Virtual Academy for Sustainability

WBGU
German Advisory Council on Global Change

Lecture 2: Global Megatrends

Episode 1: Megatrends of the Earth System

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World in Transition: A Social Contract for Sustainability *supported by*

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Deutsche Bundesstiftung Umwelt

Episode 1: Megatrends of the Earth System

Episode 2: Megatrends of the Global Economy and Society

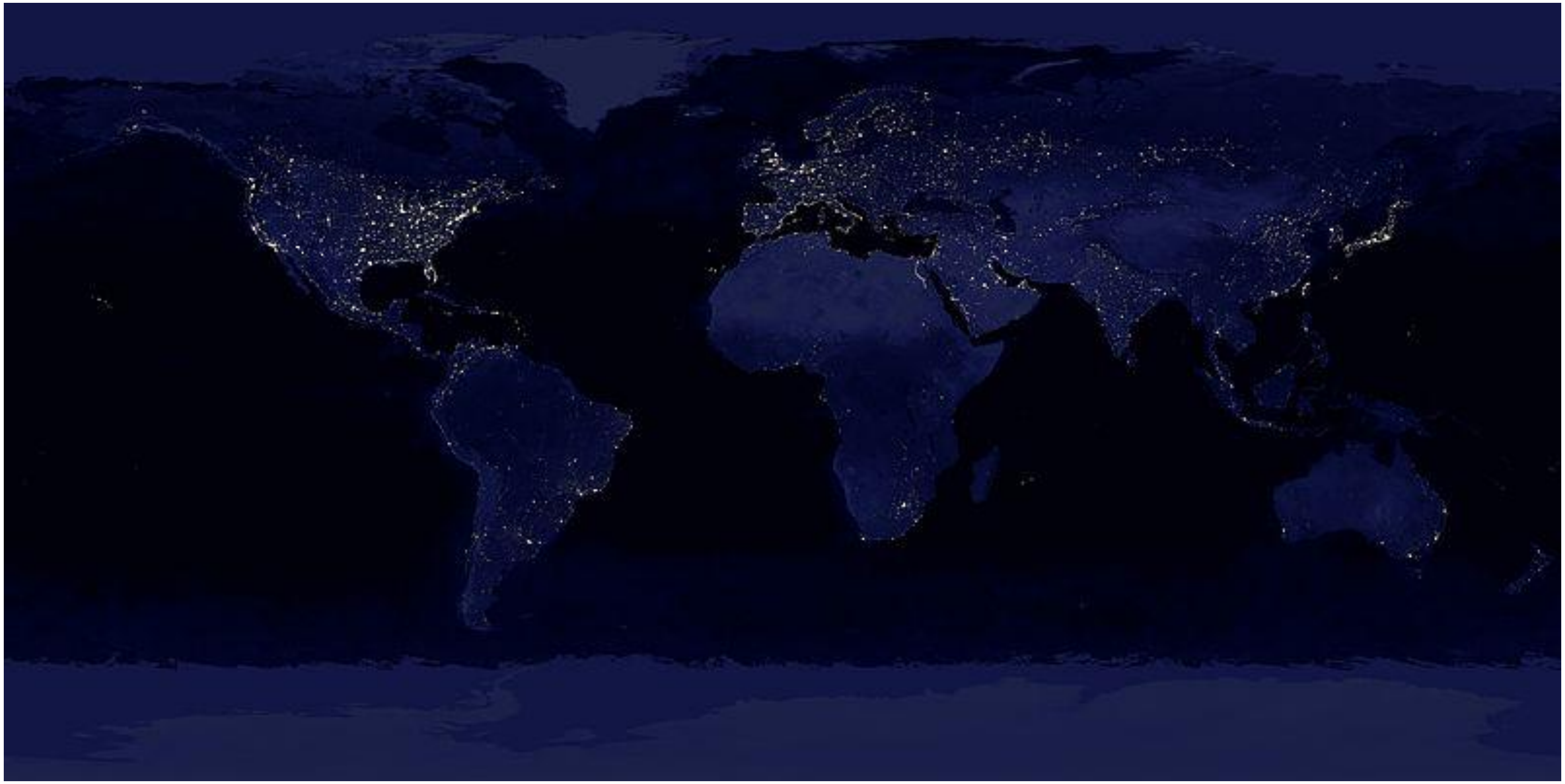
Episode 3: Interview

1. You will learn why **Anthropocene** might be the appropriate name for the present and the future when dealing with global megatrends and their transition towards sustainability.
2. You will learn which **factors and processes** drive the earth system towards endangerment of our society
3. You will learn why **planetary guard rails**, such as the 2° C goal might be a useful tool to help keeping the **planetary system** within its natural **boundaries**.
4. You will learn about **interaction, interdependancies and feedback loops** of humankind-driven natural processes

Content

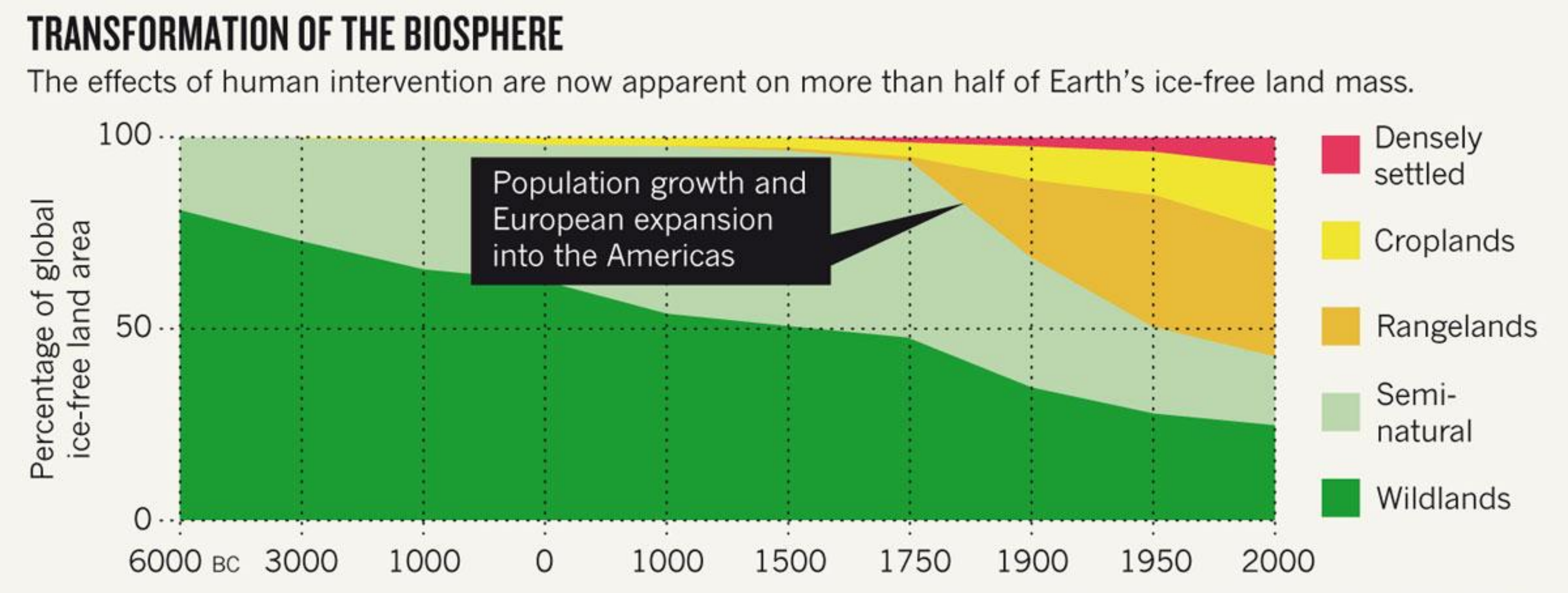
- The Anthropocene Concept
- Planetary Boundaries, Guard Rails and Sustainable Development
- Climate Change Trend and Related Issues
- Land Degradation and Desertification
- Water Shortage and Water Pollution
- Raw Materials, Nutrients, Pollutants
- Interaction and Feedback Loops

The Age of Humankind



Source: Image by Craig Mayhew and Robert Simmon, NASA GSFC, wikimedia commons, public domain

Only 23% of ice free land are pristine



Source: Nature, 12 May 2011, after Ellis 2011

- **77%** of (ice free) **land surface** used by humans
- **50%** of **available fresh water** used / controlled by humans
- Severe **overfishing** world wide
- **100-1000x higher extinction rate** of animals and plants than natural
- **Biomass of humans and its domestic animals** amounts to **90%** of biomass of all living mammals
- Increase of **energy consumption** since 1900: **> 16 x**
- **Highest** atmospheric **CO_2 and CH_4**-concentrations **since 400.000 years**
- **NO_x und SO_2-emissions now higher than natural sources**
- Mean **erosion rate** since 500 million years:
  24 m / mio years, **today: ca 700** m / mio years

> Humankind has become a major earth system factor

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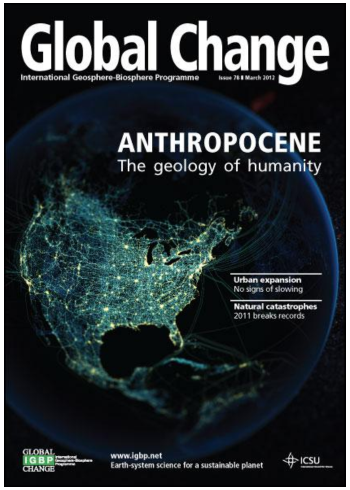
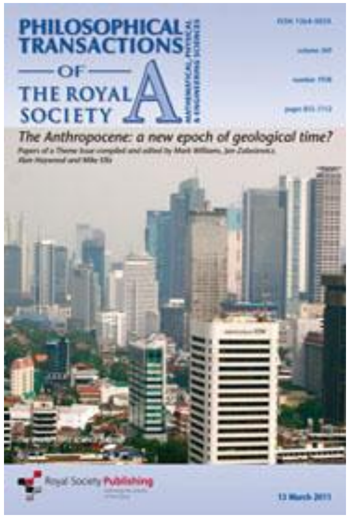
- Nobel laureate Paul Crutzen 2000 (Meteorologist, Chemist)
- **Man as earth system factor**, part of nature
- Anthropocene **geologically definable** and preservable
- **Systemic: combines natural-, social-, economic-, cultural sciences, humanities, technology, art, experienced knowledge, indigenous knowledge into one concept**
- **Assume responsibility for the future**
- **Design the present** for a sustainable future on a knowledge basis (to be continuously readjusted)

> **Learn from the Past** (History of Earth, Human Evolution, Cultural Evolution, Technical Evolution etc), **the Present and the Future** (Scenarios, models)

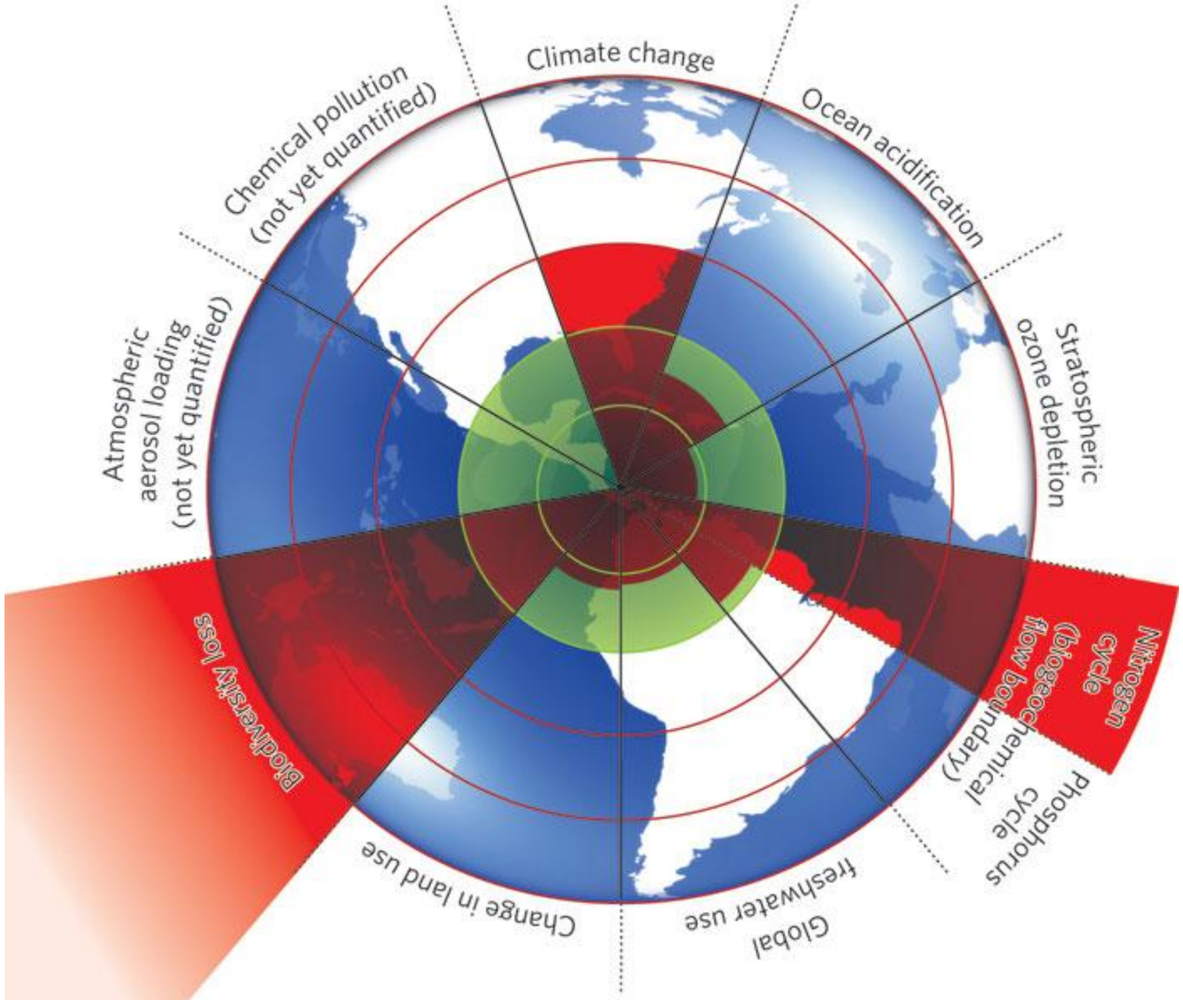
Key responsabilities for the Anthropocene





- No longer dualism „good nature vs. (bad) humankind“
- No way back to Holocene
- No simplistic solutions, systemic thinking needed

Planetary Boundaries



Source: Rockström et al., Nature, 24. Sept. 2009

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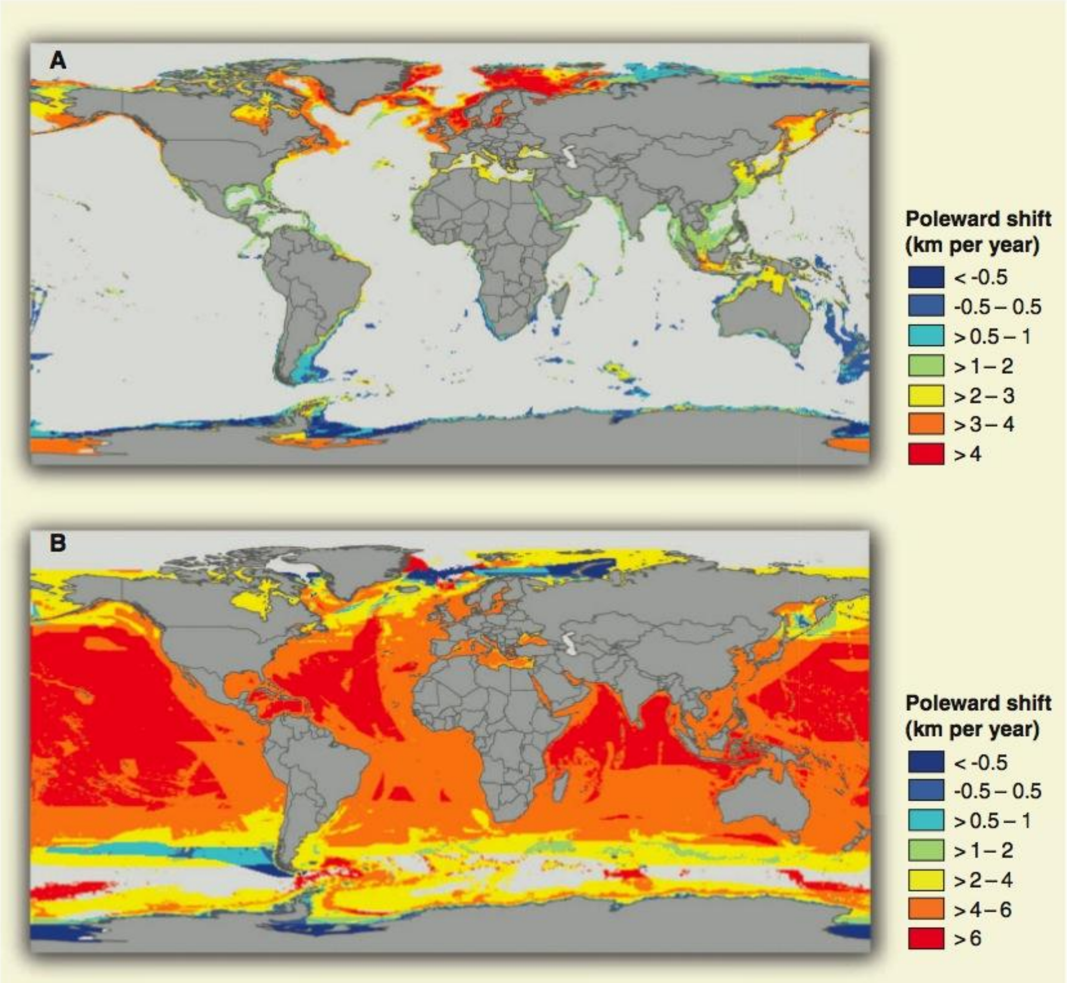
Projected rate of range shifts in marine organisms caused by climate change from 2005 to 2050



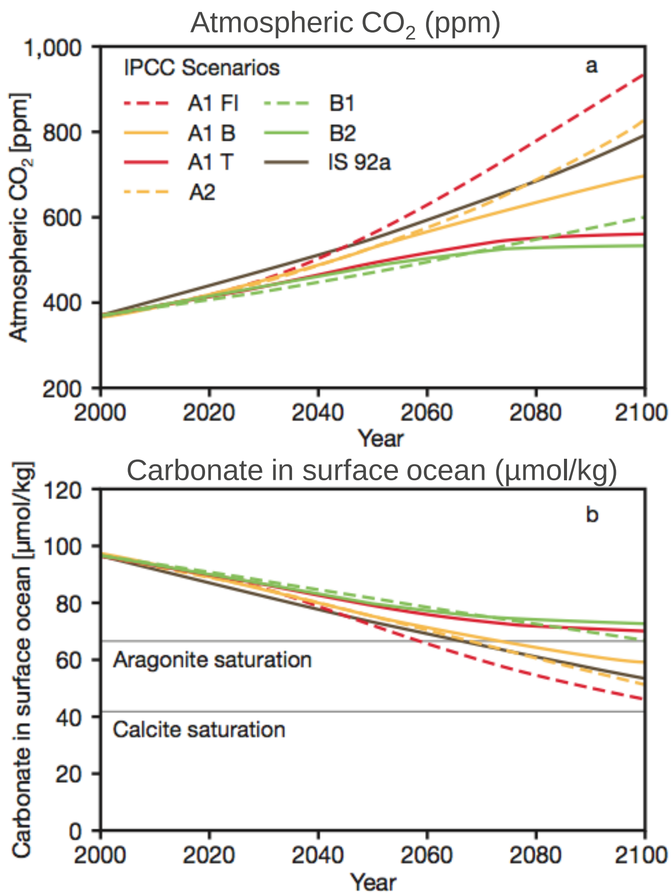
Demersal species (< 2000m)

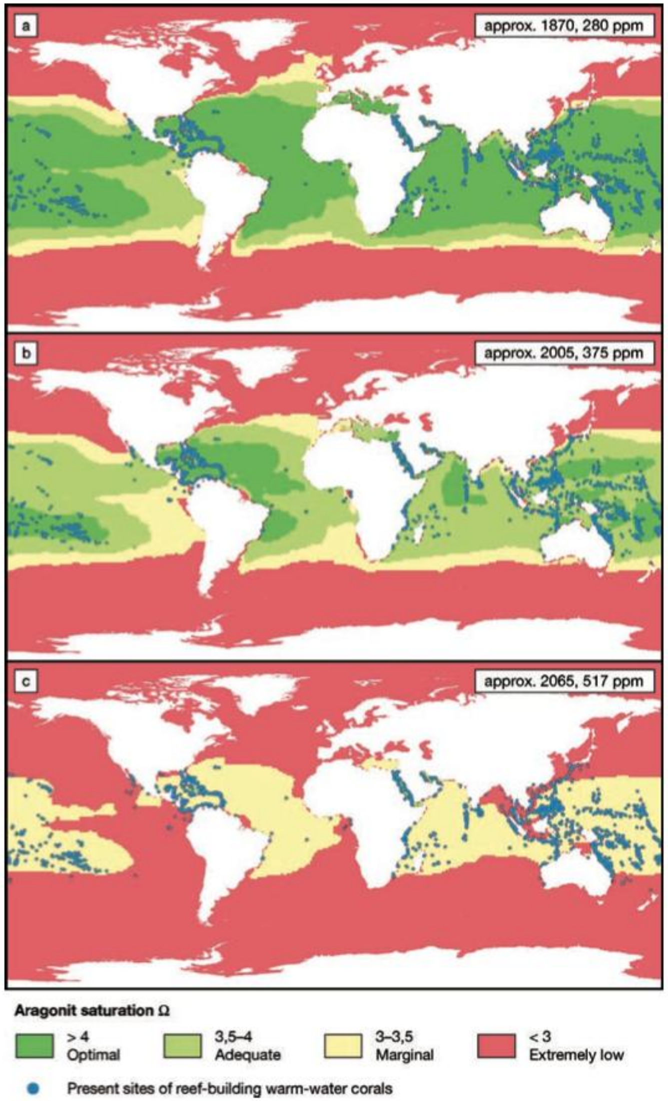
Pelagic species

Based on bioclimatic envelope models for 1066 spec of fish and invertebrates, under IPCC SRES A1B

Source: Pereira et al., 2010; Science, 330

Acidification of oceans





1870, 280 ppm

2005, 375 ppm

2065, 517ppm

Source: WBGU 2008

Examples of **Ecosystems Goods**:

- food
- fibres
- building materials
- industrial raw materials

Examples of **Ecosystems Services**:

- protection
- freshwater supply
- soil fertility
- unpolluted air
- pollination

Biomes or ecosystems	Typical cost of restoration (high scenario) [US$/ha]	Estimated annual benefits from restoration (average scenario) [US$/ha]	Net present value of benefit over 40 years [US$/ha]	Internal rate of return [%]	Benefit/ cost ratio
Coral reefs	542,500	129,200	1,166,000	7	2.8
Coastal ecosystems	232,700	73,900	935,400	11	4.4
Mangroves	2,880	4,290	86,900	40	26.4
Inland wetlands	33,000	14,200	171,300	12	5.4
Lakes and rivers	4,000	3,800	69,700	27	15.5
Tropical forests	3,450	7,000	148,700	50	37.3
Other forests	2,390	1,620	26,300	20	10.3
Woodland and shrubland	990	1,571	32,180	42	28.4
Grasslands	260	1,010	22,600	79	75.1

Source: Sukhdev, 2008

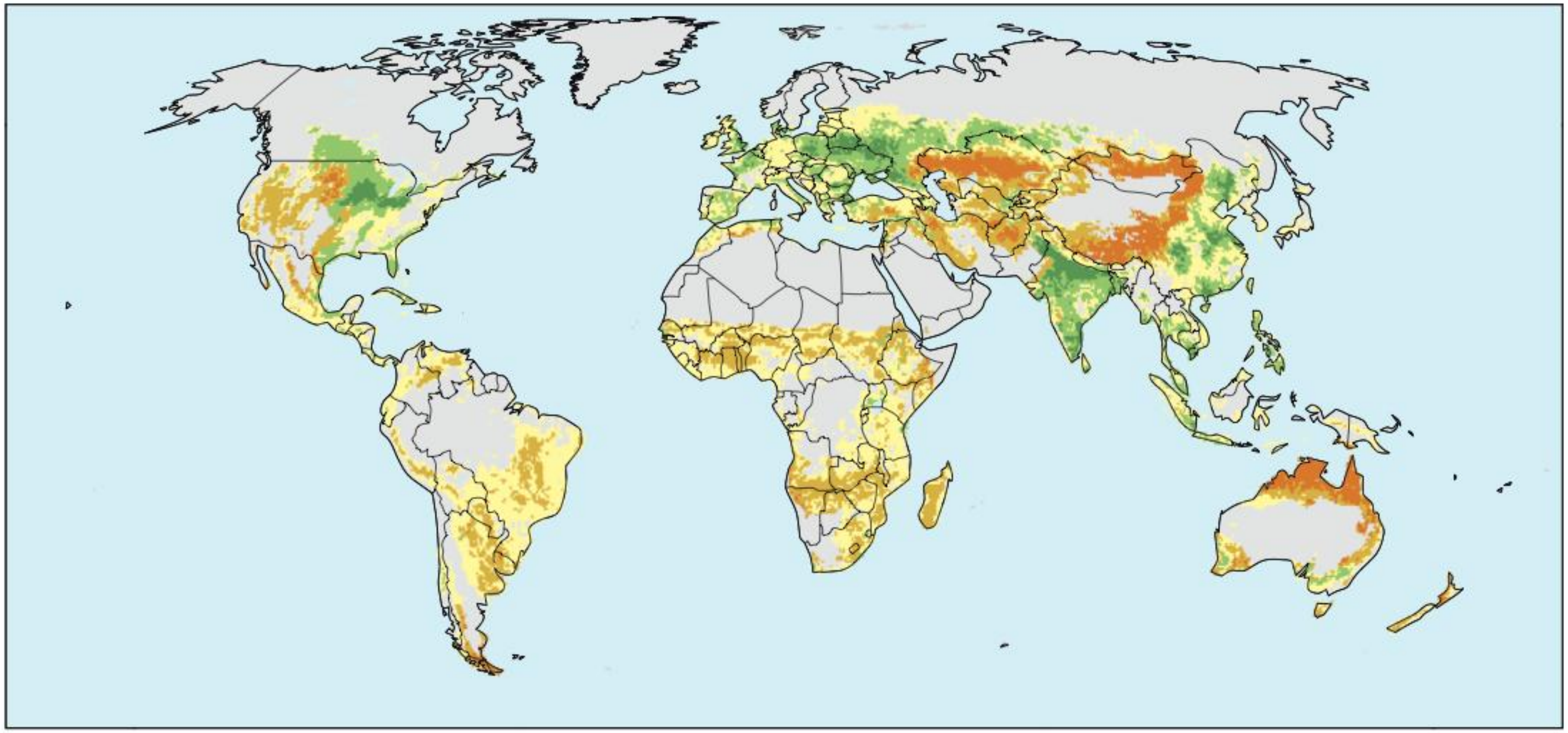
Drivers of biodiversity loss:

- land use and fresh water management
- overexploitation of oceans
- pollution of all kind
- climate change, acidification of oceans
- invasion of alien species by human infrastructures
- speed of change

Endangered to extinct, some figures:

- 22% of mammals
- 14% of birds
- 31% of amphibians
- 28% of conifers
- 52% of cycads
- etc.

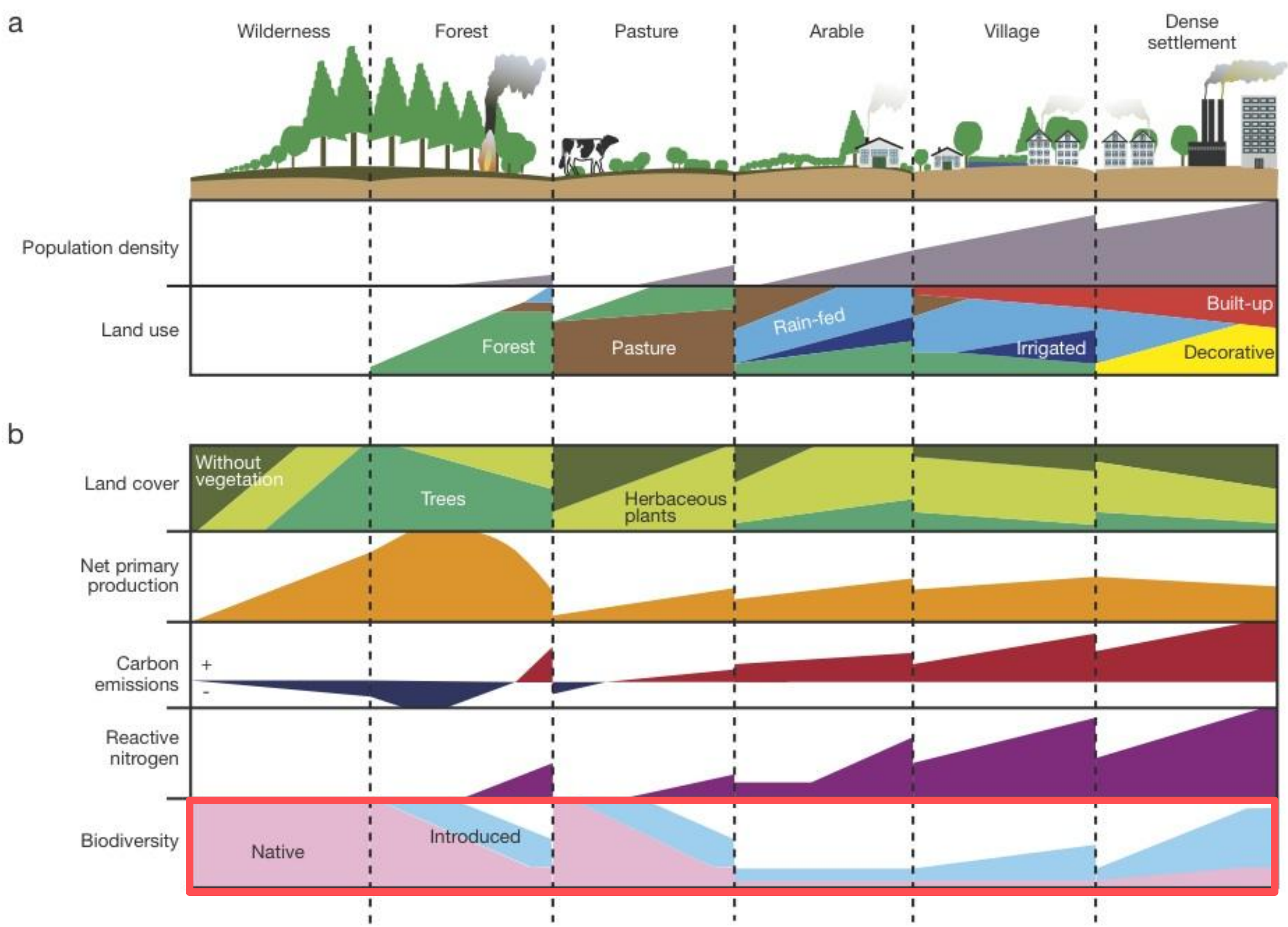
Source: MA, 2005; Vié et al., 2008



Source: UNEP, 2007

Ecosystems Services and Biodiversity Loss

Living in „anthromes“, rather than biomes



Source: Ellis and Ramancutty, 2008

Guard Rails, Institutions

- Suggested planetary boundary: extinction rate **max. 10x** of natural background rate (Rockström et al. 2009)
- Current status: **100-1000x**
- WBGU Guard Rail: **10-20%** protected areas on land, **20-30%** on sea
- UN-Convention on Biological Diversity (CBD), Nagoya protocol, targets: land **17%**, marine areas **10%**

Source: WBGU, 2011; MA, 2005

Main drivers:

- Deforestation
- Overgrazing
- Expansion of non-sustainable agriculture
- Soil salinisation
- Soil sealing
- Urban growth

> Annual loss of productive land: 20,000-50,000 km^2
> Desertification ca. 66-103 Gt CO_2 of soil carbon release

> Sustainable management/restoration of grassland:
Storage capacity 100-800 Mt CO_2/year

Source: MA, 2005; Vié et al., 2008

Guard Rails, Institutions

- Suggested planetary boundary: **max. 15%** of total global terrestrial area for agriculture (Rockström et al. 2009)
- Current usage: **nearly 12%**
- WBGU Guard Rail: Soil loss should not exceed soil reformation; e.g. temperate zone: max **1-10 t** soil loss per hectare per year

- United Nations Convention to Combat Desertification (UNCCD)
- Weakest of all Rio Conventions, adresses drylands. Wetlands, forests to some extent in CBD, global soil protection strongly neglected

Source: WBGU, 2011; MA, 2005

Some facts:

- Increase of freshwater use over last century: 8x
- Continues to grow about 10% each decade
- 40-50% used/controlled by humankind
- Falling groundwater tables
- River water not reaching the sea owing to usage
- Severe pollution problems:
  - Salinisation, nutrient and sediment contamination
  - Chemicals, incl. plastics, pharmaceuticals, pesticides
  - Biological depletion

WBGU 2011, MA 2005

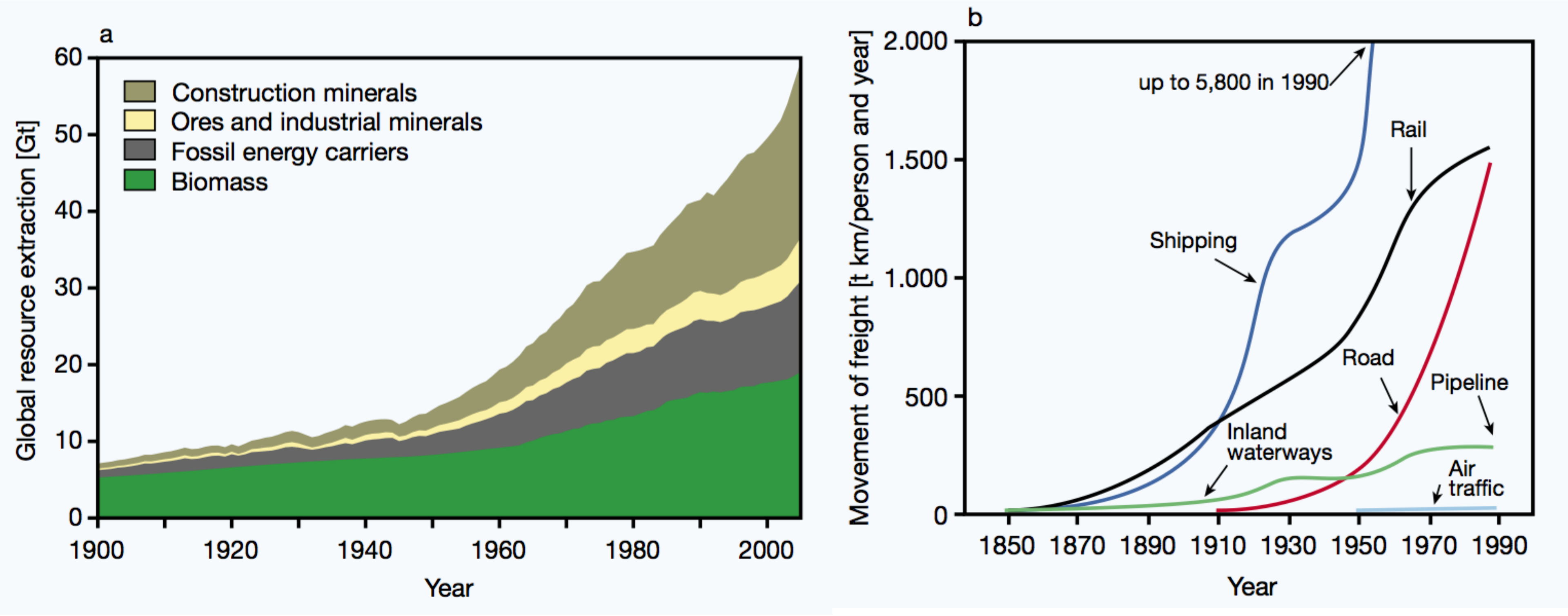
Guard Rails, Institutions

- Suggested planetary boundary: Removal of > **4,000 km³/y** of „blue water“ (rivers, lakes, groundwater) (Rockström et al. 2009)
- Current usage: **2,600 km³/y**, rapidly increasing

- Protection and sustainable use best achieved by local to regional institutional control and policies
- However, general water scarcity and pollution need global regulation: World Water Council (NGO), presently runs as dialogue process.

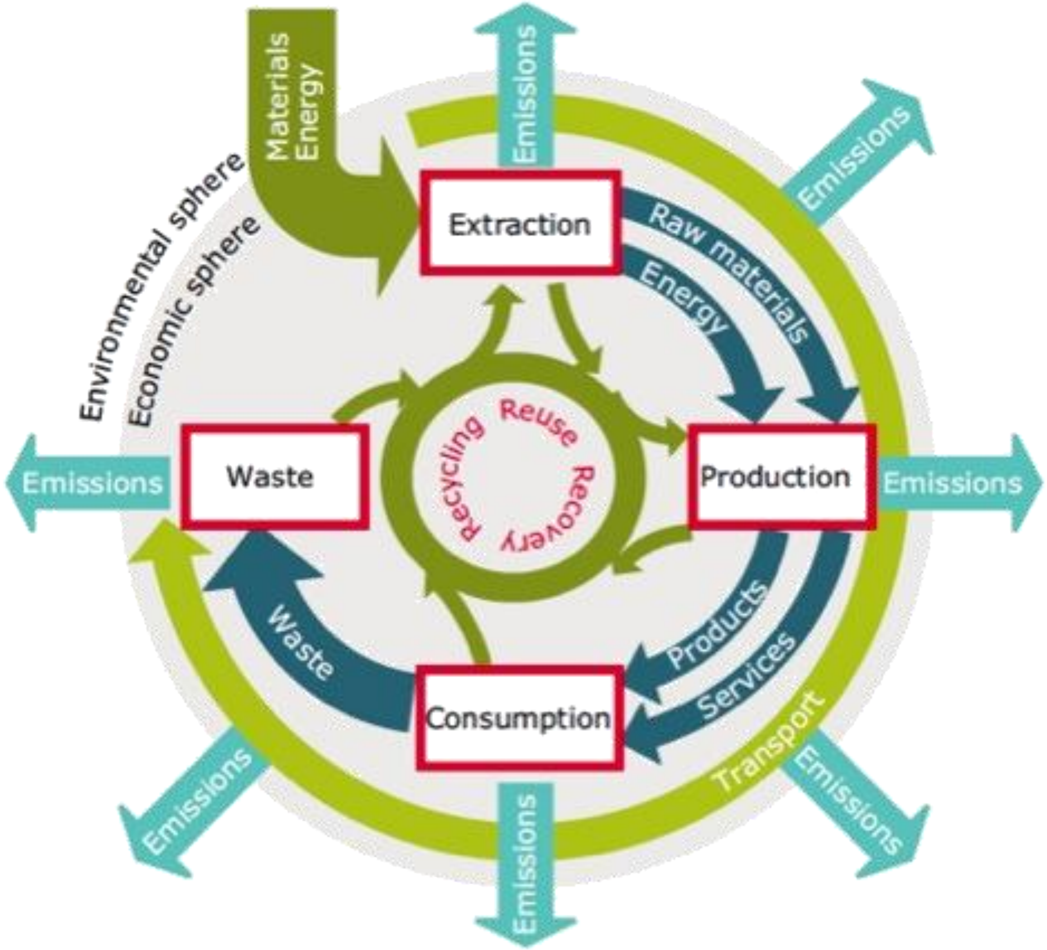
Source: WBGU, 2011; MA, 2005

Extraction and transport of resources and products



Source: Gilbert, 2001; Krausmann et al., 2009

The WBGU-Vision of a full industrial metabolism concept



Source: after EEA, 2010

Raw Materials:

Coal, ores, crude oil, natural gas: known problems

Increasing scarcity of other strategic mineral resources, e.g.:

- **Lithium:**
  - Annual growth rate of Li-batteries: **20%**
  - Reserves **9.9 mio t**, resources, **25.5 Mio t** (USGS 2010)
  - Global production 2009: **18,000 t**
- **Rare Earths, Rare Metals and Semimetals:**
  - **Gallium, indium** for photovoltaic industry
  - **Neodymium** for permanent magnets (e.g. electric engines, wind power
  - **Germanium** (optoelectronics), **scandium** (fuel cells), **tantalum** (mobile telephones), **platinum** (catalytic converters etc.).: demand will partially outstrip production and reserves.

Nutrients:

Reactive **Nitrogen**

- Production of reactive nitrogen: 10x since beginning of industrialisation (from 15-156 Mt N/y, exceeding natural flows)
- 257 Mt/y expected for 2050
- Obtained from air (leguminosan or energy-intensive Haber-Bosch process)
- Planetary Boundary suggestion: 35 Mt N/y (Rockström et al. 2009)

Nutrients:

Phosphorus

- P as fertilizer 3x from 1960-1990
- Today, 20 Mt P/y extracted
- 50% of this ends up in oceans (prehistorical input: 0.2 Mt P/y)
- Ca 60% of all reserves in Morocco and China. South Africa, USA important
- Peak phosphorus either reached in 2007 or in 2030, not yet high on political agenda
- Suggested planetary boundary: 11 Mt/y (Rockström et al. 2009)

Pollutants: Examples

Persistent Organic Pollutants (POPS)

- greatly toxic, strongly mobile, very long-lived
- number and volume has significantly increased
- spreading globally
- accumulating in food chains

Heavy Metals

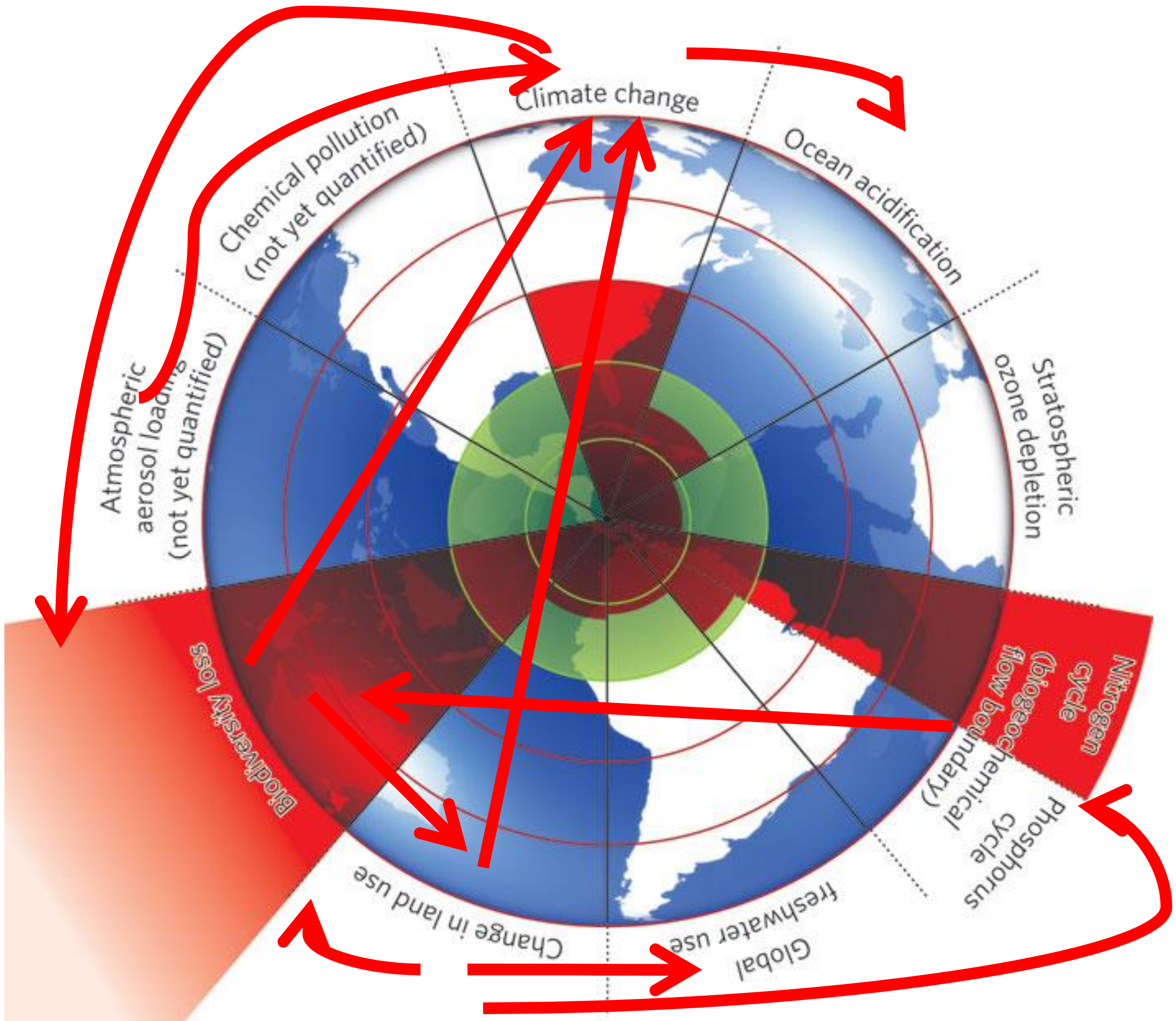
- lead and mercury major problems, long live span, globally distributed (incl. arctic).
- lead problem diminished (lead-free petrol)
- mercury still increases and is inadequately regulated

Pollutants: Examples

Many other examples cannot be adressed in this lecture, they include

- State of Ozone layer
- Air pollutants (aerosols etc.)
- Wasted food (up to 50%)
- Plastic garbage accumulating in the oceans
- Allergenic substances, e.g. by invasive species
- Etc.

Interaction and Feedback Loops



Source: Rockström et al., Nature, 24. Sept. 2009

Interaction and Feedback Loops

Impact of / on	Climate change	Biodiversity loss	Freshwater scarcity and pollution	Soil degradation, desertification	Pollutants and nutrients
Climate change		CO_2 emissions through the loss of natural ecosystems (stocks and sinks); albedo change		Loss of CO_2 stock and sink function: albedo increase	Impact of aerosols: CFCs; ground-level ozone; stratospheric ozone
Biodiversity loss	Overtaxation of ecosystems' and species' ability to adapt (e.g. coral bleaching)		Degradation of limnic ecosystems; species loss	Ecosystem degradation; species loss	Accumulation of pollutants in natural ecosystems; eutrophication; species loss
Freshwater scarcity and pollution	Altered precipitation volumes and patterns	Altered local hydrological balances, e.g. through deforestation, increased sediment load in rivers		Increased pollutant and sediment burden	Contamination of water resources (e.g. through mercury, pesticides); sediment burden
Soil degradation, desertification	Desertification as a consequence of less precipitation in arid areas	Increased erosion through loss of plant cover	Salinisation		Soil burdening through heavy metals and organic substances
Pollutants and nutrients		Less air filtration; decelerated pollutant degradation	Decelerated pollutant degradation	More dust through wind erosion	

Source: WBGU, 2011

Exercises for self study

1. Which new kind of „fossils“ an Anthropocene Age might provide?
2. Find out more about the monetarisation of ecosystems goods and services, e.g. in the TEEB study
3. Try to find more examples for interaction of climate and biodiversity
4. How high is the proportion of carbon release by land use change relative to all anthropocenic carbon emission?
5. How far is the technical development for recycling phosphorus?
6. Try and find some examples where the industrial metabolism concept could be applied already
7. Find out about plastics in the oceans. Why is it a problem and how could we solve it?

References

Basic reading:

- WBGU (2011): World in Transition: A Social Contract for Sustainability, chapter 1. Berlin. www.wbgu.de

Further reading:

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