Topic 2:

At the roots of unsustainability: the Anthropocene

1965 Adlai Stevenson II
(US ambassador at UN)
speech in Geneva, 9th July

Earth as a spaceship

(focus on EQUITY)

February 5, 1900 – July 14, 1965

We travel together, passengers on a **little spaceship**,
dependent on its vulnerable reserves of air and soil;
all committed for our safety to its security and peace;
preserved from annihilation only by the care, the work, and, I will say, the love we give our fragile craft.
We cannot maintain it half fortunate, half miserable,
half confident, half despairing,
half slave [...] half free in a liberation of resources undreamed of until this day.
No craft, no crew can travel safely with such vast contradictions.
On their resolution depends the survival of us all

K. E. Boulding (1910-1993)

1966: **The economics of coming Spaceship Earth**

SUSTAINABLE DEVELOPMENT: PRINCIPLES AND POLICY 2020/21

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https://elearning.ec.unipi.it/course/view.php?id=1508&section=6

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Syllabus

Portale esami

news from your teachers

SDGs | Exam

All about the EXAM

HOW will the exam be and your assignments

Quiz on Boulding's Spaceship Earth

Before the quiz on Boulding: 1.anonymous

Before the quiz on Boulding: 2.named

Accesso vincolato Condizioni per l'accesso: Appartenere a qualsiasi gruppo

Boulding's Spaceship Earth

Accesso vincolato Condizioni per l'accesso: Appartenere a qualsiasi gruppo

IF you missed its KEY MESSAGES (questions 1 and 2), please STUDY it again and THEN

try the quiz again. You can see the score (Punteggio). If you do not get the maximum, read the paper again. Then try the quiz again ...

Takeaway points?

Assign a score ….

1 2 4 5

The planet has limited resources

The earth is a closed system

We must stop linear economic processes

We are going to reach our boundaries

K. E. Boulding (1910-1993)

1966: **The economics of coming Spaceship Earth**

"The closed economy of the future might similarly be called the 'spaceman' economy,
in which the earth has become a single spaceship,
without unlimited reservoirs of anything,
either for ***extraction*** or for ***pollution***,
and in which, therefore,
man must find his place in a **cyclical ecological system**

Anthropocene

Geological epoch???

Geologic Time Scale

•The geologic time scale is like a calendar extending from Earth's formation to the present. The scale is divided into eons, eras, period and epochs.

GEOLOGICAL TIMES: defined by major geological events and changes in species

•Eon: The largest group: billions of years long

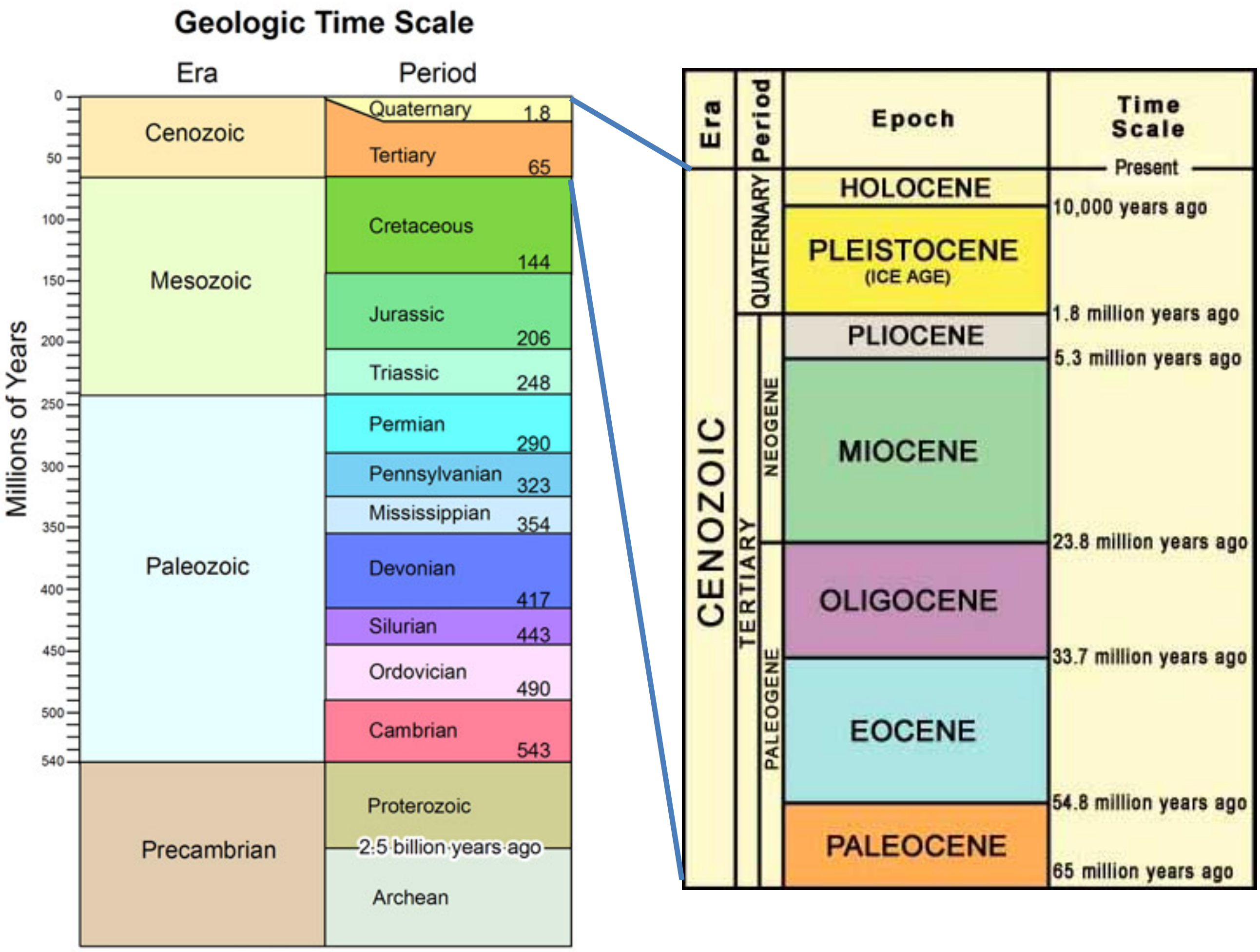
•Era: mass extinctions mark the boundaries between the eras; hundreds of millions of years long

•Period: tens of millions of years long

•Epoch: divisions of the most recent periods; several million years long.

Geologic Periods

Eons	Eras	Period	Epoch	Start Date	Event
Phanerozoic	Cenozoic	Quaternary*	Holocene	0.01	End of most recent Glaciation until Present (Current Interglacial period)
			Pleistocene	1.8	Repeated Glaciations
		Tertiary	Pliocene	5	Forests and Cooler Temperatures - Ape and Monkey Lineages Separate from Common Ancestor
			Miocene	23	Rise of grasses
			Oligocene	34	Fewer new mammals appear than post-extinction burst in Eocene
			Eocene	55	First Glaciers in Antarctica Begins with Grande Copture, a mass extinction (meteorites in Siberia & Chesapeake?)
			Paleocene	65	Paleocene-Eocene Thermal Maximum Many new angiosperm families
	Mesozoic	Cretaceous	Named, but we won't use	144	Second Largest Extinction Event Flowering Plants appear
		Jurassic		206	Mammals common but small Pangaea breaks into Laurasia and Gondwanna
		Triassic		248	First Mammals appear, Reptiles dominate vertebrate
	Paleozoic	Permian		290	First Conifers appear Pangaea forms (Appliachian Mts.)
		Carboniferous		354	First Land Vertebrates Primitive Plants form forests
		Devonian		417	Ferns and Fern Allies appear
		Silurian		443	First Jawed Fish First Land Plants
		Ordovician		490	First Vertebrate Fossils
		Cambrian		543	Invertebrate fossils
Precambrian	Proterozoic			2500	O2 accumulates in atmosphere - Multicellularity
	Archaen			3800	First Microfossils of Prokaryotes / Eukaryote origin?
	Hadean			4500	



Industrial revolution (1800 A.D.) →

ANTHROPOCENE?

- Crutzen, P. J. & Stoermer, E. F. 2000 The Anthropocene. *Global Change Newsl.* **41**, 17–18.
- Crutzen, P. J. 2002 Geology of mankind: the Anthropocene. *Nature* **415**, 23.

Antecedents

- Stoppani, A. 1873 *Corso di geologia*, vol. II (eds G. Bernardoni & G. Brigola). Milan, Italy.
- Marsh, G. P. 1874 *The earth as modified by human action: a new edition of 'Man and Nature'*.

"Anthropozoic era"

In the chapter ‘Carbon and living matter in the earth’s crust’ of his *Geochemistry*,
Vernadsky wrote:
‘But in our geologic era, in the **psychozoic era**—the era of Reason—a new geochemical factor of paramount importance appears.
During the last 10 000 or 20 000 years**,**
the geochemical influence of agriculture has become unusually intense and diverse.


1863 - 1945

The Biosphere (1926)

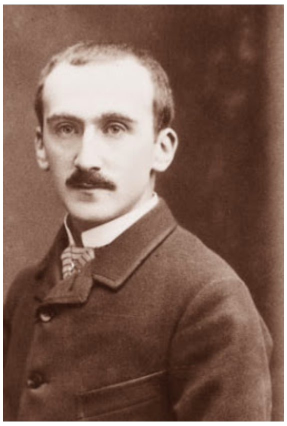
We see a surprising speed in the growth of mankind’s **geochemical work**.
We see a more and more pronounced influence of **consciousness and collective human reason upon geochemical processes**.

Formerly, organisms affected the history only of those atoms that were necessary
for their respiration, nutrition and proliferation.

Man has widened this circle, exerting influence upon elements necessary for technology and for the creation of civilized forms of life.

Man acts here not as *homo sapiens*, but as *homo sapiens faber*’ [21, p. 342; 23, pp. 219–220].

Steffen, W., Grinevald, J., Crutzen, P., & McNeill, J. (2011).



Henri BERGSON *L'Evolution Créatrice* (1907)
'A century has elapsed since the invention of the **steam engine**,
and we are only just beginning to feel
the depths of the **shock** it gave us. . . .
In thousands of years, when, seen from the distance,
[…] our wars and our revolutions will count for little […];
but the steam engine,
and the procession of inventions of every kind that accompanied it,
will perhaps […] serve to define an age.'

A)'Man: a new geological force'
B)Evolution of the biosphere and its transformation by
the development of human's noösphere^
(including the **technosphere** and the so-called **industrial metabolism**).

→ ***The Earth as Transformed by Human Action***

^Noösphere: Teilhard de Chardine, Vernadsky, Le Roy, Paris, 1920s

INFLUENCE OF humans and their ancestors? YES!

BUT never able to fully transform the ecosystems around them.

observation and trial-and-error → more effective knowledge and increased modification of their environment

Neolithic Revolution: advent of agriculture

the clearing of forests and conversion of land to cropping (8000 yrs ago)

the development of irrigated rice cultivation (5000 yrs ago)

HOWEVER humans could not modify
the chemical composition of the atmosphere
or the oceans at the global level

1) making stone tools and rudimentary weapons.

2) Later:
hominids learned how to **control and manipulate fire,**
which helped
- → in their hunt for food sources,
- → to keep dangerous animals away from the hominid camps at night.

3) Access to protein-rich food source
from a primarily vegetarian diet to an omnivorous diet
→ shift in the physical and mental capabilities of early humans,
brain size grew threefold, to about 1300 cm3,
(humans have the largest brain-to-body ratio of any animal)
→ development of spoken language,
→and later written language,
both facilitating
the accumulation of knowledge
and social learning from generation to generation.

This has ultimately led to a
massive—and rapidly increasing—store of **knowledge**

upon which humanity has eventually developed
complex civilizations

and continues to increase its **power to manipulate the environment**.

Primary energy sources of the past:
tightly constrained in magnitude and location

biomass, water, wind, animals
All of these energy sources are ultimately derived from the FLOW of energy from the Sun

which drives atmospheric circulation and the hydrological cycle and
provides the fundamental energy source for photosynthesis.

The discovery and exploitation of fossil fuels:
a vast energy store of solar energy from the past
accumulated from tens or hundreds of millions of years of photosynthesis.

STOCK!!!

They are the perfect fuel source
- energy-rich,
- dense,
- easily transportable
- relatively straightforward to access.

Human energy use rose sharply.

LOTKA: EXOSOMATIC vs ENDOSOMATIC energy USE

The first significant human use of fossil fuels:
Coal
Song dynasty (960–1279) in China (mines in the north)

UK: By the 1600s, the city of London burned around 360 000 tonnes of coal annually

The Chinese and English combustion of coal had no appreciable impact on the atmospheric concentration of CO_2

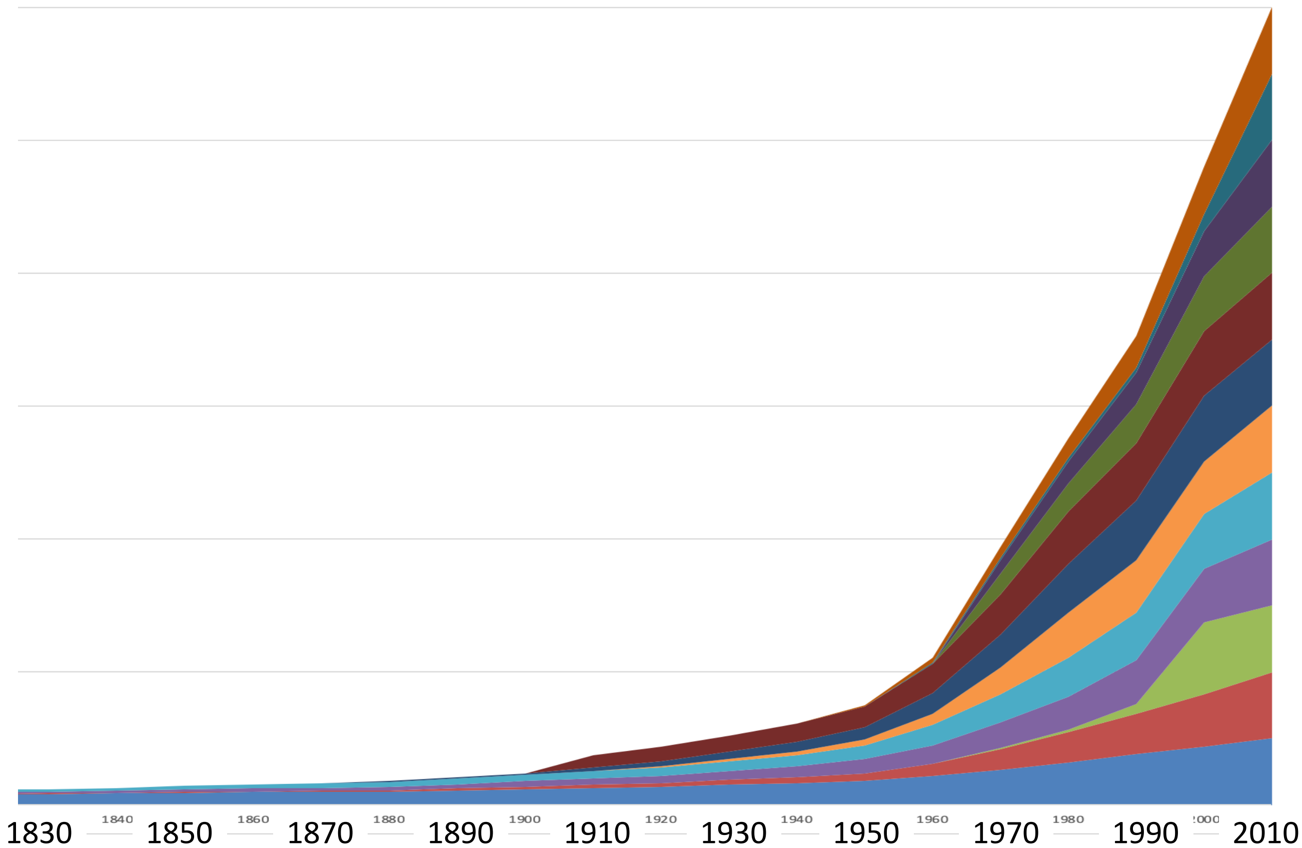
BIG CHANGE
- started with INDUSTRIAL REVOLUTION, 1800s

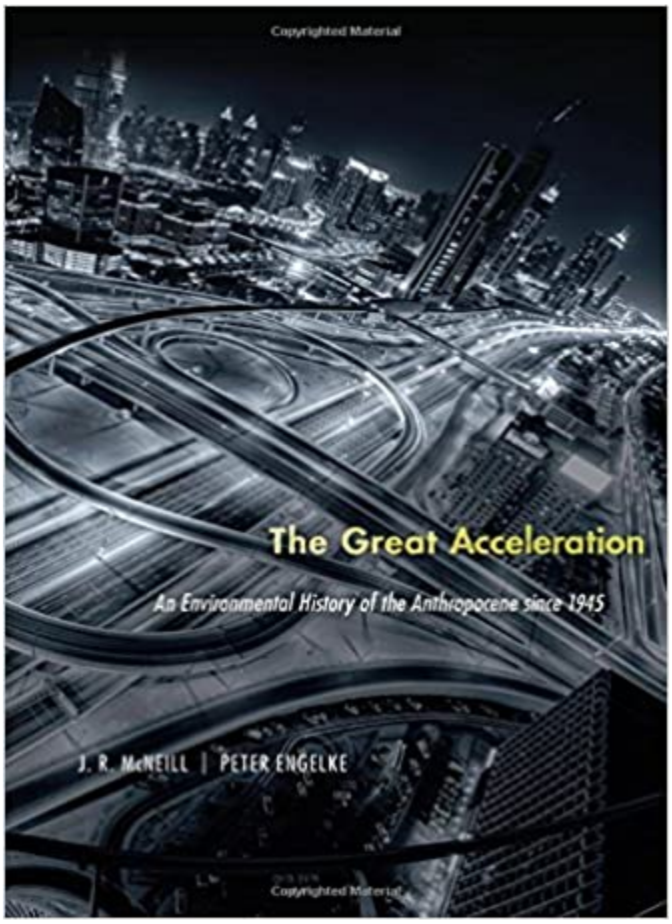
EXAMPLES:
rapid increase in the conversion
of natural ecosystems, primarily forests,
into cropland and grazing areas owing
to mechanized clearing technologies.
The increase in the
diversion of water from rivers
through the construction of large dams.

Let us see the video

[300 Years of FOSSIL FUELS in 300 Seconds]

Socio-Economic trends 1830→2010





The Great Acceleration:
An Environmental History of the Anthropocene since 1945
by J. R. McNeill, Peter Engelke

Let us see the video
The great acceleration
https://www.youtube.com/watch?v=1JAOXTOwjdY

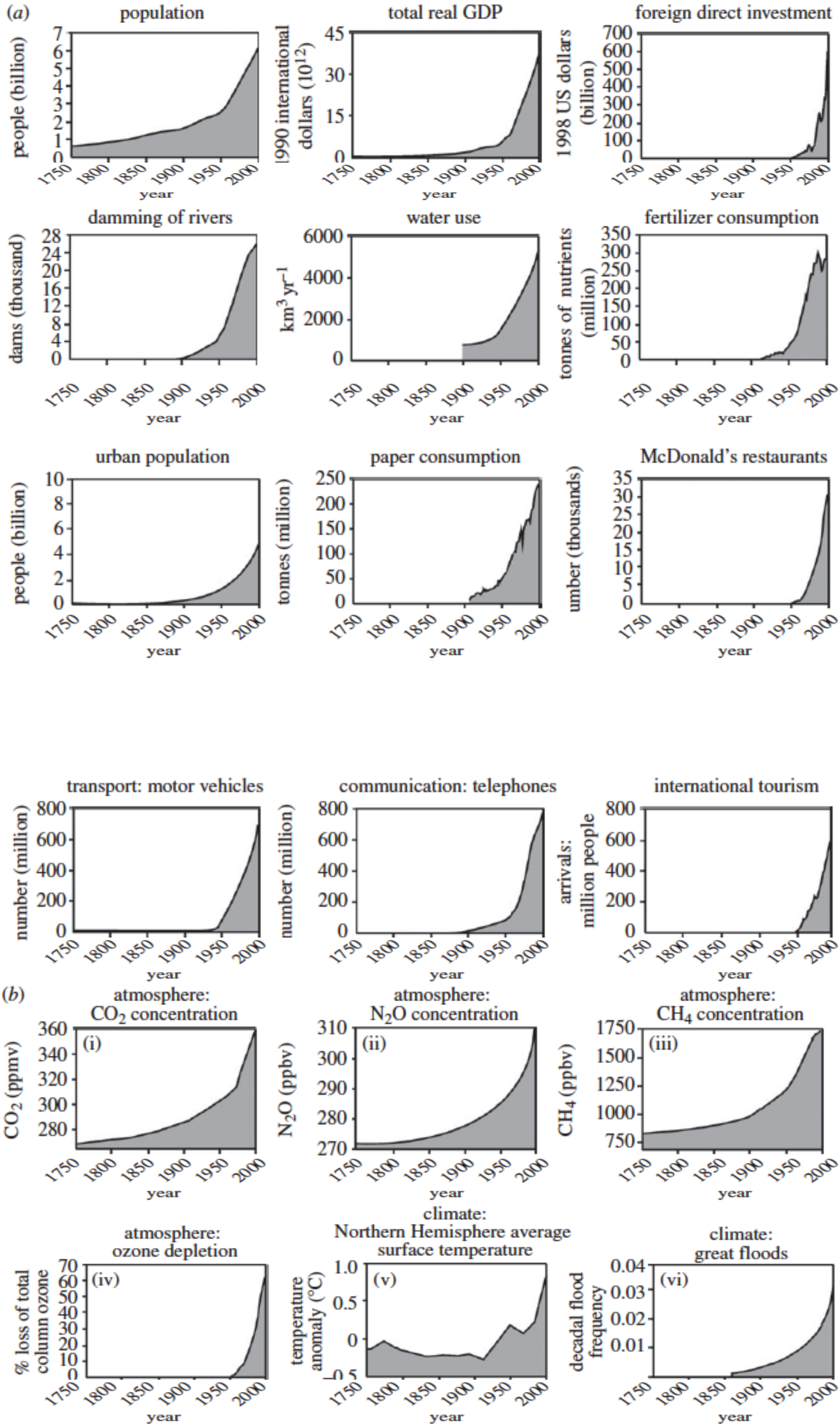
The Great Acceleration

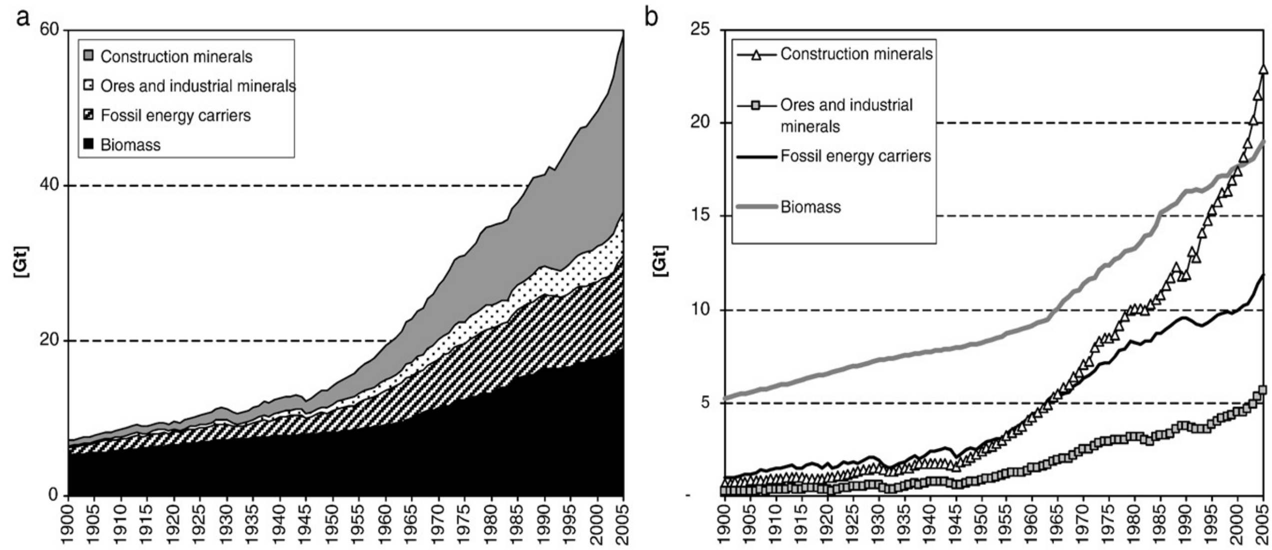
The human enterprise switched gears after World War II.

Although the imprint of human activity on the global environment was, by the mid-twentieth century, clearly discernible beyond the pattern of Holocene variability in several important ways,

the rate at which that imprint was growing increased sharply at midcentury.

The change was so dramatic that the 1945 to 2000+ period has been called the Great Acceleration


(a)
population
people (billion)
total real GDP
1990 international dollars (10^12)
foreign direct investment
1998 US dollars (billion)
damming of rivers
dams (thousand)
water use
km^3 yr^-1
fertilizer consumption
tonnes of nutrients (million)
urban population
people (billion)
paper consumption
tonnes (million)
McDonald's restaurants
umber (thousands)
transport: motor vehicles
number (million)
communication: telephones
number (million)
international tourism
arrivals: million people
(b)
atmosphere: CO2 concentration
(i)
CO2 (ppmv)
atmosphere: N2O concentration
(ii)
N2O (ppbv)
atmosphere: CH4 concentration
(iii)
CH4 (ppbv)
atmosphere: ozone depletion
(iv)
% loss of total column ozone
climate: Northern Hemisphere average surface temperature
(v)
temperature anomaly (°C)
climate: great floods
(vi)
decadal flood frequency
year
1750
1800
1850
1900
1950
2000



Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K. H., Haberl, H., & Fischer-Kowalski, M. (2009). Growth in global materials use, GDP and population during the 20th century. Ecological Economics, 68(10), 2696-2705.

CAPITALOCENE?

Moore, Jason W., "Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism" (2016). Sociology Faculty Scholarship. https://orb.binghamton.edu/sociology_fac/1/

https://global.ilmanifesto.it/anthropocene-more-like-capitalocene/

[Review: Anthropocene or Capitalocene?](https://www.simonspire.com/blog/anthropocene-or-capitalocene)
https://www.simonspire.com/blog/anthropocene-or-capitalocene

GEOENGINEERING to CONTRAST CLIMATE CHANGE

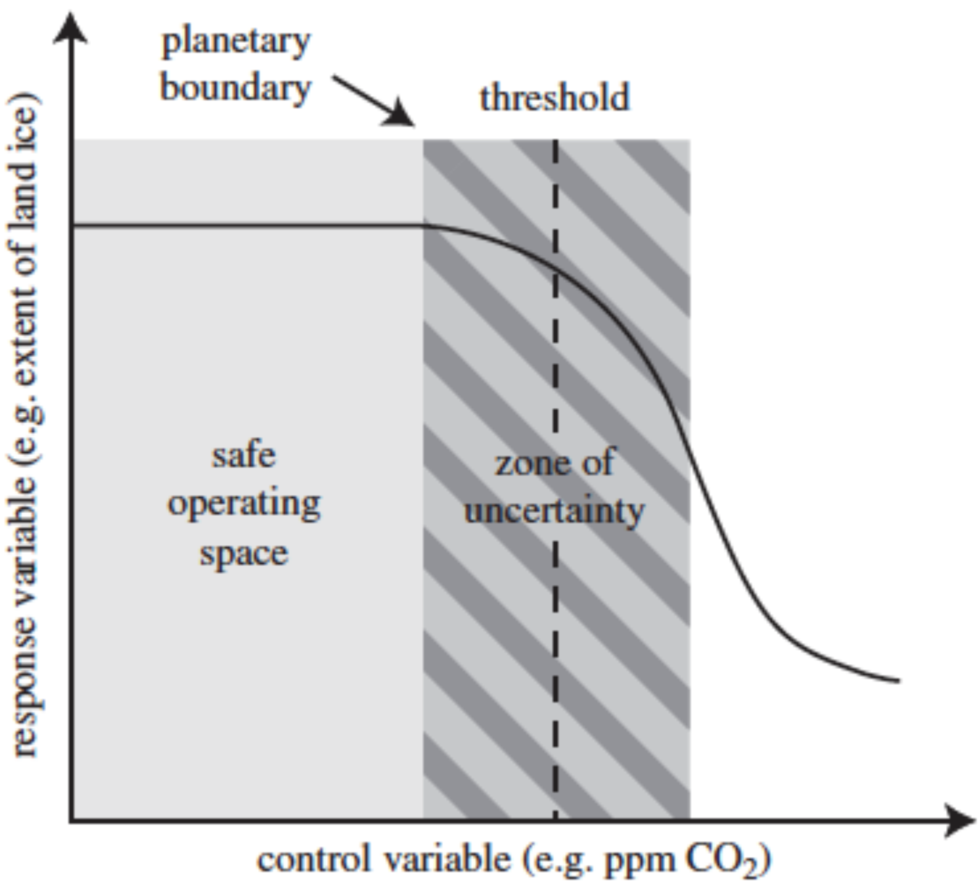
*(??? → **See the paper by Steffen et al.** in the elearning platform)*

The antithesis of geoengineering—
is the planetary boundaries concept (Rockström et al.)

The approach recognizes the severe risks associated with
trying to deliberately manipulate the Earth system
to counteract deleterious human influences,
given **the lack of knowledge** of the functioning of the Earth system
and the possibility of abrupt and/or irreversible changes,
some of them very difficult to anticipate,
when complex systems are perturbed.
The planetary boundaries approach is thus explicitly based
on returning the Earth system to the Holocene domain,
The set of planetary boundaries defines the 'safe operating space' for humanity with
respect to the Earth system,
and are based on a small number of subsystems or processes,
many of which exhibit abrupt change behaviour when
critical thresholds are crossed.

Safe minimum standard of conservation (1952!!!) (in resources)
Siegfried von Ciriacy-Wantrup, 1906-1980

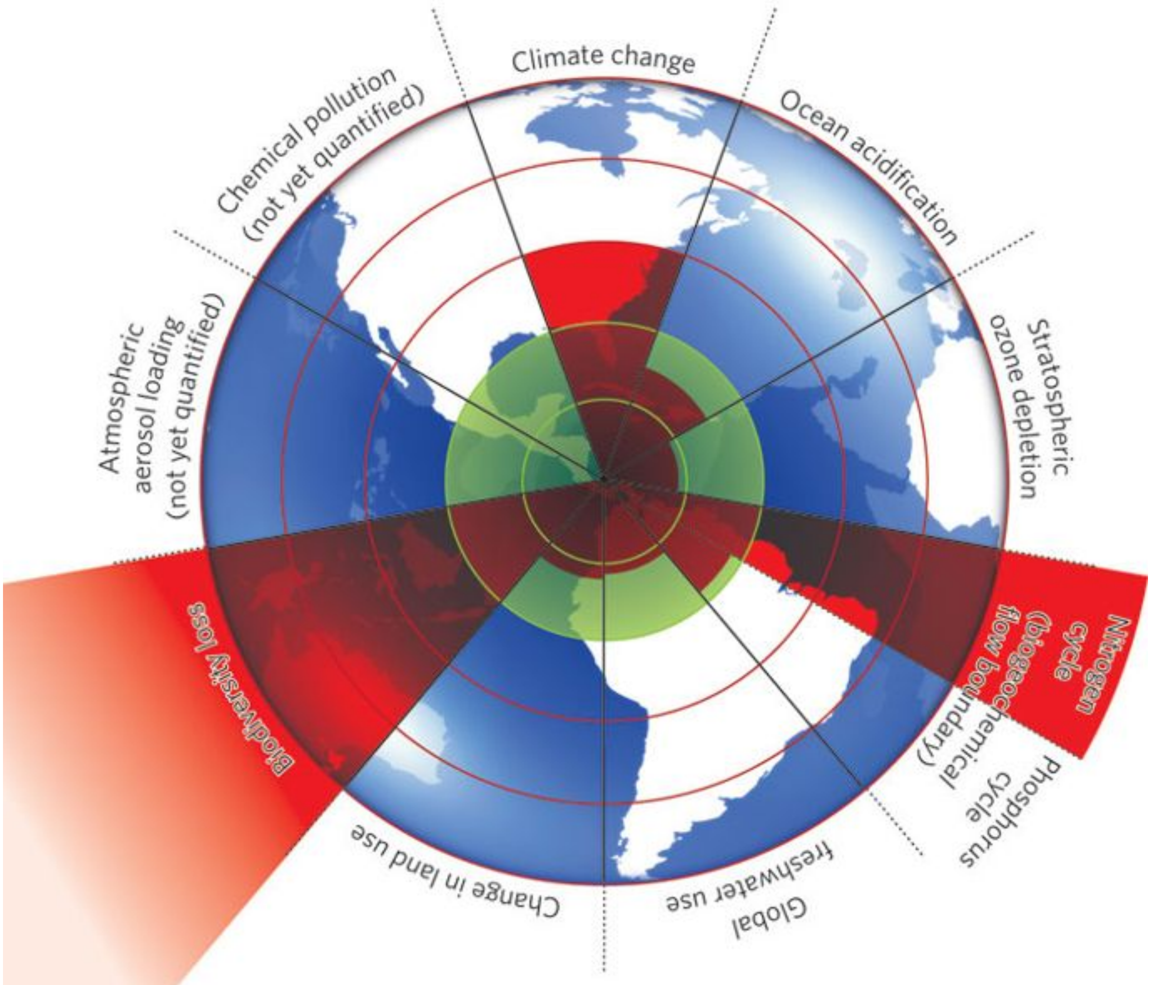
Conceptual description of planetary boundaries.



Thresholds/tipping points are intrinsic features of the Earth system
independent of human actions or desires.

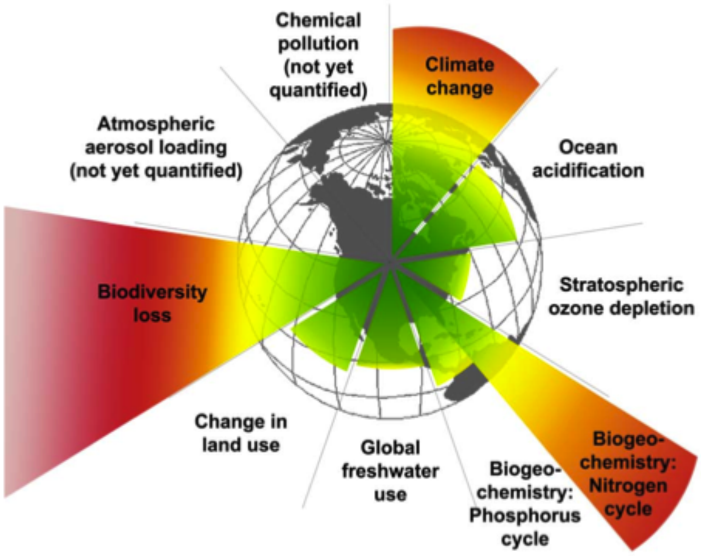
The boundaries are values of the control variable
set at a ‘safe’ distance from the threshold,
‘safe’ being a value judgement
based on how societies deal with risk and uncertainty.

Rockström et al. (2009, Nature) suggest that nine planetary boundaries comprise
the set that defines the safe operating space for humanity.



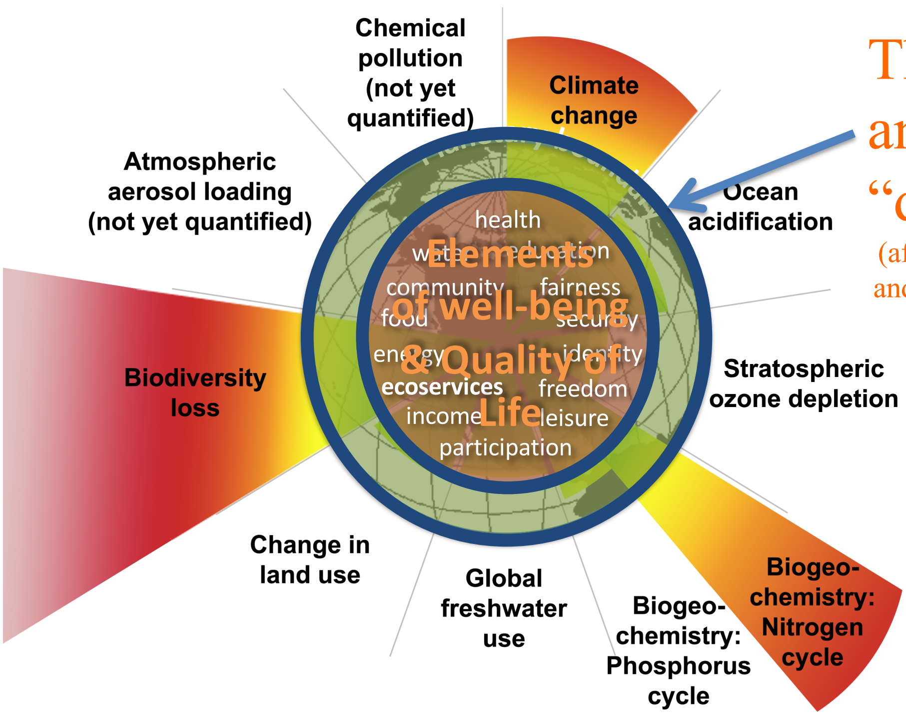
Earth-system process	parameters	proposed boundary	current status	pre-industrial value
climate change	(i) atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) change in radiative forcing (watts m^{-2})	1	1.5	0
rate of biodiversity loss	extinction rate (number of species per million species per year)	10	>100	0.1–1
nitrogen cycle (part of a boundary with the phosphorus cycle)	amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
phosphorus cycle (part of a boundary with the nitrogen cycle)	quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	–1
stratospheric ozone depletion	concentration of ozone (Dobson unit)	276	283	290
ocean acidification	global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
global freshwater use	consumption of freshwater by humans ($km^3 yr^{-1}$)	4000	2600	415
change in land use	percentage of global land cover converted to cropland	15	11.7	low
atmospheric aerosol loading	overall particulate concentration in the atmosphere, on a regional basis	to be determined		
chemical pollution	for example, amount emitted to, or concentration of persistent organic pollutants, plastics,	to be determined		

THERE ARE
FUNDAMENTAL *ECOLOGICAL* CONSTRAINTS



Rockström, J., et al. 2009. **A safe operating space for humanity.** ***Nature*** **461:472-475**

Steffen, W., J. Rockström, and R. Costanza. 2011. **How Defining Planetary Boundaries Can Transform Our Approach to Growth.** ***Solutions*****. Vol 2, No. 3, May 2011**



The Sustainable and Desirable "doughnut"

(after: K. Raworth. 2012. A safe and just space for humanity: can we live within the doughnut? Oxfam International)

The ultimate drivers of the Anthropocene […]
if they continue unabated through this century,
may well threaten the viability of contemporary civilization
and perhaps even the future existence of Homo sapiens.

(Steffen et al, 2011)

KW KAPP →…

Have we really understood the full implications of the fact that
serious incompatibilities may develop
between economic and ecological (as well as social) systems,
which threaten the economic process,
its social reproduction,
and hence the continued guarantee of human well-being
and survival?

Kapp, K.W. (1976), 'The Open System Character of the Economy and its Implications', in K. Dopfer (ed.), Economics in the Future: Towards a New Paradigm, London: Macmillan, pp. 90–105