Hamilton, Victoria
14 May 2014

Lincoln University
Te Whare Wānaka o Aoraki
CHRISTCHURCH·NEW ZEALAND

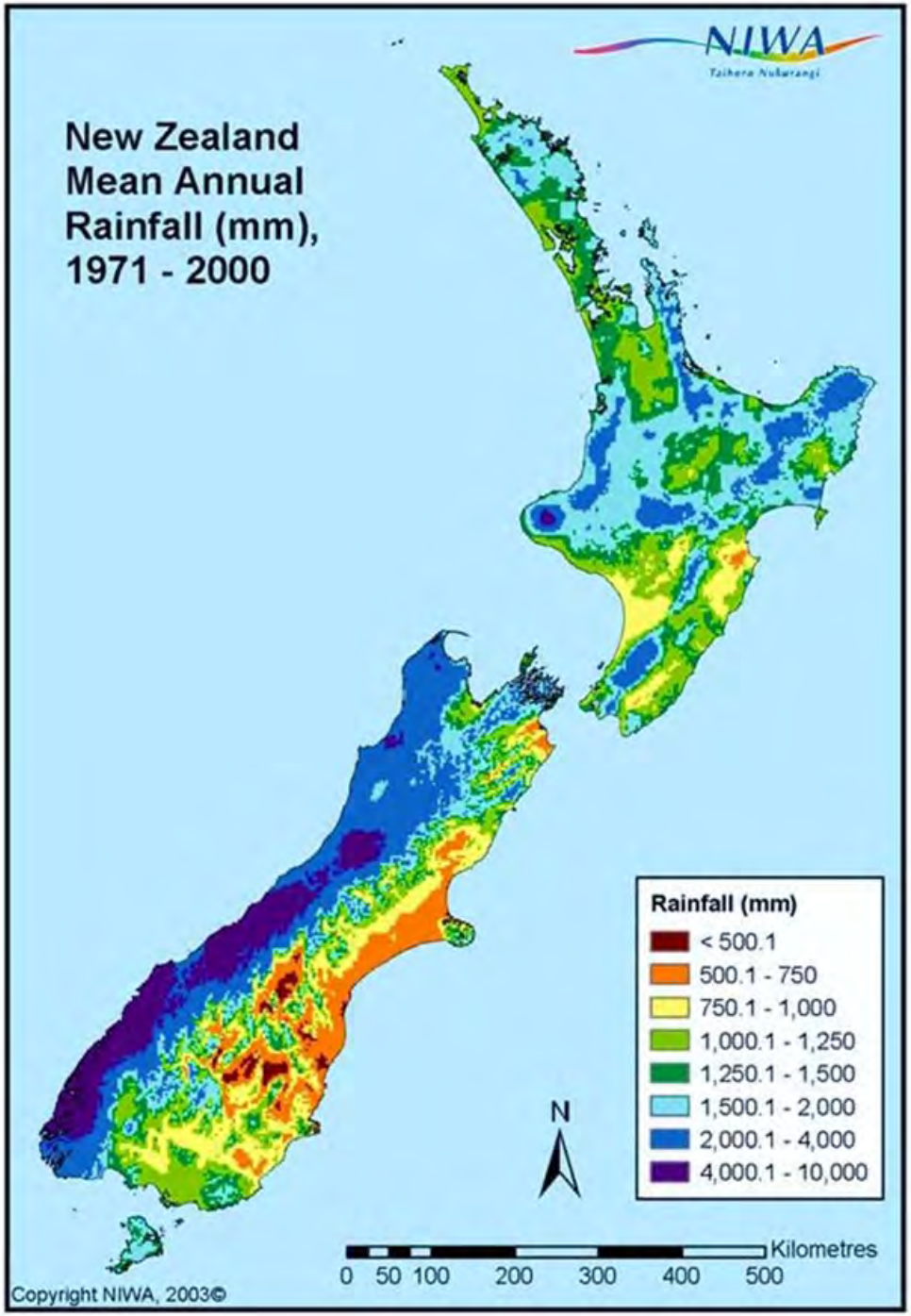
LUCERNE
Research and extension

Dr Derrick Moot
Professor of Plant Science

New Zealand's specialist land-based university

Strong rainfall gradient

West ⇒ East



Source: NIWA 2009


Rain fed 300-800 mm
East coast - summer dry
Photo: DJ Moot
Lincoln University

Farmer questions?

a) Which dryland species?

- Ryegrass/white clover familiar but fails
- Other grasses - different mgmt
- Lucerne – cut and carry - pests

Resistance to Pests and Diseases

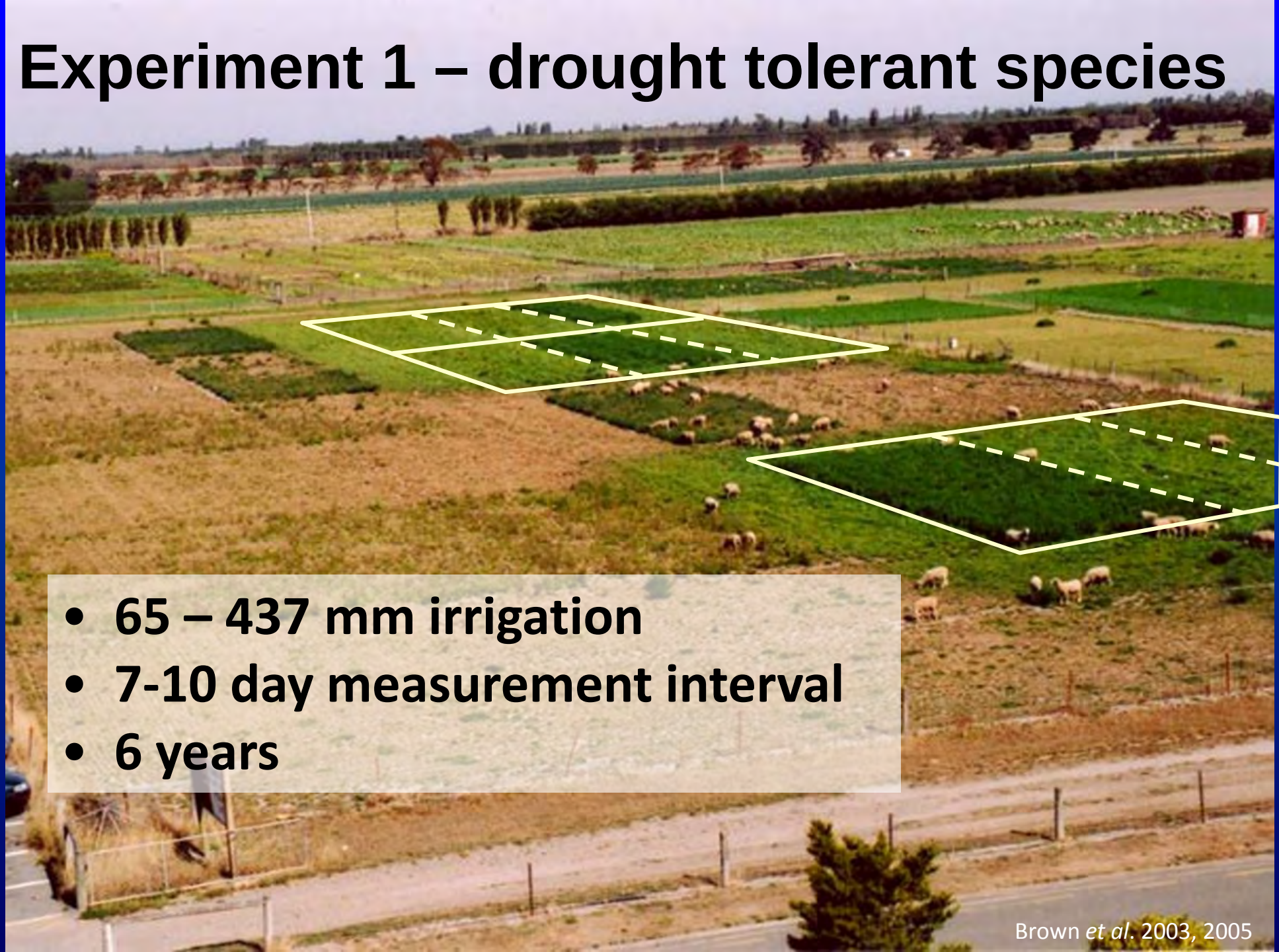
Cultivar	Dormancy	BGA	PA	SAA	BW	SN	PRR	VW	LD
Grasslands Kaituna	I	R	R	R	R	R	R	-	MR
Grasslands Otaio	I	R	R	R	R	R	R	-	S
Grasslands Torlesse	D	HR	R	R	R	-	R	-	MR
P54Q53	D	MR	MR	MR	HR	HR	HR	-	-
P54V09	D	-	HR	R	HR	HR	HR	HR	-
Runner	D	-	-	-	R	-	S	-	-
Wairau	SD	S	S	S	S	S	S	S	S
WL 325HQ	I	R	R	R	R	MR	R	-	-

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

Measurements

Light environment

Chemical Analysis:

-N (shoots and roots)

-Starch in roots

-Soluble sugars in roots

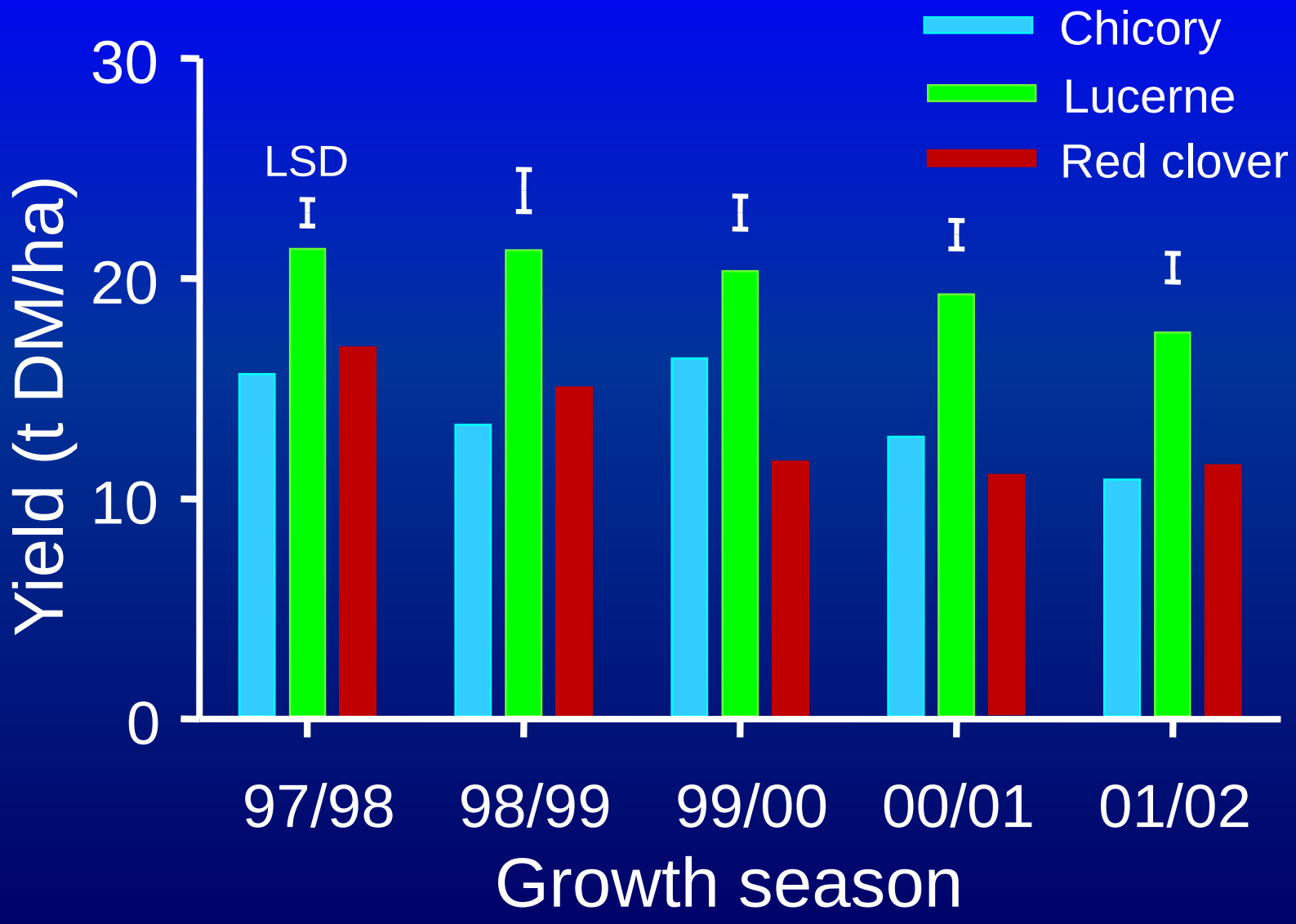
Others:

- SLW
- SPAD
- Chl_{a+b}

Soil moisture

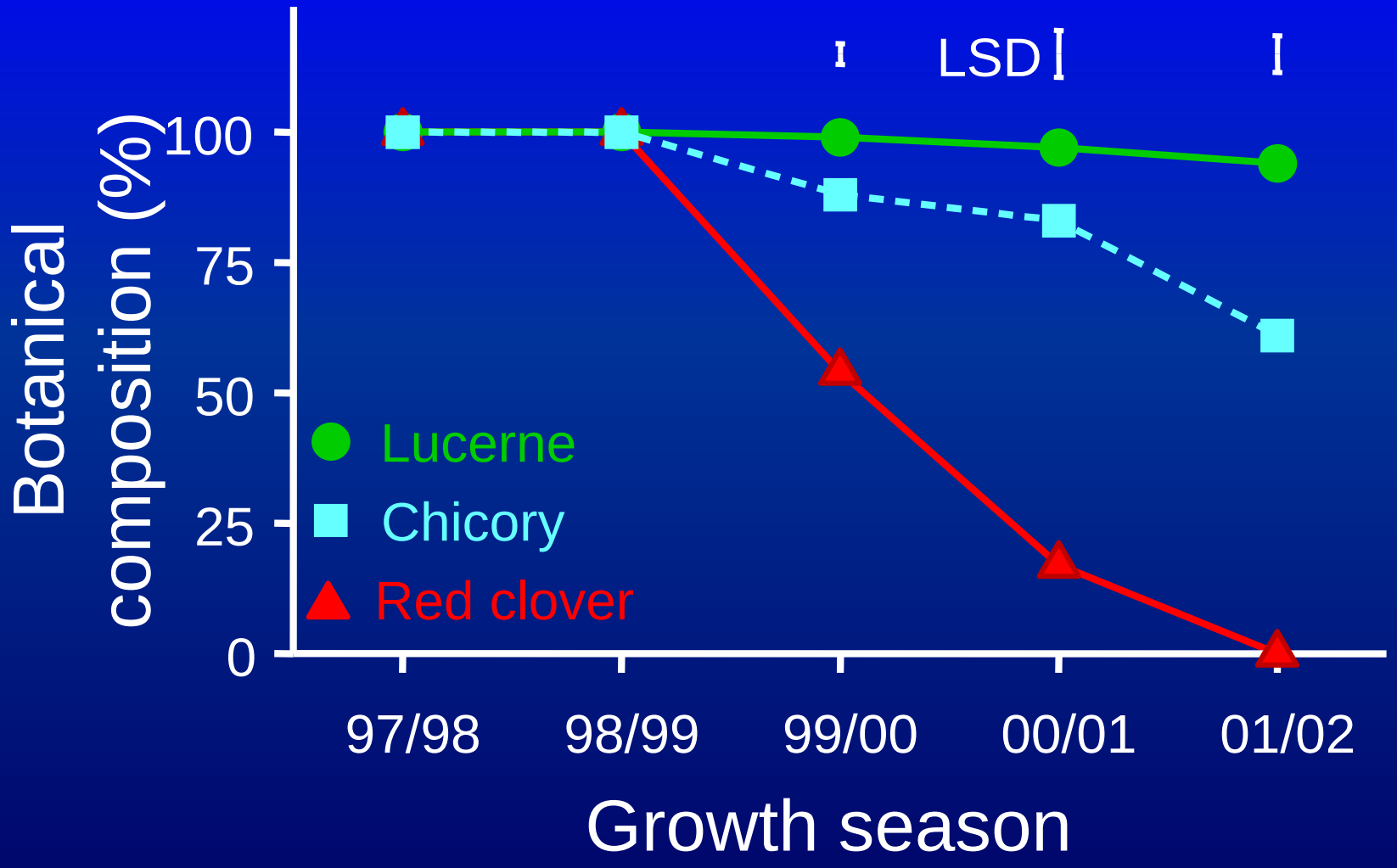
Photosynthesis

Annual dry matter yields



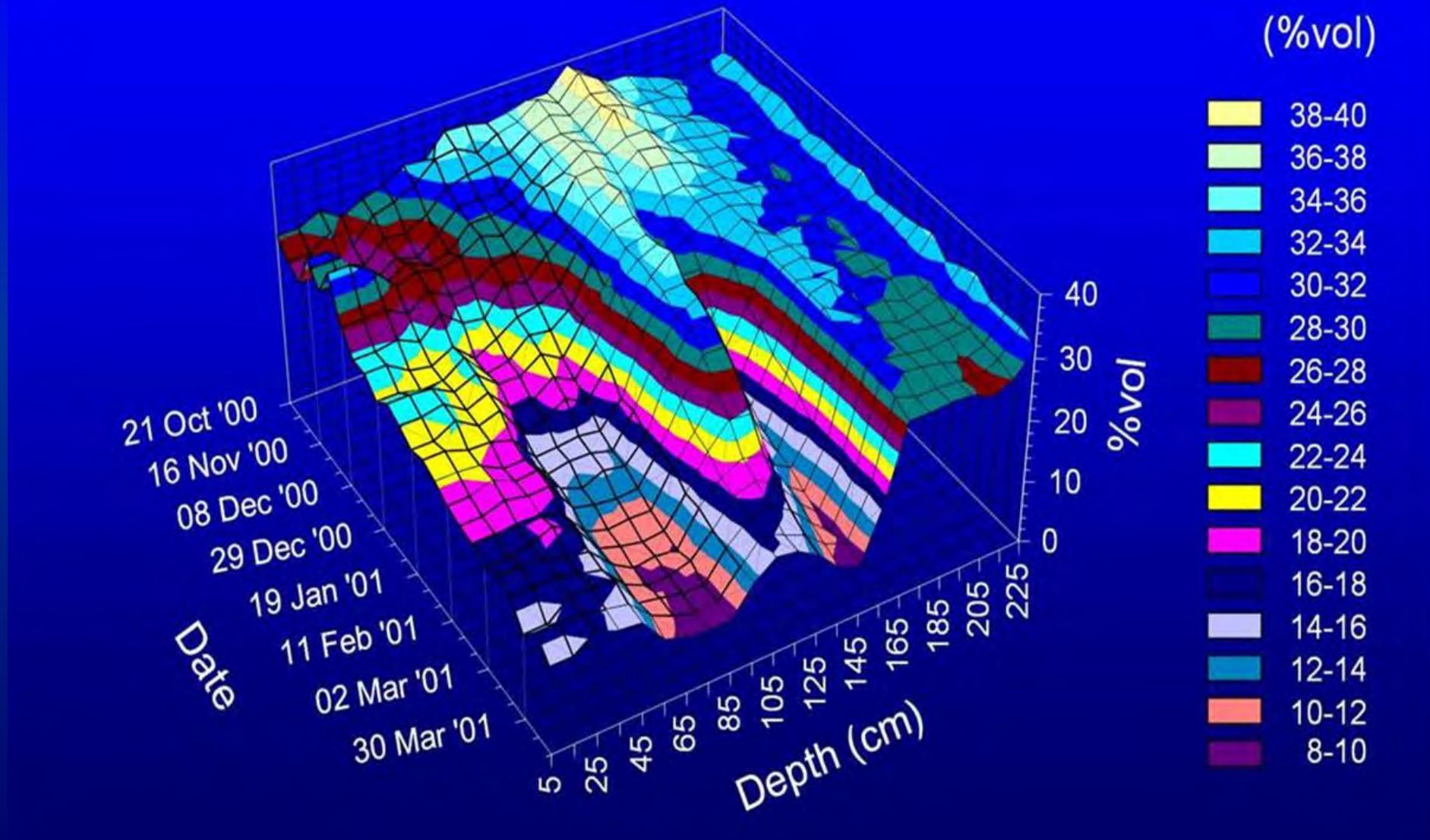
Brown *et al*. 2005

Persistence



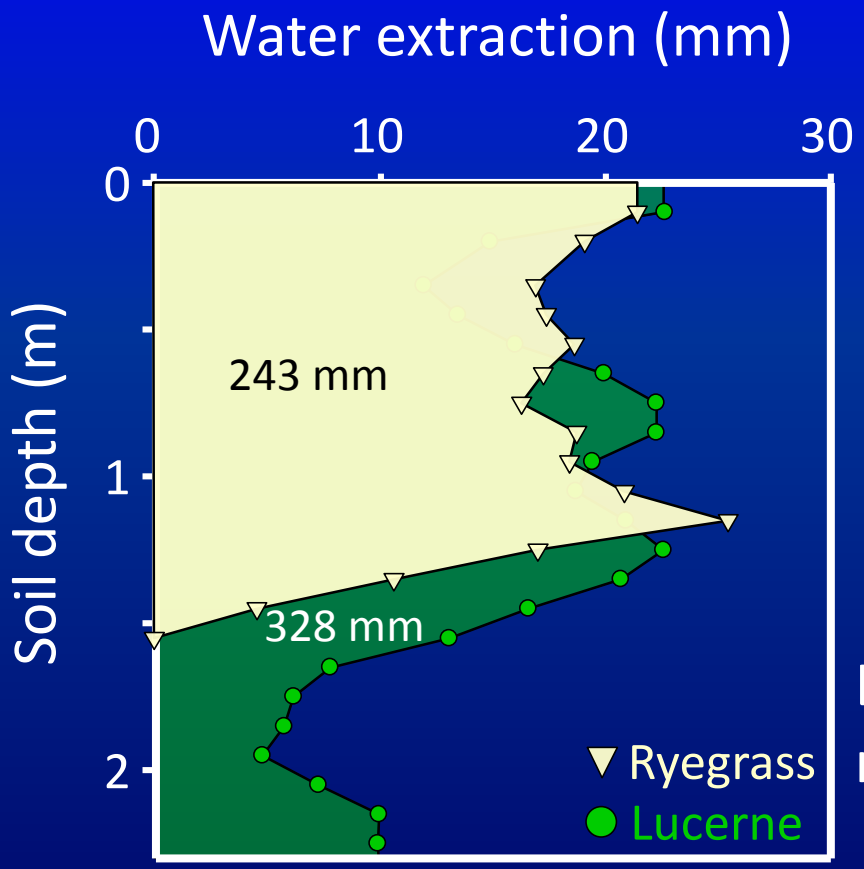
Brown & Moot 2004

Dryland Lucerne – soil moisture



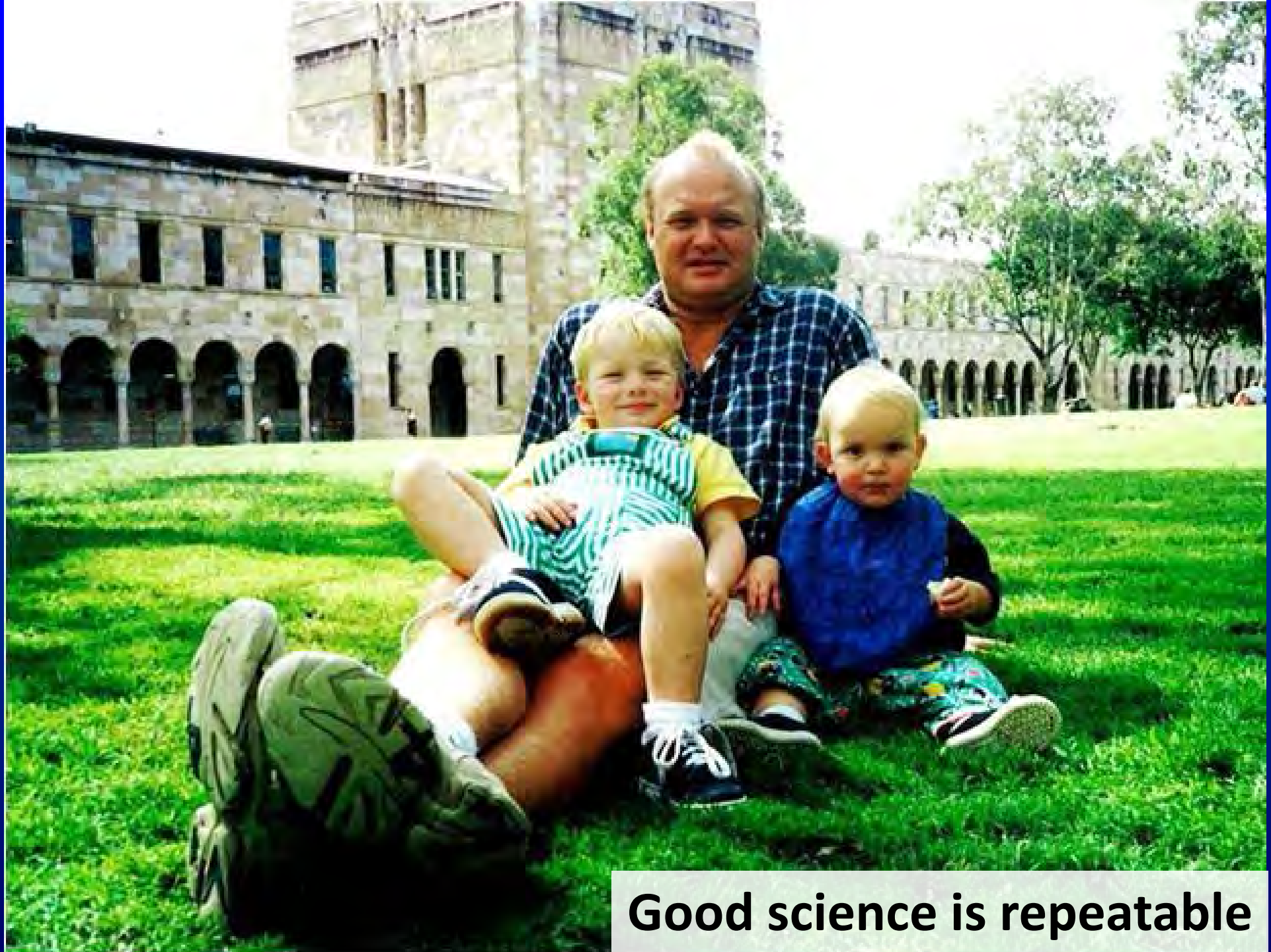
Ryegrass/clover vs. Lucerne

Soil water extraction: Species

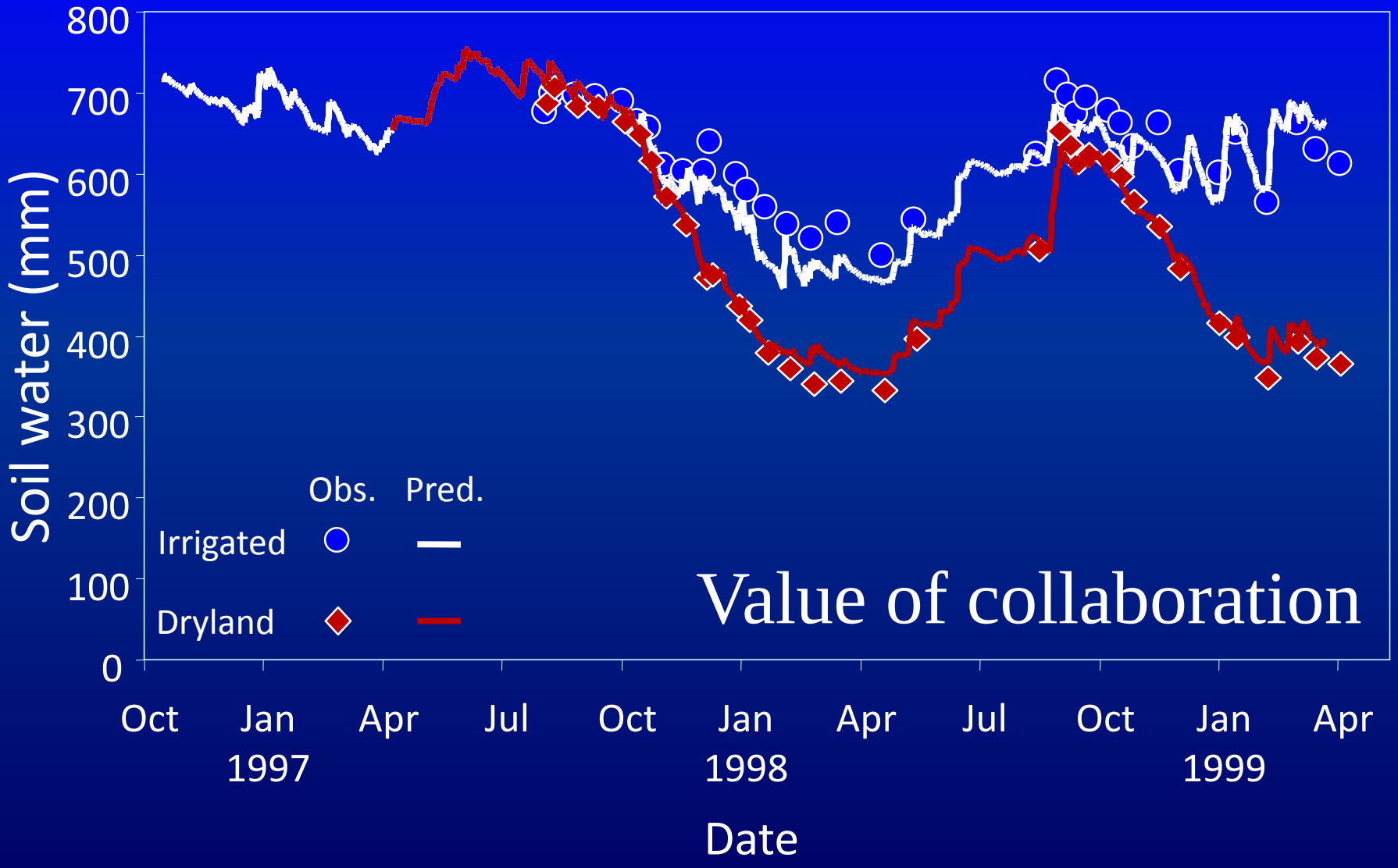


Lucerne has 85 mm more available water

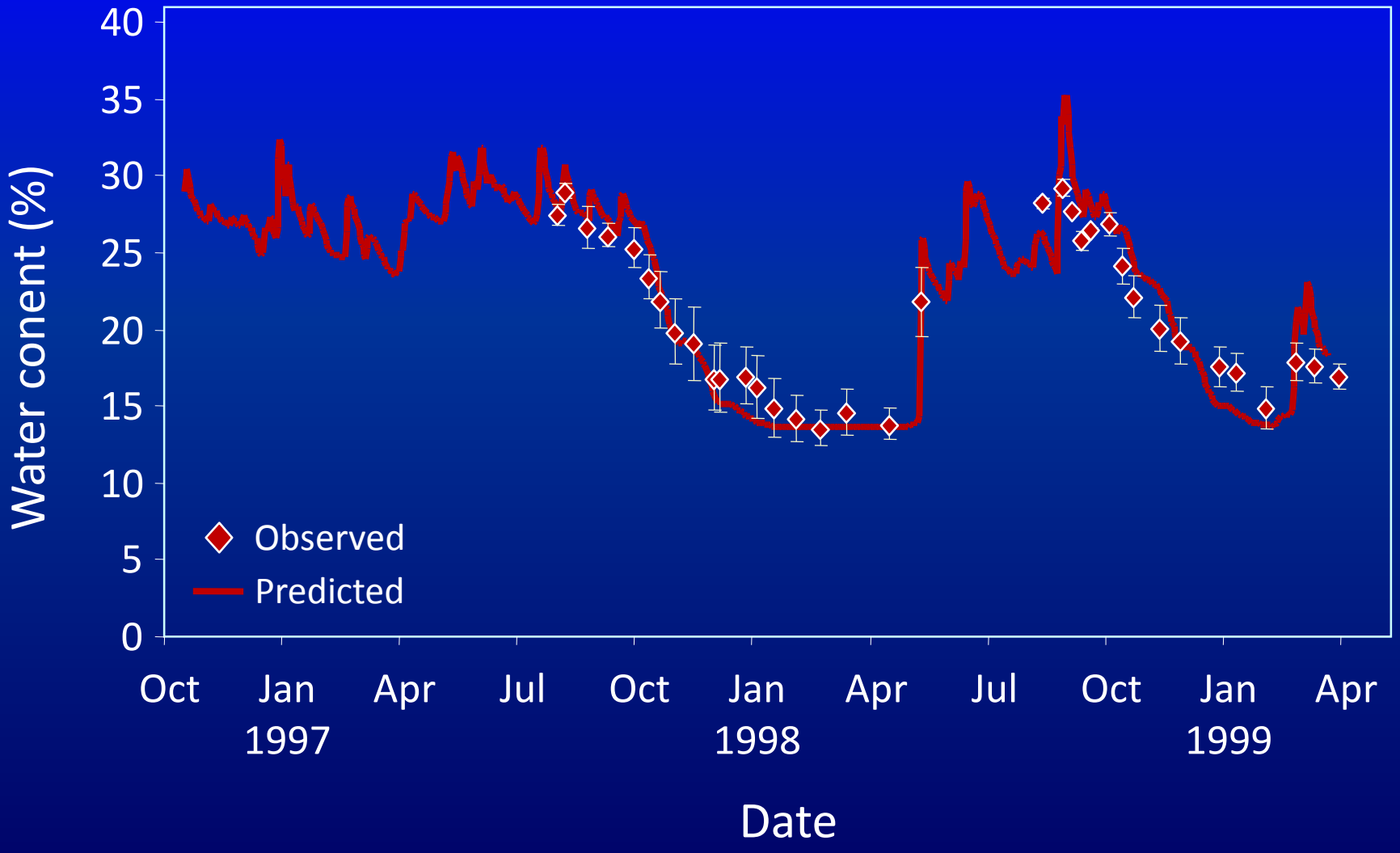
Moot *et al*. 2008


Good science is repeatable

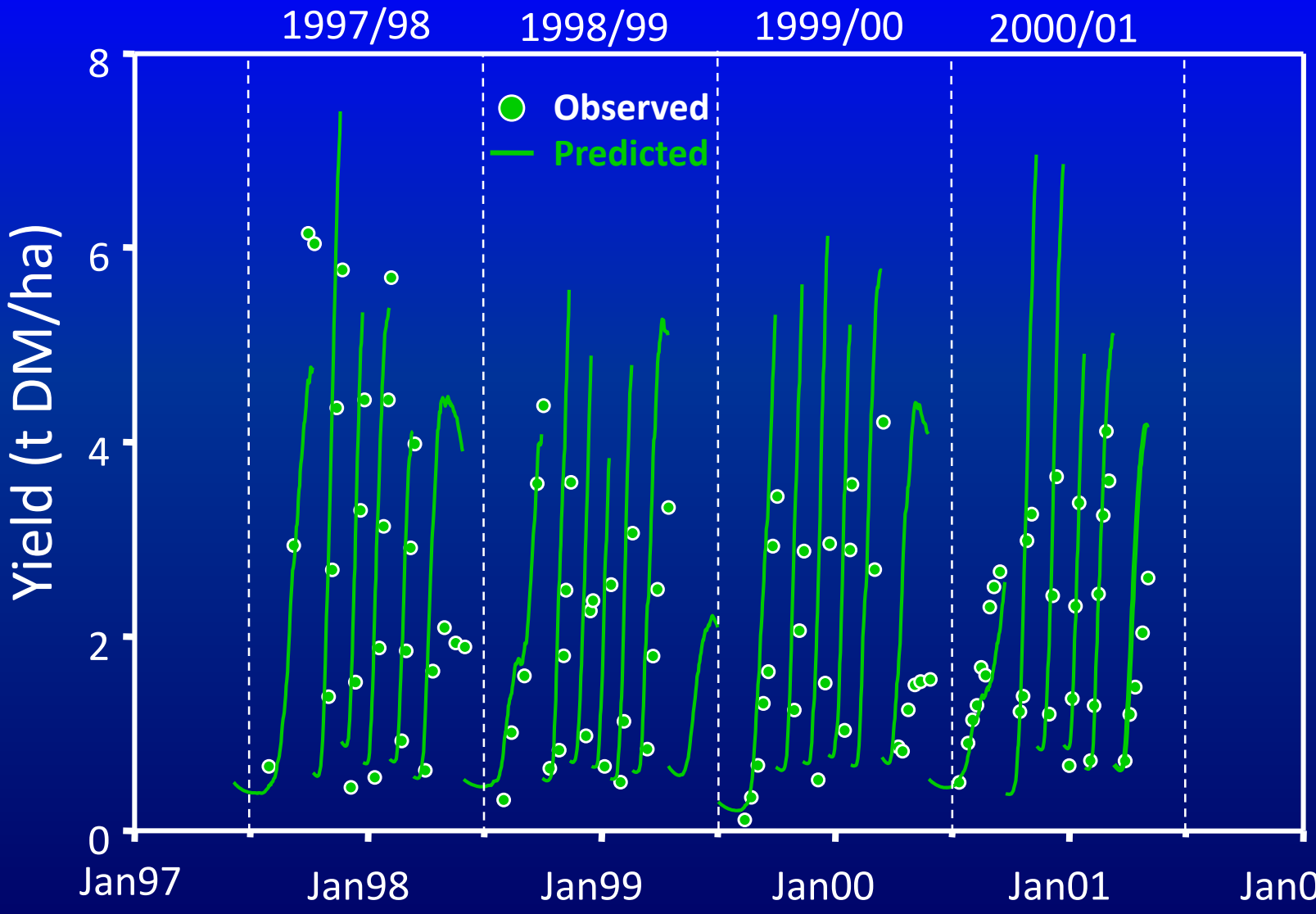
Total soil water to 2.3 m depth



Volumetric soil water at 0.35 m

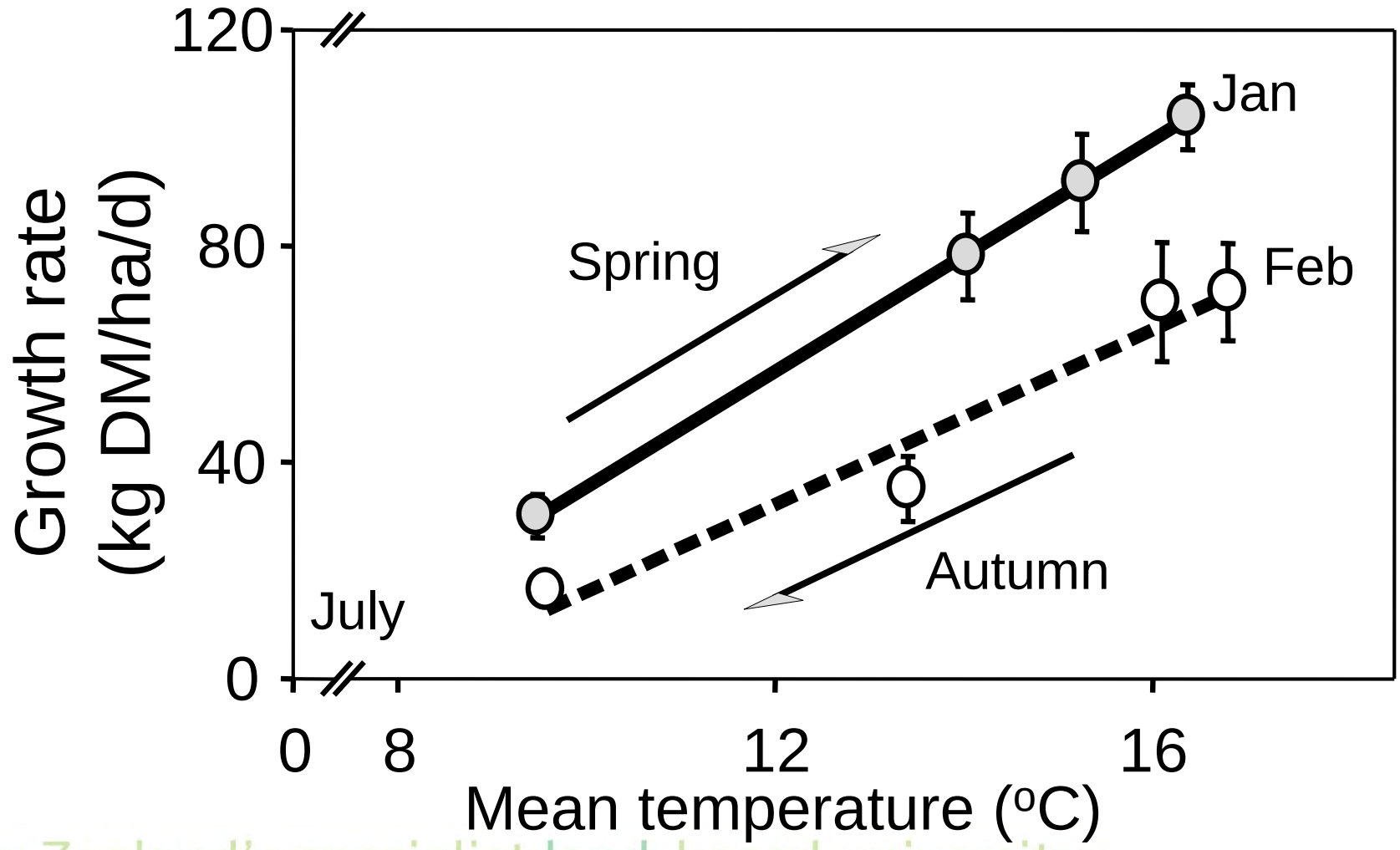


Original APSIM_Lucerne prediction



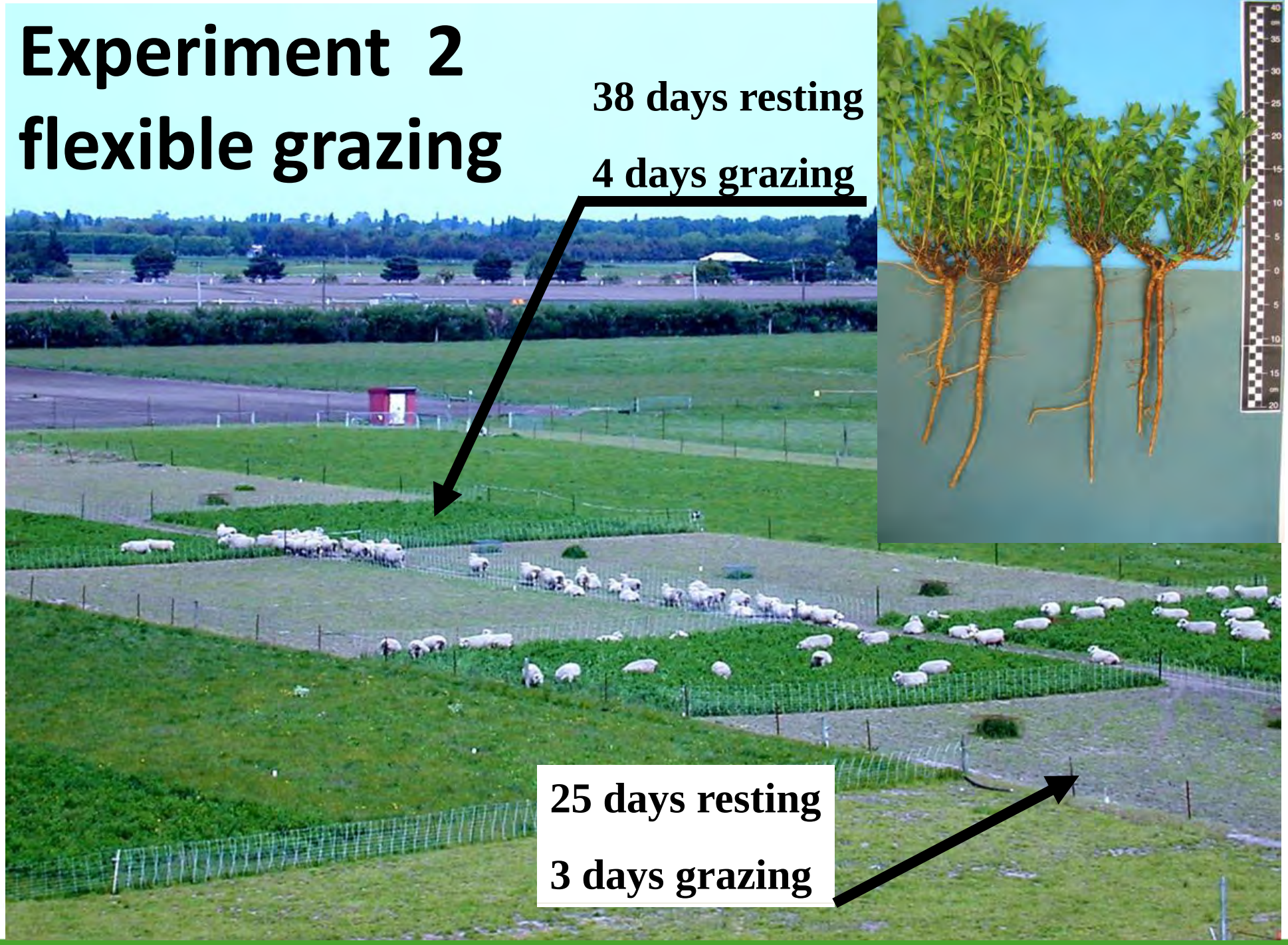
Teixeira *et al*. 2009

Vegetative growth



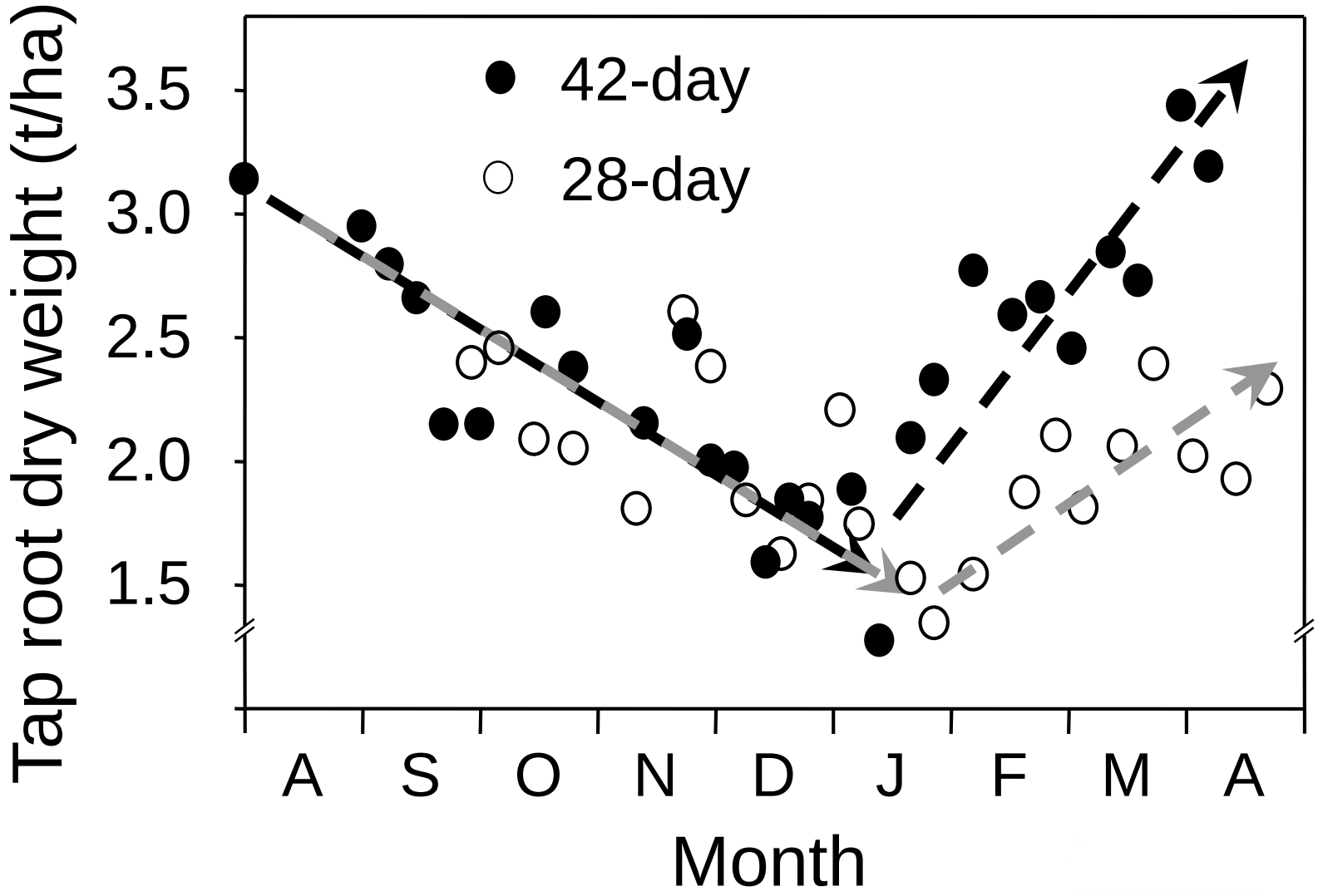
Source: Moot *et al*. 2003

Experiment 2 flexible grazing



What's going on down there?

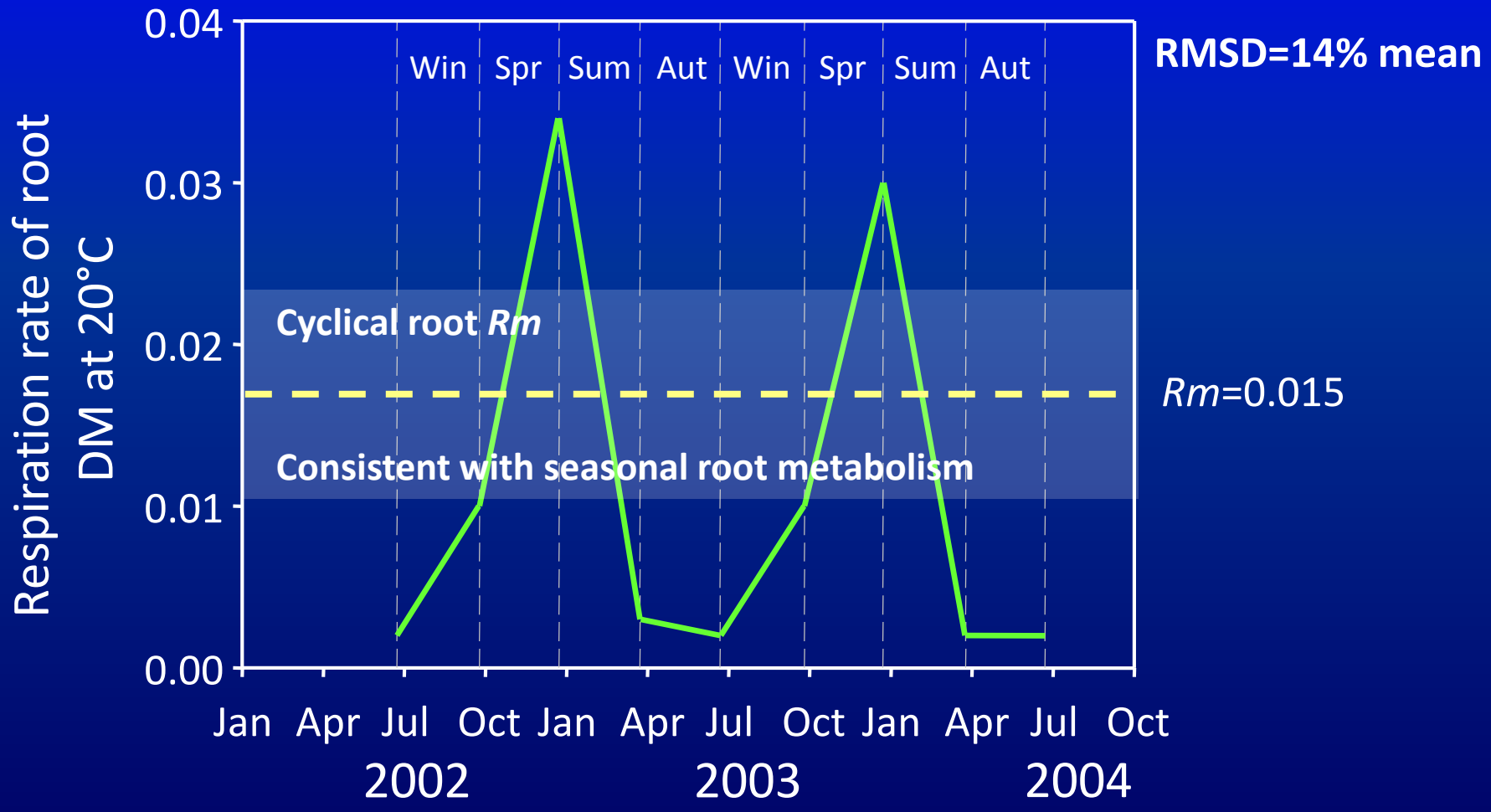
Partitioning to roots



Source: Moot *et al*. 2003

Seasonal pattern Rm values

Best fit: Seasonal pattern of R_m at 20°C

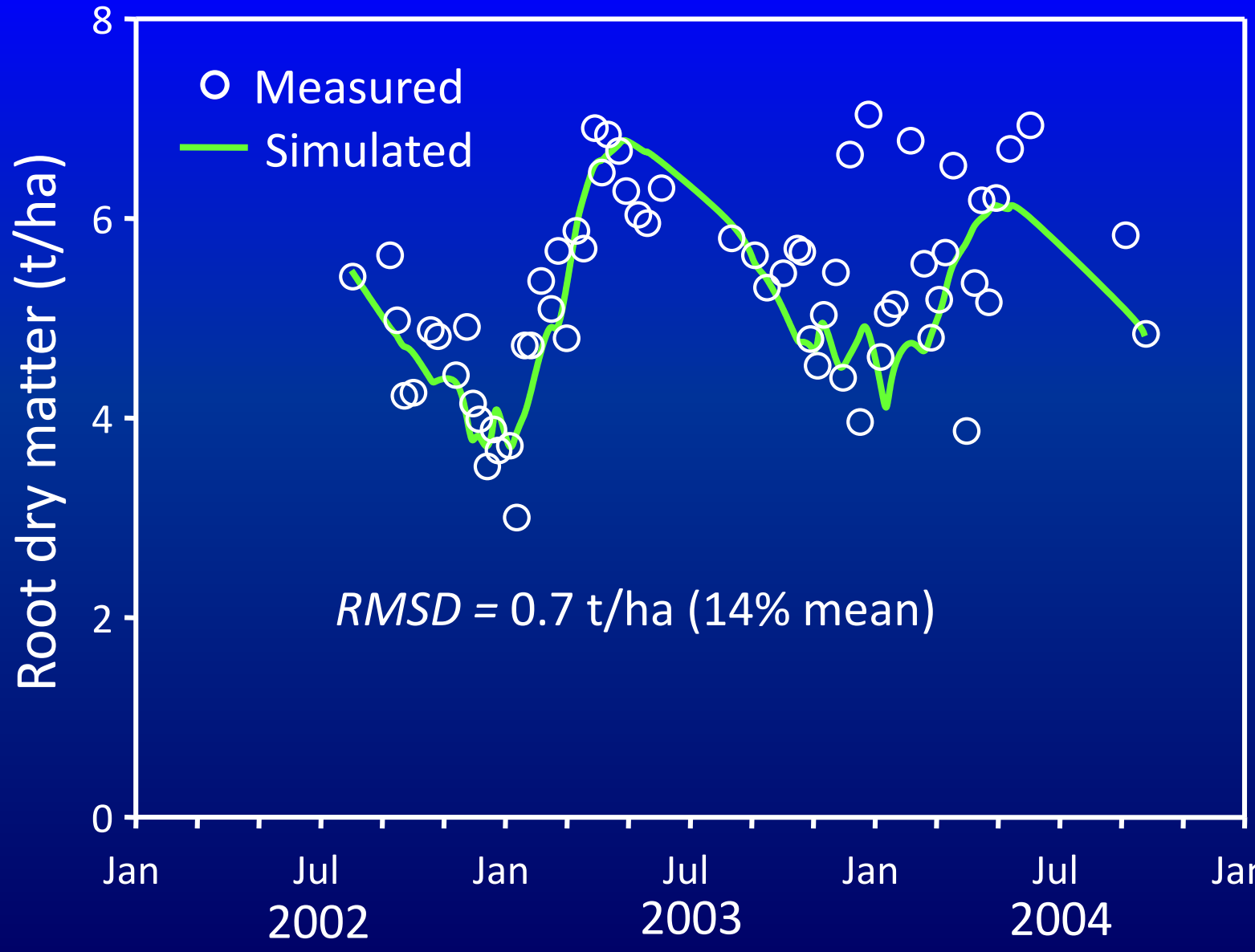


RMSD=14% mean

Rm=0.015

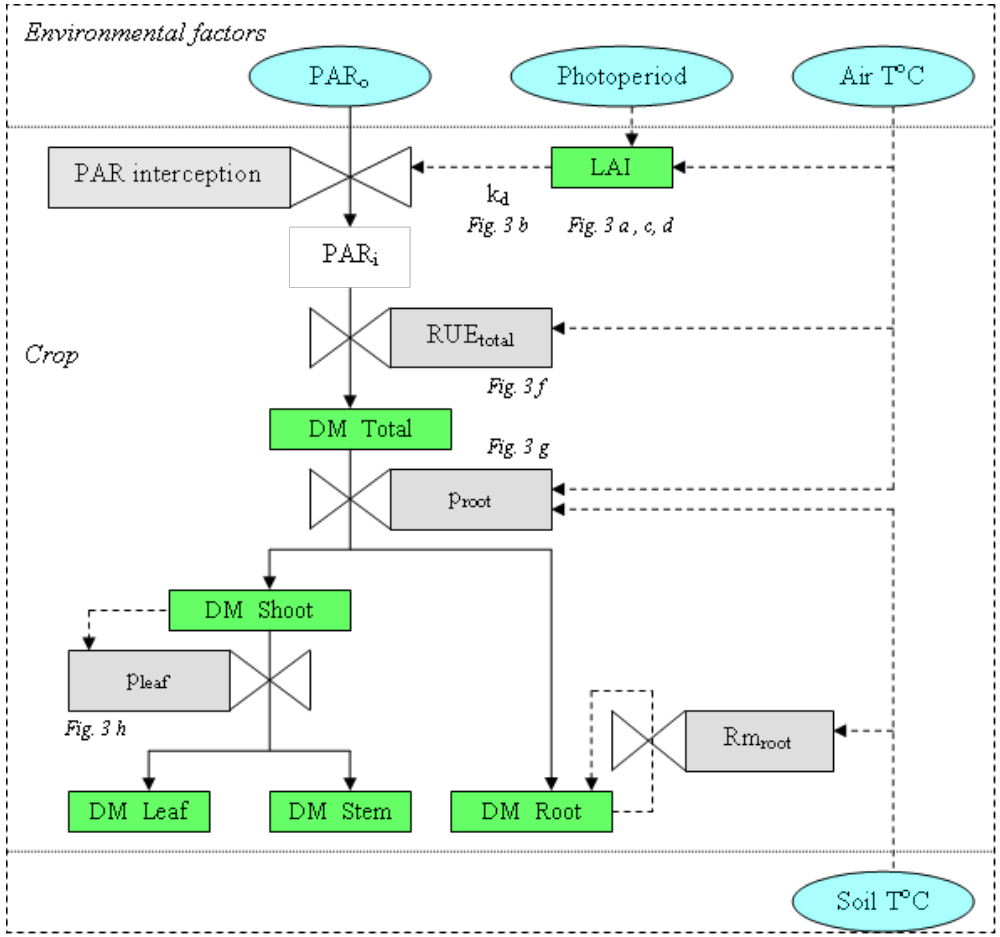
Teixeira *et al*. 2009

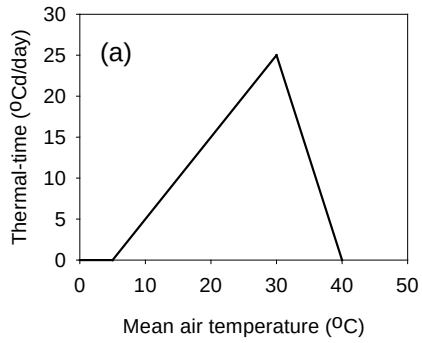
Adjusting Rm for the best fit

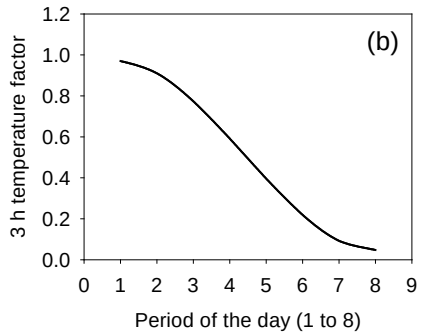


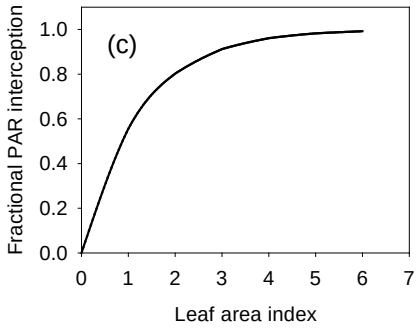
Teixeira *et al*. 2009

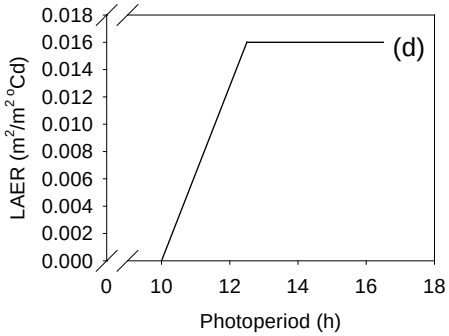
Modelling

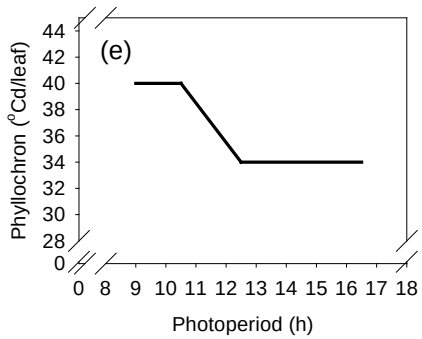

Environmental factors
PAR$_o$
Photoperiod
Air T°C
PAR interception
LAI
k_d
Fig. 3 b
Fig. 3 a, c, d
PAR$_i$
Crop
RUE$_{total}$
Fig. 3 f
DM Total
Fig. 3 g
p_{root}
DM Shoot
p_{leaf}
Fig. 3 h
Rm$_{root}$
DM Leaf
DM Stem
DM Root
Soil T°C

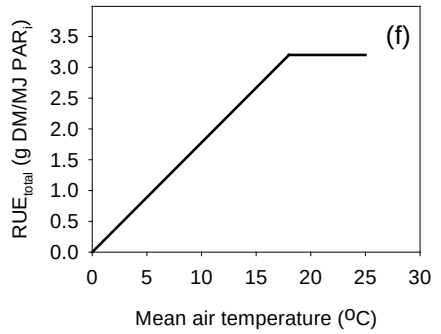

(a)
Thermal-time (°Cd/day)
Mean air temperature (°C)

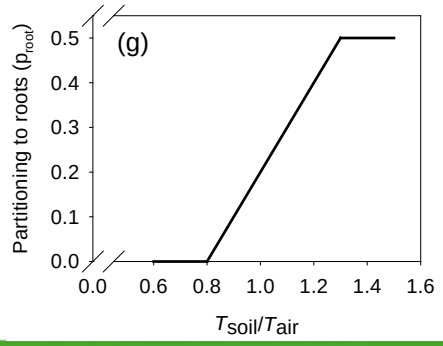

(b)
3 h temperature factor
Period of the day (1 to 8)

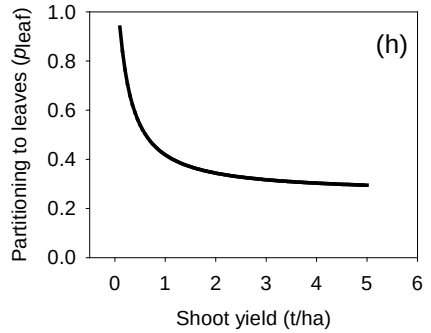

(c)
Fractional PAR interception
Leaf area index


(d)
LAER (m²/m²°Cd)
Photoperiod (h)

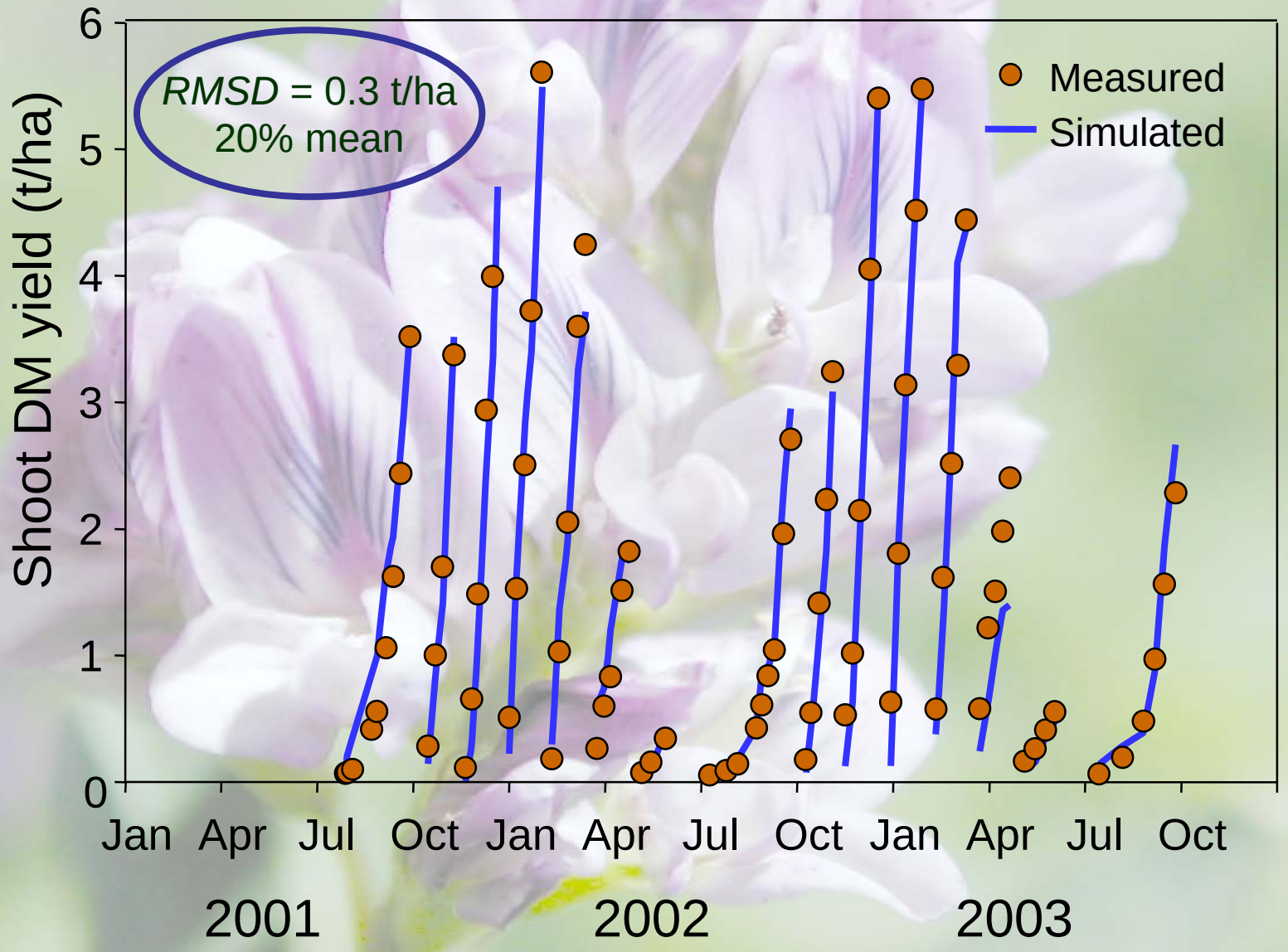

(e)
Phyllochron (°Cd/leaf)
Photoperiod (h)


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


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

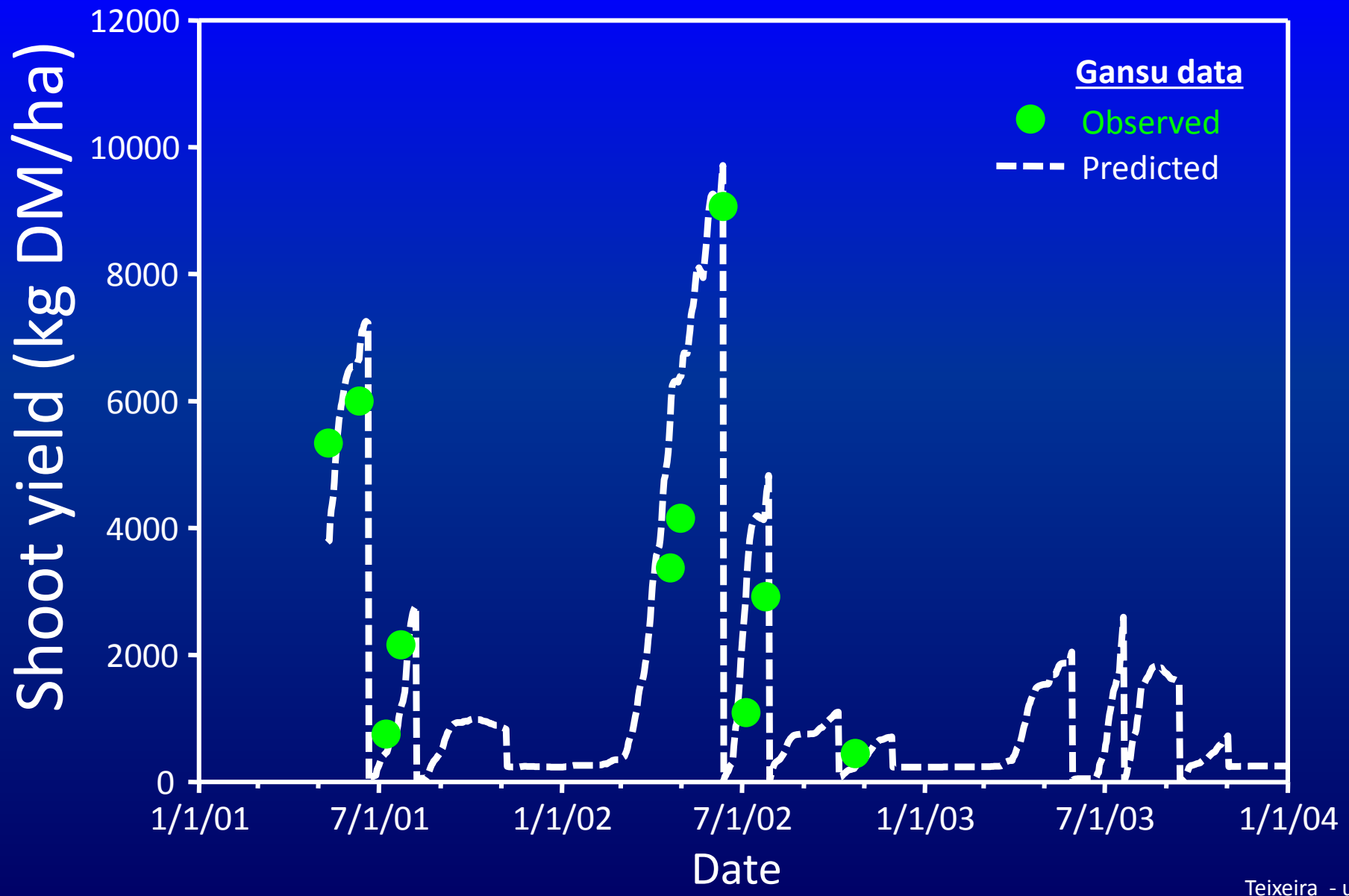

(h)
Partitioning to leaves (p_{leaf})
Shoot yield (t/ha)

Predictions of shoot yield



Source: Monks *et al*. 2009

APSIM Lucerne Validation



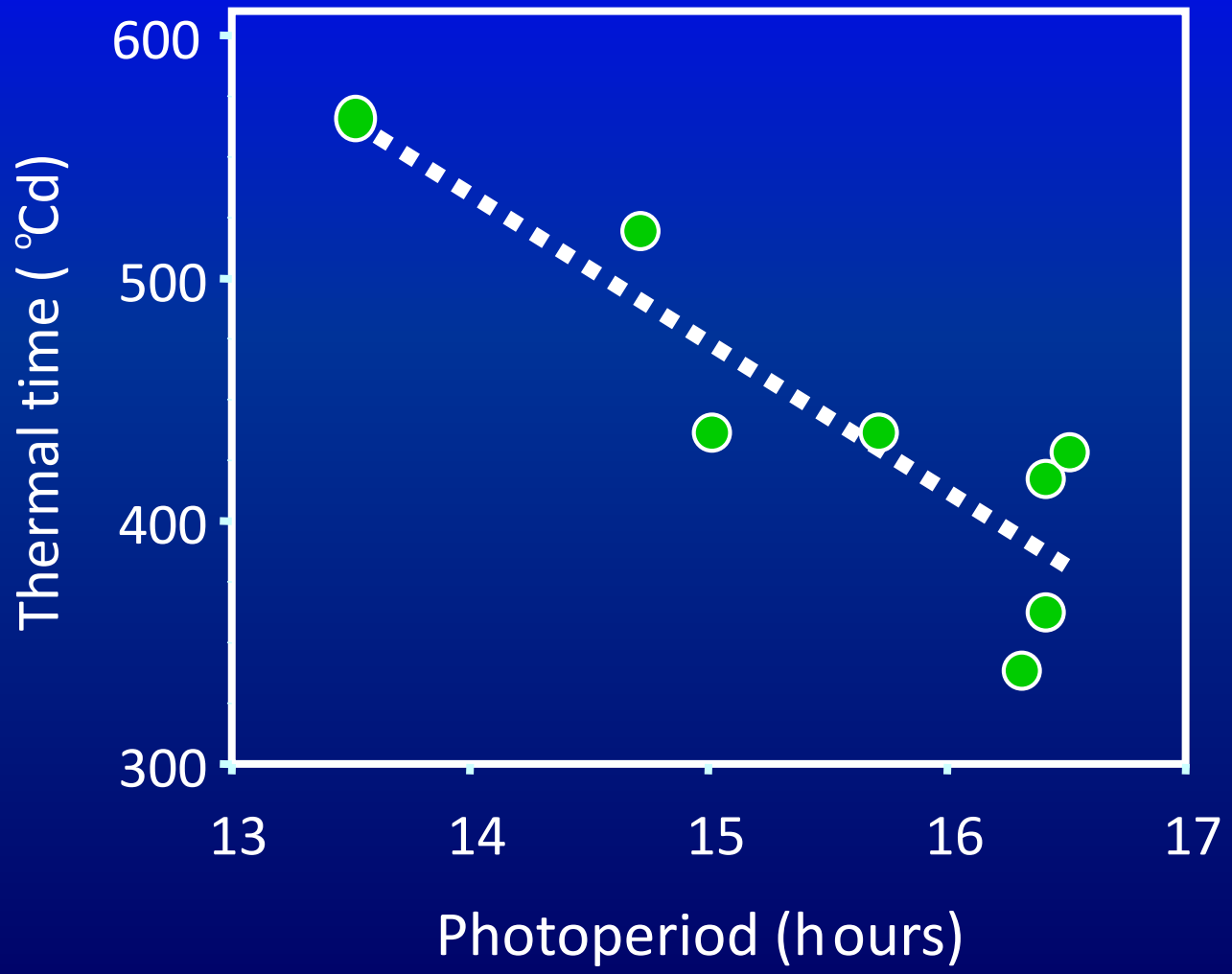
Teixeira - unpublished

Farmer issues

b) US based mgmt. recommendations

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

Thermal time to early-bud

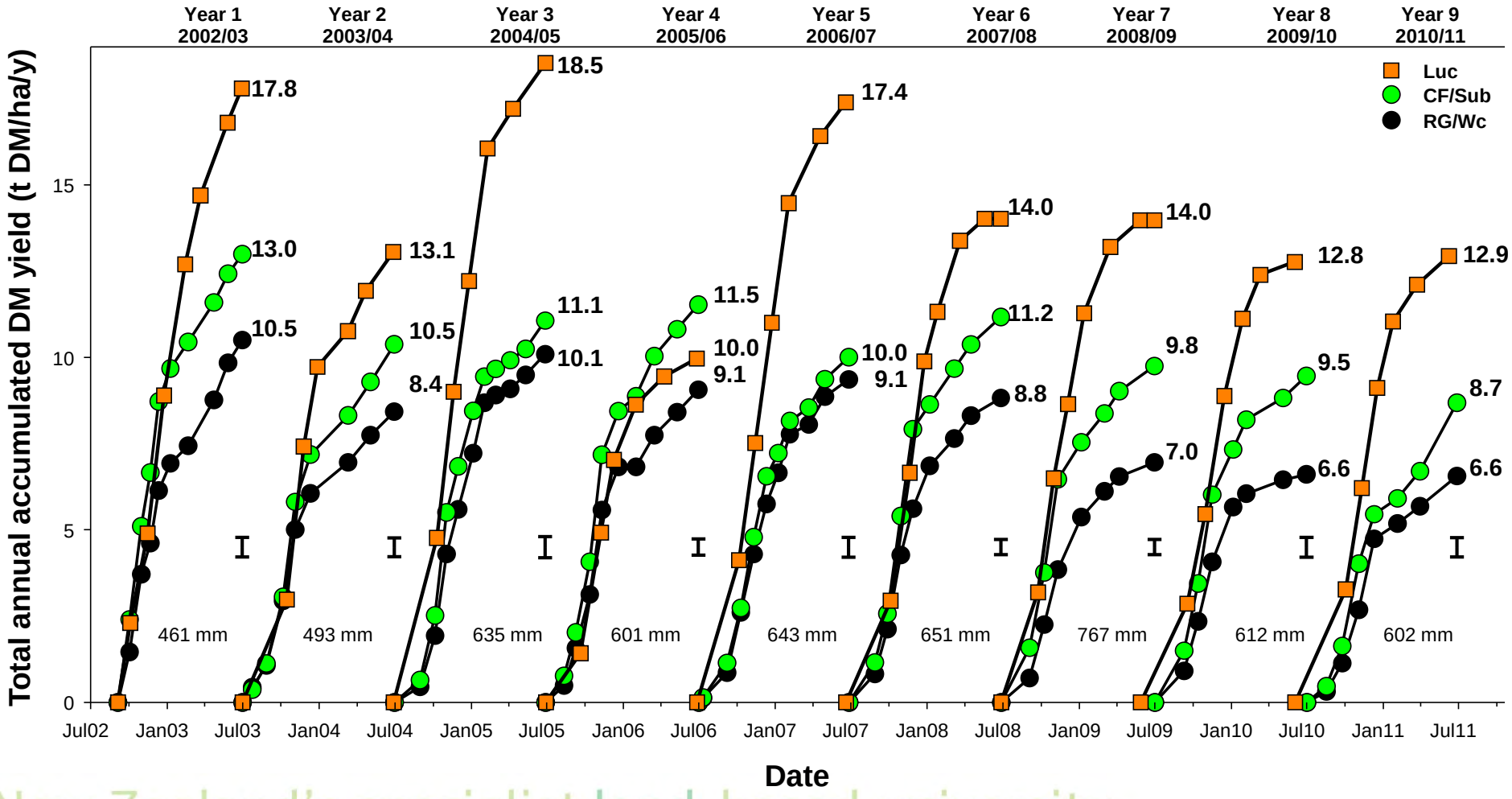


Moot *et al*. 2003

10% Flowering?

Grazing Expt. - ‘MaxClover’

MaxClover Total DM yields



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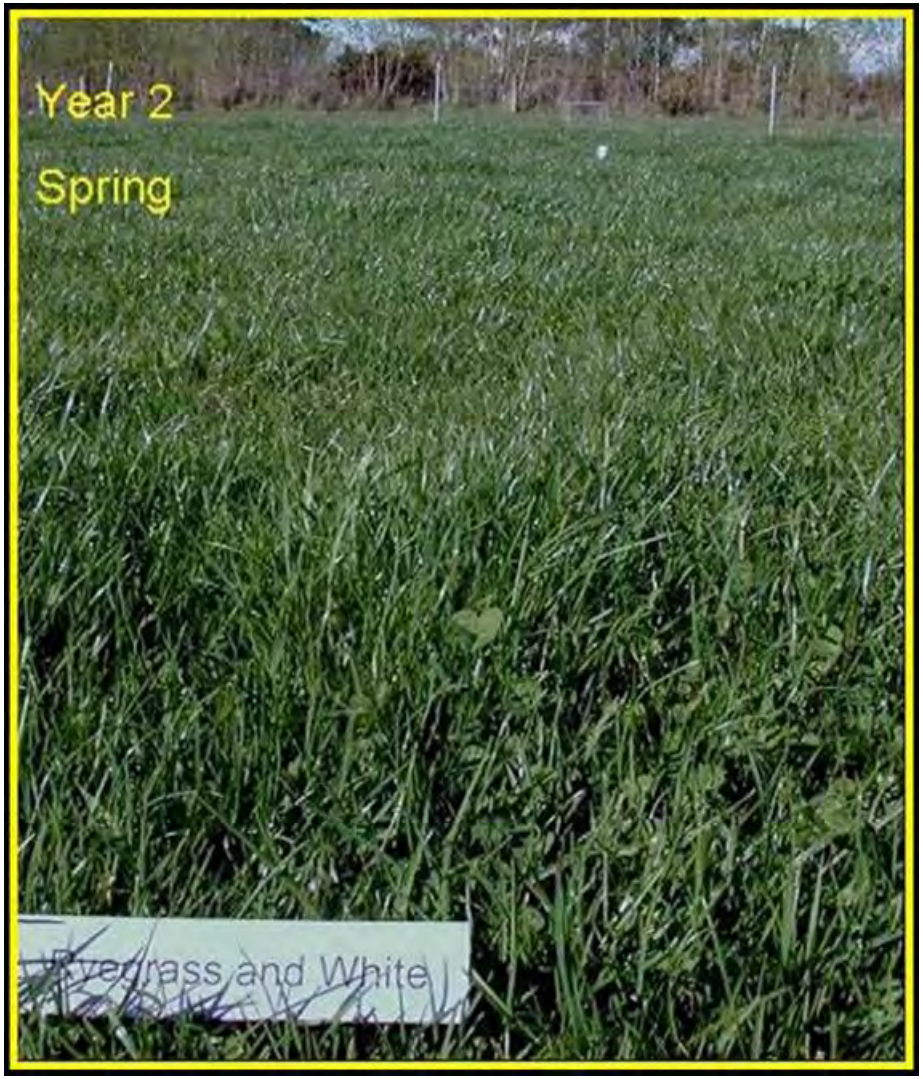
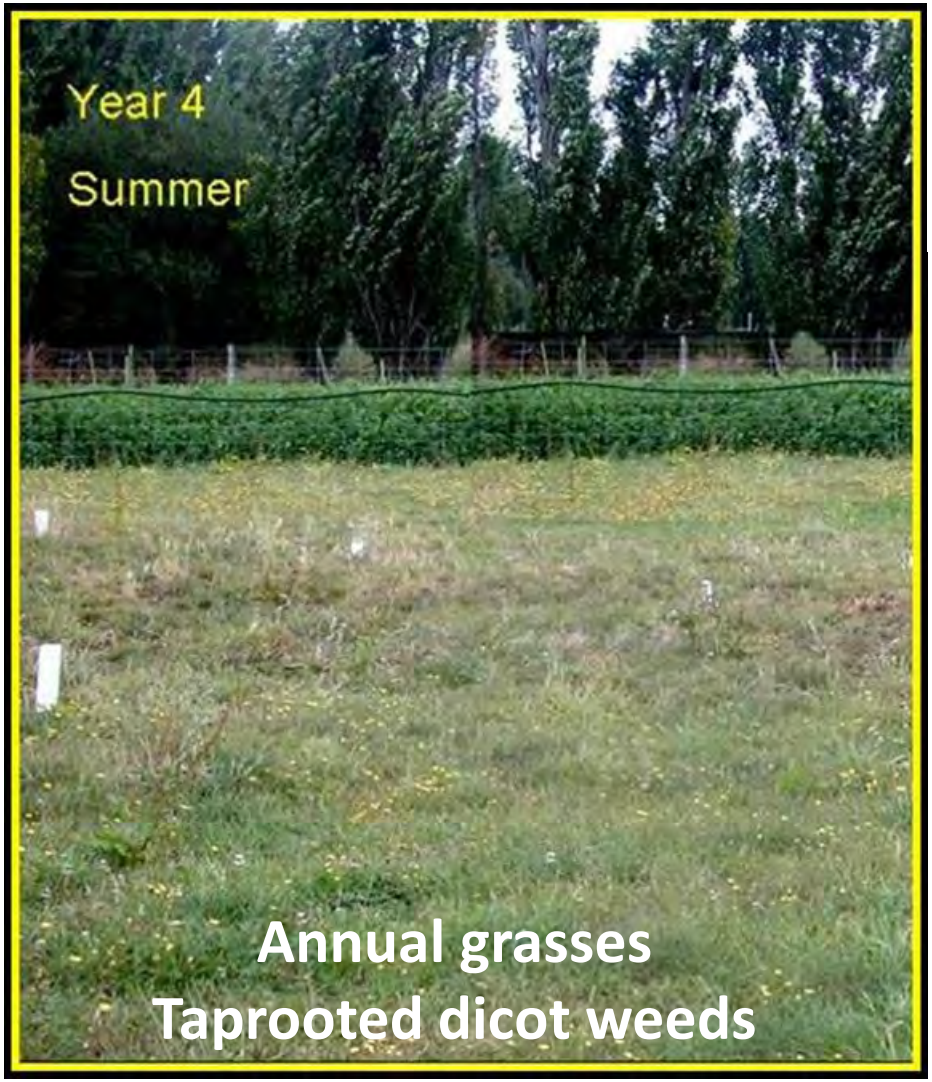
Source: Moot 2012

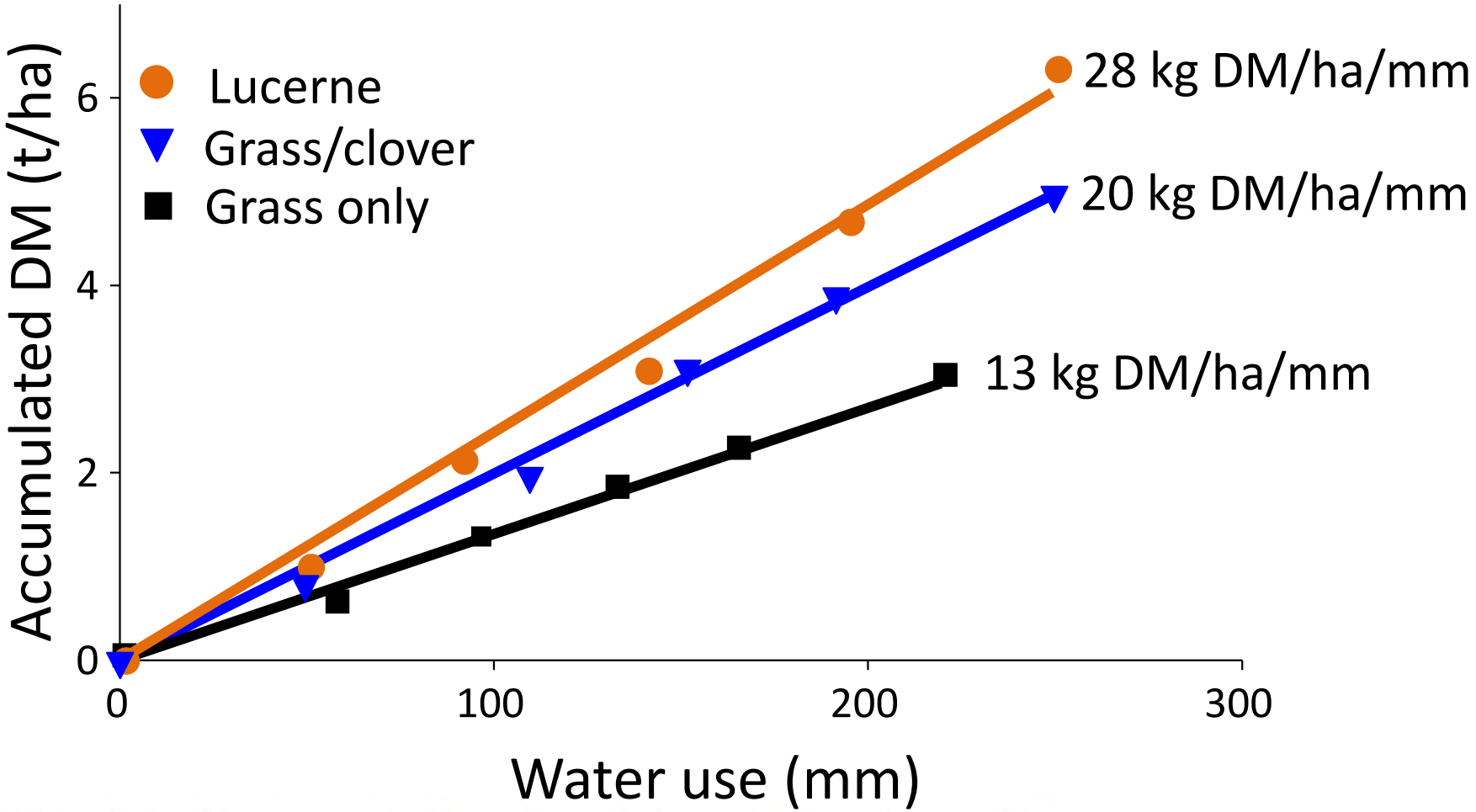




Unsown species <5% in Year 1 …….>45% in Year 6

RG/Wc pastures

Spring WUE



Source: Moot *et al*. 2008

Lucerne research outcomes

1) Identified lucerne as “God’s Plant”

2) Understood the interactions of lucerne and its biophysical environment

3) Validated science with independent data sets

4) Interpreted the science for on-farm application

Extension

SERVANT LEADER

Sustainable Farming Fund
Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

In the field

143 Extension days since 2007

(to June 2013)

Seasonal grazing management

Spring

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

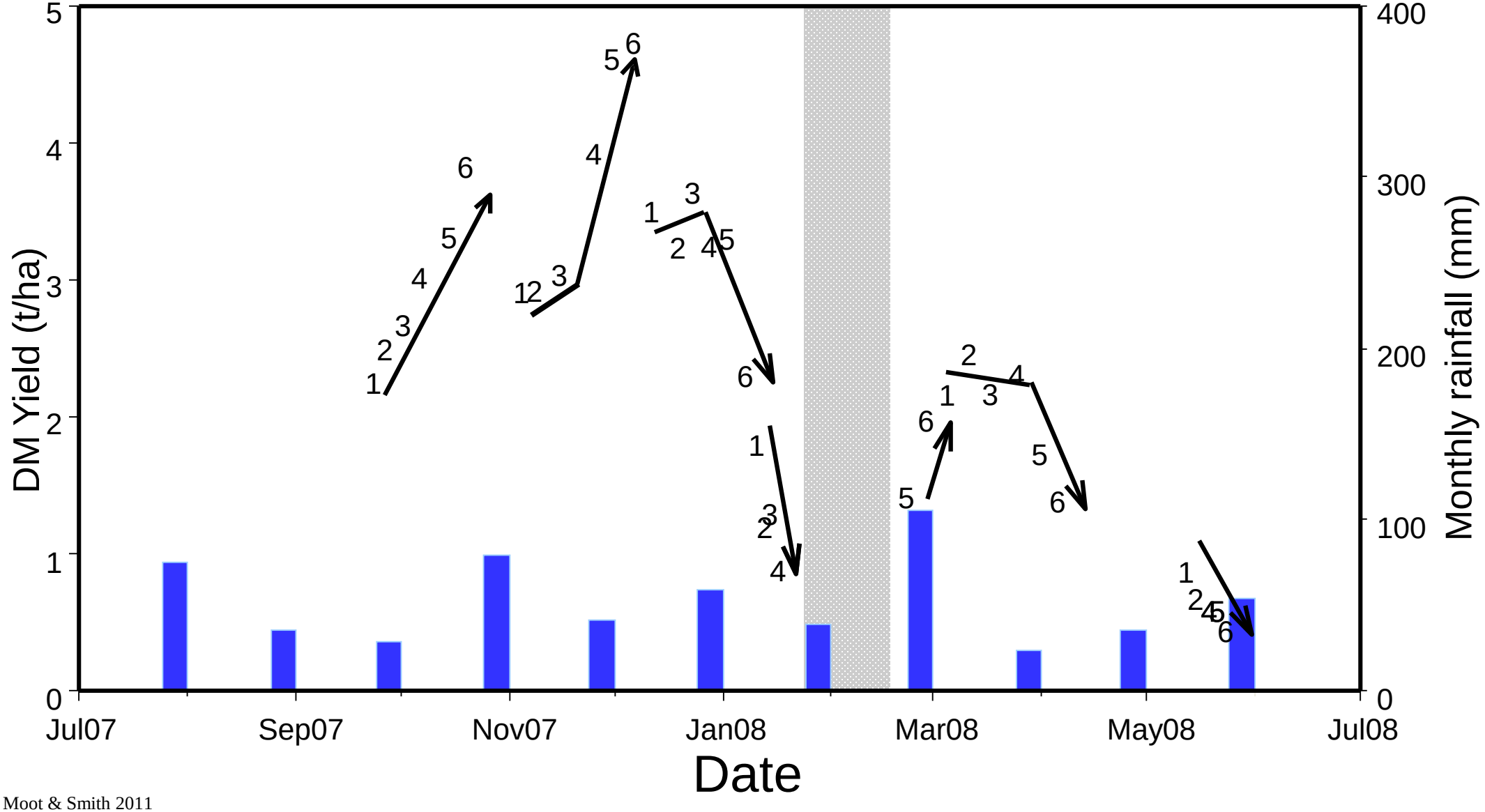
- can graze before flowers appear (~1500 kg DM/ha) ideally ewes and lambs but

Growing point at the top of the plant

5th September 2011 – Cave Sth Canterbury

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

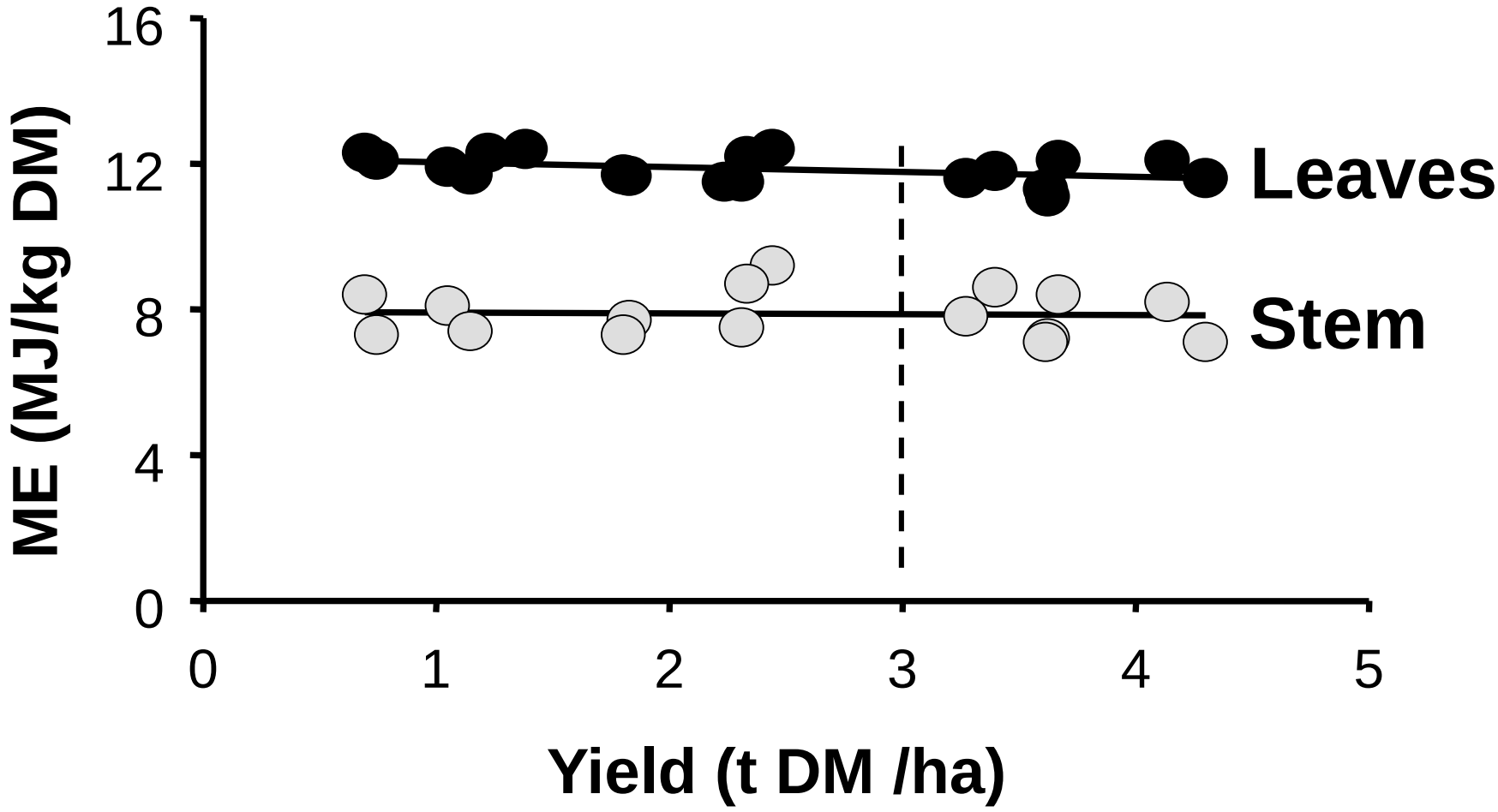
MaxClover



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

Metabolisable energy of lucerne



Source: Brown & Moot 2004

Resilience through change – “Landscape farming”

Where to plant

Landscape farming

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When to graze

Which animals?

Dairy at LU

What else to feed

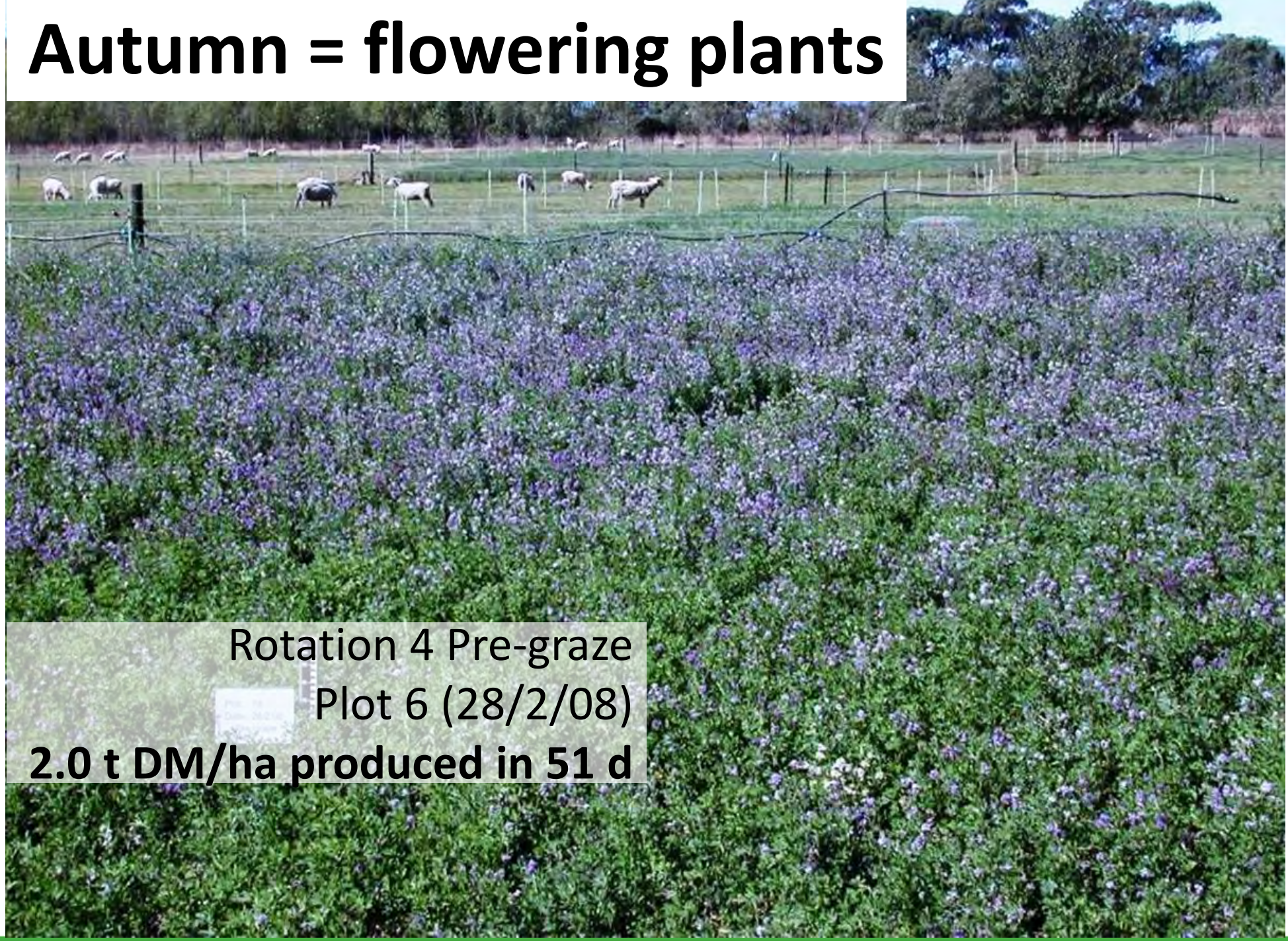
Maximize reliable spring growth – high priority stock

Seasonal grazing management

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

Autumn = flowering plants



Increased agronomic research

Soils
- deepest free draining soils
- $pH_{(H_2O)}$ 6.0 – 7.0
- RG/Wc fertility

Sowing
- 8-10 kg/ha
- 10-25 mm
- peat inoculated 8-10 kg/ha
- spring or autumn (grass grub)
- cultivated/direct drilled (DAP)
- after fallow?

Un/successful methods

- full cultivation
- direct drilling after pasture
- direct drilling after crops
- oversowing on riverbed
- oversowing on hill country
- undersown barley
- undersown rape
- spring sown
- autumn sown

Autumn Spraying

Timing is Critical

Most important tool

Glyphosate, granstar, penetrant

Key Results

Conserve soil moisture

Kill mass root systems

Source: Kearney *et al.* 2010

Drilling seed with fertiliser

Direct drilling = seed + fertiliser

Experimental design

Established 2007 LU – Templeton silt loam

Coated 'Grasslands Kaituna' lucerne.

Four sowing dates

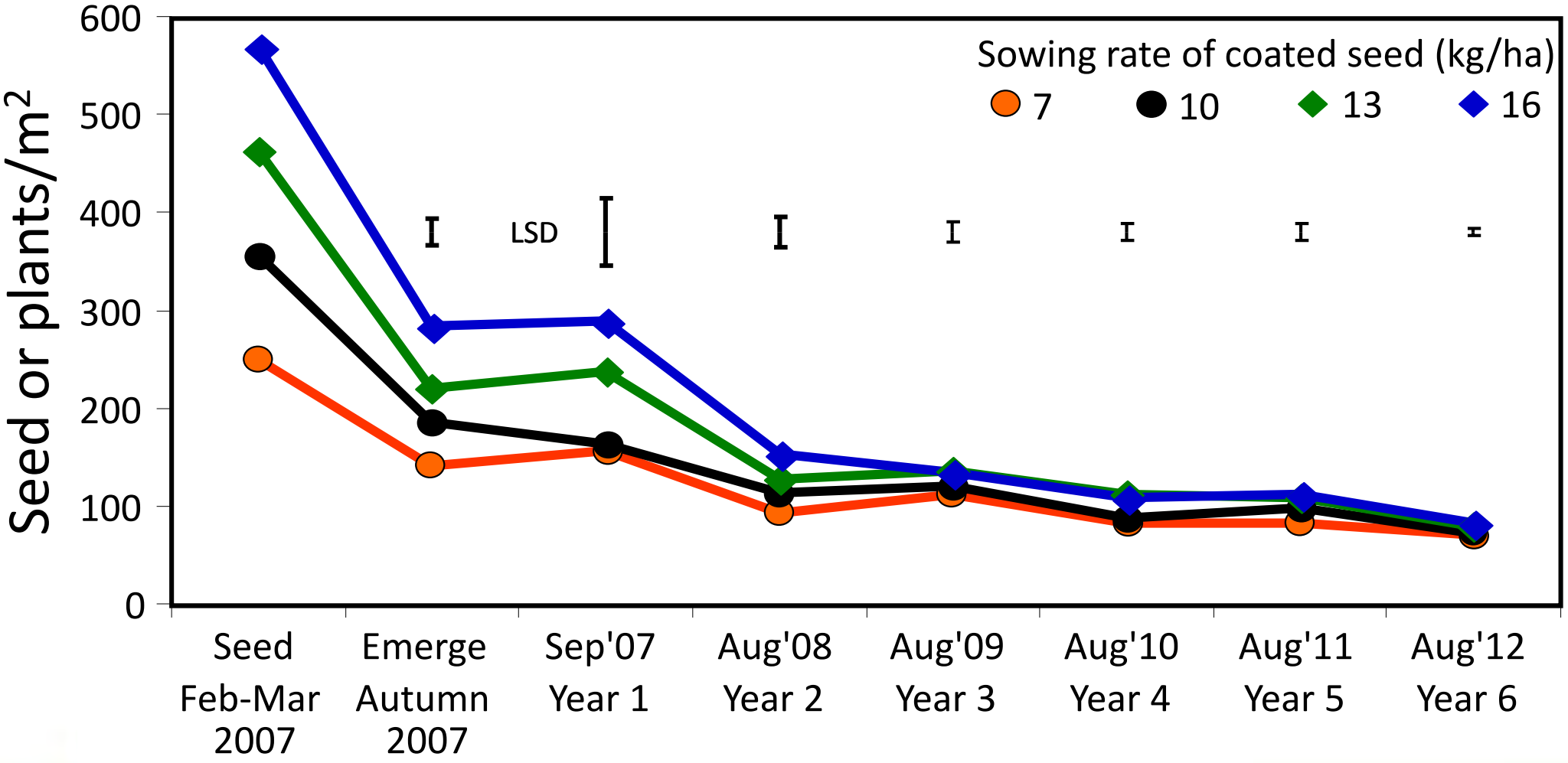
- **21 February,**
- **2 March,**
- **16 March and**
- **30 March**

Four sowing rates

- **Equivalent to bare seed @ 7, 10, 13 and 16 kg/ha**

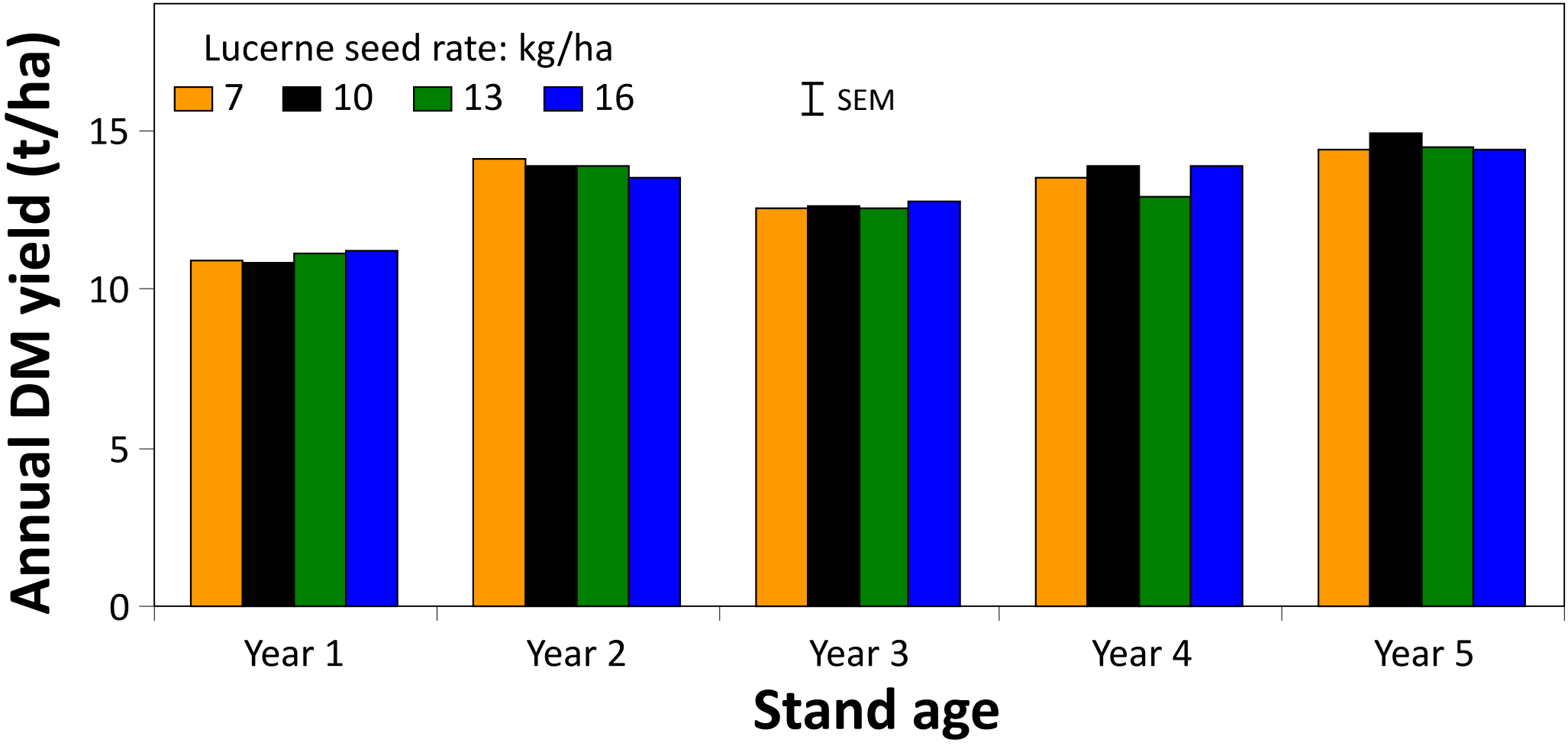
Source: Moot *et al*. 2012

Sown seed & plant population over time



Source: Moot *et al*. 2012

Annual yield in relation to sowing rate



Source: Moot *et al*. 2012

Establishment

Seed Treatments:	Sowing Dates:
ALOSCA®	21 Oct 2010
Coated seed	9 Nov 2010
Peat slurry	8 Dec 2010
Bare seed	13 Jan 2011
	3 Feb 2011

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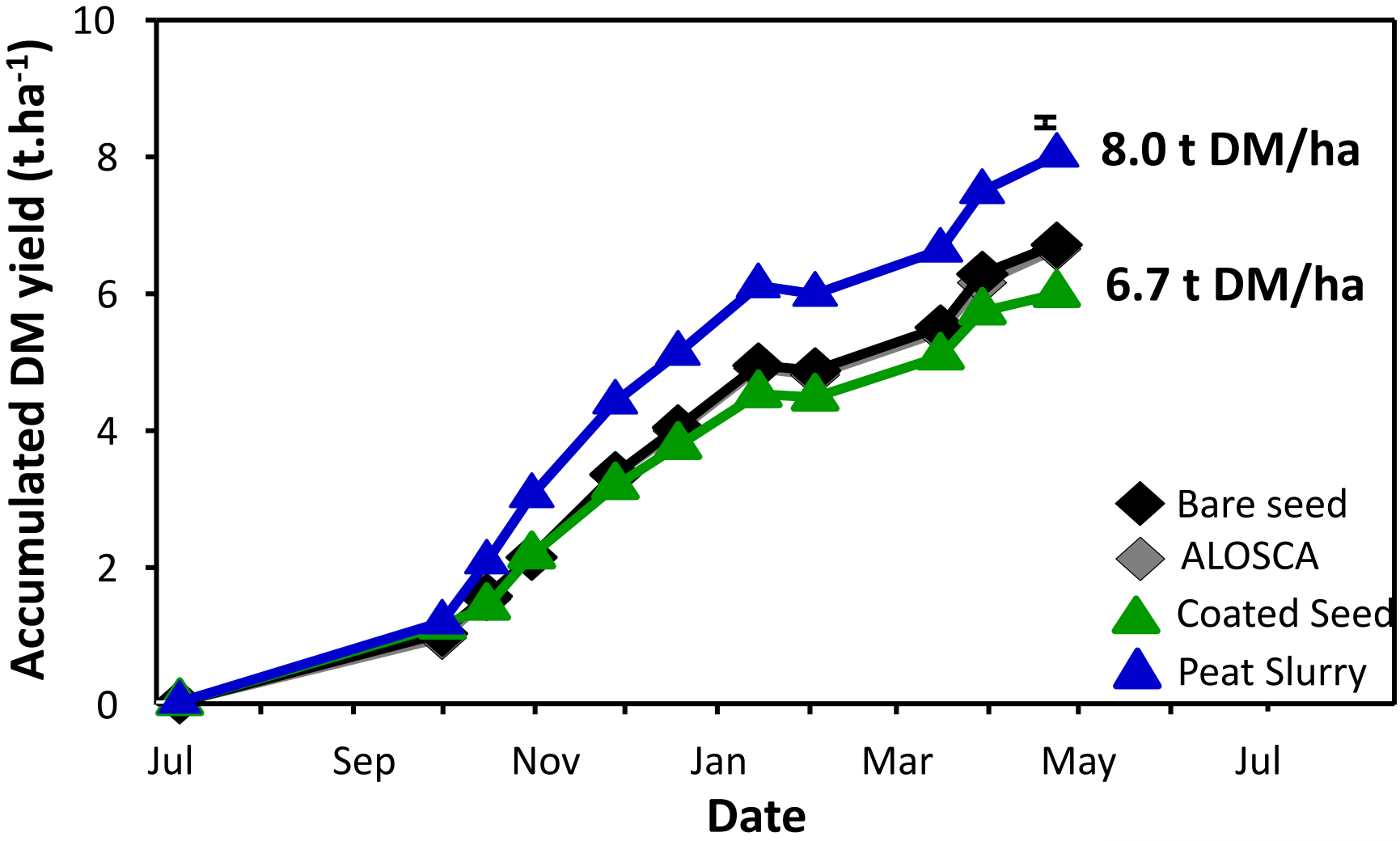
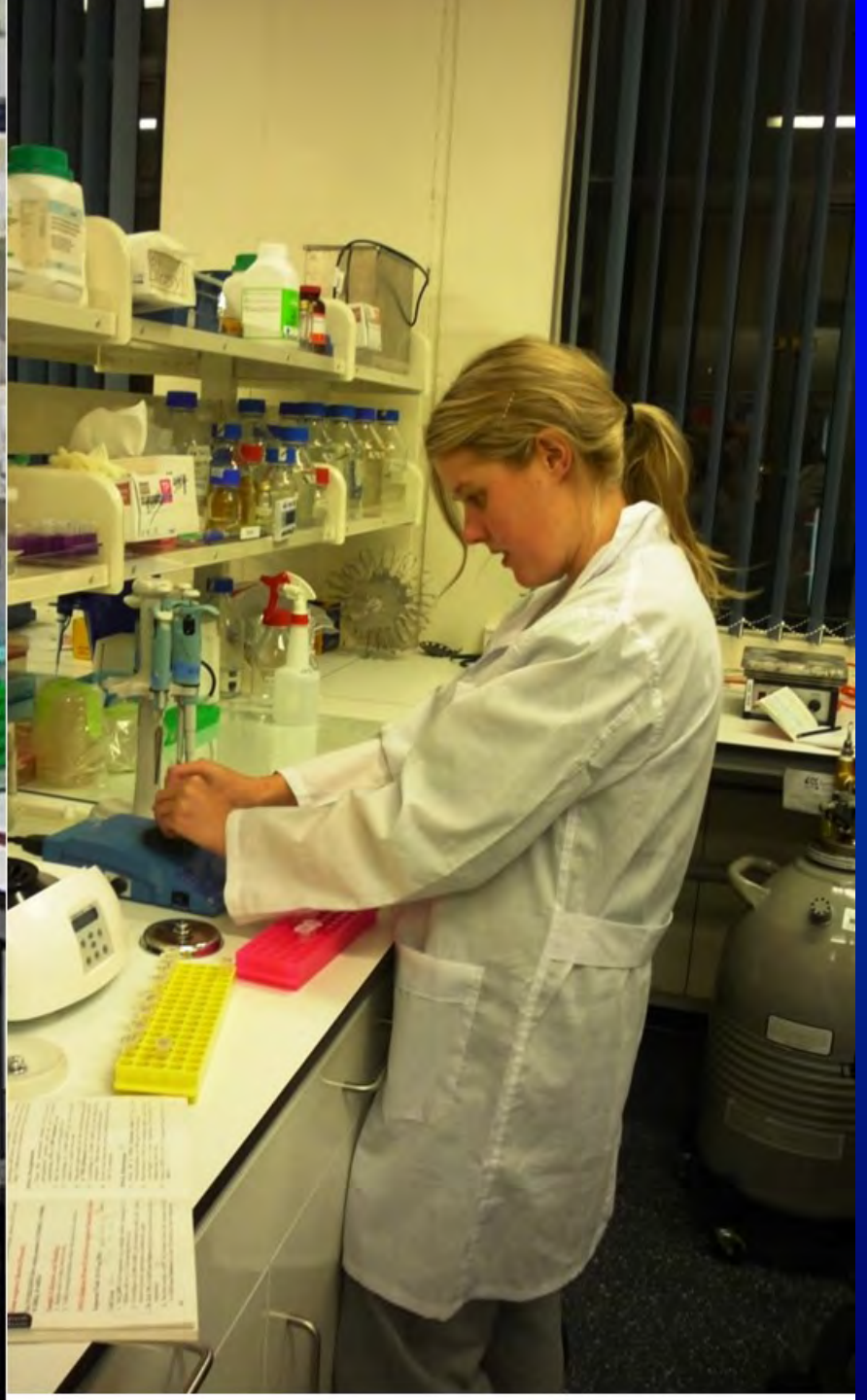
Effect of seed treatment on yield in Year 1




Which rhizobia are in here?



Ensifer meliloti in commercial inoculants

Frequency of Rhizobia

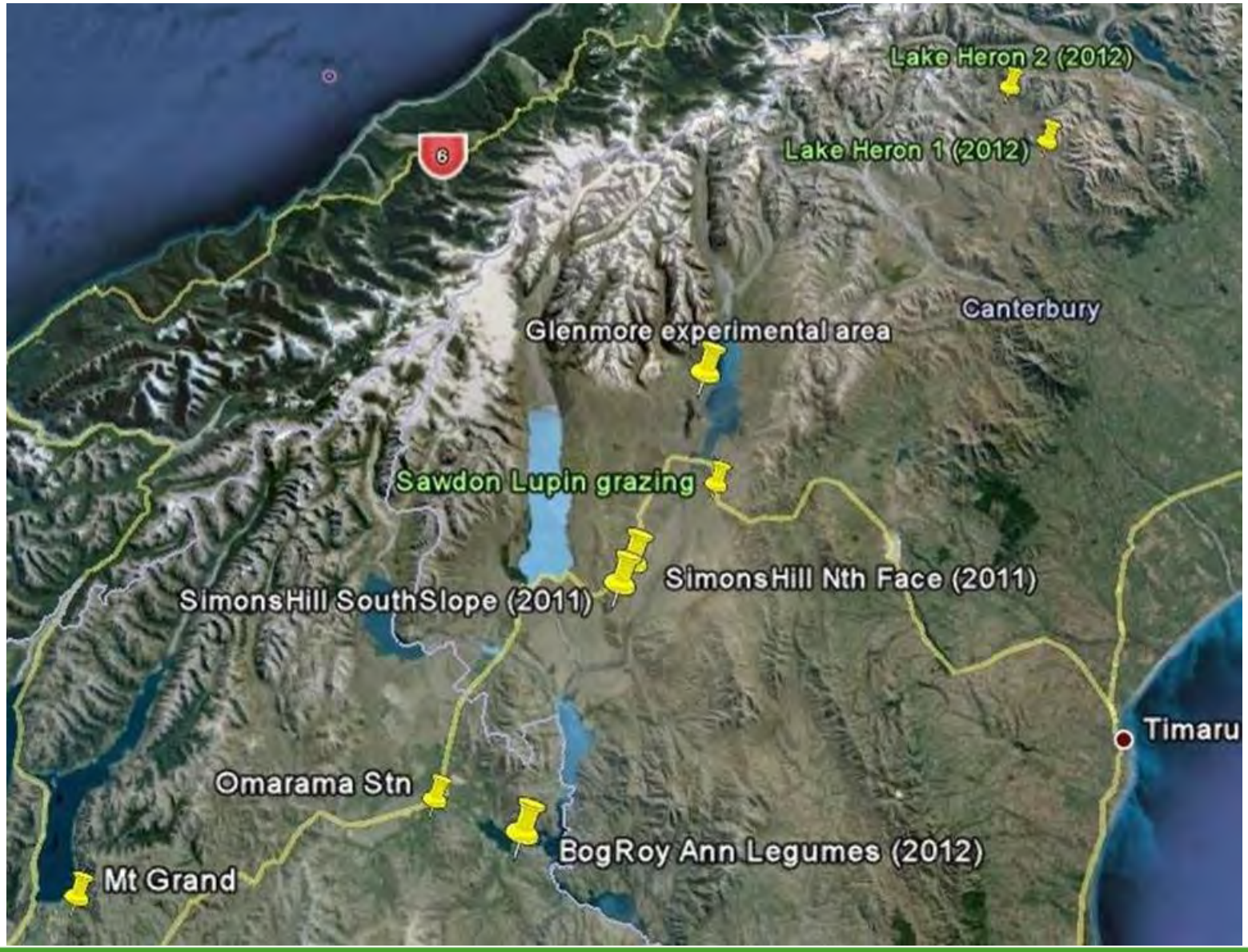
(%)

	Treatment			
Genotype	**Bare seed**	**AS**	**CS**	**PS**
***Rhizobium* sp.**	57	54	22	18
Ensifer meliloti	0	9	45	42
***Rhizobium* sp.**	4	2	6	2
***Pseudomonas* sp.**	0	7	2	4
***Pseudomonas* sp.**	6	0	2	4
***Serratia* sp.**	4	9	0	0
***Rhizobium* sp.**	0	4	0	4

Conclusions

- Adequate populations from all sowing rates and seed treatments
- Sowing after the longest day reduced the yield in Year 0 and Year 1
- Yield advantage from peat slurry treatment

High Country forages



Lake Heron

Sawdon

Glenmore

Simon's Hill

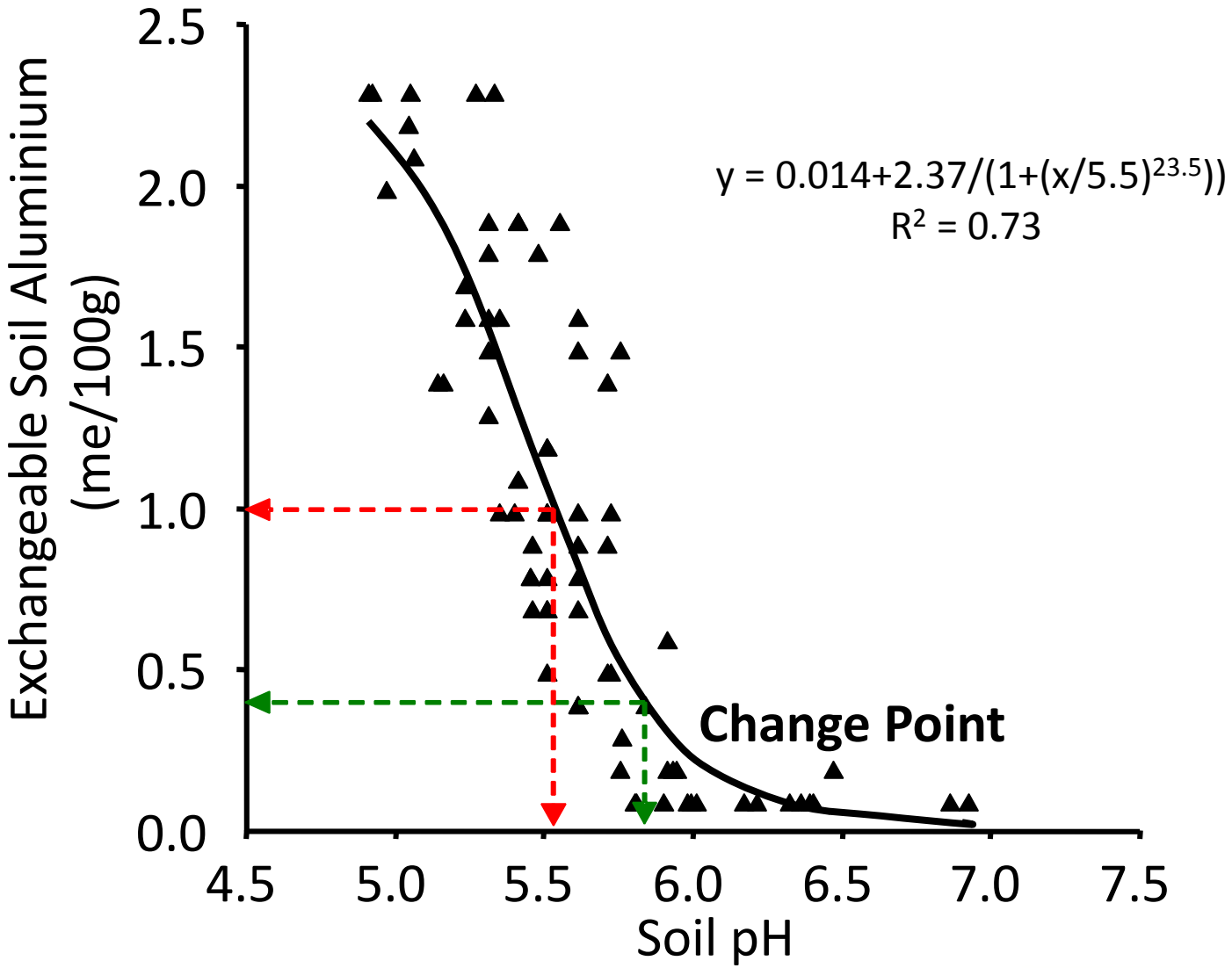
Bog Roy

Omarama

Mt Grand

Aluminium issues

Soil pH & exchangeable Aluminium



Source: Moir & Moot, 2010

Lime and Fertiliser Application

Lime 3-5 t/ha

Fertiliser 250-500 kg/ha

Transformational change
&
Resilience to climate change

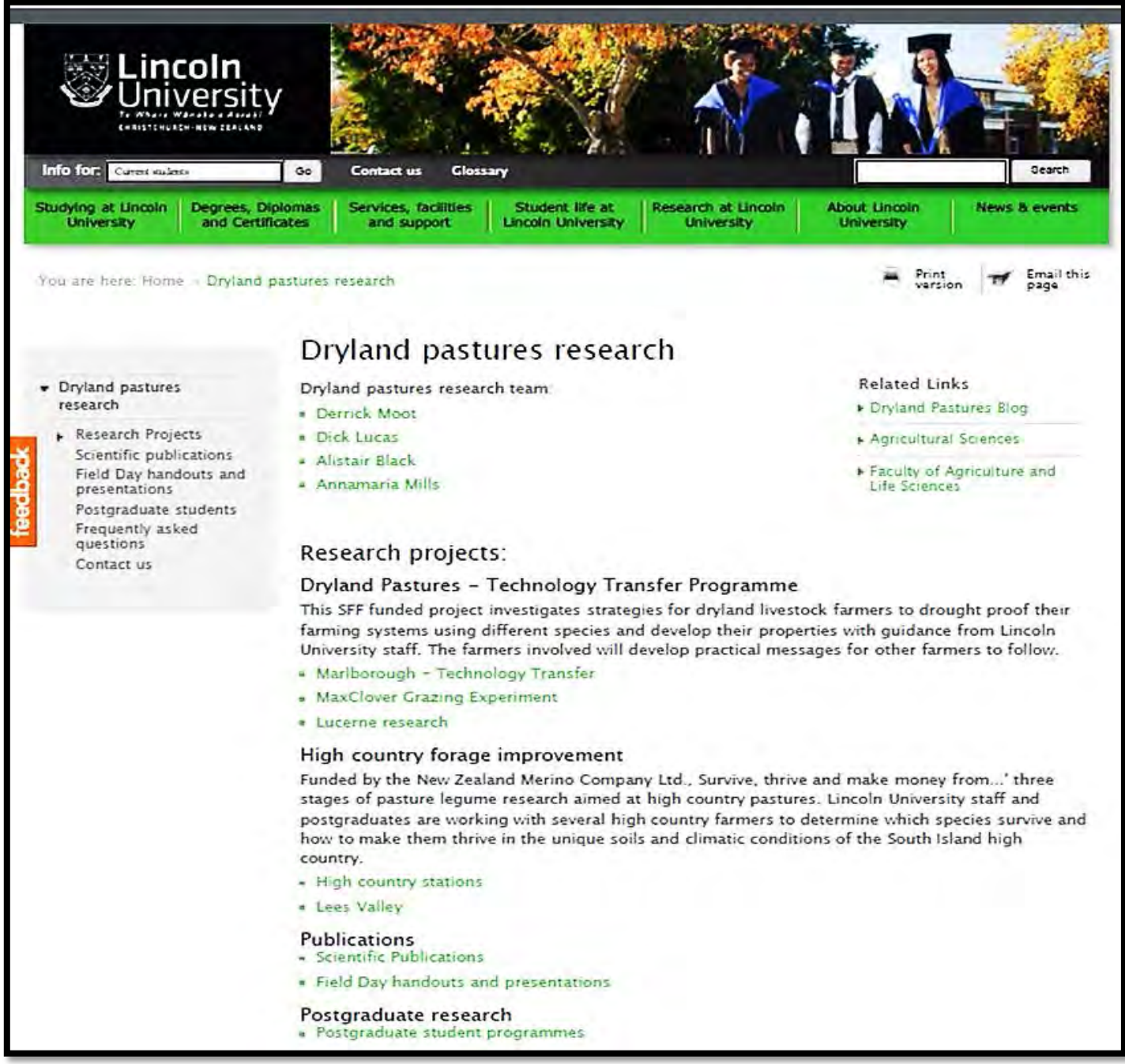

Over 60,000 ha sown and doubling of lucerne seed sales over 10 years
“35% Rate of return on investment”

Lupins tolerate aluminium

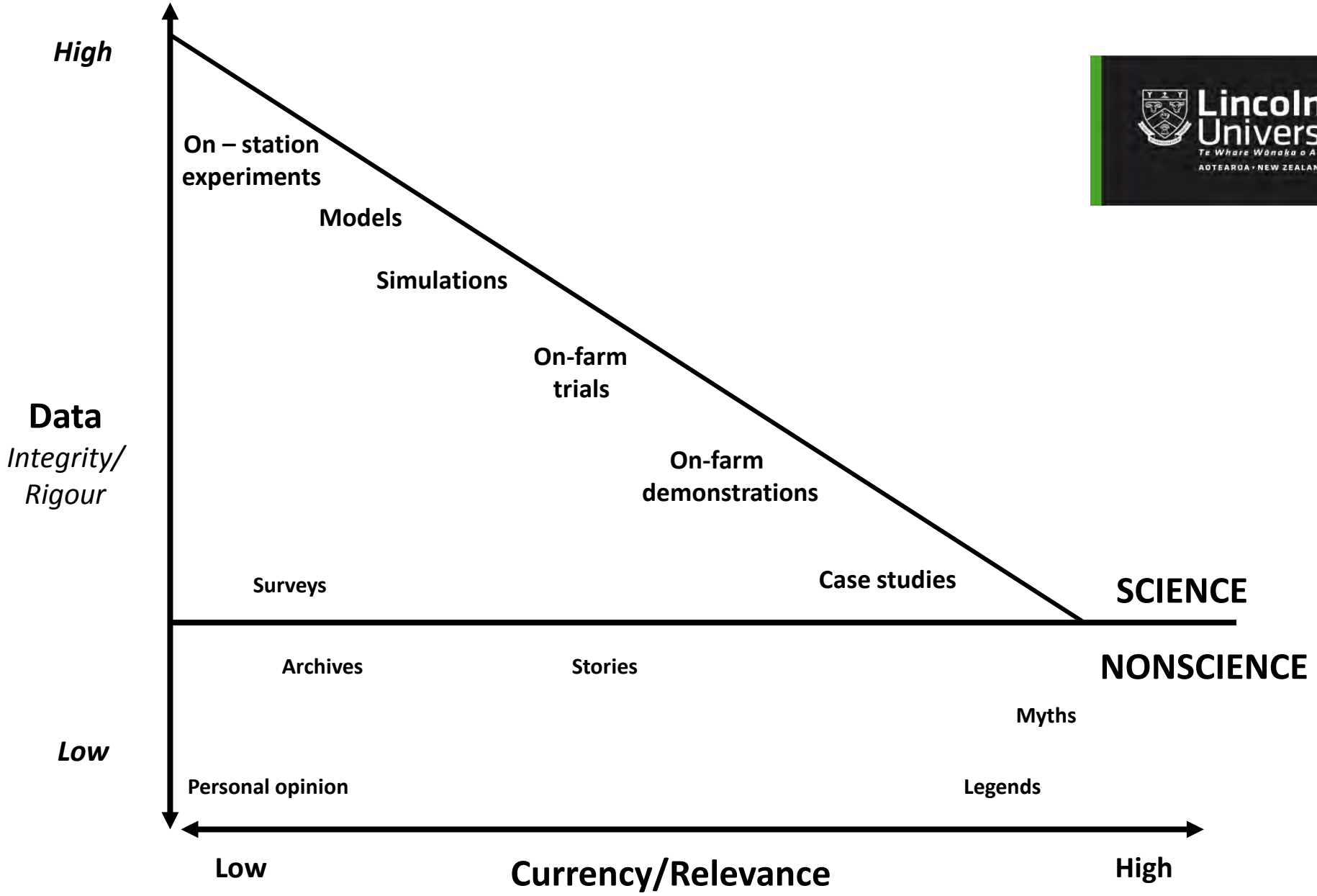
The website…

Info on:

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

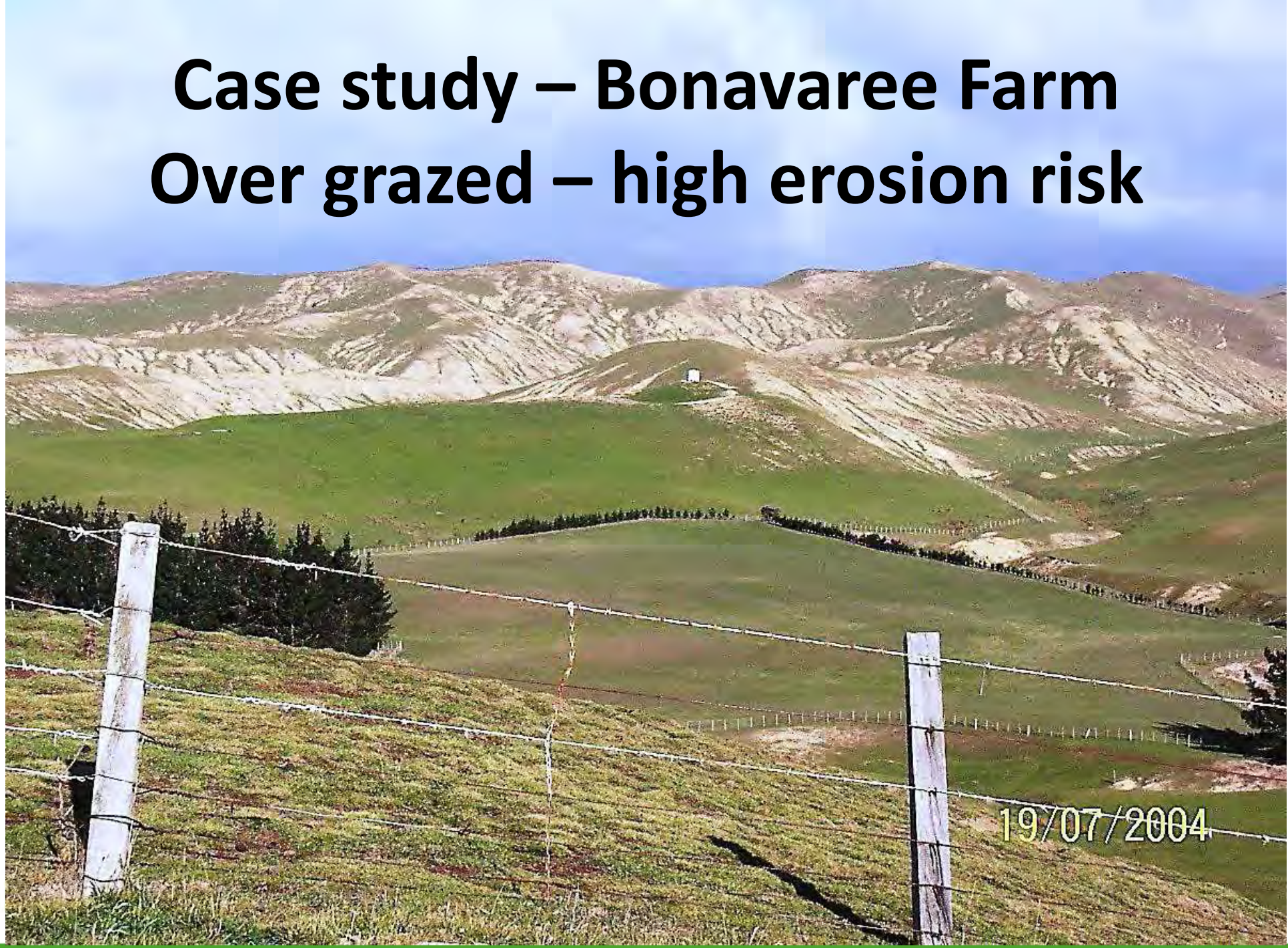


www.lincoln.ac.nz/dryland

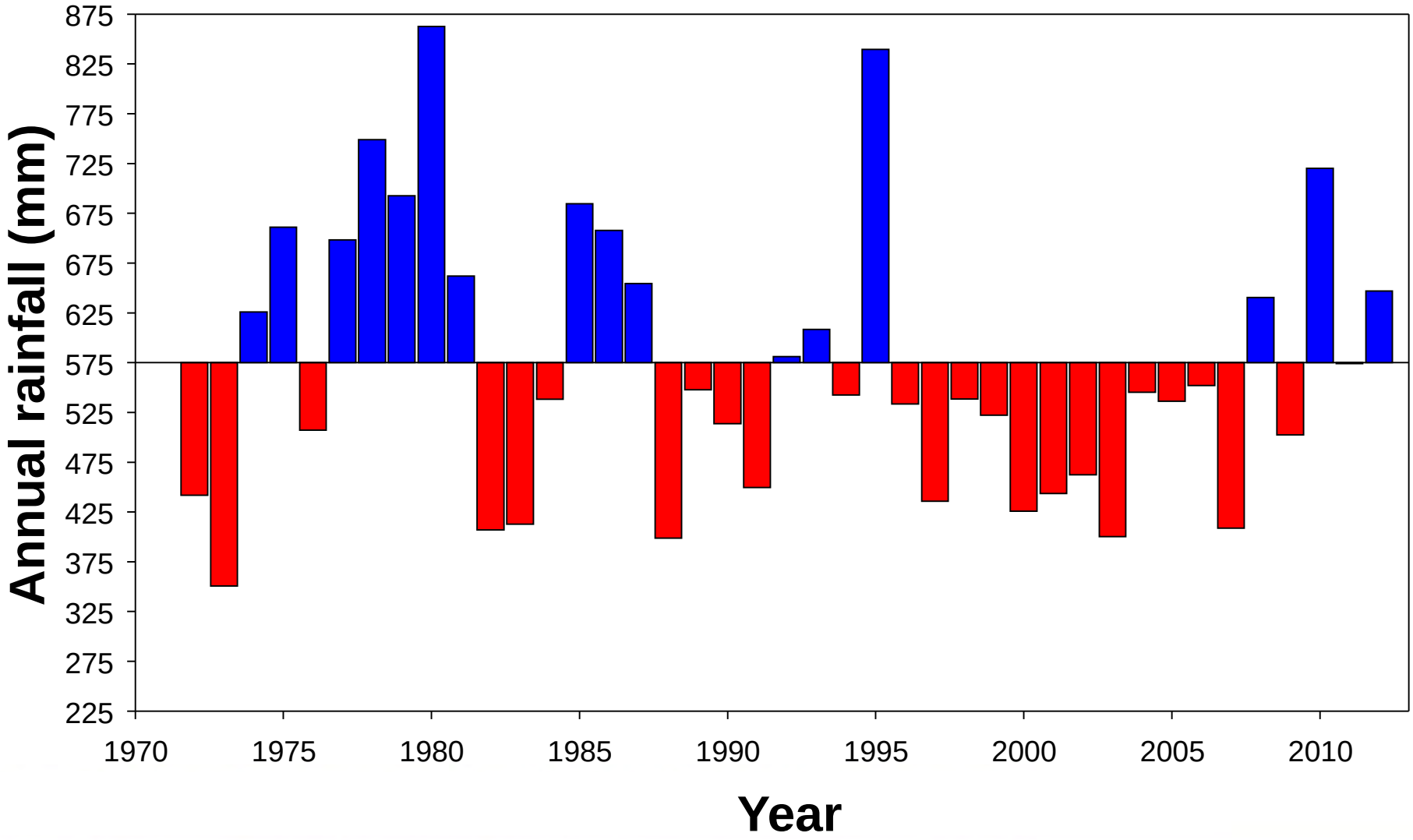


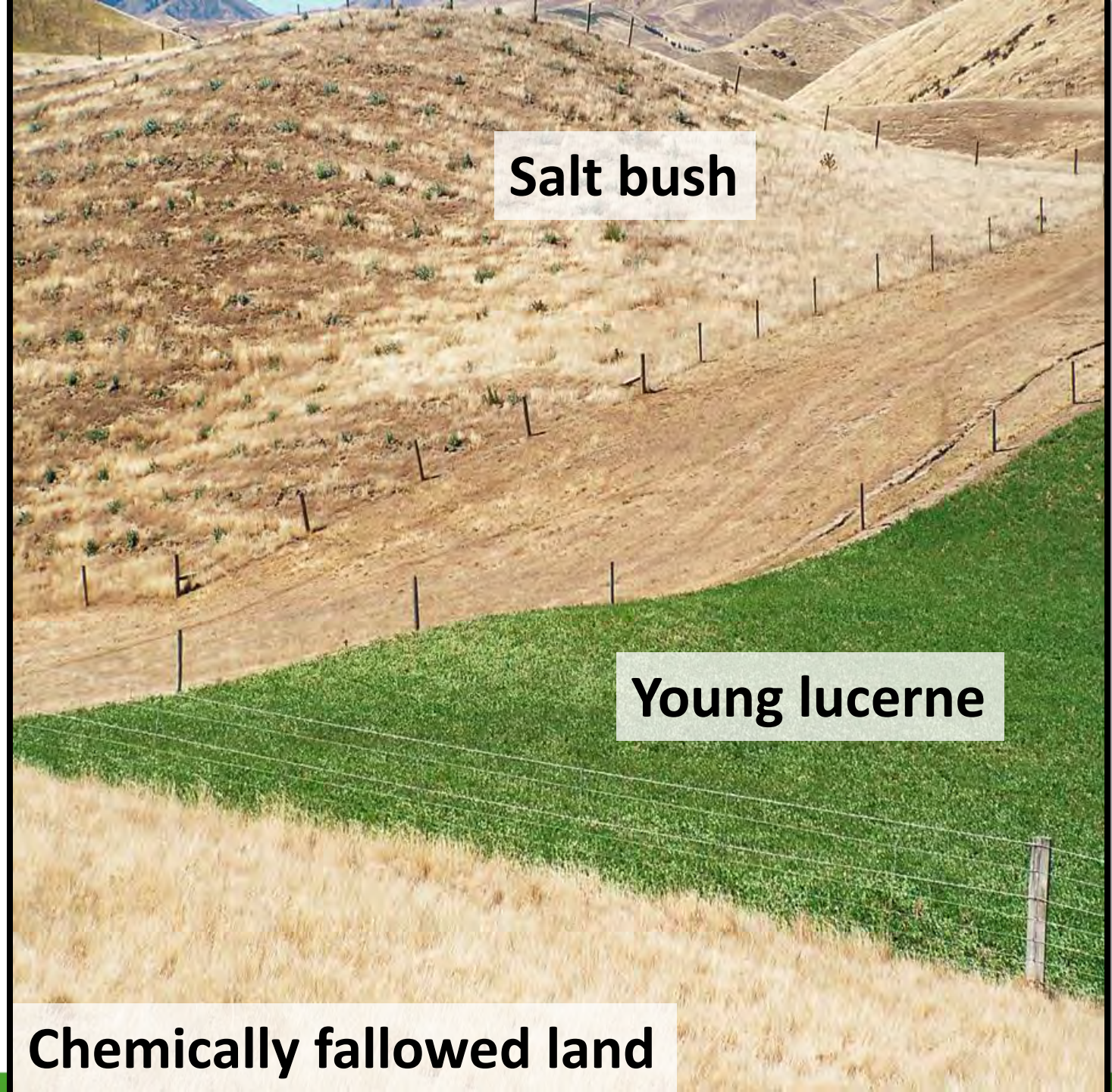
Bonoma 1985

Case study – Bonavaree Farm
Over grazed – high erosion risk



Annual rainfall at ‘Bonavaree’




Salt bush
Young lucerne
Chemically fallowed land

New Zealand's specialist land-based university

‘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%

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"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

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%)

Animal health

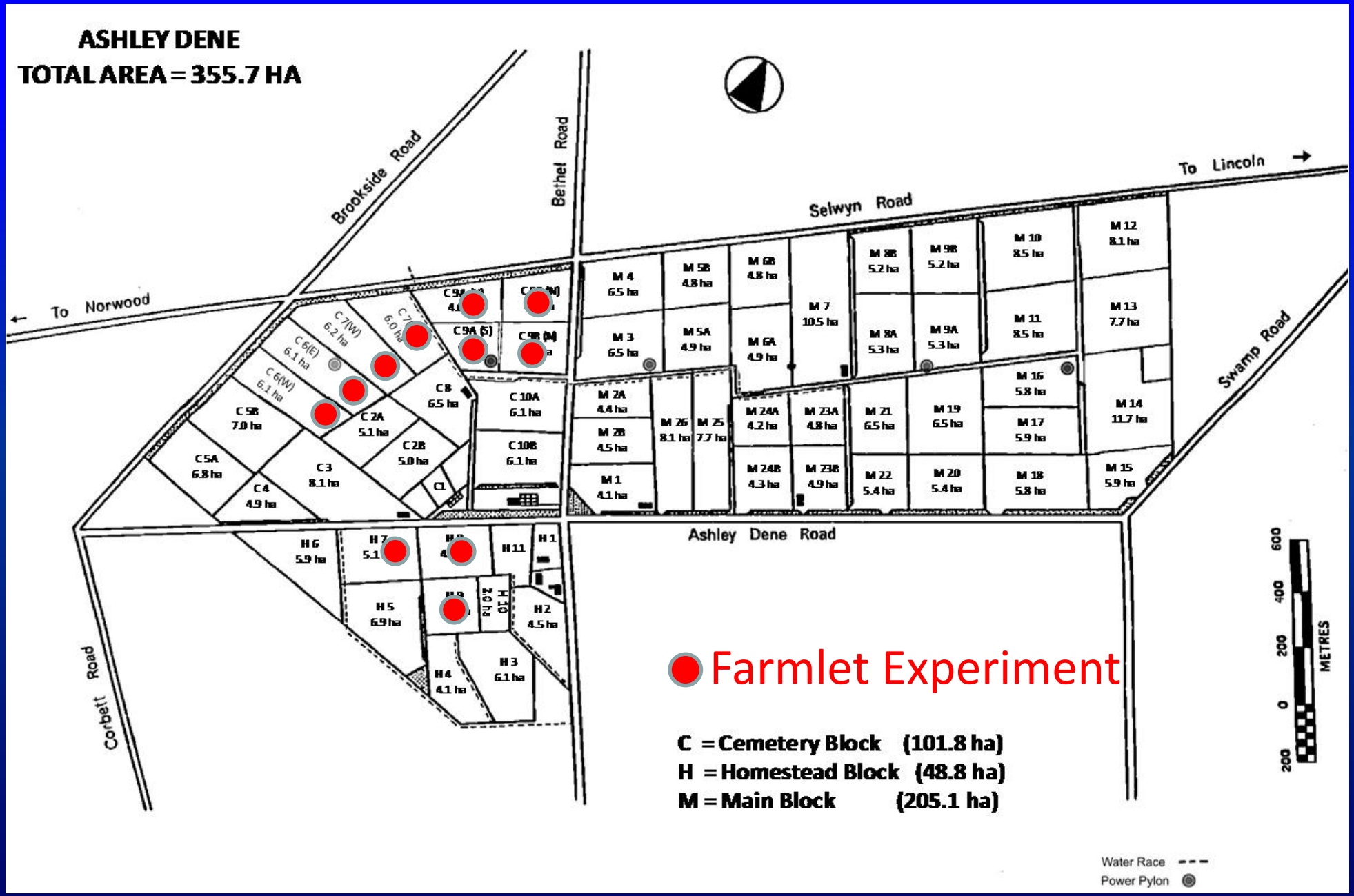
- **Clostridial bacteria:** vaccinate
- **Cobalt:** vitamin B12 injection
- **Worm haven:** Camping on small area – river edge?
- **Avoid flushing if:** leaf spots or flowering lucerne
  - new regrowth or tops only are O.K.

Current research questions

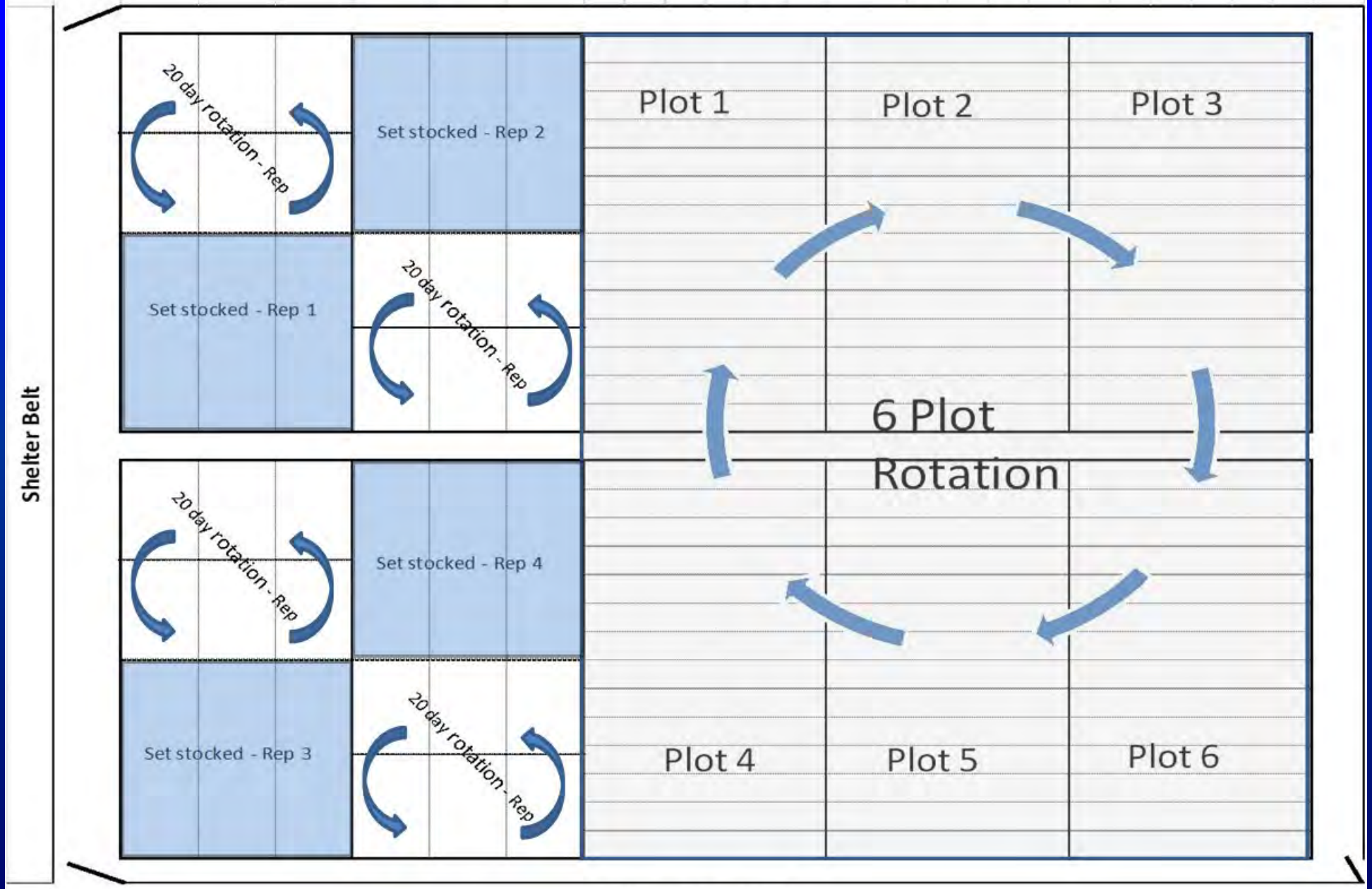
- Set stocking lucerne – grazing experiment
- Lucerne vs. Luc/grass – grazing experiment
- Oestrogens and lucerne - PhD
- Partitioning in higher FD cultivars - PhD
- Grain feeding to balance the diet - pilot

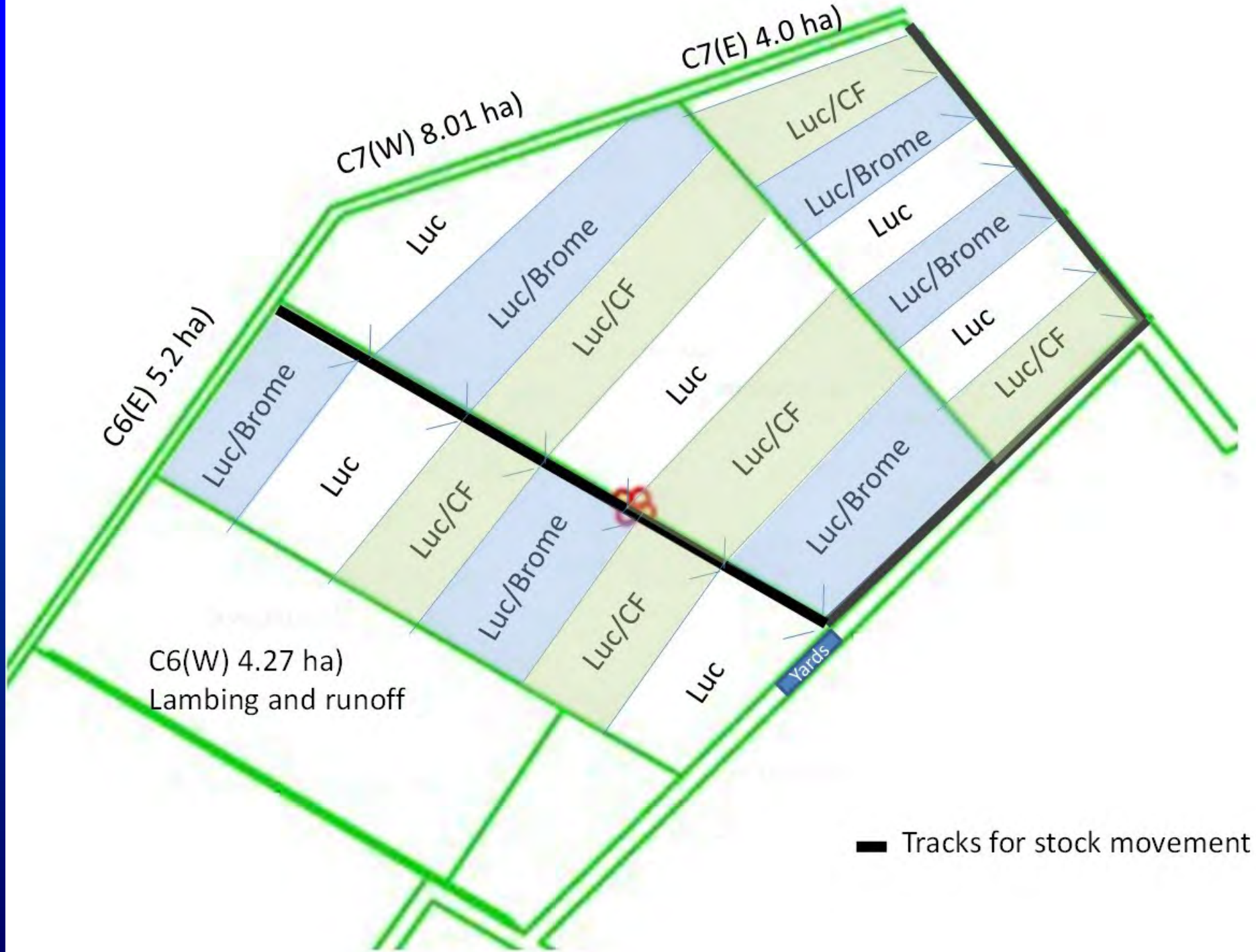
Ashley Dene Dryland Research Farm
Pastoral 21 – Phase II (5 Years)

Springston, Canterbury


ASHLEY DENE
TOTAL AREA = 355.7 HA
Brookside Road
Bethel Road
Selwyn Road
To Lincoln
To Norwood
Swamp Road
Ashley Dene Road
Corbett Road
C 7(W) 6.2 ha
C 7 6.0 ha
C 6(E) 6.1 ha
C 6(W) 6.1 ha
C 5B 7.0 ha
C 2A 5.1 ha
C 8 6.5 ha
C 10A 6.1 ha
C 10B 6.1 ha
C 2B 5.0 ha
C 5A 6.8 ha
C 3 8.1 ha
C 4 4.9 ha
C 1
M 4 6.5 ha
M 5B 4.8 ha
M 6B 4.8 ha
M 7 10.5 ha
M 8B 5.2 ha
M 9B 5.2 ha
M 10 8.5 ha
M 12 8.1 ha
M 3 6.5 ha
M 5A 4.9 ha
M 6A 4.9 ha
M 8A 5.3 ha
M 9A 5.3 ha
M 11 8.5 ha
M 13 7.7 ha
M 2A 4.4 ha
M 2B 4.5 ha
M 1 4.1 ha
M 26 8.1 ha
M 25 7.7 ha
M 24A 4.2 ha
M 23A 4.8 ha
M 24B 4.3 ha
M 23B 4.9 ha
M 21 6.5 ha
M 19 6.5 ha
M 22 5.4 ha
M 20 5.4 ha
M 16 5.8 ha
M 17 5.9 ha
M 18 5.8 ha
M 14 11.7 ha
M 15 5.9 ha
H 6 5.9 ha
H 7 5.1
H 11
H 1
H 5 6.9 ha
H 10 2.0 ha
H 2 4.5 ha
H 4 4.1 ha
H 3 6.1 ha
Farmlet Experiment
C = Cemetery Block (101.8 ha)
H = Homestead Block (48.8 ha)
M = Main Block (205.1 ha)
600
400
200
0
200
METRES
Water Race
Power Pylon

Ashley Dene Lucerne - H7 – Grazing Treatments




C7(E) 4.0 ha)
C7(W) 8.01 ha)
C6(E) 5.2 ha)
C6(W) 4.27 ha)
Lambing and runoff
Luc/CF
Luc/Brome
Luc
Yards
Tracks for stock movement

Close up of a prairie grass and lucerne mixture

‘Bonavaree’ Marlborough
July 2010

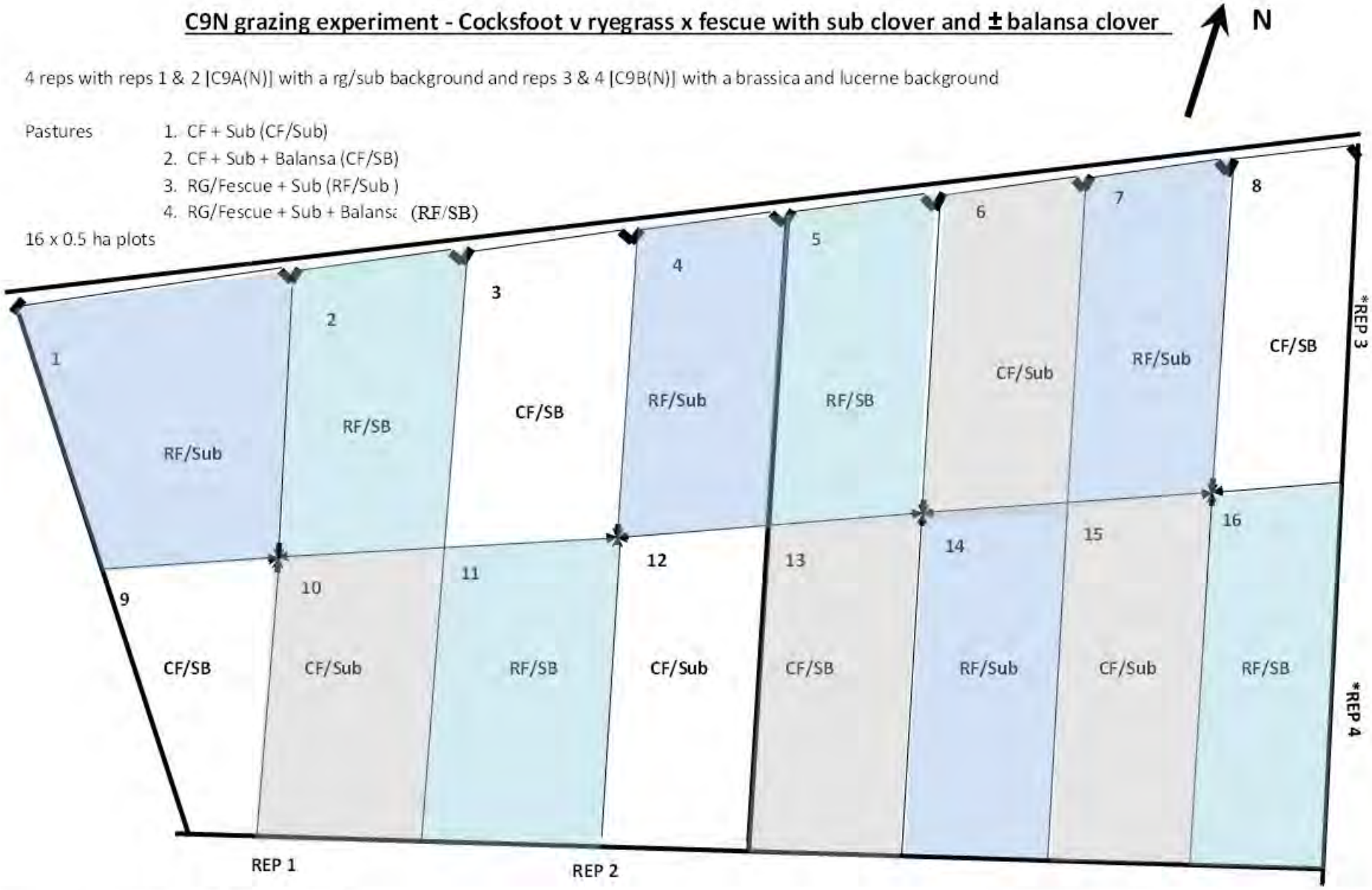
Lucerne + cocksfoot

C9N grazing experiment - Cocksfoot v ryegrass x fescue with sub clover and ± balansa clover

4 reps with reps 1 & 2 [C9A(N)] with a rg/sub background and reps 3 & 4 [C9B(N)] with a brassica and lucerne background

Pastures
1. CF + Sub (CF/Sub)
2. CF + Sub + Balansa (CF/SB)
3. RG/Fescue + Sub (RF/Sub)
4. RG/Fescue + Sub + Balansa (RF/SB)

16 x 0.5 ha plots



Sown 5 April 2013

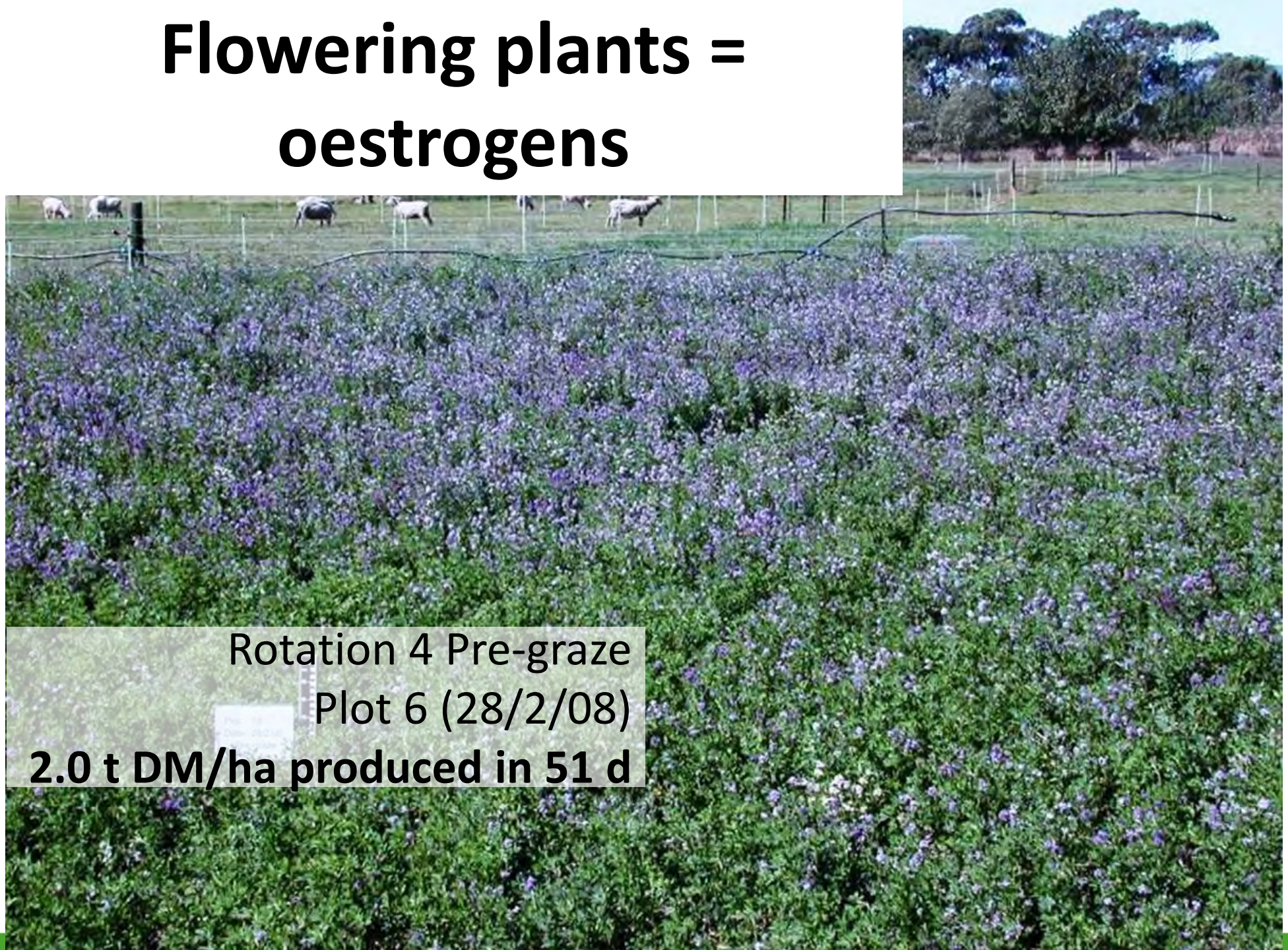
*Reps 3 & 4 reallocated after tree fall 2013

Corriedale 2th flushed on wilting lucerne

Lucerne (is not grass!!!)

- flushing at ‘Bonavaree’

Flowering plants = oestrogens



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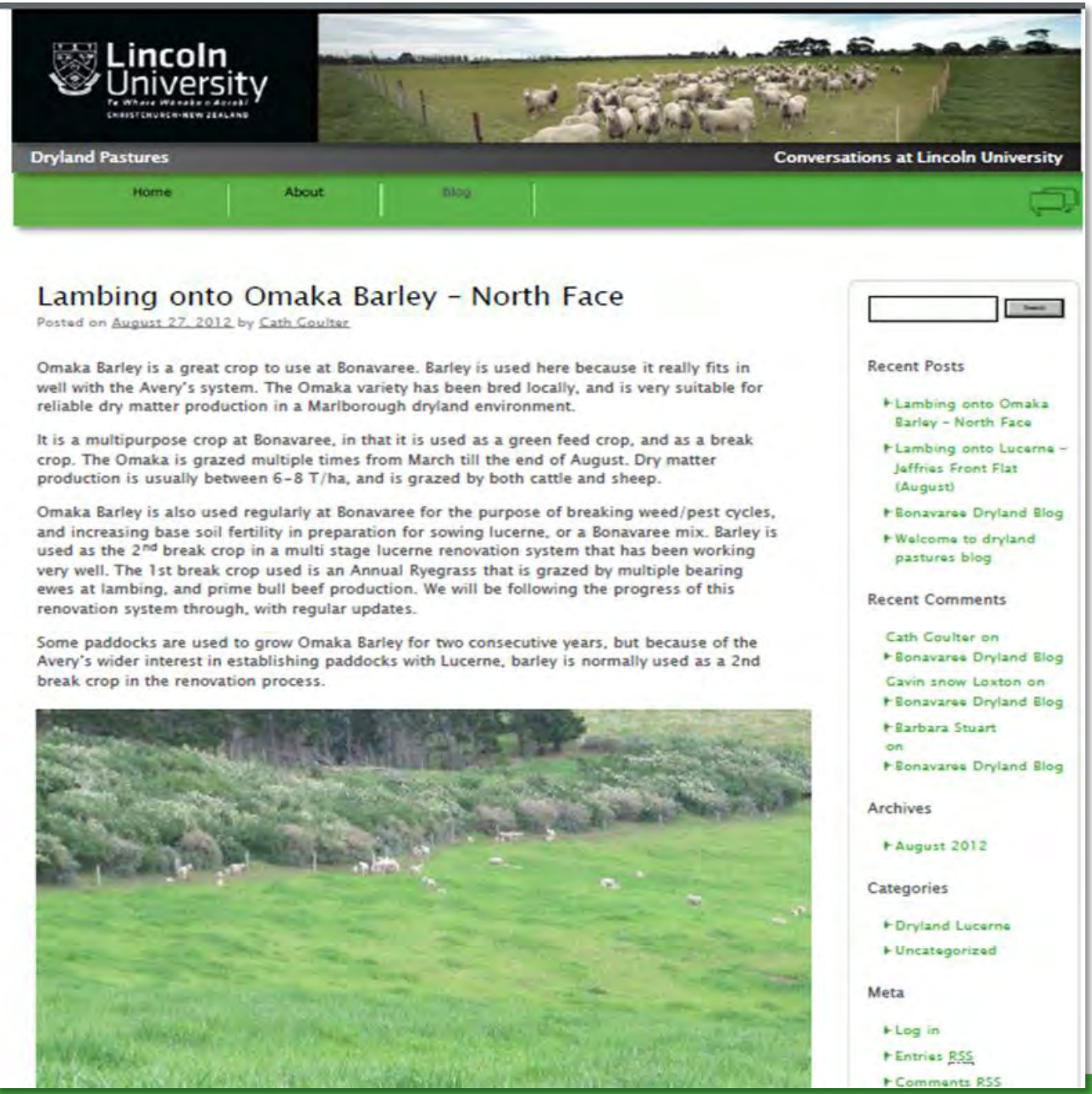
Current extension activity

- Txt service – 600+ subscribers
- Winter round-up on-farm NZGA
- Paired comparisons of paddocks – on-farm- blog
- Financial implications of extra feed FARMAX analysis NZGA

www.lincoln.ac.nz/conversation/drylandpastures



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The Blog……

- On-farm activity diary
- Slide shows, photos and video
- Ability for farmers to comment/question/query
- Farmers and researchers can respond

Sustainable transformation

- 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.
- By-in by farmers followed by agribusiness

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, Qakathekile, Morris
Honours students: Dunne, Lewis, Kearney, Inch, Sim, Brown, Murray-Cate Wigley, Stocker, Tapp, Kearns, Lewis, Neal, Crutchley, Coutts, Neal,

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