

# Carbon Budget 2007

GCP-Global Carbon Budget team: Pep Canadell, Philippe Ciais, Thomas Conway, Christopher B. Field,  
Corinne Le Quéré, Richard A. Houghton, Gregg Marland, Michael R. Raupach



Last update:  
1 July 2009

# Outline

1. Atmospheric CO<sub>2</sub> Concentration
2. CO<sub>2</sub> Emissions from Fossil Fuel and Cement
3. Drivers of Fossil Fuel Emissions
4. CO<sub>2</sub> Emissions from Land Use Change
5. Natural CO<sub>2</sub> Sinks
6. Summary of the Global Carbon Budget

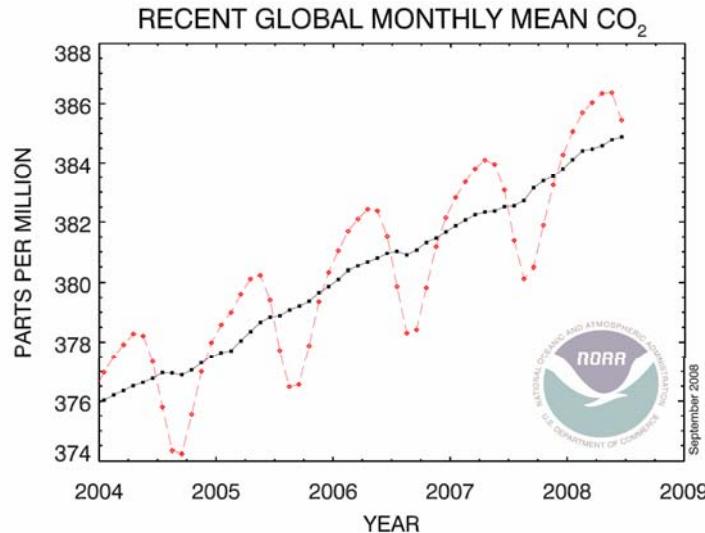


1.

# Atmospheric CO<sub>2</sub> Concentration

# Atmospheric CO<sub>2</sub> Concentration

Year 2007  
Atmospheric CO<sub>2</sub>  
concentration:  
**383 ppm**  
37% above pre-industrial



1970 – 1979: 1.3 ppm y<sup>-1</sup>

1980 – 1989: 1.6 ppm y<sup>-1</sup>

1990 – 1999: 1.5 ppm y<sup>-1</sup>

2000 - 2007: 2.0 ppm y<sup>-1</sup>

2007: 2.2 ppm y<sup>-1</sup>



Data Source: Pieter Tans and Thomas Conway, NOAA/ESRL



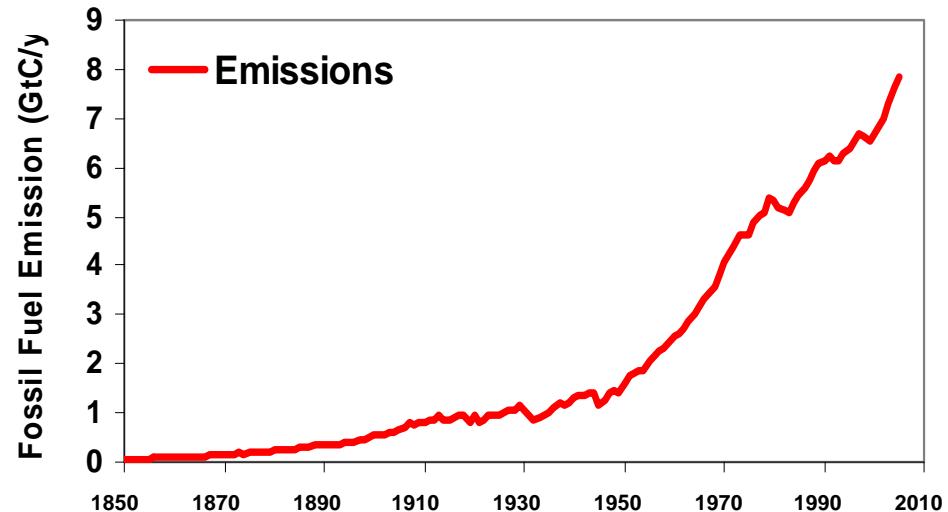
# 2. Emissions from Fossil Fuel and Cement



# Emissions from Fossil Fuel + Cement



2007 Fossil Fuel: 8.5 Pg C



1990 - 1999: 0.9%  $y^{-1}$

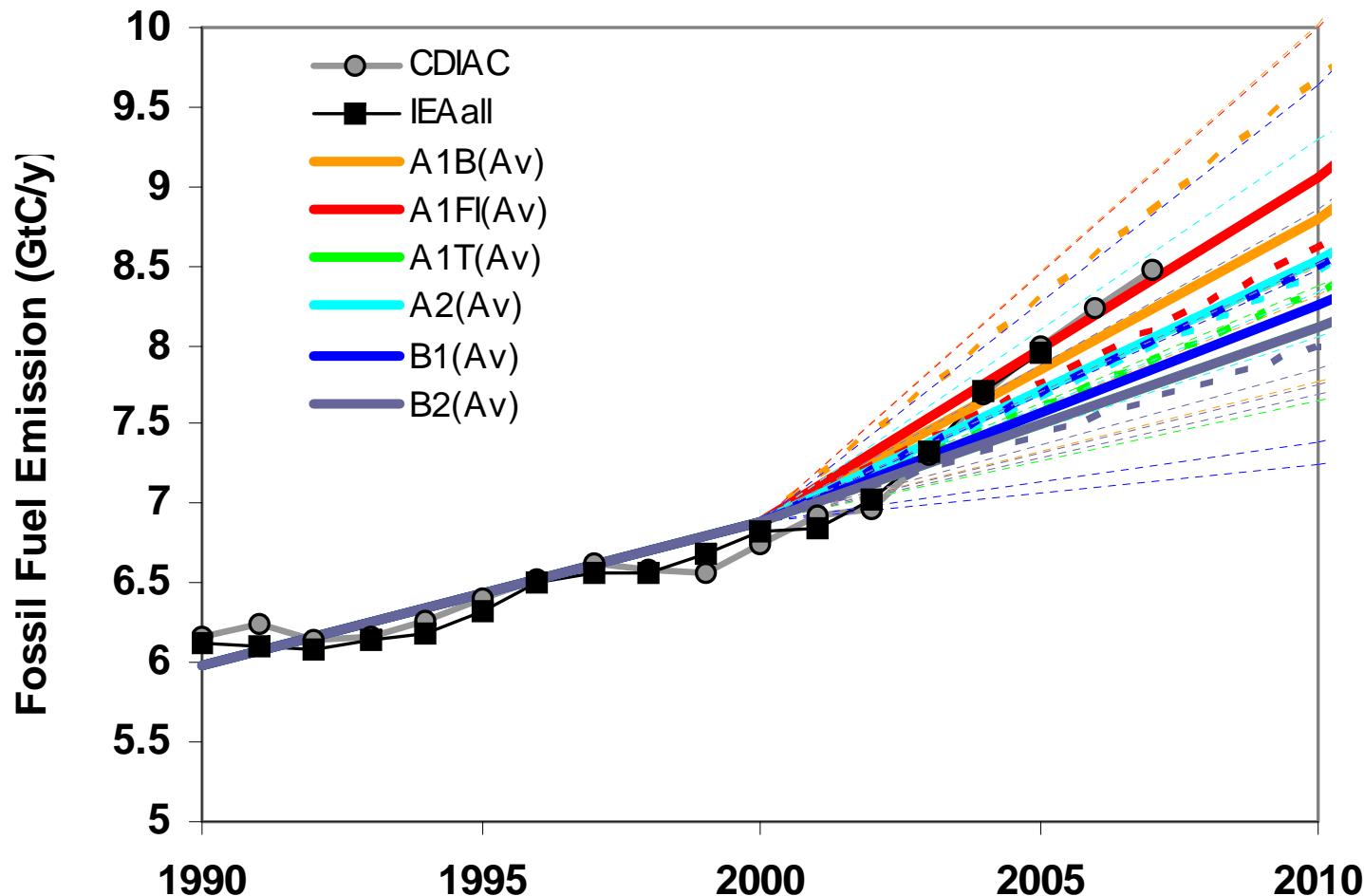
2000 - 2007: 3.5%  $y^{-1}$



Data Source: G. Marland, T.A. Boden, R.J. Andres, and J. Gregg at CDIAC



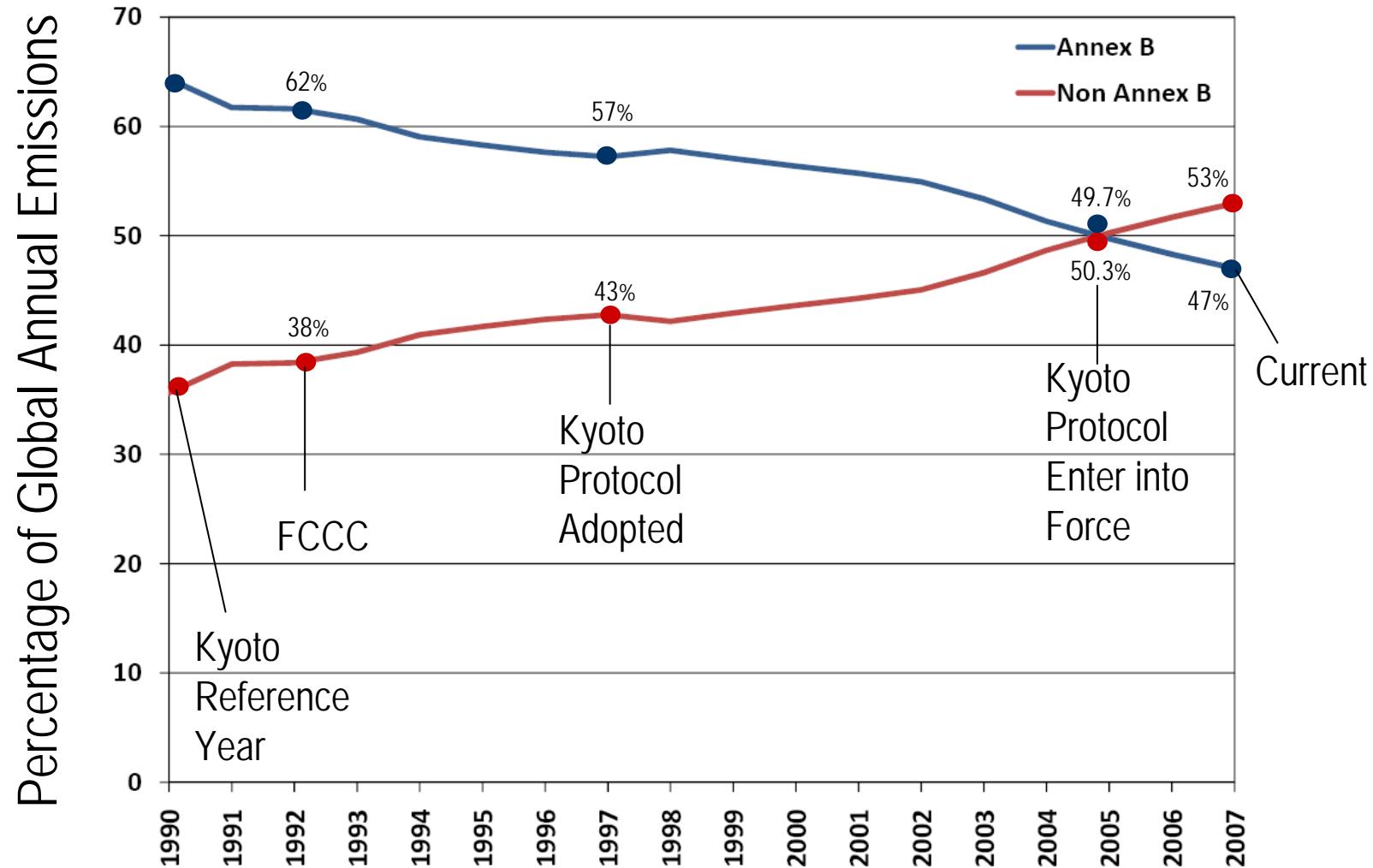
# Fossil Fuel Emissions: Actual vs. IPCC Scenarios



Raupach et al 2007, PNAS (updated)



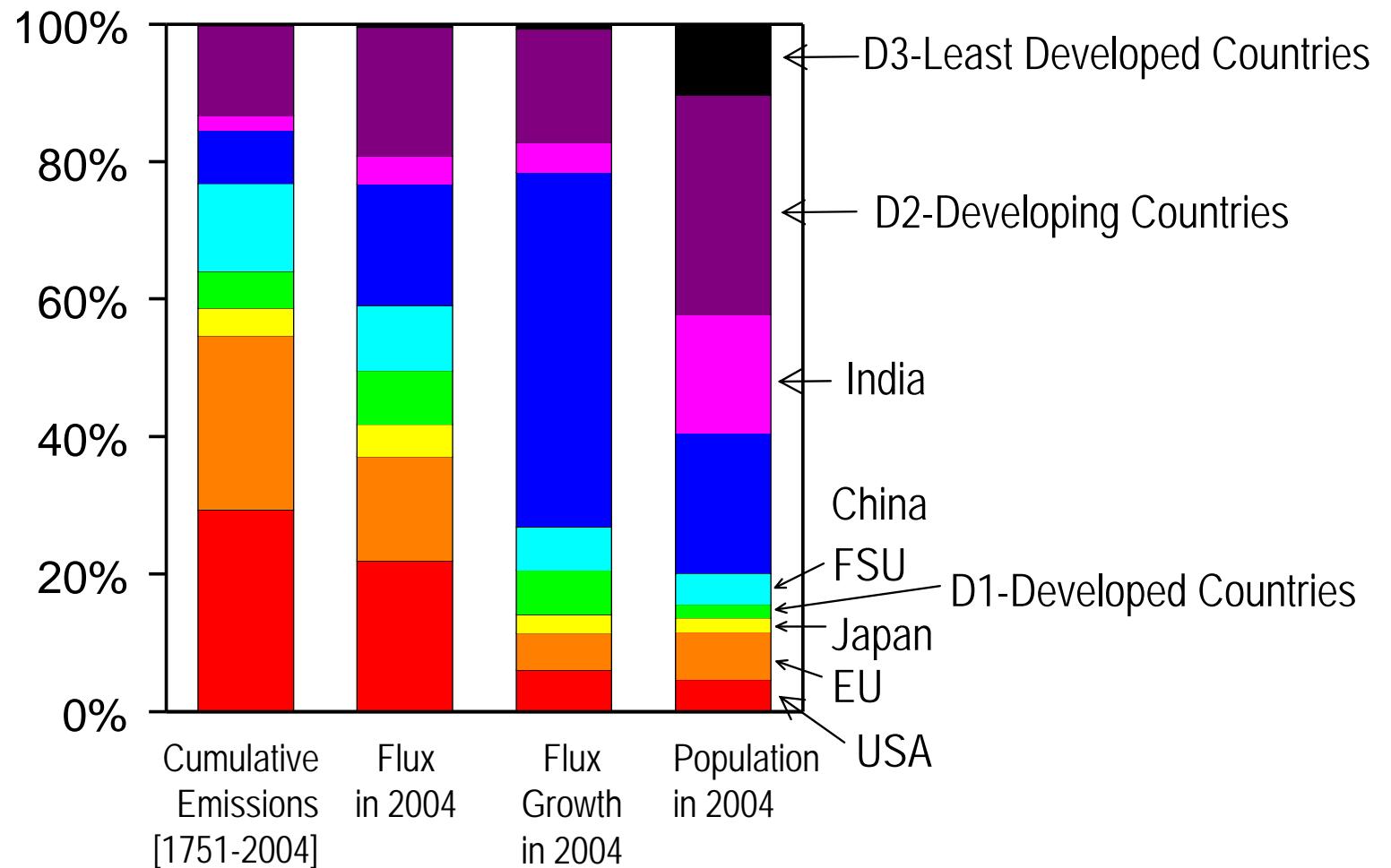
# Regional Shift in Emissions Share



J. Gregg and G. Marland, 2008, personal communication



# Regional Share of Fossil Fuel Emissions



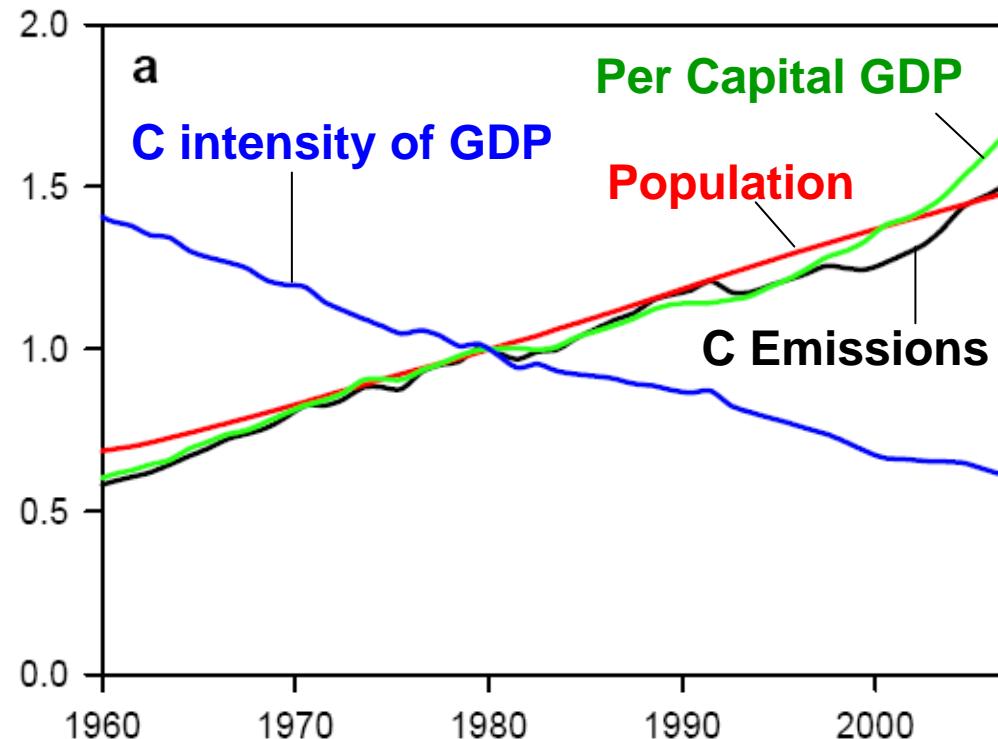
3.

## Drivers of fossil fuel emissions

# Human and Biophysical Drivers of Accelerating AtmCO<sub>2</sub>

## Kaya Identity

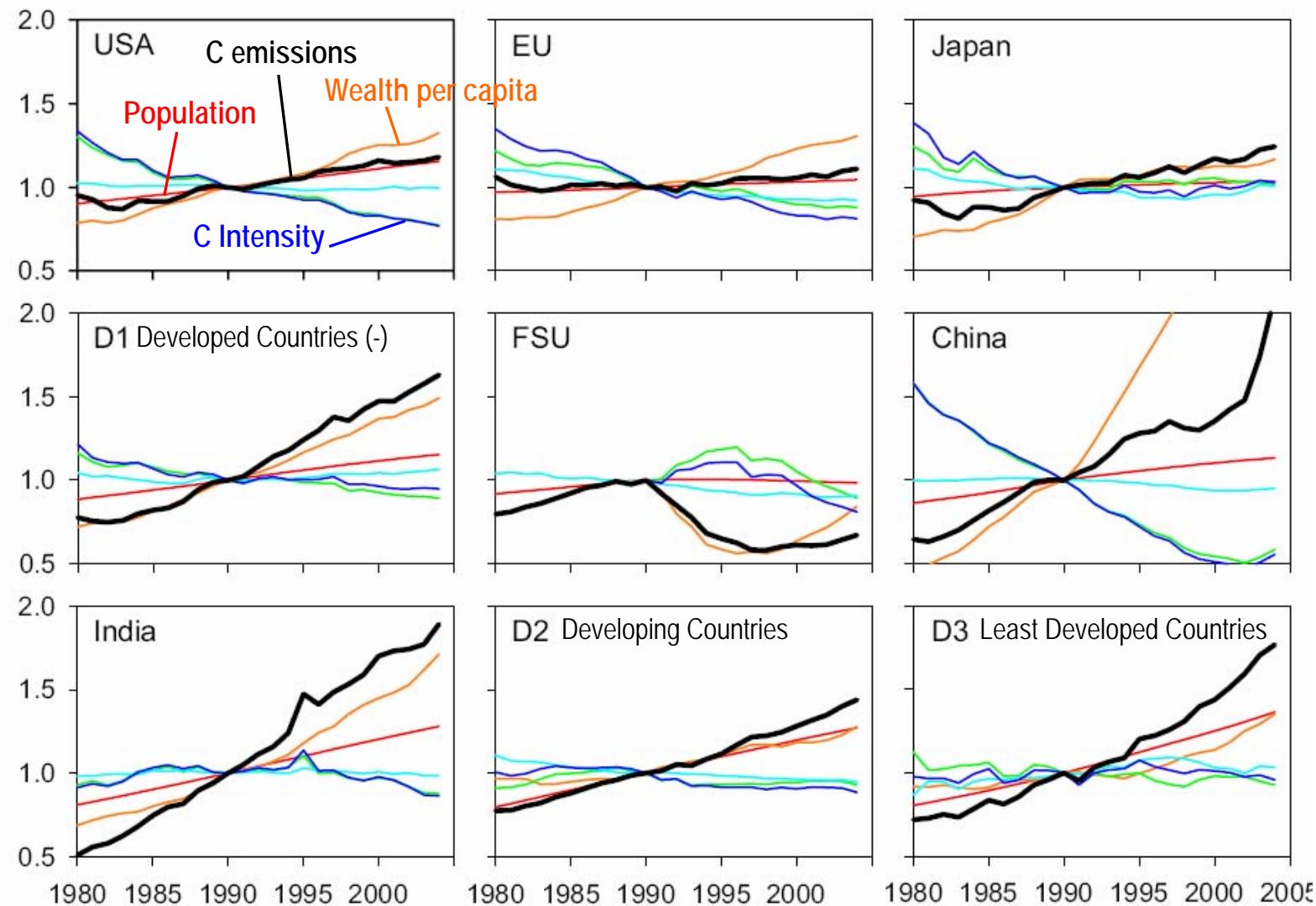
C Emissions = Population x Per Capita GDP x C intensity of GDP



Raupach, Canadell, Le Quere, 2008, Biogeoscience



# Regional Emission Pathways



4.

# Emissions from Land Use Change

# Carbon Emissions from Land Use Change

Borneo, Courtesy: Viktor Boehm



Tropical deforestation

13 Million hectares each year

2000-2007

Tropical Americas  $0.6 \text{ Pg C y}^{-1}$

Tropical Asia  $0.6 \text{ Pg C y}^{-1}$

Tropical Africa  $0.3 \text{ Pg C y}^{-1}$

$1.5 \text{ Pg C y}^{-1}$

[2007-Total Anthropogenic Emissions:  $8.5 + 1.5 = 10 \text{ Pg}$ ]

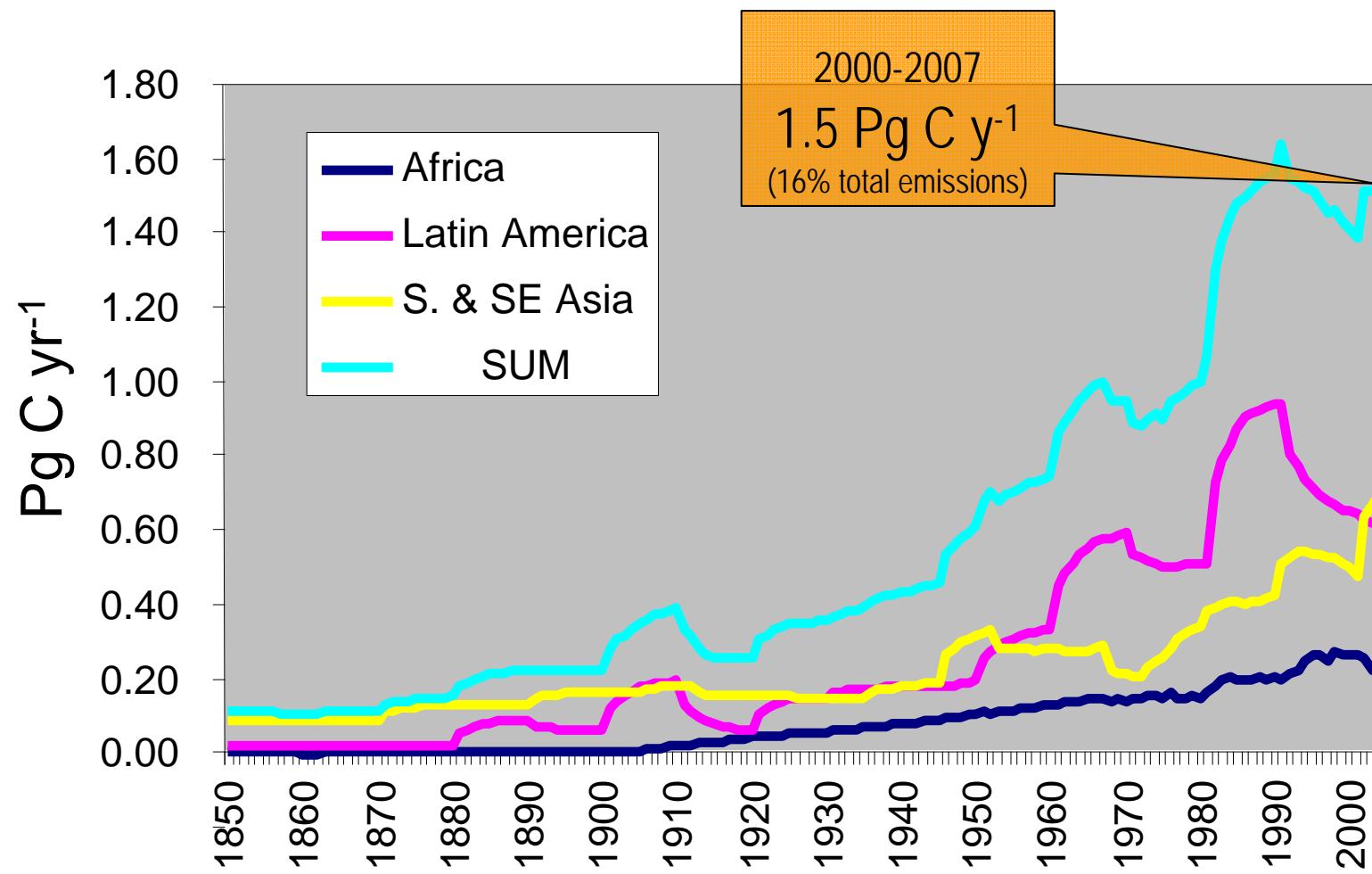


Canadell et al. 2007, PNAS; FAO-Global Resources Assessment 2005



# Historical Emissions from Land Use Change

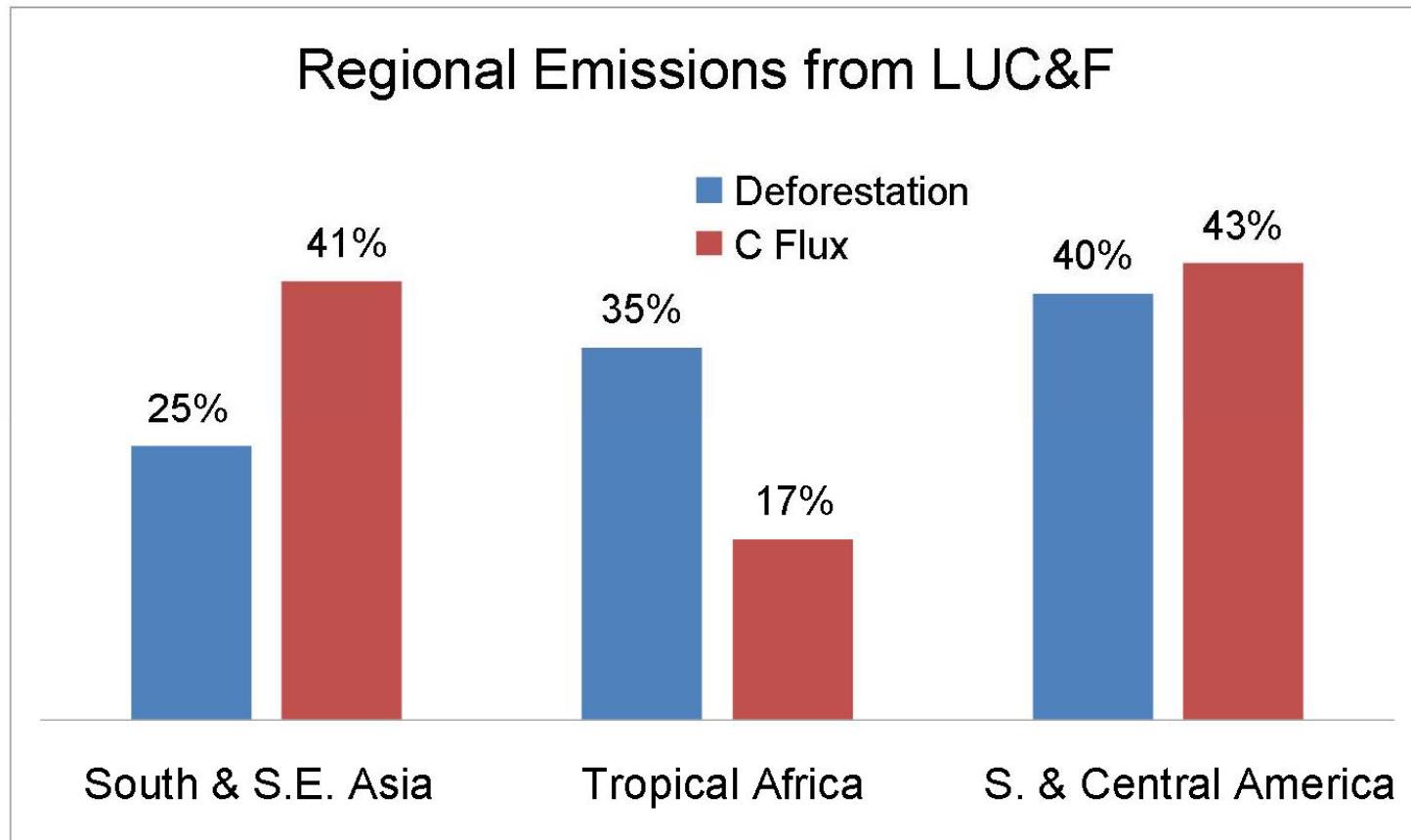
## Carbon Emissions from Tropical Deforestation



R.A. Houghton, unpublished



# Regional Share of Emissions from Land Use Change



Canadell, Raupach, Houghton, 2008, Biogeosciences, submitted



# 5. Natural CO<sub>2</sub> sinks

# Fate of Anthropogenic CO<sub>2</sub> Emissions (2000-2007)

1.5 Pg C y<sup>-1</sup>



7.5 Pg C y<sup>-1</sup> +



4.2 Pg y<sup>-1</sup>  
Atmosphere

46%



2.6 Pg y<sup>-1</sup>  
Land  
29%



2.3 Pg y<sup>-1</sup>  
Oceans  
26%



# Climate Change at 55% Discount

Natural CO<sub>2</sub> sinks absorb 55% of all anthropogenic carbon emissions slowing down climate change significantly.



They are in effect a huge subsidy to the global economy worth **half a trillion US\$** annually if an equivalent sink had to be created using other climate mitigation options (based on the cost of carbon in the EU-ETS).



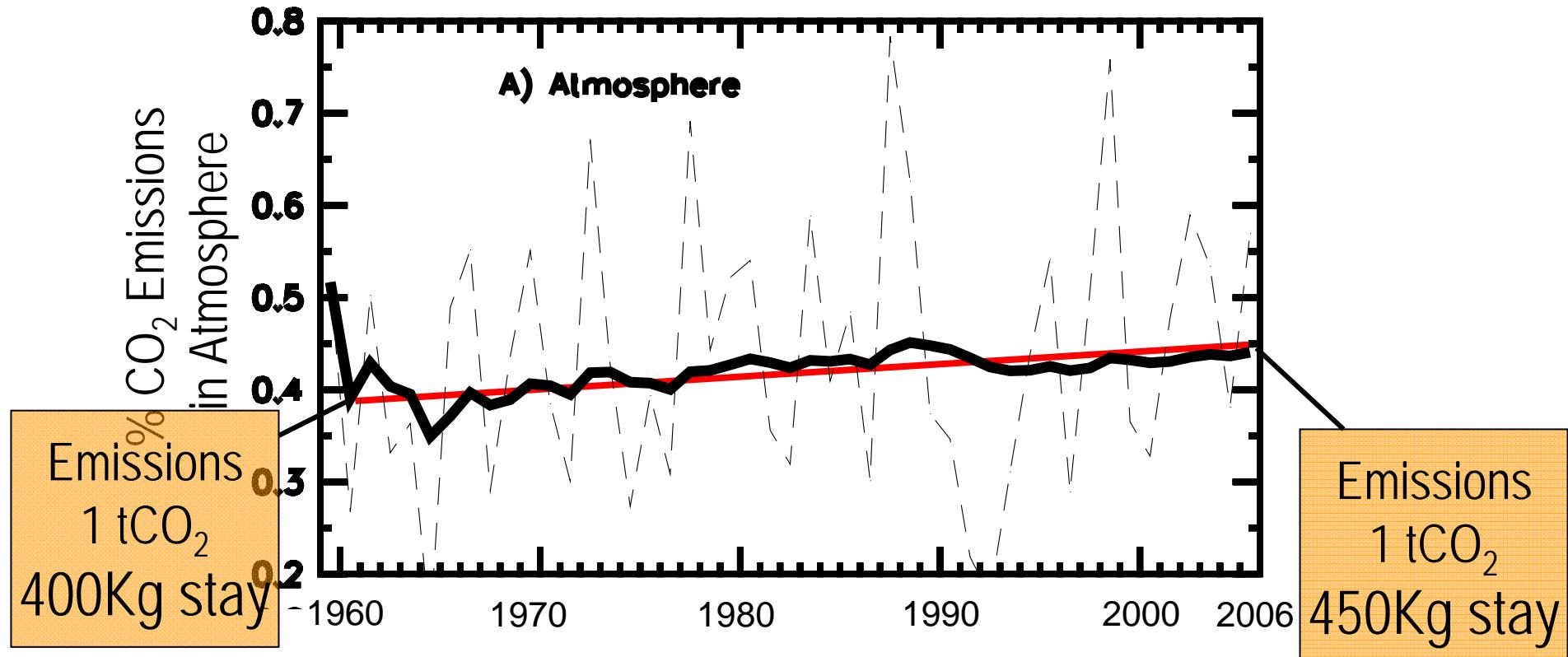
# Factors that Influence the Airborne Fraction

1. The rate of CO<sub>2</sub> emissions.
2. The rate of CO<sub>2</sub> uptake and ultimately the total amount of C that can be stored by land and oceans:
  - Land: CO<sub>2</sub> fertilization effect, soil respiration, N deposition fertilization, forest regrowth, woody encroachment, ...
  - Oceans: CO<sub>2</sub> solubility (temperature, salinity),, ocean currents, stratification, winds, biological activity, acidification, ...



# Decline in the Efficiency of CO<sub>2</sub> Natural Sinks

Fraction of all anthropogenic emissions that stay in the atmosphere

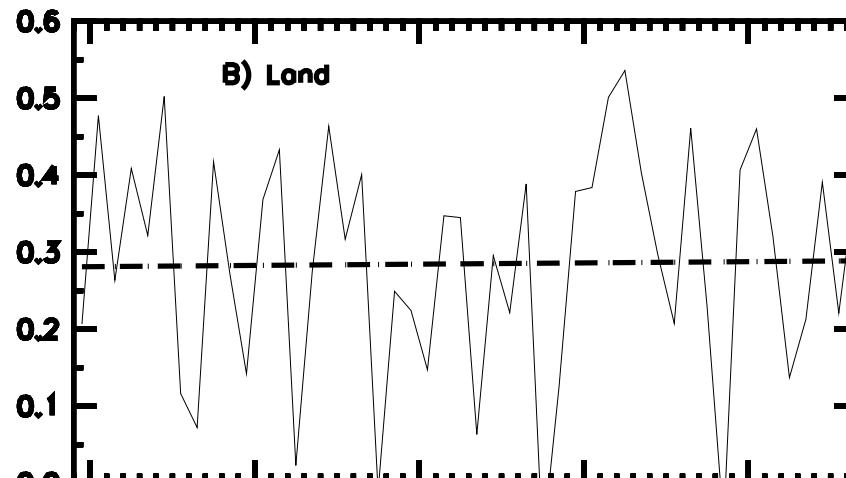


Canadell et al. 2007, PNAS

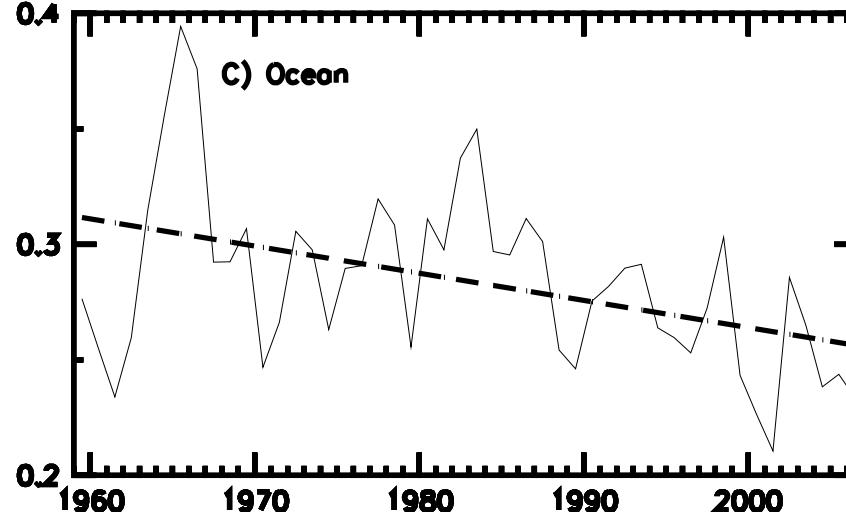


# Efficiency of Natural Sinks

## Land Fraction



## Ocean Fraction



# Causes of the Declined in the Efficiency of the Ocean Sink



Credit: N. Metz, August 2000, oceanographic cruise OISO-5

- Part of the decline is attributed to up to a 30% decrease in the efficiency of the Southern Ocean sink over the last 20 years.
- This sink removes annually 0.7 Pg of anthropogenic carbon.
- The decline is attributed to the strengthening of the winds around Antarctica which enhances ventilation of natural carbon-rich deep waters.
- The strengthening of the winds is attributed to global warming and the ozone hole.



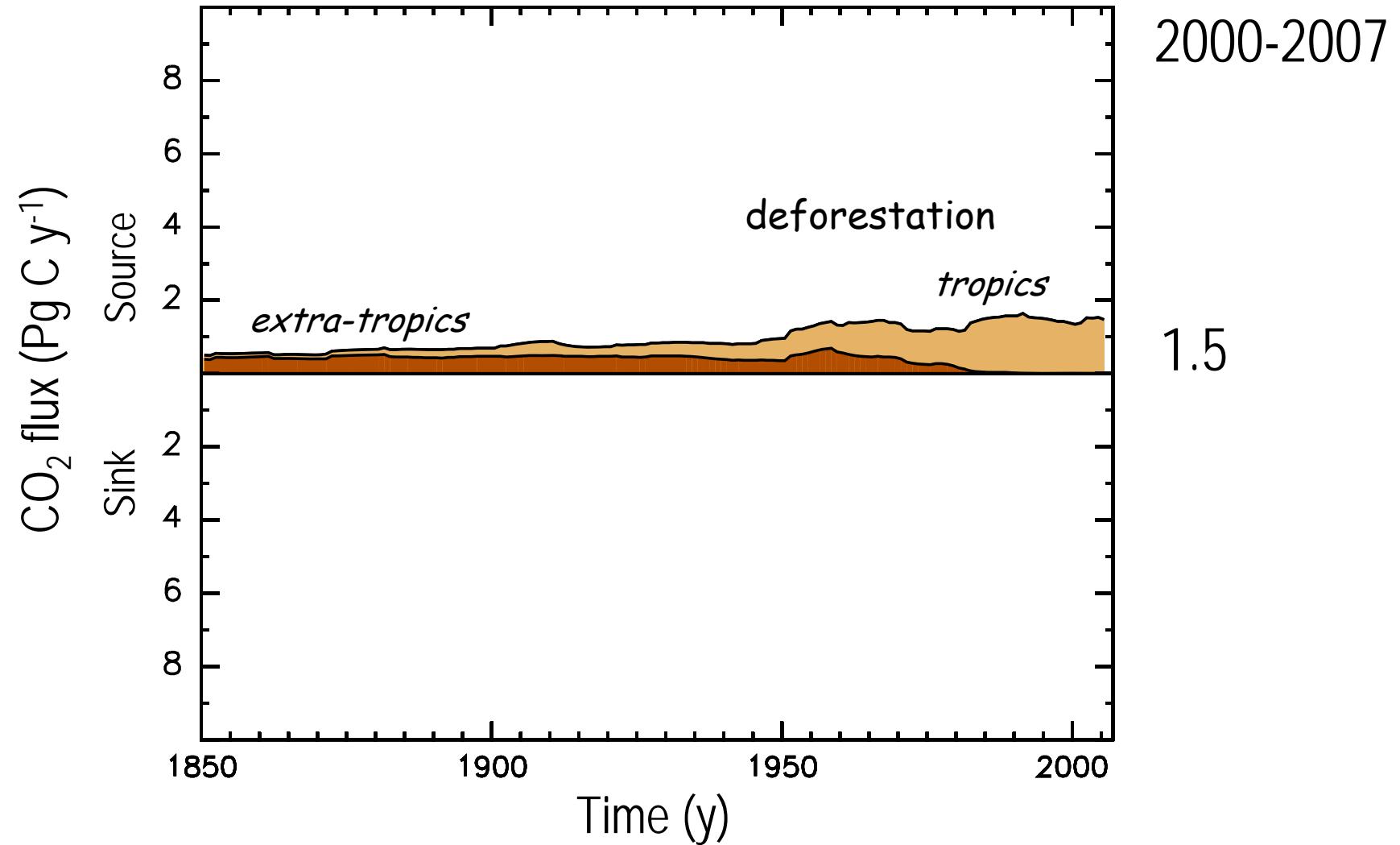
Le Quéré et al. 2007, Science



6.

# Summary of the global carbon budget

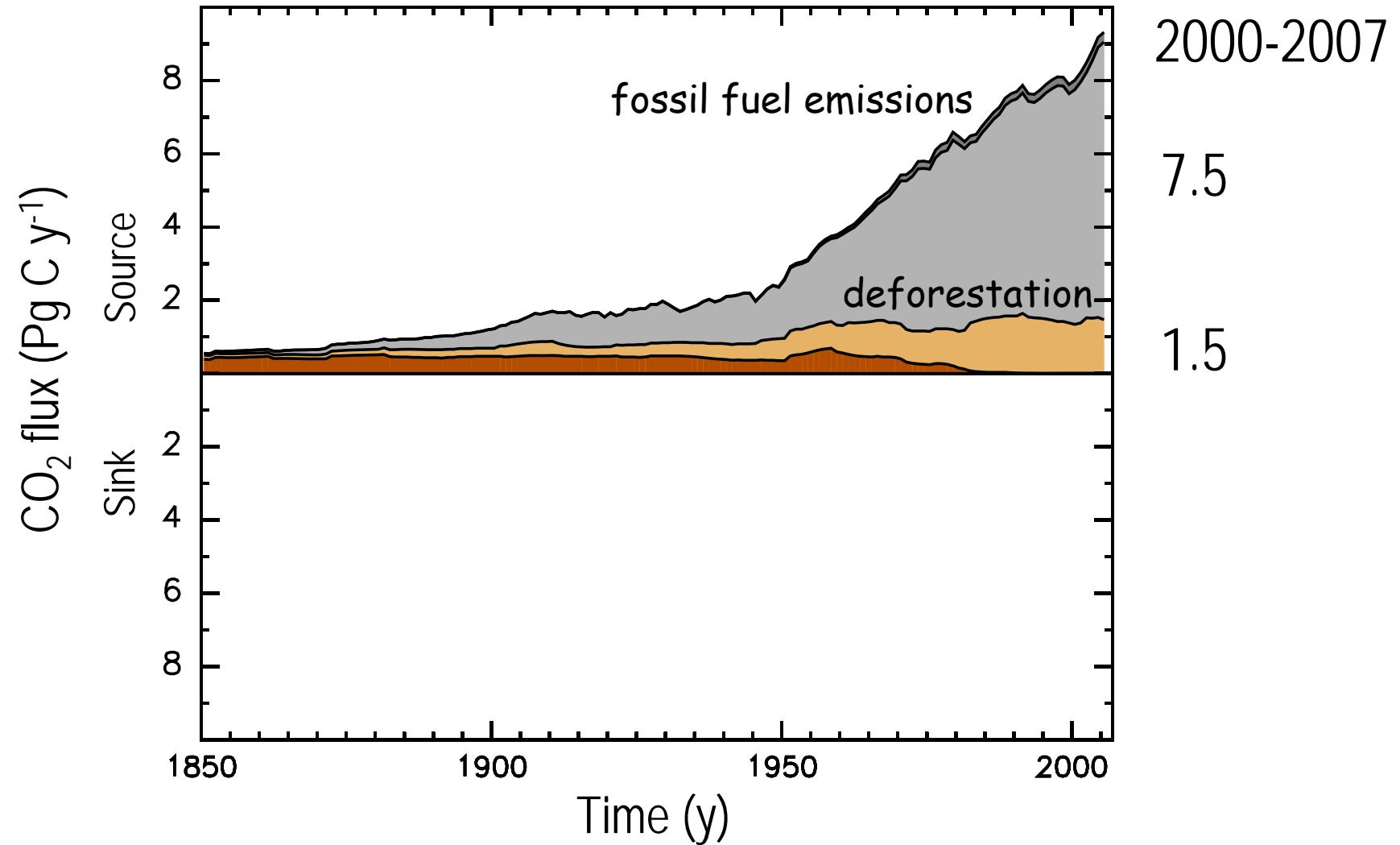
# Human Perturbation of the Global Carbon Budget



Global Carbon Project (2008)



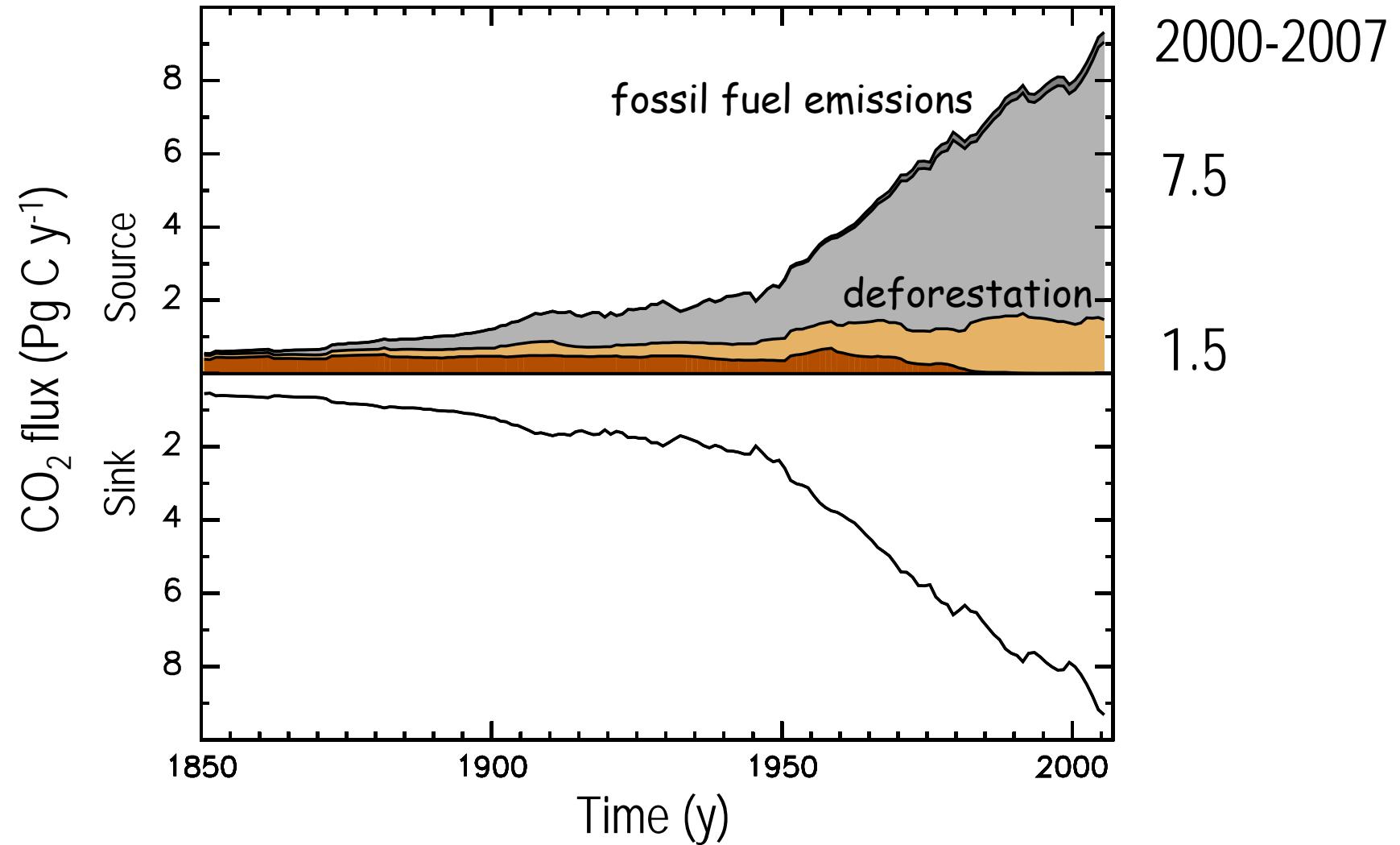
# Human Perturbation of the Global Carbon Budget



Global Carbon Project (2008)



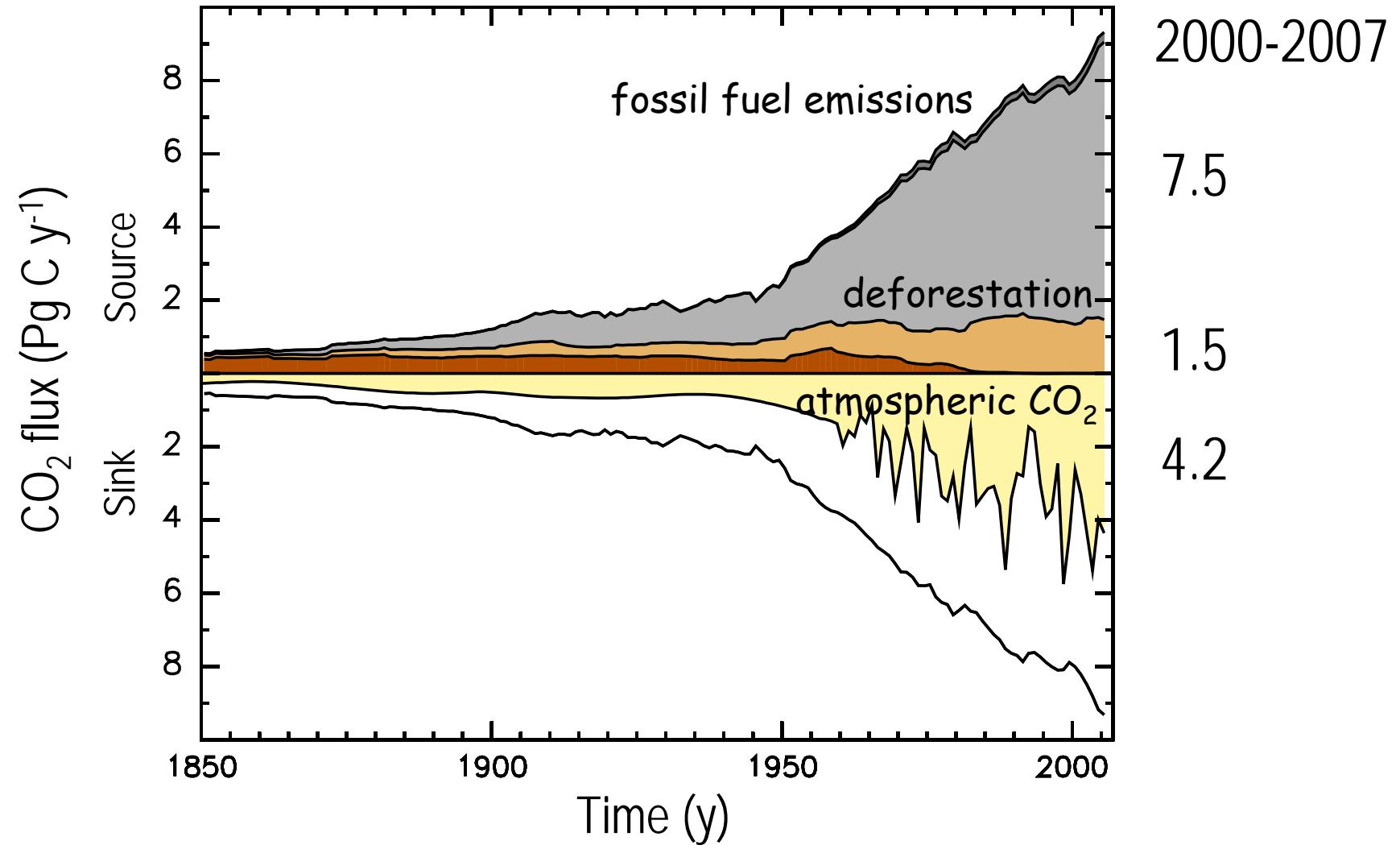
# Human Perturbation of the Global Carbon Budget



Global Carbon Project (2008)



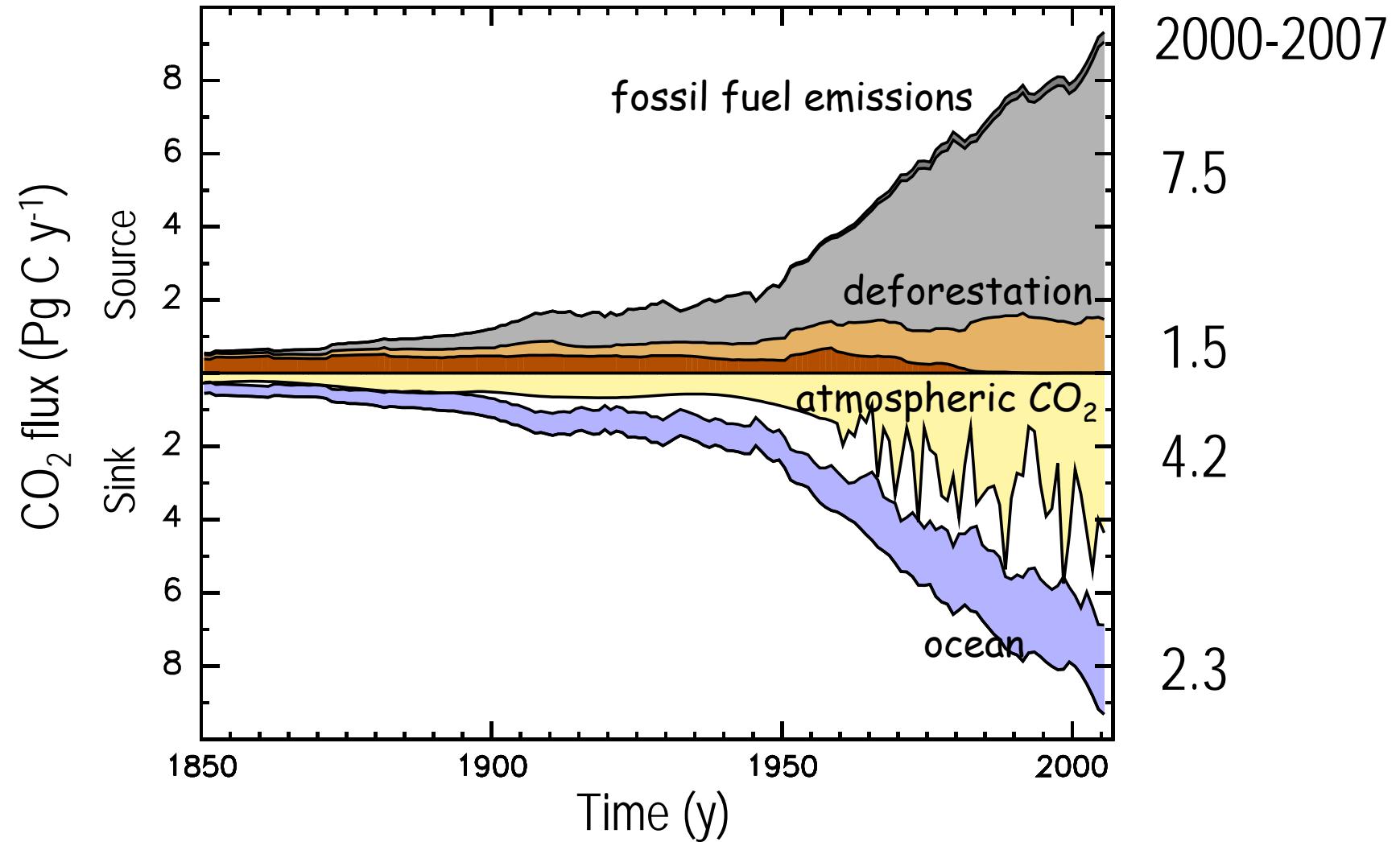
# Human Perturbation of the Global Carbon Budget



Global Carbon Project (2008)



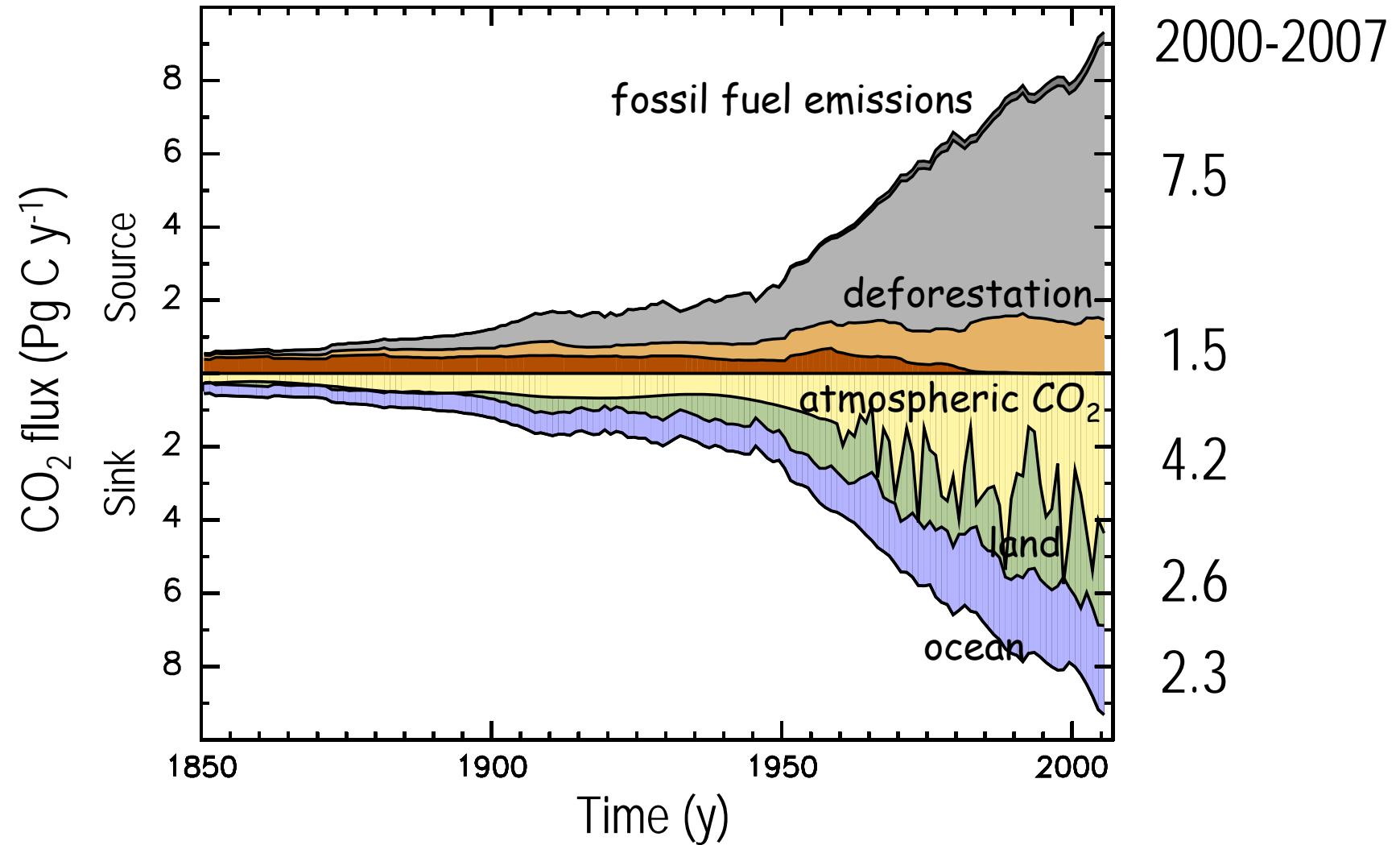
# Human Perturbation of the Global Carbon Budget



Global Carbon Project (2008)



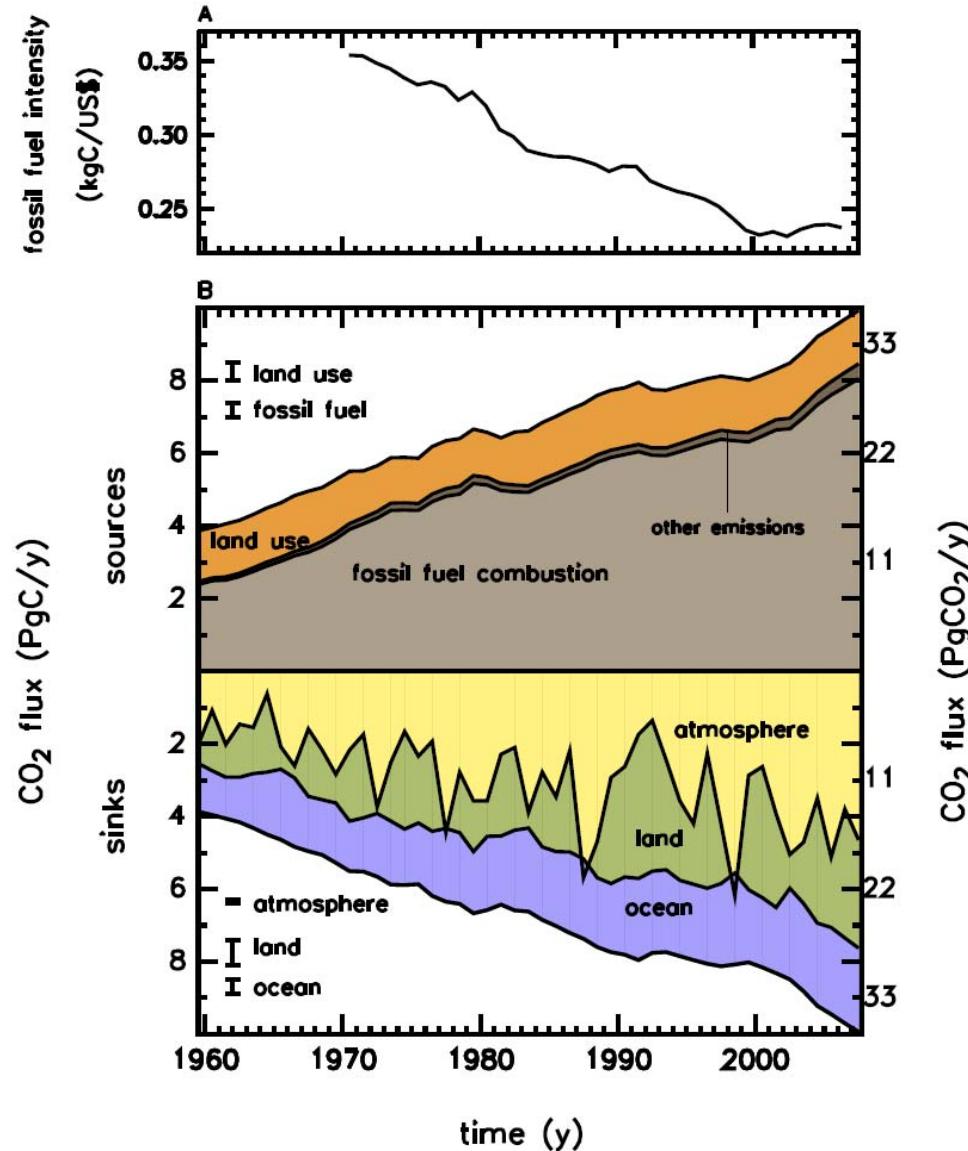
# Human Perturbation of the Global Carbon Budget



Global Carbon Project (2008)



# Human Perturbation of the Global Carbon Budget



Canadell et al. 2007, PNAS (updated to 2007)



# Drivers of Accelerating Atmospheric CO<sub>2</sub>

1970 – 1979: 1.3 ppm y<sup>-1</sup>  
1980 – 1989: 1.6 ppm y<sup>-1</sup>  
1990 – 1999: 1.5 ppm y<sup>-1</sup>  
2000 - 2007: 2.0 ppm y<sup>-1</sup>

To:

- Economic growth
- Carbon intensity
- Efficiency of natural sinks

65% - Increased activity of the global economy

17% - Deterioration of the carbon intensity of the global economy

18% - Decreased efficiency of natural sinks

(calculations based on the period 2000-2006)



Canadell et al. 2007, PNAS



# Conclusions (i)

- Anthropogenic CO<sub>2</sub> emissions are growing x4 faster since 2000 than during the previous decade, and above the worst case emission scenario of the Intergovernmental Panel on Climate Change (IPCC).
- Less Developed Countries are now emitting more carbon than Developed Countries.
- The carbon intensity of the world's economy is improving slower than previous decades.



## Conclusions (ii)

- The efficiency of natural sinks has decreased by 5% over the last 50 years (and will continue to do so in the future), implying that the longer it takes to begin reducing emissions significantly, the larger the cuts needed to stabilize atmospheric CO<sub>2</sub>.
- All these changes have led to an acceleration of atmospheric CO<sub>2</sub> growth 33% faster since 2000 than in the previous two decades, implying a stronger climate forcing and sooner than expected.





[www.globalcarbonproject.org](http://www.globalcarbonproject.org)

[info@globalcarbonproject.org](mailto:info@globalcarbonproject.org)