April 25

Planetary Boundaries & The International Trade Game

Patrícia Fortes

Fundamentals on Environment and Sustainability

NOVA SCHOOL OF BUSINESS & ECONOMICS
NOVA SCHOOL OF SCIENCE & TECHNOLOGY

WHO I AM

Patrícia Fortes

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> Associate Researcher at NOVA School of Science and Technology (www.fct.unl.pt/)

> Coordinator Energy and Climate research line of CENSE-Center for (www.cense.fct.unl.pt/)

> Responsible for the design of the mitigation path of energy and industry sectors in the Portuguese Carbon Neutrality Roadmap 2050 (https://descarbonizar2050.apambiente.pt/en/roadmap/)

Contact: p.f@fct.unl.pt

AT THE END OF THIS CLASS YOU SHOULD KNOW

- What is the Anthropocene
- What are Planetary Boundaries
- The Number and Core Planetary Boundaries.
- Trends in Planetary Boundaries.
- Importance and Challenges of Socio-Economic Development within Planetary Boundaries.

Planetary Boundaries

EARTH SYSTEM

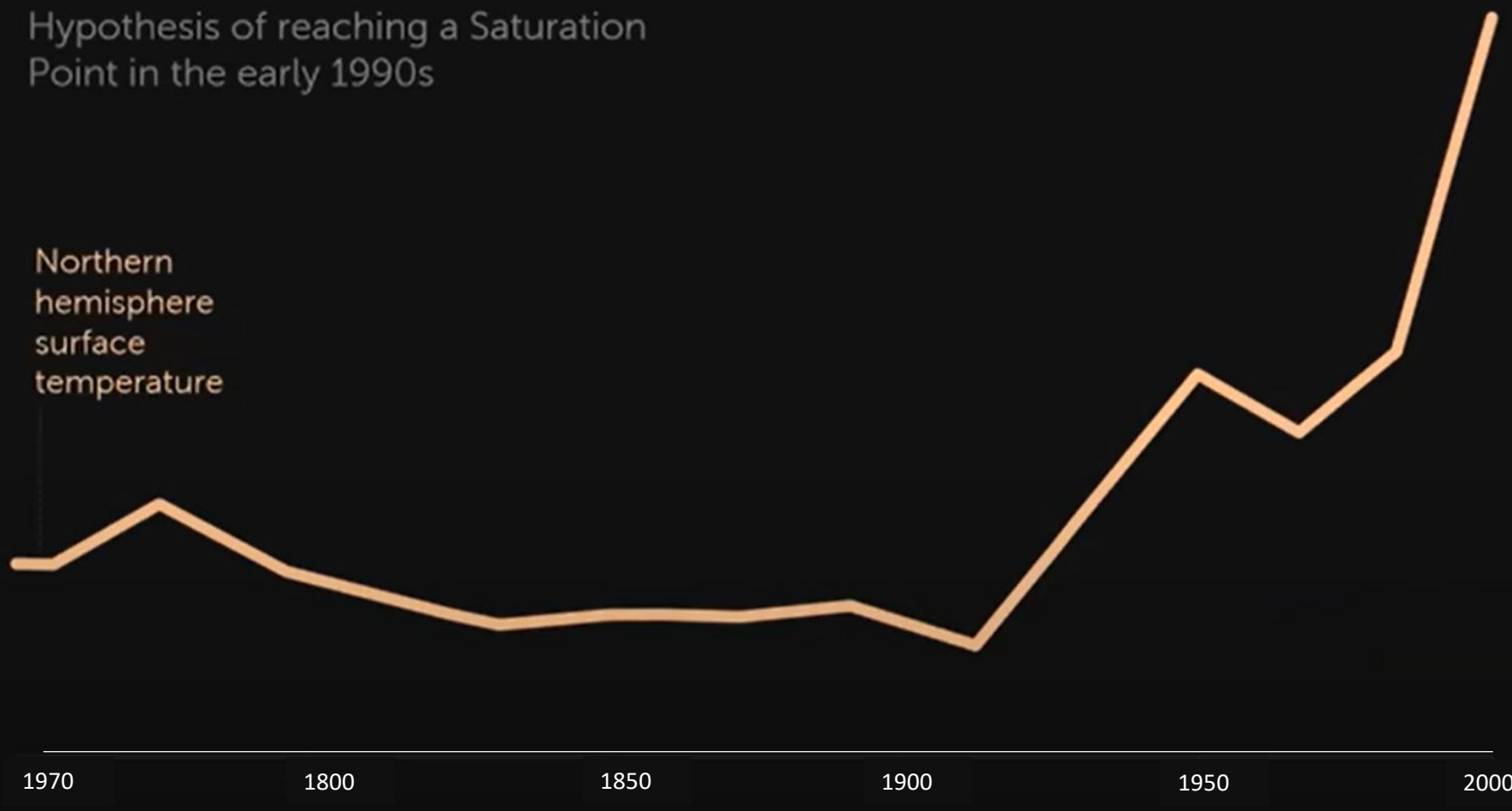
> The Earth system is a complex network of interactions among different spheres:
  - *geosphere* (land),
  - *hydrosphere* (water)
  - *atmosphere* (air)
  - *biosphere* (life)

Red Code for Humanity

António Guterres
UN Secretary-General

The Great Acceleration

Hypothesis of reaching a Saturation Point in the early 1990s



New Scientist 2008 from Steffen et al. 2004

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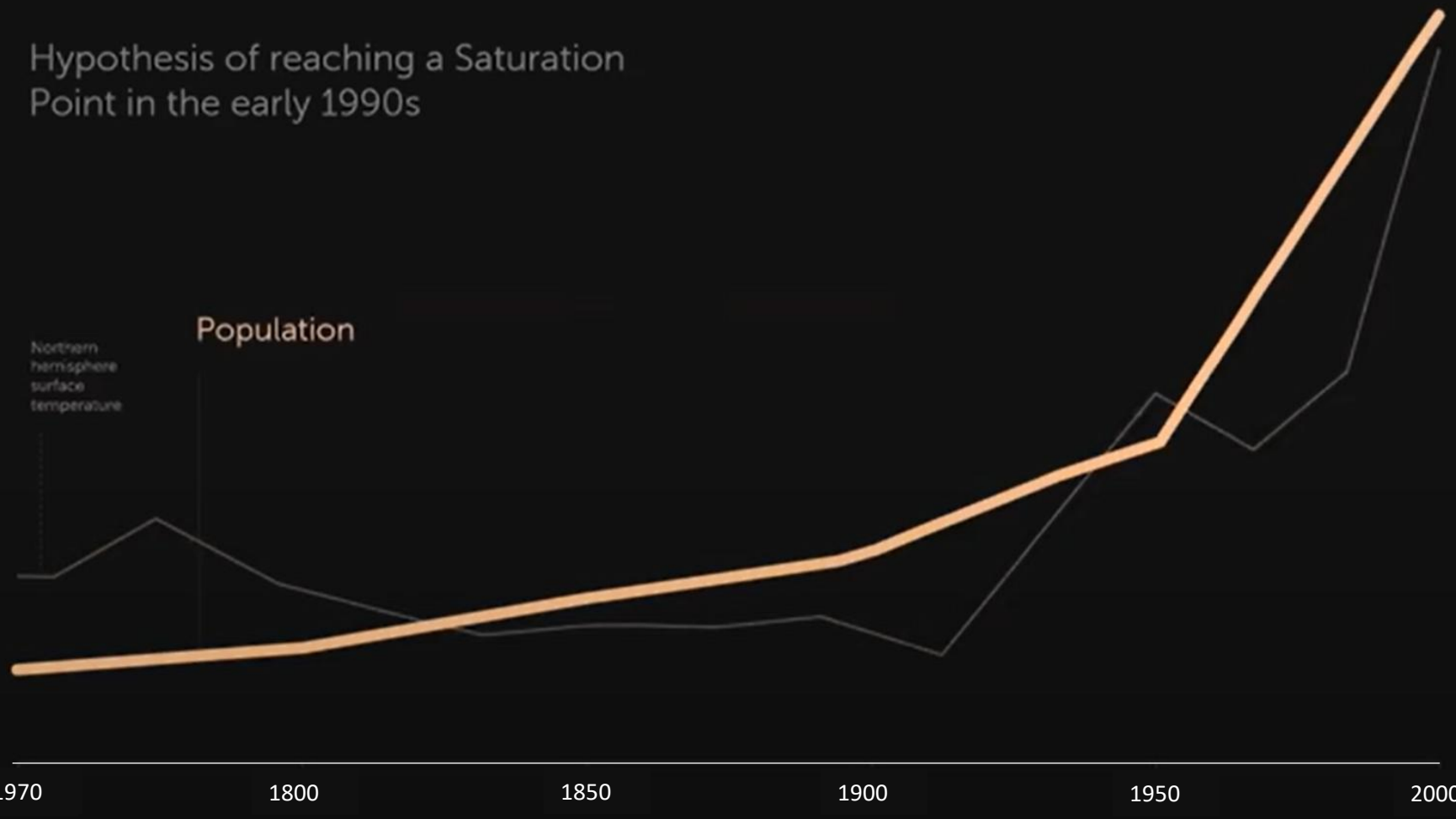

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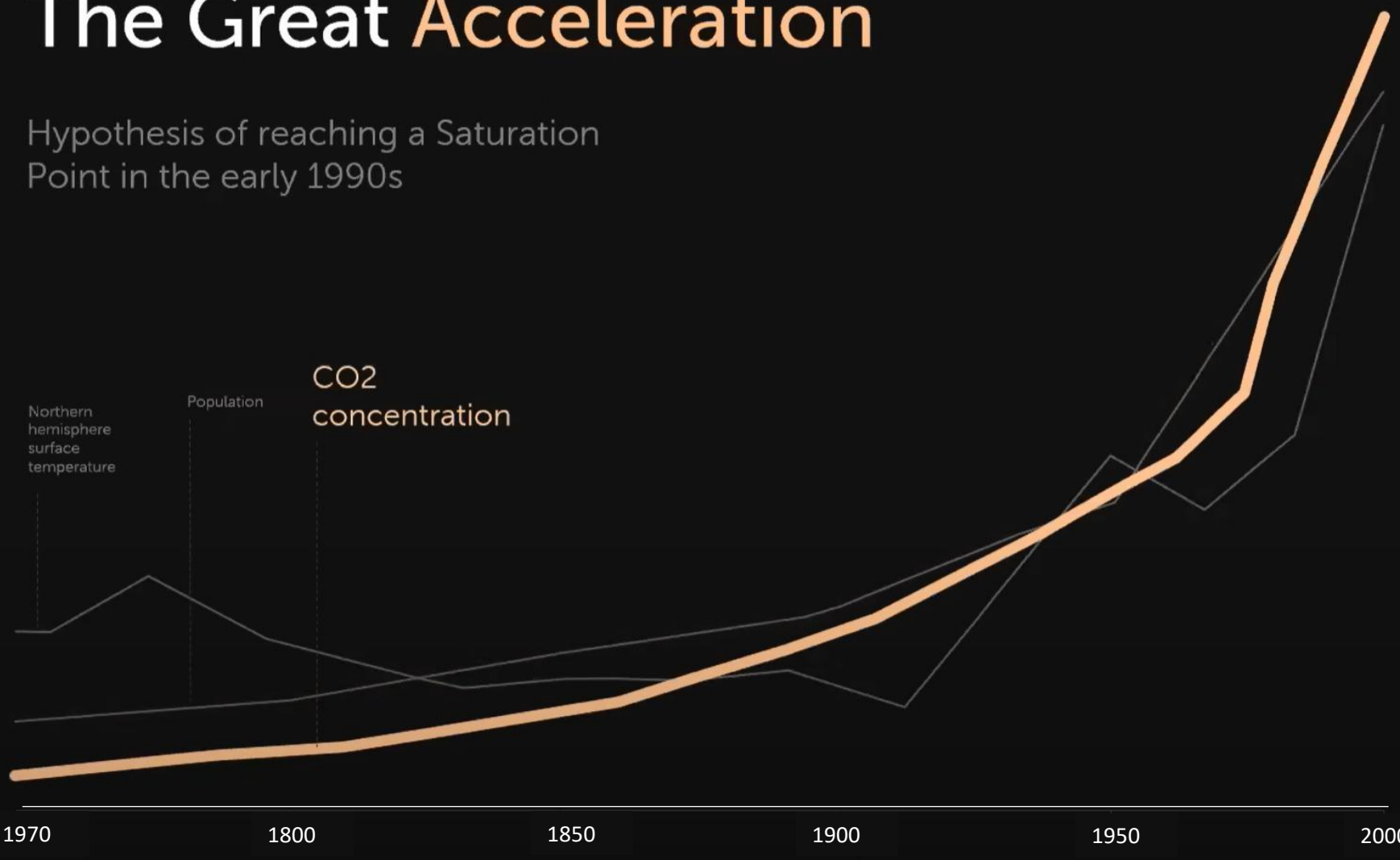

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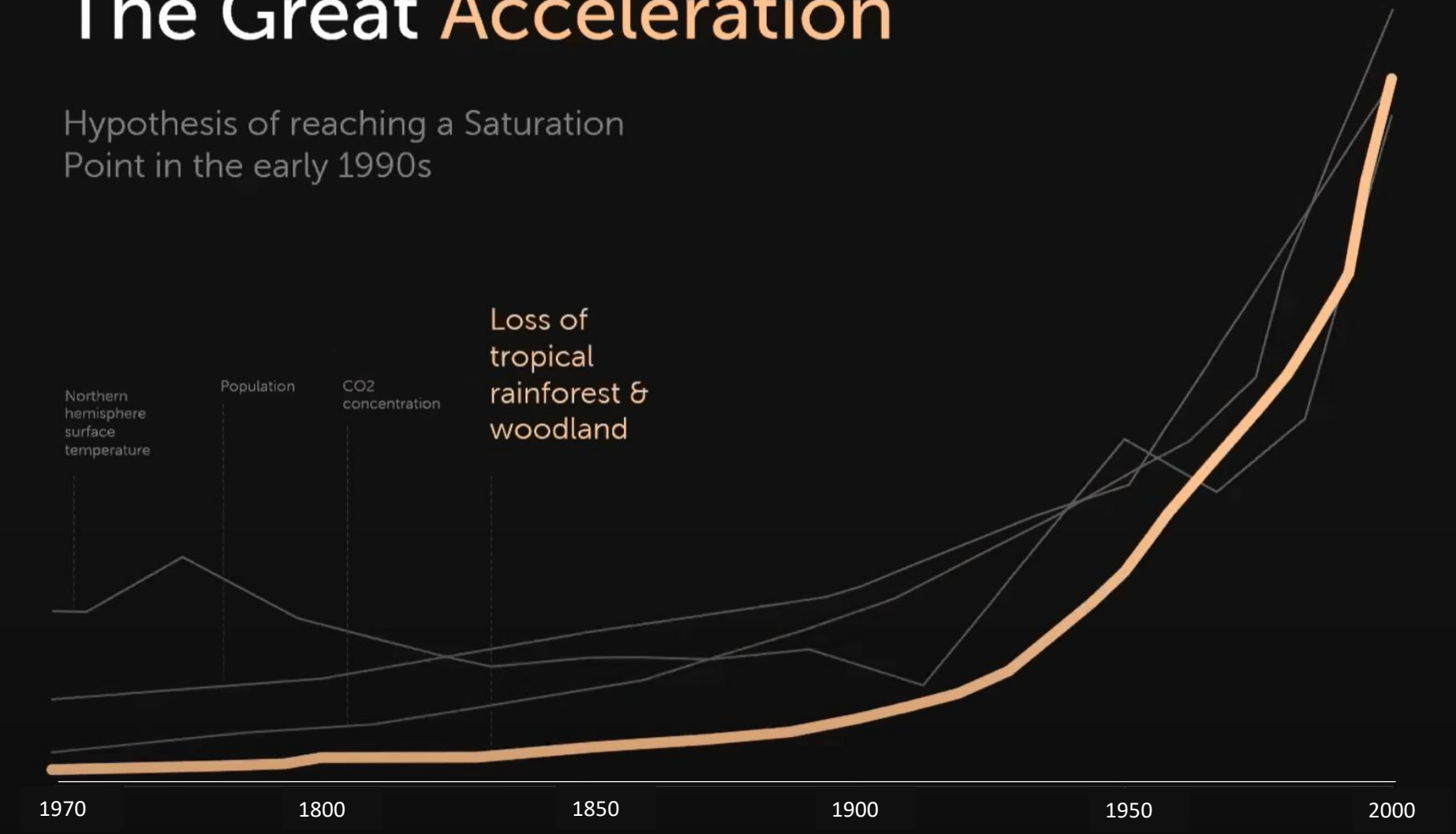

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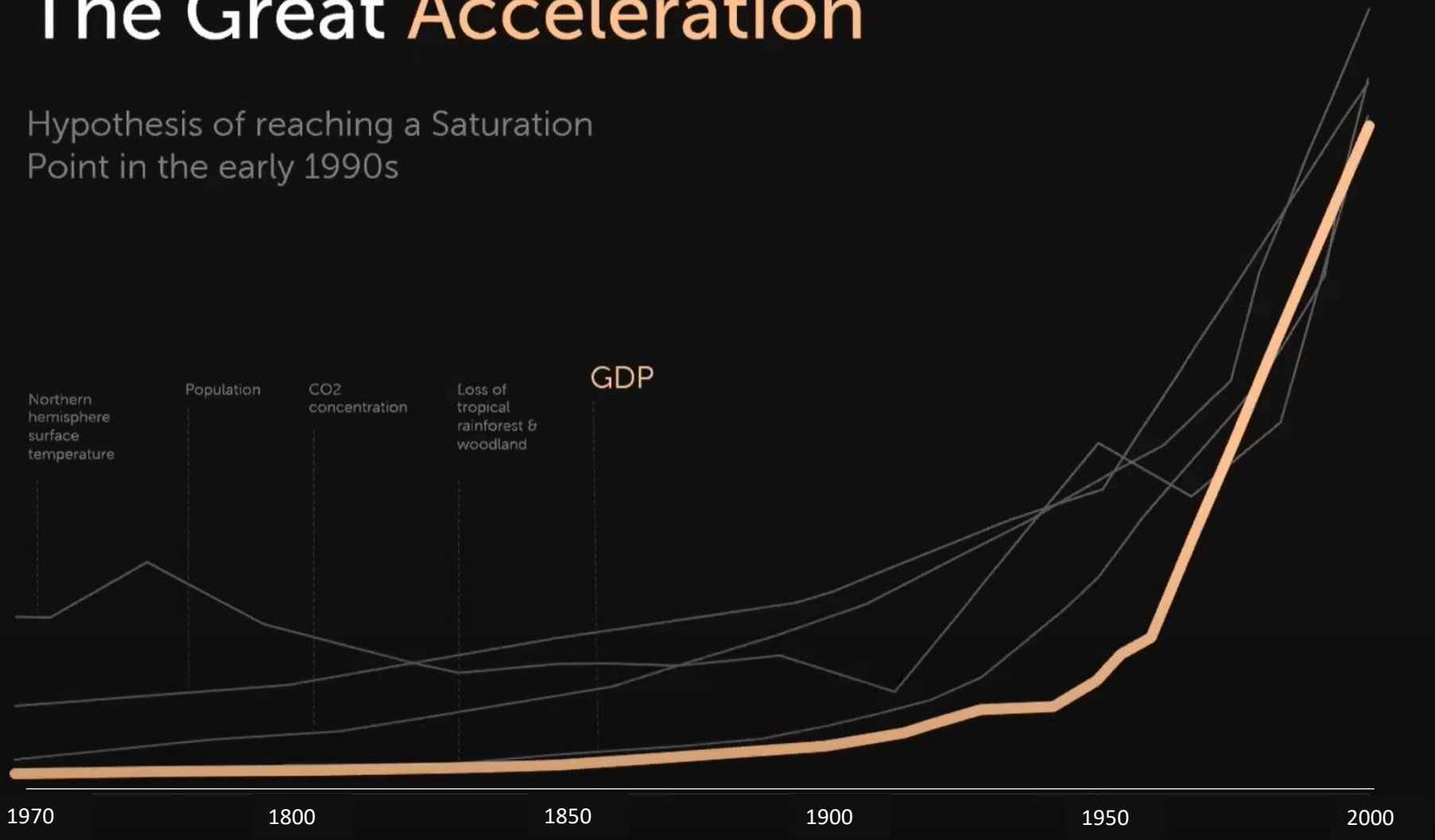

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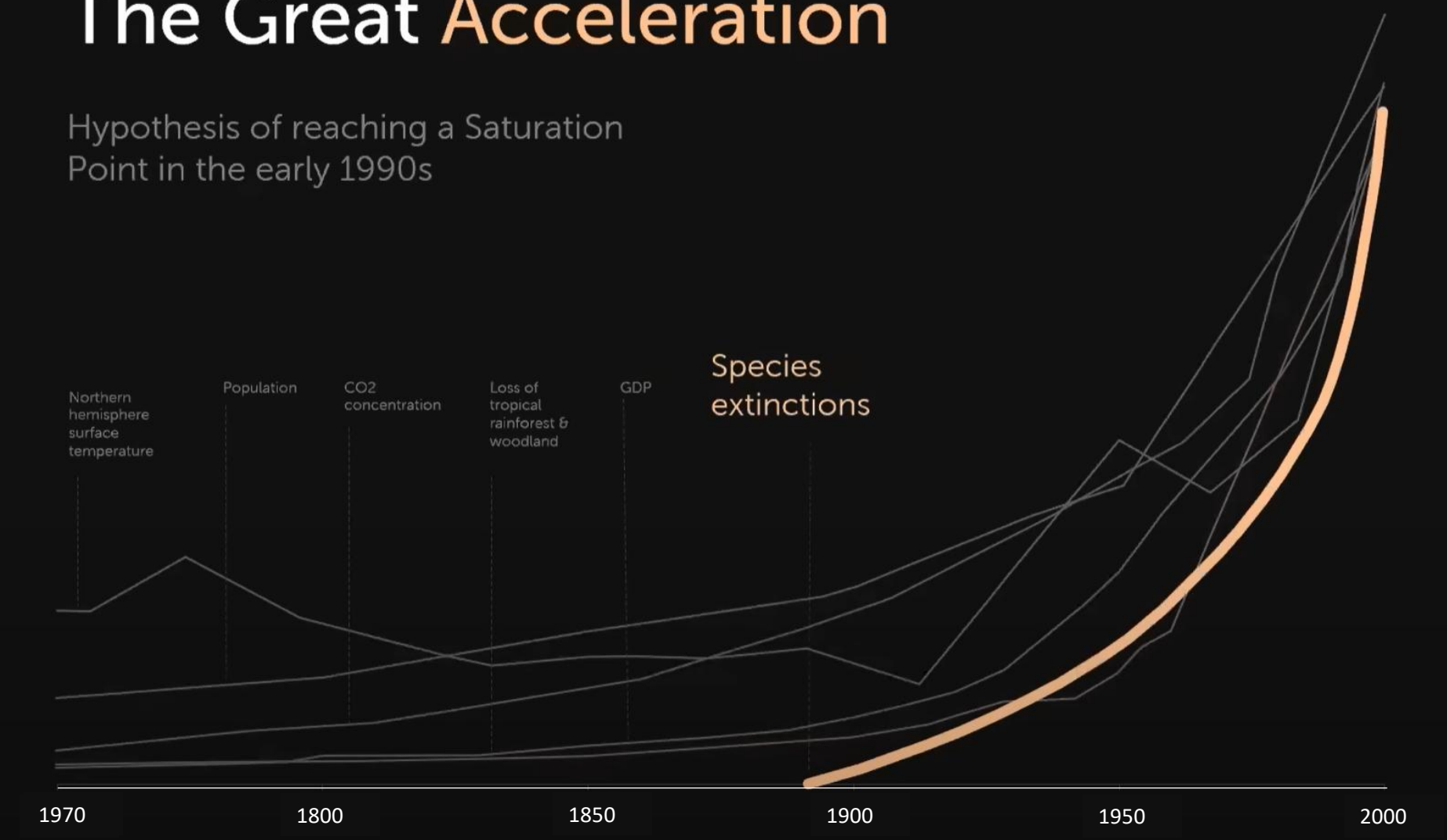

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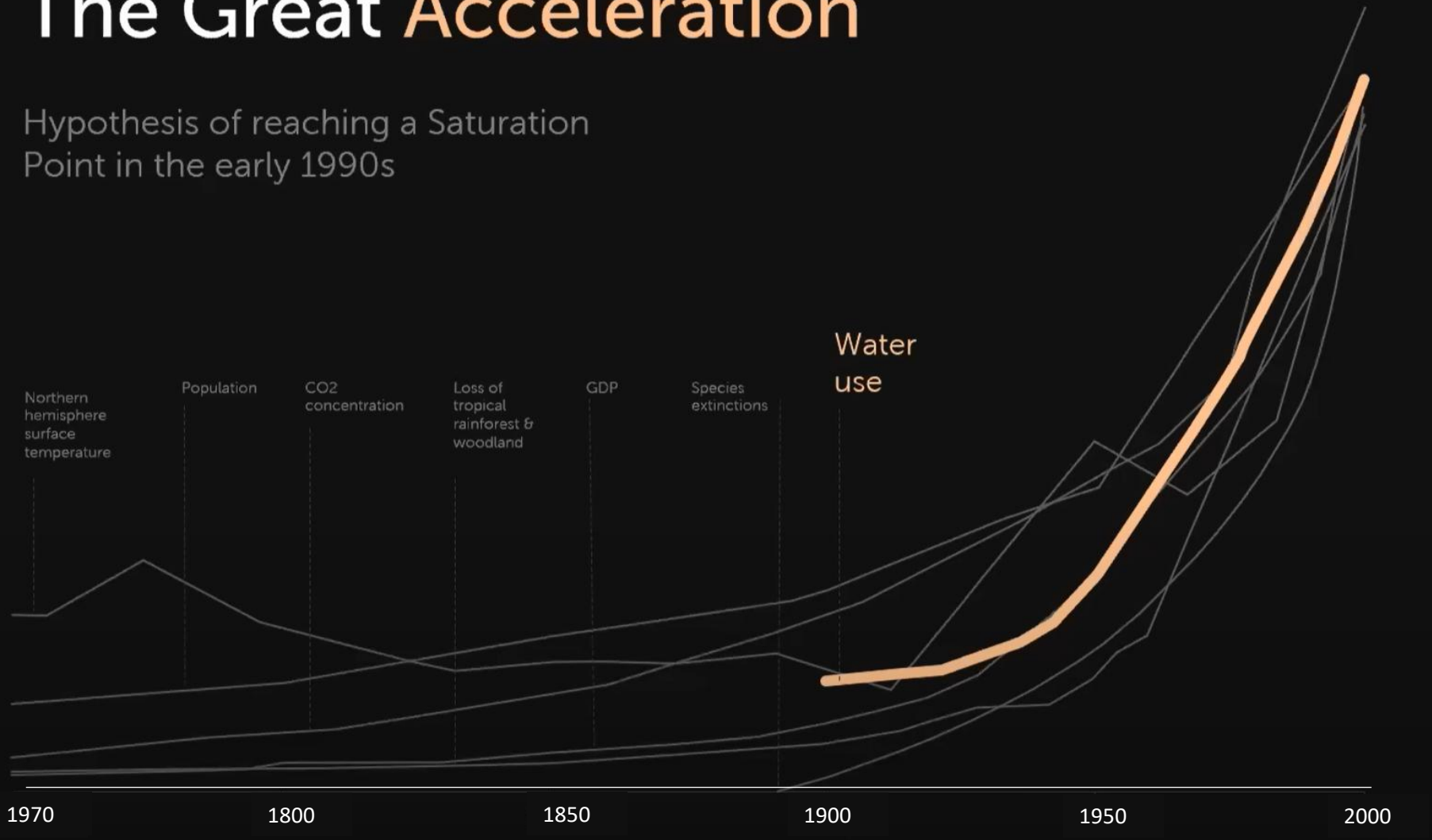

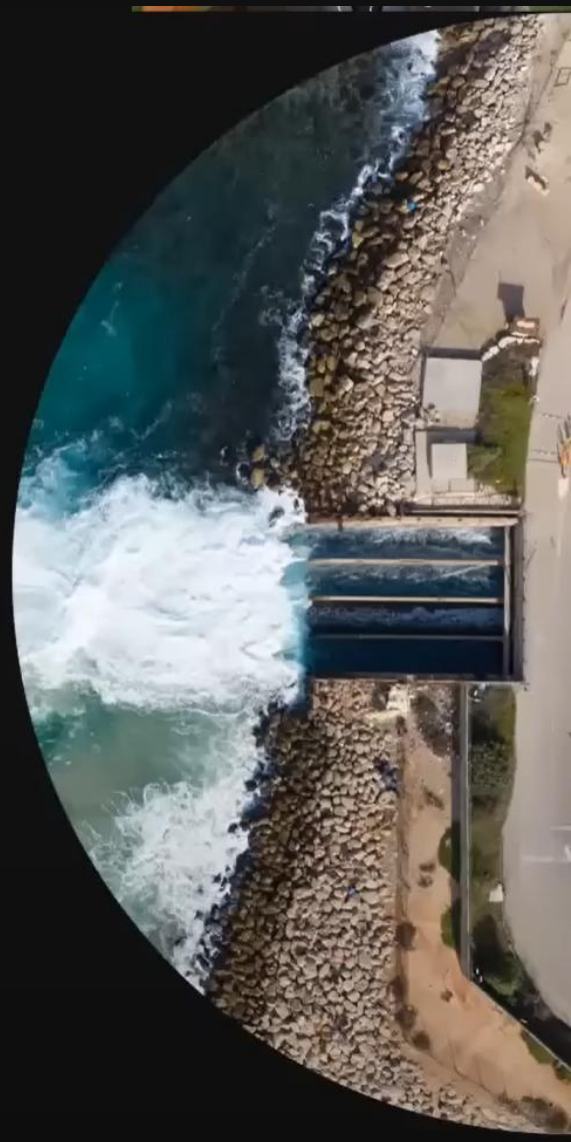

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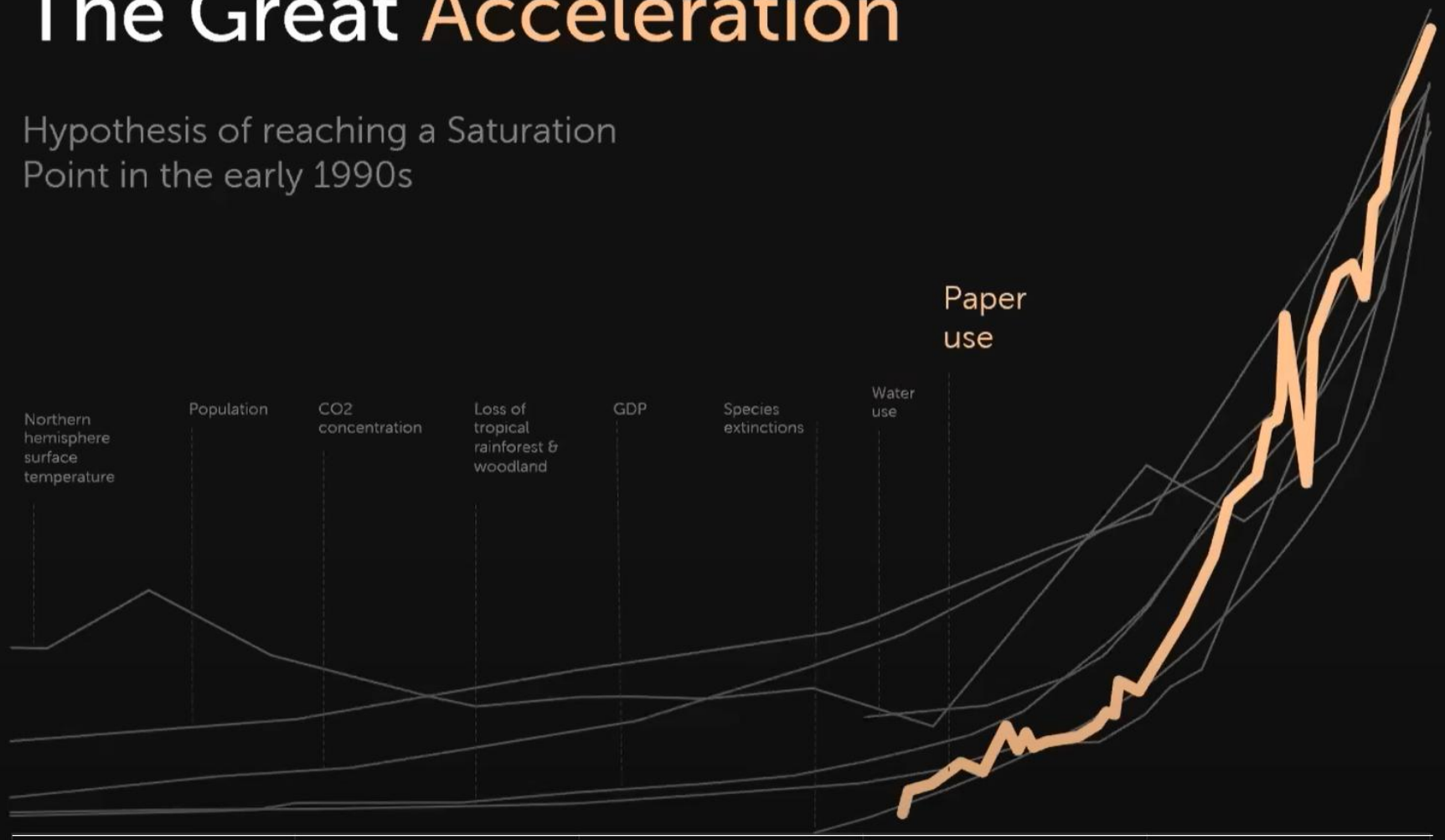

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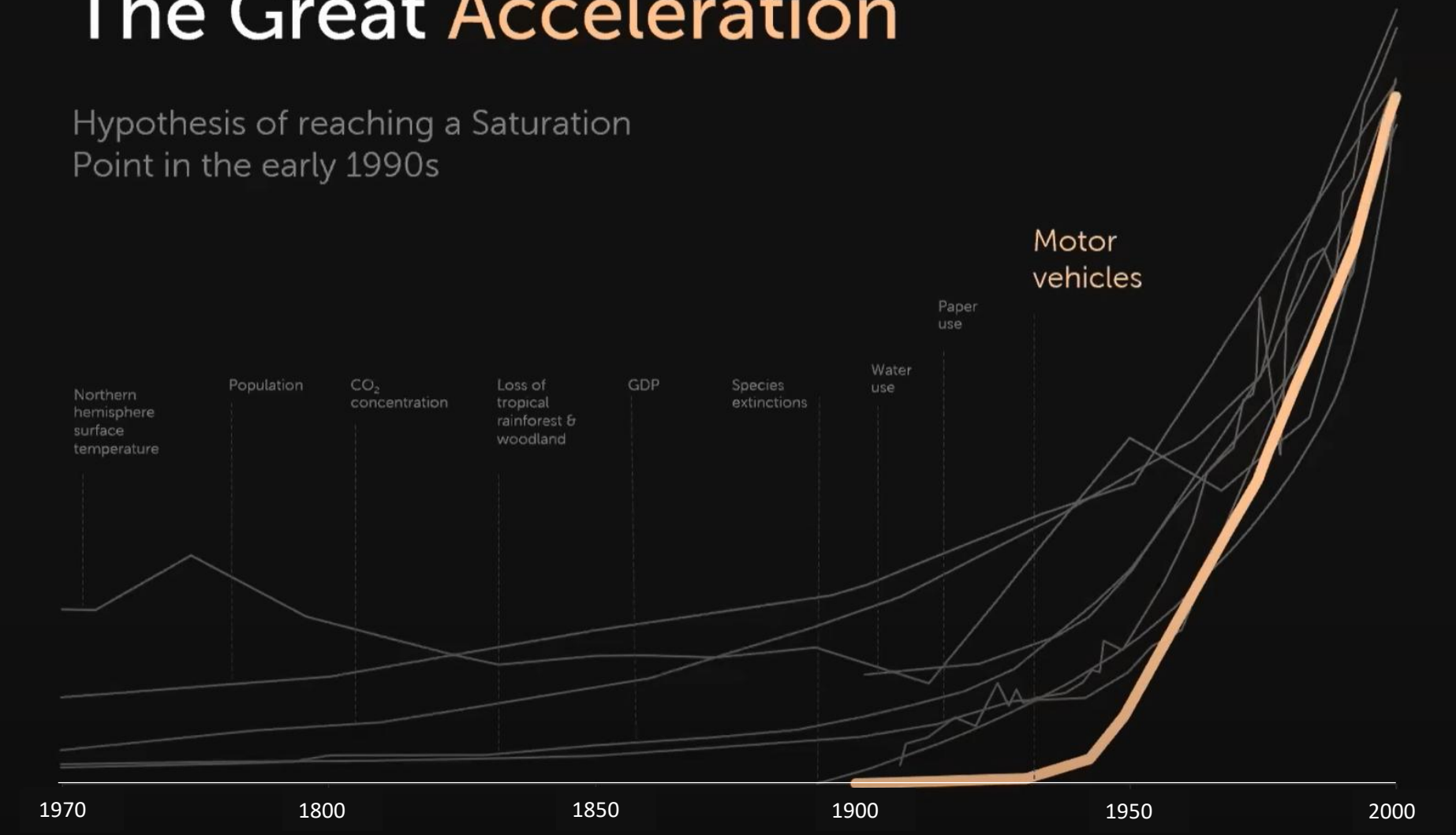

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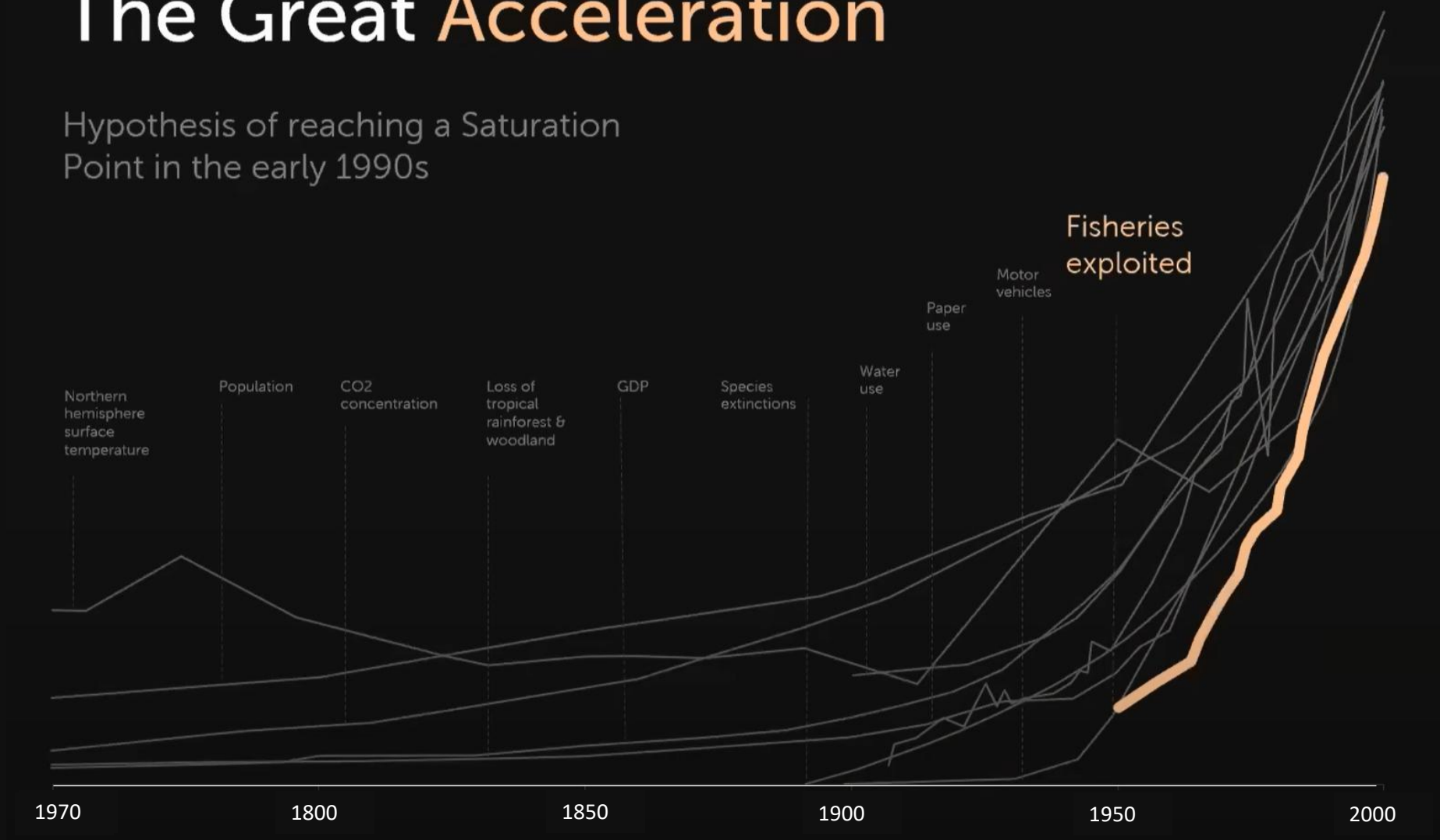

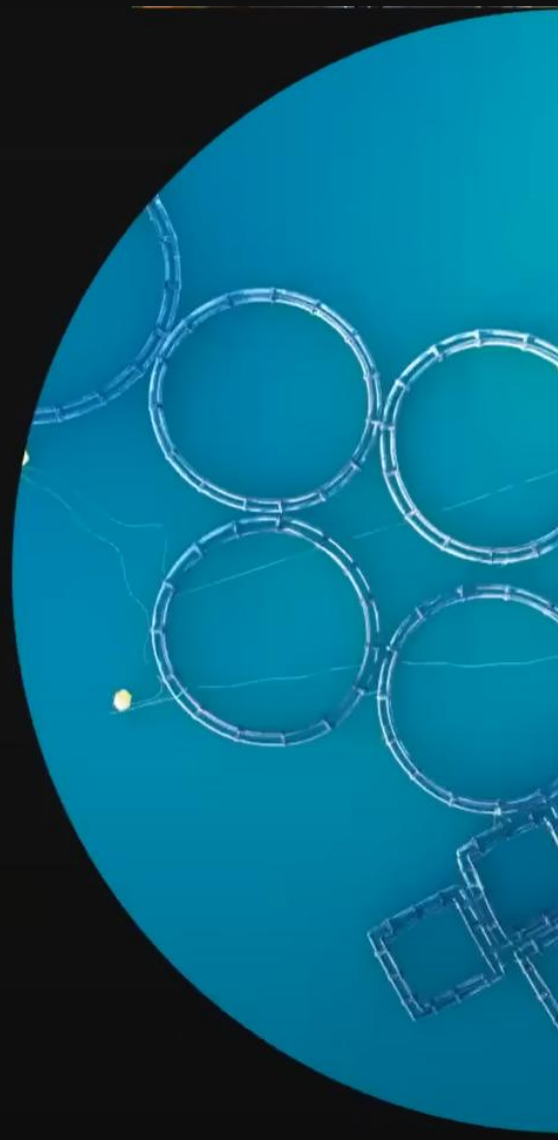

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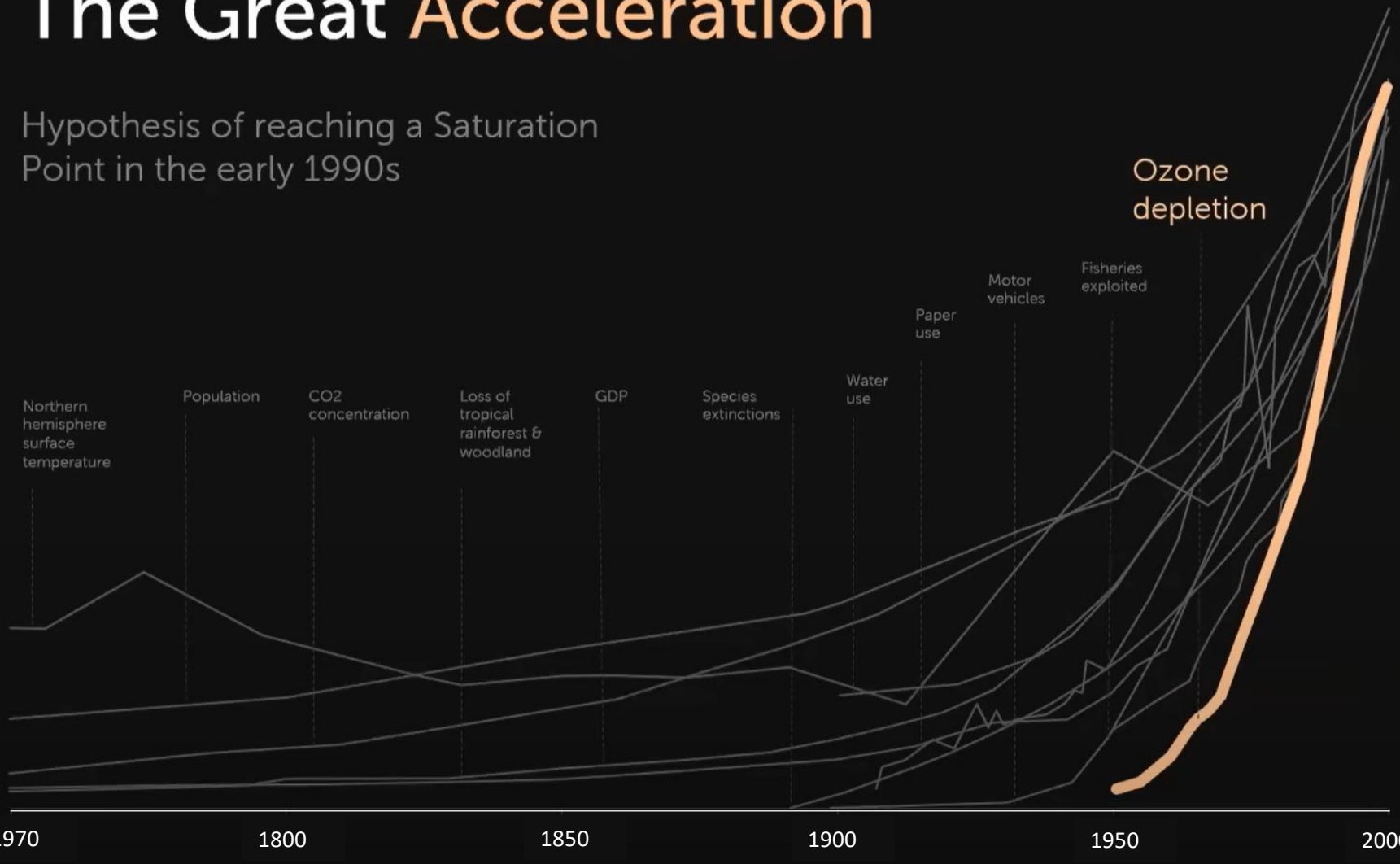

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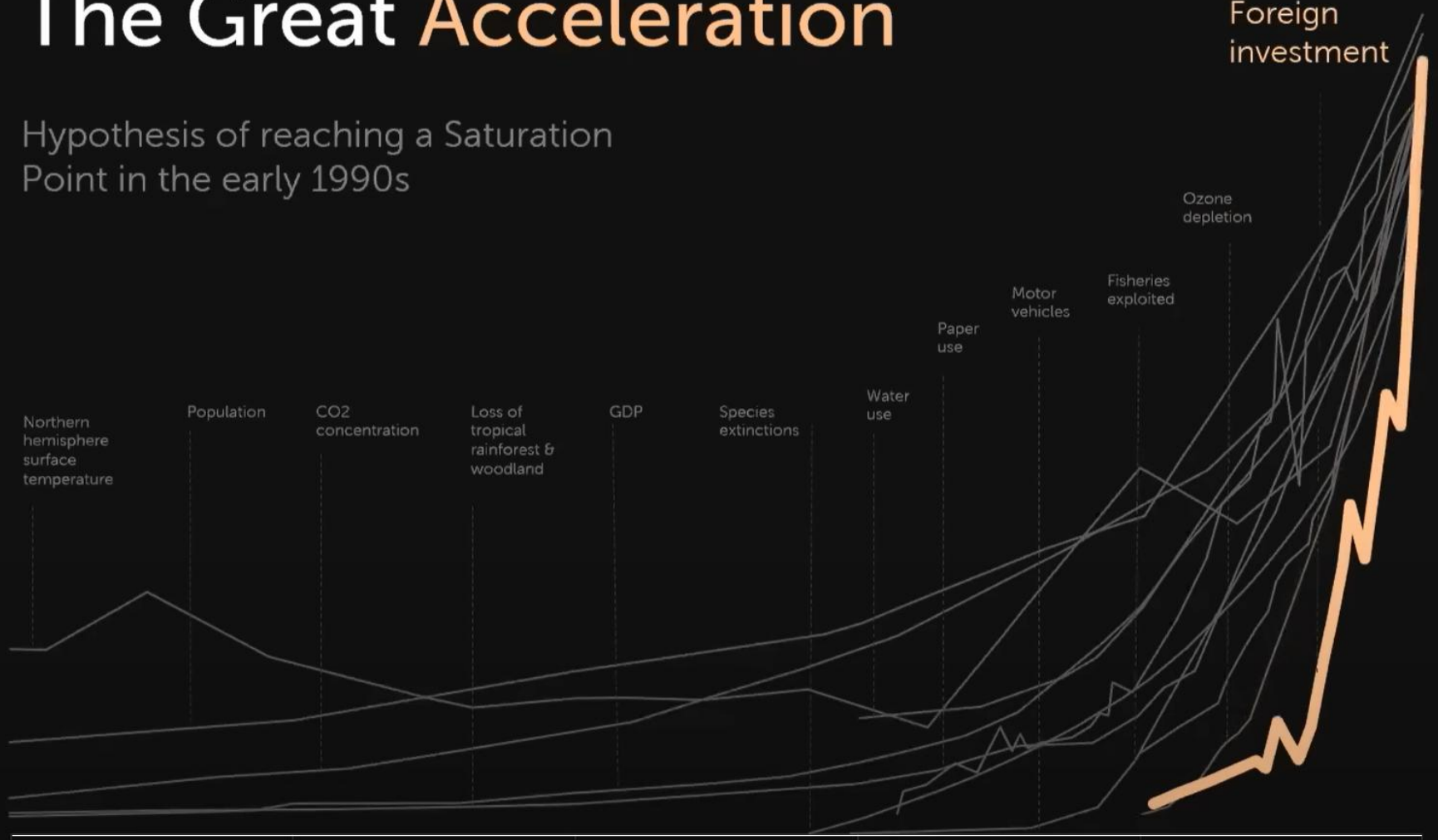

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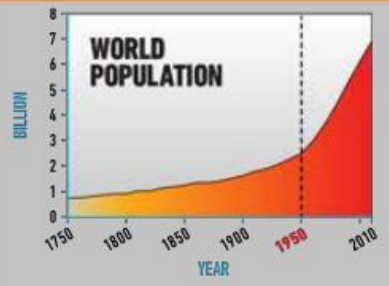
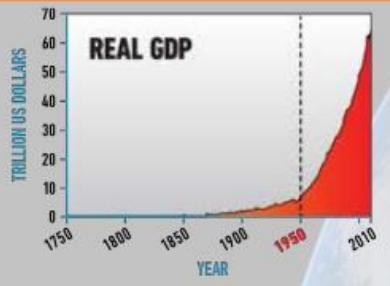
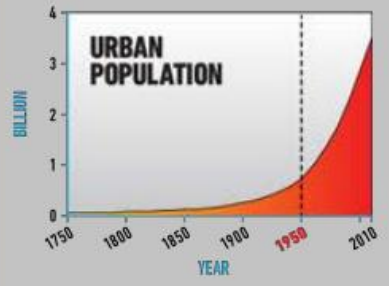
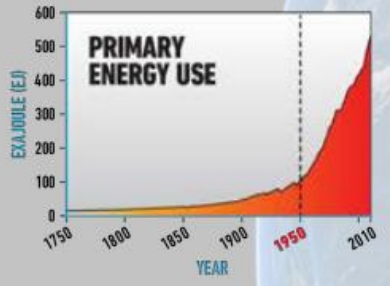
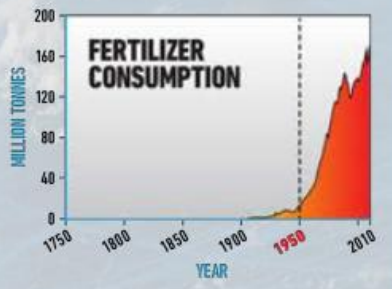

WORLD POPULATION
BILLION
YEAR

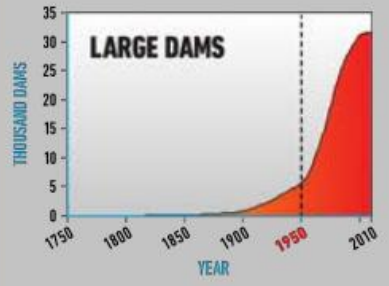

REAL GDP
TRILLION US DOLLARS
YEAR

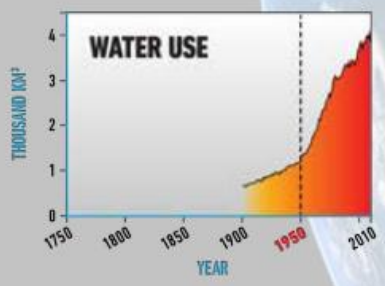

FOREIGN DIRECT INVESTMENT
TRILLION US DOLLARS
YEAR

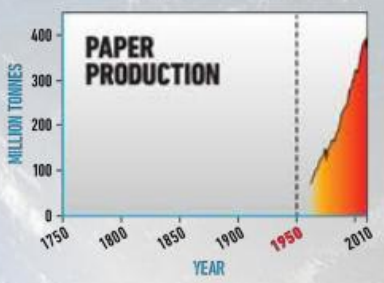

URBAN POPULATION
BILLION
YEAR

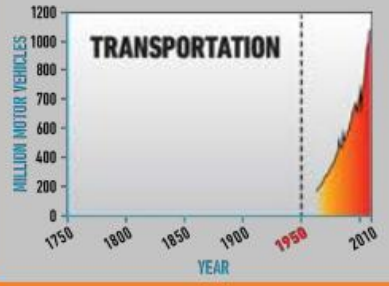

PRIMARY ENERGY USE
EXAJOULE (EJ)
YEAR

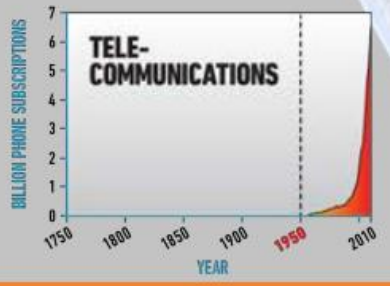

FERTILIZER CONSUMPTION
MILLION TONNES
YEAR


LARGE DAMS
THOUSAND DAMS
YEAR

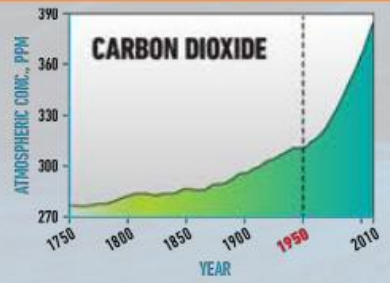

WATER USE
THOUSAND KM³
YEAR

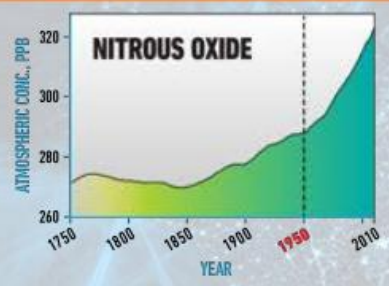

PAPER PRODUCTION
MILLION TONNES
YEAR

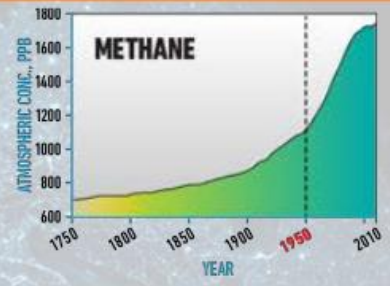

TRANSPORTATION
MILLION MOTOR VEHICLES
YEAR


TELE-COMMUNICATIONS
BILLION PHONE SUBSCRIPTIONS
YEAR

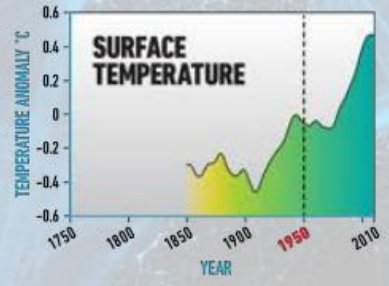

INTERNATIONAL TOURISM
MILLION ARRIVALS
YEAR

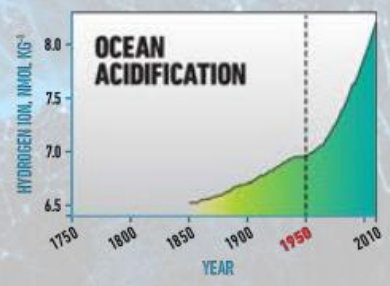

CARBON DIOXIDE
ATMOSPHERIC CONC., PPM
YEAR

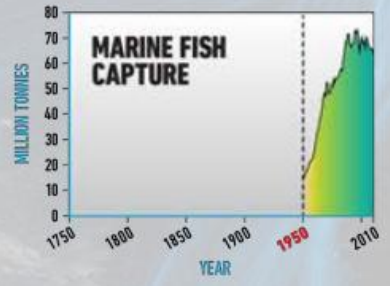

NITROUS OXIDE
ATMOSPHERIC CONC., PPB
YEAR

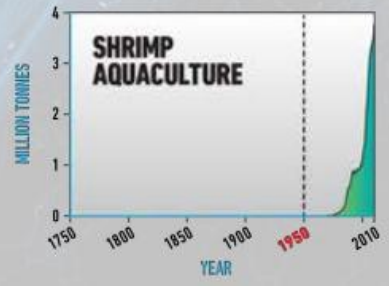

METHANE
ATMOSPHERIC CONC., PPB
YEAR

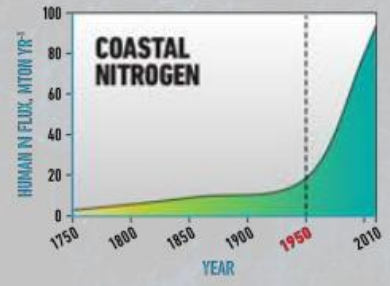

STRATOSPHERIC OZONE
% LOSS
YEAR

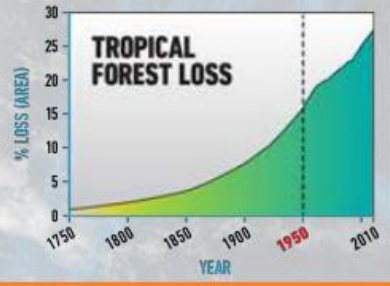

SURFACE TEMPERATURE
TEMPERATURE ANOMALY °C
YEAR

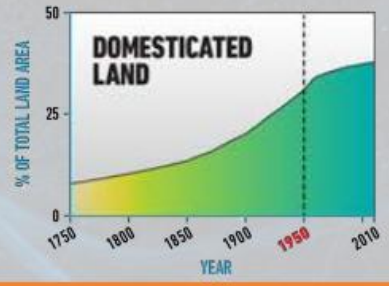

OCEAN ACIDIFICATION
HYDROGEN ION, NMOL KG⁻¹
YEAR

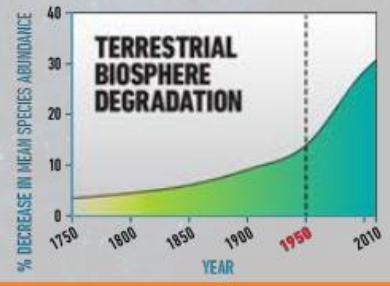

MARINE FISH CAPTURE
MILLION TONNES
YEAR


SHRIMP AQUACULTURE
MILLION TONNES
YEAR

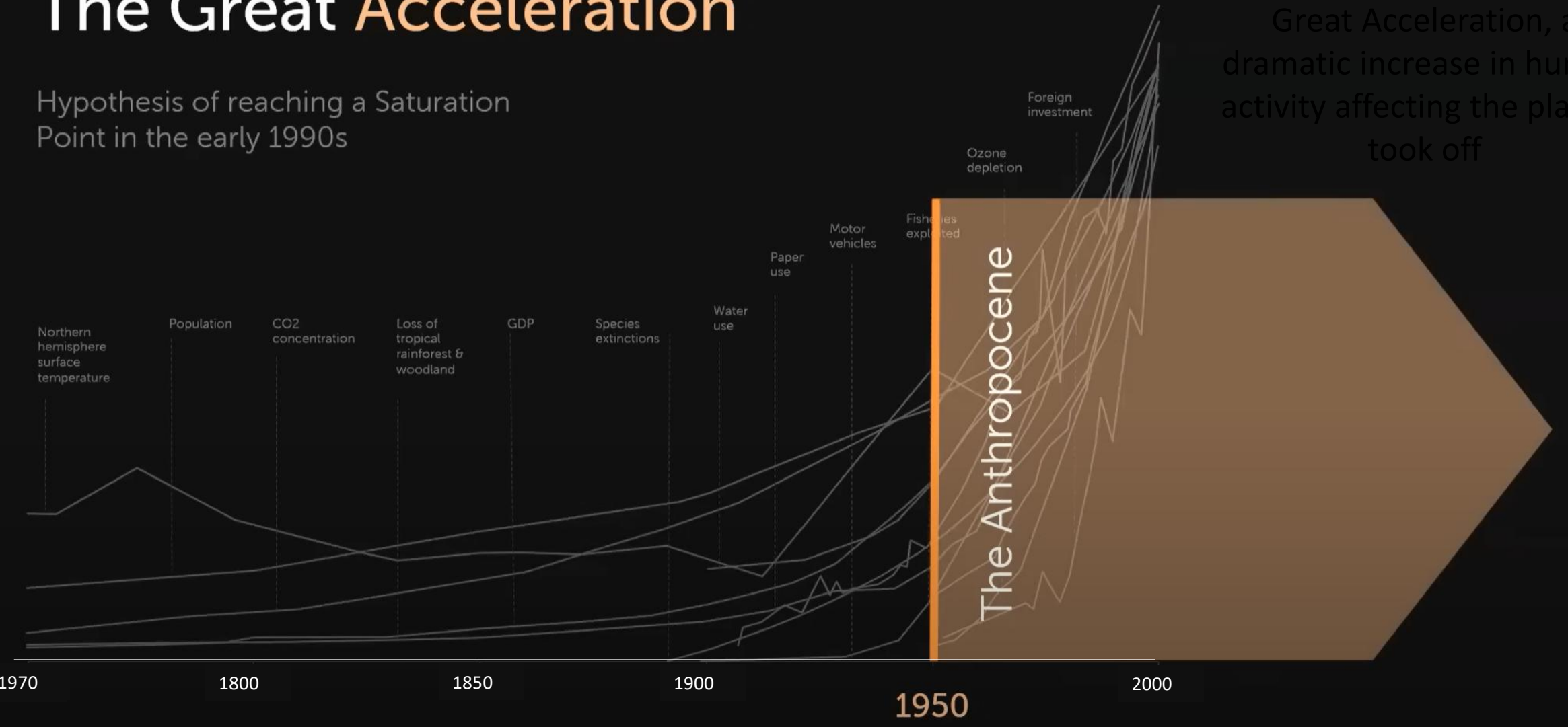

COASTAL NITROGEN
HUMAN N FLUX, MTON YR⁻¹
YEAR


TROPICAL FOREST LOSS
% LOSS (AREA)
YEAR


DOMESTICATED LAND
% OF TOTAL LAND AREA
YEAR


TERRESTRIAL BIOSPHERE DEGRADATION
% DECREASE IN MEAN SPECIES ABUNDANCE
YEAR

The Great Acceleration



New Scientist 2008 from Steffen et al. 2004

Great Acceleration, a dramatic increase in human activity affecting the planet, took off

ANTHROPOCENE

> The Anthropocene is a term used to describe the current geological age, viewed as the period during which human activity has been the dominant influence on climate and ecosystems.

> Anthropocene Epoch is an **unofficial** unit of geologic time

NEWS | 06 March 2024 | Correction 06 March 2024

Geologists reject the Anthropocene as Earth's new epoch — after 15 years of debate

But some are now challenging the vote, saying there were 'procedural irregularities'.

By Alexandra Witze

The sediments of Crawford Lake near Toronto, Canada, have collected and preserved signs of humanity's impact on Earth, including microplastics and plutonium from hydrogen-bomb tests. Credit: The Canadian Press/Alamy

COMMENT | 26 August 2024

The meaning of the Anthropocene: why it matters even without a formal geological definition

Even though geologists have rejected the designation of an Anthropocene epoch, the idea of a major planetary transition in the mid-twentieth century remains useful across physical and social sciences, the humanities and policy.

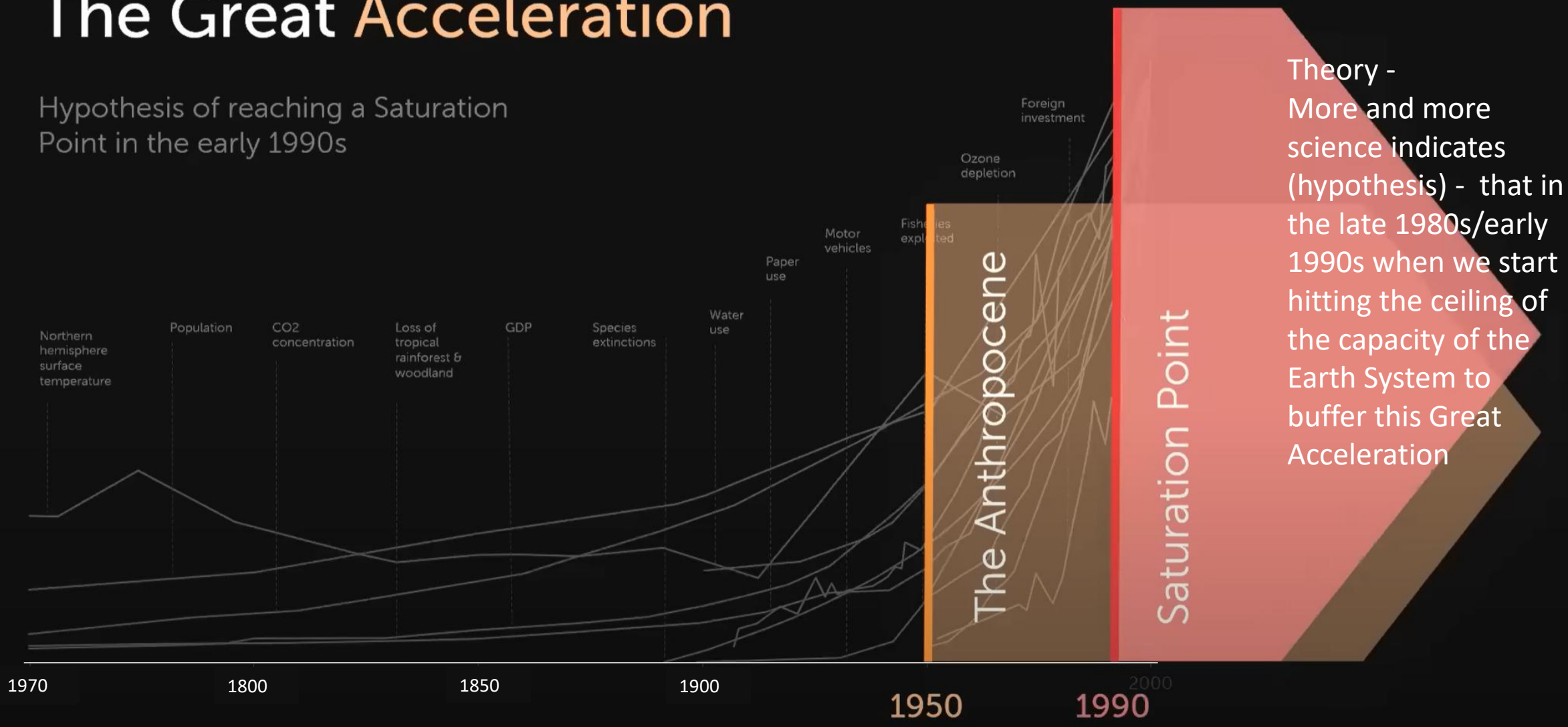
By Jan Zalasiewicz, Julia Adeney Thomas, Colin N. Waters, Simon Turner & Martin J. Head

Anthropocene has been widely adopted to describe, analyse and interpret the transformed conditions in which humans now live

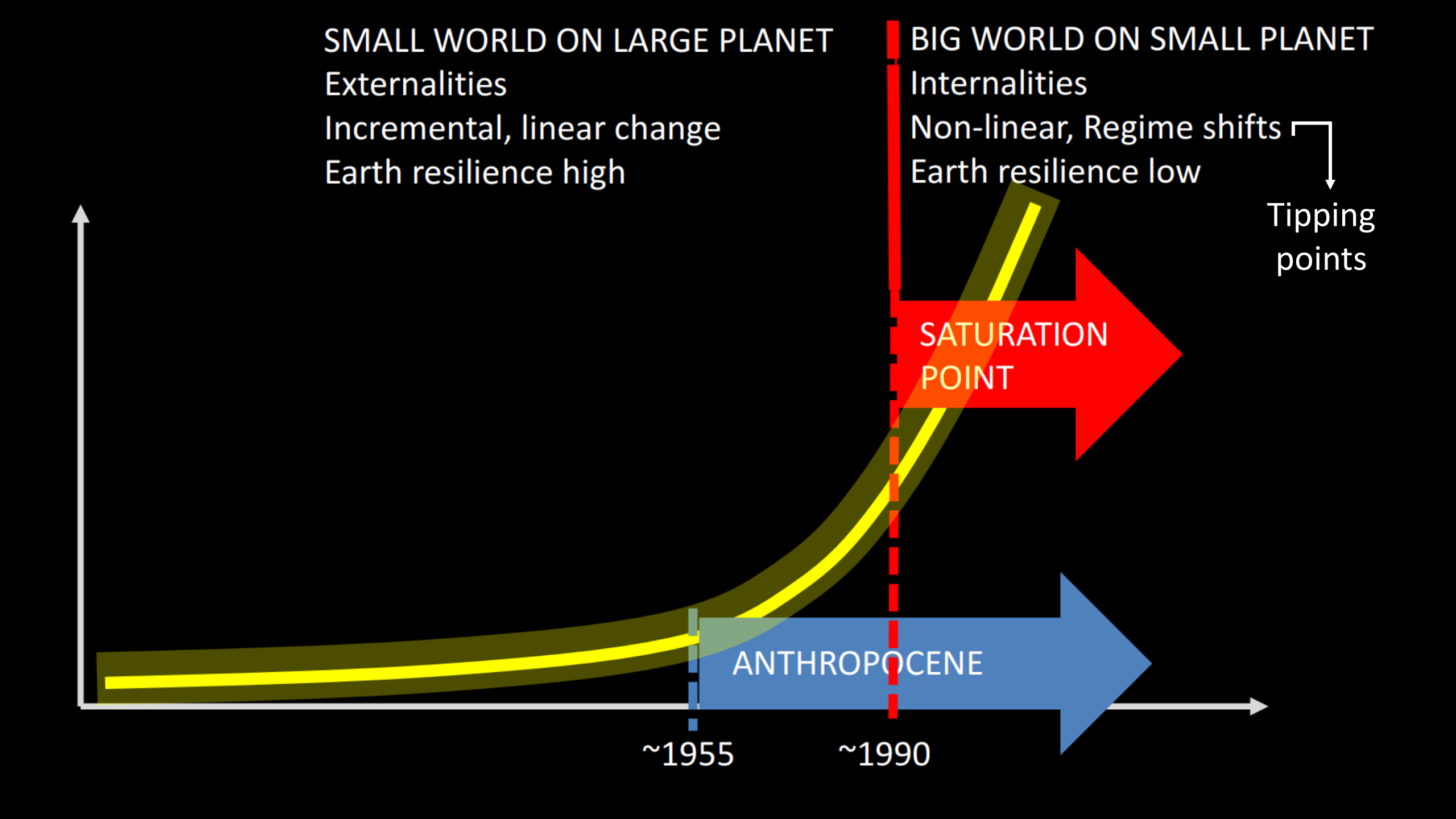
It is used by different groups.

- **Earth-System Science**: To model and assess human impacts on Earth's systems, particularly regarding transgressing planetary boundaries.
- **Humanities & Social Sciences**: Explores how human activities have begun to dominate natural forces, influencing history, philosophy, politics, and culture.
- **Policymakers & Urban Planners**: Focuses on understanding human-driven changes to climate and biosphere, critical for creating effective mitigation and adaptation strategies.

The Great Acceleration

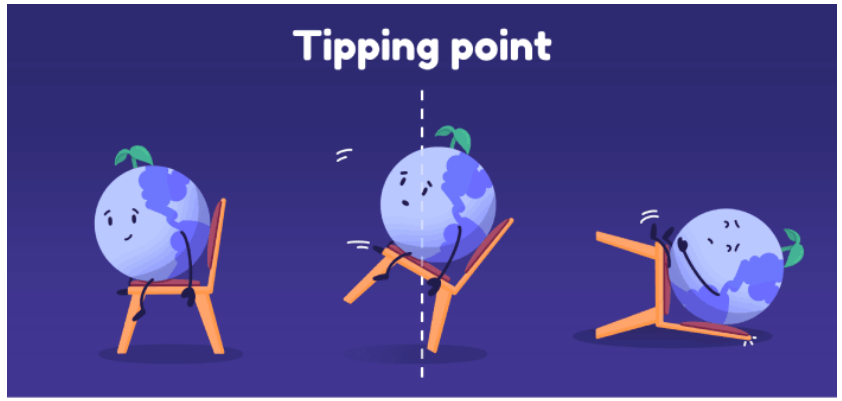


Theory -
More and more science indicates (hypothesis) - that in the late 1980s/early 1990s when we start hitting the ceiling of the capacity of the Earth System to buffer this Great Acceleration


SMALL WORLD ON LARGE PLANET
Externalities
Incremental, linear change
Earth resilience high
BIG WORLD ON SMALL PLANET
Internalities
Non-linear, Regime shifts
Earth resilience low
Tipping points
SATURATION POINT
ANTHROPOCENE
~1955
~1990

TIPPING POINTS

- **Tipping Points:** Critical thresholds in a system that, when exceeded, can lead to a significant change in the state of the system, often with an understanding that the change is irreversible
- Threshold represents the point up to which a system can absorb “stresses” and adapt without experiencing fundamental shifts in its structure or function



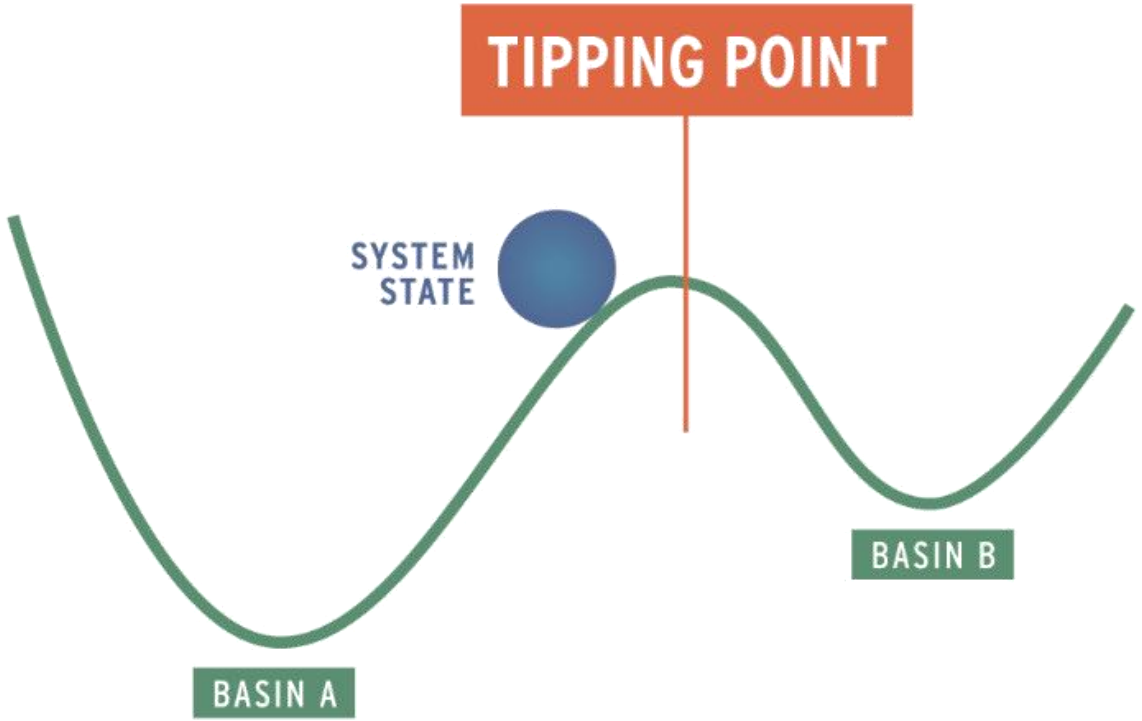
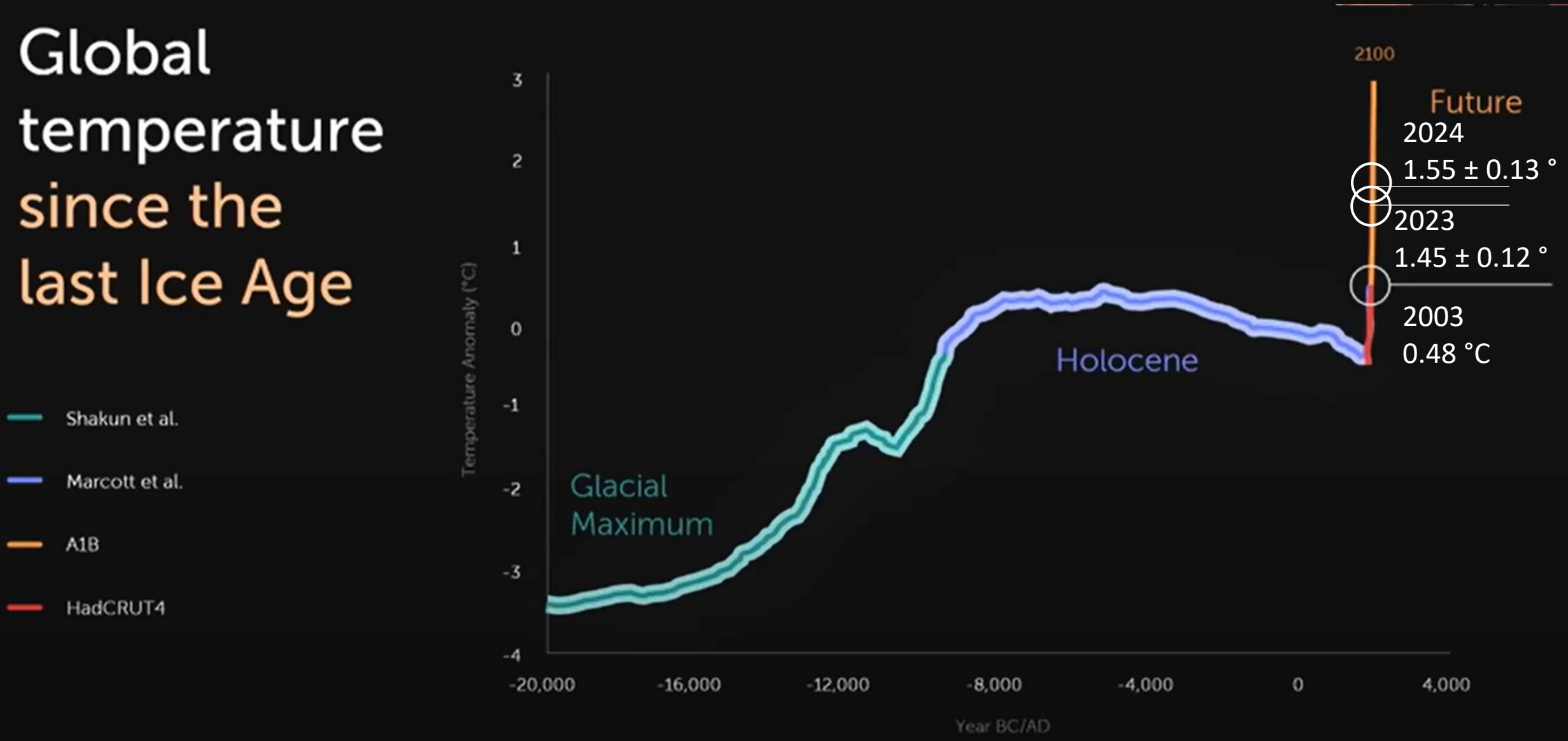
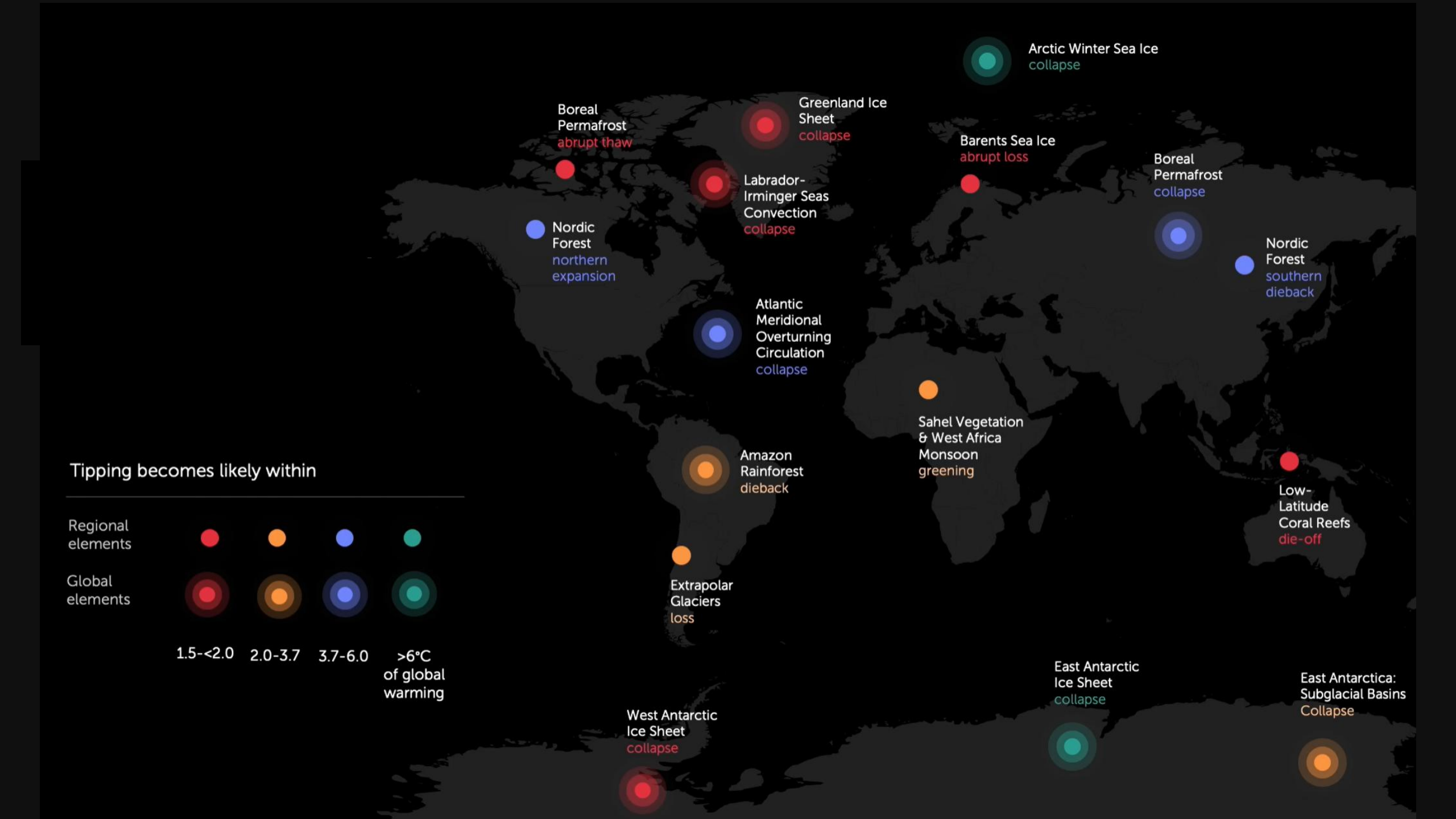
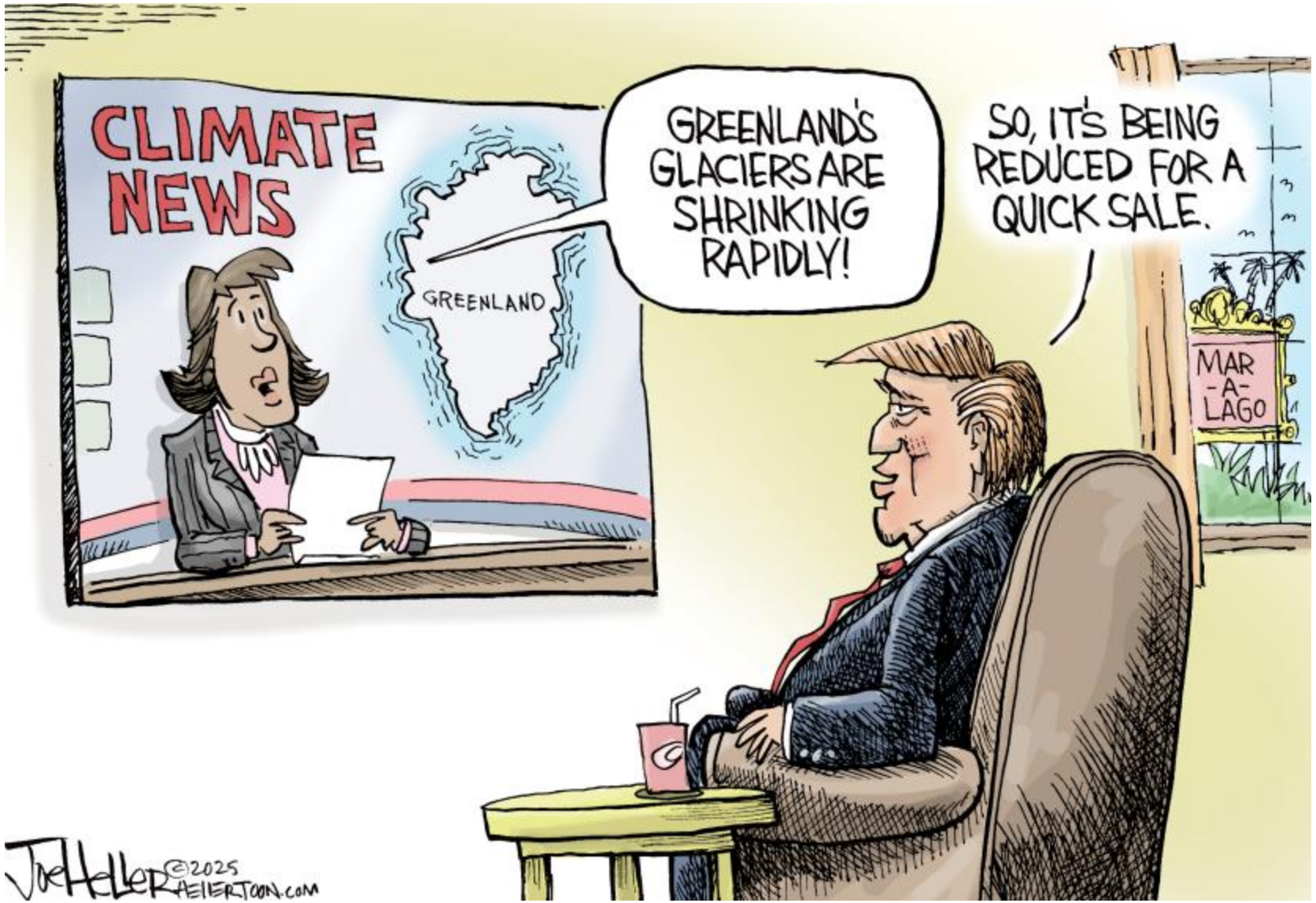


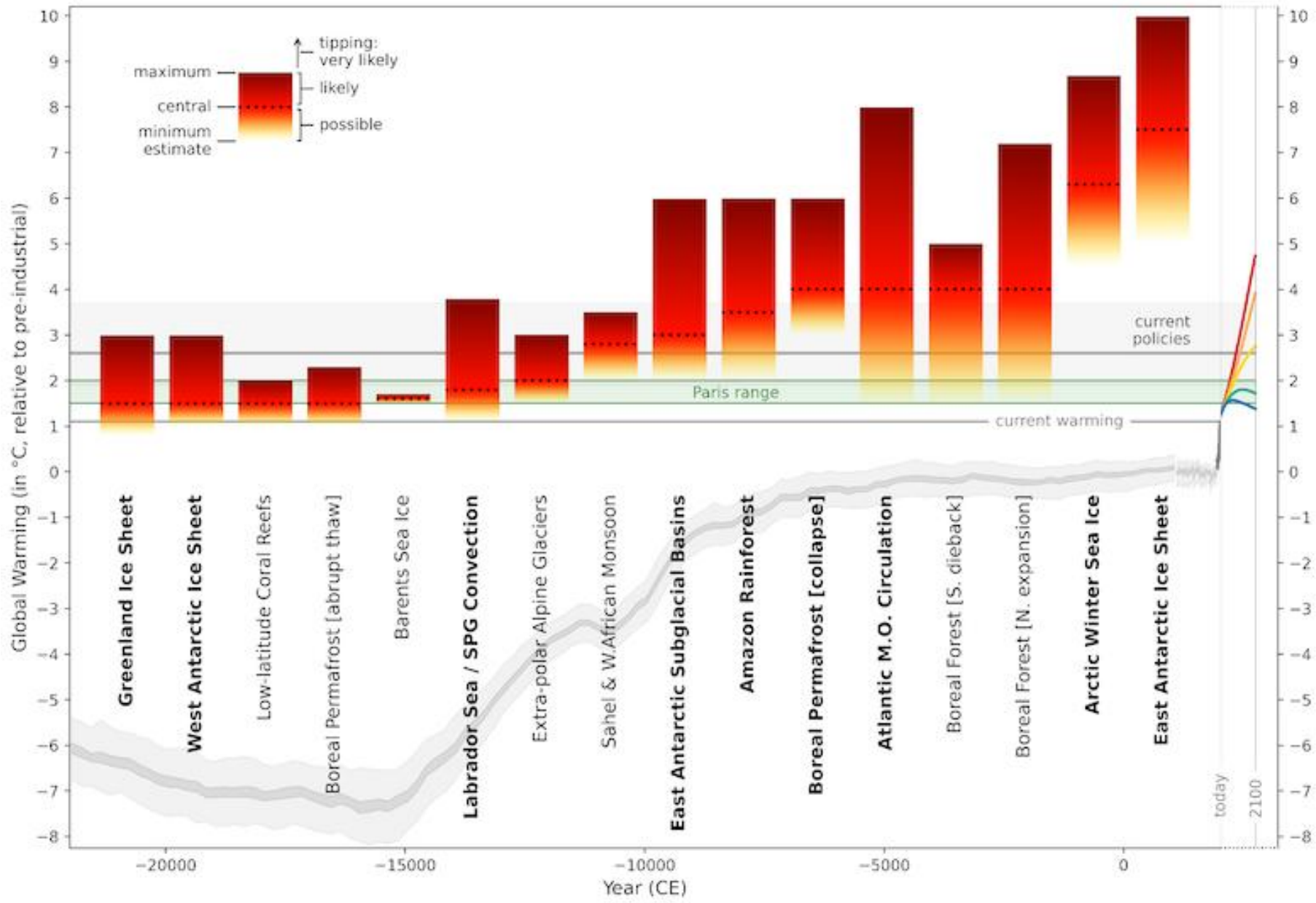
Illustration by Andrew Bernier, adapted from Walker, B. & Salt, D. (2006) Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press: Washington, DC.

Global temperature since the last Ice Age



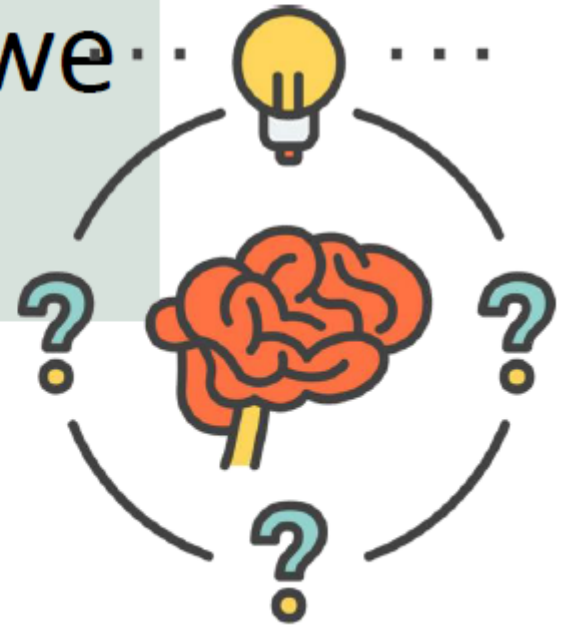

Arctic Winter Sea Ice
collapse
Boreal Permafrost
abrupt thaw
Greenland Ice Sheet
collapse
Barents Sea Ice
abrupt loss
Boreal Permafrost
collapse
Labrador-Irminger Seas Convection
collapse
Nordic Forest
northern expansion
Nordic Forest
southern dieback
Atlantic Meridional Overturning Circulation
collapse
Sahel Vegetation & West Africa Monsoon
greening
Amazon Rainforest
dieback
Low-Latitude Coral Reefs
die-off
Extrapolar Glaciers
loss
Tipping becomes likely within
Regional elements
Global elements
1.5-<2.0
2.0-3.7
3.7-6.0
>6°C of global warming
West Antarctic Ice Sheet
collapse
East Antarctic Ice Sheet
collapse
East Antarctica: Subglacial Basins
Collapse


CLIMATE NEWS
GREENLAND
GREENLAND'S GLACIERS ARE SHRINKING RAPIDLY!
SO, IT'S BEING REDUCED FOR A QUICK SALE.
MAR-A-LAGO
JoeHeller ©2025 HELLERTOON.com


maximum
central
minimum estimate
tipping: very likely
likely
possible
current policies
Paris range
current warming
Global Warming (in °C, relative to pre-industrial)
Year (CE)
Greenland Ice Sheet
West Antarctic Ice Sheet
Low-latitude Coral Reefs
Boreal Permafrost [abrupt thaw]
Barents Sea Ice
Labrador Sea / SPG Convection
Extra-polar Alpine Glaciers
Sahel & W.African Monsoon
East Antarctic Subglacial Basins
Amazon Rainforest
Boreal Permafrost [collapse]
Atlantic M.O. Circulation
Boreal Forest [S. dieback]
Boreal Forest [N. expansion]
Arctic Winter Sea Ice
East Antarctic Ice Sheet
today
2100

Is the burden of human activities on Earth's systems reaching a critical level? Are we crossing tipping points?

real



What is the safe operating system for humanity on planet Earth?

What are the limits of key Earth system processes that we cannot exceed if we want to avoid rapid and catastrophic environmental change?


MONGABAY
Earth, oceans, atmosphere. These interconnected
systems exist in a delicate balance that has kept

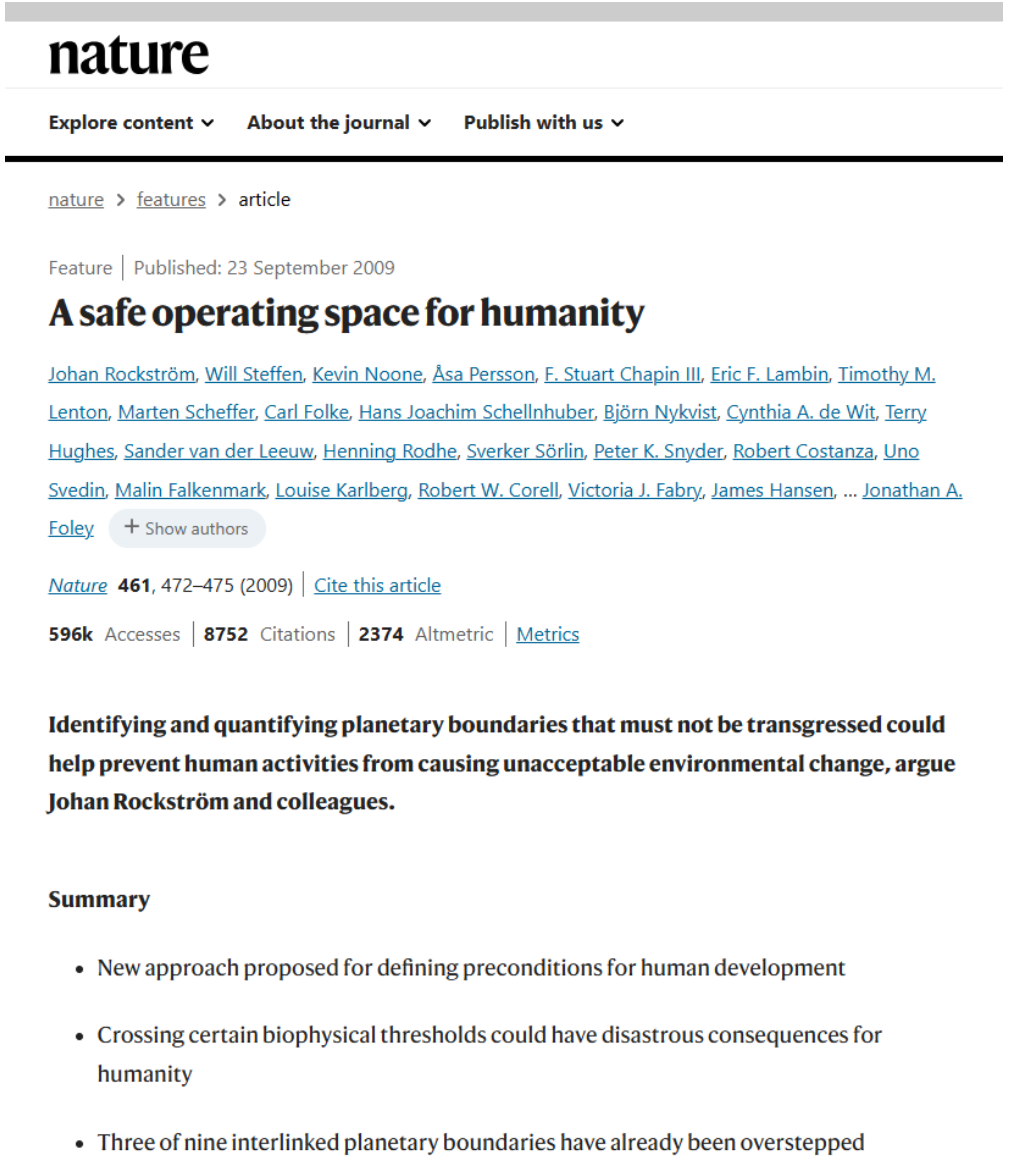
PLANETARY BOUNDARIES

> Johan Rockström from the Stockholm Resilience Centre and Will Steffen from the Australian National University led a group of scientistic and develop the **Planetary Boundaries Framework** in 2009

> The Planetary Boundaries define the safe operating space for humanity with respect to the Earth system and are associated with the **planet's biophysical subsystems**.

> No assumptions on human needs

> No assumptions on human innovation capacity



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nature › features › article

Feature | Published: 23 September 2009

A safe operating space for humanity

Johan Rockström, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart Chapin III, Eric F. Lambin, Timothy M. Lenton, Marten Scheffer, Carl Folke, Hans Joachim Schellnhuber, Björn Nykvist, Cynthia A. de Wit, Terry Hughes, Sander van der Leeuw, Henning Rodhe, Sverker Sörlin, Peter K. Snyder, Robert Costanza, Uno Svedin, Malin Falkenmark, Louise Karlberg, Robert W. Corell, Victoria J. Fabry, James Hansen, … Jonathan A. Foley + Show authors

Nature **461**, 472–475 (2009) | Cite this article

596k Accesses | **8752** Citations | **2374** Altmetric | Metrics

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue Johan Rockström and colleagues.

Summary

- New approach proposed for defining preconditions for human development
- Crossing certain biophysical thresholds could have disastrous consequences for humanity
- Three of nine interlinked planetary boundaries have already been overstepped

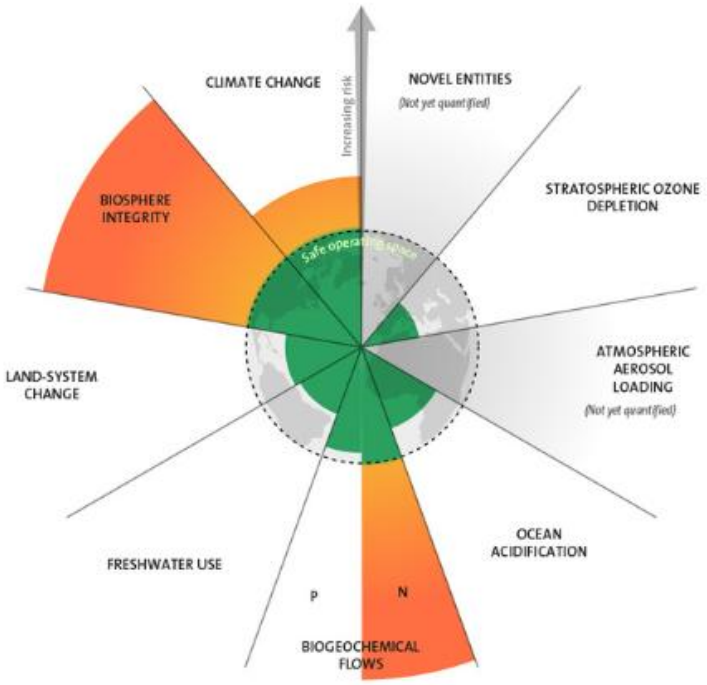
PLANETARY BOUNDARIES

- **9 processes** that are critical for maintaining the stability and resilience of Earth system as a whole and have been affected by anthropogenic activities:

1. **Climate Change**
2. **Biosphere integrity (genetic diversity):** linked to biodiversity loss
3. **Ocean Acidification** Preventing ocean acidification is crucial for preserving the health of marine ecosystems and fisheries.
4. **Biogeochemical flows (Nitrogen and Phosphorus Cycles):** Keeping these cycles within safe boundaries is essential to prevent water pollution and habitat degradation.
5. **Freshwater Use**
6. **Land Use Changes (forests):** Protecting natural habitats is crucial for maintaining ecosystem services.
7. **Atmospheric Aerosol Loading**
8. **Stratospheric Ozone Depletion**
9. **Novel Entities (Chemical Pollution) -** aims to limit the release of synthetic chemicals (e.g., microplastics), which affects human and ecosystem health.

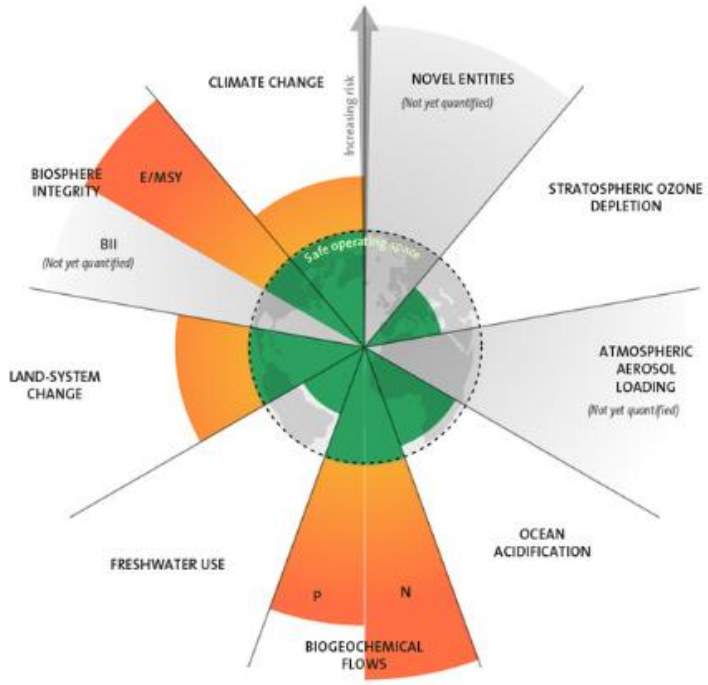
Core Planetary Boundaries the most critical because they affect the other boundaries altogether- Significantly altering either of these "core boundaries" would "drive the Earth System into a new state"

2009



7 boundaries assessed,
3 crossed

2015

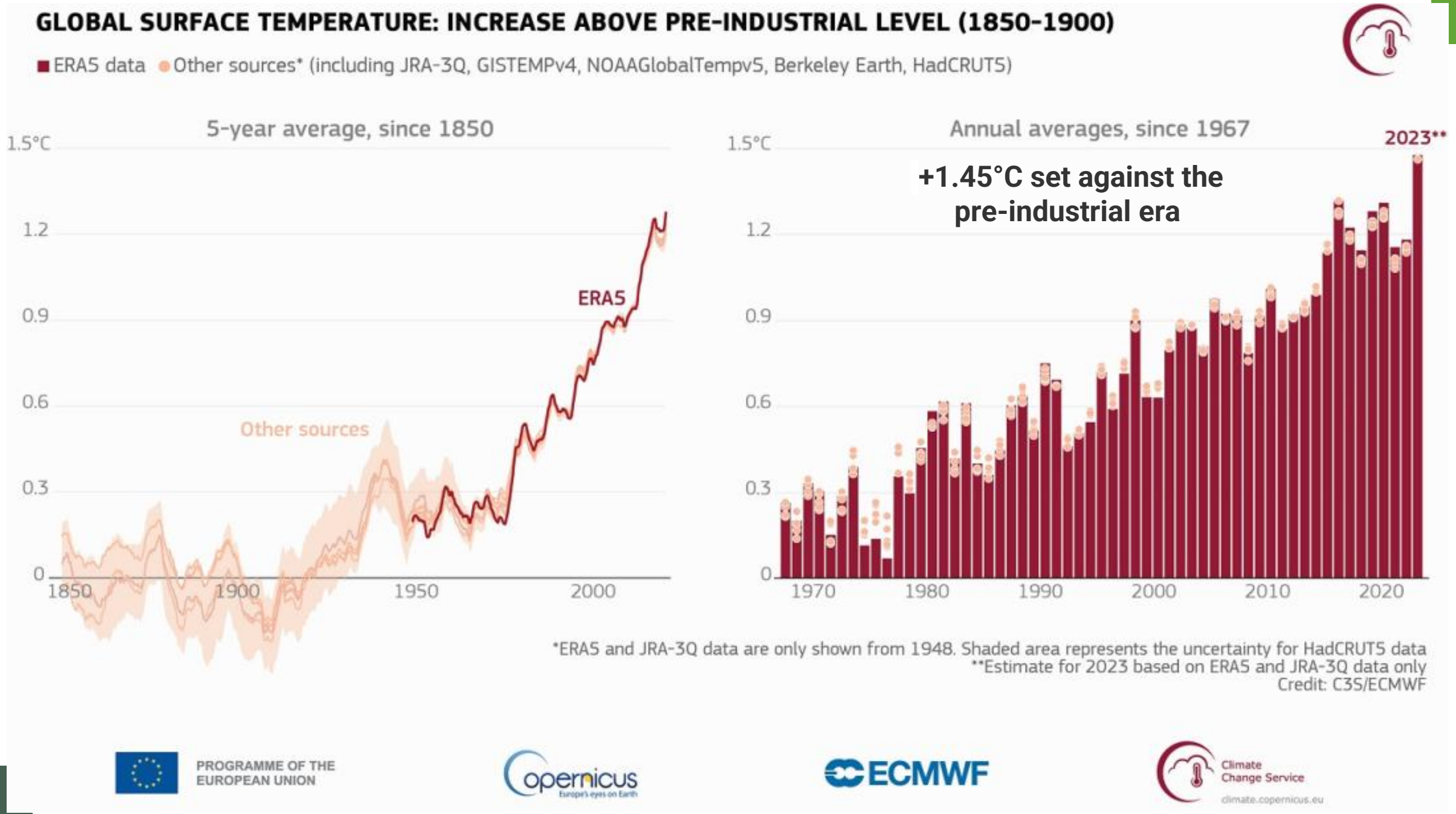


7 boundaries assessed,
4 crossed

2023

How are we today?

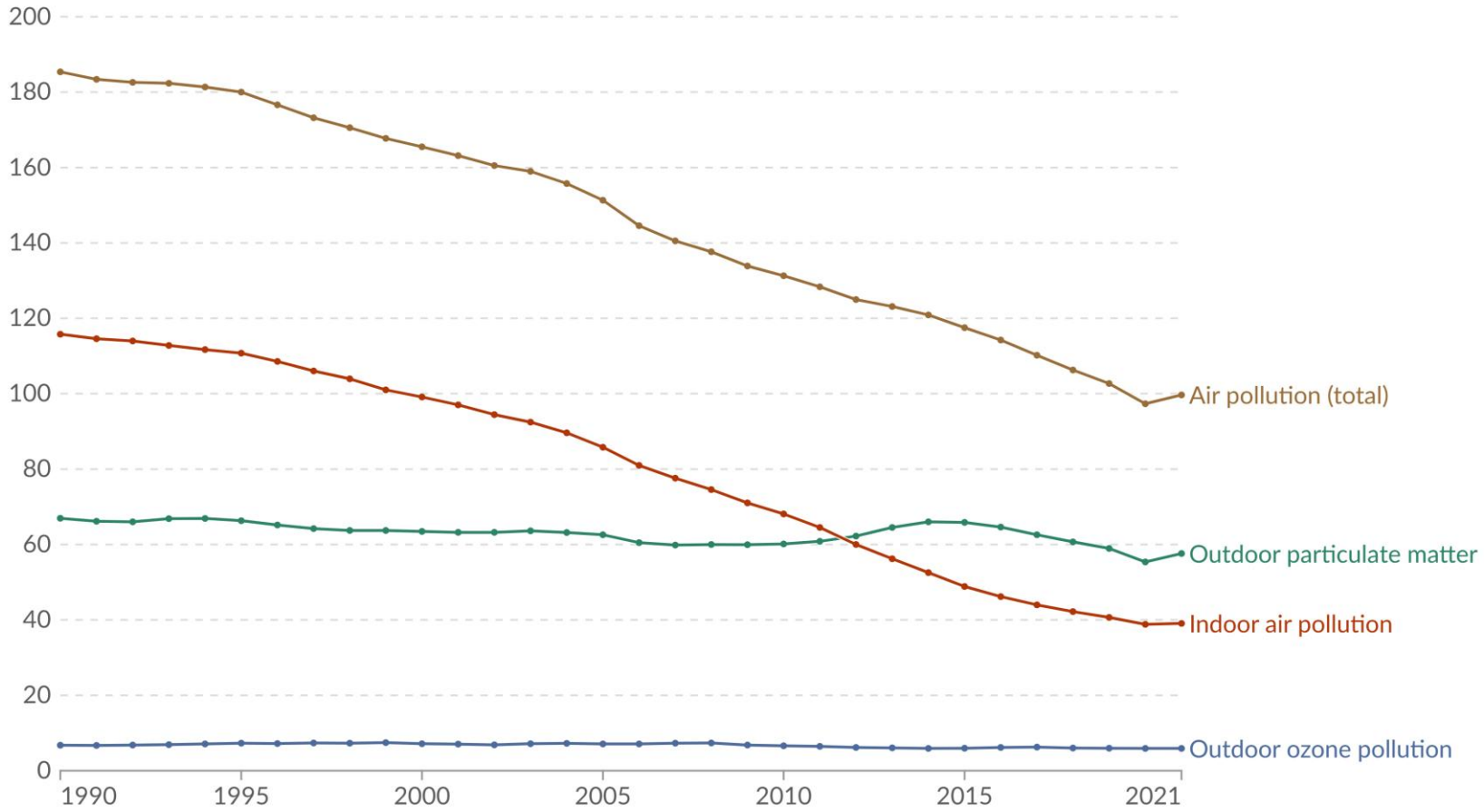
Stockholm Resilience Centre | Stockholm University


GLOBAL SURFACE TEMPERATURE: INCREASE ABOVE PRE-INDUSTRIAL LEVEL (1850-1900)
ERA5 data
Other sources* (including JRA-3Q, GISTEMPv4, NOAAGlobalTempv5, Berkeley Earth, HadCRUT5)
5-year average, since 1850
1.5°C
1.2
0.9
0.6
0.3
0
1850
1900
1950
2000
ERA5
Other sources
Annual averages, since 1967
2023**
+1.45°C set against the pre-industrial era
1970
1980
1990
2000
2010
2020
*ERA5 and JRA-3Q data are only shown from 1948. Shaded area represents the uncertainty for HadCRUT5 data
**Estimate for 2023 based on ERA5 and JRA-3Q data only
Credit: C3S/ECMWF
PROGRAMME OF THE EUROPEAN UNION
opernicus
Europe's eyes on Earth
ECMWF
Climate Change Service
climate.copernicus.eu

Death rate from air pollution, World

Our World in Data

Estimated number of deaths attributed to different types of air pollution per 100,000 population. Deaths can be attributed to multiple risk factors.



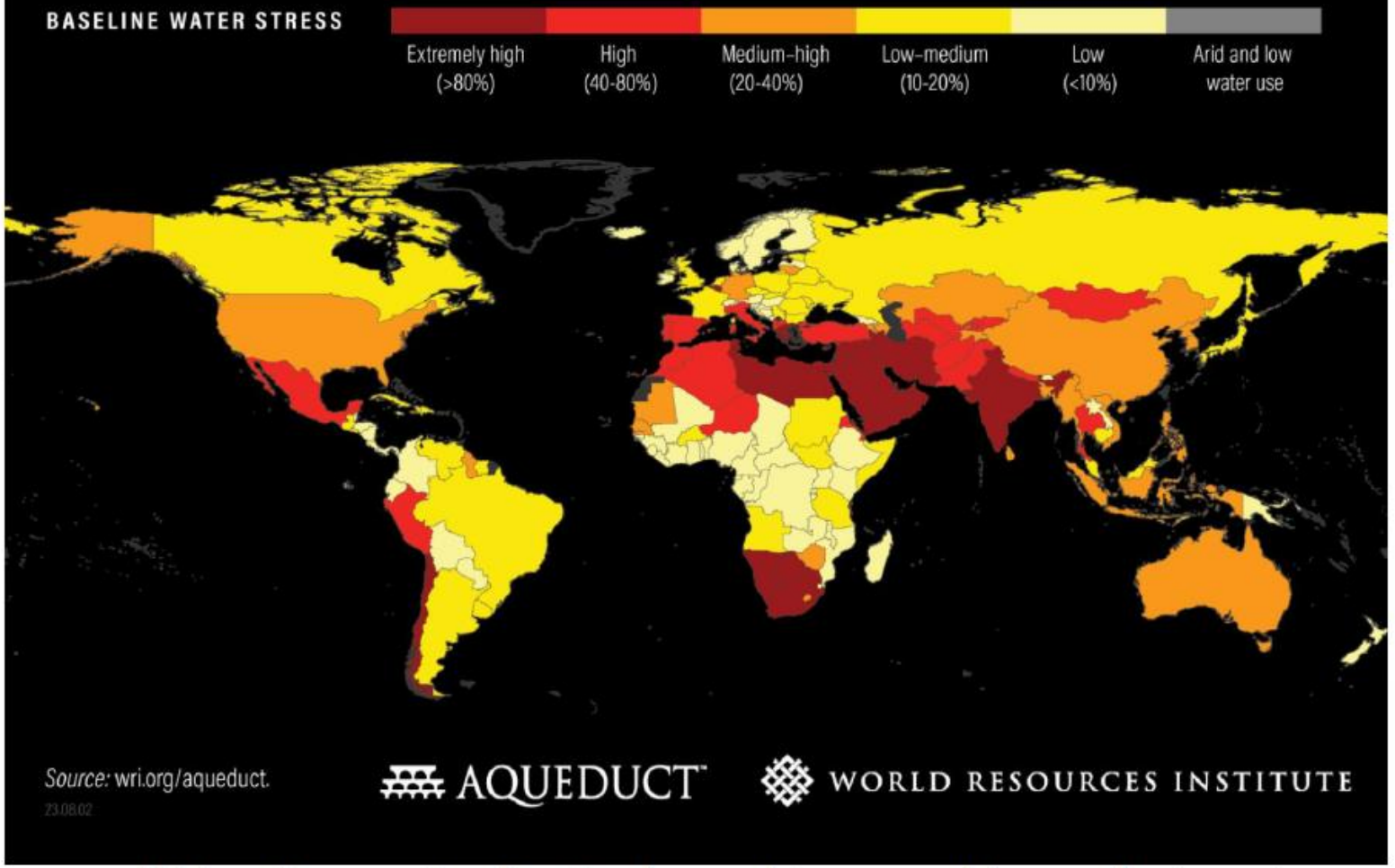
Data source: IHME, Global Burden of Disease (2024)

OurWorldinData.org/air-pollution | CC BY

Note: To allow for comparisons between countries and over time, this metric is age-standardized[1].

1. Age standardization: Age standardization is an adjustment that makes it possible to compare populations with different age structures, by standardizing them to a common reference population. Read more: How does age standardization make health metrics comparable?

25 COUNTRIES ARE CURRENTLY EXPOSED TO EXTREMELY HIGH WATER STRESS ANNUALLY



Water stress: ratio of water demand to renewable supply. A country facing "extreme water stress" means it is using at least 80% of its available supply, "high water stress" means it is withdrawing 40% of its supply.

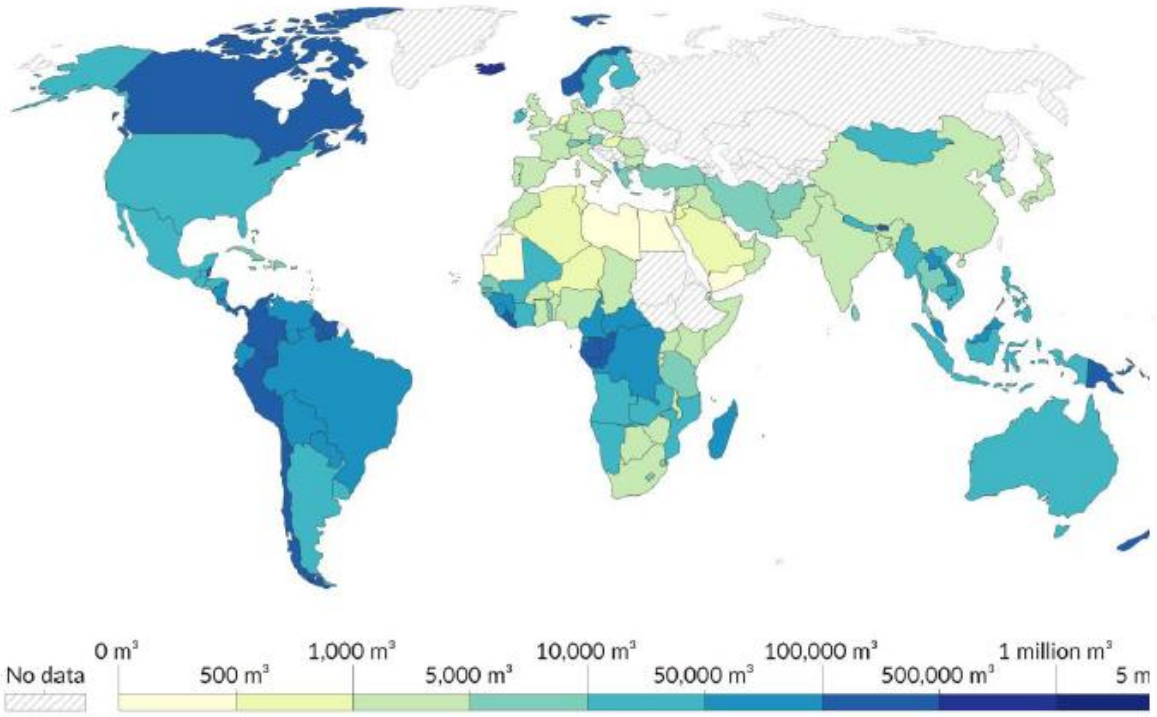
1/4 of the global population — face extremely high water stress each year, regularly using up almost their entire available water supply.

At least 50% of the world's population live under highly water-stressed conditions for at least one month of the year.

Renewable freshwater resources per capita, 1961

Renewable internal freshwater resources flows refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country.

Our World in Data

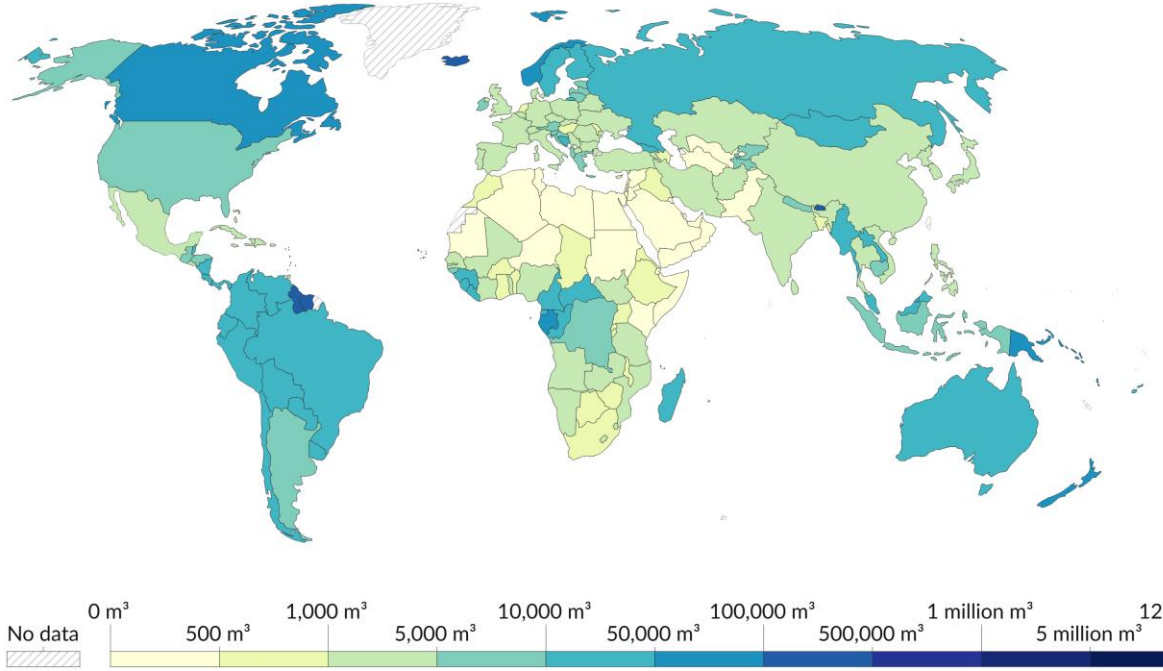


Data source: Food and Agriculture Organization of the United Nations (via World Bank)
OurWorldInData.org/water-use-stress | CC BY

Renewable freshwater resources per capita, 2021

Renewable internal freshwater resources flows refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country.

Our World in Data



Data source: Food and Agriculture Organization of the United Nations (via World Bank) (2025) OurWorldinData.org/water-use-stress | CC BY

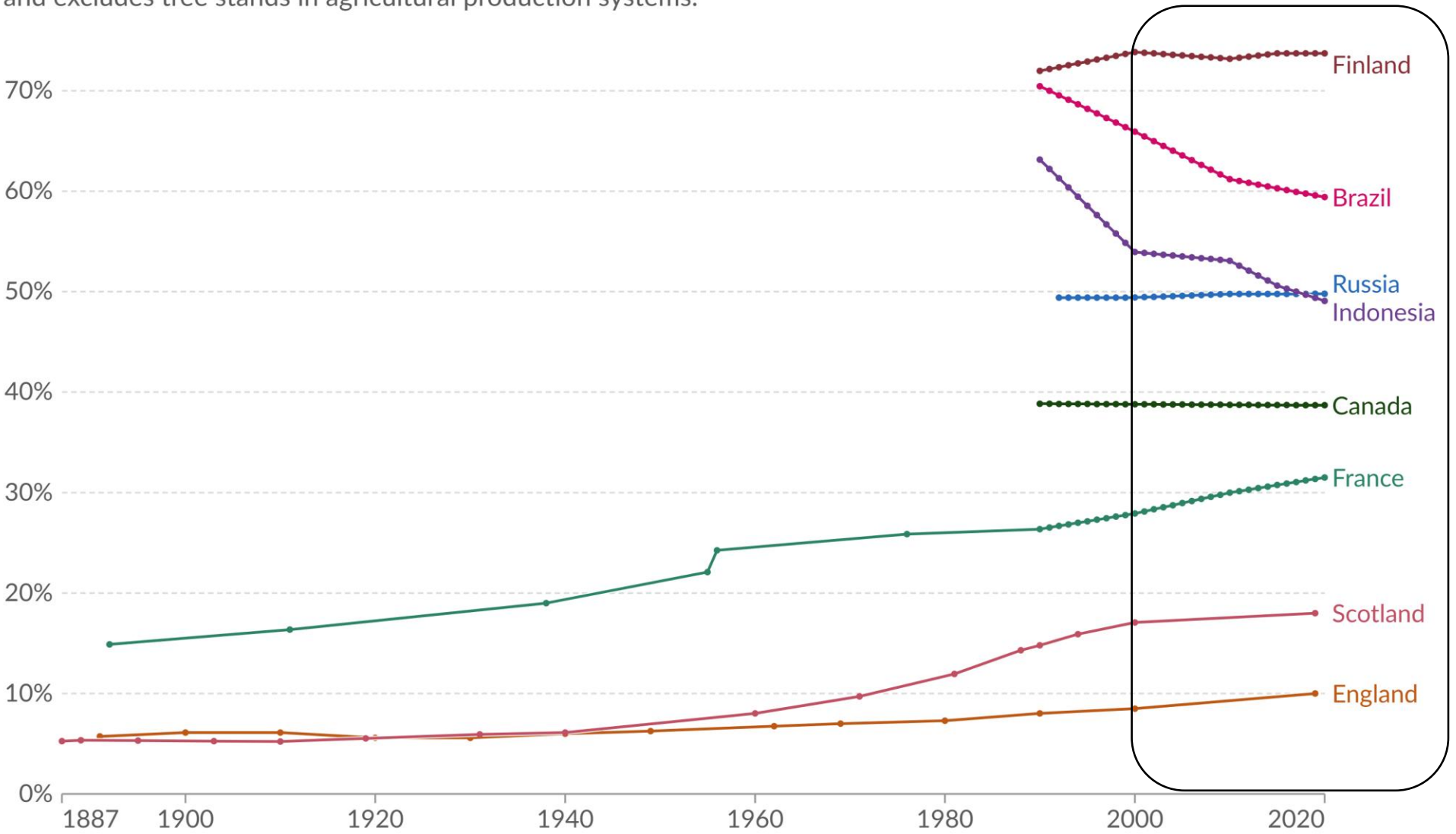
“A total of 4.1 million hectares of primary tropical forest were lost in 2022” (global forest loss 4% higher than in 2021)

Source: WWF (2023) The Forest Pathways Report. Gagen, M.H., Dudley, N., Jennings, S., Timmins, H.L. BaldwinCantello, W., D’Arcy, L., Dodsworth, J.E., Fleming, D., Kleymann, H., Pacheco, P., Price, F., (Lead Authors). WWF, Gland, Switzerland.

Share of land covered by forest

Our World in Data

Forest area is land with natural or planted stands of trees at least five meters in height, whether productive or not, and excludes tree stands in agricultural production systems.



Data source: Food and Agriculture Organization of the United Nations and historical sources

OurWorldInData.org/forests-and-deforestation | CC BY

The rapid loss of species we are seeing today is estimated by experts to be between 1,000 and 10,000 times higher than the *natural extinction rate*.

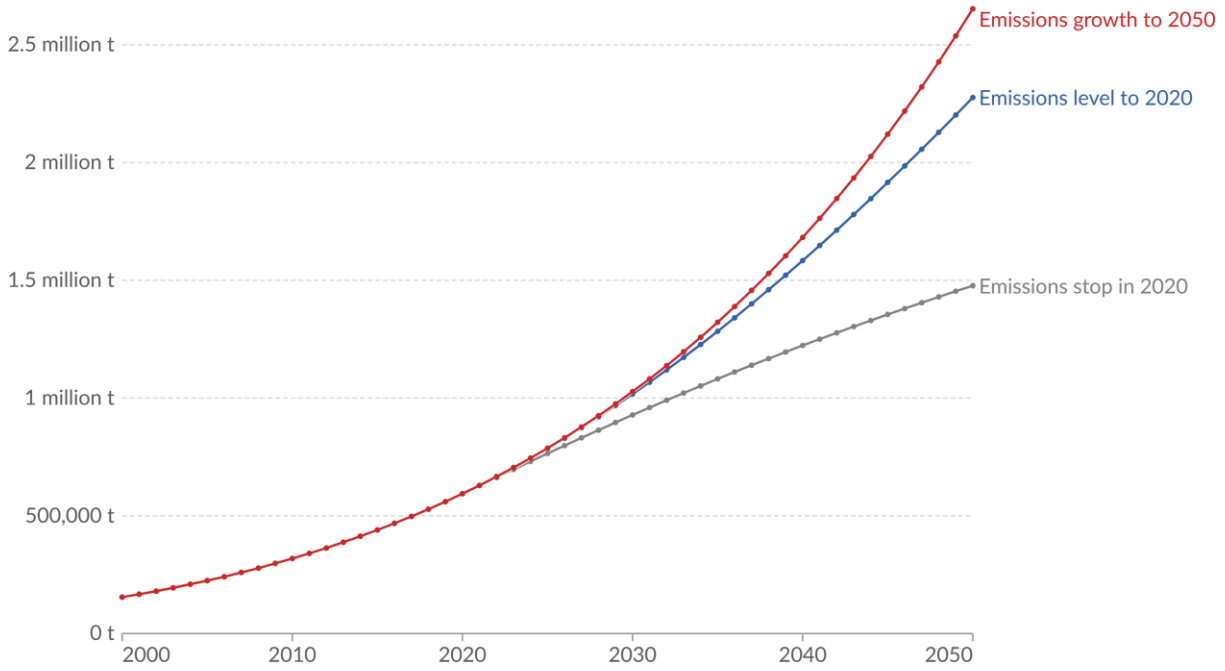
Between 0.01 and 0.1% of all species will become extinct each year

Source: wwf.panda.org/discover/our_focus/biodiversity/biodiversity/

Microplastics in the surface ocean, 2000 to 2050

Our World in Data

Microplastics are buoyant plastic materials smaller than 0.5 centimeters in diameter. Future global accumulation in the surface ocean is shown under three plastic emissions scenarios: (1) emissions to the oceans stop in 2020; (2) stagnate at 2020 rates; or (3) continue to grow until 2050 in line with historical plastic production rates.



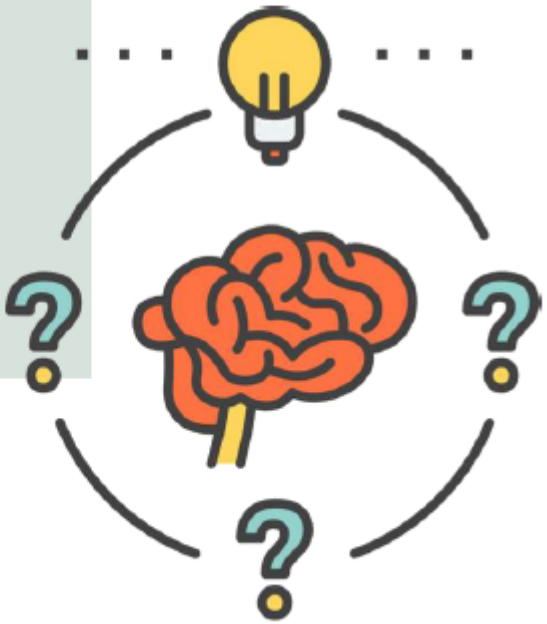
Data source: Lebreton et al. (2019)

OurWorldInData.org/plastic-pollution | CC BY

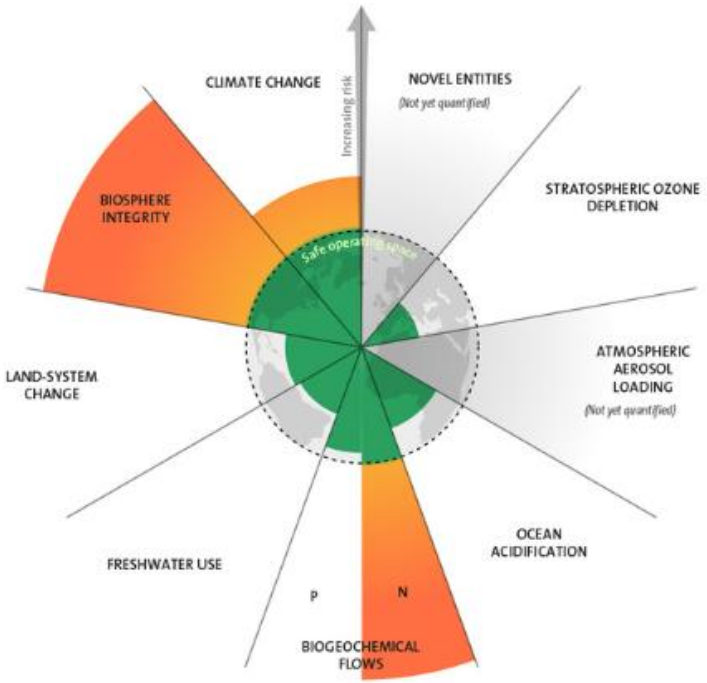
A 2018 Scientific Report in Nature puts the size of the Great Pacific Garbage Patch at 1.6 million km2

France (EU) size = 543,94K km²

How do you think it is our position today regarding planetary boundaries?

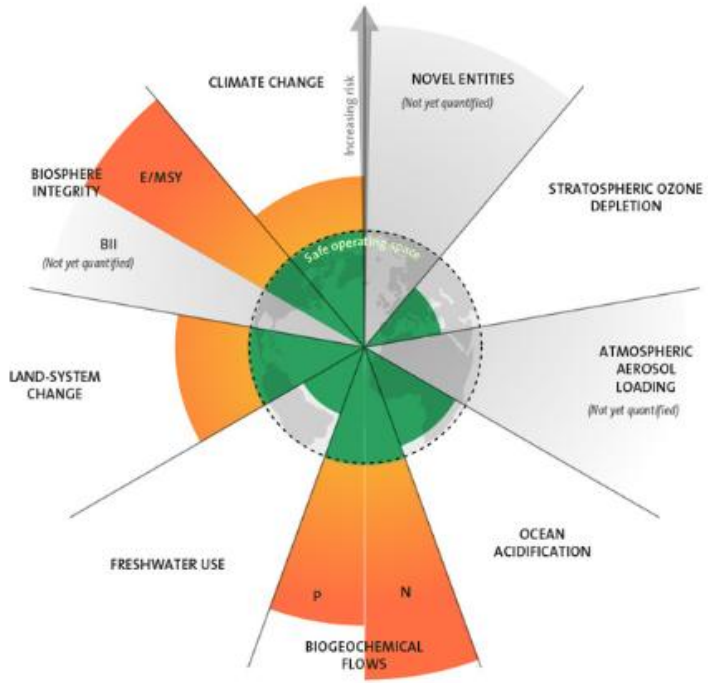


2009



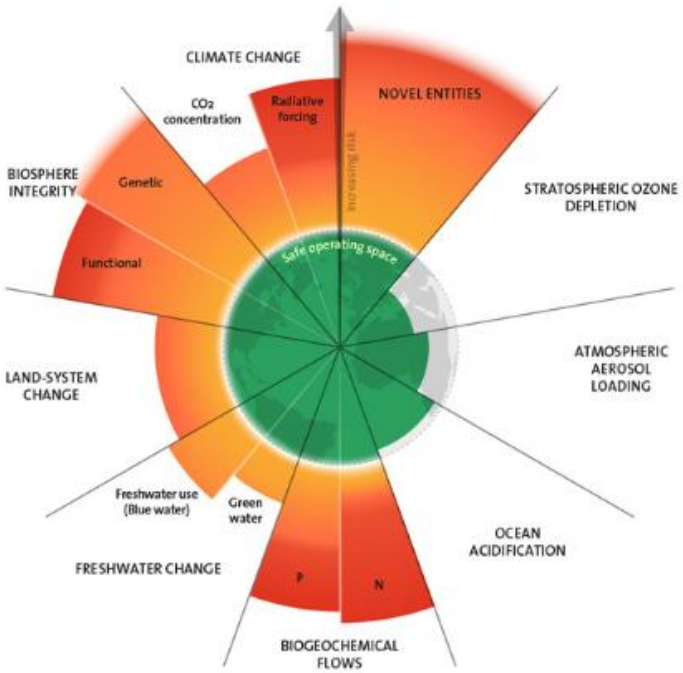
7 boundaries assessed,
3 crossed

2015



7 boundaries assessed,
4 crossed

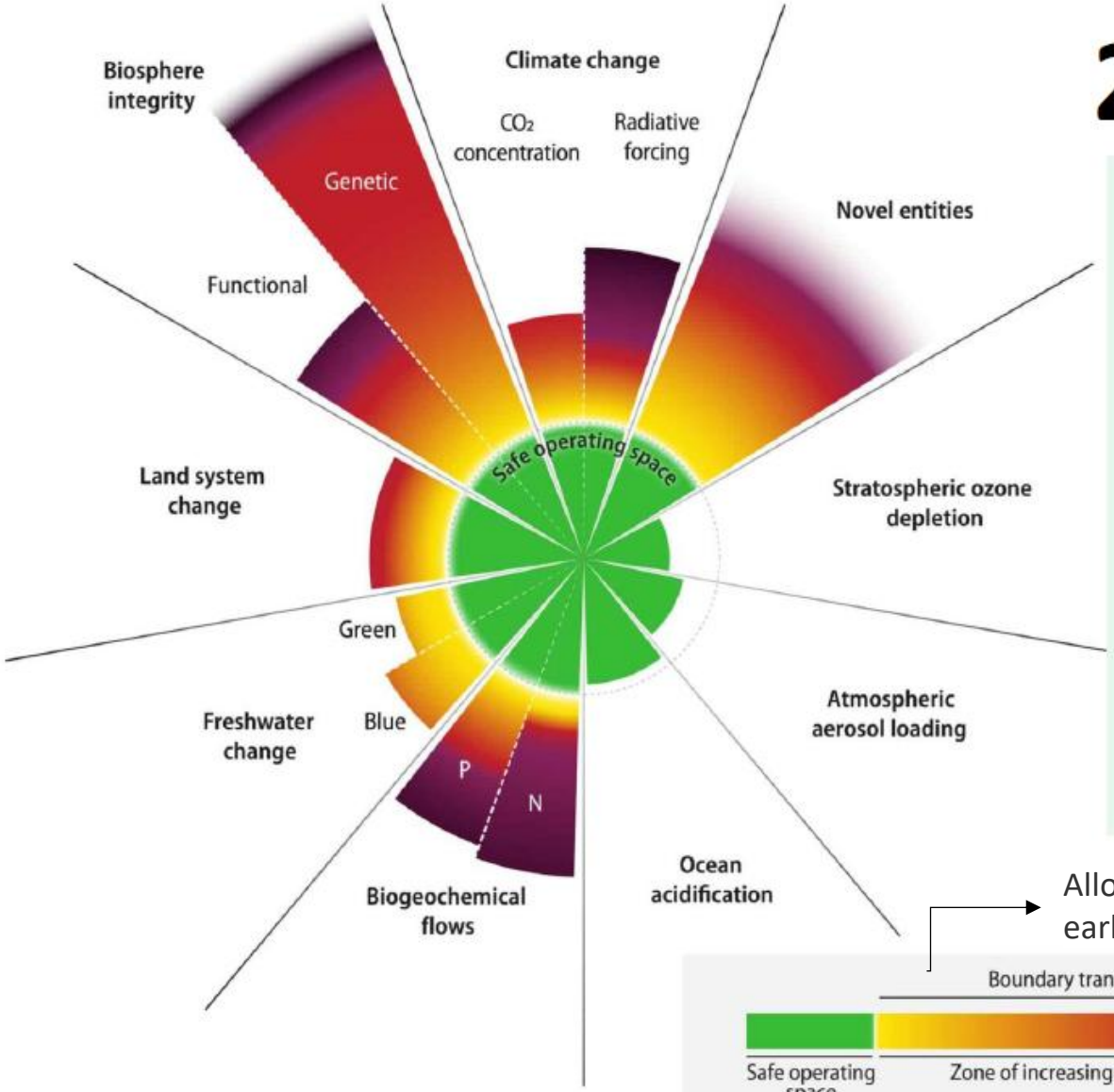
2023



9 boundaries assessed,
6 crossed

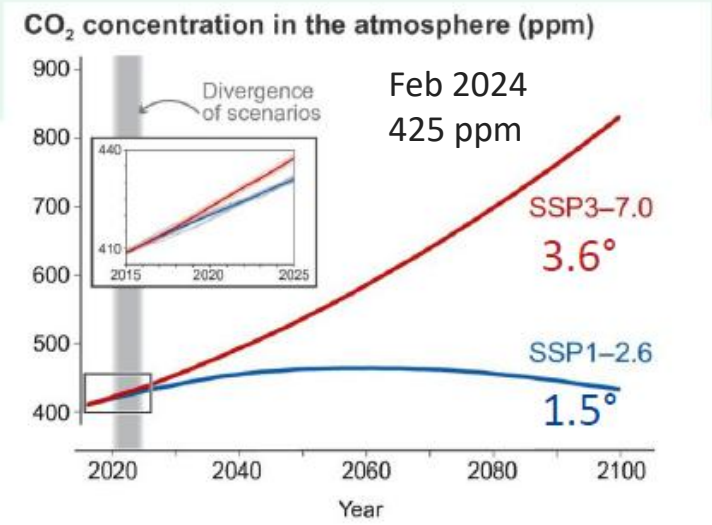
Stockholm Resilience Centre | Stockholm University

2023 | Climate Change



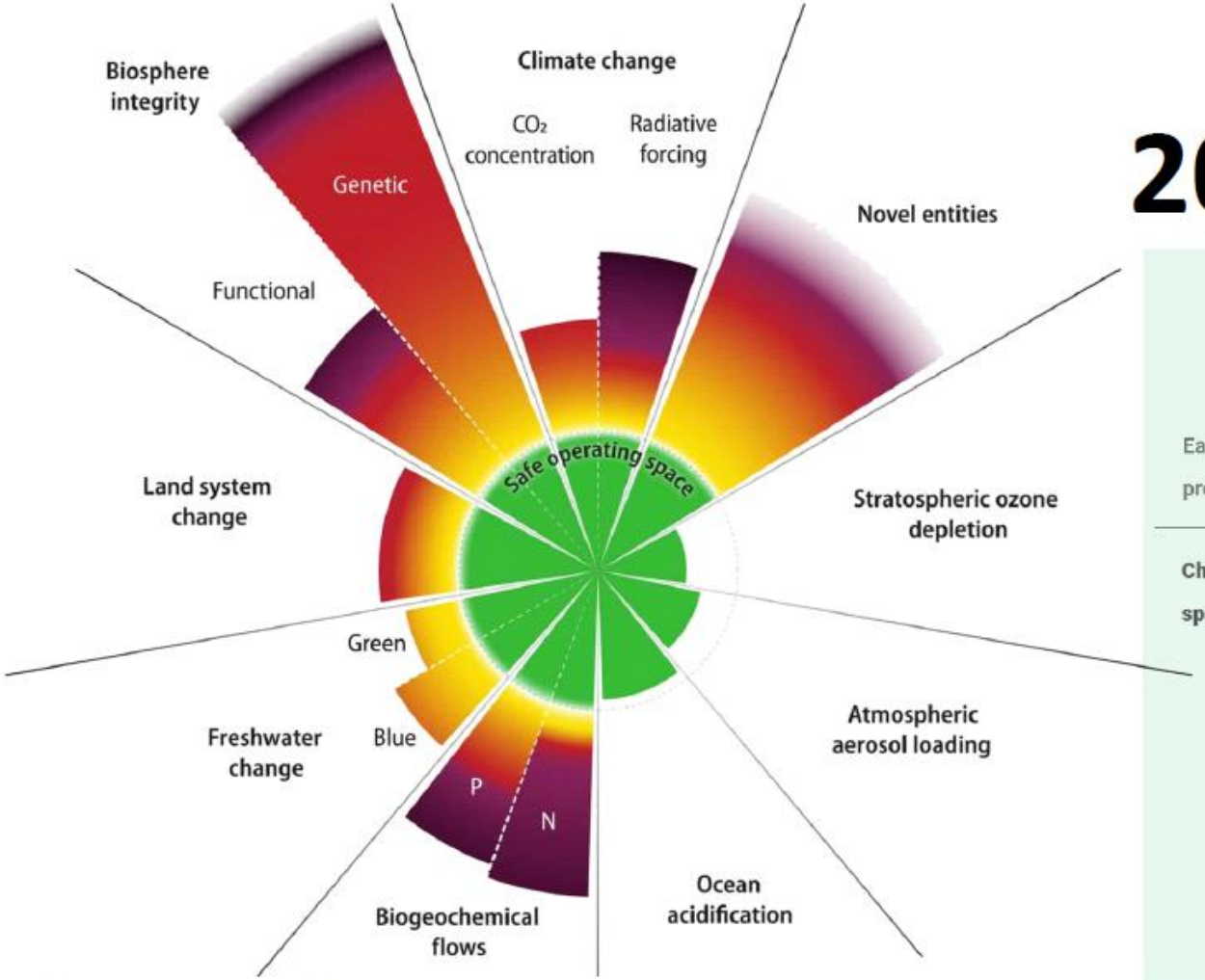
Allows society time to react to early warning signs

Earth system process	Control variable(s)	Planetary boundary	Preindustrial Holocene base value	Upper end of zone of increas-ing risk	Current value of control variable
Climate change	Atmospheric CO_2 concentration (ppm CO_2)	350 ppm CO_2	280 ppm CO_2	450 ppm CO_2	417 ppm CO_2 (*41*)
	Total anthro-pogenic radia-tive forcing at top-of-atmos-phere (W m^{-2})	+1.0 W m^{-2}	0 W m^{-2}	+1.5 W m^{-2}	+2.91 W m^{-2} (*41*)



Source: Richardson et al. (2023). Earth beyond six of nine planetary boundaries. Science, 9(37). doi.org/10.1126/sciadv.adh2458

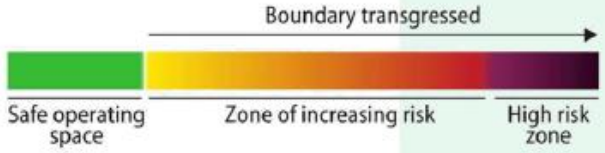
2023 | Biodiversity



Earth system process	Control variable(s)	Planetary boundary	Preindustrial Holocene base value	Upper end of zone of increasing risk	Current value of control variable
Change in biosphere integrity	Genetic diversity: E/MSY	<10 E/MSY but with an aspirational goal of ca. 1 E/MSY (assumed background rate of extinction loss)	1 E/MSY	100 E/MSY	>100 E/MSY (*24–26*)
	Functional integrity: measured as energy available to ecosystems (NPP) (% HANPP)	HANPP (in billion tonnes of C $year^{-1}$) <10% of preindustrial Holocene NPP, i.e., >90% remaining for supporting biosphere function	1.9% (2σ variability of preindustrial Holocene century-mean NPP)	20% HANPP	30% HANPP (see the Supplementary Materials)

E/MSY = extinctions per million species-years

HANPP: Human Appropriation of Net Primary Productivity



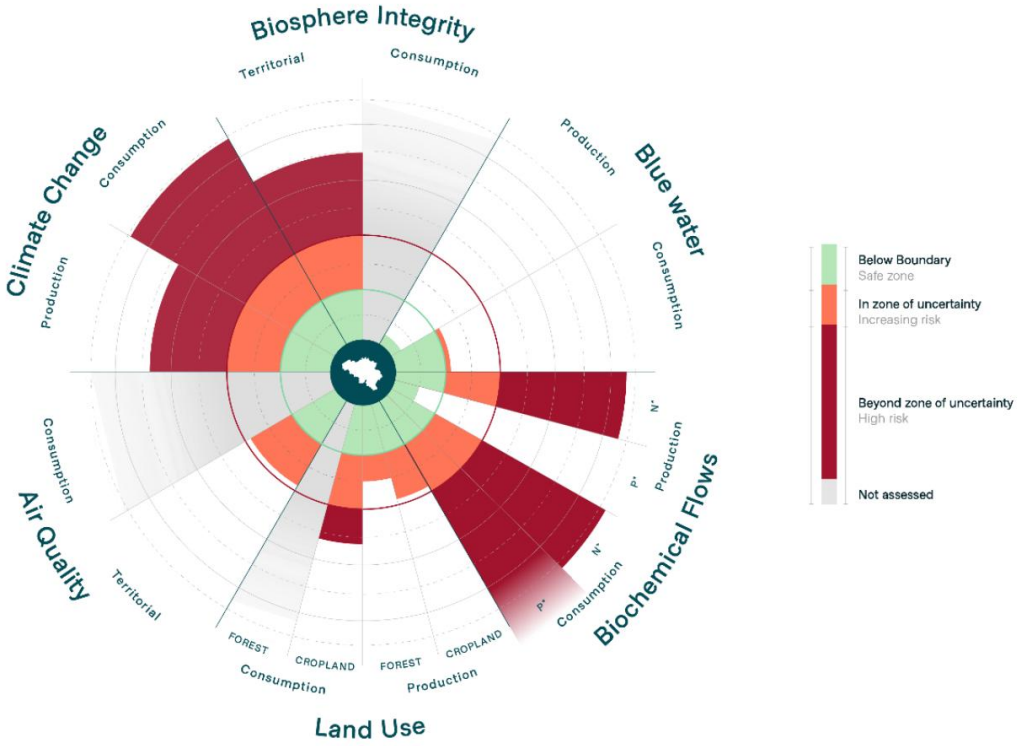
"Estimated 8 million plant and animal species, around 1 million are threatened with extinction, and over 10% of genetic diversity of plants& animals may have been lost over the past 150 years"

Source: Richardson et al. (2023). Earth beyond six of nine planetary boundaries. Science, 9(37). doi.org/10.1126/sciadv.adh2458

TRANSLATING THE PLANETARY BOUNDARIES FRAMEWORK TO A NATIONAL LEVEL

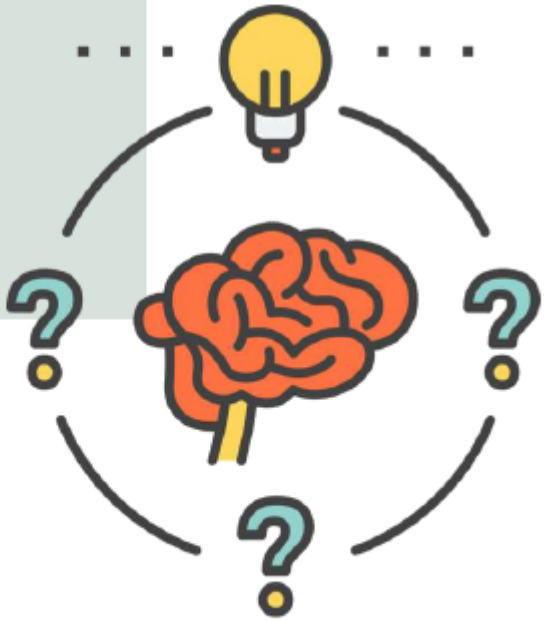
> ‘Downscaling’ - translation of globally defined planetary boundaries into locally or nationally actionable targets.

How can we share the Planetary Boundaries fairly?



> Equality – equal share per capita
> Right to develop – equal share of development index

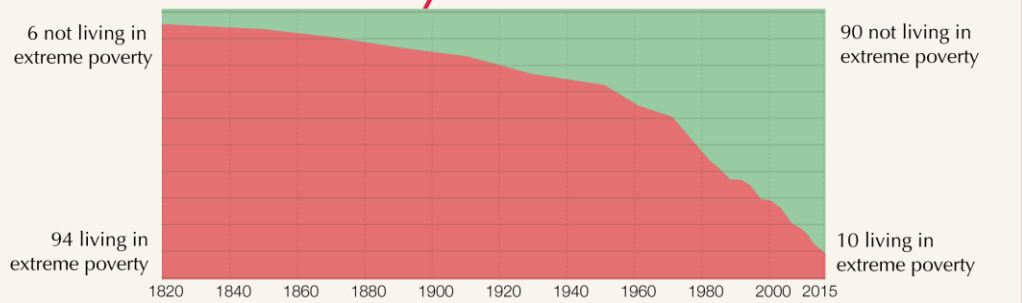
From a socioeconomic perspective how do you think the world is changing?



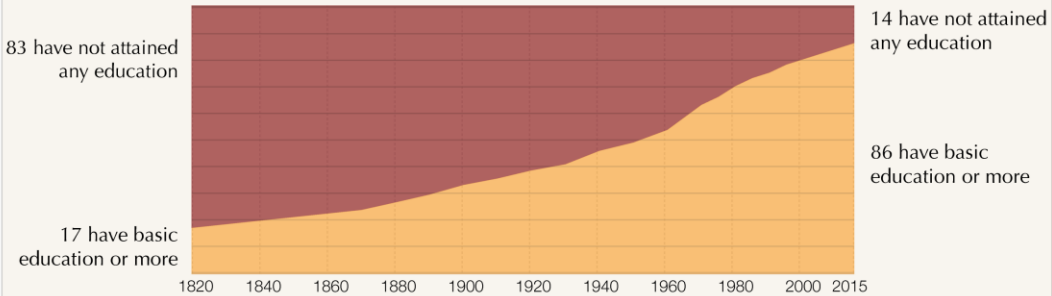
The World as 100 People
over the last two centuries

Our World in Data

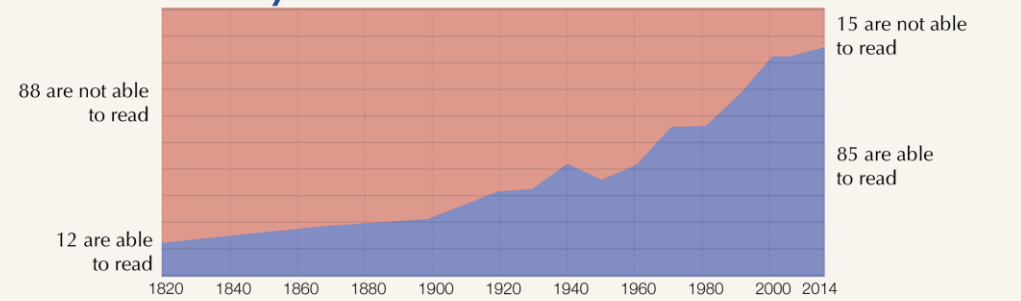
Extreme Poverty



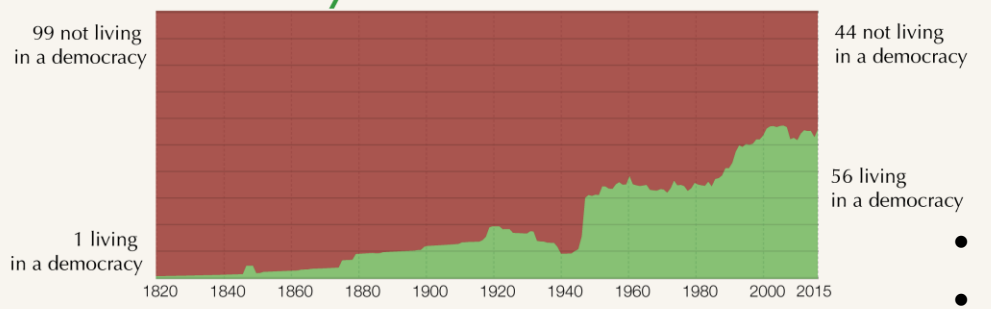
Basic Education



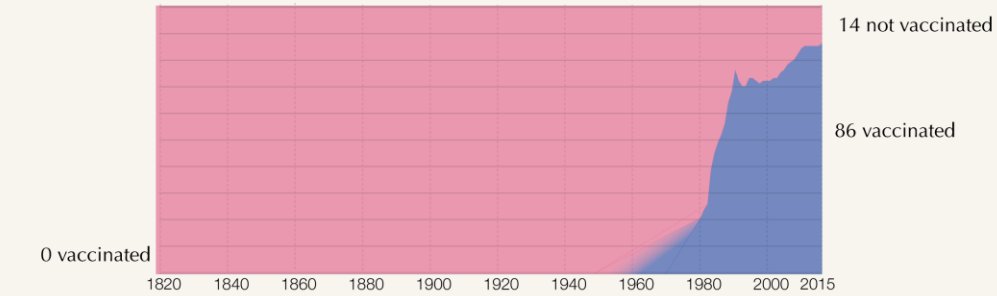
Literacy



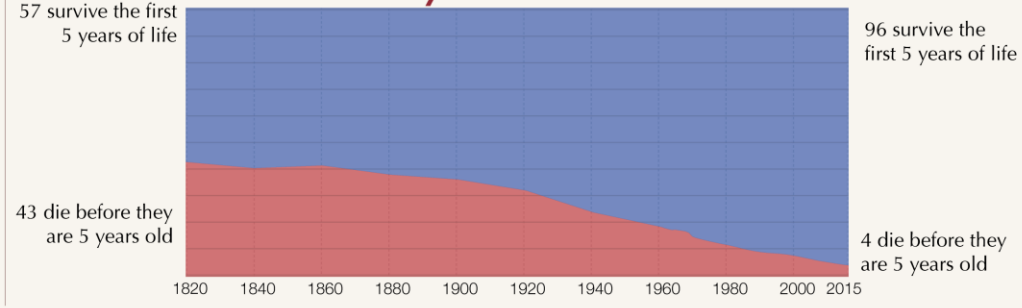
Democracy



Vaccination against diphtheria, pertussis (whooping cough), and tetanus

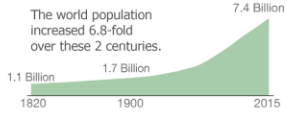


Child Mortality



- Better health
- Fewer in poverty
- Better education

Data sources:
Extreme Poverty: Bourguignon & Morrison (2002) up to 1970 – World Bank 1981 and later (2015 is a projection).
Vaccination: WHO (Global data are available for 1980 to 2015 – the DPT3 vaccination was licenced in 1949)
Education: OECD for the period 1820 to 1960. IIASA for the time thereafter.
Literacy: OECD for the period 1820 to 1990. UNESCO for 2004 and later.
Democracy: Politiy IV index (own calcluation of global population share)
Colonialism: Wimmer and Min (own calcluation of global population share)
Continent: HYDE database
Child mortality: up to 1960 own caluclations based on Gapminder; World Bank thereafter

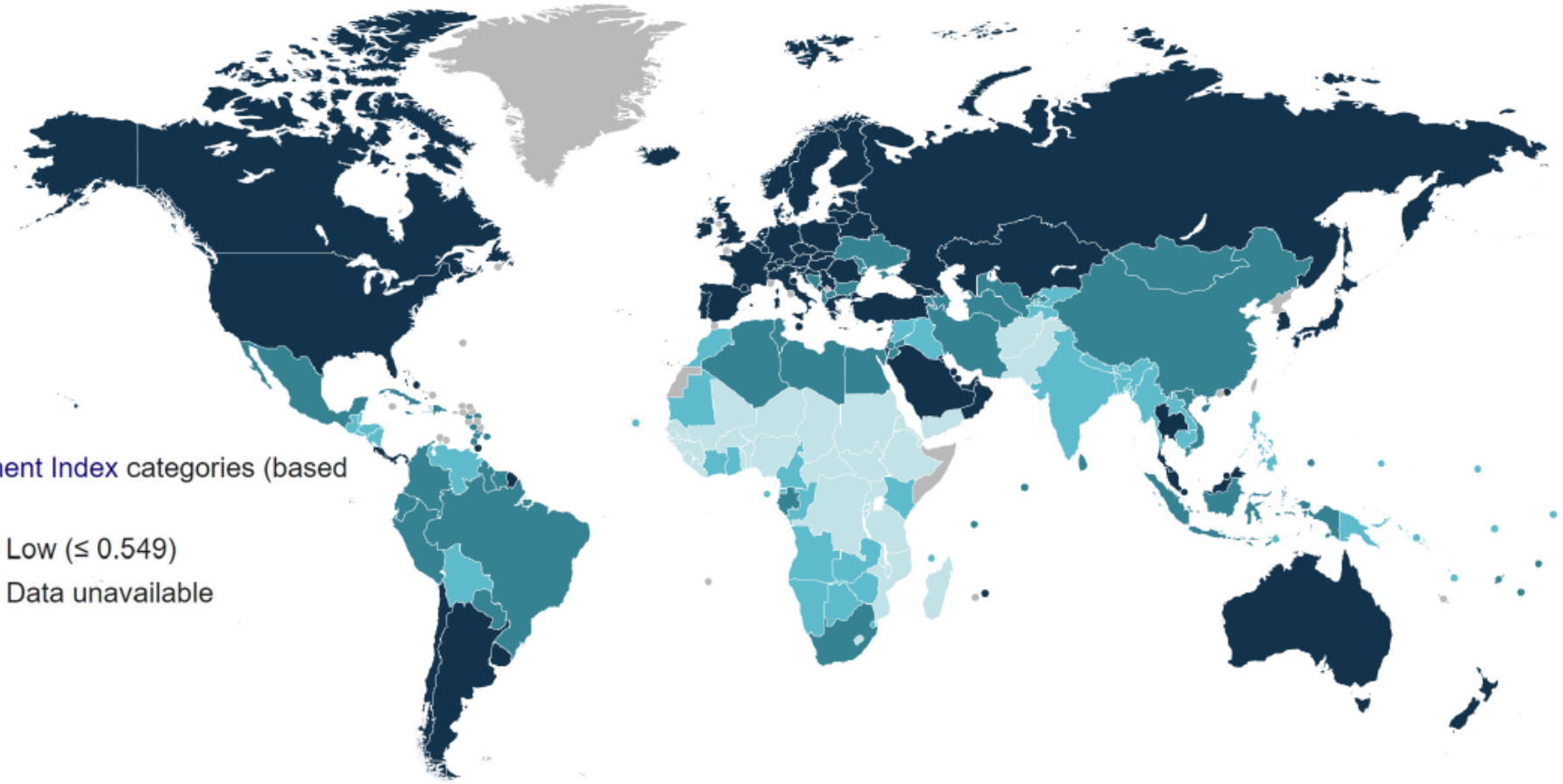


All these visualizations are from OurWorldInData.org an online publication that presents the empirical evidence on how the world is changing.

The economic system has heavily relied on resource depletion (e.g., water, minerals), significant waste generation, and environmental externalities such as climate change and biodiversity loss

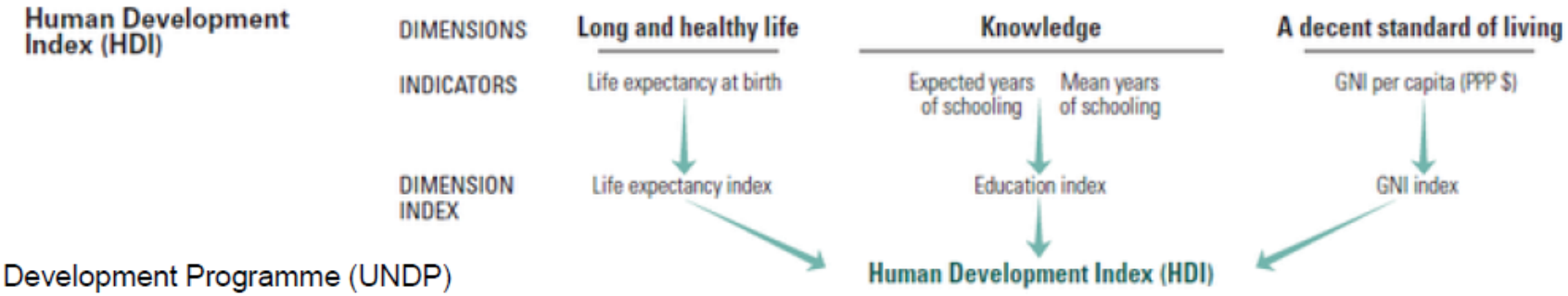
HUMAN DEVELOPMENT INDEX (HDI)

There is still a huge path to run



World map representing Human Development Index categories (based on 2021 data, published in 2022)

- Very high (≥ 0.800)
- High (0.700–0.799)
- Medium (0.550–0.699)
- Low (≤ 0.549)
- Data unavailable



Source: United Nations Development Programme (UNDP)

Humanity faces the challenge of how to achieve a high quality of life for >8 billion people without destabilizing critical planetary systems


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

The economy should be able to grow within a planetary boundary operating space

Can we envisage an economy growing within a safe operating space?

Towards transformation

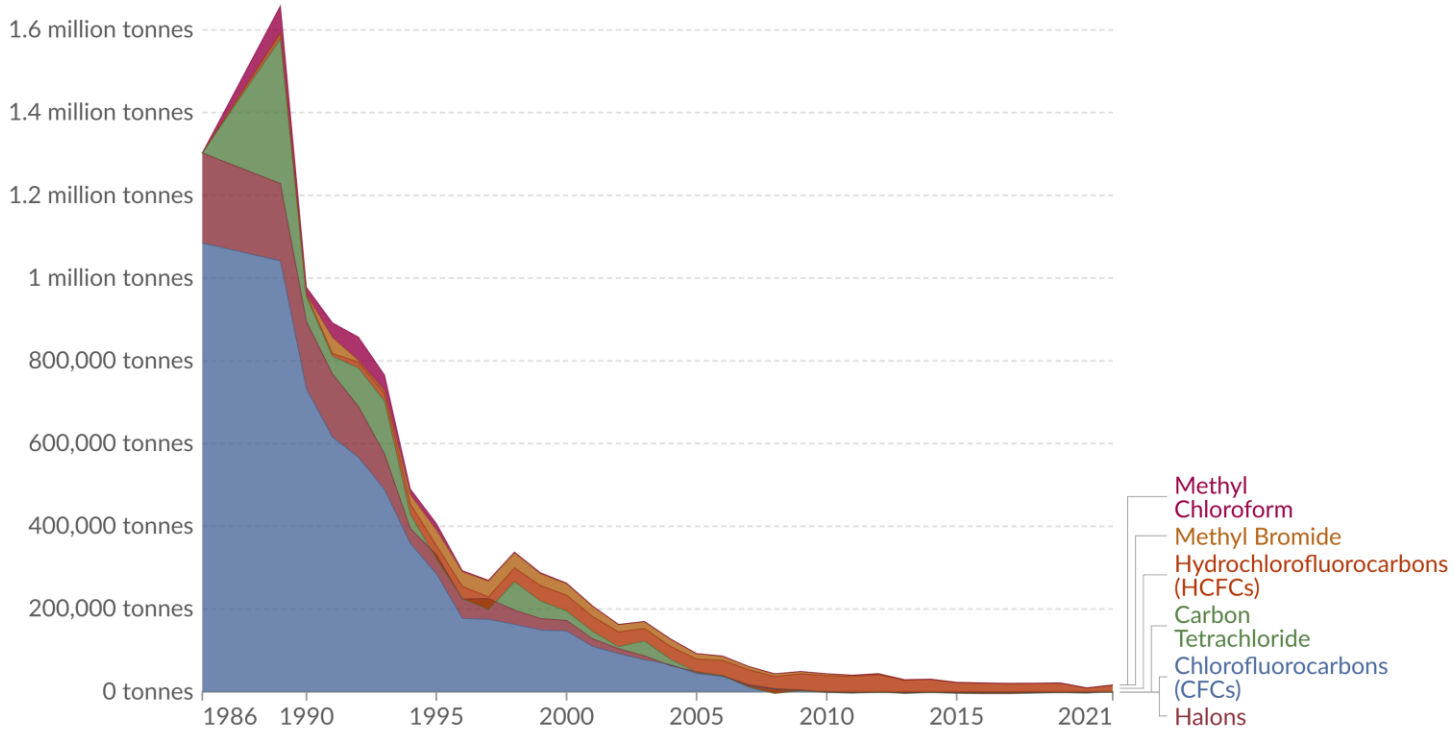
- Global energy system transformation
- Transformation towards sustainable cities & urbanisation
- Transformation towards a healthy & sustainable food system
- A transformation to a circular economy paradigm

"EXPONENTIAL" GROWTH OF SOLUTIONS

Emissions of ozone-depleting substances, World

Our World in Data

Annual consumption of ozone-depleting substances. Emissions of each gas are given in ODP tonnes[1], which accounts for the quantity of gas emitted and how "strong" it is in terms of depleting ozone.



Data source: UN Environment Programme (2023) OurWorldinData.org/ozone-layer | CC BY

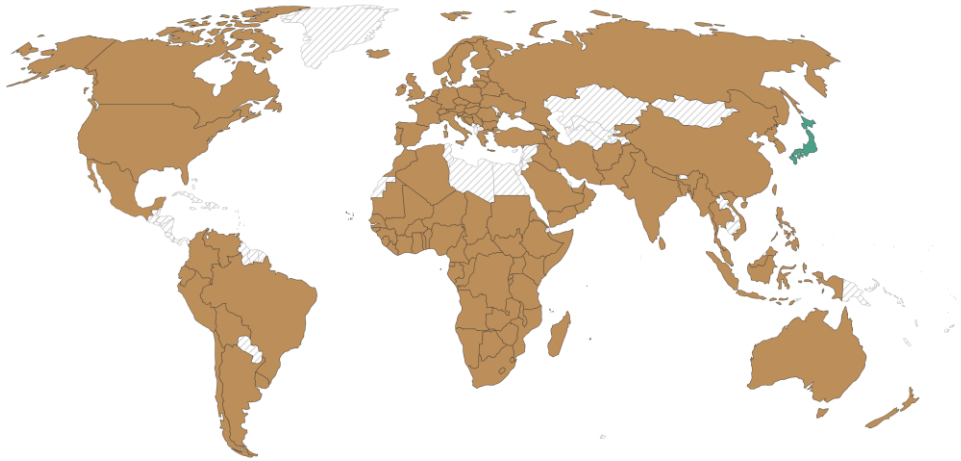
Note: In some years, gases can have negative consumption values. This occurs when countries destroy or export gases that were produced in previous years (i.e. stockpiles).

1. Ozone-depleting tonnes (ODP tonnes): Ozone-depleting tonnes measure the total potential of substances to deplete the ozone layer. Some substances that deplete the ozone layer are 'stronger' than others, meaning one tonne will cause greater damage than one tonne of another. ODP tonnes are calculated by multiplying a substance's emissions in tonnes, by its 'ozone-depleting potential'. Ozone-depleting potential measures how much depletion a substance causes relative to CFC-11, which has a value of 1.0. If one tonne of a gas caused twice the depletion of CFC-11, it would have a potential of 2.0.

Global phase-out of leaded petrol in road vehicles, 1986

All countries have banned the use of leaded petrol in road vehicles. Algeria was the final country to do so in 2021.

Our World in Data



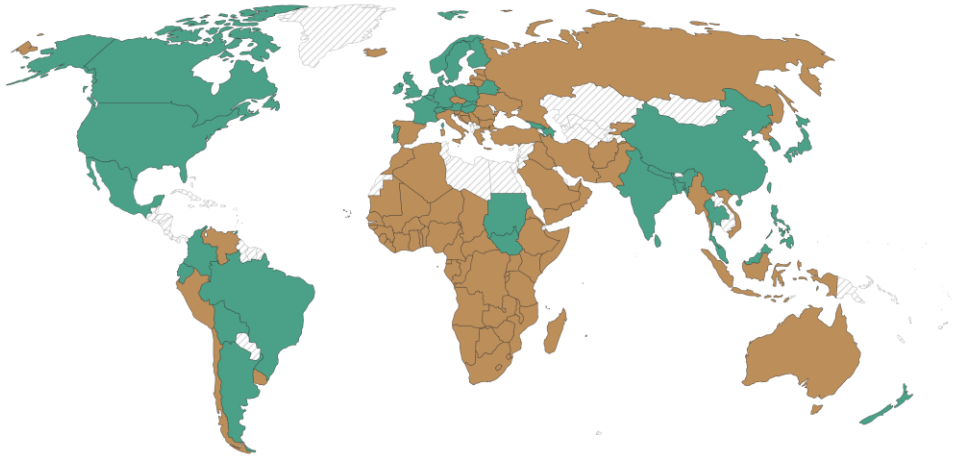
Still in use Banned

Data source: Collected by Our World in Data based on multiple sources
Note: The specific date of phase-out could not be found for some countr

Global phase-out of leaded petrol in road vehicles, 2000

All countries have banned the use of leaded petrol in road vehicles. Algeria was the final country to do so in 2021.

Our World in Data



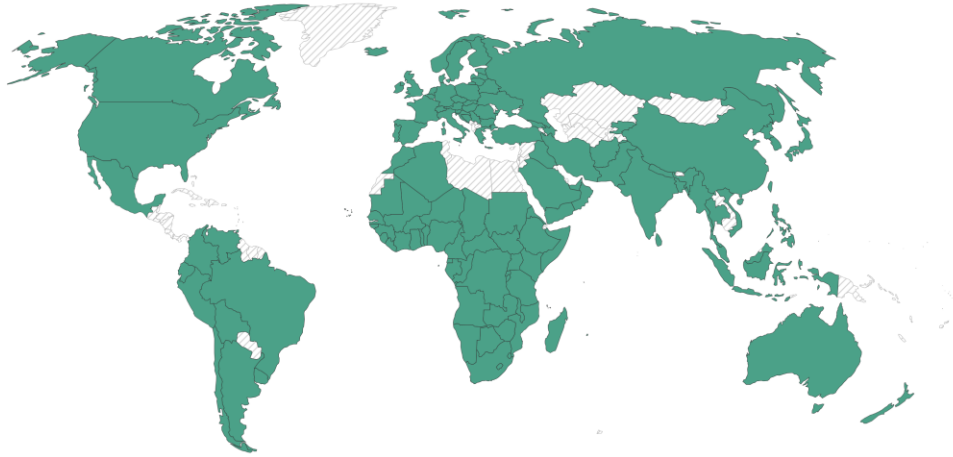
Banned Unknown year of ban

ıltiple sources OurWorldinData.org/lead-pollution | CC BY
or some countries, but all countries have banned its use.

Global phase-out of leaded petrol in road vehicles, 2021

All countries have banned the use of leaded petrol in road vehicles. Algeria was the final country to do so in 2021.

Our World in Data



Still in use Banned Unknown year of ban

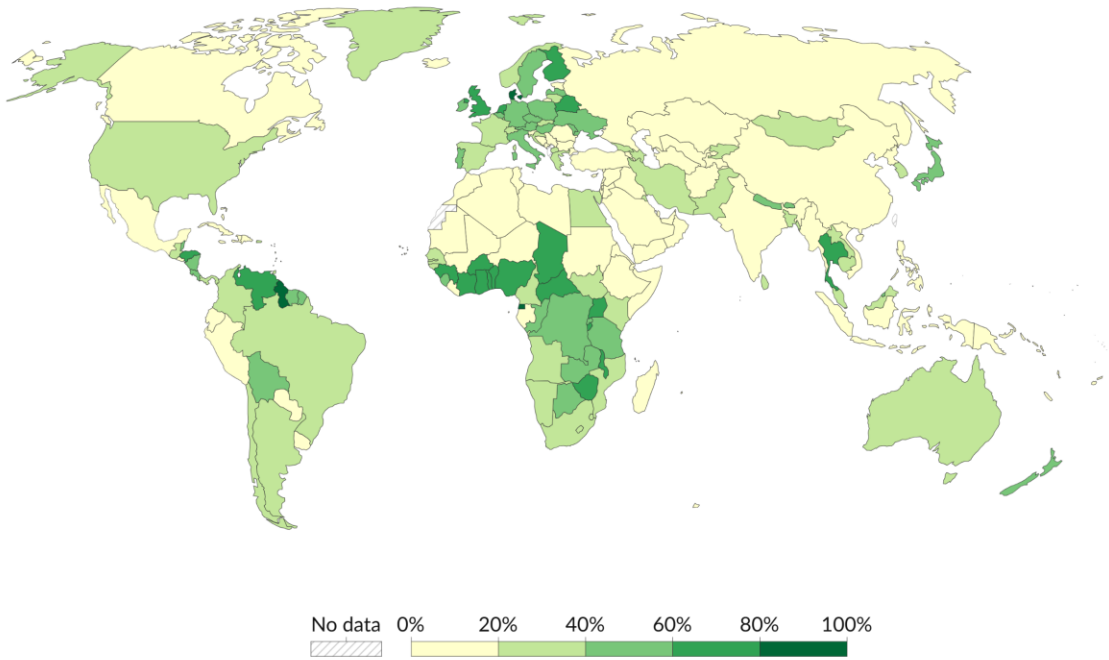
Data source: Collected by Our World in Data based on multiple sources OurWorldinData.org/lead-pollution | CC BY
Note: The specific date of phase-out could not be found for some countries, but all countries have banned its use.

Phase-Out of Leaded Fuel

Share of terrestrial Key Biodiversity Areas that are protected, 2000

Proportion of terrestrial Key Biodiversity Areas (KBAs)[1] that are covered by designated protected areas[2].

Our World in Data



Data source: BirdLife International, IUCN and UNEP-WCMC

OurWorldinData.org/biodiversity | CC BY

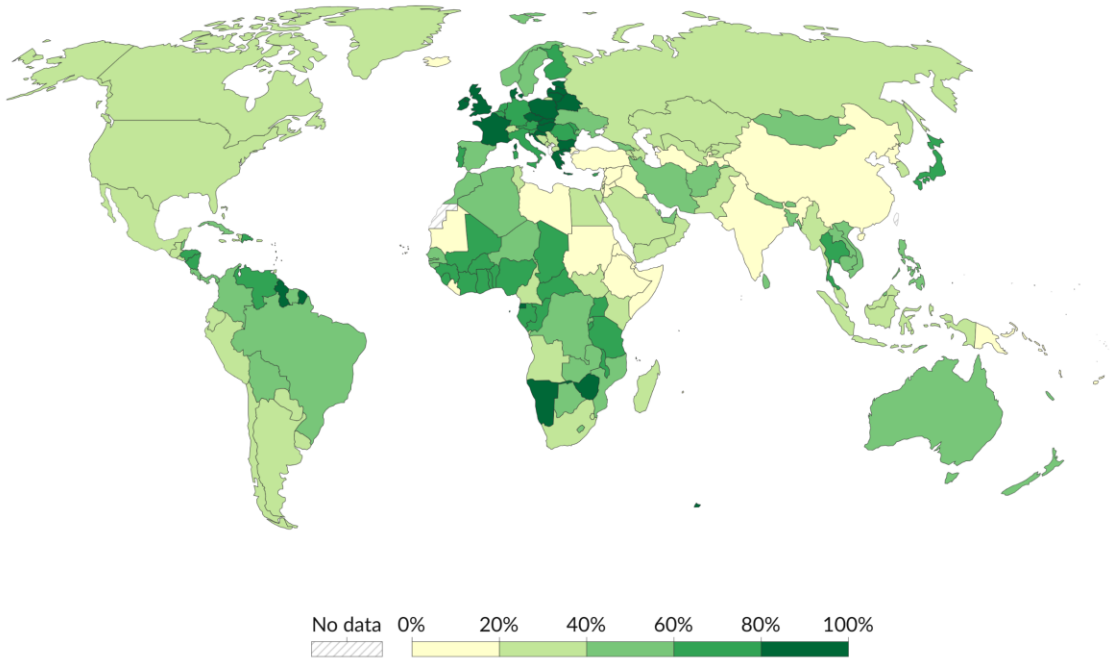
1. Key Biodiversity Area (KBA): A Key Biodiversity Area is a site that makes a significant contribution to the global persistence of biodiversity. This is often the case if a site contains many unique species. It can also mean that the site is home to a species that isn't found anywhere else, or is only found in a few other locations. The IUCN uses 11 criteria to assess whether a site is a KBA. These cover five categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes (e.g. nesting) and irreplaceability.

2. Protected area: A protected area is a clearly defined geographical space that is recognised, and managed through legal or other effective means. Protected areas are managed to preserve their ecosystem services and cultural values over the long-term. There are seven different categories of protected areas, ranging from strict nature reserves which are protected from all but light human use; to protected areas which allow the sustainable use of natural resources (such as logging, or fishing). Protected areas can be in the ocean (a marine protected area – MPA) or on land.

Share of terrestrial Key Biodiversity Areas that are protected, 2023

Proportion of terrestrial Key Biodiversity Areas (KBAs)[1] that are covered by designated protected areas[2].

Our World in Data



Data source: BirdLife International, IUCN and UNEP-WCMC

OurWorldinData.org/biodiversity | CC BY

1. Key Biodiversity Area (KBA): A Key Biodiversity Area is a site that makes a significant contribution to the global persistence of biodiversity. This is often the case if a site contains many unique species. It can also mean that the site is home to a species that isn't found anywhere else, or is only found in a few other locations. The IUCN uses 11 criteria to assess whether a site is a KBA. These cover five categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes (e.g. nesting) and irreplaceability.

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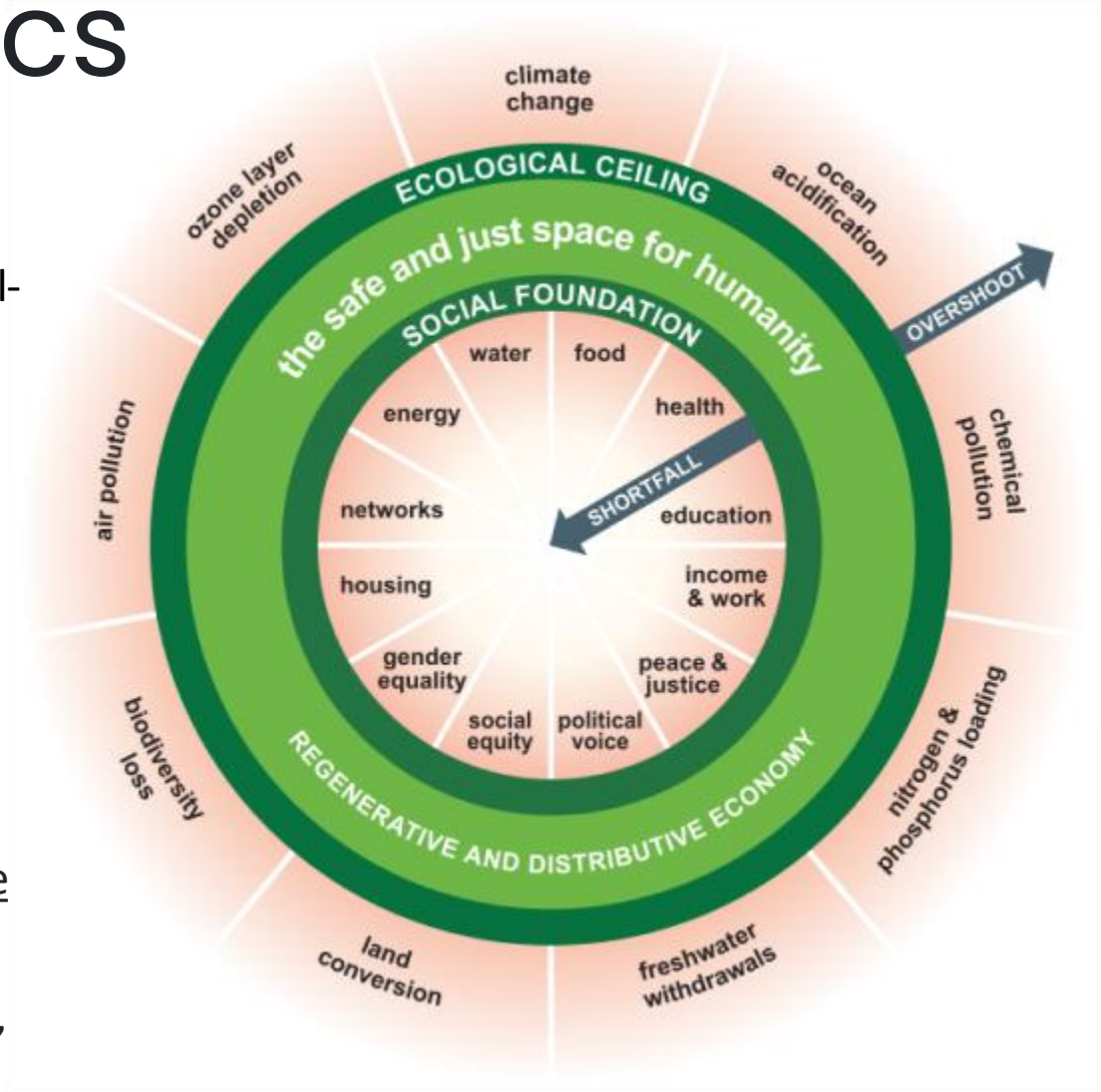
Green growth: 30% of regions worldwide achieve economic growth while reducing carbon emissions

Source: https://doi.org/10.1073/pnas.241141912

Doughnut Economics

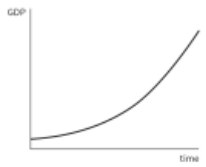
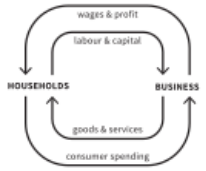
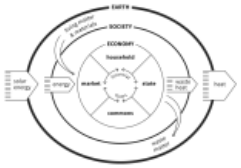
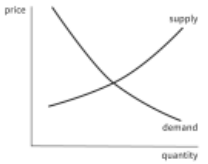
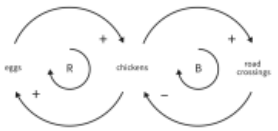
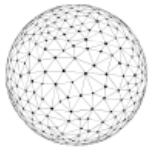
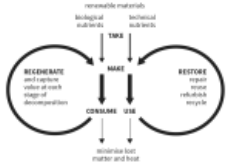
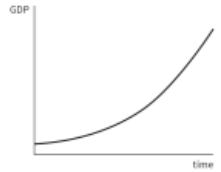
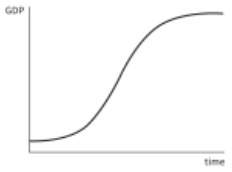
- Developed by economist Kate Raworth, Doughnut Economics provides a framework to ensure human well-being within ecological limits.
- **Social foundation**, to ensure that no one is left falling short on life's essentials
- **Ecological ceiling**, to ensure that humanity does not collectively overshoot the planetary boundaries
- Between these two sets of boundaries - both ecologically safe and socially just: a space in which humanity can thrive.

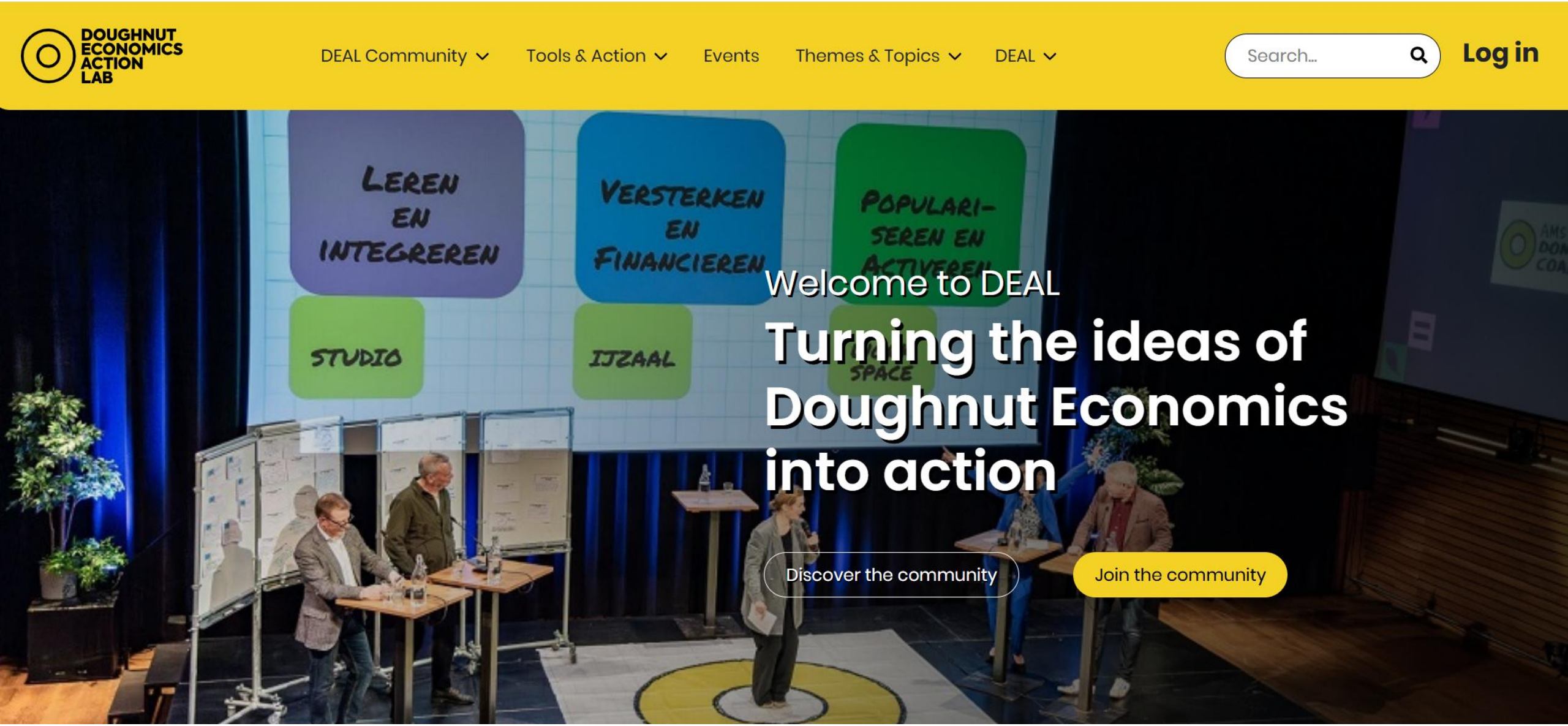
- Interactions between the Planetary Boundaries and the Social Foundation - Environmental stress can exacerbate poverty and vice versa, and policies aiming to reduce environmental pressure, if not well designed, can exacerbate poverty and vice versa.



DOUGHNUT ECONOMICS ACTION LAB

Seven ways to think like a 21st century economist

Seven Ways to Think:	From 20th-Century Economics		To 21st-Century Economics	
1. Change the Goal		GDP		the Doughnut
2. See the Big Picture		self-contained market		embedded economy
3. Nurture Human Nature		rational economic man		social adaptable humans
4. Get Savvy with Systems		mechanical equilibrium		dynamic complexity
5. Design to Distribute		growth will even it up again		distributive by design
6. Create to Regenerate		growth will clean it up again		regenerative by design
7. Be Agnostic about Growth		growth addicted		growth agnostic


DOUGHNUT ECONOMICS ACTION LAB
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IJZAAL
Welcome to DEAL
Turning the ideas of Doughnut Economics into action
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Join the community

International Trade Game

INTERNATIONAL TRADE GAME + PLANETARY BOUNDARIES

> This game is an adapted version of the World Trade Game developed by the Third World development charity Action Aid (https://www.economicsnetwork.ac.uk/showcase/sloman_game#Introduction)

> Teams represent 5/6 countries in this game: A1, A2, B1(B2), C1, C2

> Countries compete against each other to 'manufacture' materials (papers shapes: circles, triangles, rectangles) and sell them to an international commodity market trader at posted prices, which vary with supply and demand

Objective: become the richest country at the end of the game

RULES

> You may only use the materials provided (do not cut the envelops please)

> You can choose to make any of the shapes shown on the diagrams.

> All the shapes must be cut with clean sharp edges using scissors and must be the exact size shown.

> Take the shapes to the banker in batches who will check them for accuracy and exchange them for cash. Inaccurate shapes will be rejected or paid at a lower price

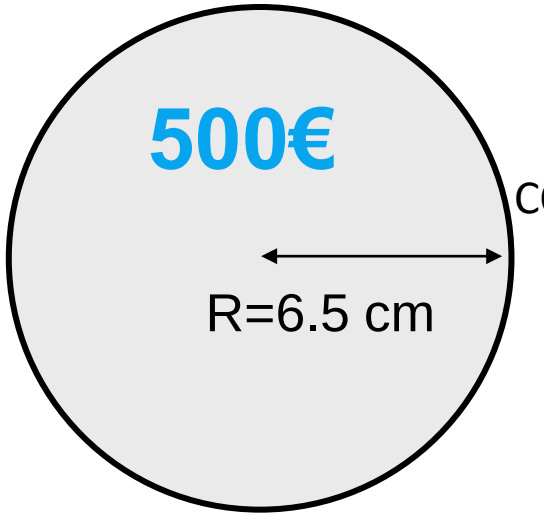
> You can manufacture as many shapes as you like - the more you make, the richer you will become.

> If you hear me clap hands, you must immediately stop what you are doing and pay attention.

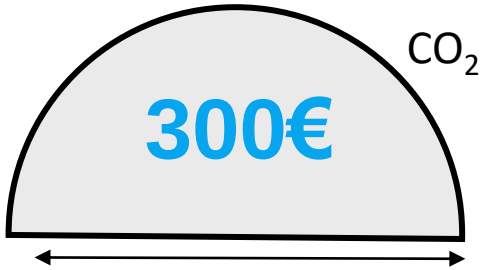
> If there is any dispute, I will settle it. My word is final! No physical force is to be used in the game

You have 50 minutes to boost your economy!

Shapes and money



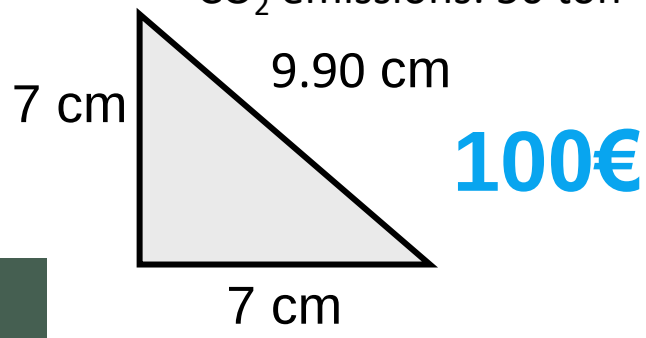
CO_2 emissions: 450 ton

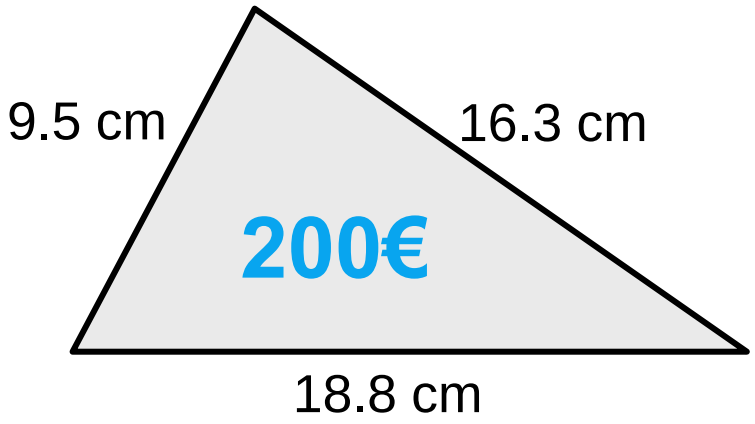


CO_2 emissions: 200 ton

CO_2 emissions: 125 ton

CO_2 emissions: 50 ton





CO_2 emissions: 100 ton

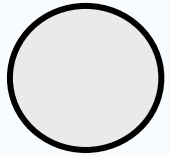
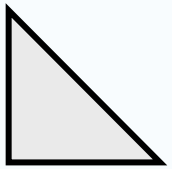
50€

100€

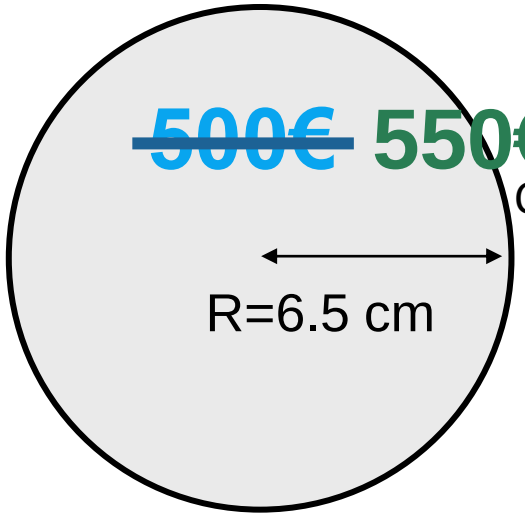
500€

1.000€

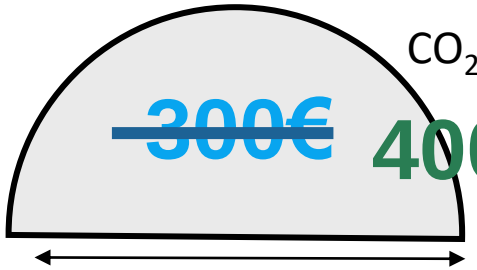
2.000€

	A1	A2	A3	B1	B2	B3	C1	C2	C3
									
									
									
									
									

New Prices



CO_2 emissions: 450 ton



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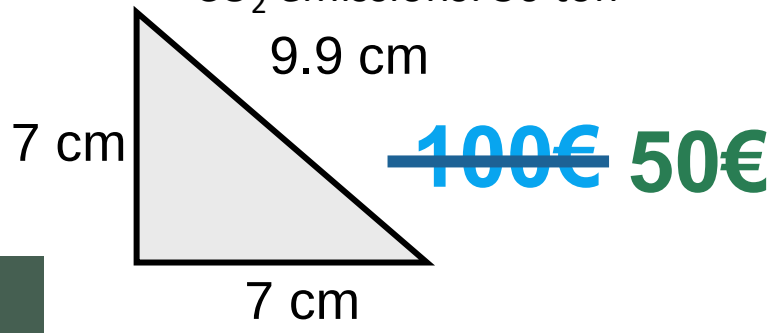
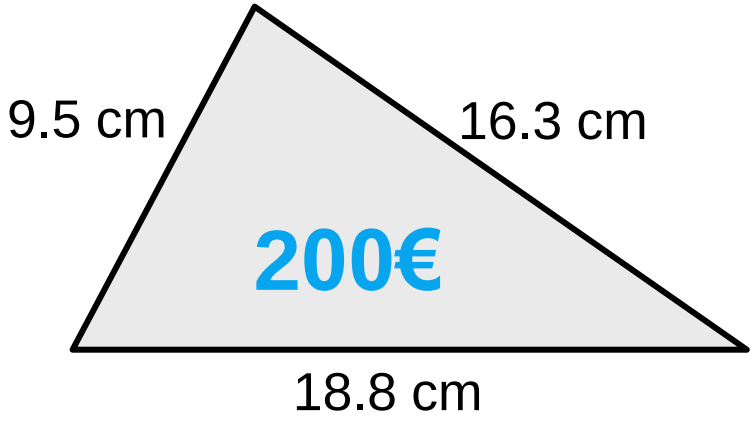




CO_2 emissions: 100 ton

50€

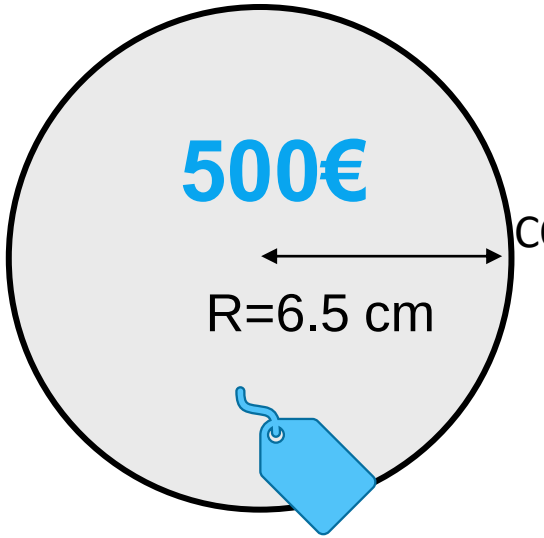
100€

500€

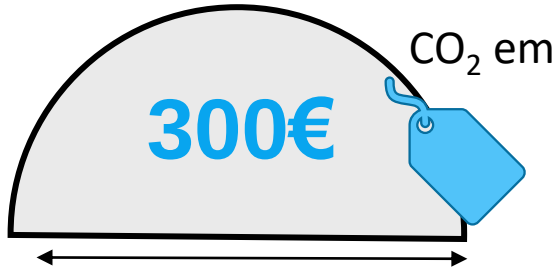
1.000€

2.000€

Only the shapes with blue post-it can be sell



CO_2 emissions: 450 ton



CO_2 emissions: 200 ton

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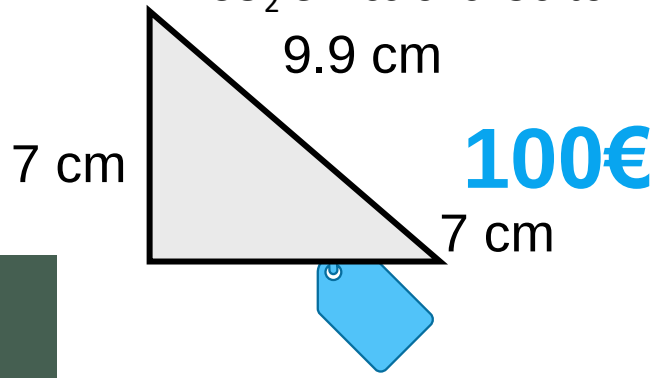
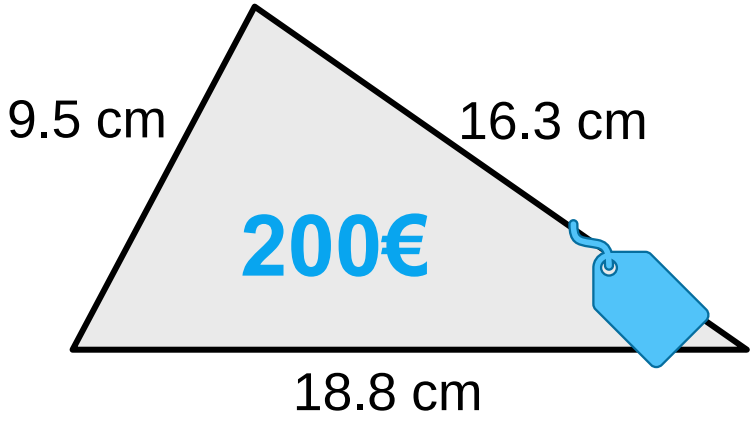




CO_2 emissions: 100 ton

50€

100€

500€

1.000€

2.000€

Objective: become the richest country at the end of the game

But…

Minimize your environmental impact

PENALTIES

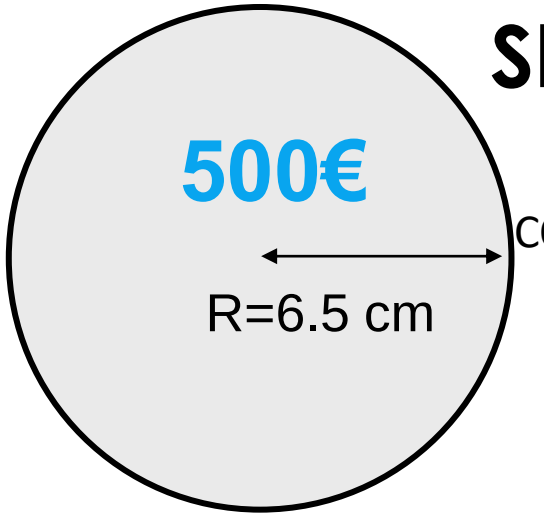
> **CO_2 Emissions**: 1€/t per shape produced

> **Water Usage**: -50€ per shape except semicircles

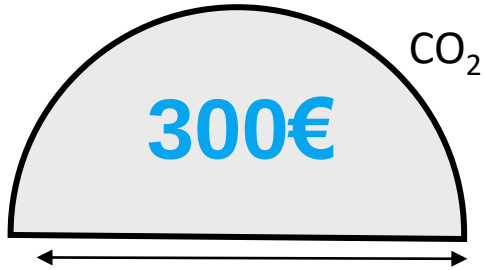
> **Deforestation**: -10€ per shape

Shapes and money

- **CO_2 Emissions**: 1€/t per shape produced
- **Water Usage**: -50€ per shape except circles and semicircles
- **Deforestation**: -10€ per shape



CO_2 emissions: 450 ton



CO_2 emissions: 200 ton

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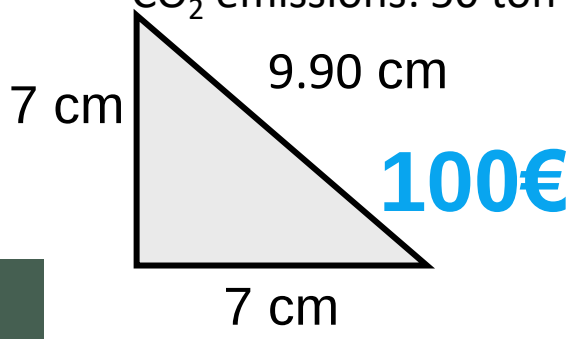
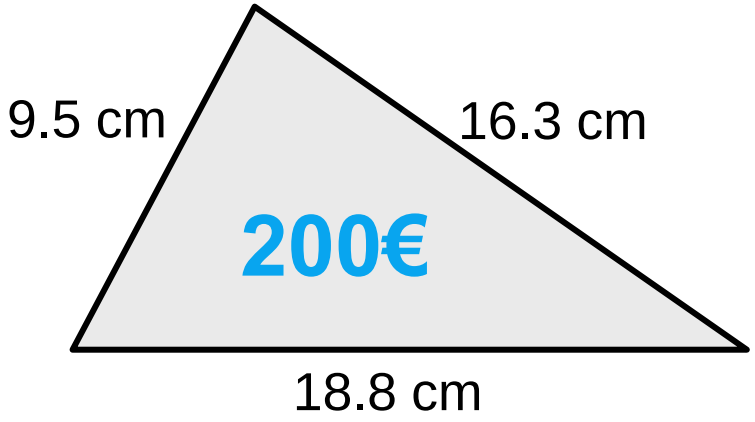
CO_2 emissions: 50 ton





CO_2 emissions: 100 ton

50€

100€

500€

1.000€

2.000€

#	What was in the envelope?	What tools do you own now?	How much money do you have? (€)	CO_2 emissions?(kt)
			Planet A	Planet A
A1	1 sheet of paper, 2 scissors, 2 rulers, 3 shapes already made, 2 pencils, 600€			
A2				
A3				
B1	10 sheet of paper, 1 ruler, 2 pencils, 300€			
B2				
B3				
C1	4 sheets of paper, 2 pencils, 200€ and a bad feeling…			
C2				
C3				

BONUS

> Bonus for providing free technology or resources: **+10% of total funds** for countries that share resources or technology at no cost with other countries.

> Bonus for alliances: **+5% of total funds each** for countries that form alliances to share technologies or knowledge

> These bonuses reward cooperative behaviour, encouraging sustainable collaboration and support among countries.

DEBRIEFING

> How do you felt when you opened the envelopes?

> How much of the difference between the groups was due to strategies pursued and how much to the initial endowment?

> Why is it so difficult to change the system?

> How this simulates real world?

> **Who owns the world's natural resources?**

> **Who owns the world's technology?**

> (To more successful countries) How did you achieve your success? What problems did you experience and what strategies did you use to overcome them?

> (To less successful countries) What factors limited your success? What strategies did you pursue? Which strategies failed and why? Now that you have learned how to play the game, what would you do differently next time?

> (To countries that formed alliances) Why did you form the alliance? How well did it work? What prevented it from breaking up?

ESSENTIAL TAKE AWAYS FROM THE WORLD TRADE GAME + PLANETARY BOUNDARIES

> The World Trade Game illustrates the disparities and imbalances among countries and shows the challenges of balancing economic growth with the reduction of environmental externalities.

> Within the framework of this game, participants can explore fundamental concepts like economic inequality, uneven resource distribution (e.g., critical minerals vital for clean energy technologies), technology availability and environmental impacts.

> Many developing countries are rich in resources, but they struggle to benefit from them due to trade rules, weak infrastructure, and limited technology. In some cases, poor governance, social challenges, and weak environmental regulations make the negative impacts worse.

> The exploration of some resources can be affected by environmental impacts, particularly in regions that are already vulnerable. For example, some mineral extraction methods require large amounts of water, making climate-related problems even more serious in vulnerable regions.

ESSENTIAL TAKE AWAYS FROM THE CLASS

> The Trade Game represent economic inequality, the challenges of balancing economic growth with the reduction of greenhouse gas emissions and other environmental externalities, and resource distribution challenges

> What is the Anthropocene (slide 21) and Tipping Points (slide 26)

> What are Planetary boundaries? (slide 34 and video on slide 33)

> How many Planetary boundaries exist and what are the two core ones? (slide 35)

> Are the Planetary boundaries independent or interrelated? (video slide 33)

> How has the crossing of planetary boundaries evolved over time? (slide 46)

> What transformations can be done to ensure a good quality of life for a globally expanding population while avoiding the crossing of planetary boundaries? (slide 57)

Thank you!

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