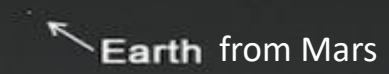
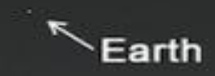
Biophysical limits to growth; the degrowth imperative



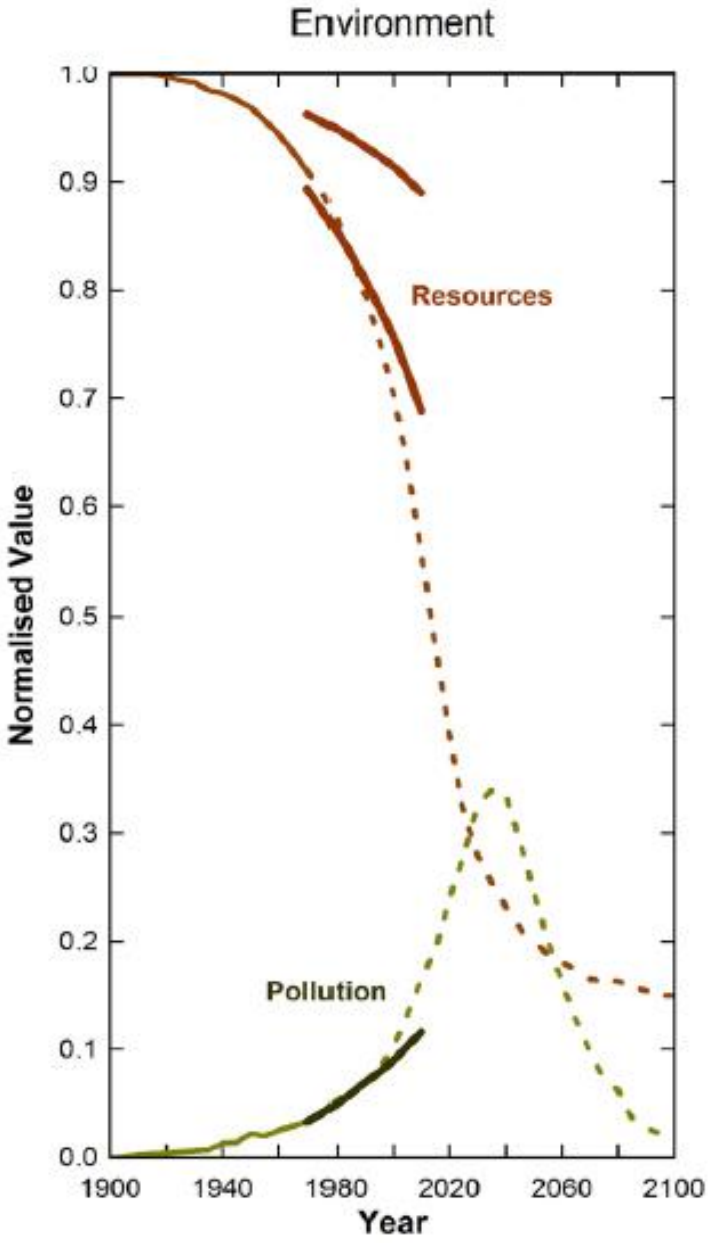
Anyone who believes in indefinite growth of anything physical on a physically finite planet is either a madman or an economist. (Kenneth Boulding, economist and President Kennedy's Environmental Advisor)

- Dr Mike Joy, The Morgan Foundation Senior Research Fellow in Freshwater Ecology
- Te Herenga Waka—Victoria University of Wellington

Biophysical limits to growth; the degrowth imperative



- Huge changes are coming, we will instigate a degrowth framework or have disaster, apologies I'm going to talk more about why we can’t continue with BAU than how planned degrowth will work.
- There is a huge industry determined to keep business as usual and make sure we don’t get the reality.
- Very very few people are talking about the reality, despite all the highly paid so called leaders it takes someone like Greta to be a true leader and show the way.
- The new world will be one with much less consumption but that is NOT a bad thing and will be much better for all.


Environment
Resources
Pollution
Normalised Value
Year
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
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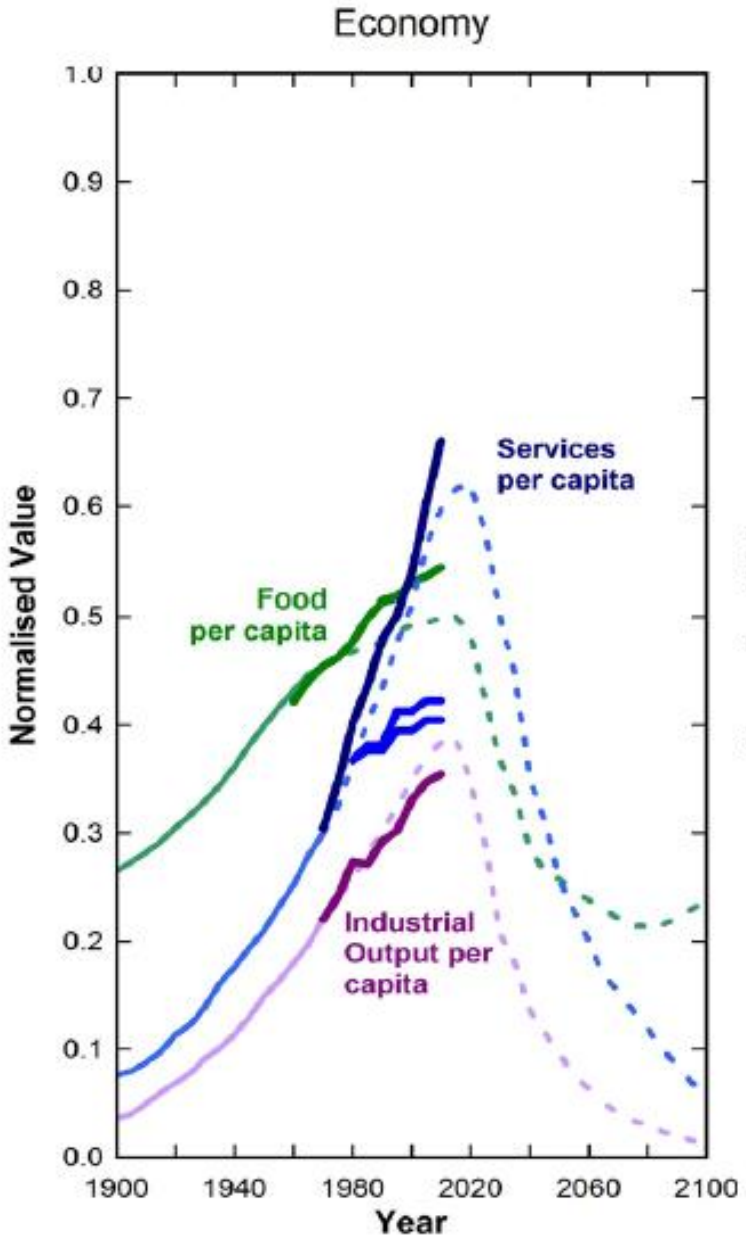
0.1
0.0
1900
1940
1980
2020
2060
2100


Economy
Services
per capita
Food
per capita
Industrial
Output per
capita
Normalised Value
Year
1.0
0.9
0.8
0.7
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0.5
0.4
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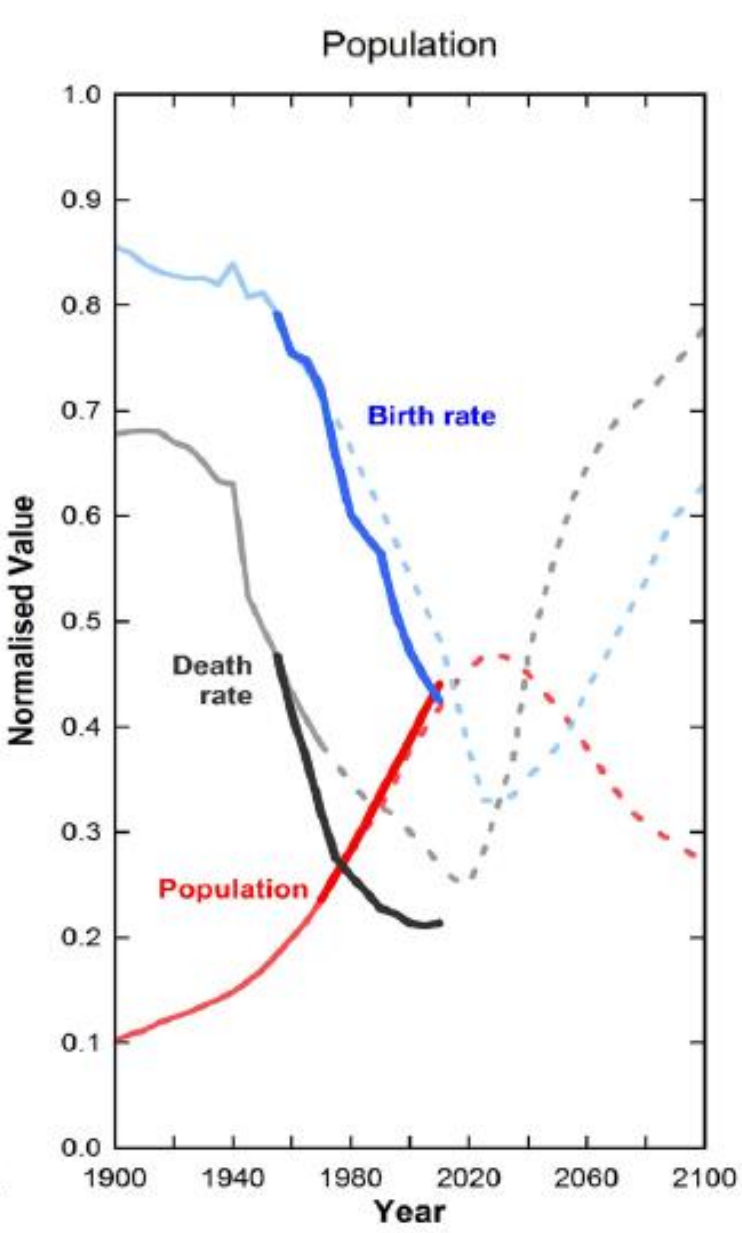
1900
1940
1980
2020
2060
2100


Population
Birth rate
Death
rate
Population
Normalised Value
Year
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1900
1940
1980
2020
2060
2100

73

0 by

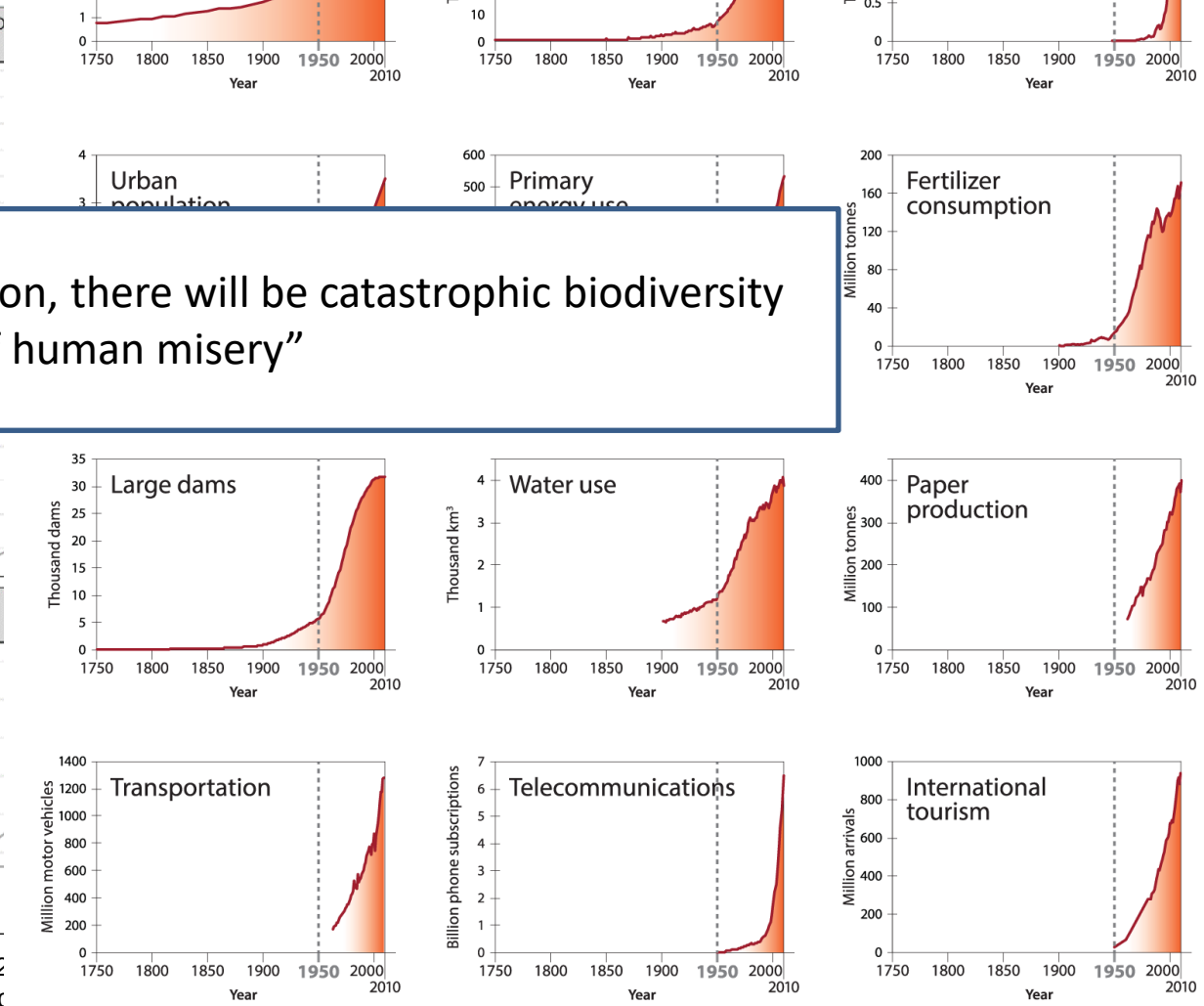
Manifestation of exceeding “Li

20,000 scientists give dire warning about the future in 'letter to humanity' – and the world is listening

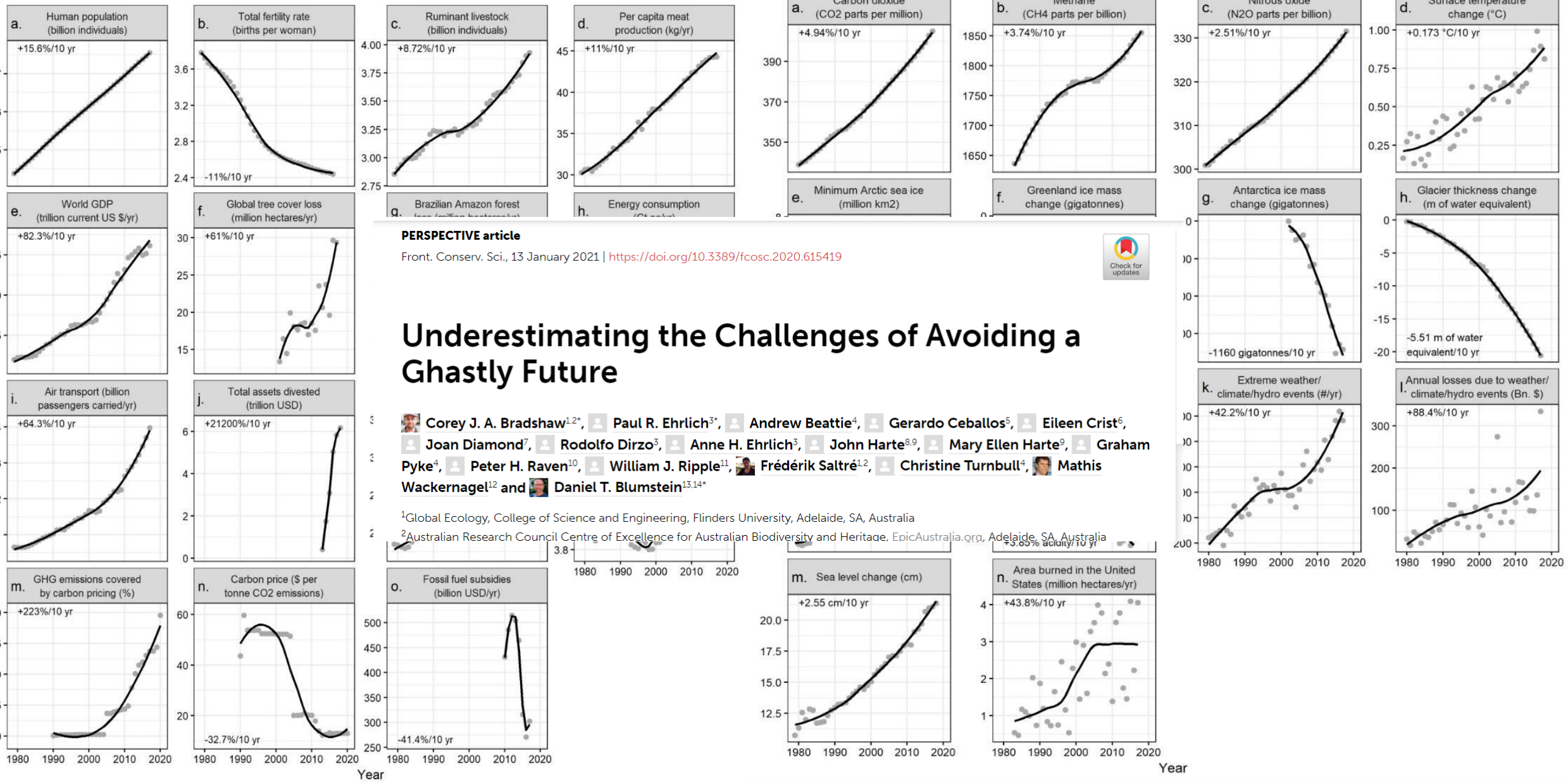
The paper is now one of the most discussed scient
experts

Trevor Nace Contribut
Science

“If the world doesn't act soon, there will be catastrophic biodiversity loss and untold amounts of human misery”



From: World Scientists’ Warning to Humanity: A Second Notice BioScience. 2
by Oxford University Press on behalf of the American Institute of Biological Sc



PERSPECTIVE article

Front. Conserv. Sci., 13 January 2021 | https://doi.org/10.3389/fcosc.2020.615419

Underestimating the Challenges of Avoiding a Ghastly Future

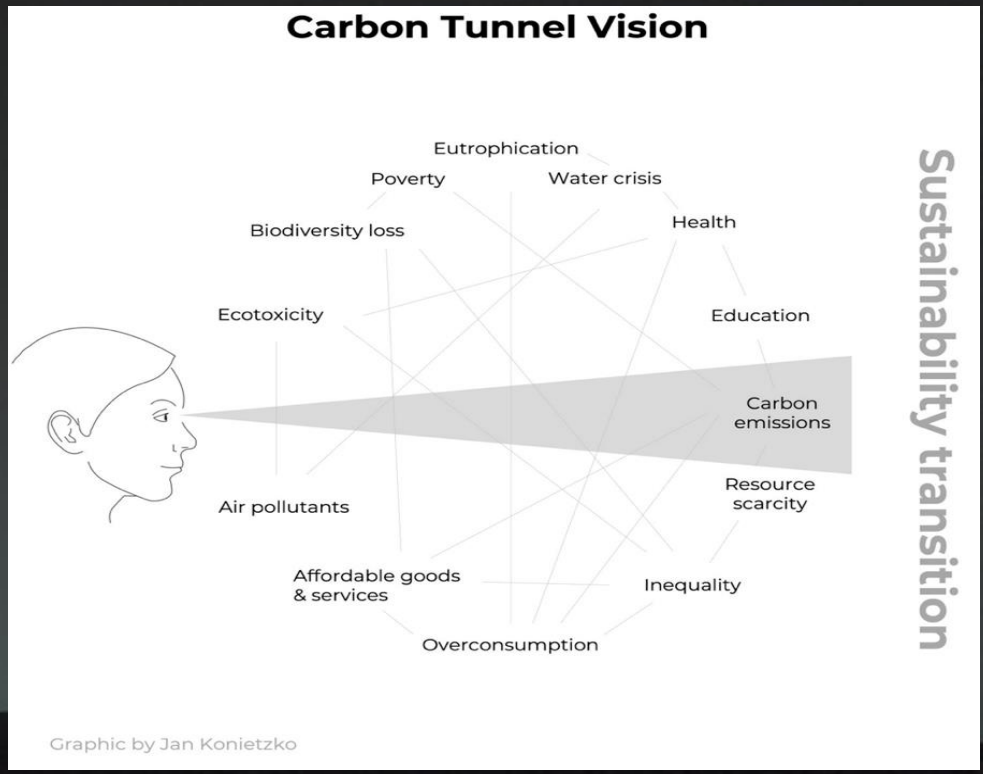
Corey J. A. Bradshaw[1,2*], Paul R. Ehrlich[3*], Andrew Beattie[4], Gerardo Ceballos[5], Eileen Crist[6], Joan Diamond[7], Rodolfo Dirzo[3], Anne H. Ehrlich[3], John Harte[8,9], Mary Ellen Harte[9], Graham Pyke[4], Peter H. Raven[10], William J. Ripple[11], Frédérik Saltré[1,2], Christine Turnbull[4], Mathis Wackernagel[12] and Daniel T. Blumstein[13,14*]

[1]Global Ecology, College of Science and Engineering, Flinders University, Adelaide, SA, Australia

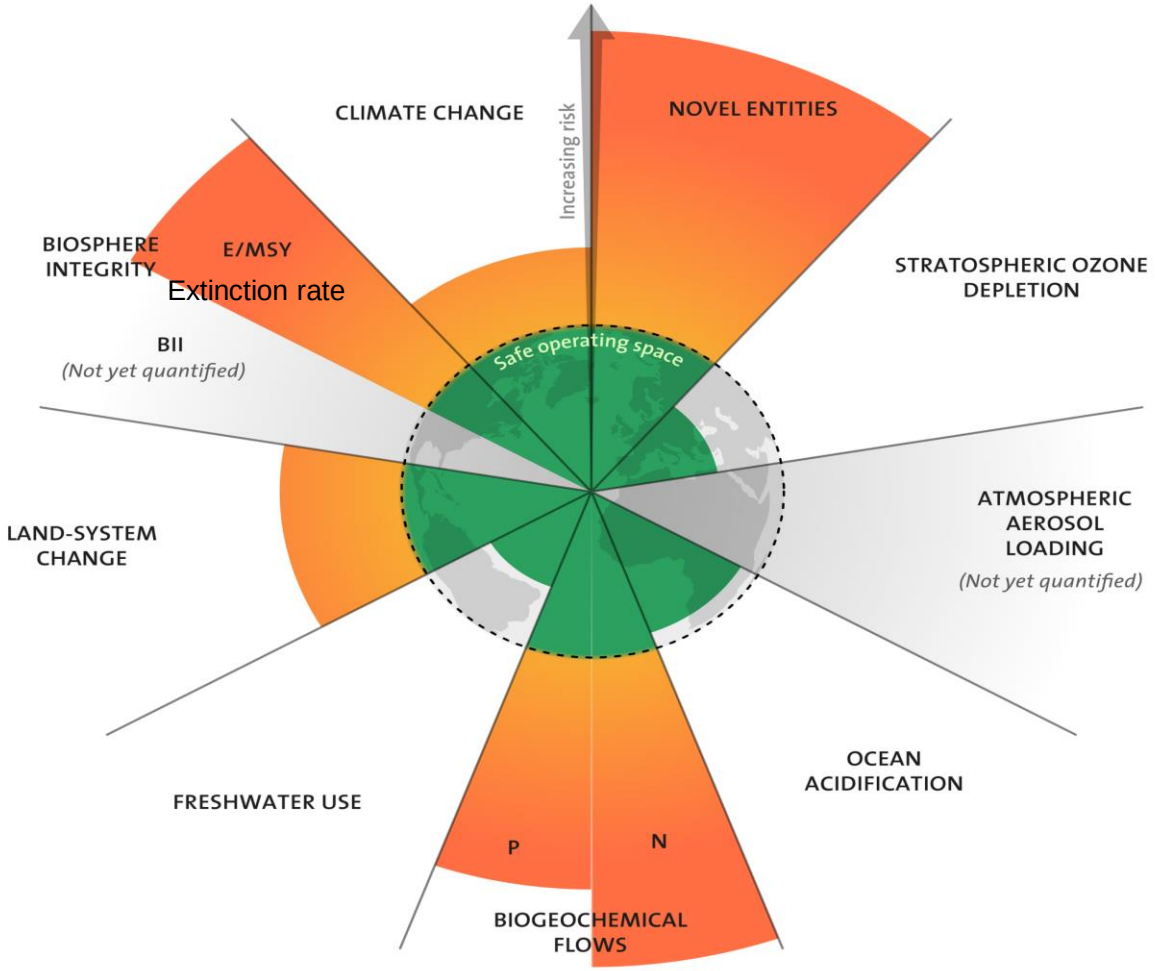
[2]Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage, EpicAustralia.org, Adelaide, SA, Australia

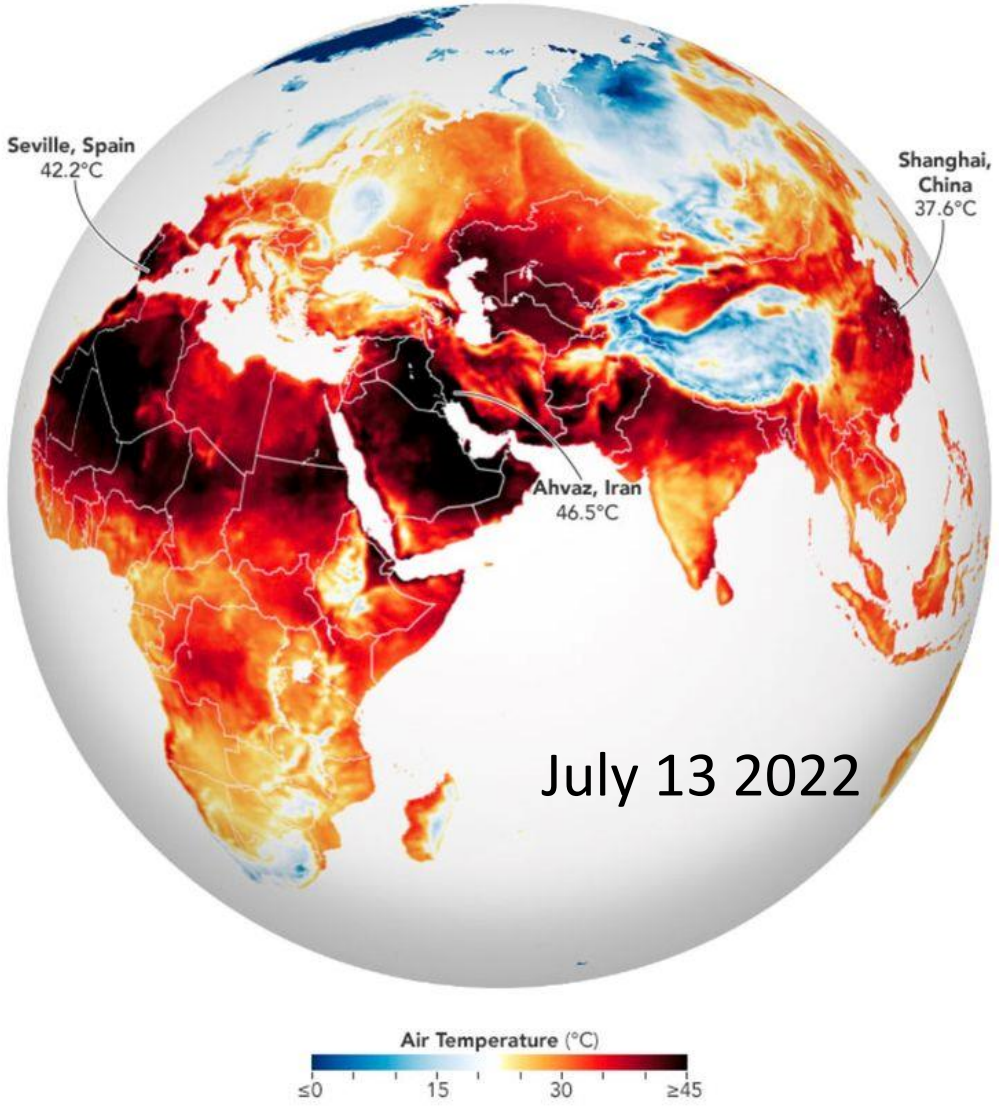
Manifestation of reaching “Limits to growth”

- Soil erosion
- Soil degradation
- Groundwater depletion
- Deforestation
- Invasive species
- Biodiversity crash
- Ozone depletion
- Fisheries collapse
- Eutrophication
- Overpopulation
- Ocean acidification
- Nuclear waste
- Phosphate depletion
- Carrying capacity overshoot
- land-use change
- Decaying infrastructure.



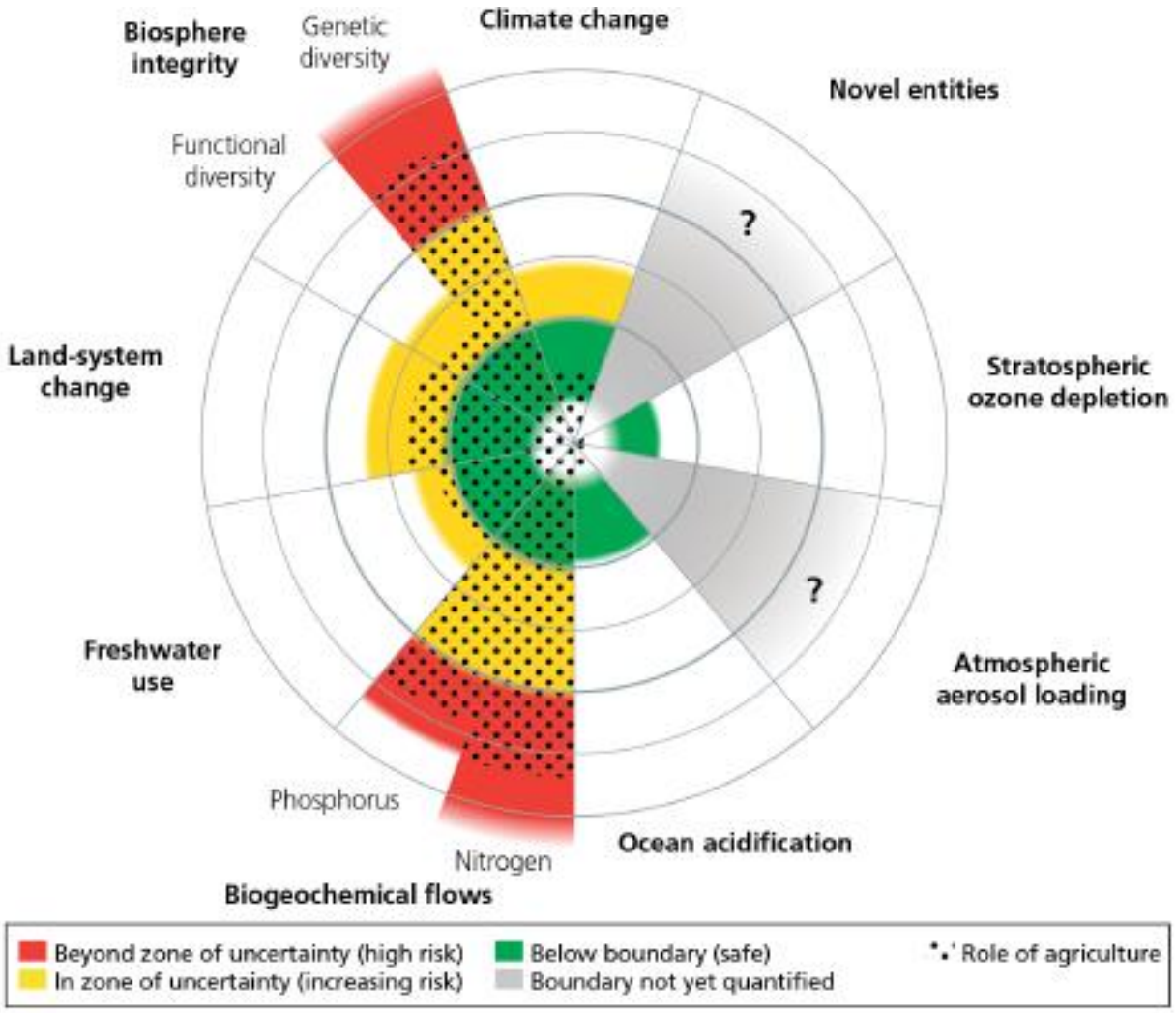
Manifestation of “Limits to growth” global heating



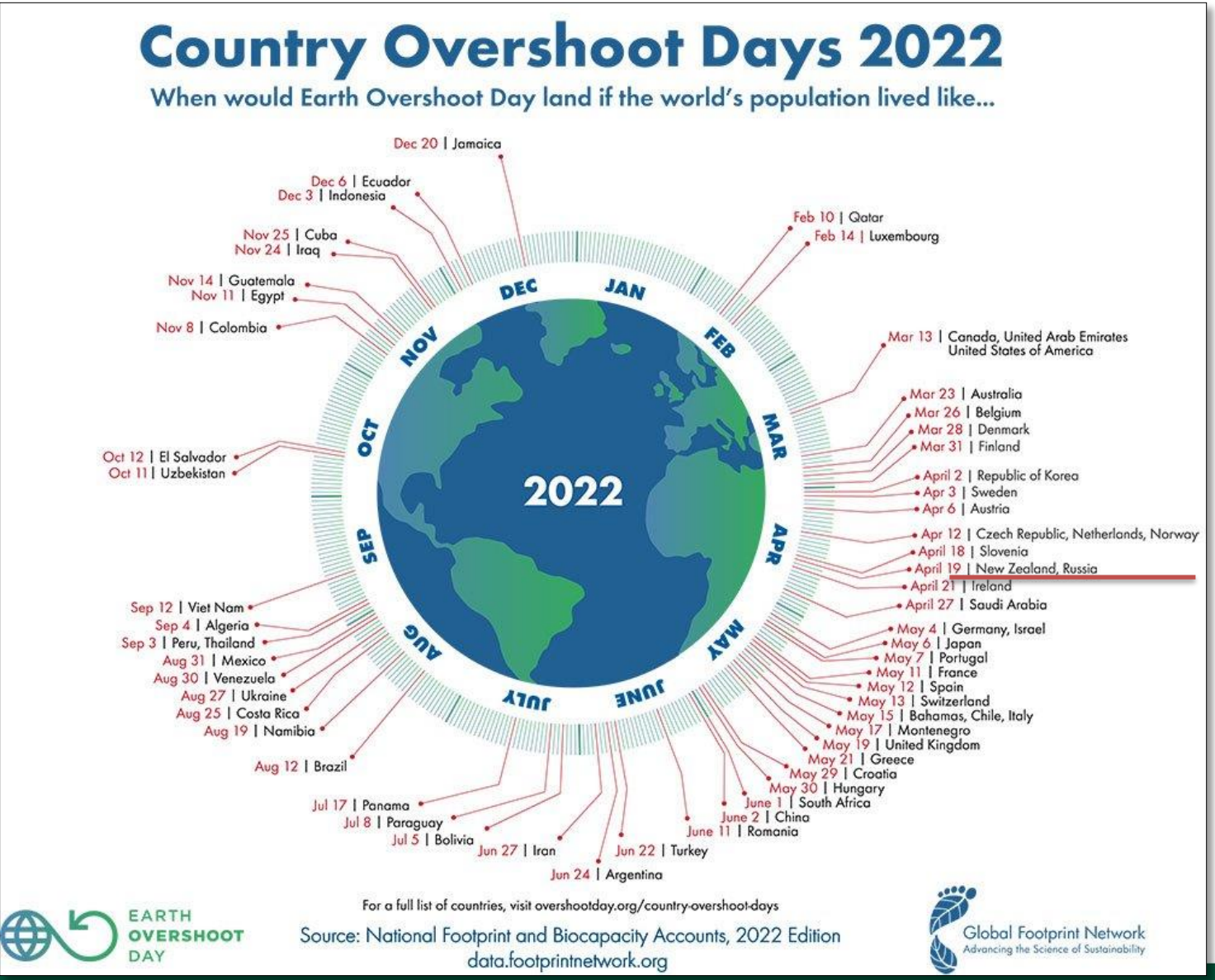


Manifestation of “Limits to growth” the living world

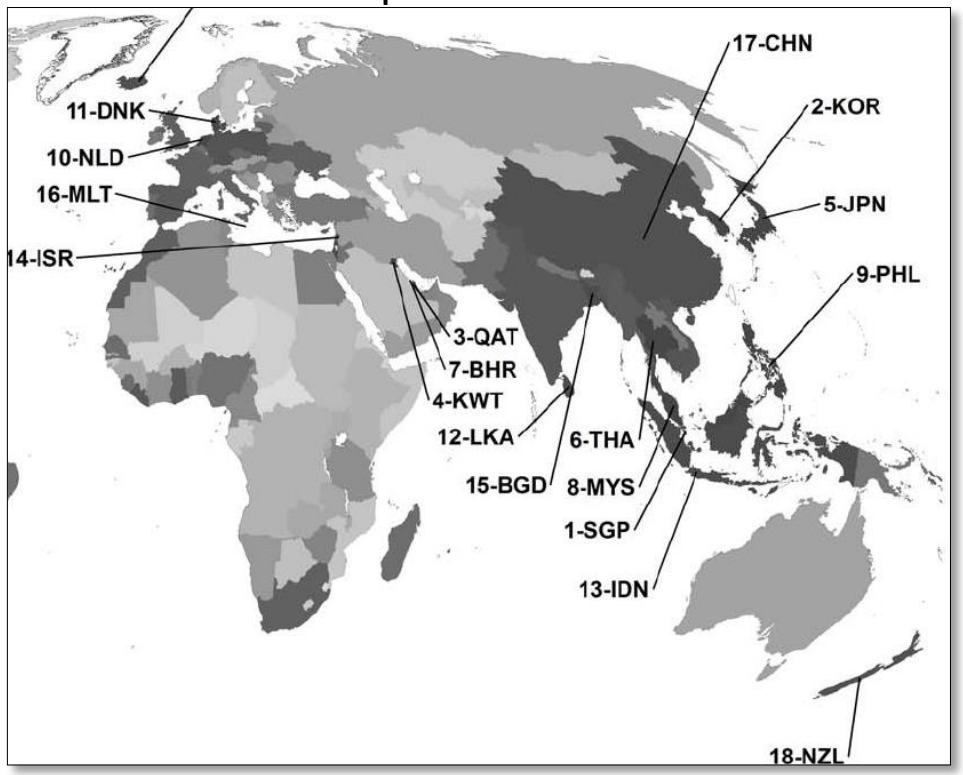
- Planetary boundaries exceeded
- Food production ever more dependent on fossil fuels, Agriculture, aquaculture, fishing and forestry (AAFF) 43% fossil fuels in 1970 - 62% now
- AAFF currently 68% of earths terrestrial surface
- 22% of GHG emissions (2010)
- https://link.springer.com/article/10.1007/s41247-020-00074-3
- In the last 2 decades animal-based food products contributed ~95% of the global increase in food GHG emissions.
- https://www.nature.com/articles/s43016-023-00768-z#citeas



Manifestation of “Limits to growth” New Zealand



Environmental performance indicators NZ



Twenty worst-ranked countries by proportional composite environmental (pENV) rank

OPEN ACCESS Freely available online

PLoS one

Evaluating the Relative Environmental Impact of Countries

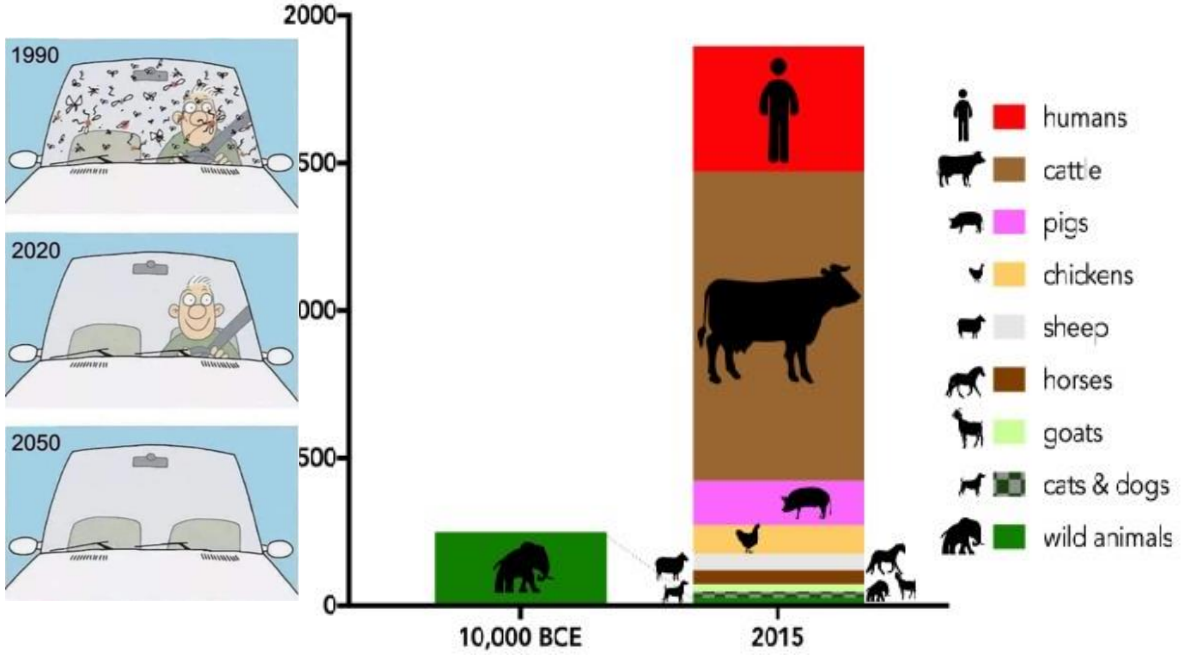
Manifestation of “Limits to growth” the living world

- Vertebrate animal communities shrunk on average 68 percent between 1970 and 2016, now just 3% of global vertebrate biomass (the rest us and what we eat)
- Tropical Americas animal populations declined 94 percent
- Animal communities in or near freshwater globally have fallen by 84 percent

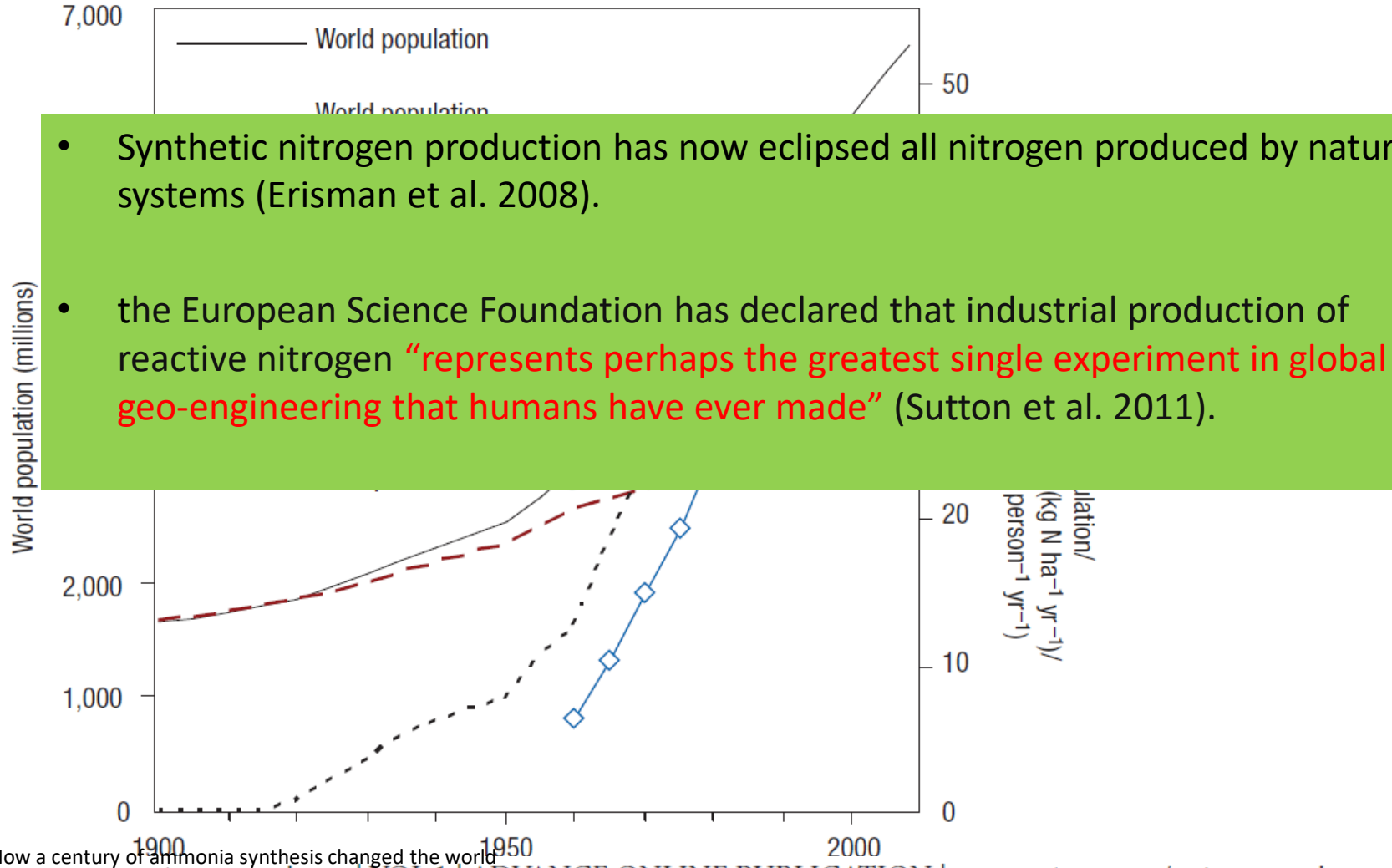
Humans too

- 6.4 billion ppl live on countries exposed to medium or high ecological threats (worst are in Sub-Saharan Africa)

- More than 2.6 billion ppl live in the 46 countries with high or extreme water stress. (don’t receive enough water to meet needs)



The green (or fossil fuel) revolution? The industrialisation of food production



- Synthetic nitrogen production has now eclipsed all nitrogen produced by natural systems (Erisman et al. 2008).
- the European Science Foundation has declared that industrial production of reactive nitrogen "represents perhaps the greatest single experiment in global geo-engineering that humans have ever made" (Sutton et al. 2011).

How a century of ammonia synthesis changed the world

Overdose for some not enough for others and energy loss

- But ~ s, while 2.1 billion highly proce nd meats.
  - Fo liser - in n 10 - 33 units of nsport, refine, pa energy to be ea nd the globe
  - Producing 1 calorie food in USA uses 21 calories of fossil energy

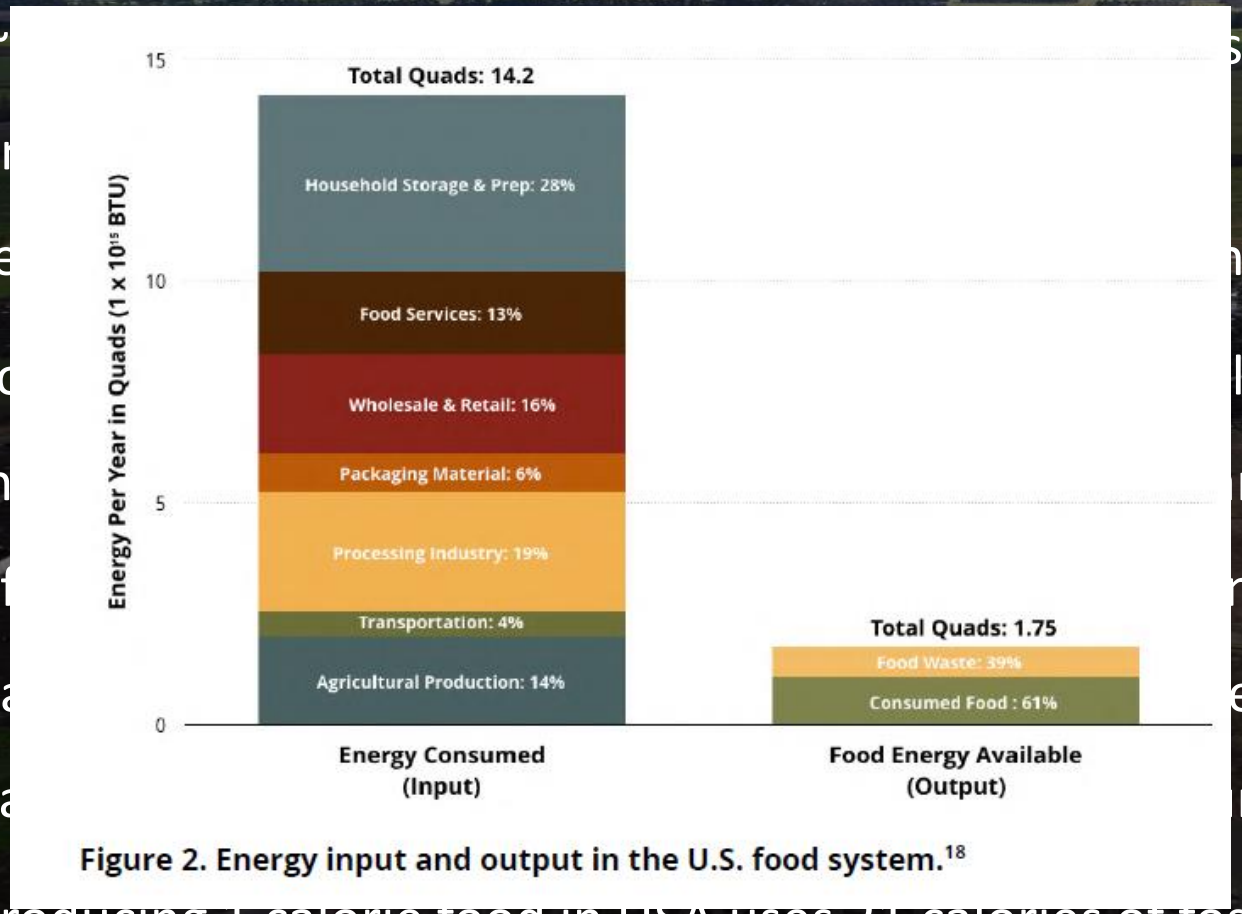
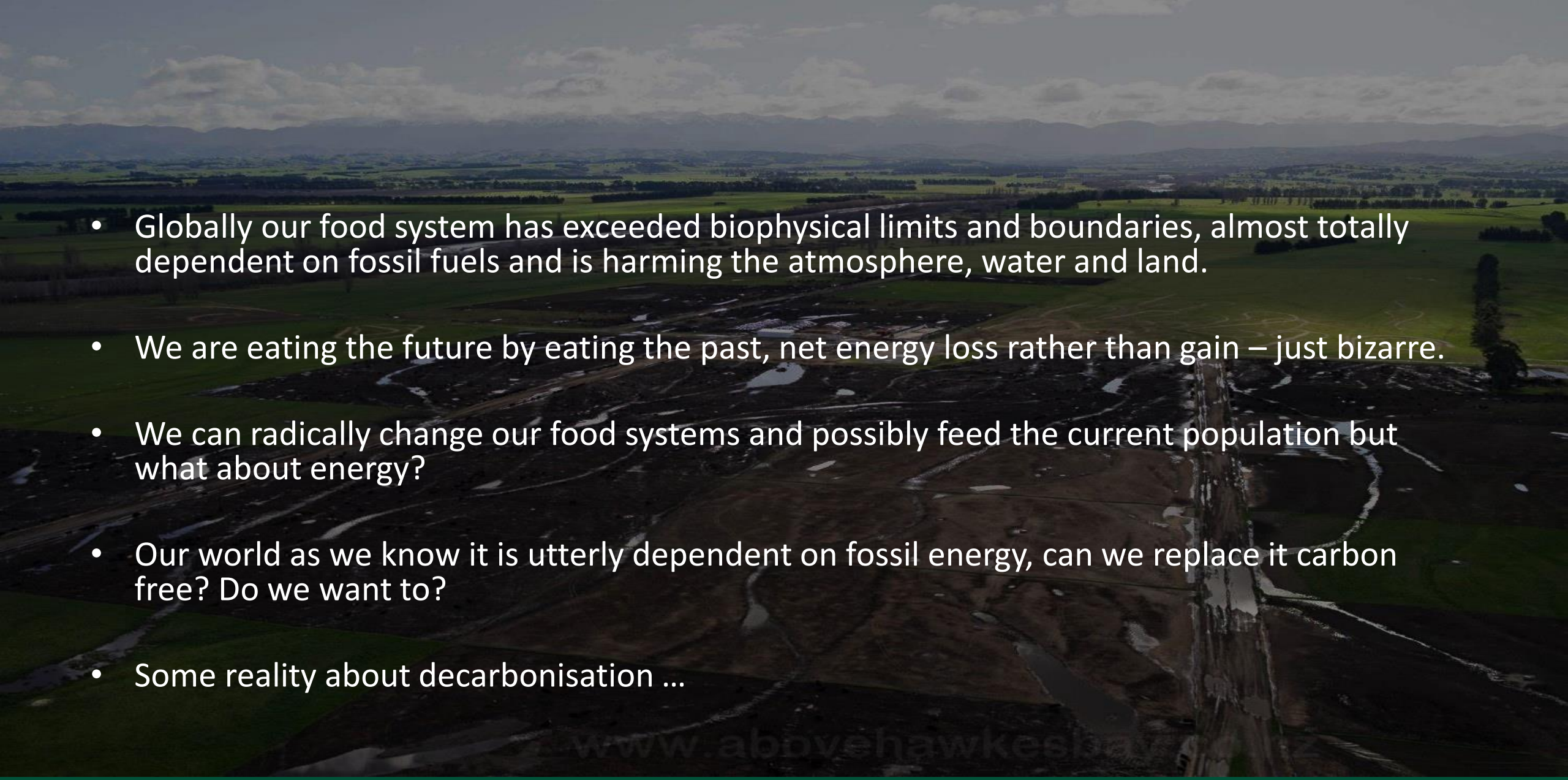


Figure 2. Energy input and output in the U.S. food system.[18]



- Globally our food system has exceeded biophysical limits and boundaries, almost totally dependent on fossil fuels and is harming the atmosphere, water and land.
- We are eating the future by eating the past, net energy loss rather than gain – just bizarre.
- We can radically change our food systems and possibly feed the current population but what about energy?
- Our world as we know it is utterly dependent on fossil energy, can we replace it carbon free? Do we want to?
- Some reality about decarbonisation …

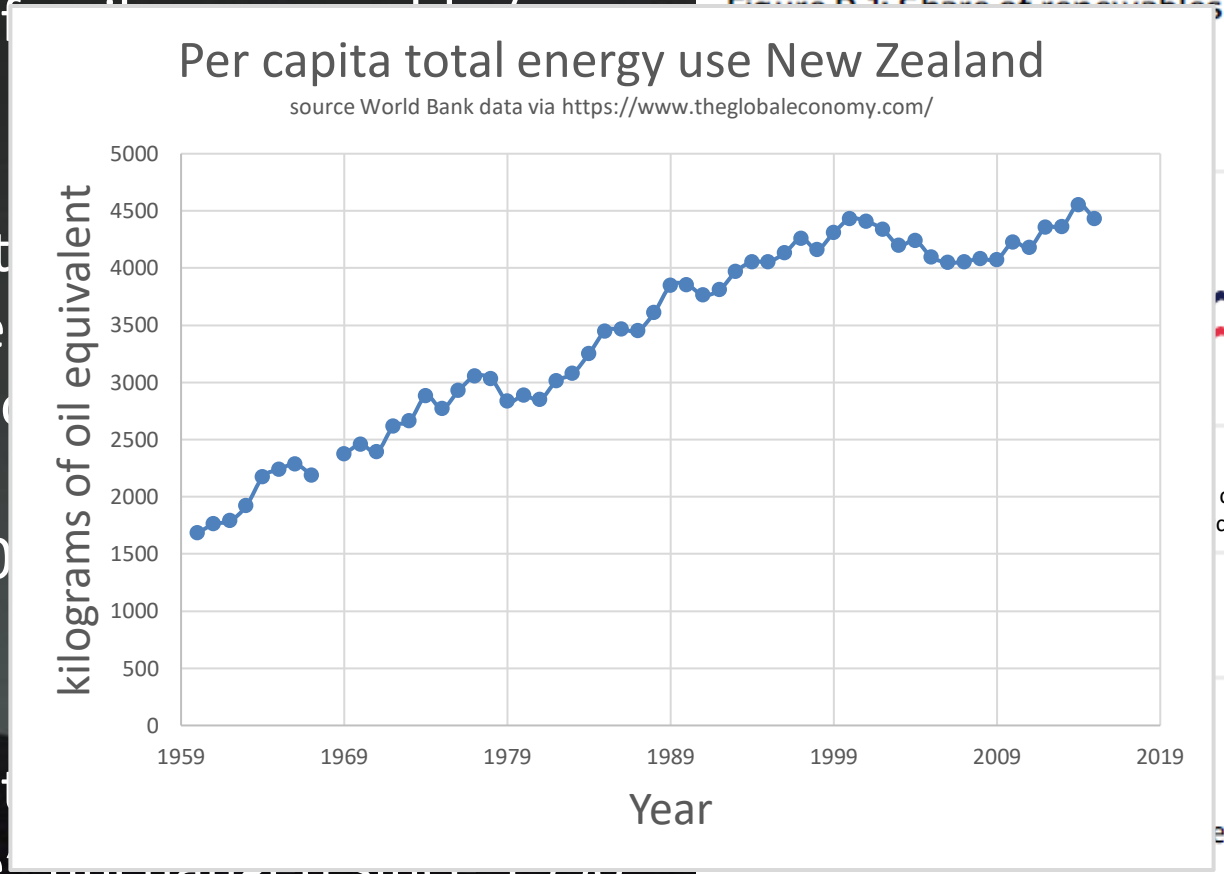
Ok so how is our transition to a zero carbon world coming along?

Energy use f
capita)

Despite all t
have less re
proportion

But NZ is 80

Um NO!!
29% of our t
"renewable" unchanged since 1990



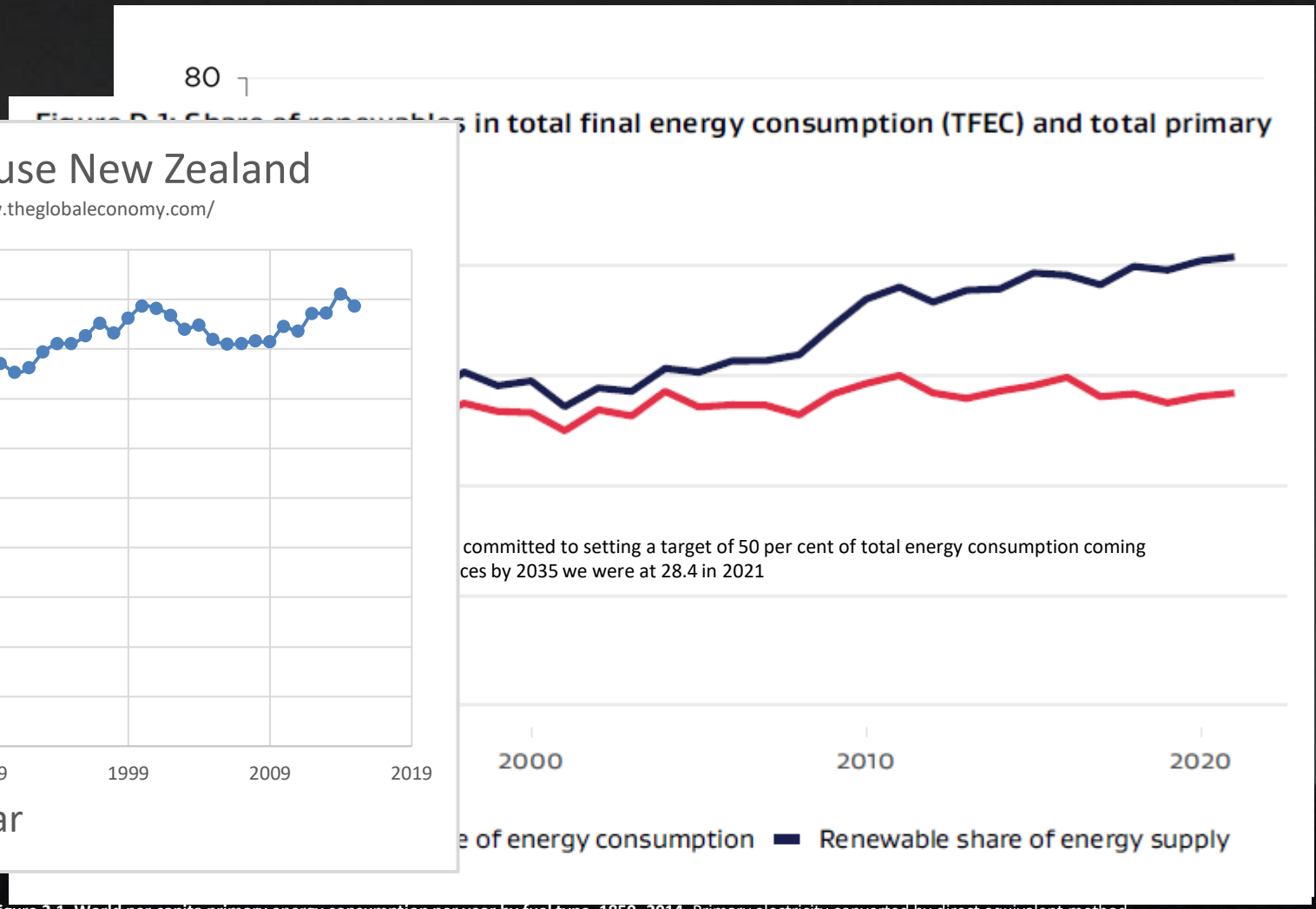


Figure 2.1. World per capita primary energy consumption per year by fuel type, 1850–2014. Primary electricity converted by direct equivalent method.
Source: Data compiled by J. David Hughes from Arnulf Grubler, "Technology and Global Change: Data Appendix," (1998), and BP, *Statistical Review of World Energy*, (annual

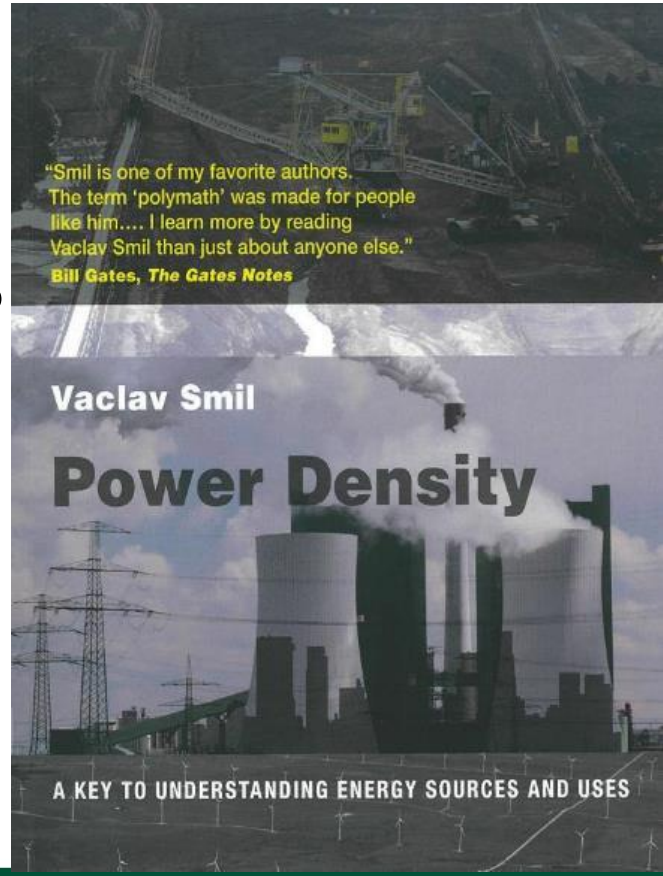
How do we transition to this decarbonised world?

Historic energy transitions …

Biomass → coal → hydrocarbons → ?

Can we move to a world without fossil fuels that looks a lot like today?

One crucial issue to understand is power density



The transition to a decarbonised world

Energy density of different energy options

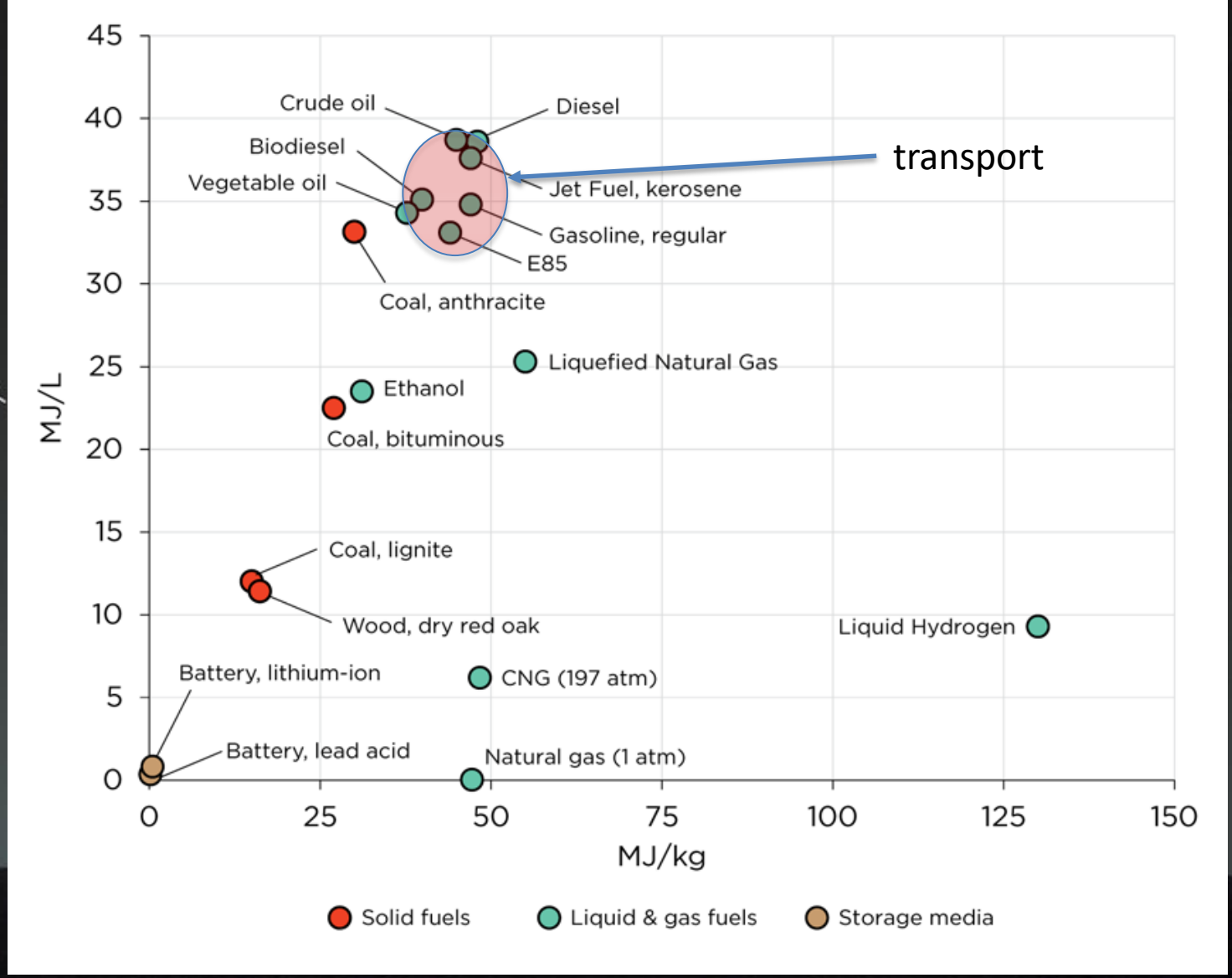


Figure 1.3. Volumetric and gravimetric density of fuels and storage media.
Sources: Coal: Tadeusz Patzek and Gregory Croft, "A Global Coal Production Forecast with Multi-Hubbert Cycle Analysis," *Energy* 35 (2010): 3111. Natural gas. Crude oil and wood. Batteries and additional batteries. All others: Charles Hall and Kent Klitgaard, *Energy and the Wealth of Nations: Understanding the Biophysical Economy* (New York: Springer, 2012).

Energy 101

Converting our energy use to human worker equivalents to make it understandable

- In 2018 the global economy ran on 17 trillion watts of energy 80% of this was from oil which is equivalent to 500 billion human workers (c.f. ~ 4 billion real workers)

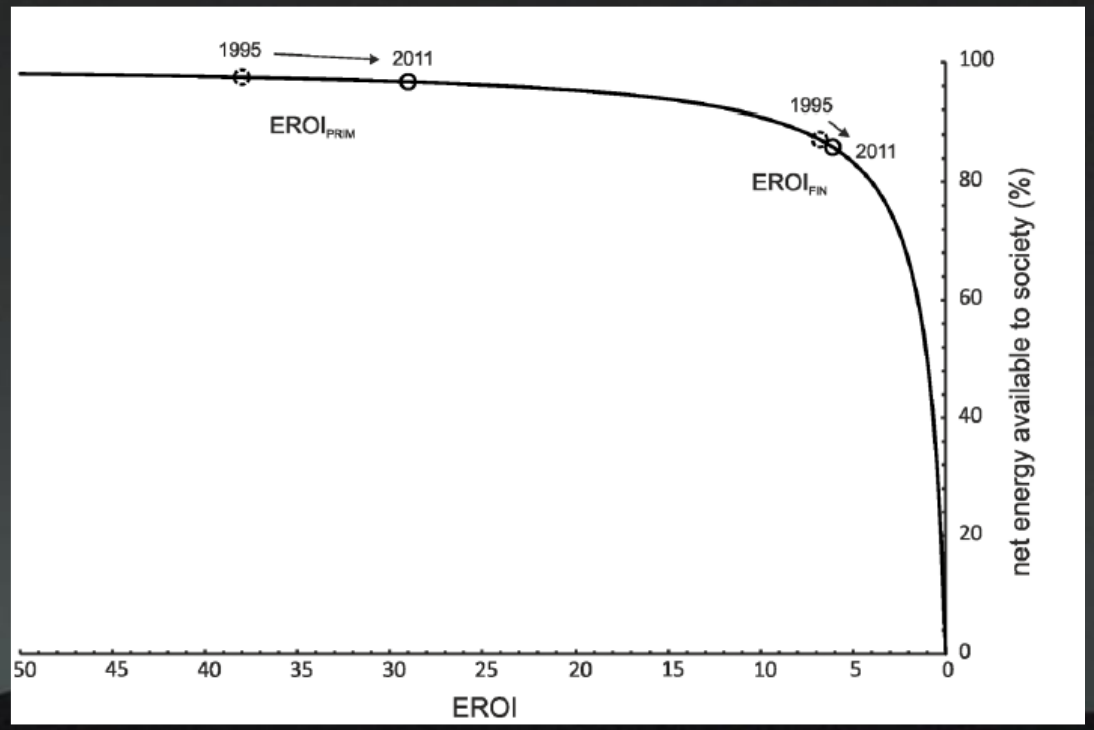
- That is 70 for every human on planet but many humans have none ~ 200 energy slaves for each one of us in wealthy world (and we pay them ~ 1 cent/hr

- We must very rapidly transition away from fossil fuels

Net Energy reality

EROEI (Energy Return On Energy Invested) can be thought of like fitness (Darwin) and must be applied to energy as well.

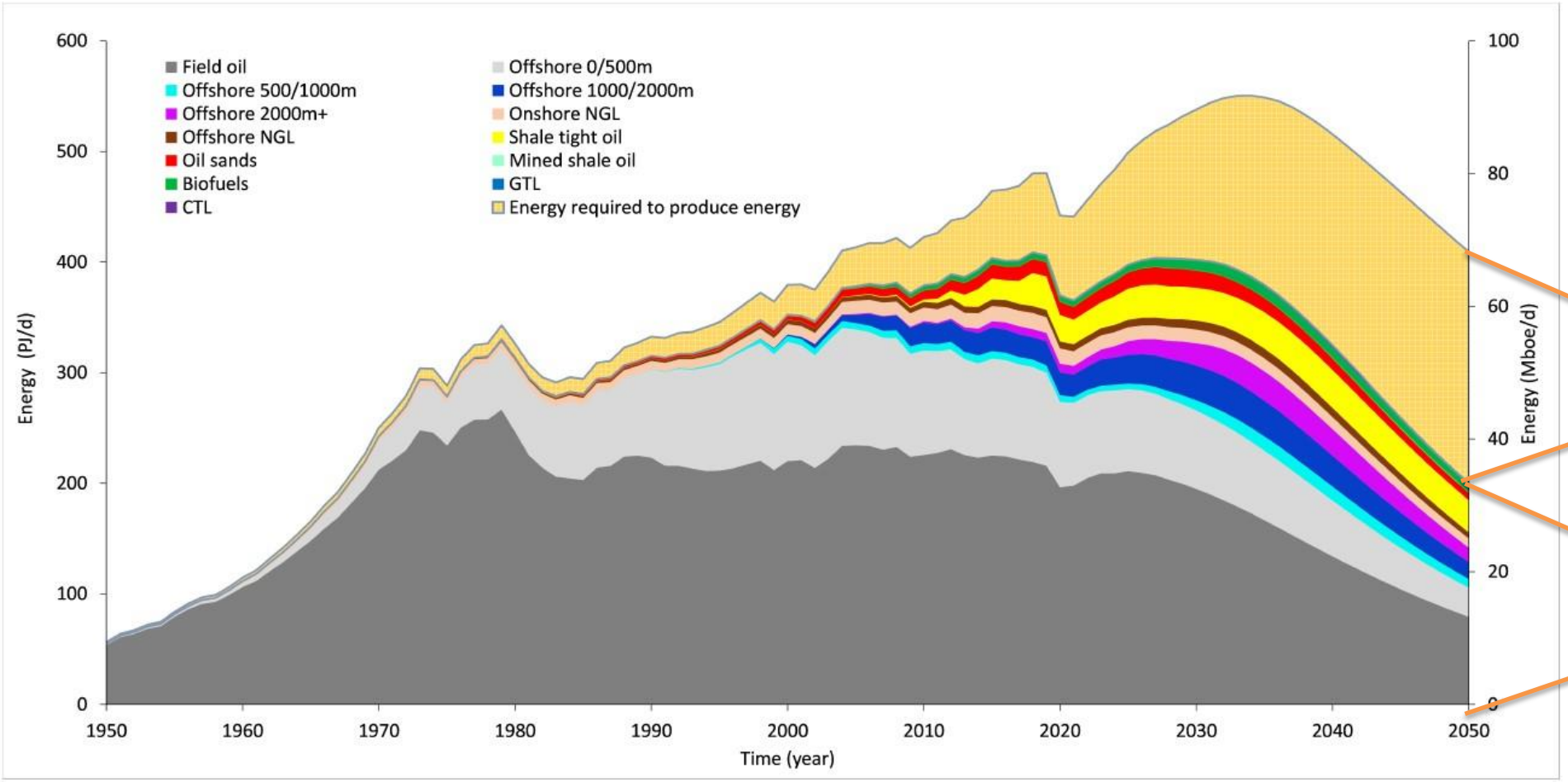
Fossil energy EROI is declining fast



Brockway, P. E., A. Owen, L. I. Brand-Correa, and L. Hardt. 2019. Estimation of global final-stage energy-return-on-investment for fossil fuels with comparison to renewable energy sources. Nature Energy **4**:612-621.

Peak oil and the low-carbon energy transition: a net-energy perspective

Louis Delannoy,Pierre-Yves Longaretti,David J. Murphy,Emmanuel Prados



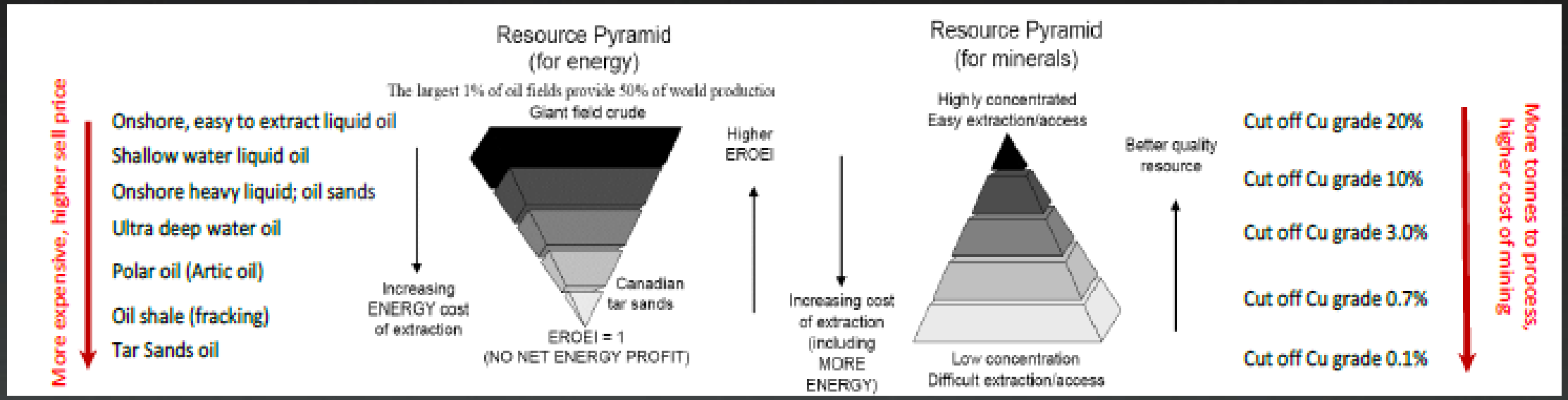
Energy required to produce energy

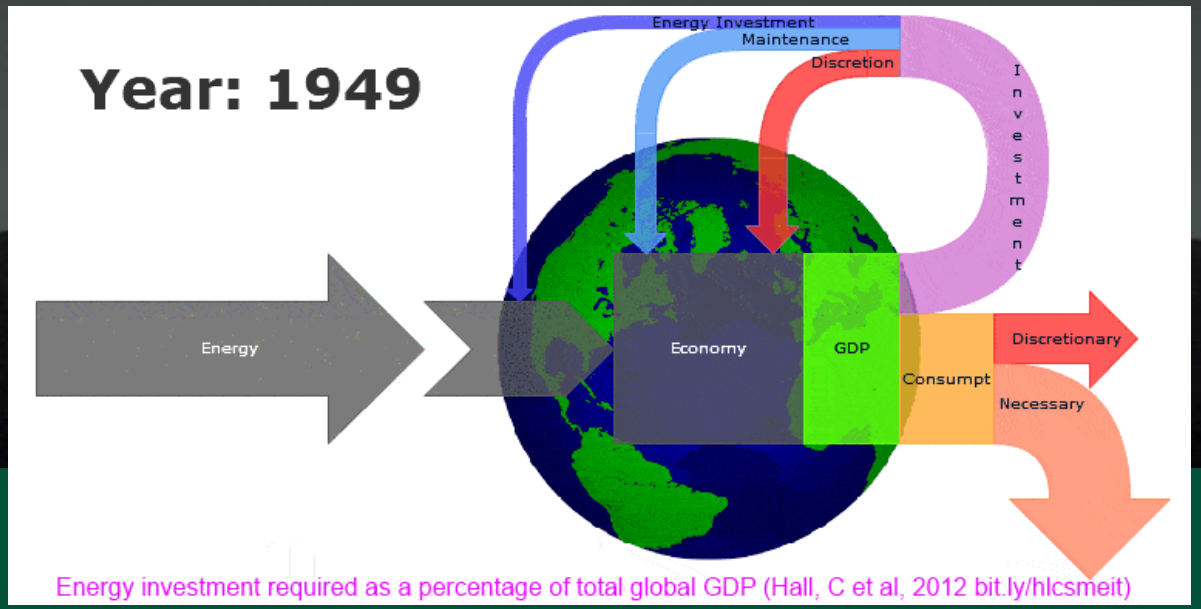
Energy available for use

Because all alternative energy systems are built with fossil fuels then their eroi will decline with fossil fuels

Louis Delannoy, Pierre-Yves Longaretti, David J. Murphy, Emmanuel Prados, Peak oil and the low-carbon energy transition: A net-energy perspective, Applied Energy, Volume 304, 2021, 117843, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2021.117843

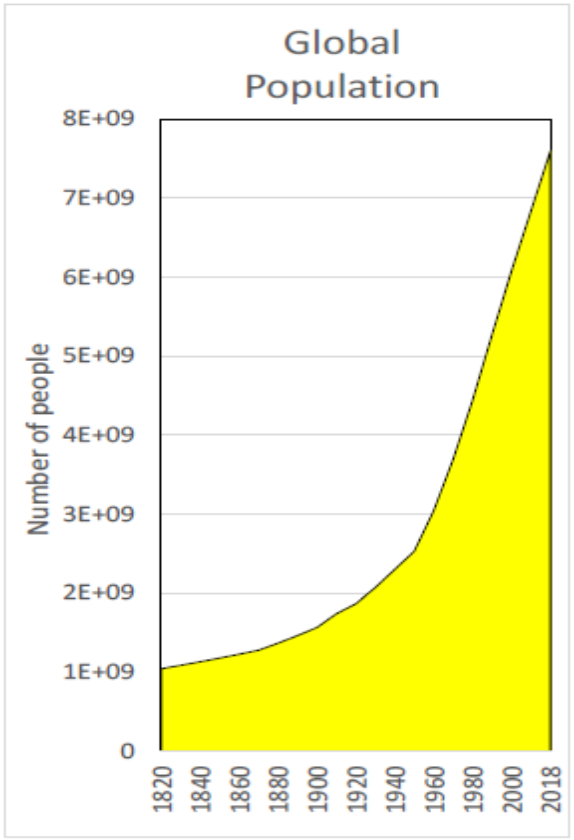
The physical limits to growth; the hardly ever mentioned resource pyramid conundrum multiplier for declining eroi net energy reduction



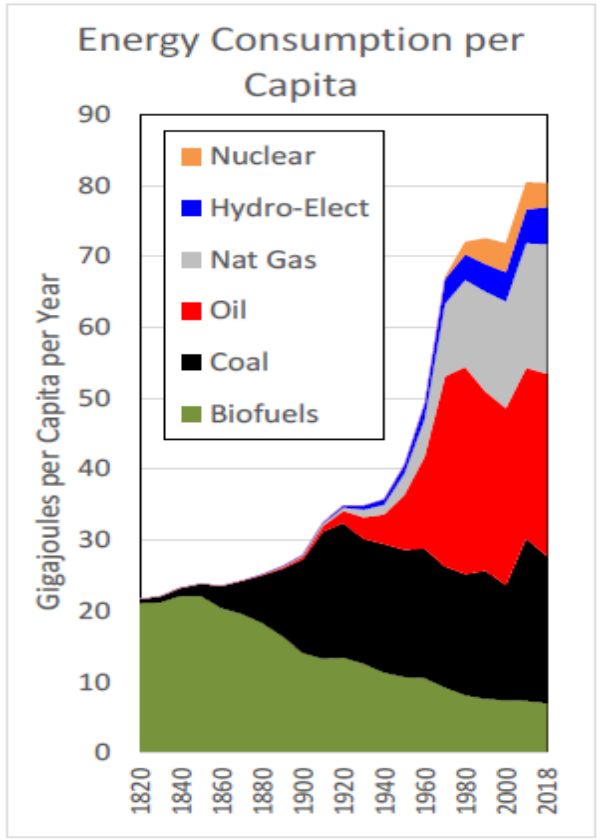


Energy investment required as a percentage of total global GDP (Hall, C et al, 2012 bit.ly/hlcsmeit)

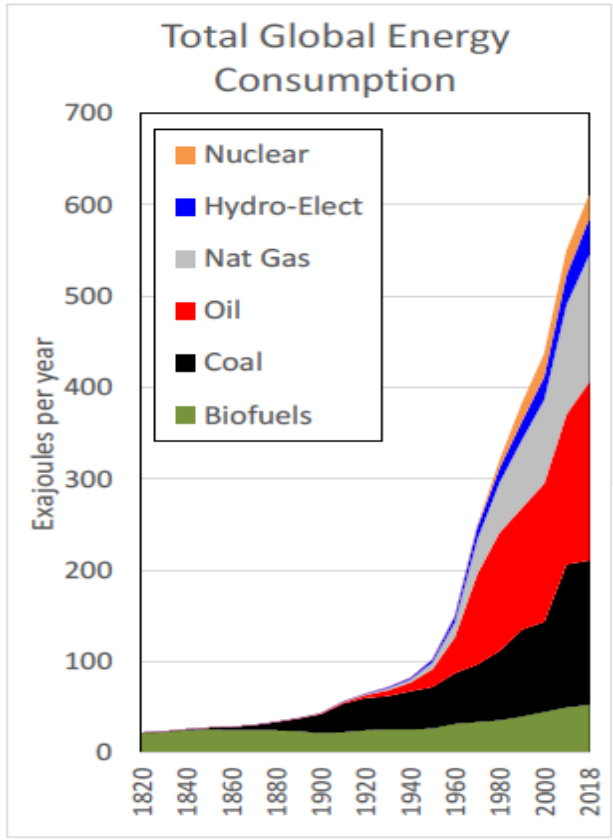
Myth: energy use declines as new technology leads to gains in efficiency –
Reality: we use ever more energy and materials



1820-2018
Population Growth x 7.3



1820-2018
Per Capita Growth x 3.7



1820-2018
Consumption Growth x 27.1

Use of material resources
- 10.5 Gigatonnes P/A in 1990
- 88.6 Gigatonnes P/A in 2017

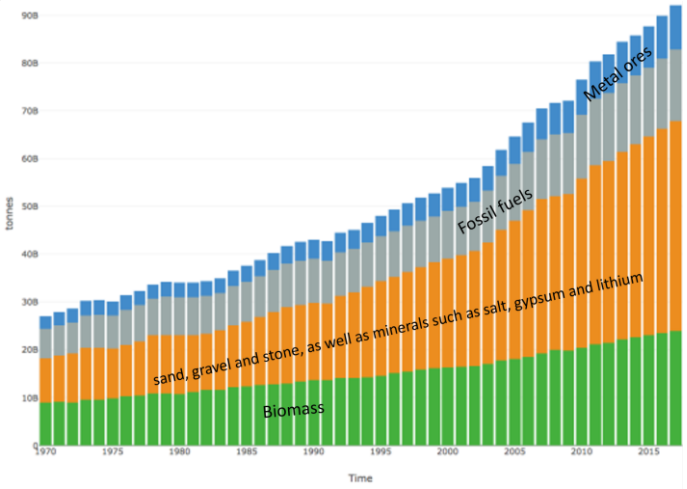
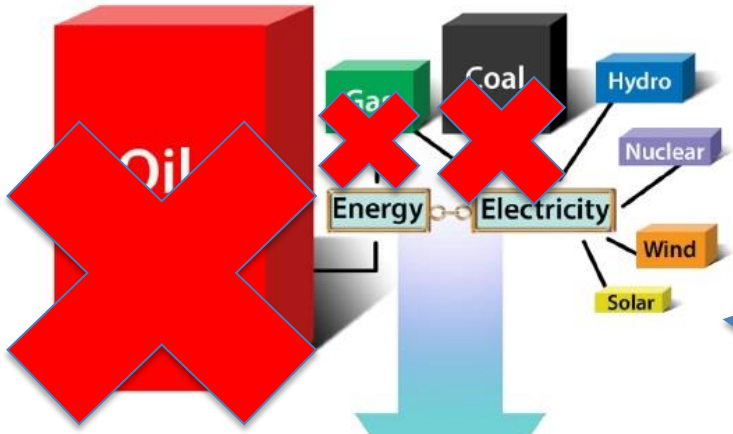


Figure 17. World population, per capita-, and total energy consumption, 1820-2018
(Source: Data from Tverberg, G. https://ourfiniteworld.com/, and BP Statistical Review of the World Energy 2019, US Census Bureau)



Most rivers that could be dammed are and very extensive biological and physical impacts plus methane emissions

Expensive, slow and unsolved waste issues

All dependent on fossil fuels

Big installation environmental and material footprint. Intermittent. Need rebuilding every few decades

Large material footprint. Intermittent. Need complete replacement every few decades

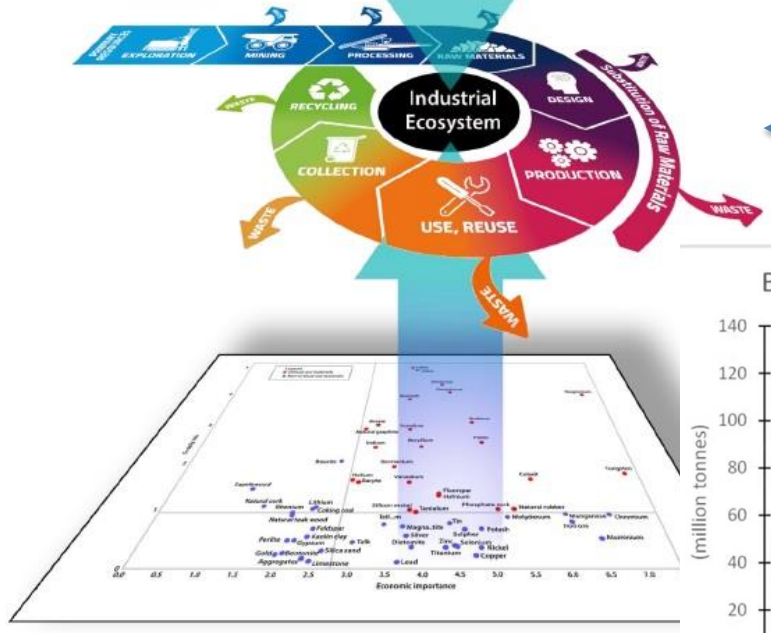
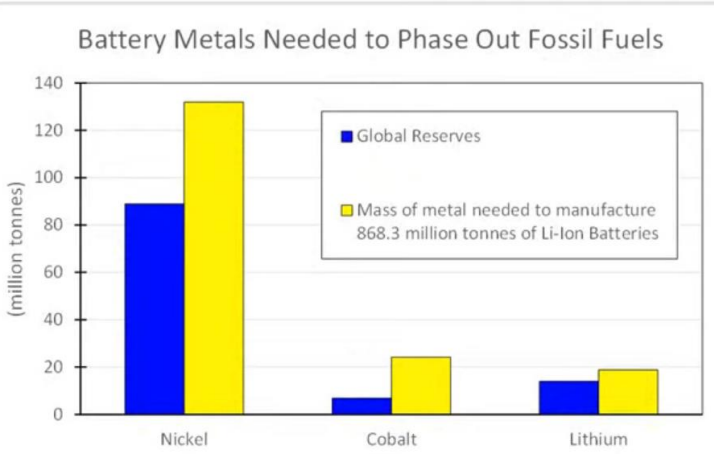


Figure 301. Proposed paradigm for the next generation of the Circular Econo
(Image: by Tania Michaux, EIT Raw Materials, and European Commission)

Circular economy



or negative

a very energy inefficient energy

discover another 7.13 DRC Congo cobalt deposits

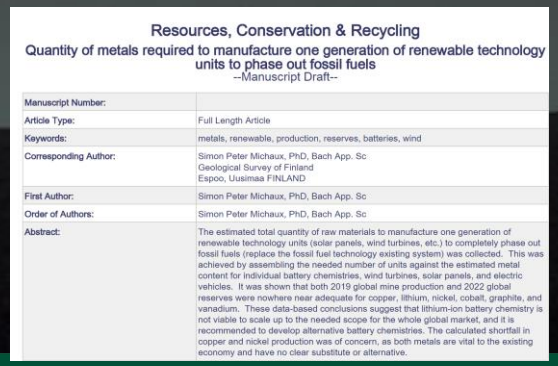
discover another 6.97 Australian lithium deposits

discover another 6.28 Indonesian nickel deposits

Energy limits and mineral and metal limits

Total metal requirement to produce one generation of technology units to phase out fossil fuels (tonnes)

- 2019 global mine production and 2022 global reserves were nowhere near adequate for copper, lithium, nickel, cobalt, graphite, and vanadium.
- E.g. Copper we would need 4,575,523,674 t – but only 19% of that amount exists.
- PLUS ore concentrations declining rapidly, every 1000 deposits discovered only 2 – 3 become working mines and takes 10 -15 years to develop…

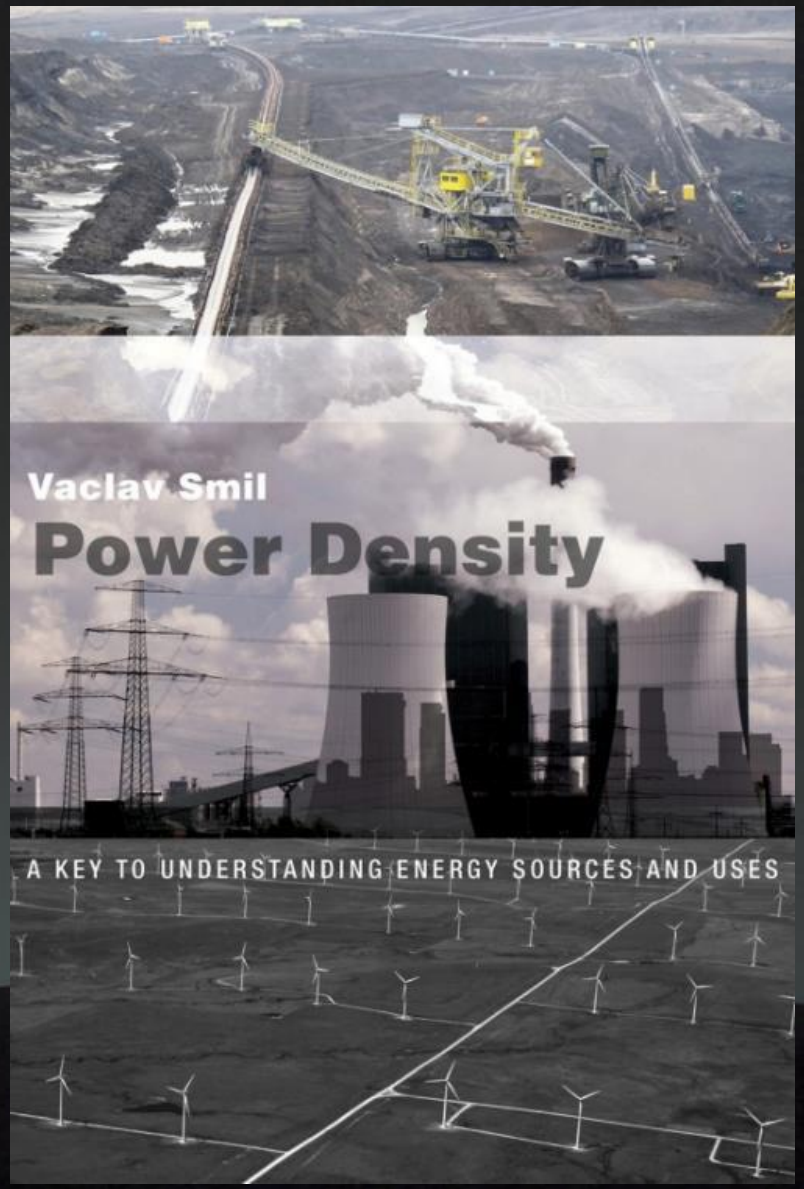


Resources, Conservation & Recycling

Quantity of metals required to manufacture one generation of renewable technology units to phase out fossil fuels

--Manuscript Draft--

Manuscript Number:	
Article Type:	Full Length Article
Keywords:	metals, renewable, production, reserves, batteries, wind
Corresponding Author:	Simon Peter Michaux, PhD, Bach App. Sc Geological Survey of Finland Espoo, Uusimaa FINLAND
First Author:	Simon Peter Michaux, PhD, Bach App. Sc
Order of Authors:	Simon Peter Michaux, PhD, Bach App. Sc
Abstract:	The estimated total quantity of raw materials to manufacture one generation of renewable technology units (solar panels, wind turbines, etc.) to completely phase out fossil fuels (replace the fossil fuel technology existing system) was collected. This was achieved by assembling the needed number of units against the estimated metal content for individual battery chemistries, wind turbines, solar panels, and electric vehicles. It was shown that both 2019 global mine production and 2022 global reserves were nowhere near adequate for copper, lithium, nickel, cobalt, graphite, and vanadium. These data-based conclusions suggest that lithium-ion battery chemistry is not viable to scale up to the needed scope for the whole global market, and it is recommended to develop alternative battery chemistries. The calculated shortfall in copper and nickel production was of concern, as both metals are vital to the existing economy and have no clear substitute or alternative.



Rebuildable (aka renewable energy) energy non-renewable mineral and metal reality … Green energy? Green hydrogen?

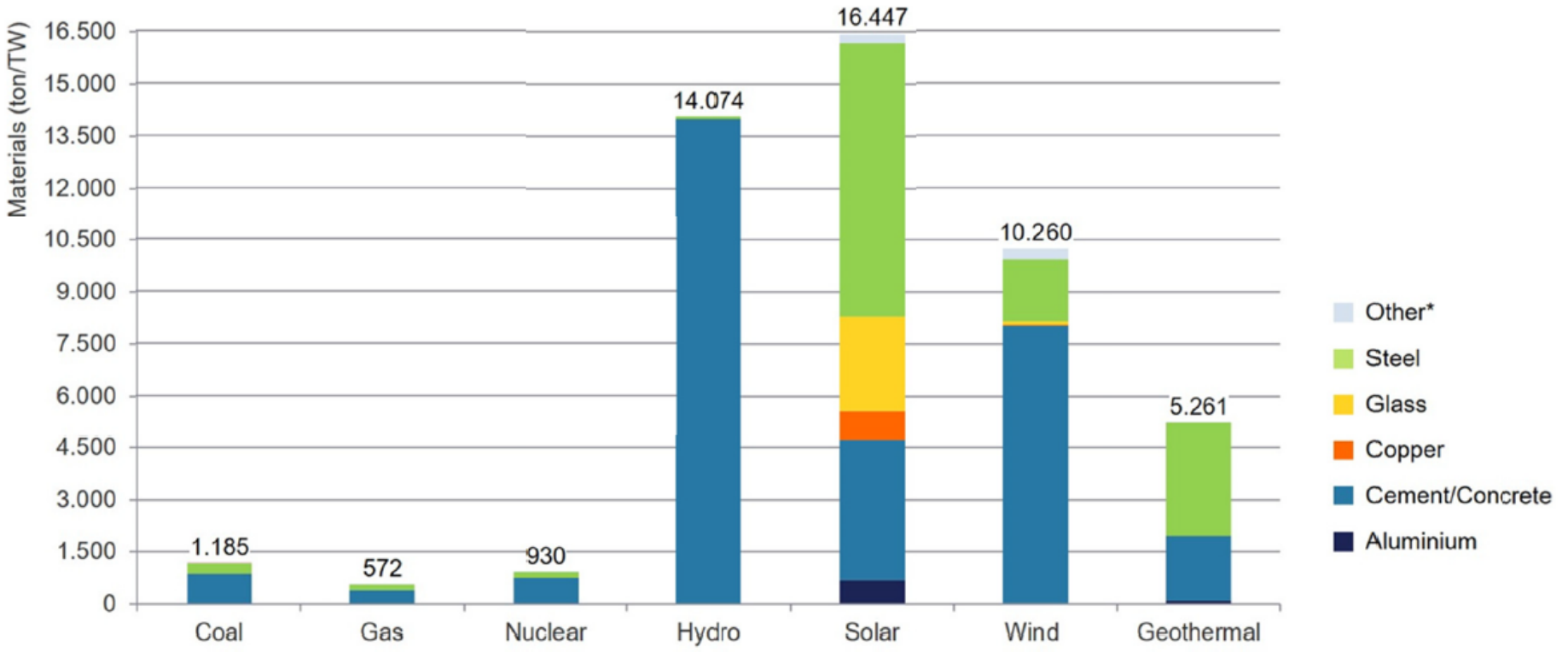


Figure 4. Base-material input per 1 TW generation

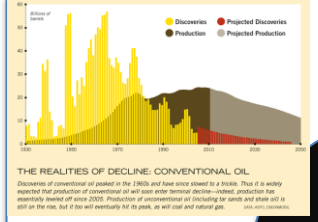
Note: Other includes iron, lead, plastic, and silicon

Source: Adapted from DOE, 2015, Table 10.4, p. 390.

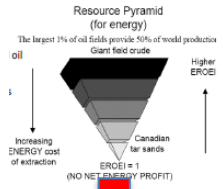
https://click.endnote.com/viewer?doi=10.5539%2Fjms.v12n1p96&token=WzI0MzU5NDgsIjEwLjU1Mzkvam1zLnYxMm4xcDk2Il0.ESQsDAYRHKrBE8sTPoBdSSHB6t4

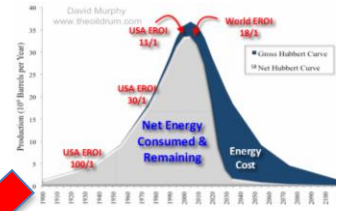
Zero carbon reality sum

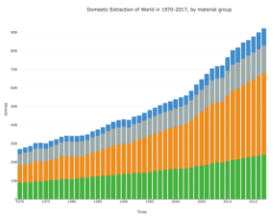
What if we discovered a free non harming energy source tomorrow would we be better off?

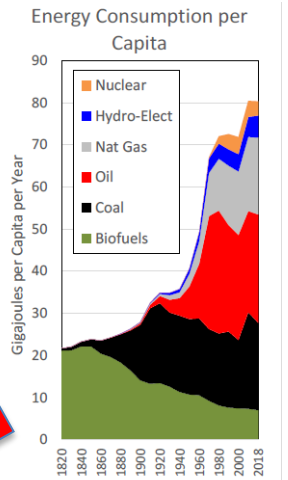


Peak oil



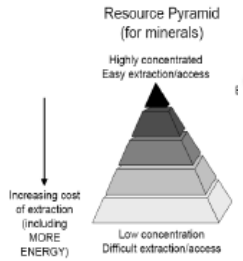






More effort required to get minerals

energy required



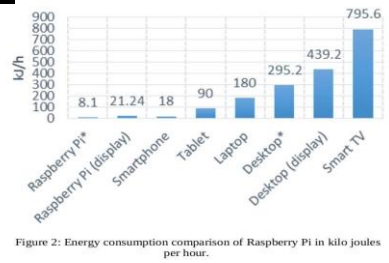


Figure 2: Energy consumption comparison of Raspberry Pi in kilo joules per hour.

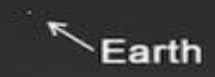
Carbon zero for liveable planet

transition to renewables

Carbon sequestration

Food production uses more fossil fuels 43% 1970, 62% now

- We naively think (or are told) we can replace a complex industrial ecosystem that took more than a century to build using cheap and abundant oil which is the highest calorifically dense source of energy the world has ever known combined with unlimited mineral resources



- All this at a time when we have ever more expensive energy, declining EROI, declining mineral densities, an unprecedented human population and a deteriorating environment teetering at the limits, and conflict over almost all resources…

- If we don't focus on reducing consumption and energy waste, and instead fixate on replacing fossil fuels with so-called renewable (replaceable) energy, we are simply swapping one race to destruction with another.

- The rise of the self delusion industry
  - Net zero
  - Green growth
  - Magic energy solutions – hydrogen etc.
  - Carbon capture and storage

The "fake news" designed to make us think we can carryon as we are

net-zero carbon by 2050

net zero companies

zero carbon flights

zero carbon motoring

renewable energy …

Net-zero carbon by 2050?

Net zero means we can “off-set” our emissions by sequestering carbon - planting trees. Can't we?

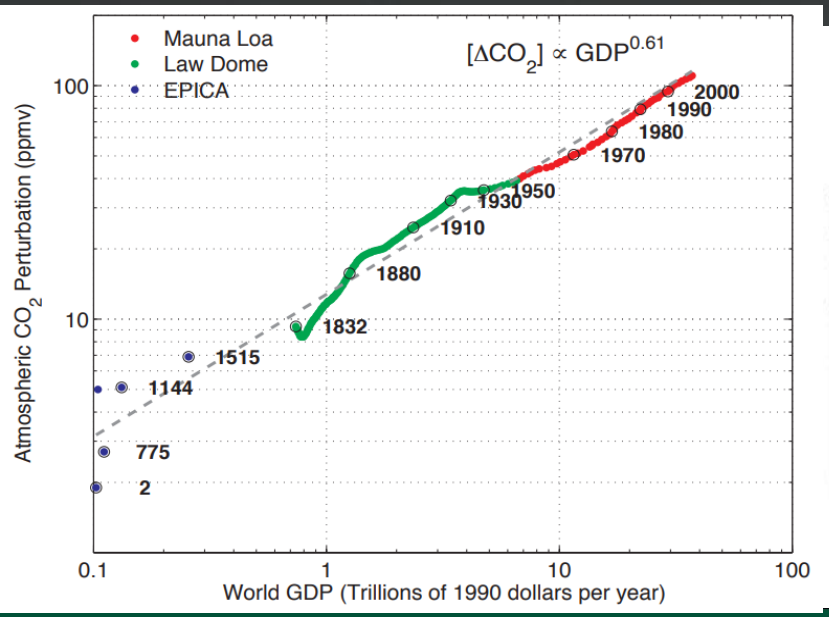
The carbon causing our climate problems today come from fossilised biology formed through ancient carbon cycles, mostly over the 200 million years of the Mesozoic era (ending 66 million years ago). Even if we were to replace all the trees, wetlands, soil carbon etc. all we could achieve would be replacing the carbon we released altering the earth to produce this industrial society but not a kilogram of fossil carbon sequestered way back in the Mesozoic.

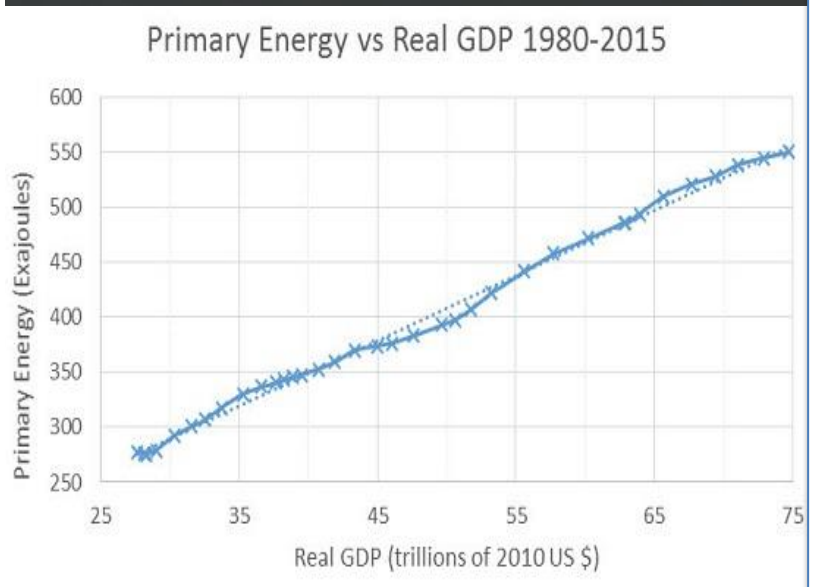
Dangerous trees - Any tree is good tree except one that allows us to burn fossil fuels

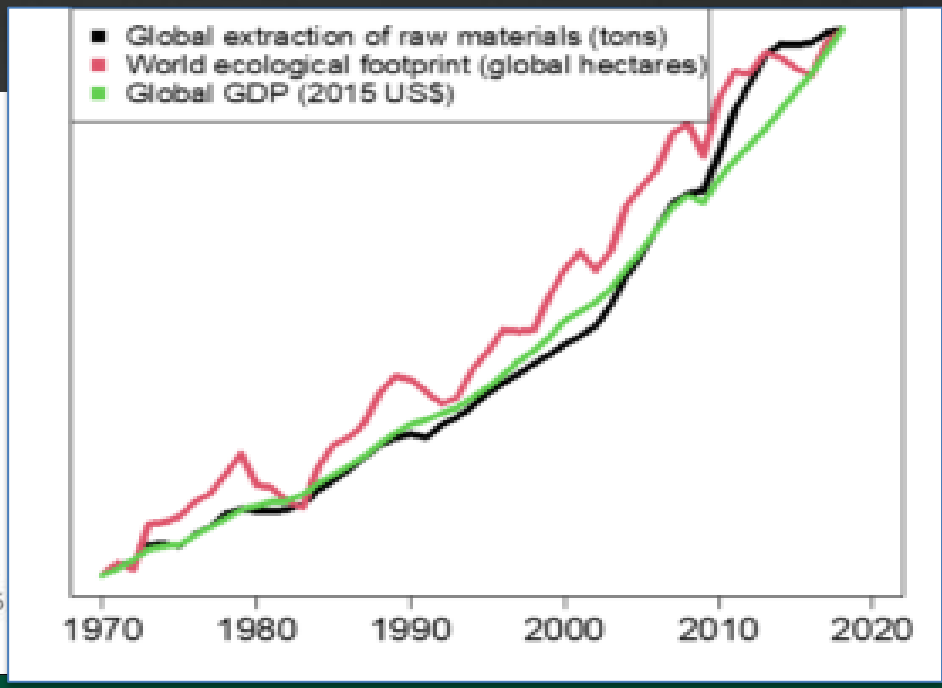
So, ‘net-zero carbon’ is not real the reality is its zero carbon = no fossil fuels by 2050

- We must be carbon zero not net-zero by 2050 at latest
- so ~ 10% reduction every year …
- here is our dilemma
- The fossil Energy, ecological harm, non-renewable material extraction - GDP - carbon linkage

Earth







As uncomfortable as I know this is, we must face the reality that we are the problem

Earth

A net worth of NZ $150,000 is enough to make you richer than 90 percent of people in the world. This 10% above that (~50% of NZers) are responsible for >50% of GHG emissions plus waste etc.

Top 10% of NZers are in the global 1%

https://www.cnbc.com/2018/11/07/how-much-money-you-need-to-be-in-the-richest-10-percent-worldwide.html

https://www.wgtn.ac.nz/__data/assets/pdf_file/0007/1935430/WP-21-10-wealth-inequality-in-New-Zealand.pdf

nature COMMUNICATIONS

PERSPECTIVE

https://doi.org/10.1038/s41467-020-16941-y OPEN

Check for updates

Scientists' warning on affluence

Thomas Wiedmann [1✉], Manfred Lenzen [2], Lorenz T. Keyßer [3] & Julia K. Steinberger [4]

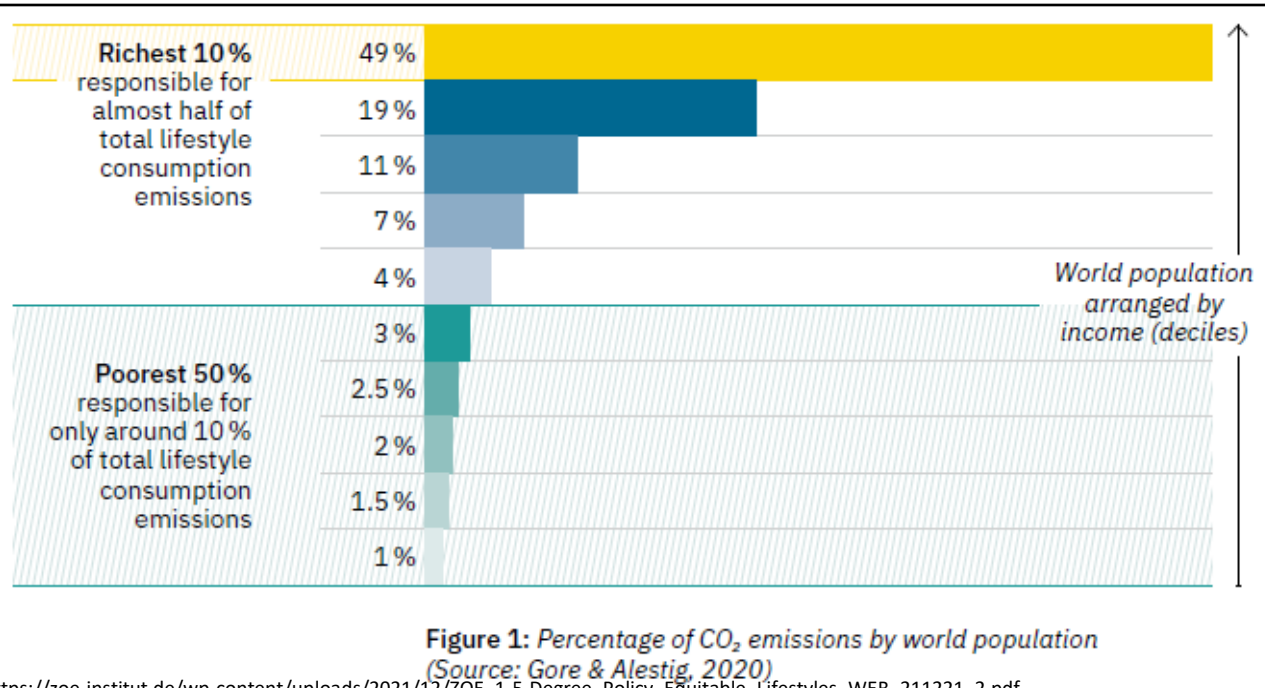
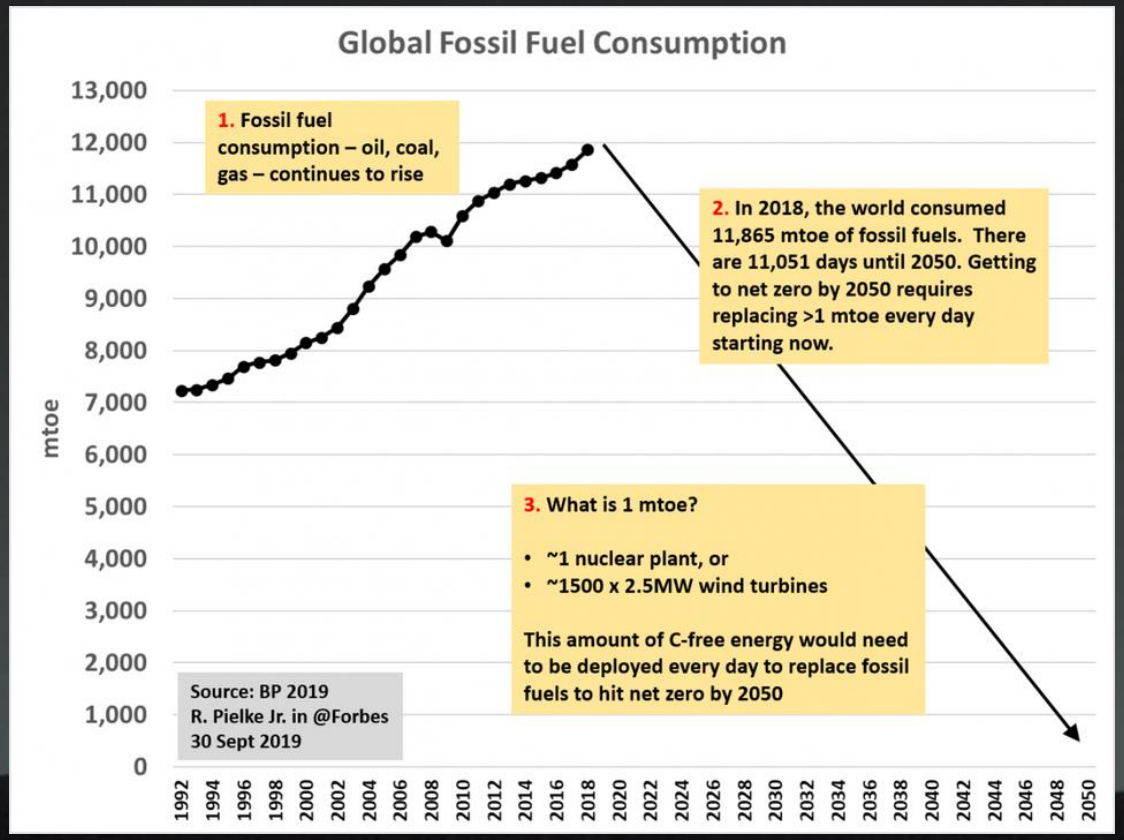


Figure 1: *Percentage of CO_2 emissions by world population (Source: Gore & Alestig, 2020)*

https://zoe-institut.de/wp-content/uploads/2021/12/ZOE_1-5-Degree_Policy_Equitable_Lifestyles_WEB_211221_2.pdf

Reality check – why we have to act now and why we must consume way way less

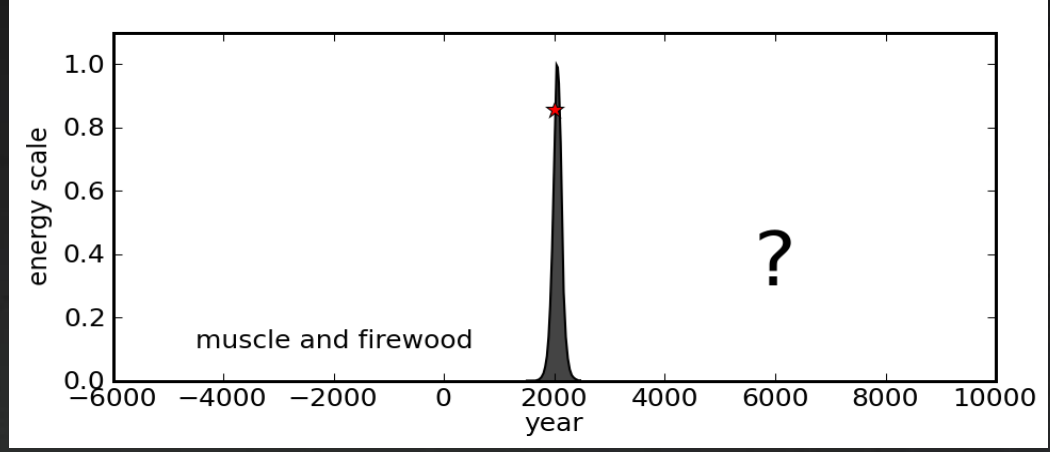


https://www.forbes.com/sites/rogerpielke/2019/09/30/net-zero-carbon-dioxide-emissions-by-2050-requires-a-new-nuclear-power-plant-every-day/?fbclid=IwAR0arZXkUCKU_QndkmlTYvQ04clCJyG_axZ70_6EswVcgu6xsCR_0X8_lmI#1c3eb84135f7

- In 2018 the world consumed 11,743 mega-tonnes of oil equivalent (mtoe) fossil fuel
- So to reach net-zero carbon by 2050 (~11,000 days) we need to replace about 1 mtoe every day from now until 2050
- Thus, we would need to build 1500 2.5 mw wind turbines (covering 777 km^2) every day from now until 2050, or 1 large nuclear power plant per day! 8 mill km2 = area of continental USA
- Then there is the material needs to connect it all, and the electrification of everything currently powered by fossils ++++

Summary

- Energy is the basis of all aspects of human society.



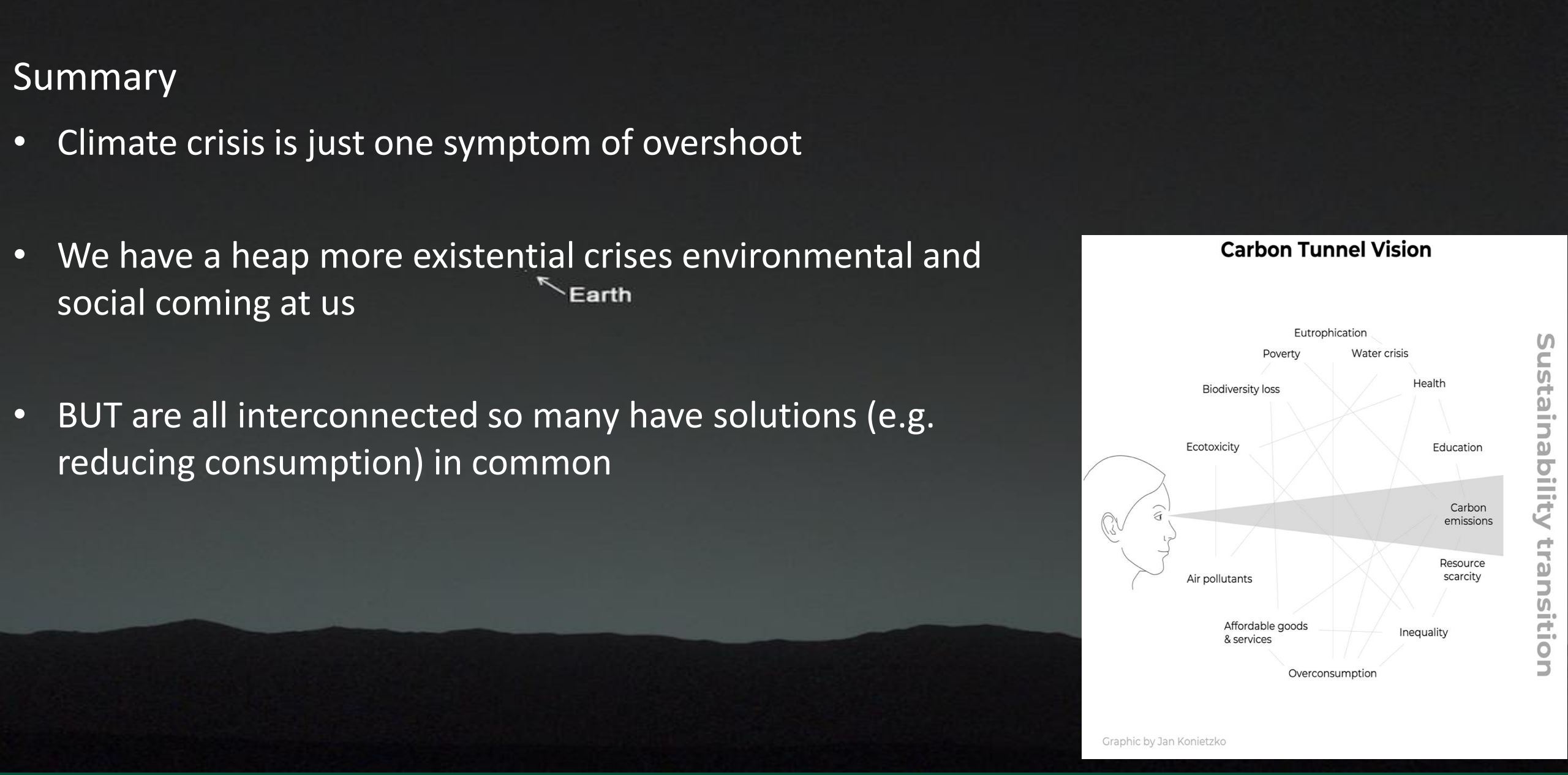
- Fossil fuels enabled a dramatic expansion of energy usable by humanity enabling unprecedented growth in human population, economic activity, and material consumption.

- It takes energy to get energy, and the ratio of energy returned versus energy spent net-energy has historically been extremely high for fossil fuels, as compared to previous and future energy sources.

Summary

- Climate crisis is just one symptom of overshoot

- We have a heap more existential crises environmental and social coming at us



- BUT are all interconnected so many have solutions (e.g. reducing consumption) in common

Conclusion

- We must utterly change how we live, what we value and what it means to be successful.

- Transformative action at the scale we need seems unlikely to happen under politics-as-usual. All political parties, here and globally, are too tribal and popularity driven, pitting people against each other is their default setting, and the required tough decisions would see them gone by lunchtime

The only possible realistic future - degrowth

1. End the self delusion
    - Net zero, carbon zero tree planting
    - CCS
    - Decoupling emission from GDP
    - Military & international aviation emissions

2. Bring in some reality
    - Begin consumption based accounting of GHG emissions
    - Use the remaining carbon budget (<10 yrs) on preparation only
    - TEQs for embodied carbon or embodied emissions" and degrowth

The possible realistic future - degrowth

- 50 -75% reduction in consumption
- Regenerative food production which builds topsoil while capturing and storing atmospheric CO_2 (note only replacing what we lost not fossil)
- Low tech—the revival of past, and often forgotten, technologies as a ways to cope under conditions of more expensive and less abundant energy
- Ecosystem protection and restoration led by indigenous peoples, set aside more land and oceans for ecosystem restoration and recovery
- Energy rationing systems—such as tradable energy quotas, pioneered by the late British economist David Fleming
- Transition engineering, as explored by Susan Krumdieck and colleagues
- Building (or rebuilding) strong neighbourhood networks so that people can support each other in times of need (and have some fun in other times). (Richard Heinberg)

Food and agriculture in NZ

- Establish full emissions profile (atmosphere and water) of industrial agriculture and horticulture then apply the full costs to the industry

- This would level the playing field and sustainable food production would be the obvious economic choice.

- Investigate the true value of food systems in terms of nutrition and human health. The current system does not differentiate the crucial difference between junk food and real food (milk powder)

- New food systems, local, no external inputs, no emissions, no monocultures, must be EROI positive.

ENVIRONMENT JUN 21, 2023

Degrowth: Is There Any Alternative?

To slow climate change and rescue key ecosystems from the brink, a new economic paradigm is needed.

The goal in a degrowing society is a good quality of life for everyone within ecologically necessary limits.

Electric aircraft

- *"Replacing regional, narrowbody, and widebody aircraft would require roughly 6x (1500km), 9x (3000km), and 20x(8,800km) improvements in the specific energy of the battery pack. In the 25 years from 1991 to 2015, the specific energy and energy density of lithium-ion batteries improved by a factor of 3."*
- [8] Jayant Mukhopadhaya, "What to expect when expecting electric airplanes", ICCT, July 14, 2022.

low carbon kāpiti

HOME ABOUT CAMPAIGNS

Wishing for fairy dust – why the NZ Biofuels Obligation is the worst kind of magical thinking

By Jake Roos, BSc (Hons), MAppSc Energy Management
11 July 2022

Wouldn't it be great if wishes came true, and all your problems just went away? If all you needed to do is ask for something and it materialised out of thin air before you? Of course it would, but the world doesn't work like that. But it seems the NZ Government is in the thrall of such magical thinking when it comes to 'sustainable' biofuels.

Biofuel mandates

- it is estimated that since 2011, the added demand for land to grow crops to satisfy the EU's legal requirements for biodiesel resulted in tropical deforestation of an area greater than the Netherlands, the destruction of 10% of the remaining global orangutan habitat and greenhouse gas emissions of 381 million tonnes of CO2-equivalent, three times higher than if they had simply used fossil fuels. Read that again – that's 254 million tonnes more emissions compared to if they had done nothing.