NZ Agricultural Production

Professor Derrick Moot

1 Dec 2017
Alberta, Canada (held at LU)

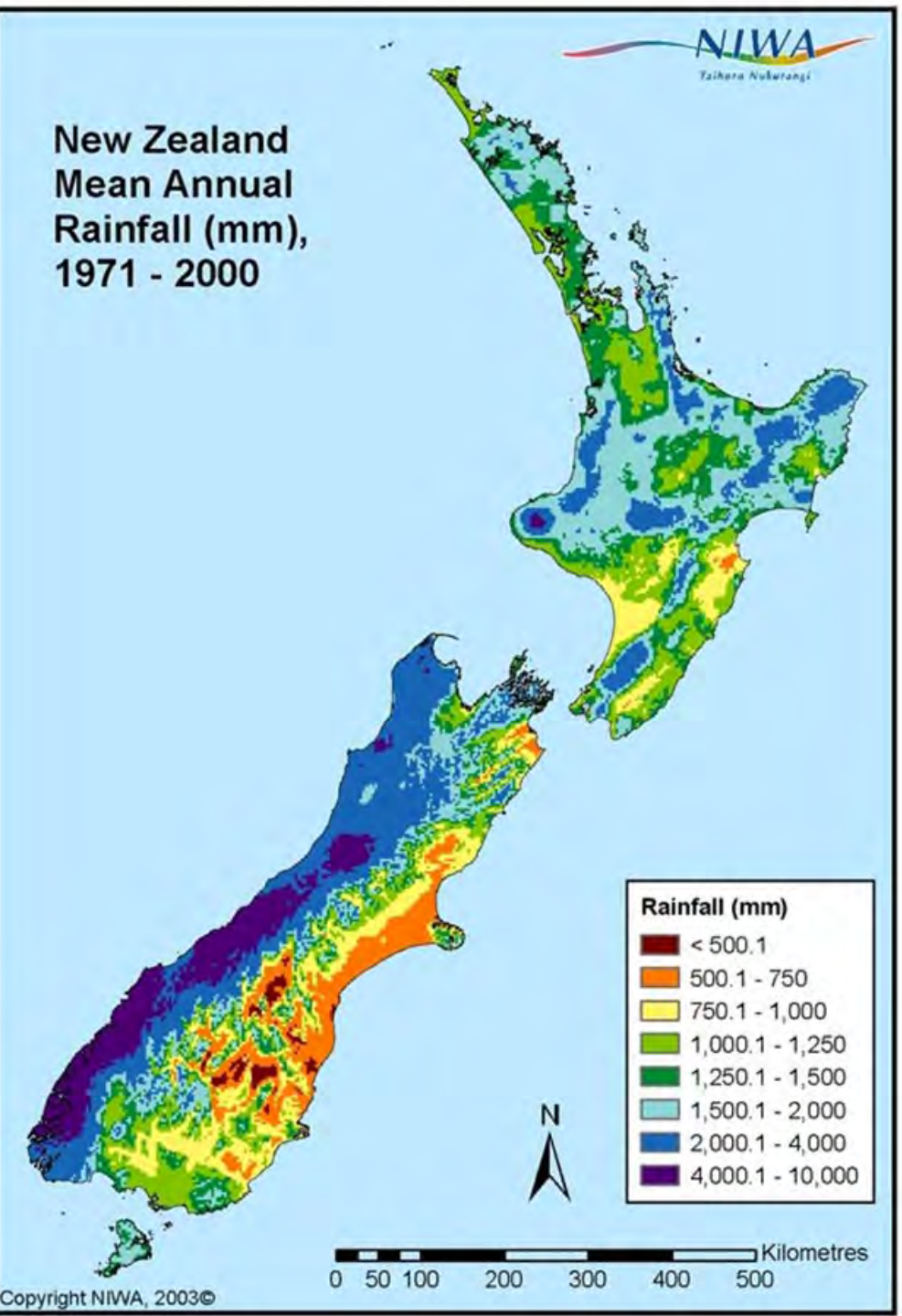
New Zealand's specialist land-based university

Animals graze outside all year

Photo: WR Scott
Lincoln University

Characteristics required of Pasture Plants

- Survive under grazing/defoliation, trampling, climate extremes, burning;
- Prostrate growth habit
- Growing points below ground
- Rapid vegetative development (tillers, stolons)
- Or massive seed production (annuals)



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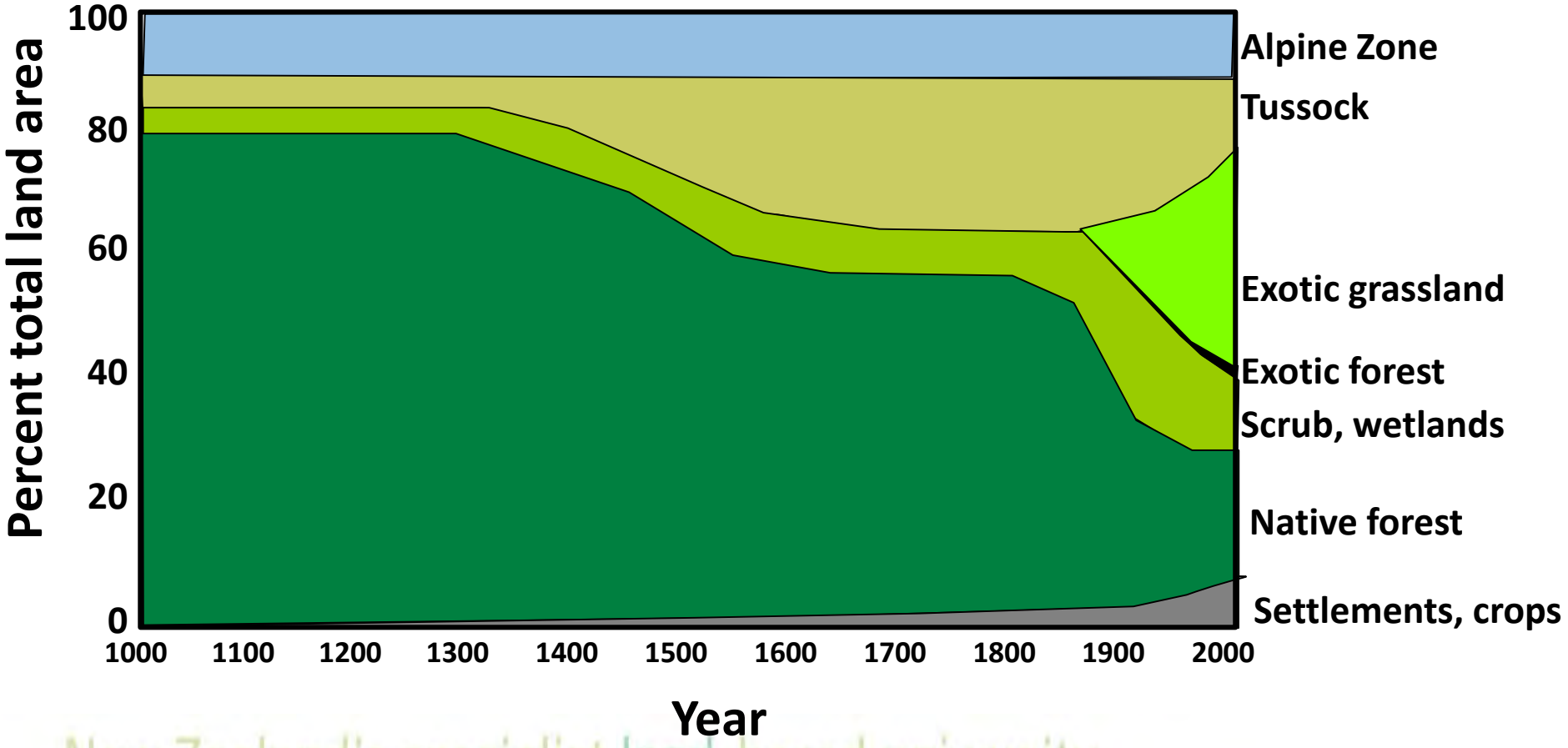
Climate

- West - rainfall satisfies demand
- East - soil moisture deficits
- Extent of deficit determined by soil type.
- Temperature gradient north to south

Historical land cover in NZ



Ministry for the Environment 2007

Farming everywhere?

Photo supplied by M Bloomburg
Lincoln University

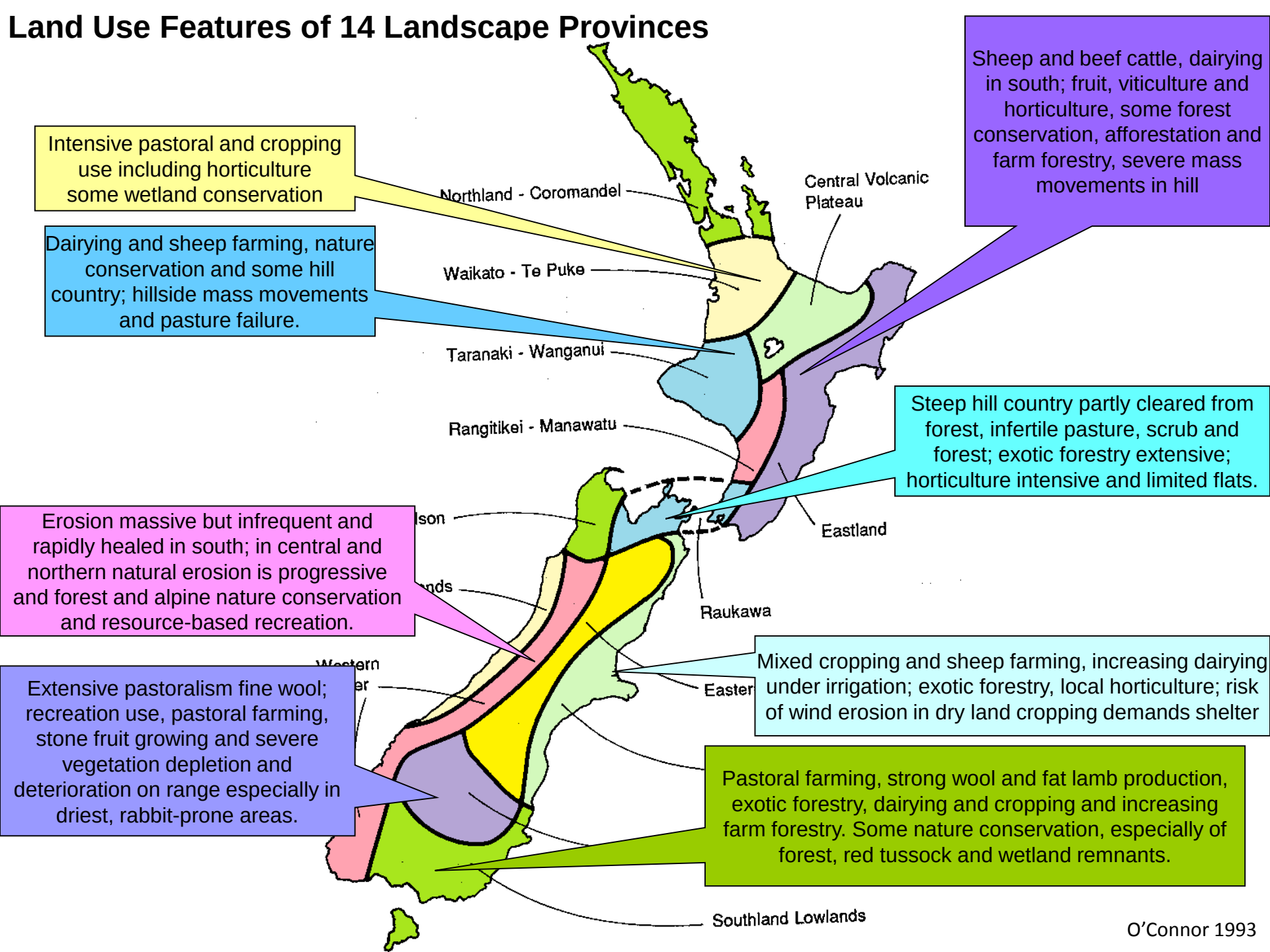
Land Use Classes in NZ

4 land-cover classes

18 predominant land-use classes

Natural Land Cover 52%	Pastoral Land Use 37%	8. Planted Forest 7.3%	Others 3.7%
1. Tussock 2. Native forest 3. Rivers, lakes, snow, ice 4. Scrub	1. Dairy 2. Intensive sheep and beef 3. Hill-country sheep and beef 4. High-country sheep and beef 5. Deer 6. Other Animals 7. Ungrazed		9. Arable crops 10. Vegetables 11. Berryfruit 12. Pipfruit 13. Grapes 14. Summer fruit 15. Tropical fruit 16. Kiwifruit 17. Flowers 18. Urban

Land Use Features of 14 Landscape Provinces



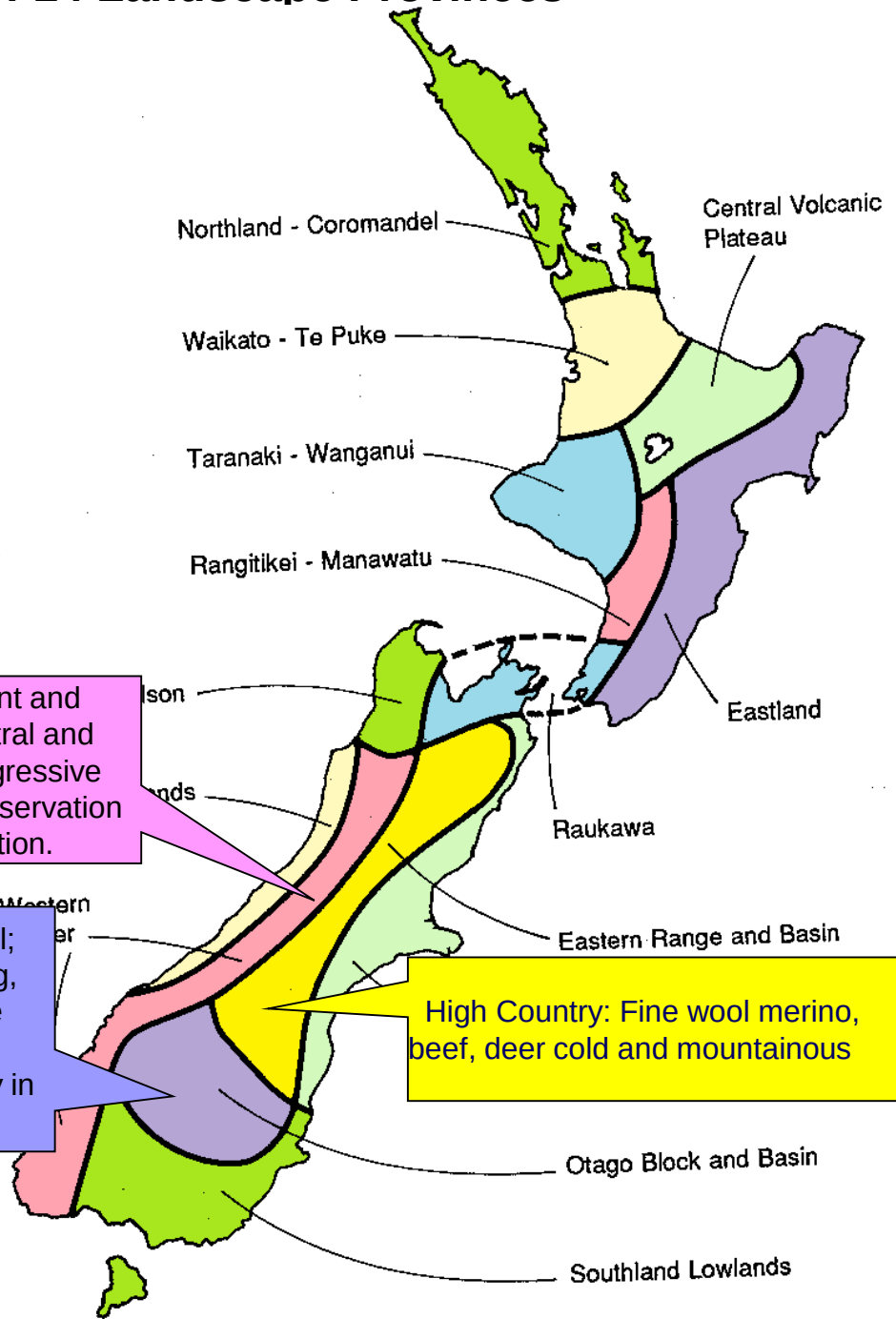
O'Connor 1993

NZ Farming Systems

- Most produce 1 -2 products
- Pasture based with conserved feed or forage crops when pasture supply is inadequate due to temperature extremes and/or drought
- Big movements of livestock from Hill Country to lower/easier country
- Sheep/beef farms provide dairy support: rearing young stock or wintering cows

1. High Country – South Island

Land Use Features of 14 Landscape Provinces



Erosion massive but infrequent and rapidly healed in south; in central and northern natural erosion is progressive and forest and alpine nature conservation and resource-based recreation.

Extensive pastoralism fine wool; recreation use, pastoral farming, stone fruit growing and severe vegetation depletion and deterioration on range especially in driest, rabbit-prone areas.

High Country: Fine wool merino, beef, deer cold and mountainous

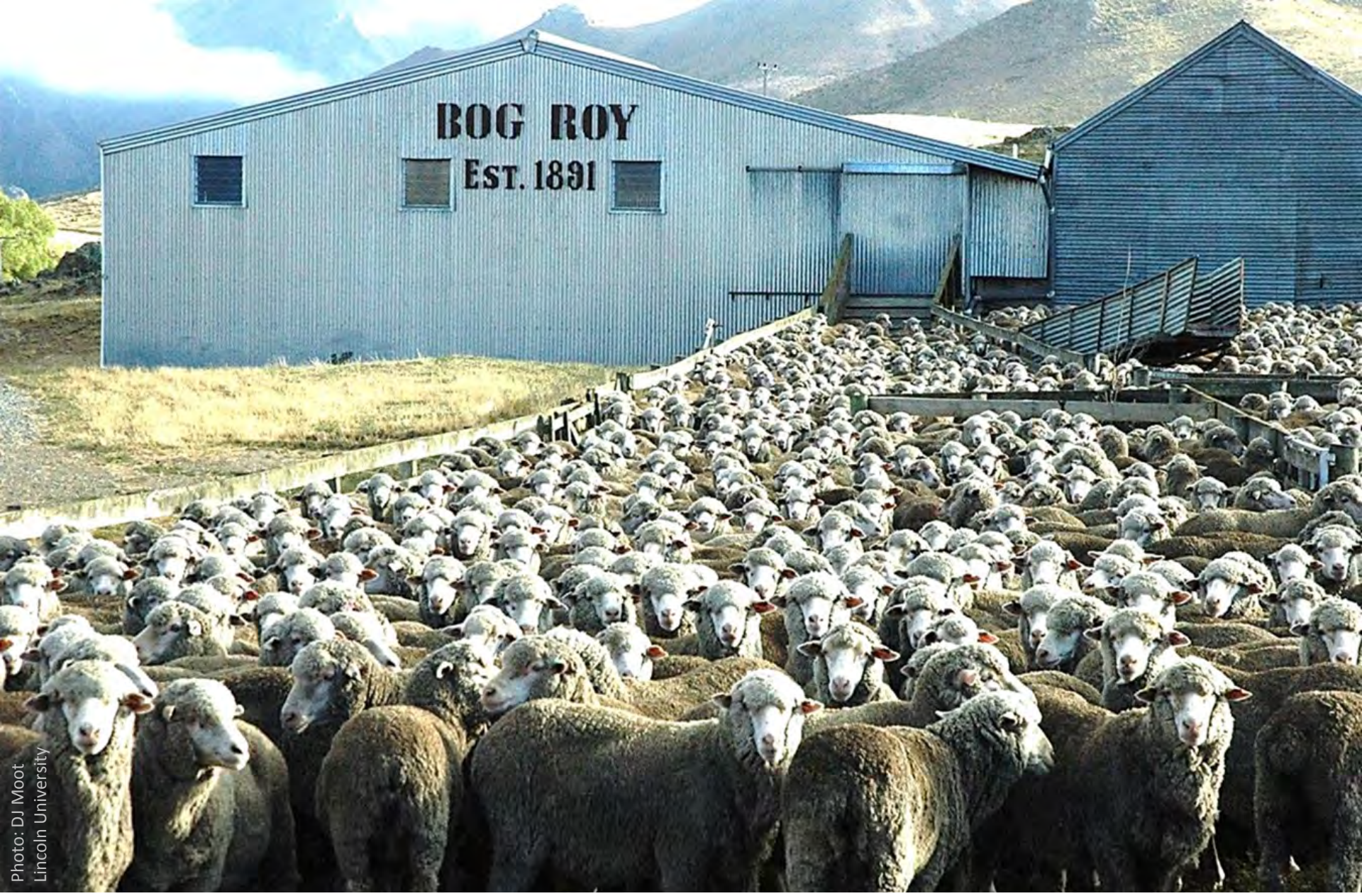
O'Connor 1993

Extensive run country located at high altitude

Photo: WR Scott
Lincoln University

Mountain and hill country
Native tussocks – replaced forestry

Photo: DJ Moot
Lincoln University



Merino sheep fine wool main source of income

Inland – Lees Valley, MacKenzie Basins

Risk of stock losses through snow most years

Beef cattle &/or deer

<u>Continental climate</u>

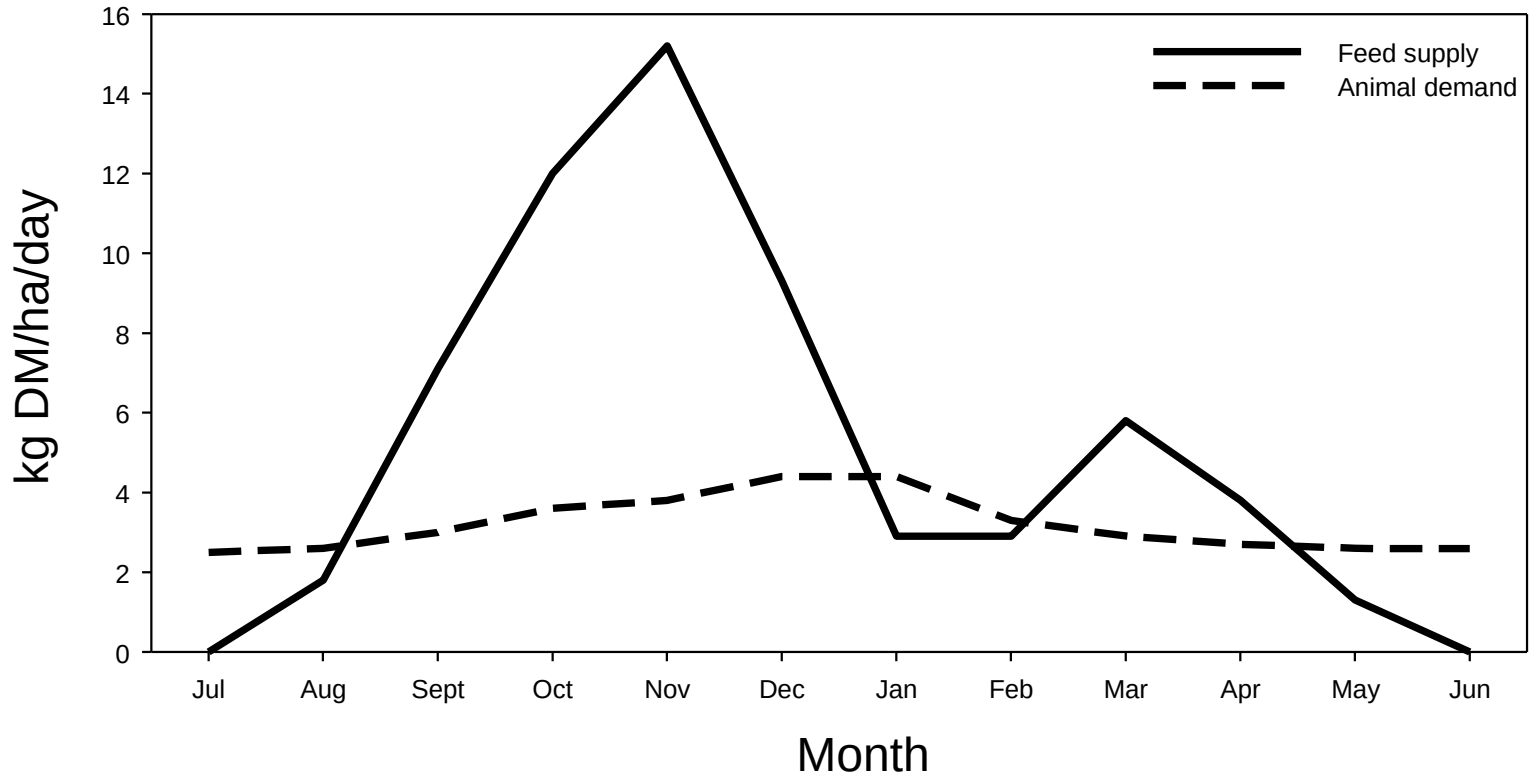
150 days of winter

100 days spring growth

100+ days summer dry

Autumn – unreliable ???

Pasture supply & Animal demand



Anderson *et al*. 2014

Heavy reliance on conserved feed

Kearney *et al*. 2010

Supplement Production

- Balage/Hay/Silage/Chaff

Kearney *et al.* 2010

Medicago sativa - lucerne - Gods plant!

Photo: DJ Moot
Lincoln University

Landscape farming

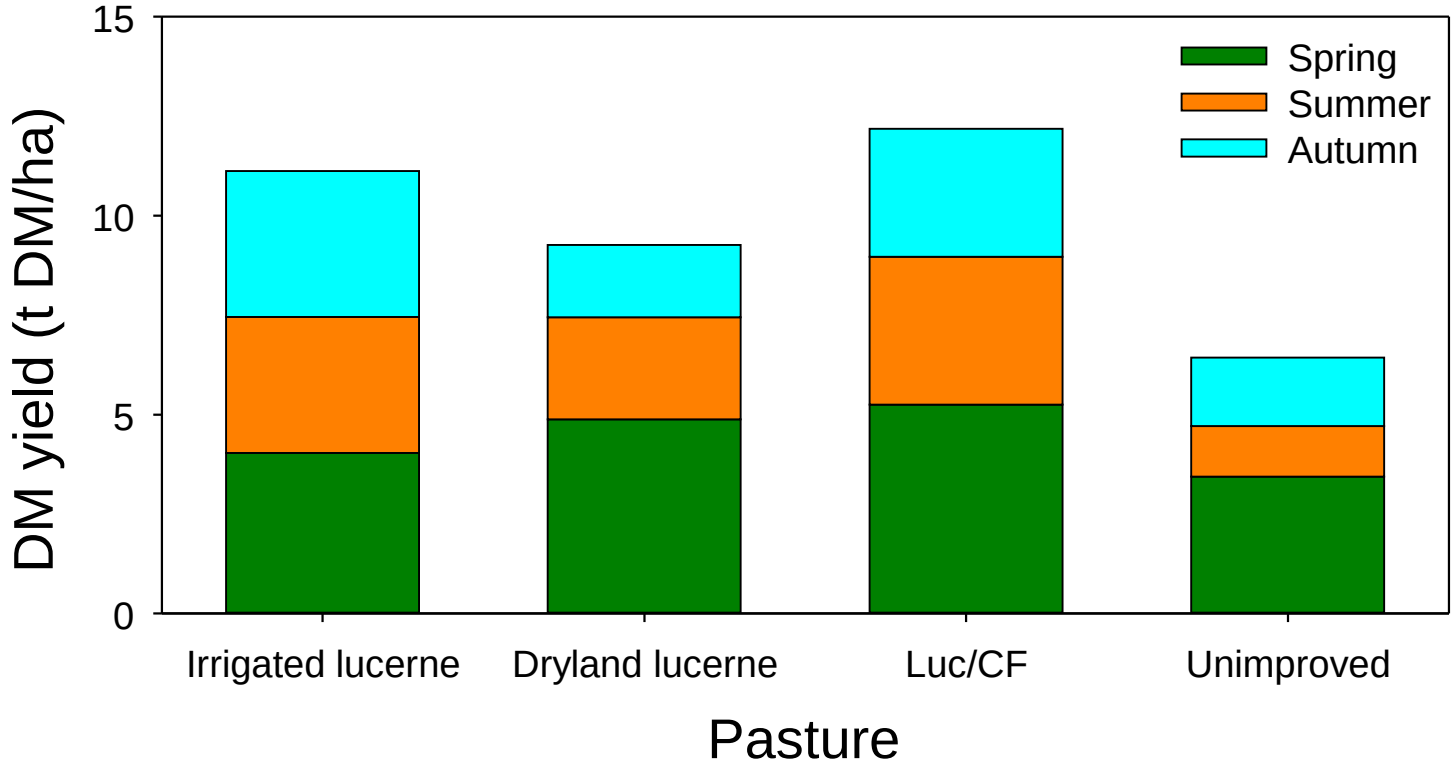
Lucerne development

Drill mid December,

Phosphorous and N supplied

Photo: DJ Moot
Lincoln University

Seasonal pasture production (3-yr average)



Anderson *et al*. 2014

Photo: DJ Moot
Lincoln University

Browntop – *Agrostis capillaris* – stolons and rhizomes

Photo: KM Pollock
Lincoln University

Autumn herbicide and burn

Photo: DJ Moot
Lincoln University

Ryecorn – *Secale cereal*

Break feed in winter/spring

Winter Forage Crops

- Product sold - animals consume forage crop
- Standing feed transferred to cold low growth periods
- Break crops to renew pasture

Cereal Green feeds - annuals

- Triticale – *Triticosecale spp*
- Oats – *Avena sativa*
- Barley – *Hordeum vulgare*

Winter Leaf forage crops – Kale – *Brassica oleracea*

Photo: DJ Moot
Lincoln University

Forage bulb crops e.g. Swedes *Brassica napus*

Turnips – *Brassica campestris* - Biennials

Lake Heron Station, Ashburton

Irrigated tall fescue - *Festuca arundinacea*

Simons Hill Station, Tekapo

Photo: DJ Moot
Lincoln University

Tall fescue – perennial, summer heat

Photo: AD Black
Lincoln University

Lake Heron Station, Ashburton

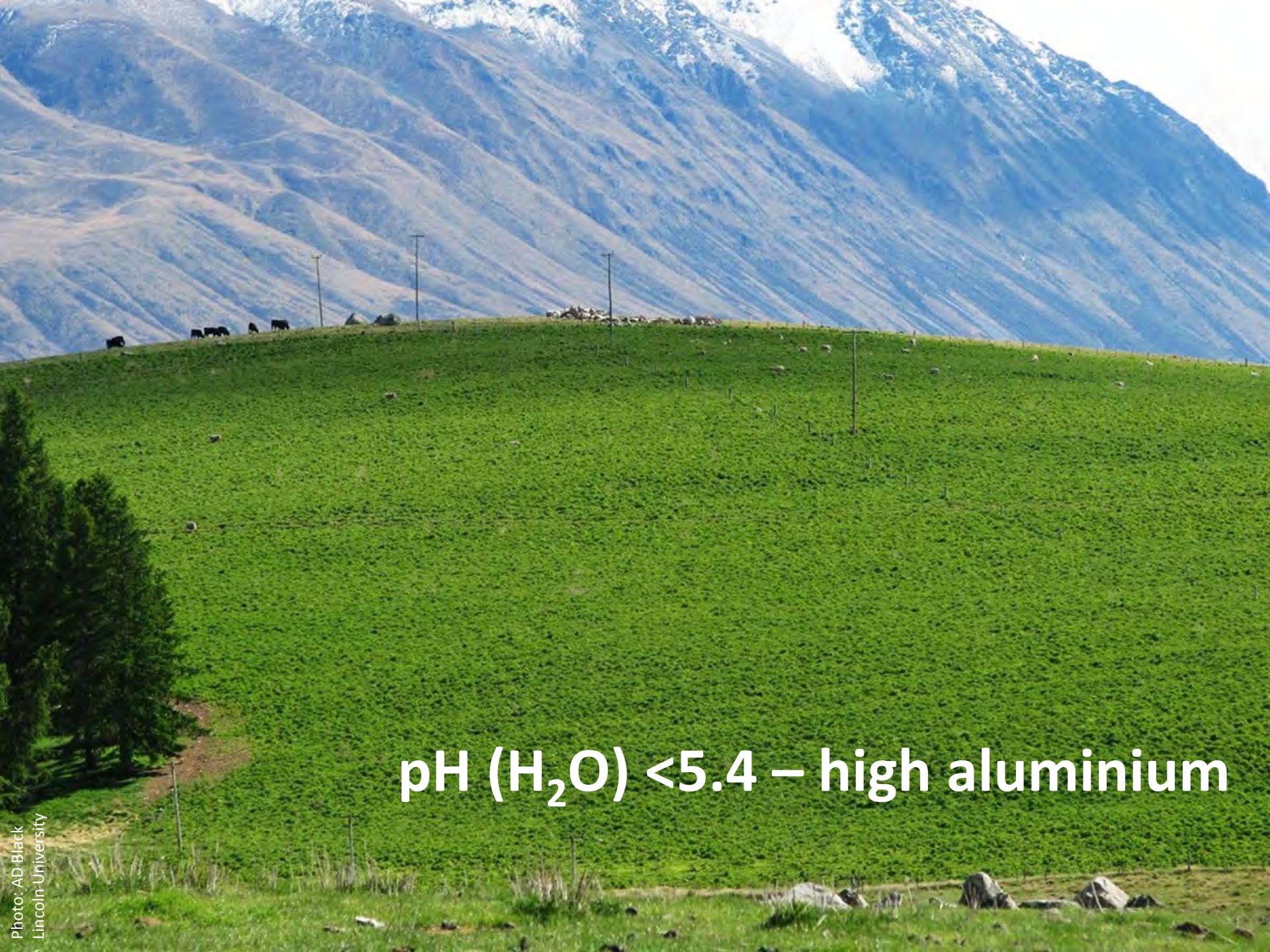


Photo: AD Black
Lincoln University

No Lime - Lucerne

Photo: KM Pollock
Lincoln University

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Photo: DJ Moot
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Photo: D Hendrie
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FLEXISEEDER
www.flexiseeder.com
AGMARDT
ENABLING TRANSFORMATIONAL
INNOVATION

Paddocks of lupin

- Sown December 2013
- After 1 year of ryecorn

Photo: KM Pollock
Lincoln University

Russell lupin – *Lupinus polyphyllus*

Photo: KM Pollock
Lincoln University

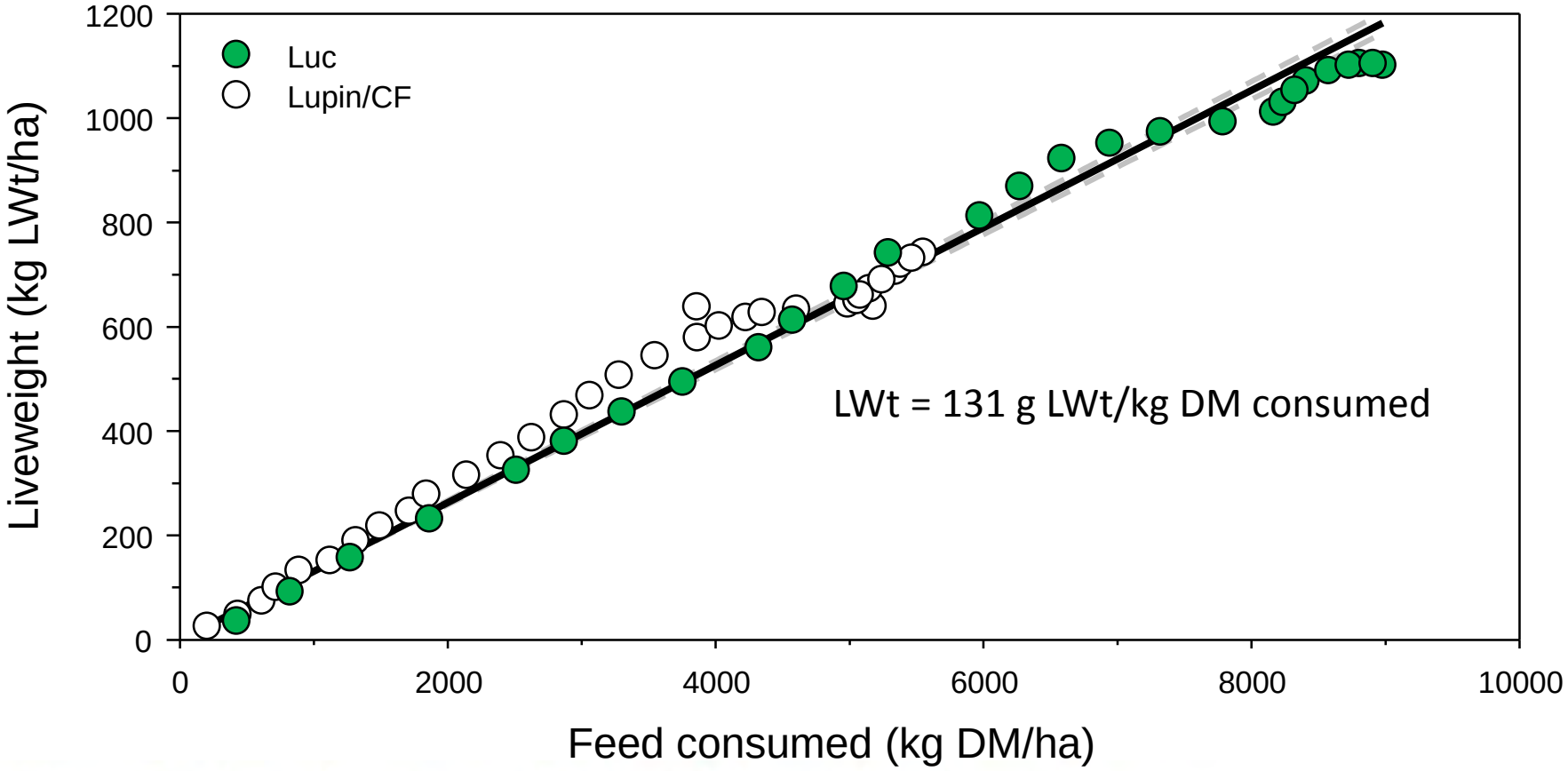
Seedlings @ 6 weeks after sowing

Caucasian clover and cocksfoot included in the seed mix

Caucasian Clover – *Trifolium ambiguum*

4 months after sowing

Relationship between LWt production and feed consumed

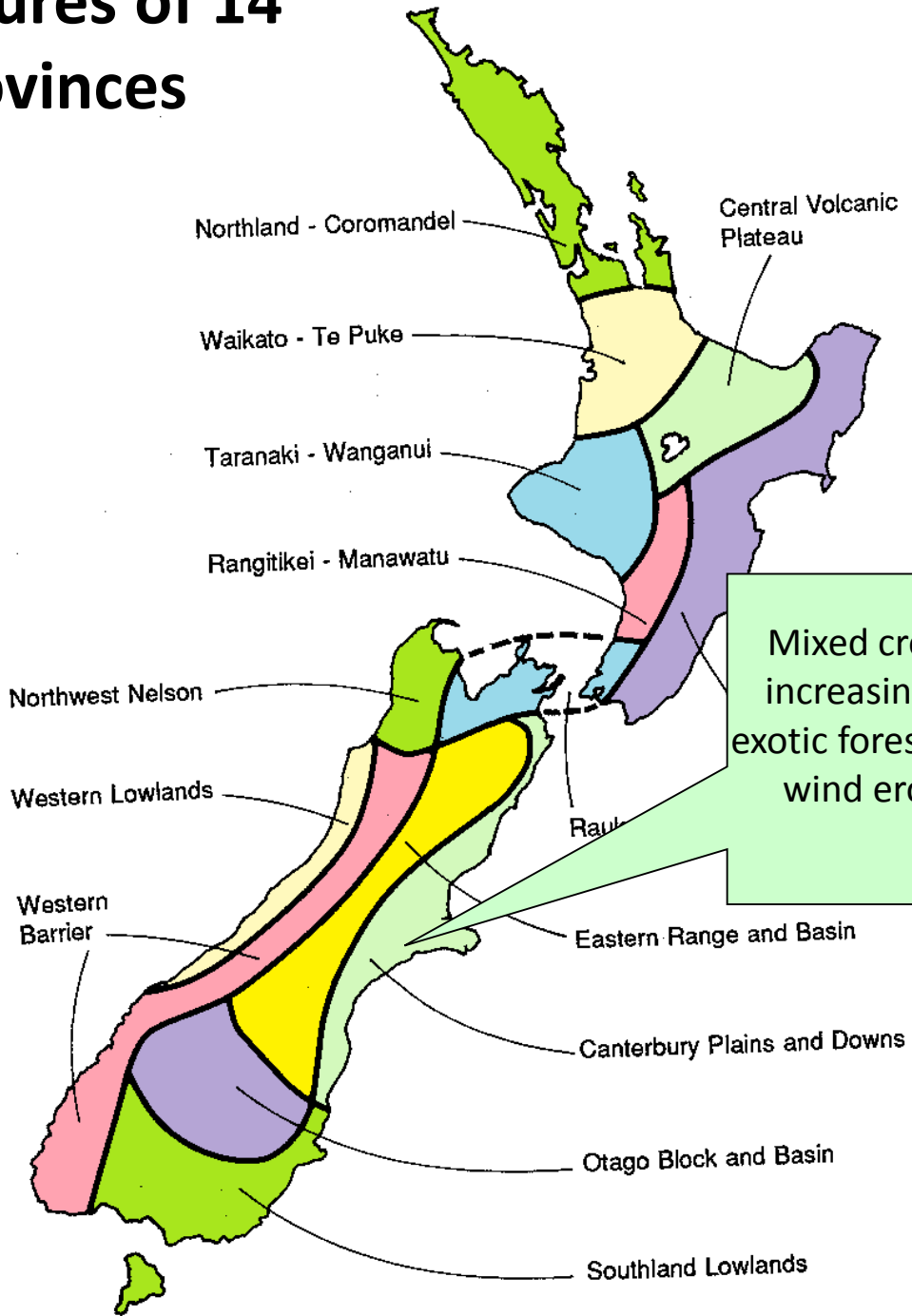


T Ryan-Salter unpublished

Photo: AD Black
Lincoln University

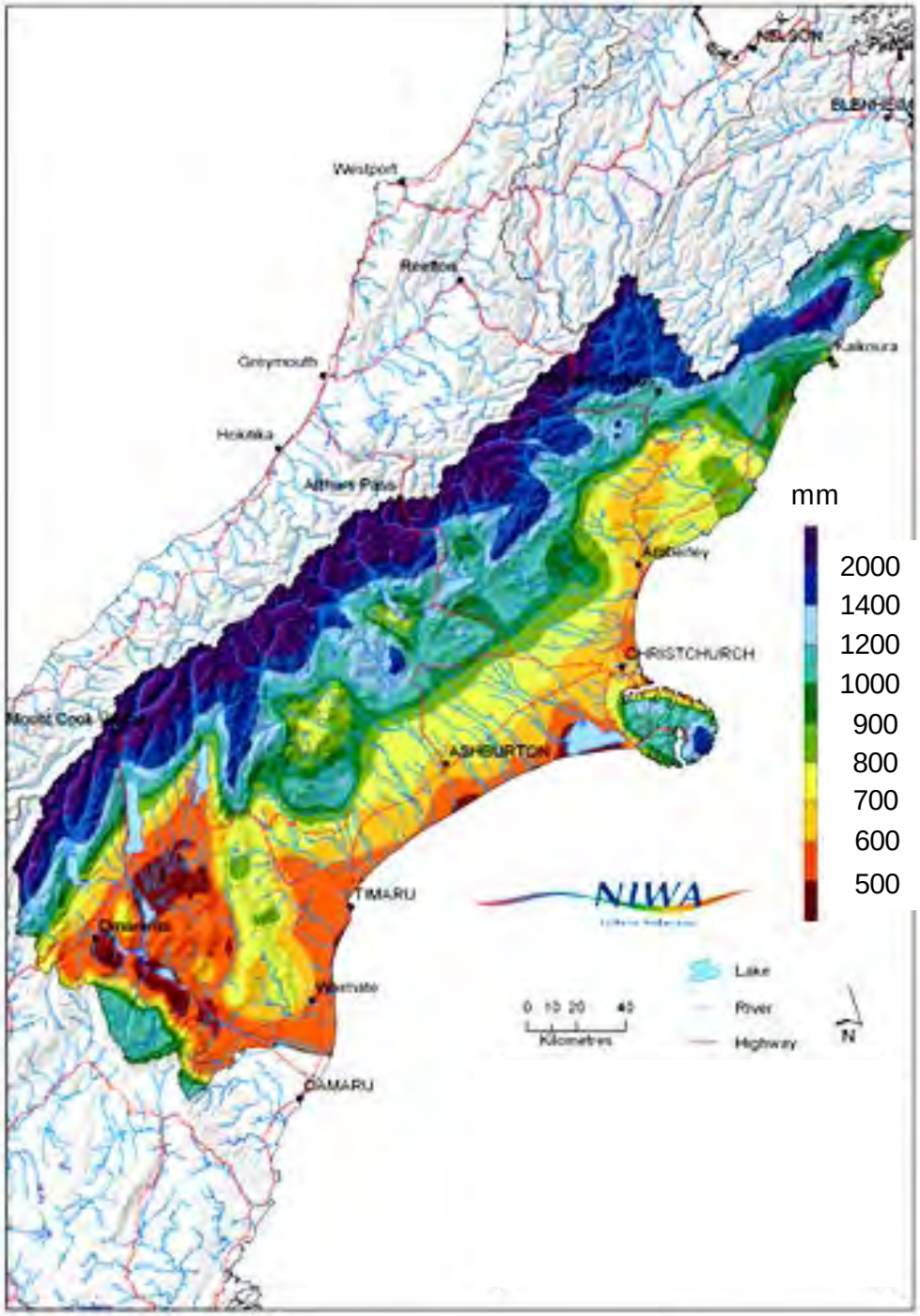
2. Hill Country South Island – West vs. East

Land Use Features of 14 Landscape Provinces



Mixed cropping and sheep farming, increasing dairying under irrigation; exotic forestry, local horticulture; risk of wind erosion in dry land cropping demands shelter

O'Connor 1993



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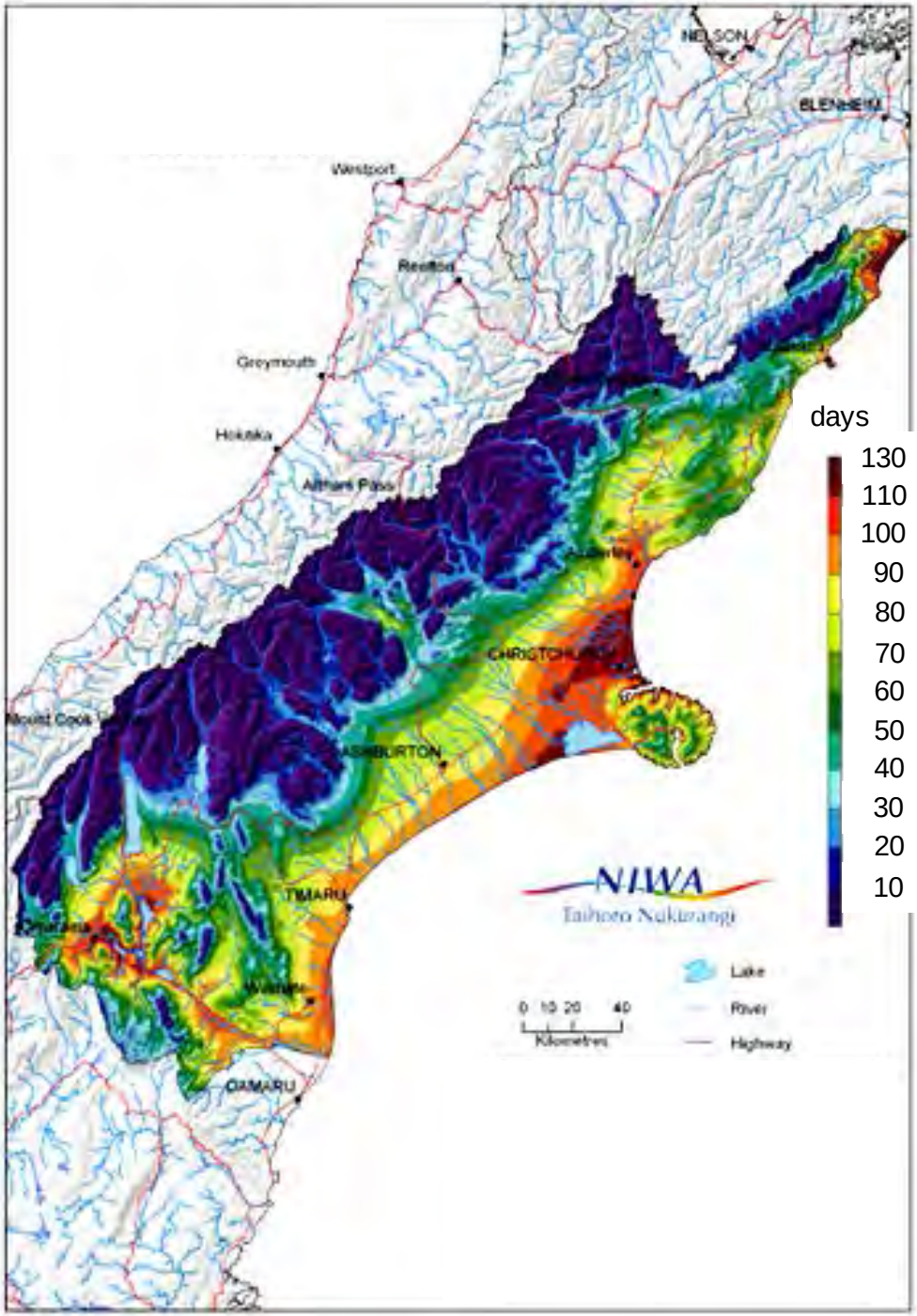
Climate

Median rainfall (mm) (1971-2000)

Climate Explorer; NIWA, 2010



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Climate

SMD days
(1971-2000)

Driest region in terms of PED

Climate Explorer; NIWA, 2010

Norwest rain - selling wool, store lambs, dairy grazing

Photo: WR Scott
Lincoln Universty

East - dry easy contour converted to viticulture

Cocksfoot and *Notodanthonia* tag – prone to burn

East – only spring is reliable

Photo: DJ Moot
Lincoln University

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Photo: Derrick Moot
Lincoln University
9/3/2017

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Photo: Derrick Moot
Lincoln University
9/3/2017

Californian thistle – *Cirsium arvense*

Photo: Derrick Moot
Lincoln University

Yarrow – *Achillea millefolium*

Couch/Twitch - *Agropyron repens*

Photo: Derrick Moot
Lincoln University

Cocksfoot (*Dactylis glomerata*) recovering – after burn


Photo: Derrick Moot
Lincoln University

Subterranean (sub) clover - *Trifolium subterraneum*

Photo: Doug Avery
Bonavaree, Marlborough

Ruminants prefer 70% legume 30% grass

Bulls grazing sub. dominant pasture
8 Oct 2015

Photo: DJ Moot
Lincoln University

Annual Legumes

- Escape drought as seed in soil
- Prolific seed production
- e.g. Balansa, Persian, Arrowleaf clovers
- Adventive: Striated, cluster, suckling clovers
- Haresfoot Trefoil
- Early spring feed for lactation

Nitrogen fixation
25-30 kg N/t DM

Photo: DP Monks
Lincoln University

Lucas *et al*. 2010

Plantain – *Plantago lancelota – summer active herb*

Photo: DJ Moot
Lincoln University

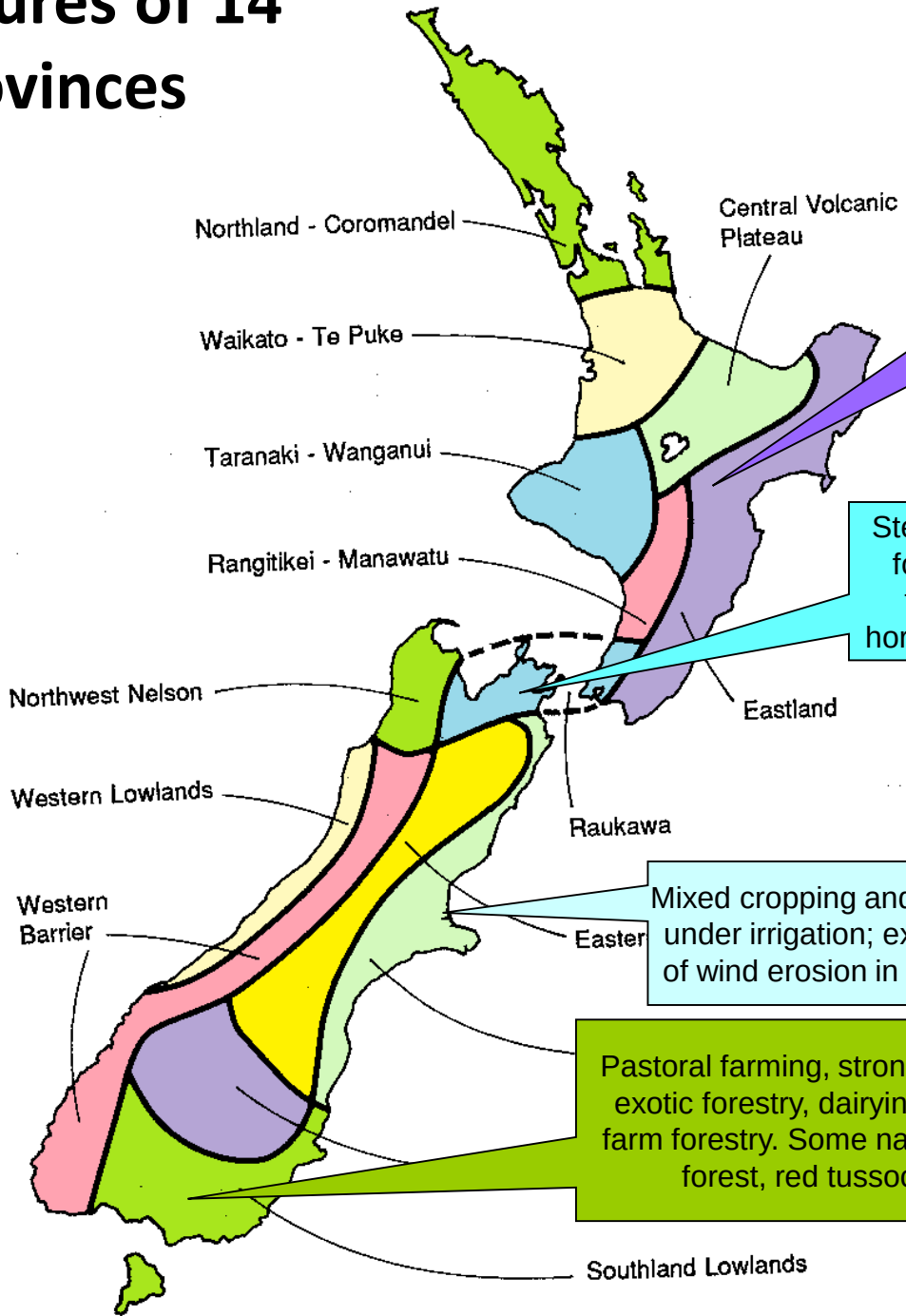
North Island – mudstone and sandstone soils

Chicory – *Chicorium intybus* – summer active herb

Red clover – *Trifolium pratense*

3. Mixed Cropping and Finishing Farms

Land Use Features of 14 Landscape Provinces



Sheep and beef cattle, dairying in south; fruit, viticulture and horticulture, some forest conservation, afforestation and farm forestry, severe mass movements in hill

Steep hill country partly cleared from forest, infertile pasture, scrub and forest; exotic forestry extensive; horticulture intensive and limited flats.

Mixed cropping and sheep farming, increasing dairying under irrigation; exotic forestry, local horticulture; risk of wind erosion in dry land cropping demands shelter

Pastoral farming, strong wool and fat lamb production, exotic forestry, dairying and cropping and increasing farm forestry. Some nature conservation, especially of forest, red tussock and wetland remnants.

O'Connor 1993

The Canterbury region

- Largest region in NZ
  4.53 M ha (17% of NZ)

- Young landscape
  - continued re-working of materials destroys evidence of previous landscapes

- Tectonic uplift (& gravity), historic glaciation, fluvial, alluvion, aeolian and volcanic activity....

Stop, drop, cover, hold!

Photo: WR Scott
Lincoln University

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Canterbury = largest flat land area - floodplains


Brown & Naish, GNS

High variability over short distances

New Zealand's specialist land-based university

Soil water extraction - Wakanui

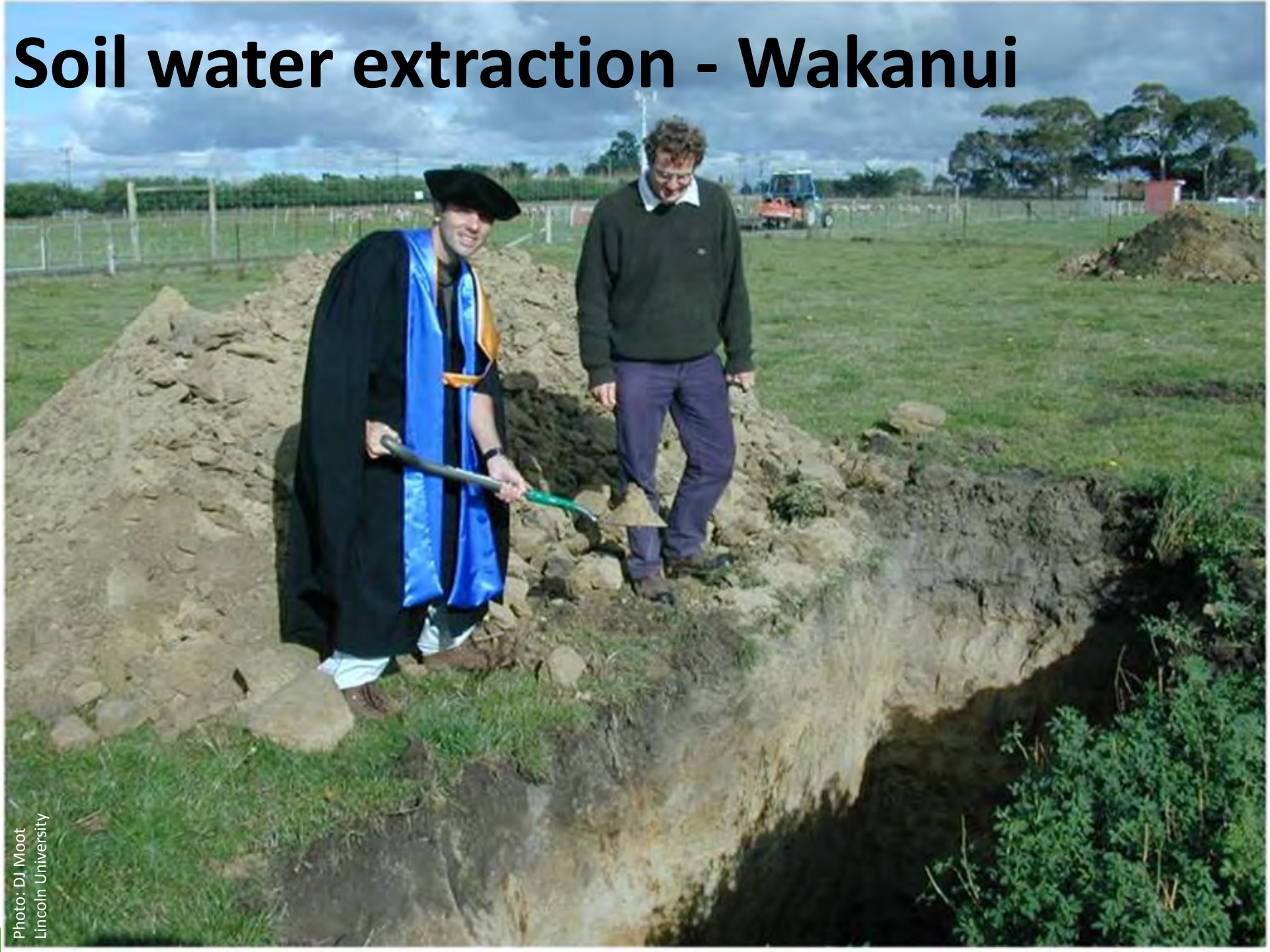
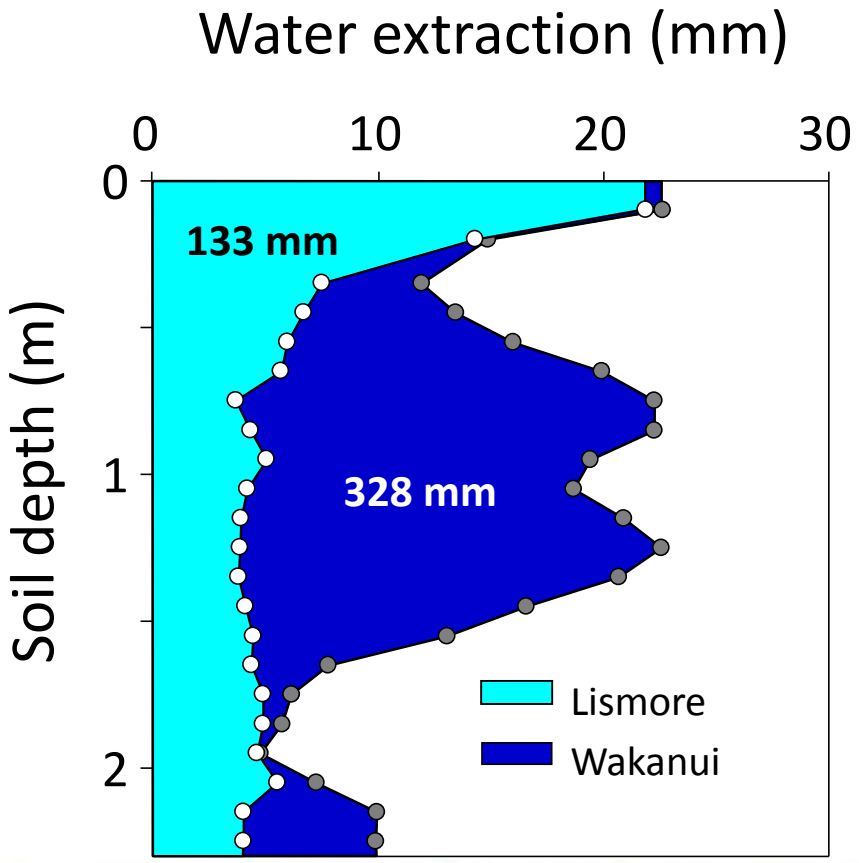


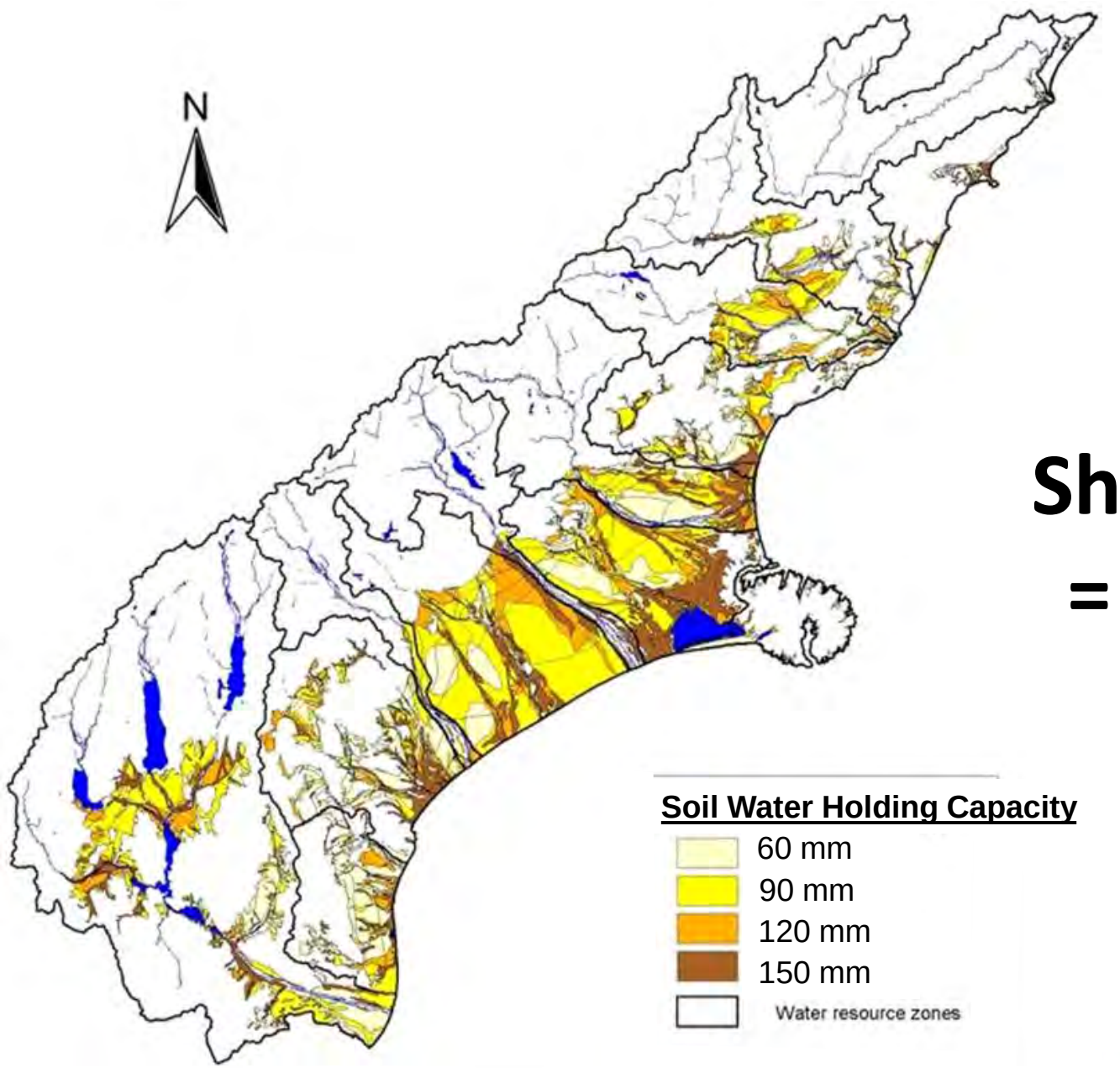
Photo: DJ Moot
Lincoln University

Soil water extraction



Deep Wakanui soil has 200 mm more available water

Moot *et al*. 2008



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Shallow soils = low WHC

Morgan *et al*. 2002

Wheat *Triticum aestivum* 15 t/ha; 40,000 ha

Barley *Hordeum vulgare* 13 t/ha 40,000 ha

Cash crops – yield & quality

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Product sold from plant production

a) Grain crops: wheat, barley, oats, Peas (*Pisium sativum*)

b) Small seeds: grasses, clovers – brassica seeds

c) Processed vegetables e.g. peas, beans, asparagus, carrots, tomatoes, sweet corn, squash.

Photo: WR Scott
Lincoln University

~60% of the fresh and process peas

Dry summers suit harvest of cash crops

Photo: WR Scott
Lincoln University

Onions for export, 4,000 ha of potatoes

van Gogh, The Potato Eaters **1885**

Maize or sweet corn or pop corn = *Zea mays*

White clover - *Trifolium repens* - finishing lambs

10,000 ha clover seed for export

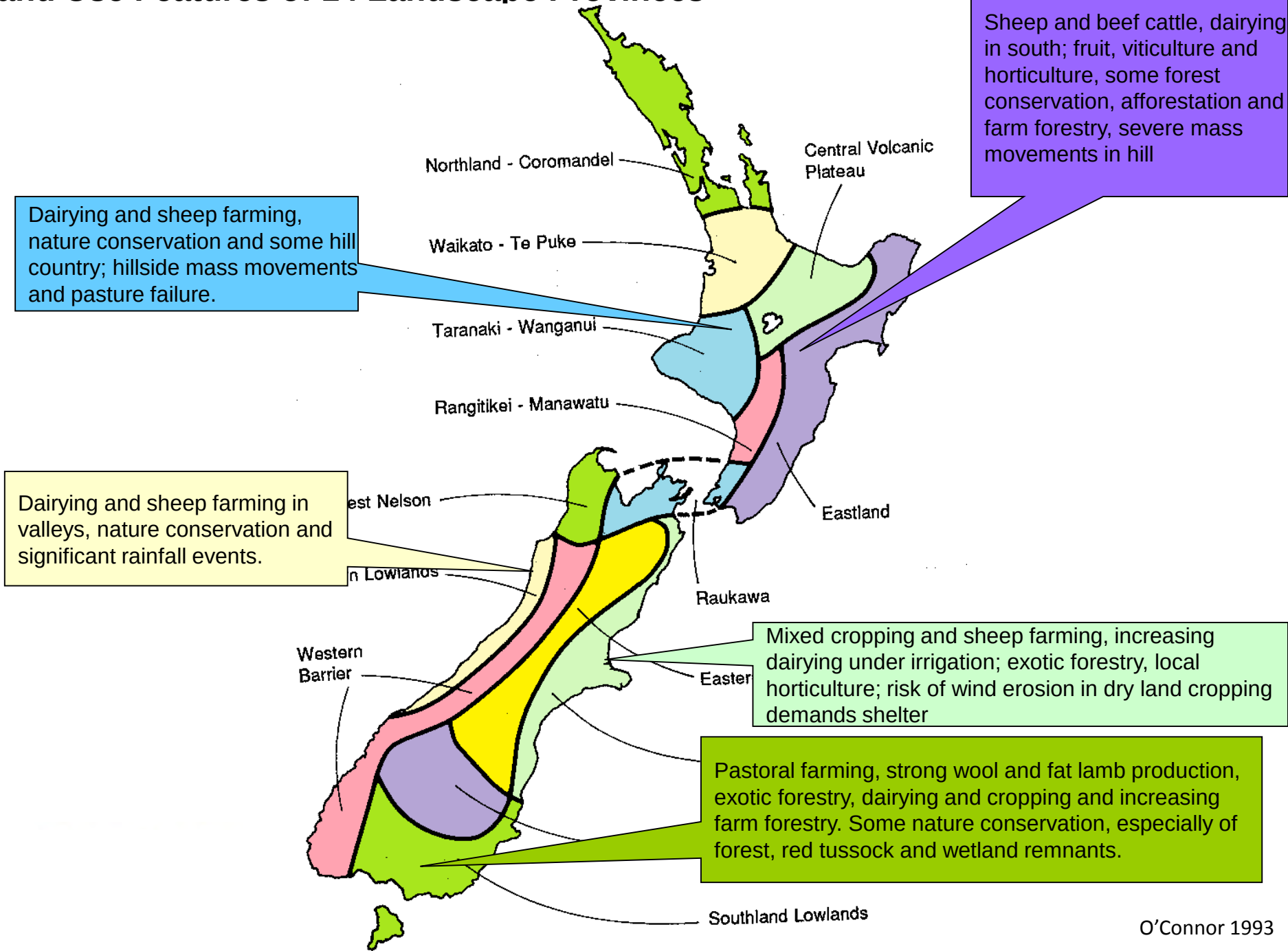
Photo: WR Scott
Lincoln University

Herbage grasses 1.5 – 3.0 t seed/ha.

60-70% of all green beans,

4. Dairy

Land Use Features of 14 Landscape Provinces



Sheep and beef cattle, dairying in south; fruit, viticulture and horticulture, some forest conservation, afforestation and farm forestry, severe mass movements in hill

Dairying and sheep farming, nature conservation and some hill country; hillside mass movements and pasture failure.

Dairying and sheep farming in valleys, nature conservation and significant rainfall events.

Mixed cropping and sheep farming, increasing dairying under irrigation; exotic forestry, local horticulture; risk of wind erosion in dry land cropping demands shelter

Pastoral farming, strong wool and fat lamb production, exotic forestry, dairying and cropping and increasing farm forestry. Some nature conservation, especially of forest, red tussock and wetland remnants.

O'Connor 1993

Traditional perennial ryegrass/white clover

Photo: DJ Moot
Lincoln University

Consistent ~1000 mm/yr rainfall

Northland, South Auckland, Waikato, Taranaki, Manawatu, Nelson, West Coast

SUMMER BULB TURNIPS – *Brassica campestris*

Summer Forage Crops

- Product sold - animals consume forage crop
- Standing feed transferred to dry periods
- Break crops to renew pasture
- Clean-up weeds

Options

- Rape – *Brassica napus*
- Pasja – Leaf turnip – *Brassica rapa*

SUMMER RAPE – *Brassica napus*

LEAF TURNIPS – *Brassica rapa*

Photo: WR Scott
Lincoln University

Dairying with irrigation

Photo: WR Scott
Lincoln University

Dairying in Canterbury and Southland on irrigated land

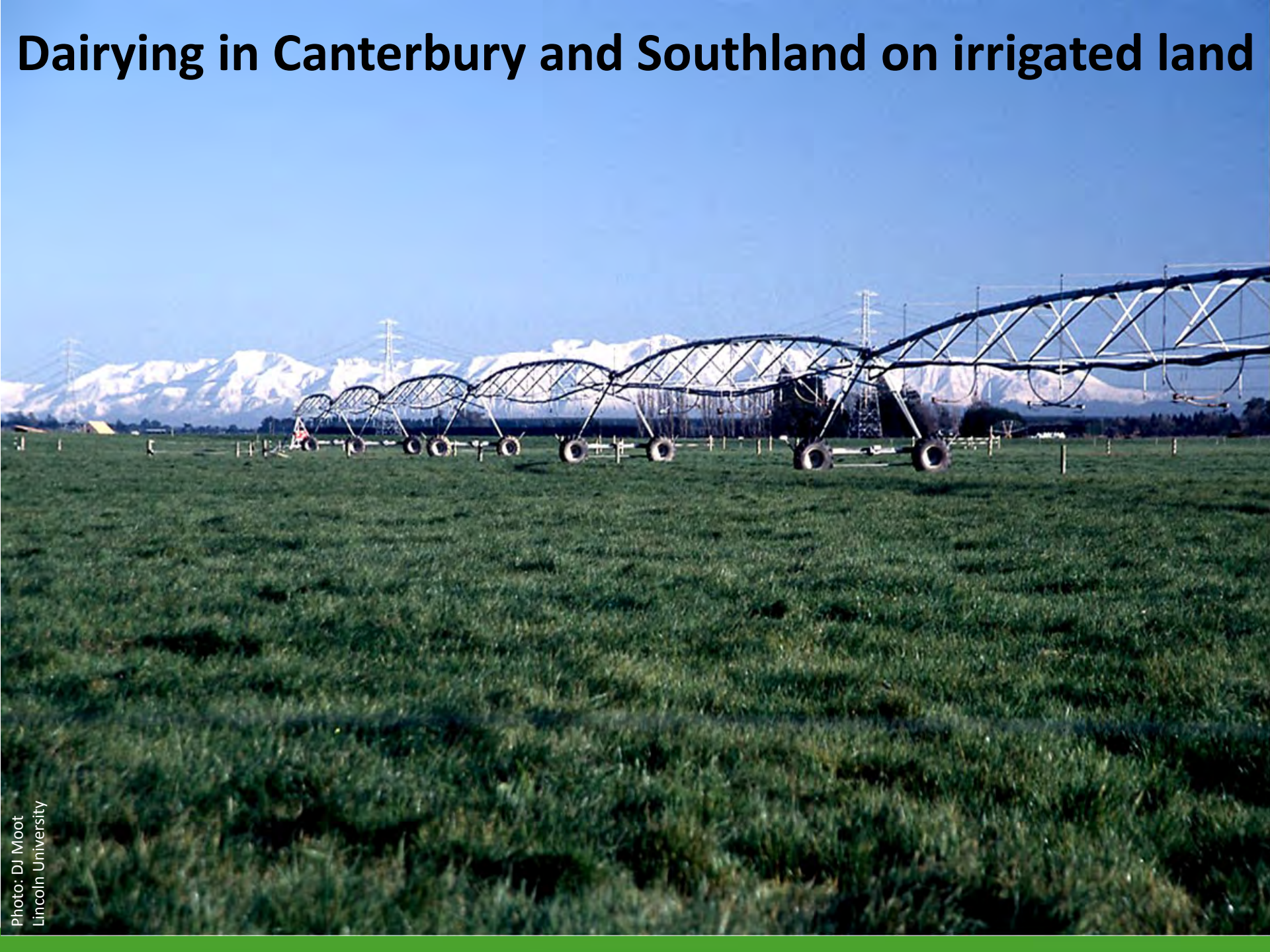


Photo: DJ Moot
Lincoln University

Water and nitrogen = ryegrass (230,000 ha irrigated dairy)

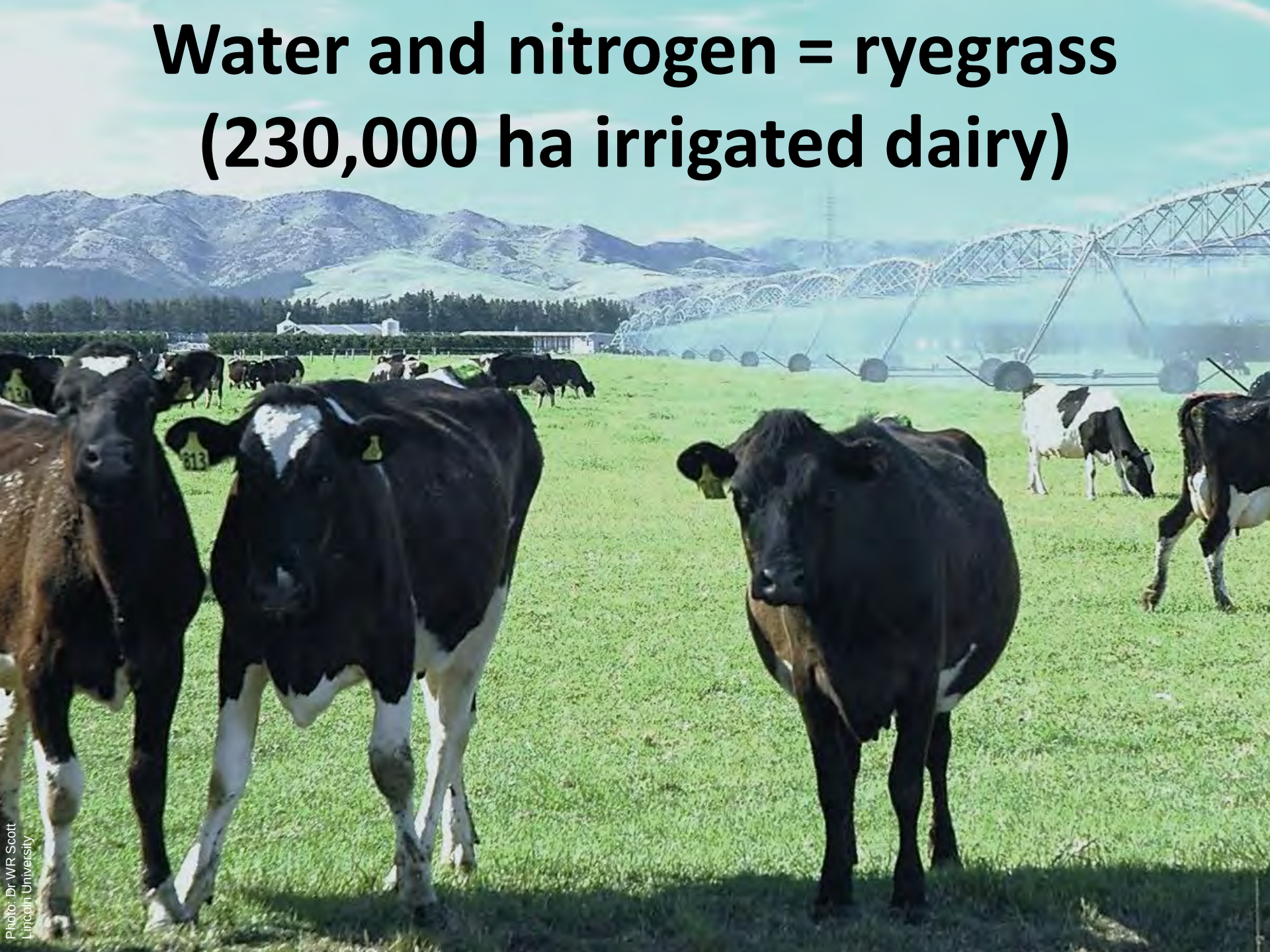


Photo: Dr WR Scott
Lincoln University

The Water Resource…..

Agriculture is the largest user of groundwater

(84%) (>350 000 ha)

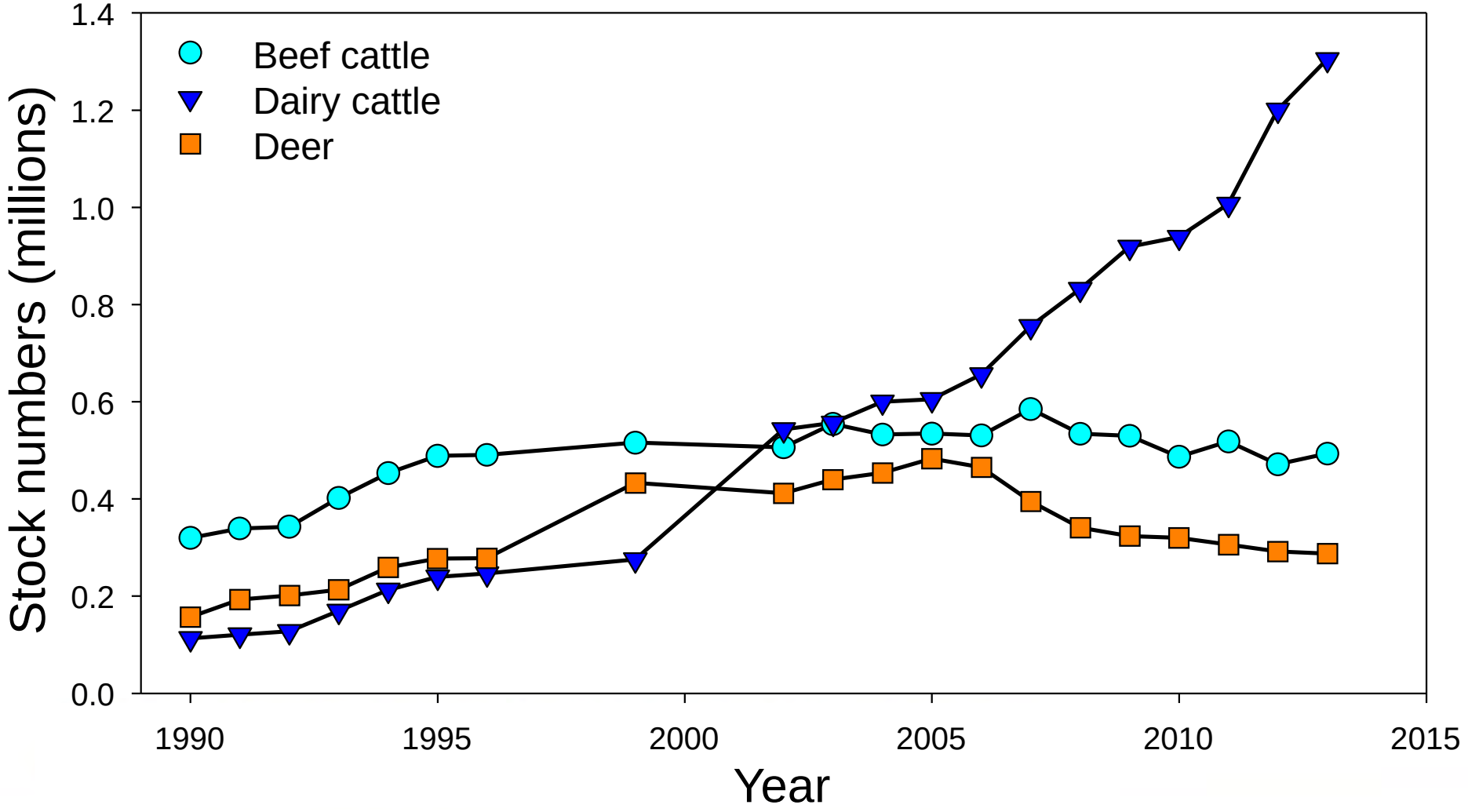
In 2008 Canterbury accounted for:

- 54% of NZ's allocated water
- 67% of NZ's irrigated land
- 65% of NZ's hydro storage

Canterbury Water Strategy

- CWMS1 – Can irrigate 1.0M ha
- CWMS2 – Suitable storage sites are scarce
- CWMS3 – Water quality affected by
  - i) sediment displacement
  - ii) N and P use
  - iii) faecal coli forms
- Nitrate exceed WHO standards in <20 m ground water
  - >20 m recharge causes dilution

Deer & cattle numbers in Canterbury



Moot *et al.* 2010: Department of Statistics

Cold areas require forage crops and conserved feed

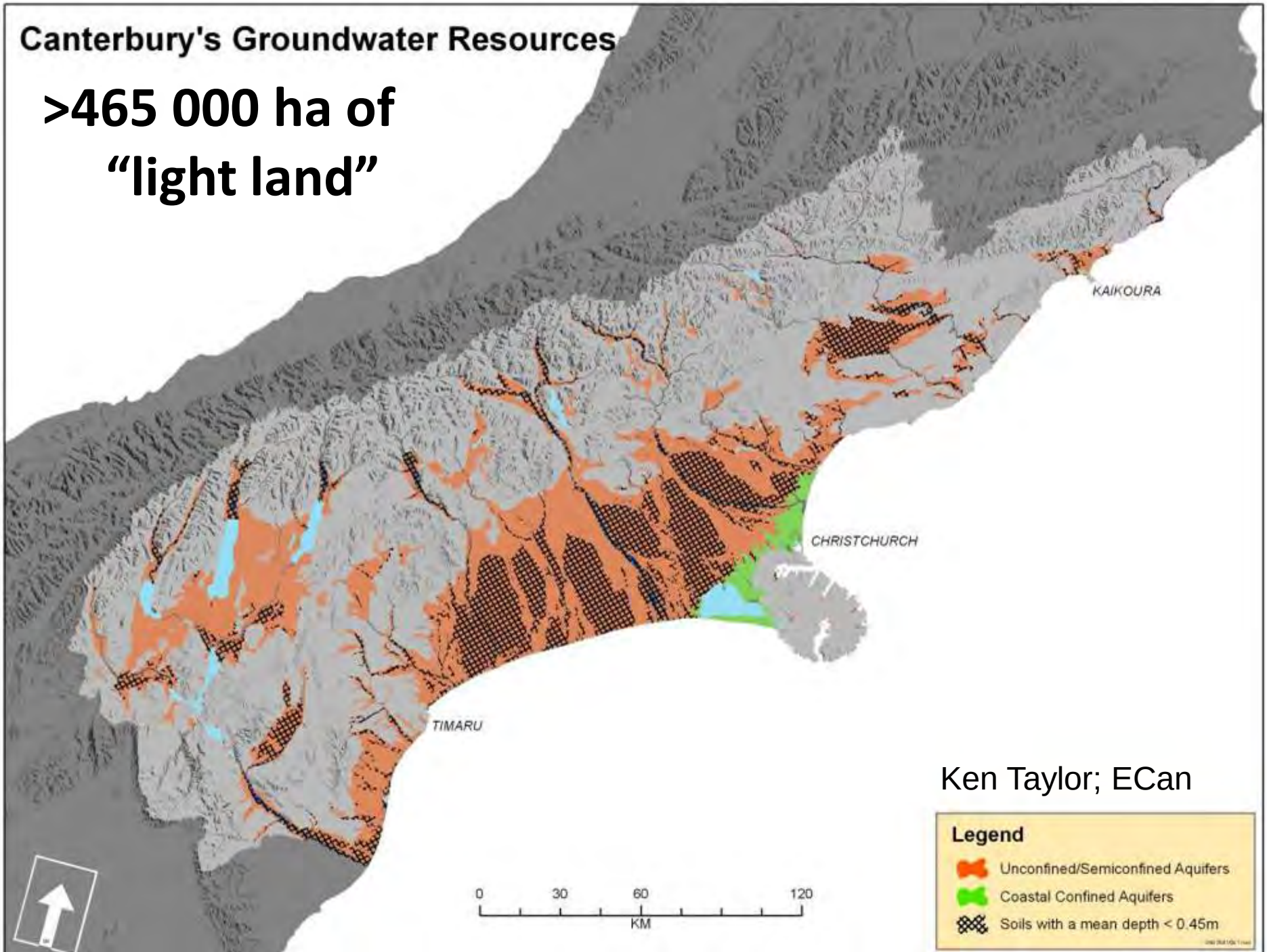
South Island dairying

Fodder beet

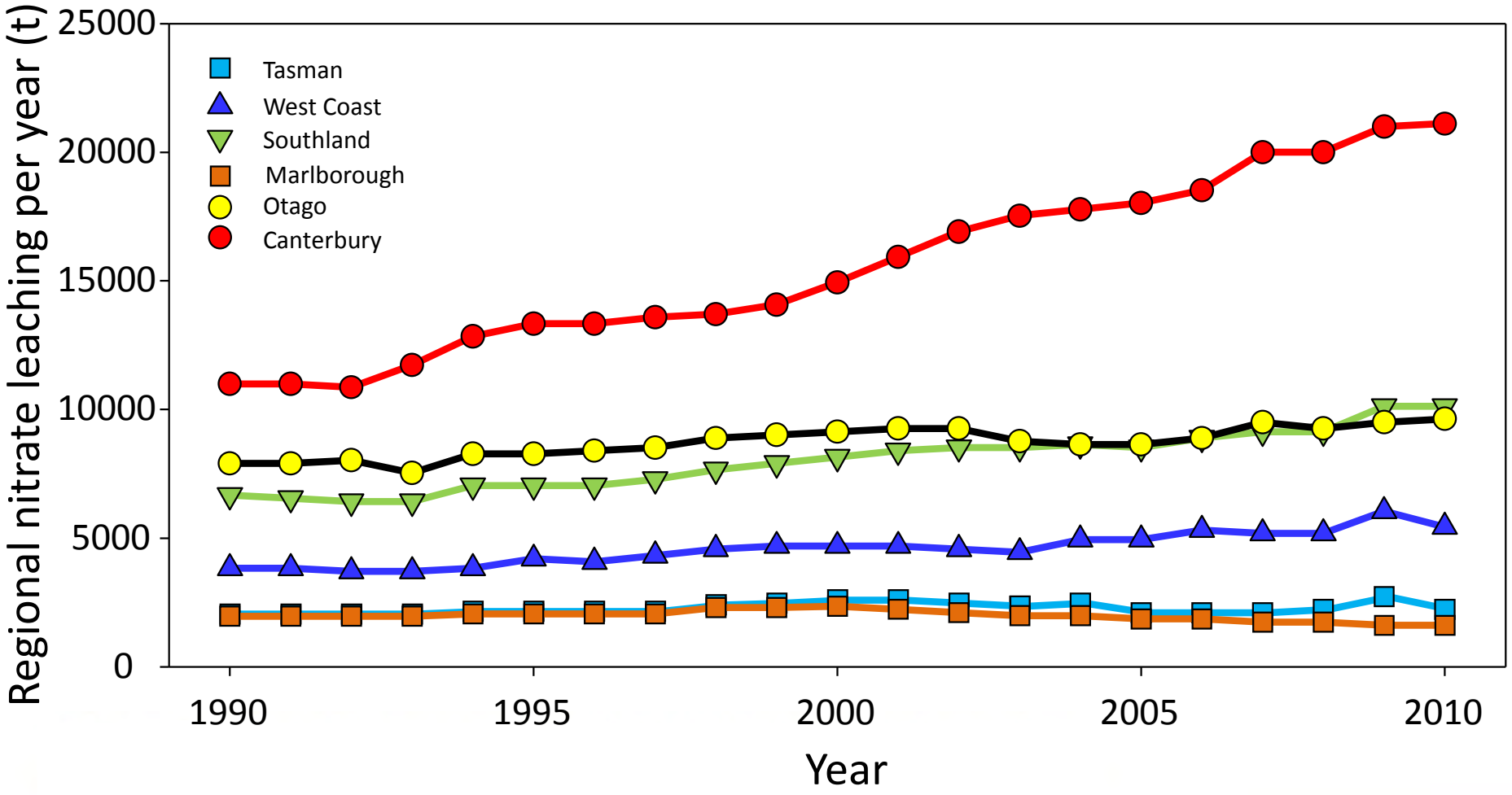
(*Beta vulgaris)*

high sugar crop

Photo: WR Scott
Lincoln University

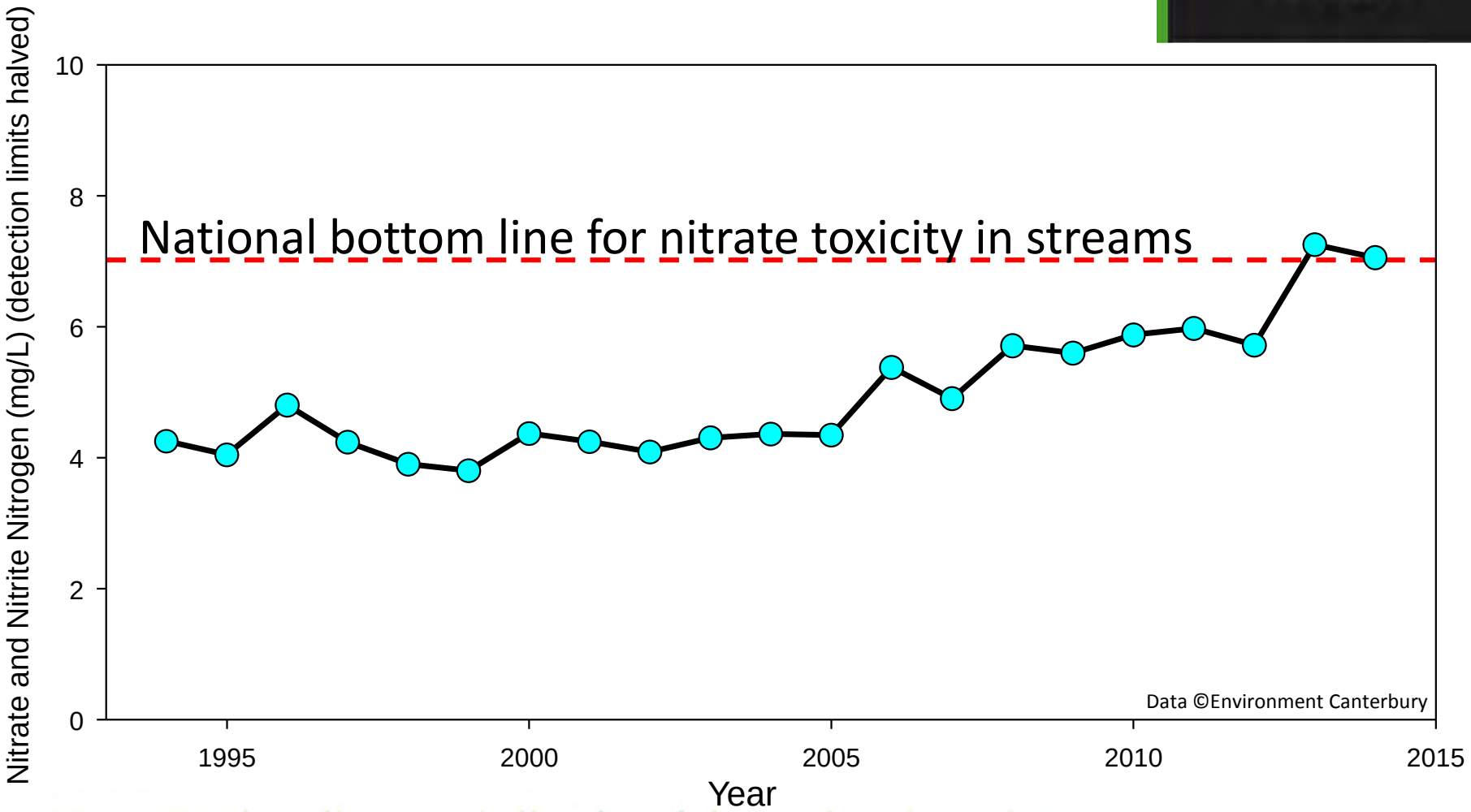

Canterbury's Groundwater Resources
>465 000 ha of
"light land"
KAIKOURA
CHRISTCHURCH
TIMARU
0
30
60
120
KM
Ken Taylor; ECan
Legend
Unconfined/Semiconfined Aquifers
Coastal Confined Aquifers
Soils with a mean depth < 0.45m

Regional annual nitrate losses - Sustainable regionally?



Redrawn from Dymond *et al.* 2013

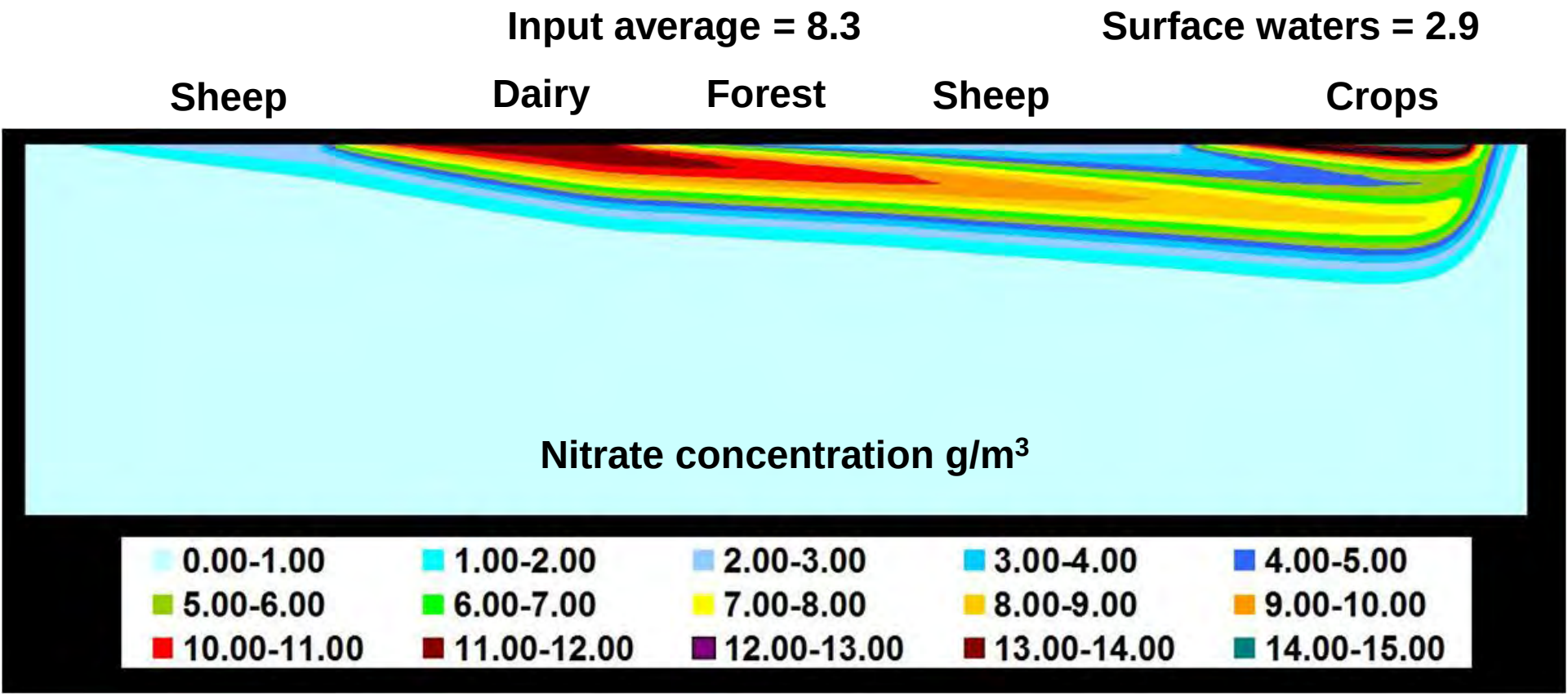
Mean annual nitrate levels in Harts Creek - Sustainable locally?



Forest conversion 100,000 ha

Photo: Dr WR Scott
Lincoln University

Introduction of dairy farming changes the amount and distribution of nitrate in the aquifer



Policy & management questions

- What types of land uses, and

- How intensive can they be without exceeding a groundwater system's limits?

- How might land be managed to maximise profitability and remain within the limits?

  –i.e. How many dairy farms, potato farms, onion paddocks, market gardens, sheep paddocks… should be allowed on a "catchment"

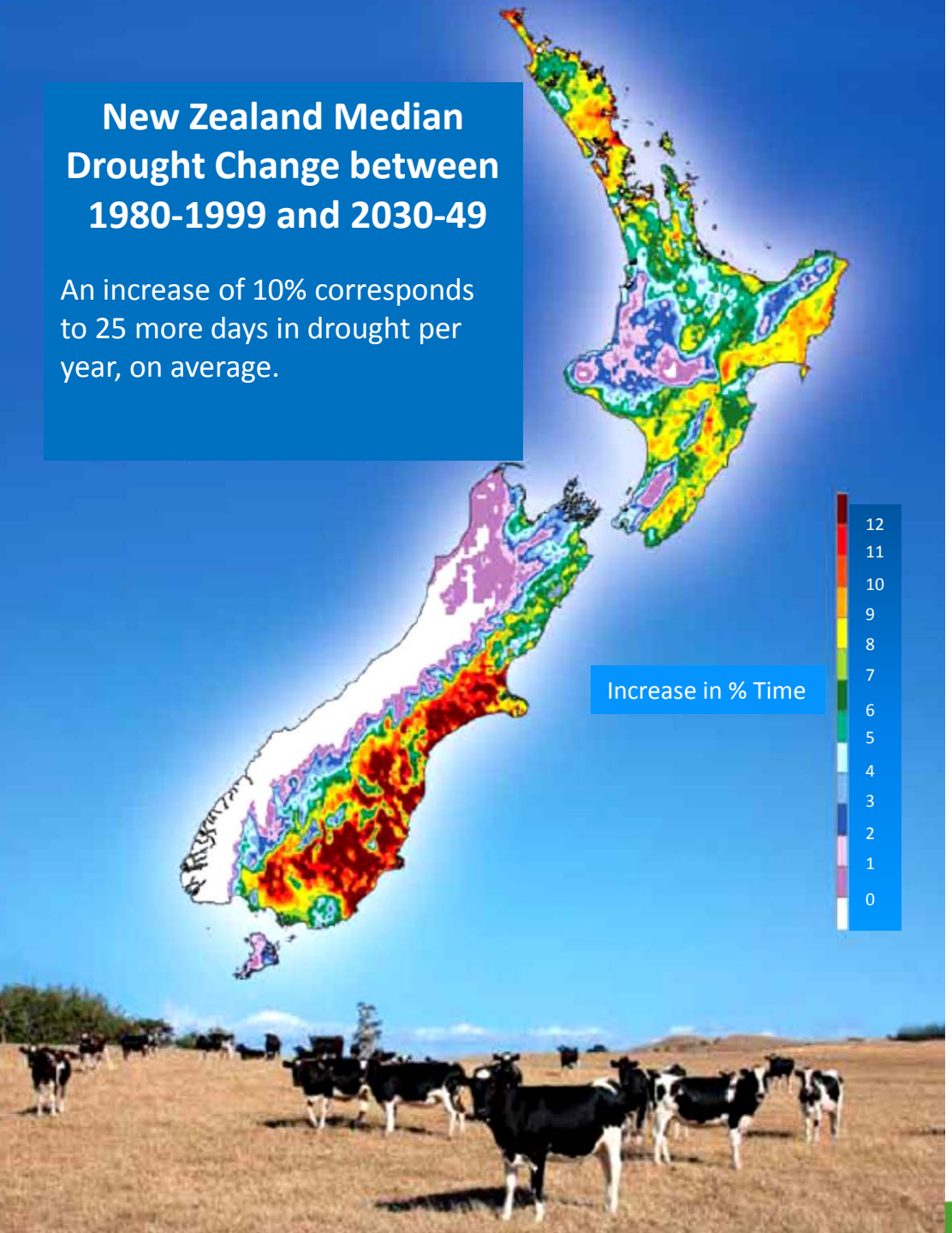
Summary

- NZ climate, soils and topography require a range of agricultural species to feed animals outside year round.
- These transfer feed from seasons of growth to no growth.
- The diversity of species used is greater in more variable climates.
- Nutrient and water efficient plants are required to maximize production while minimising environmental footprints.

Agricultural Research

- Background science – NTW
- Dryland case study – lucerne
- Hill country – annual clovers
- Irrigated dairy pastures – Canterbury's future?

- Dryland Pastures Research (DPR) Team



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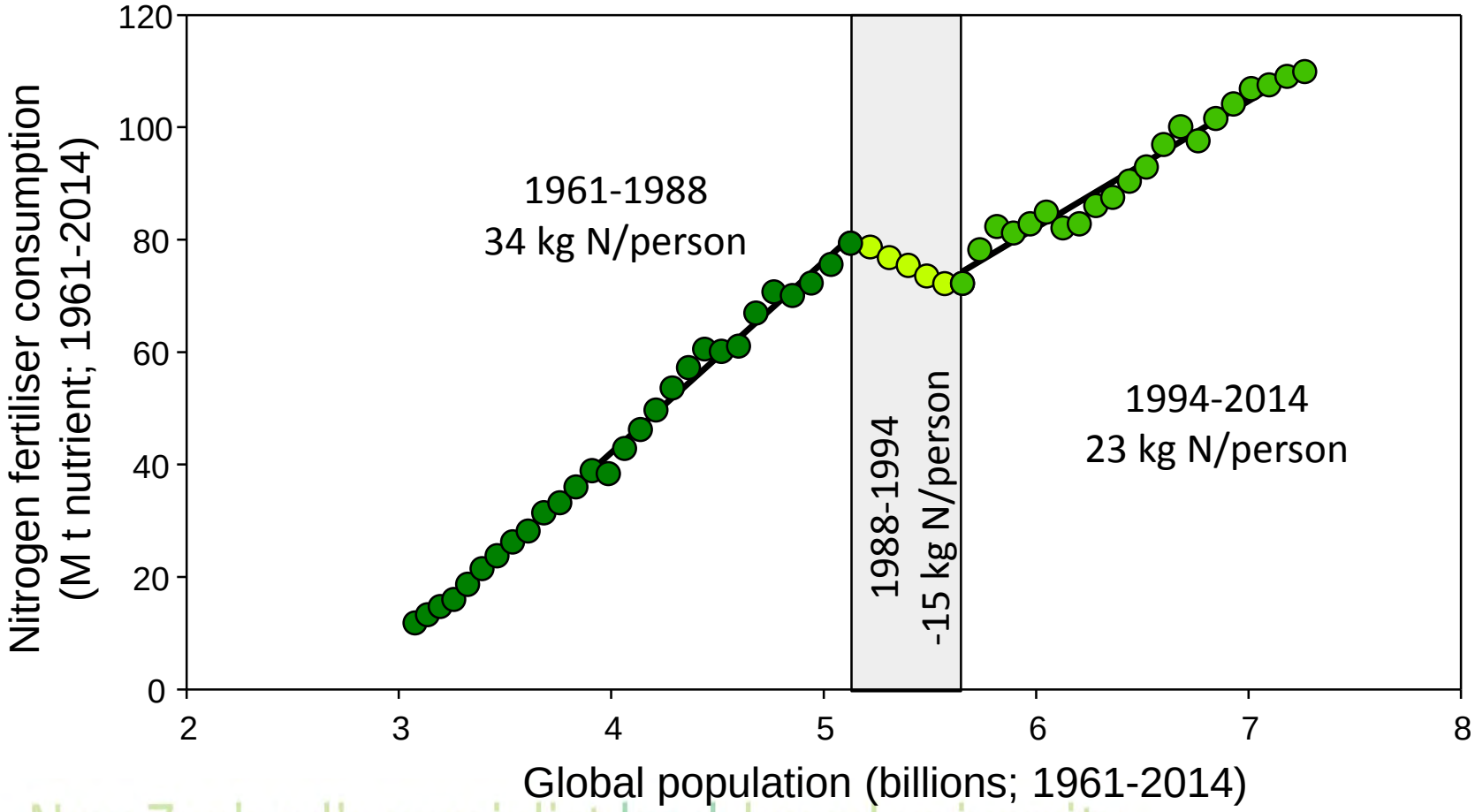
Predicted climate change in New Zealand by 2040

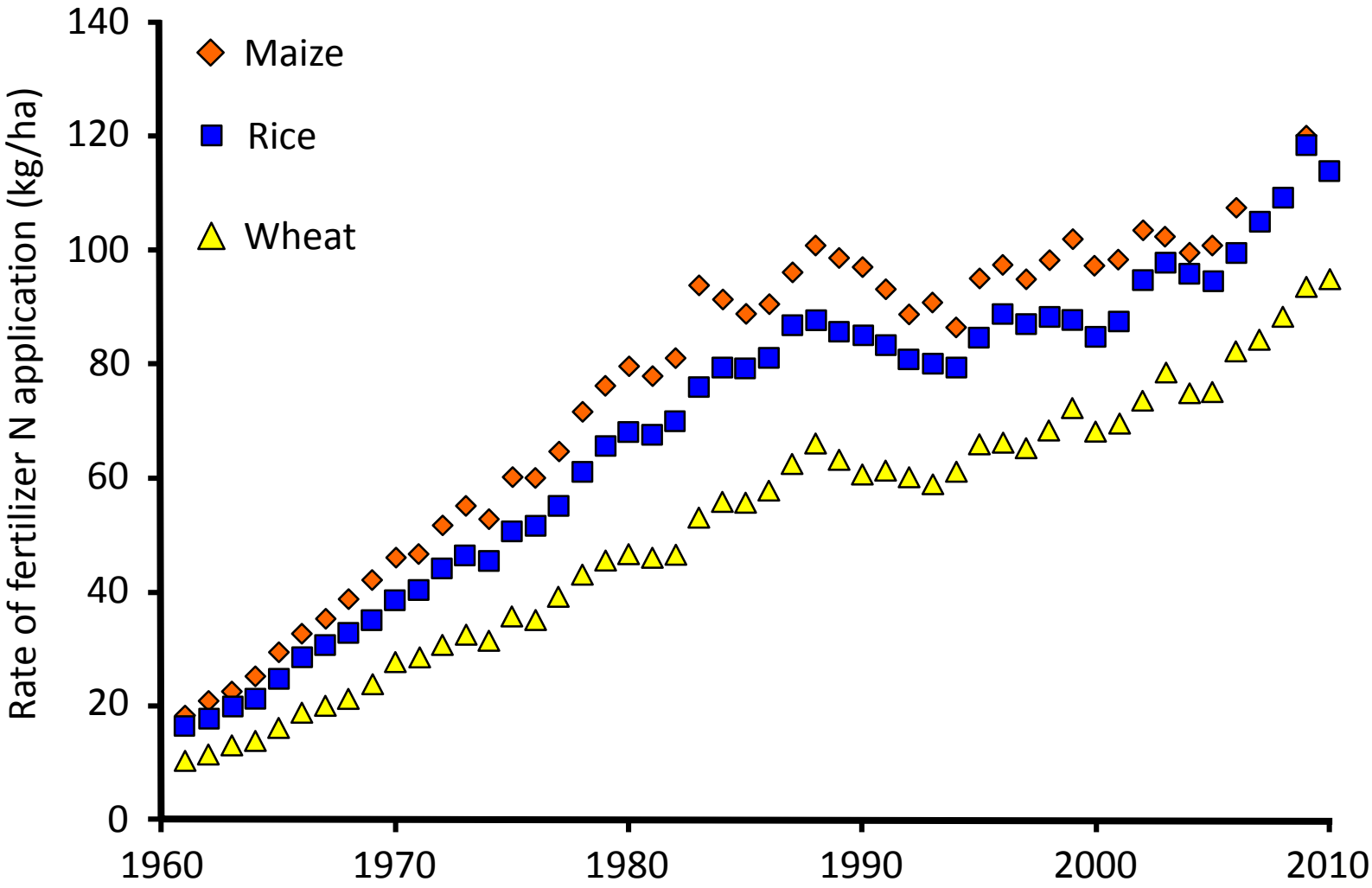
MPI-NIWA-Drought-in-a-Changing-Climate%20.pdf
http://www.mpi.govt.nz/document-vault/133

Global N fertiliser use



This graph contains data sourced from FAOStat (global population) and IFAData (International Fertilizer Association; Total N consumption)

Average global N fertilizer application rates in maize, rice, & wheat



Ladha *et al*. 2016

Experiment site

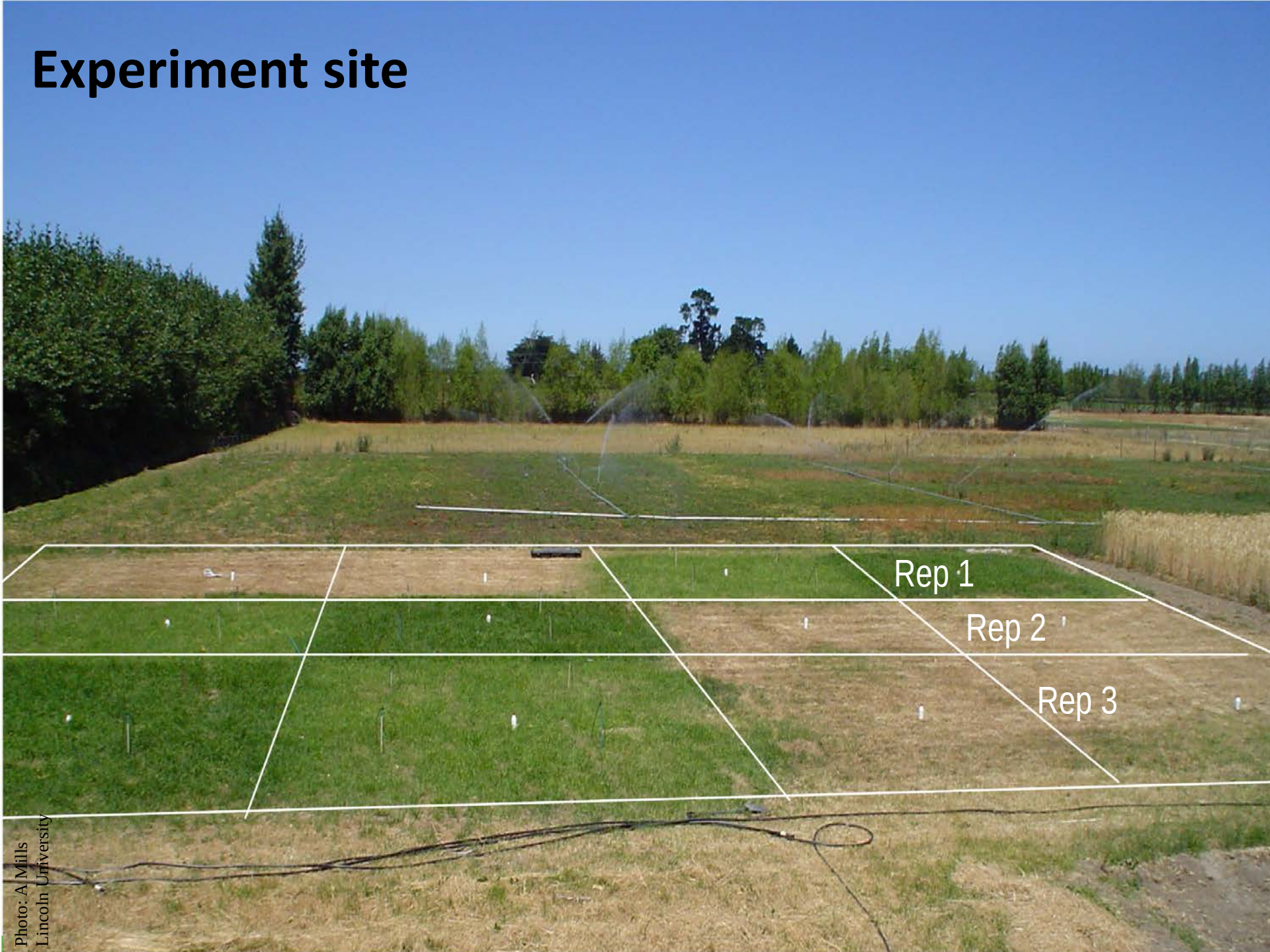
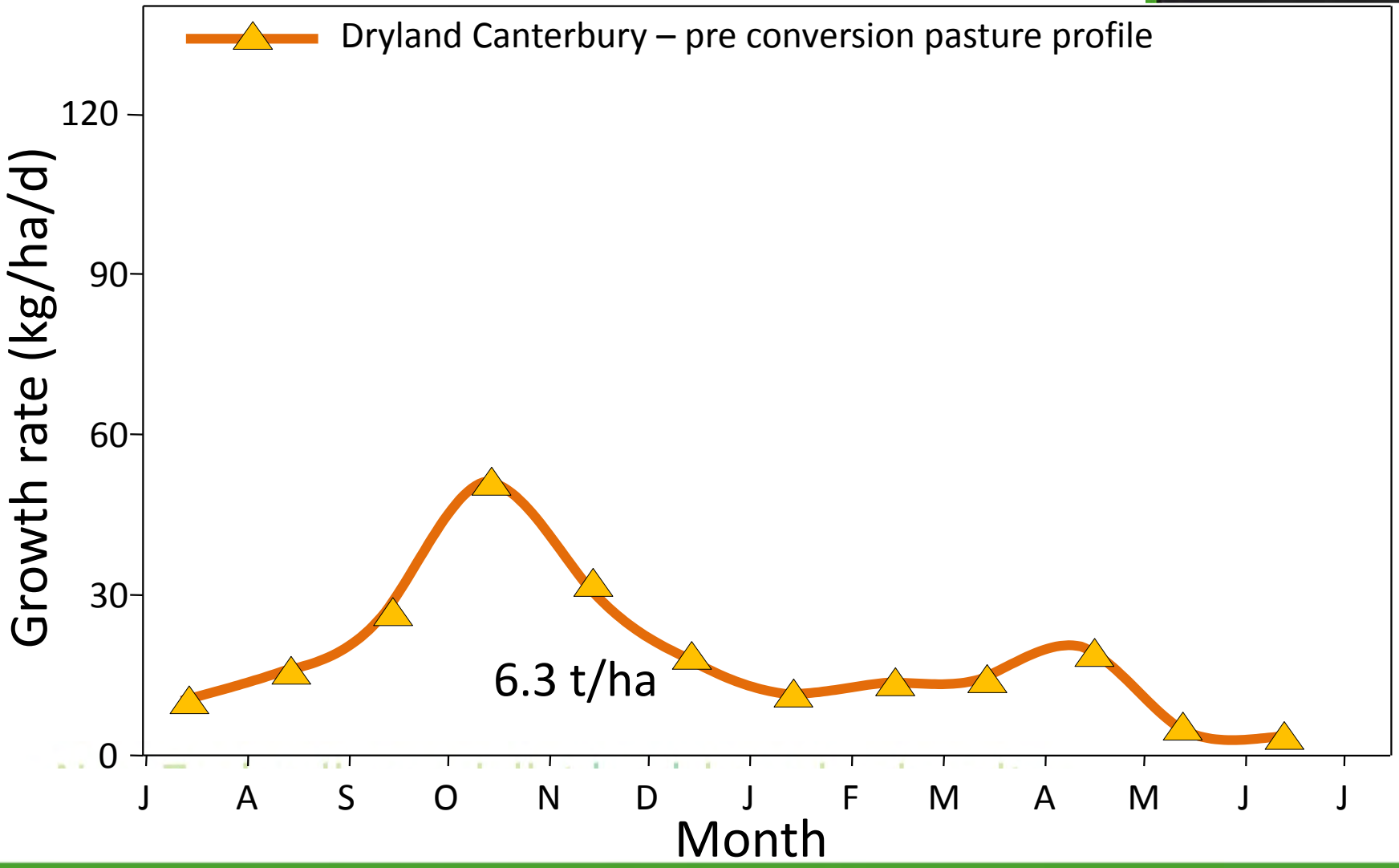


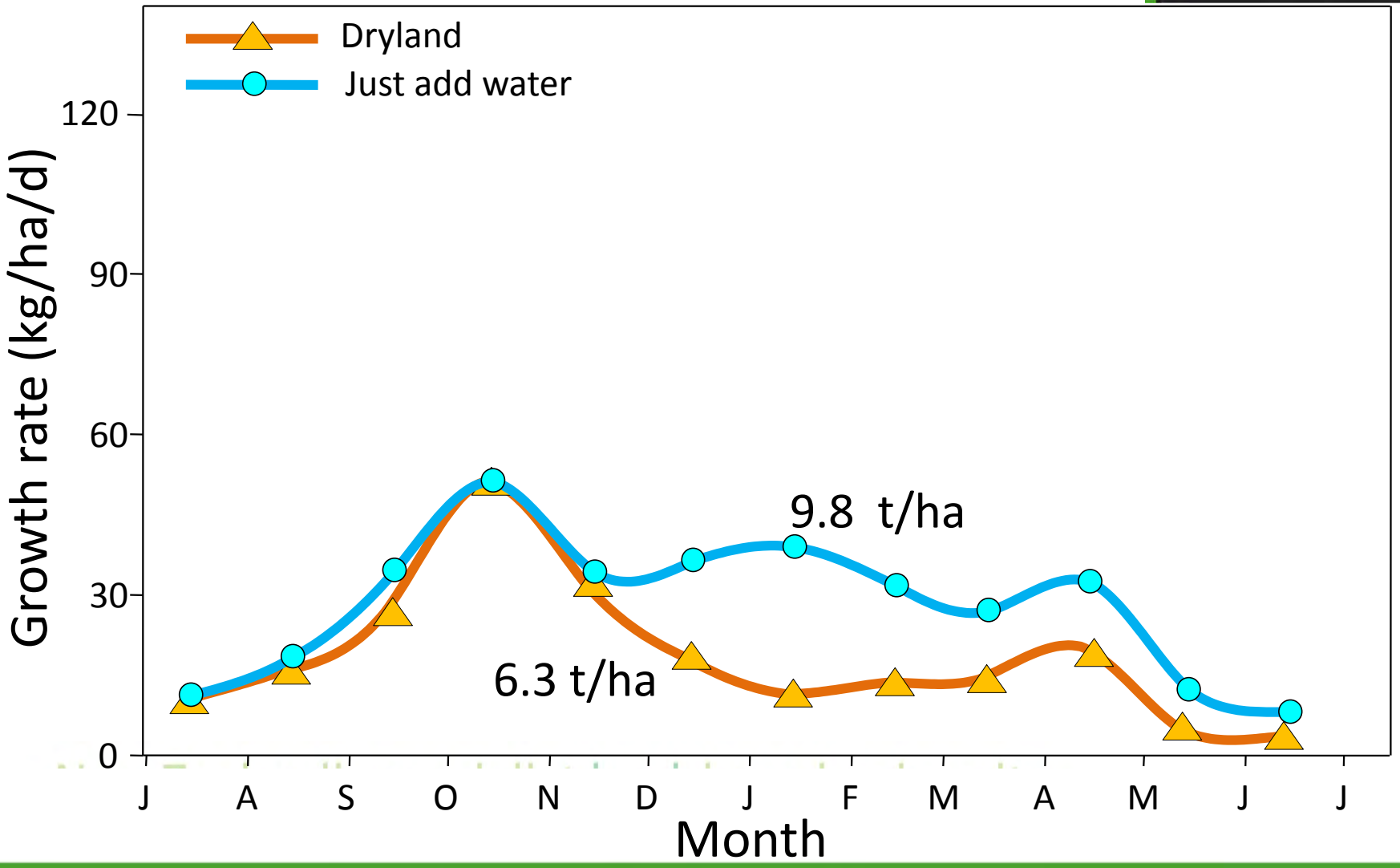
Photo: A Mills
Lincoln University

Growth rates (2 year means)



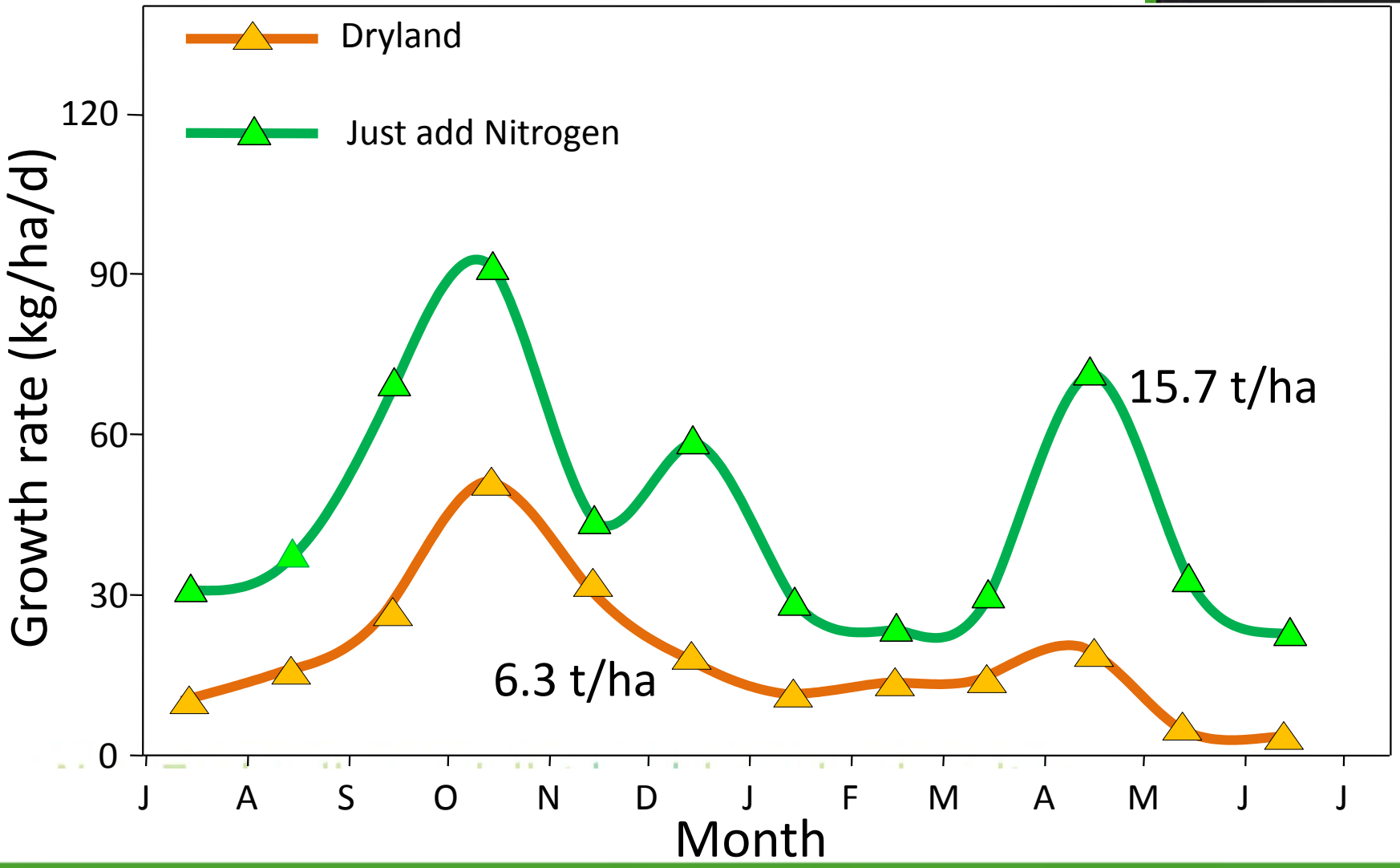
Mills *et al*. 2006, 2009

Growth rates (2 year means)



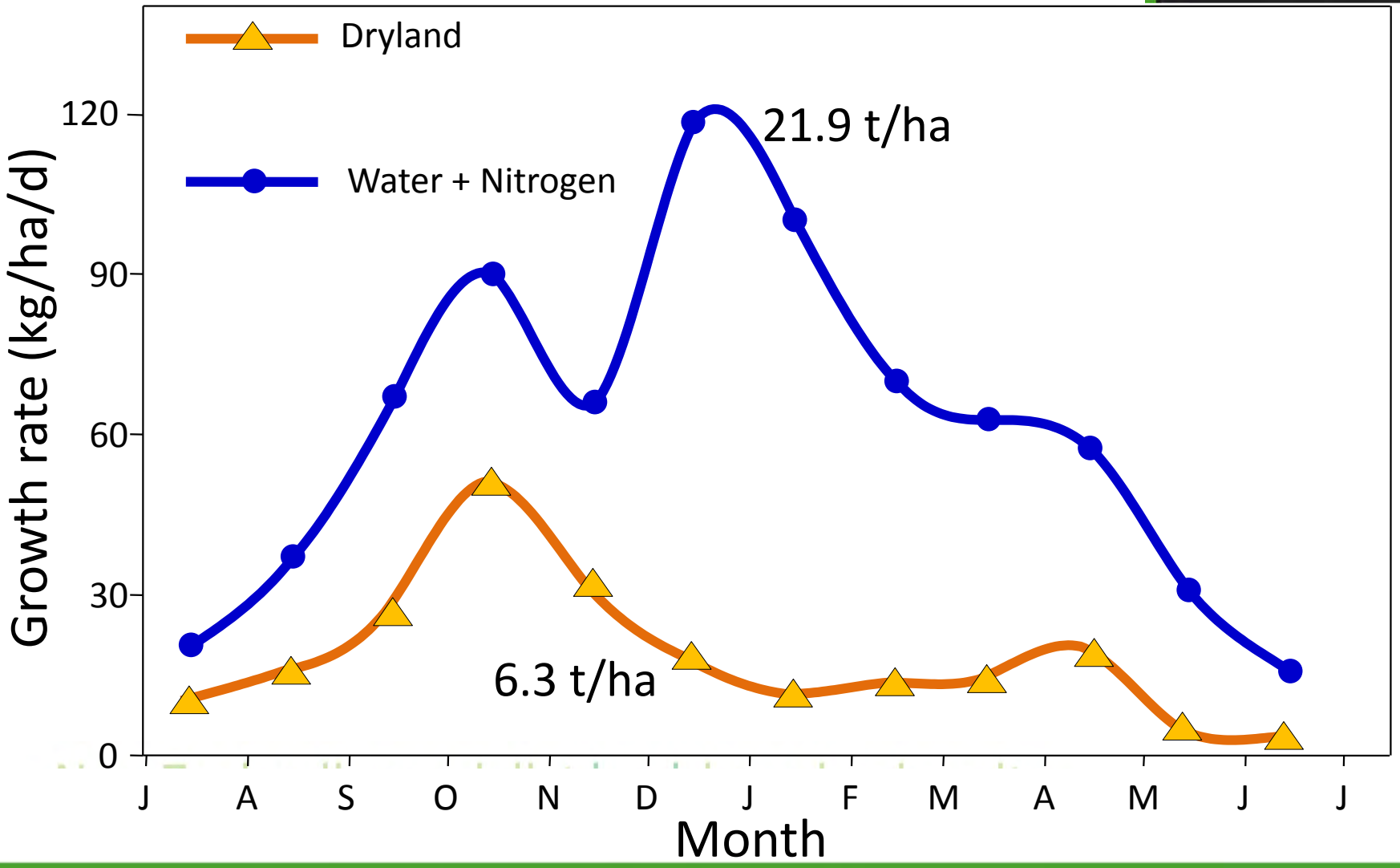
Mills *et al*. 2006, 2009

Growth rates (2 year means)



Mills *et al*. 2006, 2009

Growth rates (2 year means)

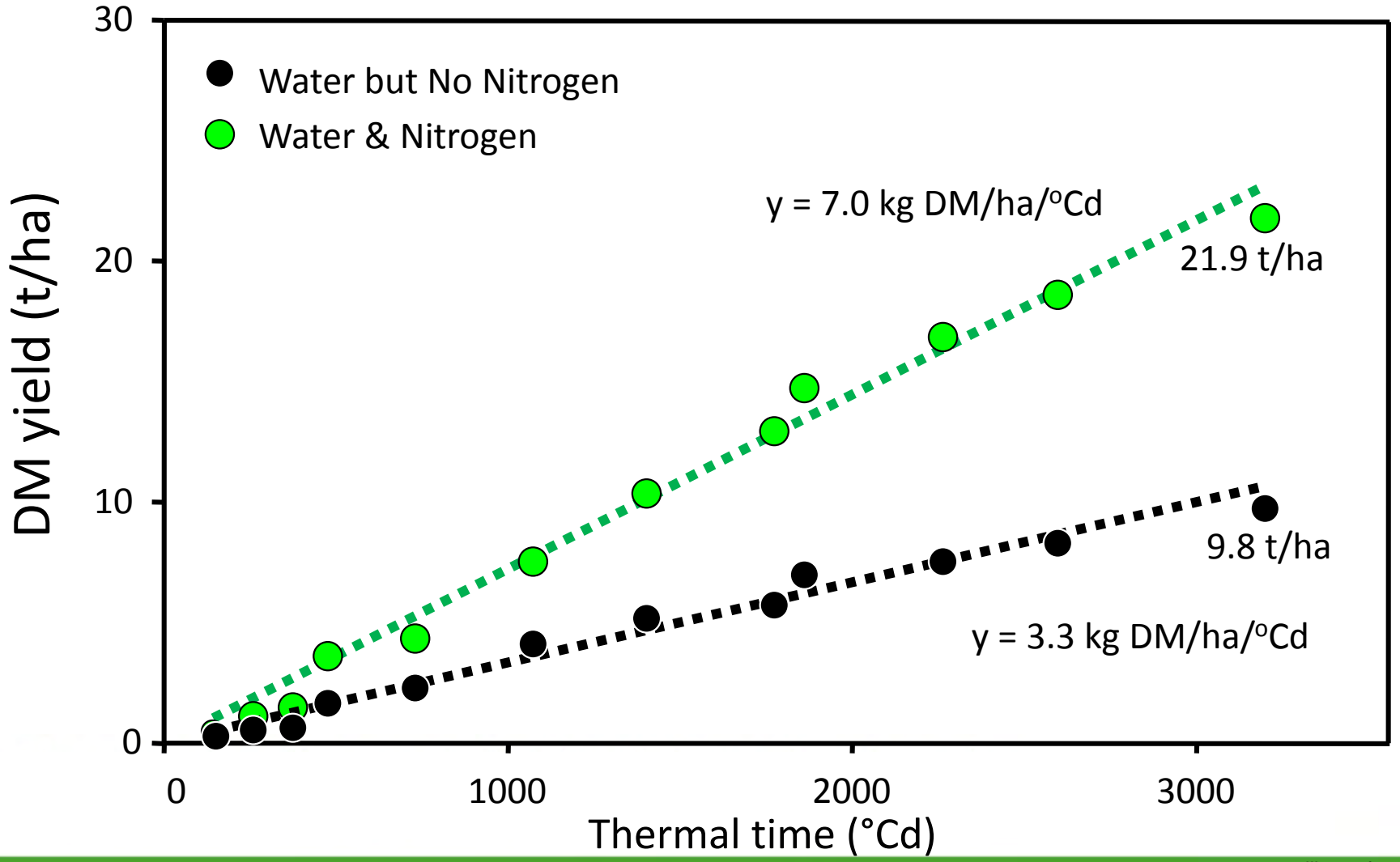


Mills *et al*. 2006, 2009

Winter
⇒ temperature response

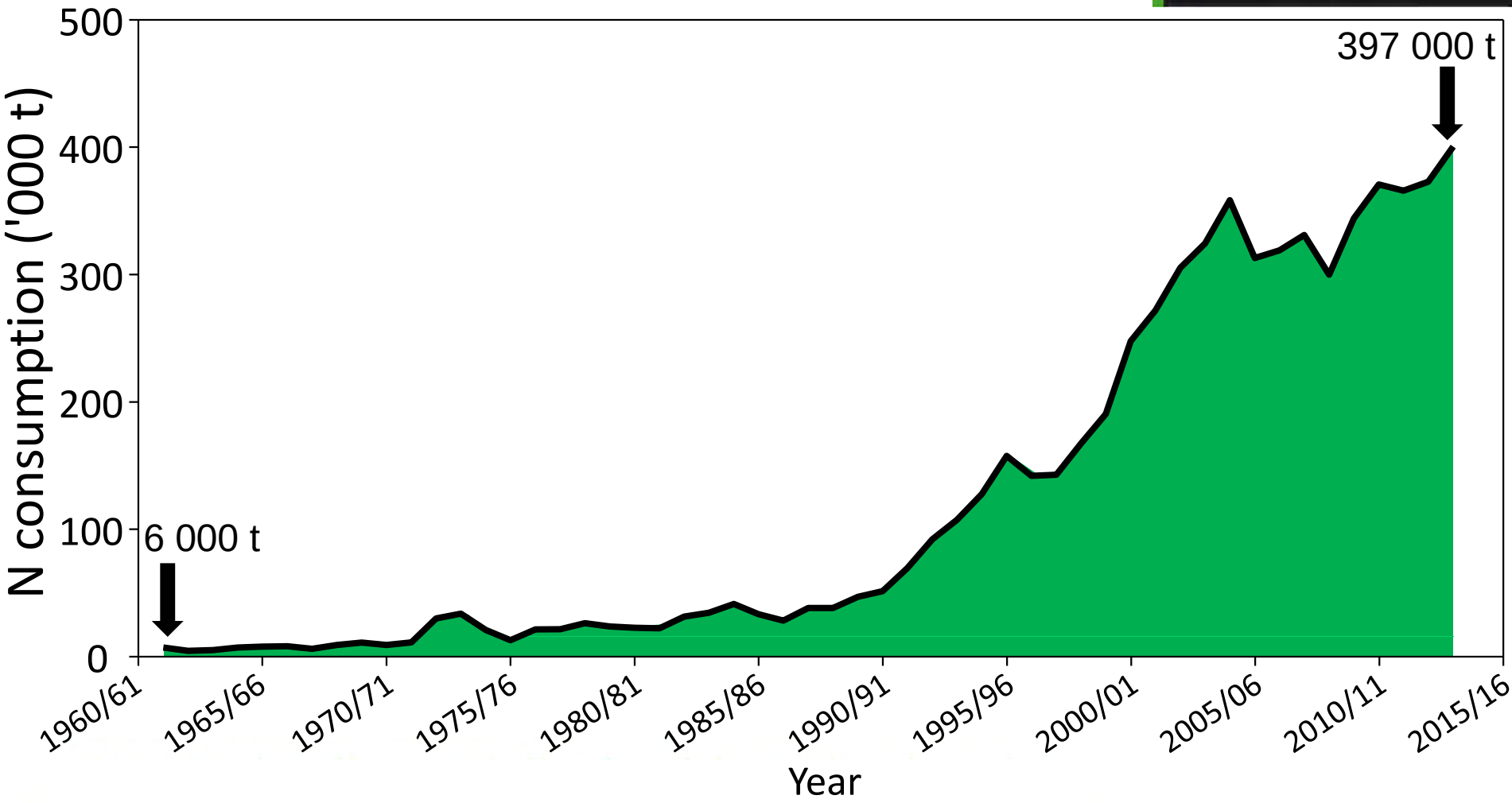
Photo: KM Pollock
Lincoln University

Where do we get our N?

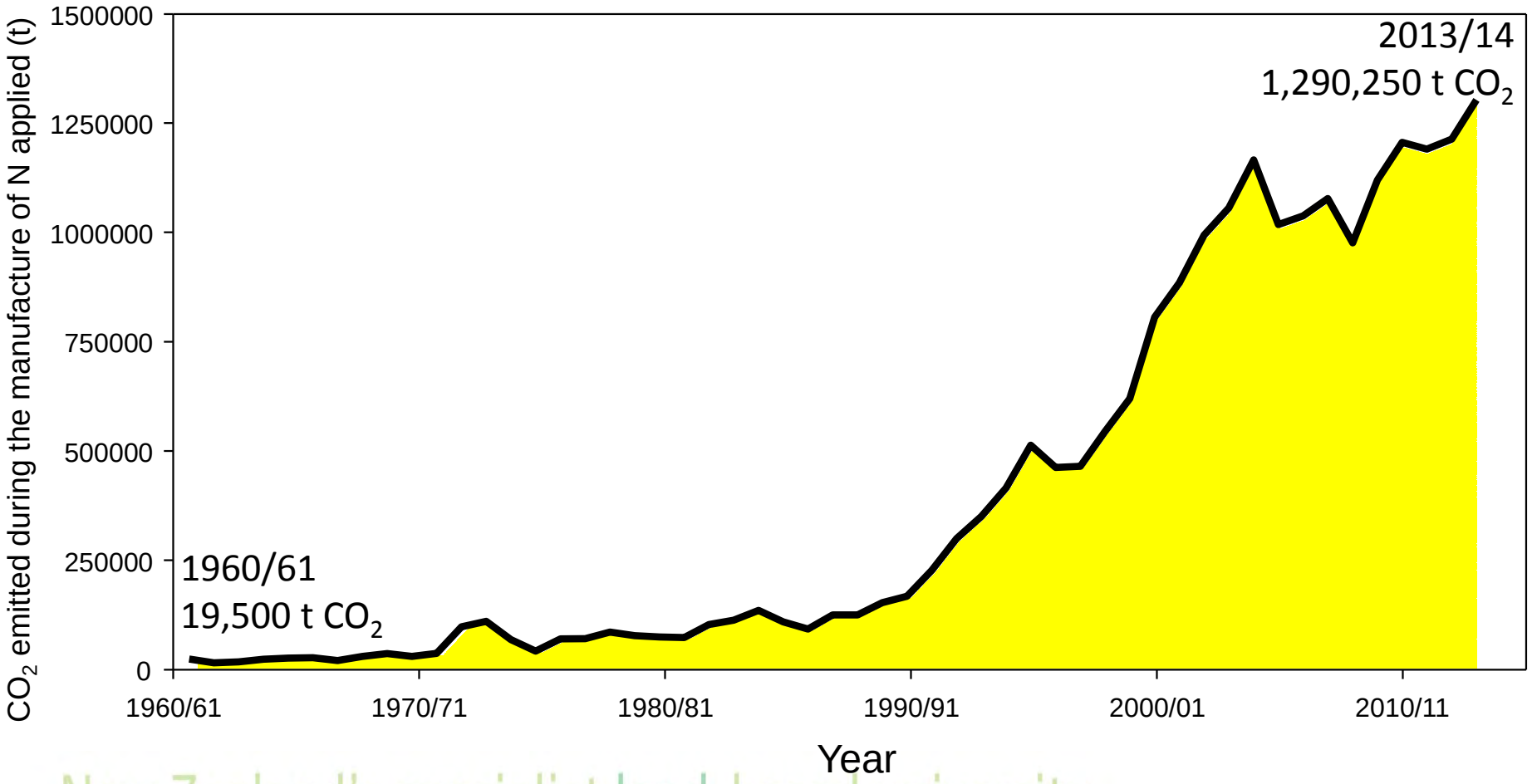


Mills *et al*. 2006; 2009

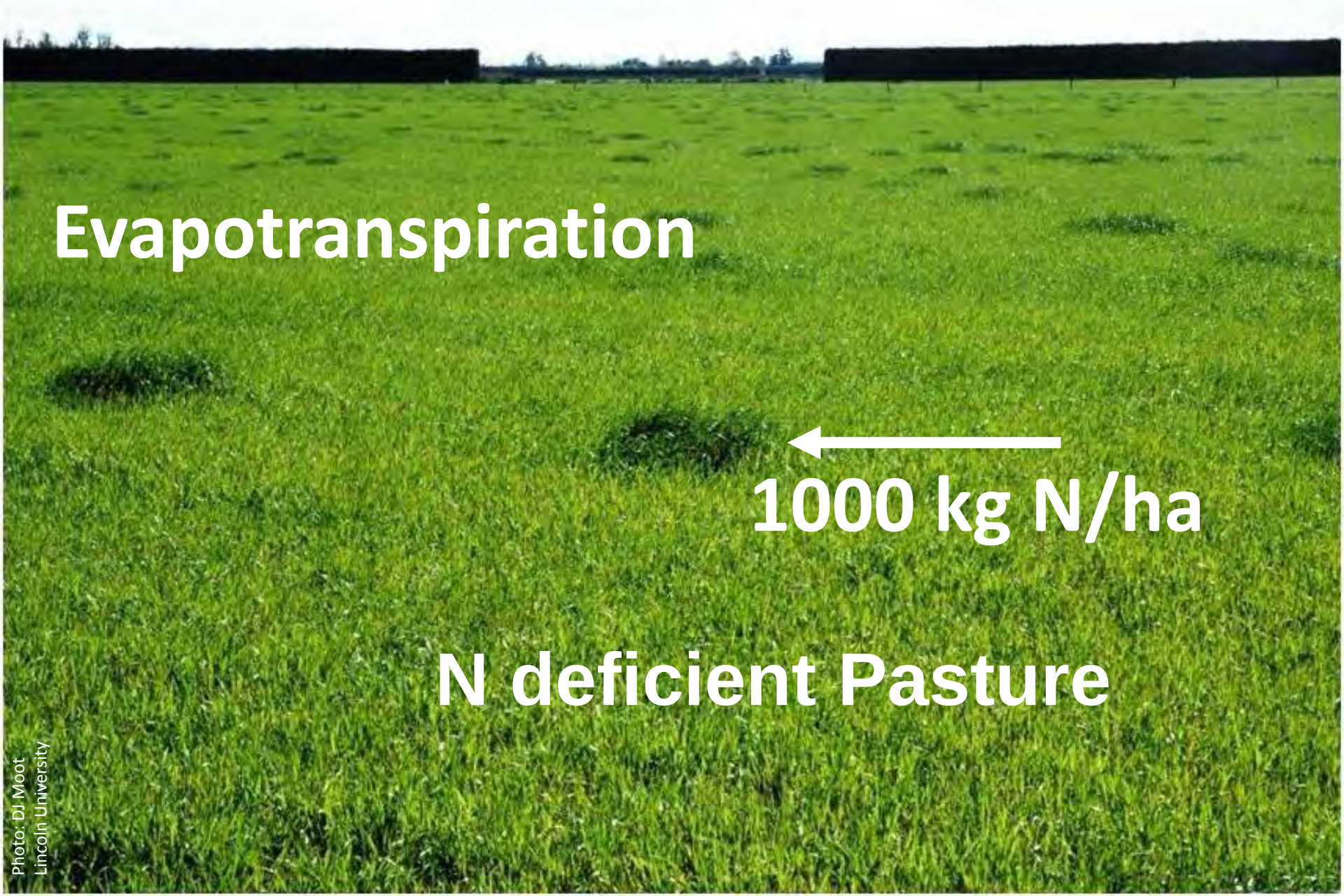
Fertiliser N use in NZ
- Nationally sustainable?



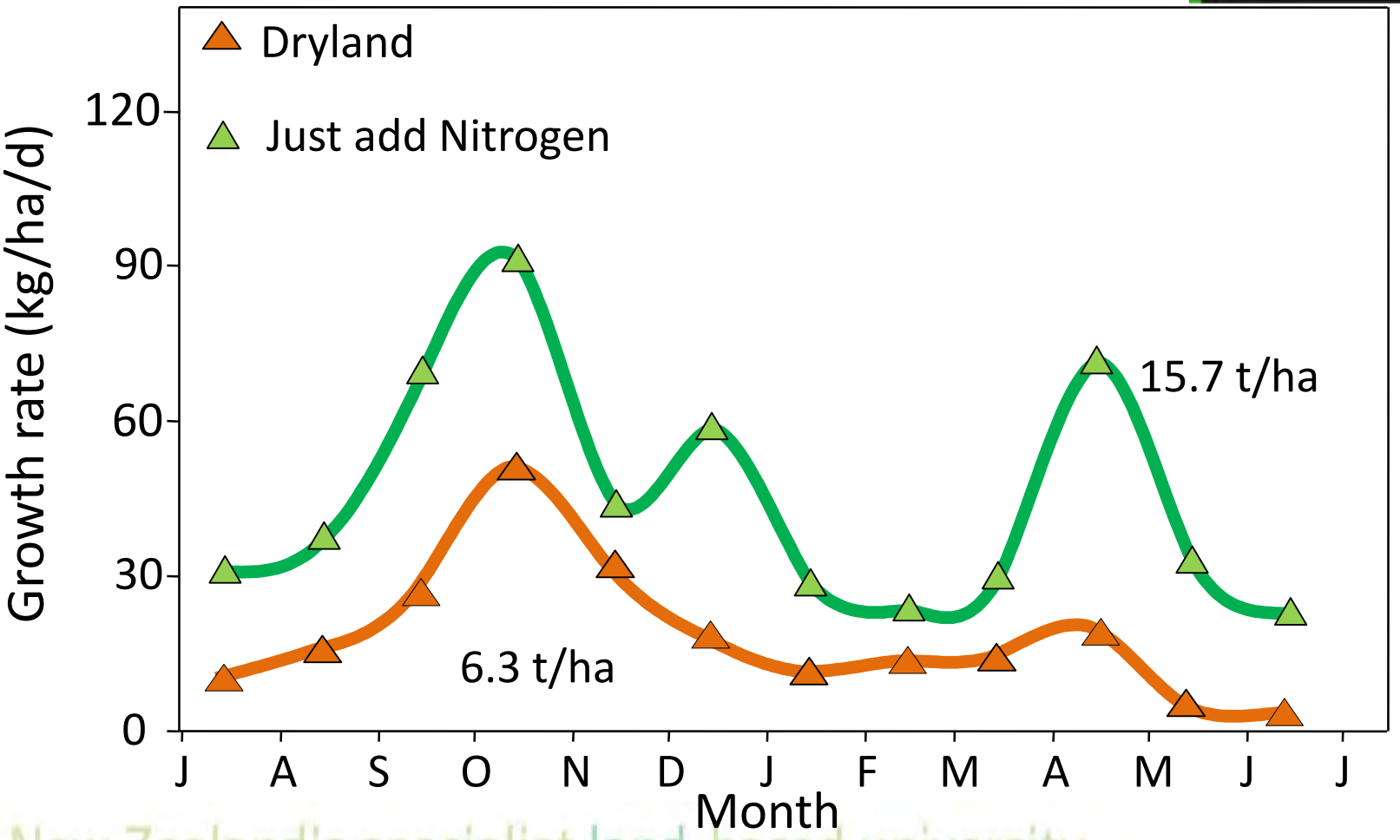
CO_2 emitted in production of our N - Globally sustainable?



Based on energy use of 65 MJ/kg N produced and an emission rate of 0.05 kg CO_2/MJ energy used (Saunders *et al*. 2006)

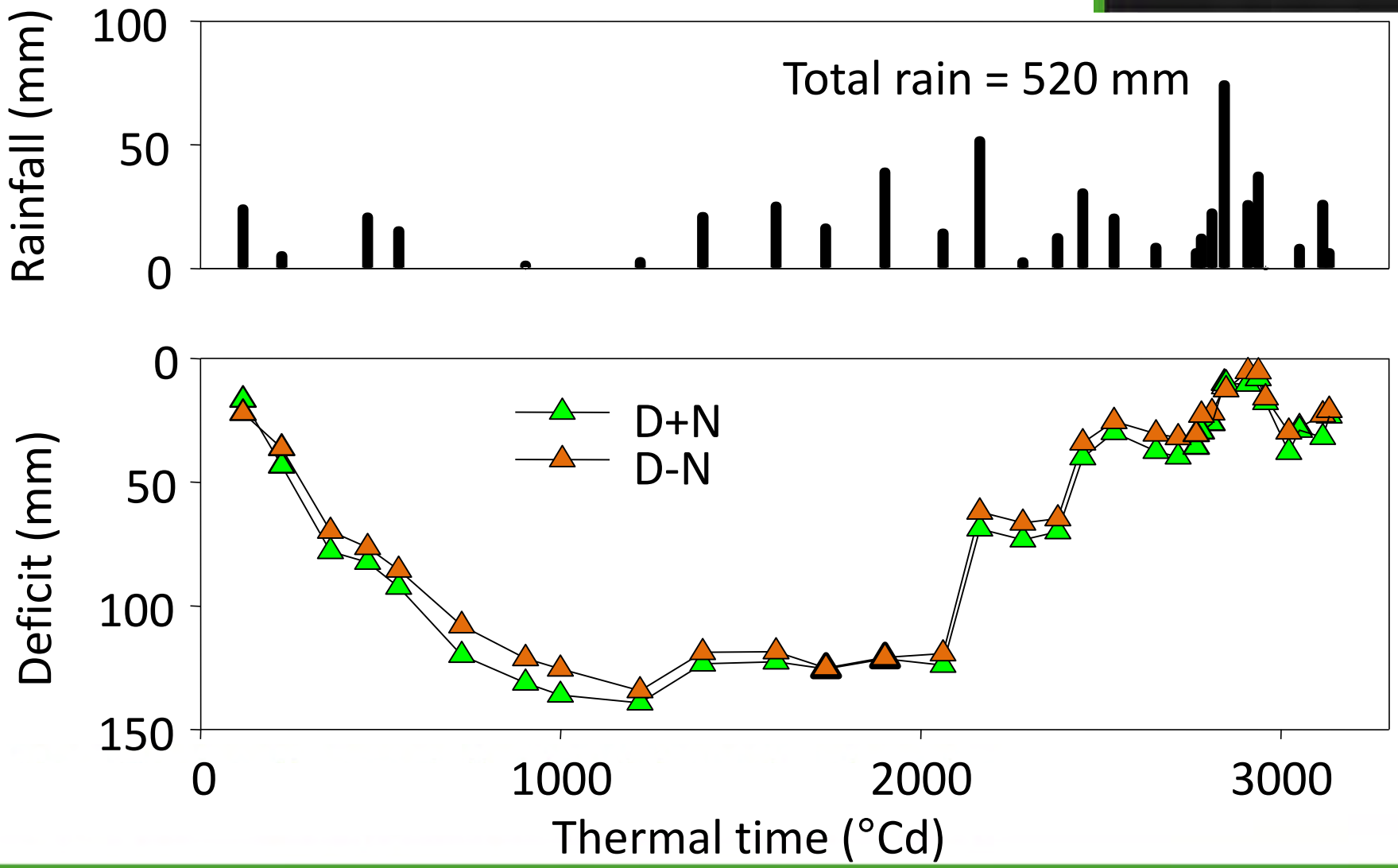

Evapotranspiration
1000 kg N/ha
N deficient Pasture
Photo: DJ Moot
Lincoln University

Growth rates (2 year means)



Mills *et al*. 2006, 2009

Soil moisture deficit 2003/04



Mills 2007

Photo: DJ Moot
Lincoln University

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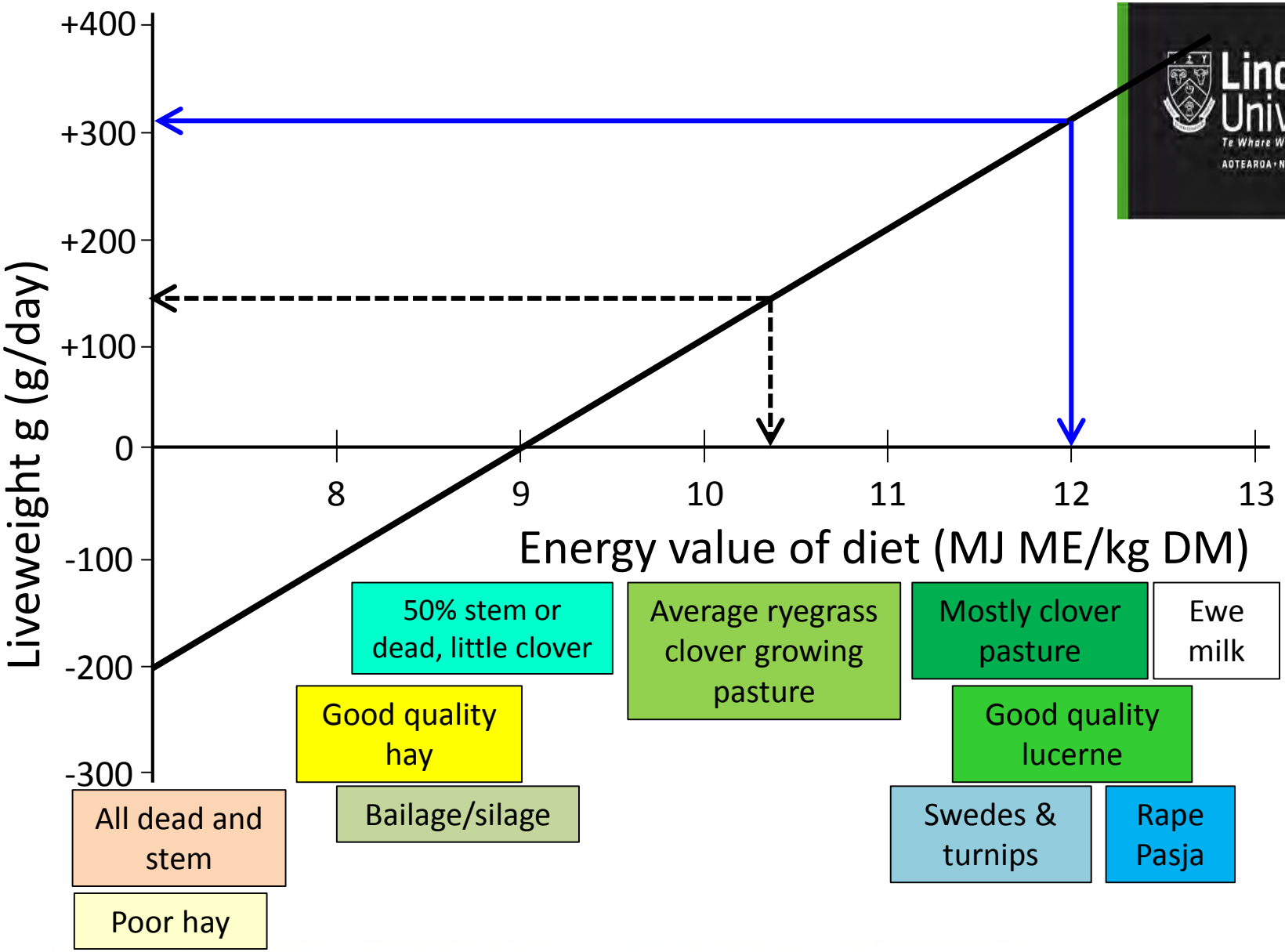
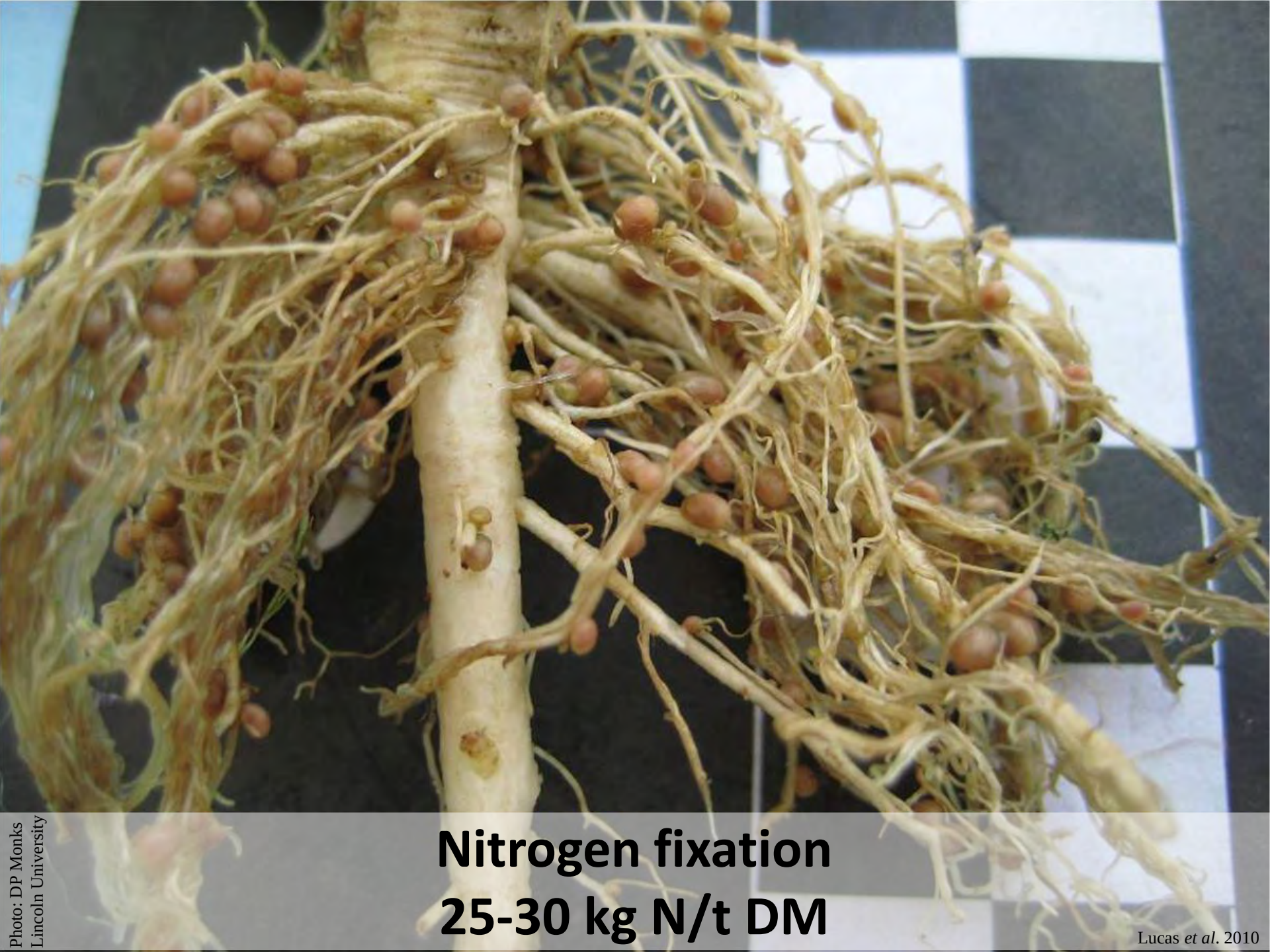


Adapted from: Kerr, 400 Plus. A guide to improved lamb growth



Nitrogen fixation
25-30 kg N/t DM

Photo: DP Monks
Lincoln University

Lucas *et al*. 2010

Dryland pastures

- Soil water recharge most springs
- Low N fertilizer use
- High spring feed demand – breeding systems
- Adaptable to climate variability – future scenarios
- Sustainable – financially, socially, environmentally
- Limited cultivation possible

Why lucerne (alfalfa) in NZ?

- High quality, deep tap-rooted, perennial legume suited to grazing and/or conservation for stock finishing on free-draining drought prone soils
- Why not? cut and carry- inflexible for grazing

Growth:

is dry matter accumulation as a result of light interception and photosynthesis

Development:

is the ‘age’ or maturity of the regrowth crop e.g. leaf appearance, flowering

Growth and development are both influenced by environmental signals

The canopy: the energy capture device

Photo: DJ Moot
Lincoln University

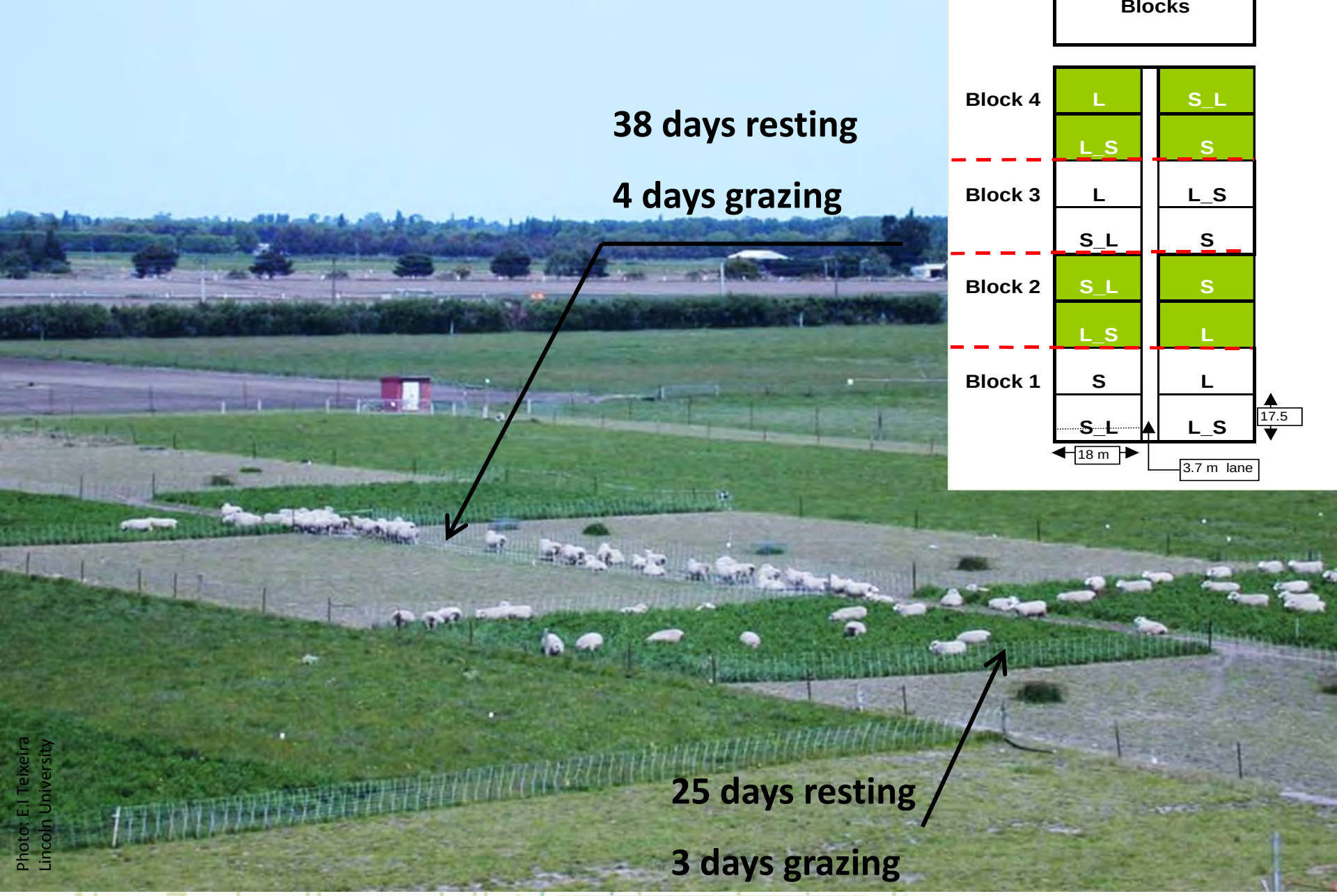
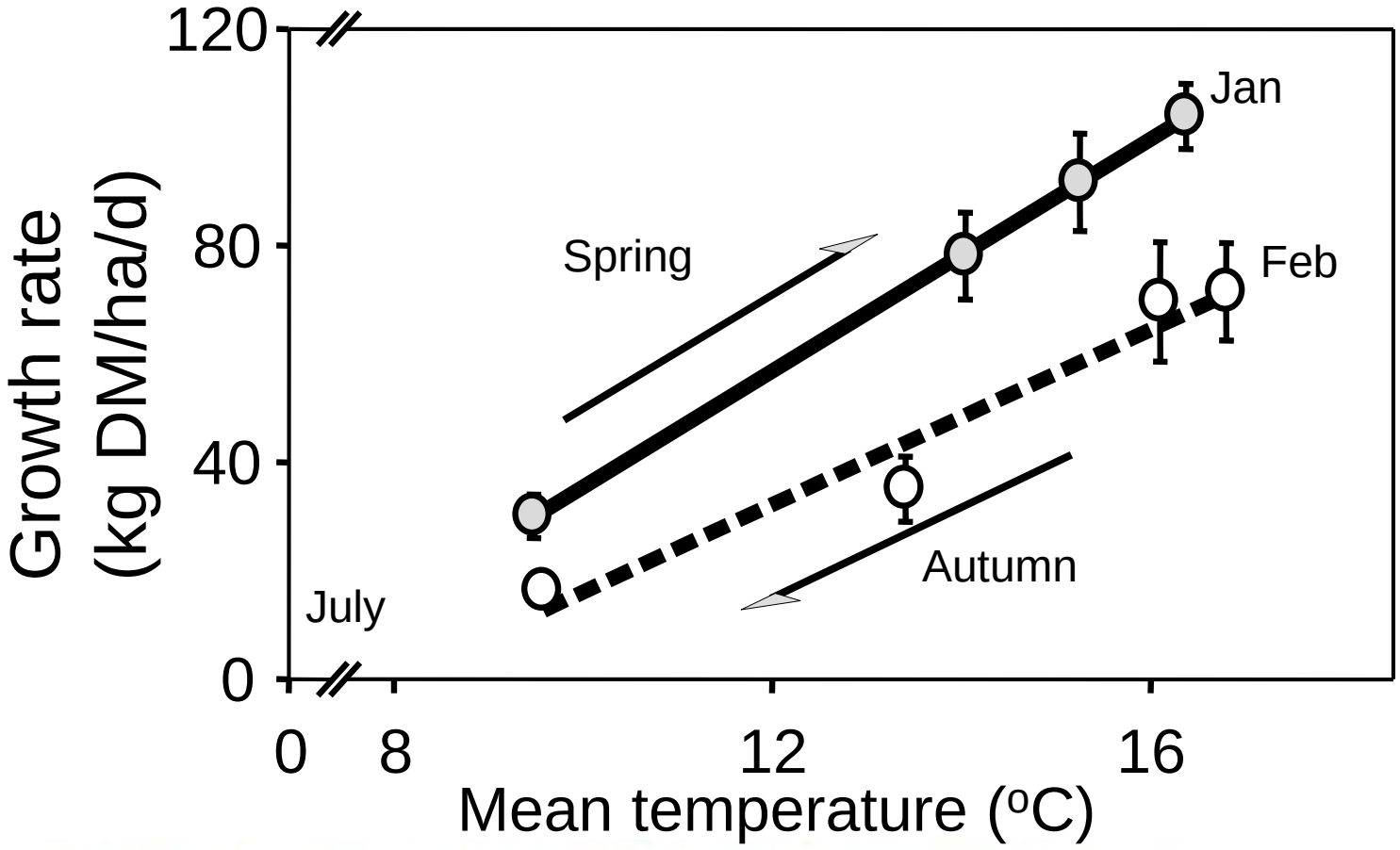


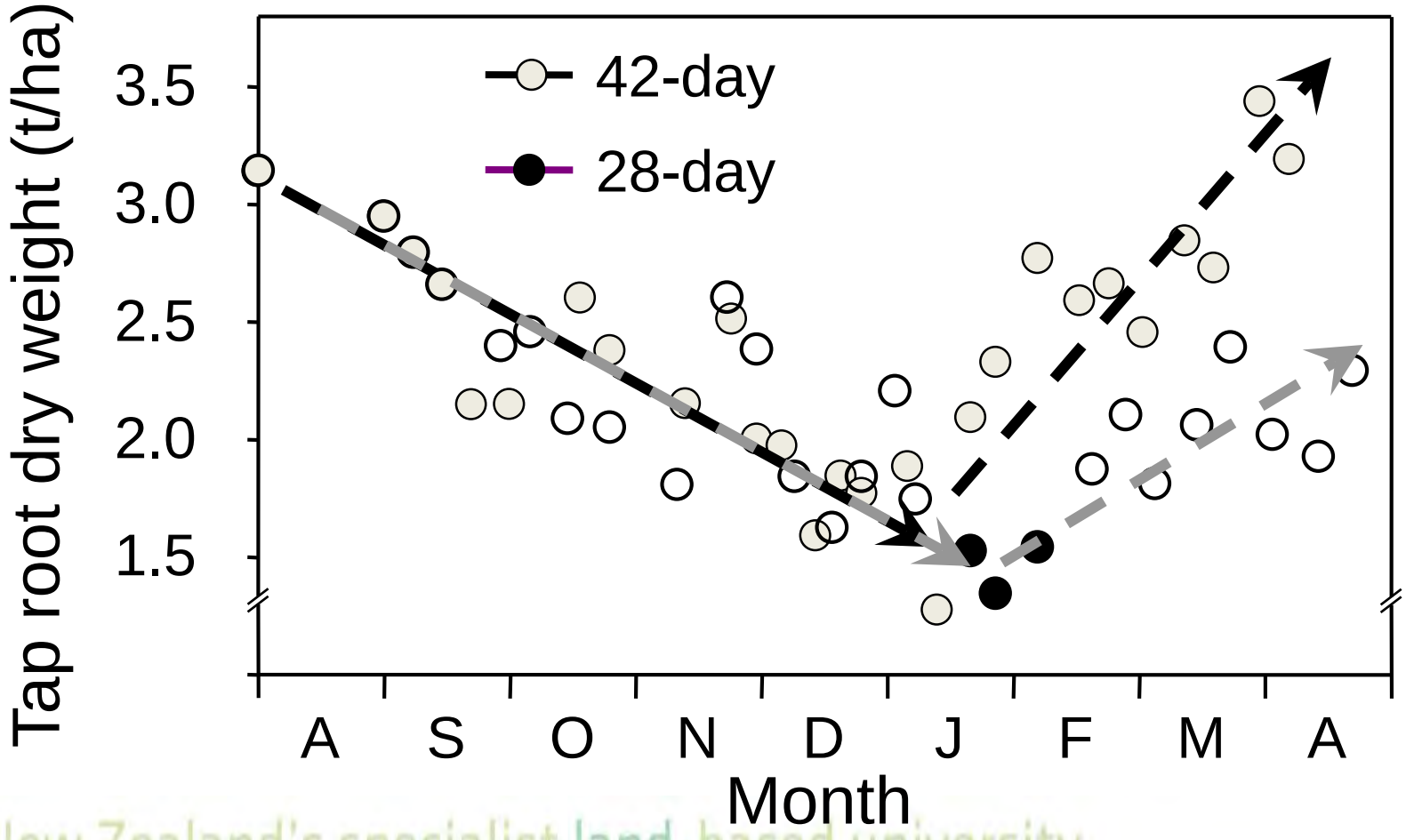
Photo: E.I Teixeira
Lincoln University

Vegetative growth



Moot *et al*. 2003

Partitioning to roots



Moot *et al*. 2003

Case study – Bonavaree farm, Marlborough

Over grazed – high erosion risk

Financially – no return

Dryland lucerne conversion

Photo: Doug Avery
Bonavaree, Marlborough

East coast dryland Drought…….. 8 years of it

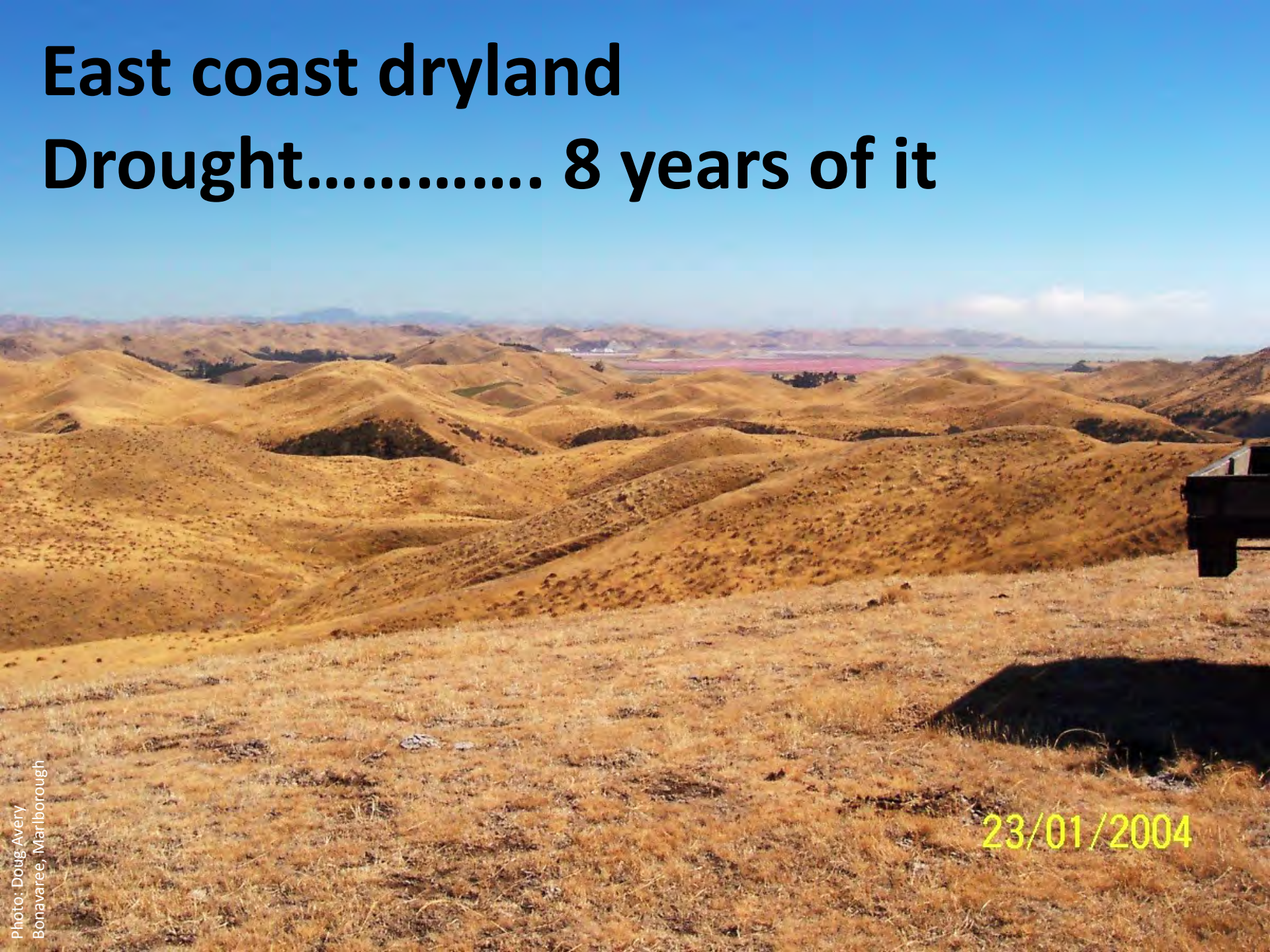


Photo: Doug Avery
Bonavaree, Marlborough

Photo: Bonavaree

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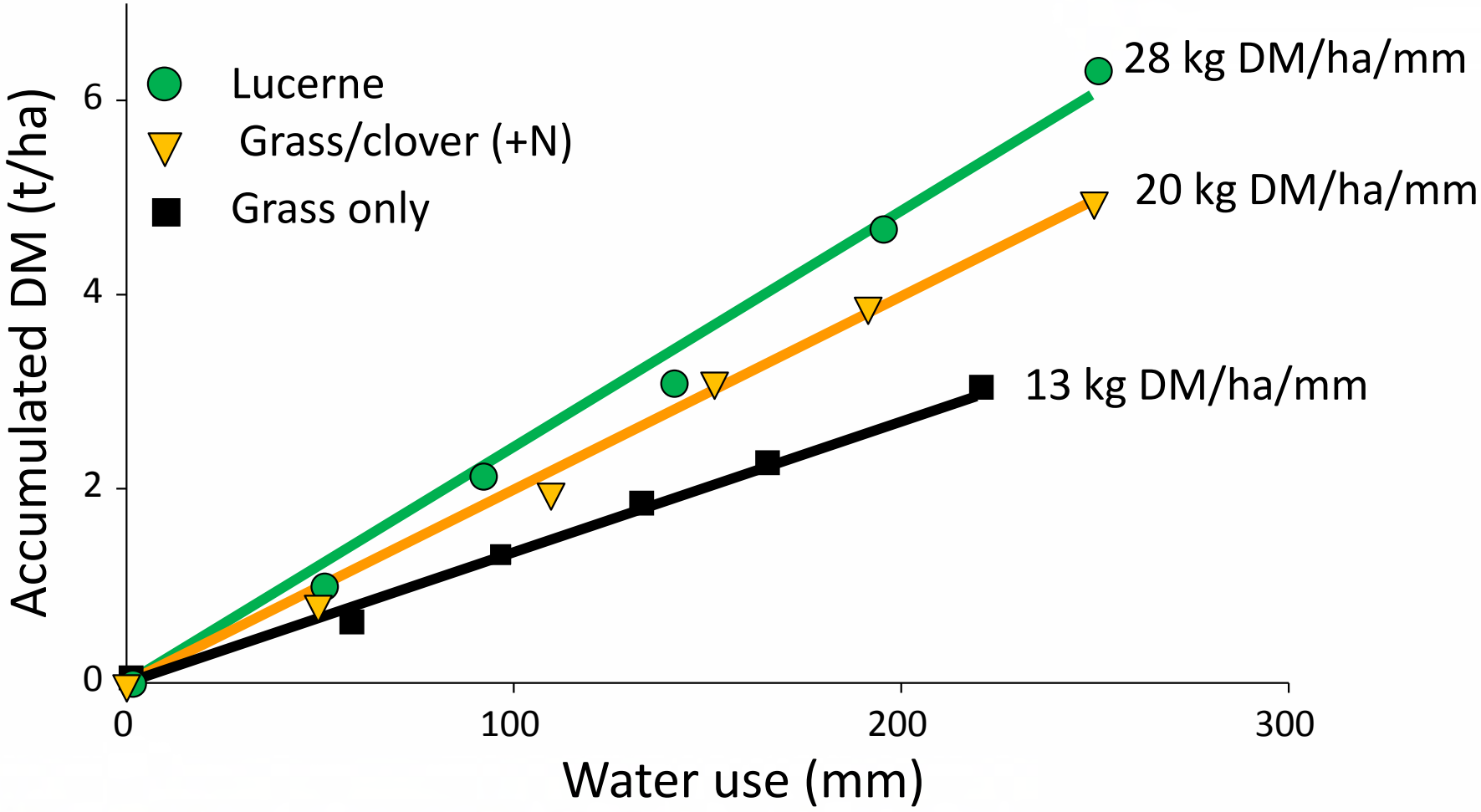
Doug and Fraser Avery “Bonavaree”

Photo: Doug Avery
Bonavaree, Marlborough

Spring WUE



Moot *et al*. 2008

Seasonal grazing management

Spring

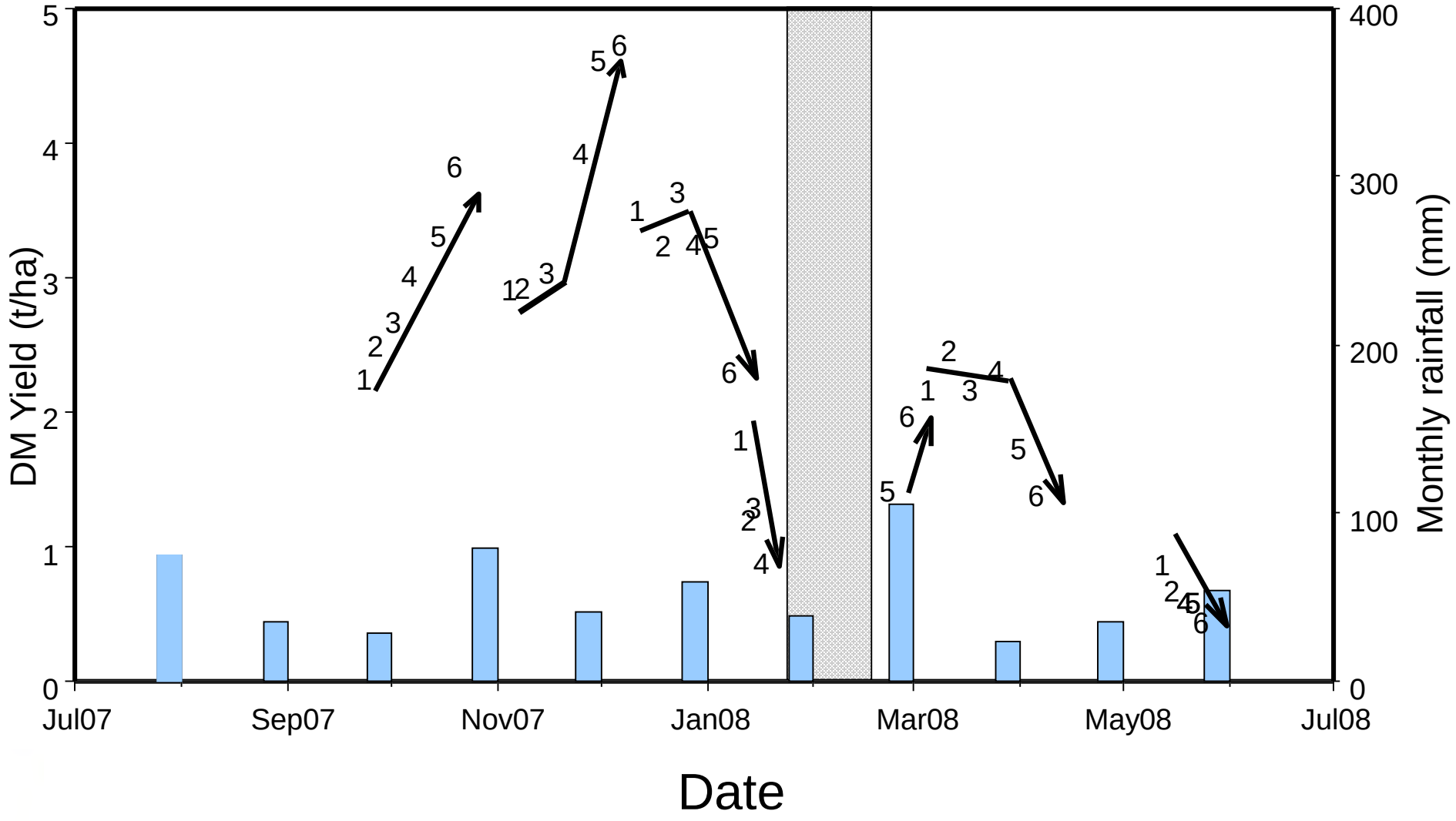
- 1st rotation aided by root reserves to produce high quality vegetative forage.

- can graze before flowers appear (~1500 kg DM/ha) ideally ewes and lambs but

Never lamb on or set stock lucerne

5th September 2011 – Cave Sth Canterbury

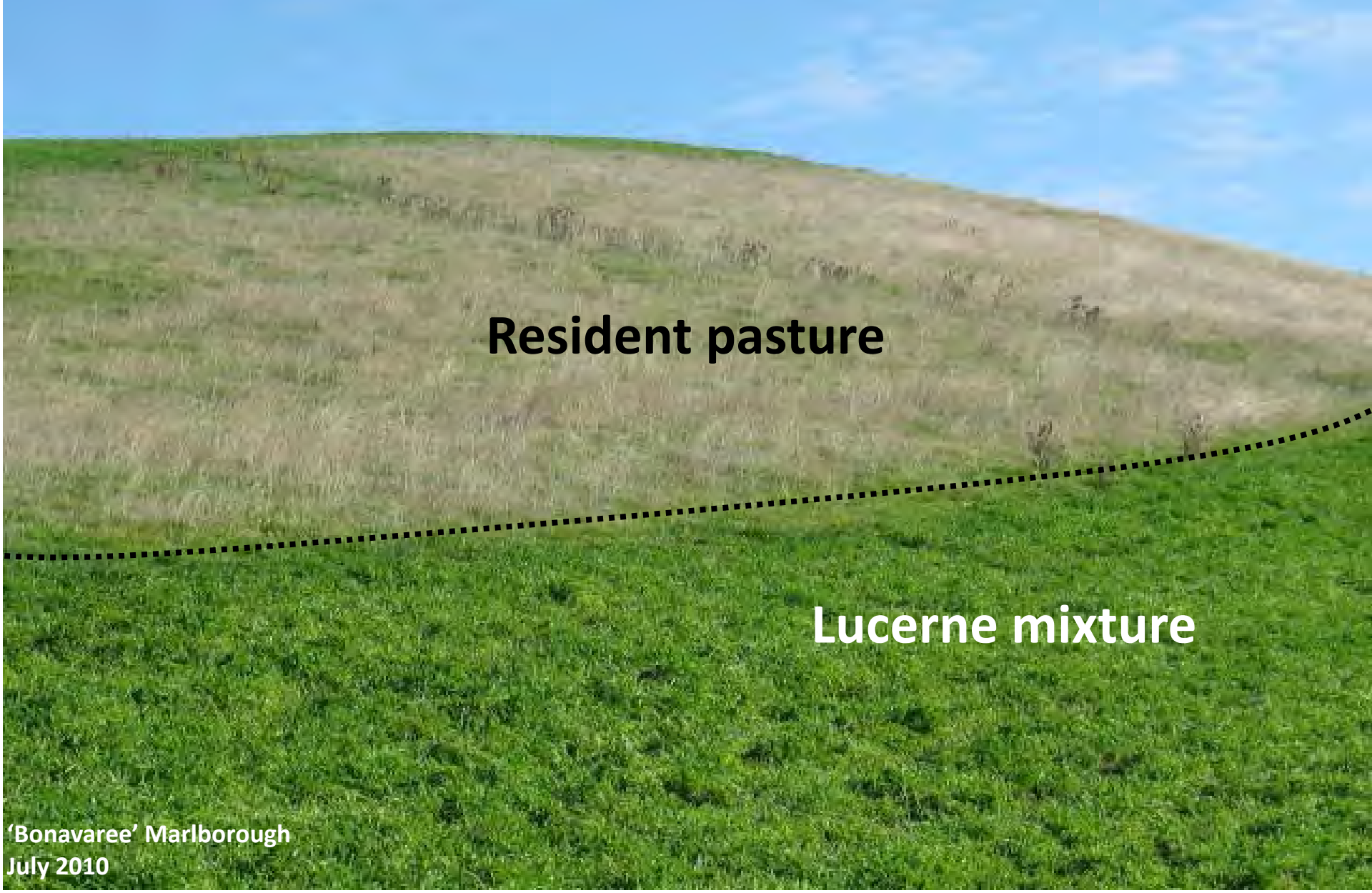
Grazing Rotations at Lincoln University



Seasonal grazing management

Spring/summer (Nov-Jan)

- Priority is stock production (lamb/beef/deer)
- graze 8-12 weeks solely on lucerne
- 5-6 paddock rotation stocked (7-10 days on)
- 10-12 ewes plus twin lambs per hectare



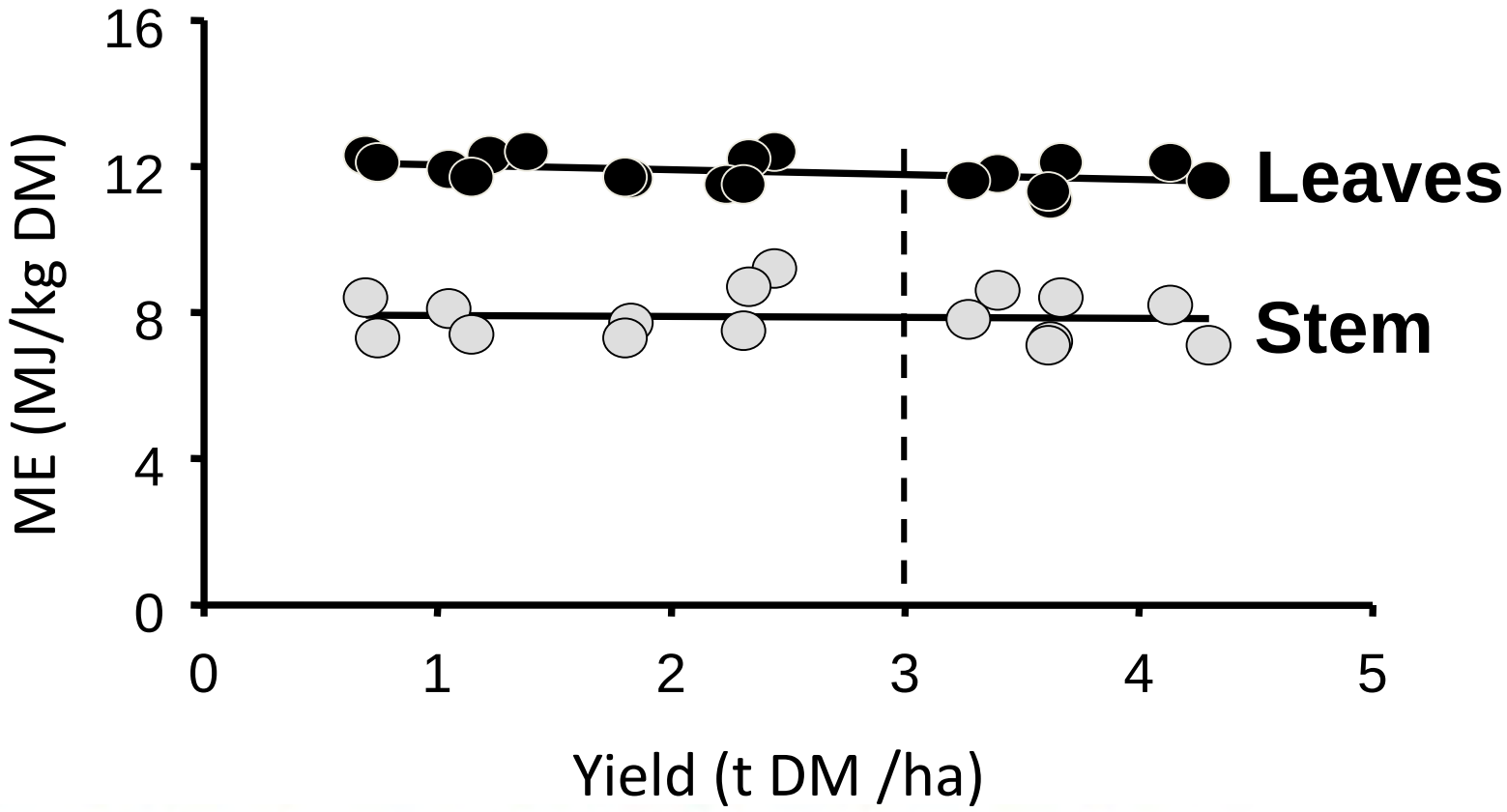
'Bonavaree' Marlborough
July 2010

‘Bonavaree’ Marlborough
July 2010

Maximize reliable spring growth – high priority stock

Bonavaree, Marlborough

Metabolisable energy of lucerne



Brown & Moot 2004

Bonavaree, Marlborough

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No moisture = No Growth

Photo: D Avery
Bonavaree, Marlborough

Two weeks later

Photo: D Avery
Bonavaree, Marlborough

Photo: M Smith
Lincoln University

Rotation 4 Pre-graze
Plot 6 (28/2/08) **2.0 t DM/ha produced in 51 d**

Post-graze (4/3/08) **0.6 t DM/ha**
UTILISATION = **70%**

Animal health

- **Redgut:** problem on high quality feeds – fibre
- **Bloat:** cattle more than sheep – capsules
- **Na def.** (0.03%): salt licks/fence-line weeds/pasture
  - Require 0.11% Na - sheep/beef/dairy (13%)

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Animal health (cont'd)

- **Clostridial bacteria:** vaccinate with 10 in 1
- **Cobalt:** vitamin B12 injection
- **Worm haven:** Camping on small area – river edge?
- **Leaf spot in autumn:** avoid flushing on older lucerne
  - new regrowth or tops only are O.K.

Bonavaree, Marlborough

New Zealand's specialist land-based university

Bonavaree 14/8/2017

Photo: DJ Moot
Lincoln University

Photo: Doug Avery, Bonavaree

Change in stock performance

Ewes growing lambs at 360- 400 g hd per day.

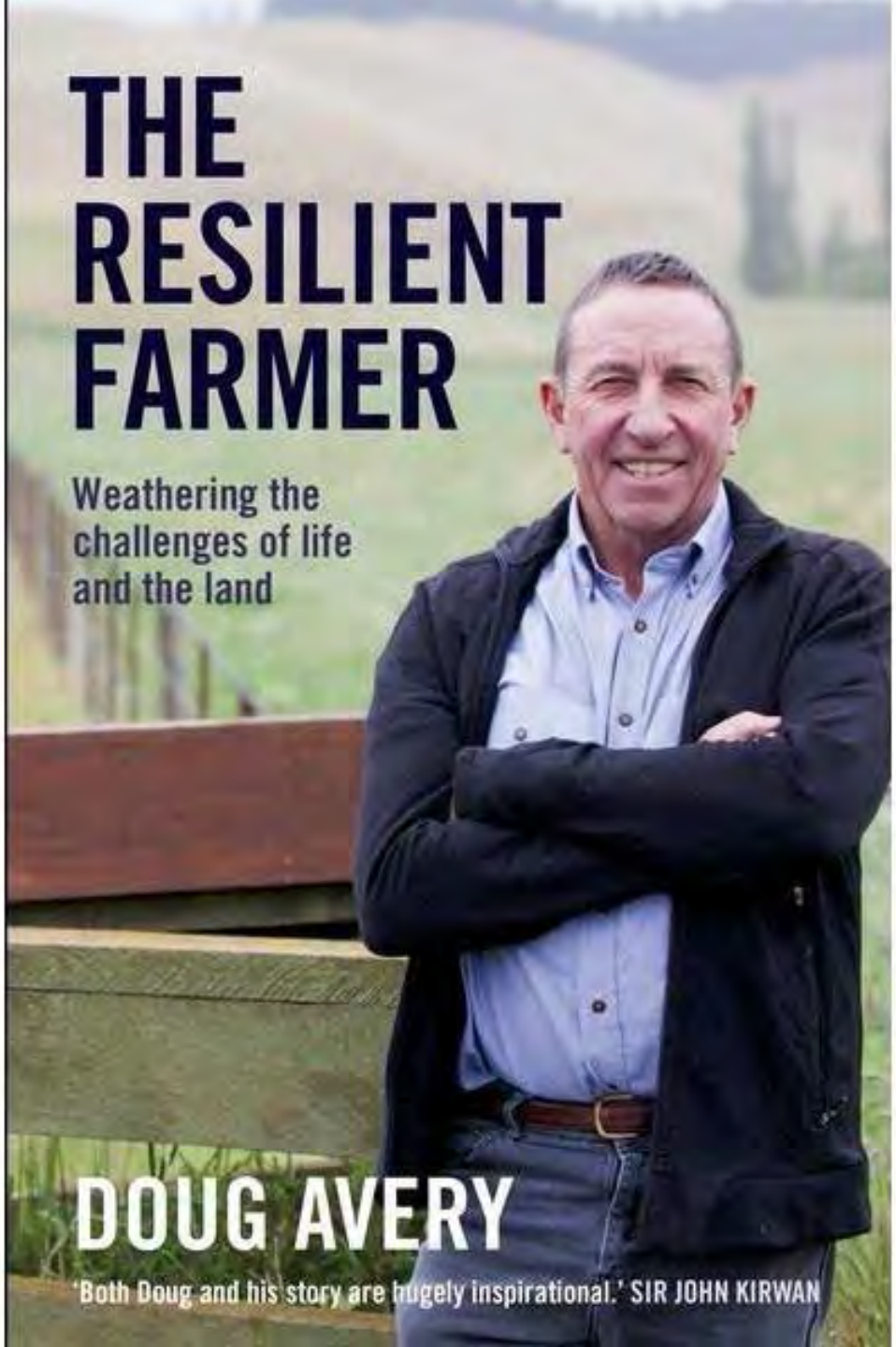
Average for NZ is 175 g hd per day

Photo: Doug Avery, Bonavaree

Hogget scanning increased from 40% to 162%

‘Bonavaree’ production change over 10 years

	2002	2012	Change
Land area (ha)	1100	1800	↑64%
Sheep numbers	3724	4158	↑12%
Lambing (%)	117	145	↑24%
Lamb weights (kg)	13.3	19	↑43%
Lamb sold (kg)	38324	74460	↑94%
Wool (kg)	18317	20869	↑14%
Sheep:cattle	70:30	50:50	
Gross trading profit (ha)	$317	$792	↑149%



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Landscape farming – Bog Roy Station

Photo: DJ Moot
Lincoln University

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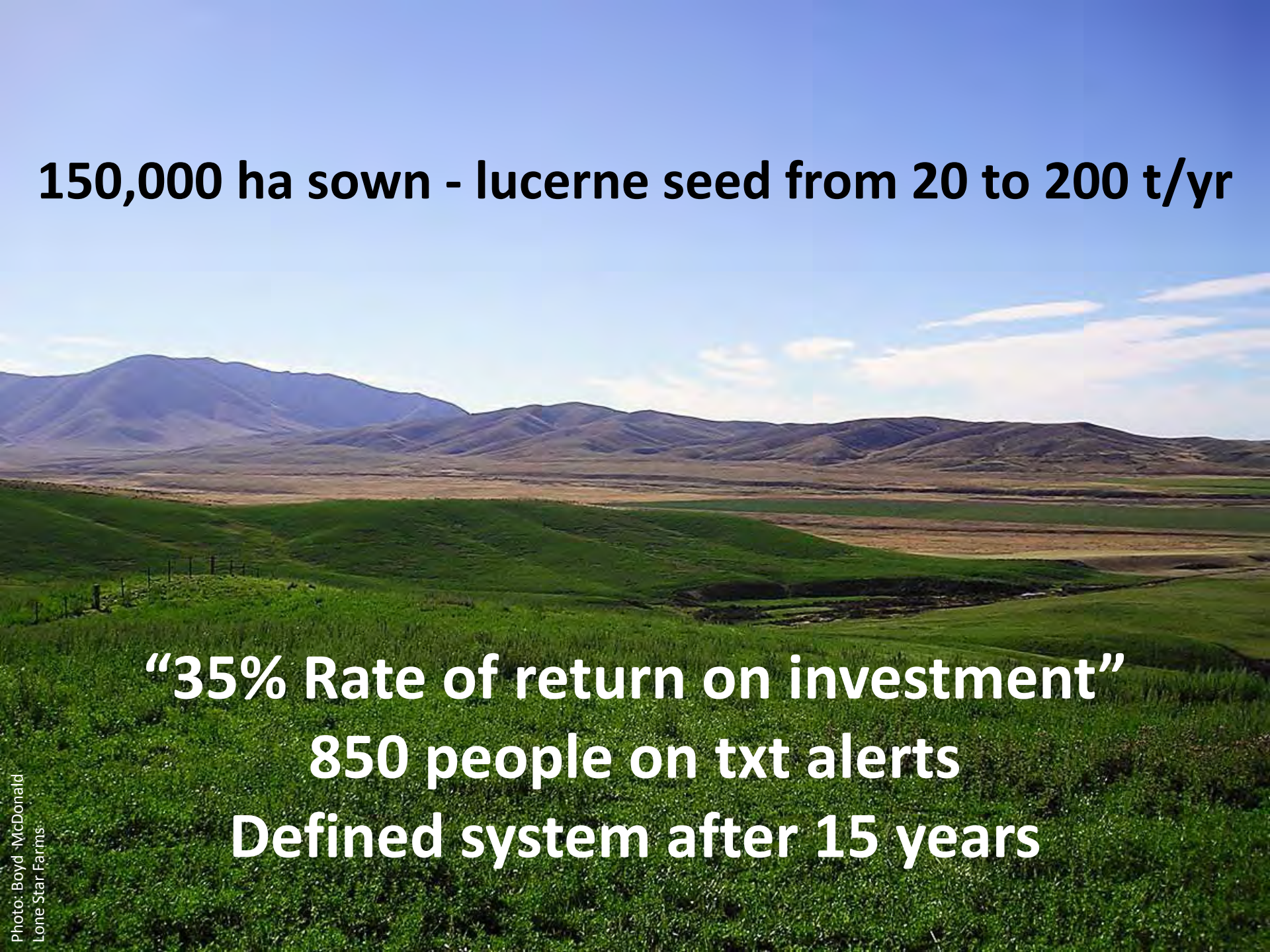
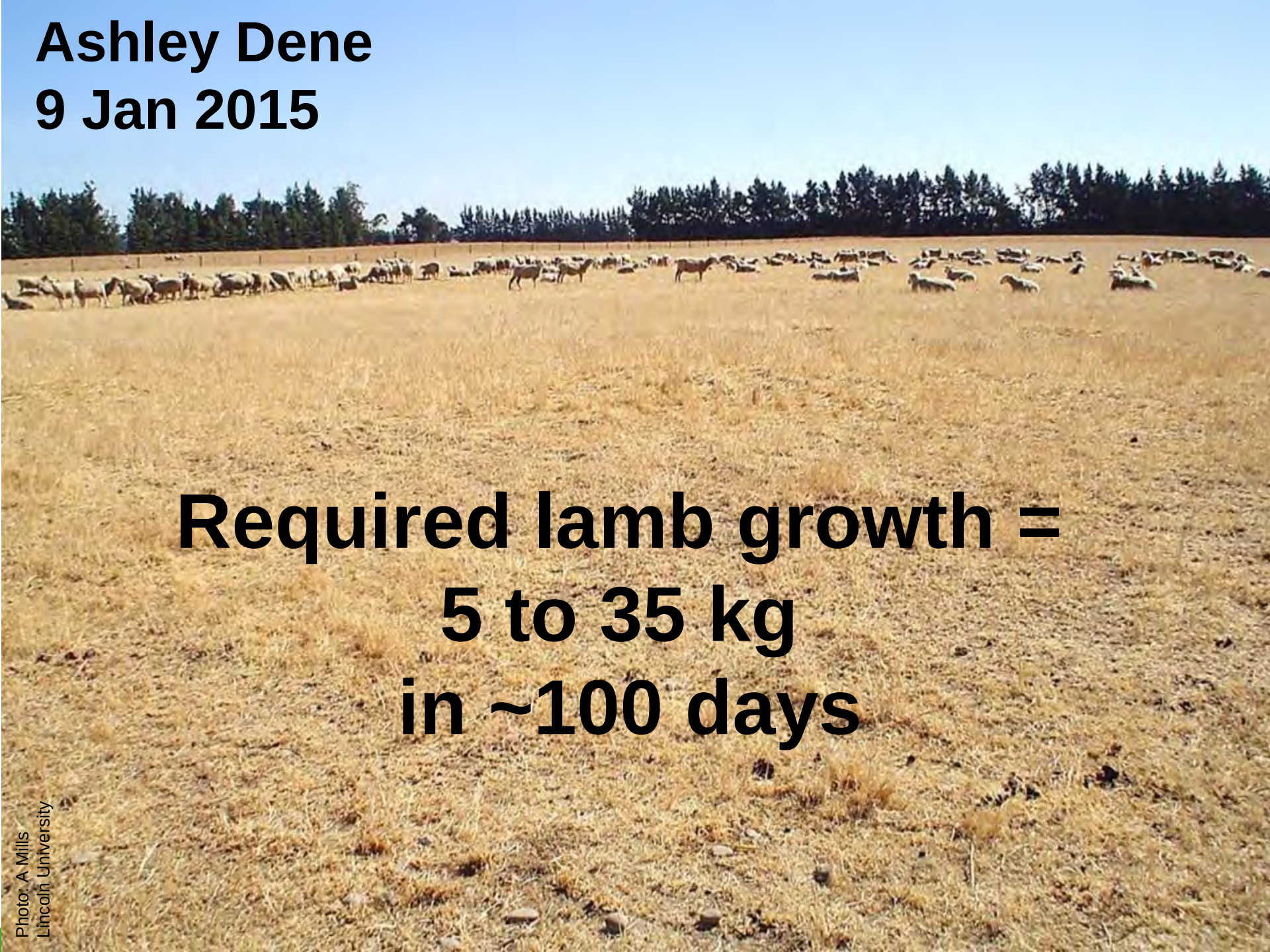
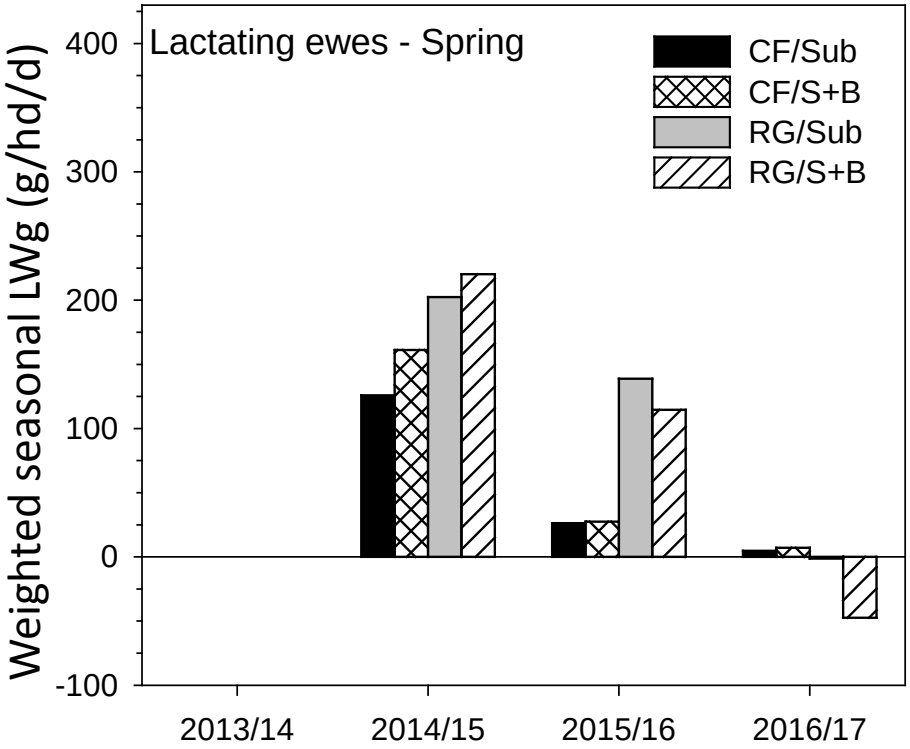
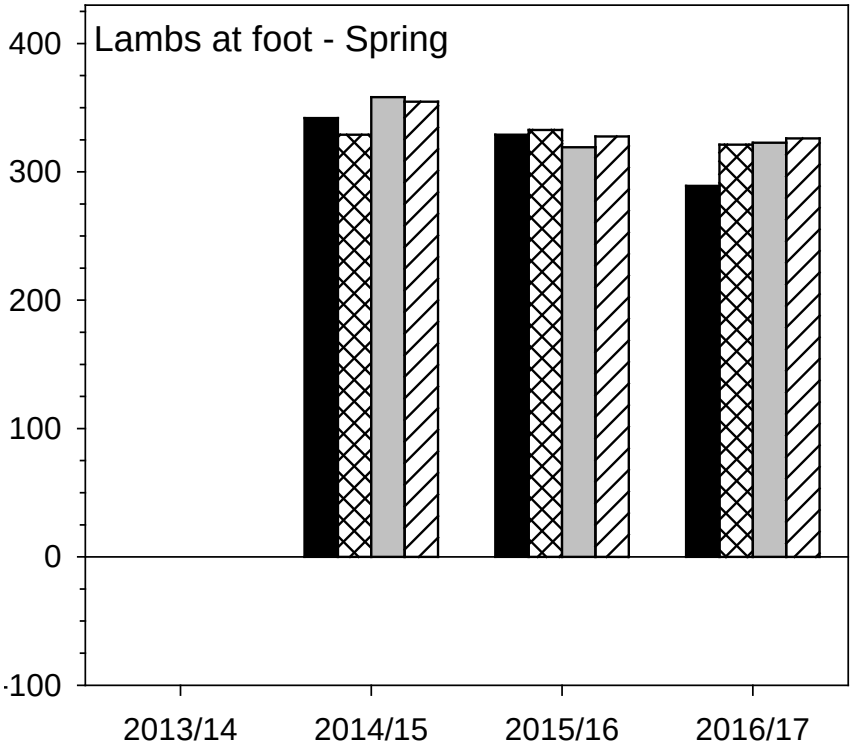

150,000 ha sown - lucerne seed from 20 to 200 t/yr
“35% Rate of return on investment”
850 people on txt alerts
Defined system after 15 years
Photo: Boyd McDonald
Lone Star Farms


Ashley Dene
9 Jan 2015
Required lamb growth =
5 to 35 kg
in ~100 days
Photo: A Mills
Lincoln University

MaxAnnuals





Growth Season

Tempello

meat - wool - wine

Photo: Jo Grigg
Tempello

Uncultivated – grazing only – no seed…

Photo: A Mills
Lincoln University

Tempello, Marlborough
26/2/2016

Reap the benefits in the following years. You probably only need to repeat this every 10-15 years or so.

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Photo: Jo Grigg
Tempello

Over 560 ha Tempello Corrie area

In poor price year with $4.40/kg CW and $1.80/kg store ... $40,000 ahead if lambs 7 kg heavier at weaning.

Tonnes meat increased from 60 to 76 tonnes despite fewer ewes.

Dryland lessons for Canterbury dairy ?

Water and nitrogen = ryegrass

(230,000 ha irrigated dairy)

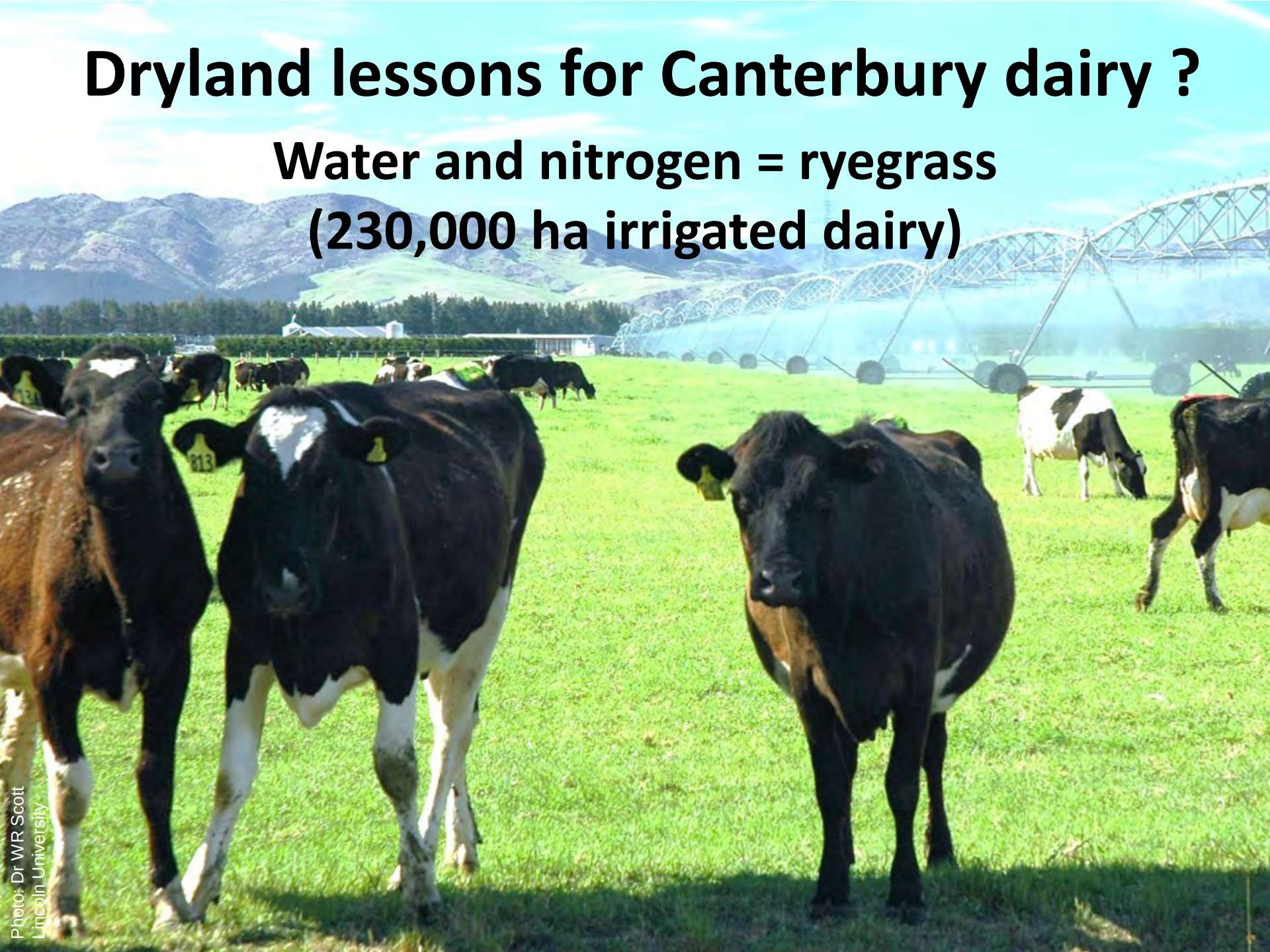
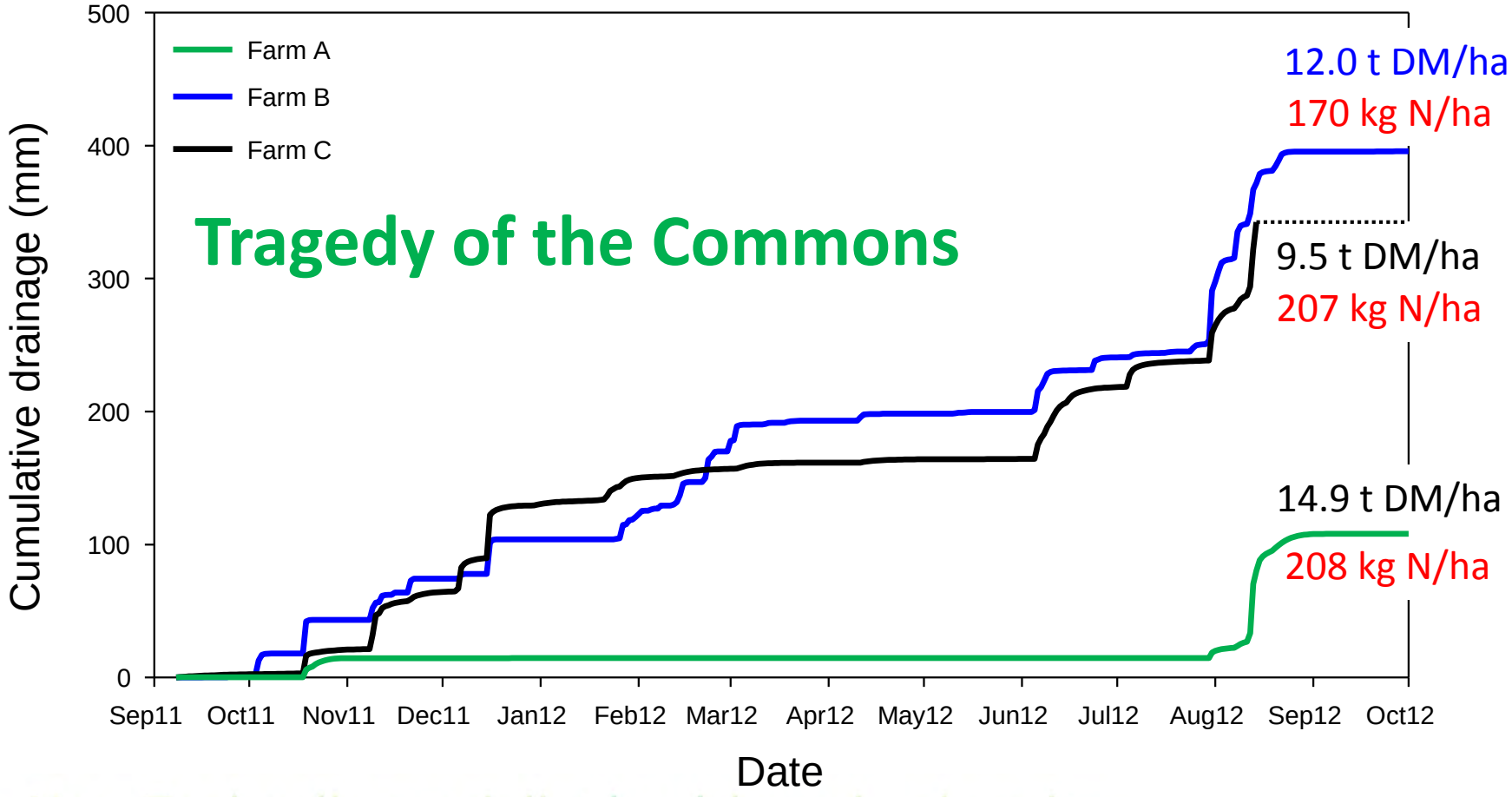


Photo: Dr WR Scott
Lincoln University

Fenced water ways, large herds – N deficient pastures

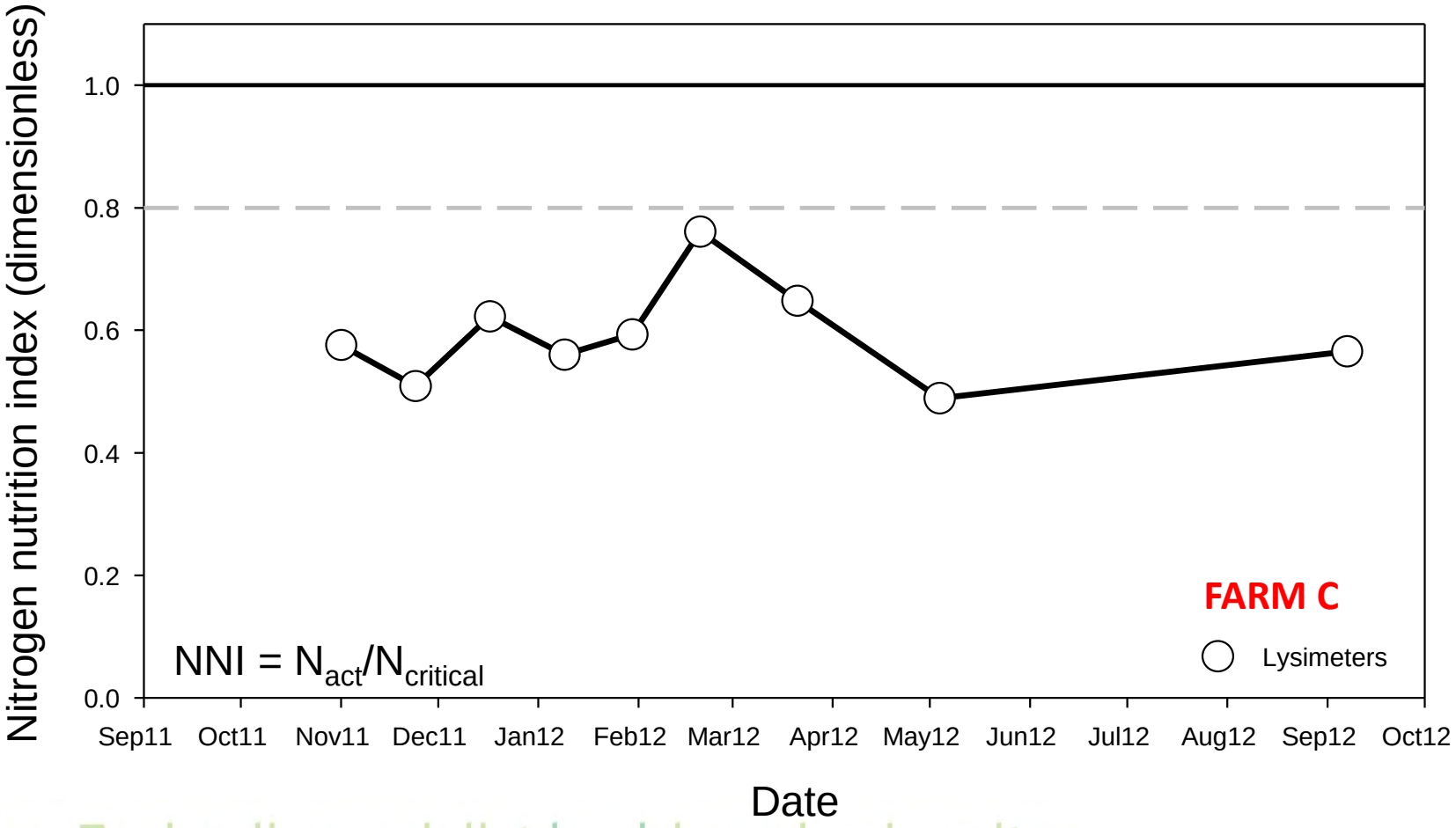
Photo: DJ Moot
Lincoln University

Cumulative drainage (mm)



Nitrogen nutrition index

Over irrigated under fertilized



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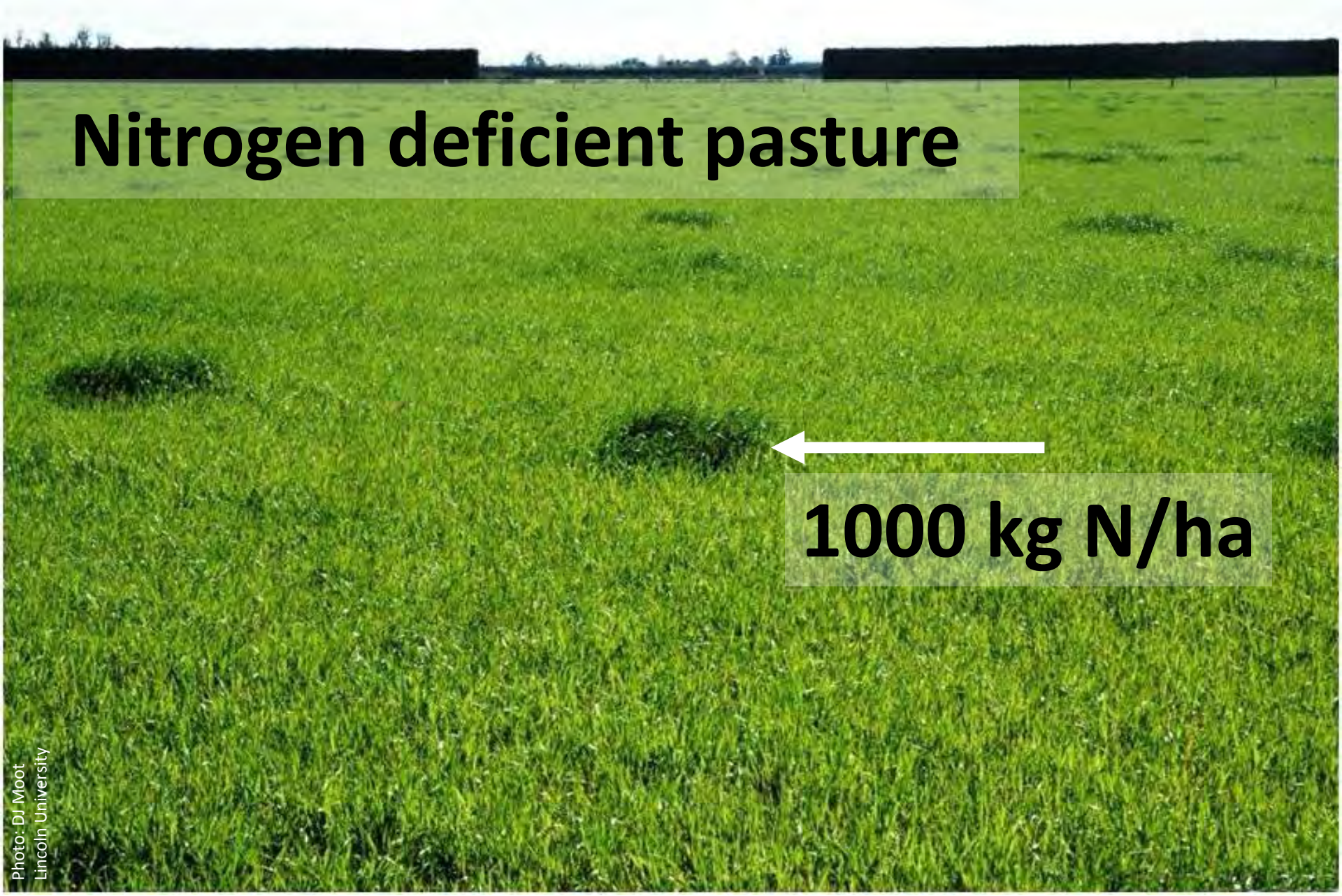
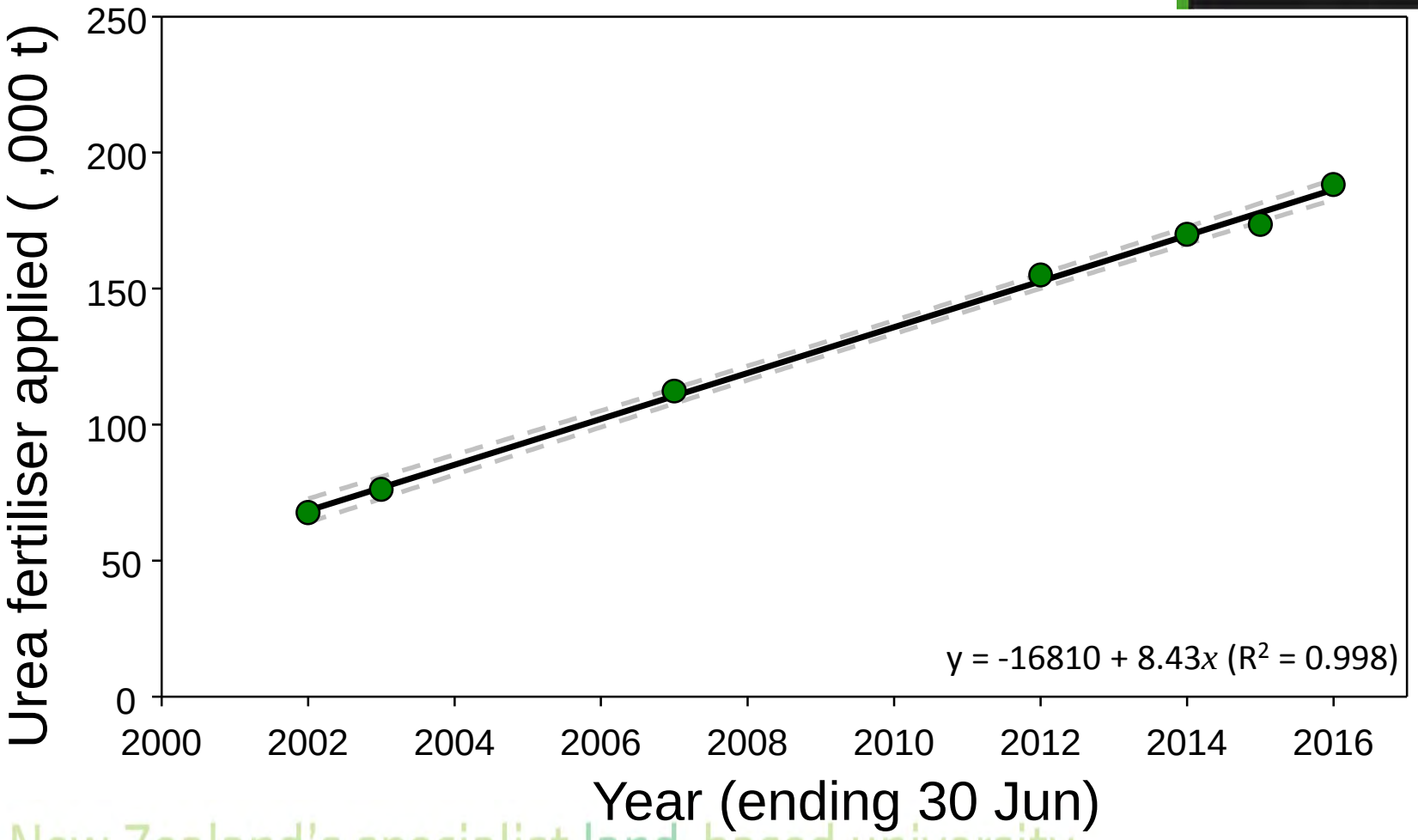

Nitrogen deficient pasture
1000 kg N/ha
Photo: DJ Moot
Lincoln University

Urea use in Canterbury



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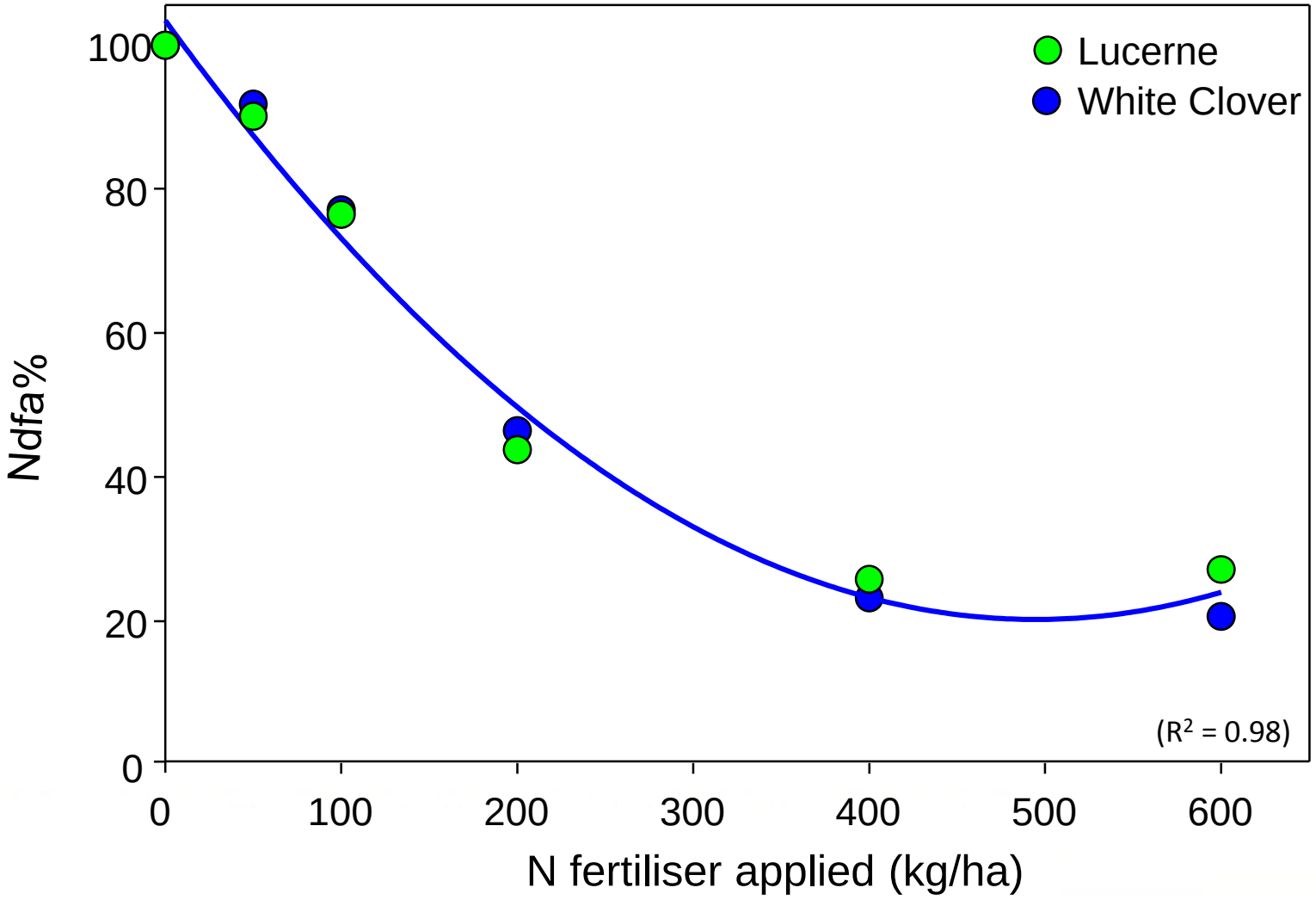
Contributions from BNF



Ryan-Salter unpublished

Future dairy pastures

- Farm environment plans
- Levy on irrigation water used
- Mandatory soil water budget for irrigation events
- Levy on nitrogen fertilizer – ETS
- Levy on methane emissions – ETS
- CPW (200 kg N/ha)
- Divergent systems – low (≤3.0 cows) vs high (4+ cows)/ha

System 1 – high legume low SR pasture fed cows

Tall fescue, red and white clovers 29 August 2017
“keeps growing under water restrictions”

Irrigated red clover

Photo: DJ Moot
Lincoln University

Dryland dairy grazing lucerne

Photo: DJ Moot
Lincoln University

October 2016 ***"once on lucerne - 2000 litres extra milk overnight"***

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Changed irrigation management

Photo: DJ Moot
Lincoln University

System 2 – High SR – housing or partial housing

Photo: DJ Moot
Lincoln University

Photos: Richard Cookson

Conclusions

- Diverse NZ landscapes = diverse systems
- No single solution
- Nitrogen feeds and pollutes the world
- Biology cannot be fooled
- Sustainable legume systems exist!
- Transformational change is hard but rewarding

Excellent agricultural science only happens in the field

Acknowledgements for data/graphs

- Environment Canterbury (ECAN) for Harts Creek data (data ©ECAN)
- New Zealand Fertiliser Association for the nitrogen fertiliser data
- The Foundation for Arable Research (FAR) for the herbage seed production data

Websites/Social Media presence

Lincoln University Dryland Pastures Website:
http://www.lincoln.ac.nz/dryland

Lincoln University Dryland Pastures Blog:
https://blogs.lincoln.ac.nz/dryland

YouTube:
https://www.youtube.com/DrylandPastures

Facebook:
https://www.facebook.com/DrylandPasturesResearch

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