



# SVENSKA ARALSJÖSÄLLSKAPET

Swedish Aral Sea Society



## 2. Resource flows

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Uppsala University

**Master Course on Sustainable Development and Sustainability Science  
For Uzbekistan by SASS and Karakalpak State University Spring 2023**

# Something New Under the Sun

John McNeill, 2000

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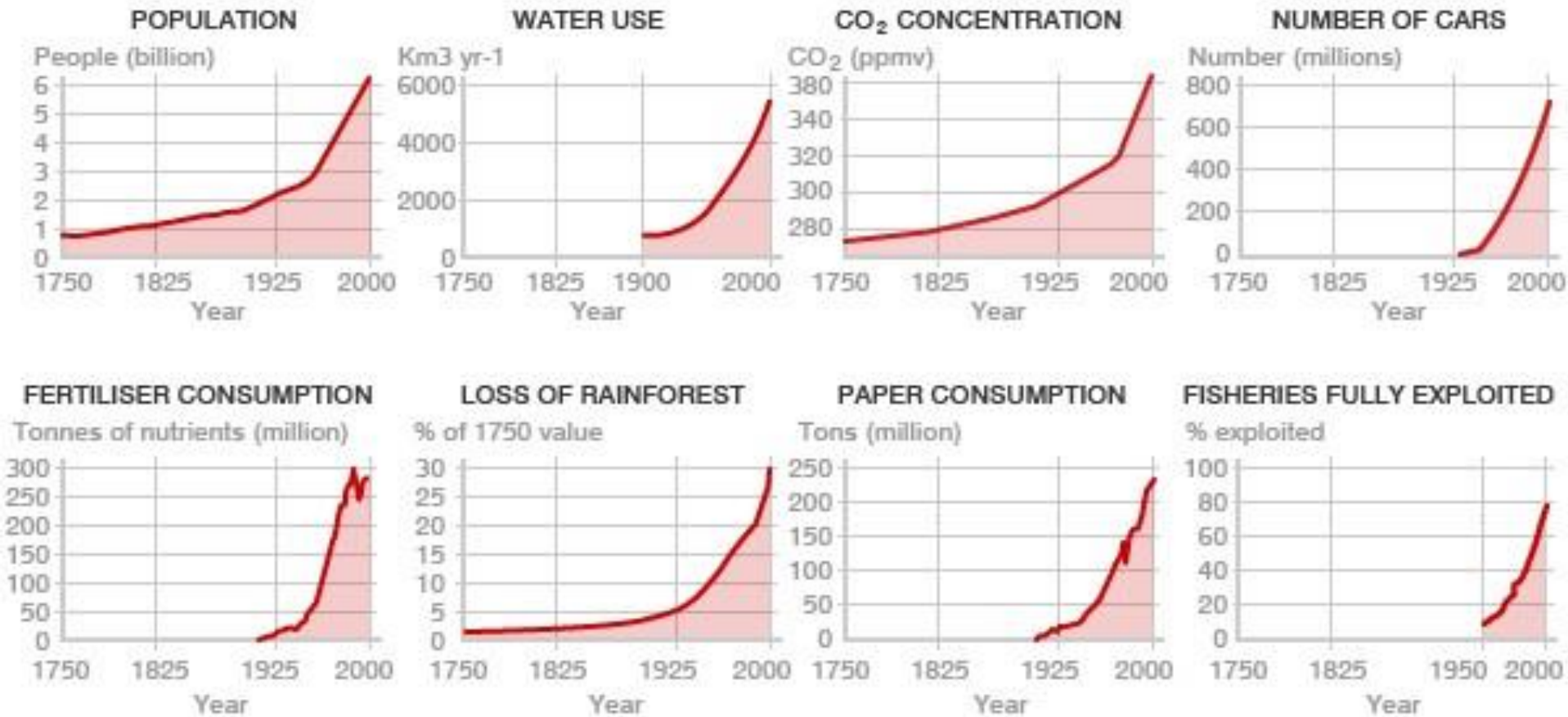
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## Development 1900 – 2000

- global population 4 x
- global economy 14 x
- industrial production 40 x
- energy use 16 x
- carbon dioxide emissions 17 x
- sulphur dioxide emissions 13 x
- ocean fishing catches 35 x
- number of pigs 9 x
- forests 0.8 x
- agricultural fields 2 x
- blue whale 0.0025 x



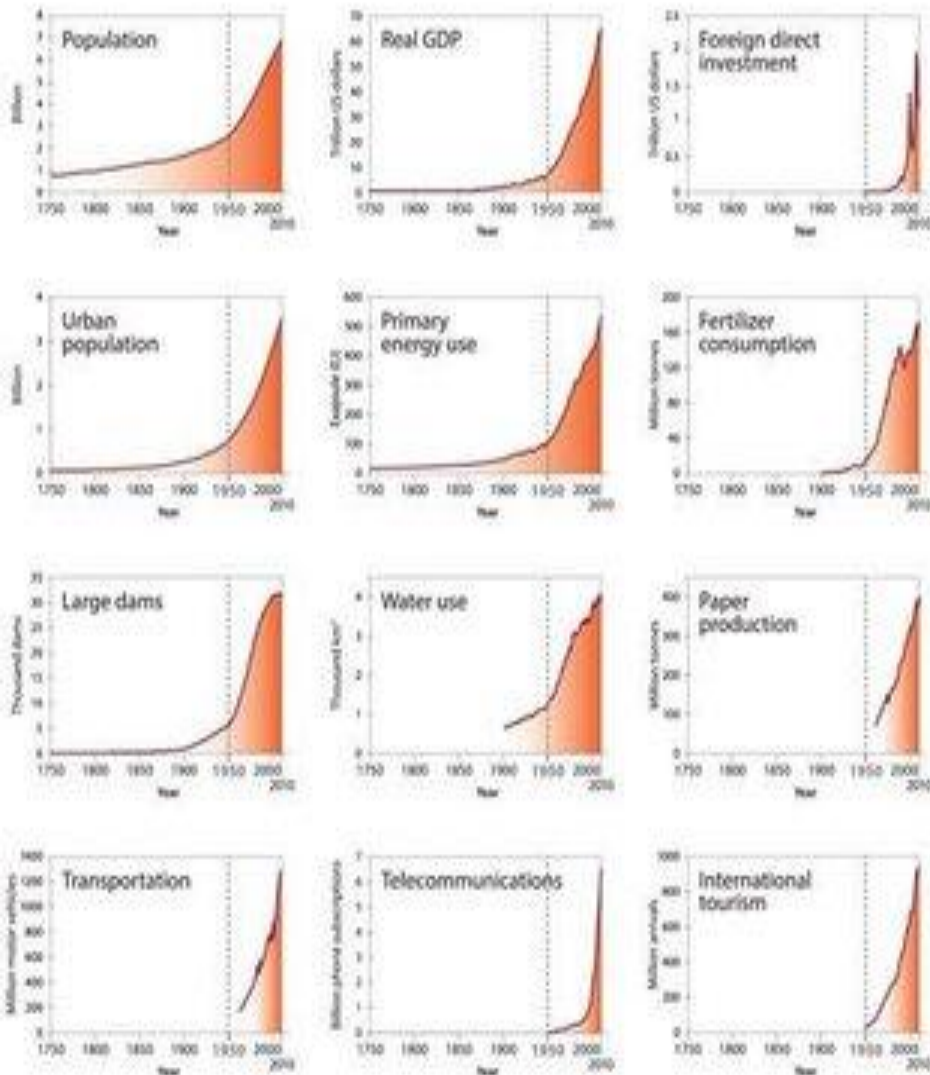
# Exponential Growth



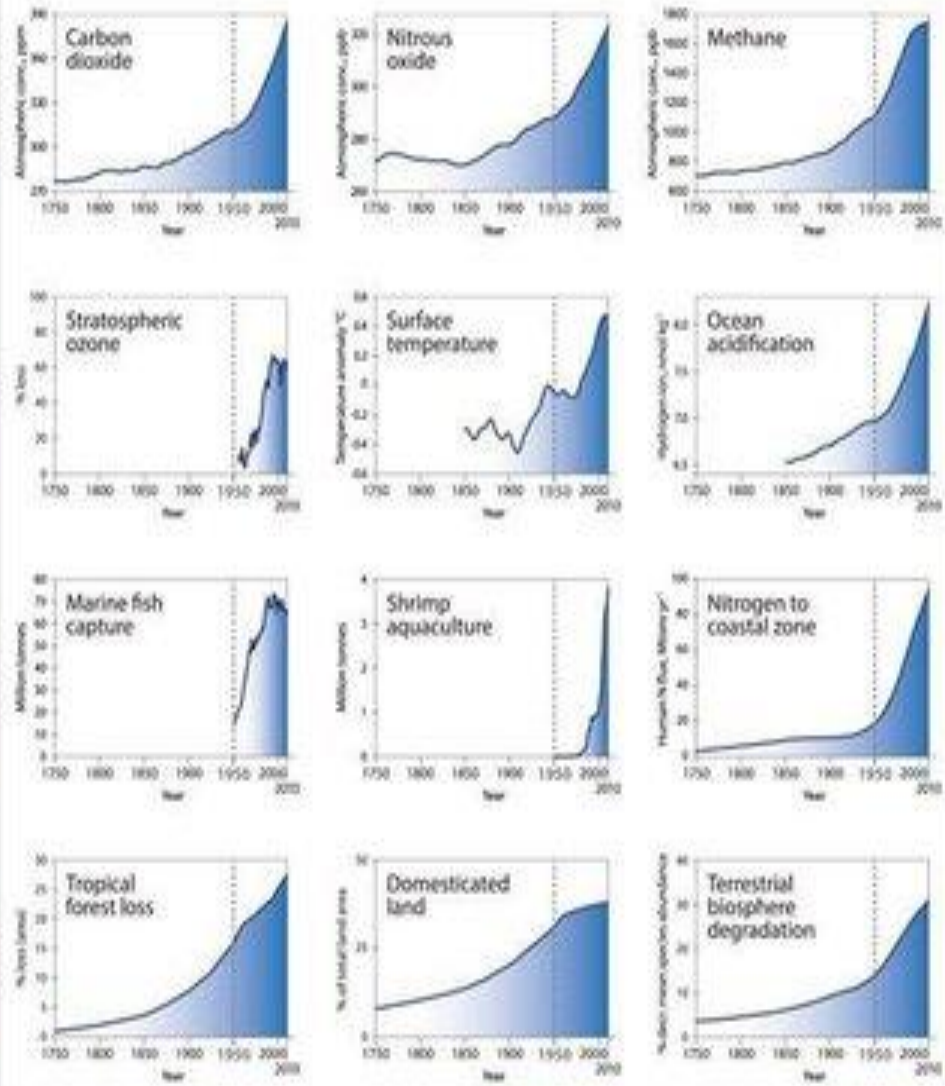
SOURCE: International Geosphere-Biosphere Programme (Steffen et al 2004)

# The Great Acceleration

## Socio-economic trends



## Earth system trends



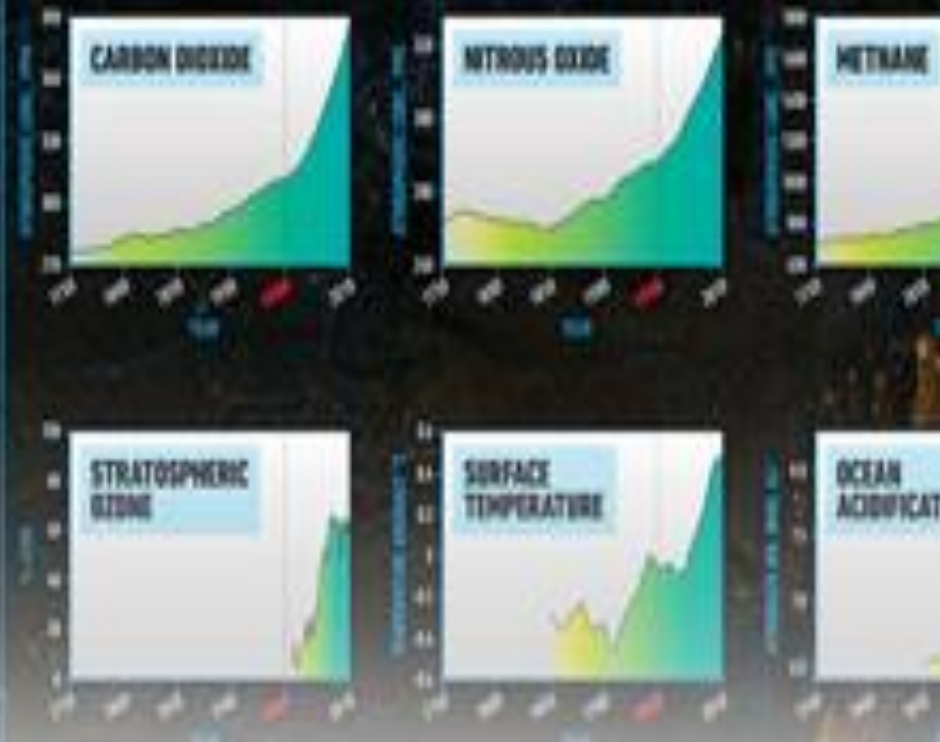


# THE GREAT ACCELERATION

## SOCIO-ECONOMIC TRENDS



## EARTH SYSTEM TRENDS



# The high resource consumption continues

## Some data from 2020

Consumption *per capita* globally of some key resources for 8 billion people

- 703 kg of coal
- 530 kg cement
- 240 kg steel
- 500 000 liter of fresh water

**”We live  
in the  
Anthropocene”**



# **Non-renewable resources**

**Mined from the crust of the earth  
They are slowly emptied**

**The environmental consequences  
of the accumulation of the end product  
will often appear before the resource is emptied.**



# Fossil fuels coal, oil, gas



Lignite mining  
Germany

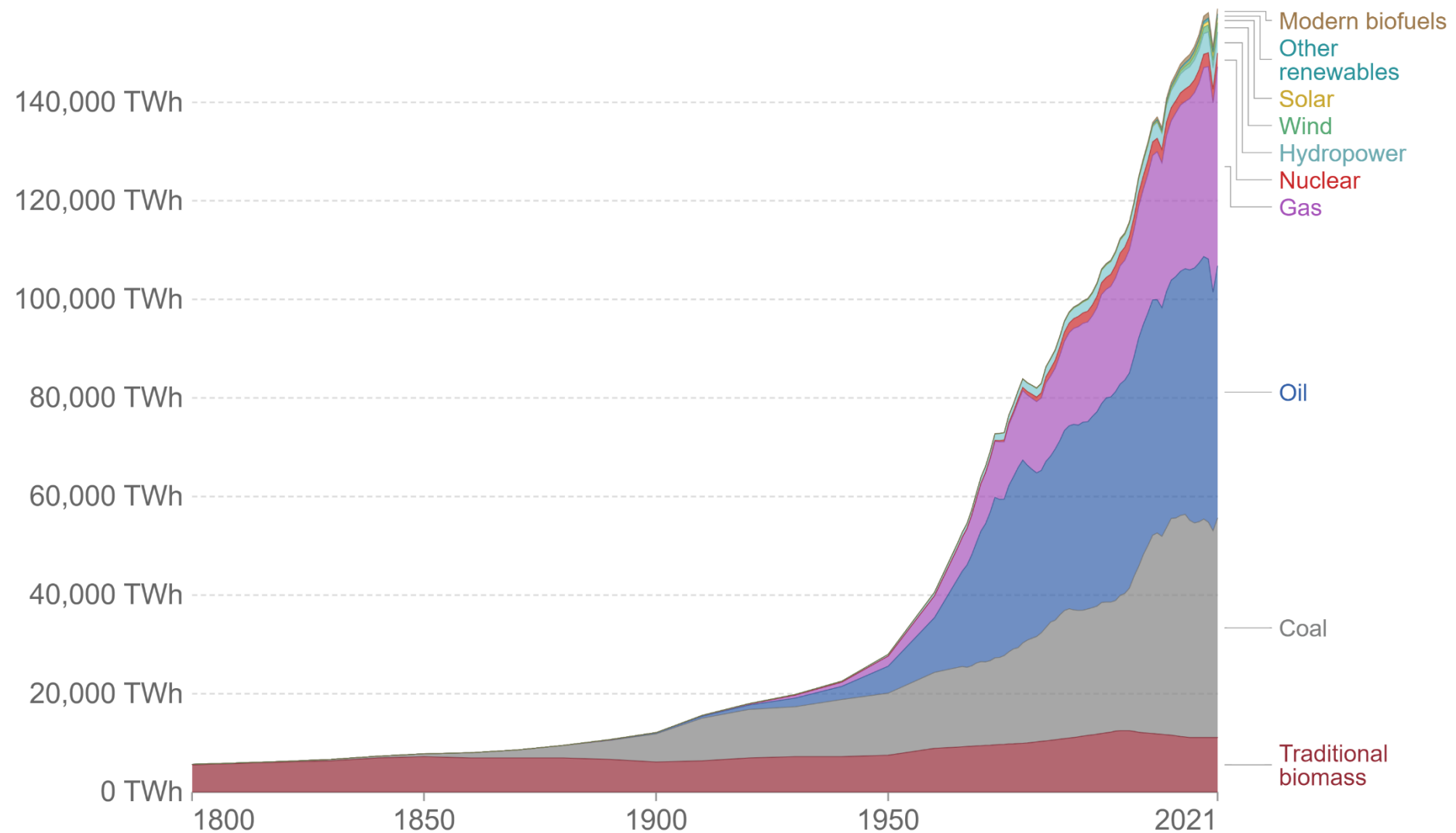
**Lignite Power Plant Belchatow, Poland**



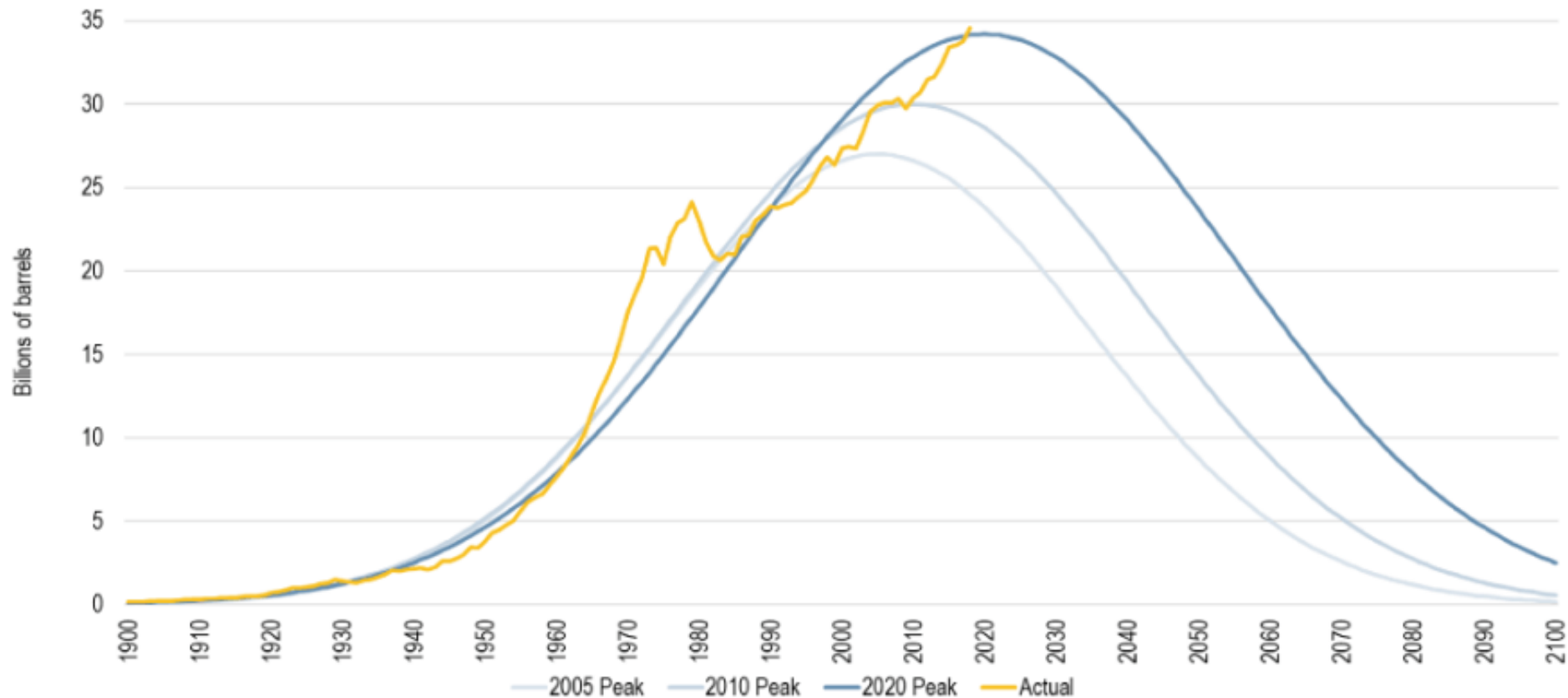
# Global direct primary energy consumption

Direct primary energy consumption does not take account of inefficiencies in fossil fuel production.

Our World  
in Data



# World Annual Oil Production and Peak Oil

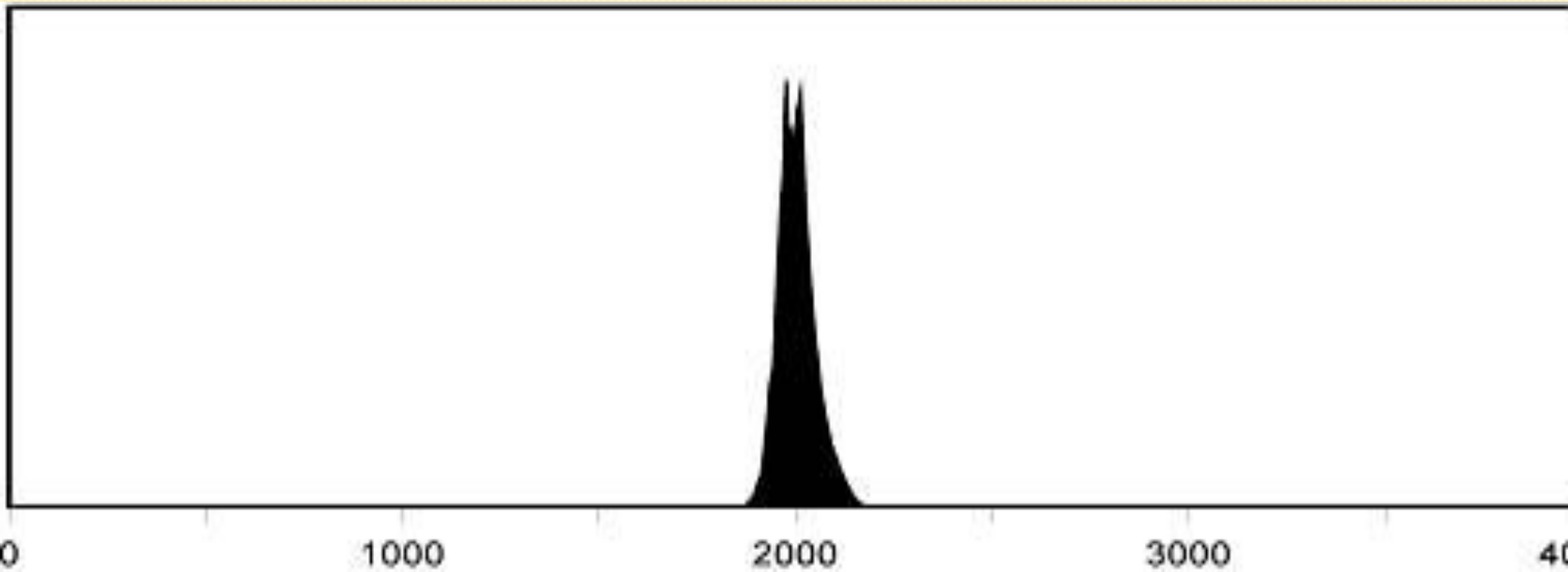




# The future of energy

**Economist.com**

## The end of the Oil Age



Efforts to out-phase fossils are ongoing in building sector, transport sector by developing new energy sources to combat climate change





# Iron mine Kiruna Sweden



# Looming crisis in rare earth metals

China produces and exports 95% of the rare earth metals in the world. Virtually every developed nation in the world imports REM. Rare earths are vital to new technologies such as iphones, flat screen televisions and green energy technology.

Lately REM has declining worldwide supply and skyrocketing prices. This has Western governments worried, as rare earth metals are also key to high tech military applications.

## HYBRID electric motor and generator

- Neodymium
- Praseodymium
- Dysprosium
- Terbium

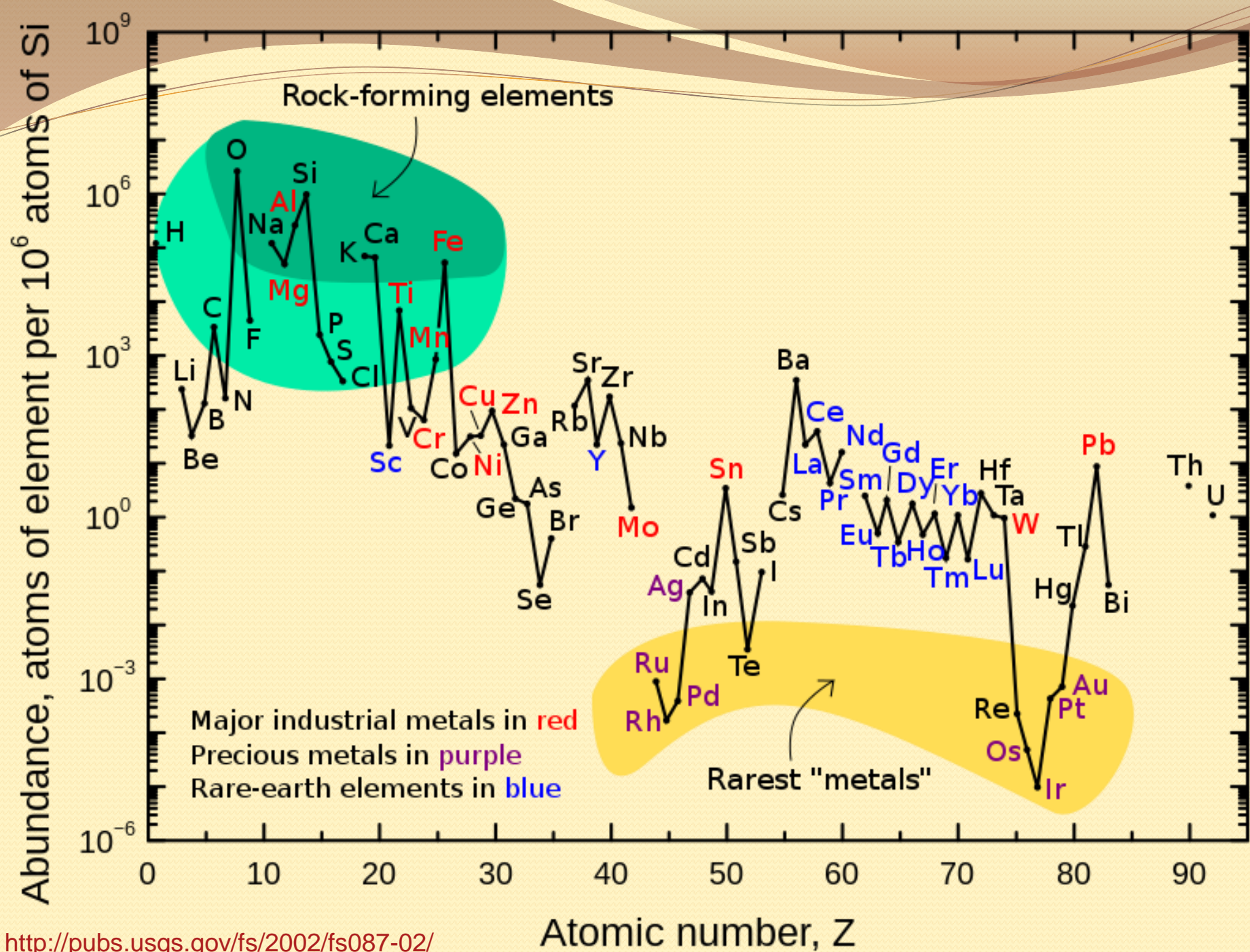
## HYBRID NiMH battery

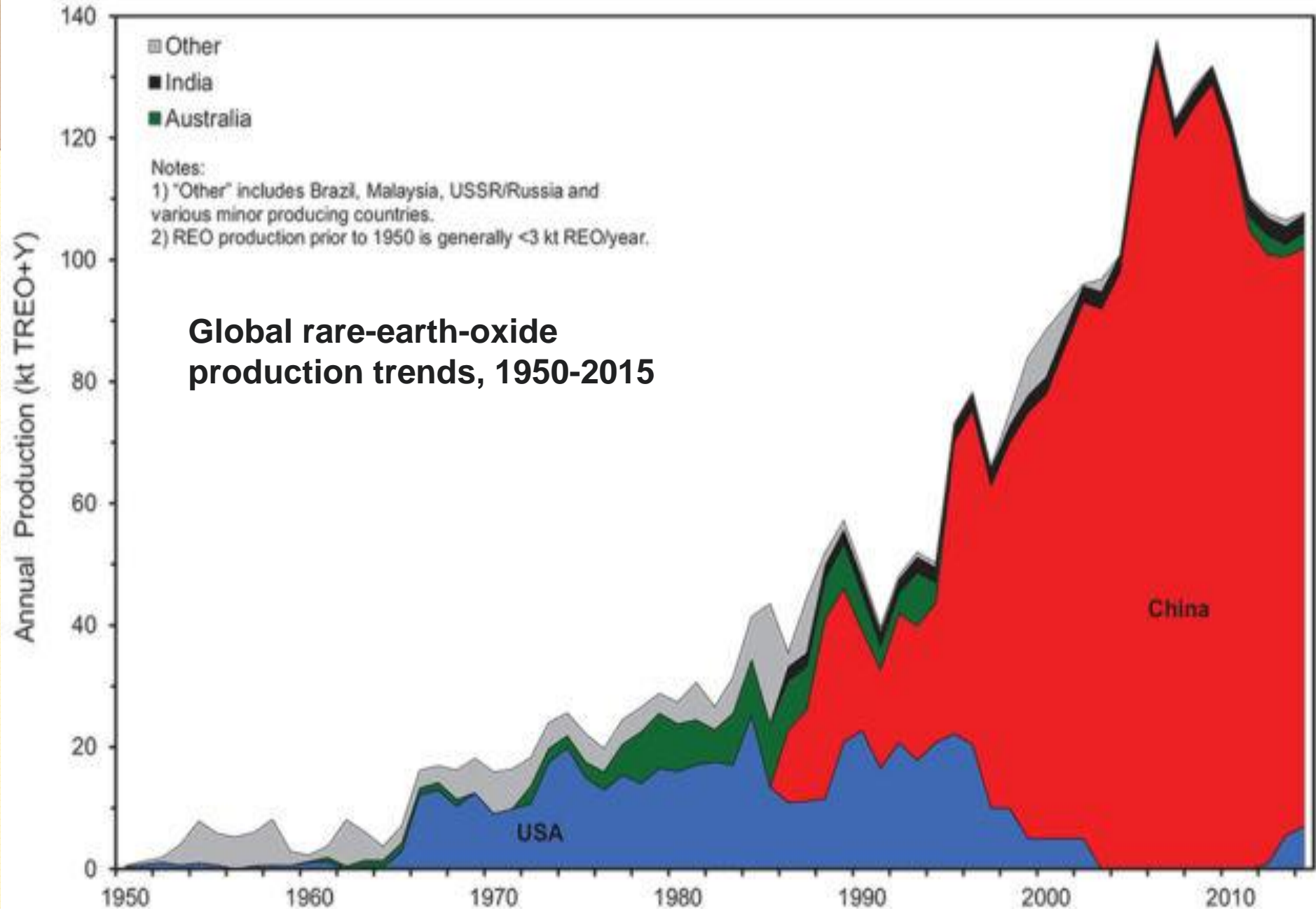
- Lanthanum
- Neodymium
- Cerium



*Hybrid technology is totally dependent on Rare Earths*







# Recycling of non-renewable resources – metals

- **Steel** is today produced from scrap iron and some virgin metal.
- Recycled **copper** is paid well
- **Lead** recycling is requested by law and is >99%
- **Mercury** is taken out of resource flow and stored
- Recycling of **REM** has to be improved

# **Renewable resources**

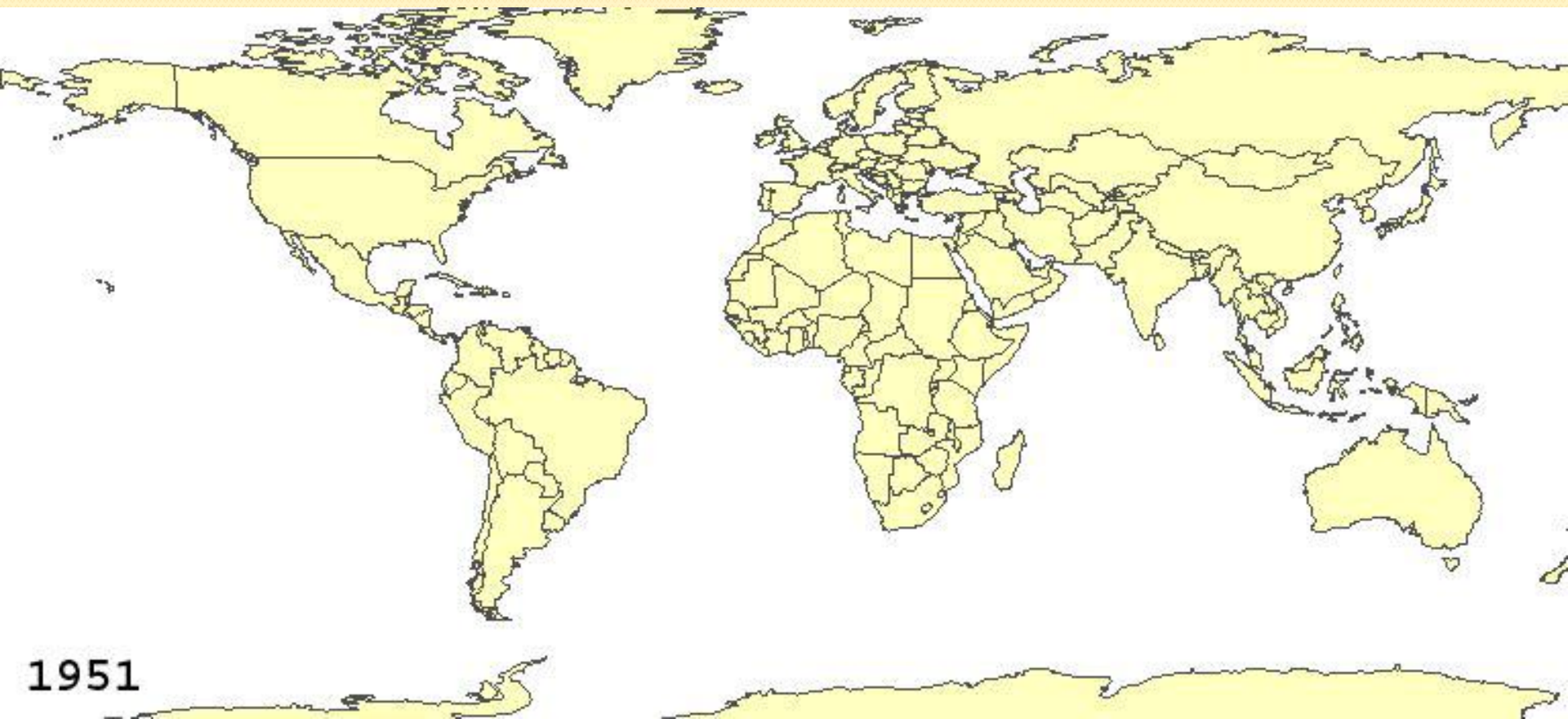
**These can not be harvested faster then the  
reproduction rate;  
Also renewable resources can be emptied.**



# FISHERIES



# Fisheries

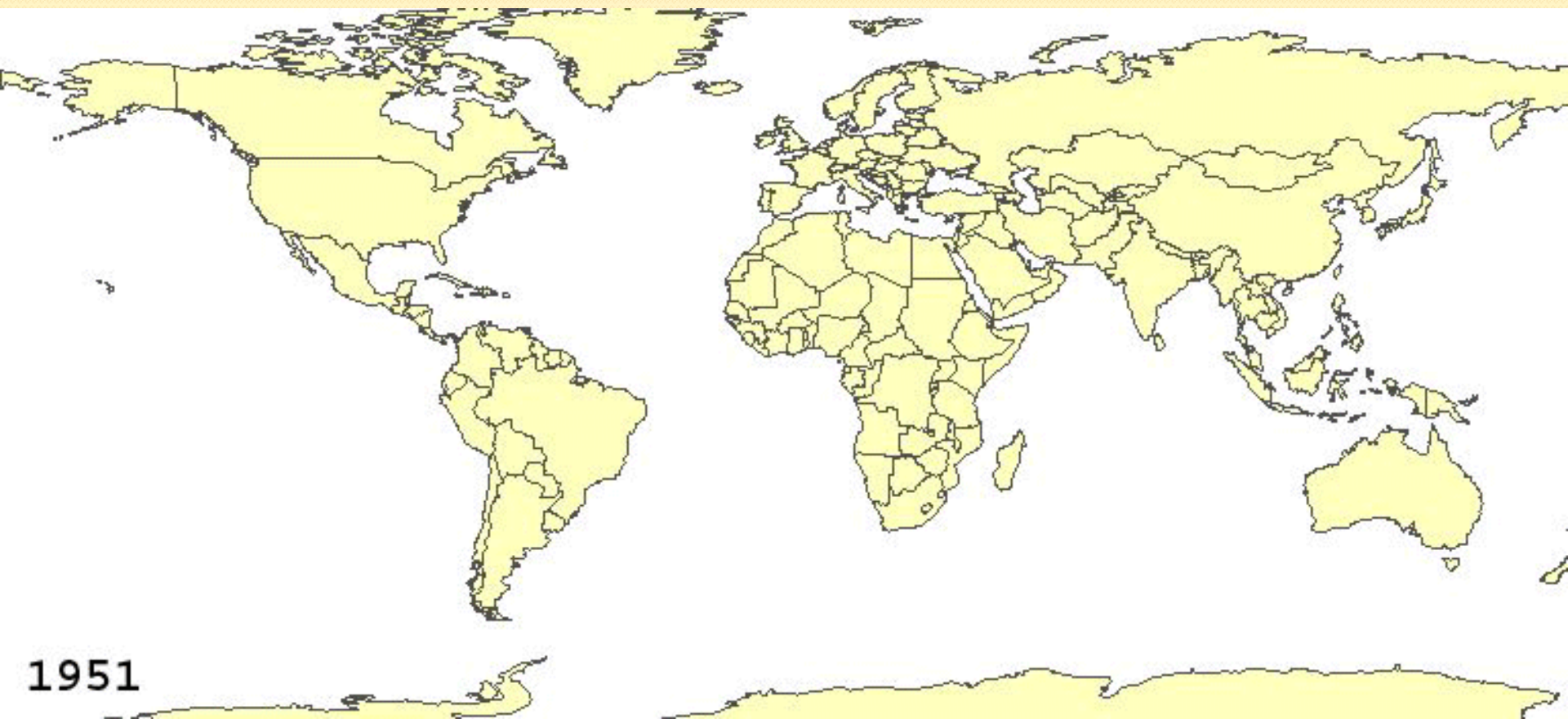


1951

Year of Peak Fish Harvest

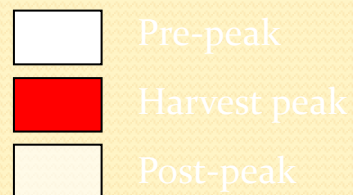






1951

Year of Peak Fish Harvest

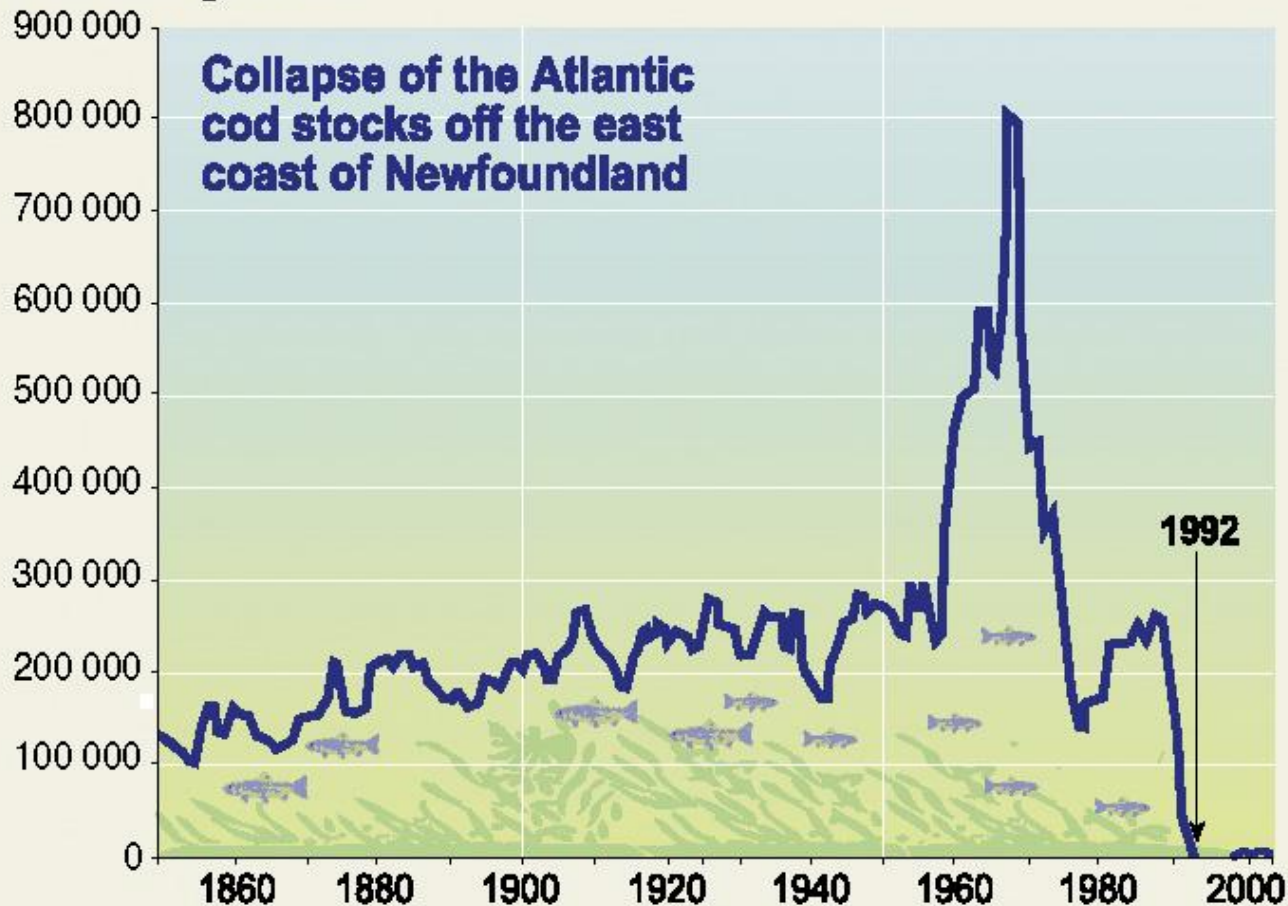


# MARINE FISHERIES

Global  
Footprint  
Network

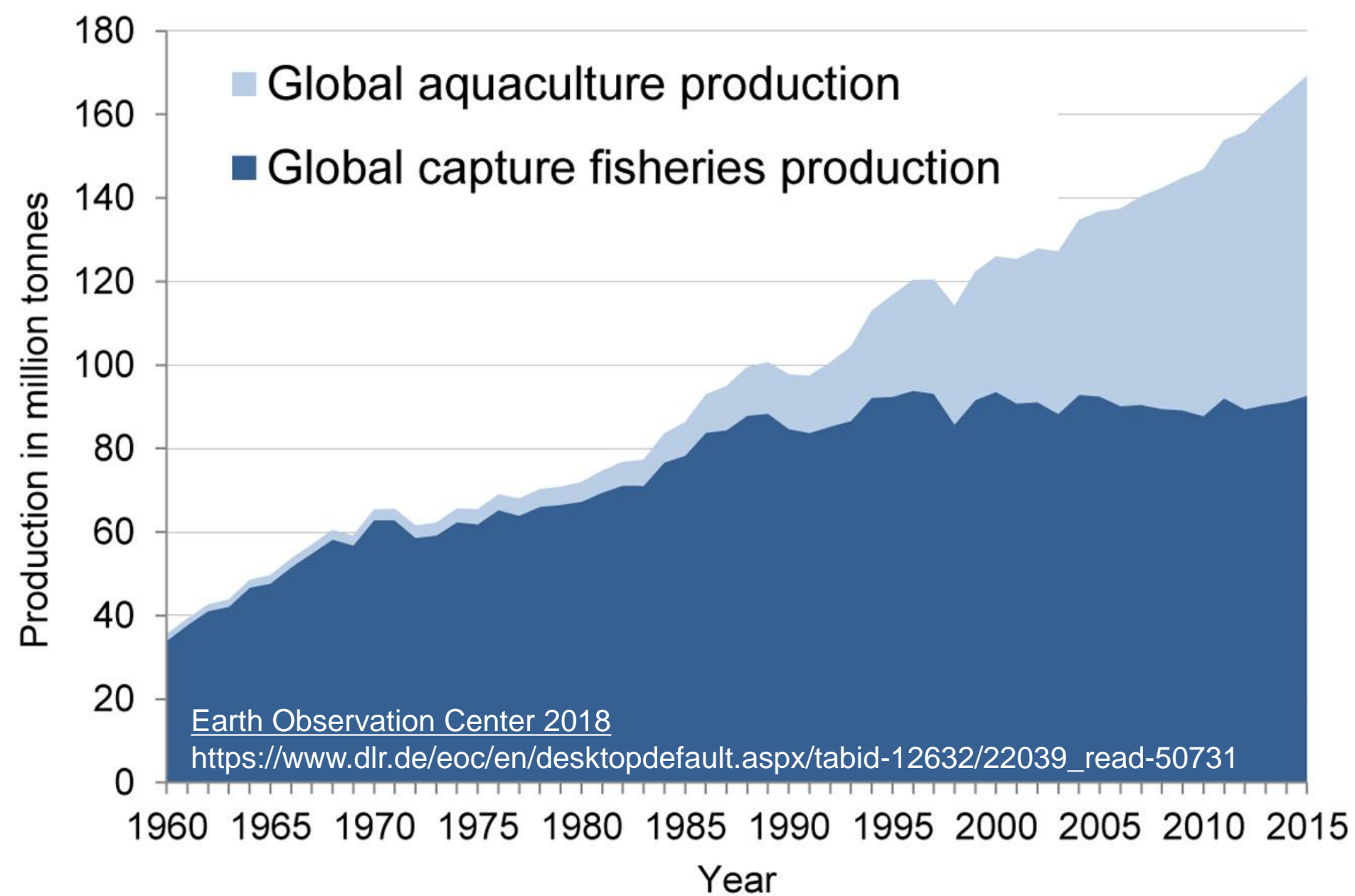
The dramatic collapse of cod stocks off Newfoundland illustrates how quickly the services of an ecosystem can disappear when its resources are overexploited.

## Fish landings in tons



Source: Millennium Ecosystem Assessment





Aquaculture today accounts for 45 percent of the total production of aquatic products. Fish consumption has doubled since the 1960s and today amounts to 19 kg per person.

# FORESTS

*Sustainable Forestry is a main concern in Sustainable Development*

New land

Wood

Timber

Paper



Top soil is reduced 100 times faster than it is renewed

**TOP SOIL**





# **WATER**





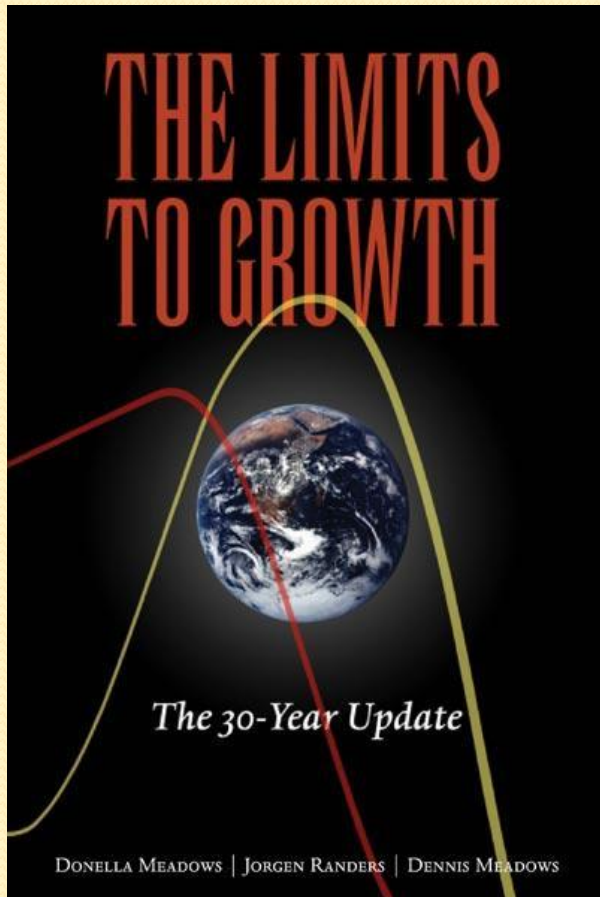
# The study of the limits of global resources

1. *Limits To Growth*, Meadows et al (1972) first computer model; the Limits To Growth a 30 year update (2003).  
Jörgen Randers 2052 (2012)
2. *Ecological footprint network* and biocapacities, 1990s (Rees and Wackernagel).
3. *Material flows* Wuppertal Institute and the ecological rucksack, *MIPS and Factor 10*. 1990s (Schmidt-Bleek).
4. *Socio-ecological Principles* for a Sustainable Society Holmberg 1994, Chalmers, Göteborg. Natural Step Foundation,
5. *Planetary Boundaries* Stockholm Environment Institute, Stockholm Resilience Centre, 2009.

Limits to Growth (1972):

The 30 year update (2003)

We are Witnessing a Terrible Validation

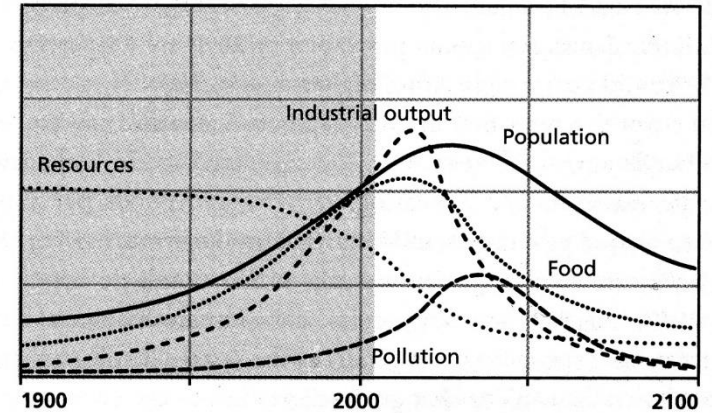


- Original “Club of Rome Report” alerted world to the dangers of continued **exponential growth against natural limits in a finite system**
- Noted that humanity had the capacity to create **systems that were sustainable**
- Vehemently attacked at the time, especially by economists
- Now validated — unfortunately — by over 30 years of data

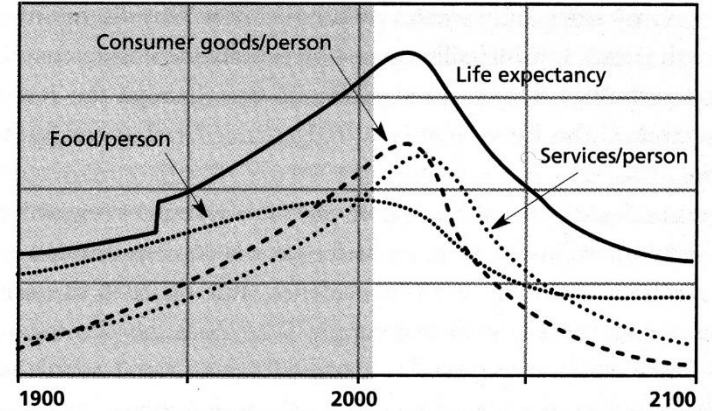
# Basic scenario in Limits to Growth 2003

## World3

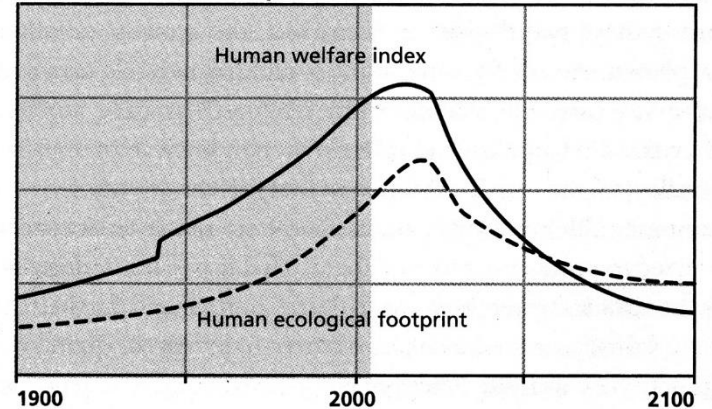
State of the World



Material Standard of Living



Human Welfare and Footprint



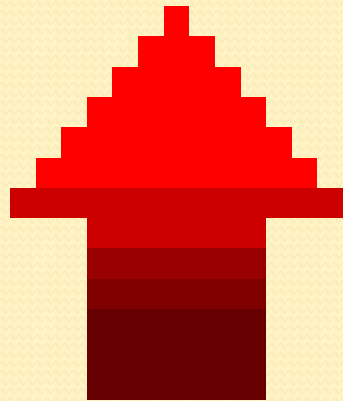
Scenario 1



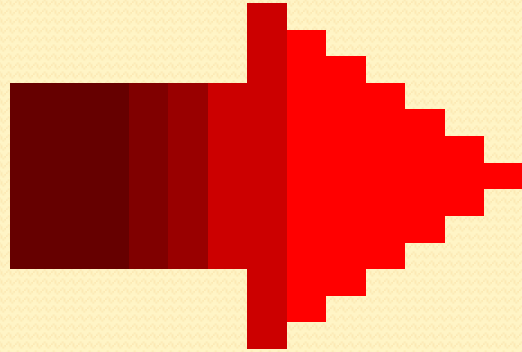
**Resource Management  
can be improved!**



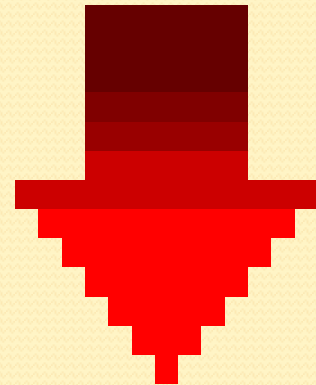
**Production**



**Resource**

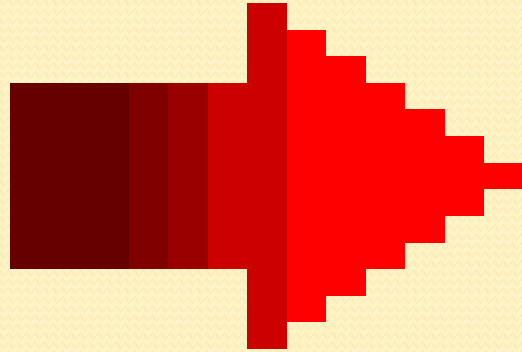


**Consumption**



**Waste**

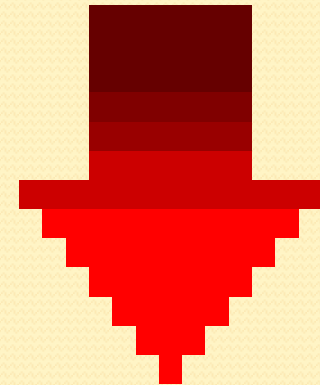
**Production**



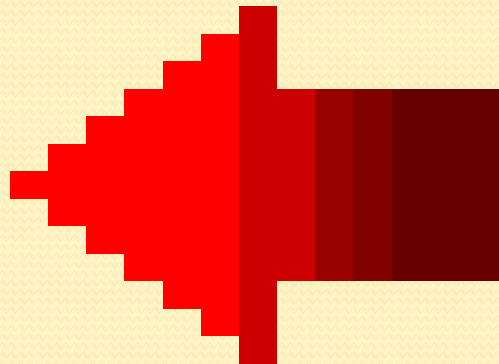
**Consumption**



**Resource**



**Waste**



3R

**Reduce-Reuse-Recycle**



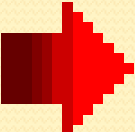
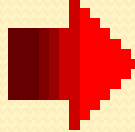
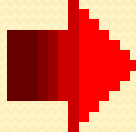
**3R**

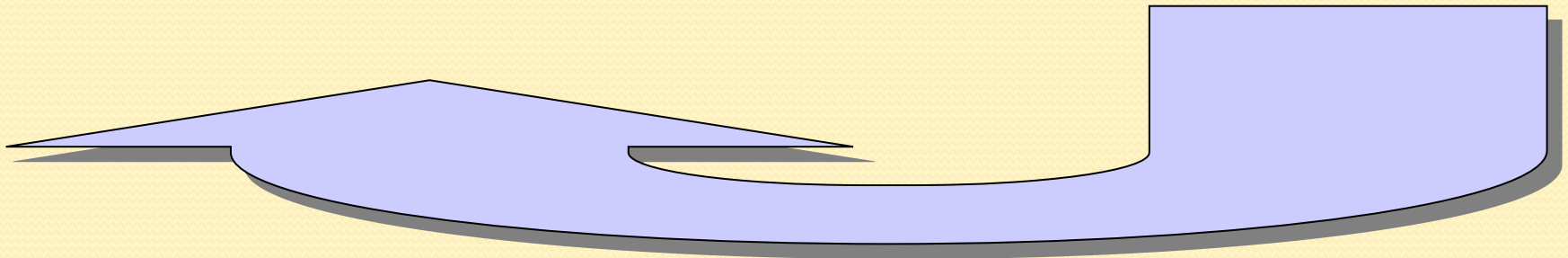
**Reduce-Reuse-Recycle**

**4R**

**Reduce-Reuse-Recycle-  
Recover**

# We need Perfect recycling

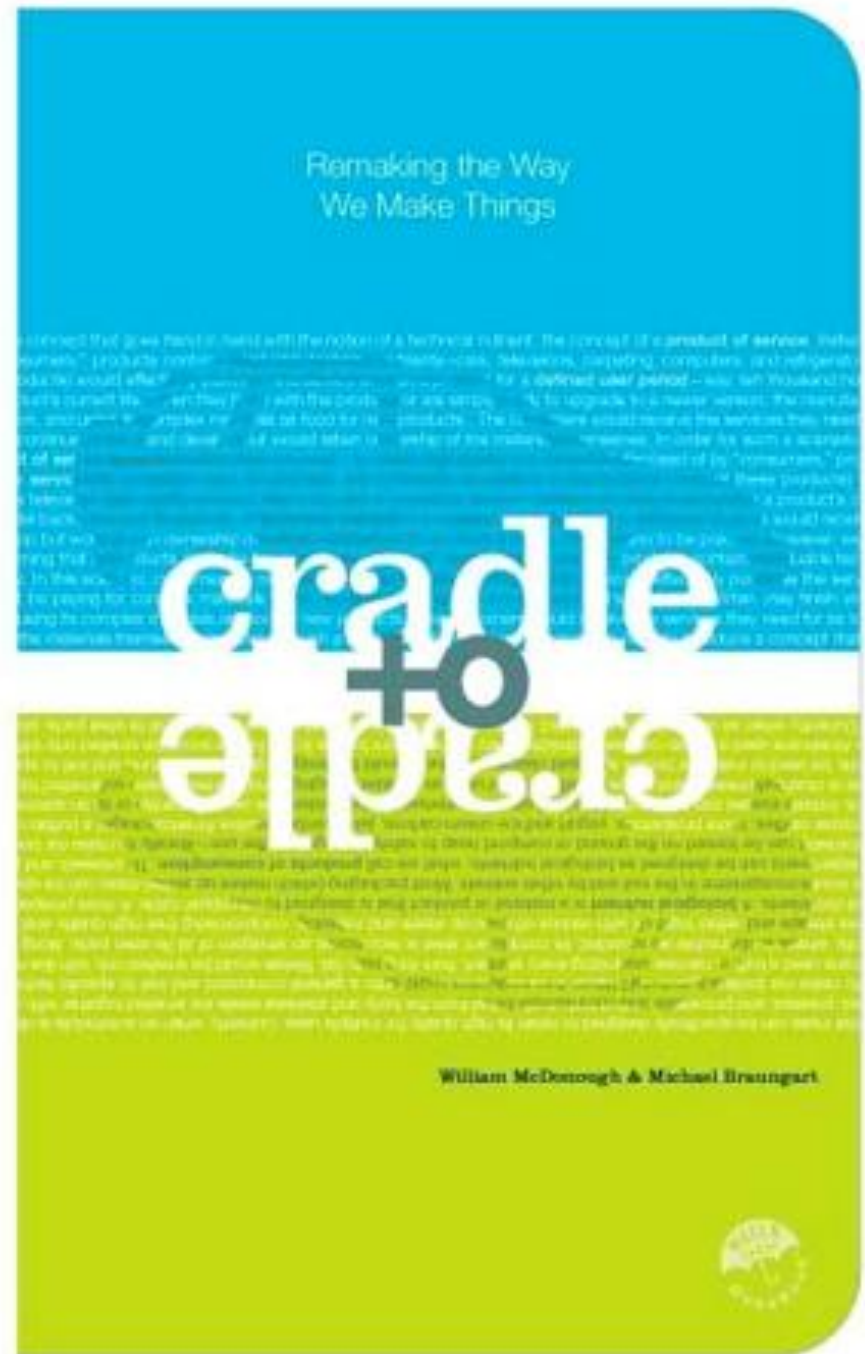
Resource  Production  Use  End-of-life



# Cradle to Cradle Products Innovation Institute

Developed by  
Michael Braungart,  
Hamburg and  
William McDonough,  
San Francisco

[http://www.mcdonough.com/  
cradle\\_to\\_cradle.htm](http://www.mcdonough.com/cradle_to_cradle.htm)





# 30 minutes

- Discuss what you do yourself to improve resource use.
- Do you apply the 3R?
- How do you manage waste?

After 10 minutes you tell me.

(Students who did not talk so far. It is your turn!)

## **II. Quantification of resource flows**

# Ecological Rucksack

Today, less than 5 % on average of the material resources taken from nature ends up in products. The rest becomes waste on the way. Some 30 tons of nature is used to create one ton of car – without counting water consumption - and for many industrial goods the ratio is similar.

Information and Communication Technology [ICT]: the costs for one message on Internet is equal to that of producing four aluminum cans for beer.

*Wuppertal Institute – Material Intensity factors of materials and energy sources*  
<https://www.gdrc.org/sustdev/concepts/27-rucksacks.html>



# Life Cycle Assessments, LCA

## Material intensities

**Material intensities** can be used for calculating LCA for many products.

**Ecological Rucksack** for the cradle to the point of sale, the amount of material used which is not in the product itself can be calculated from LCA.

**MIPS** for cradle to cradle Material Input [in kg] Pro unit Service (per unit value or utility) obtained.

Material intensities and LCA for many products are available in databases. Total Material Flows, TMF output and input, are available for many countries.

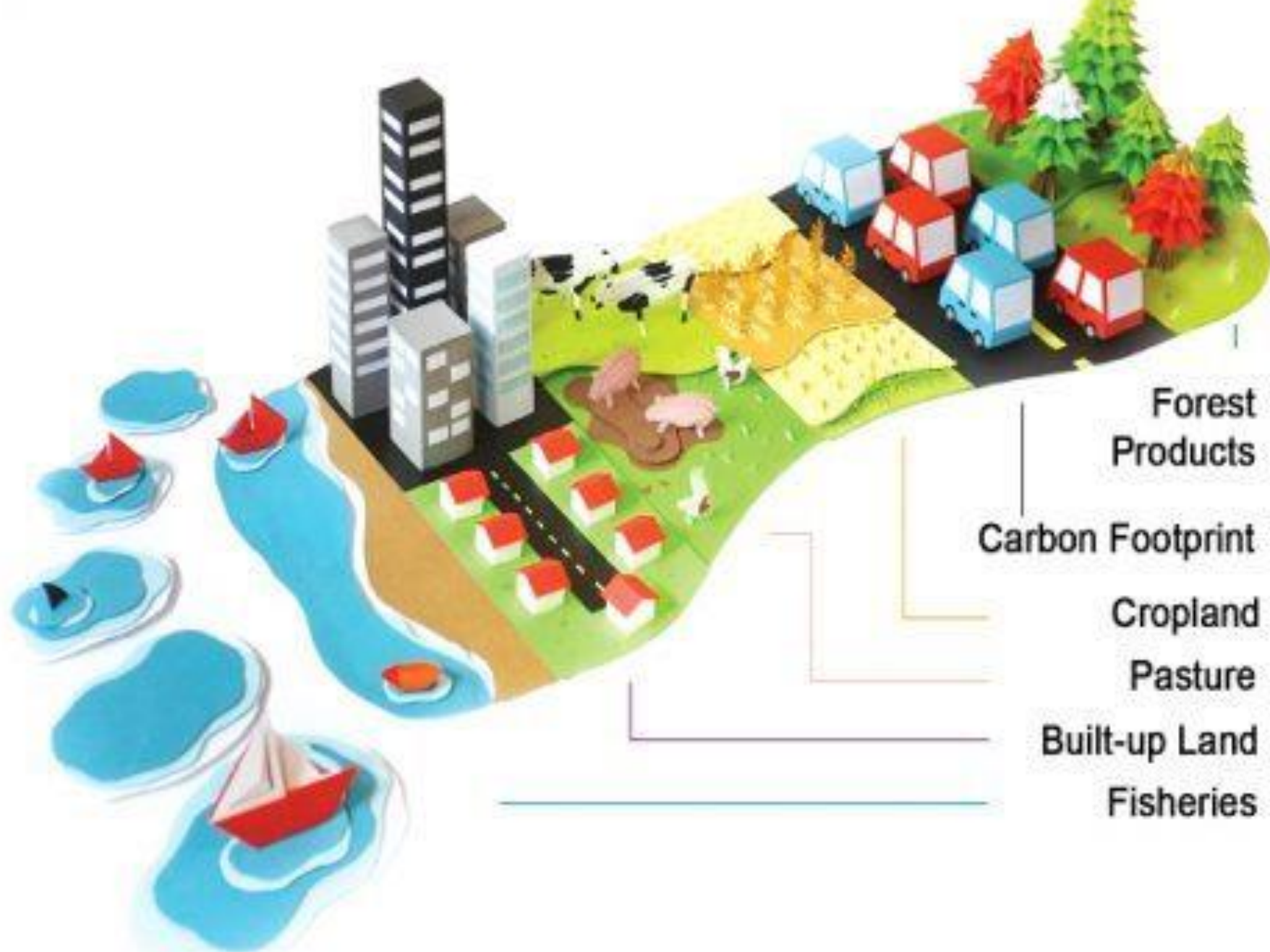


# Ecological Footprints

# Ecological Footprints

- William Rees introduced the concept of ecological footprint in 1992.
- The ecological footprint is "*the surface area a population needs to continually satisfy its needs and produce its products and services*". It is measured in so-called global ha. There is today about 1.8 Gha/cap on the planet.
- Ecological footprint is today of wide use in society – the general public, companies and authorities.
- Ecological footprint is a quantitative information and not the same as environmental labelling.
- <http://www.footprintnetwork.org>





Forest  
Products

Carbon Footprint

Cropland

Pasture

Built-up Land

Fisheries

# Total Ecological Footprint

## Food, fibre, and timber footprint

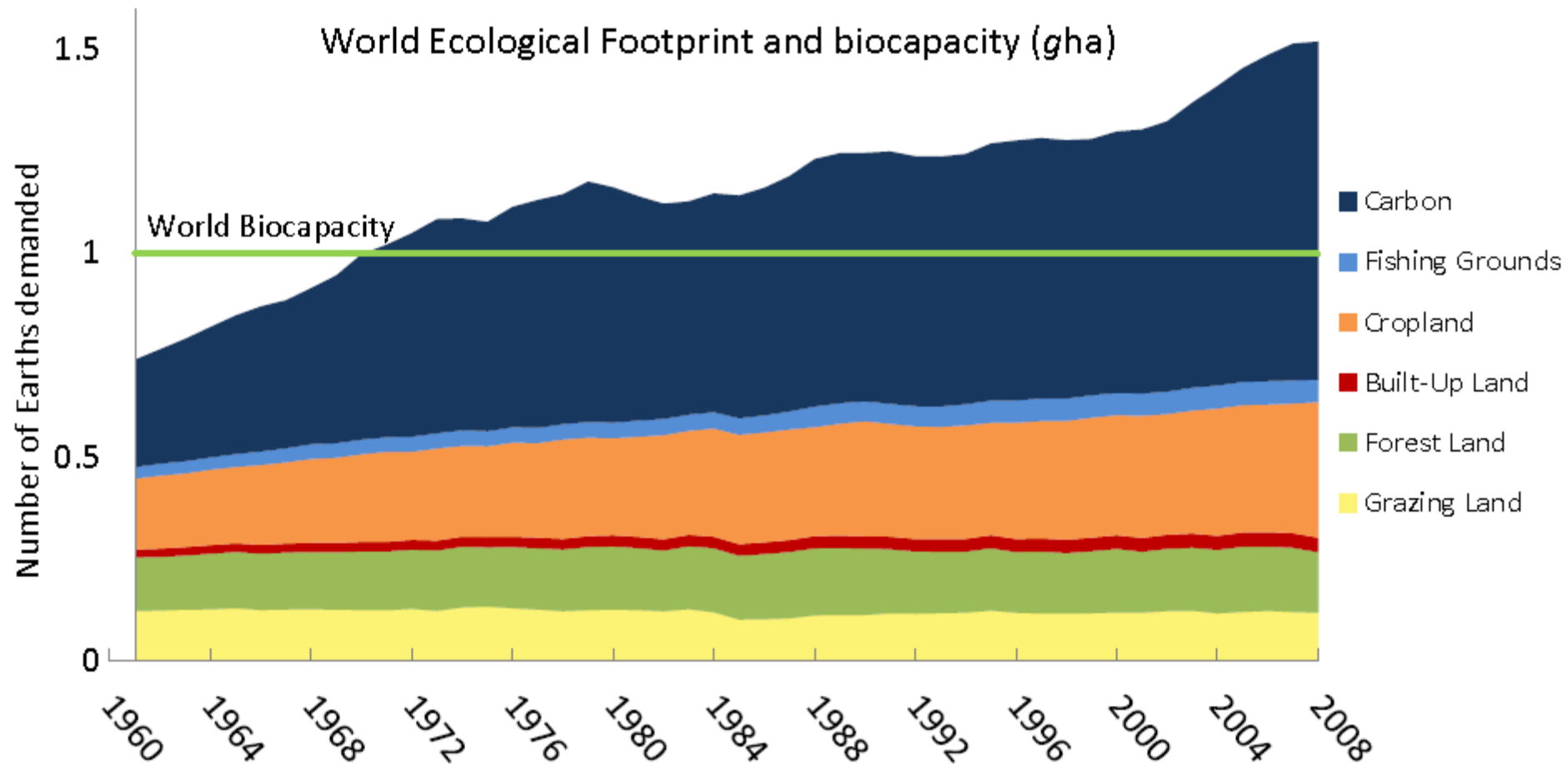
*Cropland, Forest, Grazing land, Fishing ground*

## Energy footprint

*CO<sub>2</sub> from fossil fuels, Fuel wood, Nuclear, Hydro, Built-up land*

## Bio capacity

*Cropland, Grazing land, Forest, Fishing ground*



The National Footprint Accounts, 2011 Edition. Global Footprint Network  
[http://www.footprintnetwork.org/images/uploads/NFA\\_2011\\_Edition.pdf](http://www.footprintnetwork.org/images/uploads/NFA_2011_Edition.pdf)



Biocapacity  
per person

1.6

gha



-

Ecological Footprint  
per person

2.8

gha



=

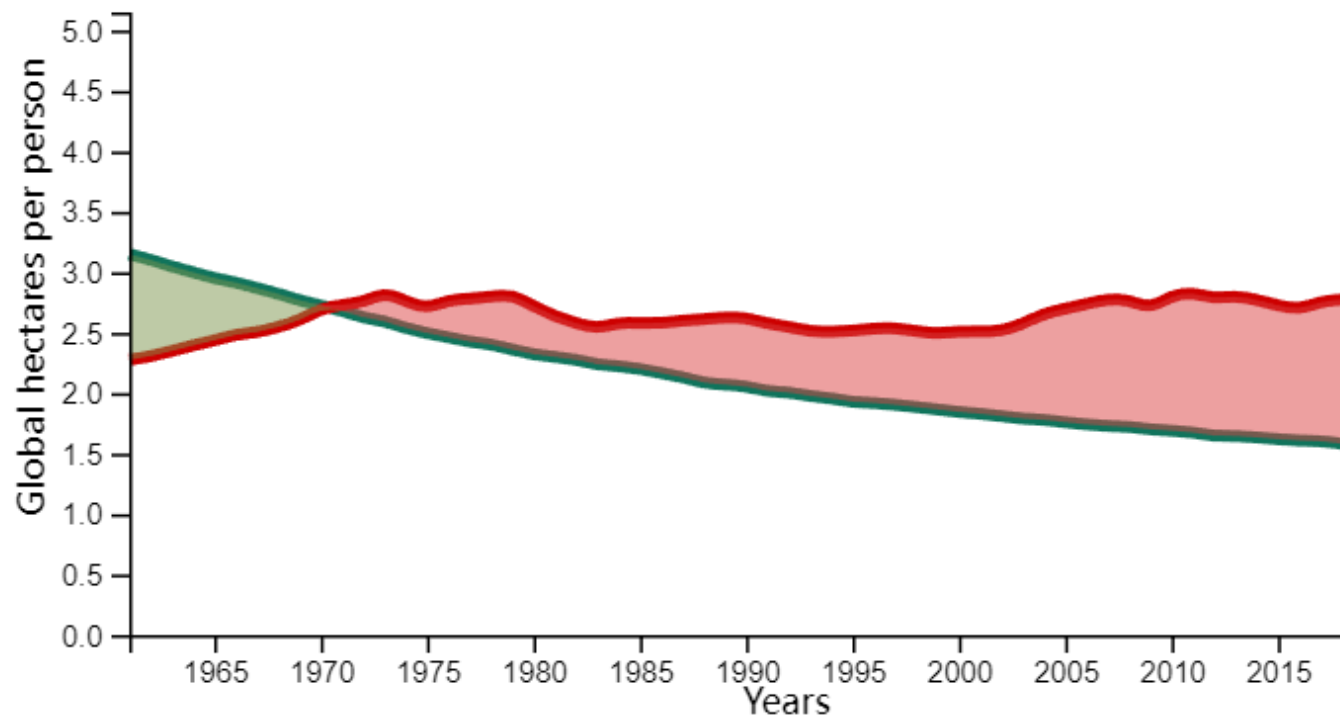
BIOCAPACITY  
RESERVE(+)/DEFICIT(-)

-1.2

gha

Ecological Footprint and  
Biocapacity  
From 1961 to 2018Ecological  
Footprint per  
personBiocapacity per  
person

Learn More



**Data Sources:** [National Footprint and Biocapacity Accounts 2022 edition \(Data Year 2018\)](#);  
GDP, World Development Indicators, The World Bank 2020; Population, U.N. Food and  
Agriculture Organization.



ECOLOGICAL  
DEFICIT/RESERVE

## TOTAL ECOLOGICAL FOOTPRINT

## ECOLOGICAL FOOTPRINT PER PERSON

TOTAL BIOCAPACITY

BIOCAPACITY  
PER PERSON

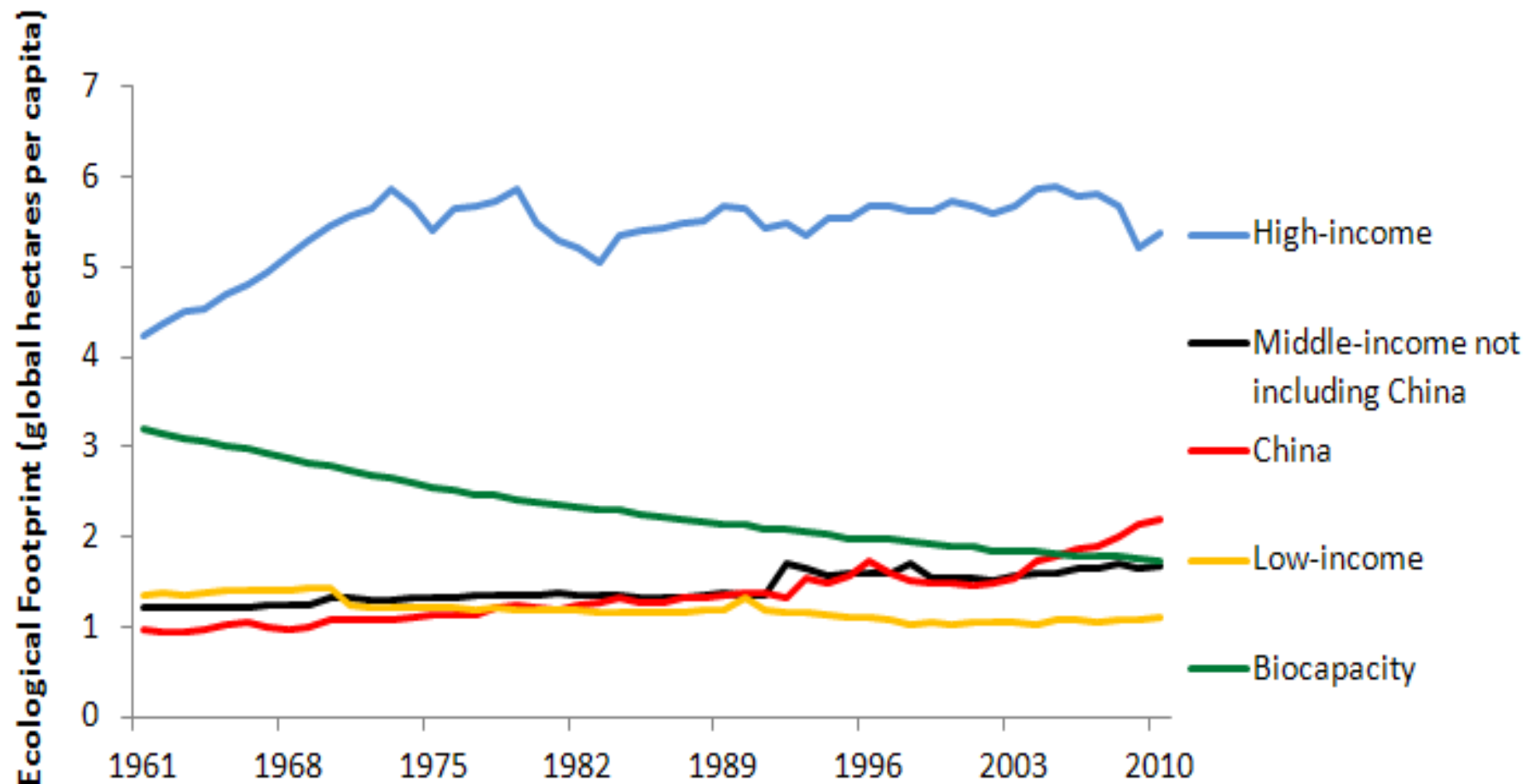
BIOLOGICAL DEFICIT/RESERVE

An ecological deficit occurs when the **Ecological Footprint** of a population exceeds the **biocapacity** of the area available to that population. A national ecological deficit means that the nation is importing biocapacity through trade, liquidating national ecological

**BIOCAPACITY CREDITORS**  
***BIOCAPACITY GREATER THAN FOOTPRINT***

**BIOCAPACITY DEBTORS**  
**FOOTPRINT GREATER THAN BIOCAPACITY**

# Ecological Footprint Per Capita in High-, Middle- and Low-Income Countries



# Global earth overshoot day 2022 was July 28

in Uzbekistan October 11, in Sweden April 3

Global ecological overshoot became a reality in the early 1970s and is driven by these key factors: how much we consume, how efficiently products are made and used, how many people are living on our planet, and how much nature's ecosystems are able to produce.

Global biocapacity is 1.6 gha per person (in 2017). To support human activities today we use just over 1.6 Earths per year. To keep up with our level of demand by 2030 we would need the capacity of two Earths. This puts the well-being of many of the planet's residents at risk.



# Country Overshoot Days 2021

When would Earth Overshoot Day land if the world's population lived like...



Source: National Footprint and Biocapacity Accounts, 2021 Edition  
data.footprintnetwork.org

# Estimate your footprint

## 1. **Global Footprint Network**

How much land area does it take to support your lifestyle? Take this quiz to find out your Ecological Footprint, discover your biggest areas of resource consumption, and learn what you can do to tread more lightly on the earth.  
[www.footprintcalculator.org](http://www.footprintcalculator.org).

## 2. **World Wildlife Found, WWF**

Worried about your impact on the environment? The way we use the planet's resources makes up our ecological footprint. Measuring yours takes less than 5 minutes and could set you on a life-changing journey...  
<https://footprint.wwf.org.uk/#/>

**How can we improve  
things?**

**There are many ways to  
resource efficiencies!**

# The Blue Economy

## A Report to the Club of Rome 2009

A hummingbird with iridescent green and white feathers is shown in profile, hovering and facing right. It is positioned next to a small, five-petaled white flower with a yellow center. The background is a soft, out-of-focus green.

**10 years  
100 innovations  
100 million jobs  
inspired by nature**

**Prof. Dr. Gunter Pauli**

Founder Director of the ZERI Foundation

Member of the Club of Rome

Professor Systems Design at the Faculty of Architecture Politecnico di Torino

© 2009, Pauli

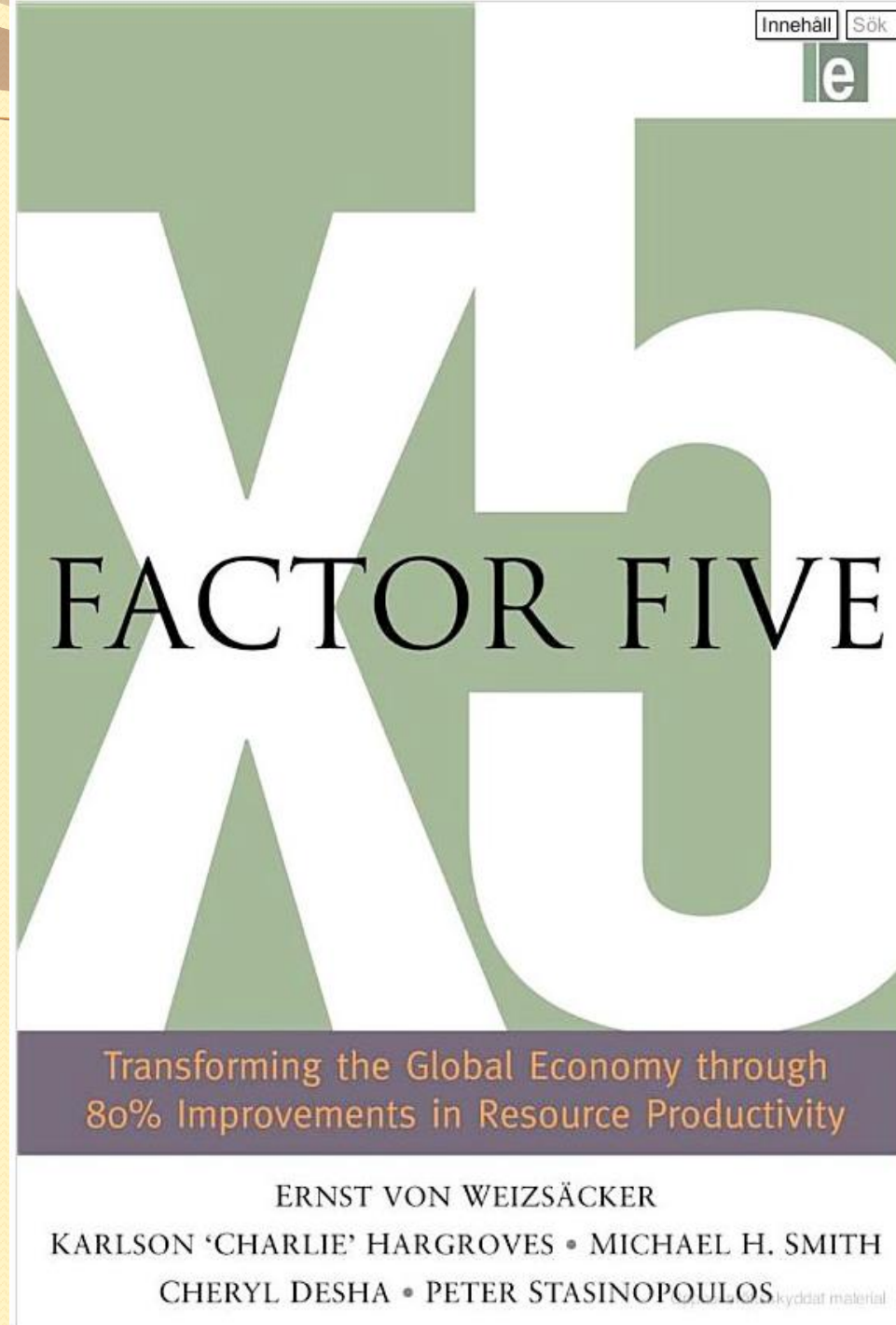
Singapore

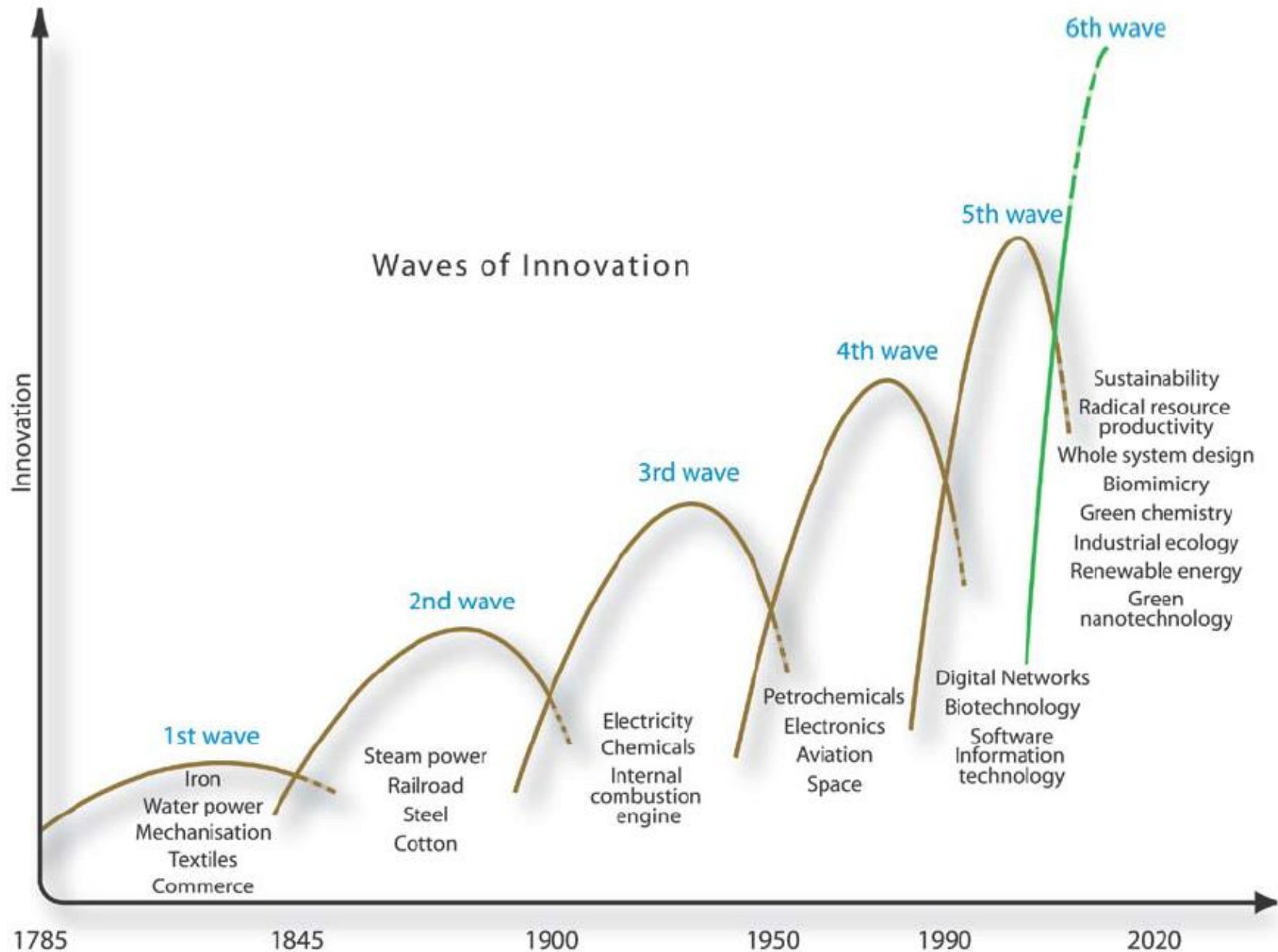
13th of November 2009



# Wuppertal Institute for Climate, Environment, and Energy

[http://www.wupperinst.org  
/en/home/index.html](http://www.wupperinst.org/en/home/index.html)





**Figure 4** *Waves of Innovation*

Source: Courtesy of The Natural Edge Project<sup>19</sup>

**The production itself is a very  
important part – it may be  
improved tremendously by**

**Cleaner Production, CP**

**Cleaner Production is good  
not only for the environment  
but also for the economy!**

**Of course!**

**You make products efficiently,  
not pollutants - inefficiently**



# Planetary Boundaries: A stable operating space for humanity

NATURE Vol 461 24 September 2009

- A safe operating space for humanity
- Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human
- activities from causing unacceptable environmental change, argue **Johan Rockström** and colleagues.



**Stockholm Resilience Centre**  
Research for Governance of Social-Ecological Systems

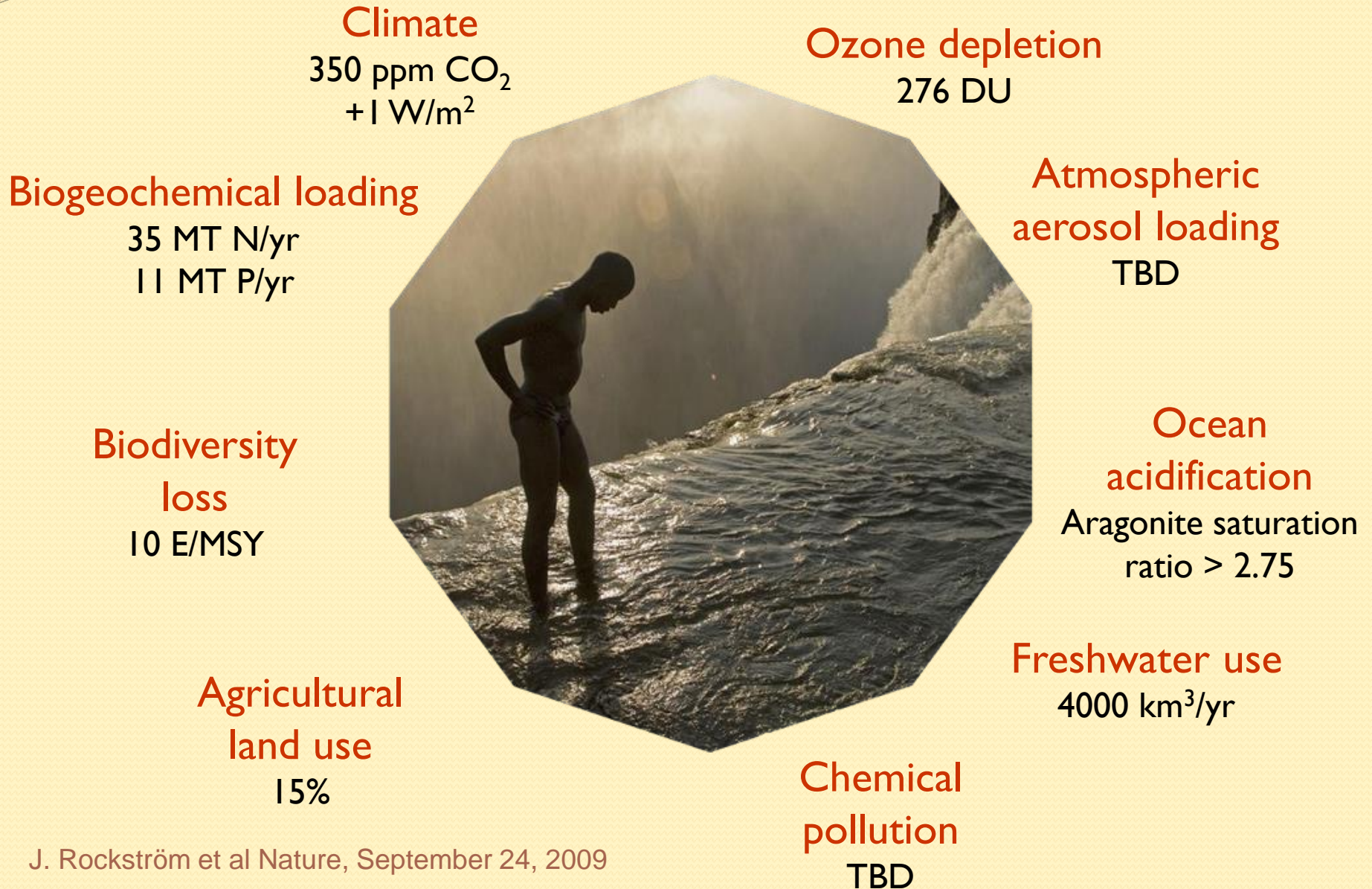


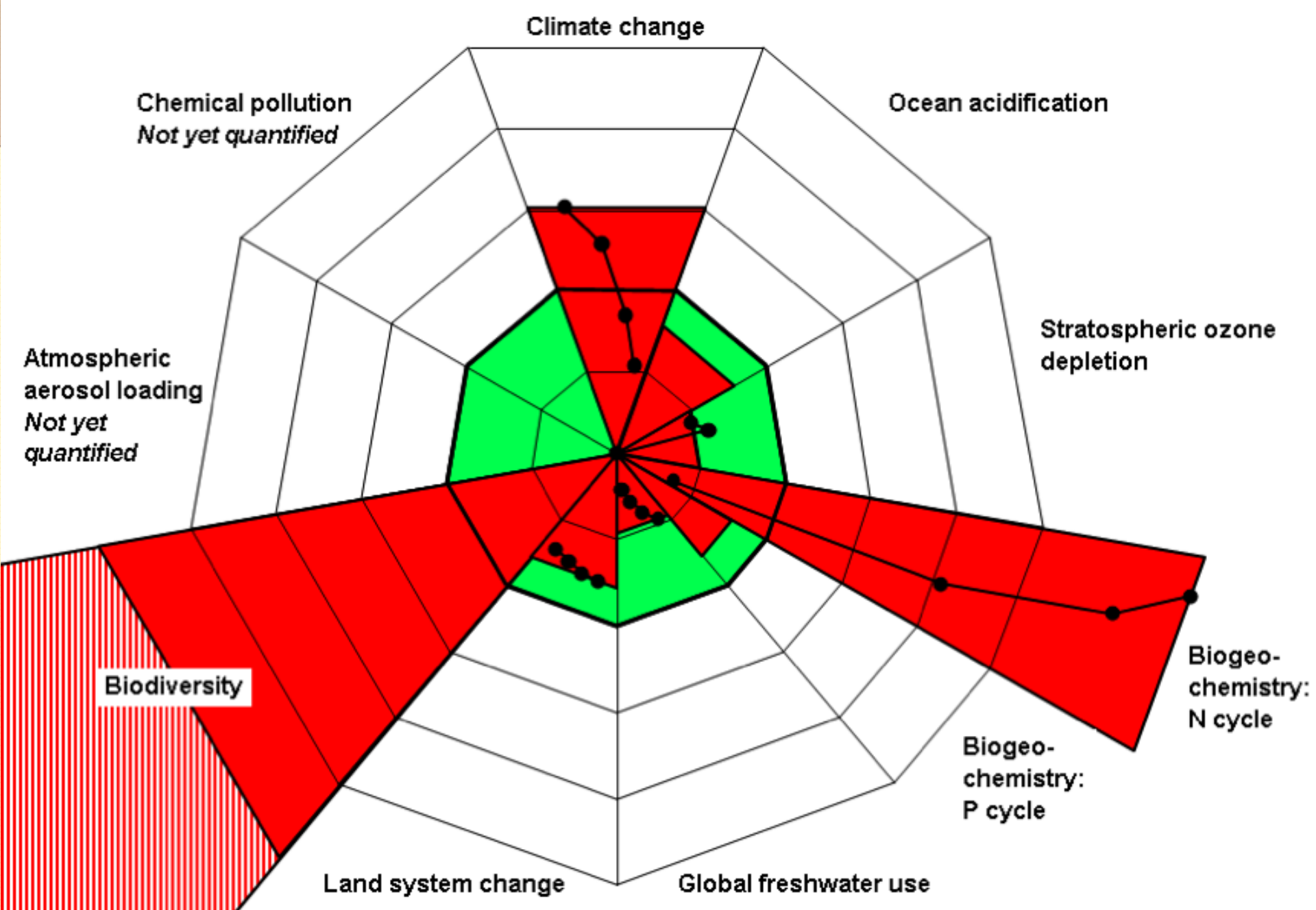
Stockholm  
University

A centre with:

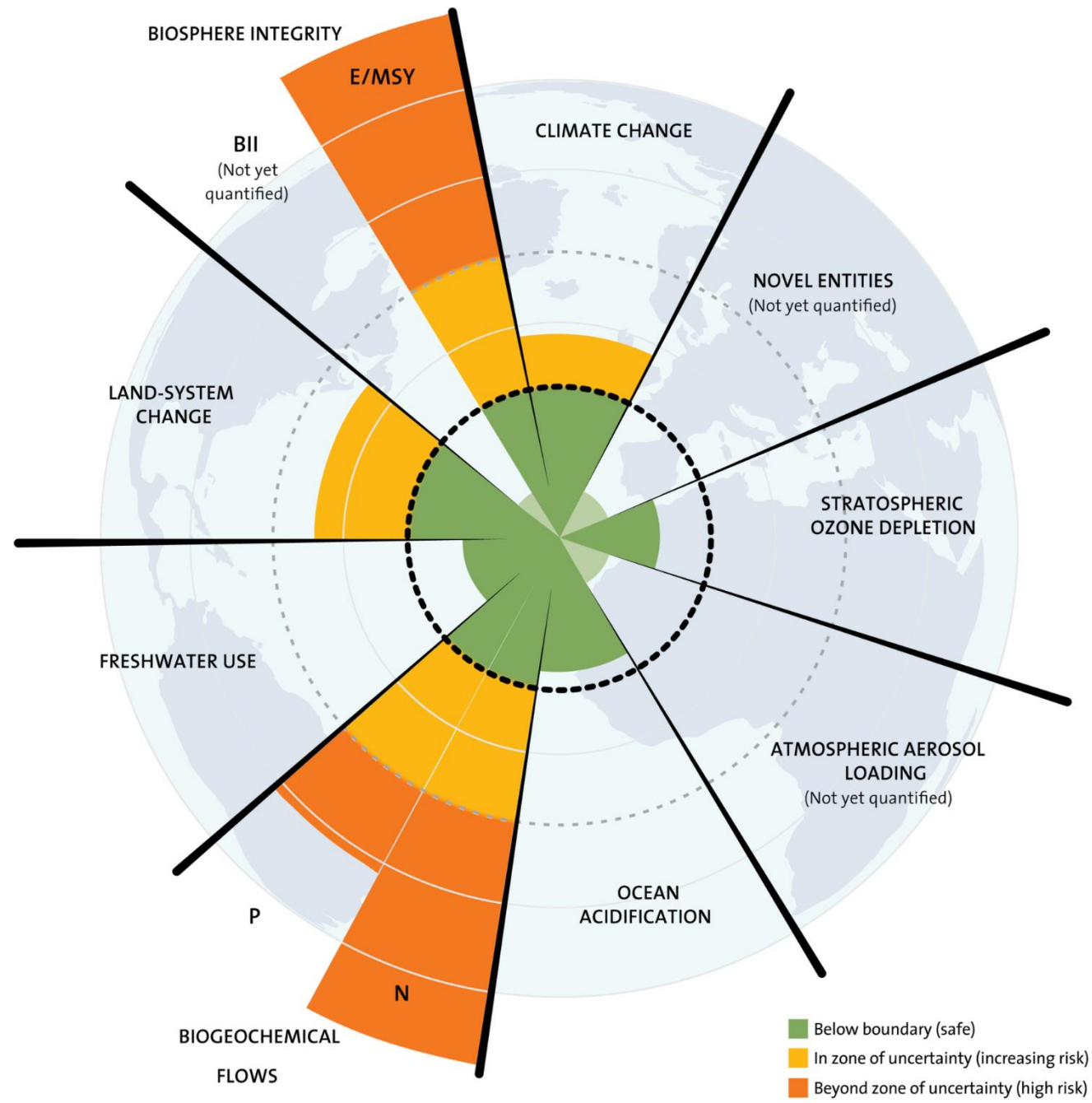


# Planetary boundaries





Source:  
J. Lokrantz/Azote  
based on Steffen et  
al. 2015.

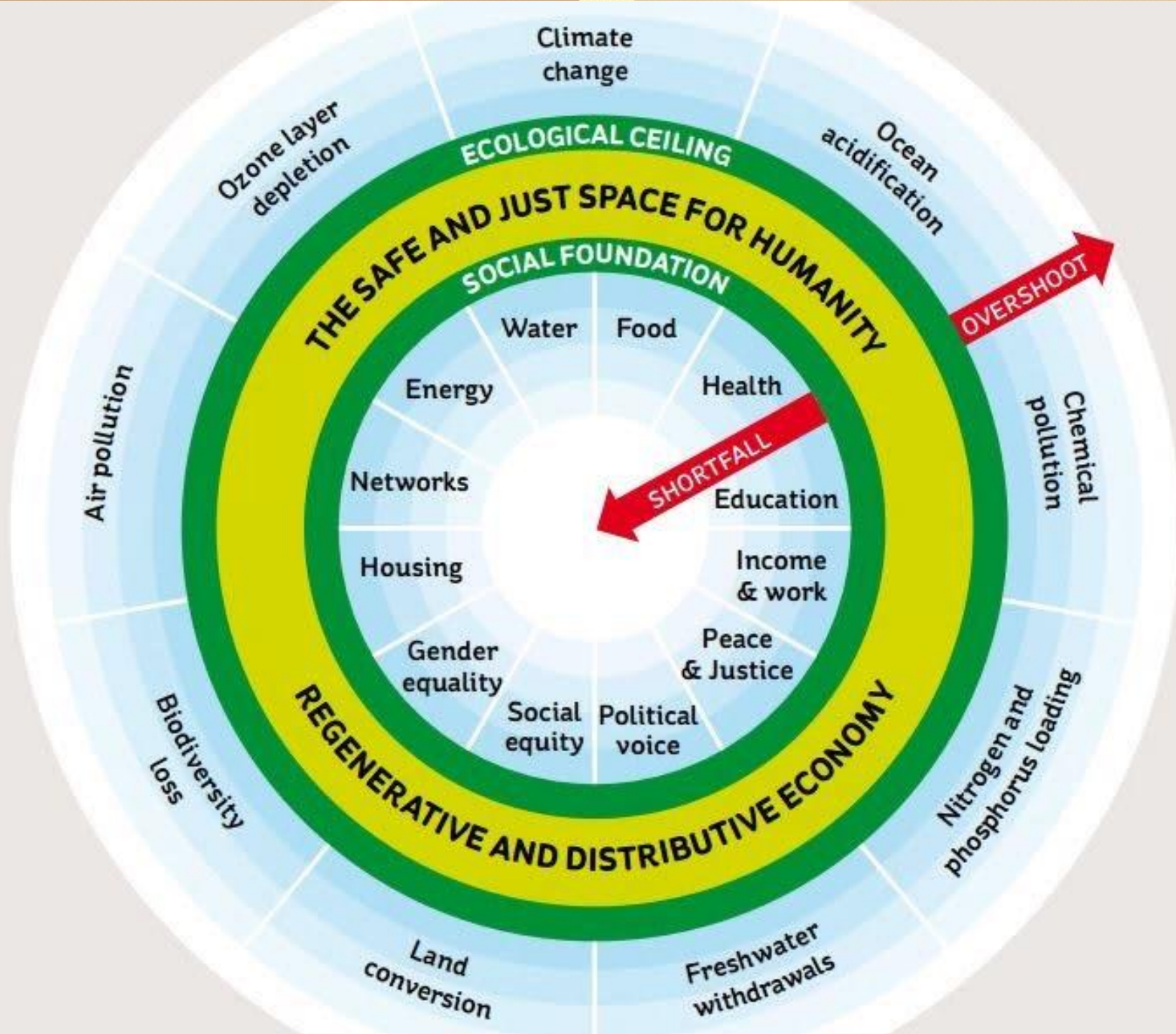






The **Doughnut**, or **Doughnut economics**, combine the **planetary boundaries** with social boundaries. It is a concept proposed by the British economist Kate Raworth.

<https://www.kateraworth.com/doughnut/>



**We need to do both!**

**Sufficiency**

**Efficiency**

*To read*

## Lecture 2. Resources

- Sustainable Use and Management of Natural Resources.  
Chapter 2 *The planet and its natural resources*. pp 26-45.
- Sustainable Use and Management of Natural Resources.  
Chapter 11 *Reducing the resource flows by a Factor of 4, 5 or 10*.  
pp 189-207.