Dryland pastures:
From research to farmer adoption

Dr Derrick Moot

Professor in Plant Science

LINCOLN UNIVERSITY
Te Whare Wānaka O Aoraki

‘Do you think that to be an agriculturist it is necessary to have tilled the earth or fattened fowls oneself?

It is necessary rather to know the composition of the substances in question – the geological strata, the atmospheric actions, the quality of the soil, the minerals, the waters. One must know botany, be able to distinguish between plants which are wholesome or deleterious, unproductive or nutritive, if it is well to put them up here and resow them there, to propagate some, destroy others; in brief, one must keep pace with science by means of pamphlets and public papers, be always on the alert to find out improvements.’

from ‘Madame Bovary’..... *Gustave Flaubert 1856*

PLSC 401 AGRONOMY 1986

Back Row: Graeme BASSETT, Justin de la ROCHE, Peter MOYNIHAN, Ivan LINES, George STEVEN, Kathy NICHOLSON, Nigel UDY, Gaya PRASAD.

Front Row: Derrick MOOT, Roger BANFIELD, Malcolm MURRAY, John McCOY, Ann BOWEN, Andrew McKAY, Bruce McKAY.

Absent: Helen CAMERON, Ian TATE.

Value of good data

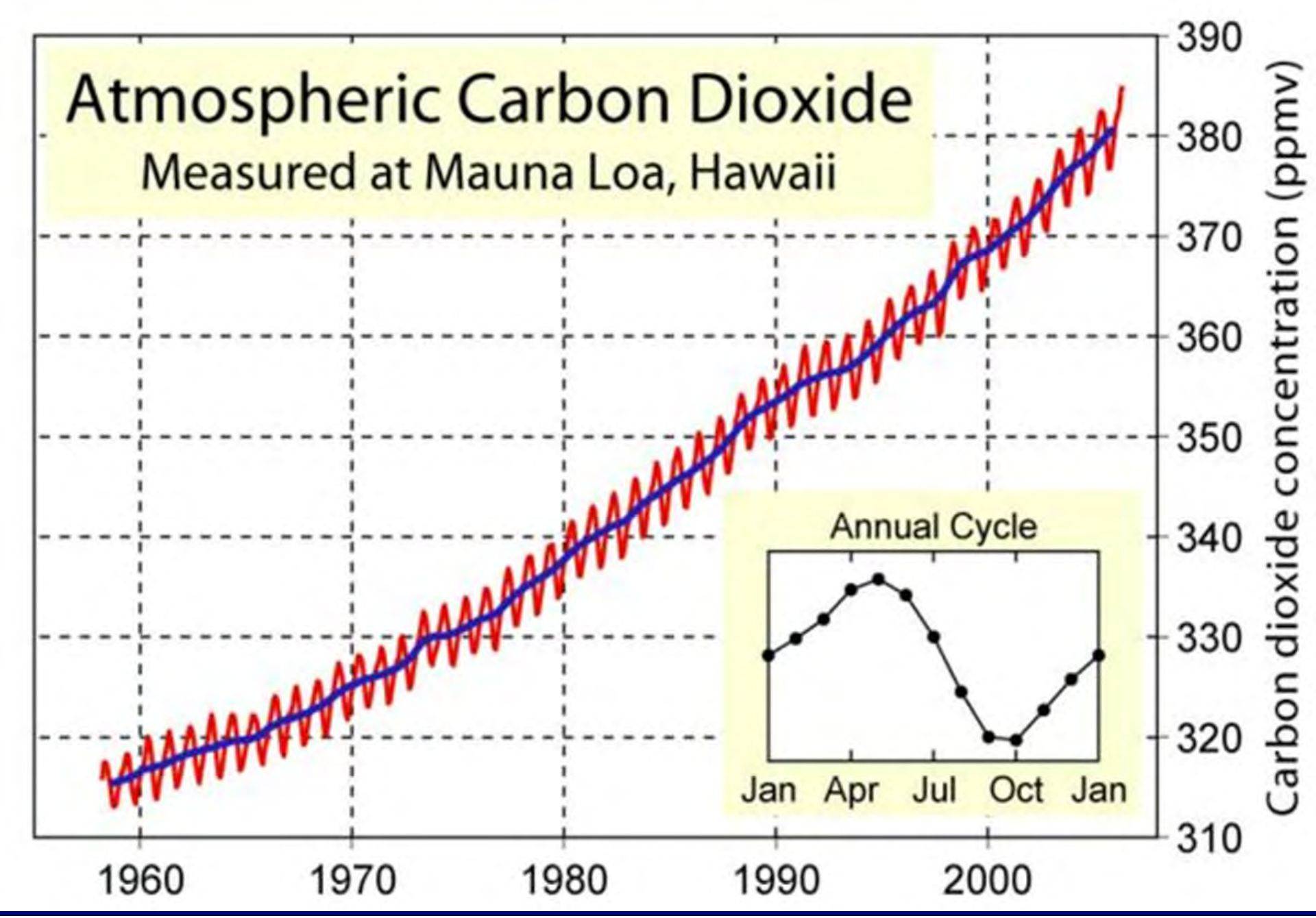
Value of support

The Village Pub

Roger Protz *and* Homer Sykes

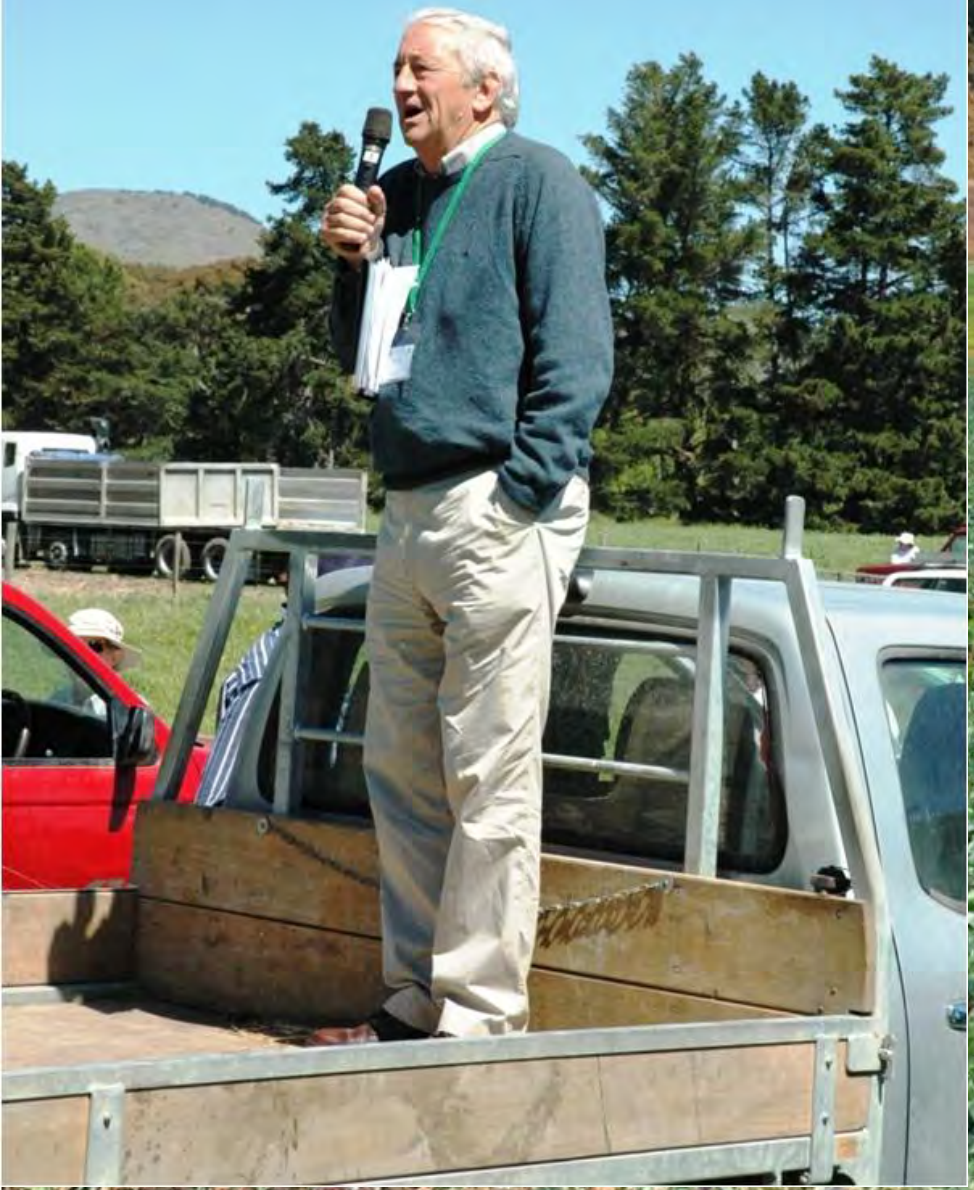
Photo: Derrick Moot
Lincoln University

Value of a Lincoln PhD



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

You can achieve a lot if you give away a good idea



Practical science in the service of rural industries

Crop physiology

Photo: A Mills
Lincoln University

Forage crops

Dryland Pasture Research

1) Farmer survey (1998 – 1 Masters)

2) Directed Experiments:

- 19 PhD
- 9 Masters
- 18 Honours students
- 25 interns (9 countries)

3) Science and Modeling – (2000 – present):

- 40 international journal
- 80 conference

Acknowledgements

Drs Mills, Brown, Teixiera, **Pollock**, Varella, Peri, Black, Moir, Scott, Ridgeway, Monks , Ates, Kosgey
Lucas, **Smith**, Fasi, Dunne, Lewis, Kearney, Andreucci, Inch, Barnes, Sims, Morris, Tonmukayakul, Qakathekile, Nori, Berenji, Maxwell, Powers, Gillespie, Wigley, Stocker, Tapp, Kearns, Lewis, Neal, Crutchley, Oliveria, Chakwizira, Kirsopp, Marshall, Heffer, Jack, Dash, Richards

beef + lamb new zealand

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

Lucerne issues

A) Pests and diseases – 1980's

- Largely overcome by new cultivars from NZ and Nth America

B) Which deep-rooted species?

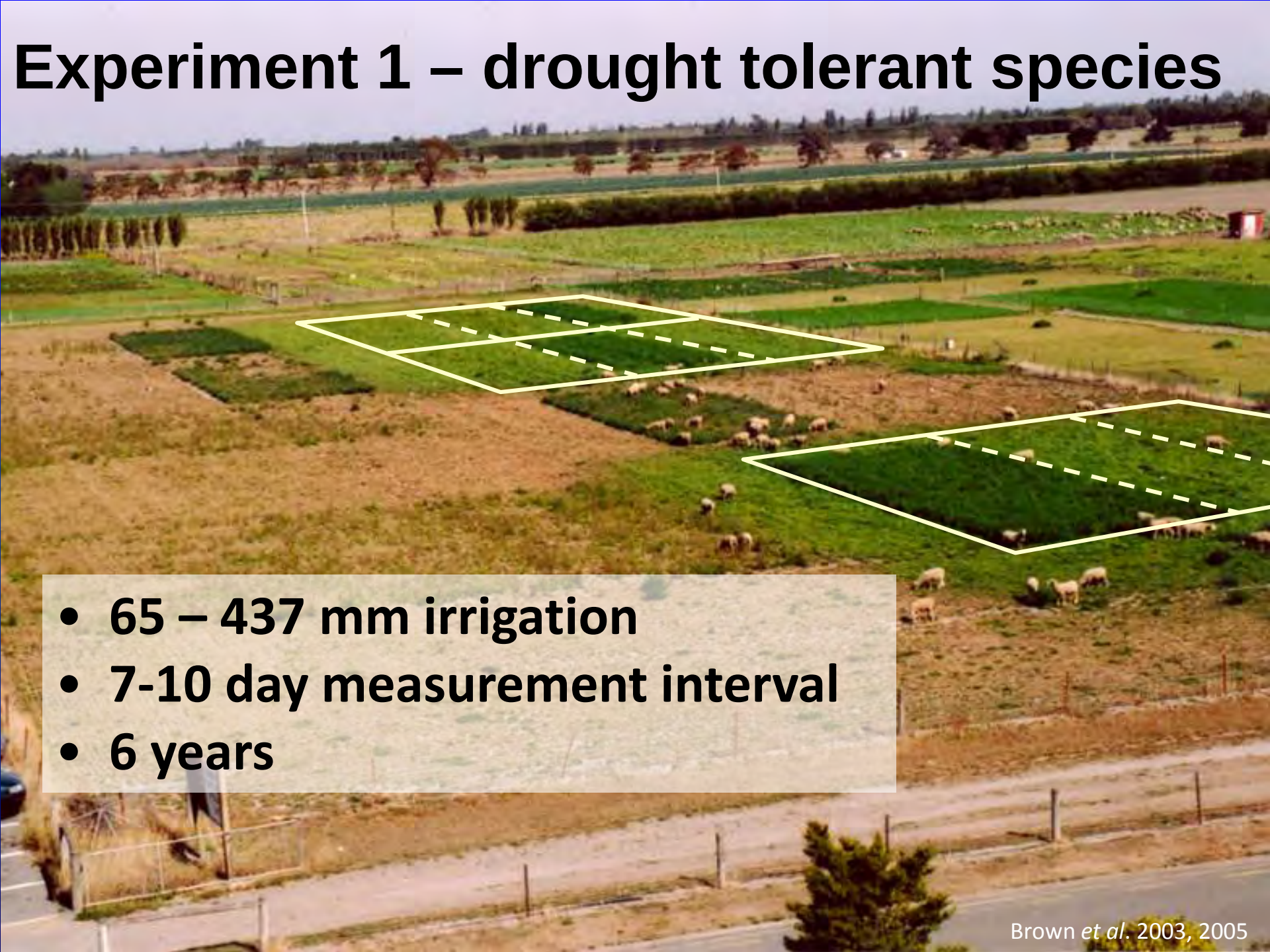
e.g. chicory, lucerne, red clover

Lucerne issues

C) Lambing time

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

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

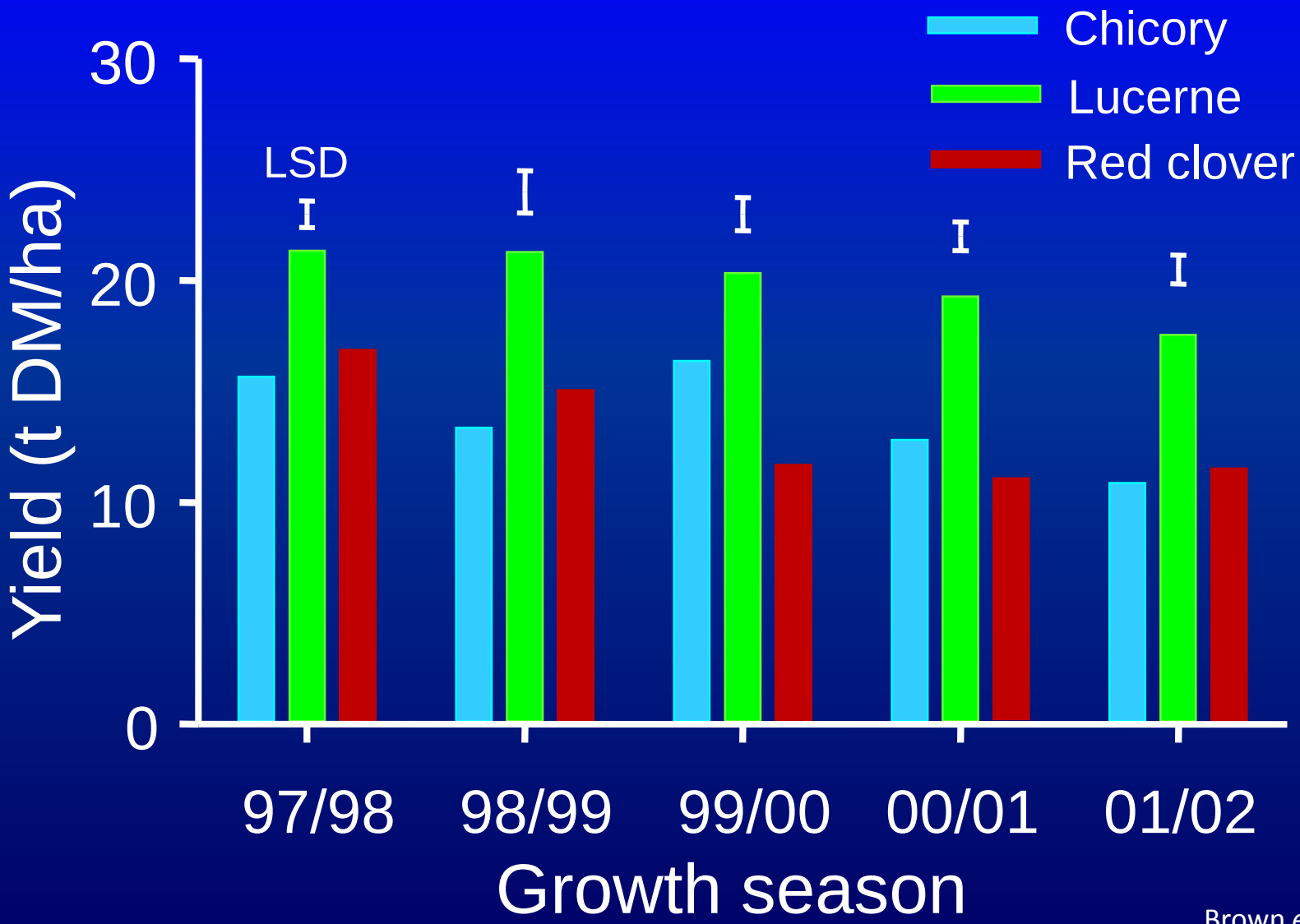
Others:

- SLW
- SPAD
- Chl_{a+b}

Soil moisture

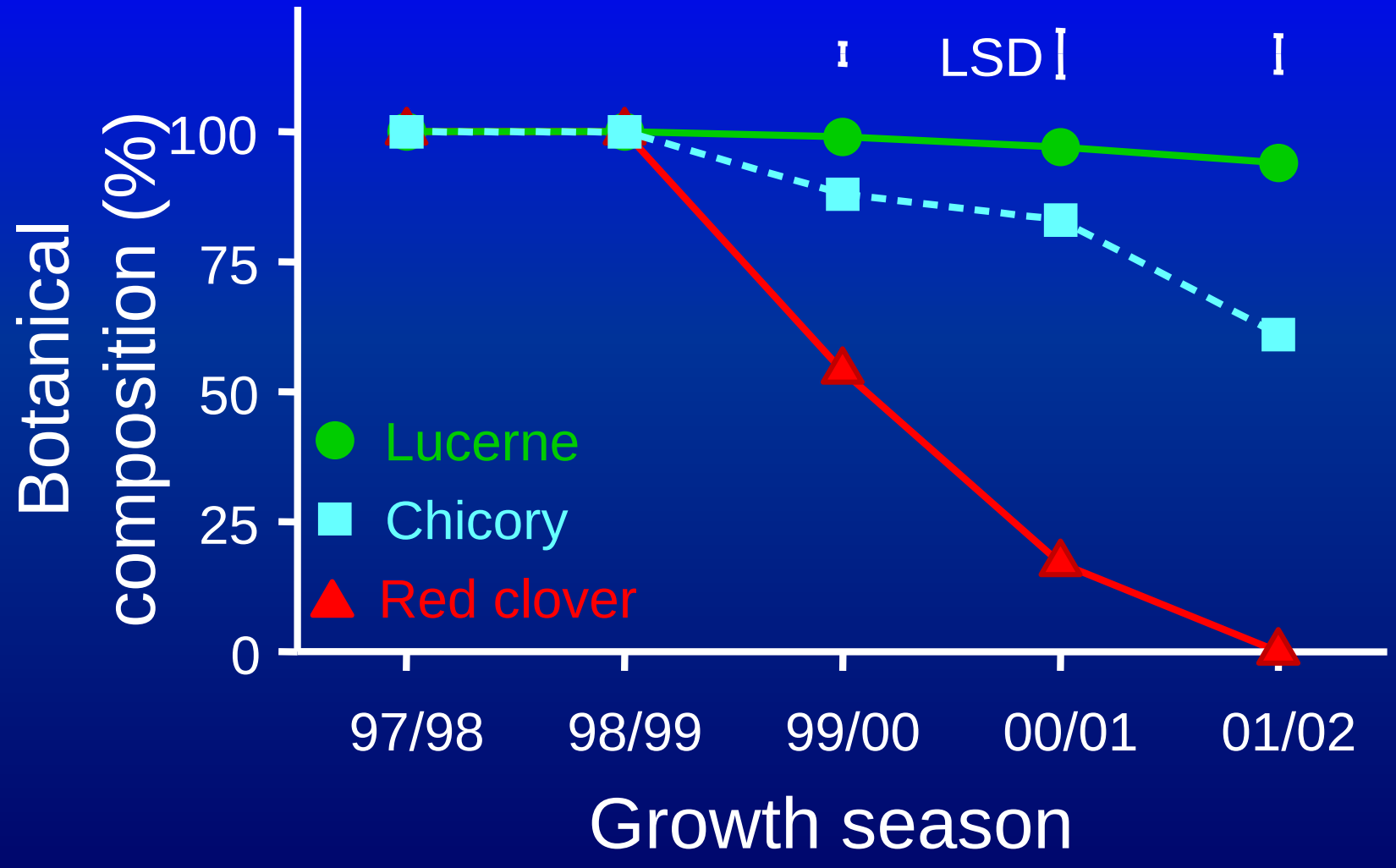
Photosynthesis

Annual dry matter yields



Brown *et al*. 2005

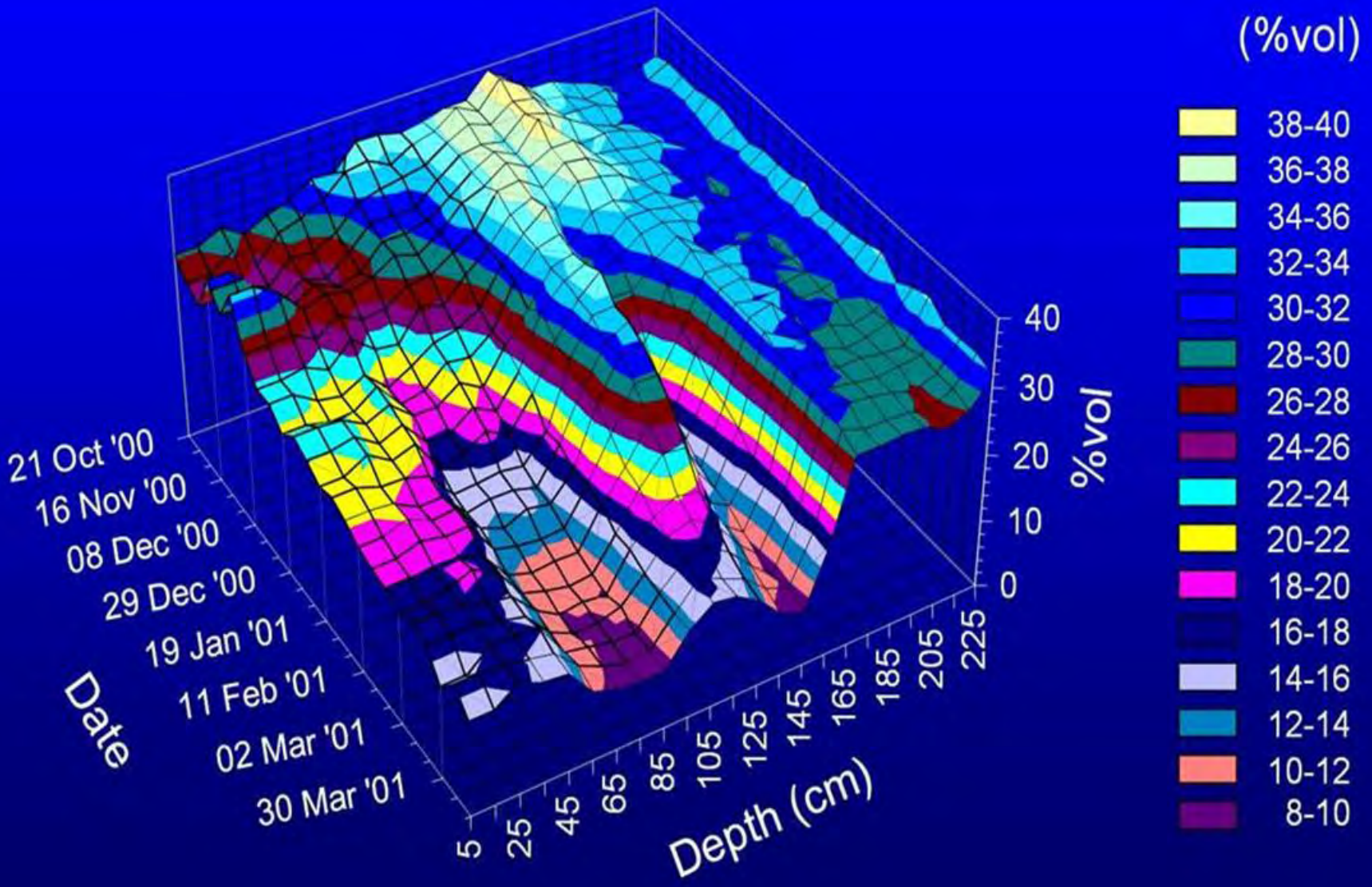
Persistence



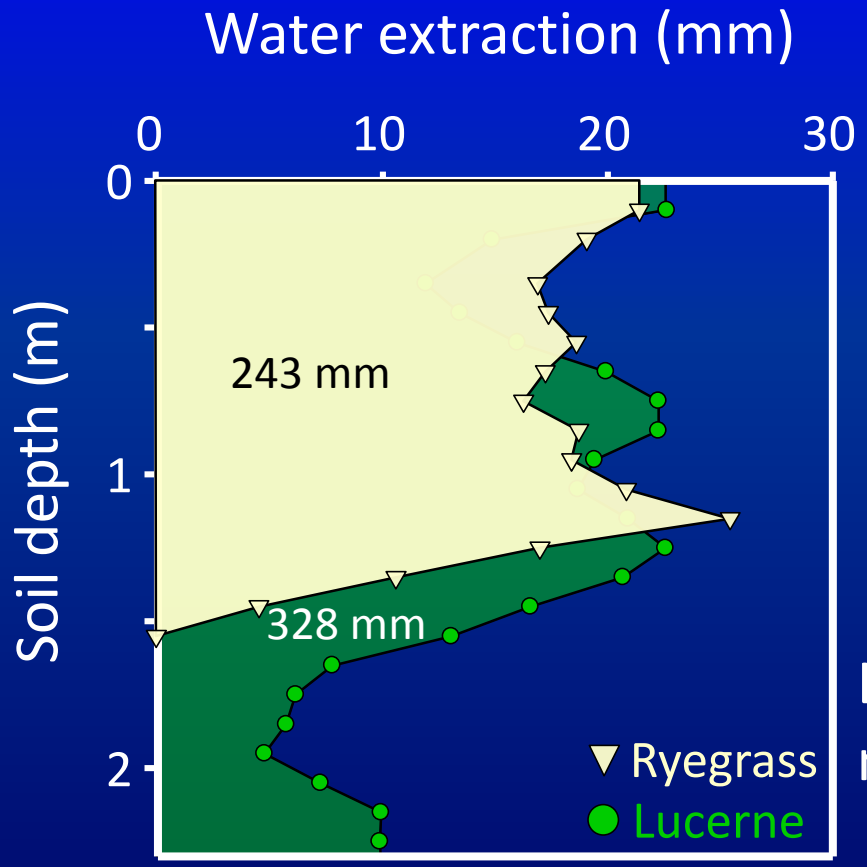
Brown & Moot 2004

Ryegrass/clover vs. Lucerne

Dryland Lucerne – soil moisture

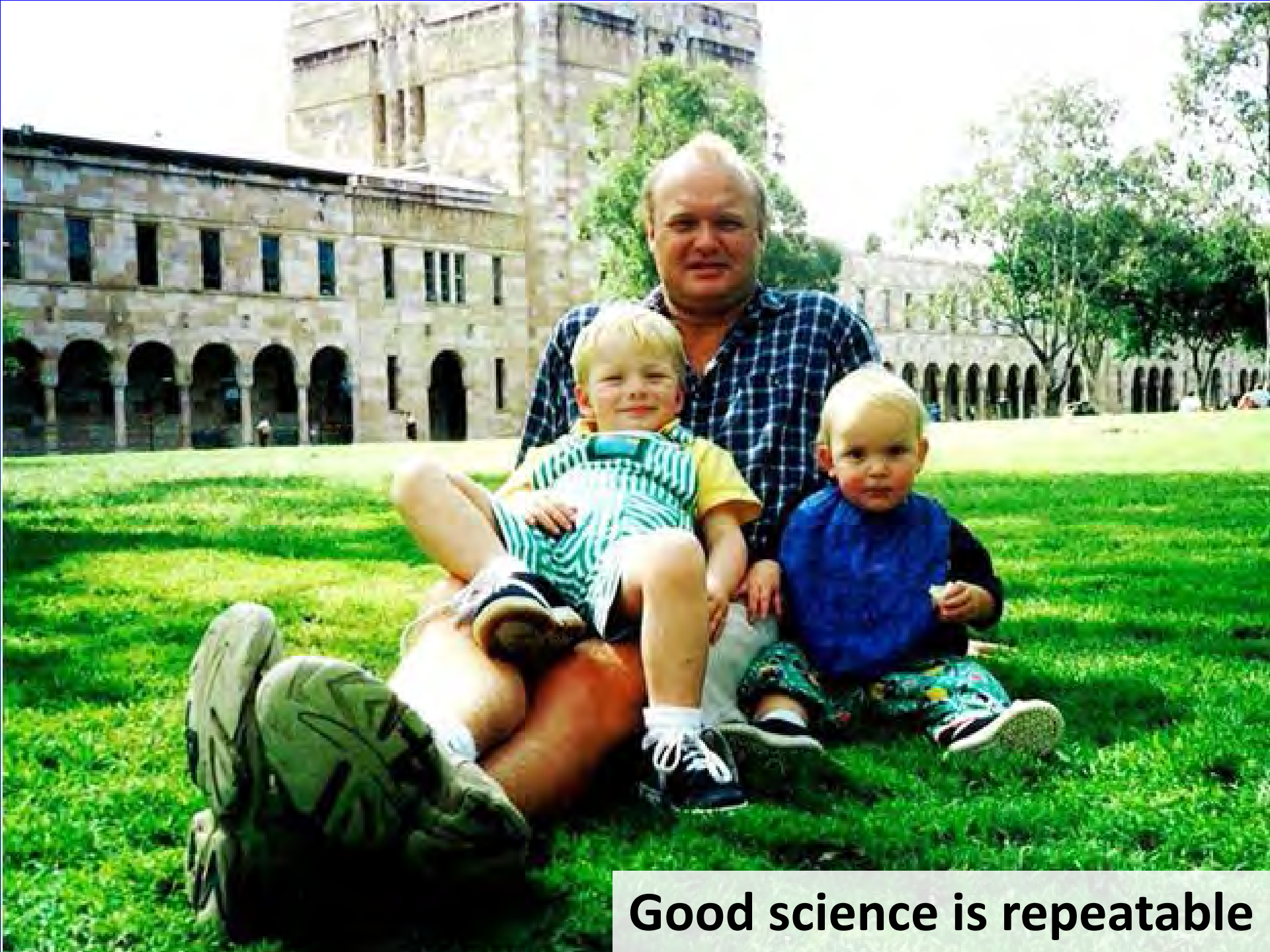


Soil water extraction: Species

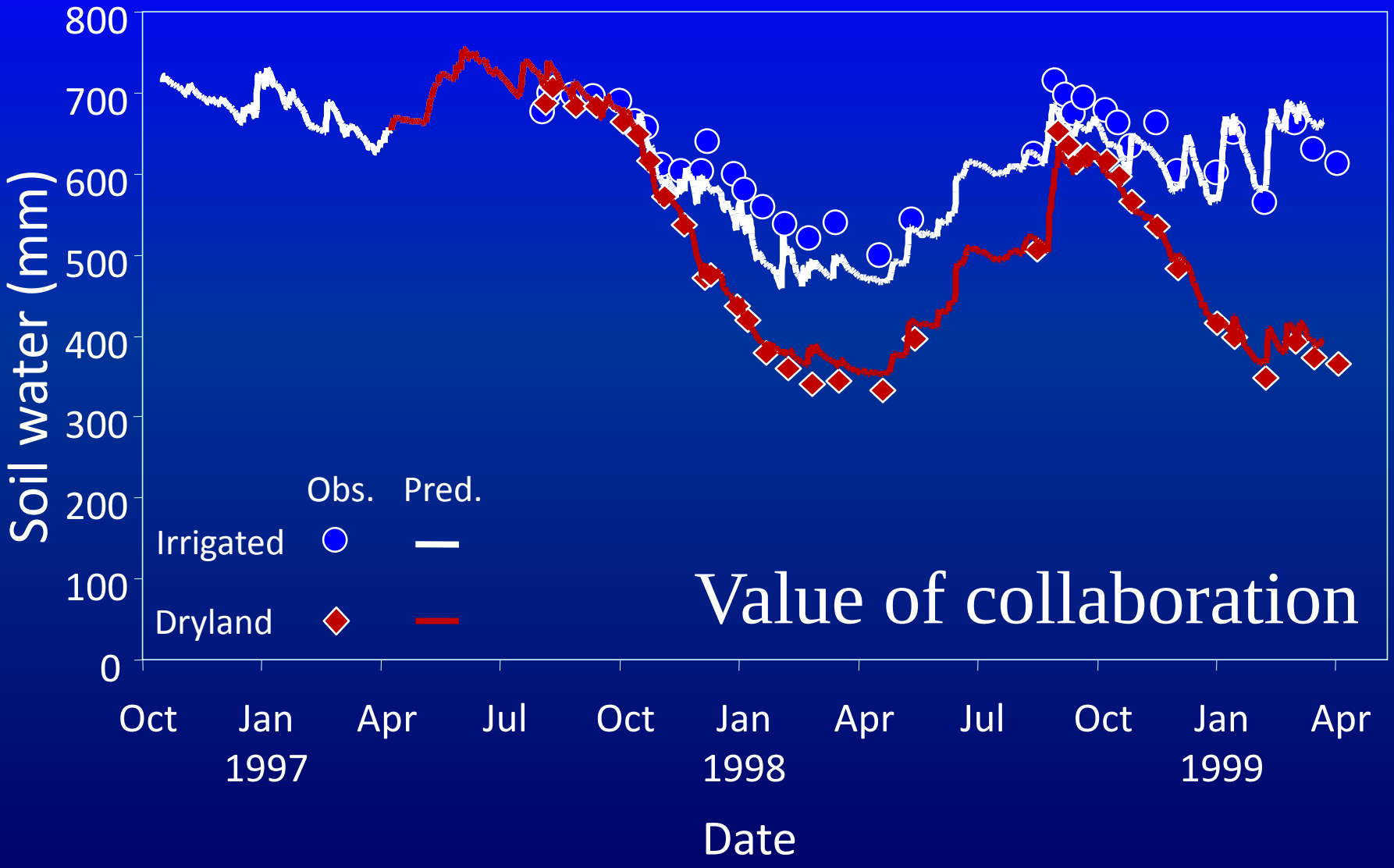


Lucerne has 85 mm more available water

Moot *et al*. 2008

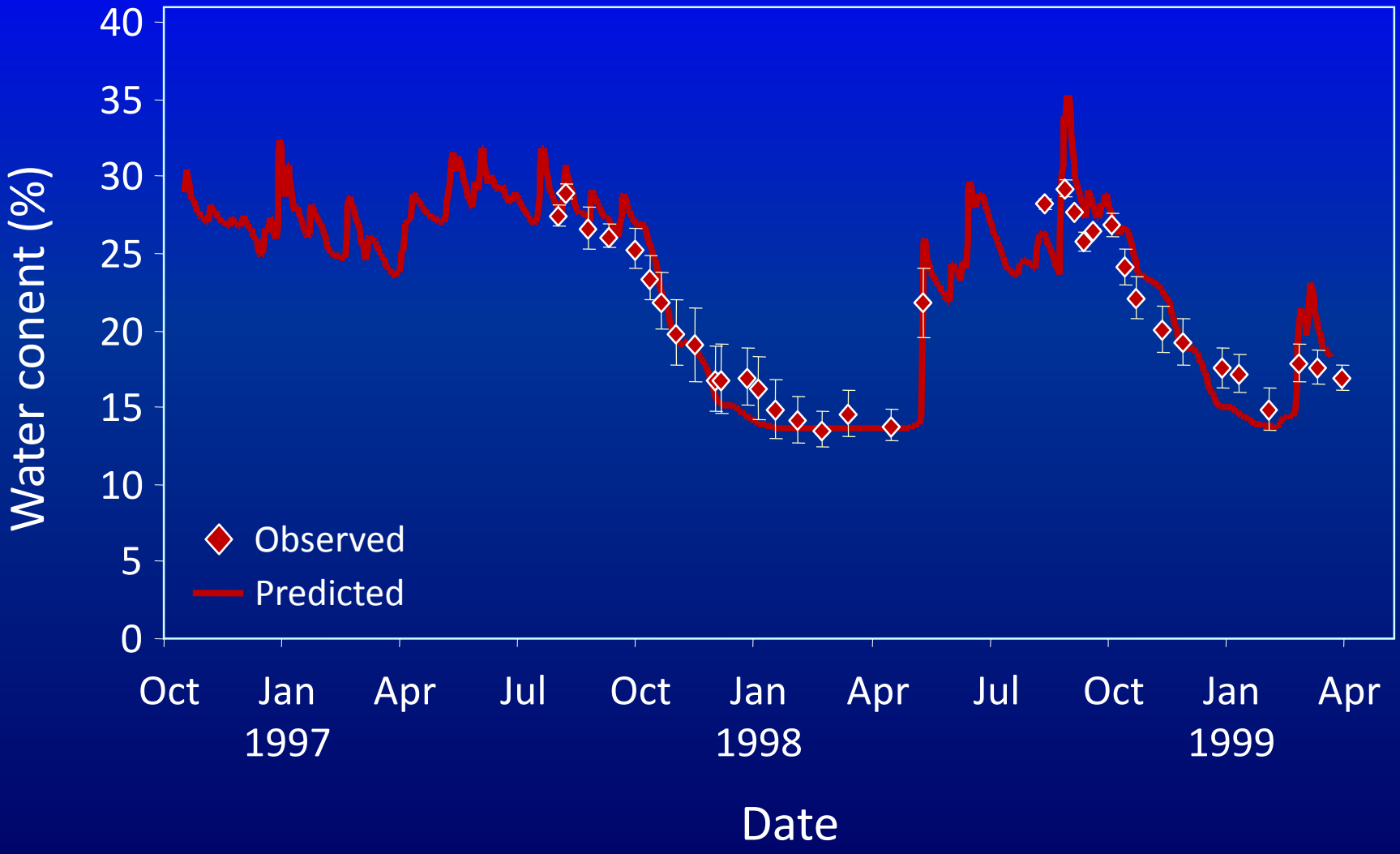

Good science is repeatable

Total soil water to 2.3 m depth



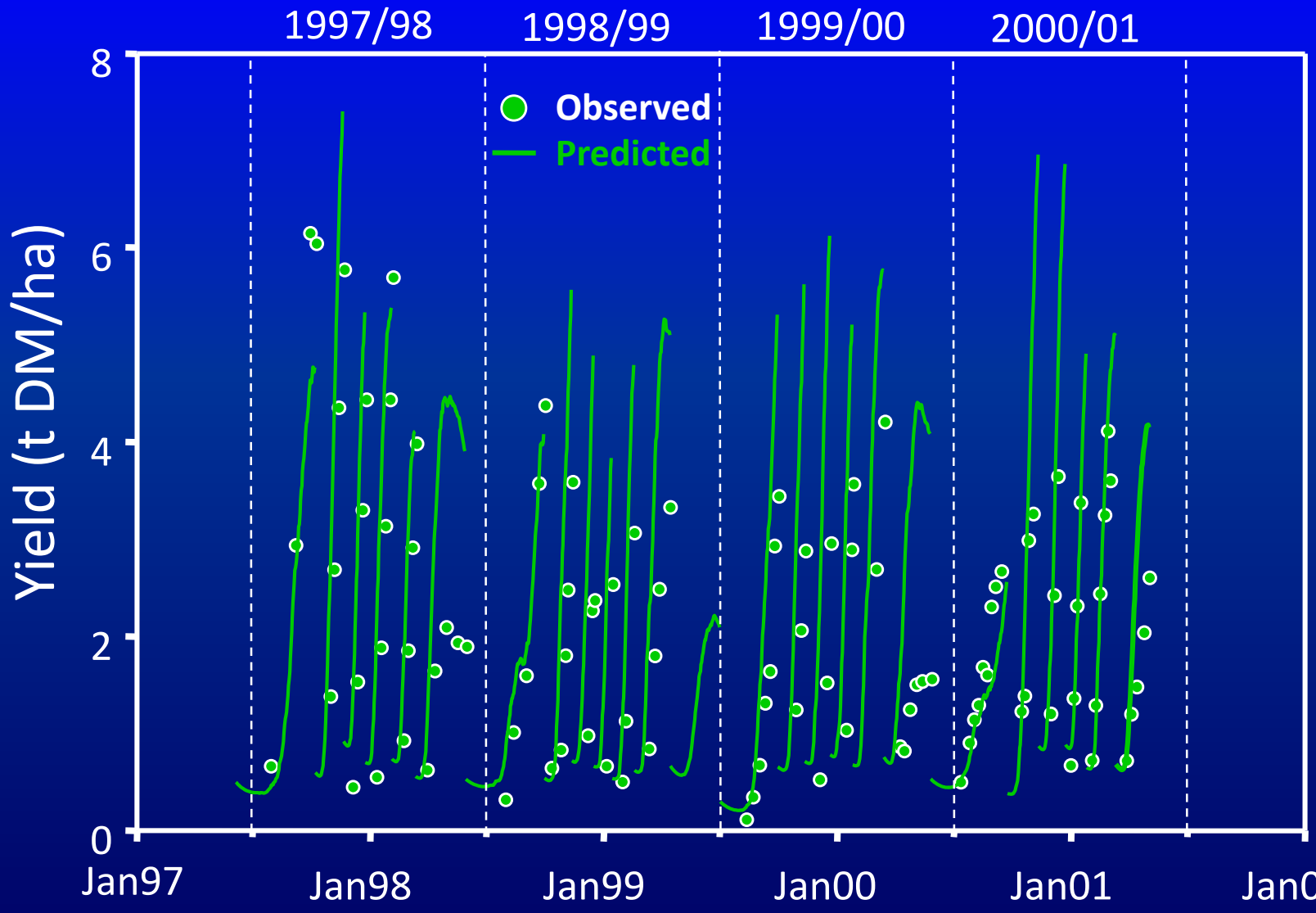
Moot *et al*. unpublished

Volumetric soil water at 0.35 m



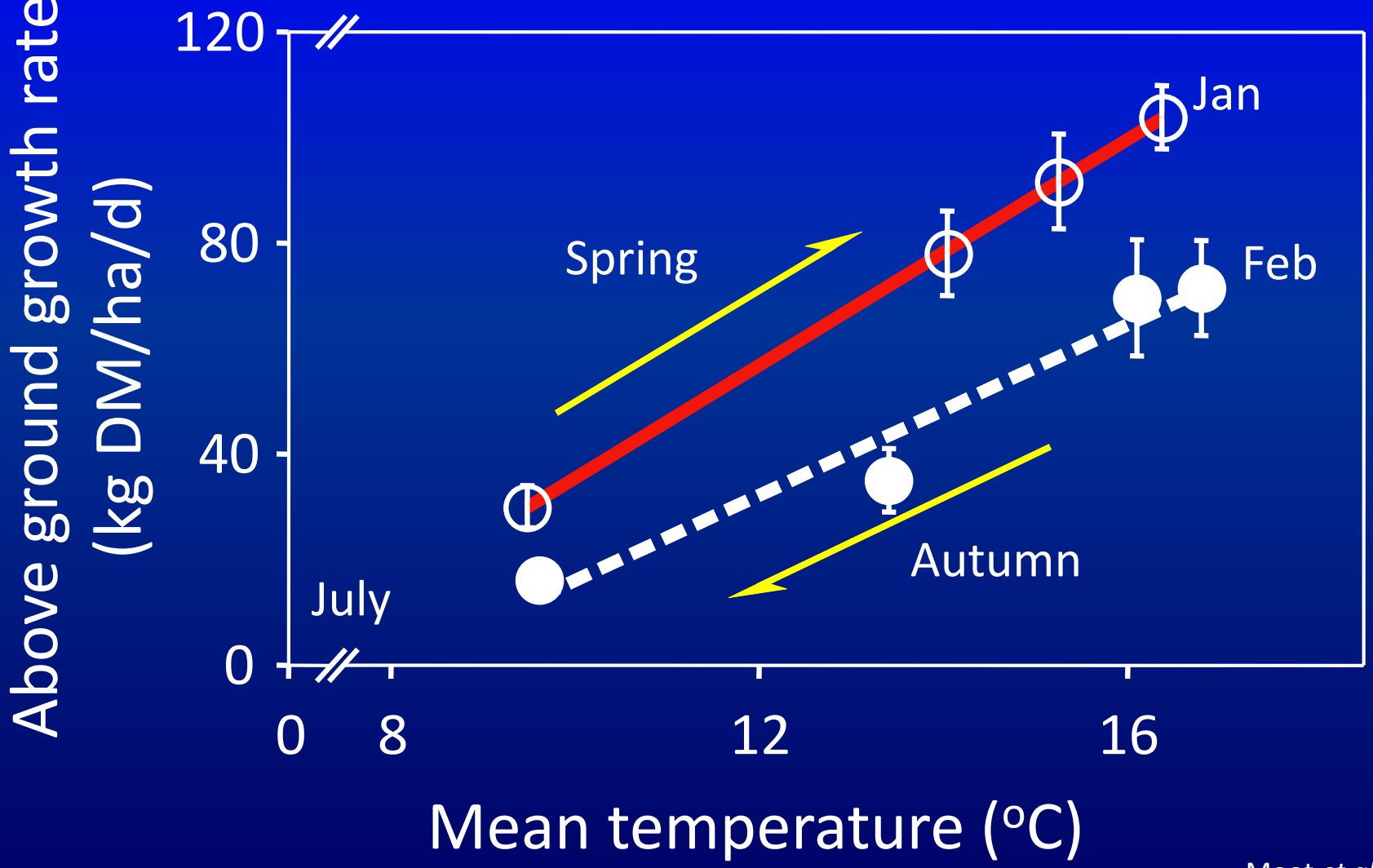
Moot *et al*. unpublished

Original APSIM_Lucerne prediction



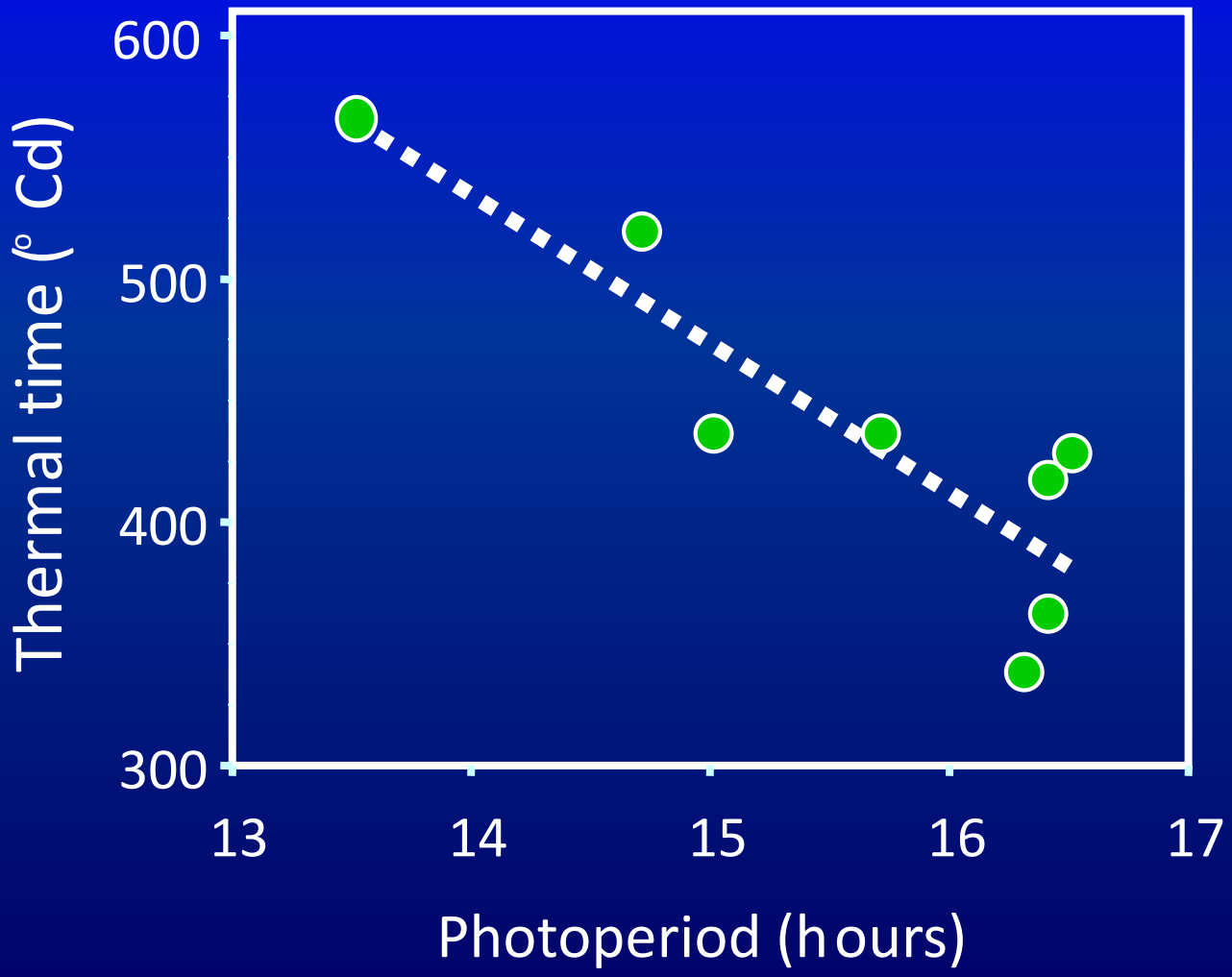
Teixeira *et al*. 2009

Vegetative growth



Moot *et al*. 2003

Thermal time to early-bud

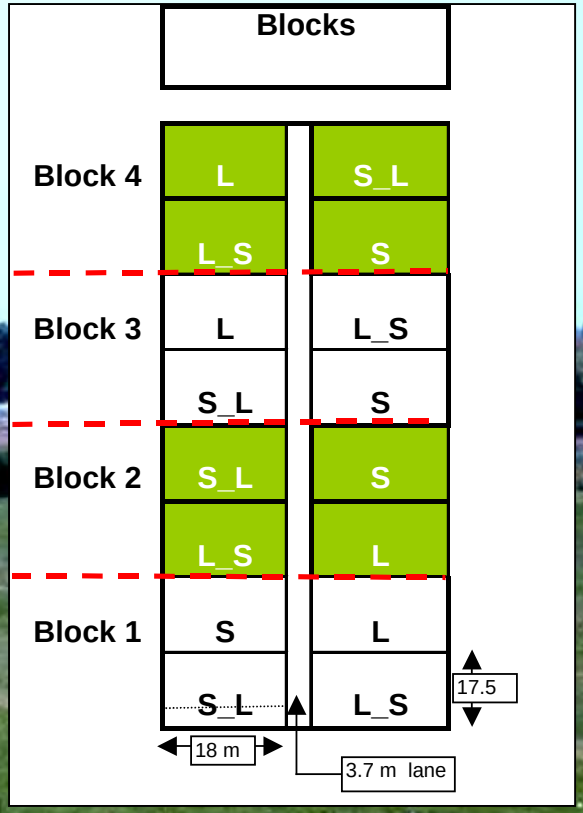


Moot *et al*. 2003

What's going on down there?

Experiment 2

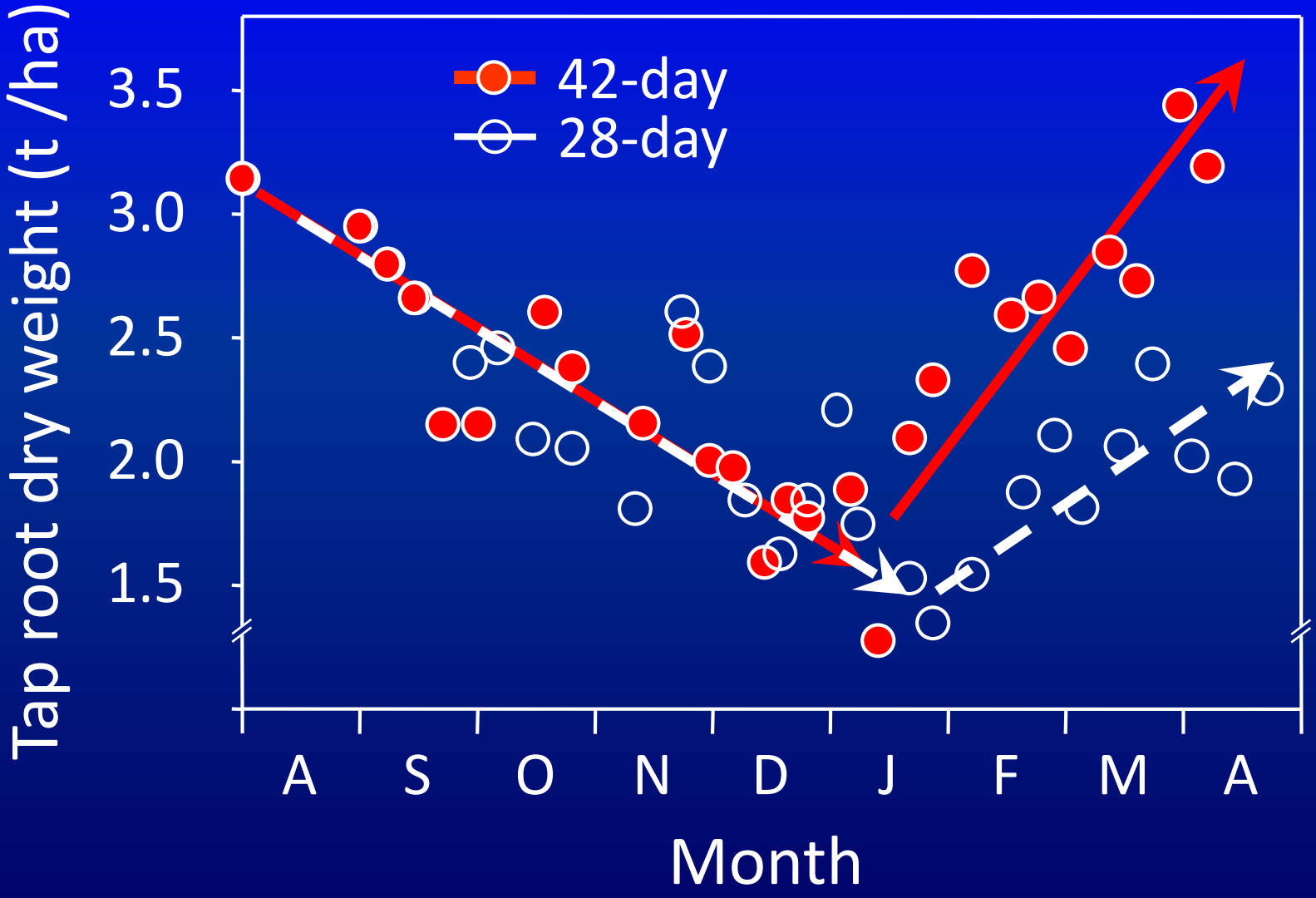
38 days resting
4 days grazing



25 days resting
3 days grazing

Photo: Edmar Teixeira
Lincoln University

Partitioning to roots

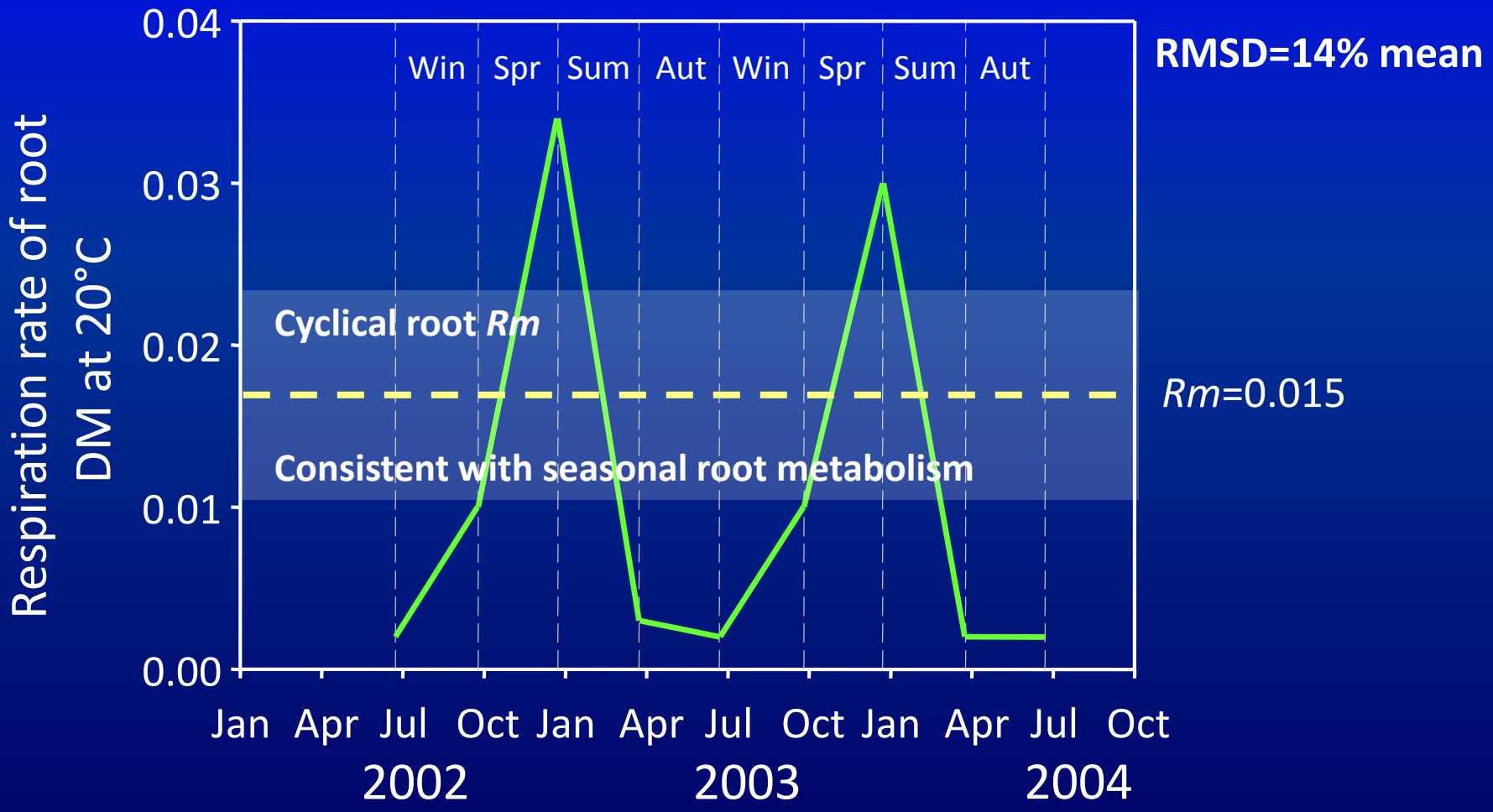


Moot *et al*. 2003


Photo: Edmar Teixeira
Lincoln University
20
15
10
5
0

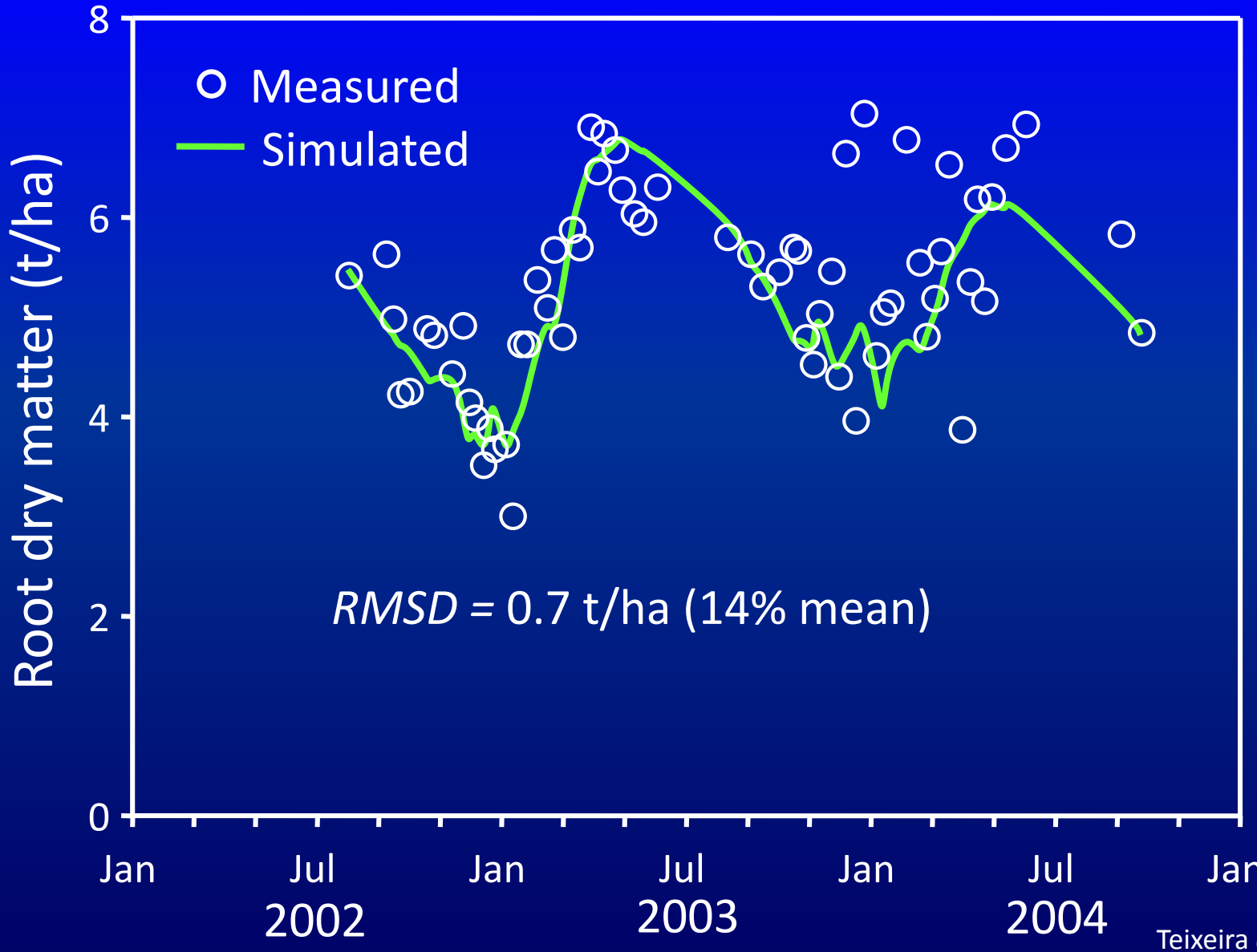
Seasonal pattern Rm values

Best fit: Seasonal pattern of R_m at 20°C



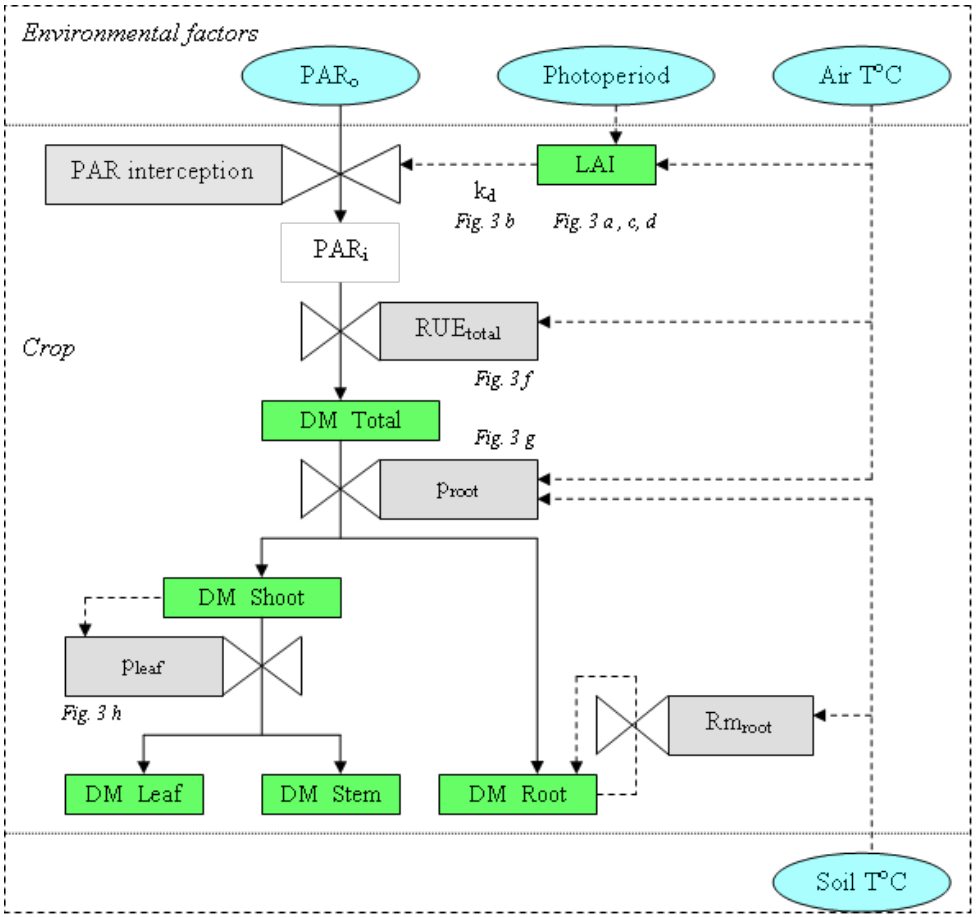
Teixeira *et al*. 2009

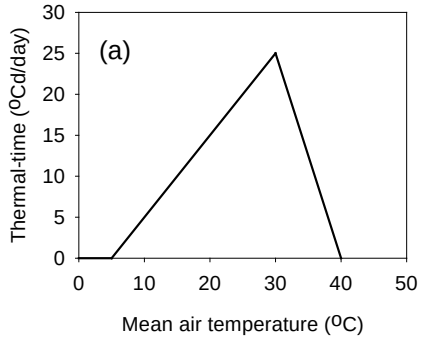
Adjusting Rm for the best fit

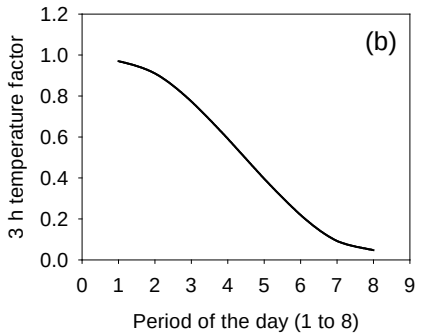


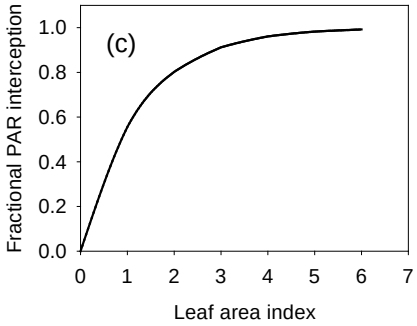
Teixeira *et al*. 2009

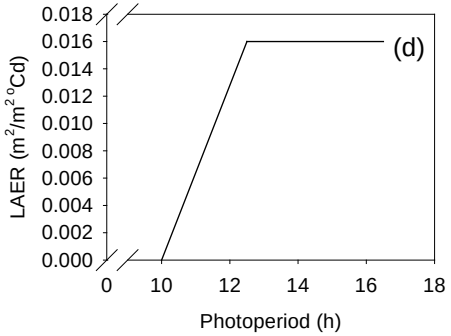
Model maker

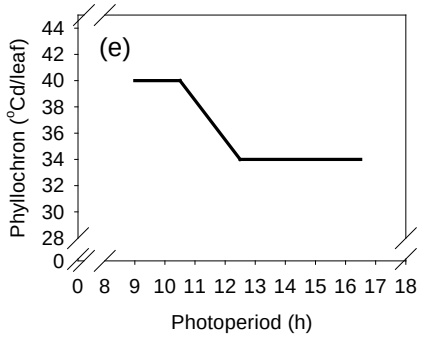


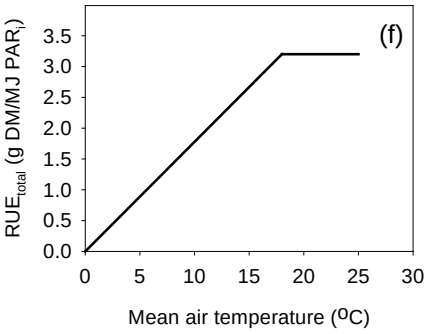


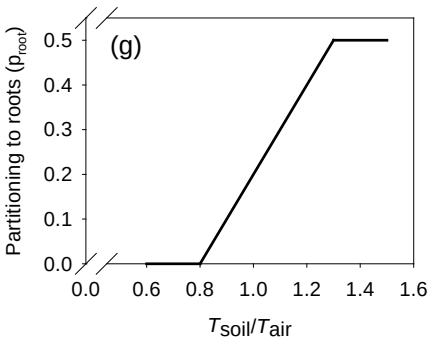


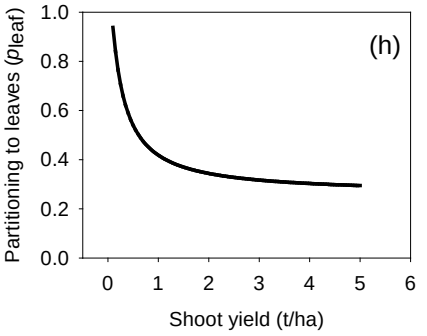






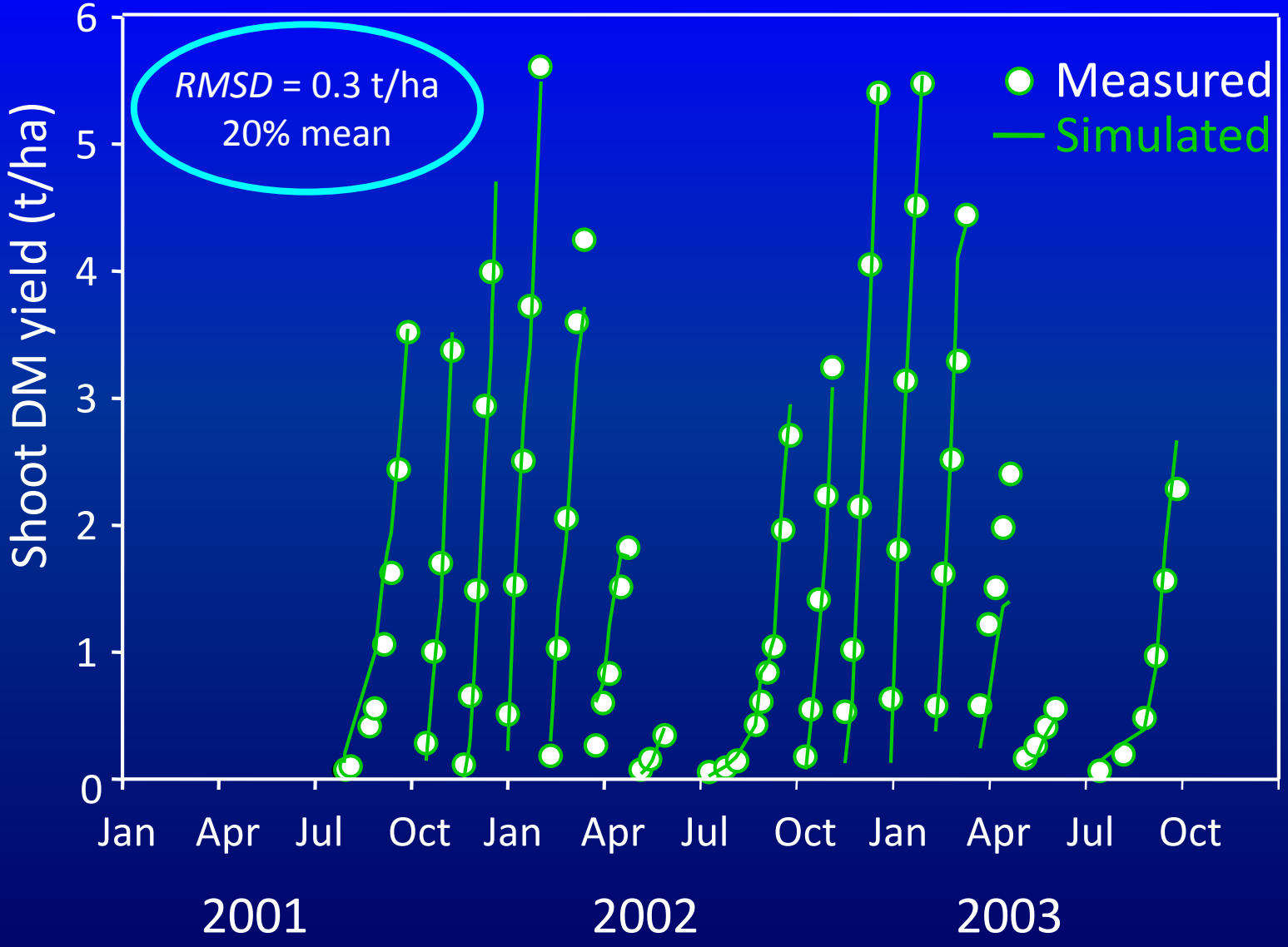






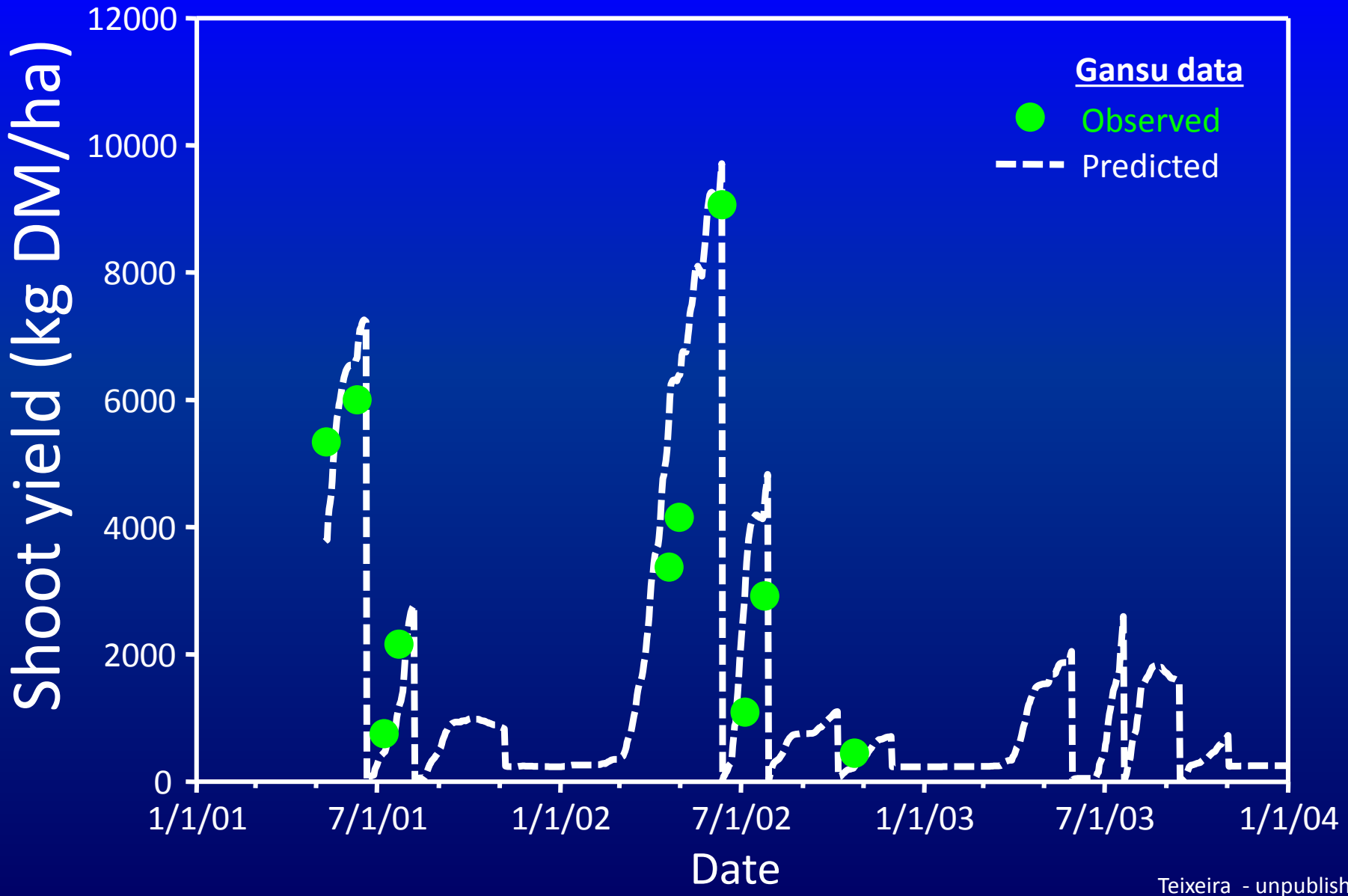
Teixeira *et al*. 2009

Predictions of shoot yield



Teixeira *et al*. 2009

APSIM Lucerne Validation



Teixeira - unpublished

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

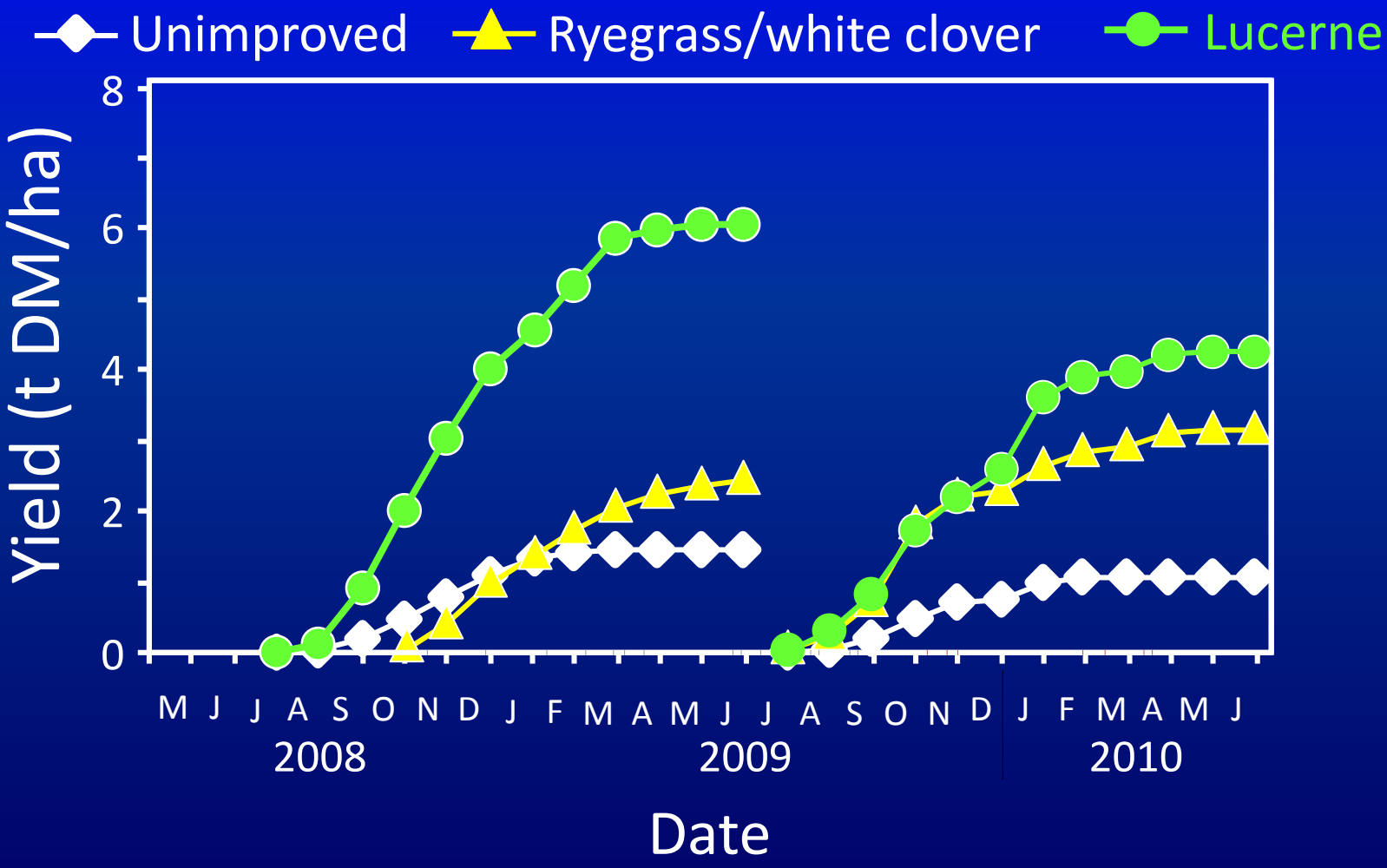
Transformational change
&
Adaptation to climate change

Kearney *et al*. 2010

Hills Creek Station – 60,000 ha by one company

Trebled lucerne seed sales + 500M/yr to the rural economy

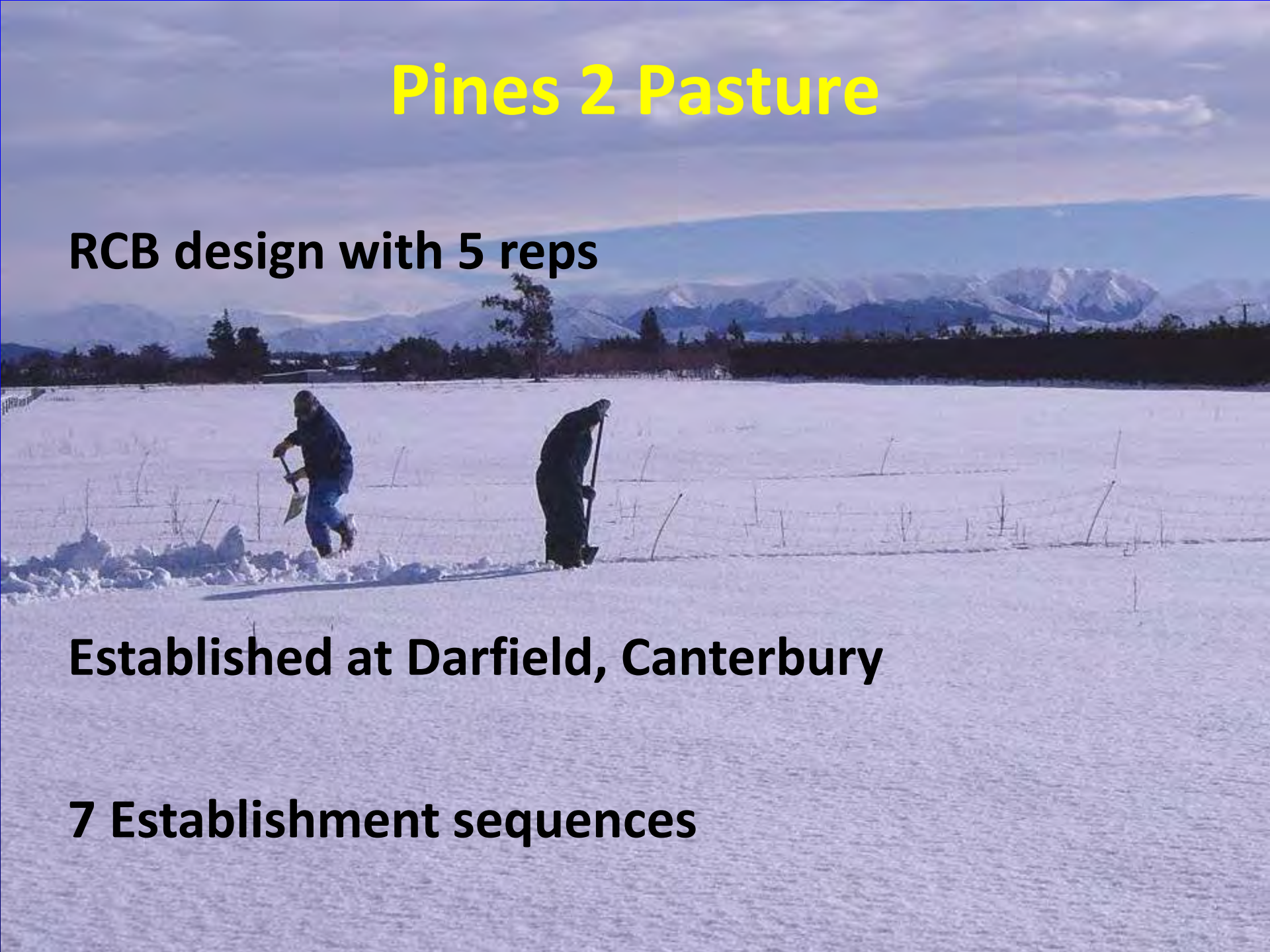
Pasture growth



Kearney *et al*. 2010

Forest conversion 100 000 ha

Pines 2 Pasture



RCB design with 5 reps

Established at Darfield, Canterbury

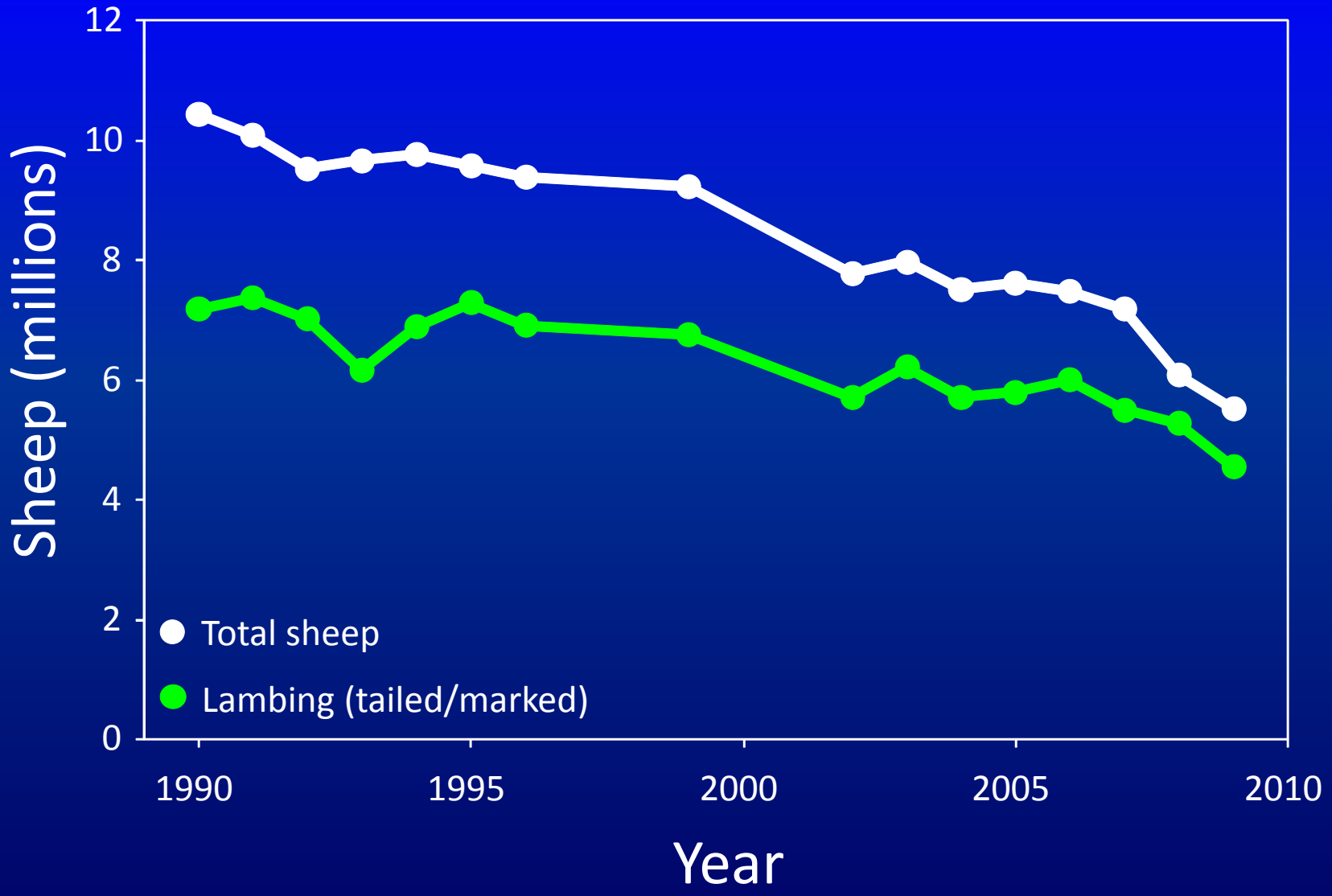
7 Establishment sequences

Weed free after 6 months

Moot et *al*. 2007

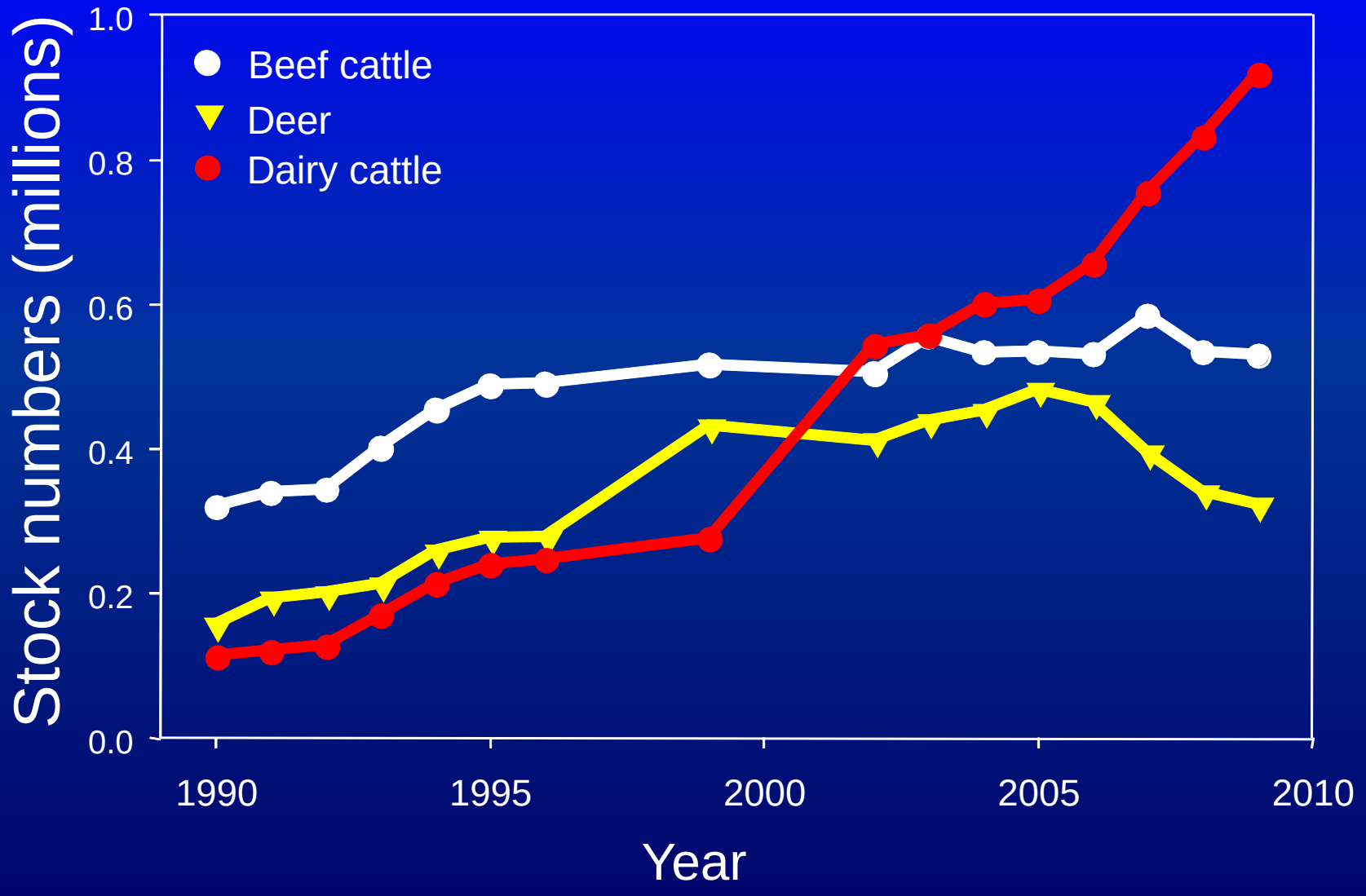

You will fail

Canterbury.....sheep numbers



Moot *et al*. 2010

Canterbury...deer & cattle numbers



Moot *et al*. 2010

Water and nitrogen = ryegrass

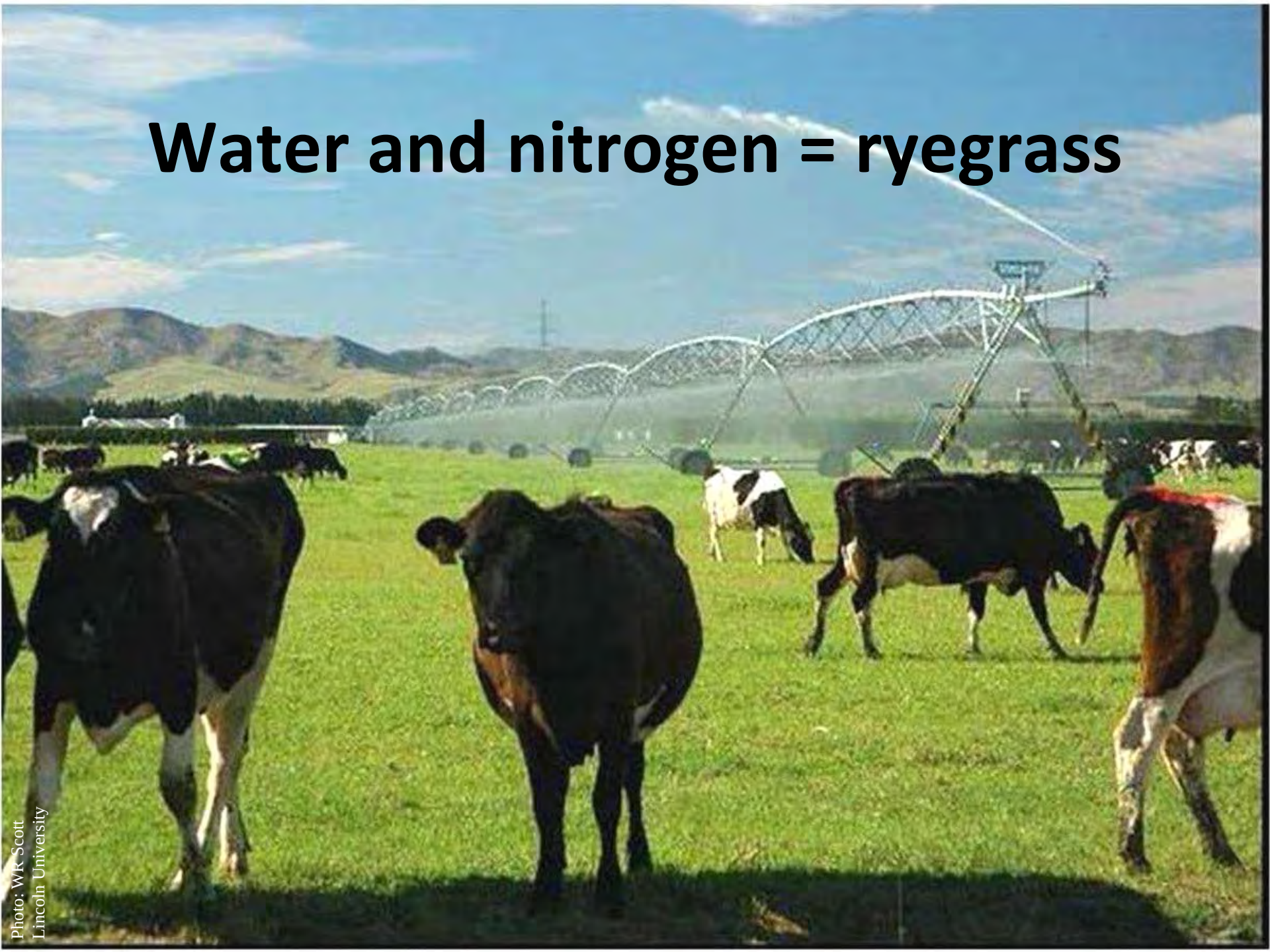
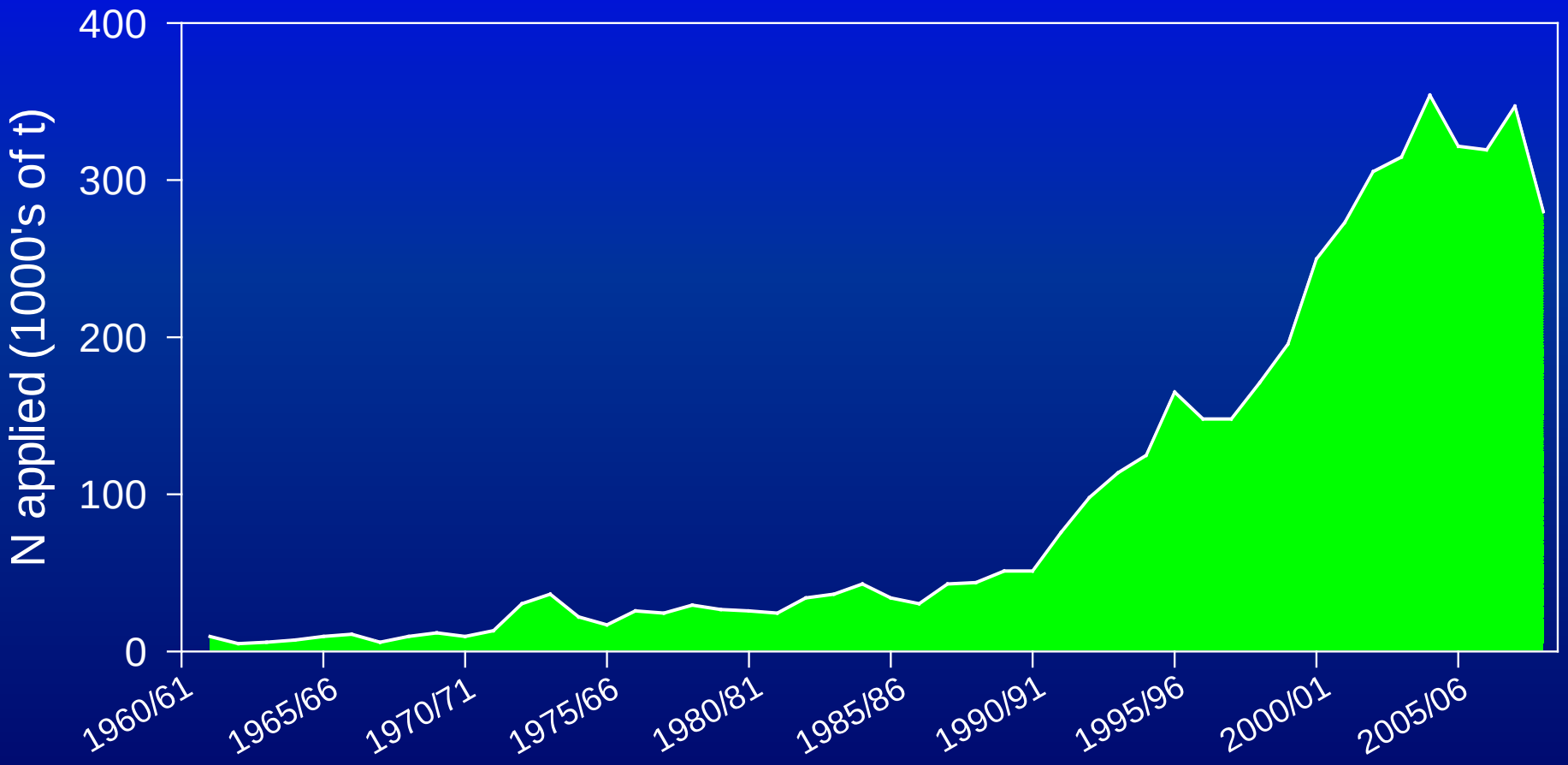


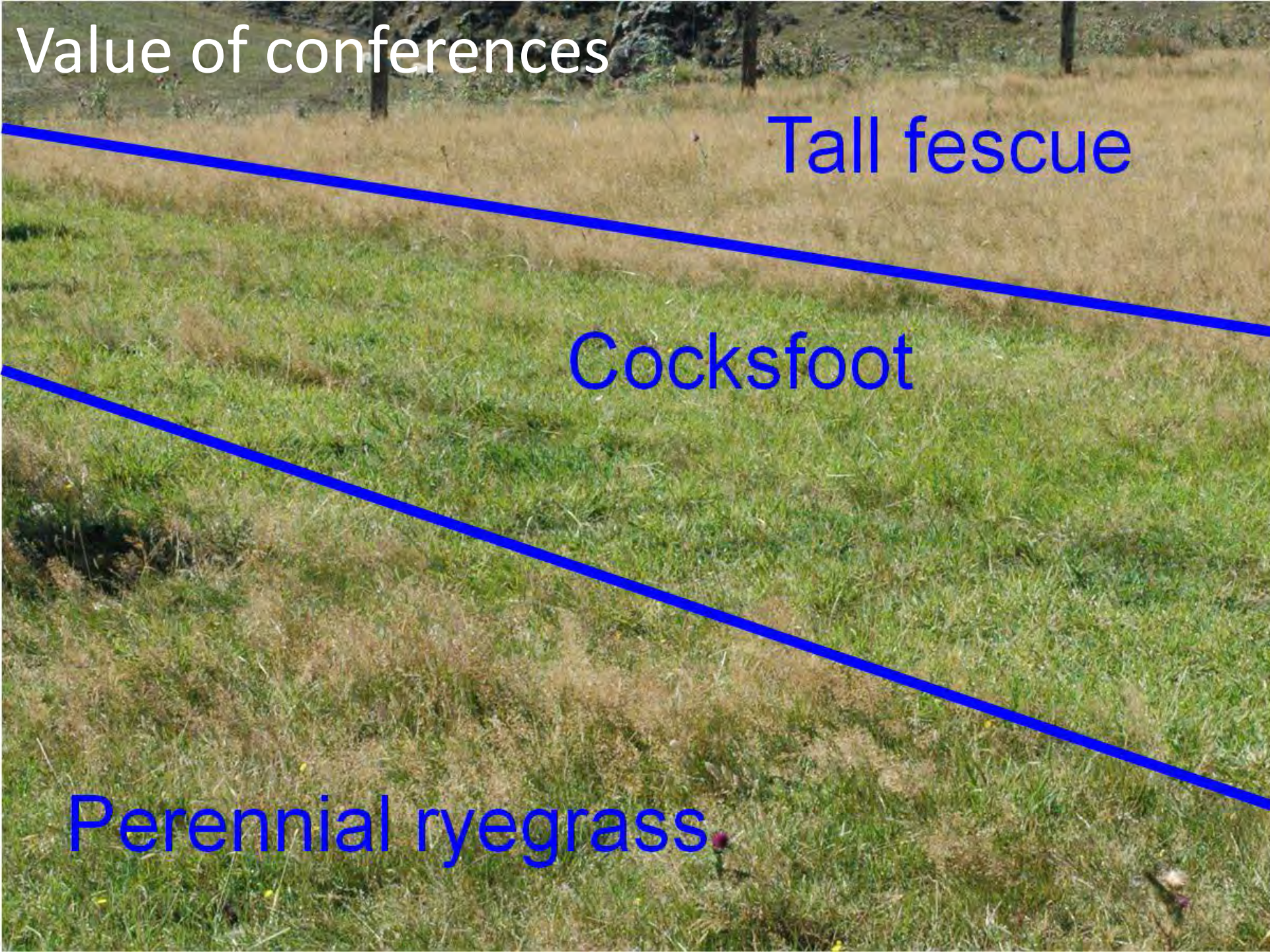
Photo: WR Scott
Lincoln University

Nitrogen deficient pasture

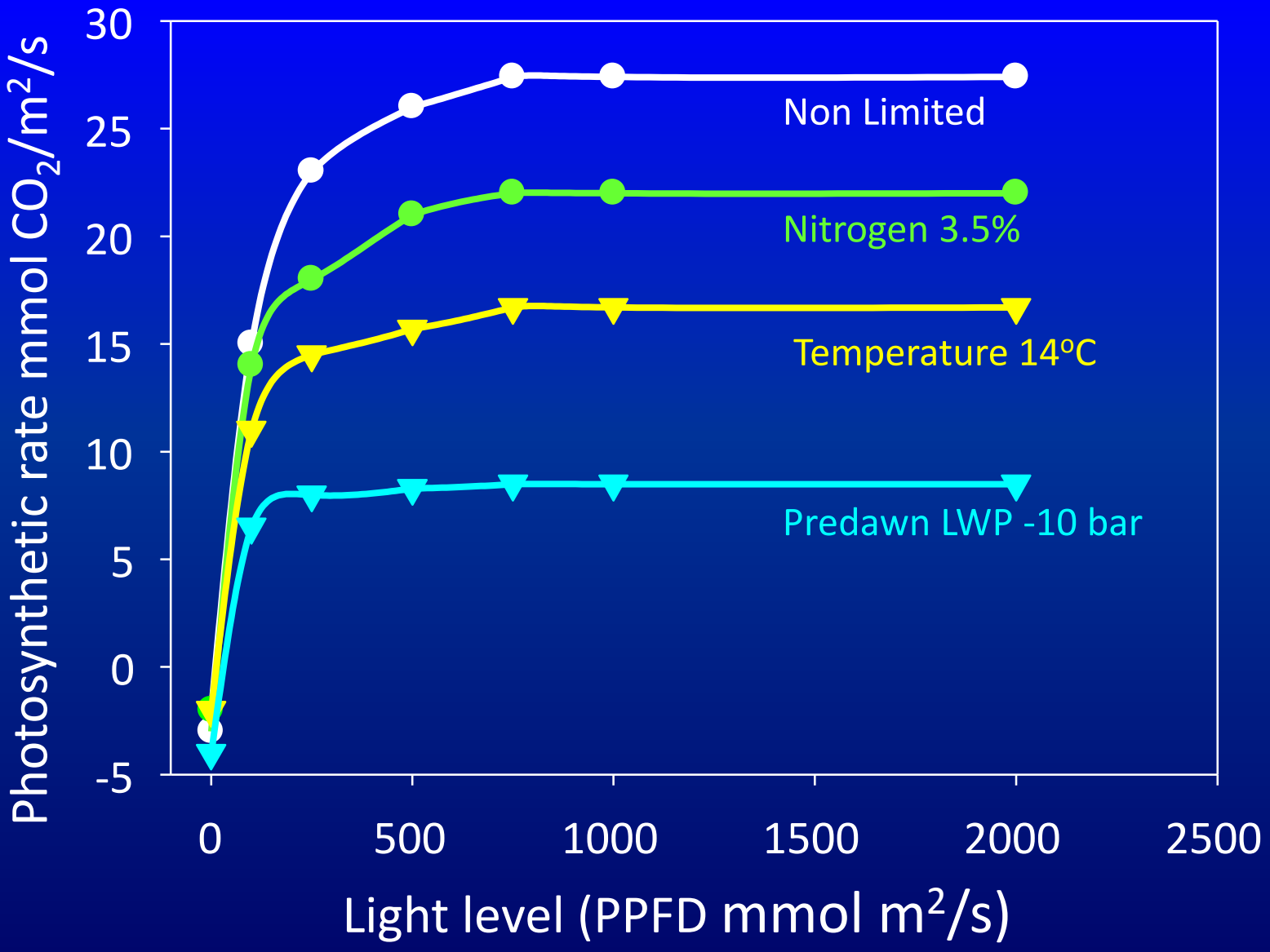
1000 kg N/ha

Nitrogen fertiliser use

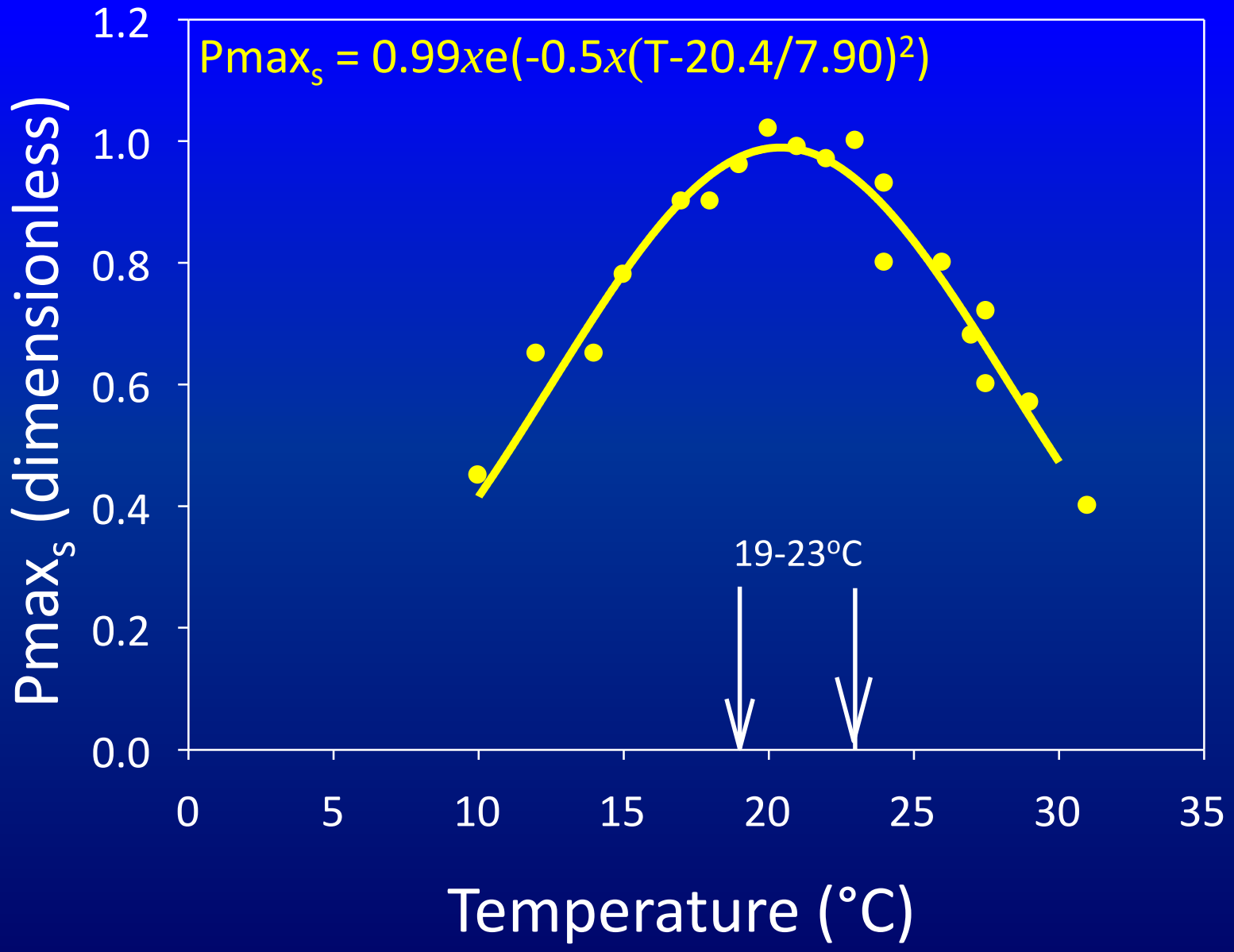



Value of conferences
Tall fescue
Cocksfoot
Perennial ryegrass

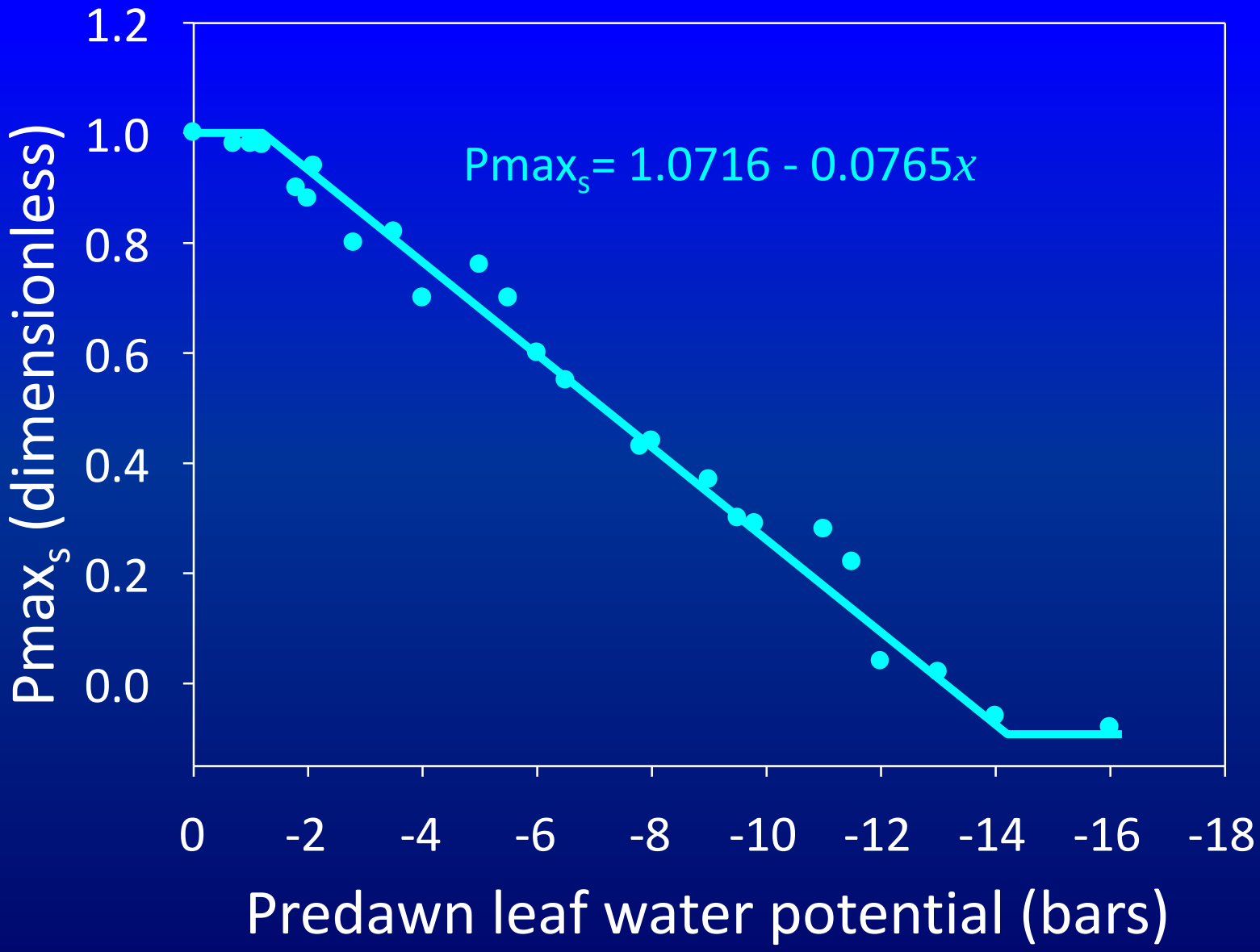
Pablo Peri, 2002



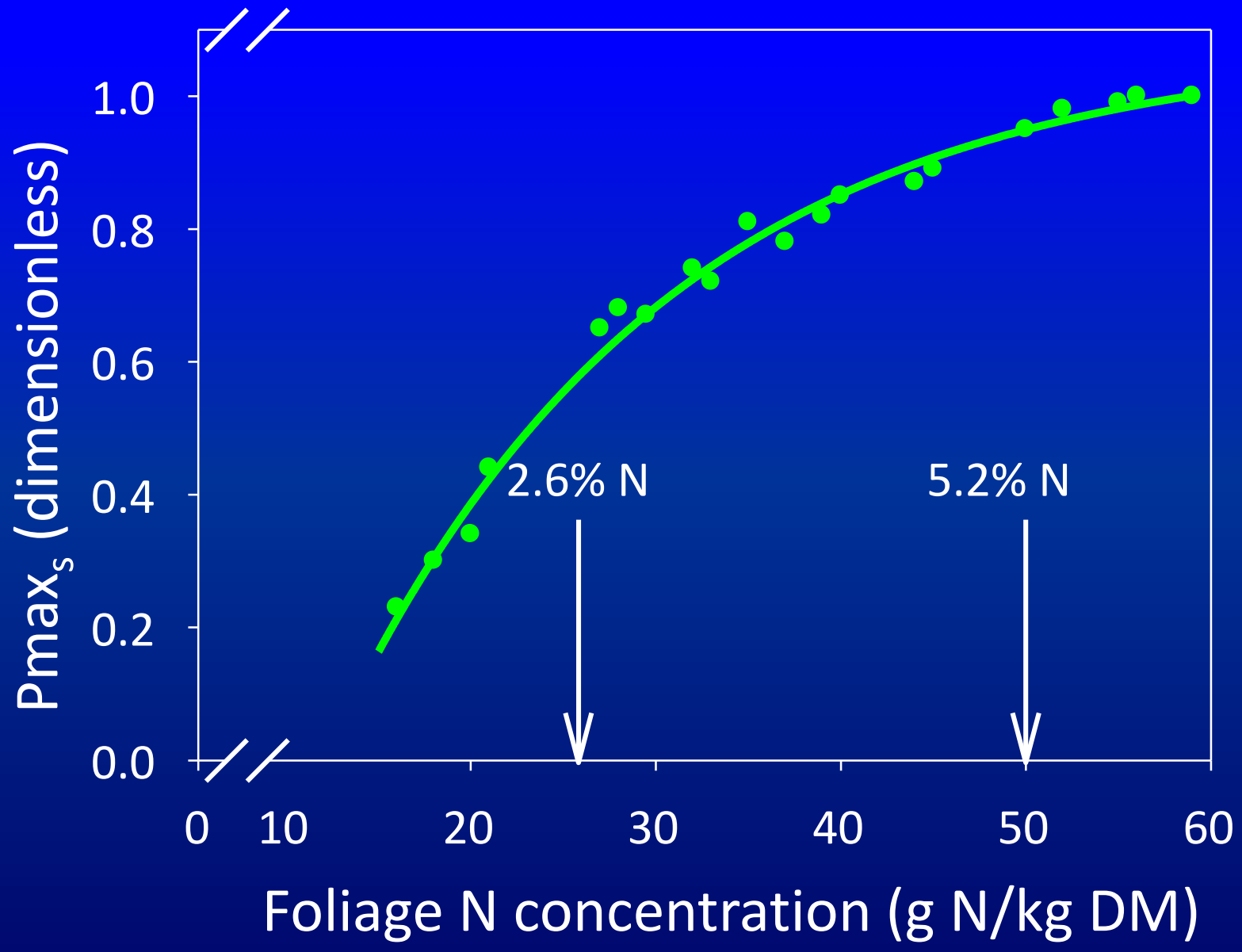
Peri *et al*. 2002



Peri *et al*. 2002



Peri *et al.* 2002



Peri *et al*. 2002

Modelling photosynthesis

Pp_{max} * { *f*(T) } * { *f*(N) } * { *f*(ψ_{lp}) }

°C	$Pmax_s$	%N	$Pmax_s$	ψ_{lp}	$Pmax_s$
10	0.47	1.5	0.25	-0.1	1.00
19	1.00	2.6	0.70	-1.2	1.00
23	1.00	5.2	1.00	-14.0	0.00
31	0.38	5.9	1.00	-16.0	-0.05

Where Pp_{max} is the maximum measured photosynthetic rate of

27.4 mmol CO_2 m^{-2} s^{-1}

Most basic approach

Peri *et al.* 2002

Experiment 3

Rep 1

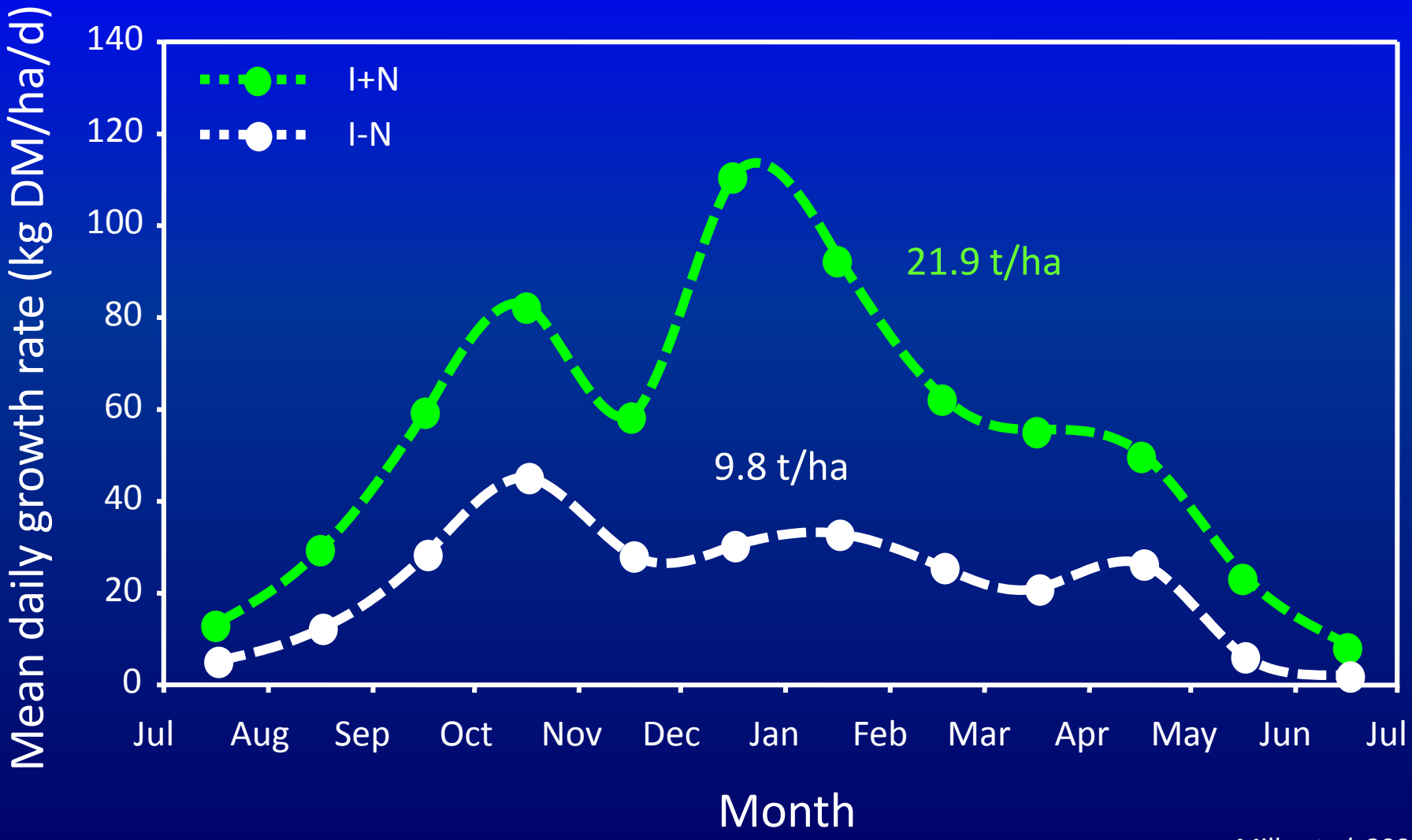
Rep 2

Rep 3

Objective

Quantify the effect of temperature, moisture and nitrogen on cocksfoot yields.

Pasture Growth Rates – 2 yr mean

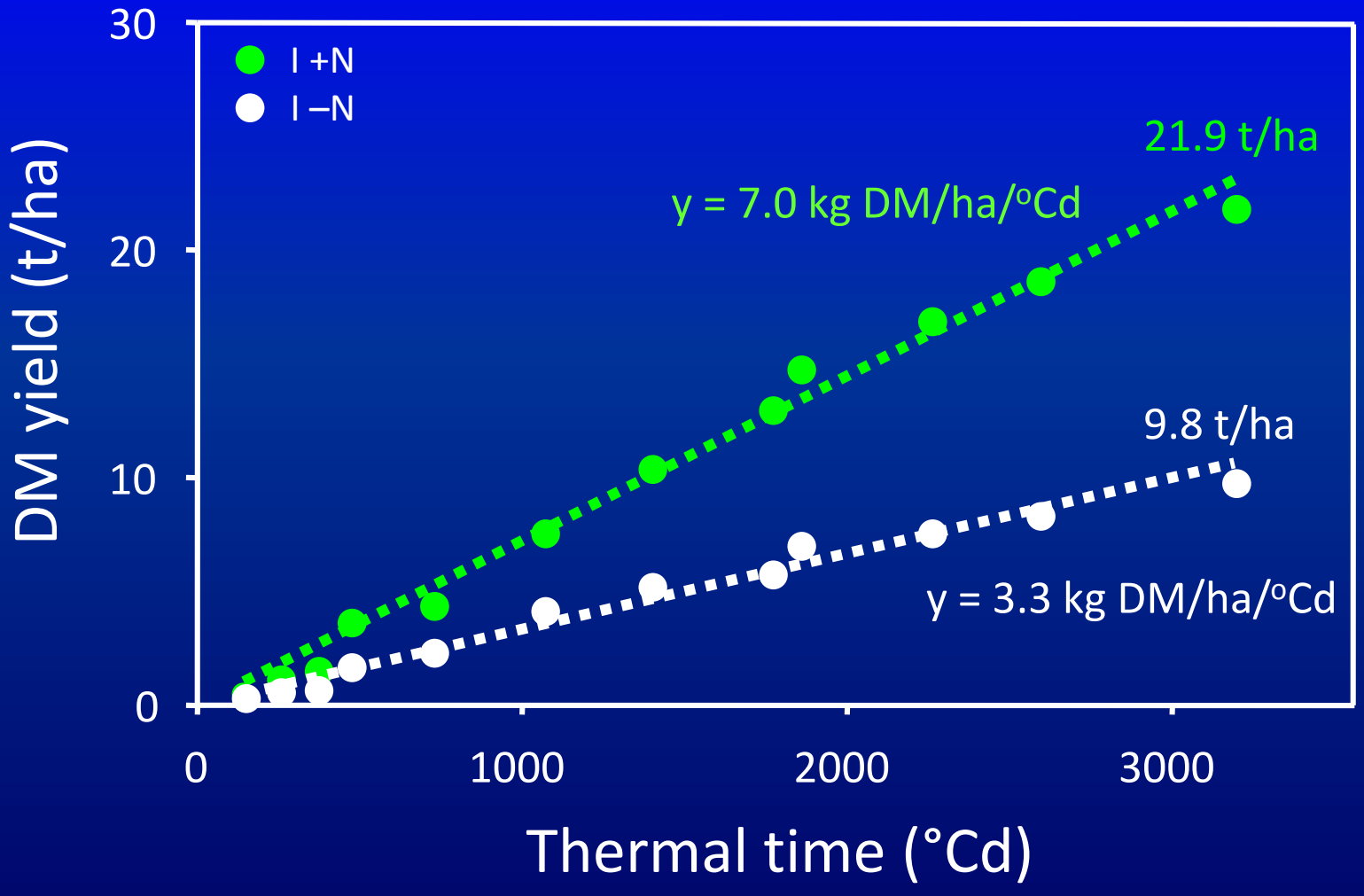


Mills *et al*. 2006

Winter ⇒ temperature response

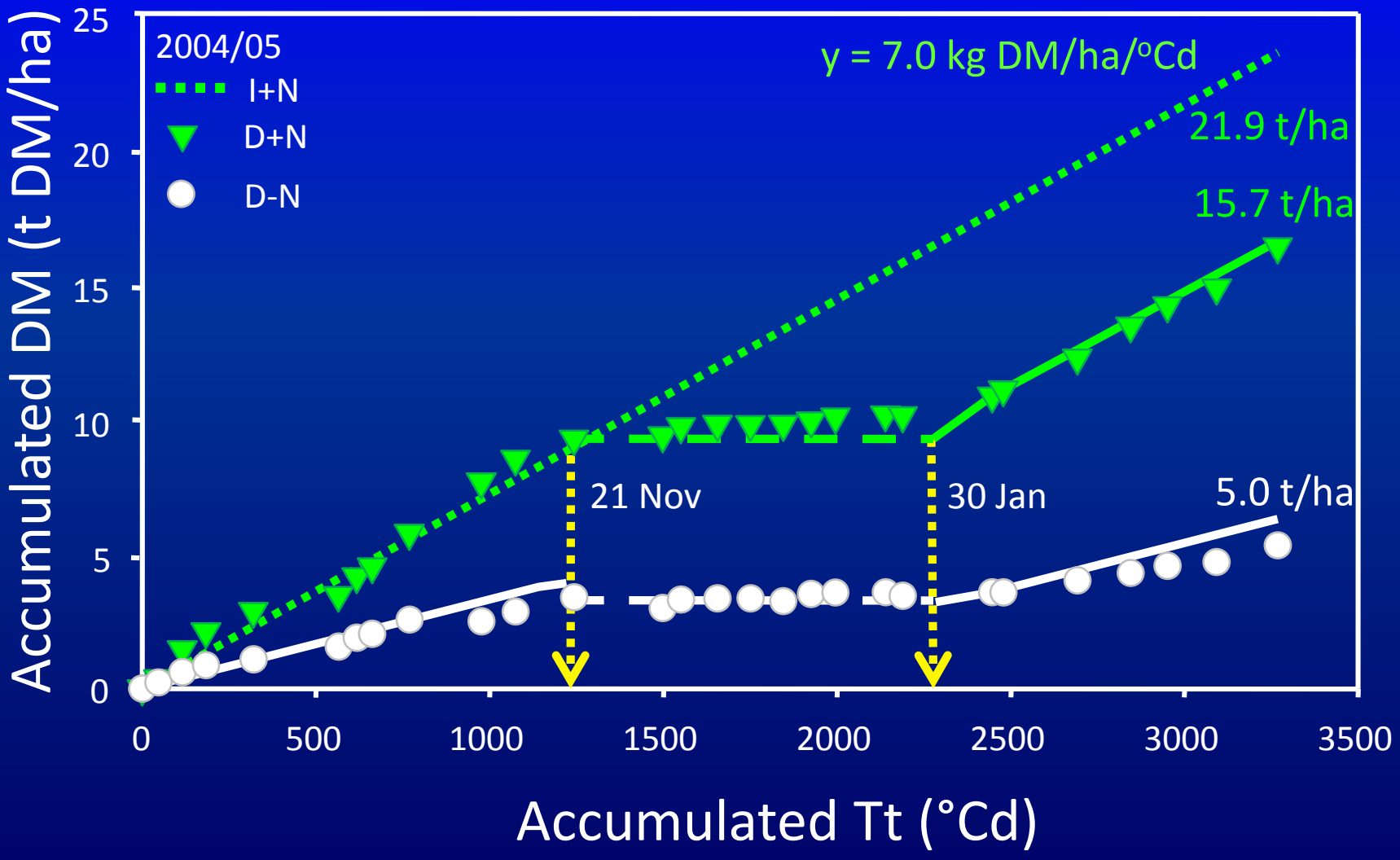
Photo: KM Pollock
Lincoln University

The Nitrogen gap



Mills *et al*. 2006

The Nitrogen gap



Mills *et al*. 2006

Nitrogen fixation
25 kg N/t DM

Lucas *et al*. 2010

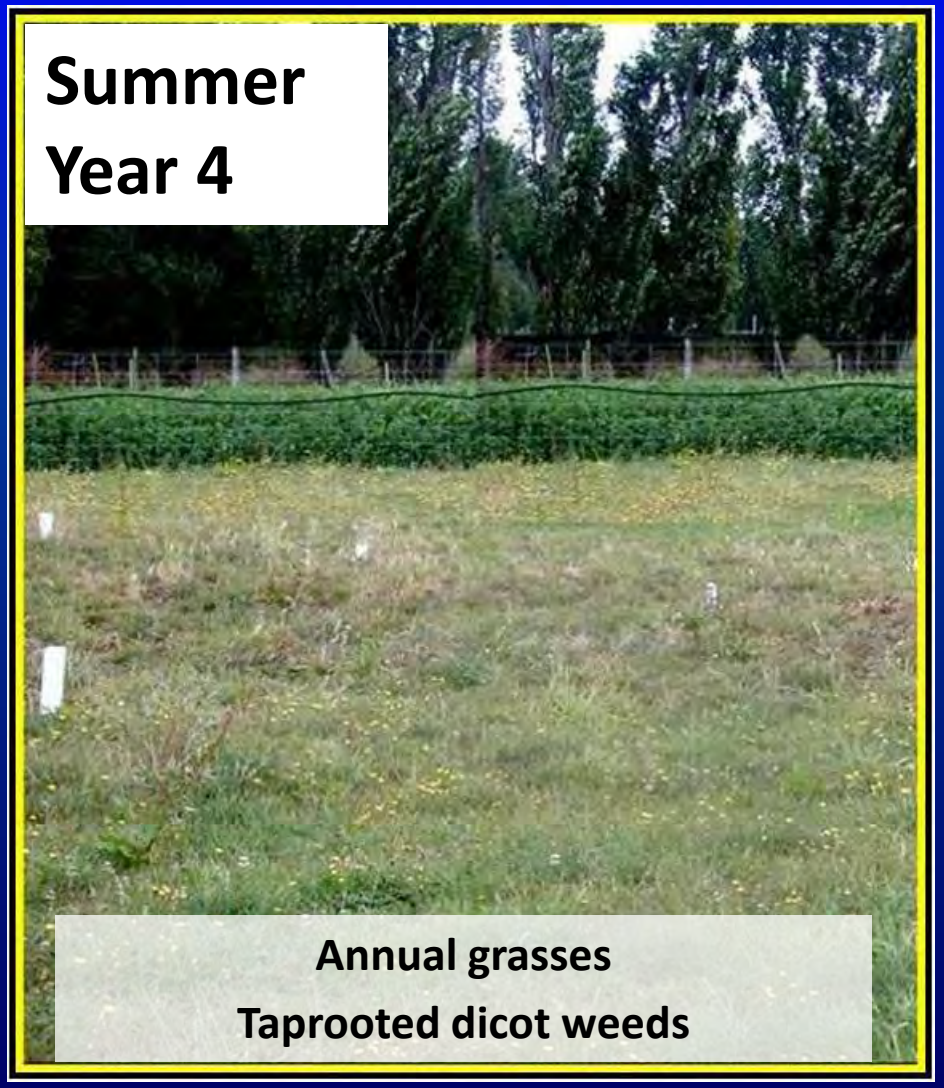
Experiment 4 - ‘MaxClover’

RG/Wc pastures

Unsown species

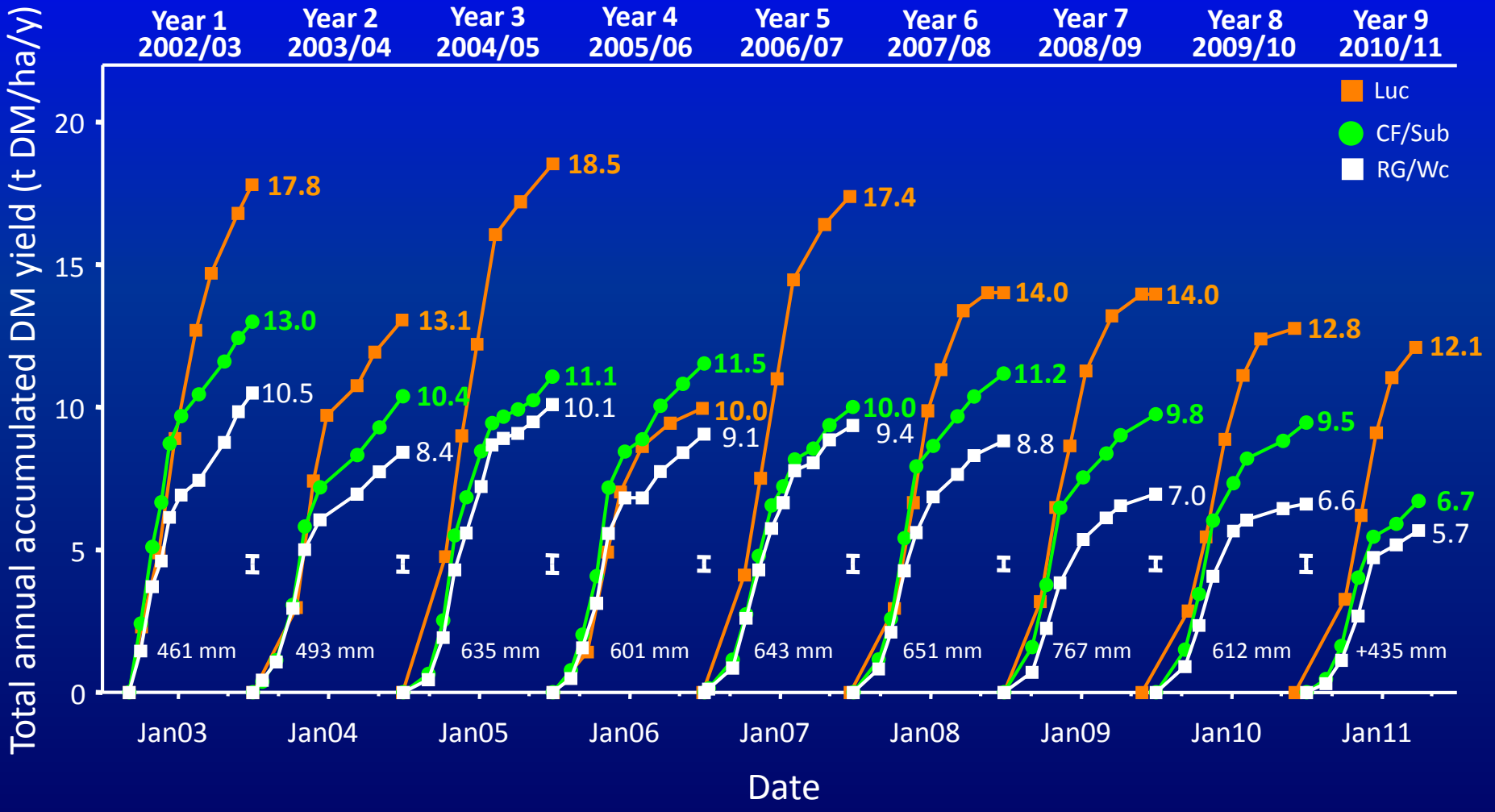
<5% in Year 1

>45% in Year 6



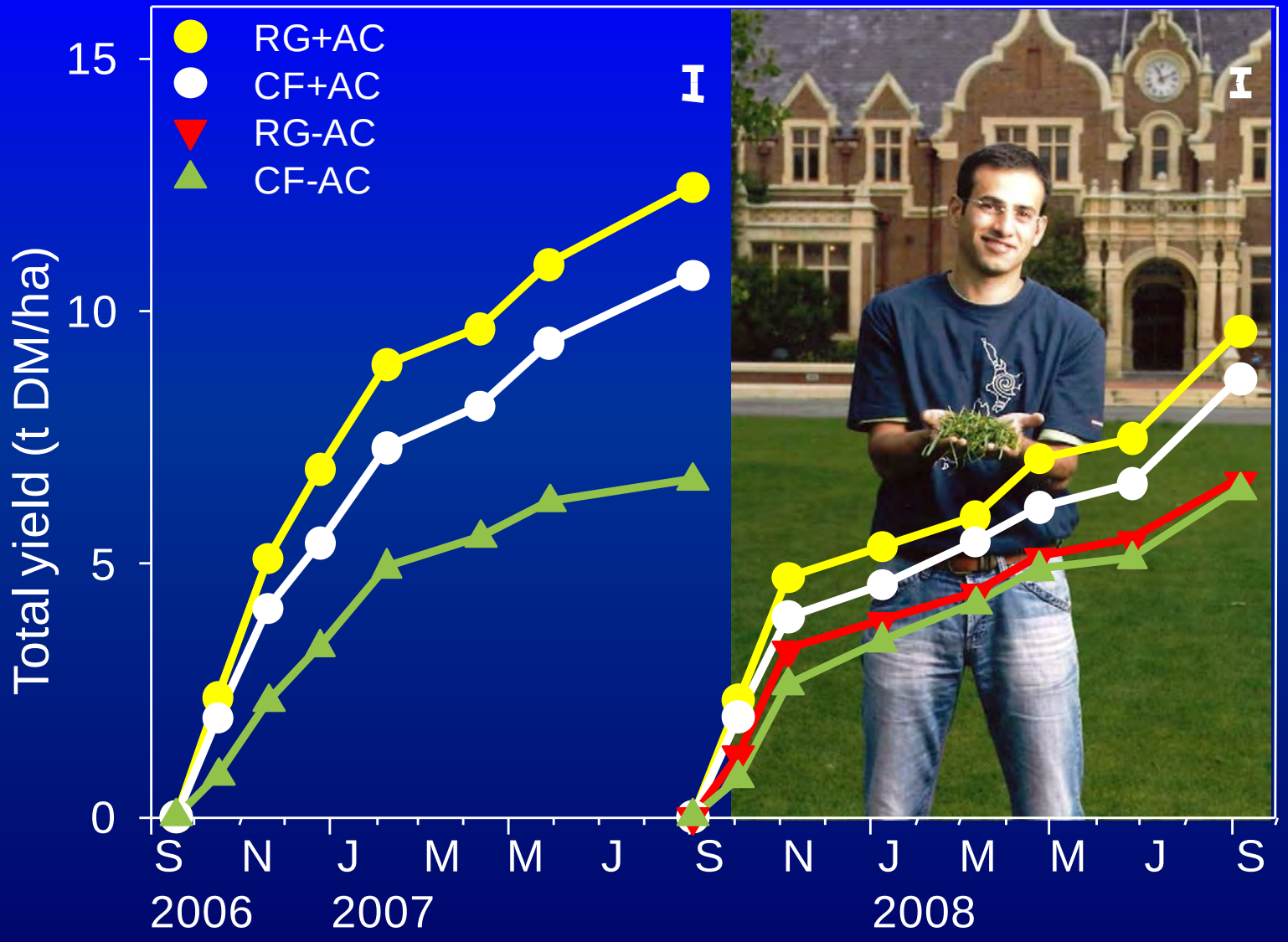
‘MaxClover’ Total DM Yields

(to 30 March 2011)



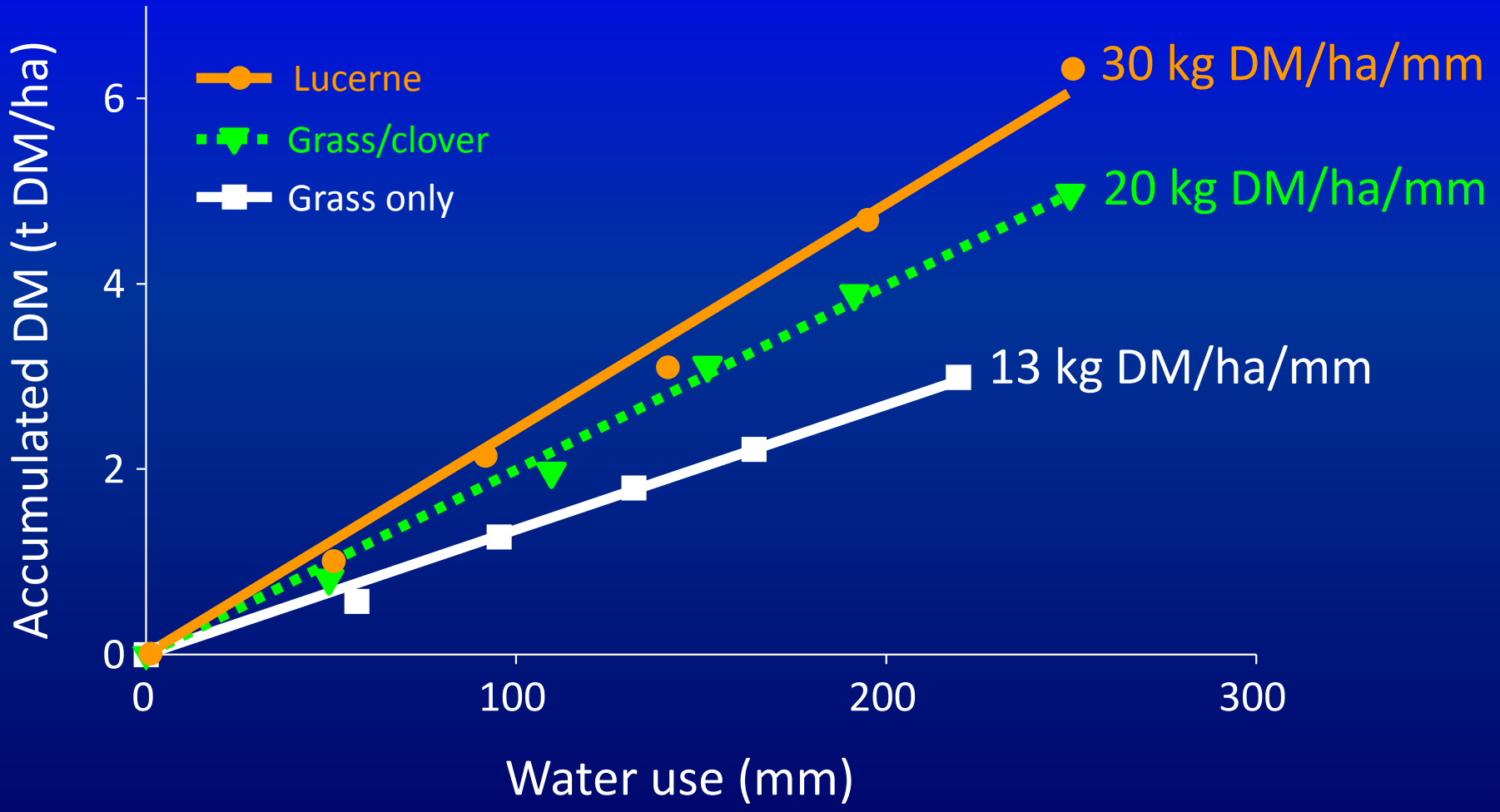
Sub clover

Total DM yield

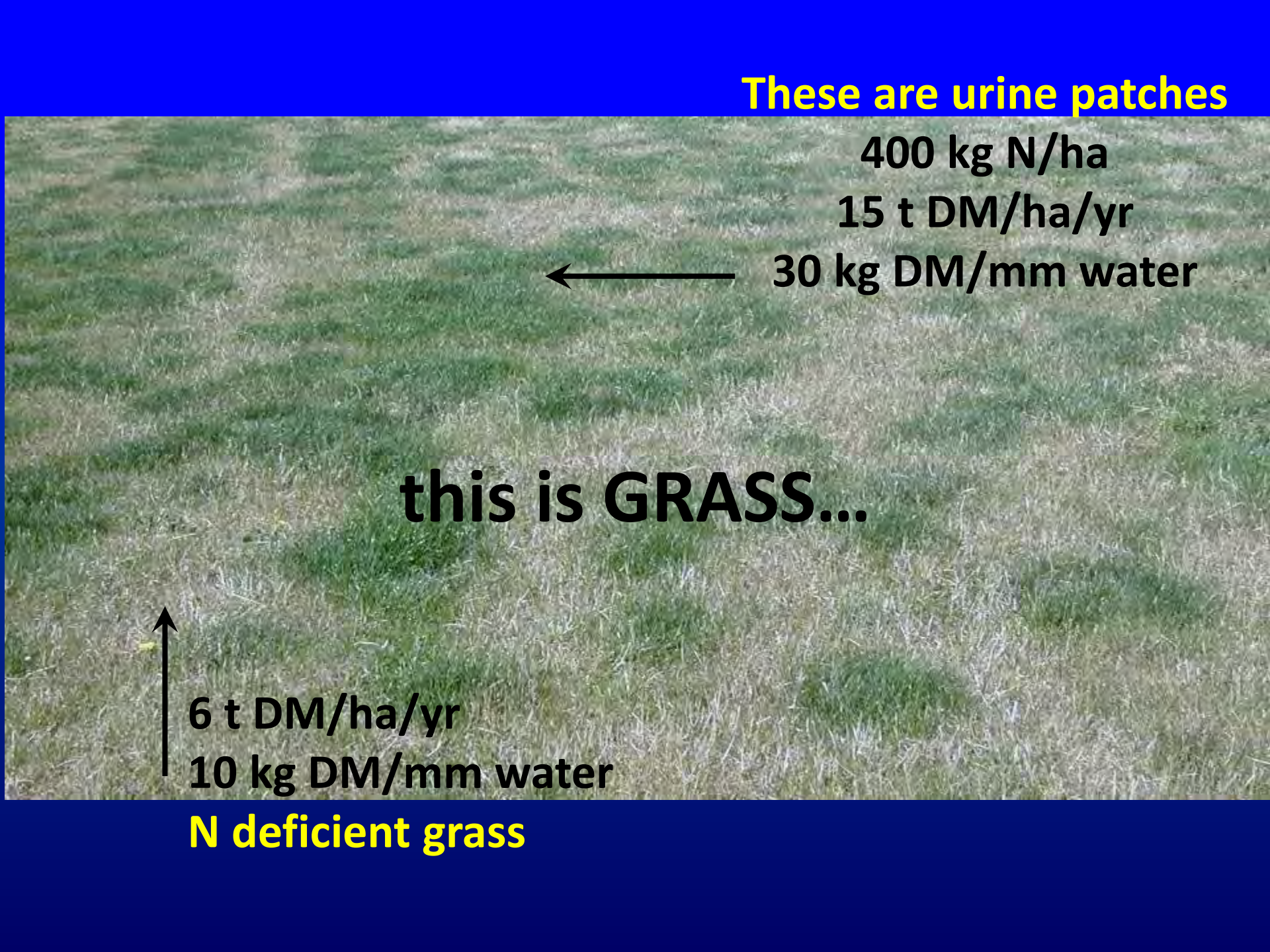


Ates *et al*. 2010

Spring WUE: legume = (nitrogen)



Moot *et al*. 2008


These are urine patches
400 kg N/ha
15 t DM/ha/yr
30 kg DM/mm water
this is GRASS…
6 t DM/ha/yr
10 kg DM/mm water
N deficient grass

Sheep prefer 70% legume, 30% grass

Key dryland extension messages

- Lucerne
- Physiologically, N not H_2O limits growth
- Cocksfoot survives but is nitrogen deficient
- Annual and perennial legumes required

Patagonia

Field trips are invaluable to provide solutions!

Peru

Farming in the developing world

Communal grazing

Over grazed – high erosion risk - Peru

Over grazed – high erosion risk - Marlborough

Problems have common solutions

Extension

SERVANT LEADER

Sustainable Farming Fund

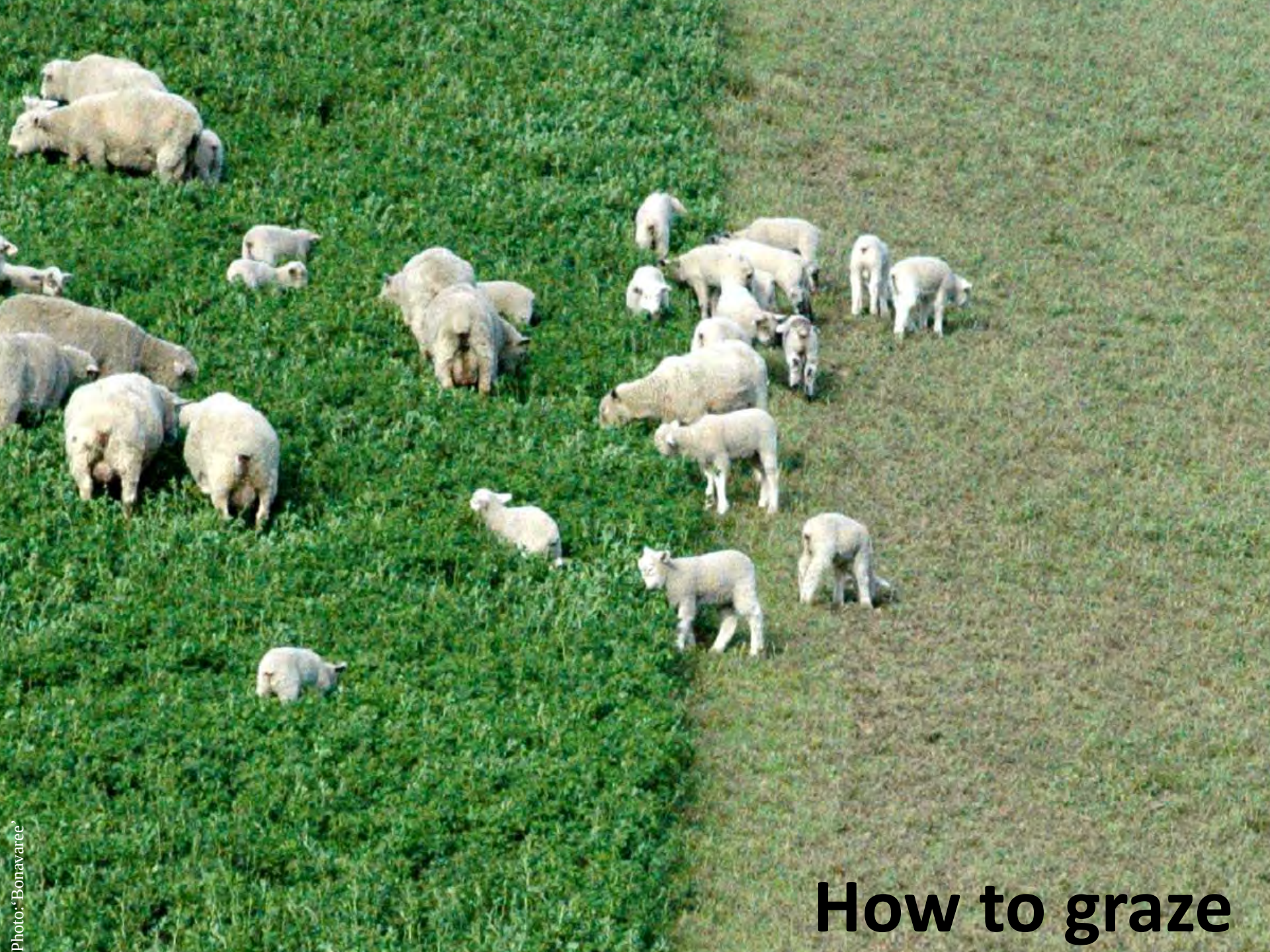
Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

Where to plant

Photo: Doug Avery
'Bonavaree'

When to graze

Photo: 'Bonavaree'

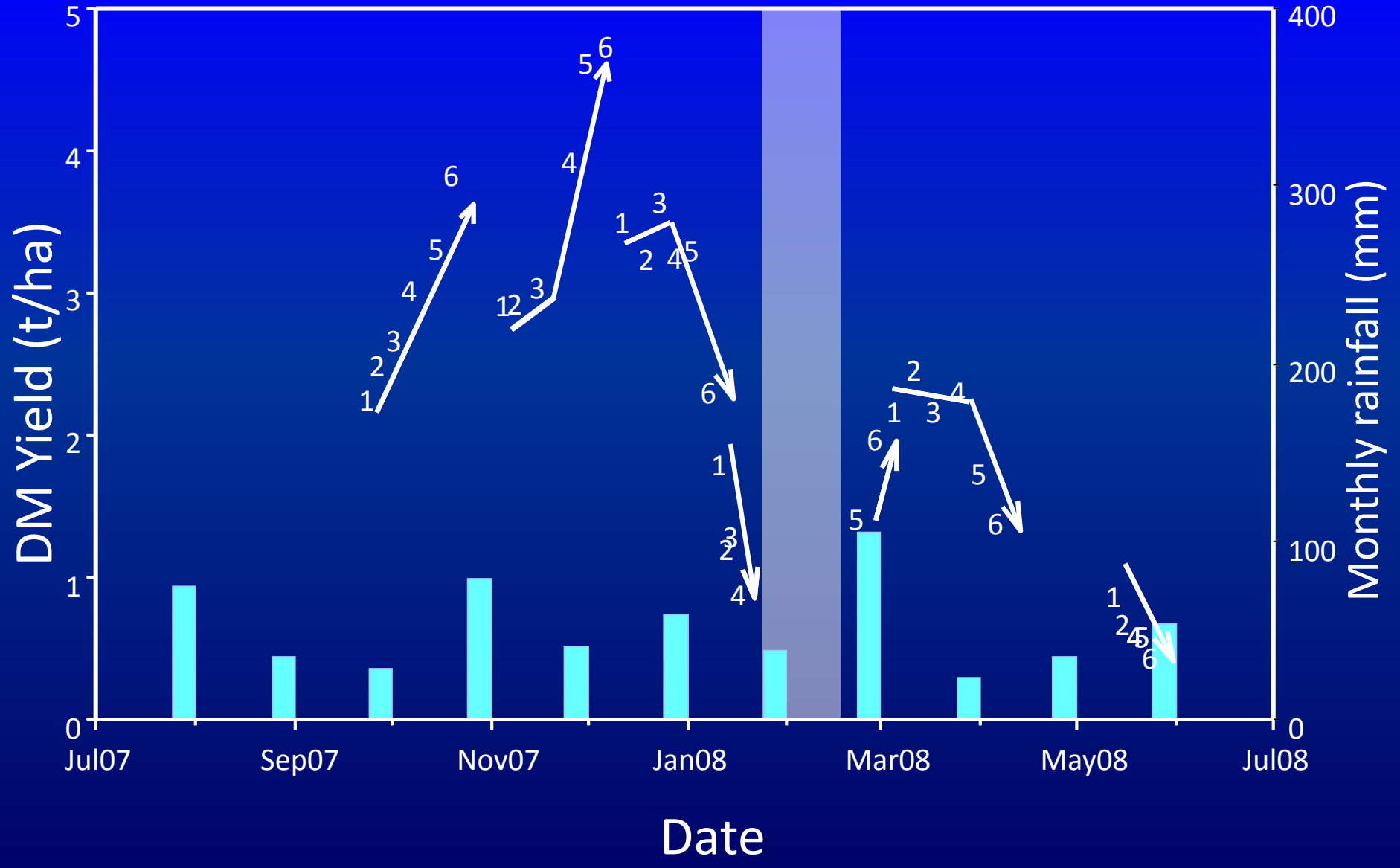


How to graze

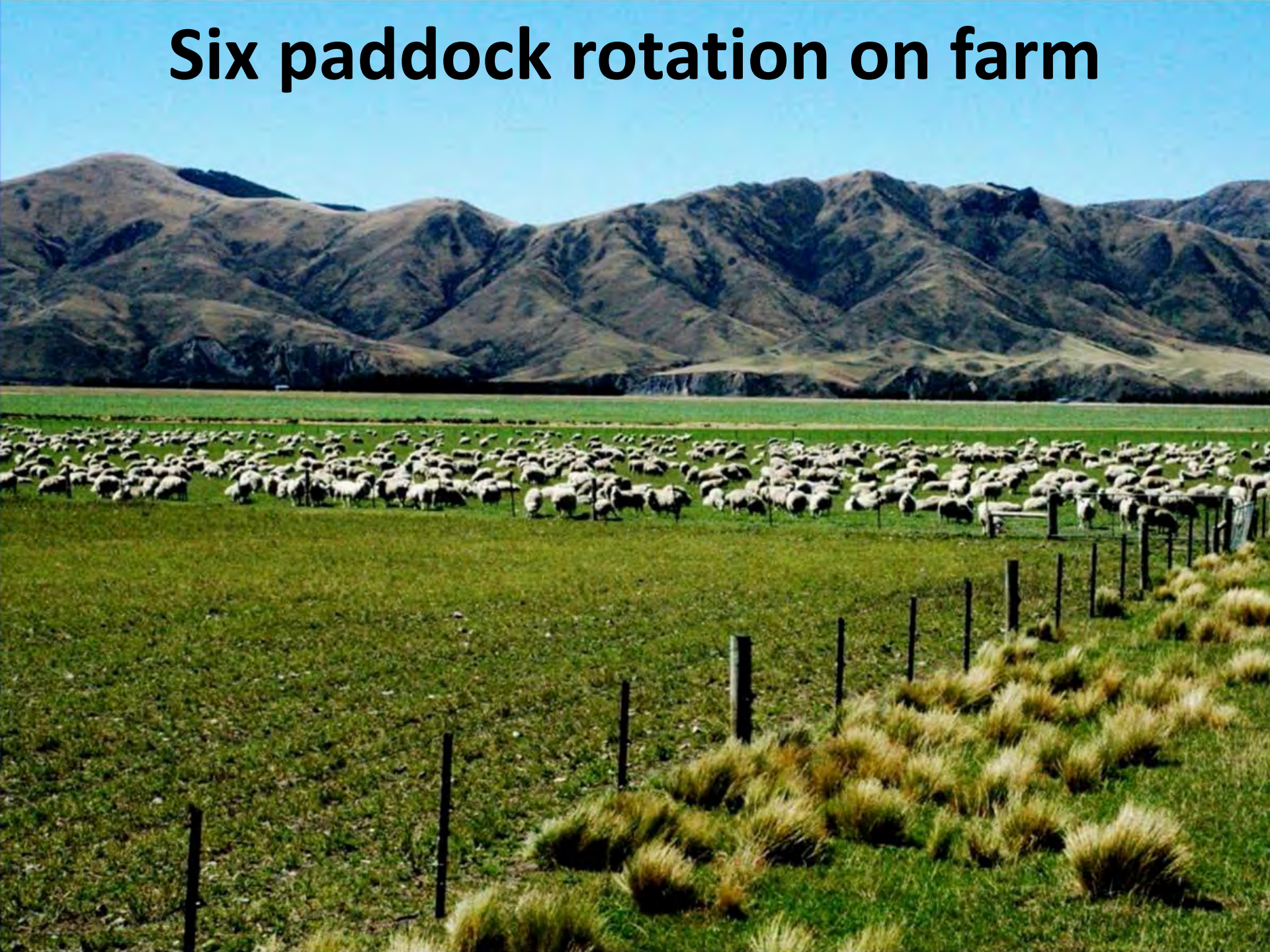
Photo:'Bonavaree'

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

Lucerne grazing - Maxclover



Six paddock rotation on farm



What else to feed

Photo: 'Bonavaree'

Spring = animals

Photo: 'Bonavaree'

Autumn = flowering plants

Rotation 4 Pre-graze

Plot 6 (28/2/08) **2.0 t DM/ha produced in 51 d**

Which animals?

Photo: 'Bonavaree'

Deer = no risk of bloat

How to overcome feed shortages

How to manage water

Talk to the farmers

In the field

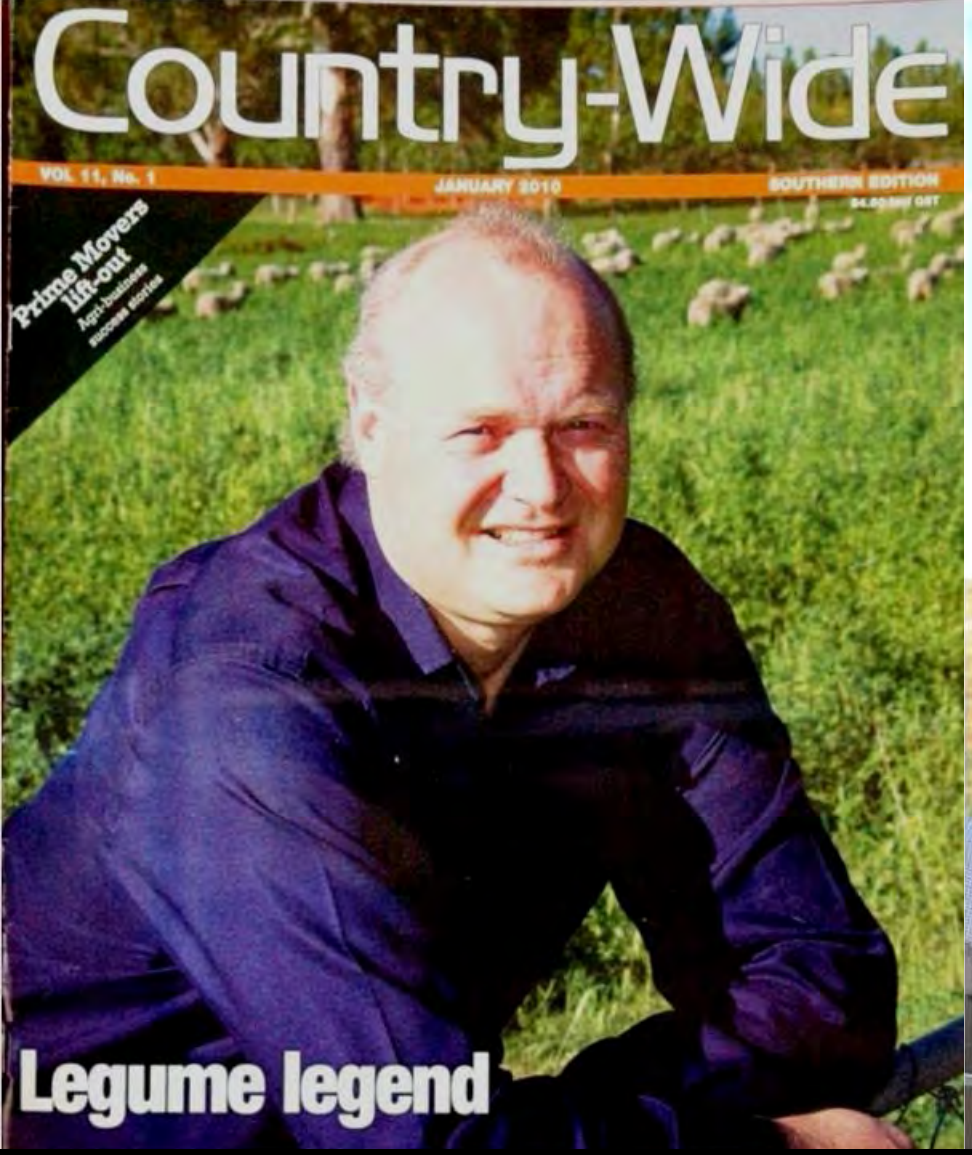
Again


And again

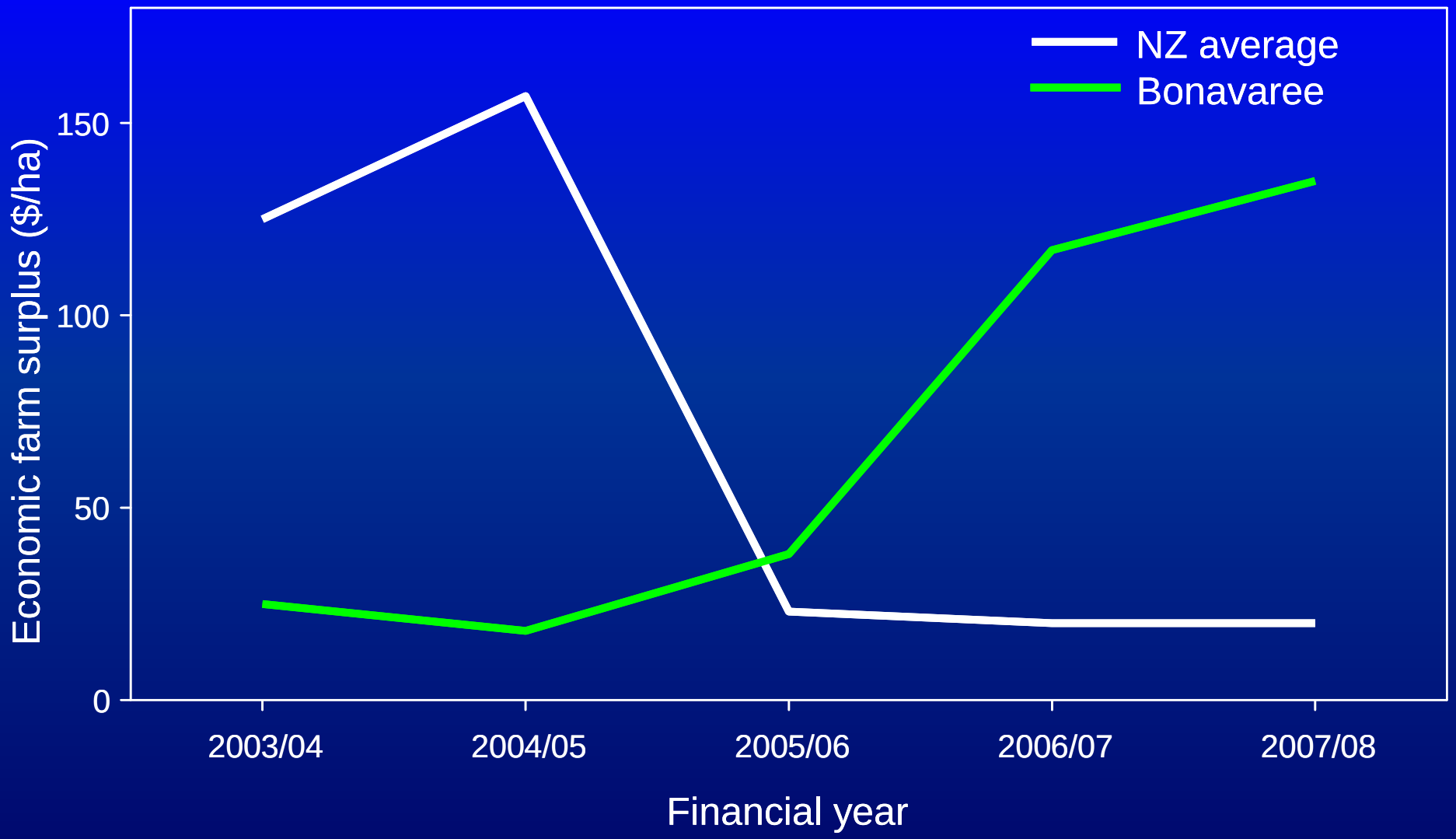
And again

77 Field days since 2007


10
MonitorFarm
Old fashioned pasture species proving their worth
by Howard Keene
Plant species choice key to success
Profit in the dry
Making the most of Water
Lucerne powers change on-farm
NEW WAYS WITH LUCERNE
Stop, look, and change
Legume legend
Lucerne is likely drought-beater
Lucerne behind four-fold increase in profit
'God's plant' the saving grace
87 rural news articles since 2007
Cocksfoot on the comeback trail
Moot points on management
Clear signal for system change
Innovation is the key
Benefits of climate change
Lucerne beats drought
Lucerne myths exposed at Marlborough field day
Professor sings lucerne's praises
Subterranean clover key to farm system
Profits despite drought



Integrity & Trust



Avery *et al*. 2008

Diverse drought-proofed landscape

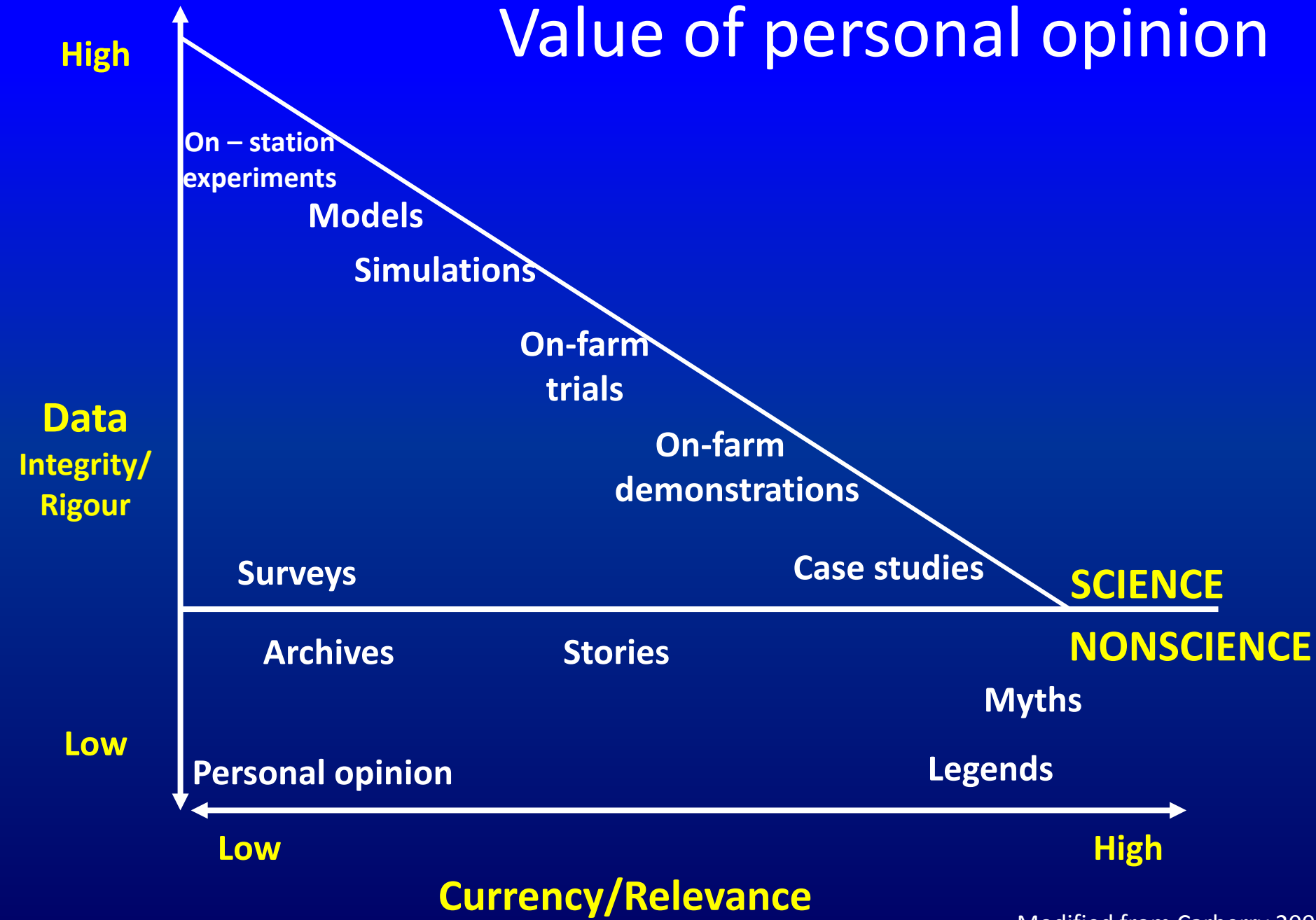
SI Farmer of the Year 2010

Marlborough District Council Farming Environment Award 2011

Keys to extension success ?

- Innovative farmers with incentives to change
  - Economic, land sustainability, social.
- Attention to all technical aspects at the same time
  - Without sub division grazing mgmt does not exist.
- Appropriate research to deliver best mgmt.
- Mutual integrity and trust between scientist and farmers with ongoing engagement and mentoring.

Value of personal opinion



Modified from Carberry 2001


By 2030 - Drier:
Drought – increased duration and frequency
Warmer winters
Photo: DJ Moot
Lincoln University

Lucerne 4 Lambs

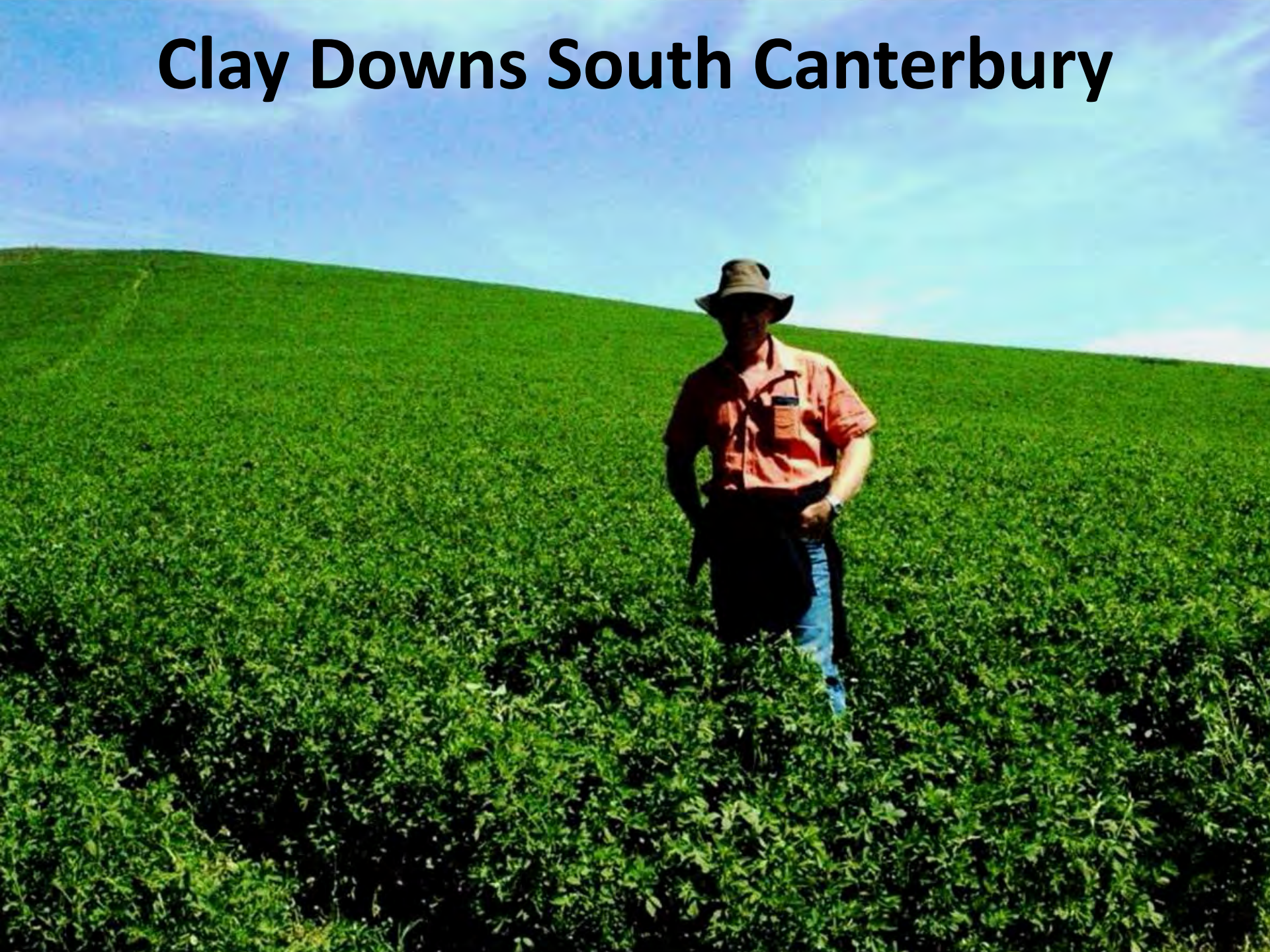
Sustainable Farming Fund

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

Hills – ideal lucerne country ??

Lucerne + cocksfoot – Haka Valley

Clay Downs South Canterbury



Lucerne + Prairie grass Nth Canterbury

Non cultivatable Hill Country

Balansa clover

Gland clover

High Country

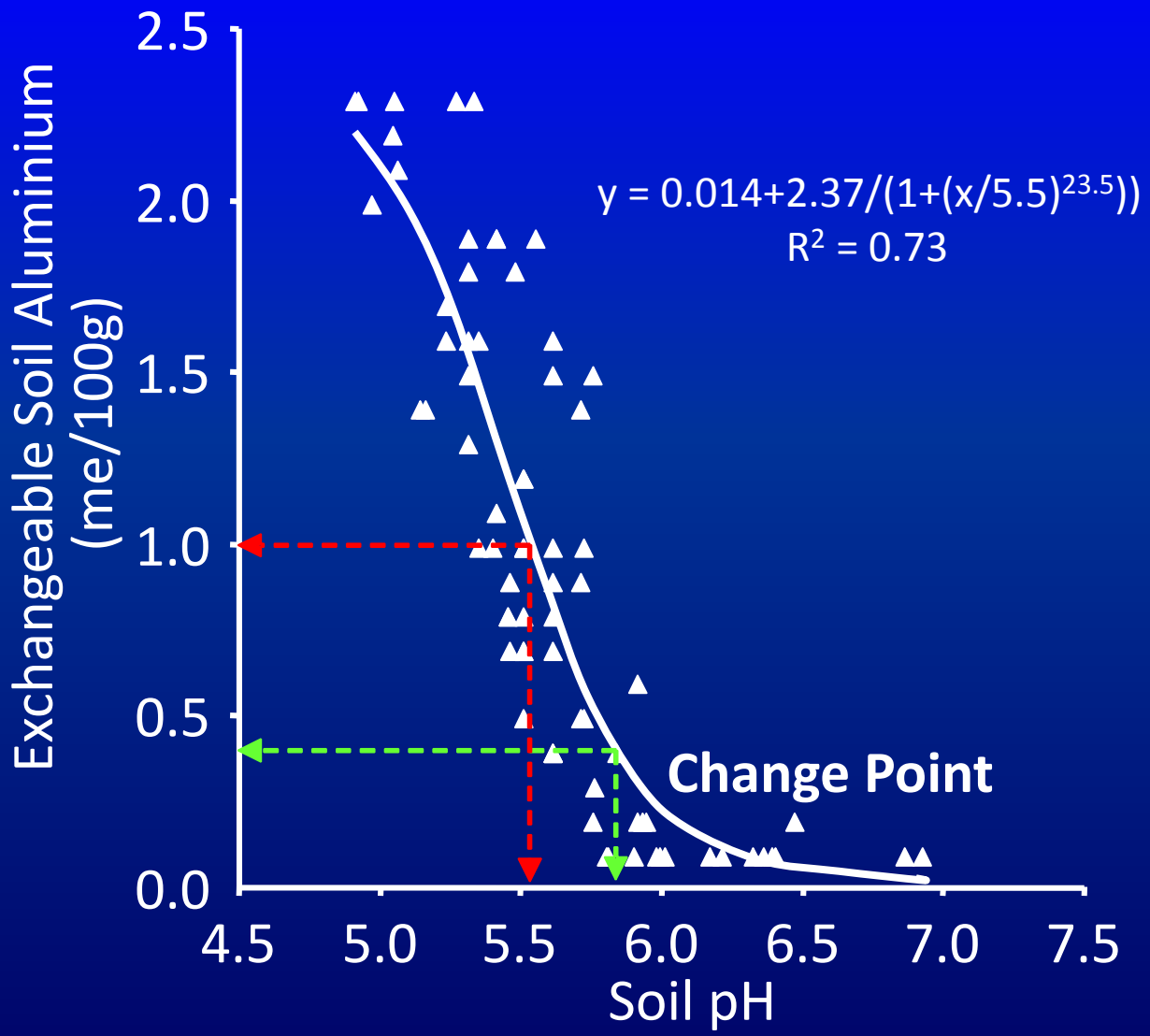
Unfinished business

Less Valley – Pasture Persistence

Sustainable Farming Fund

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

Soil pH & exchangeable Aluminium

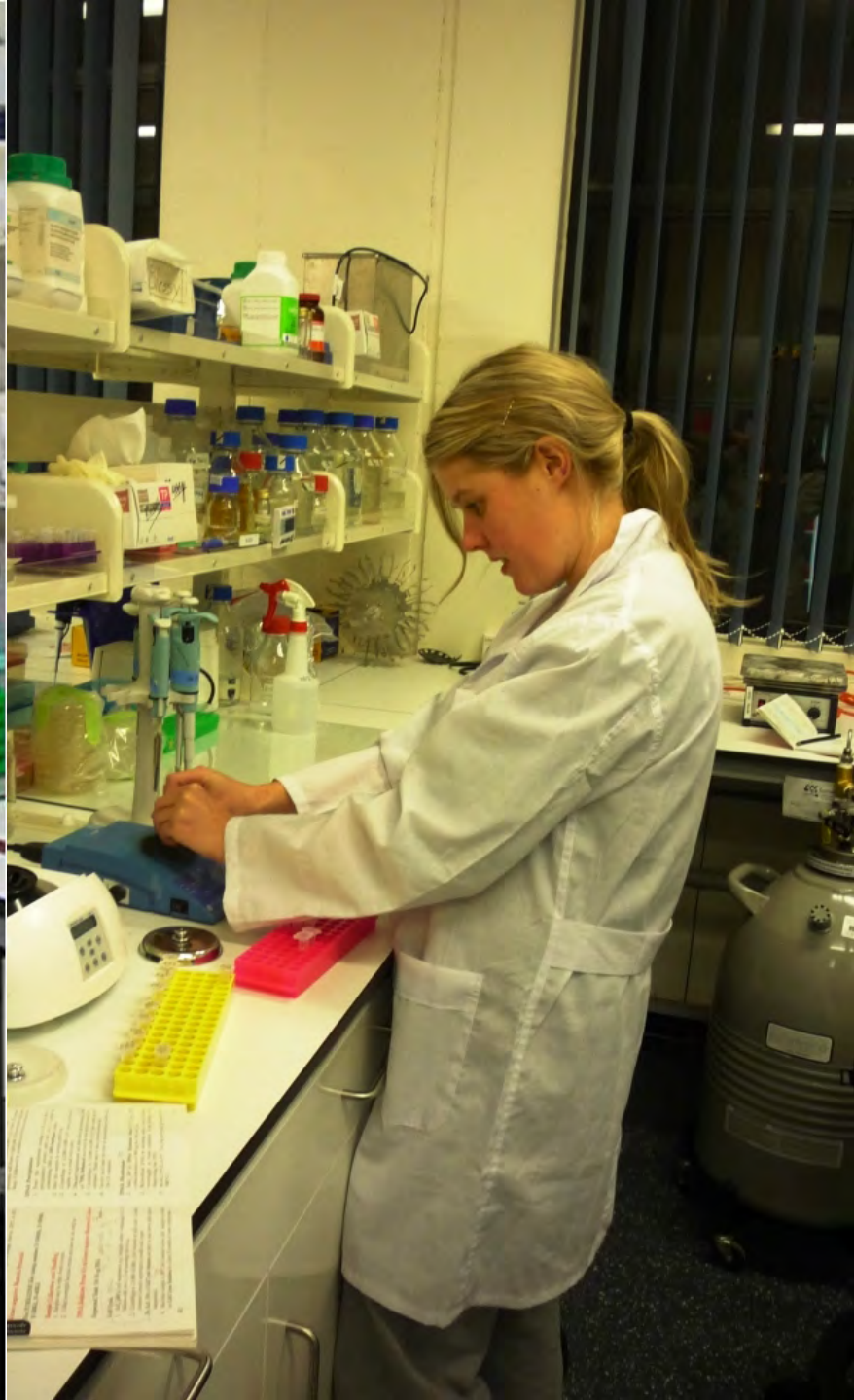


Moir & Moot, 2010

Caucasian Clover

Hurst *et al*. 2000

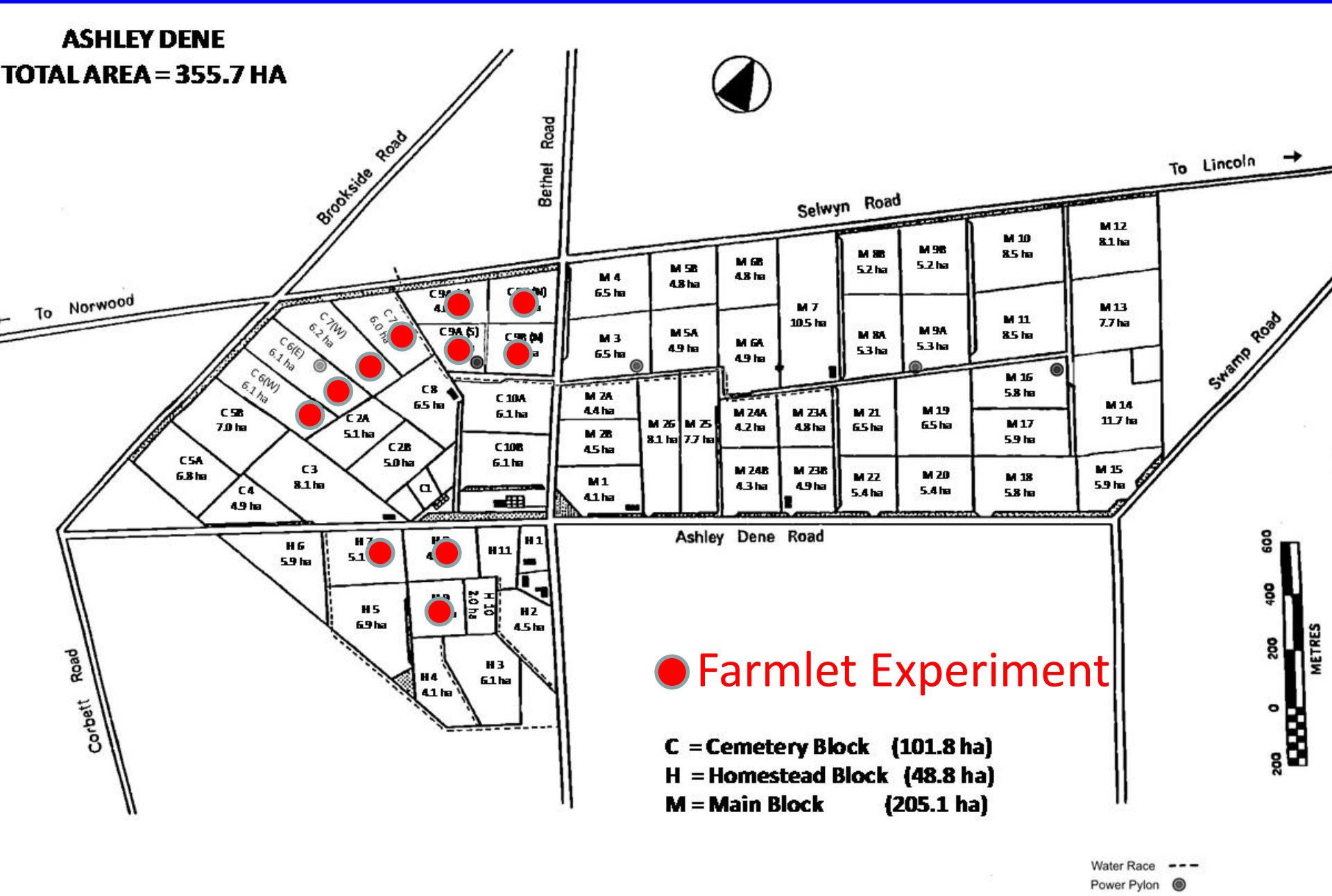

Which rhizobia are in here?



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

Springston, Canterbury

Flexible grazing management

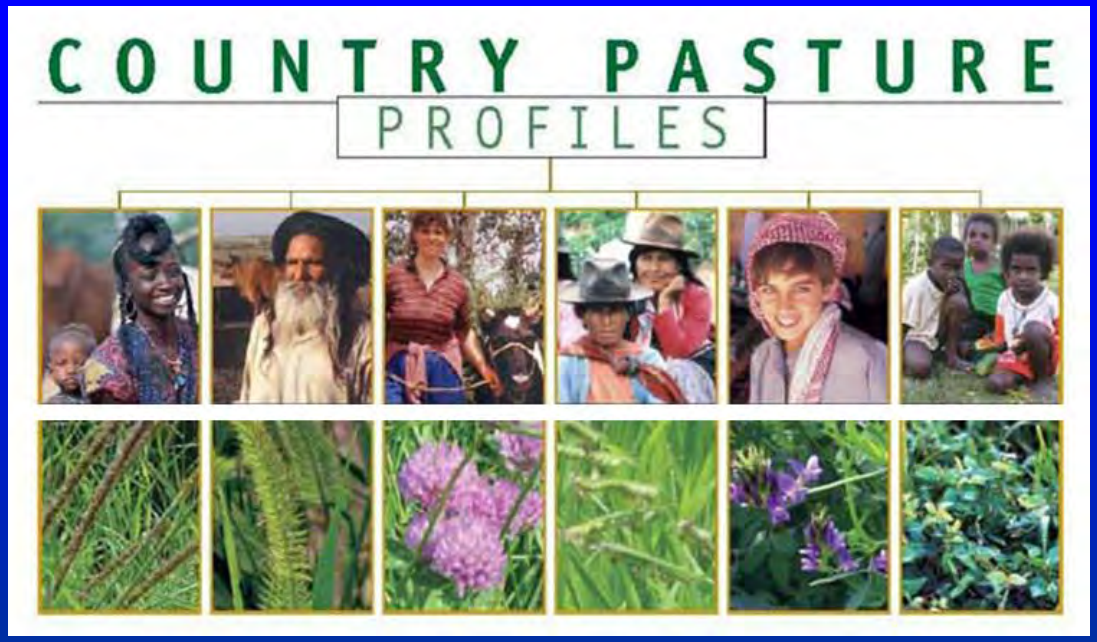

ASHLEY DENE
TOTAL AREA = 355.7 HA
Brookside Road
Bethel Road
To Lincoln
Selwyn Road
To Norwood
Swamp Road
Ashley Dene Road
Corbett Road
C 7(W) 6.2 ha
C 7 6.0 ha
C6(E) 6.1 ha
C6(W) 6.1 ha
C9A (S)
C8 6.5 ha
C 10A 6.1 ha
C 10B 6.1 ha
C5B 7.0 ha
C2A 5.1 ha
C2B 5.0 ha
C5A 6.8 ha
C3 8.1 ha
C4 4.9 ha
C1
M 4 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 21 6.5 ha
M 19 6.5 ha
M 16 5.8 ha
M 17 5.9 ha
M 14 11.7 ha
M 24B 4.3 ha
M 23B 4.9 ha
M 22 5.4 ha
M 20 5.4 ha
M 18 5.8 ha
M 15 5.9 ha
H6 5.9 ha
H11
H1
H5 6.9 ha
H10 2.0 ha
H2 4.5 ha
H4 4.1 ha
H3 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

Research questions

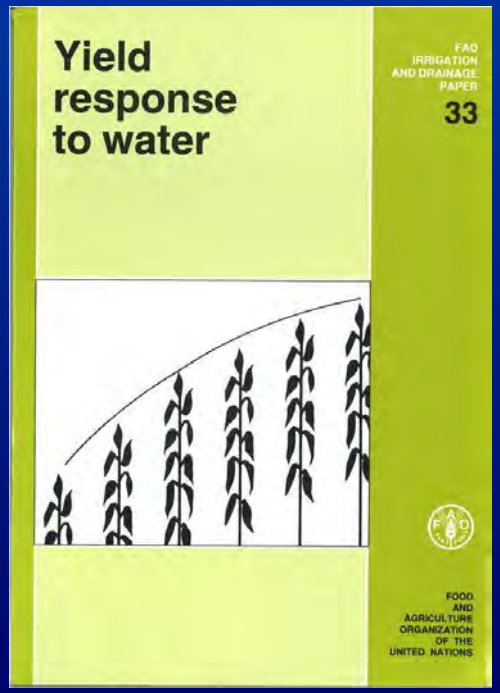
- Animal and pasture production and persistence
- Lucerne vs. luc/grass – N use, H_2O use, quality
- Management of new annual clovers.
- Farm system – winter forages, mating on lucerne, parasite burden .....?

Food and Agriculture Organization of the United Nations

for a world without hunger



http://www.fao.org/ag/AGP/AGPC/doc/Counprof/newzealand/newzealand1.htm



Country Pasture/Forage Resource Profiles
New Zealand

By

Derrick Moot, Annamaria Mills, Dick Lucas and Warwick Scott

Main recommendations

To meet WHO air quality standards by 2005

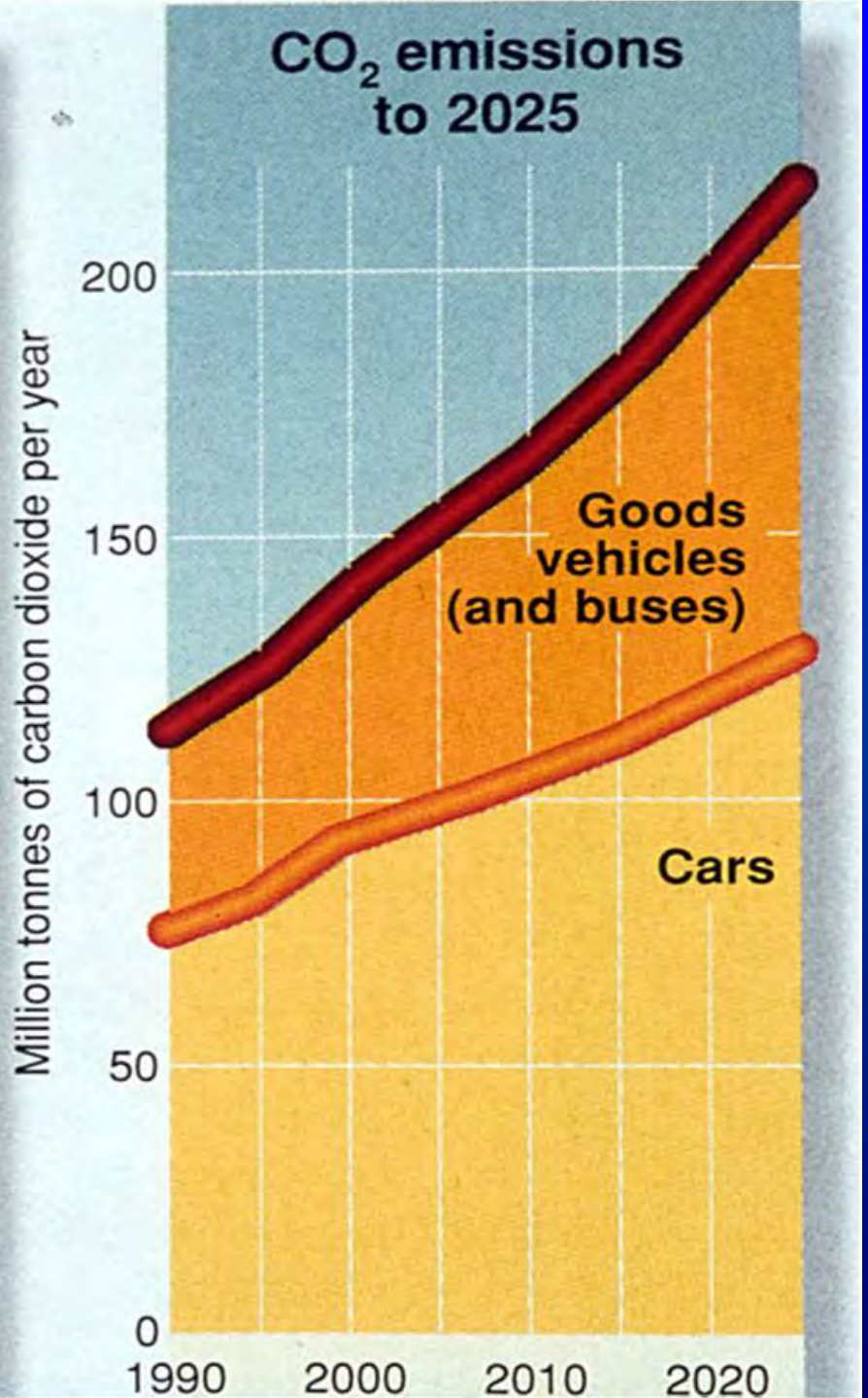
To improve the fuel efficiency of new cars by 40 per cent by 2005

A doubling of the price of petrol by 2005

To cut emissions of carbon dioxide to 80 per cent of the 1990 levels by 2020

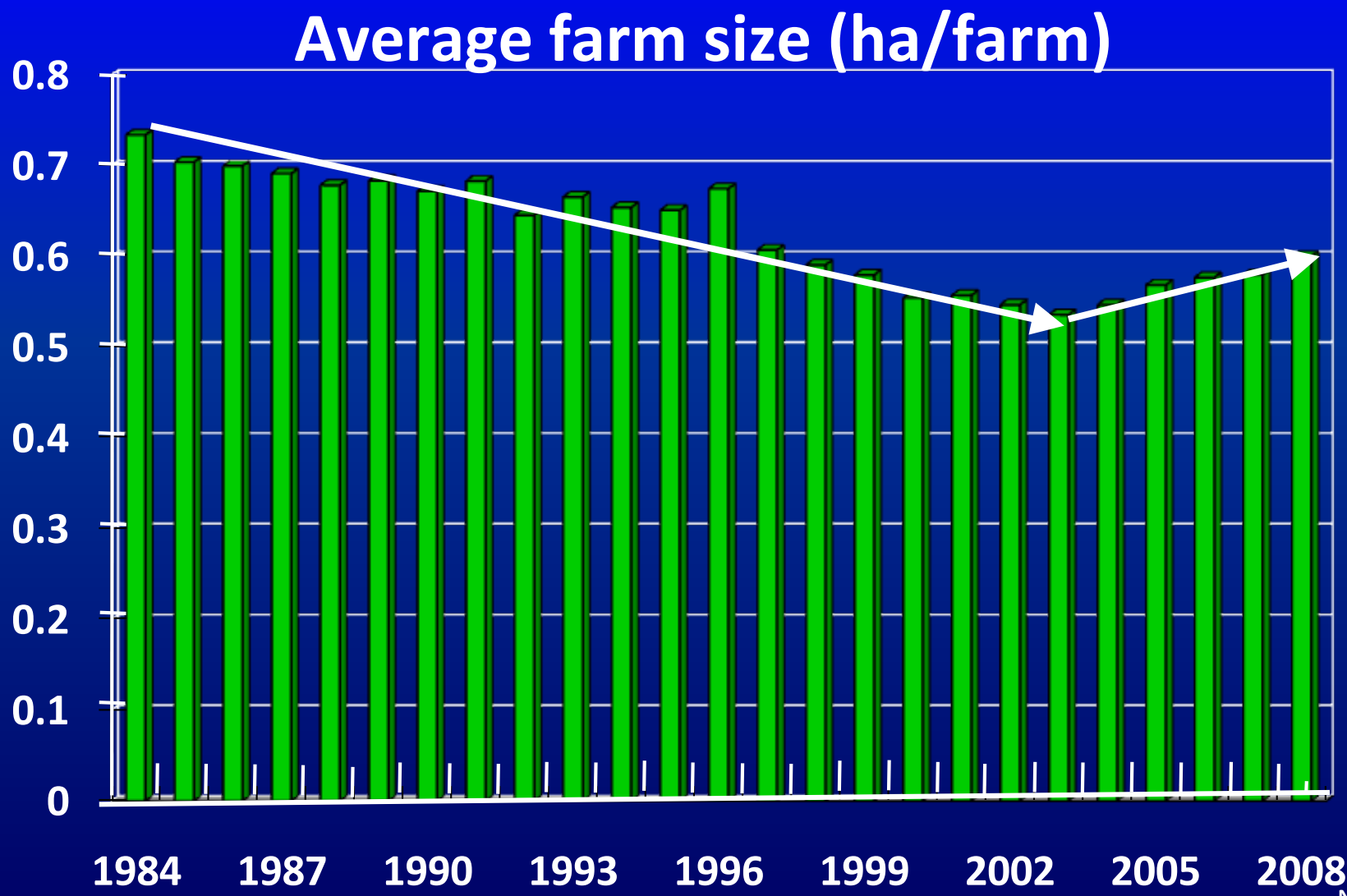
To increase the proportion of rail freight from 6·5 per cent to 10 per cent by the end of the century and to 20 per cent by 2010

To tax aircraft fuel



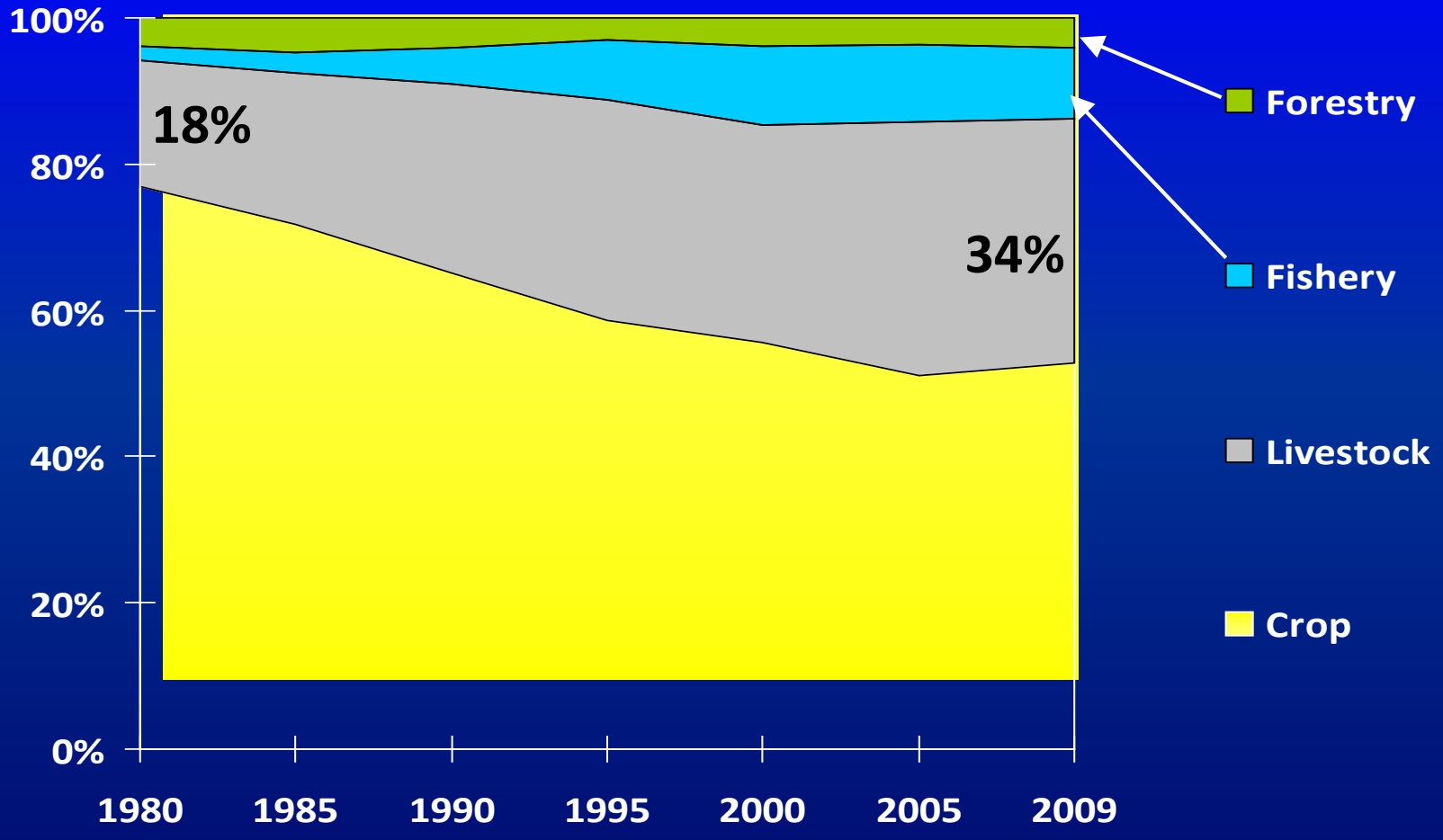
1 new coal fired power plant every week for the next two years

Small farming: modernizing agriculture and food safety



NSBC, 2011

Shares of output values within agricultural sector 1980-2009, (%)

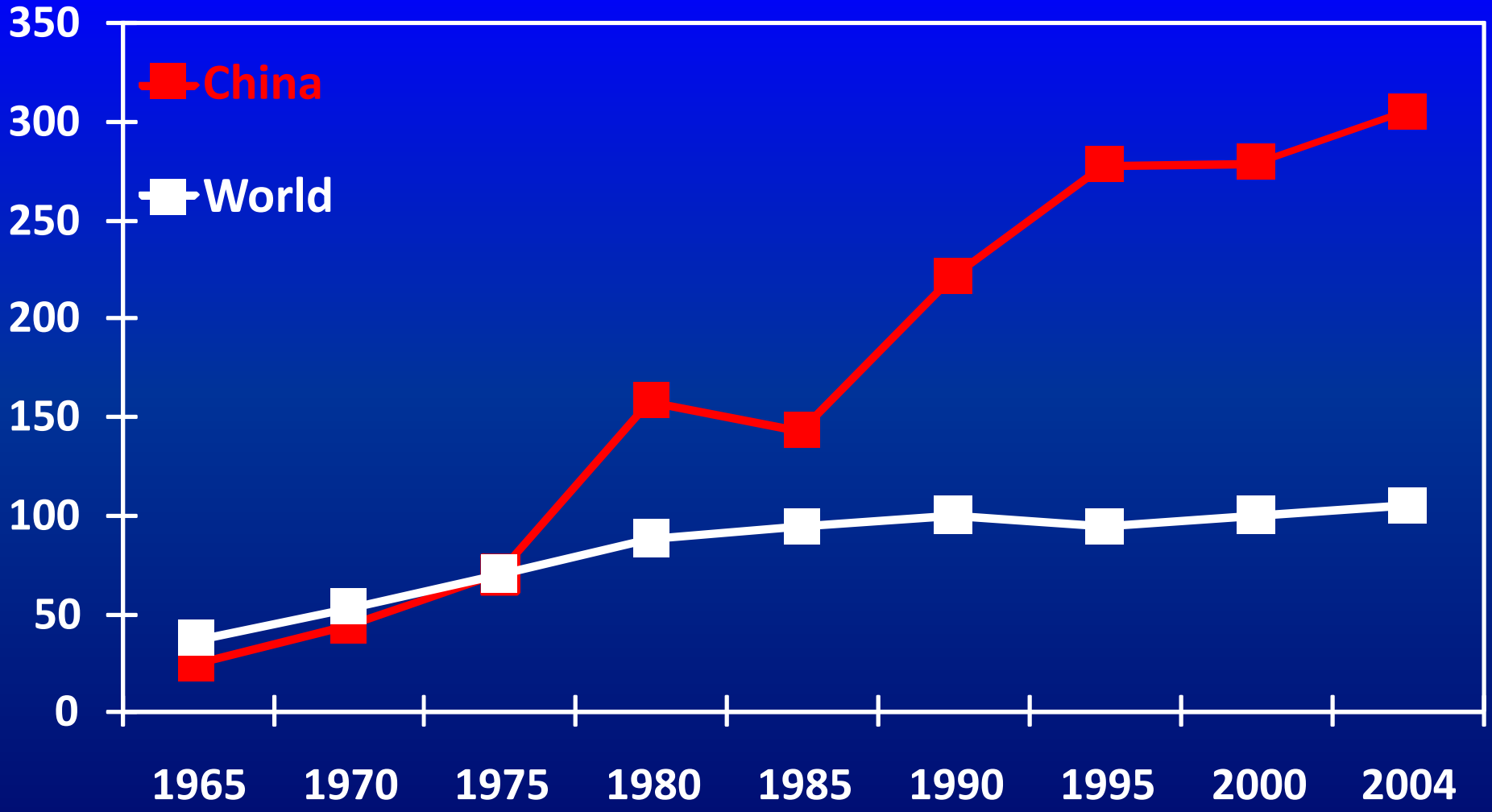


Meat sector has grown fastest at the expense of crops

NSBC, 2011


草业科技发展战略高端论坛
d Summit on Strategic Development in Science and Techn
国工程院 Chinese Academy of Engineering
国家外国专家局 State Administration of Fore
黄土高原草地农业系统国际研
ternational Conferen ce on Far Systems on the Loes
草地农业系统国家重点实验室(筹
aboratory of Gra ssland Farming S
2011年6月1
e 14

Fertilizer use intensity (kg/ha)



4th highest in the world: Japan → Korea → Holland → China

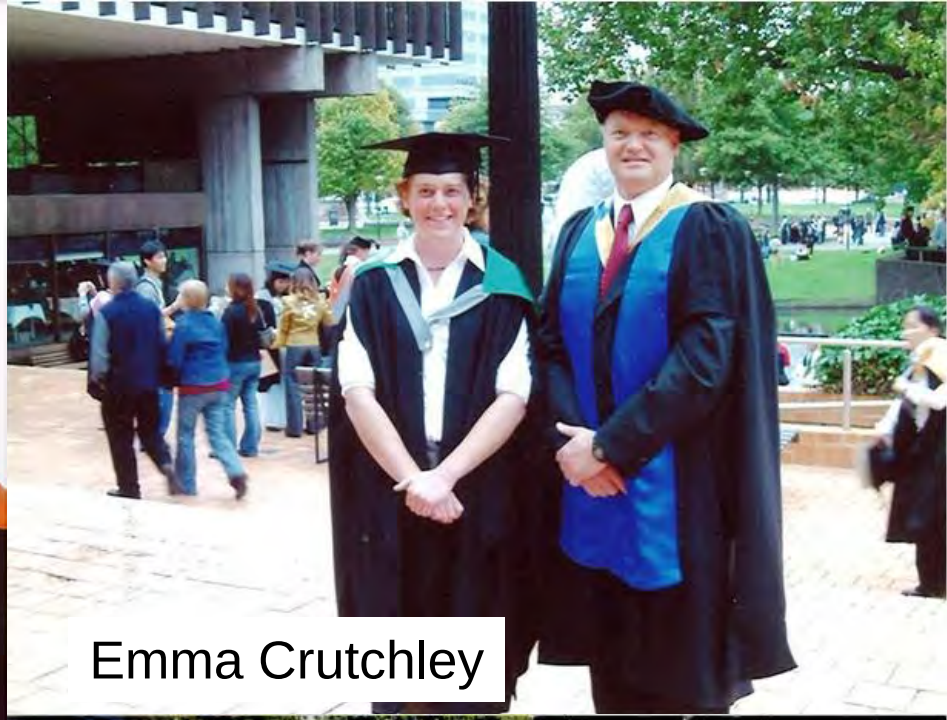
NSBC, 2011

Conclusions

- Transformed vulnerable farms to be economically, environmentally and socially resilient
- Local and global future requires regionally specific technical solutions and ongoing extension
- Global demand for meat will exceed supply for at least the next decade
- Insufficient graduates to meet those demands?


Rebecca Dunne


Alex Varella


Emma Crutchley


Emily Kearns


Nicole Morris


Nicholls, Inch, Garb, Black,

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Lincoln University Dryland Pastures Blog: http://www.lincoln.ac.nz/conversation/drylandpastures/

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