



Where a piano must stand.

Caption (and photo?): Veda Hille.



Where a summer school must take place.

Vision and photo: Wolfgang Cramer.

Ecosystem Services and Global Change – The Environmental Dimension of Human Vulnerability



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Outline

1. The concept of Ecosystem Services.
 - A change of perspectives,
 - Classic and current example of application,
 - Its link to human vulnerability.
2. Three studies - Ecosystem services and global change:
 - Organisms (short),
 - Environmental history (short),
 - Future projections (long),
 - Urgency, land use and organising a plate of spaghetti.

How we see the environment

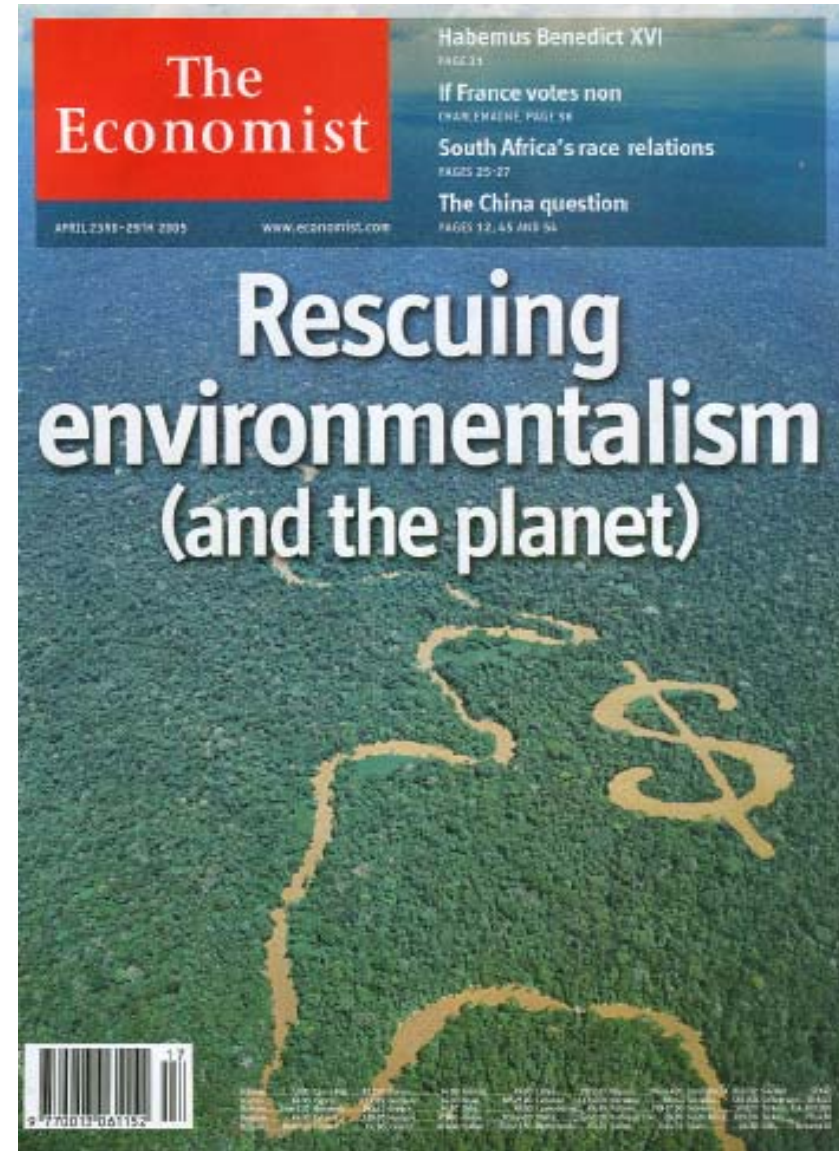
pre 1990s
“environment = a restriction”



A decade of
excitement and
doubt.

post 2000
“environment = an asset”

The **Millennium Ecosystem Assessment**. An eminent first stepping stone for the journey into **more doubt, discovery and practice**. “MA2”.



April 25th, 2005, The Economist.

Classic example: Catskill watershed and New York City

- supplies New York City with water (9.5 Mio. people)
- NYC bought land and opted for ecosystem restoration over technical filtration plant
 - \$1.5 vs. 6-8 billions
- 18 months of negotiations, 1000+ pages, 80+ signatories, 10 years ...then renewal
- Successful since 1996.
- Full, fascinating story: Paul Barten, Uni of Massachussetts.



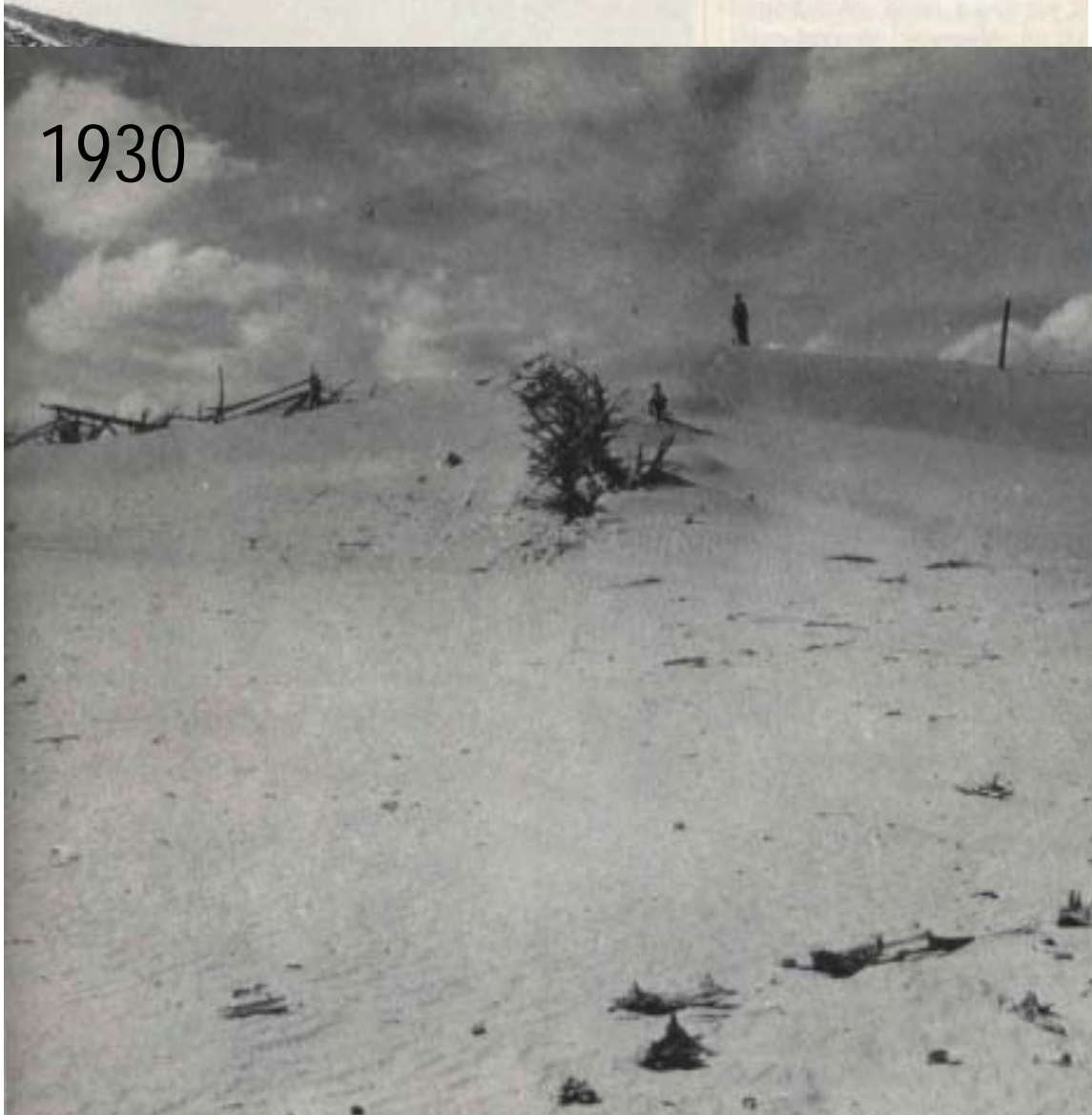
Current example: Grain-to-Green Projekt, West-China

- Grain and cash subsidies for farmers
 - steep slopes: convert cropland to grassland and forest.
- Area 32 Million ha
 - includes the Yangtse and Yellow River catchment
 - includes 15 Mio. ha steep slopes
- Runs since 1999. Up to 2010: € 23 billion.
- 2008 PNAS study by Liu et al. shows
 - lessened soil erosion, flood risk, land degradation, desertification, and novertv



Slope within the Grain-to-Green project,
area, West-China.

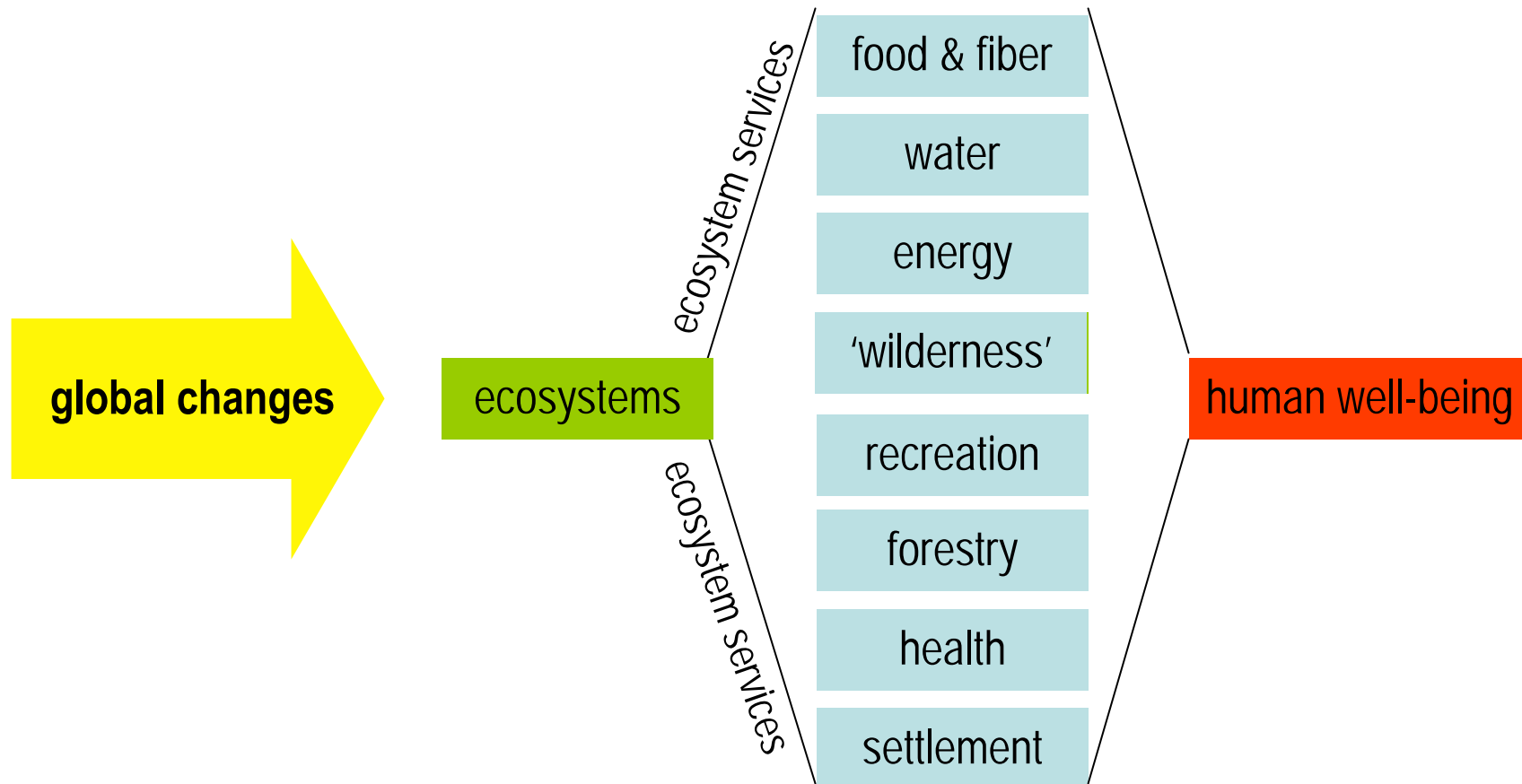
1910



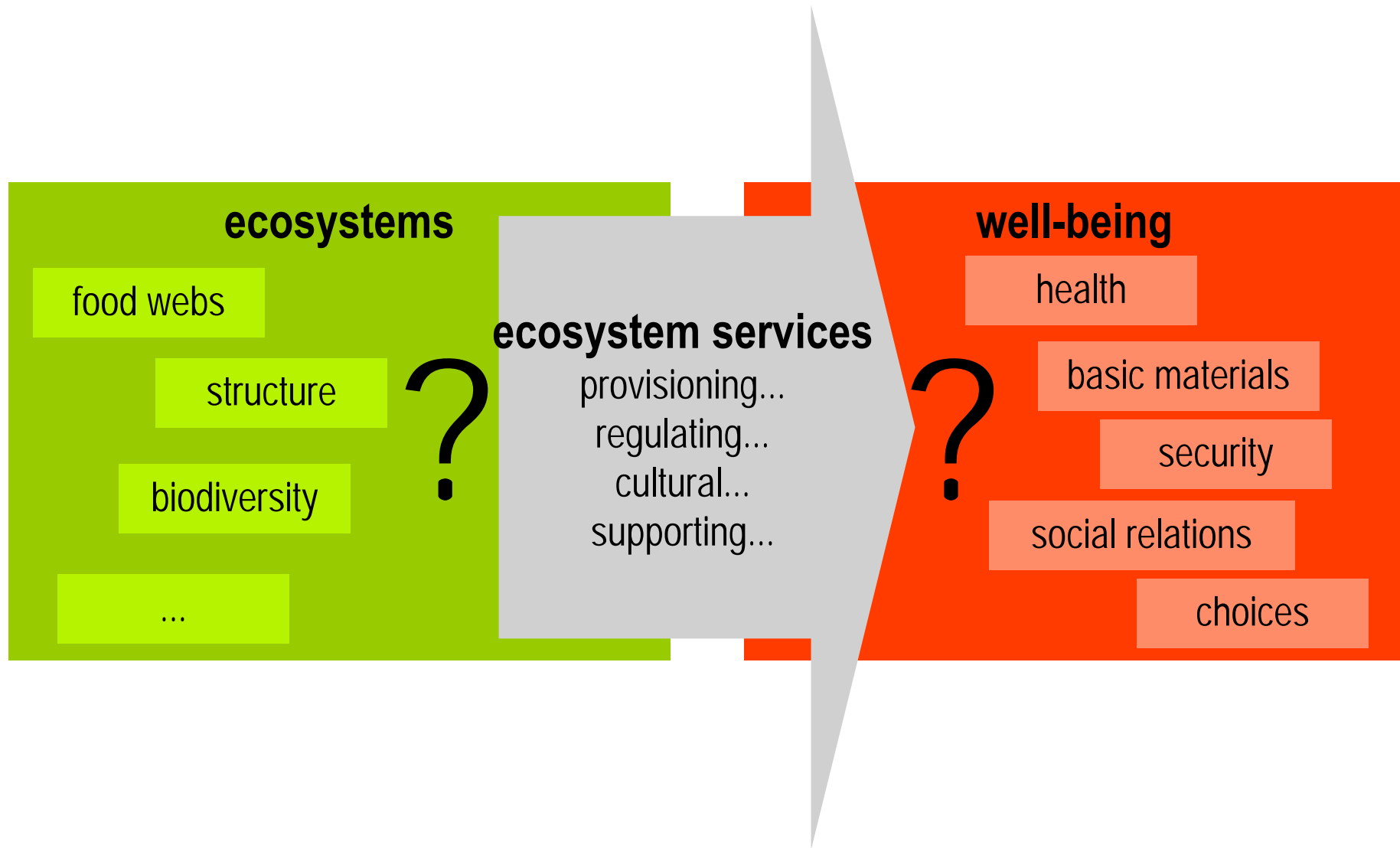
1930



A change in thinking: “mainstreaming ecosystems”



Discoveries needed...



Based on:
Millennium Ecosystem Assessment, 2003.

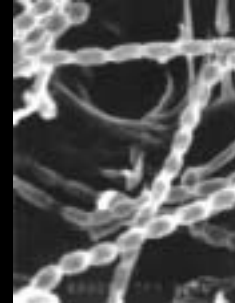
Study 1: Organisms, Ecosystem Services and Global Change



Euglypha strigosa



Nebela lageniformis



Actinomycete spores



Bacteria



Cantharellus cibarius



Bullinularia indica



Schoenbornia humicola



Nematode mouthparts



Dicyrtoma fusca



Acari

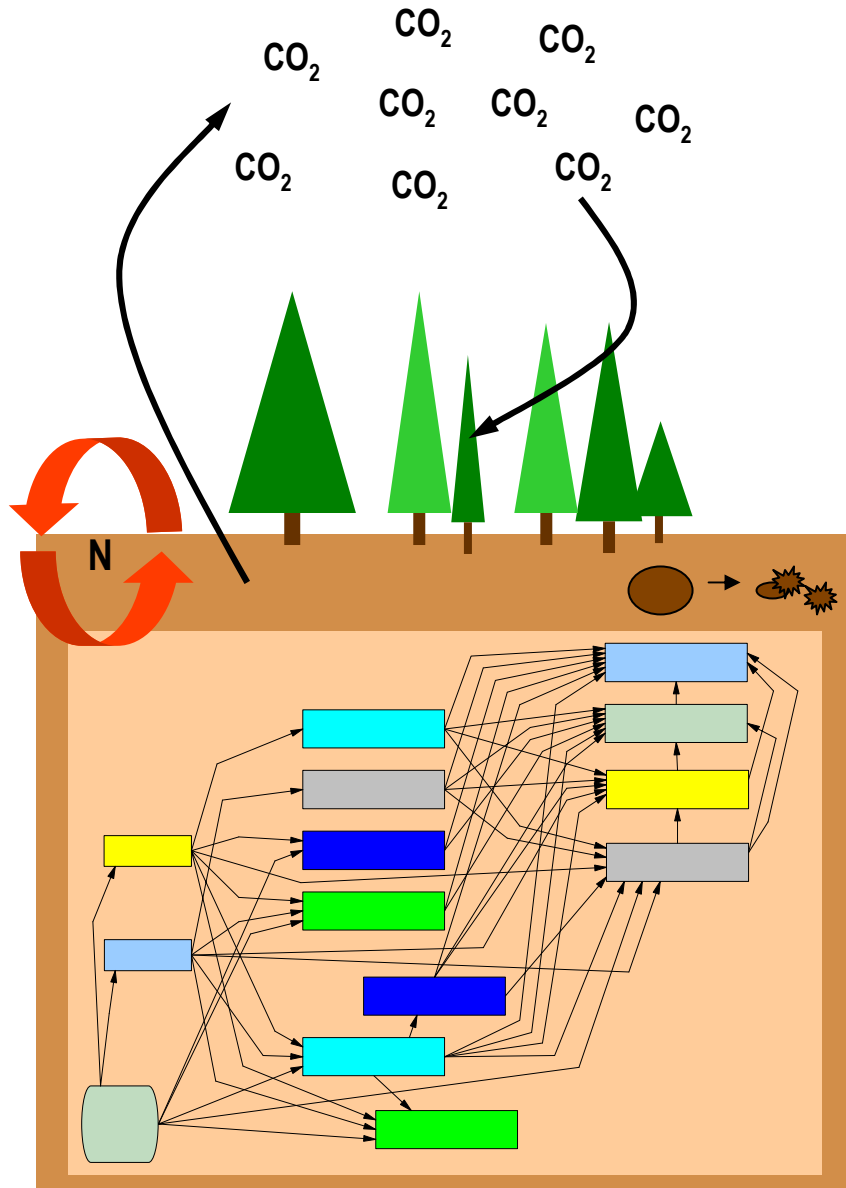
Photo credits:

Nematoda and mites - D.H. Wall

Collembola - A. Pflug

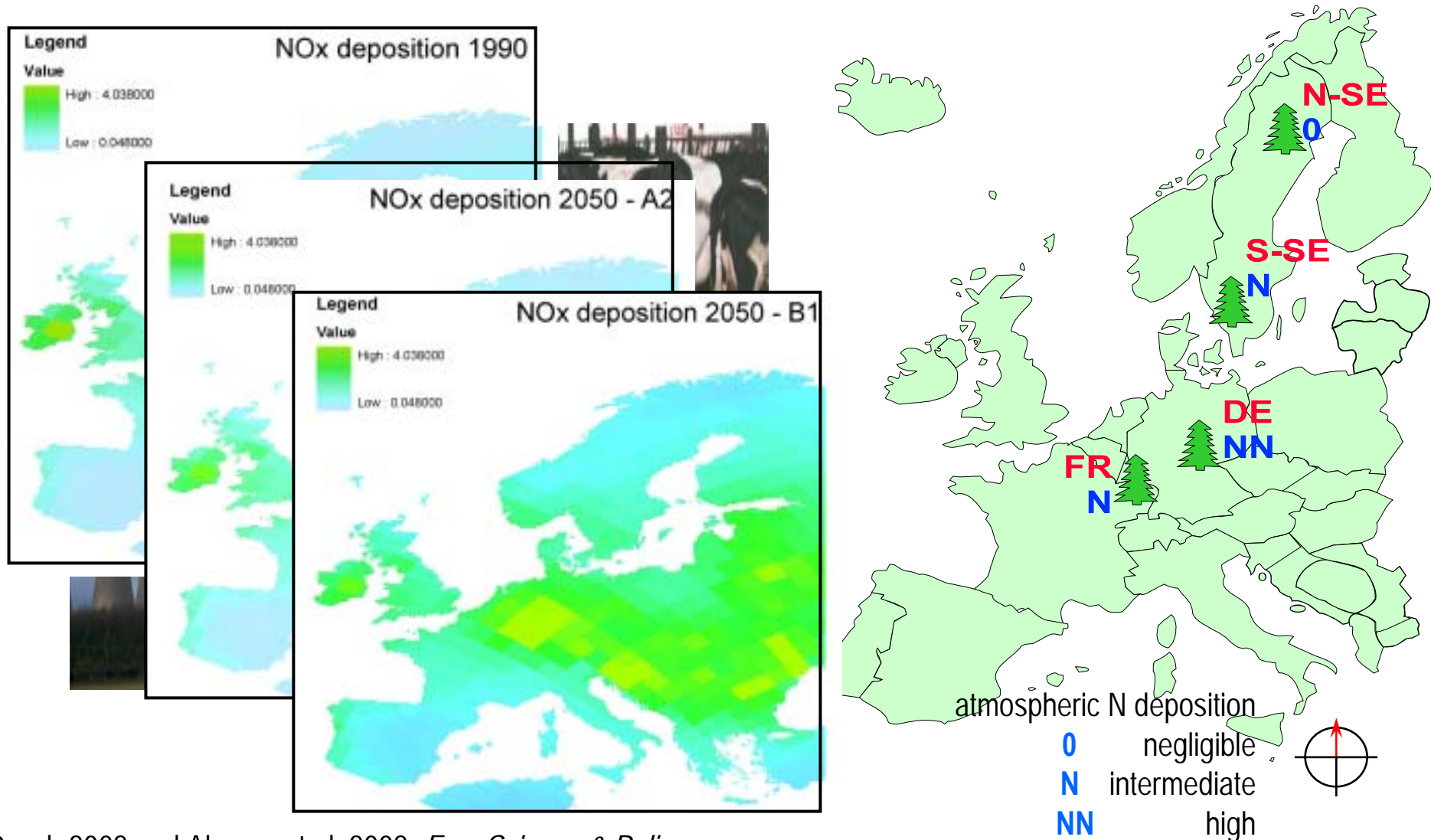
Testate Amoebae - D. Schröter

Organisms of the Decomposer Food Web



Ecological Process	Ecosystem Service
Nitrogen mineralisation	Nutrient cycling
Decomposition	Soil formation
Carbon storage	Climate regulation

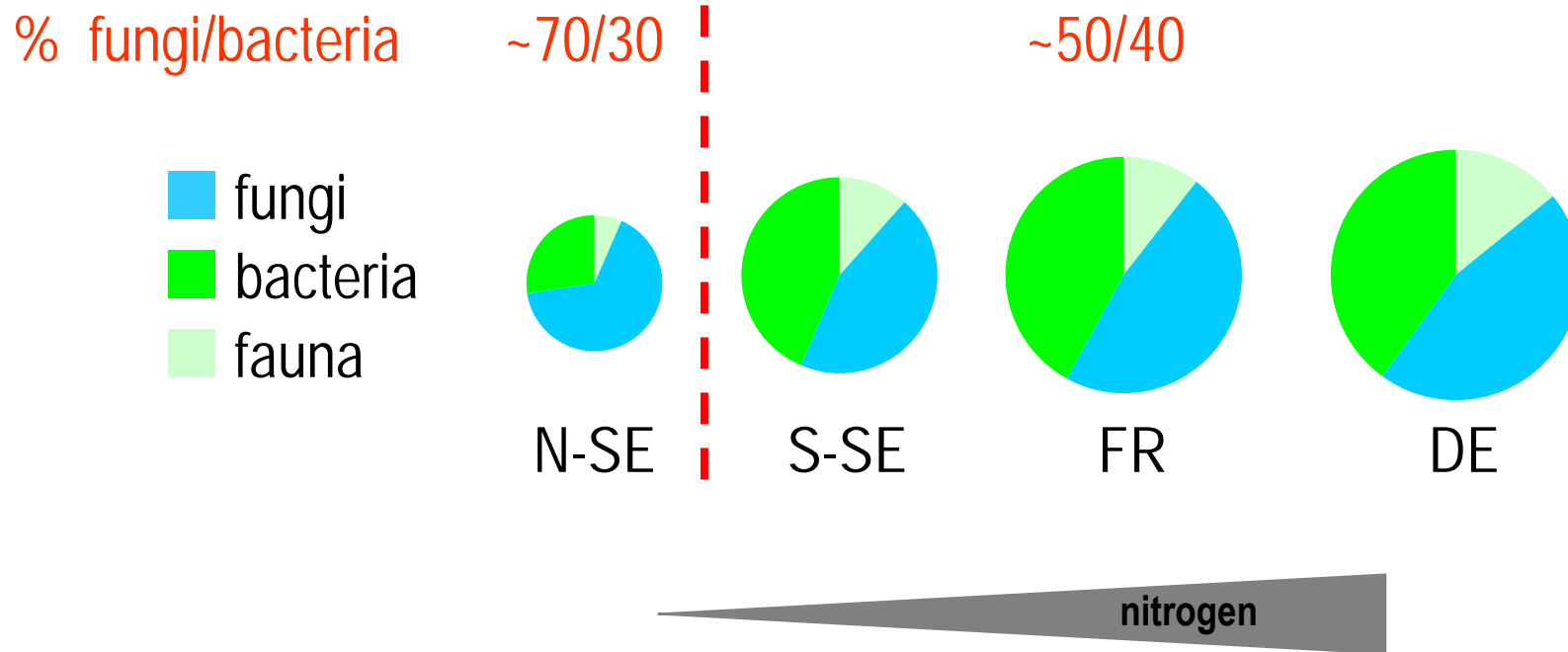
Decomposer food webs on a climatic and depositional gradient



Posch 2002 and Alcamo et al. 2002, *Env. Science & Policy*.

Wolters et al. 2000. In: *Carbon and Nitrogen Cycling in Forest Ecosystems*.

Structure and function are linked



1. Same total biomass,
2. Increasing total carbon flux, and
3. Shift in structure (fungal → bacterial/protozoa based food web).

Study 2: Environmental History, Ecosystem Services and Vulnerability



Hispaniola: One Island, Two Stories

Haiti and the Dominican Republic

Hurricane Jeanne, 2004

- Jeanne brought **torrential rainfall** to Hispaniola
- In **Haiti** this resulted in **flooding and mudslides**
- **Similar exposure, different vulnerability**

	Haiti	Dominican Republic	Florida
Direct casualties	2 745	11	6
Injured	2 620	9	0
Lost homes	14 048	0	0
Resulting homeless	200 000	0	0
Total affected	315 594	14 009	40 000
Damage (US\$)	21 Million	206 Million	7 Billion

EM-DAT, Emergency Disasters Data Base, Université Catholique de Louvain;
and National Hurricane Center, NOAA.

Farming Marginal Lands



Soil erosion leads to river silting, desertification, loss of hydropower option, hazards.

Degradation seen from space



Ecosystem services obviously affected:
Slope stabilisation, soil fertility maintenance, water purification, recreational value ...

From space: clear divide between Haiti and the Dominican Republic. Both have similar water resources.
Photo: NASA.

One Island, Two Stories

	Haiti	Dominican Republic
Economy	Poorest country outside Africa	Poor, but booming economy
Agriculture	Subsistence	Exports
Tourism	Few enclaves	Large industry
Population (Millions)	~10	~5
Population growth rate	High (3%)	Low (1.6%)
Forest area (%)	1	28
National Parks	4	74

Diamond, *Collapse*, 2005.
Schröter, CID Harvard Working Paper, 2005.

Study 3: Ecosystem Services on a European Scale



A Vulnerability Study







Main result

The **vulnerability of some European regions to global changes** in the 21st century is **likely to increase** due to **decreased supply of ecosystem services**, particularly in the **Mediterranean and mountain regions**, as a study based on multiple scenarios of climate and land use change, a range of ecosystem models, and an embedded stakeholder dialogue shows.

Project details

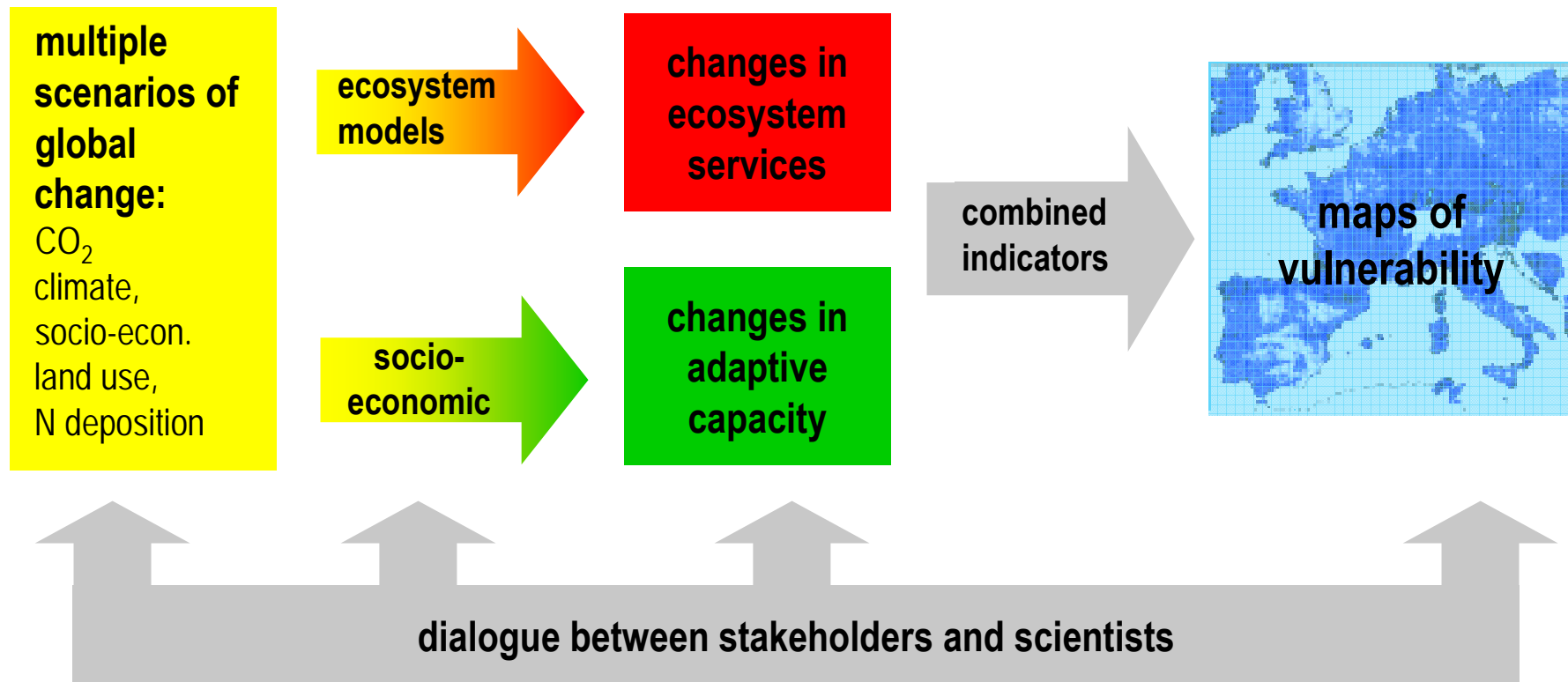
ATEAM: 17 partners and sub-contractors.
Funded by the European Union, 2001-2004.

Sectors, ecosystem services and indicators

Sector	Service		Modelled indicator
Water	Water supply (domestic, industrial, agricultural, hydropower, navigation)		<ul style="list-style-type: none"> • Runoff quantity • Runoff seasonality • Additional number of people under water stress
Carbon storage	Climate protection		<ul style="list-style-type: none"> • Carbon storage in vegetation • Carbon storage in soil
Forestry	Wood & fibre production Biomass energy production		<ul style="list-style-type: none"> • Tree productivity: growing stock & increment • Frequency of forest fires • Shifts in suitable tree species
Agriculture	Food & fibre production Biomass energy production		<ul style="list-style-type: none"> • Agricultural land area (Farmer livelihood) • Suitability of crops • Biomass energy yield
Nature conservation	Beauty Life support processes (e.g. pollination)		<ul style="list-style-type: none"> • Species richness and turnover (plants, mammals, birds, reptiles, amphibian) • Shifts in suitable habitats
Tourism	Winter sports opportunities Recreation		<ul style="list-style-type: none"> • Snow (elevation of snow line) • Slope stability

European Vulnerability Study

Methodology



Stakeholder Dialogue

- **Aims**
 - Identify relevant indicators for ecosystem services
 - Settle useful scales and units
 - Discuss thresholds to indicate limits of adaptive capacity
 - Discuss results, clarify and agree on formats
- **Format**
 - 3 large workshops (beginning, middle, end)
 - 11 smaller workshops focussing on particular sectors
- **People** (multiple countries and languages)
 - 203 identified
 - 152 invited
 - 58 participated in at least one event

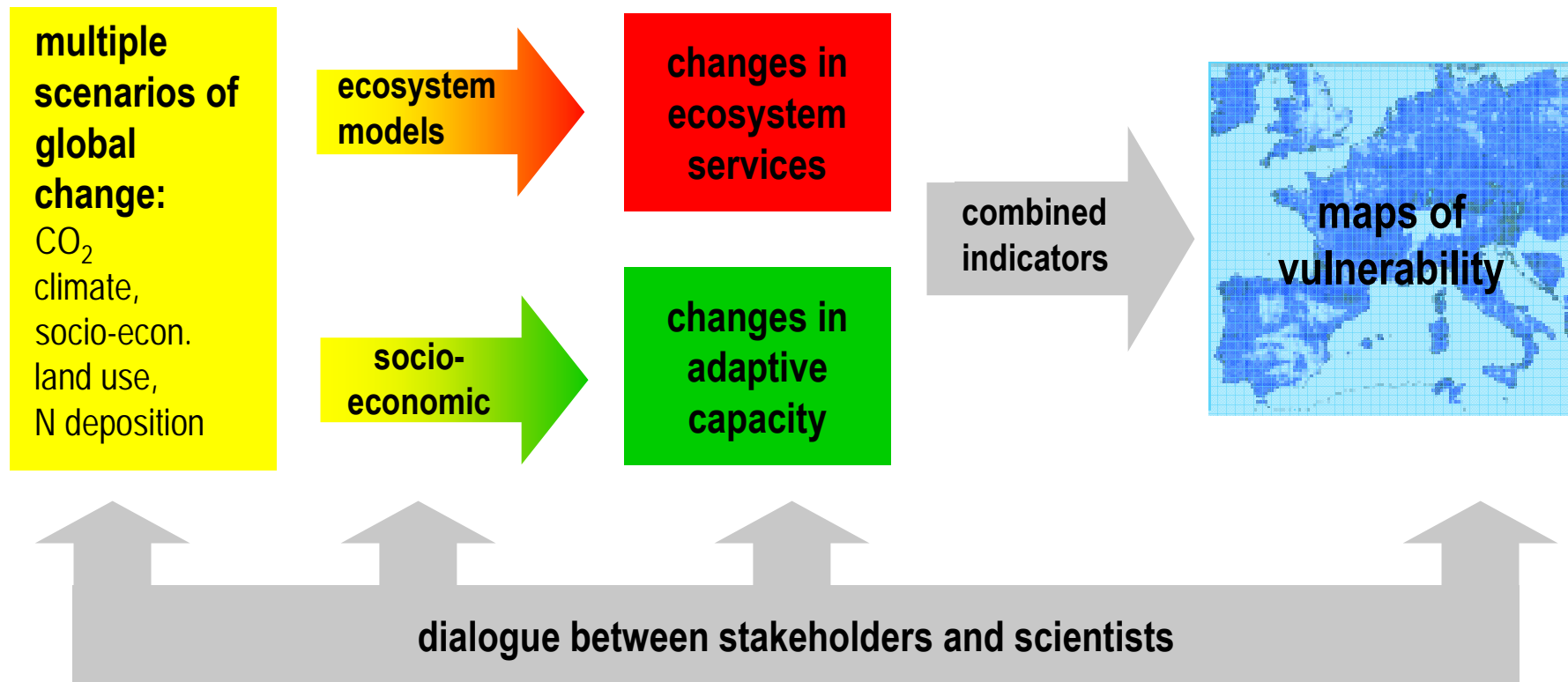
Stakeholder Dialogue

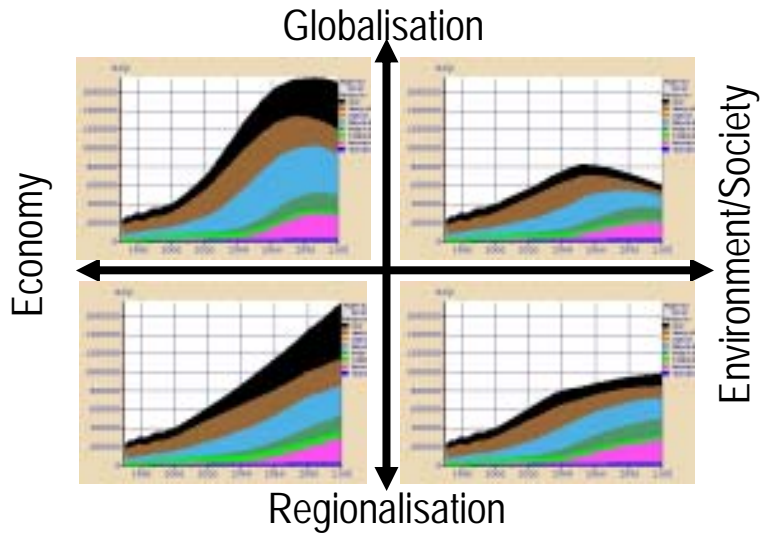
Who were our stakeholders?

- **Private sector:** farmers, land owners, agricultural association, hydropower and bioenergy producers, foresters, paper industry, winter tourism enterprises, tourism consultants, and more
- **Non-governmental organisations:** Nature conservation (e.g. RSPB), Bioenergy promoters
- **Policy makers and governmental organisations:**
 - Federal environmental agencies
 - EU directorates
 - UNFCCC
 - European Environmental Agency (EEA)
 - German Foreign Ministry

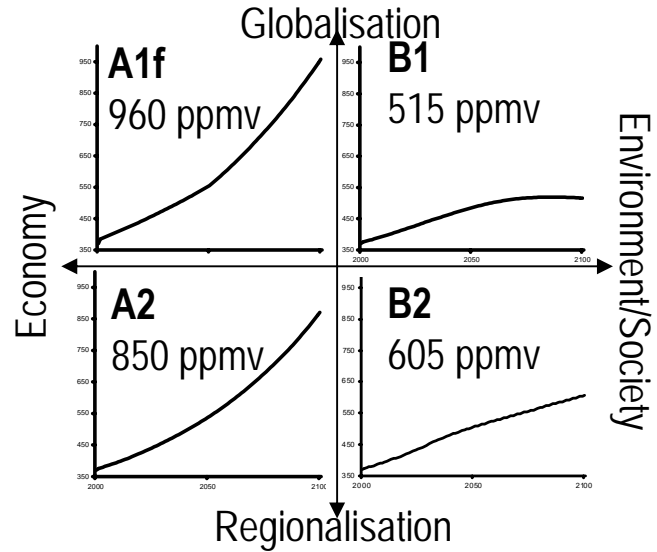
European Vulnerability Study

Methodology

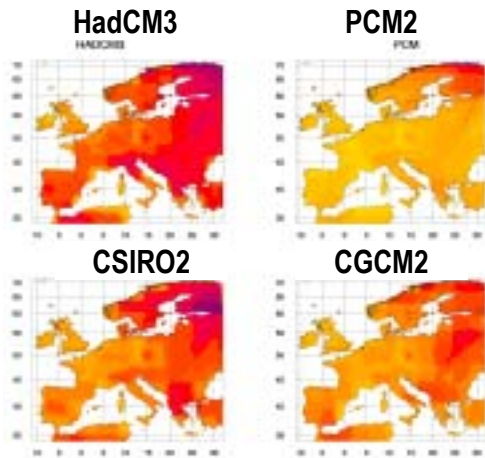




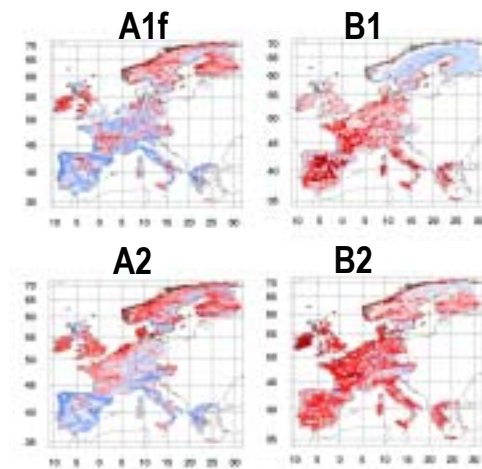
SRES quantification: Energy use
(integrated assessment model IMAGE)



Atmospheric greenhouse gas concentration



Climate Scenarios
(four general circulation models, GCM)



Landuse Change Scenarios
(agriculture, forest, grassland, urban, protected area)

Communicating uncertainty

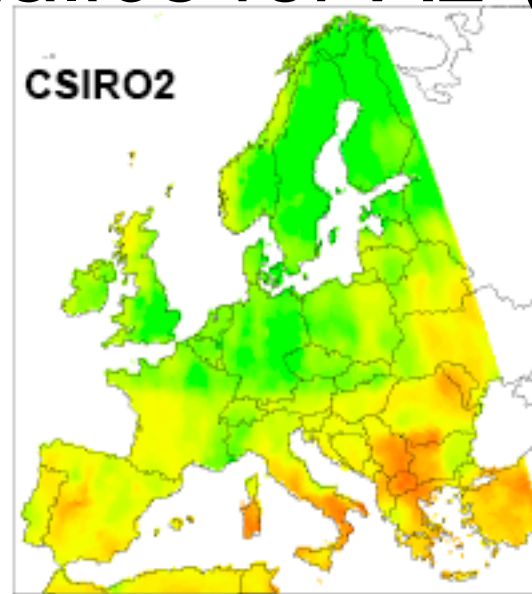
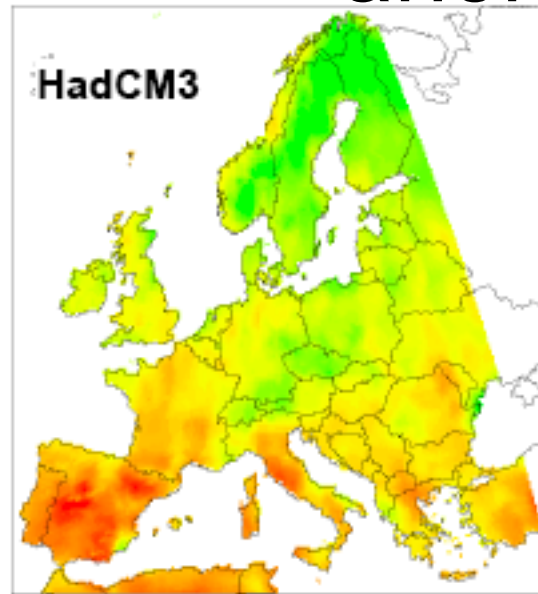
- **Multiple scenarios**
 - Focus on **seven priority scenarios**
 - Variation across storylines reflects **socio-economic choices**
 - Variation across GCMs reflects **“climatic uncertainty”**

Socio-economic choices

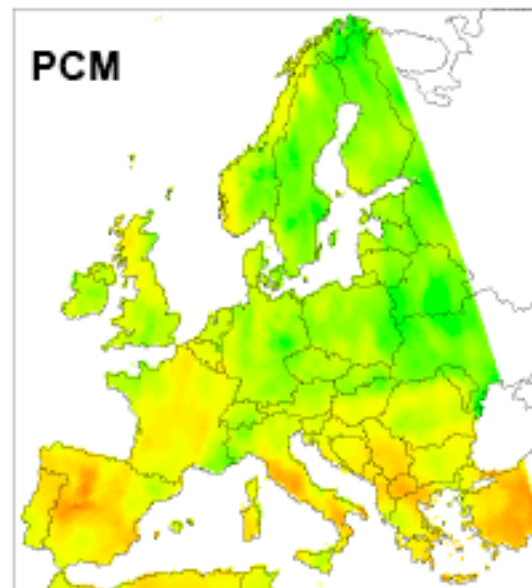
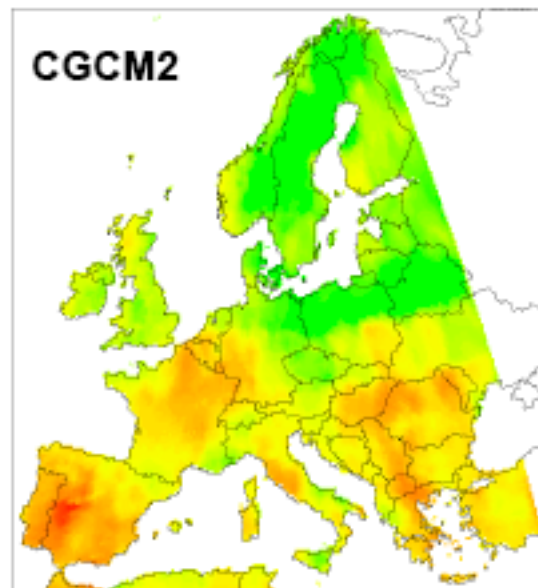
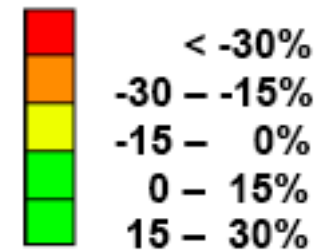
A1fi HadCM3	A1fi CSIRO	A1fi CGCM2	A1fi PCM
A2 HadCM3	A2 CSIRO	A2 CGCM2	A2 PCM
B1 HadCM3	B1 CSIRO	B1 CGCM2	B1 PCM
B2 HadCM3	B2 CSIRO	B2 CGCM2	B2 PCM

“climatic uncertainty”

Annual average precipitation anomalies for A2 (%)

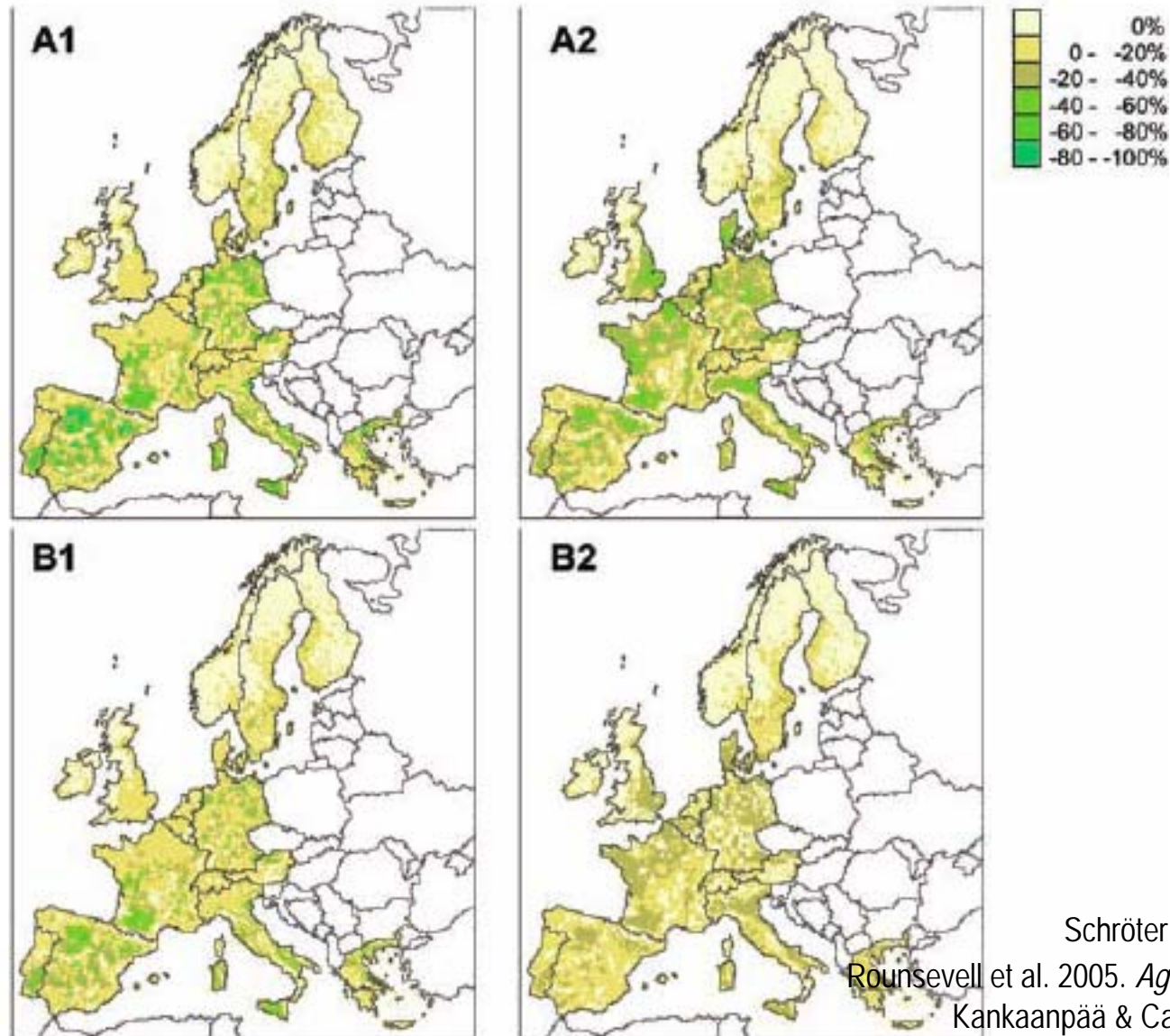


2051-2080
compared to
1961-1990



ΔP Iberian Peninsula JJA
-14 to -27 %
(for A2, across GCMs)
-18 to -26 %
(for HadCM3, across storylines)

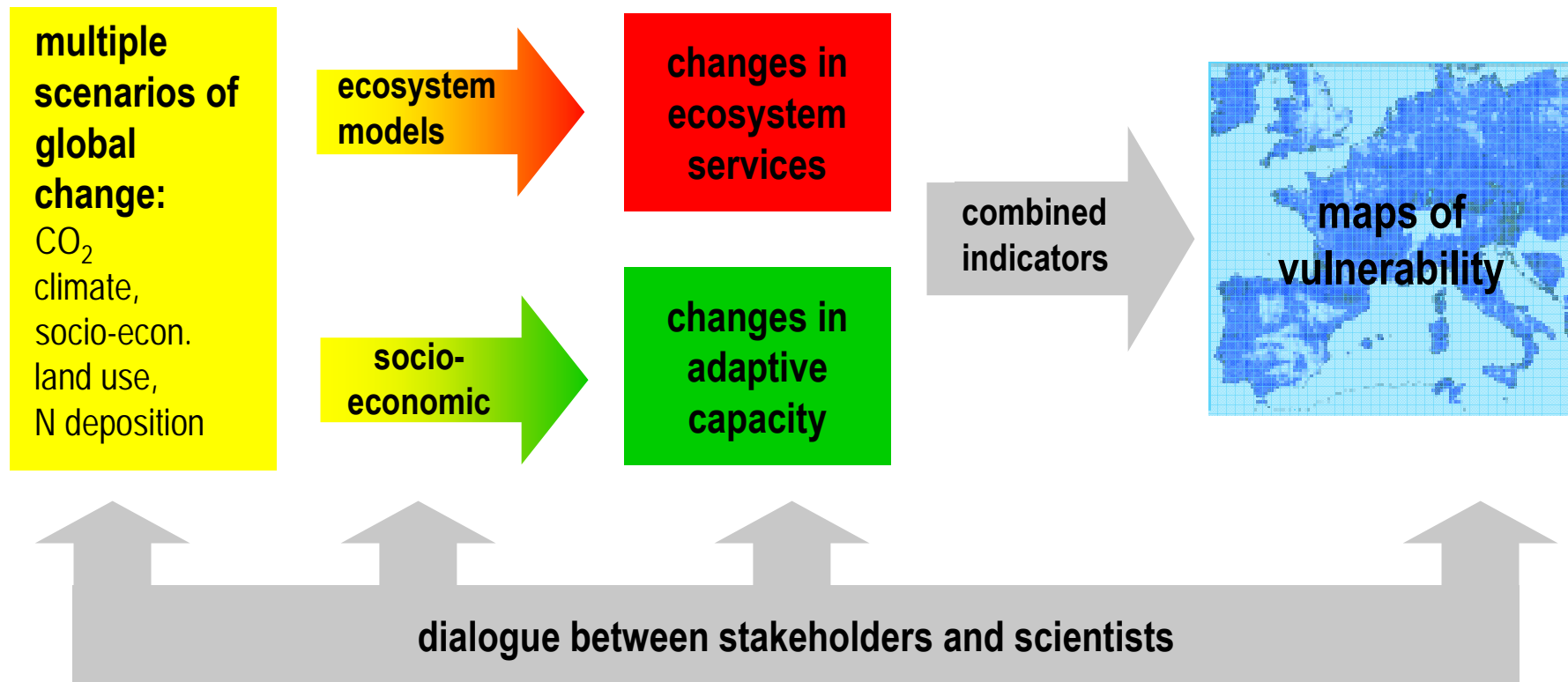
Changes of cropland area for food production by 2080



Schröter et al. 2005. *Science*.
Rounsevell et al. 2005. *Agric. Ecosyst. Environ.*
Kankaanpää & Carter 2004. *Finn. Env.*

European Vulnerability Study

Methodology



Water

- By 2080, with climate change **6-44 million additional people** projected to live under **severely limited water resources***.
- **Water stress** projected to **increase for 18-70 million** already stressed people.
- **14-38% of the Mediterranean population** would be living in watersheds with **increased water stress**.
- **Runoff seasonality changes** in Northern and alpine catchments → implications for
 - Hydropower,
 - Downstream users (industry, agriculture, tourism, domestic sector, navigation).

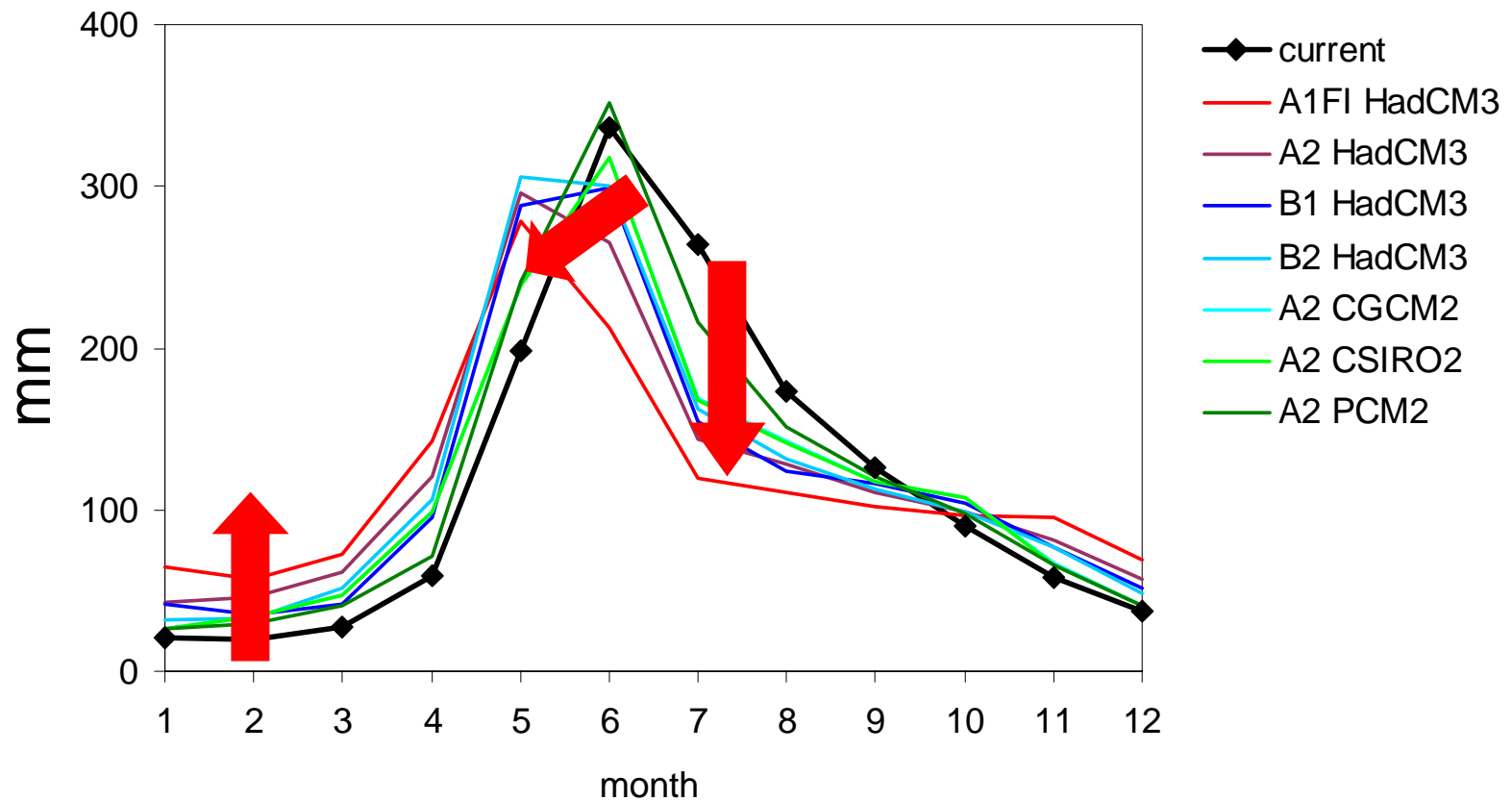
* less than 1700 m³ per capita and year

Zierl et al. 2005. *Water Resour. Res.*
Arnell et al. 2004. *Global Environmental Change.*
Schröter et al. 2005. *Science.*



Alpine runoff regimes

Example Dischma valley, 2051 - 2080

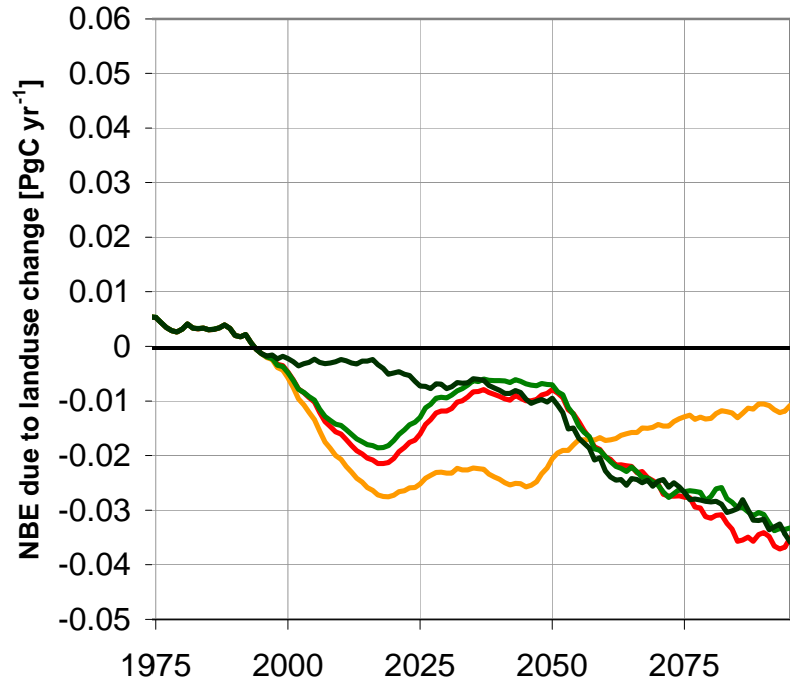


Carbon storage

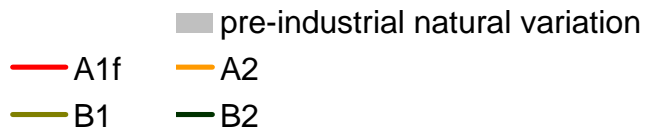
- Europe's terrestrial biosphere currently acts as a net carbon sink.
- All scenarios show a weakening of this carbon sink after 2050.
- Positive effects of land use, negative effects of climate change:
 - **Drought** stress and increased **fire risk** in **Mediterranean**,
 - Boreal forests accumulate carbon, but eventually **soil loses more than trees take up.**



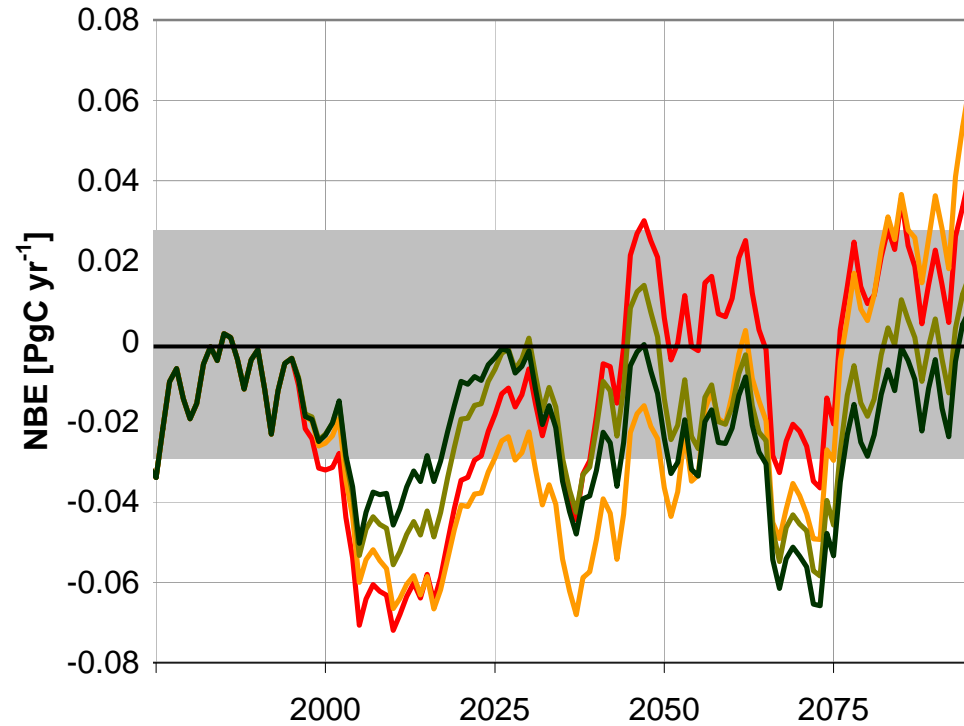
Declining carbon sink after 2050



Land use change *only*:
positive effect, **sink increases.**

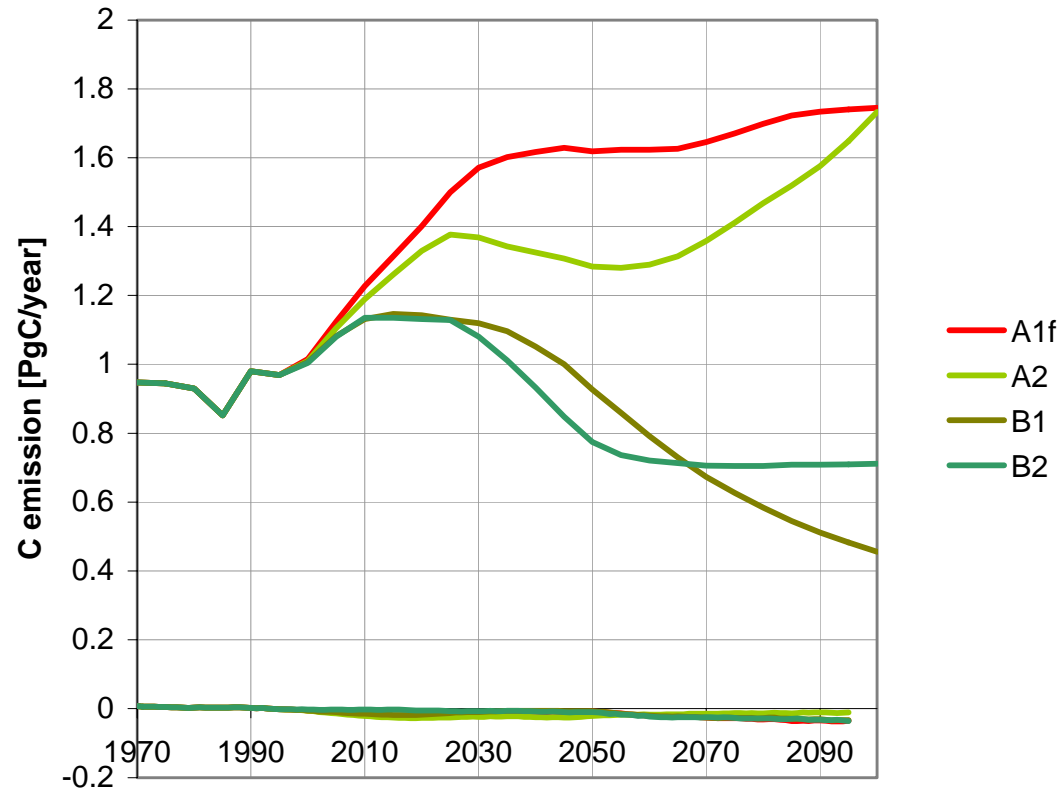


Land use *and* climate change together:
negative effect, **sink declines.**



Does it matter?

Carbon uptake by land use change vs. anthropogenic emissions.



→ even the most optimistic additional potential sink is very small.

... our digital atlas: ATEAM mapping tool

Ca. 3200 maps and many more summarising charts.

Download at www.pik-potsdam.de/ATEAM

Metzger, Leemans, Schröter, Cramer and the ATEAM consortium. 2004. The ATEAM vulnerability mapping tool. *Quantitative Approaches in Systems Analysis No. 27, CD-ROM publication*, Office C.T. de Wit Graduate School, PE&RC, Wageningen, The Netherlands.

Explore the vulnerability of different sectors to global change impacts in Europe.

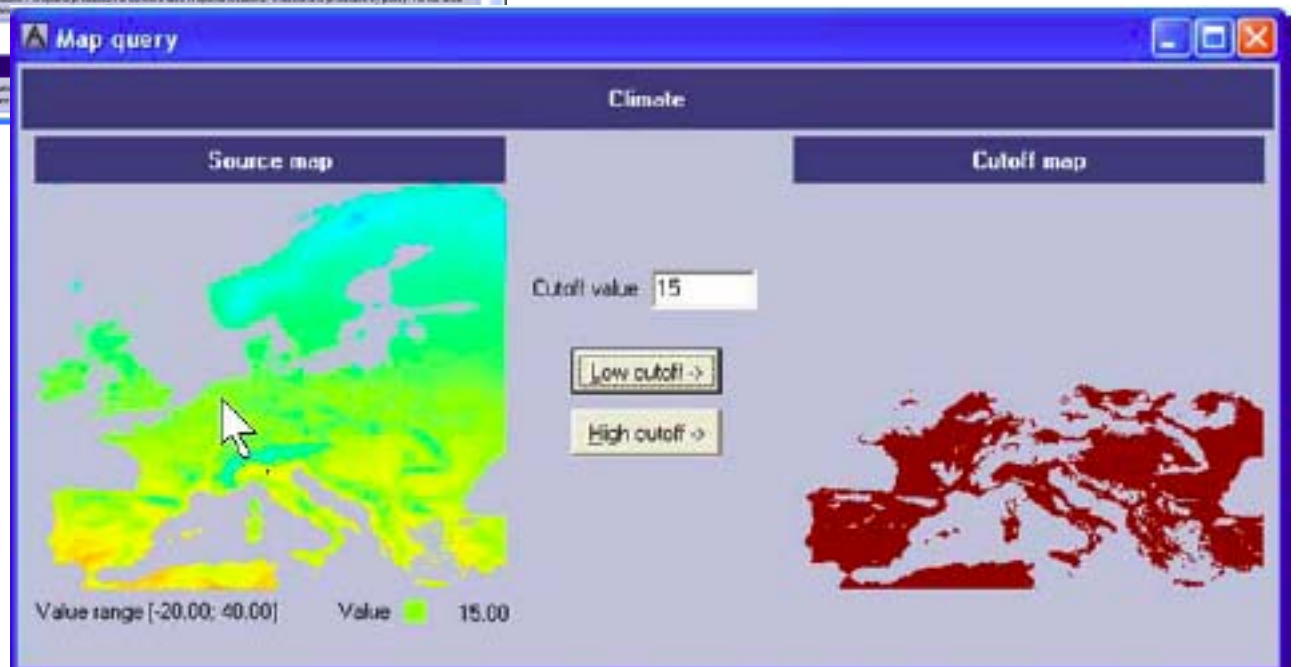




Explore scenarios...

Run simple queries...

European Environment Agency agreed to further develop this tool.

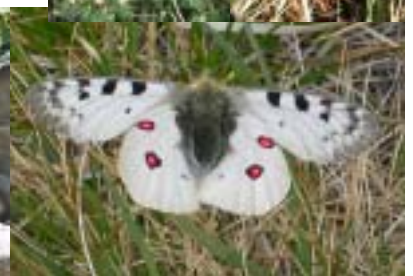




Climate change
increases the **urgency**
to manage
ecosystem services well.

Land use
is the global change driver
that we can influence
most directly and
immediately.

Lightning in the sky above Zürich, CH.



- + Water provision
- + Hazard protection
- + Hydropower
- + Dairy and meat production
- + Diversity & Recreation

Ecosystem Services and Land Use

	Forestry	Agriculture	Nature Conservation	Tourism	Settlement
Water	+++	++	++	?	--
Hazard protection	+++	++	++	-	-
Hydropower	+++	++	++	?	--
Dairy & meat	0	+++	+	?	0
Diversity	+	++	+++		
Recreation	+	+	+	+++	+++
...					

Conclusions

1. Global change **vulnerability** has an **environmental dimension** through potential reduction in the **supply of vital ecosystem services**.
2. The concept of **ecosystem services**
 - connects **people with their environment** and **with each other** (e.g. upstream with downstream);
 - helps us think about ecosystem **states and processes**;
 - gives us **a clearer language** to communicate **across borders** (transdisciplinary, applied research, science-policy-user dialogues);
 - brings environmental concerns **to the political center stage** ("mainstreaming").
3. **Ecosystem features** and their **management** matter for **ecosystem service supply**. *But how?*
4. **People value ecosystem services differently**. *How do we work with that?*
5. Global changes alter supply of ecosystem services. **Land use is often our most immediate control lever**. *Spatially explicit studies can support management.*



Thank you!