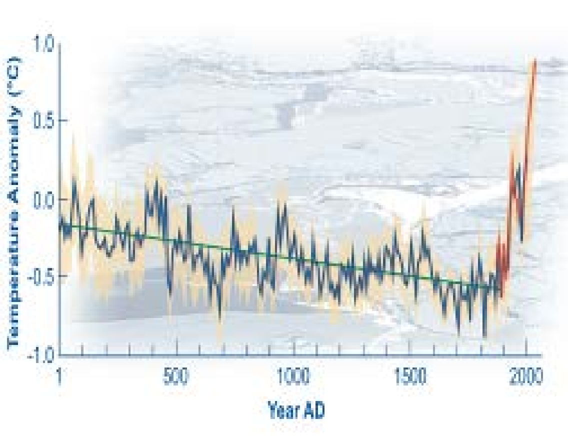
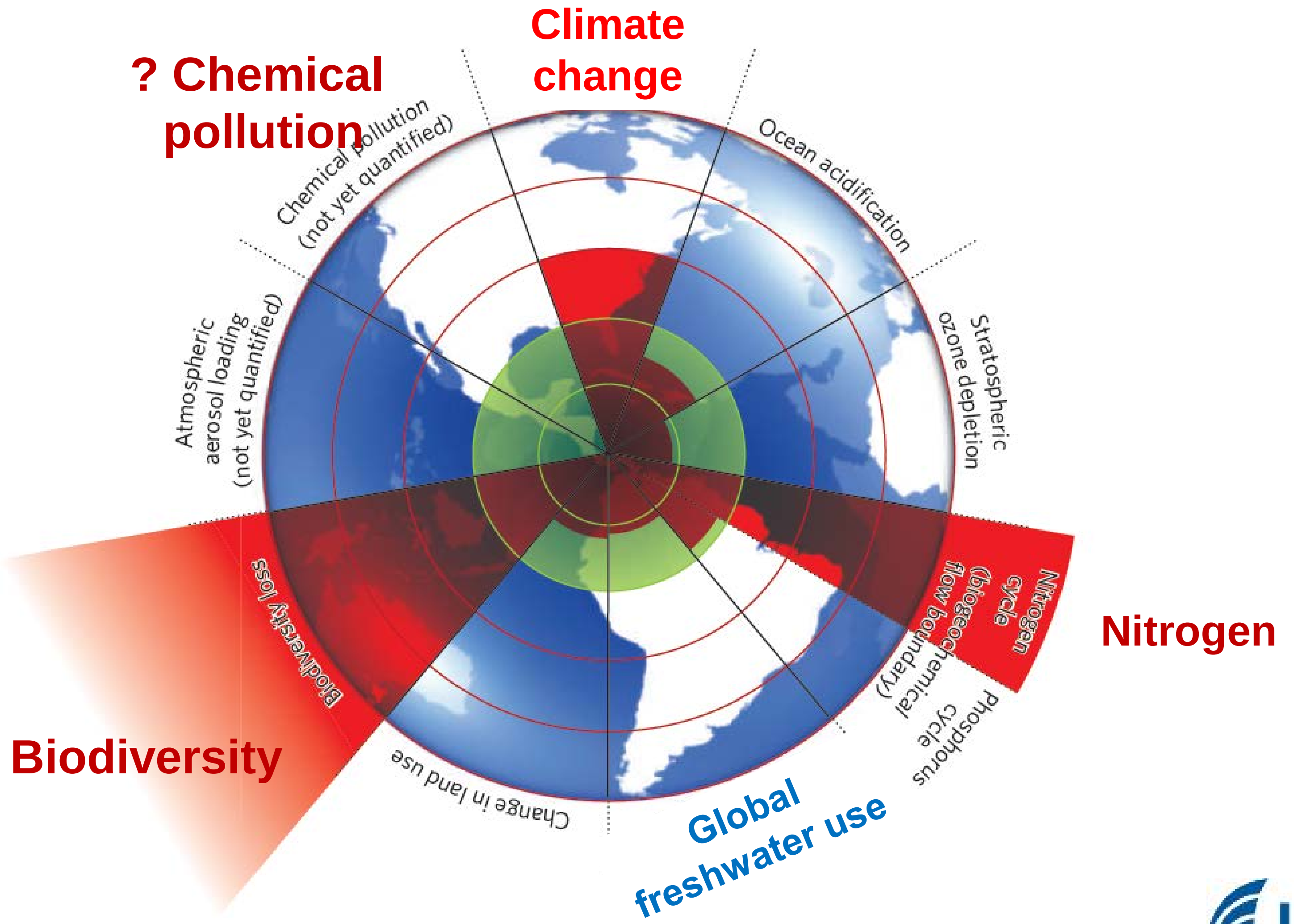


„Good water quality“ under climate change: a feasible or doomed environmental objective?

Prof. Dr. Dietrich Borchardt
Helmholtz-Centre for Environmental Research- UFZ
TU Dresden

HELMHOLTZ
CENTRE FOR
ENVIRONMENTAL
RESEARCH – UFZ

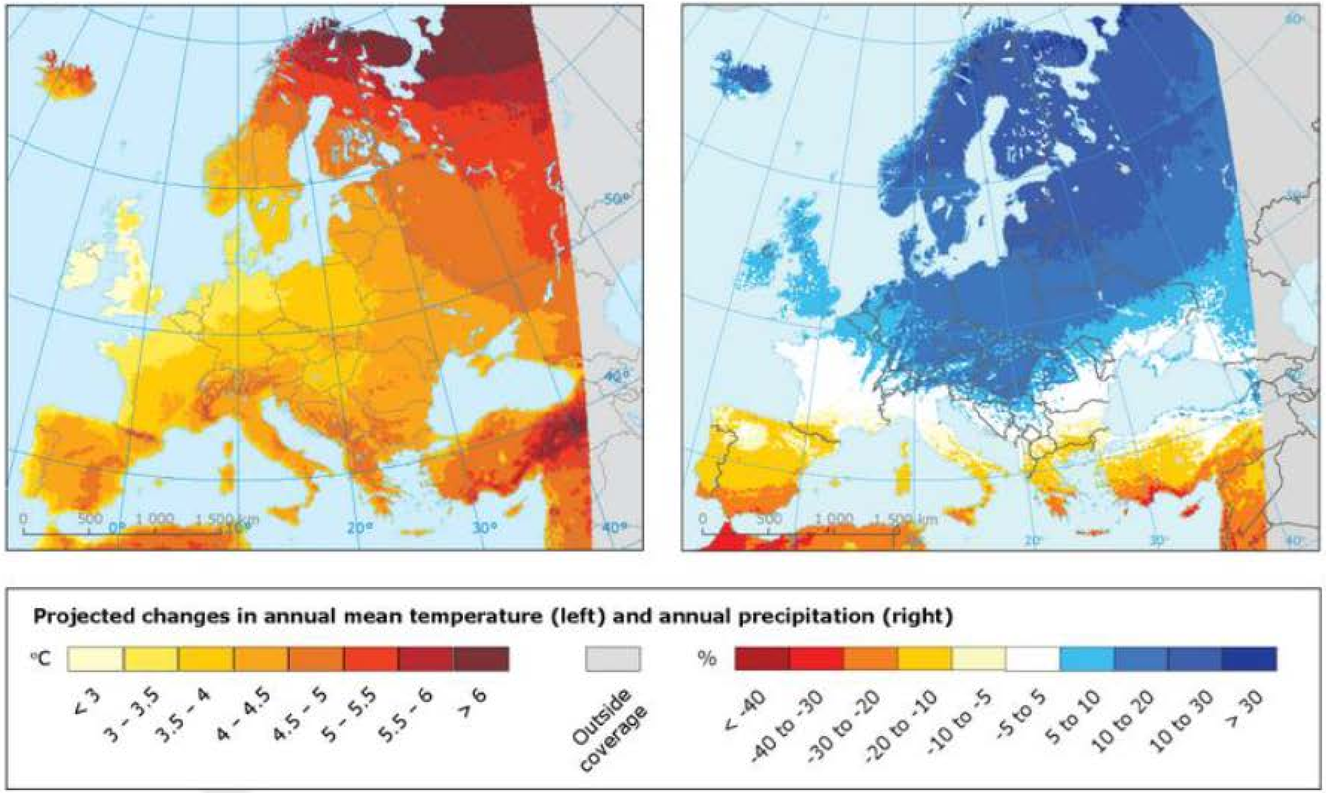
„Safe operating space“ for humanity and „planetary boundaries“



Rockström et al. (2009)

Projected changes in temperature and precipitation for Europe

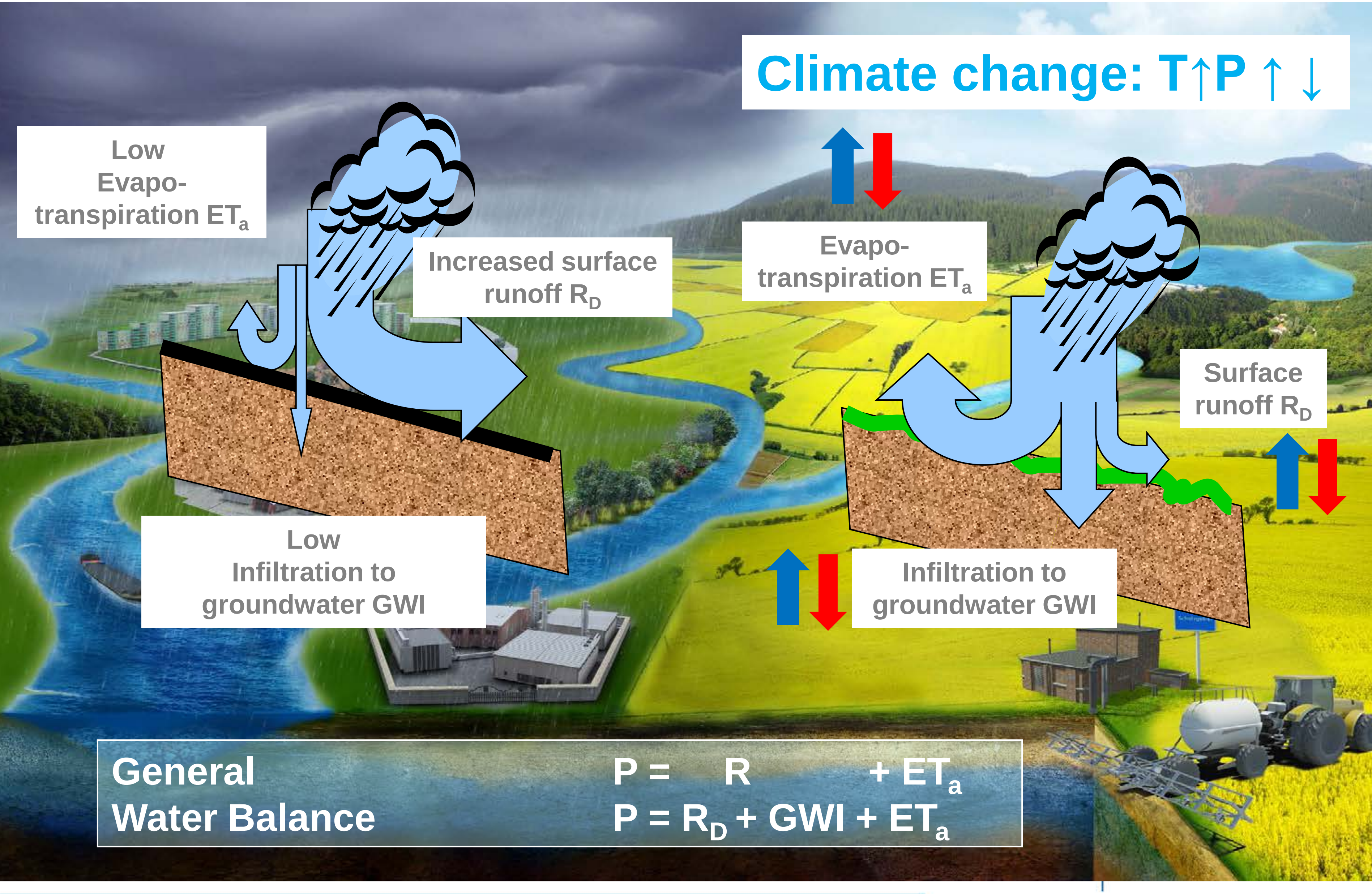
Temperature **Precipitation**



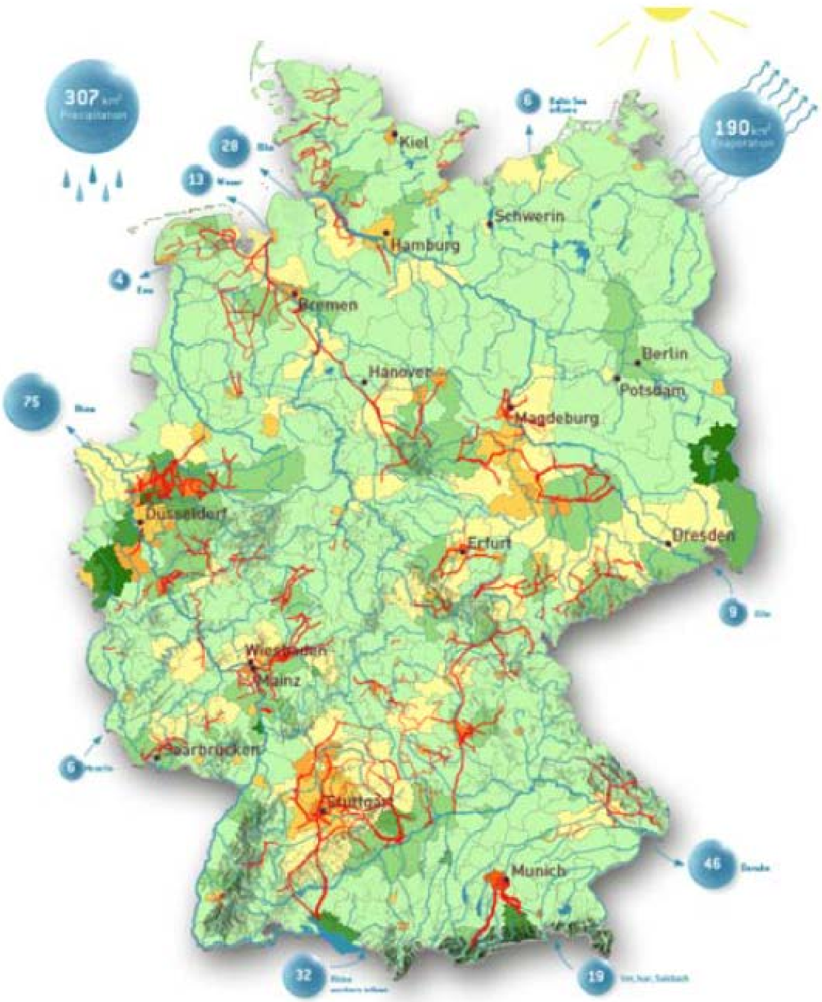
Source: Climate change projections for Europe based on an ensemble of regional climate model simulations provided by the EURO-CORDEX initiative. Note: Projected changes are for 2071-2100, compared to 1971-2000, based on the average of a multi-model ensemble forced with the Representative Concentration Pathways (RCP) 8.5 high emissions scenario. All changes marked with a colour (i.e. not white) are statistically significant. Individual models from the EURO-CORDEX ensemble or high-resolution models for smaller regions may show different results. Indicators: Global and European temperature (CSI 012), Mean precipitation (CLIM 002).

Projections are for 2017 – 2100 compared to 1971 - 2000

Water pathways, „climate“ and „land use“ impacts…



Long- distance water supplies of Public and Non-public water Water uses in Germany



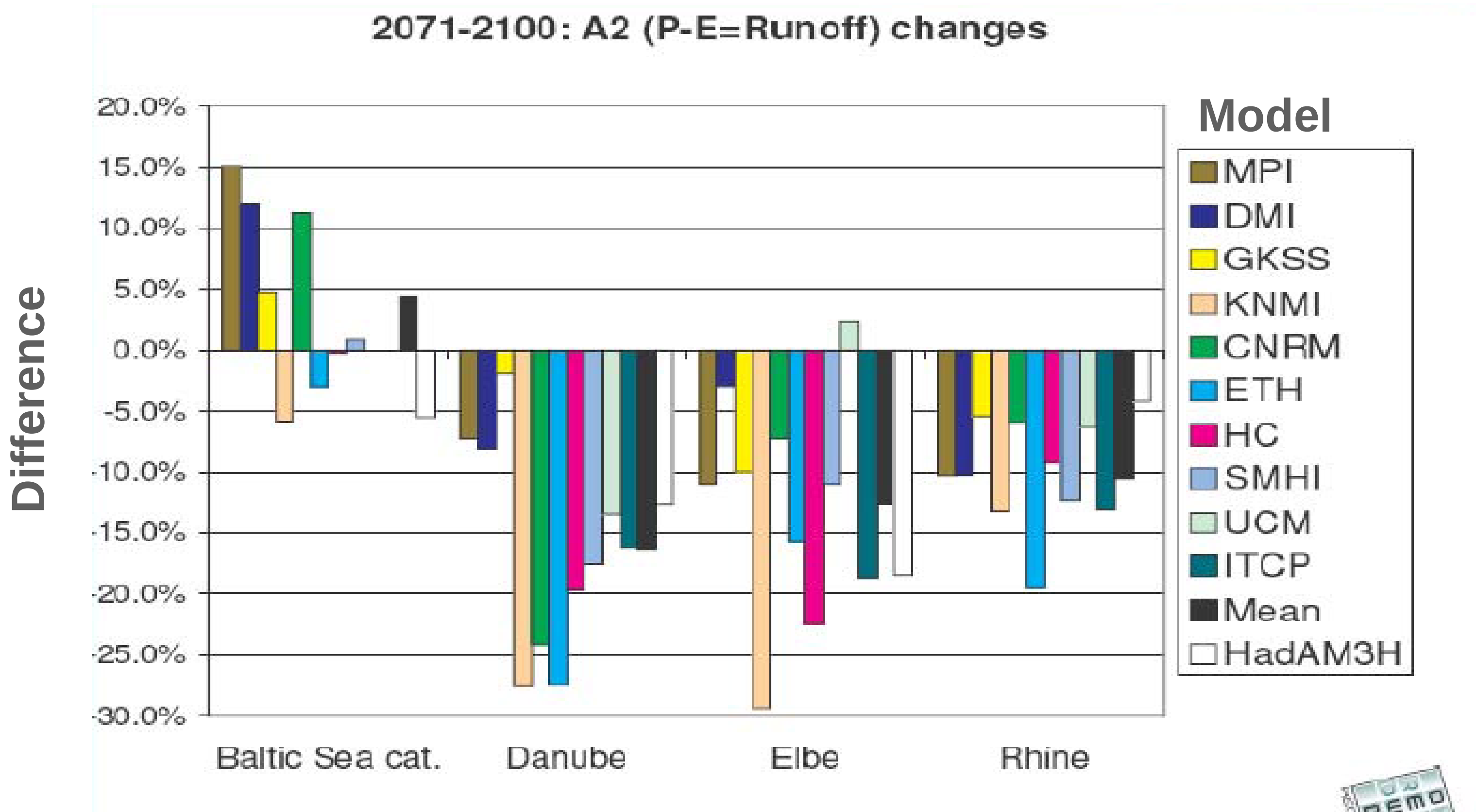
Many regions in Germany use much more water than they can actually generate on their own territory (yellow to orange areas on the map).

Thus, they have to rely on long-distance water supplies (red lines) from adjoining or more remote areas.

(Hirschfeld et al. 2014)

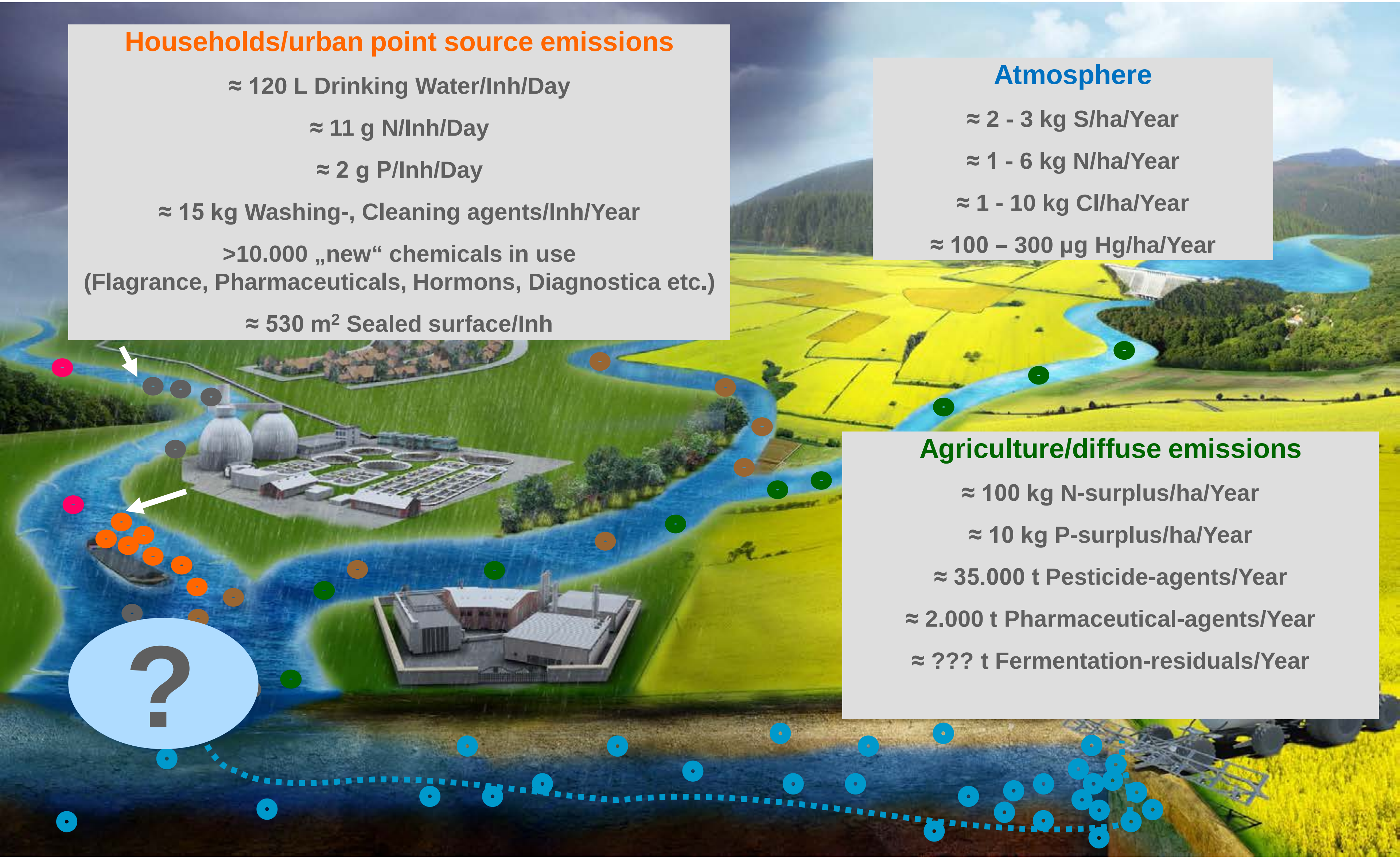
Projected runoff differences for major river catchments in Europe under climate change

(Periods 2071 - 2100 compared to 1971 – 2000)



Jacob, D. (2007)

Where does the pollution come from?



Households/urban point source emissions

≈ 120 L Drinking Water/Inh/Day

≈ 11 g N/Inh/Day

≈ 2 g P/Inh/Day

≈ 15 kg Washing-, Cleaning agents/Inh/Year

>10.000 „new“ chemicals in use
(Flagrance, Pharmaceuticals, Hormons, Diagnostica etc.)

≈ 530 m^2 Sealed surface/Inh

Atmosphere

≈ 2 - 3 kg S/ha/Year

≈ 1 - 6 kg N/ha/Year

≈ 1 - 10 kg Cl/ha/Year

≈ 100 – 300 µg Hg/ha/Year

Agriculture/diffuse emissions

≈ 100 kg N-surplus/ha/Year

≈ 10 kg P-surplus/ha/Year

≈ 35.000 t Pesticide-agents/Year

≈ 2.000 t Pharmaceutical-agents/Year

≈ ??? t Fermentation-residuals/Year

Urban wastewater infrastructures in D

Connection to WWTP´s
≈ 95 %

Connection to sewers
≈ 96 %

No of WWTP´s
9.933

Length of sewer network
541.000 km

Total length ≈ 13,5x circumference of earth

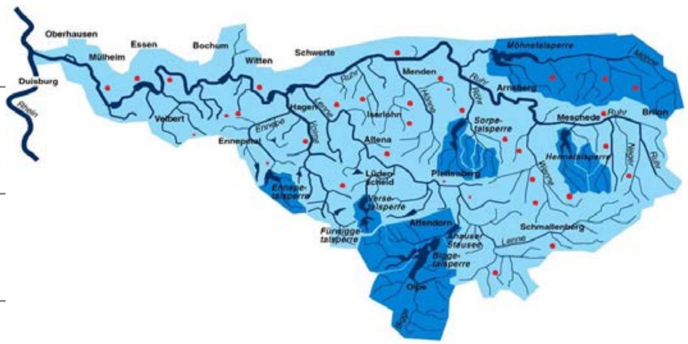
Wastewater	**≈ 5.2 Mrd. m³**
Sewer Infiltration	**≈ 2.1 Mrd. m³**
Stormwater	**≈ 2.8 Mrd. m³**
Total amount	**≈ 10.1 Mrd m³**

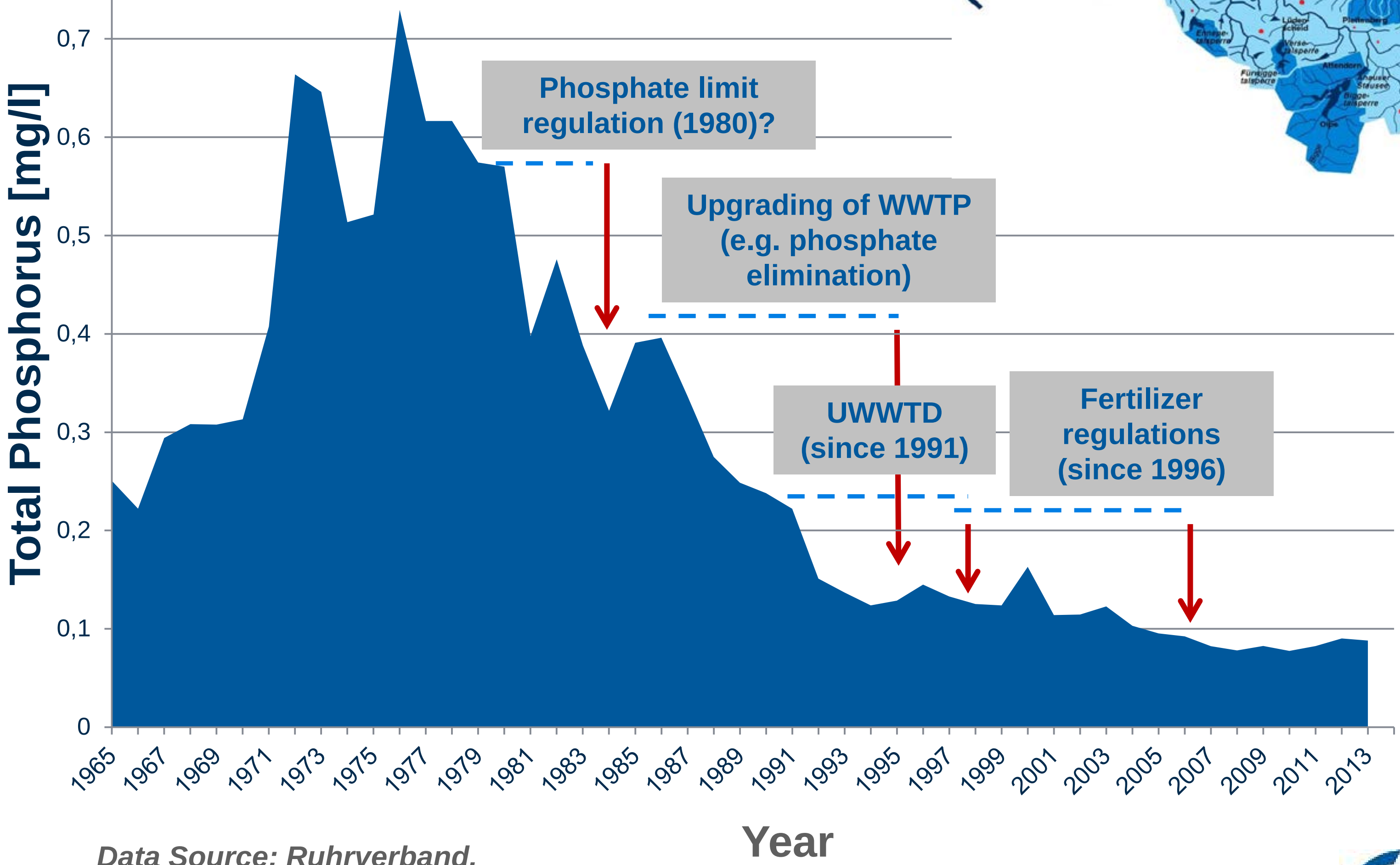
≈ 5 x $V_{\text{Lake Chiemsee}}$ per year
Removal efficiency: Phosphorus ≈ 90 %, Nitrogen ≈ 80%

Source: Statistisches Bundesamt (2009)

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Phosphorus reduction by source control and wastewater treatment

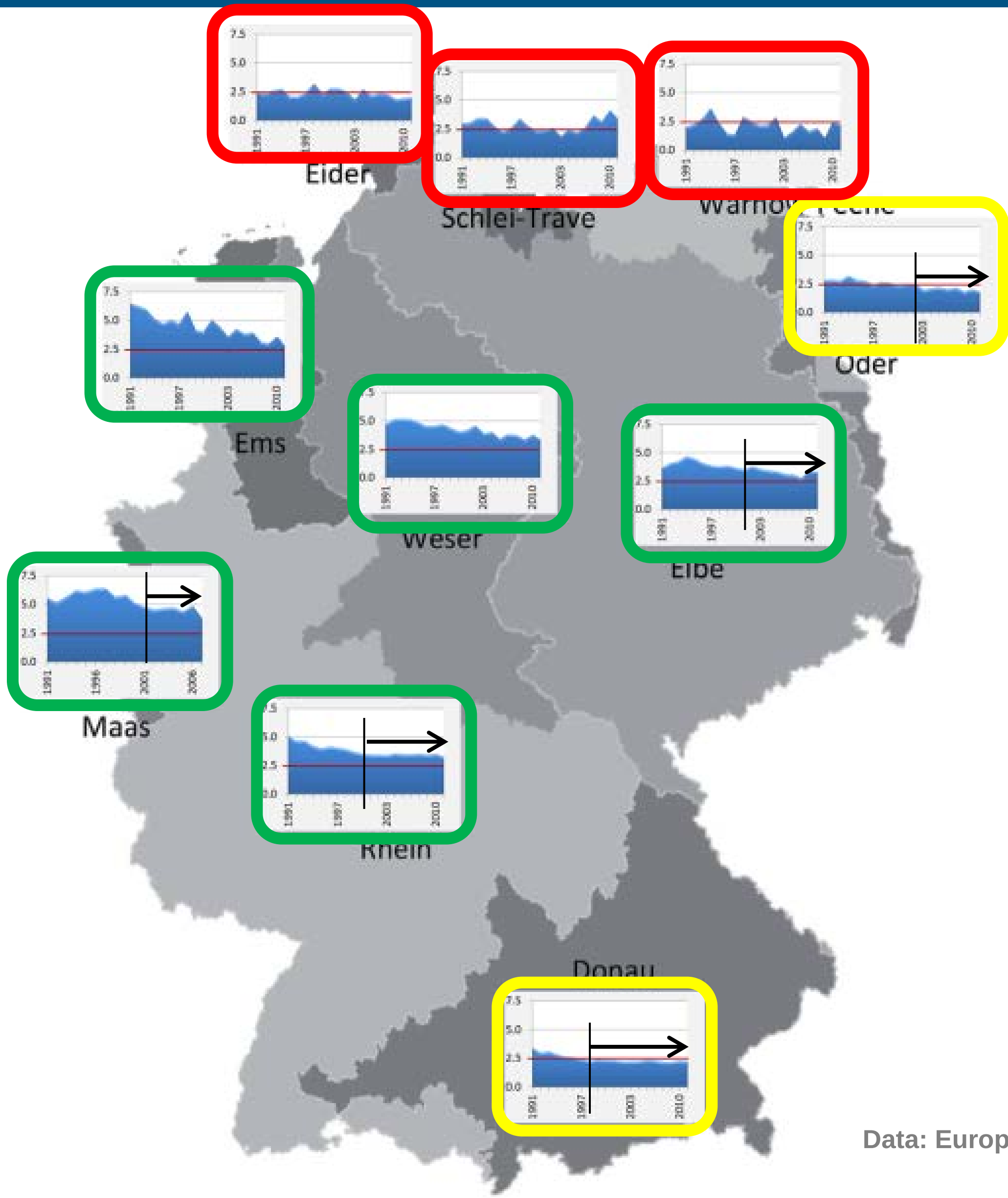




Data Source: Ruhrverband,
Analysis: Annual mean value

UFZ

Nitrogen trends in the large rivers of D since 1991



Significantly decreasing trends; but N-concentrations still exceed target value of 2,5 mg/l NO_3-N for „good status“

Slightly decreasing trend; since 2000 N-concentrations below target values

No or even increasing trend; N-concentrations around or exceeding target value

Further decline of N-concentrations questionable („legacy“ or „memory effects“ in catchments)

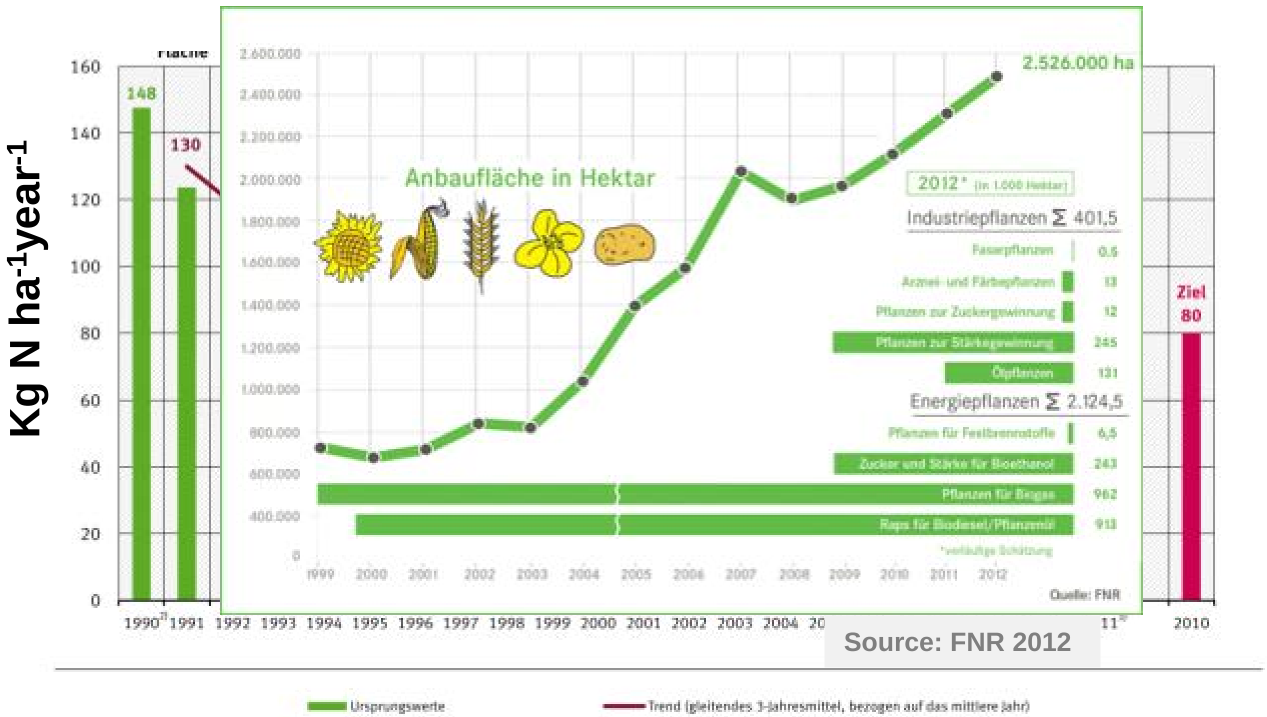
Nutrient loading of coastal and marine waters prevails at high levels

Data: European Environment Agency 2013.

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Nitrogen surplus of agricultural land in D since 1990

Cropland renewable resources since 1999

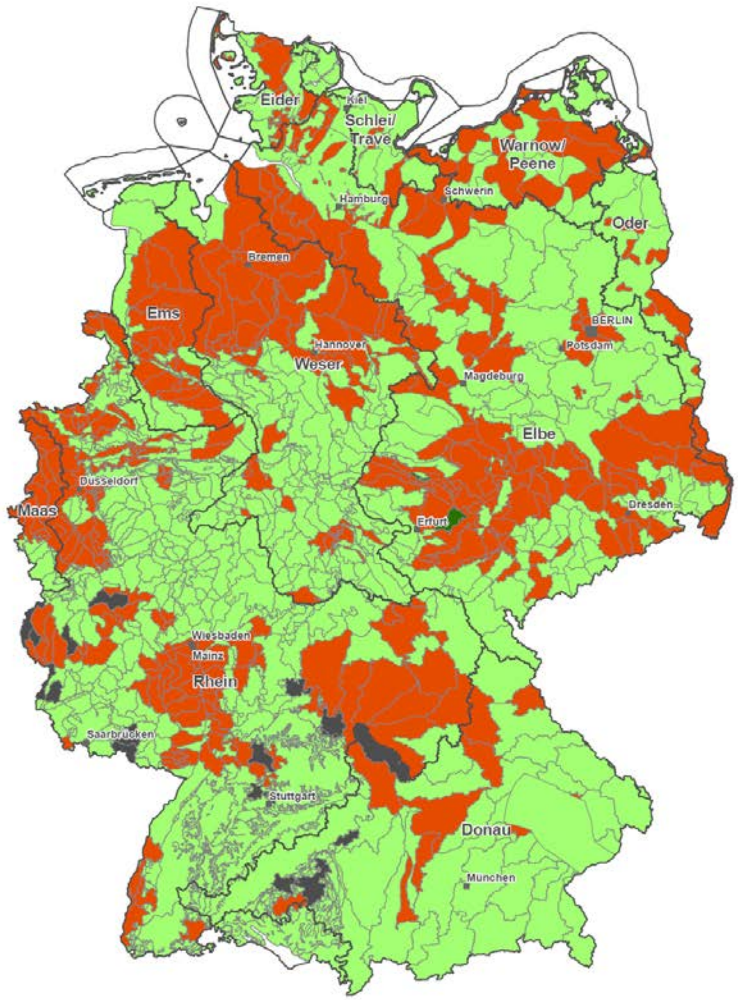


Data base for calculating the N surpluses of 2011 partially provisionally (N surpluses are calculated from a moving 3-year average)

Source: Institut für Pflanzenbau und Bodenkunde 2013 in UBA 2013

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

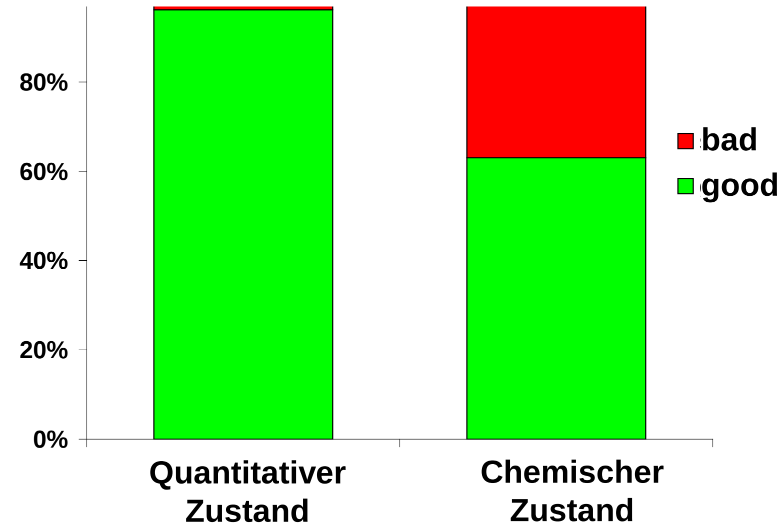
„Status“ of Groundwater Bodies in D



- Landeshauptstadt
- Bundeshauptstadt
- Flussgebietseinheit
- Zielerreichung heute
- Zielerreichung geplant für 2015
- Inanspruchnahme einer Ausnahme nach Artikel 4
- nicht klassifiziert

Stand: Januar 2010

Quelle: Berichtsportal WasserBLIcK/BfG, Stand 22.01.2010



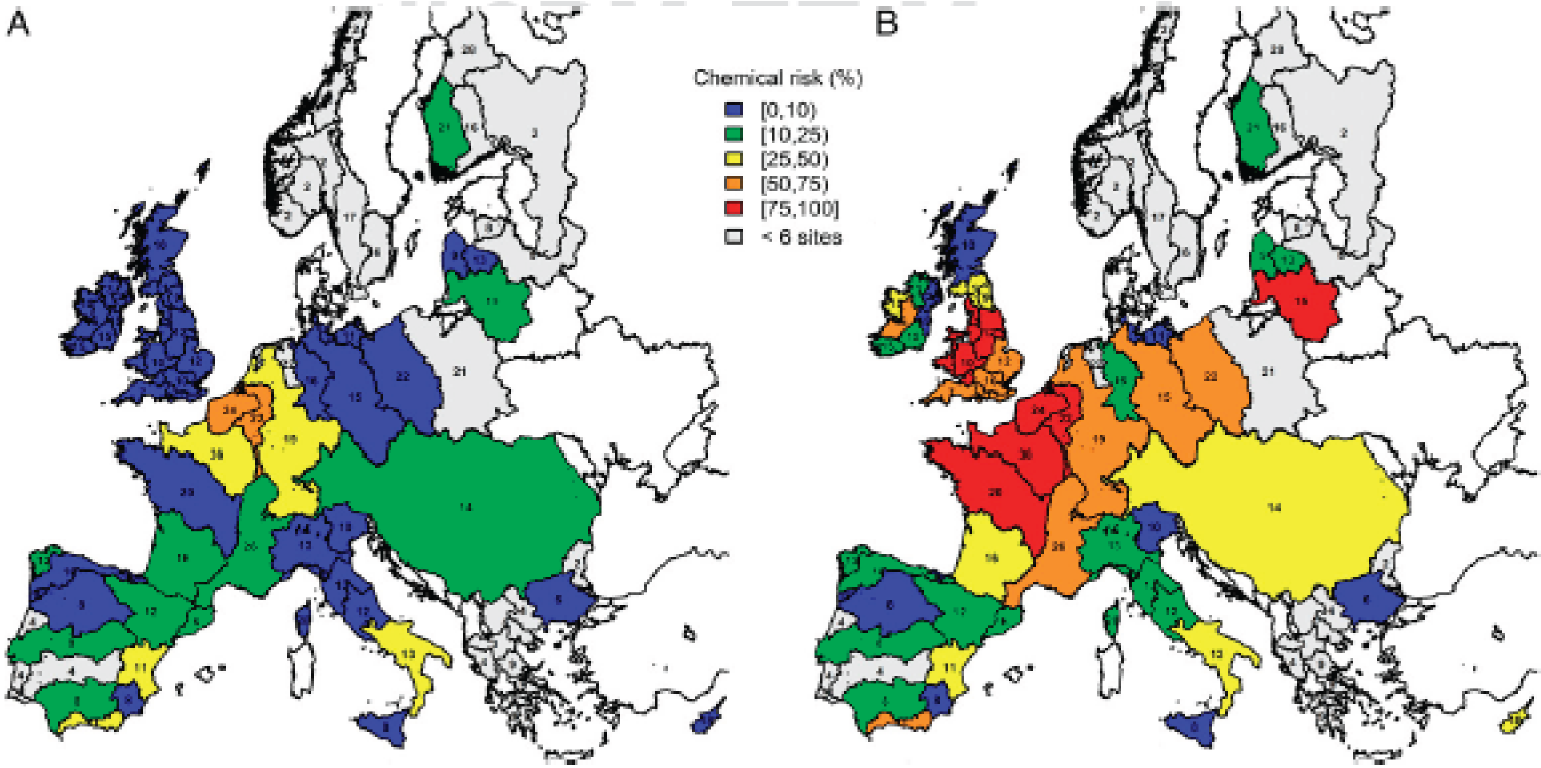
ca. 95% of GWB´s „good quantitative status“

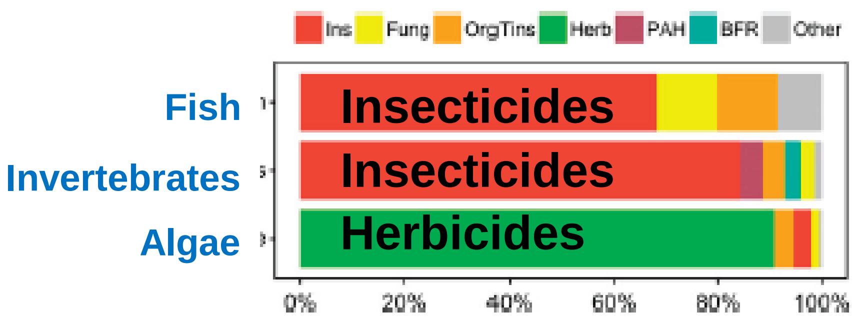
ca. 60% of GWB´s „good chemical status“

HELMHOLTZ
CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

„Chemical risk“ for ecological status

Acute Toxicity | Chronic Toxicity

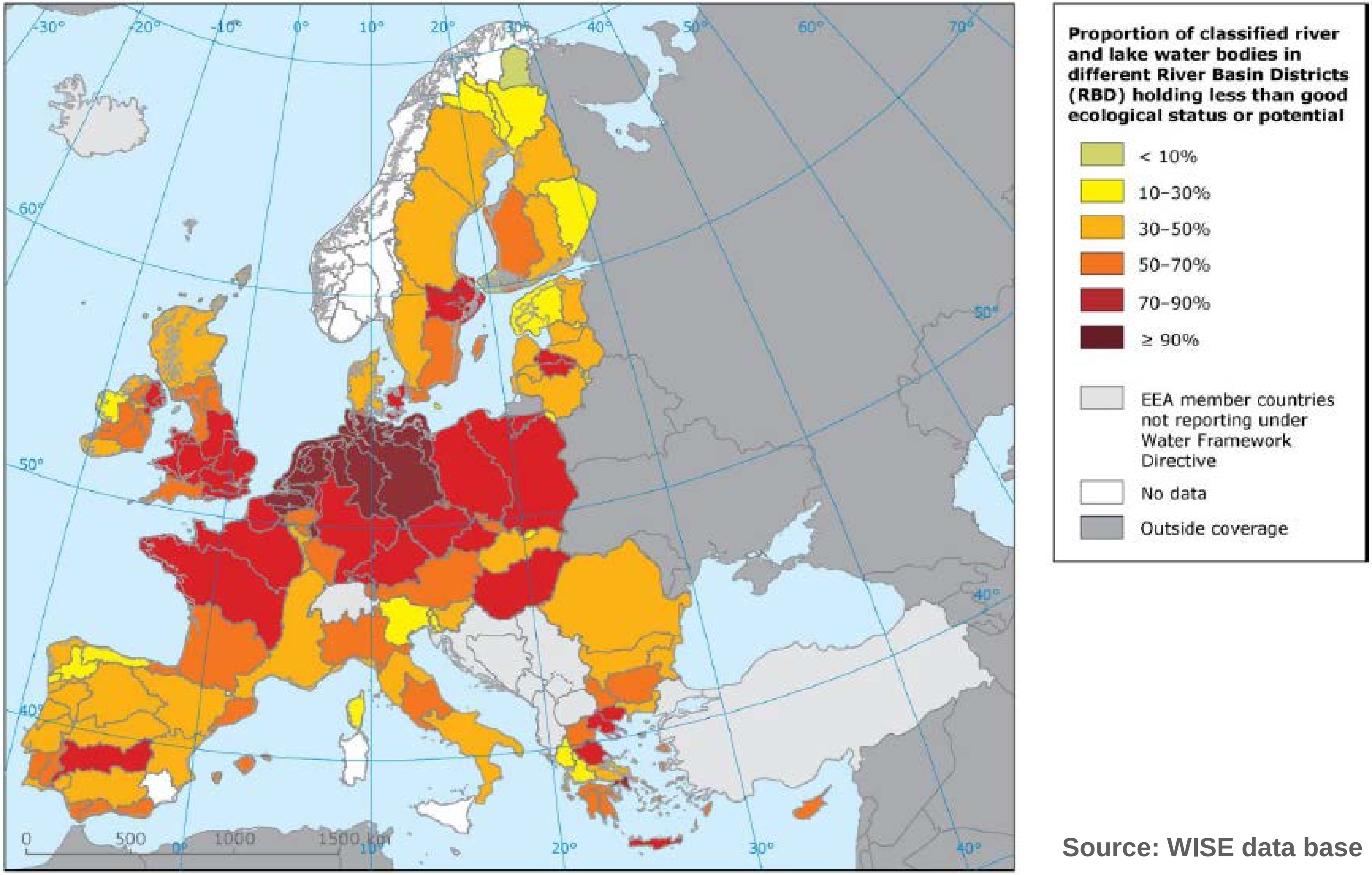




Manaj et al, PNAS, 2014

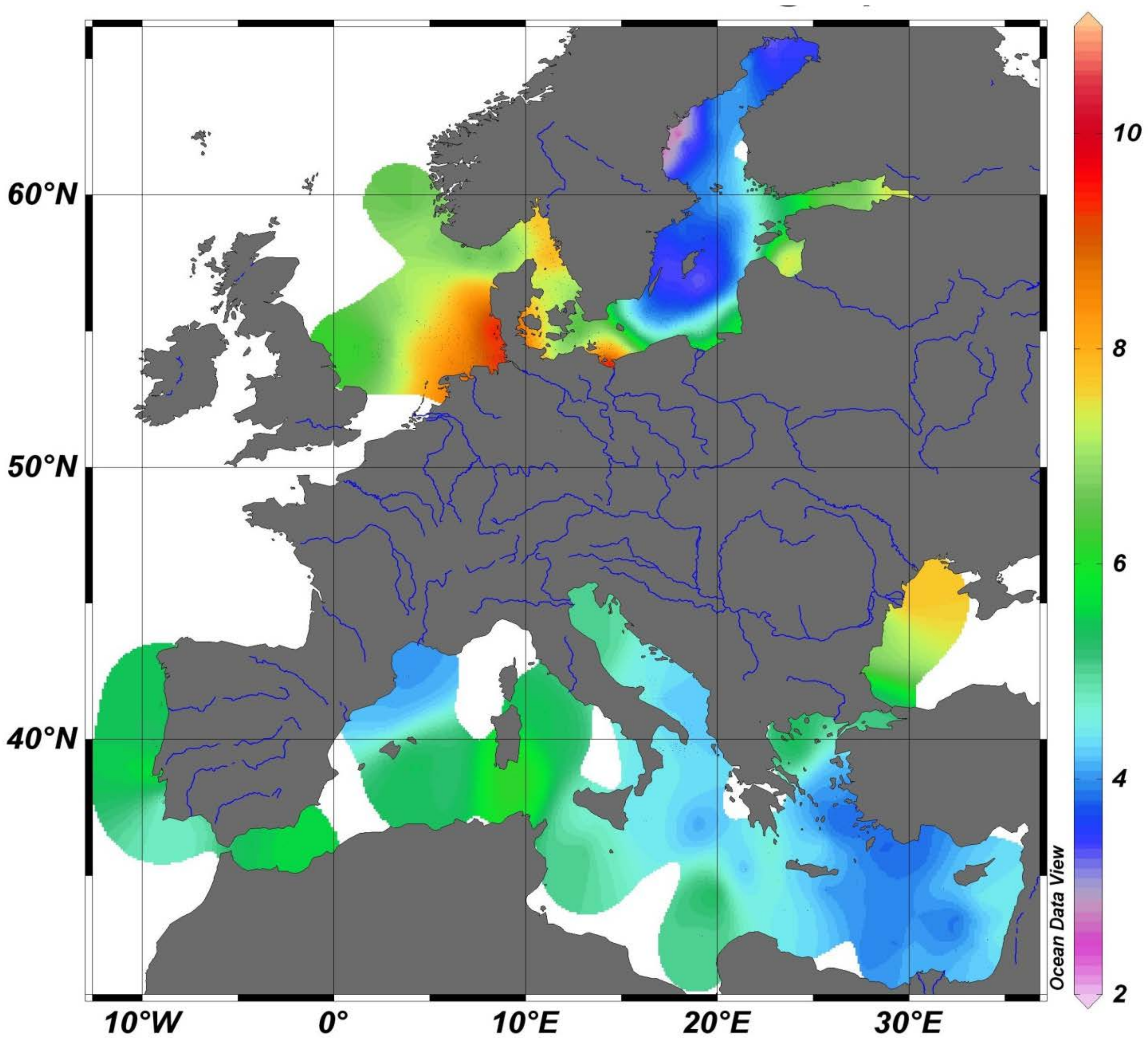
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Proportion of river and lake ecosystem in less than „Good Status“



Source: WISE data base

„Anthropogenic“ Nitrogen in coastal zones

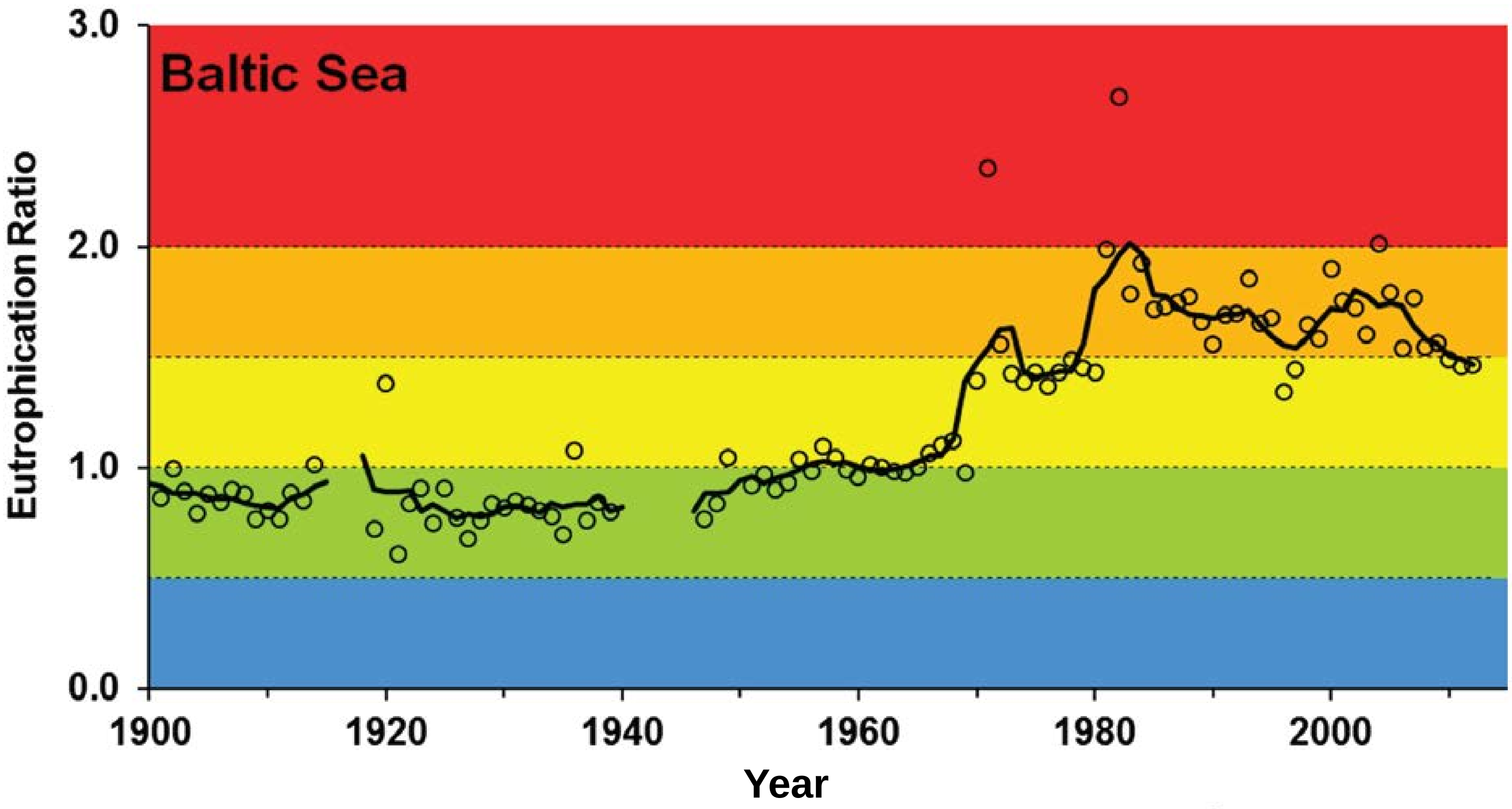


$\delta^{15}N$
(‰ vs. air N_2)
in surface
sediments
(0-1 cm)

(Eimis 2011)

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

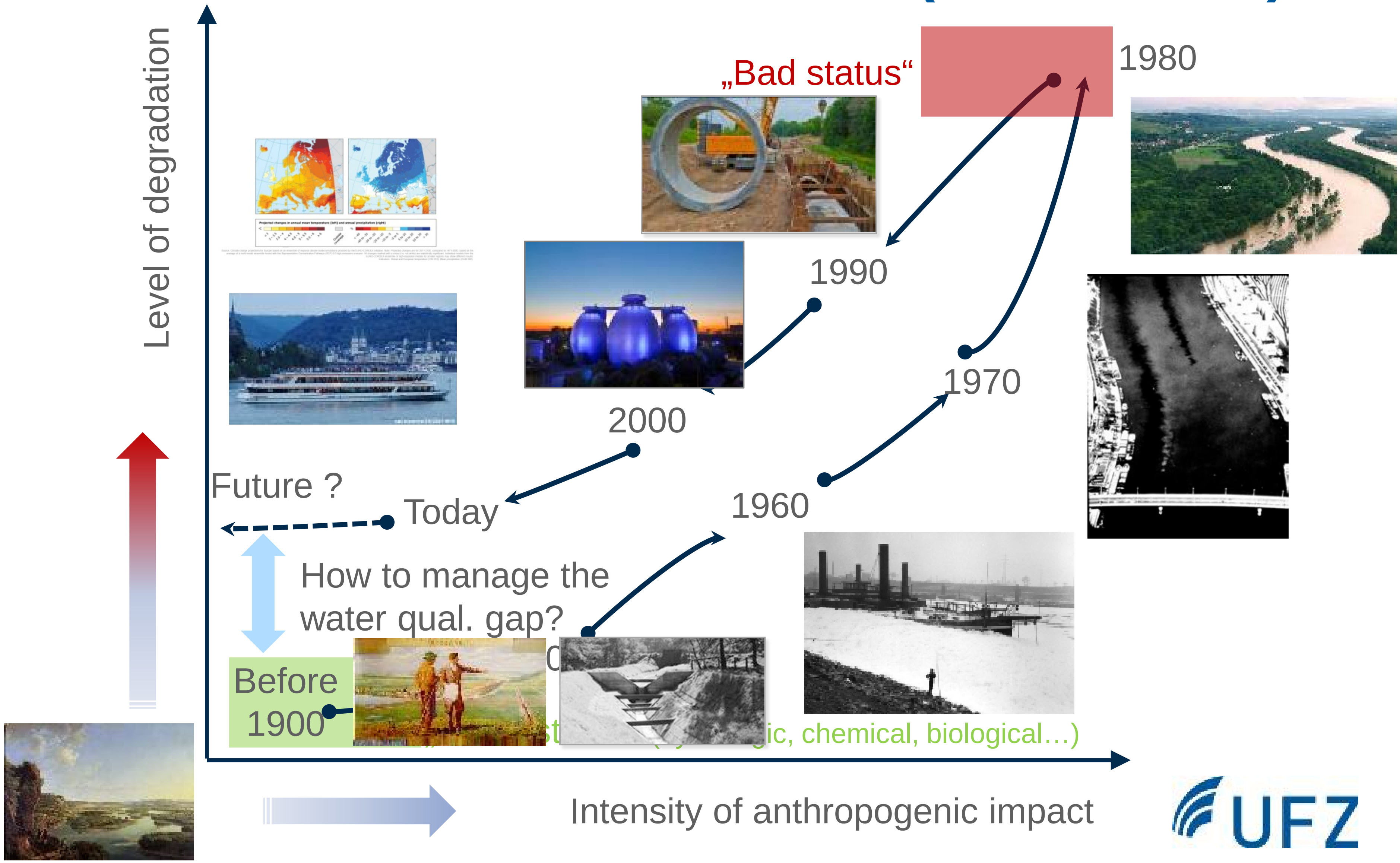
Long-term trend of eutrophication in the Baltic Sea (1900 – present)



(Andersen et al. 2015)

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

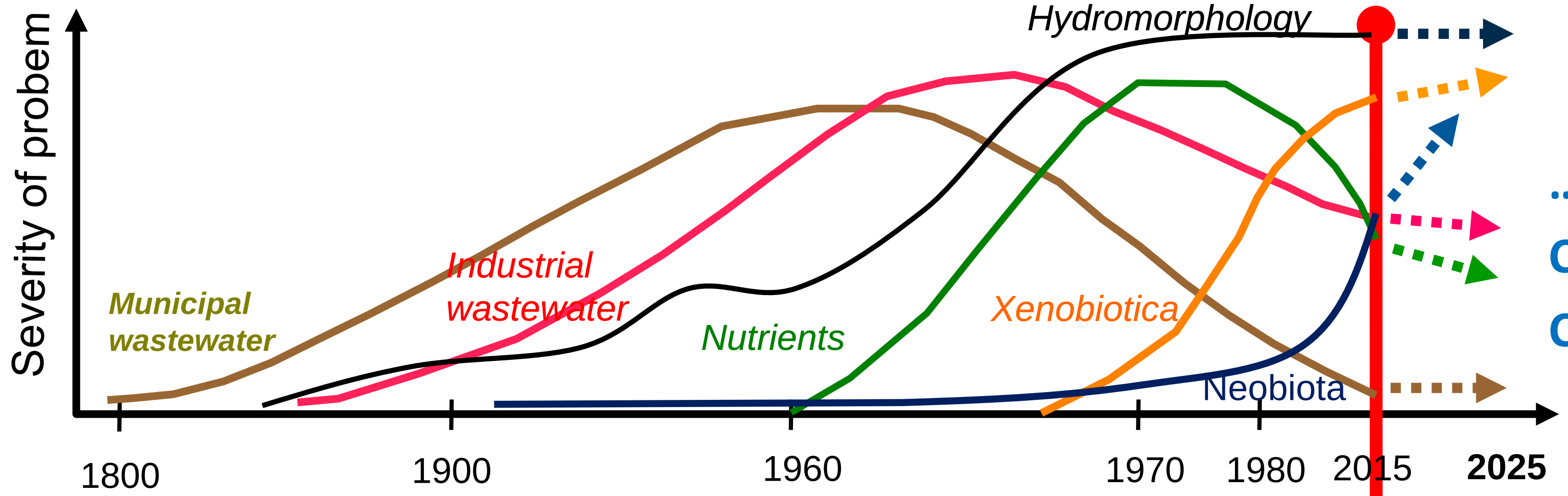
„Water quality trajectory“ of a major European river catchment since 1900 (River Rhine)



Anthropogenic pressures and impacts over time

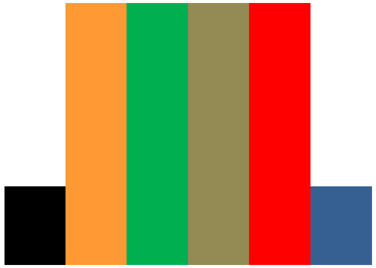


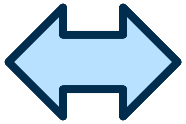




...and Climate Change...

India (Ganges)

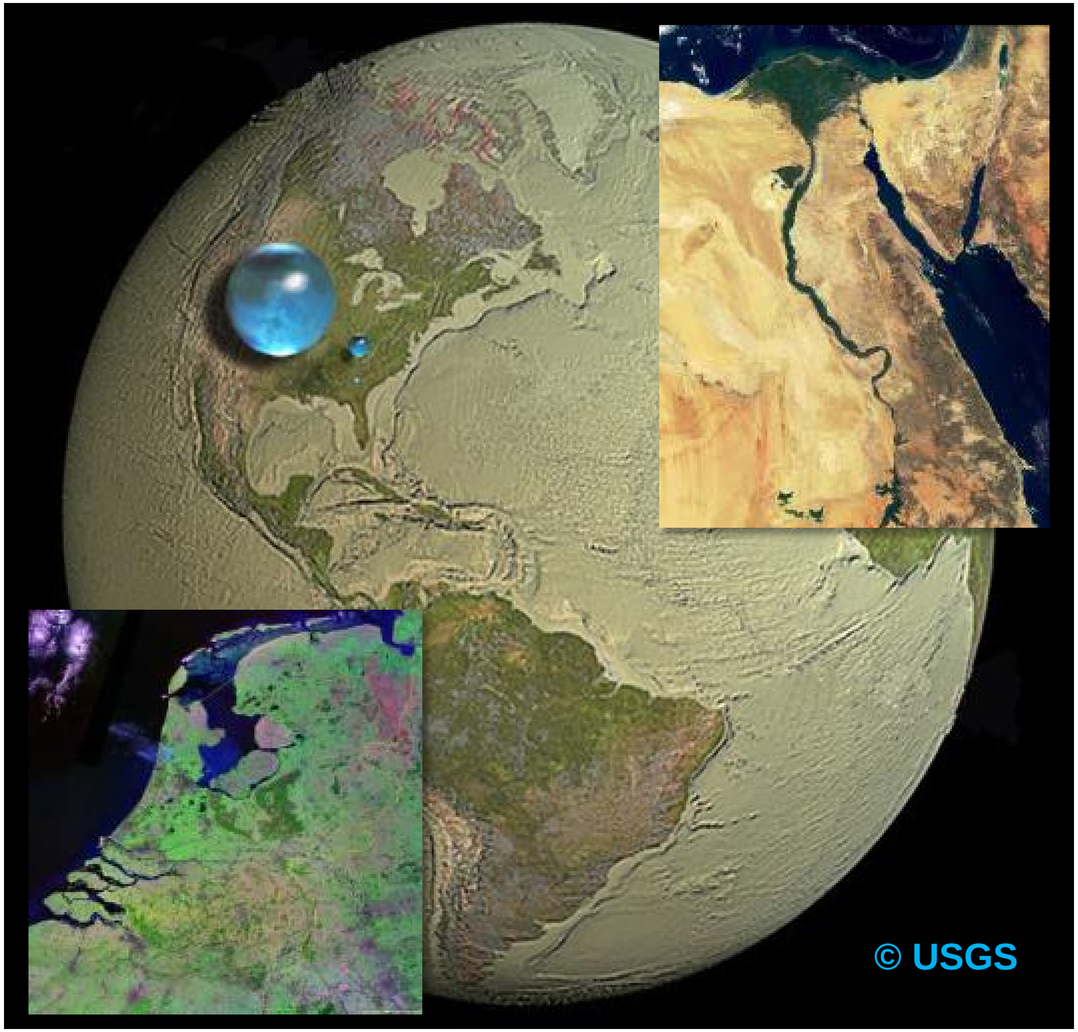




Regional priorities different

Europe (Rhine)

Water Security in the 21st Century – a Grand Challenge



Critical status and progressive deterioration

Land use changes,
demographic changes,
urbanisation,
energy demand,
climate change…

Where and when will we exceed the thresholds of quantitative and qualitative water security ?

Sustainable pathways for water security ?

How to achieve „good water quality“ under climate change ?

- **Comprehensive approaches** at various scales and between sectors
  - **Mitigate** known adverse environmental impacts (ressource efficient agriculture, energy production, wastewater treatment, etc.)
  - **Restore** aquatic ecosystems (river networks, floodplains, lakes, groundwater) and maintain water infrastructures (drinking water, sewerage, waste water treatment)
  - **Avoid** potentially serious environmental harm to humans and ecosystems (precautionary principle and prevention)
  - **Adapt** to expected climate and socio-economic changes (increase the resilience of connected natural and anthropogenic water systems)
- **„Safe boundaries“** of water for humans and ecosystems rather than „Good status“

UFZ