Plant & Food™ Research
Rangahau Ahumāra Kai

Greenhouse gas emissions from perennial horticultural systems

Brent Clothier & friends

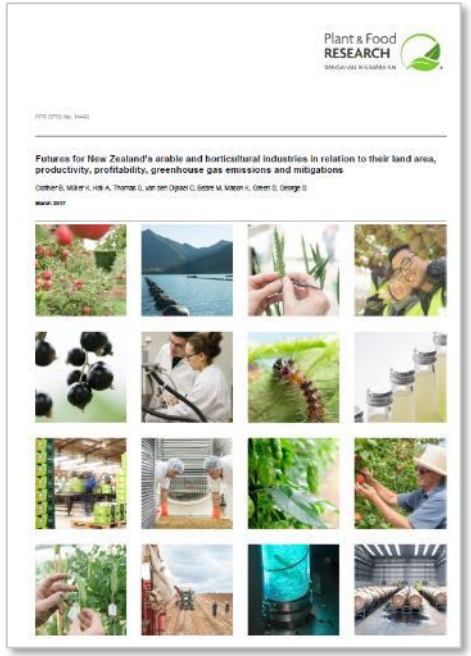
A recent report by our Productivity Commission …

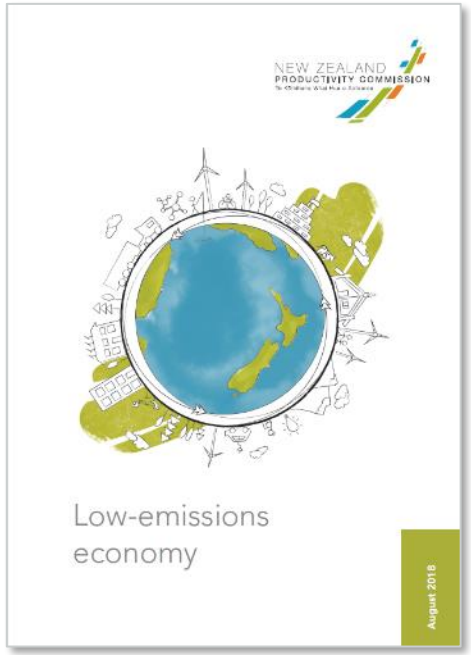
Land-use change, agriculture and emissions pricing

Land use will need to change substantially if New Zealand is to transition to a low-emissions economy. In particular, modelling undertaken for the Commission indicates that land planted in forests will need to increase by between 1.3 million and 2.8 million hectares, mostly converted from marginally profitable beef and sheep farms. Growth in horticulture (from a relatively small base) will likely also play a significant role in reducing agricultural emissions. The needed rate of land-use change is comparable to the rate at which, over the last 30 years, beef and sheep farming converted to forestry, dairying and other uses.

An emissions price that covers all land use, including agriculture, should be the main driver of land-use change. A well-designed and stable NZ ETS will incentivise land-use change.

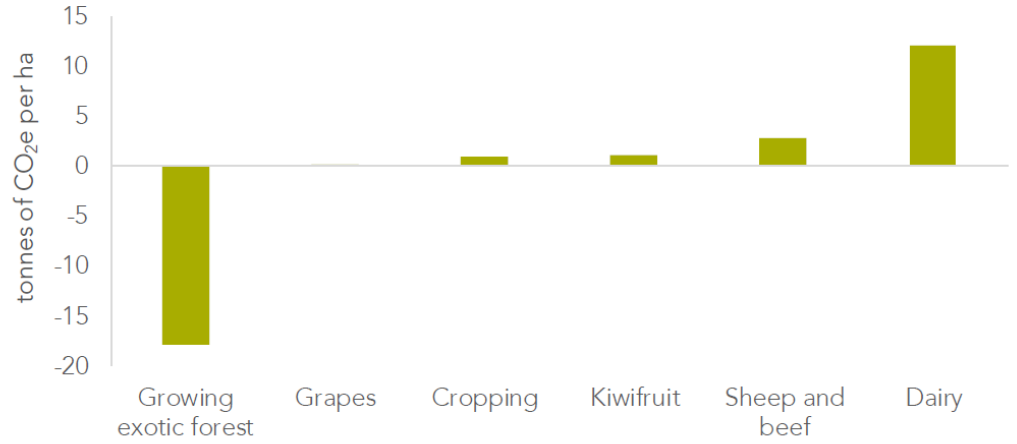
Our report provided input into the Low Emissions Economy report





On greenhouse gas emissions & mitigations

Figure 10.1 Indicative yearly biological emissions per hectare from different land uses



Source: Clothier et al. (2017); Reisinger et al. (2017); MAF (n.d.).

And on land-use change & future landscapes

Andy Reisinger (sub. 28) notes that while on paper opportunities to move into horticulture seem profitable, a better understanding of these barriers and how they may vary by region is needed.

Even so, the land devoted to horticulture and the value of horticultural production and exports (particularly fruit and wine) have been steadily increasing over the last decade or more, and are projected to continue to do so (Clothier et al., 2017; Horticulture New Zealand, sub. 41).[109]

Profitability: Earnings Before Interest & Tax (EBIT) & Return on Investment (ROI) of Horticulture.

We found that for …

Kiwifruit

The medium term assessments for orchard-gate returns from green kiwifruit are predicted to be \$60-70,000 ha^{-1} with a return on investment (ROI) of 11–13%. The EBIT for SunGold is higher, over \$120,000 ha^{-1}.

Grapes

The reported EBIT for Sauvignon blanc grapes in Marlborough is given as \$12,000 ha^{-1} and between \$8,000 (Chardonnay) and \$11,000 (Merlot) in the Hawke's Bay. The ROI is between 5–9%.

Apples

In Hawke's Bay, the reported EBIT for apples is \$23,000 ha^{-1} with an ROI of 21.3%, whereas in Nelson the EBIT is \$14,000 ha^{-1} and an ROI of 14%.

We took for our heuristic exercise …

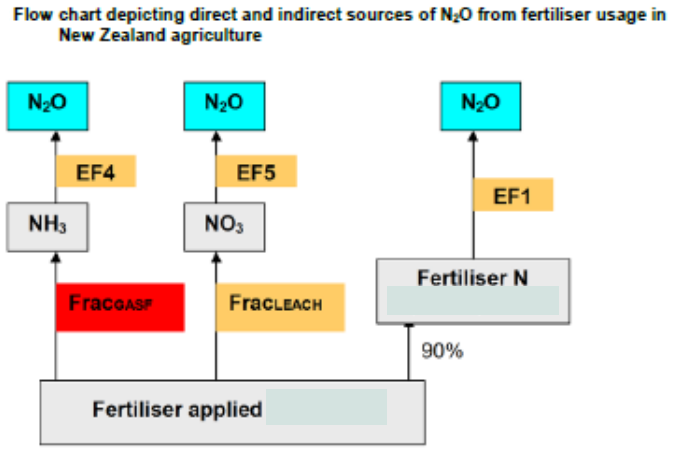
A simple and conservative EBIT for horticulture of **\$10,000 ha^{-1}**, reflecting the range from \$8000 to \$120,000 ha^{-1}, for these big-three horticultural crops.

Biological greenhouse gas emissions from horticulture

The IPCC protocols

Carbon balance [Ignored] *Methane* [None] *Nitrous Oxide* [Computed]

Direct & Indirect N_20 Emissions from Fertiliser



Currently used values:

$Frac_{GASF}$ = 0.10
$Frac_{LEACH}$ = 0.07

EF1 = 0.01
EF4 = 0.01
EF5 = 0.025

N_20 Emissions from Prunings

$$N_2O_{direct\ crop\ residue\text{-}N} = TRG_N \times EF_1 \times 44 / 28 \times 10^6$$

TRG_N = Total amount of nitrogen returned to soils from crop residue.

	Kiwifruit	Apples	Grapes
Fertiliser N [kg-N ha^{-1} y^{-1}]	130	40	5
Pruning N [kg-N ha^{-1} y^{-1}]	70	105	30
Biological Emissions [T $CO_{2\text{-}e}$ ha^{-1} y^{-1}]	1.03	0.71	0.17

The Productivity Commission recommended that …

R10.3 Agricultural emissions should be fully included in the New Zealand Emissions Trading Scheme (NZ ETS).

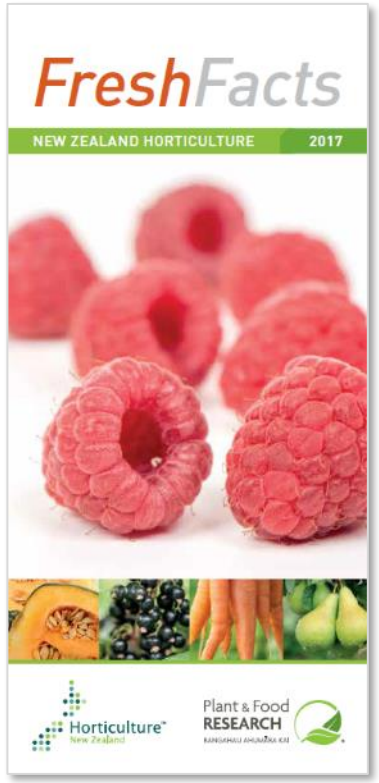
So what's the impact of a putative \$50 $T_{CO2\text{-}e}$ price on EBIT?

	Biological GHG Emissions [T $CO_{2\text{-}e}$ ha^{-1}]	Areal Cost @ \$50 T $CO_{2\text{-}e}$ [\$ ha^{-1}]	EBIT [\$ ha^{-1}]	**Carbon GHG cost/EBIT [%]**
Kiwifruit	1.03	51.50	10,000	0.51%
Apples	0.71	35.50	10,000	0.36%
Grapes	0.17	8.50	10,000	0.09%

The Productivity Commission found that …

F10.2

The rate of land change needed to transition to a low-emissions economy over the next three decades is comparable in magnitude to the overall rate of change over the last three decades. Yet high rates of afforestation will need to be sustained for a much longer period in the future than happened in the past; and the past movement into horticulture may need to accelerate.



Currently the area of:

- Kiwifruit comprises 12,600 ha
- Grapes are across 37,130 ha
- Apples cover some 9,500 ha.

The ‘big three’ cover just under 60,000 ha.

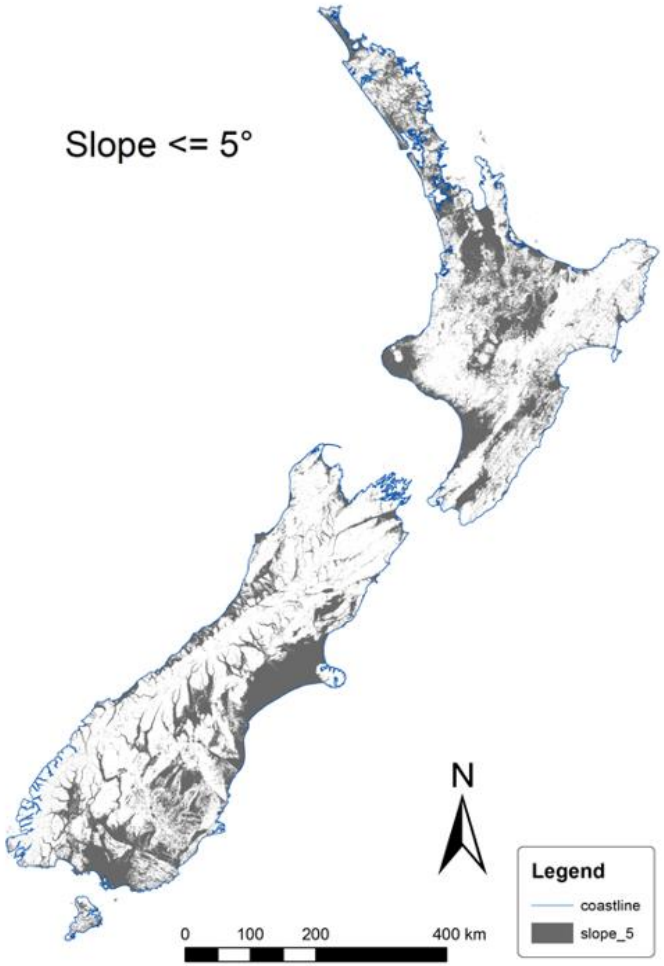
Total horticultural & vegetable farming covers 120,000 ha.

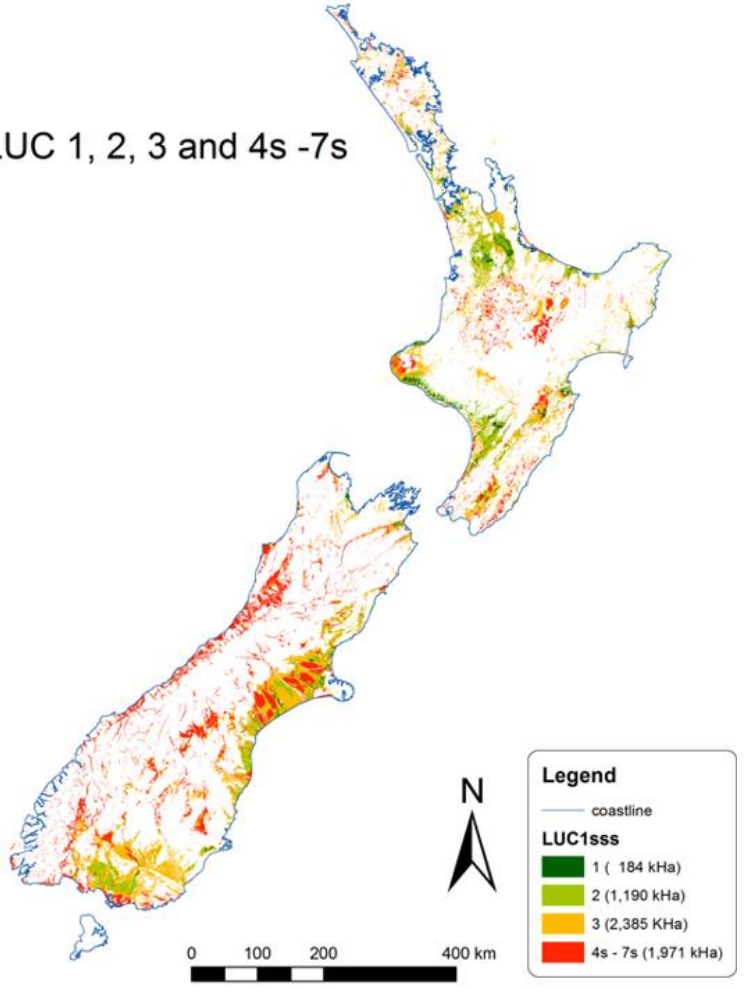
And we lose 40,000 ha y^{-1} to urban expansion and infrastructure

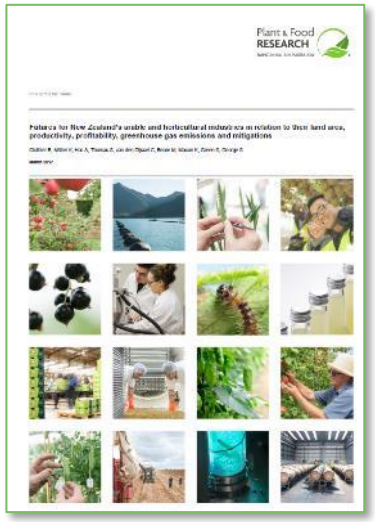
So where could our horticultural industries expand to?

We have made a simple ‘biophysical’ assessment of ‘where to’ …

Horticulture requires ‘flat’ land (<5º)



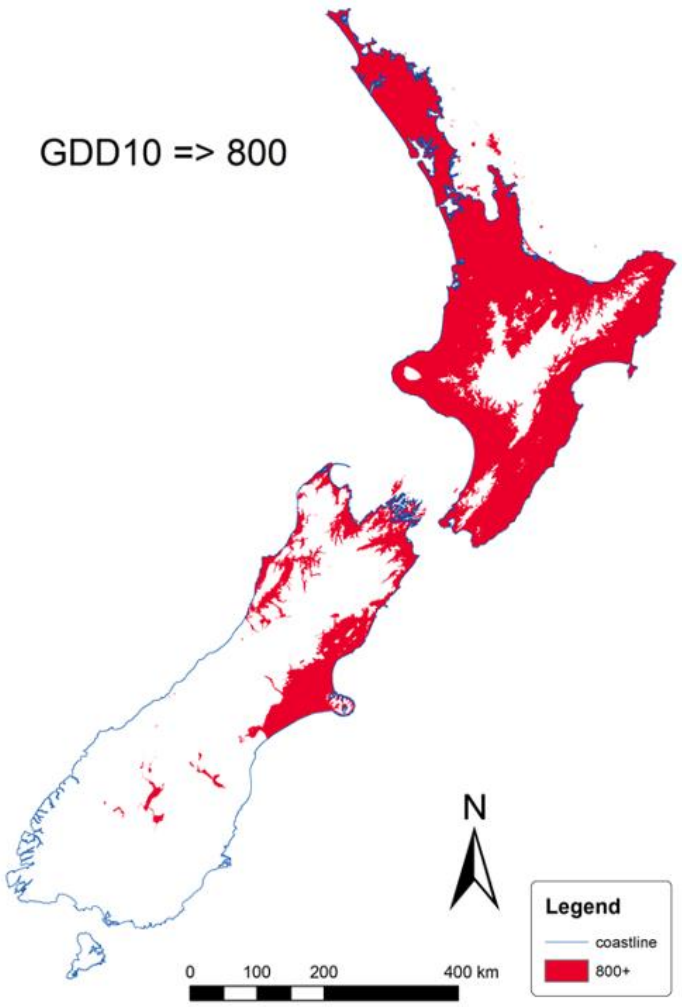


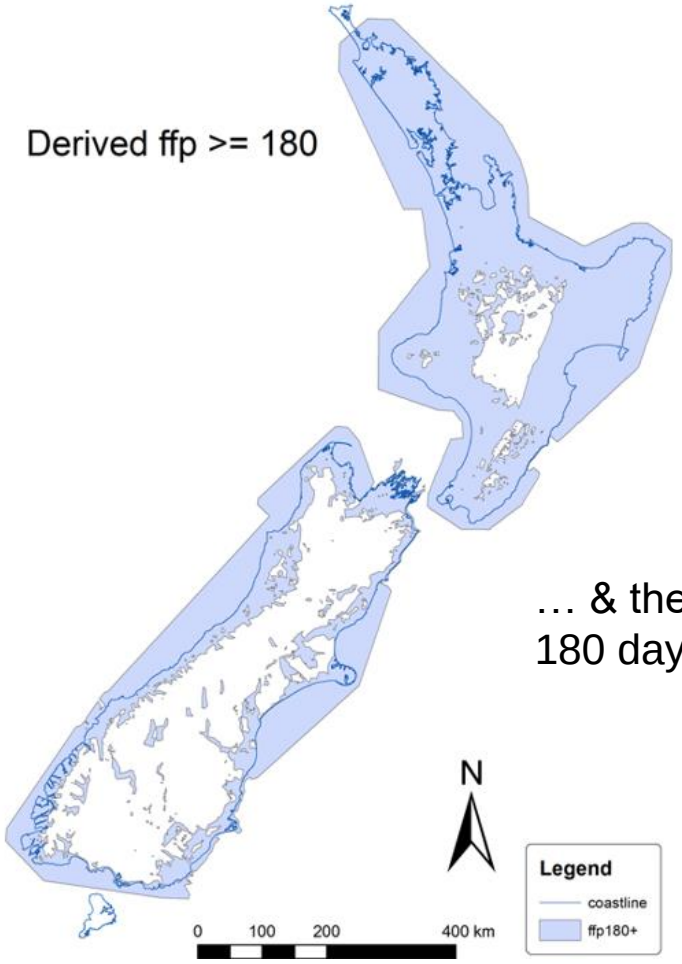


… and relies on the better Land Use Capability (LUC) classes

Horticulture also requires an equable climate

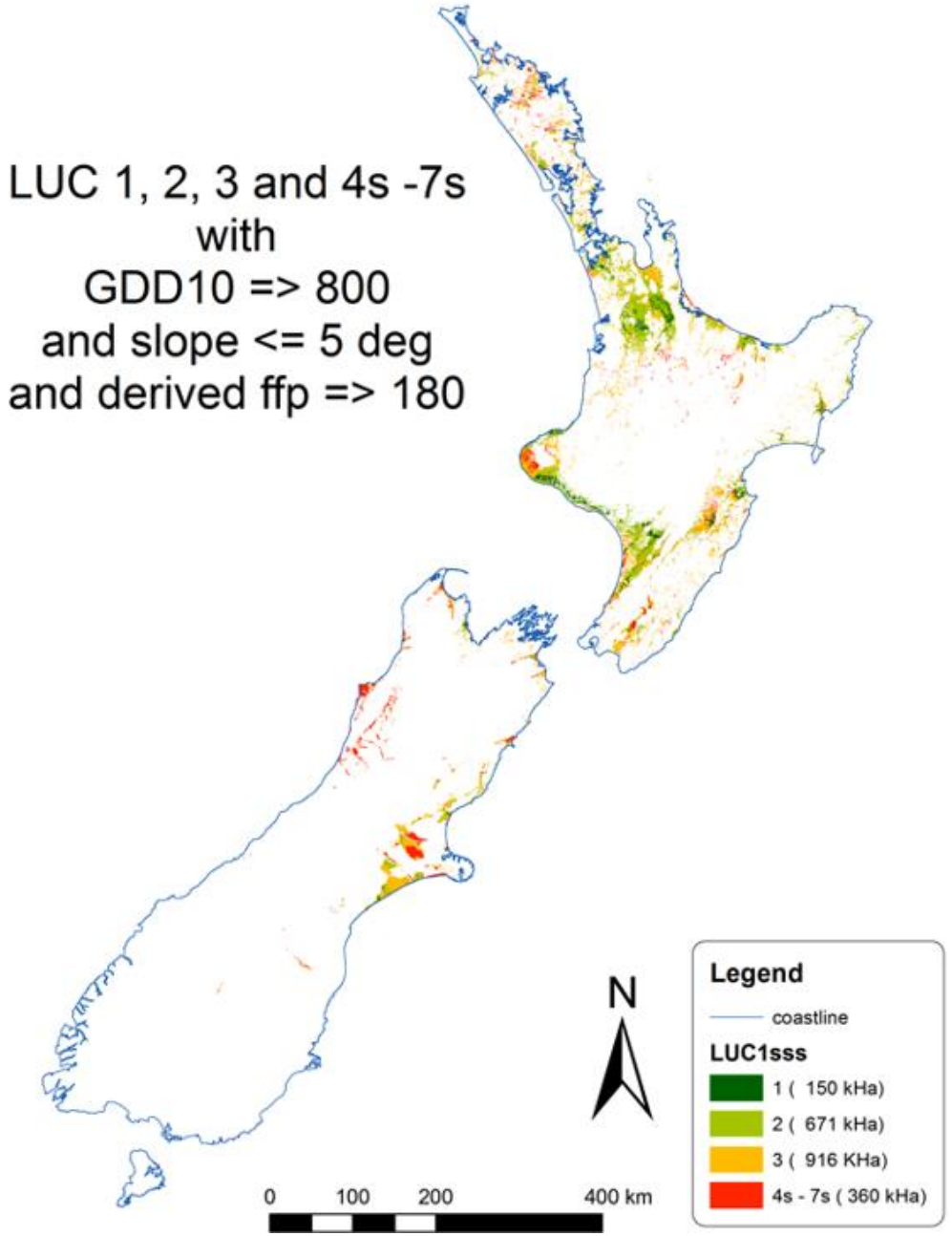
For fruit maturation, growing degree days (base 10) GDD_{10} should exceed 800





… & there should be a frost-free period (ffp) of over 180 days to enable flowering & fruit maturation

The Intersection of these 4 Layers is the Potential Area for Horticulture



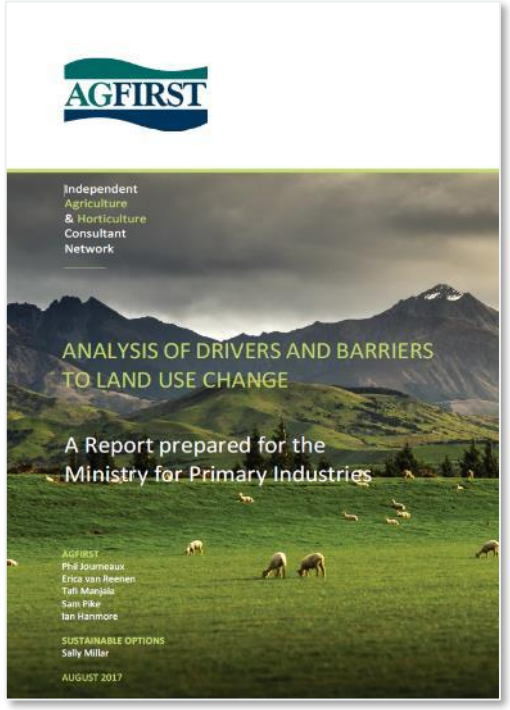
In sum, that's 2,097,000 ha.

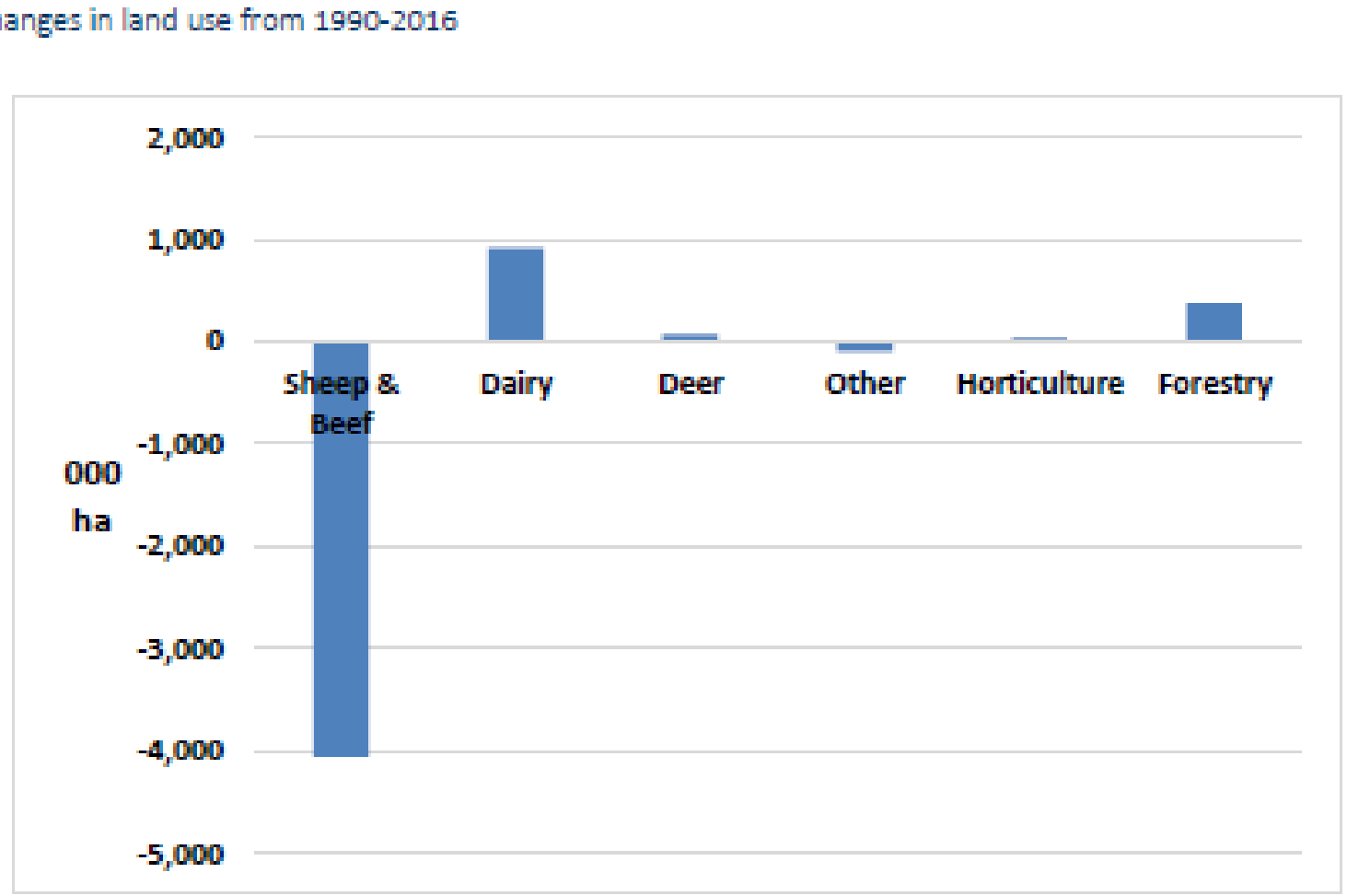
That's over 17 times the current area.

Why not?

Over the last 25 years, our landscapes have changed.

There's more than just biophysical factors though!

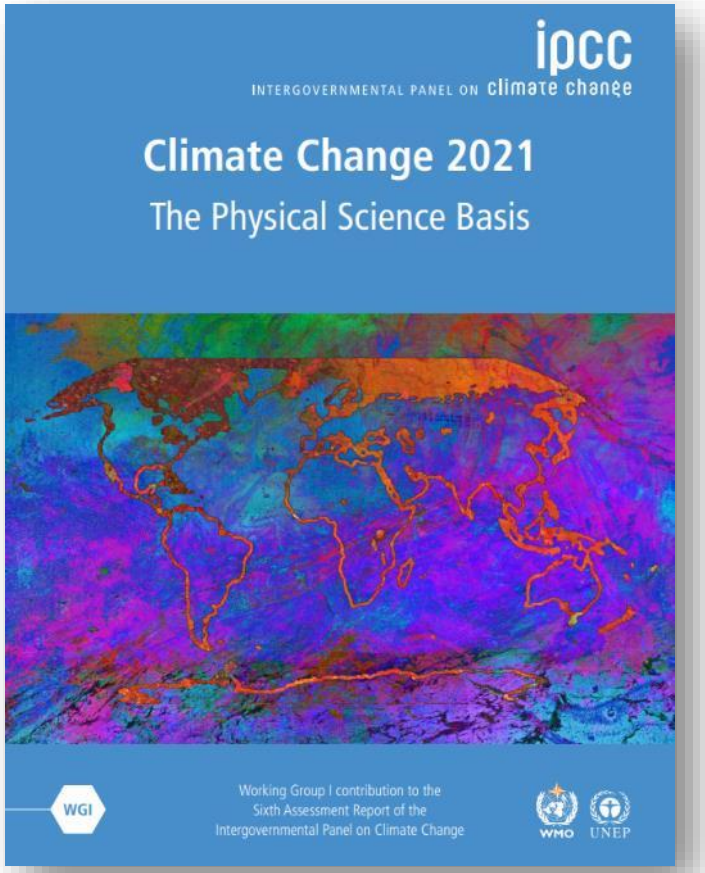




Reasons for land-use change listed as:

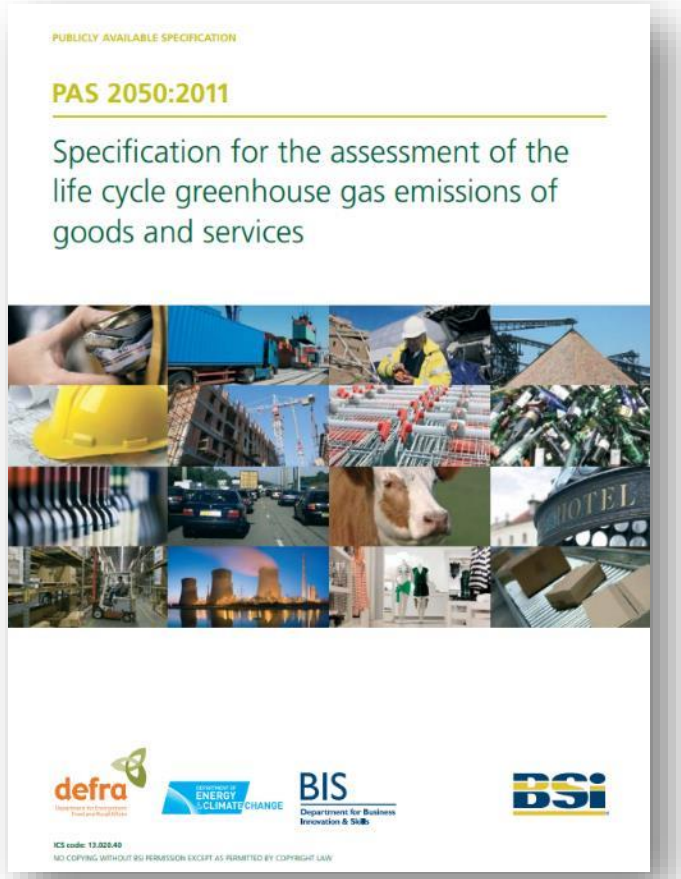
- Biophysical
- Economic
- Technology
- Societal pressure & "Licence to farm"
- Personal factors

Shifting from an IPCC perspective … to eco-credentials … Two sides of the same coin



GHG Emissions

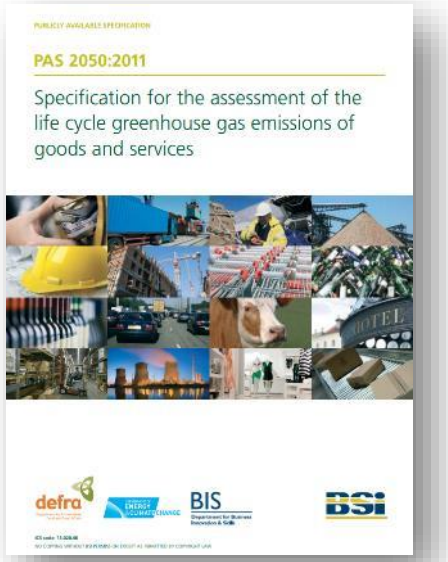
Paris Accord & NDCs

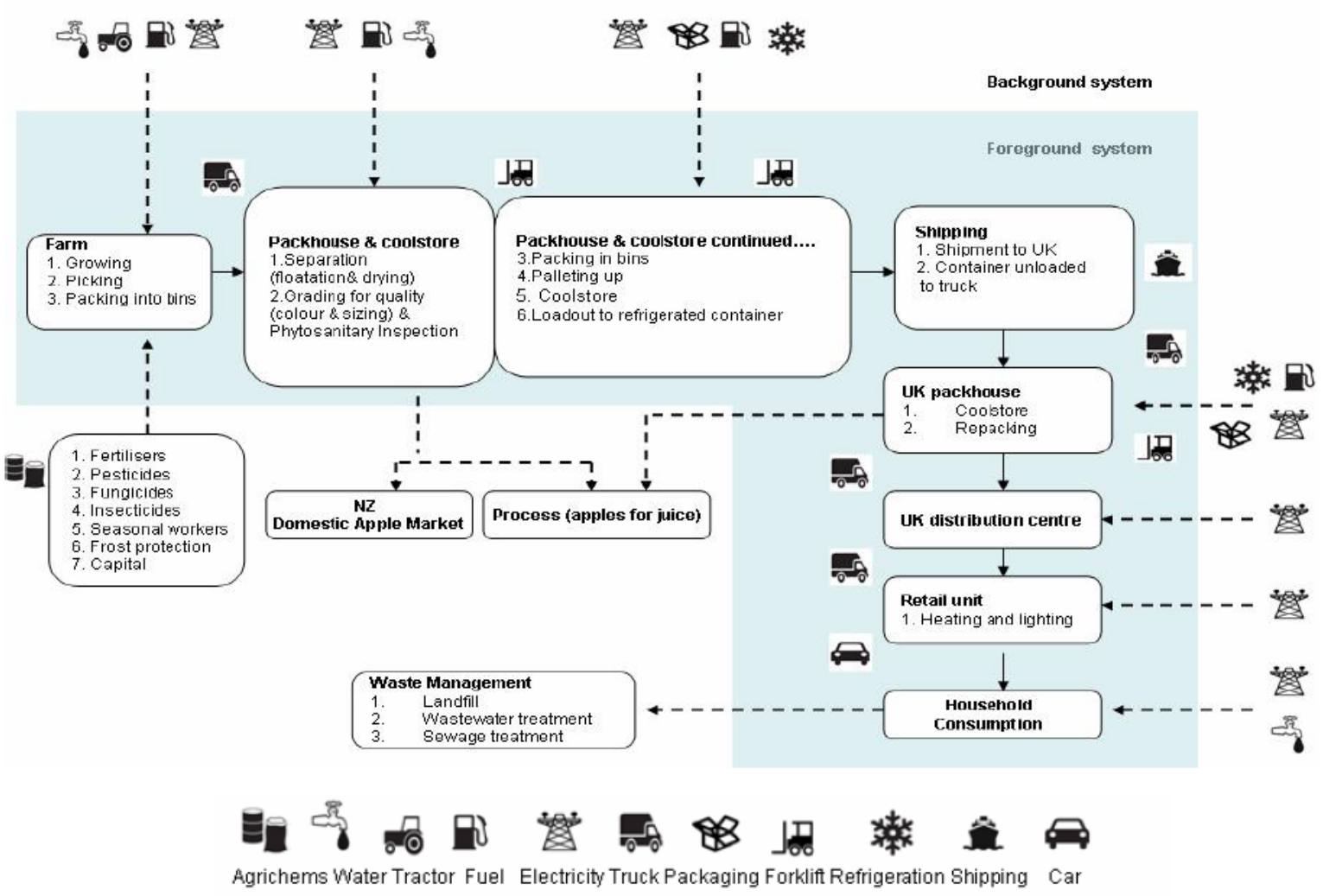


Life Cycle Assessment

Consumers & Eco-Premiums

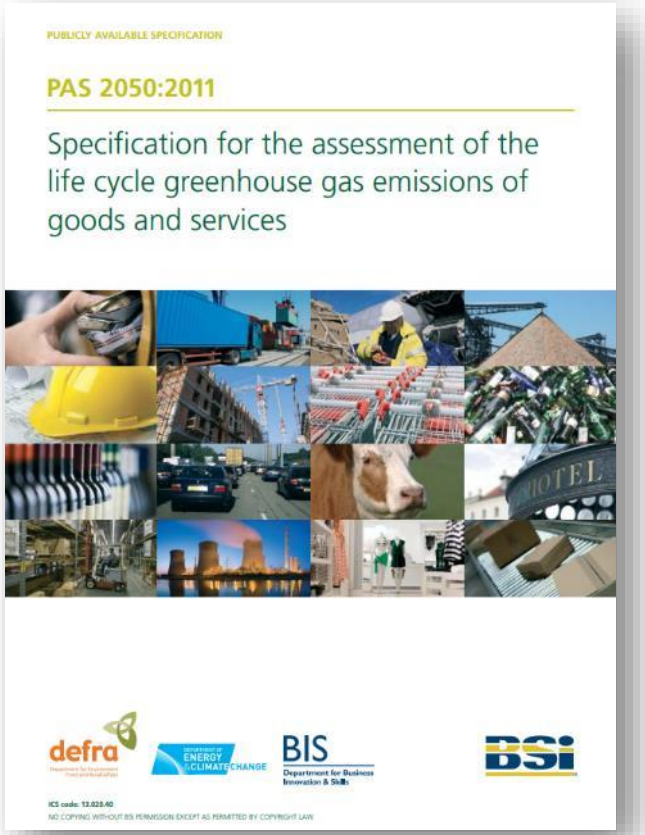
A Full Life Cycle Assessment of NZ Export Apples: 2008





Hume et al., 2009 Carbon Footprinting for the Apple Supply Chain: Methodology & Scoping Study

LCA-stage	Contribution of stage to footprint in %
Orchard operations	20
Packhouse & Coolstore	13
Shipping	30
Repackaging	4
Retailer	7
Consumer	26



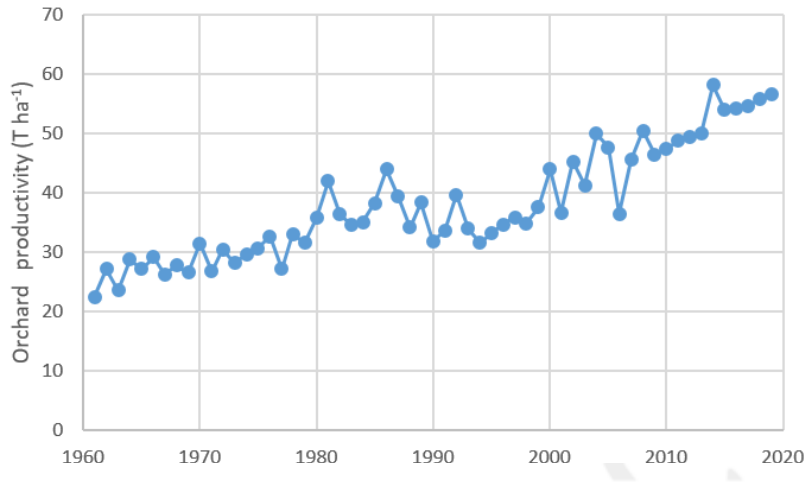
Globally weighted footprint of NZ Export Apples in 2008 was 0.83 kg $CO_{2\text{-}e}$ kg^{-1}

Updating of the Carbon Footprint of NZ's Apple Industry

Clothier & McNally (2021)

Major changes:

- Productivity increases



	2008	2019
Planted area (ha)	8,832	10,719
Export orchards (#)	952	996
Export packhouses (#)	74 *	52
Exporters (#)	90	73

* Interpolated

- Packhouse & Exporter Consolidation

- Higher pack-outs

	2008	2019
Apples produced ('000 tonnes)	446	567 *
Apples exported ('000 tonnes)	261	395
National pack-out	59%	70%

* FAOSTAT

- Changed destinations: Less shipping distances

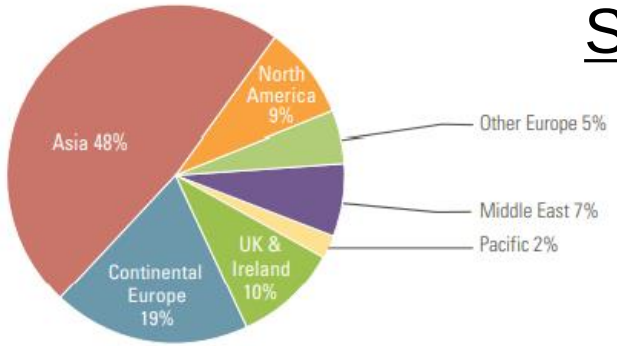
Export Destination	2008 *		2019 @	
	Export ($ m)	Percent	Export ($ m)	Percent
Continental Europe	122	35.4%	149	19.2%
SE & E Asia	71	20.5%	460	55.5%
United Kingdom	58	16.8%	74	9.6%
North America	58	16.8%	92	11.1
Middle East	8	2.3%	38	4.6%

* Total exports $345 m @ Total exports $829 m. Δ change =2.5

Total Carbon Footprint for NZ Export Apples in 2021 *cf.* 2008

Orchard, Packhouse & Coolstore

0.16 down to 0.13 $CO_{2\text{-}e}$ kg^{-1} Δ = - 19%



Shipping

0.38 down to 0.30 $CO_{2\text{-}e}$ kg^{-1} Δ = - 21%

Total LCA Footprint of NZ Export Apples

0.83 down to 0.72 $CO_{2\text{-}e}$ kg^{-1} Δ = - 13% … or -1% y^{-1}

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Rangahau Ahumāra Kai

Thank you

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