Rutherglen, Victoria
23rd July 2014

Lincoln University
Te Whare Wānaka o Aoraki
CHRISTCHURCH·NEW ZEALAND

LUCERNE
Agronomy and grazing

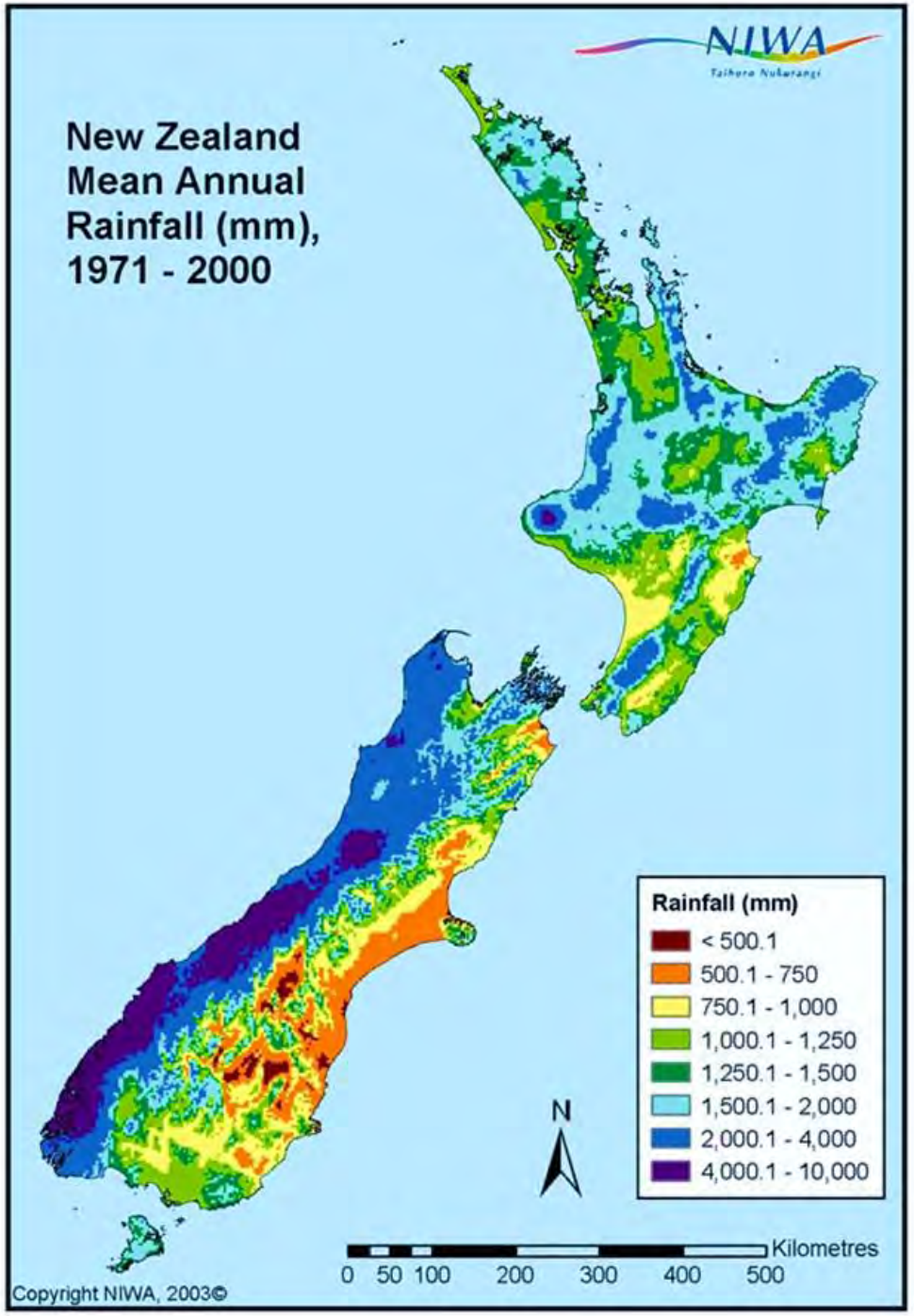
Dr Derrick Moot
Professor of Plant Science

New Zealand's specialist land-based university

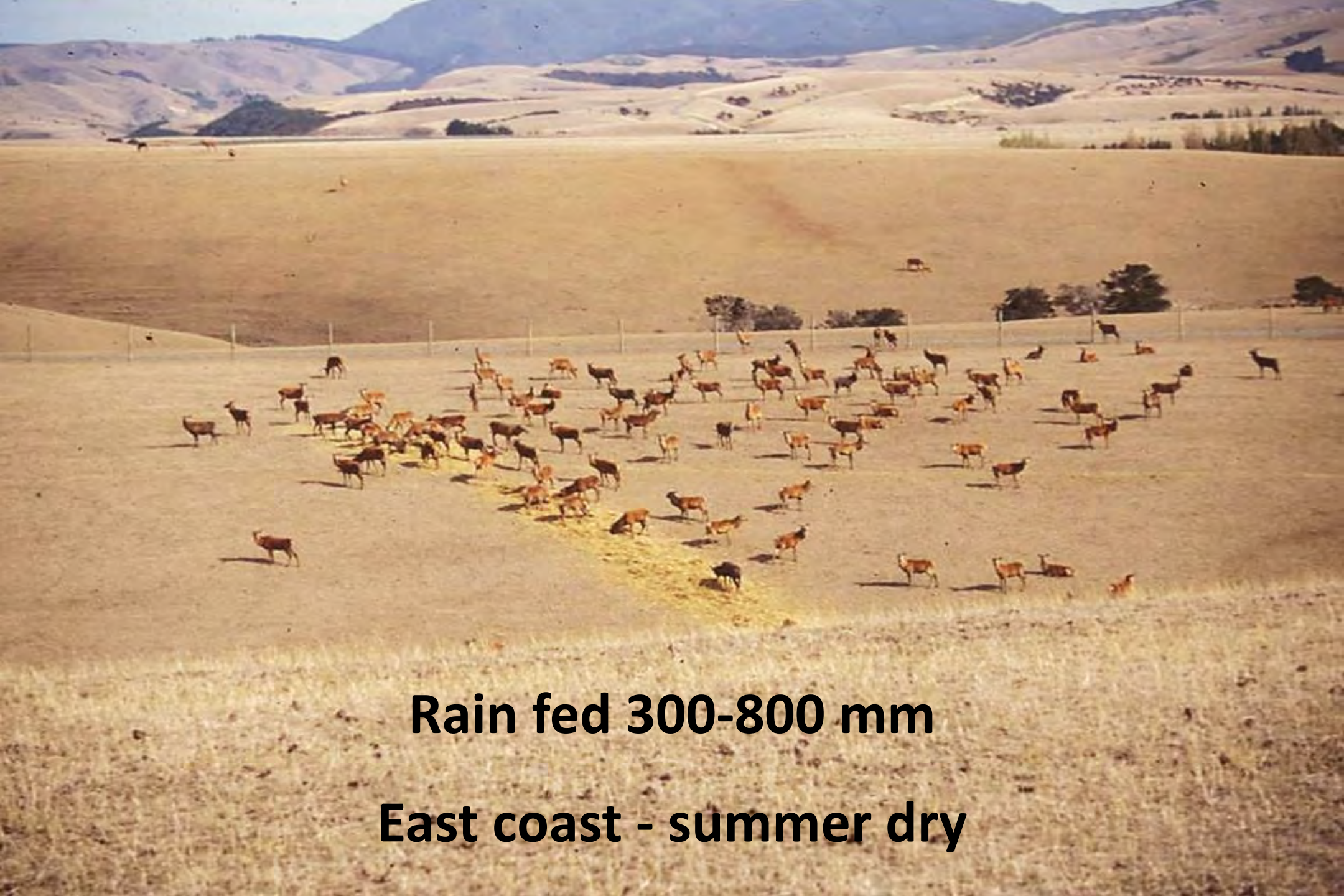
The Village Pub

Roger Protz *and* Homer Sykes

Strong rainfall gradient
West ⇒ East



Source: NIWA 2013



Rain fed 300-800 mm

East coast - summer dry

By 2030 - Drier:

Drought – increased duration and frequency

Annual and tap rooted dryland pasture species?

Objectives

- Outline the role of lucerne in New Zealand farming systems
- Describe management to maximise production, quality and persistence
- Reference “Legumes for Dryland Pastures” Grassland Research and Practice Series No. 11. 2003. pg’s 201-208.
- www.lincoln.ac.nz/dryland

Why lucerne 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?

a) Farmer questions?

- Which dryland species?
- Lucerne – cut and carry in spring
- Pests in the 80’s

Resistance to Pests and Diseases

Lincoln University
Te Whare Wānaka o Aoraki
CHRISTCHURCH·NEW ZEALAND

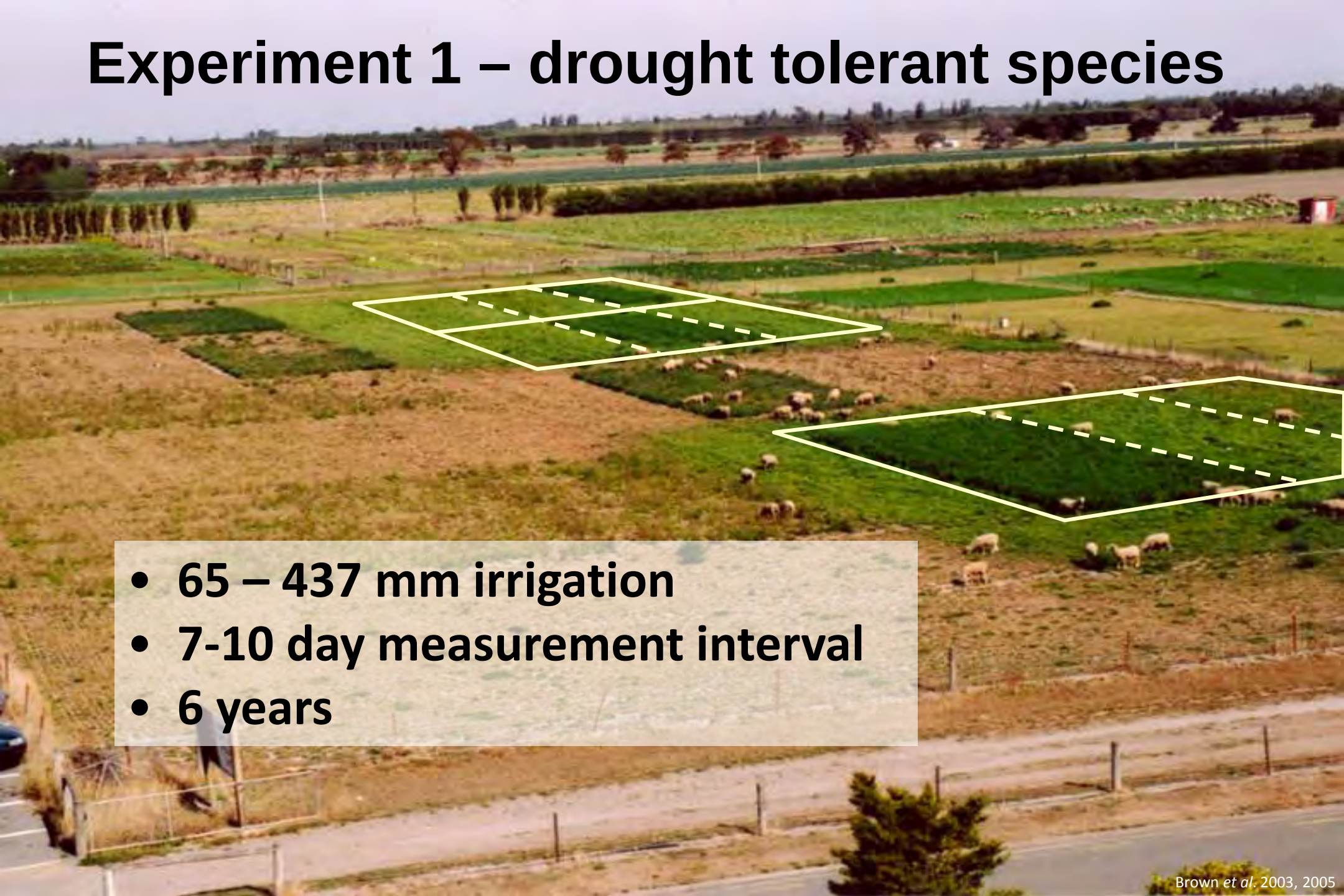
Cultivar	Dormancy	BGA	PA	SAA	BW	SN	PRR	VW	LD
Grasslands Kaituna	I	R	R	R	R	R	R	-	MR
Grasslands Otaio	I	R	R	R	R	R	R	-	S
Grasslands Torlesse	D	HR	R	R	R	-	R	-	MR
P54Q53	D	MR	MR	MR	HR	HR	HR	-	-
P54V09	D	-	HR	R	HR	HR	HR	HR	-
Runner	D	-	-	-	R	-	S	-	-
Wairau	SD	S	S	S	S	S	S	S	S
WL 325HQ	I	R	R	R	R	MR	R	-	-

BGA = Blue-green aphid
PA = Pea aphid
SAA = Spotted alfalfa aphid
BW = Bacterial Wilt
SN = Stem nematode
PRR = Phytopthora root rot
VW = Verticillium wilt
LD = Leaf diseases

D = Dormant
HR = 50%+ resistant
R = Resistant = (31-50%)
SD = Semi-dormant
MR = 16-30%
S = Susceptible

Adapted from: Dunbier & Easton 1982

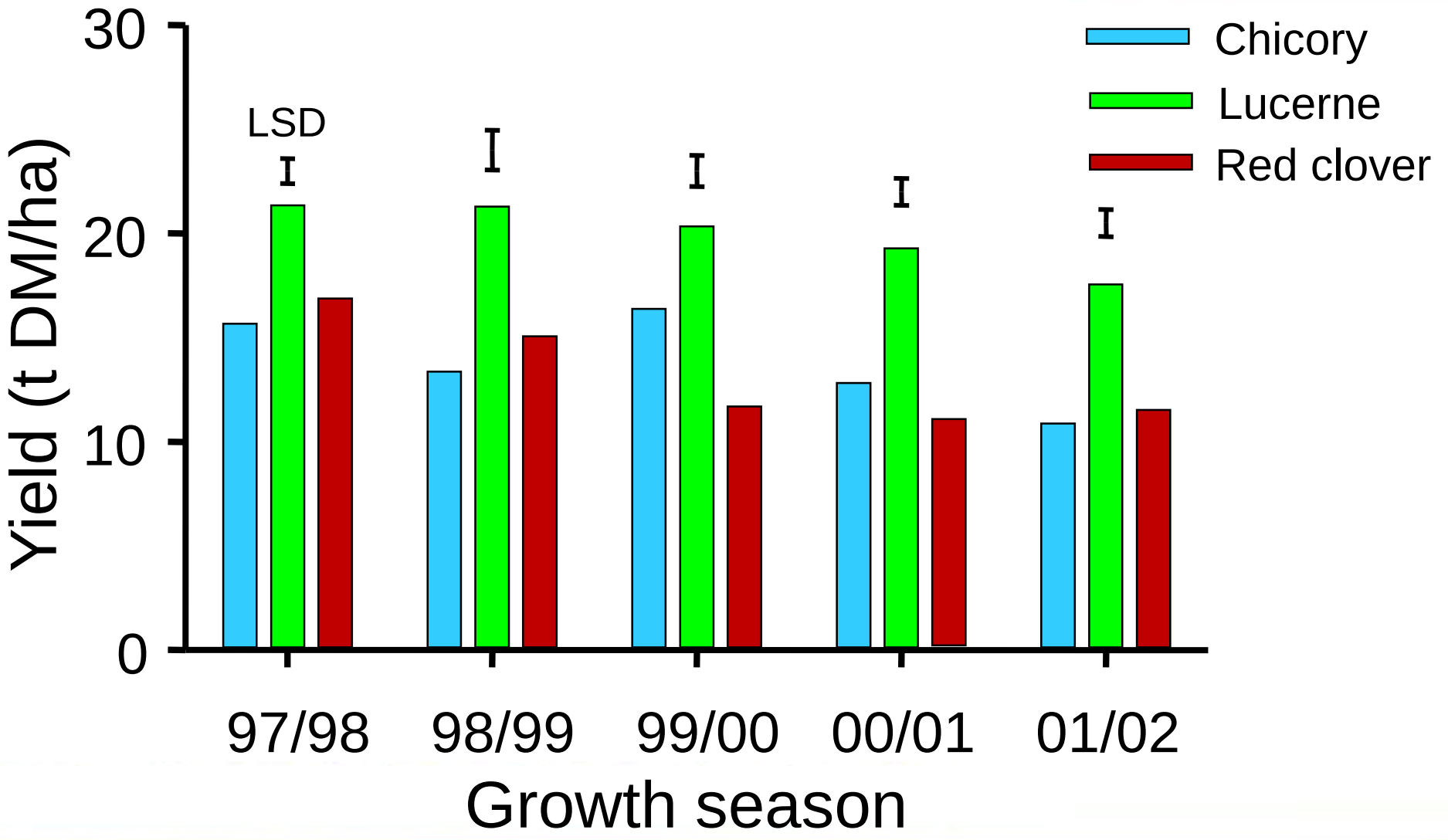
Experiment 1 – drought tolerant species



- 65 – 437 mm irrigation
- 7-10 day measurement interval
- 6 years

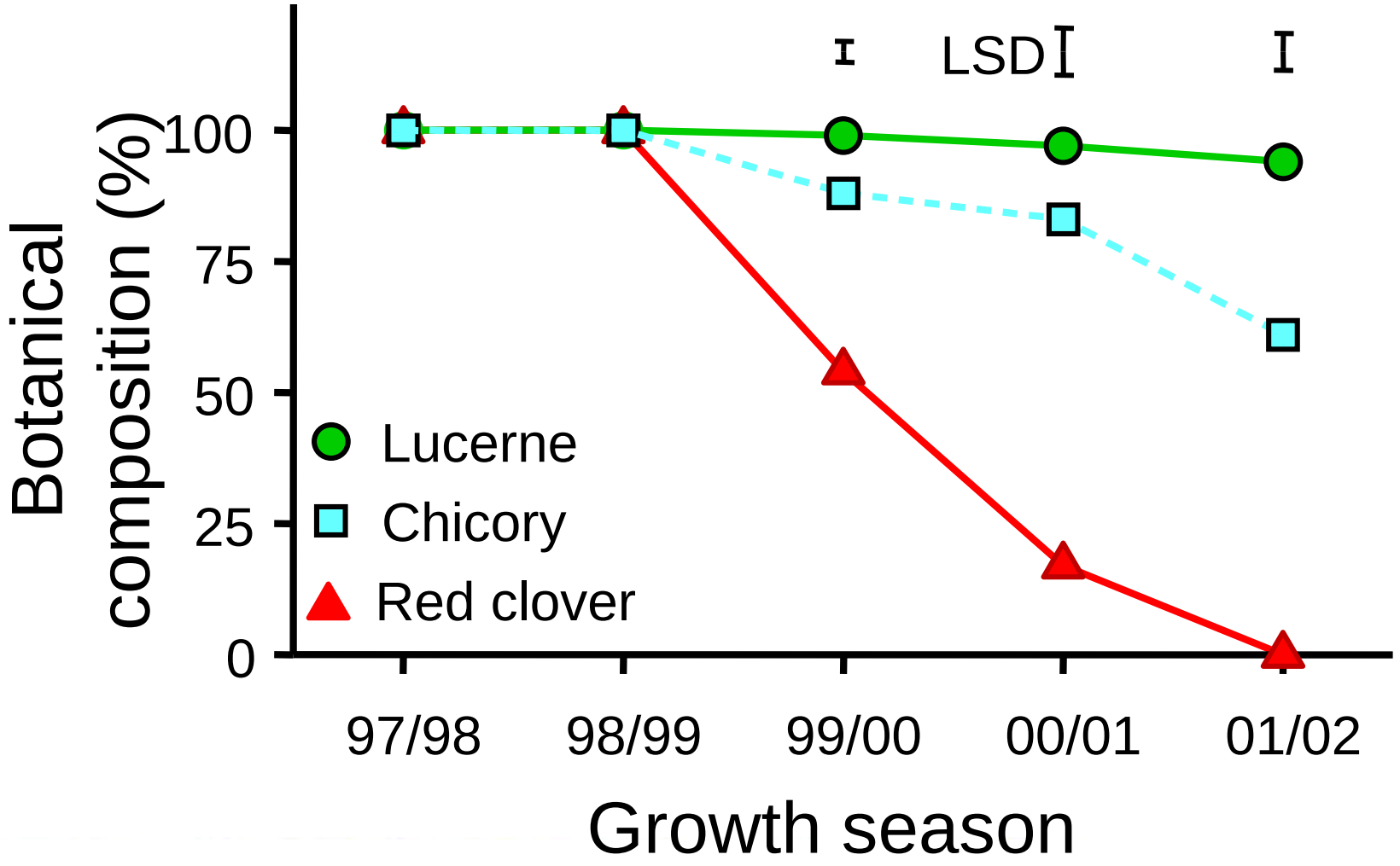
Brown *et al.* 2003, 2005

Annual dry matter yields



Brown *et al*. 2005

Persistence



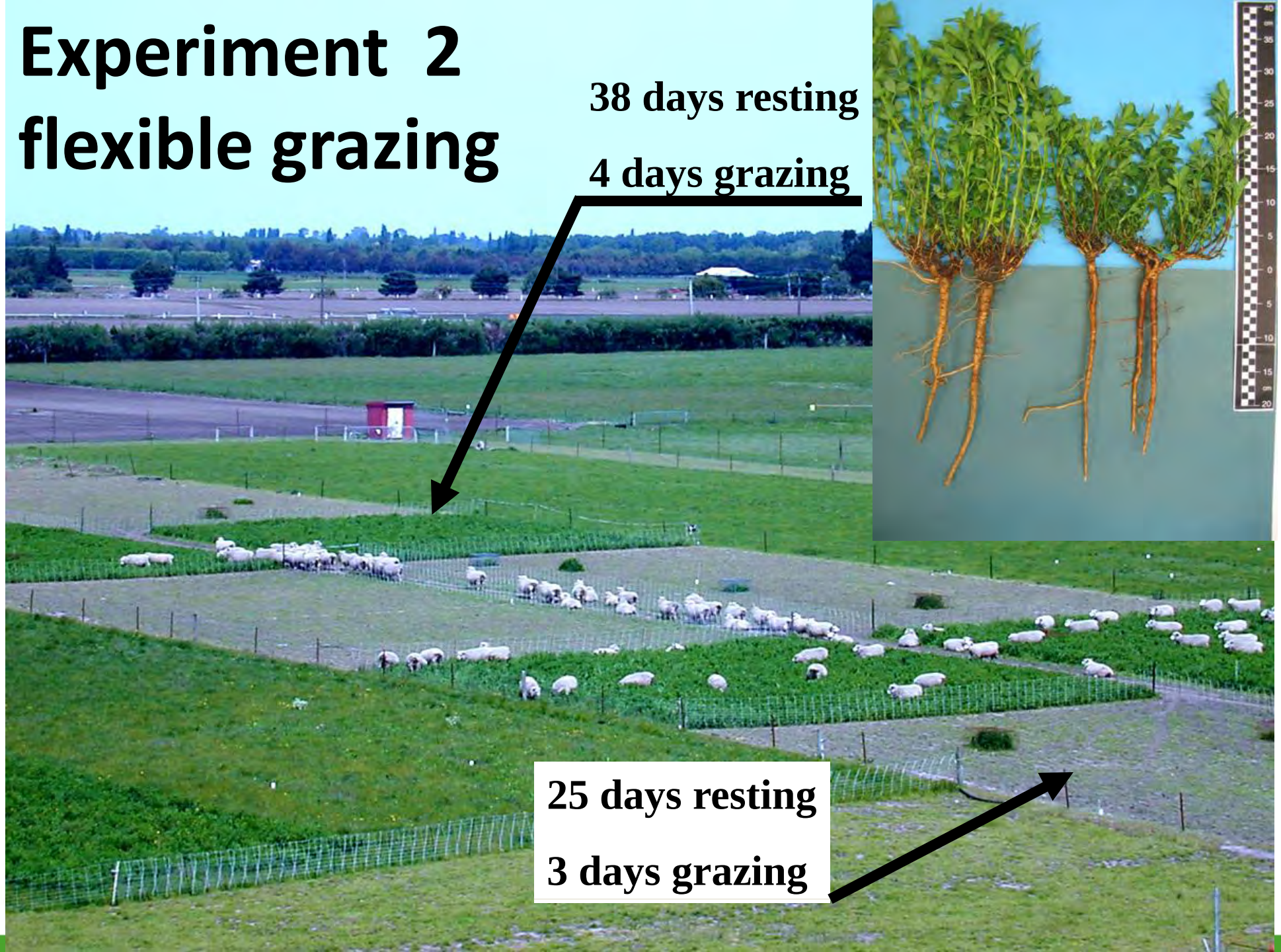
Brown *et al*. 2004

Farmer issues

b) With lucerne - inappropriate US mgmt!

- 10% flowering – basal bud formation
- Average 23% higher but 3-weeks later
- Ewes and lambs on lucerne pre-weaning

Experiment 2 flexible grazing



Growth:

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

Development:

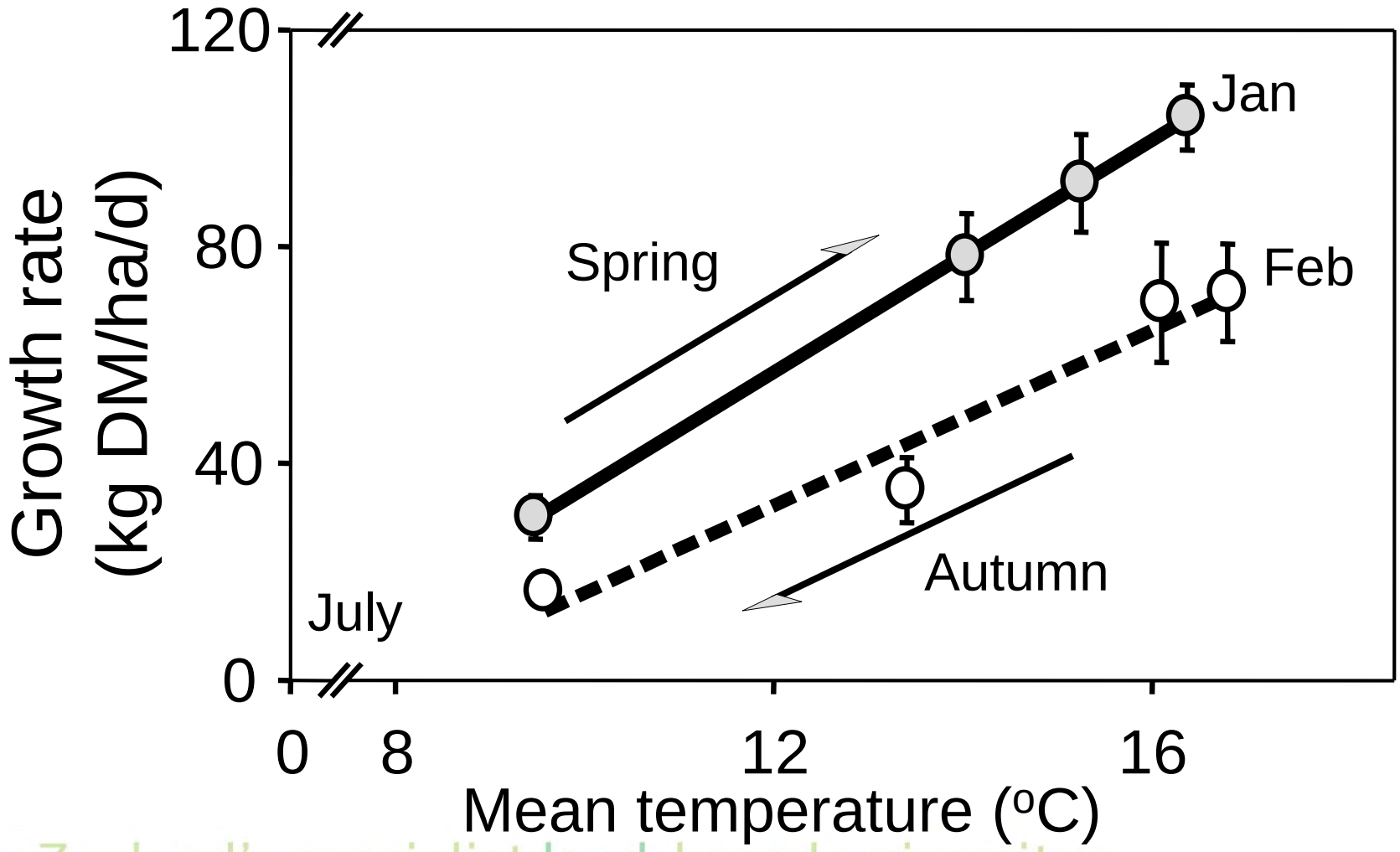
is the 'age' or maturity of the regrowth crop

e.g. leaf appearance, flowering

Growth and development are both influenced by environmental signals

The canopy: the energy capture device

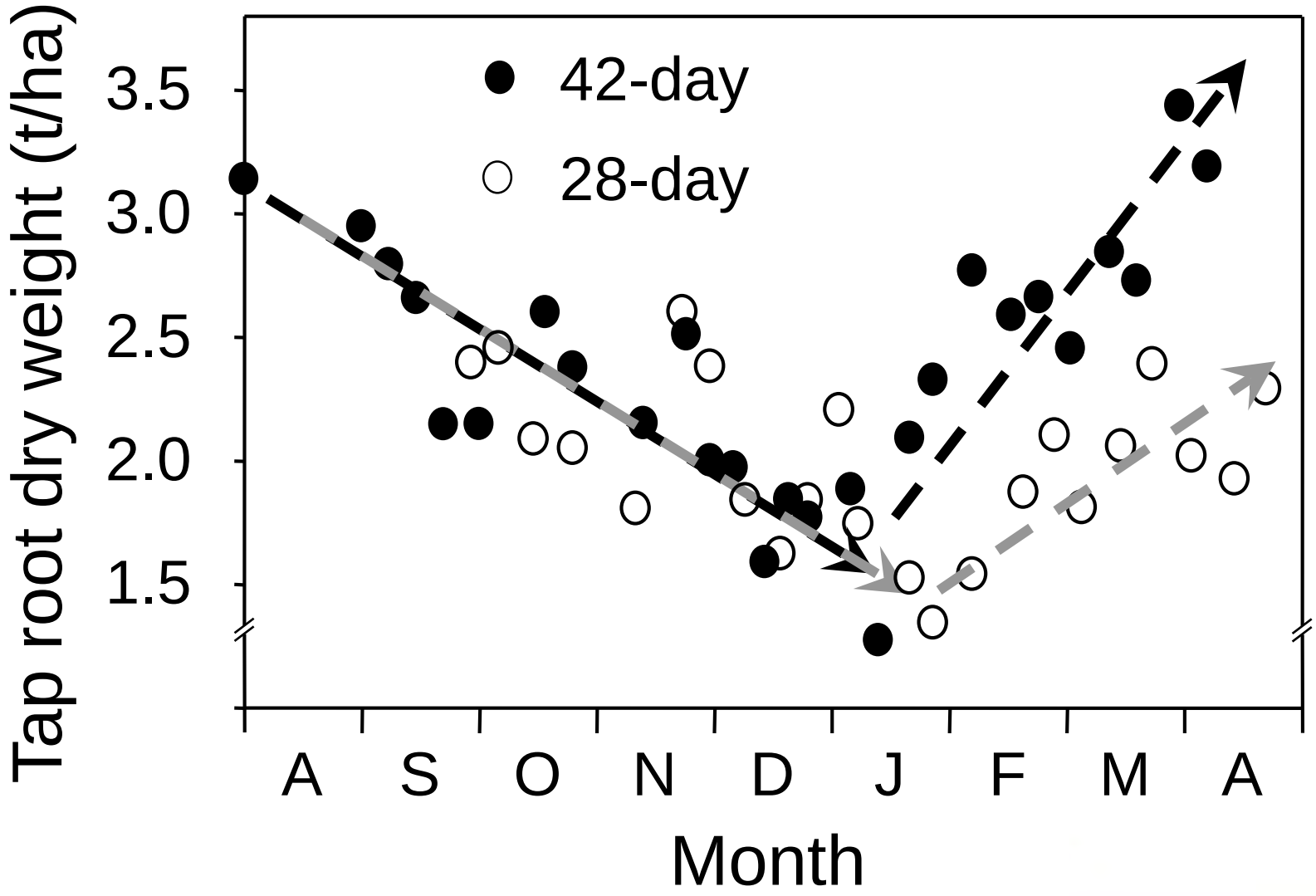
Vegetative growth



Source: Moot *et al*. 2003

What's going on down there?

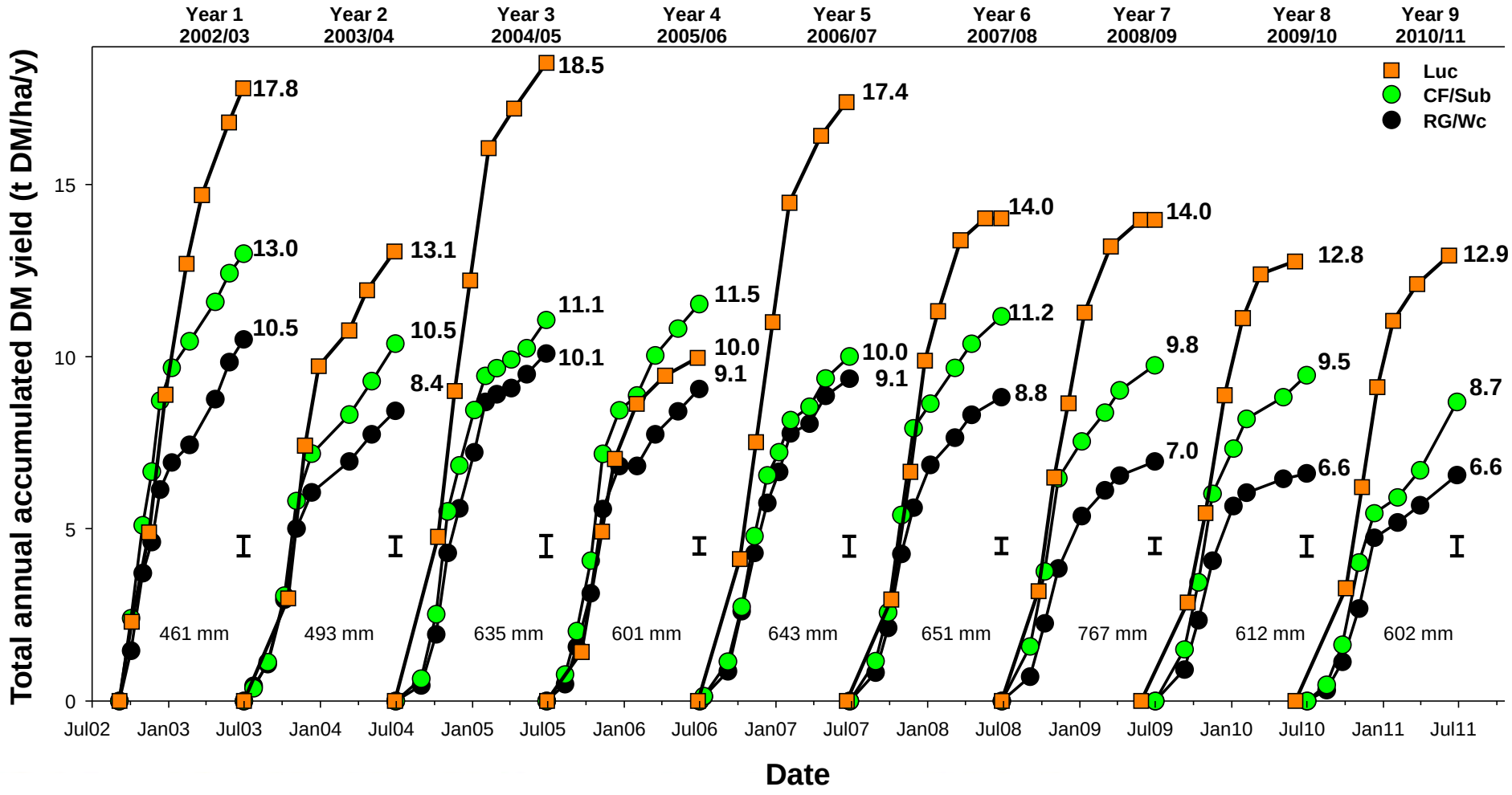
Partitioning to roots



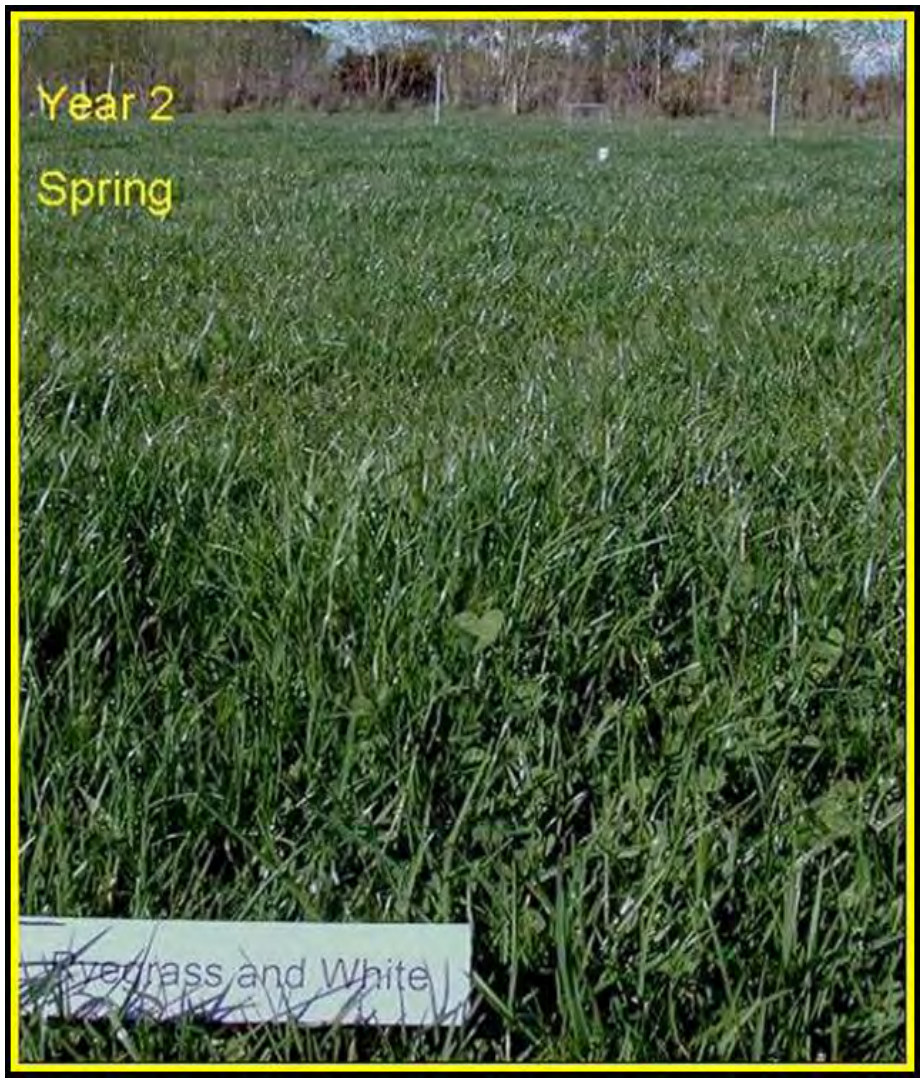
Source: Moot *et al*. 2003

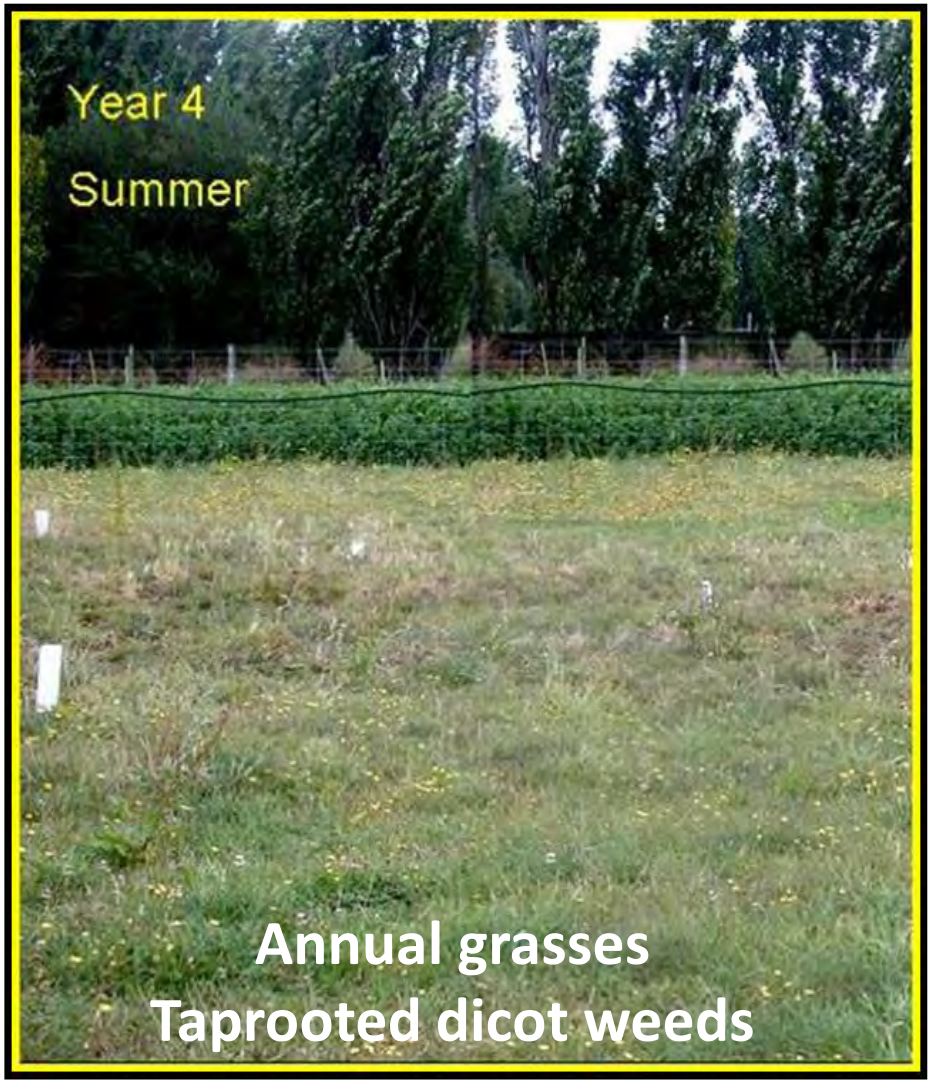
Grazing Expt 3 - ‘MaxClover’

MaxClover Total DM yields



Source: Moot 2012

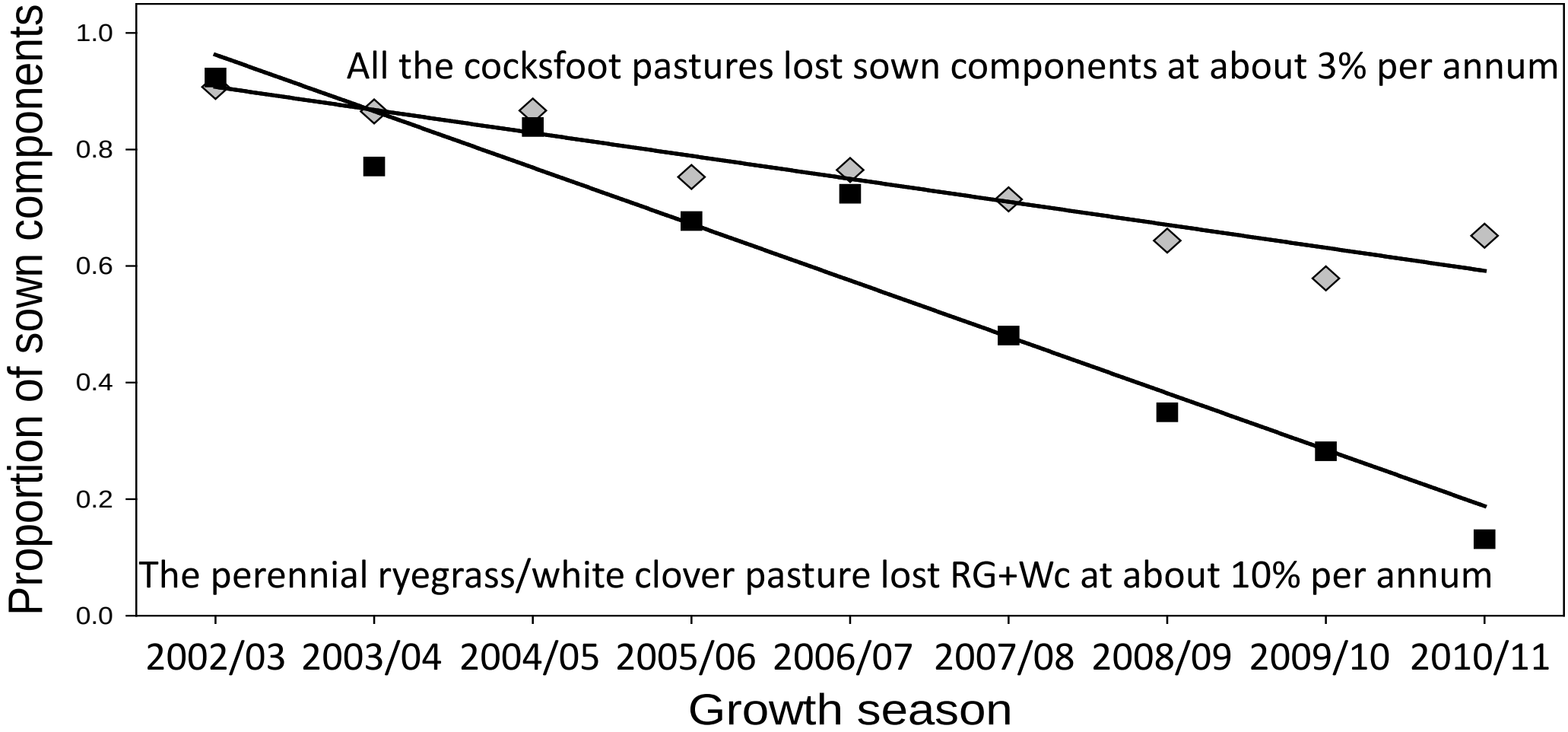




Unsown species <5% in Year 1 …….>45% in Year 6

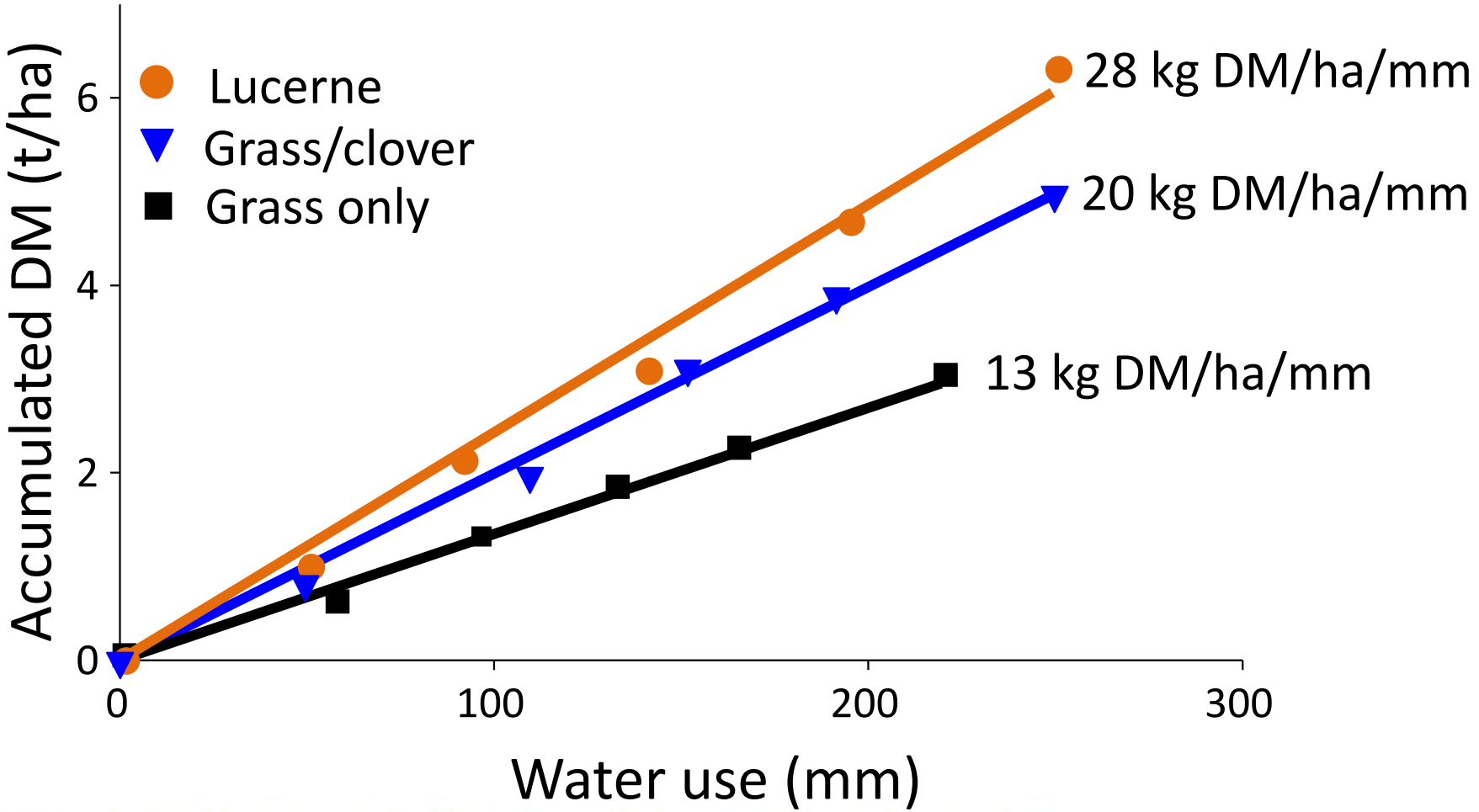
RG/Wc pastures

Change in the proportion of originally sown pasture components (grass + clover) over time



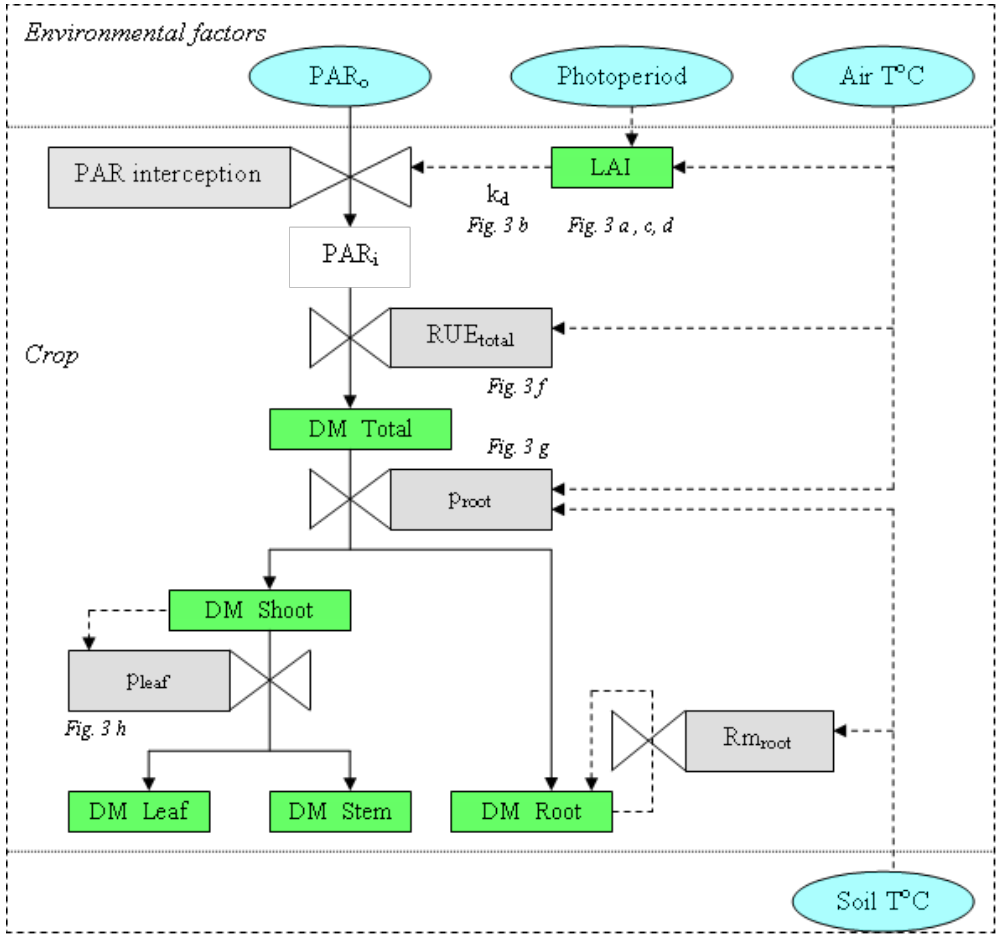
Source: Mills *et al.*, 2014a

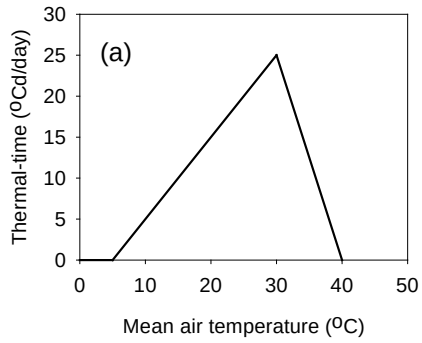
Spring WUE

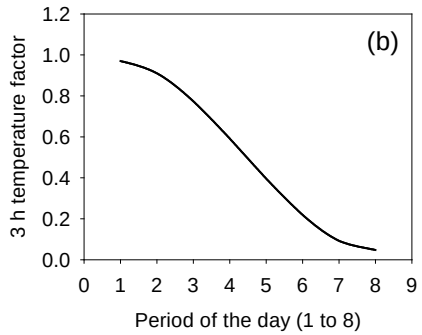


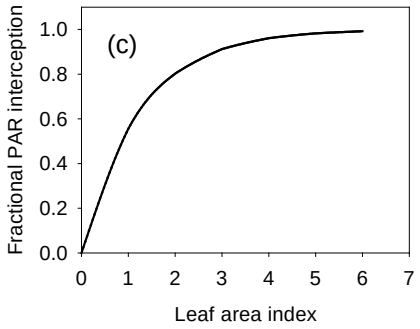
Source: Moot *et al*. 2008

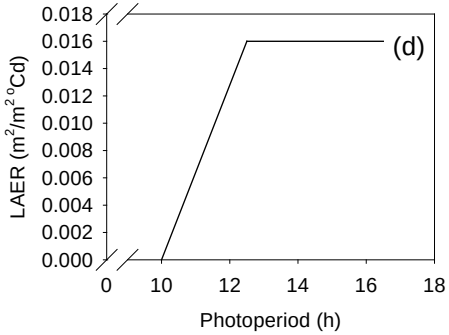
Modelling

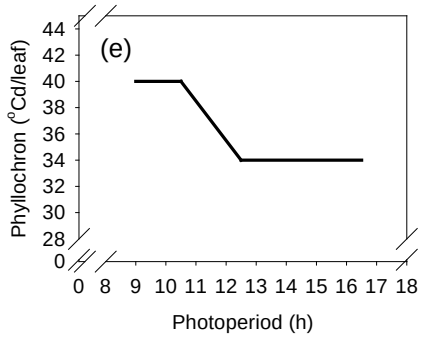

Environmental factors
PAR$_o$
Photoperiod
Air T°C
PAR interception
LAI
k_d
Fig. 3 b
Fig. 3 a, c, d
PAR$_i$
Crop
RUE$_{total}$
Fig. 3 f
DM Total
Fig. 3 g
p_{root}
DM Shoot
p_{leaf}
Fig. 3 h
Rm$_{root}$
DM Leaf
DM Stem
DM Root
Soil T°C

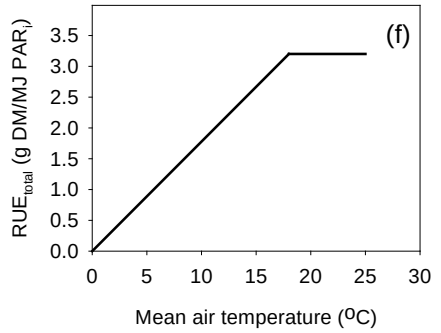

(a)
Thermal-time (°Cd/day)
Mean air temperature (°C)

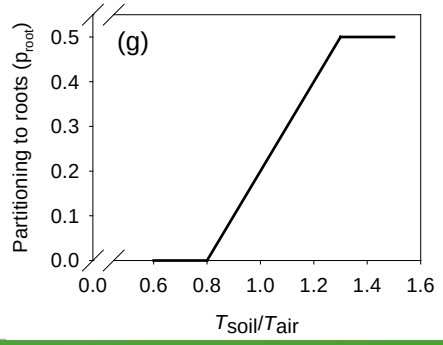

(b)
3 h temperature factor
Period of the day (1 to 8)

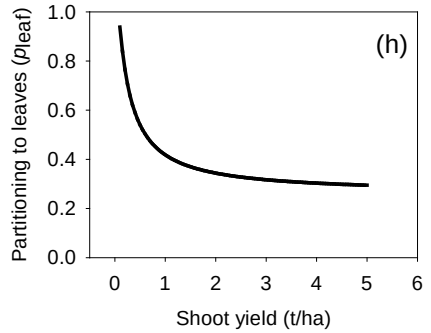

(c)
Fractional PAR interception
Leaf area index


(d)
LAER (m²/m²°Cd)
Photoperiod (h)

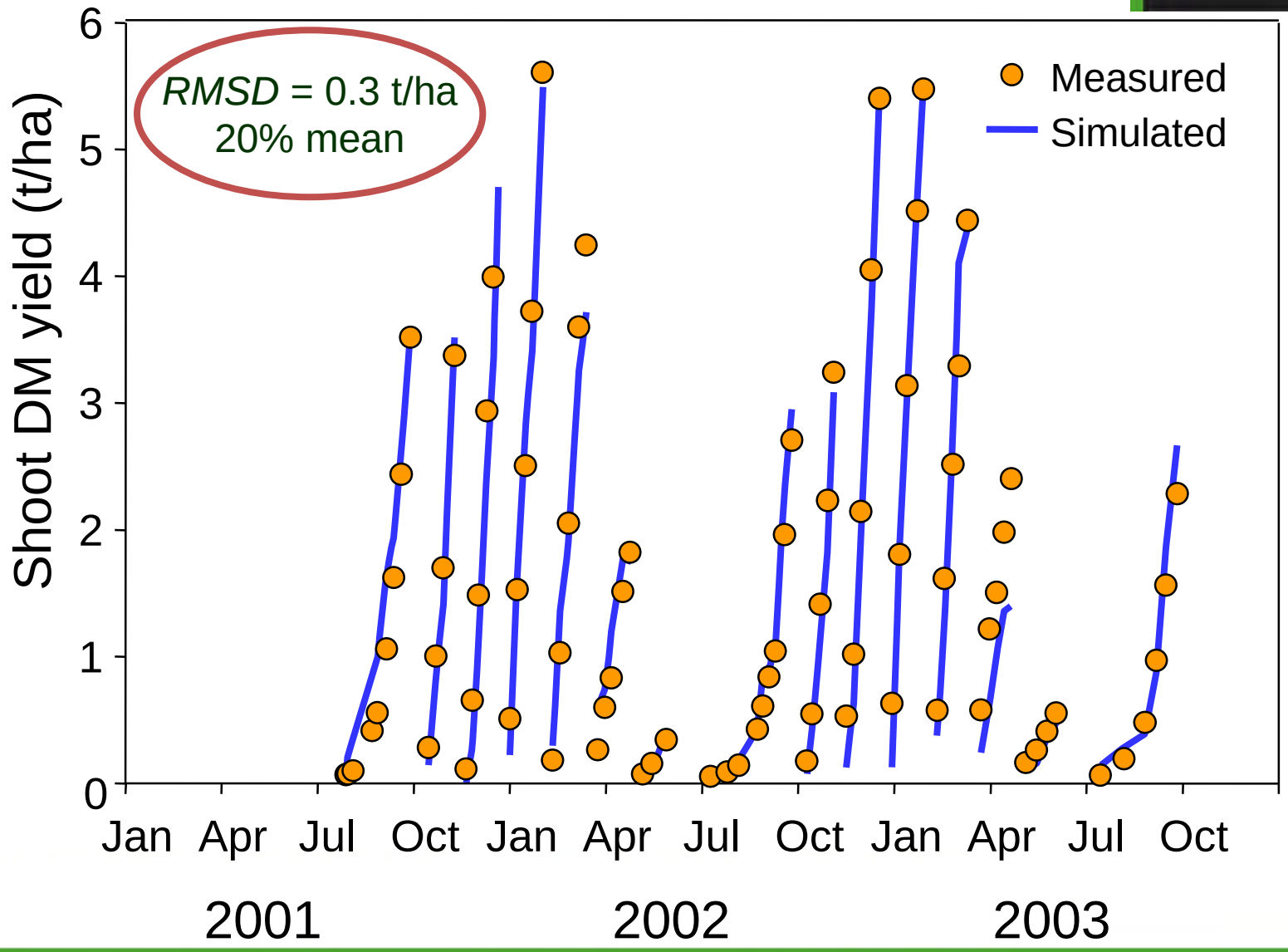

(e)
Phyllochron (°Cd/leaf)
Photoperiod (h)


(f)
RUE$_{total}$ (g DM/MJ PAR$_i$)
Mean air temperature (°C)

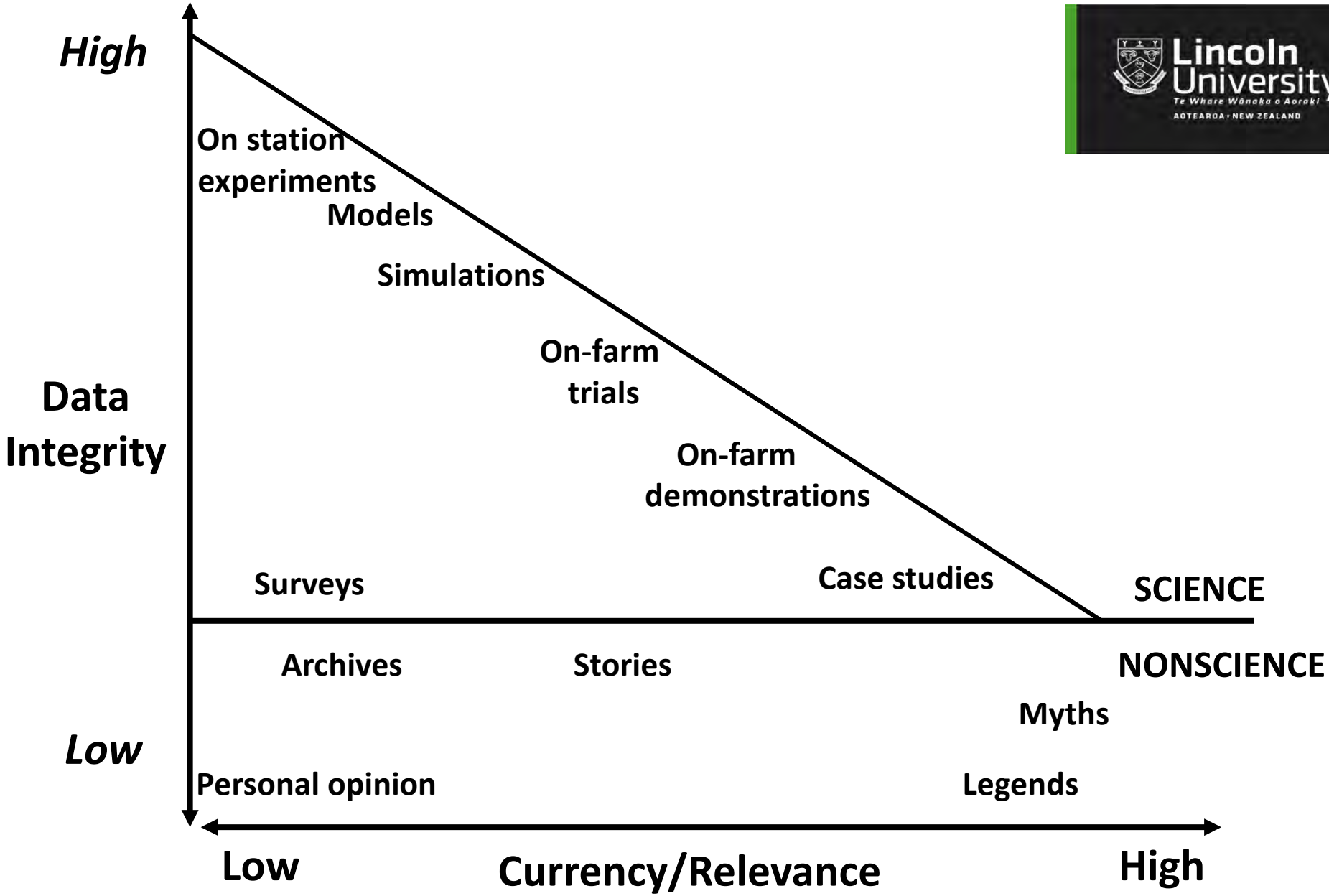

(g)
Partitioning to roots (p_{root})
T_{soil}/T_{air}


(h)
Partitioning to leaves (p_{leaf})
Shoot yield (t/ha)

Predictions of shoot yield



Source: Teixeira *et al*. 2011



Source: Modified from Carberry 2001, based on Bonoma 1985 and Crookston 1994

SERVANT LEADER

Extension – solution to every problem

Seasonal grazing management

Spring

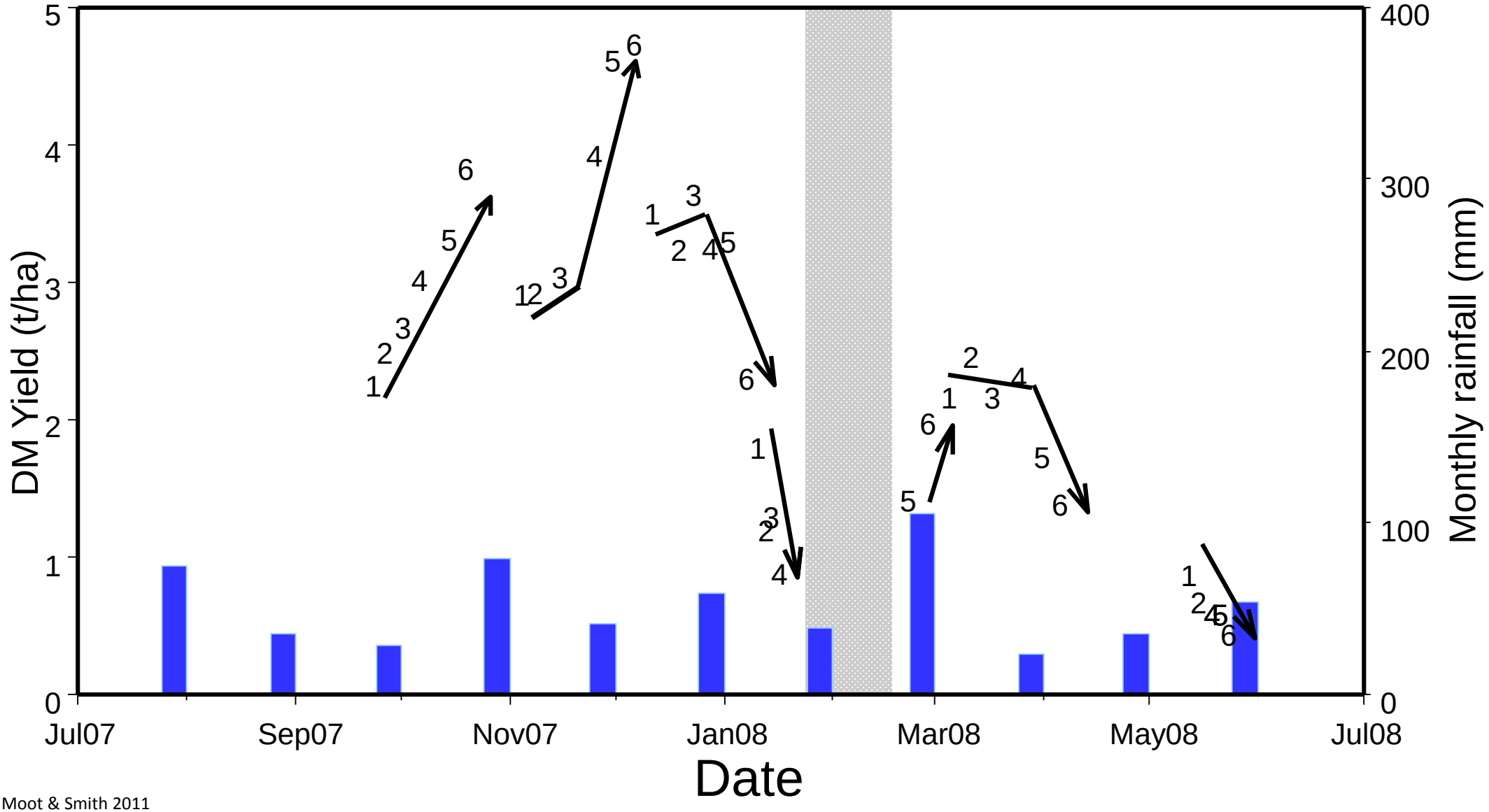
- 1st rotation aided by root reserves to produce high quality vegetative forage.

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

Growing point at the top of the plant

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

MaxClover – 38-42 day rotation



Moot & Smith 2011
Practical Lucerne Management Guide

Rotation 2 Pre-graze
Plot 1 (2/11/07, 38 d)
2.9 t DM/ha
35-40 cm tall

5th September 2011 – Cave Sth Canterbury

Lincoln University
Te Whare Wānaka o Aoraki
AOTEAROA • NEW ZEALAND

Photo: A Black

Stocking rates in New Zealand

- Spring 14 ewes plus twins/ha
- Summer 70 lambs/ha
- Ideally 7-14 days maximum on any one paddock
- Less intensive systems – don’t open the canopy


Spring grazing

Seasonal grazing management

Lincoln University
Te Whare Wānaka o Aoraki
CHRISTCHURCH • NEW ZEALAND

Spring/summer (Nov-Jan)

- Priority is stock production (lamb/beef/deer)
- graze 6-8 weeks solely on lucerne
- 5-6 paddock rotation stocked with one class of stock (7- 10 days on)
- allowance 2.5-4 kg DM/hd/d – increase later in season


14 ewes + twins/ha

High numbers for 7-10 days


Fibre and salt

Maximize reliable spring growth – high priority stock

Seasonal grazing management

Lincoln University
Te Whare Wānaka o Aoraki
AOTEAROA • NEW ZEALAND

Early autumn (*Feb-April*)

- terminal drought ⇒ graze standing herbage
- allow 50% flowering
- long rotation (42 days) somewhere between Jan and end of May.

⇒ **build-up root reserves for spring growth and increase stand persistence**

Autumn = flowering plants
But don't flush on this!

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

Animal health

- **Clostridial bacteria:** vaccinate
- **Cobalt:** vitamin B12 injection
- **Worm haven:** Camping on small area – river edge?
- **Avoid flushing if:** leaf spots or flowering lucerne
  - new regrowth or tops only are O.K.

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

Lucerne establishment

- **Weed control** – pre sowing
- **Sowing method** – cultivation or direct drill
  e.g. Post spring fallow in low (<600 mm) environments
- **Management** – hard graze at 15 cm if weedy
- **Flowering** – 50% of stems with an open flower and then graze or cut.

Lucerne root

~8 months after sowing

> 1.5 m length

Photo: D. Hollander
Lincoln University

Resilience through change – “Landscape farming”

Where to plant

Sheep prefer 70% legume, 30% grass


BOG ROY
EST. 1891


Landscape farming

Establishment

Soils
- deepest free draining soils
- pH 6.0 (in H_20 = approx. 5.2 in CaCl)
- RG/Wc fertility

Sowing
- 8-10 kg/ha
- 10-25 mm
- peat inoculated 8-10 kg/ha
- *spring or autumn*
- cultivated/direct drilled (DAP)

Autumn Spraying

Timing is Critical

Most important tool

Glyphosate, granstar, penetrant

<u>Key Results</u>

Conserve soil moisture

Kill mass root systems

Source: Kearney *et al.* 2010

Transformational change
&
Resilience to climate change

Lime and Fertiliser Application

Lime 3-5 ton/ha

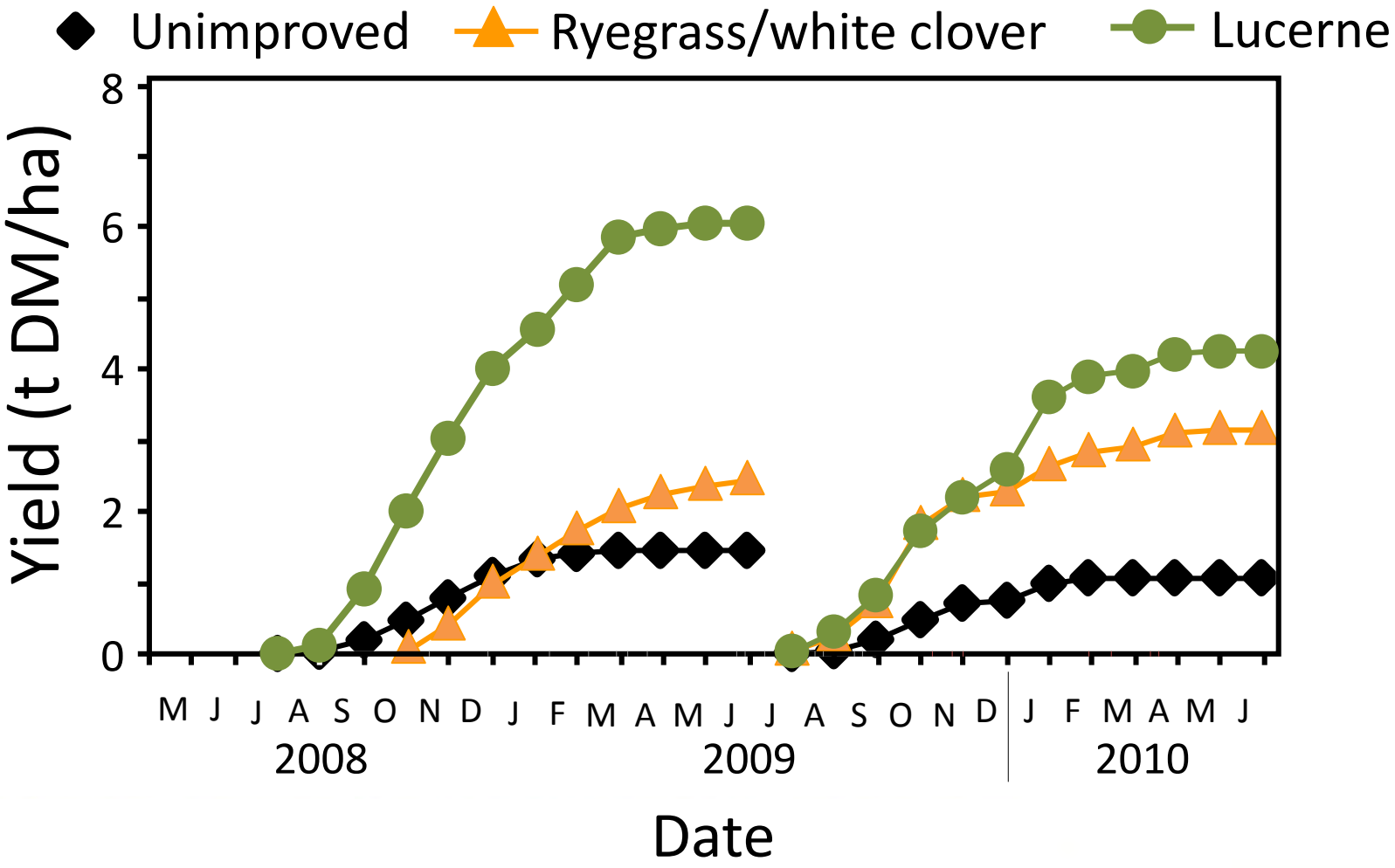
Fertiliser 250-500kg/ha

Drilling seed with fertiliser
Direct drilling = seed + fertiliser

Over 60,000 ha sown and doubling of lucerne seed sales over 10 years

“35% Rate of return on investment”

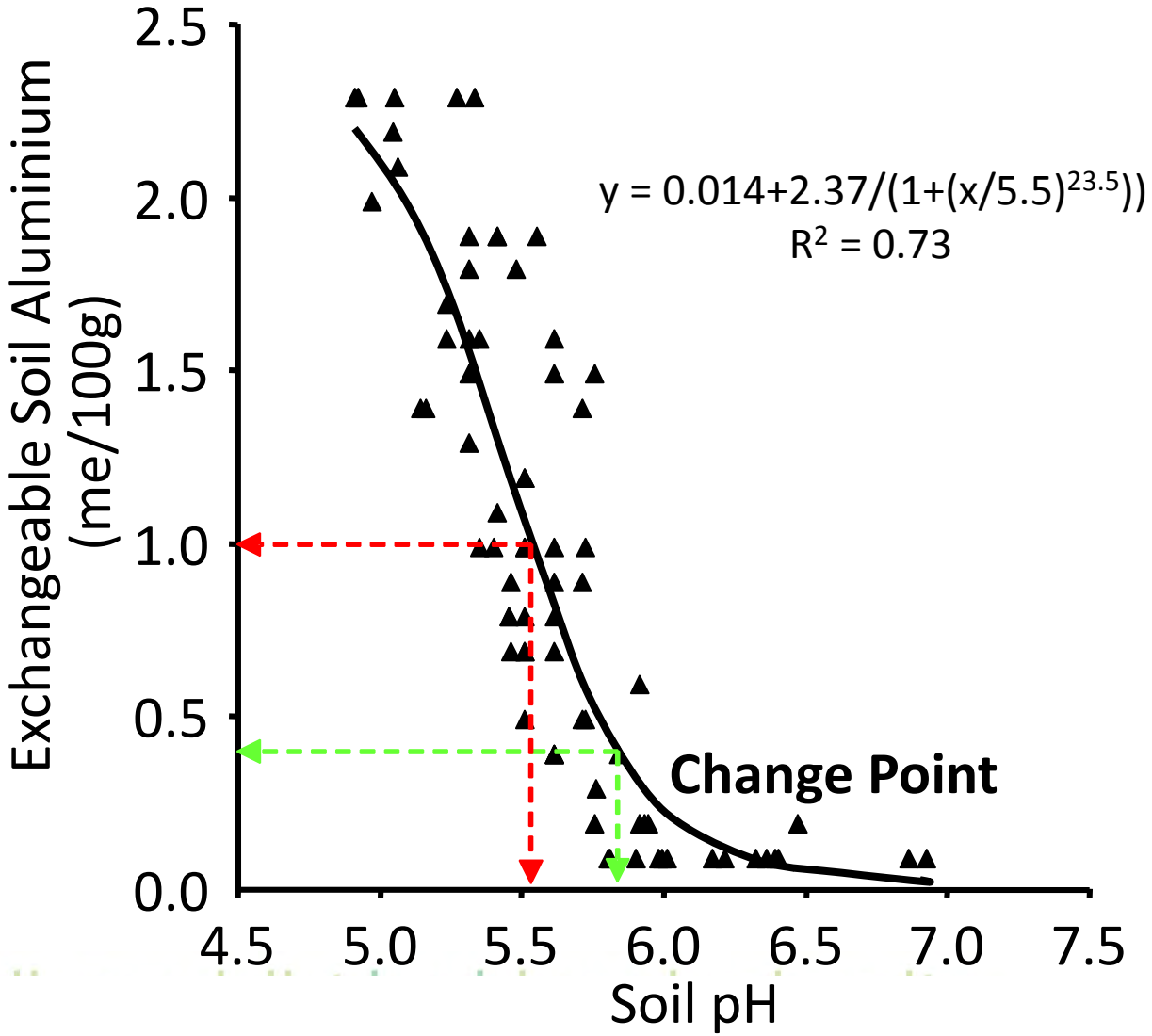
Pasture growth



Kearney *et al*. 2010

Aluminium issues

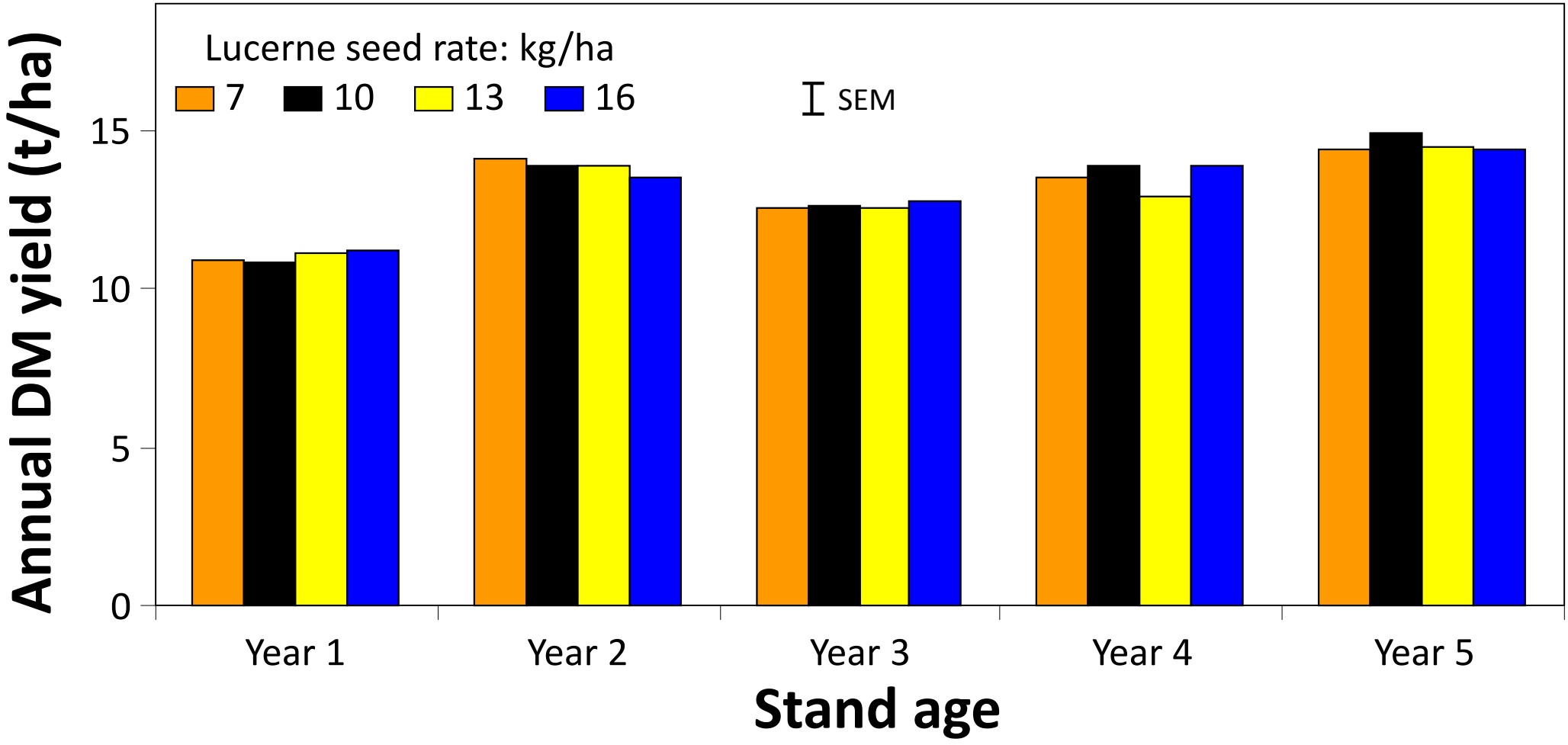
Soil pH & exchangeable Aluminium



Moir & Moot, 2010

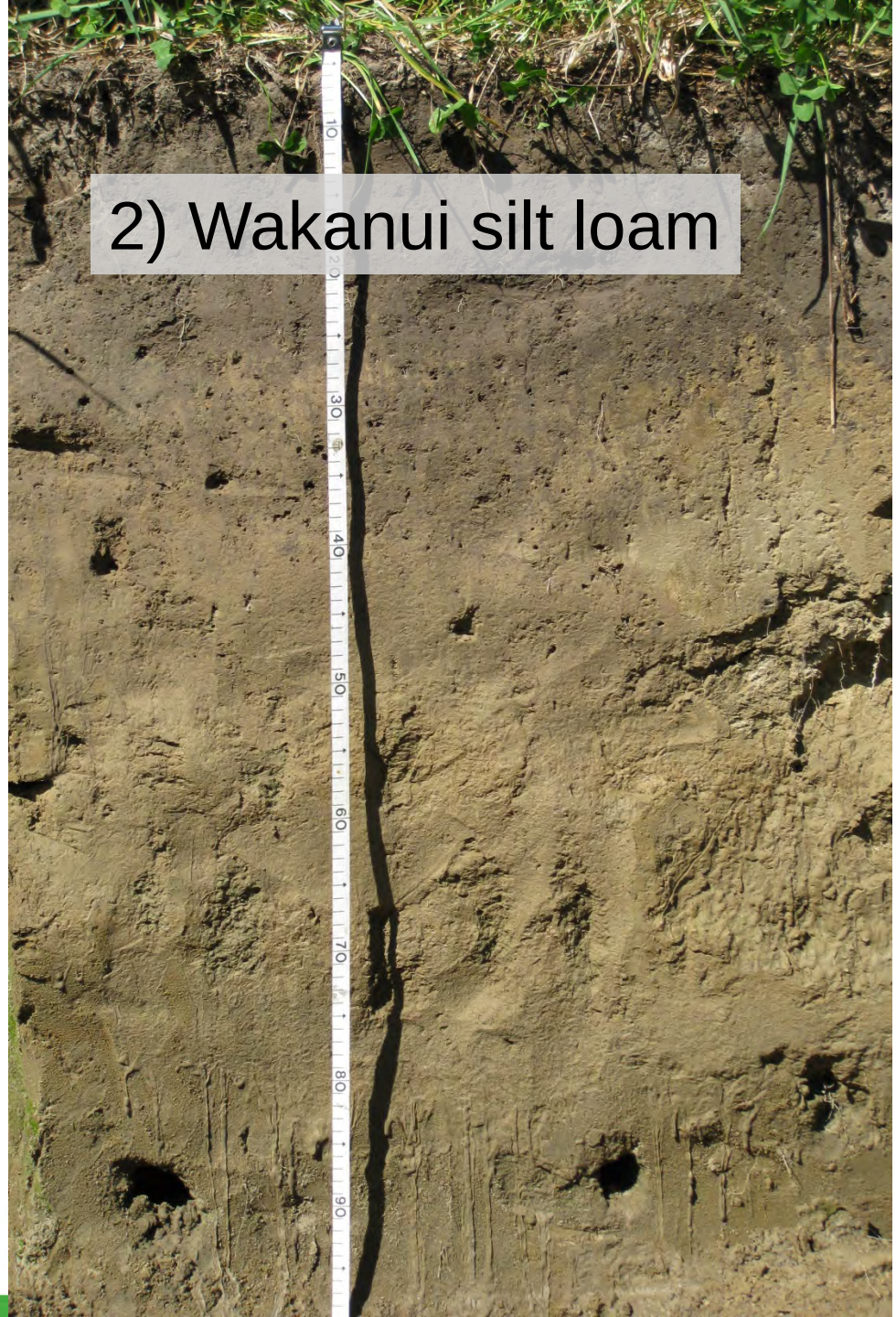
Lupins tolerate aluminium

Annual yield in relation to sowing rate

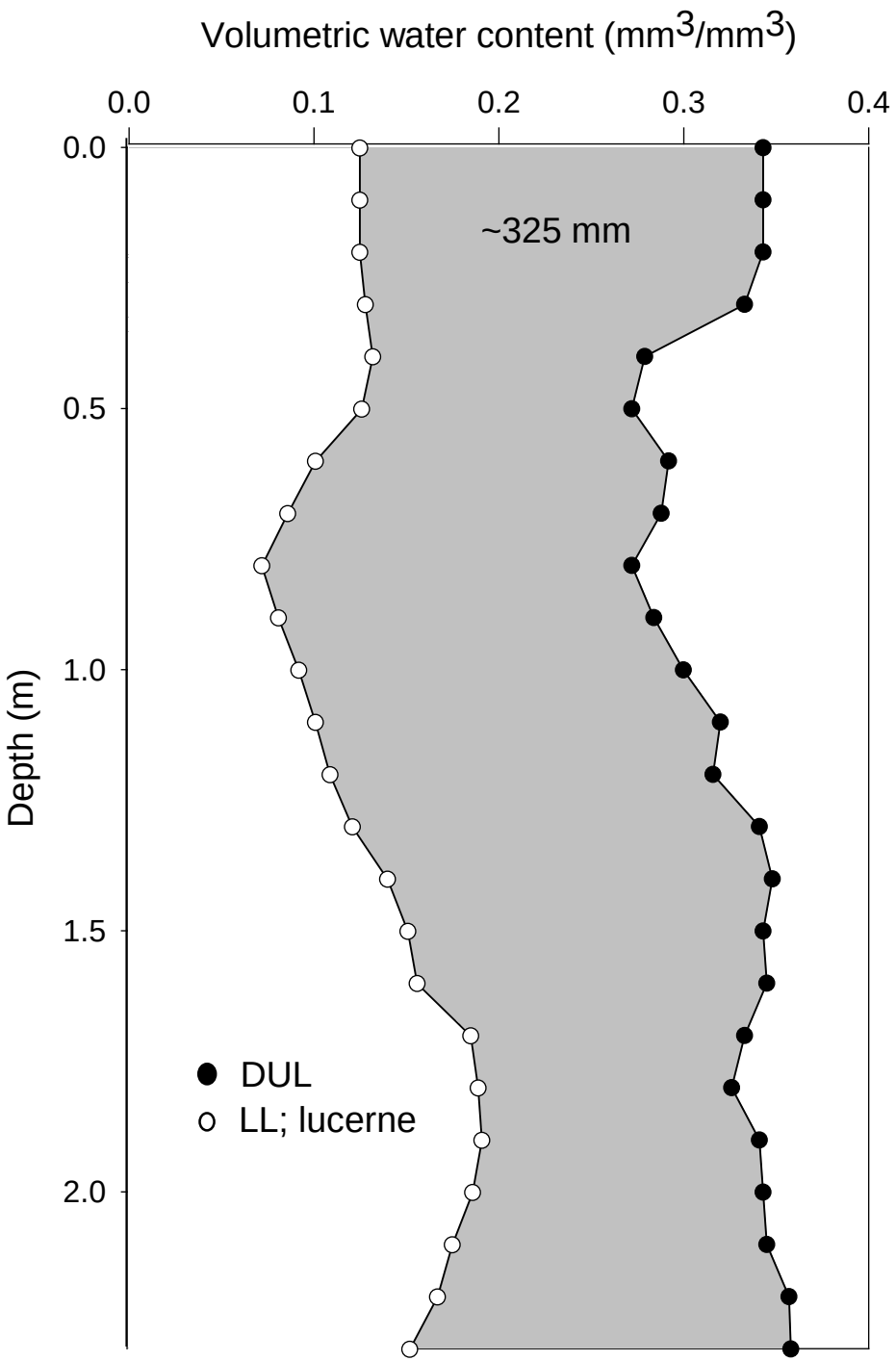


Source: Moot *et al*. 2012

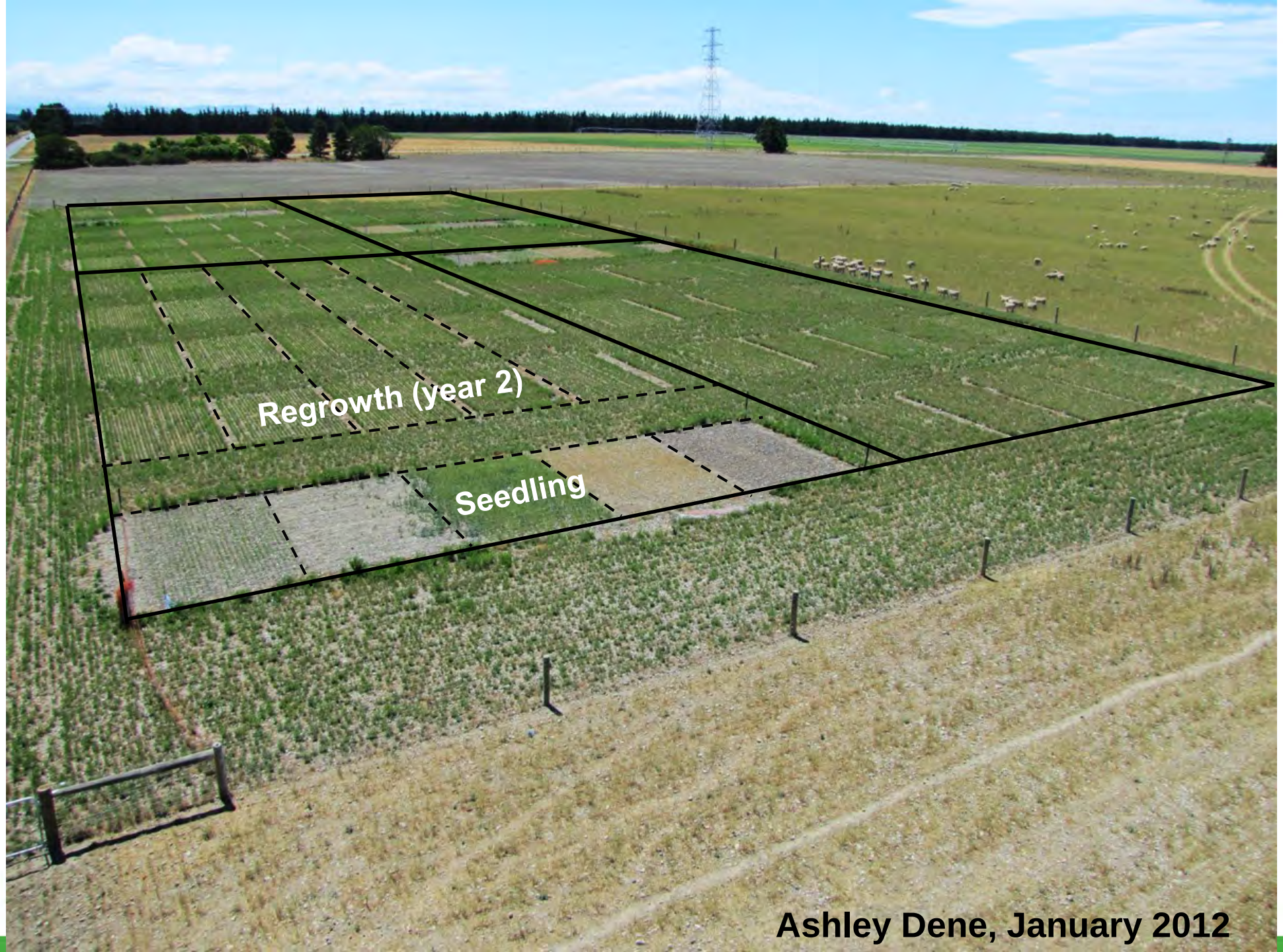

Iversen 12, January 2012
Seedling
Regrowth (year 2)



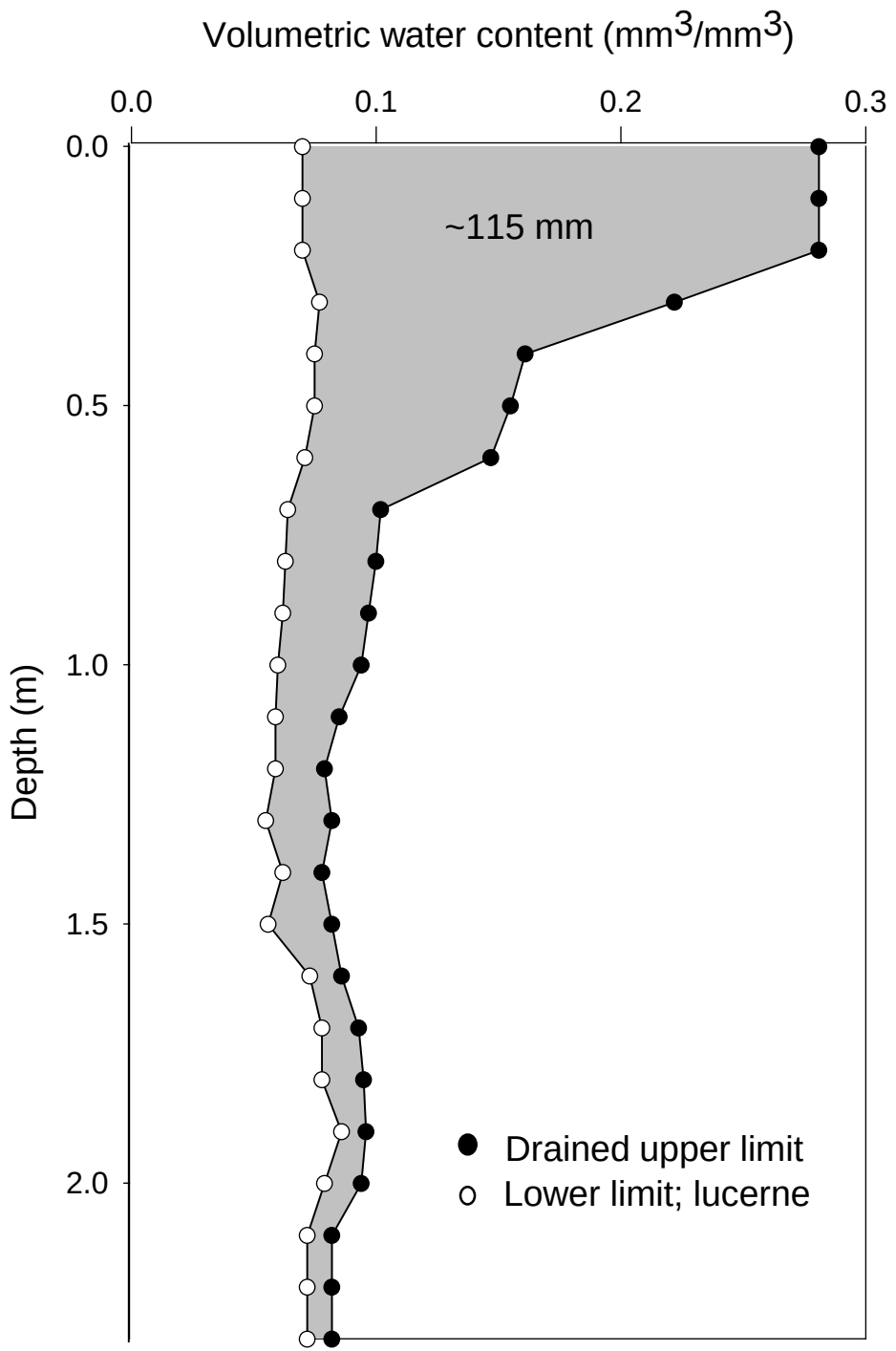
2) Wakanui silt loam



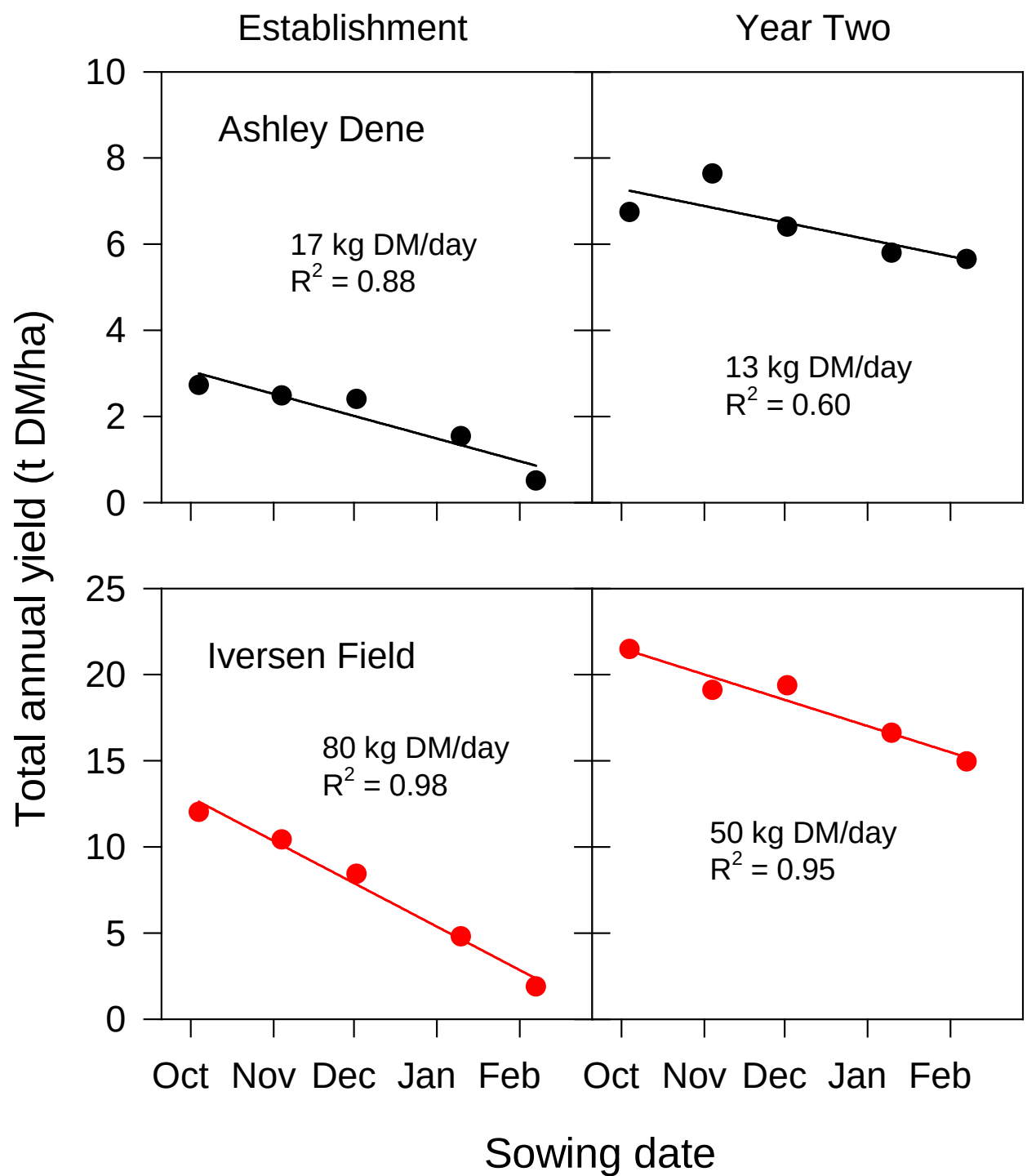
Sim, 2014


Regrowth (year 2)
Seedling
Ashley Dene, January 2012


1) Lismore stony silt loam


Volumetric water content (mm3/mm3)
0.0
0.1
0.2
0.3
0.0
0.5
1.0
1.5
2.0
Depth (m)
~115 mm
Drained upper limit
Lower limit; lucerne

Delayed sowing cost to yield



Sim, 2014

Sown:
February ~ October

Sampled: June

Lincoln University
Te Whare Wānaka o Aoraki
AOTEAROA • NEW ZEALAND

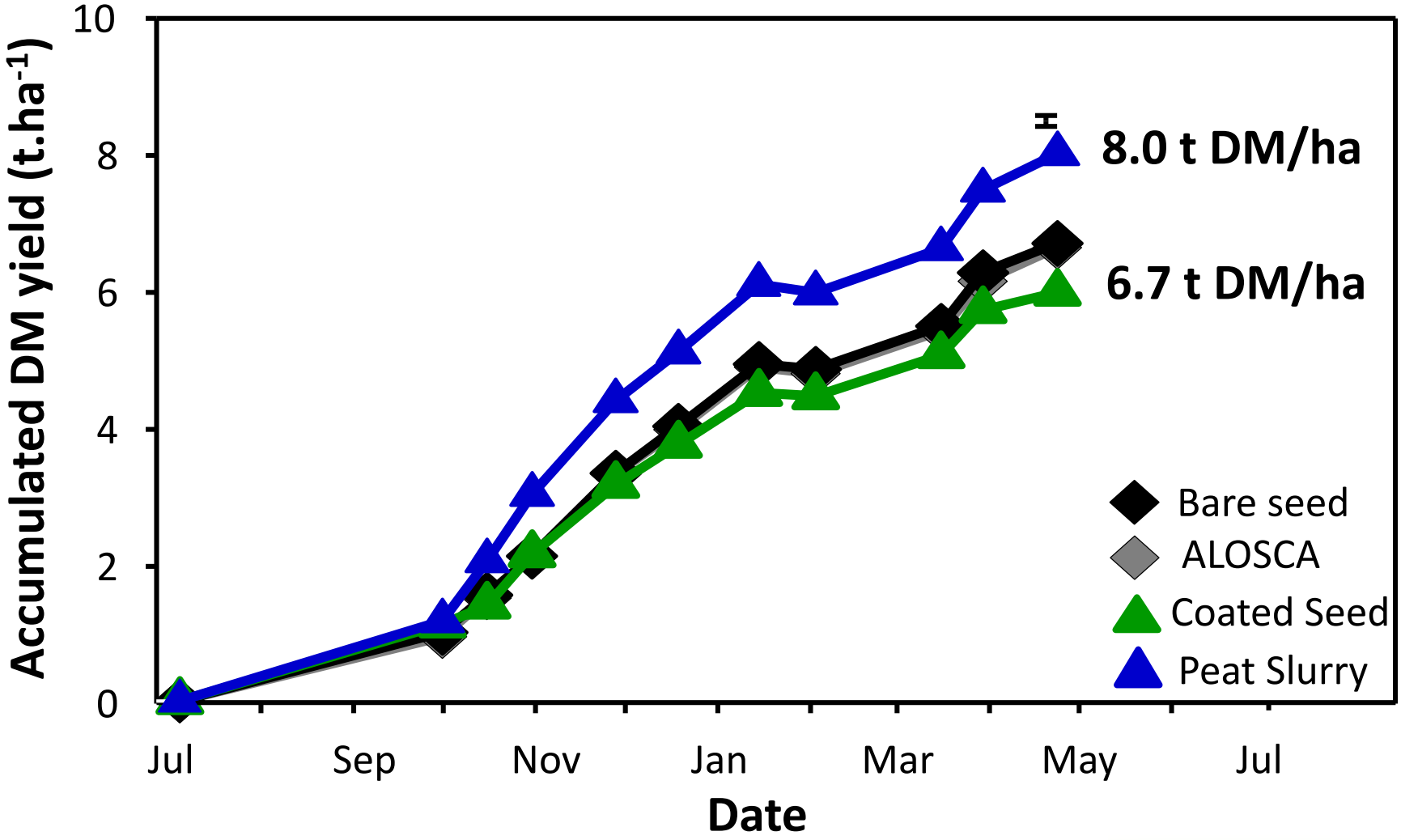
Taproot mass

Taproot mass – Iversen 12

	Root mass (t DM/ha)		
Sowing date	Establishment	Year Two	Shoot+root (year 2)
October	5.3 $_{b}$	6.7 $_{a}$	21.9
November	5.7 $_{a}$	6.6 $_{a}$	20.0
December	4.9 $_{ab}$	6.6 $_{a}$	21.2.
January	3.2 $_{c}$	6.9 $_{a}$	20.3
February	1.1 $_{d}$	5.7 $_{b}$	19.5
P	<0.001	<0.05	
SEM	0.30	0.23	

Establishment – sowing to June 2011; Year Two – June 2011 to July 2012

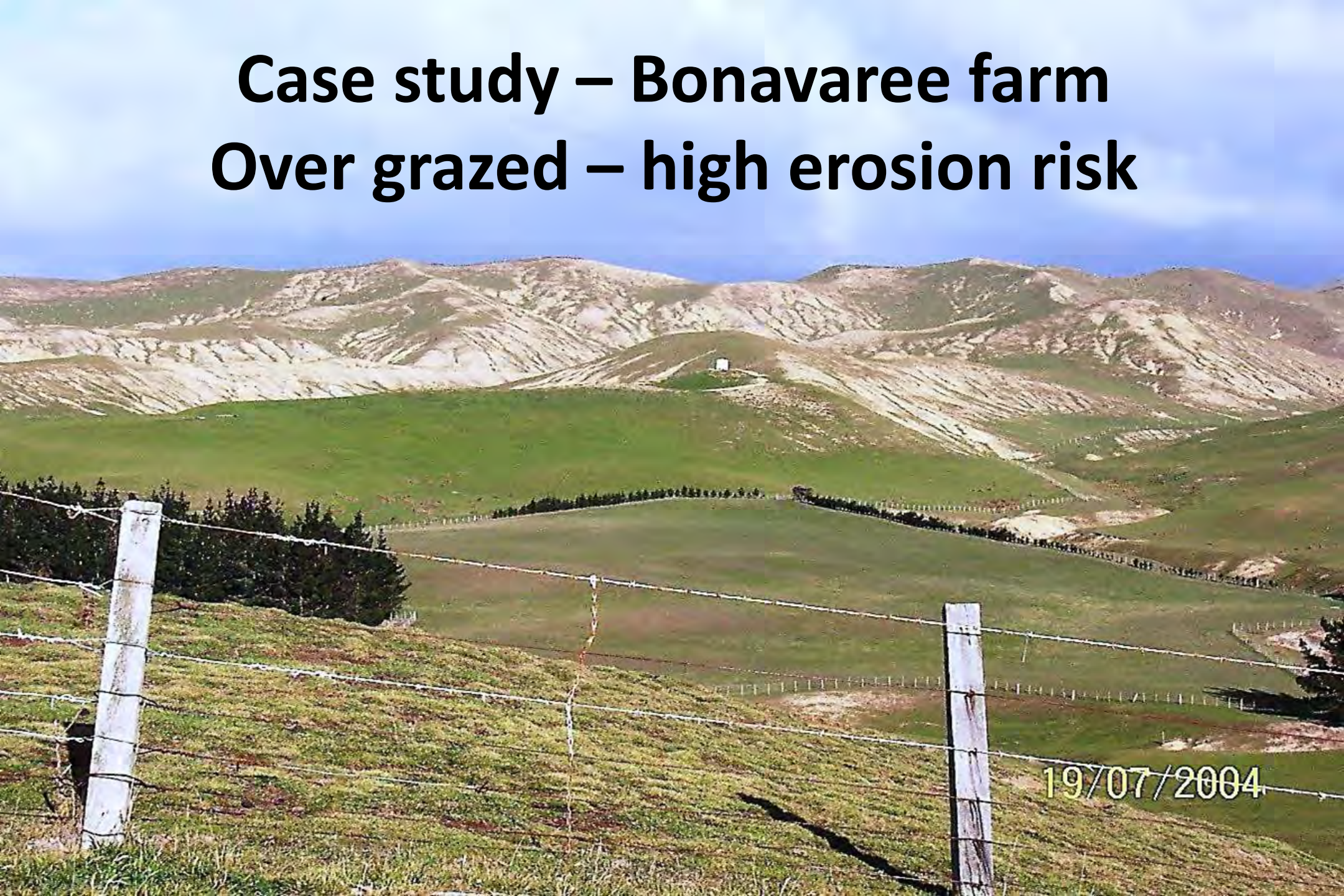
Effect of seed treatment on yield in Year 1



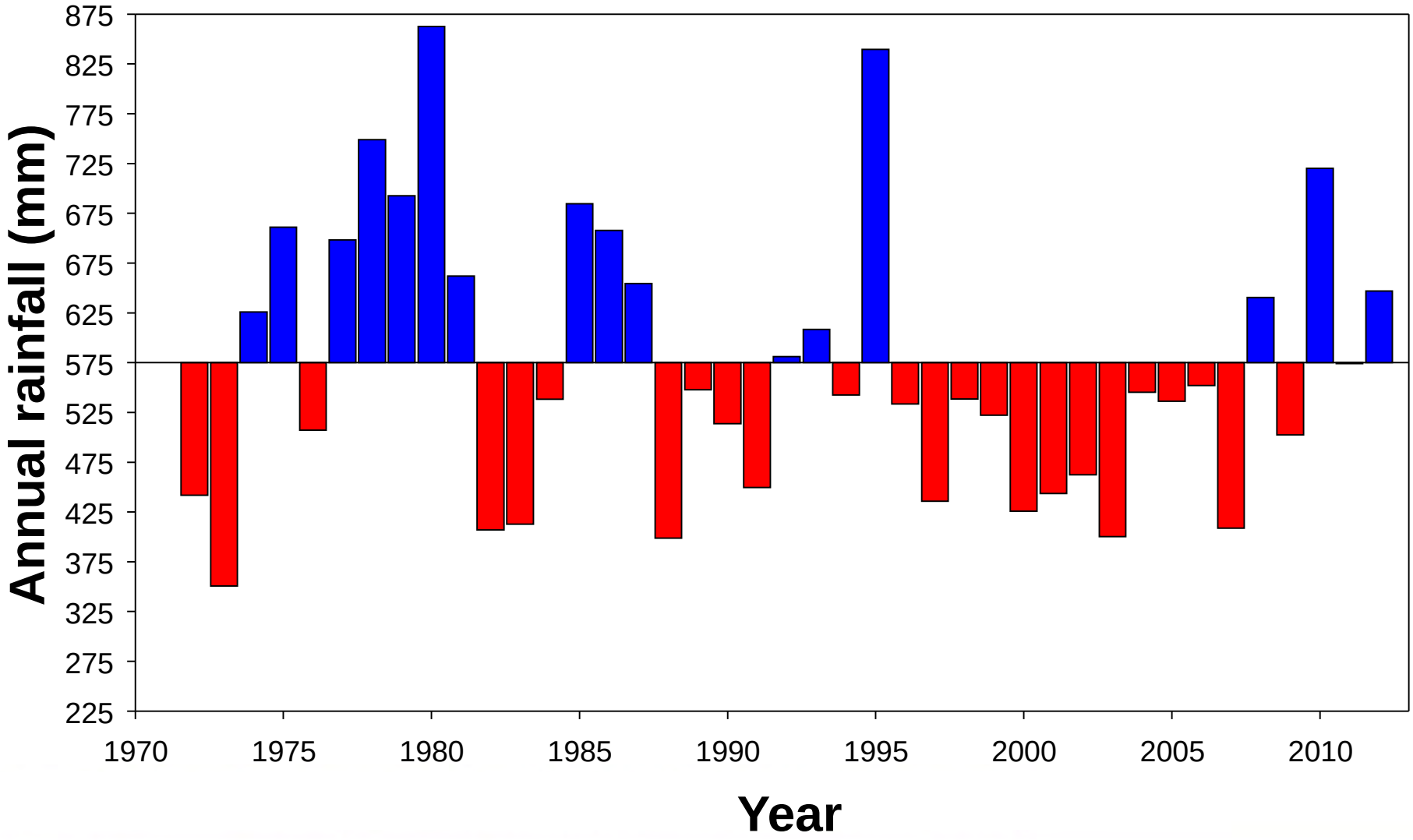
Wigley *et al.*, 2012

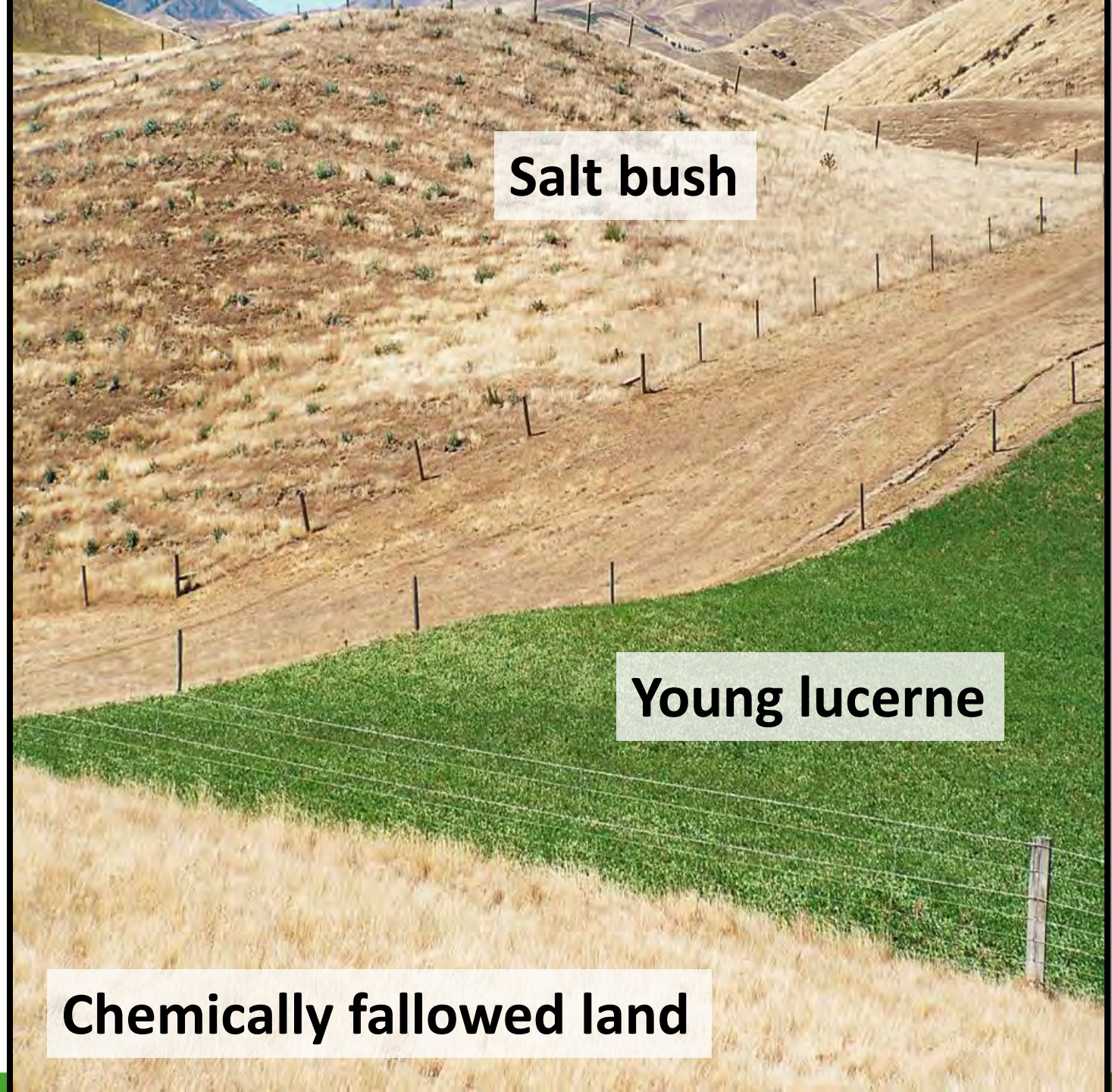

Which rhizobia are in here?

Case study – Bonavaree farm
Over grazed – high erosion risk



Annual rainfall at ‘Bonavaree’




Salt bush
Young lucerne
Chemically fallowed land

‘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)	$US267	$US665	↑ 149%

Lincoln University
Te Whare Wānaka o Aoraki
AOTEAROA • NEW ZEALAND

"With better income we can focus on the environment and preserve it for generations to come"

(Doug Avery)

Resilient drought-proofed landscape

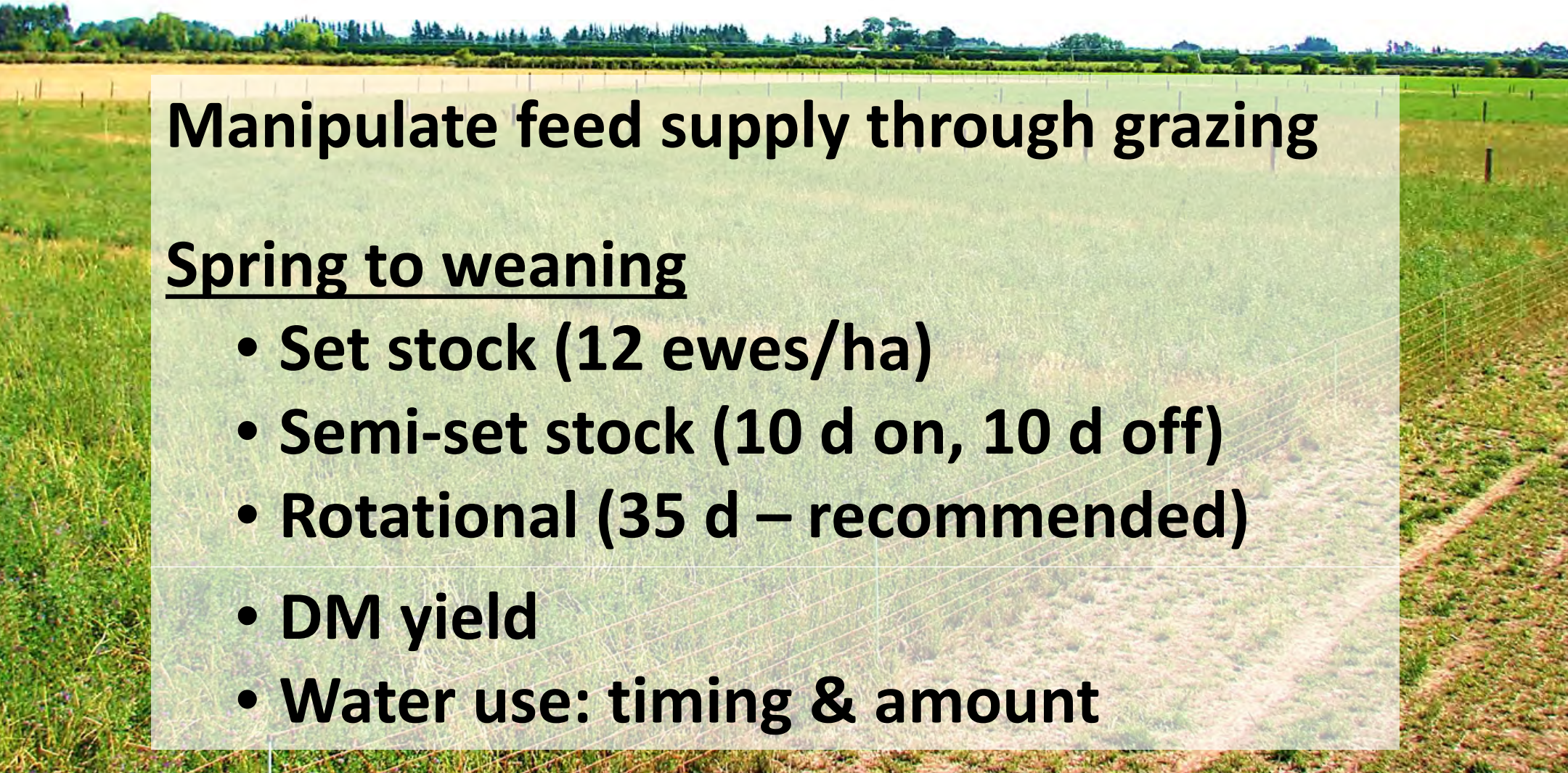
SI Farmer of the Year 2010

Close up of a prairie grass and lucerne mixture

‘Bonavaree’ Marlborough
July 2010

Lucerne + cocksfoot

Even more flexibility in spring – set stocking
Ashley Dene – 2011 - ongoing



Manipulate feed supply through grazing

<u>Spring to weaning</u>

- **Set stock (12 ewes/ha)**
- **Semi-set stock (10 d on, 10 d off)**
- **Rotational (35 d – recommended)**

- **DM yield**
- **Water use: timing & amount**

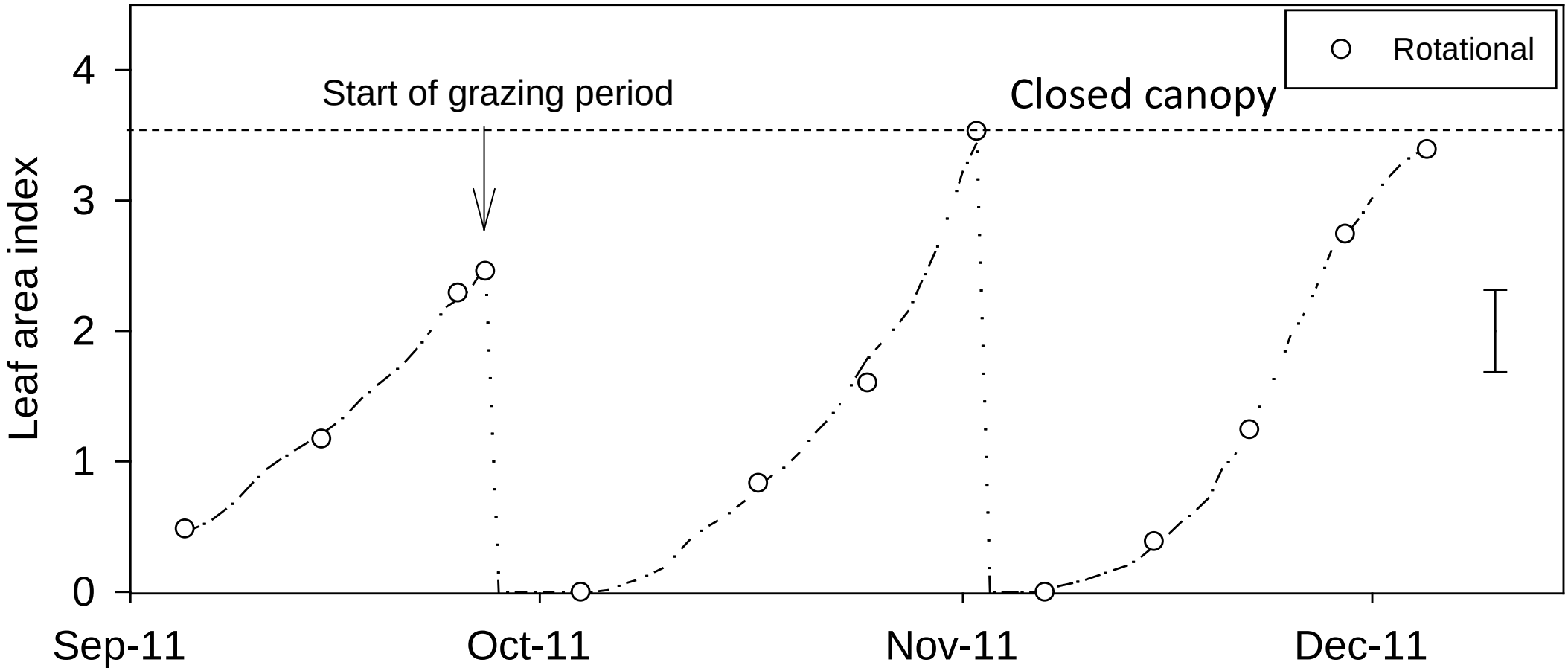

Lambs set stocked

Grazing management and yield

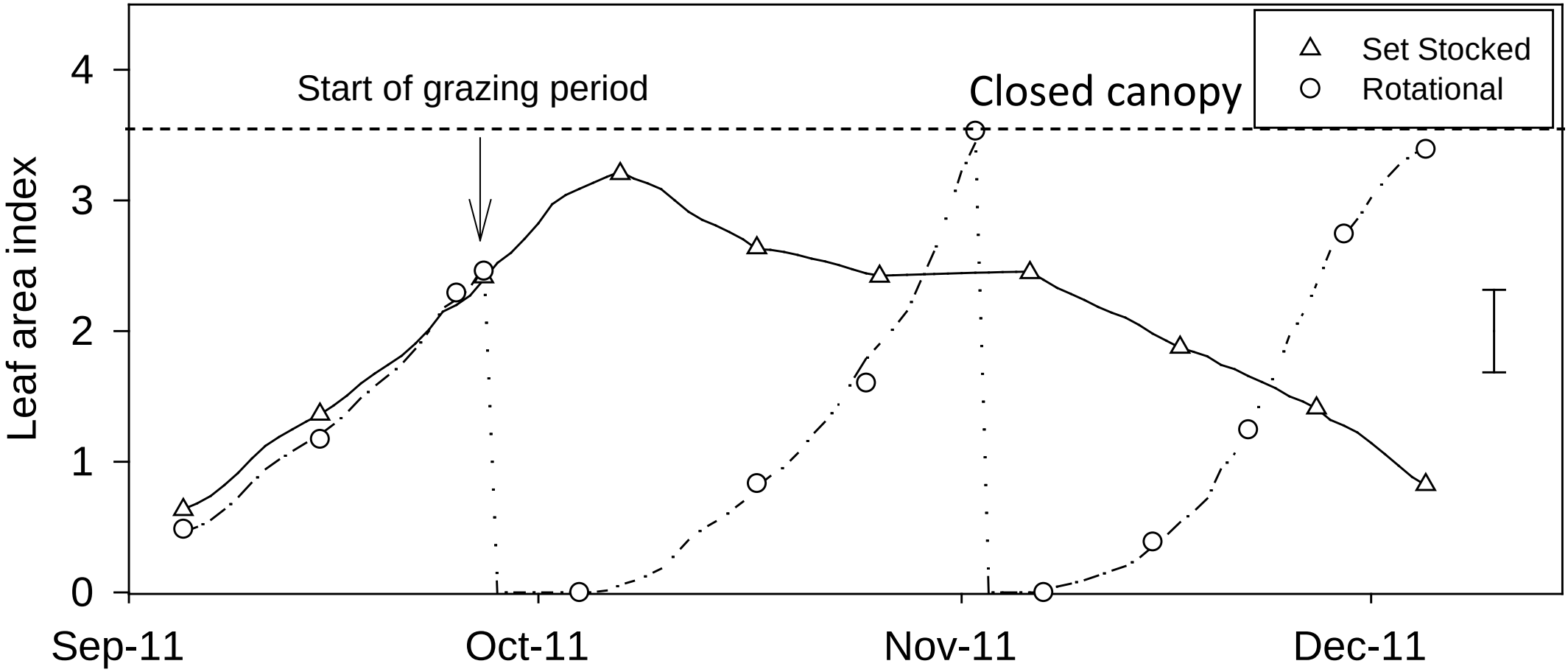
Set stocked until weaning only

Grazing treatment	Spring DM (t/ha)	Annual DM (t/ha)
Set stocked	6.1	10.6 $_{b}$
Semi-set stocked	5.9	10.5 $_{b}$
Rotational	6.8	12.1 $_{a}$
P	ns	<0.05
SEM		0.33

Crop canopy


Rotational
Start of grazing period
Closed canopy
Leaf area index
0
1
2
3
4
Sep-11
Oct-11
Nov-11
Dec-11

Crop canopy


Start of grazing period
Closed canopy
Set Stocked
Rotational
Leaf area index
0
1
2
3
4
Sep-11
Oct-11
Nov-11
Dec-11

Water Use (mm)

Grazing treatment	Transpiration	E_S	Total WU
Set stocked	297 $_a$	77 $_b$	374
Semi-set stocked	282 $_a$	76 $_b$	358
Rotational	231 $_b$	128 $_a$	359
P	<0.05	<0.05	ns
SEM	10.6	8.0	

Results

- Defoliation management did not offer opportunities improve total WU – soil evaporation
  - E_T and E_S were inversely related due to spring rainfall
- Set stocking was successful because:
  - LAI was maintained at 2-3 (80-90% R_i)
  - Increased R_i compensated for lower RUE_{Shoot}

Agronomic implications

- Set stocking in spring was a viable grazing option
  - Only spring – recharge in autumn
  - Weed ingress – if canopy is opened
  - Maintain canopy cover LAI>2.0 (20-25 cm)

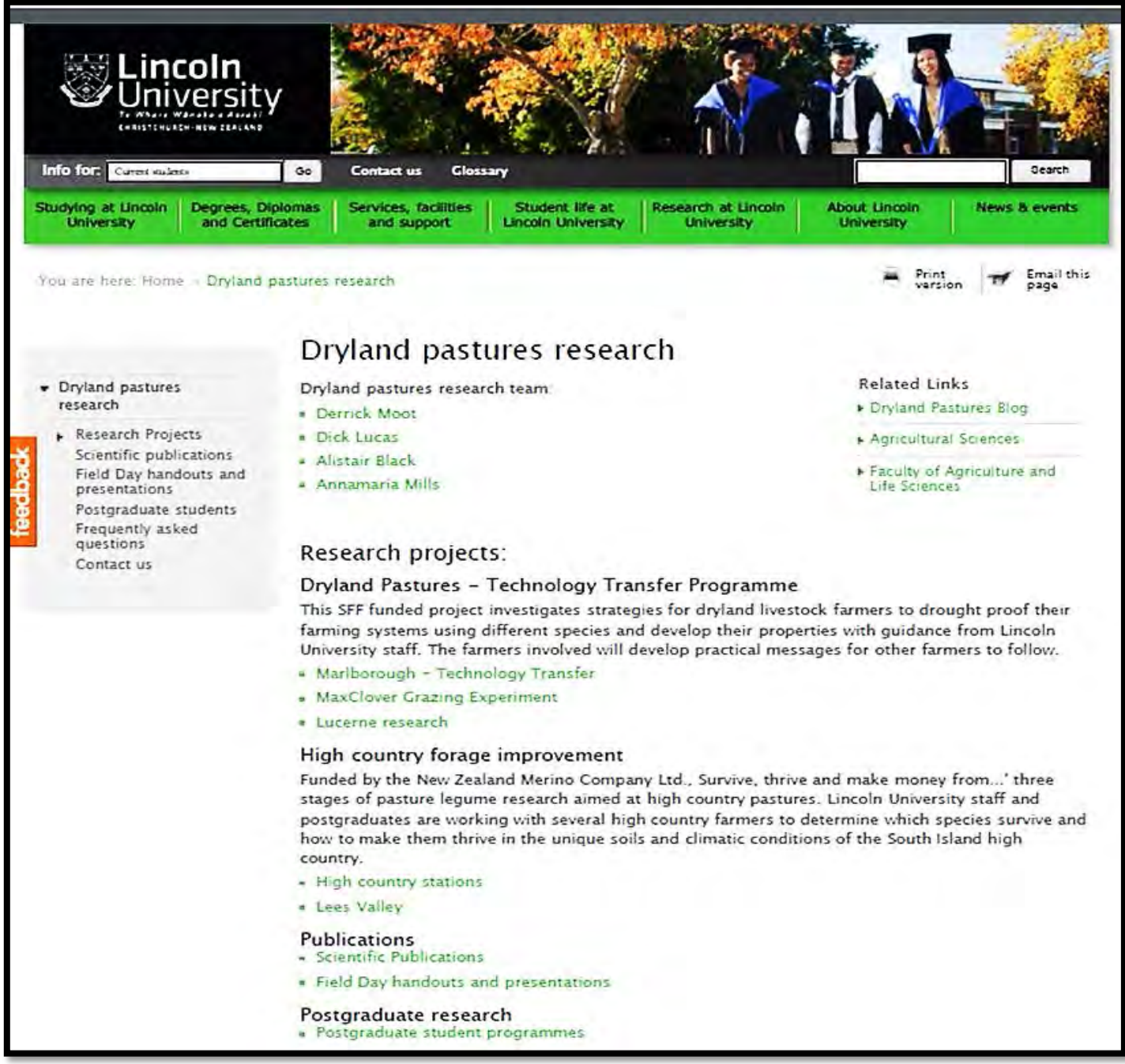
Sustainable transformation with lucerne

- Farmers with incentives to change – economic, land sustainability, social.
- Appropriate research - on-farm application to reduce complexity of intensification.
- Mutual integrity and trust between scientist and farmers.
- On-going engagement and mentoring.

The website…

Info on:

- Current projects
- Field day presentations
- Scientific publications
- FAQs
- Postgraduate study



www.lincoln.ac.nz/dryland

Acknowledgements

Post Doc – Annamaria Mills
Technical staff: Dr Keith Pollock, Malcolm Smith

Students
PhD: Brown, Teixiera, Varella, Peri, Sim, Monks, Nori, Berneji, Wigley, Ta, Downward, A. Black,
Masters: Kirsopp, D. Black, Power, Gillespie, Tonmukayakul, Khumalo, Morris
Honours students: Dunne, Lewis, Kearney, Inch, Sim, Brown, Murray-Cawte, Wigley, Stocker, Tapp, Kearns, Lewis, Neal, Crutchley, Coutts, Neal

References

Brown, H. E., Moot, D. J. and Pollock, K. M. 2003. Long term growth rates and water extraction patterns of dryland chicory, lucerne and red clover. *In*: D.J. Moot (Ed.). Legumes for Dryland Pastures. Proceedings of a New Zealand Grassland Association Symposium. 18-19 November 2003, Lincoln University, New Zealand. New Zealand Grassland Association. **Research & Practice Series Vol. 11**. p 91-99.

Brown, H. E., Moot, D. J. and Teixeira, E. I. 2005. The components of lucerne (*Medicago sativa*) leaf area index respond to temperature and photoperiod in a temperate environment. *European Journal of Agronomy*, **23**, 348-358.

Carberry, P. S. 2001. Are science rigour and industry relevance both achievable in participatory action research? *In*: B. Rowe, D. Donaghy, N. Mendham (Eds.). "Science and Technology: Delivering Results for Agriculture?". Proceedings of the 10th Australian Agronomy Conference, January 2001, . 29 Jan - 1 Feb 2001, Hobart, Tasmania. Australian Agronomy Society.

Dunbier, M. W. and Easton, H. S. 1982. Longer stand life with new cultivars. *In:* R. B. Wynn-Williams (ed). Lucerne for the 80's. Special Publication No. 1. Palmerston North: Agronomy Society of New Zealand, 121-126.

Kearney, J. K., Moot, D. J. and Pollock, K. M. 2010. Dryland lucerne production in Central Otago. *Proceedings of the New Zealand Grassland Association*, **72**, 121-126.

Mills, A., Lucas, R. J. and Moot, D. J. 2014. 'MaxClover' Grazing Experiment: I. Annual yields, botanical composition and growth rates of six dryland pastures over nine years. *Grass and Forage Science*, ***In Press***. (DOI: 10.1111/gfs.12130)

Moir, J.L. and Moot, D.J. 2010. Soil pH, exchangeable aluminium and lucerne yield responses to lime in a South Island high country soil. Proceedings of the New Zealand Grassland Association, 72, 191-196.

Moot, D. J., Brown, H. E., Teixeira, E. I. and Pollock, K. M. 2003. Crop growth and development affect seasonal priorities for lucerne management. *In:* D. J. Moot (ed). Legumes for Dryland Pastures Proceedings of a New Zealand Grassland Association Inc Symposium held at Lincoln University, 18-19 November, 2003. Christchurch: New Zealand Grassland Association, 201-208.

Moot, D. J., Brown, H. E., Pollock, K. and Mills, A. 2008. Yield and water use of temperate pastures in summer dry environments. *Proceedings of the New Zealand Grassland Association*, **70**, 51-57.

Moot, D. J. 2012. An overview of dryland legume research in New Zealand. *Crop and Pasture Science*, **63**, 726–733. (http://dx.doi.org/10.1071/CP12103)

Moot, D. J. and Avery, D. 2013. Sustainable intensification of livestock grazing systems in low rainfall regions of New Zealand. *In*: First International Conference on Global Food Security, 29 September - 2 October 2013, Noordwijkerhout, The Netherlands. Elsevier Ltd. p O3.O3 (4 pgs).

Moot, D. J., Pollock, K. M. and Lewis, B. 2012. Plant population, yield and water use of lucerne sown in autumn at four sowing rates. *Proceedings of the New Zealand Grassland Association*, **74**, 97-102.

NIWA. 2013. Climate Explorer – New Zealand Median Annual Rainfall Map. Date Accessed: 1/10/2010. http://climate-explorer.niwa.co.nz. Last Updated: 1/10/2010.

Sim, R.E. 2014. Water extraction and use of seedling and established dryland lucerne crops. Ph.D thesis, Lincoln University, Lincoln, Canterbury. 264 pp.

Teixeira, E. I., Brown, H. E., Meenken, E. D. and Moot, D. J. 2011. Growth and phenological development patterns differ between seedling and regrowth lucerne crops (*Medicago sativa* L.). *European Journal of Agronomy*, **35**, 47-55.

Wigley, K., Moot, D. J., Khumalo, Q. and Mills, A. 2012. Establishment of lucerne (*Medicago sativa*) sown on five dates with four inoculation treatments. *Proceedings of the New Zealand Grassland Association*, **74**, 91-96.