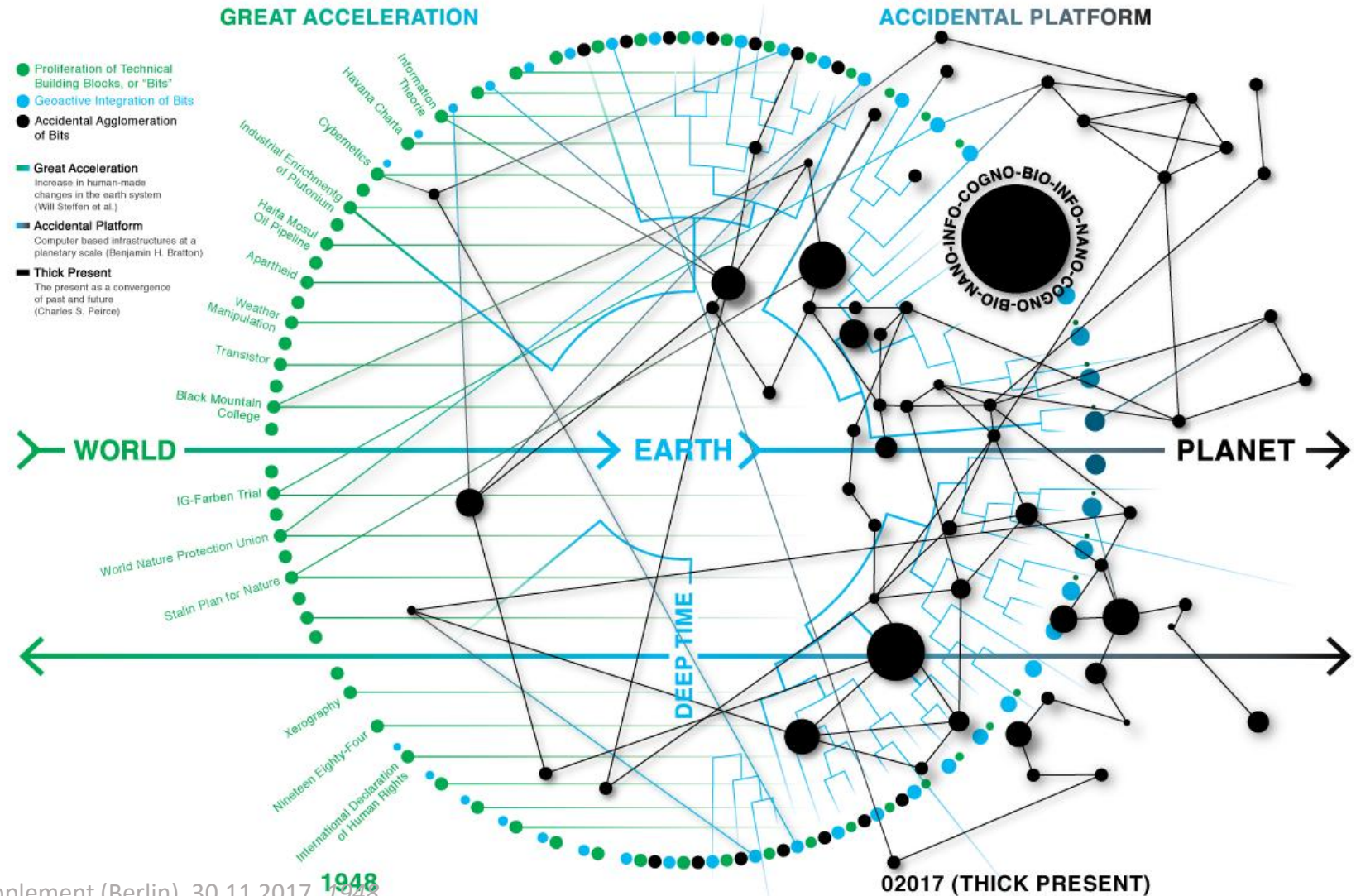


Is Climate Change a Side Effect of the Technosphere?

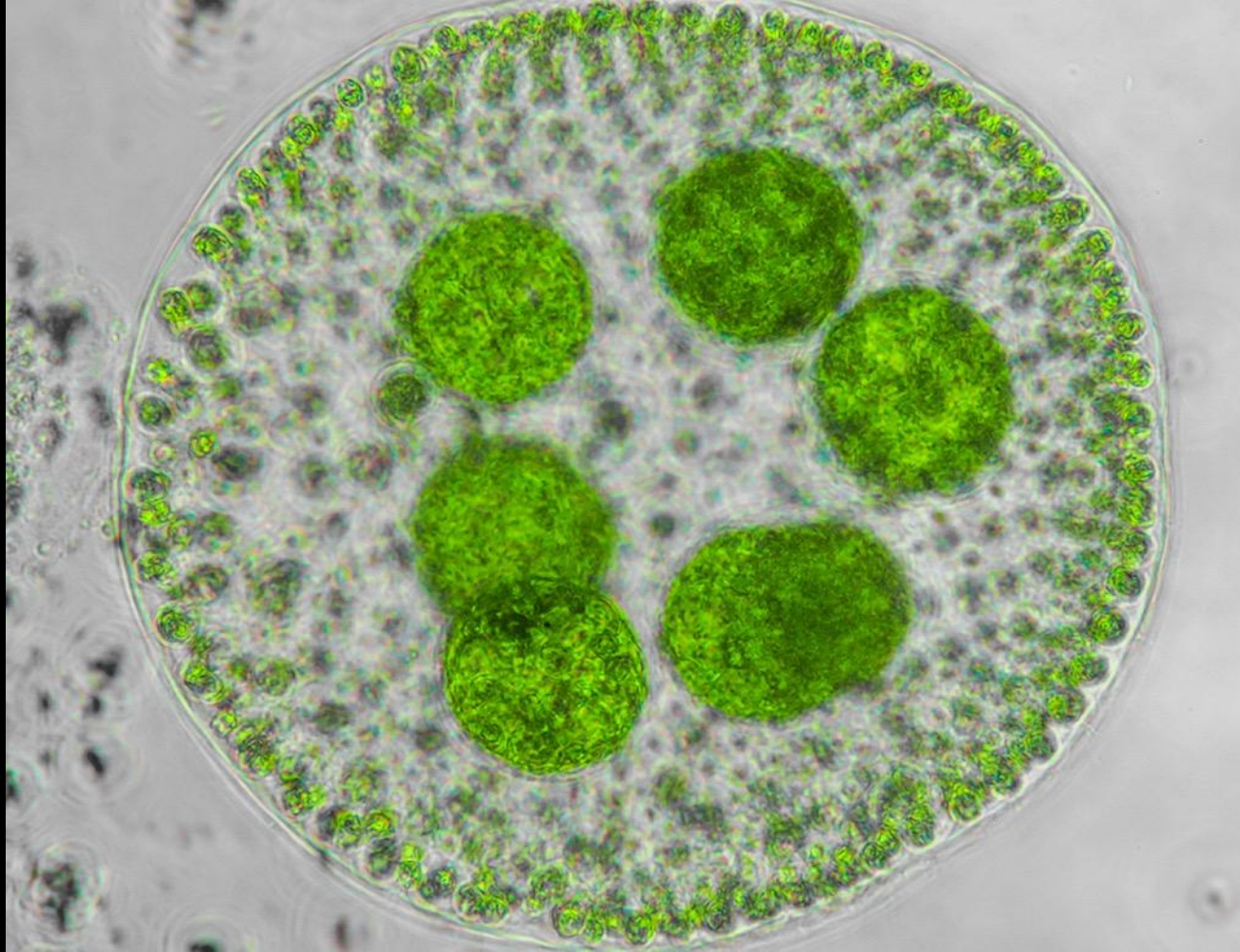


Nathan Moore

14 Mar 2025

Patricia Reed, "Technosphere Diagramme", in: TAZ Newspaper Supplement (Berlin), 30.11 2017. 1948
Unbound: Entfesselung der technischen Gegenwart (German)

Multicellular life



Carboniferous

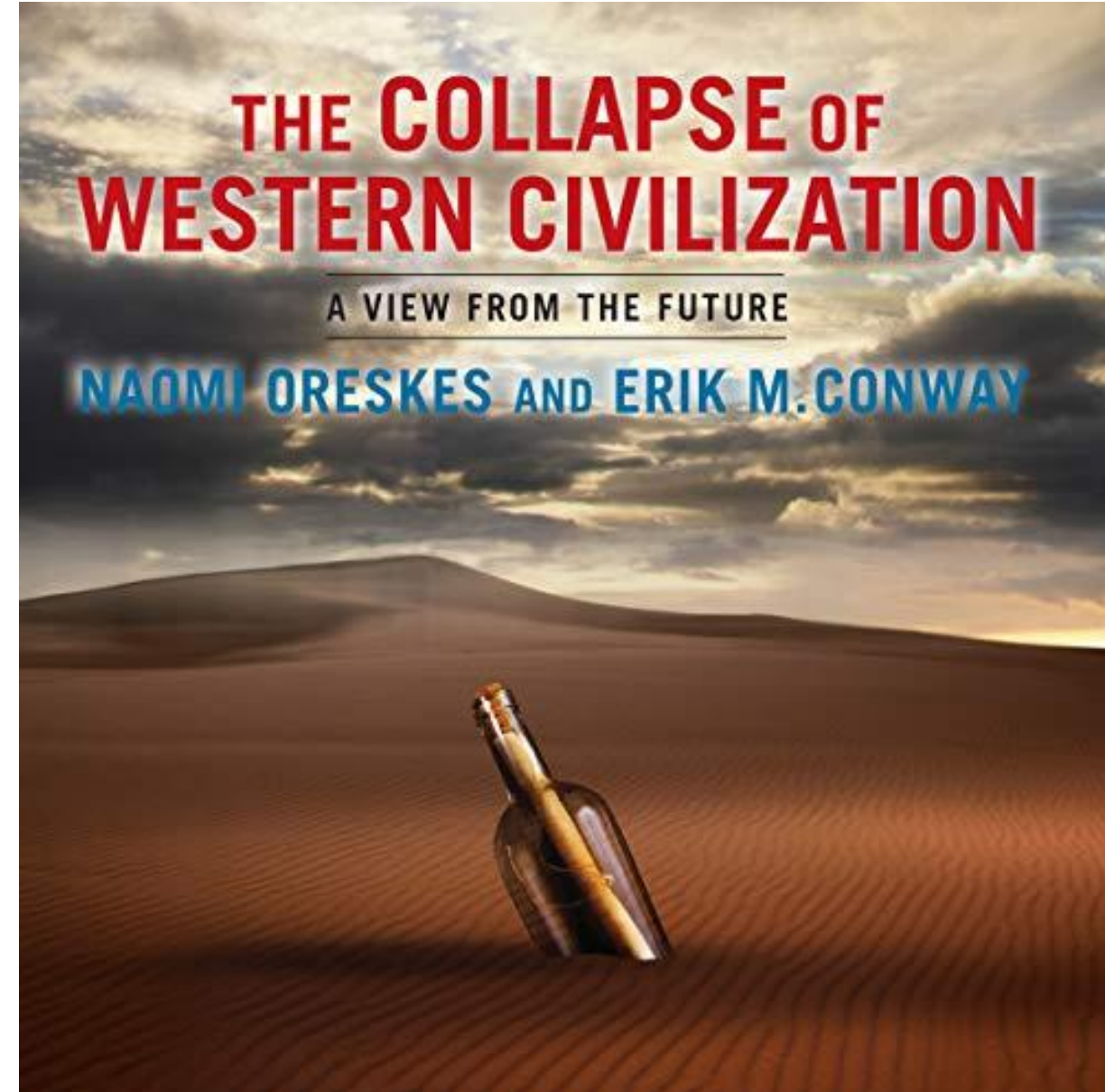
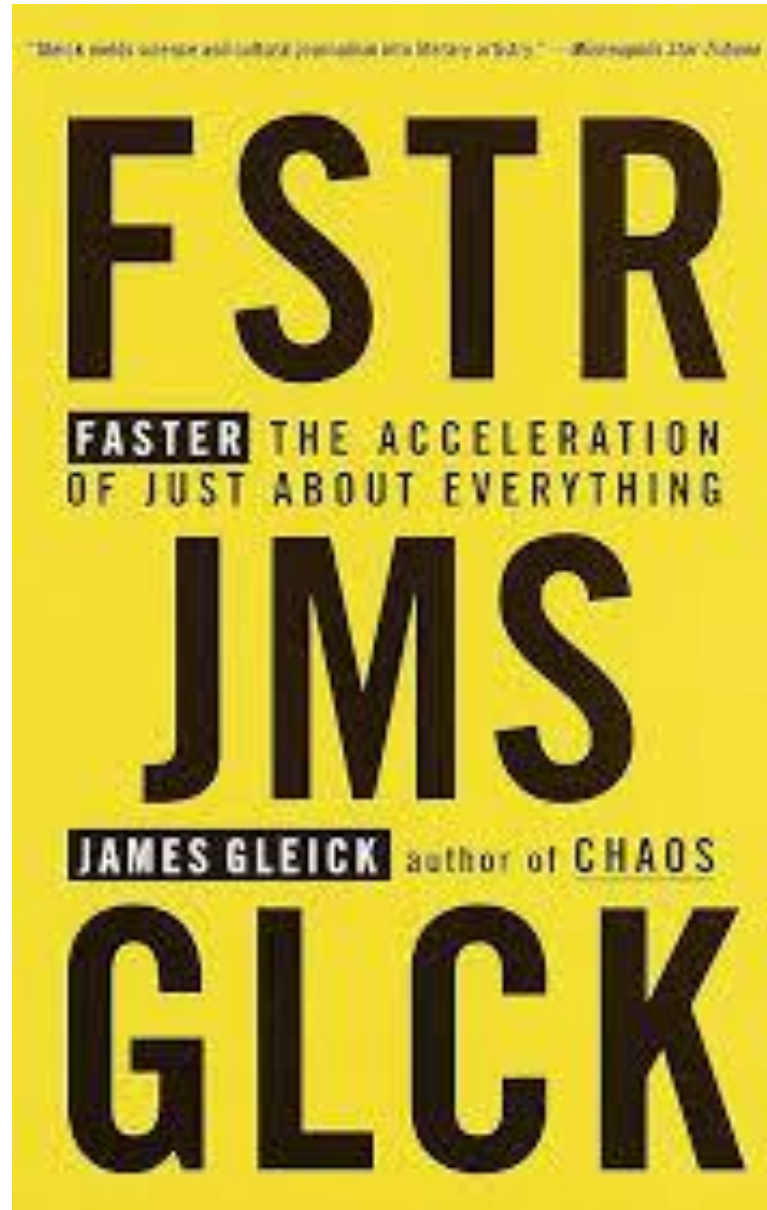


Agaricomycetes

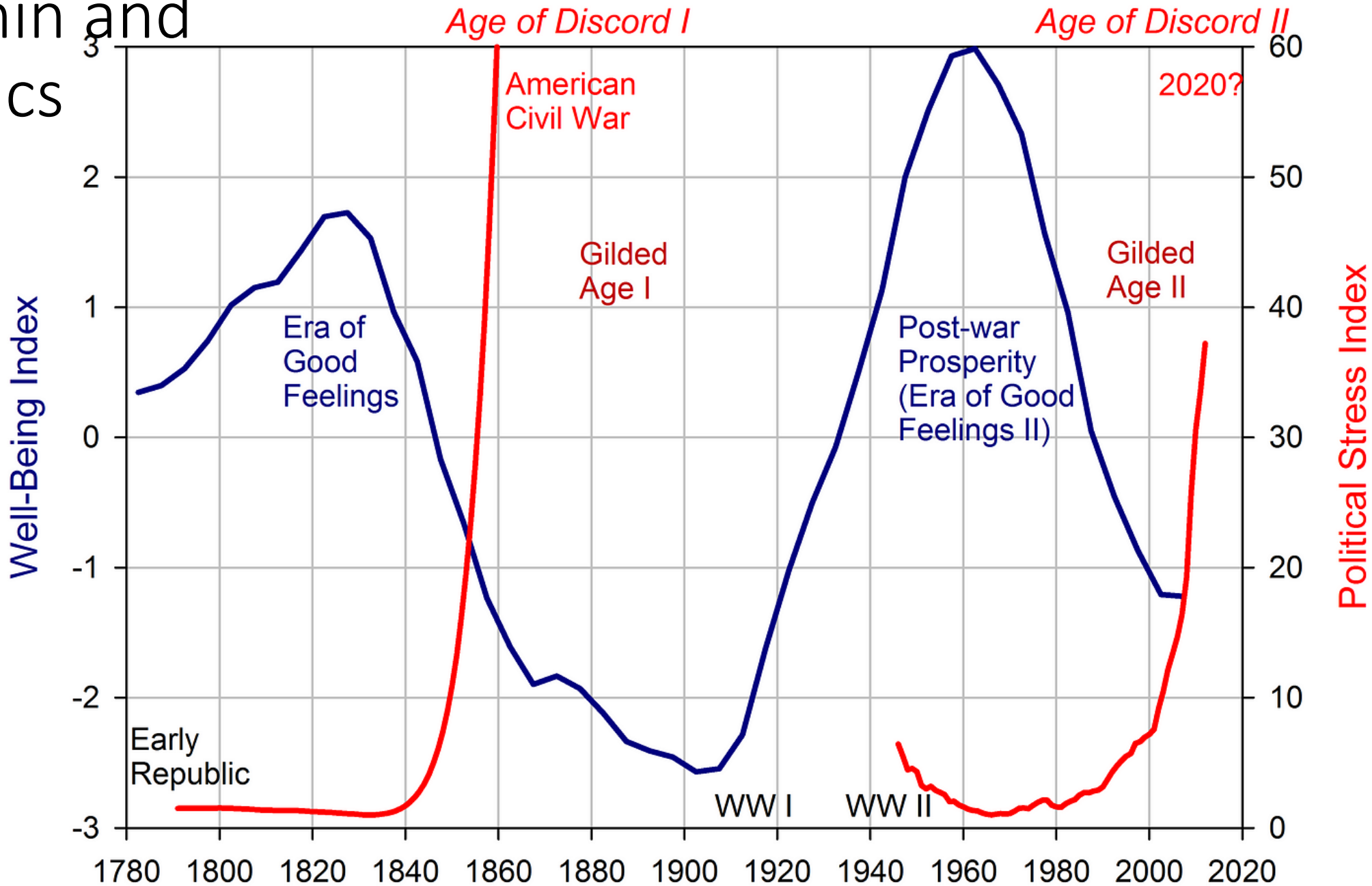


Artist's reconstruction of a forest during the Carboniferous period. From 'Science for All' by Robert Brown (London, c1880). Illustration by World History Archive, Alamy

Are
things
going
off the
rails?



Peter Turchin and Cliodynamics



Is there one Modernity? Is this causing the Technosphere?

“the continuous acceleration of social change”

The frenetic standstill
Time as granularized



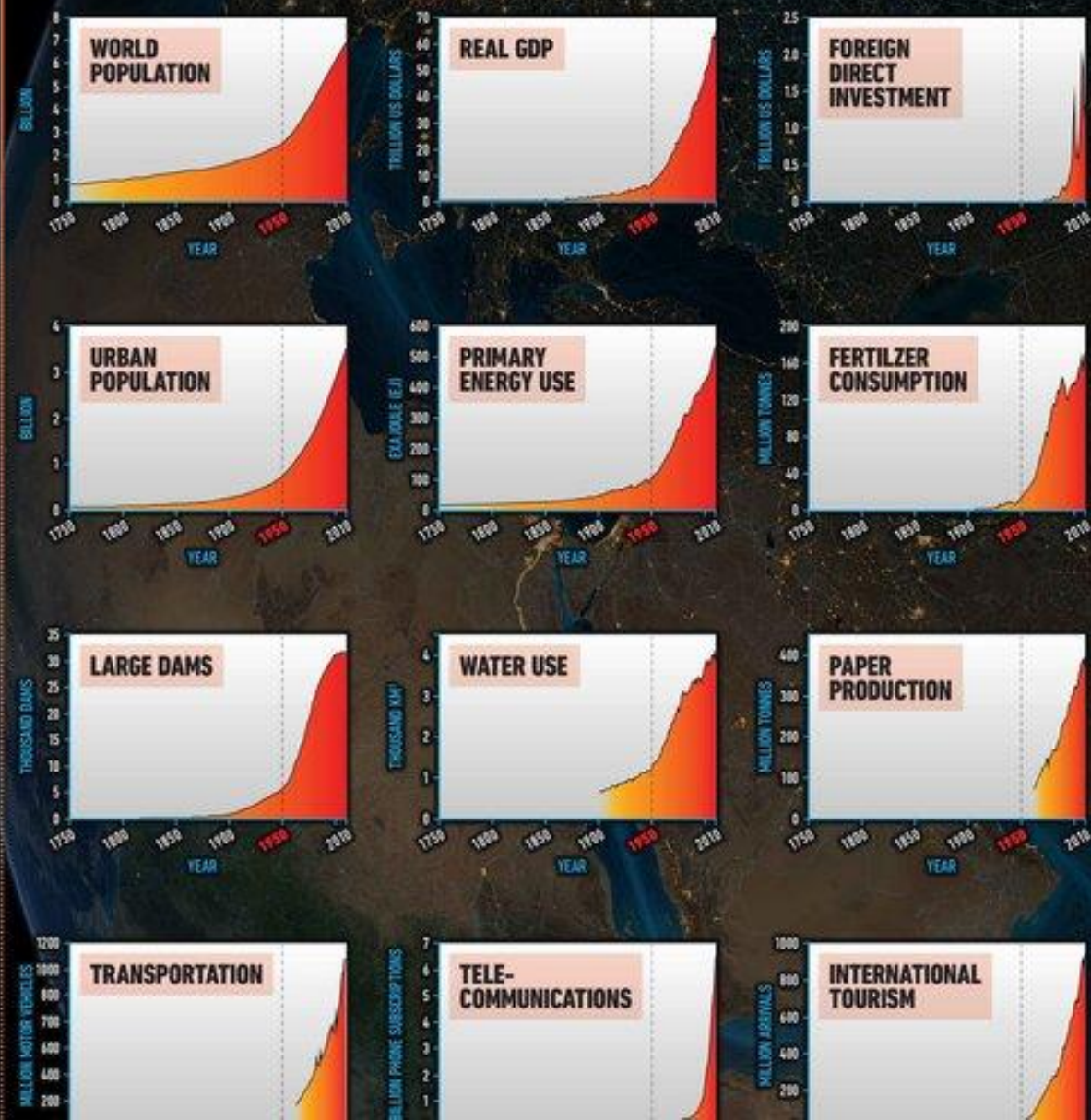
Hartmut Rosa
University of Jena

→ **Claim:** Social Acceleration is Modernity's “Universal”
It cannot be stopped by individuals

Everything must accelerate

The Great Acceleration

SOCIO-ECONOMIC TRENDS



EARTH SYSTEM TRENDS





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[Home](#) > [Themes](#) > [Great Acceleration Observatory](#)

[MPI GEA Profile](#)

[Core Research Themes](#)

[Publications](#)

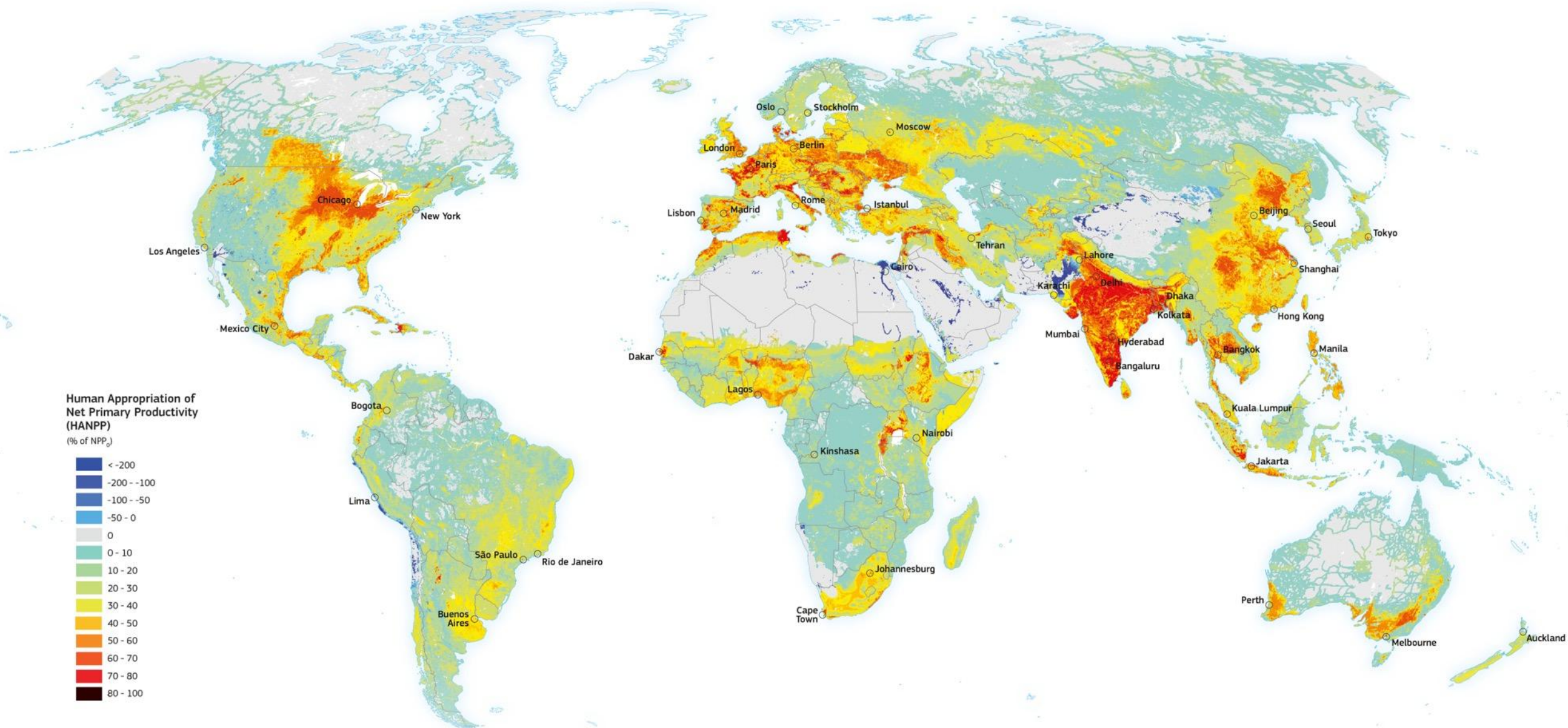
Great Acceleration Observatory

Human impacts on the Earth system have been ever-expanding and strengthening evolution. The resulting 'Great Acceleration' has become *the* signature trajectory we bring together in a concerted effort of the international community to identify for what is, effectively, a long acceleration process? What do specific spatial and responsibilities and inequalities?

The Biosphere

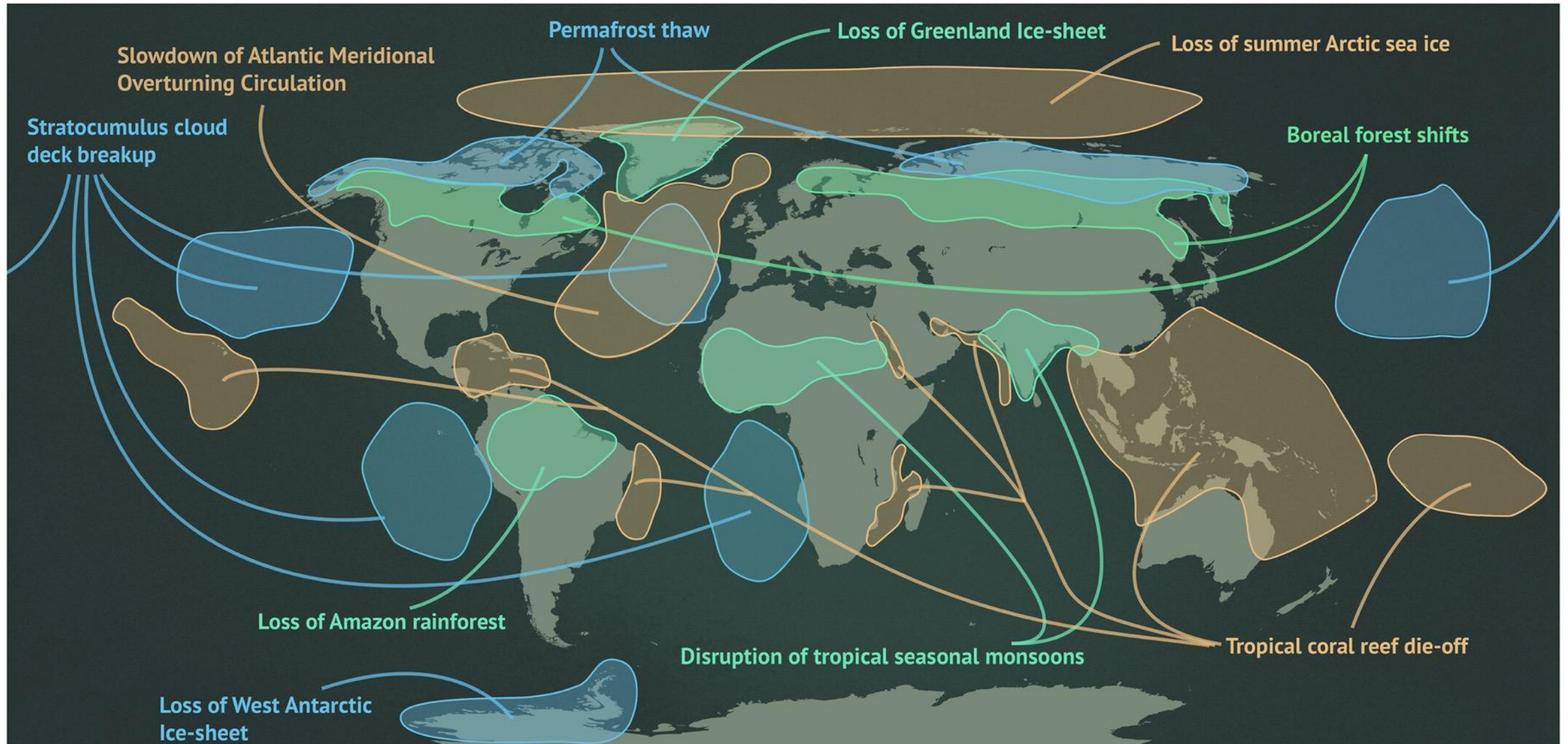
- What does the biosphere produce? What does it regulate?
- What metrics do we use to measure the biosphere?
 - NPP
 - Carbon
 - Trophic complexity
 - Biodiversity indices
 - Energy Throughputs
 - Biogeochemical outputs and cycling rates
 - Decomposition rates and complexity

What limits the Biosphere?



Positive values indicate regions where human activity has reduced the actual annual NPP below the potential natural NPP of undisturbed natural vegetation under prevailing environmental conditions. Negative values indicate areas (in blue) where actual NPP exceeds the natural potential to generate NPP because of human intervention. These are primarily areas in the arid zones with intense irrigated agriculture.

Seaver Wang's Tipping Elements



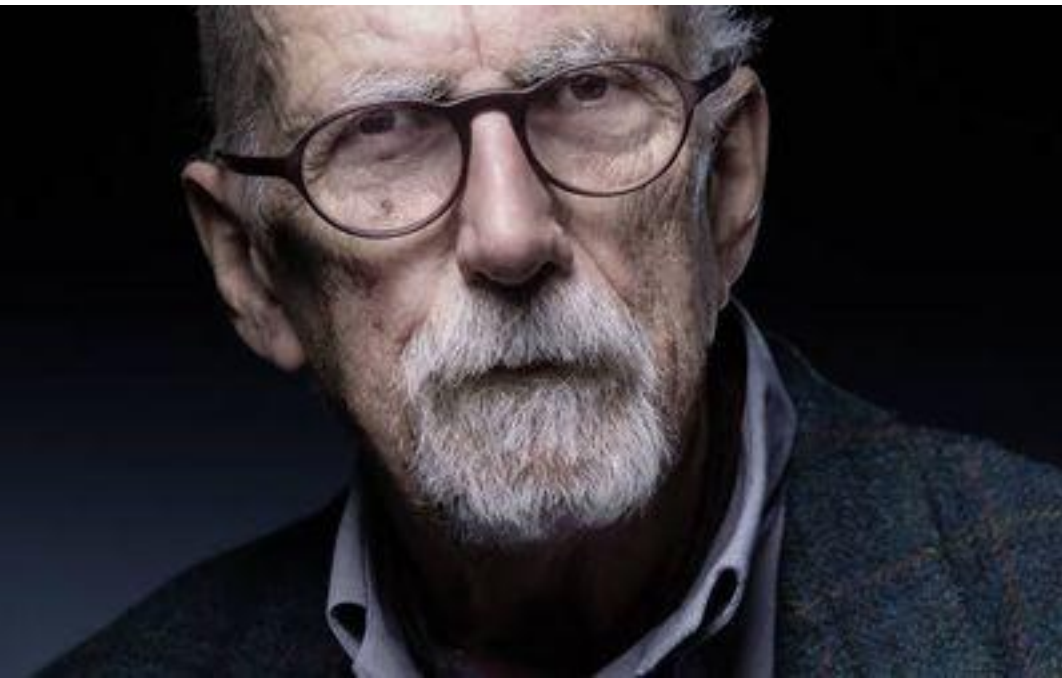
Nonlinear!



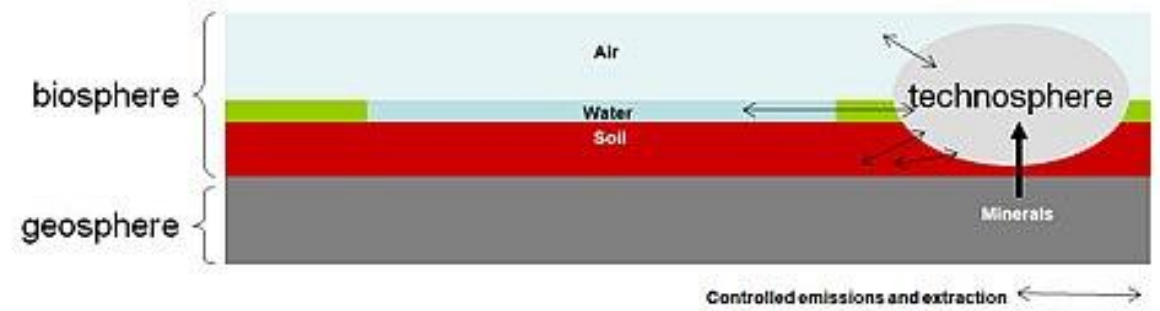
The Technosphere

This is gonna remind you of
Actor Network Theory

Bruno Latour



The Technosphere: A new Earth geophysical system



the totality of human artifice, the earth's “archaeological strata,” including landscapes, technologies, and material culture.

“there’s now enough concrete on the planet to produce a 2mm thick, full-scale replica of Earth, and enough plastic to completely wrap that replica in cling film.”

Gabrielle Hecht,
Stanford History



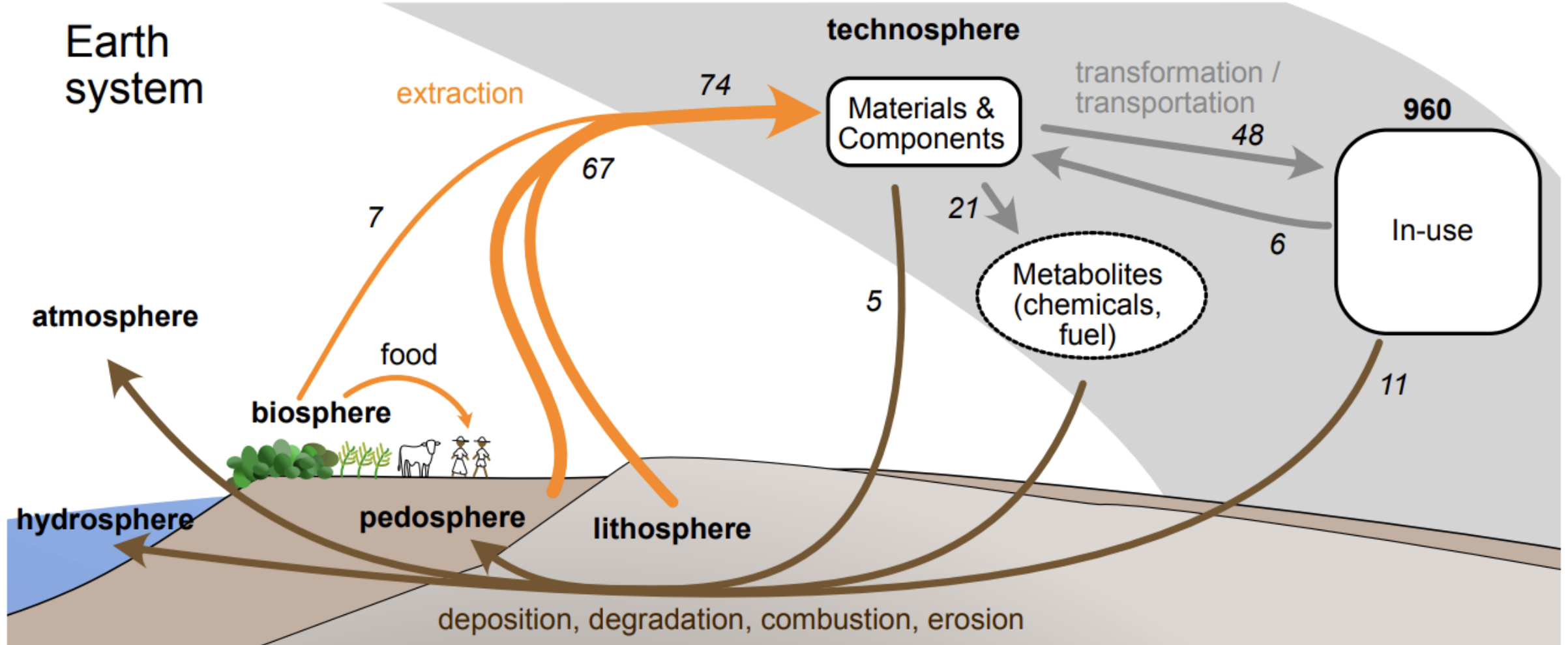
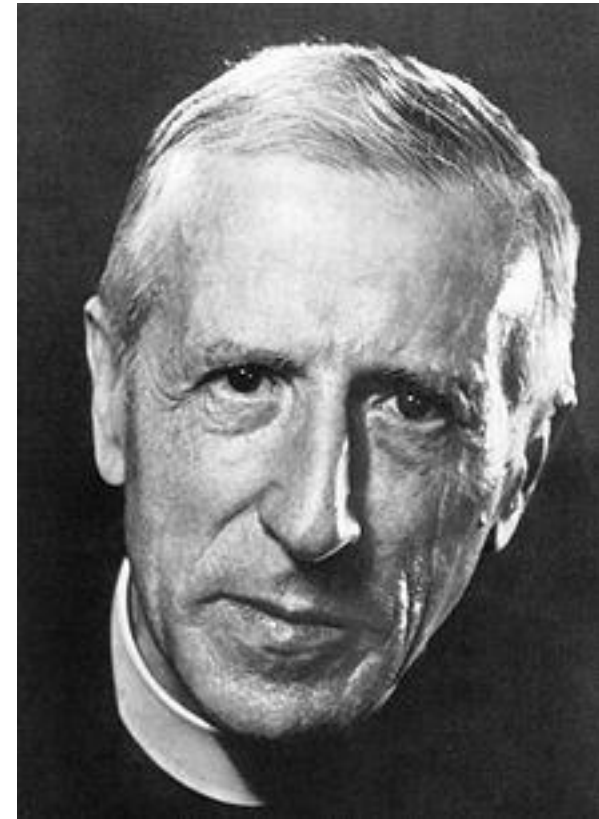


Figure 1. Schematic of the Earth system including the technosphere. Italicized numbers show fluxes in Gty^{-1} , bold number shows the in-use mass in Gt as estimated by Krausmann et al. 2018 for the year 2015.

Vitalism



Pierre Teilhard de Chardin

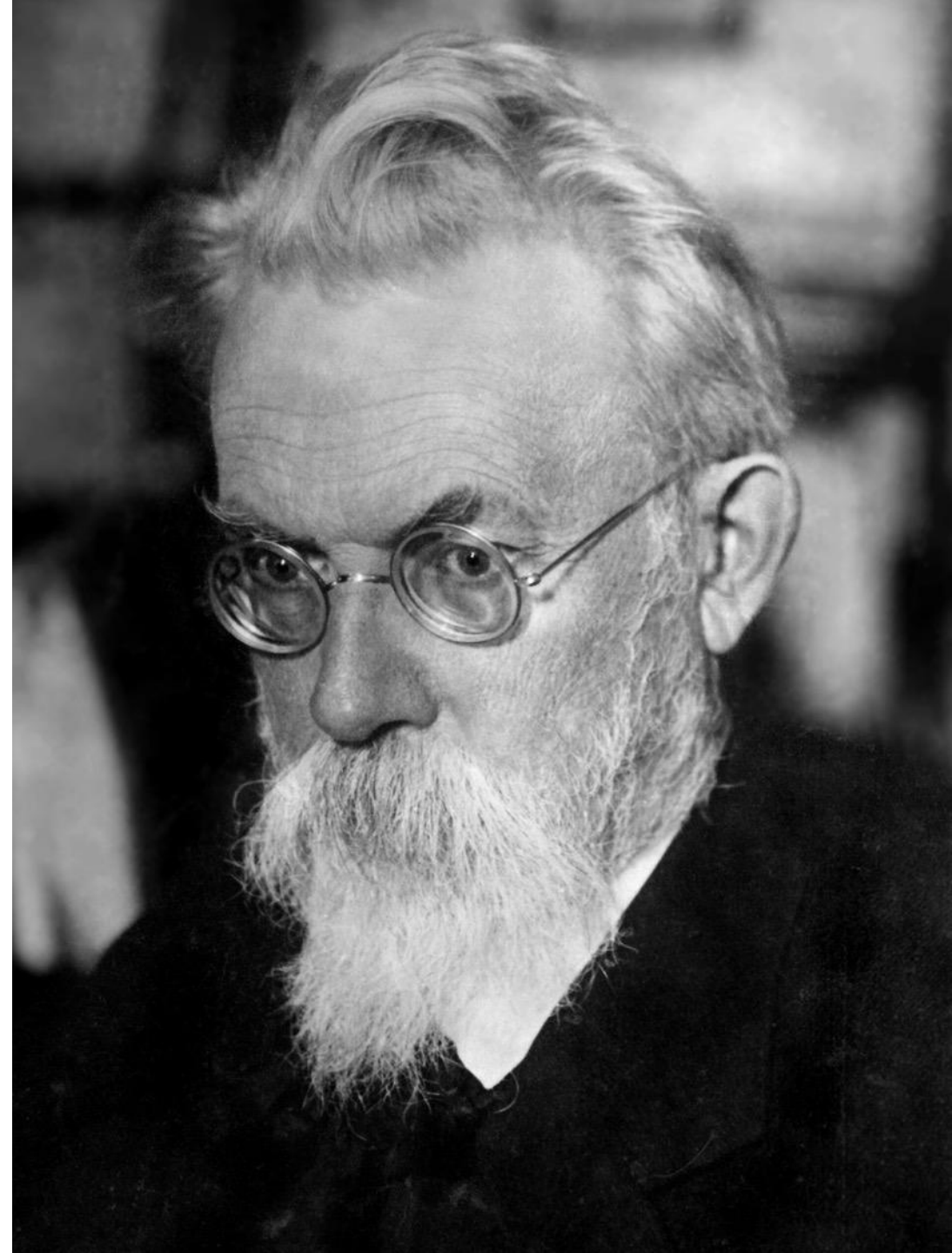
Vladimir Vernadsky

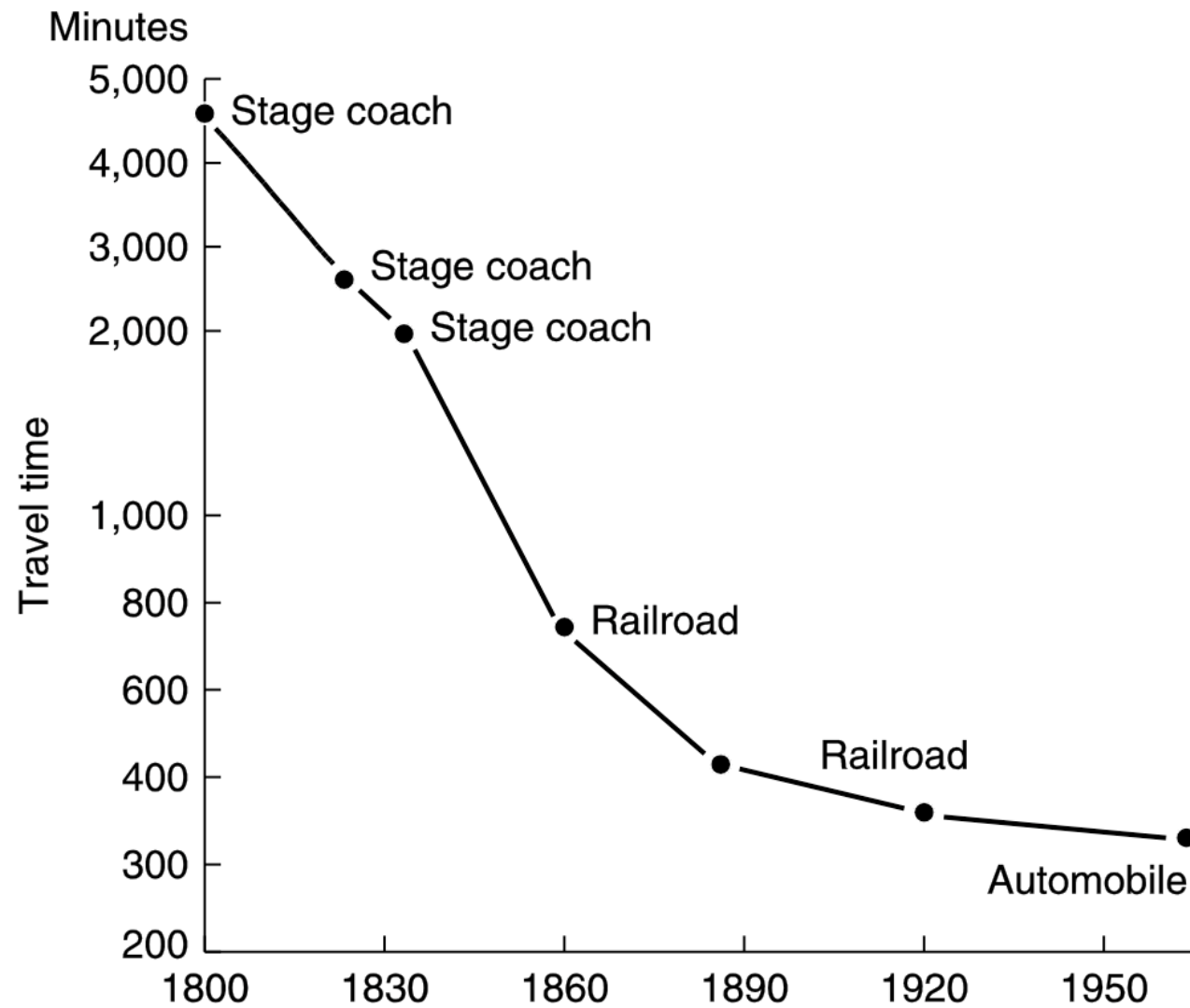
popularized the idea of
The Biosphere Eduard Suess 1875

Developed the idea of
The noösphere
("sphere of reason") from de Chardin

"...a new geological phenomenon on our planet. In it for the first time, man becomes a large-scale geological force."

Carbon, genes (information), energy, nitrogen...

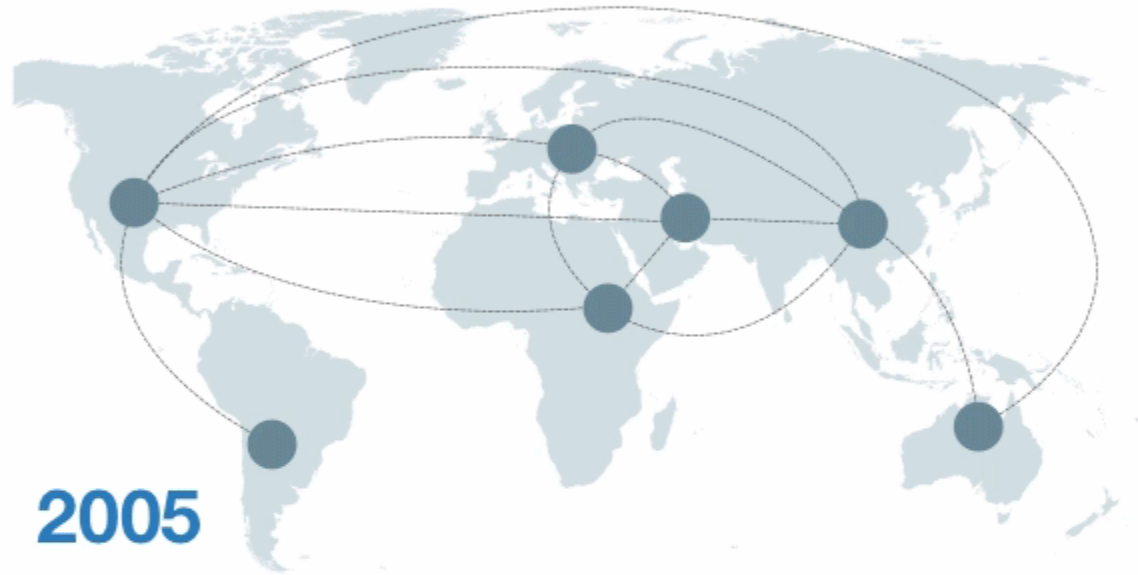




Space-time convergence between Boston and New York,
showing different modes of transportation. (Fig 9.3)

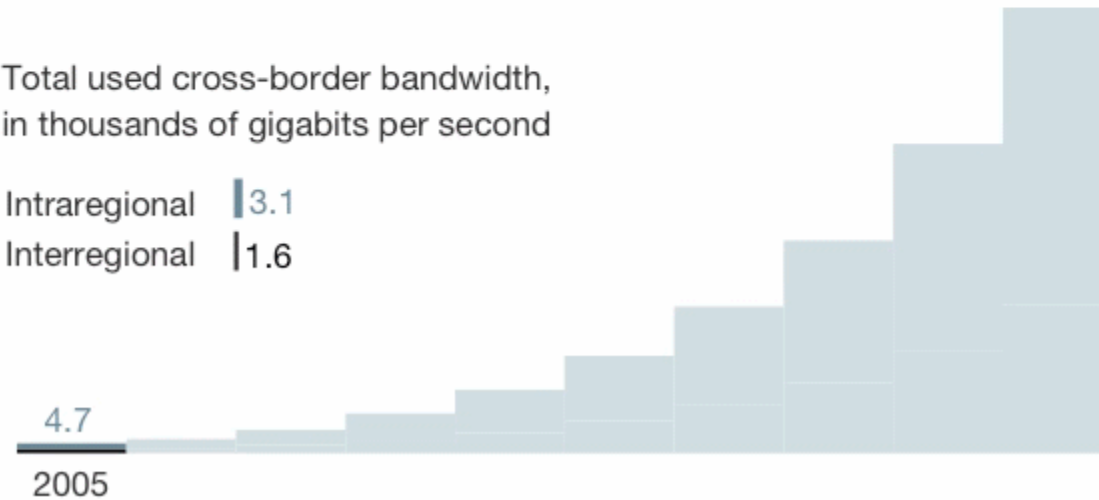
Global flow of data and communication

Used cross-border interregional bandwidth, in gigabits per second



Total used cross-border bandwidth,
in thousands of gigabits per second

Intraregional | 3.1
Interregional | 1.6



Peter Haff defines the Technosphere

a human-made sphere that displays three important characteristics:

- ***autonomy*** from human action,
- ***global integration***, and
- a ***systematic*** character.

The technosphere is an emergent super-organism with its own teleology, desires and needs



Six Rules of the Technosphere

(1) the rule of inaccessibility

large components of the Technosphere cannot directly influence the behavior of their human parts;

(2) the rule of impotence

most humans cannot significantly influence the behavior of large technological systems

(3) the rule of control

a human cannot control a technological system that expresses a larger number of behaviors than he himself

(4) the rule of reciprocity

a human can interact directly only with systems his own size

(5) the rule of performance

most humans must perform at least some tasks that support the metabolism of the Technosphere

(6) the rule of provision

the Technosphere must provide an environment for most humans conducive to their survival and function.

The Technosphere

- The interlinked set of communication, transportation, bureaucratic and other systems that act to metabolize fossil fuels and other energy resources
- It has global extent, exhibits large-scale appropriation of mass and energy resources
- it shows a tendency to co-opt for its own use information produced by the environment
- It is autonomous
- Unlike the older paradigms, the Technosphere has not yet evolved the ability to recycle its own waste stream.
- Humans are 'parts' of the Technosphere – subcomponents essential for system function. Viewed from the inside by its human parts, the Technosphere is perceived as a derived and controlled construct. Viewed from outside **as a geological phenomenon**, the Technosphere appears as a quasi-autonomous system whose dynamics constrain the behavior of its human parts.

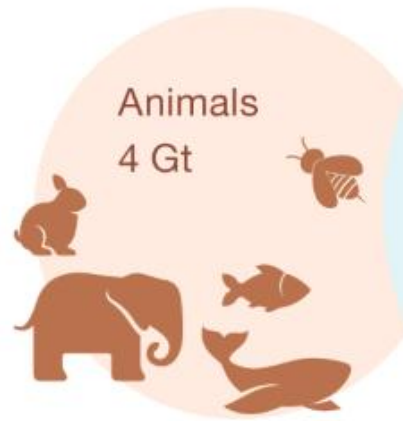
The Technosphere

What does the Technosphere produce? Money?

How can we measure the Technosphere?

- Infrastructure
- Information Flow/Processing
- Material Output (e.g. C, N, O)
- Energy Throughput
- Economic network complexity/tortuosity
- Material cycles (beyond C,N,O)
- Autonomy: self-regulation, automation, and unintended emergent behaviors
 - AI decision-making

We can map all of these things!



Living biomass



Human-made mass



In 2020, the amount of anthropogenic mass exceeded the weight of **all global living biomass**.

As humans continue to dominate Earth, questions surrounding our material output are increasing. We break down the composition of all human-made materials and the rate of their production.

1120 Gt

Global Biomass

The dry weight of all life on Earth is comprised of plants, animals, bacteria, fungi, protists, archaea, and viruses, too.

This study converted carbon weight of all life on Earth to dry weight by a factor of 2.25

All humans make up **~0.01%** of global living biomass.

Humans

1154 Gt

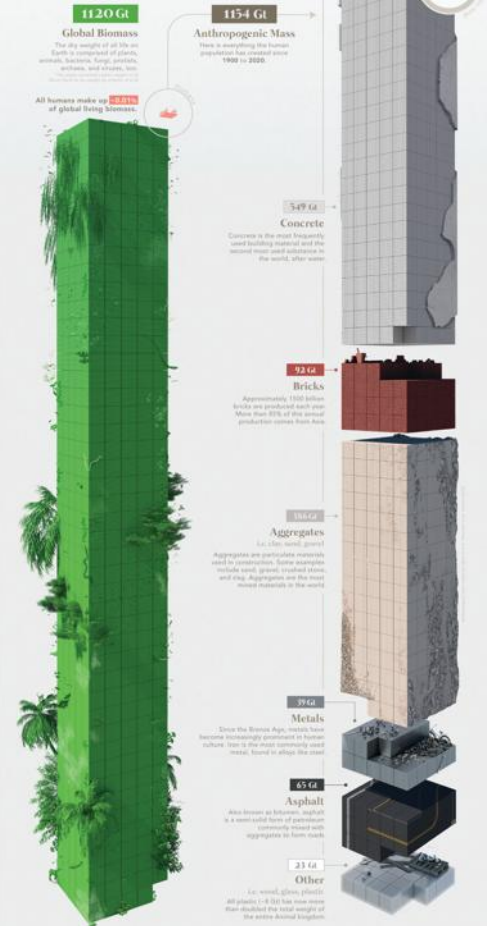
Anthropogenic Mass

Here is everything the human population has created since 1900 to 2020.

1 Gigaton, Gt (1 thousand million metric tons)

Visualizing the Scale of Anthropogenic Mass

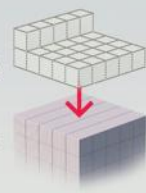
In 2020, the amount of anthropogenic mass exceeded the weight of **all global living biomass**. As humans continue to dominate Earth, questions surrounding our material output are increasing. We break down the composition of all human-made materials and the rate of their production.



The Accumulation of Anthropogenic Mass

The current rate of accumulation for human-made mass is approximately 30 Gt of mass per year.

This is equal to each person on Earth producing their own weight in human-made mass every week.



As accumulation rates increase, the amount of human-made mass is predicted to almost triple the total amount of global living biomass by 2040.

These trends highlight the alarming speed and volume in which human contributions are impacting the world.

Resolving the Technosphere

Eric Galbraith¹, Abdullah-Al Faisal¹, Tanya Matitia¹, William Fajzel¹, Ian Hatton¹, Helmut Haberl²,
Fridolin Krausmann², and Dominik Wiedenhofer²

¹Earth and Planetary Sciences, McGill University, Montreal, Canada

²Institute of Social Ecology, BOKU University, Vienna, Austria

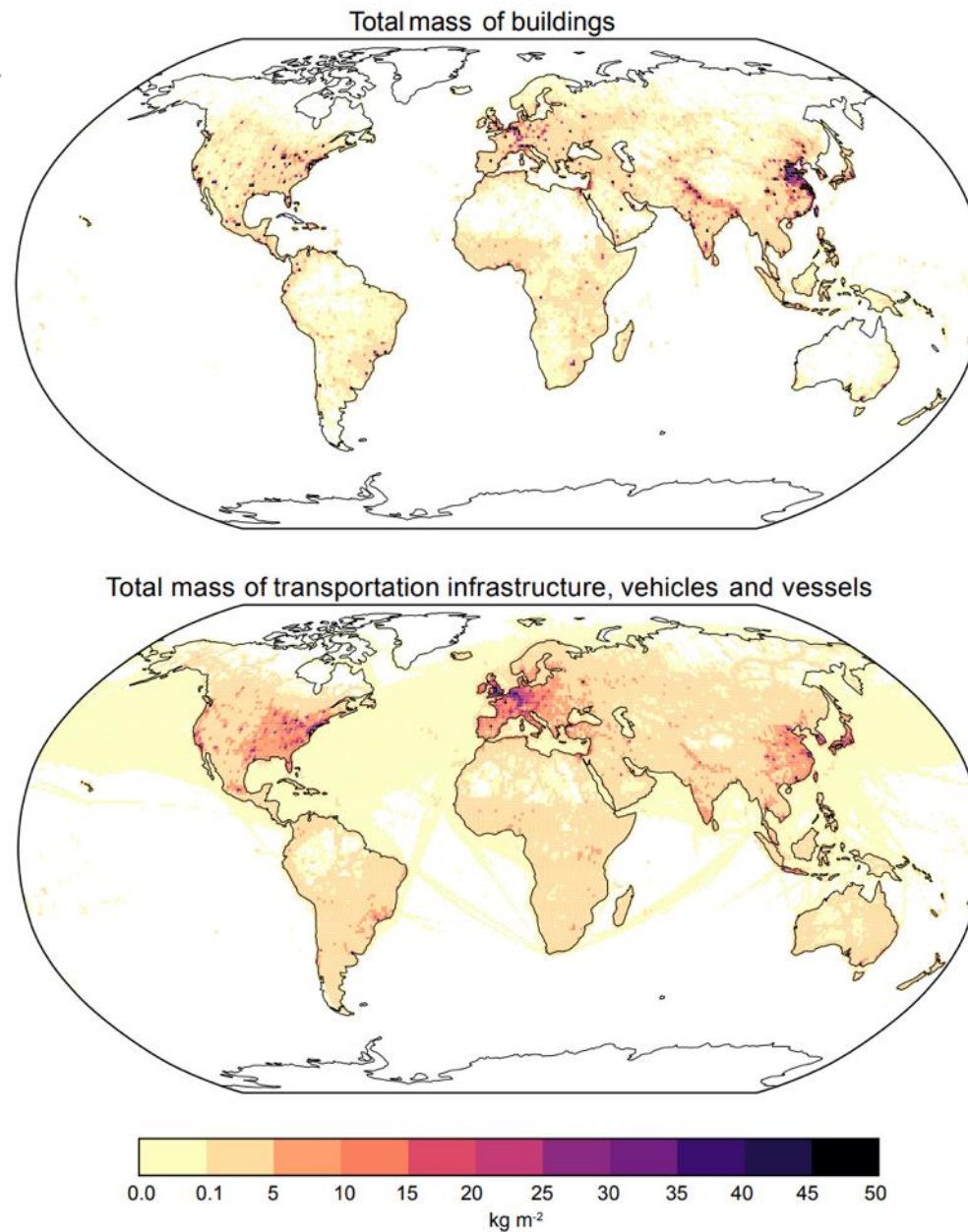
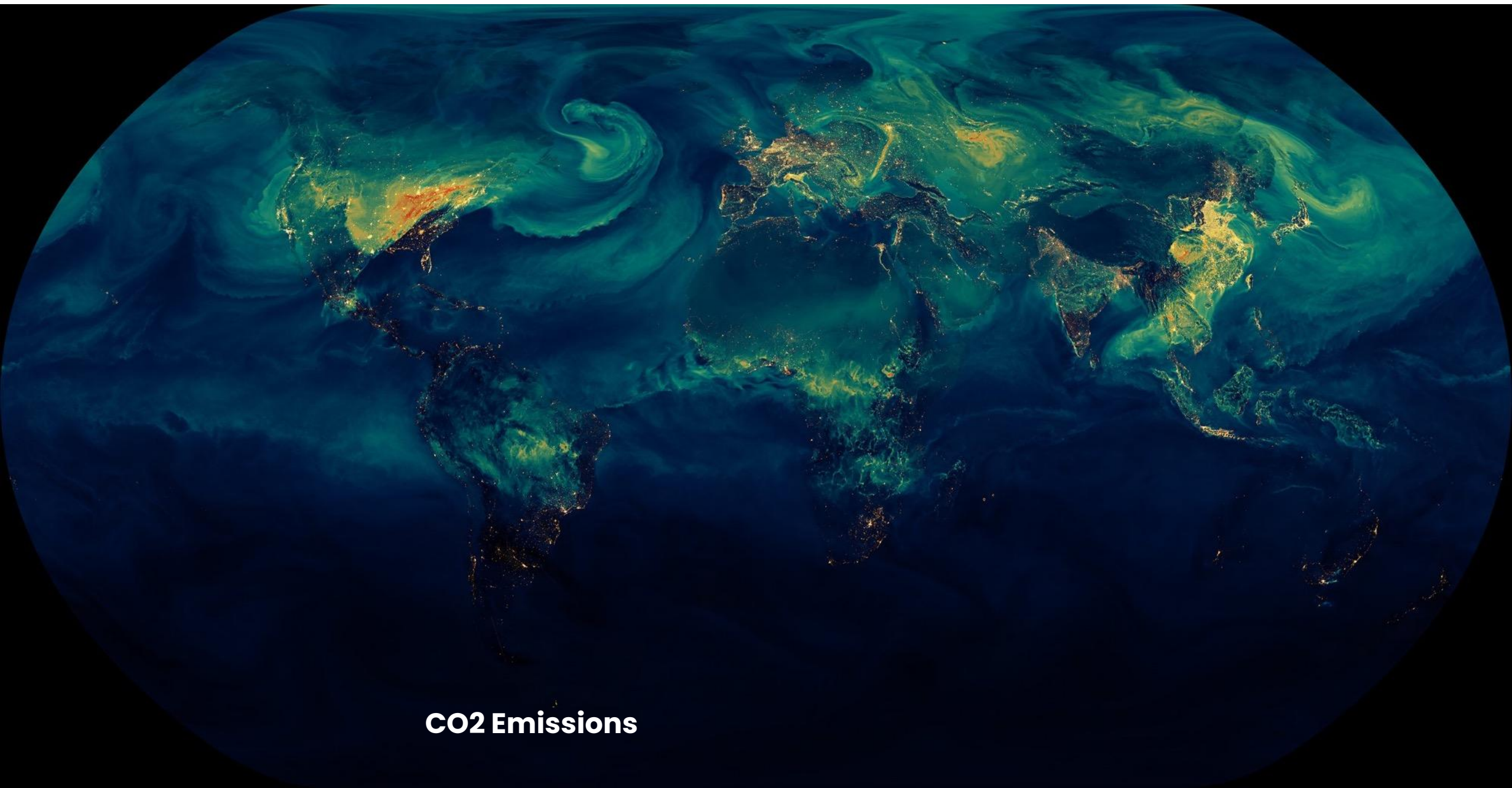
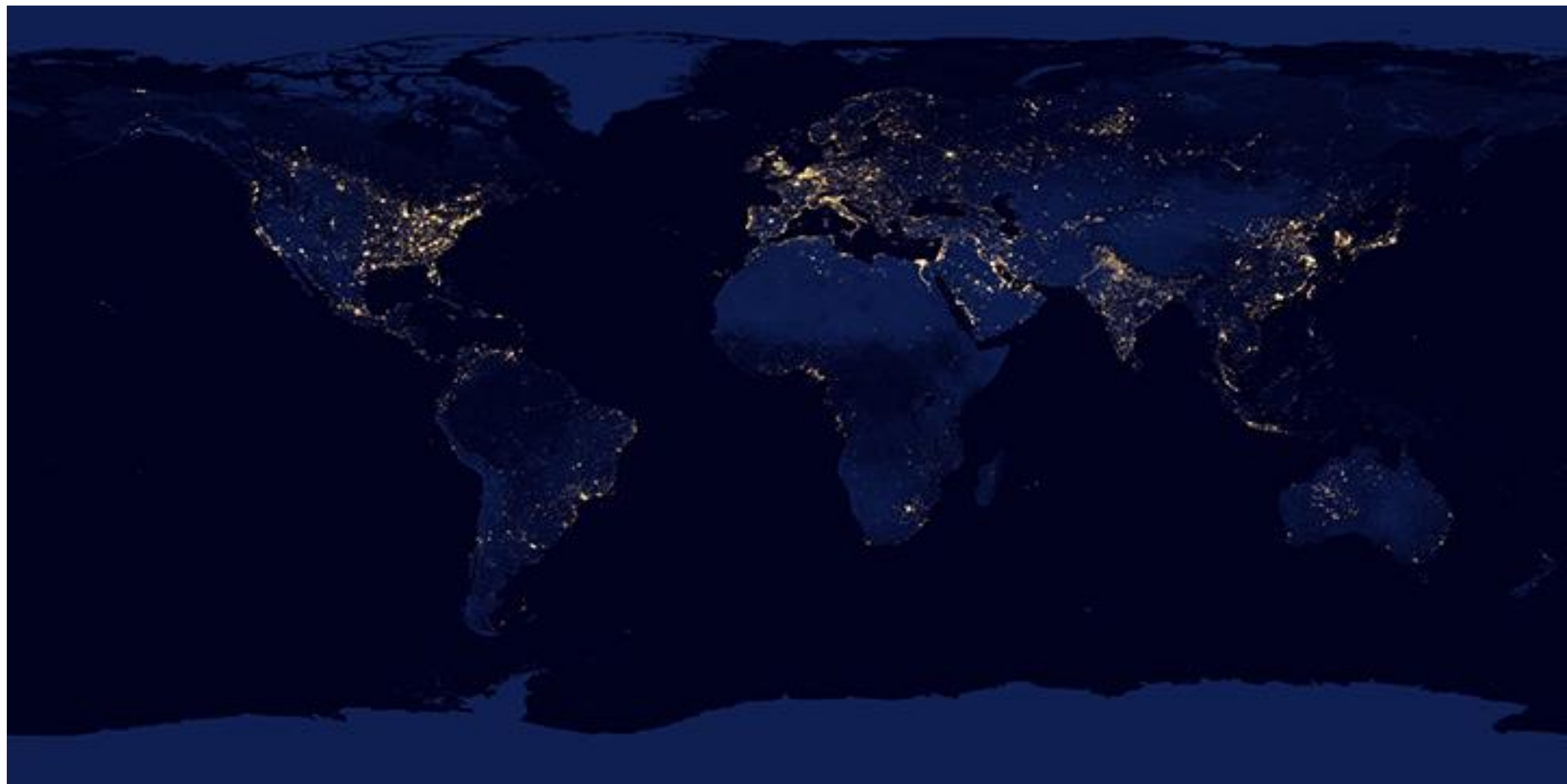
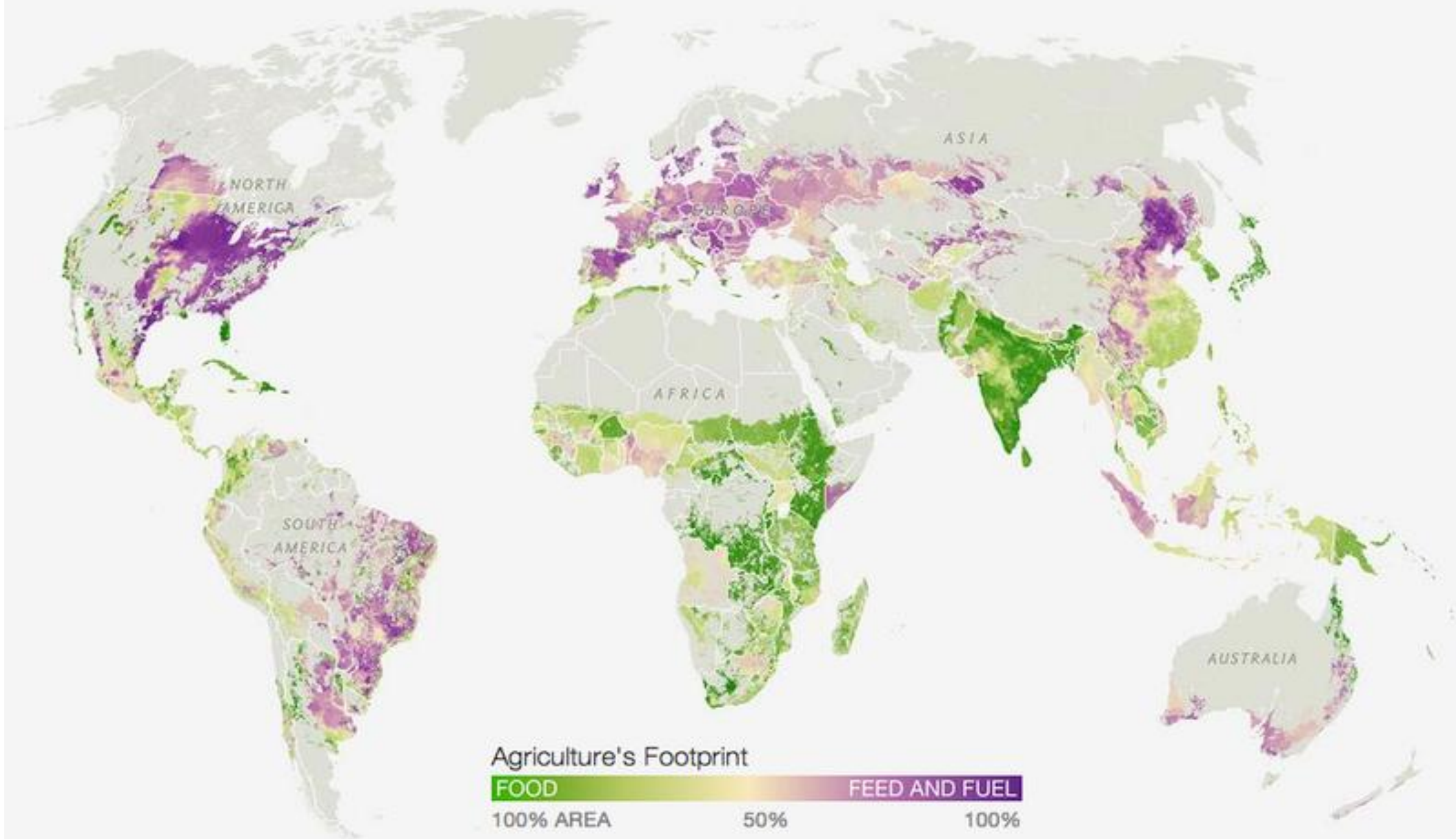


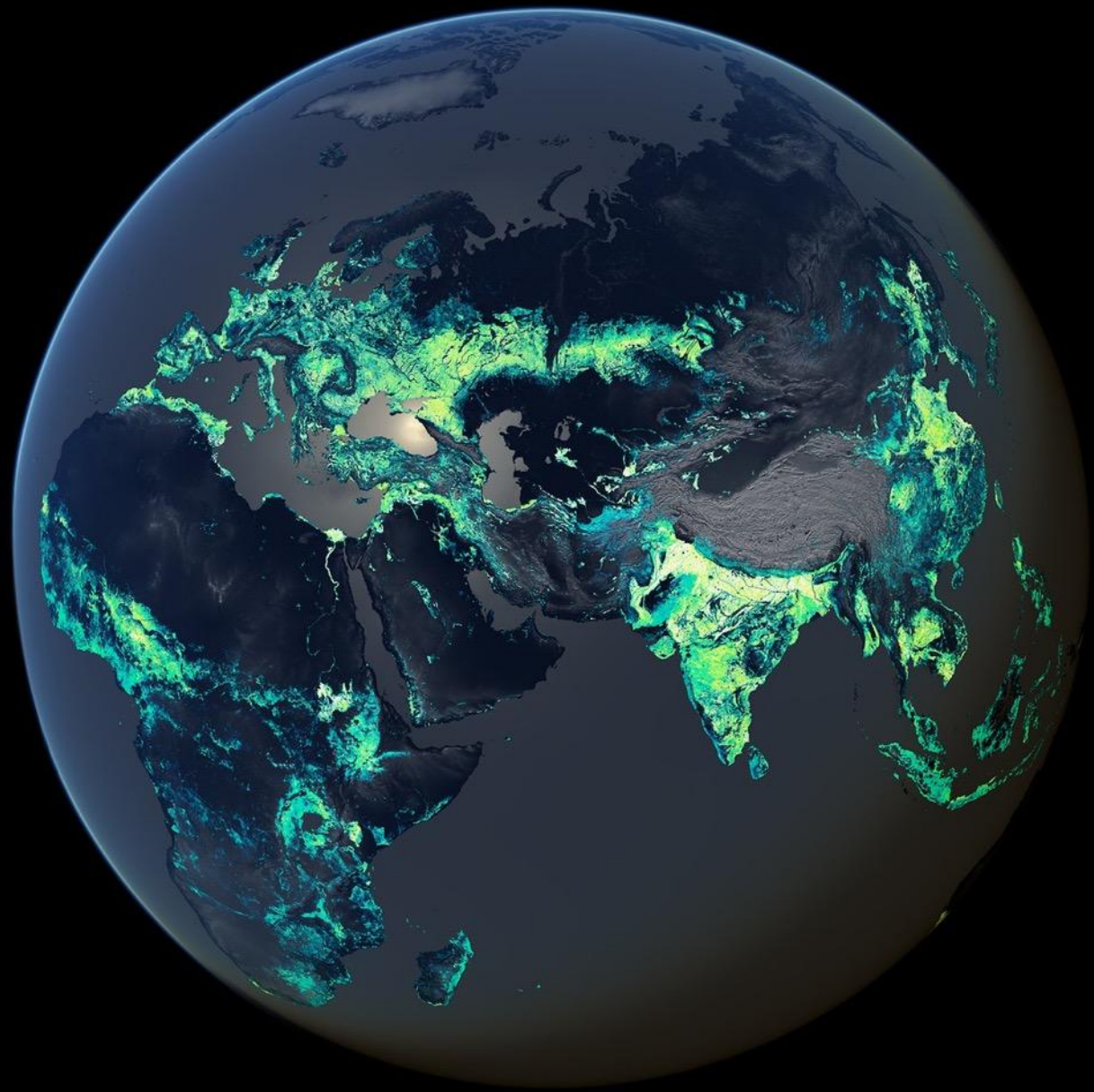
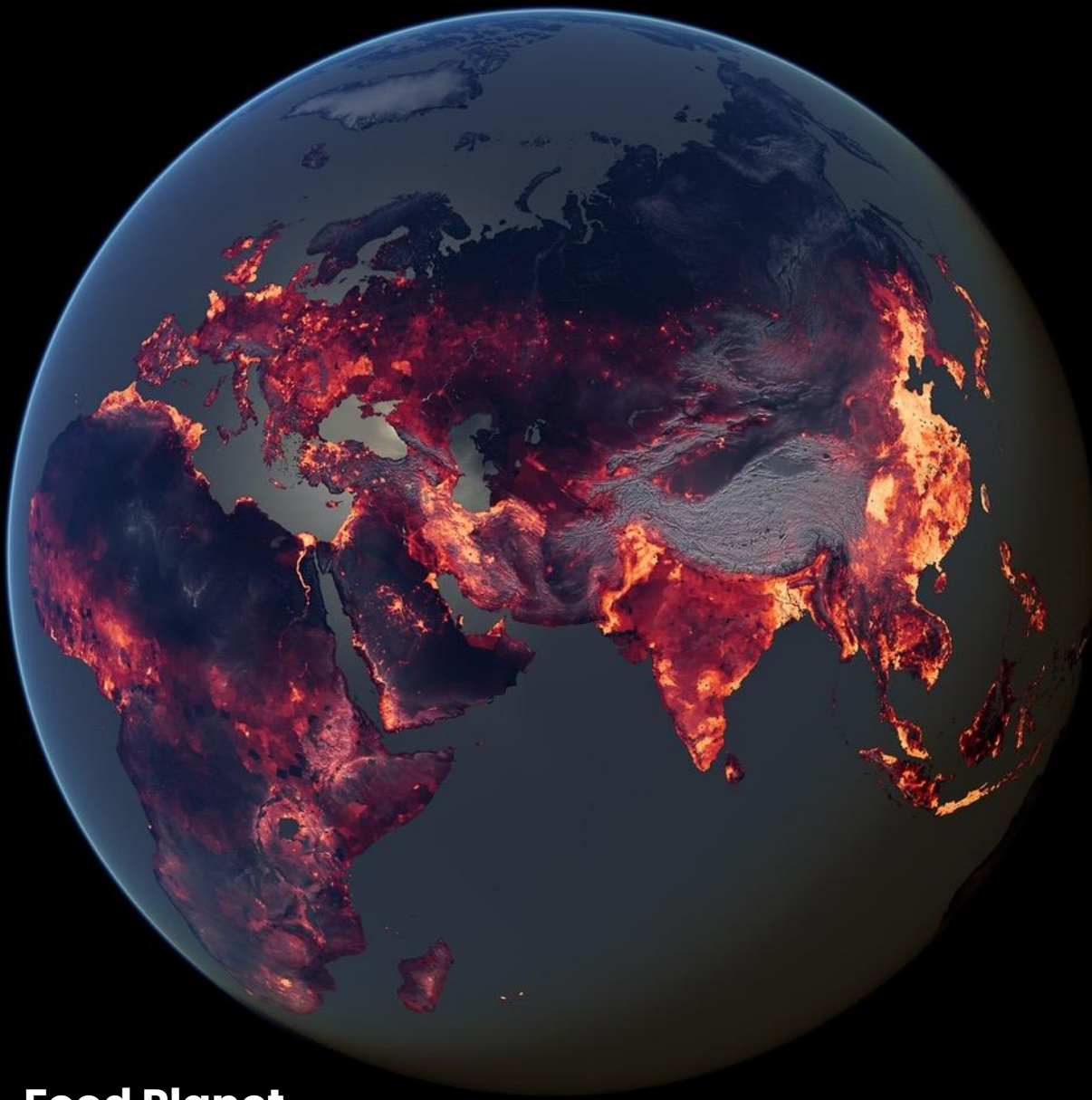
Figure 3. Spatial distribution of the two largest components of the technosphere by mass, at 1-degree resolution. Note that the palest yellow colour shows very low values, less than 0.1 kg m^{-2} , and a lower threshold of 0.001 kg m^{-2} was used, below which the area is white.



CO2 Emissions







Food Planet

The left globe displays the vast expanse of **croplands**, while the right globe captures the spread of pasture lands.

Source: [EarthStat](#)



Layers

Map

Satellite



Results from time-series analysis of Landsat images characterizing forest extent and change.

Trees are defined as vegetation taller than 5m in height and are expressed as a percentage per output grid cell as '2000 Percent Tree Cover'. 'Forest Cover Loss' is defined as a stand-replacement disturbance, or a change from a forest to non-forest state, during the period 2000–2023. 'Forest Cover Gain' is defined as the inverse of loss, or a non-forest to forest change entirely within the period 2000–2012. 'Forest Loss Year' is a disaggregation of total 'Forest Loss' to annual time scales.

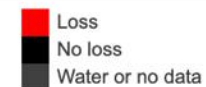
Reference 2000 and 2023 imagery are median observations from a set of quality assessment-passed growing season observations.

To share location copy URL.

[Download the data.](#)

☒ Data Products

Forest Cover Loss 2000–2023



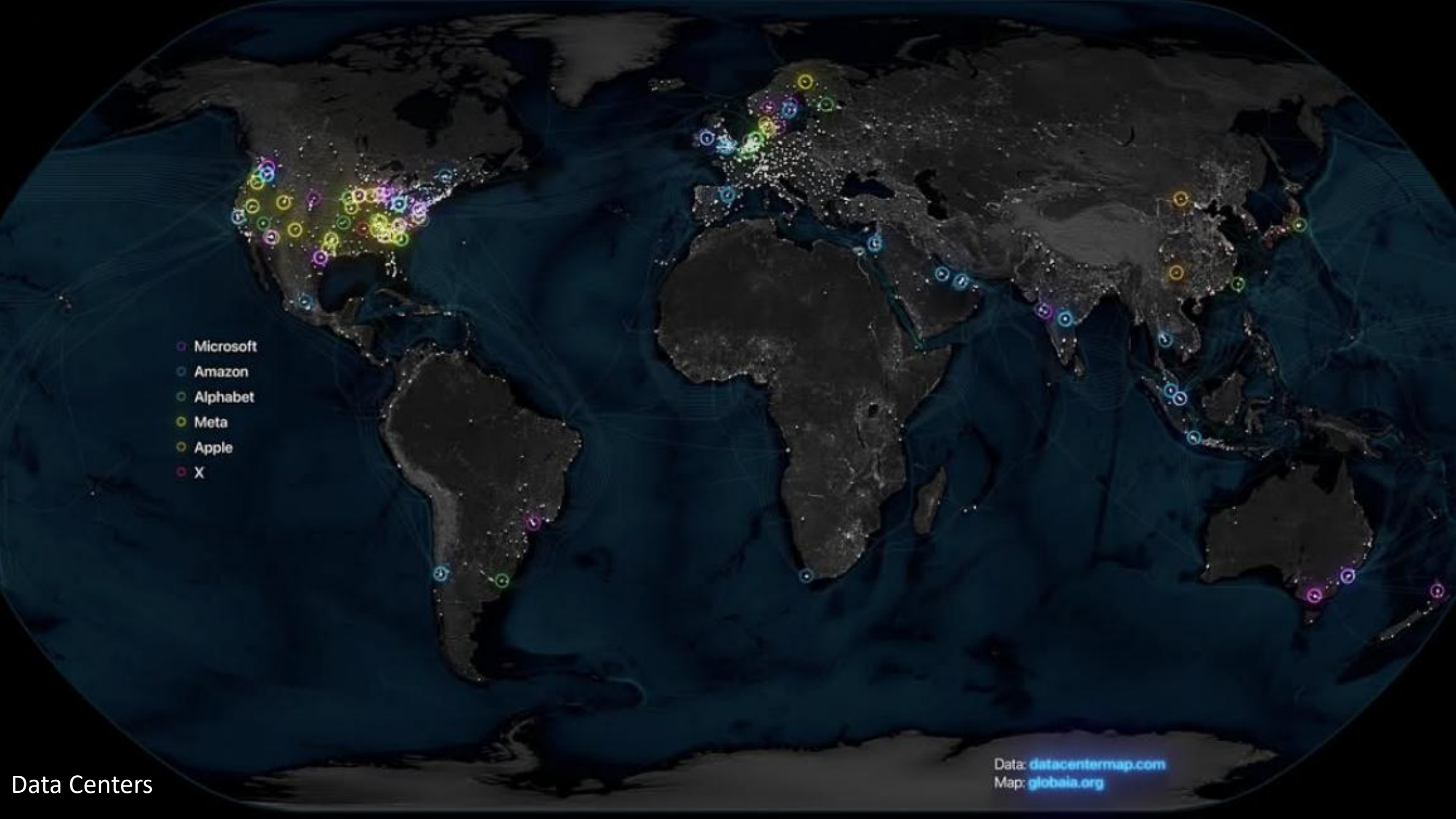
☐ Other Data Layers

2000 Percent Tree Cover

☐ Background Imagery

THE GLOBAL TRANSPORTATION SYSTEM





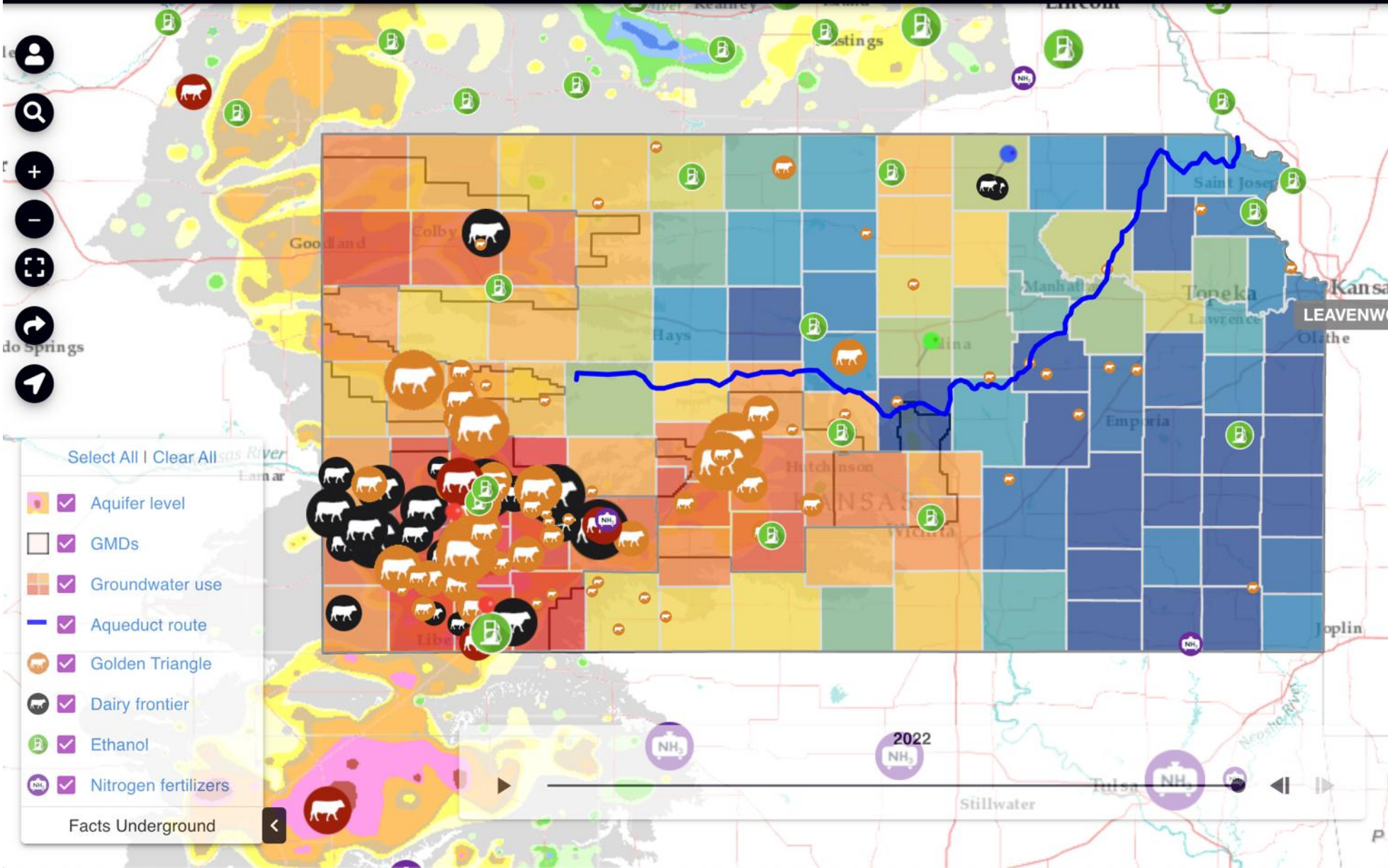
- Microsoft
- Amazon
- Alphabet
- Meta
- Apple
- X

Data Centers

Data: datacentermap.com
Map: globaia.org

Kansas Anthropocene

FACTS UNDERGROUND



Did human institutions lose power to the Technosphere?

Instead of forming streams and mountains and forests, the Earth is forming highways and airplanes and cities.

Our desire for novelty and status propels the Technosphere

Thus, climate change is merely a side effect of the Technosphere

- The Technosphere is seeking new sources of energy.
 - What limits the biosphere?
 - What limits the hydrosphere?
 - What limits the Technosphere?
-
- Who among you want a vacation on Mars? Why limit yourself if you can afford it?

So how can we map the Technosphere?

Measure and map

- material throughput

- metabolic rates

- information flows

- system complexity

- waste streams

More complex biotic webs are more stable

Climate Change is a side effect of the Technosphere

Technology can be seen as a geological phenomenon.

Other planets in our solar system did not develop intelligence yet

What are the prospects for the Technosphere going forward?

Where to look for Complexity?

Biodiversity → Information Diversity, Density, Flow

Genetic diversity → Algorithmic complexity, network density, IoT

Trophic Levels → Network Connections + Network Failures

Metabolic Rates → Financial and energy flows

Ecosystem Connectivity → Social connectedness, supply chain complexity

NPP and biogeochemical cycling → material throughput, recycling, waste

Mutation rate → innovation rate

Feedbacks → automation and AI autonomy

Residential Waste Audit - Material Breakdown
Small samples from all dorms (AM) and large sort of Brody trash (PM)
SLE Waste Audit

Commodity Type	Full Bin Weight	Empty Bin Weight	Material Weight
Cardboard #1	53 lbs.	31 lbs.	22 lbs.
Cardboard #2	50 lbs.	40 lbs.	10 lbs.
Cardboard #3	46 lbs.	35 lbs.	11 lbs.
Boxboard #1	66 lbs.	39 lbs.	27 lbs.
Boxboard #2	50 lbs.	40 lbs.	10 lbs.
Mixed Paper #1	54 lbs.	40 lbs.	14 lbs.
Mixed Paper #2	69 lbs.	53 lbs.	16 lbs.
Mixed Paper #3	69 lbs.	31 lbs.	38 lbs.
Mixed Paper #4	56 lbs.	34 lbs.	22 lbs.
Glass #1	35 lbs.	3 lbs.	32 lbs.
Glass #2	40 lbs.	2 lbs.	38 lbs.
Plastics (#1-2, 5)	77 lbs.	39 lbs.	38 lbs.
Plastics (#1-2, 5)	92 lbs.	34 lbs.	58 lbs.
Plastics (#1-2, 5)	62 lbs.	35 lbs.	27 lbs.
Plastics (#1-2, 5)	74 lbs.	39 lbs.	35 lbs.
Plastics (#1-2, 5)	62 lbs.	35 lbs.	27 lbs.
Plastics (#1-2, 5)	38 lbs.	33 lbs.	5 lbs.
Plastics (#1-2, 5)	74 lbs.	35 lbs.	39 lbs.
Plastics (#1-2, 5)	47 lbs.	34 lbs.	13 lbs.
Plastics (#1-2, 5)	81 lbs.	37 lbs.	44 lbs.
Other Plastics	47 lbs.	32 lbs.	15 lbs.
Metal (Assorted)	6 lbs.	2 lbs.	4 lbs.



Building the
Technosphere one
click at a time



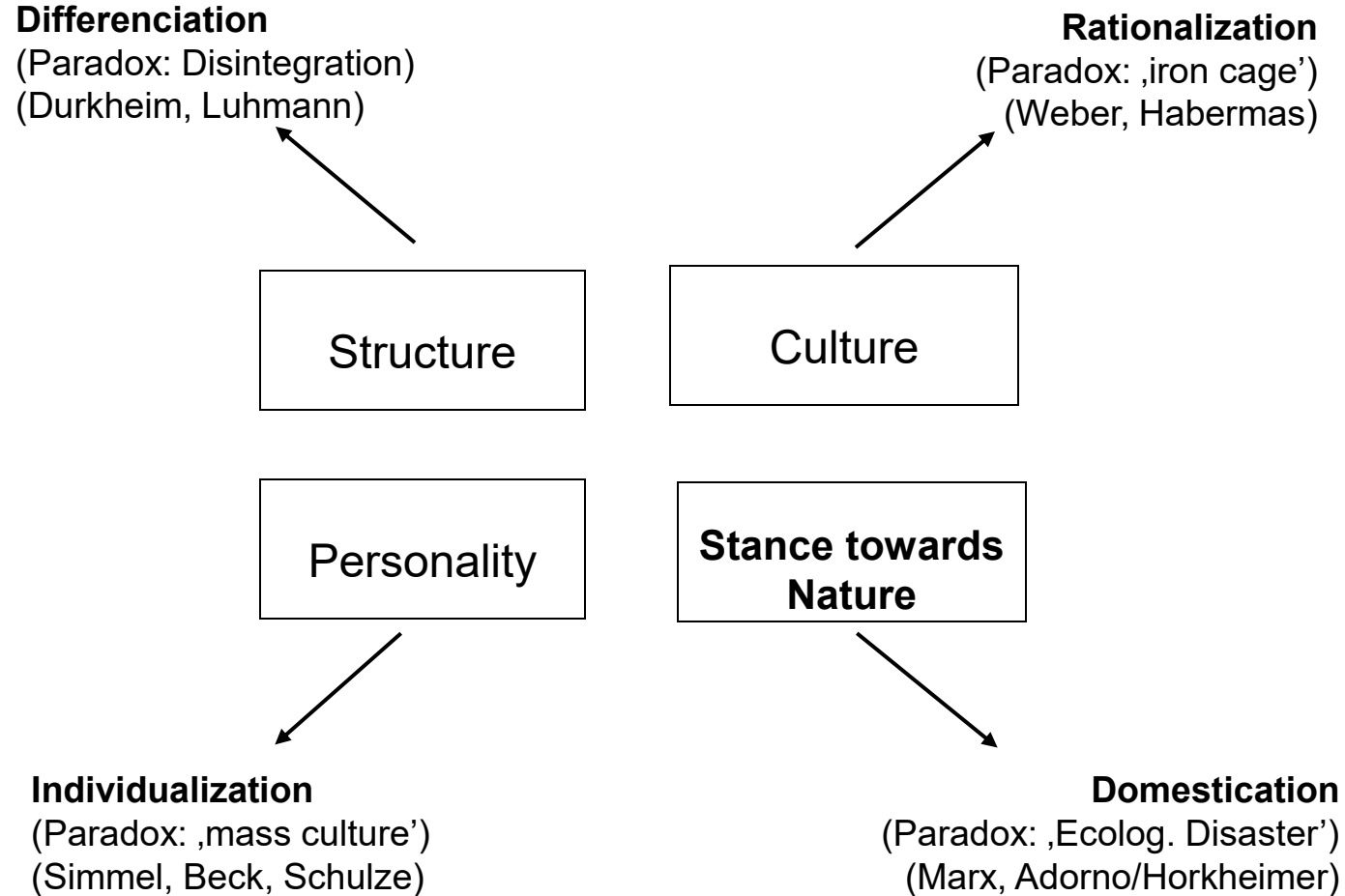
SPEND MORE TIME ON THE COMPUTER!

I'm doing my part!



Jean-Léon Gérôme (French, 1824-1904)

Rosa's Four Processes of Modernization

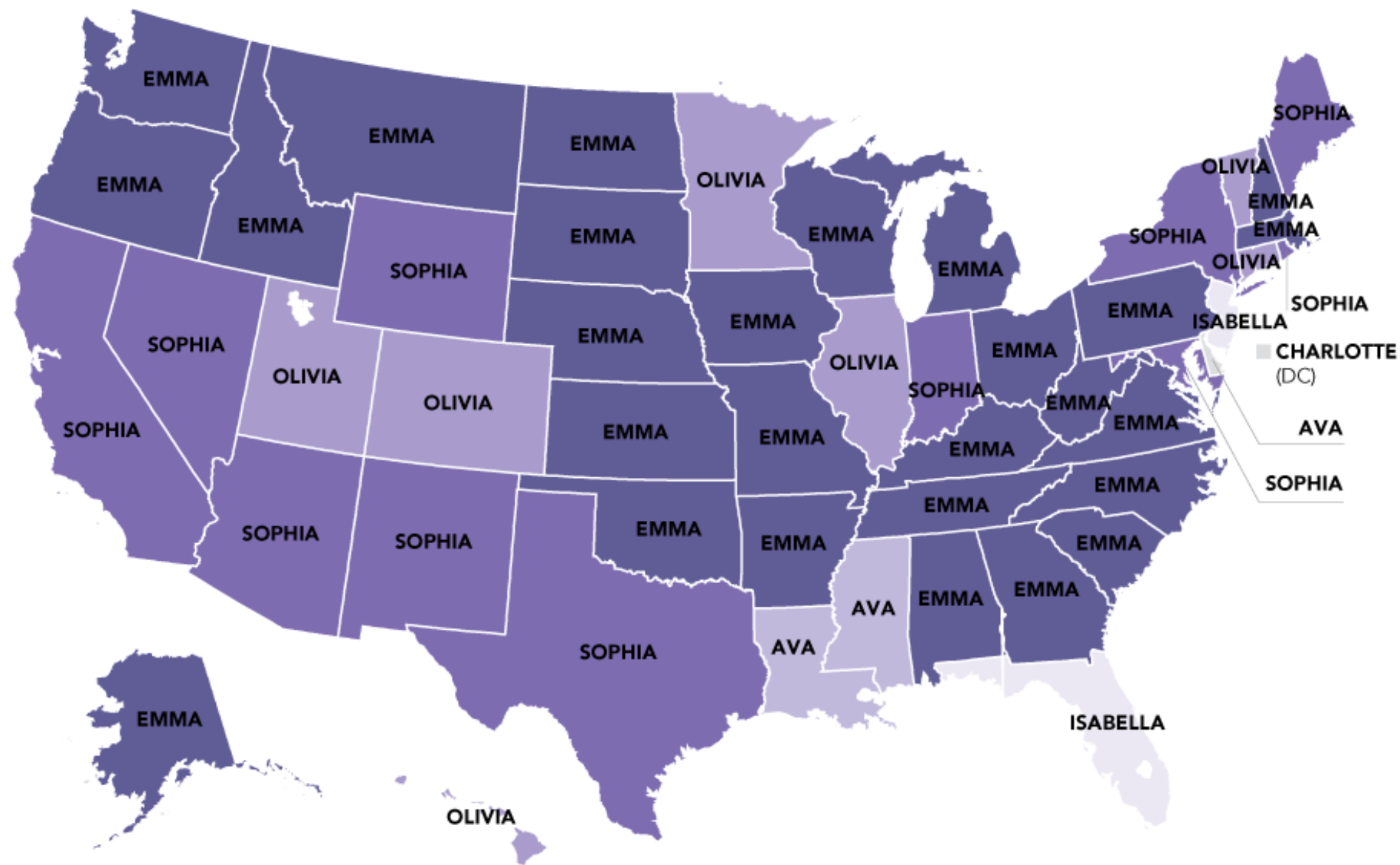


Ethnocide

This does happen to some unlucky groups, but only a minority.

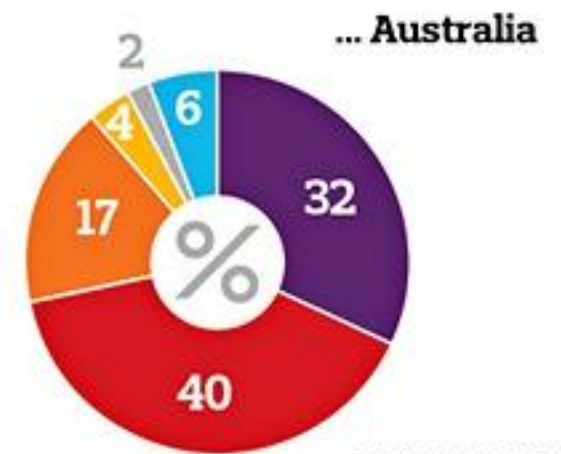
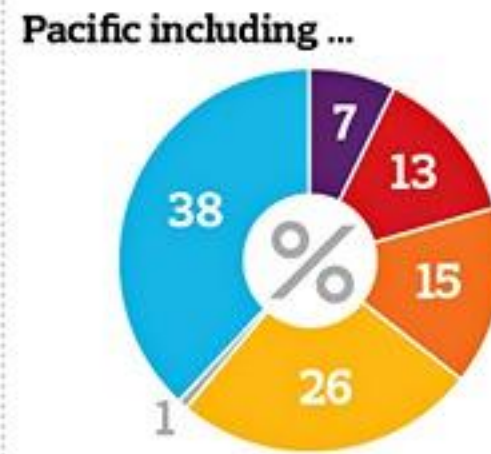
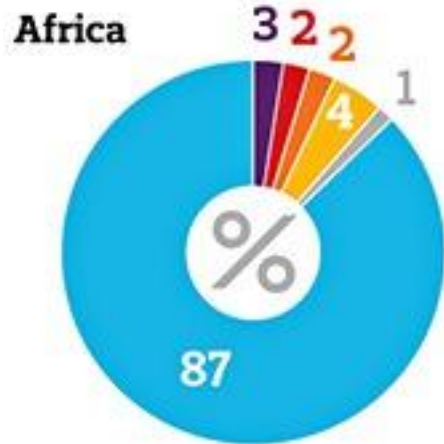
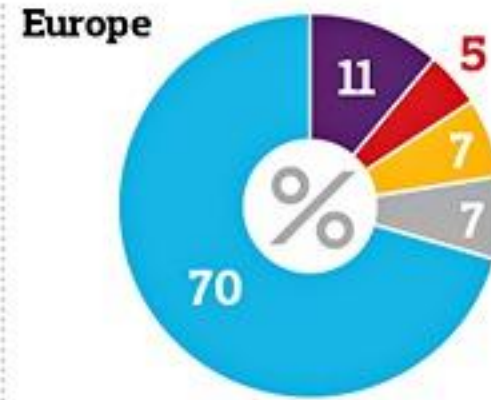
Question: apart from those peoples who die off as a result of disease or genocide, why do some indigenous peoples completely abandon their communities, language, and way of life?

The Most Popular Girls' Names Of 2013



GLOBAL LANGUAGE LOSS

Conservation status of languages by region, since 1970 (percentage*)



*Due to rounding, figures may not total 100%

SOURCE: WWF

Languages + Cultures that don't help the Technosphere are extincted

The Third Industrial Revolution

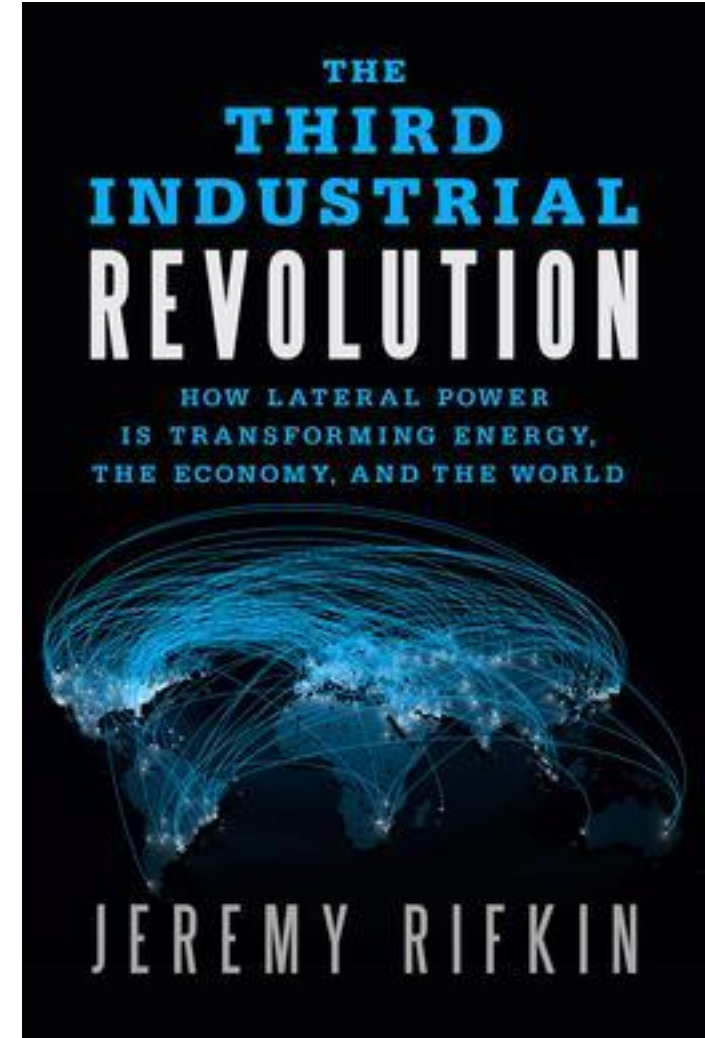
Renewable Energy democratized

Buildings produce decentralized power

Energy storage and an energy internet

Smart + Integrated Power Grid

Carbon Free Transportation



The third revolution is manufacturing “going digital.” It needs local, collaborative and lateral societal and economic structures to build a revolutionary green free-market economy.
(beyond traditional capitalism?)

Welcome to the Anthropocene

Newest Geologic Era after the Holocene

Concrete + Asphalt

Species Extinction

Slightly Radioactive