Welcome to the Anthropocene - The Earth in Our Hands

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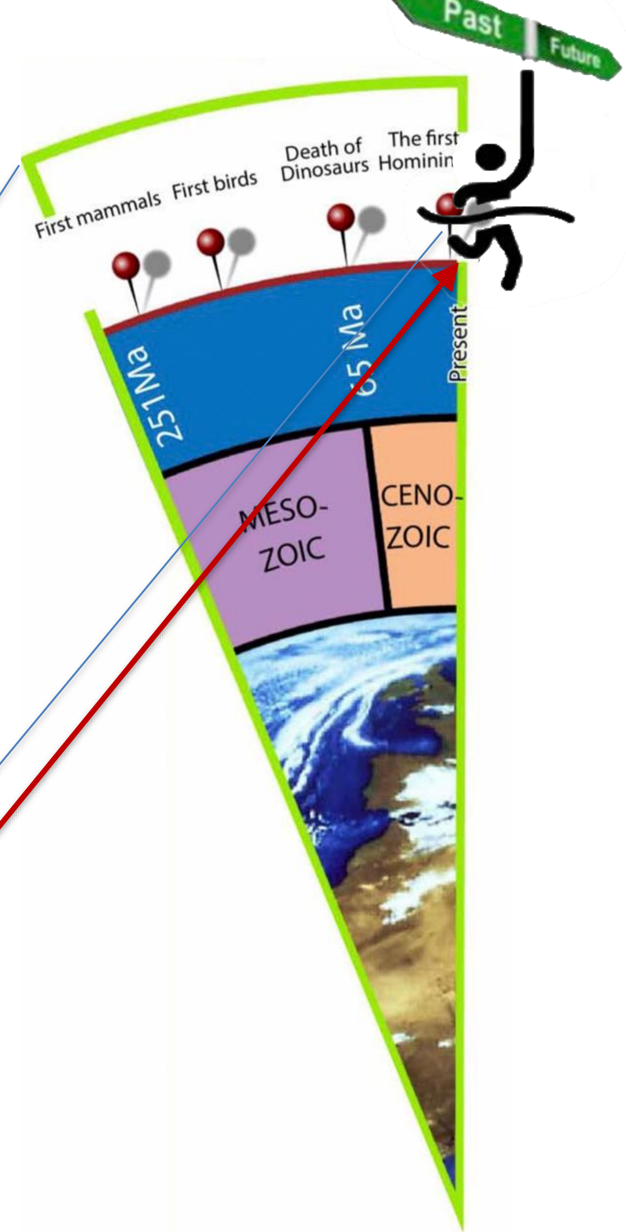
The 25 Biggest Turning Points in Earth's History

1) 4.5b years ago: Earth is born
2) 4-3.5b years ago: The origin of life
3) 3.4 b years ago: Life harnesses-the power of sunlight
4) 3.0b years ago: The beginning of plate tectonics (?)
5) 2.4b years ago: The great oxidation event
6) 2-1b years ago: Endosymbiosis
7) 1.2b years ago: The first sex (?)
8) 1.0b years ago: Multicellular life
9) 850-635m years ago: Snowball Earth
10) 535m years ago: The Cambrian Explosion
11) 465m years ago: Plants colonise the land
12) 460-430m years ago: The first mass extinction
13) 375m years ago: Fish that walk on land
14) 320m years ago: Dawn of the reptiles
15) 300m years ago: Pangaea
16) 252m years ago: The great dying
17) 220m years ago: The first mammals
18) 201m years ago: The Triassic extinction
19) 160m years ago: The first birds
20) 130m years ago: Flowers flower
21) 65m years ago: Death of dinosaurs
22) 60-55m years ago: The first primates evolve
23) 32-25m years ago: Supercharged plants
24) 13-7m years ago: The first hominins
25) 200,000 years ago: The human race

26) ca. 70 years ago: The Anthropocene

http://www.bbc.com/earth/bespoke/story/20150123-earths-25-biggest-turning-points/



Geology of Mankind – The Anthropocene

Paul Crutzen

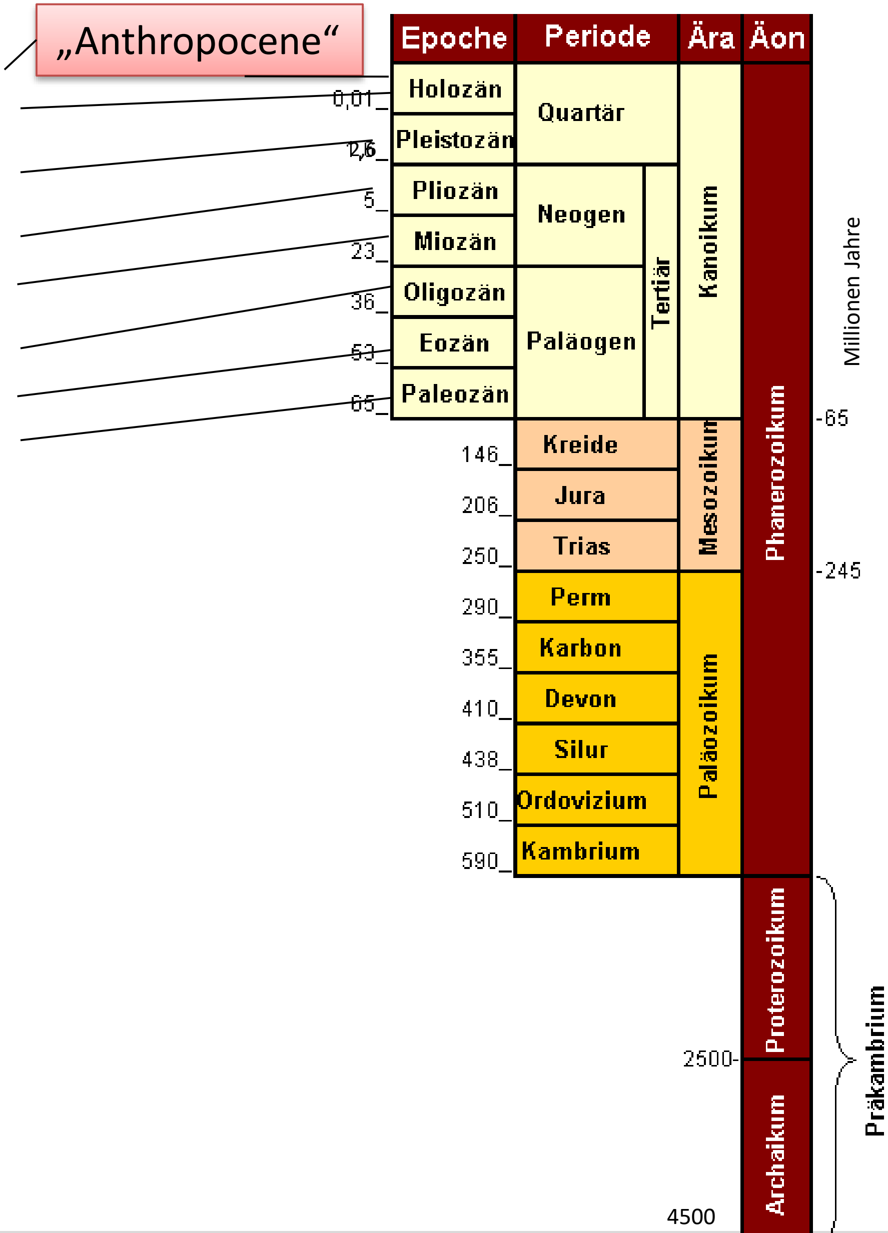
„We live in the Anthropocene"

Martyna Zalatyte, University of the Arts Berlin ,
(In: A. Hamann, H. Wagenbreth, H. Trischler, R. Leinfelder, 2014

Geology of Mankind – The Anthropocene

Paul Crutzen

The human new
The totally new
The most new
The more new
The little new
The slightly new
The rising new
The old new



„We live in the Anthropocene“

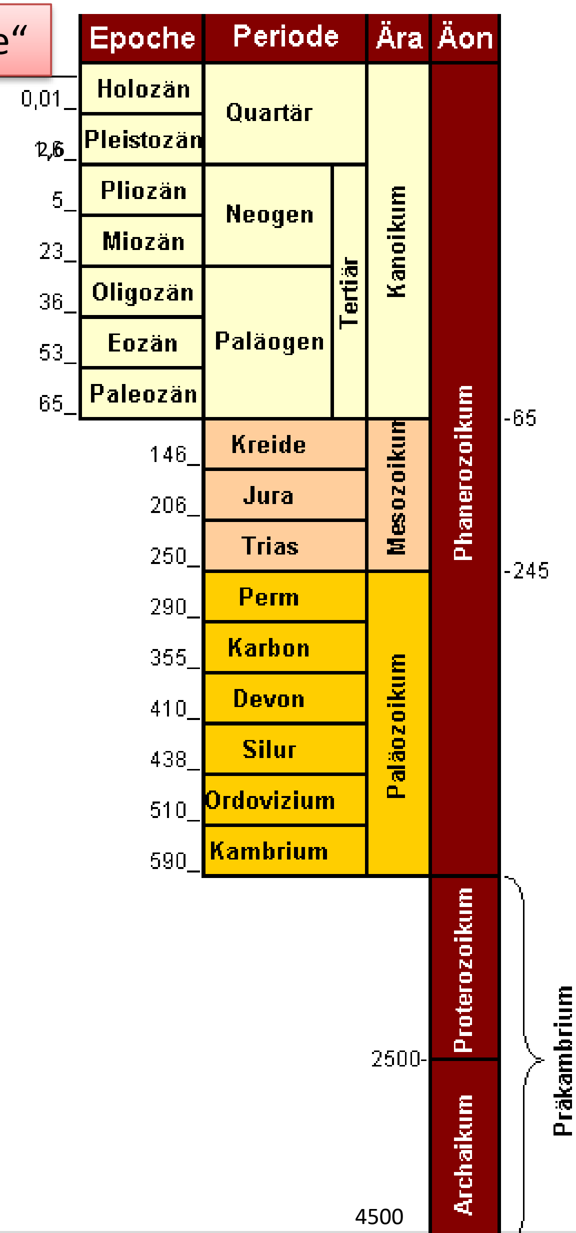
Geology of Mankind – The Anthropocene

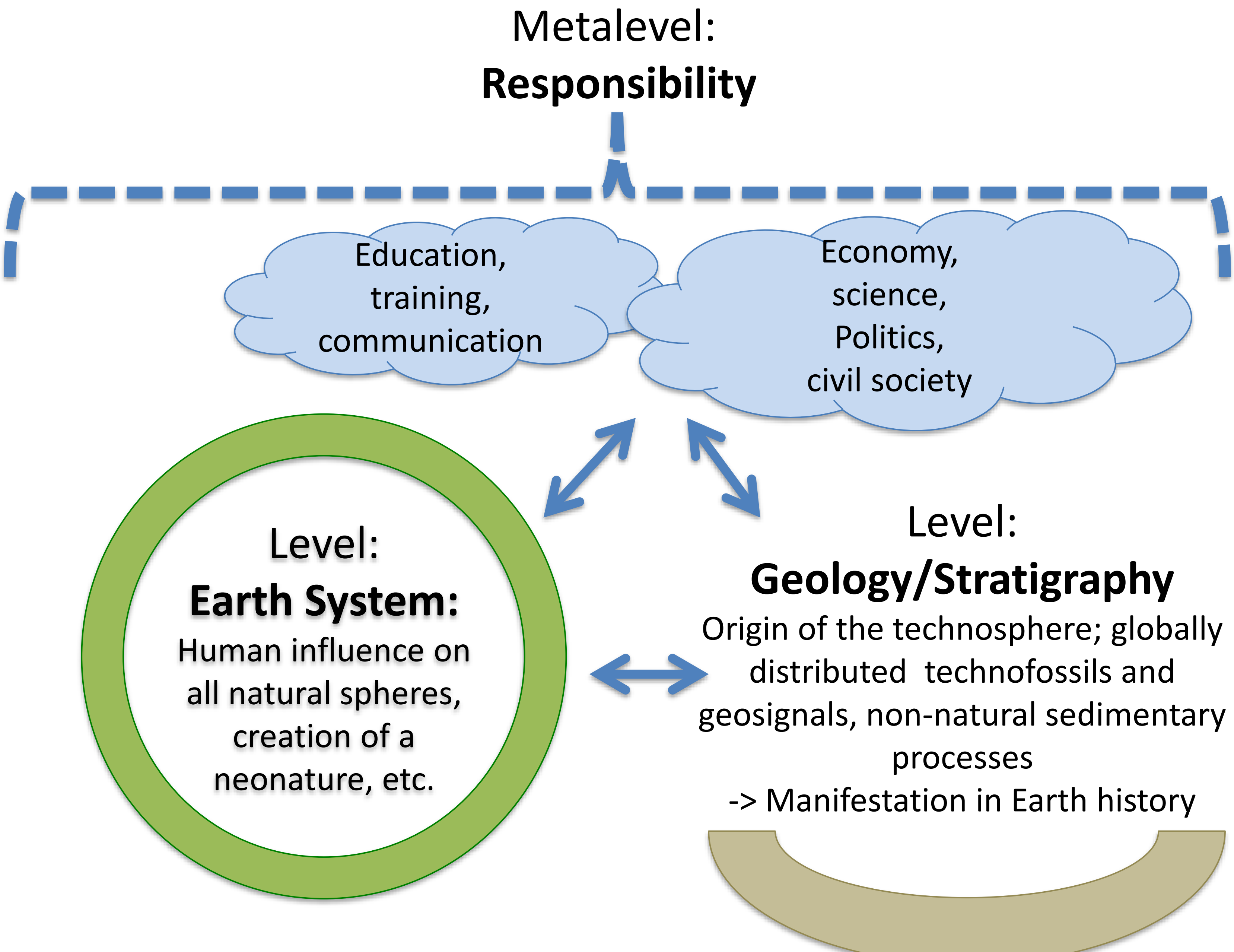
Paul Crutzen

„Anthropocene“

Crutzen‘s hypotheses:

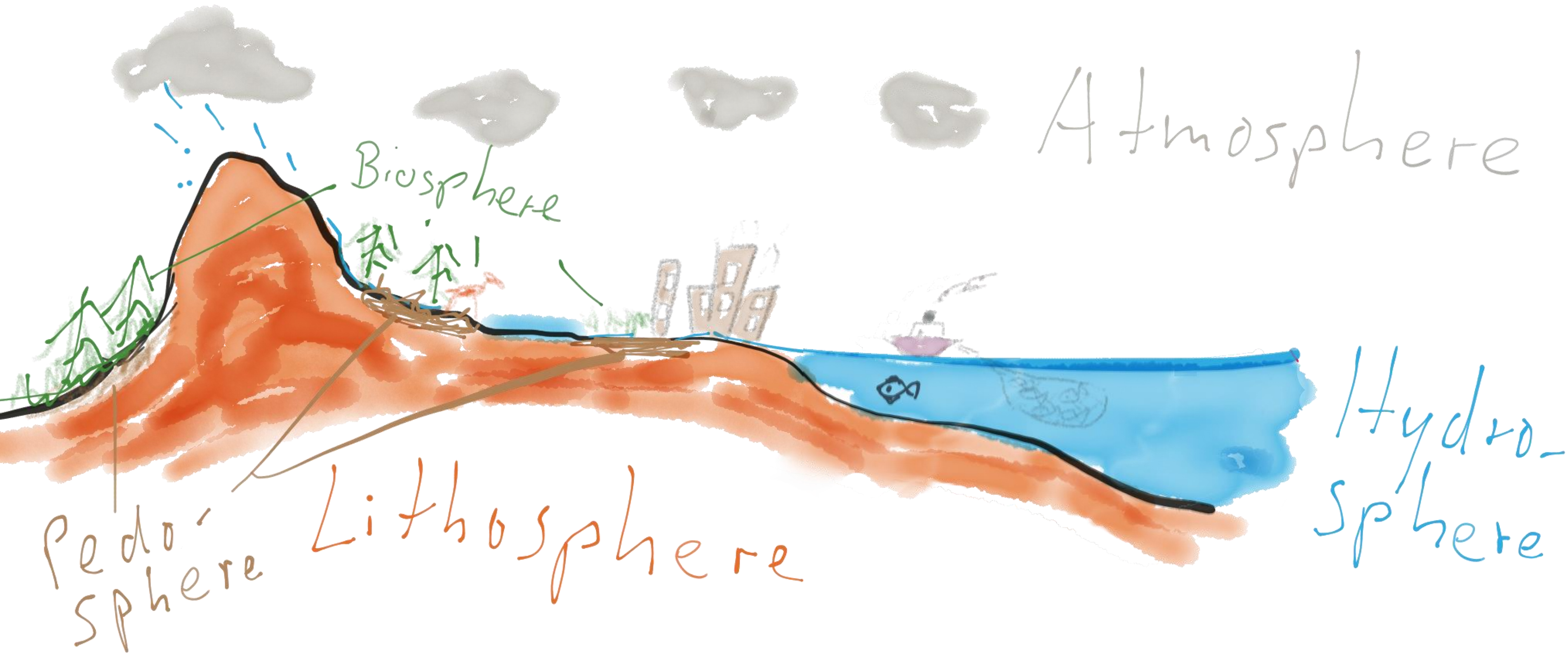
- Humans have a very strong imprint on the Earth System in the Anthropocene
- Humankind has become a “geological factor“
- The Anthropocene is geologically preservable
- Responsibilities also for science



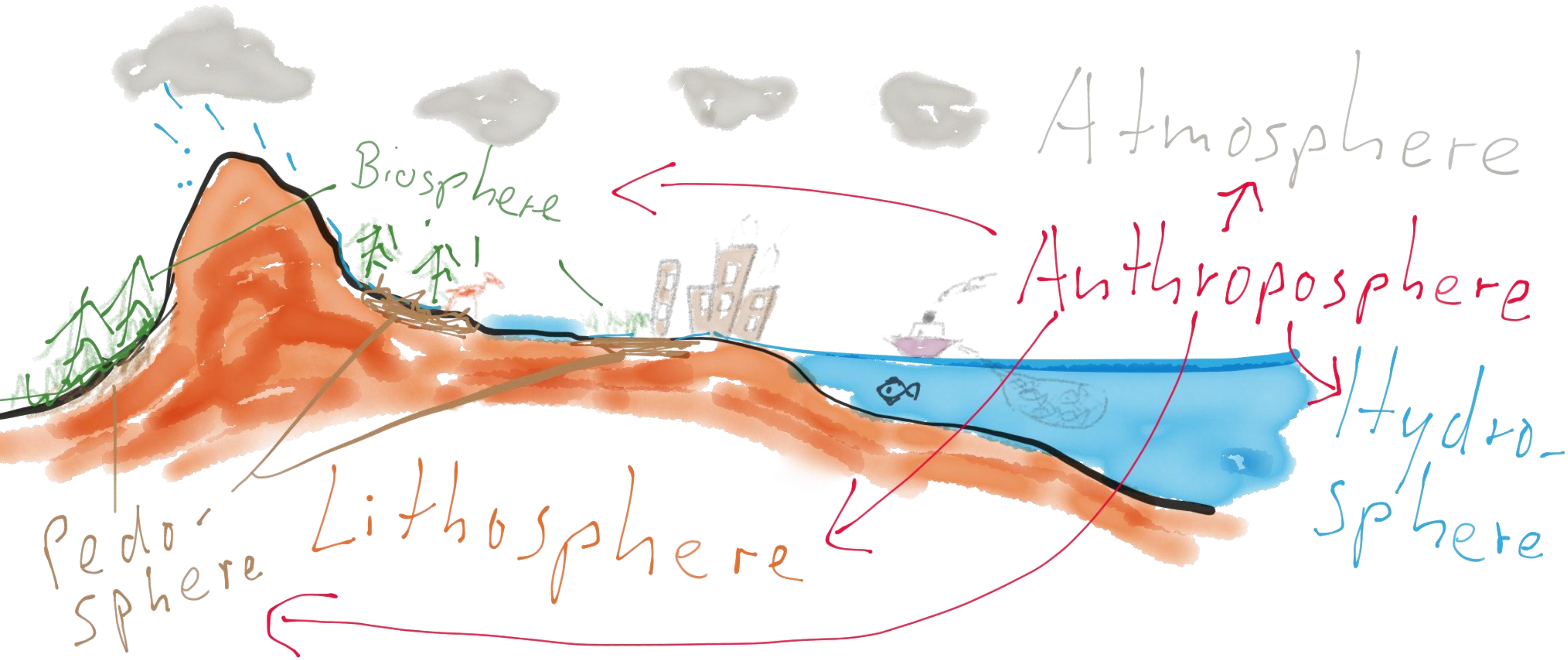


From Leinfelder 2017 … Phosphorus…., translated

Earth system spheres

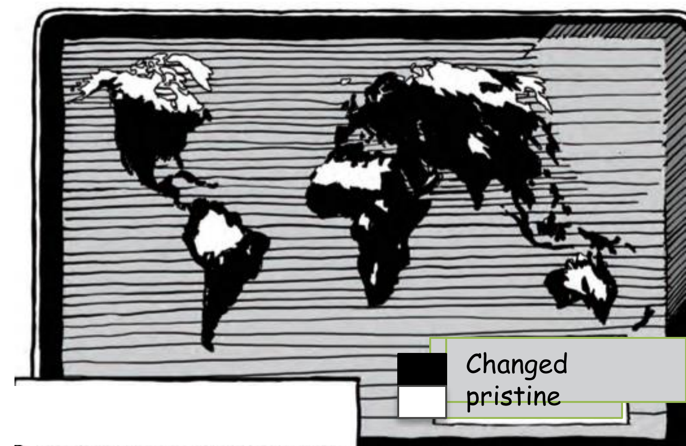


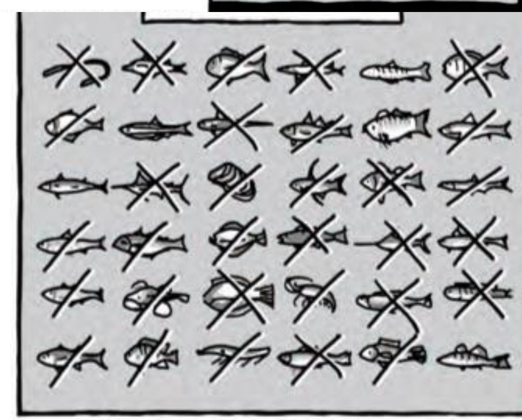
Earth system spheres



Earth system changes: quantities / overview

- **77%** of (ice-free) **land surface** not pristine any longer**,** most of **freshwater** used / managed by humans
- **Highest** atmospheric **CO_2**-concentrations **since >>800.000 (5 Mio?) years, Global avg. temperature** ca. **+ 1,1° C** (rel. to 1880-1920 mean), esp. since last 50 years, **Sea level rise ca 3,2 mm/y**, considerably accelerated.
- **Anthropogenic NO_x SO_2, reactive phosphorus etc. by far higher than natural sources**
- **60-80% exhaustion / overfishing** world wide (FAO), Oceans as source and sink
- **Highly increased extinction rate** of animals and plants
- **Biomass of humans and its domestic animals** amounts to **90%** of biomass of all living mammals
- Mean **erosion rate 10-30x higher** than average of last 500 million years)
- **Annual production of plastic close to bulk weight of all living humans**
- **Technosphere: 30 trillion tons**

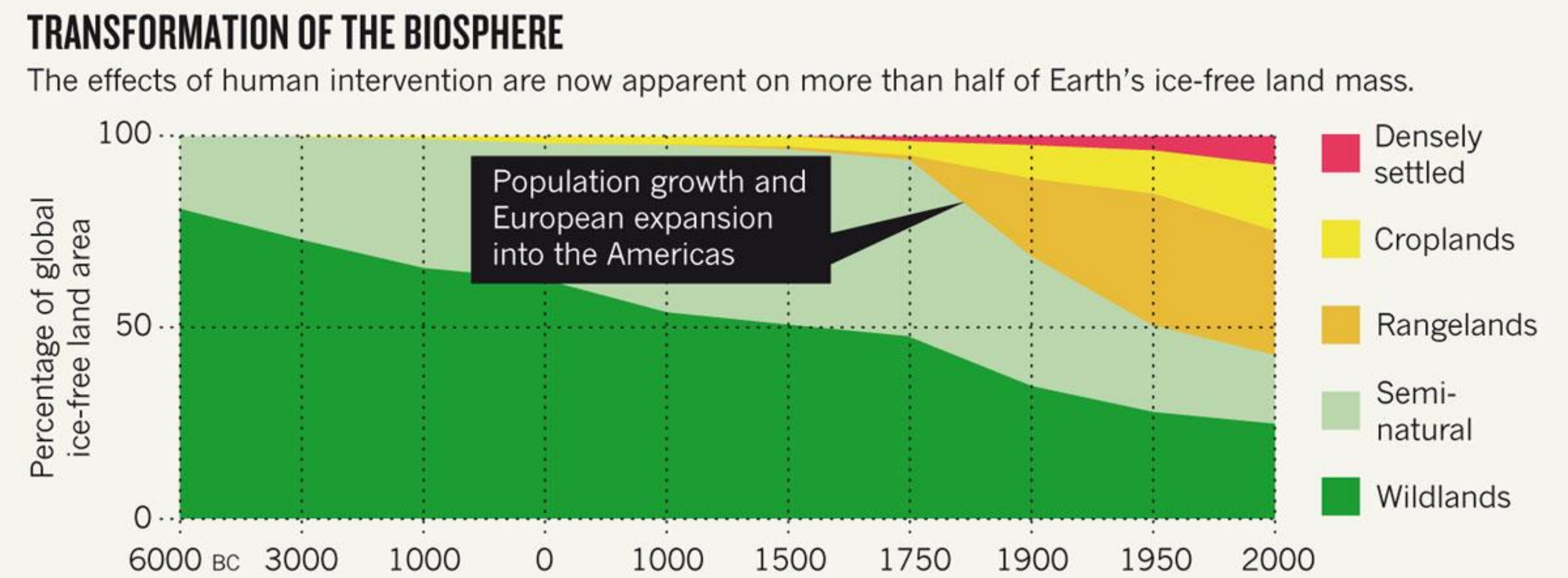




Imgs:
WBGU-Comic 2013

Earth system changes: quantities / land use

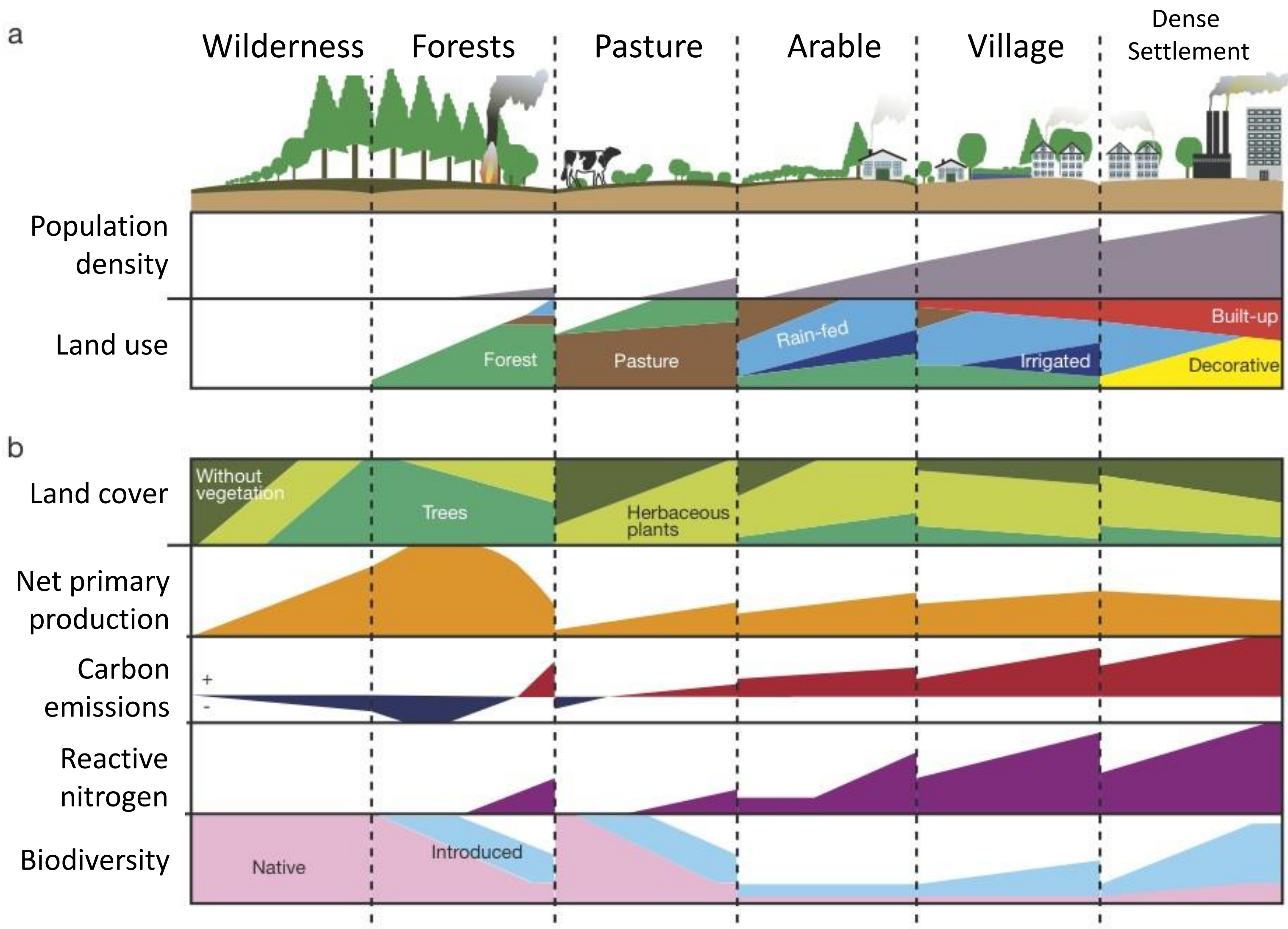
only 23% of land surface pristine nature
only 11% photosynth. primary production in pristine nature



Nature, 12 May 2011, after Ellis 2011

Earth system changes: quantities / land use

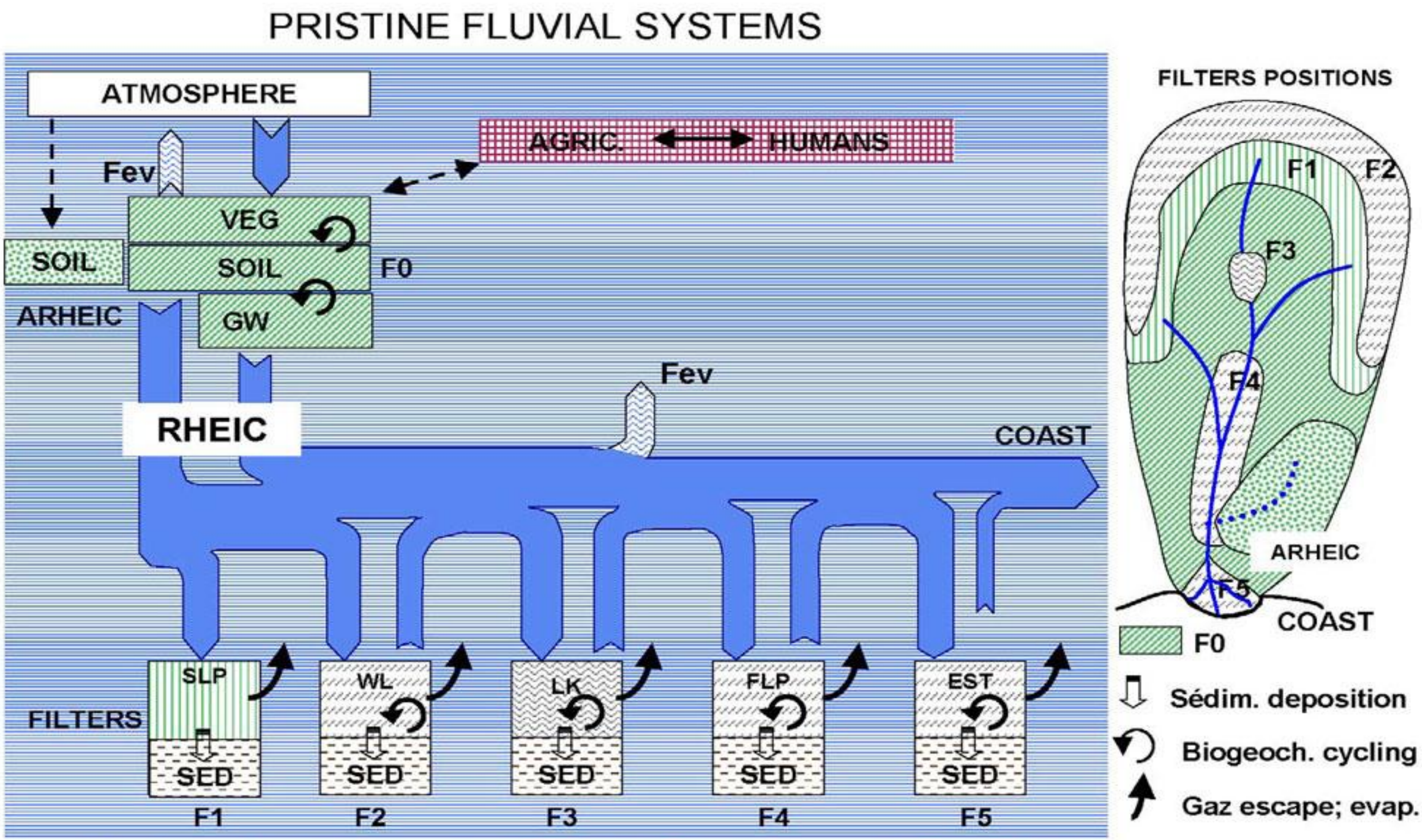
Anthromes instead of Biomes



Source: Ellis and Ramankutty, 2008, Ellis 2011

Earth system changes: quantities / freshwater management

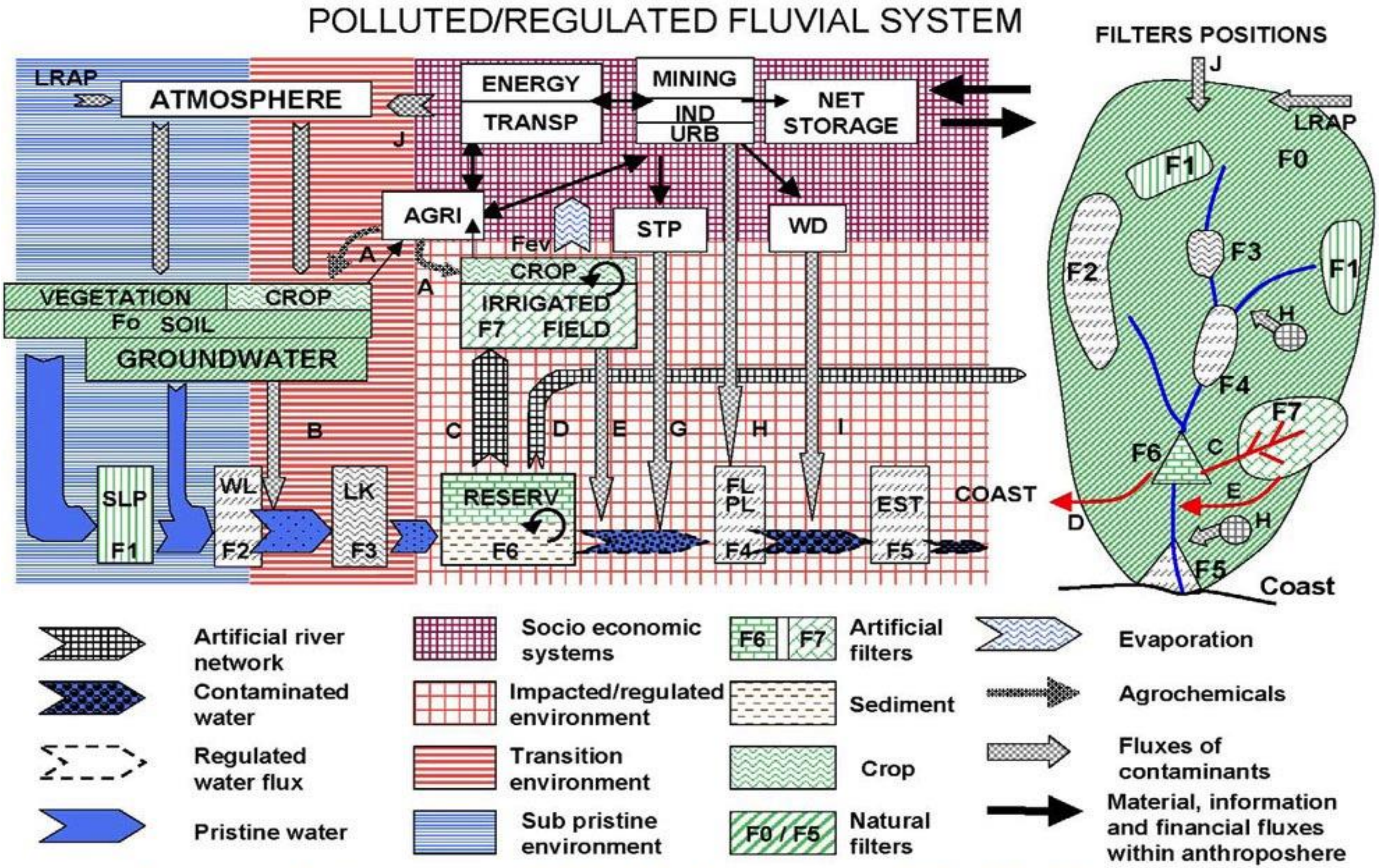
Holocene



aus: Meybeck & Vörösmarty 2005, CR Geoscience 337 107-123

Earth system changes: quantities / freshwater management

Anthropocene



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Earth system changes: quantities / freshwater management

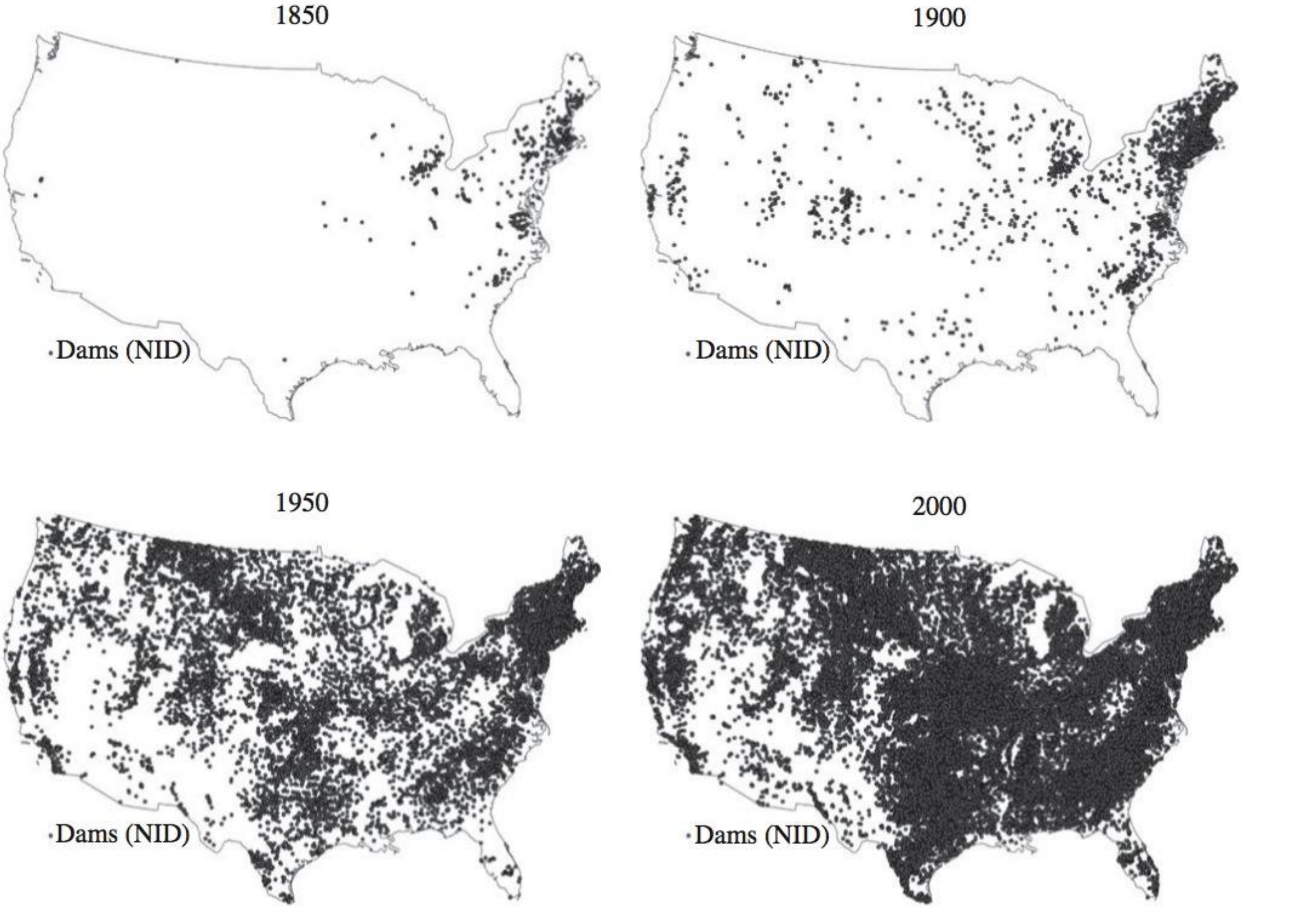
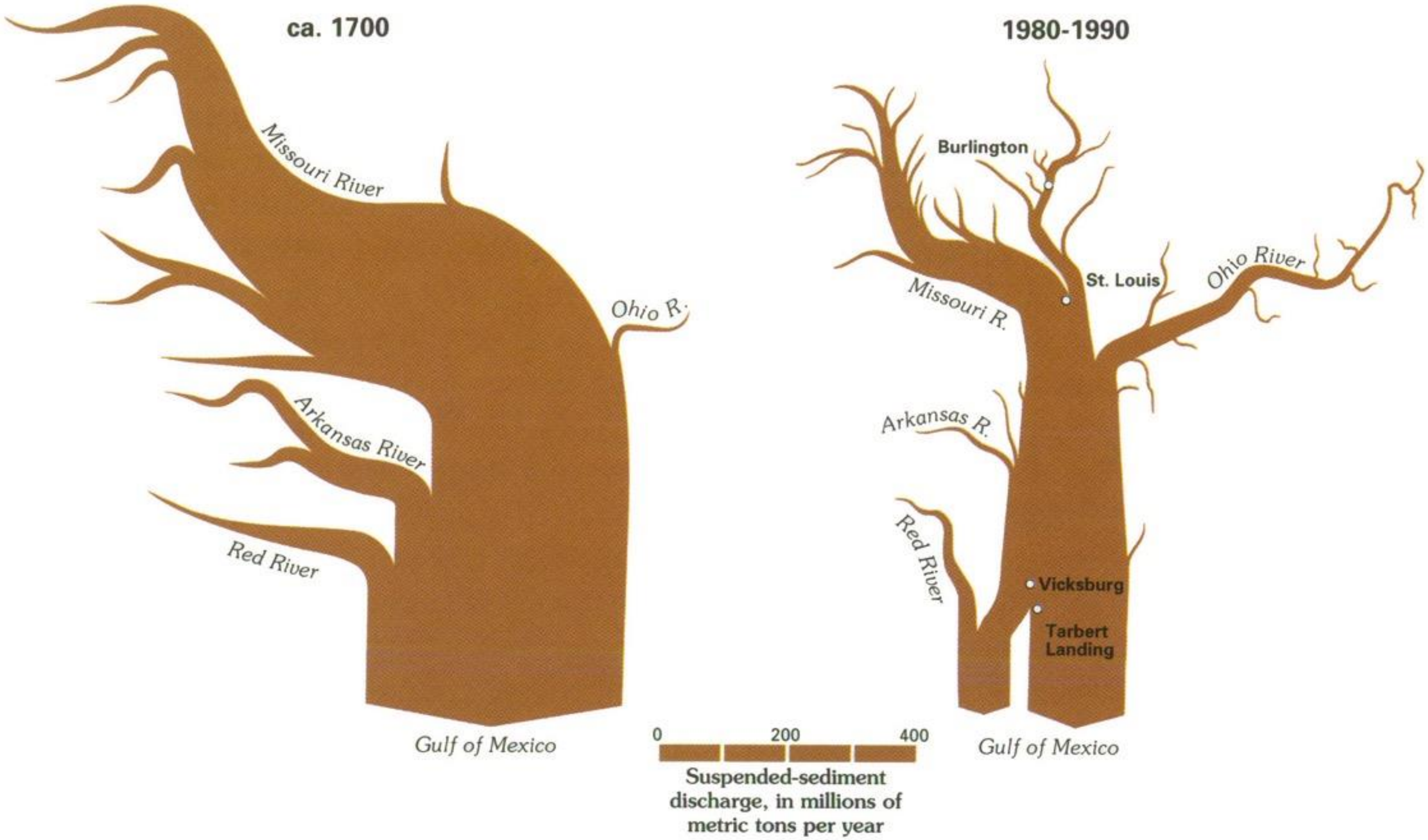


Figure 3. The growth of US dams and reservoirs as recorded in the National Inventory of Dams (NID). Four periods shown: 1850, 1900, 1950 and 2000. There were no dams in 1800.

Syvitski & Kettner 2011

Earth system changes: quantities / freshwater management

Sediments reaching the Mississippi River delta have declined significantly since 1700 due to dams and levees.



Earth system changes: quantities / freshwater management

Locally severely accelerated relative rise of sea level

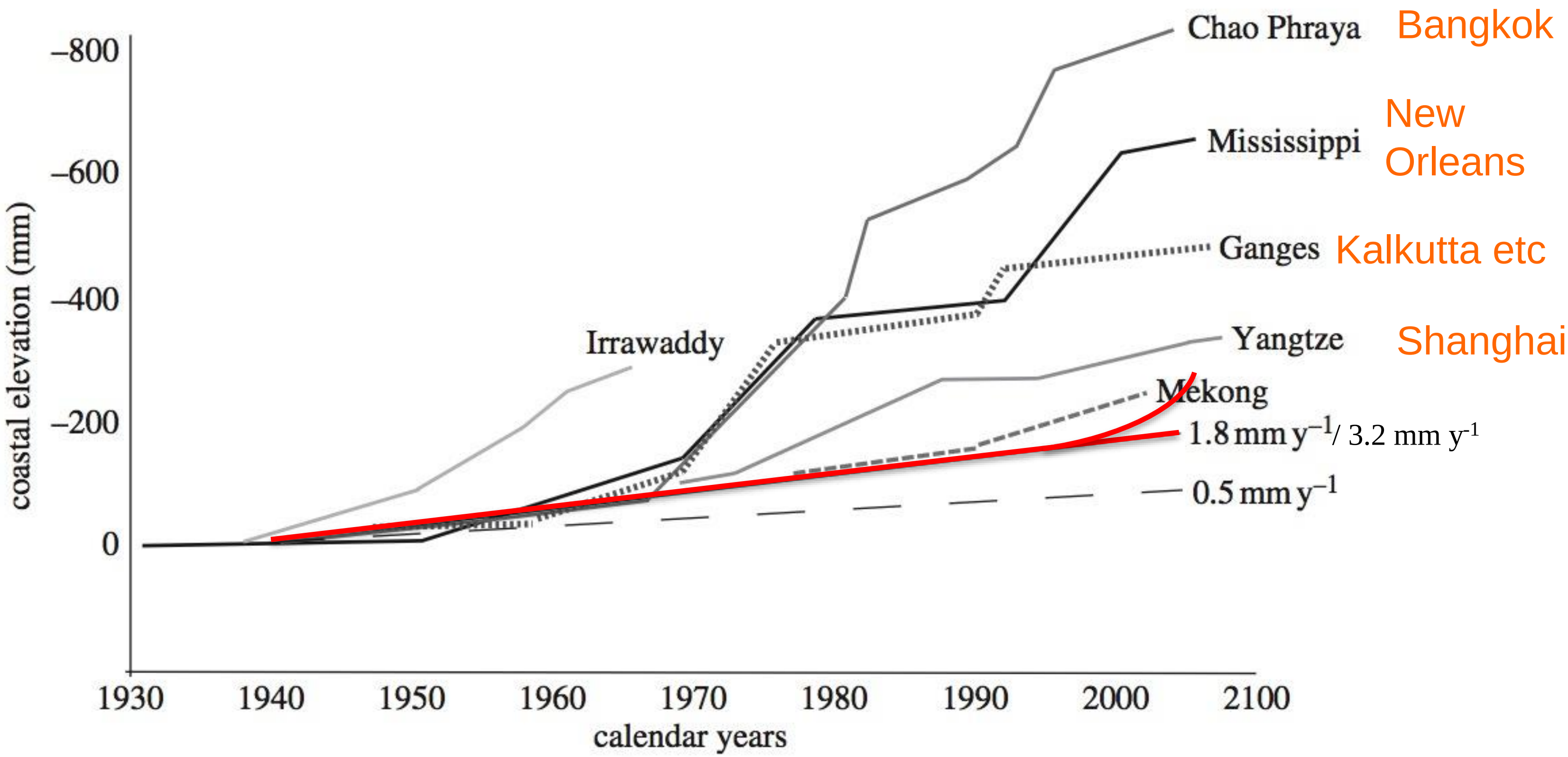
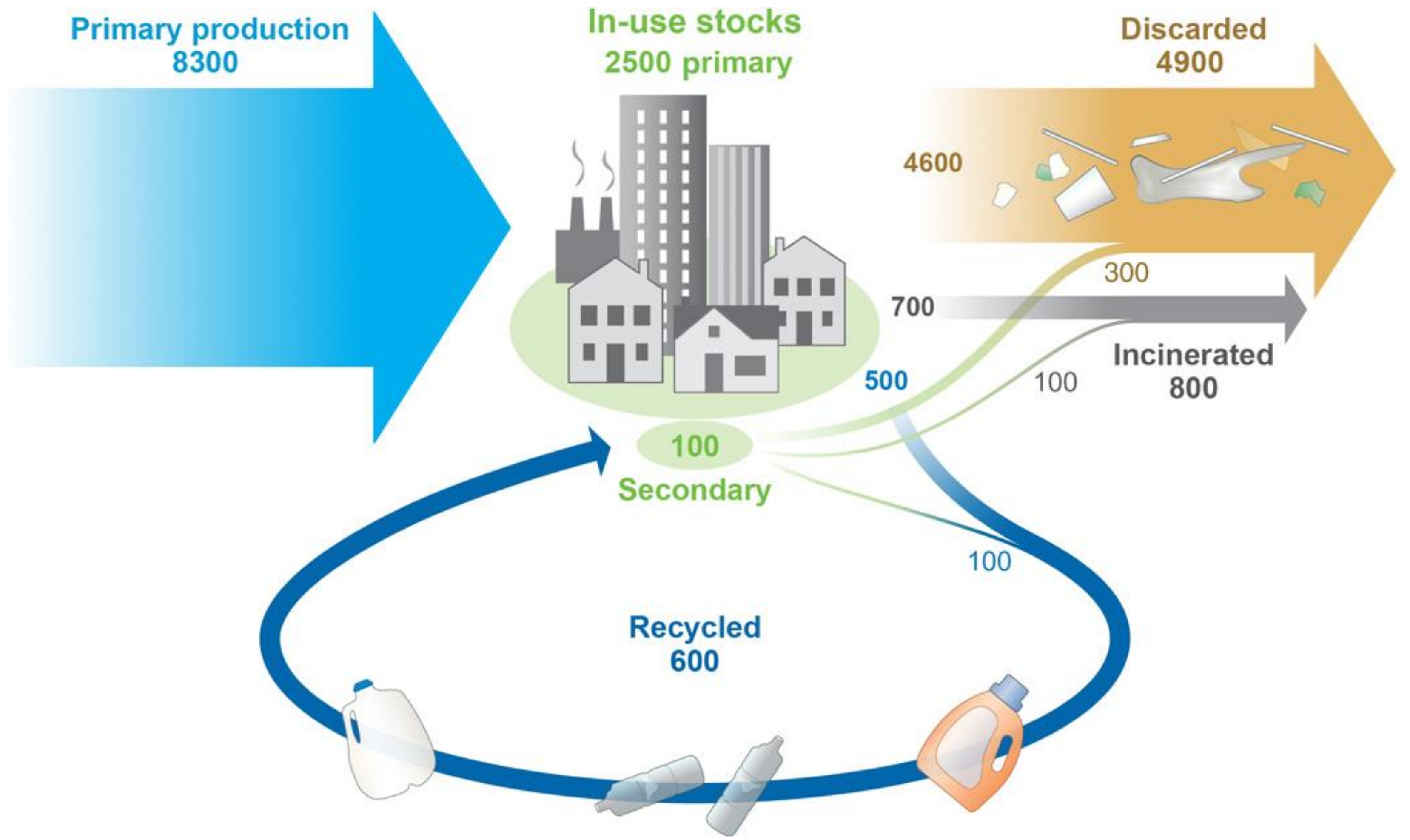


Figure 7. The relative rate of sea-level rise on selected deltas is many times faster than the ambient pre-Anthropocene sea-level rate of less than 0.5 mm yr^{-1} and the global warming eustatic sea-level rise of 1.8 mm yr^{-1}. Deltaic subsidence relates to natural and accelerated compaction, greatly reduced aggradation and the weight of the sediment load of the delta (isostasy).

Syvitski & Kettner 2011

Earth system changes: quantities / plastics

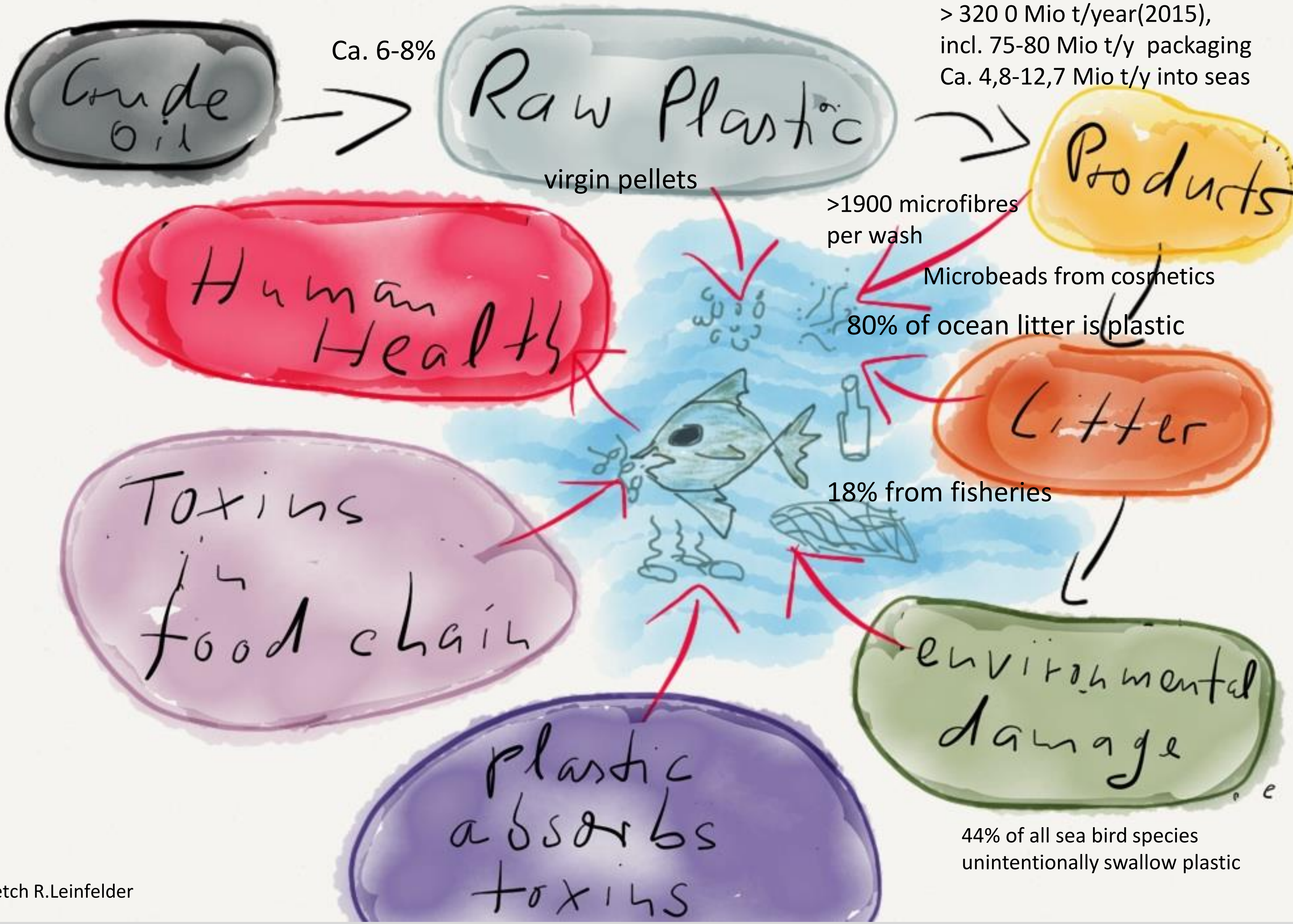
Global production, use, and fate of polymer resins, synthetic fibers, and additives (1950 to 2015; in million metric tons).



Roland Geyer et al. Sci Adv 2017;3:e1700782
Published 19 Jul 2017

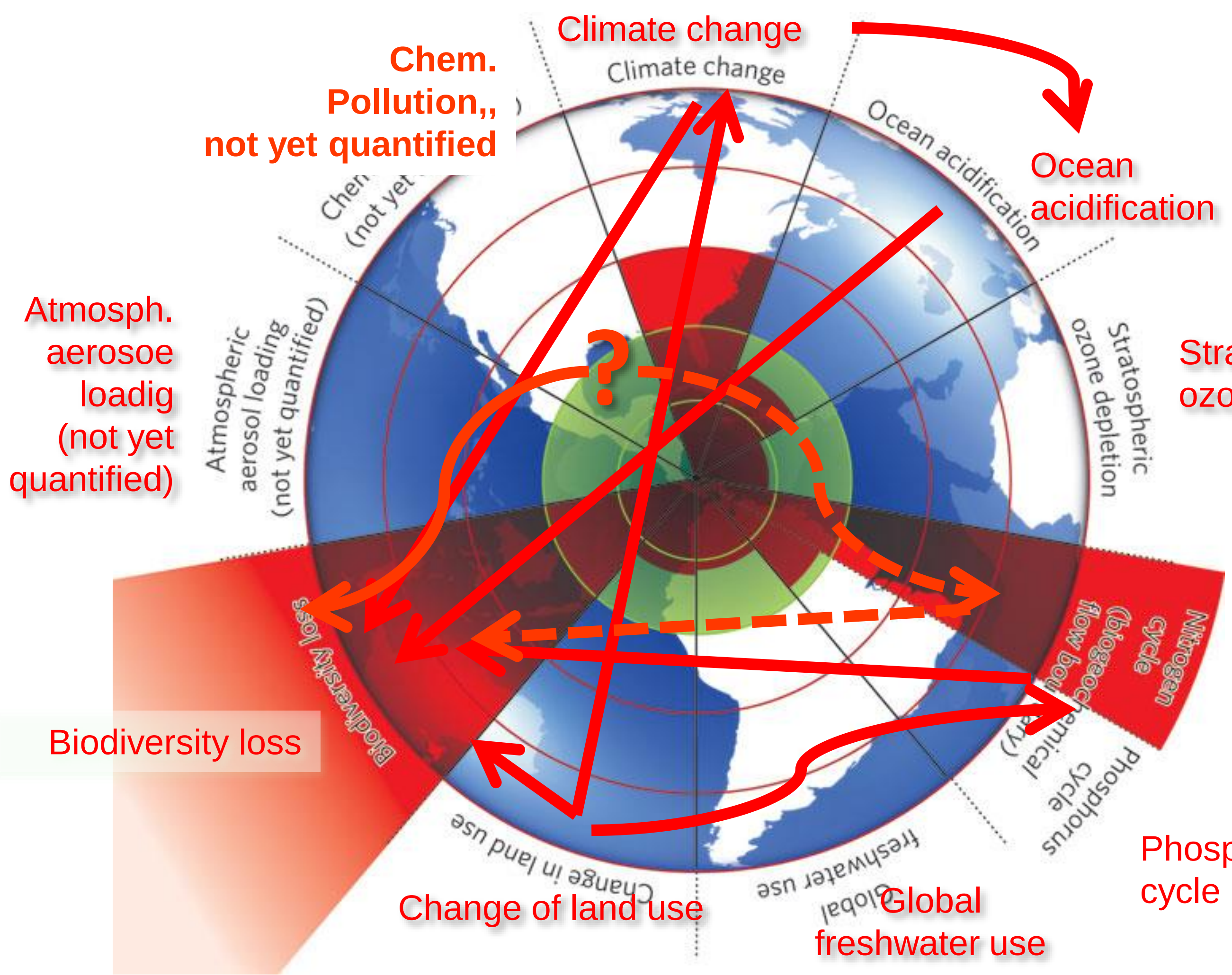
Published by AAAS

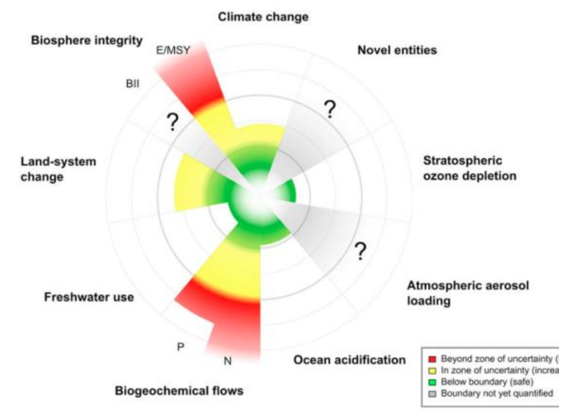
Earth system changes: quantities / plastics



Sketch R.Leinfelder

Earth System Changes: Interdependencies and feedbacks

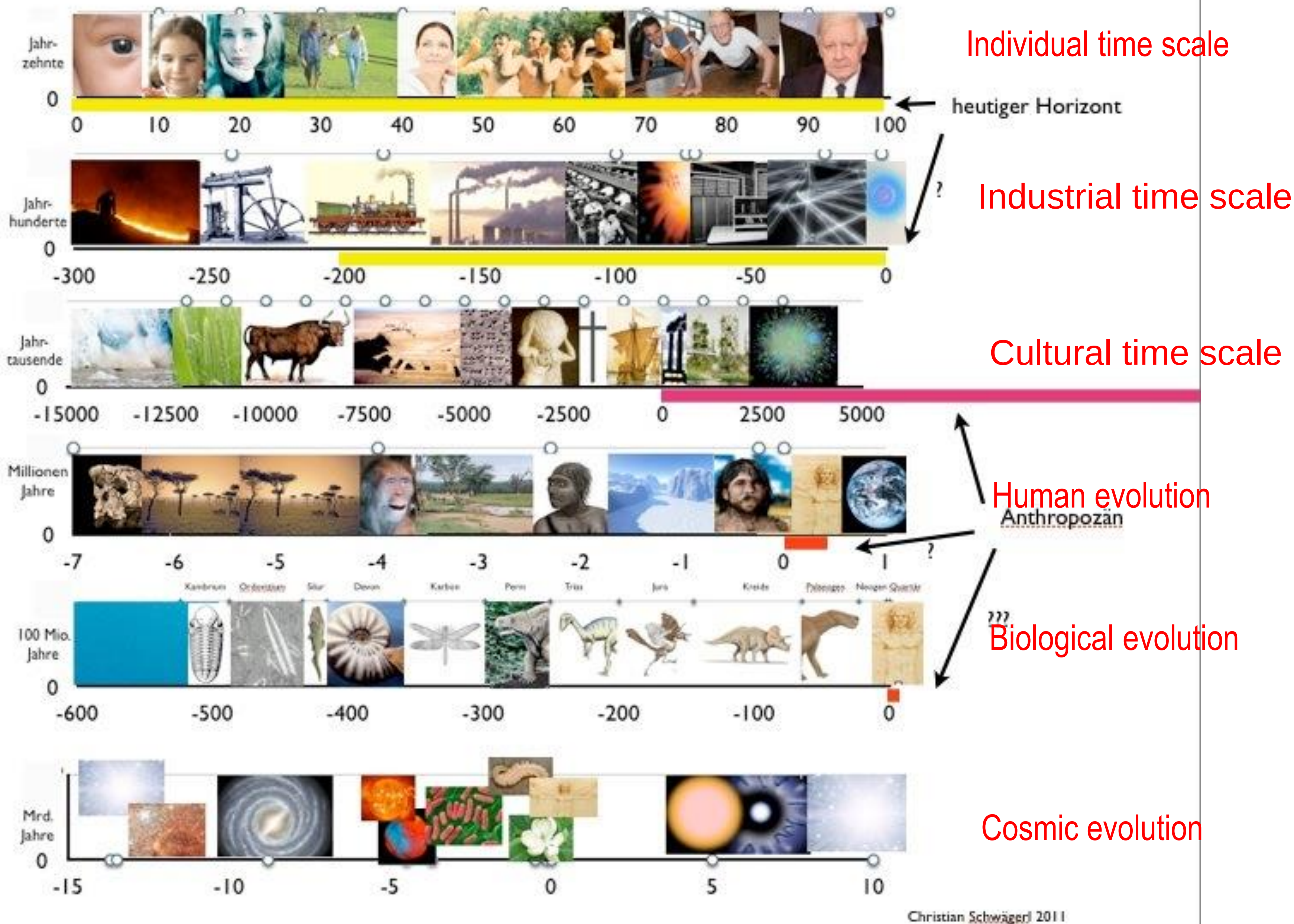




Steffen et al. 2015

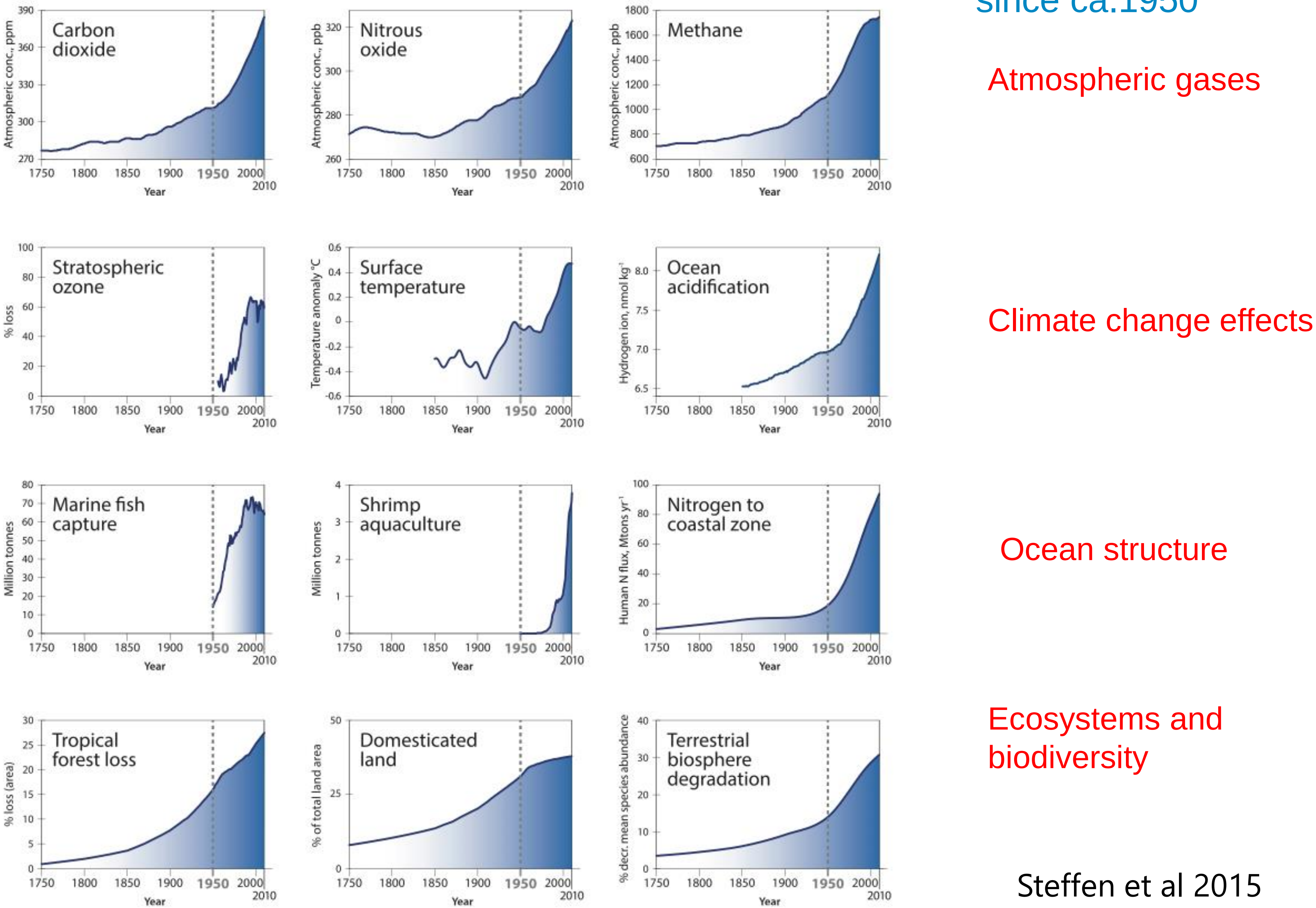
Source: Rockström et al., Nature, 24. Sept. 2009

Earth system changes: temporal dynamics



Earth system changes: temporal dynamics

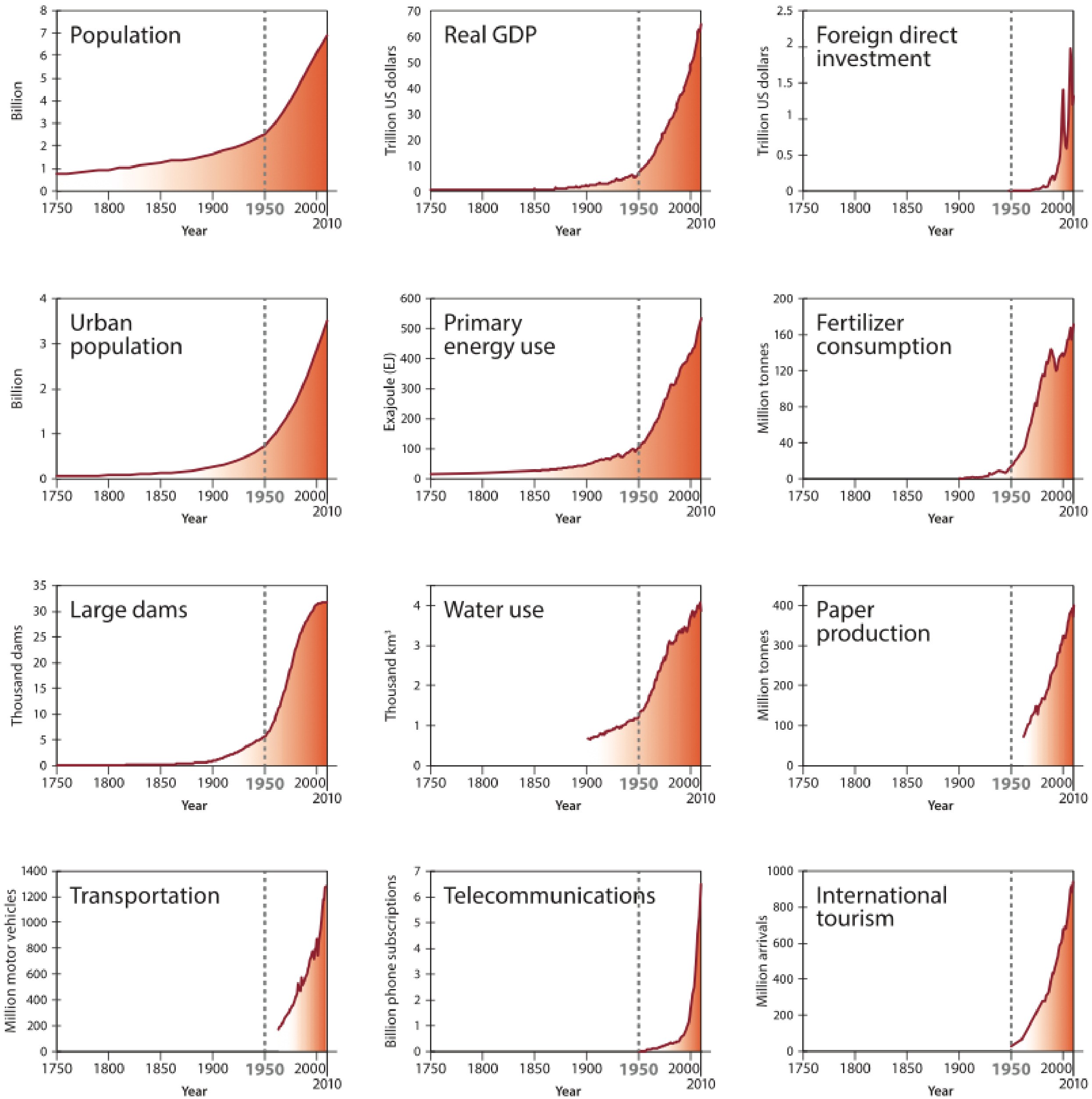
The Great Acceleration; since ca.1950



Steffen et al 2015

Earth system changes: temporal dynamics

The Great Acceleration; since ca.1950



Population and economy

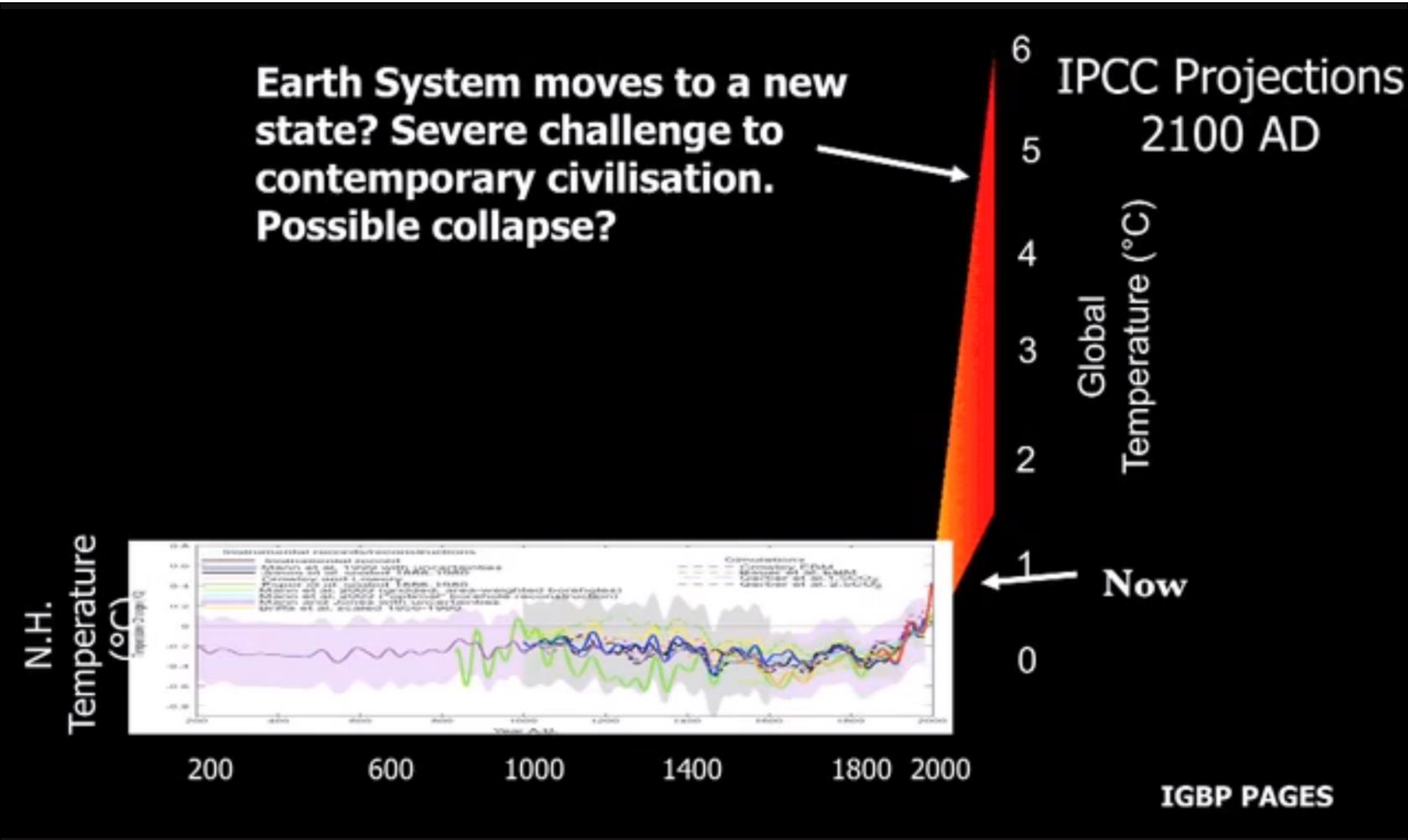
Cities, Energy, Fertilizers

Land and water use

Infrastructures, communication, tourism

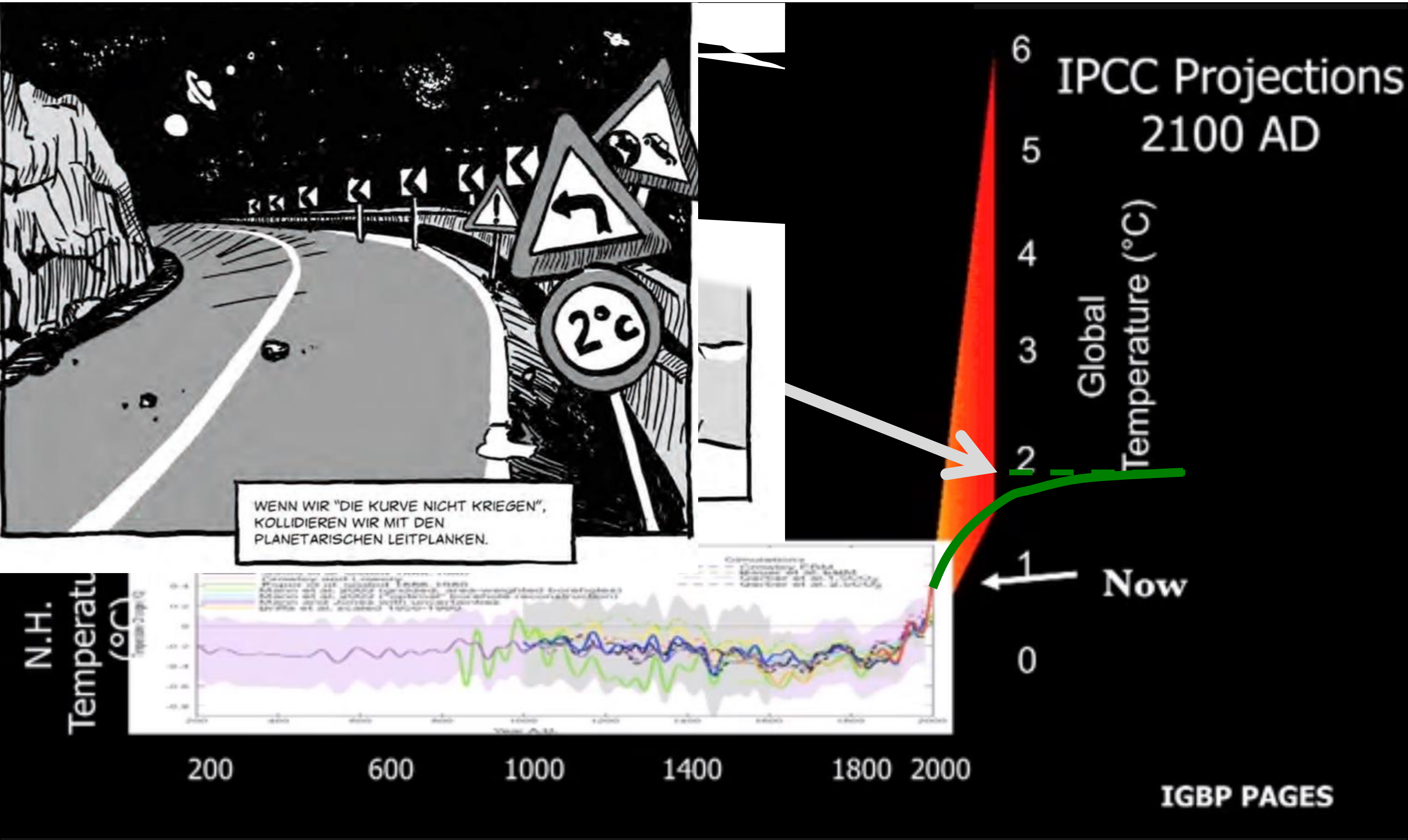
Steffen et al 2015

Earth system changes: temporal dynamics



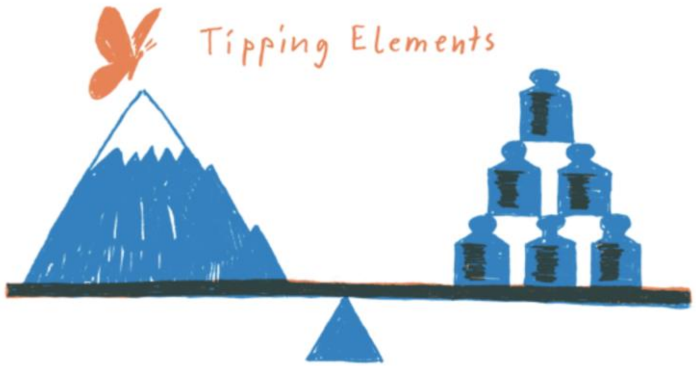
Slide court. Will Steffen

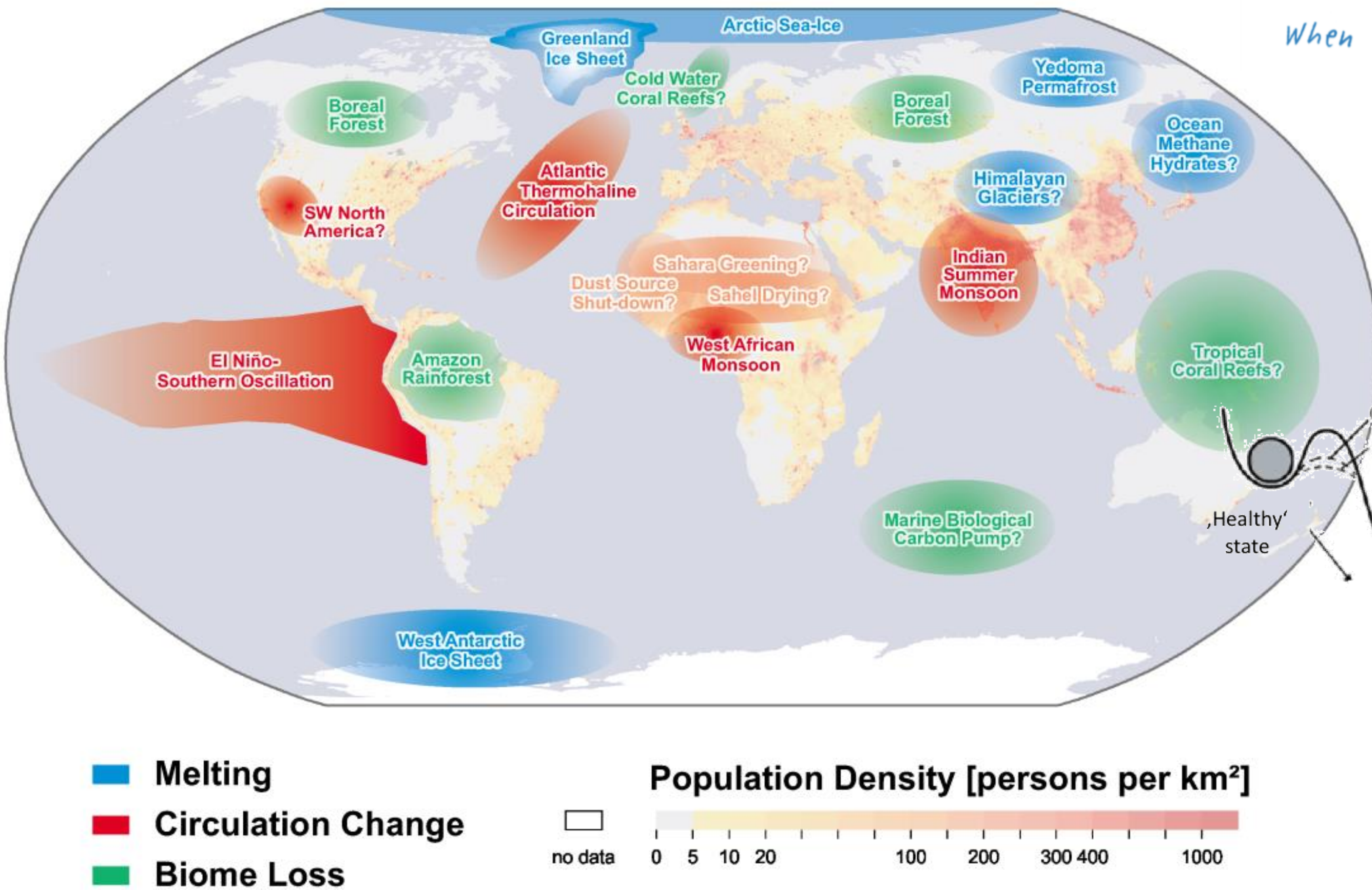
Earth system changes: temporal dynamics

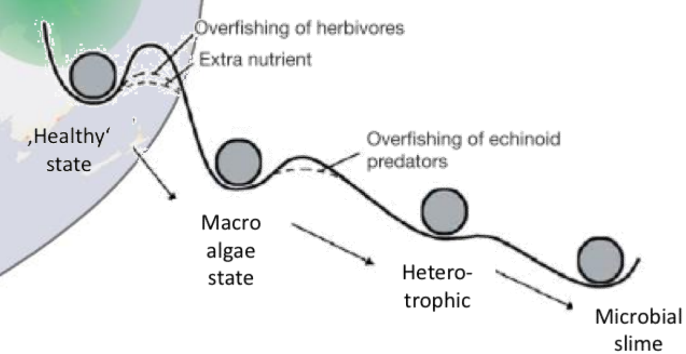


Slide court. Will Steffen

Earth system changes: temporal dynamics

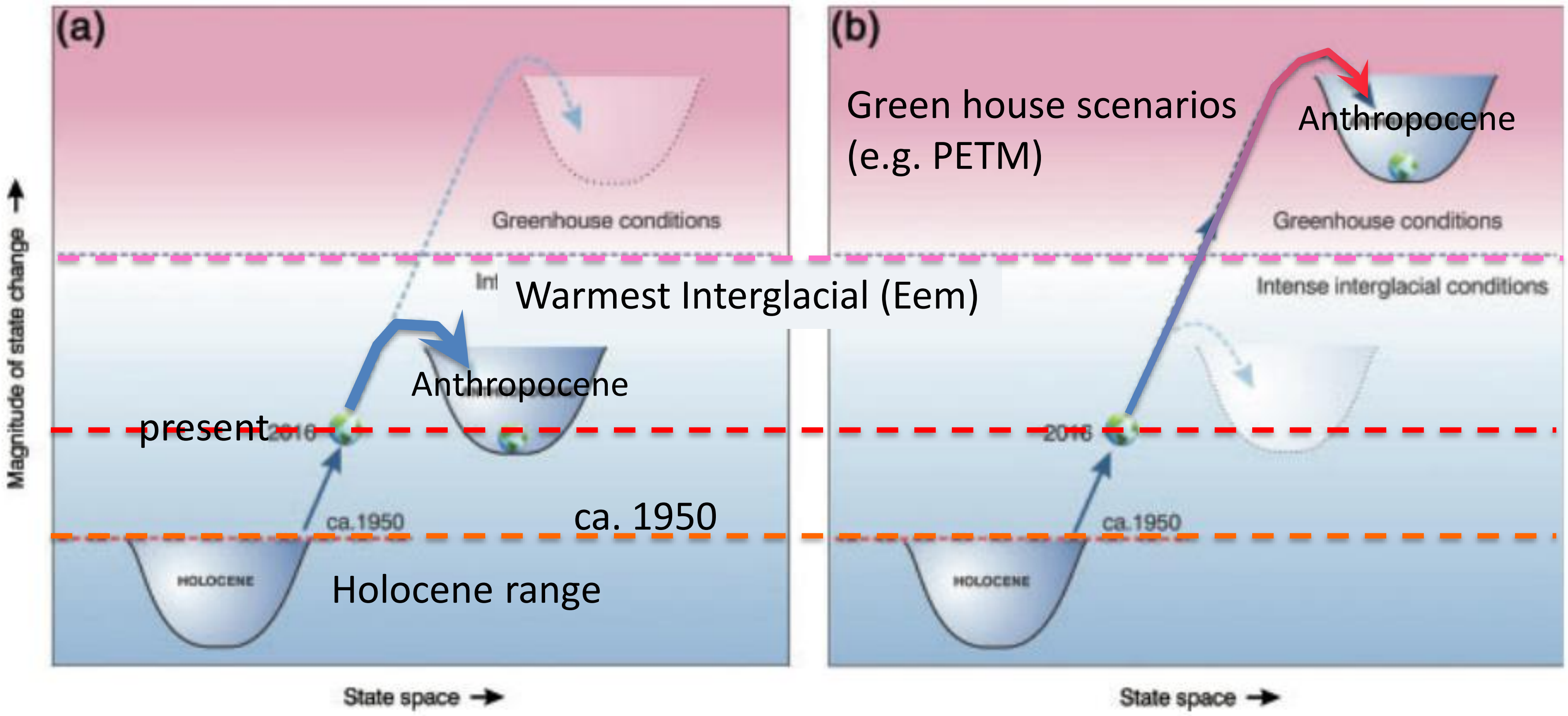






Earth system changes: temporal dynamics

The Big Question:
will the future be within or outside the Quaternary range?



From Steffen, Leinfelder et al. 2016

The Anthropocene Concept

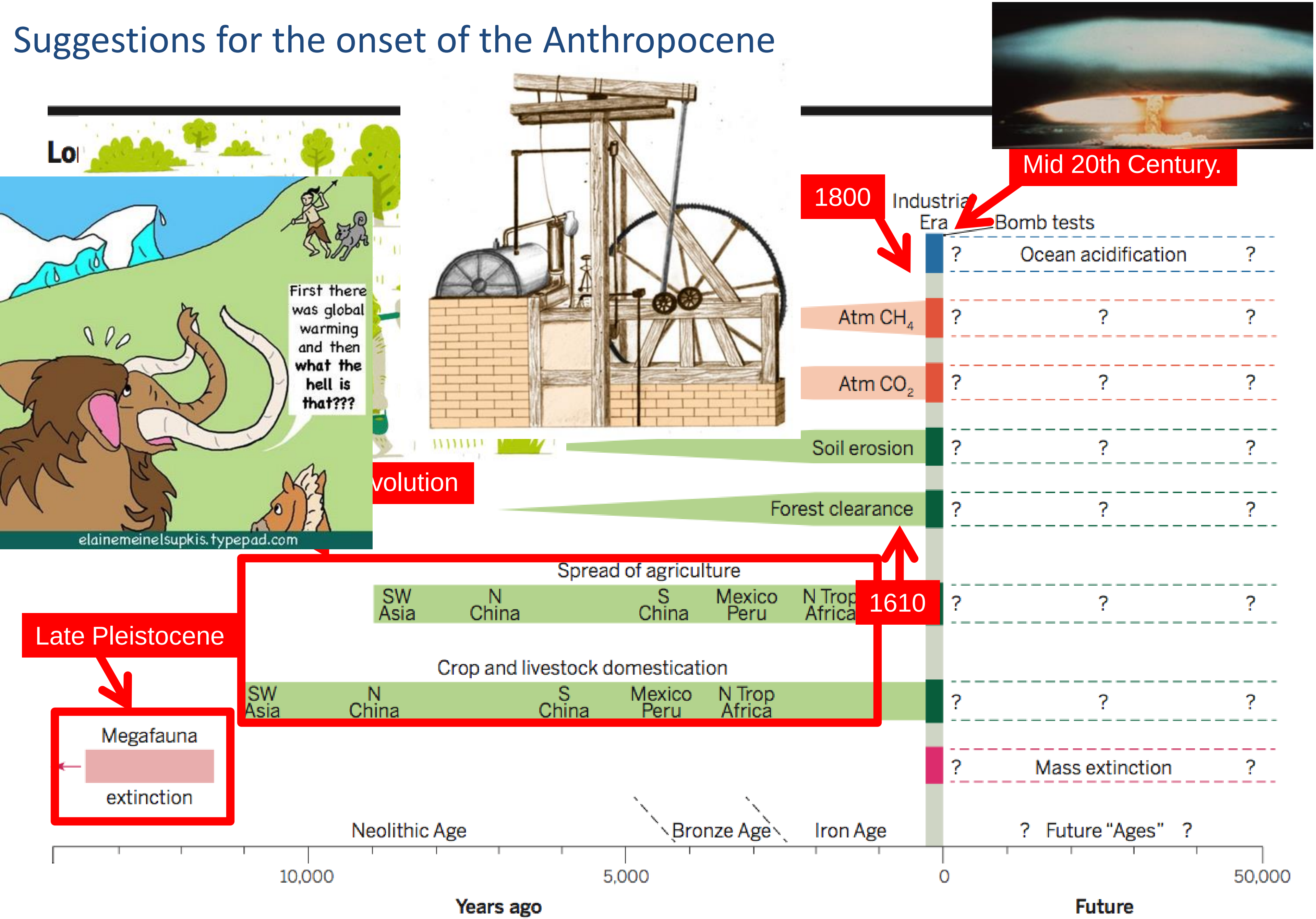
Level:
Earth System:
Human influence on all natural spheres, creation of a neonature, etc.

→

Level:
Geology/Stratigraphy
Origin of the technosphere; globally distributed technofossils and geosignals, non-natural sedimentary processes
-> Manifestation in Earth history

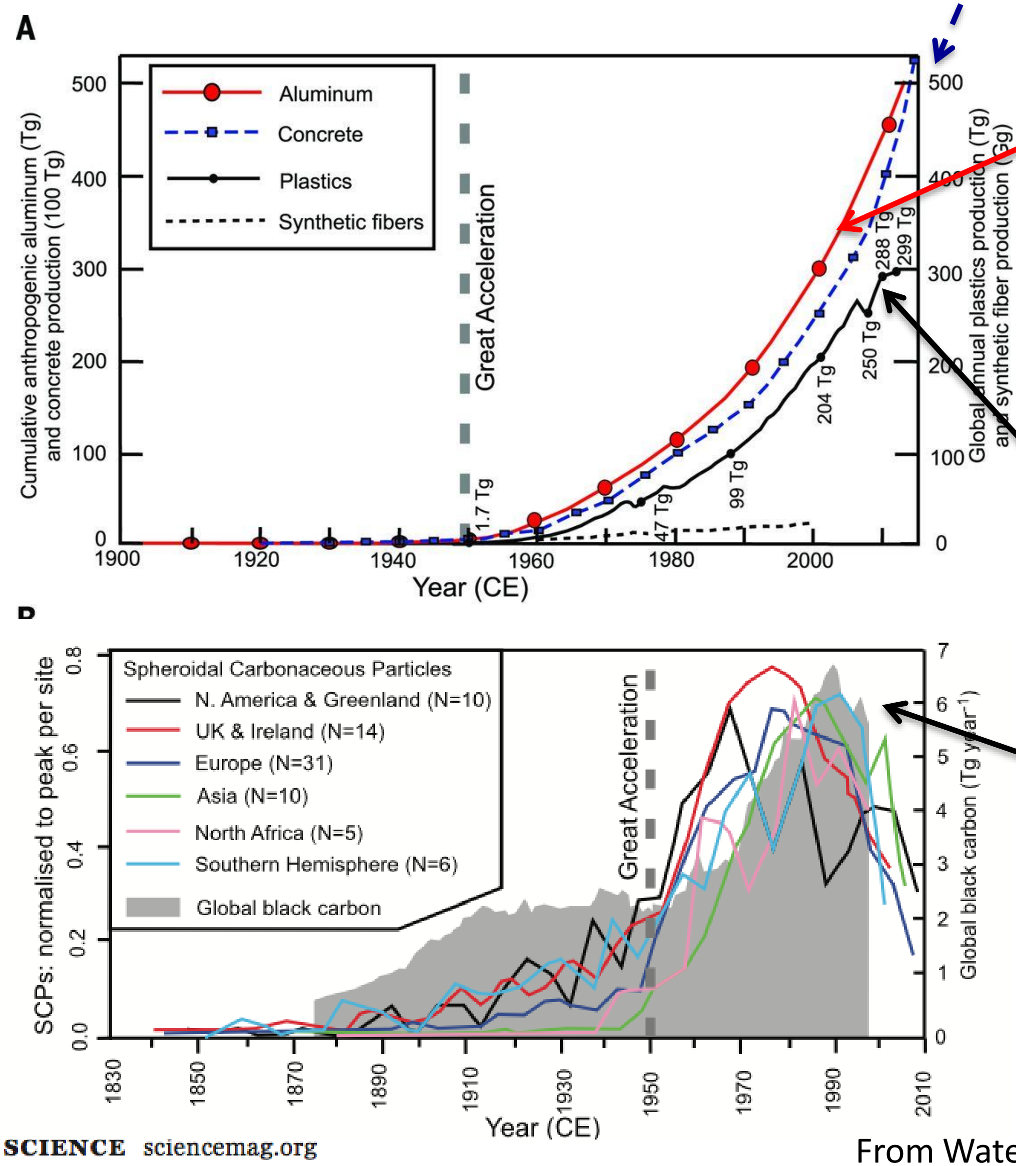
From Leinfelder 2017 … Phosphorus…., translated

Suggestions for the onset of the Anthropocene



From Ruddiman et al. 2015, Science

Geological Signatures



Concrete:

- Invented by romans
- 50% produced since 1995
- ca.1 kg concrete per m^2 of earth surface

Elementary aluminium:

- Al most frequent metal in nature, but not in elementary form
- elementary since19. Jhd.
- 98% since 1950

Plastics esp. since WorldWar II and thereafter

Industrial fly ash, POPs, pesticides, „spice metals“, Rare Earths, etc,

+ radioactive fallout (1950/60ies)

+ atmospheric anomalies

From Waters et al. 2016

Geological Signatures

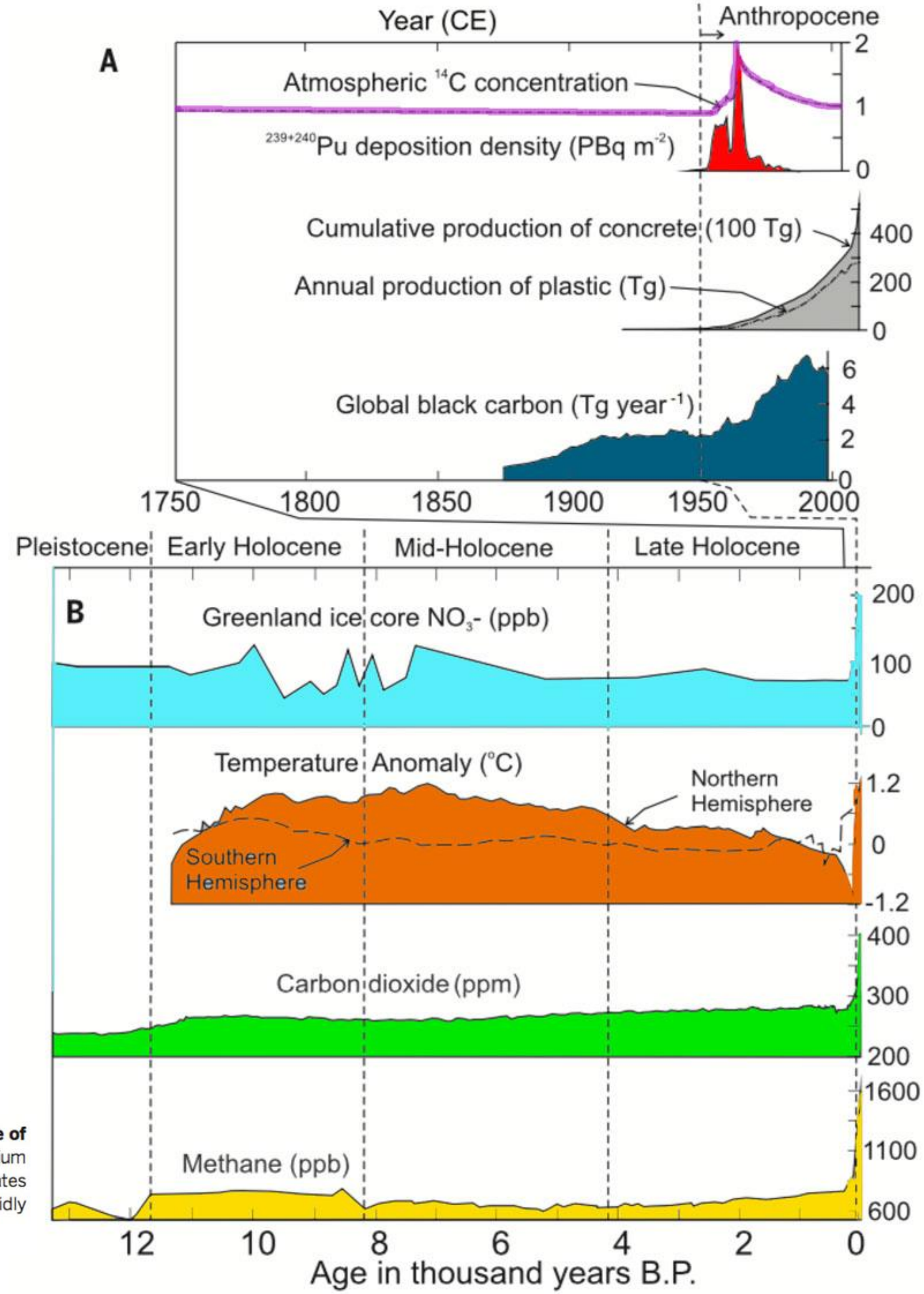
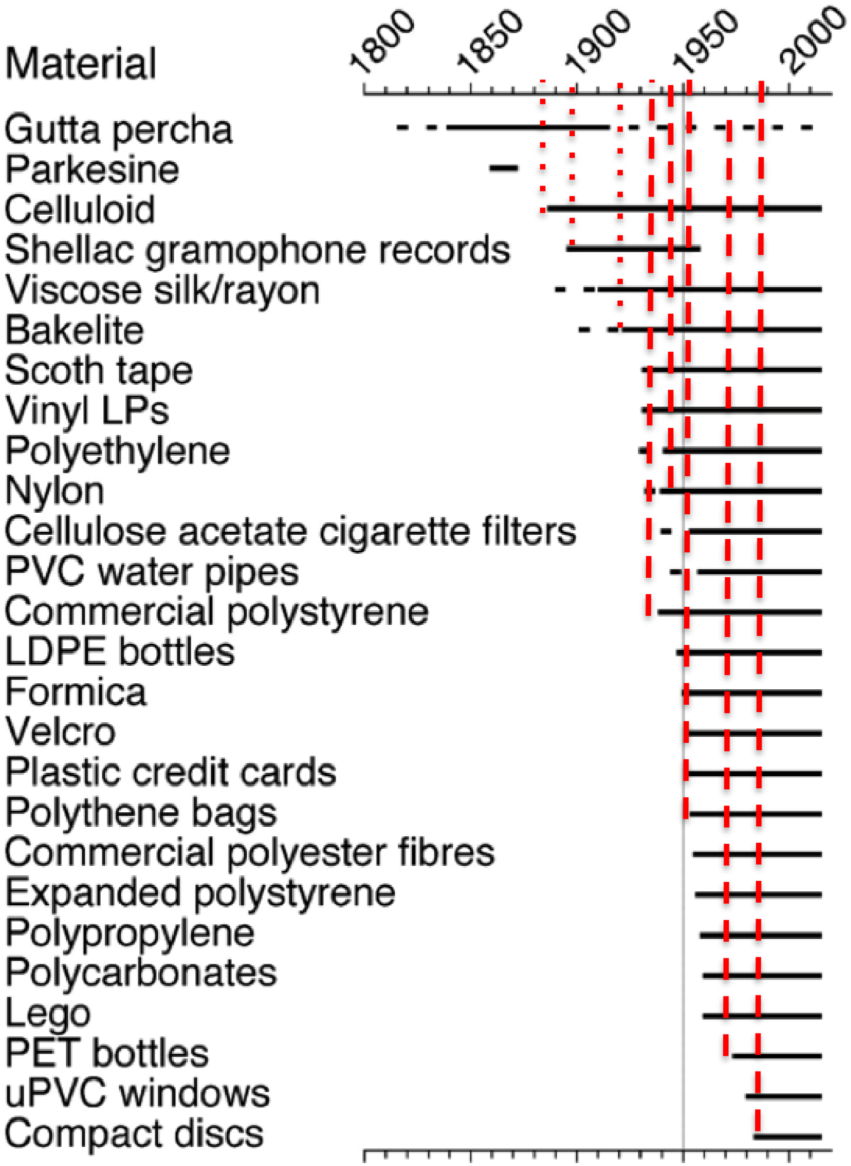


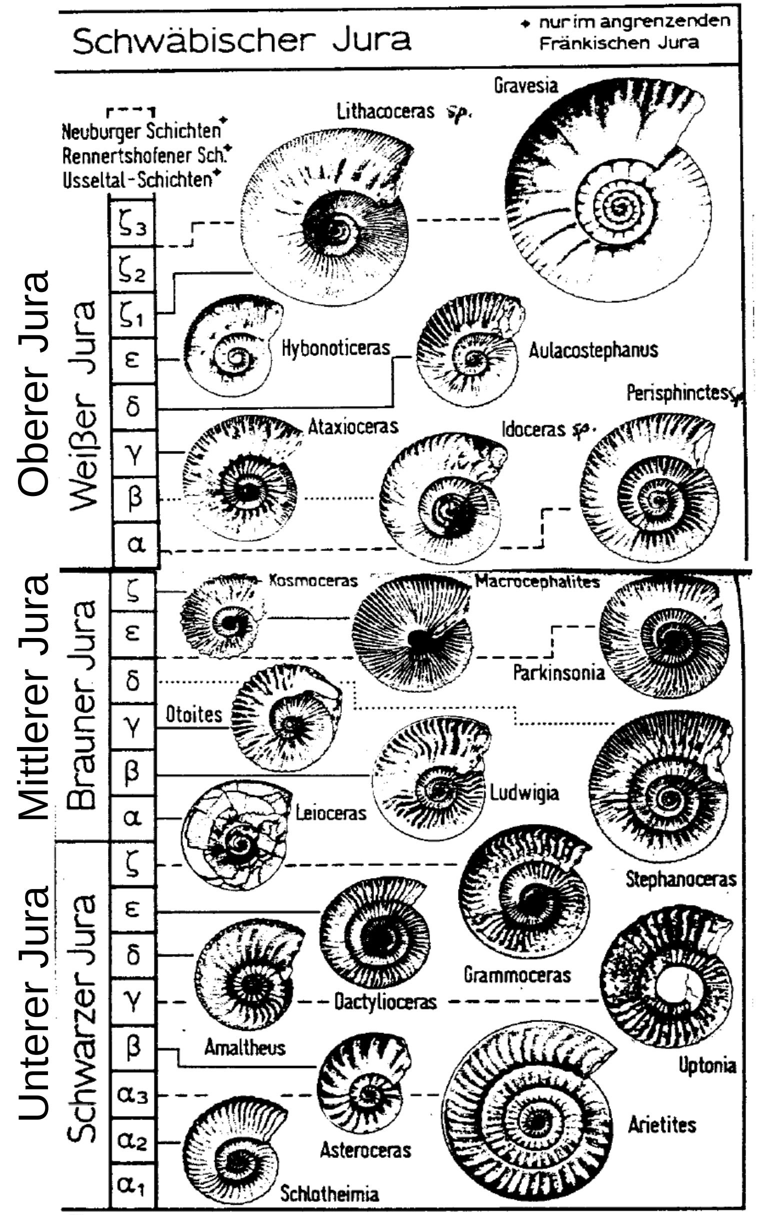
Fig. 1. Summary of the magnitude of key markers of anthropogenic change that are indicative of the Anthropocene. (**A**) Novel markers, such as concrete, plastics, global black carbon, and plutonium (Pu) fallout, shown with radiocarbon (^{14}C) concentration. (**B**) Long-ranging signals such as nitrates (NO_3^-), CO_2, CH_4, and global temperatures, which remain at relatively low values before 1950, rapidly rise during the mid-20th century and, by the late 20th century, exceed Holocene ranges.

From Waters et al. 2016

Microstratigraphy with Plastics?



Zalasiewicz et al. 2016



Technosphere 30 trillion tons ($3x10^{13}$ t)

Table 1. Approximate mass of the major components of the physical technosphere, arranged in order of descending mass (where 1 Tt = 10^{12} metric tonnes).

Component	Area (10^6 km^2)	Thickness (cm)	Density (g/cm^3)	Mass (Tt)	Percent (%)
Urban areas	3.70	200	1.50	11.10	36.9
Rural housing	4.20	100	1.50	6.30	20.9
Pasture	33.50	10	1.50	5.03	16.7
Cropland	16.70	15	1.50	3.76	12.5
Trawled sea floor	15.00	10	1.50	2.25	7.5
Land use and eroded soil	5.30	10	1.50	0.80	2.7
Rural roads	0.50	50	1.50	0.38	1.3
Plantation forest	2.70	10	1.00	0.27	0.9
Reservoirs	0.20	100	1.00	0.20	0.7
Railways	0.03	50	1.50	0.02	0.1
Totals (where applicable)	81.83			30.11	

Cities: 2,5% of land surface, nearly 40 % of technosphere: 11,1 Tt

4000 t /living human, or 60 kg/m^2 (land and sea), or 180 kg/m^2 (only land)
(mean: surface per person: whole Earth: 48 456 m^2 / living human ; ca 7 football fields)

from: Jan Zalasiewicz, Mark Williams, Colin N Waters, Anthony D Barnosky, John Palmesino, Ann-Sofi Rönnskog, Matt Edgeworth, Cath Neal, Alejandro Cearreta, Erle C Ellis, Jacques Grinevald, Peter Haff, Juliana A Ivar do Sul, Catherine Jeandel, Reinhold Leinfelder, John R McNeill, Eric Odada, Naomi Oreskes, Simon James Price, Andrew Revkin, Will Steffen, Colin Summerhayes, Davor Vidas, Scott Wing, Alexander P Wolfe (2016, online first): **Scale and diversity of the physical technosphere: A geological perspective.**- The Anthropocene Review, doi:10.1177/2053019616677743

Illustration by Henning Wagenbreth, UdK Berlin

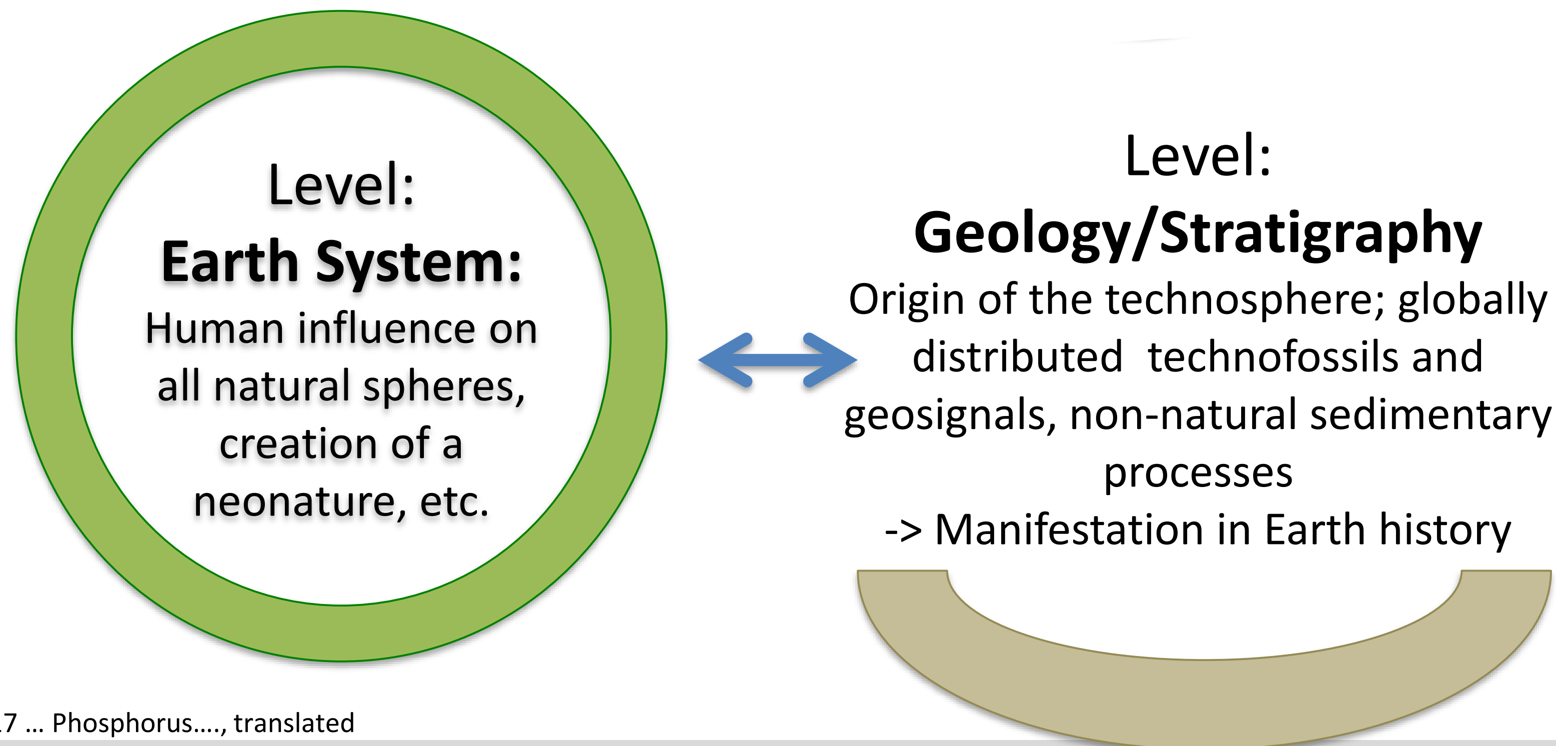
From: https://tinyurl.com/anthropocene-milestones

Mid 20th-century GSSP-possibilities

Environment \ Marker	Black Carbon	Fly ash	Lead	PCBs	Pesticides (DDT)	NO_3^-	$\delta^{15}N$	Sulphur	SO_4^{2-}	CO_2	CH_4	$\delta^{13}C$	$\delta^{18}O$	D &/or dust	^{239}Pu	^{14}C
Marine anoxic basins (1)	?	?	1965 (1970s)	1945 (1967)	1952 (1967)	?	x	x	x	x	x	?	?	x	1950-54 (1970s)	?
Coral bioherms & marine bivalves (2) (3)	?	?	Late 1940s (1970s) (2)	?	x	~1970 (3)	~1950 (3)	x	x	x	x	1955 (2)	~1950 (2)	x	1952 (1964) (2)	1958 (1972) (3)
Estuaries/ Deltas (4) (5)	?	1900s (5)	(1915) (4)	1950s (1965-1977) (4)	?	?	x	x	x	x	x	?	?	x	?	?
Lakes (6) (7) (8) (9) (10)	1940s-1950s (2004-6) (8)	~1950 (1970-1990)	1960s (Post-2000) (8)	~1960 (9)	1950s (9)	?	~1950 (7)	~1950 (10)	x	x	x	?	?	x	~1955 (1964) (6)	?
Peat & peat-lands (11) (12)	x	1950s (1970s) (11)	1810 (1979) (12)	(1960-1976) (12)	x	x	x	x	x	x	x	?	x	x	x	x
Ice (13) (14)	~1880 (~1910) (14)	?	~1940 (~1970) (14)	?	?	~1950 (14)	~1950 (1980) (14)	~1940 (~1970) (14)	~1940 (14)	~1950 (13)	~1950 (13)	1955 (13)	1980s (2010) (14)	~1850 (13)	1953 (1962) (13)	1954 (1966) (13)
Speleothems (15)	x	x	?	?	?	?	?	1980 (2000)	1880 (15)	x	x	~1840 (1860)	1875 (1940)	x	x	~1965 (~1975)
Trees (16) (17) (18)	x	x	?	?	?	?	1945 (18)	1960s (15)	?	x	x	1940 (1750) (16)	?	1960	?	1956 (1964) (17)

From Waters et al. 2018, *also see EGU 2018 Vienna, Session SSP2.1, 13th Apr, 13:30*

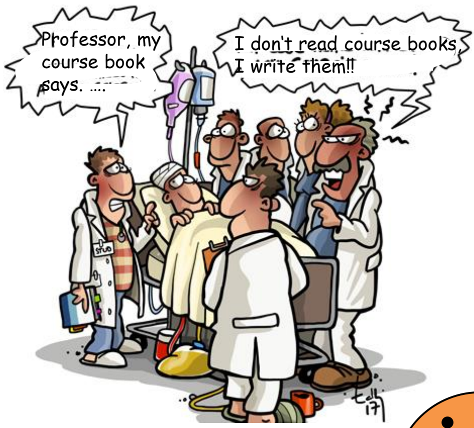
The Anthropocene Concept

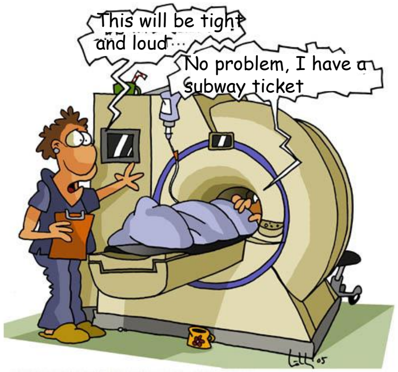


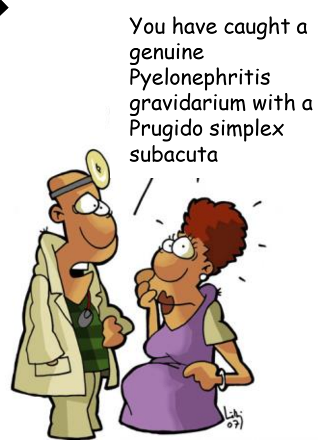
From Leinfelder 2017 … Phosphorus…., translated

The Physician Metaphor for the Earth System in the Anthropocene

Good knowledge of the body system → Full-fledged medical analysis → Diagnosis





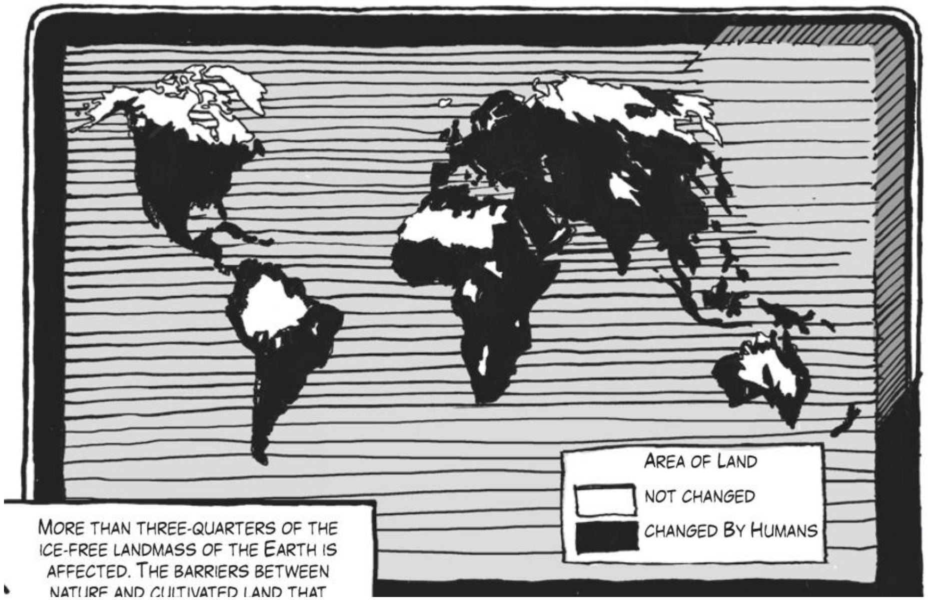


- **Explaining** the diagnosis
- **Suggesting** further action
- **Treatment and care** via general physician, or if needed:
- Medical **referral to specialists**
- **Accompanying, surveying, assessing and communicating** the entire treatment/care process
- **Advising** life style changes

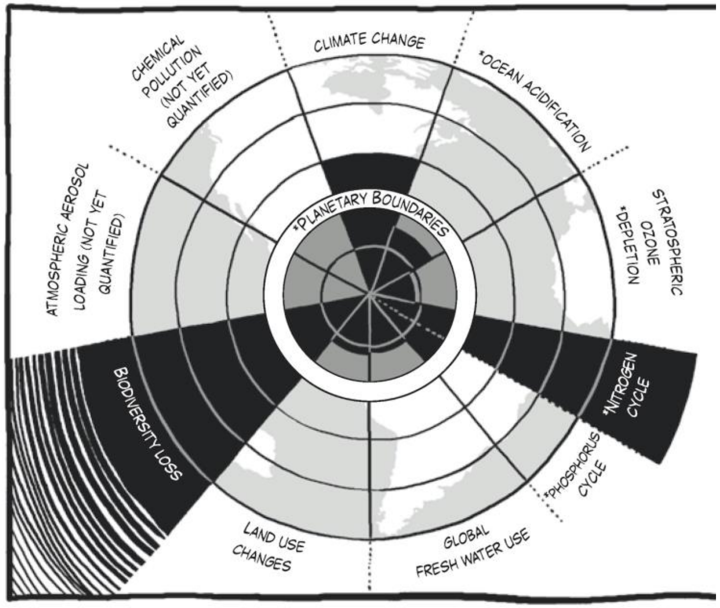
Cartoons from medi-learn.de

Challenges for Education

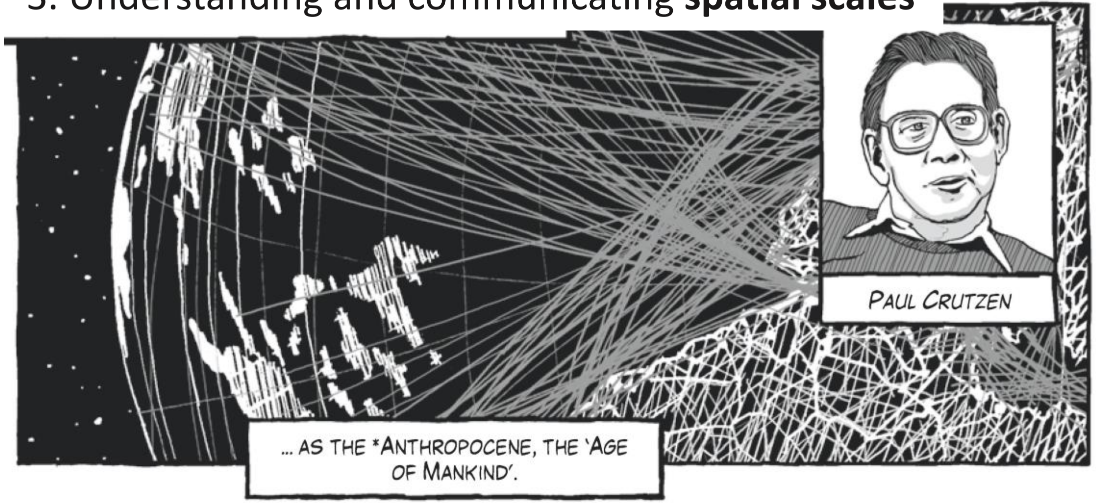
1. Understanding and communicating **quantities**



2. Understanding and communicating **complexities**



3. Understanding and communicating **spatial scales**

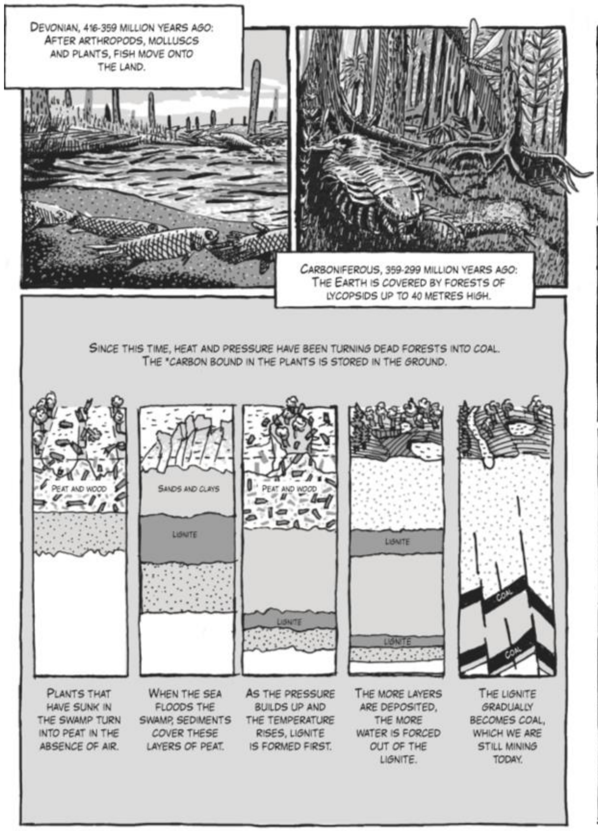


Figs. from Hamann, Zea-Schmidt, Leinfelder 2014

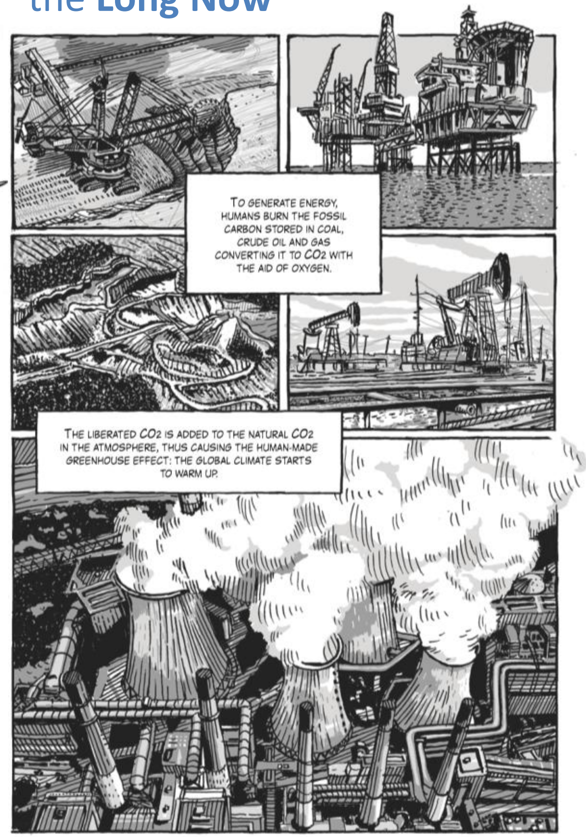
Challenges for Education

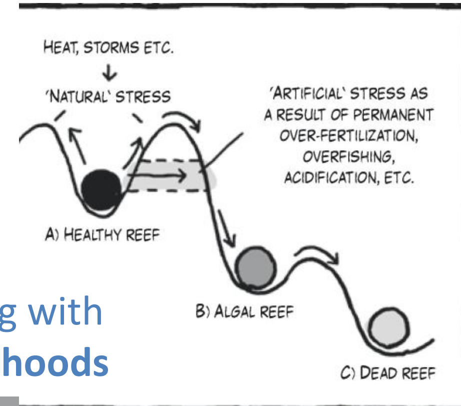
4. Understanding and communicating **temporal scales**

Living with deep **Earth history**



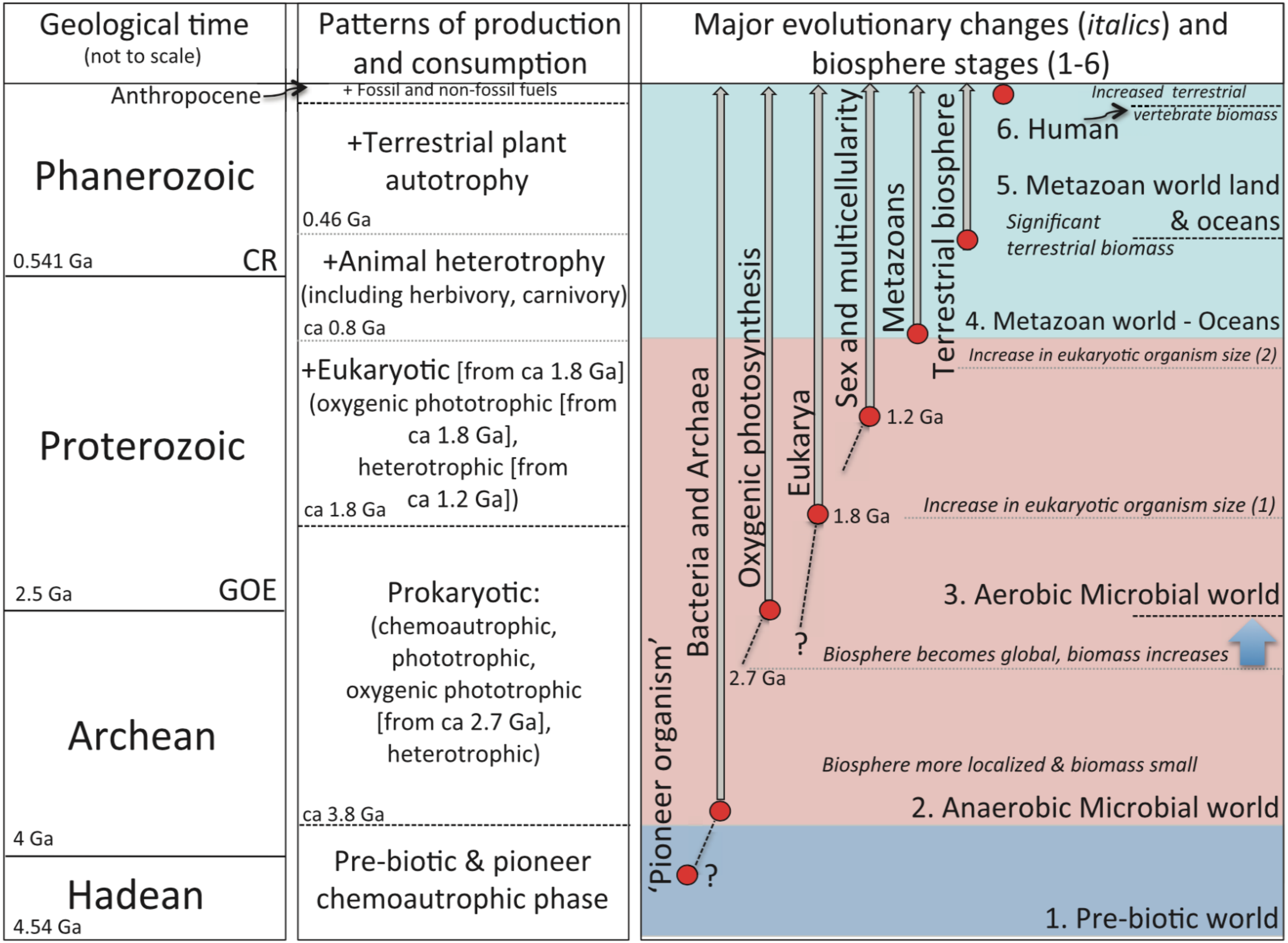
The Great Acceleration & the **Long Now**





Living with **likelihoods**

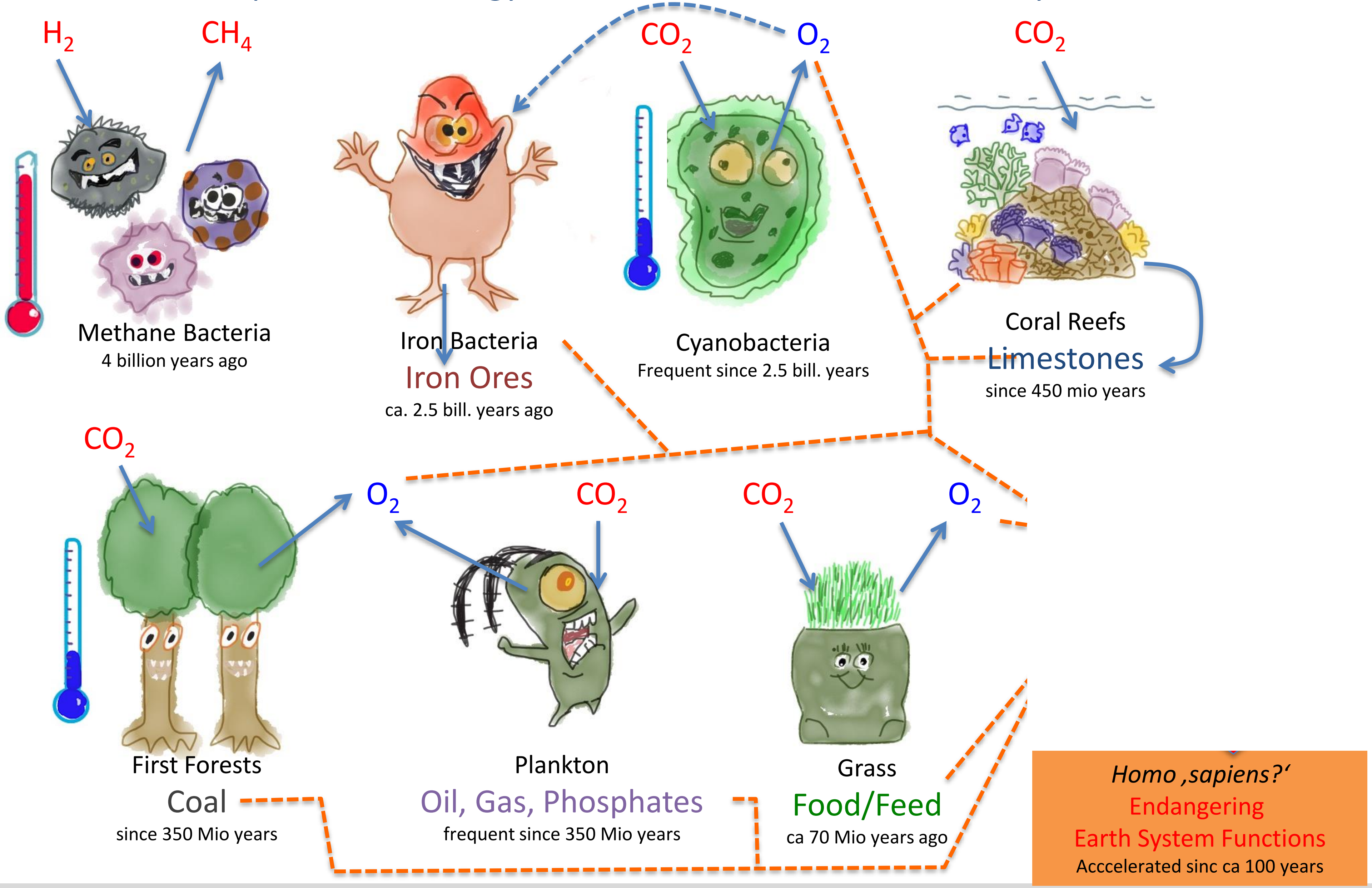
Figs. from Hamann, Zea-Schmidt, Leinfelder 2014



From Williams et al. 2016

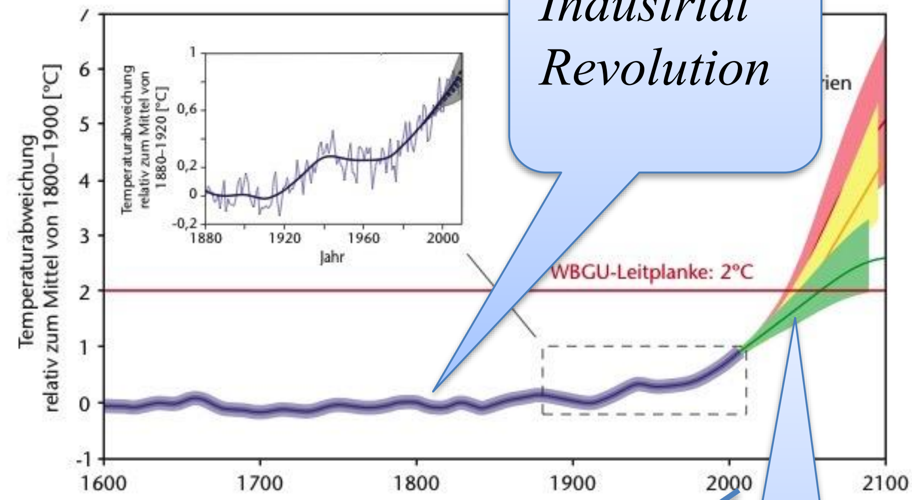
New Narratives

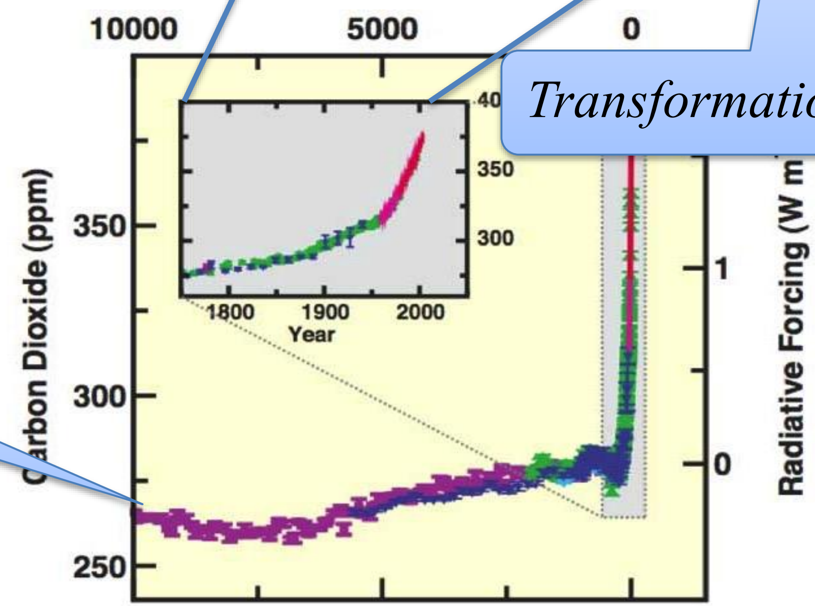
Example 1: Geobiology: The Hall of Fame of Earth History Critters



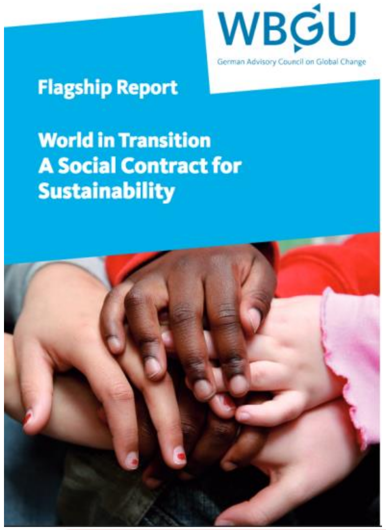
Example 2: Humans and their cultural-societal development: Environmental stability as a prerequisite

Aus Leinfelder, Hamann et al. (2016) Die Anthropozän-Küche

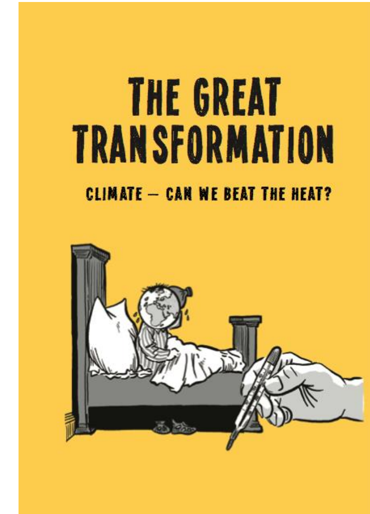




3. Who is „We“? Social Contract for a Great Transformation



Top-Down: UN, G20, EU, multinational alliances, states



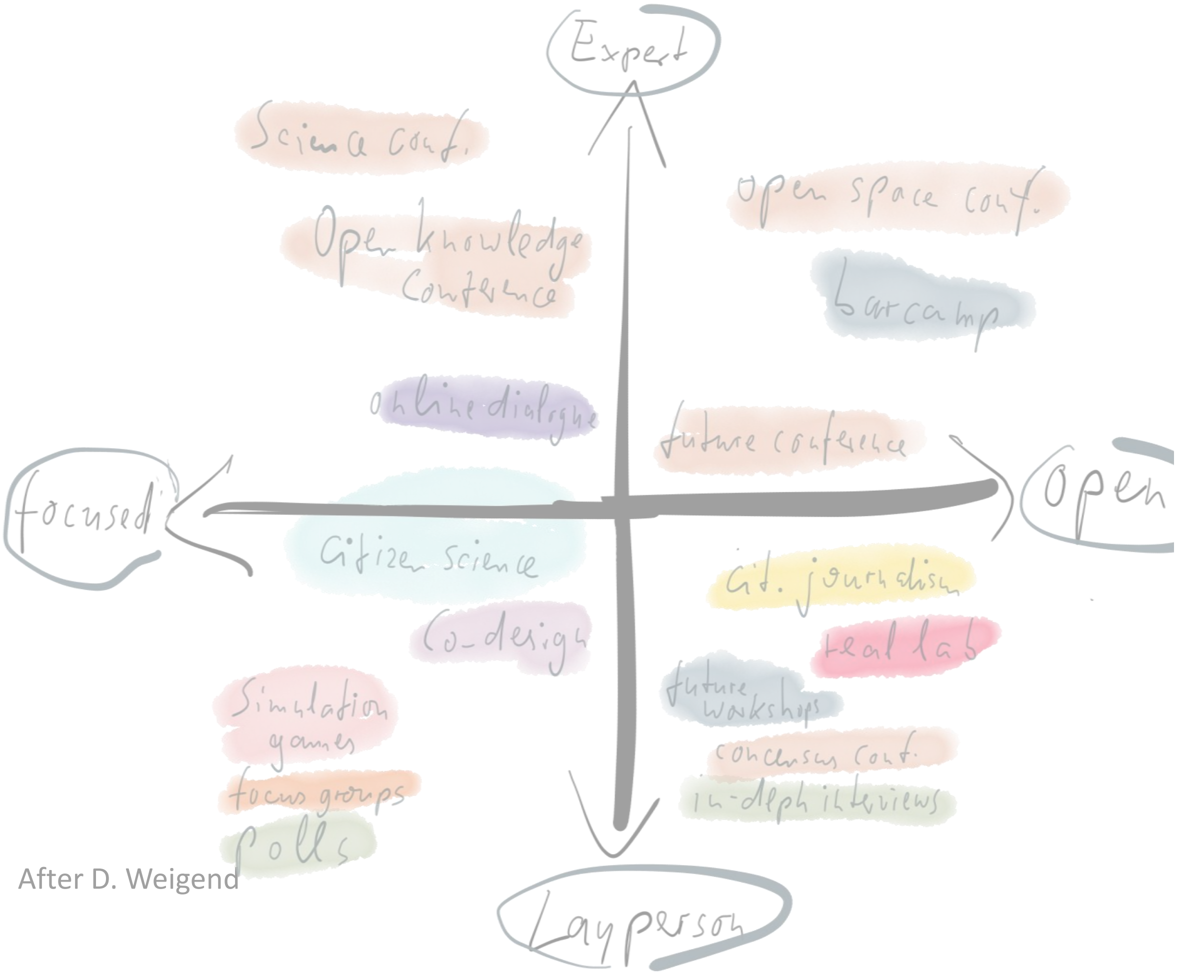
„We together“: cooperation of **science, humanities, technology, education and civil society,** new ways of political participation, best-practice examples, innovative companies, dedicated authorities, municipalities, foundations, other pioneers und promoters of change, etc.

Bottom-up: NGOs, initiatives, protest movements, masterminds etc.

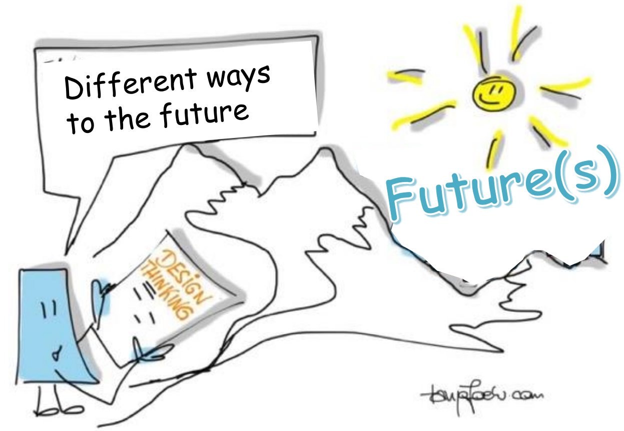
Based on WBGU 2011

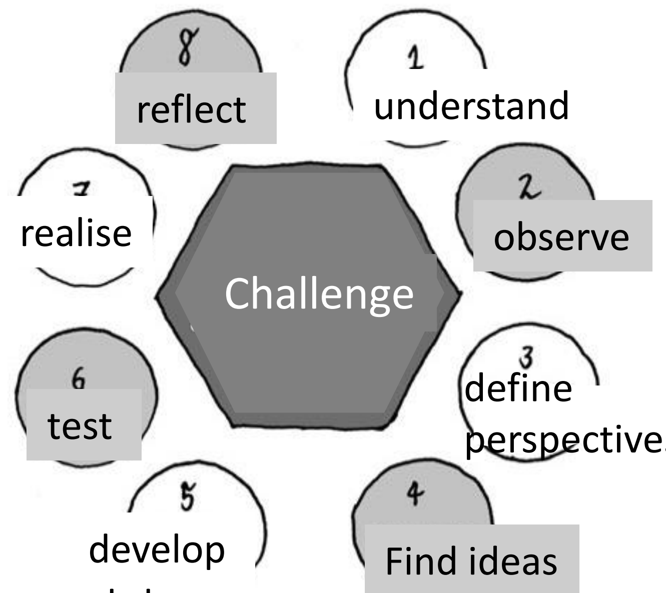
Participative formats

for co-science, co-design, co-government etc.



After D. Weigend

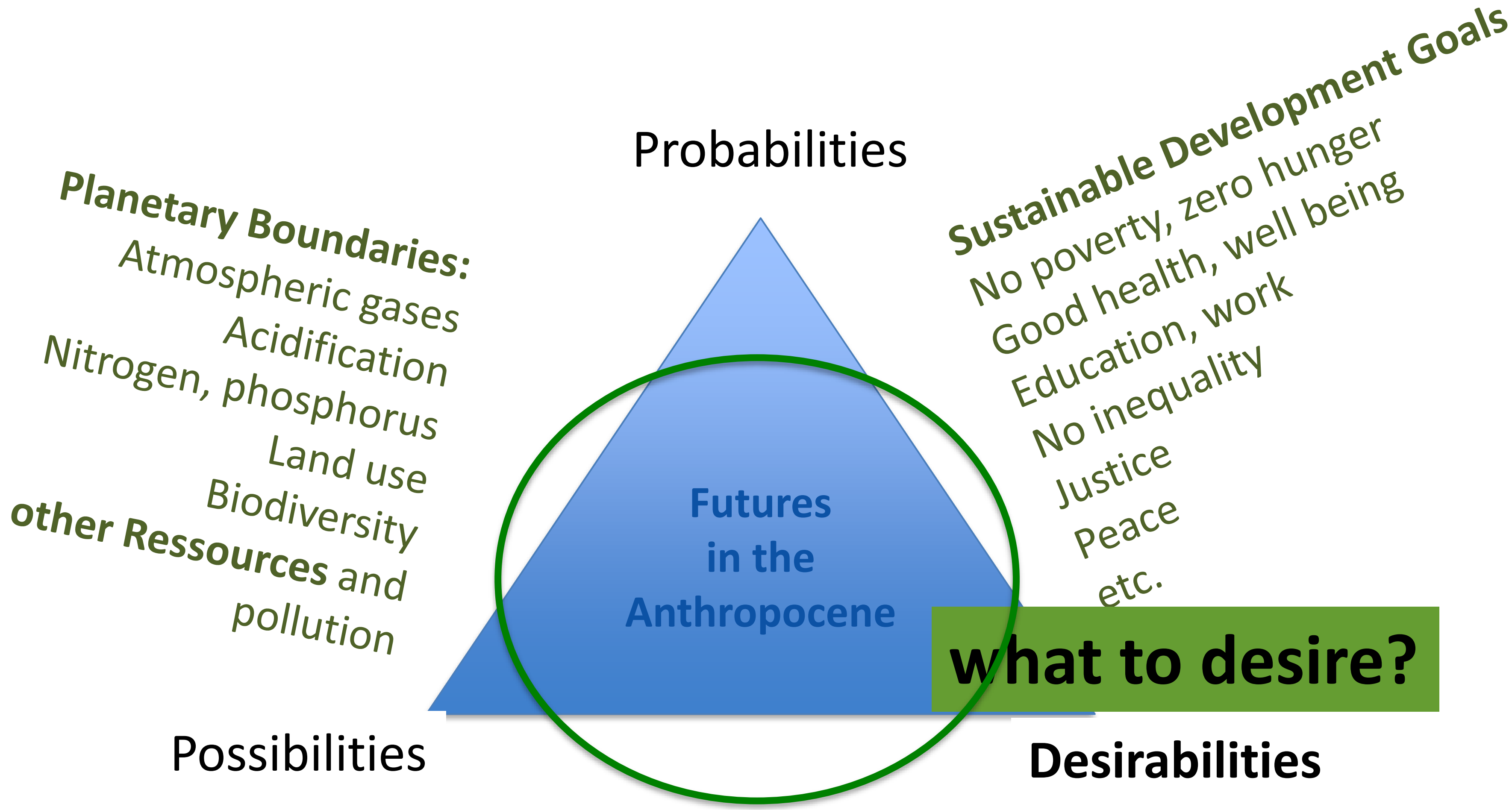




Design Thinking

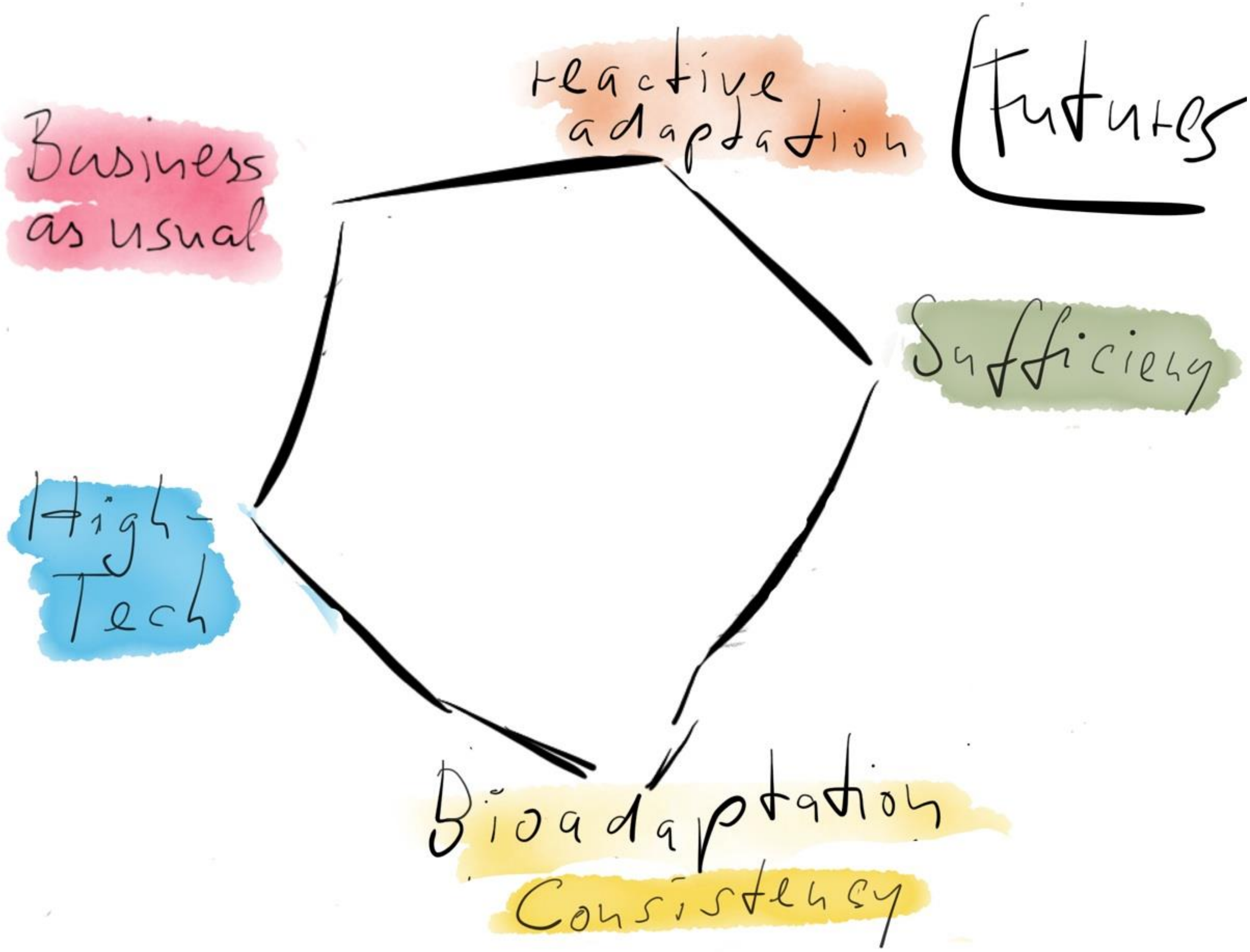
after Hasso Plattner (from teacher's handout WBGU-Comic)

4. Designing Future – seeing futures as desirabilities

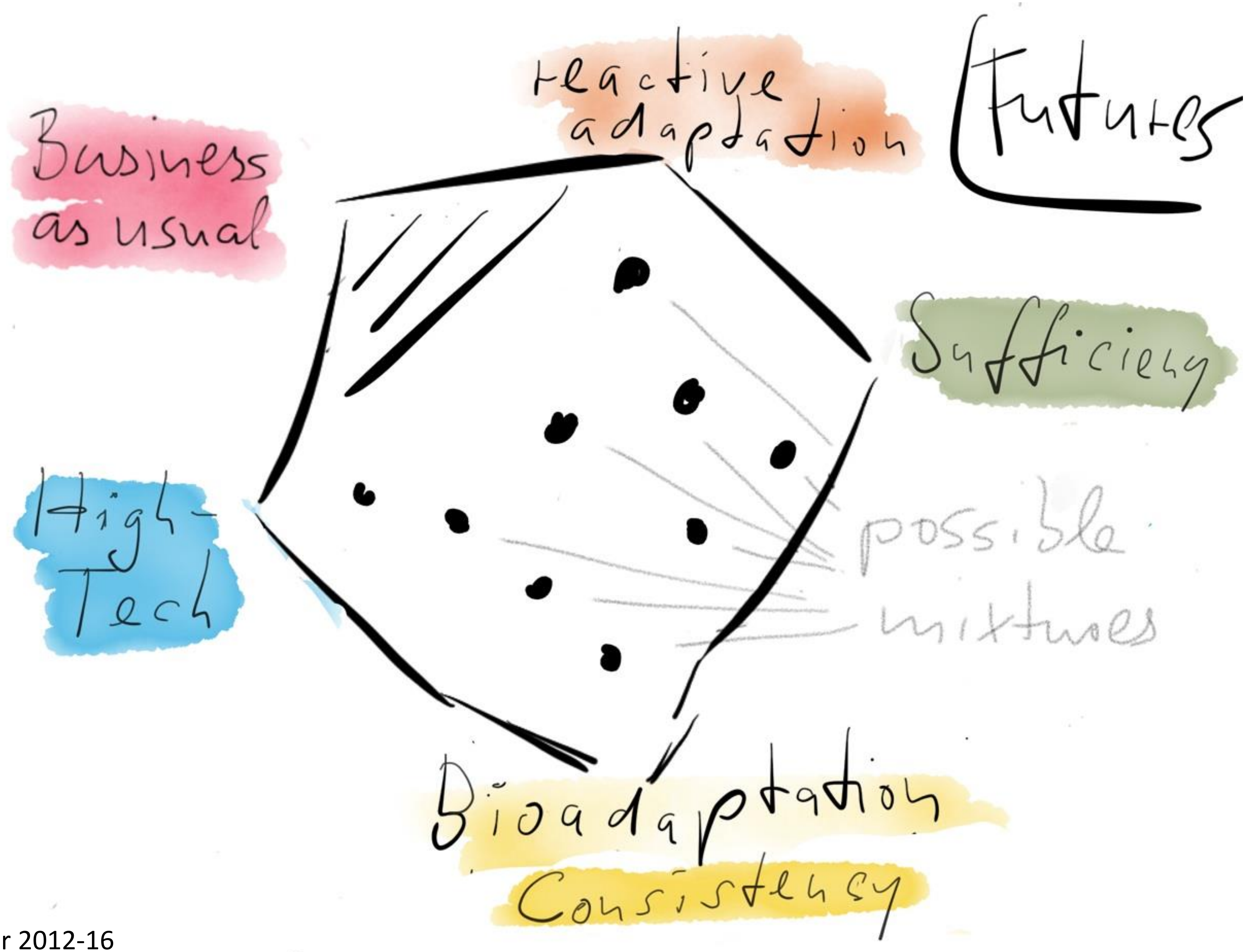


Aus Leinfelder 2014

4. Develop and „negotiate“ visions



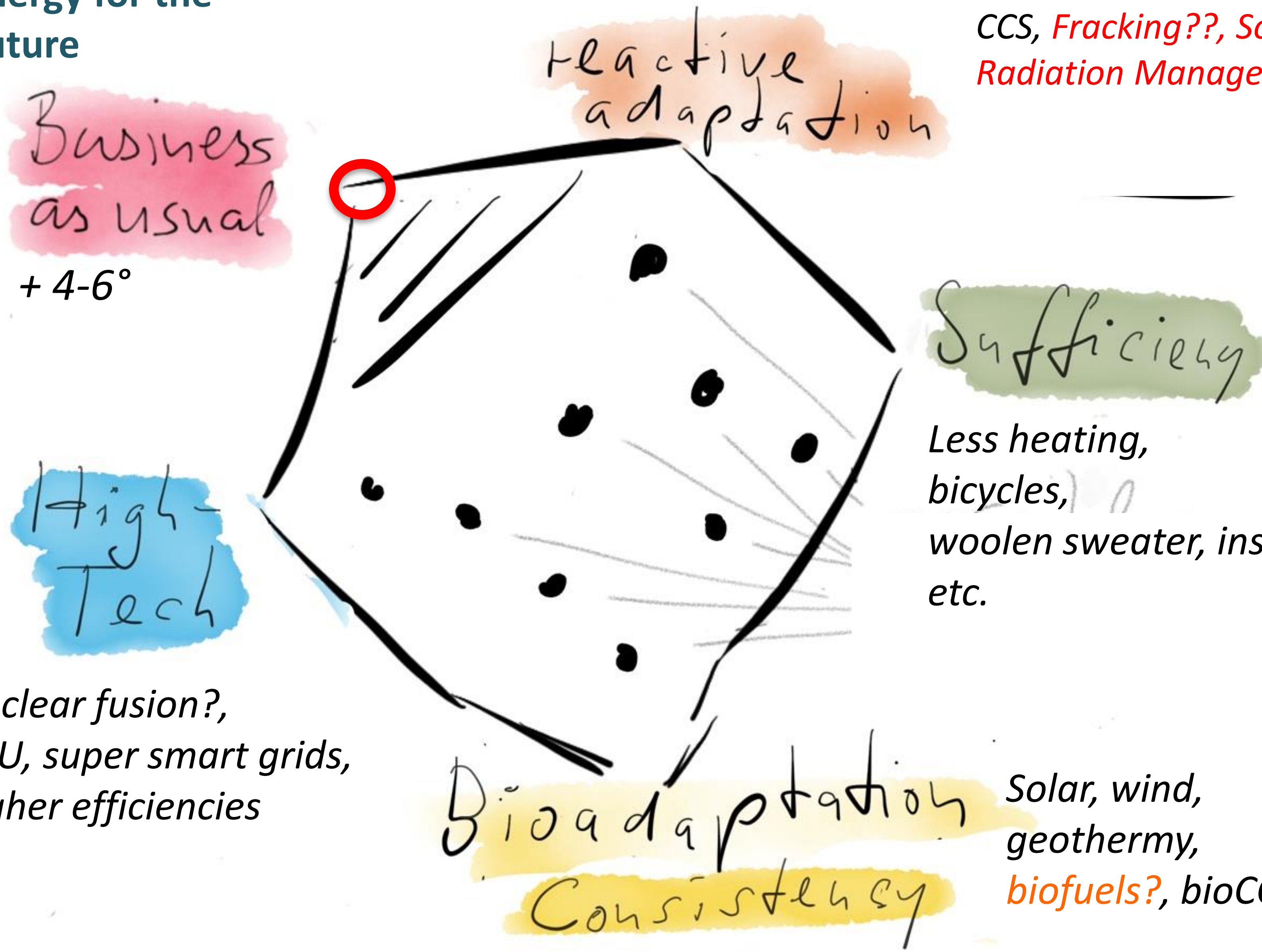
4. Develop and „negotiate“ visions



Leinfelder 2012-16

4. Develop and „negotiate“ visions

Energy for the Future



+ 4-6°

CCS, Fracking??, Solar Radiation Management???

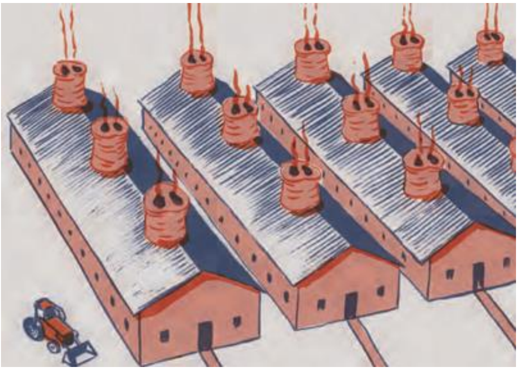
Less heating,
bicycles,
woolen sweater, insulation
etc.

Nuclear fusion?,
CCU, super smart grids,
higher efficiencies

Solar, wind,
geothermy,
biofuels?, bioCCS

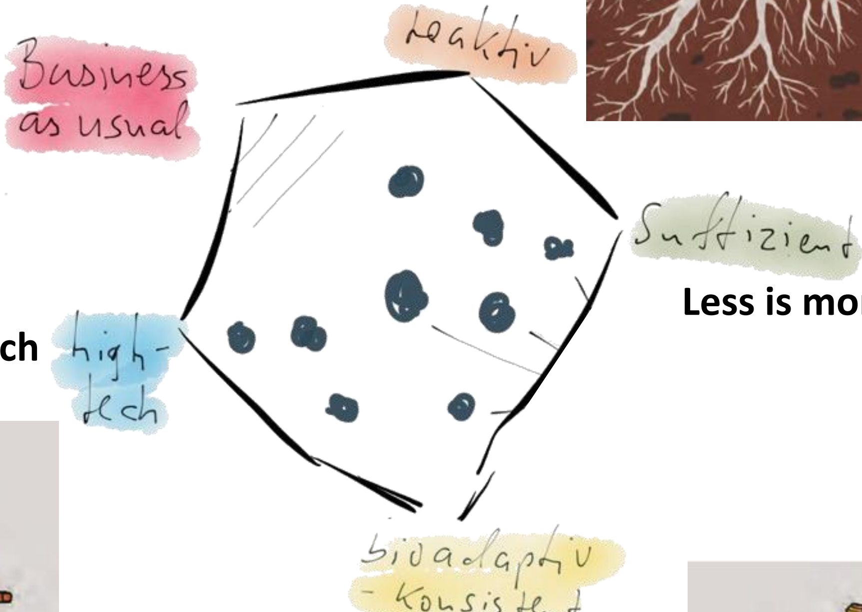
The Future of Food

4. Develop and „negotiate“ visions



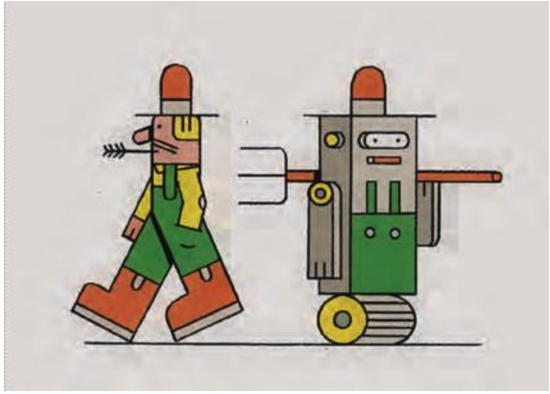
Fight symptoms

Keep on going



Less is more

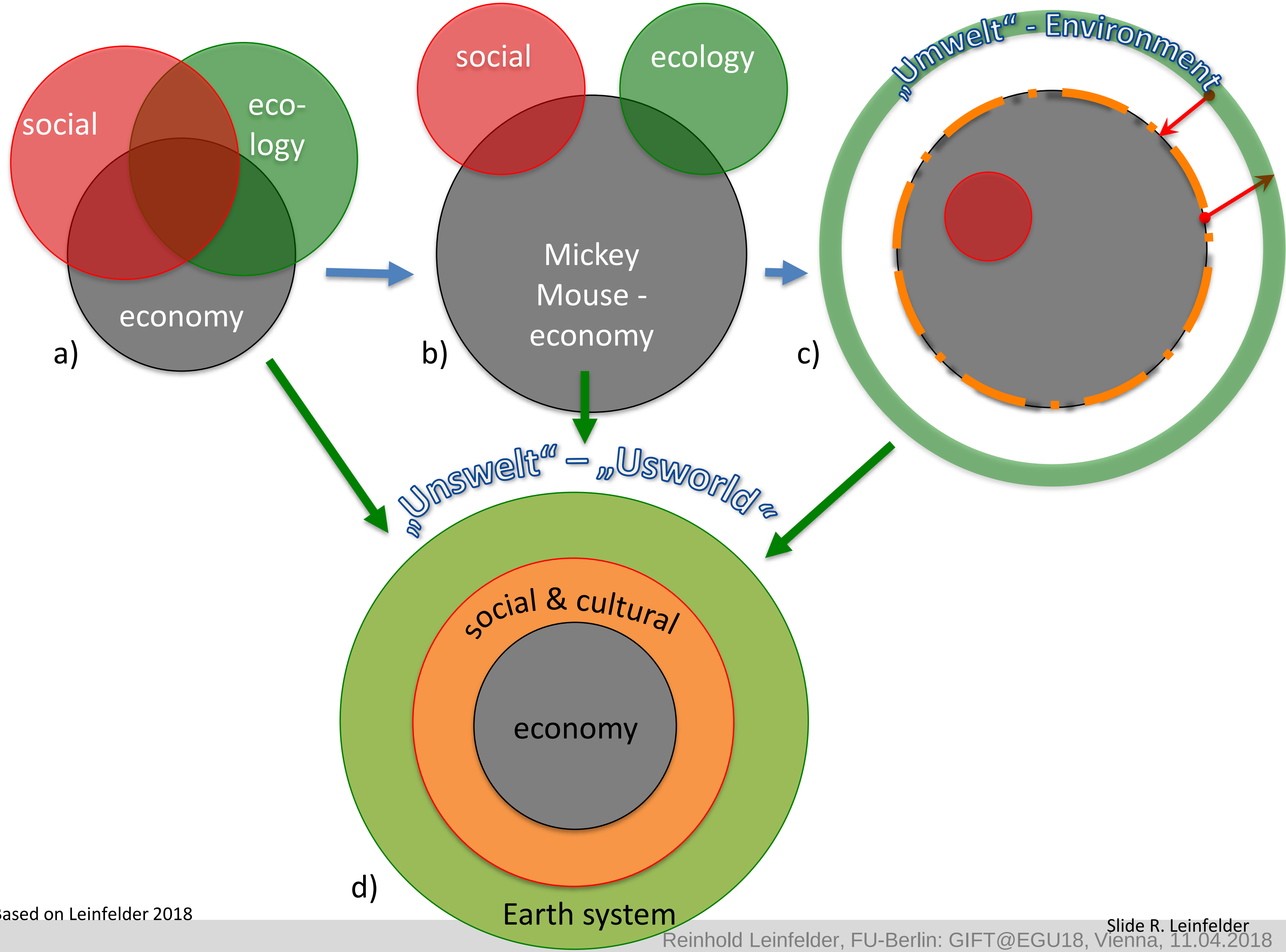
Future Tech



Nature as a role model

From Hamann et al. (2016) Mehlwumburger .... Lehrerhandreichungen
Vvia http://anthropocene-kitchen.com

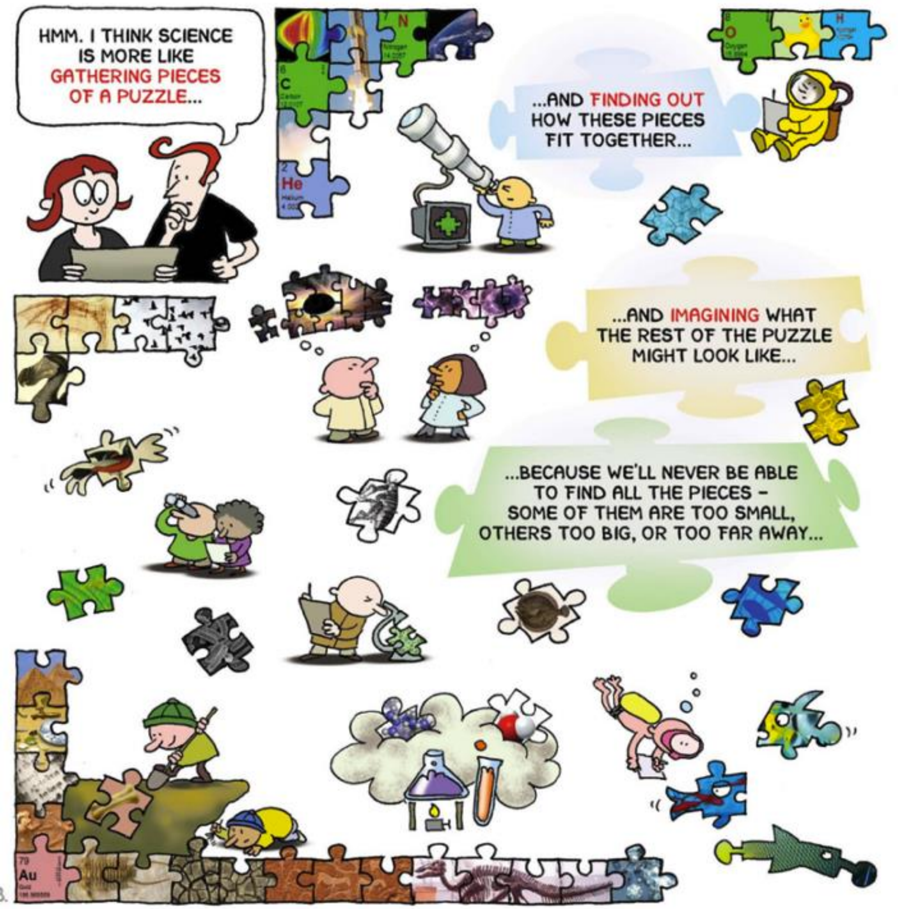
Conclusion 1: Rethink Sustainability in an Anthropocene Earth System Context



Based on Leinfelder 2018

Slide R. Leinfelder

Conclusion 2:
Develop systemic, integrative views (e.g. via cross-curricular teaching)

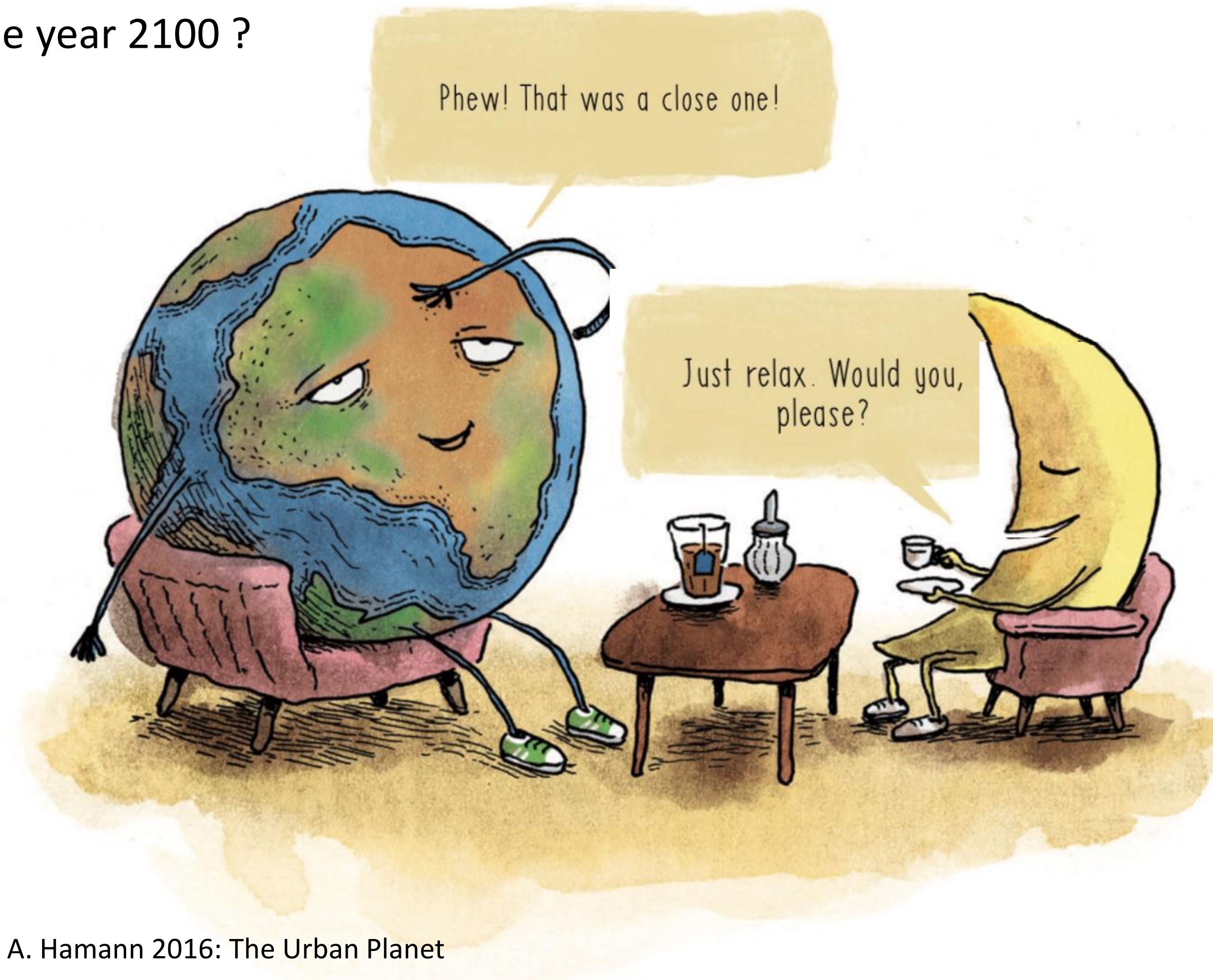


Aus: Margreet de Heer: Science. A discovery in comics

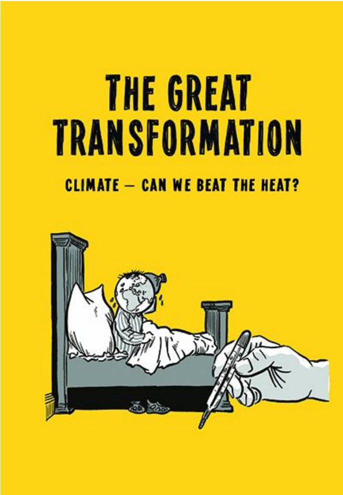
Conclusion 3:

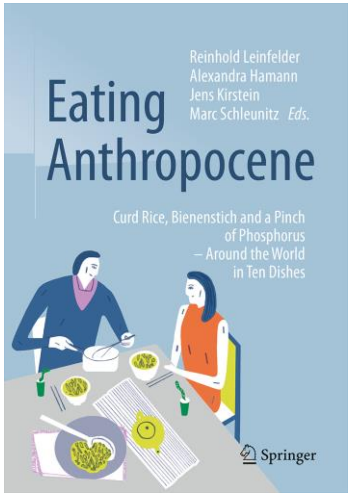
- Be **creative** and **constructive**, **experiment**, **try out**.
- Help to develop **enjoyment skills**, **self acceptance**, **self-efficacy** and support **mindfulness**, **construction of meaning** and **solidarity.**

In the year 2100 ?



From WBGU & A. Hamann 2016: The Urban Planet





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Food comic	www.anthropocene-kitchen.com
Anthro Milestones	tinyurl.com/anthropocene-milestones
Climate Comic	http://die-grosse-transformation.de
Other WBGU-Comics	wbgu.de/en/comics/