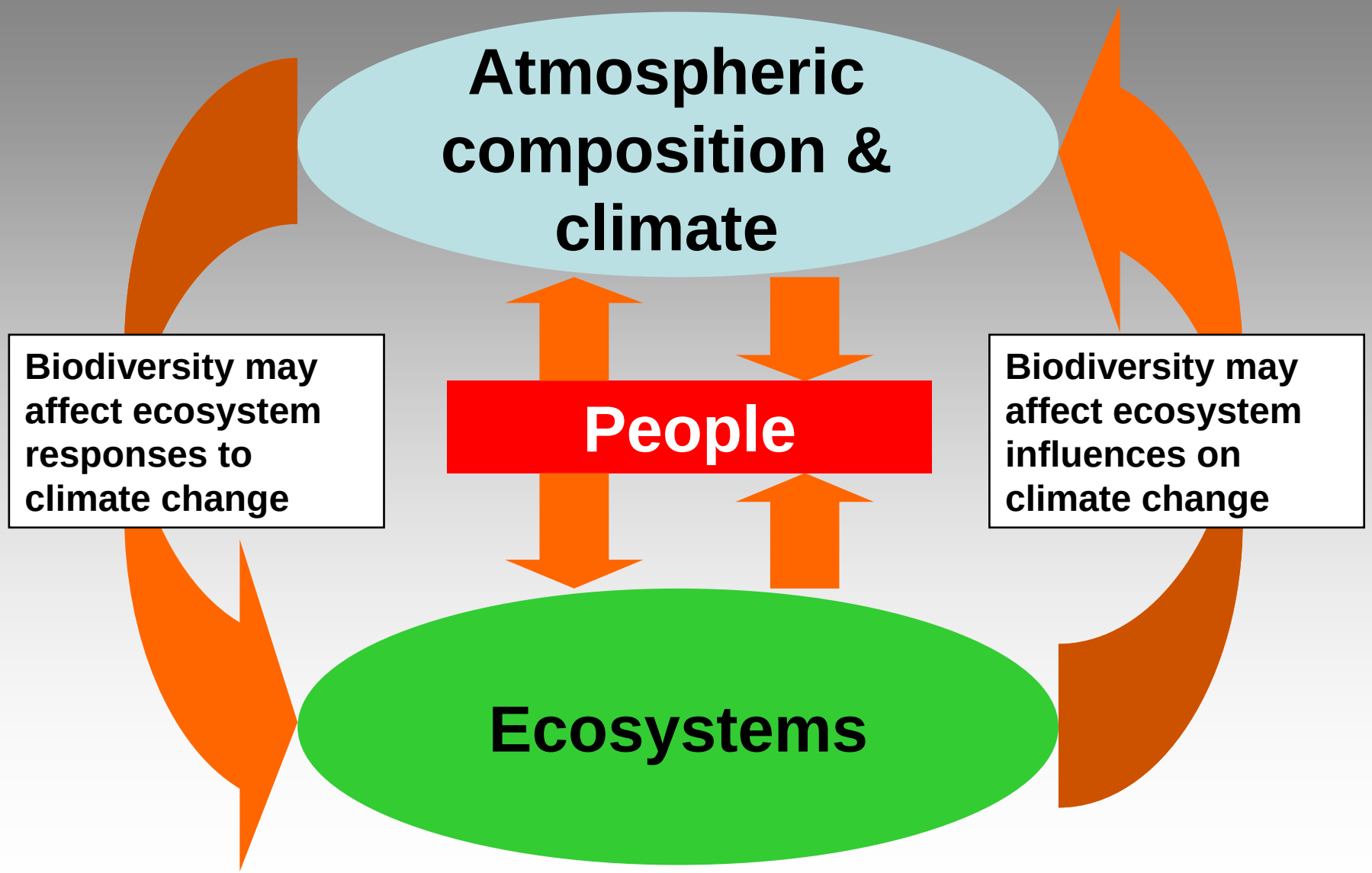
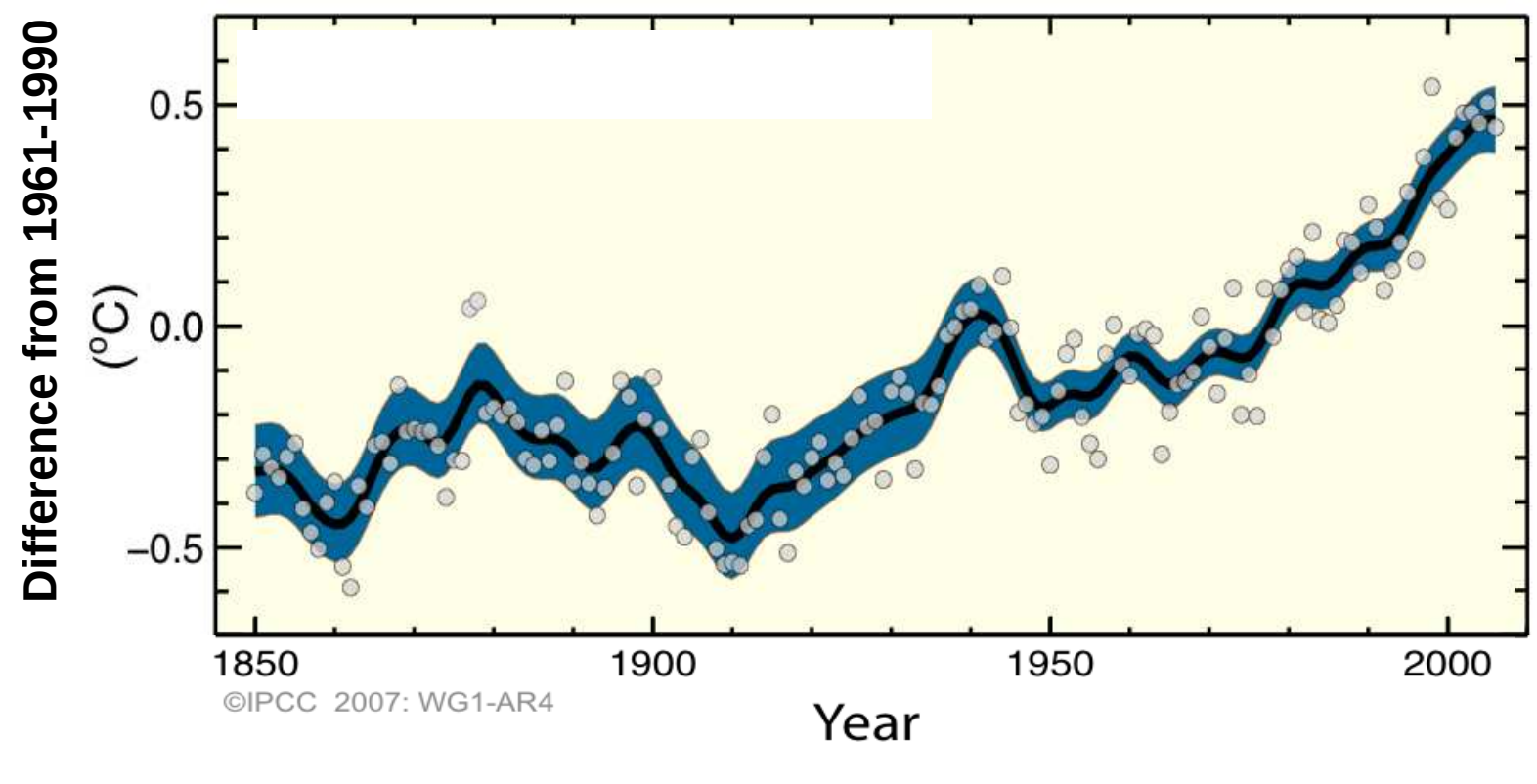
Interactions, impacts and the role of biodiversity in the climate system and human livelihoods

Richard Betts
Met Office Hadley Centre, UK

Roles of biodiversity in the Climate System



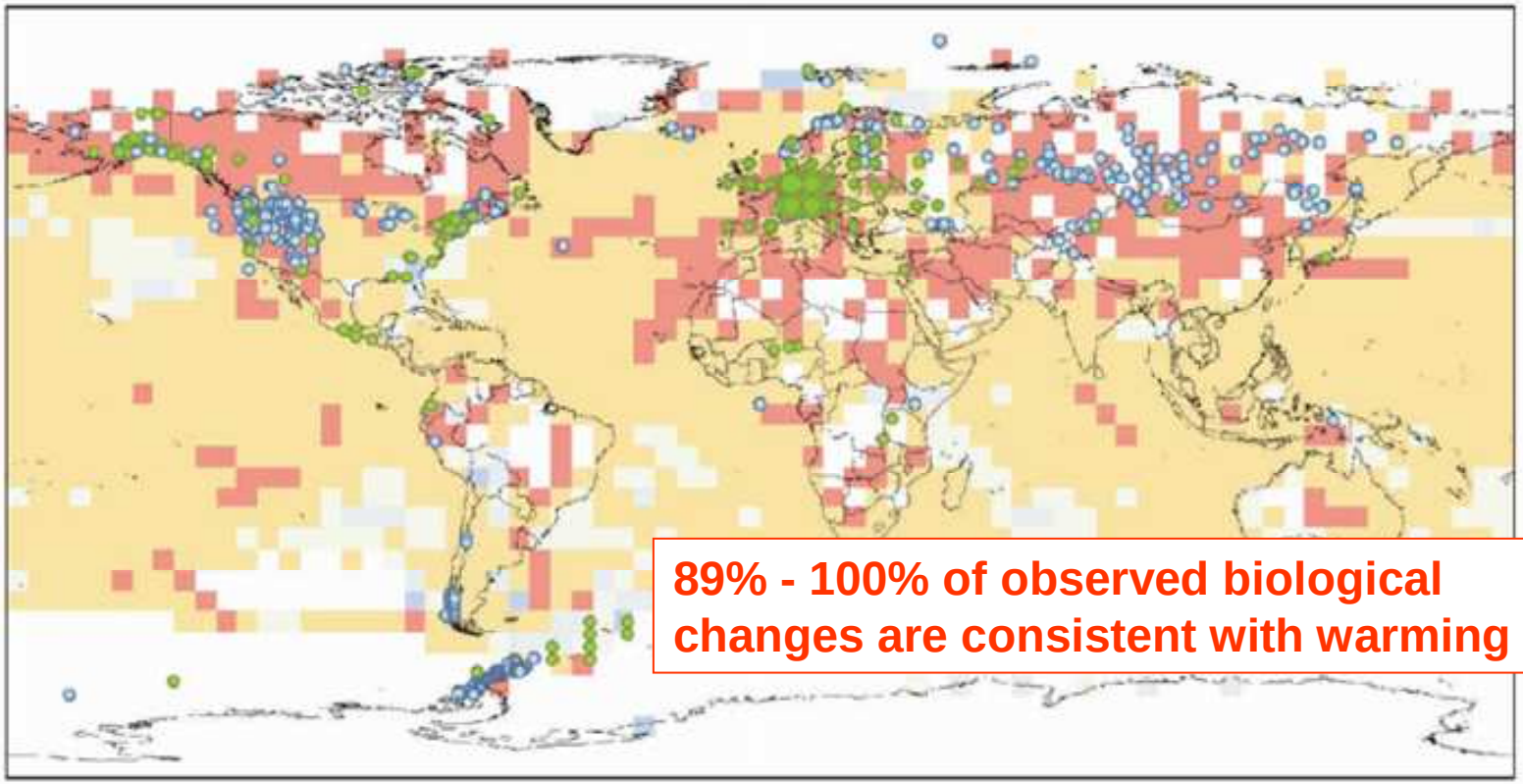
Observed climate change and its causes



“Warming of the climate system is unequivocal” (IPCC 2007)

“Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations” (IPCC 2007)

Changes in physical and biological systems and surface temperature 1970-2004



89% - 100% of observed biological changes are consistent with warming

Observations

- Physical systems (cryosphere, hydrology, coastal processes)
- Biological systems (marine, freshwater, and terrestrial)

*Dots in Europe represent 1 to 7500 observations.

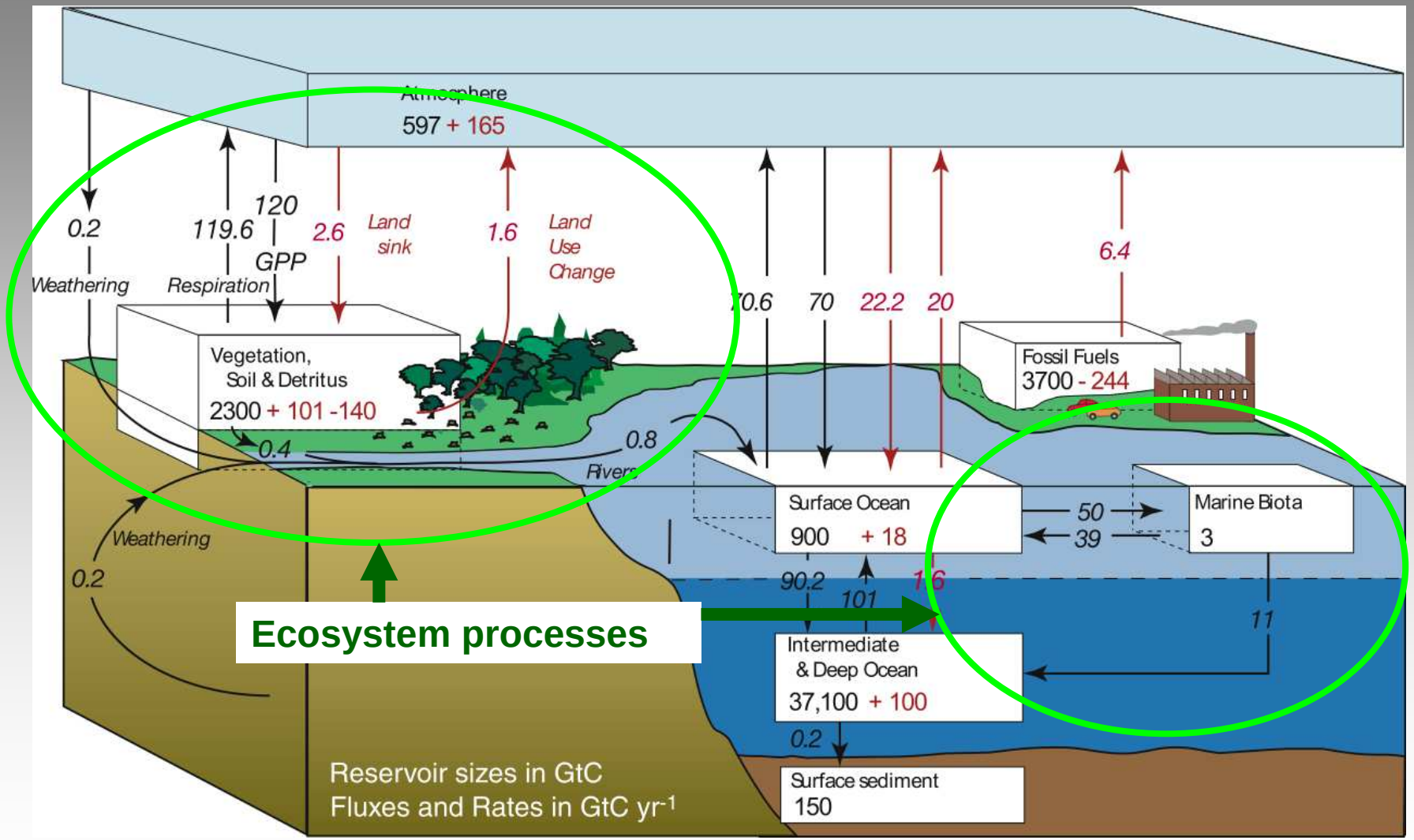
Europe*

- 1-30
- 31-100
- 101-800
- 801-1200
- 1201-7500

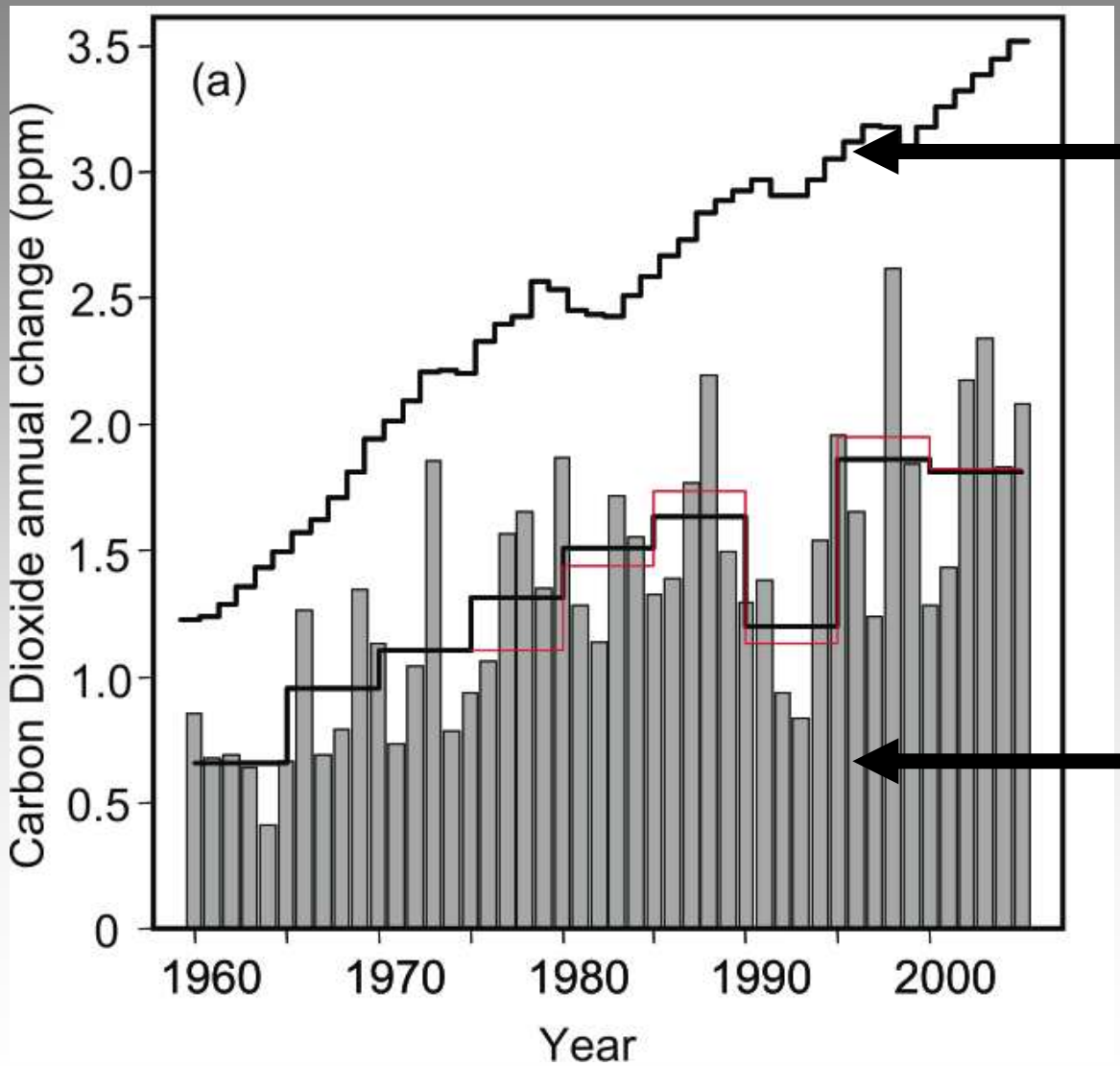
Temperature change °C 1970-2004

-2.0 -1.0 -0.2 0.2 1.0 3.5

The global carbon cycle: roles of land and marine ecosystems



Land ecosystems and oceans are buffering us from the full effects of our CO_2 emissions



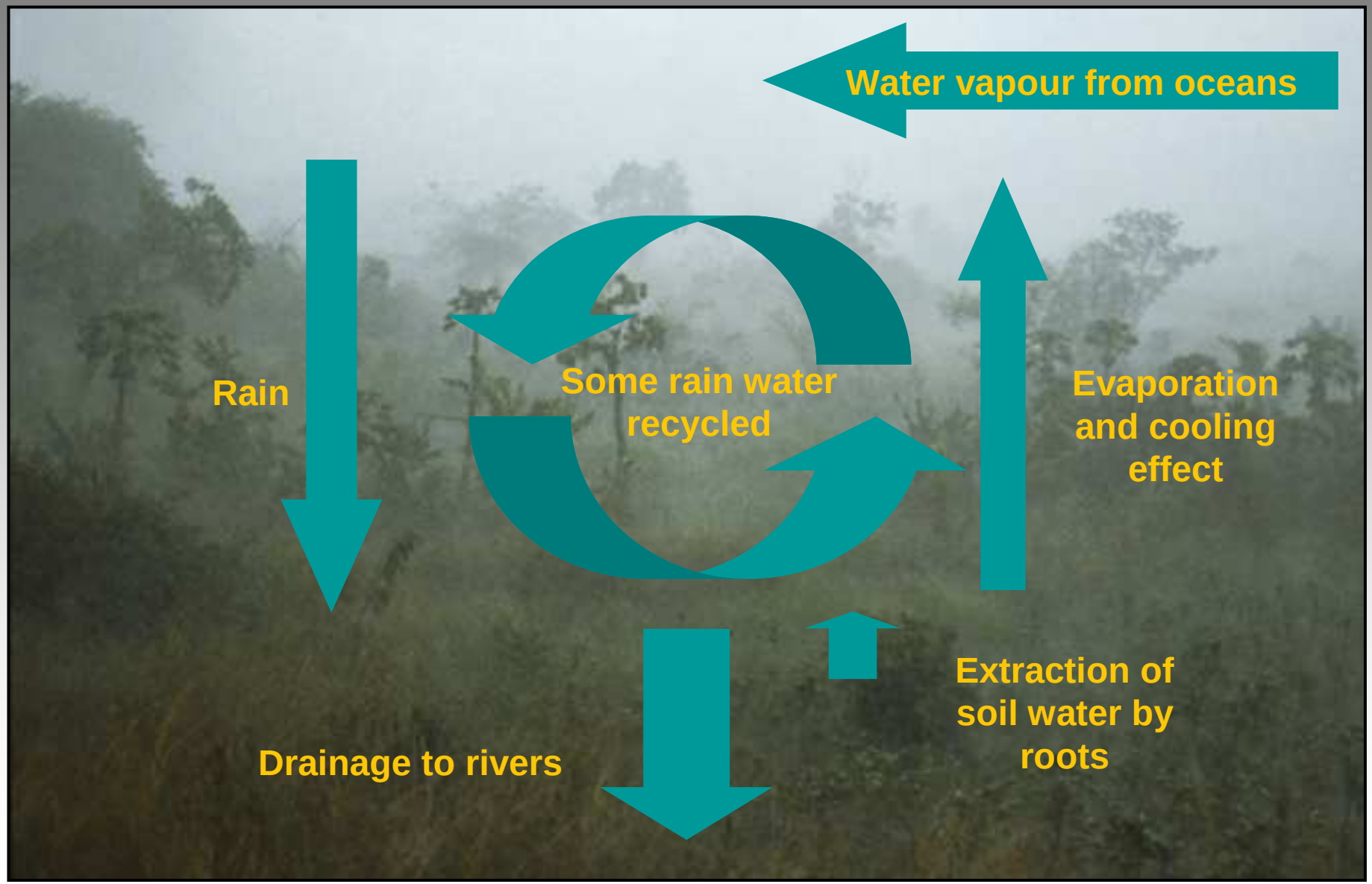
Annual rise in atmospheric CO_2 that would occur if all fossil fuel emissions remained in atmosphere

Actual observed annual rise in CO_2 (about 60% of emissions)

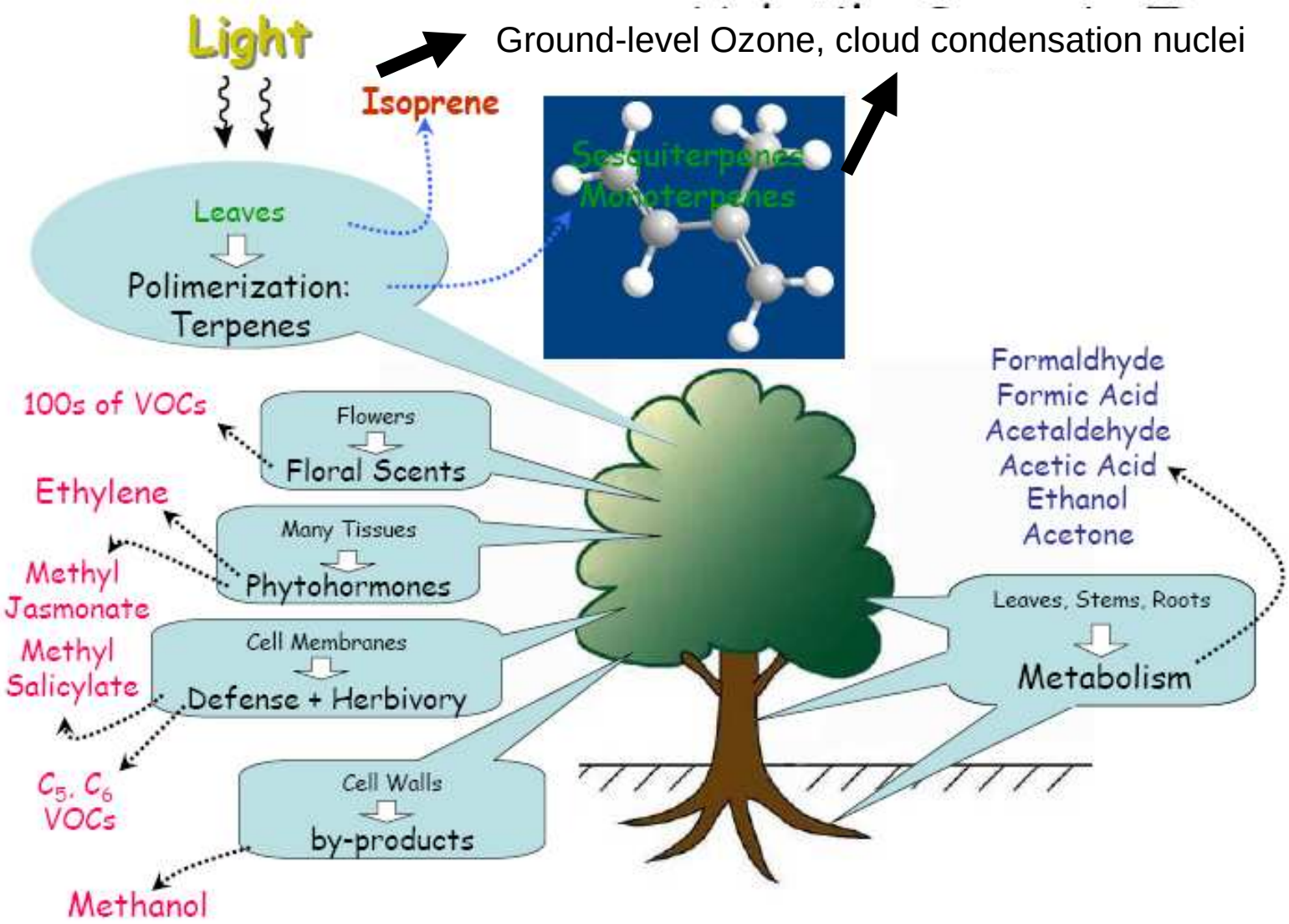
Role of boreal forests in climate: surface albedo (absorption of solar radiation)

Photo: Tim Hewison

Role of rainforests in local climate: recycling rain water and cooling via evaporation

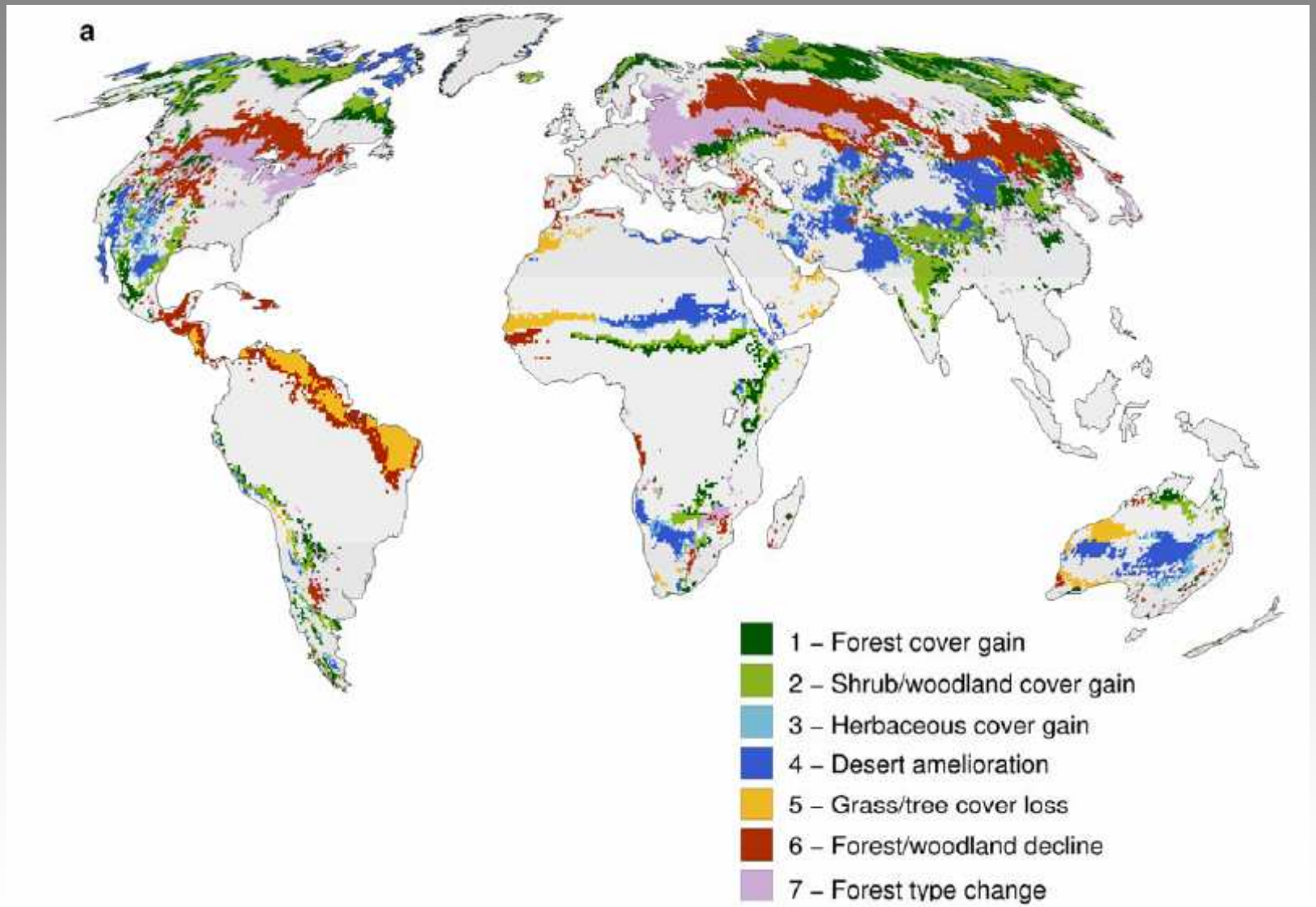


Ecosystems and atmospheric chemistry

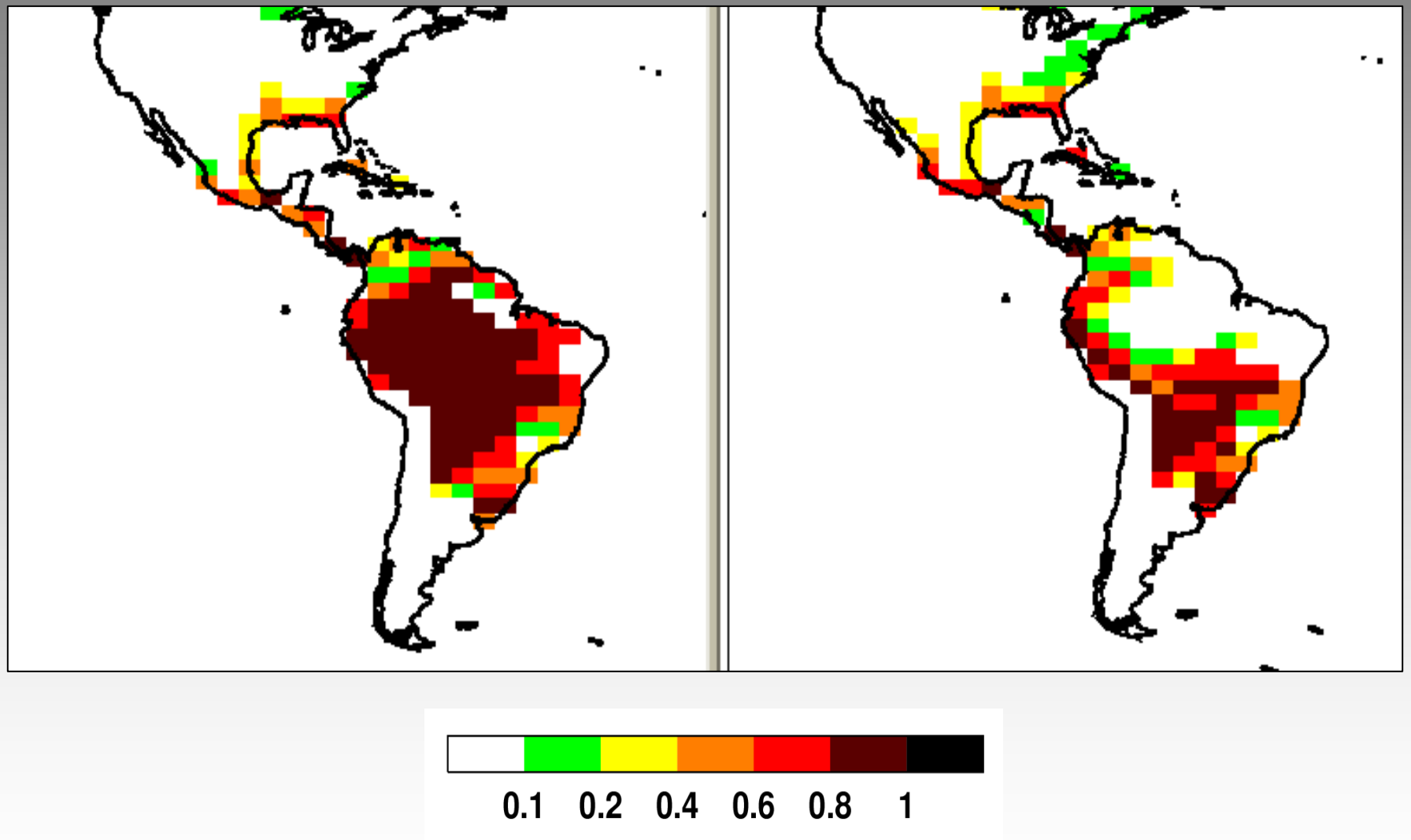


Modified from *Fall, R.*, University of Colorado, Boulder at http://www.rfall.net/

Projected changes in major land ecosystems (1 climate model, 1 ecosystem model)

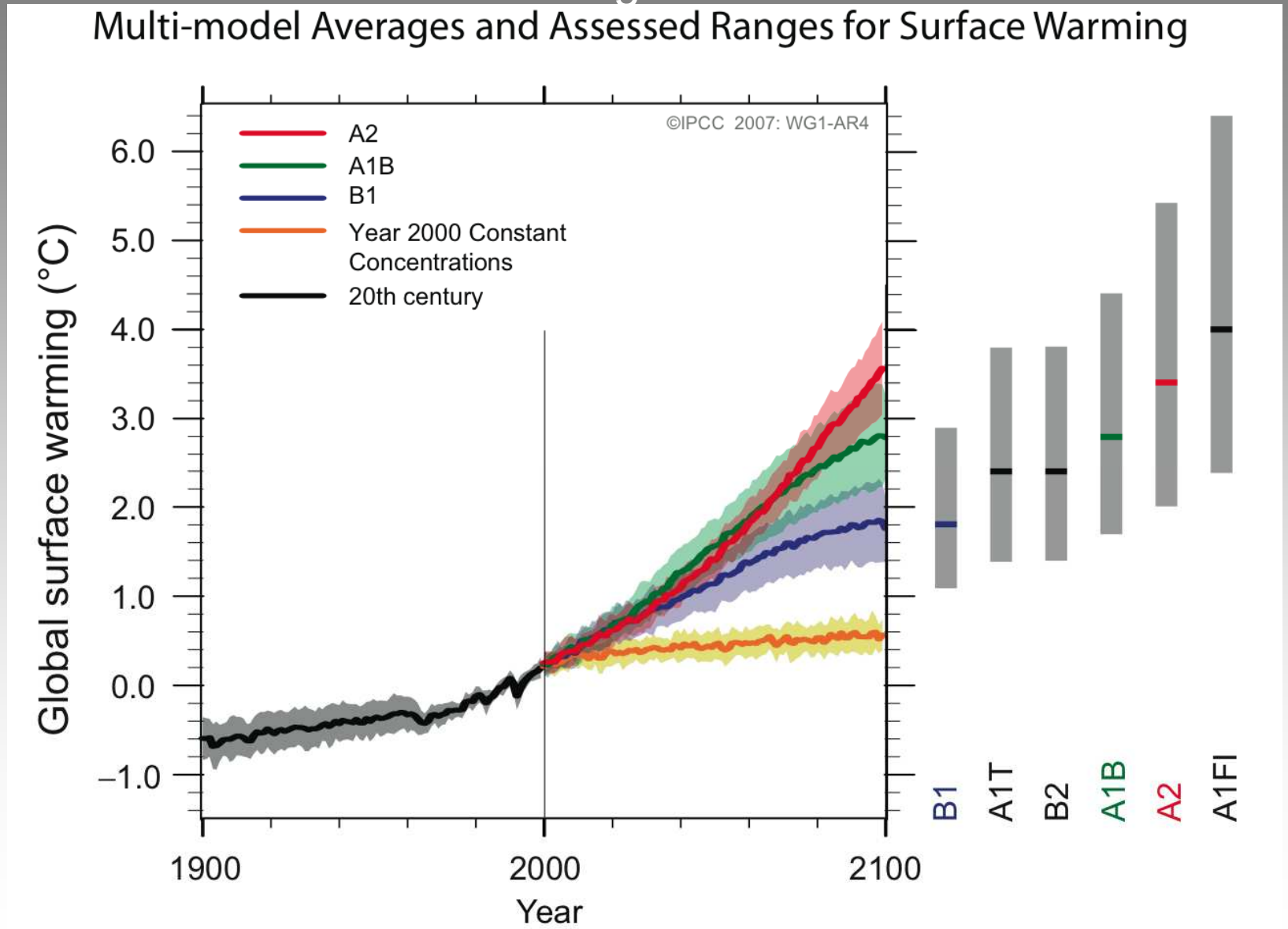


Projected changes in South American forest cover (Hadley Centre climate – vegetation model)

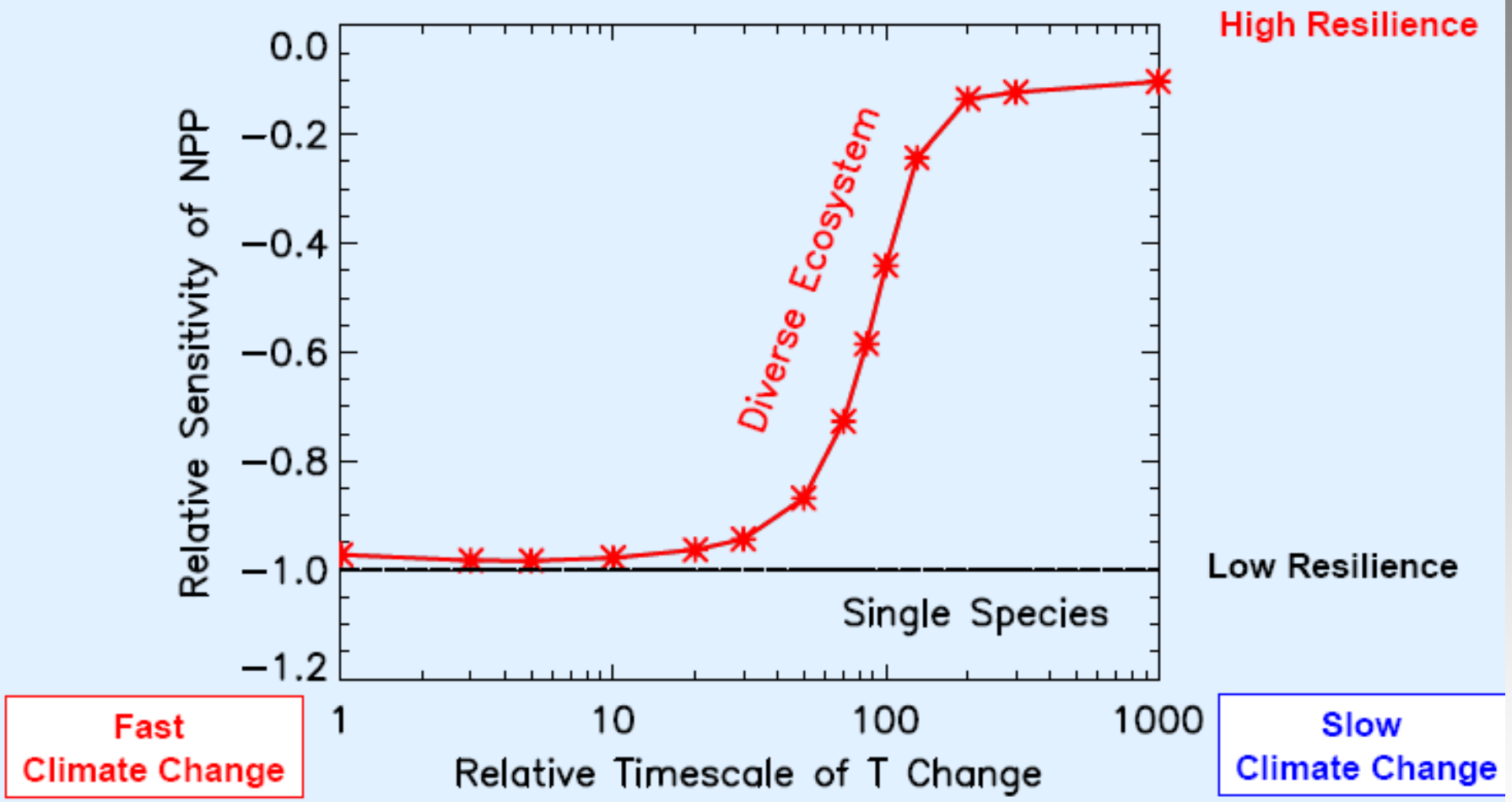


Fraction of land covered by forest

Ecosystem feedbacks and uncertainties in future climate change



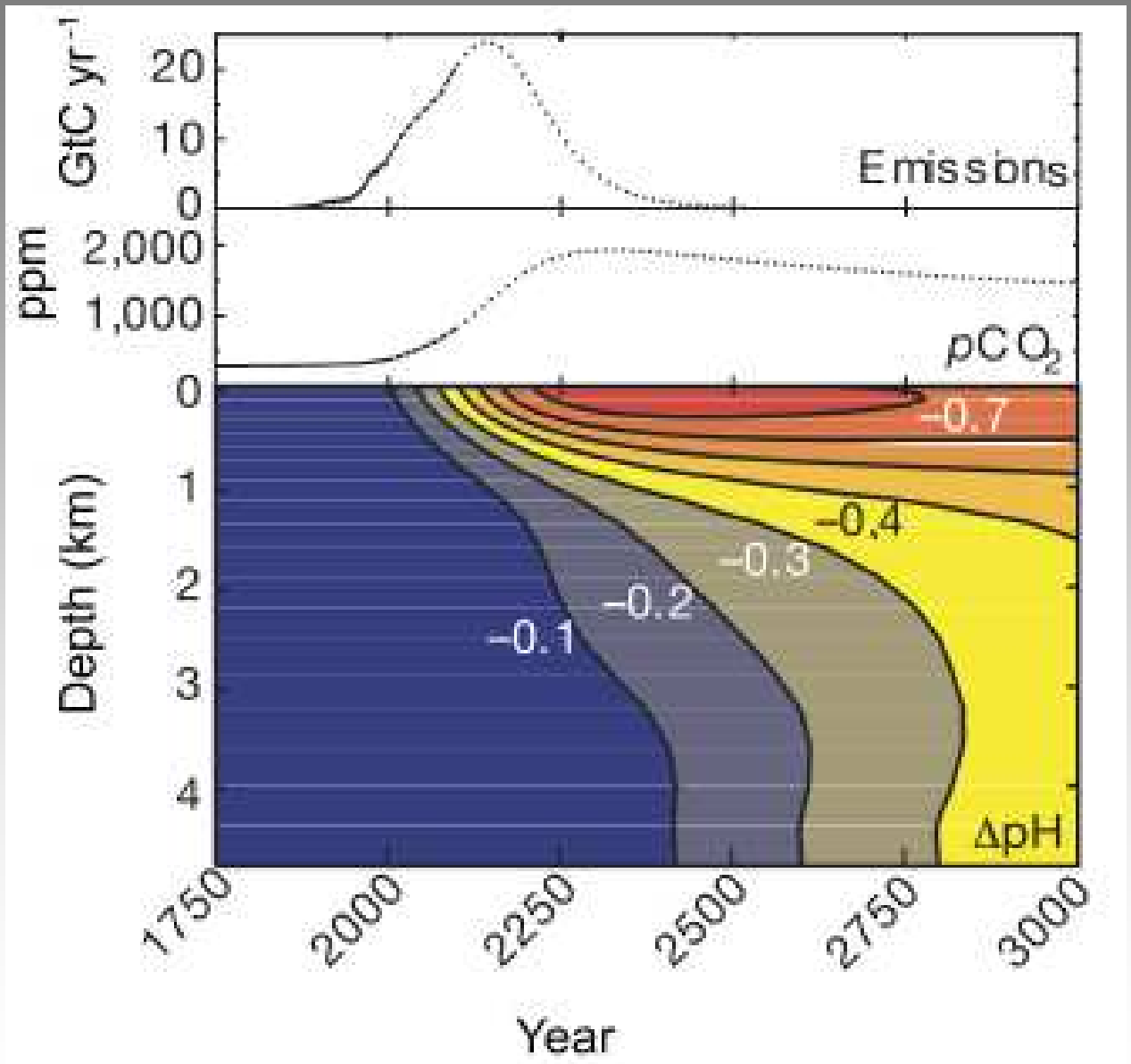
Diversity leads to greater resilience (i.e. less sensitivity) to climate change…



…but only if the climate change is slower than the ecosystem adaptation timescale

P. Cox

Ocean acidification by rising CO_2



Research priorities

- Need internationally strategic approach - biodiversity, climate, and human livelihoods research communities must work more closely together
- Research into the mechanisms of biodiversity-climate interactions is essential
  - Use palaeo-ecological information more to improve understanding of mechanisms
- Test the hypothesis that highly diverse systems are more resilient to global change
- Improve understanding of local and regional climate processes for informing climate change prediction and development of adaptation options.
- Improve understanding of impacts of climate change on biodiversity assessments
- Develop scenarios for impacts on biodiversity and ecosystem services - inform development of management priorities and identify potentially dangerous levels of biodiversity loss
- Focus research on climatically-important ecosystems where biodiversity is changing rapidly or at a large scale, or where there are major impacts on human livelihoods
- Test sensitivity of climate models to complexity of biological systems – requires more powerful and sophisticated climate models

Research priorities

- An internationally strategic approach is needed - biodiversity, climate, and human livelihoods research communities must work more
- closely together

- Research into the mechanisms of biodiversity-climate interactions is essential. Priority: testing the hypothesis that systems with high biological diversity are more resilient to global change than less diverse systems
-
- Focus research on ecosystems important in the climate system (eg peatlands) in areas where
- biodiversity is changing rapidly or at a large scale, or where there are major impacts on human livelihoods

- Use palaeo-ecological information more

- Test sensitivity of climate models to complexity of biological systems

- Improve understanding of local and regional climate processes for informing climate change prediction and development of adaptation options.

- Improve understanding of impacts of climate change on biodiversity assessments.

- More powerful and sophisticated climate models will be
- required to undertake this work.

- Develop scenarios for impacts on biodiversity and ecosystem services under different levels of
- climate change - inform development of management priorities and identify potentially dangerous levels of biodiversity loss.

Climate change

- Climate change is now unequivocal and is very likely to be caused by humans
- Future climate changes are projected to be outside the historical range of climate variability in which many species have evolved
- Impacts on biodiversity – “canaries in the cage” that climate change may be dangerous for us
- Ecosystem change as driver of climate change (carbon emissions, change in rainfall)
- Ecosystem feedbacks on climate change
- Potential importance of biodiversity in maintaining ecosystem resilience of climate change –impacts on ecosystems, also feedbacks to climate change– but need to know more

Ecosystem services

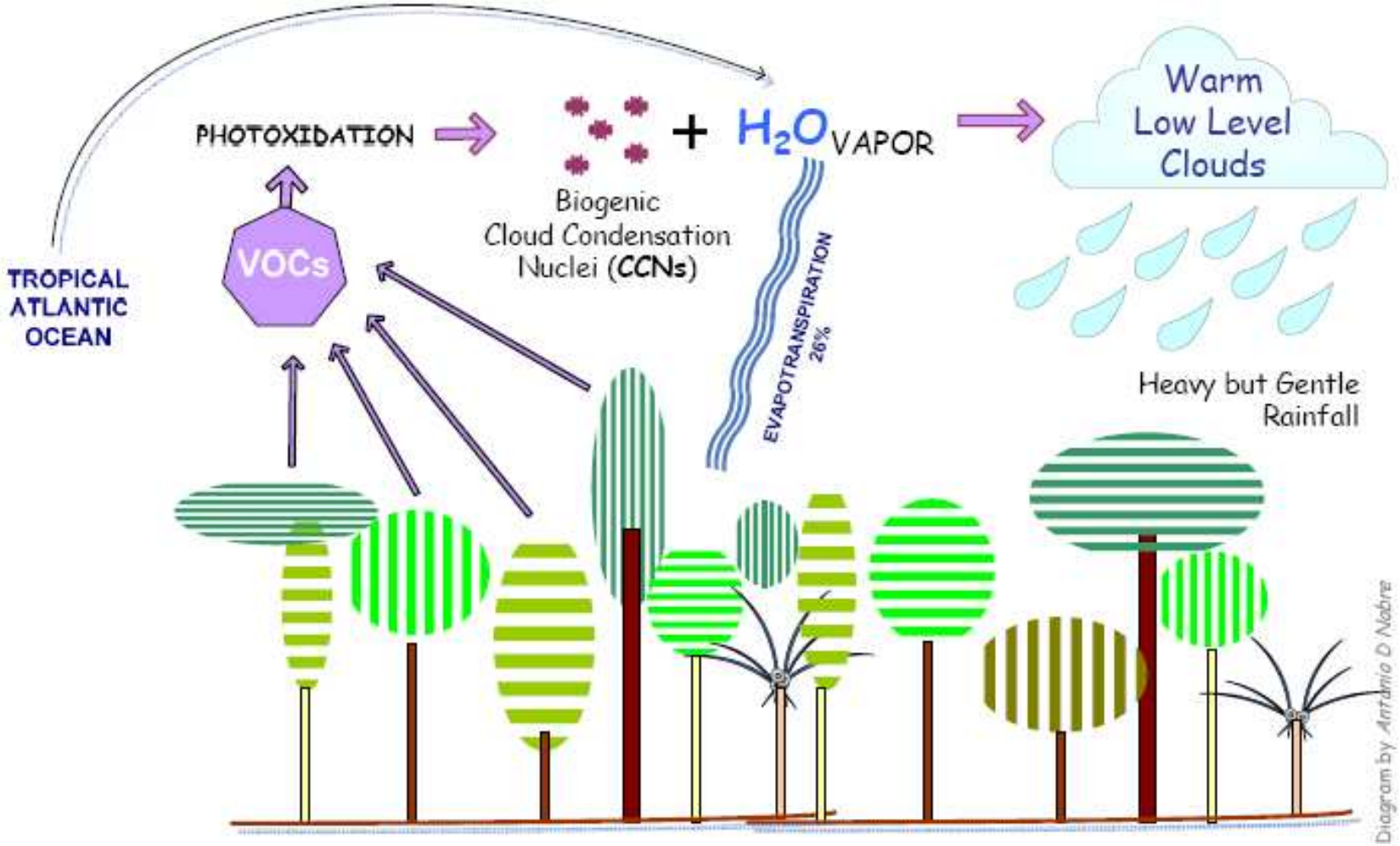
- Ecosystem services
  - Intrinsic value of biodiversity
  - Other services mostly indirect via provisioning services (food supply…) and insurance services (climate – evaporation, carbon sinks, BVOCs and rainfall…)
- Need to know much more about role of biodiversity in these
  - eg; role of different ecosystem types (pristine forest, monocultures, bamboo, etc) on climate processes such as carbon cycle, BVOC emissions

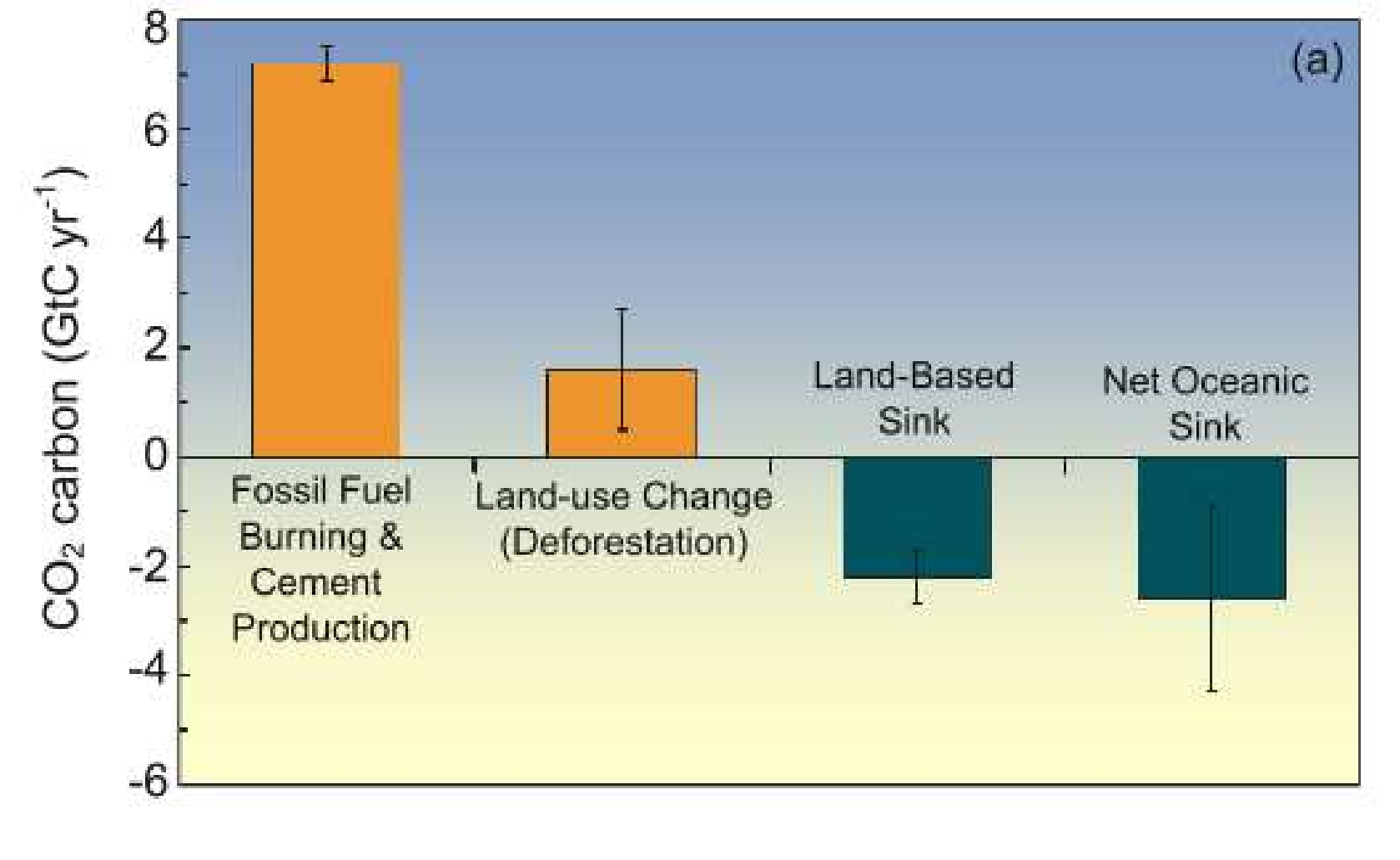
Ecosystem change

- Many direct and indirect drivers of change in ecosystems (one of which is climate change)
- Last generation of biologists to study natural systems?
- General large erosion of Earth's natural capital, with negative consequences
- Society has largely benefited so far, but erosion of capital is unsustainable
- Expect effects on livelihoods, often (but not always) detrimental
- Again, need to know more about actual role of biodiversity in these

RAINFALL MECHANISM IN AN UNDISTURBED RAINFOREST [MODEL]

CLEAN ATMOSPHERE



based on results of LBA: Claeys et al and Andrea et al. *Science* 2004; Marengo et al 2004, 2005; others

Current sources and sinks of CO_2