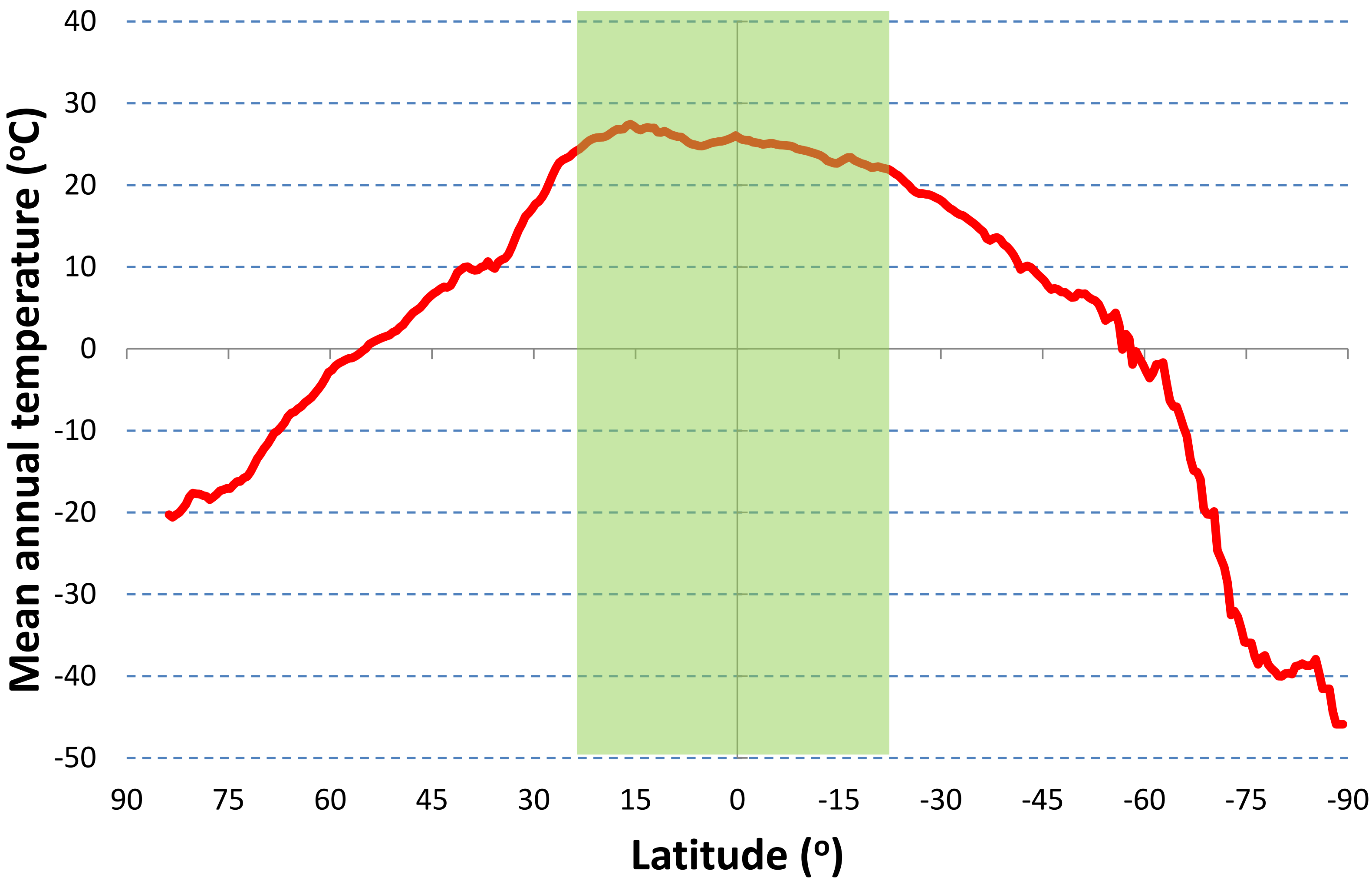
Climate change and the tropical forest biome

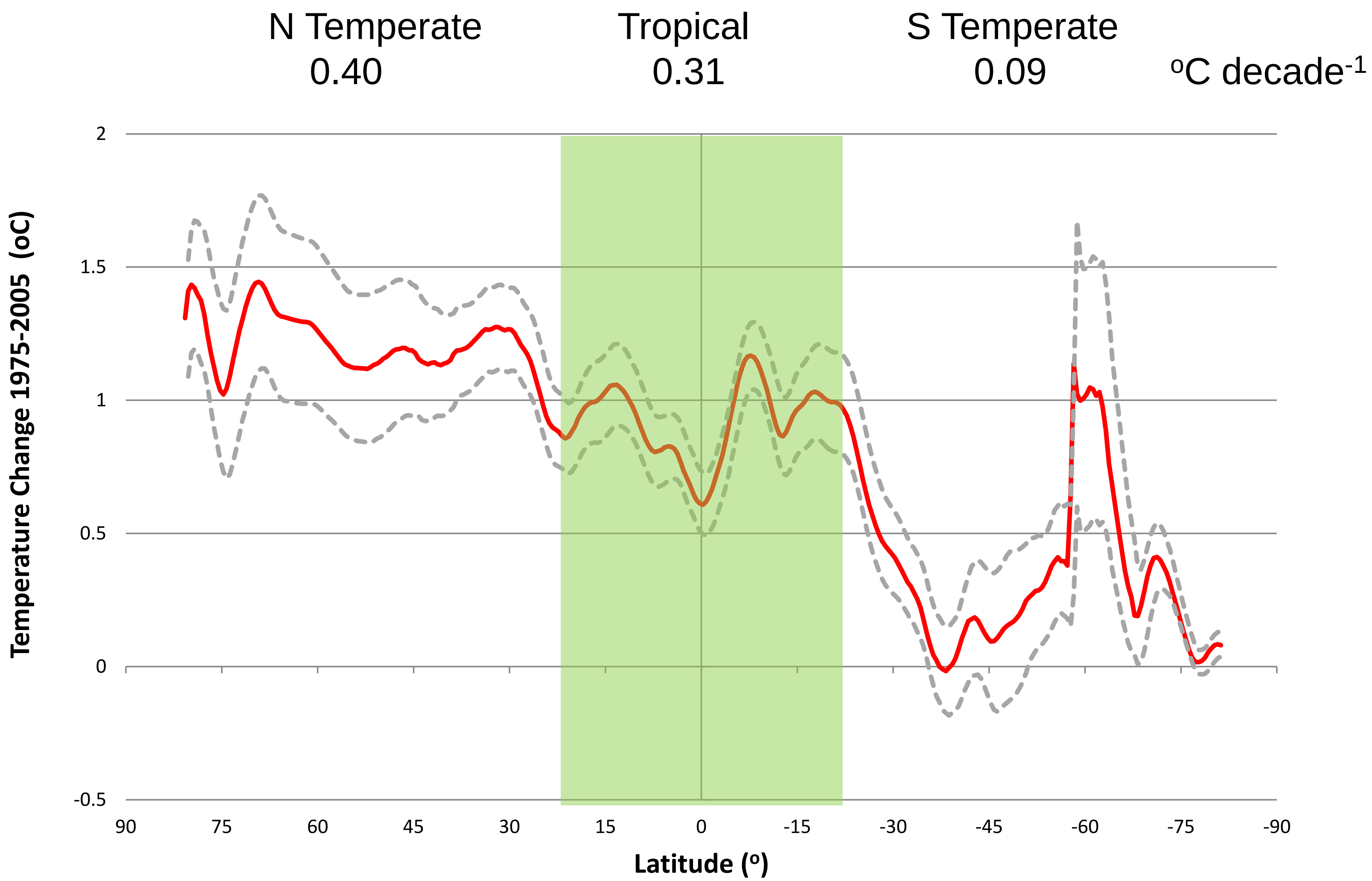


Yadvinder Malhi
Environmental Change Institute
School of Geography
Oxford University, UK

Mean temperature of land regions, 1975-2005

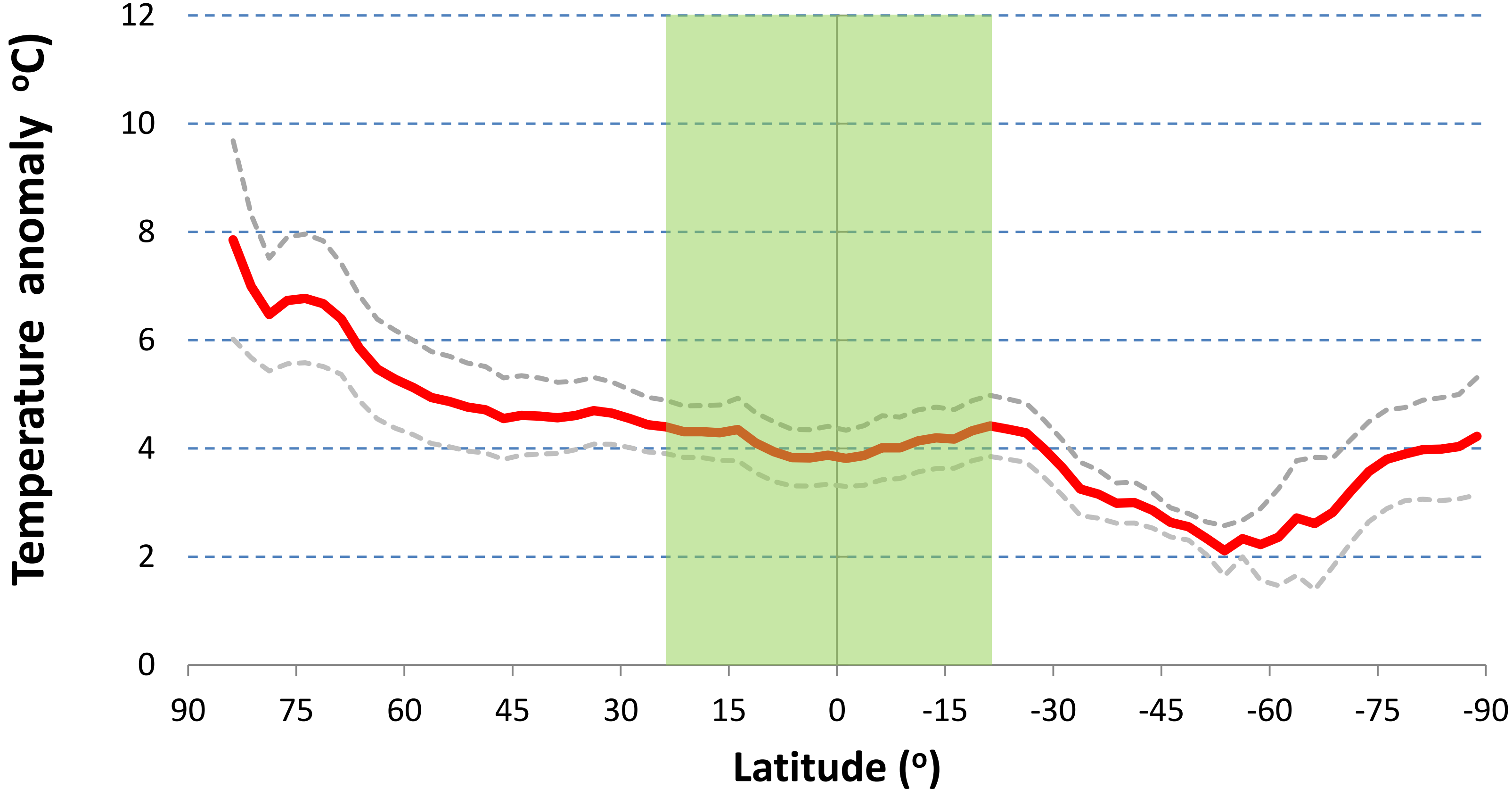


Rate of warming of land regions, 1975-2005

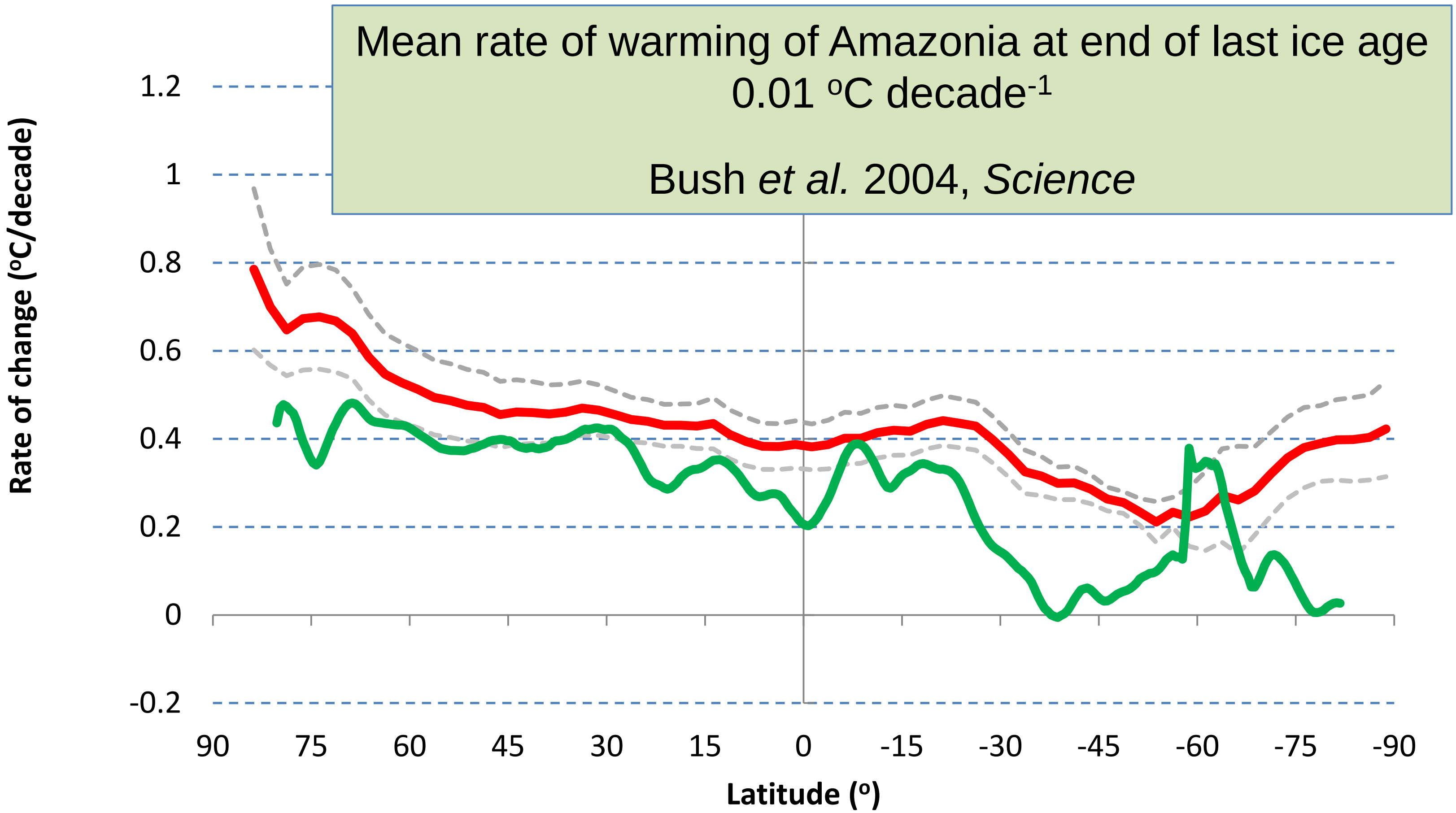


Project warming in land regions by late 21st century under A2 emissions scenario

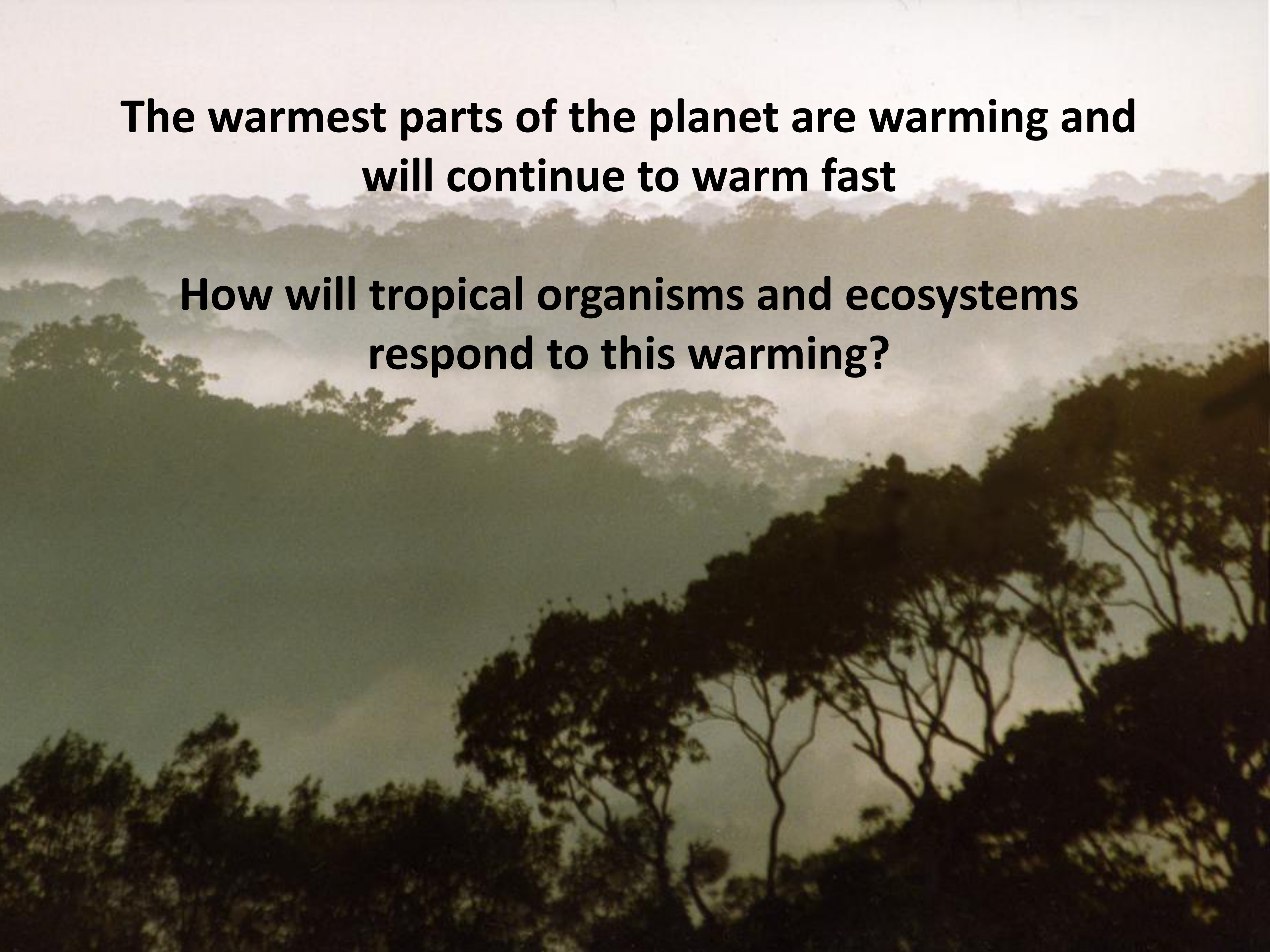
Mean of 15 IPCC Global Climate Models



Modelled and observed rates of change

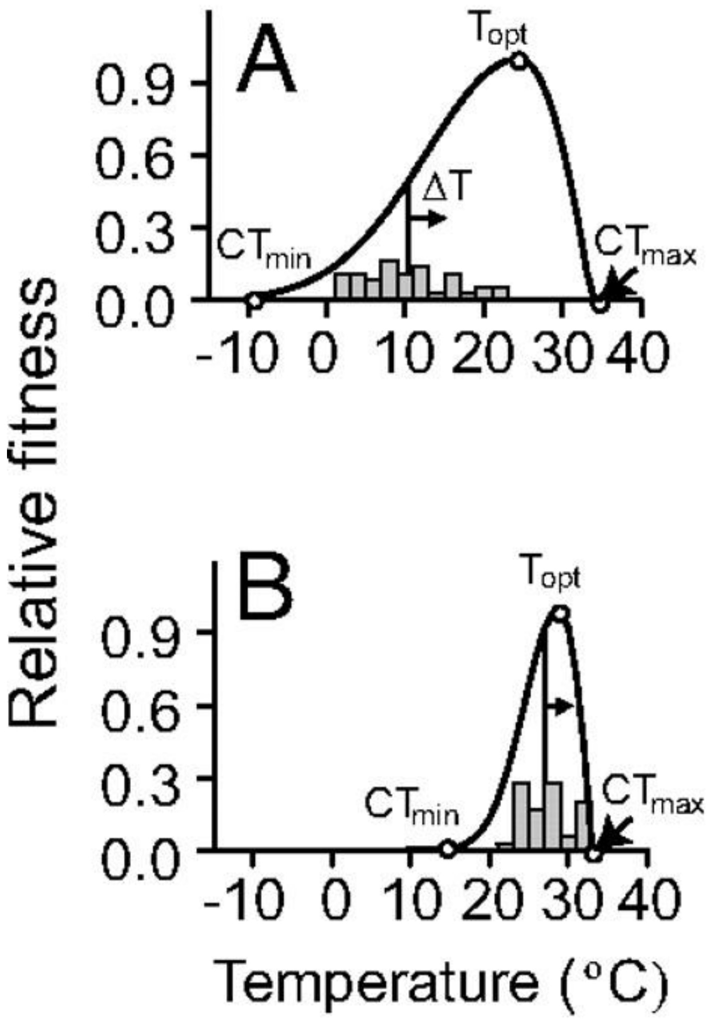


Modelled rates: late 20th to late 21st century, A2 emissions scenario
Observed rates: 1975-2005

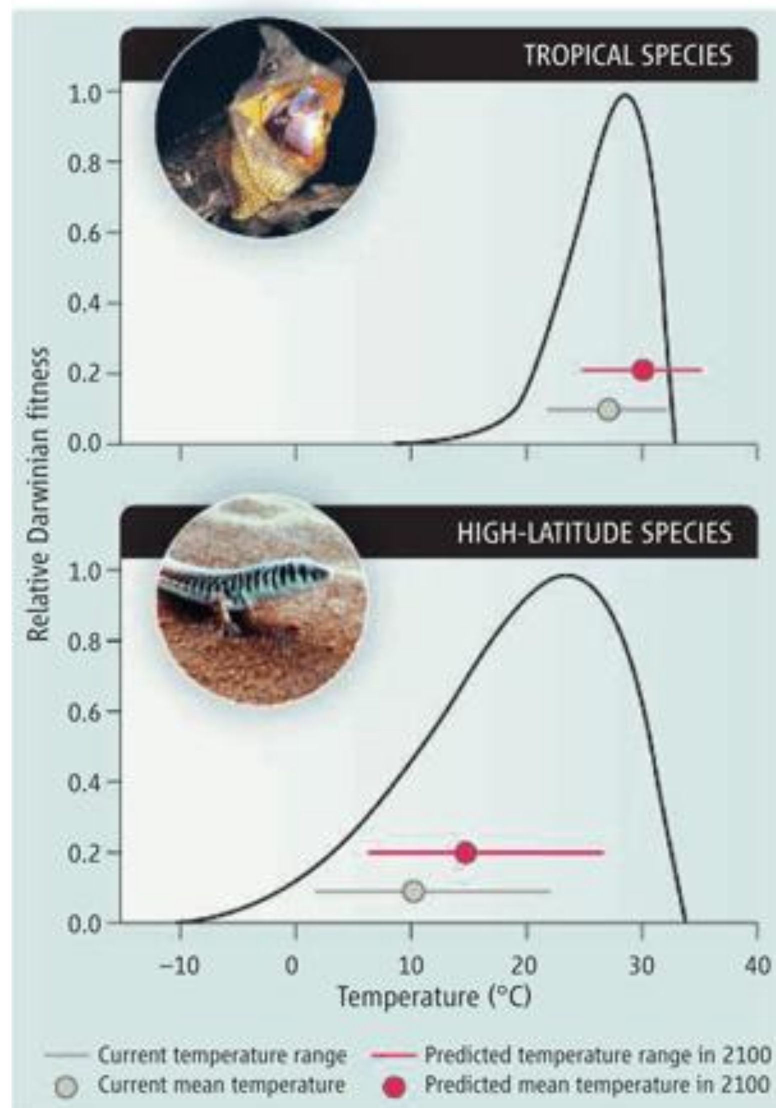

The warmest parts of the planet are warming and will continue to warm fast
How will tropical organisms and ecosystems respond to this warming?

Tropical species have narrower current thermal tolerances

Insects



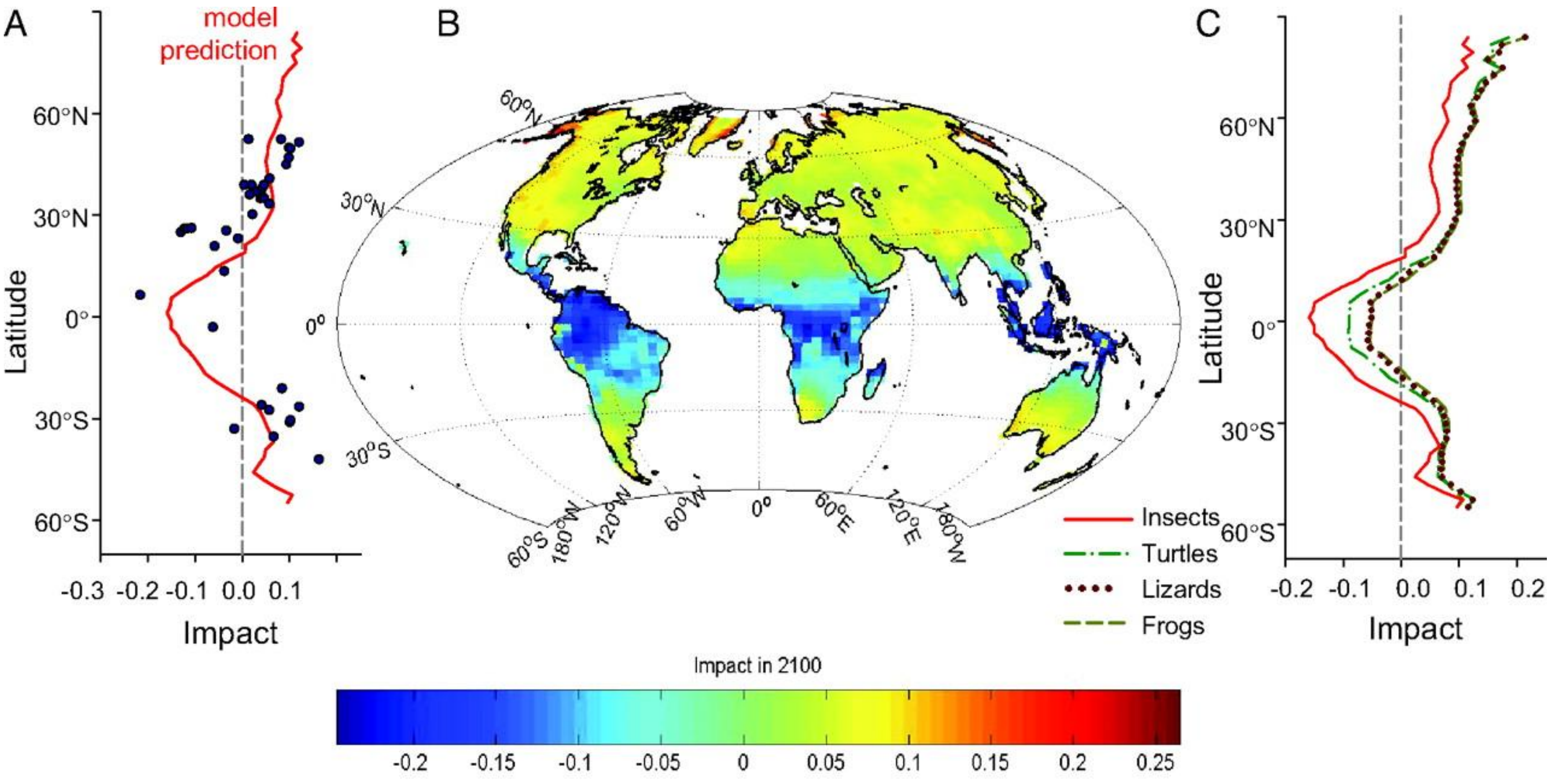
Lizards



Deutsch C. A. et.al. PNAS 2008

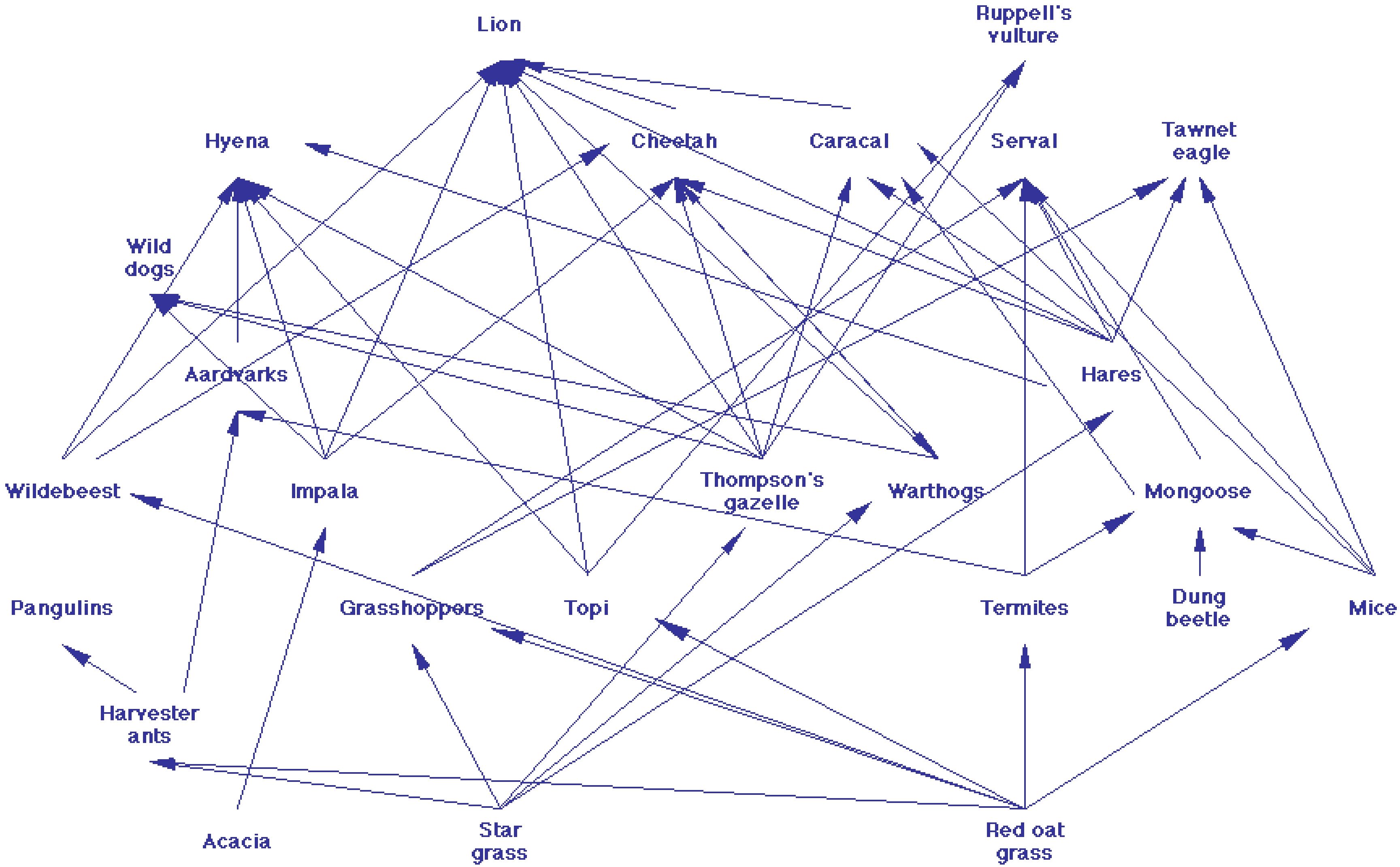
Tewksbury et.al. Science 2008

Predicted impact of warming on the thermal performance of ectotherms in 2100



Deutsch C. A. et.al. PNAS 2008;105:6668-6672

All these changes in fitness will be imposed on nodes of the “tangled web”



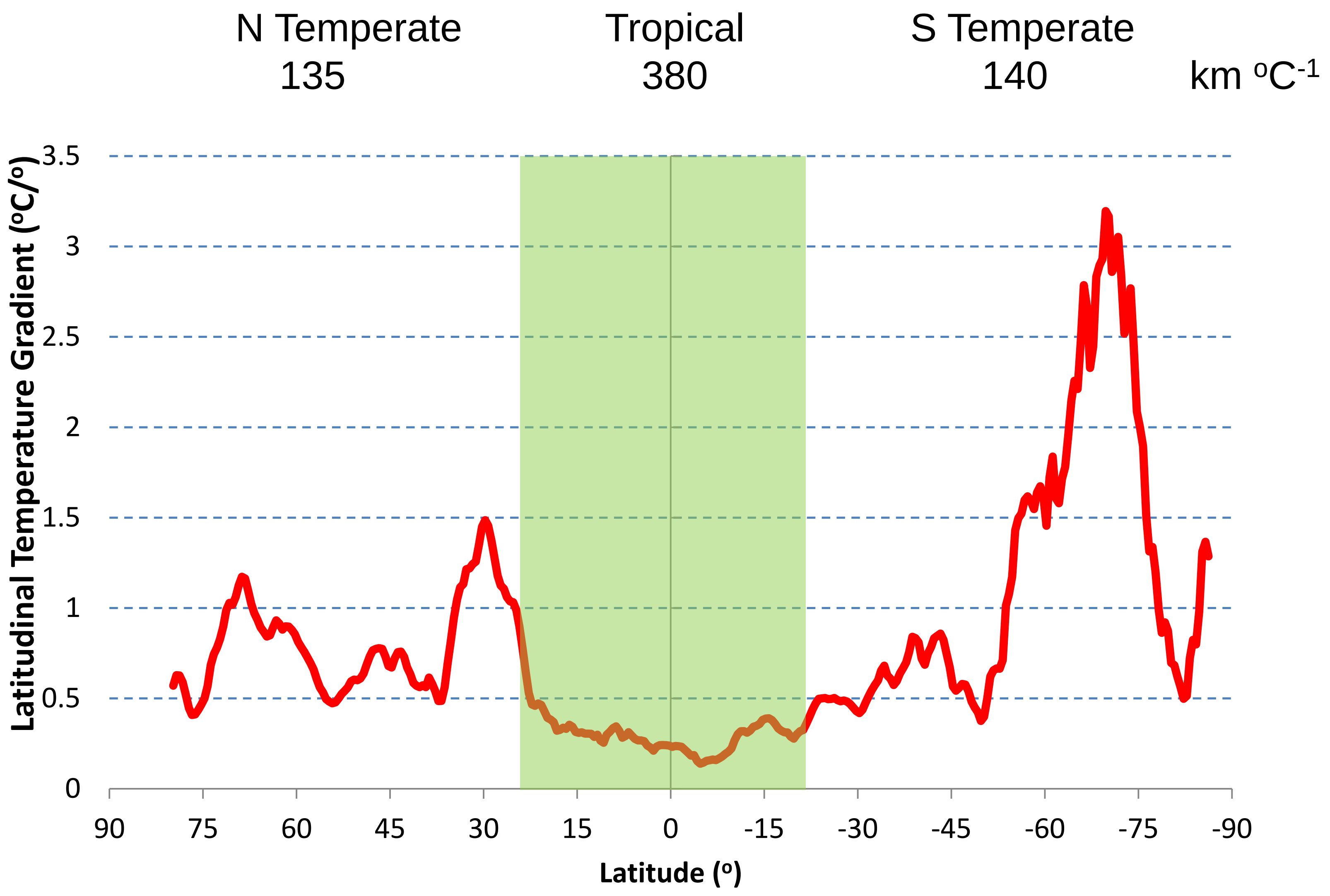
Responses to potential decline in performance

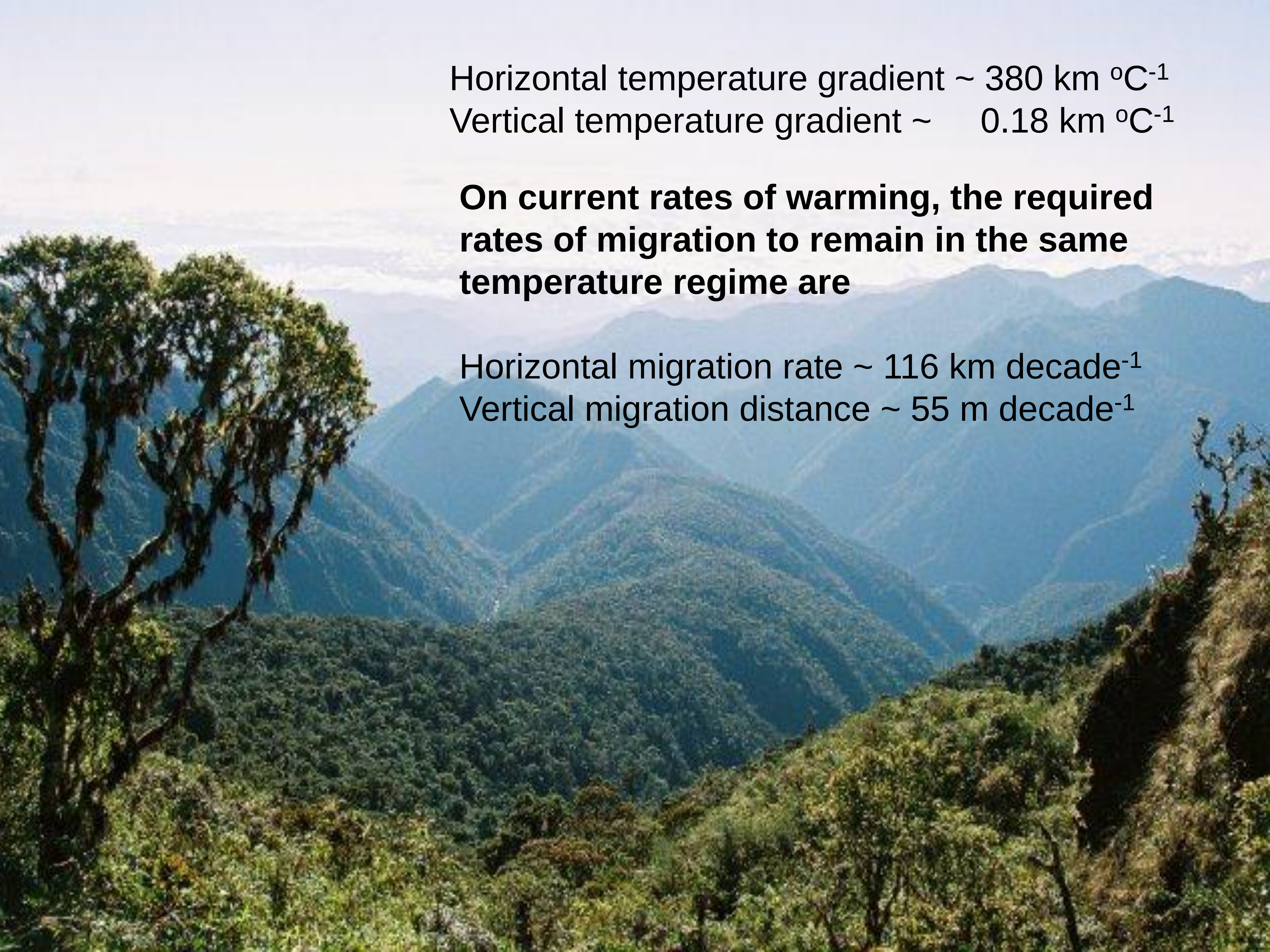
Responses of organisms , species and ecosystems will be complex – do not simply map onto decline in performance.

- Plasticity of physiological thresholds and acclimation of physiology
- Within-species trait diversity
- Rapid evolutionary adaptation
- Behavioural change – timing and spatial distribution of activities
- Migration

In all cases the *RATE* of change is probably the greatest challenge

Spatial gradients in temperature are shallow in the tropics





Horizontal temperature gradient ~ 380 km $^{o}C^{-1}$
Vertical temperature gradient ~ 0.18 km $^{o}C^{-1}$

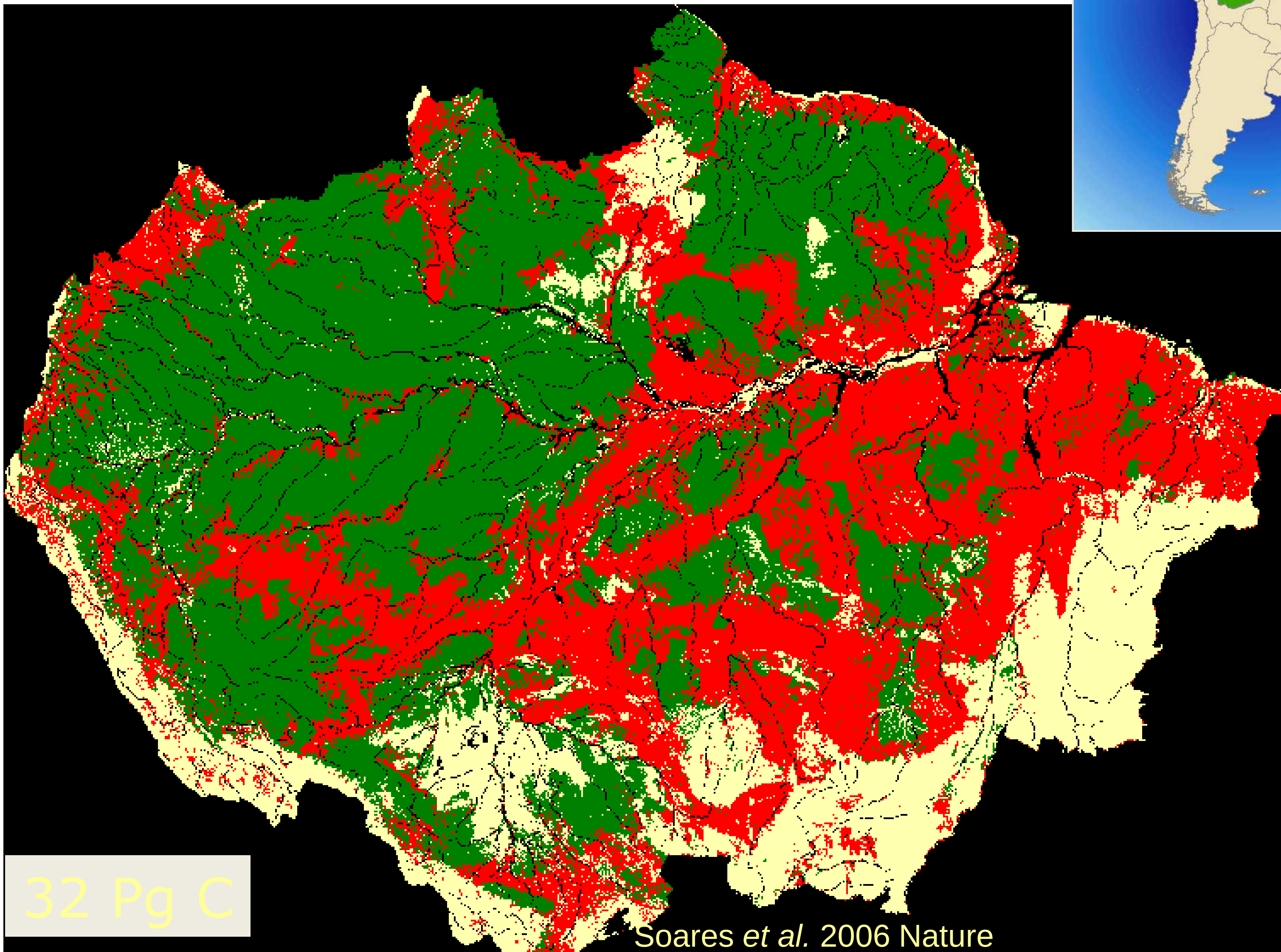
On current rates of warming, the required rates of migration to remain in the same temperature regime are

Horizontal migration rate ~ 116 km $decade^{-1}$
Vertical migration distance ~ 55 m $decade^{-1}$

Deforestation
2006
Soares et al. 2006. *Nature*

2050 Business-as-Usual Scenario:

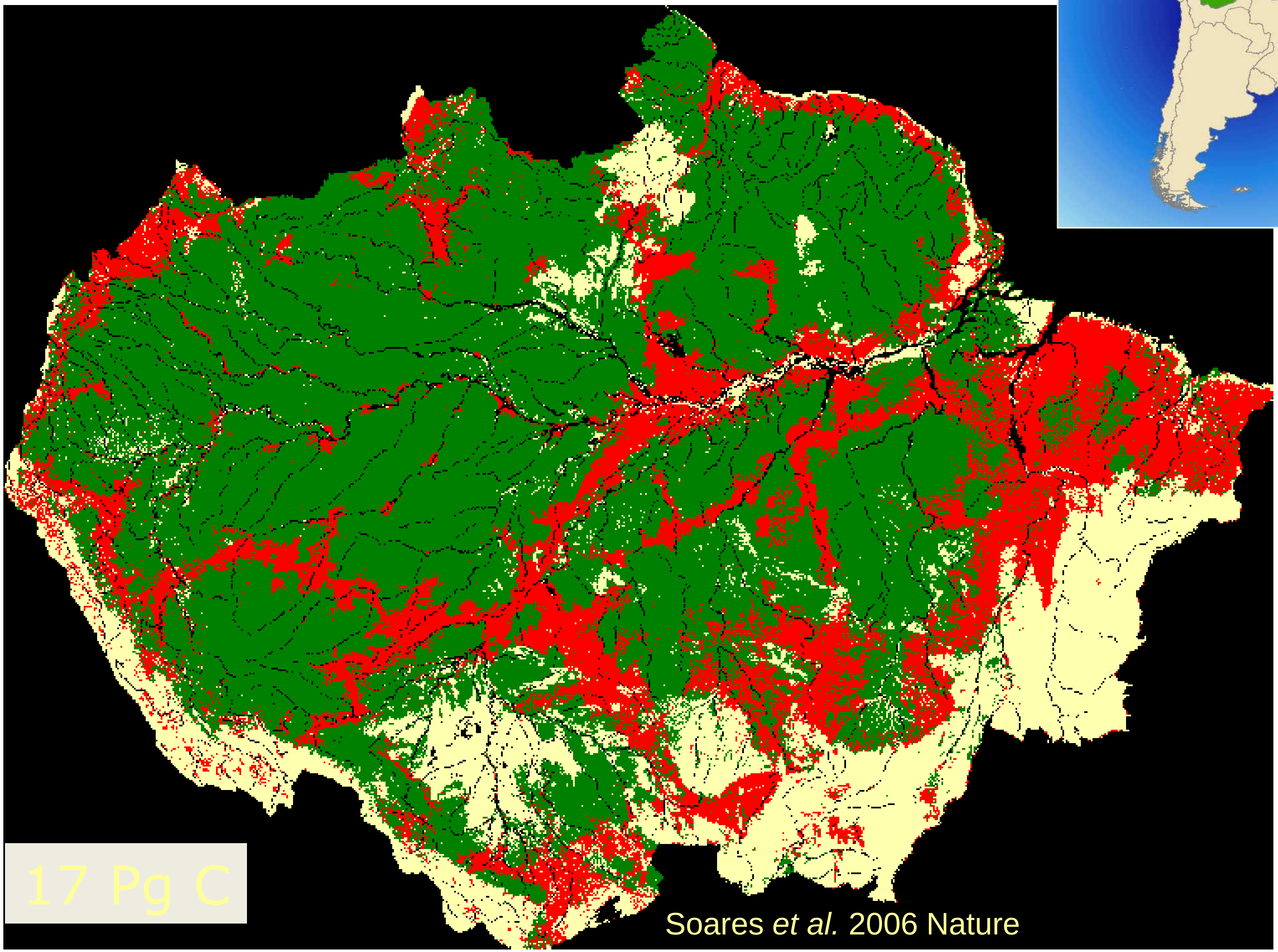
Deforested	2.7 million km^2
Forest	3.3 million km^2
Non-forest	1.5 million km^2



Soares *et al.* 2006 Nature

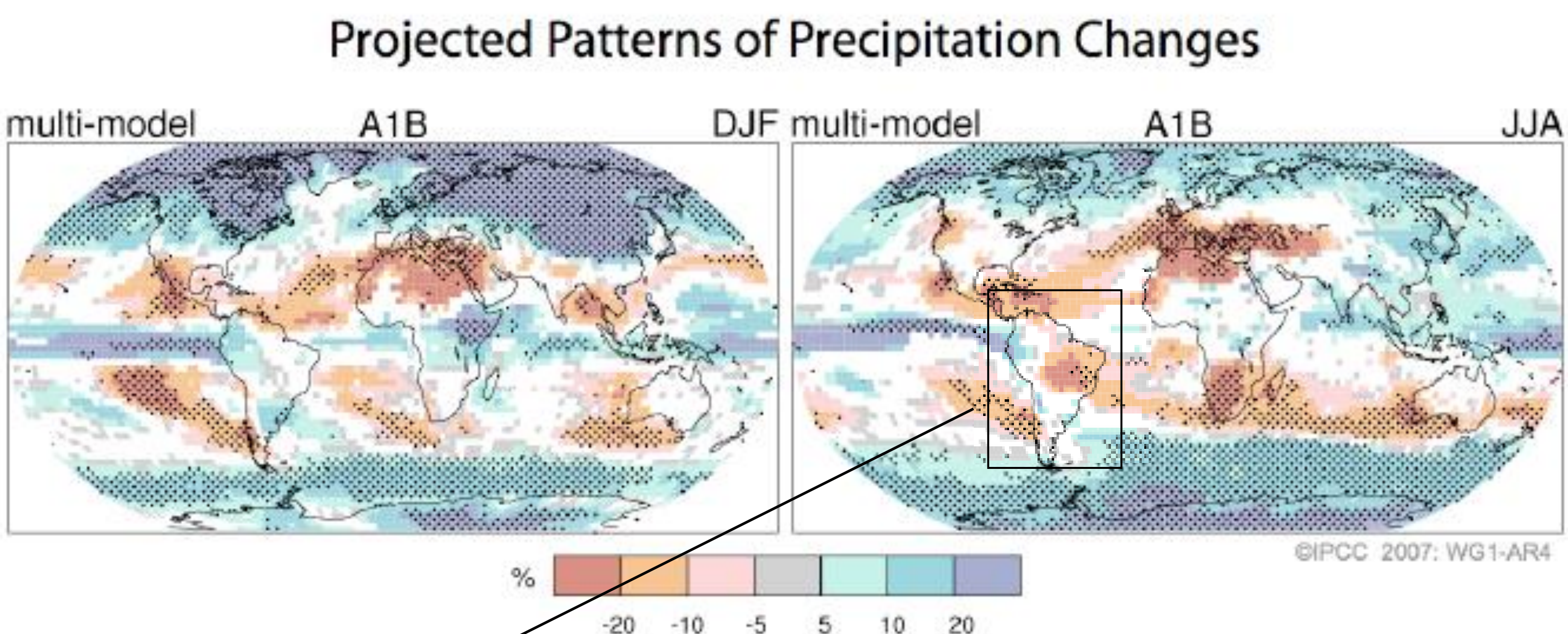
2050 Governance Scenario:

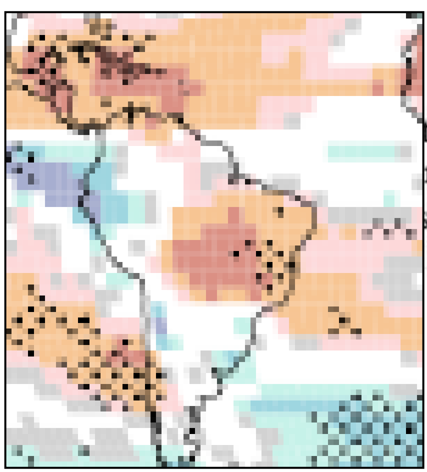
Deforested	1.7 million km^2
Forest	4.4 million km^2
Non-forest	1.5 million km^2



Precipitation

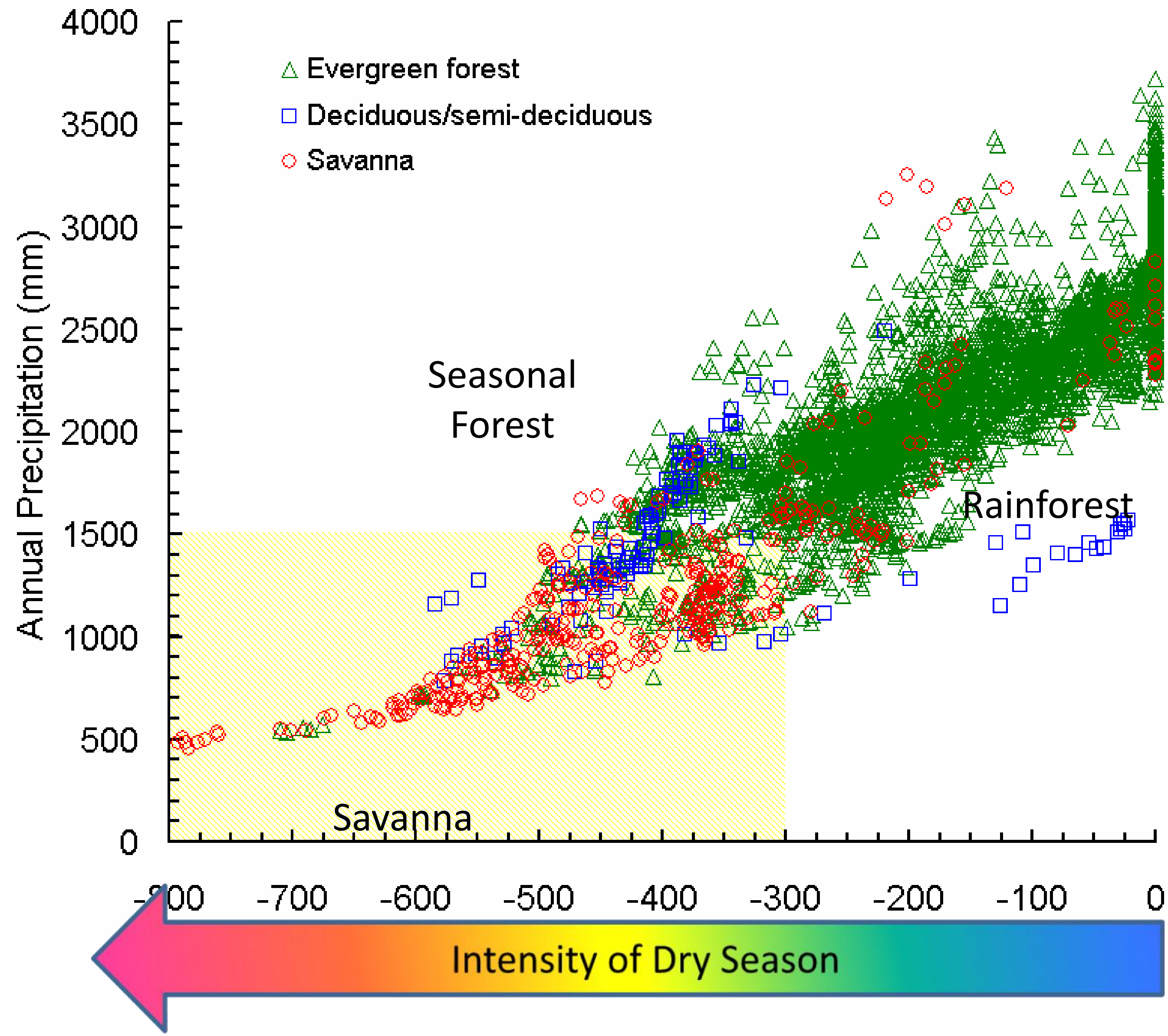
IPCC Fourth Assessment Report





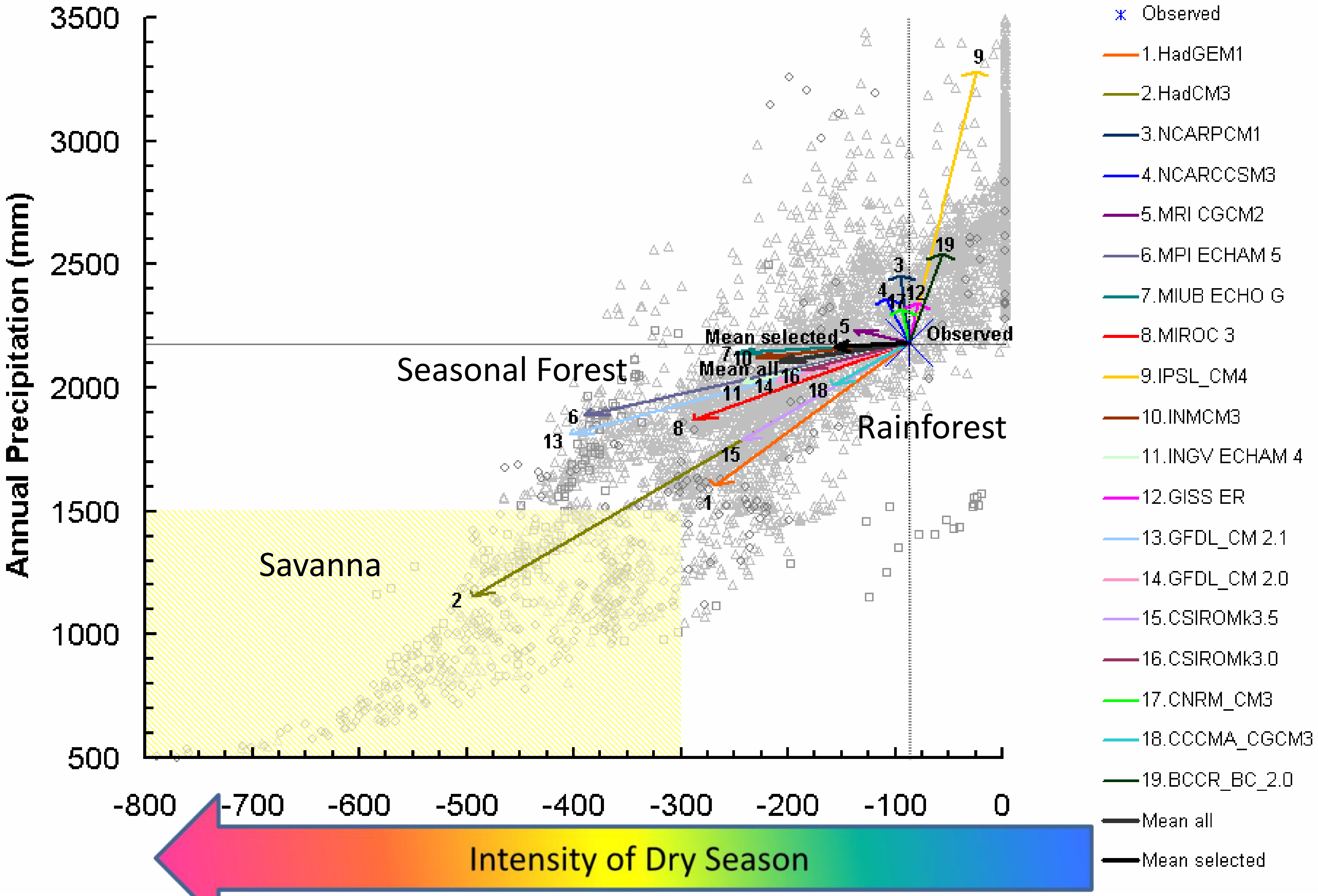
tive changes in precipitation (in percent) for the period 2090–2099, relative to
multi-model averages based on the SRES A1B scenario for December to February
st (right). White areas are where less than 66% of the models agree in the sign of
areas are where more than 90% of the models agree in the sign of the change.

A simple rainfall biogeography of Amazonia



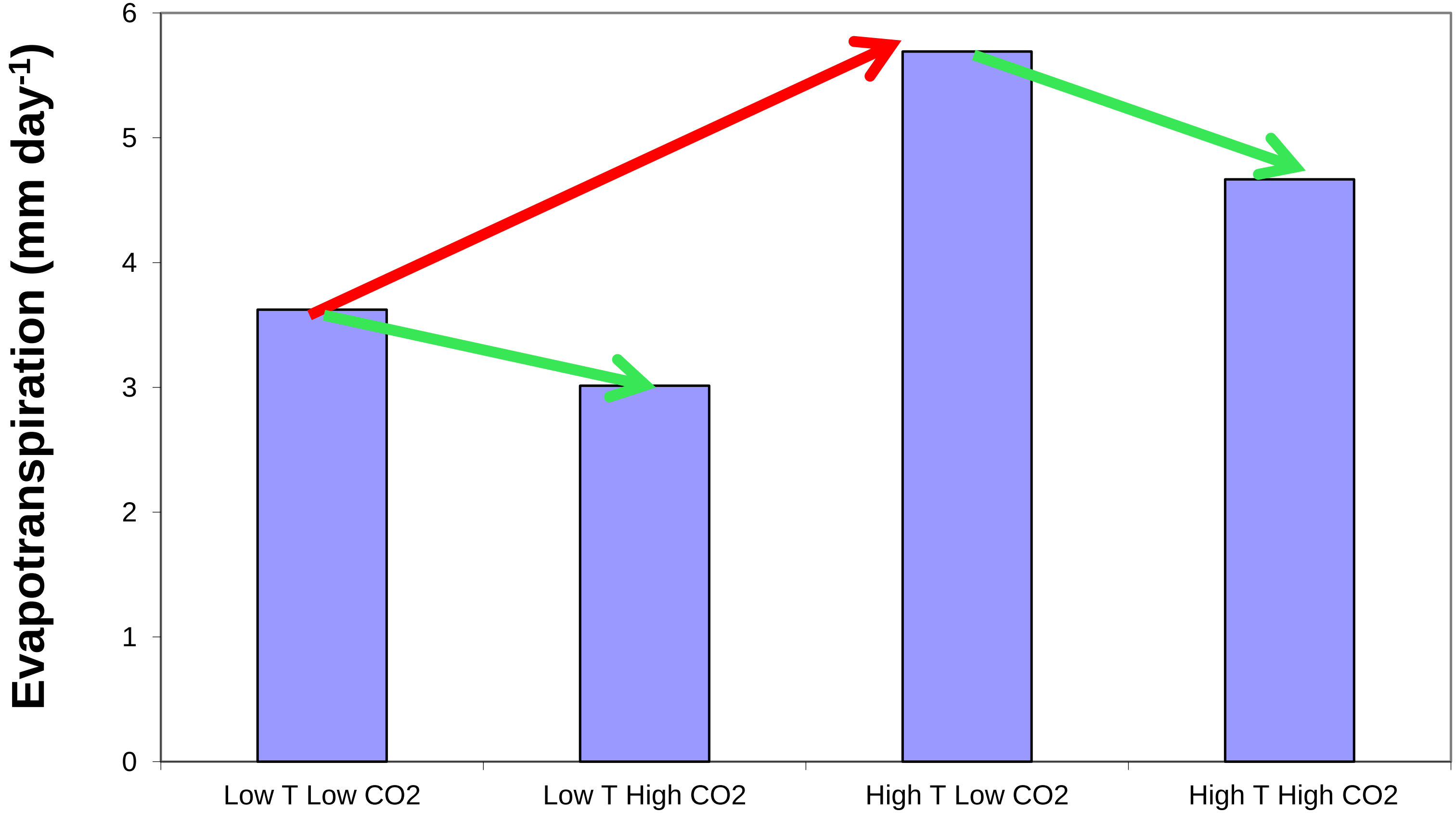
Malhi *et al.*, 2008 **Exploring the likelihood and mechanism of a climate-change induced dieback of the Amazon rainforest,** *Proceedings of the National Academy of Sciences*.

Adjusted climate model predictions for Amazonia



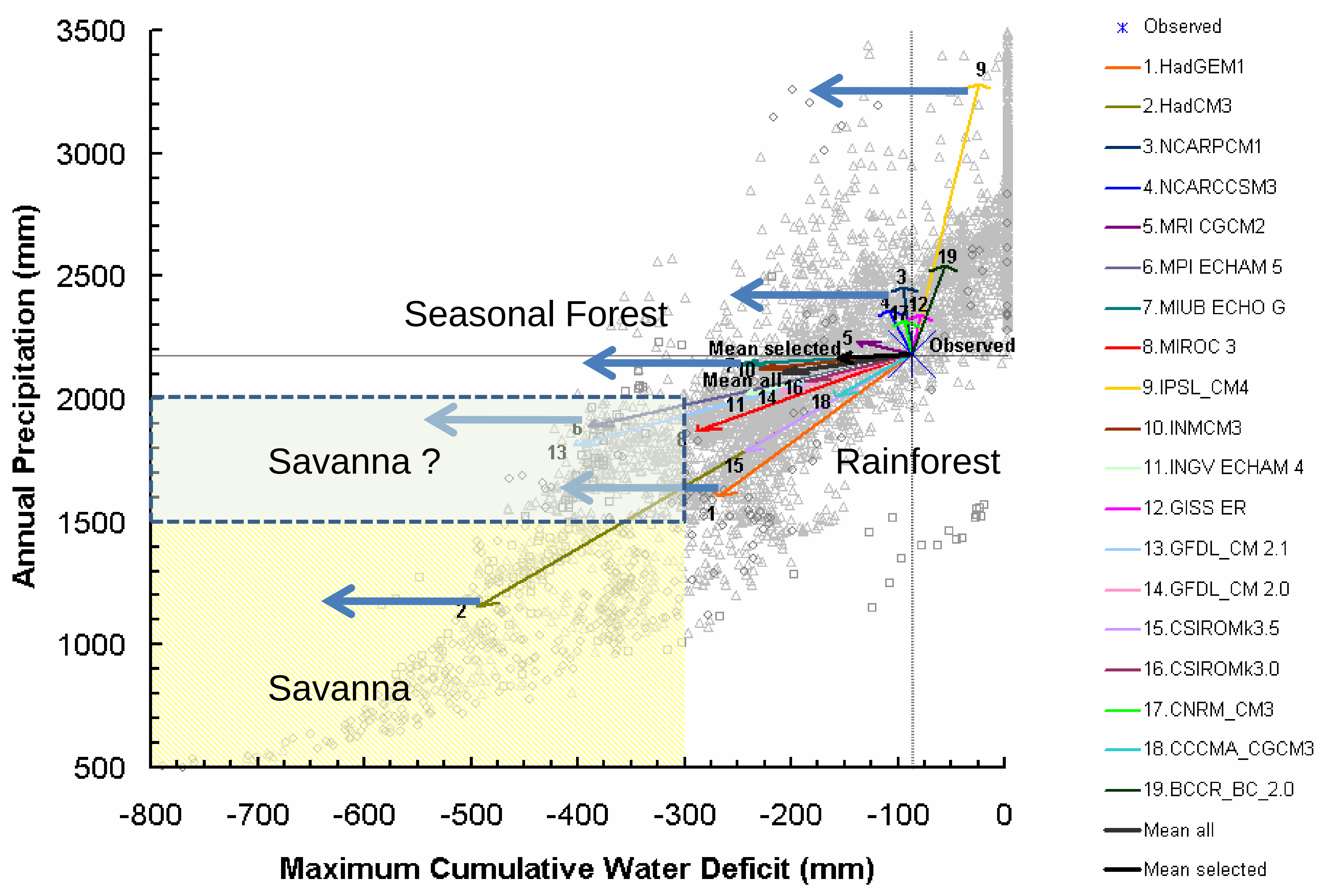
Malhi *et al.* 2009, **Exploring the likelihood and mechanism of a climate-change induced dieback of the Amazon rainforest,** *Proceedings of the National Academy of Sciences*,

Effects of temperature and CO_2 on water use



UK MOSES-TRIFFID Model
Low CO_2 = 280 ppm, High CO_2 = 850 ppm
Change in T = +4.5 °C

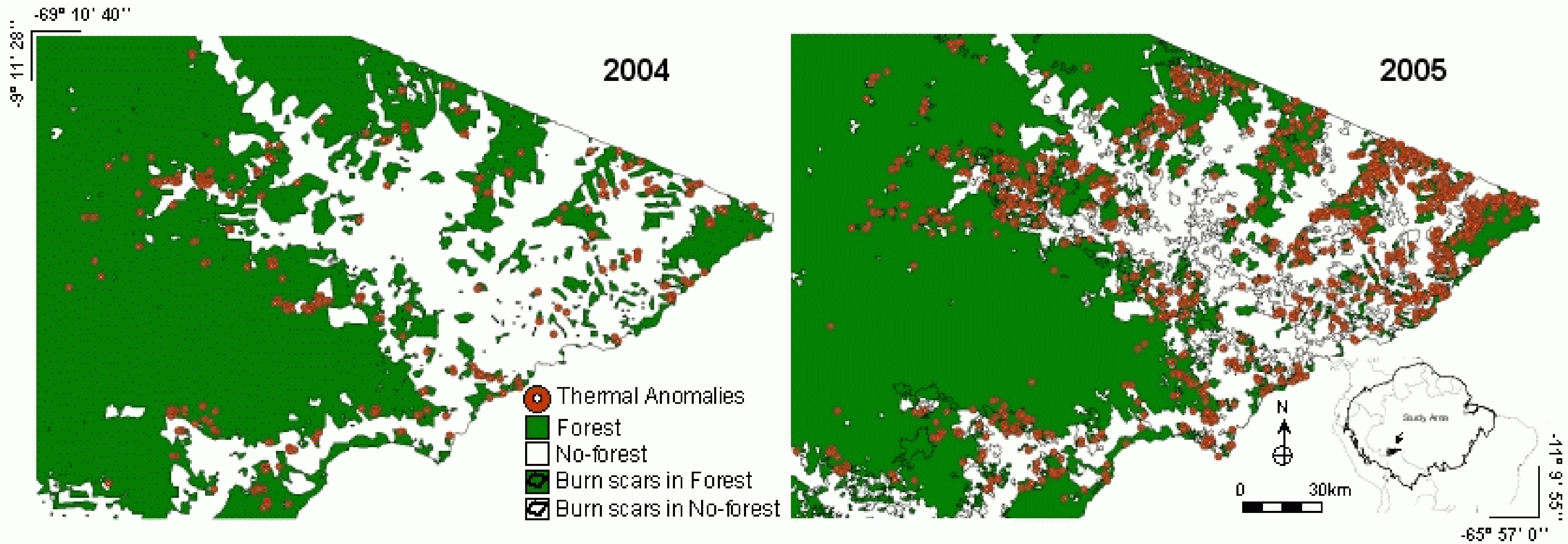
Malhi *et al.* 2009, **Exploring the likelihood and mechanism of a climate-change induced dieback of the Amazon rainforest,** *Proceedings of the National Academy of Sciences,*



Annual Precipitation (mm)
3500
3000
2500
2000
1500
1000
500
-800
-700
-600
-500
-400
-300
-200
-100
0
Maximum Cumulative Water Deficit (mm)
Seasonal Forest
Savanna ?
Savanna
Rainforest
Observed
Mean selected
Mean all
Observed
1.HadGEM1
2.HadCM3
3.NCARPCM1
4.NCARCCSM3
5.MRI CGCM2
6.MPI ECHAM 5
7.MIUB ECHO G
8.MIROC 3
9.IPSL_CM4
10.INMCM3
11.INGV ECHAM 4
12.GISS ER
13.GFDL_CM 2.1
14.GFDL_CM 2.0
15.CSIROMk3.5
16.CSIROMk3.0
17.CNRM_CM3
18.CCCMA_CGCM3
19.BCCR_BC_2.0
Mean all
Mean selected

The role of fire

Forest fires in eastern Acre State (Brazil) during the 2005 Amazonian drought

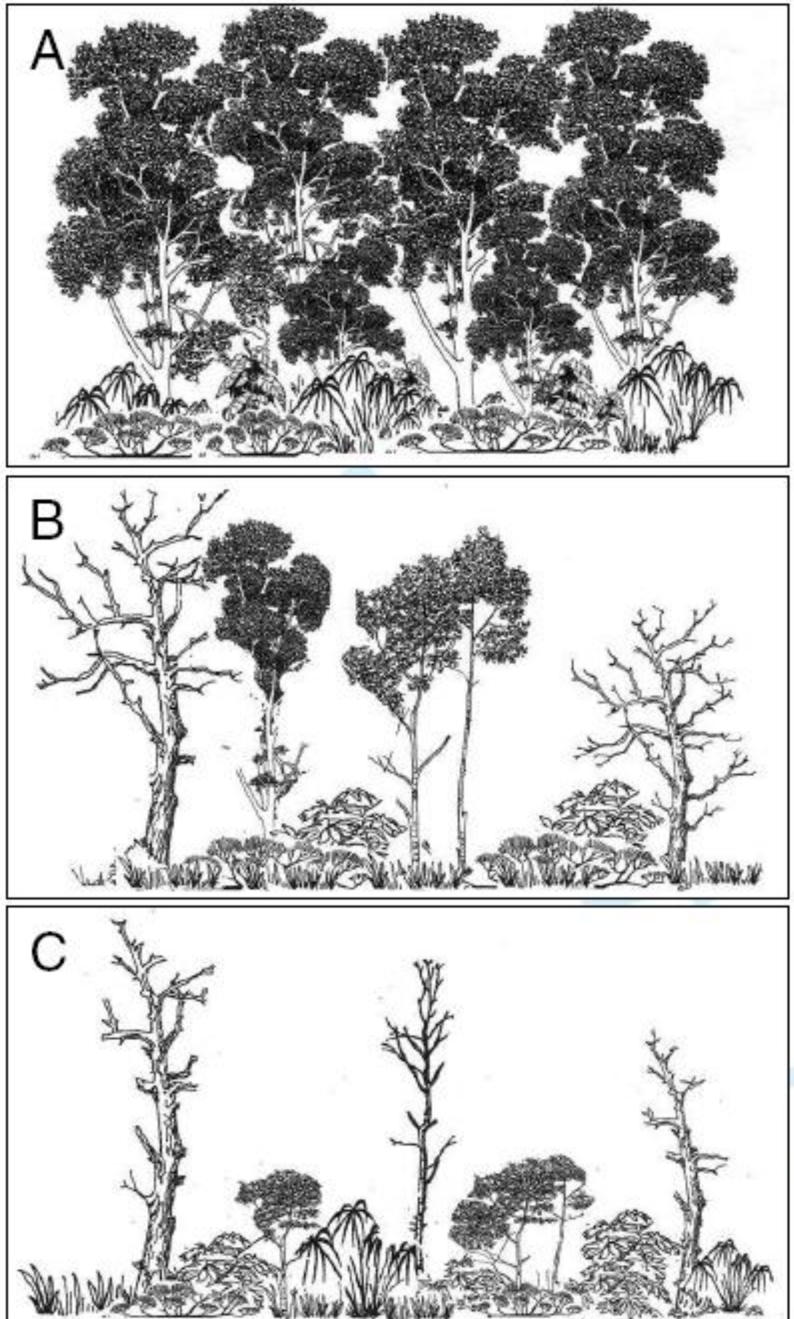


Aragão, Malhi *et al*, Spatial patterns and fire response of recent Amazonian droughts, *Geophysical Research Letters. (2007)*

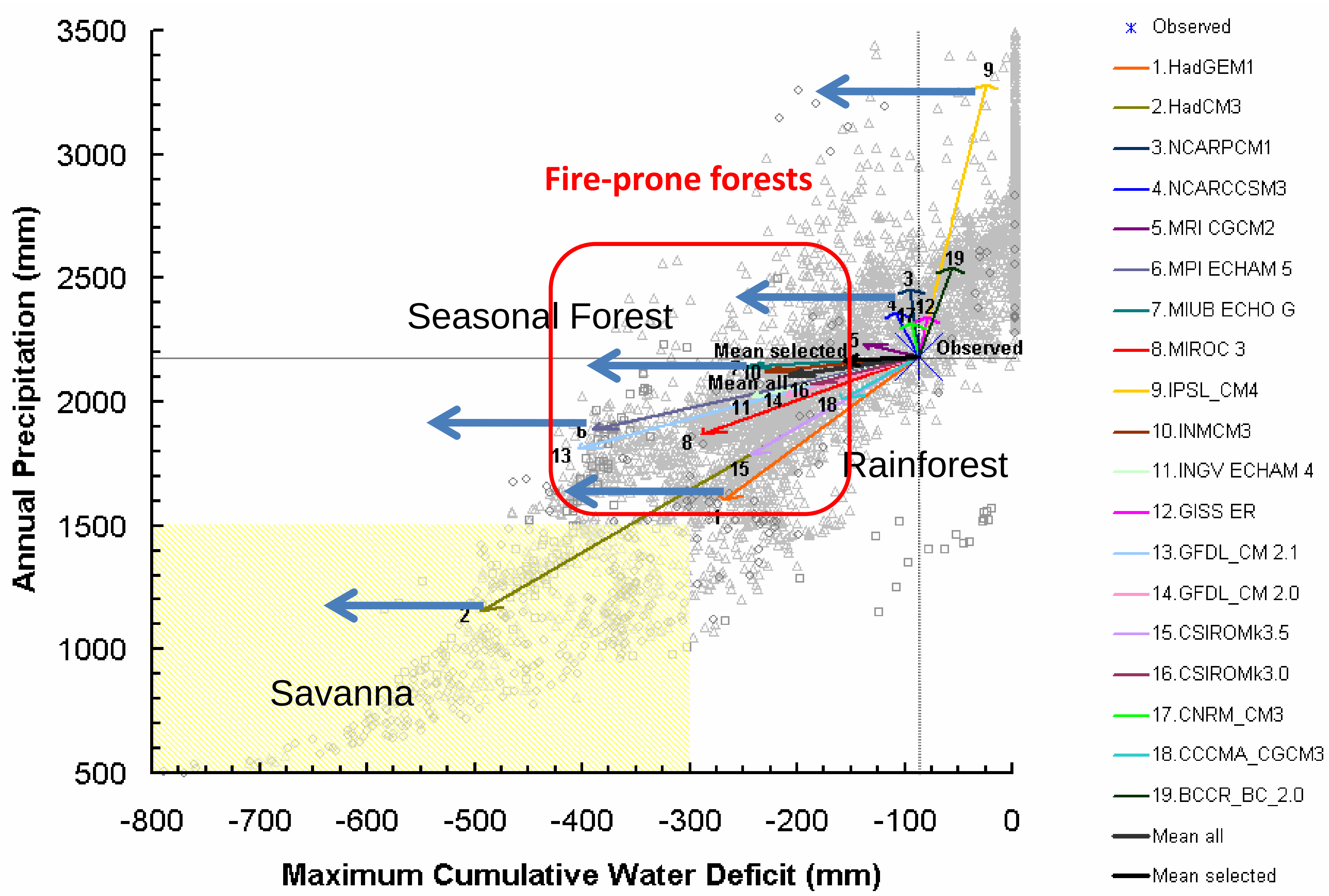
No burn

First burn

Second or third burn



Barlow J & Peres CA (2008) Fire-mediated dieback and compositional cascade in an Amazonian forest. *Philos Trans R Soc London*

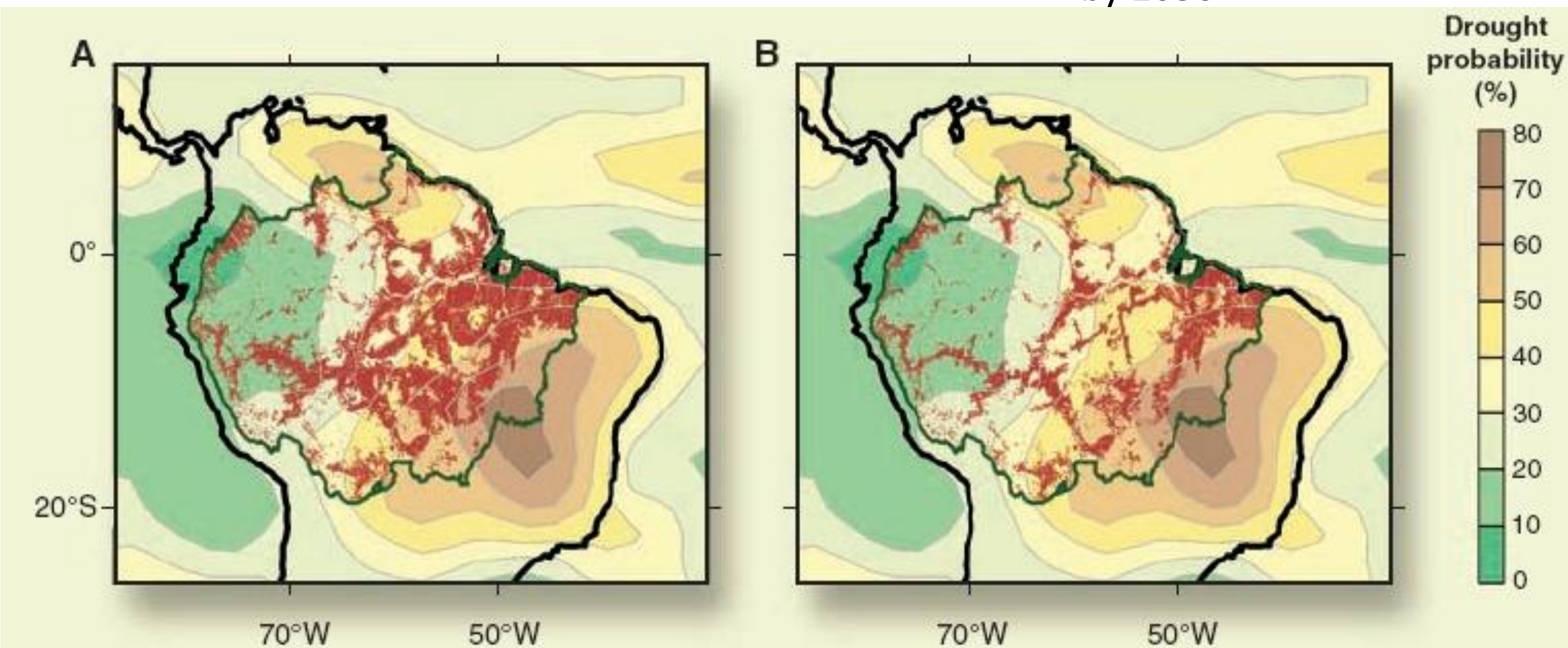


Fire-prone forests
Seasonal Forest
Rainforest
Savanna
Mean selected
Mean all
Observed
Annual Precipitation (mm)
Maximum Cumulative Water Deficit (mm)
Observed
1.HadGEM1
2.HadCM3
3.NCARPCM1
4.NCARCCSM3
5.MRI CGCM2
6.MPI ECHAM 5
7.MIUB ECHO G
8.MIROC 3
9.IPSL_CM4
10.INMCM3
11.INGV ECHAM 4
12.GISS ER
13.GFDL_CM 2.1
14.GFDL_CM 2.0
15.CSIROMk3.5
16.CSIROMk3.0
17.CNRM_CM3
18.CCCMA_CGCM3
19.BCCR_BC_2.0
Mean all
Mean selected

Interactions between potential deforestation and climate change

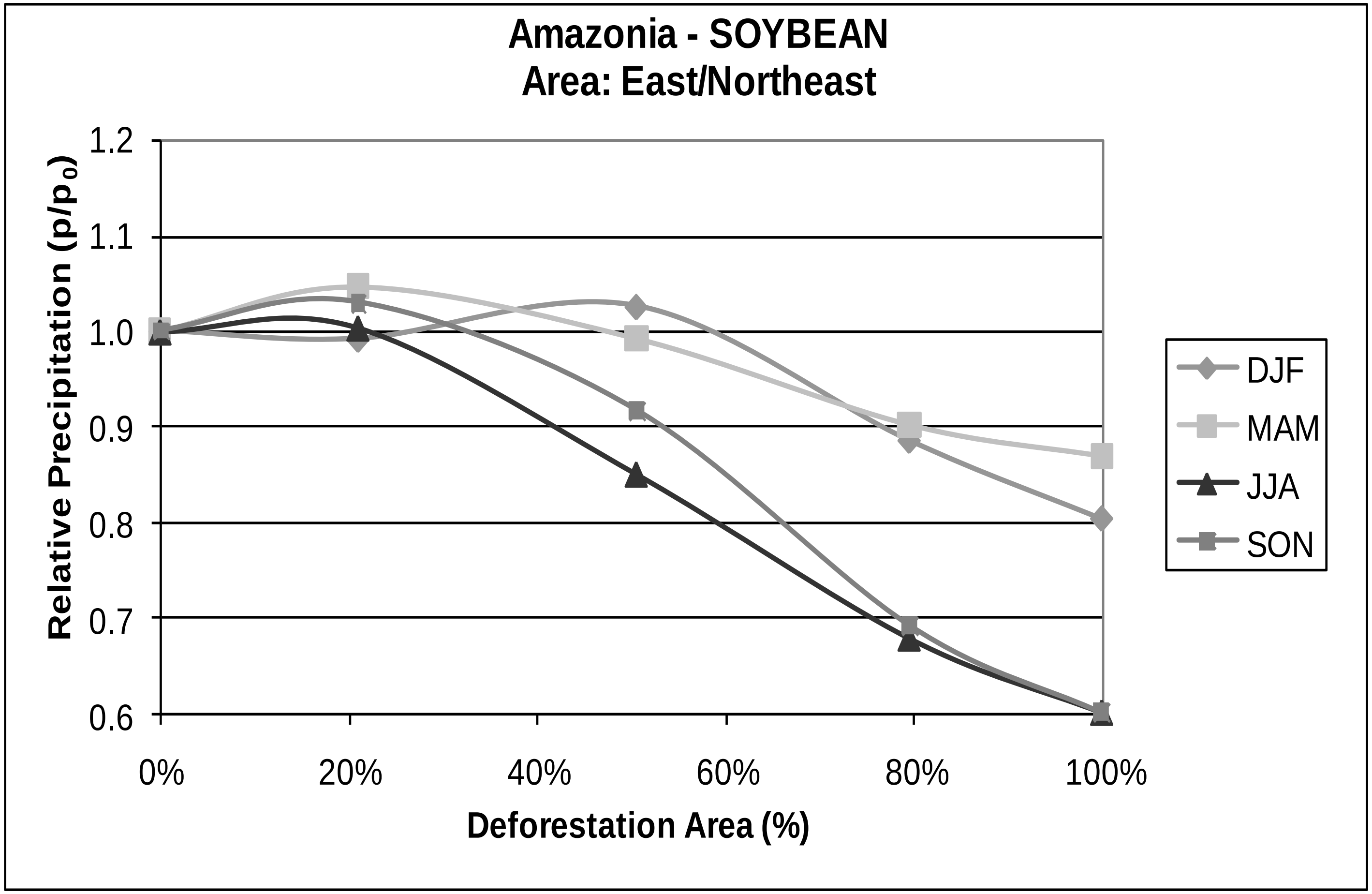
"Business as usual" deforestation by 2050

"High governance" deforestation by 2050



Malhi *et al. (2008)*
Climate change, deforestation, and the fate of the Amazon, *Science*.

Modelled effect of conversion to soybean on rainfall in Eastern Amazonia



Salazar *et al. 2008*
Journal of Geophysical Research

Maintaining tropical forest area is a strategy for adapting to climate change

- Minimise contact points between forest fragments and fire zones
- Lower surface temperatures because of evaporative cooling of near-surface area
- Maintenance of shade habitats
- Maintainance of dry season rainfall
- Maintain connectivity for species migration to highland refugia

Forest protection is also a component strategy for **mitigation** of global climate change.

This presents an opportunity

Money is a necessary but not enough Challenges for tropical carbon governance

- Avoid perverse trade-offs
- Build capacity in governance
- Build capacity for monitoring
- Develop models and mechanisms for delivery

of carbon finance in a manner that is efficient, effective , equitable and ethical

Conclusions

Rapid change is coming to tropical forests – climate change and deforestation present a dangerous synergy.

We are only beginning to comprehend its impacts of this change

New opportunities for tropical forest conservation are emerging – we are only beginning to grasp the challenge that this opportunities will bring

There is an urgent need for investment in capacity, for (i) monitoring, (ii) planning and implementing conservation and adaptation (iii) developing governance structures that make tropical forest conservation effective