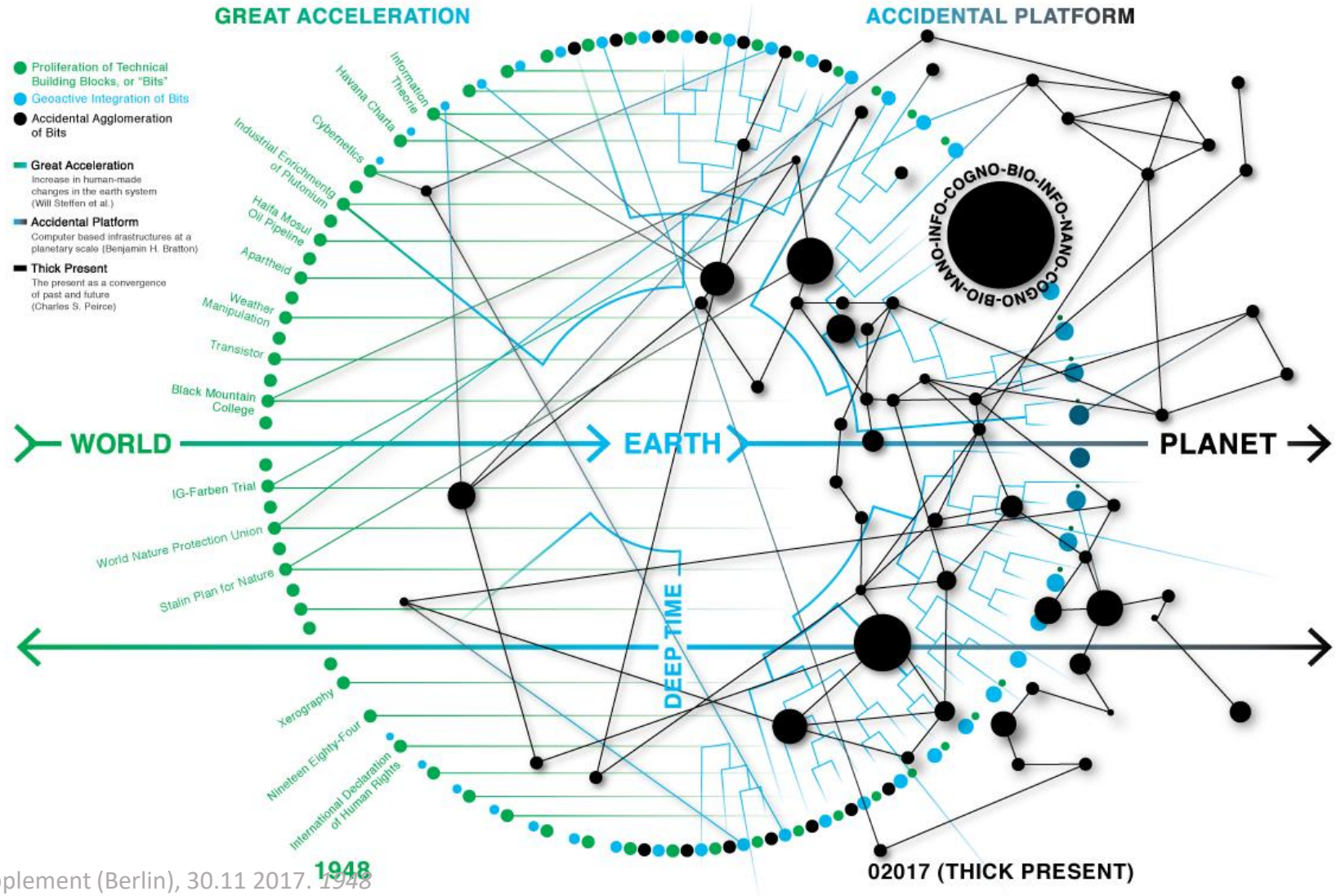
How Can We Help Build the Technosphere?

Nathan Moore

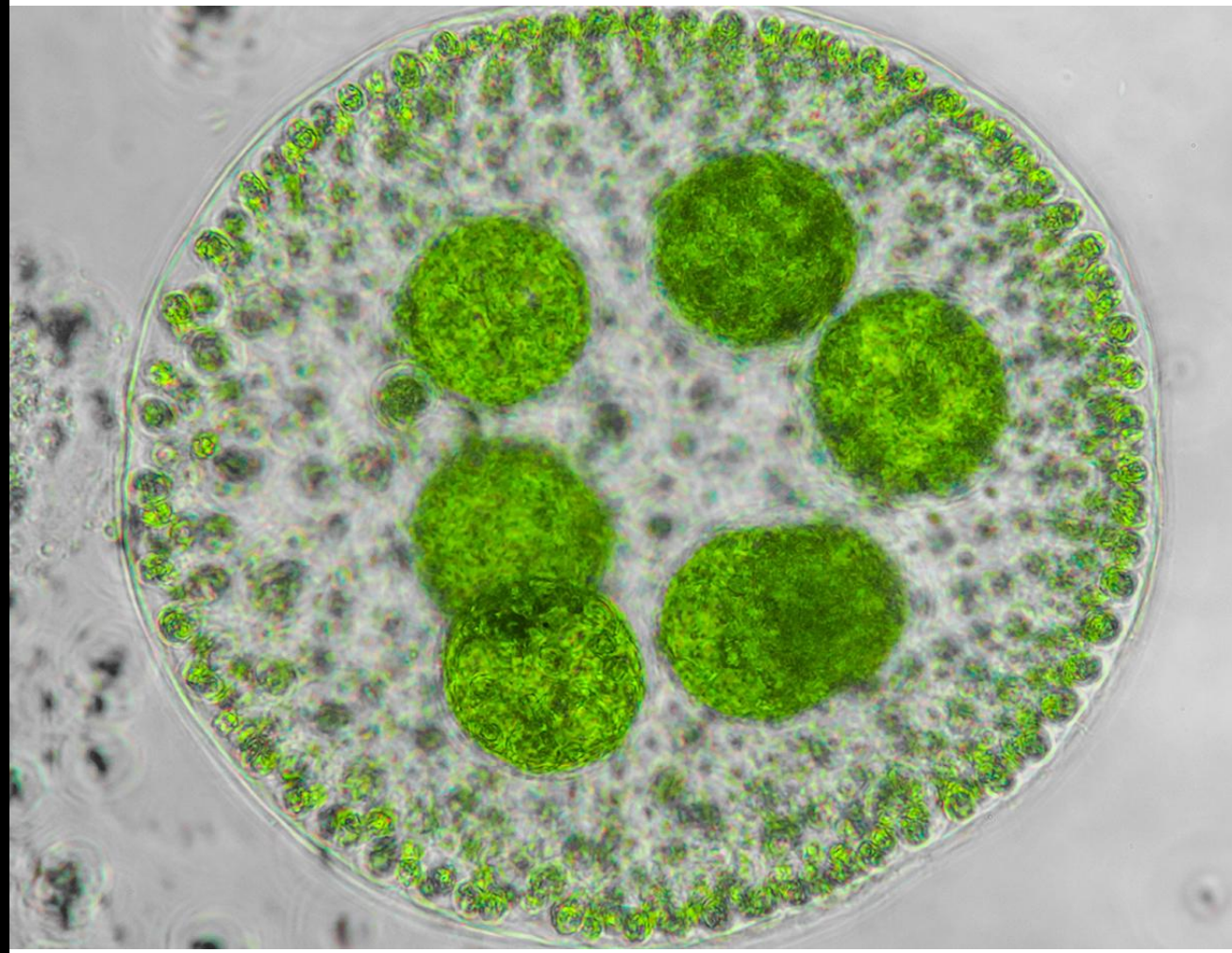
Department of Geography



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

Multicellular life





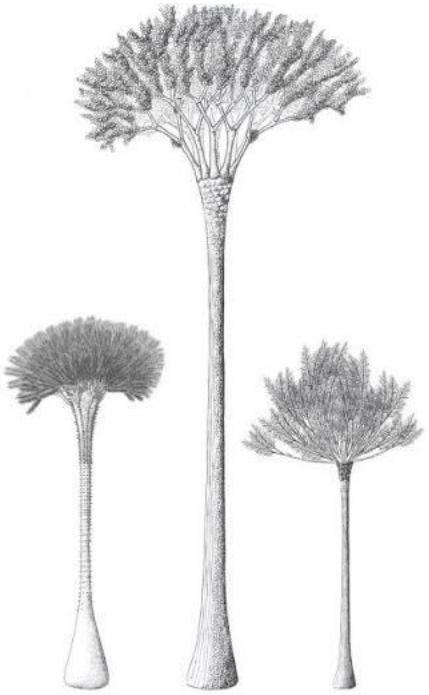
Vascular Plants evolved 400 Million Years Ago and everything changed



Related to lycopods



Archaeopteris



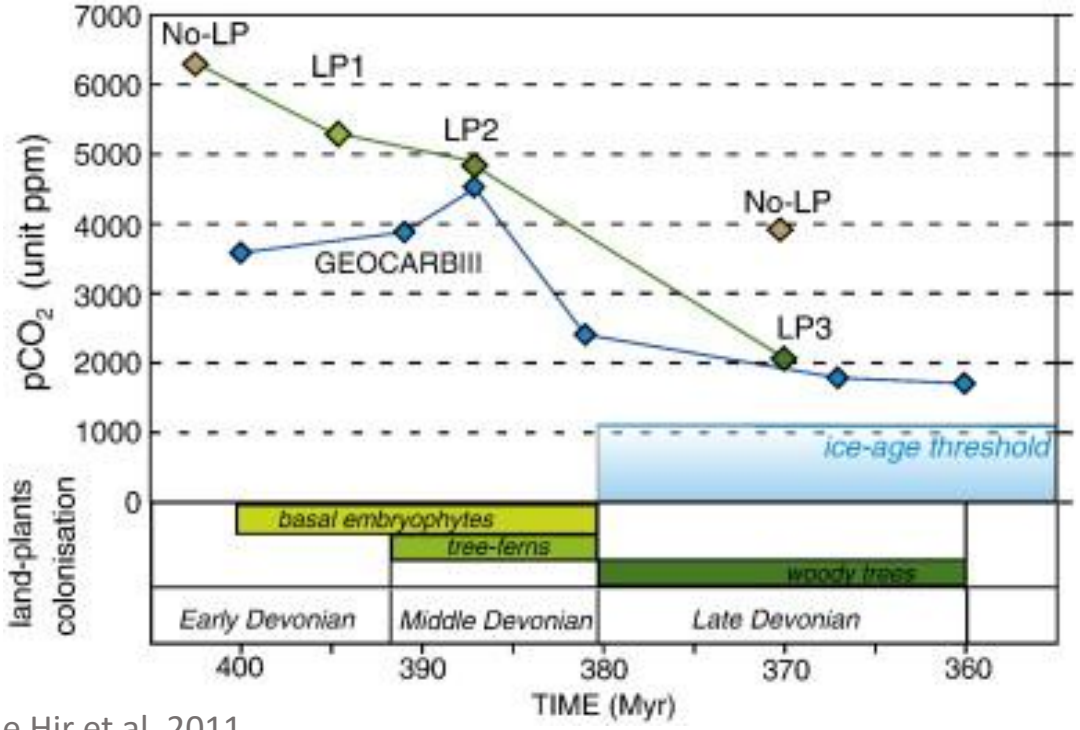




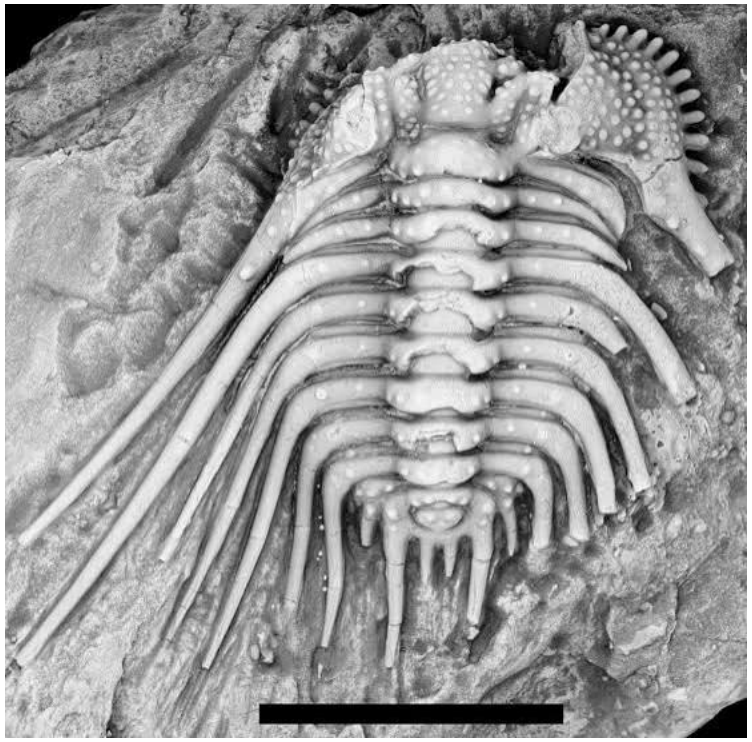
Massive increase in weathering
Drop in CO_2
Ocean Anoxia and the Devonian Extinction

How the First Trees Nearly Froze the Earth

By Patrick Mellor December 21, 2022



Le Hir et al. 2011



Neogene Grasslands Explosion

Tropical savannas invaded and replaced tropical forests
Massive increase in annual fires
Herbivores evolved, became dominant



C4-dominated grassland (*Festuca costata* in the foreground)
South Africa's Drakensberg Mountains



Kangaroo grass (a C4 grass) in eastern Victoria, AUS

So, life changes the planet every now and then

Are we just the latest in a line of planet-changers?

For you have made him a little lower than the angels, and you have crowned him with glory and honor.

- Psalm 8:5



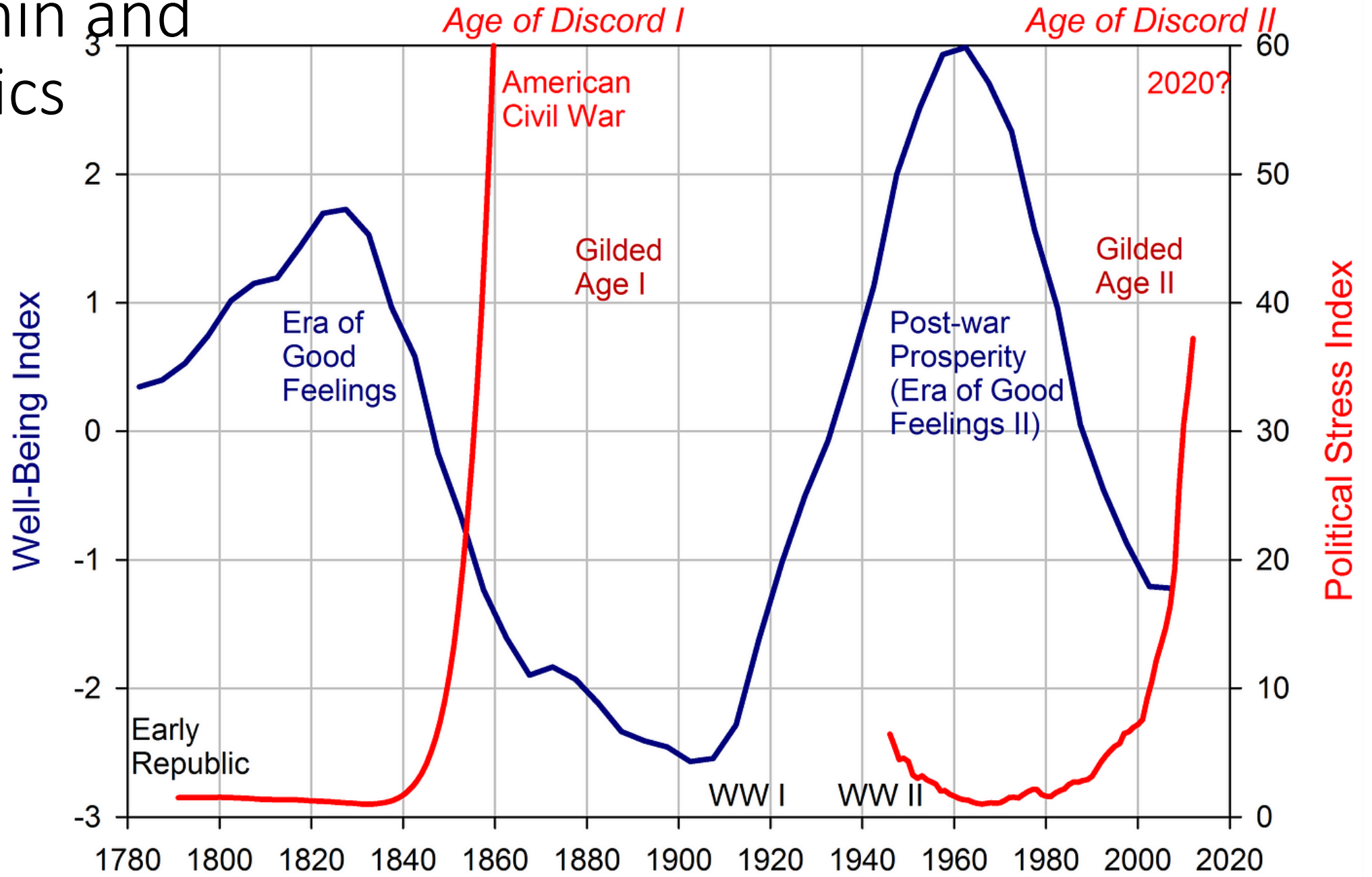
Is there a natural state of humanity? Maybe Diogenes?



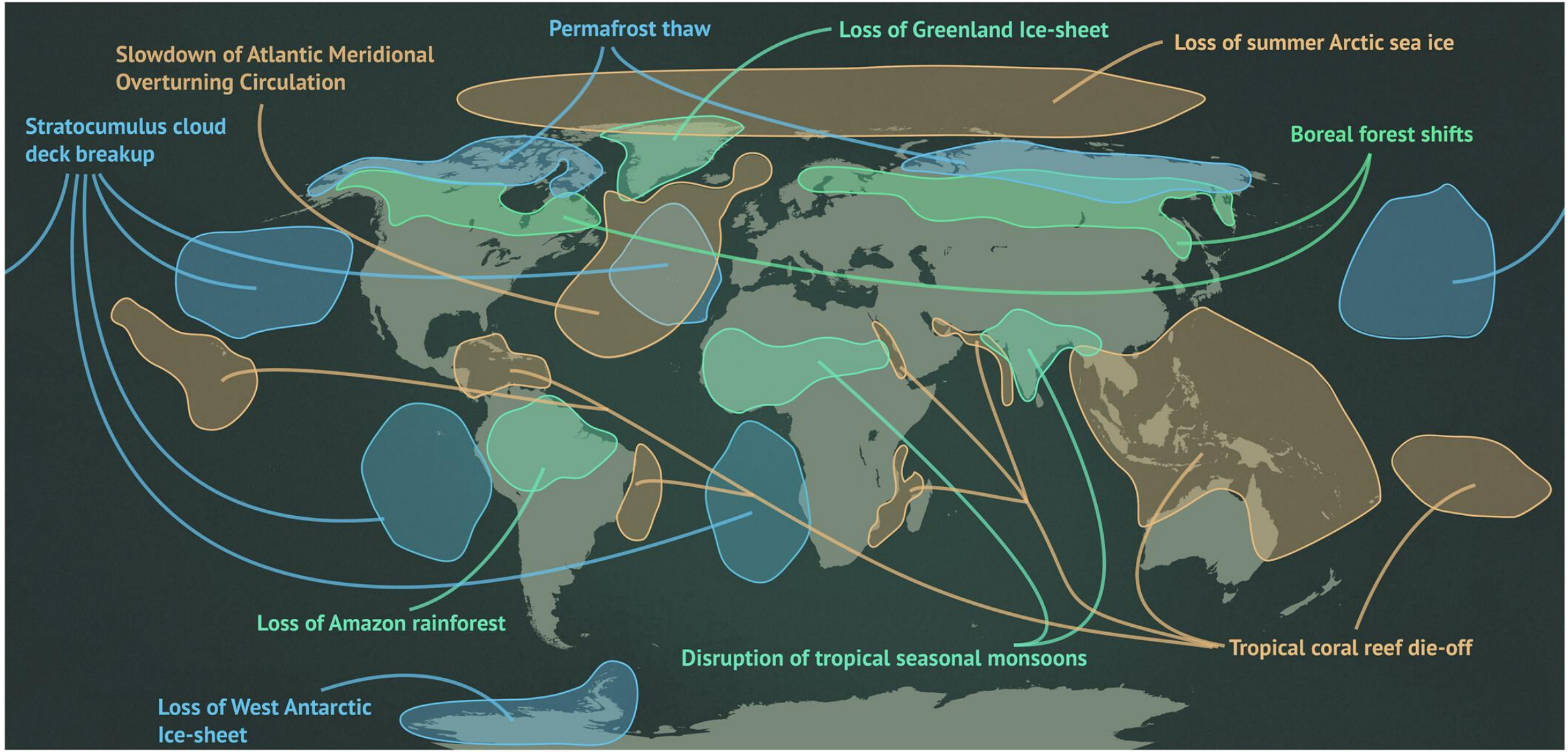
Jean-Léon Gérôme (French, 1824-1904)

Peter Turchin and Cliodynamics



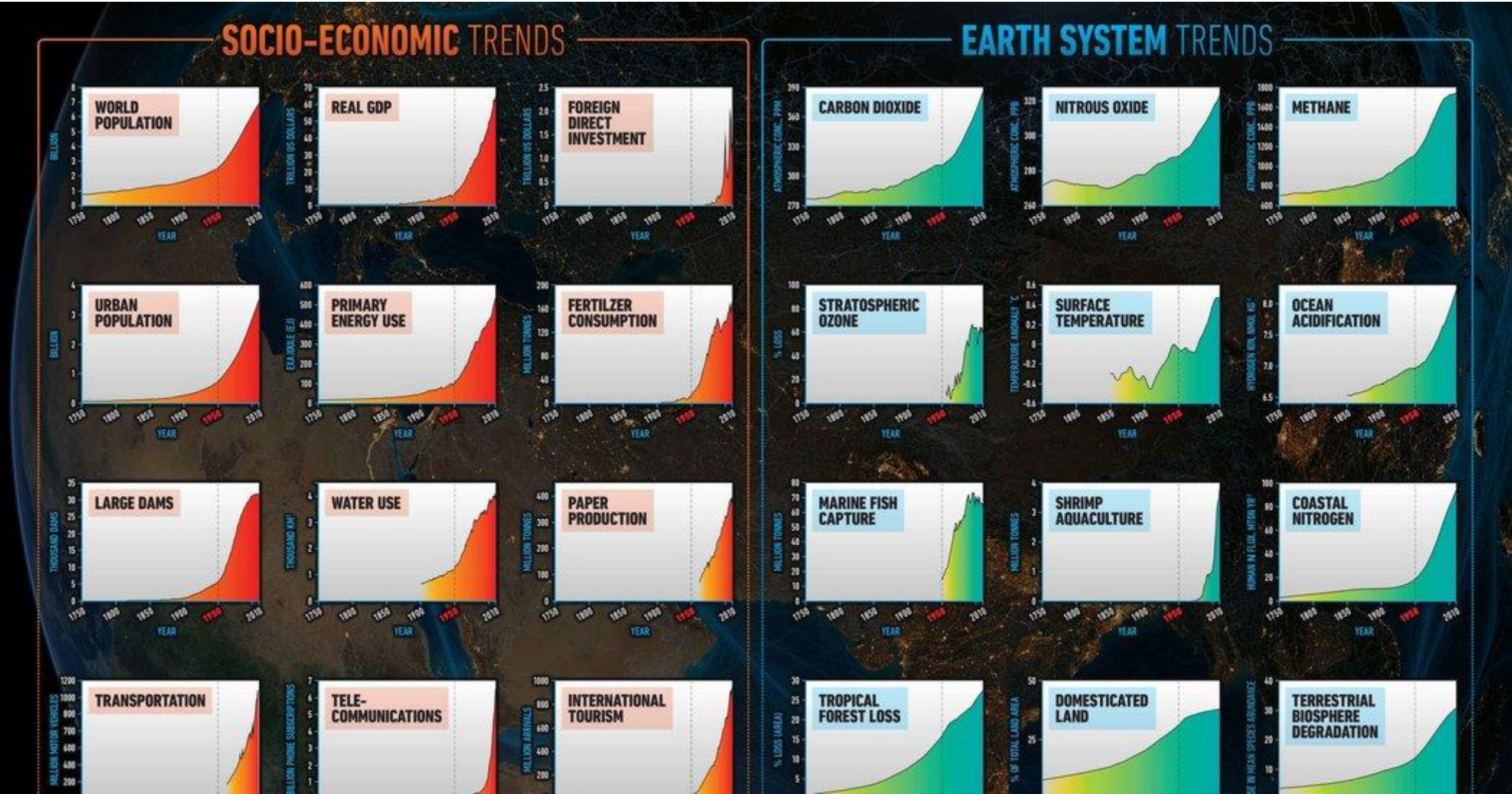


Seaver Wang's Tipping Elements



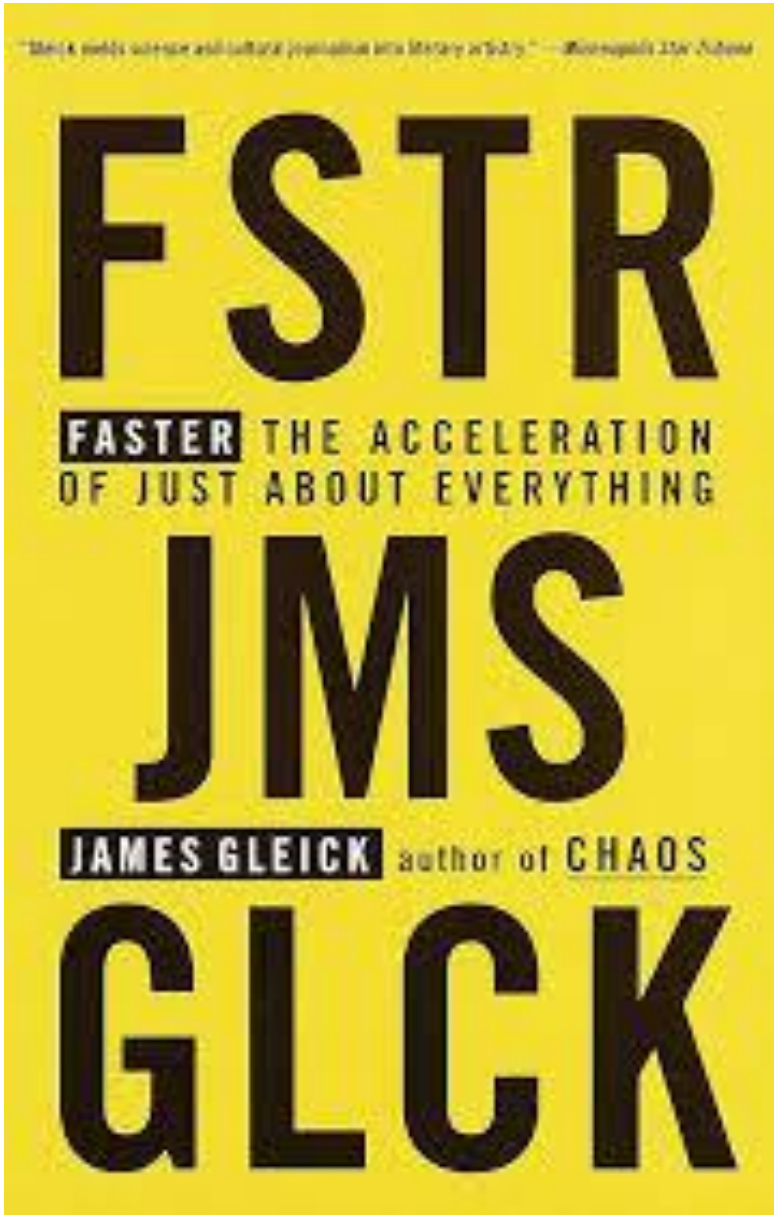
Nonlinear!

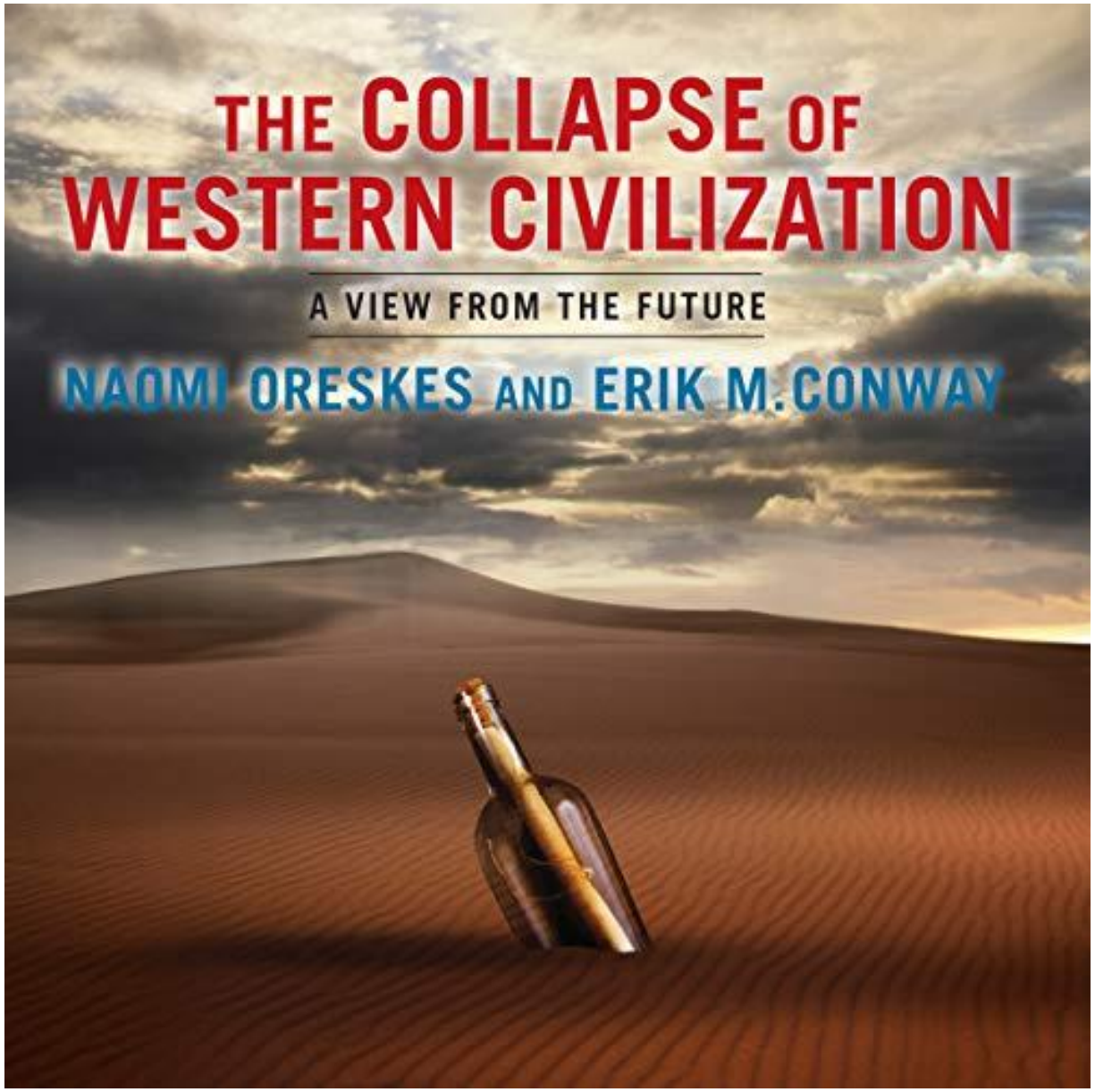
The Great Acceleration



Are things going off the rails?

Or is it the dawn of a new geologic order?





What’s causing this?

Is there one Modernity?

Is this causing the Technosphere?



Hartmut Rosa

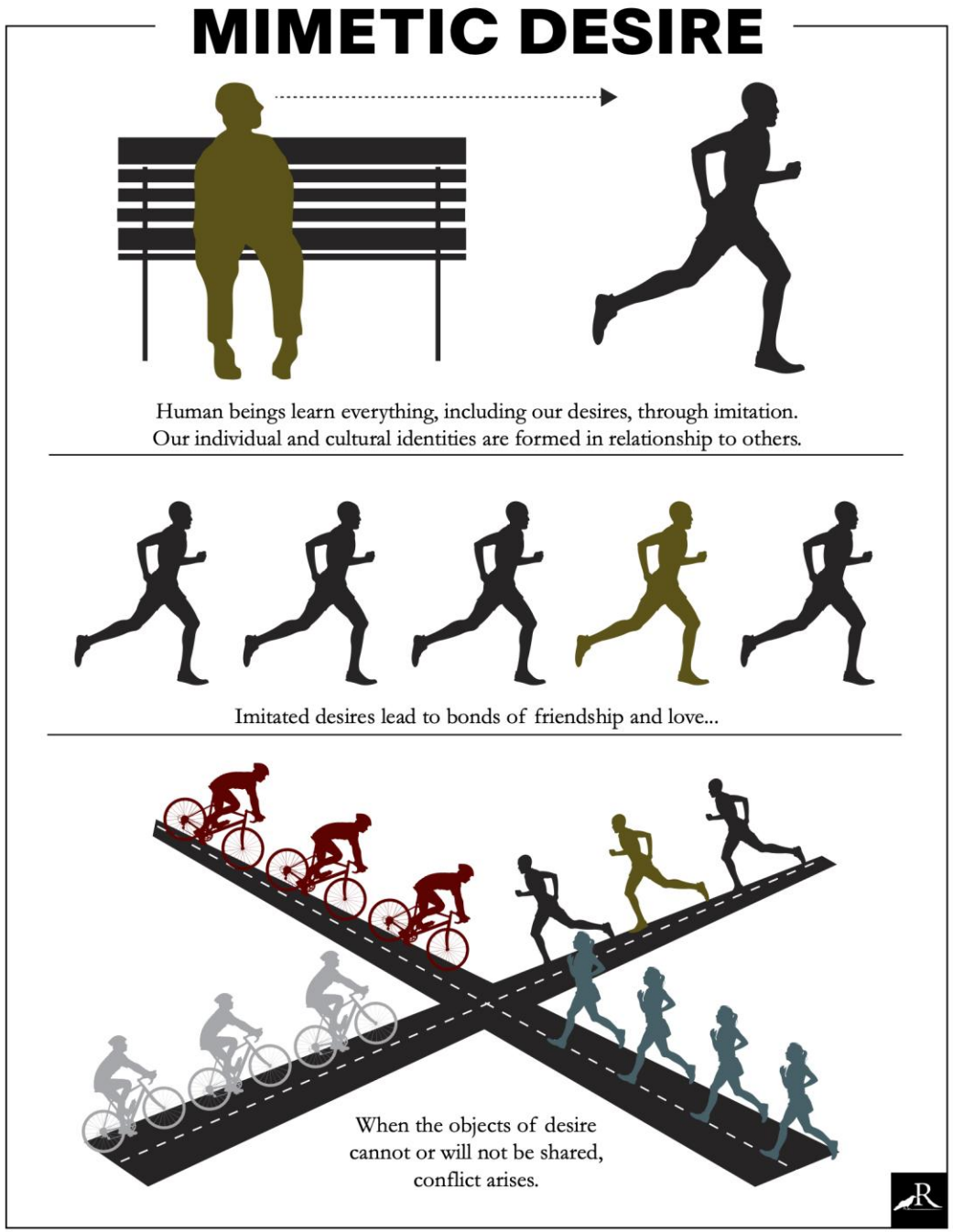
University of Jena

Three possible objections:

- four different processes
- ruptures, breaks and phases
- cultural diversity: ‘multiple modernities‘

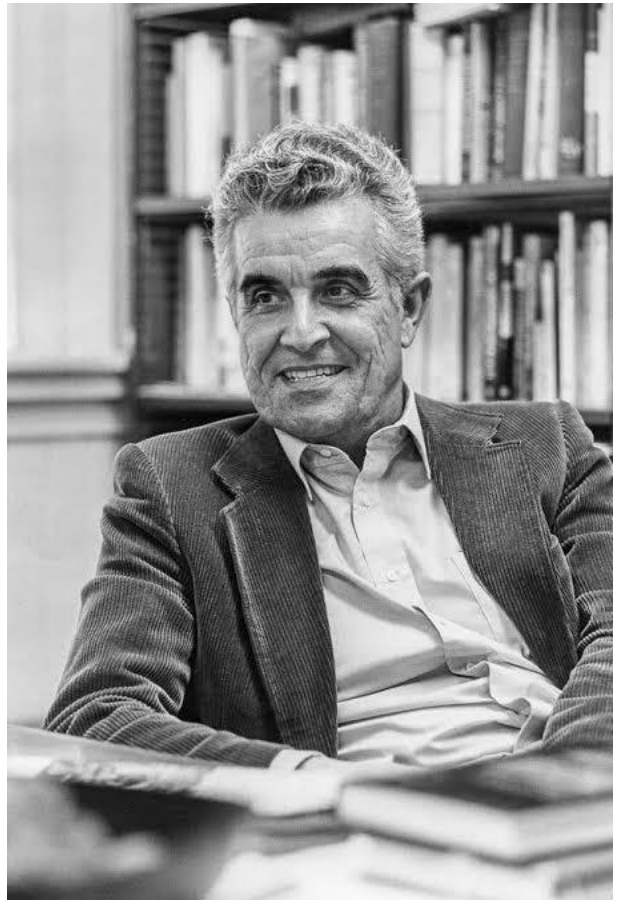
→ **Claim**: Social Acceleration is Modernity‘s “Universal”

Mimetic Theory

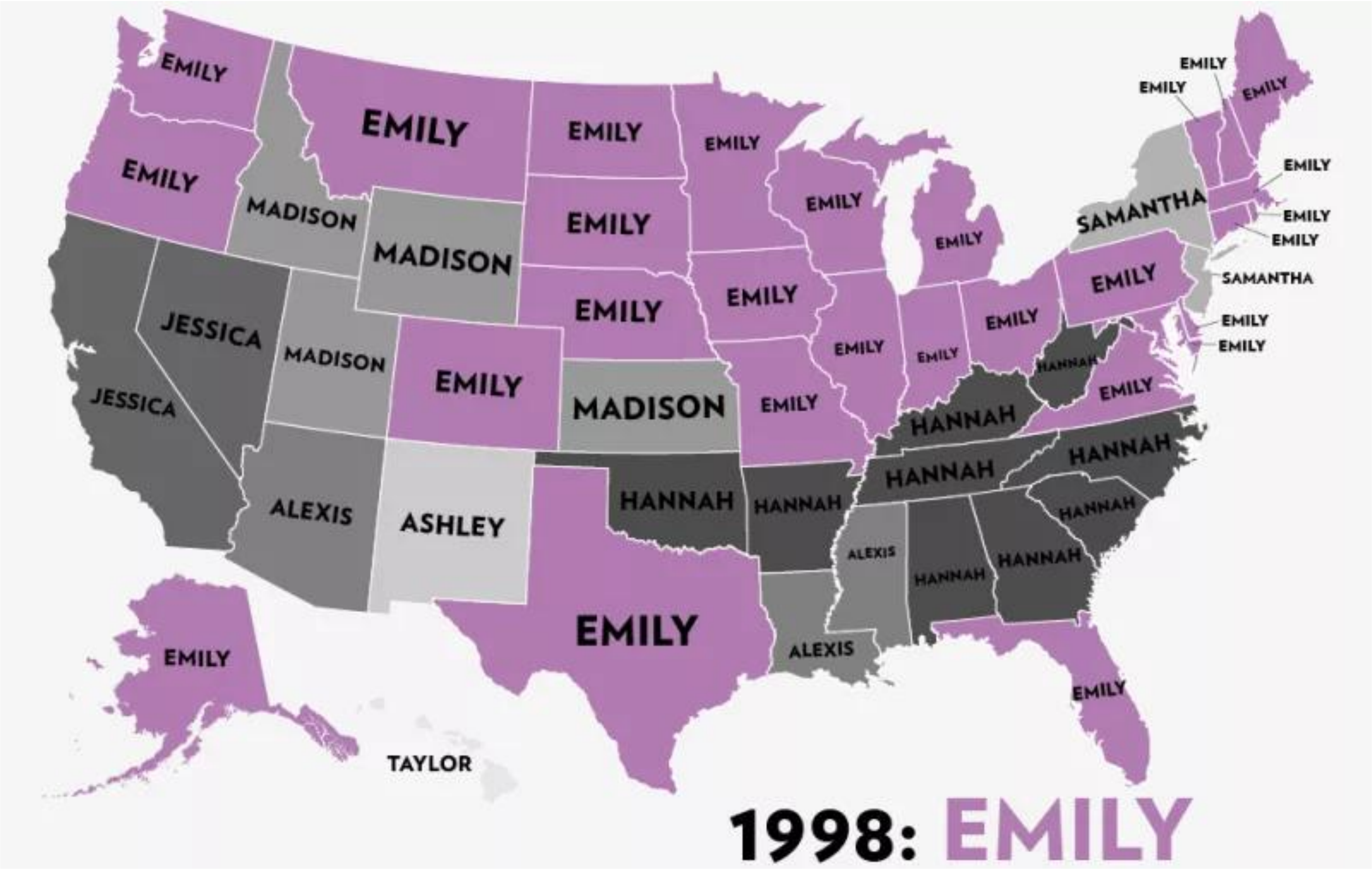


I want what others have

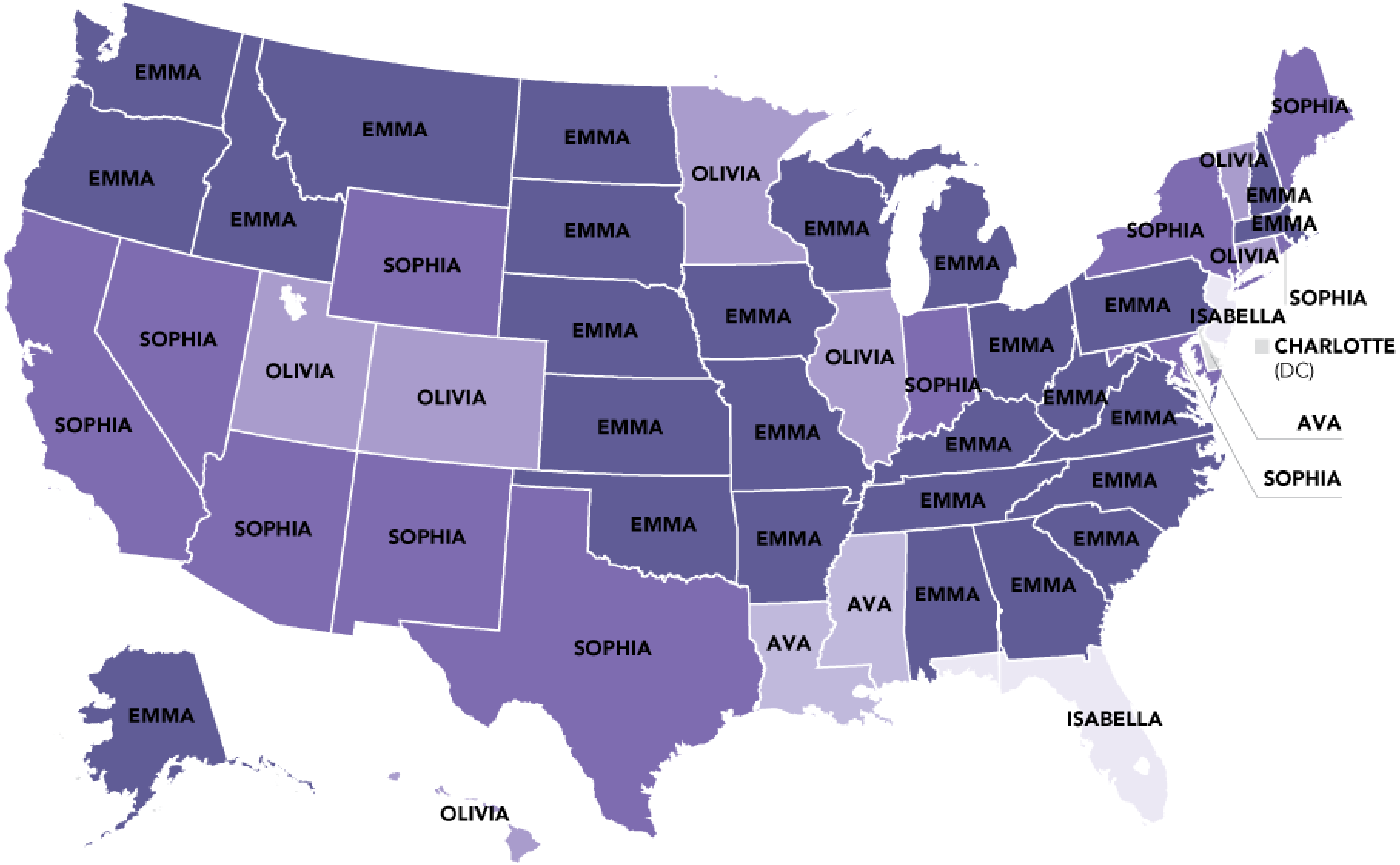
This is the motor
of the Technosphere



René Girard


EMILY
EMILY
MADISON
EMILY
MADISON
EMILY
EMILY
EMILY
EMILY
EMILY
EMILY
EMILY
EMILY
EMILY
SAMANTHA
EMILY
EMILY
EMILY
SAMANTHA
JESSICA
JESSICA
MADISON
EMILY
MADISON
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EMILY
EMILY
HANNAH
EMILY
HANNAH
HANNAH
HANNAH
ALEXIS
ASHLEY
HANNAH
HANNAH
HANNAH
ALEXIS
HANNAH
HANNAH
EMILY
ALEXIS
EMILY
EMILY
TAYLOR
1998: EMILY

The Most Popular Girls' Names Of 2013



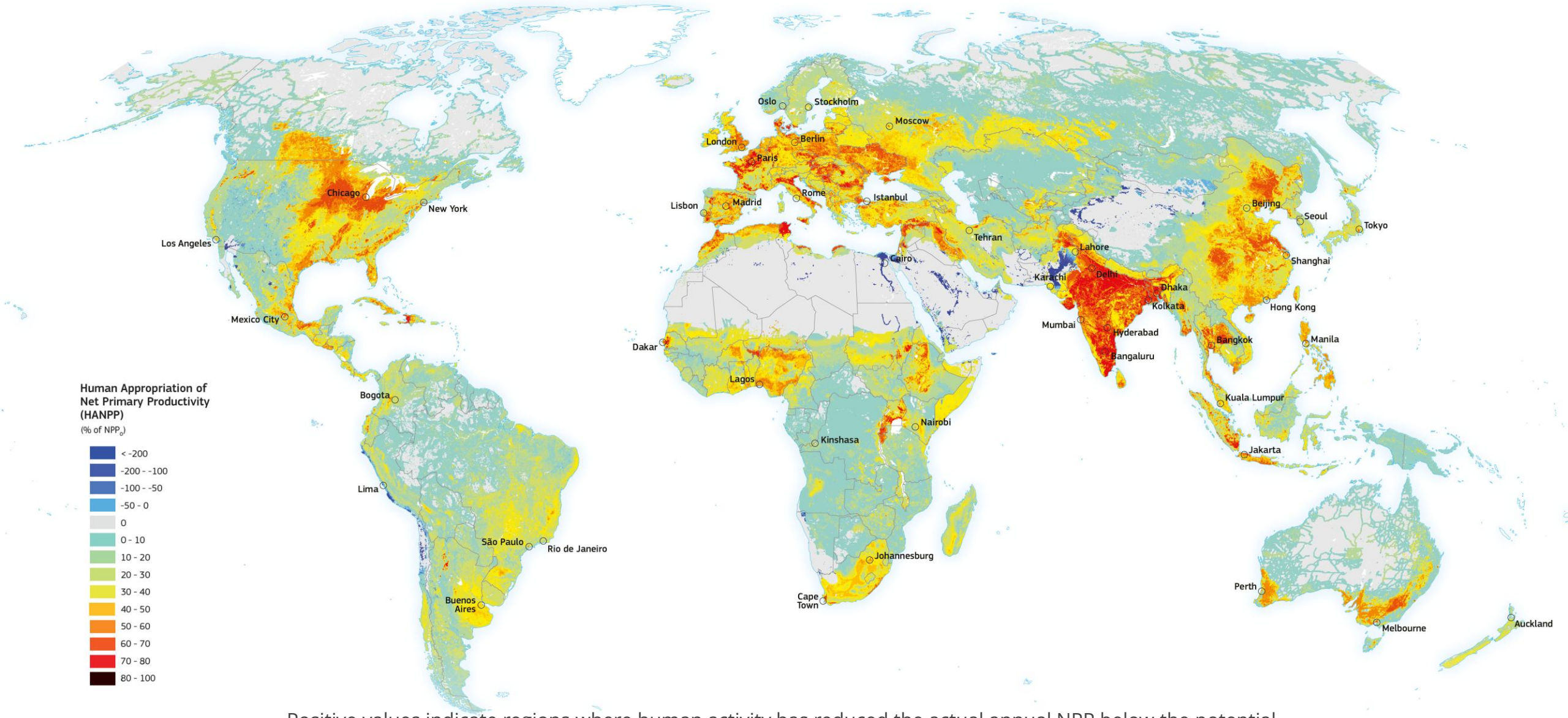
Source: Social Security Administration

THE HUFFINGTON POST

The Biosphere: a helpful analogy

- 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.



Welcome to the Anthropocene, brought to you by the Technosphere

Newest Geologic Era

after the Holocene

Concrete + Asphalt

Species Extinction

Slightly More Radioactive



The Technosphere can be understood via Actor Network Theory



Bruno Latour



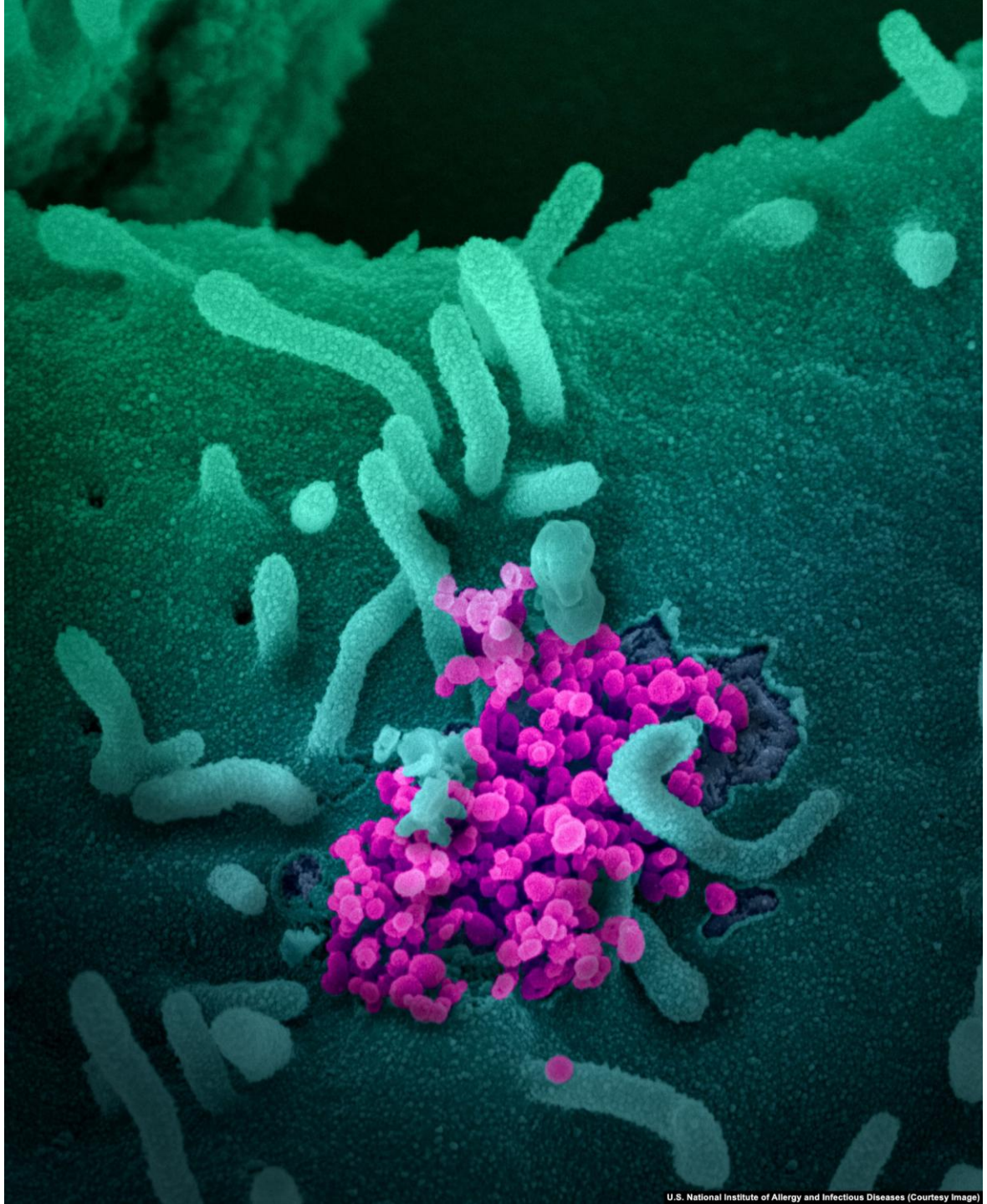
ANT: Virus example

Virus has no emotions

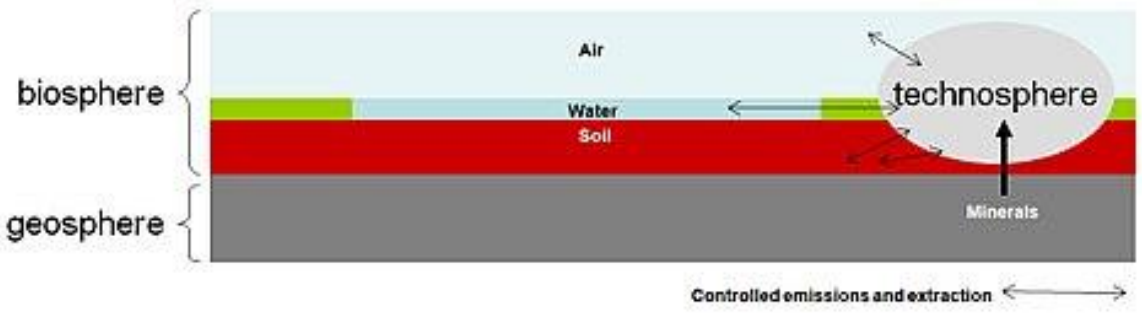
No nervous system

Maybe not technically alive

Does it want anything?



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



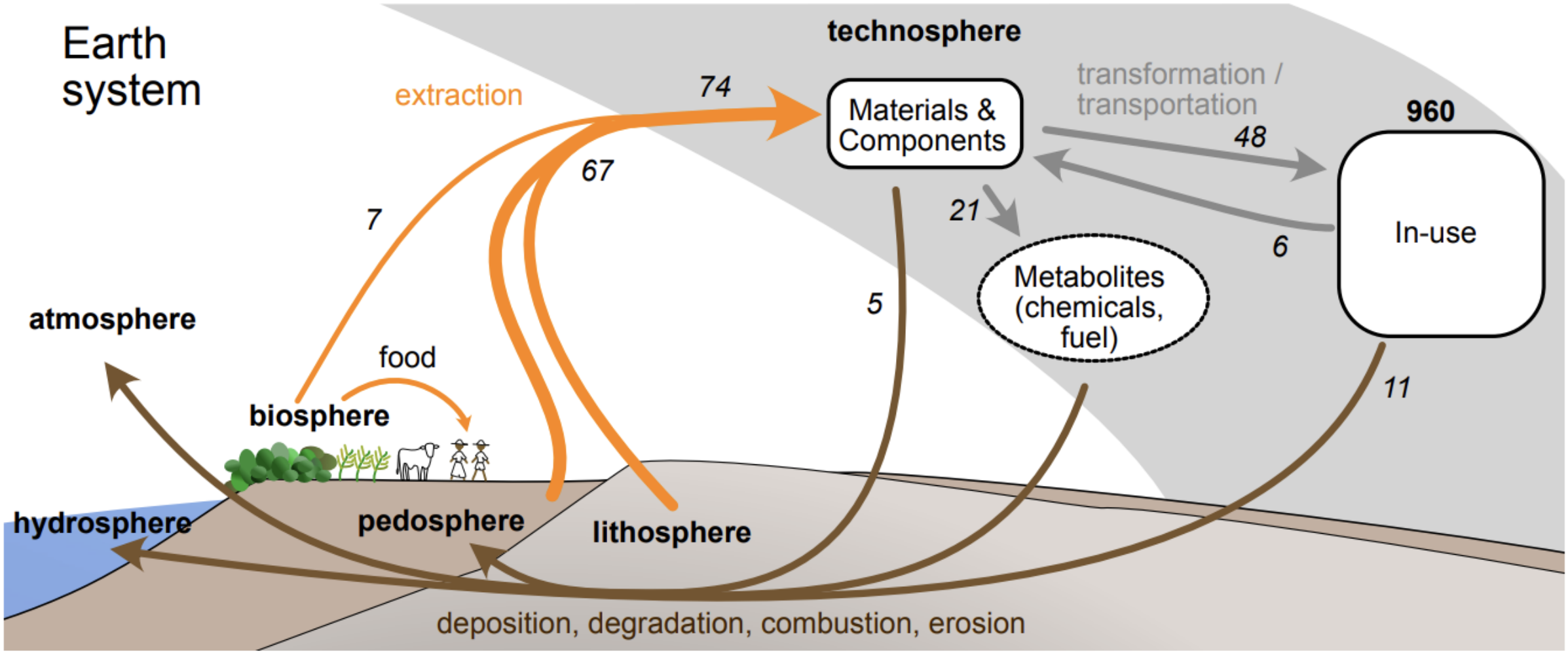


Figure 1. Schematic of the Earth system including the technosphere. Italicized numbers show fluxes in Gty^{-1}, bold number shows the in-use mass in Gt as estimated by Krausmann et al. 2018 for the year 2015.

Vernadsky

popularized the idea of
The Biosphere Eduard Suess 1875

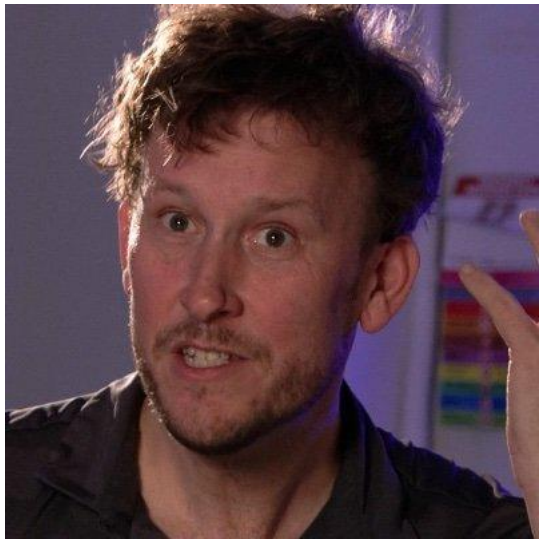
Developed the idea of
The **noösphere** (“sphere of reason”)

“…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…



civilization is an **open, non-equilibrium thermodynamic system**



Prof Tim Garrett
Univ. of Utah

IT MUST GROW or else we don't get new things.

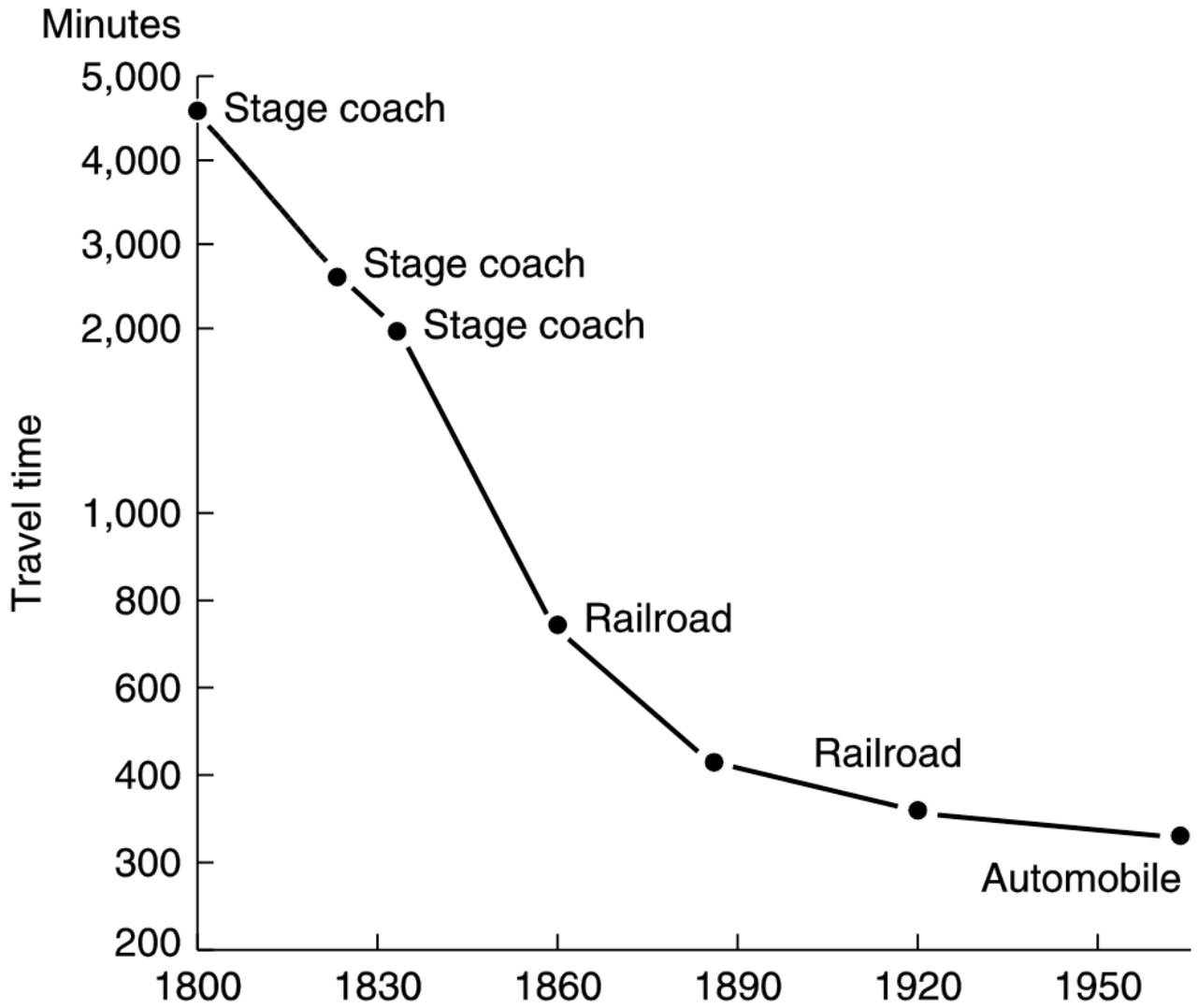
Civilization is a global heat engine

$$a = \lambda C$$

$a =$ Primary Energy Consumption Rate (EJ/year)

C = Economic Wealth (inflation-adjusted US $)

λ = The energy constant of Civilization ($\lambda \approx 7.1$ milliwatts/$)

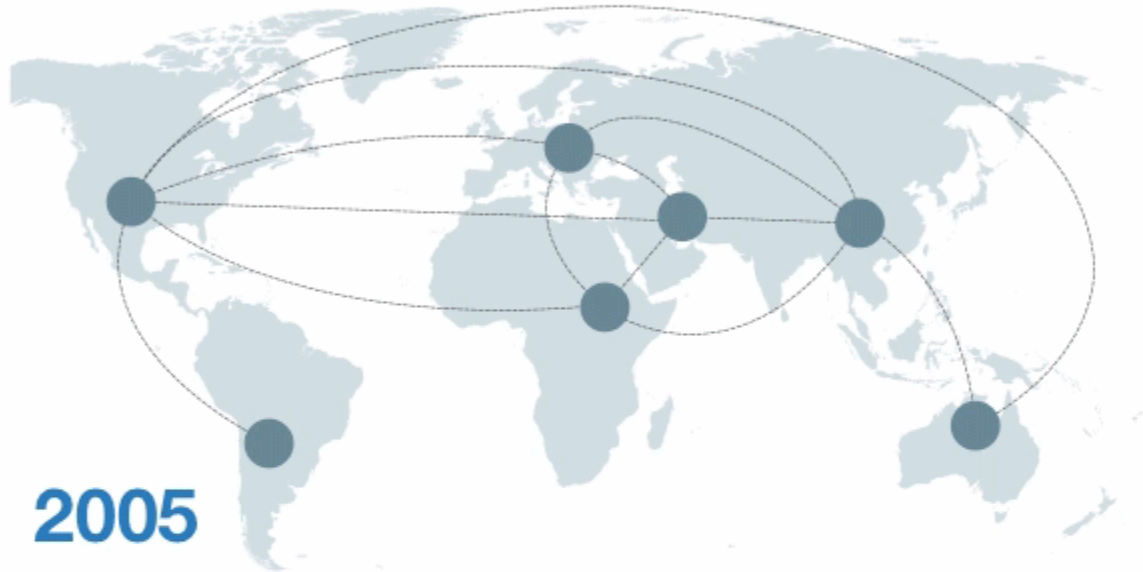


Space-time convergence between Boston and New York, showing different modes of transportation. *(Fig 9.3)*

Global flow of data and communication

Used cross-border interregional bandwidth, in gigabits per second

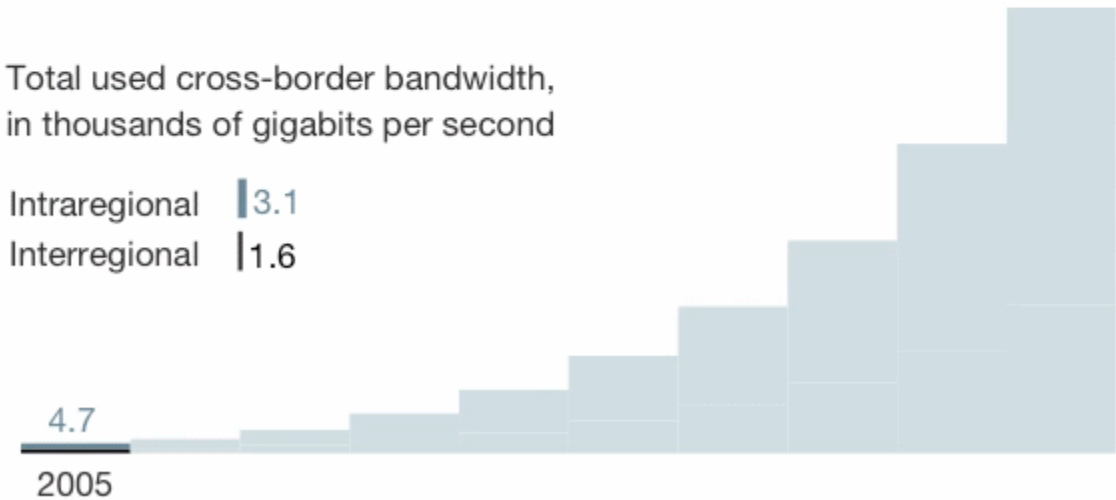
≤1,000 >1,000 2,000 5,000 10,000 15,000 20,000 24,405



2005

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

Intraregional 3.1
Interregional 1.6



McKinsey&Company | SOURCE: TeleGeography; McKinsey Global Institute analysis

Peter Haff defines the Technosphere

a human-made sphere that displays three important characteristics:

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



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

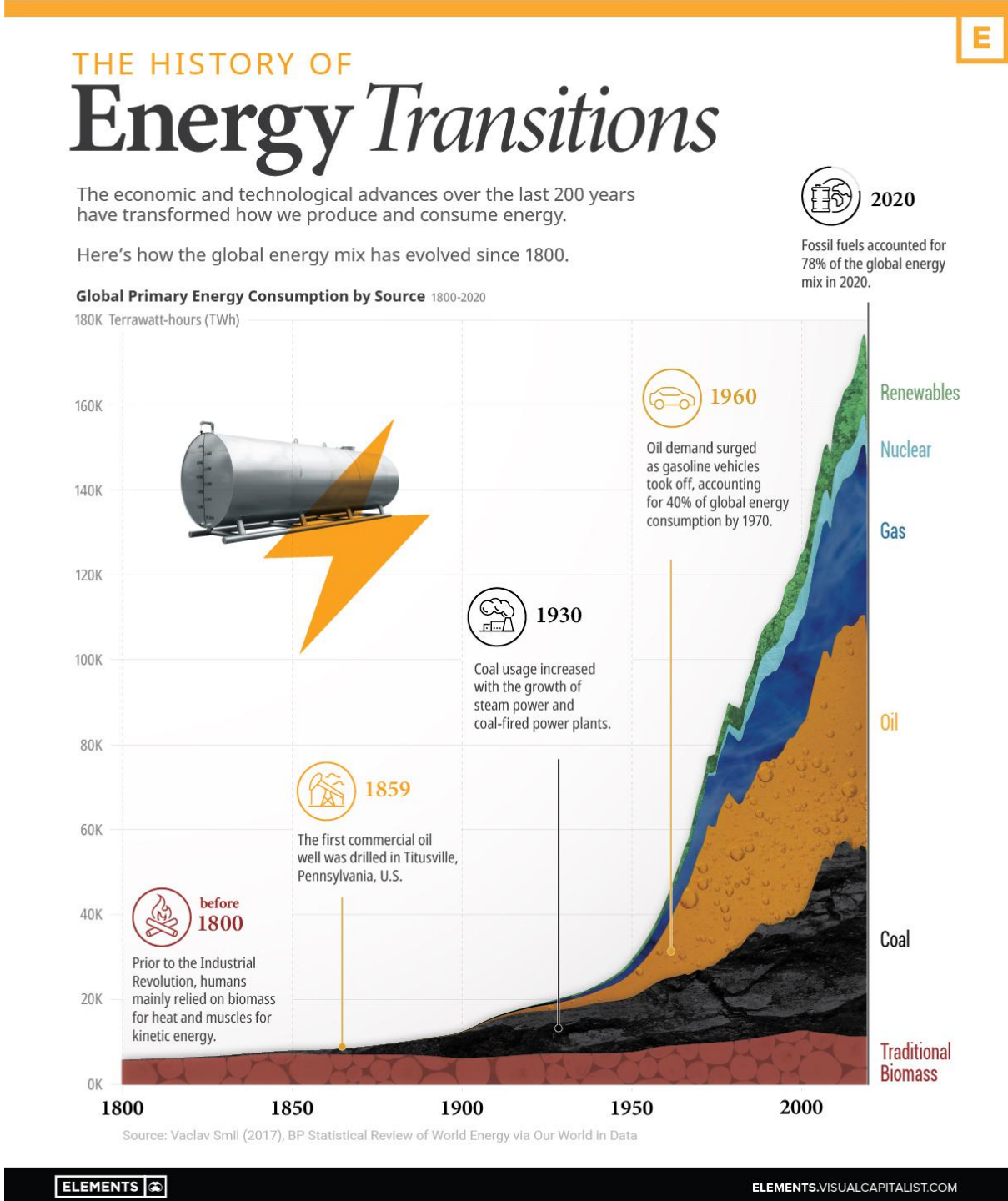
(6) the rule of provision

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 **information** produced by the environment for its own use



The Technosphere

- 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.

Demo

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!

MPI GEA Profile

Core Research Themes

Publications

Great Acceleration Observatory

Human impacts on the Earth system have been ever-expanding and strengtheni
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?

Biosphere → Technosphere

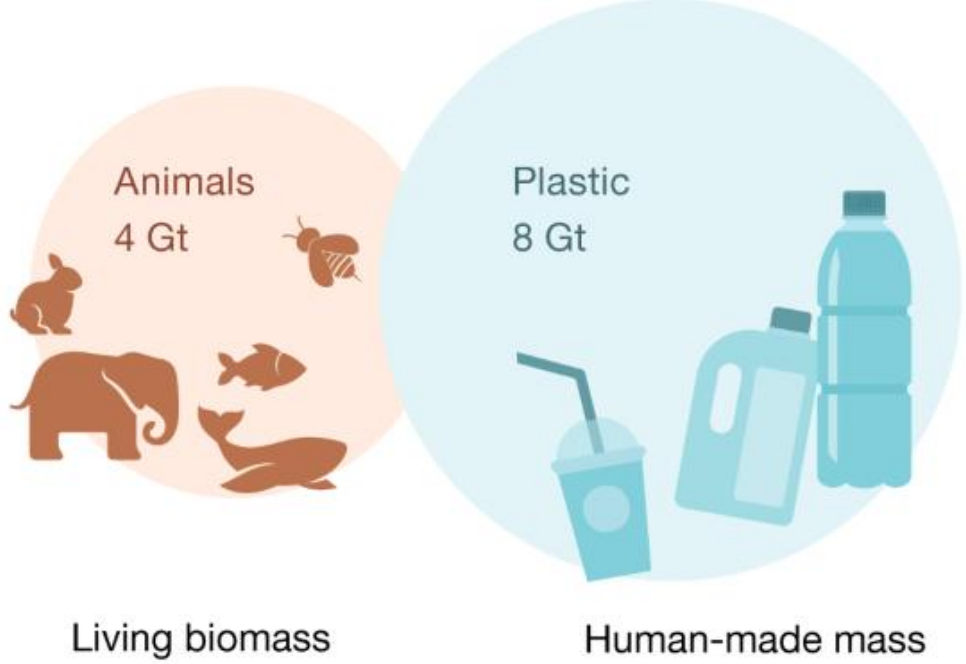
Photosynthesis → Fuels

Trees and Plants → Humans

Forests & Grasslands → Cities

O_2 and biomass → CO_2 and landfills

Fertilizer → Data





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.

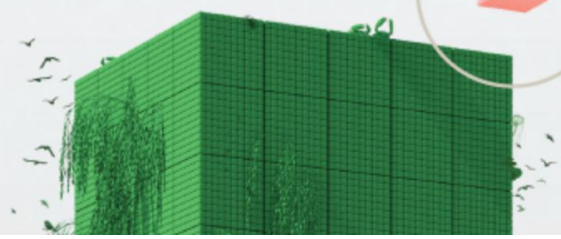
1120 Gt

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

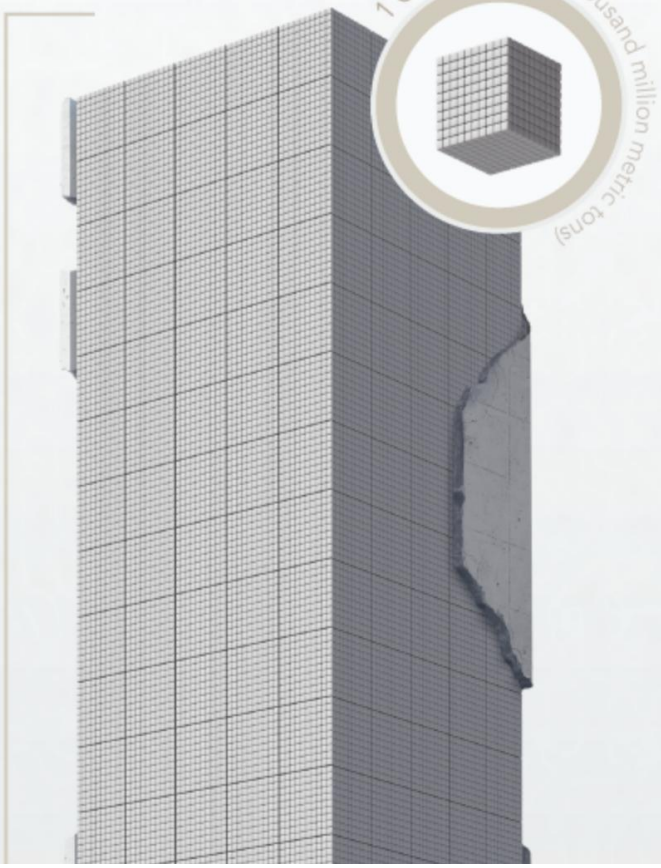
All humans make up ~0.01% of global living biomass.

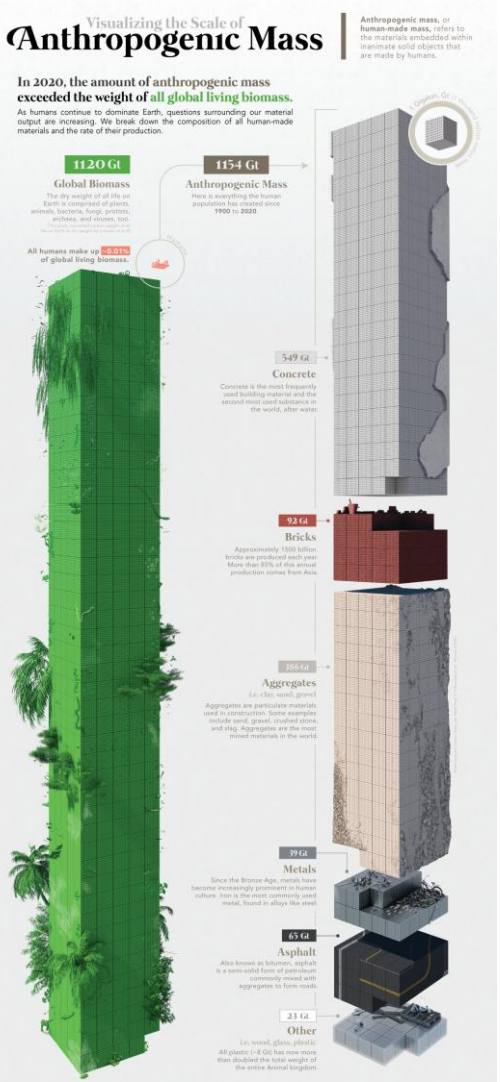


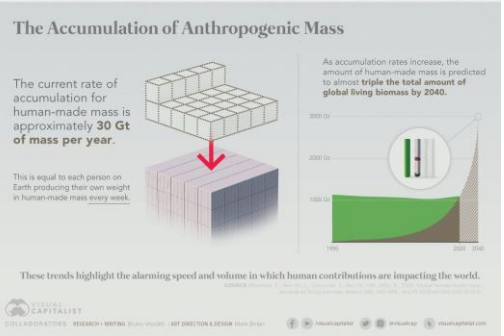
1154 Gt

Anthropogenic Mass

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







Resolving the Technosphere

Eric Galbraith[1], Abdullah-Al Faisal[1], Tanya Matitia[1], William Fajzel[1], Ian Hatton[1], Helmut Haberl[2], Fridolin Krausmann[2], and Dominik Wiedenhofer[2]

[1]Earth and Planetary Sciences, McGill University, Montreal, Canada
[2]Institute of Social Ecology, BOKU University, Vienna, Austria

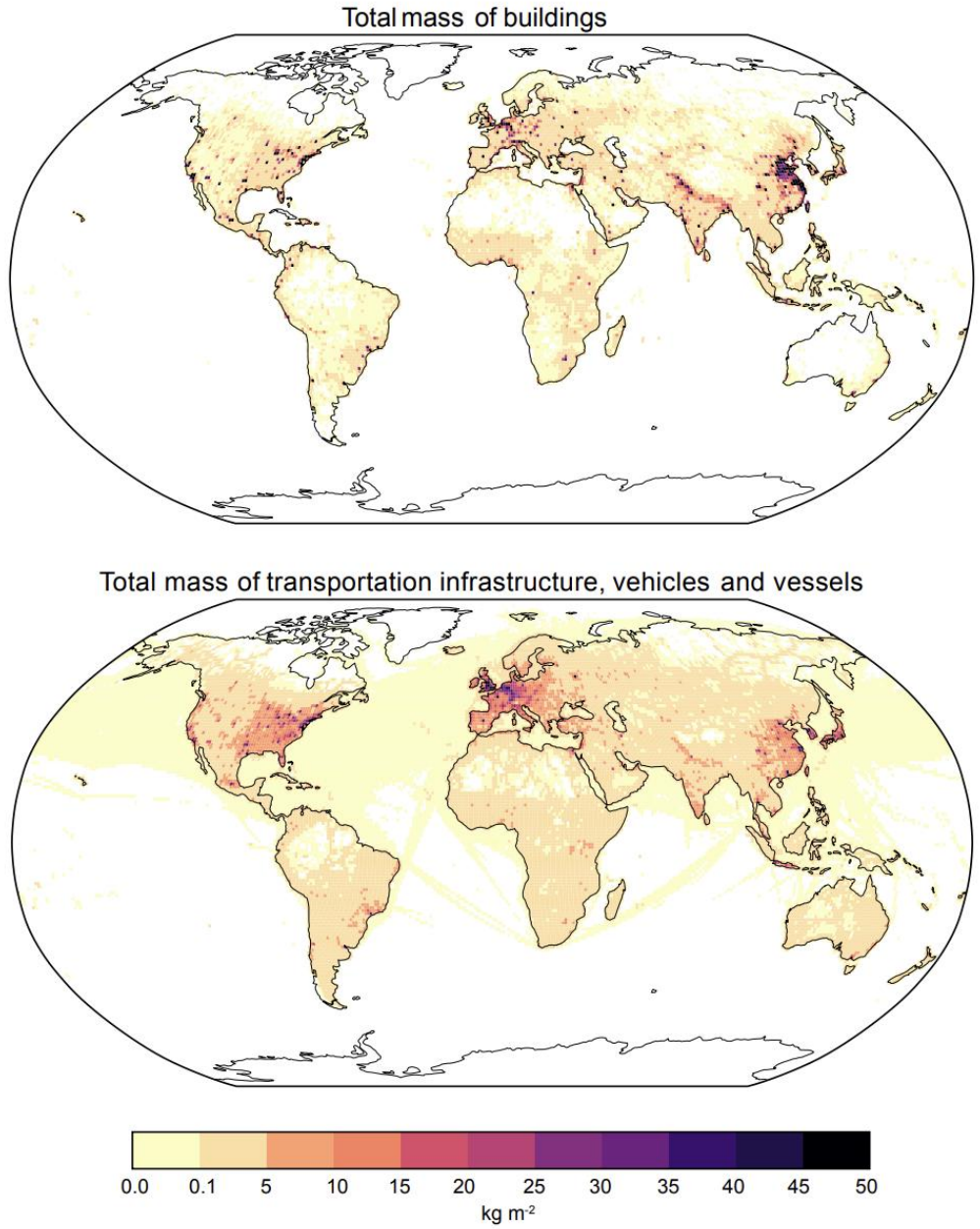
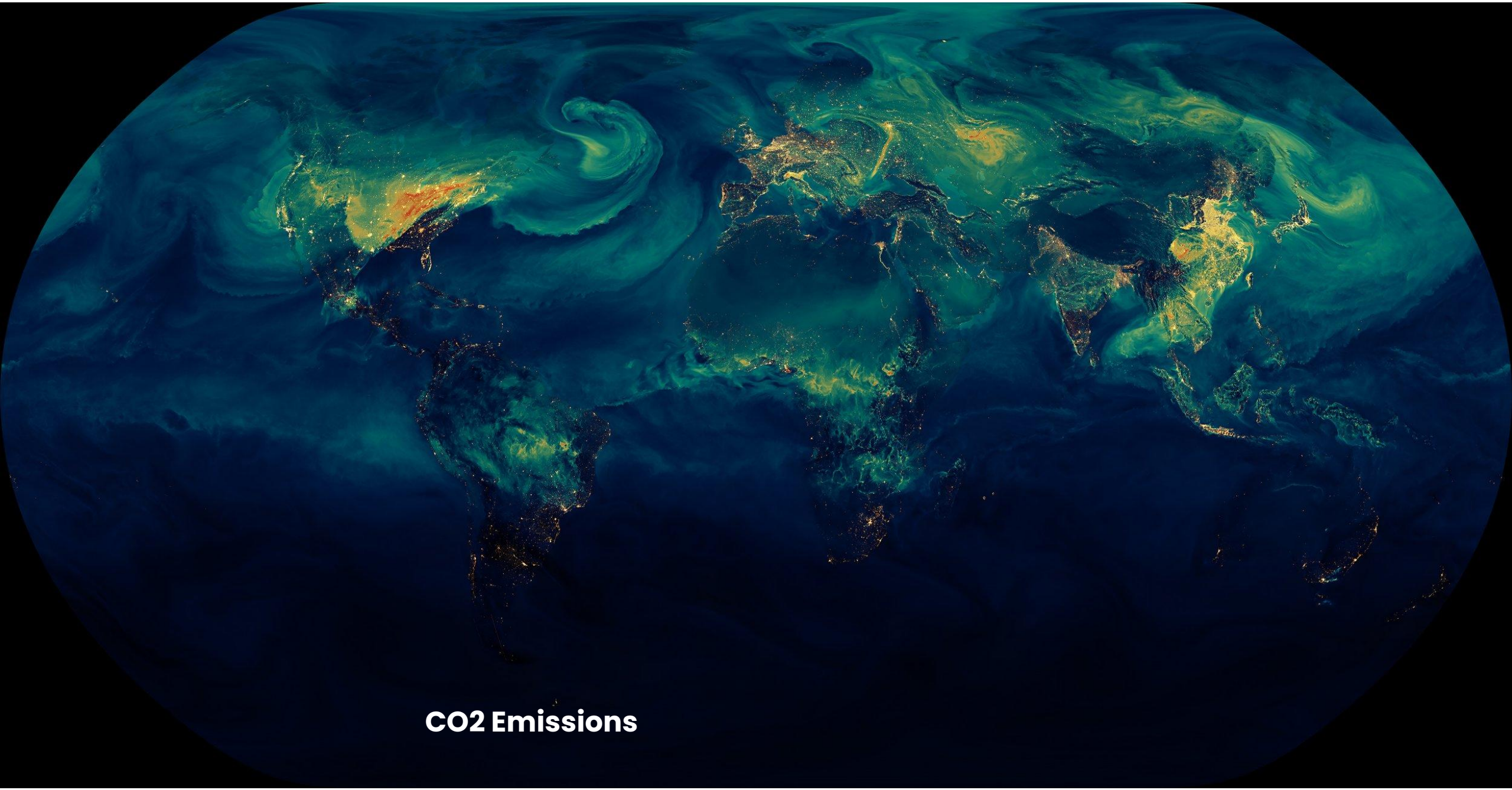
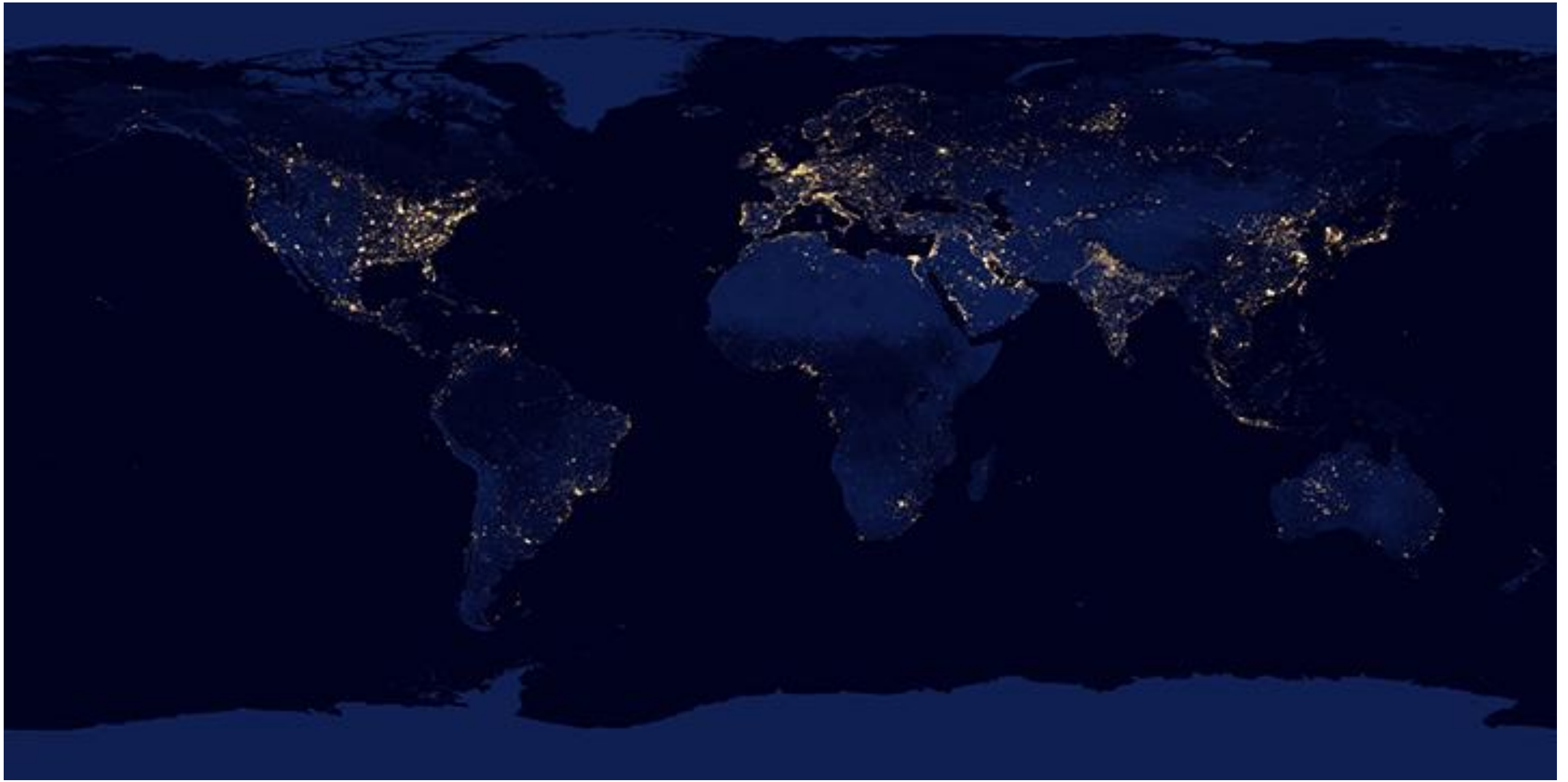
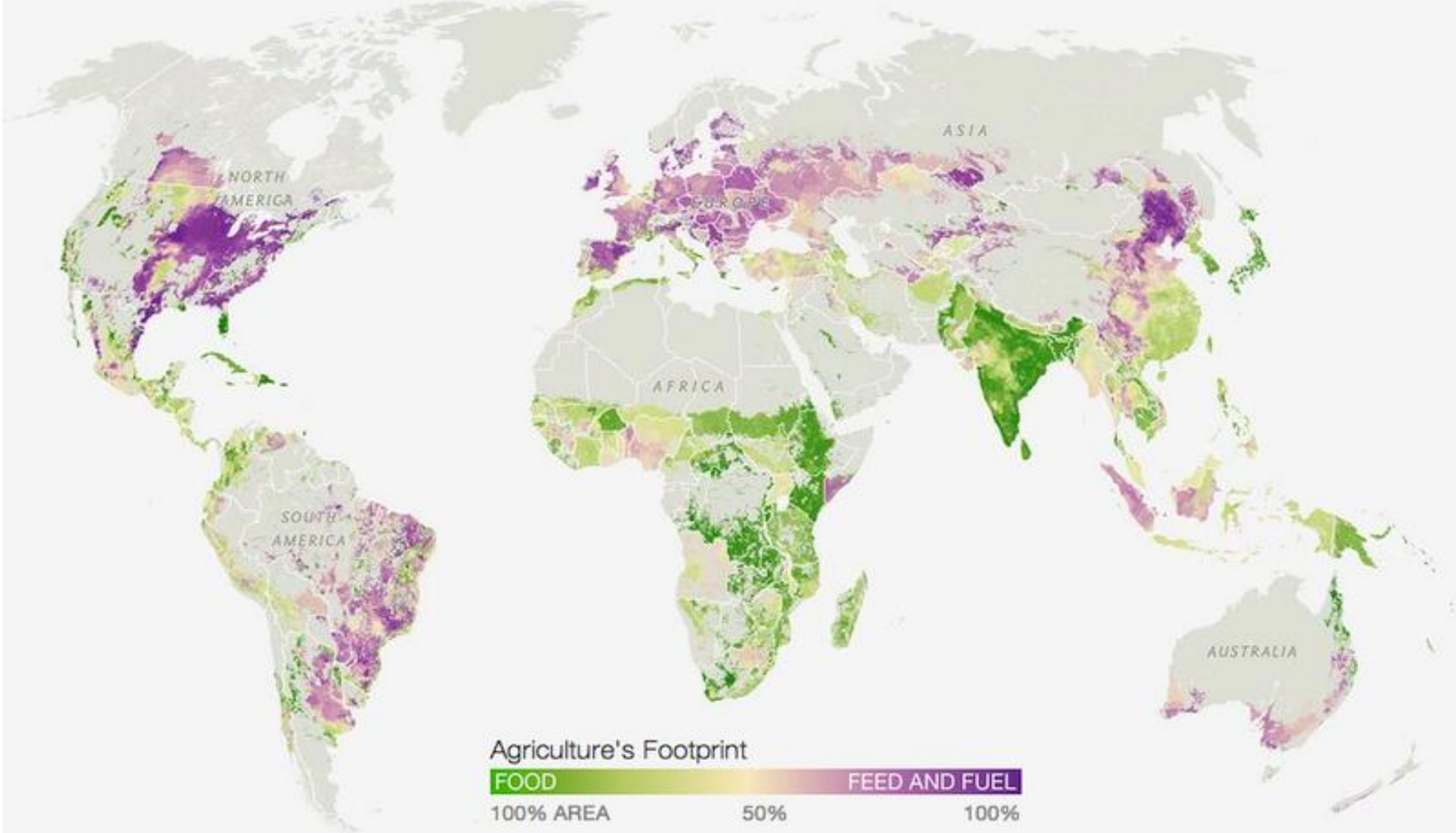


Figure 3. Spatial distribution of the two largest components of the technosphere by mass, at 1-degree resolution. Note that the palest yellow colour shows very low values, less than 0.1 $kg\,m^{-2}$, and a lower threshold of 0.001 $kg\,m^{-2}$ was used, below which the area is white.

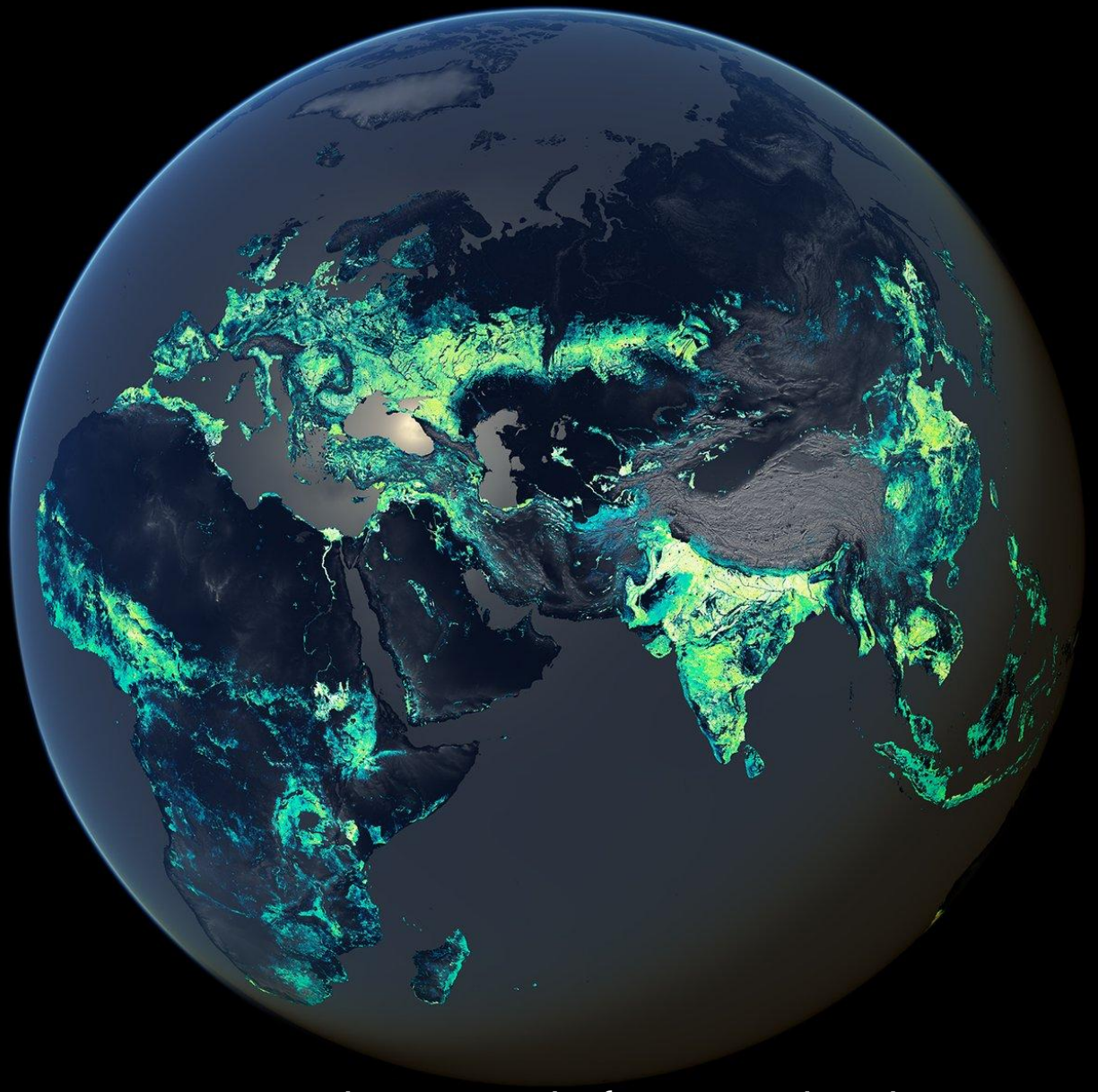

CO2 Emissions




NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
Agriculture's Footprint
FOOD
FEED AND FUEL
100% AREA
50%
100%



the vast expanse of **croplands**



the spread of pasture lands

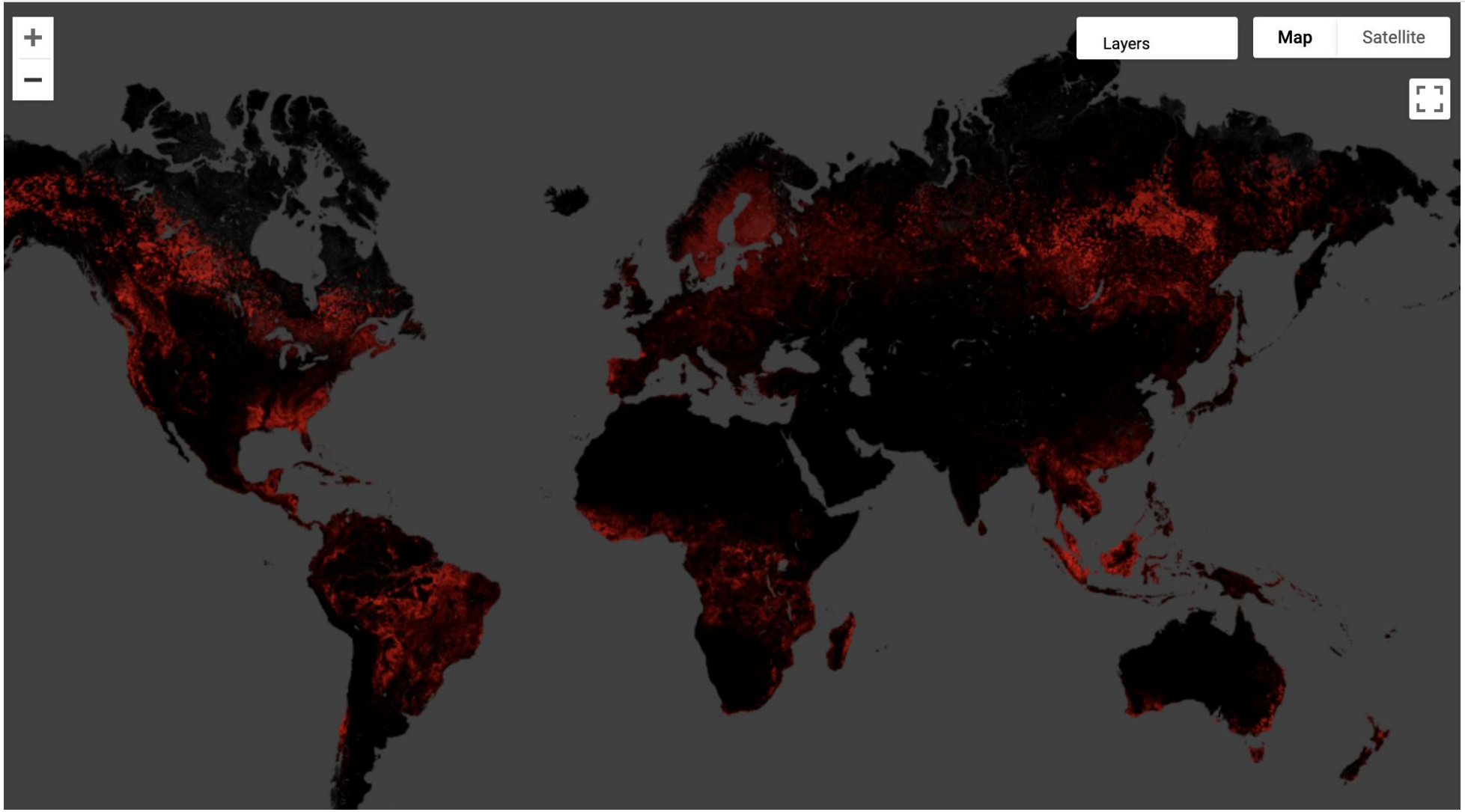
Source: EarthStat, “**Food Planet**”

Humans need more, and cheaper!

Global Land Analysis & Discovery

Search places

Earth Engine Apps



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 tota '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

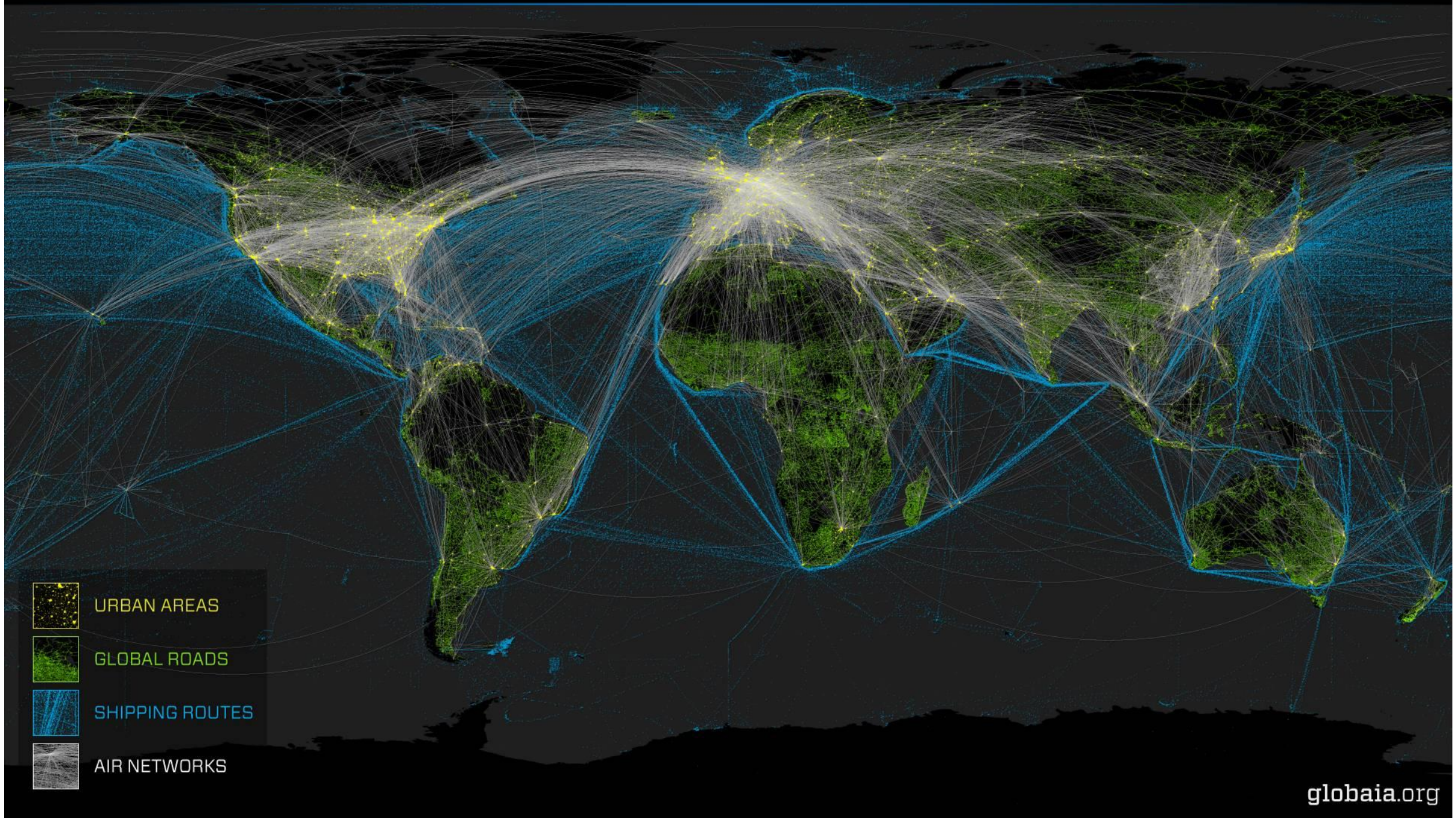
Loss
No loss
Water or no data

Other Data Layers

2000 Percent Tree Cover

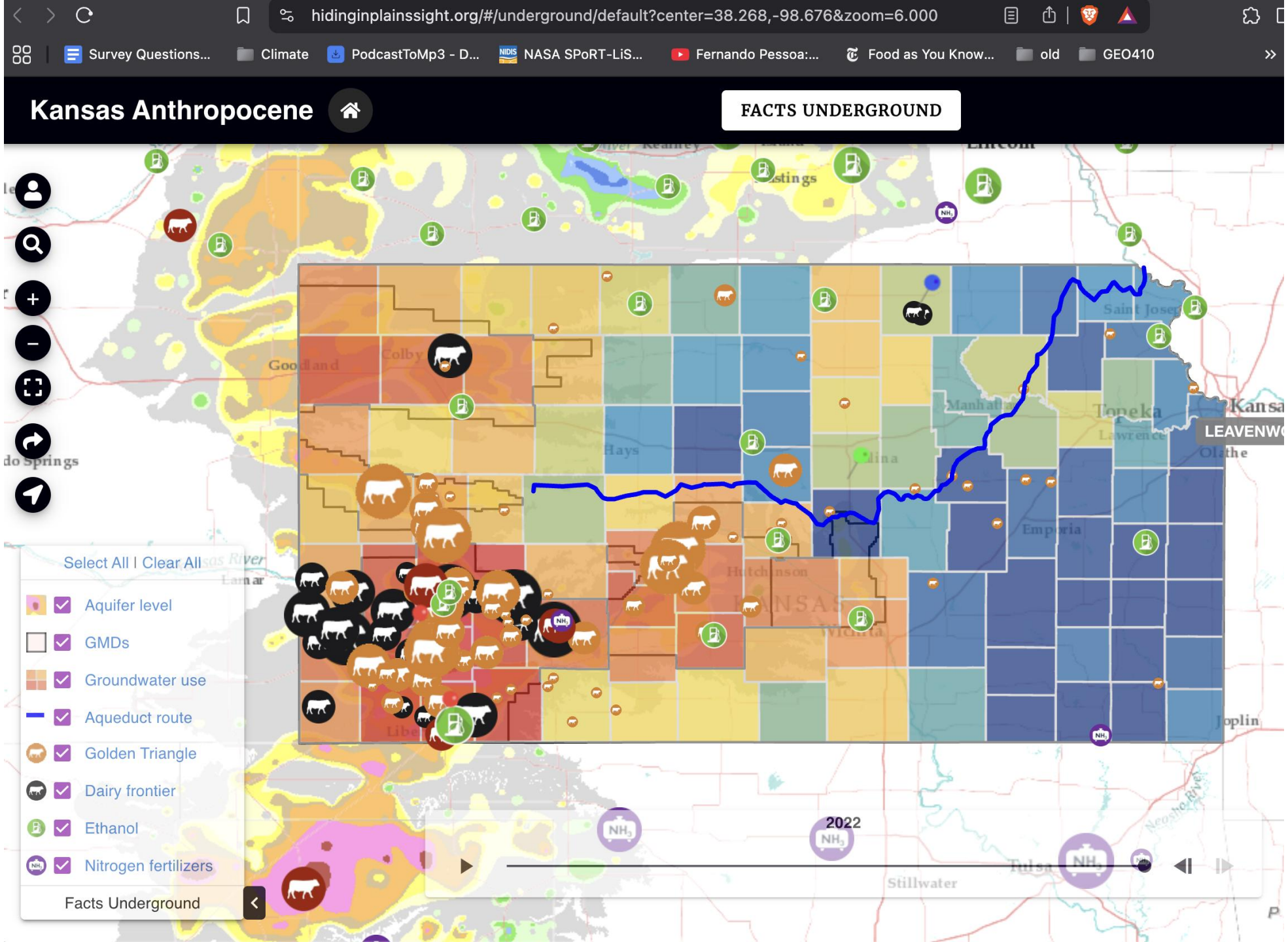
Background Imagery

THE GLOBAL TRANSPORTATION SYSTEM





Data Centers


hidinginplainssight.org/#/underground/default?center=38.268,-98.676&zoom=6.000
Survey Questions...
Climate
PodcastToMp3 - D...
NASA SPoRT-LiS...
Fernando Pessoa:...
Food as You Know...
old
GEO410
Kansas Anthropocene
FACTS UNDERGROUND
Select All | Clear All
Aquifer level
GMDs
Groundwater use
Aqueduct route
Golden Triangle
Dairy frontier
Ethanol
Nitrogen fertilizers
Facts Underground
2022
Goodland
Colby
Hays
Manhattan
Topeka
Lawrence
Olathe
Emporia
Hutchinson
Wichita
Joplin
Stillwater
Tulsa
LEAVENW

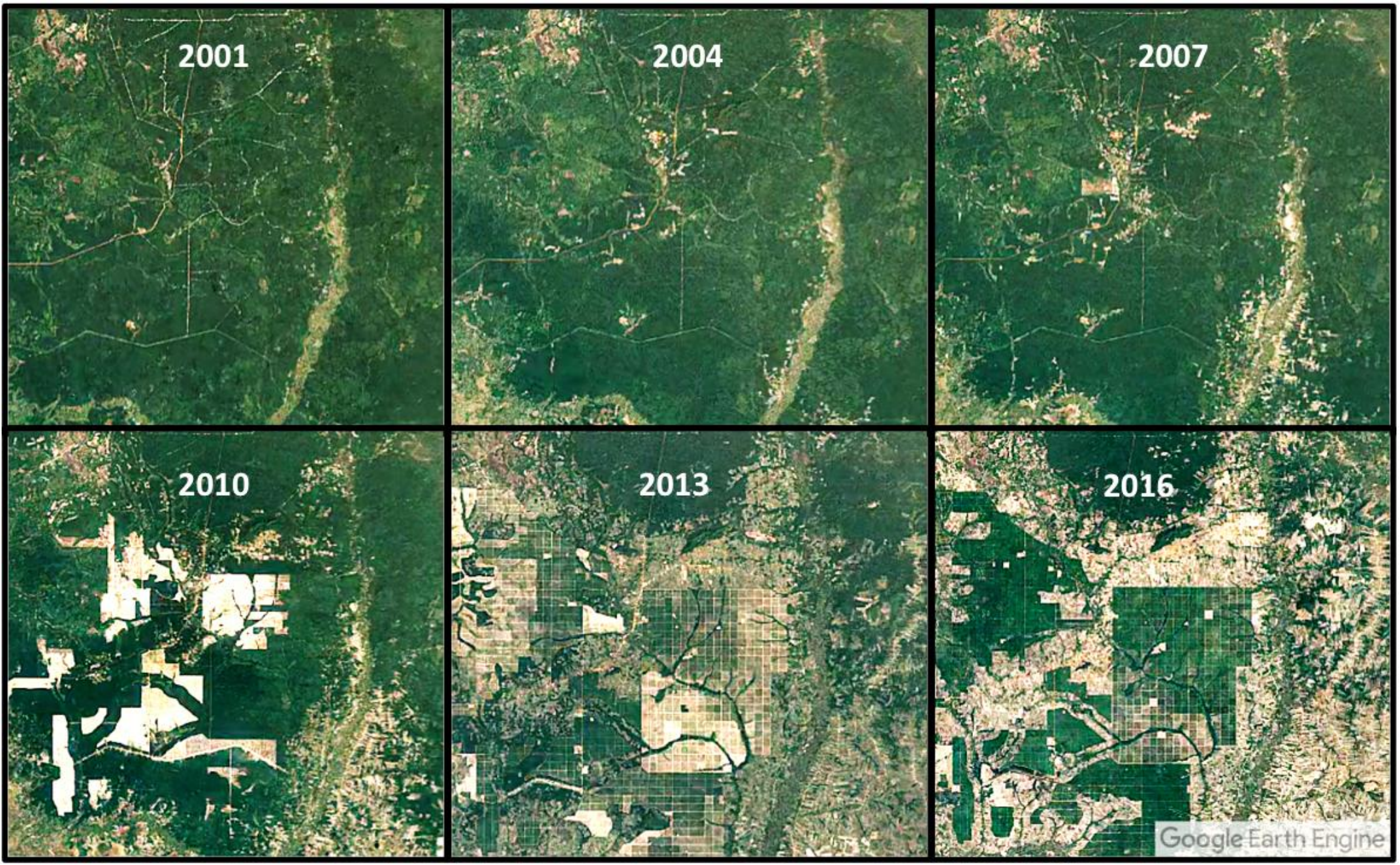
Jerrod Carmichael

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



Forests in Cambodia. Most forest clearing is illegal


adidas

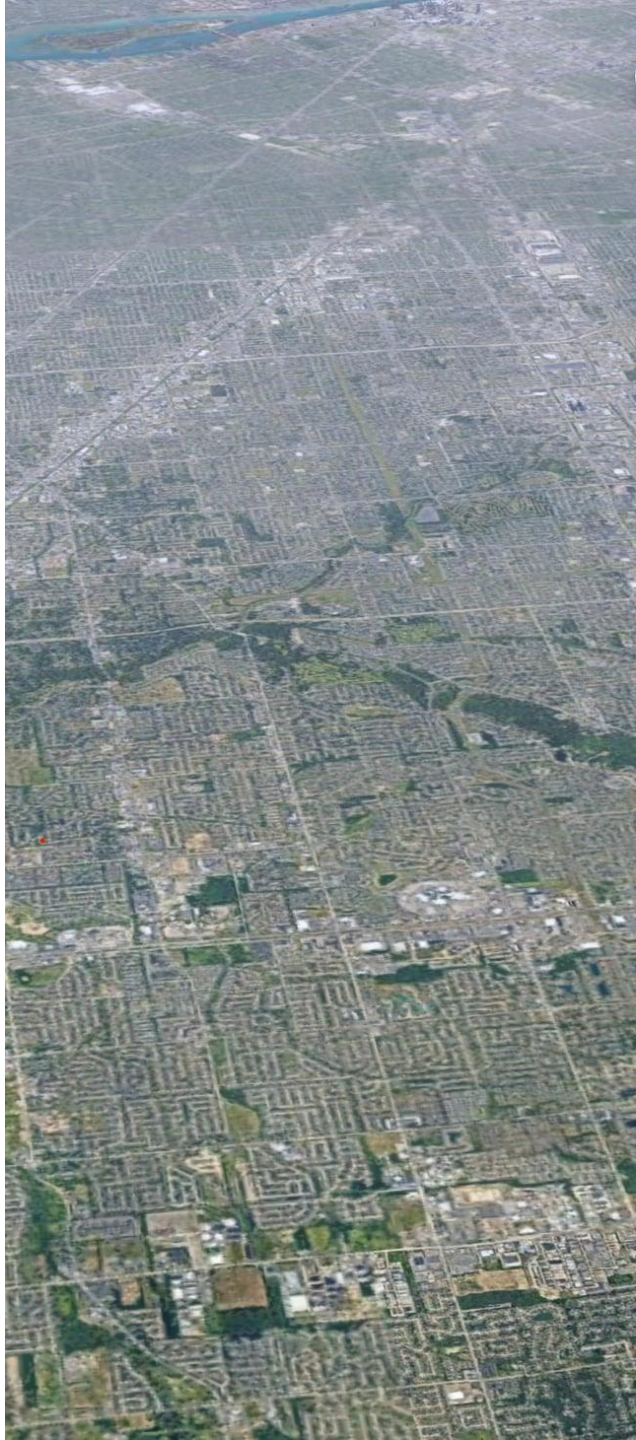

nutiva
ORGANIC
red palm oil
FLAVORFUL CULINARY OIL
VITAMINS A & E
15 FL OZ
(444 mL)
PALM
DONE RIGHT



We change our landscapes too







- 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?

- Are there Tipping Points?

Are we near a tipping point?
What are some early indicators?

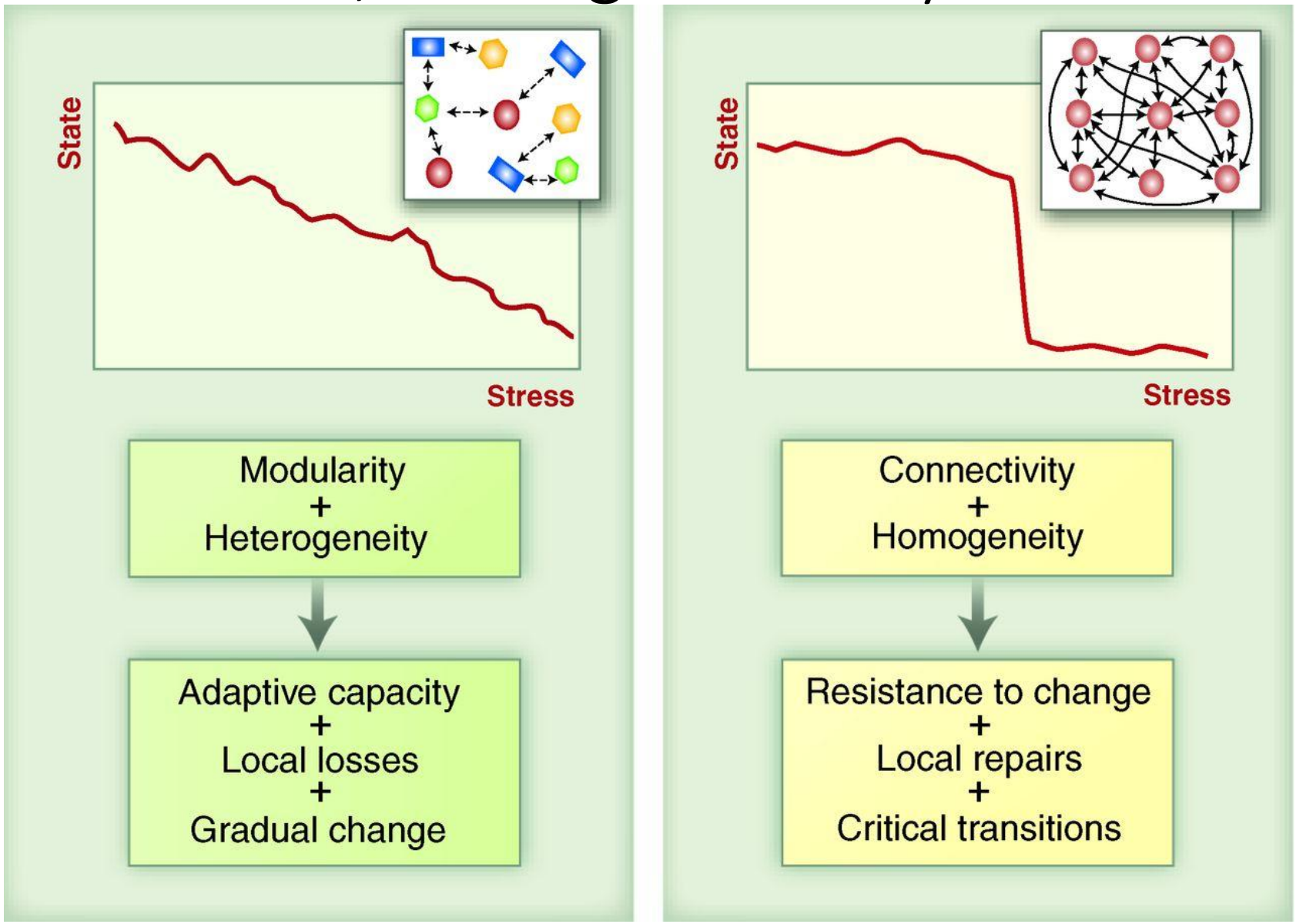


https://sites.google.com/d/1zAtZhpNNV4PV0pAT1phrW_pVjuCBWg7P/p/1_uK4DbsA6wmi6QN1Uv8G6TQVUby-T4Df/edit

Heterogeneous systems behave differently if modular than connected, homogeneous systems

Marten Scheffer et al.

Science 338 (2012)

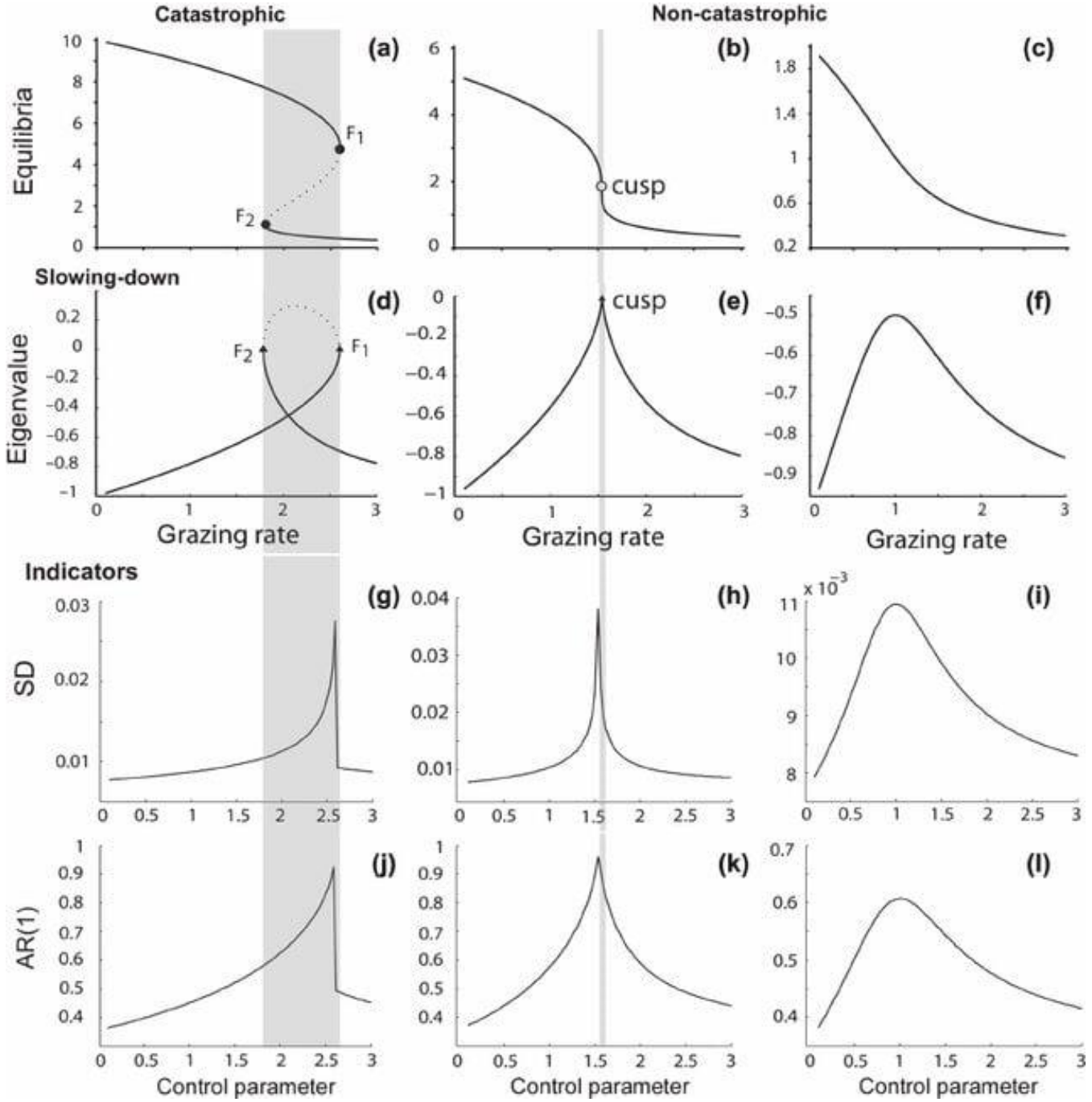


Early warning signals also precede non-catastrophic transitions

critical slowing down is a key phenomenon to measure the distance to a tipping point in ecosystems



Sonia Kéfi



Where to look for adaptation?

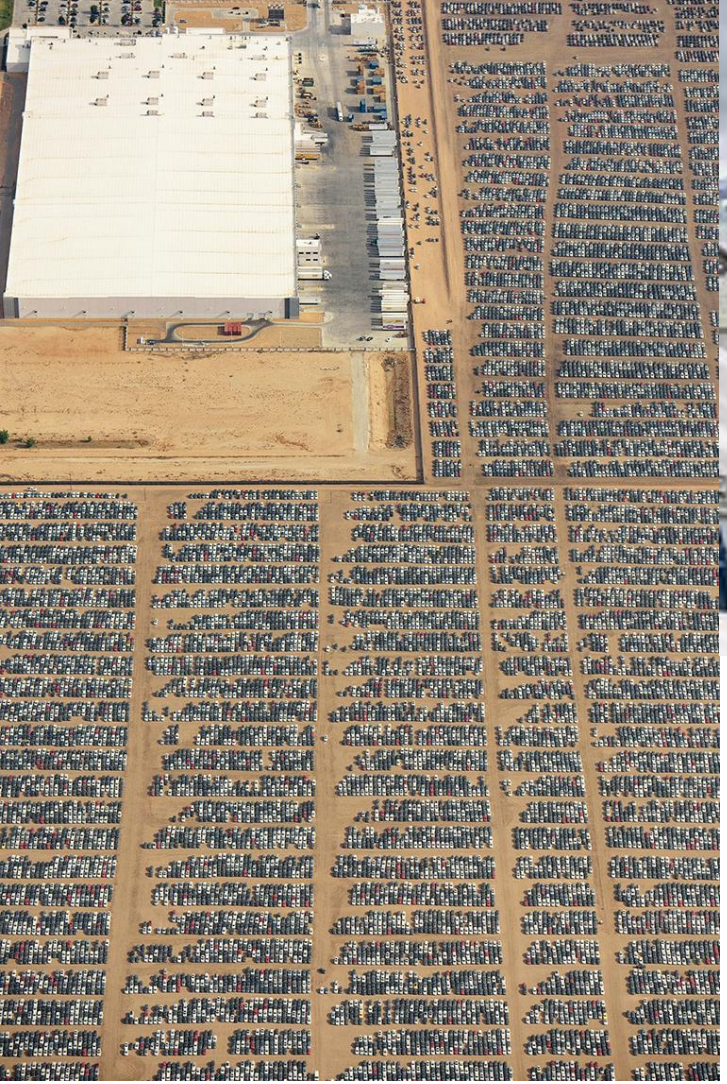
Biosphere Element	Technosphere Element
Biodiversity	→ Information Diversity, Density, Flow
Genetic diversity	→ Algorithmic complexity, network density, IoT
Trophic Levels	→ Network Connections + Network Failures
Metabolic Rates	→ Financial and energy flows
Ecosystem Connectivity	→ Social connectedness, supply chain complexity
NPP and biogeochemical cycling	→ material throughput, recycling, waste
Mutation rate	→ innovation rate
Feedbacks	→ automation and AI autonomy

Innovation in cycling

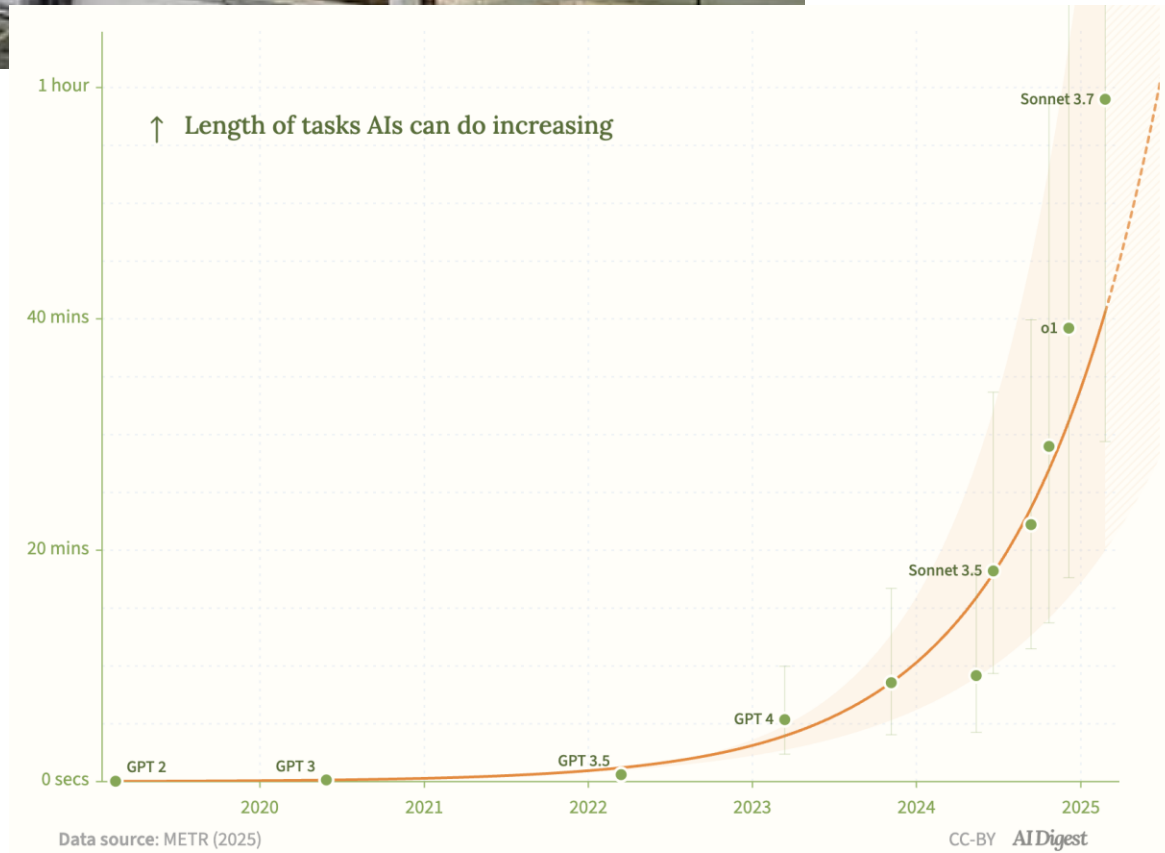
Residential Waste Audit - Material Breakdown
Small samples from all dorms (AM) and large sort of Brody trash (PM)
SLE Waste Audit

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.









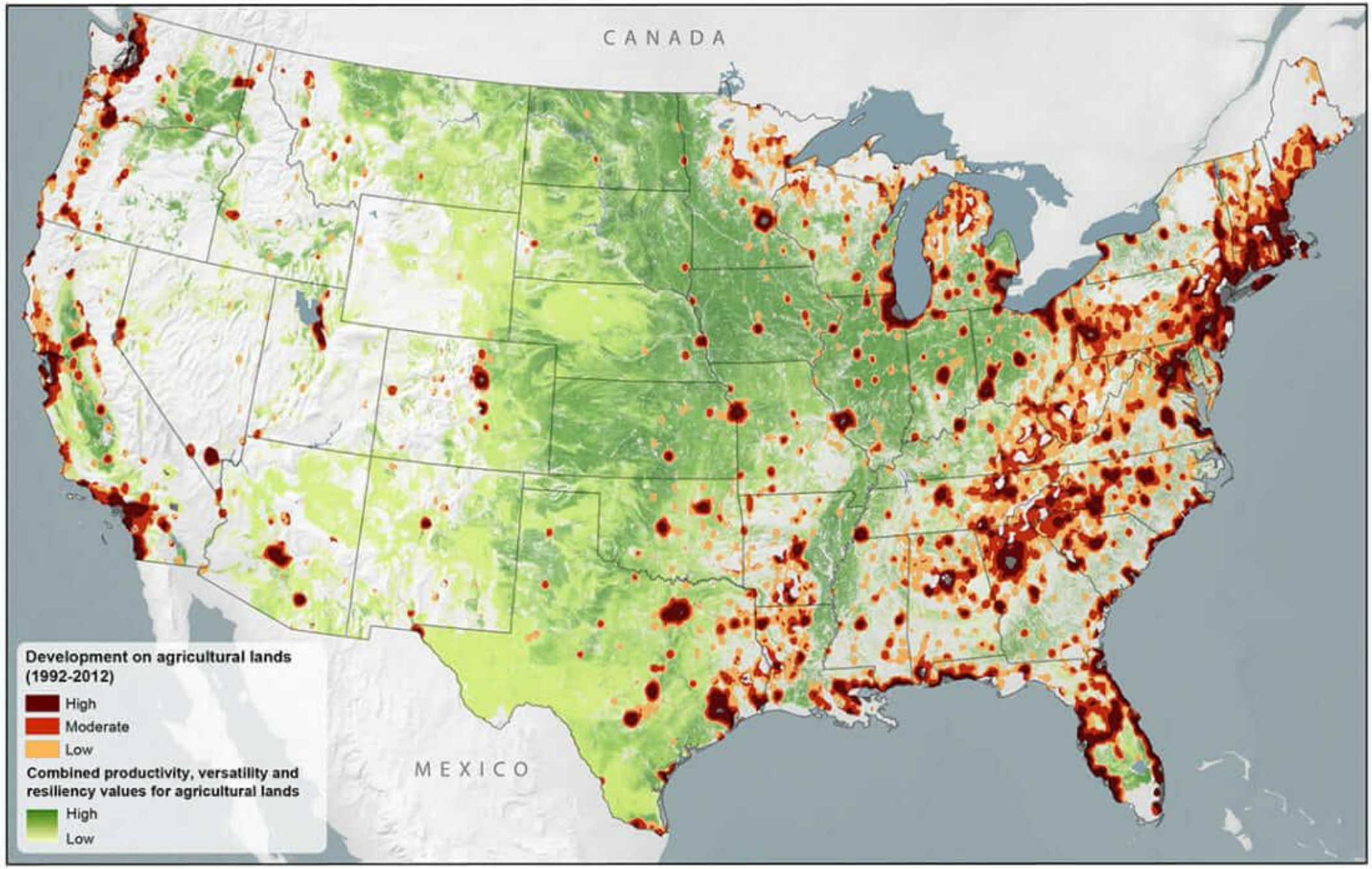
March 27th, 2025

A new Moore's Law for AI agents

When ChatGPT came out in 2022, it could do 30 second coding tasks.

Today, AI agents can autonomously do coding tasks that take humans an hour.

Scroll to continue


CANADA
MEXICO
Development on agricultural lands (1992-2012)
High
Moderate
Low
Combined productivity, versatility and resiliency values for agricultural lands
High
Low

Building the Technosphere one click at a a time







Help bring about the new world of the Technosphere! Create more data about how you, as a subcomponent, think.



Build your life more efficiently than previous generations did

- Live where you work/work where you live
- Public goods
- Spend time with people, not things.
  - Get Involved!
- Buy it For Life
- Seek First to Understand

There is a continuum forming in the Technosphere

But there are extremes!

Do you want to live like this?

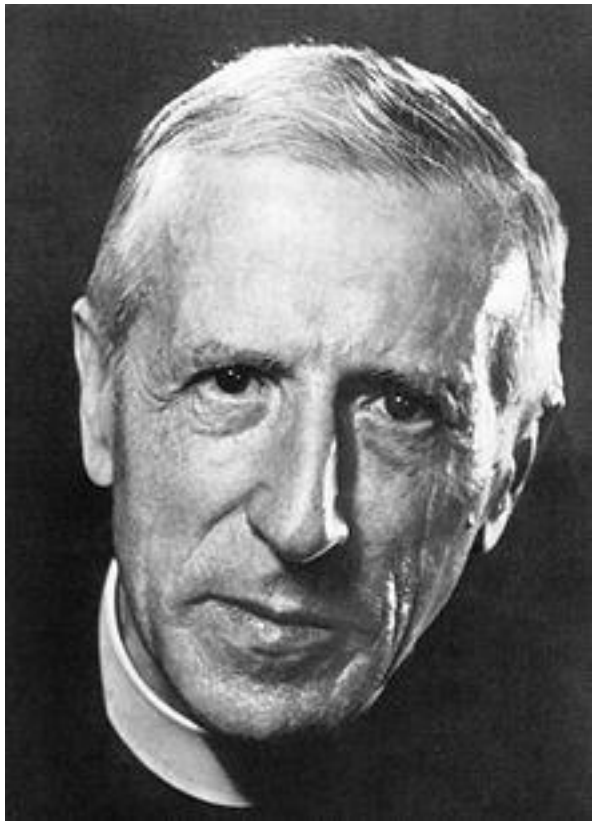


Or live like Diogenes?



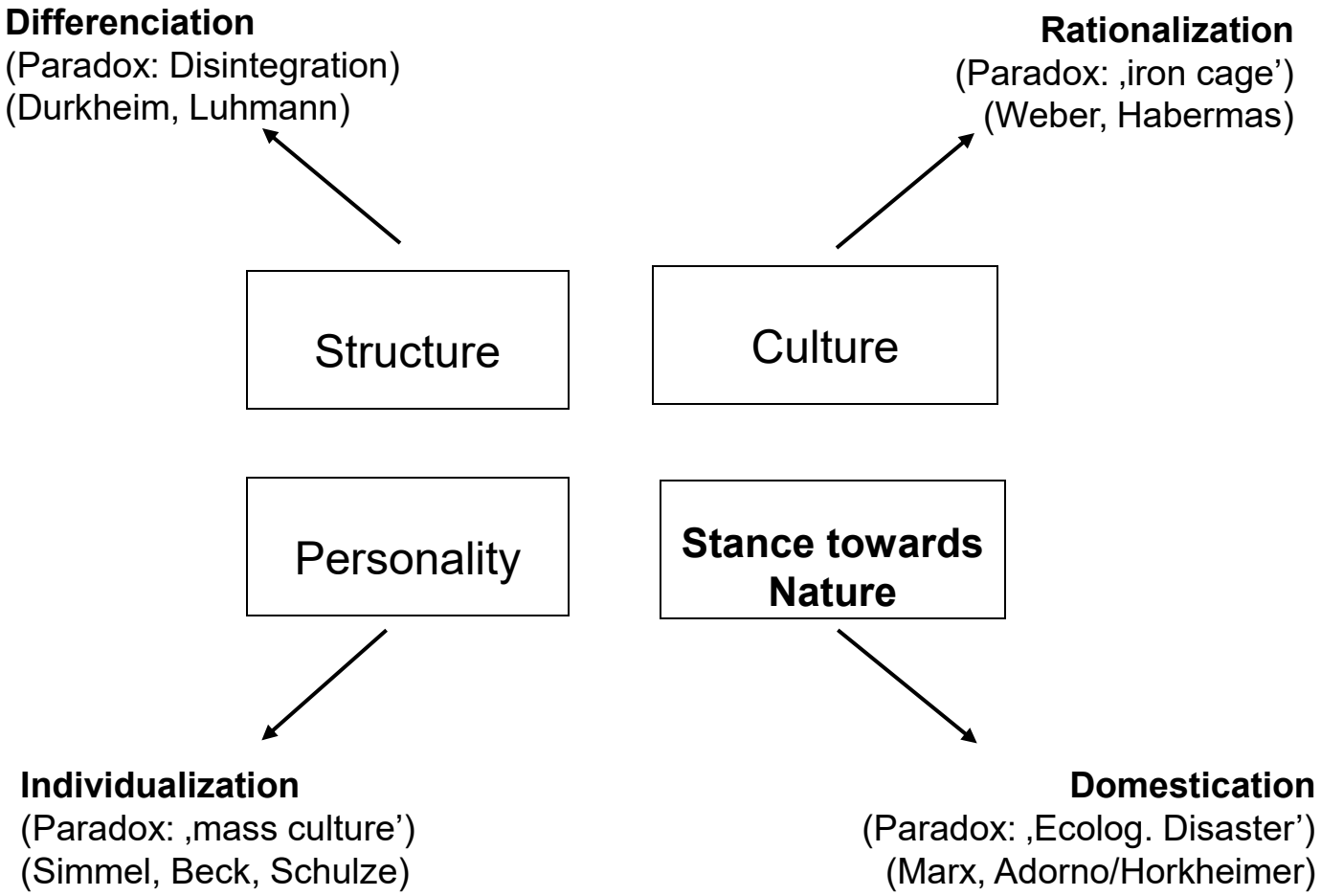
Jean-Léon Gérôme (French, 1824-1904)

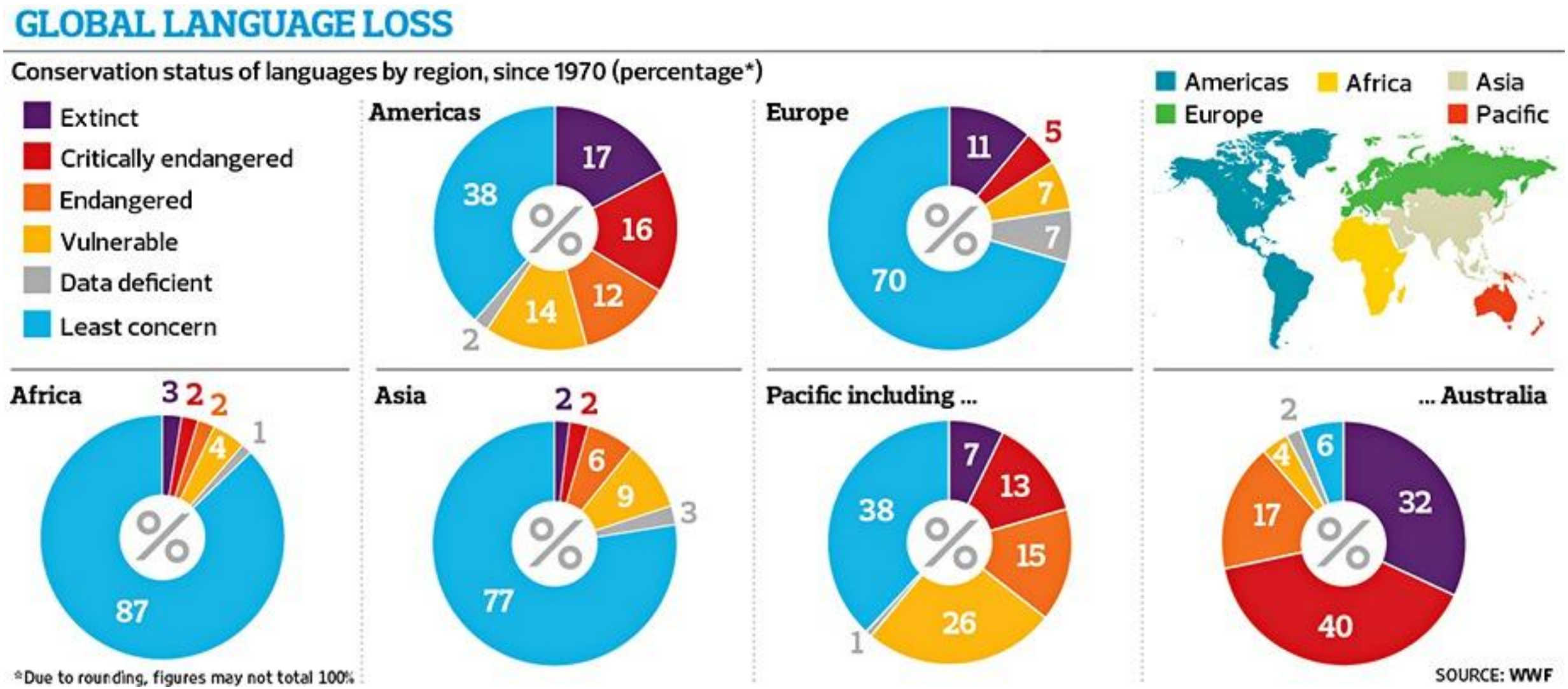
Vitalism



Pierre Teilhard de Chardin

Rosa's Four Processes of Modernization

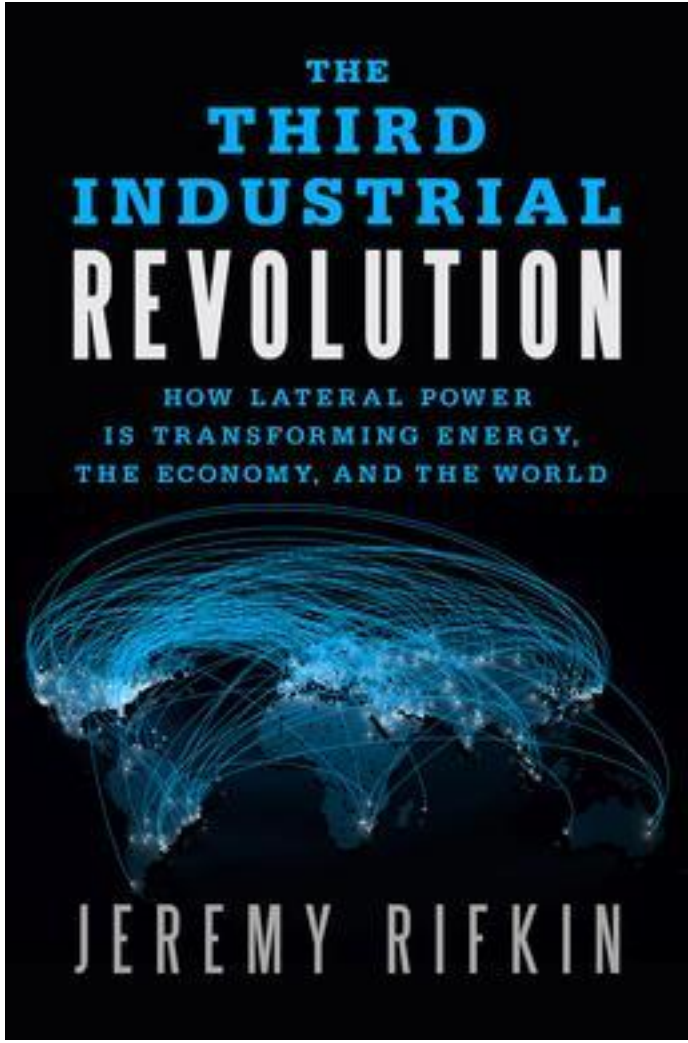




Languages + Cultures that don't help the Technosphere are extincted

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?)