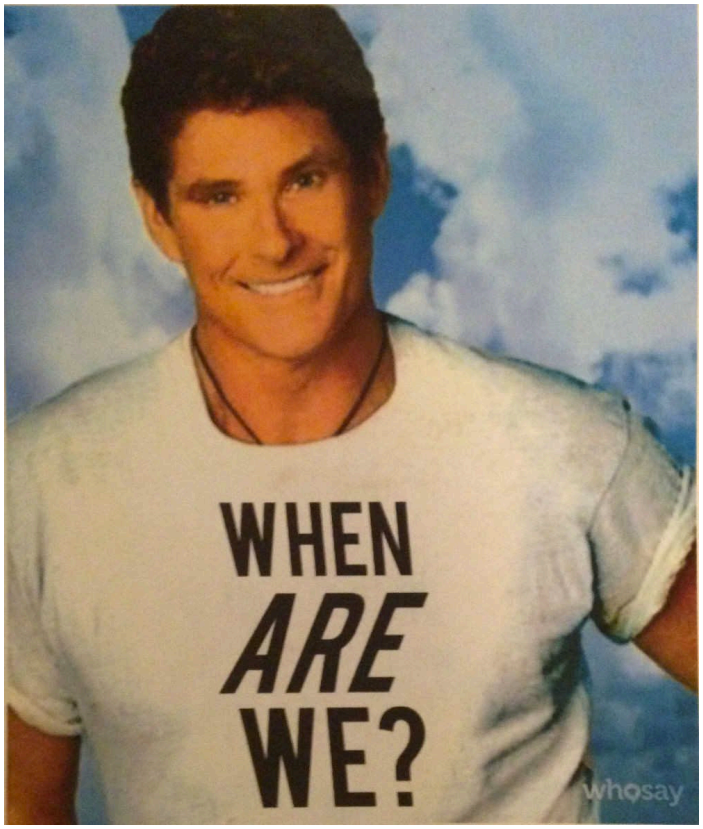
Sustainability:
Shifting our scientific culture too?

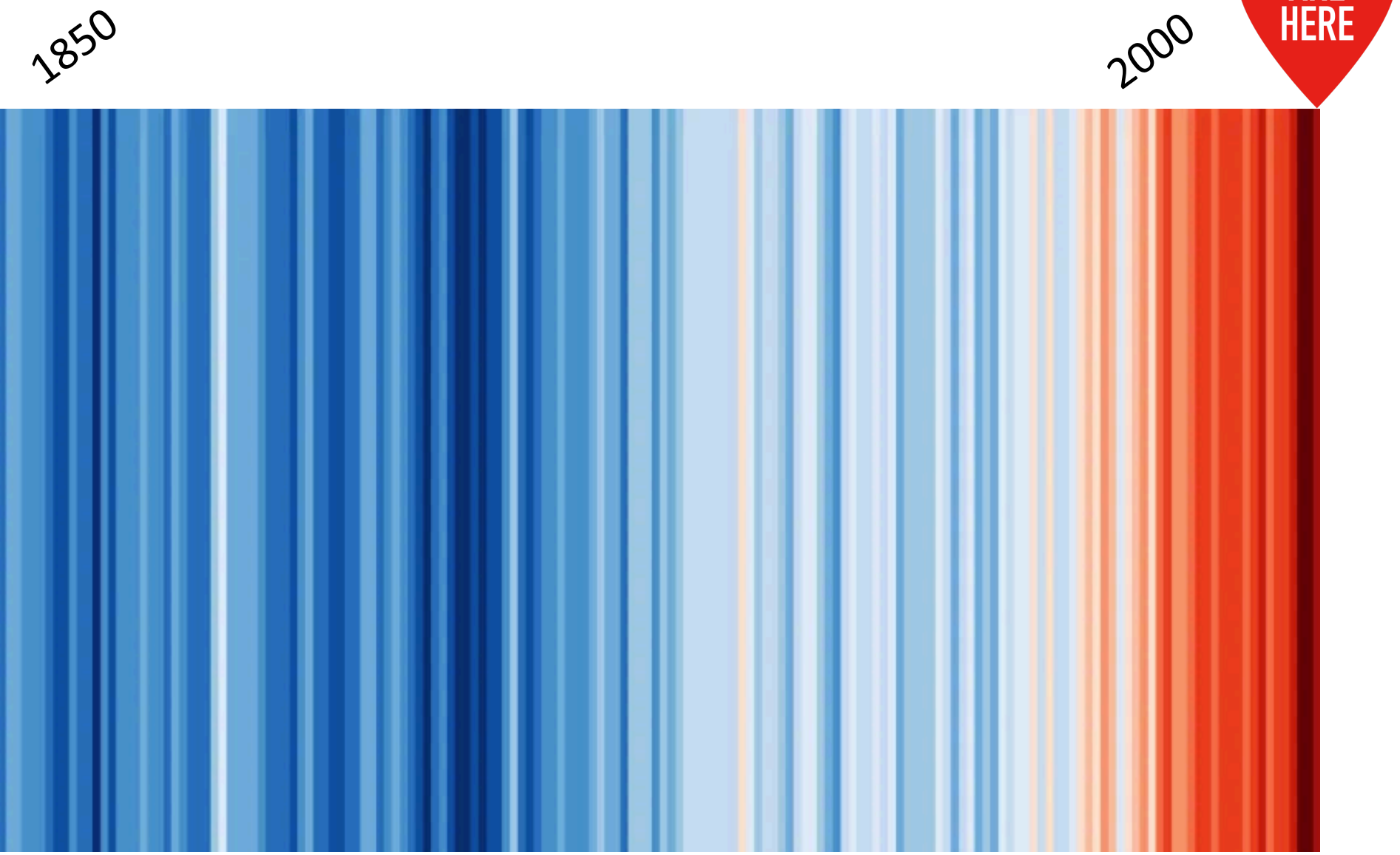
Olivier Hamant
ENS Lyon, France

1. When are we?
2. Plants as solutions
3. A new scientific culture?
4. Actions

I. Anthropocene



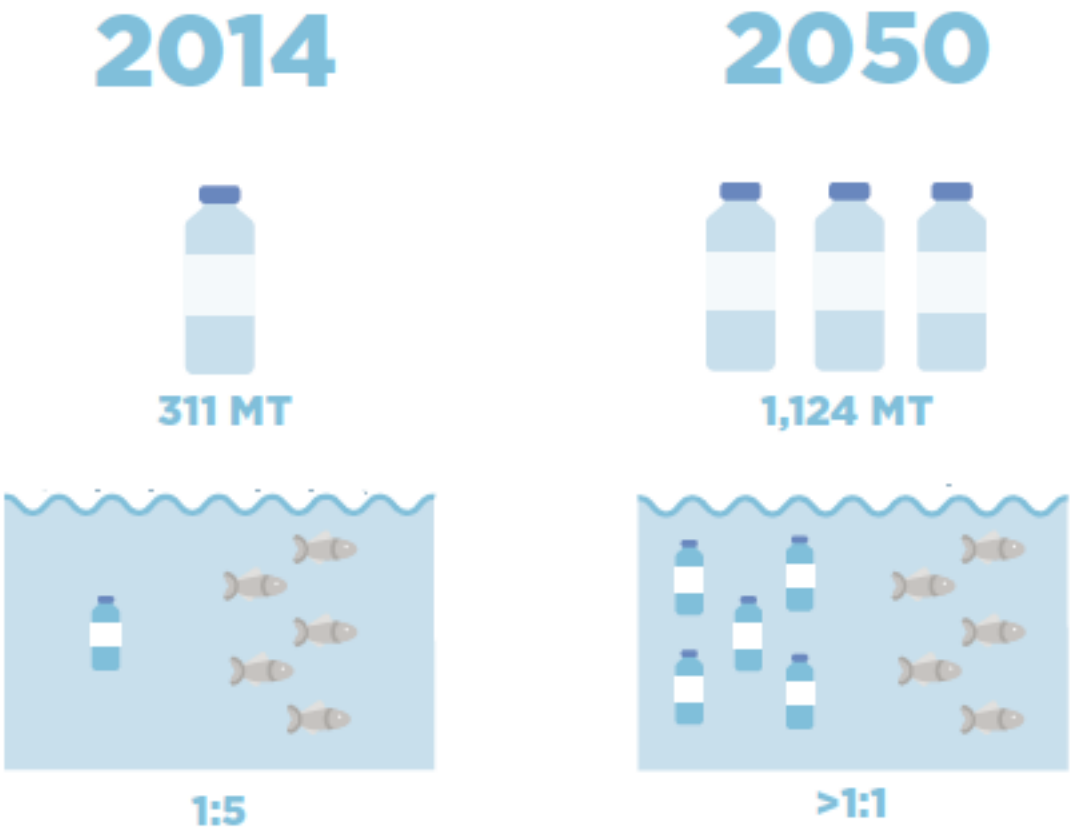
The climate crisis



« Air pollution is the new tobacco » (*WHO director general*)

7 million deaths linked to air pollution annually

As much plastic as fish in the oceans by 2050



Ellen MacArthur Foundation, 2016 WEF

A forcing on non-renewable resources

Lithium mines Atacama

60 to 80% of the periodic table in your smartphone

ELEMENTS COLOUR KEY: ALKALI METAL | ALKALINE EARTH METAL | TRANSITION METAL | GROUP 13 | GROUP 14 | GROUP 15 | GROUP 16 | HALOGEN | LANTHANIDE

SCREEN

49 In Indium
50 Sn Tin
8 O Oxygen

Indium tin oxide is a mixture of indium oxide and tin oxide, used in a transparent film in the screen that conducts electricity. This allows the screen to function as a touch screen.

13 Al Aluminium
14 Si Silicon
8 O Oxygen
19 K Potassium

The glass used on the majority of smartphones is an aluminosilicate glass, composed of a mix of alumina (Al_2O_3) and silica (SiO_2). This glass also contains potassium ions, which help to strengthen it.

39 Y Yttrium
57 La Lanthanum
65 Tb Terbium
59 Pr Praseodymium
63 Eu Europium
66 Dy Dysprosium
64 Gd Gadolinium

A variety of Rare Earth Element compounds are used in small quantities to produce the colours in the smartphone's screen. Some compounds are also used to reduce UV light penetration into the phone.

ELECTRONICS

Copper is used for wiring in the phone, whilst copper, gold and silver are the major metals from which microelectrical components are fashioned. Tantalum is the major component of micro-capacitors.

29 Cu Copper
47 Ag Silver
79 Au Gold
73 Ta Tantalum

Nickel is used in the microphone as well as for other electrical connections. Alloys including the elements praseodymium, gadolinium and neodymium are used in the magnets in the speaker and microphone. Neodymium, terbium and dysprosium are used in the vibration unit.

28 Ni Nickel
66 Dy Dysprosium
59 Pr Praseodymium
65 Tb Terbium
60 Nd Neodymium
64 Gd Gadolinium

Pure silicon is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added in order to allow the chip to conduct electricity.

14 Si Silicon
8 O Oxygen
51 Sb Antimony
33 As Arsenic
15 P Phosphorus
31 Ga Gallium

Tin & lead are used to solder electronics in the phone. Newer lead-free solders use a mix of tin, copper and silver.

50 Sn Tin
82 Pb Lead

BATTERY

3 Li Lithium
27 Co Cobalt
8 O Oxygen
6 C Carbon
13 Al Aluminium

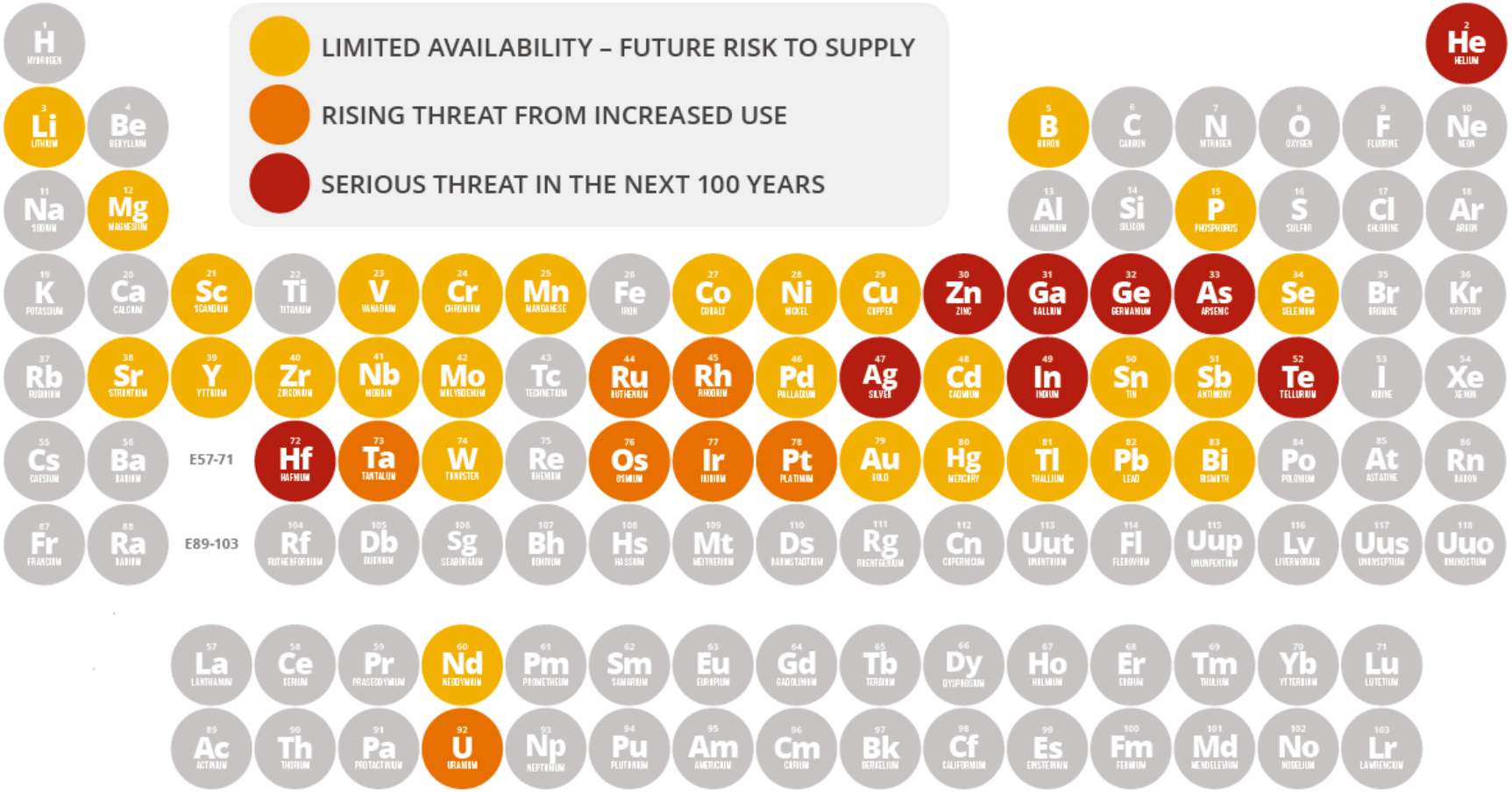
The majority of phones use lithium ion batteries, which are composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Some batteries use other metals, such as manganese, in place of cobalt. The battery's casing is made of aluminium.

CASING

Magnesium compounds are alloyed to make some phone cases, whilst many are made of plastics. Plastics will also include flame retardant compounds, some of which contain bromine, whilst nickel can be included to reduce electromagnetic interference.

6 C Carbon
12 Mg Magnesium
35 Br Bromine
28 Ni Nickel

THE PERIODIC TABLE'S ENDANGERED ELEMENTS



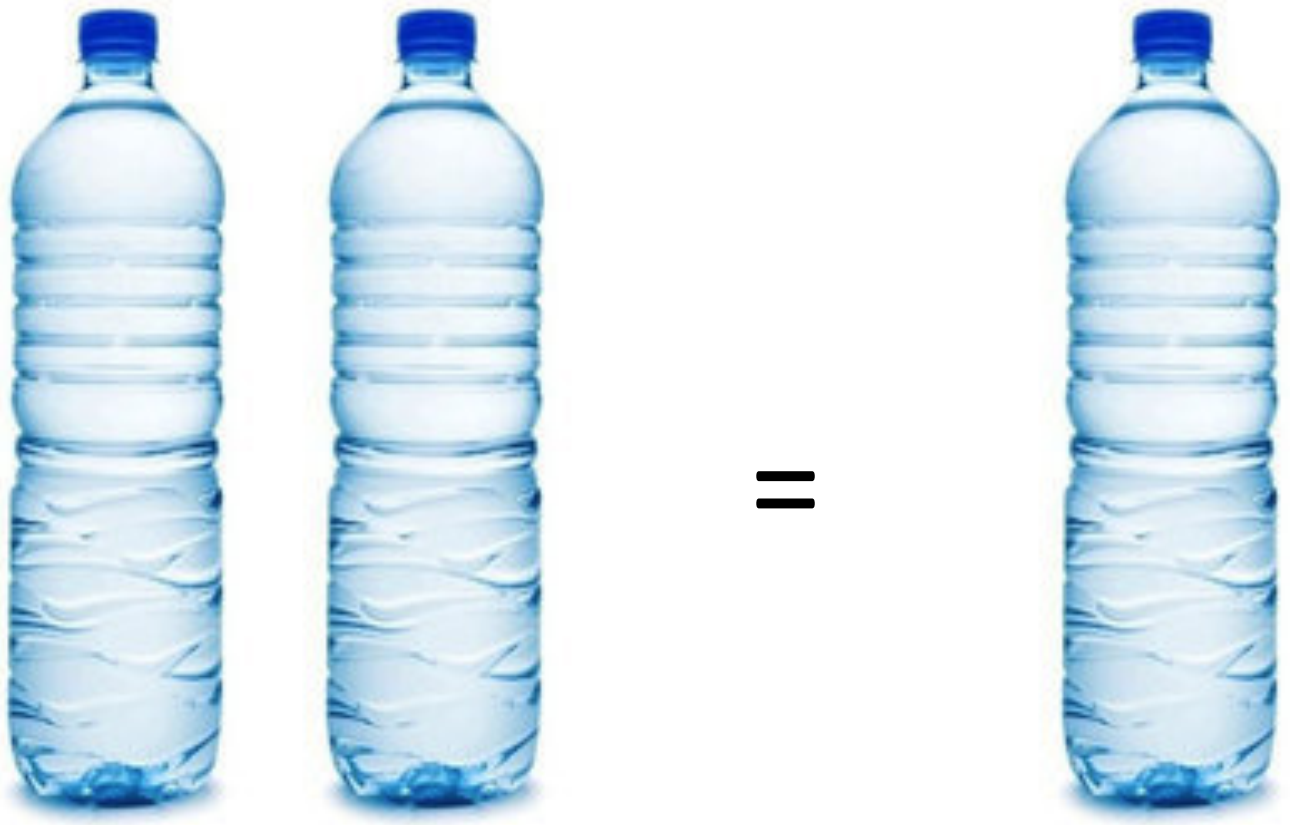
SOURCE: CHEMISTRY INNOVATION KNOWLEDGE TRANSFER NETWORK

ACS Chemistry for Life

ACS Green Chemistry Institute®

Ci

It takes 2L of water to produce the plastic for a 1L bottle

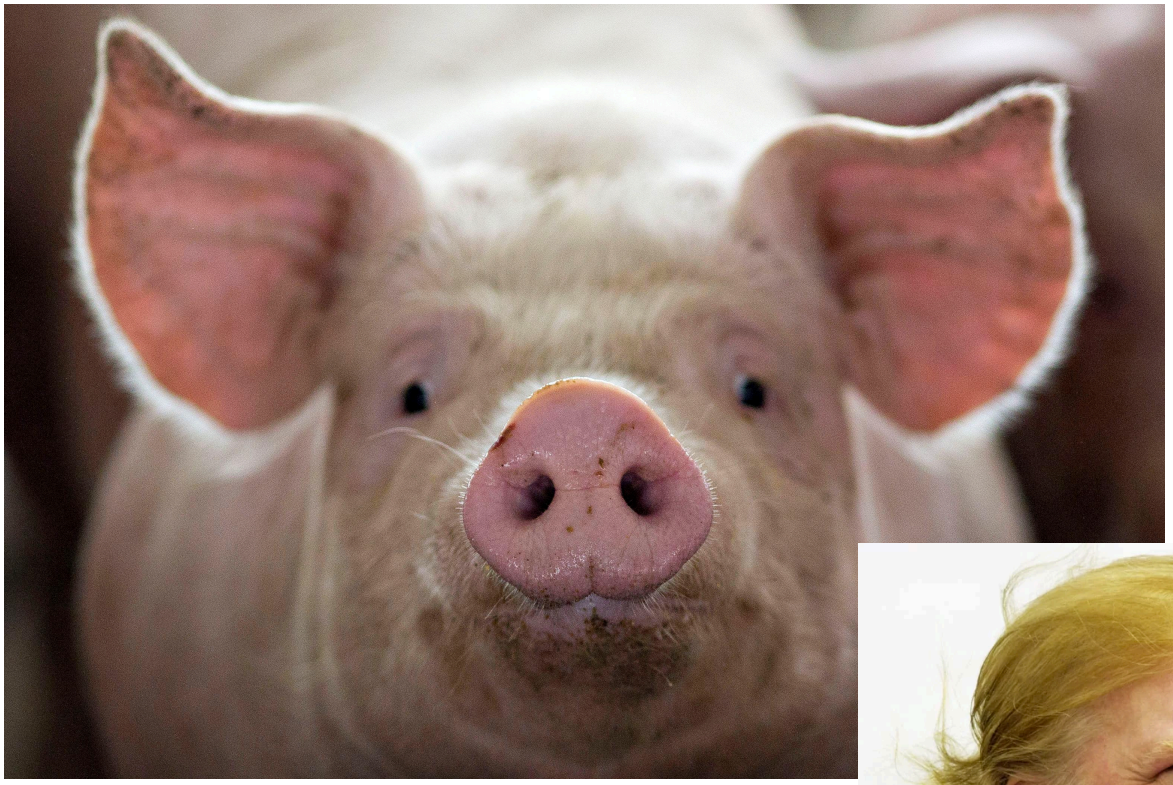


Radleys 2018

A forcing on renewable resources

Plastic sea, Spain

Vertebrate on continents (in mass)



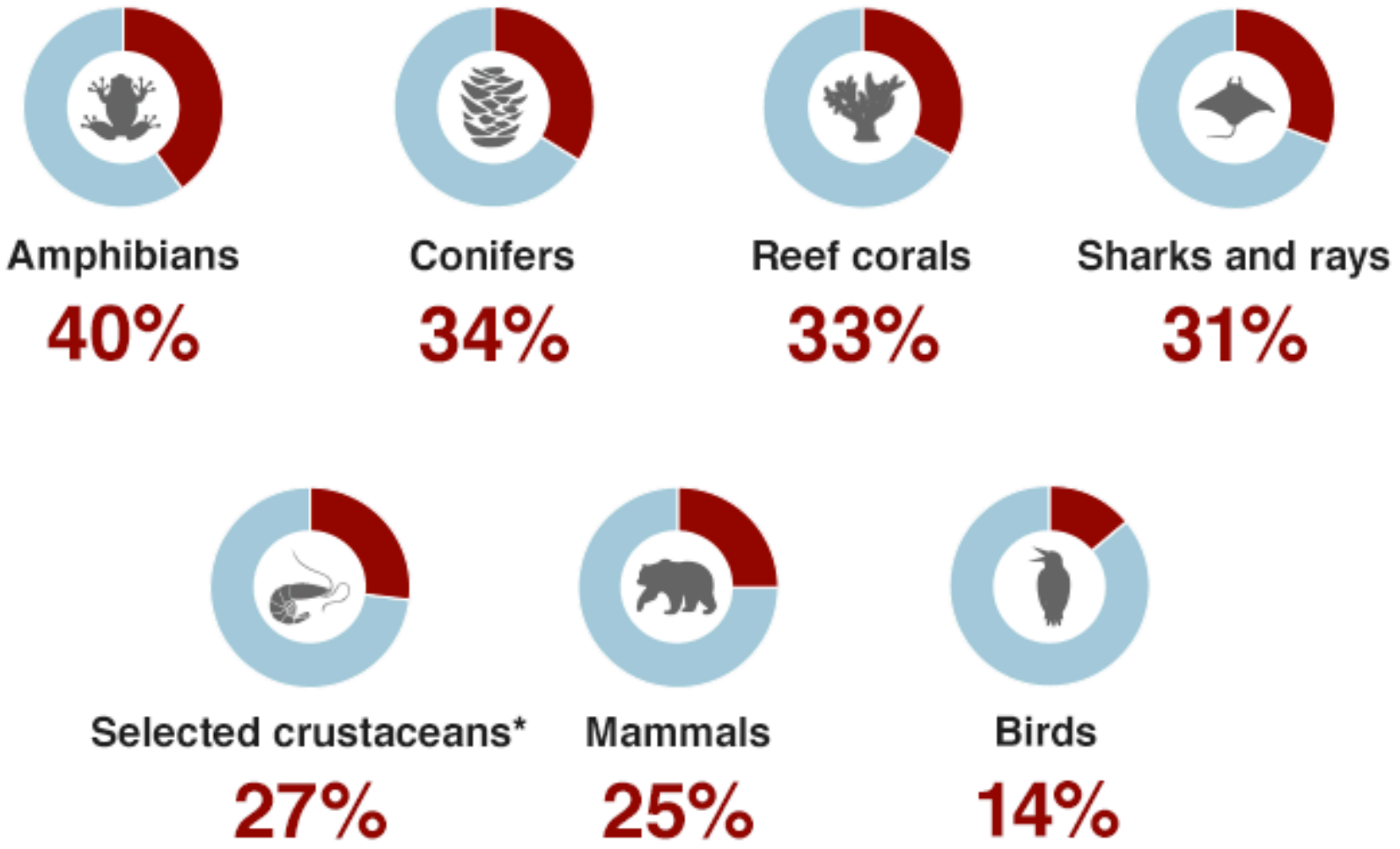
Domesticated animals
65%

Humans
32%

Wild vertebrates
<3%

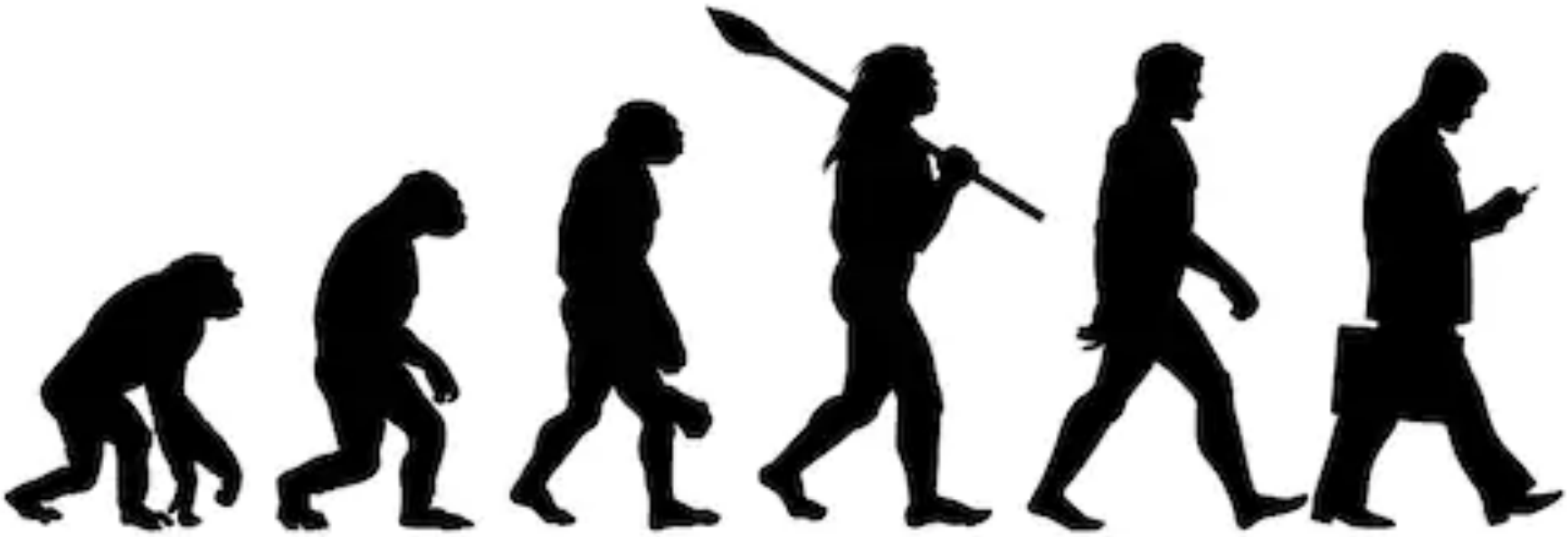
Smil, 2002

6th mass extinction of species

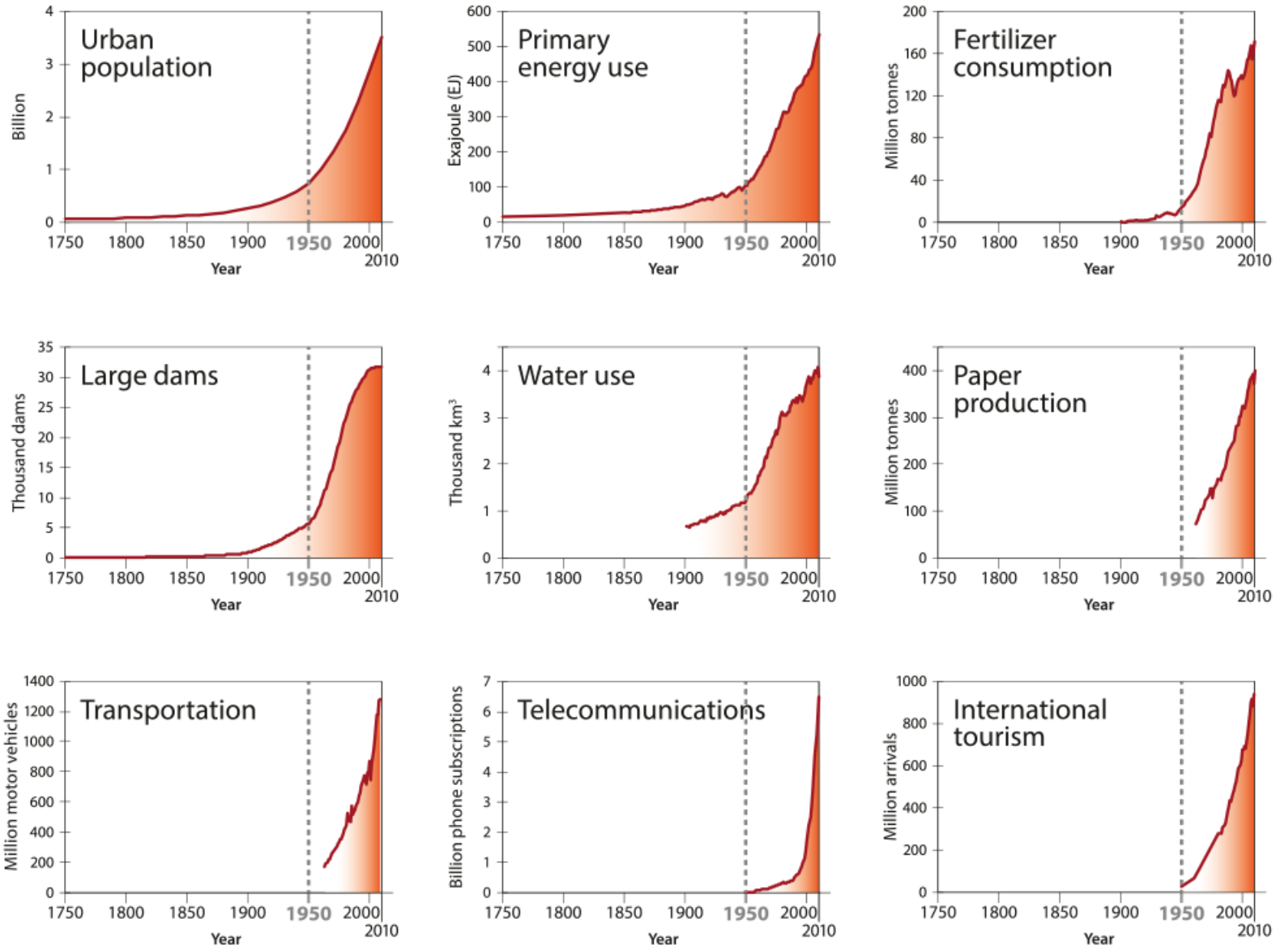


Source: IUCN

A linear dynamics?

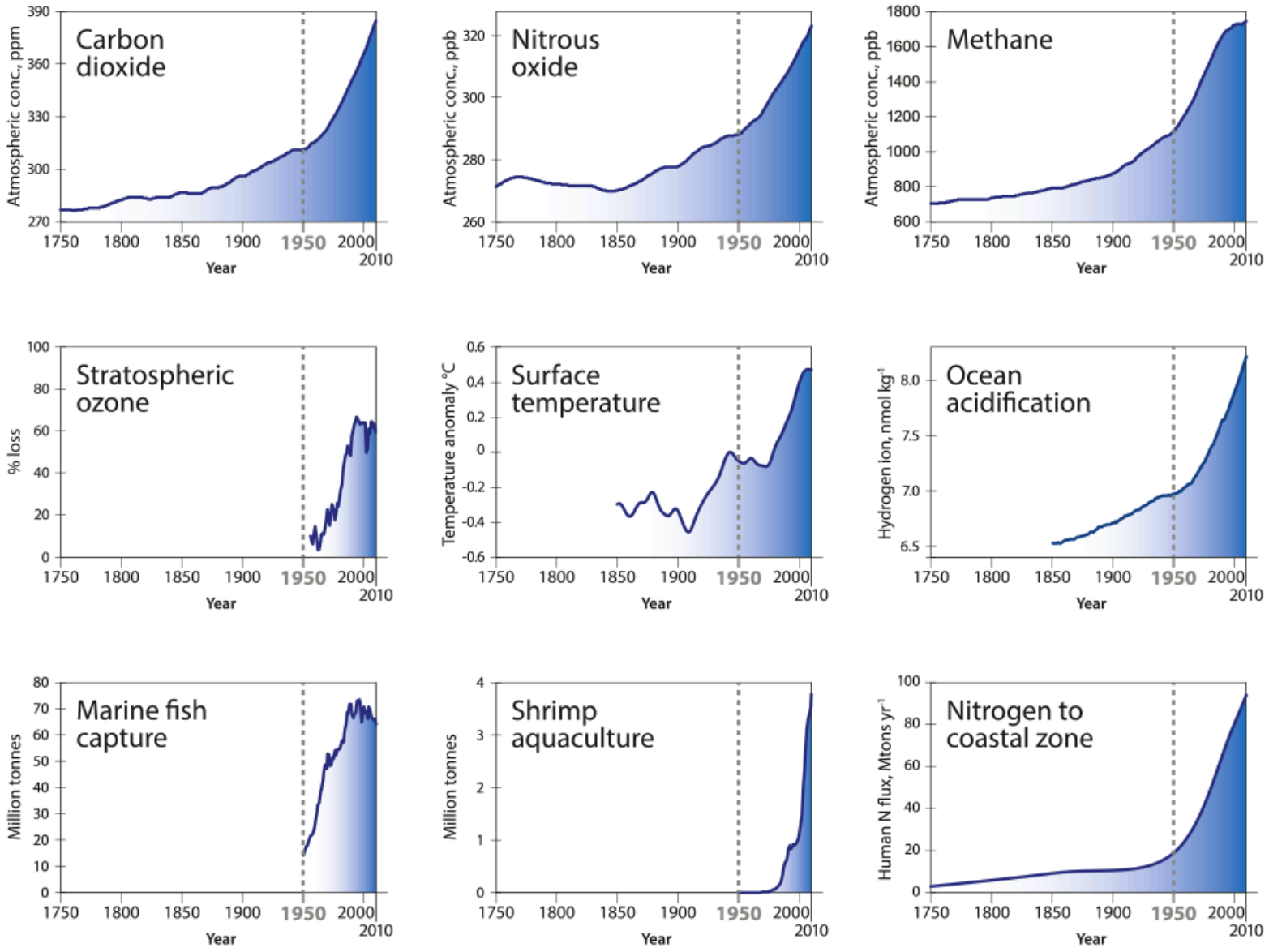


A very recent trend: the great acceleration



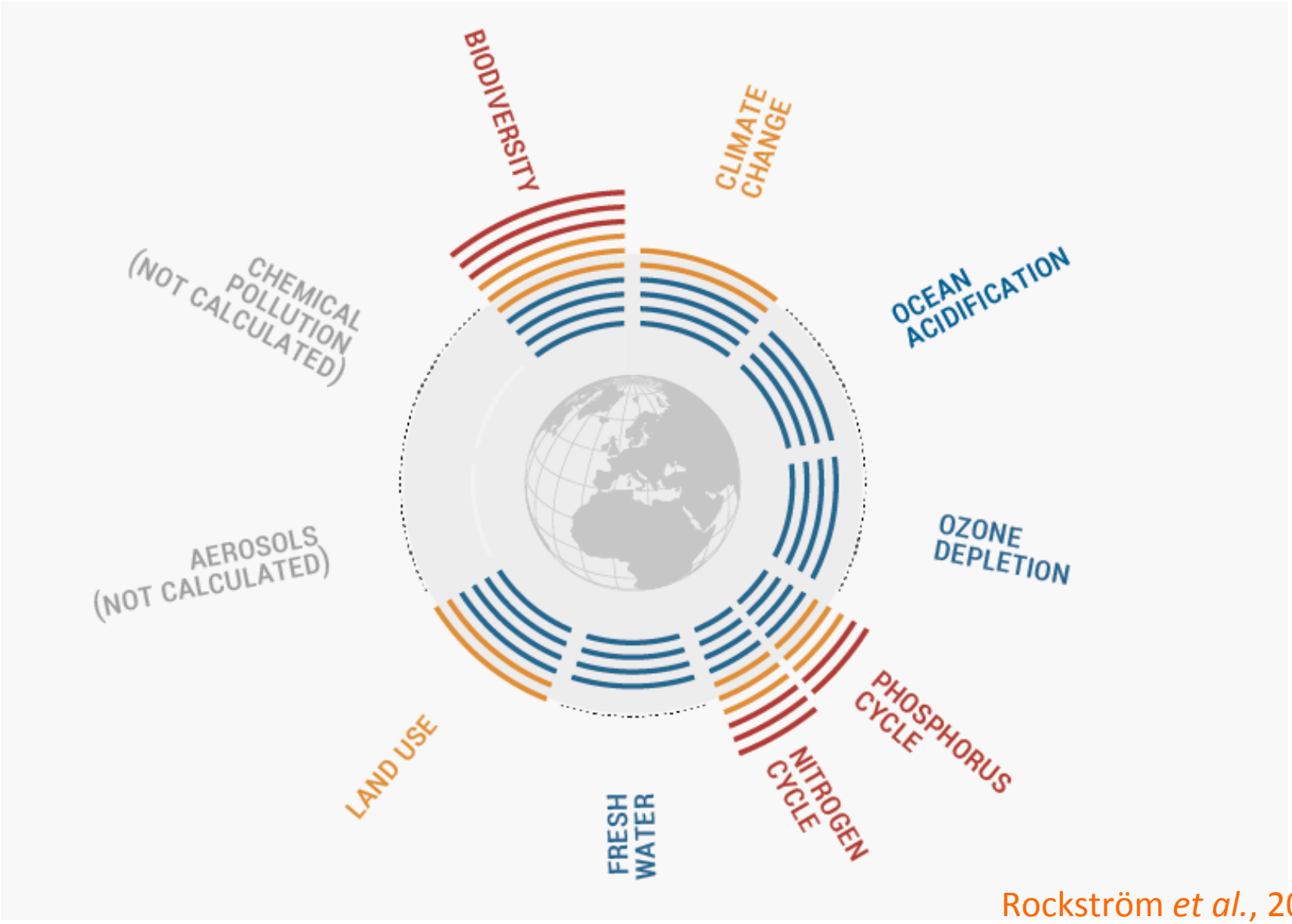
Steffen *et al.*, 2007

A matching impact on the ecosystems



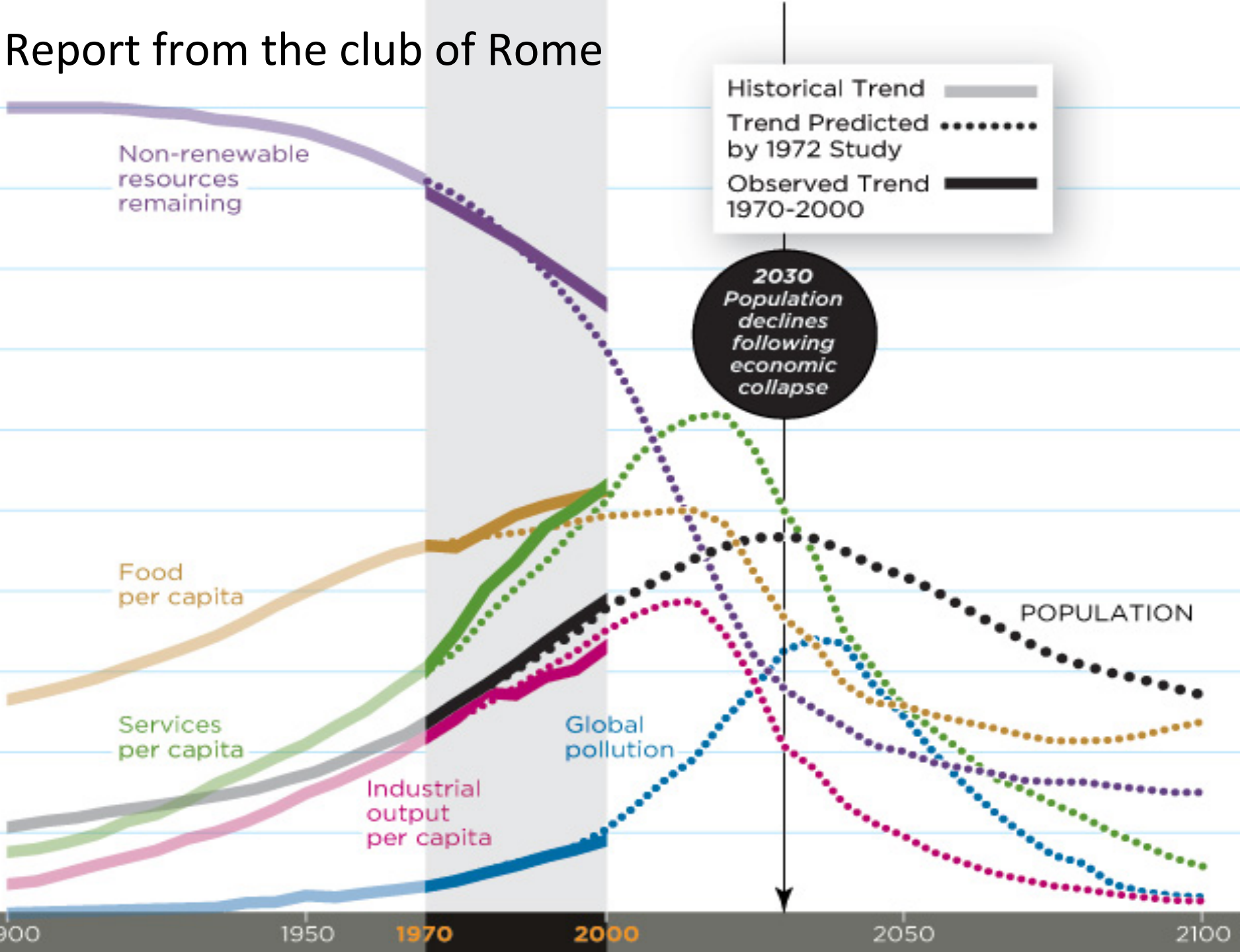
Steffen *et al.*, 2007

An alert: planetary boundaries



Rockström *et al.*, 2009

Report from the club of Rome



How are we going to fix this problem?

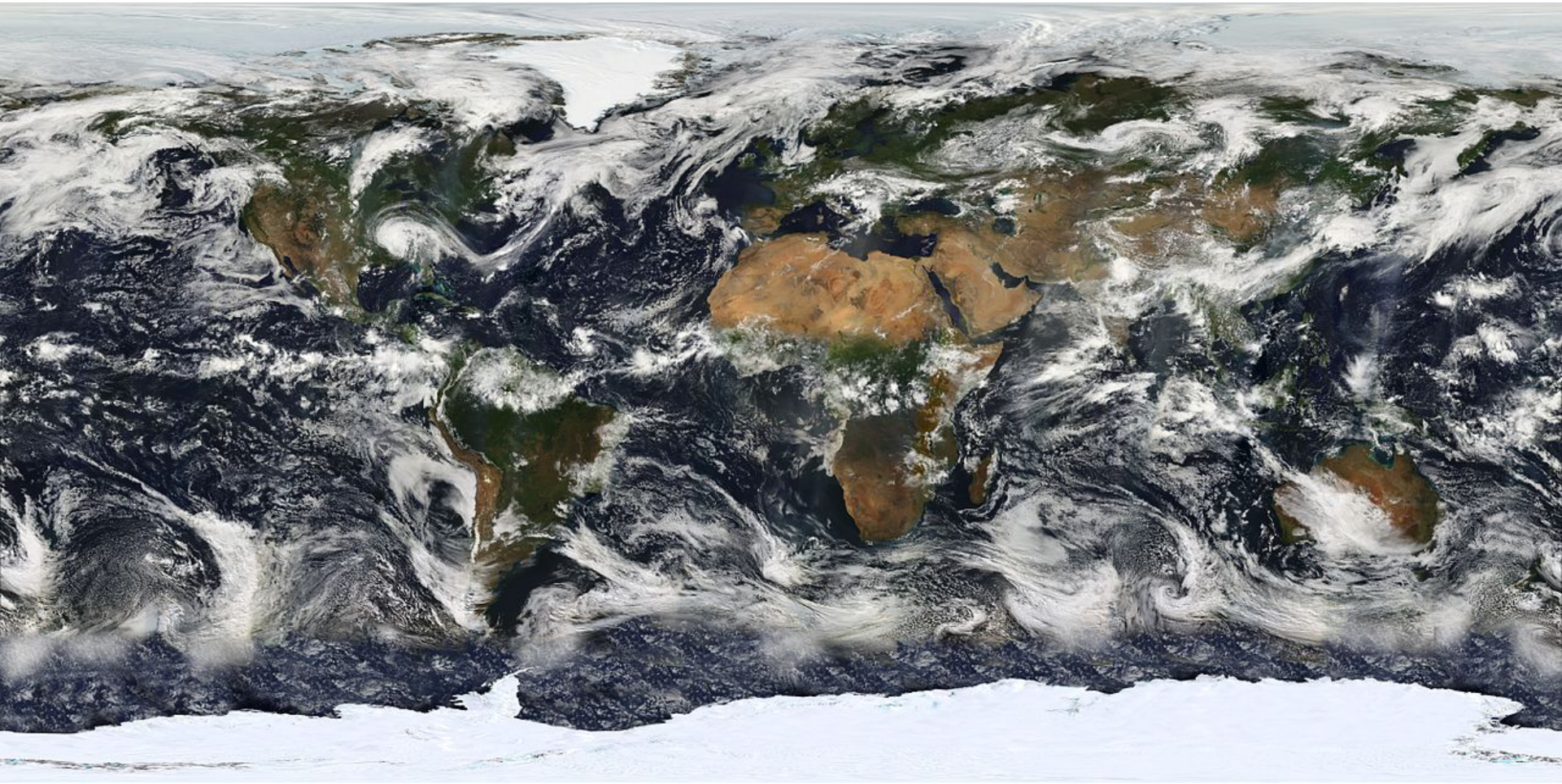
Maarten Van Den Eynde, 2003

II. Plants as solutions

Soil: our civilisation depends on plants

It takes 500 years to make an inch of topsoil.

Water and O_2: our civilisation depends on plants



Without plants, clouds would stop 500 km into the continents.

Cooling and microclimate: our civilisation depends on plants

Large shade trees can reduce local ambient temperatures by 3 to 5 °C

The central role of plants in the future

The central role of plants in the future

econick

BFF
Biomass For the Future

Agromining
& phytoremediation
& phytates

Biomaterials

A green digital world?

A shift in our scientific questions

From performance…

to resilience

III. A new scientific culture?

IPCC proposals are radical (+1.5°C target)

- -63% CO_2 emissions by 2030
- Car mileage divided by 2 by 2030
- 1 kg new clothes / year / person by 2022
- No more short route flights by 2022
- Meat consumption divided by 3 by 2030
- …

IPCC
INTERGOVERNMENTAL PANEL ON climate change

Scientists are vocal

But is scientific culture changing?

We are wasting a lot of plastic

The world's biomedical and agricultural science laboratories could be producing more than 5 million tonnes of plastic waste every year,

i.e. the weight of 500 Eiffel towers / year

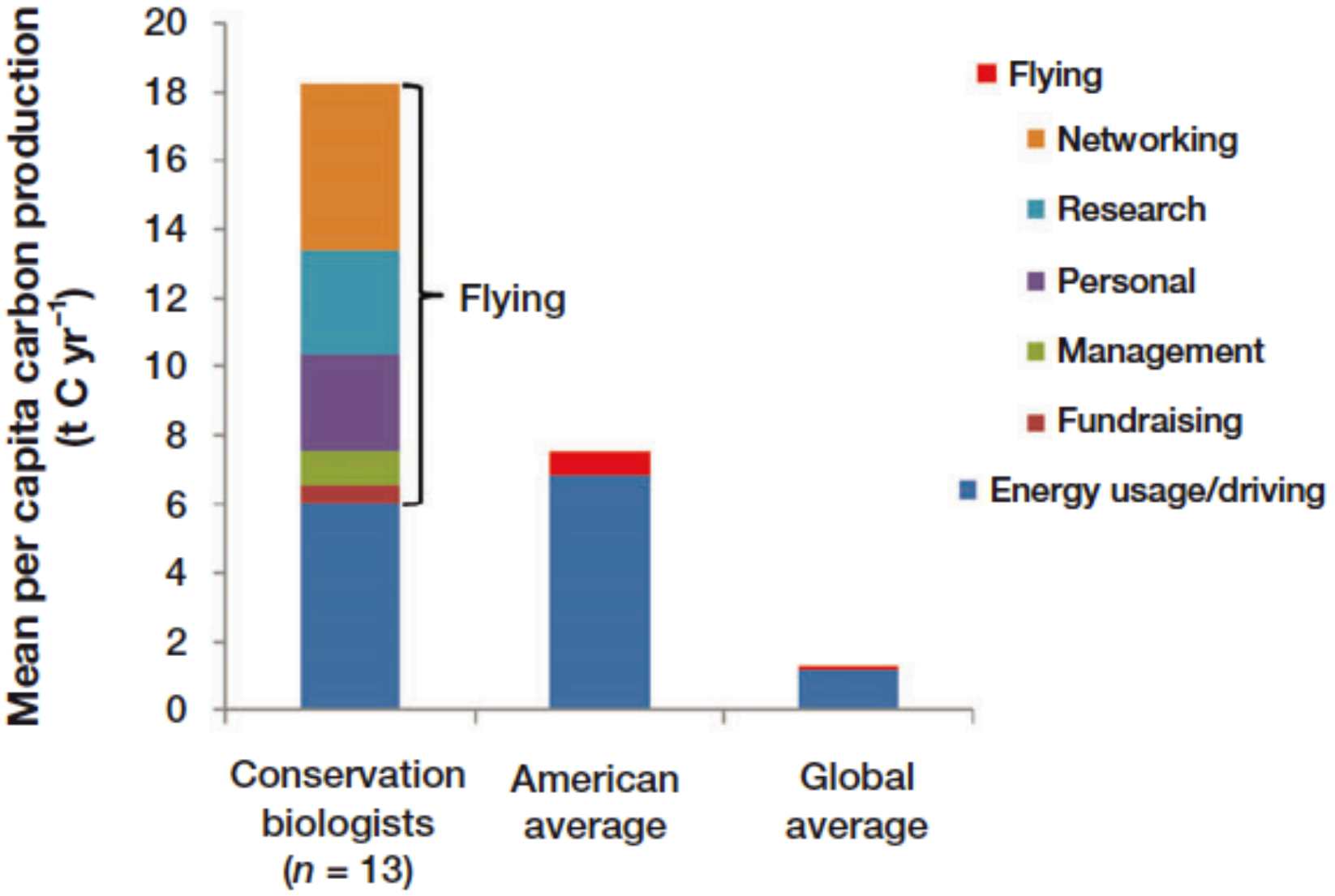
Urbina *et al.*, 2015 Nature

Lab vs. Wall St

Lab buildings are 3 to 5 times more energy intensive than office buildings

Source: US Department of Energy

We are flying more than most

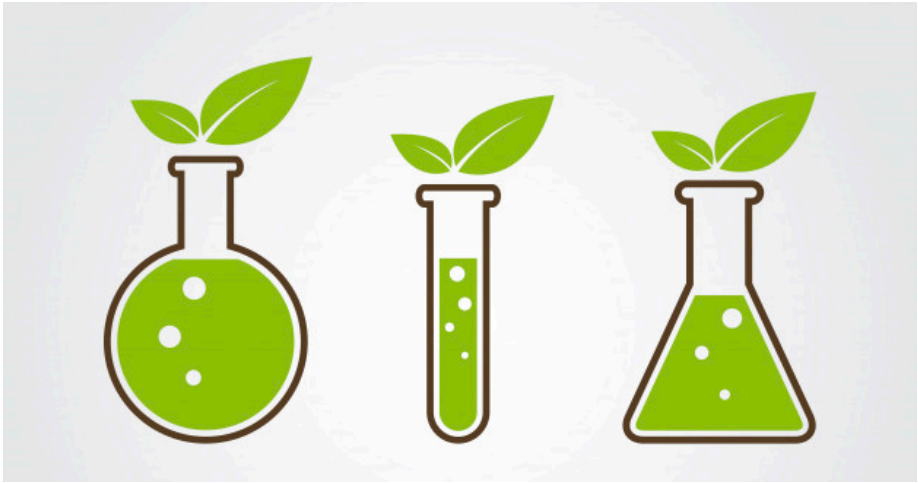


Fox *et al.,* 2009 Front. Ecol. Env.

Why shall we care?

- Well… see above
- If scientists do not lead by example, then who else will?
- The rise of citizen science
- We are largely self-organized

IV. Actions



At the bench

- Individual action:
  - Talk to your superviser

- Systemic action:
  - Share equipments and space
  - Switch new -80°C freezers to -70°C
  - Switch back to glass (e.g. pipet, petri dish) when possible
  - Use recyclable plastics (PS, PP, HDPE/LDPE)
  - Mail back your styrofoam
  - Use thin plastic alternatives
  - Put the price of all consumables for students to be more frugal
  - Select the most sustainable providers
  - Request your provider to become more sustainable
  - Be frugal: shut fume hood cupboards when not in use, turn off computer at night,…
  - …

At the office

- Individual action:
  - Print less, use unbleached recycled paper
  - Bring your own cup
  - Watch your energy/resource usage

- Systemic action:
  - Question the sustainability of your coffee machine
  - Promote a green campus (meadows, veggie menus, no single use plastics, air condition hours…)
  - Don’t throw facts at people, start a conversation
  - Request washable/reusable/metallic silverware/dishes
  - …

Digital waste

- Individual action:
  - Erase your old emails, clean your cloud
  - Change your computer only when >5 years old

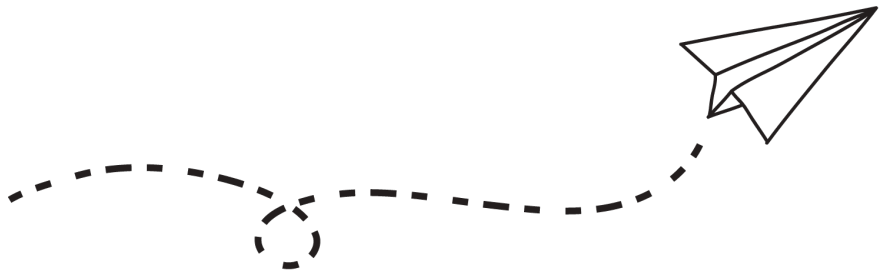
- Systemic action:
  - Data responsability
  - …

10% of world electricity gone to Data servers in 2020

Conferences

- Individual action:
  - Reduce your flight mileage
  - Use and promote videoconference

- Systemic action:
  - Conference pooling/rationalization
  - Take advantage of videoconferences
  - Open videoconference registration option
  - When local, reimburse train rides only
  - Career: who should fly most?
  - …



Initiatives: shaping a sustainable scientific culture

- New conferences: pooling/video/long stay?
- New lab certifications?
- New labels on papers/grant applications?
- A resilience officer in your lab?
- Eco competitions?
- Audit your waste (source reduction and recycling)?
- Request a campus ecological imprint quantification
- Take inspiration from ecofeminism, resilience, degrowth…
- …

Commitments: a manifesto?

eLIFE

Inventing a new sustainable scientific culture

Resources

https://www.mygreenlab.org/

https://labos1point5.org

https://www.sustainability.upenn.edu/

The Guardian

Reading