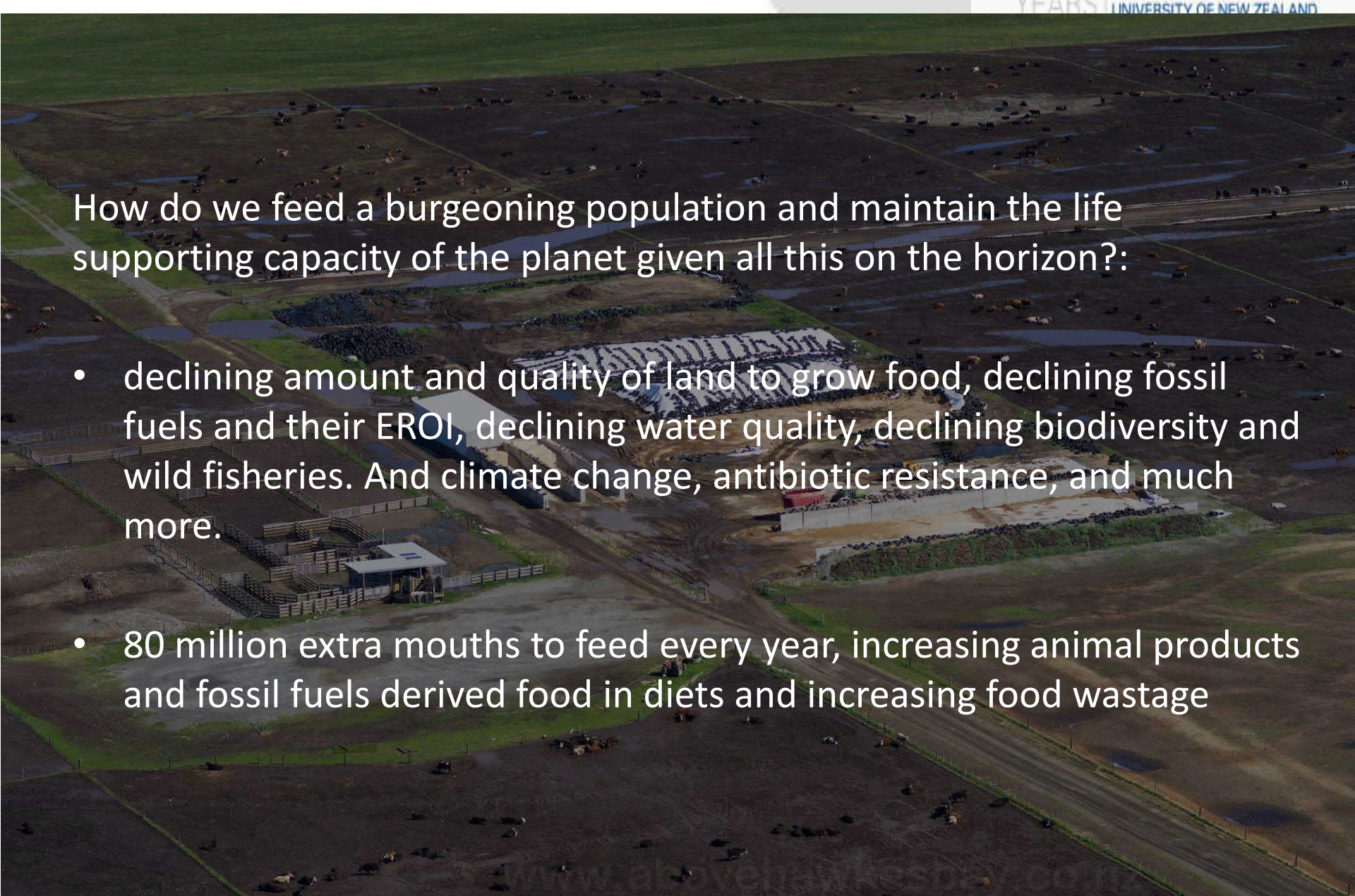
The future of food;

our deadly nitrogen and fossil fuel 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 all 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

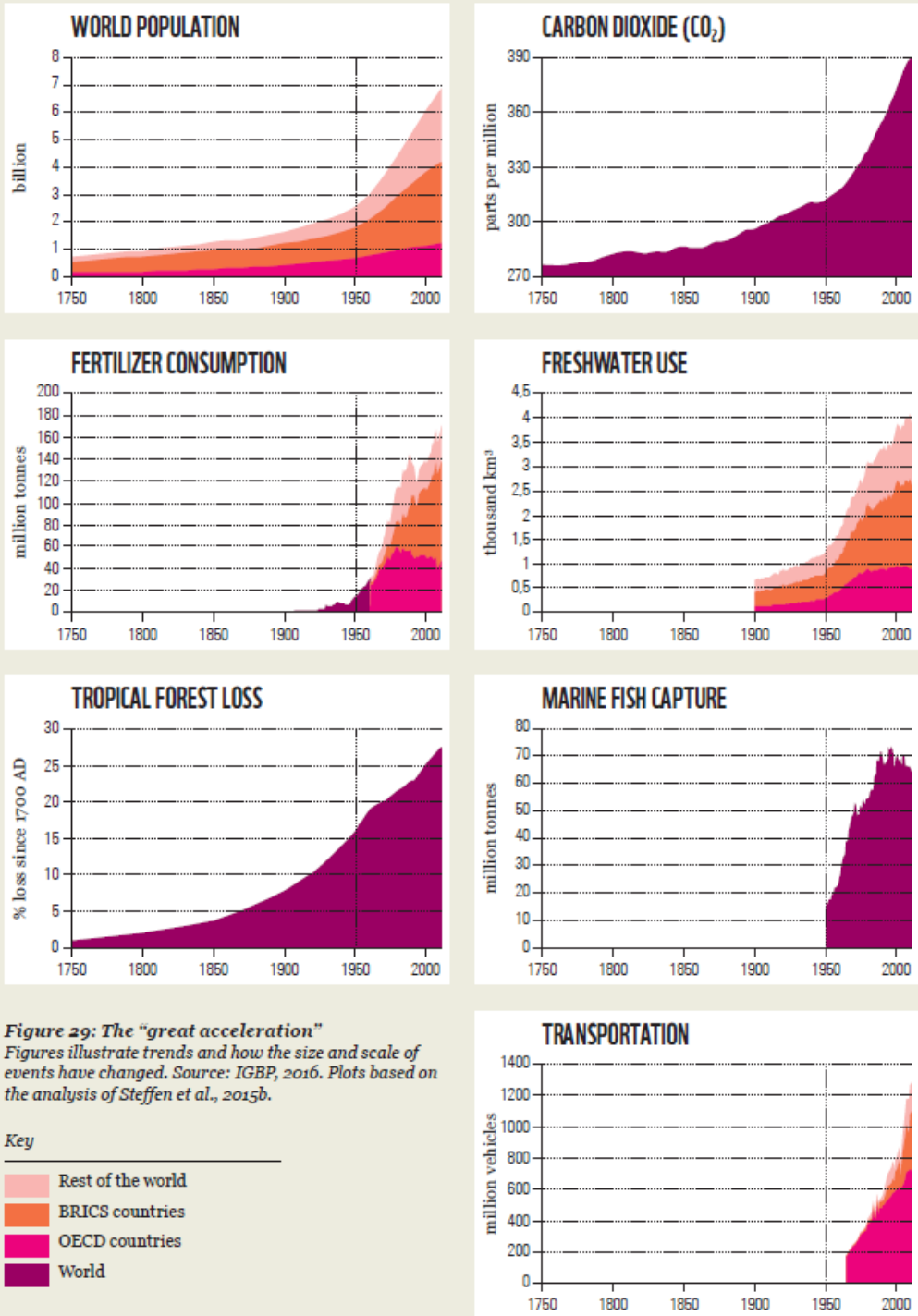
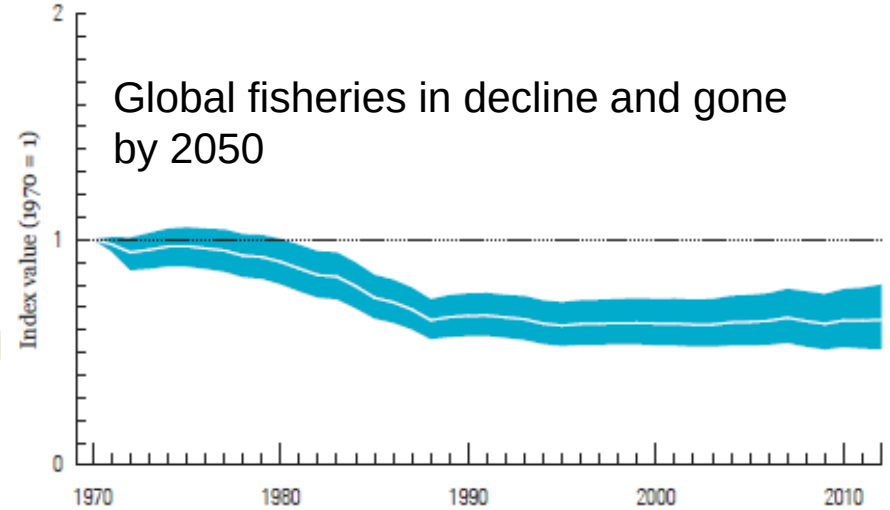


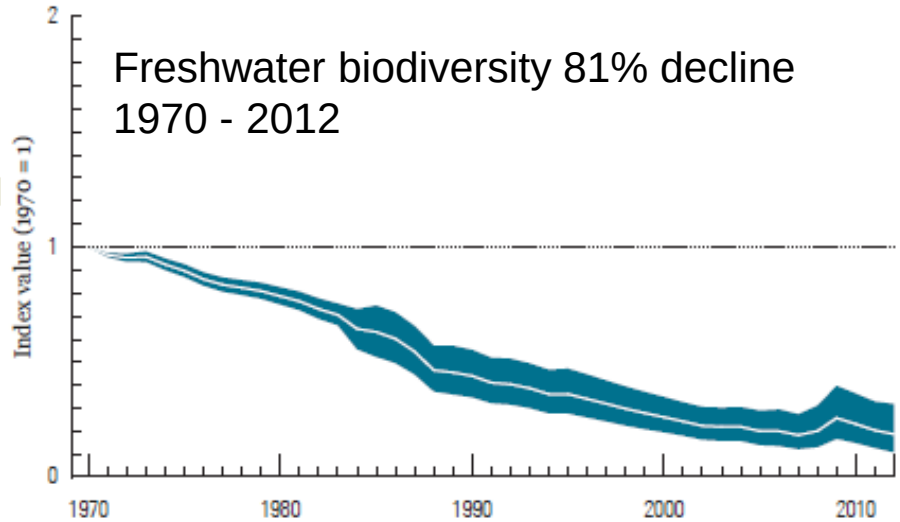
Figure 29: The "great acceleration"
Figures illustrate trends and how the size and scale of events have changed. Source: IGBP, 2016. Plots based on the analysis of Steffen et al., 2015b.

Key



Global fisheries in decline and gone by 2050

- The state of the world (WWF report)



Freshwater biodiversity 81% decline 1970 - 2012

15,000 Scientists From 184 Countries Just Issued A Dire 'Warning To Humanity'

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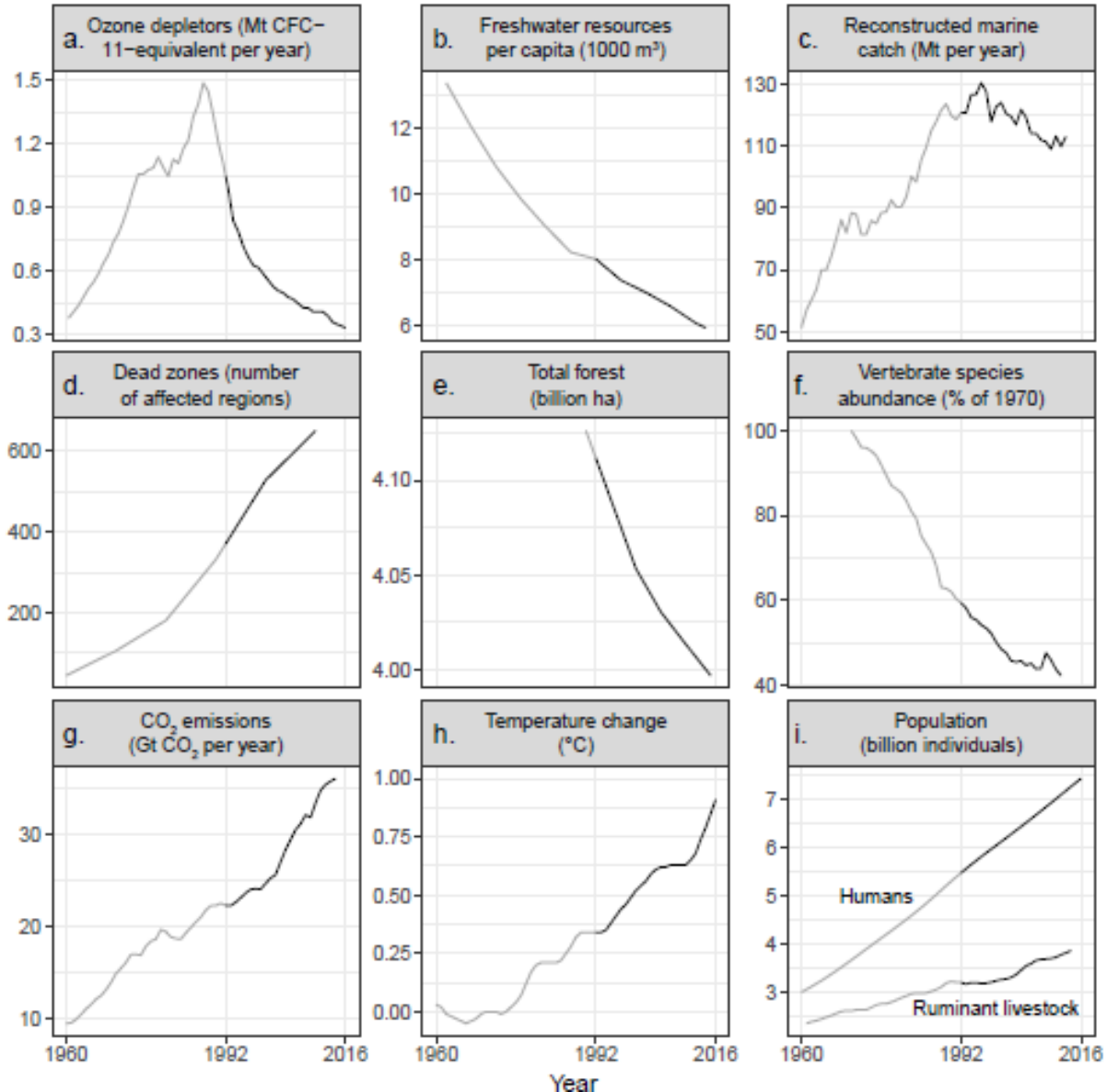
Trevor Nace, CONTRIBUTOR
FULL BIO
Opinions expressed by Forbes Contributors are their own.



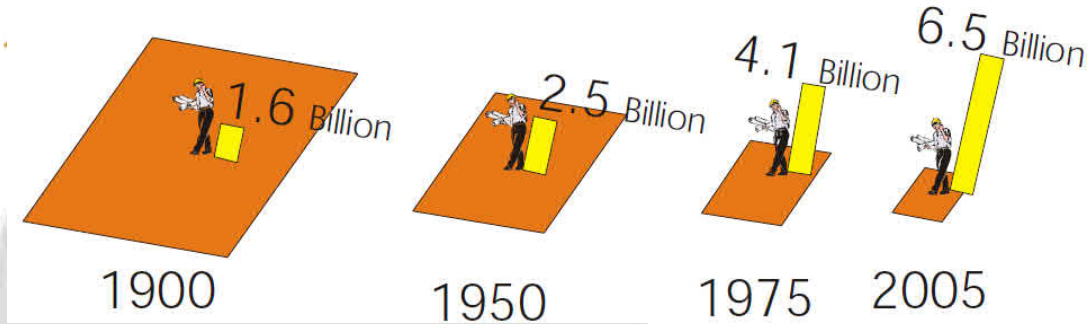
Ripple, W.J., Wolf, C., Newsome, T.M., Galetti, M., Alamgir, M., Crist, E., Mahmoud, M.I., and Laurance, W.F. (2017) World Scientists' Warning to Humanity: A Second Notice. *BioScience 67(12), 1026-1028.*

Losing the foundations - soil

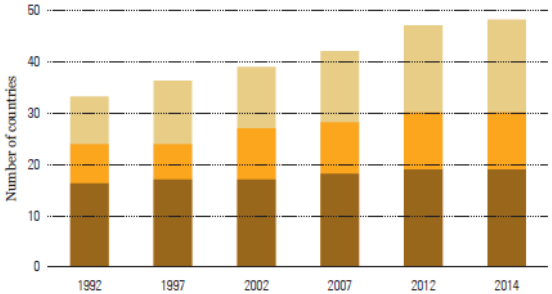
Figure 26: The state of global soil degradation (UNEP, 1997).

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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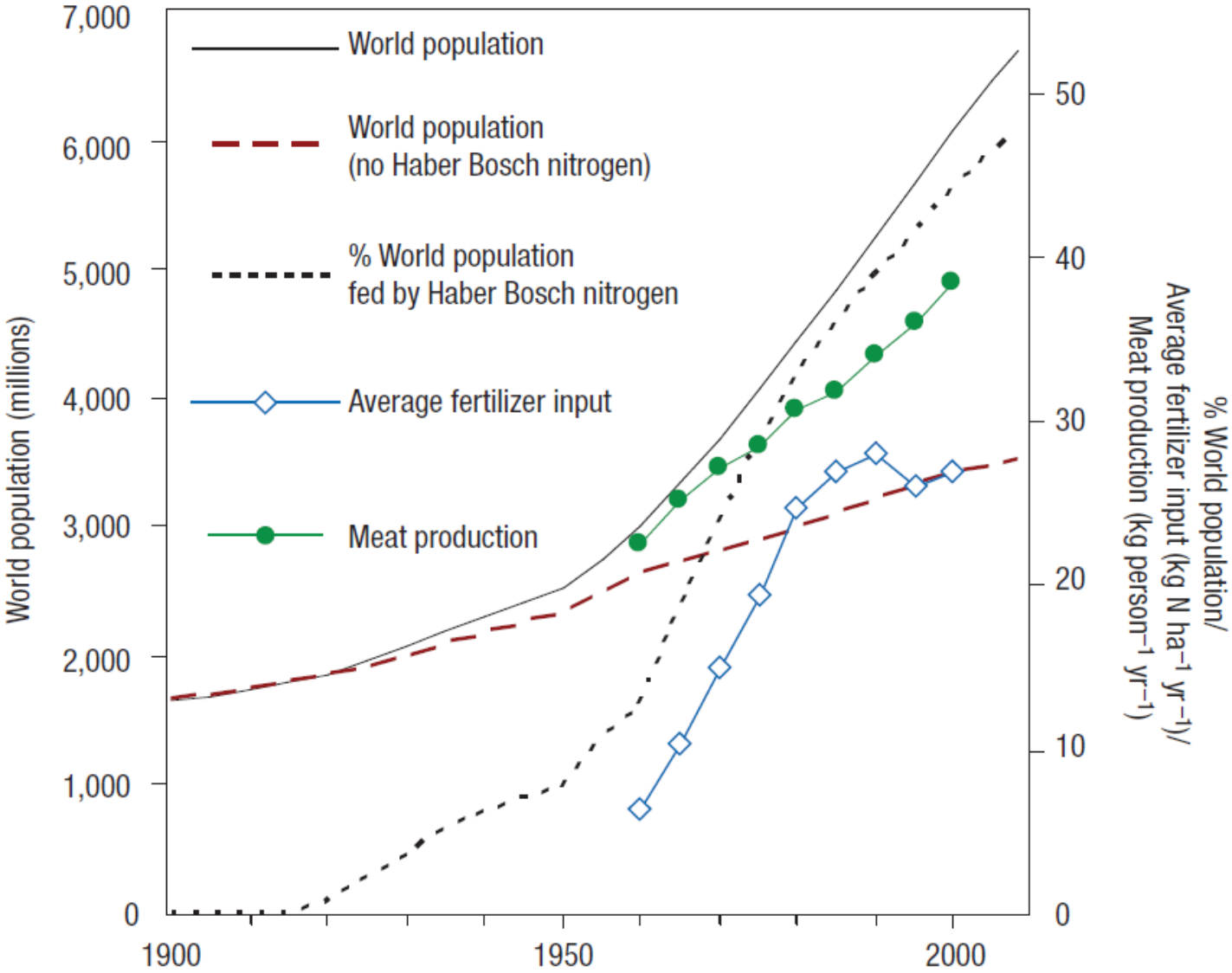
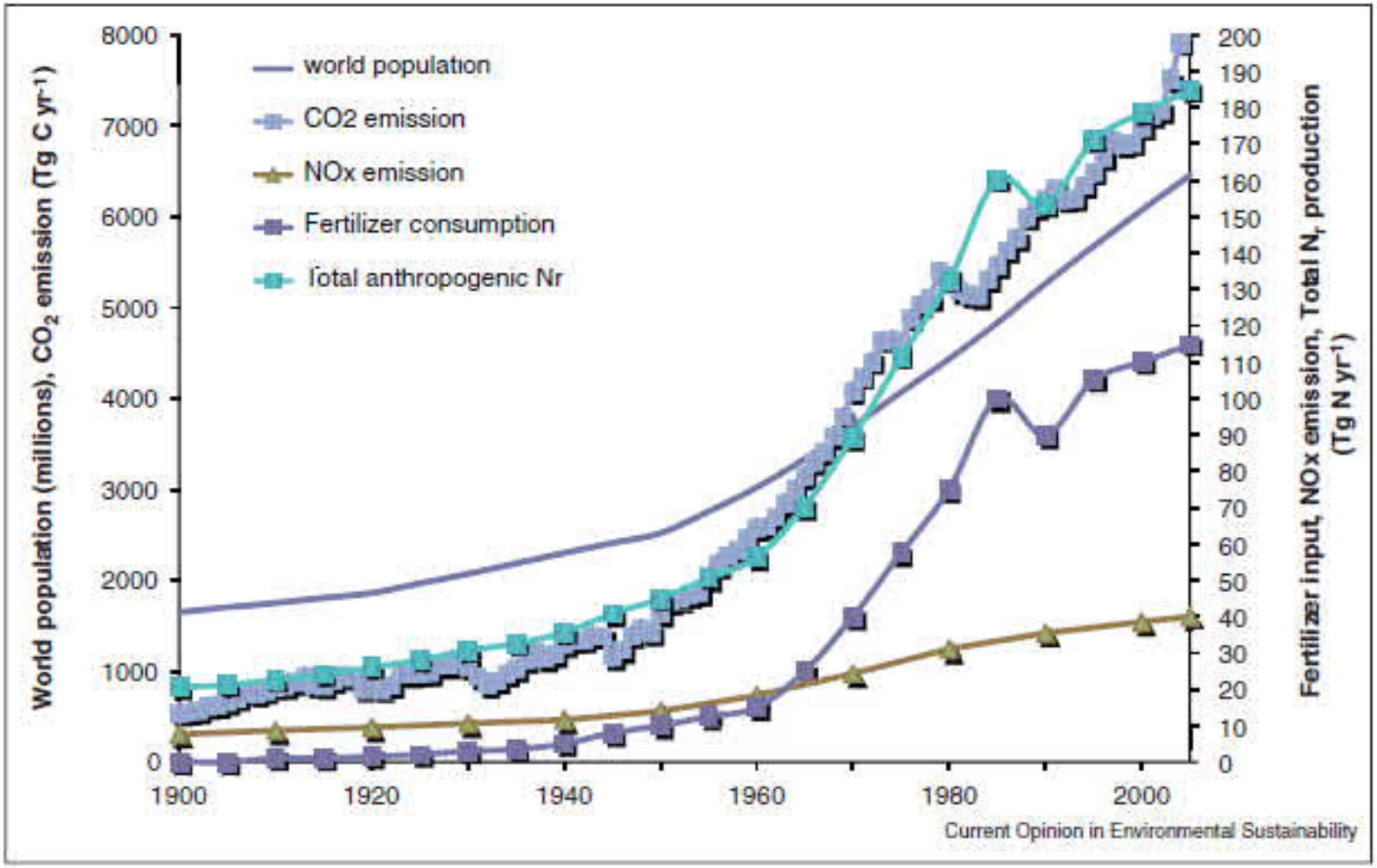
The green (fossil fuel) revolution?



How a century of ammonia synthesis changed the world



Global trends in human population, CO_2 emissions in Tg C [16] and total anthropogenic reactive nitrogen production (in Tg N) throughout the 20th century [based on [10•,17]]. The graph also includes average fertilizer production and the increase in NO_x emissions from fossil fuel burning. The natural terrestrial BNF is about 110 Tg N yr^{-1} and the natural oceanic BNF is about 140 Tg N yr^{-1} [15].

Overdose?

- But ~ 1 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.

- Not just the fossil fuel 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.

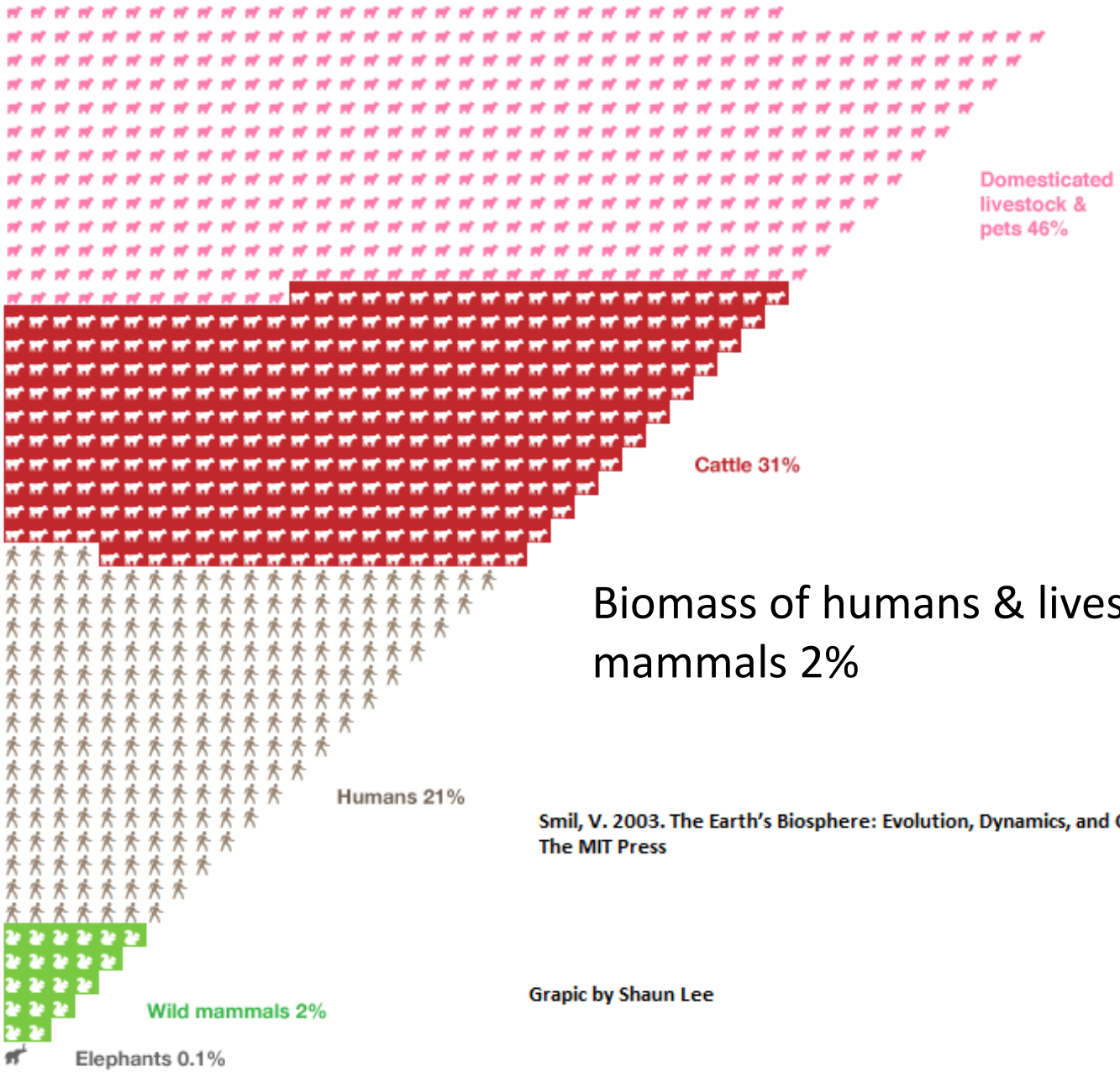
Overdose?

- 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?

Worlds 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

Grapic by Shaun Lee

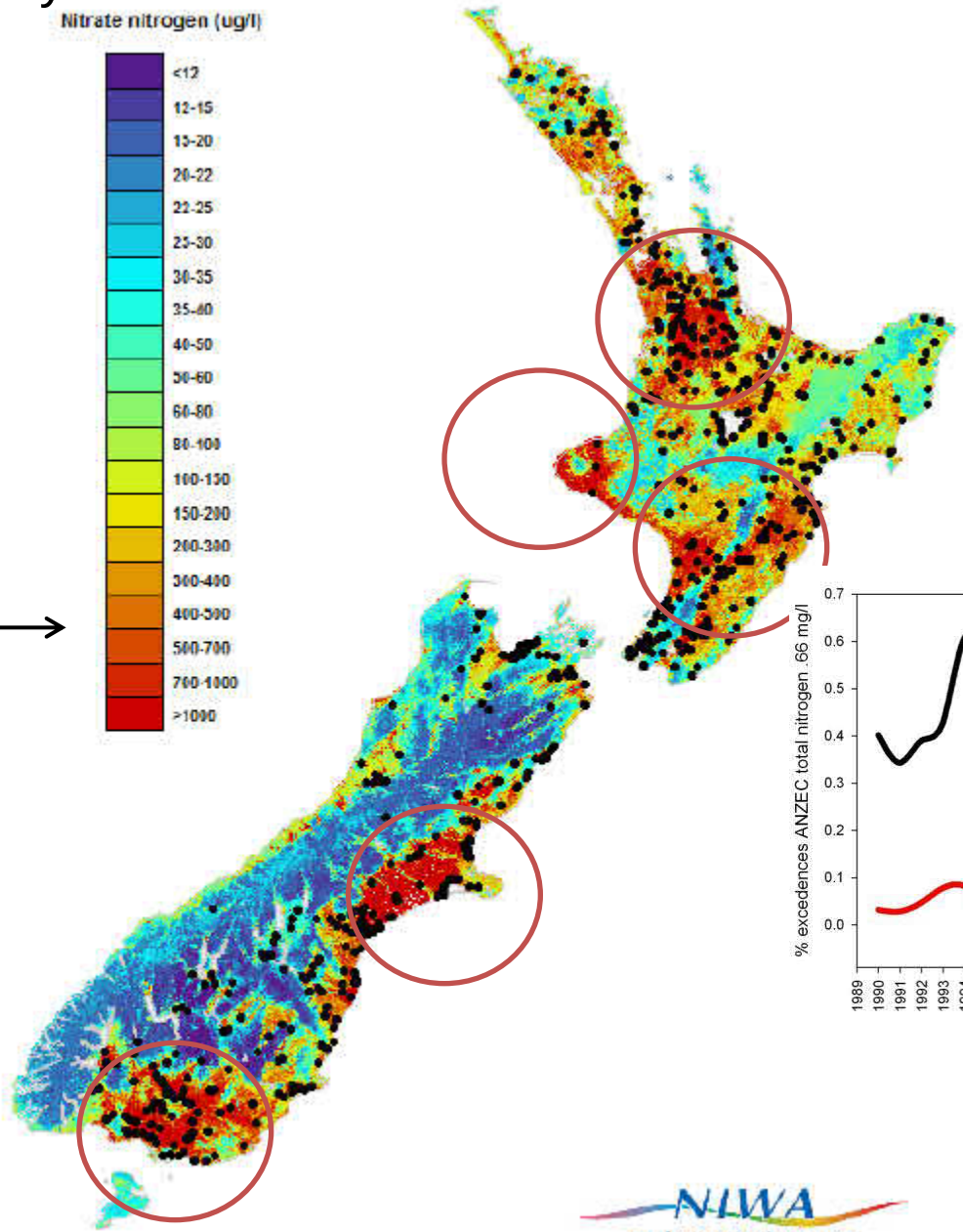
Leaky wasteful systems

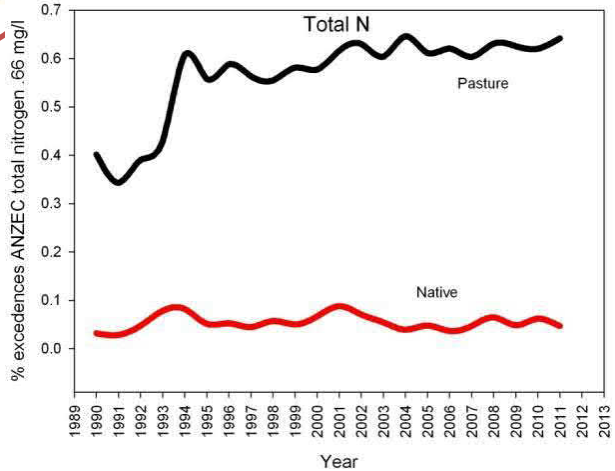
- Only 17% of the N applied as fertiliser makes it to the food we eat the rest mostly leaks out to do harm in the environment:
- For every 100 kg of nitrate fertiliser applied to soil, >1 kg ends up in the atmosphere as nitrous oxide (N_2O), 300 times more potent GHG than CO_2 and N_20 is the most ozone-depleting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

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

The result of leaky systems - nitrate in NZ rivers

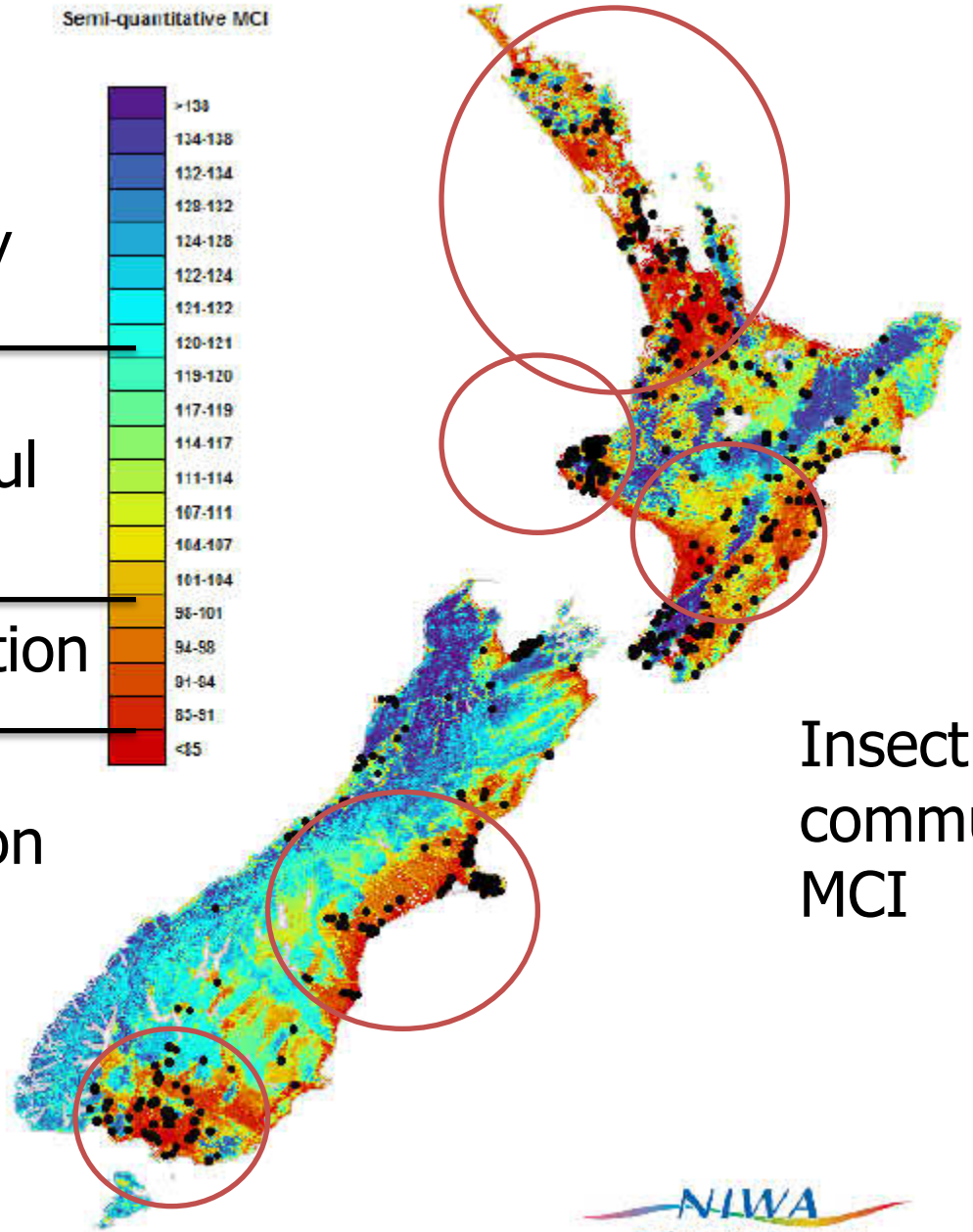
ANZECC nuisance algal growth trigger level →





+ 44% of lakes eutrophic

Nitrate + sediment ++ - the consequences



Healthy

Doubtful

Moderate pollution

Severe pollution

Insect community index MCI

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Taihoro Nukurangi

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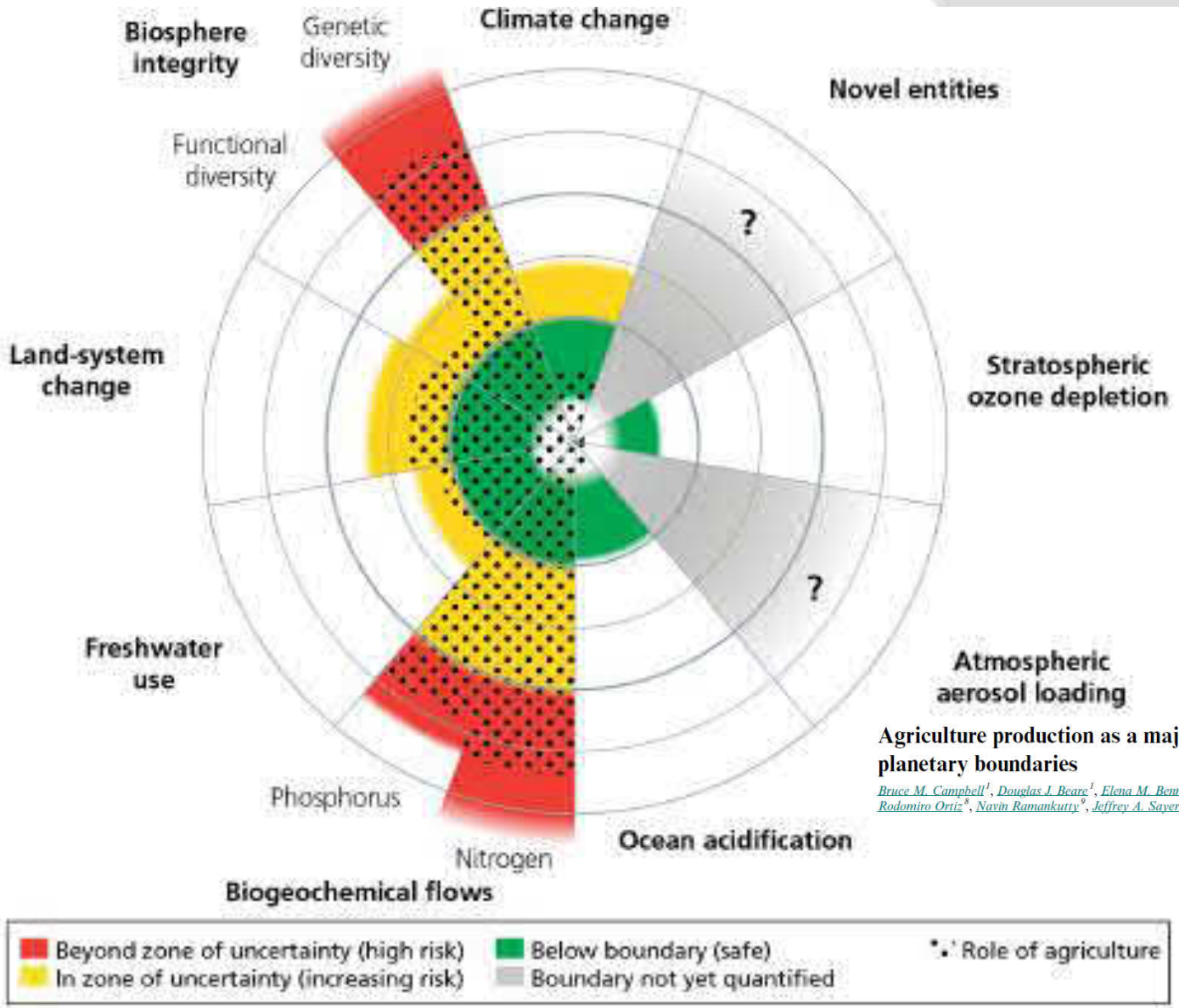
Expensive addiction

- 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. (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.

- In NZ costs to clean-up nitrate in freshwater from intensive farming between $2.4 billion and 24 billion

Nitrogen is just one planetary boundary we have overshot (Stockholm institute) & agricultures shadow



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

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

Climate change

To have a chance of keeping global warming to less than 2º C (and that 2º could still be way too much) we, that is all humans have 260b tonnes CO_2e left to emit (<25 yrs. at current rates so all used up by 2040).

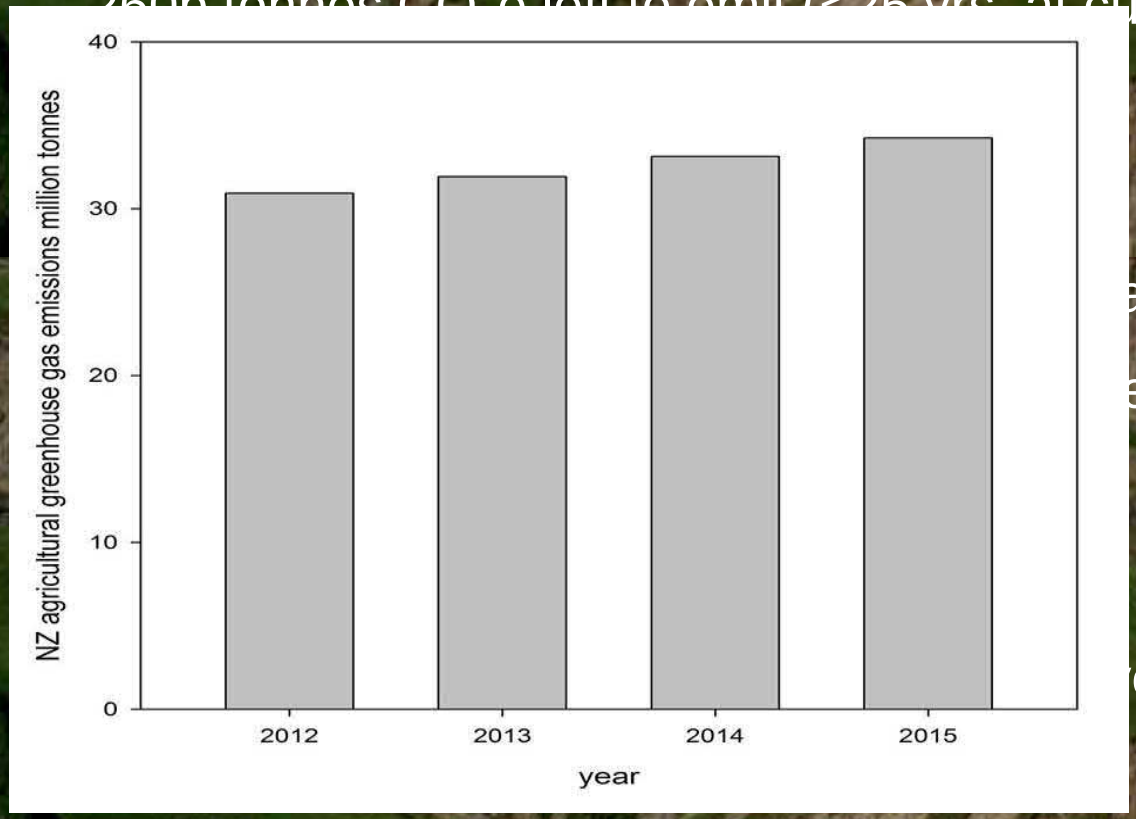
Share that debt out evenly amongst all human beings (7.5 b) then NZ at 0.061% of global population means we would be able to emit no more than 150 m tonnes CO_2e.

We (NZ) currently emit a net 11m/yr so 14 years to zero emissions (= 2030)

So how are we doing in our biggest emission area – agriculture?

Climate change

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



an beings (7.5 b) then

e would be able to emit

ears to zero emissions

So how are we doing in our biggest emission area – agriculture?

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

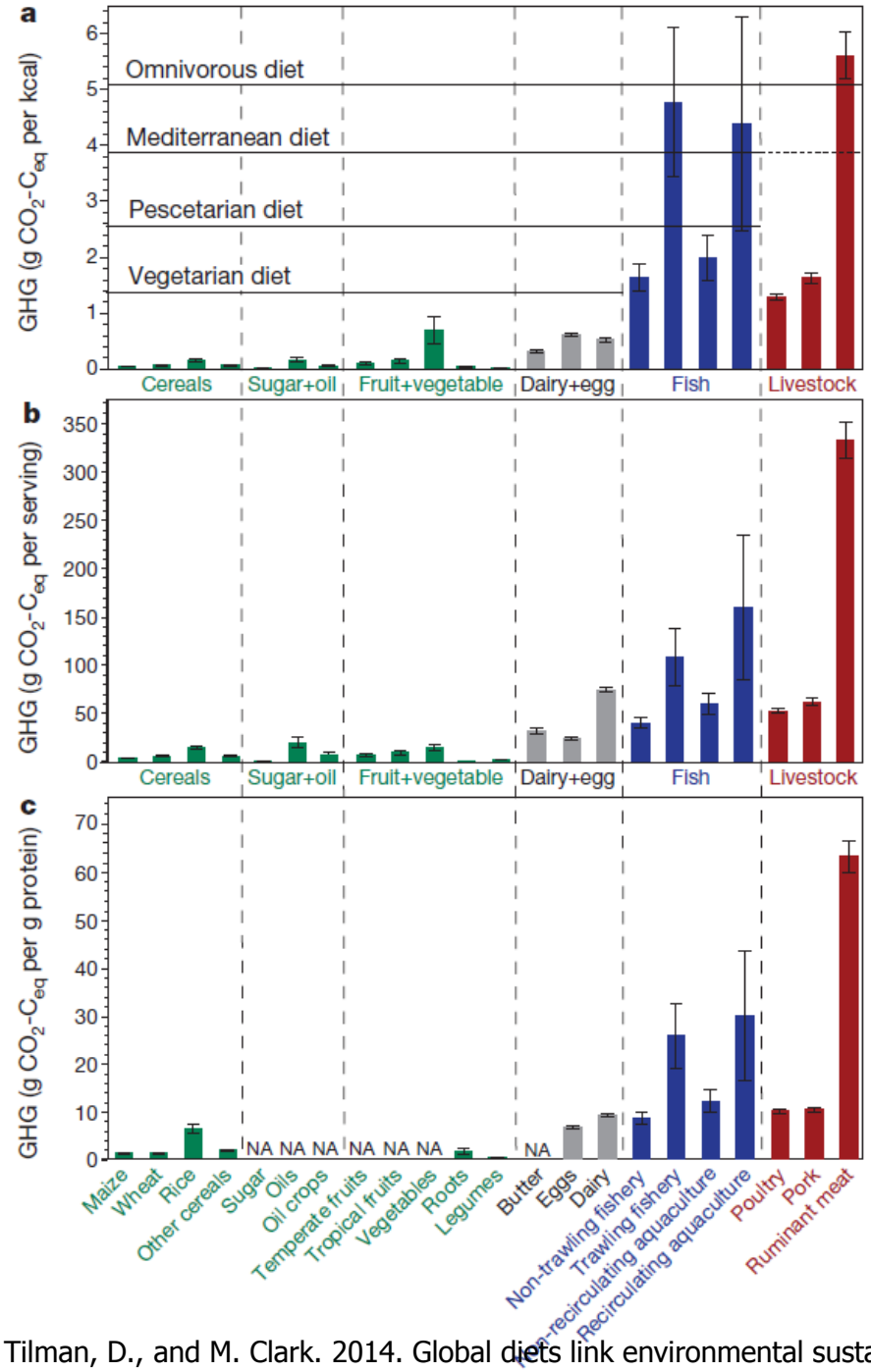
65 % of all nitrous oxide emissions.

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.

GHG emissions - 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

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 from a reduction of red meat consumption, the other half 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.

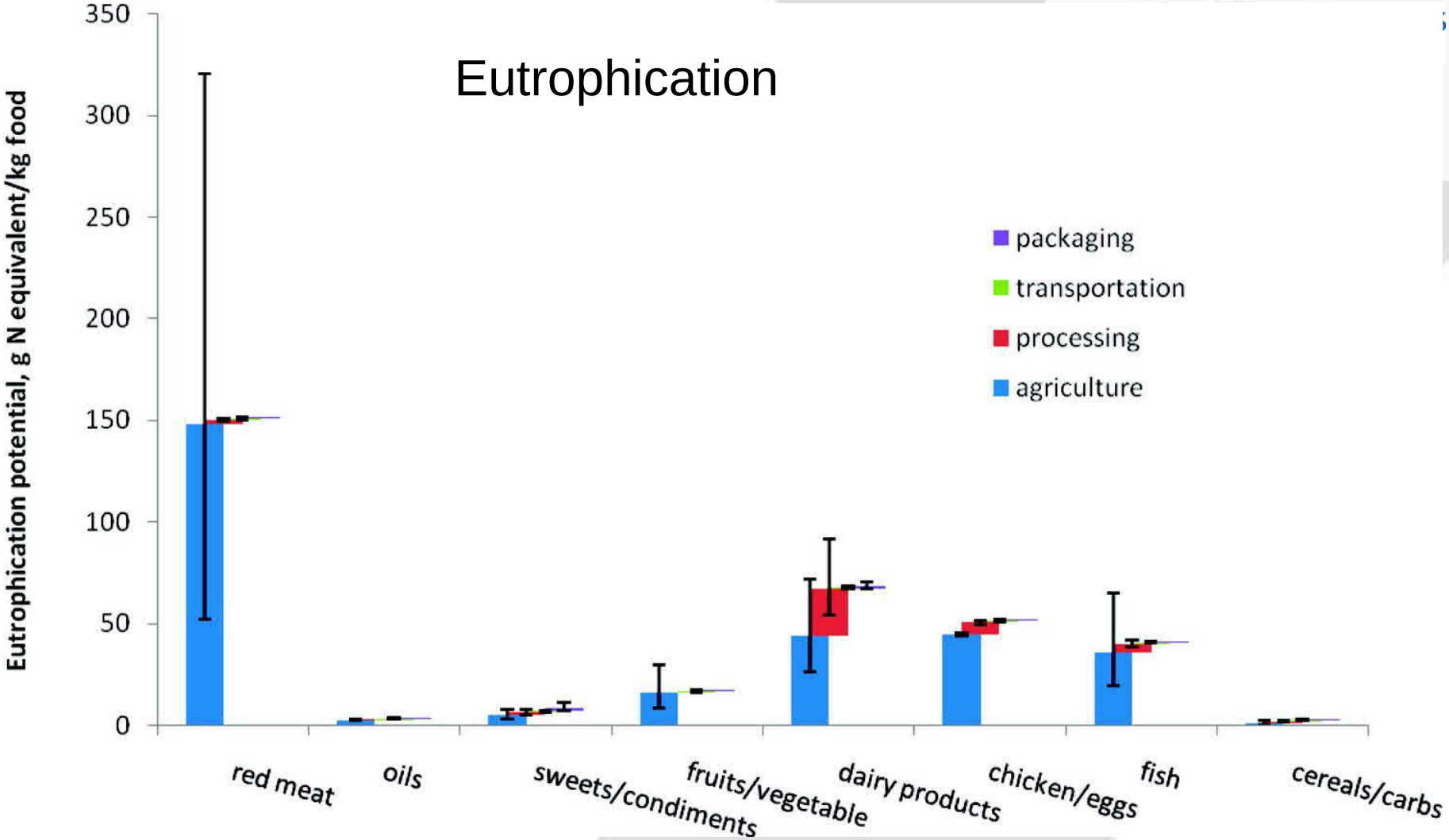
Eutrophication and water-use dietary differences

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 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

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Land - diet

Livestock occupies the largest share of global usable land, and ~ 70 percent of all agricultural land + 33% of the land surface of the planet.

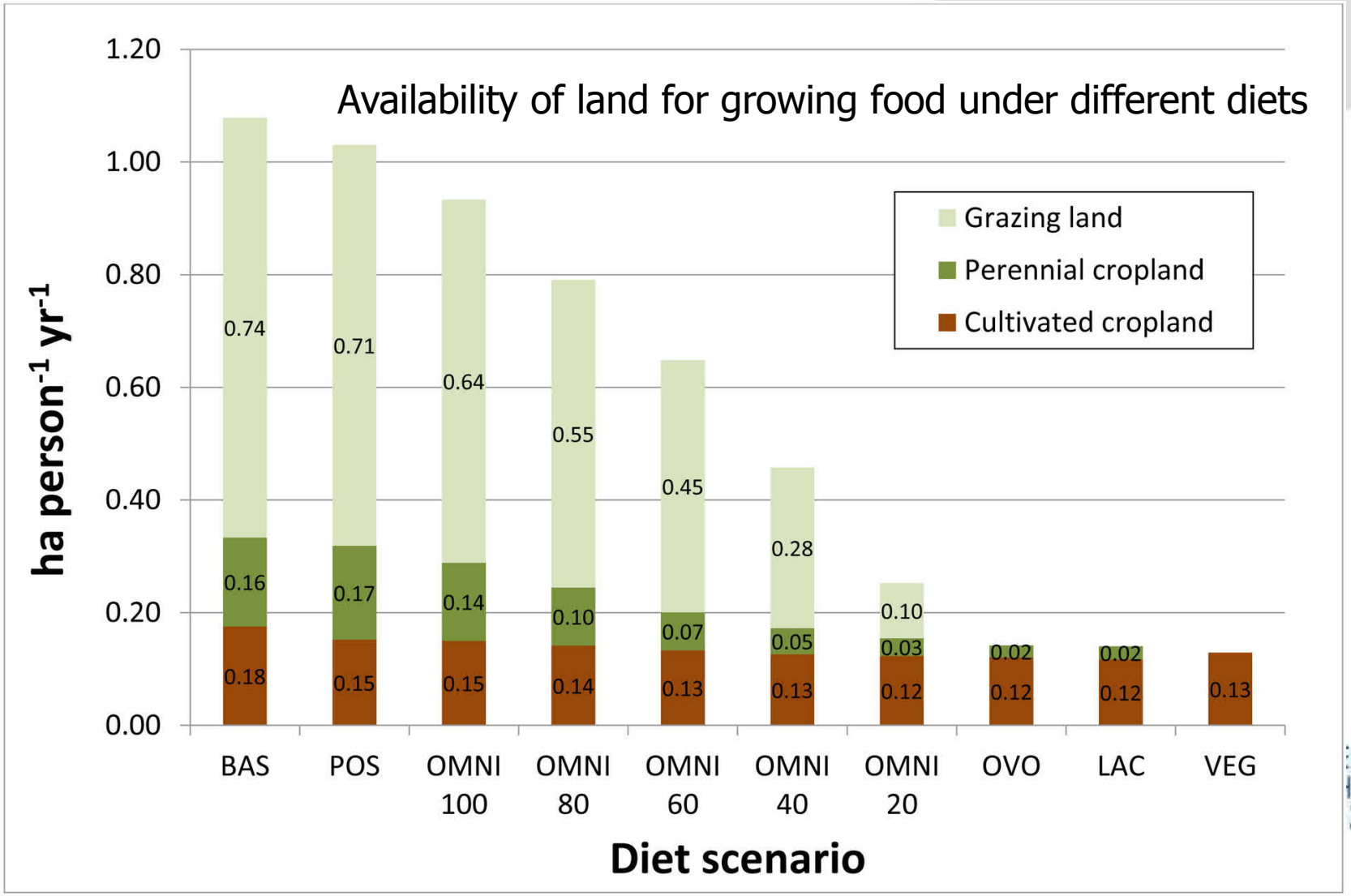
33% of cultivated land area is used for animal feed and forage livestock expansion is a major driver of land-use conversion.

From 1980 - 2000, 83 % of agricultural land expansion in the tropics occurred at the expense of forests, and livestock were a major contributor.

A vegetarian diet used on average one eighth of the area needed for a current omnivorous diet.

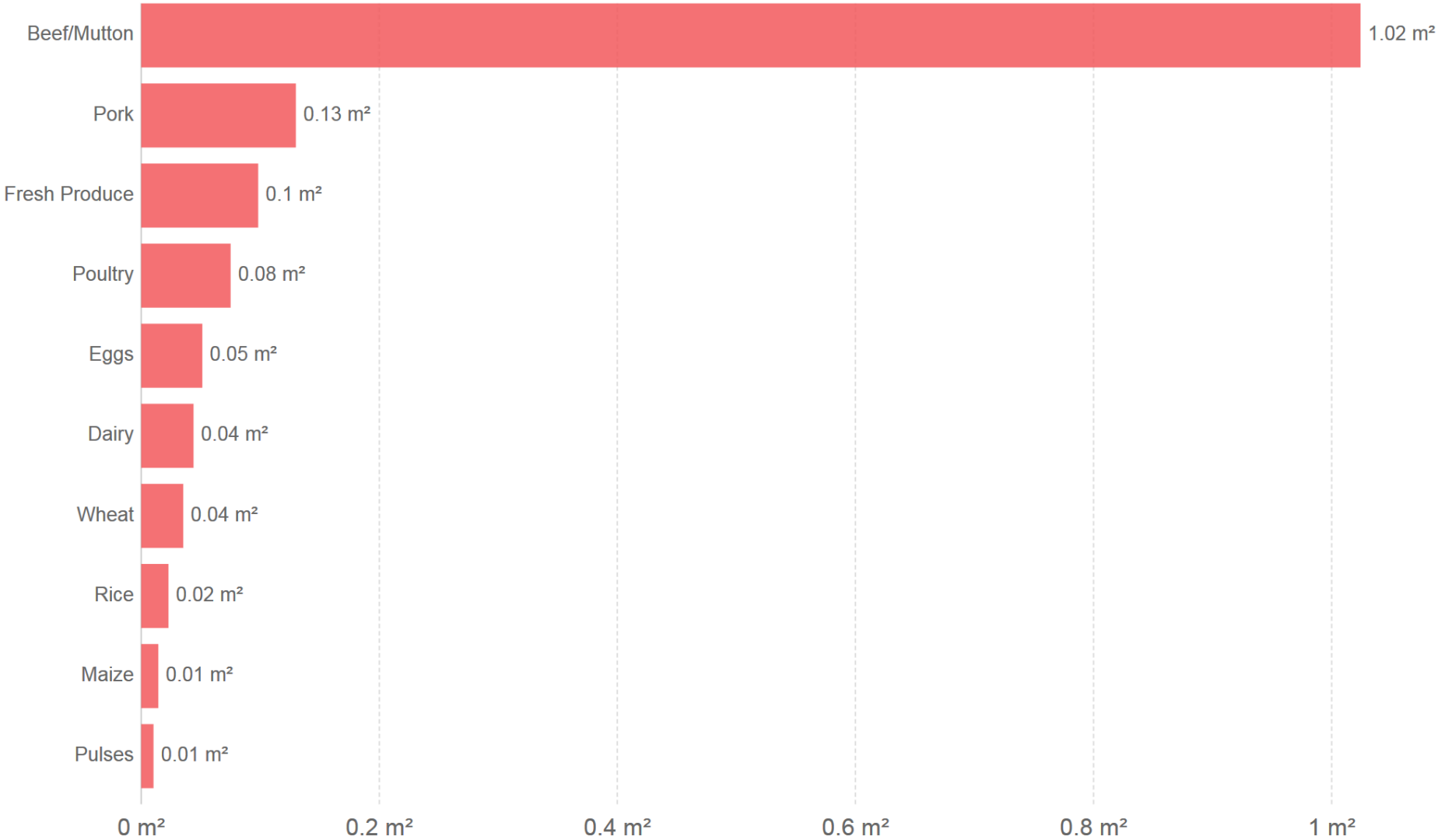
Janzen, H. H. 2011. What place for livestock on a re-greening earth? Animal Feed Science and Technology 166-67:783-796.
Geist, H. J., and E. F. Lambin. 2002. Proximate causes and underlying driving forces of tropical deforestation. Bioscience 52:143-150.
Gibbs, H. K., A. S. Ruesch, F. Achard, M. K. Clayton, P. Holmgren, N. Ramankutty, and J. A. Foley. 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. Proceedings of the National Academy of Sciences of the United States of America 107:16732-16737.
Christian J. Peters , Jamie Picardy, Amelia F. Darrouzet-Nardi, Jennifer L. Wilkins, Timothy S. Griffin, and G. W. Fick.

Land availability & diet



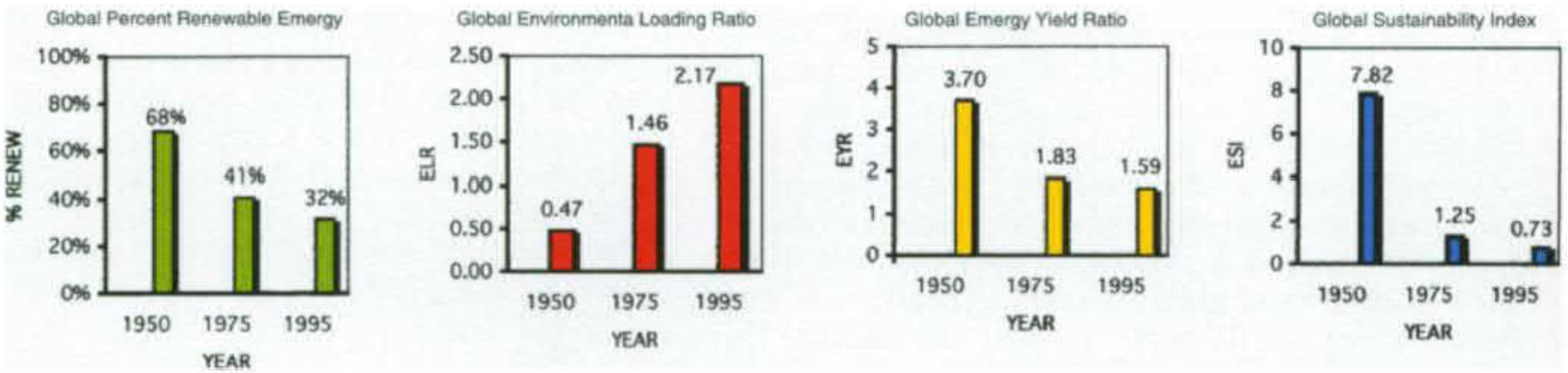
Land use per gram of protein, by food type

Average land use area needed to produce one unit of protein by food type, measured in metres squared (m²) per gram of protein over a crop's annual cycle or the average animal's lifetime. Average values are based on a meta-analysis of studies across 742 agricultural systems and over 90 unique foods.



Source: Environmental footprint by food type (protein) - Clark & Tilman (2017)

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



Food production as it is now – the threats

Threats to the current animal dominated 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
- The social license of animal agriculture

The end of social license for dairy in NZ and the NZ image under threat

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Patrick Barkham

Rod Oram

Rod Oram investigates the political, economic, and business spheres in New Zealand.

Fonterra's climate change fudge

Rod Oram looks this week at Fonterra's apparently ground-shifting announcement about reducing its net carbon emissions to zero by 2050. He writes Fonterra's caveats mean the plan is not as impressive as it looks.

Full of surprises.

The Economist Topics Print edition More

LE

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NZ 'like a beautiful person with cancer' - Eden Project founder

1 Dec, 2017 10:22am

5 minutes to read

Cows and seep

Dairy farming is polluting New Zealand's water

Government data suggests that 60% of rivers and lakes are unswimmable

Print edition | Asia ›

The New Zealand situation (dairy) the threats of non-animal milk and cellular meat

Relative input values (headwinds for NZ):	Artificial milk	NZ Milk
Land area	Low	High
Land price	Low	High
Interest rates	Low	High
Debt	Low	High
Energy use	Low	High
Wastage paddock to plate	Low	High
Cost of conversion efficiency	Low	High
Byproducts to dispose of	Low	High
Product storage/shelf cost	Low	High
Seasonality problems (peaking)	Low	High
Carbon footprint	Low	High
Water footprint	Low	High
Animal welfare issues	Low	High
Distance to market	Low	High
Point on innovation curve	Low	High
Point on cost reduction curve	Low	High
Public image issues	Moderate	Moderate
Premium on most production	No	No
Nutritional objections	Low	Medium

Our deadly nitrogen addiction NZ dairy externalities

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50 YEARS
UNIVERSITY OF NEW ZEALAND

'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	m^3/	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 m^3		
	10-year avg. export price	737	$/t	7	$/kg milk solids
		404	$/m nber	5	$/kg whole milk
	Manufactured exports	161	mil $/yr	179	million $/yr
	Employment: Upstream	84	em rest/yr	415	emp/farm/yr
	Downstream	280	em 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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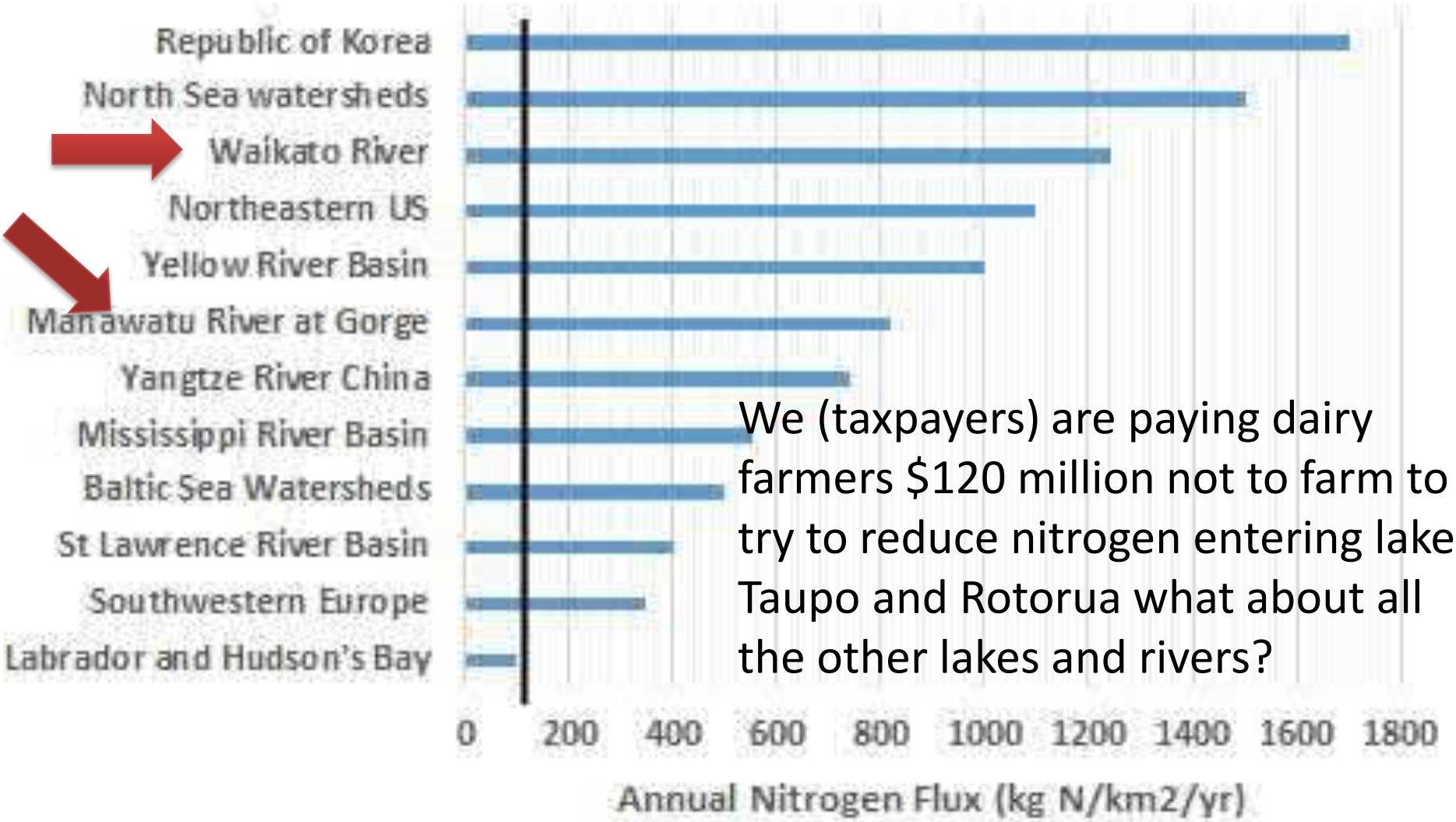
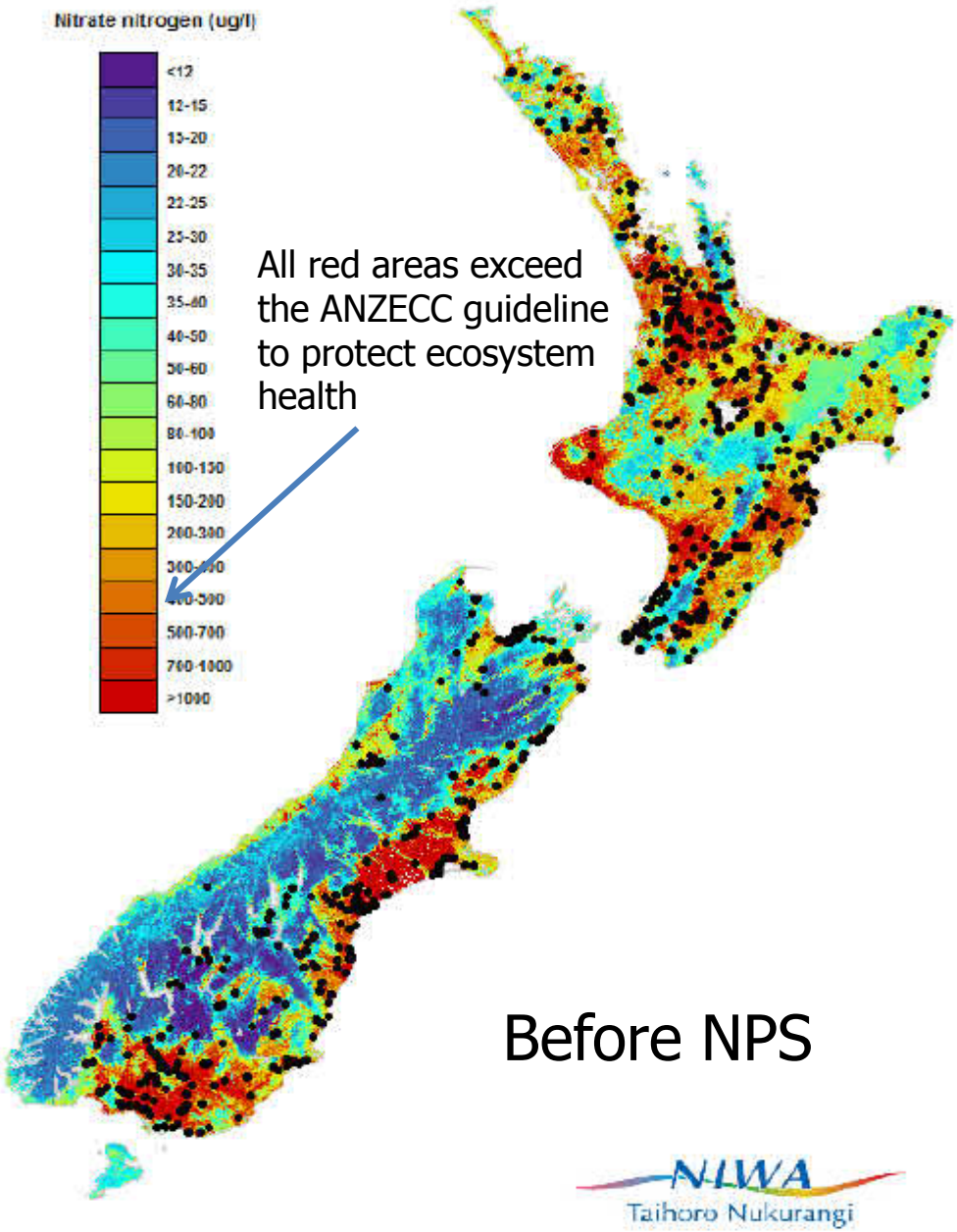
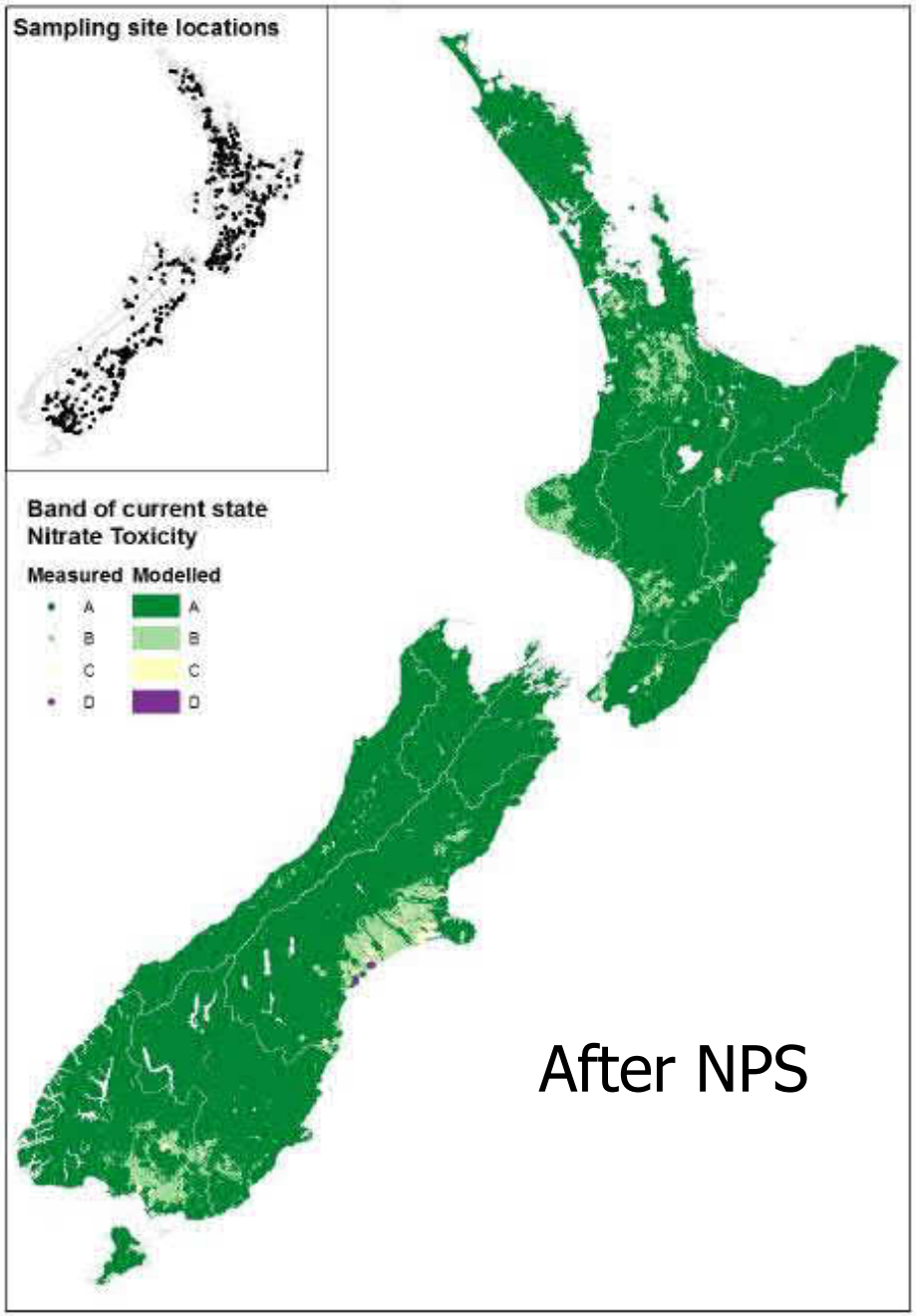
Our deadly nitrogen addiction NZ



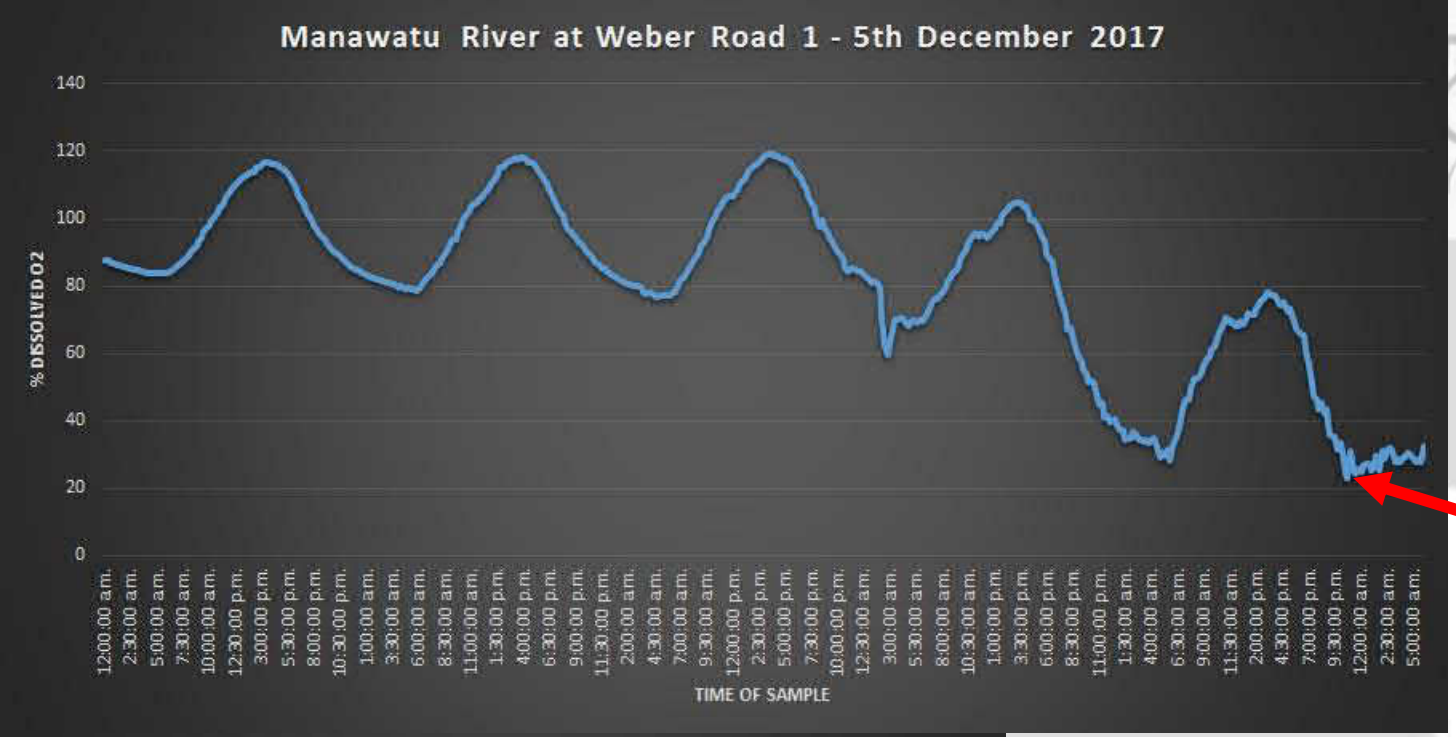
We (taxpayers) are paying dairy farmers $120 million not to farm to try to reduce nitrogen entering lake Taupo and Rotorua what about all the other lakes and rivers?

"A fresh start for freshwater" NPS objectives 2014: (making the problem disappear)





NIWA
Taihoro Nukurangi



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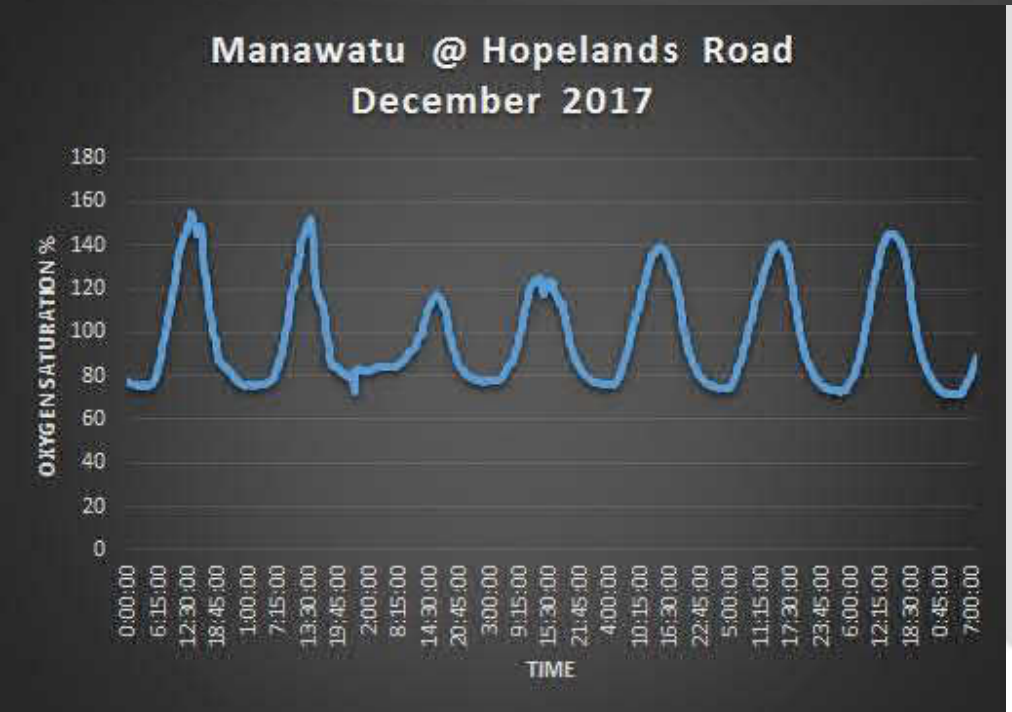
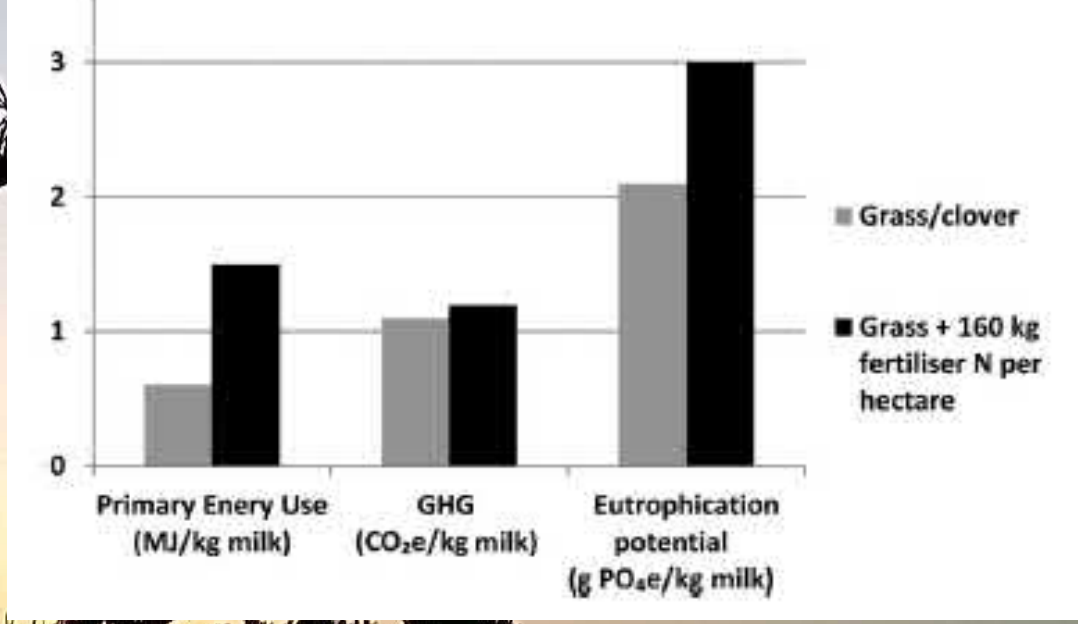


Both of these sites score an A for all water-quality measures under our NPS-FW! (Yangtze and Mississippi score a B)

And pollution allowances are being set based on this flawed system nationally

Solutions NZ -



Precision agriculture?

No more synthetic N, less animals?

Landcorp Pamu brand – no PKE, carbon neutrality, no artificial N?

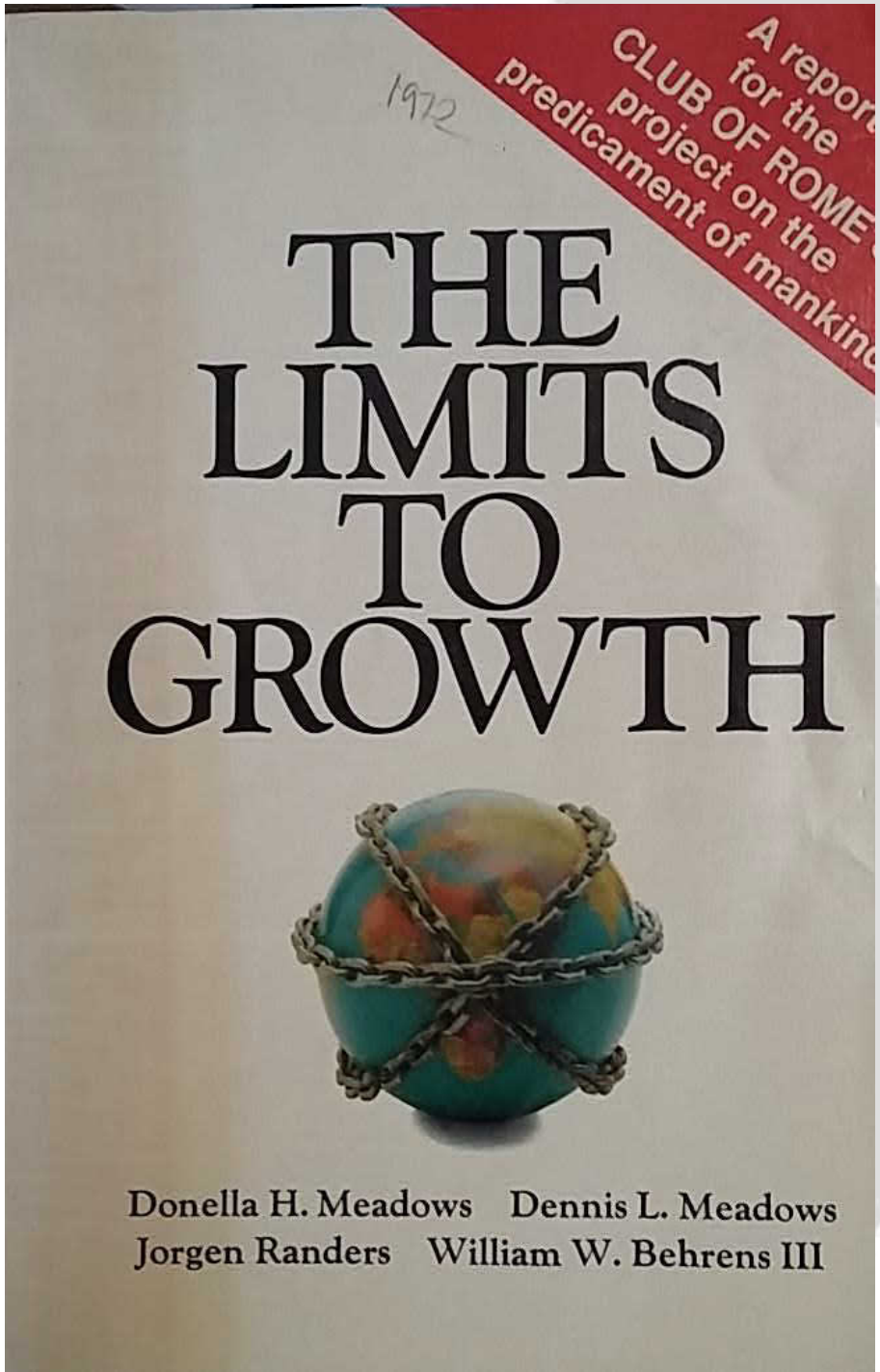
Emergy analysis to compare farming systems in NZ

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



Limits to growth (1972) updated 2014 Graham Turner (is global collapse imminent?)

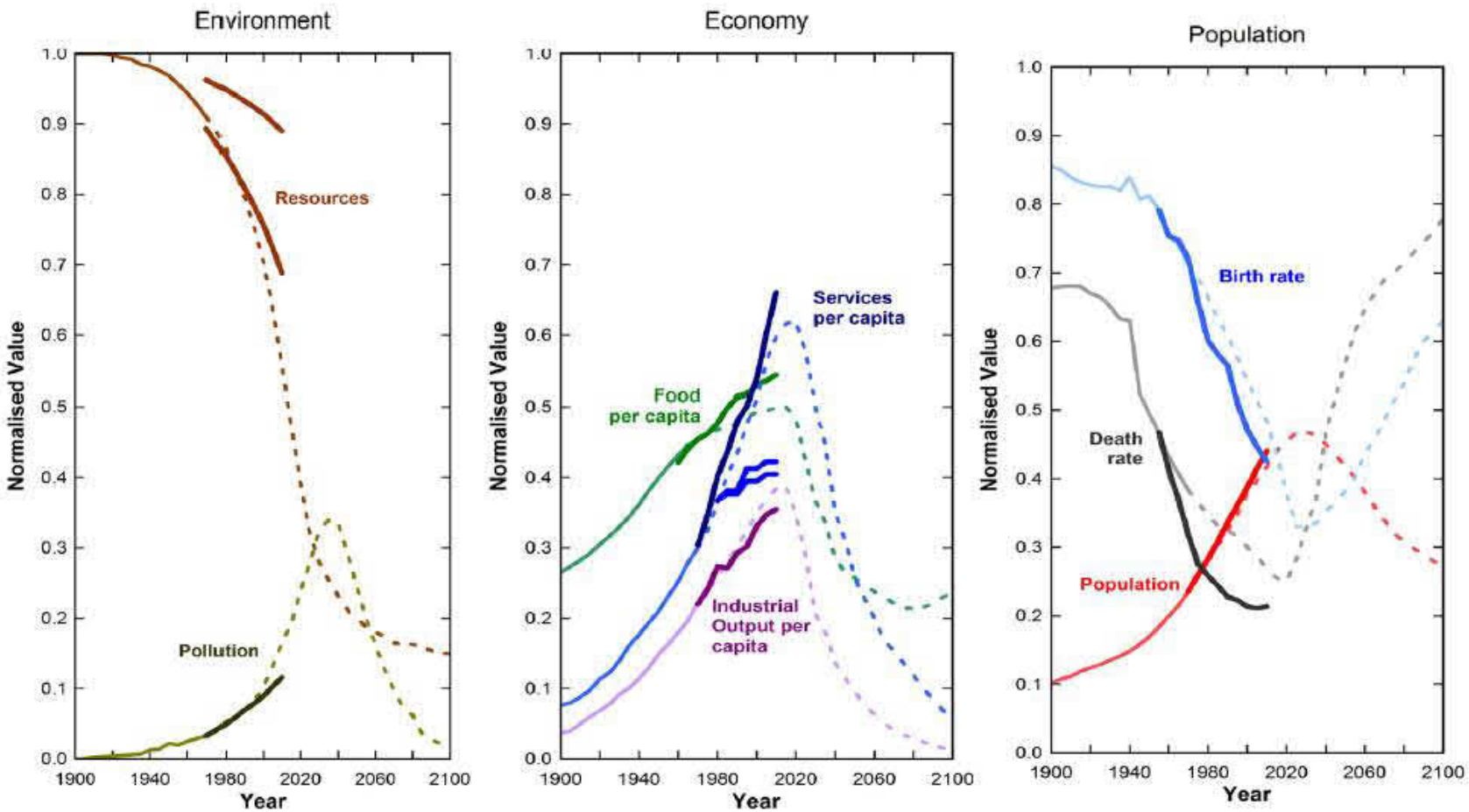
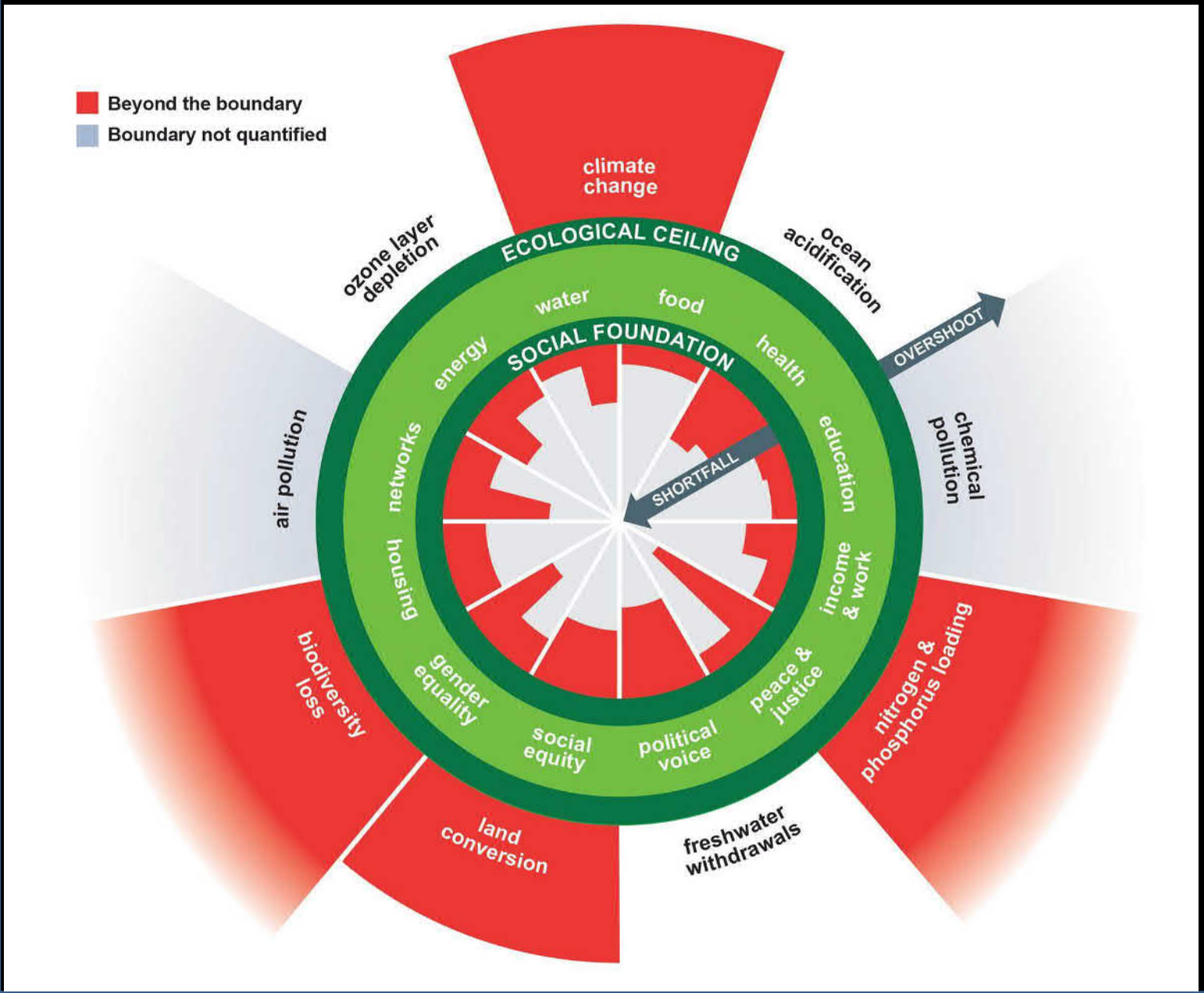


Figure 1. *LTG* BAU (Standard Run) scenario (dotted lines) compared with historical data from 1970 to 2010 (solid lines)—for demographic variables: population, crude birth rate, crude death rate; for economic output variables: industrial output per capita, food per capita, services per capita (upper curve: electricity p.c.; lower curves: literacy rates for adults, and youths [lowest data curve]); for environmental variables: global persistent pollution, fraction of non-renewable resources remaining (upper curve uses an upper limit of 150,000 EJ for ultimate energy resources; lower curve uses a lower limit of 60,000 EJ [Turner 2008]).

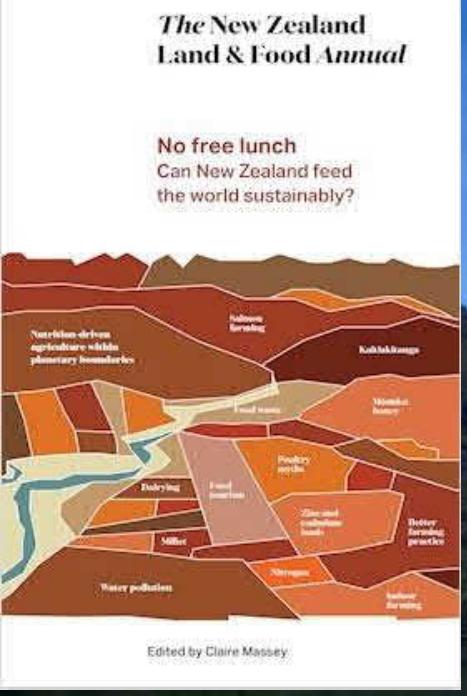
What we need to do

Doughnut Economics: seven ways to think like a 21st century economist, Kate Raworth



What we must do

- Break our nitrogen/fossil fuel addiction start the transition now
- Start regenerative/closed loop/biological farming
- Start accounting using true cost analyses (no longer allow externalities)
- Change our diets – its them (animals) or us
- Stop the growth obsession – start degrowth = a managed way down or a very nasty crash
- 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)

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