Autumn Semester 2025-2026

Global Change Ecology and Fluvial Ecosystems
ENV-512

Tom J Battin
Giulia Grandi, Oriana Lucia Llanos Paez

River Ecosystems Laboratory
(www.epfl.ch/labs/river/)

EPFL

Interactive course
Topic-related classes (3 x 2)
Student presentations and discussions

1. Hydrology and hydraulics
2. Biogeochemistry
3. Ecology

Interactive course
Topic-related classes (3 x 2)
Student presentations and discussions

1	10.Sep	Introduction
2	17.Sep	Hydro 1
3	24.Sep	Hydro 2
4	01.Oct	Hydro_Pres
5	08.Oct	Bgeo 1
6	15.Oct	Bgeo 2
7	29.Oct	Bgeo_Pres
8	05.Nov	Eco 1
9	12.Nov	Eco 2
10	19.Nov	Eco_Pres
11	26.Nov	Visiting La Sorge
12	03.Dec	Plenary talks _ Water Quality
13	10.Dec	Plenary talks _ Restoration

- Five papers per topic (see Moodle)
- You pick your paper
- Up to 2 or 3 students presenting a paper per topic
- Concluding plenary talks on water quality and restoration (2 to 3 students per talk)

EPFL

Global Change Ecology and Fluvial Ecosystems

- This course lays the foundation towards mechanistic understanding of global-change impacts on stream and river ecosystem structure and function.
- You will revisit major agents of environmental change, including climate change, damming, eutrophication, and emergent pollutants, for instance, and discuss their potential relevance for coupled physical, chemical and biological processes in fluvial ecosystems.
- This approach will enable you to better understand and predict the future of fluvial ecosystems and the services that they provide.

Global Change Ecology

‘At the interface between ecological systems and all aspects of environmental change that affects a substantial part of the globe’.

- Climate change
- Local anthropogenic alterations of the natural environment

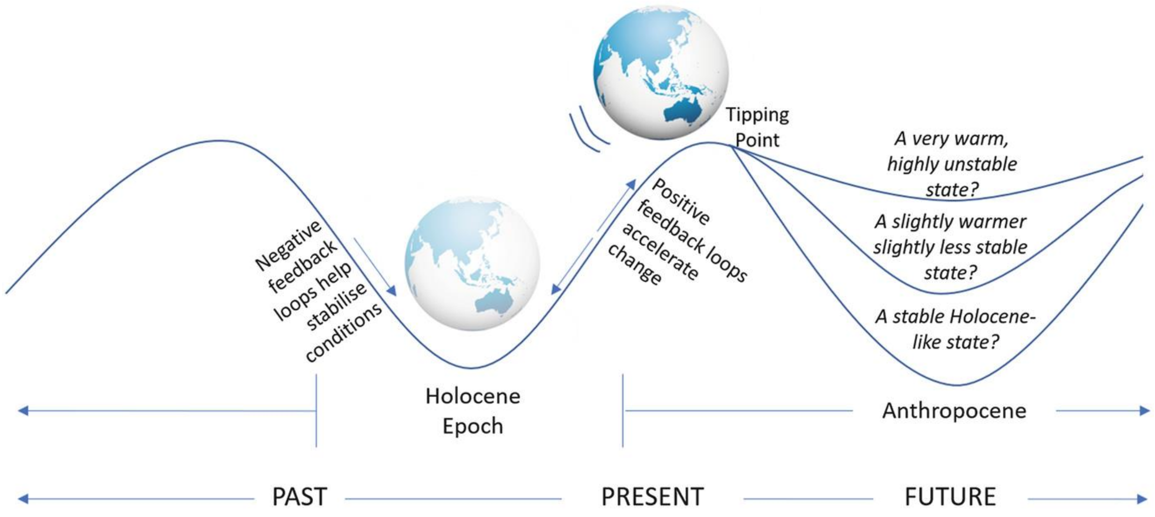
The Anthropcene

The Anthropocene

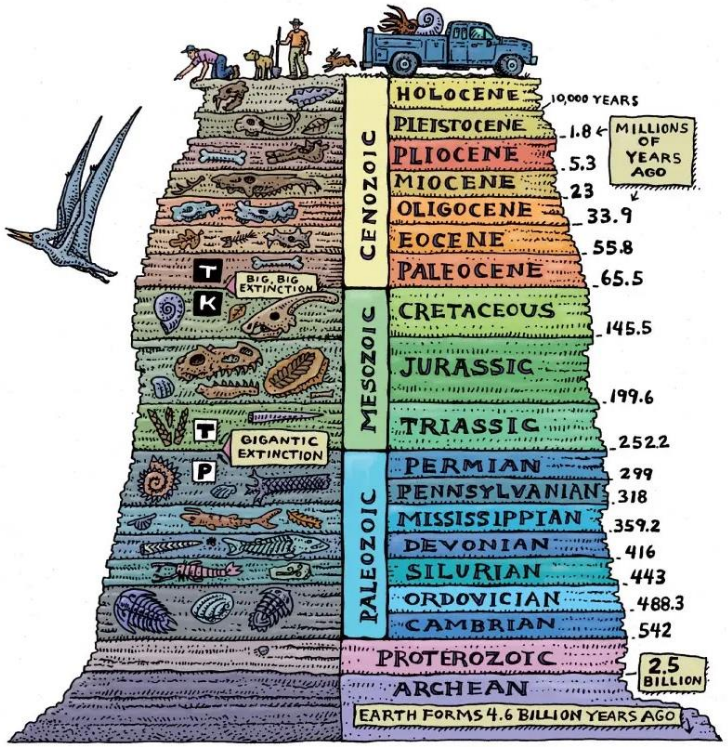
The magnitude, variety and longevity of human-induced changes, including

- land surface transformation and
- changing the world climate,

has led to the suggestion that we should refer to the present to the Anthropocene Epoch, not as to the Holocene Epoch.



https://link.springer.com/chapter/10.1007/978-981-15-1443-2_3/figures/3



A tipping point for our Earth system?

The Anthropocene

When has the Anthropocene begun?

Defining the beginning of the Anthropocene as a formal geologic unit of time requires the location of a global marker of an event in stratigraphic material, such as rock, sediment, or glacier ice, known as a Global Stratotype Section and Point (GSSP), plus other auxiliary stratigraphic markers indicating changes to the Earth system

PERSPECTIVES

doi:10.1038/nature14258

Defining the Anthropocene

Simon L. Lewis[1,2] & Mark A. Maslin[1]

Time is divided by geologists according to marked shifts in Earth's state. Recent global environmental changes suggest that Earth may have entered a new human-dominated geological epoch, the Anthropocene. Here we review the historical genesis of the idea and assess anthropogenic signatures in the geological record against the formal requirements for the recognition of a new epoch. The evidence suggests that of the various proposed dates two do appear to conform to the criteria to mark the beginning of the Anthropocene: 1610 and 1964. The formal establishment of an Anthropocene Epoch would mark a fundamental change in the relationship between humans and the Earth system.

Human activity has been a geologically recent, yet profound, influence on the global environment. The magnitude, variety and longevity of human-induced changes, including land surface transformation and changing the composition of the atmosphere, has led to the suggestion that we should refer to the present, not as within the Holocene Epoch (as it is currently formally referred to), but instead as within the Anthropocene Epoch[1–4] (Fig. 1). Academic and popular usage of the term has rapidly escalated[5,6] following two influential papers published just over a decade ago[1,2]. Three scientific journals focusing on the topic have launched: *The Anthropocene*, *The Anthropocene Review* and *Elementa*. The case for a new epoch appears reasonable: what matters when dividing geological-scale time is global-scale changes to Earth's status, driven by causes as varied as meteor strikes, the movement of continents and sustained volcanic eruptions. Human activity is now global and is the dominant cause of most contemporary environmental change. The impacts of human activity will probably be observable in the geological stratigraphic record for millions of years into the future[7], which suggests that a new epoch has begun[4].

Nevertheless, some question the types of evidence[8,9], because to define a geological time unit, formal criteria must be met[10,11]. Global-scale changes must be recorded in geological stratigraphic material, such as rock, glacier ice or marine sediments (see Box 1). At present, there is no formal agreement on when the Anthropocene began, with proposed dates ranging from before the end of the last glaciation to the 1960s. Such different meanings may lead to misunderstandings and confusion across several disciplines. Furthermore, unlike other geological time unit designations, definitions will probably have effects beyond geology. For example, defining an early start date may, in political terms, 'normalize' global environmental change. Meanwhile, agreeing a later start date related to the Industrial Revolution may, for example, be used to assign historical responsibility for carbon dioxide emissions to particular countries or regions during the industrial era. More broadly, the formal definition of the Anthropocene makes scientists arbiters, to an extent, of the human–environment relationship, itself an act with consequences beyond geology. Hence, there is more interest in the Anthropocene than other epoch definitions. Nevertheless, evidence will define whether the geological community formally ratifies a human-activity-induced geological time unit.

We therefore review human geology in four parts. First, we summarize the geologically important human-induced environmental impacts. Second, we review the history of naming the epoch that modern human societies live within, to provide insights into contemporary Anthropocene-related debates. Third, we assess environmental changes caused by human activity that may have left global geological markers consistent with the formal criteria that define geological epochs. Fourth, we highlight the

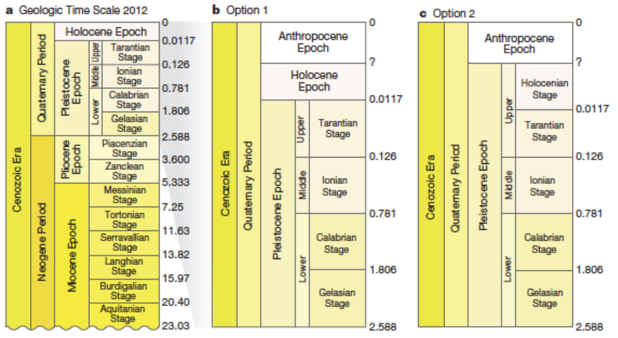


Figure 1 | Comparison of the current Geologic Time Scale[10] (GTS2012), with two alternatives. **a**, GTS2012, with boundaries marked in millions of years (ref. 10). **b**, **c**, The alternatives include a defined Anthropocene Epoch following either the Holocene (**b**) or directly following the Pleistocene (**c**). Defining the Anthropocene as an epoch requires a decision as to whether the Holocene is as distinct as the Anthropocene and Pleistocene; retaining it or not distinguishes between **b** and **c**. The question mark represents the current debate over the start of the Anthropocene, assuming it is formally accepted as an epoch (see Box 1, Fig. 2). Colour coding is used according to the Commission for the Geological Map of the World[10], except for the Anthropocene.

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PERSPECTIVES

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The Anthropocene

When has the Anthropocene begun?

PERSPECTIVES

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Defining the Anthropocene

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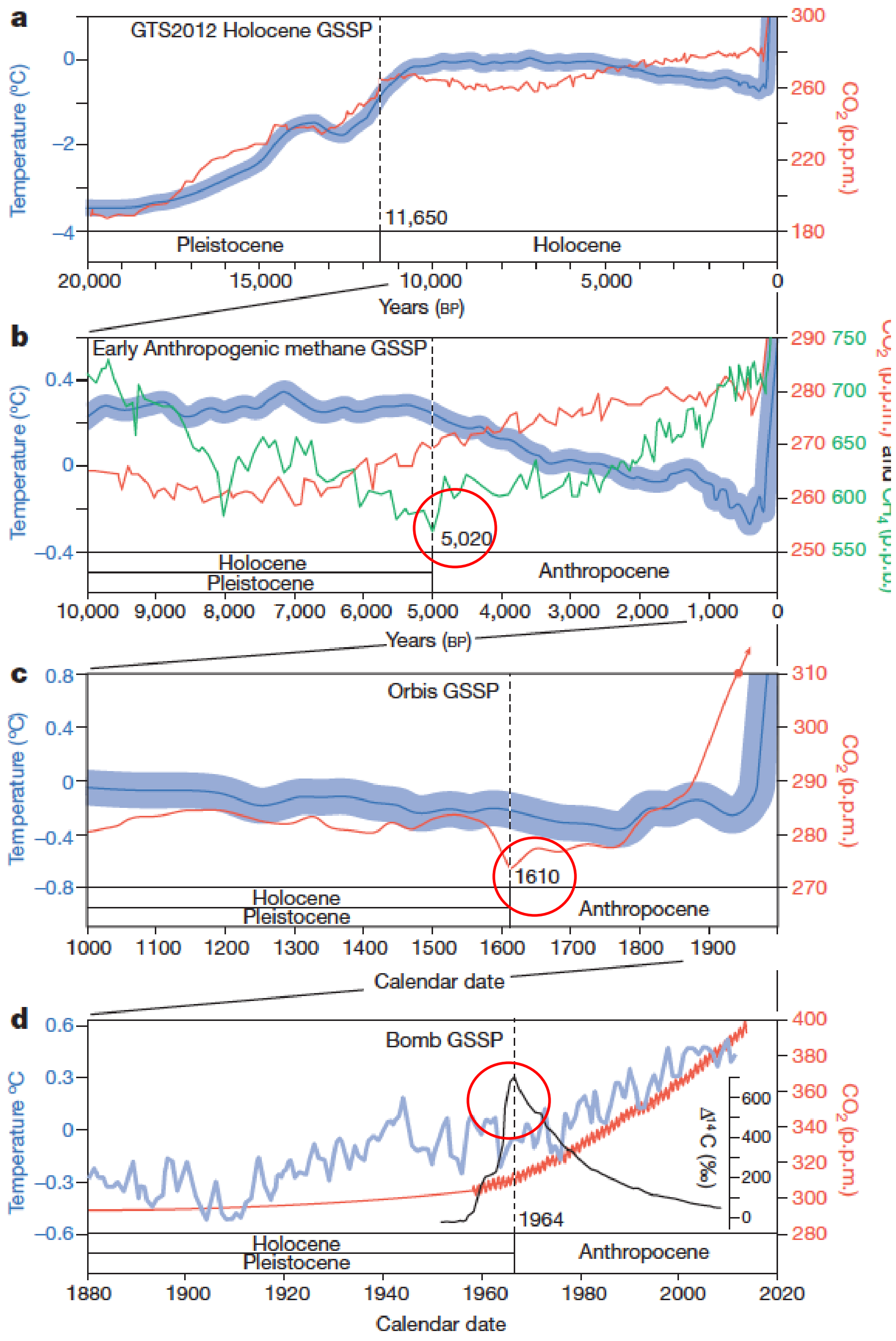
5,020 BP: Early Anthropogenic Hypothesis suggests boundary, which posits that early extensive farming impacts caused global environmental changes, defined here by the inflection and lowest level of atmospheric methane

1610: Orbis GSSP suggested boundary (dashed line), representing the collision of the Old and New World peoples and homogenization of once distinct biotas, and defined by the pronounced dip in atmospheric carbon dioxide

1964: Bomb GSSP suggested boundary, characterized by the peak in atmospheric radiocarbon from annual tree-rings (the $\Delta^{14}C$ value is the relative difference between the absolute international standard (base year 1950) and sample activity corrected for the time of collection and $\delta^{13}C$)



The Anthropocene

When has the Anthropocene begun?
Why does this matter?

PERSPECTIVES

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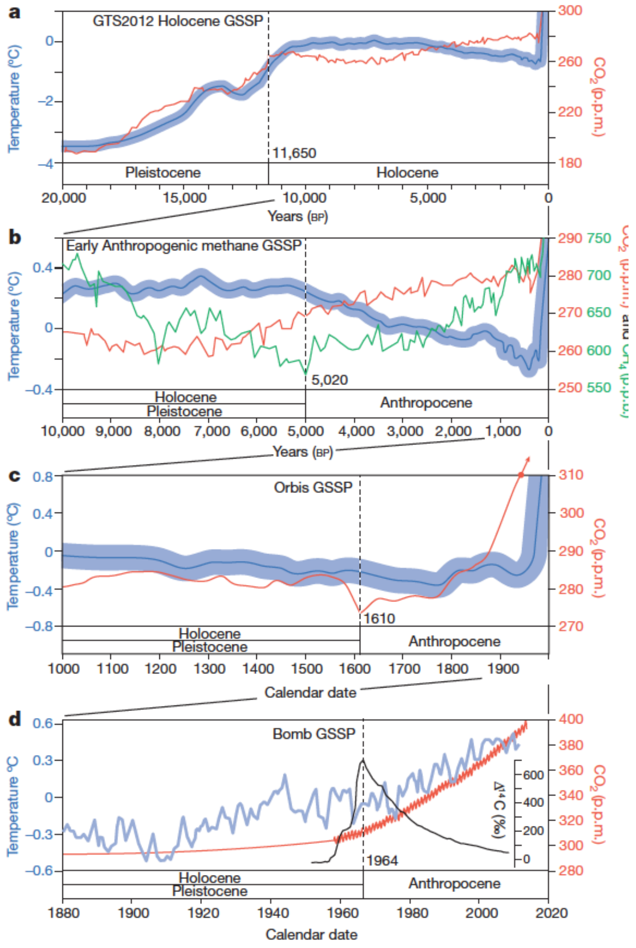
Defining the Anthropocene

Simon L. Lewis[1,2] & Mark A. Maslin[1]

The choice of either 1610 or 1964 as the beginning of the Anthropocene would probably affect the perception of human actions on the environment.

- The Orbis spike (1610) implies that colonialism, global trade and coal triggered the Anthropocene. Broadly, this highlights social concerns, particularly the unequal power relationships between different groups of people, economic growth, the impacts of globalized trade, and our current reliance on fossil fuels. The onward effects of the arrival of Europeans in the Americas also highlights a long-term and large-scale example of human actions unleashing processes that are difficult to predict or manage.

- Choosing the bomb spike (1964) tells a story of an elite-driven technological development that threatens planet-wide destruction. The long-term advancement of technology deployed to kill people, from spears to nuclear weapons, highlights the more general problem of 'progress traps'.



EPFL

The Anthropocene

Human activity profoundly affects the environment, from Earth's major biogeochemical cycles to the evolution of life.

The early twentieth-century invention of the Haber–Bosch process, which allows the conversion of atmospheric nitrogen to ammonia for use as fertilizer, has altered the global nitrogen cycle so fundamentally that the nearest suggested geological comparison refers to events about 2.5 billion years ago.

PERSPECTIVES

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Defining the Anthropocene

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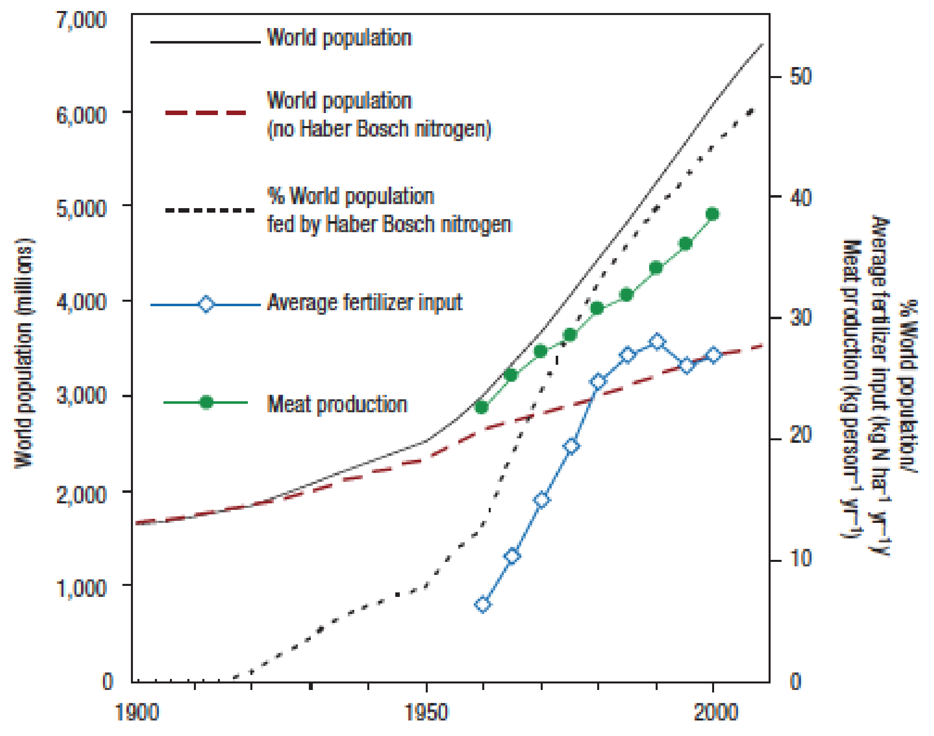


Figure 1 Trends in human population and nitrogen use throughout the twentieth century. Of the total world population (solid line), an estimate is made of the number of people that could be sustained without reactive nitrogen from the Haber–Bosch process (long dashed line), also expressed as a percentage of the global population (short dashed line). The recorded increase in average fertilizer use per hectare of agricultural land (blue symbols) and the increase in per capita meat production (green symbols) is also shown.

FEATURE

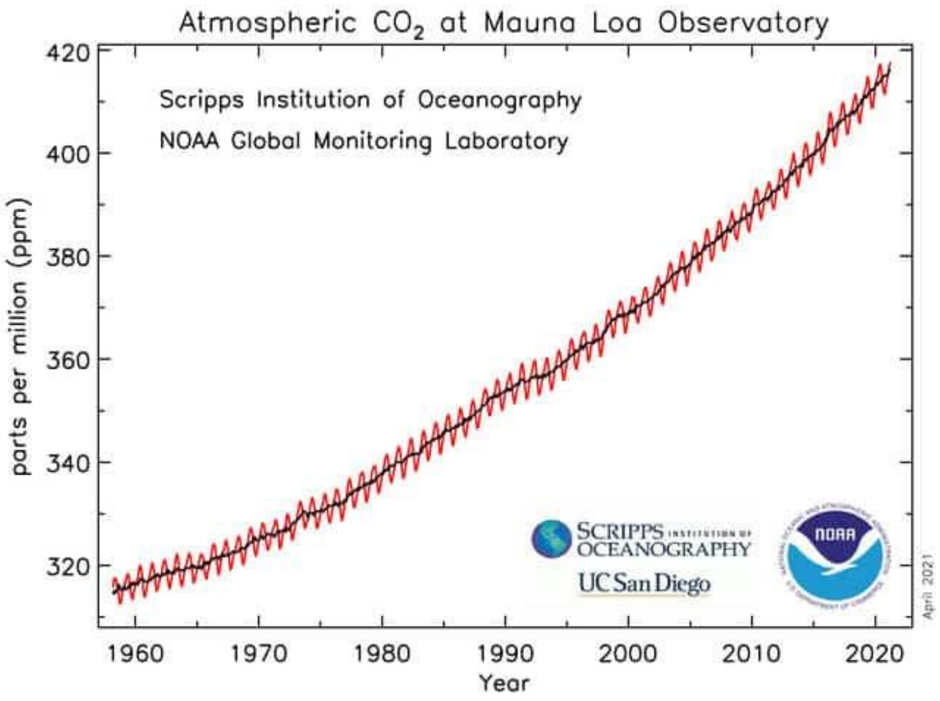
How a century of ammonia synthesis changed the world

nature geoscience | VOL 1 | OCTOBER 2008 | www.nature.com/naturegeoscience

EPFL

The Anthropocene

Human actions have released 555 petagrams of carbon (where 1 Pg=10^{15} g = billion metric tons) to the atmosphere since 1750, increasing atmospheric CO_2 to a level not seen for at least 800,000 years, and possibly several million years, thereby delaying Earth's next glaciation event. The released carbon has increased ocean water acidity at a rate probably not exceeded in the last 300 million years.



PERSPECTIVES

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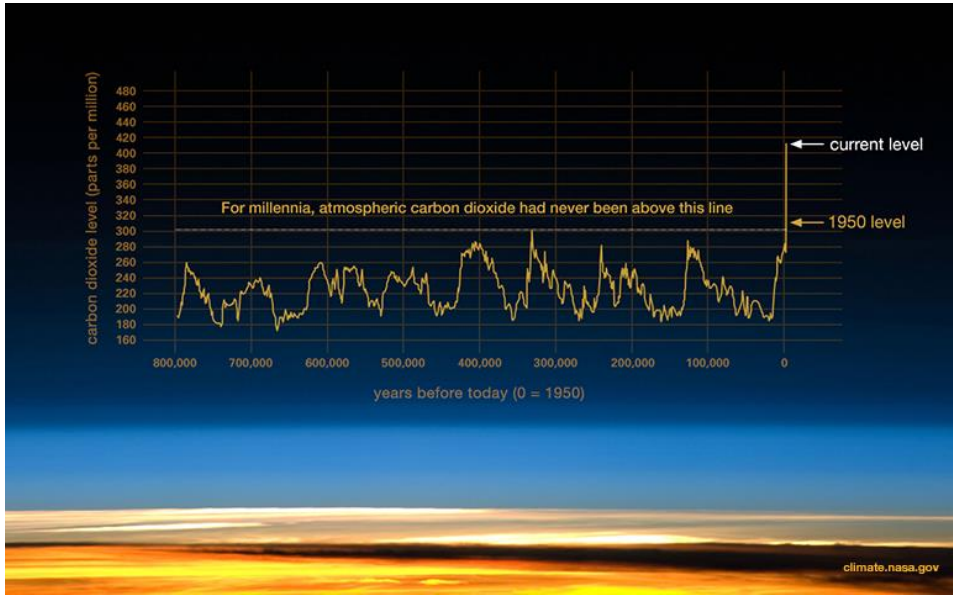

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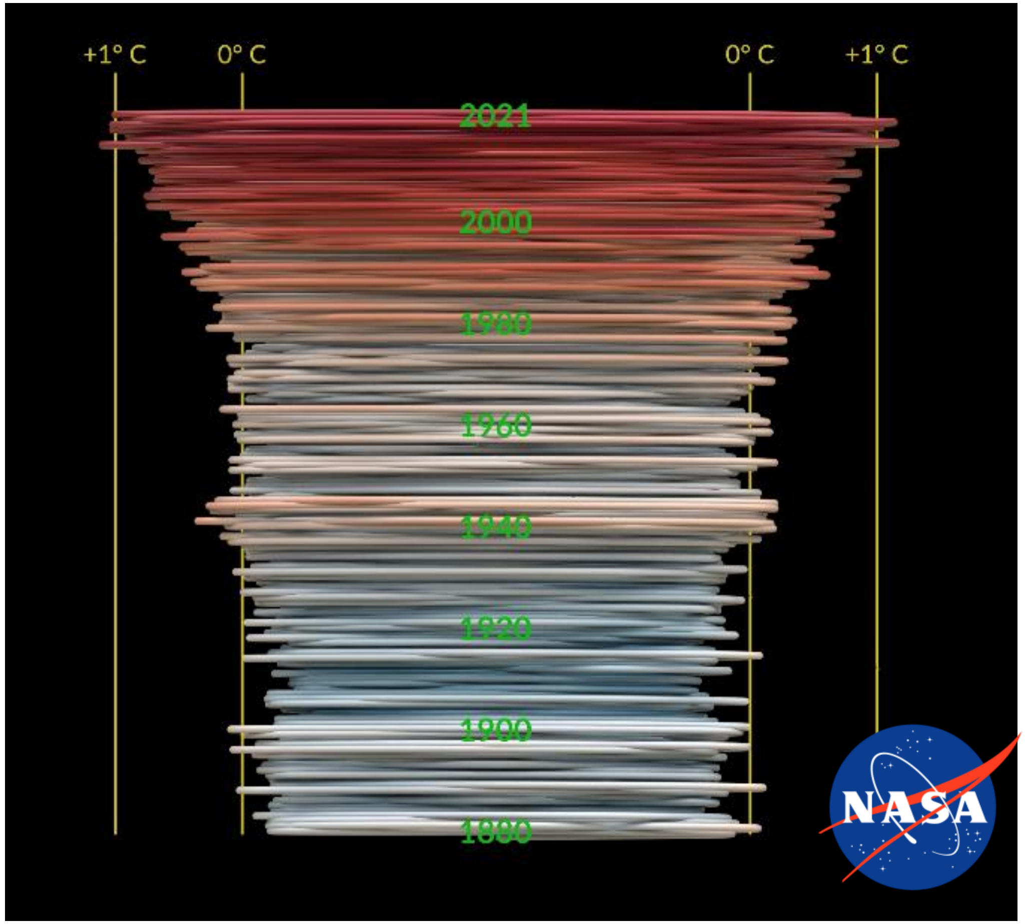
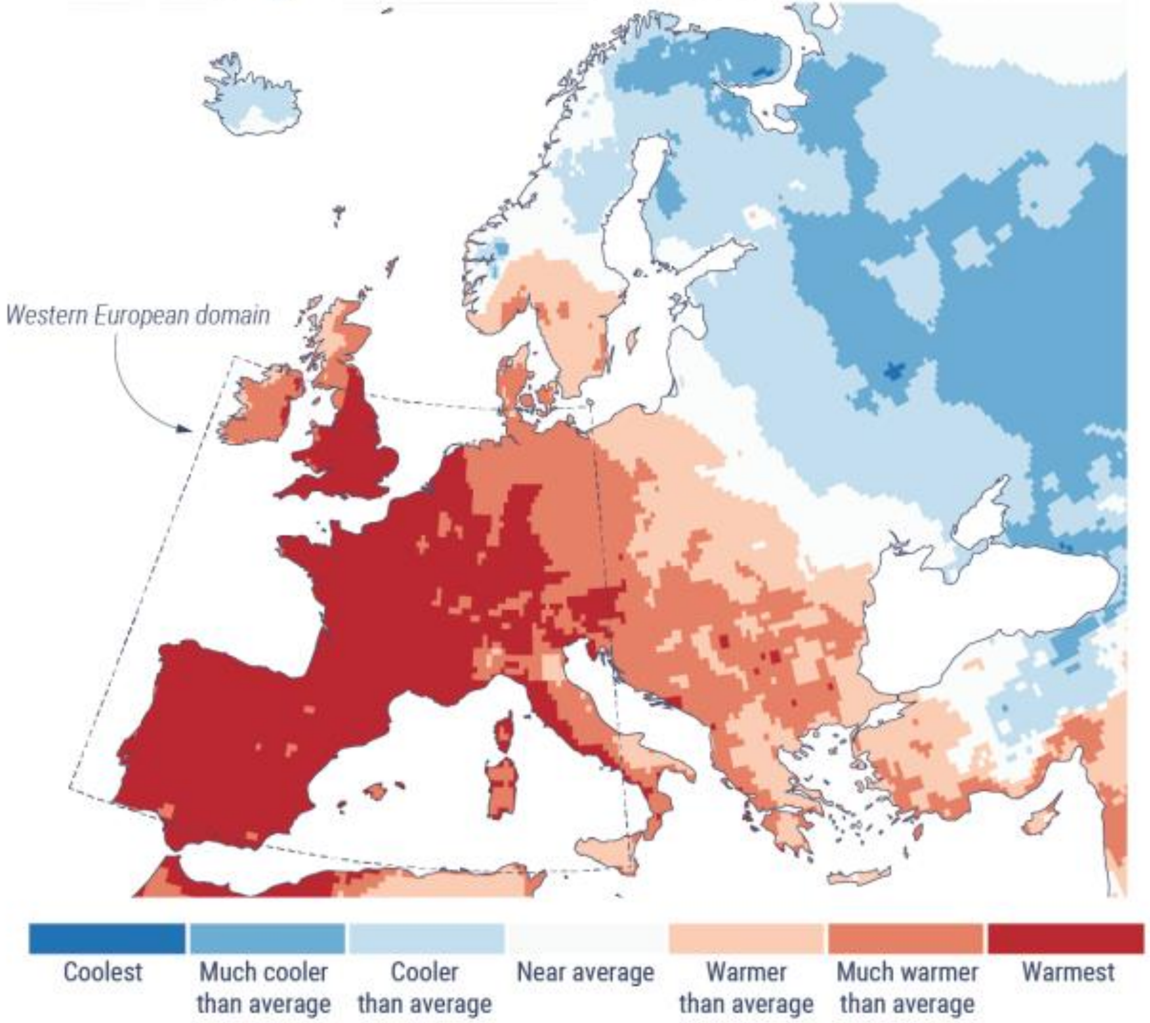


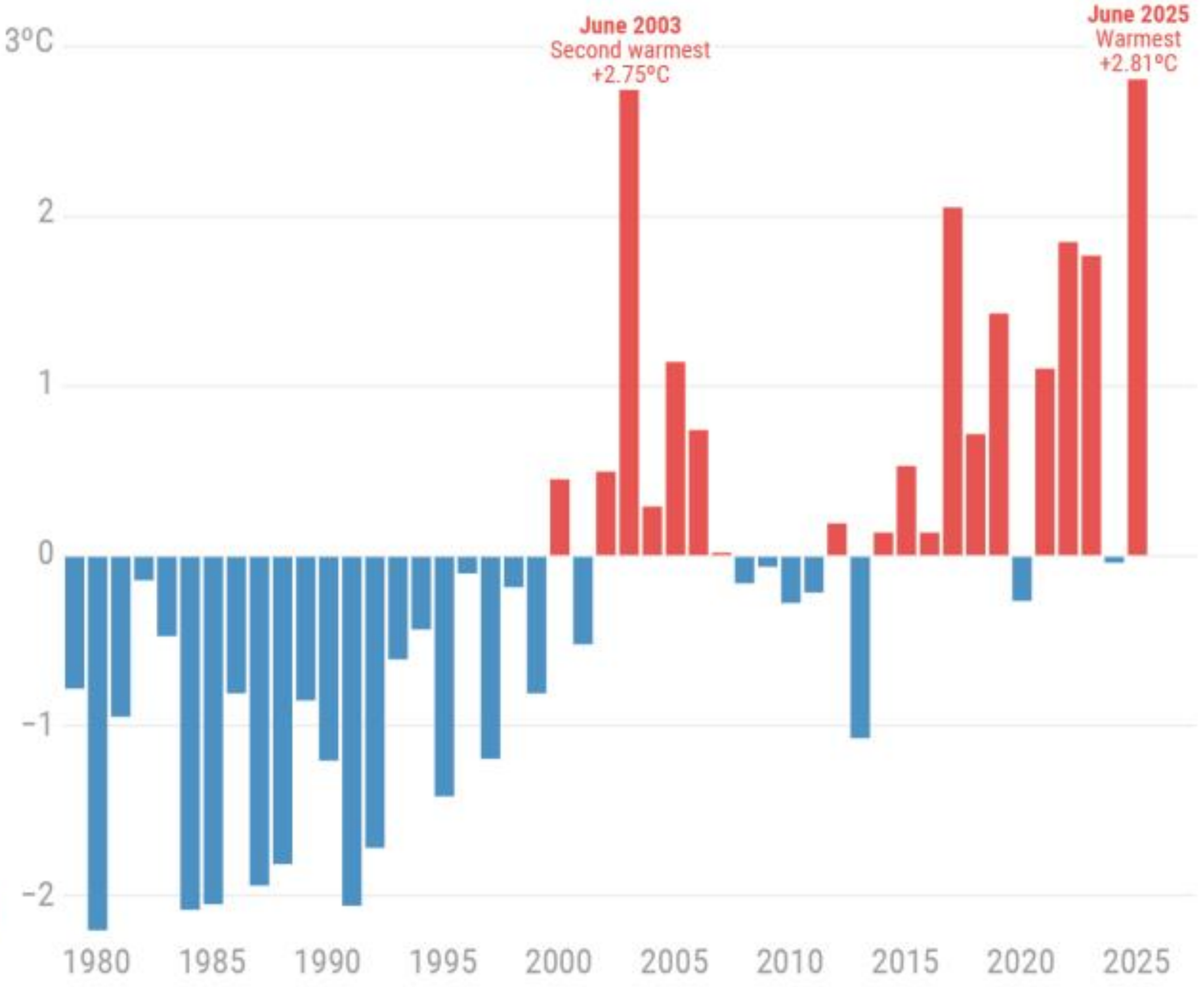
Surface air temperature anomalies

Data: ERA5 • Reference period: 1991–2020 • Credit: C3S/ECMWF

Average anomalies from 17 June to 2 July 2025



Anomalies in June in western Europe

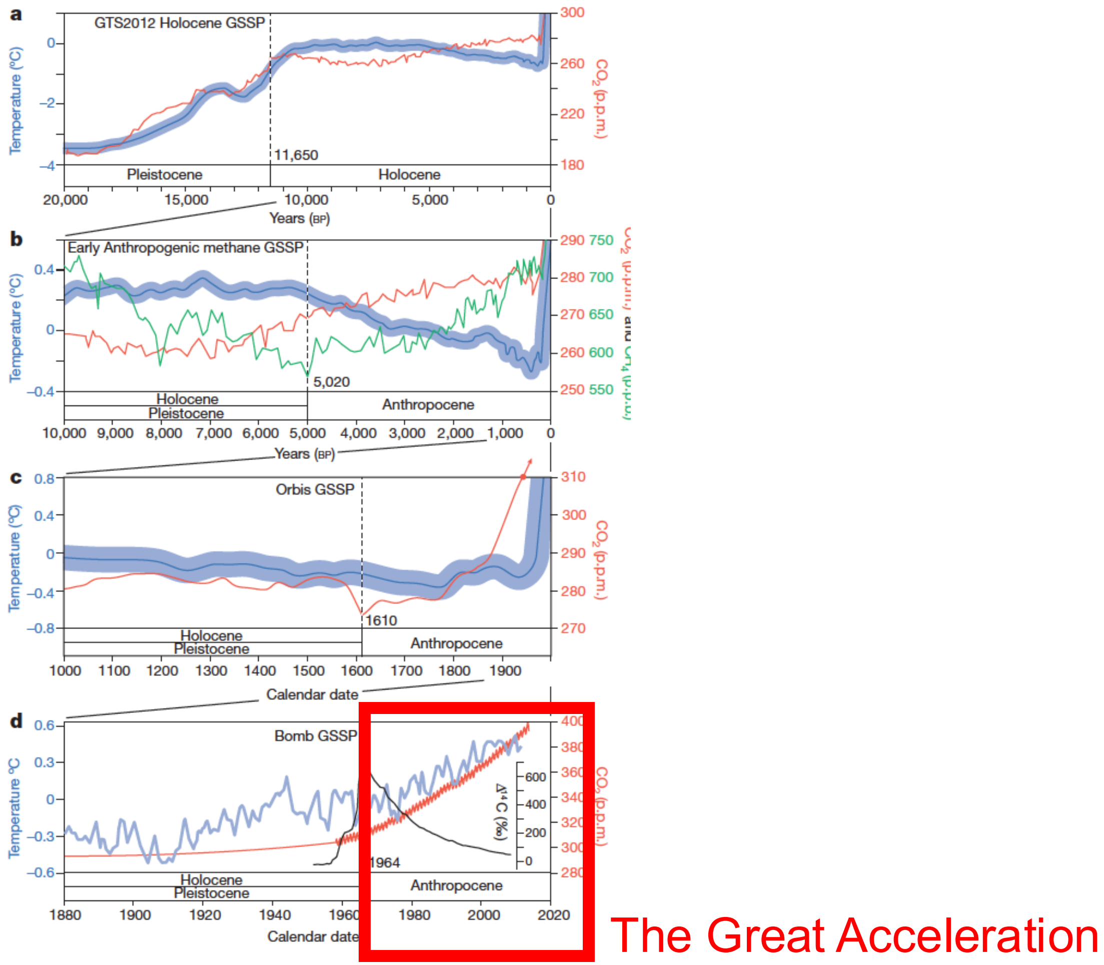


Extreme warming

Rhine River

Po River

The Great Acceleration



PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A

Phil. Trans. R. Soc. A (2011) **369**, 842–86
doi:10.1098/rsta.2010.03:

REVIEW

The Anthropocene: conceptual and historical perspectives

BY WILL STEFFEN[1,*], JACQUES GRINEVALD[2], PAUL CRUTZEN[3] AND JOHN MCNEILL[4]

The Great Acceleration

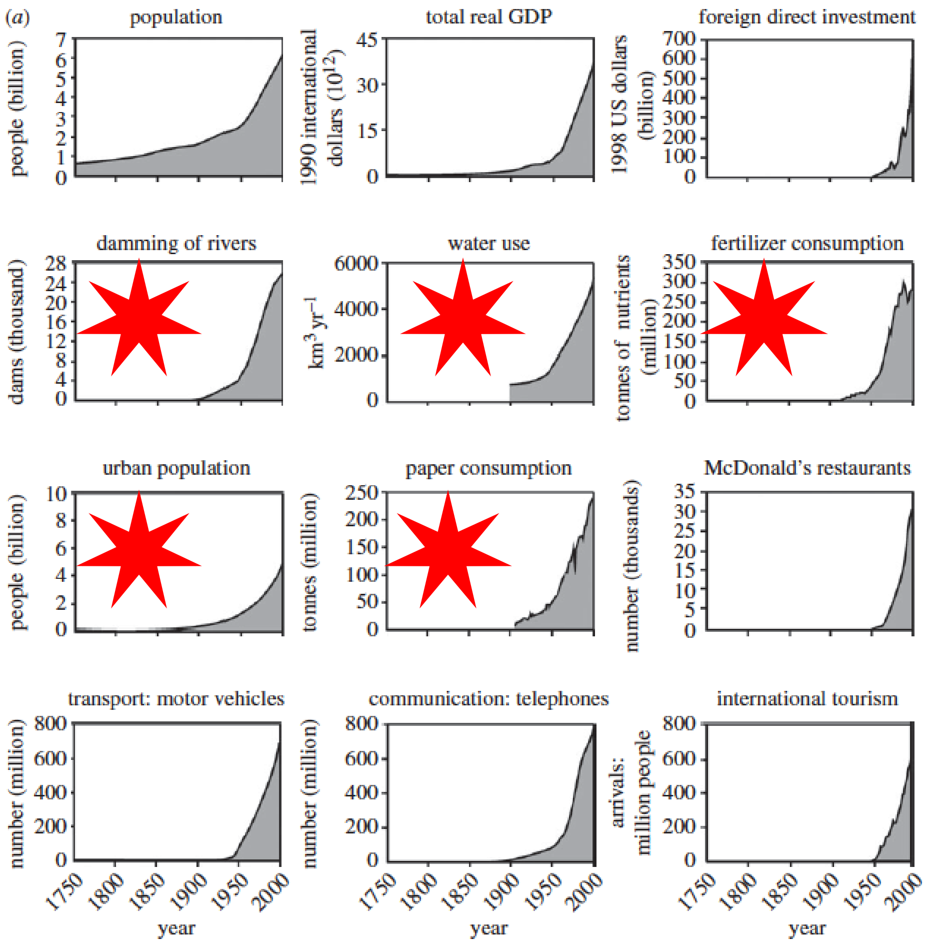


Figure 1. (*a*) The increasing rates of change in human activity since the beginning of the Industrial Revolution. Significant increases in rates of change occur around the1950s in each case and illustrate how the past 50 years have been a period of dramatic and unprecedented change in human history. From Steffen *et al.* [5], including references to the individual databases on which the individual figures are based. (*b*) Global scale changes in the Earth system as a result of the dramatic increase in human activity: (i) atmospheric CO_2 concentration; (ii) atmospheric N_2O concentration; (iii) atmospheric CH_4 concentration; (iv) percentage total column ozone loss over Antarctica, using the average annual total column ozone, 330, as a base; (v) Northern Hemisphere average surface temperature anomalies; (vi) natural disasters after 1900 resulting in more than 10 people killed or more than 100 people affected; (vii) percentage of global fisheries either fully exploited, overfished or collapsed; (viii) annual shrimp production as a proxy for coastal zone alteration; (ix) model-calculated partitioning of the human-induced nitrogen perturbation fluxes in the global coastal margin for the period since 1850; (x) loss of tropical rainforest and woodland, as estimated for tropical Africa, Latin America and South and Southeast Asia; (xi) amount of land converted to pasture and cropland; and (xii) mathematically calculated rate of extinction. Adapted from Steffen *et al.* [5], including references to the individual databases on which the individual figures are based.

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Review

The Anthropocene: conceptual and historical perspectives

By Will Steffen[1,*], Jacques Grinevald[2], Paul Crutzen[3] and John McNeill[4]

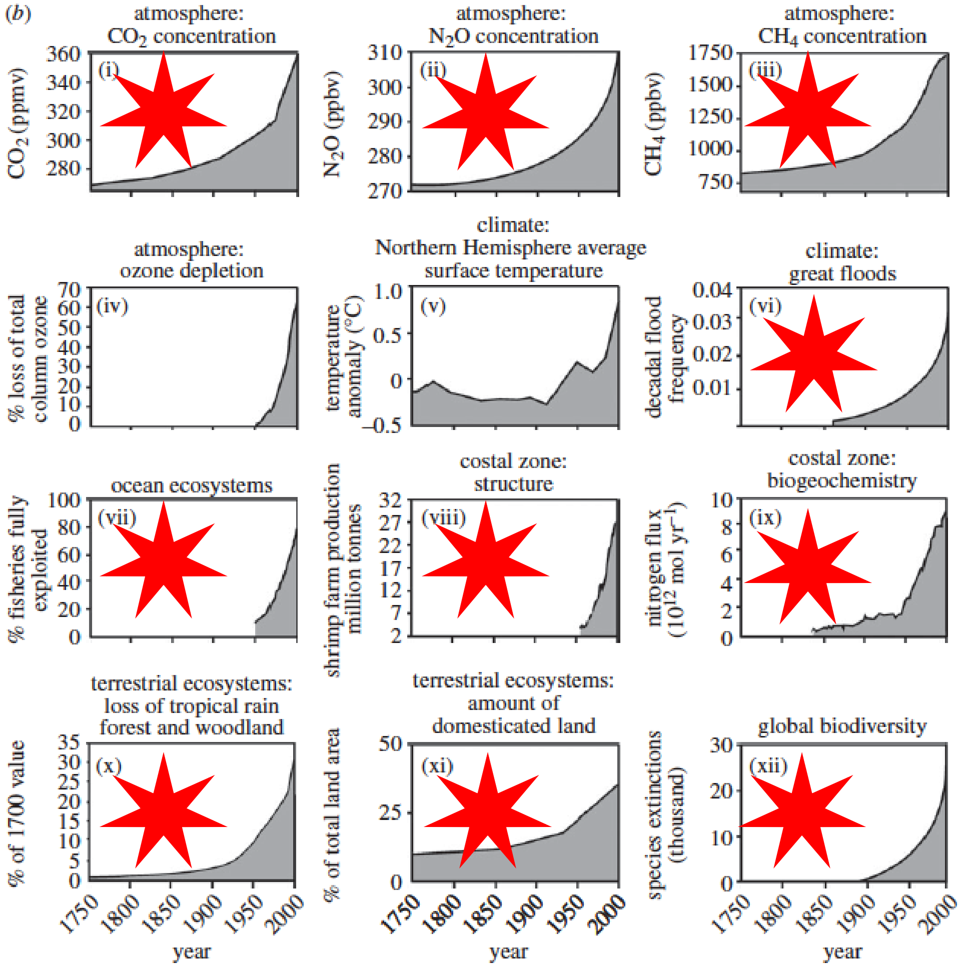

Figure 1. (*Continued.*)

The Great Acceleration

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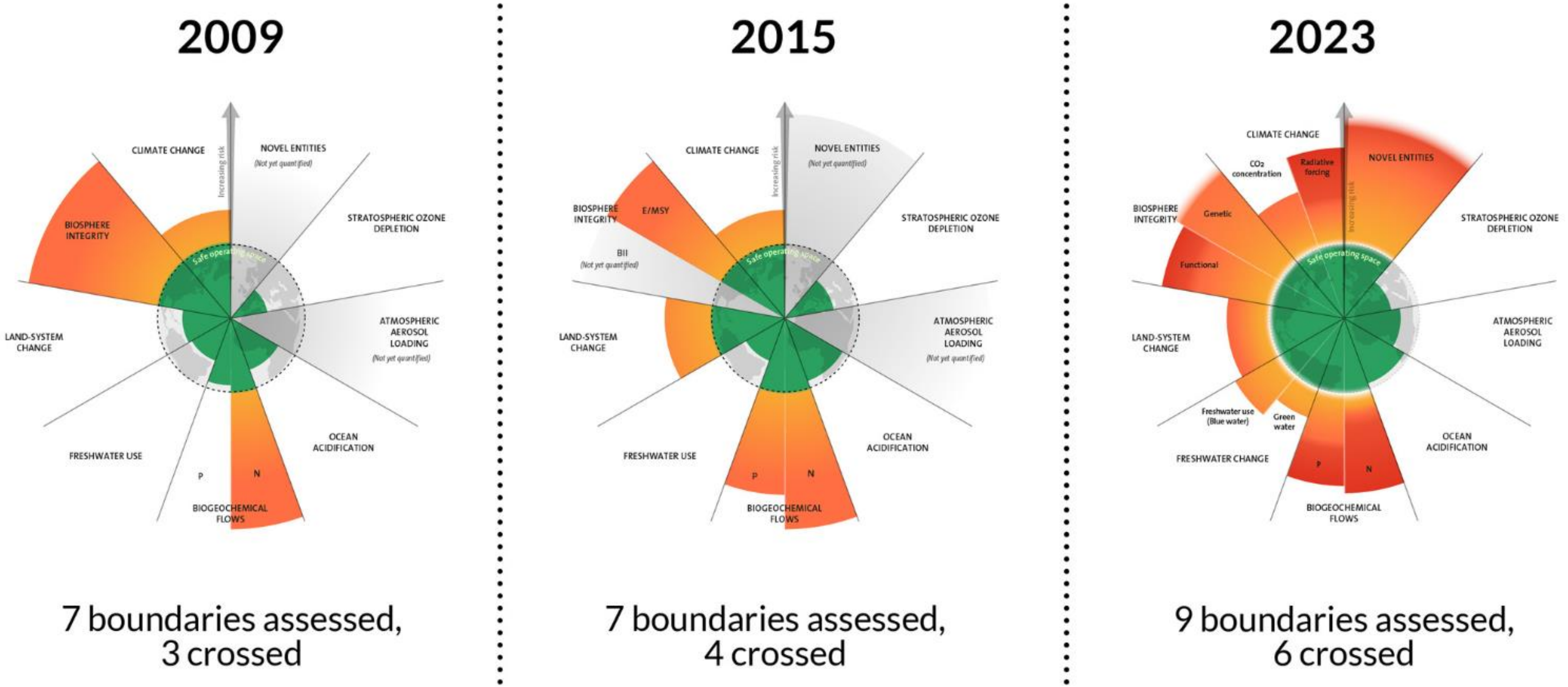
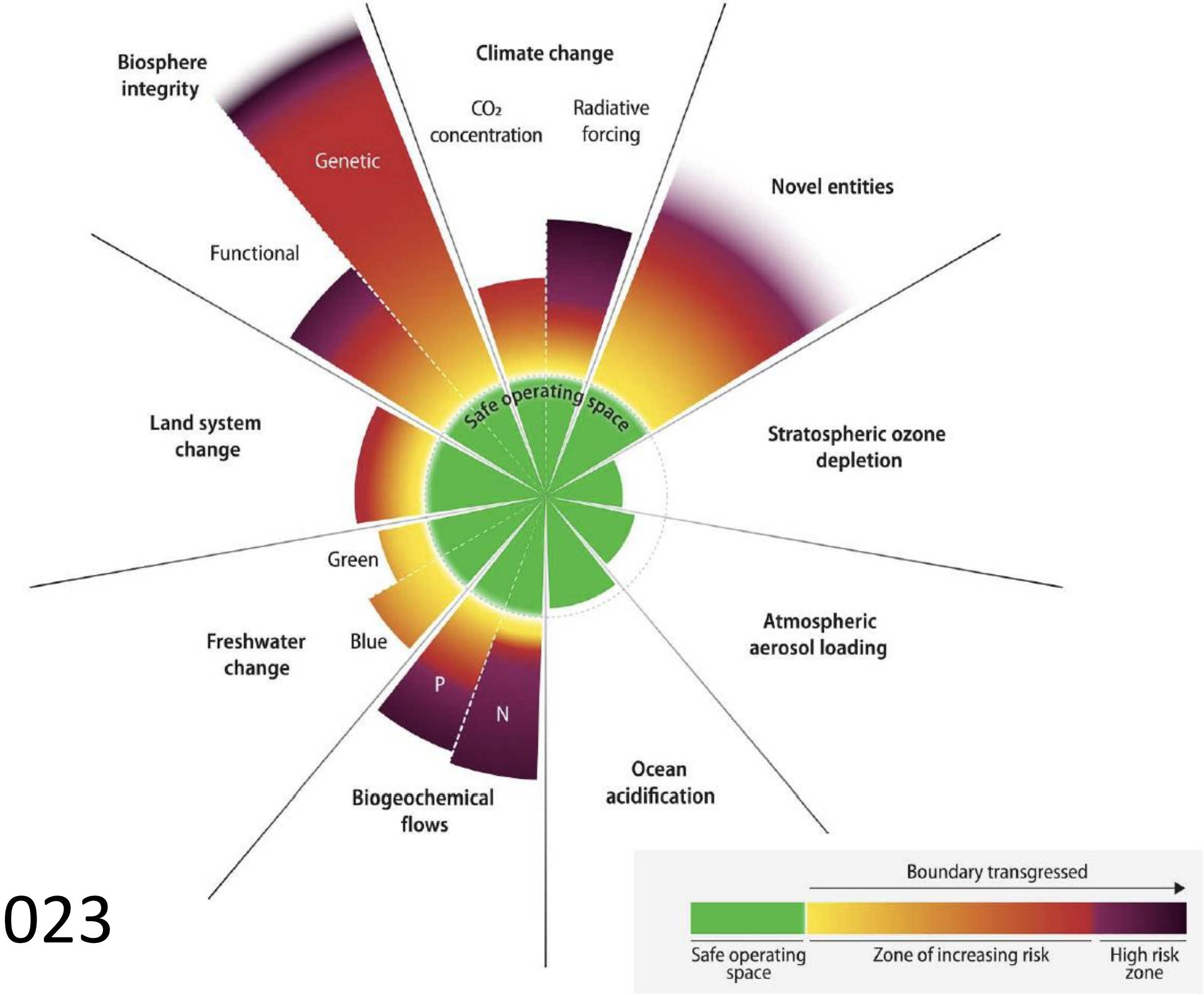
The Planetary Boundaries

Estimates of how the different control variables for planetary boundaries have changed from 1950 to present. The green shaded polygon represents the safe operating space.



https://www.stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html

The Planetary Boundaries



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SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

Earth beyond six of nine planetary boundaries

Katherine Richardson[1]*, Will Steffen[2]†, Wolfgang Lucht[3,4], Jørgen Bendtsen[1], Sarah E. Cornell[5], Jonathan F. Donges[3,5], Markus Drüke[3], Ingo Fetzer[5,6], Govindasamy Bala[7], Werner von Bloh[3], Georg Feulner[3], Stephanie Fiedler[8], Dieter Gerten[3,4], Tom Gleeson[9,10], Matthias Hofmann[3], Willem Huiskamp[3], Matti Kummu[11], Chinchu Mohan[8,12,13], David Nogués-Bravo[1], Stefan Petri[3], Miina Porkka[11], Stefan Rahmstorf[3,14], Sibyll Schaphoff[3], Kirsten Thonicke[3], Arne Tobian[3,5], Vili Virkki[11], Lan Wang-Erlandsson[3,5,6], Lisa Weber[8], Johan Rockström[3,5,15]

Planetary boundaries framework update finds that six of the nine boundaries are transgressed, suggesting that Earth is now well outside of the safe operating space for humanity.

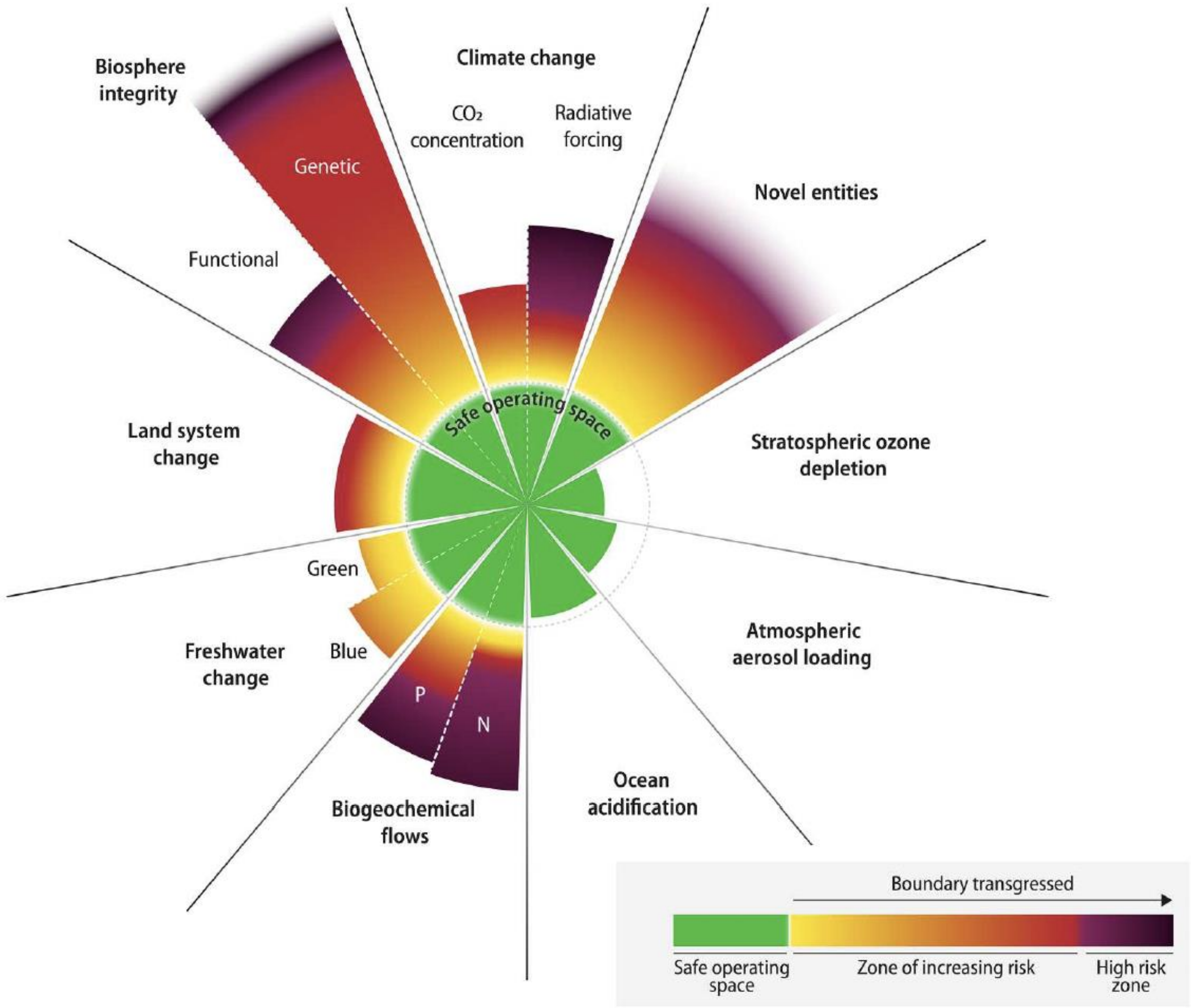
Ocean acidification is close to being breached, while aerosol loading regionally exceeds the boundary.

Stratospheric ozone levels have slightly re-covered.

The transgression level has increased for all boundaries earlier identified as overstepped.

EPFL

The Planetary Boundaries



SCIENCE ADVANCES | RESEARCH ARTICLE

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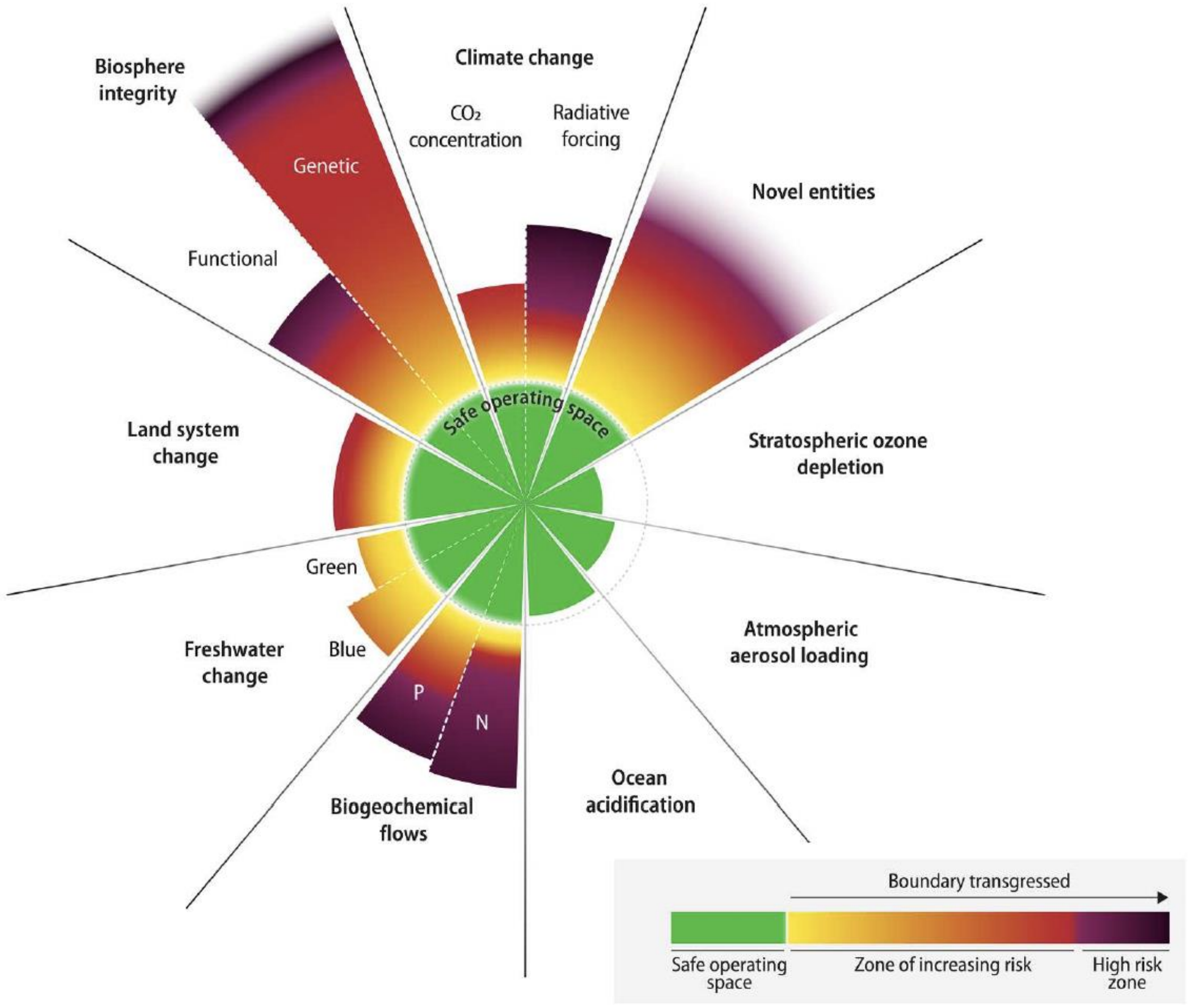
Novel entities: synthetic chemicals and substances (e.g., microplastics, endocrine disruptors, and organic pollutants); anthropogenically mobilized radioactive materials, including nuclear waste and nuclear weapons; and human modification of evolution, genetically modified organisms and other direct human interventions in evolutionary processes.

- Novel entities may serve as geological markers of the Anthropocene.
- However, their impacts on Earth system as a whole remain largely unstudied.

https://www.stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html

The Planetary Boundaries



Global net primary productivity appears to be relatively constant; however, <u>the appropriation of 25–38% of net primary productivity for human use</u> reduces the amount available for millions of other species on Earth.

This land-use conversion to produce food, fuel, fibre and fodder, combined with targeted hunting and harvesting, has resulted <u>in species extinctions some 100 to 1,000 times higher than background rates</u>, and probably constitutes the beginning of the sixth mass extinction in Earth's history.

https://www.stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html

PNAS RESEARCH ARTICLE | ECOLOGY OPEN ACCESS

Mutilation of the tree of life via mass extinction of animal genera

Gerardo Ceballos[a,1,2] and Paul R. Ehrlich[b,1]

- Not single species are lost
- Entire groups (i.e., genera) of species are lost
- Functional consequences (e.g., pollinators)

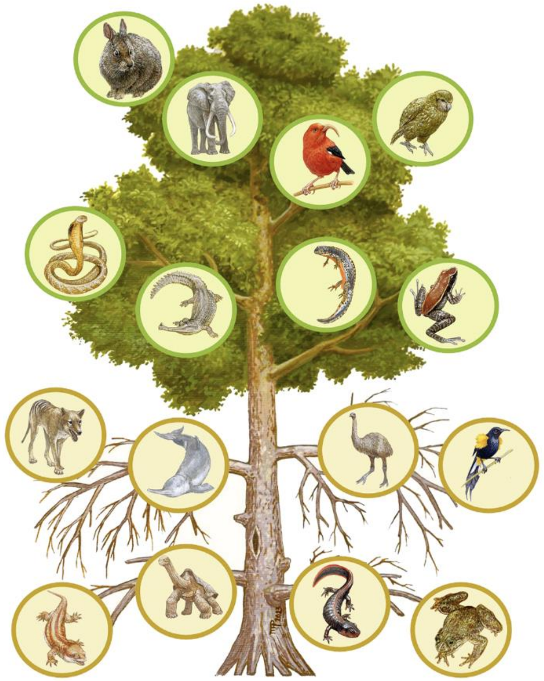


Fig. 1. Simple schematic representation of the mutilation of the Tree of life because of generic extinctions and extinction risks. The bottom half of the tree depicted as dead branches shows examples of the extinct genera, and the upper half shows examples of genera at risk of extinction. *Extinct genera*: I) Lower row left: Delcourt's giant gecko (*Hoplodactylus*, left), of which the only specimens known were found in a museum without a label, but probably they were found in New Zealand; and saddle-backed Rodrigues giant tortoise (*Cylindraspis*, right) from Rodrigues Island in the Indian Ocean. Lower row right: Yunnan Lake newt (*Cynops*, left) from China; and the Gastric brooding frogs (*Rheobatrachus*, right) from rainforests in Queensland, Australia. II) Second bottom-up row left: Thylacine (*Thylacinus*, left), the largest carnivorous marsupial, last known from Tasmania; and Yangtze River dolphin or baijii (Lipotes, right) from China, one of very few freshwater dolphins. Second bottom-up row right: Elephant birds (*Aepyornis*, left), the largest birds surviving to modern times, represent also both an extinct genus and family (Aepyornithidae) endemic to Madagascar; and Moho birds (genus *Moho*, right) represent also both an extinct genus and family (Mohidae) from Hawaii. Endangered genera: III) Third bottom-up row left: King cobra (*Ophiophagus*, left) from Asia; and Gavial (*Gavialis*, right) from India and Nepal. Third bottom-up row right: Alpine newt (*Ichthyosaura*, left) from Europe; and Mahogany frog (*Abavorana*, right) from the Malay Peninsula. IV) Upper row left: Volcano rabbit (*Romerolagus*, left) known from few mountains close to Mexico City, and Elephant (*Loxodonta*, right) from Africa. Upper row right: 'i'iwi or scarlet honeycreeper (*Drepanis*, left) from Hawaii; and Kakapo (Strigops, right) a flightless parrot from New Zealand (Illustration: Marco Antonio Pineda).

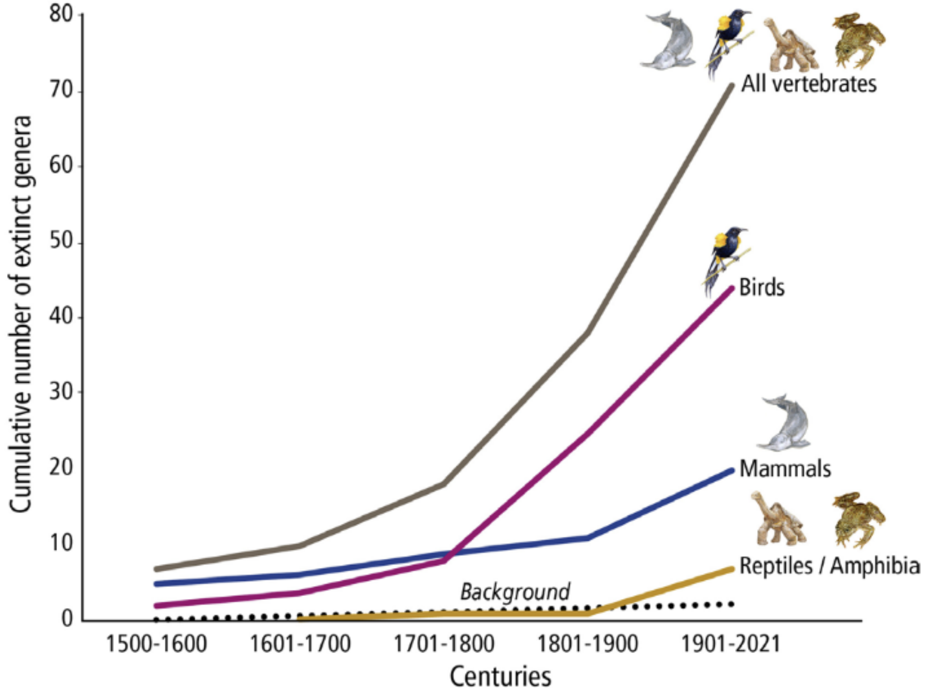


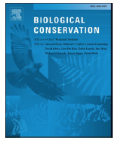
Fig. 2. Number of generic extinctions per century among in different classes of vertebrates. The low number of reptiles and amphibia, which underestimate the magnitude of extinction pattern, is probably the result of the lack of information in earlier centuries, where very few species had been described. The dotted line represent the background extinction rate.

Streams and rivers figure among the most diverse ecosystems on Earth

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon



Impacts of loss of free-flowing rivers on global freshwater megafauna

Fengzhi He[a,*], Michele Thieme[b], Christiane Zarfl[c], Günther Grill[d], Bernhard Lehner[d], Zeb Hogan[e], Klement Tockner[f,g], Sonja C. Jähnig[a,h]

Megafauna

- Top predators
- Ecosystem engineers
- Fisheries

Contents lists available at ScienceDirect

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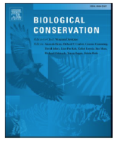

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fragmented → free-flowing

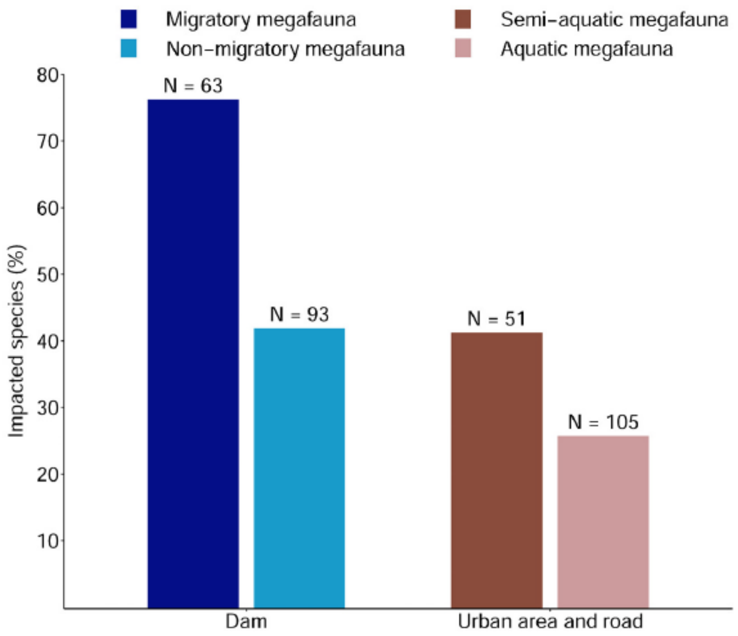

Fig. 1. Percentages of freshwater megafauna taxa with different life histories threatened by dams and by urban areas and roads, according to IUCN Red List assessments (IUCN, 2019). The numbers above the bars indicate the number of taxa within the corresponding life history trait and threat category.

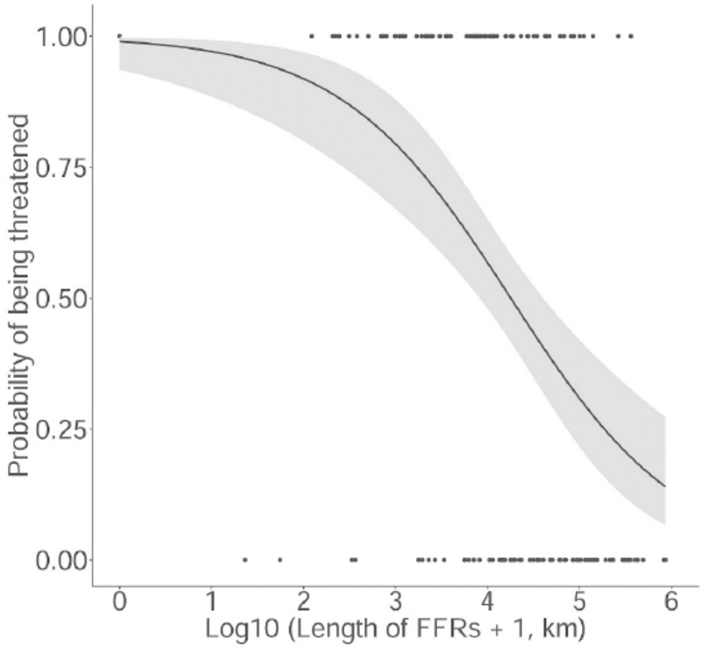

Fig. 2. Logistic relationship between the probability of species being threatened and the accumulated length of FFRs within their distribution ranges. Shaded area indicates 95% confidence interval. The dots indicate log10 (x + 1)-transformed length of FFRs within the distribution range of each taxon.

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Impacts of loss of free-flowing rivers on global freshwater megafauna

Fengzhi He[a,*], Michele Thieme[b], Christiane Zarfl[c], Günther Grill[d], Bernhard Lehner[d], Zeb Hogan[e], Klement Tockner[f,g], Sonja C. Jähnig[a,h]

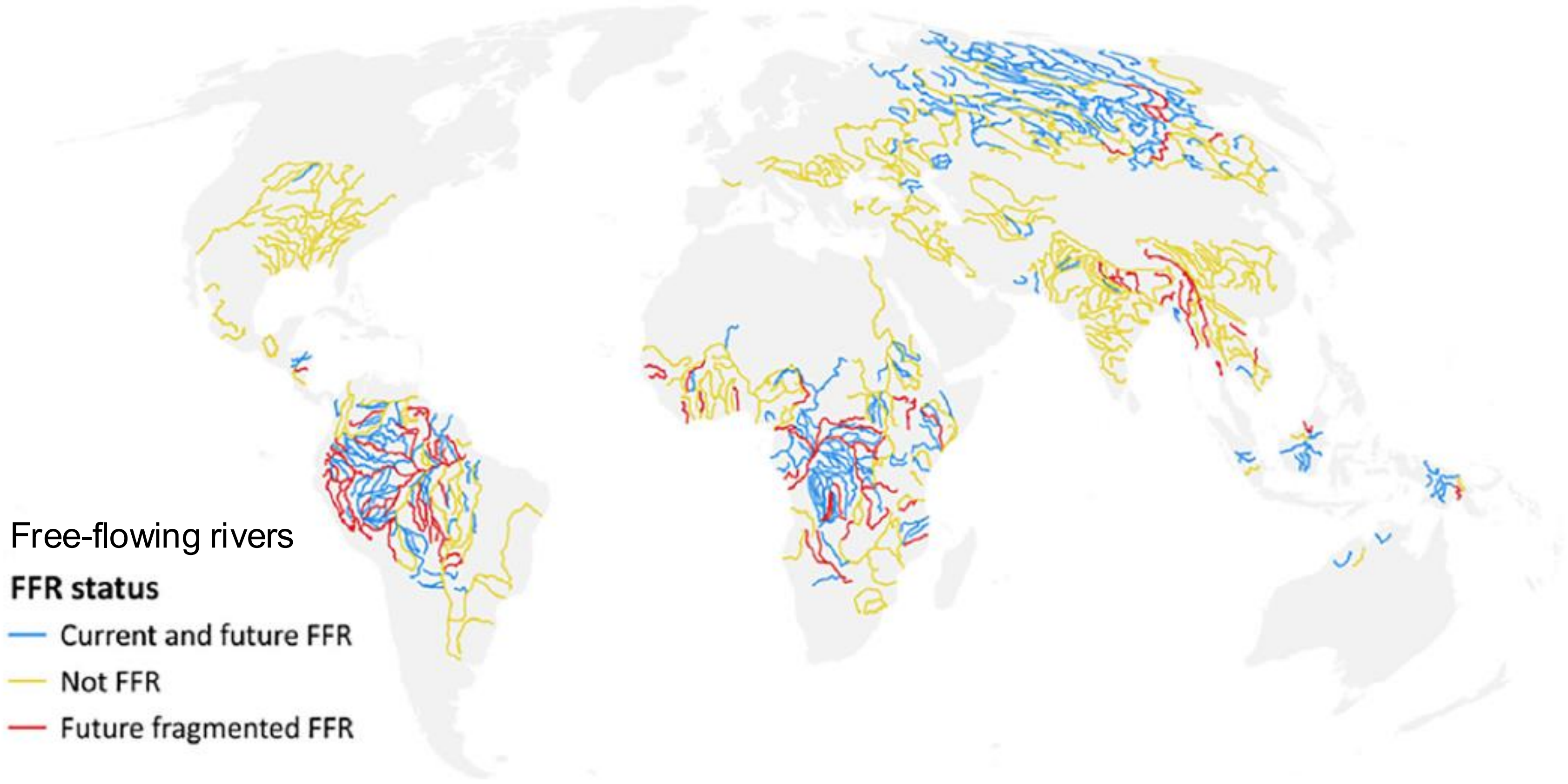

Fig. 5. Free-flowing status of rivers longer than 500 km that provide habitat for threatened freshwater megafauna (i.e., listed as Critically Endangered, Endangered, or Vulnerable in the IUCN Red List; IUCN, 2019).

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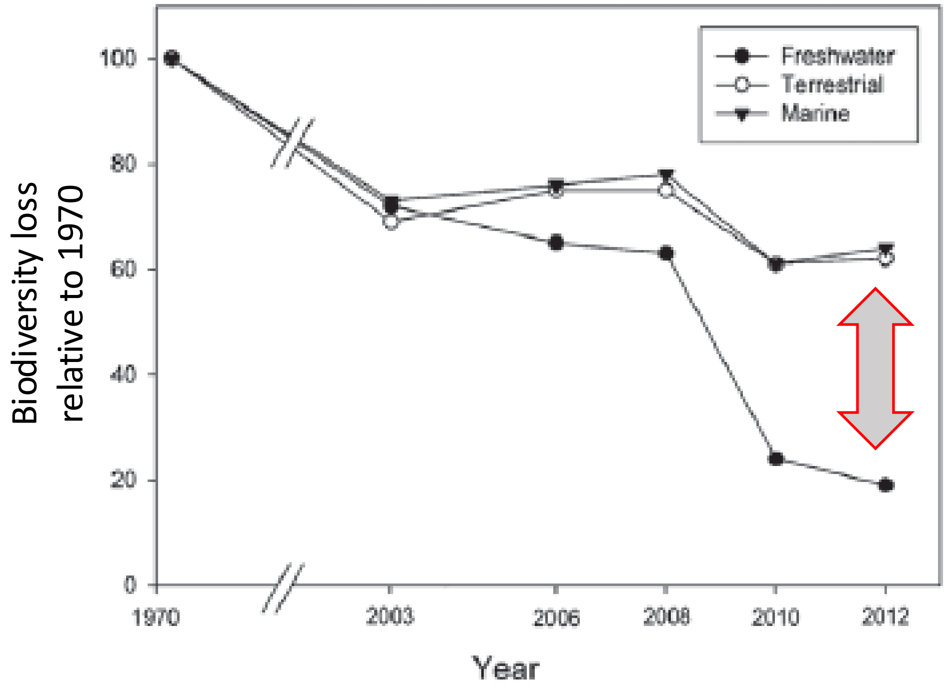
Emerging threats and persistent conservation challenges for freshwater biodiversity

Andrea J. Reid[1*], Andrew K. Carlson[2], Irena F. Creed[3], Erika J. Eliason[4], Peter A. Gell[5], Pieter T. J. Johnson[6], Karen A. Kidd[7], Tyson J. MacCormack[8], Julian D. Olden[9], Steve J. Ormerod[10], John P. Smol[11], William W. Taylor[2], Klement Tockner[12,†], Jesse C. Vermaire[13], David Dudgeon[14] and Steven J. Cooke[1,13]

Freshwater biodiversity is at threat

Fig. 1. The 2016 World Wide Fund for Nature (WWF) Living Planet Index (LPI) shows population trend data for a collective 'basket' of vertebrates in the freshwater (black circles), terrestrial (white circles) and marine (black triangles) realms, revealing remarkable index decreases among freshwater species. These index declines are relative to a benchmark value of 100 in 1970. Dates given here refer to years in which estimates of abundance were made, as LPI reports typically refer to data from four years earlier (e.g. the 2016 LPI is based on 2012 data). The 2012 index value of 19 for freshwater populations has confidence limits ranging from 11 to 32; the value of 62 for terrestrial populations has limits from 49 to 79; and the value of 64 for marine populations has limits from 52 to 80 (WWF, 2016).



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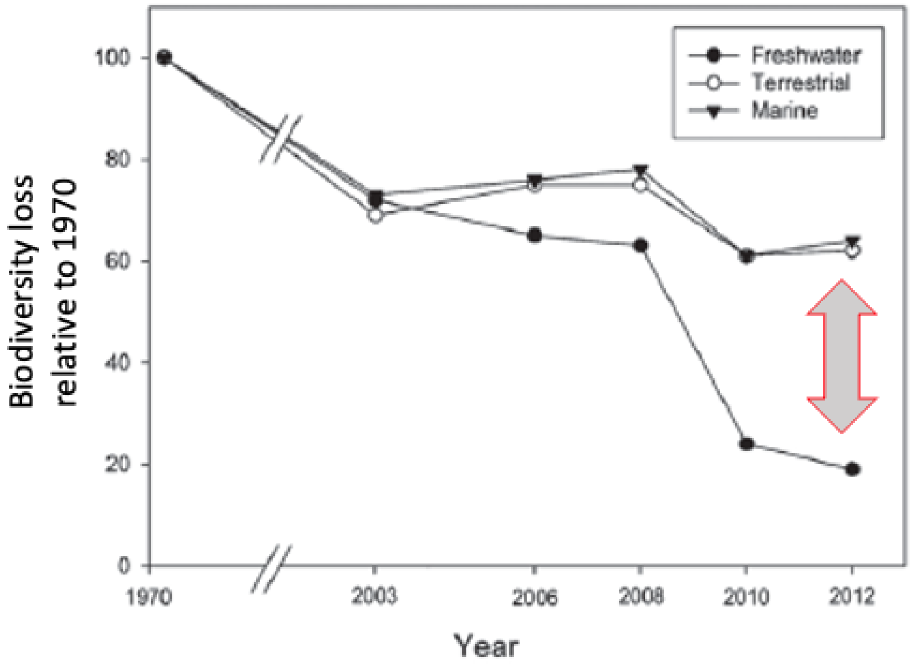
Emerging threats

(1) Changing climates
(2) E-commerce and invasions
(3) Infectious diseases
(4) Harmful algal blooms
(5) Expanding hydropower
(6) Emerging contaminants
(7) Engineered nanomaterials
(8) Microplastic pollution
(9) Light and noise pollution
(10) Freshwater salinisation
(11) Declining calcium
(12) Cumulative stressors



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Emerging threats and persistent conservation challenges for freshwater biodiversity

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Table 1. Characteristics of emerging threats to freshwater biodiversity: their geographical extent (and focal regions); the severity of their effects; examples of attendant ecological changes; our degree of understanding; and potential options for mitigating threat effects. For threat severity, categories are severe (red), moderate (yellow) or unclear (grey) and are based on links to freshwater species extinctions demonstrated in the literature. Degrees of understanding include poor (red), fair (yellow) or good (green) and are based on identified knowledge gaps and existing research challenges or unknowns. Relevant references are presented in the corresponding threat sections (see Section V.)

Emerging Threat	Geographic extent	Severity of effects	Ecological changes	Degree of understanding	Mitigation options
(1) Changing climates	Global	Already causing extinctions; likely to cause more.	Alters species size, range, phenology and survival.	Moderately well understood but high unpredictability.	Global commitments; expand protected areas; restore thermal refugia.
(2) E-commerce & invasions	Global *(primarily developed markets)*	Significant role in trade of non-native plants and animals.	Creates novel modes of long-distance dispersal.	Largely unregulated activities that are poorly understood.	Online consumer accountability tools; awareness campaigns.
(3) Infectious diseases	Global *(especially tropical systems)*	Already causing extinctions; likely to cause more.	Alters species survival, with clear ecosystem effects.	Increasingly well understood but high unpredictability.	Improve surveillance; management to favour ecosystem controls.
(4) Harmful algal blooms	Global *(warm, nutrient-rich areas)*	Linked to species losses; likely to cause more.	Reduces species growth, survival and reproduction.	Increasingly well understood, some unpredictability.	Improve surveillance; management to favour ecosystem controls.
(5) Expanding hydropower	Global *(primarily emerging markets)*	Already causing extinctions; likely to cause more.	Fragments river systems, inhibiting species movement.	Well understood, but interactive stressor effects unclear.	Ameliorate passage infrastructure; assess all project impacts.
(6) Emerging contaminants	Global *(primarily developed markets)*	Unclear how biodiversity will be changed.	Alters some species health, abundance and reproduction.	Largely understudied and thus poorly understood.	Improve medication disposal; advance wastewater treatment.
(7) Engineered nanomaterials	Global *(primarily developed markets)*	Unclear how biodiversity will be changed.	Causes minimal acute toxicity in some species.	Considerable uncertainty around long-term effects.	Improve detection and characterization; create targeted formulations.
(8) Microplastic pollution	Global *(primarily developed markets)*	Unclear how biodiversity will be changed.	Potentially detrimental effects on species health.	Considerable uncertainty around long-term effects.	Reduce plastic usage; enact legislation to curb use of specific products.
(9) Light & noise	Global *(primarily developed markets)*	Linked to species disturbance; likely to continue.	Alters behaviour and physiology of some species.	Well understood, but ecosystem-level effects unclear.	Identify less harmful types; reduce usage; educate users.
(10) Freshwater salinisation	Coastal lowlands	Linked to species losses; likely to cause more.	Reduces species growth, survival and reproduction.	Increasingly well studied and understood.	Control point sources; strategic release of freshening flow.
(11) Declining calcium	Softwater lakes	Linked to species declines; likely affecting foodwebs.	Causes shifts in lake invertebrate assemblages.	Increasingly well understood, but solutions unevaluated.	Further reduce acidic precipitation; replenish calcium in watersheds.
(12) Cumulative stressors	Global	Contributing to extinctions; likely to cause more.	Can magnify impacts and create ecological surprises.	Poorly understood with high levels of unpredictability.	Identify multi-purpose solutions that protect biodiversity hotspots.

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Biodiversity-Ecosystem Function Research: Is It Relevant to Conservation?

Diane S. Srivastava[1] and Mark Vellend[2,3]

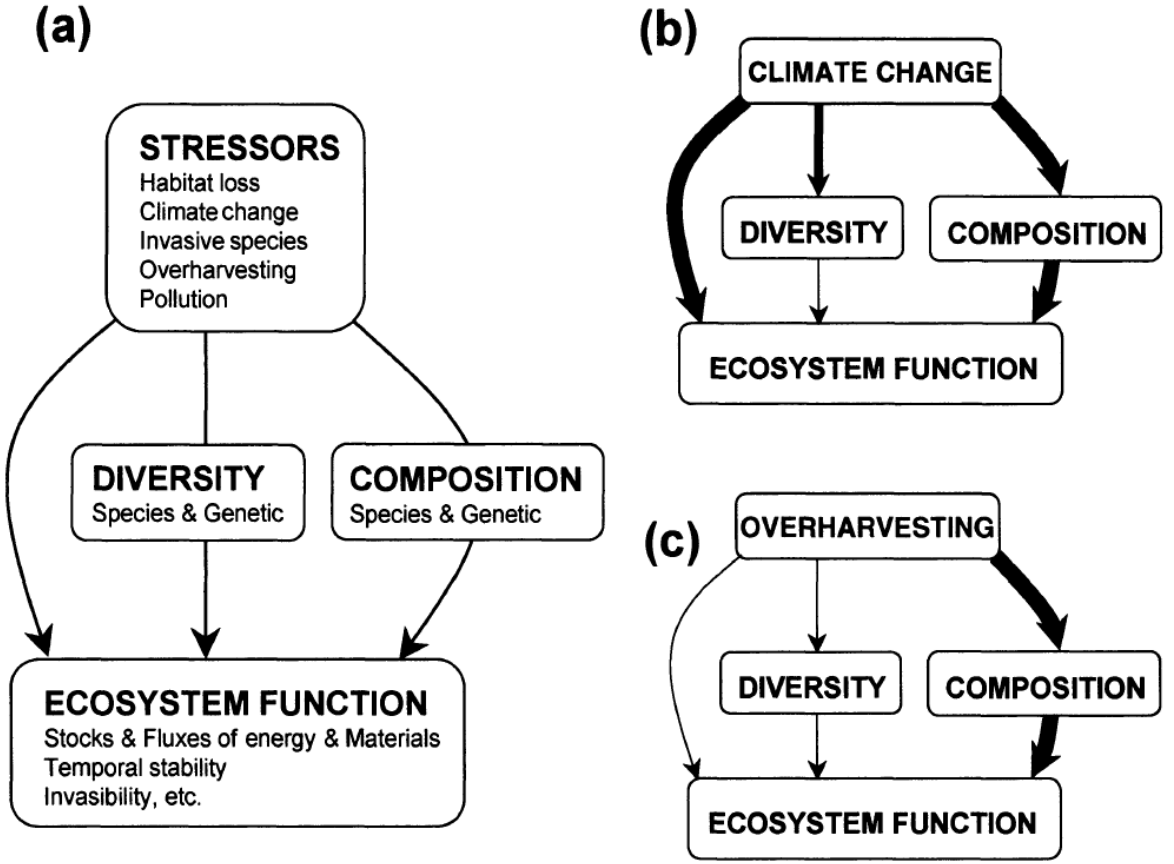

Figure 1 (*a*) There are many pathways between environmental stressors and ecosystem functions. Simply showing a positive effect of diversity on ecosystem function is insufficient evidence that reducing a stressor will lead to improvements in ecosystem functioning. The relative importance of each pathway (indicated by arrow width in *b*,*c*) may differ between specific stressors, in this case (*b*) climate change and (*c*) overharvesting.

Biodiversity, ecosystem functioning and services are connected

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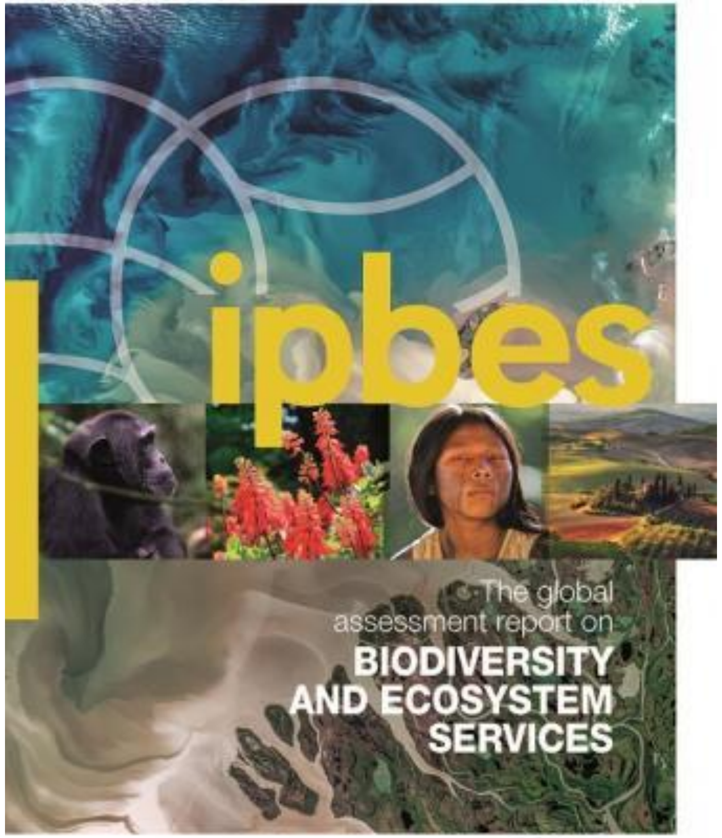

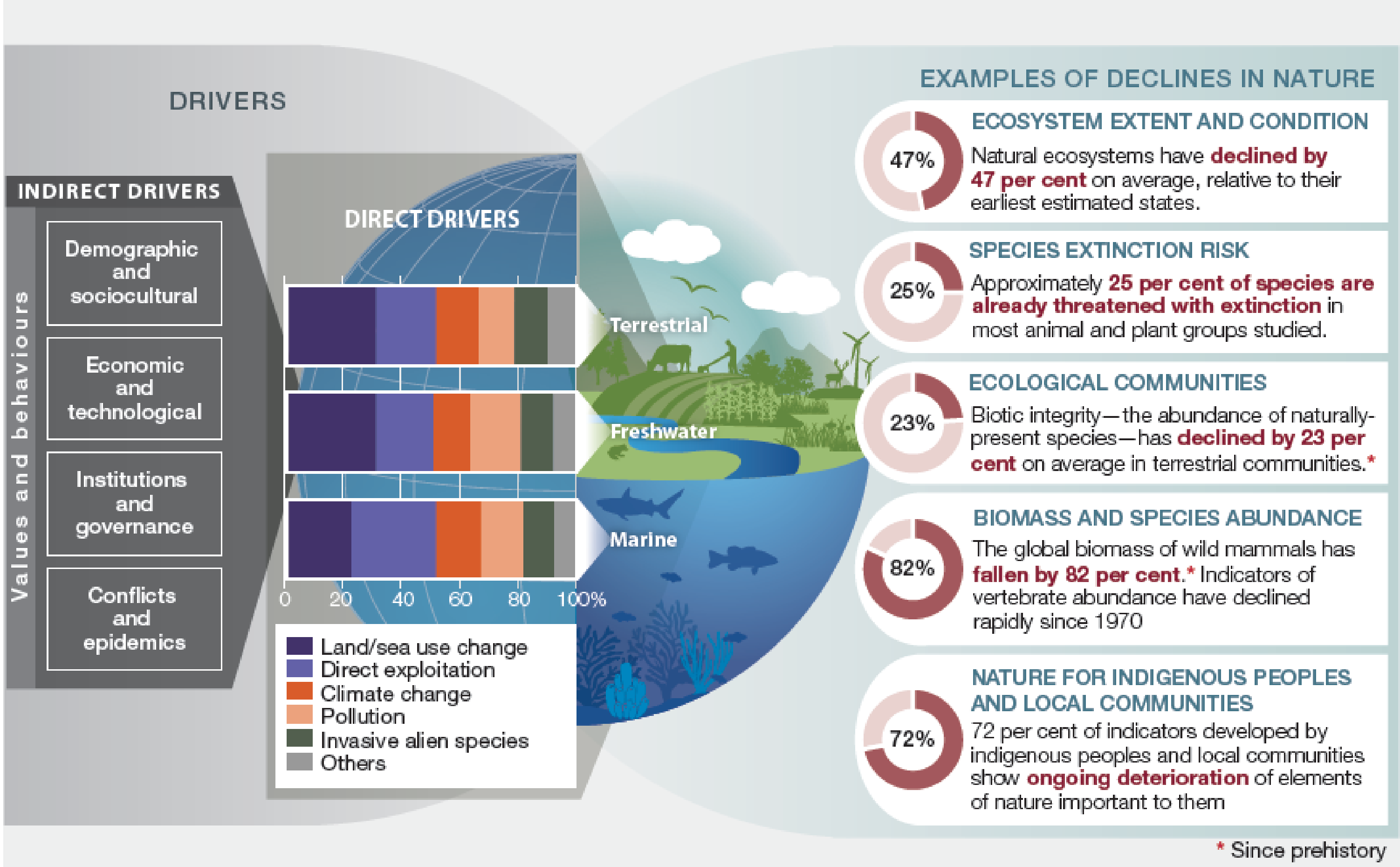

Figure SPM 2 **Examples of global declines in nature, emphasizing declines in biodiversity, that have been and are being caused by direct and indirect drivers of change.**

The direct drivers (land-/sea-use change; direct exploitation of organisms; climate change; pollution; and invasive alien species)[6] result from an array of underlying societal causes[7]. These causes can be demographic (e.g., human population dynamics), sociocultural (e.g., consumption patterns), economic (e.g., trade), technological, or relating to institutions, governance, conflicts and epidemics. They are called indirect drivers[8] and are underpinned by societal values and behaviours. The colour bands represent the relative global impact of direct drivers, from top to bottom, on terrestrial, freshwater and marine nature, as estimated from a global systematic review of studies published since 2005. Land- and sea-use change and direct exploitation account for more than 50 per cent of the global impact on land, in fresh water and in the sea, but each driver is dominant in certain contexts {2.2.6}. The circles illustrate the magnitude of the negative human impacts on a diverse selection of aspects of nature over a range of different time scales based on a global synthesis of indicators {2.2.5, 2.2.7}.

How to present a paper

Read the paper carefully

Extract the most critical information from the

- Introduction (the ‘why’)
- Methods (the ‘how’)
- Results (the ‘what’)
- Discussion (the ‘now’ and ‘next’)

Devote 20% to the introduction, 10 % to the methods, 30% to the results and 30% to the discussion

You are strongly encouraged to add your personal reflections and conclusion on top of these considerations

- Use scientific language
- Use scientific illustrations to make the argument clear
- Guide the audience through your arguments

’Ornamental’ displays (e.g., photos, pictogram) are welcome — they are, however, not a must

How to present a paper

- Build a storyline based on the introduction, results and discussion
- For this, you may follow the paper or produce your own – critically consult the abstract; it should give you a good summary of the paper

Keep your presentation time to 20 – 25 minutes
Allow enough time for discussion