

How to make the dairy farm more Carbon Neutral

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What is Carbon Farming?

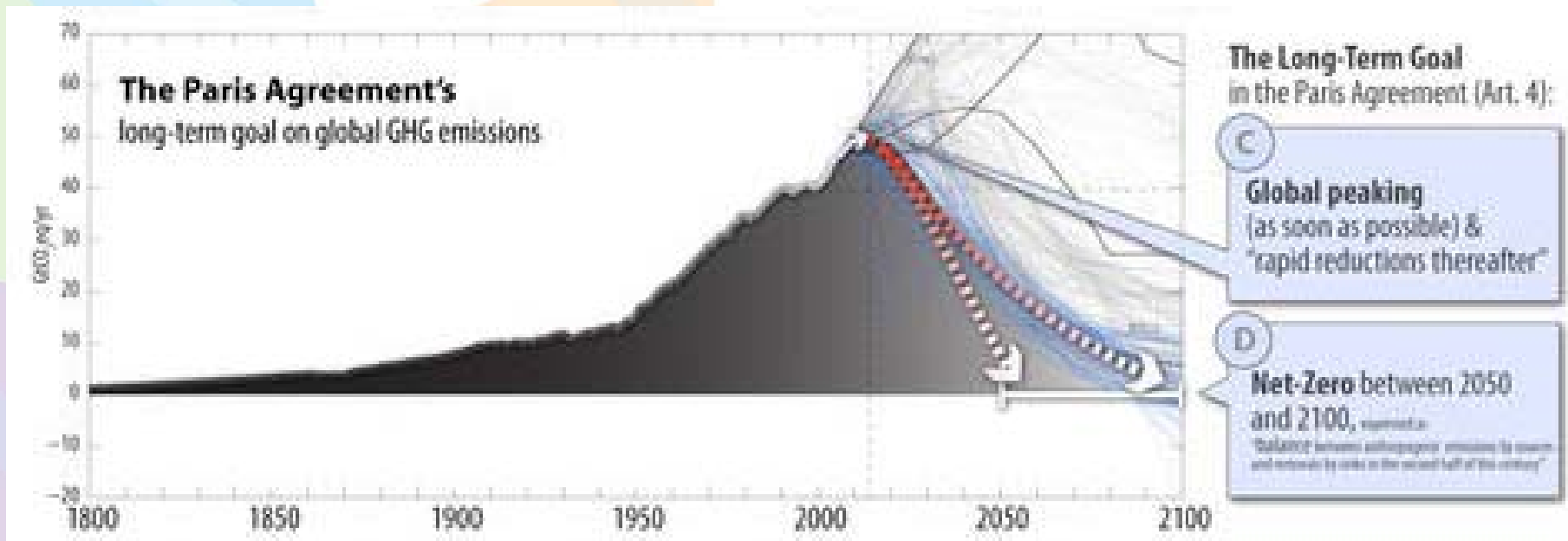
- Carbon Farming
 - Management principles that minimise GHGe, maximise carbon sequestration in the landscape, while improving the productivity and resilience of agricultural systems
 - Term not (yet) owned by a particular lobby group
 - Has bipartisan support in Australia
- Carbon Neutral
 - Management that minimises GHGe, and offsets the balance of emissions through sequestration of an equivalent amount of carbon dioxide in soils or vegetation
 - On an year-by-year basis
 - On net GHG cradle to farm-gate basis (LCA)



Why Carbon Neutral?

COP21 Paris Agreement

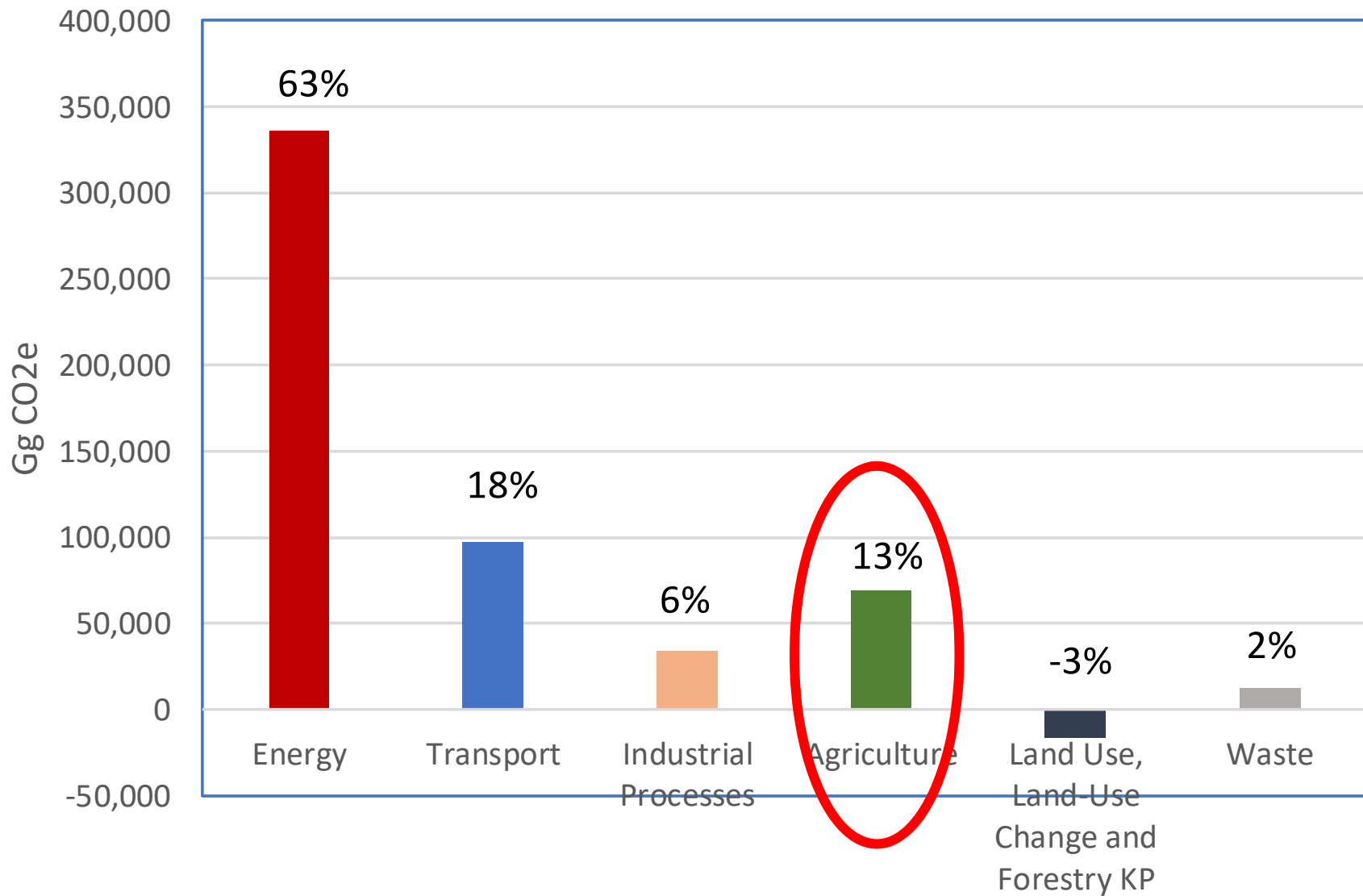
- Net zero emissions from 2050
 - Any remaining GHG emissions need to be offset
 - Business and governments are aiming to comply





Why Carbon Neutral?

Australian National Emissions

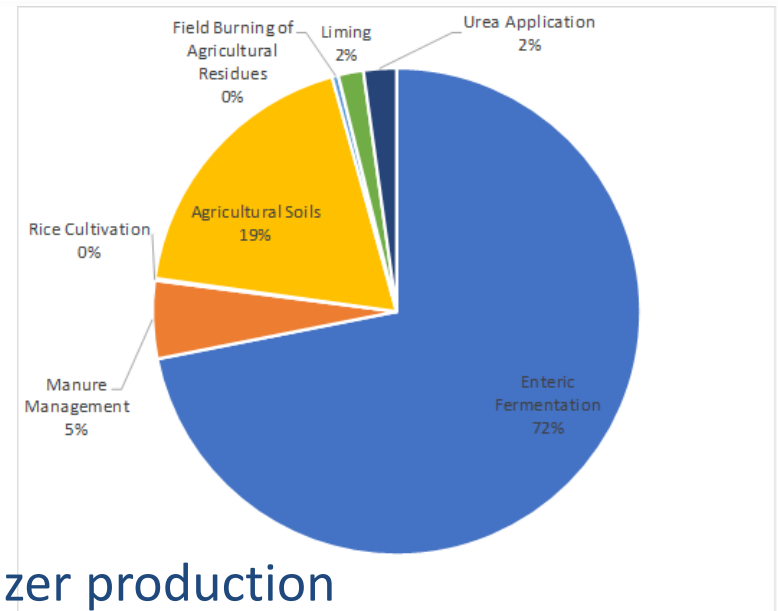




Why Carbon Neutral?

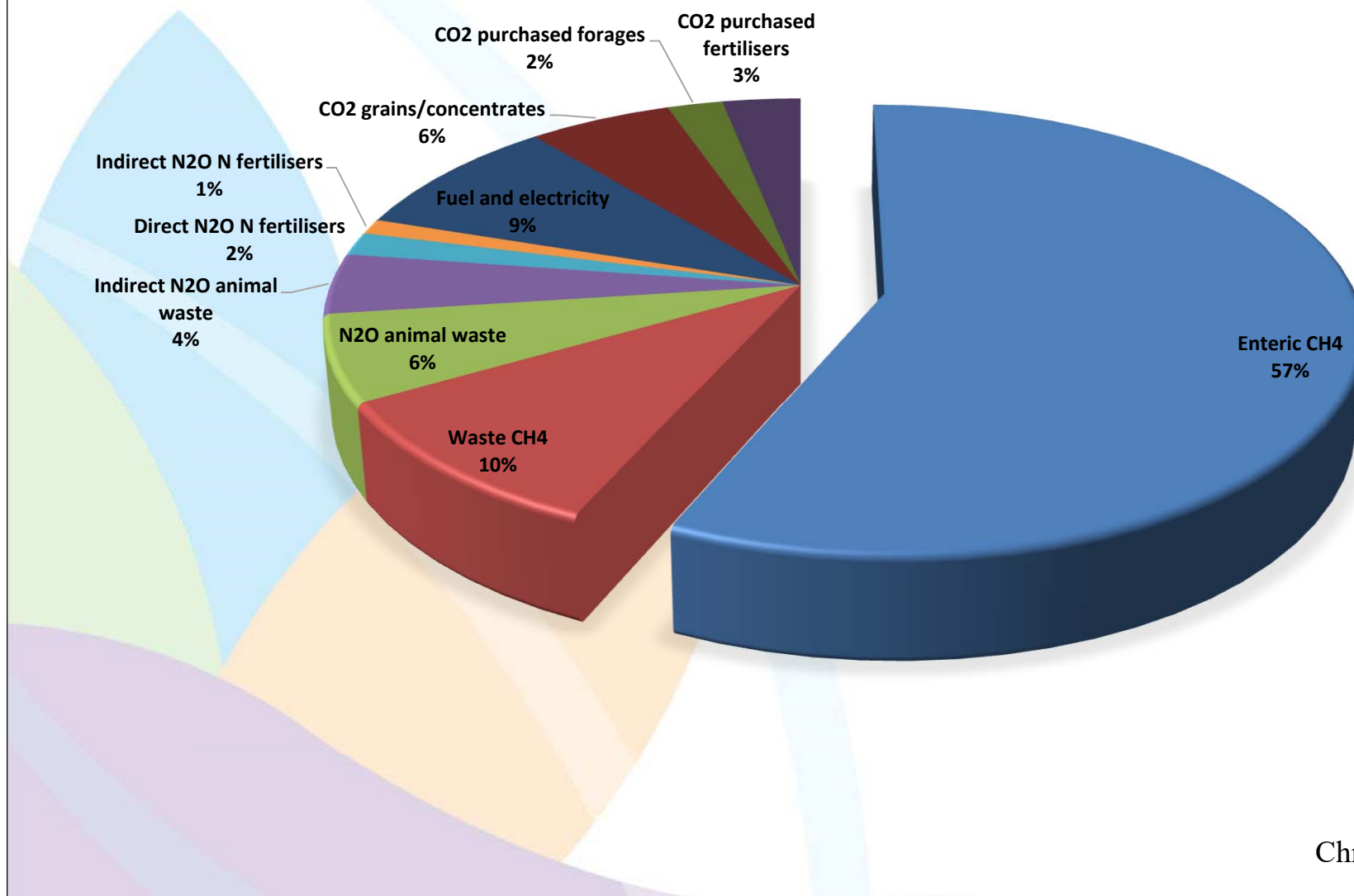
Agricultural emissions

- Methane
 - Ruminants, waste management
- Nitrous Oxide
 - Fertilizer, excreta, waste, legumes etc.
- Carbon Dioxide
 - Energy, lime, urea application and fertilizer production
- But agricultural land also has the capacity to sequester CO₂ in the soil and into trees





Typical Dairy Farm Emissions





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Investors responses

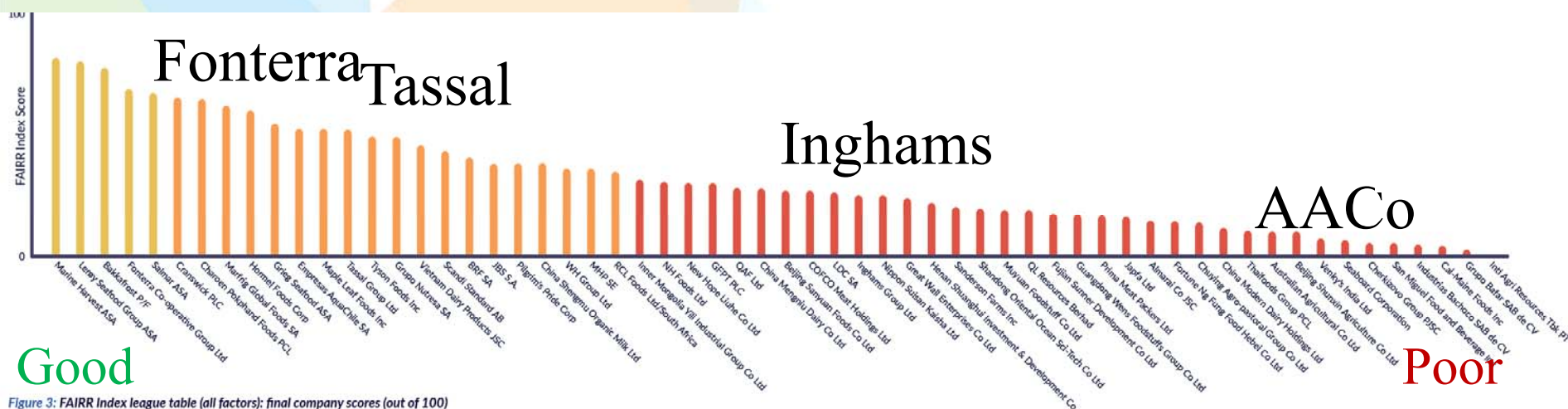
FAIRR FARM ANIMAL
INVESTMENT
RISK & RETURN
A COLLIER INITIATIVE

Coller FAIRR Protein Producer Index Report

Benchmarking intensive livestock and fish farming
on environmental, social and governance issues

FAIRR - an index to analyse livestock production
against the Sustainable Development Goals
(SDGs).

*A resource for institutional investors on risk of
investment in livestock.*





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Supply chain responses

- Fonterra
 - Climate-neutral growth to 2030 for pre-farmgate emissions from a 2015 base year
- Unilever
 - Reducing the GHG impact of their products by 50% by 2030, compared to baseline of 2010
- Mondelez
 - Reduce absolute GHG from manufacturing 15%
 - 100% renewable energy
- Nestle
 - Zero environmental impact in our operations
- Mars
 - Reduce GHG across our value chain 27% by 2025 and 67% by 2050 (from 2015 levels)
- Kellogg Company
 - 65% reduction by 2050
 - 100% renewable energy
- Pfizer
 - 60 to 80% by 2050
- Wilmar international
 - 89.72% less GHG from 2013 to 2020
 - 100% renewable energy
- Olam
 - Reduce GHGs by 50% by 2030 both in our own operations and in our supply chain
 - By 2050, we aspire to be carbon positive in operations, requiring a 5% emissions reduction per year from 2031 – 2050
- **All responding to the Paris 2050 neutral target**
- **Of the 100 largest economies 69 are companies and 31 are countries**
 - Government policy may now be less influential than market forces

(Unilever 2010; Fonterra 2017)

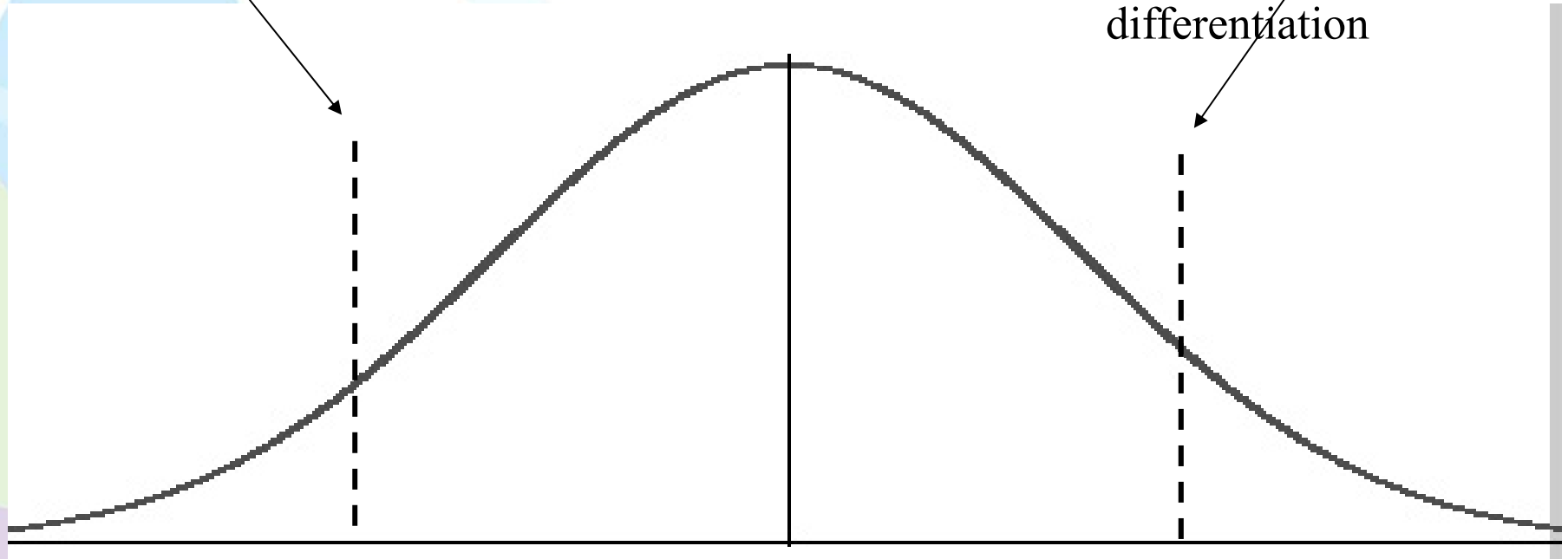


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Government vs industry

Where government
policy typically
operates – picking
up the laggards

Where industry
policy typically
operates – leading
the way for market
differentiation



Of the 100 largest economies 69 are companies and 31 are countries
Government policy may now be less influential than market forces



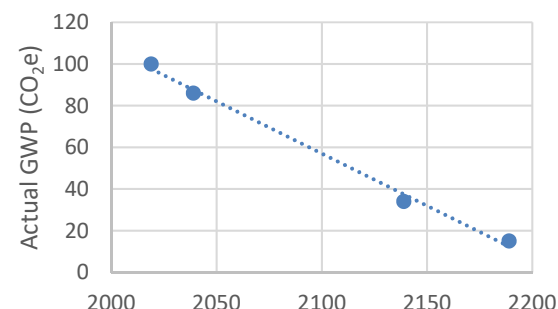
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Livestock Industry Responses

- Meat and Livestock Australia
 - Australian beef can be carbon neutral by 2030 (CN30)
 - *Given the right industry, R&D and policy settings*
- Mato Grosso do Sul (MS), Brazil
 - “MS carbon neutral” initiative
 - Including livestock
 - Carbon neutral Brazilian Beef
- New Zealand
 - Proposed Zero Carbon Bill
 - Net zero by 2050 – long lived gasses
 - Includes agriculture
 - Livestock methane target
 - 10% by 2030 and 24% - 47% by 2050 (over 2017)



Methane actual warming





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Potential impact on dairy

- Danone purchased SILK/Whitewave (2017)
 - \$12.5B Silk brands
 - Fastest growing US food and beverage company
 - 19% annual compound ground 2012 – 2015
 - Total milk sales in US declined 13% (2010-2015)
 - Plant based milks growing at 11% and organic milk at 23%
 - Danone media quotes:
 - “Accelerate our towards **sustainable** and profitable growth”
 - “Healthier and more **sustainable** eating”
 - Code for lower emissions





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Carbon Neutral Livestock

- Rapidly rising interest in Australia
 - Arcadian Organic & Natural's Meat Co's
 - 100% carbon neutral across its entire supply chain
 - Purchasing carbon credits
 - NAPCO
 - Five Founders beef brand – carbon neutral hoofprint
 - Purchasing carbon offsets
 - Flinders + Co Meats
 - Carbon neutral wholesale/distribution activities
- Regular carbon audits requested
 - Large corporates to family farms
- Major supermarkets - carbon neutral groceries
 - At 70c/week





Carbon Neutral vs Carbon Account

- Carbon account (CA)
 - (t CO₂e)
 - All GHG emissions arising within the operational and organisational boundary of the farm enterprise.
 - Scope 1 (*direct*) emissions and sources of sequestration.
 - Scope 2 (*indirect*) emissions from electricity
 - **Not** scope 3 (*downstream*) emissions
- Carbon footprint (CF)
 - (t CO₂e/t product)
 - Life cycle of all products produced
 - Includes pre-farm emissions from purchases and livestock

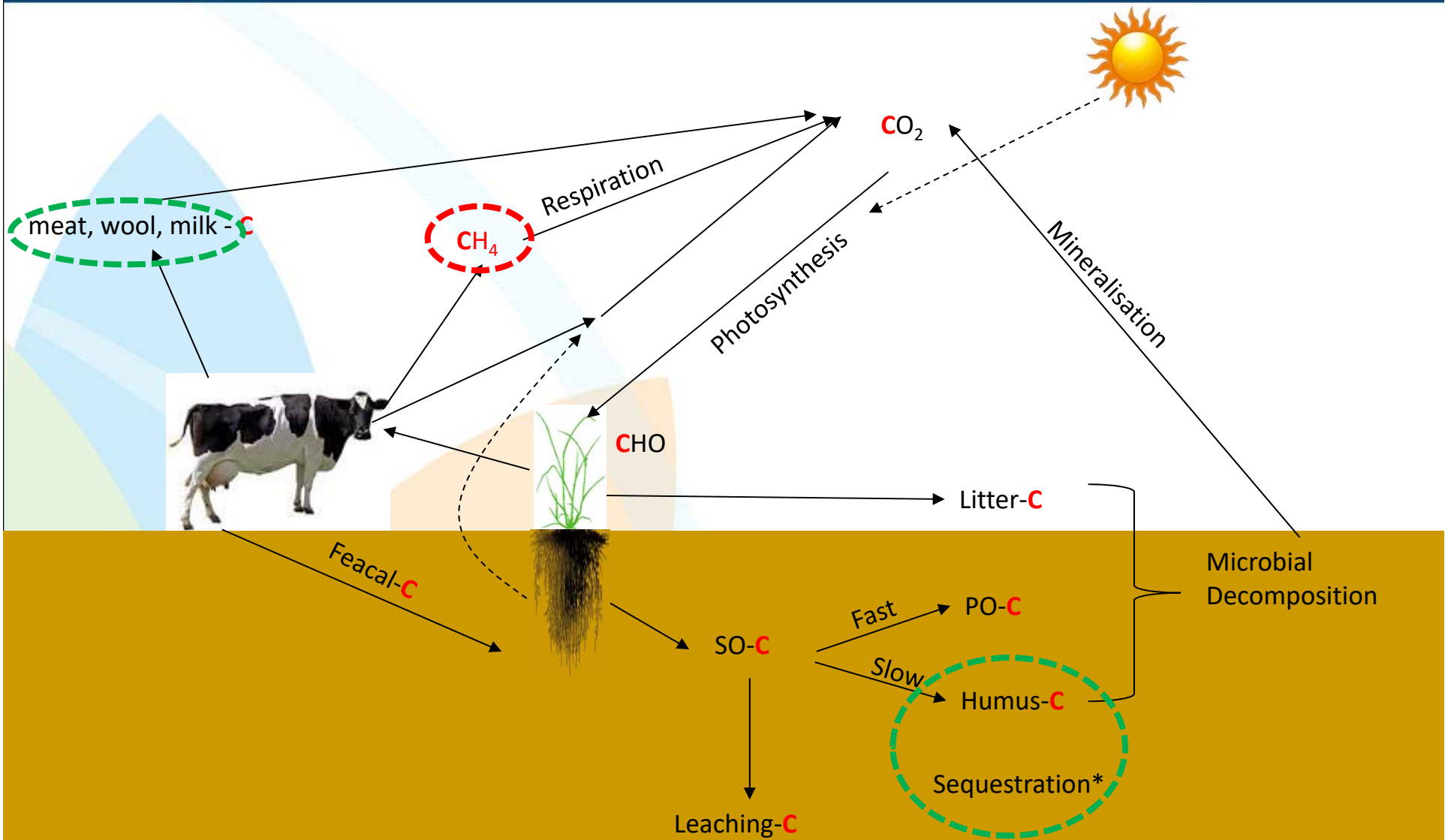


Why Carbon Farming?

- Common efficiency metrics
 - Nitrogen use efficiency
 - Water use efficiency
 - Energy use efficiency
- Why not “Carbon Use Efficiency”?
 - Atmospheric C (CO_2) -> Plants
 - CHO and protein = 43-48%
 - Plant C -> Animals
 - Proteins, carbohydrates, lipids, and nucleic acids (~23%)
 - Plant C -> Soil
 - Soil organic carbon
 - Energy efficiency



The Carbon Cycle in livestock

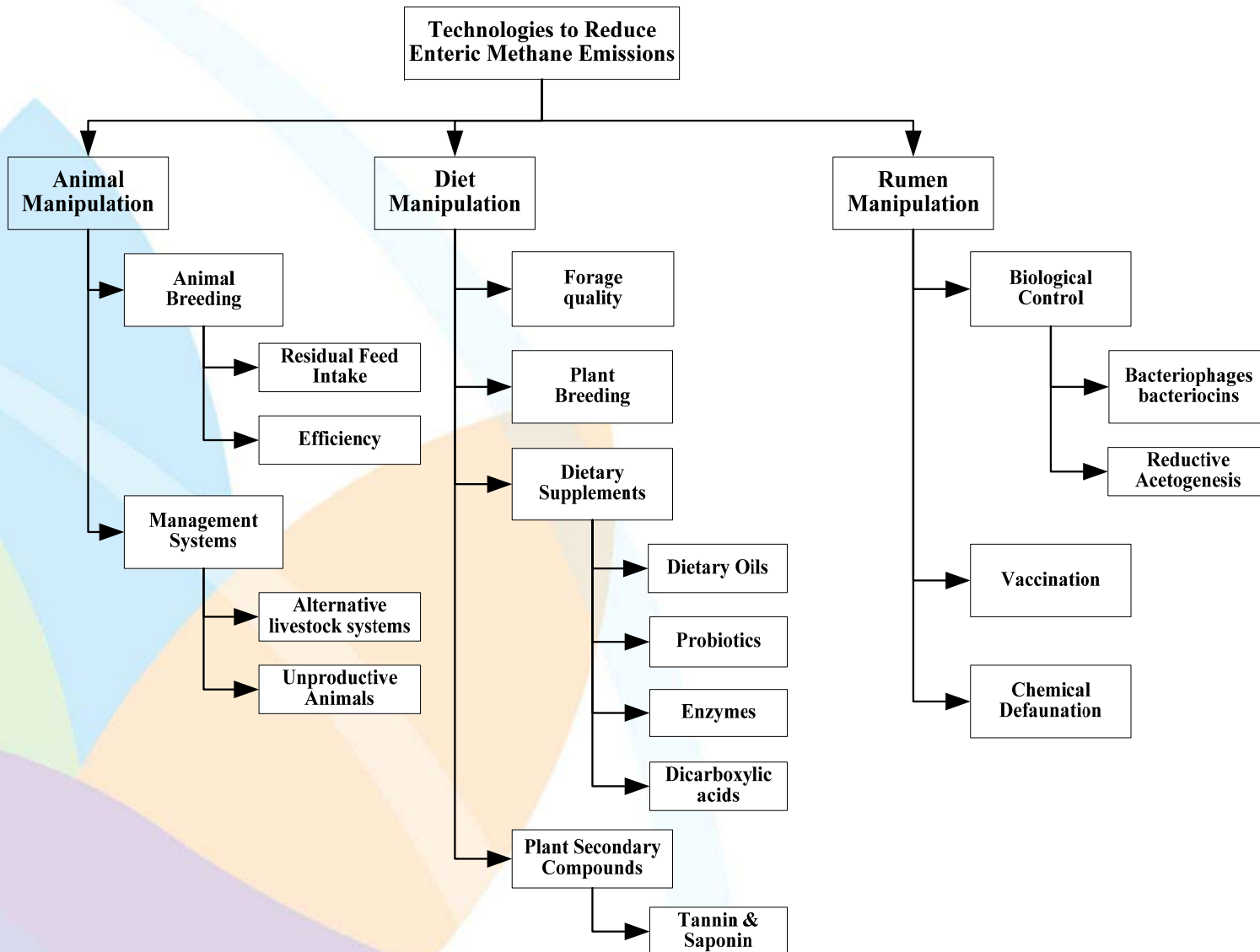


~Half of all products/compounds in farming is carbon

What can be done on farm now?

Methane

Methane from animal production

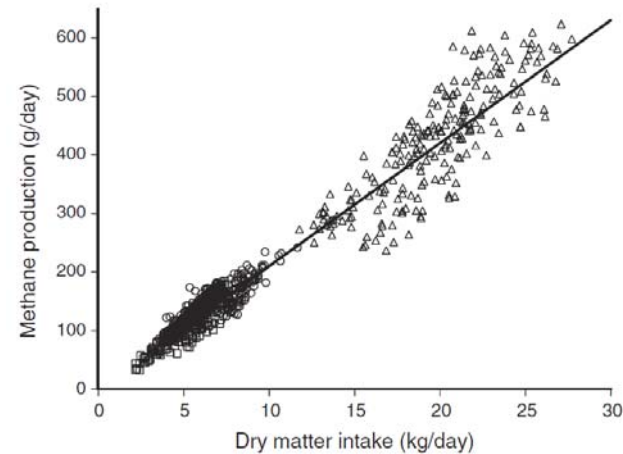




Factors affecting enteric methane loss

- Rumen passage rate
 - More/less time producing methane
- Forage quality
 - Faster digestion
- Rumen pH
 - More acid less CH₄
- Secondary compounds
 - Tannins (legumes), saponins, oils (by products)
- Direct inhibitors and vaccines

$$\text{Methane (g/day)} = 20.7 \times \text{kg DMI /day}$$

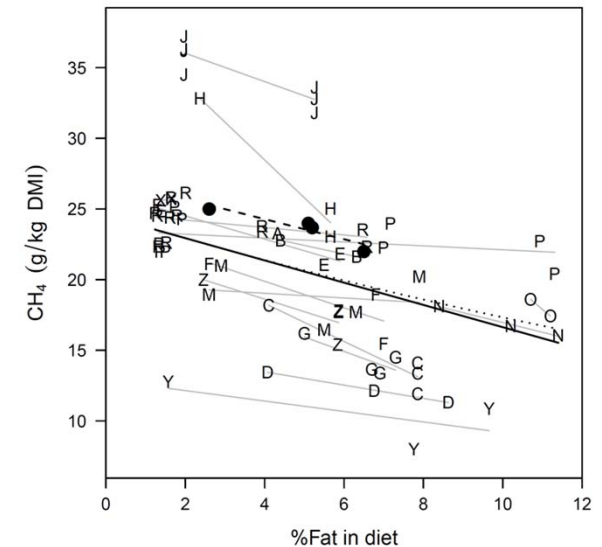




Solutions to enteric methane

Dietary supplements

- Lipids/Oils (~20%)
 - 1% added fat = 3.5% less CH₄
- Tannin (>20%)
 - e.g. Forage legumes
- Grape marc (~20%)
 - Oil and tannin
 - Cottonseed oil (14%) + tannin (11%)
 - Rapid adoption in feedlots



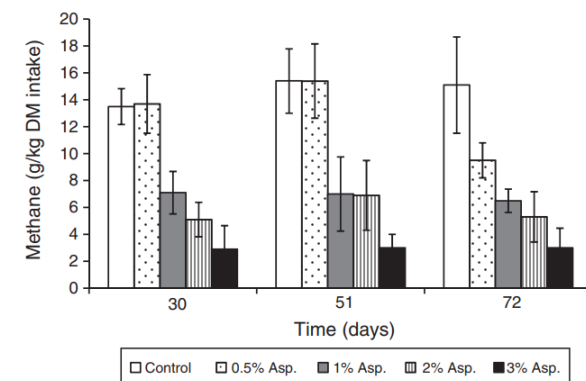
Grainger et al. (2009); Moate et al. (2011; 2014; 2016); Williams et al. (2019)



Solutions to enteric methane

Dietary supplements

- *Asparagopsis taxiformis*/ Red Algae (>80%)
 - >90% less *in vitro* CH₄
 - >80% less *in vivo* CH₄ (sheep)
- Bromoform halogenated compounds?
- Research has demonstrated significant mitigation is possible



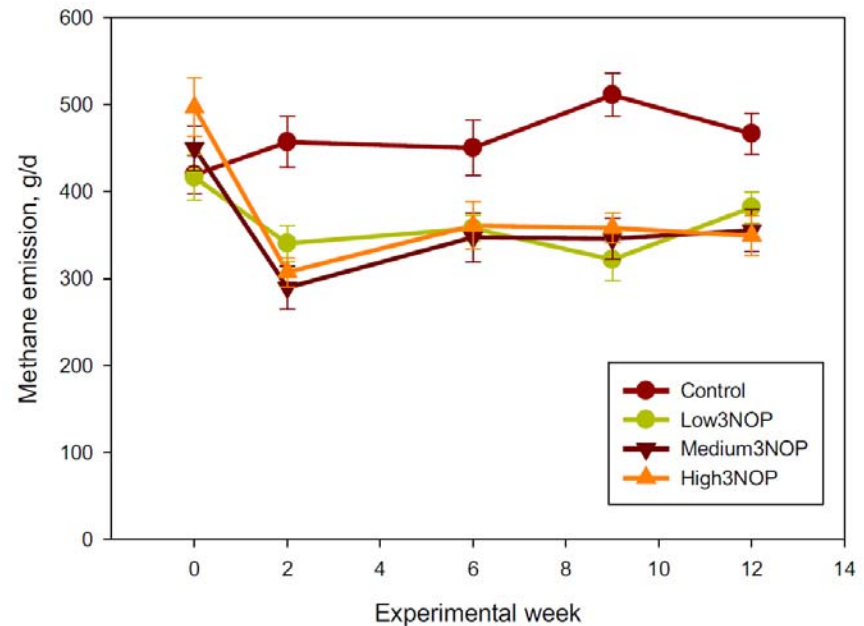
Van Nevel and Demeyer (1996); Machado et al. (2014); Li et al. (2018); Eckard and Clark (2018); Li *et al.* (2018)



Solutions to enteric methane

Rumen manipulation

- 3-nitrooxypropanol (3-NOP)
 - Inhibitor of methanogenesis
 - *In vitro* (85-96%)
 - *In vivo* (30-42%)
 - Cost?
 - 180 mg/cow/d at peak
 - 350 g/day for 200 cows
 - \$12-18/kg at @\$12/t CO₂e carbon price
 - \$5/day for 200 cows?
 - Controlled release technology in development



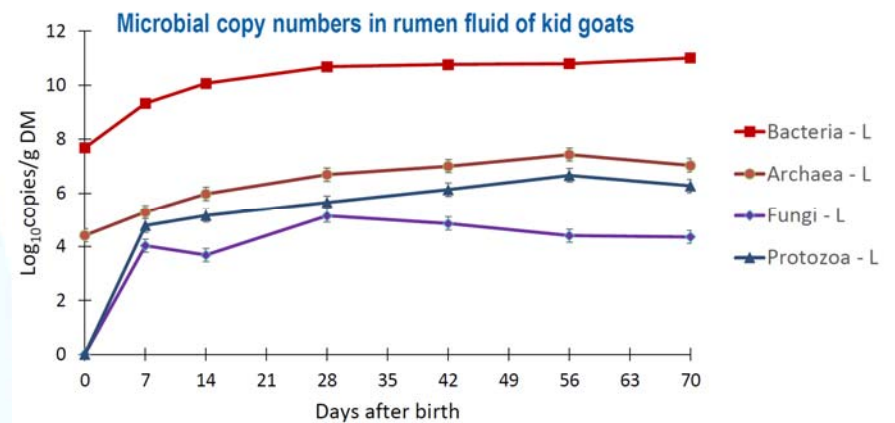
Hristov et al. (2015)



Solutions to enteric methane

Rumen manipulation

- Early life programming
 - Maternal influence on microbial community structure post-weaning
 - Nutritional intervention in early life =>
 - Modified structure of the archaeal community
 - Holds potential for
 - Low-cost, intergenerational, sustainable solution
 - No conclusive results yet
 - Potential mitigation unknown

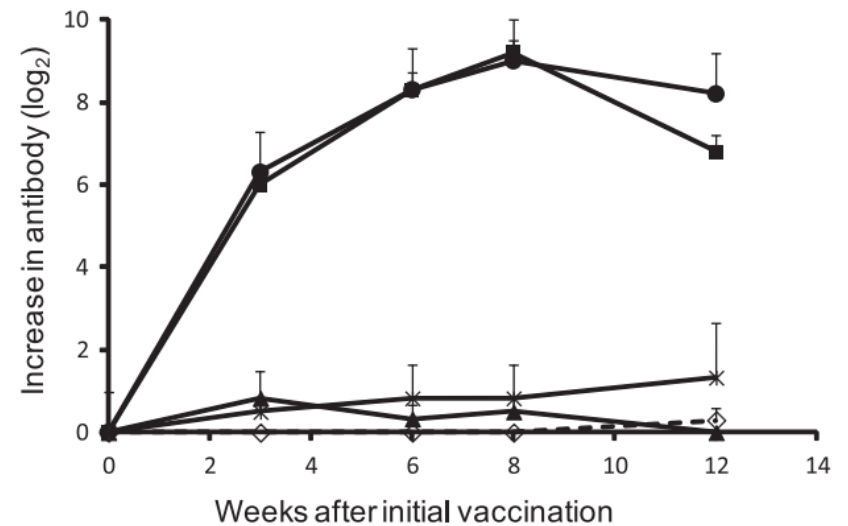




Solutions to enteric methane

Rumen manipulation

- Vaccine (20%?)
 - Methanogen surface proteins have been shown to be immunogenic in ruminants
 - Saliva antibodies shown in sufficient quantities
 - Ultimate CH_4 impacts still unclear
 - Important potential longer-term



Wedlock et al. (2013); Eckard & Clark (2018)



Solutions to enteric methane

Low emitting feeds

- Forage rape & fodder beet (18% less CH₄)
 - 20 to 50% of diet
- High sugar and high lipid ryegrass (?%)
 - No published evidence as yet
 - Less clear for high sugar, than high-lipid ryegrass



Sun et al. (2015); Jonker et al. (2017; 2018)



Solutions to enteric methane

Animal Breeding

- Breed for lower methane /kg DMI
 - Genomic markers developed for sheep
 - Heritability in cattle ($h=0.2$)
 - Could be related to passage rate or smaller rumen
 - Potential longer-term (5 to 10%)
 - Gains around 1% per year
 - Low incentive for adoption
 - Compatibility with other traits?
- Breed for increase FCE?
 - Less DMI for the same production (thus less CH_4)
 - More consistent with other productivity traits?





Solutions to enteric methane

Animal manipulation

- Animal and herd management
 - Reducing unproductive animals
 - Health and management
 - Extending lactation
 - Changing the effective replacement rate



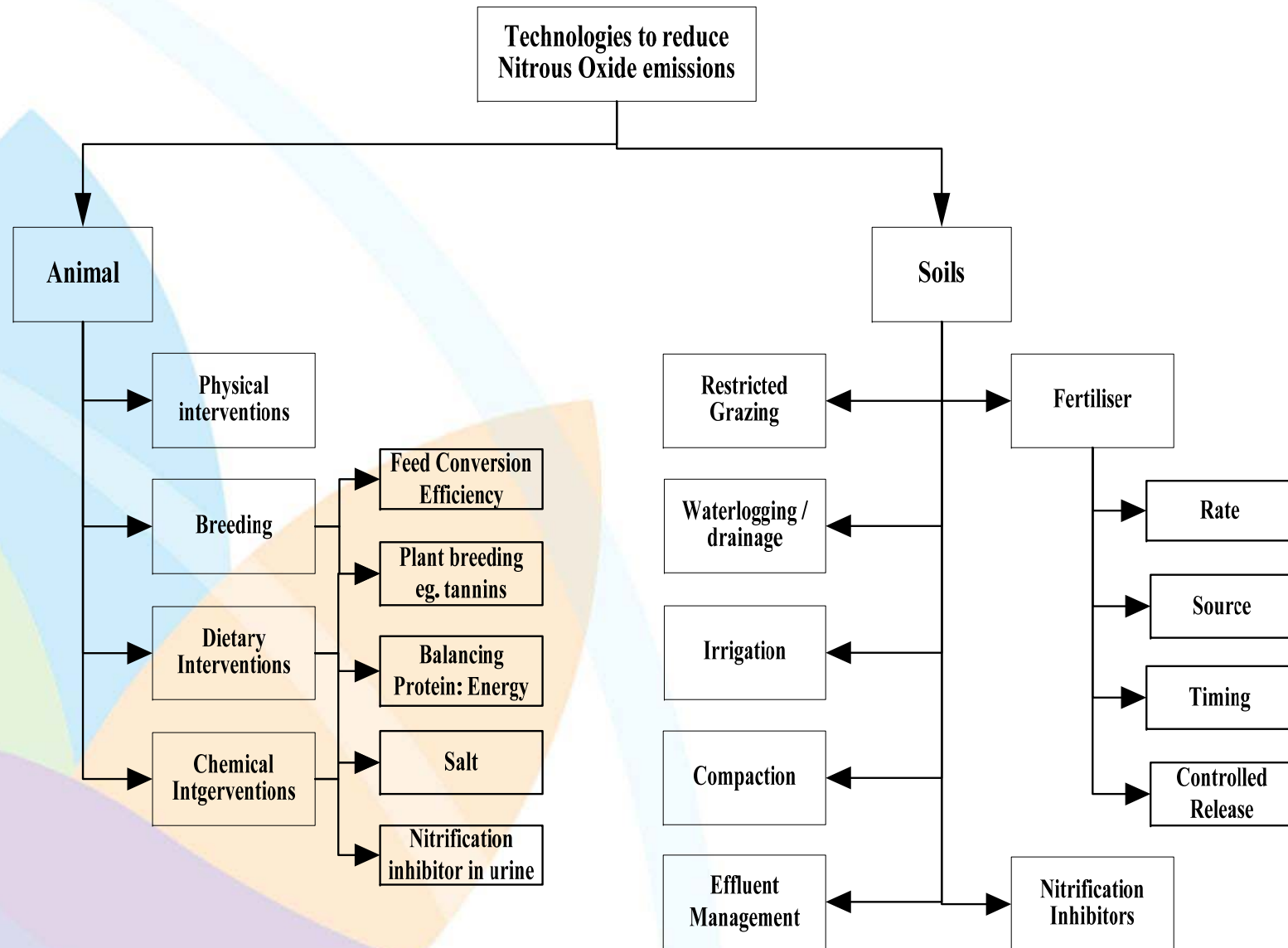
Eckard et al. (2010); Reisinger et al. (2017); Browne et al. (2014)

What can be done on farm now?

Nitrous oxide



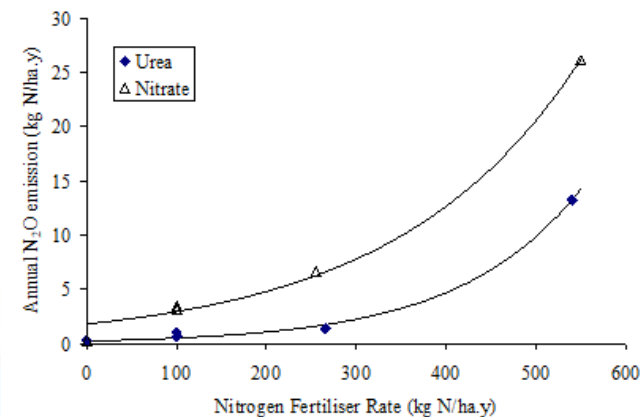
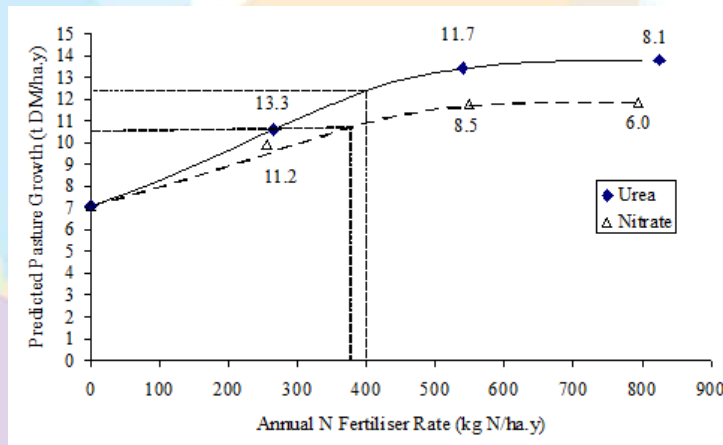
Nitrous oxide from animal production





Nitrous oxide - Nitrogen fertiliser

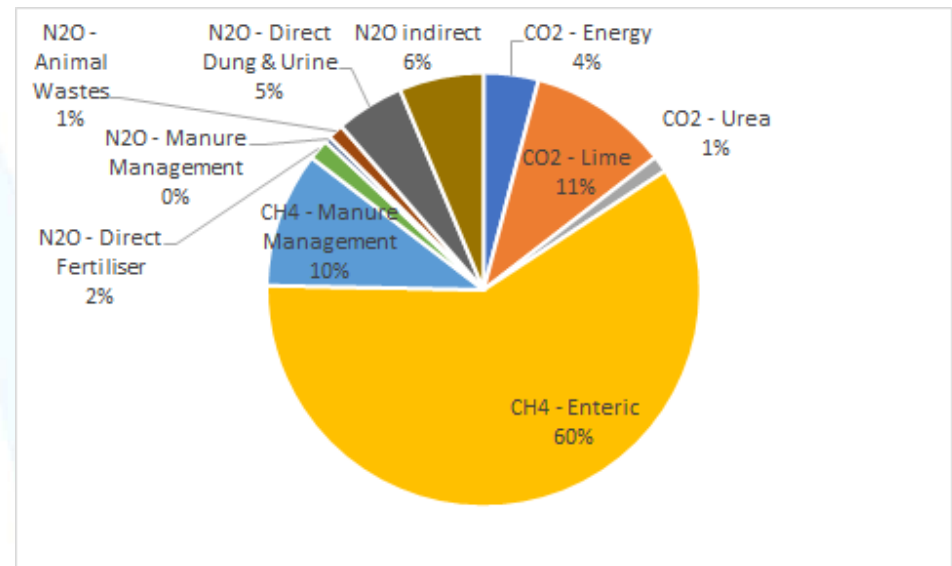
- N fertiliser
 - 3.5% of total dairy farm emissions
- Improving N use efficiency
 - Follow Fert\$mart BMPs
 - 37 and 74% less N loss



Eckard R.J. et al. (2006); Christie et al. (2018); Smith et al. (2018)

Nitrous oxide - Animal excreta

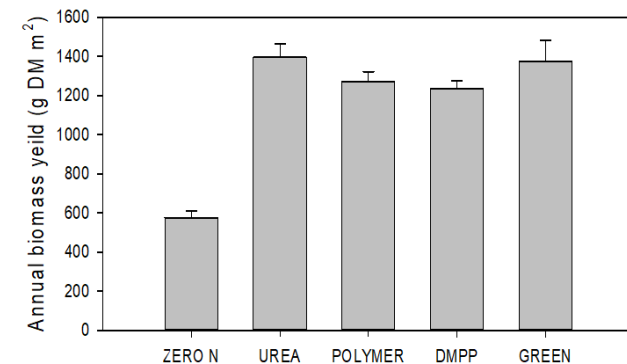
- Excess dietary N excretion in the urine
 - Balancing the energy to N ratio
 - 50% and 57% less N₂O
 - Options include
 - Grain, brassicas, plantain or fodder beet
 - High sugar ryegrass





Nitrous oxide – Nitrification inhibitors

- DCD
 - Spray and coated-urea
 - 61 and 91% less N₂O from urine patch
 - Temporarily banned
 - Likely codex listing by July 2019
- DMPP
 - Coated-urea fertiliser
 - Similar efficacy to DCD-coated urea
- Reduce the N rate by expected N loss savings



What can be done on farm now?

Soil and tree carbon



Soil organic carbon

- Building soil carbon is good practice
 - Healthy, more productive and resilient soils
 - Adaptation to climate change

Biological roles

- Reservoir of nutrients
- Biochemical energy
- Increased resilience
- Biodiversity

Physical roles

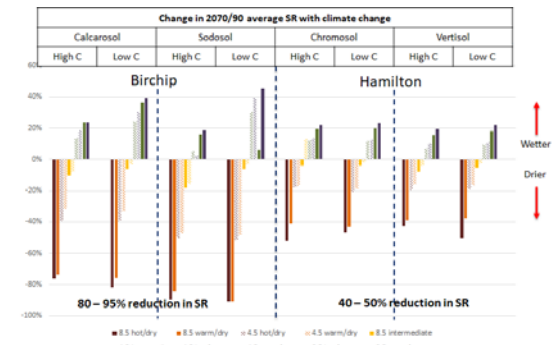
- Water retention
- Structural stability
- Thermal properties
- Erosion

Chemical roles

- Cation exchange
- pH buffering
- Complex cations

Soil organic carbon

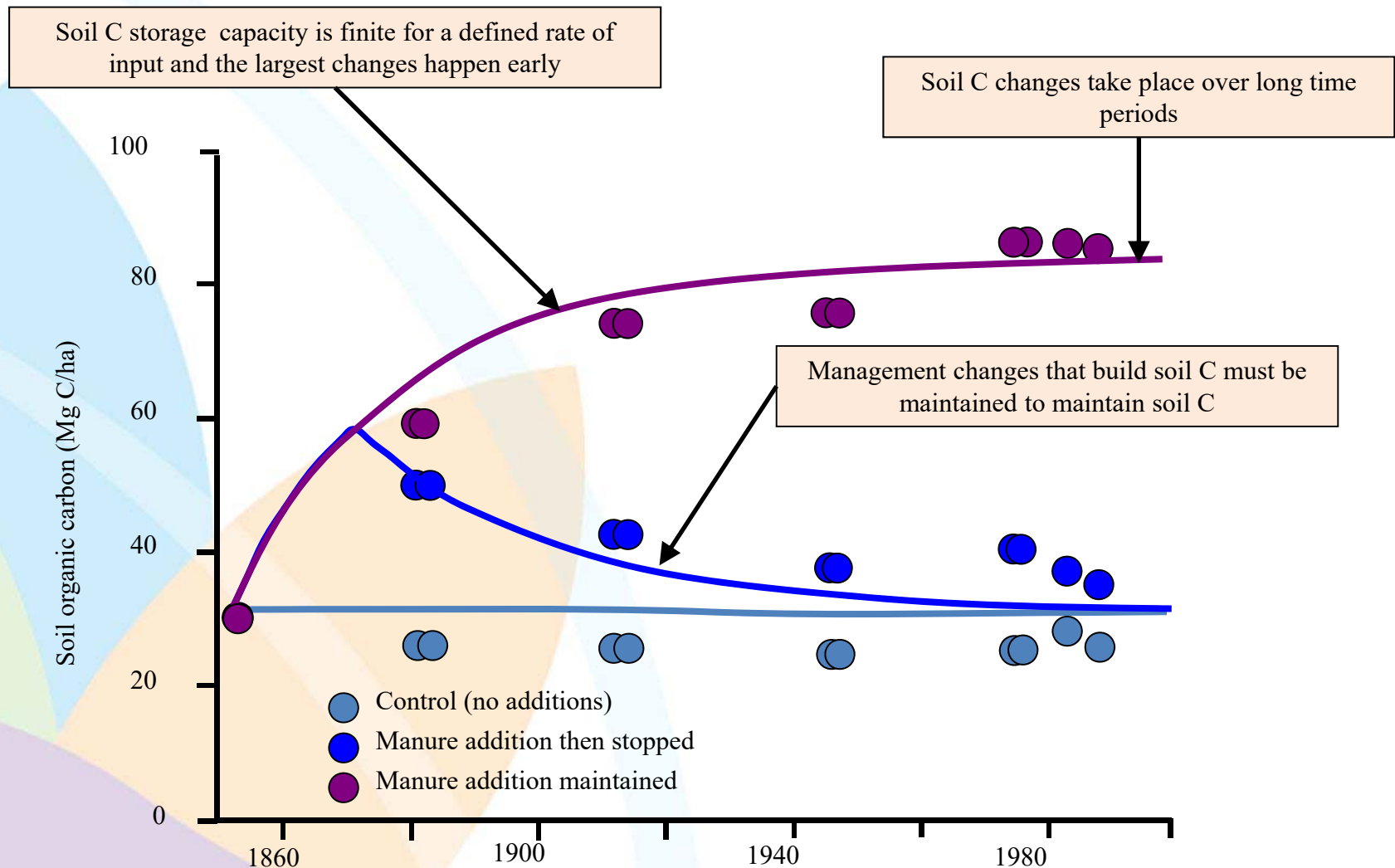
- Soil organic matter/ soil carbon
 - High under permanent pastures
- SOC possibly decreasing
 - Under high stocking rates and N
 - Under climate change in SE Australia
- Reliance on SOC as an offset may be limited





Management of soil carbon

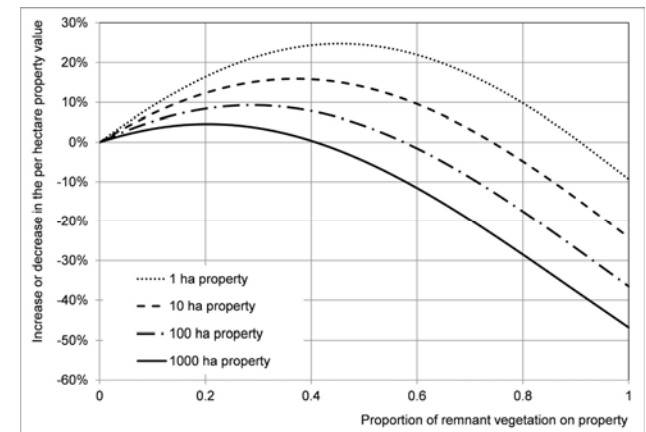
Saturation and permanence





Rethinking trees on farm

- Trees for carbon credits
 - Struggle to match milk value of land
 - Leddin et al. (2012)
- Combining multiple benefits
 - Salinity, biodiversity, aesthetics, shade and shelter, heat and cold stress
 - Income diversification/ financial resilience
 - Carbon offset income
 - Timber income
 - Nutrient sink areas in catchments
 - Capital appreciation
 - 20% tree coverage = 4% price premium
- How do we design trees on farm for these multiple objectives?

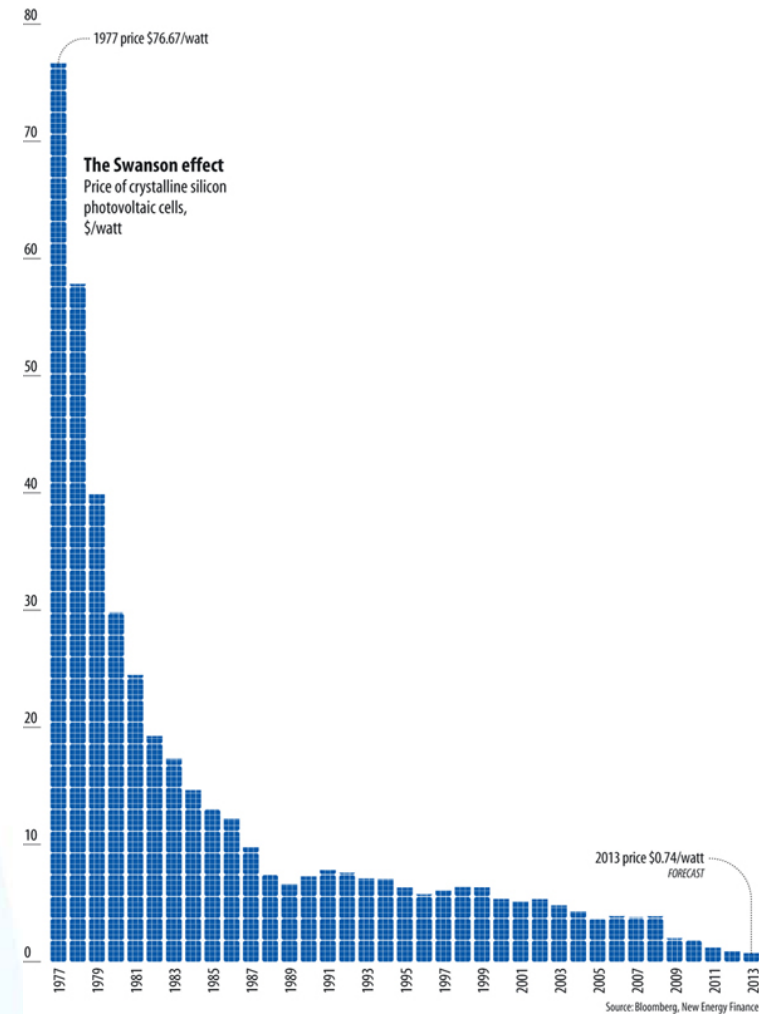


Leddin et al. (2012); Polyakov et al. (2015)



Energy Efficiency and Renewables

- Price per unit energy is dropping
- Moving to renewables
 - An economic decision
 - Manage price volatility in future





In Short

- If dairy needed to reduce GHG emissions
 - Current technology -50% is possible
 - The balance would need to come from offsets/ trees
- 3-NOP and seaweed
 - Show that far higher mitigation is possible in future
- GHG emissions are a very real threat to the future of dairy
 - Alternatives are making inroads
 - By 2050 our supply chain will only buy low emissions
 - Will it be milk or 'mylk'
 - Matching the GHGe of alternatives becomes an imperative

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