

Response to City of Darebin's Draft Climate Emergency Plan 2017 - 2022



Food choices must be included

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"[Animal food products place] undue demand on land, water, and other resources required for intensive food production, which makes the typical Western diet not only undesirable from the standpoint of health but also environmentally unsustainable"

Food and Agriculture Organization of the United Nations and the World Health Organization, 2001¹

"If you eat further down on the food chain rather than animals, which have produced many greenhouse gases, and used much energy in the process of growing that meat, you can actually make a bigger contribution in that way than just about anything. So that, in terms of individual action, is perhaps the best thing you can do."

Dr James Hansen, former director, Goddard Institute for Space Studies²

"Reforestation competes with agricultural land use; land needs could decline by reducing use of animal products, as livestock now consume more than half of all crops."

Dr James Hansen and fellow researchers³

"We have to change, we cannot go on with business as usual. We need each of us to think about our carbon footprint. Eat less meat, or no meat at all. Become vegetarian or vegan."

Mary Robinson, former president of Ireland and former UN High Commissioner for Human Rights

"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."

Dr Andrew Glikson, earth and paleoclimate scientist at Australian National University⁴

Cover Image: "Active moulin" by Henry Patton, Flickr

The image shows a moulin (crater) on Russell Glacier, Greenland. Increased rates of melting are causing lakes to form on the ice sheet (which in some places is more than two kilometres thick) and disappear down moulins to the bottom. The water cascading through the moulins warms the ice sheet and lubricates the base, contributing to further melting. There are many hundreds, possibly thousands, of moulins on the ice sheet.

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1. INTRODUCTION

I thank the City of Darebin for developing a climate emergency plan and inviting feedback on the draft.

This paper focuses on the impact of food choices, an issue that it is largely overlooked or ignored by prominent environmental groups, and not referred to in the draft plan.

The authors of a paper that appeared in the June 2017 issue of Nature have pointed out that scientists have often ignored human behaviour as the ultimate driver of environmental change.⁵ For example, they may focus on pollution or climate change, without acknowledging that factors such as human population growth, socio-economic development, and culture and values are the ultimate cause.

The paper argued that governments, non-government organisations and social movements *“can actively encourage changes in social norms that lead to improved environmental behaviours”* through the use of taxes, incentives, subsidies, education and communication.

With that approach in mind, I call on the City of Darebin to incorporate food choices in key aspects of its plan, including: community education and engagement; and advocacy programs aimed at state and federal governments.

In Australia, criticising the traditional meat-based barbecue may be considered a form of heresy, despite animal-based food consumption being a key factor in climate change and the destruction of national treasures such as our northern rainforests and the Great Barrier Reef.

That must change, and we must recognise that we will not overcome the climate crisis without addressing the issue of animal agriculture in addition to fossil fuel usage.

2. FOOD-RELATED EMISSIONS

The livestock sector, responding to demand for animal-based food products, is a key driver of climate change. For example, researchers from the Melbourne Sustainable Society Institute (MSSI) at the University of Melbourne and climate change advocacy group Beyond Zero Emissions (BZE) have estimated that it is responsible for forty-nine per cent of Australia's greenhouse gas emissions.⁶ The findings were reinforced in a subsequent peer-reviewed journal article, which had two co-authors in common with the MSSI/BZE paper, with the figure increasing to fifty per cent.⁷

The authors focused on factors that are ignored, under-stated or attributed to non-livestock categories in the national greenhouse gas inventory, such as: livestock-related land clearing; soil carbon losses; certain near-term climate forcers (NTCFs); and a 20-year "global warming potential" (GWP).

GWPs represent the relative warming effect of a unit mass of non-CO₂ greenhouse gas when compared with the same mass of CO₂ over a specific period. They enable us to aggregate the warming impact of different gases by converting them to carbon dioxide equivalents (CO₂-e). It is analogous to converting several different currencies to a common denomination. The greenhouse gases are converted by multiplying the mass of emissions by the appropriate GWPs.

A 20-year GWP (GWP₂₀) for methane (CH₄) may be more valid than the 100-year figure (GWP₁₀₀) used by most reporting bodies. The reason is that methane, a critical factor in livestock's climate change impacts, generally breaks down in the atmosphere to a significant extent within 12 years. Accordingly, a 100-year GWP (which shows the average impact over a period of 100 years) greatly understates its shorter-term impact. (12-year GWPs are not readily available from the Intergovernmental Panel on Climate Change (IPCC).)

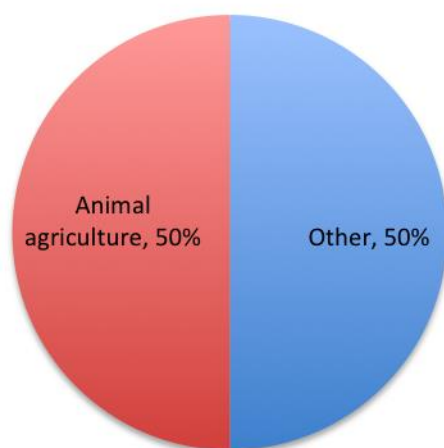
The issue is critical when considering the impact of climate change tipping points, with potentially catastrophic and irreversible consequences.

The IPCC has stated:⁸

"There is no scientific argument for selecting 100 years compared with other choices (Fuglestvedt et al., 2003; Shine, 2009). The choice of time horizon is a value judgement because it depends on the relative weight assigned to effects at different times."

The relative shares of Australia's emissions, utilising a 20-year GWP and the various other factors, are depicted in Figure 1.

Figure 1: Animal agriculture’s share of Australia’s greenhouse gas emissions (GWP 20) estimated by researchers from the University of Melbourne and Beyond Zero Emissions



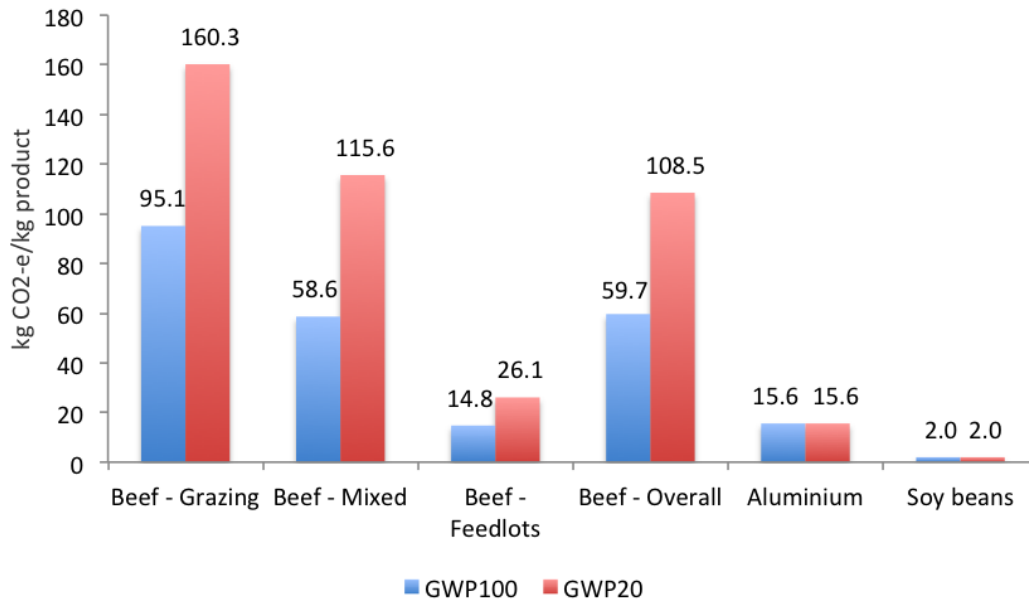
Some of the relevant factors (but not all) have been taken into account by the Food and Agriculture Organization of the United Nations (FAO) in determining the emissions intensity of various animal-based food products. Figure 2 compares the FAO’s latest figures for specialised, non-dairy beef to those for aluminium (regarded as extremely emissions intensive and at one stage responsible for 16 per cent of Australia’s electricity consumption with a lower tonnage than beef production) and soy beans (as reported by researchers from Oxford University).^{9, 10, 11, 12}

The FAO’s reference period is 2010, using its Global Livestock Environmental Assessment Model, Version 2.0 (GLEAM 2.0). It used the IPCC’s 2013 100-year GWPs, and I have calculated 20-year GWPs for the chart, using IPCC estimates and the FAO’s apportionment of the various greenhouse gases for each product. (The IPCC’s 20-year GWPs are more conservative than estimates from NASA researchers, who have allowed for aerosol interactions.¹³ The NASA estimates were used in the MSSI/BZE paper referred to earlier.)

The FAO’s figures have been updated from estimates it published in 2013, which utilised a 2005 reference period and an earlier version of its life cycle assessment model (GLEAM 1.0).¹⁴

The FAO’s figures are global averages based on carcass weight. Some studies use retail weight (resulting in higher emissions intensity), while others use live weight (resulting in lower emissions intensity).

Figure 2: Emissions intensity of various products based on product weight (2010 reference period for animal-based products)



Based on Oceania’s emissions intensity for specialised beef, it appears the overall figure for Australia is below the global average and similar to that of North America, with both around 35 kg CO₂-e per kg of product based on a 100-year GWP.¹⁵ (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 and production efficiency, but are nevertheless multiples of the plant-based alternatives.

Another approach is to base the figures on the level of protein produced for each kilogram of greenhouse gas.

The FAO’s GWP100 figures for animal products on that basis are shown in Figure 3, along with my adjustment to GWP20. The estimates for plant-based products utilise nutritional information from the US Department of Agriculture and emissions estimates published by Oxford University researchers.

The emissions intensity of pulses is included in Figure 3(b). They comprise chickpeas, lentils, dried beans and dried peas. Along with soybeans, peanuts, fresh beans and fresh peas, they are members of the “legume” food group.

Figure 3(a): Emissions intensity of beef, sheep meat and cow’s milk based on protein content (2005 reference period)

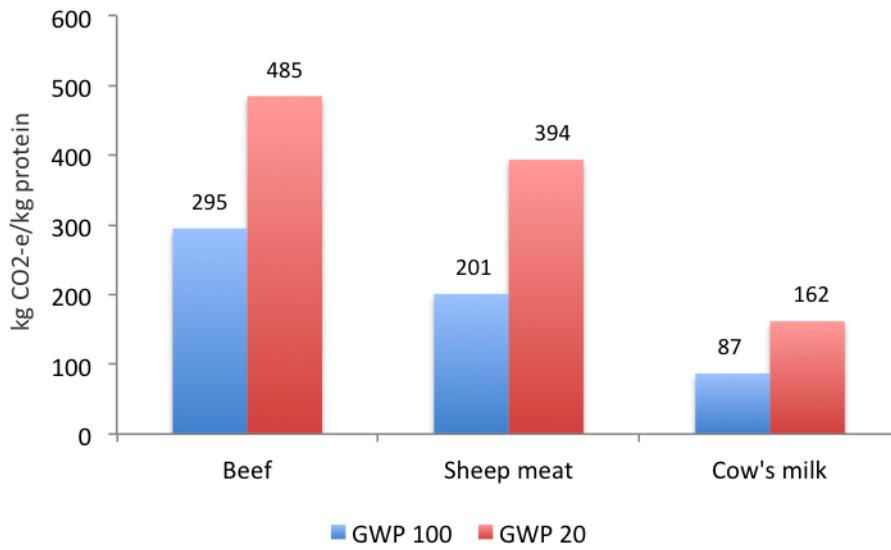
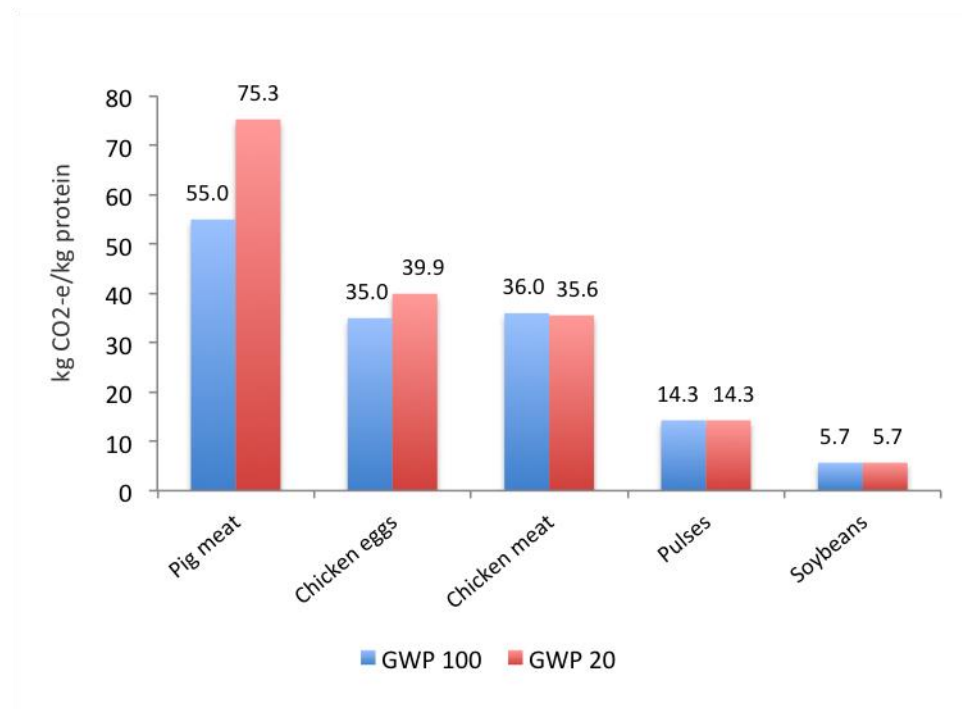


Figure 3(b): Emissions intensity of other products based on protein content (2005 reference period for animal-based products)



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.

3. LAND CLEARING

Land clearing in Australia

The state of Queensland is the beef production capital of Australia. At last count (2015), it had 11.7 million cattle, which was more than double its human population, and nearly double the cattle population of its nearest beef-producing rival, New South Wales.

Trees have been extensively cleared to establish grazing areas, with the level of activity increasing after World War 2 when the technique of dragging a massive chain, linked to two bulldozers, was introduced. (The Wilderness Society has credited the innovation to a young Joh Bjelke-Petersen, who eventually became Queensland’s longest-serving premier.)¹⁶

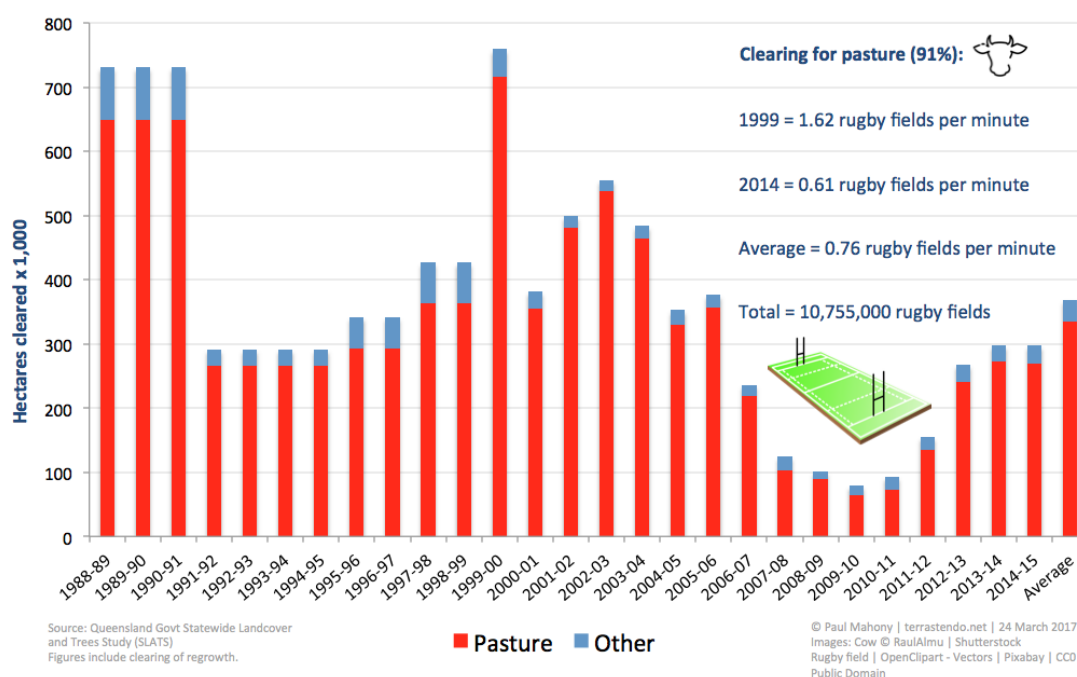
For many decades, farmers were required to clear the land as a condition of their government lease, with economic development being the driver.

The Queensland government’s State Landcover and Trees Study (SLATS) has shown that, between 1988 and 2015, 90,340 square kilometres of land were cleared or re-cleared for pasture in Queensland, which is equivalent to nearly 11 million rugby fields (or nearly 17 million American football fields), with the process accelerating in recent years after a partial ban on broadscale clearing was lifted in 2013.^{17, 18,}

The figures include clearing of regrowth, demonstrating the resilience of forest and other wooded vegetation if given the chance to regenerate. But it is seldom given such a chance in Queensland.

The problem is illustrated in Figure 4.

Figure 4: Extent of Queensland land clearing 1988-2015 including livestock-related clearing



It is also equivalent to a tract of land 10 kilometres (6 miles) wide running between Melbourne and Cairns nearly four times, or 2.3 times between Los Angeles and New York.

Figure 5(a): Livestock-related land clearing in Queensland 1988-2015 expressed as 10 km-wide tracts of land equivalent on Australian continent (Arrow width not to scale)

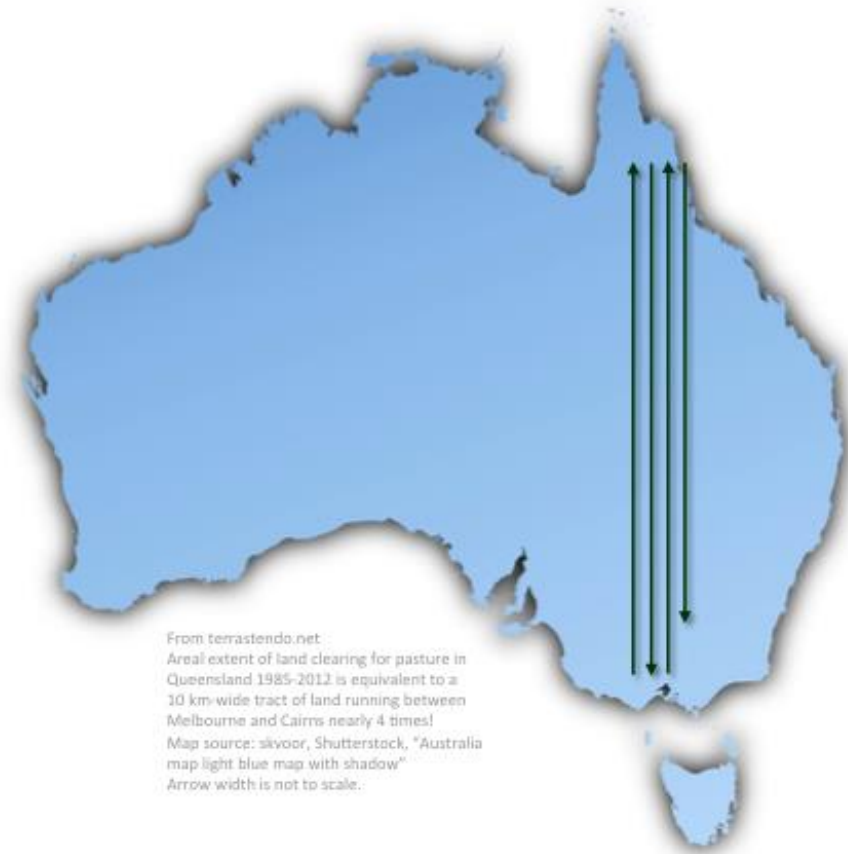
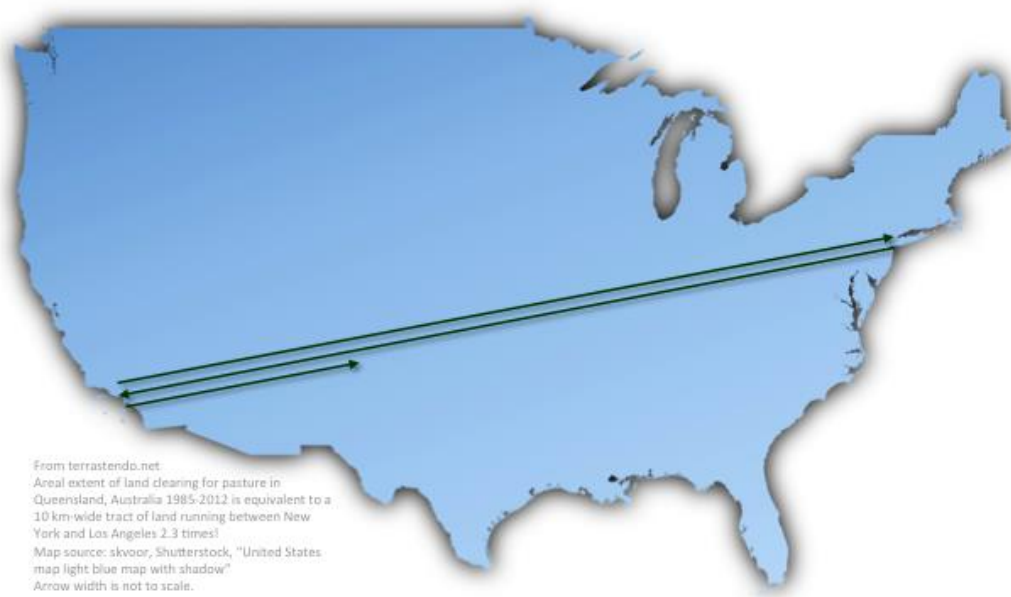


Figure 5(b): Livestock-related land clearing in Queensland 1988-2015 expressed as 10 km-wide tracts of land equivalent on contiguous states of USA (Arrow width not to scale)



Land clearing for beef production in Queensland and New South Wales is the reason the World Wide Fund for Nature (WWF) nominated eastern Australia as one of eleven global deforestation fronts for the twenty years to 2030.¹⁹

In New South Wales, the Native Vegetation Act was repealed by the conservative Liberal Party government in late 2016, with an anticipated loss of biodiversity and increased land clearing.

The clearing contributes significantly to: loss of biodiversity; the release of carbon contained in the vegetation and soil; and an ongoing loss of carbon sequestration. The carbon emissions are not allocated against livestock production in official greenhouse gas inventories, causing livestock-related emissions to be understated.

Queensland may be entering a new phase of growth, primarily driven by beef production. WWF has recently released a report with the title, *“Accelerating bushland destruction in Queensland”*.²⁰

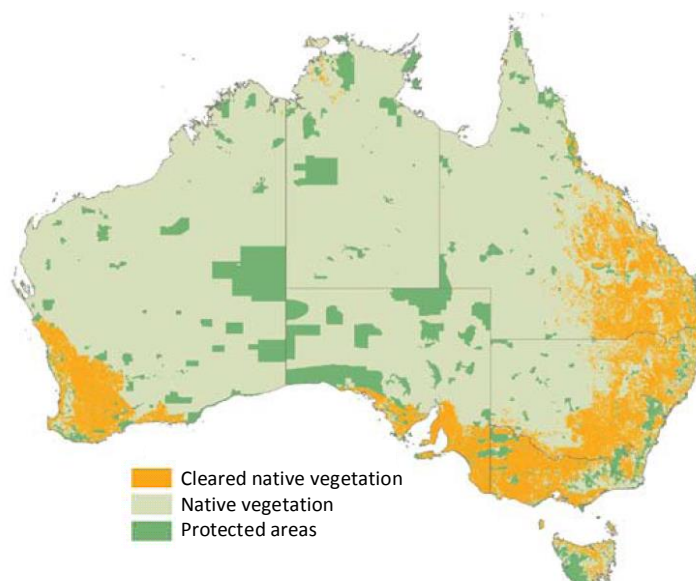
It reported that the legislative changes of 2013 allow clearing of remnant bushland at unlimited scale under “self-assessable codes” for various purposes, when previously most such clearing had required a permit. One of those codes is thinning to correct supposed “thickening” of forests. WWF has stated (with my underline):

“Thinning in particular, allows the bulldozing of up to 75% of trees in a forest, leaving only a scatter of trees behind. It is merely clearing for pasture masquerading as a beneficial treatment.”

“The Queensland Government must tighten these codes as soon as possible to prevent the growing tsunami of land clearing in Queensland.”

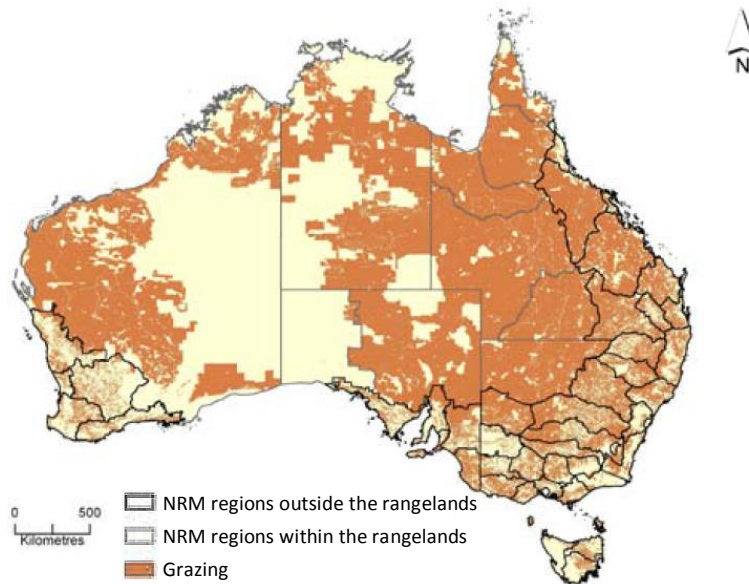
Since European settlement, we have cleared nearly 1 million square kilometres of our 7.7 million square kilometre land mass. The extent of clearing is demonstrated in Figure 6.²¹ Of the cleared land, around 70 per cent has resulted from animal agriculture, including meat, dairy and wool.²²

Figure 6: 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, with detrimental impacts including (in addition to land clearing) the introduction of invasive pasture grasses, manipulation of fire regimes, and degradation of land and natural water sources.^{23, 24}

Figure 7: The location of grazing land in Australia in 2005-06 showing NRM (natural resource management) regions within and outside the rangelands. Source ABARE-BRS



Land clearing globally

In a landmark 2008 paper, leading climate scientist, Dr James Hansen and co-authors 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 CO₂ in the atmosphere without massive reforestation.²⁵ The aim would be to reduce CO₂ 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, Hansen et al. also stated (with my underline):

“A reward system for improved agricultural and forestry practices that sequester carbon could remove the current CO₂ overshoot. With simultaneous policies to reduce non-CO₂ greenhouse gases, it appears still feasible to avert catastrophic climate change.”

The authors estimated a maximum sequestration potential of 1.6 gigatonnes of carbon per year through reforestation. With a conversion factor of 3.67, the estimate equates to around 5.9 gigatonnes of CO₂ per year.

That exceeds the annual drawdown target of 5 gigatonnes of CO₂ established in a “carbon law” articulated by group of leading climate scientists in early 2017, which they indicated would provide a 50 per cent chance of limiting global warming to 1.5°C by 2100 and a 66 per cent chance of limiting it to 2°C.²⁶

The authors (Johan Rockström, Owen Gaffney, Joeri Rogelj, Malte Meinshausen, Nebojsa Nakicenovic and Hans Joachim Schellnhuber) stated:

“Agro-industries, farms, and civil society should develop a worldwide strategy for sustainable food systems to drive healthier, low-meat diets and reduce food waste.”

In a 2013 paper, Hansen and co-authors argued that it was feasible to draw down 100 gigatonnes of carbon through reforestation between 2031 and 2080. They noted: (a) because of extensive deforestation in earlier decades, there is a large amount of land suitable for reforestation; and (b) although reforestation competes with agricultural land use; land needs could decline by reducing use of animal products, as livestock now consume more than half of all crops.

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

PBL Netherlands Environmental Assessment Agency

The PBL Netherlands Environmental Assessment Agency has stated:²⁷

“. . . 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:²⁸

“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:²⁹

“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”.

Animal feed crops represent 90% of the estimated figure (in turn representing 3.6 billion people), and biofuels only 10%.

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."

Institute for Social Ecology, Vienna

A paper from researchers at the Institute for Social Ecology, Vienna, published in April 2016, reported on the potential to avoid further deforestation while feeding a growing global population.³⁰ They considered 500 food supply scenarios using forecasts for crop yields, agricultural area, livestock feed and human diet supplied by the FAO. The lead author, Karl-Heinz Erb, has stated:³¹

"The only diet found to work with all future possible scenarios of yield and cropland area, including 100% organic agriculture, was a plant-based one."

4. THE GREAT BARRIER REEF

It appears we may be witnessing the tragic demise of one of the world's natural wonders, the Great Barrier Reef (GBR). The process has justifiably been covered extensively by media outlets around the world (and referred to by the City of Darebin in its emergency plan material), with much of the coverage focusing on coral bleaching, primarily caused by warming seas. However, has that been the main cause of coral loss?

It may surprise some to find that, until the past two years at least, the answer had been a resounding "no". This section comments on the other causes, which have been largely ignored or overlooked by many environmental groups who campaign vigorously against the use of fossil fuels.

A major contributing factor has been erosion from livestock grazing (including related tree clearing), which releases sediment and nutrients (nitrogen and phosphorous) to the GBR waters via nearby streams and rivers. The sediment inhibits coral growth and promotes the excessive development of algae, while the nutrients contribute to outbreaks of crown-of-thorns starfish, which have had a devastating impact.

Before considering those issues in detail, let's look at the extent to which live coral cover on the reef has declined.

Extent of coral cover

Let's take the 1960s as the baseline period. Professor Jon Brodie from the Australian Research Council Centre of Excellence for Coral Reef Studies at James Cook University has reported that coral covered around 50 per cent of the reef at that time, compared to around 16 per cent in 2012.³² The change represented a decline in coral extent of 68 per cent.

Estimates vary, and soon after Professor Brodie's figure was published, Dr Glenn De'ath and fellow researchers from the Australian Institute of Marine Science (AIMS) and the University of Wollongong estimated that the extent of coral cover around the same time was only 13.8 per cent, representing a decline of 72.4 per cent (again assuming 50 per cent as the base coverage extent).³³

The Great Barrier Reef Marine Park Authority (GBRMPA) has estimated a minimum figure of 17 per cent, followed by some recovery between 2012 and 2015, with an increase to 20 per cent.³⁴ On that basis, the decline from the 1960's to 2012 (assuming that was the minimum) would have been 66 per cent, and to 2015, 60 per cent.

Two mass bleaching events in 2016 and 2017, along with other factors as referred to below, have caused further declines in live coral cover. In mid-2016, the GBRMPA's interim assessment of the 2016 bleaching event indicated that 22 per cent of coral had died. It has since increased the estimate to 29 per cent.³⁵

Although the latter figure related to shallow water corals, the authority has said:

"Coral bleaching did extend to deeper corals beyond depths divers typically survey to, but mortality cannot be systematically assessed. . . . In 2017, further coral loss is expected from the second consecutive year of bleaching and the impacts of tropical

cyclone Debbie. . . . A complete picture for 2017 won't be available until early next year."

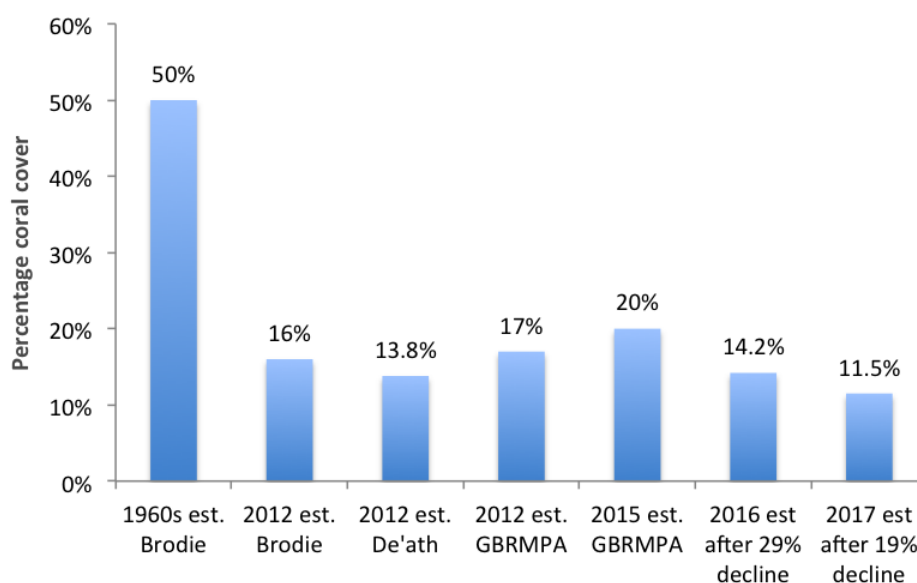
Professor Terry Hughes, Director of the ARC Centre of Excellence for Coral Reef Studies, indicated on 21st May 2017 that the figure for 2017 is 19 per cent.^{36 i}

If we assume that the figure of 29 per cent for 2016 applied to all GBR corals, and that the figure of 19 per cent for 2017 will be confirmed, the current extent of live coral cover (before allowing for declines caused by other factors over the past two years) would be around 11.5 per cent.

It seems reasonable to assume that estimates of percentage reductions are based on the extent of coverage that existed at the beginning of the period being assessed. If so, they are calculated on what has generally been a declining base.

On that basis, the decline from bleaching in 2016 and 2017 (to date) would equate to 17 per cent of the 1960s coverage, which is far less than indicated in much of the relevant media coverage.³⁷ The figures are represented in Figure 9.ⁱⁱ

Figure 8: Percentage of Coral Cover 1960s – 2017



ⁱ Professor Hughes also indicated a figure of 30 per cent for 2016. I have assumed he was rounding up the official figure of 29 per cent, and I have used the latter.

ⁱⁱ A reduction in areal extent from 20 per cent to 14.2 per cent represents a reduction of 5.8 percentage points, and from 14.2 per cent to 11.5 per cent a further 2.7 percentage points, i.e. a total of 8.5 percentage points for those two years. The reduction of 8.5 per cent represents 17 per cent of the 1960s coverage, which was 50 per cent of the reef.

Due to their close proximity in terms of timing, it is possible that the 2016 and 2017 declines were both expressed as a percentage of the 2015 areal extent. That approach would accentuate the reduction, leaving 10.4 per cent in 2017 rather than the figure of 11.5 per cent indicated here. The figures will be amended if my assumptions are found to be incorrect. Either way, they would appear to represent reasonable approximations.

On the other hand, media outlets have reported that half the coral has been lost in the past two years. Clearly, a 50 per cent reduction using the 1960s base figure would not be possible when around 80 per cent of that base figure had already been lost by 2015.

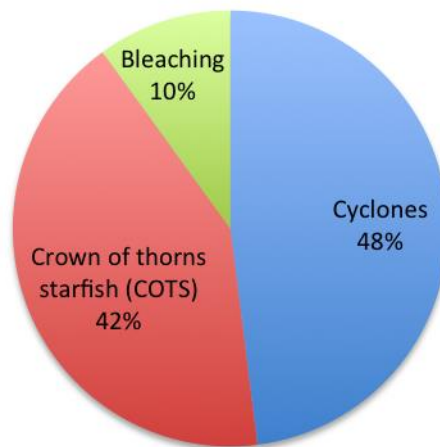
Ominous warnings have been issued in the recent past, including the following comment from AIMS and University of Wollongong researchers in 2012, as referred to earlier:

“ . . . coral cover on the GBR is consistently declining, and without intervention, it will likely fall to 5–10 per cent within the next 10 years.”

Causes of coral decline

In researching the causes of coral decline between 1985 and 2012, Dr Glenn De’ath and his co-authors (referred to earlier) assessed the relative contributions of tropical cyclones, crown-of-thorns starfish (COTS) and coral bleaching. Their results are shown in Figure 10.

Figure 9: Causes of GBR coral decline 1985 – 2012



In a profound indication of the relative impact of COTS predation, the researchers estimated that there would have been a net increase in average coral cover if such predation had not occurred, rather than their estimated reduction of 50.7 per cent.

Findings from Kate Osborne and fellow AIMS researchers in 2011 indicated there was no overall loss for the period 1995-2009, with loss in some areas and species offset by expansion in others.³⁸ However, in respect of those corals that did decline, they reported COTS as the major cause at 36.7 per cent compared to cyclones at 33.8 per cent, disease at 6.5 per cent, bleaching at 5.6 per cent, with the remainder comprising multiple or unknown causes.

Jon Brodie reported in 2012 that COTS were probably the major cause of coral mortality in the period from 1960 to 1985, but pointed out that available data for the period was incomplete.³⁹

Water quality has also been a major factor, as it affects the frequency of COTS outbreaks in the central and southern GBR.

Coral bleaching

Many types of coral have a symbiotic relationship with marine algae known as zooxanthellae that live inside their tissue. The zooxanthellae are efficient food producers that provide up to 90 per cent of the energy corals require to grow and reproduce. They also give coral much of its colour.^{40, 41}

When the relationship becomes stressed due to factors such as ocean temperature or pollution, the zooxanthellae leave the coral's tissue. Without the zooxanthellae, the tissue of the coral animal appears transparent and its bright white skeleton is revealed.

Without the zooxanthellae as a food source, corals generally begin to starve.

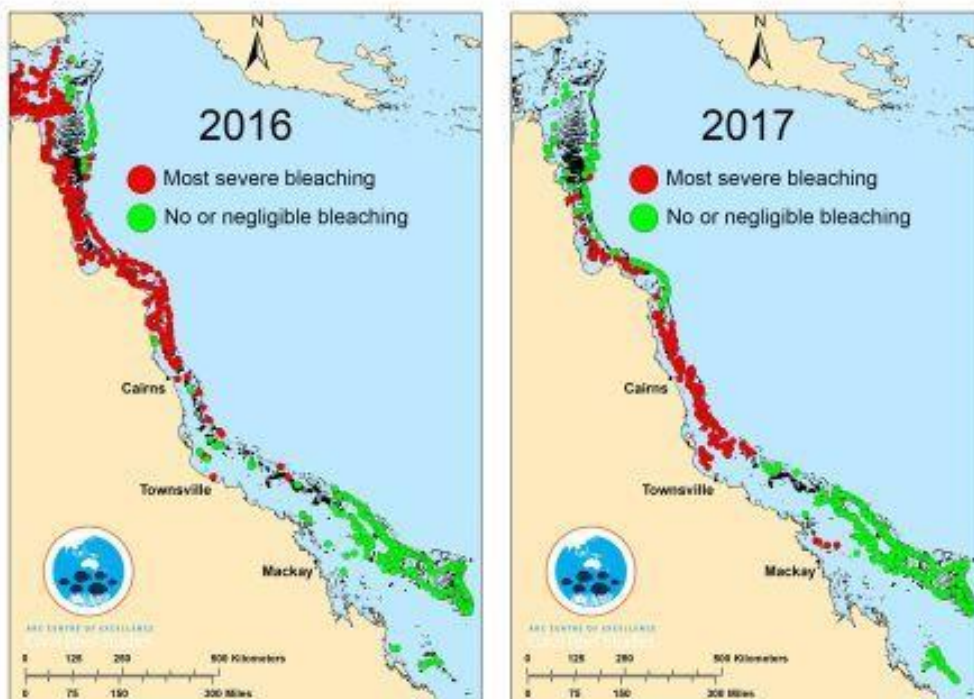
If conditions return to normal, corals can regain their zooxanthellae, return to their normal colour and survive. However, this stress is likely to cause decreased coral growth and reproduction, and increased susceptibility to disease. Bleached corals often die if the stress persists.

Rising sea temperature is the main cause of coral bleaching. Other stressors can also contribute to it but generally to a smaller extent. They include: tropical cyclones; freshwater inflows from flooding events (with low salinity); sedimentation; pollution from urban or agricultural run-off; over-exposure to sunlight; and disease.^{42, 43}

Major bleaching events have occurred on the GBR in 1998, 2002, 2016 and 2017.

Reefs can often recover from such events if given enough time, but two in quick succession in 2016 and 2017 may have caused permanent loss of large sections of the reef. The images in Figure 11, from the Australian Research Council Centre of Excellence for Coral Reef Studies, highlight the degree of impact of those two events.

Figure 10: Coral Bleaching Events 2016 and 2017



There is no doubt that coral bleaching is a critical, perhaps catastrophic, issue. Although De'ath et al. highlighted the need to improve water quality and develop relevant control measures, they stressed that such measures would only succeed if climatic conditions were stabilised, as losses from bleaching and cyclones will otherwise increase.

As a result, given the lack of meaningful response from so-called world leaders to the climate change threat, and taking into account the impact of other stressors that have destroyed much of the reef and weakened the resilience of much of the remaining coral, we may have lost the opportunity to save the reef.⁴⁴

Crown-of-thorns starfish (COTS)

COTS are marine invertebrates that occur naturally on reefs throughout the Indo-Pacific region, feeding exclusively on coral. Certain conditions enable them to reach plague proportions and devastate hard coral communities.

Figure 11: Crown-of-thorns starfish devouring coral off northern Queensland



The long-term monitoring program conducted by AIMS has shown that outbreaks have begun in the north and migrated southward, generally over periods of around 15 years, with ocean currents transporting larvae between reefs. There have been four major outbreaks on the Great Barrier Reef since the 1960s: in that decade itself; the late 1970s; the early 1990s; and 2010 (which is still under way).⁴⁵

De'ath et al. have reported that COTS were likely to have occurred every 50-80 years before European agricultural nutrient runoff commenced.

Healthy reefs generally recover between outbreaks, taking 10 to 20 years to do so. However, recovery takes longer on reefs that are affected by additional stresses, such as coral

bleaching, cyclones or poor water quality, so the coral may not fully recover before the next wave of outbreaks occurs.⁴⁶

Jon Brodie has stated “it is now well established” that the major COTS outbreaks since 1962 were most likely caused by nutrient enrichment associated with increased discharge of nitrogen and phosphorus from the land due to soil erosion and large scale fertiliser use. The nutrients promote phytoplankton growth suitable to COTS larvae.⁴⁷

The impact of livestock production within the reef’s catchment area is particularly relevant to the water quality issue (including sediment and nutrient discharge), as referred to later in this section.

Fishing also appears to be a major factor in relation to COTS outbreaks. In the mid-shelf region of the GBR, where most outbreaks occur, the frequency of outbreaks as of 2008 on reefs that were open to fishing had been 3.75 times higher than on those where it was prohibited. Although exploited fish species are unlikely to prey on COTS directly, changes in interactions between species at different positions in the food web may be the cause.⁴⁸

The impact of livestock production

AIMS has highlighted the fact that deterioration in coastal water quality has negatively affected the function, productivity and resilience of tropical marine ecosystems.

They have reported that the main coastal and marine water quality issues in northern Australia are: (a) increasing sediment, nutrients and contaminants entering coastal waters in runoff from agricultural, industrial and urban land uses (increasing five to nine fold from pre-European settlement); and (b) rising seawater temperatures and increasing seawater acidity associated with climate change.⁴⁹

Livestock production within the reef’s catchment has been a major factor in the release of sediment and nutrients. Eroded material, including nutrients, enters streams and rivers and is then carried to the coast, and from there to the Great Barrier Reef.

The Queensland Government’s 2013 Scientific Consensus Statement confirmed that grazing landscapes, primarily in the Fitzroy and Burdekin catchments, were responsible for 75 per cent of sediment, 54 per cent of phosphorous and 40 per cent of nitrogen in the reef’s waters.⁵⁰

The Great Barrier Reef Marine Park Authority has expressed its concern:⁵¹

“Most sediment entering the Great Barrier Reef comes from catchments in major pastoral areas such as the Burdekin, Herbert and Fitzroy rivers.”

“Changes in water quality affect the biodiversity and resilience of Reef systems. Higher concentrations of pollutants, such as suspended sediments, nitrogen and phosphorus, indicated by higher levels of chlorophyll and lower water clarity, leader [sic] to more algae and less coral diversity. In these conditions, algae take over and reduce the chances for new hard corals to establish and grow.”

A deleterious outcome of grazing and livestock-related land clearing is gully erosion.

The Victorian government has highlighted the role of those activities in gully erosion generally (with my underline):⁵²

“Under natural conditions, run-off is moderated by vegetation which generally holds the soil together, protecting it from excessive run-off and direct rainfall.

Excessive clearing, inappropriate land use and compaction of the soil caused by grazing often means the soil is left exposed and unable to absorb excess water. Surface run-off then increases and concentrates in drainage lines, allowing gully erosion to develop in susceptible areas.”

Soils with dispersible subsoils are very common in Queensland and are vulnerable to gully erosion when the shallow layer of relatively stable top soil is disturbed. As water penetrates through early-stage erosion (referred to as rill erosion up to 30 centimetres deep), the subsoil is dispersed, leaving the topsoil unsupported. The topsoil then collapses and the process is repeated.

From that stage, even with little or no surface flow, the gully walls can become saturated, causing them to slump and the gully to expand. The Queensland government has likened the process at that point to digging a hole to the depth of the water table at the beach, with the hole expanding as the sides slump away.⁵³

The underlying rock will often limit gully depth to around two metres, but they can be as deep as fifteen metres in alluvial and colluvial soils.

To a large extent the damage has been done and is continuing in other areas, with potential to expand elsewhere as more land is cleared for cattle.

The Queensland government’s most recent Reef Water Quality Protection Plan scored graziers’ response to the calamity a “D” for “poor”.⁵⁴

In any event, it is estimated that expenditure ranging from \$5.3 billion to \$18.4 billion (most likely \$7.8 billion) would be required to reduce sediment flow by 50 per cent, which is a target established under the Australian and Queensland governments’ Reef 2050 Long-Term Sustainability Plan.⁵⁵

Figure 12: Gully erosion on cattle property in northern Queensland



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Stream bank erosion has also significantly increased sediment discharge to the reef. Here are some thoughts from the Queensland government on that issue (with my underline):⁵⁶

“The major cause of stream bank erosion is the destruction of vegetation on river banks (generally by clearing, overgrazing, cultivation, vehicle traffic up and down banks or fire) and the removal of sand and gravel from the stream bed.”

In commenting on the need to improve water quality, journalist Calla Walquist recently indicated in *The Guardian* that Jon Brodie had recommended a shift from sugar cane production in the reef’s catchment to cattle grazing.⁵⁷

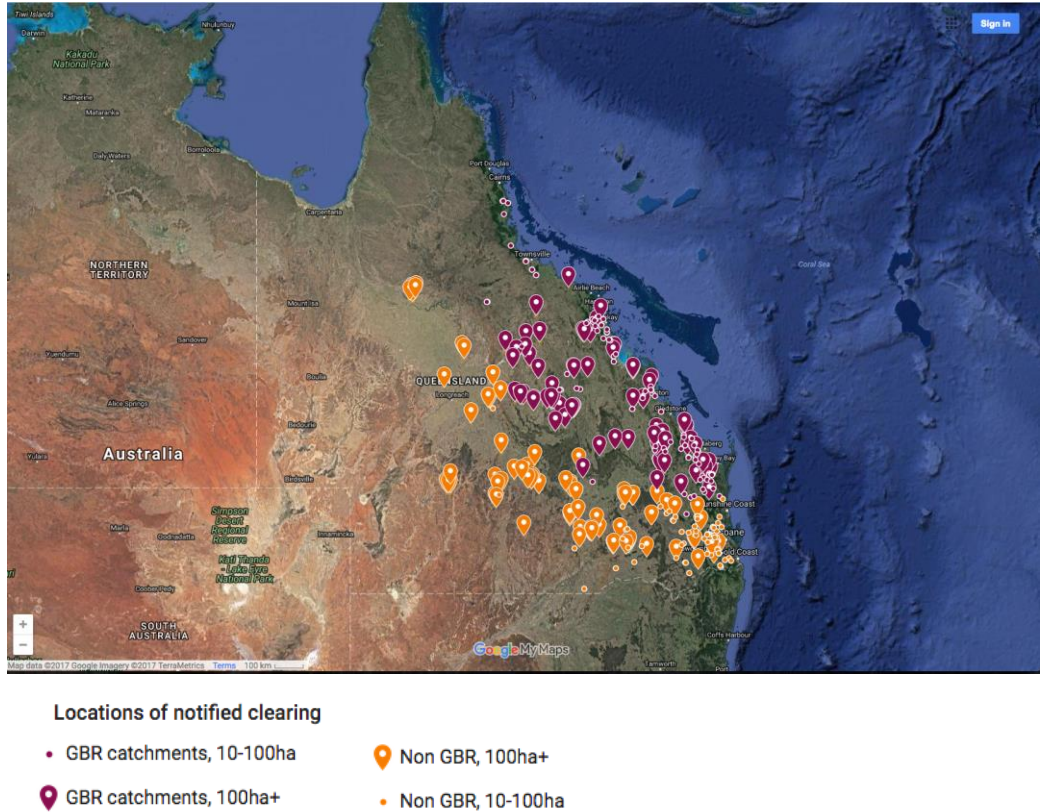
She neglected to say that it is only in the areas where sugarcane is grown that beef grazing would have little impact. Erosion is low in those areas due to high rainfall and extensive vegetation cover, with minimal use of fertilisers and pesticides. Cattle grazing on the large, low rangelands in the Burdekin and Fitzroy catchments, with variable rainfall, is responsible for greatly increased erosion and sediment delivery to the GBR.⁵⁸

Professor Brodie has previously reported that cattle grazing for beef production is the largest single land use in the reef’s catchment area, with cropping (mainly of sugarcane) and urban/residential development “considerably less in areal extent”.⁵⁹ As a result, the scope for transitioning from sugarcane production to cattle grazing may be limited.

The WWF report on Queensland land clearing referred to in the previous section included the following map, showing notifications of 10 hectares or more under the self-assessable codes from the end of July 2016 to February 2017. Those marked in purple are within the Great Barrier Reef catchment. The smaller icons indicate notifications of 1-10 hectares, while

larger icons indicate notifications of more than 100 hectares. After adjusting for anomalies in the data, WWF reported that notifications jumped fifty per cent from January to February 2017.

Figure 13: Land clearing notifications in Queensland Jul 2016 – Feb 2017



Beef versus tourism

As referred to elsewhere in this paper, the environmental cost of beef production is not adequately allowed for in the price paid by the end user.

The current, low-price arrangements may soon come at the expense of the tourism industry as the GBR deteriorates further. In Queensland alone, the industry generates revenues of nearly \$23 billion and supports nearly 220,000 jobs directly and indirectly. With 42 per cent of international visitors ranking the reef as the most appealing tourist attraction in Australia, it is also a significant factor in the tourism industry nationally, for which the corresponding figures are \$98 billion and 922,000.^{60, 61, 62}

By comparison, the beef industry generated less than \$18 billion in revenues nationally in 2015/16 (less than tourism in Queensland alone), including \$10 billion of exports, with 200,000 people employed (also less than tourism in Queensland), including on-farm production, processing and retail.⁶³

Concluding comments on the reef

In Australia (as stated in the Introduction), criticising the traditional meat-based barbecue may be considered a form of heresy, despite meat consumption being a key factor in the

destruction of a global treasure and critical economic asset in the form of the GBR. Indeed, even without climate change, the reef's demise may have been assured due to decades of relentless sediment and nutrient pollution from grazing and other properties within the reef's catchment.

Using the phrase "death by a thousand cuts", Professor Terry Hughes (referred to earlier) and co-authors of a paper that appeared in the June 2017 issue of Nature highlighted the need to consider the interaction between multiple factors contributing to the deterioration of coral reefs. They referred to models indicating that "synergistic human impacts can reduce resilience and cause unexpected ecological collapse, even when individual drivers or stressors remain at levels that are considered to be safe".

Even if we focus solely on climate change, the livestock sector is a key driver, as demonstrated elsewhere in this paper.

To the extent that we have any chance of saving the reef, it is critical that prominent individuals and groups campaigning for that purpose communicate honestly about the factors that are contributing to its parlous state.

5. SOME LINKS BETWEEN CLIMATE CHANGE AND CONSUMPTION OF SEA ANIMALS

A September, 2015 paper published in Nature Climate Change highlighted some of the impact of industrial and non-industrial fishing on our climate system.⁶⁴ 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 City of Darebin has expressed concern in its draft climate emergency plan about the impact of climate change on mangrove forests, but may be unaware of the impact of fishing.

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.

6. HEALTH AND NUTRITION

Plant-based food options are extremely nutritious, as demonstrated in part by the following protein figures from the USDA:⁶⁵

Figure 14: Protein content of various foods (grams per kilogram)

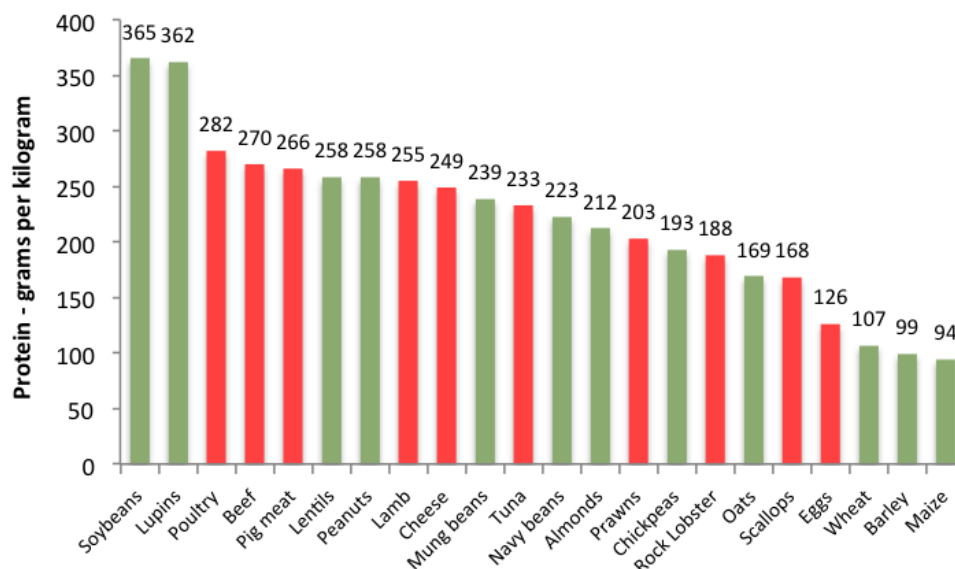
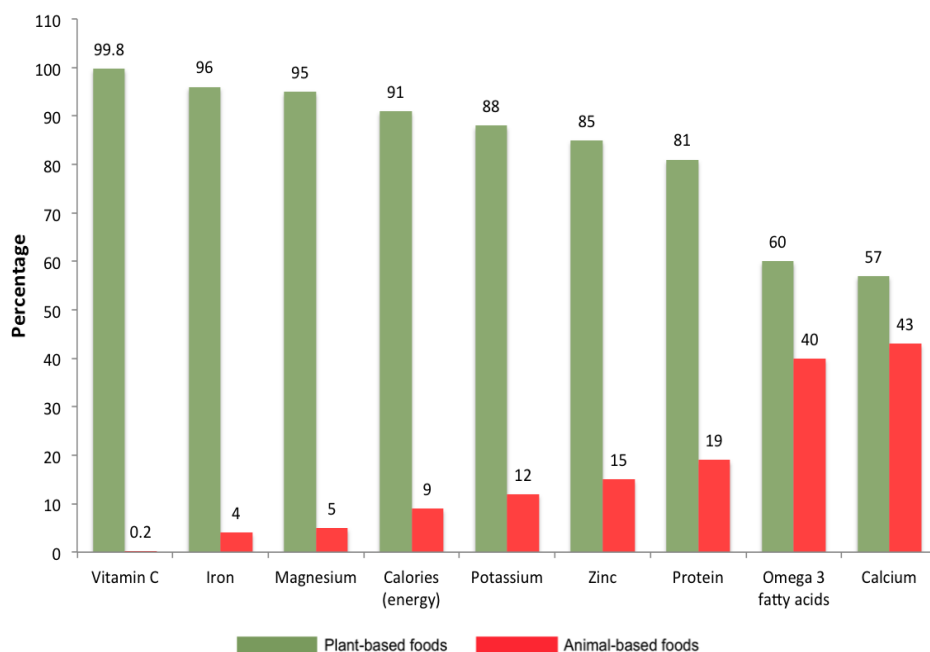


Figure 16 shows that 81 per cent of protein produced in Australia in 2011/12 came from plants, and only 19 per cent from animals.

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 15: 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";⁶⁶ and (b) nutritional information for each product from the United States Department of Agriculture's (USDA) *National Nutrient Database for Standard Reference*.⁶⁷

The American Dietetic Association has said:⁶⁸

"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 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).⁶⁹

"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."

An April 2016 study by researchers from the Oxford Martin School (University of Oxford) reported on the health and climate change benefits of changing diets, including reduced consumption of animal products.⁷⁰ The researchers estimated that if the global population were to adopt a vegetarian diet, 7.3 million lives per year would be saved by 2050. If a vegan diet were adopted, the figure would be 8.1 million per year.

More than half the avoided deaths would be due to reduced red meat consumption. (The health organisations classify pig meat as red meat.) The results primarily reflect anticipated reductions in the rate of coronary heart disease, stroke, cancer, and type 2 diabetes.

7. SOCIAL JUSTICE

The City of Darebin has a proud history of social justice.

As referred to earlier in this paper, the Institute on the Environment at the University of Minnesota has estimated that we would have the capacity to feed another four billion people by converting crops from animal feed and biofuels to food for human consumption. They were not suggesting that we should aim for that level of population increase, but were highlighting the current impact of animal-based food production.⁷¹

As mentioned, animal feed crops represent 90% of the estimated figure (in turn representing 3.6 billion people), and biofuels only 10%.

The FAO estimates that around 795 million people were chronically under-nourished in the period 2014-2016.⁷²

And let's not forget the animals themselves. We currently breed and slaughter around 70 billion land animals annually, compared to a human population of around 7.4 billion.⁷³ The livestock reproduction rate is significantly above natural levels, and involves abuse and confinement on a massive scale, even for so-called "free range" systems.

In Australia and elsewhere, animal cruelty has been legalised by way of exemptions to so-called "prevention of cruelty to animals" legislation in favour of livestock and other industries.

Former president of Ireland and UN High Commissioner for Human Rights, Mary Robinson, has recently called for those who care about climate change to stop eating animals and animal-based products.⁷⁴



Here is some of what she said:

“We have to change, we cannot go on with business as usual. We need each of us to think about our carbon footprint. Eat less meat, or no meat at all. Become vegetarian or vegan.”

Mrs Robinson was speaking at the “One Young World Summit” in Ottawa, Canada in September 2016, attended by young leaders from 196 nations.

8. ENGAGING WITH THE COMMUNITY AND ADVOCATING TO STATE AND FEDERAL GOVERNMENTS

The City of Darebin's engagement with the local community should include an education and awareness in relation to the impact of animal agriculture.

However, we must be careful not to direct all blame and responsibility toward individuals. In the words of professor of social sciences at Yale-NUC College Singapore, Michael Maniates:⁷⁵

“A privatization and individualization of responsibility for environmental problems shifts blame from state elites and powerful producer groups to more amorphous culprits like ‘human nature’ or ‘all of us’.”

For that reason, governments have critical role to play. The beef industry is a good example of where more needs to be done.

Two-thirds of Australia's beef was exported in 2012-2013, with the figure likely to have grown since then due to an expansion of the China-Australia Free Trade Agreement (ChAFTA).^{76, 77} As a result, modification of diet by the nation's residents will not be enough to adequately reduce beef production's negative impacts.

At present, the environmental cost of beef production is not adequately allowed for in the price paid by the end user. Consequently, beef producers are effectively subsidised, while consumers in Australia, China and elsewhere are paying artificially low prices with no effective price signal encouraging them to purchase products with less environmental impact.

The words of CSIRO researcher, Dr Barney Foran, come to mind:⁷⁸

“We should be paying more for products that have a high environmental account balance. The consumer should be expected to pay a realistic price for food so that we play a part in fixing up the bush, instead of sitting in town and wringing our hands about it.”

We must decide if we wish to support environmentally destructive industries at the expense of: (a) our natural environment; (b) other industries such as tourism that will suffer as it deteriorates further; and (c) a safe climate.

9. CONCLUSION

With no time to waste if we are to have any chance of overcoming the climate crisis, it is imperative that we use all tools at our disposal in our efforts to do so.

The issue of food consumption and production offers one such tool, with some elements providing rapid benefits that would increase our chances of avoiding tipping points and runaway climate change.

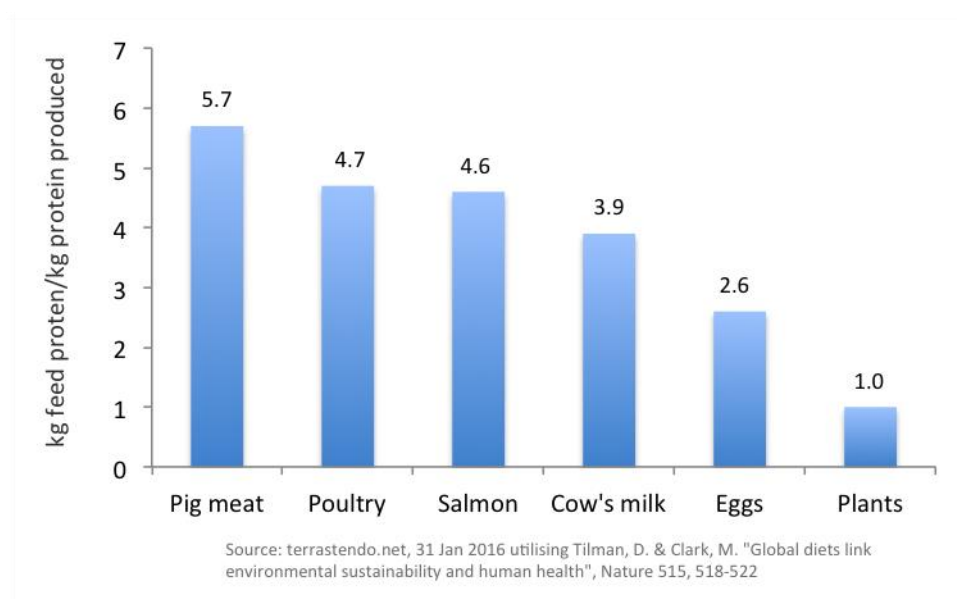
I trust this document is taken into account by the City of Darebin in finalising its emergency plan, ultimately improving our ability to respond to the existential threat of climate change.

Supplement: Additional comments on pig meat, poultry, fish, egg and dairy products

The inherent inefficiency of all animal-based food products means we require far more resources, including land, than with plant-based options. That creates grave risks for what are currently carbon sinks, such as the Amazon rainforest. With no buffer in our need to deal with the climate crisis, we must use every mitigation opportunity available, including revegetation and avoidance of further land clearing.

The point is highlighted by the fact that we need many kilograms of plant-based protein to produce one kilogram of the animal-based variety, as shown in Figure S.1.^{79, iii}

Figure S.1: Feed conversion ratios



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.⁸⁰

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 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.

ⁱⁱⁱ The feed conversion ratio for beef (not shown in the chart) is 20.

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