Adaptation of forests to climate change

Andreas Fischlin

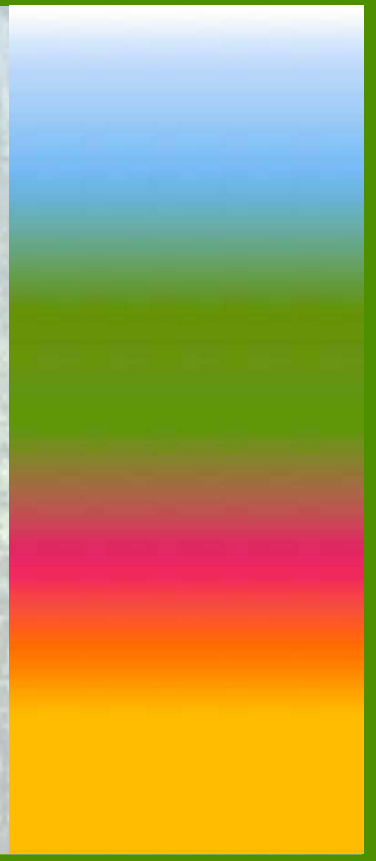
Coordinating Lead Author
Chapter «Ecosystems», WG II, Fourth Assessment Report IPCC

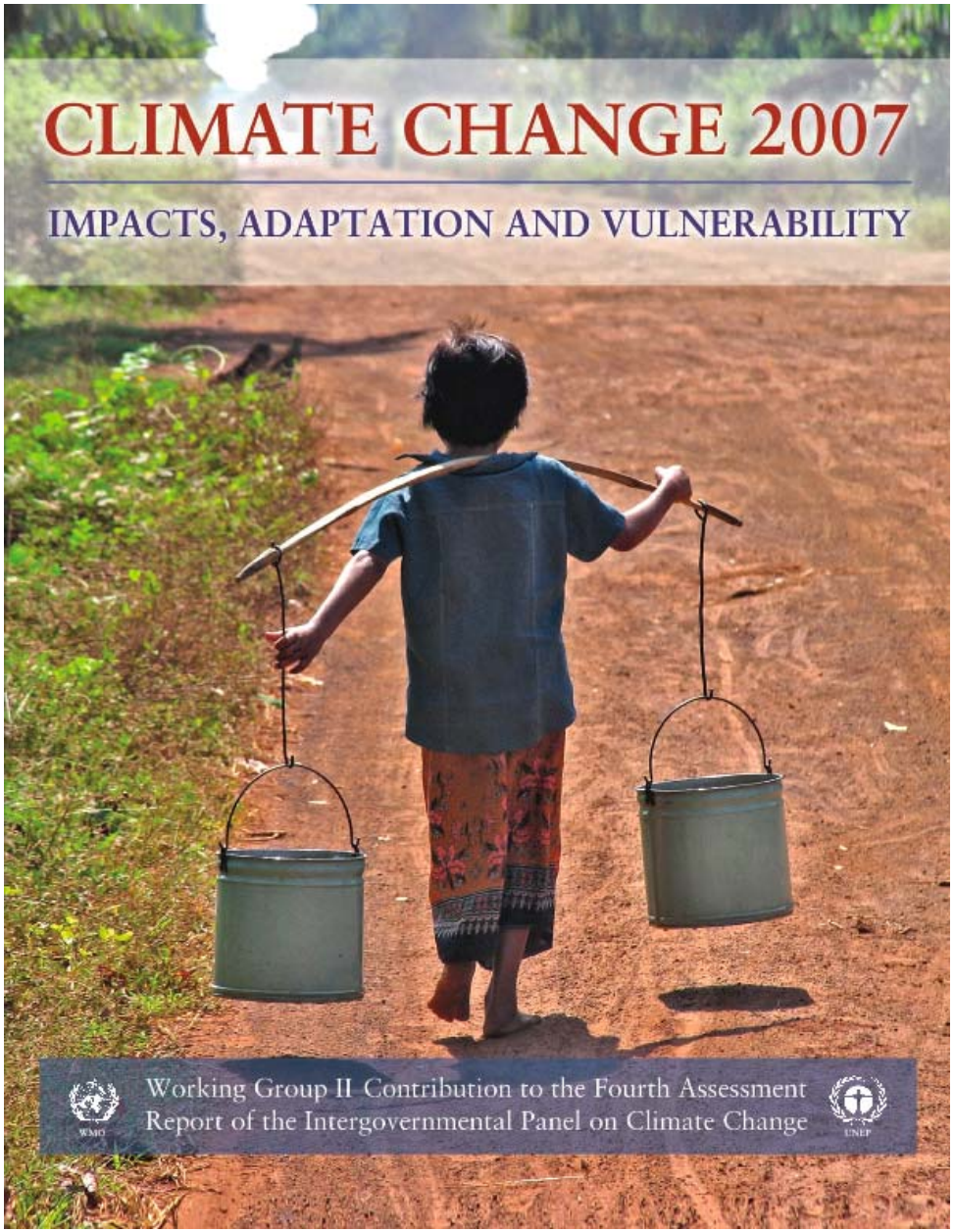
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Systems Ecology, Institute of Integrative Biology (IBZ), Environmental Sciences

Contents

1. **Current climatic trends**
2. **Future climate change**
3. **Impacts on forests**
4. **Adaptation and forests**
5. **Conclusions**





Working Group II - Fourth Assessment Report of IPCC

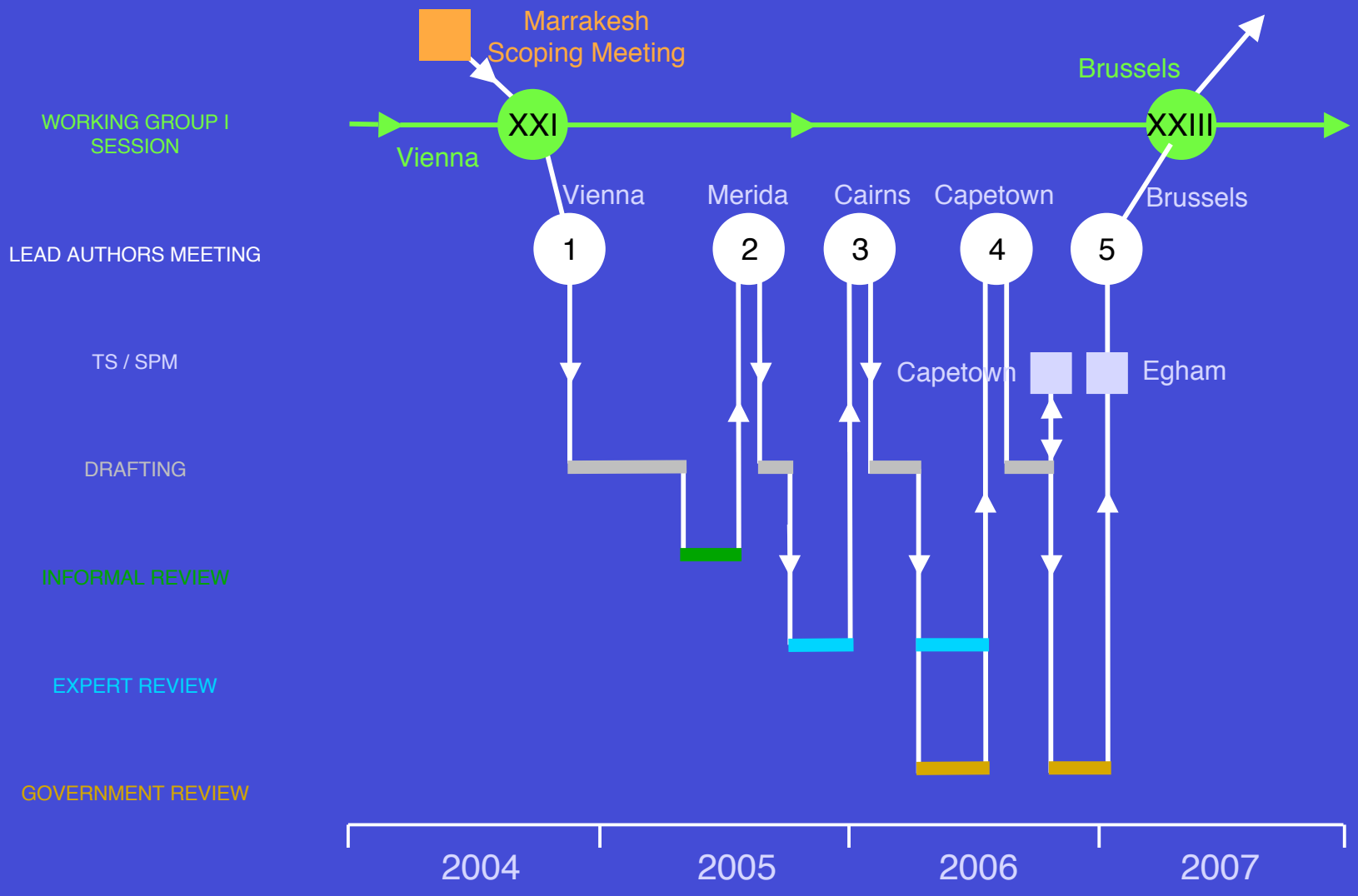
- 48 coordinating lead authors
- 173 lead authors
- 356 authors
- 45 review editors
- 910 expert reviewers
- 4 years work
- 70 countries
- 1 technical support unit (~10 experts)

IPCC Assessment Report 4 WGII, Chapter 4

«Ecosystems, their properties, goods, and services»

- 2 CLAs: Andreas Fischlin, Guy F. Midgley
- 8 LAs: Jeff Price, Rik Leemans, Brij Gopal, Carol Turley, Mark Rounsevell, Pauline Dube, Juan Tarazona, Andrei Velichko
- 19 CAs with outstanding conributions from Jacqueline de Chazal and Rachel Warren
- 2 REs
- Hundred of expert reviewers, scientists etc.
- >3200 scientific articles reviewed
- 915 cited

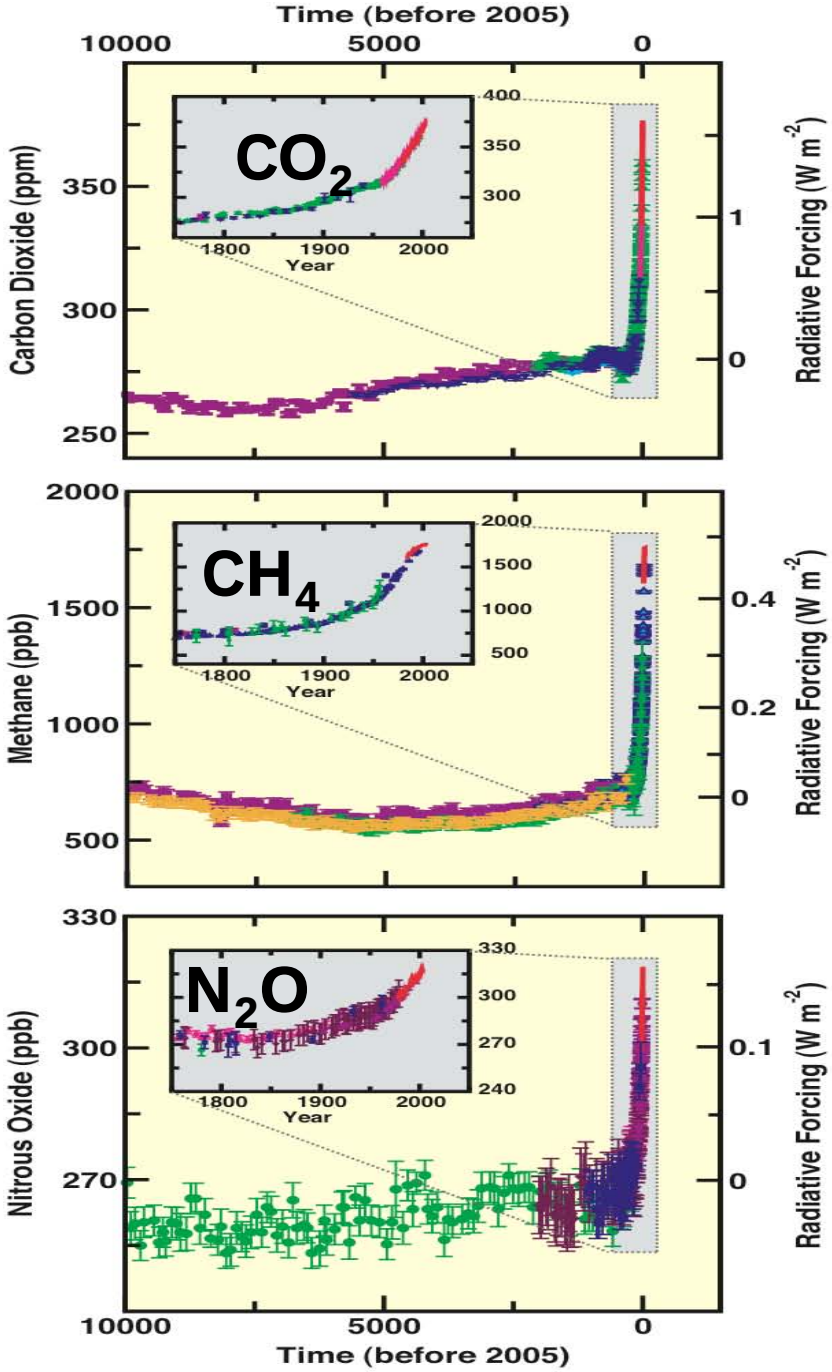
Key steps in preparation of Working Group II (science) component of Fourth Assessment Report



1 Current Climate Change Trends

Greenhouse Gases

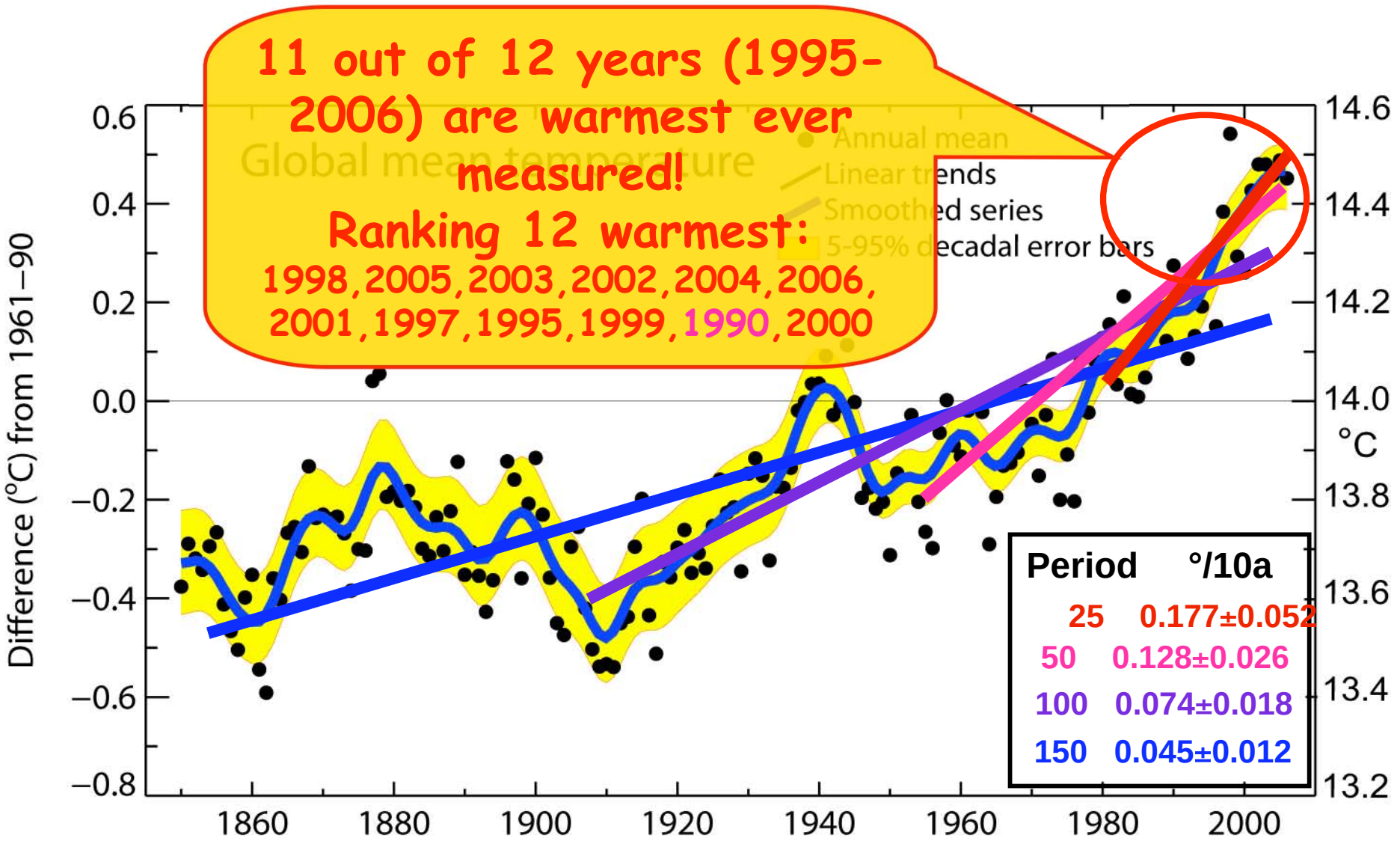
CO_2	Fossil fuels, Deforestation (Land use change)
CH_4	Livestocks, Landfills, Rice cultivation, Gas pipe leakages
N_2O	Fertilisation
CFCs etc.	Heat pumps, cleaning etc.



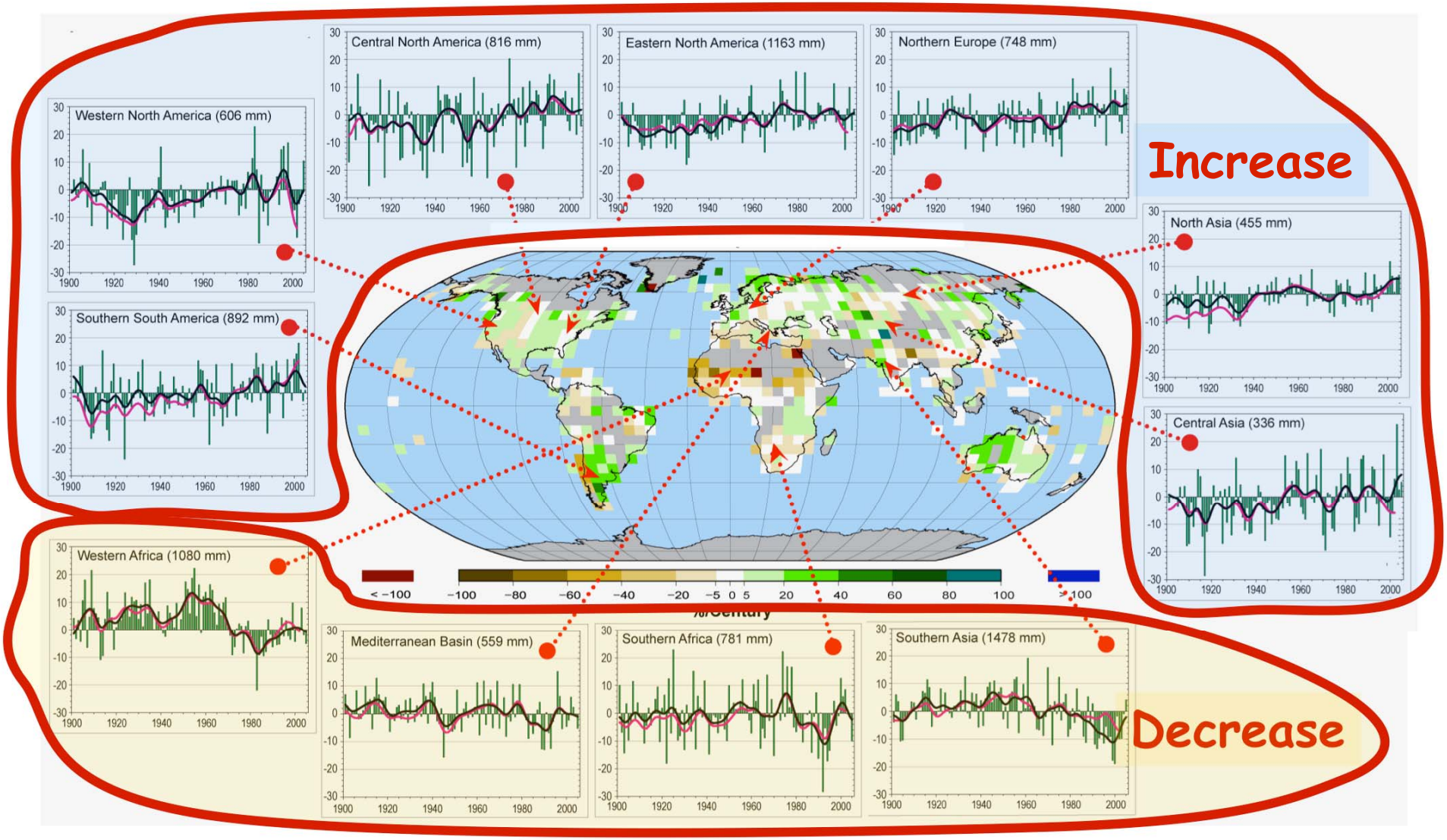
After Figure SPM.1 (IPCC, 2007. Summary for Policy Makers WGI)

Observed Temperatures

After Figure TS.6 (IPCC, 2007. Technical Summary WGI)



Changes in Precipitation (1900-2005)



Smoothed anomalies (%) over continents

After Figure 3.14 (Trenberth *et al.*, 2007. IPCC WGI)

2 Future Climate Change

The future can't be predicted…

…only projected!

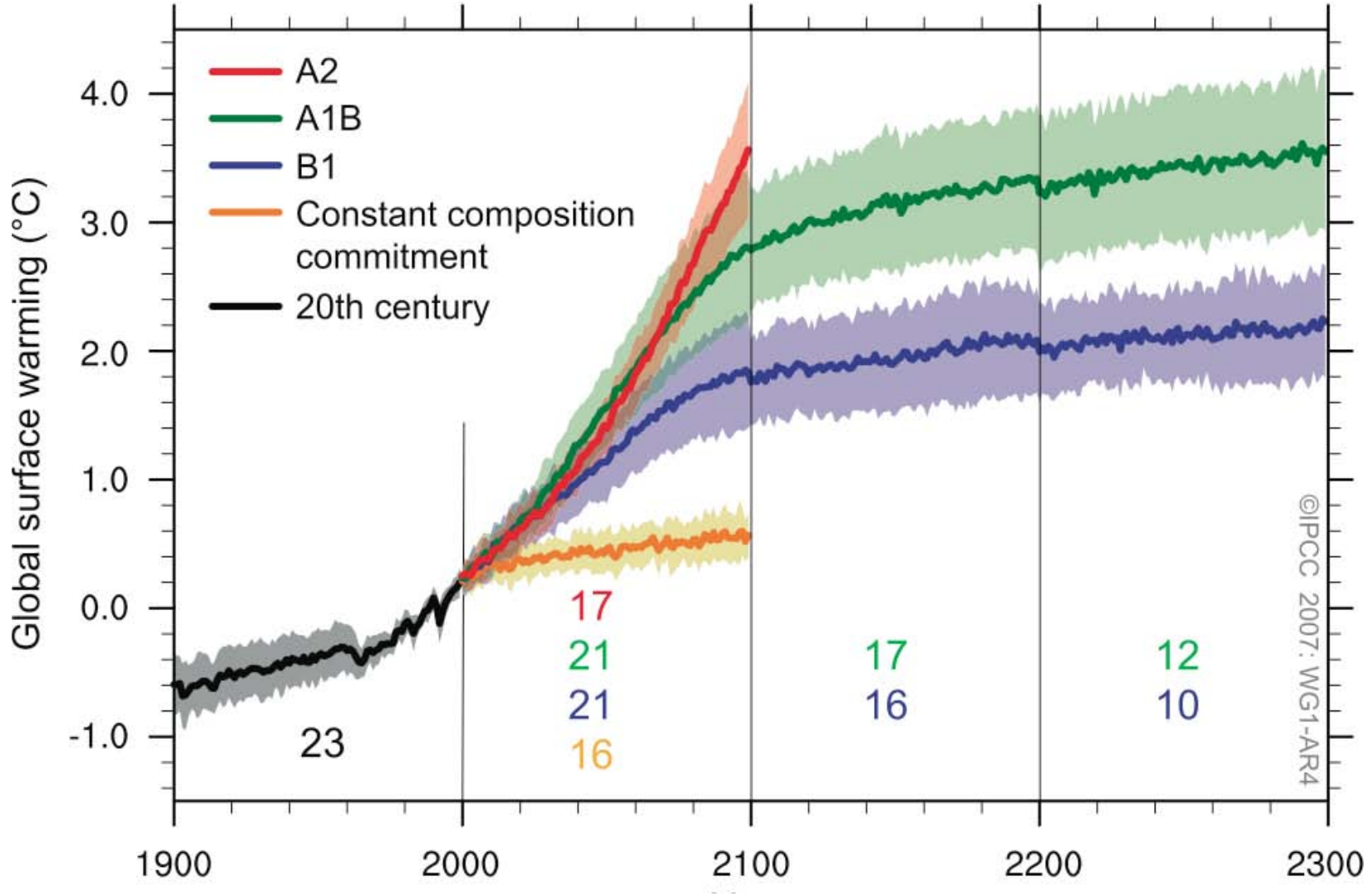


Figure TS.32: Multi-model means of surface warming (IPCC, 2007. Technical Summary WGI)

Scenario differences become more pronounced as we advance in time

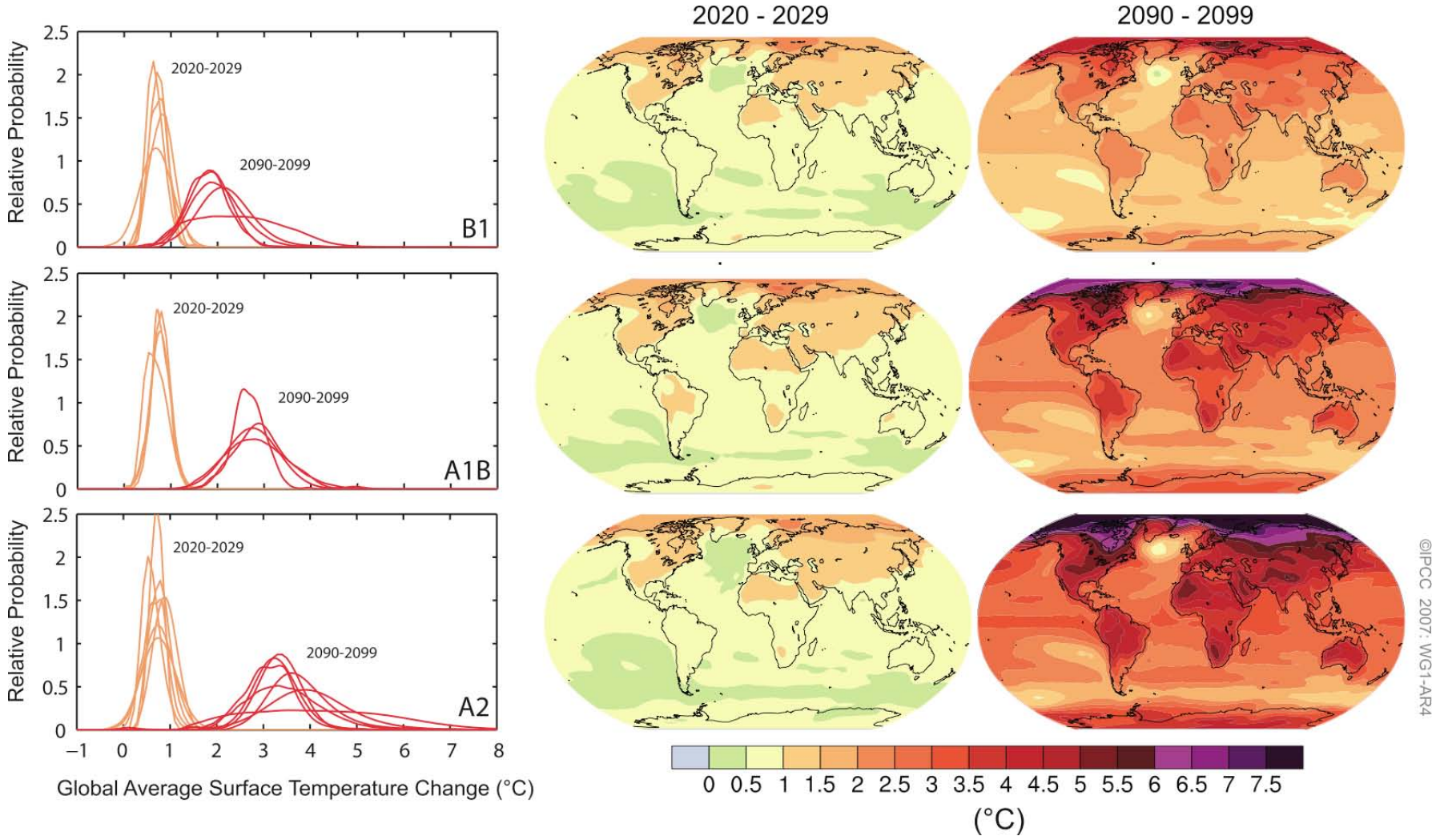


Figure TS.28: Projected surface temperature changes (IPCC, 2007. Technical Summary WGI)

Extremes and Growing Season

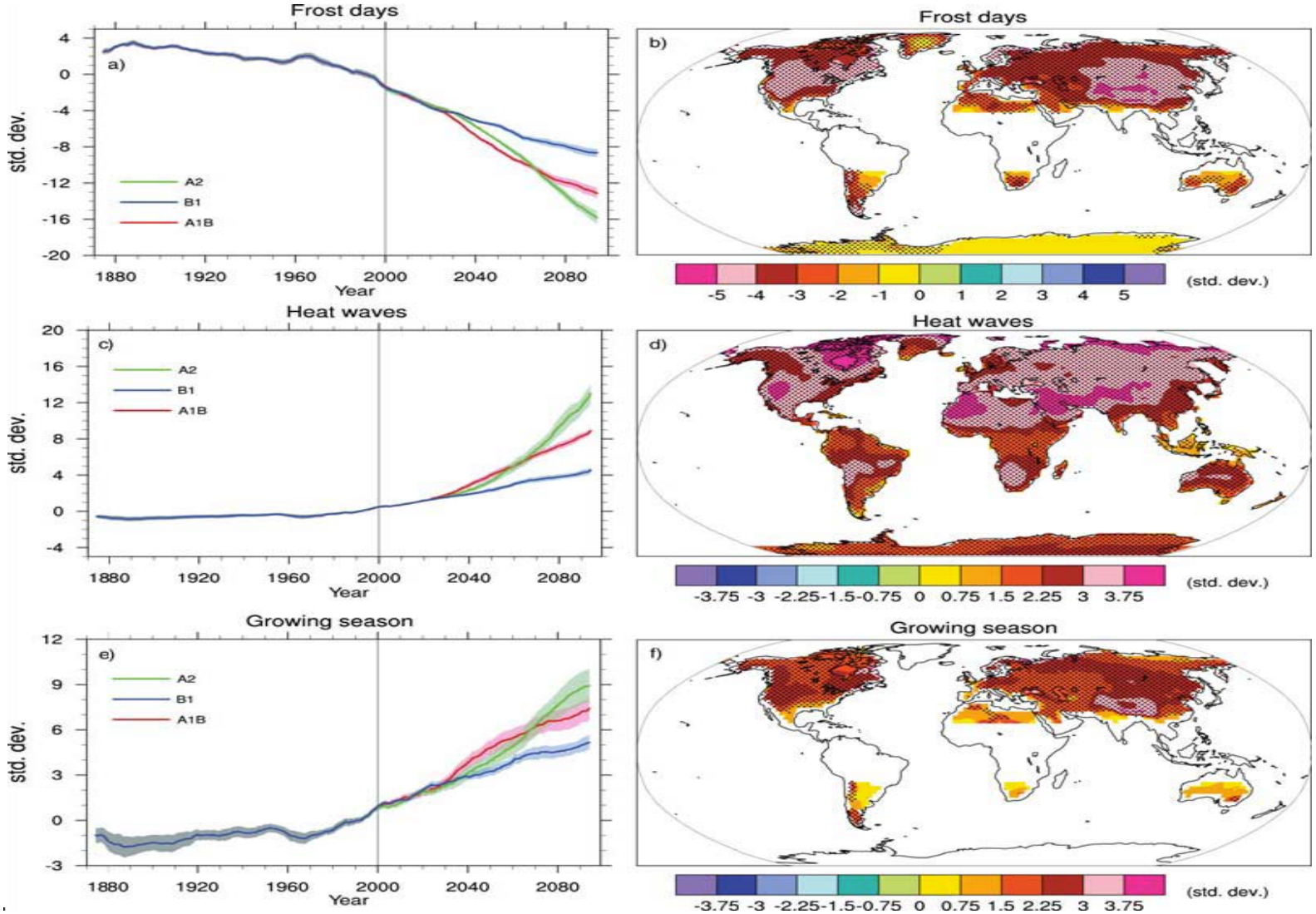
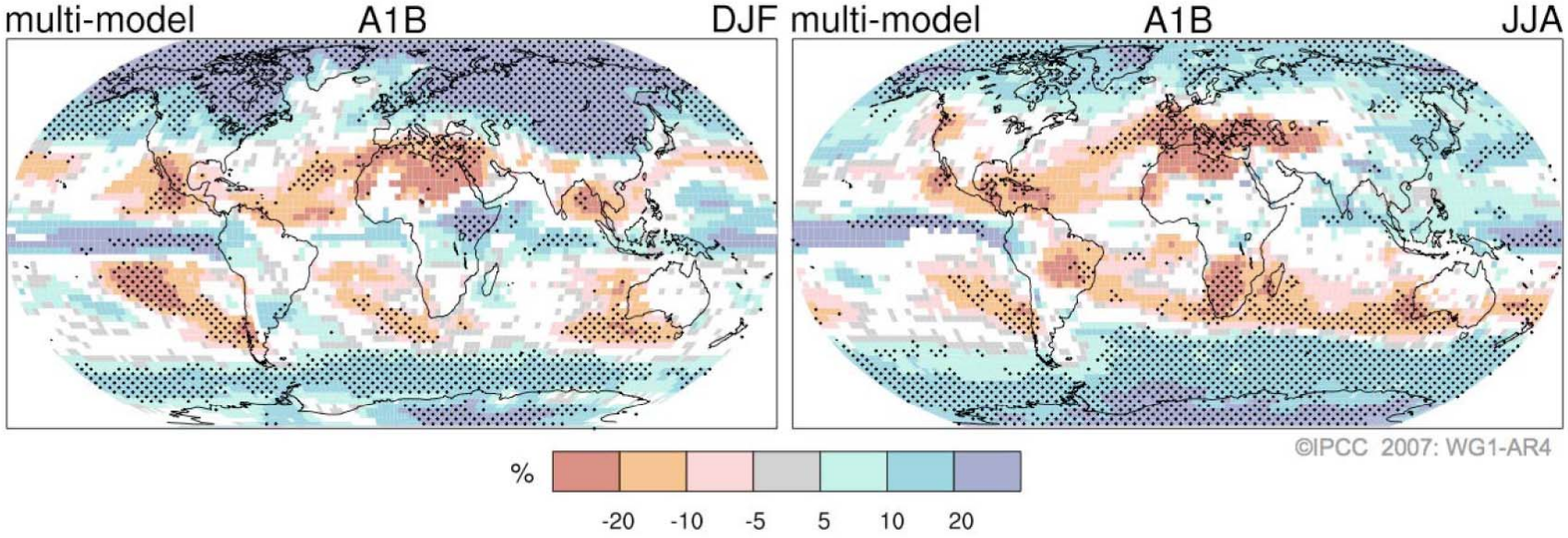


Figure 10.19: Changes in extremes - multi-model means (Meehl *et al.*, 2007. IPCC WGI)

Future: Changes in Precipitation



- Rain increases at high latitudes (*very likely*);
- Rain decreases at low latitudes (*likely*);

Figure SPM.7: Relative changes in precipitation 2090-2099 vs. 1980-1999 (IPCC, 2007. Summary for Policy Makers WGI)

Regional Projections - E.g T,R Europe

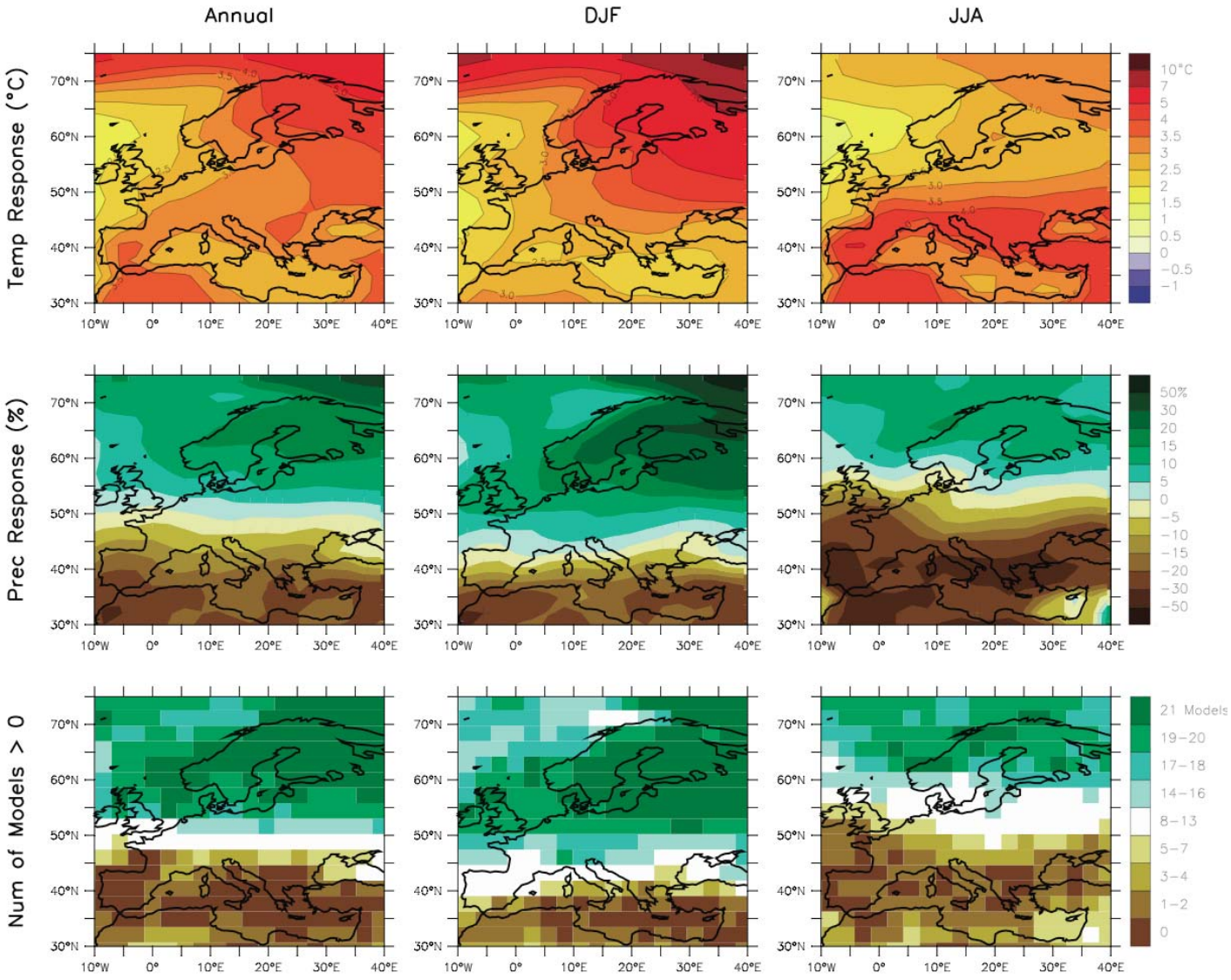
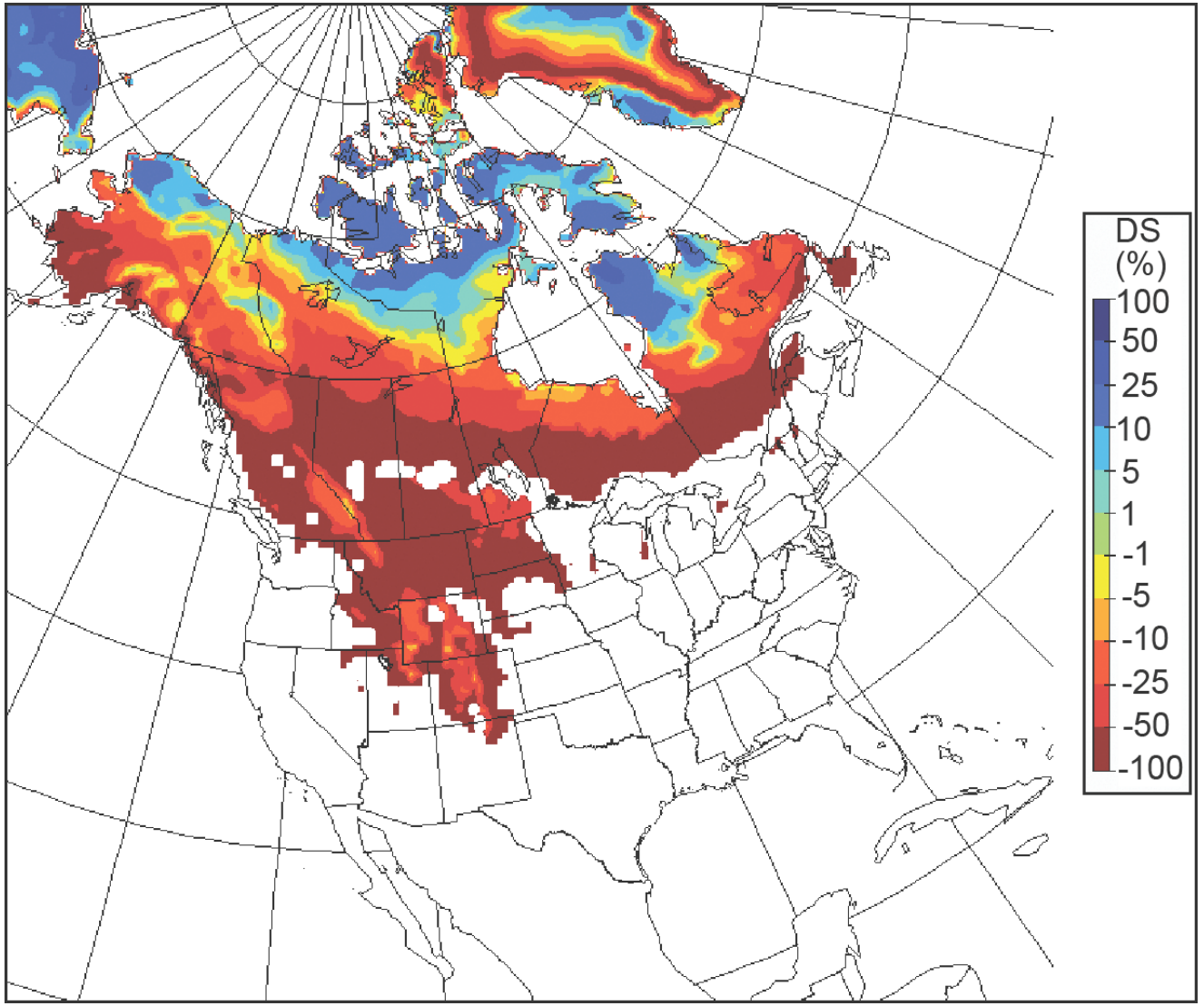


Figure 11.5: Temperature (T) and precipitation (R) changes over Europe (Christensen *et al.*, 2007. IPCC WGI)

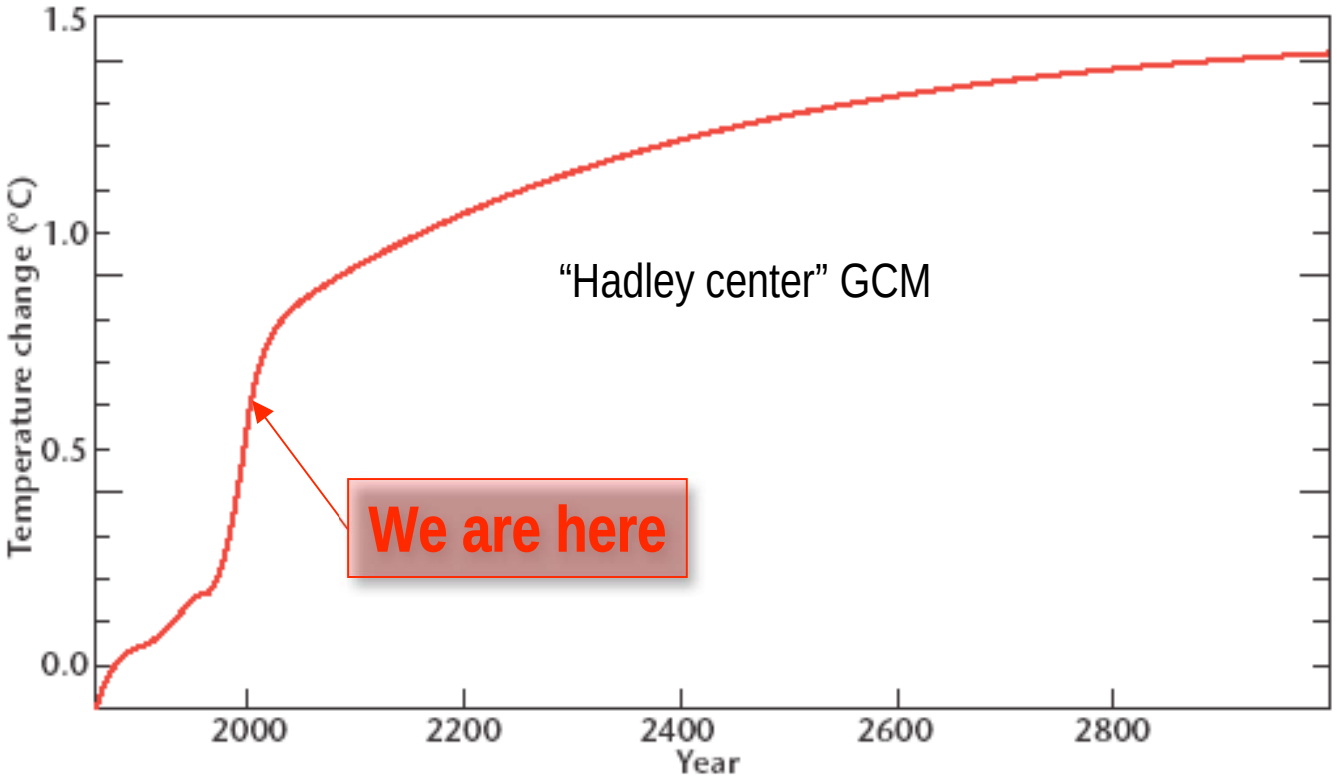
Regional Projections - E.g. Spring Snow



% Change in
snow depth
IPCC SRES A2
~2041-2070
relative to
1961-1990

Figure 11.13: Percent snow depth changes in March over North America (Christensen *et al.*, 2007. IPCC WGI)

Long term perspective - often overlooked - highly relevant for forests



The rise in global mean temperature following stabilisation of greenhouse gas concentrations at present-day levels.

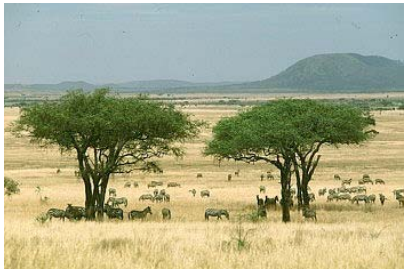
3 Impacts on Forests

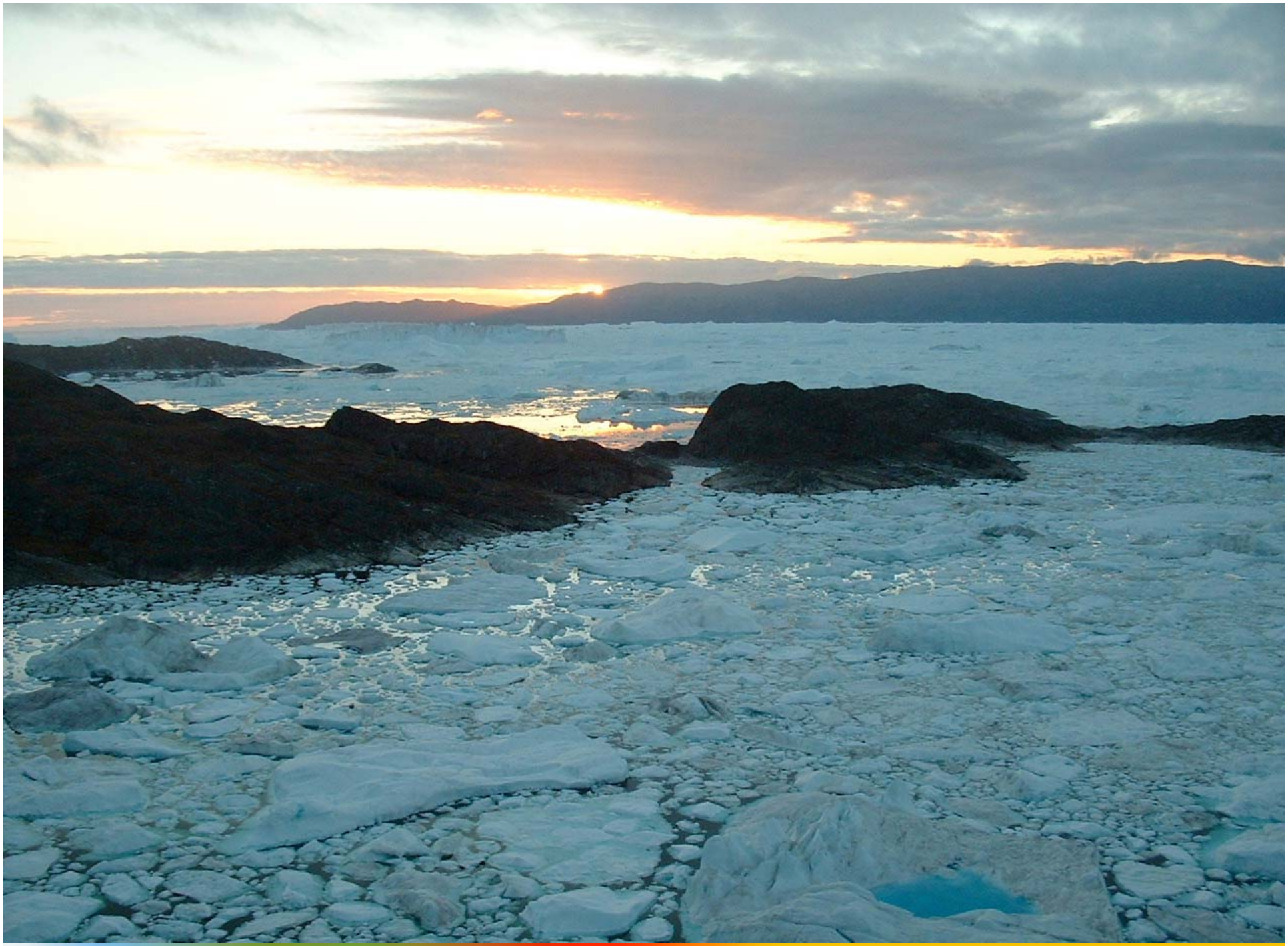
«Ecosystems

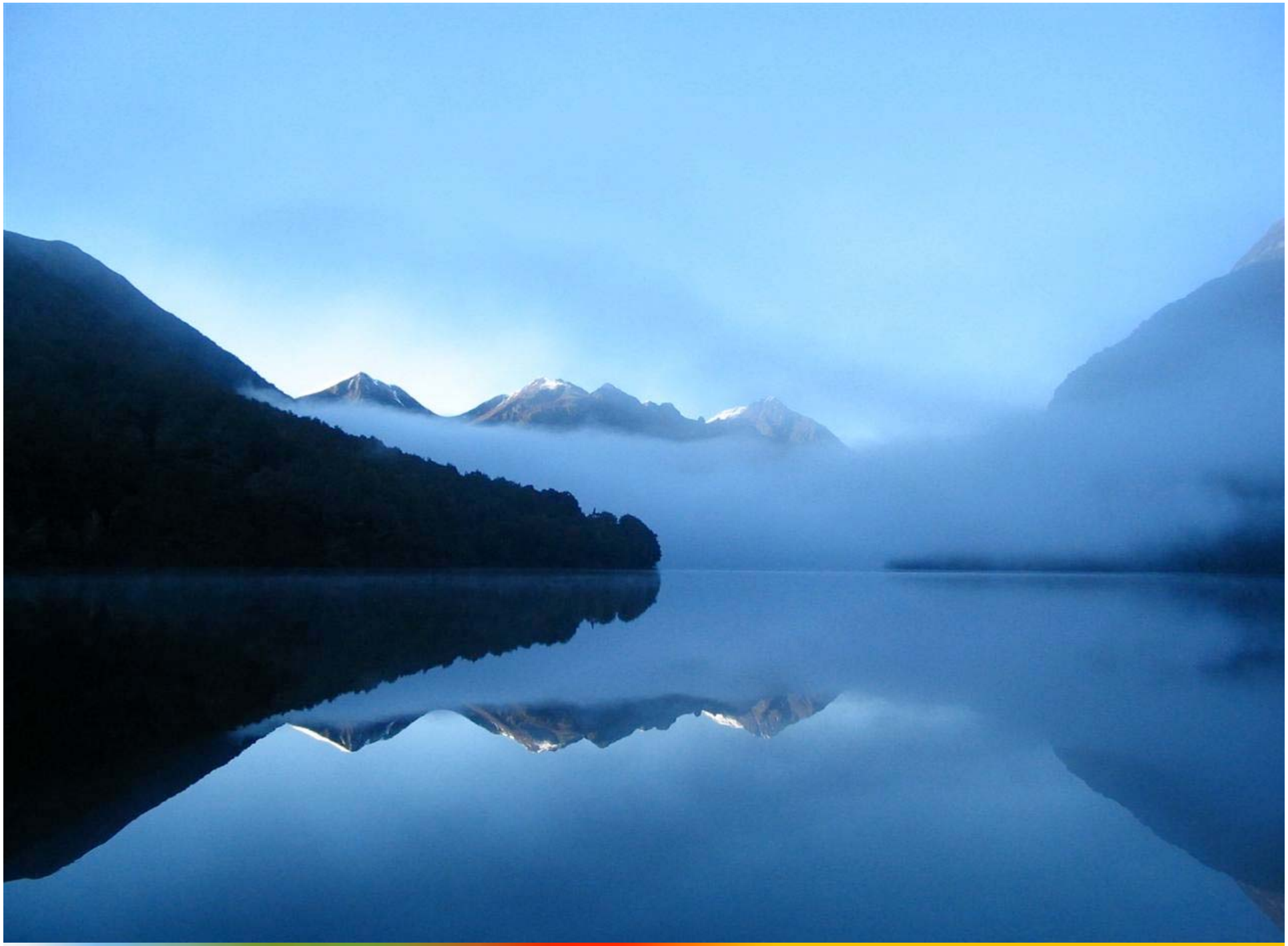
Their properties, goods and services» Fischlin *et al*., 2007. In IPCC WGII Fourth Assessment Report

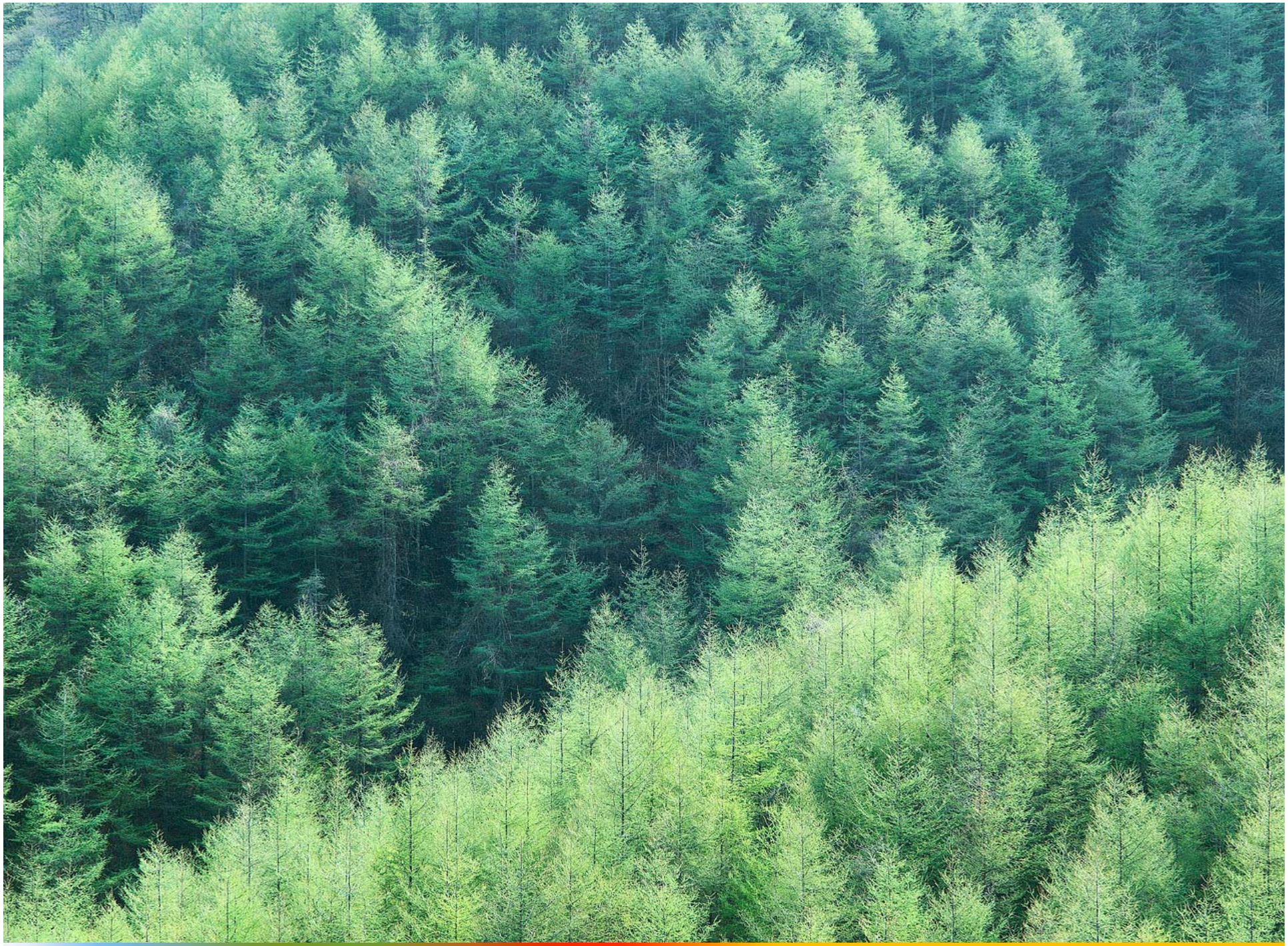










On the role of terrestrial ecosystems (including forests)

Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change.

(high confidence)

IPCC, 2007. SPM WGII, p.11

More Carbon Stored in Ecosystems

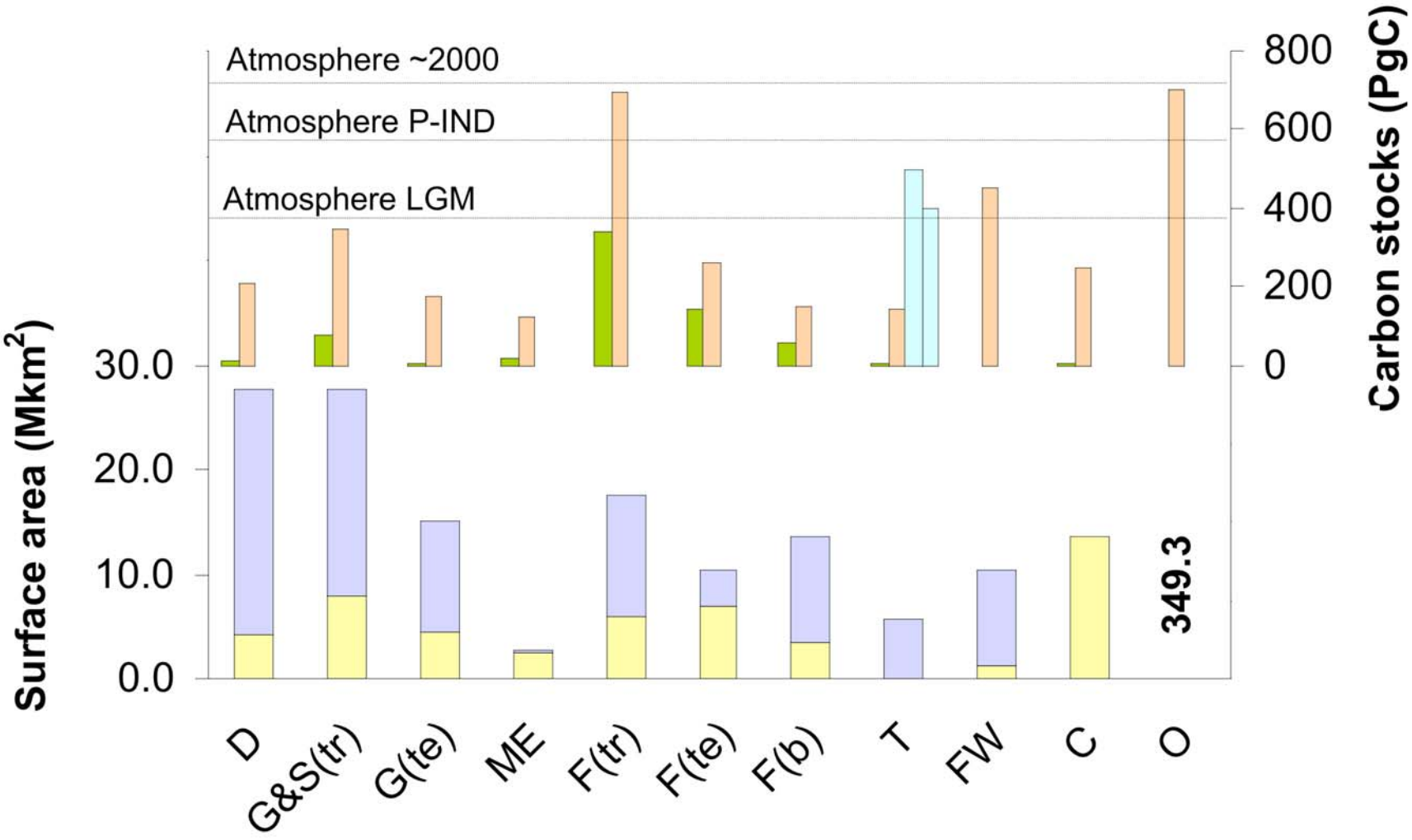


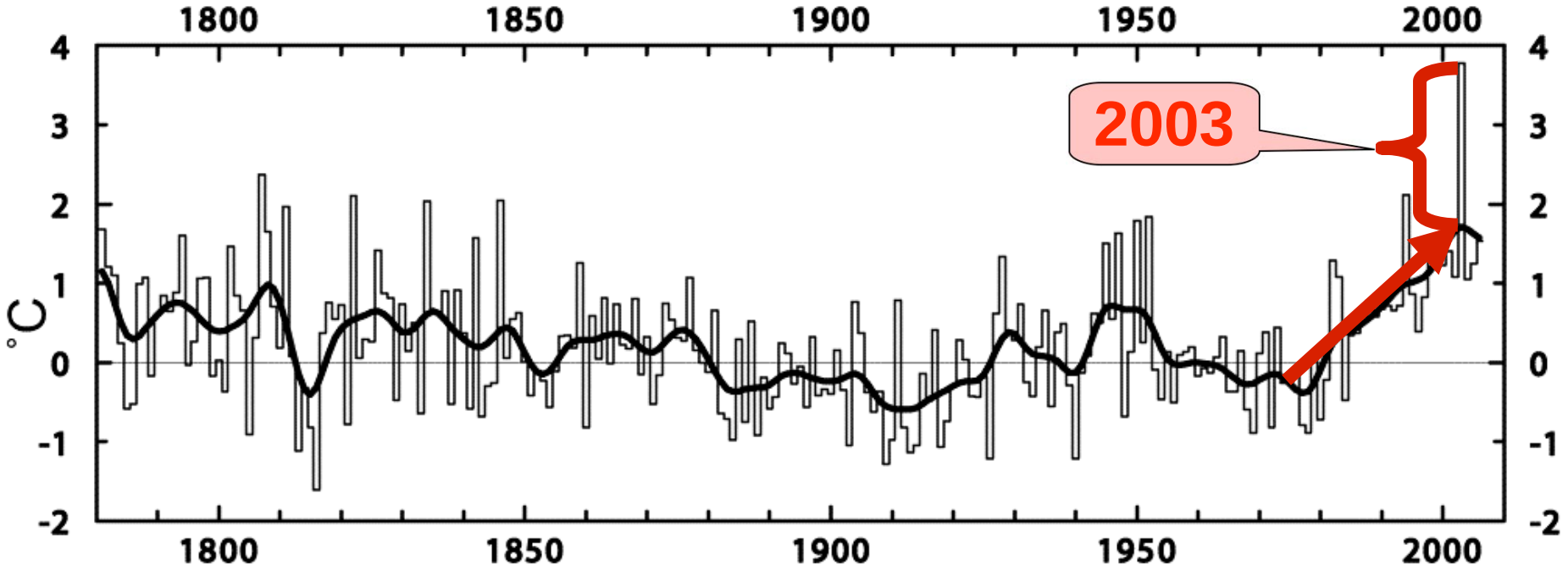
Figure 4.1: Ecosystems addressed - C stocks, areal extent (Fischlin *et al*., 2007. IPCC WGII)

More Carbon Stored in Ecosystems

Yedoma - in permafrost entrapped undecomposed organic material - 30,000 years old grass roots (Zimov *et al*., 2006)

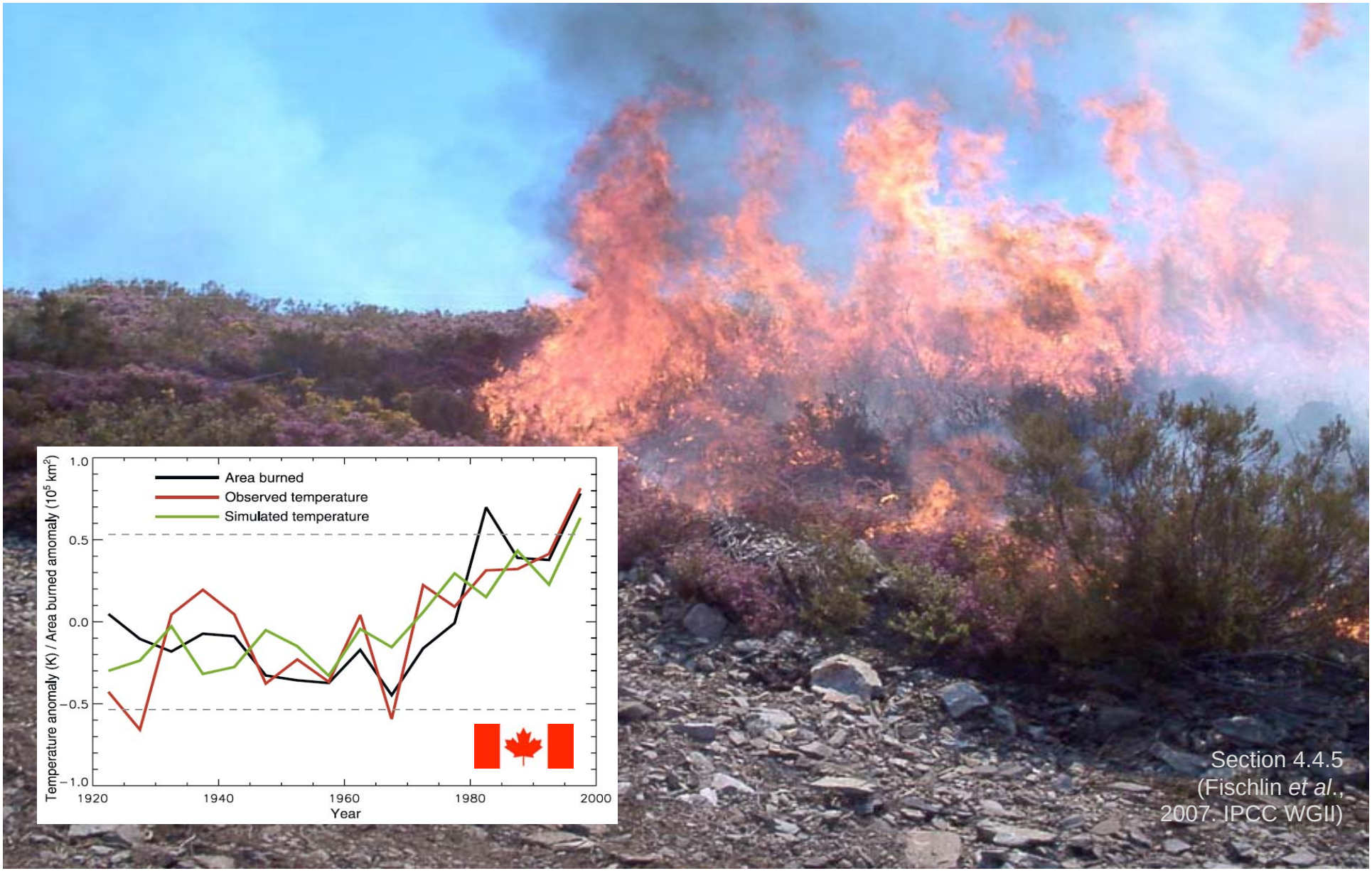

Relevance?

Heat wave trends - E.g. Europe



Anomalies from mean summer temperatures (JJA)

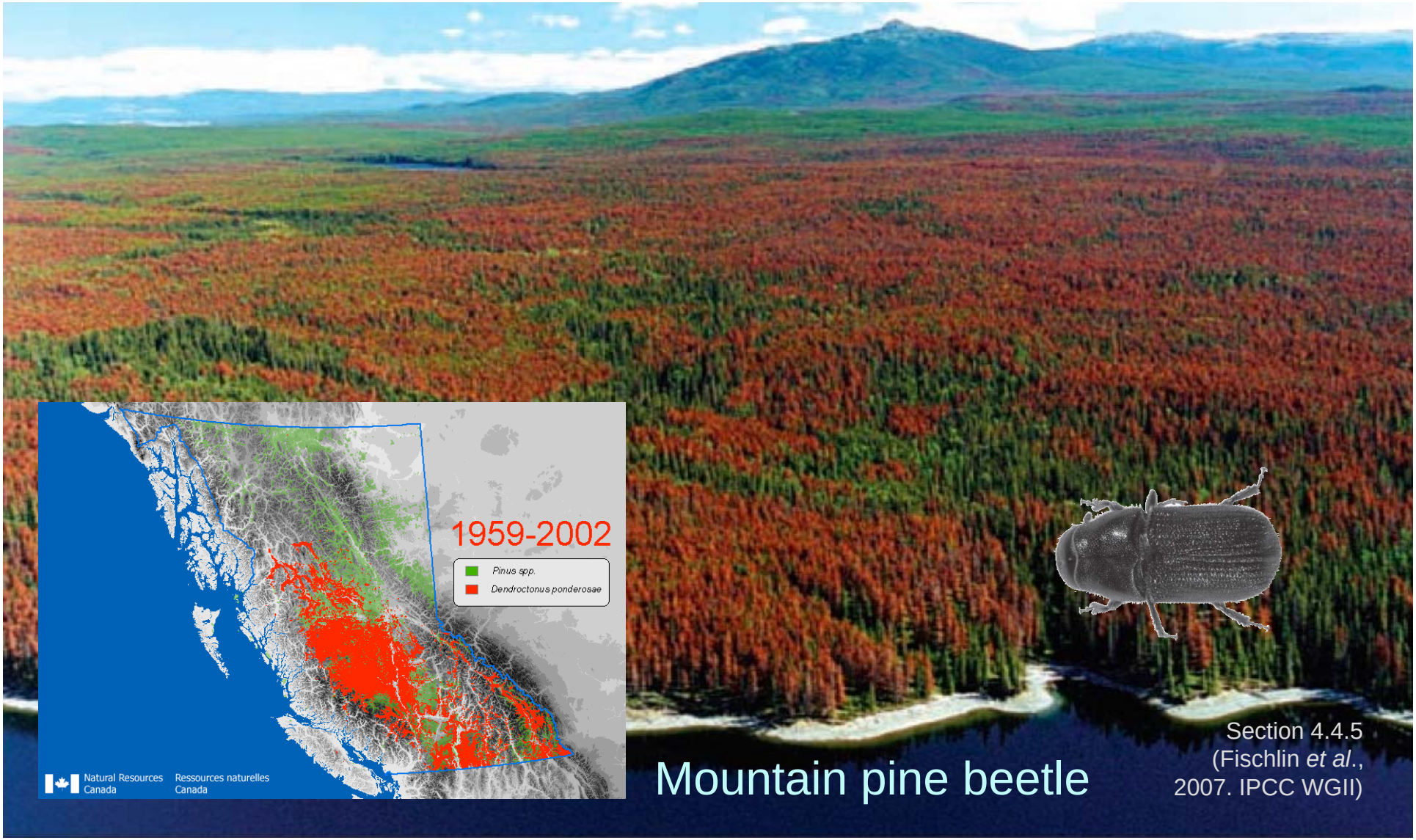
Increasing Trends in Fire Frequencies



Section 4.4.5
(Fischlin *et al*., 2007. IPCC WGII)

Recent trends forest pests - E.g. Canada

(***Dendroctonus ponderosae, Col., Scolytidae***)



Section 4.4.5
(Fischlin *et al.*,
2007. IPCC WGII)

Some DGVM Results - LPJ A2 HadCM3

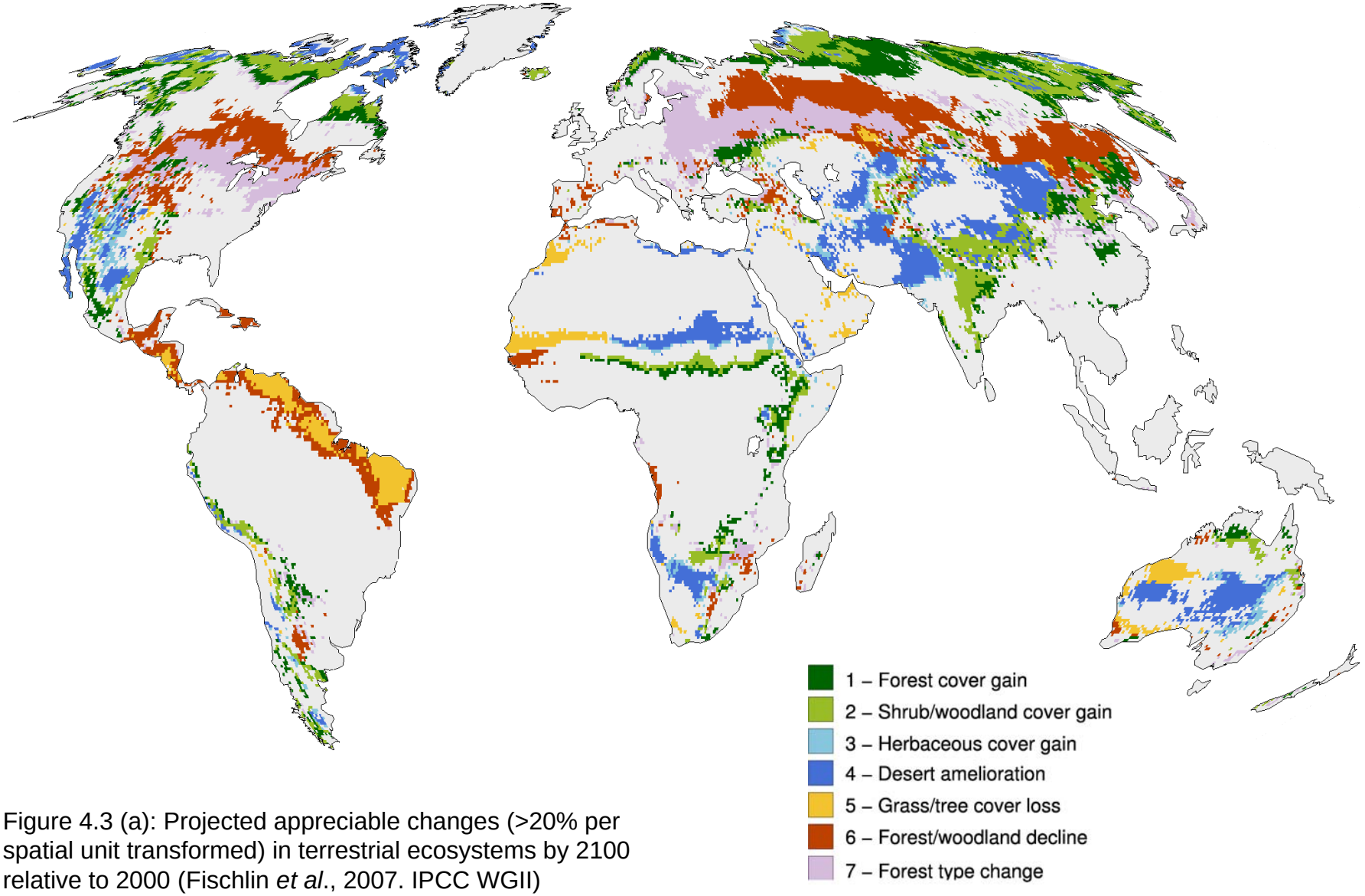
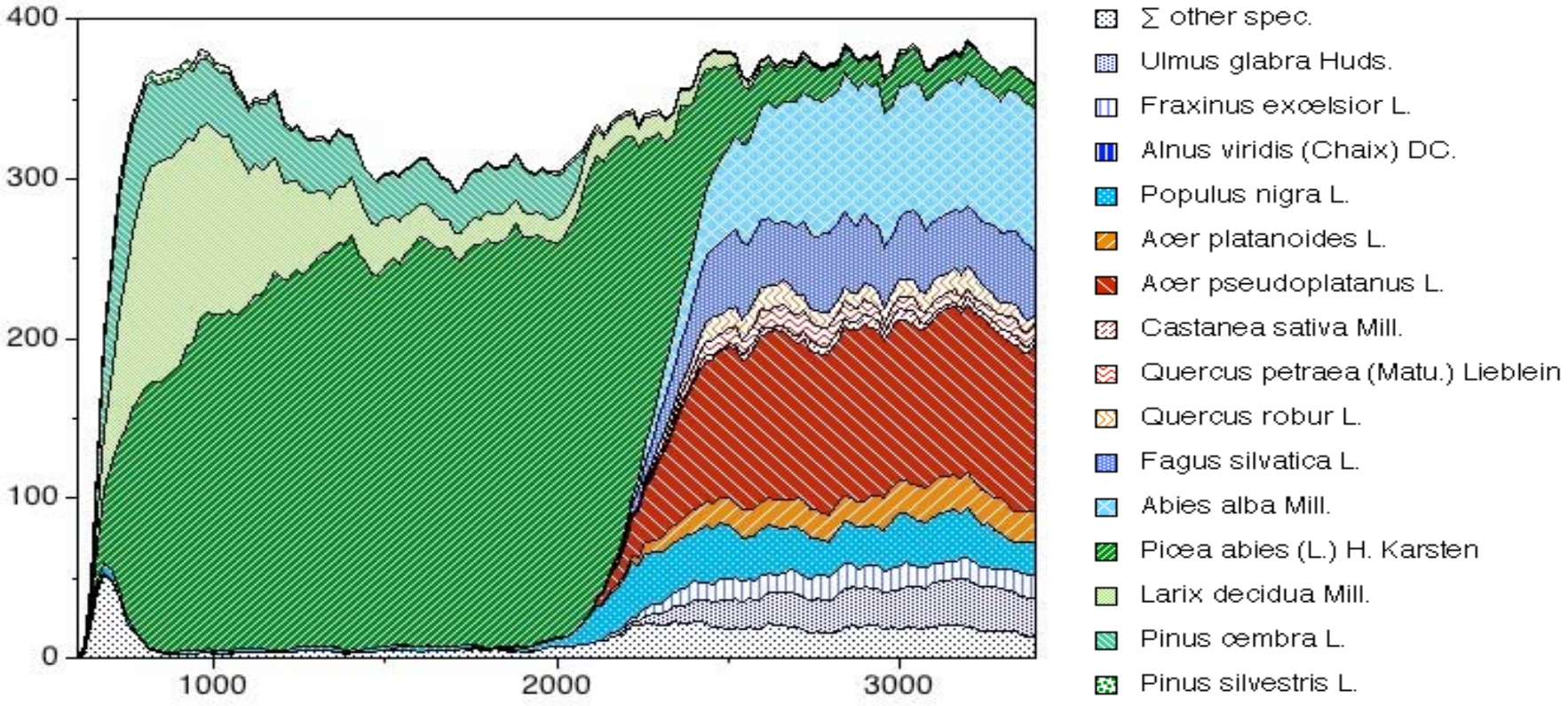


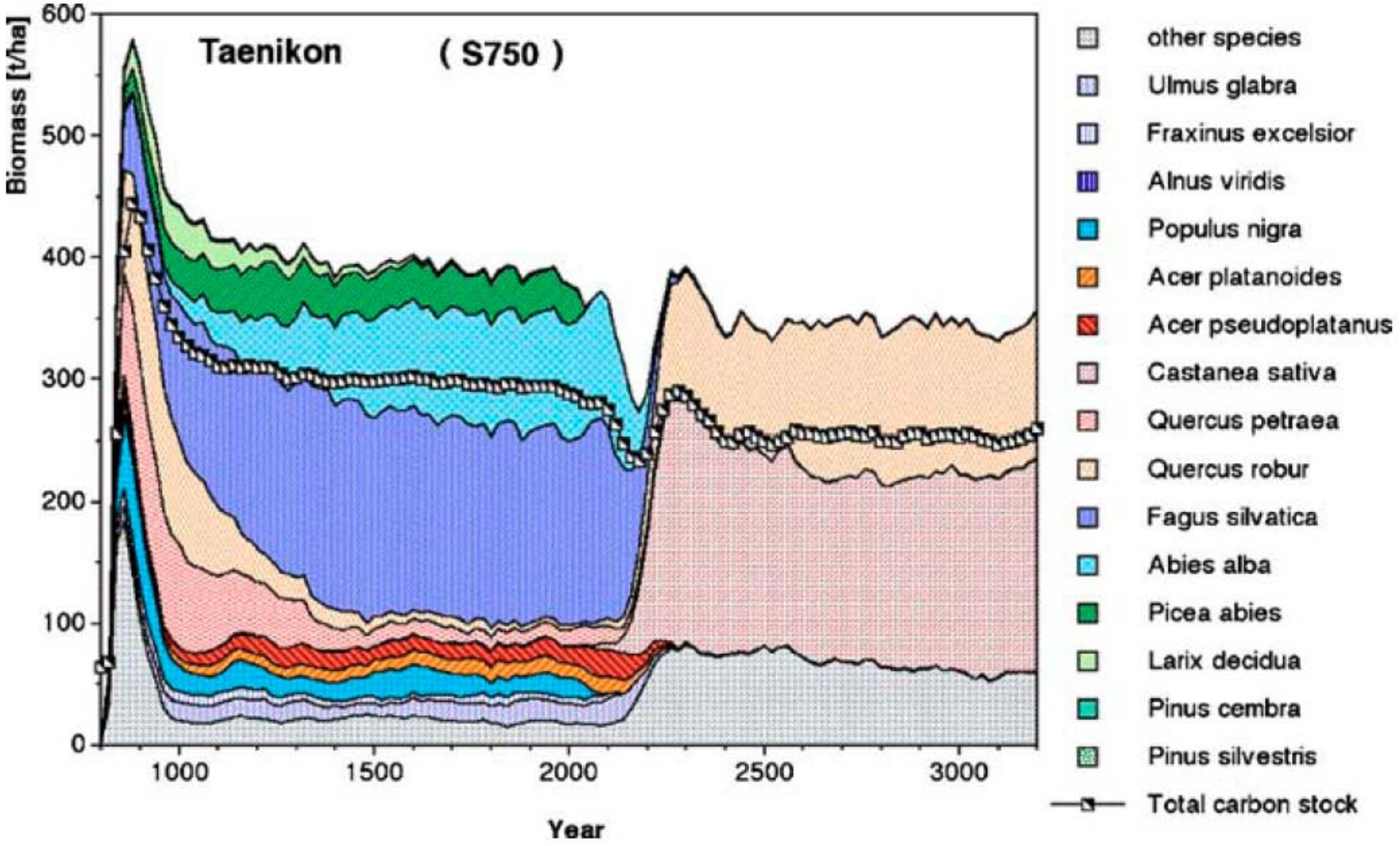
Figure 4.3 (a): Projected appreciable changes (>20% per spatial unit transformed) in terrestrial ecosystems by 2100 relative to 2000 (Fischlin *et al.*, 2007. IPCC WGII)

Ex. subalpine Forests



Fischlin & Gyalistras, 1997. Global Ecol. Biogeogr. - Hafner, 2000.

…and temperate forests



Fuhrrer, Beniston, Fischlin, Frei, Goyette, Jaspte &, Pfister, 2006. Clim. Change, 79: 79-102

Sink service at risk

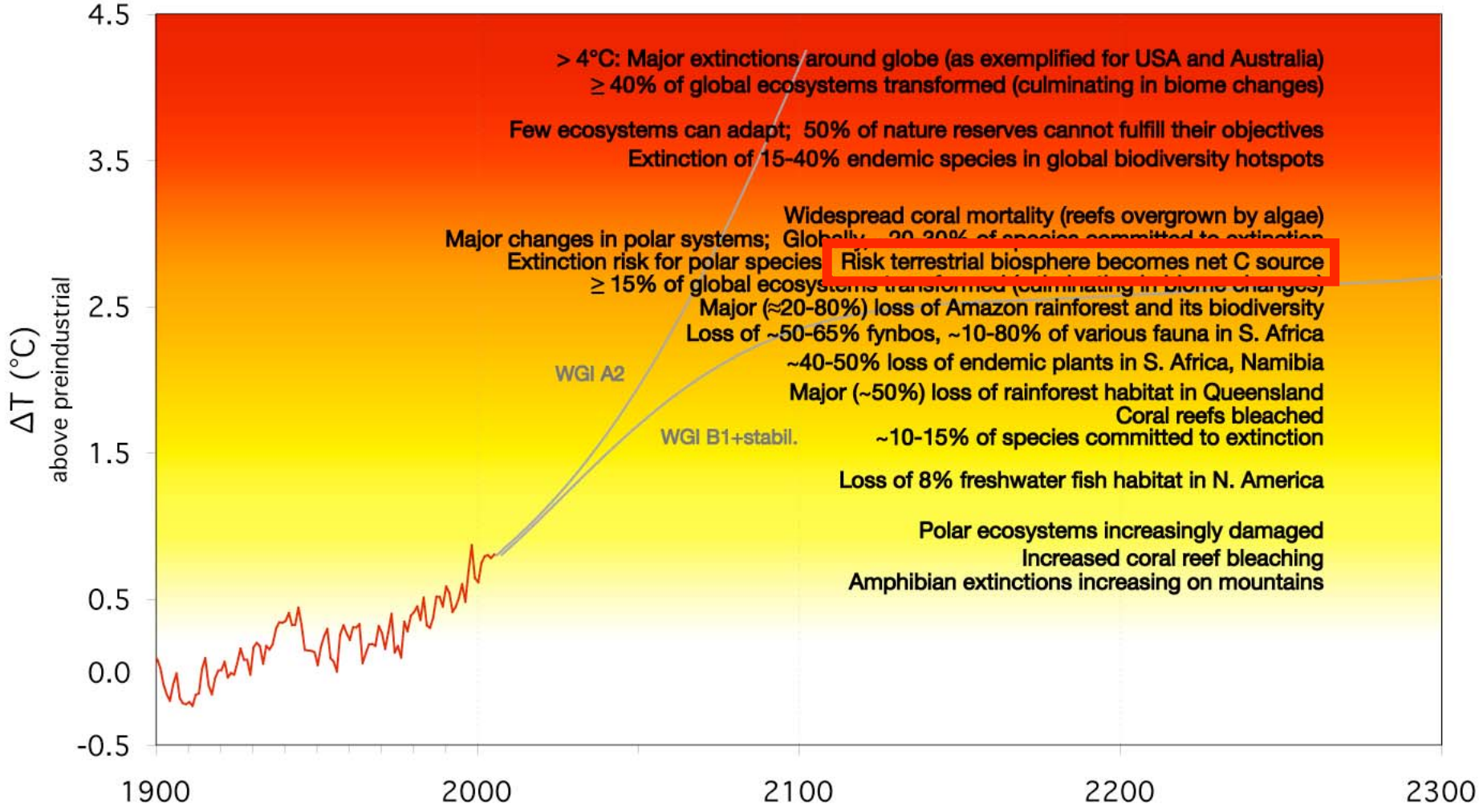


Figure TS.6:Compendium of projected risks due to critical climate change impacts on ecosystems for different levels of global mean annual temperature rise IPCC, 2007. Technical Summary WGII

Sink service at risk

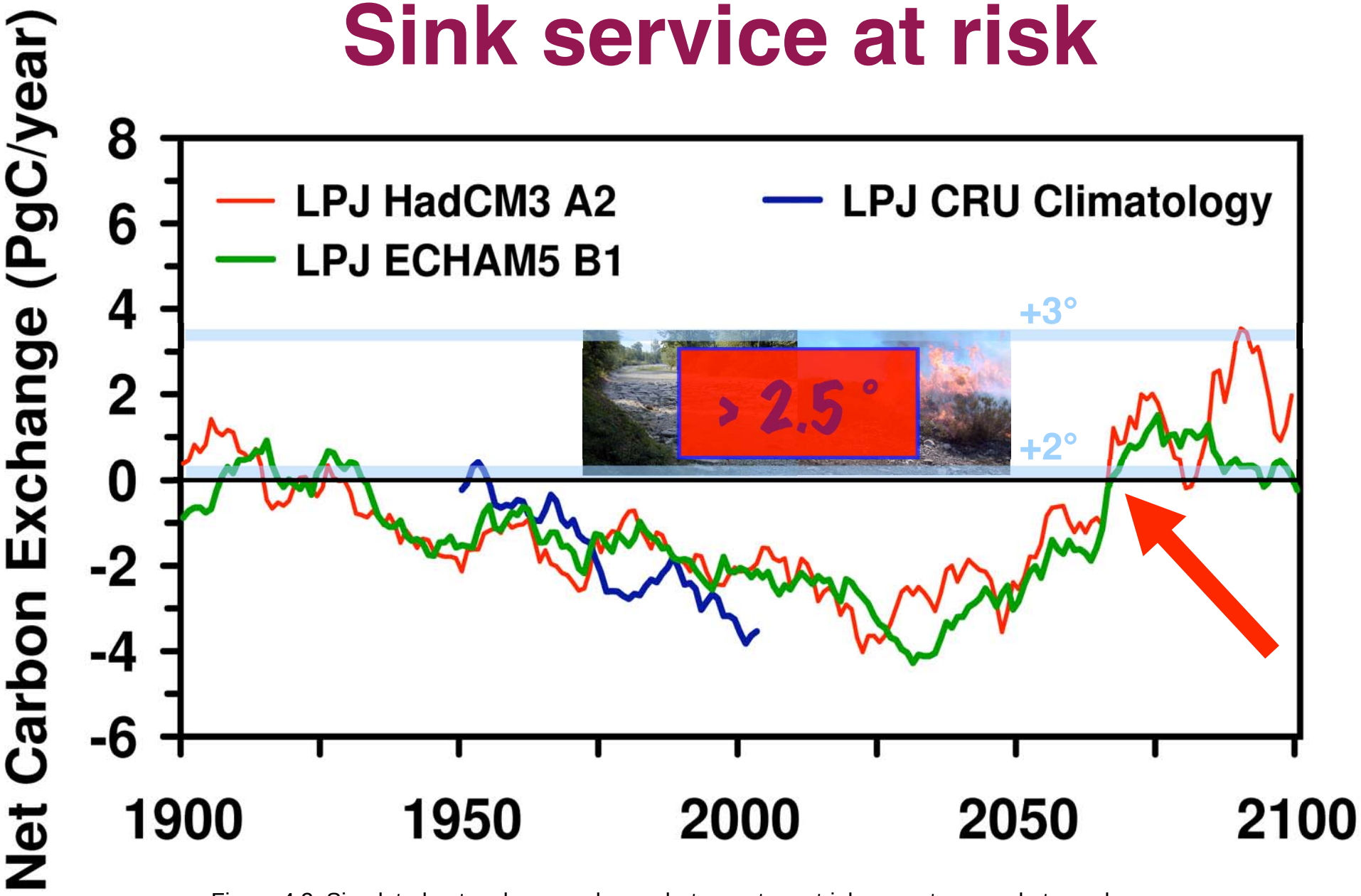
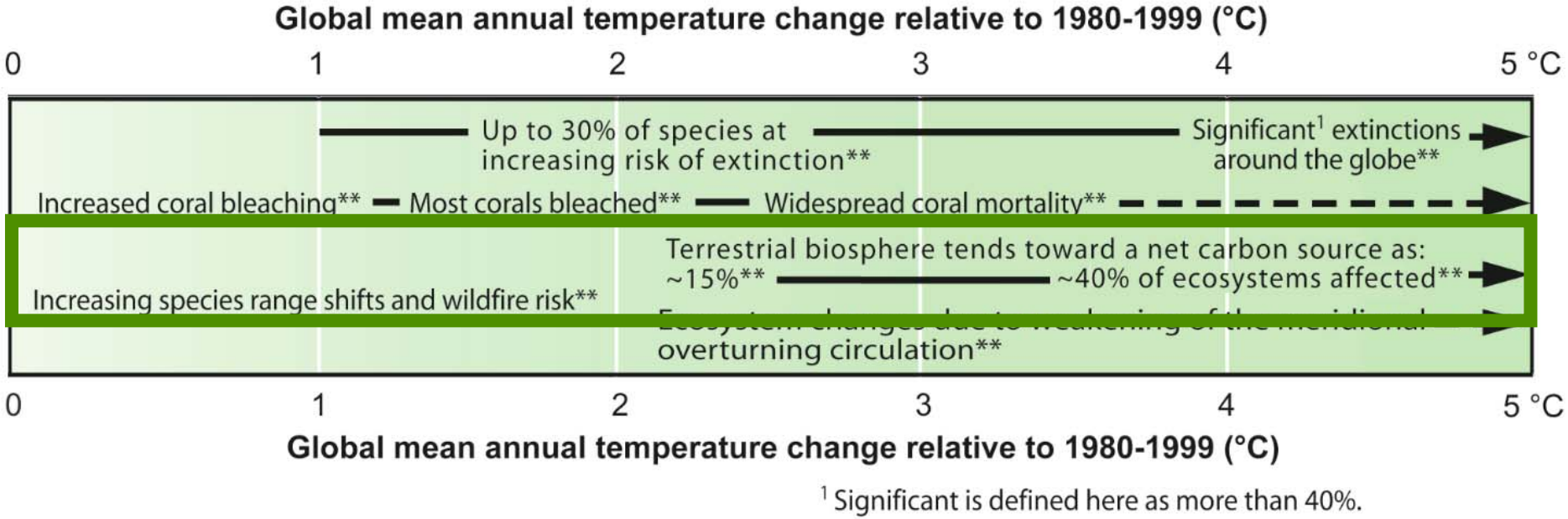


Figure 4.2: Simulated net carbon exachange between terrestrial ecosystems and atmosphere (Fischlin *et al*., 2007. IPCC WGII)

Summary

Emissions from ecosystems (incl. forests)



From Figure SPM.2

(IPCC, 2007. Summary for Policy Makers by Working Group II AR4 IPCC)

4 Adaptation and Forests

- Ecosystems' resilience matters

Some adaptation has become unavoidable

Adaptive adaptation is needed

Foster diversity to enhance resilience

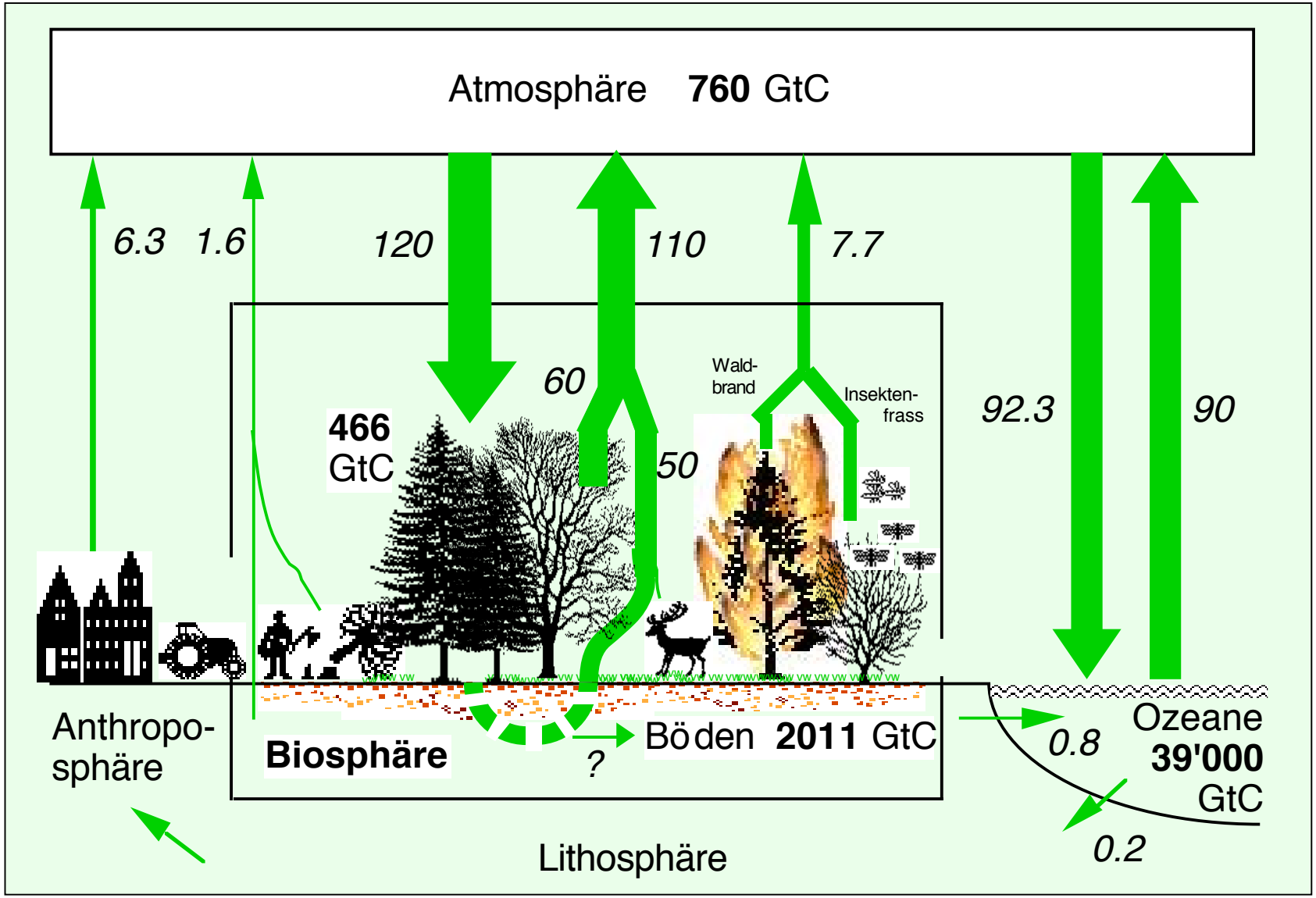
Future Resilience of Ecosystems

The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g., land use change, pollution, overexploitation of resources).

(high confidence)

IPCC, 2007. SPM WGII, p.11

Forests are crucial in the clobal C-cycle



Fischlin, 2000

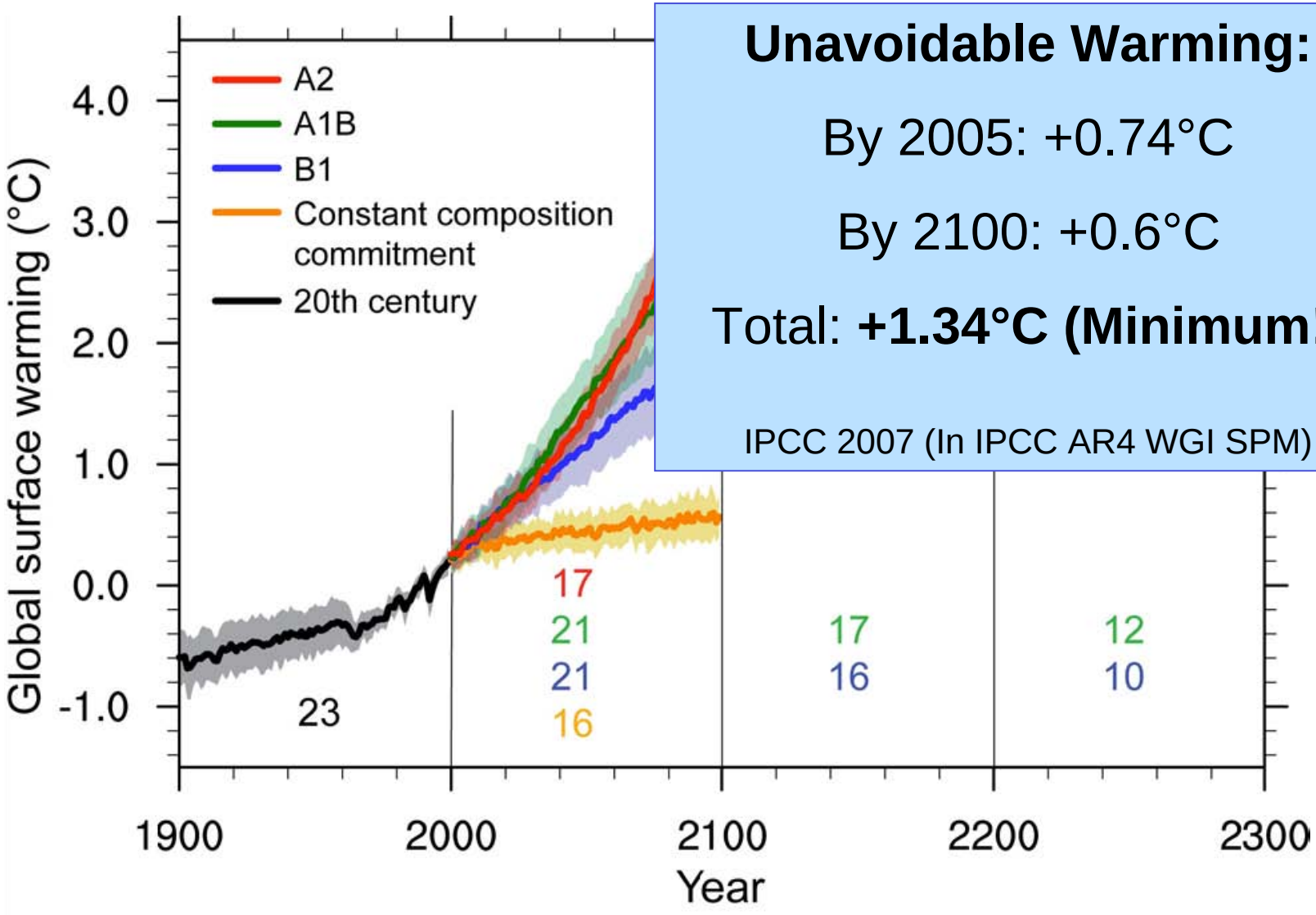
- Ecosystems' resilience matters

Some adaptation has become unavoidable

Adaptive adaptation is needed

Foster diversity to enhance resilience

Some Climate Change Now Unavoidable



Unavoidable Warming:

By 2005: +0.74°C

By 2100: +0.6°C

Total: **+1.34°C (Minimum!)**

IPCC 2007 (In IPCC AR4 WGI SPM)

Figure TS.32: Multi-model means of surface warming (IPCC, 2007. Technical Summary WGI)

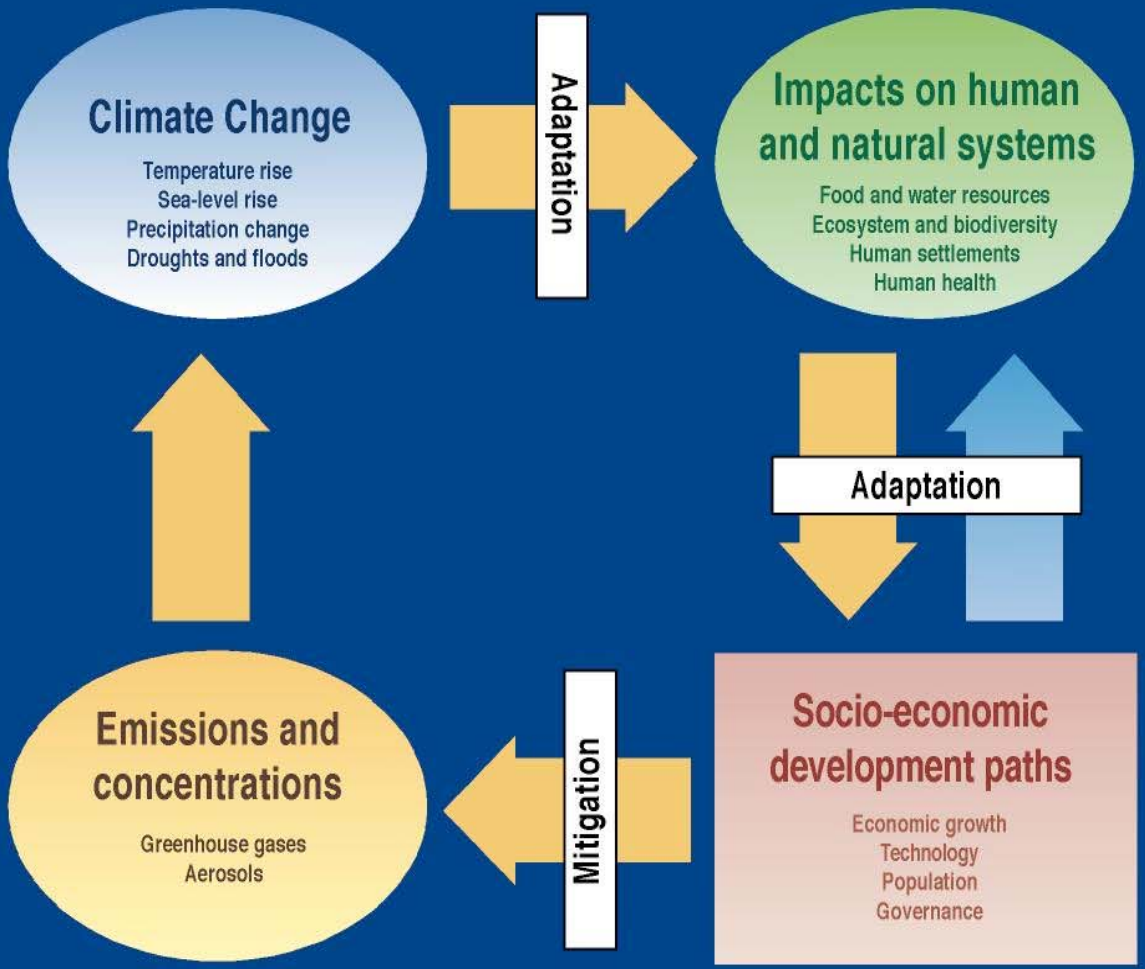
- Ecosystems' resilience matters

Some adaptation has become unavoidable

Adaptive adaptation is needed

Foster diversity to enhance resilience

Climate Change - an integrated framework



SYR FIGURE 1-1

Limiting Warming to Max of 2°C

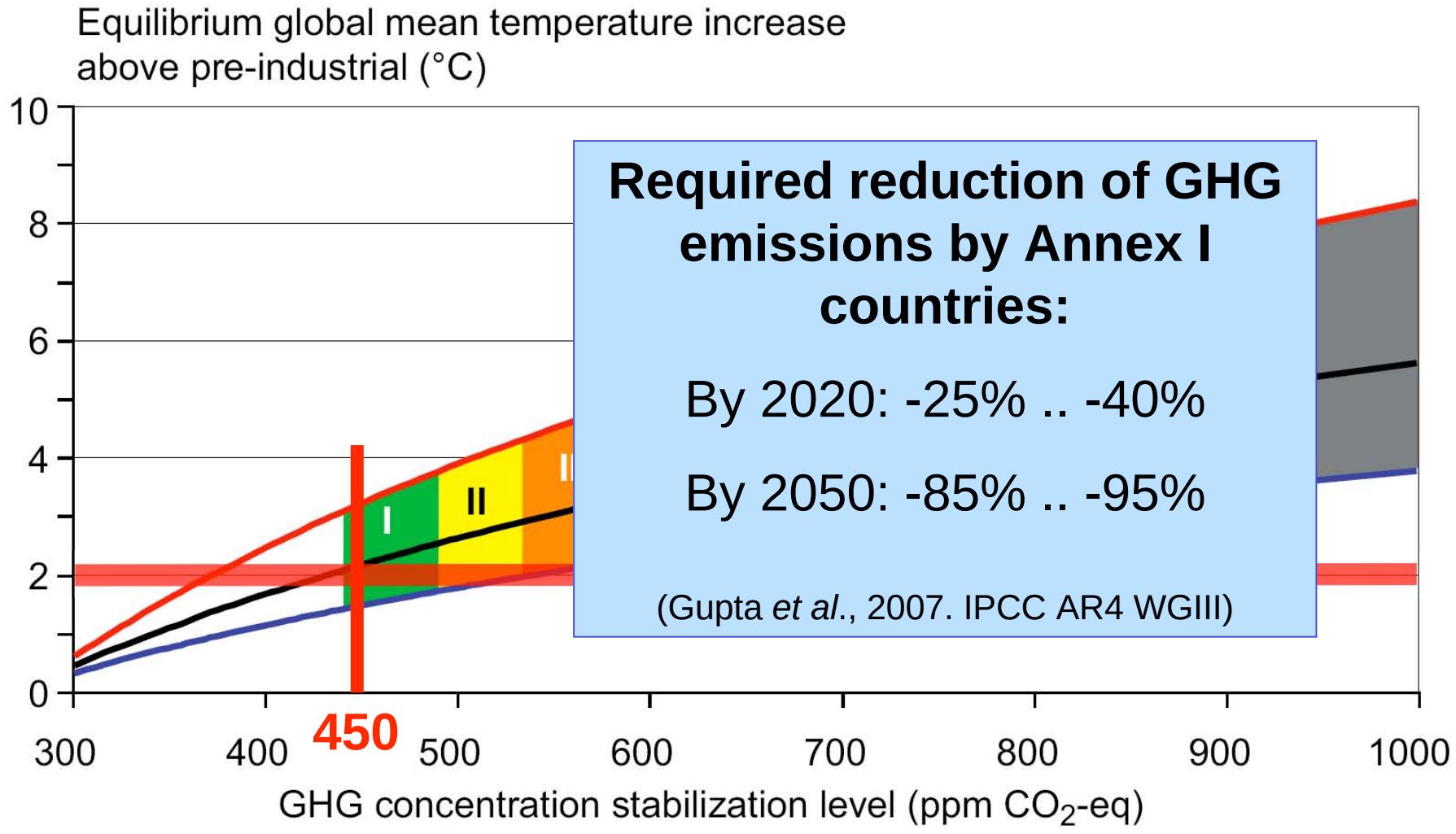
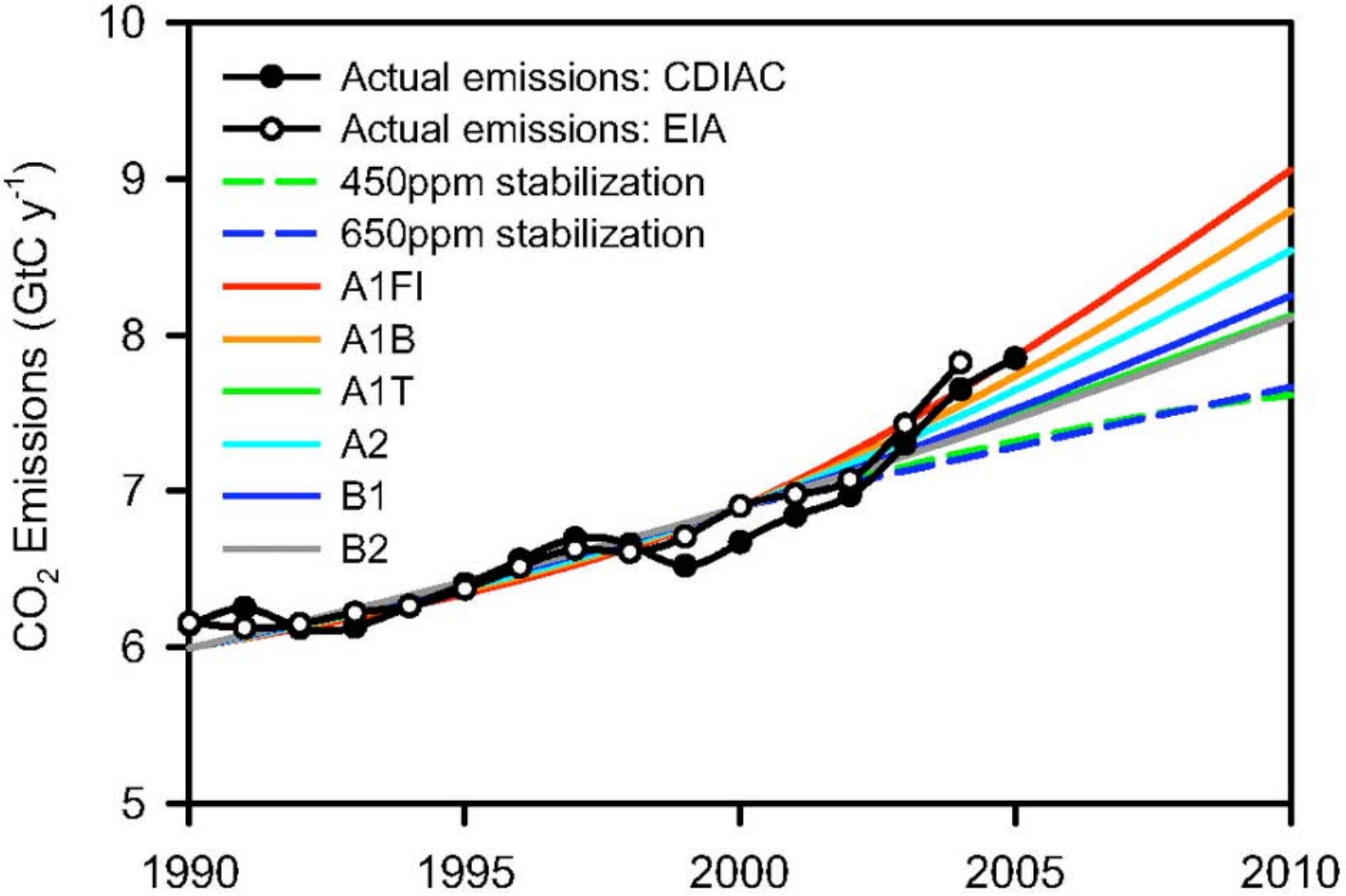


Figure SPM.8: Global warming and GHG stabilization levels (IPCC, 2007. Summary for Policy Makers WGIII)

Recent emission trends

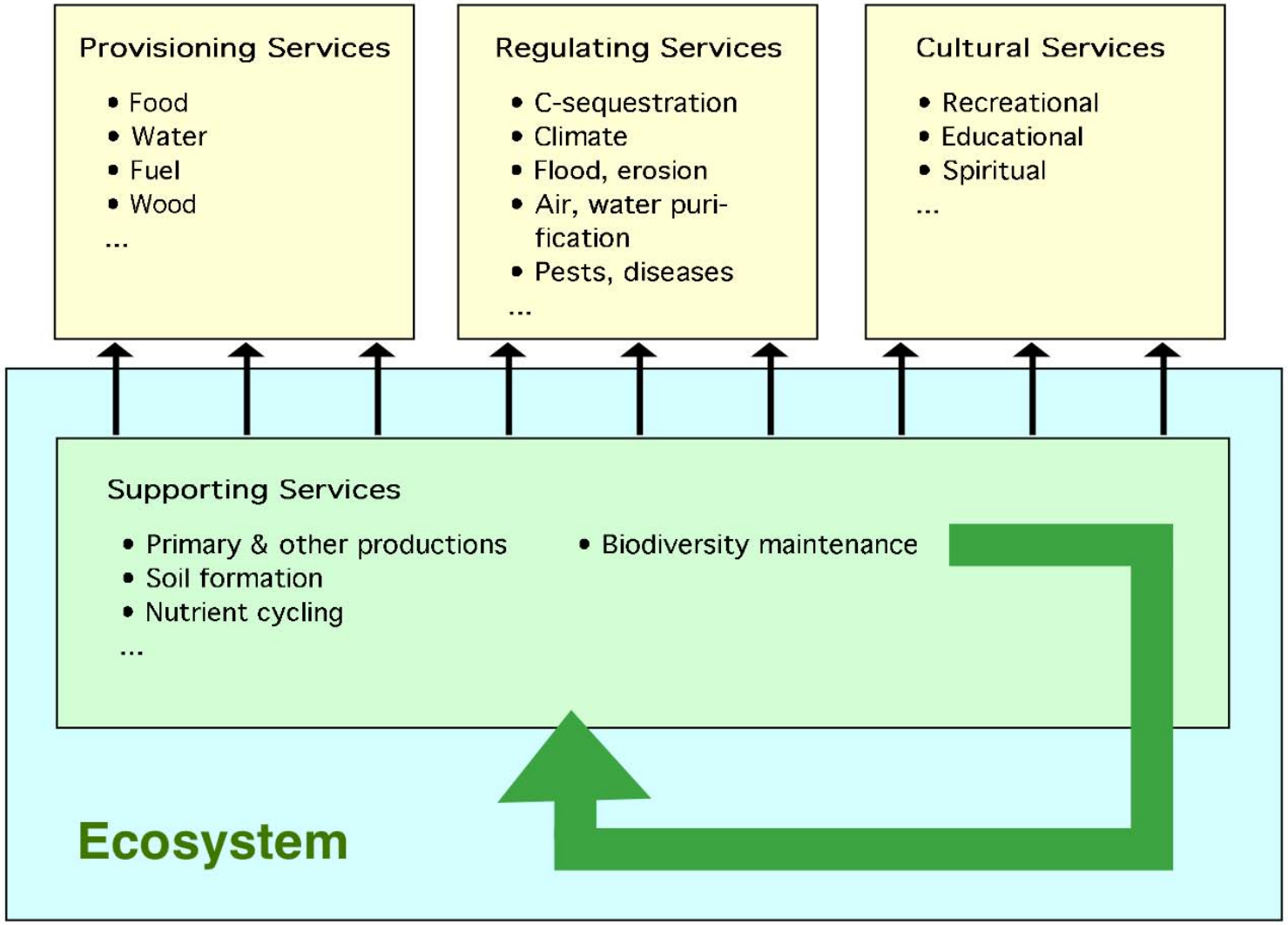


Raupach et al., 2007. PNAS

5 Conclusions


• Ecosystems' resilience matters
Some adaptation has become unavoidable
Adaptive adaptation is needed
Foster diversity to enhance resilience

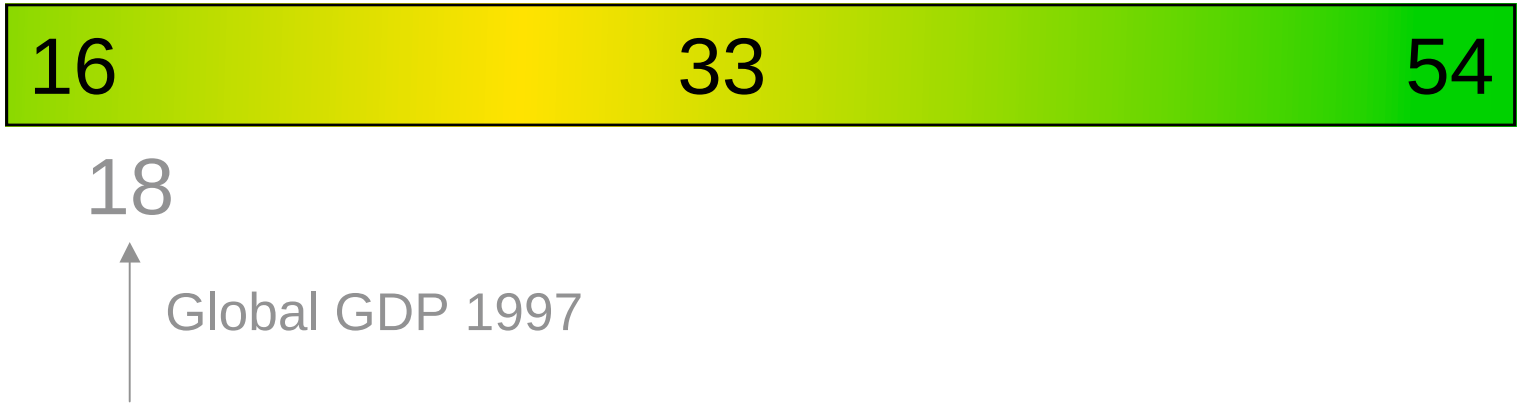
Ecosystems Services



Valuation of Ecosystem Services

Economic value of services provided annually by biosphere:

Trillions (=10^{12} =Tera) US $



Costanza *et al.*, 1997. *Nature*, 387: 253-260

Climate Convention (UNFCCC) - Article 2

UNFCCC (United Nations Framework Convention of Climate Change) after World Summit in Rio 1992.

Since 1994 in force, ratified by 189 Parties (e.g. USA as 4th.)!

The ultimate objective of this Convention .... is to achieve, …. stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Such a level should be achieved within a time-frame sufficient:

- **to allow ecosystems to adapt naturally to climate change**
- **to ensure that food production is not threatened, and**
- **to enable economic development to proceed in a sustainable manner.**

Ecosystem's resilience exceeded

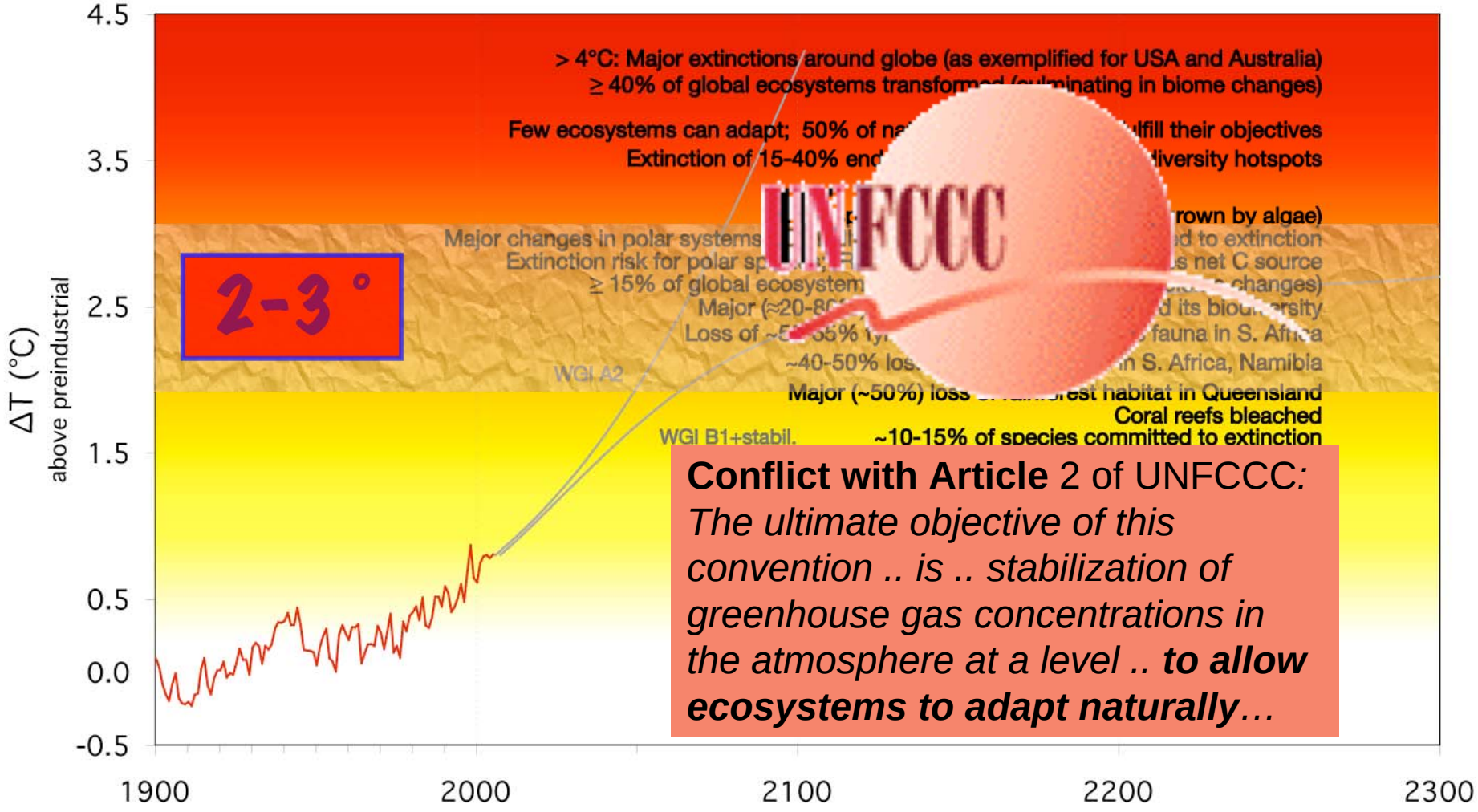
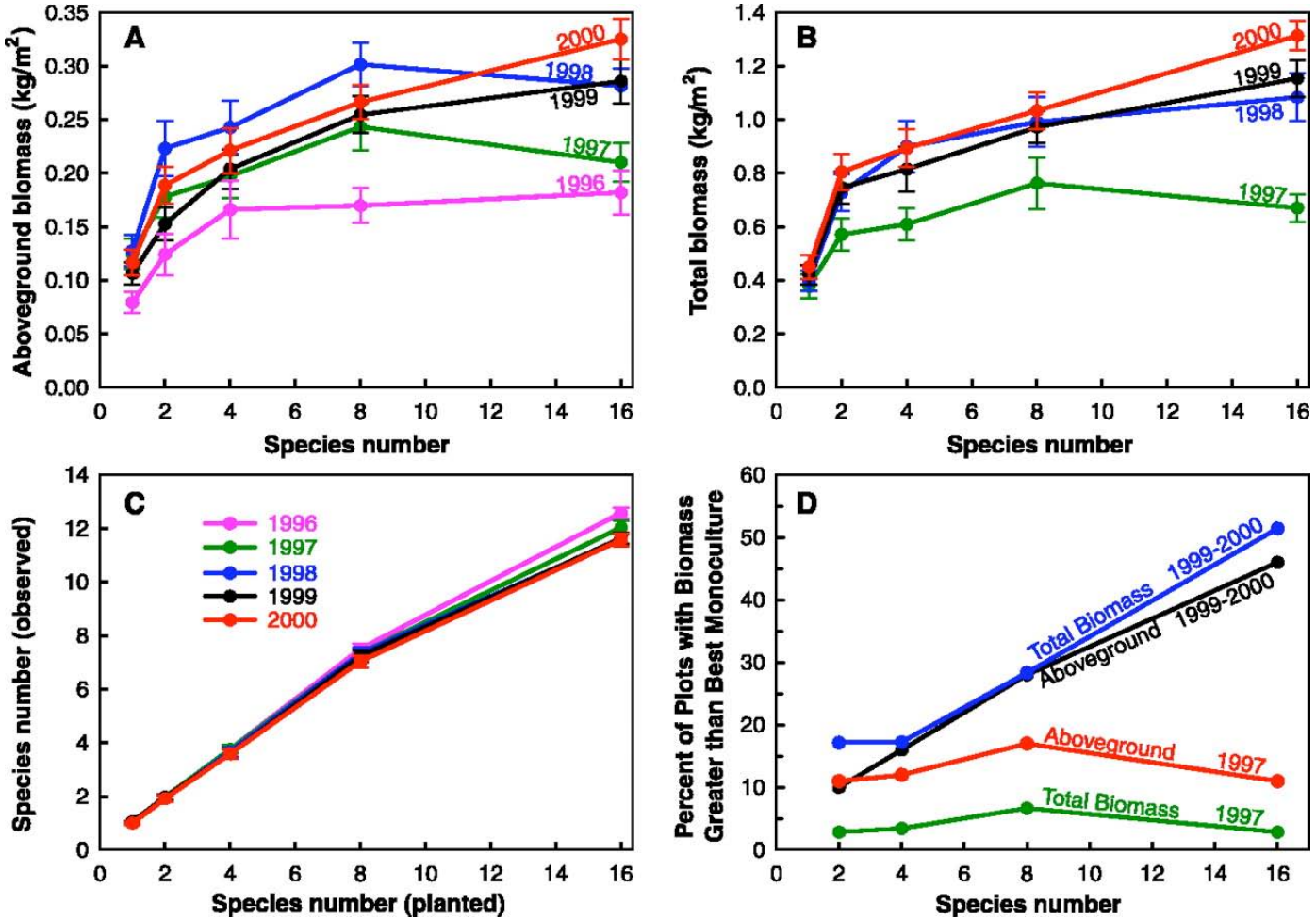


Figure TS.6:Compendium of projected risks due to critical climate change impacts on ecosystems for different levels of global mean annual temperature rise IPCC, 2007. Technical Summary WGII

High productivity if diversity high



Tilman et al., 2001. Science, 294: 843 -845

Thanks for your attention

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

www.ipcc.ch
www.sysecol.ethz.ch
andreas.fischlin@env.ethz.ch