Agricultural transitions in the Amazon region: consequences for biogeochemistry and the need for land-use scenarios

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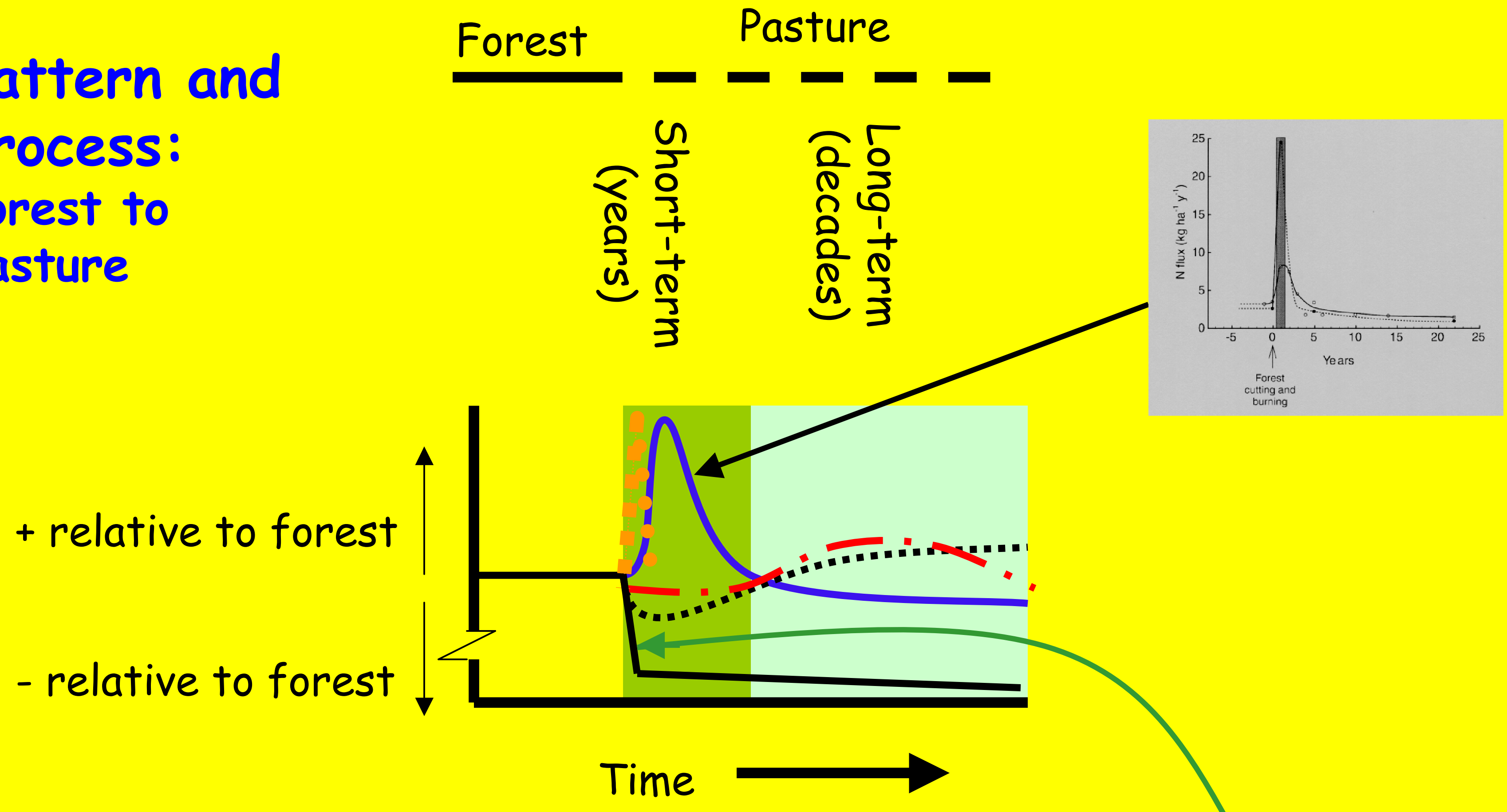
Agricultural Transitions in the Amazon Basin:
An LBA Synthesis

Biogeochemistry

LBA I (natural vegetation to pasture) and LBA I+ (transitions to mechanized agriculture)

Pattern and Process:
forest to pasture



- e.g., CH_4 from fire
- e.g., N_2O and DIN fluxes
- e.g., CH_4 from cattle
- e.g., soil organic C
- plant biomass

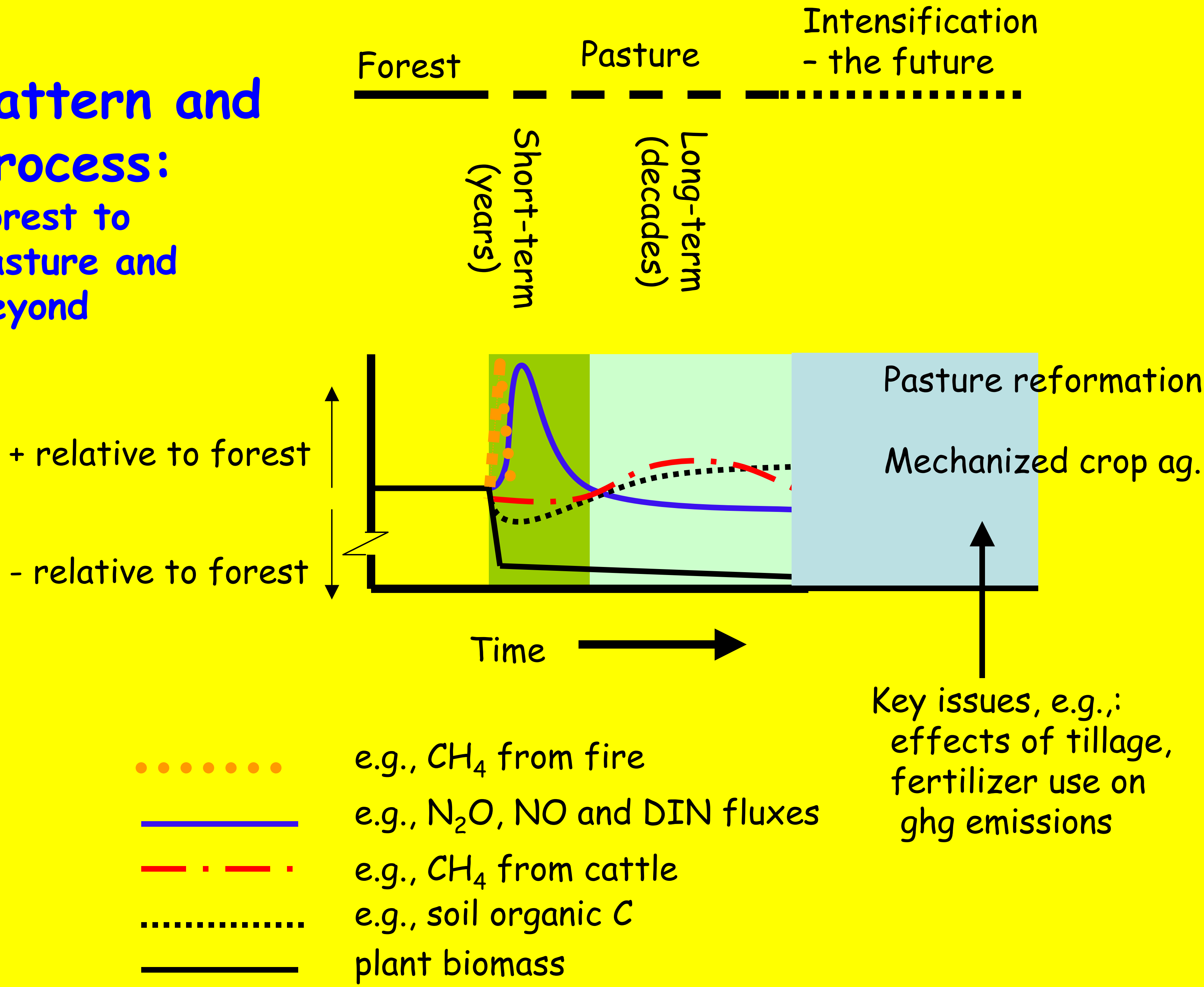
Large losses of plant carbon associated with forest clearing – estimated average of 160 Mg C/ha

Net effects on global warming potentials (GWPs) of forest-to-pasture conversion and 20 years of pasture management*

Net Source (+)/Sink (-)	Range	Estimate	CO_2-Equivalents ($Mg\ CO_2\ ha^{-1}$)	References
Forest plant biomass ($Mg\ C\ ha^{-1}$)	+110 to +250	+160	+600	Houghton et al. 2001
Soil carbon ($Mg\ C\ ha^{-1}$)	-15 to +12	-10	-40	Neill and Davidson, 2000
Soil N_2O ($kg\ N\ ha^{-1}$)	-5 to -40	-20	-9	Mellilo et al. 2001; Verchot et al. 1999
Soil CH_4 ($kg\ CH_4\ ha^{-1}$)	-20 to +20	+10	+0.2	Steudler et al. 1996; Verchot et al. 2000
Cattle CH_4 ($kg\ CH_4\ ha^{-1}$)	+500 to +2000	+1000	+20	Steudler et al. 1996
Total			+570	

* After Neill et al. – Chapter 4, LBA Ag synthesis volume

Pattern and Process:
forest to pasture and beyond



Nitrous Oxide and Methane Fluxes in Commercial Soybean, Rice, and Maize Crops on the Santarem-Belterra Plateau, Para State

OLIVEIRA, KELLER, CRILL

Soybean

Rice

Maize

N_2O Fluxes from soybean and other crops

Crop	Year	Growing period	Fertilizer input	N_2O flux
		Days	kgN/ha/y	kgN/ha/y
	2005	107	28.5	44.84
Rice	2006	123	12.0	11.75
	2007	107	30.0	3.65
	2005	68	8.0	5.29
Soybean	2006	120	No fert.	29.38
	2007	106	8.0	4.54
Corn#	2007	139	60.4	14.23
Soybean#	2007	111	7.4	6.54

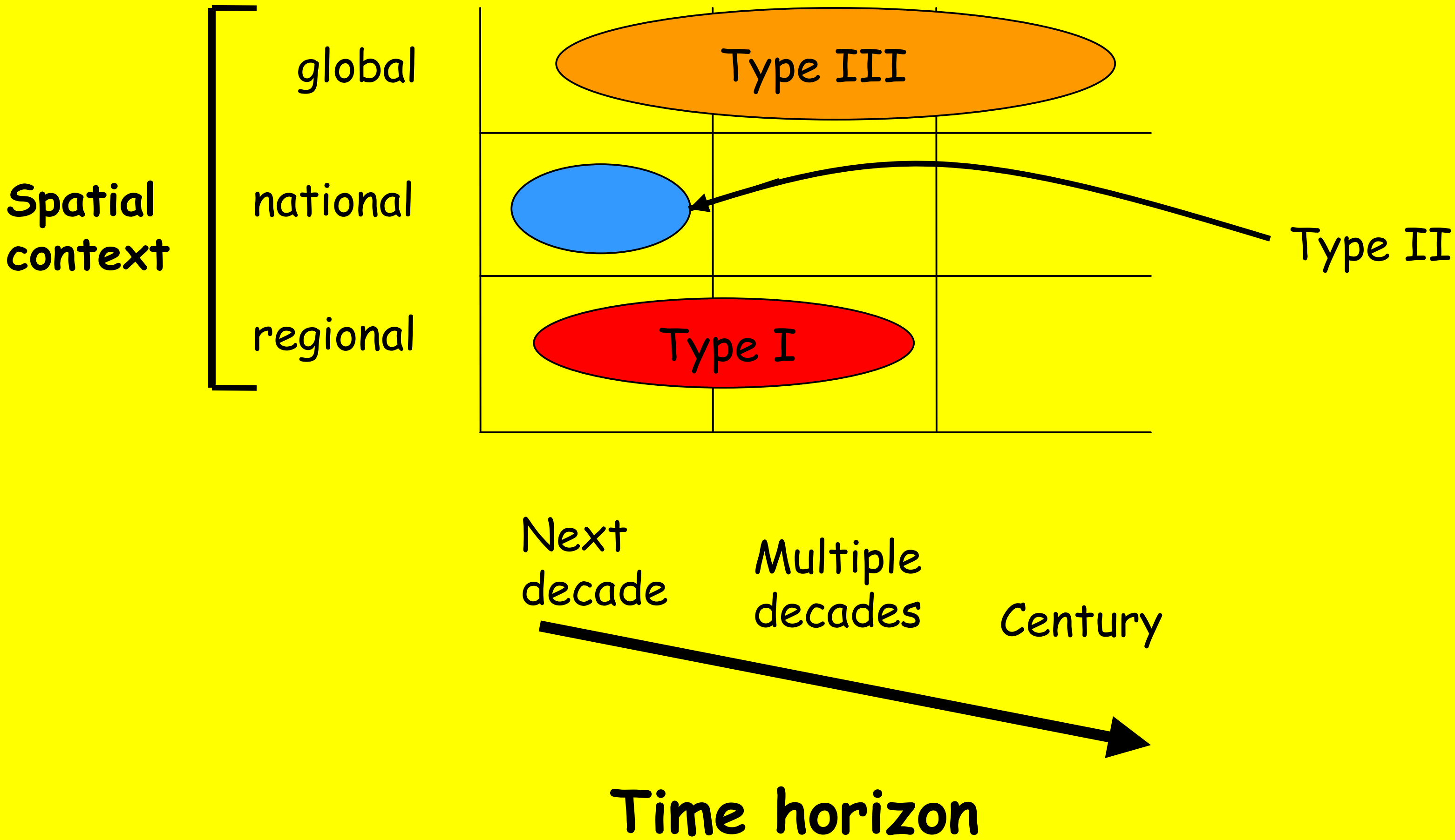
No till

Scenarios and the world of biofuels

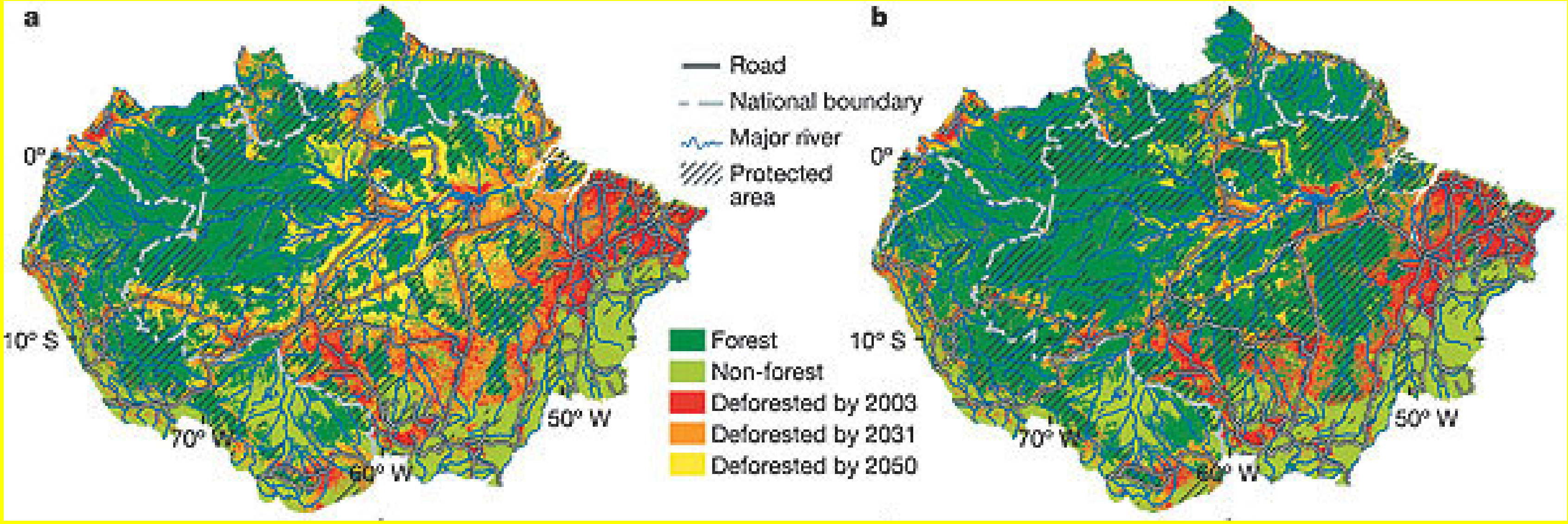
LBA I+ and II

"Very often, meaningful action requires memory
-- Scenarios provide us with memory of the future."

Scenarios for Agricultural Transitions in the Amazon



Type I



Evaluating alternative scenarios for deforestation pathways through 2050. Soares-Filho et al.

Type II

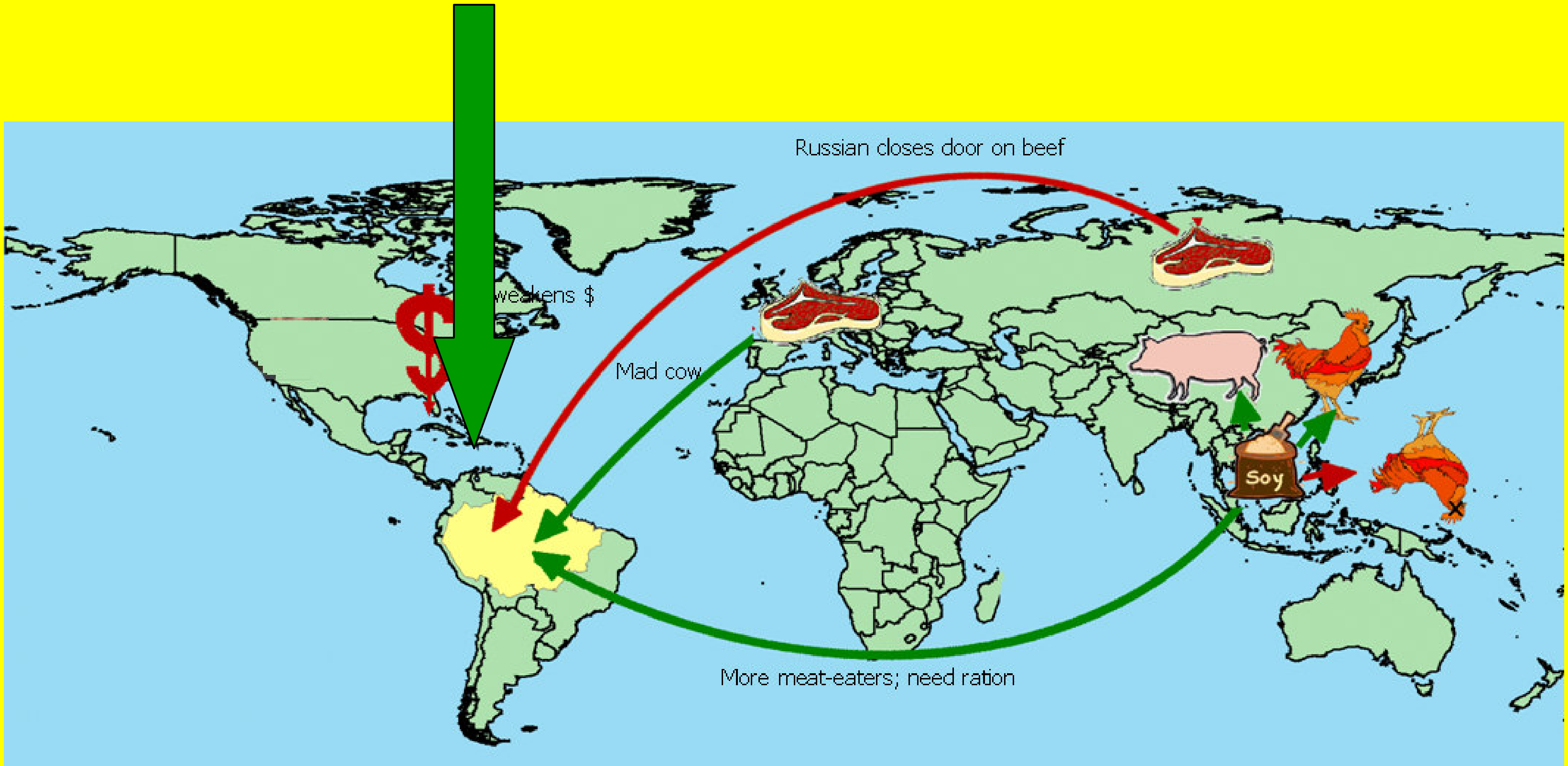
Crop expansions in Brazil by 2015

Crop	Change in area million ha
Sugar cane	6.0 (+97%)
Oil crops for biodiesel	6.4 (0 currently)
Forestry (eucaliptys, pinus etc)	1.8 (+35%)
Cotton	0.4(+29%)
Soybean	3.6 (+16%)
Total	18.2

How do we use the whole Brazilian landscape and what are the implications the Amazon? C. C. Cerri et al.

Amazon deforestation driven by economic "teleconnections"

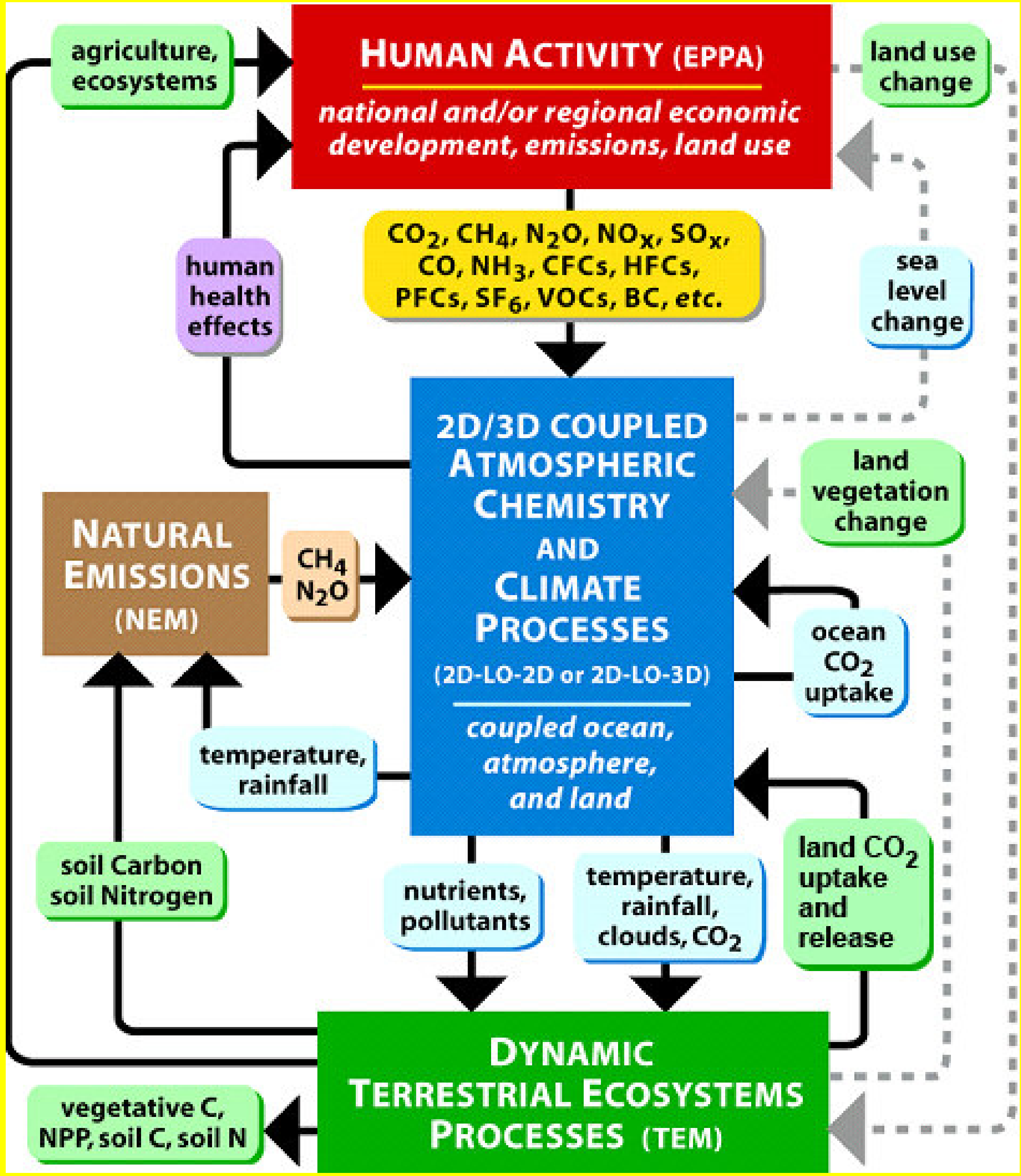
Biofuels



Source: Nepstad, Stickler, Almeida 2006. Cons. Biol: Nepstad, Stickler, in press, J Sust. Forestry

Type III

MIT Integrated Global Systems Model – used in integrated assessment studies of climate Change

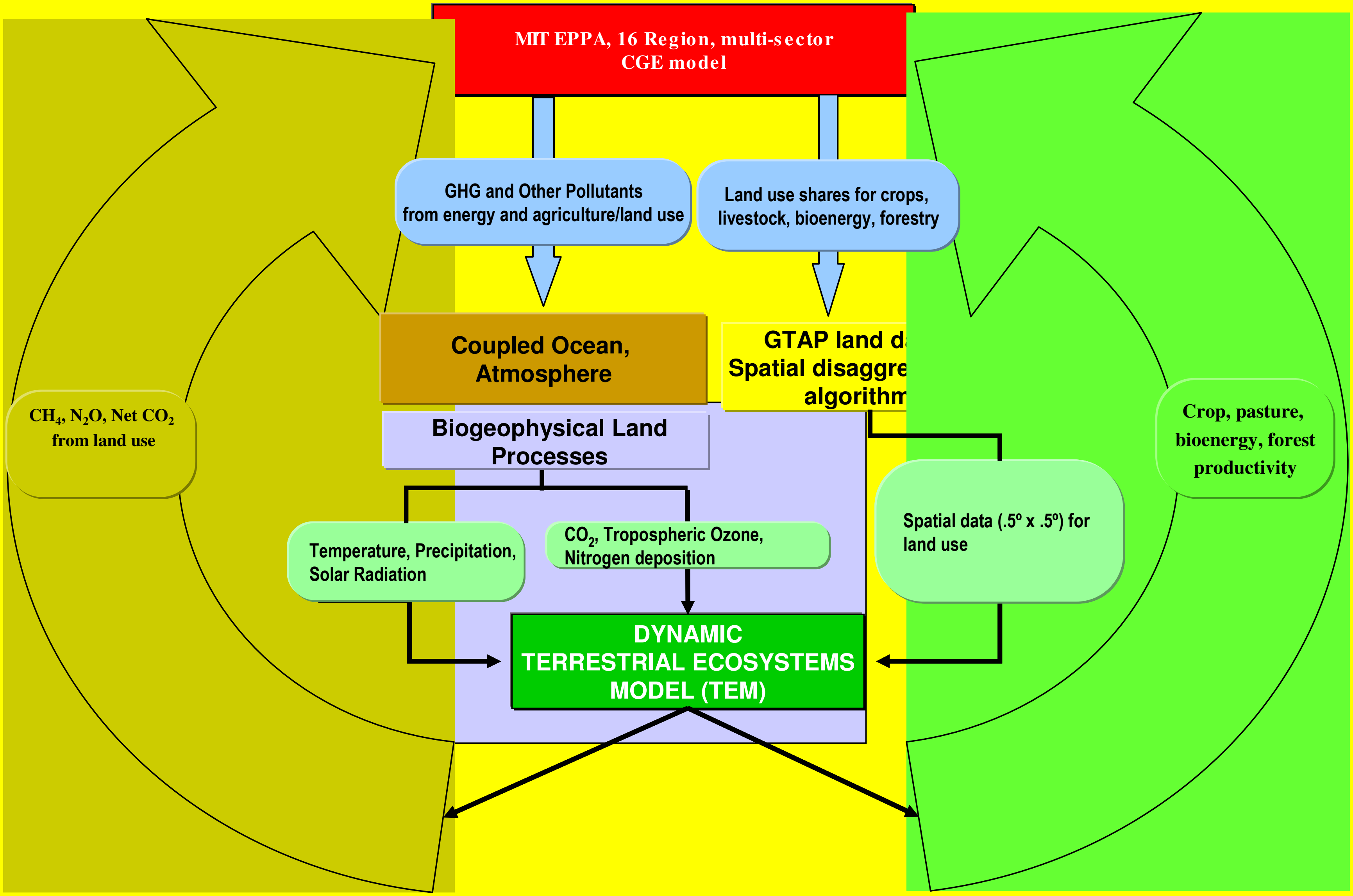


What with the global landscape look like in a world heavily dependent on cellulosic biofuels (for 200-250 Ej/yr in 2100) and what are likely to be some of the unintended consequences?

The EPPA Economic Model

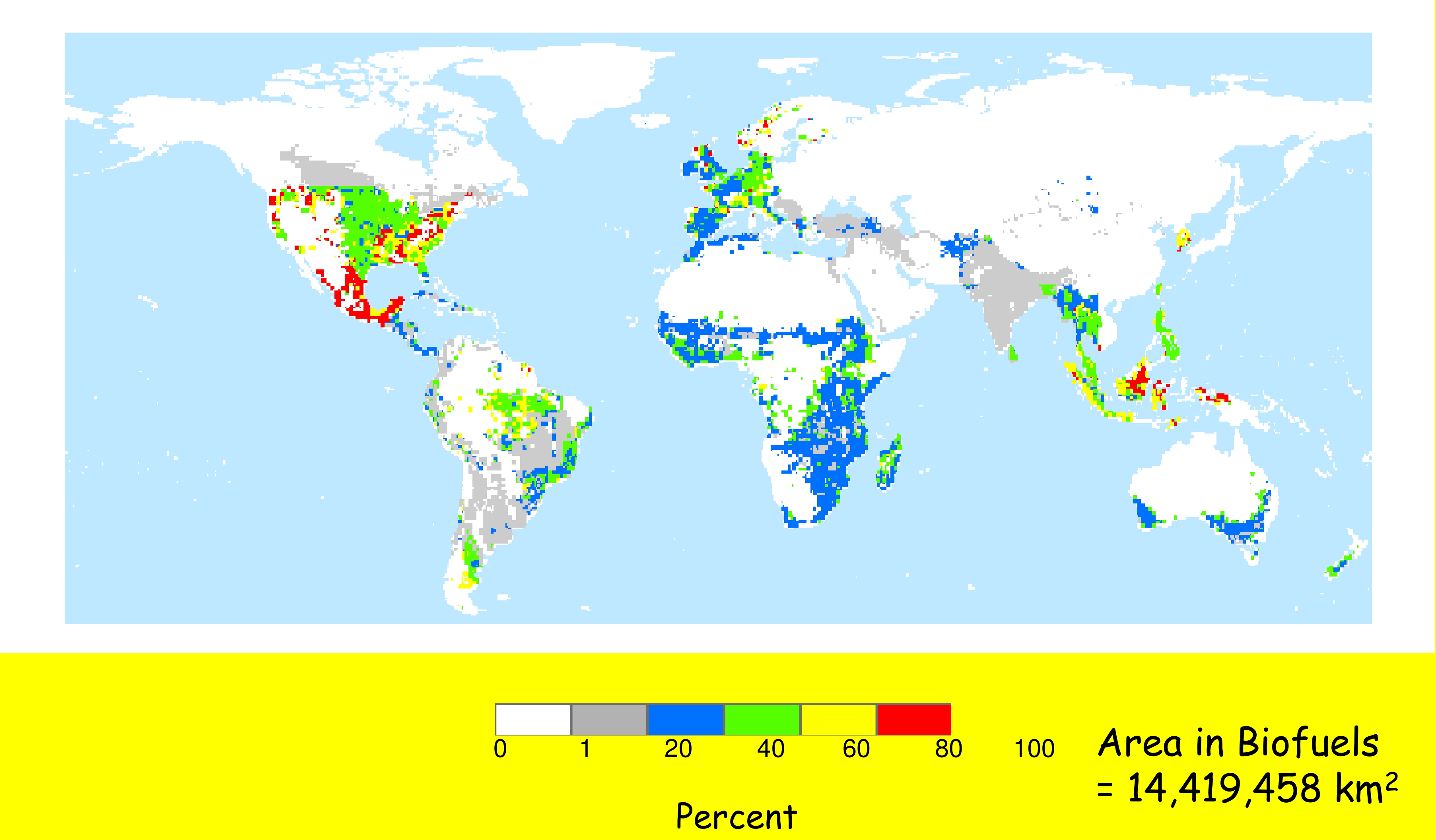
- Emissions Predictions and Policy Analysis (EPPA) model
  - A computable general equilibrium model of the world economy (globalchange@mit.edu) Report 145
  - Competition for labor, capital, land and other resources is represented in the model
  - Target in this study – stabilize of [CO_2] at 550 ppm using an aggressive biofuels policy

EPPA-Global Land System Interactions



Percent of each 0.5° x 0.5° grid cell in cellulosic biofuels in 2050

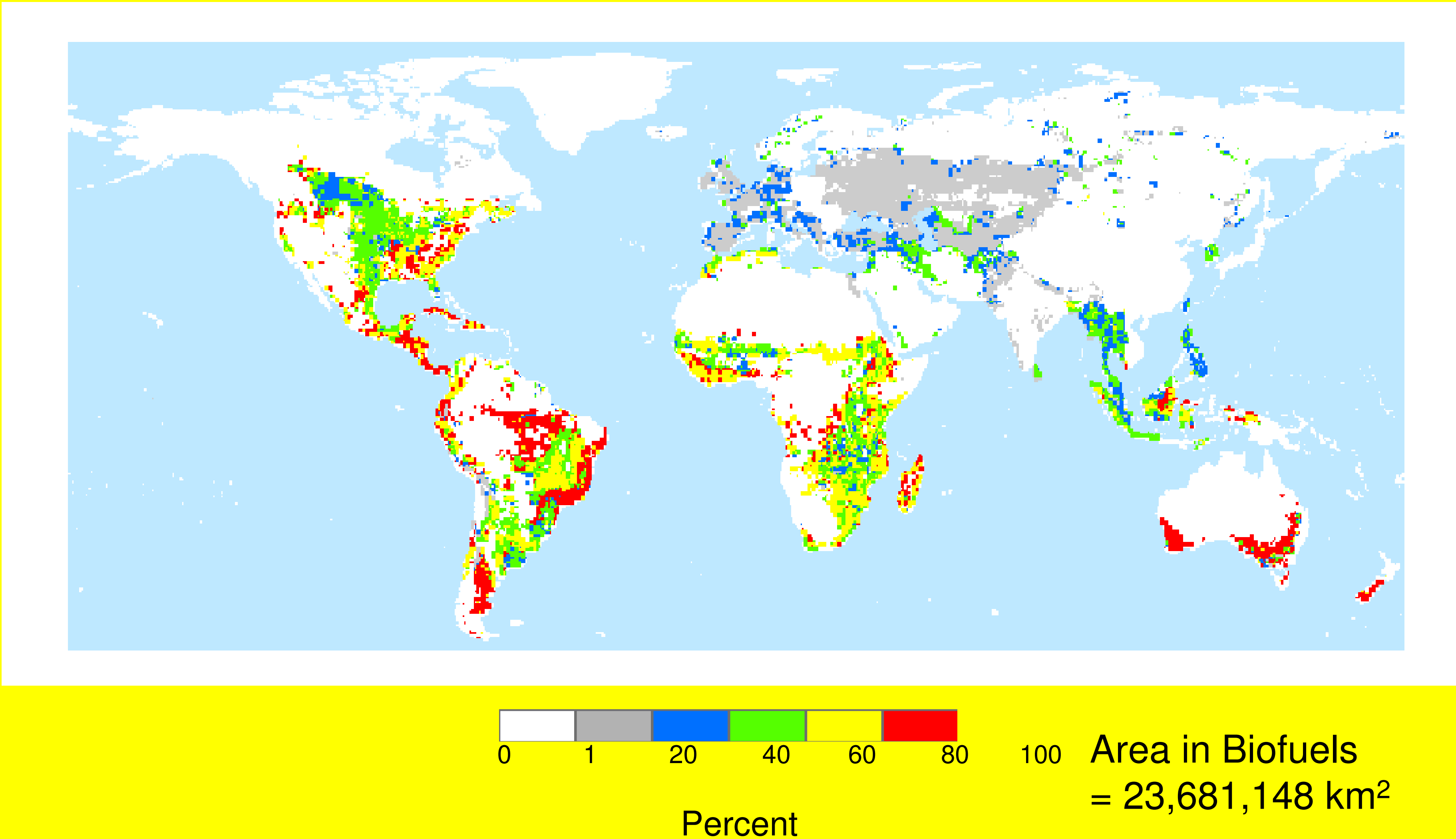
(550 PPM CO_2, Climate change)



Area in Biofuels = 14,419,458 km^2

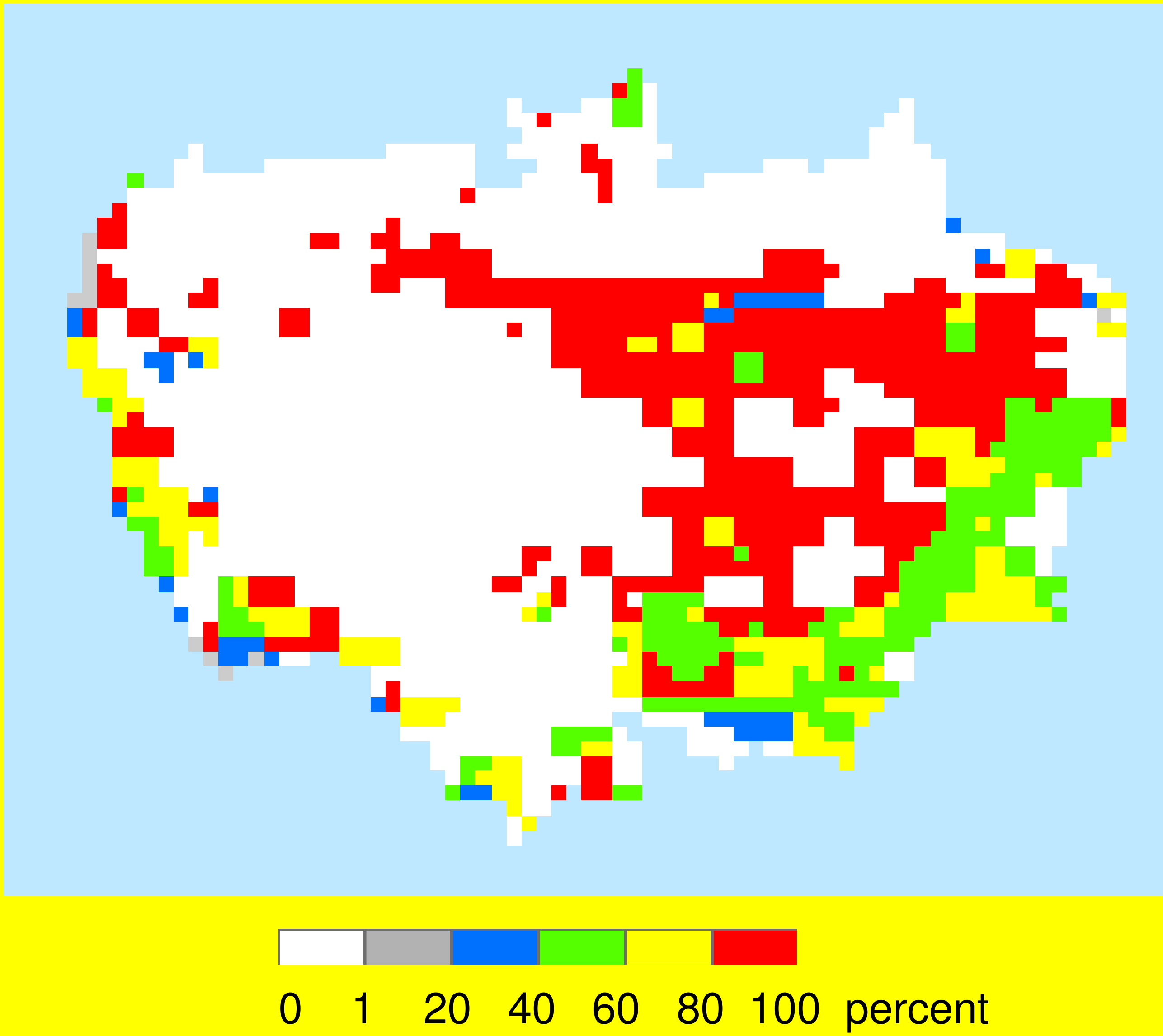
Percent of each 0.5° x 0.5° grid cell in cellulosic biofuels in 2100

(550 PPM CO2, Climate change)

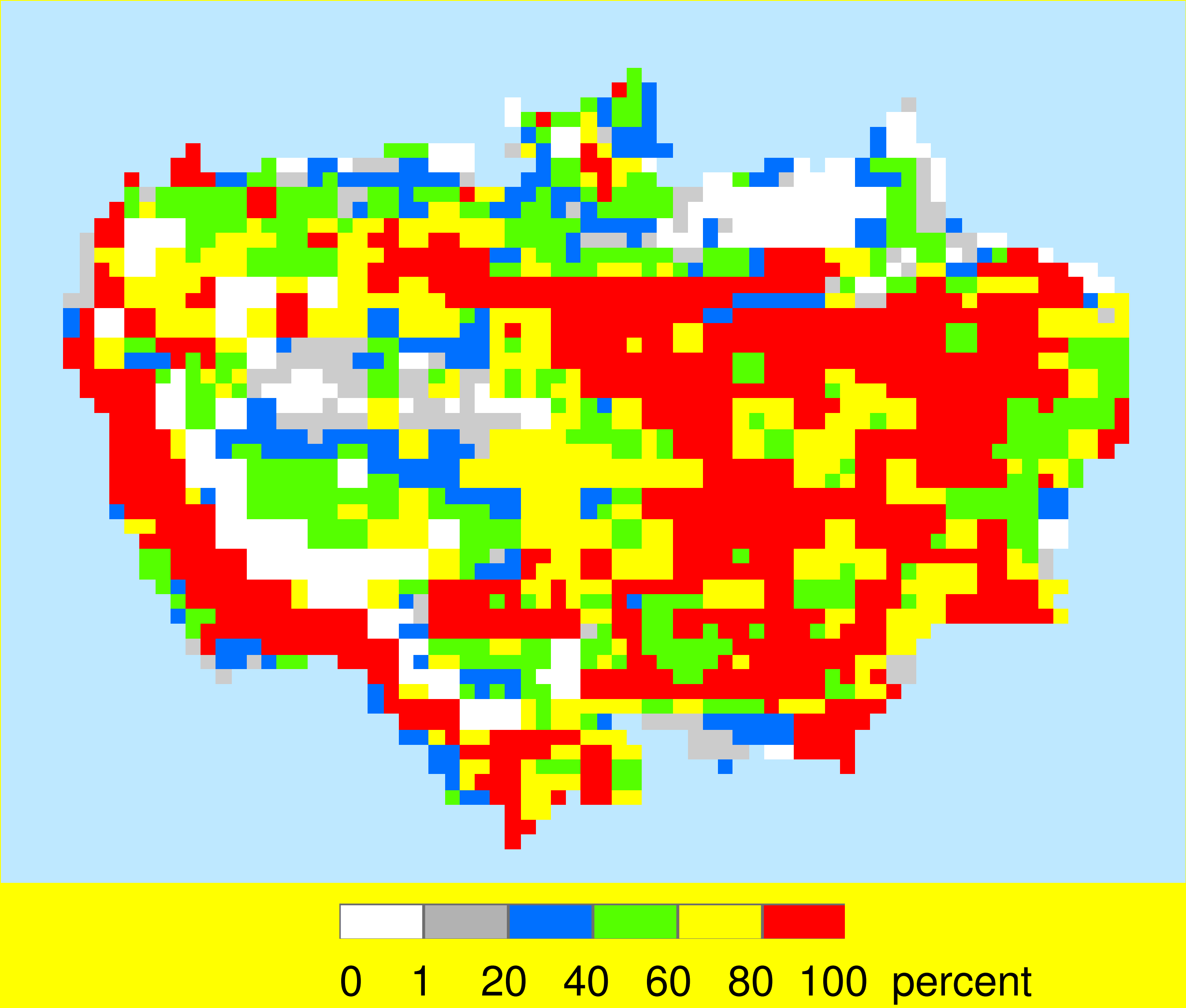


Area in Biofuels = 23,681,148 km²

Percent of each 0.5° x 0.5° grid cell in cellulosic biofuels in 2100 (550 PPM CO2, Climate change)



Percent of each 0.5° x 0.5° grid cell in all agricultural activities in 2100
(550 PPM CO2, Climate change)



Projected Land Cover Areas (km^2) in the Amazon Basin and Environs by EPPA-TEM (550 PPM CO_2, Climate change)

Year	Biofuels	Food Crops	Pasture	Forest and Cerrado	Grass-land	Other
2000	0	353,711	801,932	5,357,605	460,188	227,141
2030	7,986	774,679	1,034,905	4,730,550	425,316	227,141
2050	1,212,581	1,214,096	1,095,176	3,070,973	380,610	227,141
2100	2,320,262	1,534,696	605,929	2,166,550	345,999	227,141

Cumulative Changes in Carbon in the Amazon Basin From 2000 Due to Expanding Agriculture and Biofuels "Plantations" Projected by EPPA-TEM (550 PPM CO2, Climate change)

Year	Change in Carbon (Pg C)
2010	-6.1
2020	-11.8
2030	-21.8
2040	-44.9
2050	-66.7
2060	-78.0
2070	-83.5
2080	-88.8
2090	-92.2
2100	-94.2

-32 +/- 8 Pg C

Soares-Filho et al. 2006; assumes current trends in land use, no biofuels

Summary

- During LBA I, we have learned a great deal about changes in biogeochemical patterns and processes with agricultural transitions, especially transitions of natural vegetation to pastures
- As we move into LBA II, we are gaining new knowledge about transitions to mechanized agriculture that will help design the next generation of field and modeling experiments
- Scenarios coupled with simulation models hold promise for providing policy-relevant information at large spatial scales over decades to a century