The Low Emissions Diet

Eating for a safe climate

Paul Mahony

With recipes from Mel Baker - The Kind Cook

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"The Low Emissions Diet: Eating for a safe climate"

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Disclaimer:
No information in this booklet is intended to represent nutritional, dietary, medical, health or similar advice, and should not be relied upon as such.

"Our lives begin to end the day we become silent about things that matter."

Martin Luther King, Jr.

". . . if we could recognise who we really are, rather than beings who were magically and separately created from the rest of nature, and if we could come to grips with that reality, then maybe we could be aroused from the stupor that we find ourselves in and begin to save ourselves."

Ann Druyan[1]

"Contrarian claims by sceptics, misrepresenting direct observations in nature and ignoring the laws of physics, have been adopted by neo-conservative political parties. A corporate media maintains a 'balance' between facts and fiction. The best that governments seem to do is devise cosmetic solutions, or promise further discussions, while time is running out.

Good planets are hard to come by."

Andrew Glikson[2]

"If cattle were to form their own nation, they would rank third behind China and the United States among the world's largest greenhouse gas emitters."

World Resources Institute[3]

"If we could live happy and healthy lives without harming others, why wouldn't we?"

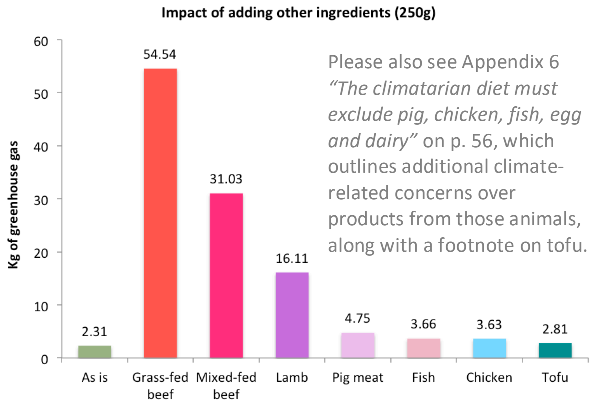
Pam Ahern[4]

Contents

Introduction

The aim of this booklet is to highlight the greenhouse gas emissions associated with different types of food. To assist you in adopting or retaining a climate-friendly diet, we have included a sample of mouth-watering recipes complemented by charts showing the relevant carbon footprints.

An example is the recipe for spicy sweet potato and bean enchiladas. The chart on the right shows the greenhouse gas emissions associated with cooking the dish as shown in the recipe, and the extra emissions produced by adding various ingredients. Here we see that adding meat will increase greenhouse gas emissions by between 1.6 and 24 times.



Overcoming climate change will require actions on many levels. Not only must we stop burning fossil fuels, we must also reforest large tracts of land and reduce the emissions of non-CO2 warming agents. Those warming agents could be reduced, and vast amounts of land reforested, with a general transition away from animal-based food products.

We can reduce our individual emissions considerably by changing the amount and type of meat we consume. However, even relatively low emissions-intensity products such as chicken, pig, fish, egg and dairy could contribute unnecessarily to critical thresholds being breached, potentially leading to runaway climate change. In view of our precarious position, consumption of such products must be reduced or avoided altogether.

The link between livestock production and climate change involves many inter-related factors, including:

- livestock's inherent inefficiency as a food source;
- the large scale of the industry (including tens of billions of land animals slaughtered for food annually);
- land clearing for feed crops and pasture;
- extensive grazing on open rangelands, with resultant degradation and loss of soil carbon;
- greenhouse gases such as carbon dioxide, methane and nitrous oxide, along with other warming agents such as black carbon.

In various respects, many official figures under-report the livestock sector's climate change impacts. The under-reporting occurs because relevant factors are: (a) omitted entirely; (b) classified under non-livestock headings; or (c) considered but with conservative calculations.

A critical problem is that traditional reporting methods understate the shorter-term impacts of animal agriculture. This booklet focuses on such impacts, as it is critical that we mitigate the relevant risks in an effort to avoid climate change tipping points, where a small change in human activity can lead to abrupt and significant changes in earth systems. Even in the absence of clear tipping points, climate feedback mechanisms create accelerating changes, which are potentially irreversible.

In addition to the efforts of individuals, governments must play a key role. A meaningful measure would be to create price signals through carbon pricing mechanisms that include the agriculture sector. With its environmental cost factored into the end price, a product such as beef would be considered a luxury, with a substantial reduction in demand and supply. All proceeds from (for example) a carbon tax could be returned to the community through personal income tax reductions and adjustments to welfare payments (as advocated by leading climate scientist, Dr James Hansen).

As they have in the past, economies will need to adapt to changing circumstances, as planetary systems will not adapt to suit a nation's economy.

While all forms of diet generate greenhouse gas emissions, if those who currently eat meat and dairy products were to convert to a plant-based diet, their net dietary emissions may be close to nil after allowing for the resultant vegetative regrowth and sequestration of carbon. More details are available in Appendix 4 "Land Clearing".

Our aim in producing this booklet is to contribute to efforts aimed at overcoming the enormous threat of climate change and helping our magnificent planet and all her inhabitants thrive. We hope you find it beneficial.

PART 1: GREENHOUSE GAS EMISSIONS AND FOOD

1. Emissions from animal-based foods

Some context can be added to greenhouse gas emissions from animal-based food production by comparing them to other emissions sources, such as plant-based foods, motor vehicles and activities recognised for particularly high emissions, such as aluminium smelting and fossil fuel-based electricity generation.

For some of the comparisons found in this section, we have considered greenhouse gas emissions intensity, which represents the amount of carbon dioxide-equivalent ("CO_2-e") greenhouse gases produced per unit of end product or nutrient, measured by weight.

In respect of animal-based figures from the Food and Agriculture Organization of the United Nations (FAO), we have retained its approach of reporting on the basis of carcass weight. Some studies use retail weight (resulting in higher emissions intensity), while others use live weight (resulting in lower emissions intensity).

In using retail weight, all emissions relating to the animal are attributed to (for example) the meat on the plate. It could be argued that emissions should also be attributed to other products, such as liver, kidneys, tripe, tongue, gelatin, glue and leather, thereby reducing the emissions attributed to the retail cut of meat. That approach is taken by the FAO in respect of dairy cattle, to the extent the emissions figures are attributed to both meat and dairy products.

On the other hand, if the sole focus is the particular food product under review, then the approach of using retail weight is valid.

Our approach of retaining the FAO's carcass weight figures is effectively one of taking the middle road.

Comparison with plant-based foods

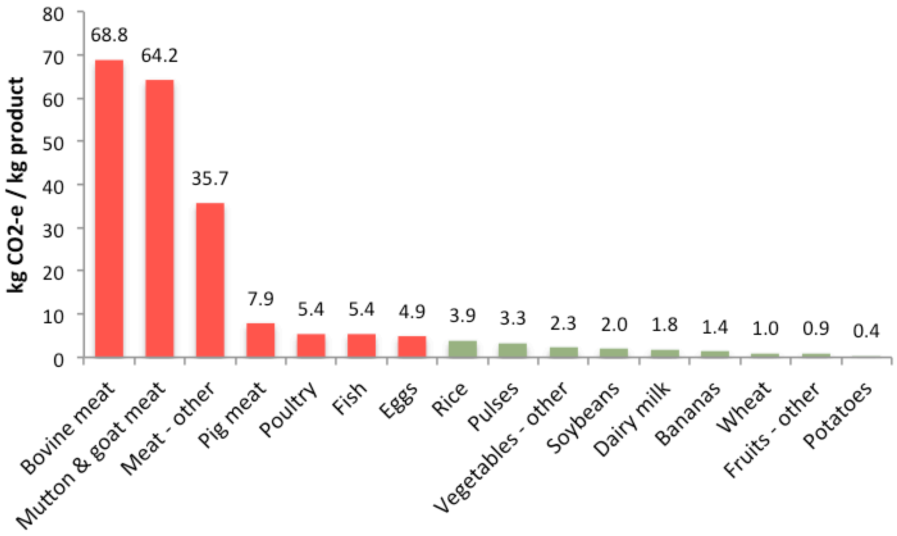
Although specific results vary, the overwhelming conclusion of many studies is that the greenhouse gas emissions intensity of animal-based foods is far higher than that of plant-based alternatives, and that some animal based products are far more emissions intensive than others.

A 2014 study by Oxford University researchers provided a comprehensive list of food-related emissions intensity figures for alternative types of diet in the United Kingdom.[5] A selection can be found in Figure 1, with a more detailed listing in Appendix 1. The study was based on information provided by around 55,000 participants ranging from high meat eaters to vegans.[6]

The figures are based on a 100-year "global warming potential" (GWP) for methane and nitrous oxide. It can be argued that a more valid time horizon for dietary emissions is 20 years, which would result in far higher figures for various meat products than those shown here. The 20-year figure is used later in this document.

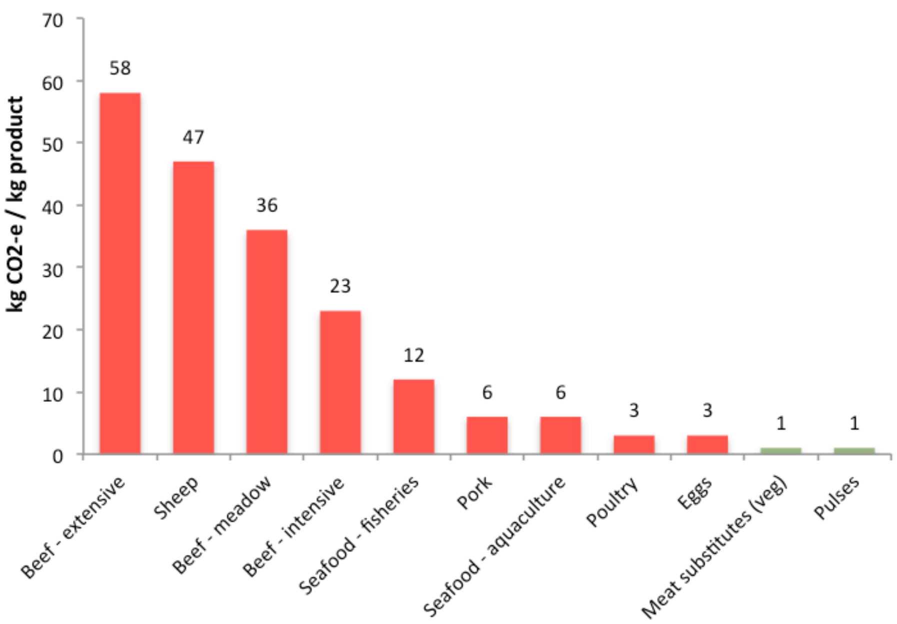
The GWP methodology allows the emissions of different gases to be aggregated by converting them to the uniform measure of CO_2-e. It is analogous to converting different currencies to a common denomination. (For more details on GWP, please see Appendix 3.

Figure 1: Greenhouse Gas Emissions Intensity of Food Products Consumed in the UK (GWP100)



Citing a review by Nijdam, et al. of 52 life cycle assessment studies, a January 2014 article by Ripple, et al. in the journal Nature reported that the emissions intensity of ruminant meat is, on average, 19-48 times higher than that of high-protein plant-based foods.[7, 8] The key results are shown in Figure 2.

Figure 2: Average carbon dioxide equivalent footprint of protein-rich solid foods per kilogram of product from meta analysis of 52 life cycle assessment studies (GWP100)



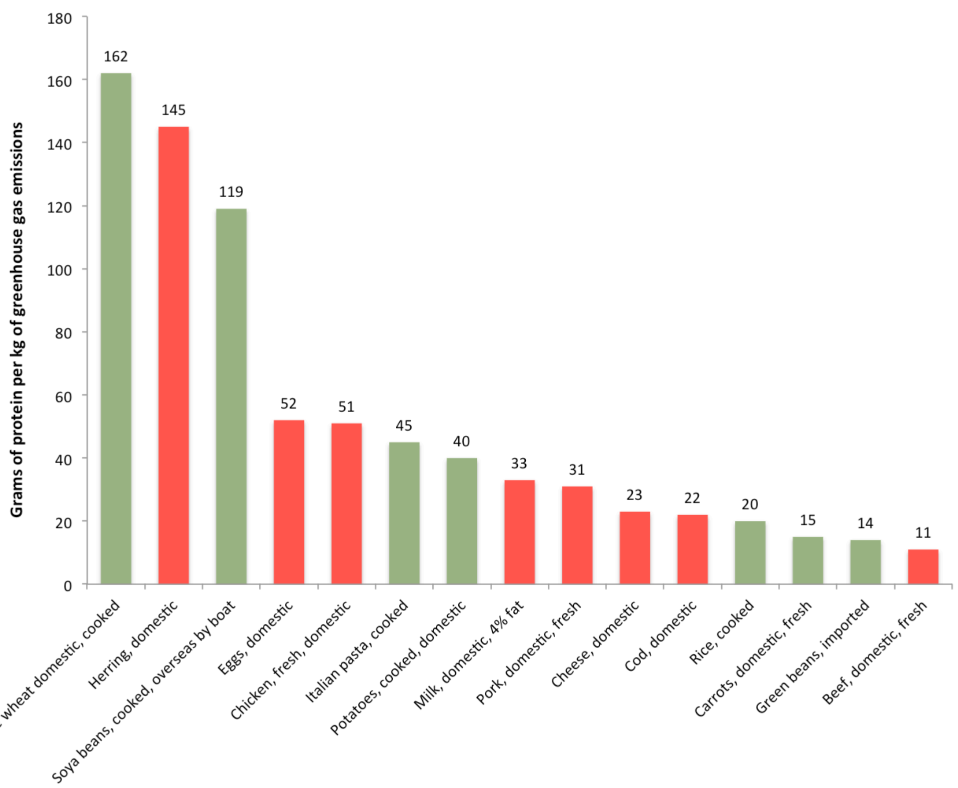
The paper indicated that a “farm to fork” analysis was generally used in the LCA studies, involving: enteric fermentation (producing methane); manure; feed; fertilizer; processing; transportation; and land use change. However, the approach was not common across all the studies. For example, the study that reported the lowest figures for beef’s emissions did not include emissions occurring after the product had left the farm, and did not appear to include land use change. Nevertheless, the results of the meta-analysis are informative.[9]

A 2003 report commissioned by the Australian Greenhouse Office reported an emissions intensity figure for beef of 51.7 kg, and for wheat 0.4 kg. It is possible that the beef industry's share of deforestation has reduced from the figure of 85.1 per cent used in the study following a ban (with exemptions) on broad-scale land clearing in Queensland with effect from December 2006. However, legislation was introduced during 2013, allowing significant levels of clearing in respect of land deemed to be of *"high agricultural value"*, and the extent of clearing is estimated to have tripled between 2009/10 and 2013/14.[10] (Please see Appendices 4 and 5 for more details.)

A 2009 Swedish study, by researchers Annika Carlsson-Kanyama and Alejandro Gonzalez, also provided emissions intensity figures for a wide range of foods, including legumes, fruit and vegetables. It included CO_2-e emissions involved in farming, transportation, processing, retailing, storage and preparation.[11]

The researchers pointed out that beef is the least climate efficient way to produce protein, being less efficient than vegetables that are not recognised for their high protein content, such as green beans and carrots. Stated another way, per kilogram of greenhouse gas emissions produced, carrots have more protein than beef. By the same measure, wheat has around thirteen times and soybeans around ten times more protein than beef. (Please see Section 3 for more comments on protein and other nutrients.)

Figure 3: Protein content per kilogram of greenhouse gas emissions (GWP100)



In November 2013, the FAO estimated that the global average emissions intensity of specialised beef (excluding dairy cows whose flesh is consumed as beef) was 67.6 kg based on carcass weight.[12]

What about grass-fed cattle?

Beef from grass-fed cattle is far more emissions intensive than beef from mixed feed systems, involving grain and grass. No cattle are exclusively grain-fed for their entire lives, as they have not evolved to consume grain and would not survive. "Grain-fed" cattle are usually "finished" on grain for the last 120 days or so of their lives.

The FAO report provided separate emissions intensity figures for specialised beef from "mixed" and "grazing" systems. Adjusting them for a 20-year GWP results in the following comparisons for overall global beef production:[13]

Table 1: Emissions intensity of beef (kg of greenhouse gas per kg of product)

Description	Mixed fed	Grass fed
100-year GWP	56	102
20-year GWP	115	209

Comparison with aluminium smelting

Aluminium smelting is an extremely emissions intensive process. It has been reported to consume around 16 per cent of Australia's electricity production[14], for less than 1 per cent of Gross Domestic Product and less than 0.1 per cent of jobs. (The electricity consumption figure may have reduced in recent times as two smelters have closed, representing around 18% of production capacity.) Because the electricity is primarily generated from coal, including brown coal in Victoria, the emissions intensity of Australian aluminium has at times been around 2.5 times the global average.

The former CEO of mining giant, BHP Billiton, Marius Kloppers, once described aluminium as *"the ultimate proxy for energy".* [15]

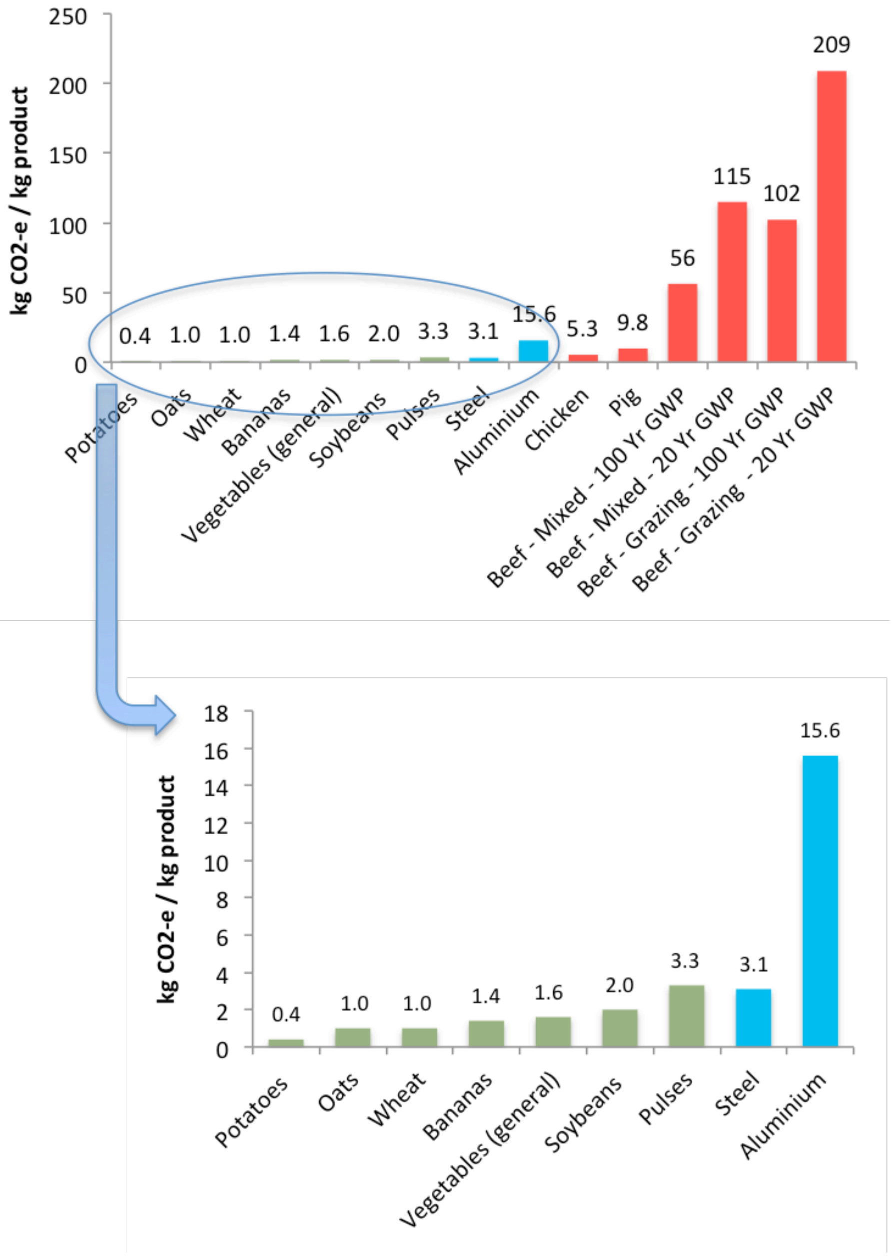
Mining Weekly magazine said, *"To phrase it in terms of the industry joke, aluminium is congealed electricity."*[16]

In 2003, a report commissioned by the Australian Greenhouse Office indicated that the emissions intensity of Australian aluminium was 20 kg.[17] The industry has reported that the figure in 2011 had reduced to 15.6 kg.[18]

How do food products compare with aluminium and steel?

There is a common misconception that agricultural emissions are not significant relative to emissions-intensive activities such as aluminium smelting. In fact, some agricultural activities are amongst the most emissions intensive in the economy. The following chart compares various food-related emissions intensity figures from the Oxford and FAO studies with figures for Australian aluminium and steel.

Figure 4: Greenhouse Gas Emissions Intensity



Despite aluminium smelting's significant drain on Australia's electricity supply, beef from grass-fed cattle (global average) is more than thirteen times as emissions intensive when measured with a 20-year time horizon.

Beef's overall emissions are also significant relative to aluminium, as Australia produces at least ten per cent more beef than aluminium by weight.[19]

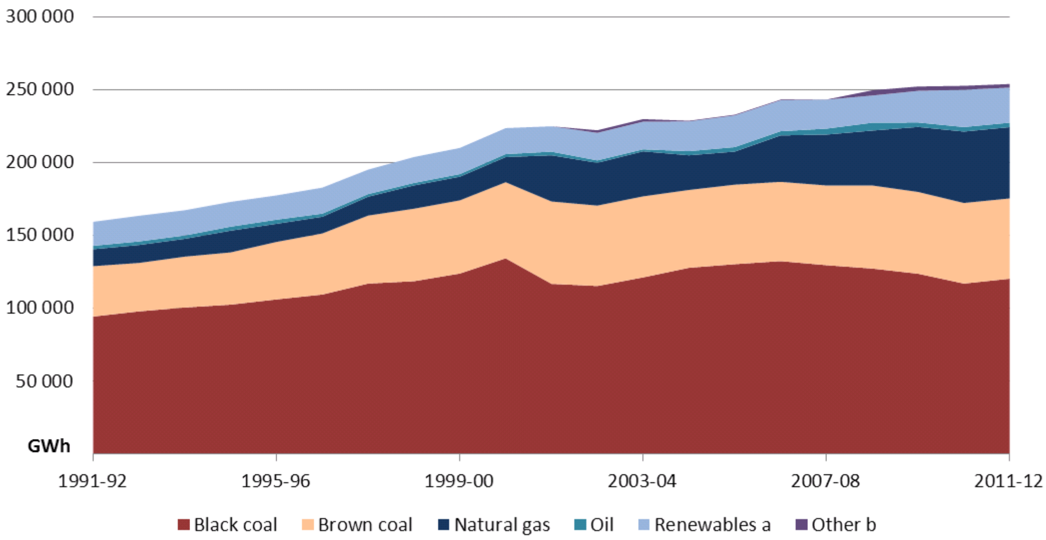
The "20-year GWP" figures of 115 kg and 209 kg in Table 1 and Figure 4 are based on the global average percentage apportionment of the various factors contributing to beef's emissions intensity, and are intended to be approximations only. As methane's percentage contribution would be lower in mixed systems than in grazing systems, the figure of 115 kg may be overstated, while the figure of 209 kg may be understated.

The charts in Figure 4 do not include rice due to uncertainties about the product's emissions intensity over a 20-year time horizon. For more comments please see Appendix 2.

Comparison with electricity generation

Nearly 90 per cent of Australia's electricity is generated from traditional fossil fuels, with 69 per cent from coal and 19 per cent from natural gas. [20] Largely as a result of Australia's heavy reliance on fossil fuels, its per capita emissions are amongst the highest in the developed world. To provide some context, in terms of gross domestic product, The World Bank ranked Australia's economy number 12 of 214 nations for 2014.[21]

Figure 5: Australian electricity generation, by fuel type

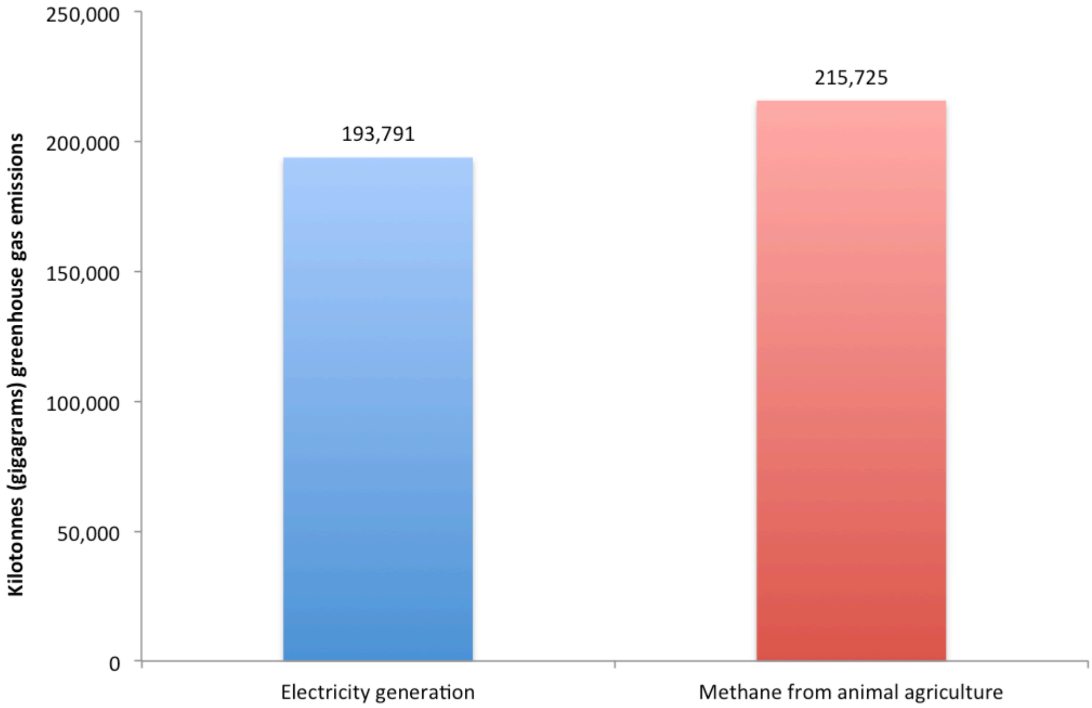


Note: a includes wind, hydro, solar PV and bioenergy; b includes multi-fuel power plants

Applying a 100-year GWP, Australia's 2012 National Greenhouse Inventory reported 57.9 megatonnes of CO_2-equivalent (CO_2-e) methane emissions from livestock production.[22] Assuming that 57 per cent of savanna burning was livestock related, as reported in 2003, the figure increases to 62.7 megatonnes.[23] That equates to 215 megatonnes of CO_2-e emissions using a 20-year GWP, which is more than the emissions from all electricity generation.[24] A similar approach was utilised in a 2007 article in Australasian Science titled *"Meat's Carbon Hoofprint"*.[25]

We have used the IPCC's 20-year GWP for methane of 86 (including climate carbon feedbacks). That is a conservative figure relative to NASA's estimate of 105.[26] After adjusting for a 20-year GWP on methane and nitrous oxide, the emissions of electricity generation become 193,791 kilotonnes, compared to the original figure of 193,008.

Figure 6: Kilotonnes (gigagrams) of greenhouse gas emissions from electricity production and methane-related emissions from livestock (20-year GWP)



Note: 1 megatonne = 1,000 kilotonnes or 1,000 gigagrams

The analysis shows that, even before allowing for factors such as land clearing and nitrous oxide emissions from excrement, the emissions from animal agriculture in Australia are more than those from electricity generation, most of which is coal-fired.

The electric cow

The above comparison is like saying that if farm animals ran on electricity instead of food, water and oxygen, and greenhouse gas emissions were used to gauge the amount used, then our current level of electricity generation would be insufficient to supply our current food mix. That would be the case even if we ceased using electricity for other purposes.

It is also like saying that a general move toward a plant-based diet would benefit the climate more over the coming twenty years than replacing Australia's fossil fuel-based electricity generation with carbon-free power generation.

Comparison with motor vehicles

Researchers at the University of Chicago have reported that converting from a typical Western diet to a plant-based diet is 50 per cent more effective in reducing greenhouse gas emissions than changing one's car from a conventional sedan to a hybrid.[27]

Similarly, Carlsson-Kanyama and Gonzalez (referred to earlier) have reported that the consumption of 1 kg of domestic beef is equivalent to 160 kilometres (99 miles) of automobile use.

Scarborough et al. have reported that moving from a high meat diet to a vegan diet would reduce an individual's carbon footprint by 1,560 kg CO_2-e per year. In comparison, driving a small, 10 year old family car for 6,000 miles would create a carbon footprint of 2,440 kg CO_2-e per year.[28]

2. Daily and weekly emissions from food

The following chart demonstrates potential greenhouse gas emissions for one day based on alternative sample food mixes. Each food mix is identical, except for the choice between soy milk and cow's milk, and either: (a) grass-fed beef; (b) beef from mixed feeding systems; (c) chicken; (d) fish; and (e) a combination of tofu, soybeans and kidney beans

The figures are based on 20-year GWPs of 86 for methane and 268 for nitrous oxide, and allow for some impacts of livestock-related land clearing, although foregone sequestration is not accounted for. The Calorie intake ranges from around 2,100-2,300 Calories (plant-based and fish-based diets, depending on preparation method) to 2,600 Calories (beef-based diets).

Figure 7: Greenhouse gas emissions of alternative diets (sample food intake for one day):

Beef grass fed 200g	**Beef mixed 200g**	**Chicken 200g**	**Fish 200g**	**Tofu 100g**
Broccoli 50g	Broccoli 50g	Broccoli 50g	Broccoli 50g	**Soybeans 50g**
Carrot 50g	Carrot 50g	Carrot 50g	Carrot 50g	**Kidney beans 50g**
Potato 50g	Potato 50g	Potato 50g	Potato 50g	Broccoli 50g
Almonds 50g	Almonds 50g	Almonds 50g	Almonds 50g	Carrot 50g
Banana 150g	Banana 150g	Banana 150g	Banana 150g	Potato 50g
Orange 150g	Orange 150g	Orange 150g	Orange 150g	Almonds 50g
Oats 80g	Oats 80g	Oats 80g	Oats 80g	Banana 150g
Quinoa 100g	Quinoa 100g	Quinoa 100g	Quinoa 100g	Orange 150g
Spinach 100g	Spinach 100g	Spinach 100g	Spinach 100g	Oats 80g
Dried Apricots 65g	Dried Apricots 65g	Dried Apricots 65g	Dried Apricots 65g	Quinoa 100g
Avocado 50g	Avocado 50g	Avocado 50g	Avocado 50g	Spinach 100g
W'meal bread 130g	W'meal bread 130g	W'meal bread 130g	W'meal bread 130g	Dried Apricots 65g
Cow's milk 400g	**Cow's milk 400g**	**Cow's milk 400g**	**Cow's milk 400g**	Avocado 50g
				W'meal bread 130g
				Soy milk 400g

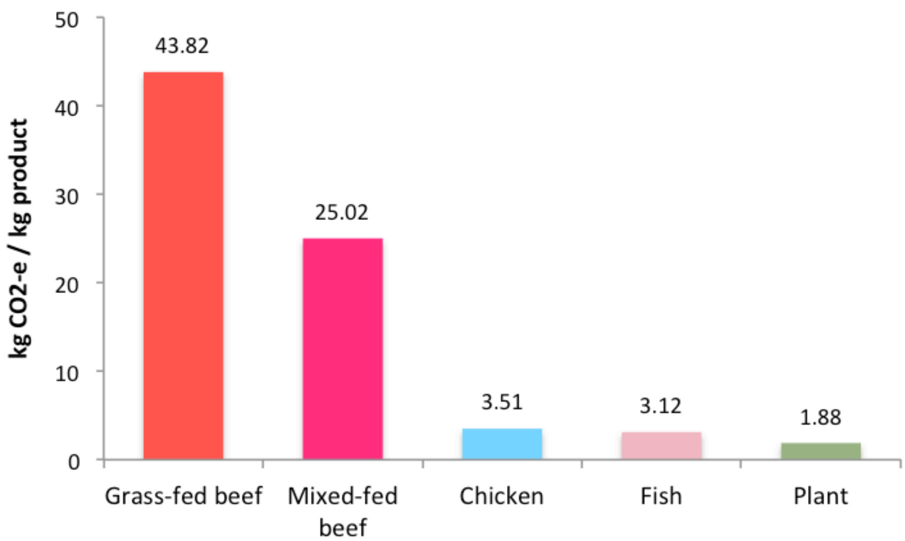


Figure 7 shows the vast differences in carbon emissions associated with the sample diets. By choosing to eat mixed-fed rather than grass-fed beef as part of the sample daily diet, our carbon footprint can be reduced by 43 per cent. Furthermore, if you were to eat chicken, fish or tofu rather than grass-fed beef, your carbon footprint could be reduced by 92 to 96 per cent.

In respect of tofu, the calculations use an emissions intensity figure equivalent to the Oxford study's figure for soy. That is a conservative approach, as the figure is the highest of several studies that have estimated the emissions intensity of soybeans or tofu.[29] [30] [31] [32]

Using the above figures, along with emissions relating to lamb and pig meat, Figure 8 demonstrates how selecting different foods can affect our weekly dietary greenhouse gas emissions.

Figure 8: Estimated weekly greenhouse gas emissions of alternative diets (20-year GWP):

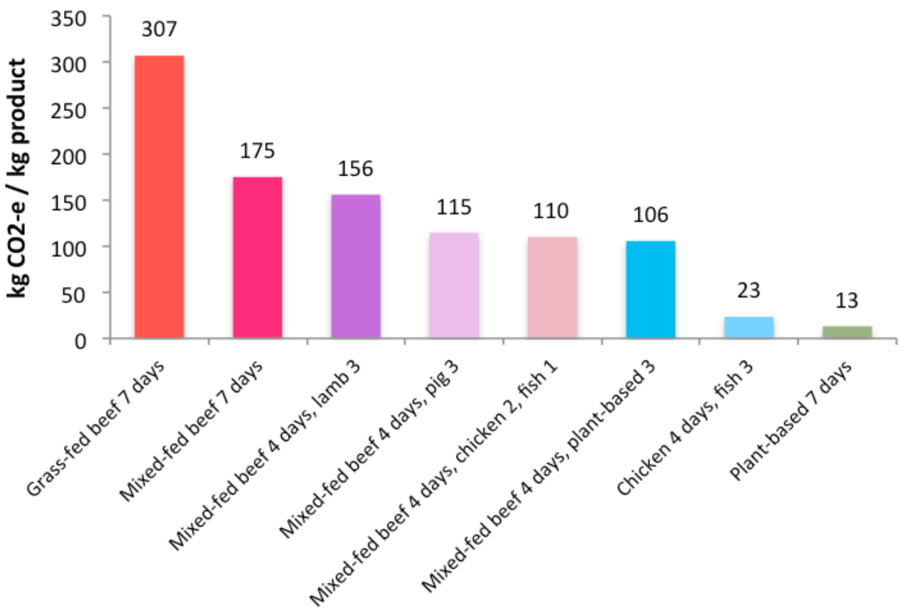


Figure 8 shows that your weekly carbon footprint could be reduced by 49 per cent if you were to change from eating grass-fed beef every day, to eating mixed-fed beef for four days and lamb for three. If you were to stop eating beef altogether, and instead ate chicken, fish or plant-based foods, your weekly carbon footprint could be reduced by 93 to 96 per cent.

However, as mentioned earlier, even relatively low emissions-intensity products such as chicken, pig, fish, egg and dairy could contribute to critical thresholds being breached, potentially leading to runaway climate change. (Please refer to Appendix 6 for more details.)

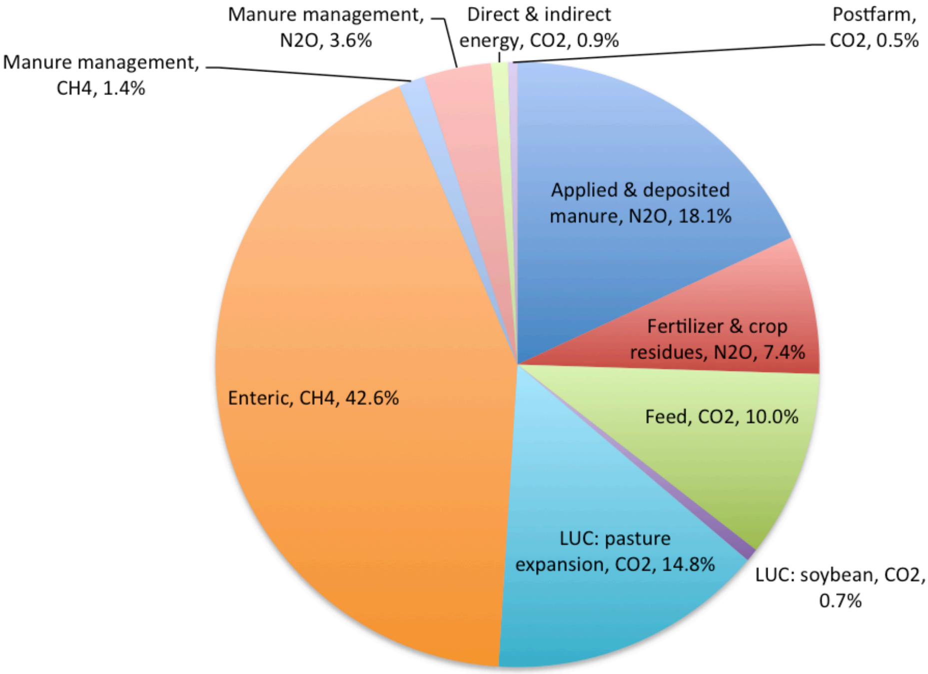
The impacts of buying locally produced food

The FAO has reported that "post-farm" emissions, including those from transportation, only account for 0.5 per cent of beef's global average emissions, so there is little benefit in purchasing the locally produced product. [33]

For lower-emissions products, transportation's share of emissions will be higher than beef's. Nijdam, et al. have reported an average contribution across all food types of around 11 per cent.[34]

The type of transport is important, with air transportation adding considerably to the emissions intensity of a product.

Figure 9: Breakdown of beef's greenhouse gas emissions (global average)



Note: LUC = Land use change

Summary:

Enteric fermentation (producing methane)	42.6%
Manure (3 categories)	23.1%
Feed & fertiliser	17.4%
Land use change - Pasture	14.8%
Energy	0.9%
Land use change - Soybean	0.7%
Postfarm (transport and processing)	0.5%
Total	100.0%

The relatively minor "land use change" component attributed to soybeans would probably not exist at all if land was not already being utilised, in an inherently inefficient fashion, for livestock grazing and feed crop production.

Based on a 20-year time horizon (GWP20), enteric fermentation's share increases to 71.7 per cent, and methane's overall share (including manure management) to 74.1 per cent.

3. Protein and other nutrients

Before considering the recipes, it may be a good idea to review some nutritional issues.

One of the most common questions heard by any vegetarian or vegan is: *"Where do you get your protein?"*

The question arises because of a common misconception that protein is only available in meat or other animal products, such as chickens' eggs or cows' milk, or that plant-based protein is somehow inferior.

The fact that some of the largest, strongest animals are herbivores or near-herbivores should alert people to the fact that there is plenty of protein available without eating animals. The range of such animals includes elephants, rhinoceroses, giraffes, cattle, horses and great apes such as chimpanzees, gorillas, and orangutans.

The position is further highlighted by comments from Dr David Pimentel of Cornell University, who reported in 2003 that the grain fed each year to livestock in the United States could feed 840 million people on a plant-based diet.[35]

Referring to US Department of Agriculture statistics, Pimentel has also stated that the US livestock population consumes more than 7 times as much grain as is consumed directly by the entire American population.

He and Marcia Pimentel have also reported:

" . . . each American consumes about twice the recommended daily allowance for protein"

Those comments, and others from the University of Minnesota referred to in Appendix 4, partially reflect the gross and inherent inefficiency of animals as a food source.

Is it difficult to replace animal protein with plant protein?

The Physicians Committee for Responsible Medicine (PCRM) has stated:[36]

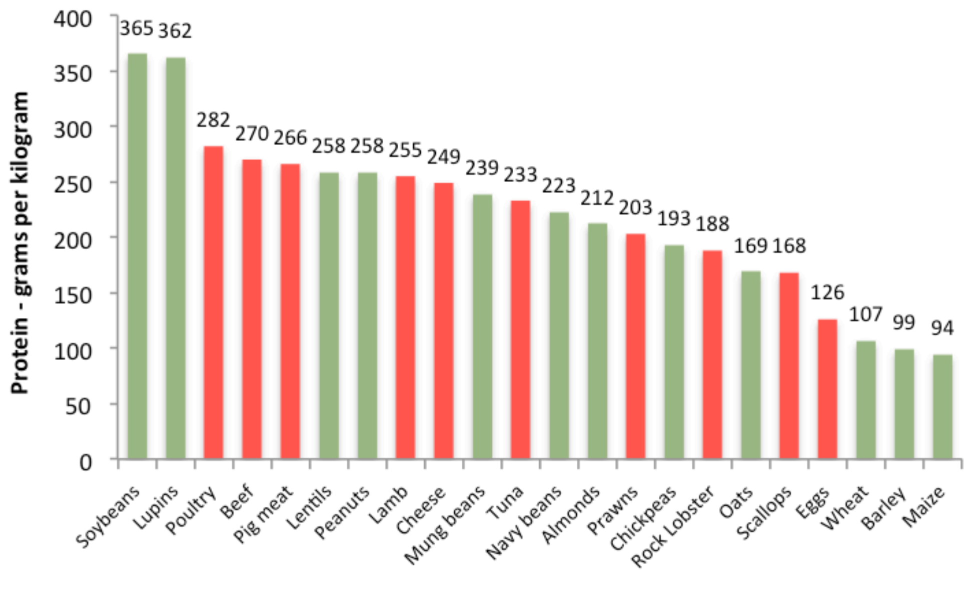
> *"To consume a diet that contains enough, but not too much, protein, simply replace animal products with grains, vegetables, legumes (peas, beans, and lentils), and fruits. As long as one is eating a variety of plant foods in sufficient quantity to maintain one's weight, the body gets plenty of protein."*

Also:

> *"It was once thought that various plant foods had to be eaten together to get their full protein value, but current research suggests this is not the case. Many nutrition authorities, including the American Dietetic Association, believe protein needs can easily be met by consuming a variety of plant protein sources over an entire day. To get the best benefit from the protein you consume, it is important to eat enough calories to meet your energy needs."*

The US Department of Agriculture has reported the following protein content for a variety of food products:[37]

Figure 10: Protein content of various foods (grams per kilogram)

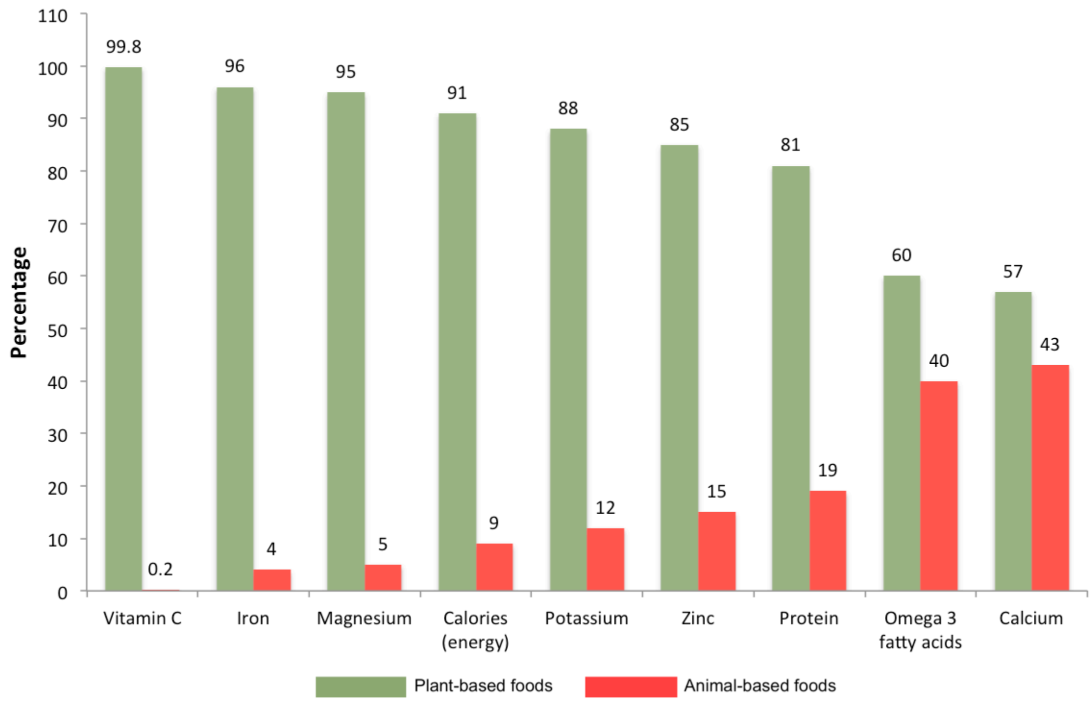


The legume figures (soy beans, lupins, peanuts, mung beans, navy beans, chickpeas and lentils) are based on raw product. Due to increased water content, soaking or boiling reduces protein content per kilogram. (The emissions attributed to the product, per kilogram, are also reduced.)

Figure 11 shows that 81 per cent of protein produced in Australia in 2011/12 came from plants, and only 19 per cent from animals.

It includes products that are exported and/or used as livestock feed. The inclusion of the latter means there is some double counting of protein and other nutrients. However, given animal agriculture's relatively low output level, the double counting is not significant in most cases.

Figure 11: Nutrient Value of Australian Food Production 2011/12



The chart is based on: (a) production figures from the Department of Agriculture, Fisheries and Forestry's *"Australian food statistics 2011-12"*;[38] and (b) nutritional information for each product from the United States Department of Agriculture's (USDA) *National Nutrient Database for Standard Reference*.[39]

Adequacy of Alternative Diets

The American Dietetic Association (referred to earlier) has said:[40]

> *"It is the position of the American Dietetic Association that appropriately planned vegetarian diets, including total vegetarian or vegan diets, are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases. Well-planned vegetarian diets are appropriate for individuals during all stages of the life cycle, including pregnancy, lactation, infancy, childhood, and adolescence, and for athletes. A vegetarian diet is defined as one that does not include meat (including fowl) or seafood, or products containing those foods."*

The extent of fortification of foods with nutrients such as vitamin B12 and vitamin D varies by country. As a result, it is important to review the adequacy of your diet based on local conditions, as partially reflected in this statement from Australia's National Health and Medical Research Council (also supporting vegetarian and vegan diets):[41]

> *"Appropriately planned vegetarian diets, including total vegetarian or vegan diets, are healthy and nutritionally adequate. Well-planned vegetarian diets are appropriate for individuals during all stages of the lifecycle. Those following a strict vegetarian or vegan diet can meet nutrient requirements as long as energy needs are met and an appropriate variety of plant foods are eaten throughout the day. Those following a vegan diet should*

choose foods to ensure adequate intake of iron and zinc and to optimise the absorption and bioavailability of iron, zinc and calcium. Supplementation of vitamin B12 may be required for people with strict vegan dietary patterns."

Vitamin B12

The vitamin B12 found in certain animal-based food products is produced by soil microbes that live in symbiotic relationships with plant roots, and which find their way into the animals' digestive tracts. Such bacteria are also found in humans' digestive tracts, but too far along to be readily absorbed for nutritional purposes.[42]

Vitamin B12 is not synthesised by plants, nor is it generally found with vegetables in our modern sanitised lifestyle. However, B12 supplements are readily produced from microbes, to be ingested directly or incorporated in various other food products. That is a far more natural approach than: (a) destroying rainforests and other natural environs; and (b) operating livestock production systems; purely for animal-based food products.

Calcium

There are ample plant-based sources of calcium, including unhulled tahini (sesame seed paste), chia seeds, almonds, turnips, kale, and spinach.

Animal proteins and excess amounts of calcium have been found to adversely affect bone density.[43] PCRM (referred to earlier) has reported that animal protein tends to leach calcium from the bones, encouraging its passage into the urine and from the body.

Amongst many studies on the subject, a 2000 study from the Department of Medicine at the University of California at San Francisco showed that American women aged fifty and older have one of the highest rates of hip fractures in the world. The only countries with higher rates were Australia, New Zealand and certain European countries, where milk consumption is even higher than in the United States.[44]

Vitamin D

It may be best not to rely on animal-based foods to satisfy your vitamin D requirements. The Medical Journal of Australia has reported: [45]

> *"Most adults are unlikely to obtain more than 5%-10% of their vitamin D requirement from dietary sources. The main source of vitamin D for people residing in Australia and New Zealand is exposure to sunlight."*

Whether or not you eat animal products, you need sunshine if possible, or perhaps supplements.

Iron

There are two types of iron in food: haem and non-haem. Haem iron is absorbed by the body more readily than non-haem, and is only available in animal products. Is that a problem? Not according to authors writing in the Medical Journal of Australia, who said:[46]

> *"Well planned vegetarian diets provide adequate amounts of non-haem iron if a wide variety of plant foods are regularly consumed. Research studies indicate that vegetarians are no more likely to have iron deficiency anaemia than non-vegetarians. Vegetarian diets are typically rich in vitamin C and other factors that facilitate non-haem iron absorption."*

PCRM has highlighted the role of excessive iron levels in the formation of cancer-causing free radicals. It has argued that iron from vegetarian food sources may be the better choice, as it is sufficient to promote adequate levels without encouraging iron stores above the recommended range.[47]

Zinc

While noting that vegetarians have an overall lower risk of common chronic diseases than non-vegetarians, another article in the Medical Journal of Australia concluded that well planned vegetarian diets *"can provide adequate zinc for all age groups, and vegetarians appear to be at no greater risk of zinc deficiency than non-vegetarians".*[48]

Although phytic acid in legumes, unrefined cereals, seeds and nuts can inhibit zinc absorption, the effect can be offset by the presence of sulphur-containing amino acids in a range of seeds, nuts, grains and vegetables and hydroxy acids in citrus fruits, apples and grapes, which bind to zinc and enhance its absorption.

Everyday practices such as soaking, heating, sprouting, fermenting and leavening food also assists. Soaking is the typical approach in relation to legumes, as is fermenting and leavening bread by including yeast as an ingredient.

In any event, our bodies generally adapt to a lower zinc intake by absorbing more of the zinc consumed and excreting less.

The authors also noted that *"different types of protein influence zinc absorption in different ways".* For example, casein in milk inhibits zinc absorption but soy protein does not.

4. Humans and the Food Web

Despite what many people may believe, humans do not sit at the top of the food web. (It is a web rather than a chain, due to the many complex interactions involved.)

An article commenting on our position in the food web was published in the Proceedings of the National Academy of Sciences (PNAS) in late 2013.[49]

According to the head of the research team, Sylvain Bonhommeau of the French Research Institute for Exploitation of the Sea in Sète, *"We are closer to herbivore than carnivore. . . . It changes the preconception of being top predator."*[50]

The article considered the trophic level of different species and nations. Trophic levels *"represent a synthetic metric of species' diet, which describe the composition of food consumed and enables comparisons of diets between species".*

A species' trophic level is calculated as the average of trophic levels of food items in its diet, weighted by quantity, plus one.

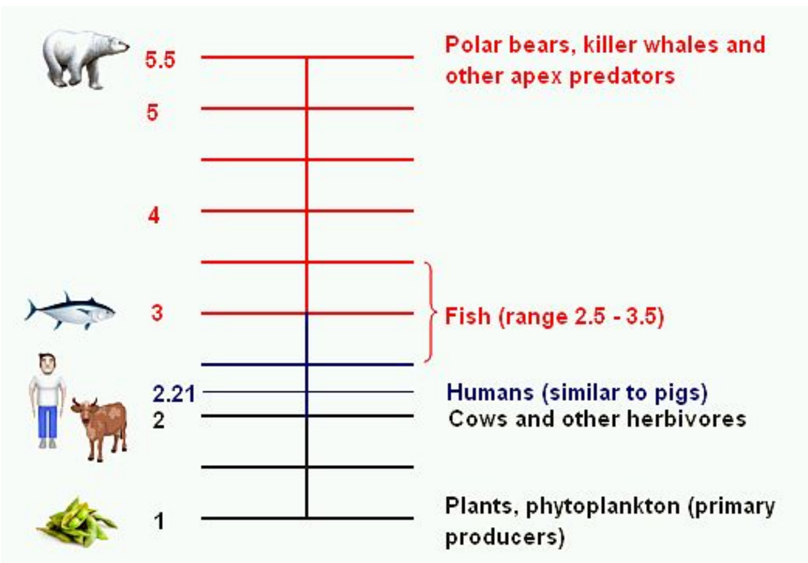
Plants and other "primary producers", such as phytoplankton, have a trophic level of 1. A species that consumes only plants, such as a cow or elephant, has a trophic level of 2. The trophic level of apex predators, such as polar bears and killer whales is 5.5.

If an animal were to eat nothing but cattle, its trophic level would be 3, calculated as the sum of 2 (the cow's trophic level) and 1. The trophic level of another animal that were to only eat that animal would be 4, and so on.

The researchers reported that the global median human trophic level (HTL) in 2009 was 2.21, representing a 3 per cent increase since 1961. The authors said, *"In the global food web, we discover that humans are similar to anchovy or pigs and cannot be considered apex predators".*

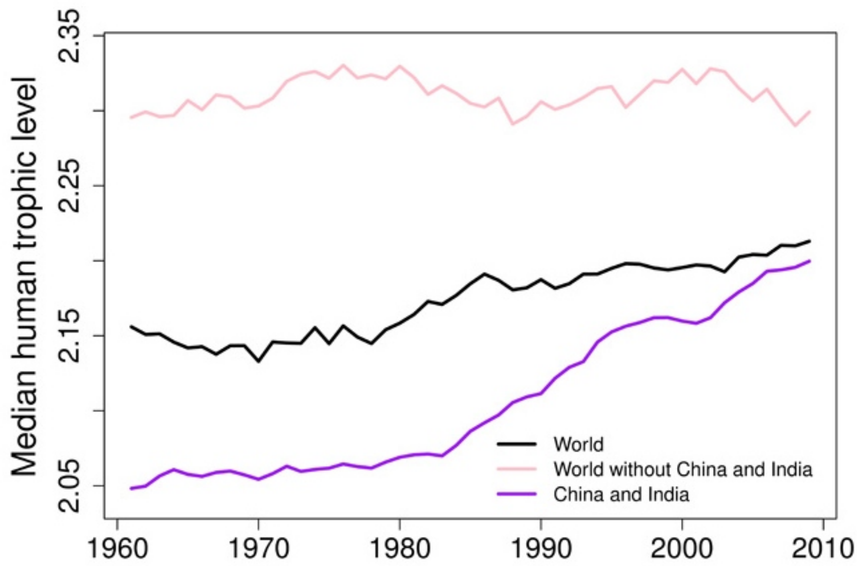
Here's how the rankings of a few species can be depicted, without attempting to display the complex interactions involved:

Figure 12: Trophic level of various species



A major concern in terms of the environment is the increasing overall human trophic level, driven largely by growing levels of meat consumption in China and India. The authors stated, *"With economic growth, these countries are gaining the ability to support the human preference for high meat diets".*

Figure 13: Trends in human trophic level (1961-2009)



Like other countries, China and India have much to lose from climate change, and a reversal of recent dietary trends should be a high priority.

PART 2: RECIPES AND RELATED EMISSIONS

The recipes in this section (feeding two to four people) show the greenhouse gas emissions associated with different dishes, along with the impact of adding 250 grams of certain ingredients.

Our emissions estimates are based on the main ingredients, and do not include emissions from spices, seasonings, oil and the like due to the small amounts involved.

The figures for all products are from sources referred to earlier, adjusted to reflect the 20-year global warming potential in respect of livestock products. They will vary by region from the estimates shown here.

The figures are also based on raw product.

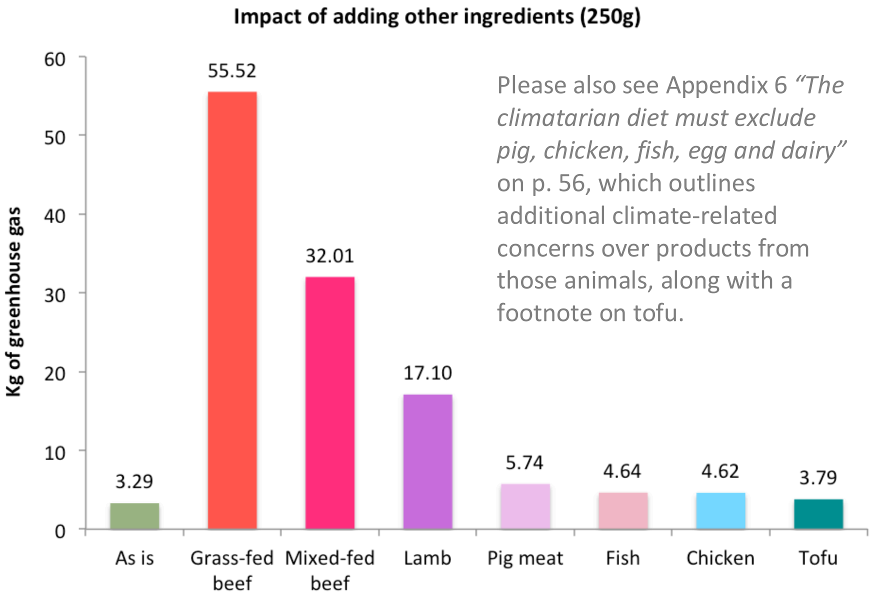
Due to soaking, the emissions figures for legumes may be lower than those we have used. However, that would be offset to some extent by processing and packaging in respect of canned products. (Bulk products can be used in preference to the canned options.)

The recipes are all main courses, but you can visit The Kind Cook[51] for delicious desserts and other choices.

"We at The Kind Cook have welcomed the opportunity to contribute to 'The Low Emissions Diet'. We hope you enjoy our recipes, and that they assist you in contributing meaningfully to our combined effort of overcoming the enormous threat posed by climate change."

Mel Baker, Founder, The Kind Cook (thekindcook.com)

Cauliflower & Chickpea Curry



YOU NEED

1 head of cauliflower (approx. 4 loose cups), cut into florets
1 can chickpeas, rinsed well
6 tomatoes, core removed and roughly chopped
1 medium brown onion, peeled and finely diced
1 teaspoon of fresh ginger, very finely diced
1 small red chilli, seeded and very finely diced
1 teaspoon ground cumin powder
1 teaspoon ground turmeric
1 heaped tablespoon of curry powder
1/2 teaspoon ground coriander
1 teaspoon salt
2 cups vegetable stock
1/3 cup tomato puree

1 capsicum (also known as bell pepper)
1 bunch fresh washed coriander, roots removed, stems finely sliced and leaves roughly chopped
2-3 teaspoons besan flour (also known as chickpea or garbanzo flour)

YOU DO

Heat a small amount of water in a large non stick pan and sauté the onion on a low to medium heat until it softens. Add the ginger and chilli and cook for another minute or so.

Add a little more water and add the cumin, turmeric, curry powder, ground coriander and salt and continue to stir on a low to medium heat for a few minutes. Add a little extra water if you need to, in order to stop the spices from burning.

Add the tomatoes, stir all the ingredients together and let them gently simmer for another couple of minutes to allow the tomatoes to start breaking down.

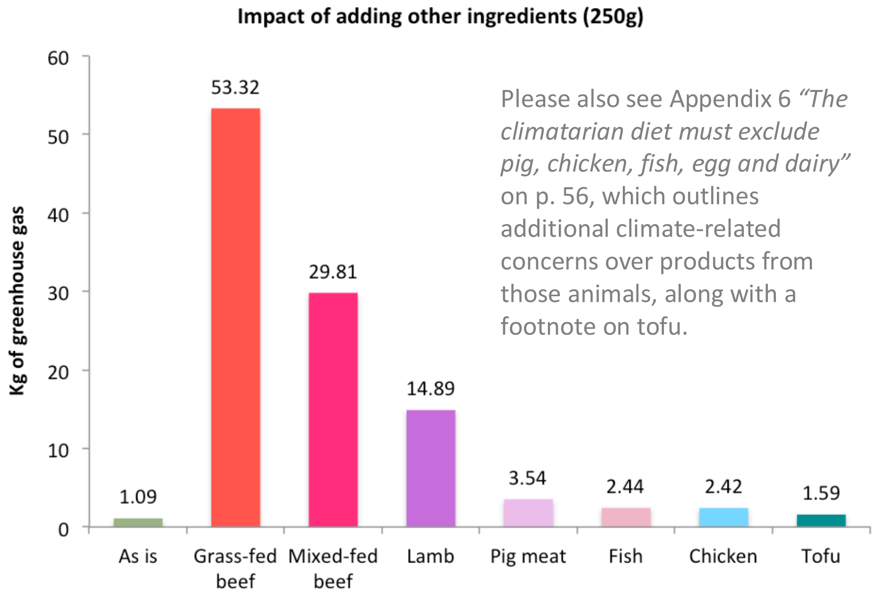
Pour the vegetable stock and tomato puree into the pan. Add the cauliflower, capsicum and chickpeas. Cover the pan with a lid and simmer very gently for about 10 – 15 minutes until the cauliflower is cooked. I allowed mine to remain slightly firm.

Just before the cauliflower is cooked, place 2 teaspoons of besan flour in a small dish with enough water to make a loose paste and pour the mixture into the pan. Stir it through the other ingredients and allow the dish to simmer and the sauce to thicken. If you want the curry to be a little thicker, make a paste with the remaining teaspoon of besan flour and some water and repeat. Serve, once the cauliflower is tender.

Garnish with lots of fresh washed coriander. Serve with steamed basmati or brown rice and pappadams.

Servings: 4
Time: 30 minutes
Freezing: Not recommended.
Notes: Fresh whole spices are always more fragrant. You just grind them as you need them.
You can purchase besan flour in any well stocked health food store.

Giant Penne Pasta with Mushroom Sauce



YOU NEED

250 grams of large penne pasta (dry)
1 teaspoon salt for the pasta water
2 large cloves garlic
1/2 large brown onion, peeled and finely diced
4 cups of Swiss brown mushrooms, sliced (stalks and all)
1/3 cup of dry white wine
1.5 cups of rice milk
1 teaspoon of porcini powder (optional but amazing)
1 teaspoon cornflour
1 teaspoon of fresh rosemary, chopped
2 cups asparagus, sliced (be sure to cut the woody ends off)
Oil
Salt/pepper to taste

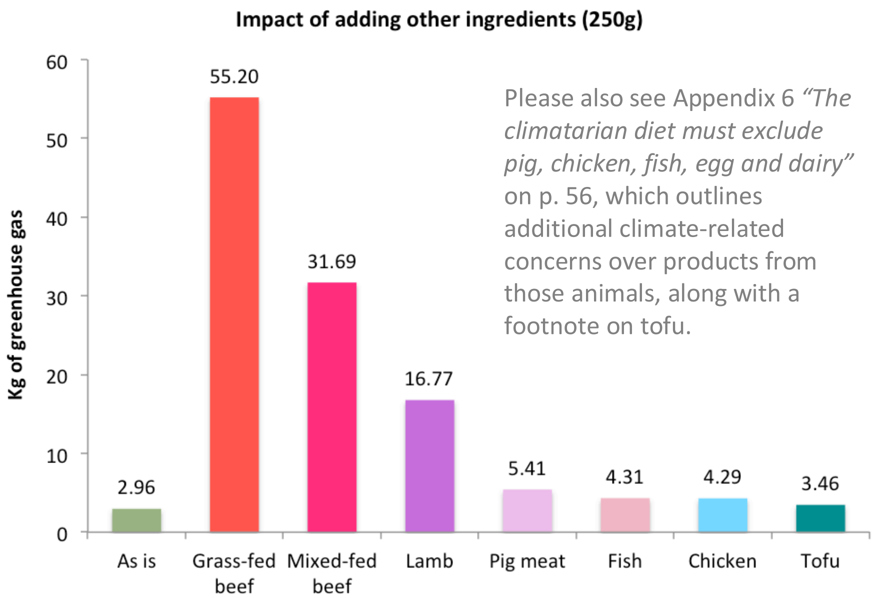
YOU DO

Place a large pot of water and a teaspoon of salt on stove top and bring to the boil.
Heat some oil in a pan. Throw in the onion and garlic and cook till the onion is caramelised.
Add a little more oil to the pan and add the mushrooms. Sauté on a medium heat until soft and nicely browned. This is where a lot of your flavour is going to come from, so don't get impatient and rush this part.
Add the white wine and deglaze the pan.
Add the rice milk and porcini powder to the mushroom mix and simmer gently.
In a small separate container mix the cornflour with enough water to combine to a watery consistency and stir till free of lumps. Add the cornflour mixture slowly to the mushroom mix, until you achieve required consistency. The sauce should coat the back of a spoon. Continue to gently simmer for another minute or so.
Add the asparagus and rosemary. Mix through and check the seasoning. If you need to, add salt and pepper to taste.

Cook pasta in boiling water till al dente. Strain the pasta once it is cooked and add it to the mushroom sauce and combine.

#Optional ~ If you want some "cheesiness", add a tablespoon of nutritional yeast flakes and stir through before serving.

Harissa Bean Tagine



Harissa is a hot paste from Tunisia (North Africa), made from chilli, herbs and spices. Traditionally cooked in a tagine, this dish can also be done by gently cooking on your stove top. Choose good quality chopped tomatoes and go easy on the harissa paste if you are not great with chilli.

This is such a simple, uncomplicated, warming, economical and nourishing dish. Loads of fresh herbs lift its earthy notes.

YOU NEED
Oil for cooking
1 large brown onion, peeled and finely diced
4 cloves of garlic, peeled and minced
2 x 400 gram cans chopped tomatoes
1 – 1.5 teaspoons of harissa paste
2 teaspoons of pure maple syrup

2 cans cannellini beans, rinsed well and drained
1 cup of fresh parsley, washed well and roughly chopped
1 bunch of fresh coriander, washed well, stems finely diced, leaves roughly chopped
1/2 teaspoon salt/cracked black pepper
#optional – 1 teaspoon of dried chilli

YOU DO
Heat a small amount of oil in a large pan. Alternatively just use a little water and sauté the onion until softened. Add the garlic and cook on a gentle heat for another minute or two.
Add the crushed chopped tomatoes, harissa paste and maple syrup. Stir to combine and simmer gently for 10 minutes.
Add the beans. Stir through the parsley and coriander. Bring everything to the boil.
Check the seasoning. Add some chilli flakes if you want more heat.

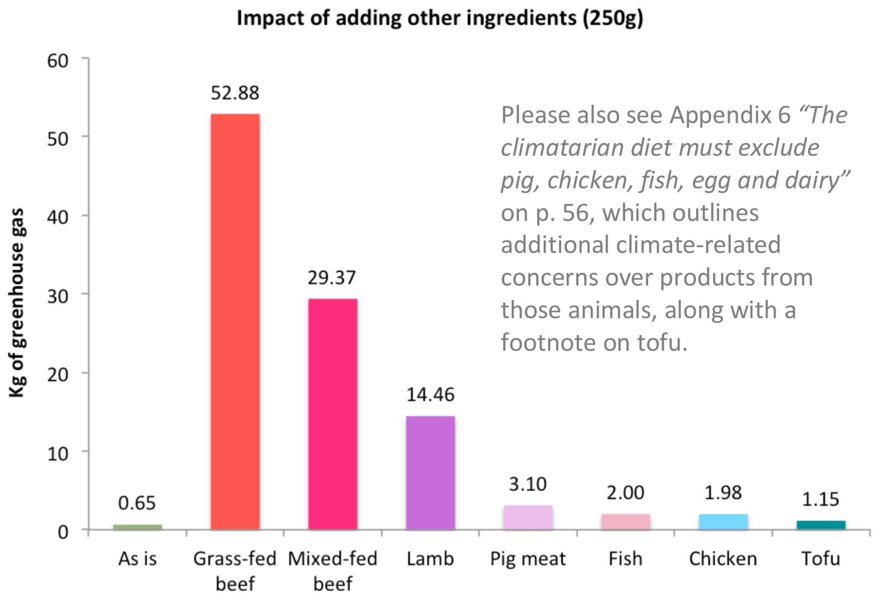
Serving suggestion: This is lovely served with cous cous, steamed maple carrots, loads of salad dressed in fresh lime juice and olive oil. Fresh bread to mop up all the juices is also a great accompaniment.

Yields: 4 small serves

Time: Takes about 30 minutes.

Notes: Harissa paste is available in well stocked delis. I often also add a generous handful of good quality Kalamata olives to this dish, when I add the beans.

Pad Thai



YOU NEED

1 tablespoon peanut oil
1 teaspoon sesame oil
½ tablespoon fresh minced ginger
1 small red chilli, finely sliced
2 large cloves of garlic, peeled and minced
¼ cup soy sauce (or Tamari if you want this to be gluten free)
¼ cup soft brown sugar (or you could use agave instead if you prefer)
¼ cup freshly squeezed lime juice
2 tablespoons peanut butter (I only had smooth but crunchy would be brilliant in this)
200 grams rice noodles
2 cups Chinese cabbage, finely shredded
1 cup spring onion, washed and finely sliced
1 large bunch coriander, washed well, roots finely sliced and leaves roughly chopped

#optional 200 grams tofu (I use Blue Lotus Organic), cut into cubes
½ cup peanuts
handful dried shallots

YOU DO

Heat the oils in a wok and sauté the ginger, chilli and garlic on a low heat. Turn the heat off.

Whisk the soy sauce, sugar, lime juice and peanut butter together in a bowl, add to the wok and stir to combine.

Cook or soak the noodles as per the packet instruction and drain. Be careful to not overcook them.

Bring the sauce in the wok to the boil and add the noodles, cabbage, spring onion, coriander and tofu, if you are using it. Mix everything well.

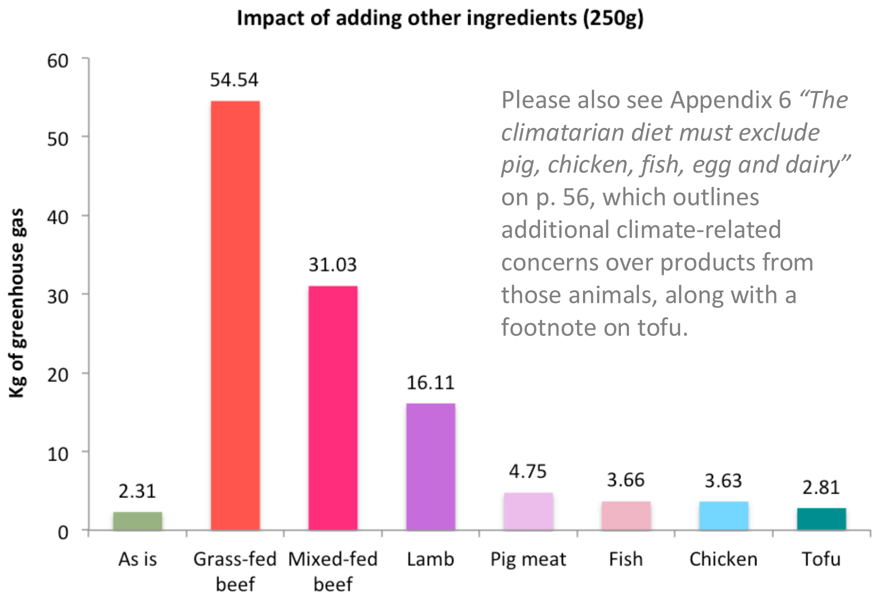
Serve immediately and garnish with the peanuts and dried shallots.

Yields: 2 serves.

Time: Takes about 25 minutes.

Freezing: Not suitable.

Spicy Sweet Potato & Bean Enchiladas



Please also see Appendix 6 *"The climatarian diet must exclude pig, chicken, fish, egg and dairy"* on p. 56, which outlines additional climate-related concerns over products from those animals, along with a footnote on tofu.

YOU NEED

1 large sweet potato
1 teaspoon of chilli powder (less or more depending on how hot you want them)
1 teaspoon garlic powder
1 tablespoon cumin powder
dash of cayenne
1 teaspoon dried oregano
1/4 cup diced red onion
1 cup kidney beans, washed well and drained
1/2 cup diced capsicum
1/2 cup cooked brown rice
1/4 cup of corn kernels

3/4 cup tomato puree
1 can crushed tomatoes
1 teaspoon pure maple syrup
6 soft tortillas
1 x 400 gram tin of tomato based sauce of your choice
salt and pepper to taste

YOU DO

Peel and cut the sweet potato into large chunks, and steam until tender. When it's cooked, mash it until you get a smooth texture and set aside.

Combine the chilli powder, garlic powder, cumin, cayenne, and oregano and set aside.

Sauté the red onion on a medium to low heat in a small amount of water until soft and slightly translucent. Add the mixed spices you had set aside and cook for a minute or so.

Add the kidney beans, capsicum, rice, corn, tomato puree, crushed tomatoes and maple syrup. Cook on a slow to medium heat for 10 – 15 minutes. Stir occasionally so it doesn't stick to the bottom of the pan. Continue cooking until the mixture thickens. Check the seasoning and add salt and pepper to taste.

Lay the tortillas on your bench. Spread the mashed sweet potato down the centre of each tortilla. Top with the black bean and vegetable mix, roll and place on an oven tray

Top the enchiladas with a tomato based sauce of your choice. I just use whatever is in the fridge that needs using up which is why the dish pictured is topped with chopped vegetables. I often top with "Enchilada Capsicum sauce" from the Mexican section of the supermarket as it has a nice kick to it.

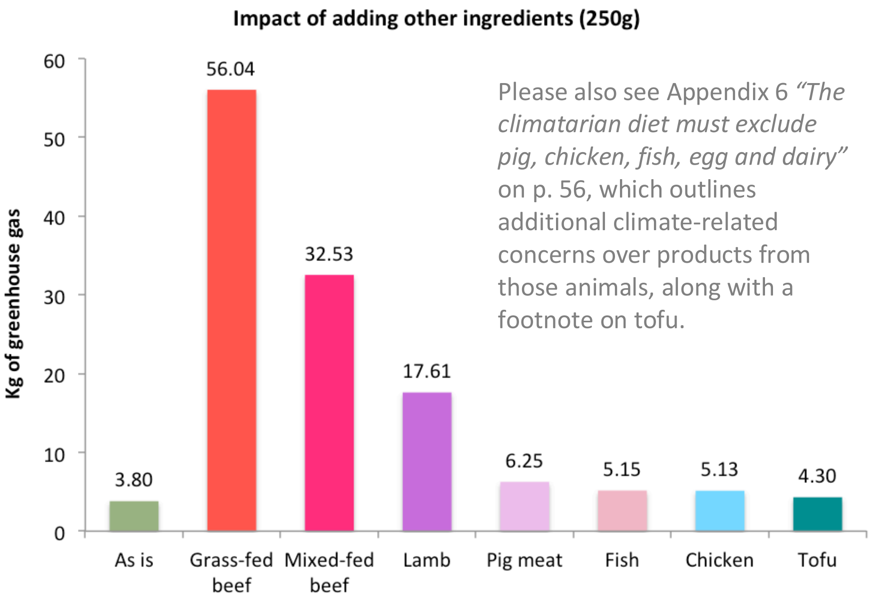
Pop into a preheated oven at 180c. Cook until the enchiladas have heated through and start to brown. Serve with salad.

Yields: 6 serves.

Freezing: Can be frozen.

Notes: Left over enchiladas taste even more amazing the next day.

Sweet Potato & Black Bean Pies with Mango Mint and Lime Salsa



YOU NEED

1 large sweet potato
1 tablespoon of rice bran oil
1 large brown onion, peeled and finely diced
3 cloves of garlic, peeled and minced
¼ teaspoon of dried crushed hot chilli
1 teaspoon of ground coriander
1 teaspoon of pimento allspice
1 large green capsicum
1 can of crushed tomatoes
2 cans of black beans

¾ cup of vegetable stock
20 grams of dairy free (70% cocoa) dark chocolate
3/4 teaspoon of salt
Cracked black pepper to taste
4 handfuls of Kataifi pastry
2 large mangos, cut into cubes
1 cup of fresh mint leaves, washed
2 limes

YOU DO

Preheat your oven to 180c and get a steamer on to boil. Peel the sweet potato, cut it into rough cubes and steam them until the potato is tender. Once the potato is cooked, mash it and set it aside.

Heat the oil in a large pan. Add the onion and garlic and cook on a low heat until the onion is caramelised. Add the chilli, coriander and pimento allspice and cook, stirring frequently for another minute or 2.

Add the capsicum, tomatoes, black beans and stock and gently simmer on a low to medium heat for 5 minutes. Once all the ingredients have cooked down, stir in the chocolate, salt and some ground black pepper, to taste. Continue cooking until the chocolate has melted and the mixture is a thick, wet consistency.

Spoon equal amounts of the bean mixture into 4 shallow, single serve pie dishes. Top each with some mashed potato. Then top each pie with a handful of Kataifi pastry. Place the pies into the oven and cook until the pastry has started to brown.

Make the salsa by juicing the 2 limes, roughly chopping the mint and combining them with the mango. Place into a small serving dish.

Serve the pies hot from the oven, accompanied with the salsa.

Yields: 4 serves.

Time: 25 – 30 minutes preparation. Plus 15 minutes cooking time.

Notes: You can purchase black beans at well stocked health food stores. If you don't have black beans you can substitute them with kidney beans.

Kataifi pastry can be found in well stocked delis. Otherwise substitute with filo pastry. The pies are also lovely with no pastry.

Appendix 1: Listing of food products from Oxford study

The following table contains most products included in the Oxford study referred to in "Comparison with plant based foods" within Section 1 of Part 1.

Table A.1.1: Emissions intensity of food products (kg CO2-e/kg product - Scarborough, et al.)

Sugar & Sweeteners	0.1	Spices	1.6	Sunflower seed Oil	3.3
Sugar (Raw Equiv.)	0.1	Spices, Other	1.6	Cocoa Beans	3.4
Maize Germ Oil	0.4	Vegetables	1.6	Beverages, Alcoholic	3.5
Potatoes	0.4	Butter, Ghee	1.8	Pulses, Other	3.5
Starchy Roots	0.4	Cereals - Excl. Beer	1.8	Barley	3.8
Onions	0.5	Cereals, Other	1.8	Beer	3.8
Lemons, Limes	0.6	Milk - Excl. Butter	1.8	Rice (Milled Equiv.)	3.9
Oranges, Mandarines	0.6	Oil crops	1.8	Sesame seed	4.2
Apples	0.7	Soya bean Oil	1.8	Sesame seed Oil	4.2
Citrus, Other	0.7	Pineapples	1.9	Olive Oil	4.5
Maize	0.7	Tea	1.9	Olives	4.5
Beans	0.8	Soya beans	2.0	Eggs	4.9
Grapefruit	0.8	Tree nuts	2.0	Cephalopods	5.4
Grapes	0.8	Coconut Oil	2.1	Crustaceans	5.4
Fruits - Excl. wine	0.9	Coconuts - Incl Copra	2.1	Demersal Fish	5.4
Fruits, Other	0.9	Vegetables, Other	2.2	Fish, Seafood	5.4
Groundnut Oil	0.9	Oil crops, Other	2.3	Freshwater Fish	5.4
Honey	1.0	Beverages, Fermented	2.4	Marine Fish, Other	5.4
Oats	1.0	Cream	2.4	Pelagic Fish	5.4
Rye	1.0	Oil crops Oil, Other	2.4	Poultry Meat	5.4
Wheat	1.0	Pepper	2.5	Pig meat	7.9
Wine	1.0	Rape and Mustard Oil	2.9	Coffee	10.1
Dates	1.1	Rape and Mustard seed	2.9	Fats, Animals, Raw	35.6
Peas	1.2	Pimento	3.2	Meat, Other	35.7
Bananas	1.4	Vegetable Oils	3.2	Offals	35.9
Groundnuts	1.4	Alcoholic Beverages	3.3	Animal Fats	40.1
Tomatoes	1.5	Palm Oil	3.3	Mutton & Goat Meat	64.2
Plantains	1.6	Pulses	3.3	Bovine Meat	68.8

Appendix 2: Emissions intensity of rice

As mentioned in Part 1, the charts in Figure 4 do not include rice due to uncertainties about the product's emissions intensity over a 20-year time horizon. A rare feature of rice production relative to other plant products is the high level of methane emissions.

The authors of the Oxford study have confirmed in correspondence that they derived their 100-year GWP emissions intensity figure for rice (3.9 kg CO2-e / kg of product) by adjusting the 20-year figure reported by researcher Annika Carlsson-Kanyama in 1998 (6.4 kg CO2-e / kg of product).[52, 53] However, Carlsson-Kanyama and fellow researcher, Alejandro Gonzalez, reported a 100-year figure in 2009 of 1.3 kg CO2-e / kg of product, which was one third of the figure used in the Oxford study.[54]

In her 1998 paper, Carlsson-Kanyama stated (p. 283), *"almost all emissions during crop farming of rice were caused by CH4 from irrigated rice fields. It is important, however, to emphasise that the calculated emission levels of CH4 from rice farming have substantial uncertainties associated".*

The inclusion or otherwise of land use and land use change factors would appear to have little influence on the figures, as Audsley, et al. (whose findings were utilised in the Oxford study) indicated that such factors only represent around 9 per cent of rice's greenhouse gas emissions.[55]

Regardless of which findings are used, the emissions intensity of rice production is well below that of most animal-based food products, particularly red meat. For example, rice's emissions intensity based on a 20-year time horizon is less than 10 kg CO2-e / kg of product, compared to 209 kg CO2-e / kg of product (carcass weight) for beef from grass-fed cattle.

Yet another unfortunate outcome of increasing CO2 concentrations and a warming climate may be an increase in methane emissions from rice production, as reported in a 2012 paper by van Groenigen, et al.[56] Although not referred to in the paper, the increased methane emissions can warm the climate further and trigger more CO2 emissions which can, in turn, trigger more methane emissions. Such a process would represent the type of feedback mechanism that is a prominent feature of climate change.

Appendix 3: Greenhouse gases and black carbon

In national greenhouse gas inventories, the only greenhouse gases generally attributed to livestock are methane (CH_4) and nitrous oxide (N_2O). As stated in the Introduction, other relevant warming agents are either excluded altogether or reported in different categories. An example is carbon dioxide emissions from livestock-related deforestation, which are attributed to the category "land use, land use change and forestry".

Two of the warming agents generally omitted are tropospheric ozone and black carbon, as referred to below. They are referred to as short-lived climate forcers, as their impact on climate primarily occurs within a decade from the time they are emitted, and generally within days or weeks for these particular warming agents. Those timeframes are critical, as meaningful action in reducing emissions of such warming agents provides rapid benefits, and can contribute to us avoiding tipping points and runaway climate change as our energy infrastructure is transformed.

National inventories also exclude estimates of foregone sequestration, which is the loss of carbon absorption arising from the loss of forest and other vegetative matter through land clearing. Allowing for that factor would help identify a significant mitigation measure, namely reforestation, along with other measures to reinstate biomass and soil carbon.

Global Warming Potential

An issue particularly relevant to methane is the concept of "global warming potential" or "GWP". The emissions of different gases can be aggregated by converting them to carbon dioxide equivalents (CO_2-e). It is analogous to converting different currencies to a common denomination. The greenhouse gases are converted by multiplying the mass of emissions by the appropriate GWP, representing the relative warming effect of a unit mass of the gas when compared with the same mass of CO_2 over a specific period. The choice of time horizon is critical in relation to methane's emissions, as referred to below.

Carbon Dioxide (CO_2)

The main CO_2-related emissions from livestock arise from land clearing and loss of soil carbon in relation to grazing and feed crop production. Energy used in preparing livestock feed is also a factor. Loss of soil carbon can be in the form of oxidation and combustion of deforested and drained tropical peat lands or overgrazing of land, with resultant loss of top soil and release of carbon.

Nitrous Oxide (N_2O)

Nitrous oxide is emitted through the use of fertiliser for feed production and from depositing manure on pasture or during the management and application of manure on crop fields.

Methane (CH_4)

The Intergovernmental Panel on Climate Change (IPCC) has reported that the livestock sector is responsible for around 44 per cent of anthropogenic methane emissions.[57] While the emissions may not be reducing in absolute terms, livestock's share may be reducing over time due to increasing volumes of gas production and related fugitive emissions.

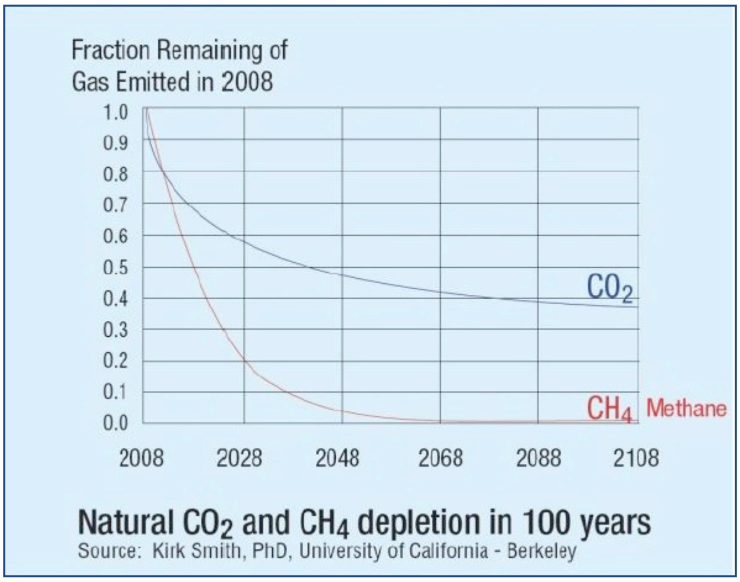
The main livestock source of methane is the process of enteric fermentation, which occurs in the digestive system of ruminant animals, such as cattle, sheep and goats. In their rumen (stomach), food is broken down into simple molecules that can be more easily digested. Methane is a by-product, and is mainly emitted through belching and breathing.

Manure management is another source of methane.

A key factor in relation to methane is the choice of time horizon for calculating CO_2-e emissions figures.

By using a 100-year timeframe, traditional reporting methods have understated its shorter-term impact. The reason is that it breaks down in the atmosphere much faster than carbon dioxide, and is almost non-existent for much of the 100-year reporting period. Its rapid breakdown is demonstrated in Figure A.3.1.

Figure A.3.1: Natural carbon dioxide and methane depletion over 100 year timeframe[58]



The IPCC's 100-year GWP for methane was 25 in 2007 but was increased to 34 (with climate carbon feedbacks) in 2013.[59]

The figures for a 20 year timeframe were 72 in 2007 and 86 in 2013.

NASA has reported figures of 33 for 100 years and 105 for 20 years. [60]

In its Fifth Assessment Report, released in 2013, the IPCC stated:[61]

"There is no scientific argument for selecting 100 years compared with other choices. . . . The choice of time horizon is a value judgement since it depends on the relative weight assigned to effects at different times."

Tropospheric Ozone[62]

Tropospheric ozone is formed through a series of chemical reactions involving nitrogen oxide, methane, carbon monoxide and other non-methane volatile organic compounds. It is the third most prevalent greenhouse gas after carbon dioxide and methane (not allowing for water vapour). Major sources of carbon monoxide are agricultural waste burning, savanna burning and deforestation. Livestock grazing is one of the main drivers of deforestation and savanna burning.

In its fifth assessment report, the IPCC stated, *"there is robust evidence that tropospheric ozone also has a detrimental impact on vegetation physiology, and therefore on its CO_2 uptake".*[63]

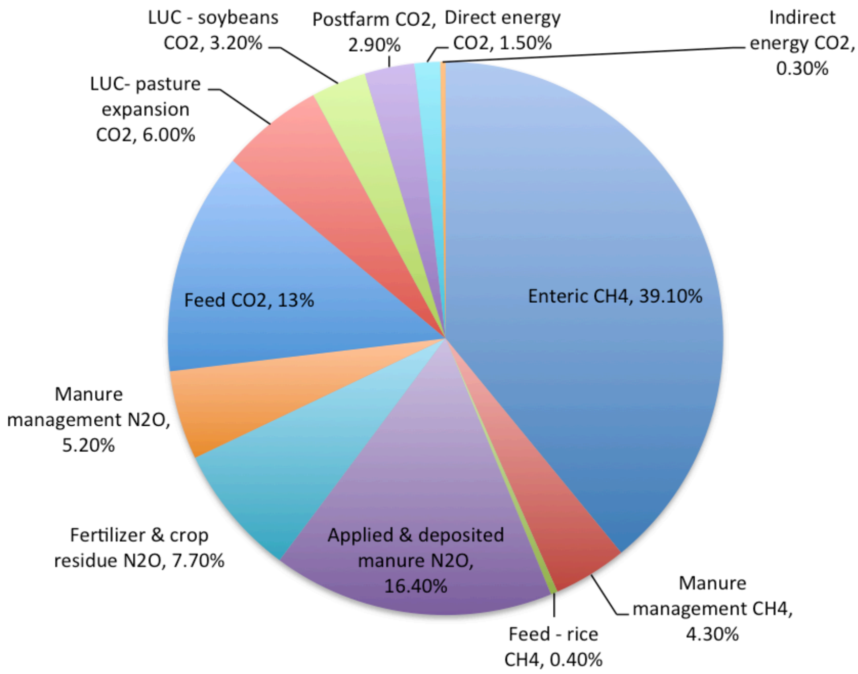
Black Carbon[64]

Black carbon is a microscopic particulate that is formed through the incomplete combustion of fossil fuels, biofuels and biomass. The greatest single sources of black carbon are savanna and forest fires, with livestock production playing a key role. Black carbon contributes to global warming in two ways. Firstly, the particulates create heat by absorbing the sun's radiation while airborne. Secondly, they can blow thousands of kilometres to land on glaciers and polar ice caps, where they cause solar radiation to be absorbed, rather than reflected, thereby speeding melting. (Refer to Appendix 4.)

Food and Agriculture Organization of the United Nations (FAO)[65]

In estimates of livestock emissions published in November 2013, the FAO included some categories of carbon dioxide emissions in addition to methane and nitrous oxide. The full breakdown is depicted in the following chart.

Figure A.3.2: Global emissions from livestock supply chains by category of emissions



Note: LUC = Land use change

Summary:

Methane:		
▪ Enteric fermentation	39.1%	
▪ Manure management	4.3%	
▪ Feed – rice	0.4%	43.8%
Nitrous Oxide:		
▪ Applied & deposited manure	16.4%	
▪ Fertilizer & crop residues	7.7%	
▪ Manure management	5.2%	29.3%
Carbon Dioxide:		
▪ Feed	13.0%	
▪ Land use change – pasture	6.0%	
▪ Land use change – soybeans	3.2%	
▪ Postfarm	2.9%	
▪ Direct energy	1.5%	
▪ Indirect energy	0.3%	26.9%
Total		100.0%

The chart does not allow for the impact of foregone sequestration, namely the ongoing loss of carbon absorption by forests and other forms of vegetation that have been cleared for animal agriculture.

Appendix 4: Land clearing

The impact of animal agriculture on land clearing, and therefore the ability of the biosphere to retain its existing carbon stores and to draw excessive carbon from the atmosphere, has been significant. Massive areas are cleared for feed crop production and grazing. Much of the latter is reflected in the fact that livestock graze on between 30 and 45 per cent of the planet's terrestrial land surface.[66]

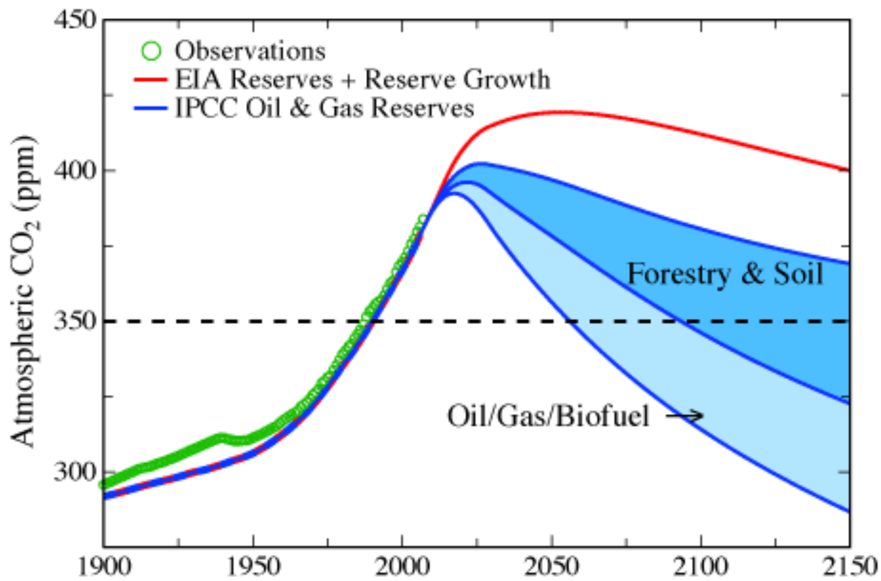
In a landmark 2008 paper, leading climate scientist, Dr James Hansen and colleagues argued that, in addition to dealing with coal-fired power, we would not achieve a critical threshold level of 350 ppm (parts per million) of CO_2 in the atmosphere without massive reforestation.[67] The aim would be to reduce CO_2 concentrations (currently around 400 ppm) by drawing them from the atmosphere, while also reducing ongoing emissions.

While stressing the critical need to cease burning coal, Dr Hansen and his colleagues also stated (with our underline):

"A reward system for <u>improved agricultural and forestry practices</u> that sequester carbon could remove the current CO_2 overshoot. With simultaneous policies to reduce non-CO_2 greenhouse gases, it appears still feasible to avert catastrophic climate change."

The following image shows the estimated trajectory of atmospheric concentrations of CO_2, assuming a phase-out of coal usage by 2030. Based on the IPCC's estimates of oil and gas reserves, meaningful action on forestry and soil would contribute significantly to achieving the target of 350 ppm before 2100. The estimated contribution from such action is a reduction of around 50 ppm.

Figure A.4.1: Atmospheric Concentrations of CO_2 with Coal Phase-out by 2030



The only way to meaningfully reforest in the context of the climate emergency is to reduce the extent of animal agriculture.

Other organisations have commented as follows on reforestation and animal agriculture:

PBL Netherlands Environmental Assessment Agency

The PBL Netherlands Environmental Assessment Agency has stated:[68]

> *". . . a global food transition to less meat, or even a complete switch to plant-based protein food [was found] to have a dramatic effect on land use. Up to 2,700 Mha of pasture and 100 Mha of cropland could be abandoned, resulting in a large carbon uptake from regrowing vegetation. Additionally, methane and nitrous oxide emissions would be reduced substantially*."

They said that a plant-based diet would reduce climate change mitigation costs by 80 per cent. A meat-free diet would reduce them by 70 per cent. Their assessment was based on a target of 450 ppm. The issue is even more critical when aiming for 350 ppm.

Zero Carbon Britain

The Centre for Alternative Technology in Wales is responsible for the Zero Carbon Britain 2030 plan. A summary of the plan states:[69]

> *"Zero Carbon Britain 2030 will revolutionise our landscape and diets. An 80% reduction in meat and dairy production will free up land to grow our own food and fuel whilst also sequestering carbon from the atmosphere. The report also represents an opportunity to tackle the relationship between diet and health in the UK by promoting healthier diets and lifestyles."*

The University of Minnesota

The position is further highlighted by the fact that a 2013 paper from the Institute on the Environment at the University of Minnesota stated:[70]

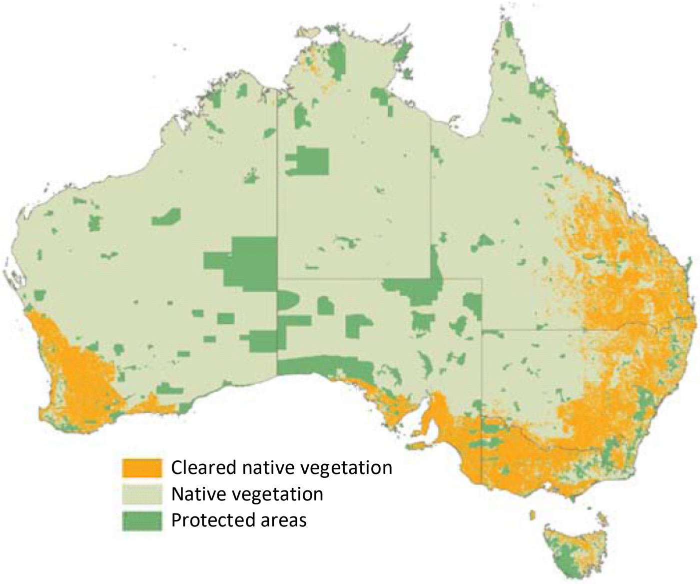
> *"The world's croplands could feed 4 billion more people than they do now just by shifting from producing animal feed and biofuels to producing exclusively food for human consumption".*

The paper's lead author, Emily Cassidy, has said:

> *"We essentially have uncovered an astoundingly abundant supply of food for a hungry world, hidden in plain sight in the farmlands we already cultivate. Depending on the extent to which farmers and consumers are willing to change current practices, existing croplands could feed millions or even billions more people."*

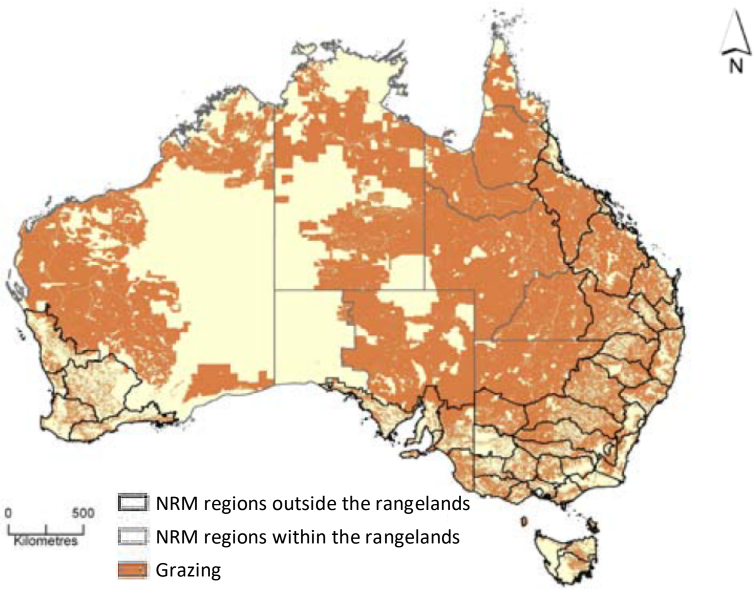
In Australia, since European settlement, we have cleared nearly 1 million square kilometres of our 7.7 million square kilometre land mass. The extent of clearing is demonstrated in Figure A.4.2.[71] Of the cleared land, around 70 per cent has resulted from animal agriculture, including meat, dairy and wool.[72]

Figure A.4.2: Cleared native vegetation and protected areas in Australia



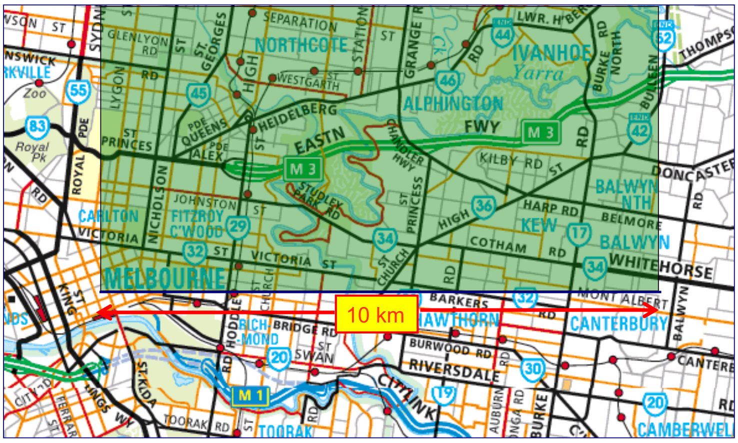
That may not be surprising when you consider the proportion of our landscape used for livestock grazing:[73]

Figure A.4.3: The location of grazing land in Australia in 2005-06 showing NRM (natural resource management) regions within and outside the rangelands. Source ABARE-BRS



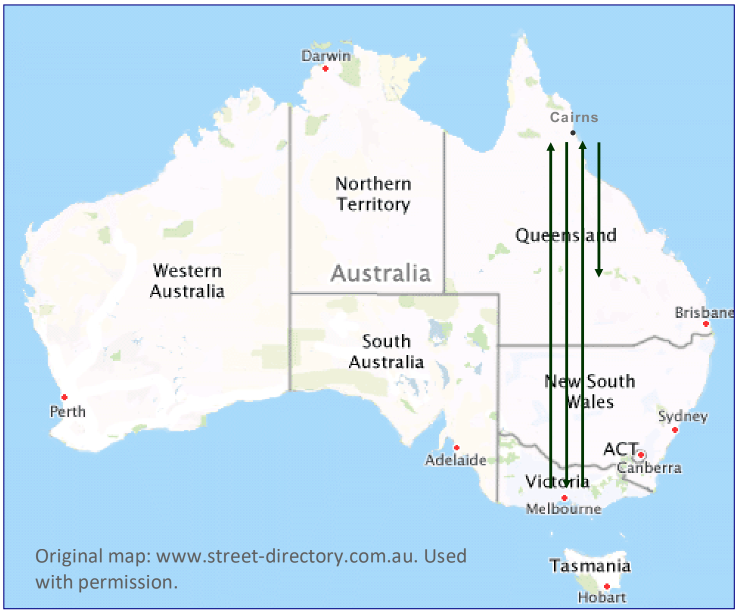
In Queensland alone, from 1988 to 2008, around 86,000 square kilometres of land was cleared, 91 per cent of which (78,000 square kilometres) was for livestock pasture.[74] The vast majority of clearing in the "pasture" category was for cattle grazing.[75] If we were to draw a line 10 kilometres east of Melbourne's GPO building, it would almost take us to Balwyn Road, in the suburb of Balwyn (Figure A.4.4). If we assumed that all the land north of that line was wooded vegetation, including forest, and we wanted to clear as much as was cleared in Queensland for pasture in that twenty-year period, how far would the 10 kilometre tract of land extend?

Figure A.4.4: 10 kilometre-wide tract of land to the east of Melbourne's Central Business District



The 10 kilometre wide tract of land would extend between Melbourne and Cairns 3.3 times (Figure A.4.5), a total distance of around 7,800 kilometres. That's similar to a tract of land of the same width winding around the US east coast 3.3 times from Boston to Miami.

Figure A.4.5: The equivalent land area cleared in Queensland for livestock 1988 - 2008



The officially reported extent of clearing includes clearing of regrowth, so an area that has been cleared twice would have contributed on each occasion to the total figure as depicted in Figure A.4.5. It is critical that we allow the forests and other wooded vegetation to return if we are to have any chance of overcoming climate change, so the clearing of regrowth is of vital importance.

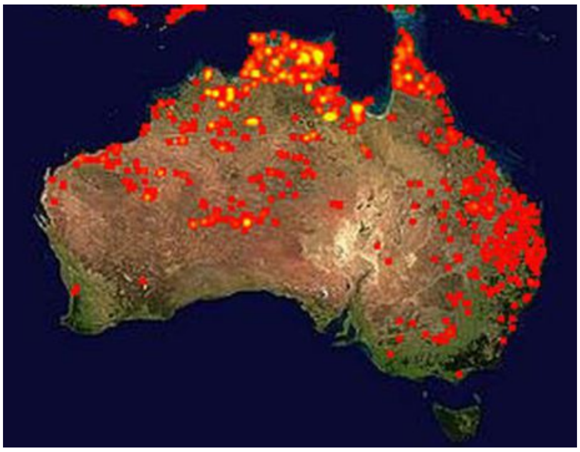
Please see Appendix 5 for more details of livestock-related land clearing in Australia.

Forests, other wooded vegetation and perennial grasses are also adversely affected by livestock-related burning. The areas are generally burnt each year to prevent the forest from regrowing and to encourage growth of new, high-protein grass. In some countries and regions, burning is the initial form of land clearing.

The images that follow are extracts of MODIS Fire Maps from NASA Earth Data.[76] Each of the fire maps accumulates the locations of the fires detected by satellites over a 10-day period. Colour ranges from red where the fire count is low to yellow where the number of fires is large.

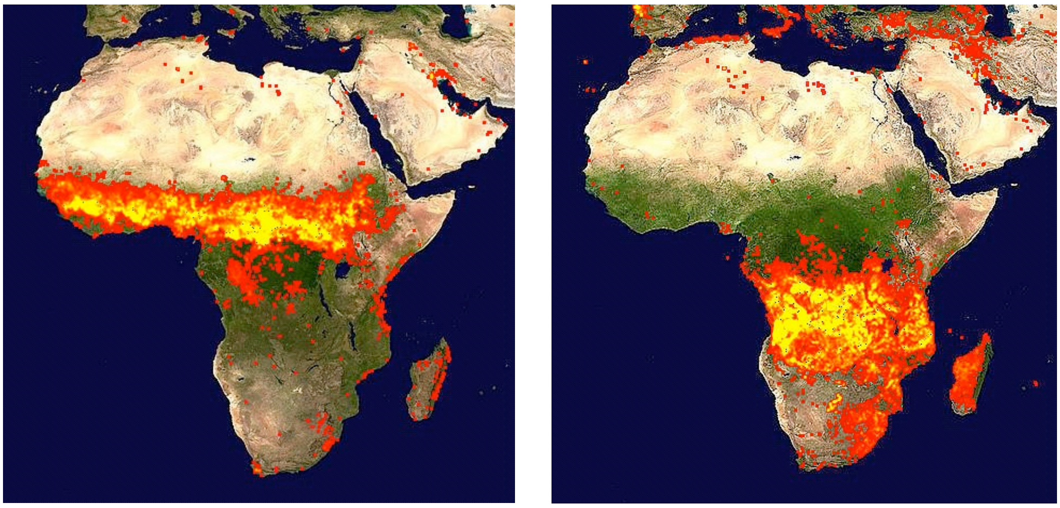
In Australia, the 2009 Black Saturday bushfires in the state of Victoria burnt around 4,500 hectares. In comparison, each year in northern Australia where 70 per cent of the country's cattle graze, around one hundred times that area is burnt across the tropical savanna. The savanna covers around 1.9 million square kilometres across northern Australia, which is around one-quarter of the nation's land mass.[77]

Figure A.4.6: Extract of MODIS Firemap of Australia from July/August, 2012



Here are images depicting the extent of burning in the northern and southern Guinea Savanna of Africa.

Figure A.4.7: Extracts of MODIS Firemaps of Africa

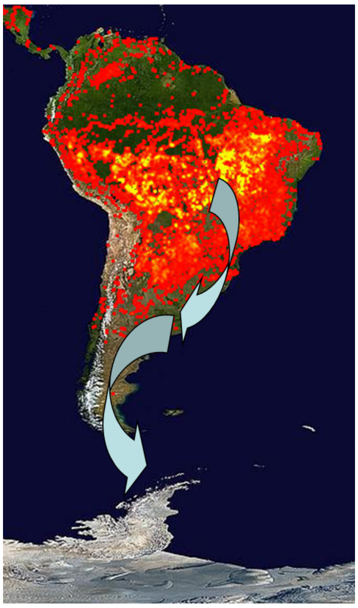


An area roughly corresponding to the yellow burning area in the maps has an average rainfall of over 780 mm and could revert to forest if given the opportunity. Its status as savanna is anthropogenic and not a product of natural attributes such as soil type and climate.[78]

Africa has around 310 million cattle, compared to Australia's 29 million.[79]

Livestock-related burning also occurs in South America for cattle grazing and feed crop production. The burning produces black carbon, which is a potent warming agent while airborne. Prevailing winds from South America and Africa blow black carbon to Antarctica, where it lands on ice and contributes to melting by causing the ice to absorb, rather than reflect, solar radiation.

Figure A.4.8: MODIS firemap of South America with overlay representing winds to Antarctica



While some land clearing in South America relates to soybean plantations, soy's prominence as an agricultural commodity has been driven by its use in livestock feed.[80] According to the Food and Agriculture Organization of the United Nations (FAO), *"Expansion of livestock production is a key factor in deforestation, especially in Latin America where the largest amount of deforestation is occurring – 70 per cent of previously forested land in the Amazon is occupied by pastures, and feedcrops cover a large part of the remainder."*[81]

The potential for nil net emissions from diet

Dr James Hansen and his fellow researchers (referred to earlier in this appendix) have reported a maximum sequestration potential of 1.6 gigatonnes of carbon per year through reforestation.[82] That equates to around 5.9 gigatonnes of carbon dioxide per year.[83] (Global carbon emissions in 2012 were 9.7 gigatonnes, equivalent to 35.6 gigatonnes of carbon dioxide.)[84]

Assuming (hypothetically) that all those who currently eat meat converted to a plant-based diet, there would be around 5.8 billion new dietary vegans globally, being the current population of around 7.3 billion less an estimated 1.5 billion who are already vegetarian.[85] Assuming that each of those person's subsequent dietary greenhouse gas emissions were 2 kg per day, in aggregate they would be emitting around 4.2 gigatonnes of greenhouse gases through their diet annually. That is less than the 5.9 gigatonnes sequestered through revegetation, much of which would arise from the general transition to a plant-based diet.

On that basis, the benefit to be derived from those people converting to a plant-based diet, simply in terms of reforestation, may be greater than their ongoing diet-related emissions.

Appendix 5: Emissions intensity of Australian beef

In early 2015, a paper by Wiedemann, et al., funded and promoted by Meat and Livestock Australia, was published in the journal Agricultural Systems.[86] [87] It reported on the performance of Australia's beef industry in relation to greenhouse gas emissions and its efficiency in terms of water use, fossil fuel energy demand and land occupation. This appendix focuses on greenhouse gas emissions.

The paper reported that the greenhouse gas emissions intensity of Australian beef production had reduced 14 per cent between 1981 and 2010. The reported reduction was from 15.3 kg to 13.1 kg of CO2-equivalent greenhouse gases per kilogram of live weight (kg CO2-e/kg live weight).

Both reported figures are low relative to other studies, but the results may not be as positive as they initially seem.

Background

The Wiedemann paper was based on a life cycle assessment of Australian beef production, covering processes and inputs from "cradle to farm gate", immediately prior to "processing". It excluded beef from dairy cattle and the live export trade.

Dairy cattle may have been excluded due to the fact that their emissions are attributed to dairy products in addition to beef, which is a key reason for beef-related emissions from dairy cattle being far lower than those from the specialised beef herd.

The authors were not in a position to collect data on the final stages of live export animals.

Factors considered in the report

Emissions factors considered in the study included methane from enteric fermentation in the digestive system of ruminant animals; nitrous oxide and methane from manure management; carbon dioxide from fossil fuels; land clearing (deforestation) to promote pasture growth; and soil carbon losses from various sources.

Comparison with other emissions intensity assessments

Many assessments of greenhouse gas emissions intensity of food products have been conducted. In terms of Australian beef, perhaps the most recent reports suitable for comparison were published by the FAO in November 2013 (as referred to earlier in this booklet).

As mentioned, the FAO reports were based on findings from life cycle assessments using its Global Livestock Environmental Assessment Model (GLEAM). The model takes into account emissions along the supply chain to the retail point. It reported that "post-farm" emissions represented only 0.5 per cent of beef's global average emissions intensity. As those emissions were relatively minor, the FAO studies would seem to be a reasonable comparison with Wiedemann's.

Although not specifically reporting on Australian beef, the FAO did report on Oceania, of which Australia is the dominant specialised beef producer. In 2010, Australia produced around 2.3 million tonnes of beef, with New Zealand's output equivalent to just over a quarter of that figure. Excluding beef from the dairy herd (consistent with the Wiedemann study), New Zealand's relative output may be significantly lower than indicated by those figures.

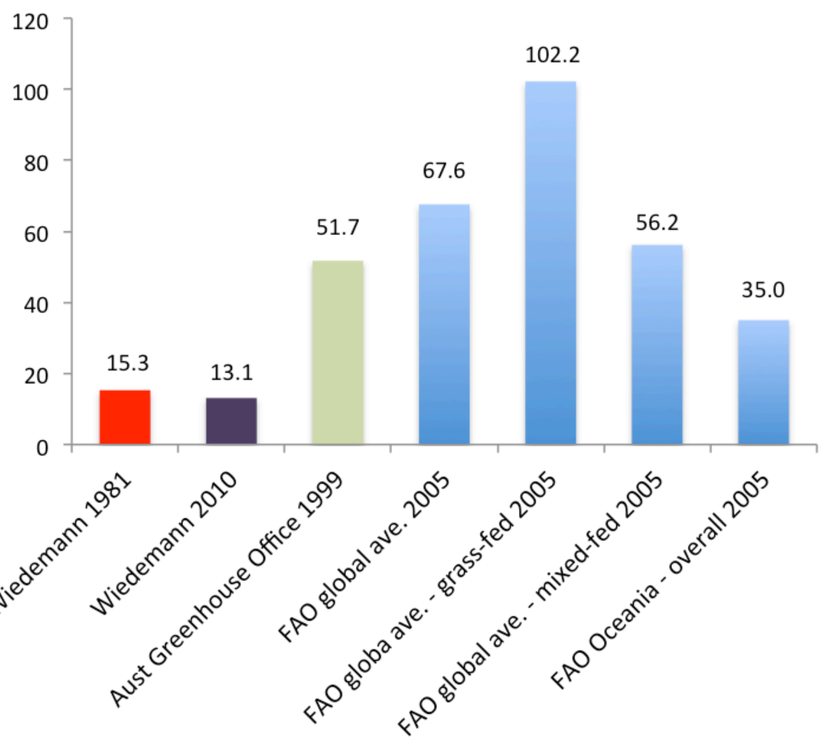
The FAO's estimate of emissions intensity of specialised beef in Oceania was approximately 35 kg CO2-e/kg product (carcass weight), based on a 100-year GWP.[88] That was an overall figure based on animals from grazing and mixed feeding systems. The emissions intensity of beef from animals raised solely on grass would be far higher than that of animals raised on both grass and grain. (Although land clearing rates and related timing differences may account for some of the difference between the FAO's Oceania figure and the Wiedemann study's results, those land clearing rates are again increasing, as referred to below.)

The FAO's global average figure for specialised beef was 67.6 kg, noting that feed digestibility, weight and age at slaughter, and the extent of land clearing are contributing factors. Its figure for beef from grass-fed animals was 102.2 kg, and from animals raised on a combination of grass and grain, 56.2 kg.[89] Those figures are based on a 100-year GWP and would be higher if a 20-year GWP had been utilised (as referred to below).

A 2003 "end use" report commissioned by the Australian Greenhouse Office (using a 100-year GWP) estimated an overall figure for Australian beef of 51.7 kg CO2-e/kg product for the 1999 reference period and up to 79.9 kg for earlier periods.[90]

Here's a snapshot of the comparisons:

Figure A.5.1: Comparative Emissions Intensities of Beef (kg CO2-e/kg product) showing relevant reference period



Alternative methodologies would appear to account for some of the differences between Wiedemann's findings and those from other reports, as Wiedemann and co-authors indicated a relatively low figure for each of their reference periods, being 1981 and 2010.

The approach to measuring emissions from enteric fermentation would almost certainly account for some of the difference. Enteric fermentation is the process that occurs in the digestive systems of ruminant animals, producing methane, an extremely potent greenhouse gas. For the northern cattle herd consuming tropical feed, the authors based their emissions intensity figure on a 2011 study by Kennedy and Charmley, who estimated methane emissions 30 per cent lower than those used in the National Greenhouse Gas Inventory (NGGI).[91] That approach is likely to be adopted for future NGGIs.[92]

However, alternative approaches to calculating methane's impact are unlikely to account for the significant differences between the Wiedemann report and other analyses, as it represents thirty per cent of one part (the northern cattle herd) of one factor (methane from enteric fermentation) amongst several.

As the study allowed for the reduced methane emissions of the northern herd (representing the majority of Australia's specialised beef cattle) estimated by Kennedy and Charmley, it would seem to have also effectively allowed for Charmley's subsequent estimate of a 24 per cent reduction in forage-fed cattle's methane emissions nationally.[93]

Some concerns with the Wiedemann paper

Out of date "global warming potential" (GWP)

The emissions of different greenhouse gases can be aggregated by converting them to carbon dioxide equivalents (CO2-e) using the appropriate "global warming potential" factor. (For more details, please see Appendix 3.)

The GWP used by the paper's authors for methane was already out of date when the paper was originally submitted to the journal for consideration in July 2014, and even further out of date when a revised version was submitted in November that year. The IPCC (Intergovernmental Panel on Climate Change) used a GWP multiplier of 25 in 2007 until it increased it to 34 (with climate-carbon feedbacks) and 28 (without those feedbacks) in its 2013 Fifth Assessment Report. If updated methane and nitrous oxide figures (including climate-carbon feedbacks) had been used, beef's emissions intensity would have been around 20 per cent higher than reported, at 15.7 kg CO2-e/kg live weight.

Please also see comments below regarding a 20-year GWP.

Live weight versus carcass weight

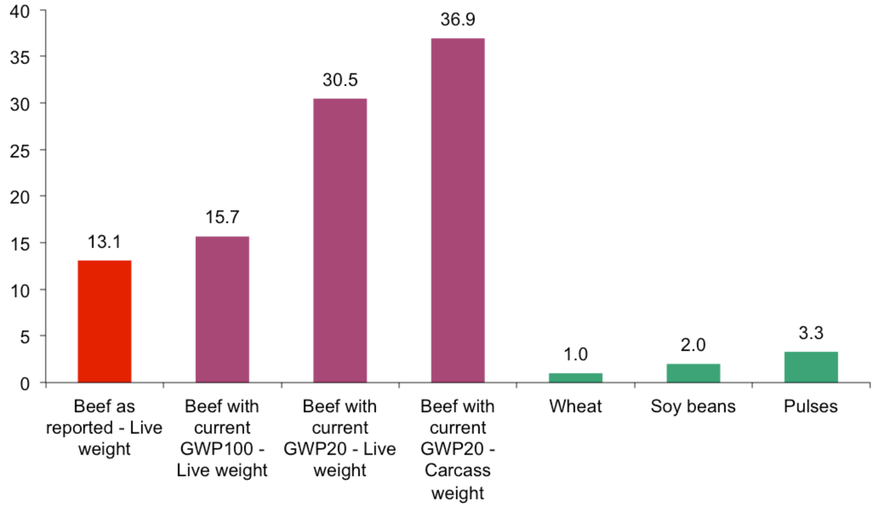
The study is unusual to the extent that it bases its emissions intensity figures on live weight of the animal, rather than carcass weight or weight of the end product.

If we use the same adjustment factor for converting from live weight to carcass weight as was used in a report cited in the Wiedemann paper, then the emissions intensity would increase to 19.0 CO2-e/kg carcass weight.[94]

20-year GWP should also be considered

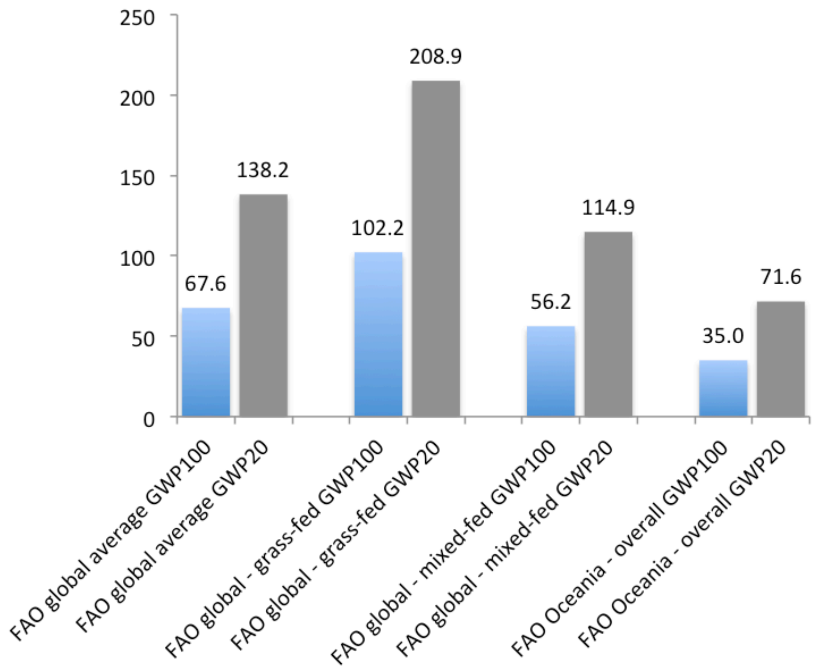
A time horizon of 100 years is commonly used in applying GWPs, and that was the case with this paper. On the basis of carcass weight and a 20-year GWP for methane and nitrous oxide, the emissions intensity in this case would have been 36.9 kg CO2-e per kg carcass weight, without allowing for additional factors referred to below. The comparison is shown in Figure A.5.2.

Figure A.5.2: Alternative measures of beef's emissions based on Wiedemann paper along with certain plant-based options (kg CO2-e/kg product)



As another comparison, the FAO's figures (referred to above) would increase as indicated in Figure A.5.3.

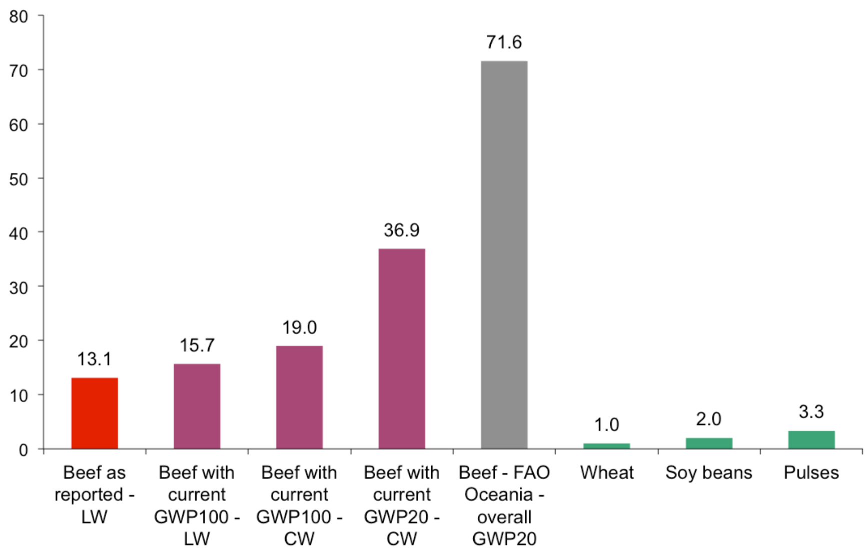
Figure A.5.3: FAO Emissions Intensity figures GWP100 vs GWP20 (kg CO2-e/kg product)



The "20-year GWP" figures in Figures A.5.2 and A.5.3 are based on the global average percentage apportionment of the various factors contributing to beef's emissions intensity, and are intended to be approximations only.

Allowing for the FAO's estimate for Oceania (dominated by the Australian beef industry) gives us the following comparison with figures based on the Wiedemann study and some plant-based alternatives, as shown above.

Figure A.5.4: Alternative measures of beef's emissions based on Wiedemann paper and FAO along with certain plant-based options (kg CO2-e/kg product)



Livestock-related land clearing is increasing

In promoting the Wiedemann paper, MLA reported that a reduction in emissions from land use *"reflects the ban on broad scale clearing in Queensland".* Unfortunately, due to exemptions and possible illegal clearing, livestock-related land clearing did not cease after the so-called ban (introduced by the previous Labor government) commenced in December, 2006.

In any event, the relevant legislation was overturned by the Liberal National government in 2013 in respect of land deemed to be of *"high agricultural value".*[95] Even with the ban in place, extensive clearing for pasture occurred, including an estimated 134,000 hectares in 2011/12.[96]

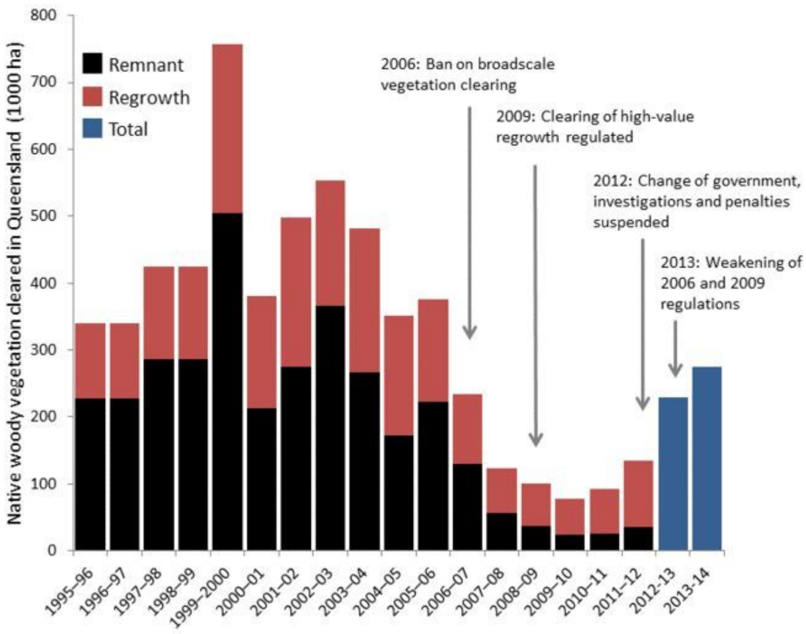
Labor regained power in early 2015. In November that year, it announced plans to re-introduce stricter land clearing controls. However, Labor has only 43 seats in the 89-seat, single-house Parliament, with the balance of power held by two Katter's Australia Party MPs and two independents, one of whom is the Speaker. The Katter party has said it will not support the proposed legislation.[97]

Prior to Labor's announcement, Fairfax Media's "Queensland Country Life" reported[98]:

> *". . . the minority Labor government is stymied from delivering pre-election commitments because it would require the support of pro-farmer Speaker Peter Wellington and the Katter Party."*

An estimated 275,000 hectares was cleared in Queensland in 2013/14, representing more than a tripling since 2009/10.[99 100]

Figure A.5.5: Queensland land clearing 1995 – 2014



The Wiedemann paper allowed for average annual beef-related clearing of around 158,000 hectares in Queensland for the five years to 2010. That may be a reasonable estimate for that period, but could be understated in terms of future clearing.

In the paper's supplementary material (Table A12), the authors conservatively estimated that over 8 million hectares (80,000 square kilometres) were cleared for beef production in Queensland from 1981 to 2010. (The figures shown in the table are the annual average per five-year period.)

A report by the World Wildlife Fund has identified eastern Australia as one of eleven global "deforestation fronts" for the twenty years to 2030. It has stated[101]:

> *"A weakening of laws to control deforestation in Queensland and New South Wales could bring a resurgence of large-scale forest clearing, mainly for livestock farming."*

WWF's concern in respect of New South Wales relates to the fact that the Liberal/National Party coalition government intends repealing the Native Vegetation Act.[102]

The forests will always be at risk of further clearing, depending largely on the inclination of the government of the day. The recently signed China-Australia Free Trade Agreement and the recently agreed (but yet to be ratified) Trans Pacific Partnership agreement increase the likelihood of accelerated livestock-related land clearing.

Savanna burning omitted

Estimates of the percentage of savanna burning attributable to livestock production can be somewhat arbitrary. For example, a 2003 report commissioned by the Australian Greenhouse

Office assigned a figure of approximately 57 per cent, based on the percentage of continental land area used as pasture.[103]

The Wiedemann study ignored savanna burning in relation to livestock production, supporting the view expressed in the National Greenhouse Gas Inventory that the burning would occur naturally if not instigated by graziers. (The 2010 National Greenhouse Inventory attributed 10.8 per cent of agriculture's emissions to savanna burning.)

However, that position is not supported by climate change campaign group Beyond Zero Emissions and Melbourne Sustainable Society Institute (University of Melbourne), who have stated[104]:

> *"This position was based on largely anecdotal evidence that Aboriginal 'firestick farming' was extensively practiced prior to colonisation. Instead substantial expert opinion supports the conclusion that these emissions, categorised under Prescribed burning of Savannas, are anthropogenic. There is also evidence that savanna fires are far more widespread and frequent than would naturally occur."*

The Pew Charitable Trusts have also commented extensively on the destructive environmental impacts of livestock grazing, including manipulation of fire regimes (along with tree clearing, introduction of invasive pasture grasses, and degradation of land and natural water sources).[105]

Foregone sequestration omitted

The report's authors did not consider foregone sequestration, despite the fact that (as referred to in Appendix 4) livestock production has been responsible for around 70 per cent of clearing in Australia. That is, they did not allow for the fact that current atmospheric carbon concentrations are far higher than they would have been if forest and other wooded vegetation had been retained, removing carbon from the atmosphere.

That approach is consistent with official emissions estimates, but they all contribute to society failing to clearly identify significant causes of climate change and relevant mitigation opportunities.

What many of us assume to be natural landscapes may be very different to what existed before livestock and other pressures were introduced. The problem is highlighted in the following words from authors David Lindenmayer of Australian National University and Mark Burgman from The University of Melbourne[106]:

> *"It was once possible to walk from Melbourne to Sydney through almost continuous woodland cover, but now much of it is gone and the remaining patches are small and highly disturbed."*

Short-lived global warming agents omitted

Two warming agents generally omitted from official figures, and also from the Wiedemann paper, are tropospheric ozone and black carbon, as referred to in Appendix 3.

The Wiedemann paper's approach on savanna burning, as referred to above, may be a factor in the omission.

Soil carbon losses may be understated

The Wiedemann study considered loss of soil carbon arising from *"cultivation for feed grain or fodder production, associated with land management and the conversion of pasture to crop land".*

Other relevant soil carbon emissions are not allowed for in official figures, and do not appear to have been considered in the Wiedemann paper.

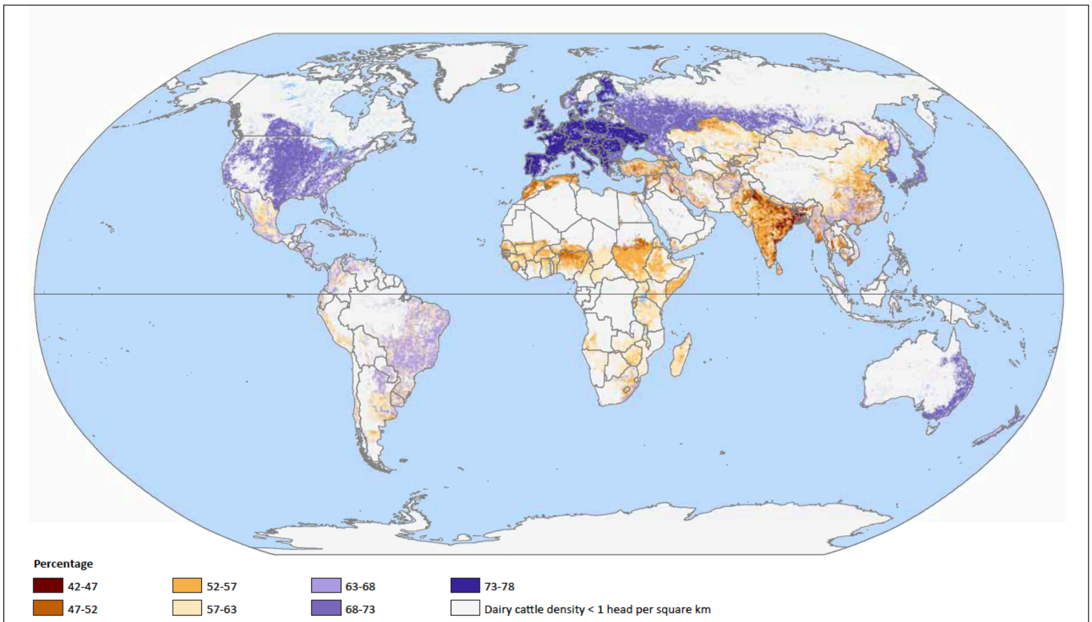
Beyond Zero Emissions and Melbourne Sustainable Society Institute have highlighted the significant loss of soil carbon due to wind and water erosion that is *"greatly accelerated by the removal and disturbance of vegetation".* They have reported that 80 per cent of Australia's soil organic carbon loss comes from rangeland grazing areas, highlighting the impact of rangeland deforestation and degradation.[107]

Comparison with other regions

Based on Oceania's emissions intensity for specialised beef (FAO estimate in Figure A.5.3), it appears the figure for Australia is similar to that of North America, with both around 35 kg CO2-e per kg of product based on a 100-year GWP. (They would be roughly double that figure on the basis of a 20-year GWP.) They are below the global average due to relatively high feed digestibility (refer to Figure A.5.6) and production efficiency.

Due to low feed digestibility, low reproduction efficiency, poor herd management practices, genetics and high animal mortality, higher emissions intensity figures occur in South Asia (which has the highest figure globally at around 155 kg CO2-e per kg of product based on a 100-year GWP), sub-Saharan Africa, Latin America and the Caribbean, and East and Southeast Asia. Low feed digestibility is also a factor in another high emissions intensity region, the Near East and North Africa.

Figure A.5.6 Average feed digestibility for beef cattle[108]



Source: GLEAM calculation, see Appendix A for the methodology. GIS data source: You, L. *et al.* (2010); Haberl, H. *et al.* (2007); FAO (2007; 2011).

Conclusion to Appendix 5

Despite the Wiedemann paper indicating relatively favourable results for Australian beef production's greenhouse gas emissions, the material presented here indicates that beef's performance is extremely poor (with emissions intensity figures more than ten times those of plant-based alternatives) after allowing for various additional factors. We must take those factors into account if we are to address the threat of climate change (including the essential mitigation measures) with the focus and urgency required.

Appendix 6: The climatarian diet must exclude pig, chicken, fish, egg and dairy

Solely on the basis of emissions intensity, it may be tempting to argue in favour of certain forms of meat consumption over others.

That is a key element of the so-called "climatarian" diet. Here is how the New York Times defines it[109]:

> *"A diet whose primary goal is to reverse climate change. This includes eating locally produced food (to reduce energy spent in transportation), choosing pork and poultry instead of beef and lamb (to limit gas emissions), and using every part of ingredients (apple cores, cheese rinds, etc.) to limit food waste."*

But can such choices realistically achieve what may be hoped for?

In regard to the practice of eating locally produced food, it should be noted that "post-farm" emissions, including those from transportation, only account for 0.5 per cent of beef's average global emissions. [110] As a result, for beef, the local approach provides little benefit. For lower-emissions products, transportation's share of emissions is higher; Nijdam, et al. have reported an average contribution across all food types of around 11 per cent.[111]

Emissions intensity

As demonstrated earlier in this booklet, many life cycle assessment (LCA) studies have shown that meat from ruminant animals, such as cattle and sheep, is far more emissions intensive than that from pigs, chickens or fish, while emissions from plant-based foods are lower still.

Comparative emissions intensities of different food products, relative to their protein content, are outlined in Figure A.6.1. The figures have been calculated utilising emissions intensity and nutrition sources referred to earlier. Due to its relatively low protein content, the emissions intensity of cow's milk in this instance is more pronounced than in Figure 1.

The twenty-year figures for beef, sheep meat, pig meat and cows' milk are influenced by the high proportion of methane emissions, ranging from 25.8 per cent (pigs) to 56.9 per cent (sheep). Most of pigs' methane emissions, representing 19.2 per cent of their total emissions, come from manure management.

Is it reasonable to eat other animal products?

Even using the conservative 100-year time horizon, pig meat is nearly 10 times as emissions intensive as soybeans, increasing to 13 times when based on a 20-year time horizon. Comparative multiples are 7 for eggs, 6 for chicken meat, and 4 for fish. The time horizon does not materially affect the emissions intensity of eggs, chicken meat and fish, as methane is not a significant factor in their emissions.

The GWP100 protein-based emissions intensity figures in Figure A.6.1.1, and for pig meat, chicken meat and eggs in Figure A.6.1.2, are from the UN FAO[112], adapted to IPCC GWP20-based figures where relevant. The remaining figures utilise Oxford researcher's GWP100 estimates based on product weight, adapted to protein-based figures using USDA nutrition data and (where relevant) IPCC GWP20 data (all referred to elsewhere in this booklet).

Figure A.6.1.1: Emissions intensity (kg CO2-e/kg protein) for beef, sheep meat and cow's milk

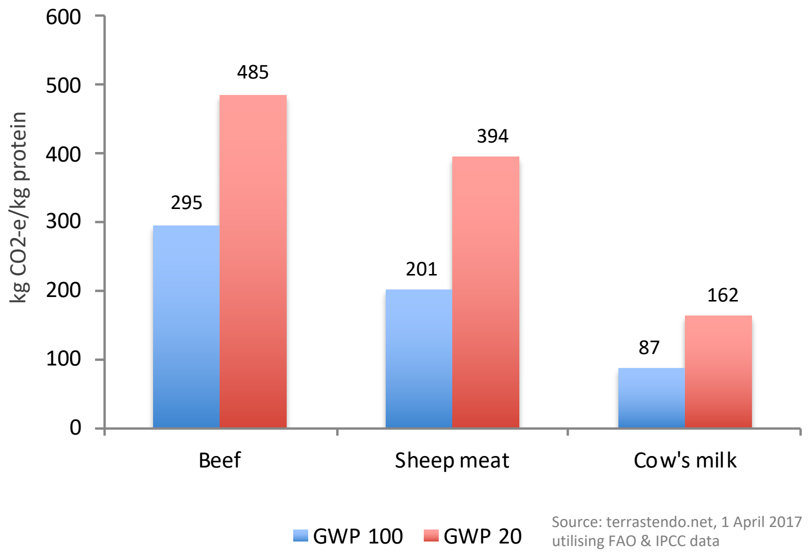
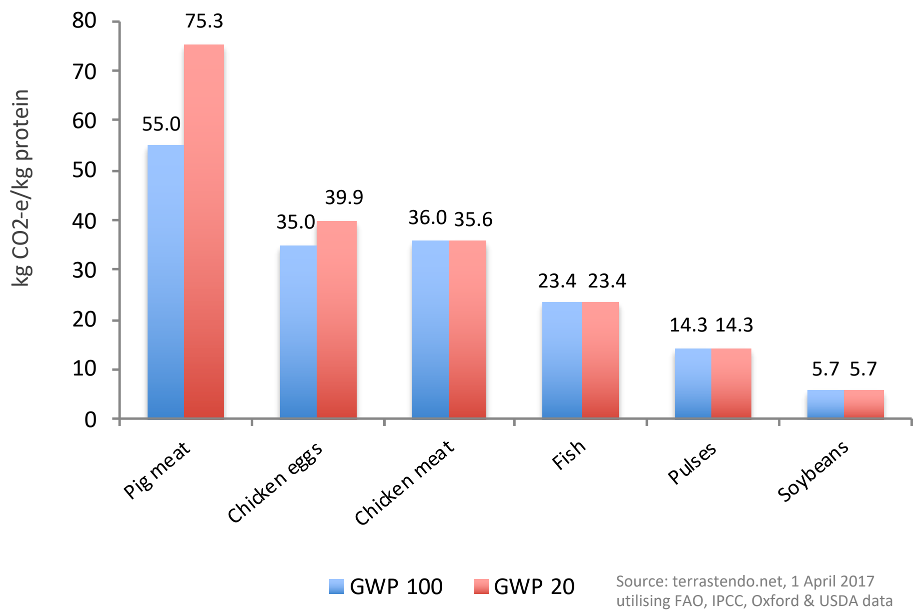


Figure A.6.1.2: Emissions intensity (kg CO2-e/kg protein) for other products



If climate change impacts were considered to be a cost in their own right, those figures could be expressed as pig meat being 1,200 per cent more "expensive", eggs being 600 per cent more "expensive", and chicken meat being 500 per cent more "expensive" than soybeans.

Inefficiencies on that scale would not normally be tolerated in government or private sector businesses, where discrepancies of 5 – 10 per cent can mean life or death to any project or program. Why should such levels of inefficiency be tolerated when they relate to greenhouse gas emissions, particularly when our current position in relation to climate change is so precarious?

A climate emergency with no buffer

As poorly as pig meat, chicken meat, fish and eggs compare to plant-based options on the basis of emissions intensity, that measure is only part of the story.

We face an emergency in which we are effectively sitting on the edge of a precipice, with little room to move before we lose any ability to favourably influence our climate system.[113] [114] In such a dangerous position, we need to select those dietary choices with the best chance of allowing us to move to a position of relative safety.

Due to the rapid expansion of soybean plantations for animal feed, consumption of pig and chicken meat, farmed fish, eggs and dairy products plays a critical role in the destruction of the Amazon rainforest and other carbon-rich ecosystems, such as the Cerrado region further south.[115]

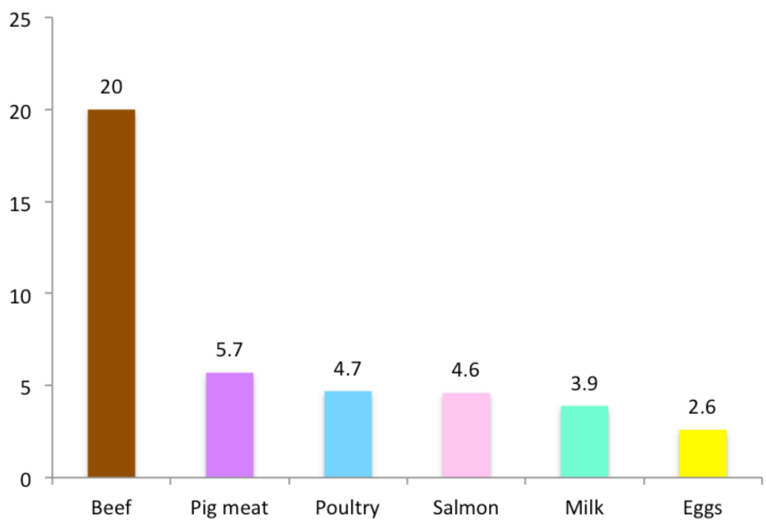
With rising global temperatures and excessive forest fragmentation, we may be pushing the rainforest toward a dangerous threshold. Such fragmentation can lead to general drying and an increased propensity for fires and other causes of loss. Studies published in late 2014 and early 2015 documented the extremely adverse long-term effects of forest fragmentation, including carbon losses far in excess of what was previously believed. Much of the fragmentation arises from agriculture, including livestock feed crops.[116] [117]

Dieback of the Amazon rainforest represents a potential tipping point, where a small change in human activity can lead to abrupt and significant changes in earth systems, with catastrophic and irreversible impacts.[118] Even in the absence of clear tipping points, climate feedback mechanisms create accelerating, potentially irreversible changes.

It could be argued that any agricultural plantation in the Amazon basin and elsewhere represents an environmental problem. That is true, but the problem is magnified in regard to animal feed, due to the gross and inherent inefficiency of animals as a food source. In converting soybean and other plant protein to pig and chicken meat for example, we lose around 80 per cent of the plant-based protein used in the production process.[119] That means the land area required is around five times the area required if we obtained the protein directly from plants.

Various feed conversion ratios of various livestock production systems, as shown in Figure 1. The researchers determined the figures by analysing between twenty-nine and eighty-three studies per item.

Figure A.6.2 Feed conversion ratios (kg feed protein required per kg of animal protein produced)



Although soybean meal for livestock feed was once considered a by-product of soybean oil production, it is the requirement for livestock feed that now drives the international soybean trade.[120]

China's livestock sector is the major global consumer of traded soy products. However, the trade is global, and demand pressure from any country contributes to an increase in overall supply, thereby increasing pressure on critical ecosystems in soy-producing regions.

In Brazil, there are serious questions about the effectiveness of the supposed soy moratorium and key aspects of environmental governance generally.[121] [122]

In the absence of an overall global shift away from ruminant meat such as beef and lamb (the opposite trend is occurring in many developing nations), any increase in the consumption of pig meat, chicken meat, fish, eggs and dairy products will almost certainly cause soybean plantations to expand, rather than contract, with the potential loss of the massive carbon sink that the Amazon basin and Cerrado region represent. On the other hand, a general move away from those products may allow vast areas of cleared land to regenerate to something approaching their natural state.

Corn is also a major component of animal feed production. The crop is far more water and nutrient intensive than soy, so its use has major implications for producing nations, including those in South America.[123]

Overlooked climate change impacts of consuming fish and other sea creatures

A September, 2015 paper published in Nature Climate Change highlighted some of the impact of industrial and non-industrial fishing on our climate system.[124] The problem arises largely from the fact that fishing disturbs food webs, changing the way ecosystems function, and altering the ecological balance of the oceans in dangerous ways. The paper focused on the phenomenon of "trophic downgrading", the disproportionate loss of species high in the food chain, and its impact on vegetated coastal habitats consisting of seagrass meadows, mangroves and salt marshes.

The loss of predators such as large carnivorous fish, sharks, crabs, lobsters, seals and sea lions, and the corresponding population increase of herbivores and bioturbators (creatures that disturb ocean sediment, including certain crabs) causes loss of carbon from the vegetation and sediment. The ocean predators are either caught intentionally by fishing fleets, or as by-catch when other species are targeted.

The affected oceanic habitats are estimated to store up to 25 billion tonnes of carbon, making them the most carbon-rich ecosystems in the world. They sequester carbon 40 times faster than tropical rainforests and contribute 50 per cent of the total carbon buried in ocean sediment.

Estimates of the areas affected are unavailable, but if only 1 per cent of vegetated coastal habitats were affected to a depth of 1 metre in a year, around 460 million tonnes of CO2 could be released. That is around the level of emissions from all motor vehicles in Britain, France and Spain combined, or a little under Australia's current annual emissions. If 10 per cent of such habitats were affected to the same depth, it would be equivalent to emissions from all motor vehicles in the top nine vehicle-owning nations (USA, China, India, Japan, Indonesia, Brazil, Italy, Germany, and Russia), whose share of global vehicle numbers is 61 per cent. It would also equate to around eight times Australia's emissions.

Loss of ongoing carbon sequestration is the other problem. If sequestration capability was reduced by 20 per cent in only 10 per cent of vegetated coastal habitats, it would equate to a loss of forested area the size of Belgium.

These impacts only relate to vegetated coastal habitats, and do not allow for loss of predators on kelp forests, coral reefs or open oceans, or the direct impact on habitat of destructive fishing techniques such as trawling. They are not accounted for in the emissions intensity figures referred to earlier, or in national greenhouse gas inventories.

Conclusion to Appendix 6

The argument of those who encourage increased consumption of pig meat, chicken meat, fish and eggs at the expense of beef and lamb, or other dairy products in favour of cheese, is essentially one of "getting the biggest bang for the buck", as reflected in the relative emissions intensity of different products. However, consumption of the supposedly more favourable animal-based foods has adverse impacts that are unaccounted for in most forms of climate change reporting, which should cause them to sit alongside ruminant meat in terms of campaigning efforts.

Footnote regarding tofu

Raw firm tofu has far less protein per kilogram (82 g) than soybeans (365 g) and another soy-based product, tempeh (185g).

Papers cited in this booklet have estimated tofu's emissions per kilogram of product to range from 0.7 kg to 2 kg. Converting those figures to kilograms of emissions per kilogram of protein results in figures ranging from 8.5 kg to 24 kg. (The range for soybeans is from 1.9 kg to 5.5 kg, with the figure shown in Figure A.6.1 being at the top of that range.)

On that basis, soy in the form of tempeh may be preferable to tofu in terms of carbon footprint. Based on its emissions intensity per kg of product as estimated in a 2008 Dutch study (1 kg), the figure per kg of protein would be 5.4 kg.[125]

The issue is also relevant to land use requirements.

Acknowledgements

Thank you to Stephen Bygrave of Beyond Zero Emissions for suggesting a booklet based on my material. As my friends know, I had been considering a book for some time, but my website and other writing opportunities had taken priority. Through subsequent discussions, and in line with my existing work, we generated the idea of including recipes (shown with my analysis in Part 2).

Thanks to Mel Baker of The Kind Cook for allowing me to select some examples of her delicious creations.

Thanks also to Vegetarian Victoria and Vegan Australia for being involved and for striving to make the world a better place.

Finally, thank you to my family for allowing me to spend so much time on this and other projects.

Paul Mahony

About the Author

Paul Mahony is a prominent environmental and animal rights campaigner based in Melbourne, Australia.

His work appears on numerous websites, and he has been a regular presenter to university, industry, environmental, animal advocacy and community groups.

He was on the expert panel of Meat Free Week Australia in 2014 and 2015, and has been featured in the book *"Guarding Eden"* (2015, Allen & Unwin) by Deborah Hart, which focuses on climate change activism.

Other Material

Papers:

- Submission in response to National Food Plan Green Paper: "The urgent need for a general transition to a plant-based diet", September 2012
- Comments on Meat & Livestock Australia's "Myth Busters", April 2012
- Some Environmental Impacts of Animal Agriculture, Part 2, December 2010
- Some Environmental Impacts of Animal Agriculture, Part 1, December 2010
- Some Key Impacts of Livestock Products on the Environment, July 2010
- Submission in Response to Victorian State Government's Climate Change Green Paper (for Vegetarian Network Victoria), September 2009
- Submission in Response to Victorian State Government's Summit Paper "A Climate of Opportunity": *"Is There Anything That I Can Do? Yes, Modify Your Diet!",* June 2008

Presentations:

- "Omissions of Emissions: Livestock and the Climate Crisis" October 2013
- "Climate Change Tipping Points and Their Implications" March 2012
- "Solar or Soy: Which is better for the planet?" February 2011

Website: terrastendo.net

About Mel Baker (The Kind Cook)

Mel Baker is a qualified chef who did not become passionate about cooking until she became vegan in 2009. She created The Kind Cook website in 2012 and has over 20,000 followers on Facebook.

Media and website coverage has included:

- "Nourish" magazine
- "GRAM" magazine
- "Wildfire" magazine
- "Food and Home Entertaining" magazine (South Africa)
- "The Vegan" magazine (Vegan Society, UK)
- "Everyday Vegans" by Kathy Divine
- "Plant Powered Women" by Kathy Divine
- "Food Made Good" e-book by Fry's Family Foods and Animals Australia
- "Edgar's Mission Guide to a Kind Christmas"
- One Green Planet website
- Lilydale and Yarra Valley Leader Newspaper (front cover)

Website: thekindcook.com

Data Limitations

Calculations for determining the 20-year GWP figures for beef, sheep meat, pig meat and chicken meat were based on the FAO's global average percentage apportionment of the various factors that contribute to each product's emissions intensity across all feeding systems. Where shown for a product that does not match that description (e.g. product from a specific region or feeding system), they are intended to be approximations only.

Revisions

Revisions since the 5th June 2016 edition:

1. Notes inserted within charts in the Introduction and Part 2 "Recipes and related emissions".

2. Various amendments within Appendix 4 "Land Clearing".

3. Updated emissions intensity figures used for Figures A.6.1.1 and A.6.1.2 and related comments in Appendix 6 "The climatarian diet must exclude pig, chicken, fish, egg and dairy".

Image References

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Figure A.3.1 from Smith, K., University of California – Berkeley, cited in World Preservation Foundation, *"Reducing Shorter-Lived Climate Forcers through Dietary Change: Our best chance for preserving global food security and protecting nations vulnerable to climate change"* (undated) (p. 38)

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Aerial view of Amazon deforestation in Brazil © Phototreat | iStock.(p. 57)

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Adult male Green turtle swimming over seagrass © Caan2gobelow | Dreamstime.com (p. 59)

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