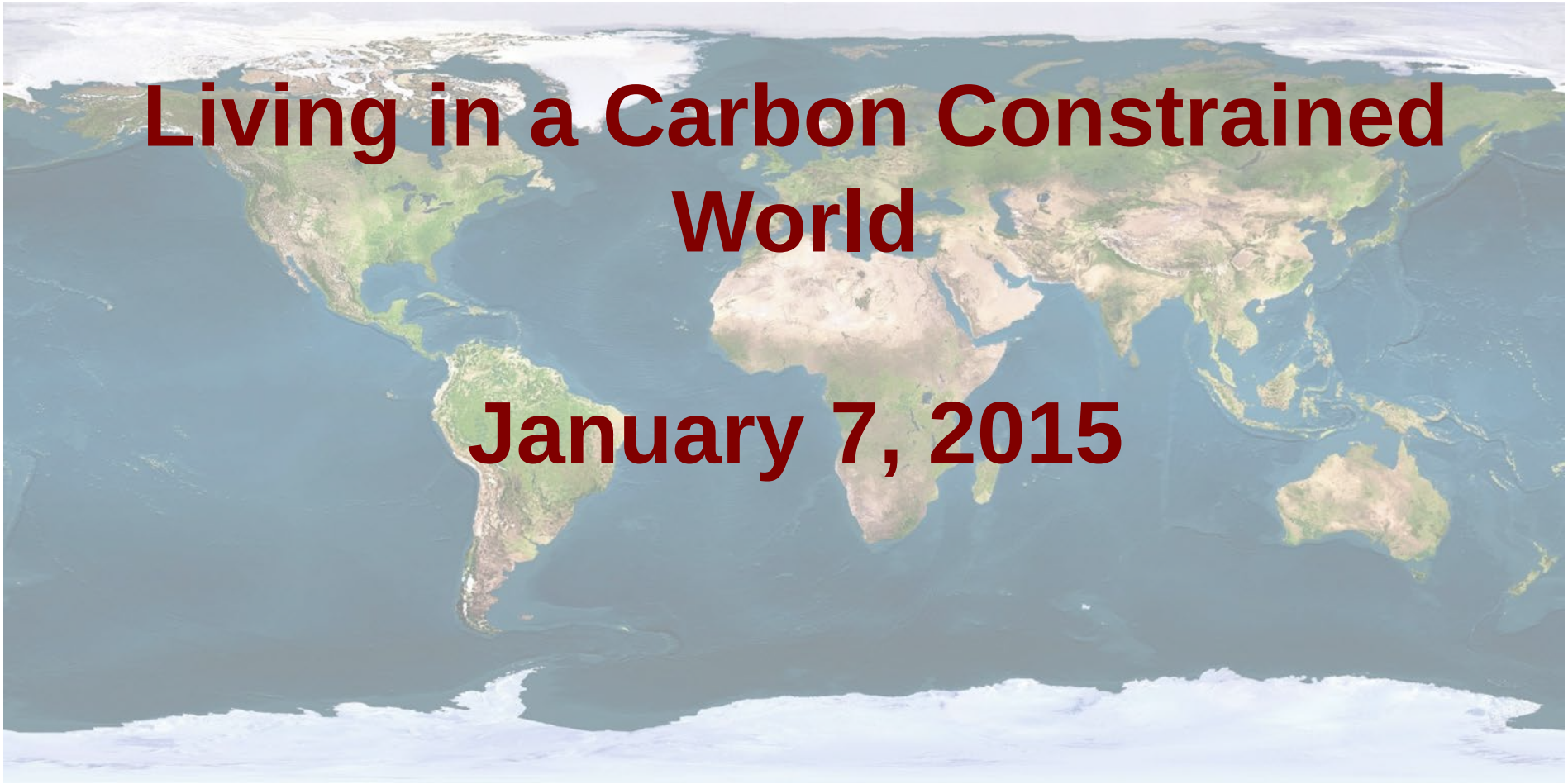

Living in a Carbon Constrained World

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Ashok J. Gadgil

Environmental Energy Technologies Division Director, LBNL

Professor of Civil and Environmental Engineering, UC Berkeley

Natural Carbon Cycle (say, till ~1800 AD)

Rapid exchange of carbon between atmosphere, biosphere & surface ocean

Very small NET carbon fluxes – 0.1 to 0.2 Gt C/yr

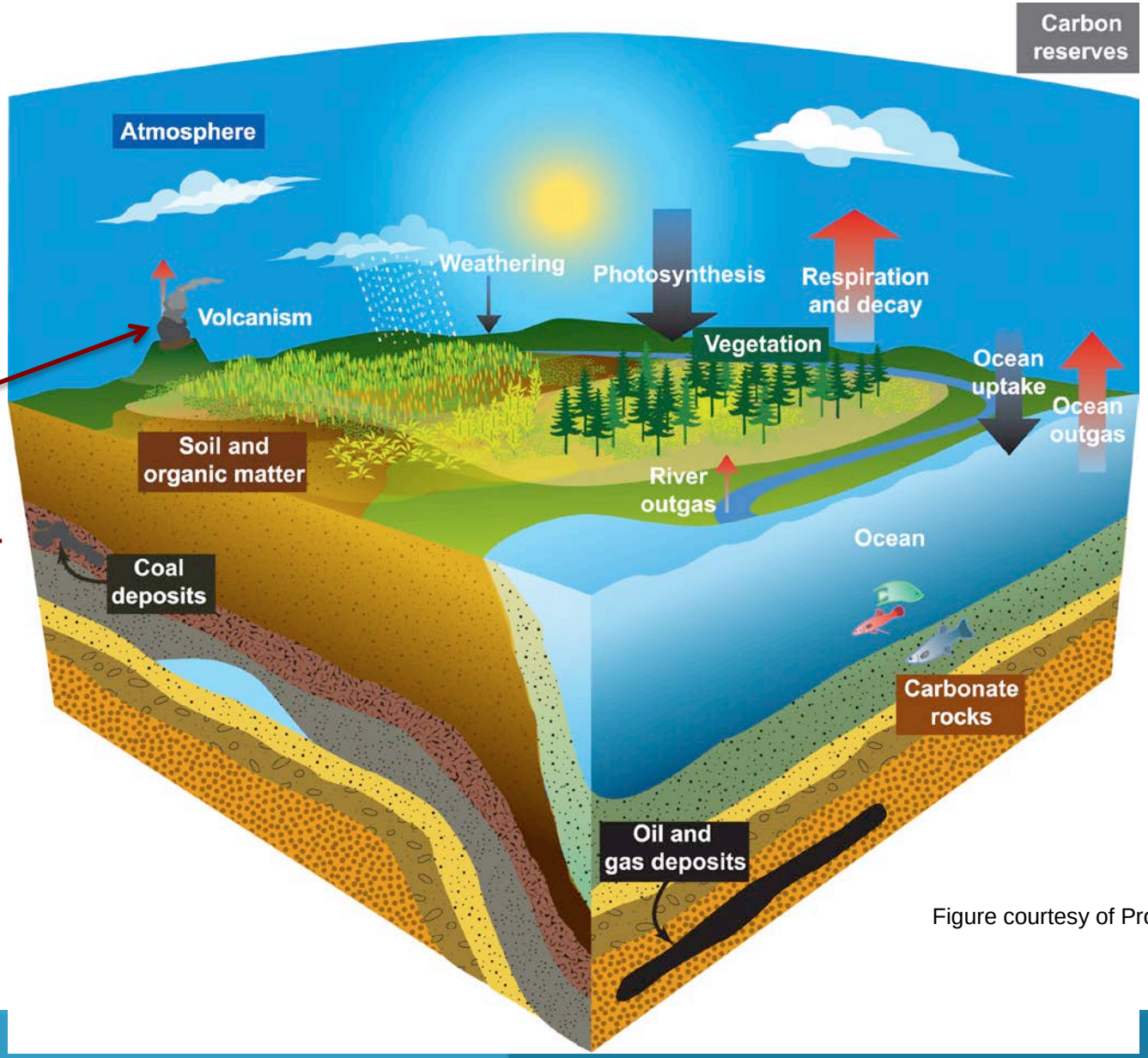
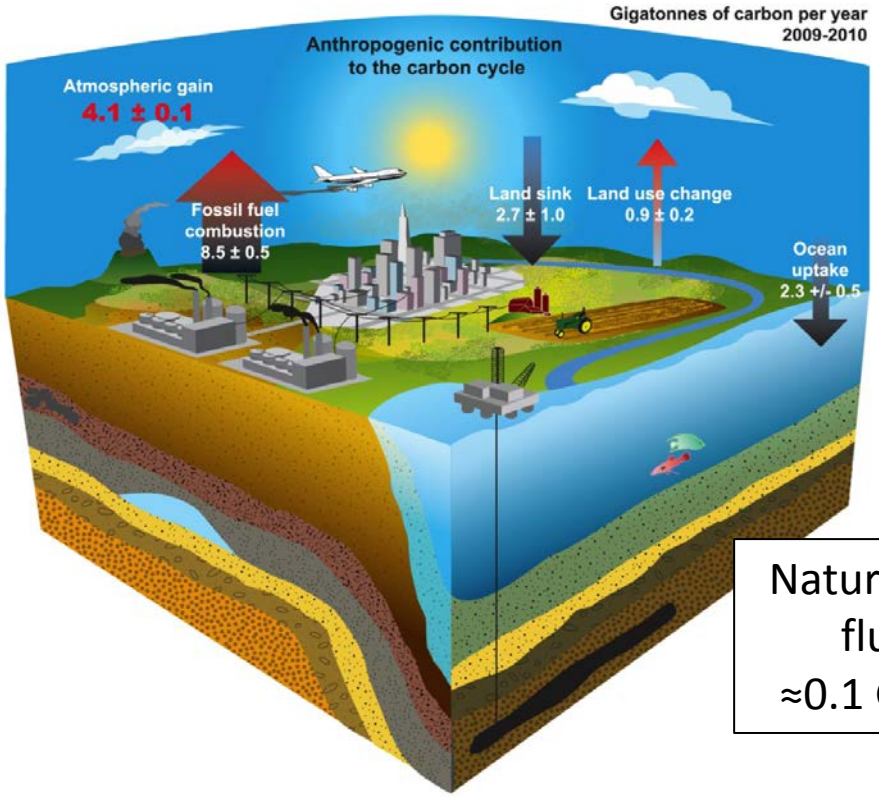


Figure courtesy of Prof. Don Depaolo

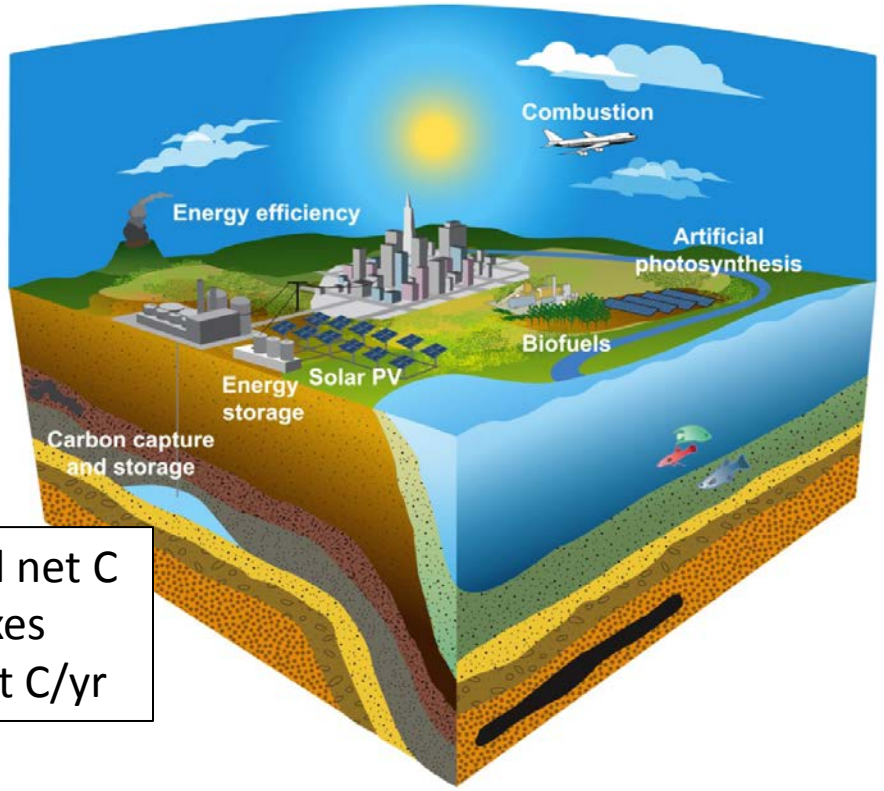
Current open-ended C cycle (2010 AD)



140 PWh/yr energy production
8.5 Gt/yr carbon emissions

60 Mt C / PWh

Desired Future: balanced C cycle (may be 2100 AD??)

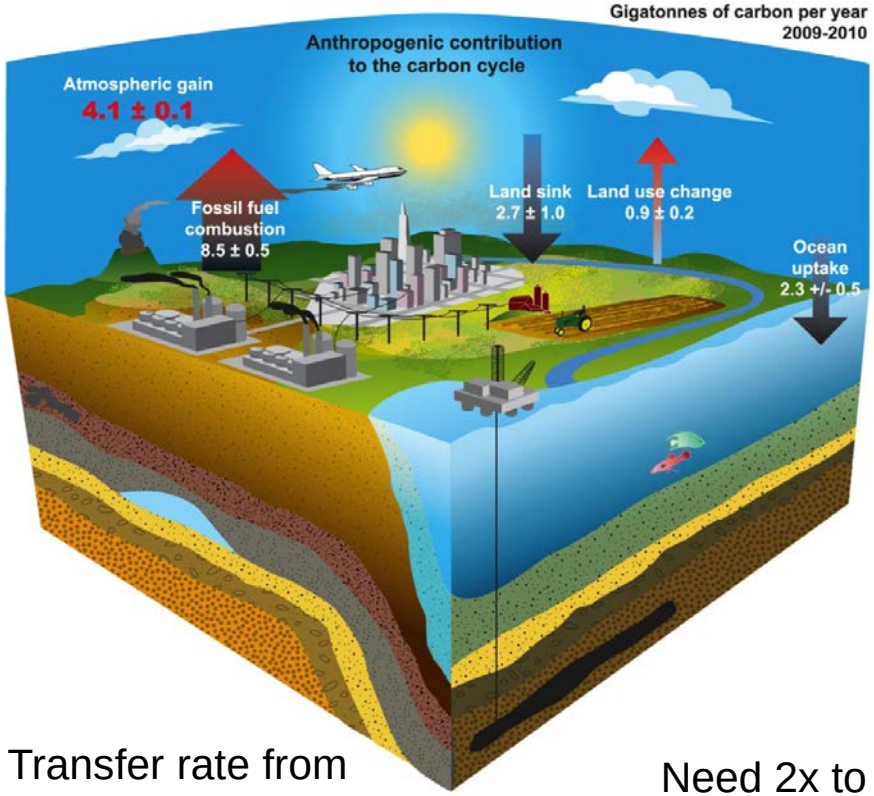


400+ PWh/yr energy production
≤ 3 Gt/yr carbon emissions

≤ 7.5 Mt C / PWh

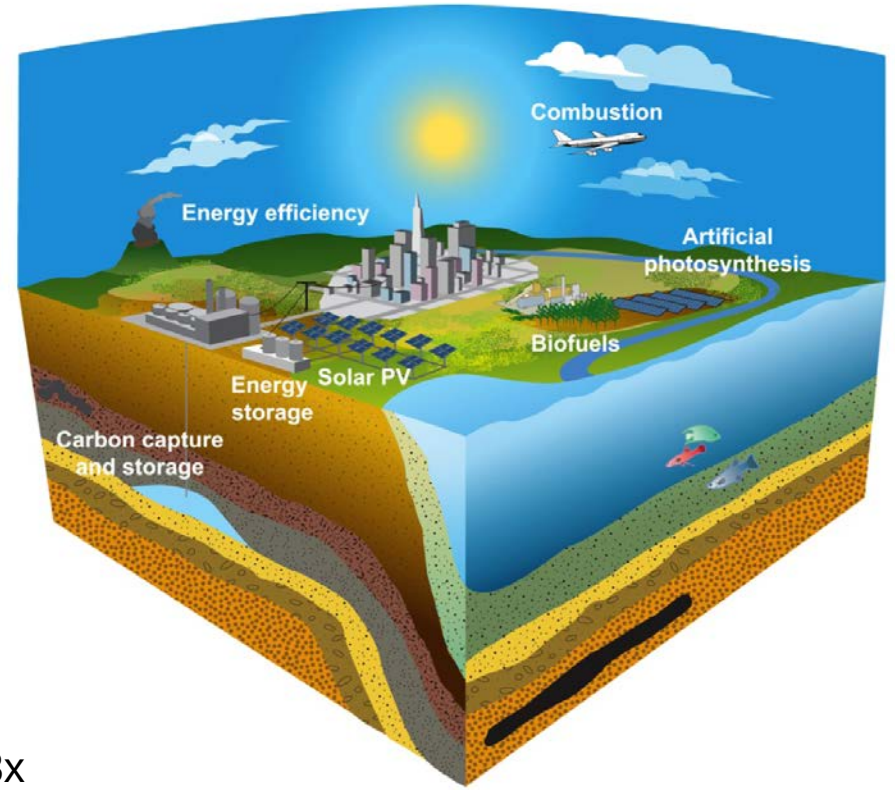
Natural net C fluxes
≈0.1 Gt C/yr

Current open-ended C cycle (2010 AD)



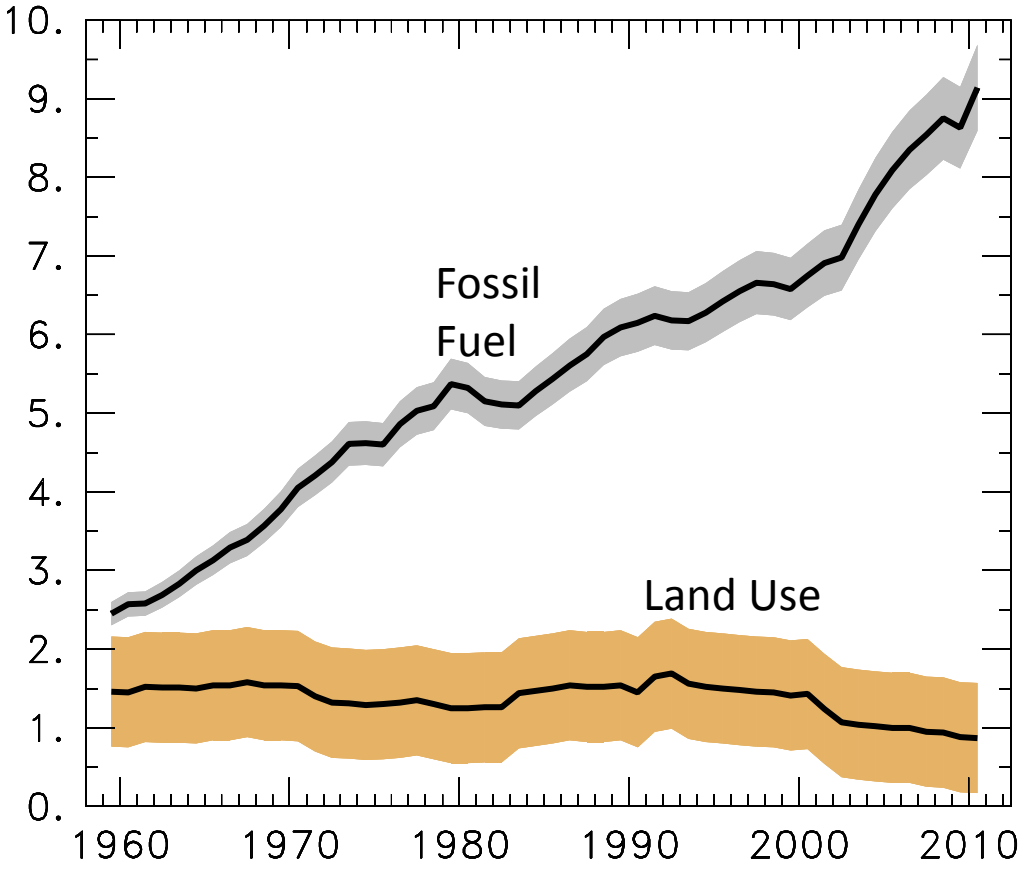
Transfer rate from geologic reservoirs = 9 Gt C/yr in 2010

Future balanced C cycle (2100 AD?)



Need 2x to 3x more energy production with <0.3 of 2010 C emissions

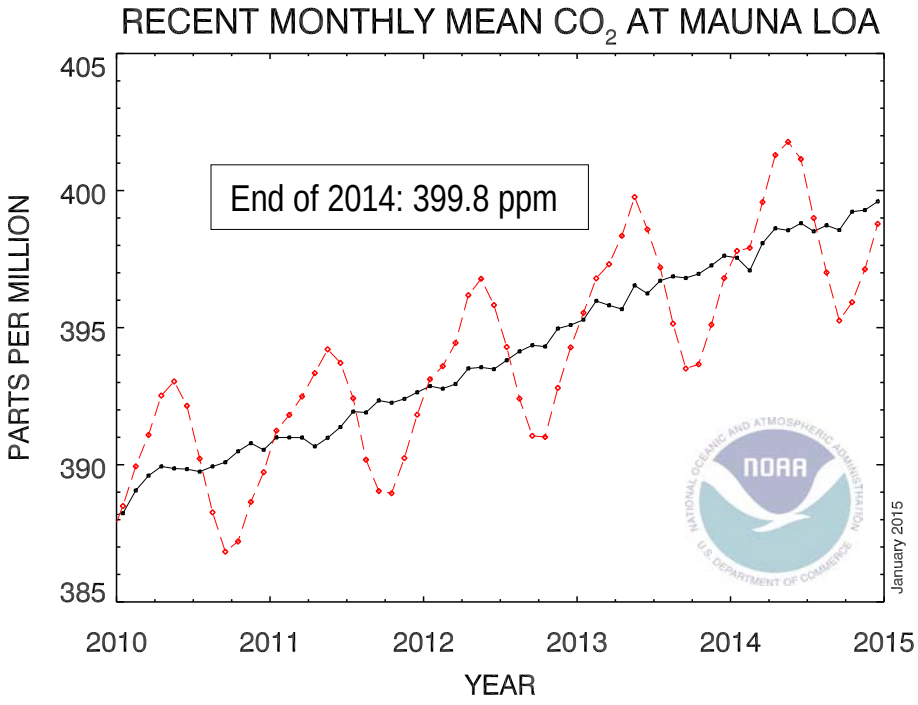
CO_2 Emissions from Fossil Fuel and Land Use Change (1960-2010)



Current LUC emissions
~10% of total CO_2 emissions

Updated from Le Quéré et al. 2009, Nature Geoscience

Atmospheric CO_2 Concentration



Annual Mea	Growth Rate (ppm y^{-1})
2014	2.32
2013	2.05
2012	2.66
2011	1.84
2010	2.43
2009	1.89
2008	1.60
2007	2.22
2006	1.76
2005	2.52
2004	1.56

Annual Growth Rates (decadal means)

1970 – 1979: 1.3 ppm y^{-1}

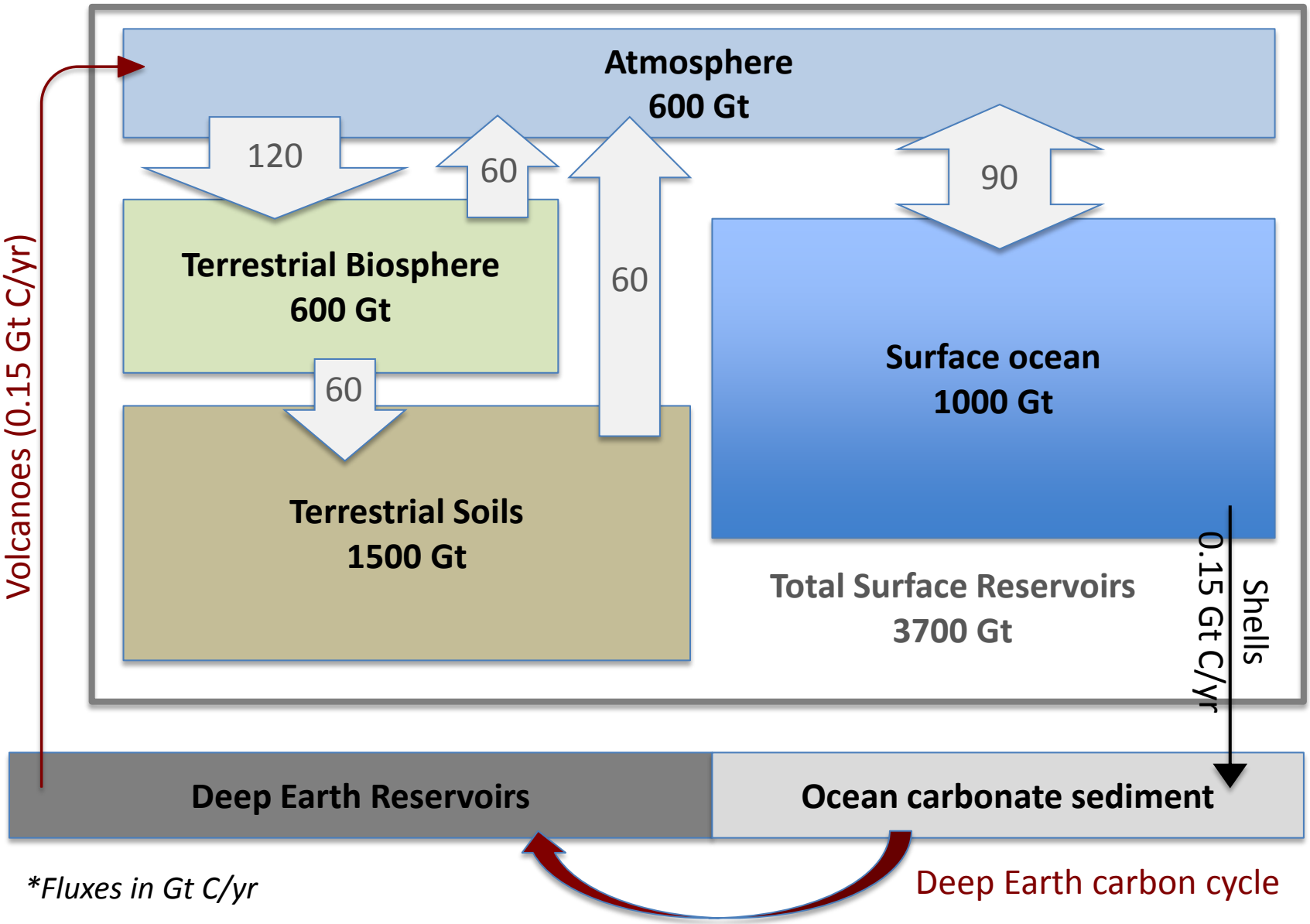
1980 – 1989: 1.6 ppm y^{1}

1990 – 1999: 1.5 ppm y^{-1}

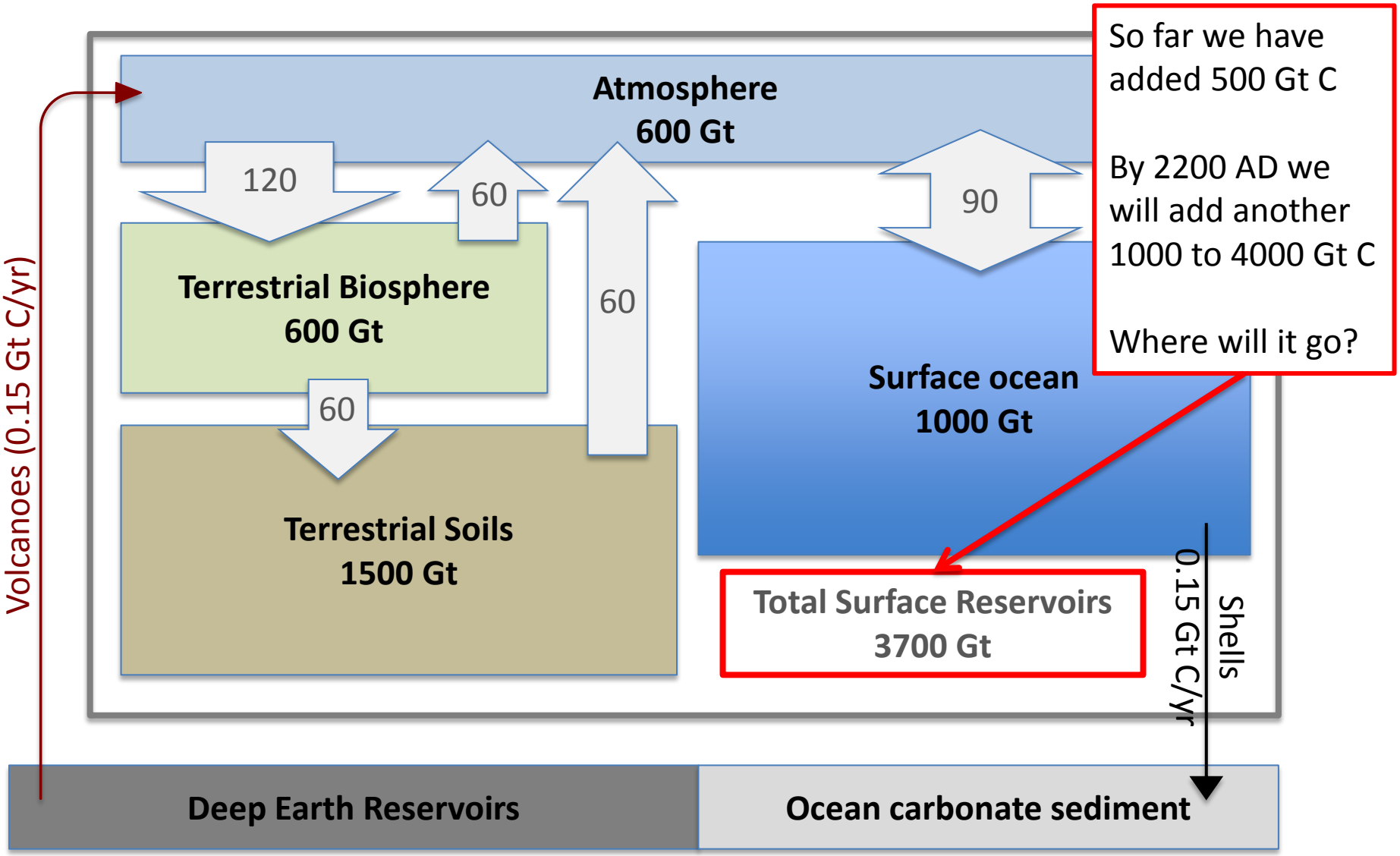
2000 – 2010: 1.9 ppm y^{-1}

Data Source: Thomas Conway, 2011, NOAA/ESRL + Scripts Institution

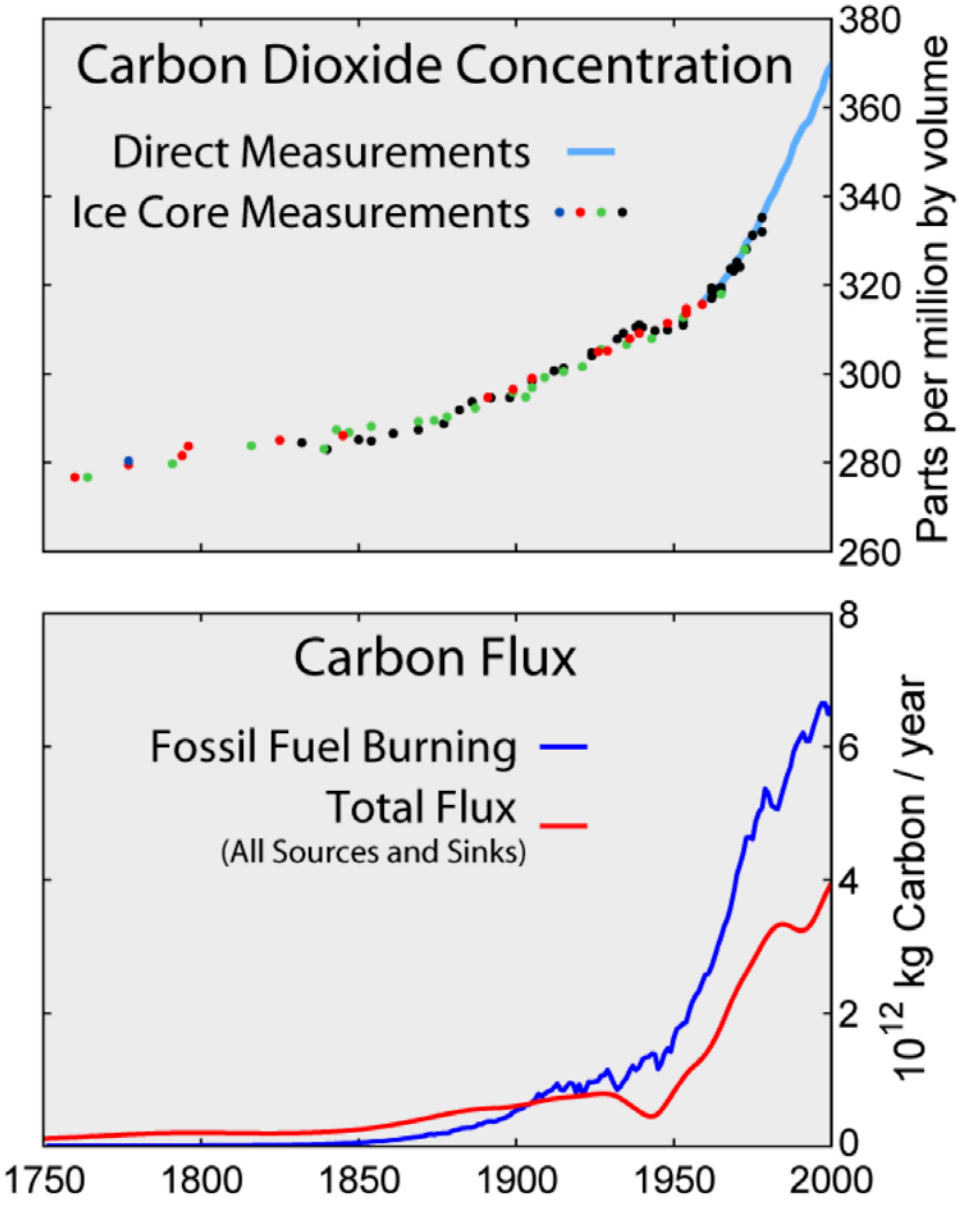
Box model version of global carbon cycle

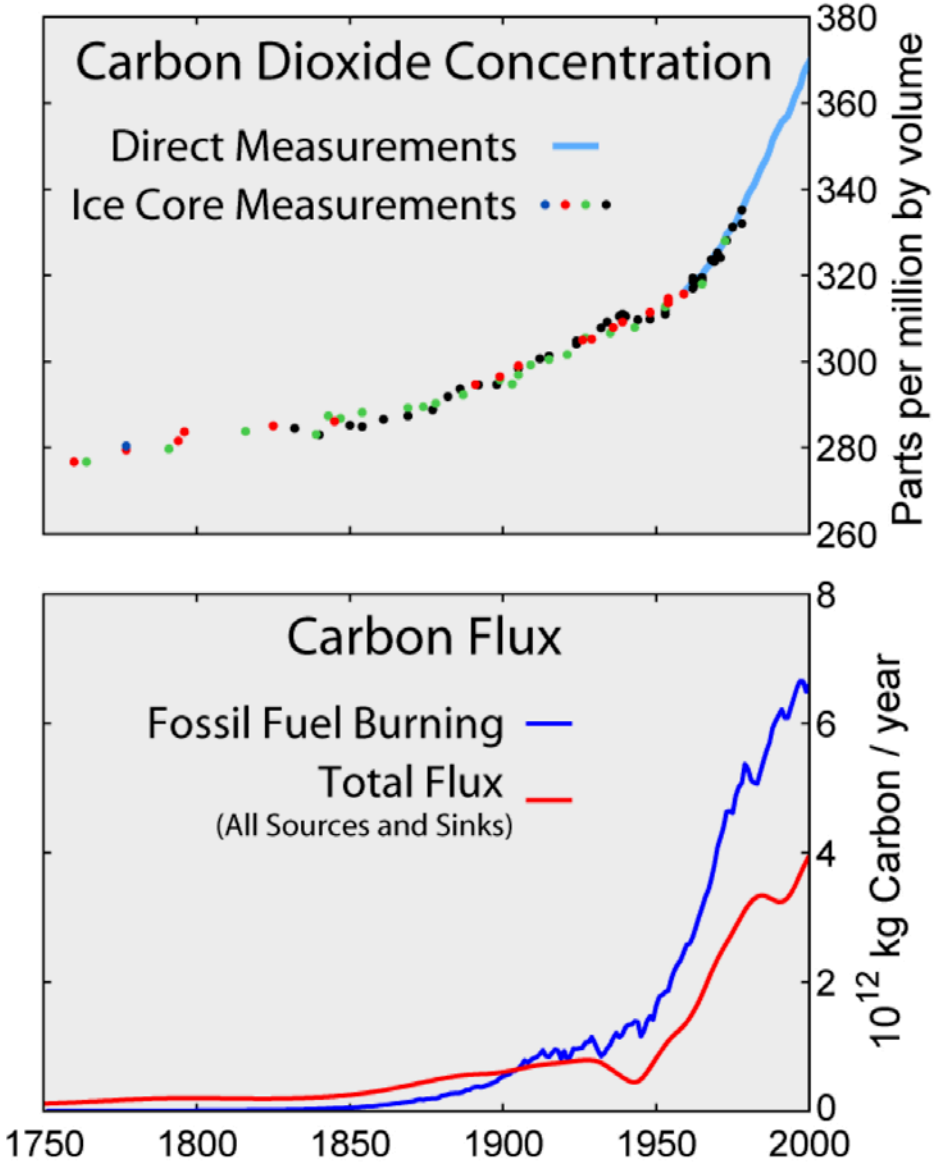


Box model version of global carbon cycle



*Fluxes in Gt C/yr


Carbon Dioxide Concentration
Direct Measurements
Ice Core Measurements
380
360
340
320
300
280
260
Parts per million by volume
Carbon Flux
Fossil Fuel Burning
Total Flux
(All Sources and Sinks)
8
6
4
2
0
10^12 kg Carbon / year
1750
1800
1850
1900
1950
2000



Pop Quiz:

Look at the figures on the left showing historical data.

What should be our desired value for the Total Carbon Flux (lower graph in the lower figure), if we want to stabilize the CO2 Concentration at 400 ppm?

DILEMMAS

- Global heating should stay below two degrees – BUT the present path points to four degrees or higher.
- At least 50 % of all fossil reserves should stay under ground, BUT new shale gas and oil are promoted.
- There are *limits to growth,* BUT all industrial countries are crying for more economic growth to cure financial crisis.
- End to infinite growth in material-consumption requires much more national and global equity, BUT inequity is increasing.
- Population growth should be reversed, BUT rich countries are working against own decreasing populations.
- Transition to Renewable Energy Systems is urgently needed, but fossil fuels get six times more state subsidies (~$500B in 2011) than renewables (~$90B in 2011).

LIMITS TO GROWTH

- Central dilemma: political neglect of *limits to growth.*
- Political excuse: without economic growth, more unemployment due to increasing productivity.
- A solution is a *flexible employment concept* where average working time is adjusted to market fluctuations -- combined with socially-responsible sharing of work.
- International problem: How should an acceptable global carbon cap be divided between nations? Fiascoes for agreement since COP15 in Copenhagen in 2009.
- Solution: Same personal emission quotas for all by 2050 (Angela Merkel: ”expand and converge”, speeches 2007) .

GREEN GROWTH

- The concept of *green growth* is primarily an excuse for continued economic growth with a green paint.
- The possible decoupling from carbon is relative but far from absolute in practice with existing technologies and production methods. *Nature reacts on absolute decoupling*.
- In practice, exploitation of solar energy and other renewables for human energy purposes has limitations.
- Dangerous to accept illusionary mitigation concepts.

Best advice: forget about Green GROWTH and focus on Green TRANSITION.

GLOBAL COLLAPSE POSSIBILITIES

Proposals by Paul and Anne Erlich

- Neglect limits to growth and global warming.
- ”Small” nuclear war - for the last oil or for other reasons.
- Use of chemical and biological weapons.
- Famines, epidemics, ressource shortages (e.g. phosphorus).
- Social disruptions, environmental refugees.

See list in Paul Erlich and Anne Erlich: ”Can a collaps of global civilization be avoided”, Proc. Royal Society, 2013.

EQUITY
A forgotten concept

- Convincingly documented that high economic and social equity gives advantages on all relevant parameters: high health level, low level of suicide, high welfare, low social controversies, high international competiveness, etc.
- In practice, the *competition society* is winning over the *welfare society* (high equity) – even in the wealthy Nordic countries.
- Global equity is necessary for international co-operation on mitigation of global warming *(Angela Merkel)*.

Without much higher national and international economic and social equity there is no hope for a green transition in time.

PROGRESSIVE TAX WILL SUPPORT MORE ECONOMIC EQUITY

- Progressively increasing tax on high income, high ownership of private property and high inheritance.
- The top one per cent in the US got more than 20 % of the nation's income in 2012. (US inequality has been growing for past 3 decades).
- 10 per cent higher US tax would generate revenues equal to 2 % of GDP (Jopseph Stiglitz).
- Some rich people may emigrate (like a French actor to Russia) – but social and cultural bounds are strong!

RESILIENCE vs. MITIGATION (?)

- New strategy: less money for mitigation of global warming – more money for resilience against global warming.
- Mitigation is based on concrete numbers – resilience is a positive and flexible concept – favourable with politicians.
- The British Stern report has documented that fast mitigation of global warming is by far the less costly solution. Resilience projects may delay mitigation.
- *Resilience projects should only have high priority where they are urgently needed or have low costs.*

REVERSAL OF POPULATION GROWTH

- Interference with human birth rates is a sensitive question for religious reasons and priority to free personal choice.
- This includes even information on pregnancy prevention.
- ”Soft” solutions are preferable to ”hard” solutions.
- Reversal of population growth requires more economic support to education of women in developing countries.
- But several rich countries are cutting down their economic support – and making efforts to counteract their own decrease in population.

Reversal of population growth is one of the three major factors in mitigating of global warming and saving the carrying capacity of the globe.

INTERNATIONAL ACTIONS

- Reintroduce control of capital movements (Keynes 1930s) - existing in the EU until the 1980s.
- Replace WTO by green trade administration responsible for global transport tax and financial (Tobin) tax.
- Change priorities of World Bank and IMF to promotion of green transition and global equity.
- Stop government subsidies for fossil fuels.
- Do not wait for large nations like the US and China. They are preventing global agreements and commitments.

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