Patoka
31/10/2019

Legumes for sheep and beef systems

Derrick Moot

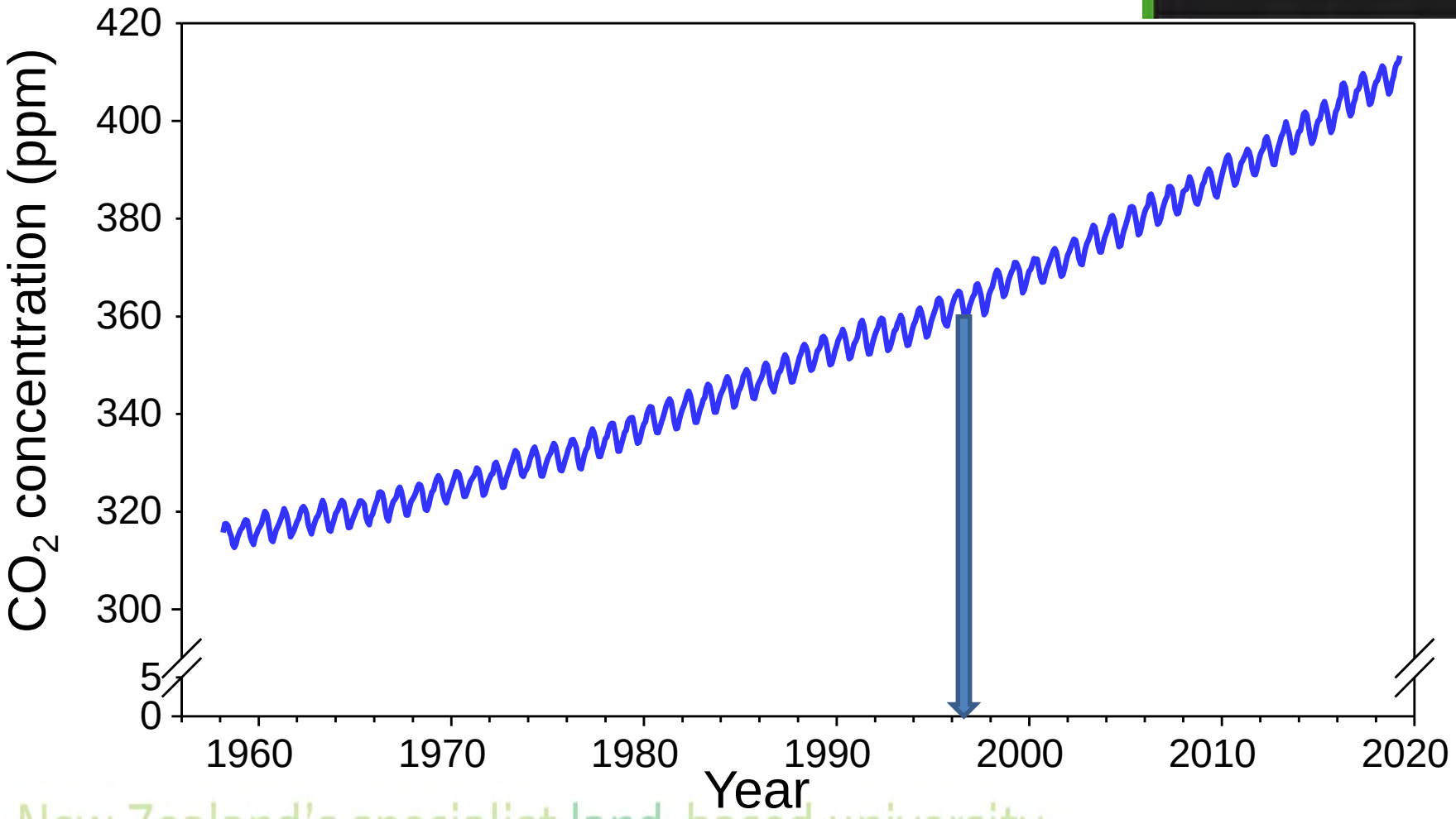
New Zealand's specialist land-based university

Introduction

- Drivers of climate change
- Agricultural responses
- Global issues – local response
- Production results of legume systems change
- Financially, socially, environmentally resilient
- Hill country development

Why legumes for GHG mitigation?

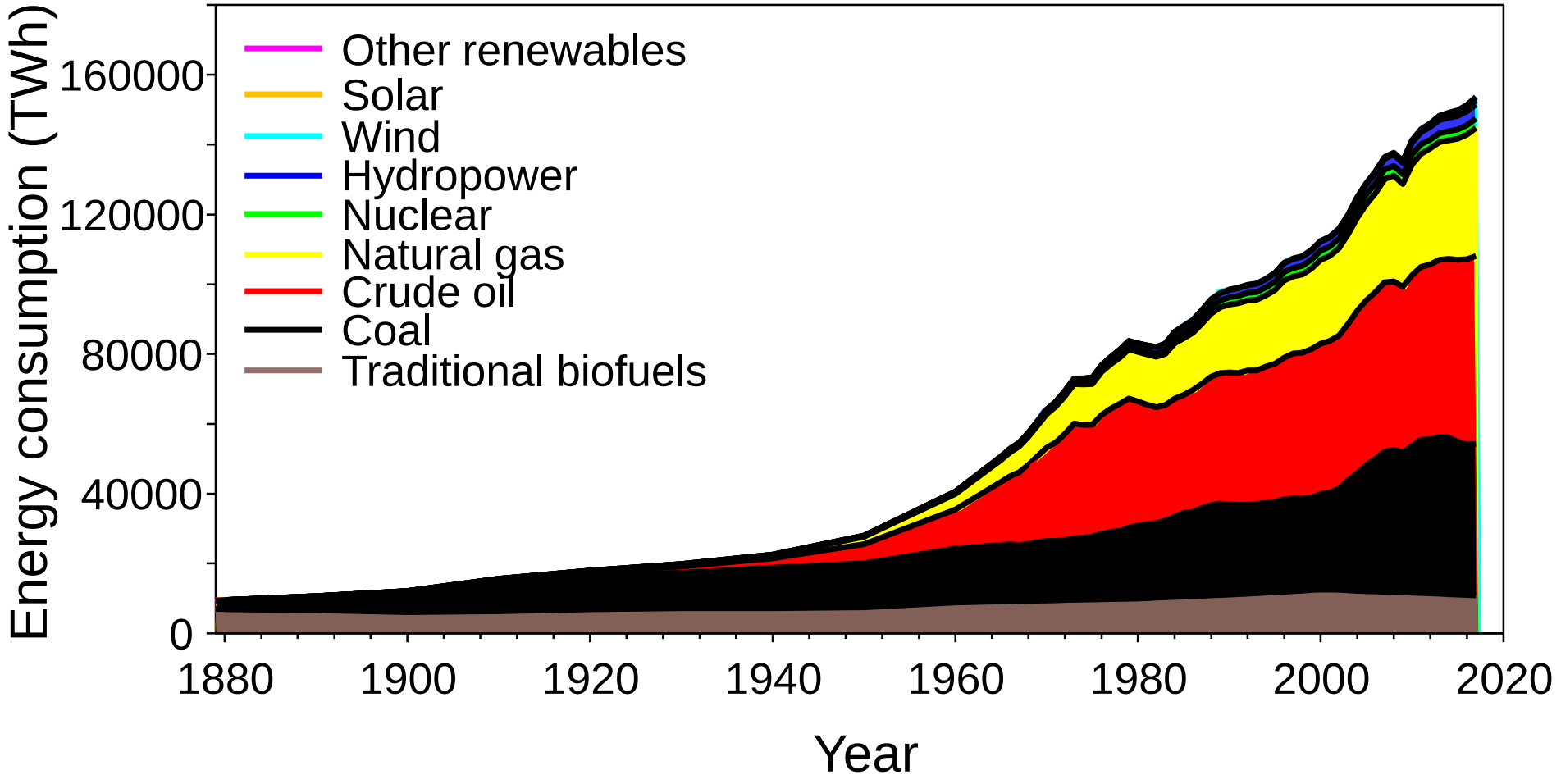
CO_2 at Mauna Loa, Hawaii



Data source:

Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Dr. Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/). (28/5/2019)

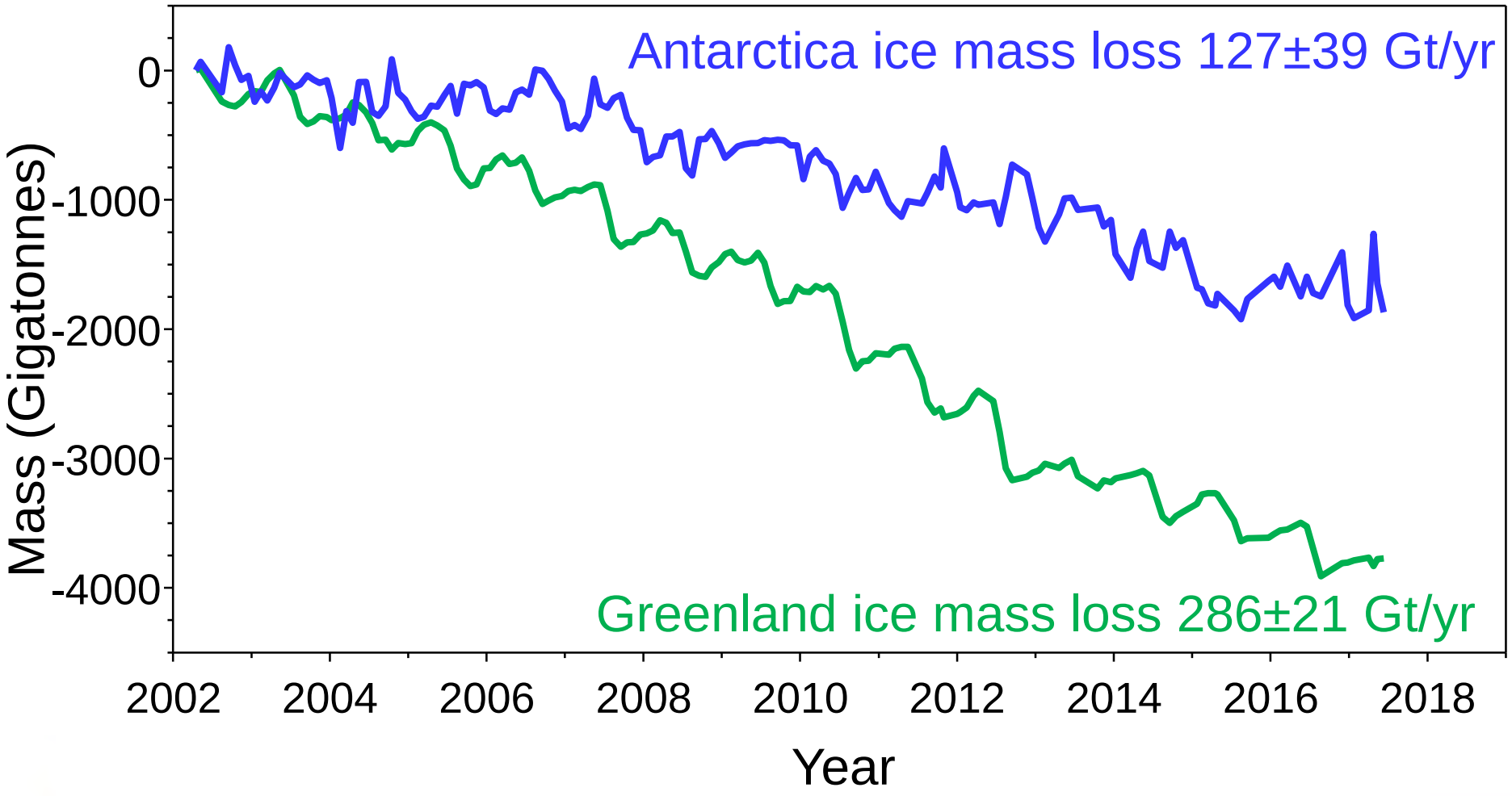
Global energy supply



Redrawn from: https://ourworldindata.org/energy-production-and-changing-energy-sources. Accessed: 2/10/2019. Based on data sourced from Smil 2017. http://vaclavsmil.com/2016/12/14/energy-transitions-global-and-national-perspectives-second-expanded-and-updated-edition/ ; https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

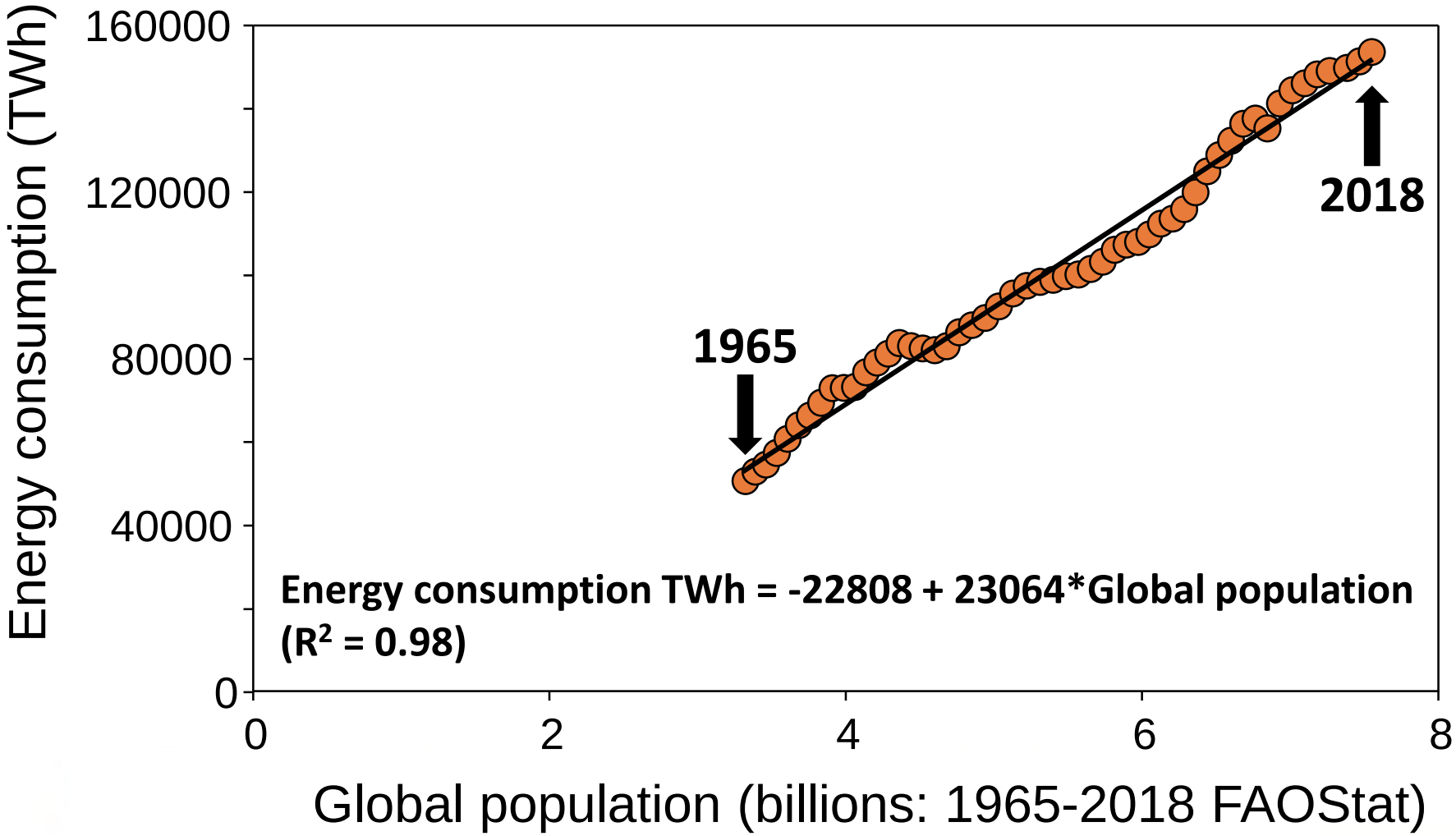
Ice sheet losses 2002-2017

(Anomalies relative to April 2002)

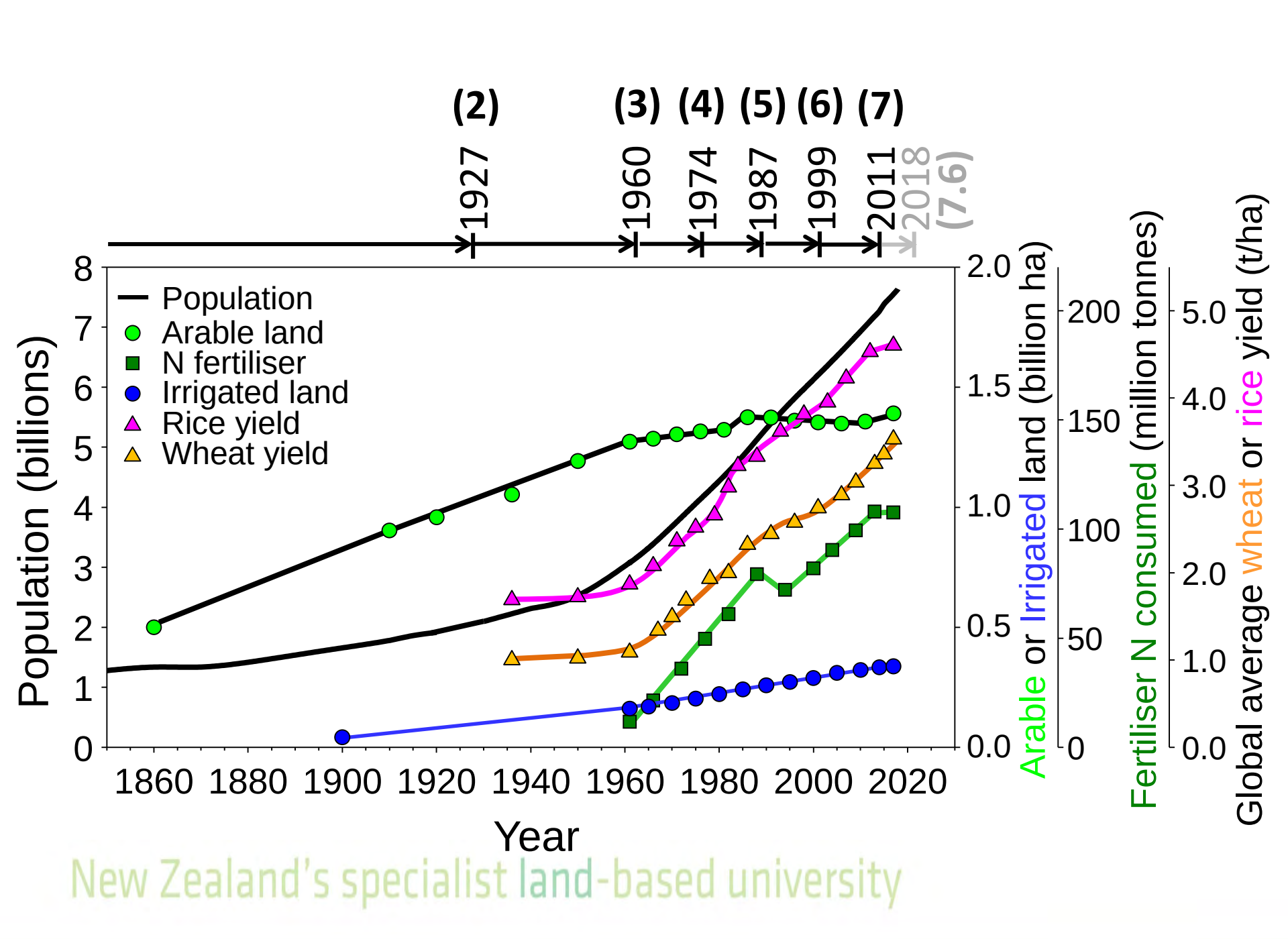


NASA. 2019. Ice mass measurement by NASA's GRACE satellites. https://climate.nasa.gov/vital-signs/ice-sheets/ ; Wiese et al. 2016

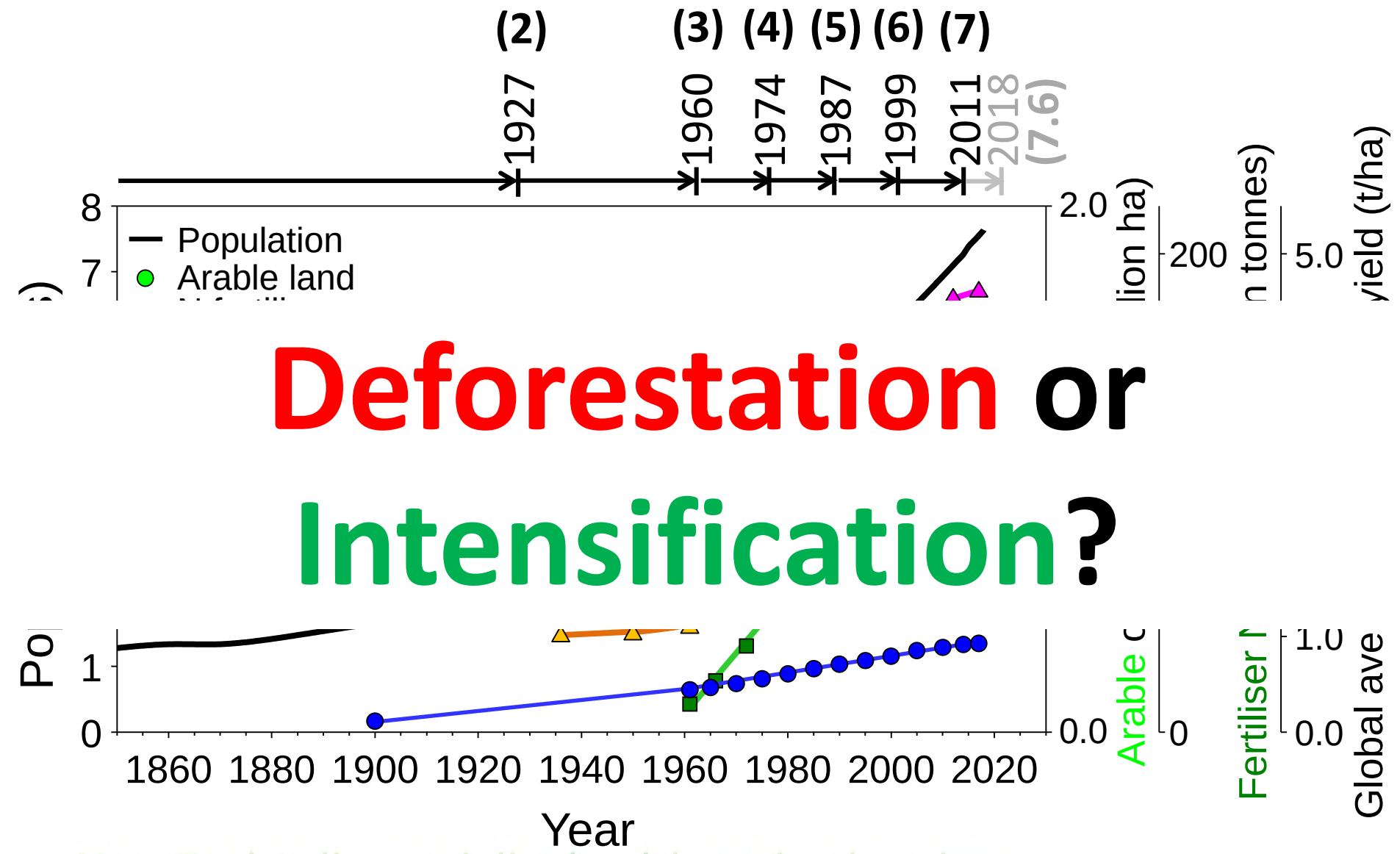
Energy consumption per capita



Data sourced from: https://ourworldindata.org/energy-production-and-changing-energy-sources Accessed 2/10/2019; Smil 2017; http://www.fao.org/faostat/en/#data/OA Accessed 4/10/2019



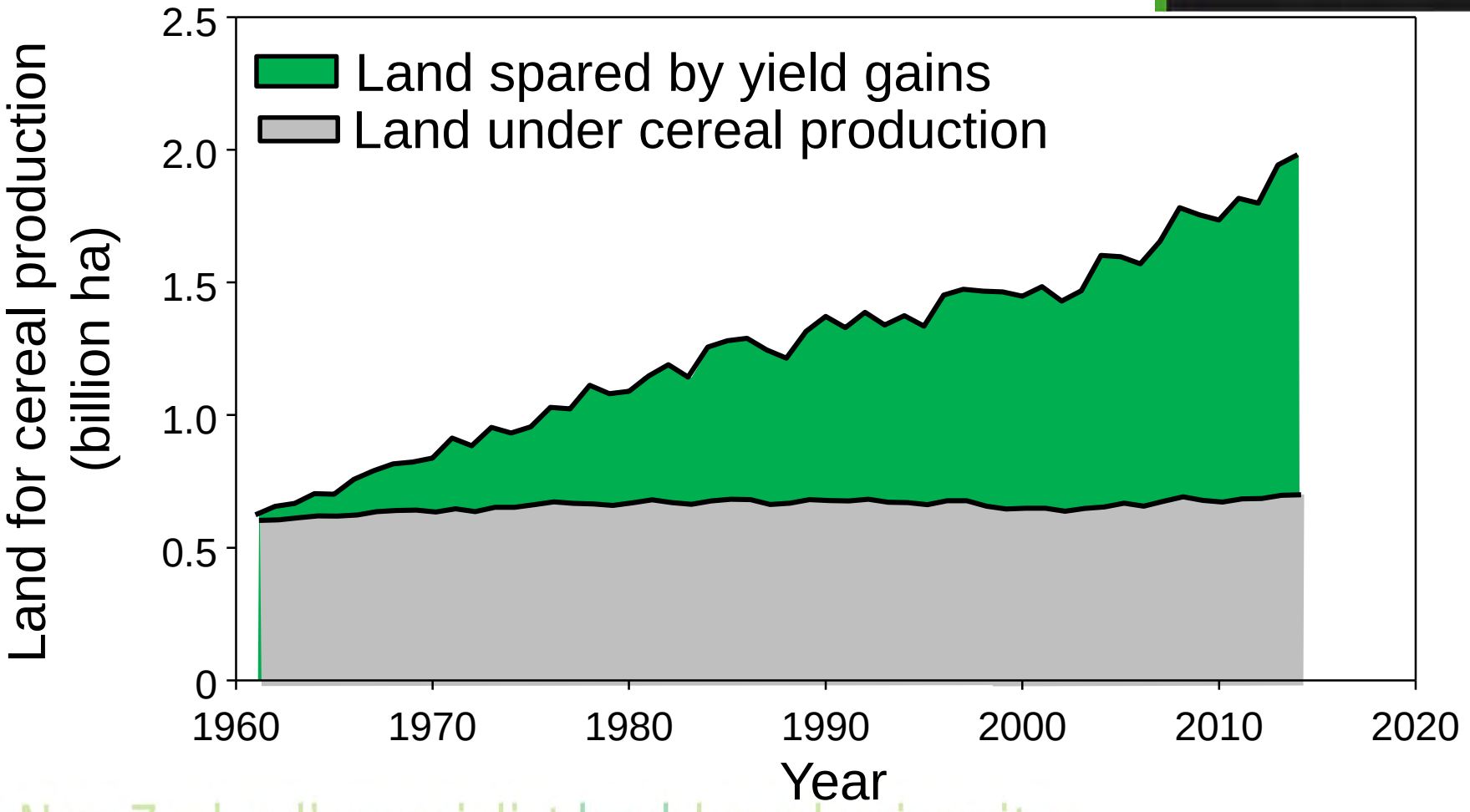
Recreated from Evans 1998, M.K. van Ittersum 2011 & FAOSTAT (2019)



Deforestation or Intensification?

Recreated from Evans 1998, M.K. van Ittersum & FAOSTAT (2019)

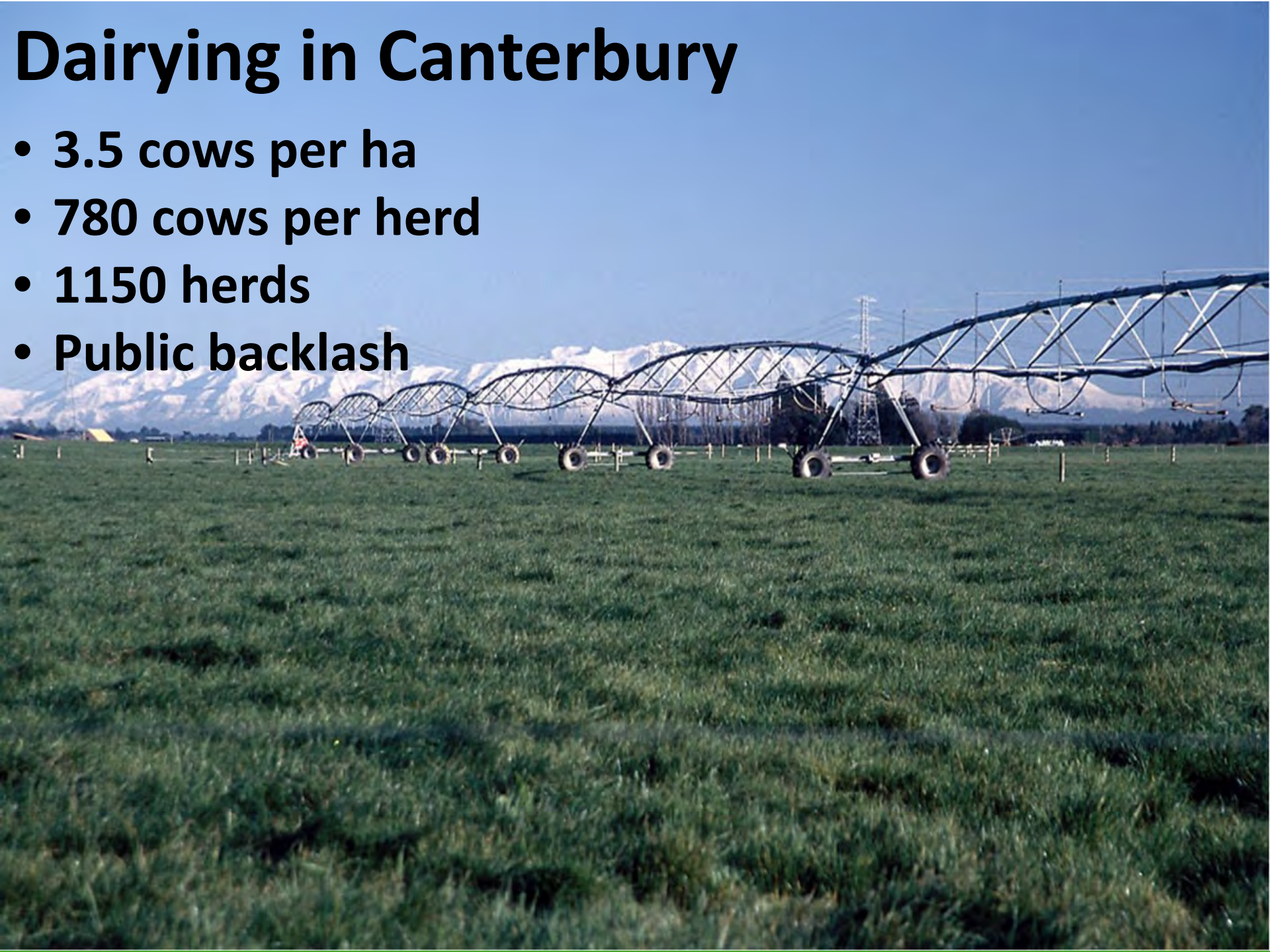
Impact of G x E x M



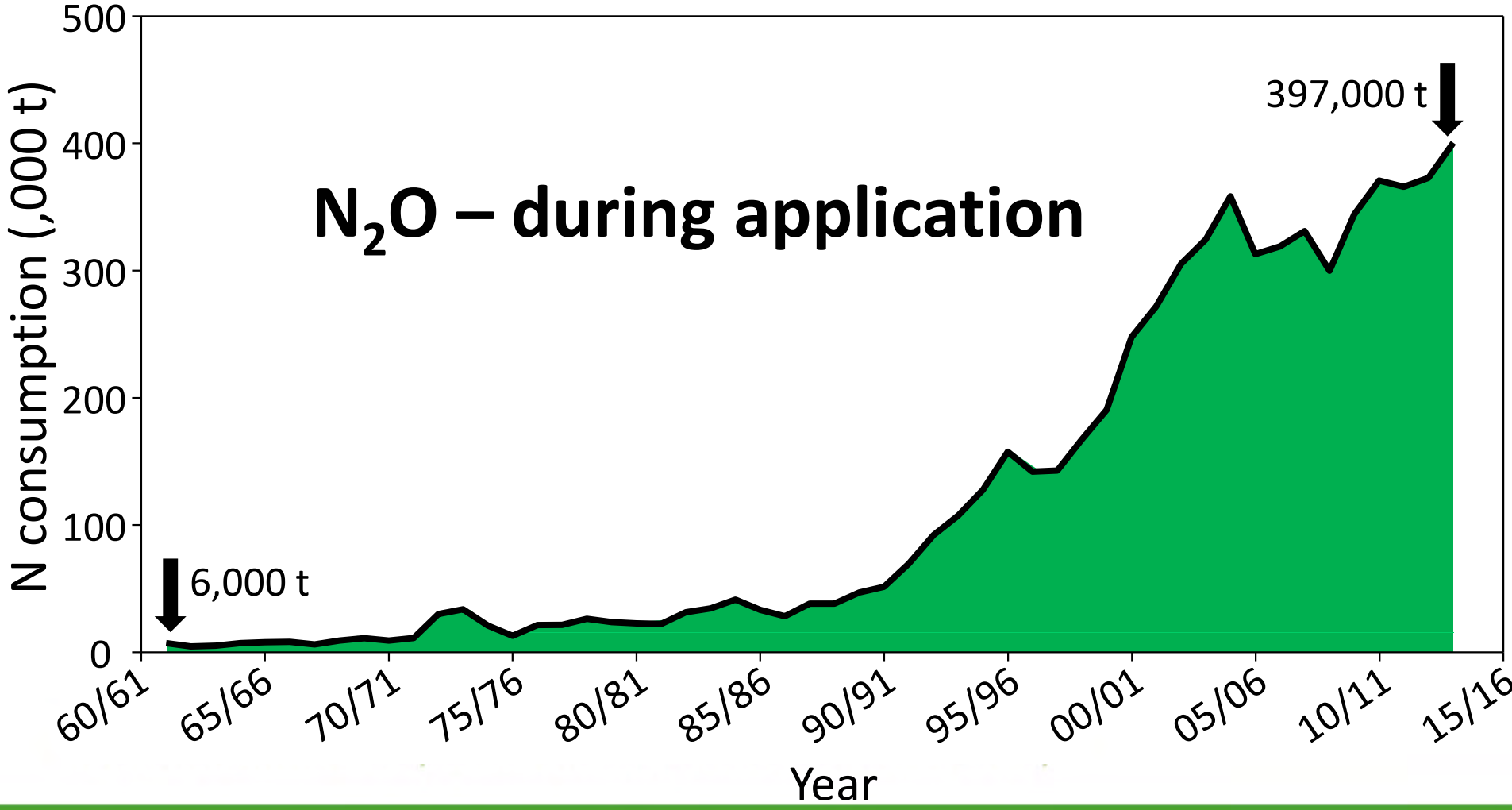
Redrawn from: https://ourworldindata.org/grapher/global-land-spared-as-a-result-of-cereal-yield-improvements . Accessed: 4/10/2019. Based on data sourced from: http://data.worldbank.org/data-catalog/world-development-indicators. Accessed: 18/7/2017.

Dairying in Canterbury

- 3.5 cows per ha
- 780 cows per herd
- 1150 herds
- Public backlash

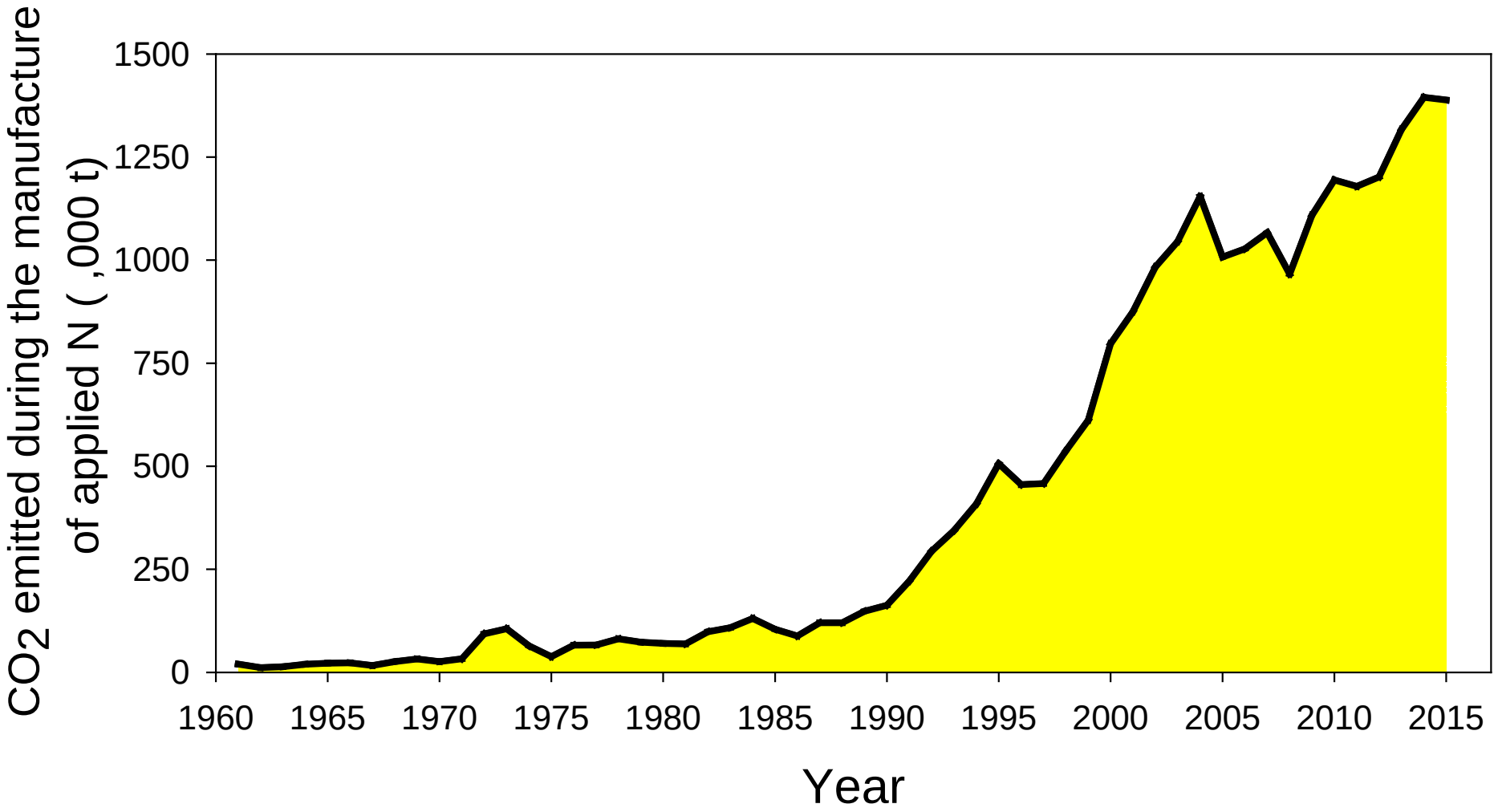


Nitrogen applied in NZ



NZ Fertiliser Association, 2015

CO_2 emitted in production of our N



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)

Experiment site

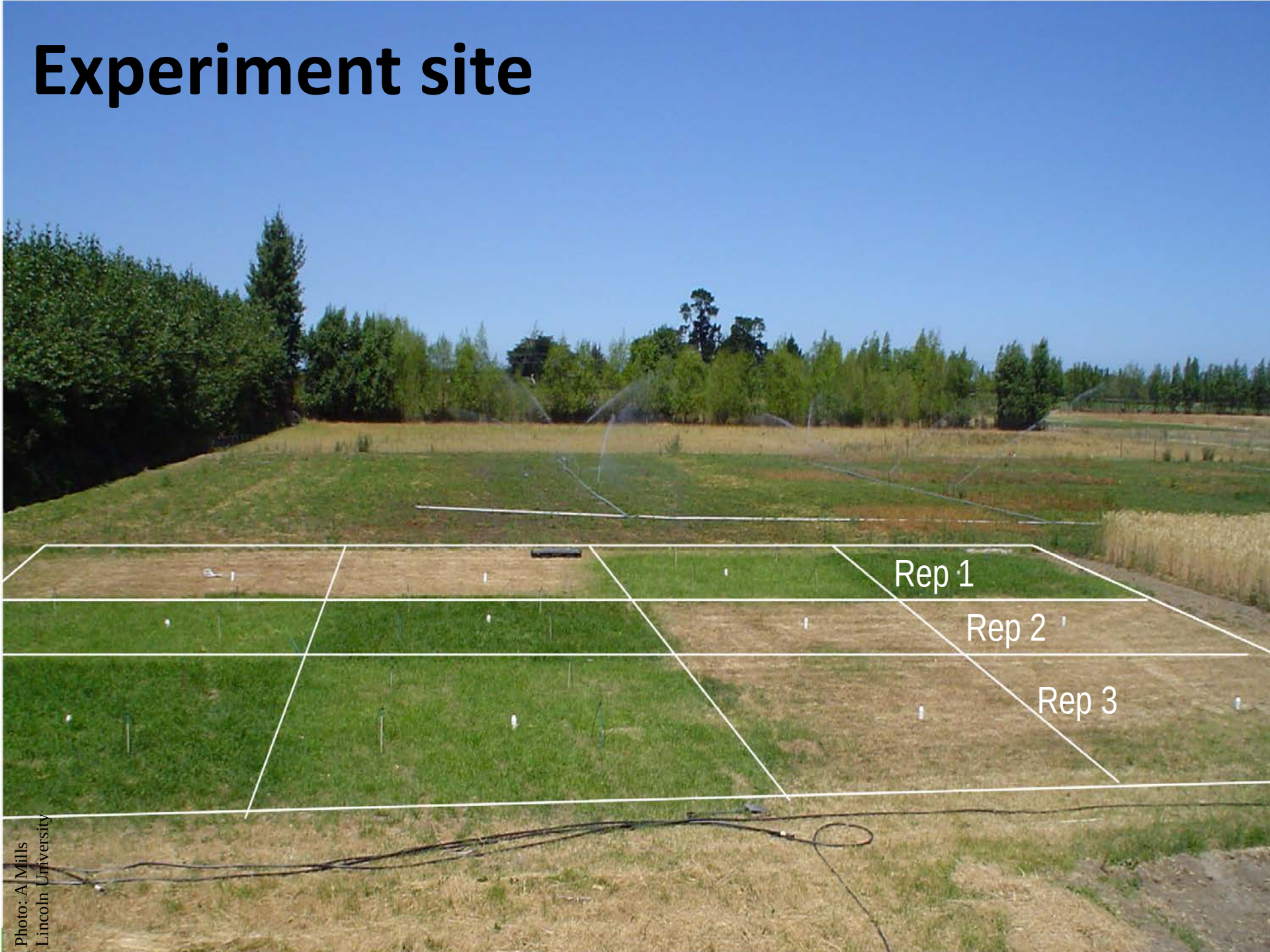
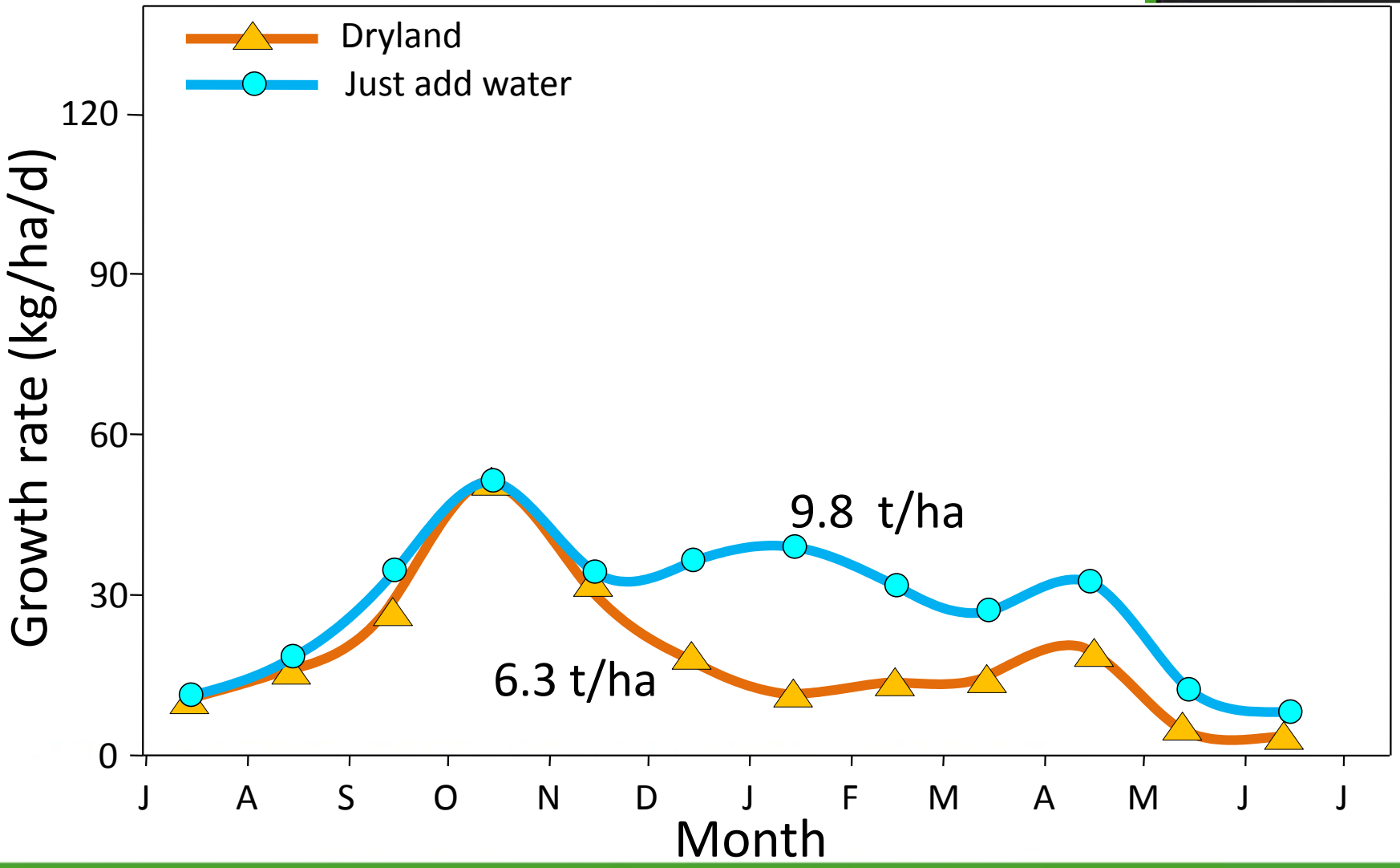


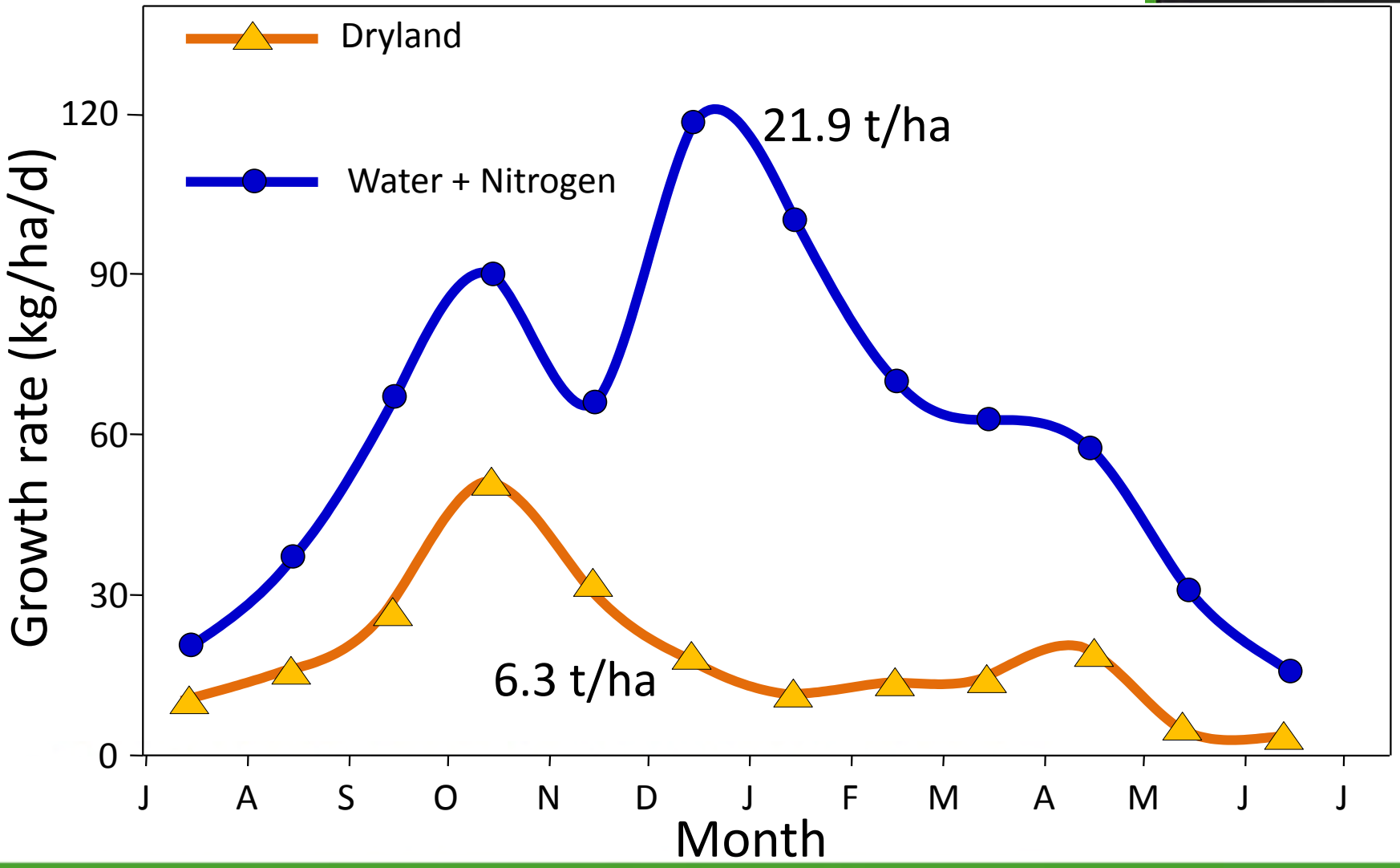
Photo: A Mills
Lincoln University

Growth rates (2 year mean)



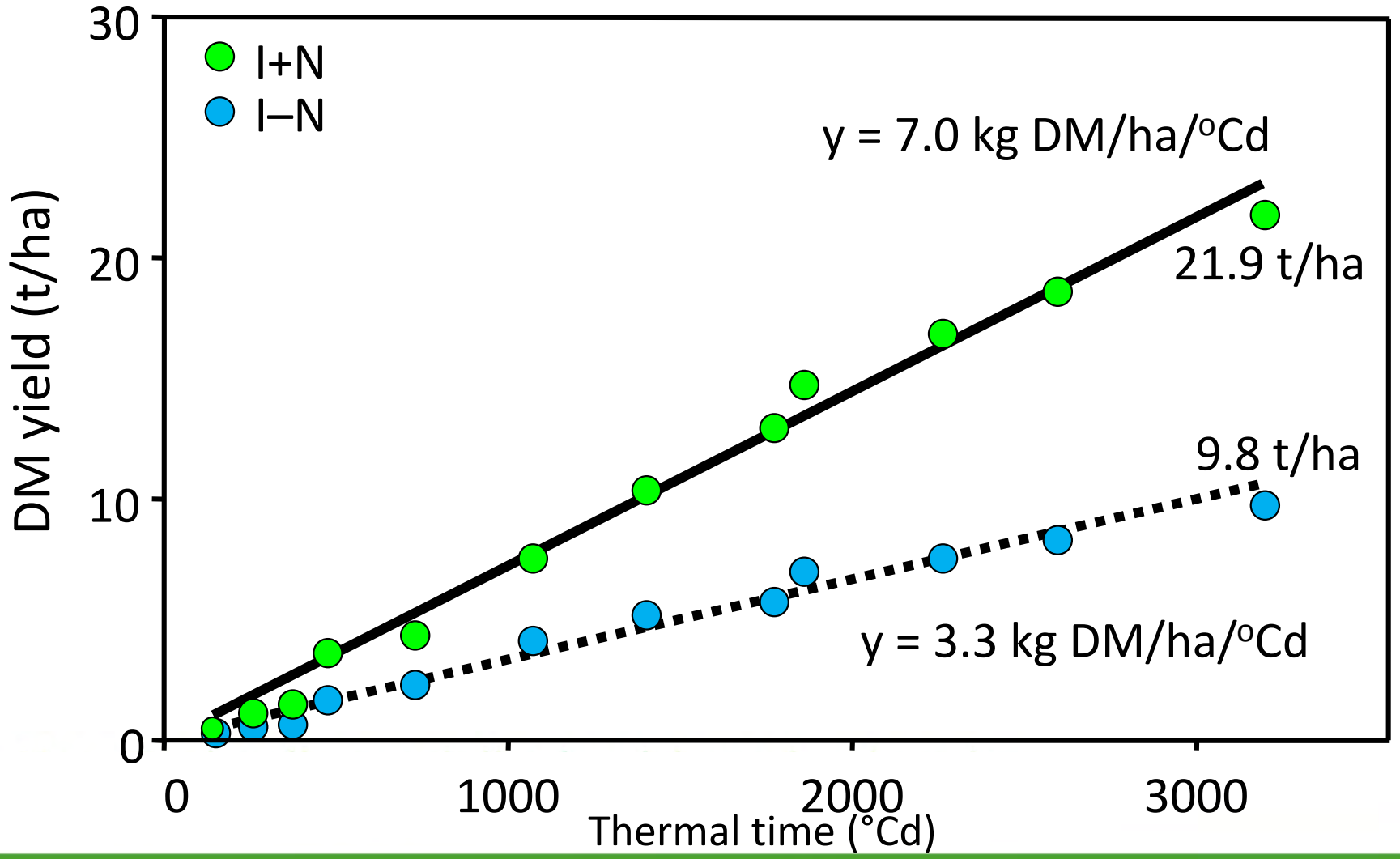
Mills *et al*. 2006, 2009

Growth rates (2 year means)

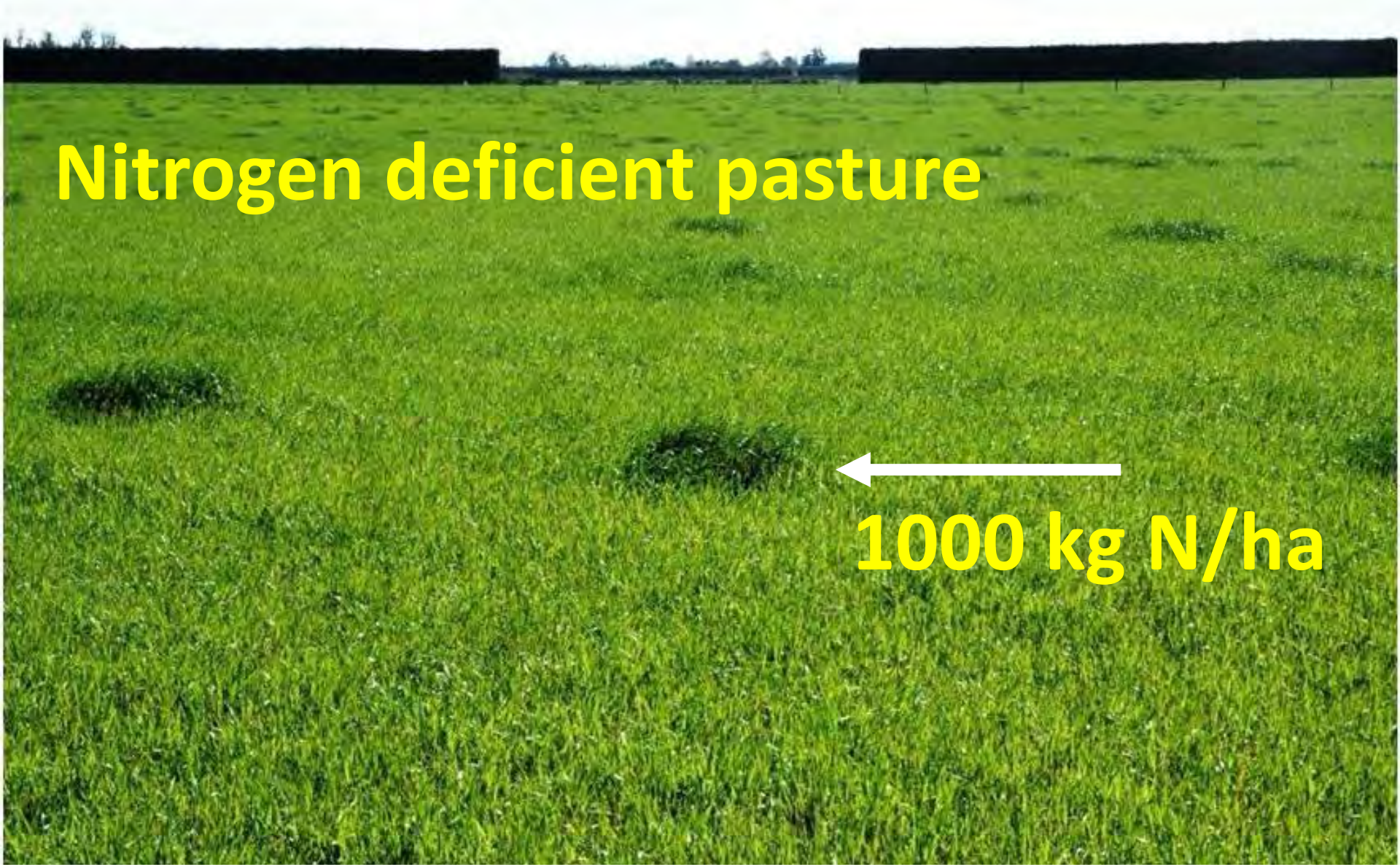


Mills *et al*. 2006, 2009

The Nitrogen gap

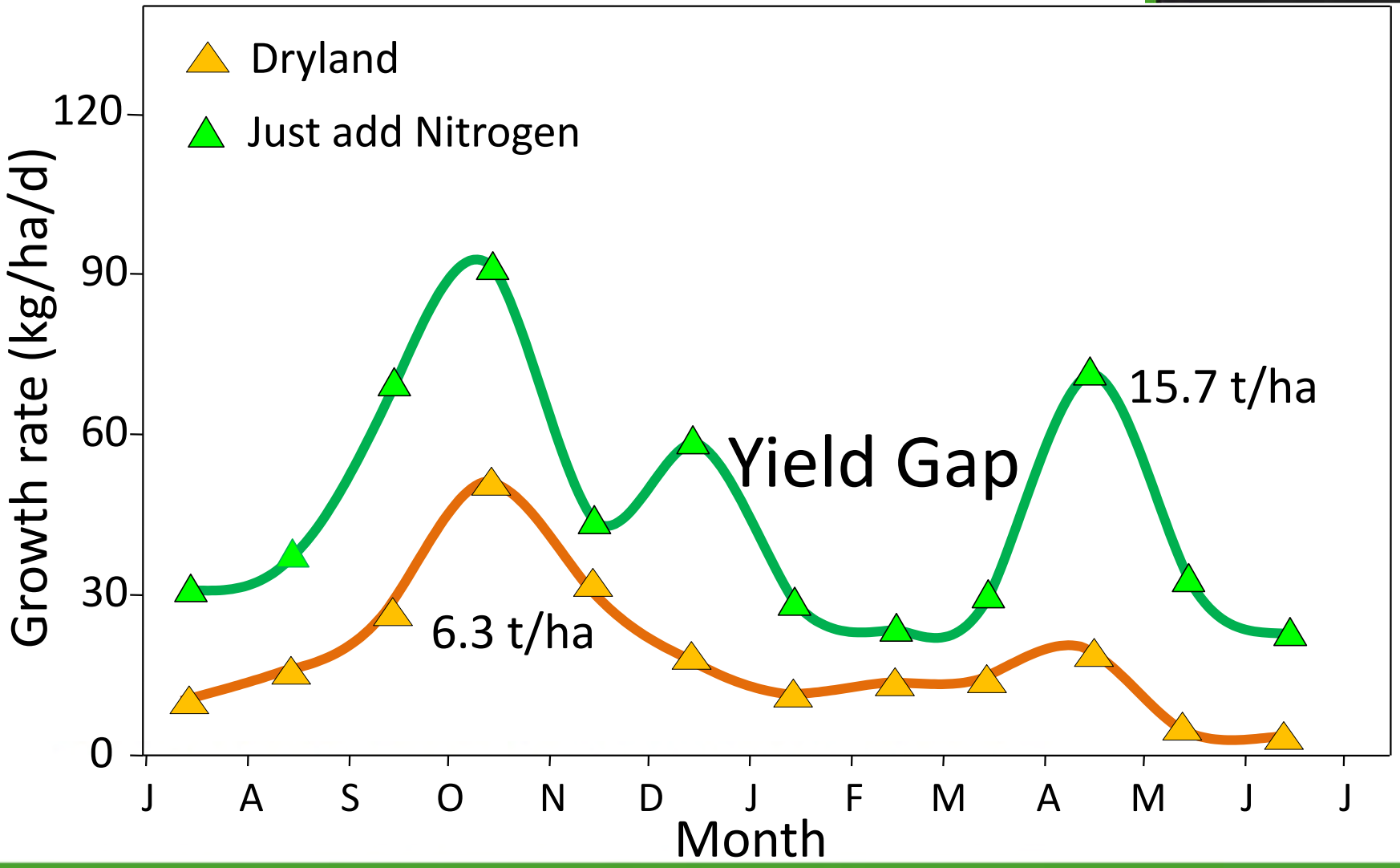


Mills *et al*. 2006; 2009



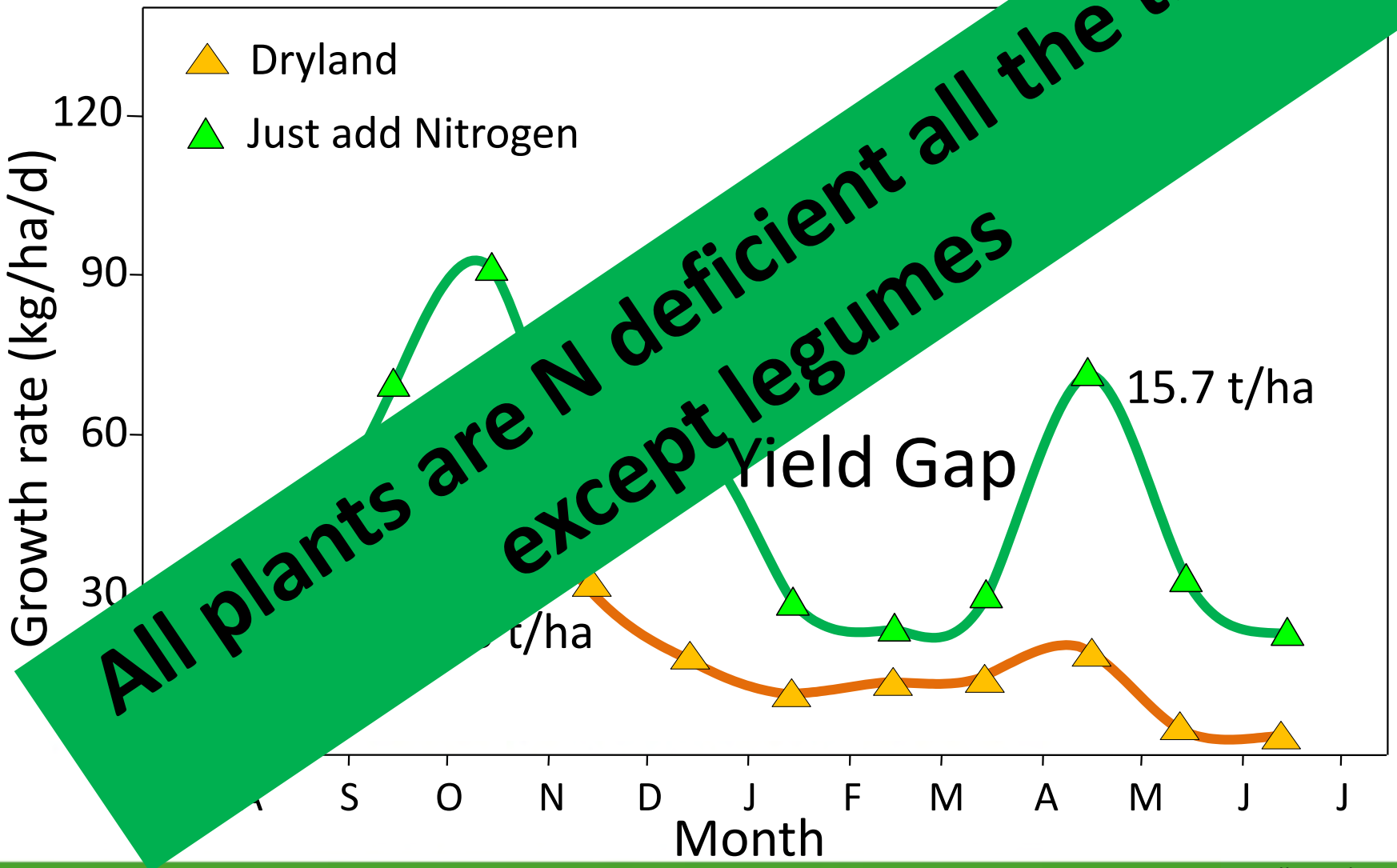
Same rate of evapotranspiration
– inefficient water use!

Growth rates (2 year means)



Mills *et al*. 2006, 2009

Growth rates (2 year means)



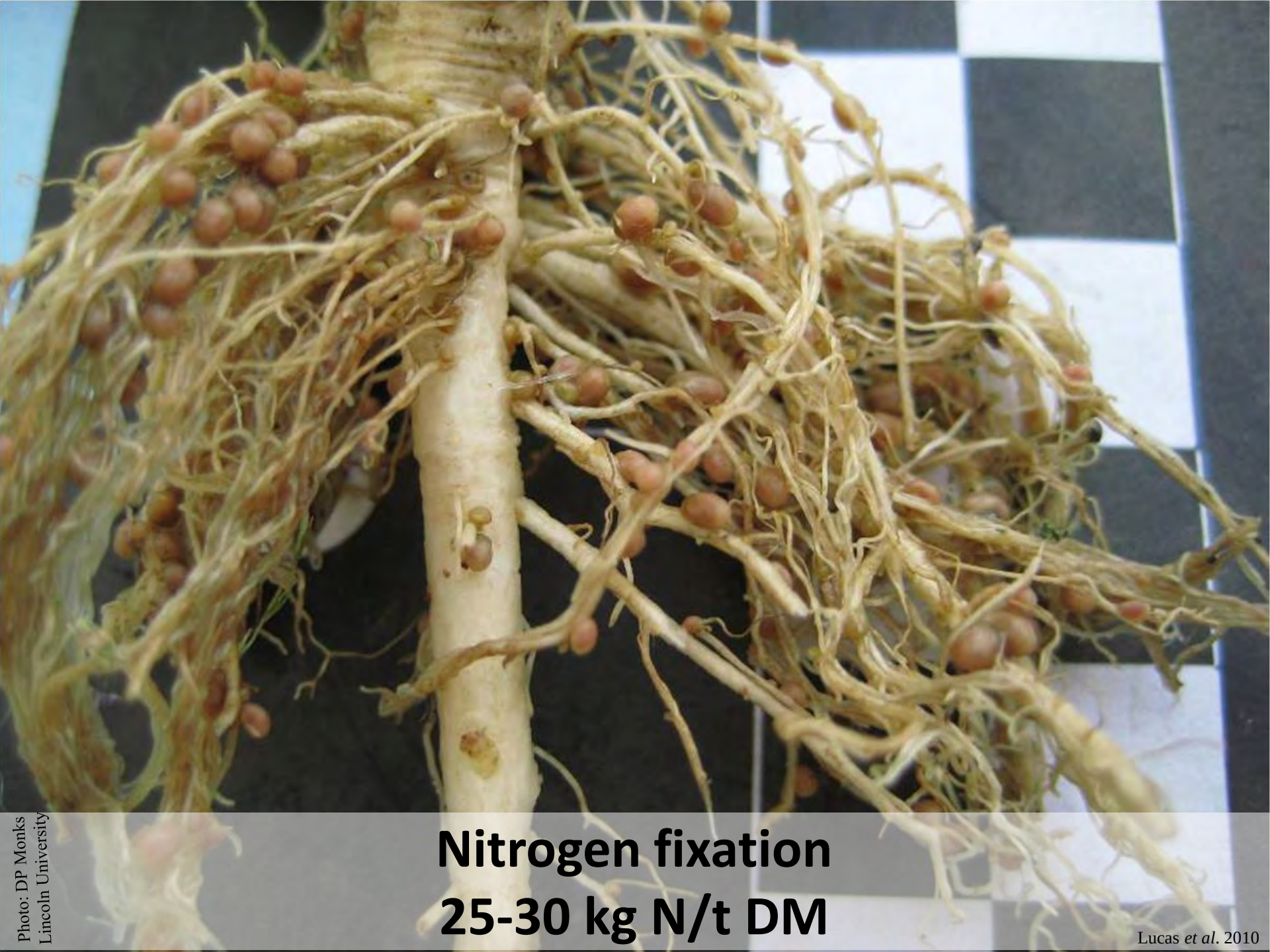
All plants are N deficient all the time except legumes

Mills *et al*. 2006, 2009

Legume based pastures

- Limited water supply
- N to make plants grow!
- Meet animal demand (lactation)
- Minimize impact on air, soil, water
- Productive and profitable
- Socially acceptable
- Reduce GHG emissions

Legume dominant

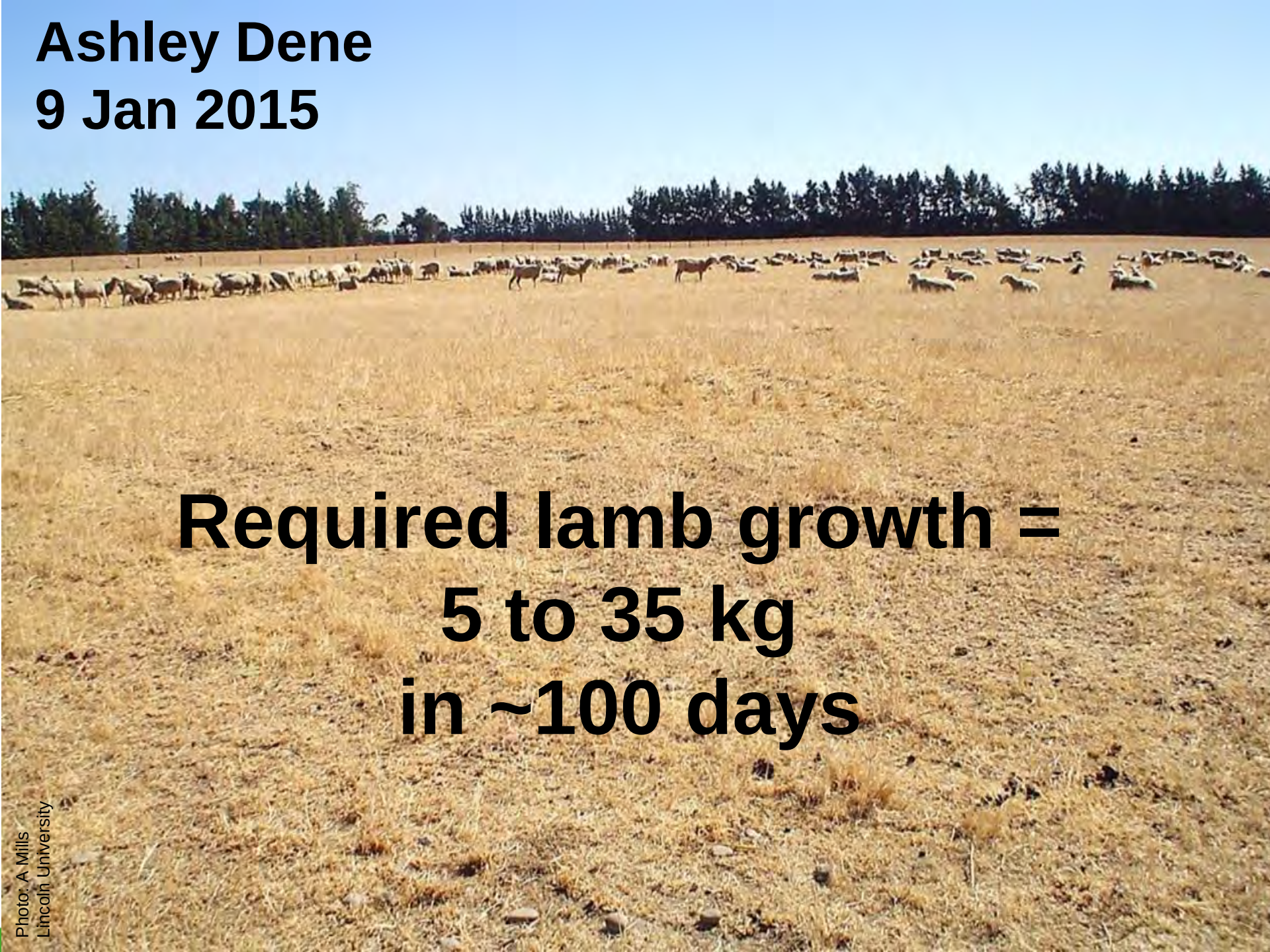


Nitrogen fixation
25-30 kg N/t DM

Photo: DP Monks
Lincoln University

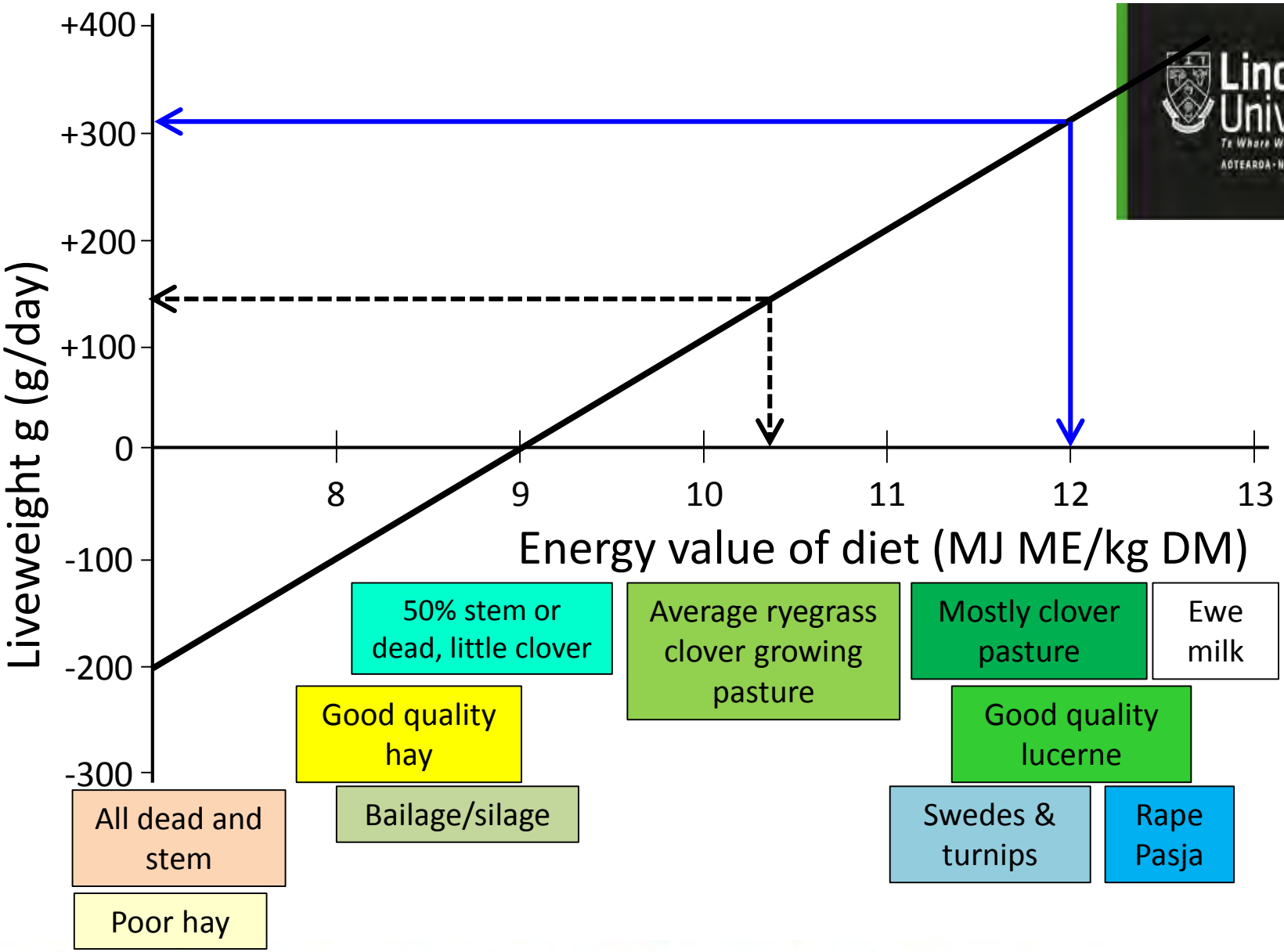
Lucas *et al*. 2010

Ashley Dene
9 Jan 2015



Required lamb growth =
5 to 35 kg
in ~100 days

Photo: A Mills
Lincoln University

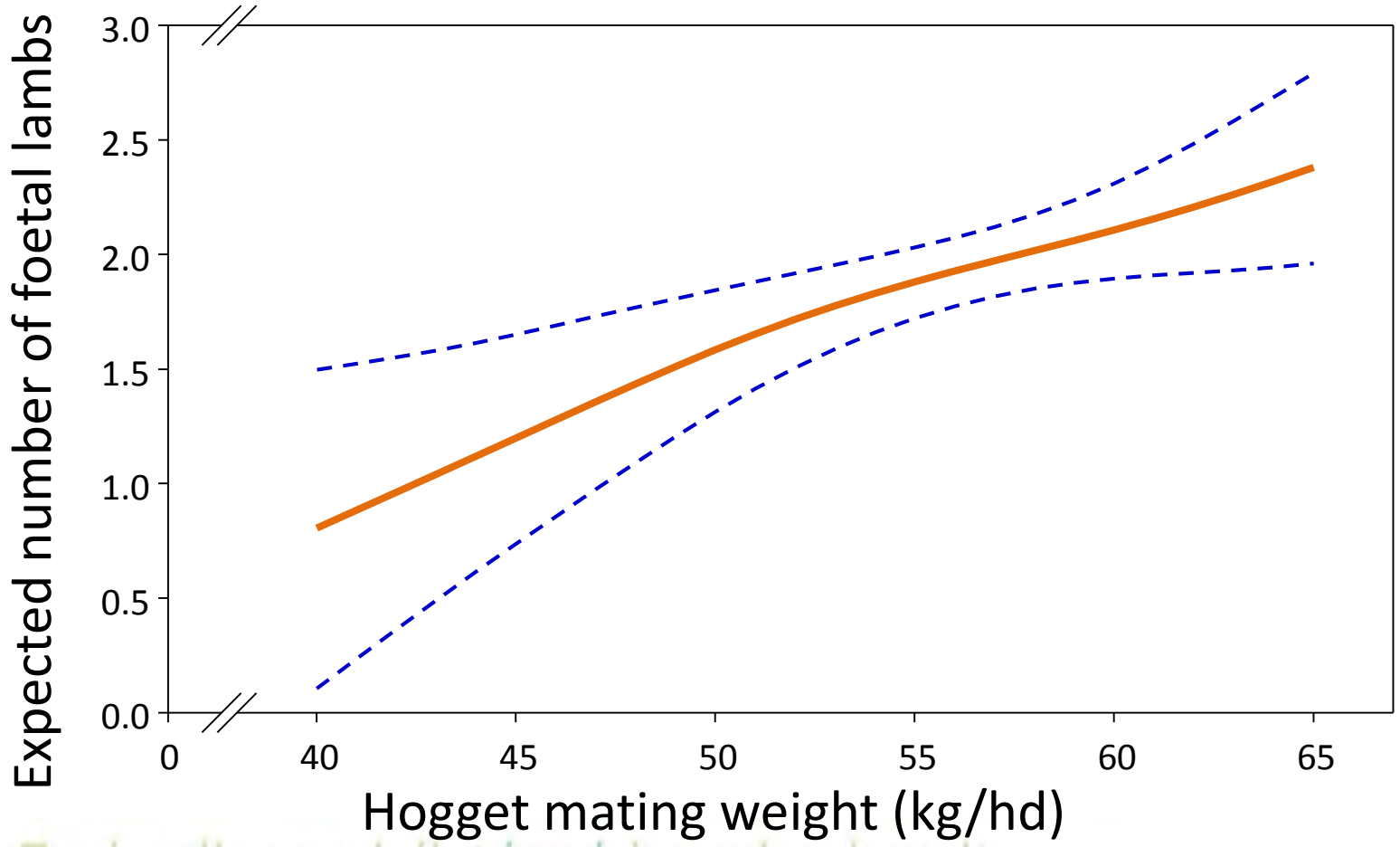


Adapted from Kerr 2010.

Sheep prefer 70% legume, 30% grass

Photo: Jo Grigg
'Tempello' Marlborough

Foetal lambs vs. mating weight



Fields et al. 2017

CH_4 reduced by faster LWG

Energy requirement (MJ ME) for lamb growth from 25 to 35 kg liveweight

Lamb growth rate (g/hd/d)	Energy per lamb per day	Days on farm	Energy consumed per lamb
100	13	100	1300
200	17	50	850 (↓53%)
300	22	33	726 (↓79%)

MJ ME: megajoules of metabolisable energy

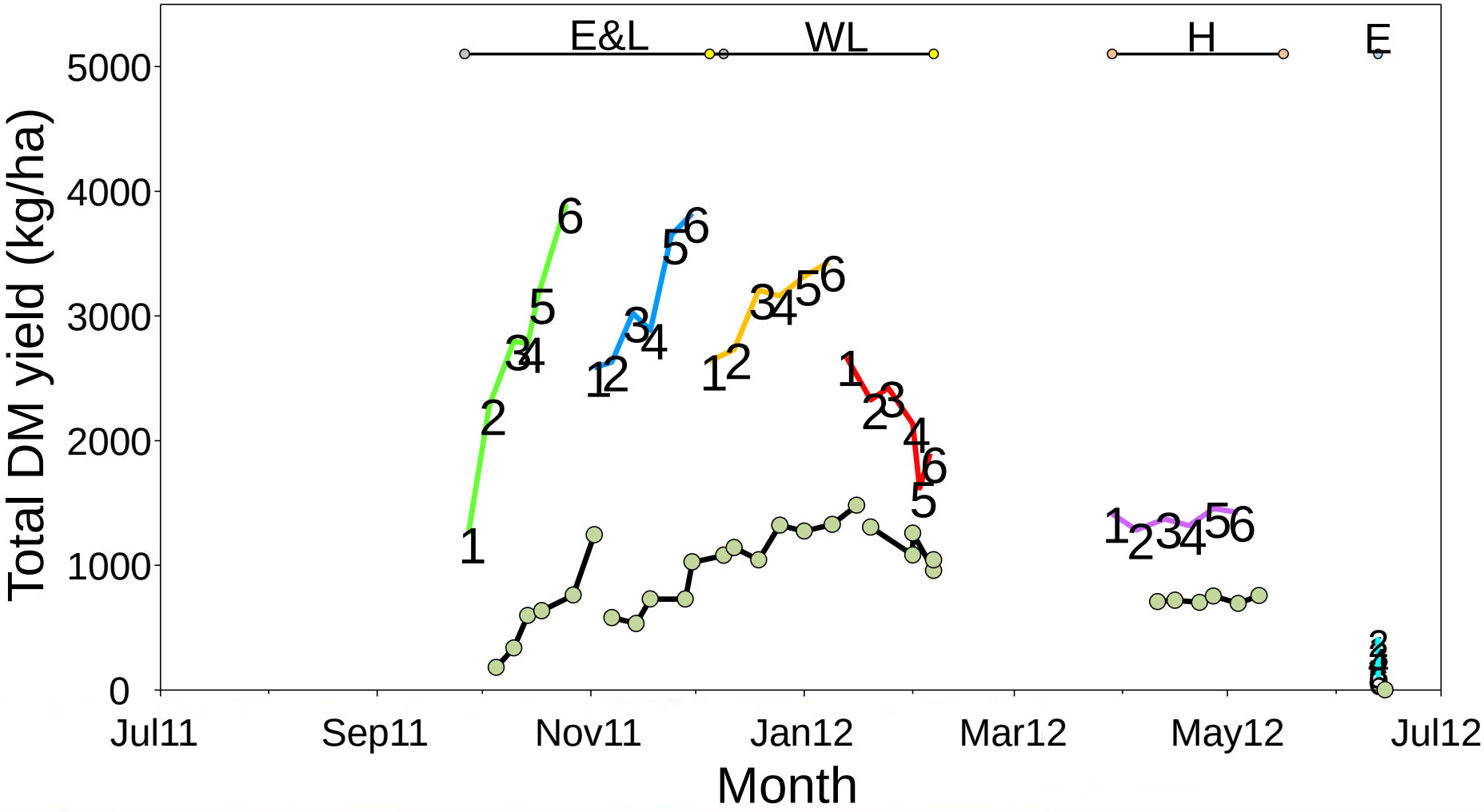
Brown 1990

Photo: Doug Avery,
Bonavaree, Marlborough

Spring grazing at ‘Bonavaree’, Marlborough

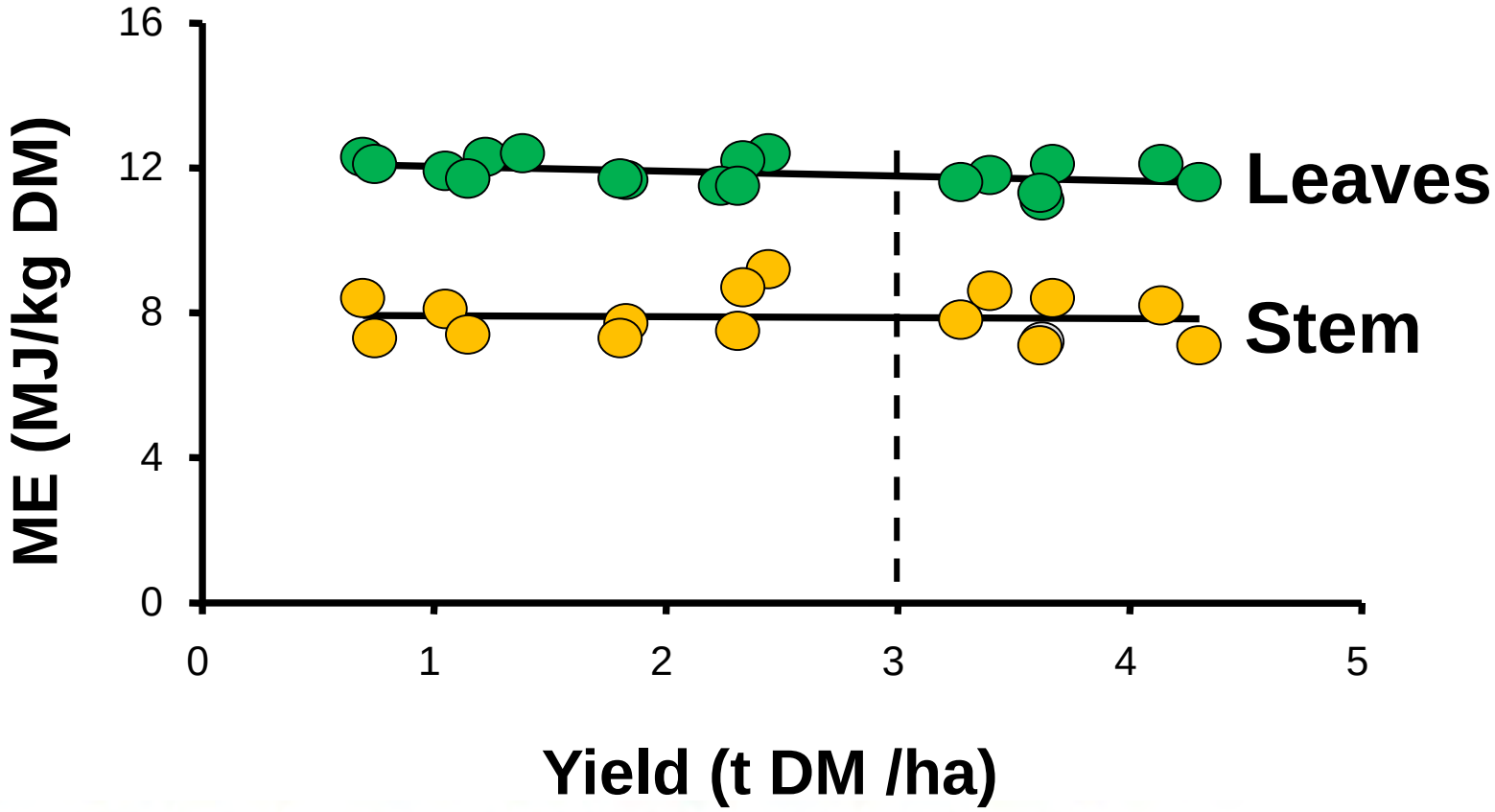
14 ewes + twins/ha

2011/12 DM production



Moot *et al*. 2016

Metabolisable energy of lucerne



Brown & Moot 2004

High numbers for 7-10 days

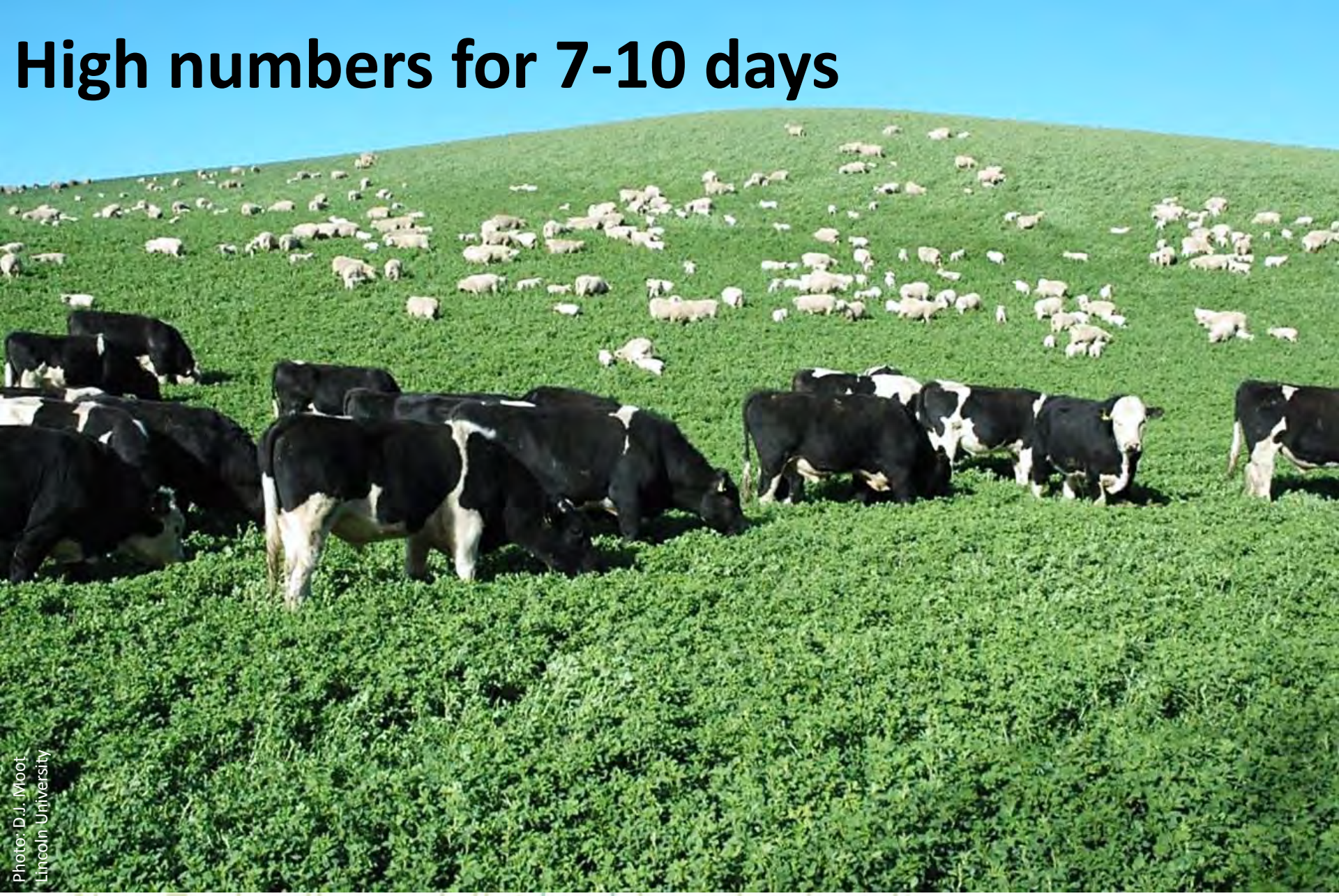
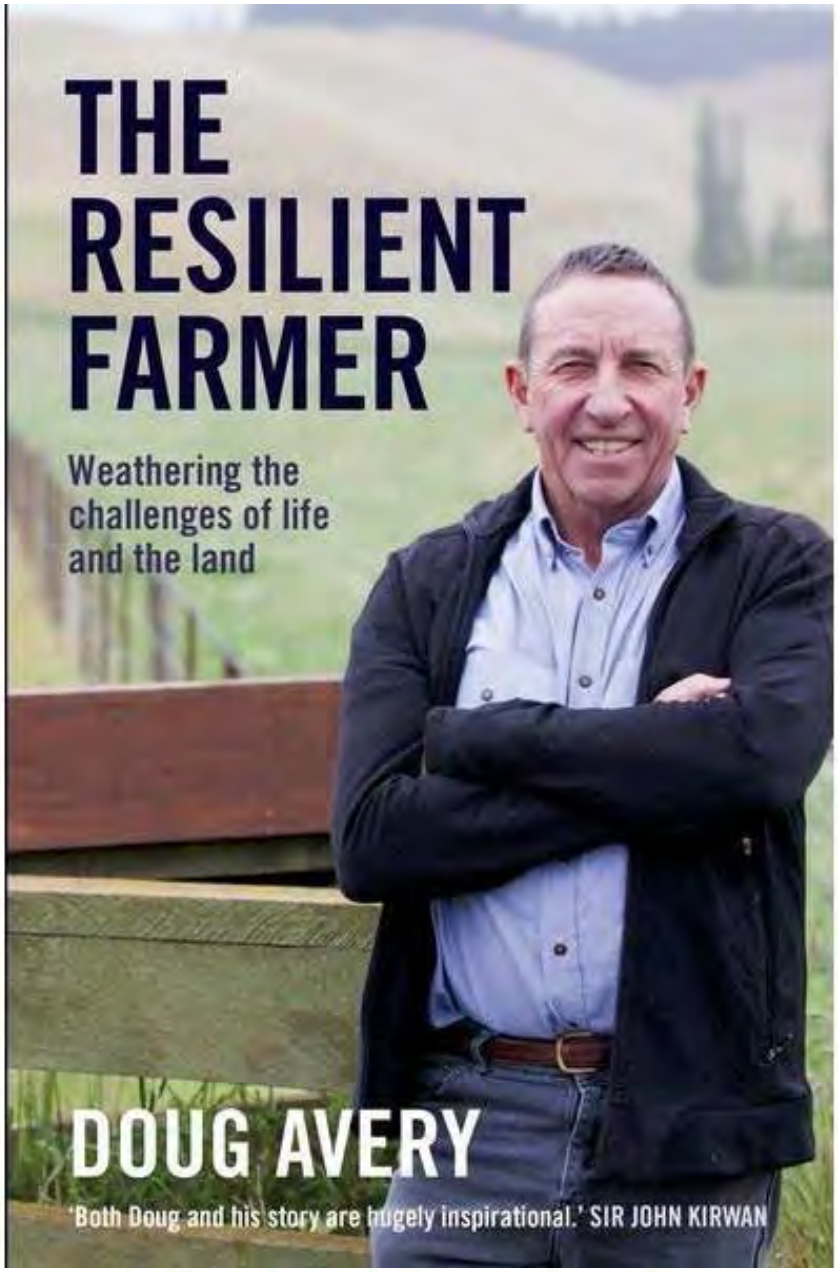


Photo: D.J. Moot
Lincoln University

Intensification allows afforestation



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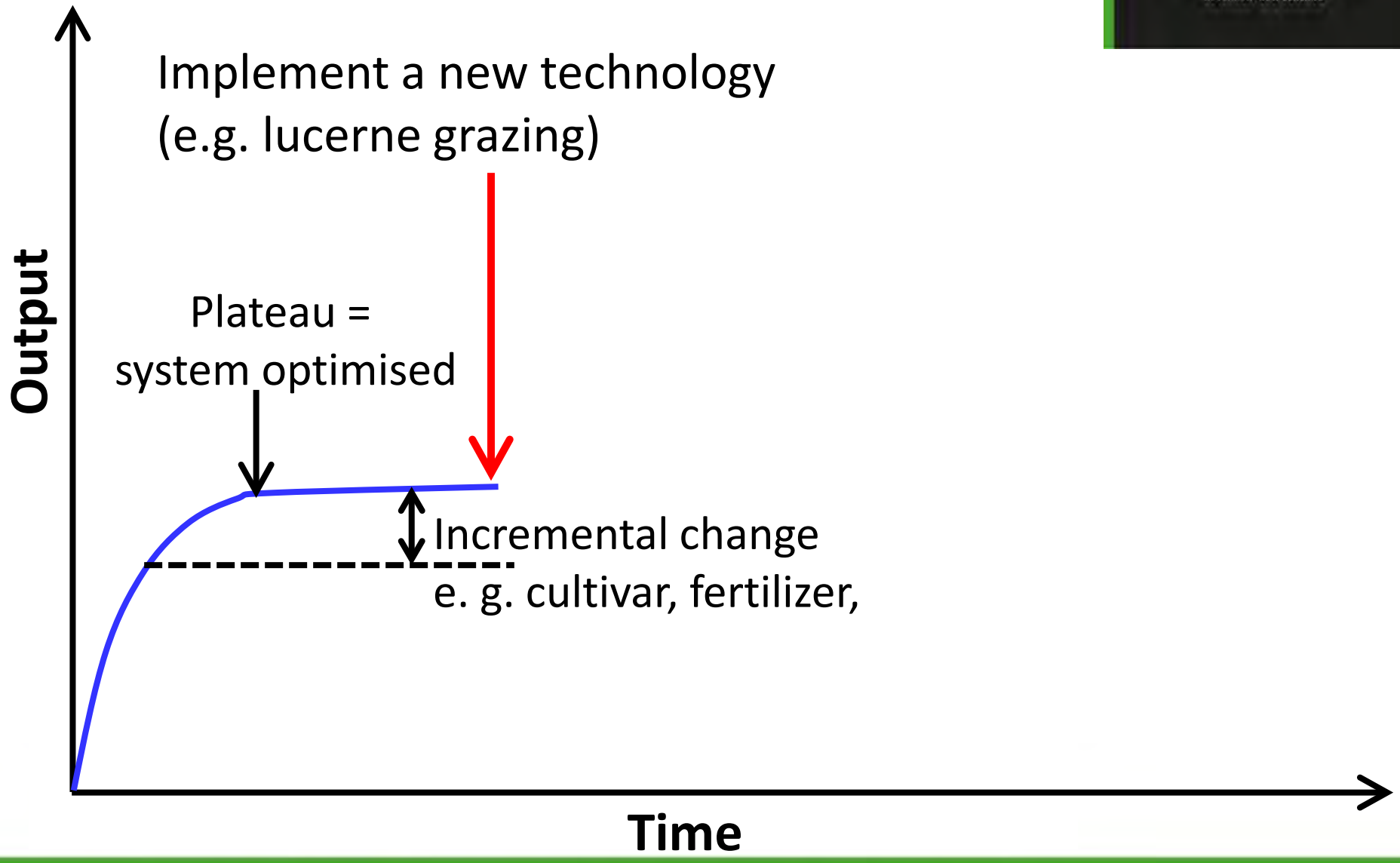
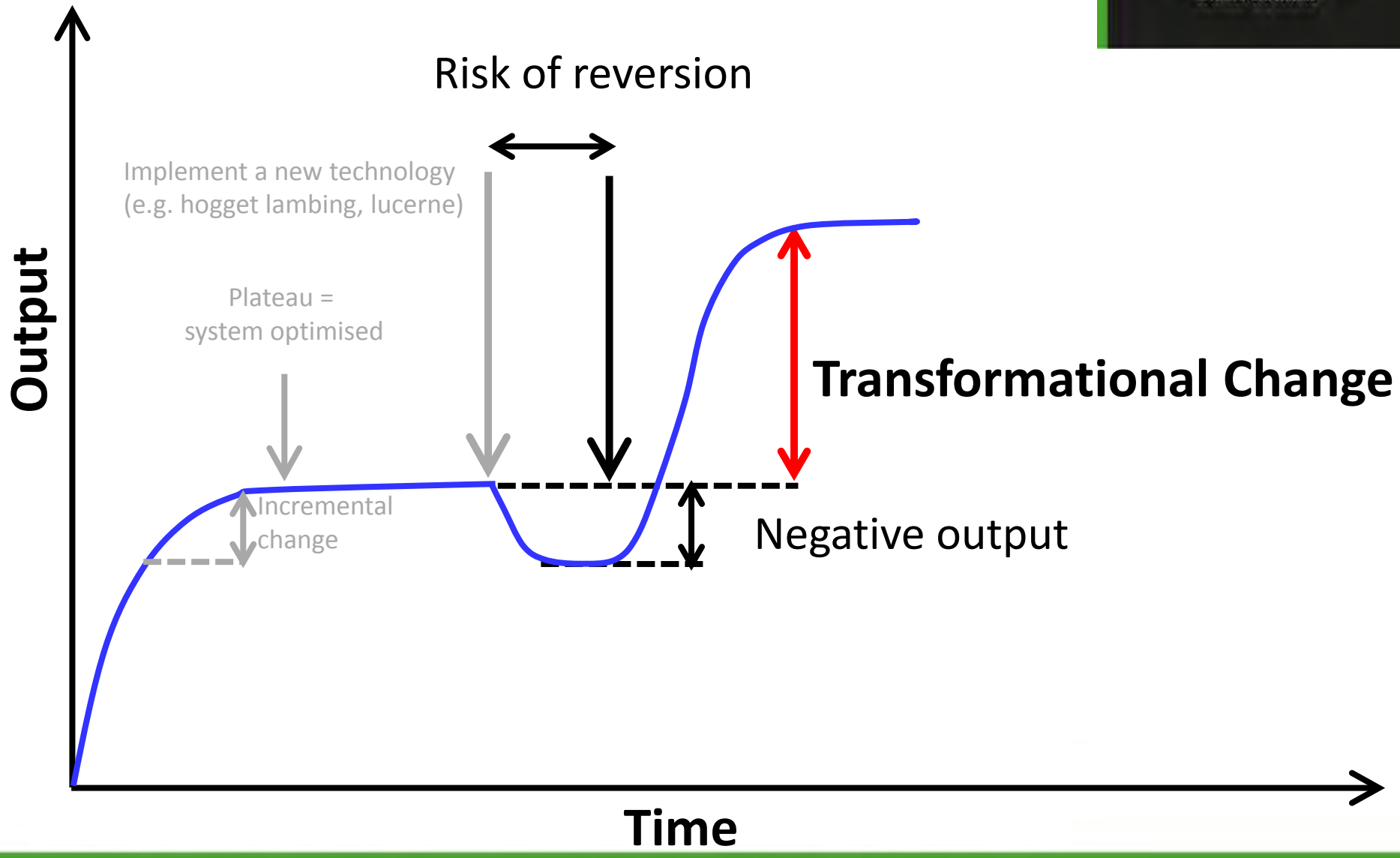
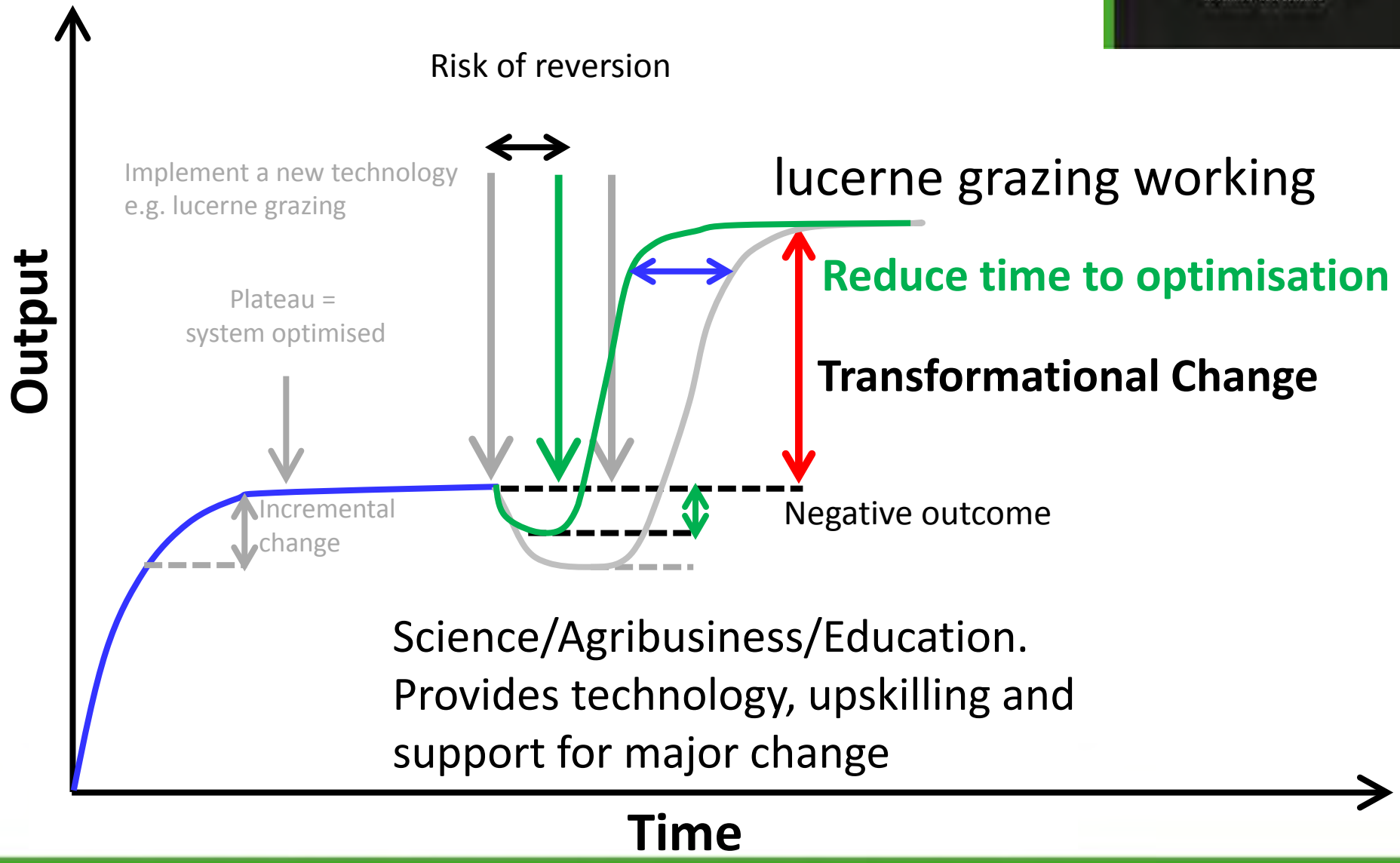
Pathway to change



System optimisation



Pathway to change



Science/Agribusiness/Education.
Provides technology, upskilling and support for major change

A story of change

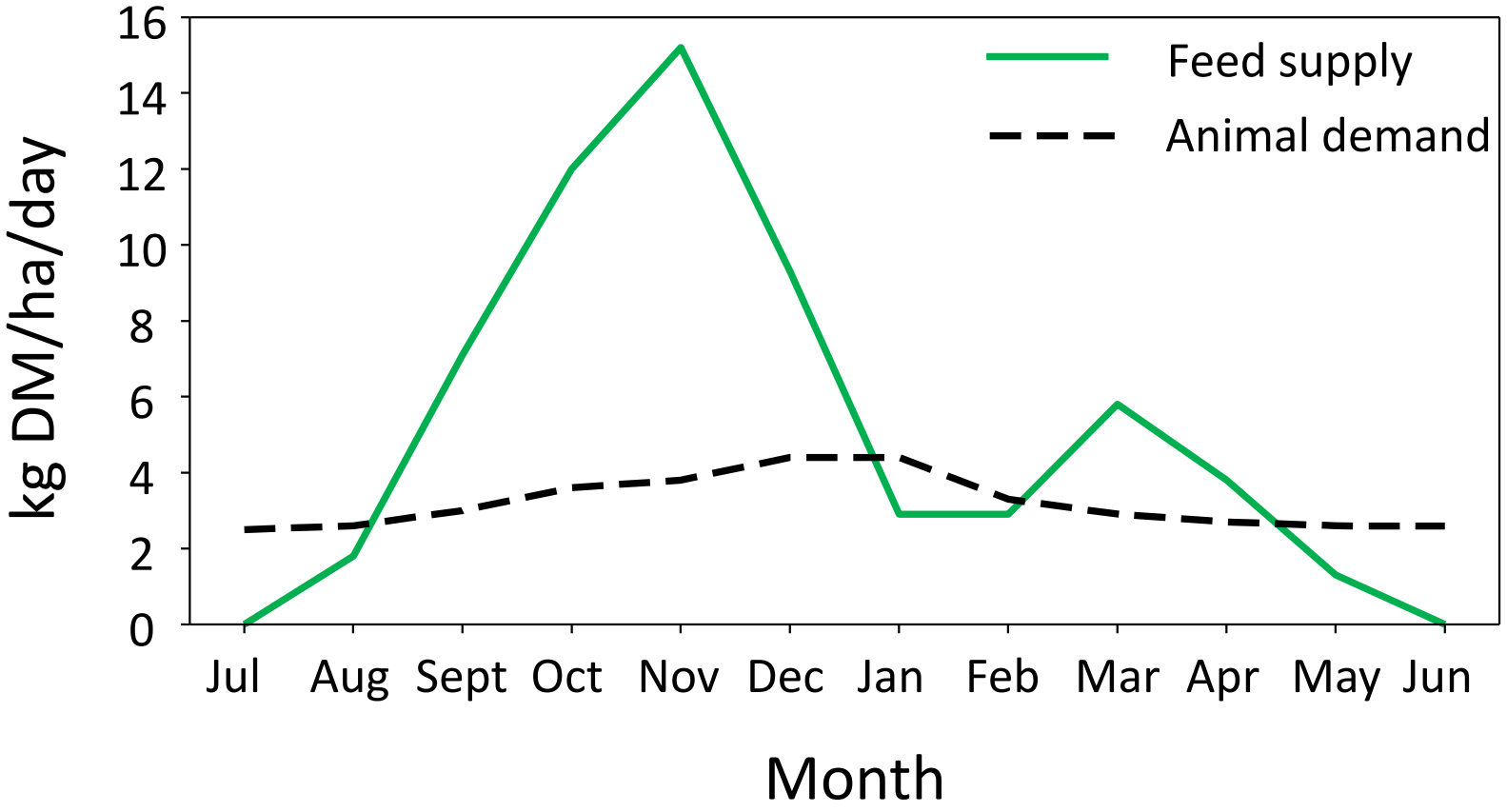
Dave (Gundy) & Lisa Anderson

Old System

- Set-stocked
- Constant grass chasing
- Hill country in decline
- 100 day supplement winter feeding
- Peak feed demand and supply misaligned

Moot *et al.* 2018

Pasture supply & Animal demand



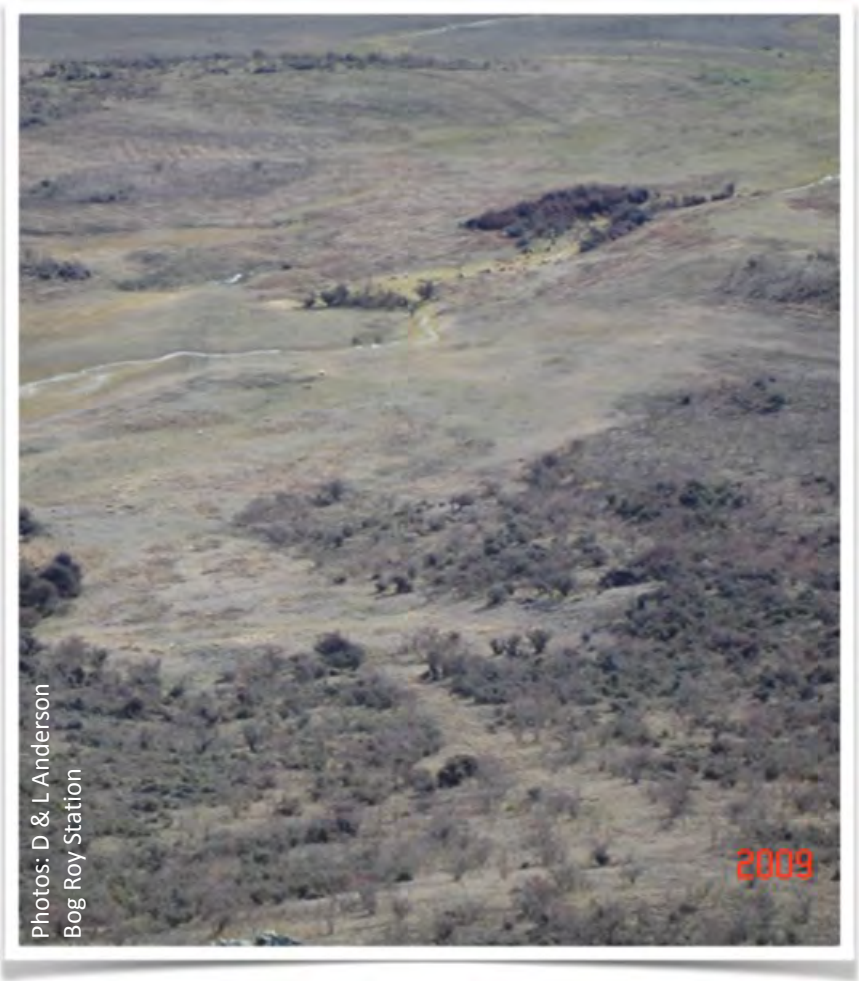
Anderson et al. 2014

Landscape farming – Bog Roy Station

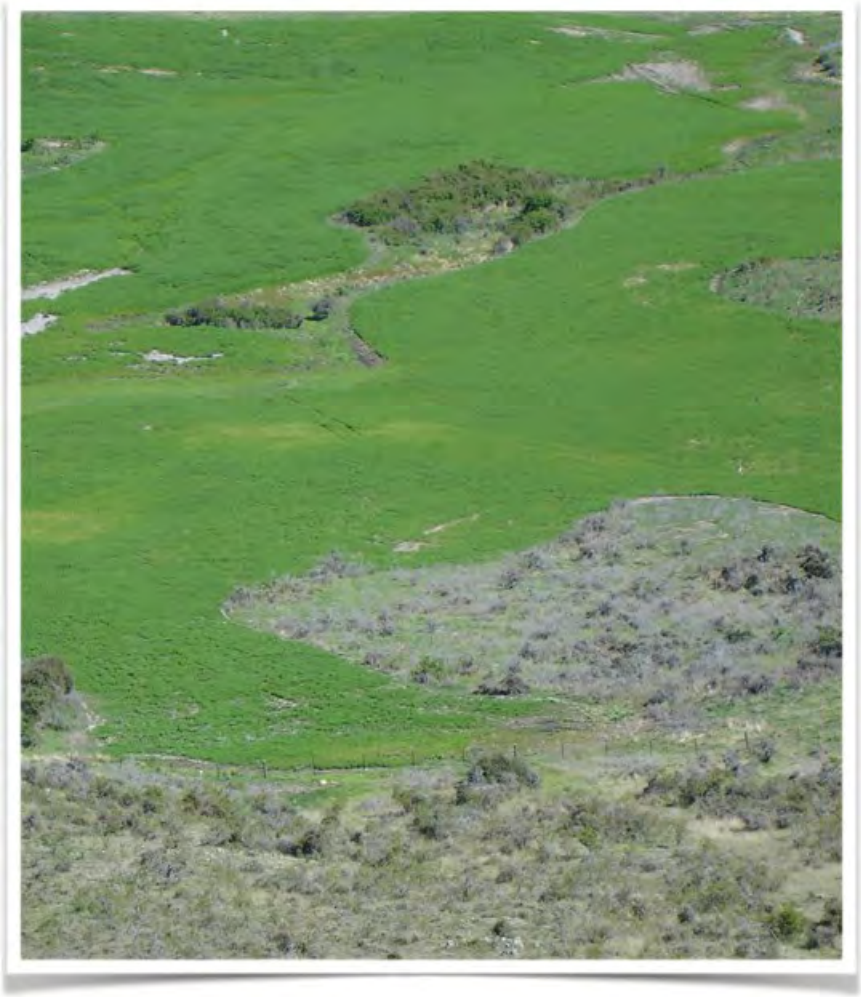
Getting Results

Photos: D & L Anderson
Bog Roy Station

Landscape farming



Photos: D & L Anderson
Bog Roy Station



Moot *et al.* 2018

Measuring, Monitoring & Analysing

Ewe flock performance

kg lamb weaned = number of lambs x weaning weight

Key Drivers are:

Ewe Performance

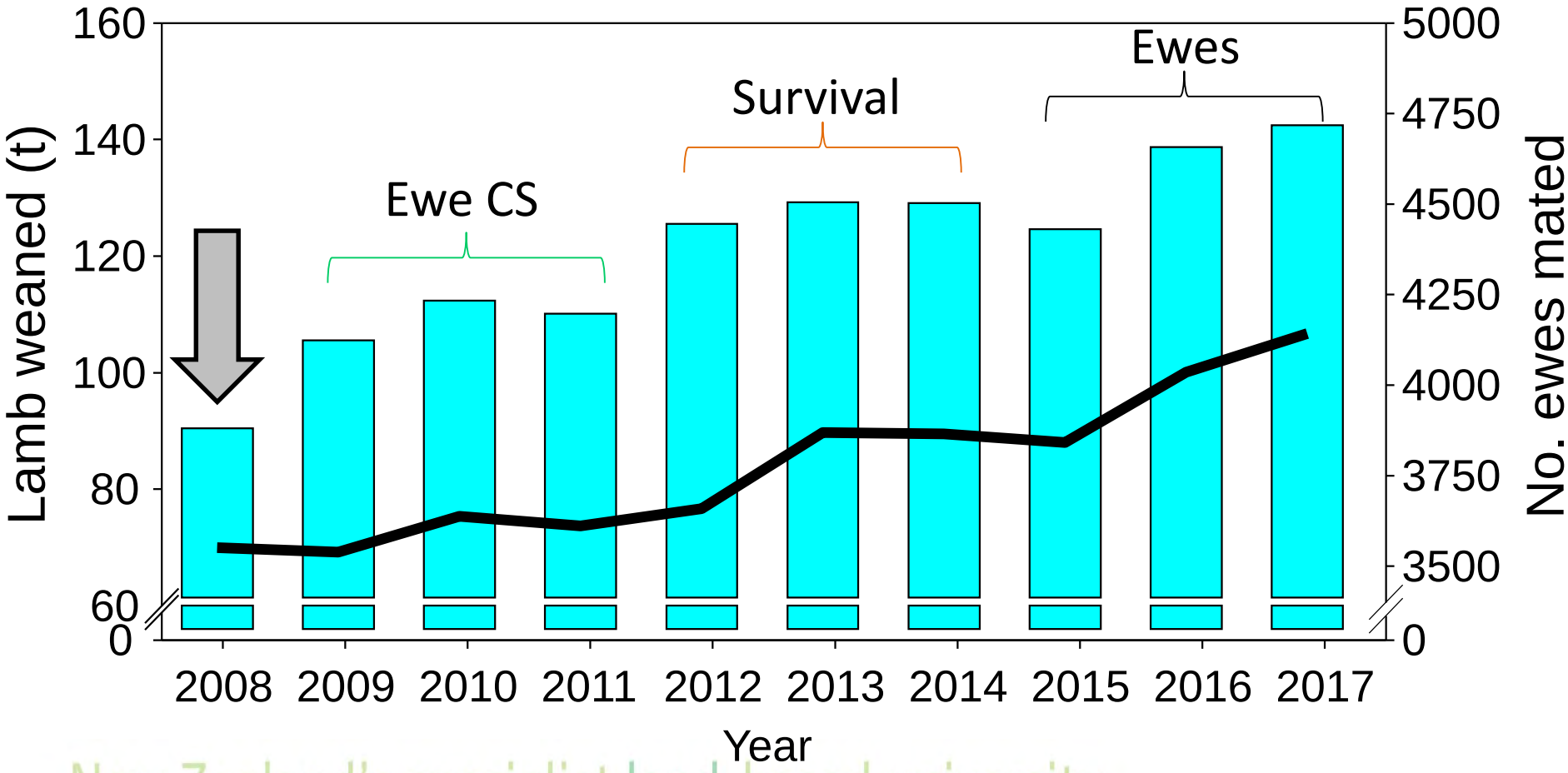
- Scanning %
- Lamb wastage %
- Lambing %

Lamb Performance

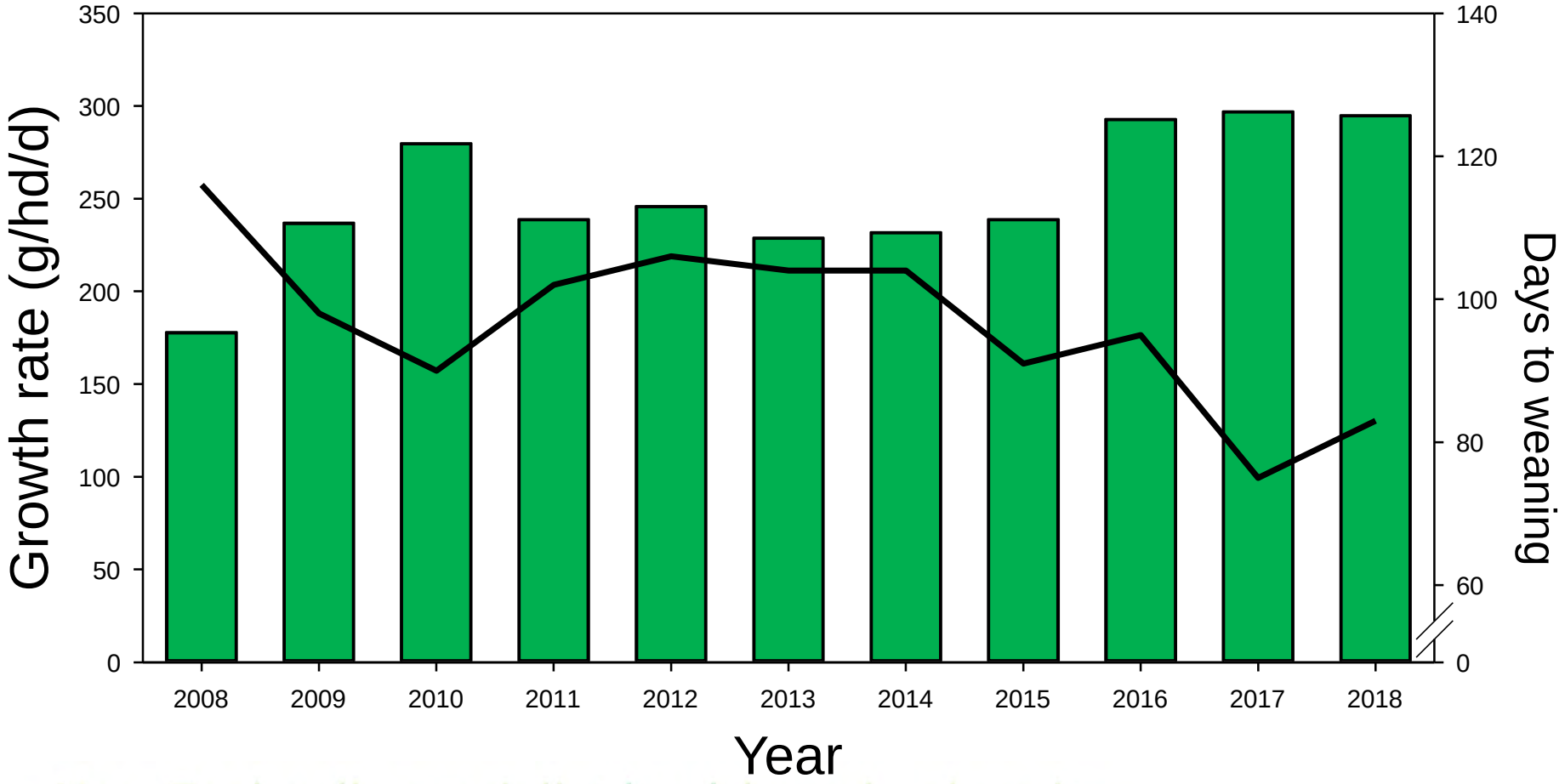
- Lamb growth rate
- Lamb weaning weight

Photo: D & L Anderson
Bog Roy Station

Change in LWt produced at Bog Roy



Mean daily lamb growth rate



Moot et al. 2019

Income and lamb sale weights over six years at Bog Roy Station

Year	Average lamb value ($/hd)	Total lamb income ($)	Average sale LWt (kg)	Average LWt value (¢/kg)
2012/13	73.97	236,409	31.5	234
2013/14	69.94	238,503	29.2	239
2014/15	74.12	256,911	31.6	234
2015/16	99.97	337,499	39.6	252
2016/17	117.21	436,956	39.4	297
2017/18	154.78	623,074	41.5	371

Moot et al. 2019

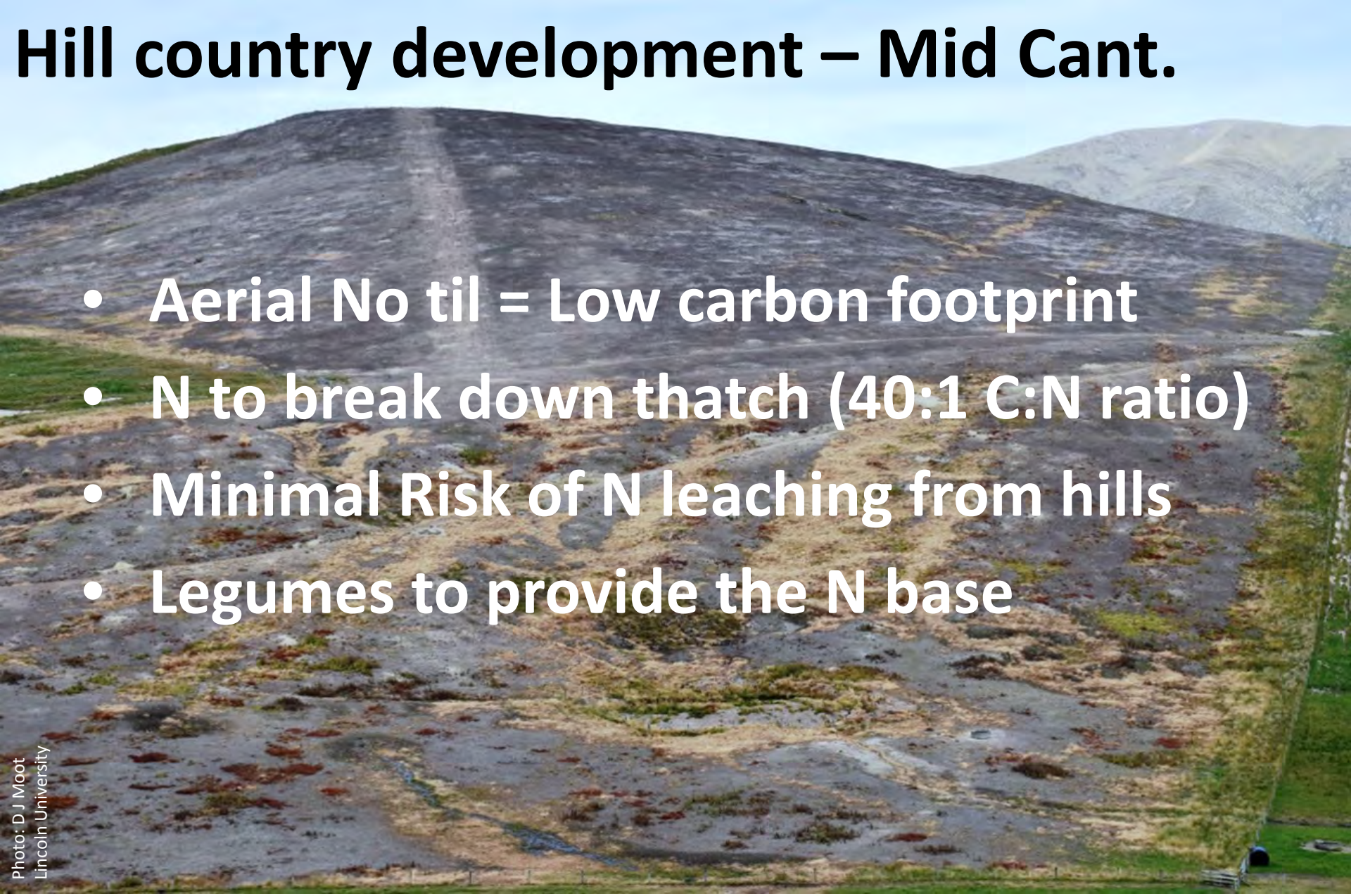
Banks Peninsula 10/10/2019

Photo: Malcolm Smith
Lincoln University

Transformational change at Bog Roy

- Change to lucerne grazing priority
- Increased per head performance of ewes
- Increased dry matter grown with new lucerne
- Less winter feed made
- Weaned lambs sold at heavier weights
- Hill country improved by developing flats

Hill country development – Mid Cant.



- Aerial No til = Low carbon footprint
- N to break down thatch (40:1 C:N ratio)
- Minimal Risk of N leaching from hills
- Legumes to provide the N base

Photo: D J Moot
Lincoln University

N deficient North Island Hill Country!

Photo: D.J. Moot
Lincoln University

Legume/herb mixes for hill country

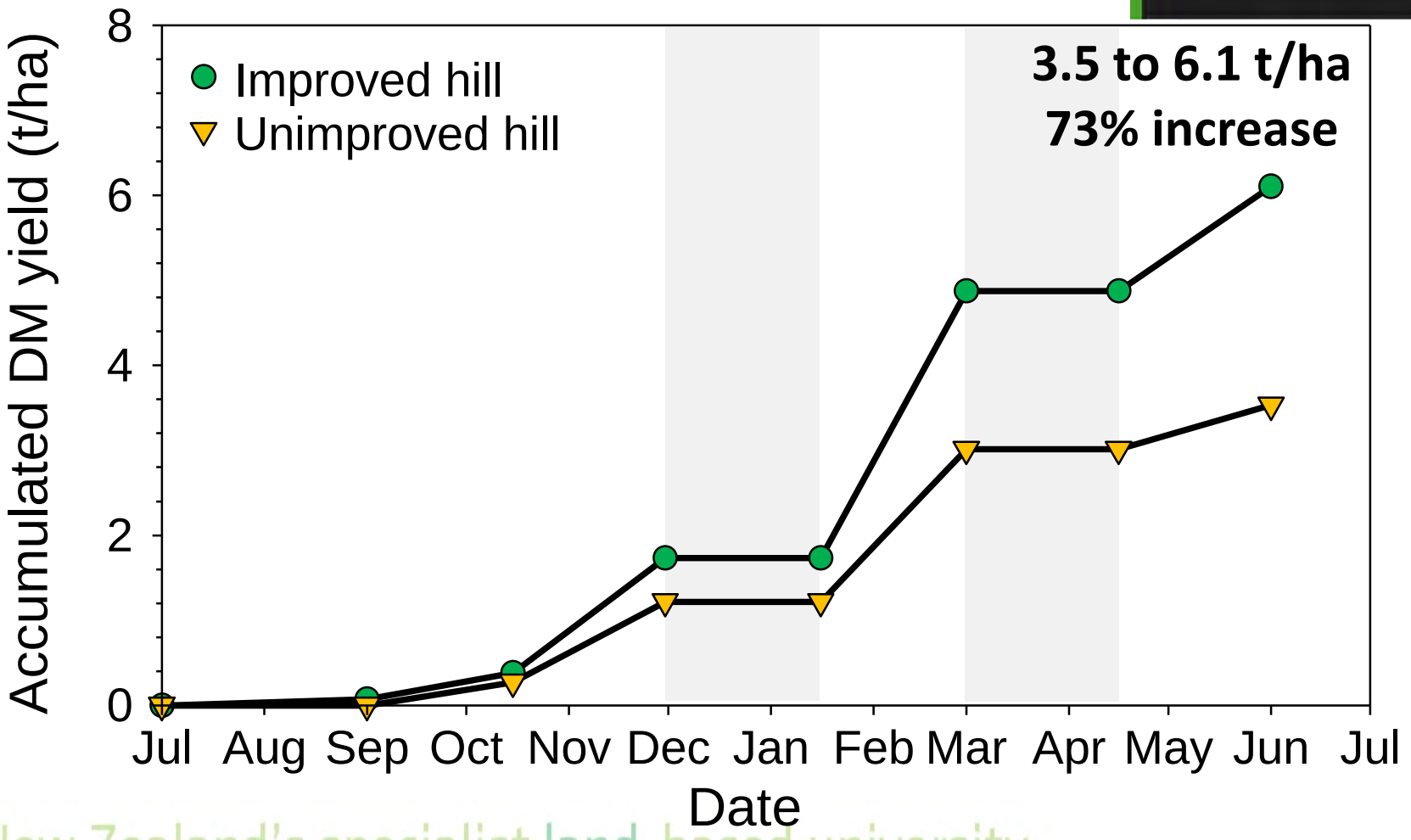
New Zealand's specialist land-based university


Photo: RJ Lucas
Lincoln University

Regenerative or Intensive $CO_2 + CH_4$

Photos: DJ Moot
Lincoln University

Mid Canterbury



Moot et al. unpublished

Red clover

- Short lived perennial – 2-3 years - disease
- With white clover and timothy - finishing pasture ?
- 8 kg red, 2 kg white 2 kg timothy – no ryegrass!
- Sowing date and depth
- Higher residuals than perennial ryegrass
- Rotational graze (6 weeks – 15 to 3 cm)
- Overdrill perennial ryegrass in Year 3
- Summer animal production – wet lucerne!


Tempello
meat - wool - wine
Photo: Jo Grigg
Tempello

Photo: Doug Avery, Bonavaree

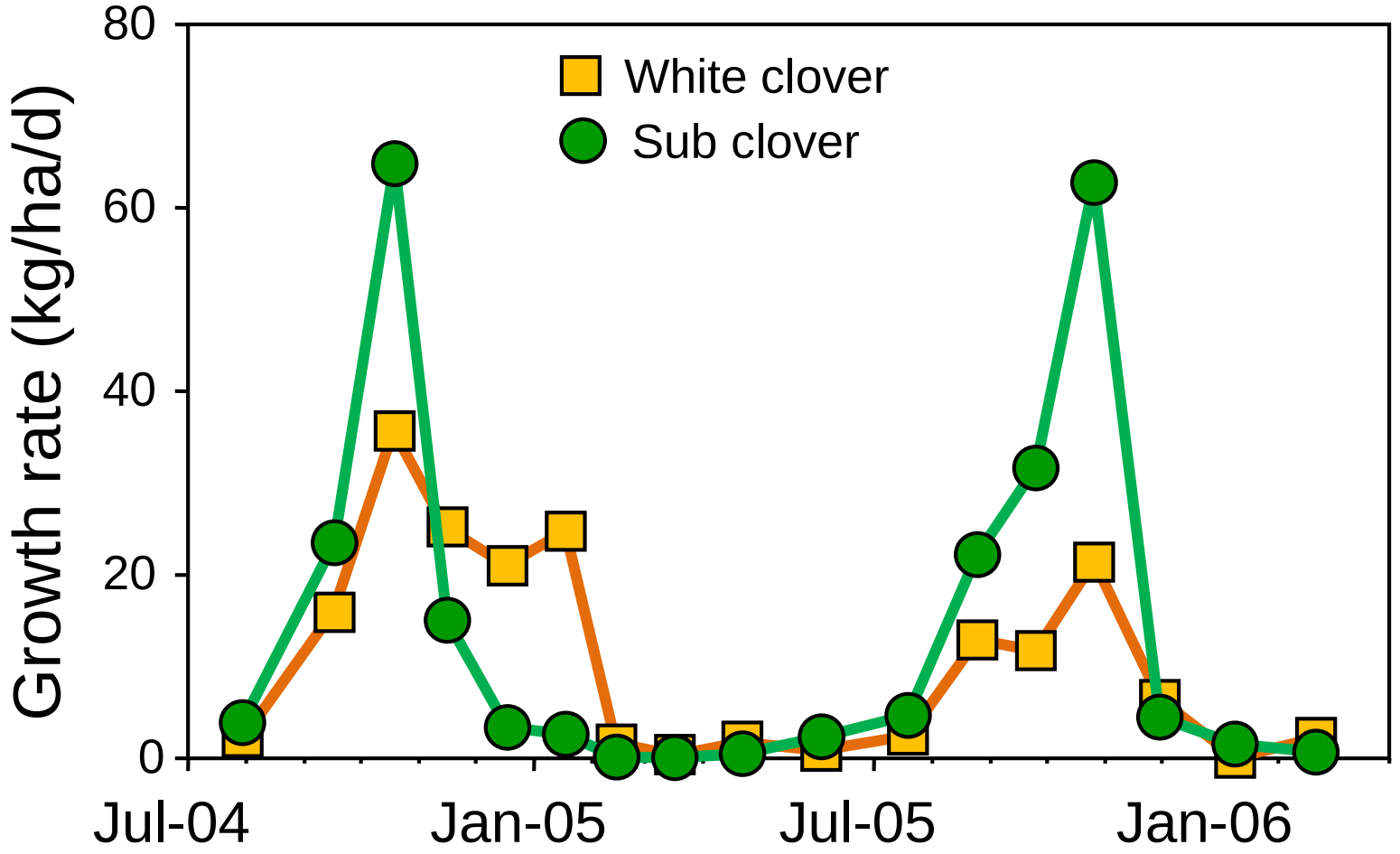
Subterranean Clover

Costello & Costello 2003

Subterranean Clover

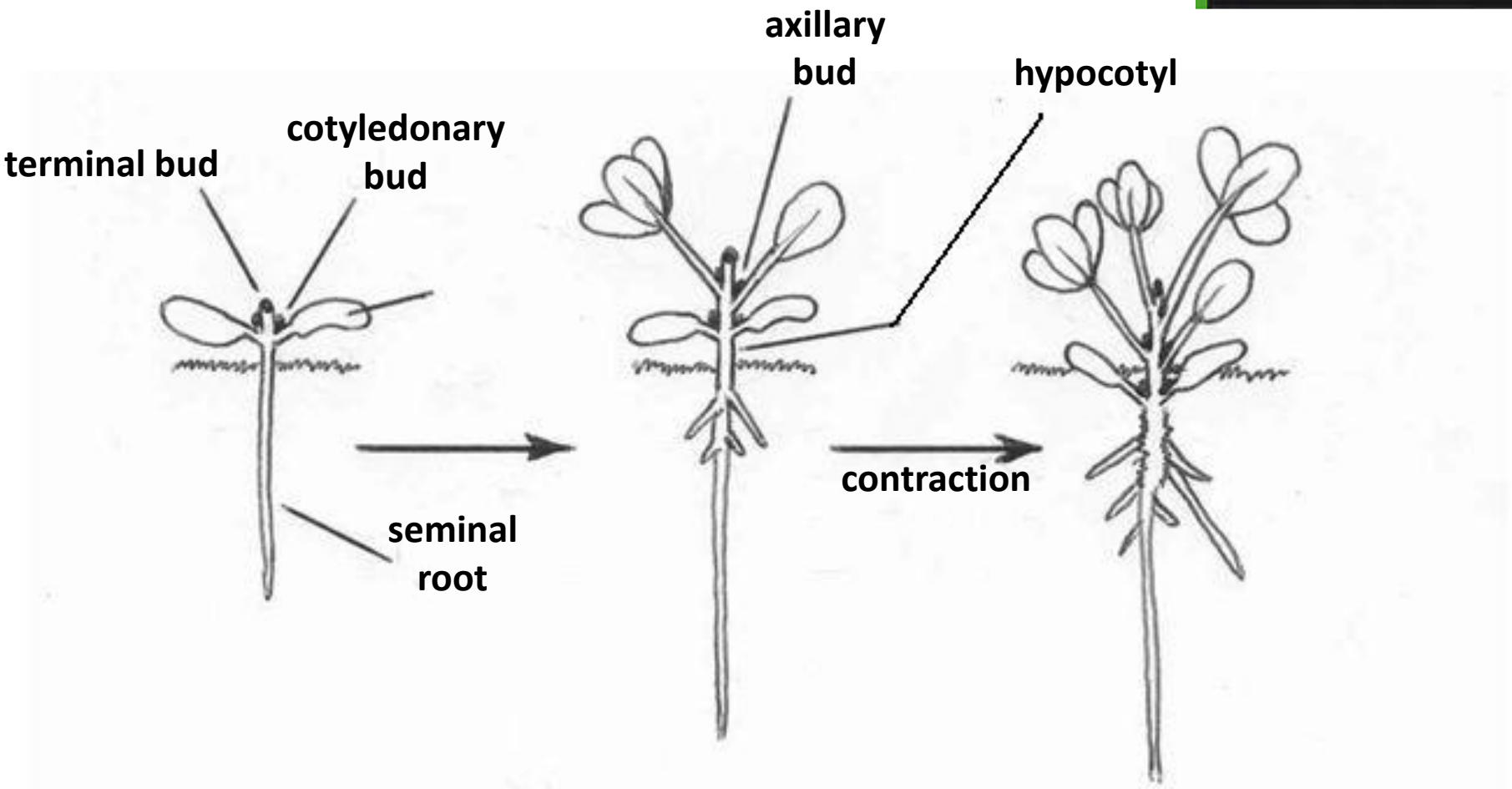
- Large seed, 10x Wc therefore 10x sowing rate
- Winter annual – autumn sow soil temp. <11°C.
- Rapid but variable germination with rainfall from Jan-May
- When can seedlings be grazed in autumn?
- How to maximize summer seed set

Seasonal clover growth



Brown et al. 2006

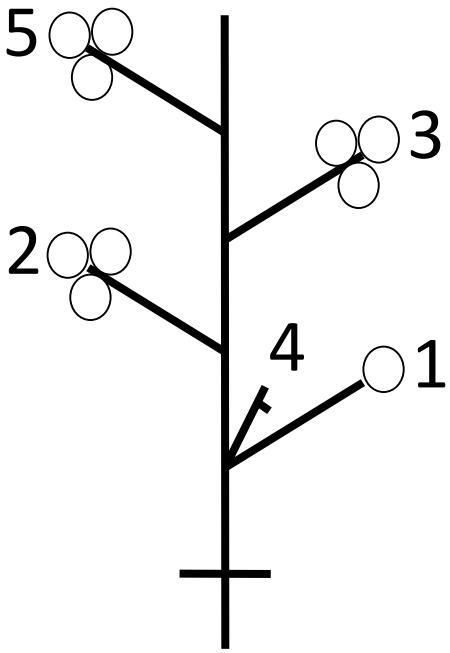
Seedling Development



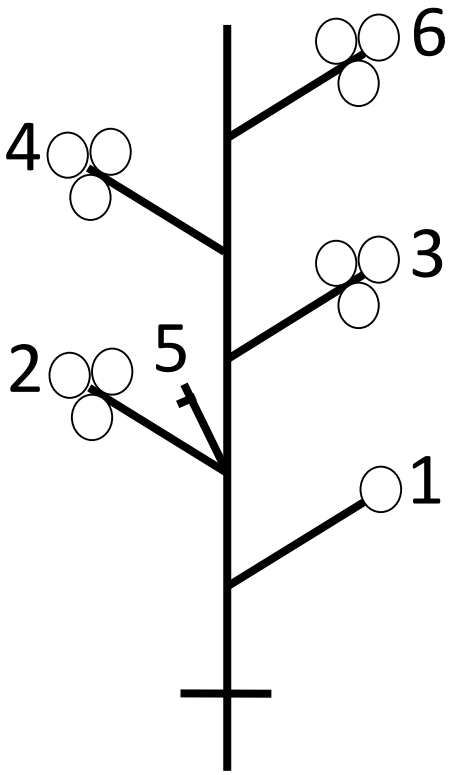
Thomas 2003

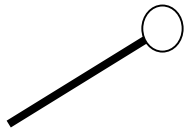
Seedling development

White clover
(486^{o} Cd)

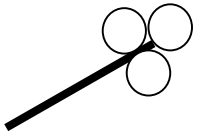


Sub. clover
(434^{o} Cd)





spade leaf



main stem trifoliate leaf

axillary bud with one emerged leaf

Direct drill before rain

Initial population for seed build up

Photo: DJ Moot
Lincoln University

Autumn Management in later years

(200 seedlings/m^2 in pasture)

- High strikes after extended hot periods
  - bare ground for seedlings to establish in
  - high temperatures break dormancy
- January rains are often false break
  - seedlings die (March is usual)
- Amount of cover in autumn is crucial


seedling

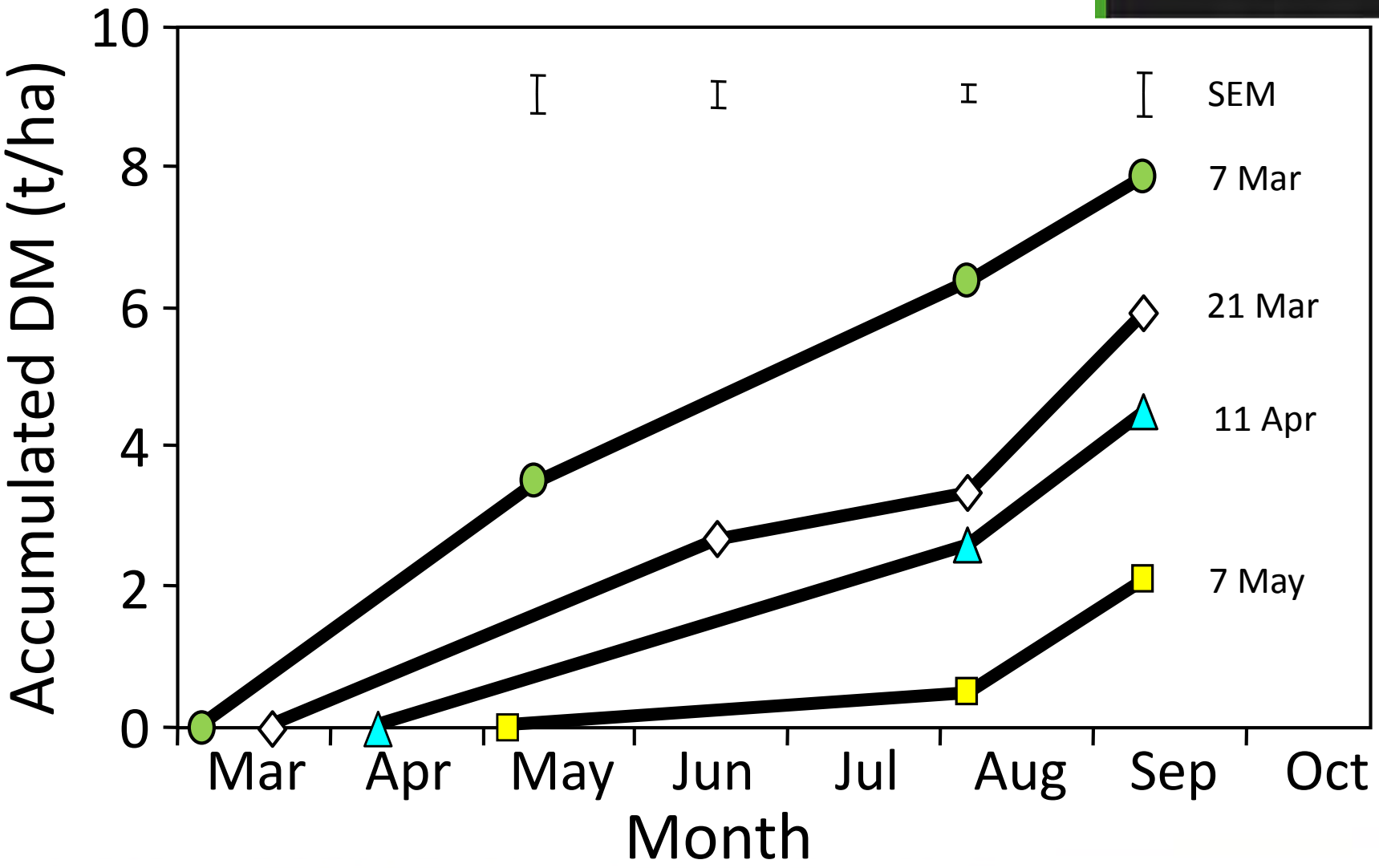
650 sub clover seedlings/m^2

21/3/17 – recovering pasture – no fences

Photo: Derrick Moot
Lincoln University
21/03/17

21 April 2017

Dry matter yields



Created from data collected by Richardon 2003

Uncultivated – grazing only – no seed…

Photo: A Mills
Lincoln University

Tempello, Marlborough
26/2/2016

Summary: How we prep a block to maximise sub-clover

- Grazing pressure in Jan/Feb to remove dry clumpy grass (cows, ewes)
- Autumn rain = strike. Leave it until 5 trifoliate leaves. Can graze after this.
- Mid-winter: strip graze with ewes behind wire (clover carpet)

Before/after summer graze

Photo: Jo Grigg
Tempello

March strike: keep off!

Photo: Jo Grigg
Tempello

May: watch it grow

Photo: Jo Grigg
Tempello

June/July

EAT IT

Strip graze hard 22 June to mid-August with twinning ewes

You have to like winter break feeding

Keeps you fit!


Photo: Jo Grigg
Tempello


Photo: Jo Grigg
Tempello

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

Costello & Costello 2003

Takes several years to build seed reserves

Costello & Costello 2003

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 from 60 to 76 tonnes despite fewer ewes.

Wairarapa experiment

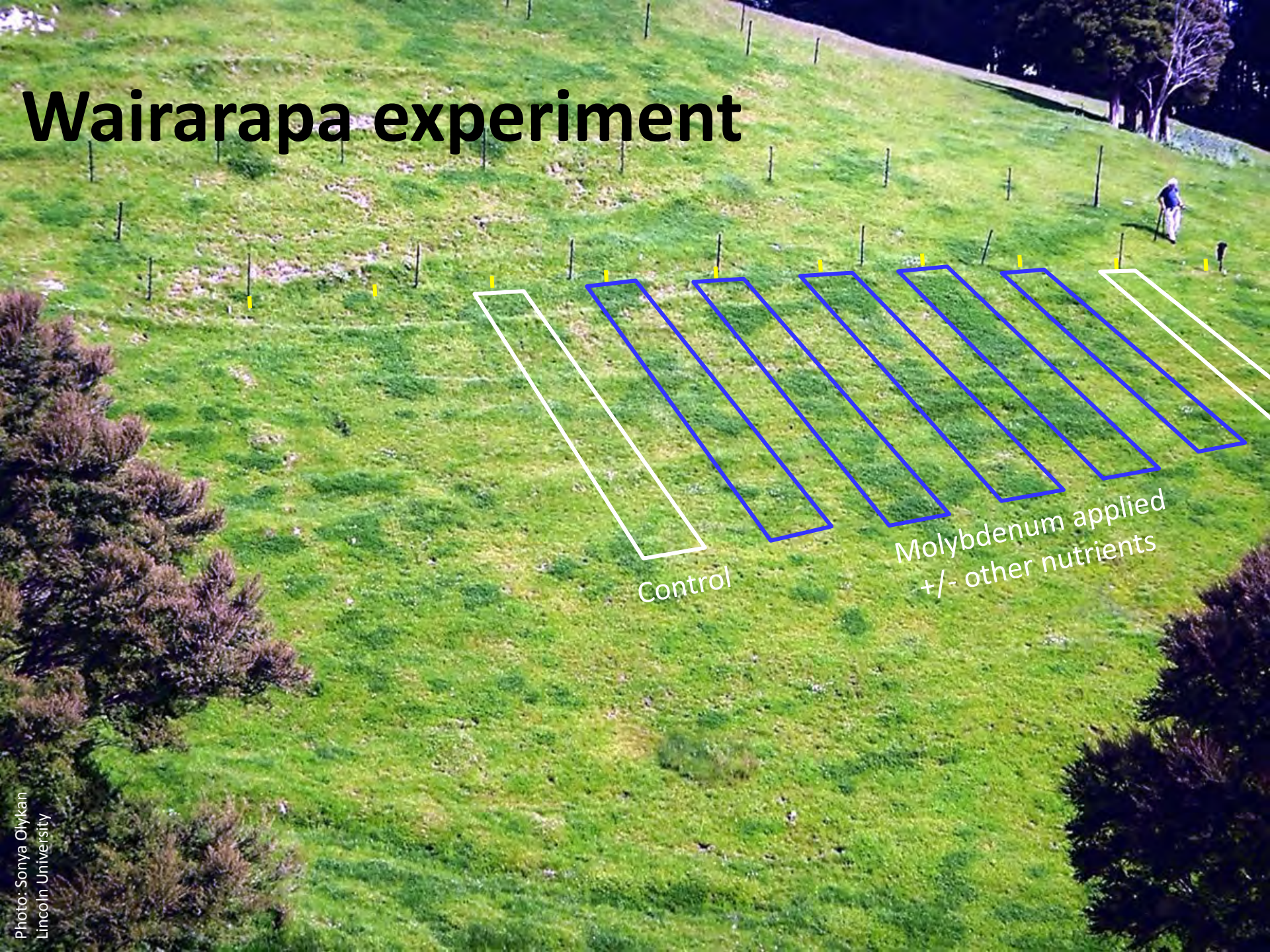
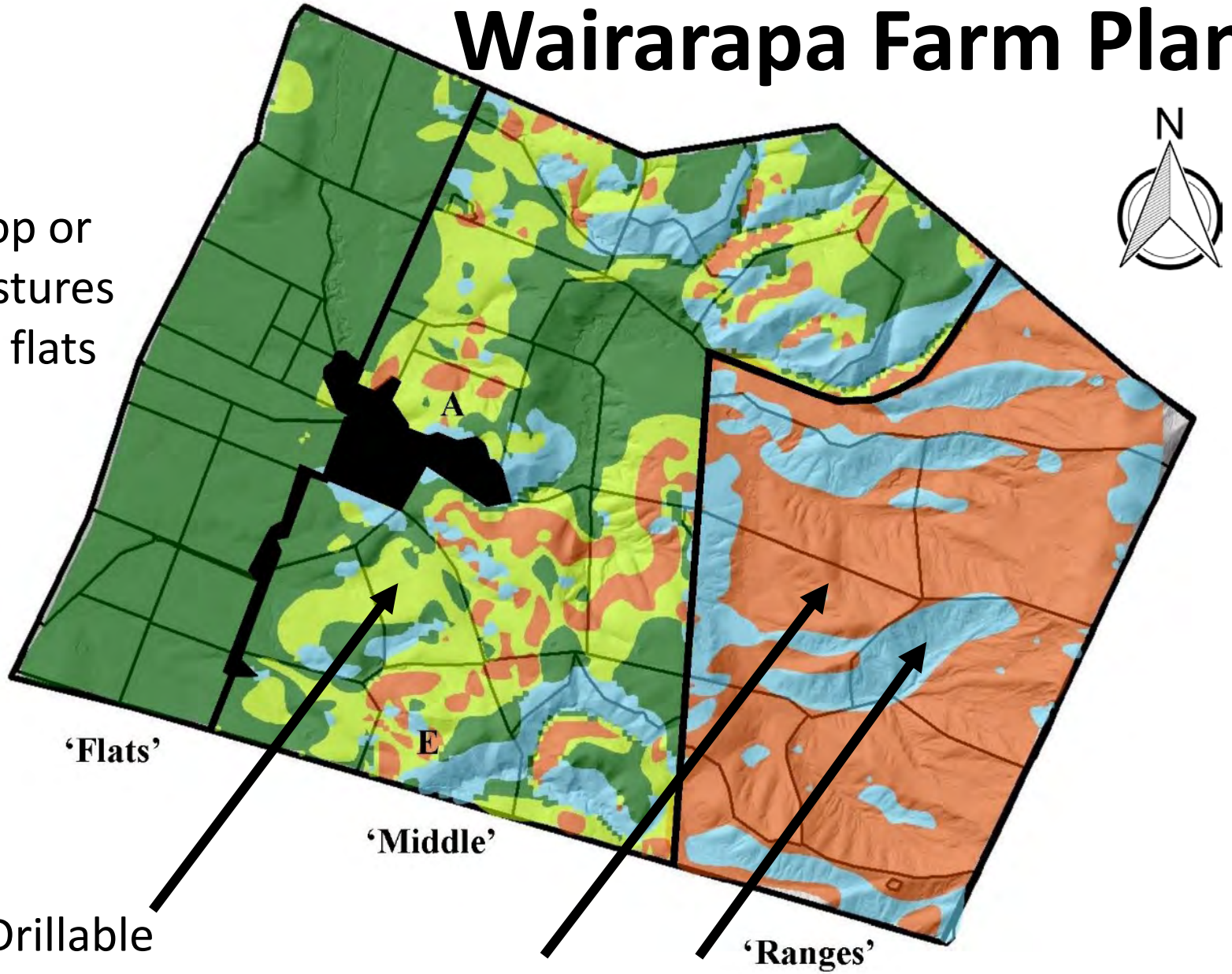


Photo: Sonya Olykan
Lincoln University

Wairarapa – P, K, Mo
(26/10/2017; Plot 25)
Fertility management

Photo: Sonya Olykan
Lincoln University

Wairarapa Farm Plan



Crop or pastures for flats

Drillable sunny Sub

Oversow Sub vs White

Southern Wairarapa = Summer dry

Sub clover ‘Antas’ drilled into pasture

Photo: Sonya Olykan, 26-10-17
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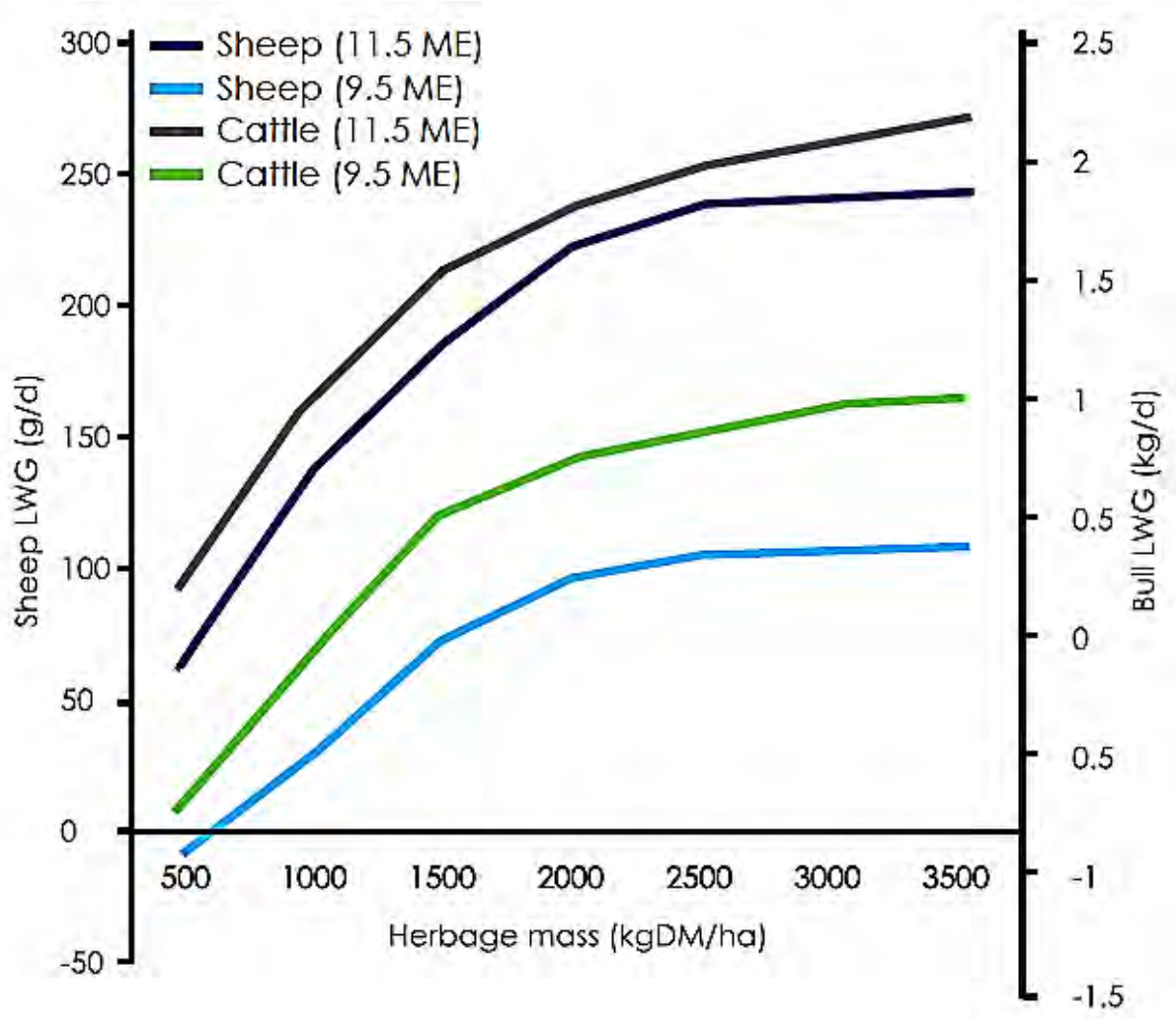
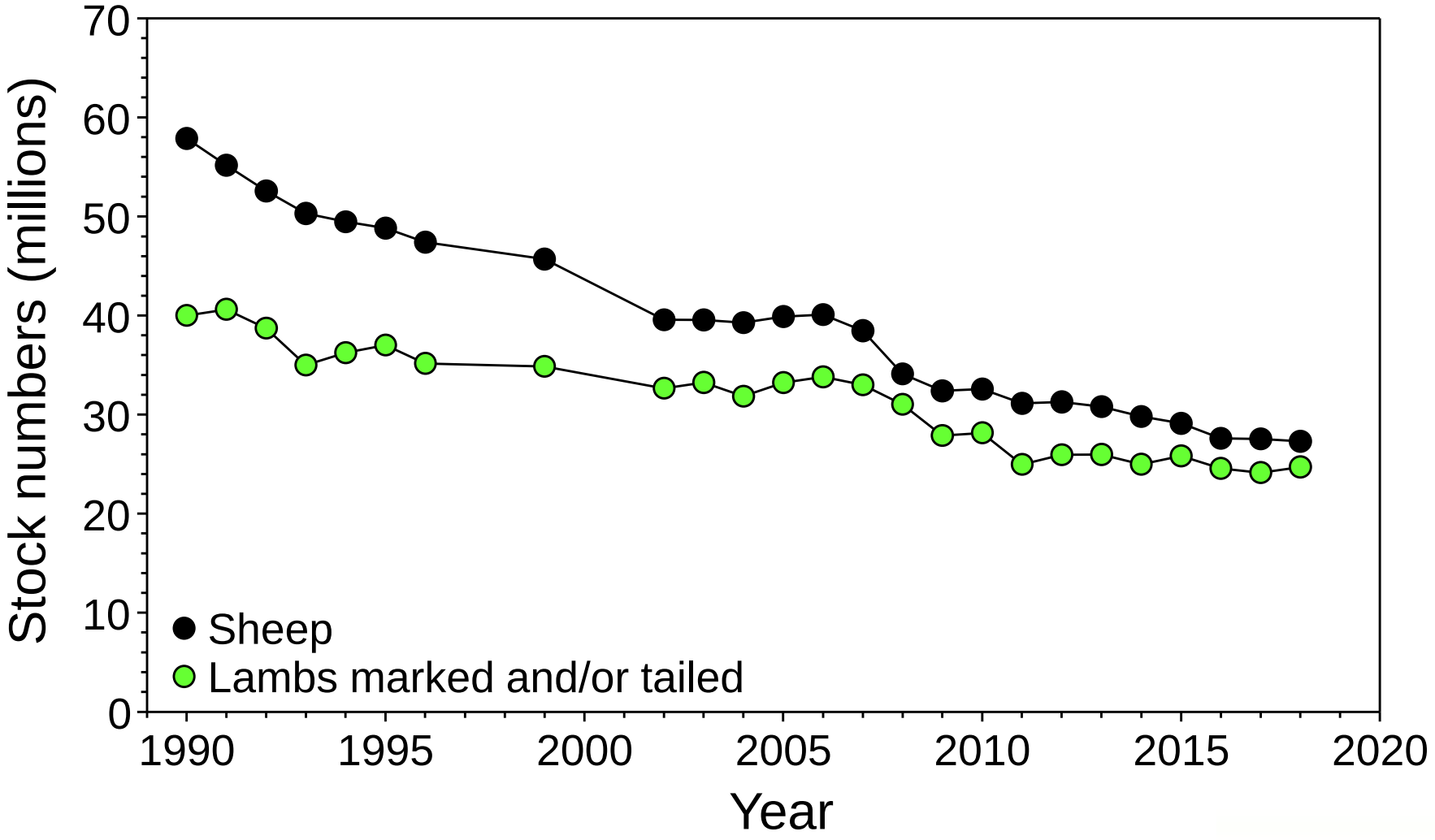
High clover but too short?

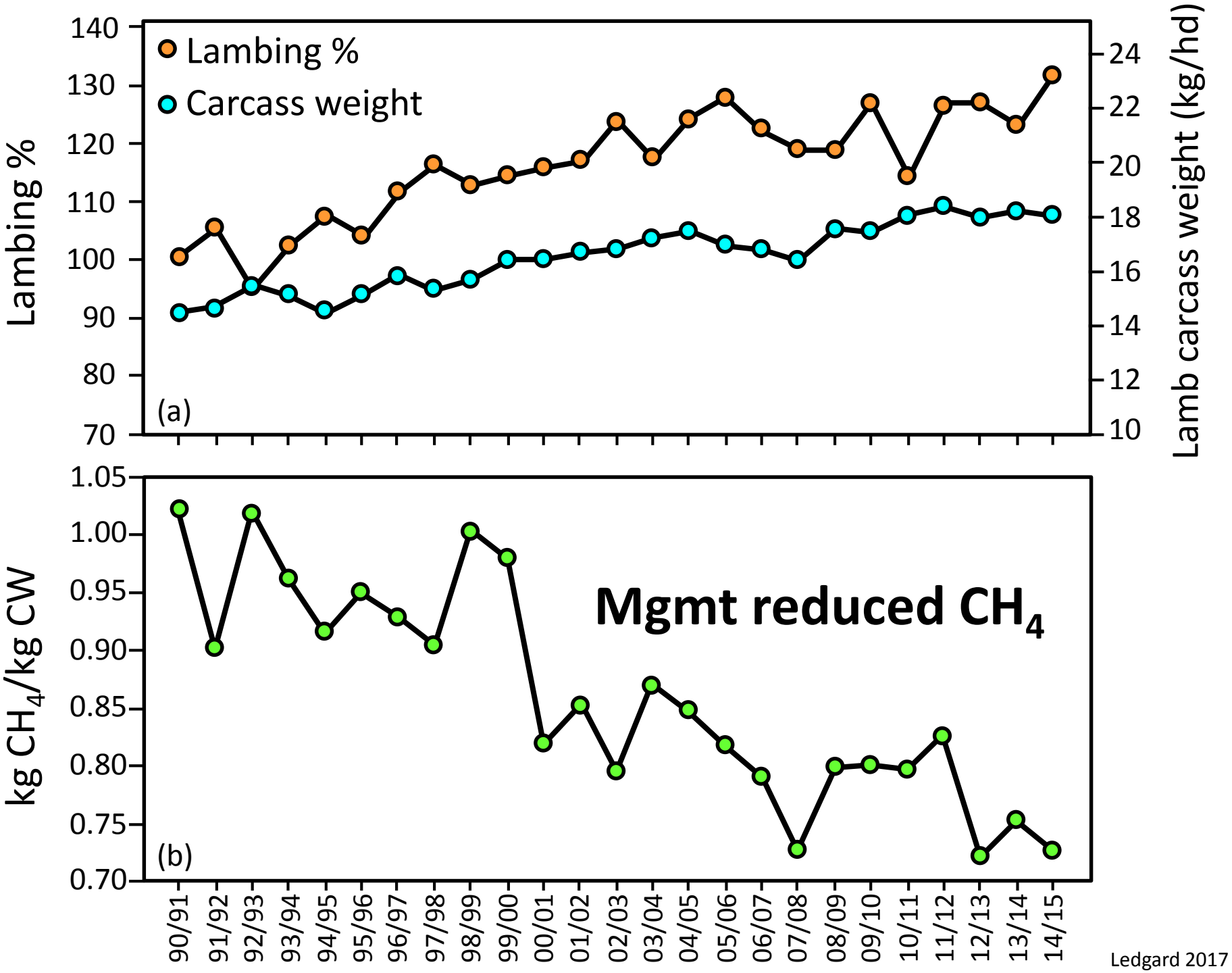
Generalised relationship between pasture herbage mass and live weight gain of animals



Beef + Lamb New Zealand. 2012. Pasture quality: Principles and management / The Q-Graze manual. Accessed 29/09/2017.
http://www.beeflambnz.com/knowledge-hub/factsheets/pasture-quality-q-graze

Sheep numbers in New Zealand





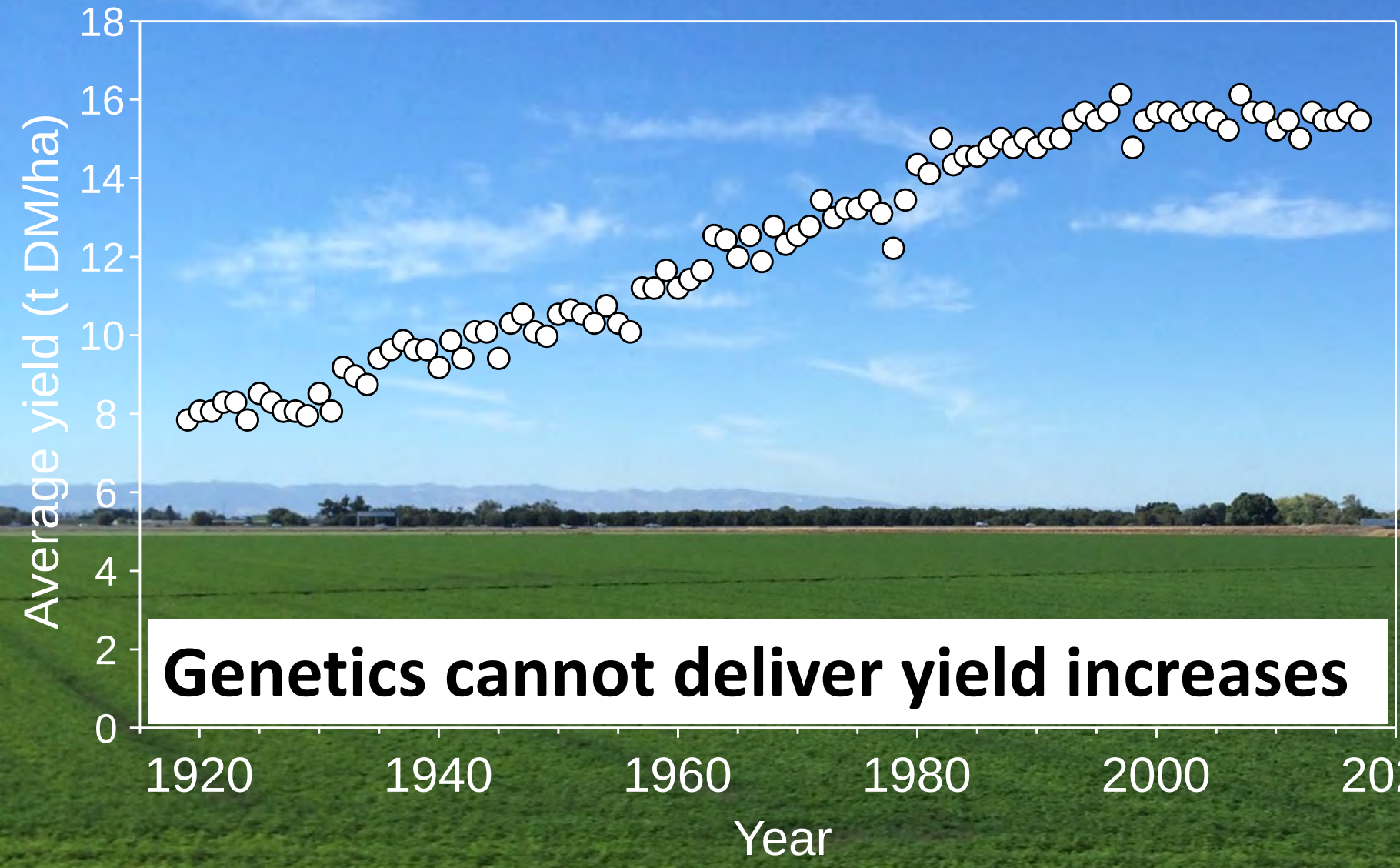
Ledgard 2017

Which legume drives your system ?

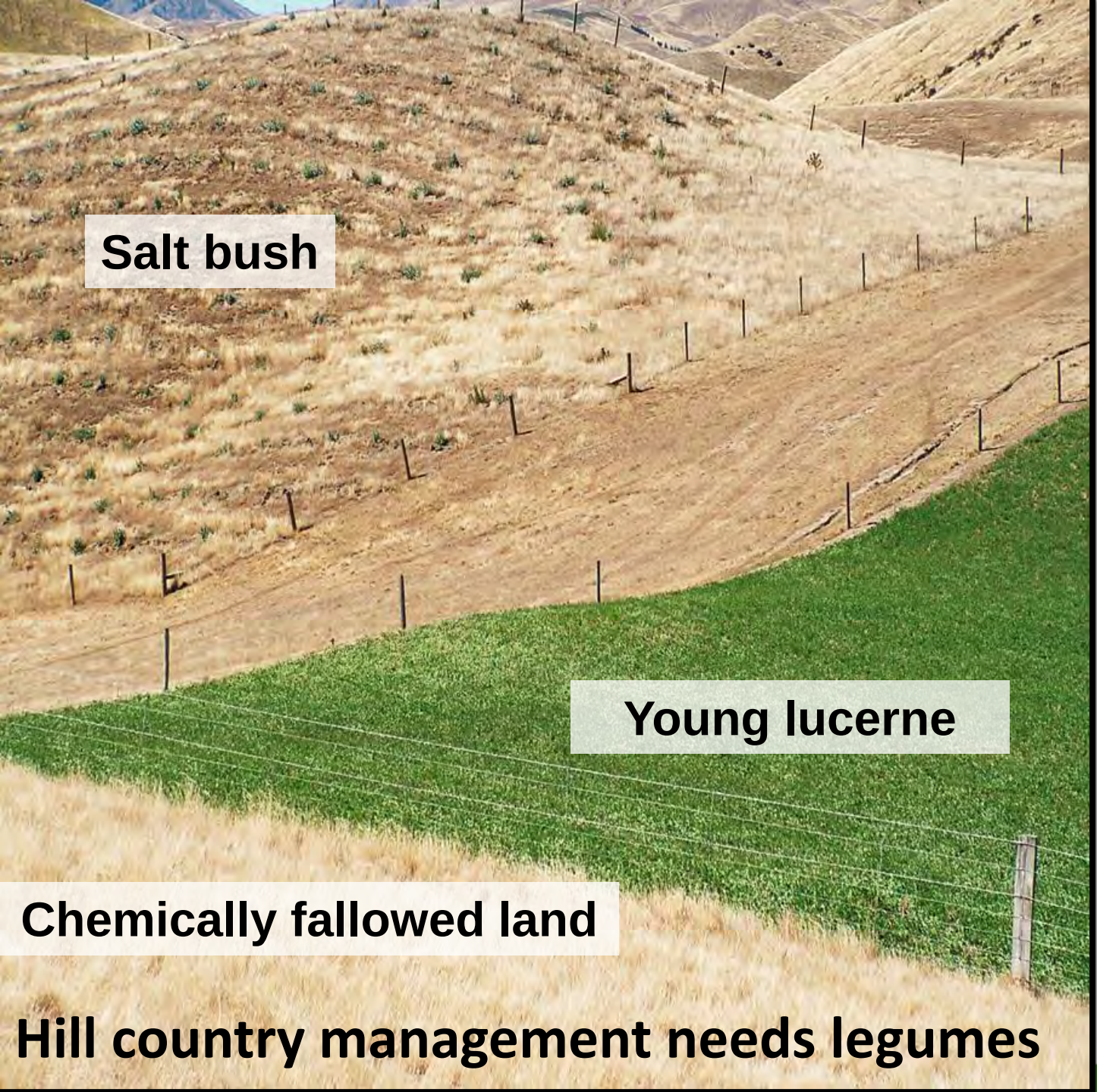
- White – set stocked small leaved – persistent
- Red – short lived, high yields rotational graze
- Lucerne- free draining – with ewes and lambs
- Annuals = sub on dry faces (2-3 months dry)
- Subdivision, super (S), seed, stock – 4 s's!

California - average lucerne yield

(USDA Ag Statistics)



Supplied by: Charlie Brummer, UC Davis



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Hill country management needs legumes

Lucerne Objectives

- Understand plant responses to the environment
- Use that information to design management practices
- Determine the influence of genotype
- Understand impacts on yield and quality

Growth:

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

Development:

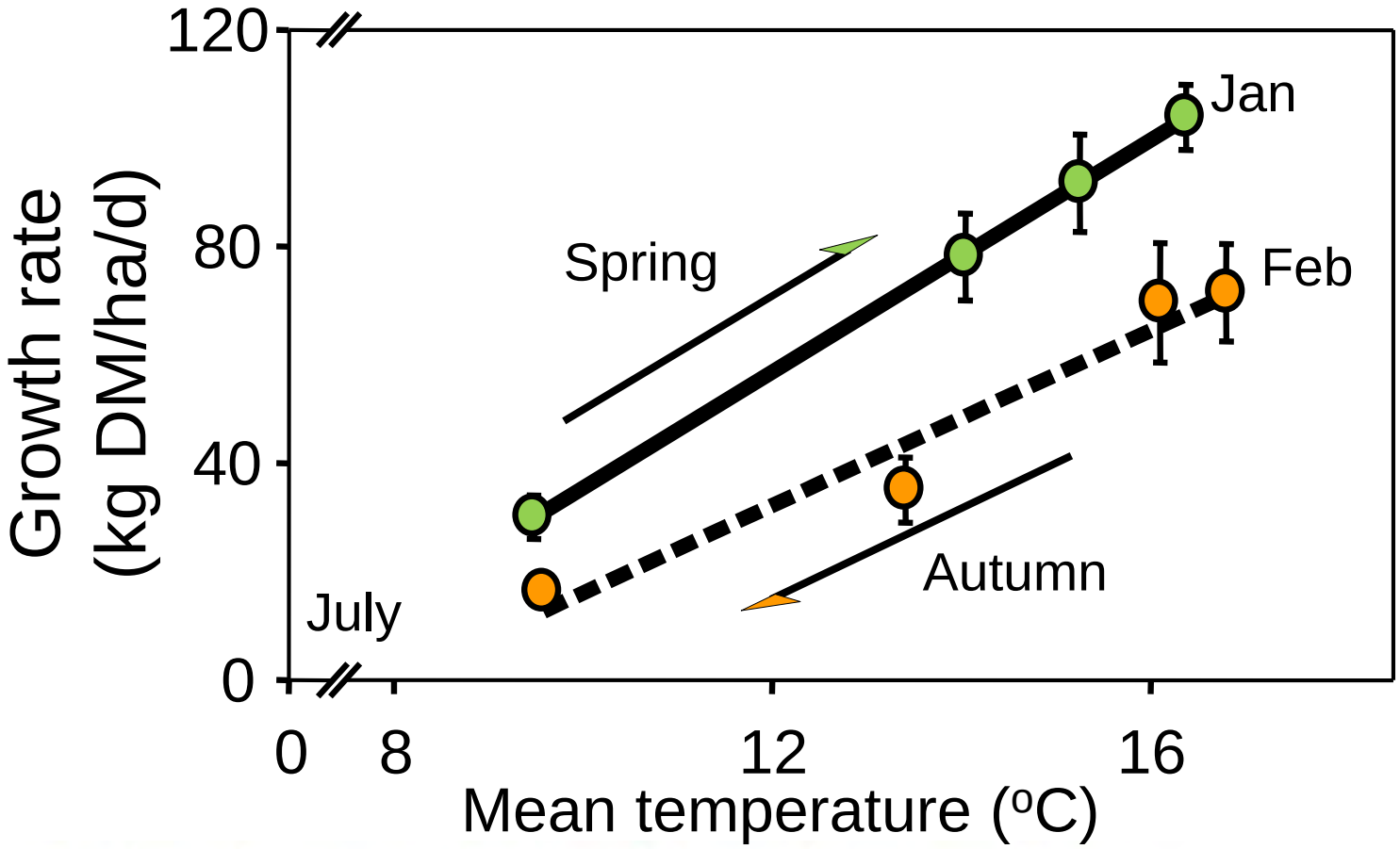
is the ‘age’ or maturity of the regrowth crop e.g. leaf appearance, flowering

Growth and development are both influenced by environmental signals

The canopy:
the energy capture device

Photo: DJ Moot
Lincoln University

Vegetative growth



Moot *et al*. 2003b

Experiment 2 flexible grazing

38 days resting

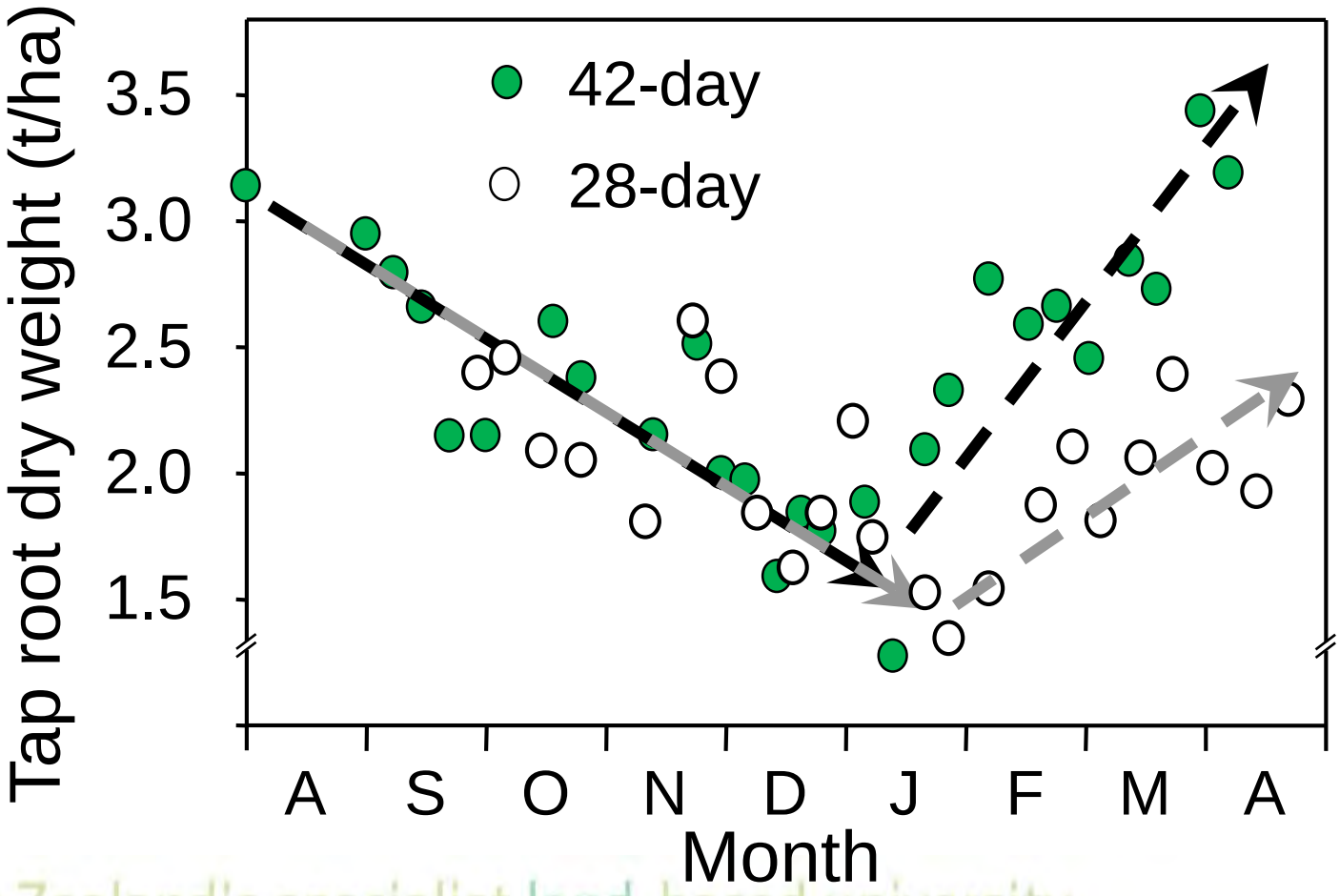
4 days grazing

25 days resting

3 days grazing

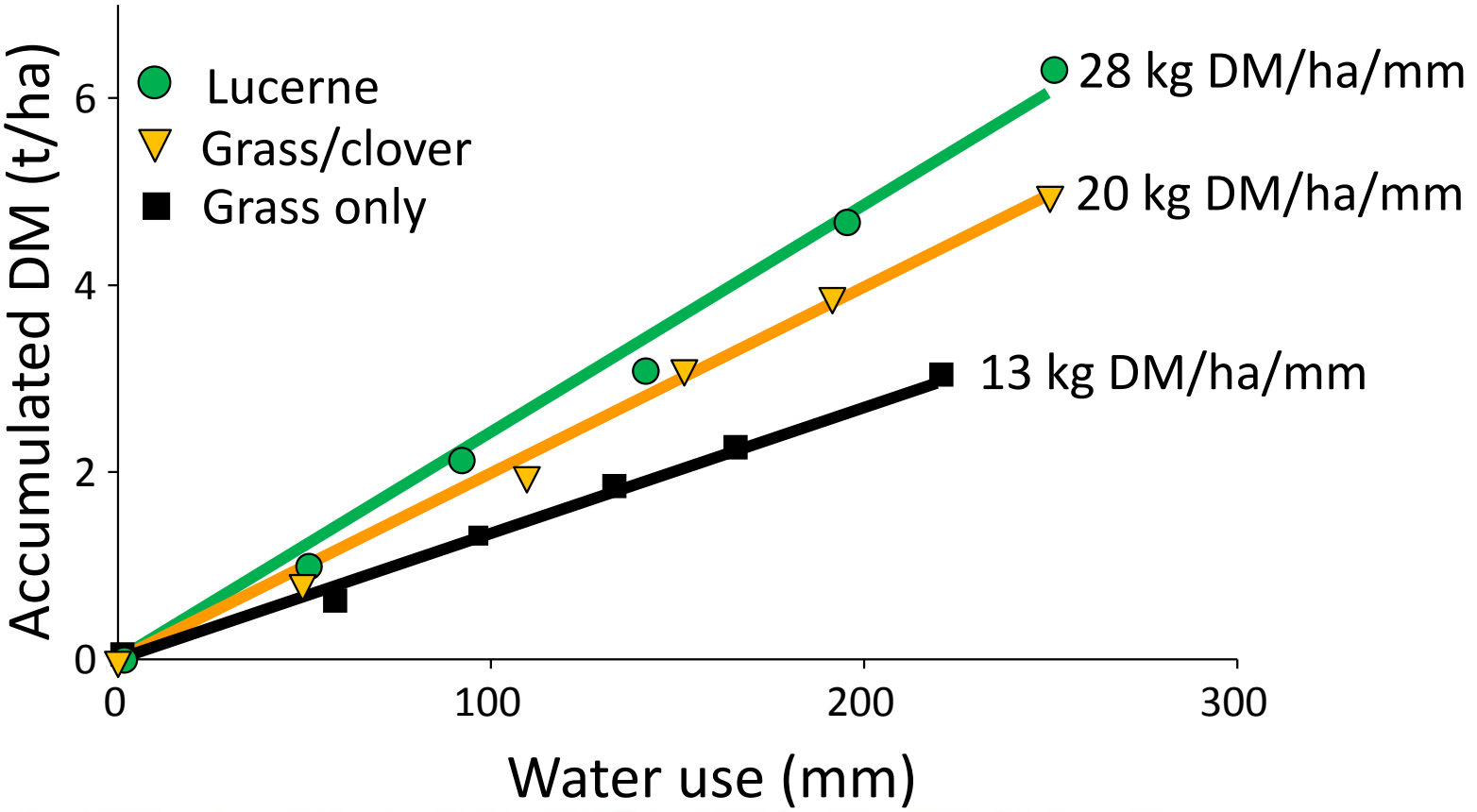
Photo: E.I. Teixeira
Lincoln University

Partitioning to roots



Moot *et al*. 2003b

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

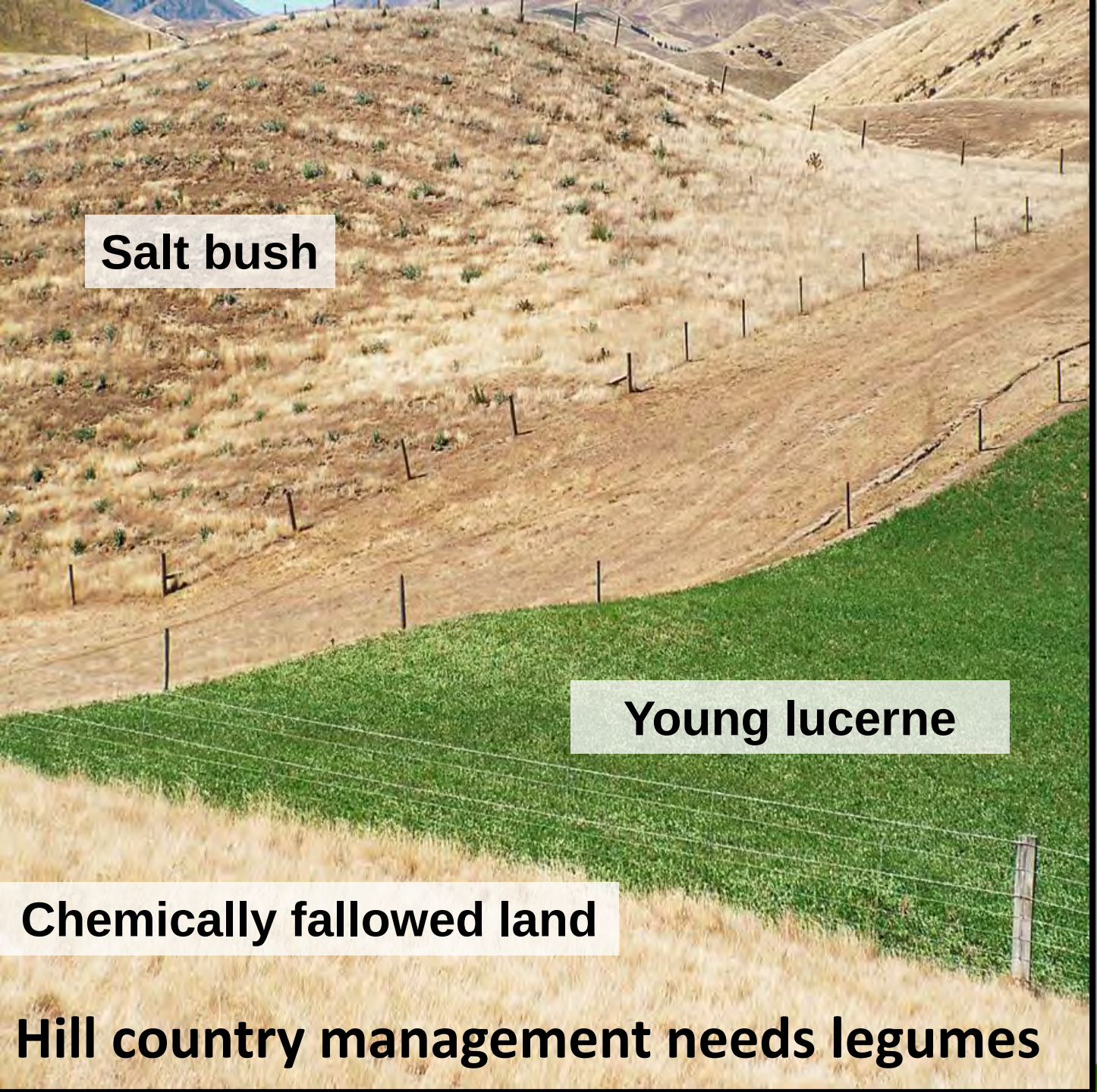
Growing point at the top of the plant

Photo: M. Smith
Lincoln University

Rotation 1 Pre-graze
Plot 1 (21/9/07)
2.3 t DM/ha
20-25 cm tall

TEMPELLO	2001 Corrie/Poll Dorset	2003 Corrie/Poll Dorset	2007 Corrie/Poll Dorset	2016 90% Corrie Flock *
Ewe tup weight	63	65	71	70
MA scanning %	145%	148%	165%	178%
2T & MA Lambing %	128%	128%	138%	135%
Lamb growth rate pre-wean (g/day)	250	374	345	295
Average lamb weaning weight	27	30.9	33	35
Lamb weight/ewe weaned kg	34.5	39.5	45.5	47.25
% Prime at weaning (>32 kg)	50%	75%	85%	89%
SU wintered/ha	8.2			11.5

Data supplied by D & J Grigg, Tempello, Marlborough



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Hill country management needs legumes

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External Data Sources

Slide 3:

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Slide 4:

Energy consumption (TWh) graph data sourced from: https://ourworldindata.org/energy-production-and-changing-energy-sources. Accessed 2/10/2019. Original graph data derived from: Vaclav Smil (2017). Energy Transitions: Global and National Perspectives. & BP Statistical Review of World Energy. Online: http://vaclavsmil.com/2016/12/14/energy-transitions-global-and-national-perspectives-second-expanded-and-updated-edition/ ; https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Slide 5:

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Slide 6:

Data sourced from: https://ourworldindata.org/energy-production-and-changing-energy-sources Accessed 2/10/2019; Smil 2017; http://www.fao.org/faostat/en/#data/OA Accessed 4/10/2019. Regression equation fitted by DPR Team, Lincoln University.

Slide 7/8:

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Slide 9;

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