

Presentation to Hutt Valley Tramping Club – Wednesday 22 April, 2020

## Biophysical Limits to Growth: the future of food and energy

**Dr Mike Joy,**

**Senior Research Fellow, Institute for Governance and Policy Studies Victoria University of Wellington.**

**Abstract:** The human population has reached a level far in excess of the ability of the planet to sustain it long-term through using synthetic nitrogen. The 'green revolution' was driven by a massive increase in fossil energy in food production; this one-off subsidy from the past is close to its end as the 'easy energy pickings' diminish. To be able to feed the burgeoning population without fossil fuels and keep greenhouse gas emissions at a safe level will require a drastic reduction in livestock for human food and in reduced emissions from transporting and processing food. This required change will have many human and ecological health benefits but puts New Zealand in a challenging position.

The slides from this talk follow.


Further sources of relevant material are available at:

the website of the Better Futures Forum – towards a more resilient Aotearoa: <https://bff.org.nz/>

a webinar - The Future of Food presented by Mike Joy: <https://thebetterbase.com/future-of-food/>

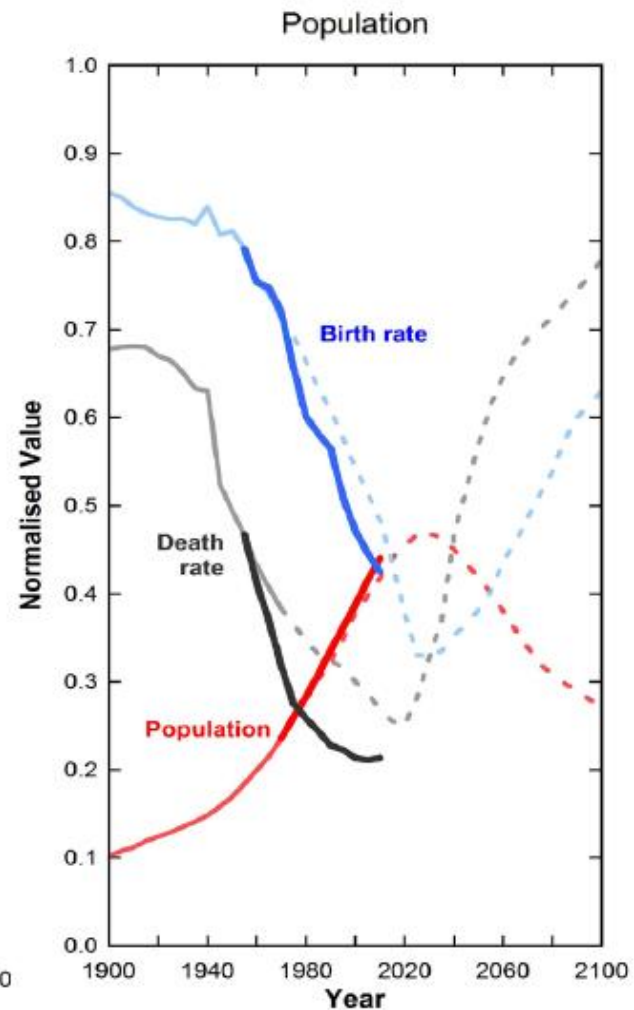
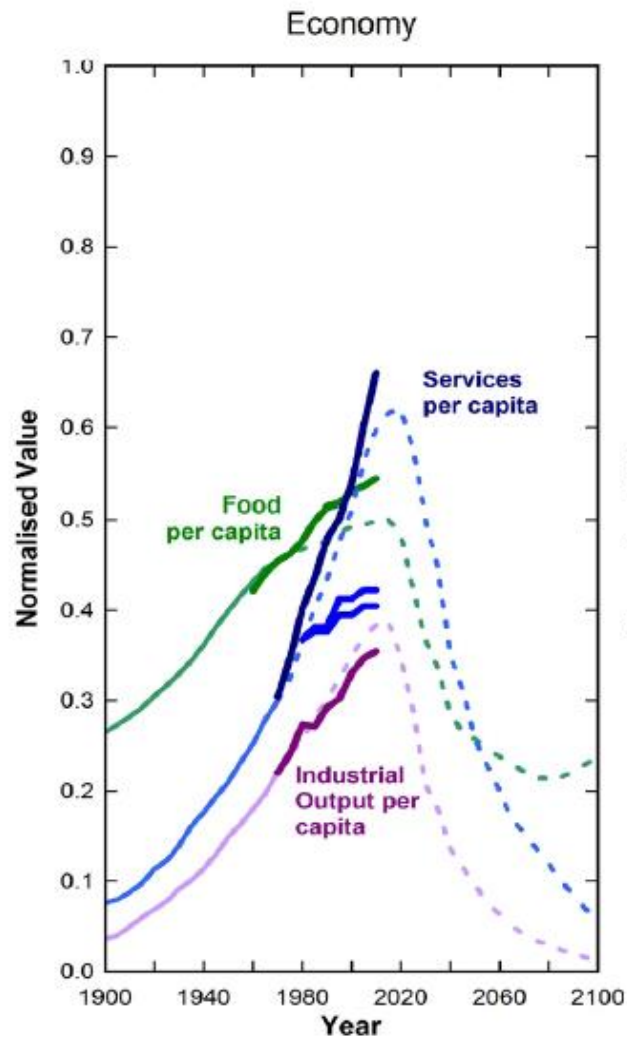
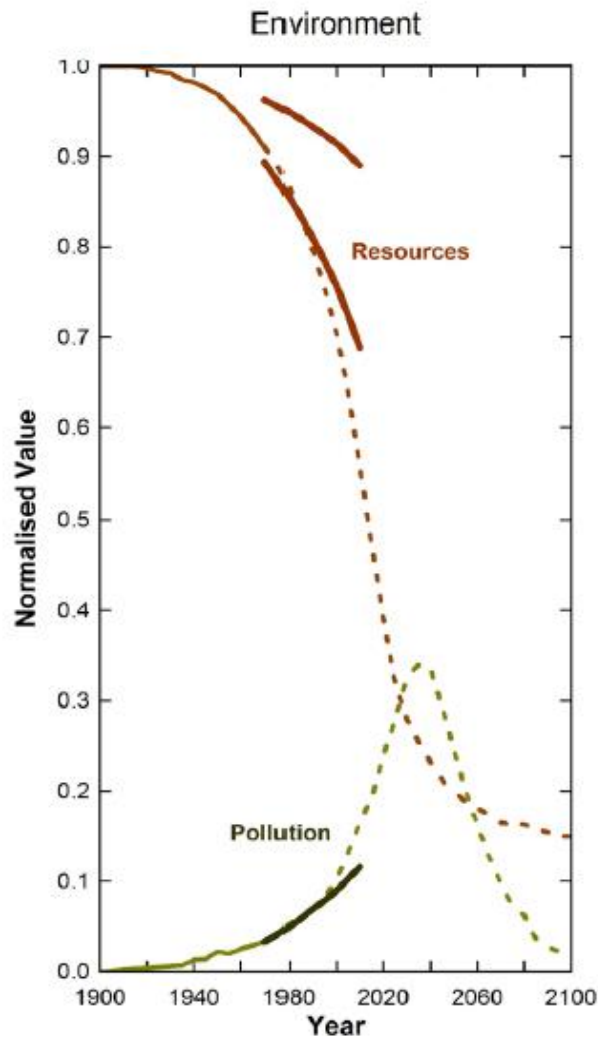
the website of the Sustainable Living Trust: <http://futurelivingskills.org.nz/>

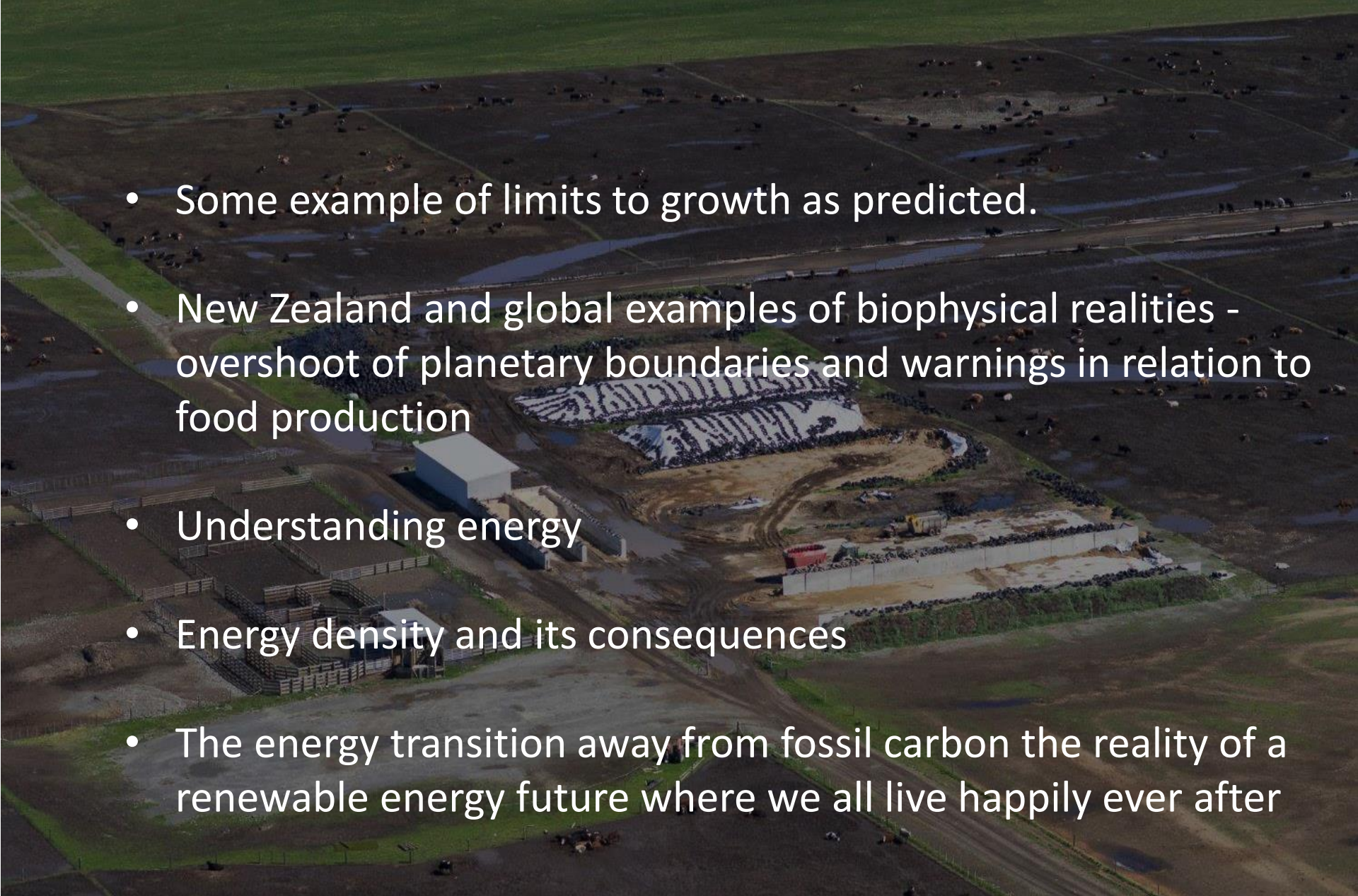
# Biophysical limits to growth; the future of food and energy

 Earth from Mars

Dr Mike Joy - Institute for Governance and Policy studies (IGPS)  
Victoria University

# Limits to growth (1972) Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens - updated 2014 Graham Turner



- 
- Some example of limits to growth as predicted.
  - New Zealand and global examples of biophysical realities - overshoot of planetary boundaries and warnings in relation to food production
  - Understanding energy
  - Energy density and its consequences
  - The energy transition away from fossil carbon the reality of a renewable energy future where we all live happily ever after

# World Scientists' Warning of a Climate Emergency

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, PHOEBE BARNARD, WILLIAM R. MOOMAW, AND 11,258 SCIENTIST SIGNATORIES FROM 153 COUNTRIES (LIST IN SUPPLEMENTAL FILE S1)

**S**cientists have a moral obligation to clearly warn humanity of any catastrophic threat and to “tell it like it is.” On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.

as actual climatic impacts (figure 2). We use only relevant data sets that are clear, understandable, systematically collected for at least the last 5 years, and updated at least annually.

The climate crisis is closely linked to excessive consumption of the wealthy lifestyle. The most affluent countries are mainly responsible for the historical GHG emissions and genera

forest loss in Brazil's Amazon has now started to increase again (figure 1g). Consumption of solar and wind energy has increased 373% per decade, but in 2018, it was still 28 times smaller than fossil fuel consumption (combined gas, coal, oil; figure 1h). As of 2018, approximately 14.0% of global GHG emissions were covered

## Project website

To view the Alliance of World Scientists website or to sign this article, go to <https://scientistswarning.forestry.oregonstate.edu>.

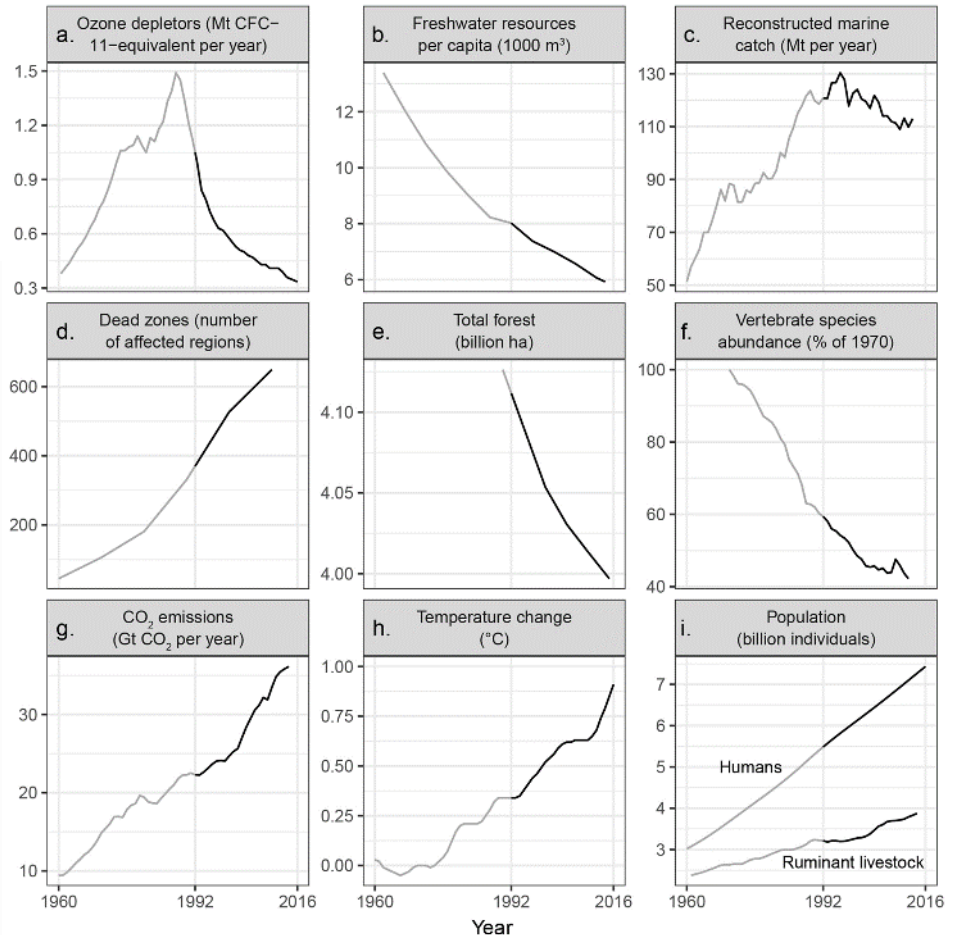
# Manifestation of “Limits to growth”

## 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 scientific works ever and has been signed by a huge number of experts



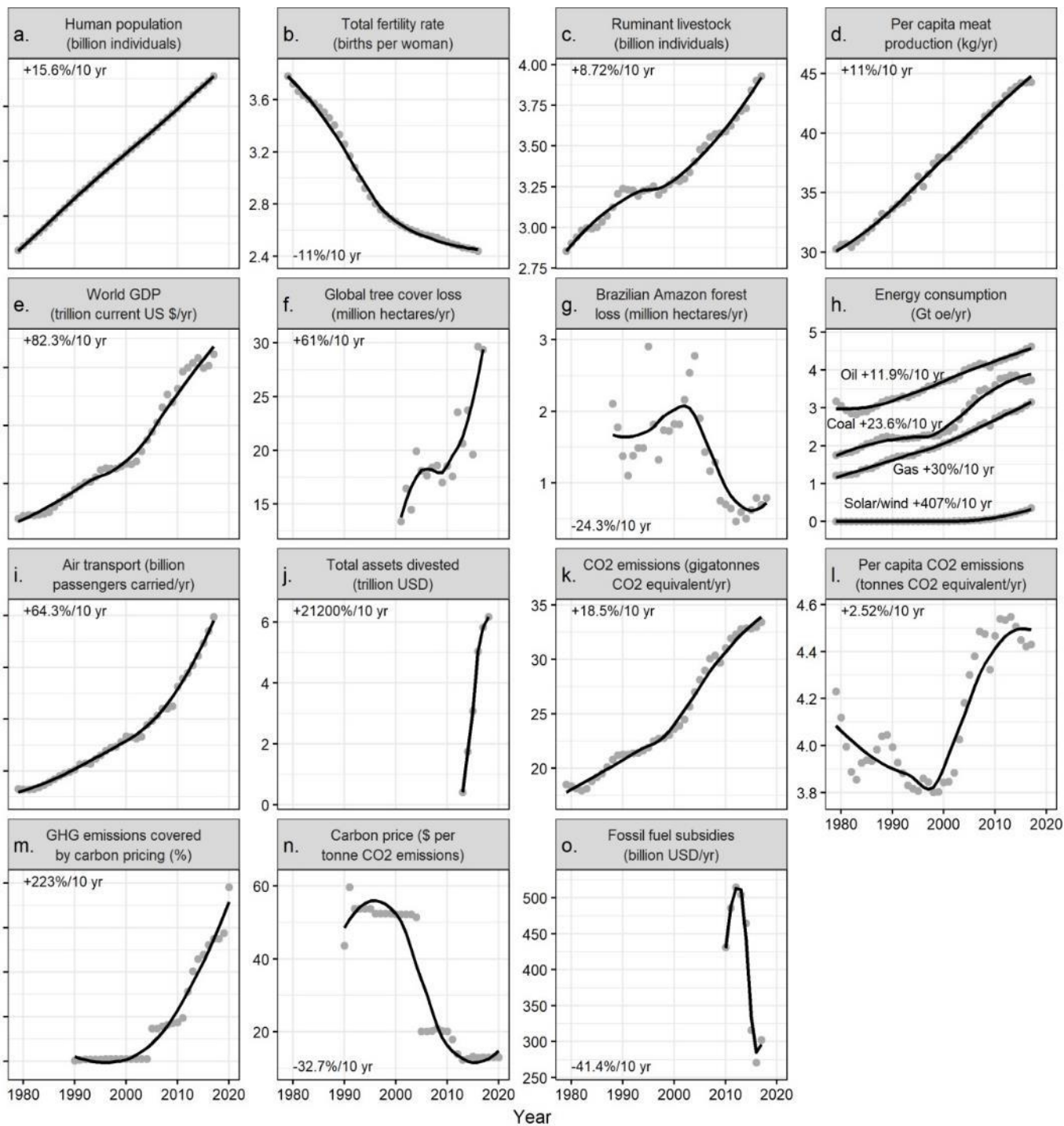
**Trevor Nace** Contributor ⓘ  
Science



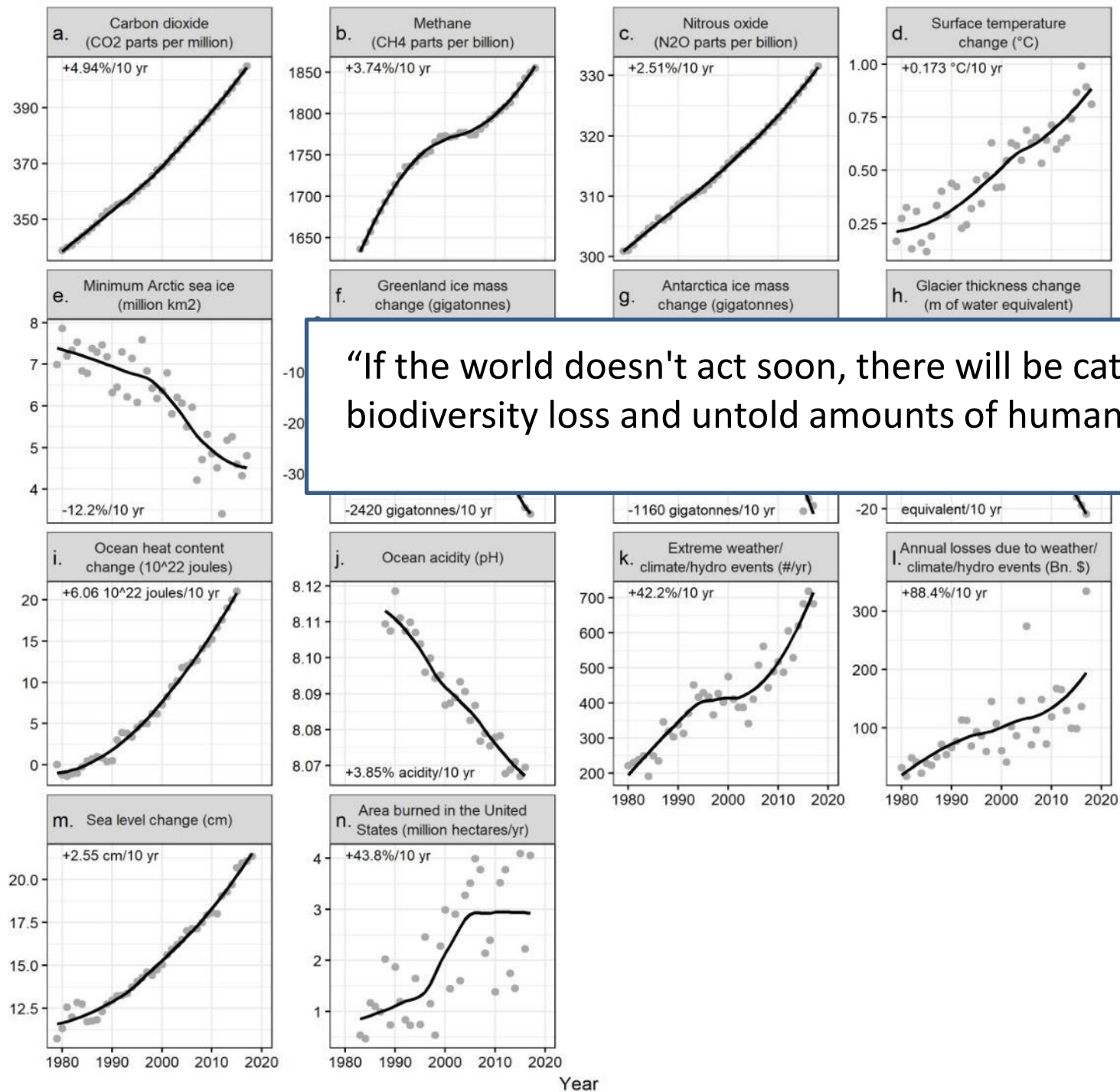
From: World Scientists' Warning to Humanity: A Second Notice

BioScience. 2017;67(12):1026-1028. doi:10.1093/biosci/bix125

BioScience | © The Author(s) 2017. Published by Oxford University Press on behalf of the American Institute of Biological Sciences. All rights reserved. For permissions, please e-mail: journals.permissions@oup.com



X axis is 1980 -  
2020



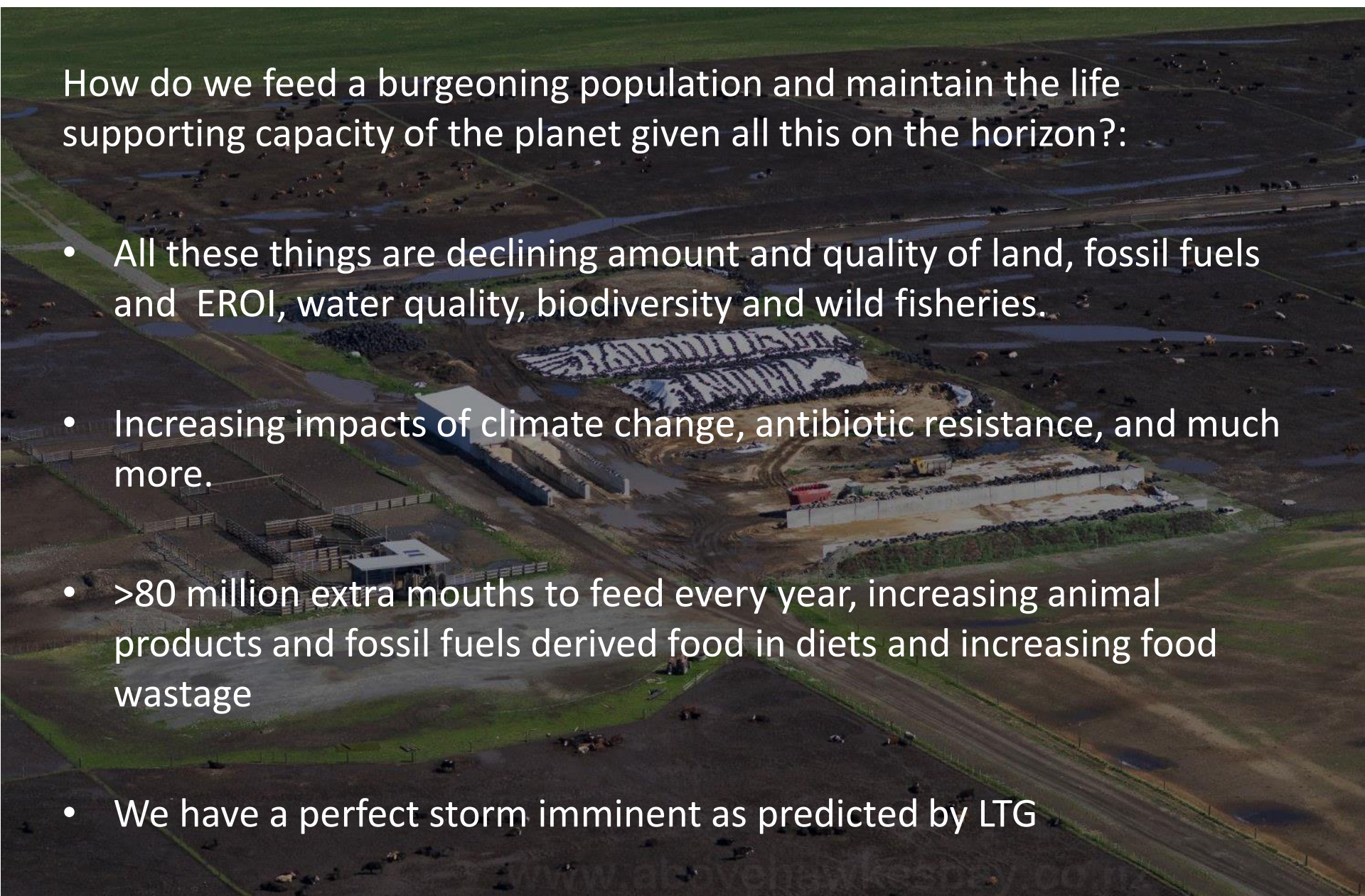
“If the world doesn't act soon, there will be catastrophic biodiversity loss and untold amounts of human misery”

X axis is 1980 - 2020

## The real issues – (not terrorism or the Kardashians)

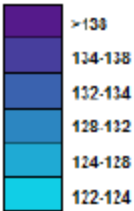
How do we feed a burgeoning population and maintain the life supporting capacity of the planet given all this on the horizon?:

- All these things are declining amount and quality of land, fossil fuels and EROI, water quality, biodiversity and wild fisheries.
- Increasing impacts of climate change, antibiotic resistance, and much more.
- >80 million extra mouths to feed every year, increasing animal products and fossil fuels derived food in diets and increasing food wastage
- We have a perfect storm imminent as predicted by LTG



# Limits to growth in New Zealand

Semi-quantitative MCI



Healthy

Environmental Management  
DOI 10.1007/s00267-015-0517-x

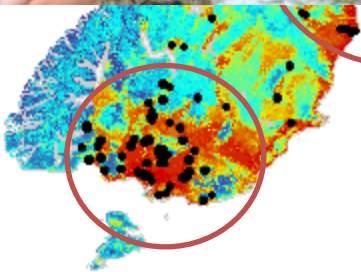


## Environment Aotearoa 2019

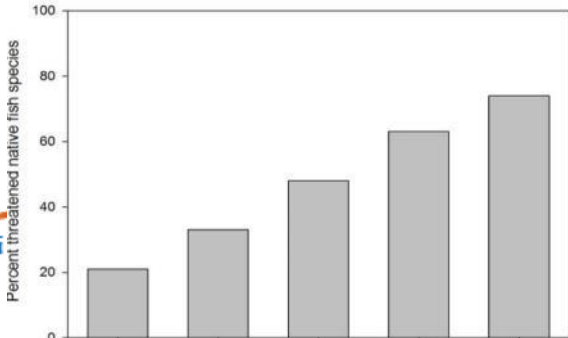
All

● Environment Aotearoa 2019 provides an overview of the state of our environment. Using five broad themes the report presents nine priority environmental issues. Each issue includes information about why it matters, what has changed, and the consequences.

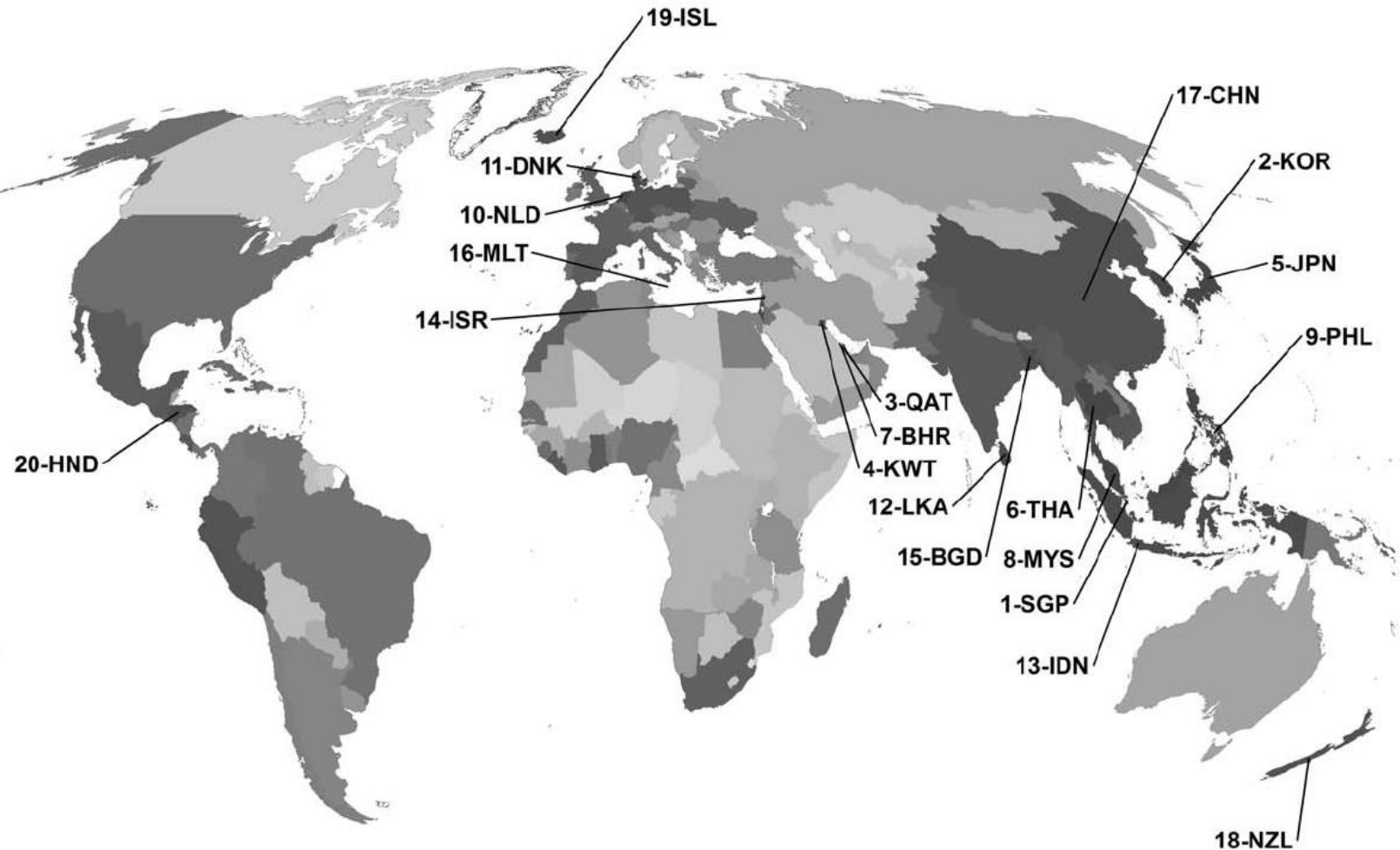
ment,



NIWA  
Taihoro Nukurangi



# Manifestation of “Limits to growth”



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

OPEN ACCESS Freely available online

PLOS one

Cap: Evaluating the Relative Environmental Impact of Countries

NGA O TE ŪPOKO O TE IKA A MĀUI  
VICTORIA  
UNIVERSITY OF WELLINGTON

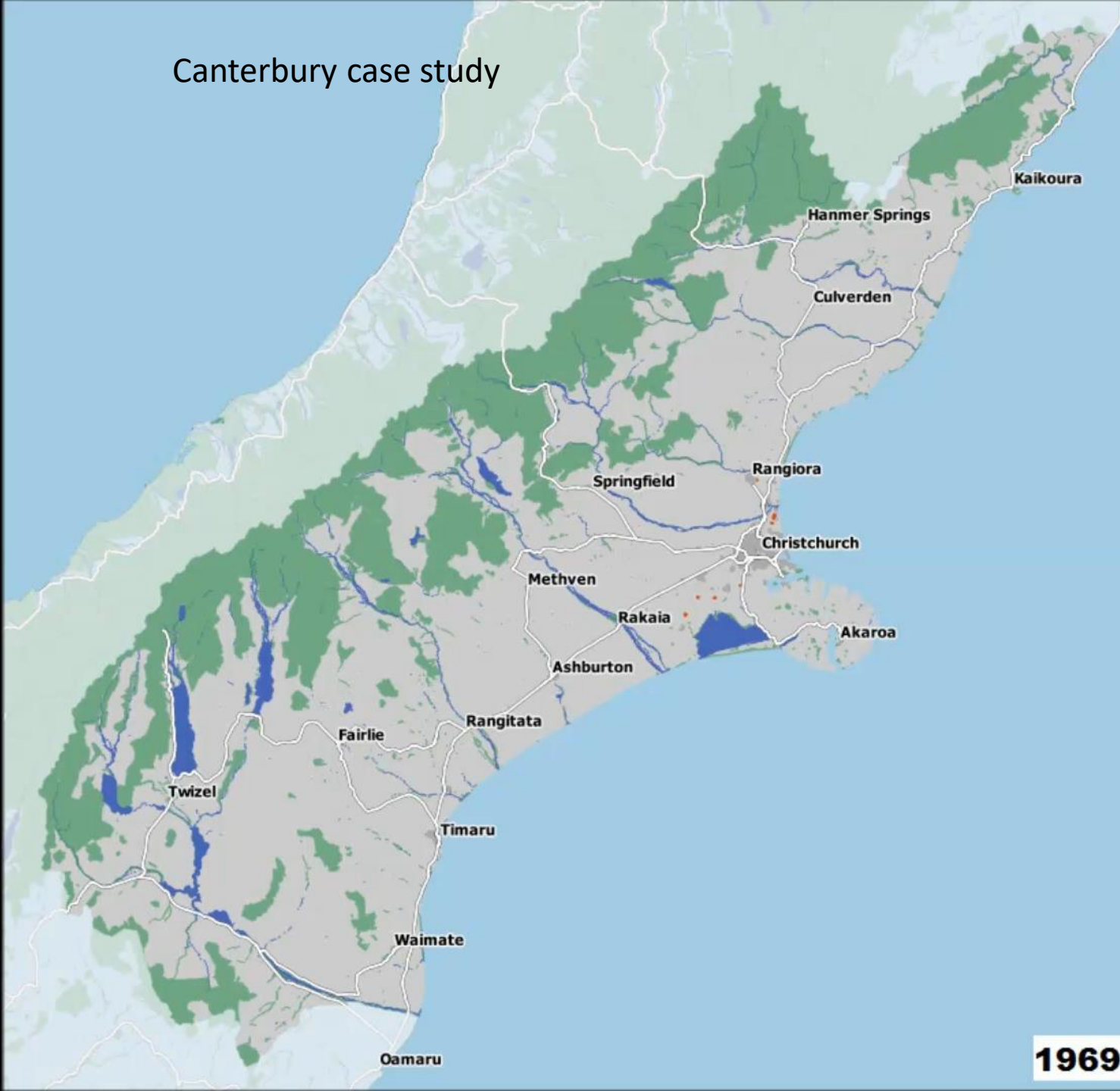
## Canterbury case study

Consents for dairy conversion

Dairy production 60 fold increase from 6 mkg in 1984 to 385 mkg 2016

And the conversions need water lots of it

And the pivot irrigators meant removing the shelter belts in the region with the greatest evapotranspiration in NZ (322 mm/pa)



1969

## Drinking water study raises health concerns for New Zealanders



IJC  
International Journal of Cancer

### Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study

Jörg Schullehner <sup>1,2,3,4</sup>, Birgitte Hansen<sup>2</sup>, Malene Thygesen<sup>3,4</sup>, Carsten B. Pedersen<sup>3,4</sup> and Torben Sigsgaard<sup>1</sup>

<sup>1</sup> Department of Public Health, Aarhus University, Aarhus, Denmark

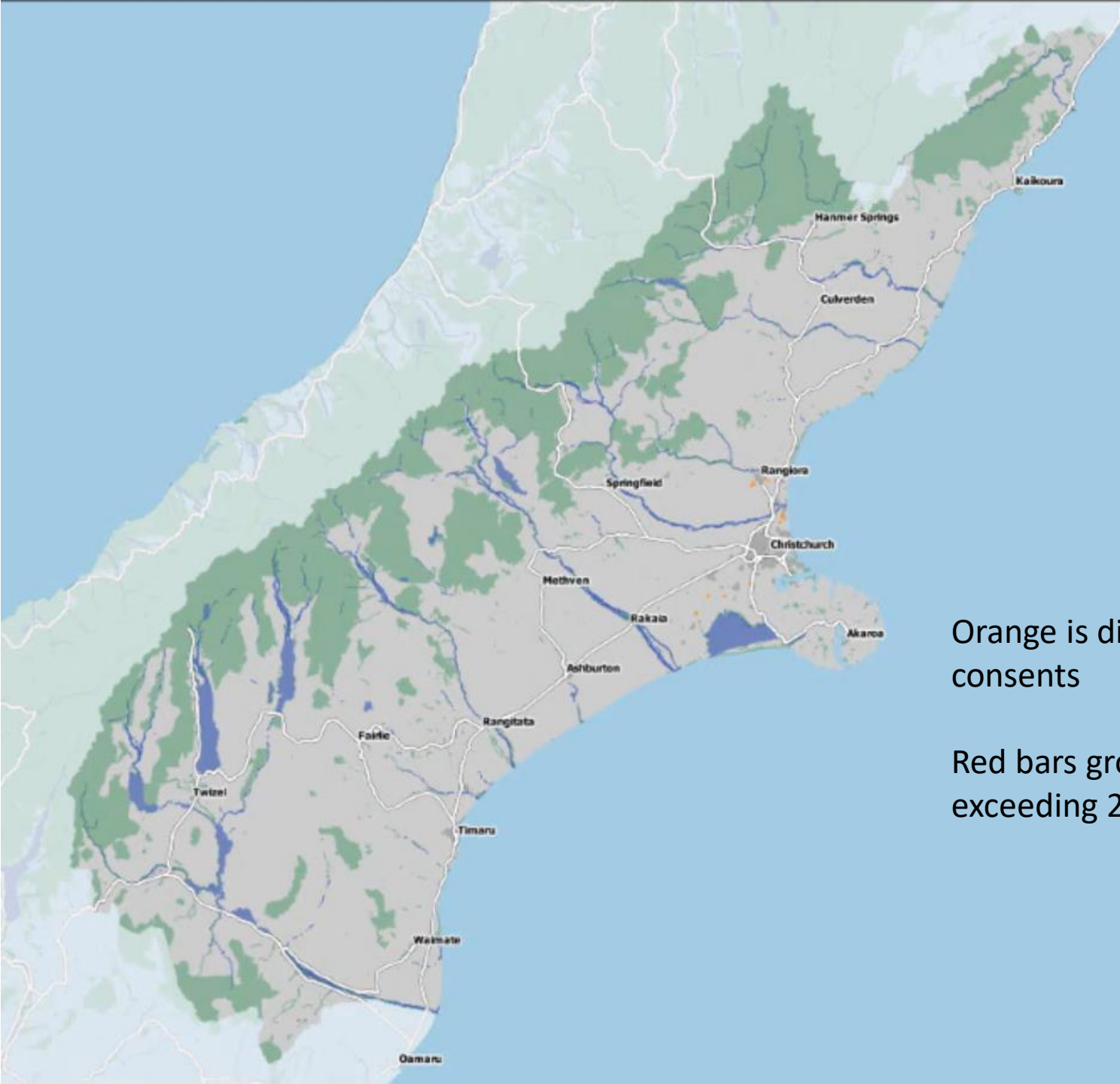
<sup>2</sup> Department of Groundwater and Quaternary Geology Mapping, Geological Survey of Denmark and Greenland, Aarhus, Denmark

<sup>3</sup> National Centre for Register-Based Research, Department of Economics and Business, Economics School of Business and Social Sciences, Aarhus University, Aarhus, Denmark

<sup>4</sup> Centre for Integrated Population Research, CIPRI, Aarhus University

<https://theconversation.com/drinking-water-study-raises-health-concerns-for-new-zealanders-108510>

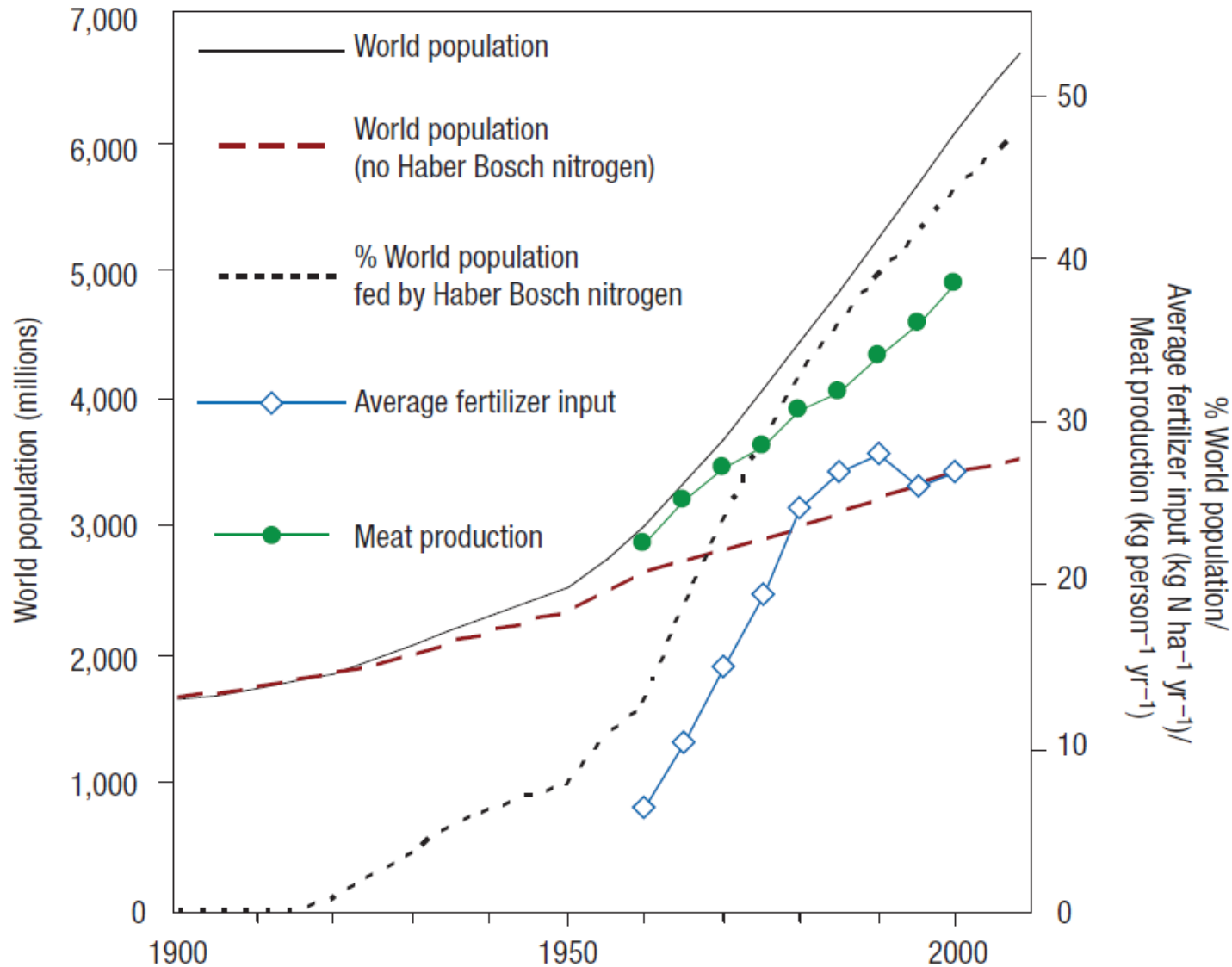
Capital thinking. Globally minded.



Orange is dairy conversion consents

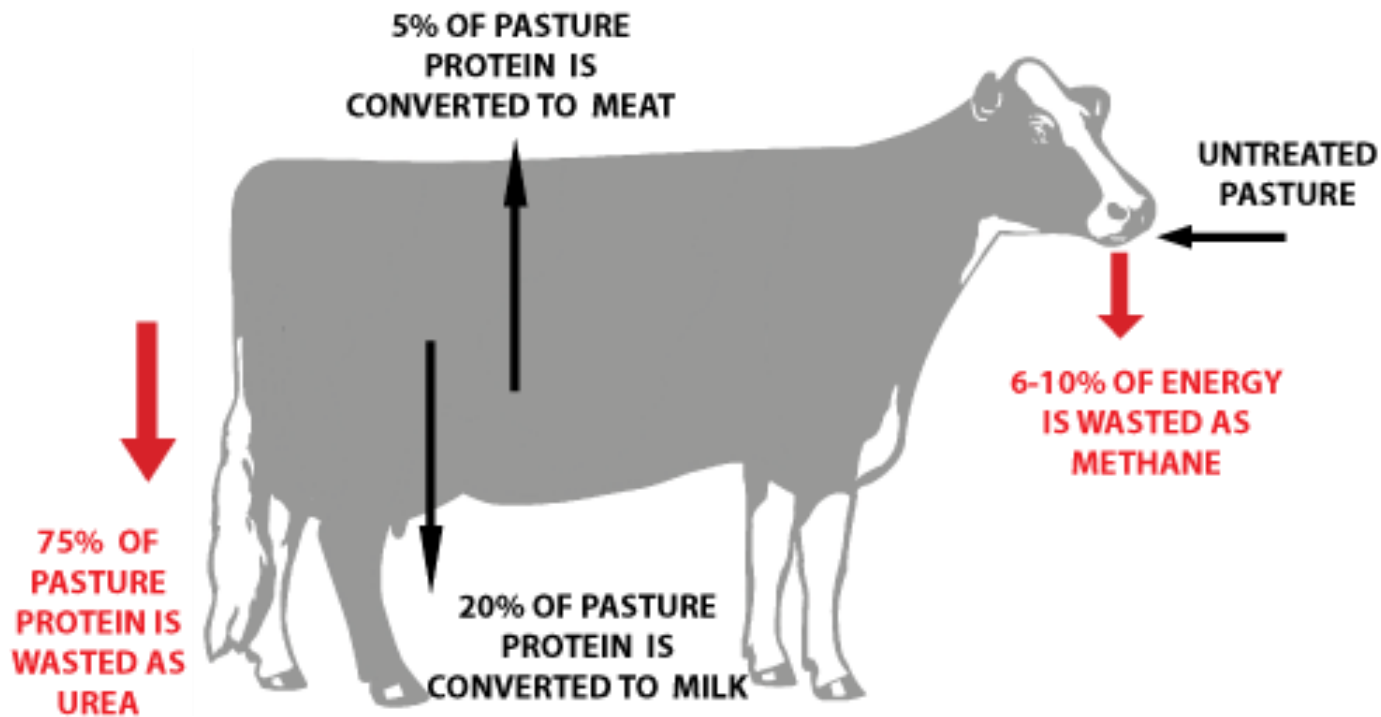
Red bars groundwater samples exceeding 2.1 mg/l

# The green (or fossil fuel) revolution?



How a century of ammonia synthesis changed the world

- For every 100 kg of nitrate fertiliser applied to soil, >1 kg ends up in the atmosphere as nitrous oxide ( $\text{N}_2\text{O}$ ), 300 times more potent GHG than  $\text{CO}_2$  and  $\text{N}_2\text{O}$  is the most ozone-depleting gas
- Every 100 kg N fertiliser has 5200Mj of embodied energy and produces 1200 kg  $\text{CO}_2\text{e}$



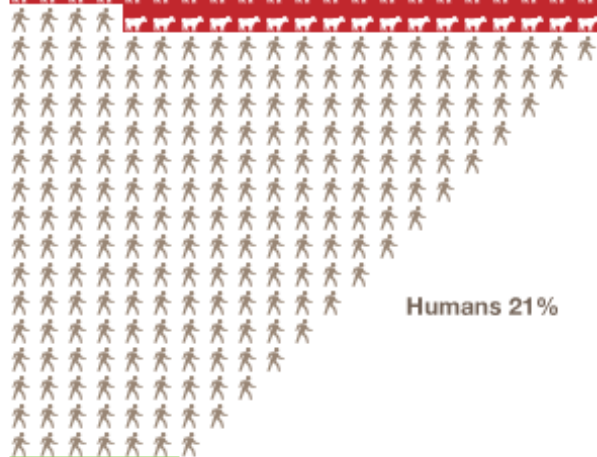
## Overdose?

- But ~ 1 billion people have inadequate and insecure diets, while 2.1 billion people are obese or overweight from the move to highly processed foods high in refined sugar, refined fats, oils and meats.
  - Food system dependant on fossil energy not just fertiliser - industrial food production system now uses more than 10 - 33 units of fossil energy to plough, plant, fertilise, harvest, transport, refine, package, store/refrigerate, and deliver 1 unit of food energy to be eaten by humans.
  - Producing 1 calorie food in USA uses 21 calories of fossil energy

# Overdose?

- More and more people dependent on fossil fuels but they are running out - EROI down from ~70 to ~ 15 globally – the easy stuff is gone
- Once we started eating oil we initiated the massive population increase of humans and the animals we eat (the 'green' revolution)
- As indicator of human dominance of the planet - the ratio of humans and our food animals and pets to wild animals?

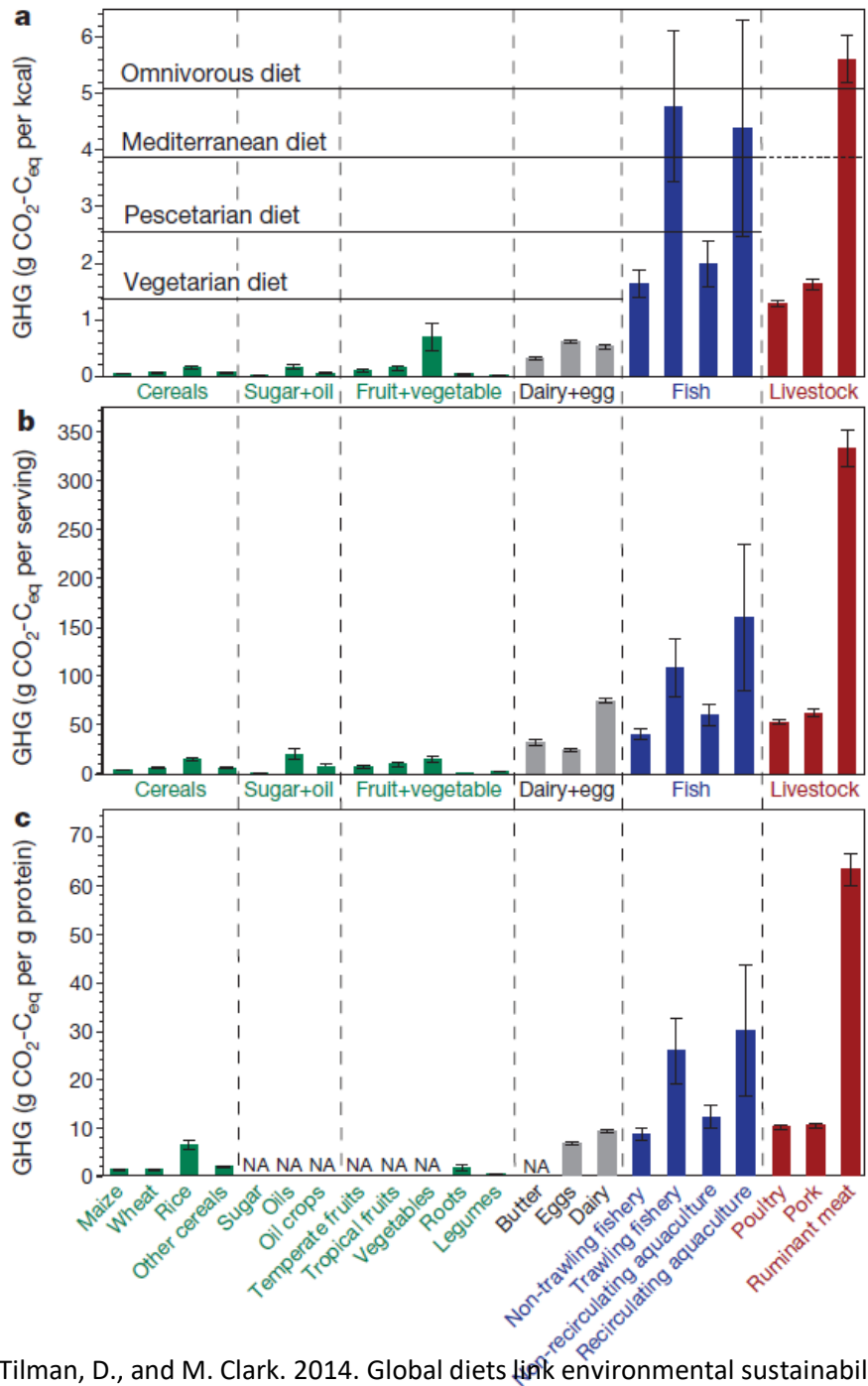
# World's land mammals by weight



Biomass of humans & livestock 98% vs. wild mammals 2%

Smil, V. 2003. The Earth's Biosphere: Evolution, Dynamics, and Change  
The MIT Press

Graphic by Shaun Lee



- What we eat makes a huge difference + animal agriculture is responsible for :

← GHG emissions

~ 55 % of the sedimentation of waterways through accelerated erosion

37 % of pesticide use

50 % all antibiotic use

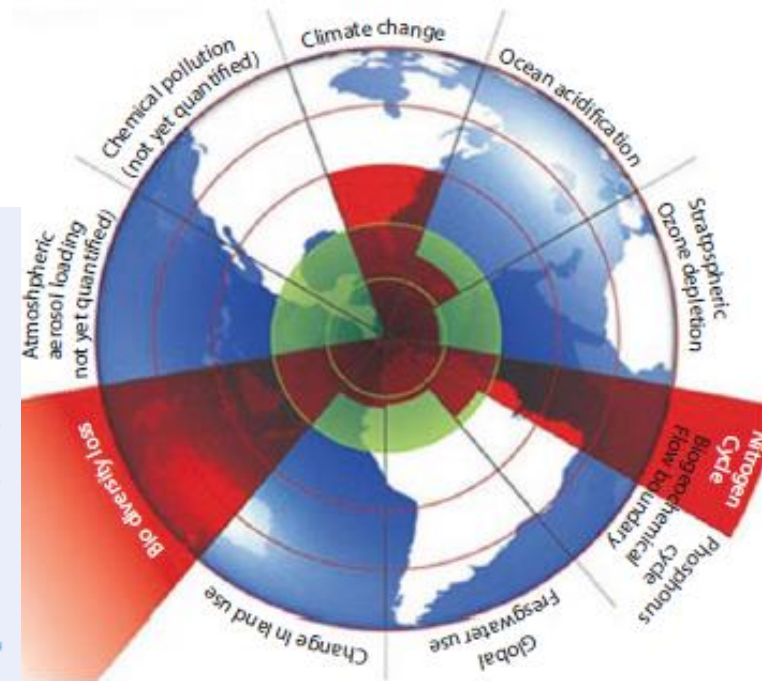
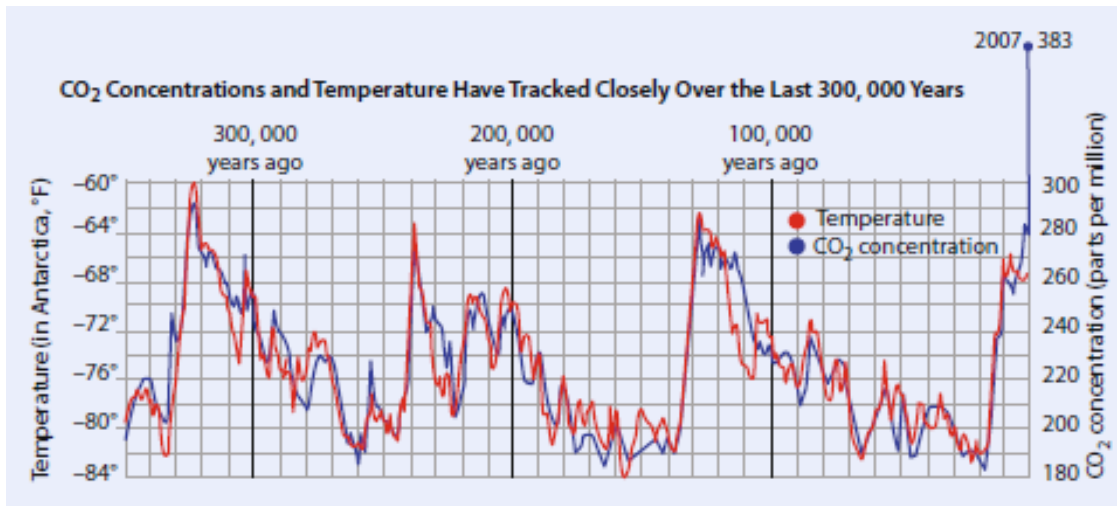
33% of anthropogenic nitrogen and phosphorus to freshwater resources

# Manifestation of “Limits to growth”

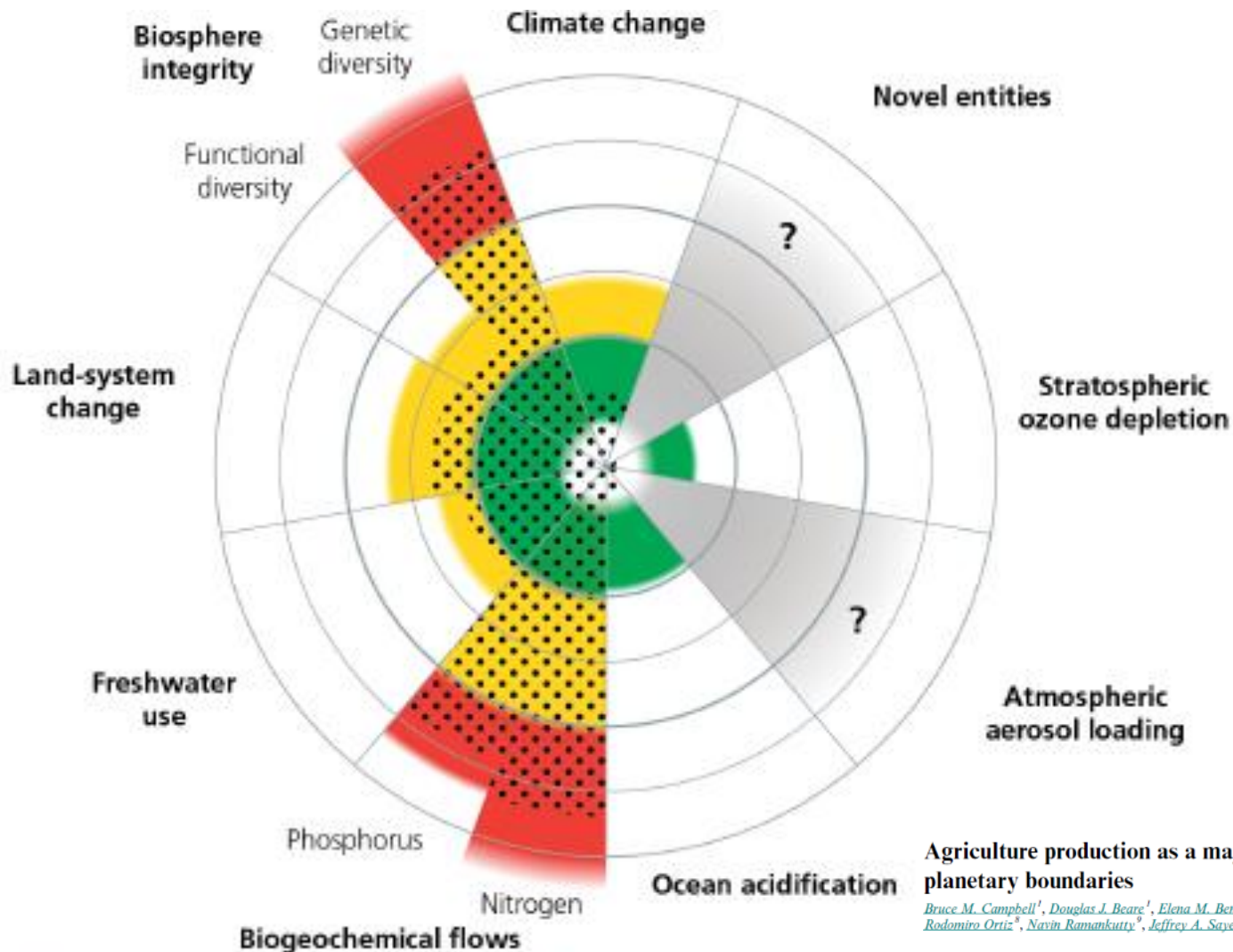
## Planetary boundaries; a safe operating space for humanity

Two converging issues:

- Easy fossil fuels gone
- Carbon neutral by 2050
- The animal agriculture footprint



# Manifestation of “Limits to growth”



**Agriculture production as a major driver of the Earth system exceeding planetary boundaries**

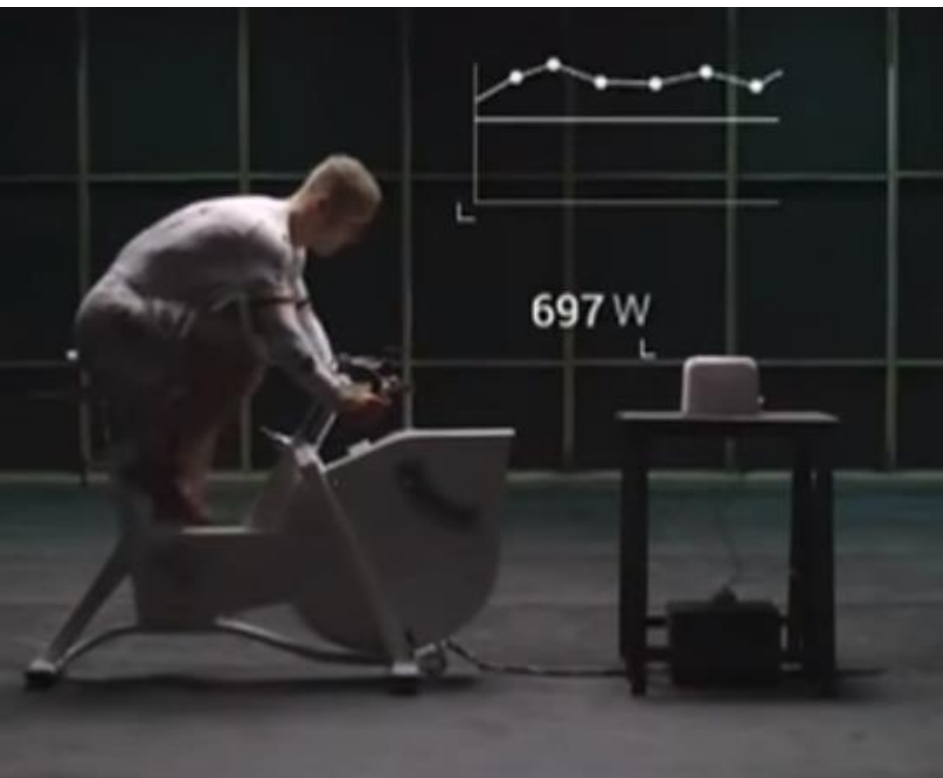
*Bruce M. Campbell<sup>1</sup>, Douglas J. Beare<sup>1</sup>, Elena M. Bennett<sup>2</sup>, Jason M. Hall-Spencer<sup>3,4</sup>, John S. I. Ingram<sup>5</sup>, Fernando Jaramilla<sup>6,7</sup>, Rodomiro Ortiz<sup>8</sup>, Navin Ramankutty<sup>9</sup>, Jeffrey A. Sayer<sup>10</sup> and Drew Shindell<sup>11</sup>*

■ Beyond zone of uncertainty (high risk)
 ■ Below boundary (safe)
 ■ In zone of uncertainty (increasing risk)
 ■ Boundary not yet quantified

\*. Role of agriculture

# Understanding energy

The energy/electricity confusion and our dependence on cheap fossil energy - the concept of energy slaves



# Personal fossil fuel energy slaves

- 1 barrel of oil = 1,700 kWh of work
- One human working one day 0.6 kWh
- So 7 years of human work in 1 barrel of oil or 4 years after conversion losses
- @ ~ \$70 per barrel that is < 1cent/hr (think of the economic consequences of this – ignored by most economists)
- Or a 60 litre petrol tank full = human working for 4 years
- How many humans to power a small car? = 184
- For the developed countries primary energy use/population = more than 150 slaves per person (working 24/7)

<https://carboncounter.wordpress.com/2015/06/01/the-future-of-energy-why-power-density-matters/>



- 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 (cf 4 billion real workers)
- That is 70 for every human on planet,

Q. So why is an ecologist talking about energy?

A. EROI (Energy return on energy invested) aka fitness  
(Darwin)



What about the future of energy (and our slaves)?  
What about peak oil?

EROI (Energy return on energy invested)

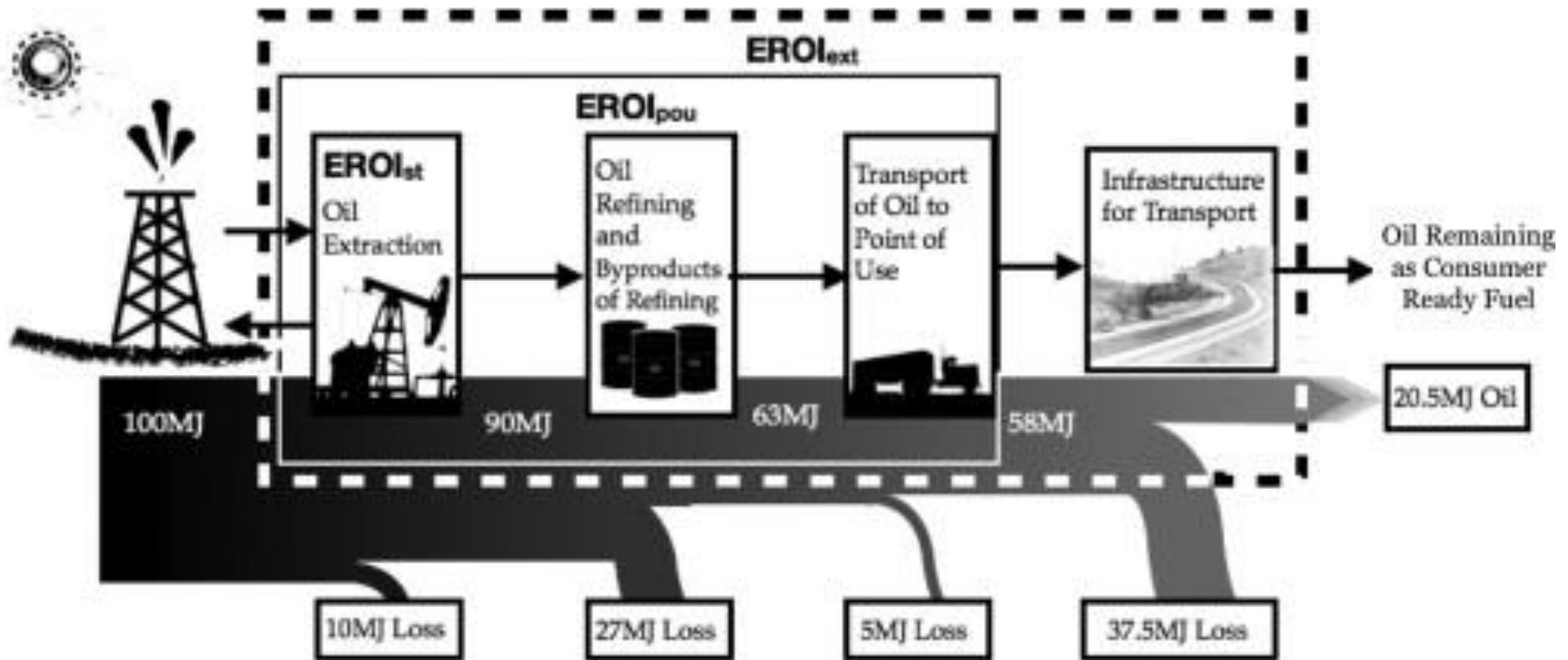
How much energy is used to capture  
the fossil energy available

net energy =  $1 - \text{EROI}$

$$\text{EROI} = \frac{\text{Energy returned to society}}{\text{Energy required to get that energy}}$$

The issue we have is that EROI of oil is  
declining and has major implications

# Thermodynamic and other realities of energy conversions

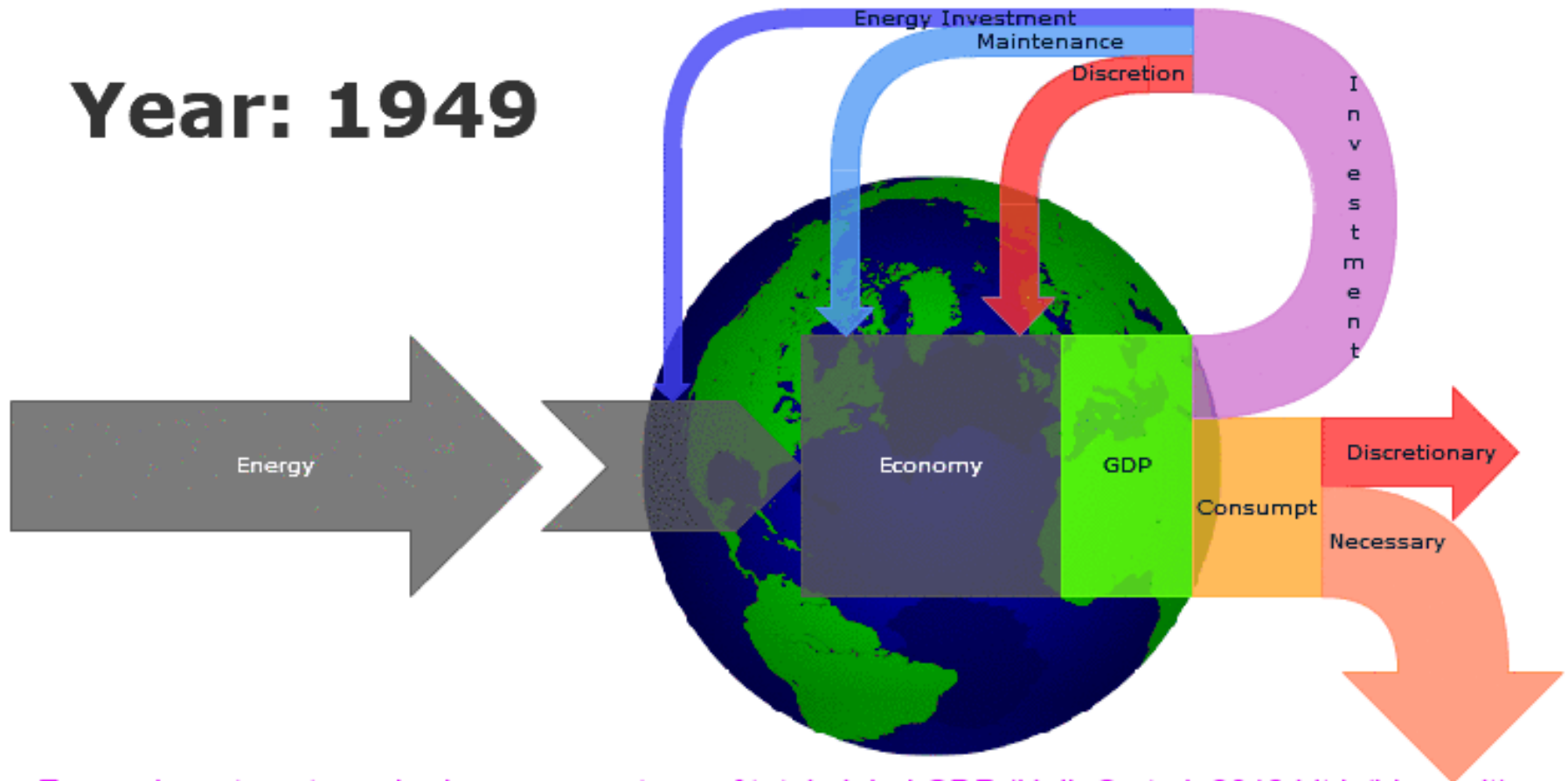


<https://carboncounter.wordpress.com/2015/06/01/the-future-of-energy-why-power-density-matters/>

Capital thinking. Globally minded.

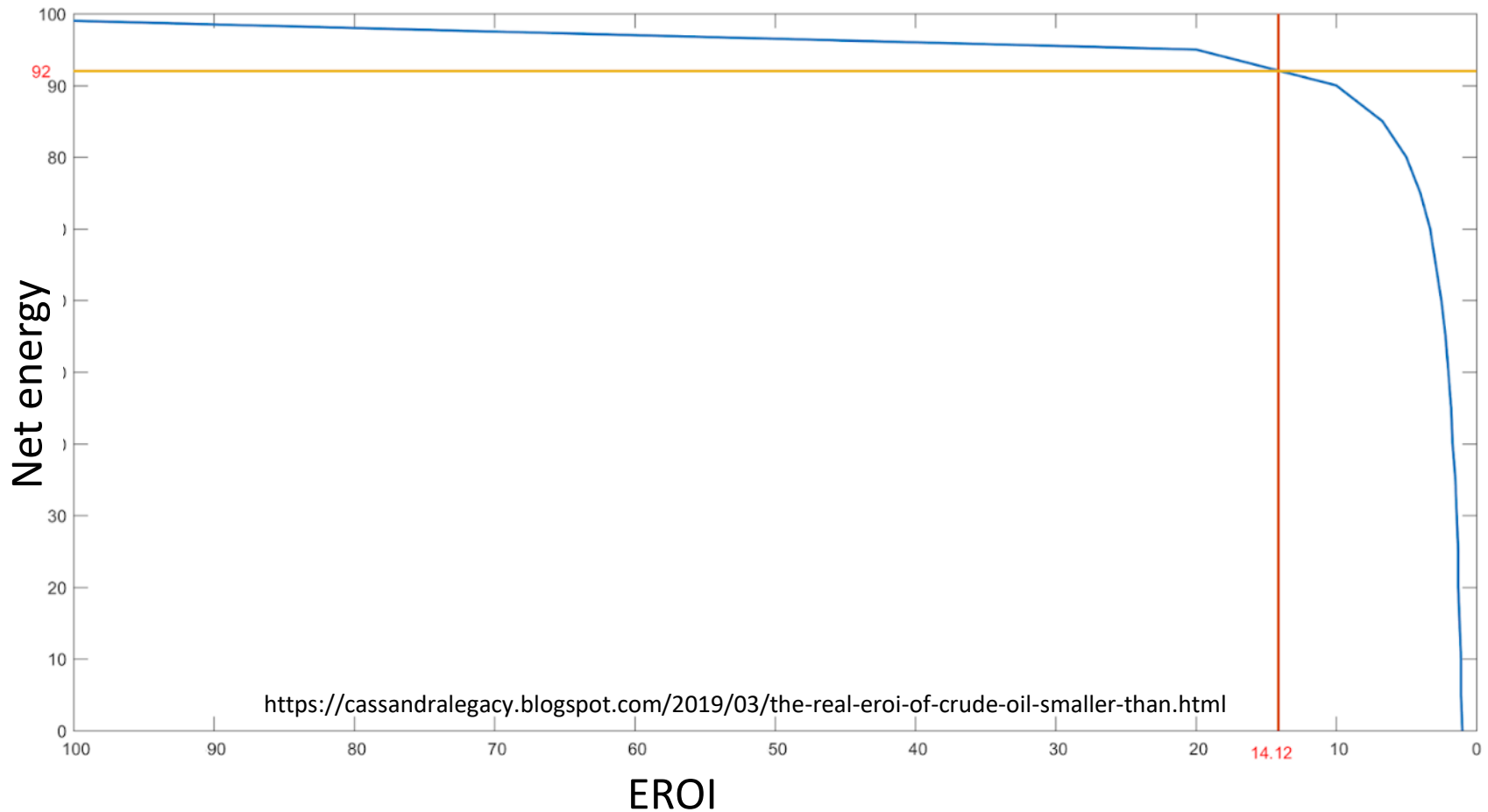
# Economic realities of how energy conversion reduces discretionary \$

**Year: 1949**



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

## The consequences - as EROI goes down - the Seneca cliff



(We are now producing and consuming 2 – 4 barrels of oil for each barrel we find)

# EROI of different energy sources and declines over time

Charles A.S. Hall  
Kent Klitgaard

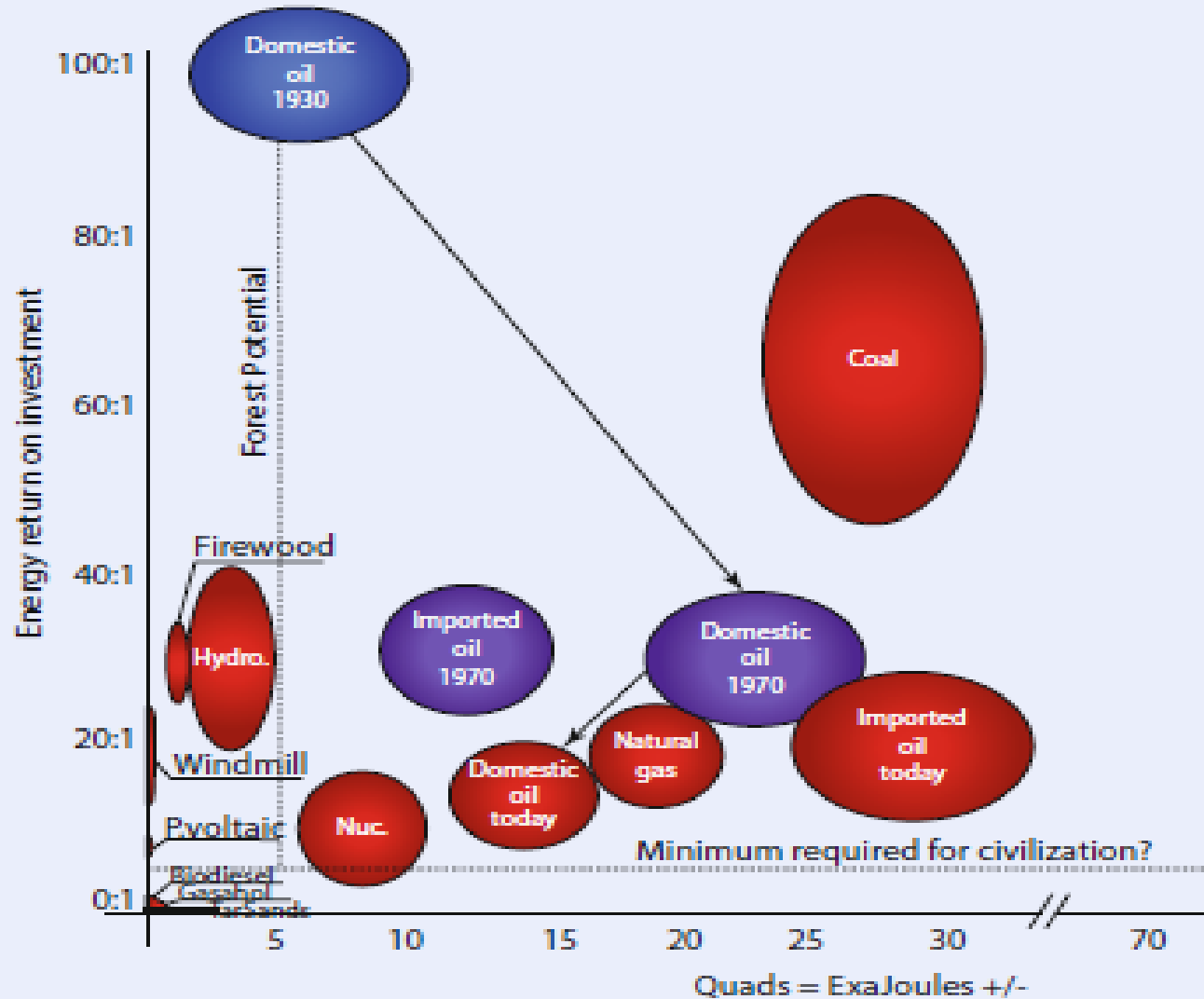
## Energy and the Wealth of Nations

An Introduction to Biophysical Economics

Second Edition

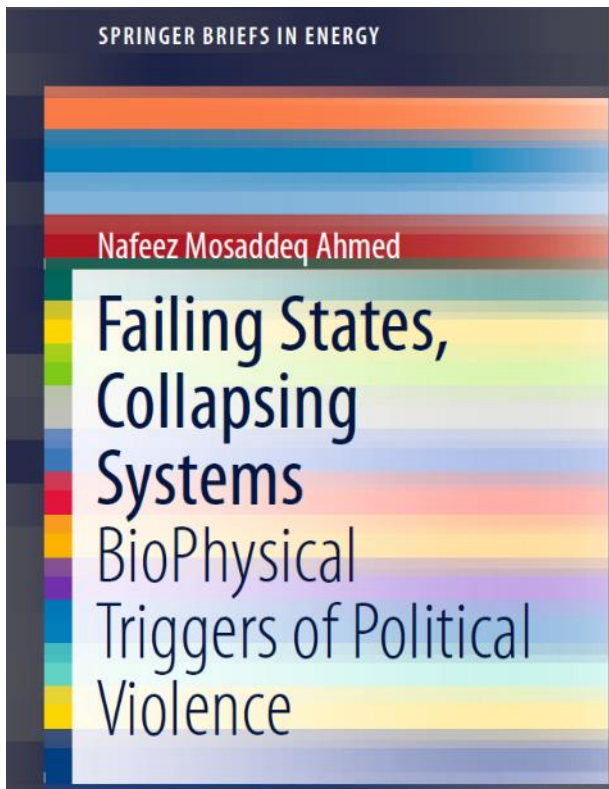


Springer



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Biophysical economics has many possible implications beyond what we are discussing tonight

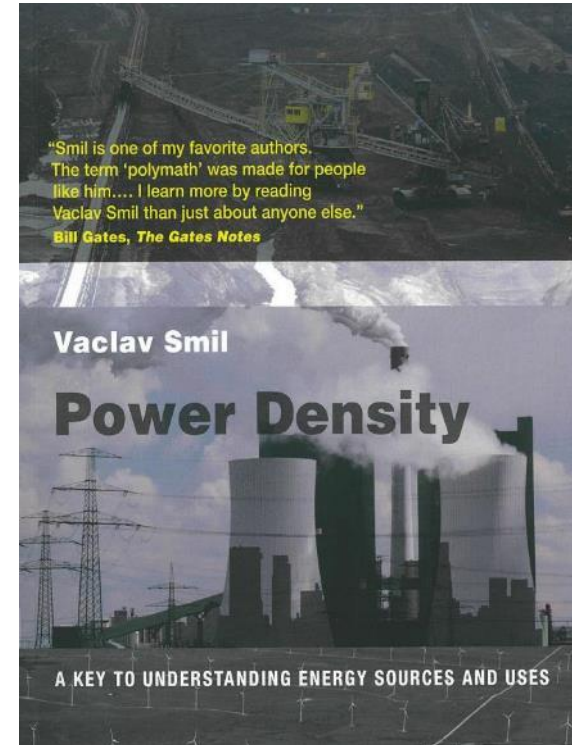


How do we transition to this decarbonised world?

Biomass → coal → hydrocarbons → ?

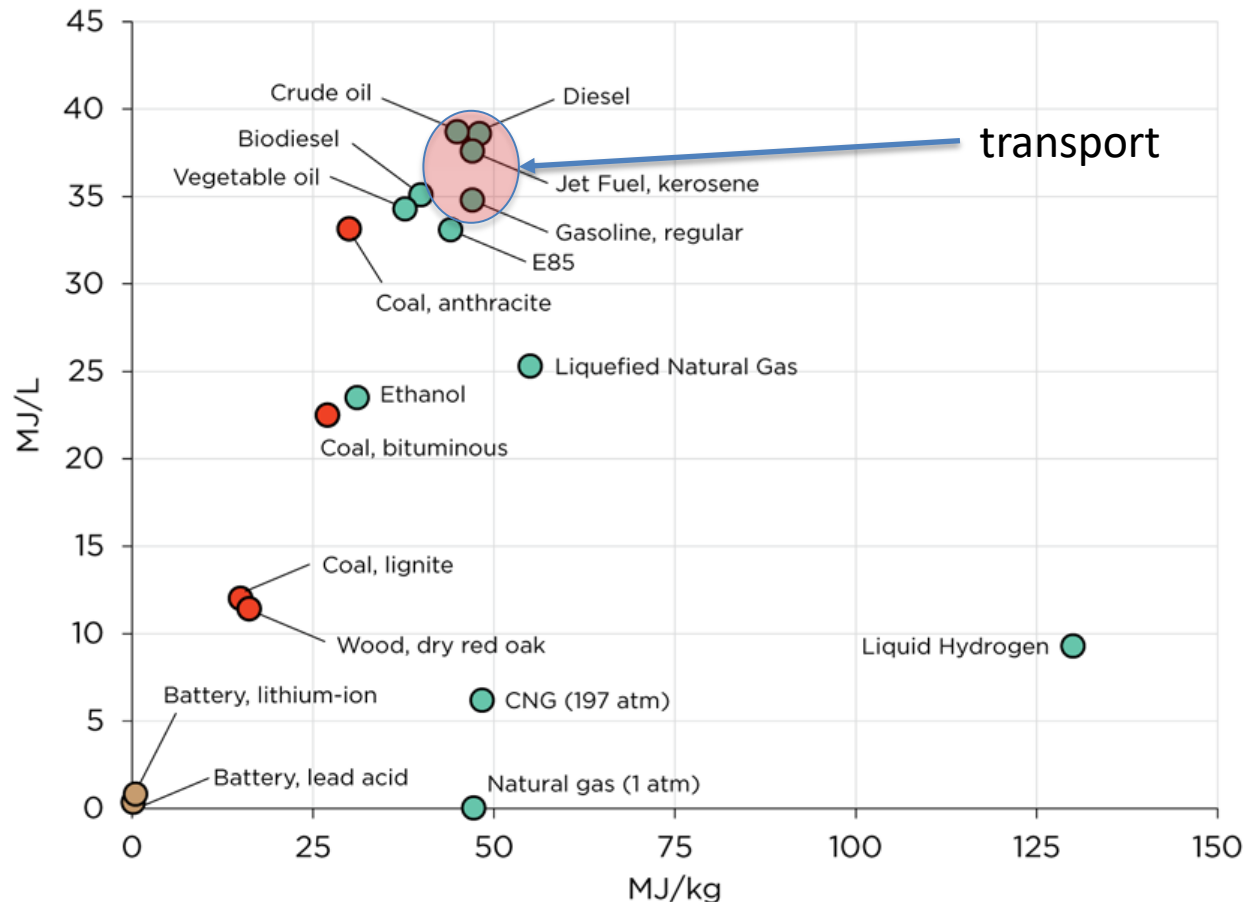
Can we move to a world without fossil fuels that looks a lot like today?

The 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.** ● Solid fuels ● Liquid & gas fuels ● 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).

# How is our transition to a decarbonised world coming along?

Where we  
are now

Energy use  
fossil vs  
renewable  
(per capita)

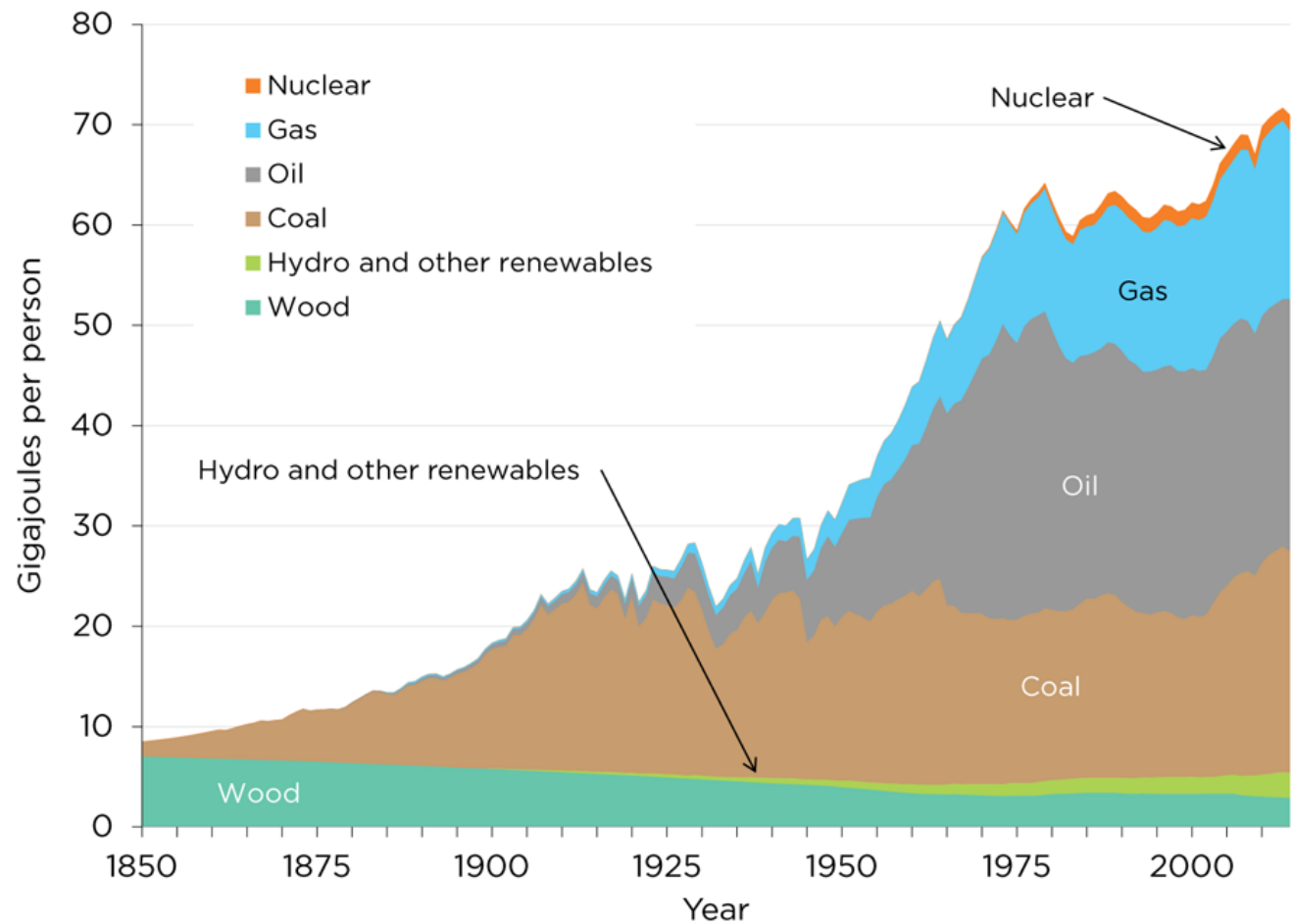


Figure 2.1. World per capita primary energy consumption per year by fuel type, 1850–2014. Primary electricity converted by direct equivalent method.

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).

# The transition to a decarbonised world

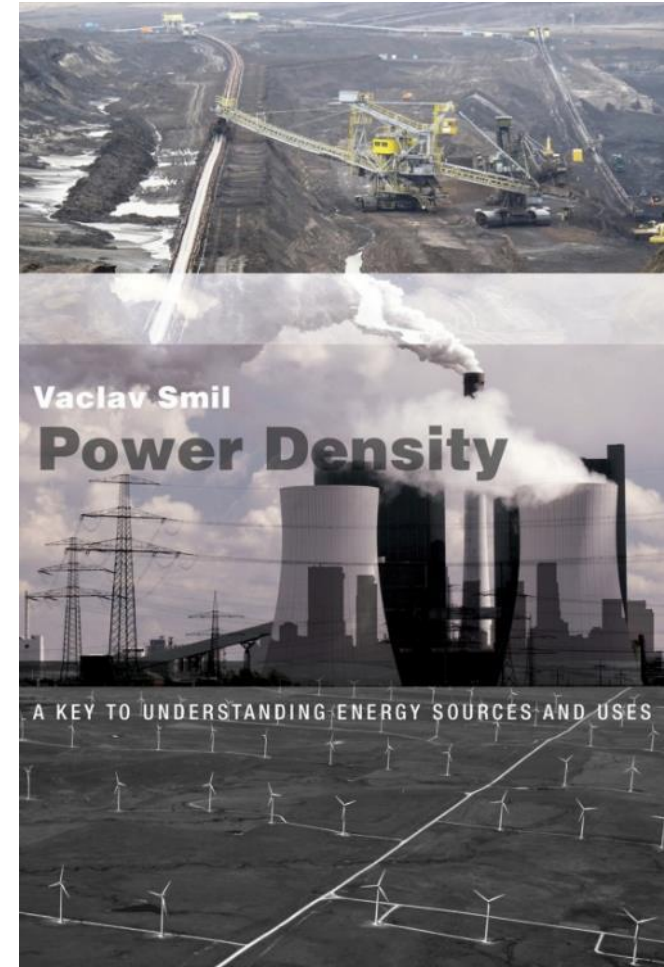
## Energy density comparisons using a common currency

Power density = energy flux per time per unit of horizontal surface

Watts per square meter

$\text{W/m}^2$

Can be used to evaluate and compare all energy fluxes in nature and society.



# The transition to a decarbonised world a reality check

Example: Britain consumes energy at a rate of about 5000 watts per person, popn. density  
= 250 people km<sup>2</sup> 1.25 watts m<sup>2</sup>

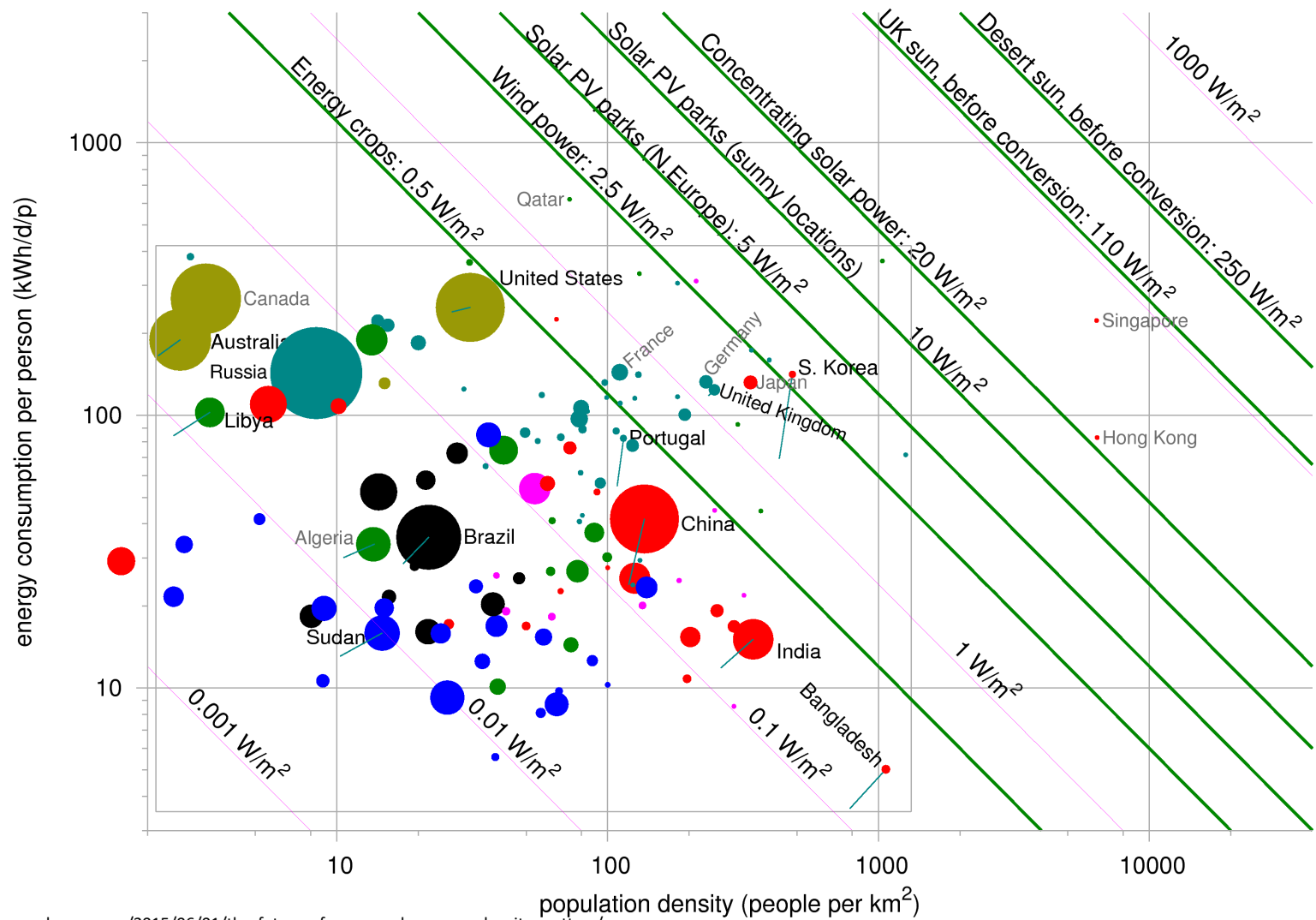
The options:

- Hydro; the gravitational potential energy of rainfall in the Scottish highlands has a raw power per unit area of roughly 0.24 watts/M<sup>2</sup>
- Biofuel; energy crops in Europe deliver about 0.5 watts/M<sup>2</sup>
- Wind; wind farms deliver roughly 2.5 watts/M<sup>2</sup>
- Solar; solar photovoltaic farms in Bavaria, Germany, and Vermont, USA, deliver 4 watts/M<sup>2</sup>

Average for a mixture of renewables ~ 1.25 watts/M<sup>2</sup> ---- see the problem?

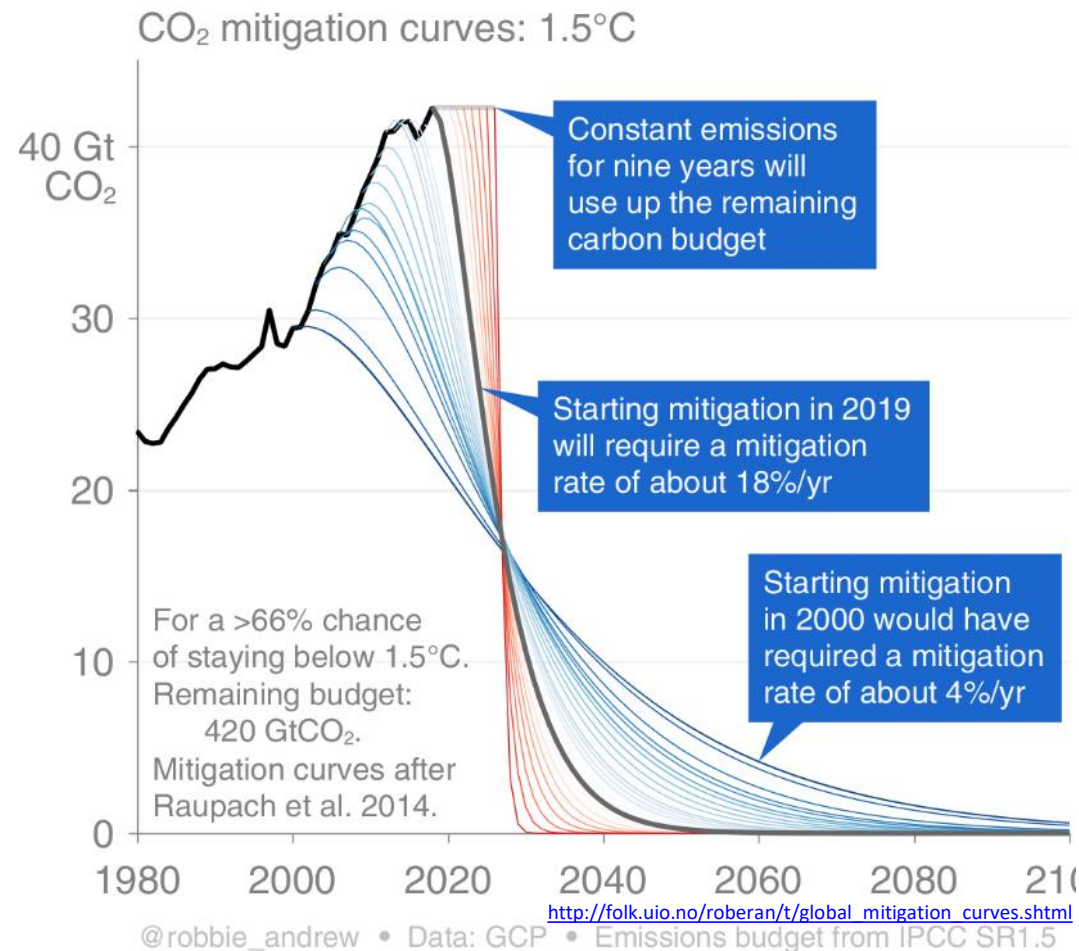
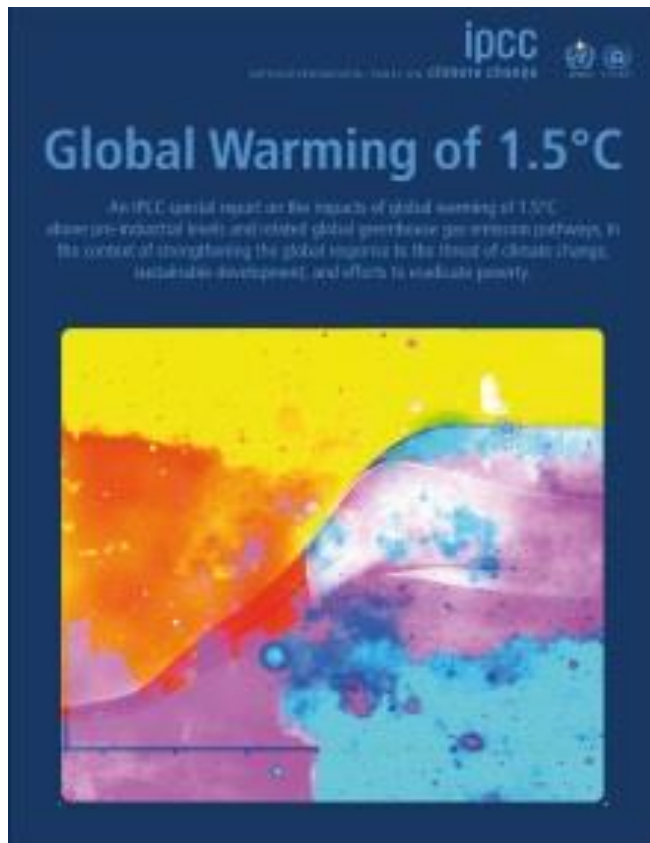
MacKay, D. J. C. (2013). "Solar energy in the context of energy use, energy transportation and energy storage." Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences **371**.

# The transition to a decarbonised world



<https://carboncounter.wordpress.com/2015/06/01/the-future-of-energy-why-power-density-matters/>

Capital thinking. Globally minded.



Only 250 gigatons of fossil carbon can be removed from geological deposits by the end of the century. That means a 10% annual reduction in oil production until the sustainable level of 10 million barrels per day is reached in about 2050

Capital thinking. Globally minded.

## WORLD ENERGY CONSUMPTION AND MIX 1800 - 2018

BASED UPON DATA FROM BP STATISTICAL REVIEW 2019 (1965 - 2018), PRE 1965 FROM SMIL, BIOMASS SINCE 1900 FROM FERNANDES

### WORLD GDP 1980 - 2018

DATA FROM IMF

MTOE/a

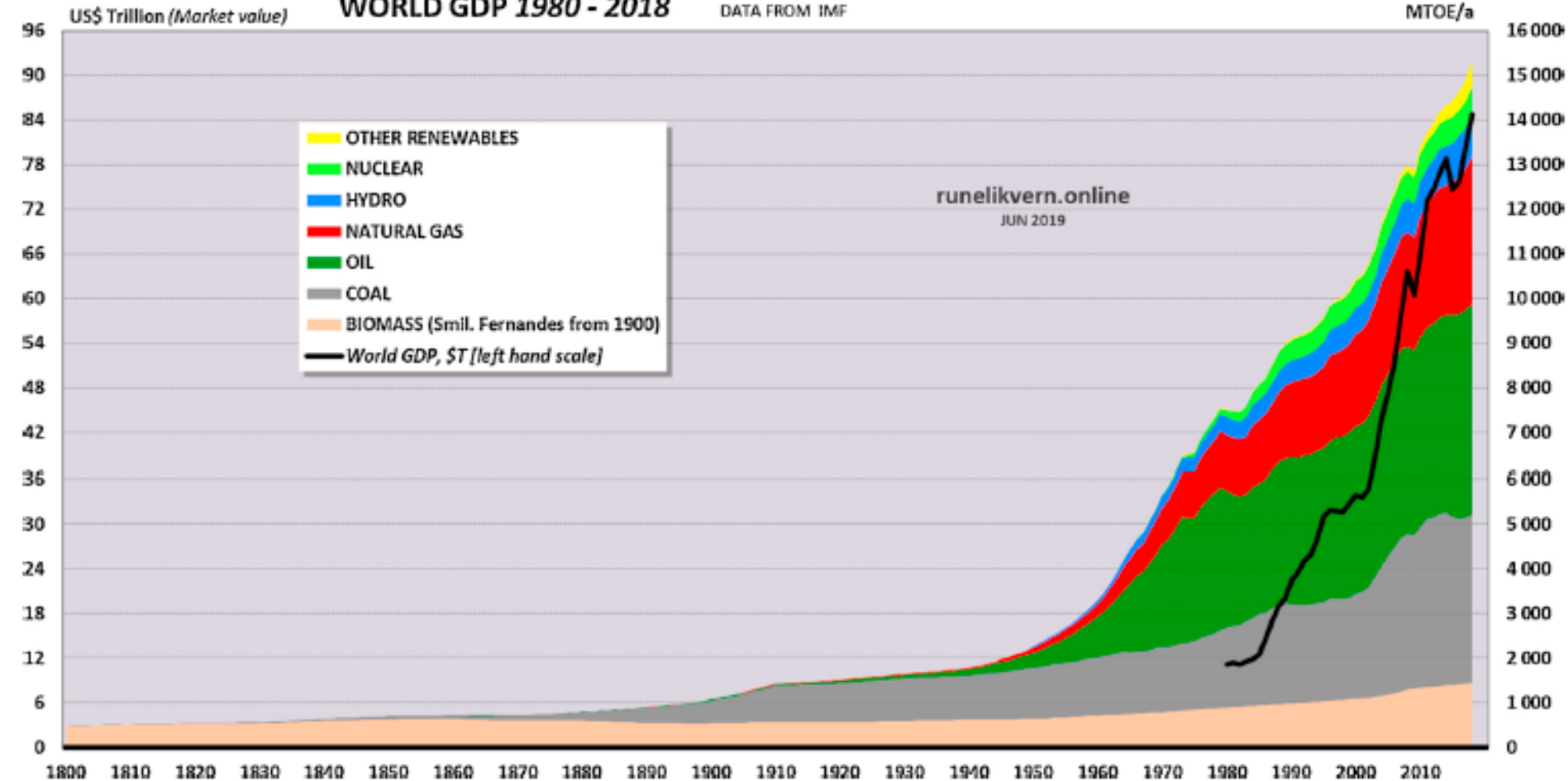
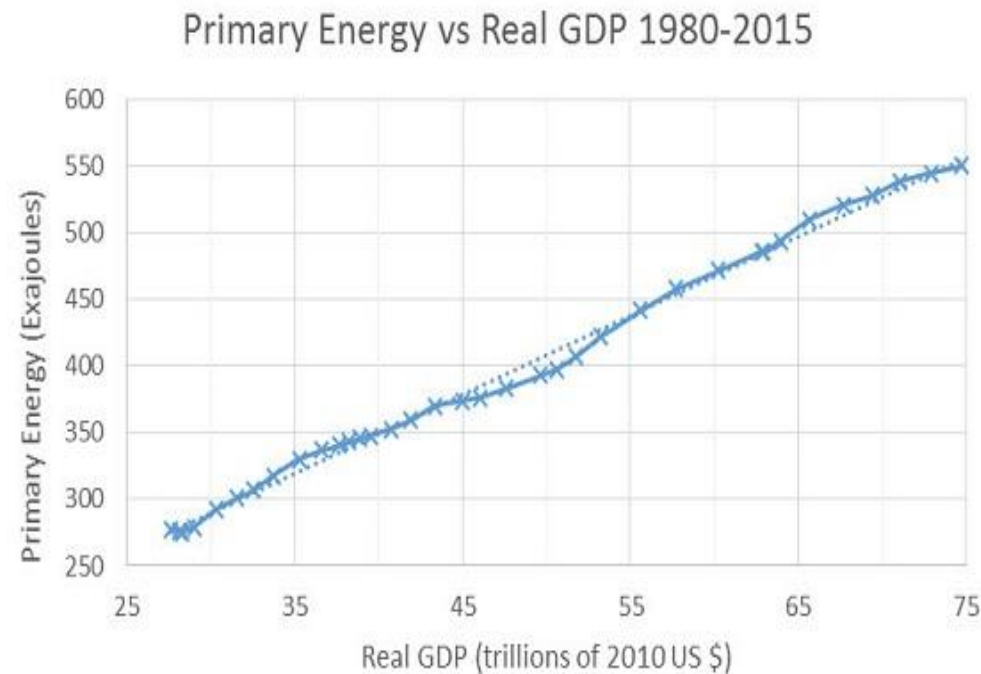
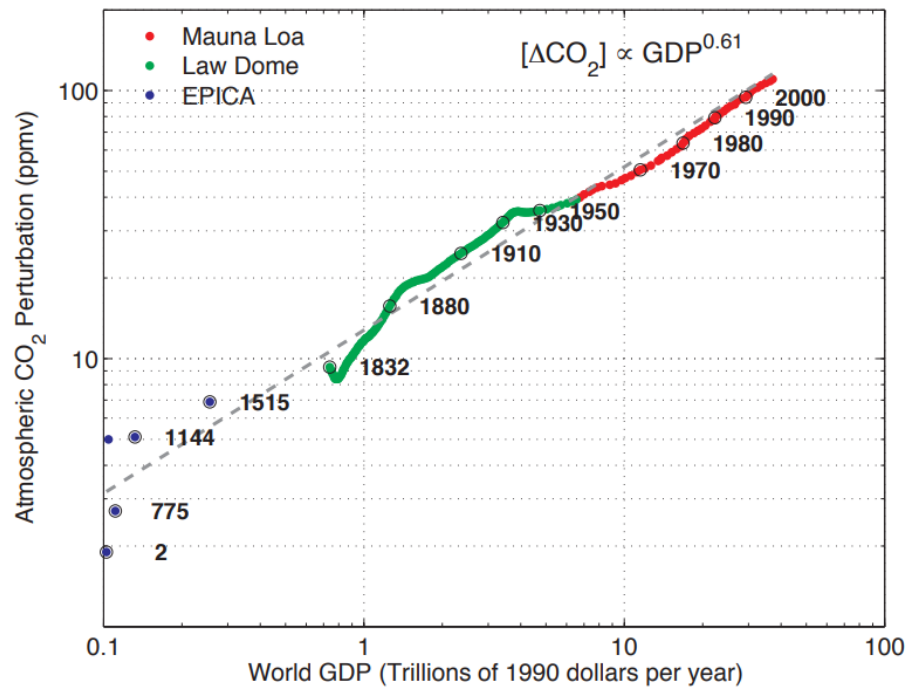


Fig. 3. Global energy mix 1800–2018 (Source: BP, 2019, Likvern 2019).

OK great the solution ~ 10% reduction every year ...

here is our dilemma

The fossil Energy - GDP - carbon linkage So imagine -10% p/a GDP

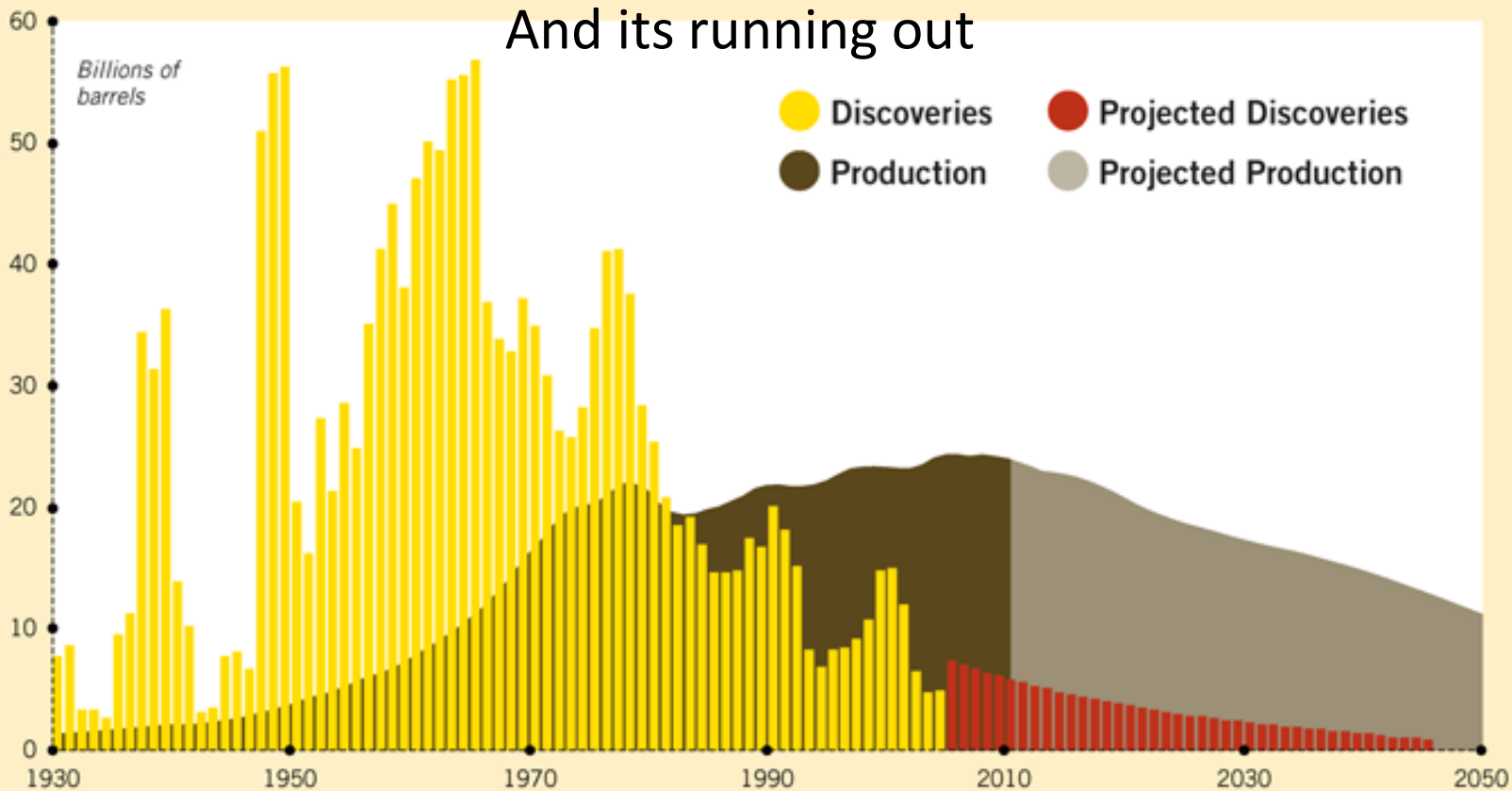


<https://carboncounter.wordpress.com/2015/06/01/the-future-of-energy-why-power-density-matters/>

Capital thinking. Globally minded.

<https://seekingalpha.com/article/3993718-energy-transition>

## And its running out

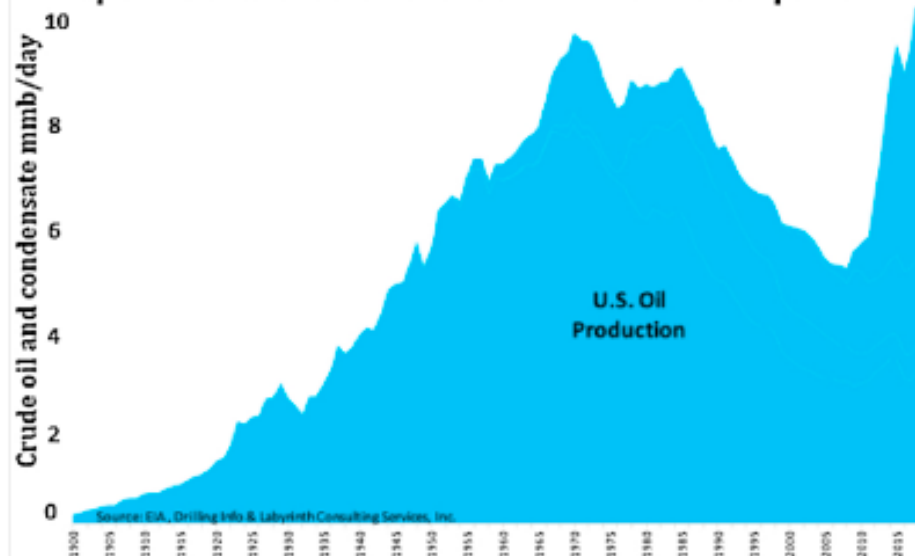


## THE REALITIES OF DECLINE: CONVENTIONAL OIL

*Discoveries of conventional oil peaked in the 1960s and have since slowed to a trickle. Thus it is widely expected that production of conventional oil will soon enter terminal decline—indeed, production has essentially leveled off since 2005. Production of unconventional oil (including tar sands and shale oil) is still on the rise, but it too will eventually hit its peak, as will coal and natural gas.*

DATA: ASPO, EXXONMOBIL

Using better technology, USA exceeds 1970 peak,  
surpasses Saudi Arabia and Russia as worlds #1 producer



Conventional Lower 48 States production has declined 60% from 7.8 to 3.1 mmb/d  
Lower 48 + Alaska + Offshore production declined 45% from 9.6 to 5.3 mmb/d  
Tight oil has increased to 5.4 mmb/d, 51% of U.S. output

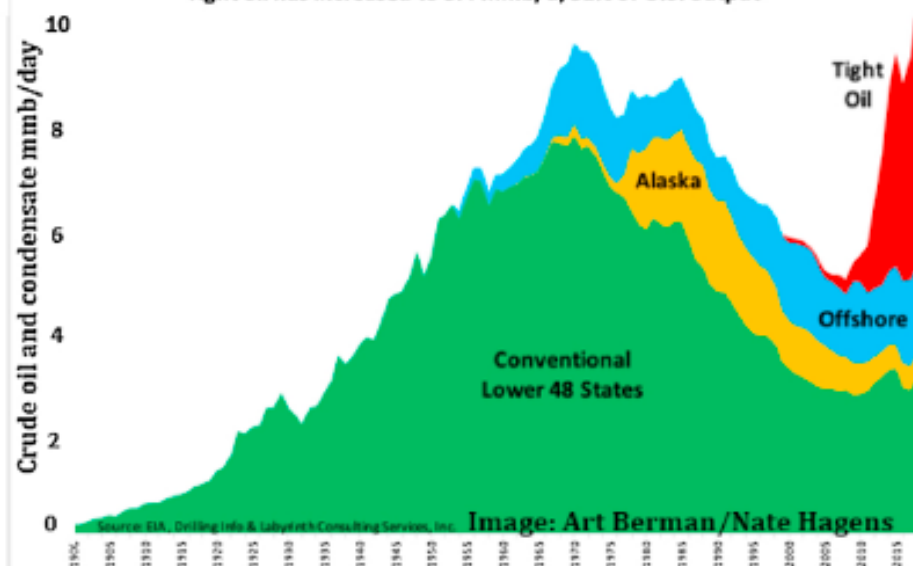
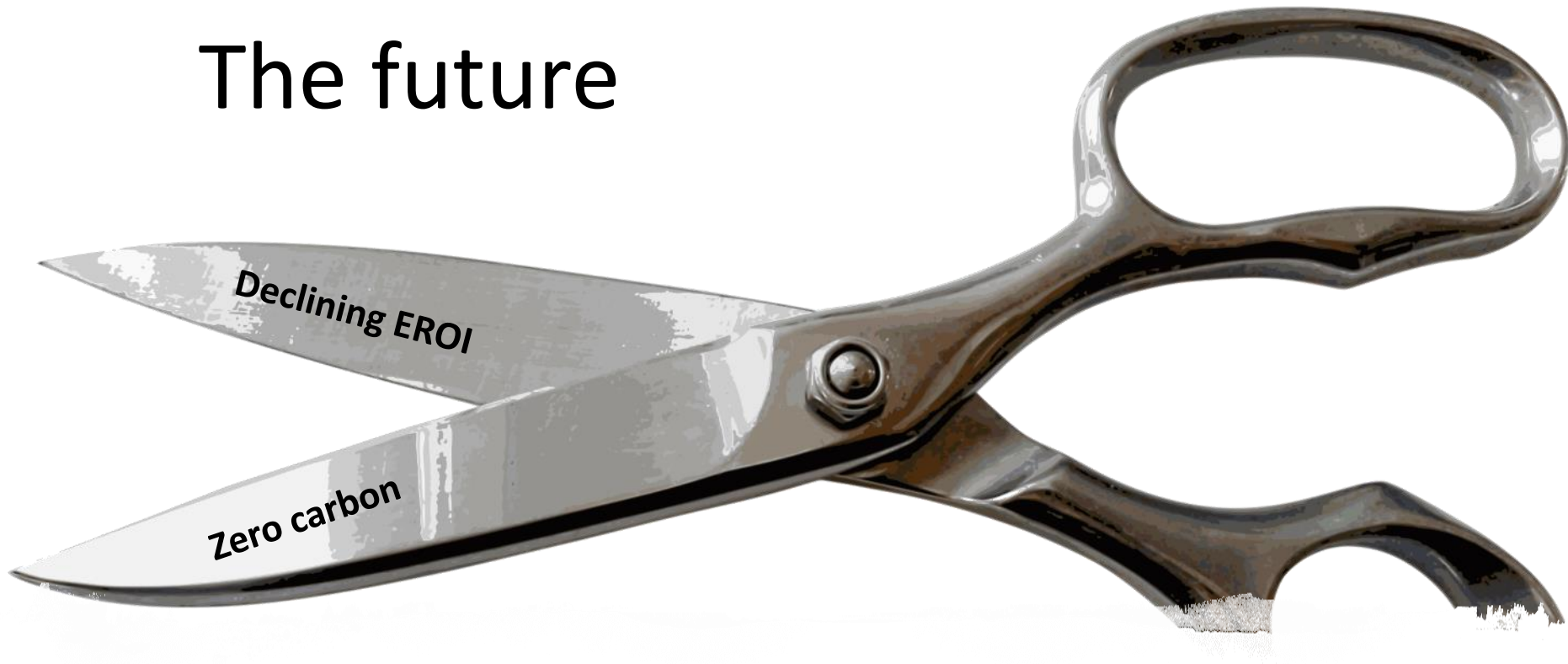


Fig. 4. U.S.A. Oil Production.1900–2018.

# The future



Either way change like we have never see is coming, and we can carry on as we are and see what happens or we can manage the change.

What do we see?

# SUNDAY STAR★TIMES

March 31, 2019 \$3.00

Sister  
in sorrow

Sport star's  
surrogacy  
heartbreak

NEWS



Holden

ADVERTISEMENT

# This is how we SUV



# The Uninhabitable Earth

A STORY OF THE FUTURE

David  
Wallace-Wells



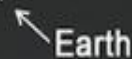
BUSINESS

## The Big Build: How Auckland Airport's \$5 billion spend-up will change the way we travel

4 Apr, 2019 5:00am

8 minutes to read

- Cognitive dissonance seems to be the norm, helped by many myths suggesting that we can carry on with business as usual by switching to renewable energy



- That switch is just not even vaguely possible. But even IPCC reports are based on as yet unproven mitigations “magic” like CCS as well as tree planting, as well as ‘renewable energy’ myths like hydrogen.
- Over hyped ‘options’ like electric vehicles and tree planting and sales people dependent on BAU pushing more consumption, crucial they keep the truth buried

# Reality check mitigation (trees)

- **Trees for sequestration** - using the average rate of sequestration by pine trees in NZ to take up our gross emissions for one year (2017) we would need 12.5 million ha of trees (half of NZ total area) or roughly 8.8 billion trees.
- Plant a tree to mitigate flight to Singapore? CO<sub>2</sub> per person for that flight is 2.35 tonnes = the annual sequestration of 0.5 Ha native trees
- **Trees globally** If we planted the whole planet that could possibly be planted in trees we could according to the latest research could over many decades of growing store up to 205 Gigatons of carbon what we emit in 5.5 years of the 2018 gross emissions of 37.1 Gt

# Reality check renewable

**Photo-voltaic panels** give 5 – 30% of rated of output and

**Wind turbines** give 10 -45% of rated output

Crucially all renewable options depend on fossil fuels for construction, maintenance and installation – renewable is not made by renewable. Most option require the same suite of rare metals as evs and all possible fossil replacements

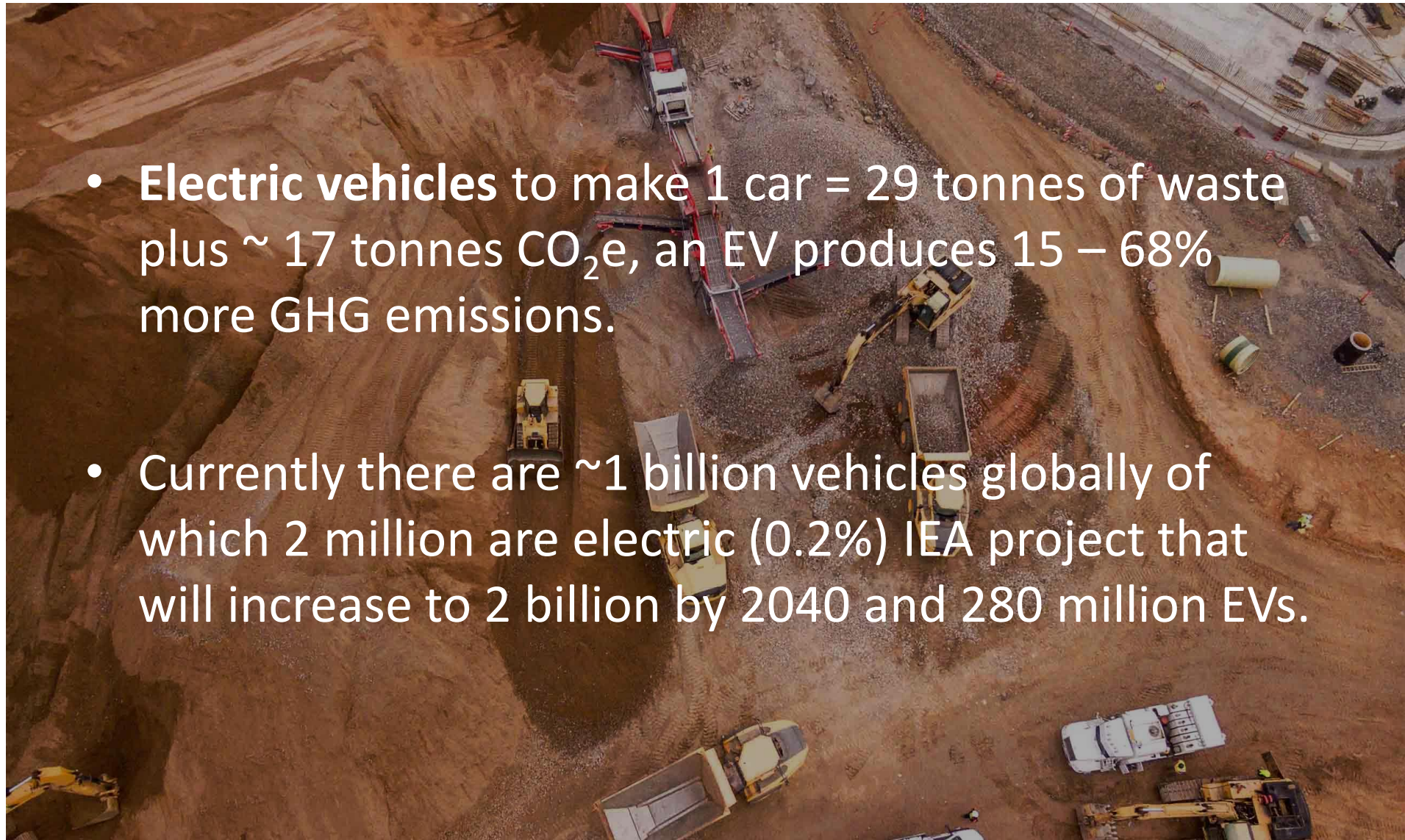
**Carbon capture and storage (CCS)** for coal uses 25 – 45% of the energy created

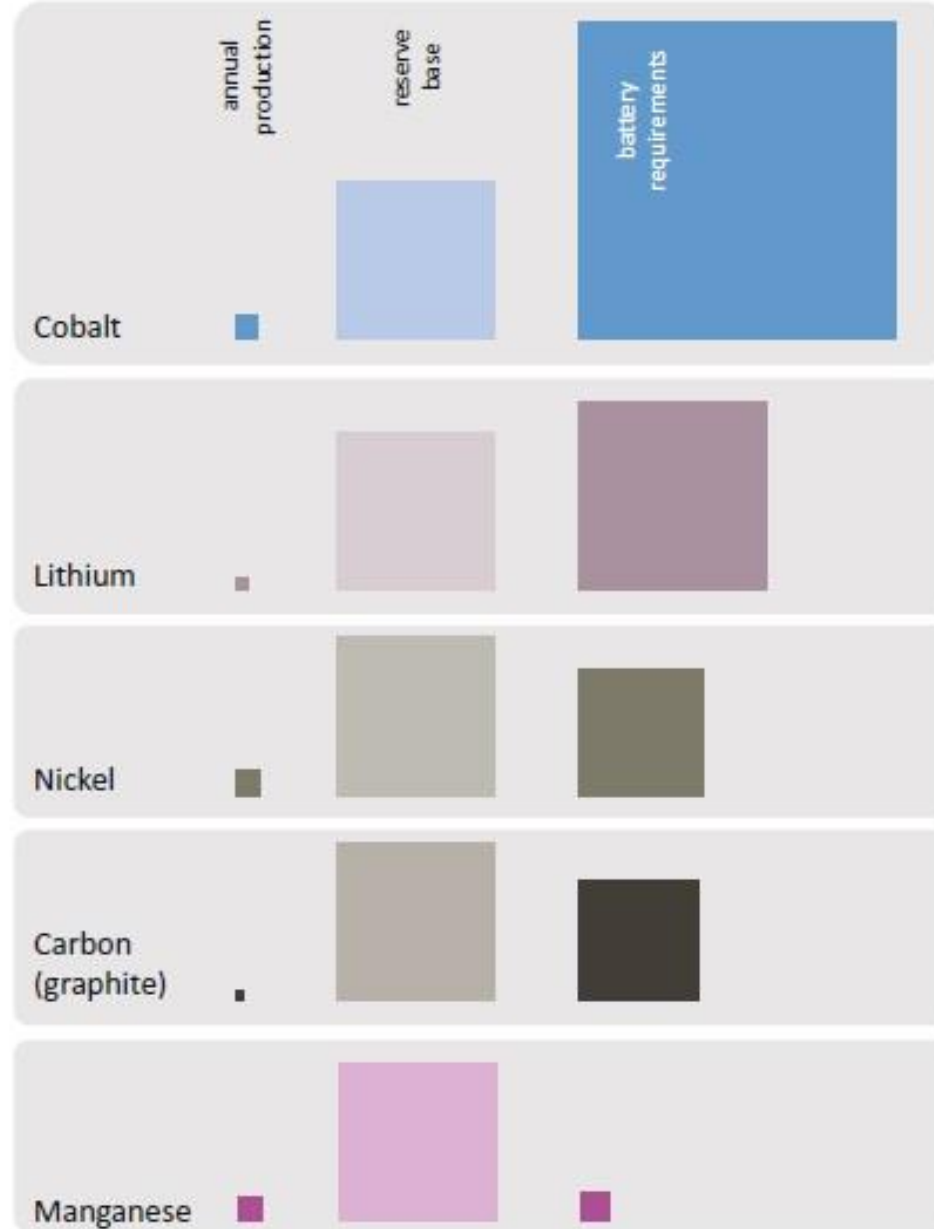
# Reality check renewable

- The 29,000 wind turbines and 1.6 million PV systems provide only 3.1% of Germany's energy needs and have cost well over 100 billion Euros so far and likely another 450 billion Euros over the next two decades.
- Hydrogen is an energy transfer medium not a source, huge problems with storage and high pressure heavy tanks, leakage and energy loss in process, if made from gas no reduction in GHG emissions

# Reality check EVs

- **Electric vehicles** to make 1 car = 29 tonnes of waste plus ~ 17 tonnes CO<sub>2</sub>e, an EV produces 15 – 68% more GHG emissions.
- Currently there are ~1 billion vehicles globally of which 2 million are electric (0.2%) IEA project that will increase to 2 billion by 2040 and 280 million EVs.

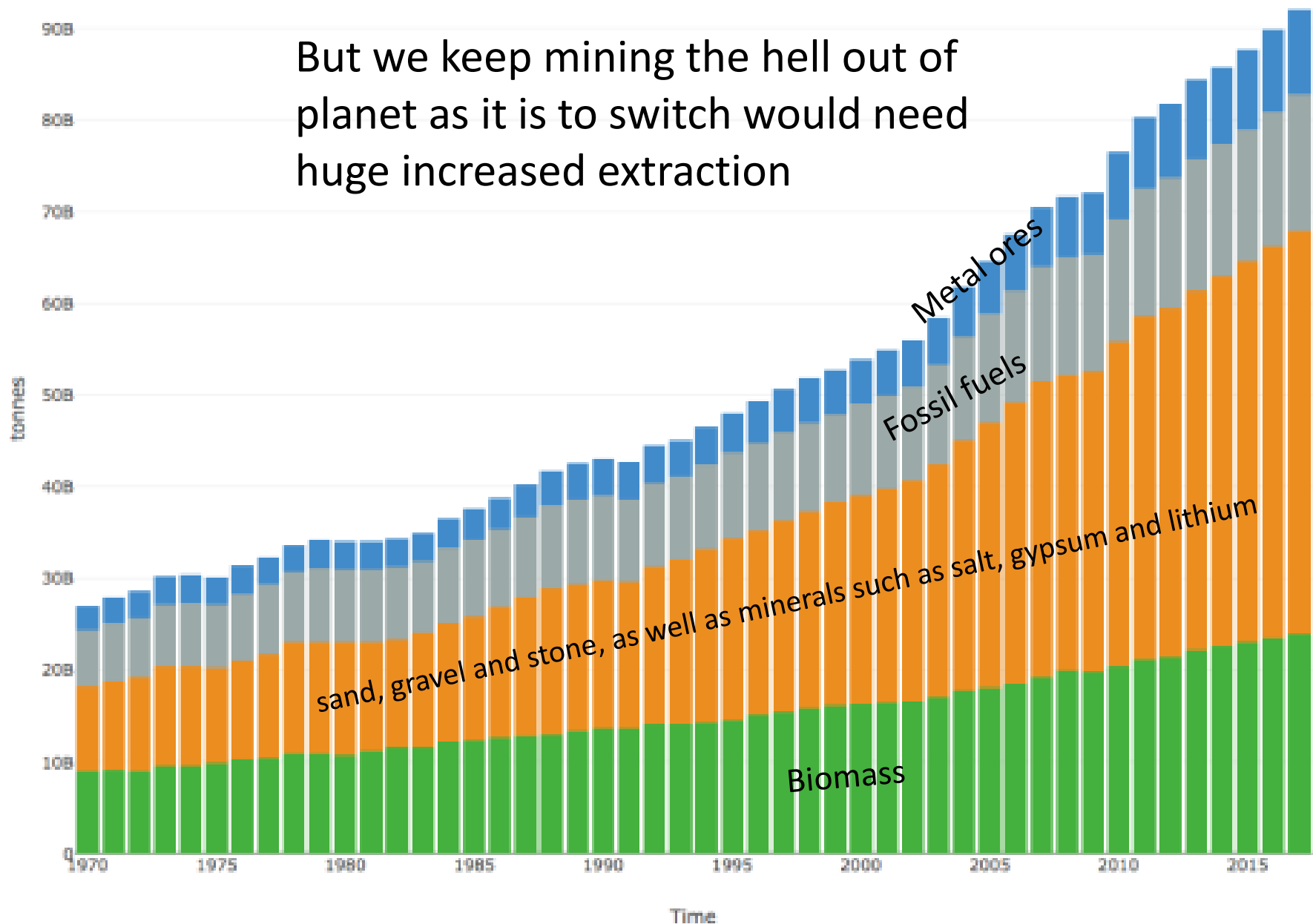




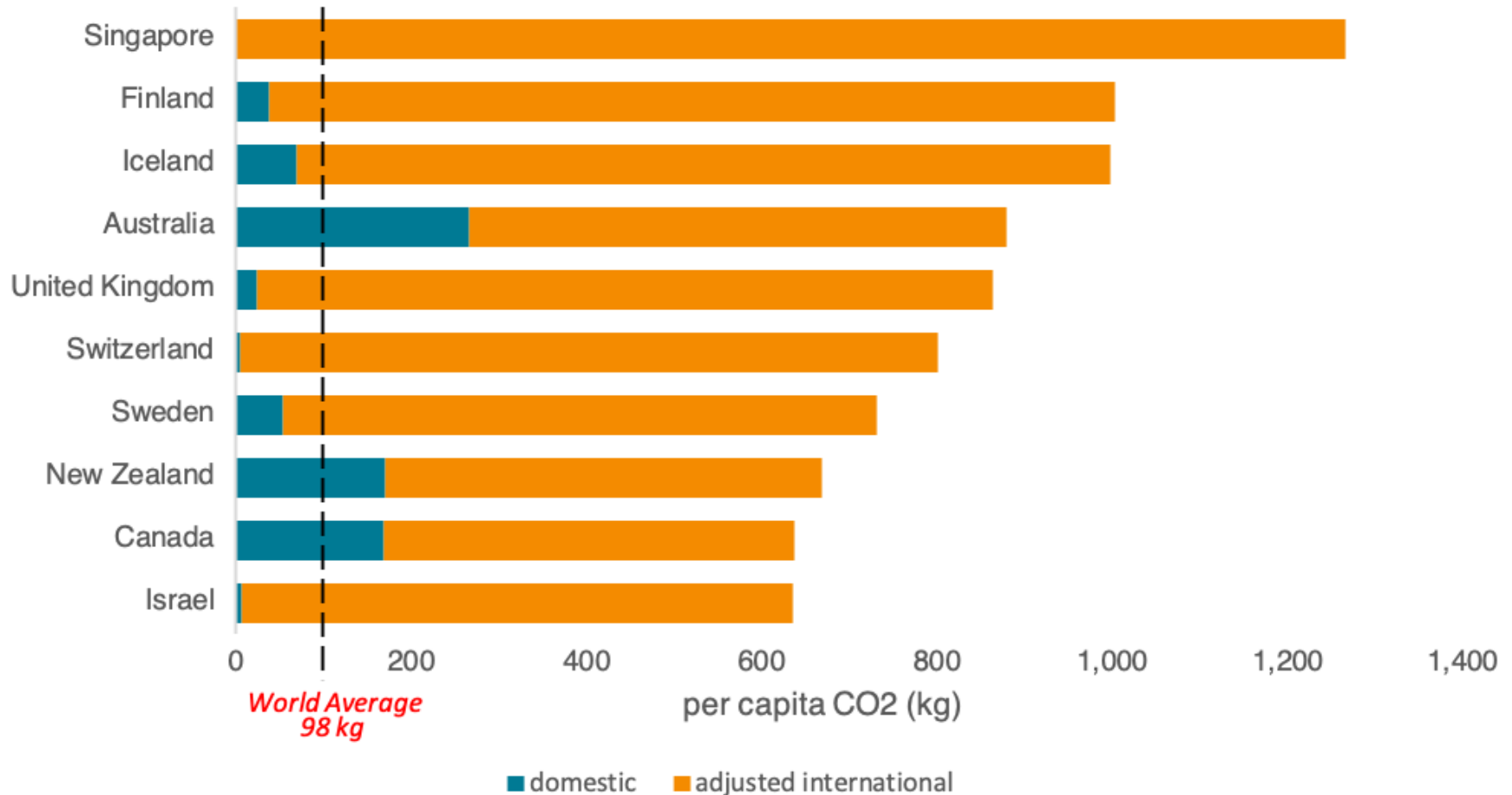
**Fig. 9.1** Illustration of battery elemental material requirements to manufacture 142 TWh of NMC-111 batteries, and annual production of materials, scaled relative to reserves in 2018. Production and reserve data from USGS (2019). USGS gives manganese as gross ore weight, for which we assume 48% manganese content from Cannon et al. (2017). Battery unit requirements from Olivetti et al. (2017, table 1)

Domestic Extraction of World in 1970-2017, by material group

But we keep mining the hell out of planet as it is to switch would need huge increased extraction

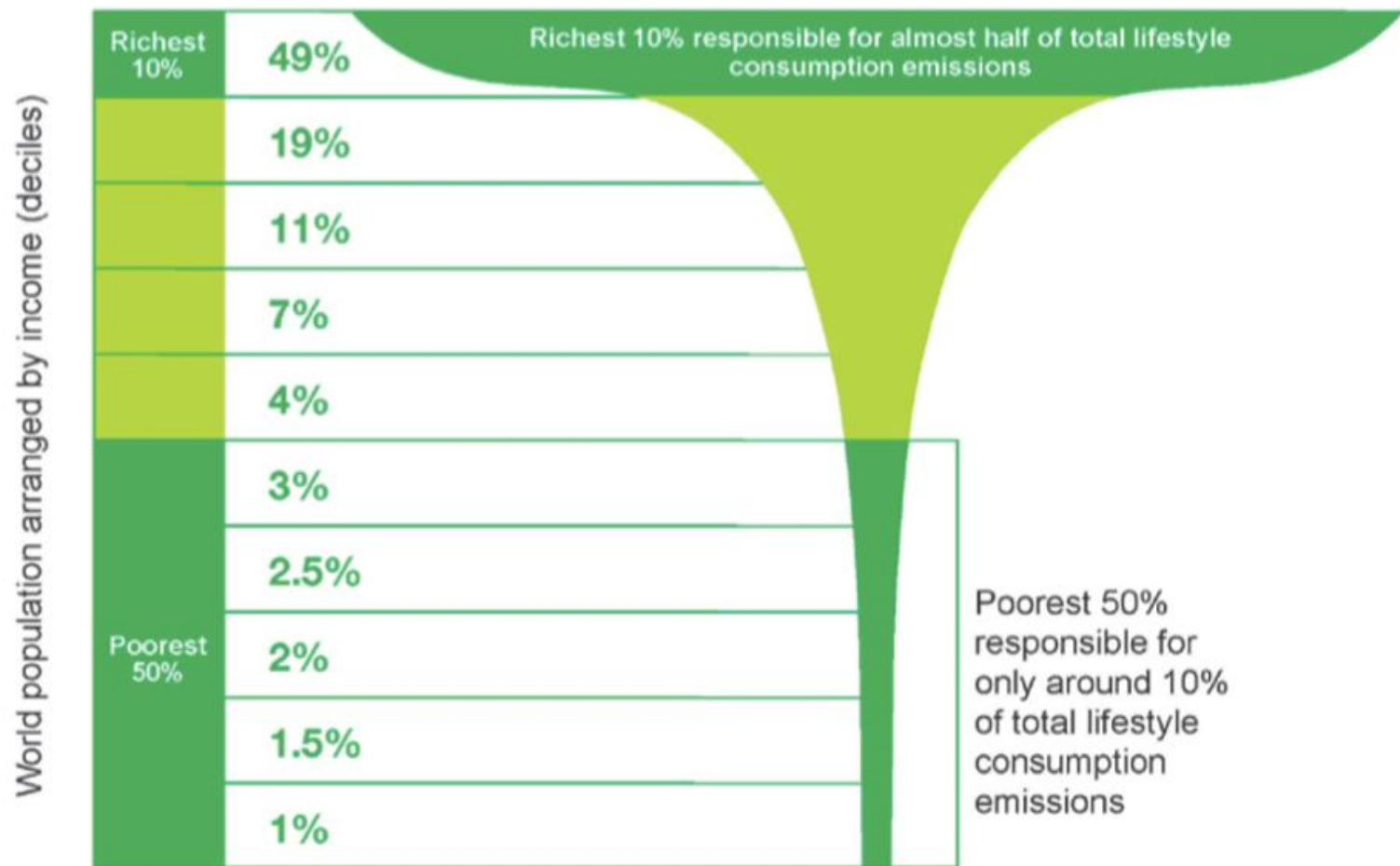


## Reality check - Flying and tourism?



# A JUST TRANSITION?

## Percentage of CO<sub>2</sub> emissions by world population



Source: Oxfam

Capital thinking. Globally minded.

# The future

*We need:*

- 1. Simpler lifestyles, much less production and consumption, much less concern with luxury, affluence, possessions and wealth.*
- 2. Small, highly self-sufficient local economies, largely independent of the global economy.*
- 3. More cooperative and participatory ways, enabling people in small communities to take control of their own development.*

# The future

- 4. A new economy, one not driven by profit or market forces, and a zero-growth or steady-state overall economy, which produces much less than the present economy.*
- 5. Agriculture that is diverse and sustainable, immediate transition from monoculture to permaculture. Close all nutrient and mineral loops and end synthetic fertiliser production, no production animals on any land where food can be produced for humans*
- 6. All remaining fossil energy used for renewable energy and sustainable life systems no more wastage*

# There is a better way to produce food: regenerative farming

- high-input ag (NZ BAU) is in a negative spiral of land use intensification and environmental degradation based on privatisation of profits and socialisation of costs.
- Urgently needed is a move to innovative agricultural systems

like regenerative agriculture, agroecology, agro-forestry, climate-smart agriculture, conservation agriculture and

building all these on indigenous and traditional knowledge.

- Make NZ a global leader in sustainable food production instead of a follower in a race to the bottom.

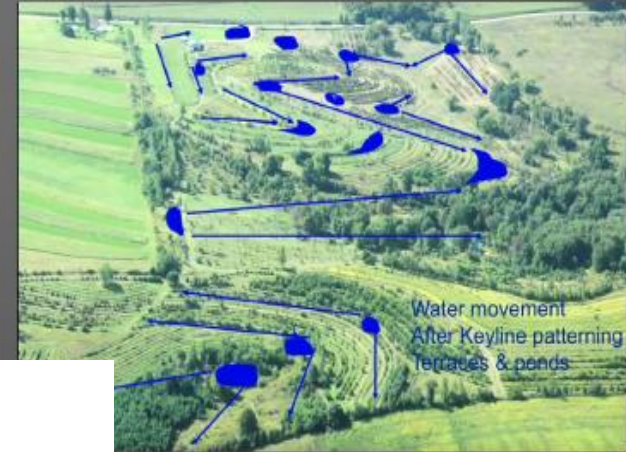


Conventional* (industrial input-output approach)		Regenerative agriculture approach	
Technique	Results	Technique	Results
Tillage	loss of topsoil, and soils structure, water holding capacity, compaction, loss of fungi and microbes, erosion	No tillage	Low/no disturbance, increase in OM and water holding and exchangeable nutrient pool
Set stocked grazing	Compaction and erosion	<div> <div>Regen ag = closing nutrient loops, no fossil fuel derived fertiliser, no/low external input, no monocultures... less agri-business more <u>agriculture</u></div> <div>How it works in nature</div> </div>	Increased nutrient cycling, rooting depth, diversity of organisms, better soils structure, water infiltration and retention, increased soil organic matter & CO2
Synthetic fertiliser	loss of soil microbes, shallow rooting depth, of nitrate leaching plants		
Irrigation	Salinisation, nutrient flow waterways and aquifers, financial cost, aquifer depletion		Water stored in landscape on farm, groundwater recharge, returning natural hydrology
Grazing (monoculture)	High nutrient load, water pollution, compaction and rutting		Increased soil biodiversity, photosynthesis and plant growth, rooting depth and soil structure
Monoculture production	Reduction in biodiversity of habitat structure facilitating increased pathogen/pest levels		Increased species richness, habitat diversity and soil microbes, disrupting pest/pathogen cycles, better animal welfare/diet/health and productivity
		Pasture cropping/cover cropping	Diverse pasture outcompetes weeds and preserves soil health and structure = higher productivity. Better erosion control, nutrient cycling and moisture retention

## Example : New Forest Farm, WI (USA)



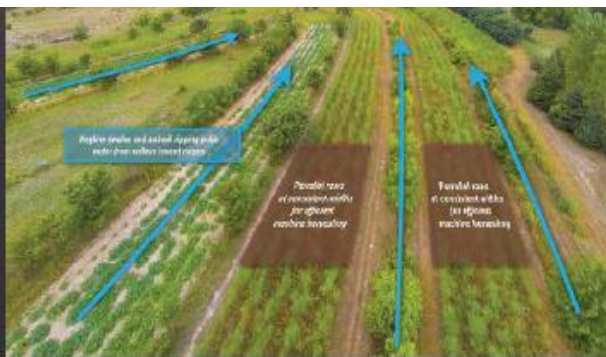
110ac Former maize farm converted to high biodiversity Eastern woodlands as the ecological model (for humans and animals), fuel, fibre & medicine. Hazelnuts, hazel crops - where they provide weed control and wind powered and farm equipment is powered



Water movement  
After Keyline patterning  
terraces & ponds

How our landscapes will look, opening up many other opportunities like on farm tourism and reinstating rural communities will be a necessity

using oak savanna, successional brushland and another to produce food (for humans and animals) managed in an integrated manner with the tree cover for the livestock. The farm is entirely solar and



A dense, diverse forest scene with various types of trees, including tall palm trees, ferns, and smaller shrubs, set against a light green background.

Native  
conservation  
forest

A forest scene dominated by tall, uniform evergreen trees, with many tree stumps visible in the background, suggesting deforestation.

Exotic  
commercial  
forest

What we have now

A pastoral landscape featuring a winding river, a fence line, and a field with numerous sheep and cows grazing. A purple circle with the text 'Pastoral agriculture' is centered in the field.

Pastoral  
agriculture

## PERMANENT FOREST

## CONTINUOUS COVER FORESTRY

## INTENSIVE FORESTRY

Native conservation forest

Carbon farming

Close-to-nature forestry

Selection and retention systems

Native commercial forest

Exotic commercial forest

Natural and assisted regeneration

Riparian planting

Pastoral agriculture

Horticulture and cropping

Urban forestry

Wood lots

How our  
opening  
opportunities  
and reinsurance  
will be a

# The Interwoven World Te Ao i Whiria

## Toward an Integrated Landscape Approach in Aotearoa New Zealand

Dr David Hall, The Policy Observatory, AUT  
June 2018

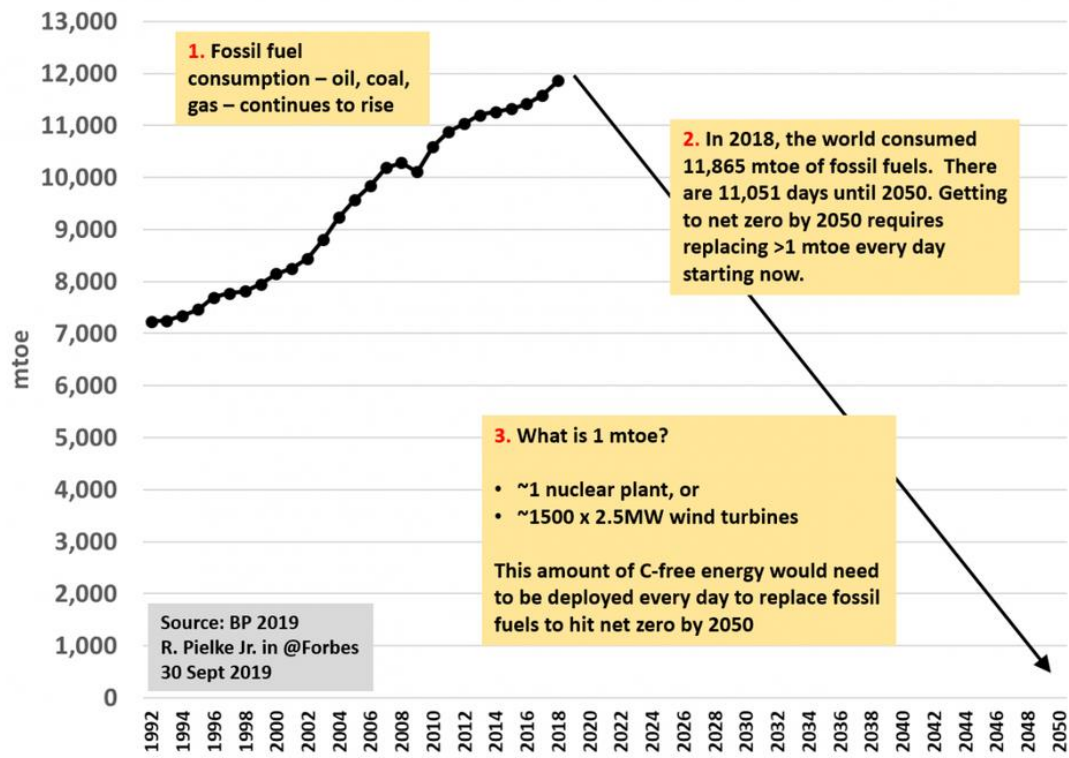
A discussion paper prepared for The Policy Observatory,  
Auckland University of Technology

k,  
tourism  
unities

# Reality check – why we have to act now

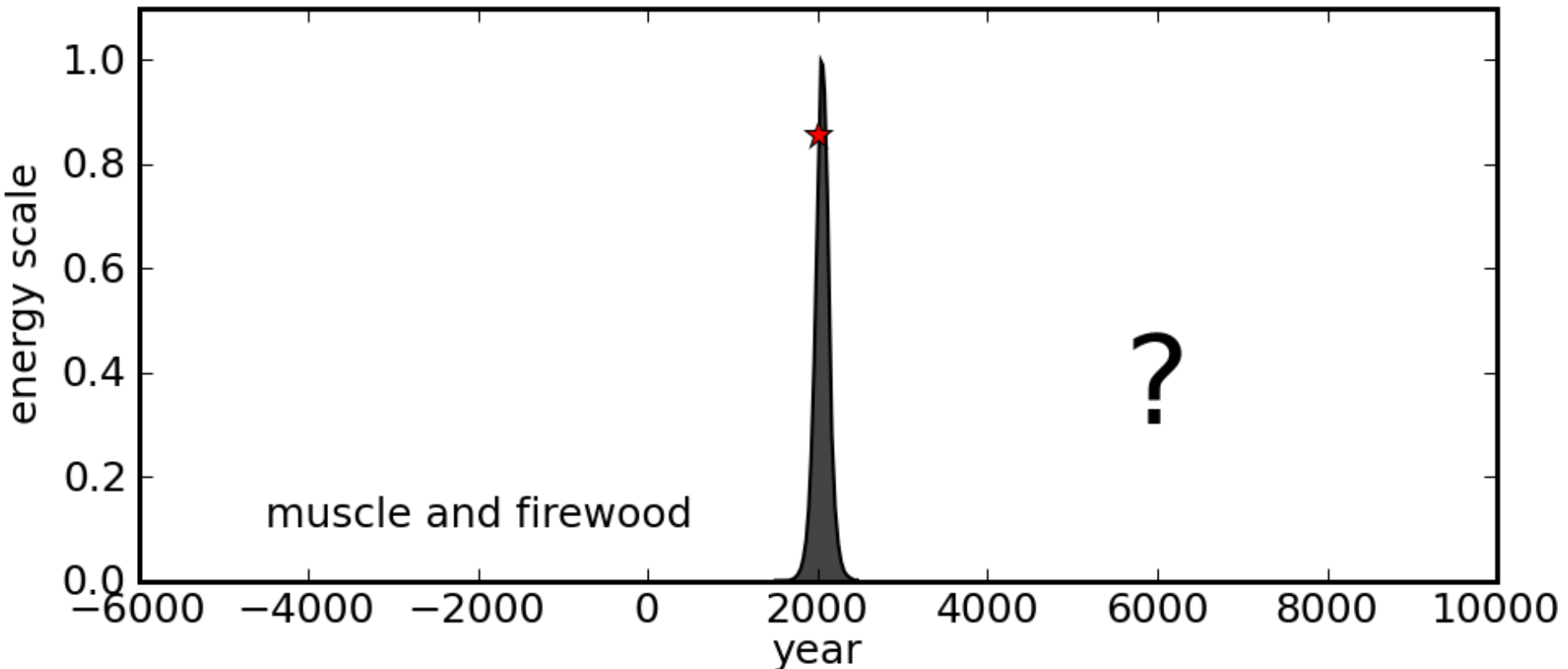
- In 2018 the world consumed 11,743 mega-tonnes of oil equivalent (mtoe) fossil fuel
- So to reach net-zero carbon by 2050 (~11,000 days) we need to replace about 1 mtoe every day from now until 2050
- Thus, we would need to build 1500 2.5 mw wind turbines (covering 777 km<sup>2</sup>) every day from now until 2050, or 1 large nuclear power plant per day!

Global Fossil Fuel Consumption



[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\\_QndkmITYvQ04clCJyG\\_axZ70\\_6EswVcgu6xsCR\\_0X8\\_lml#1c3eb84135f7](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_QndkmITYvQ04clCJyG_axZ70_6EswVcgu6xsCR_0X8_lml#1c3eb84135f7)

- We are dependent for everything that makes our modern existence including food either directly or indirectly on fossil fuels but that is almost over, 10% reduction p/a or catastrophe



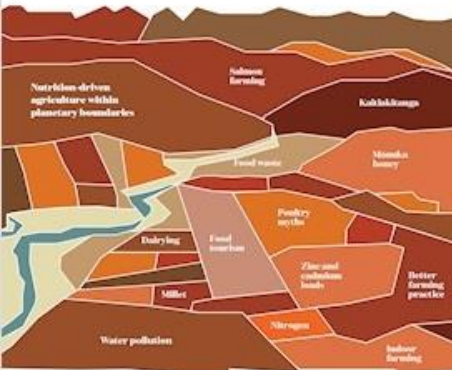
- “The real problem of humanity: we have Palaeolithic emotions; medieval institutions; and god like technology” – E.O. Wilson

 Earth from Mars

- “not everything that is faced can be changed, but nothing can be changed until its faced” – James Baldwin

**The New Zealand  
Land & Food Annual**

**No free lunch**  
Can New Zealand feed  
the world sustainably?



Edited by Claire Massey

**Mountains to Sea:  
Solving New Zealand's Freshwater Crisis**  
Edited by Mike Joy

*It strikes me with great clarity that if you look at the problems in isolation they each seem intractable; but when you grasp that there could be one single solution, then suddenly there is a glimpse of light at the end of the tunnel.*

The state of New Zealand's freshwater has become a pressing public issue in recent years. From across the political spectrum, concern is growing about the pollution of New Zealand's rivers and streams. We all know they need fixing. But how do we do it?

In *Mountains to Sea*, leading ecologist Mike Joy teams up with thinkers from all walks of life to consider how we can solve New Zealand's freshwater crisis. The book covers a wide range of topics, including food production, public health, economics and Māori narratives of water. *Mountains to Sea* offers new perspectives on this urgent problem.

**Contributors:** Mike Joy, Tina Ngata, Nick D. Kim, Vanessa Hammond, Paul Tapsell and Alison Dewes, Peter Fraser, Kyleisha Foote, Catherine Knight, Steven Carden and Phil McKenzie, Chris Perley

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(Alice Walker)

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**Polluted Inheritance**  
New Zealand's  
Freshwater Crisis

MIKE JOY

'NEW ZEALAND NOW HAS THE HIGHEST  
PROPORTION OF THREATENED AND  
AT-RISK SPECIES IN THE WORLD'

BWB Texts

Doing nothing will not make you immune to the  
consequences

[www.waterqualitynz.info](http://www.waterqualitynz.info)

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Freshwater  
activist friends  
students &  
colleagues all  
over New  
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