The future of food;
our deadly nitrogen addiction

Mike Joy - Massey University - Ecology - Institute of Agriculture and Environment

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 this on the horizon:

- declining amount and quality of land to grow food, declining fossil fuels and their EROI, declining water quality, declining biodiversity and wild fisheries. And 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

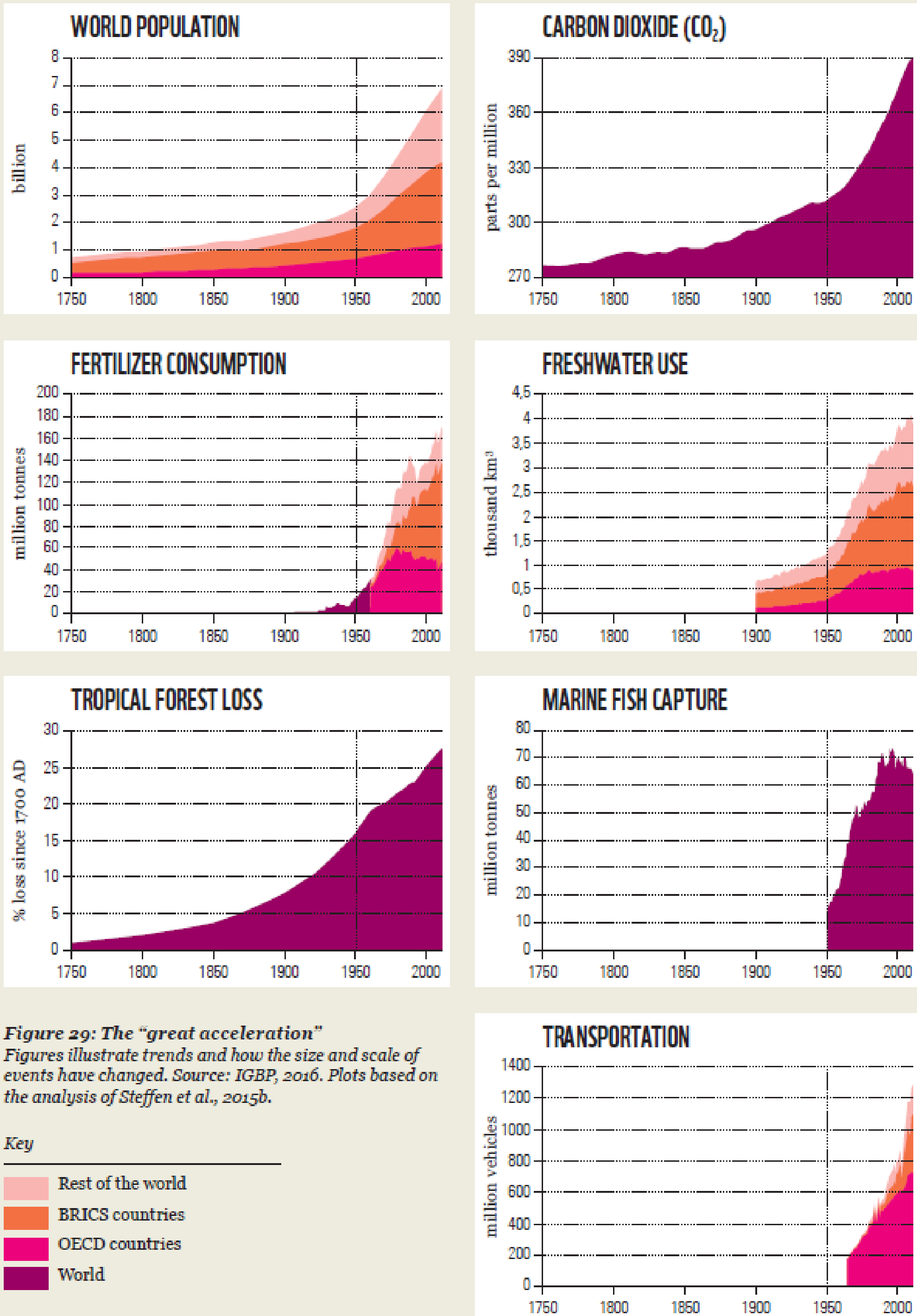
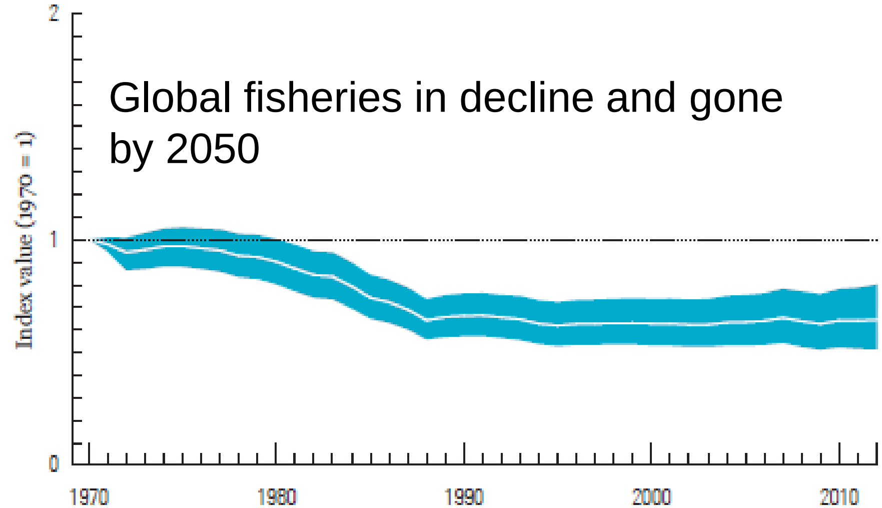


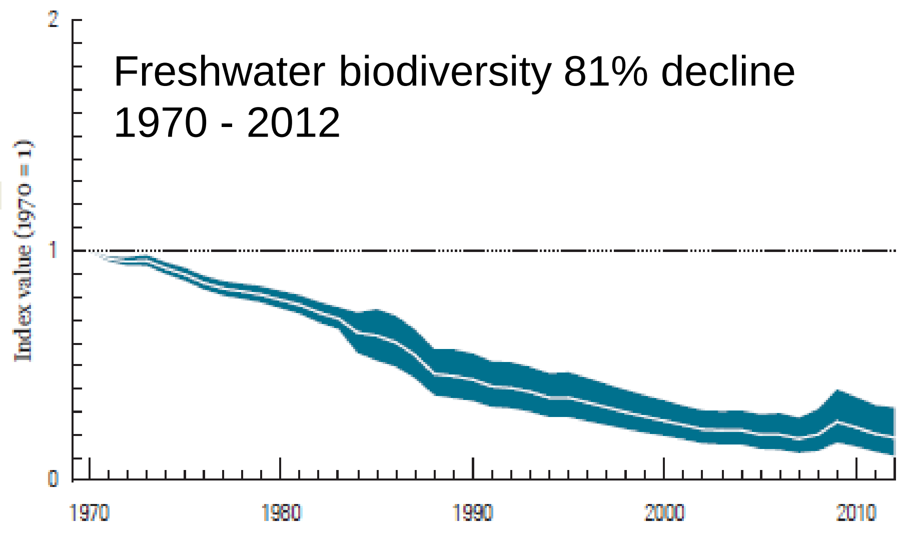
Figure 29: The "great acceleration"
Figures illustrate trends and how the size and scale of events have changed. Source: IGBP, 2016. Plots based on the analysis of Steffen et al., 2015b.

Global fisheries in decline and gone by 2050



- The state of the world (WWF report)

Freshwater biodiversity 81% decline 1970 - 2012

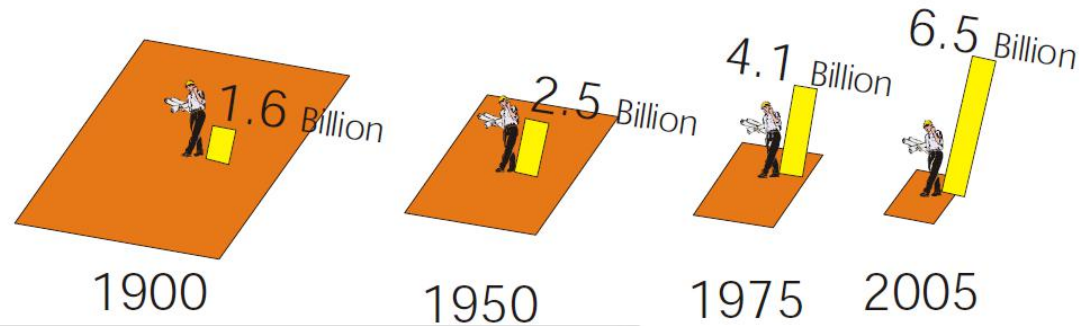


Losing the foundations - soil

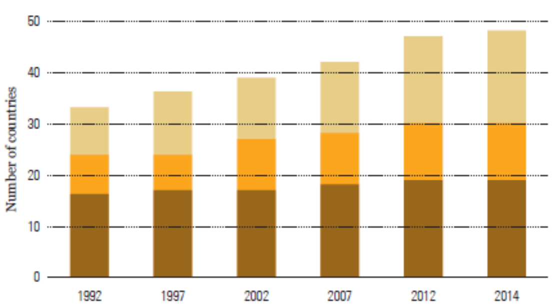
Figure 26: The state of global soil degradation (UNEP, 1997).

Key

- Very degraded soil
- Degraded soil
- Stable soil
- Without vegetation



Running out of water & land



NEARLY 50 COUNTRIES EXPERIENCED WATER STRESS OR WATER SCARCITY IN 2014

Figure 27: Number of countries experiencing different types of water stress
Number of countries experiencing different types of water stress from a total of 174 countries (FAO, 2016b). Water stress is defined as annual renewable water resources of less than 1,700 m³ per inhabitant, water scarcity as less than 1,000 m³ per inhabitant, and absolute water scarcity as less than 500m³ per inhabitant (UN-Water, 2011). Annual renewable water resources equals the amount of water available per person per year. Figure compiled by UNEP-WCMC.

Key

- Water stress
- Water scarcity
- Absolute water scarcity

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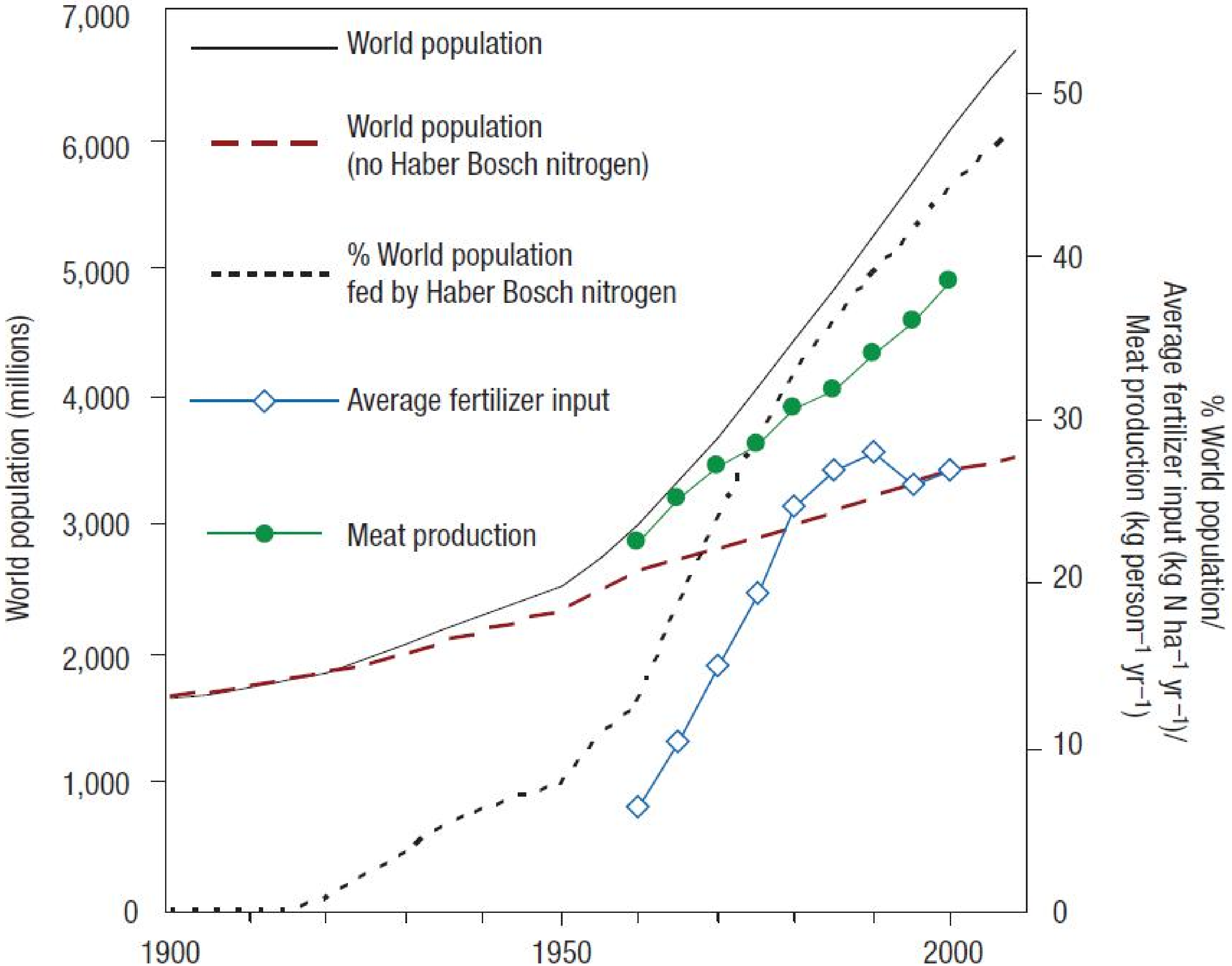
The green (fossil fuel) revolution?



How a century of ammonia synthesis changed the world

nature geoscience | VOL 1 | ADVANCE ONLINE PUBLICATION | www.nature.com/naturegeoscience

Overdose?

- Despite the massive increase in fossil derived food we have nearly a billion people suffering from inadequate and insecure diets, + 2.1 billion people obese or overweight from the move to highly processed foods high in refined sugar, refined fats, oils and meats.

- 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

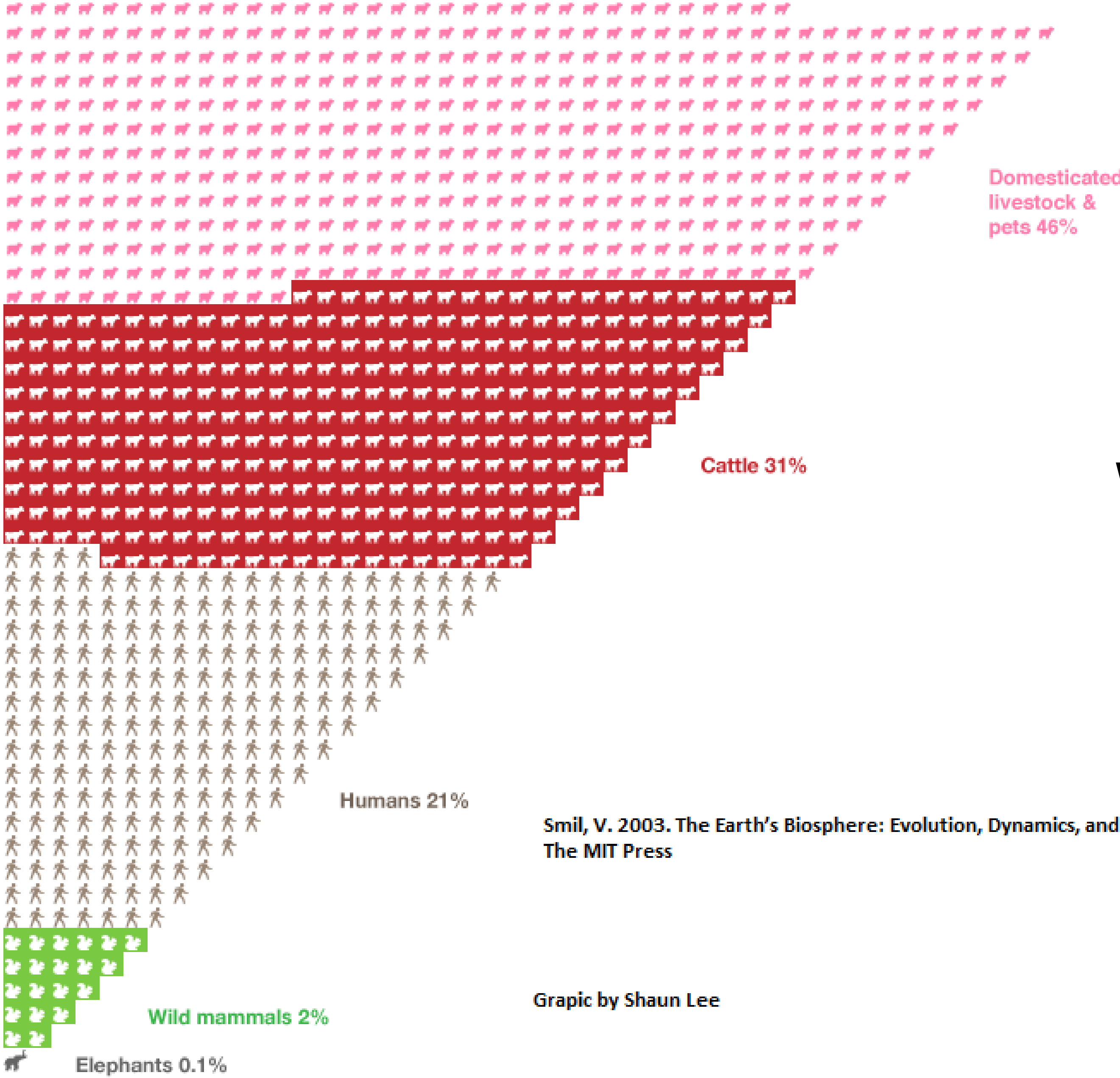
Overdose?

- Not just the fossil fuel in fertiliser but our 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.

- Once we started eating oil we initiated the massive population increase of humans and the animals we eat (the ‘green’ revolution)

- What do you think is the ratio of humans and our food animals and pets to wild animals?

Worlds land mammals by weight



Wild mammals 2%

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

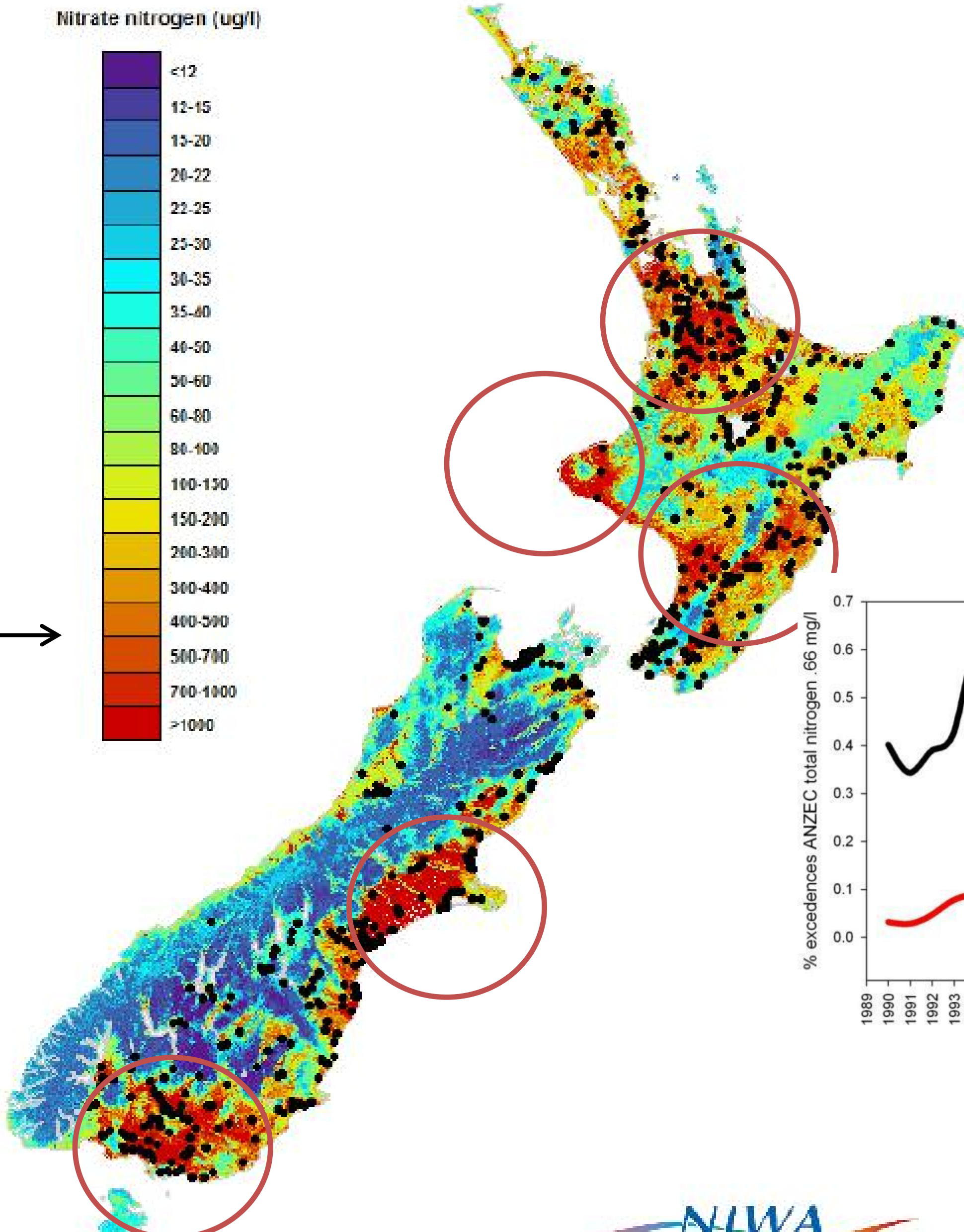
Grapic by Shaun Lee

Leaky systems

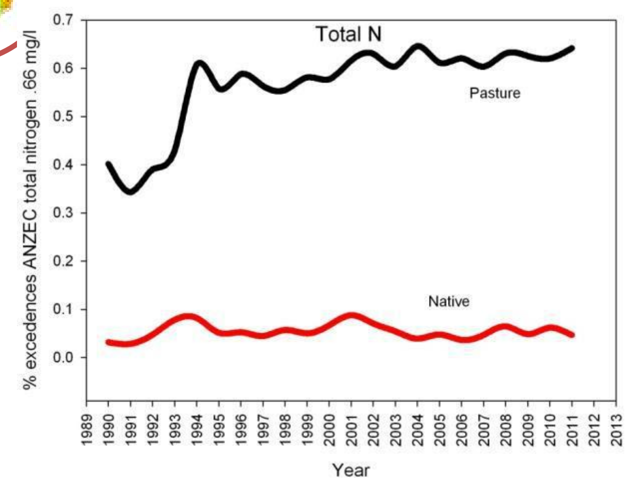
- Only 17% of the N applied as fertiliser makes it to the food we eat the rest mostly leaks out to do harm in the environment:
- For every 100 kg of nitrate fertiliser applied to soil, >1 kg ends up in the atmosphere as nitrous oxide (N_2O), a gas 300 times more potent a GHG than CO_2 and N_20 is the most ozone-depleting gas. Pre-industrial < 270 ppb atmosphere now > 320 ppb now
- eutrophication of waterways rivers, lakes
- and oceans – 400 dead zones covering 245,000 km^2

http://www.unep.org/pdf/dtie/Reactive_Nitrogen.pdf

nitrate in NZ rivers



ANZECC nuisance algal growth trigger level →



+ 44% of lakes eutrophic

Expensive addiction

- In EU ~ 11 million tonnes of N added/yr gives benefit of €20 – €80 billion/yr when long-term gains are included.
- But in EU the cost to society of excess nitrogen based on estimates of the price of damage to human health, ecosystems and biodiversity loss estimated to be between €70 billion and €320 billion per year.
- In NZ costs to clean-up nitrate in freshwater from intensive farming between $2.4 billion and 24 billion

- Sutton, M. A., O. Oenema, J. W. Erisman, A. Leip, H. van Grinsven, and W. Winiwarter. 2011. Too much of a good thing. Nature 472:159-161.

Our deadly nitrogen addiction NZ dairy externalities

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50 YEARS

'Back of the envelope' insights - 2014 SCION

		Forest		Dairy	
	Hectares	28,000		26,600	grazable
LAND	Land value	10,000	$/ha	36,100	$/ha
	Yield/unit	678	m³/	950	kg milk solids/ha
	Price range	89 to 102	$/m	5 to 9	$/kg milk solids
PROFIT	Surplus range	22 to 32	million $/yr	-6 to 96	million $/yr
	Probabilities of loss	0	%	13	%
	Manufactured Product	67,550	t p	38	million kg whole milk
		275,268	gre mber m³		
	10-year avg. export price	737	$/t p	7	$/kg milk solids
		404	$/m mber	5	$/kg whole milk
	Manufactured exports	161	mill $/yr	179	million $/yr
	Employment: Upstream	84	emp rest/yr	415	emp/farm/yr
	Downstream	280	emp ill/yr	175	emp/plant/yr
	Phosphorus	0.05	kg/ r	1	kg/ha/yr
	Nitrogen discharge	3	kg/ r	54	kg/ha/yr
	Nitrogen price	400	$/k	400	$/kg
	Carbon emitted/stored	11	t CO ha/yr seq	10	t CO_2e/ha/yr emitted
	Carbon price	7	$/t CO_2e	- 7	$/t CO_2e
EXTERN	Externality	31	million $/yr	- 18	million $/yr

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Climate change

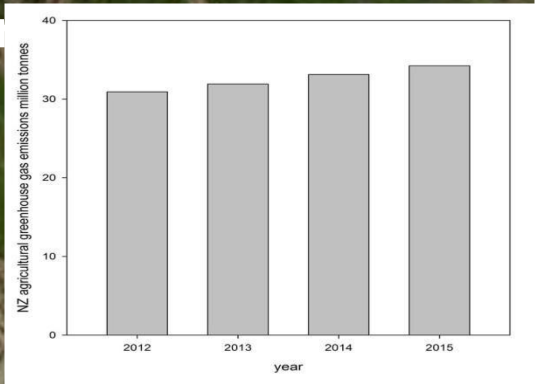
To have a 50% chance of keeping global warming to less than 2º C (and that 2º could still be way too much) we, we have a budget 260b tonnes of CO_2 left to emit (<25 yrs. at current rates so all used up by 2040).

Share that budget out evenly amongst all human beings (7.5 b) then NZ at 0.061% of global population means we would be able to emit no more than 150 m tonnes CO_2.

We (NZ) currently emit a net 11m/yr so 14 years to zer

2030)

So how are we doing in our biggest emission area?



What can we do about it? what can we do as individuals?

Globally livestock are responsible for :

~15 percent of all anthropogenic GHG emissions

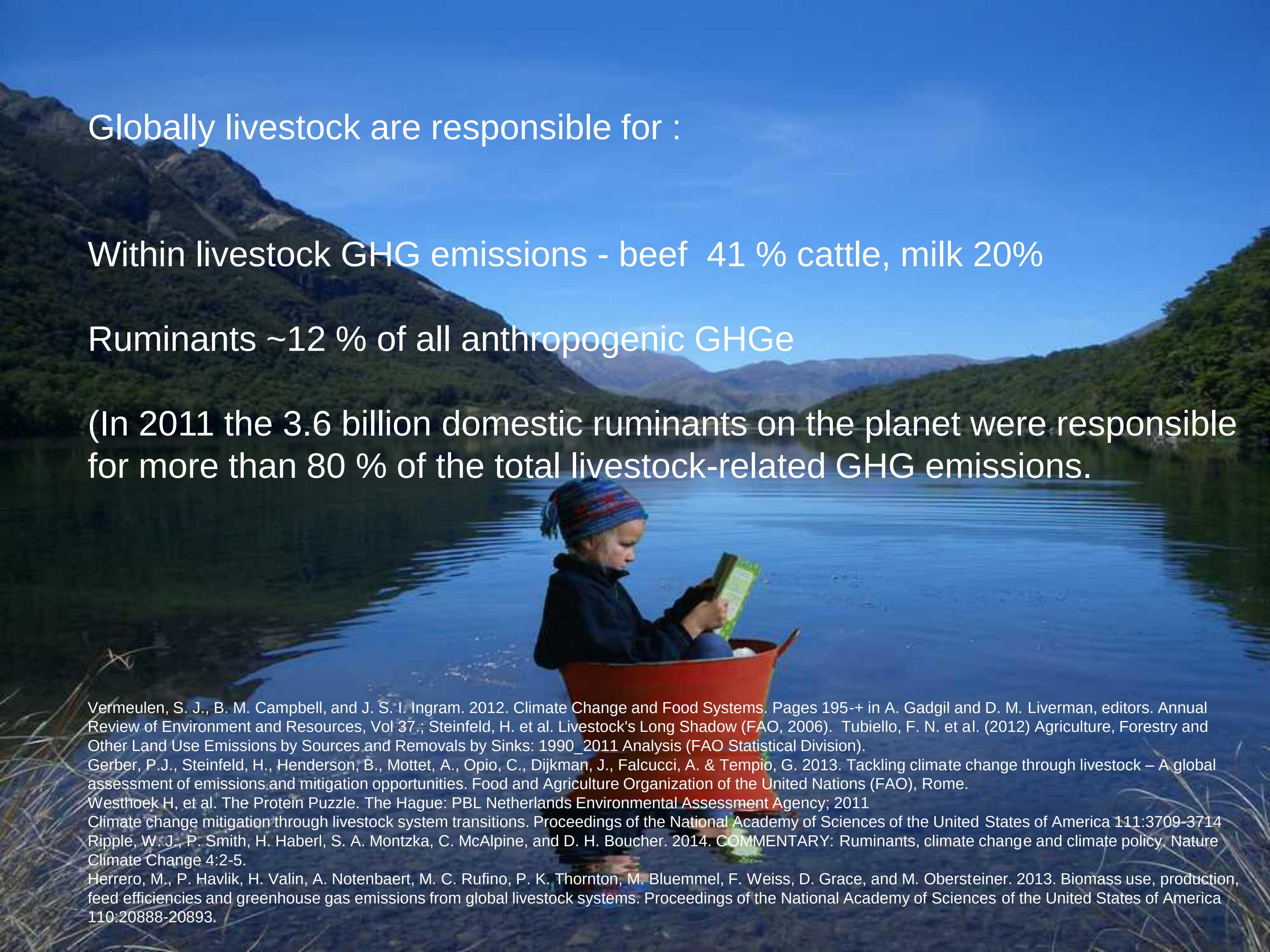
37 % of all anthropogenic methane emissions

65 % of all nitrous oxide emissions.

Within livestock:
~ 50% of the emissions are methane (CH_4)

25% nitrous oxide (N_2O) 25% carbon dioxide (CO_2).

Vermeulen, S. J., B. M. Campbell, and J. S. I. Ingram. 2012. Climate Change and Food Systems. Pages 195-+ in A. Gadgil and D. M. Liverman, editors. Annual Review of Environment and Resources, Vol 37.; Steinfeld, H. et al. Livestock's Long Shadow (FAO, 2006). Tubiello, F. N. et al. (2012) Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks: 1990_2011 Analysis (FAO Statistical Division).
Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.
Westhoek H, et al. The Protein Puzzle. The Hague: PBL Netherlands Environmental Assessment Agency; 2011
Climate change mitigation through livestock system transitions. Proceedings of the National Academy of Sciences of the United States of America 111:3709-3714
Ripple, W. J., P. Smith, H. Haberl, S. A. Montzka, C. McAlpine, and D. H. Boucher. 2014. COMMENTARY: Ruminants, climate change and climate policy. Nature Climate Change 4:2-5.
Herrero, M., P. Havlik, H. Valin, A. Notenbaert, M. C. Rufino, P. K. Thornton, M. Bluemmel, F. Weiss, D. Grace, and M. Obersteiner. 2013. Biomass use, production, feed efficiencies and greenhouse gas emissions from global livestock systems. Proceedings of the National Academy of Sciences of the United States of America 110:20888-20893.



Globally livestock are responsible for :

Within livestock GHG emissions - beef 41 % cattle, milk 20%

Ruminants ~12 % of all anthropogenic GHGe

(In 2011 the 3.6 billion domestic ruminants on the planet were responsible for more than 80 % of the total livestock-related GHG emissions.

Vermeulen, S. J., B. M. Campbell, and J. S. I. Ingram. 2012. Climate Change and Food Systems. Pages 195-+ in A. Gadgil and D. M. Liverman, editors. Annual Review of Environment and Resources, Vol 37.; Steinfeld, H. et al. Livestock's Long Shadow (FAO, 2006). Tubiello, F. N. et al. (2012) Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks: 1990_2011 Analysis (FAO Statistical Division).
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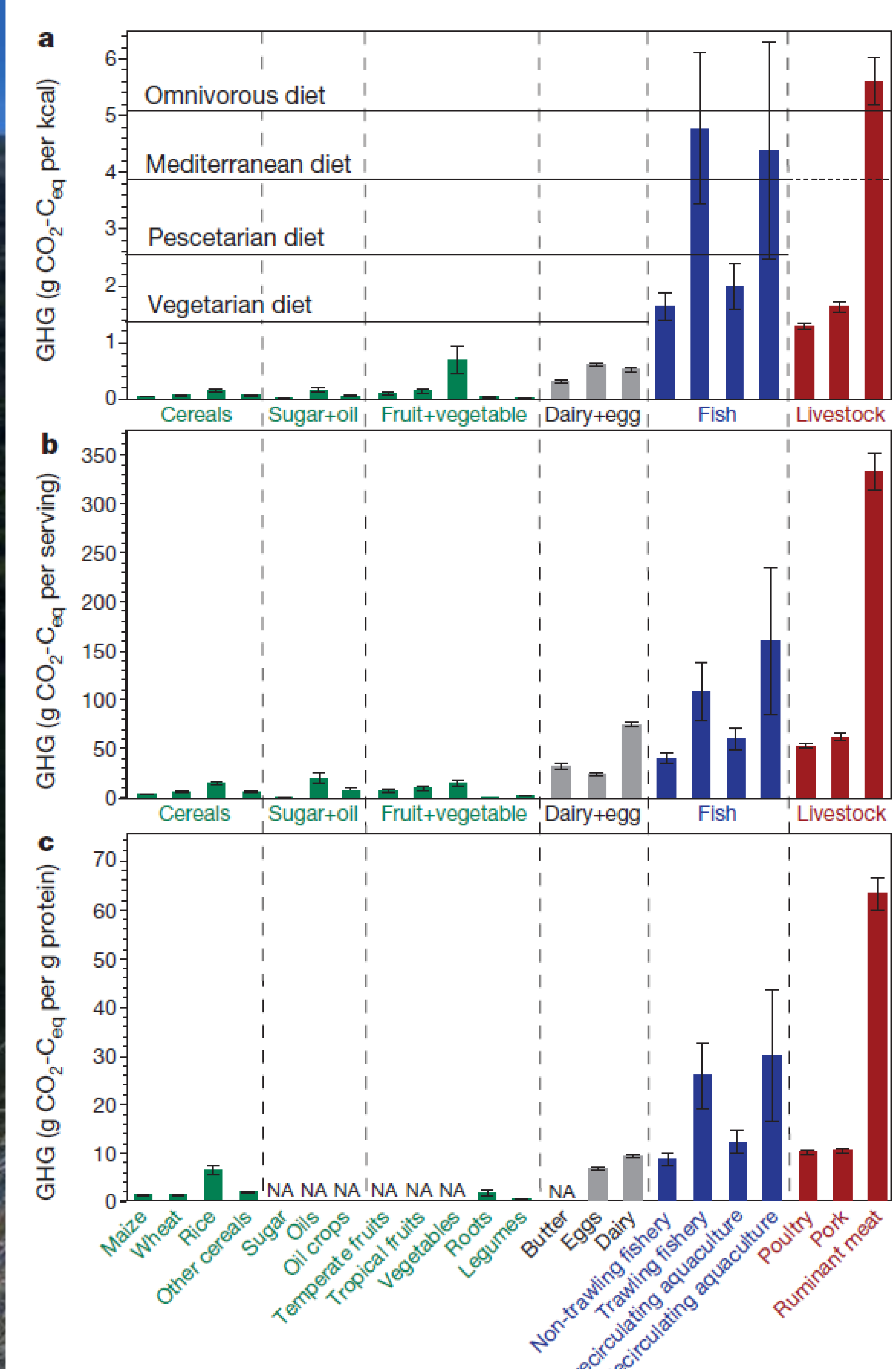


What can we do?

- what we eat makes a huge difference

Tilman, D., and M. Clark. 2014. Global diets link environmental sustainability and human health. Nature 515:518-+.

Apart from GHG emissions globally livestock are responsible for:

- ~ 55 % of the sedimentation of waterways through accelerated erosion
- 37 % of pesticide use
- 50 % all antibiotic use
- 64 % ammonia loss
- 33% of anthropogenic nitrogen and phosphorus to freshwater resources

Steinfeld, H. 2006. Livestock's Long Shadow; environmental issues and options. Food and Agriculture Organisation, Rome.

Livestock and human health

If global diets reduced meat healthcare savings and avoided climate damage of $1.5 trillion by 2050 (mortality reduction of 6 – 10 percent and reduction of 29 – 70 percent of GHG emissions).

Benefits from vegetarian diets (avoiding 7.3 million deaths) and vegan diets (avoiding 8.1 million deaths, and billions of animal deaths).

50% of the avoided deaths would come from a reduction of red meat consumption, with the other half due to a combination of increased fruit and vegetable intake and a reduction in calories, leading to fewer people being overweight or obese.

Fraser, G. E. 2009. Vegetarian diets: what do we know of their effects on common chronic diseases? (vol 89, pg. 1607, 2009). American Journal of Clinical Nutrition 90:248-248.
Craig, W. J., A. R. Mangels, and Ada. 2009. Position of the American Dietetic Association: Vegetarian Diets. Journal of the American Dietetic Association 109:1266-1282.
Springmann, M., H. C. J. Godfray, M. Rayner, and P. Scarborough. 2016. Analysis and valuation of the health and climate change co-benefits of dietary change. Proceedings of the National Academy of Sciences of the United States of America 113:4146-4151.

Eutrophication and water-use dietary differences

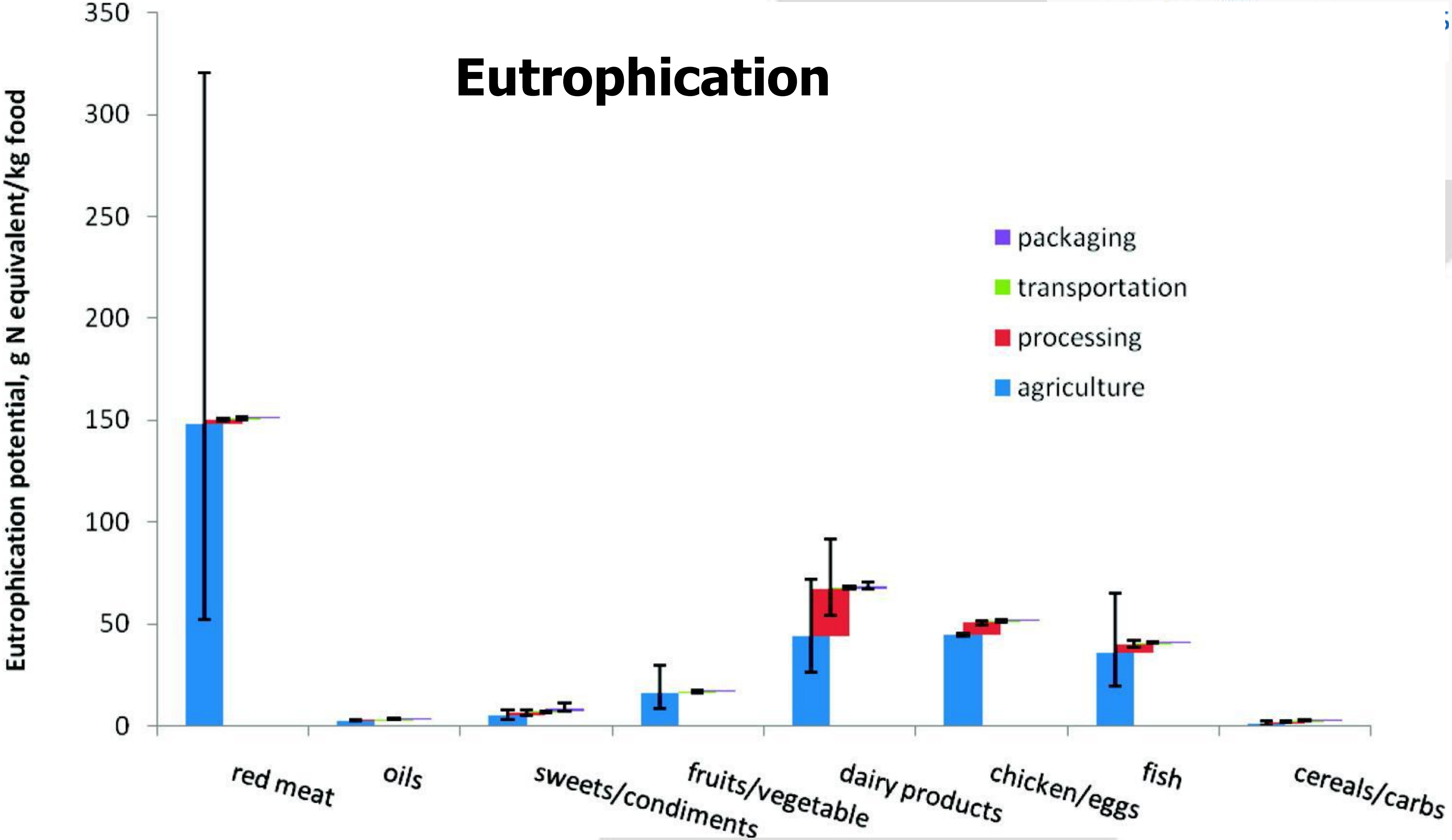
Red meat has the highest eutrophication potential then dairy, then chicken/eggs. The cereal/carbs food group has the lowest footprint among all food sub-groups (based on nutrients)

Producing, processing, transporting, and packaging 1kg of red meat generates on average 150g nitrogen-equivalent emissions, whereas to supply 1kg cereal/carbs results in around 2.6g nitrogen equivalent emissions.

> 8 times more water is used per kg for a meat diet than that needed for a vegetarian diet & livestock systems also limit the quality of available water through eutrophication resulting from their farming.

Xue, X., and A. E. Landis. 2010. Eutrophication Potential of Food Consumption Patterns. Environmental Science & Technology 44:6450-6456.
Janzen, H. H. 2011. What place for livestock on a re-greening earth? Animal Feed Science and Technology 166-67:783-796.

Eutrophication



Eutrophication potential of researched food groups by life cycle stage. Stages include the agricultural production, food processing, food packaging and transportation. Median values within this study are presented in the bar graph. Certainty bars represent the 10 and 90% confidence intervals.

Published in: Xiaobo Xue; Amy E. Landis; *Environ. Sci. Technol.* 2010, 44, 6450-6456.
DOI: 10.1021/es9034478

Land availability & diet

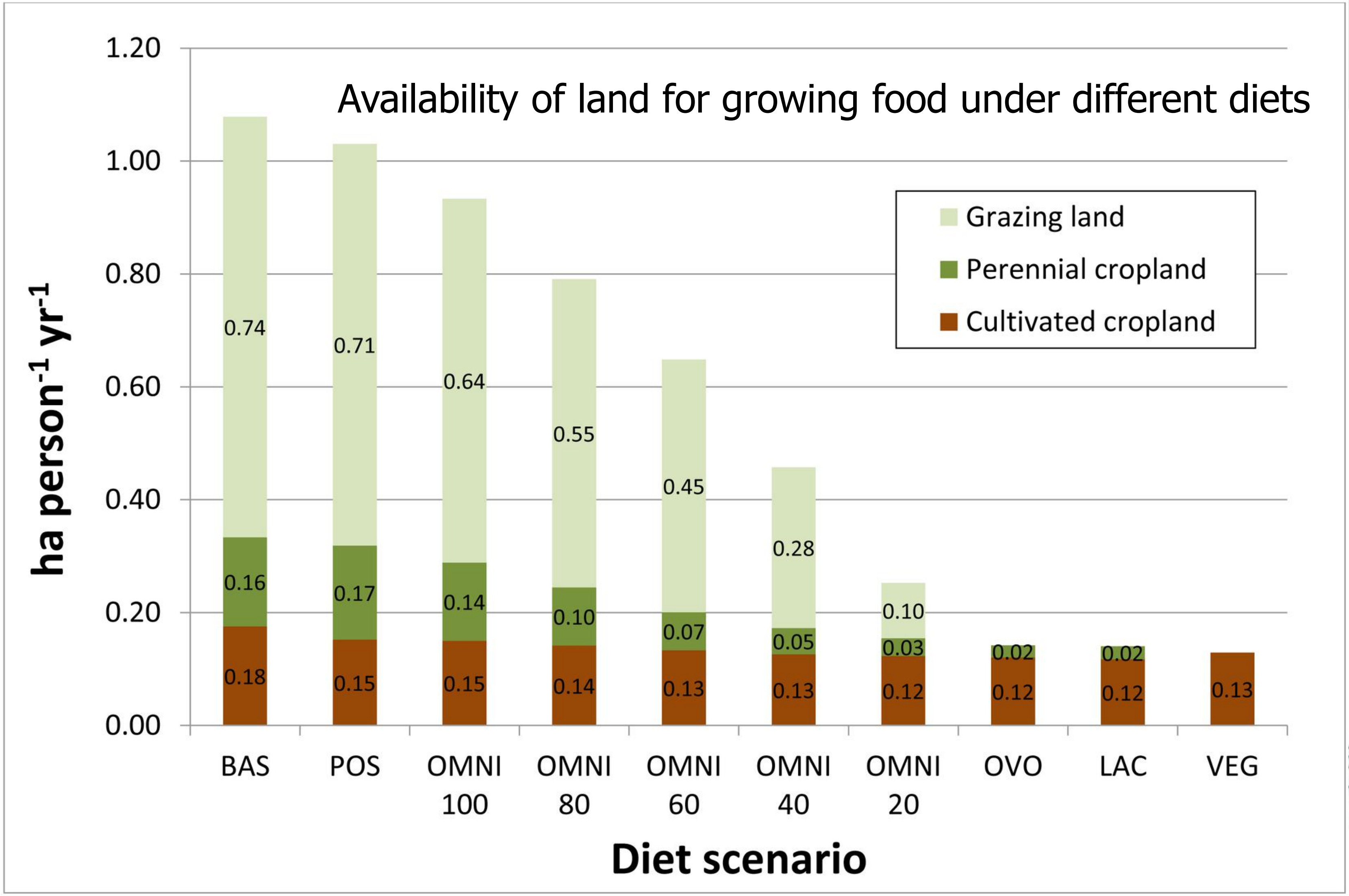
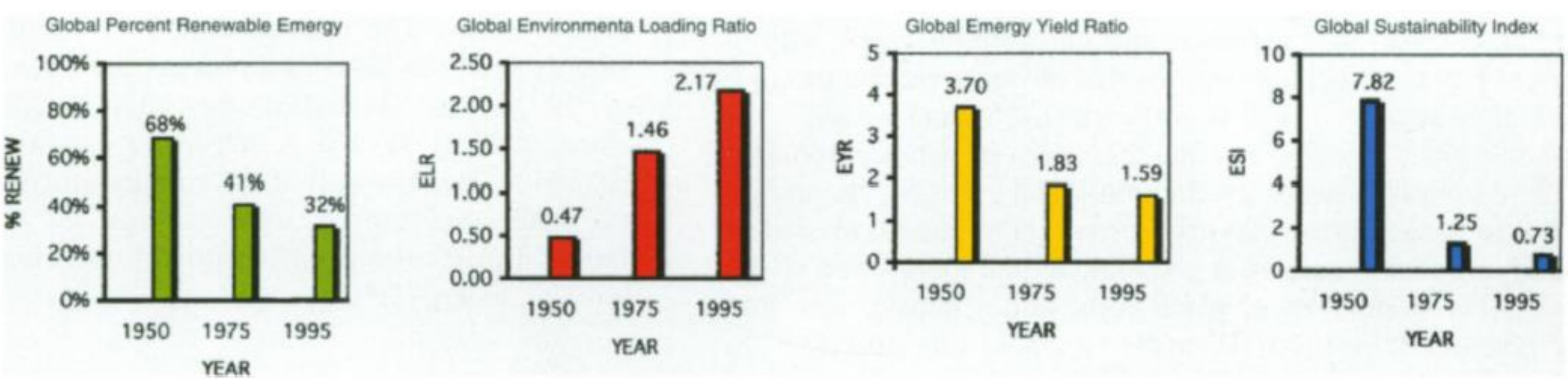
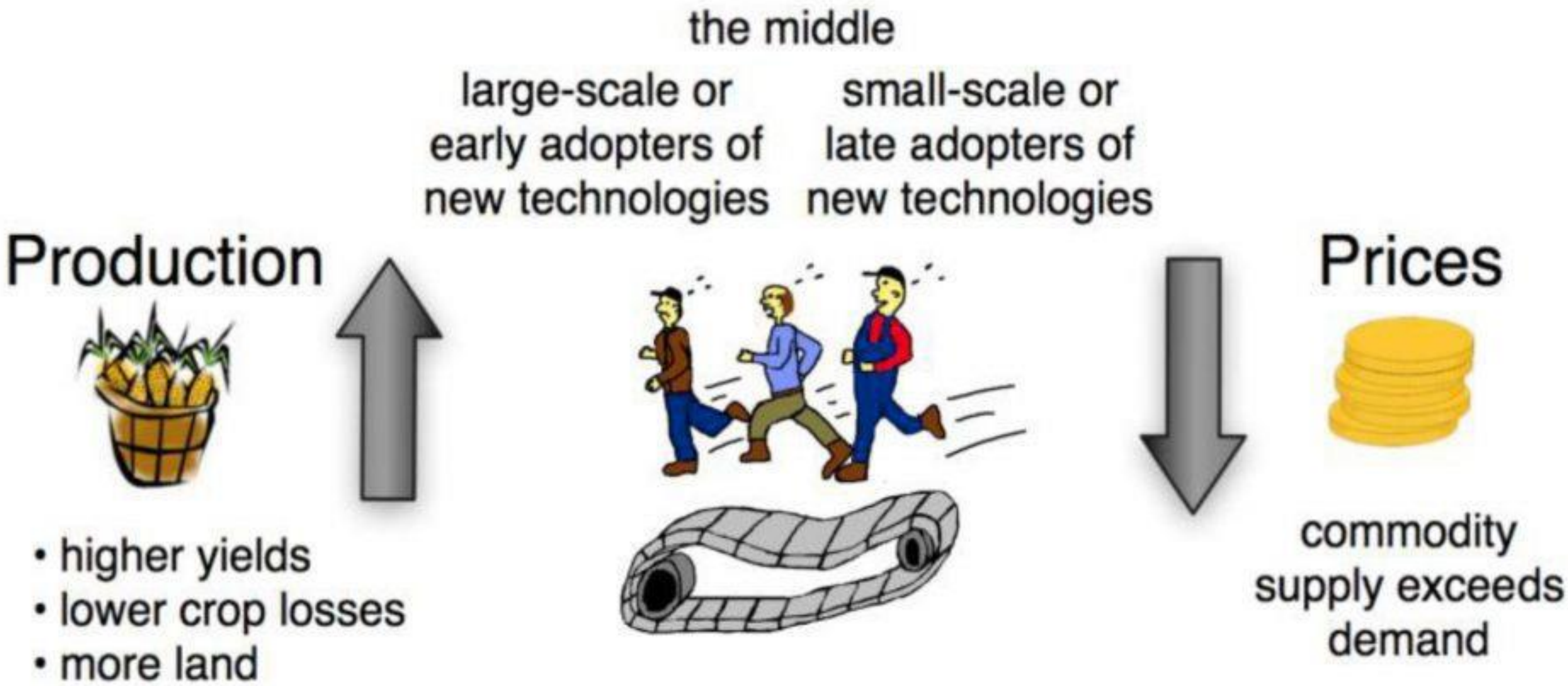
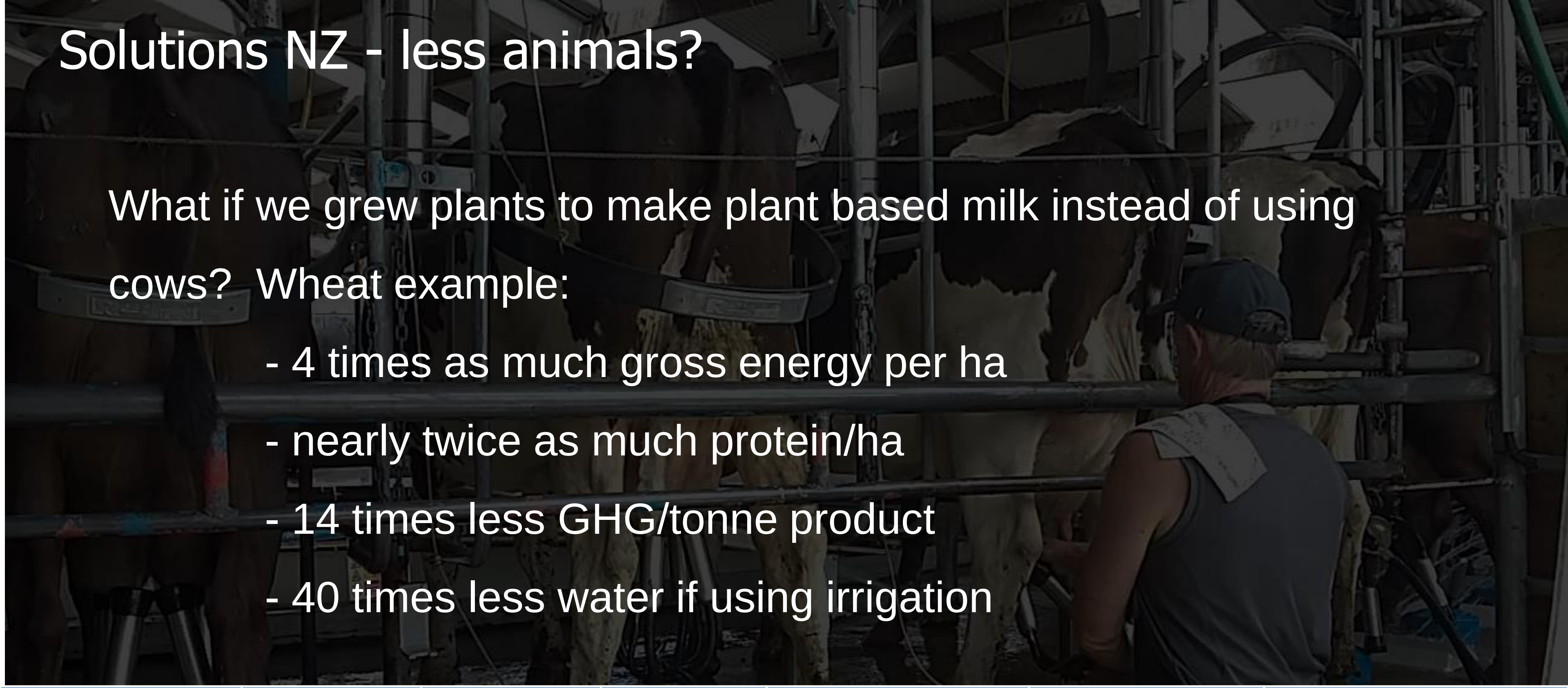


Figure 6. Graphs of the emergy indices of the biosphere for the years 1950, 1975, and 1995.



The Technological Treadmill (Cochrane 1958)





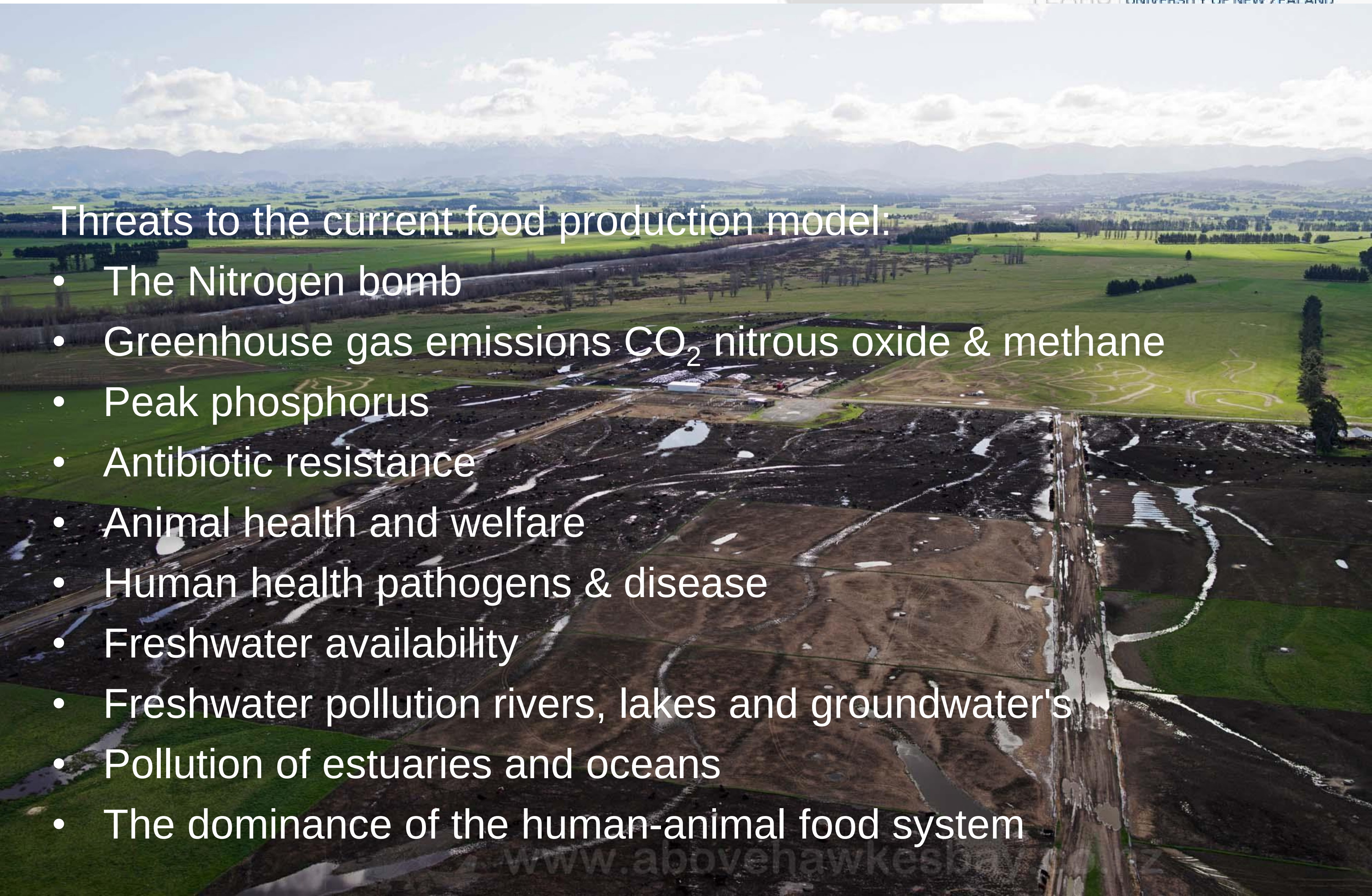
Solutions NZ - less animals?

What if we grew plants to make plant based milk instead of using cows? Wheat example:

- 4 times as much gross energy per ha
- nearly twice as much protein/ha
- 14 times less GHG/tonne product
- 40 times less water if using irrigation

	Yield: Total (t) / ha	Yield: Gross Energy (GJ) / ha	Yield: Protein (kg) / ha	GHG emission (kg CO^2 Eq.) / tonne of product	LCA Energy Input (GJ) / tonne of product	Water use (if produced from irrigation) (litres) / kg of product
NZ Dairy	1.2	35	500	10,000	20	10,000
NZ Arable (wheat)	7.5	120	800	700	2.5	250

Food production now – the threats



Threats to the current food production model:

- The Nitrogen bomb
- Greenhouse gas emissions CO_2 nitrous oxide & methane
- Peak phosphorus
- Antibiotic resistance
- Animal health and welfare
- Human health pathogens & disease
- Freshwater availability
- Freshwater pollution rivers, lakes and groundwater's
- Pollution of estuaries and oceans
- The dominance of the human-animal food system

Risks to human health from intensive agriculture

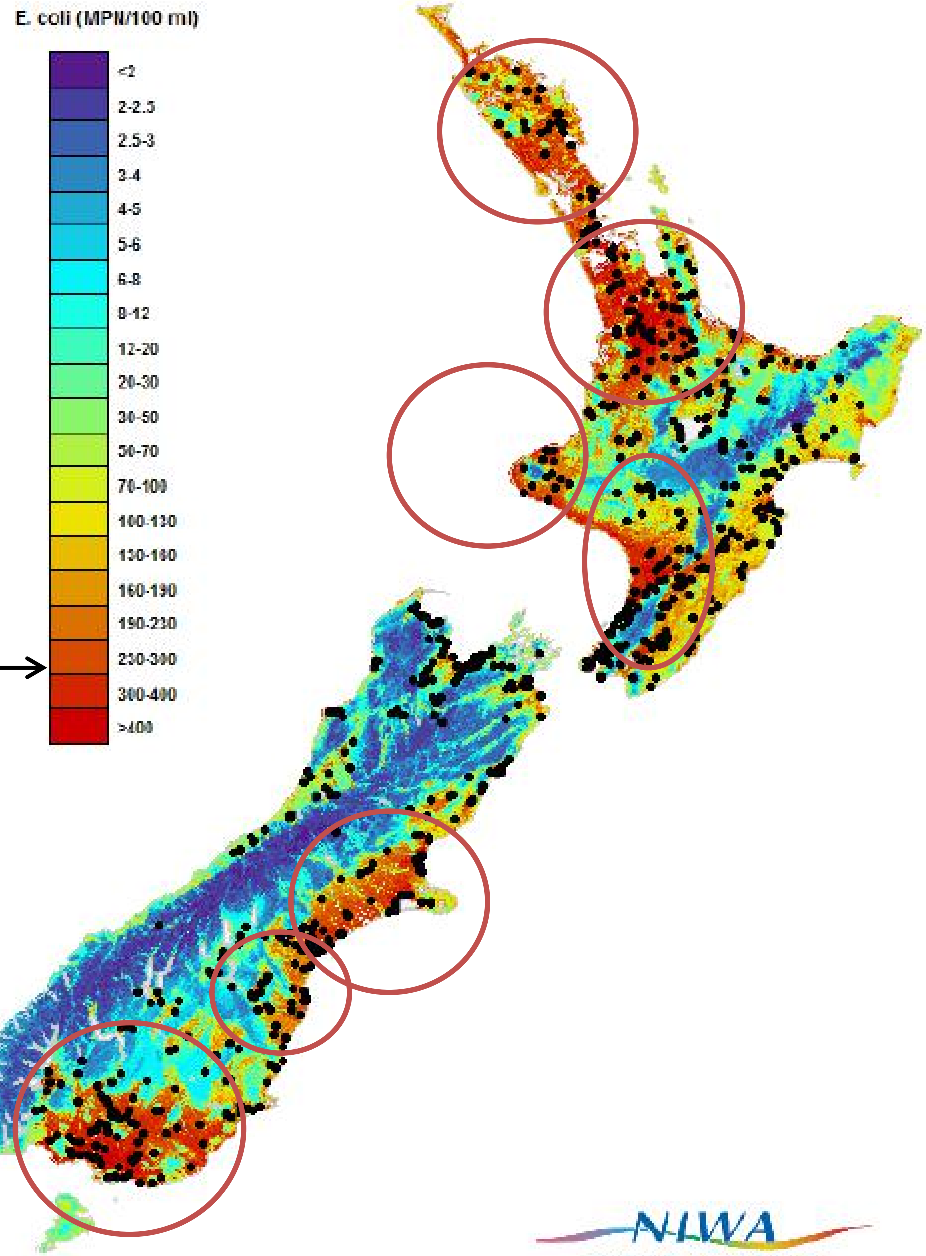
Waterborne & aerosol - irrigation of water or effluent :

- Leptospirosis
- Yersiniosis
- Campylobacter
- E. coli - STEC Shiga toxin-producing Escherichia coli
- Mycobacterium
- Cryptosporidium
- Giardiasis
- Cadmium
- Climate change

What a failed environment looks like

Pathogens

Ministry of health risk level



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21
THE ENGINE OF THE NEW NEW ZEALAND

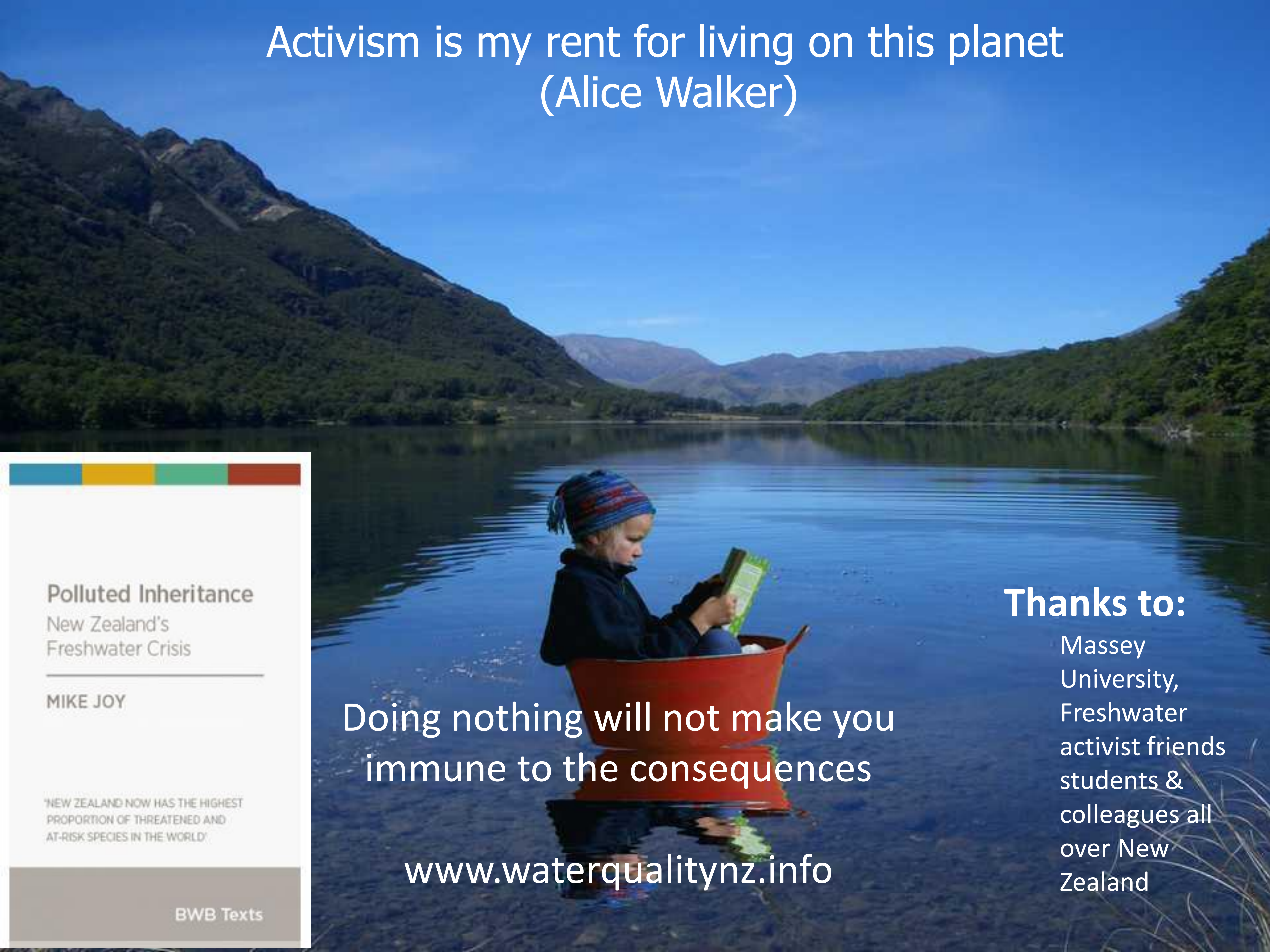
- This is not new - civilisations have failed in the past when they did what we have done - the difference this time is the scale

- We have a major global ecological crisis - we must make major changes and do it very quickly

- Where is the leadership? Do we need environmental and health lobbyists in parliament?

What we must do

- Break our nitrogen/fossil fuel addiction start the transition now to local plant based diets its them (animals) or us
- Start accounting using true cost analyses
- Change our diets –
- Face the hard facts the party is over we must get our heads out of the sand
- Beware the weapons of mass distraction


Activism is my rent for living on this planet
(Alice Walker)
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
Thanks to:
Massey University, Freshwater activist friends students & colleagues all over New Zealand