Dairy feedbase in the future environment: how is New Zealand research responding to the challenge?

David Chapman
DairyNZ
Lincoln, NZ

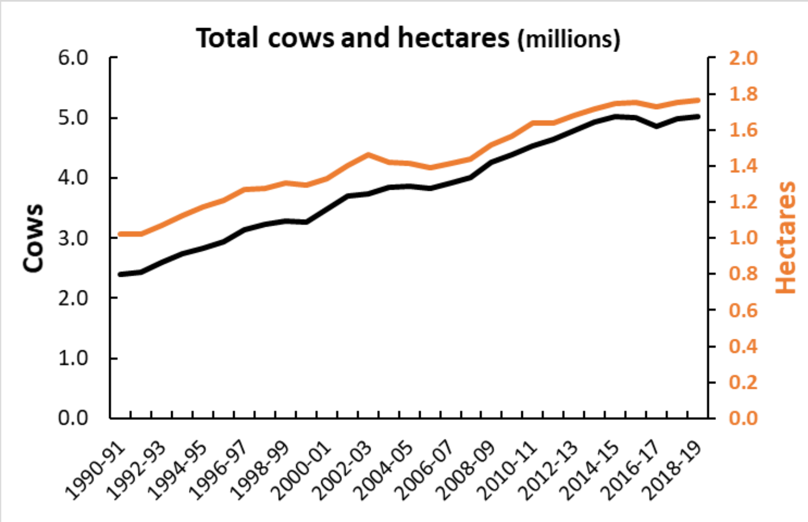
Outline

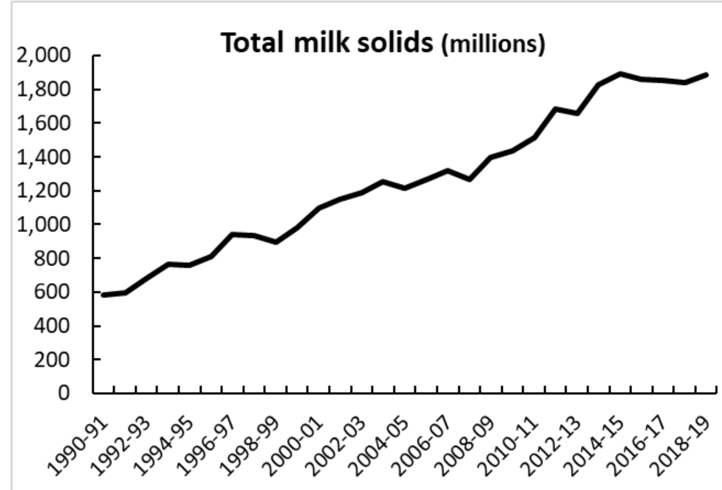
- Changes in systems and feedbase1990-2014
  - Unregulated growth
  - Systems creep
- Reaping the consequences
  - Environmental regulations
  - The role of forages
- Re-focus on pasture
  - Pasture potential
  - Persistence in a changing climate
- Concluding comments

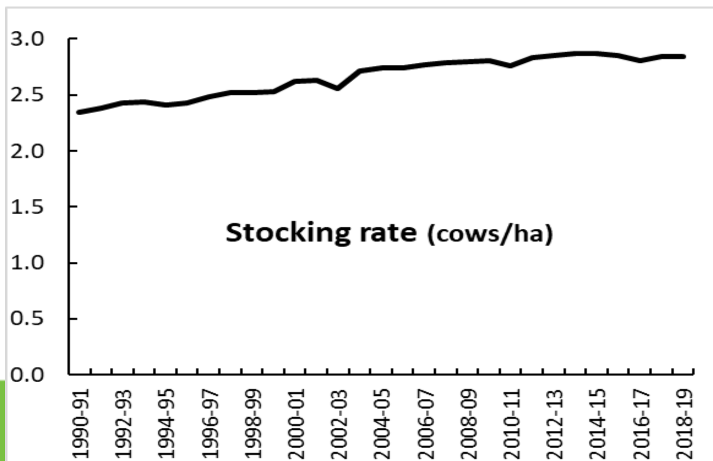
Outline

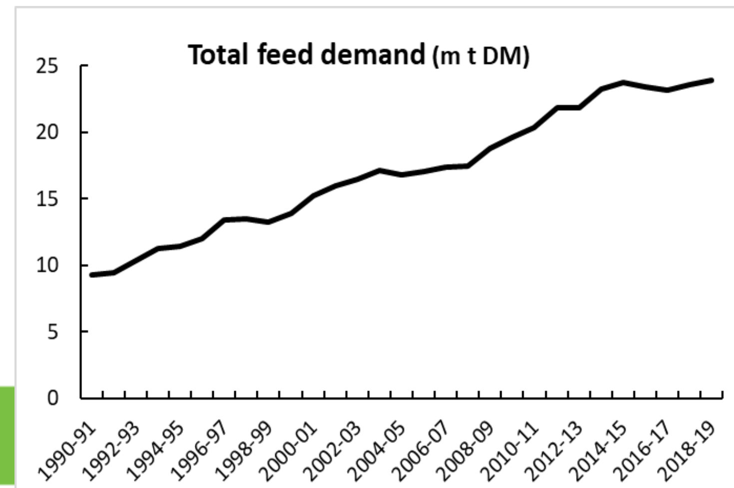
- Changes in systems and feedbase1990-2014
  - Unregulated growth
  - Systems creep
- Reaping the consequences
  - Environmental regulations
  - The role of forages
- Re-focus on pasture
  - Pasture potential
  - Persistence in a changing climate
- Concluding comments

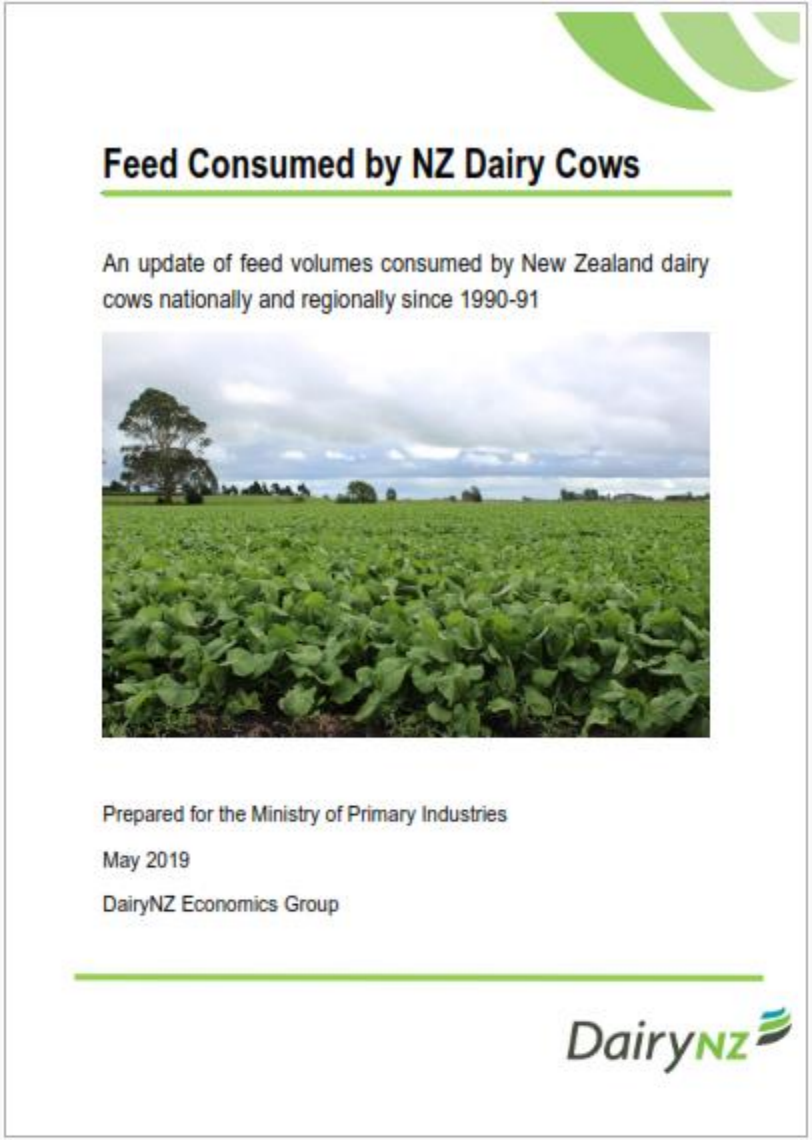
The growth years: 1990 to 2014











Feed Consumed by NZ Dairy Cows

An update of feed volumes consumed by New Zealand dairy cows nationally and regionally since 1990-91

Prepared for the Ministry of Primary Industries

May 2019

DairyNZ Economics Group

DairyNZ

Where has the additional 15 m t DM come from?

2/3rd from expansion
1/3rd from intensification

1 **Northland**
1. Far North
2. Whangarei
3. Kaipara
4. Rodney
5. North Shore City
6. Waitakere City
7. Auckland City

2 **Waikato**
8. Manukau City
9. Papakura
10. Franklin
11. Waikato
12. Hamilton City
13. Waipa
14. Otorohanga
15. Waitomo
16. Thames/Coromandel
17. Hauraki
18. Matamata/Piako
19. South Waikato
20. Taupo
21. Ruapehu

3 **Bay of Plenty**
22. Western Bay of Plenty
23. Tauranga
24. Rotorua
25. Kawerau
26. Whakatane
27. Opotiki
28. Gisborne
29. Wairoa

4 **Taranaki**
30. New Plymouth
31. Stratford
32. South Taranaki

5 **Lower North Island**
33. Wanganui
34. Rangitikei
35. Hastings
36. Napier City
37. Central Hawke's Bay
38. Tararua
39. Manawatu
40. Palmerston North City
41. Horowhenua
42. Kapiti Coast
43. Porirua City
44. Upper Hutt City
45. Lower Hutt City
46. Wellington City
47. Masterton
48. Carterton
49. South Wairarapa

6 **West Coast-Tasman**
51. Tasman
52. Buller
53. Grey
54. Westland

7 **Marlborough-Canterbury**
50. Nelson City
55. Marlborough
56. Kaikoura
57. Hurunui
58. Waimakariri
59. Christchurch City
60. Banks Peninsula
61. Selwyn
62. Ashburton
63. Timaru
64. Mackenzie
65. Waimate

8 **Otago-Southland**
66. Waitaki
67. Dunedin City
68. Clutha
69. Central Otago
70. Queenstown/Lakes
71. Gore
72. Invercargill
73. Southland

Percentage spilt between pasture eaten and non-pasture feed (crops, harvested supplements and imported supplements) eaten

Source: DairyNZ Economics Group

Figure 7: Total feed eaten by supplementary feed type from 1990-91 to 2019-20f for New Zealand

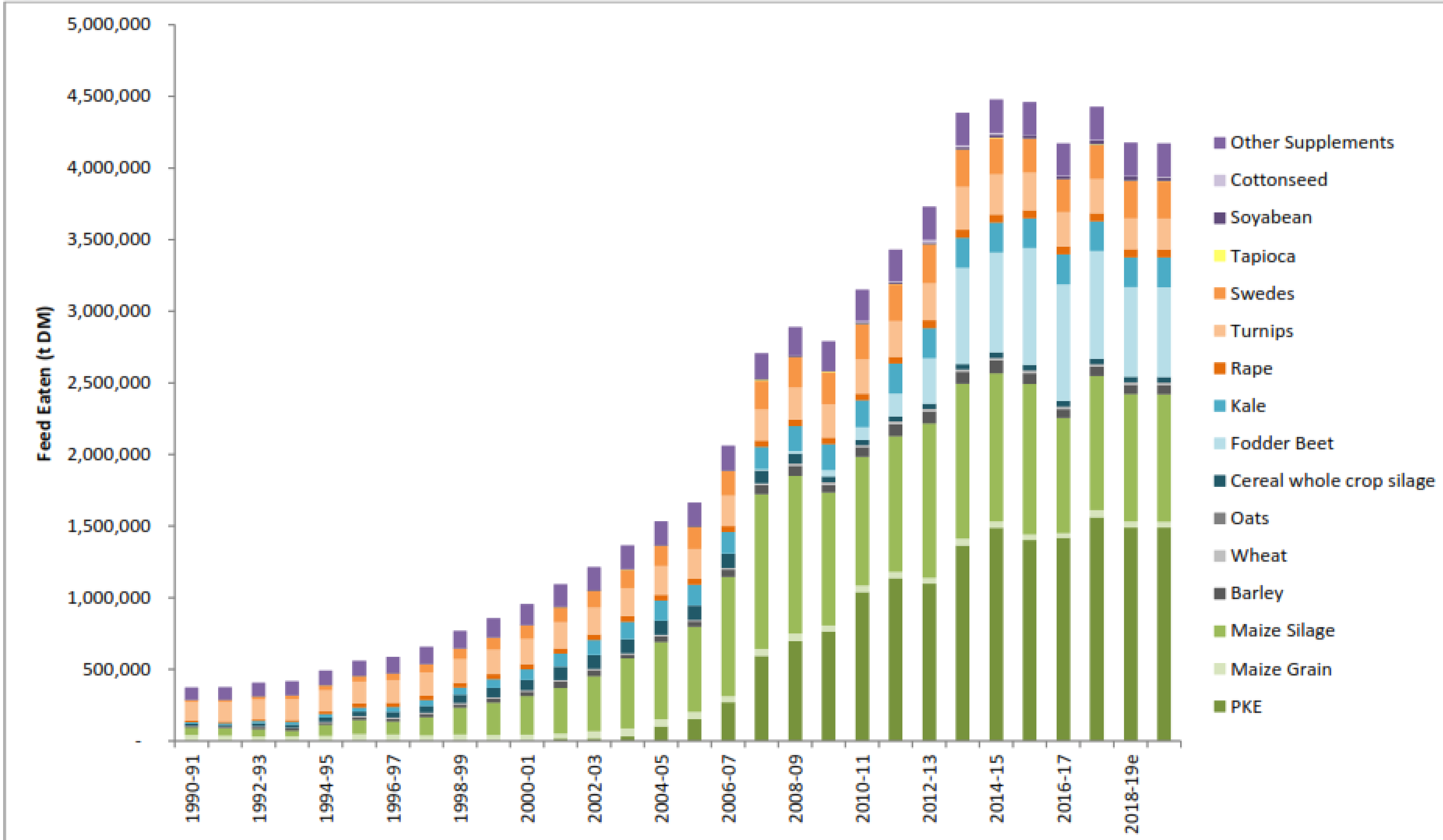
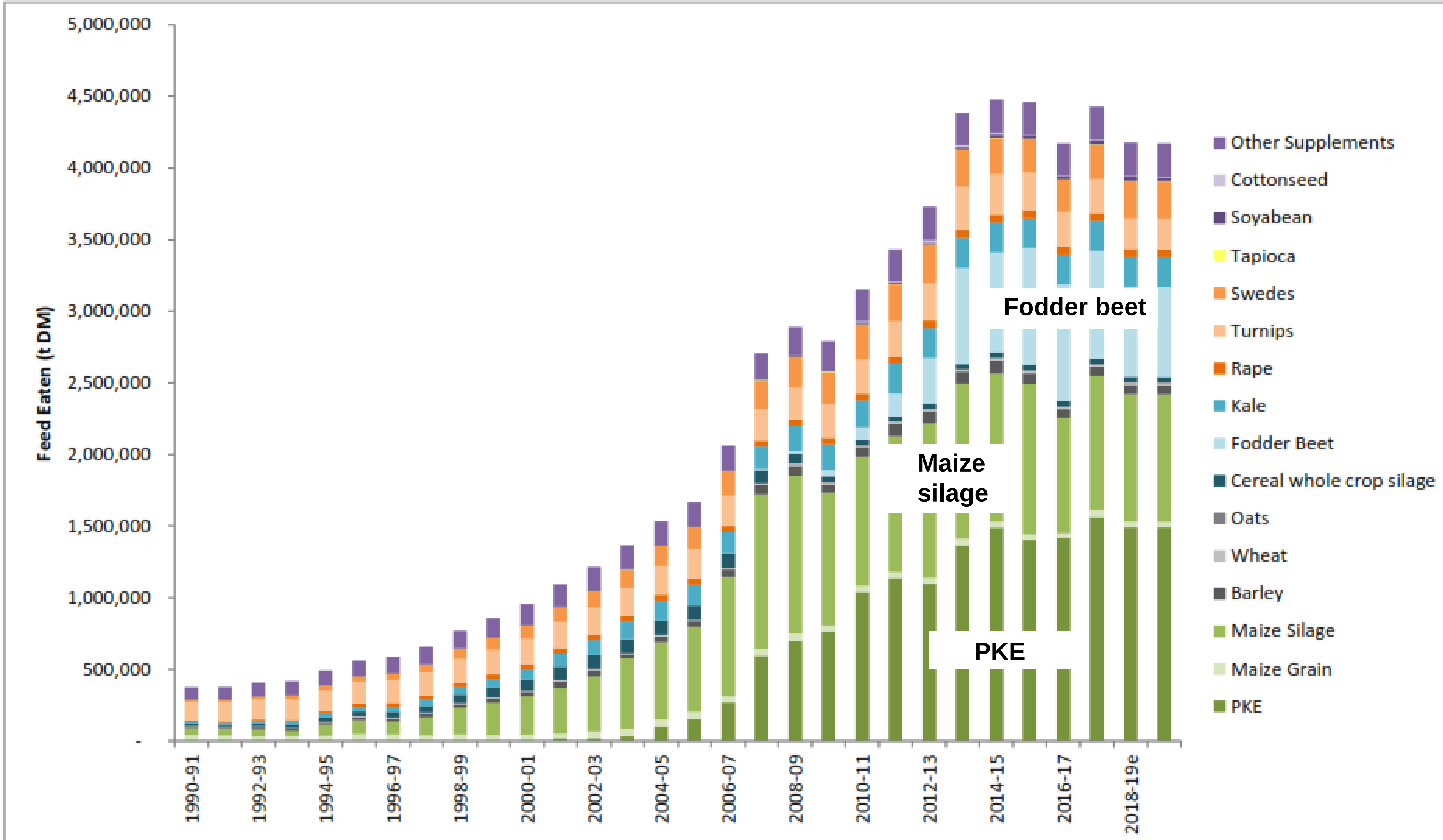
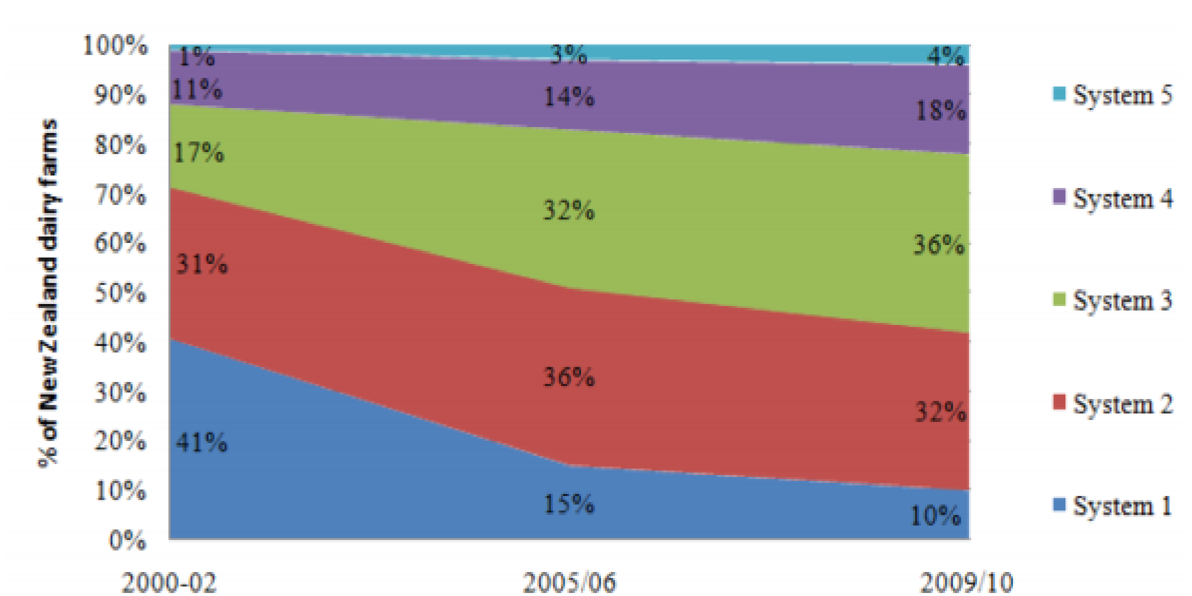


Figure 7: Total feed eaten by supplementary feed type from 1990-91 to 2019-20f for New Zealand



% farms by different system types 2000 – 2010



25-40% feed imported, fed year-round

20-30% feed imported

10-20% feed imported

4-14% feed imported, shoulders only

No feed imported

Source: DairyNZ Economics Group

By the way: did farmers make more money?

	MS/ha	Profit, ROA
Low (System 1 and 2)		
Medium (System 3)	+66	Not Signif.
High (Systems 4 and 5)	+149	Not Signif.

Lincoln University: Ma, Renwick & Bicknell (2018)

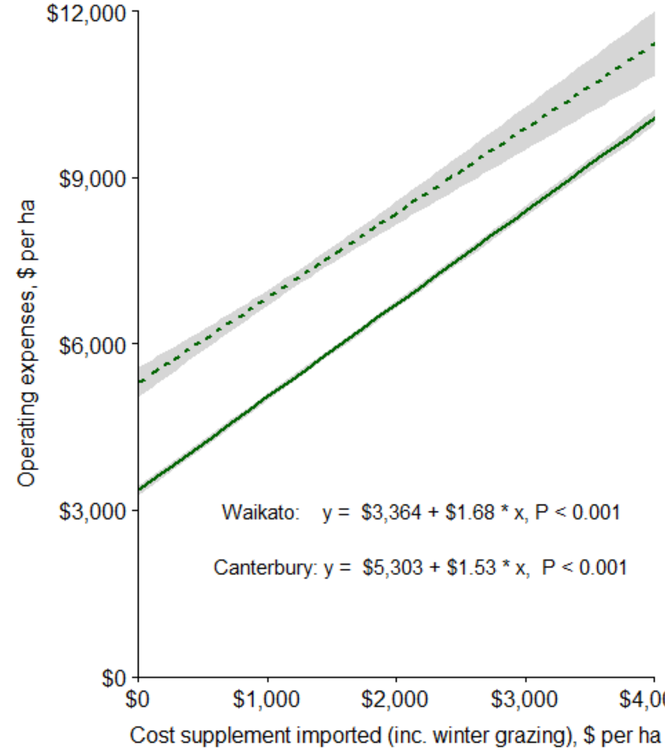
Why not?

‘Sticky’ additional costs

$ total operating costs per $ feed cost:

- Waikato: $1.68
- Canterbury: $1.53
- Ireland: $1.53
- UK: $1.62

x 1.5 rule of thumb



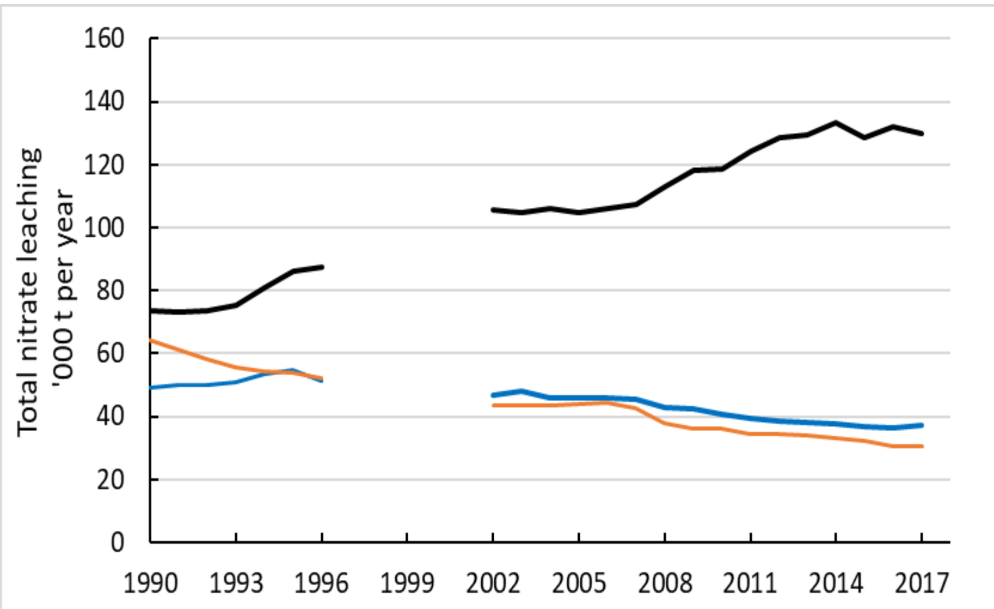
Outline

- Changes in systems and feedbase1990-2014
  - Unregulated growth
  - Systems creep
- Reaping the consequences
  - Environmental regulations
  - The role of forages
- Re-focus on pasture
  - Pasture potential
  - Persistence in a changing climate
- Concluding comments

Freshwater quality

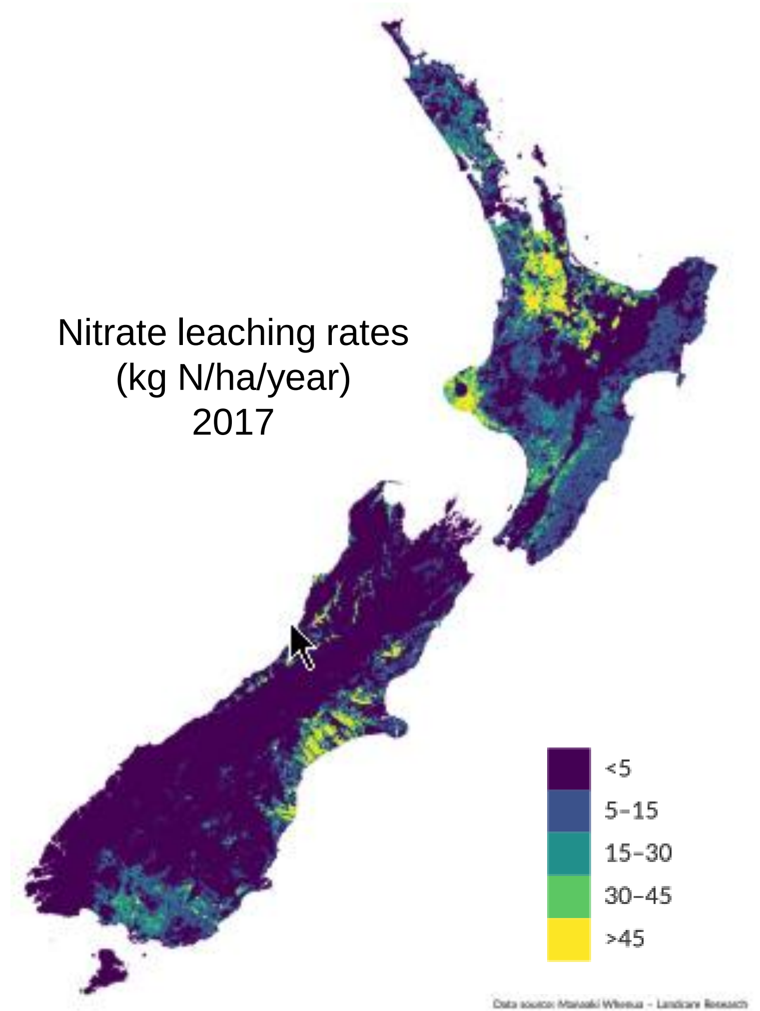
DairyNZ

Trends: Nitrate leaching



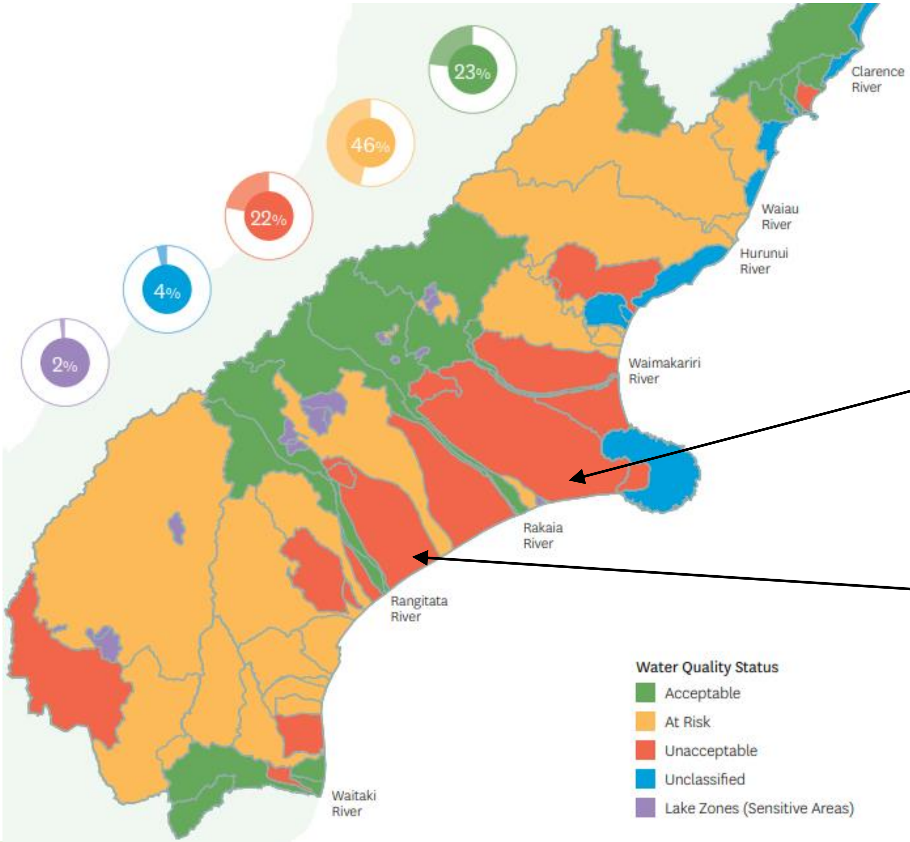
Dairy
Beef
Sheep

Stats NZ and MfE



Regional Council Land and Water Plans

Implementation and enforcement by 2025



Example: Canterbury

Selwyn-Waihora sub-catchment:
- 30% reduction in nitrate leaching beyond 'good management practice' (GMP) by 2022

Hinds sub-catchment:
- 25% below GMP by January 2030
- 36% by January 2035

NZ has too many cows, says minister

More than half of NZers say too many cows – Greenpeace poll

by Greenpeace New

A Horizon opinic
think are too ma

David Parker has
farmers may hav
rules.

"It's great to hea
that there are to
sustainable agriculture campaigner Gen Toop.

Cows are not a source of nitrogen!

It's the amount of N bought in to the system, and how it is managed, that matters

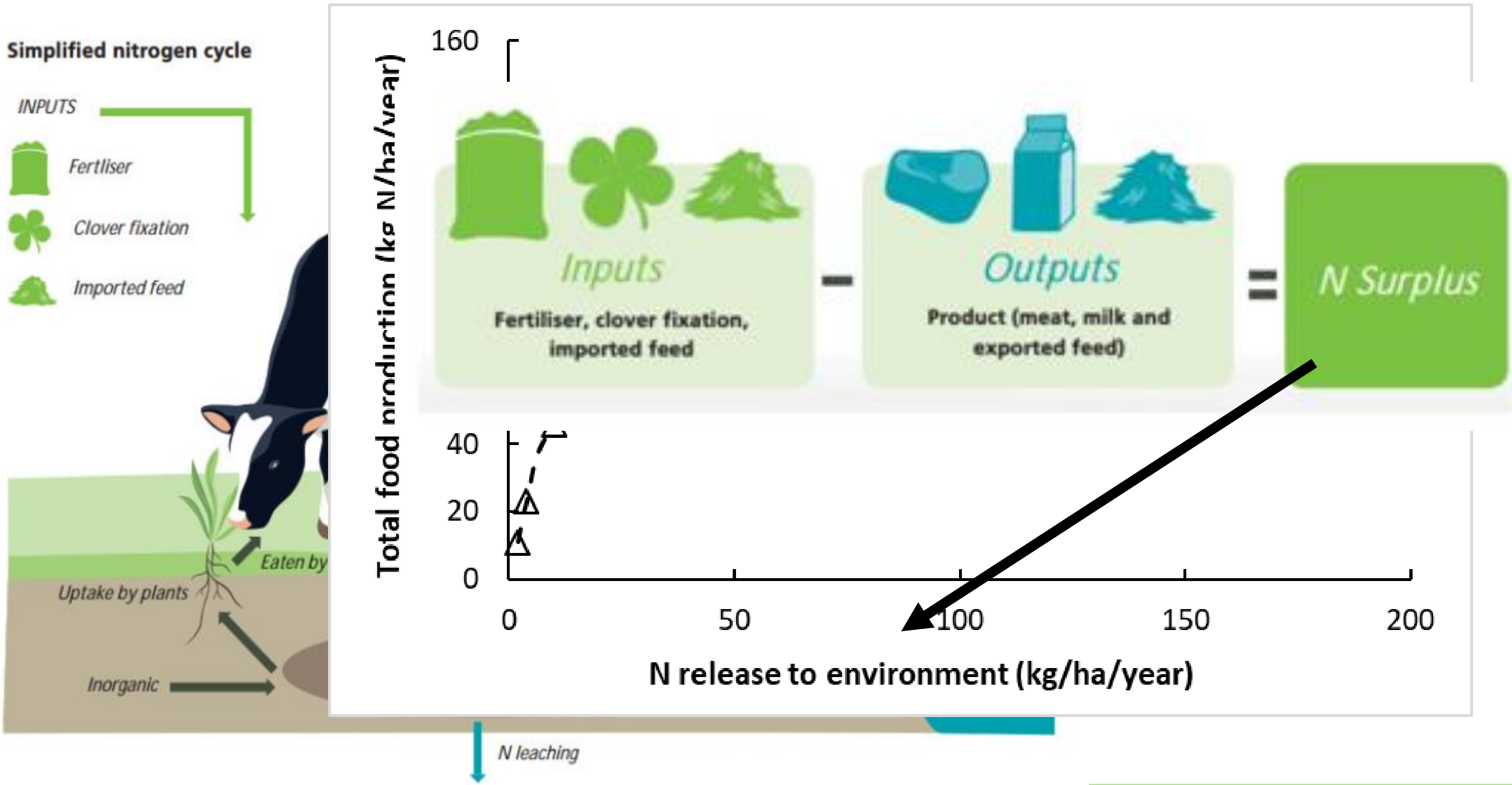
DairyNZ

Research focus (since 2010)

- System re-alignment
- Forage options
- Animal selection and breeding

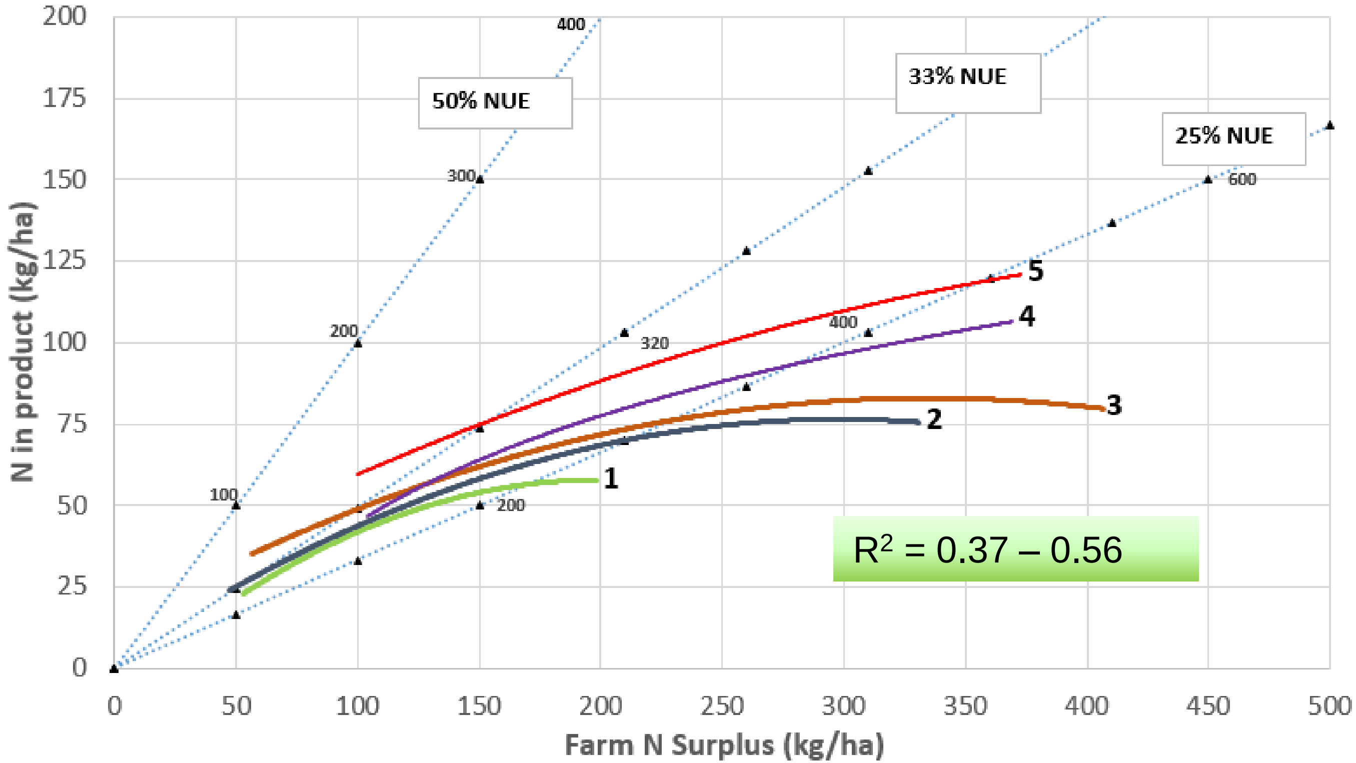
- Break negative relationship between production/profit and environmental impacts

Systems re-alignment



Relationships between systems intensification and N surplus

DairyNZ 'Baseline' project, n = 390 farms, 2015-16 season, DairyBase data + OVERSEER file for each farm



$R^2 = 0.37 – 0.56$

Dairy systems 1 to 5:

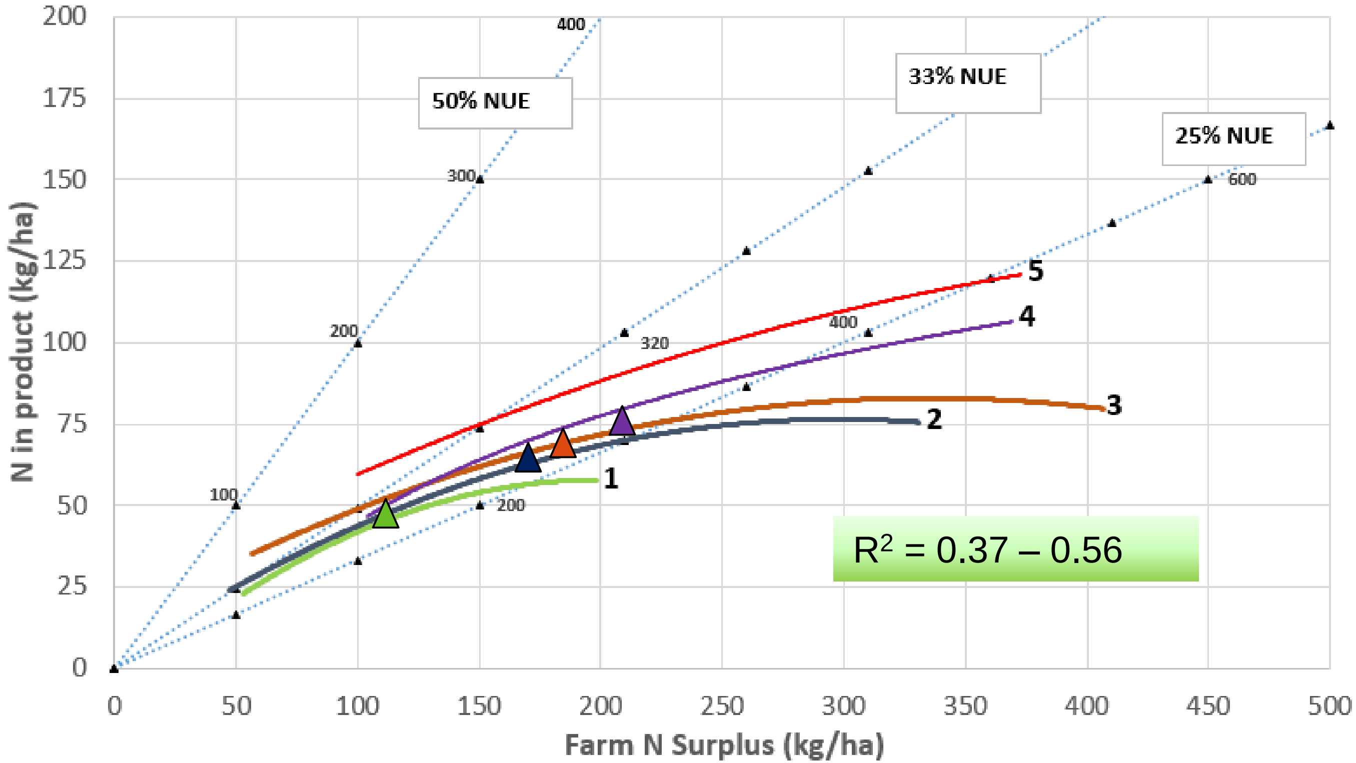
1 = no imported feed

5 = >30% of total feed is imported

Scale of intensification

Relationships between systems intensification and N surplus

DairyNZ 'Baseline' project, n = 390 farms, 2015-16 season, DairyBase data + OVERSEER file for each farm



Dairy systems 1 to 5:

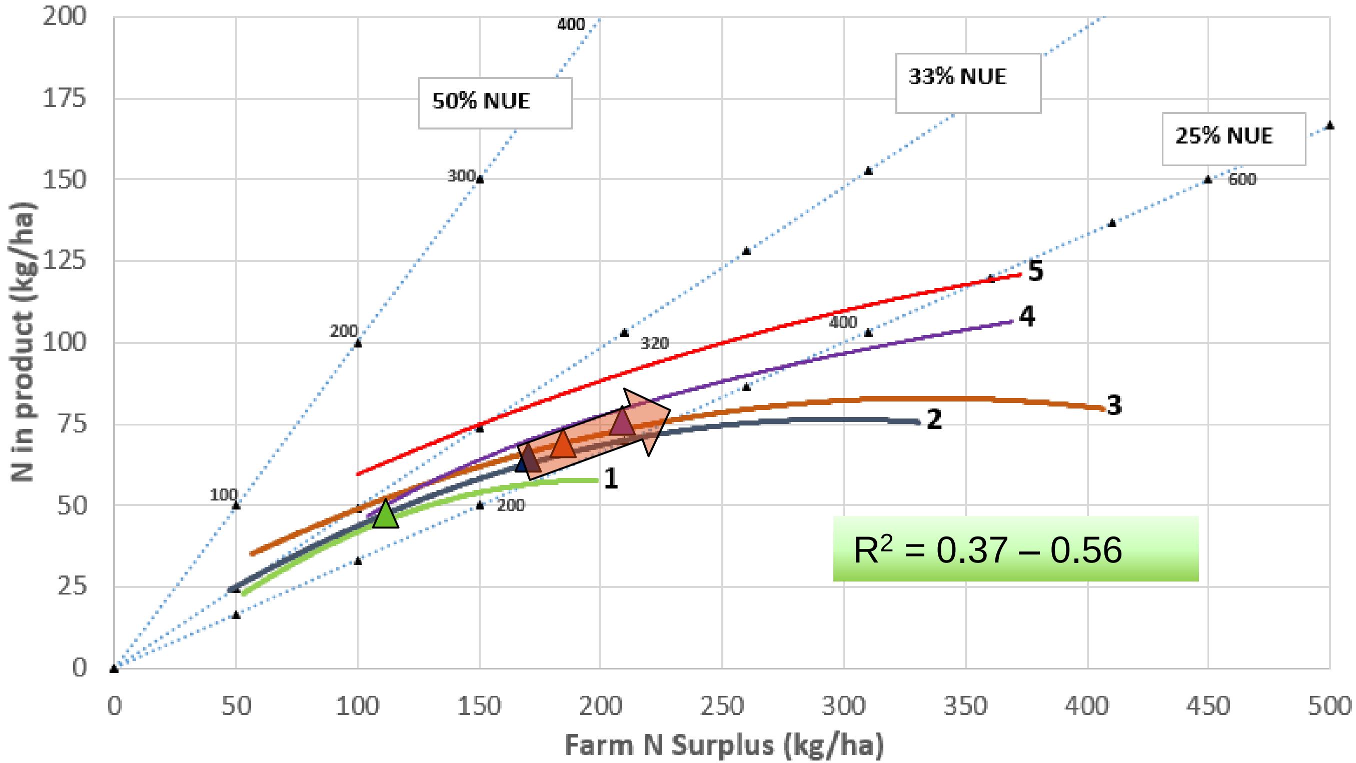
1 = no imported feed

5 = >30% of total feed is imported

Scale of intensification

Relationships between systems intensification and N surplus

DairyNZ ‘Baseline’ project, n = 390 farms, 2015-16 season, DairyBase data + OVERSEER file for each farm



Dairy systems 1 to 5:

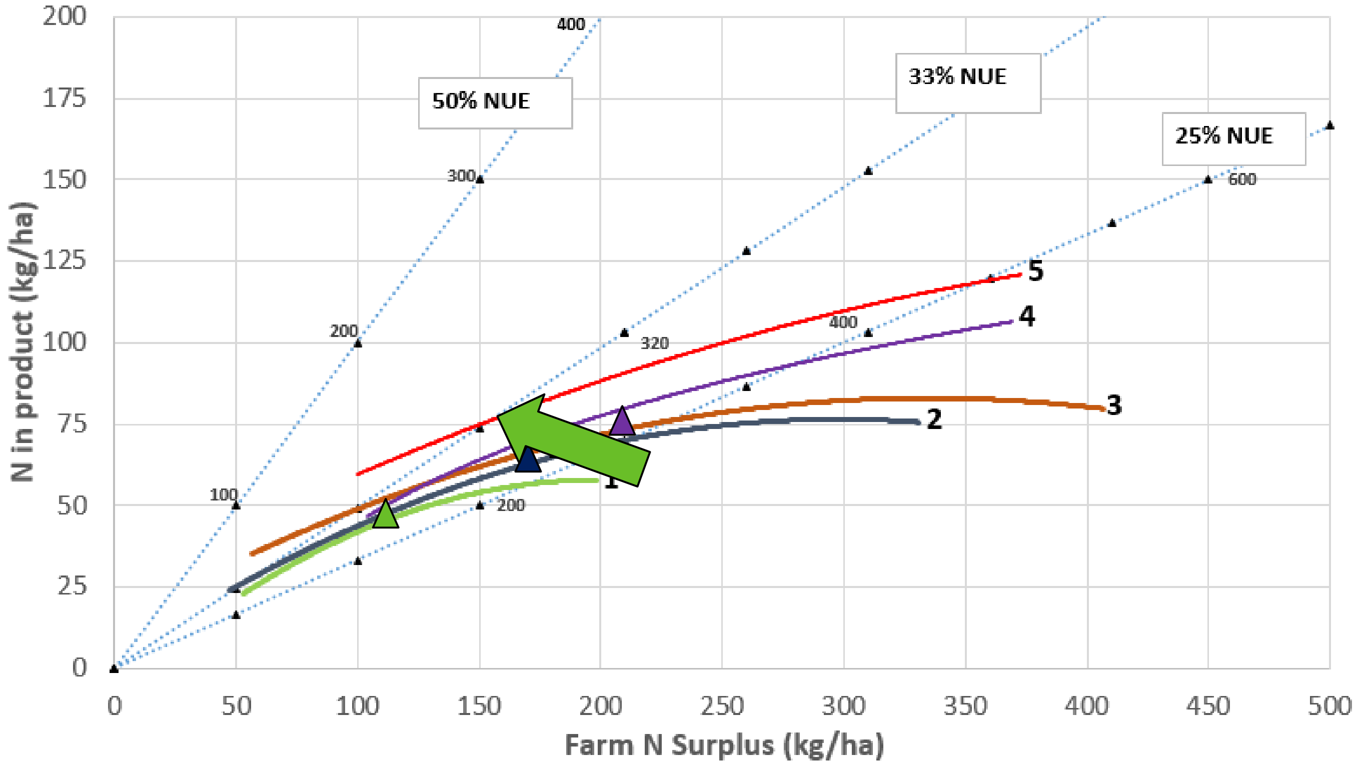
1 = no imported feed

5 = >30% of total feed is imported

Scale of intensification

Relationships between systems intensification and N surplus

DairyNZ 'Baseline' project, n = 390 farms, 2015-16 season, DairyBase data + OVERSEER file for each farm



Dairy systems 1 to 5:

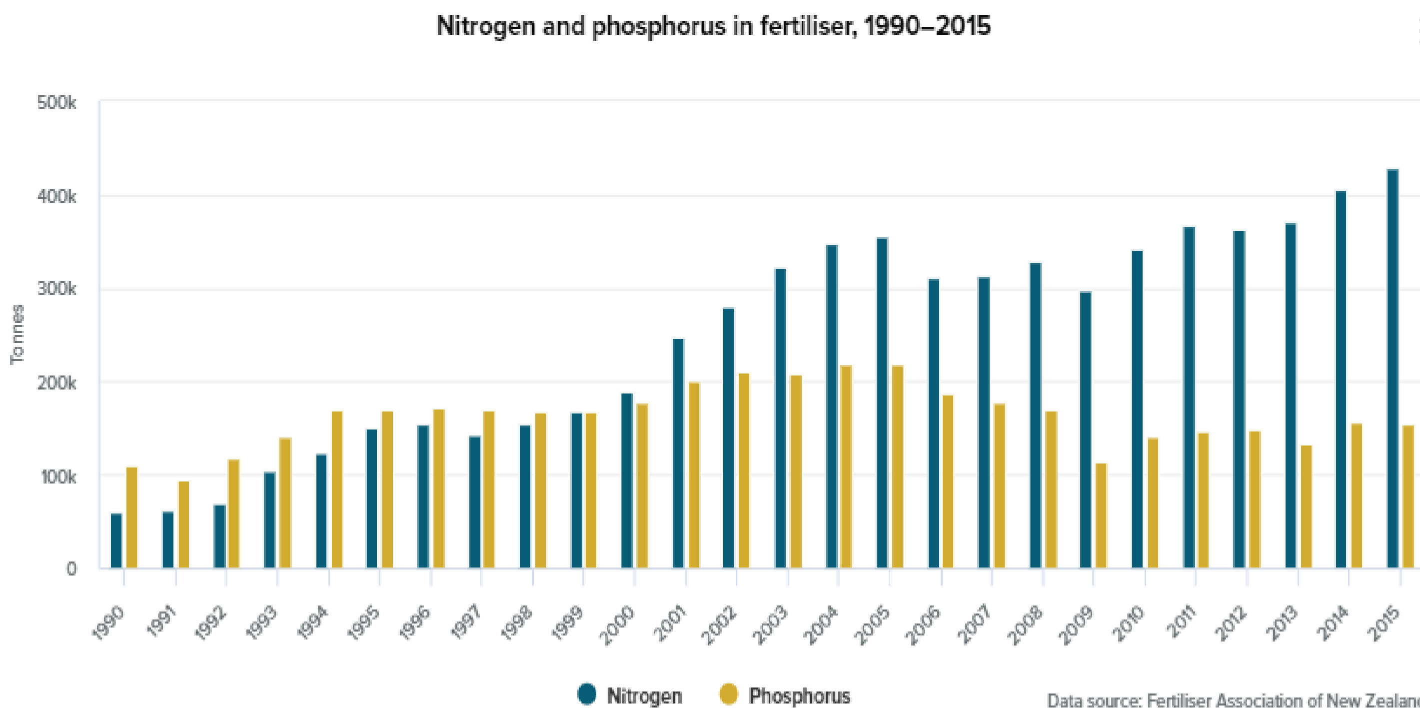
1 = no imported feed

5 = >30% of total feed is imported

Scale of intensification

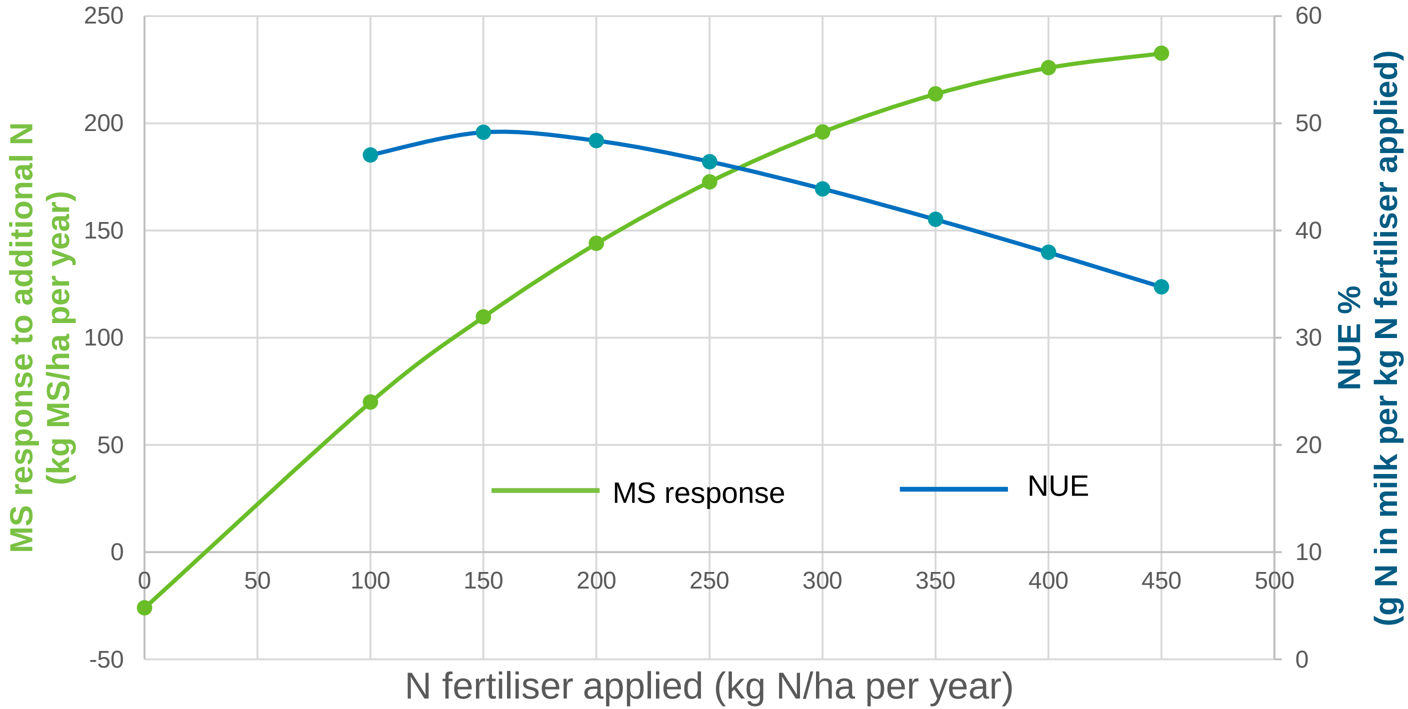
Systems re-alignment: optimising N fertiliser inputs

From 1990 to 2015, the annual application of nitrogen via fertiliser increased 627% (from 59,000 tonnes to 429,000 tonnes)



Systems re-alignment: optimising N fertiliser inputs

Whole-system milk production responses to increasing N fertiliser



Source: Clark DA. 1997. Proceedings of the Ruakura Farmers Conference. pp. 92-98.

DairyNZ

Pellow, R., 2017. Applying Pastoral 21 Farmlet Research to a Whole Farm – Results from Lincoln University Dairy Farm. In: *Science and policy: nutrient management challenges for the next generation*. (Eds L. D. Currie and M. J. Hedley). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 30. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 10 pages.

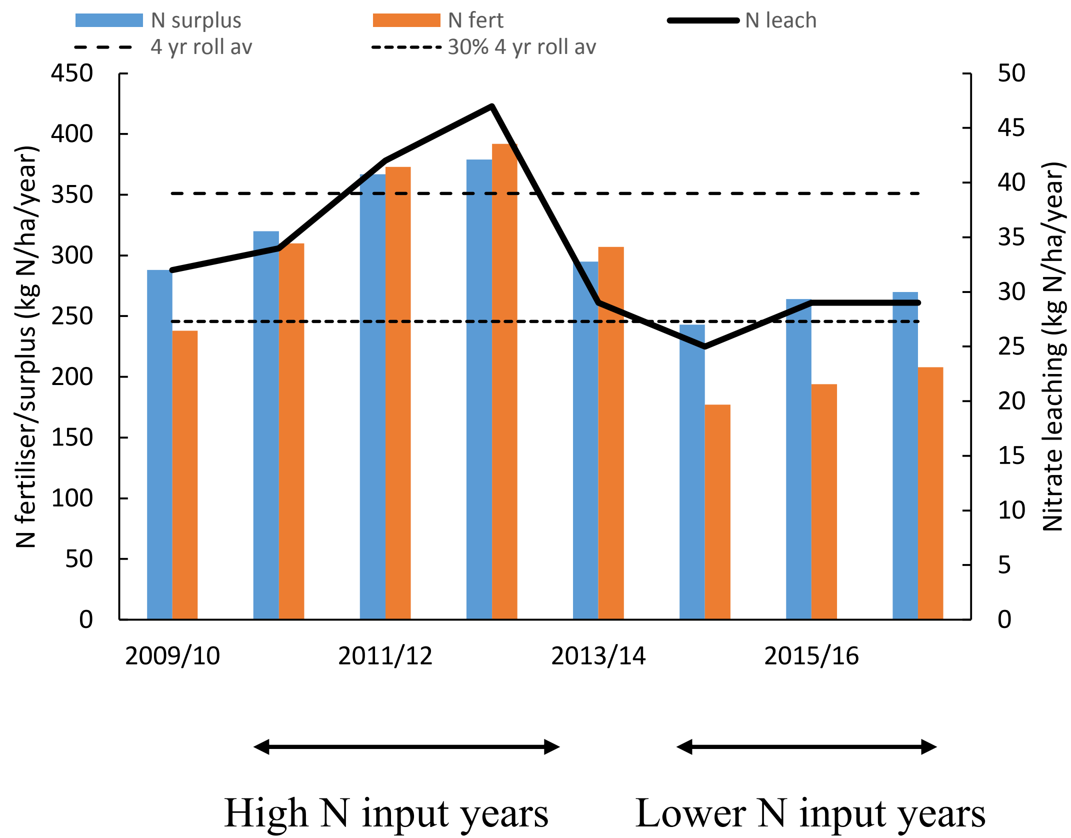
APPLYING PASTORAL 21 FARMLET RESEARCH TO A WHOLE FARM – RESULTS FROM LINCOLN UNIVERSITY DAIRY FARM

Ron Pellow

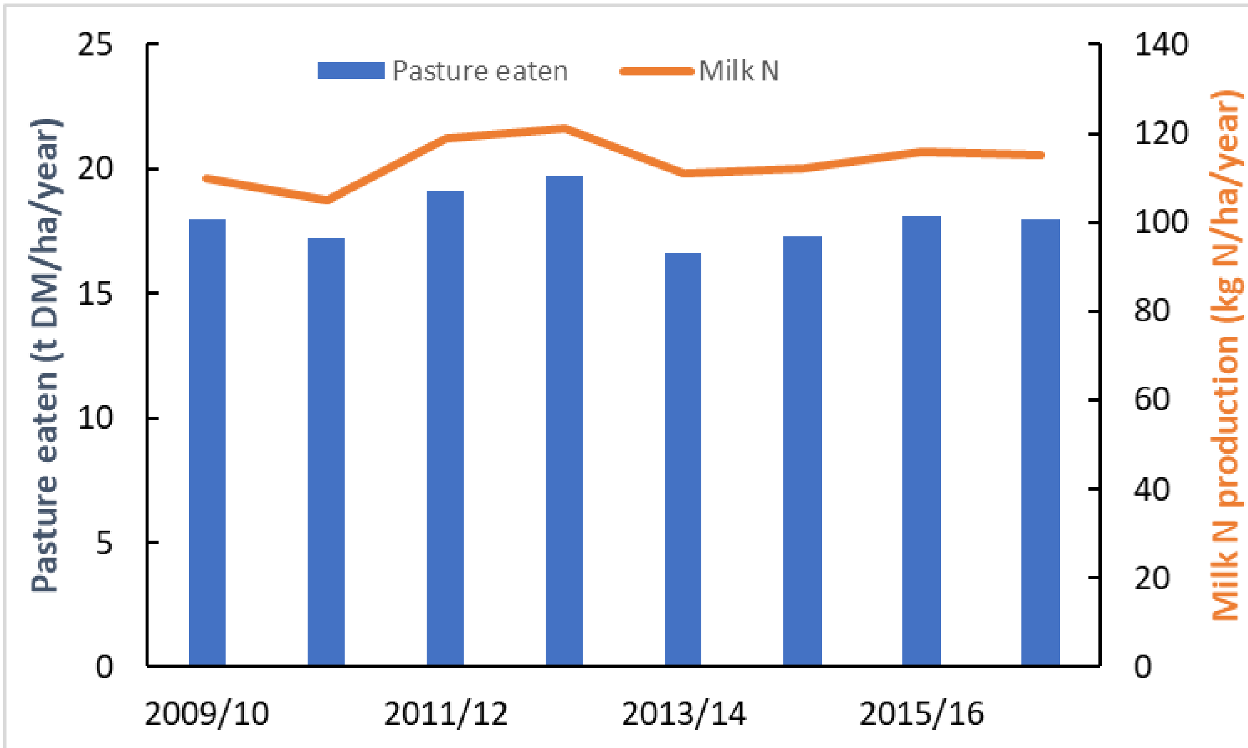
South Island Dairying Development Centre, PO Box 85160,
Lincoln University, Christchurch, 7647
Email: ron.pellow@siddc.org.nz

Partners Networking To Advance
South Island Dairying

LUDF 2009-2017: N inputs, surplus and leaching



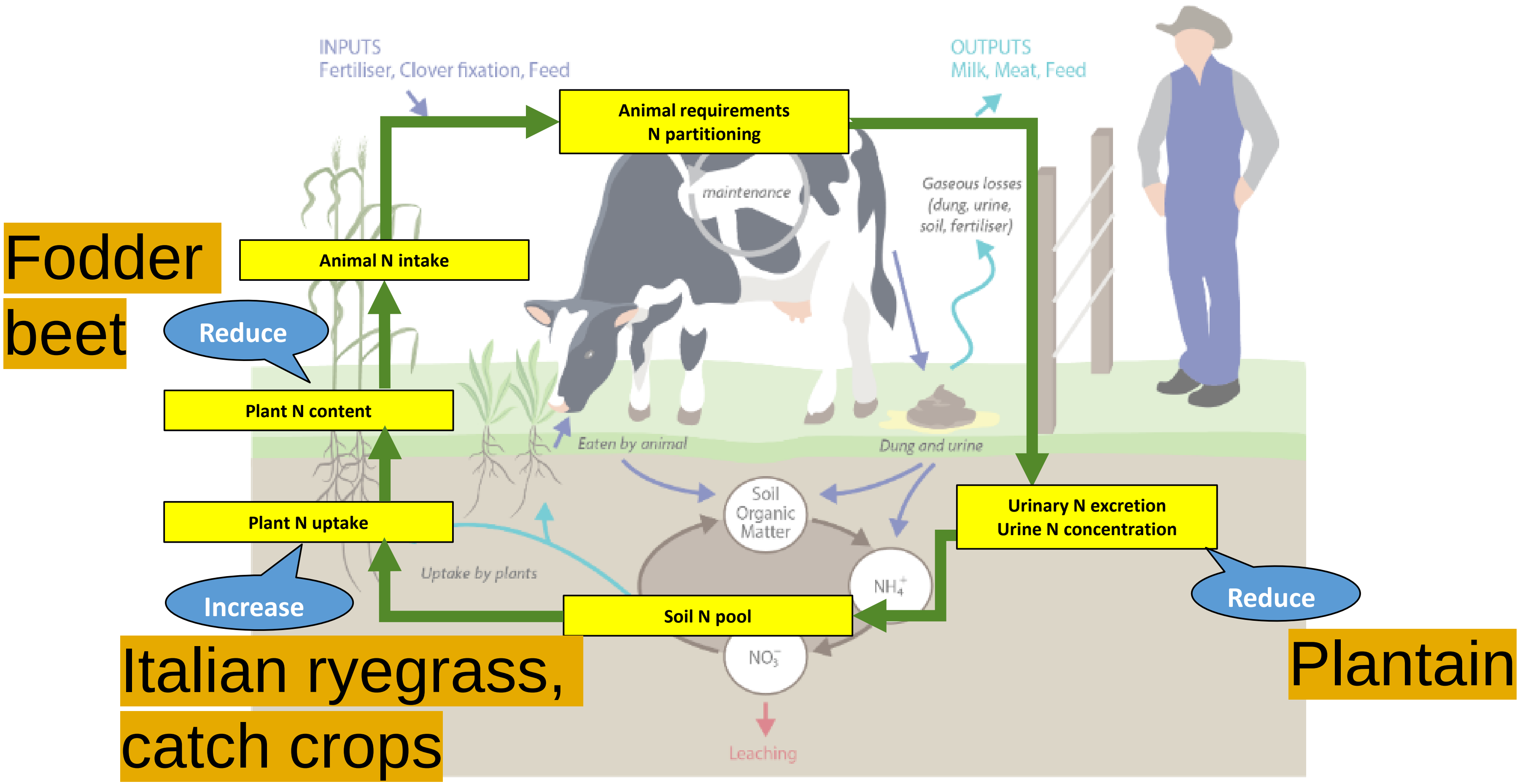
LUDF 2009-2017: Productivity



High N input years

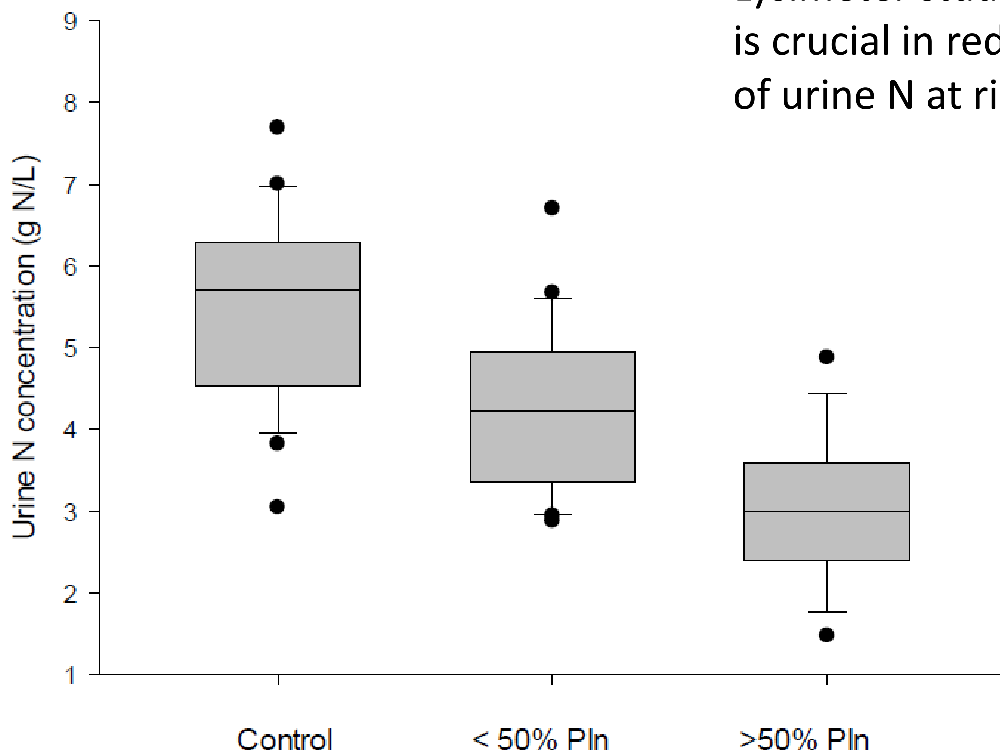
Lower N input years

Forage options



Plantain

Plantain reduces urine N concentration



Lysimeter studies show that this is crucial in reducing the amount of urine N at risk of leaching.

Bryant et al. 2017

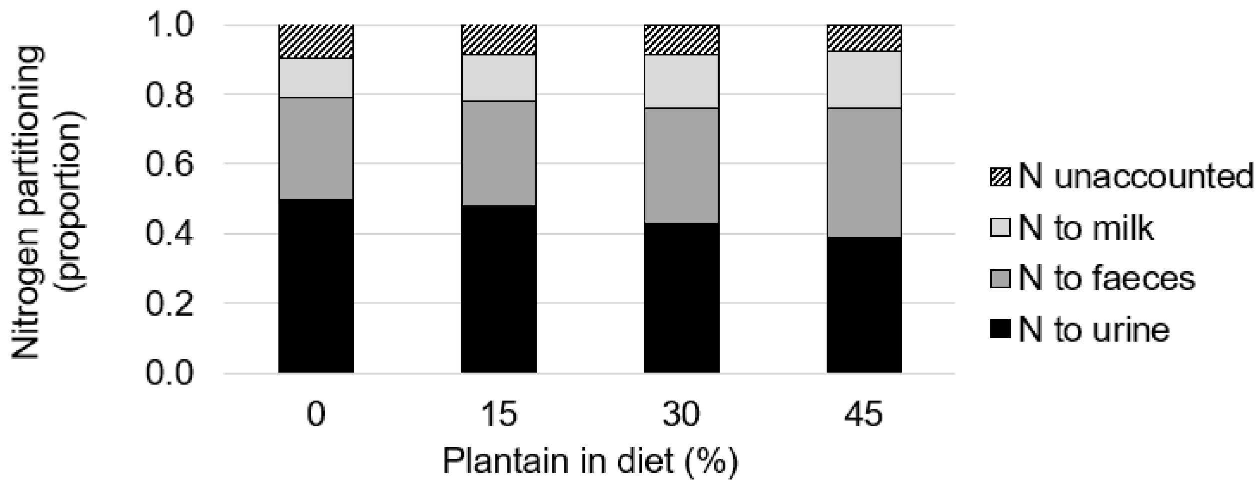
How much is required in the diet?

Metabolism stall experiment autumn 2018

	% plantain in diet				
	0	**15**	**30**	**45**	Significance
Total DMI (kg DM/cow/d)	14.8	16.5	16.8	17.4	$P < 0.05$
N intake (g/cow/day)	553	575	529	525	NS
Milk solids (kg/cow/d)	0.96	1.14	1.16	1.24	$P < 0.05$
Total N excreted to urine (g/cow/day)	270	270	240	200	$P < 0.05$

- **Similar total N intake**
- **11% and 26% lower N excretion in urine when plantain = 30% and 45% of diet**
- **21-29% increase in milk solids**

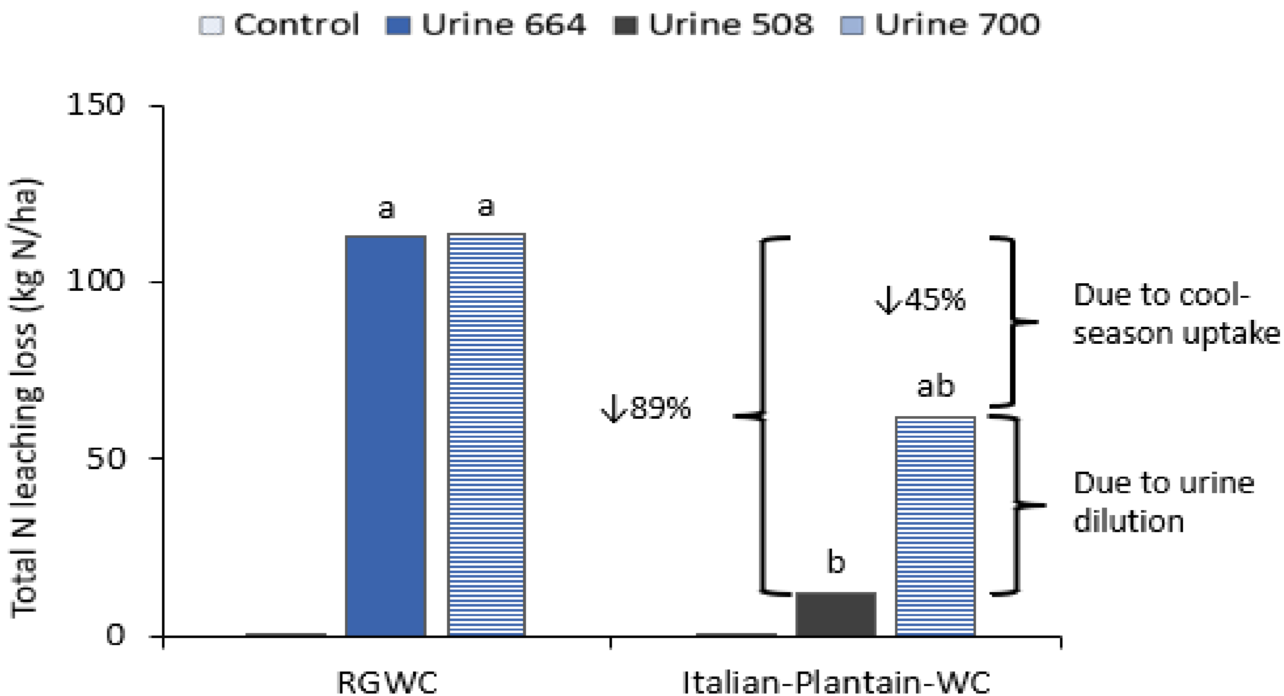
N partitioning in the animal



- Effect is explained by lower soluble protein fraction in plantain, and higher NSC:N ratio

Nutritive value attribute	Perennial ryegrass			Plantain			
	Mean	Lower 1/4	Upper 1/4	Mean	Lower 1/4	Upper 1/4	*P*-Value
Total N (% DM)	3.1	2.7	3.4	3.2	2.8	3.5	0.521
Soluble N (% total N)	38.4	31.8	45.0	12.0	5.3	18.6	< 0.01
Degradable N (% total N)	69.2	65.9	72.5	56.0	52.7	59.3	< 0.01
Non-structural CHO (%DM)	21.1	19.6	22.6	29.9	28.4	31.4	< 0.001
CHO:N ratio	6.8	7.3	6.6	9.3	10.1	9.0	

Leaching from autumn applied urine was significantly reduced by plantain and Italian ryegrass

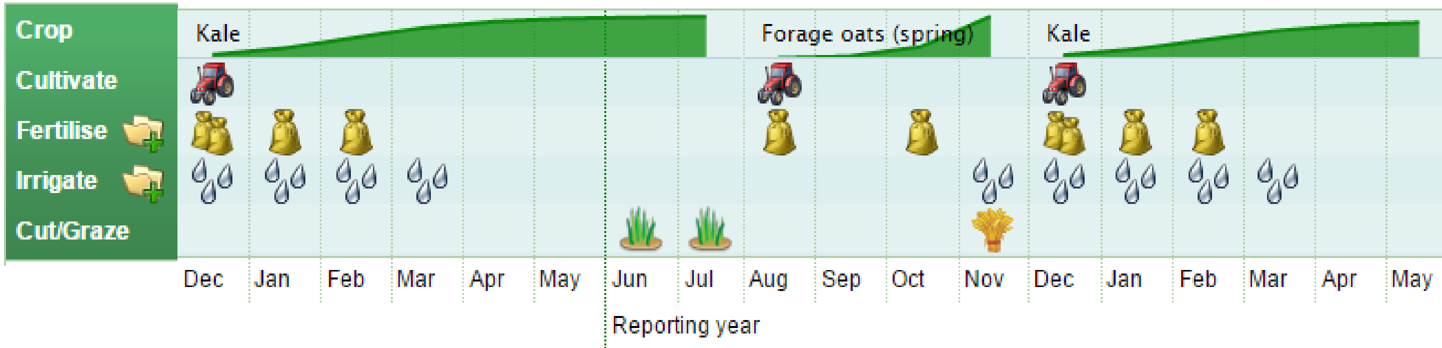


Woods et al. 2017

Plan for plantain from here

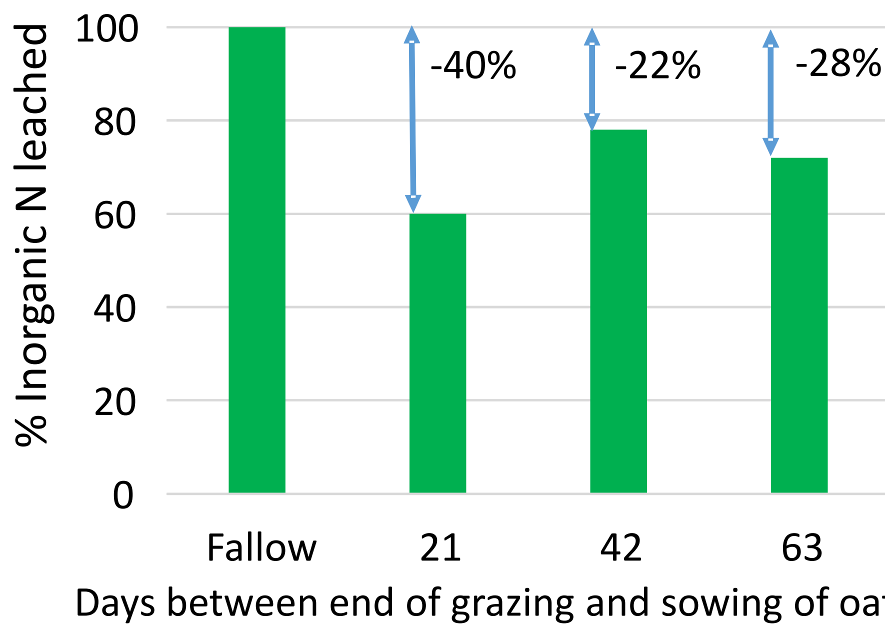
- N leaching at scale
- Modes of action
  - Root exudates
  - Proportion of plantain required in pasture/system and how to sustain it
- Milk composition and product integrity
  - Risk mitigation (market access)
  - Possible value-add opportunities
- Drive adoption
  - OVERSEER (regulatory tool)
  - Co-development programs with farmers, Regional Councils etc.

Catch crops establish and grow at low temperatures, taking up water and soil mineral N = reduced risk of nitrate leaching



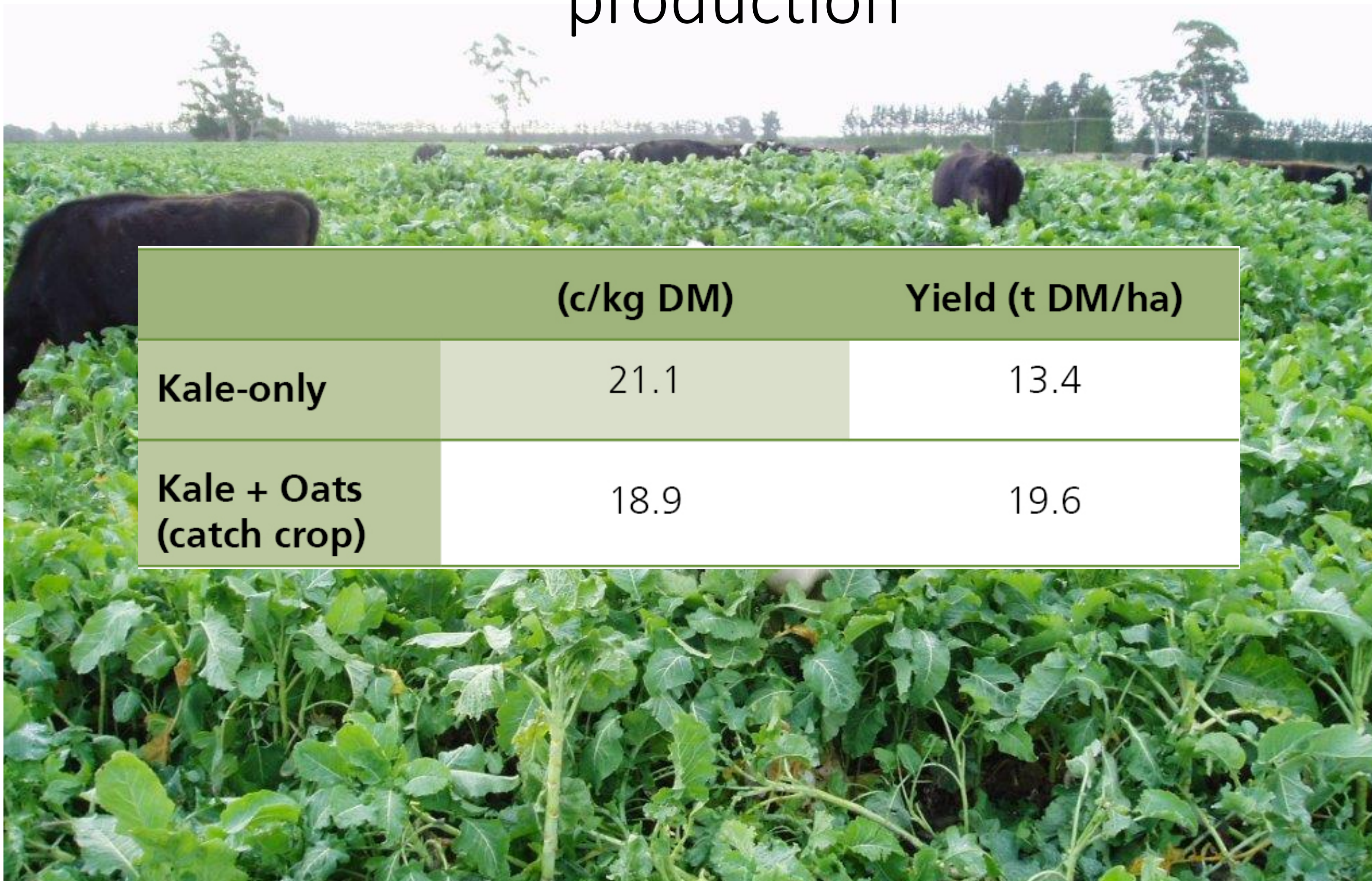
Kale grazed in-situ, followed by oats crop

Compared with leaving ground fallow until next kale crop is sown



Malcolm et al. 2019

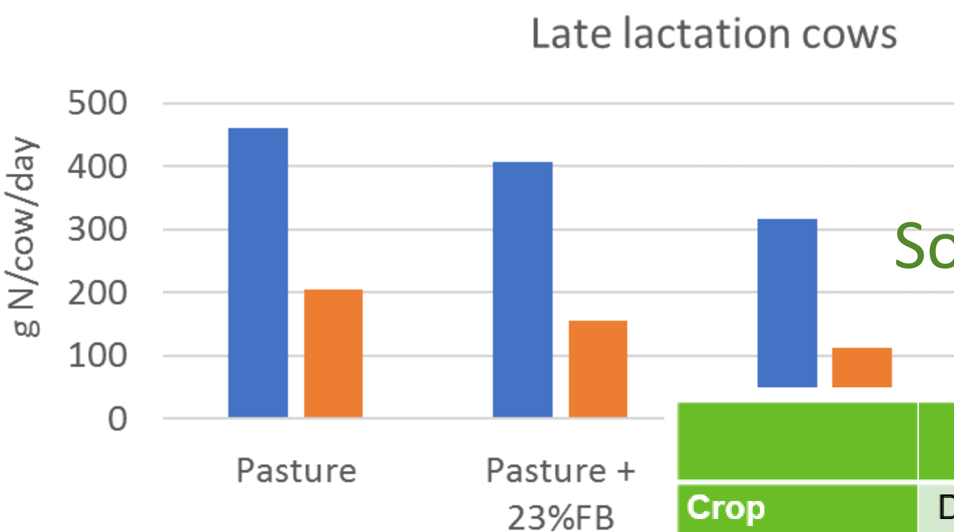
Catch crops can increase total DM production



	(c/kg DM)	Yield (t DM/ha)
Kale-only	21.1	13.4
Kale + Oats (catch crop)	18.9	19.6

(Edwards *et al*. 2014; DairyNZ, 2015)

Fodder beet is a low-N feed, and reduces N intake and urinary N excretion

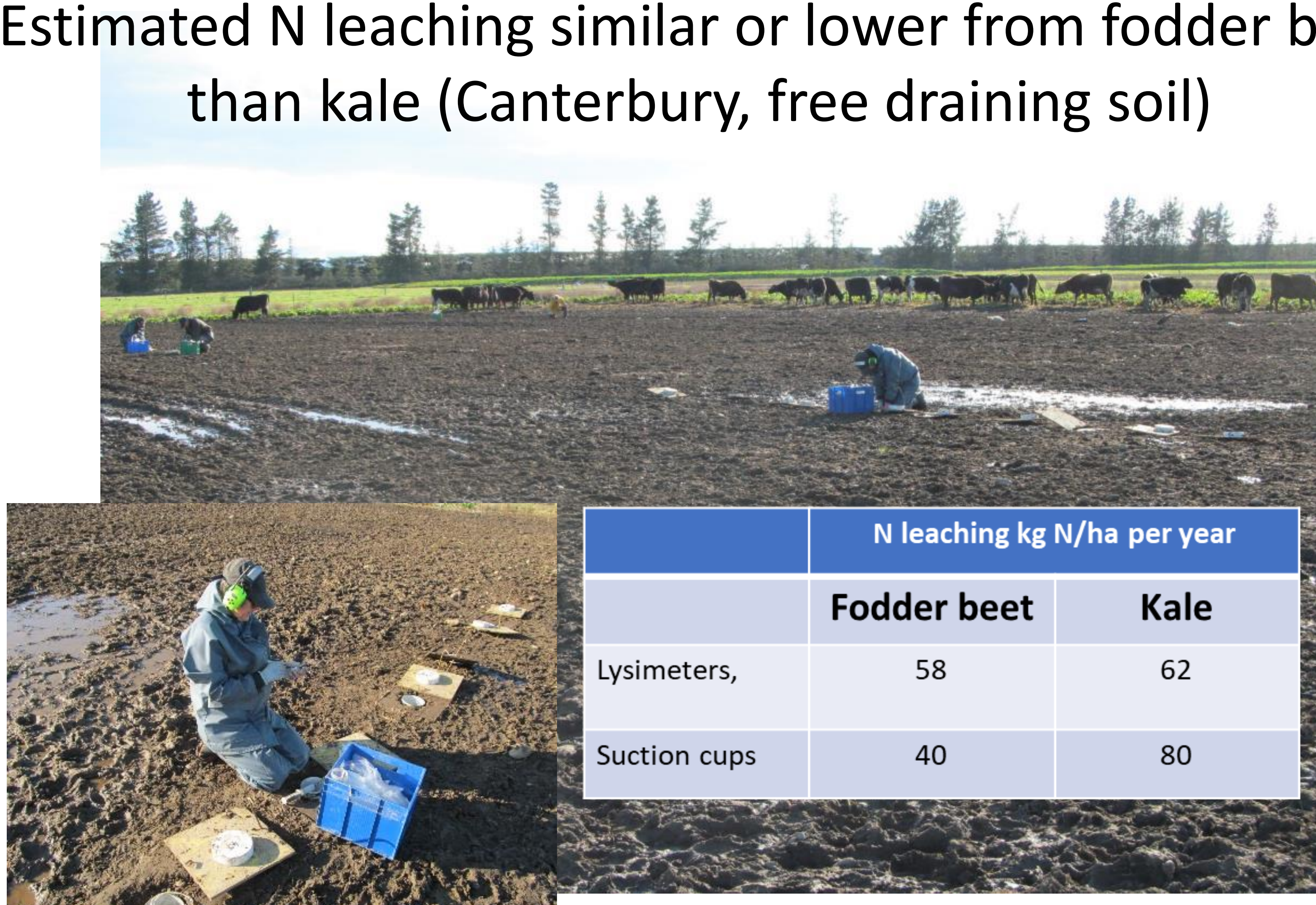


Waghorn, Dalley et al. 2018

Some dietary issues need to be managed

	Estimated dietary intakes				
Crop	Diet CP%	MJ ME	Diet P%	Diet Ca%	Diet Mg%
Requirement	Not <12%		0.3-0.35%	0.6-0.8%	0.22-0.28%
Kale	16.2	145 (11.4)	0.36	0.88	0.19
Fodder beet	14.3	165 (12.8)	**0.21**	**0.35**	0.21

Estimated N leaching similar or lower from fodder beet than kale (Canterbury, free draining soil)



	N leaching kg N/ha per year	
	Fodder beet	**Kale**
Lysimeters,	58	62
Suction cups	40	80

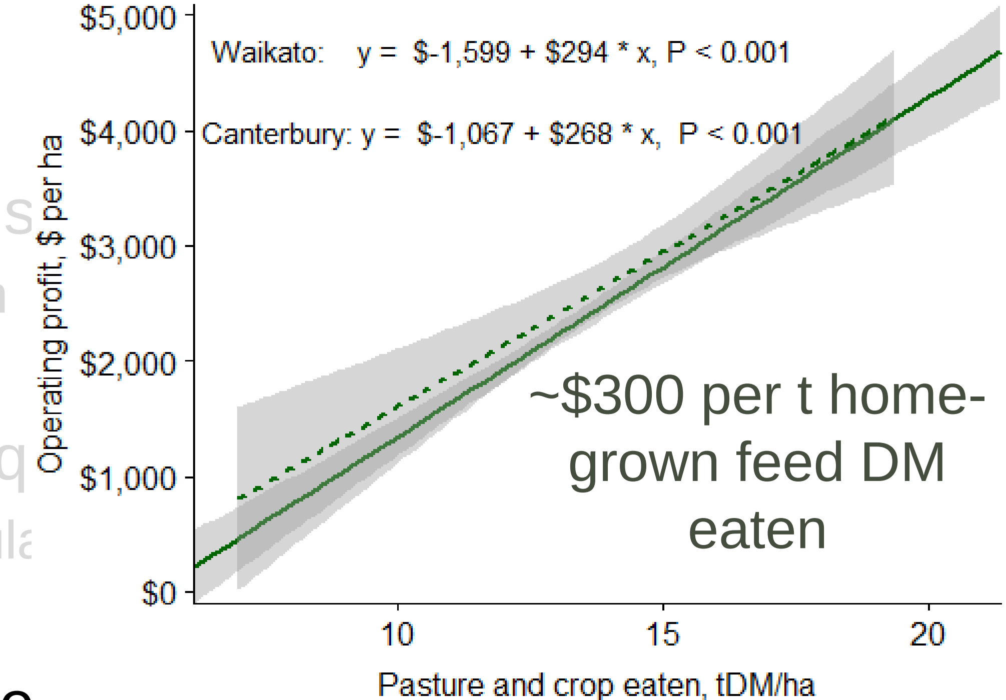
Summary of options

Mitigation options	Economic impact	Ease of use
Reduce N fertiliser, time better	May need stocking rate adjustment	Requires good pasture monitoring – tools are all available
Plantain	May increase yield, needs frequent re-establishment	
Reduce supplements, swap to low-N feed	May require infrastructure	
Catch crops	Upfront costs, may increase annual DM yield	Success weather-dependent
Early culling		Needs to reduce feed eaten
Stand-off pads		May require new skills

Dalley et al. 2018 (SIDE)

Outline

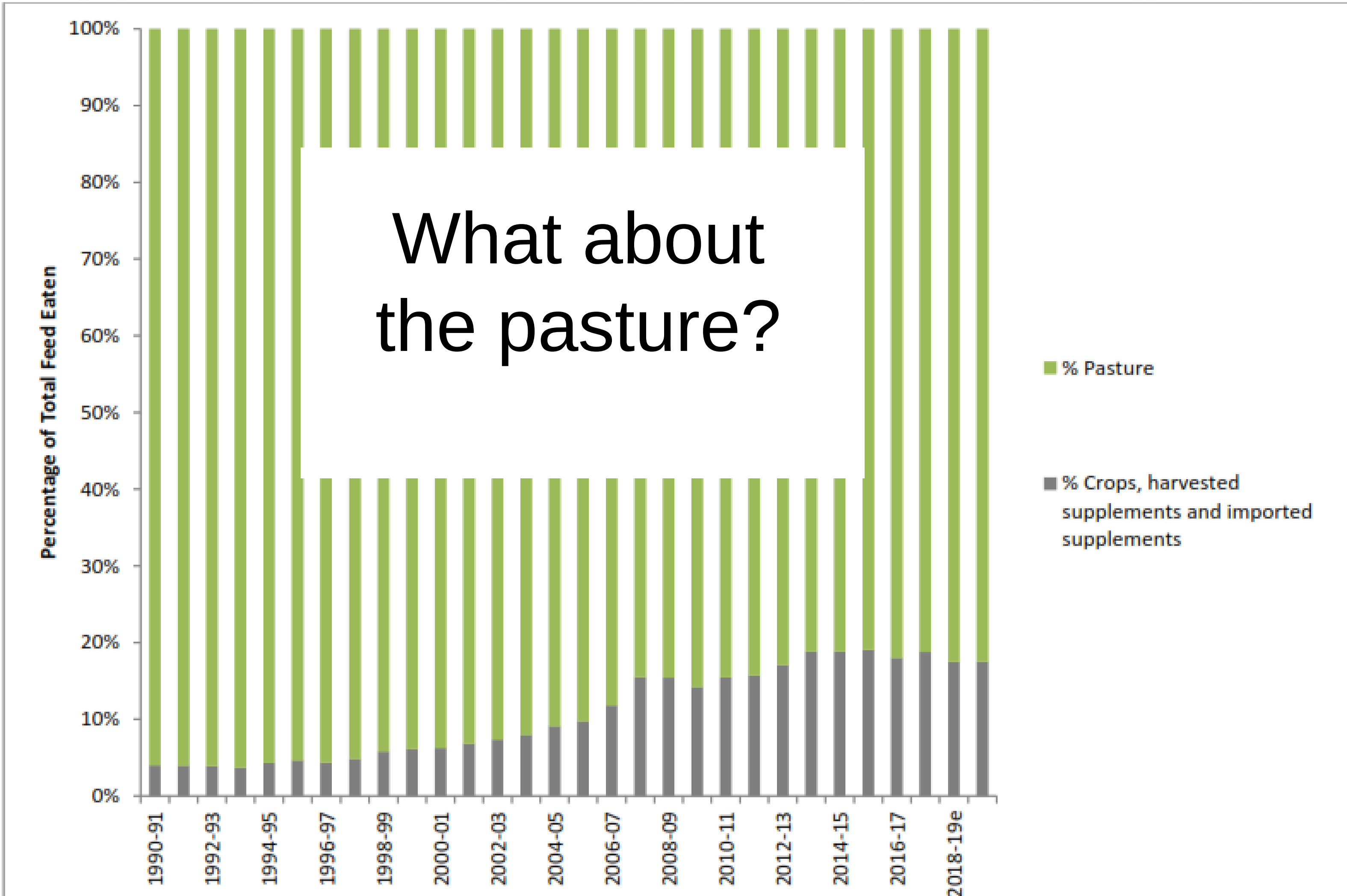
- Changes in systems
  - Unregulated growth
  - Systems creep
- Reaping the conseq
  - Environmental regul
  - The role of forages
- Re-focus on pasture
  - Pasture potential
  - Persistence in a changing climate
- Concluding comments



Concluding comments

- Heavy focus (2000-2014) on production is slowly abating
  - Capital gains are drying up, re-focus on cash flow, input costs rising sharply, **debt**
- Significant environmental regulation pressures
  - Water quality – happening now, will roll out nationally in next 5 years
  - Methane emissions – 10% reduction by 2030, 24-47% by 2050 (net carbon zero bill)
- System and forage options can solve nutrient limits equation
  - Simple, scale-able, grazed forage solutions that are still very profitable
  - Regionally-specific, still uncertainty
  - Environmental warrior species e.g. plantain
  - No wholesale movement to cropping solutions – opposite in many situations
    - Costs, soil constraints, complexity, causing pasture persistence failure?
- Re-focus on pasture
  - We've heard this before! Will it stick this time?
  - Increased rates of genetic gain are critical
  - Raise efficiency of use of inputs and environmental potential
  - Expect further head-winds from climate change

Percentage spilt between pasture eaten and non-pasture feed (crops, harvested supplements and imported supplements) eaten



Source: DairyNZ Economics Group

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**
N fertiliser kg N/ha/yr	50	200	150	Assume 8 kg DM eaten/kg N fertiliser	- 1.2 t DM/ha

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**
N fertiliser kg N/ha/yr	50	200	150	Assume 8 kg DM eaten/kg N fertiliser	- 1.2 t DM/ha
Expansion in South Island ha	110,000	660,000	550,000	Irrigation and higher summer rainfall	- 0.45 t DM/ha

DairyNZ

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**
N fertiliser kg N/ha/yr	50	200	150	Assume 8 kg DM eaten/kg N fertiliser	- 1.2 t DM/ha
Expansion in South Island ha	110,000	660,000	550,000	Irrigation and higher summer rainfall	- 0.45 t DM/ha
CO_2 concentration ppm	352	395	42	Stimulation of pasture growth 2% in 25 yrs	- 0.18 t DM/ha

DairyNZ

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**
N fertiliser kg N/ha/yr	50	200	150	Assume 8 kg DM eaten/kg N fertiliser	- 1.2 t DM/ha
Expansion in South Island ha	110,000	660,000	550,000	Irrigation and higher summer rainfall	- 0.45 t DM/ha
CO_2 concentration ppm	352	395	42	Stimulation of pasture growth 2% in 25 yrs	- 0.18 t DM/ha
Sub-total					***+1.83***

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**
N fertiliser kg N/ha/yr	50	200	150	Assume 8 kg DM eaten/kg N fertiliser	- 1.2 t DM/ha
Expansion in South Island ha	110,000	660,000	550,000	Irrigation and higher summer rainfall	- 0.45 t DM/ha
CO_2 concentration ppm	352	395	42	Stimulation of pasture growth 2% in 25 yrs	- 0.18 t DM/ha
Sub-total					***+1.83***
			Residual	= ~ 26 kg DM/ha/year 0.3% per year	**+0.65** t DM/ha in 25 years

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**
N fertiliser kg N/ha/yr	50	200	150	Assume 8 kg DM eaten/kg N fertiliser	- 1.2 t DM/ha
Expansion in South Island ha	110,000	660,000	550,000	Irrigation and higher summer rainfall	- 0.45 t DM/ha
CO_2 concentration ppm	352	395	42	Stimulation of pasture growth 2% in 25 yrs	- 0.18 t DM/ha
Sub-total					***+1.83***
Residual				= ~ 26 kg DM/ha/year 0.3% per year	**+0.65** t DM/ha in 25 years

If the residual is all from plant breeding, then it = ~ ½ the estimated rate of gain of 50-60 kg DM/ha per year of breeding effort

DairyNZ

What about the pasture?

	1990	2014	Difference		Balance sheet
Pasture eaten t DM/ha/yr	**8.80**	**11.28**	**2.48**	+ 100 kg DM/ha/yr = 1.1%/yr	**2.48**
N fertiliser kg N/ha/yr	[illegible]	[illegible]	150	Assume 8 kg DM eaten/kg N fertiliser	- 1.2 t DM/ha
Expansion in South Island ha	11[illegible]	[illegible]00	550,000	Irrigation and higher summer rainfall	- 0.45 t DM/ha
CO_2 concentration ppm	352	395	42	Stimulation of pasture growth 2% in 25 yrs	- 0.18 t DM/ha
Sub-total					***+1.83***
Residual				= ~ 26 kg DM/ha/year 0.3% per year	**+0.65** t DM/ha in 25 years

Pasture potential

- Genetic gain
- Environment and management
- Pasture persistence

Realised rates of genetic gain in pasture DM yield

- Forage Value Index predicts 40-60 kg DM/ha per year of breeding effort in perennial ryegrass
- Over 30 years = + 1.0 – 1.5 t DM/ha
- 1990-2014 analysis suggests we're seeing only ½ this, at best
- Re-grassing rates are low (except where pastures fail to persist)

Perennial Ryegrass Forage Value List

DairyNZ Forage Value Index

Upper Nth. Island

Cultivars are sorted by star rating and then alphabetically. Note:

Perennial ryegrass FVI is calculated using cultivar specific seasonal dry matter (DM) data, functional group average metabolisable energy (ME) content data and ploidy group average persistence trait data.

Cultivars with SE are not recommended as they can cause ryegrass staggers in summer and may reduce milk solid production at this time.

Cultivars with AR1 are not recommended in the Upper North Island as they provide limited protection against black beetle.

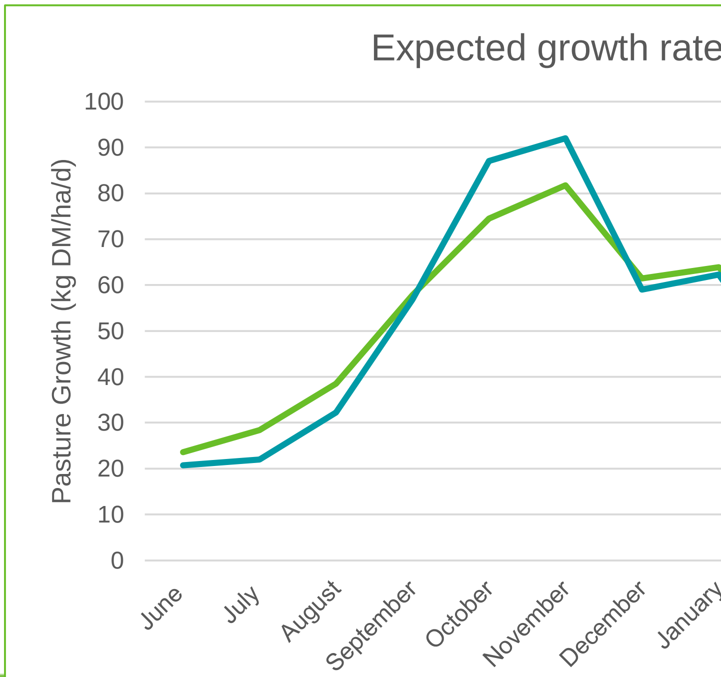
Evaluation date: 01/02/2019

			Performance Values[2] (1-5 rating)					Performance Values[3]					Persistence scalers/ costs		Other cultivar information				
FVI[1] (Star rating)	FVI Star Rating ($/ha)	Cultivar	Dry matter (DM)					Megajoules of metabolisable energy/kg DM relative to mid heading diploids					Persist. Scaler[4]	Relative renewal cost ($/ha)[5]	Endo[6]	Ploidy[7]	HD[8]	Marketer	Conf[9]
			Winter	Early spring	Late spring	Summer	Autumn	Winter	Early spring	Late spring	Summer	Autumn							
		Base AR37	5	4	4	5	5	0.47	0.42	0.58	0.31	0.40	0.71	41	AR37	T	VL	PGG Wrightson Seeds	9
		One50 AR37	5	4	4	5	5	0.09	0.05	0.20	0.06	0.10	0.75	0	AR37	D	L	Agricom	10+
★★★★★	$413 to $527	Platform AR37	5	5	4	5	5	0.09	0.05	0.20	0.06	0.10	0.75	0	AR37	D	L	PGG Wrightson Seeds	2
		Prospect AR37	5	5	5	5	4	0.09	0.05	0.20	0.06	0.10	0.75	0	AR37	D	L	Agricom	10+
		SF Hustle AR1	5	5	5	5	4	0.09	0.05	0.20	0.06	0.10	0.75	0	AR1	D	L	Seed Force	3
		Trojan NEA2	5	5	5	5	4	0.09	0.05	0.20	0.06	0.10	0.75	0	NEA2	D	L	Barenbrug Agriseeds	10+

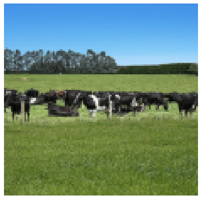
Realised rates of genetic gain in pasture DM yield

Forage Value Index ‘validation’ trial

‘Low’ v ‘high’ FVI ranking cultivars, 5 replicate herds of each, production and profit



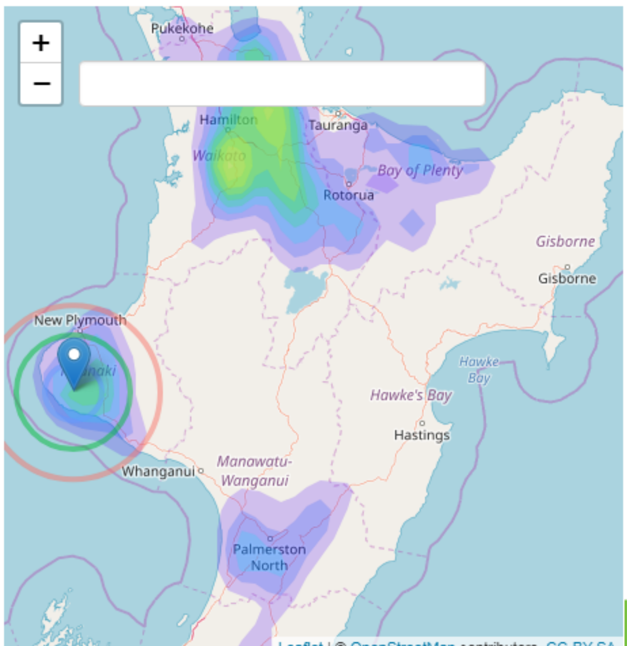
Pasture potential

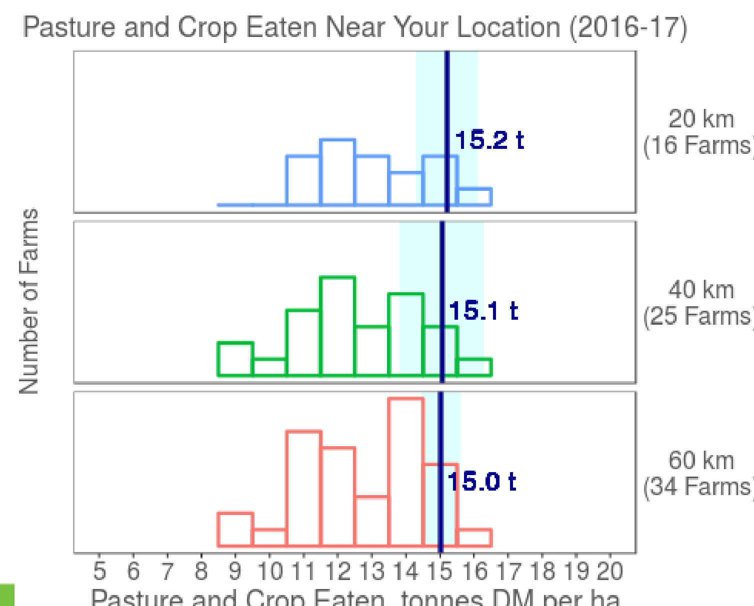


Pasture Potential Tool - DairyNZ

Use this tool to assess how your pasture potential figure stacks up with other farms of a similar N use and soil type in your local area.

https://www.dairynz.co.nz/.../pasture-and-crop-eaten/pasture-potential-tool





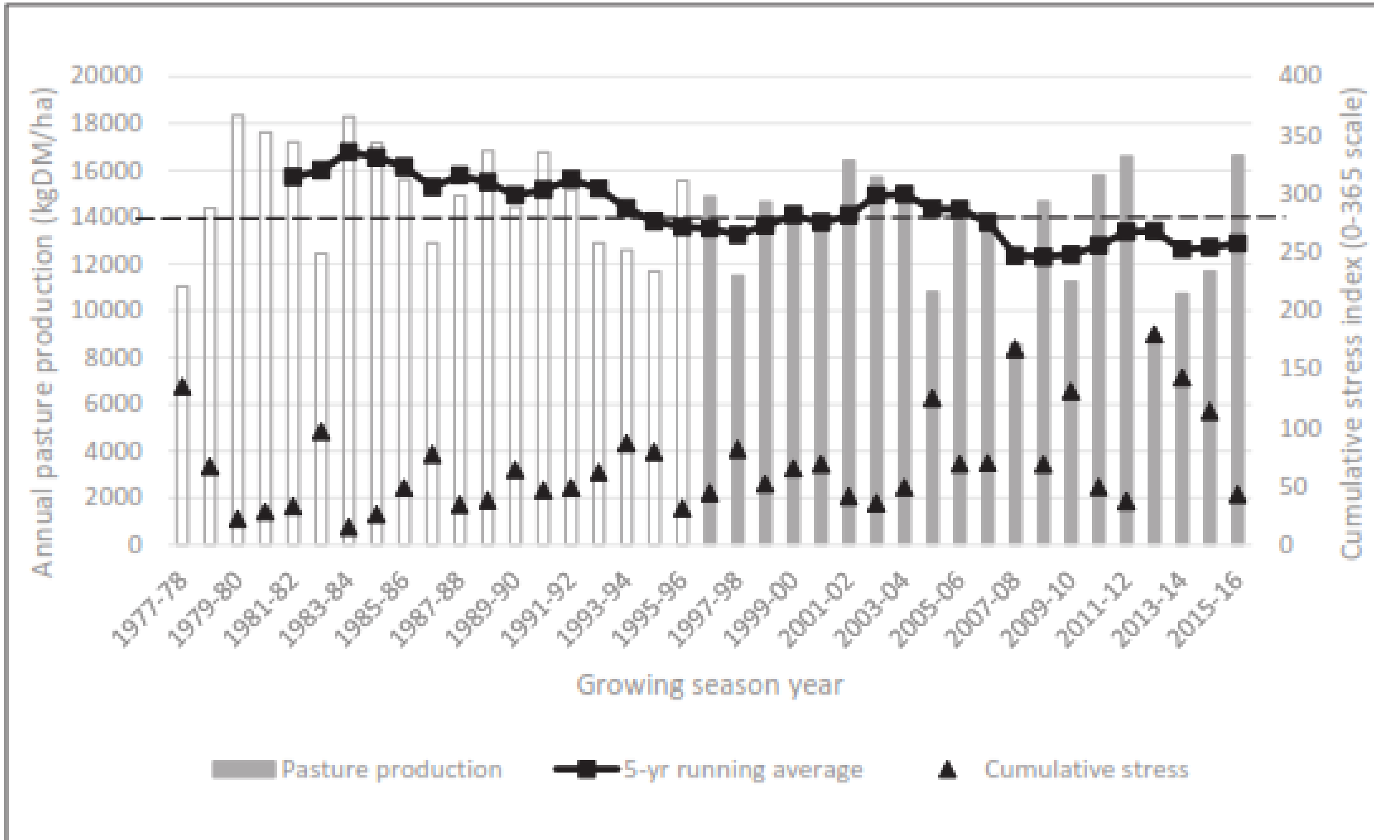
Pasture persistence

Lee et al. G&FS 2017


May 2019

Cumulative stresses and pasture growth trends

Modelled, central Waikato region



Dodd et al. 2018 JNZG

Concluding comments

- Heavy focus (2000-2014) on production is slowly abating
  - Capital gains are drying up, re-focus on cash flow, input costs rising sharply, **debt**
- Significant environmental regulation pressures
  - Water quality – happening now, will roll out nationally in next 5 years
  - Methane emissions – 10% reduction by 2030, 24-47% by 2050 (net carbon zero bill)
- System and forage options can solve nutrient limits equation
  - Simple, scale-able, grazed forage solutions that are still very profitable
  - Regionally-specific, still uncertainty
  - Environmental warrior species e.g. plantain
  - No wholesale movement to cropping solutions – opposite in many situations
    - Costs, soil constraints, complexity, causing pasture persistence failure?
- Re-focus on pasture
  - We've heard this before! Will it stick this time?
  - Increased rates of genetic gain are critical
  - Raise efficiency of use of inputs and environmental potential
  - Expect further head-winds from climate change

Mid-term future feedbase?

- Still strongly pasture-based
  - Some possible genetic gain game-changers
- Lower N fertiliser inputs
- More clover!
- Species options selected on a broader basis (than just DM and ME)
  - Environmental warrior species e.g. plantain
- 0.3 – 0.5 t DM imported feed per cow
- More self-contained (including winter grazing) – cost, biosecurity
- Much more efficient, enabled by technology
- Regionally variable
  - Regional discharge limits for N, P, sediment, e-coli
  - Climate change/variability, persistence trade-offs, soil constraints
  - Water – likely less, not more, for pastoral use