The world forest sink closes the global carbon cycle

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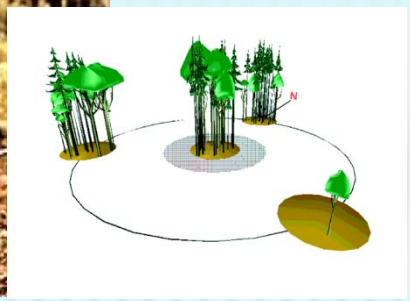
Overview

- Data sources and methods
- Regional carbon estimates and dynamics
- Forest sink and the global carbon cycle
- Uncertainty, data gaps and future improvements

Global Forest Carbon Analyses

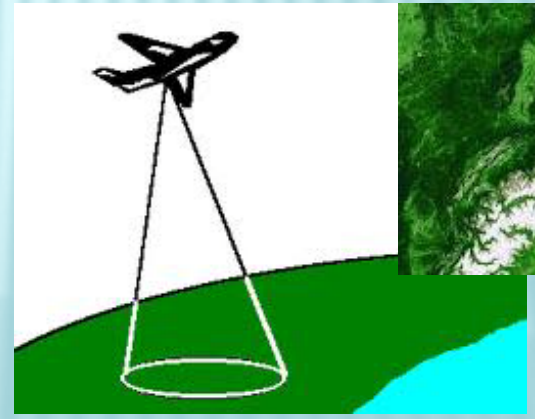
Data sources



Forest inventories for boreal and temperate regions

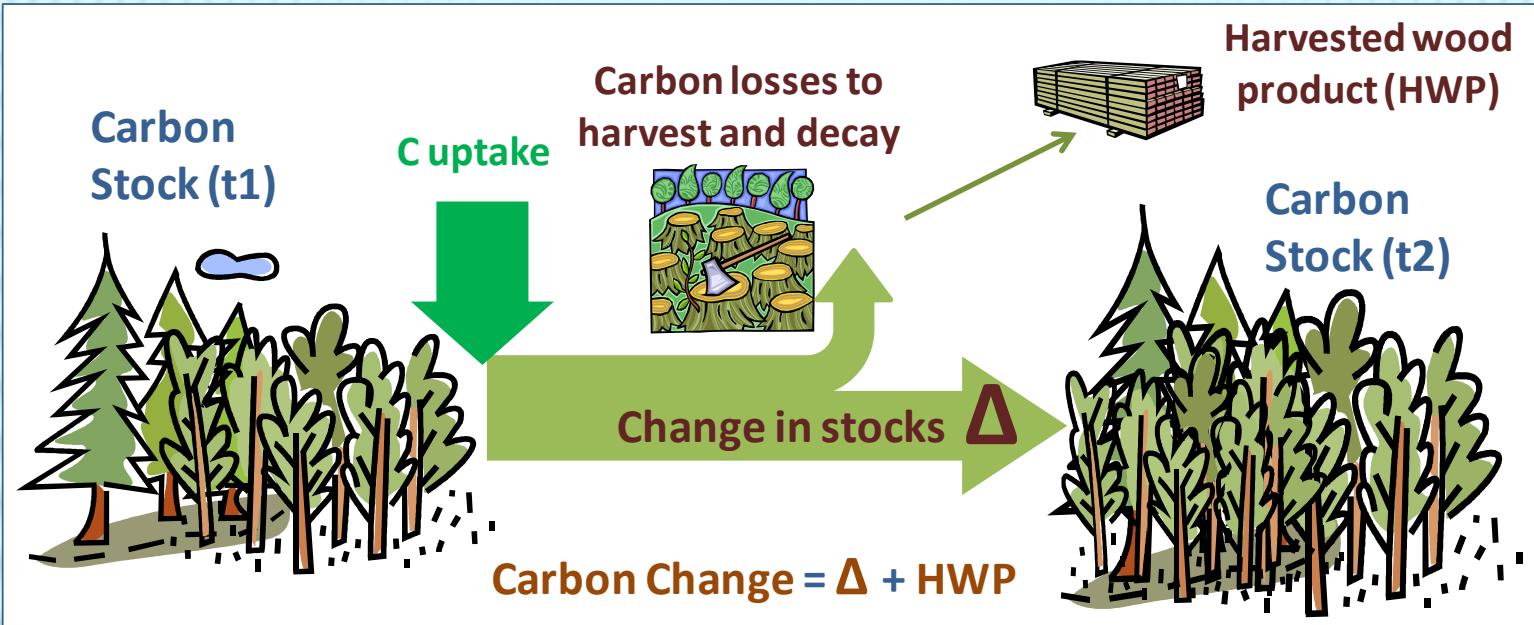
Permanent plots for tropical intact forests

Tropical land-use change (emission and regrowth) (R. Houghton)



FAO area statistics for the tropics

IPCC accounting methods



Stock-change method for boreal and temperate forests

The good practice guidance (IPCC, 2003)

Definition of forests:
Forests remain forests plus new forests

Variable carbon density method for tropical intact forests

Estimated carbon stocks and changes for 15 regions

4 boreal regions

8 temperate regions

3 tropical regions

Estimated carbon stocks and changes for 5 carbon pools

Living biomass, dead wood, litter, soil

& harvested wood products

Estimated carbon stock and changes for 2 time periods

Stocks: 1990, 2000 & 2007

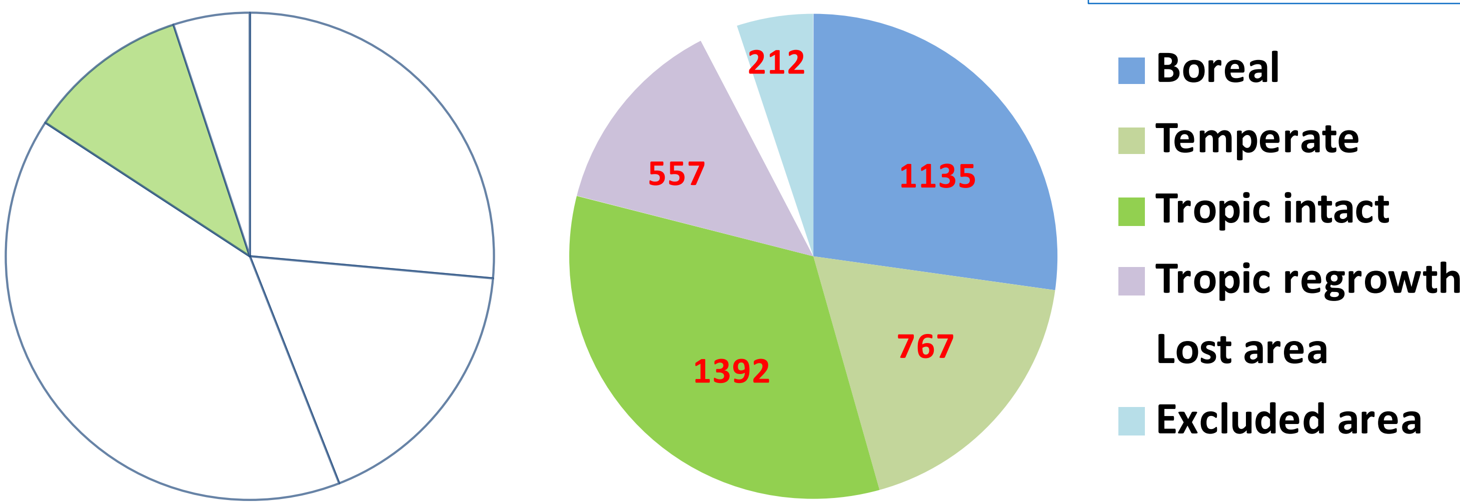
Fluxes: 1990-1999 & 2000-2007

Area of Forests and Land-use Change

Global Total Forest Area

1990: 4190 Mha

2007: 4063 Mha

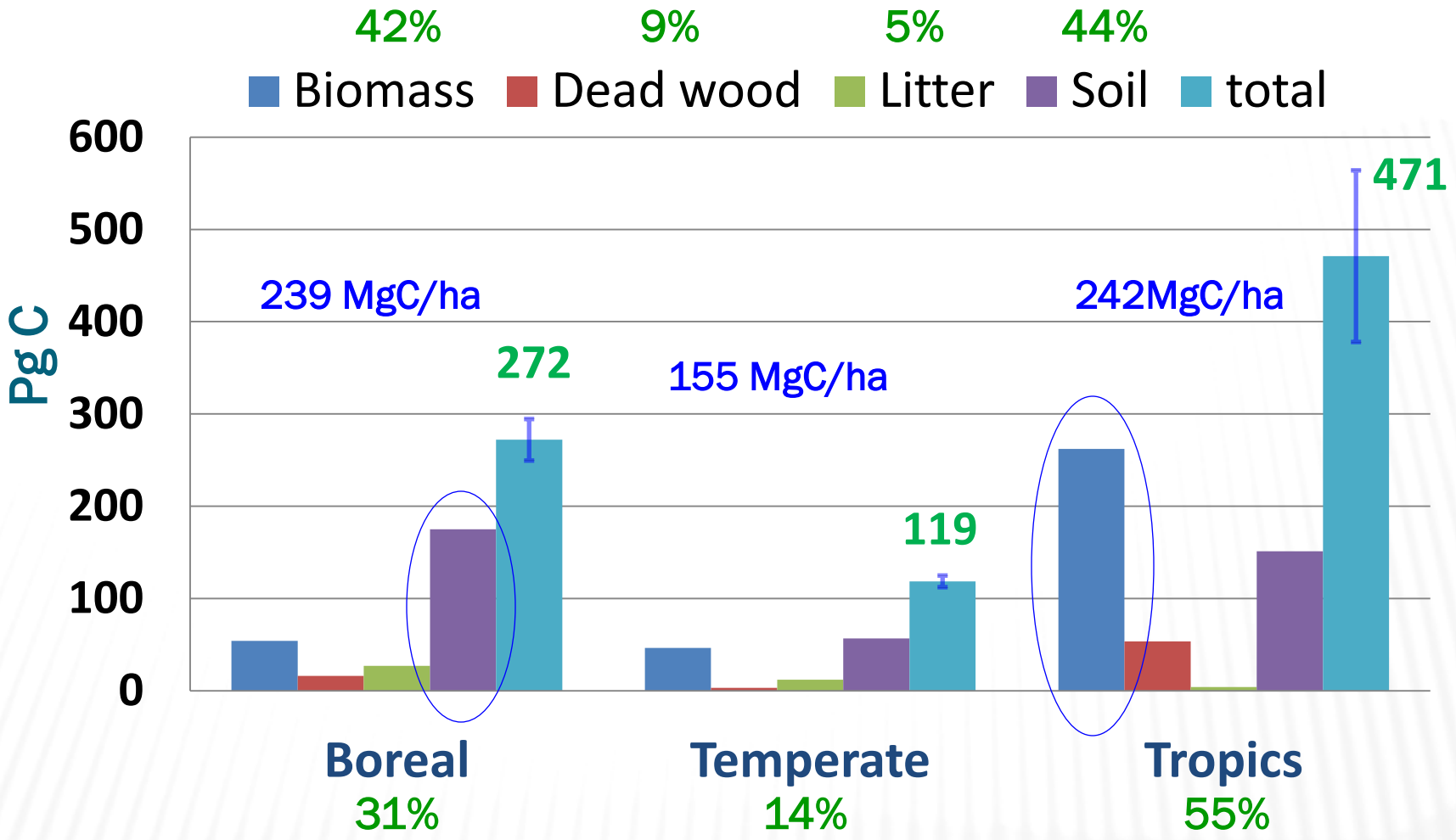


The area covered by this study represents 95% of the world's forests

Global established forests:
the area outside area of tropical land-use change, including boreal, temperate and tropical intact forests.

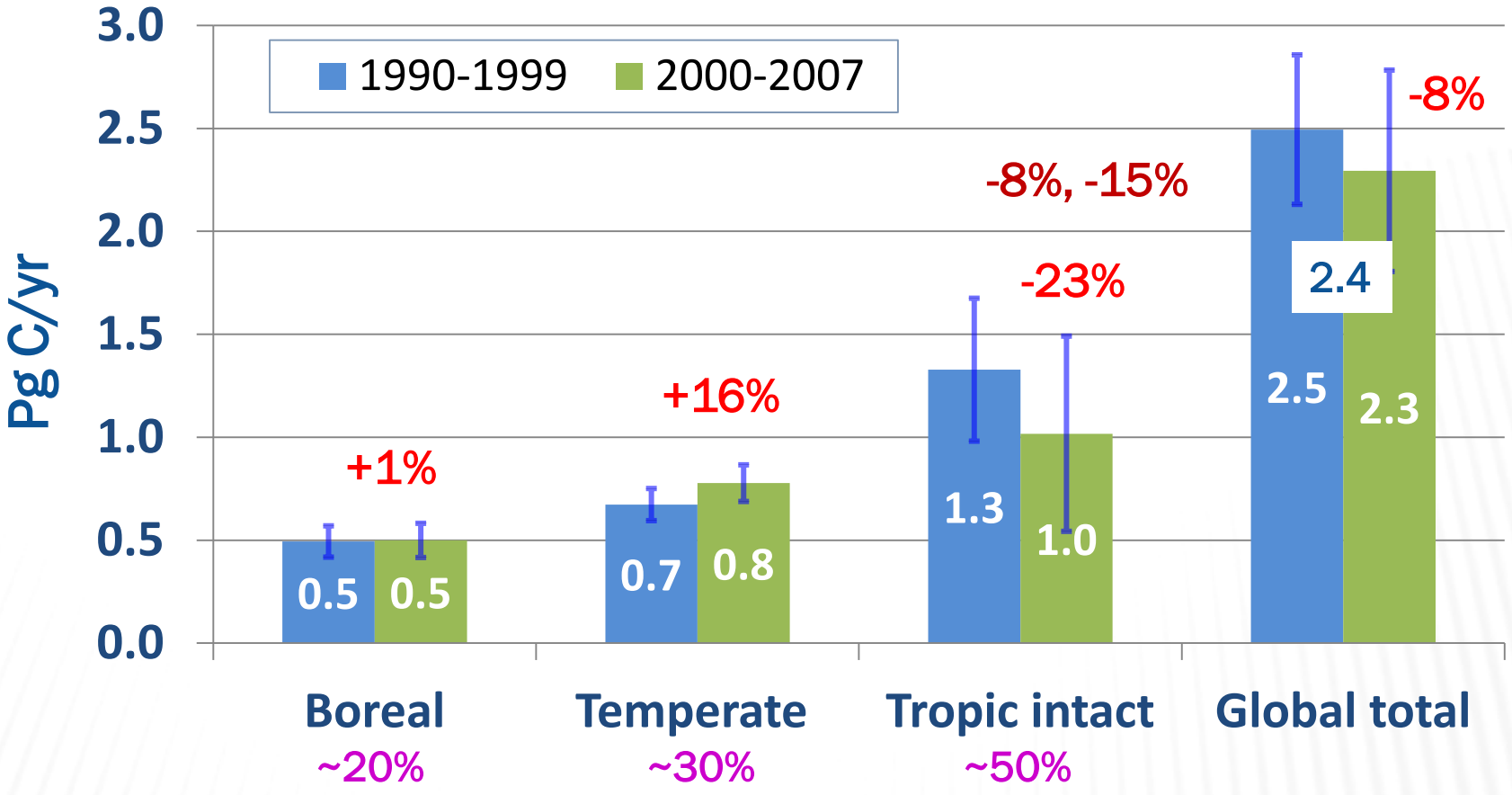
Tropical regrowth forests:
Forests that have been previously deforested. Separating LUC emission to gross deforestation emission and regrowth C uptake

Global Forest Carbon Stocks (2007)



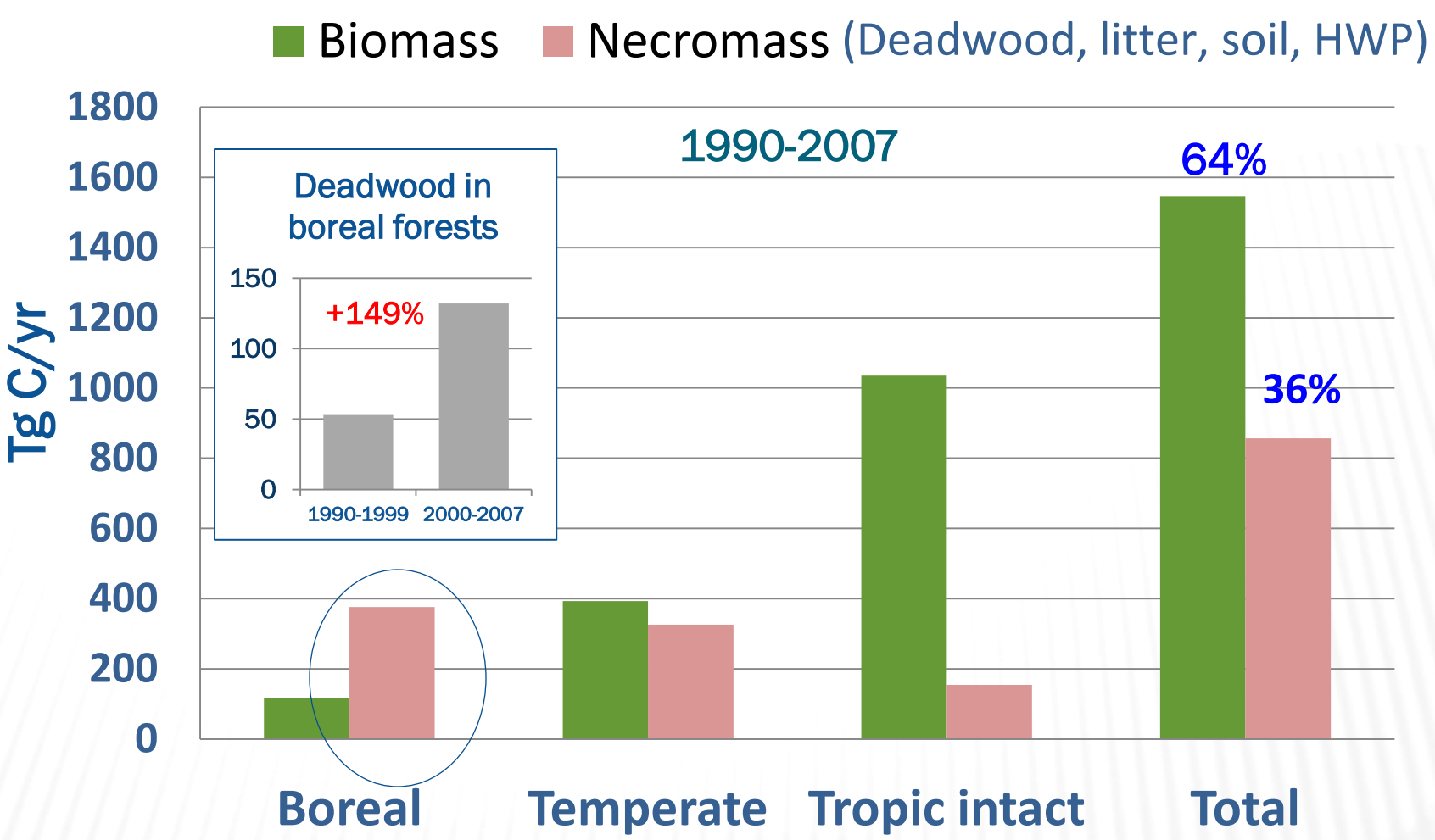
Total global forest C stock= 861 Pg C
(vs. 816 Pg C in the atmosphere)

Annual C sinks in established forests

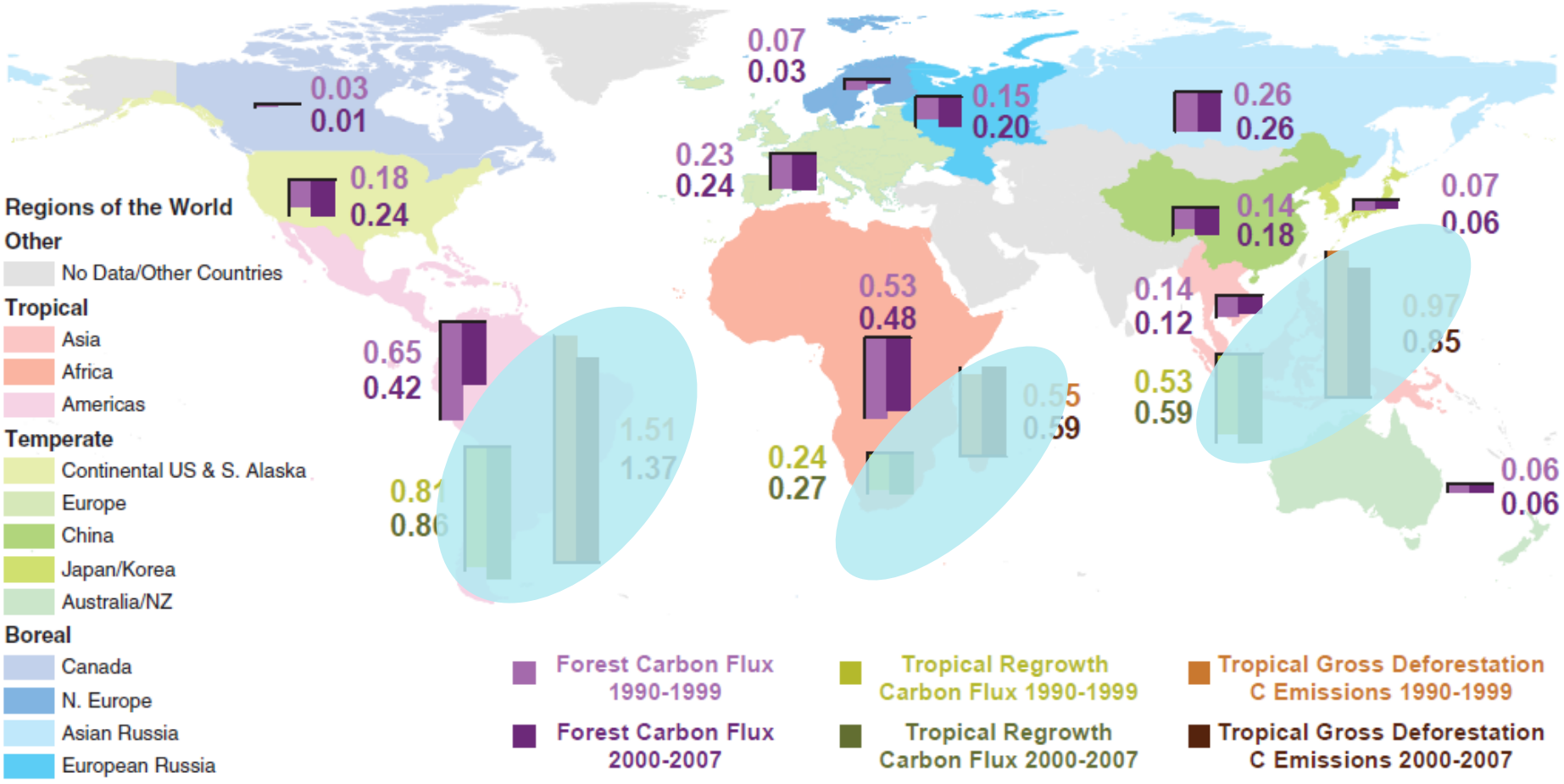


Tropic intact forests: decreased sink was caused by deforestation reducing intact forests and severe Amazon drought in 2005. However, the excess C gain over loss is resulted from progressively enhanced forest productivity in response to increased CO2 in the past decades (China).

Carbon Sinks in Biomass and other Pools



Carbon Sinks and Sources (Pg C yr^{-1}) in the World's Forests



Pan *et al.* (2011) *Science*

Global Forest Carbon Balance, 2000-2007

Forest land

Biome	(Pg C yr^{-1})
Boreal	0.5 ± 0.1
Temperate	0.8 ± 0.1
Tropical (intact)	1.0 ± 0.5
Total	2.3 ± 0.5

LUC in tropics

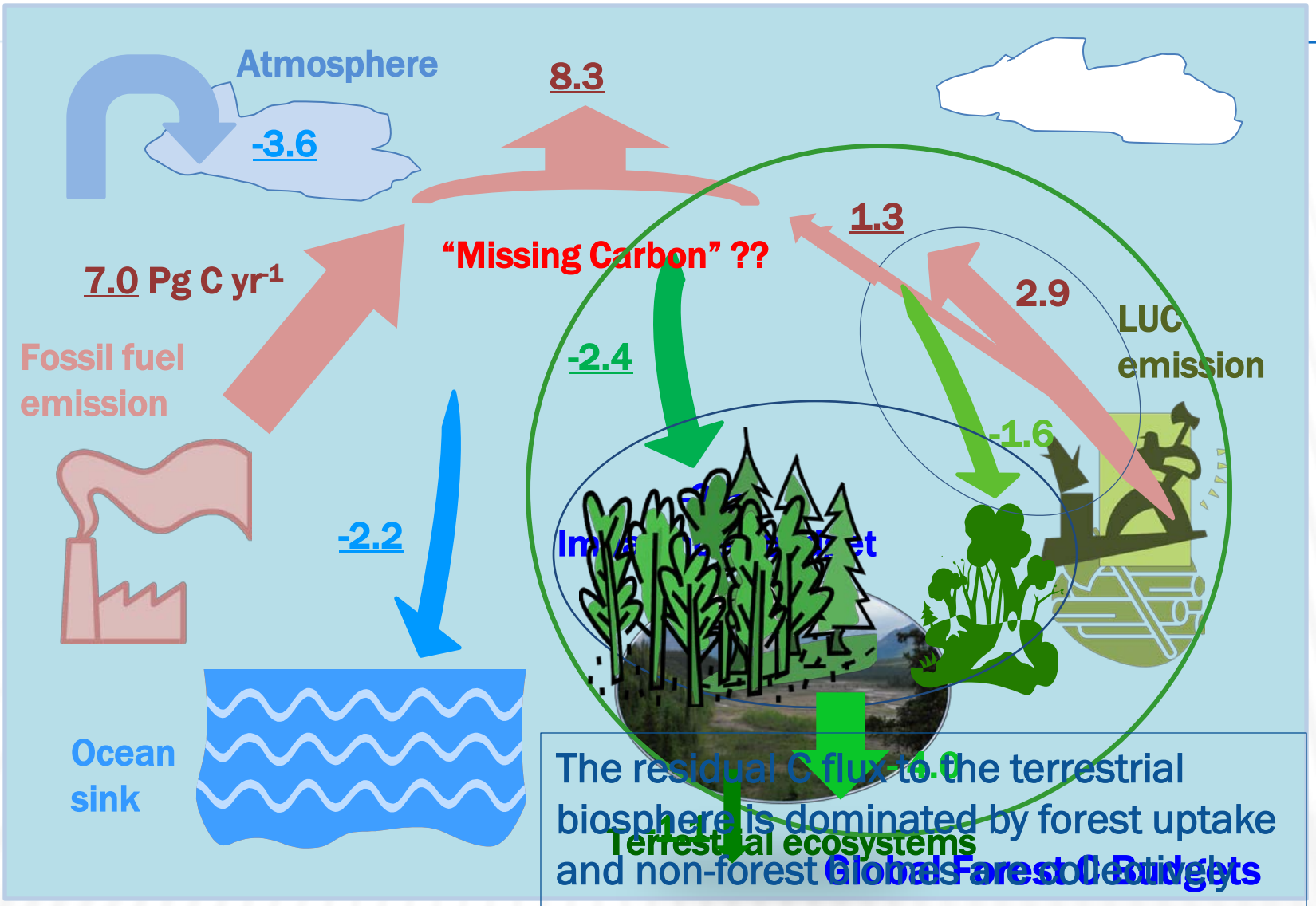
Land class	(Pg C yr^{-1})
Deforestation emissions	-2.8 ± 0.5
Regrowth (after LUC)	1.7 ± 0.5
Total	-1.1 ± 0.7

1.3 Pg C yr^{-1}

-0.1 Pg C yr^{-1}

Global *net* forest sink = 1.2 ± 0.9
(Net sinks in temperate and boreal zones)

The Global Carbon Budgets (1990-2007)



The residual C flux to the terrestrial biosphere is dominated by forest uptake and non-forest ecosystems are neither a major sink nor source

The Global Carbon Budget (PgC yr^{-1})

Sources and Sinks	1990-1999	2000-2007
Sources:		
Fossil fuel and cement (1)	6.5±0.4	7.6±0.4
Land-use change (2)	1.5±0.7	1.1±0.7
Total sources	8.0±0.8	8.7±0.8
Sinks:		
Atmosphere (2)	3.2±0.1	4.1±0.1
Ocean (3)	2.2±0.4	2.3±0.4
Forest land (4)	2.5±0.4	2.3±0.5
Total sinks	7.9±0.6	8.7±0.7
Residual (5):	0.1±1.0	0.0±1.0

Data gaps, uncertainty, and suggested improvements in global forest monitoring

❑Land monitoring should be greatly expanded in the tropics and in un-sampled regions of northern boreal forests

❑A globally consistent approach to remote sensing and forest inventory is required to combine ground truth of forest C densities from inventories and reliable forest area from remote sensing

❑Improved methods and greater sampling intensity are needed to estimate non-living C pools, including soil, litter, and dead wood

❑Better data are required in most regions for estimating lateral C transfers in harvested wood products and rivers.

New insight and perspective

- The total C sink in the world's forests outside areas of tropical land-use change was 2.4 Pg C yr^{-1}, or about 1/3 of annual fossil fuel emissions. The global forest sink is comparable to the entire terrestrial carbon sink deduced from fossil fuel emissions and land-use change sources minus ocean and atmospheric sinks

- The global forests play the large role in regulating atmospheric carbon levels (gross carbon uptake is ~ 4.0 Pg.C yr^{-1}, though a net sink is only 1.1 Pg.C yr^{-1}). The tropics is the most dynamic area for C exchange, but also with the greatest uncertainty in the estimates

New insight and perspective (continued)

- The forest C sink is found in every continent on Earth, suggesting overall favorable conditions for forest growth, which may imply a global driver such as rising atmospheric CO_2 fertilizing growth.
- Extensive areas of relatively young forests have potential to continue sequestering carbon in the future.
- Tropical biomass and boreal soils hold largest carbon pools and sinks. Warming and increased wildfires in the boreal zone, deforestation and extreme droughts, coincident with fires in the tropics, are likely the greatest risks to the continued large C sink in the world's forests.

Thank You!