Middlemarch
18th September 2014

Lincoln University
Te Whare Wānaka o Aoraki
CHRISTCHURCH·NEW ZEALAND

Lucerne
Agronomy

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New Zealand's specialist land-based university

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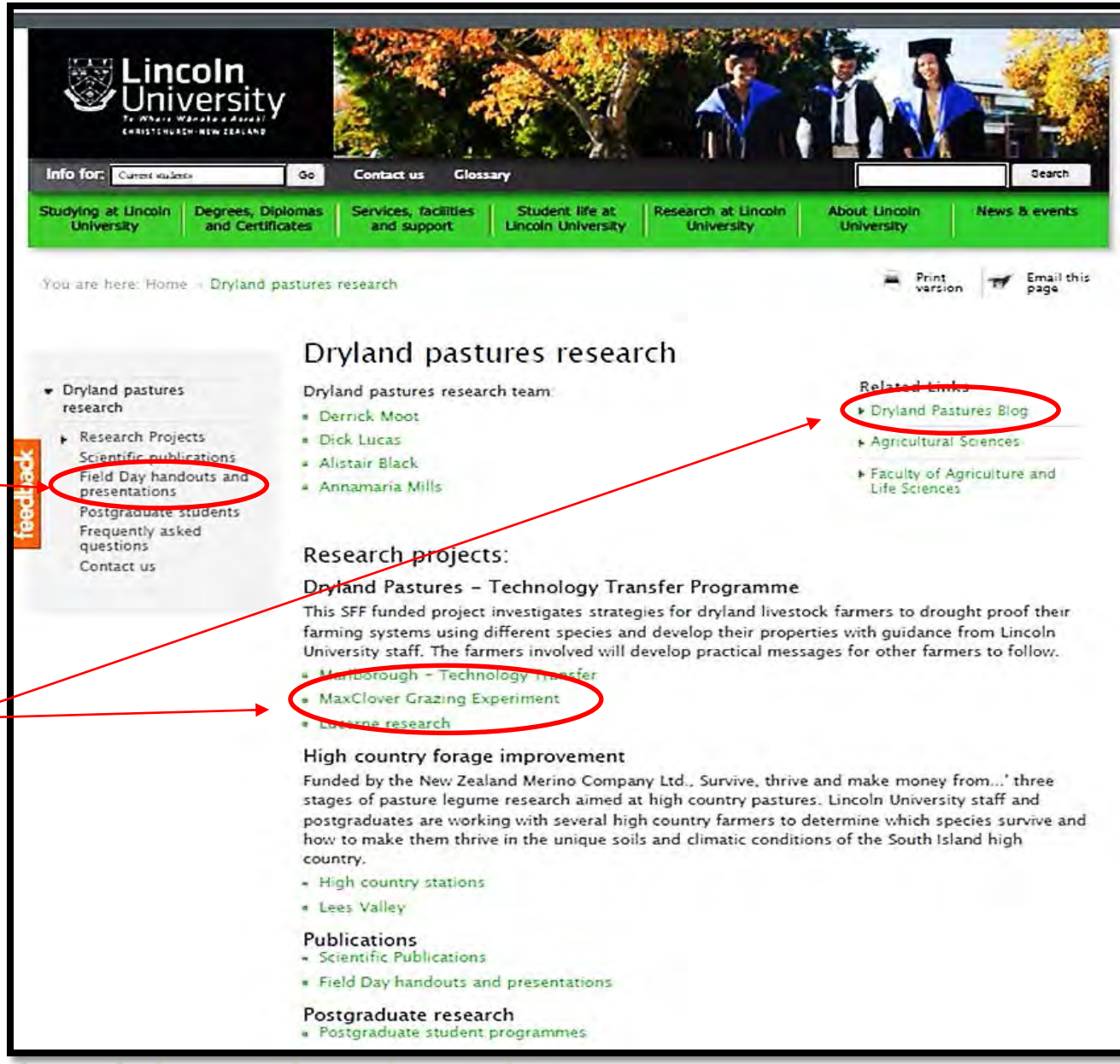
The website…

Info on:

- Current projects
- Field day presentations
- Scientific publications
- FAQs
- Postgraduate study
- Photo Diary
- Direct link to BLOG



www.lincoln.ac.nz/dryland

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Dry matter yield and botanical composition of the 'MaxClover' grazing experiment at Lincoln University, Canterbury, New Zealand

PHOTO DIARY - 2002/03 to 2010/11

Funded by:
beef+lamb new zealand

Prepared by: DJ Moot; A Mills; RJ Lucas; KM Pollock; M Smith
Lincoln University DryLAND Pastures Research Team

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General information

The ‘MaxClover’ Grazing Experiment was established at Lincoln University, Canterbury in Feb 2002.

There were six paddocks of each of the six pasture types. This gave 36 individual plots of 0.05 ha each.

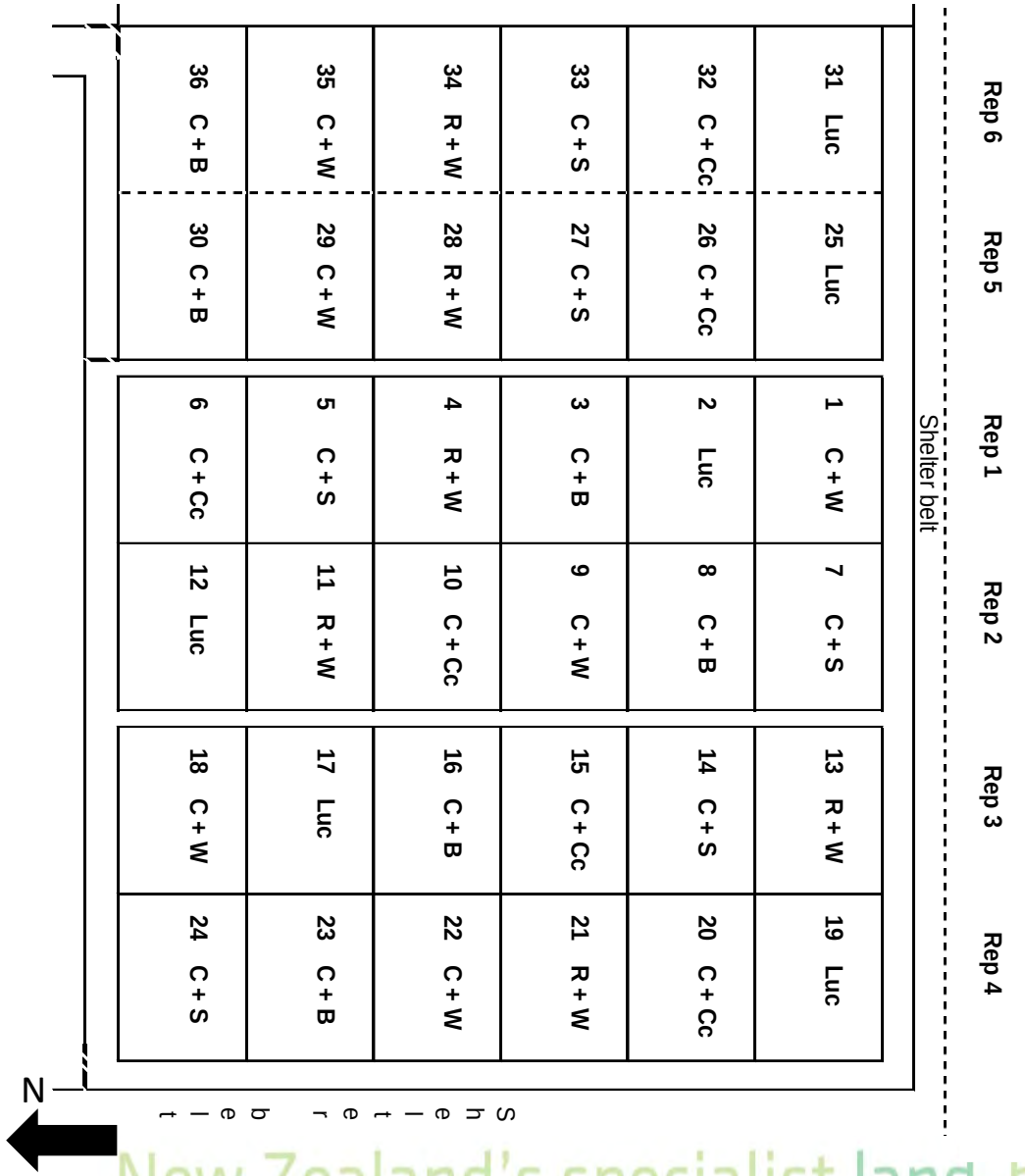
Measurements of yield and botanical composition began in Sept 2002 and continued until June 2011.

No nitrogen fertiliser or irrigation was applied to any pasture over the nine years. Other nutrients (S, P) and lime were applied in response to annual soil tests.

Annual soil test results can be found on the ‘MaxClover’ page at www.lincoln.ac.nz/dryland

No irrigation was applied. Annual rainfall ranged from 490 to 770 mm and the mean is about 630 mm/yr at this location.

Rainfall is variable and unpredictable, particularly from September to March when potential evapotranspiration exceeds rainfall leading to the development of soil moisture deficits.



Dryland
4 clovers + cocksfoot
v R/W v Luc
(Reps 1 - 4 sown Feb, 2002)
(Reps 5 & 6 sown autumn, 2003)

B	Bolta balansa clover (3.5 kg/ha)
C	Vision cocksfoot (4kg/ha, reps 1-4) (2kg/ha, reps 5 & 6)
Cc	Endura caucasian clover (5.9 kg/ha)
Luc	Kaituna lucerne (5.7 kg/ha)
R	Aries AR1 ryegrass (10 kg/ha)
S	Denmark sub clover (10 kg/ha)
W	Demand white clover (3 kg/ha)

Plot sizes

Dimensions	Area
22 x 23m	0.05 ha

Notes:
Plot numbers (1-36) are indicated for each plot.

The plan (not to scale) has been rotated so it has the same orientation as the aerial photo on the next page.

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The ‘MaxClover’ Grazing experiment in paddock H19 at Lincoln University

Grazing management

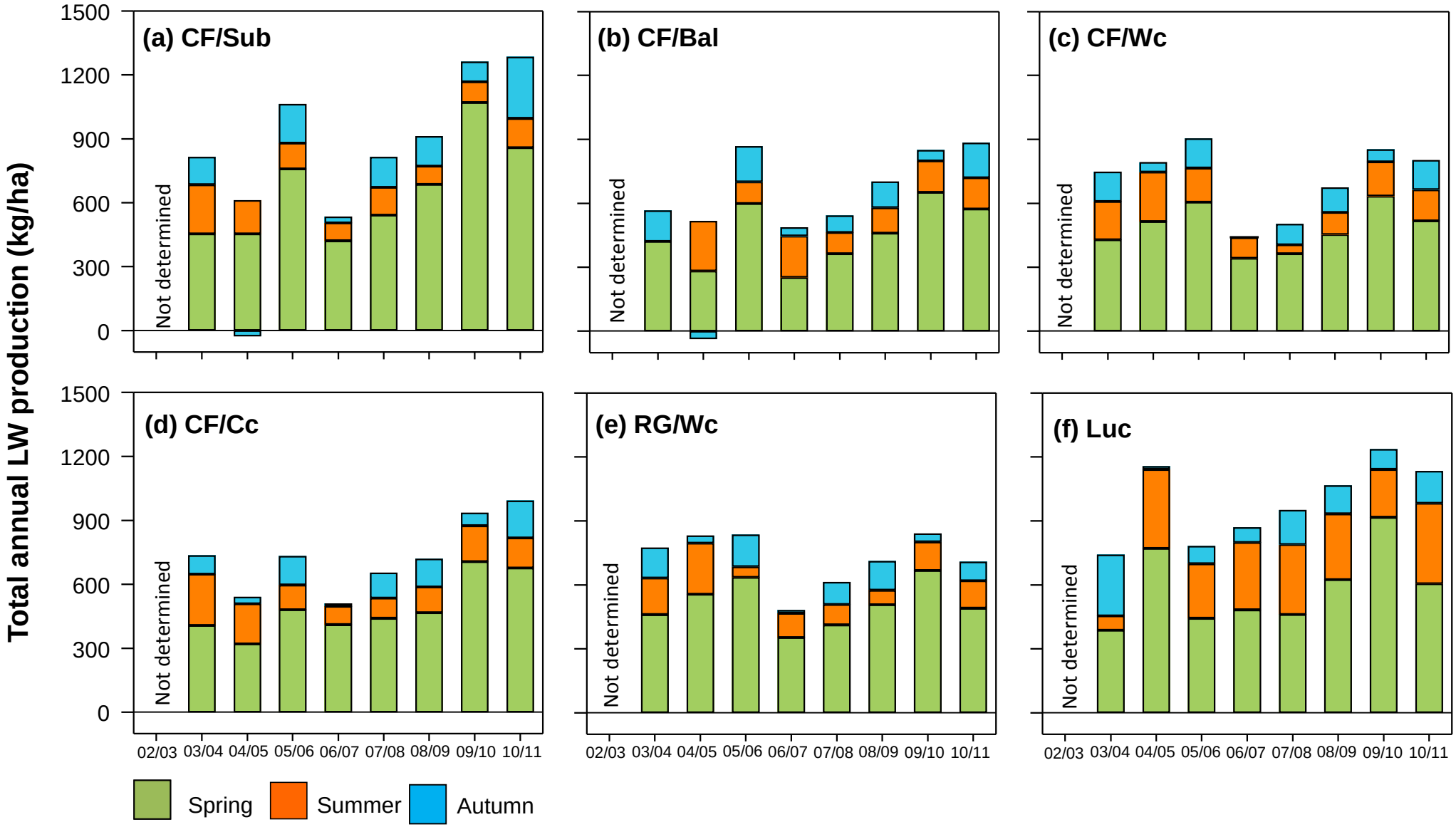
Lucerne was always rotationally grazed.

Grass-based pastures underwent a period of set stocking, short (2-paddock) or intermediate (3-paddock) rotational grazing in early spring before being rotationally grazed in a six paddock rotation until insufficient feed supply led to destocking of the pastures (drought or low winter temperatures).

Pastures were generally destocked in winter when there was insufficient feed. This simulated a commercial farm system when sheep would be removed to graze winter forage crops or a smaller area of the farm set aside for winter grazing.

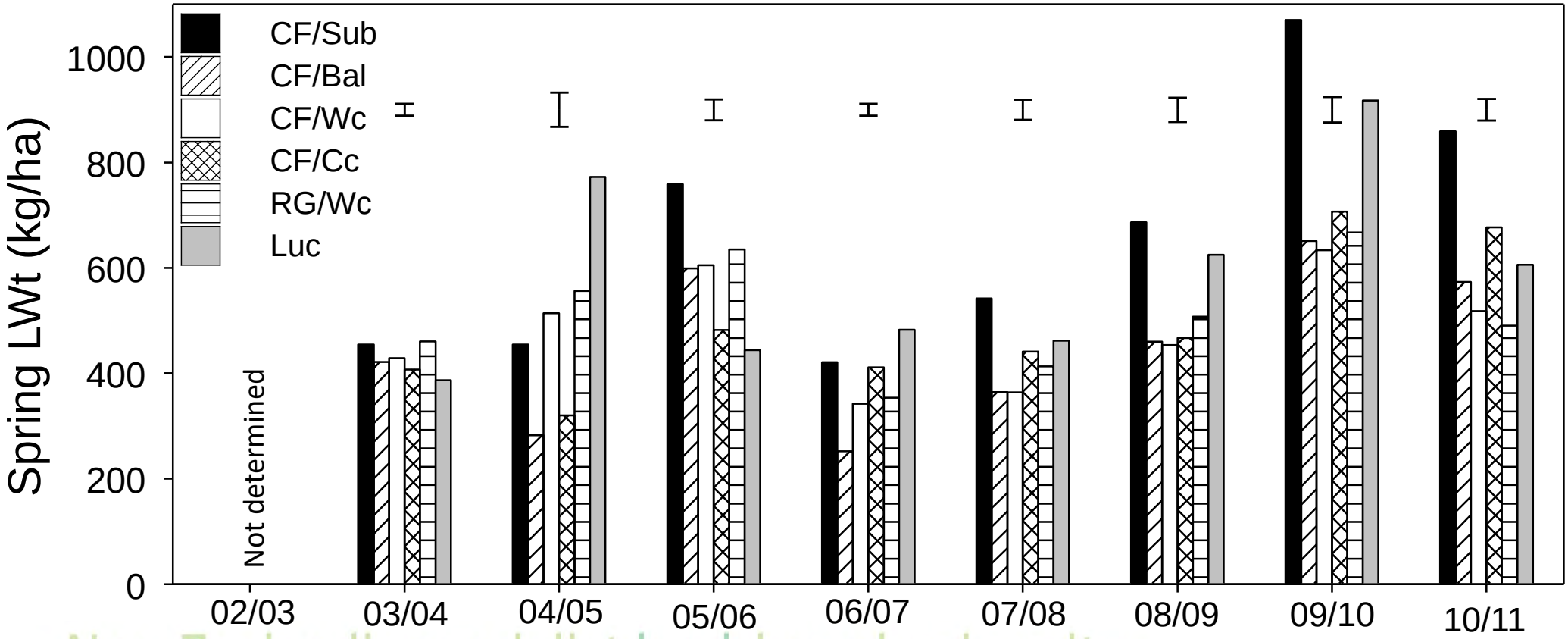
For pastures with annual clovers (sub or balansa) stock were removed to allow re-seeding. The timing differed as pastures were closed sequentially as the rotation progressed.

When necessary, ewes were used to hard graze annual clover pastures in early autumn to open the sward in preparation for the germination of annual clover seedlings after autumn rains.



Mills *et al*. 2014b

Total spring LWt production



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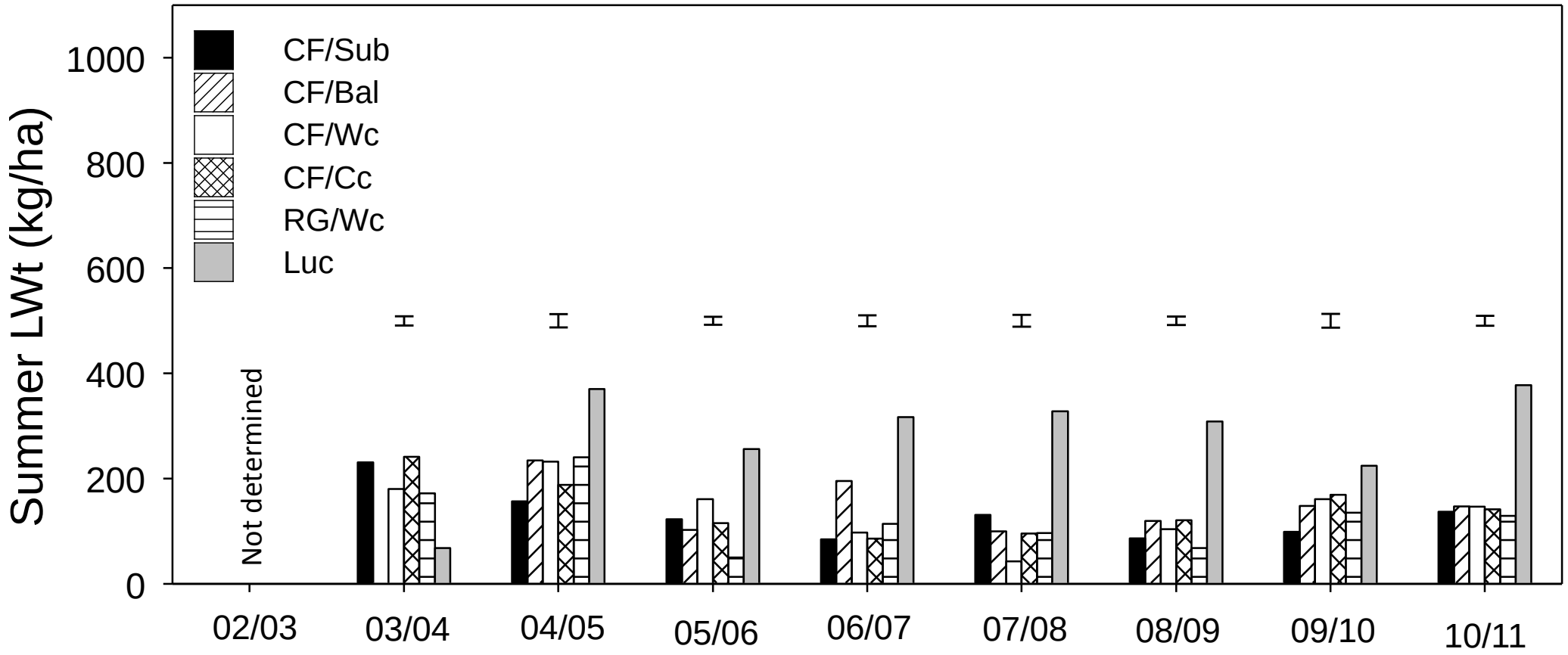
Mills *et al*. 2014b

Total summer LWt production



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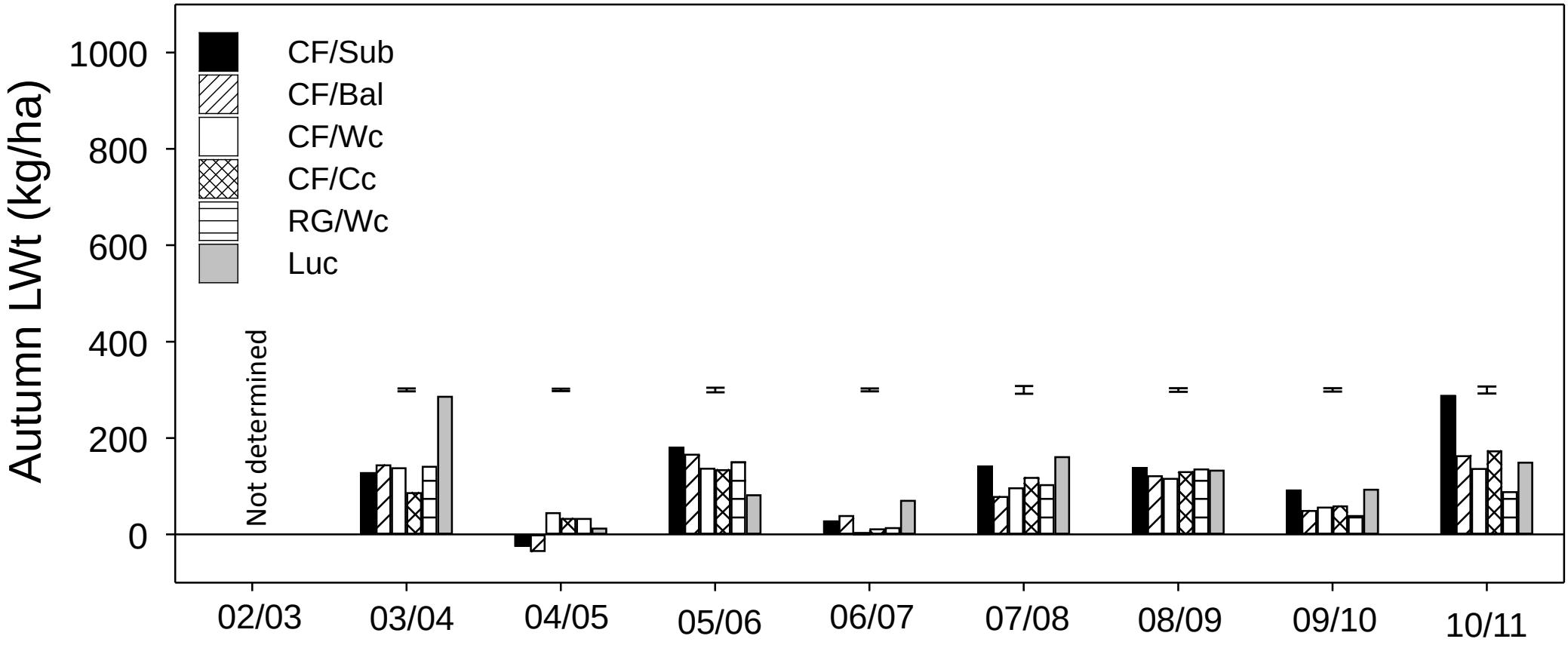
Mills *et al*. 2014b

Total autumn LWt production



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Mills *et al*. 2014b

Yield and composition of six dryland pastures over nine growth seasons

- Lucerne produced more DM than all grass based pastures in most years.
- Its tap-root enabled access to water from lower soil layers but it also used water more efficiently than the grass based pastures - especially in spring.
- CF/Sub clover was the highest yielding grass based pastures in Years 6-9.
- Yields of all pastures declined over time.

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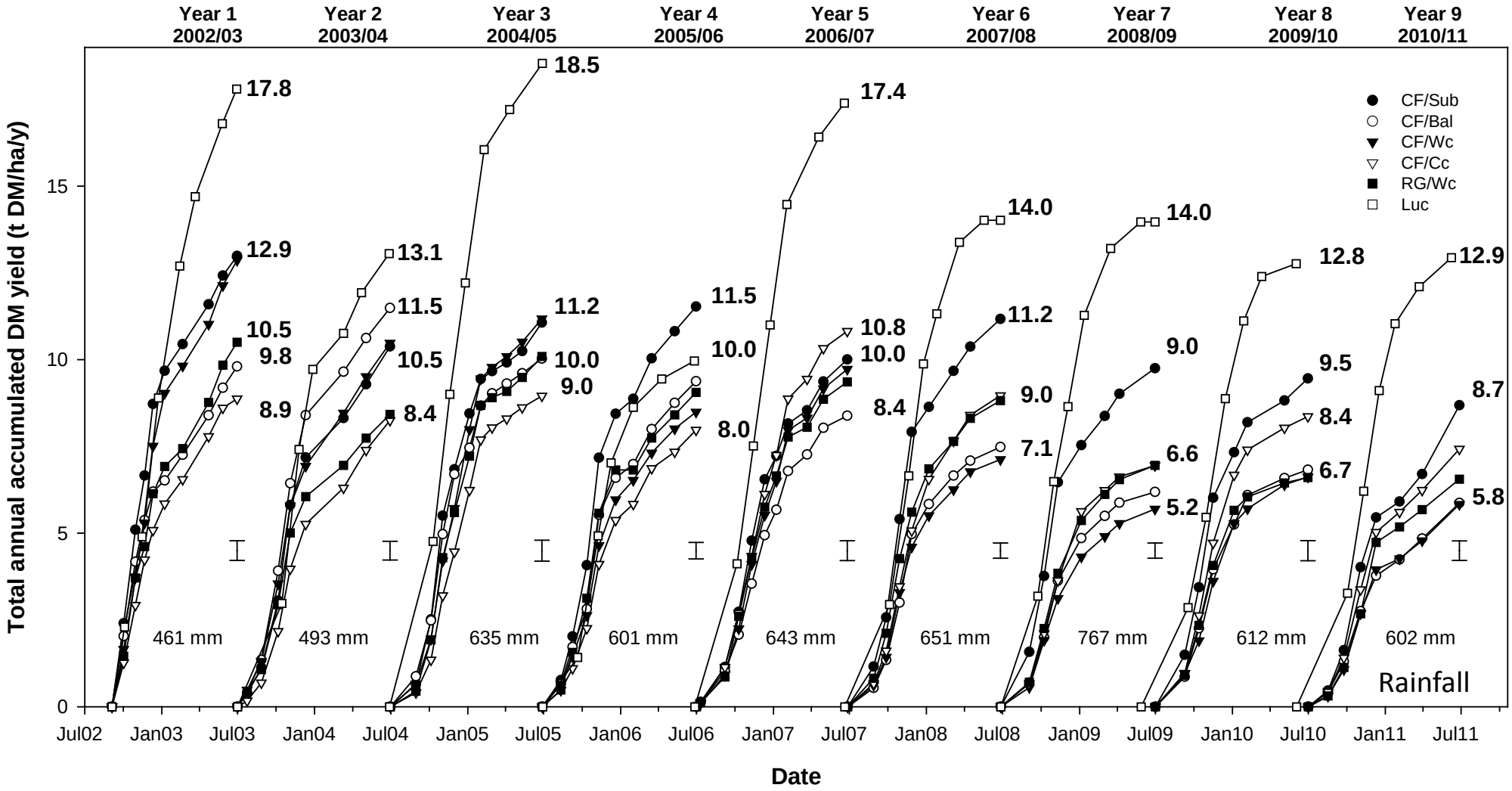
Mills *et al*. 2014a

Figure 1. Total annual accumulated dry matter production



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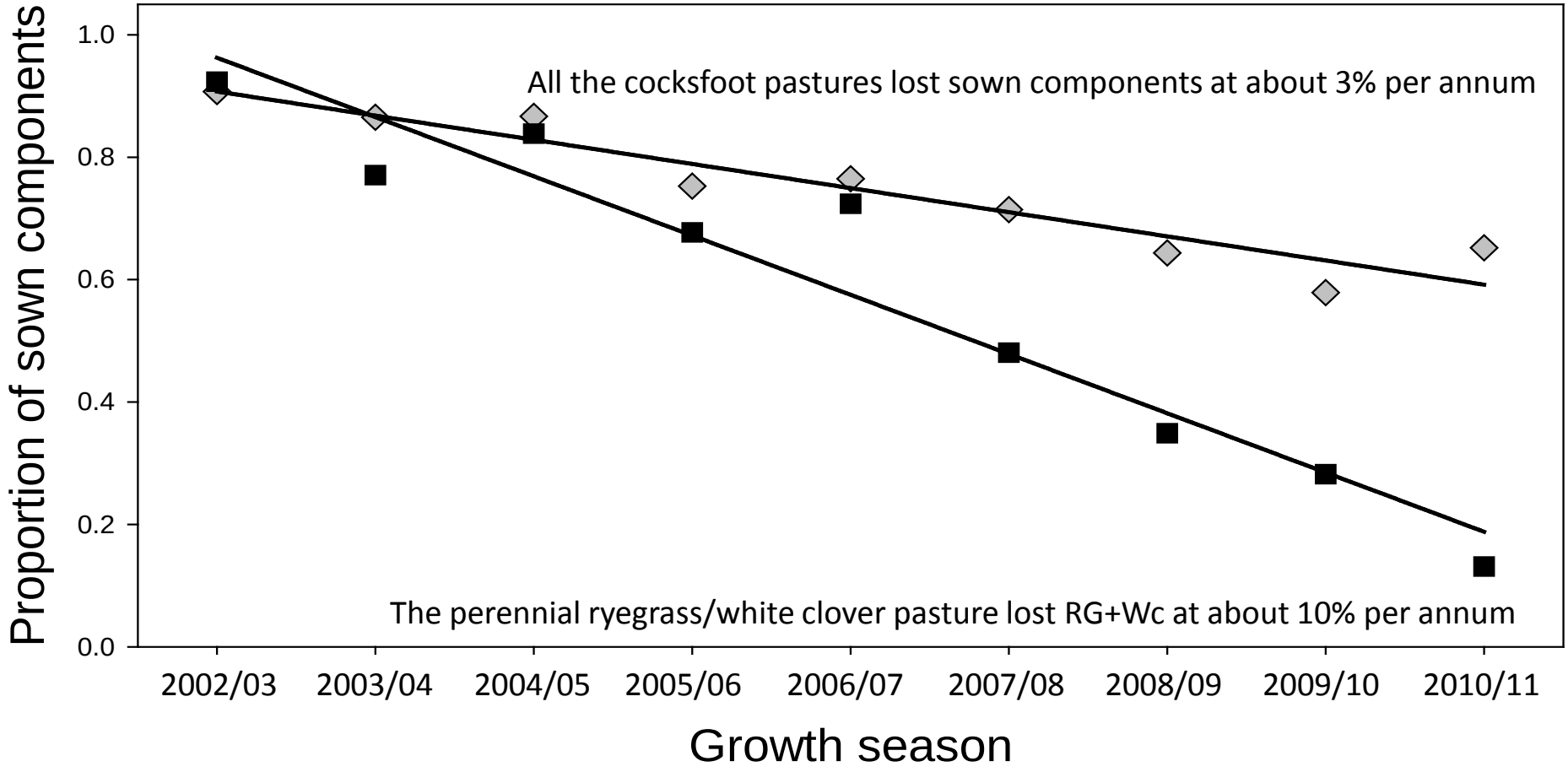
Source: Moot 2012

Summary of yields in Figure 1

- RG/Wc yield declined from 10.5 to 6.6 t/ha in Year 9.
- Lucerne yield was over 17 t/ha in 3 years and 12.9 t/ha in Year 9.
- CF/Sub yield declined from 12 t/ha to 8.7 t/ha in Year 9.
- CF/Wc, CF/Cc, CF/Bal yields were lower than CF/Sub in most years.

Figure 2. Change in the proportion of originally sown pasture components (grass + clover) over time



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Source: Mills *et al.*, 2014a

Summary of Figure 2

- After 9 years about 10% of the RG/Wc pasture was from originally sown species compared with about 60% in the cocksfoot based pastures. Lucerne (not shown) was about 85% pure due to winter weed control.
- In Years 1-3 the RG/Wc pastures maintained a high proportion of ryegrass and white clover. Most experiments only run for 3 years – this long-term experiment shows how this pasture deteriorated from Year 4 to Year 9.
- By Year 5-6 only about half the yield in RG/Wc pastures is from the sown species. Ideally pasture renewal would be recommended at this point.
- By Year 9 only about 10% of the 6.6 t DM/ha that was produced was from RG or Wc.
- For cocksfoot, sown pasture species decreased by about 3% per year. This meant after 9 years about 60% of the total yield produced by the four cocksfoot based pastures was from the originally sown pasture species.
- Cocksfoot was persistent but pasture vigour had declined. These pastures did not require renovation but had the potential for increased production. We recommend overdrilling in autumn with 10 kg/ha sub clover plus 1 kg/ha white clover to increase clover content and nitrogen fertility which would stimulate production from the existing cocksfoot component.

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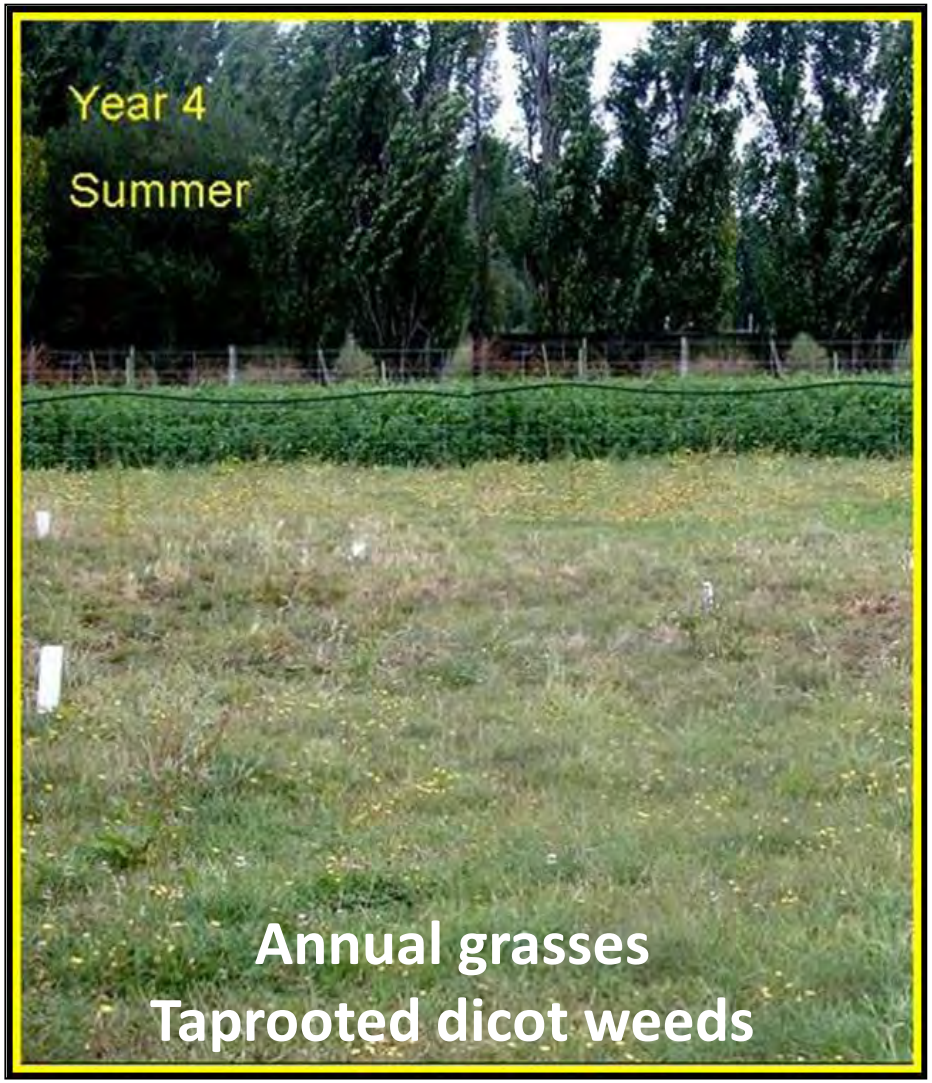
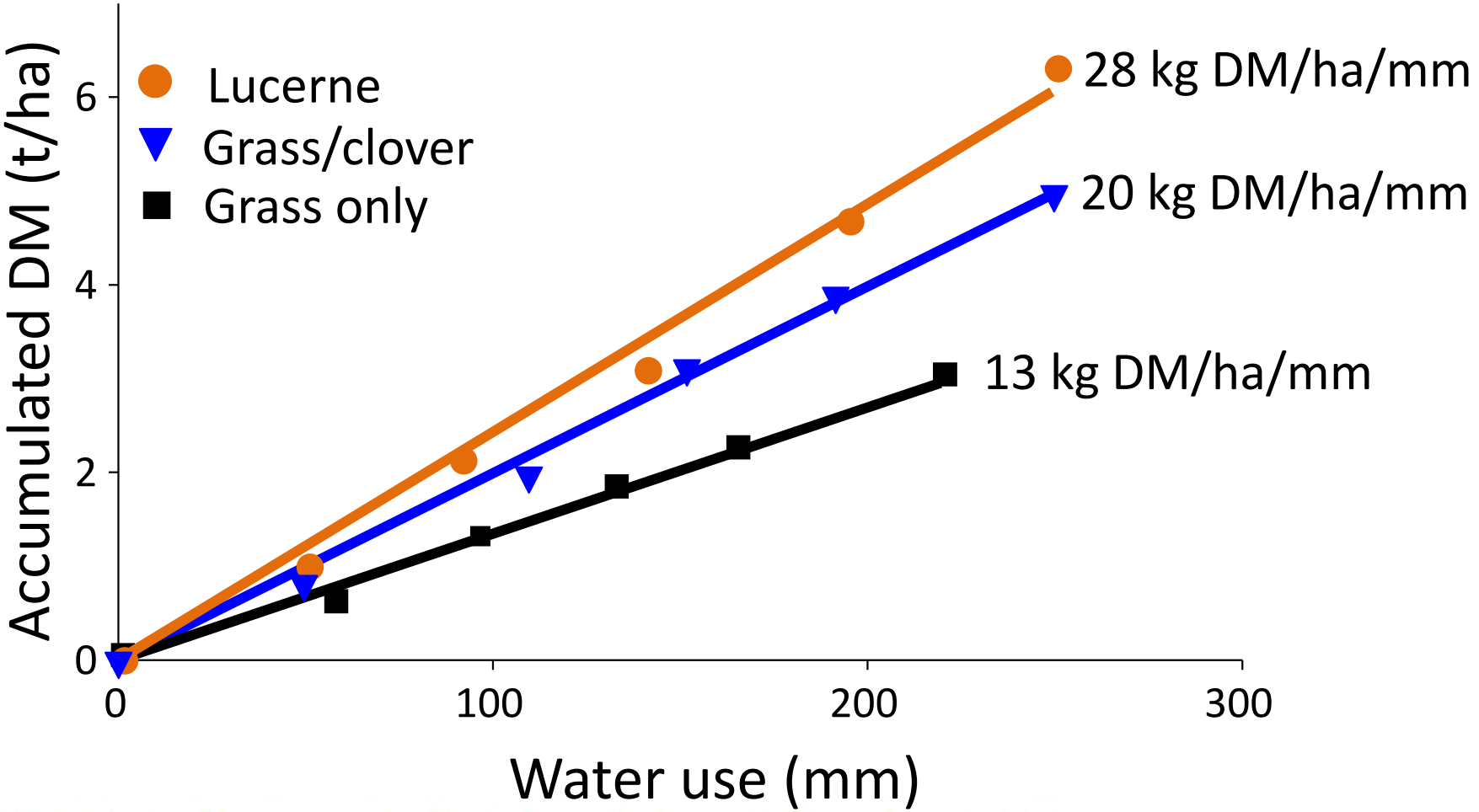


Unsown species <5% in Year 1 …….>45% in Year 6

RG/Wc pastures

Spring WUE



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Source: Moot *et al*. 2008

Lucerne Objectives

- Establishment

- Grazing management to maximise production, quality and persistence

- Examples of lucerne on farm

Establishment

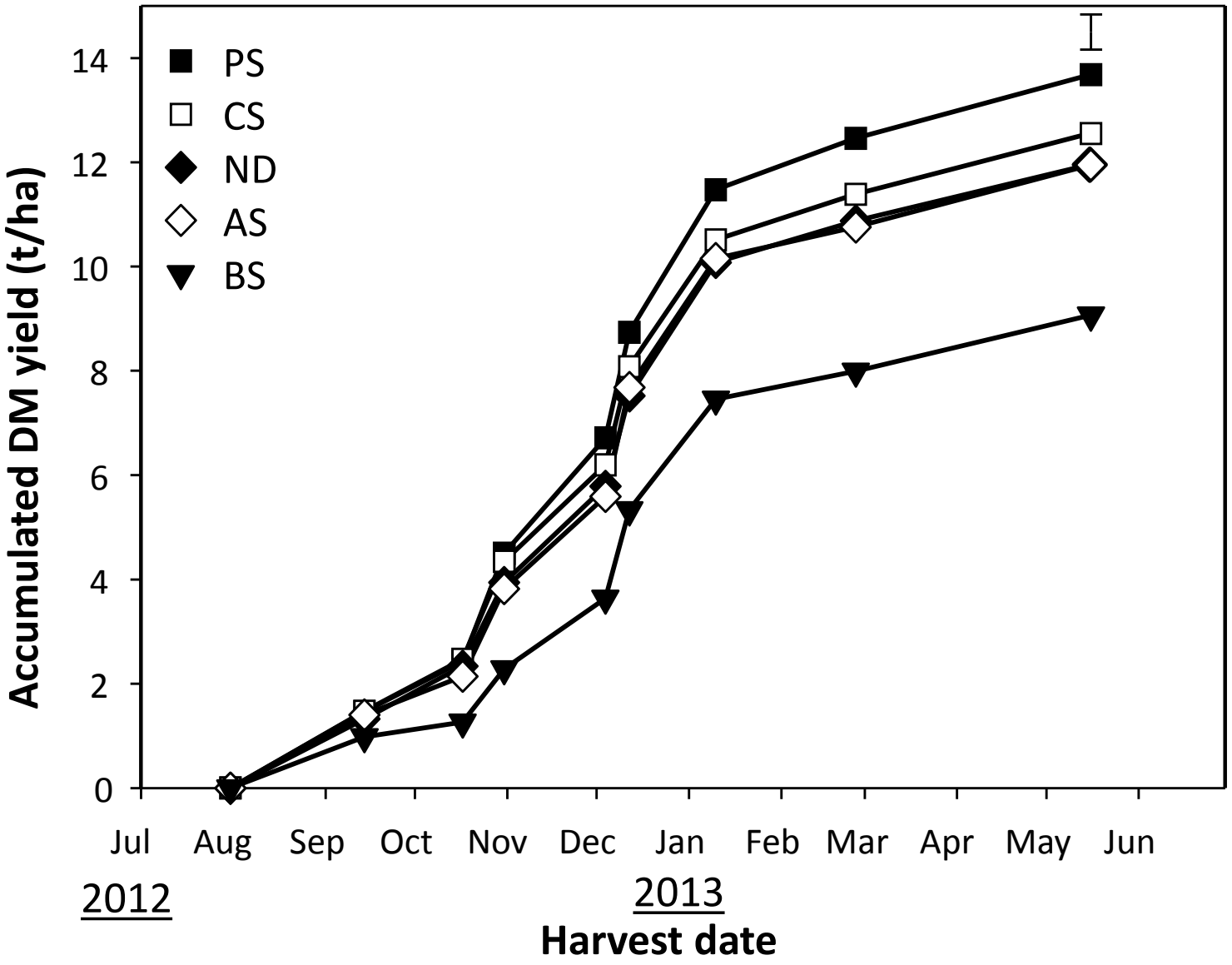
Soils - deepest free draining soils
- pH 6.0
- RG/Wc fertility

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

Inoculation Experiment

- At Lincoln University
- Dryland, variable silt loam soil
- No history of lucerne
- Split plot design with 3 replicates
- 4 sowing dates
- 4 seed inoculant technologies used
- Bare seed control also used (no rhizobia)

Black & Moot 2013



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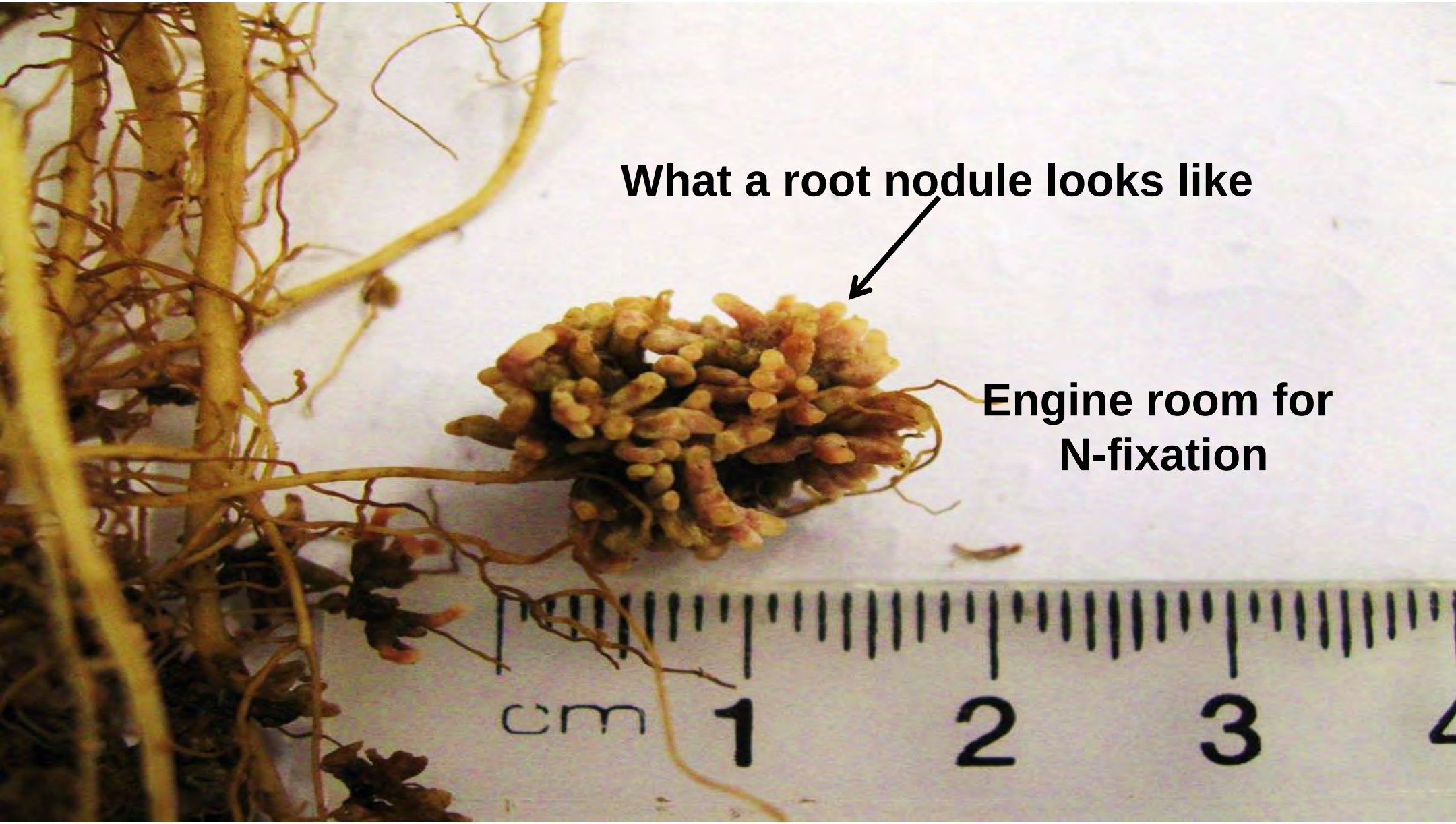
Black & Moot 2013

No inoculant (bare seed)

Inoculated with peat


What a root nodule looks like
Engine room for
N-fixation
cm
1
2
3

Lucerne root

~8 months after sowing

> 1.5 m length

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

Drilling seed with fertiliser
Direct drilling = seed + fertiliser

Hills Creek Station

Sown 4/11/2008

Photo taken 5/11/2010

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

Sowing rate and date

Established 2007 LU – Templeton silt loam

Coated 'Grasslands Kaituna' lucerne.

Four sowing dates

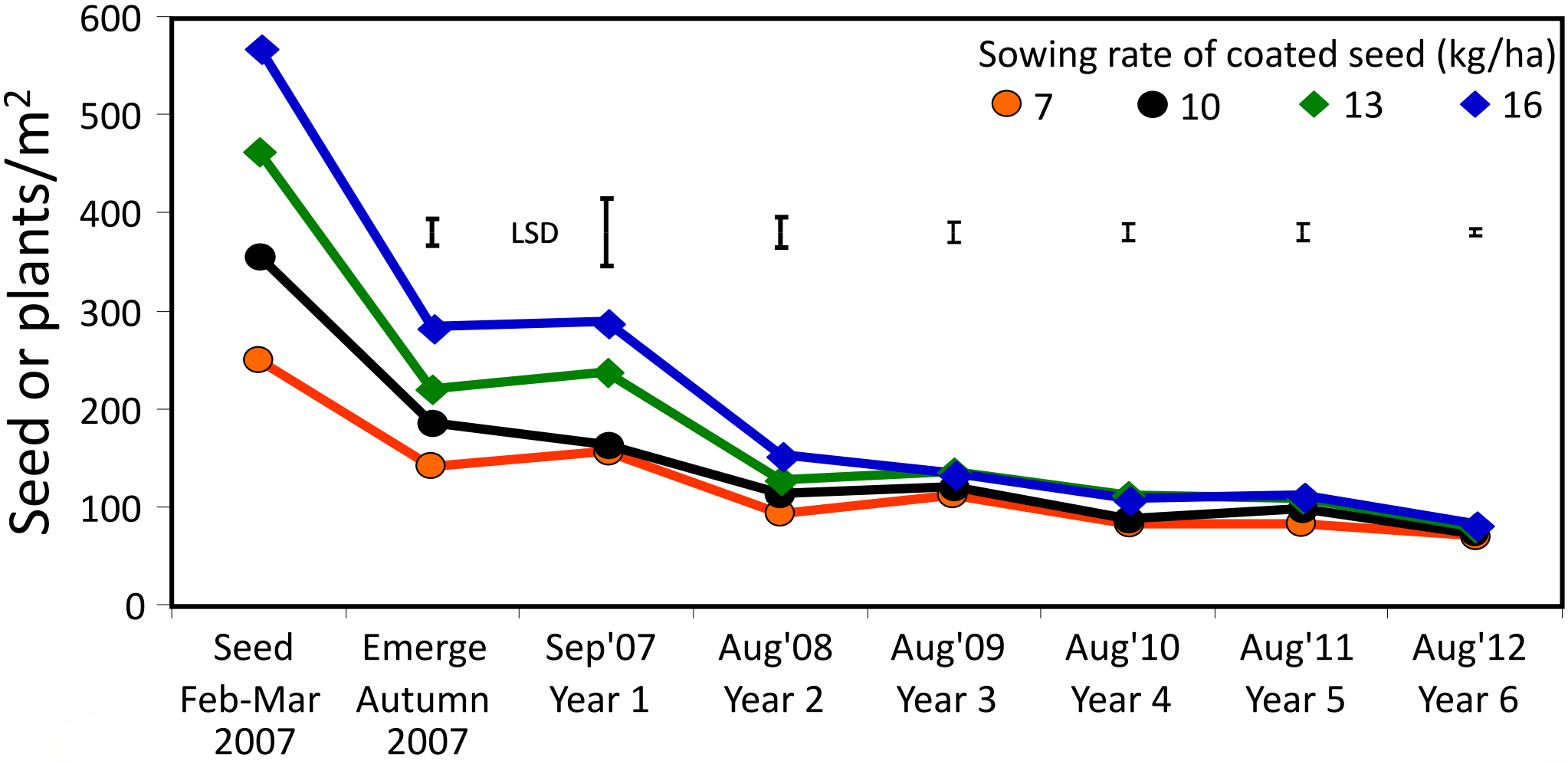
- **21 February,**
- **2 March,**
- **16 March and**
- **30 March**

Four sowing rates

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

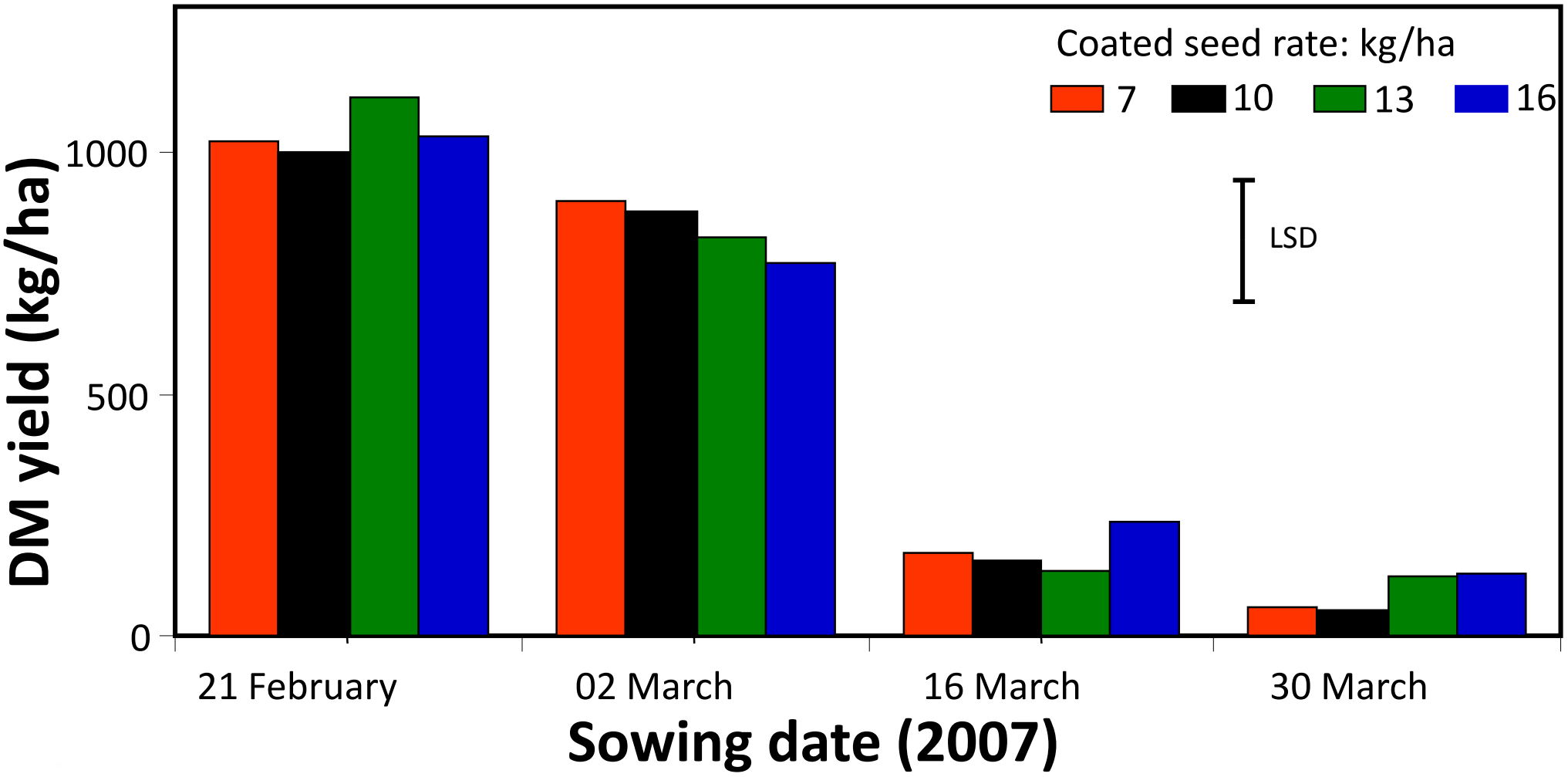
Source: Moot *et al*. 2012

Sown seed & plant population over time



Source: Moot *et al*. 2012

Seedling lucerne yield to early June

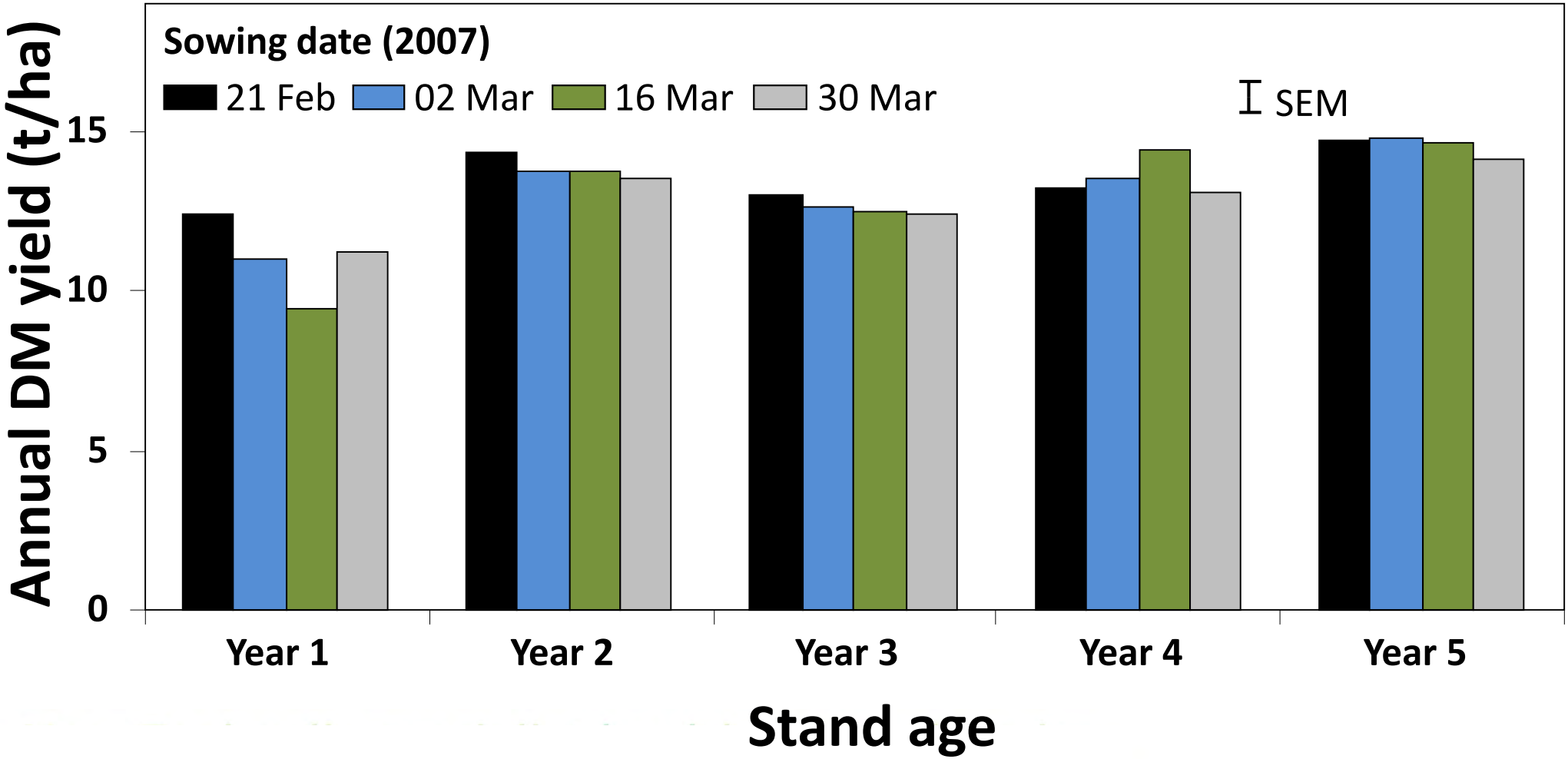


Source: Moot *et al*. 2012

Weeds present @ 09 October 2007 (Year 1)

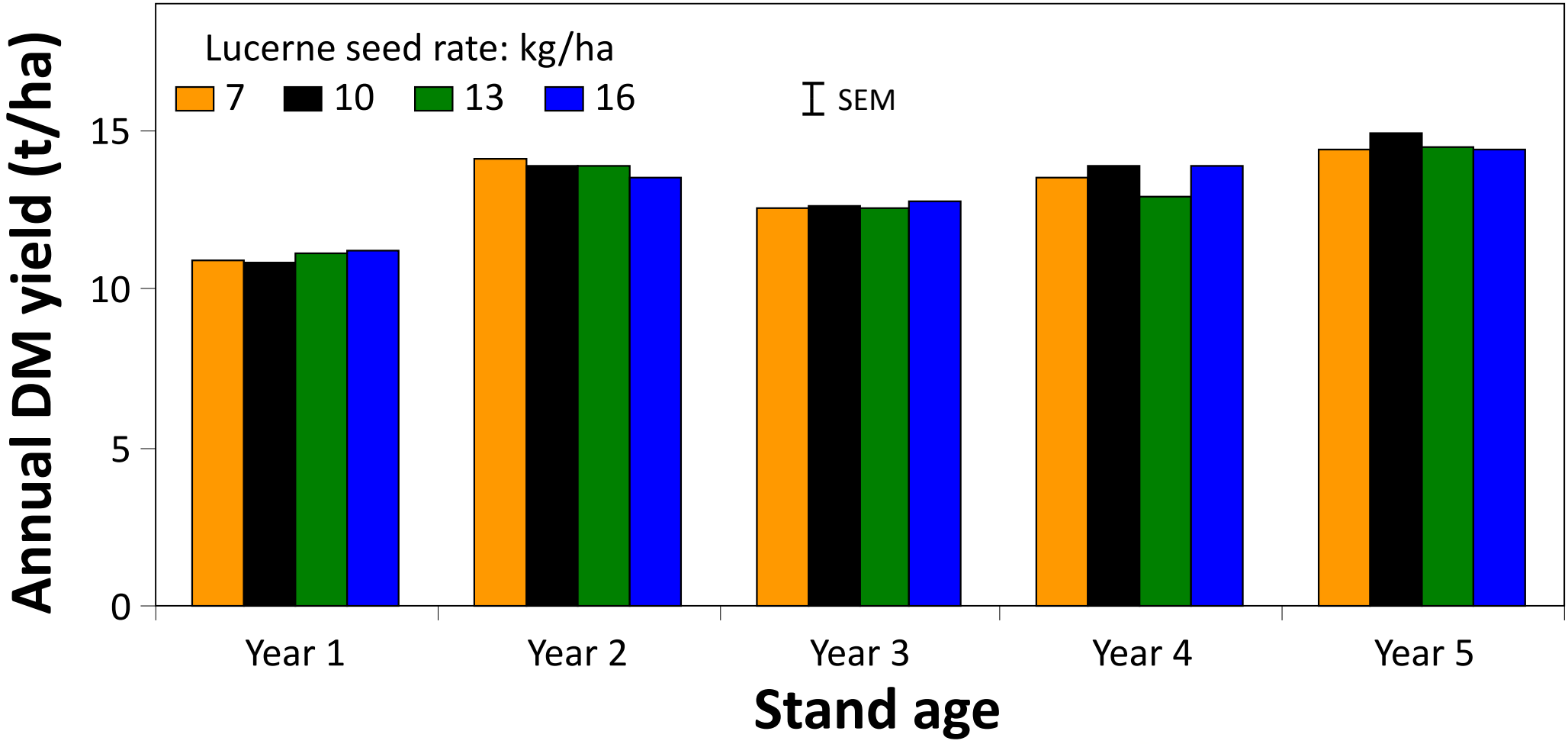
Sown 21 Feb 2007 **Sown 30 Mar 2007**

Annual yield in relation to sowing date



Source: Moot *et al*. 2012

Annual yield in relation to sowing rate

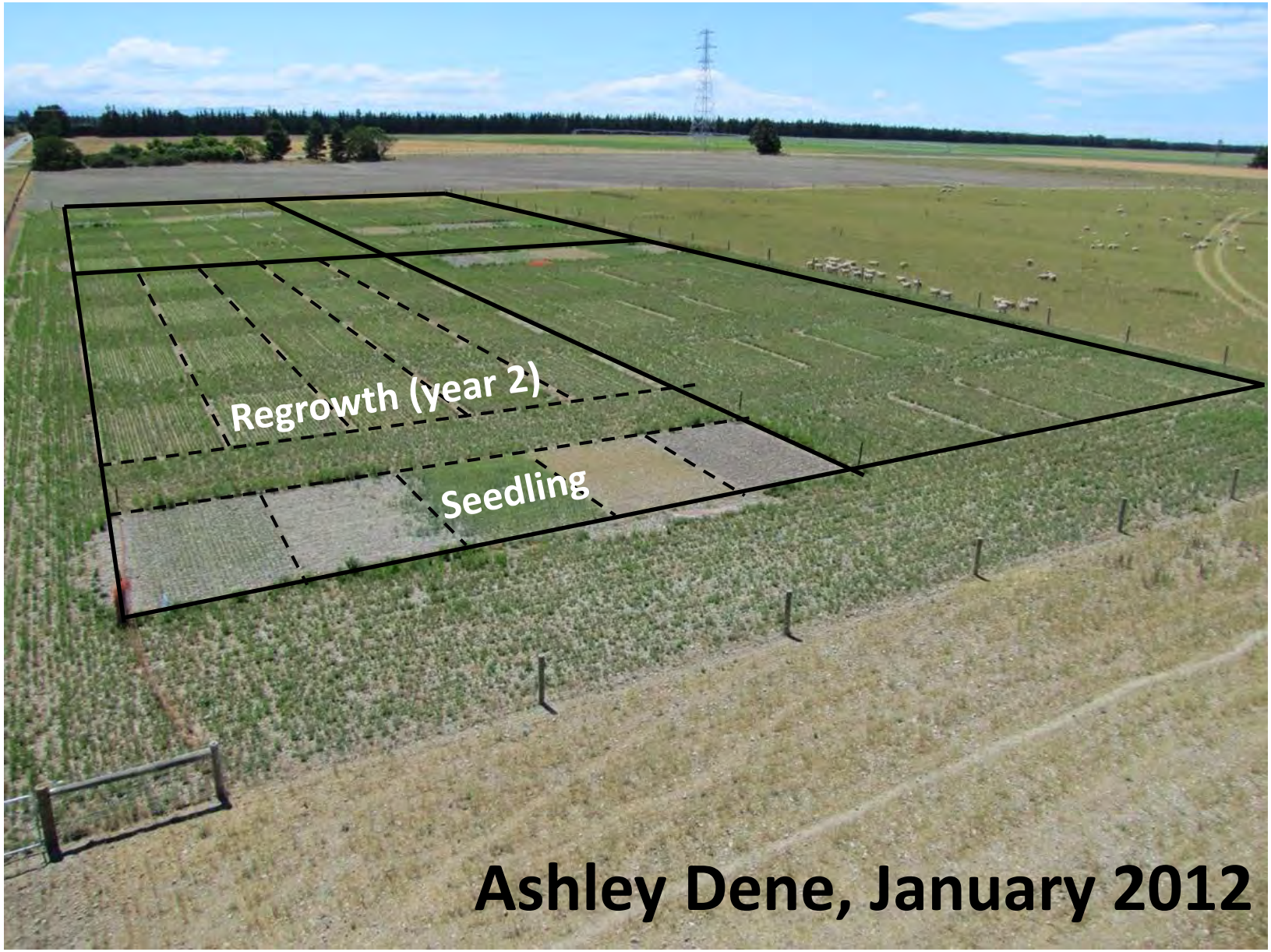


Source: Moot *et al*. 2012

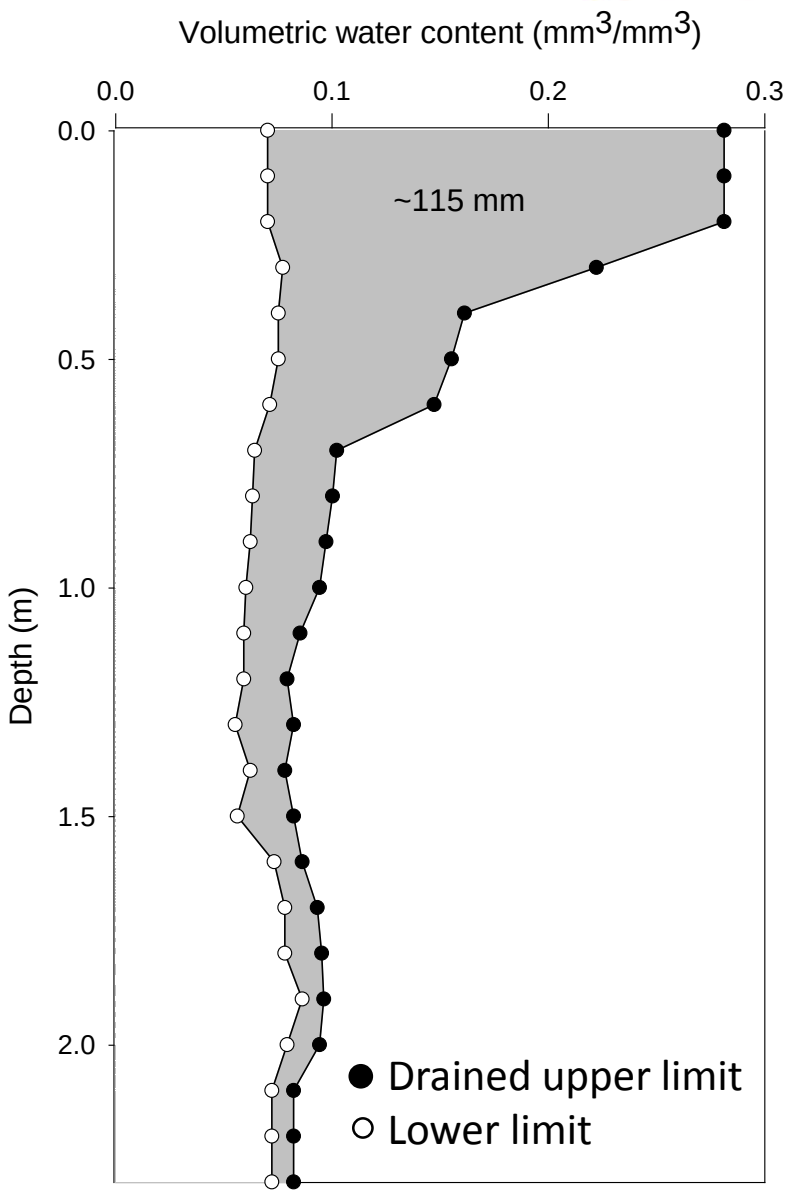
Richard Sim PhD results

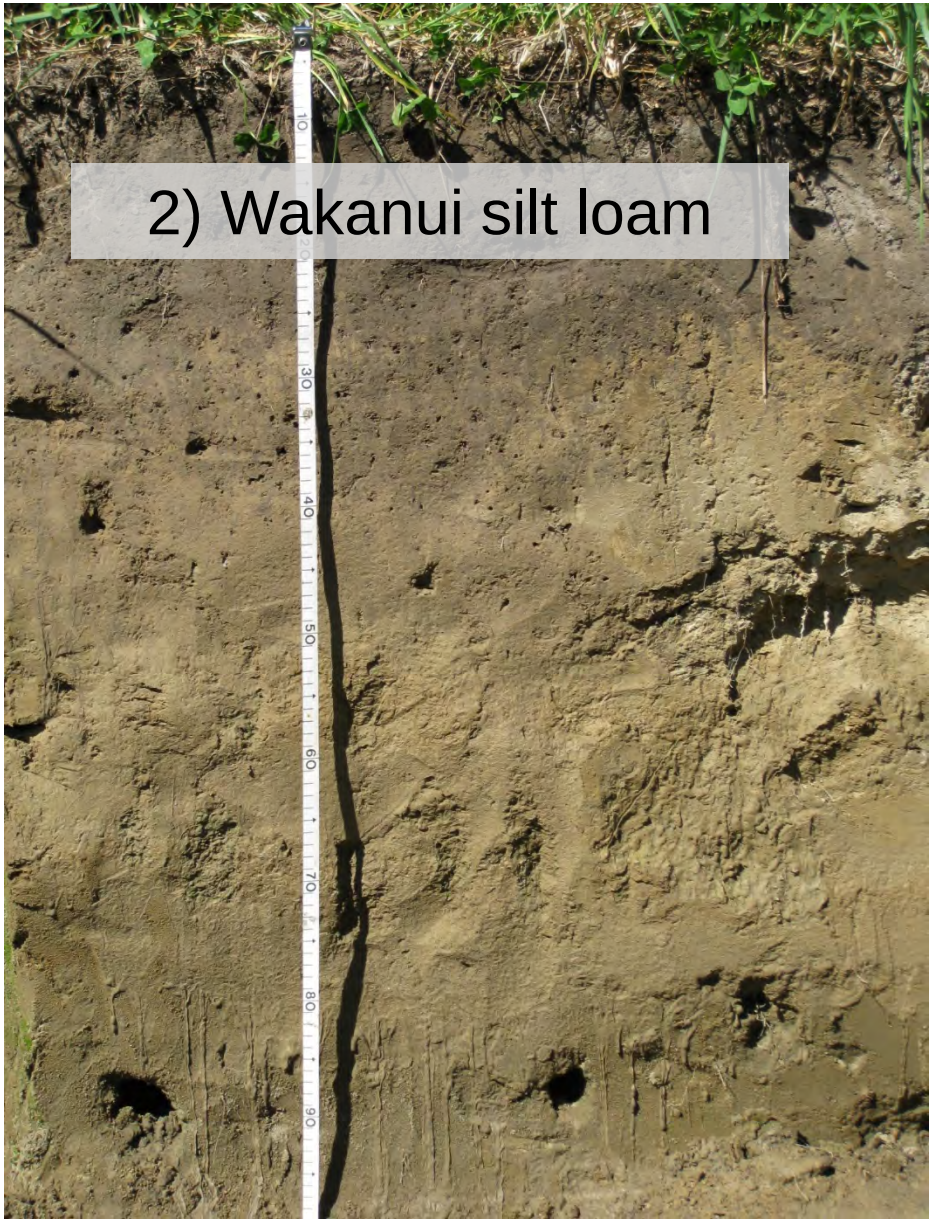
1. Soil type & sowing date
2. Seedling vs regrowth crops (yr 2)

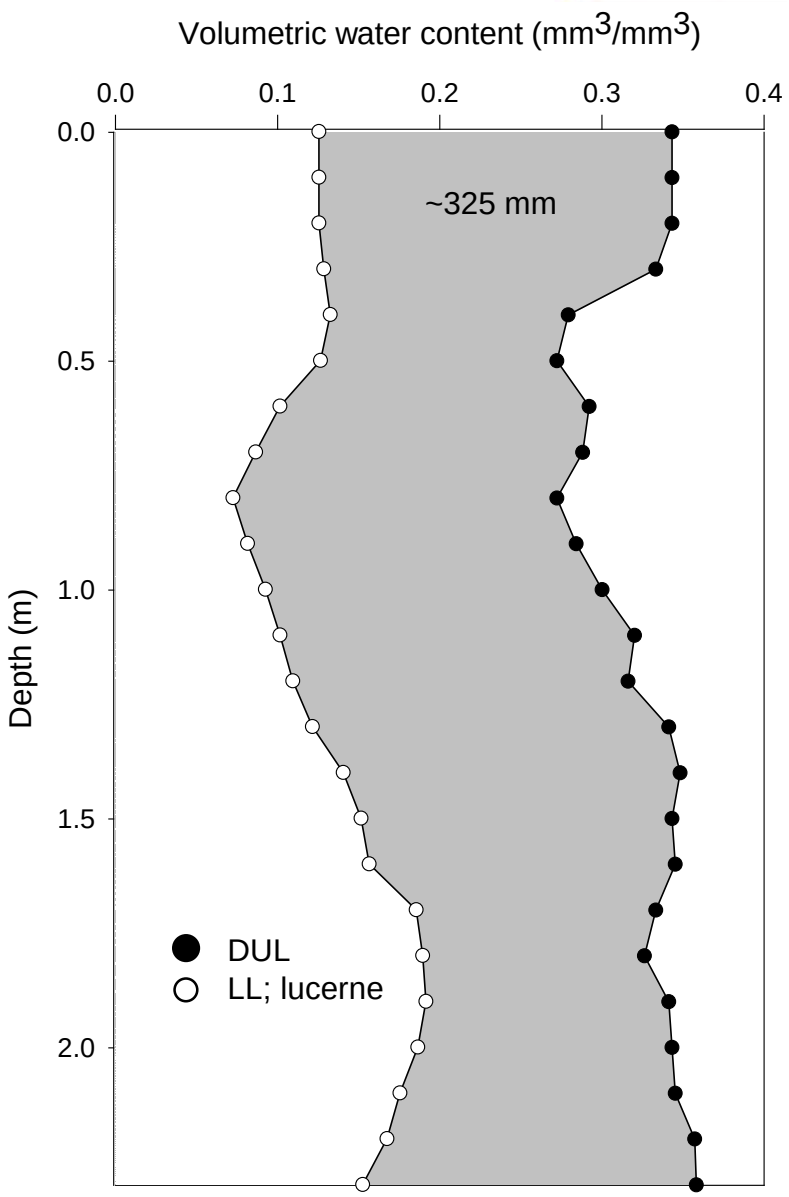
- Low soil water at Ashley Dene on stones
- High soil water at LU on silt!


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





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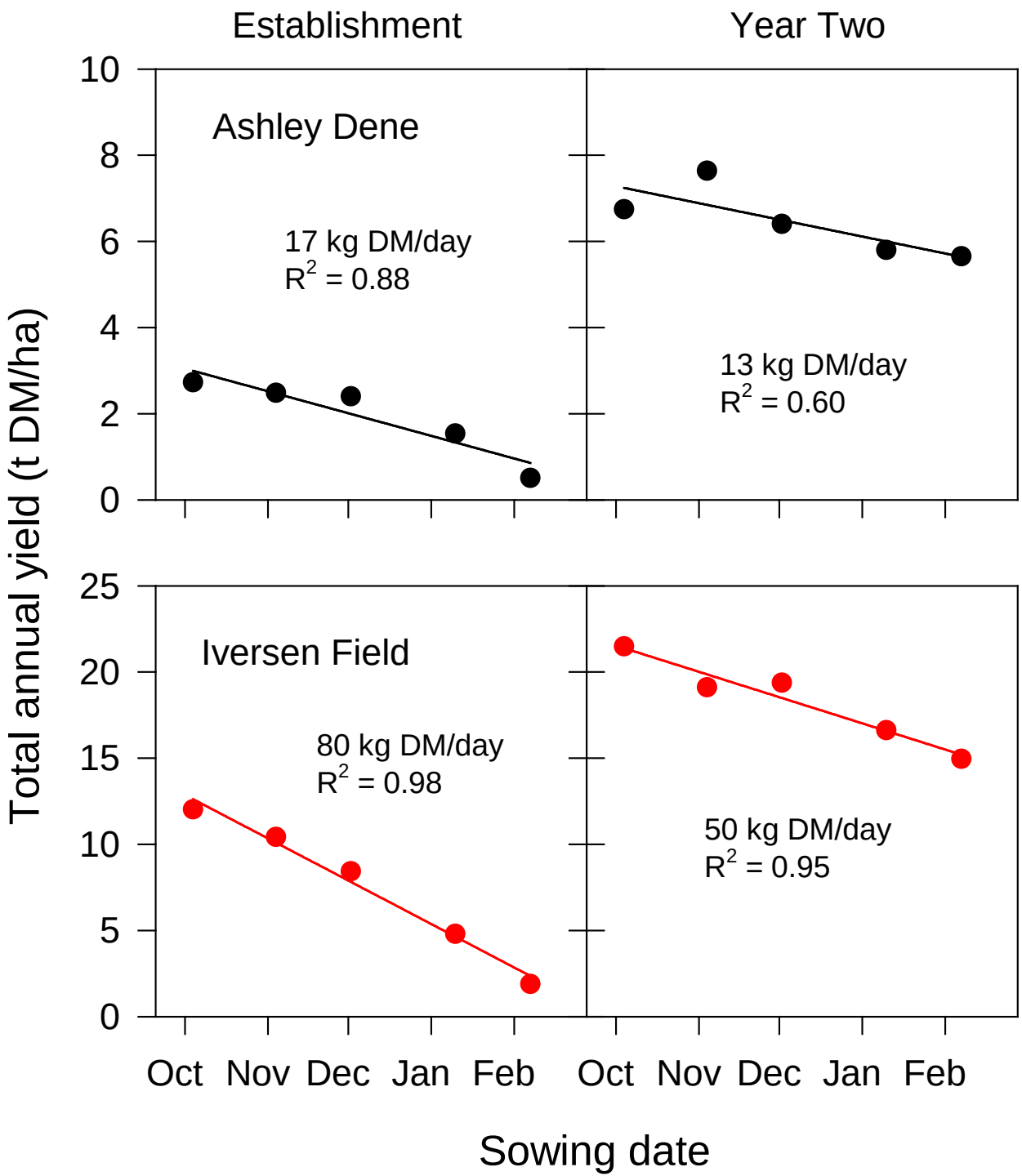
Seedling
Regrowth (year 2)
Iversen 12, January 2012



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Delayed sowing cost yield

Sim 2014

Sown: February ~ October

Sampled: June

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

Taproot mass – Ashley Dene

	Root mass (t DM/ha)		
Sowing date	Establishment	Year Two	Shoot+root (Year 2)
October	2.2 $_{a}$	4.8 $_{a}$	9.3
November	2.0 $_{a}$	4.6 $_{ab}$	9.2
December	1.6 $_{ab}$	4.0 $_{b}$	8.2
January	1.2 $_{b}$	3.5 $_{b}$	8.1
February	0.6 $_{c}$	3.4 $_{b}$	8.5
P	<0.001	<0.05	
SEM	0.19	0.24	

Establishment – sowing to June 2011

Year Two – June 2011 to July 2012

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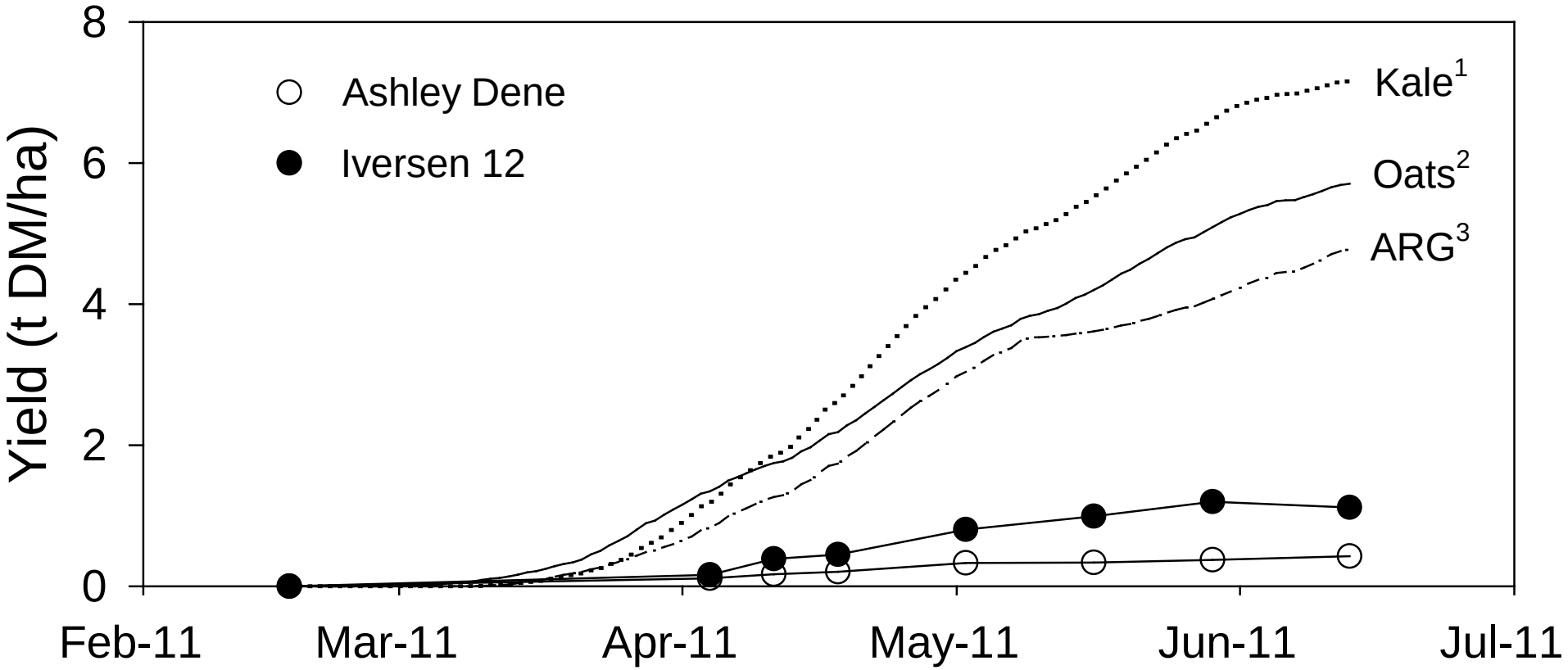
Potential yield of alternative crops



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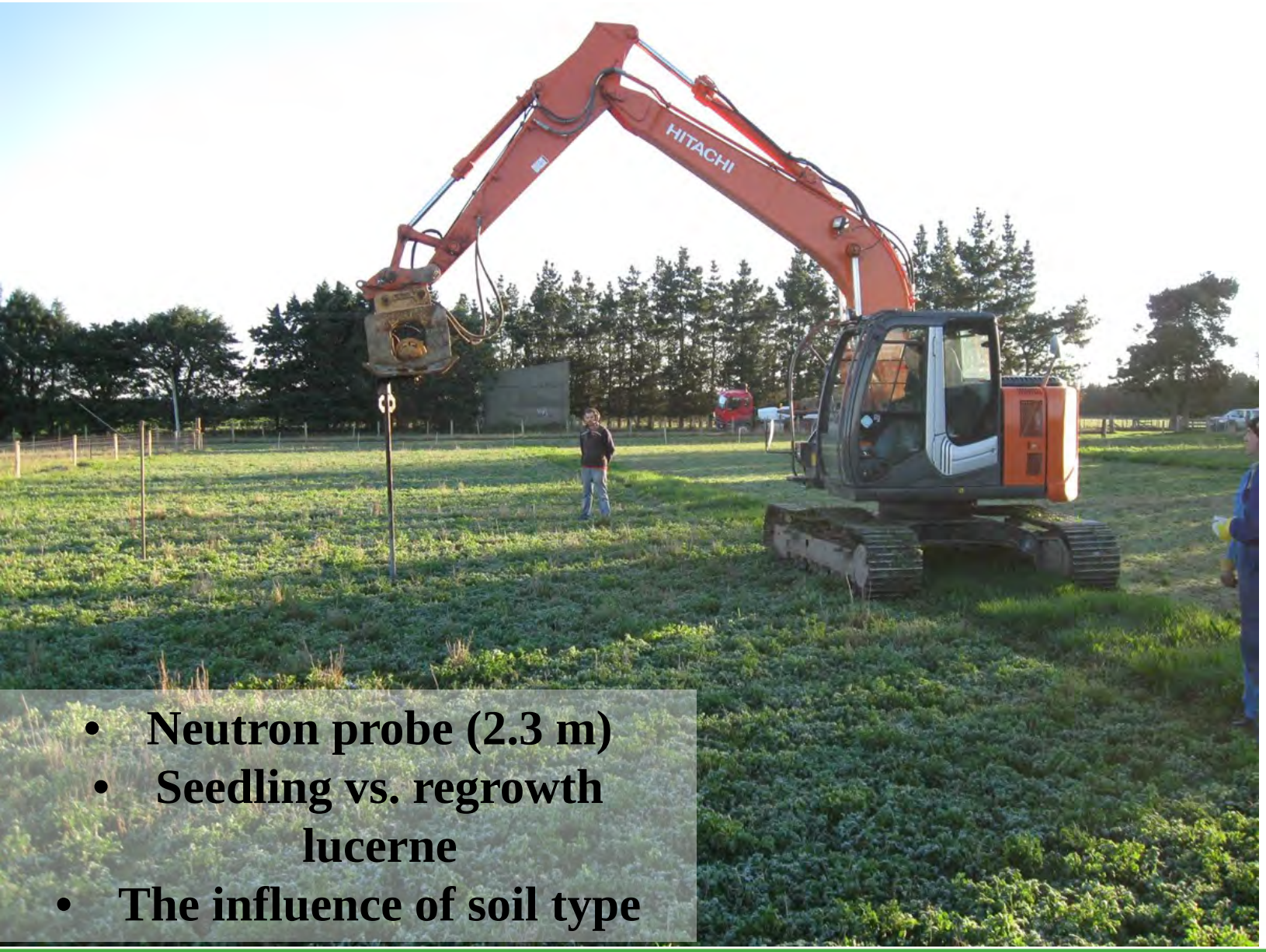
[1] Chakwizira (2008), Chakwizira *et al.*, (2011); [2] Martini et al., (2009); [3] Martini, (2012)



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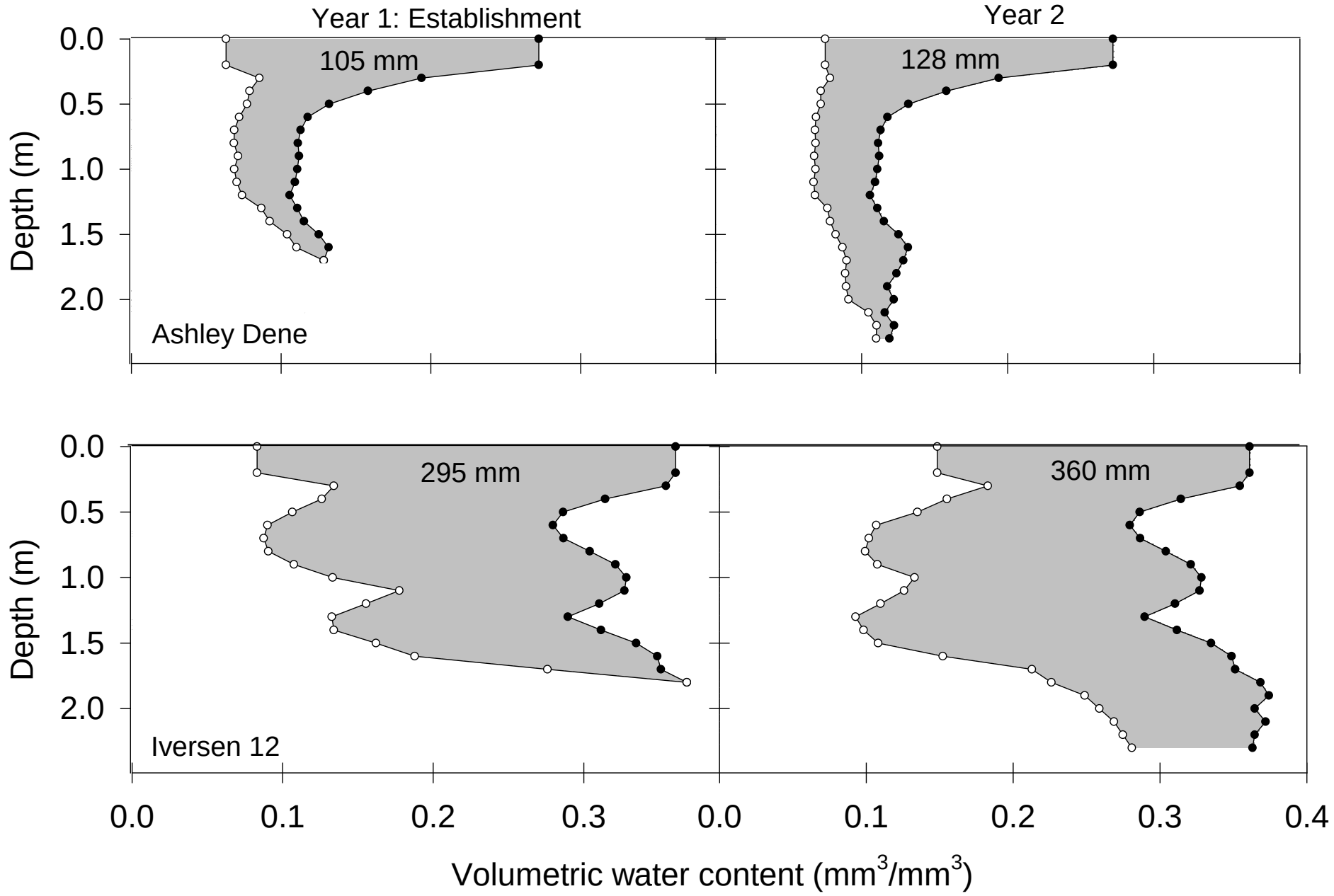
Water extraction – understanding yield

- **Neutron probe (2.3 m)**
- **Seedling vs. regrowth lucerne**
- **The influence of soil type**

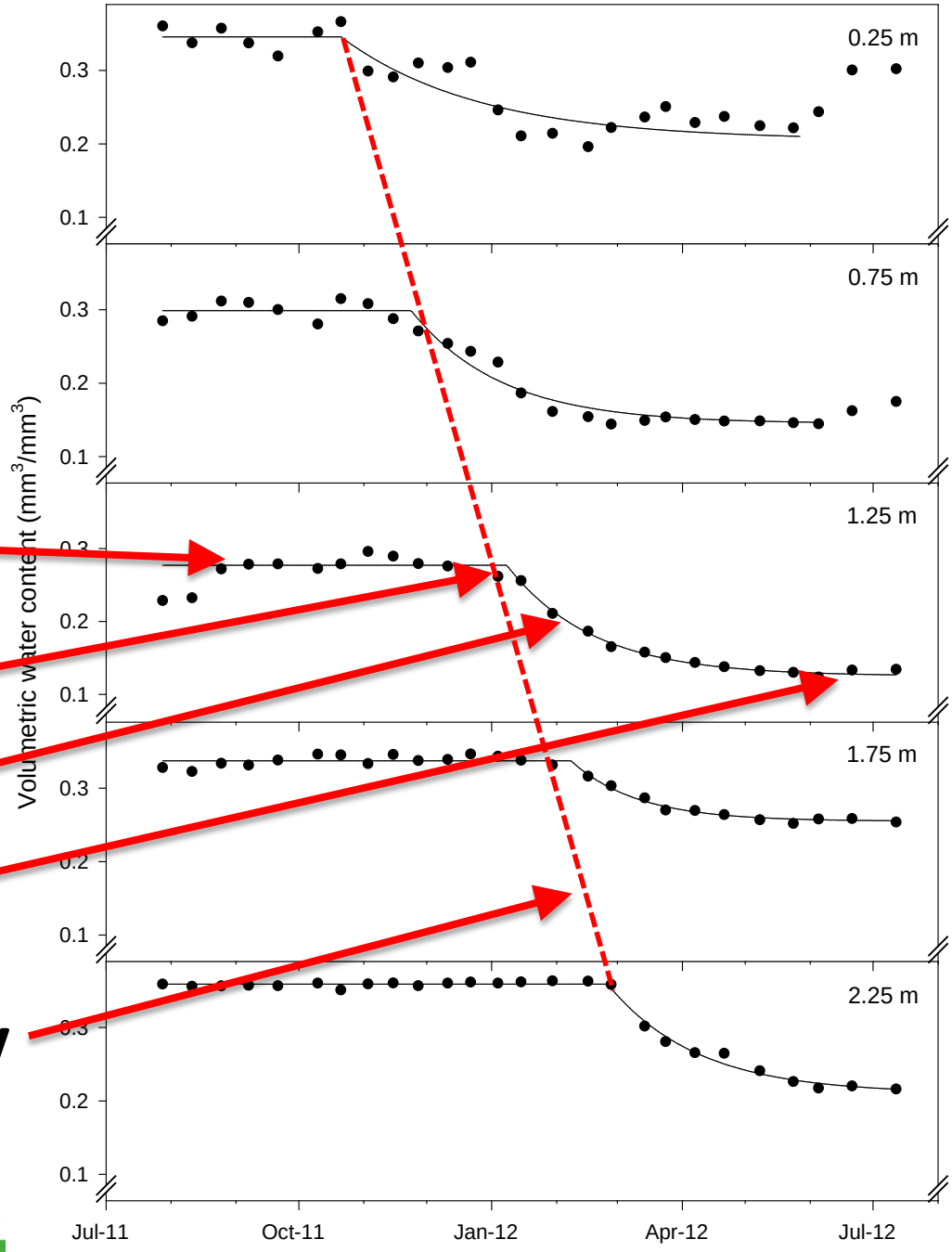
beef+lamb new zealand

Sim 2014

Water extraction



Water extraction



Field capacity

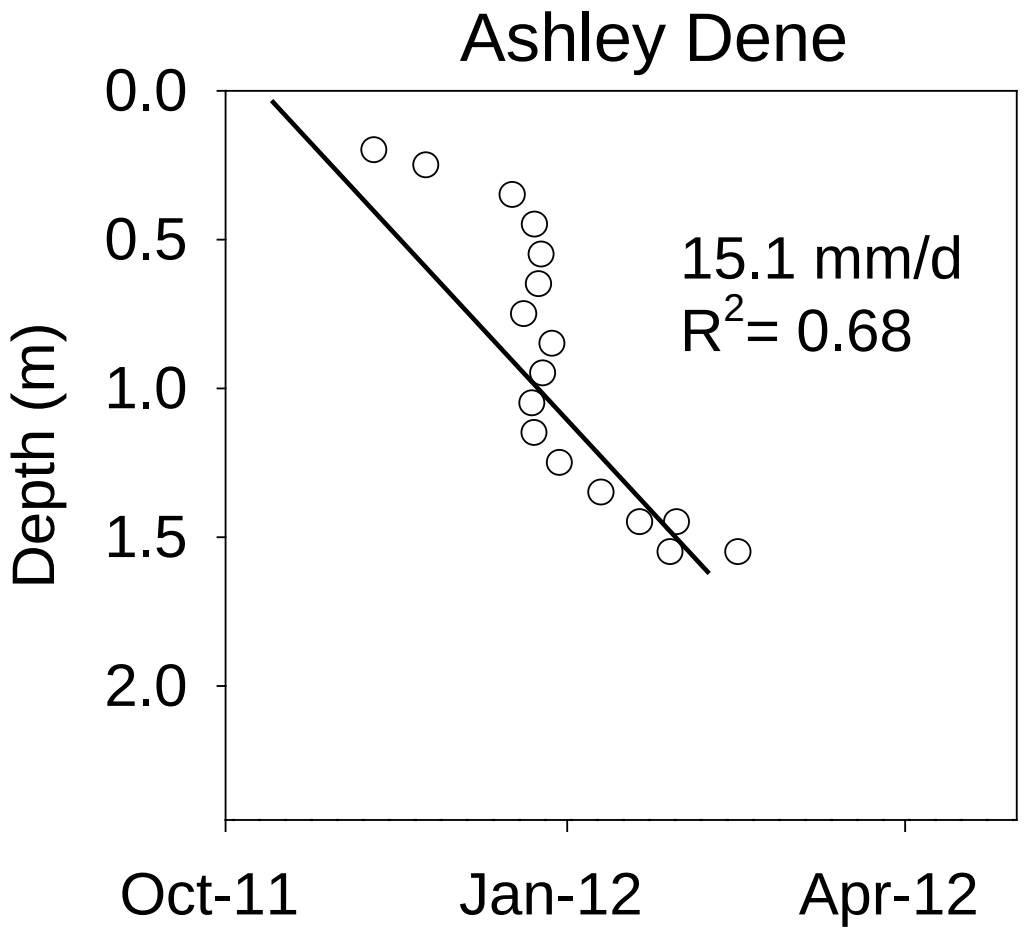
Start of extraction

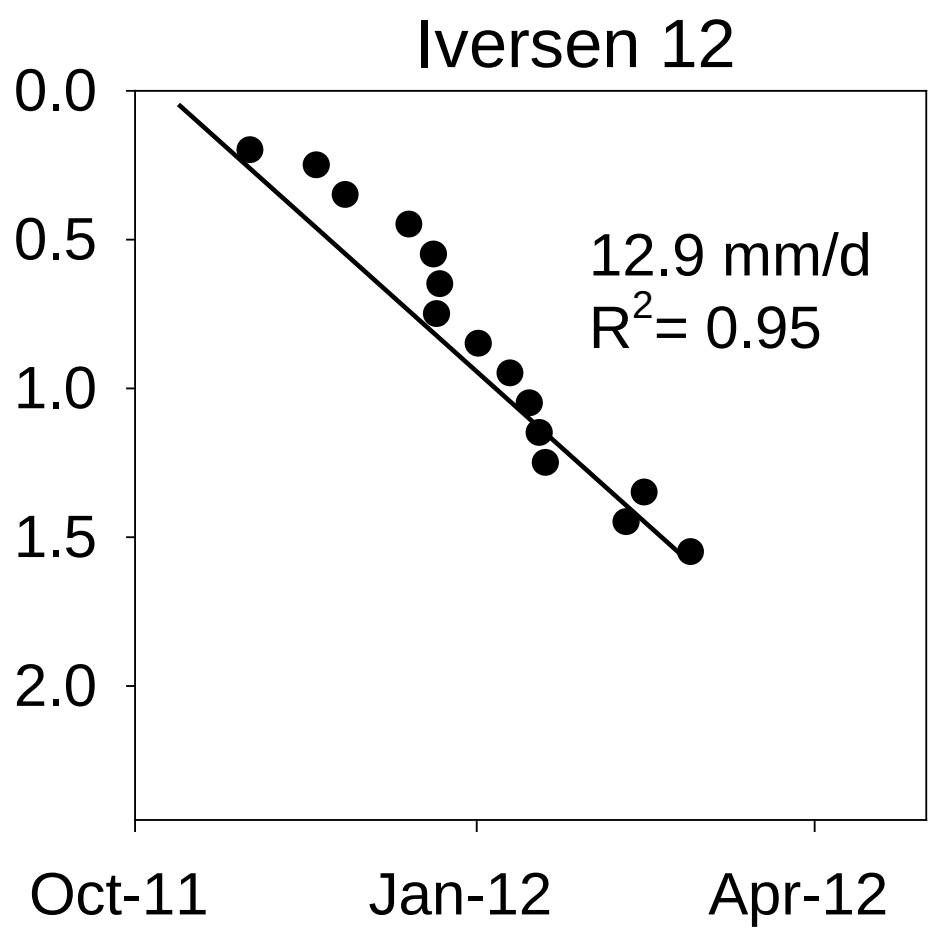
Rate of extraction

Lower limit

Extraction front velocity

Extraction front velocity - establishment





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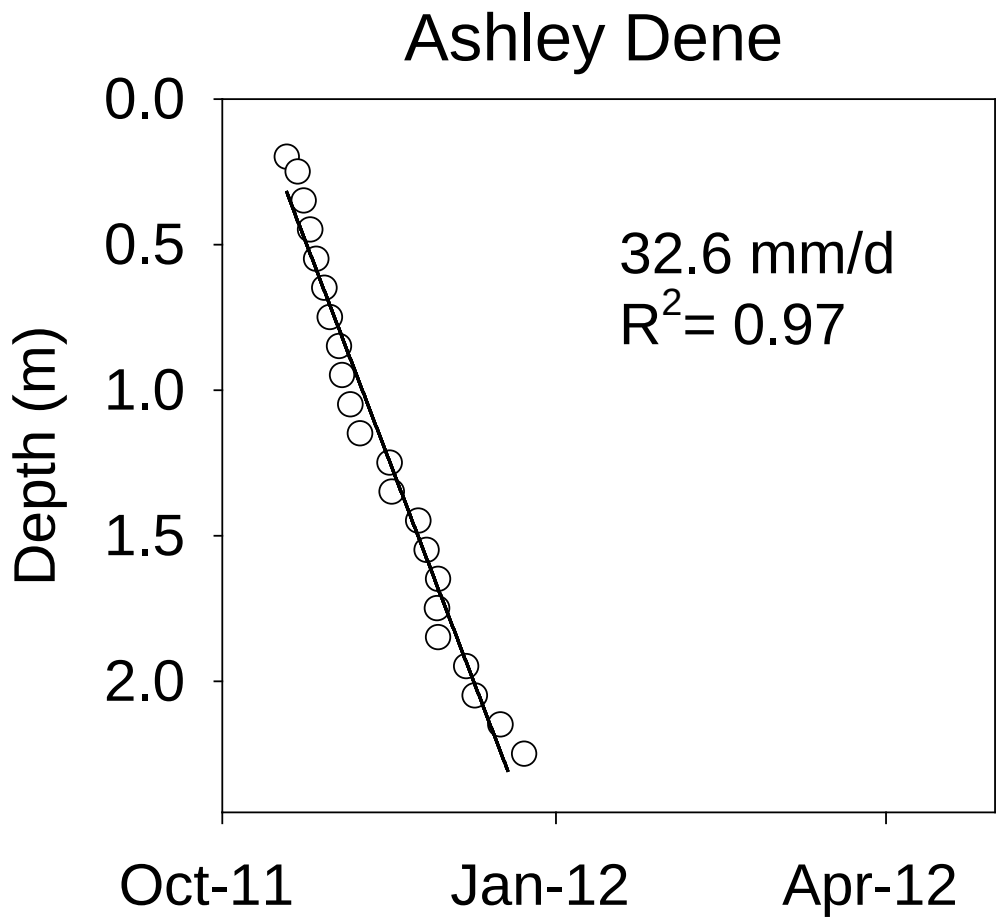
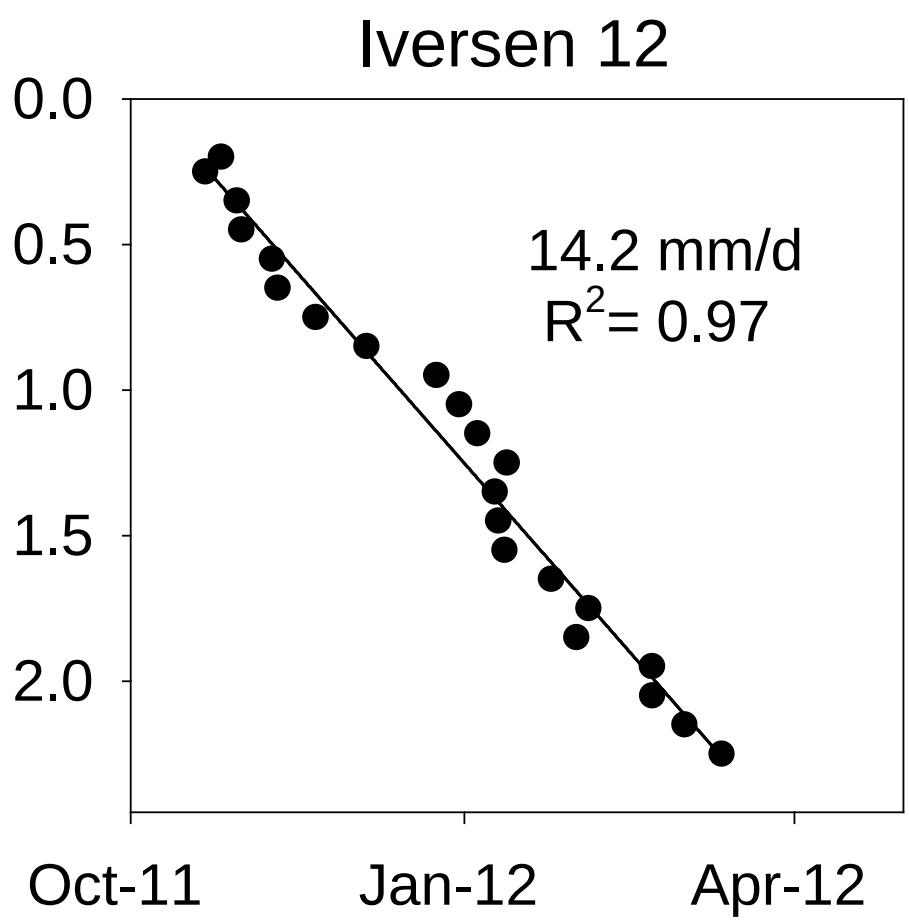
Ashley Dene
Iversen 12
Sown 10 October
Emerged 18 October
200 plants/m²

Extraction front velocity – Year 2





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Ashley Dene, January 2012

Feed supply

- **Regrowth vs seedling crops**
- **Sowing window: Oct-Dec**

→ **First grazing in 3 months (50% flowering)**

Conclusions from establishment

- Spring sow or grow a forage crop
- Yield in year one is lower due to partitioning
- Plant population self thins over time
- Inoculation is important in new sites
- Sow on deep soils
- Regrowth crops on shallow soils use soil water quickly
- Spread feed supply by new sowings each year

Growth:

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

Development:

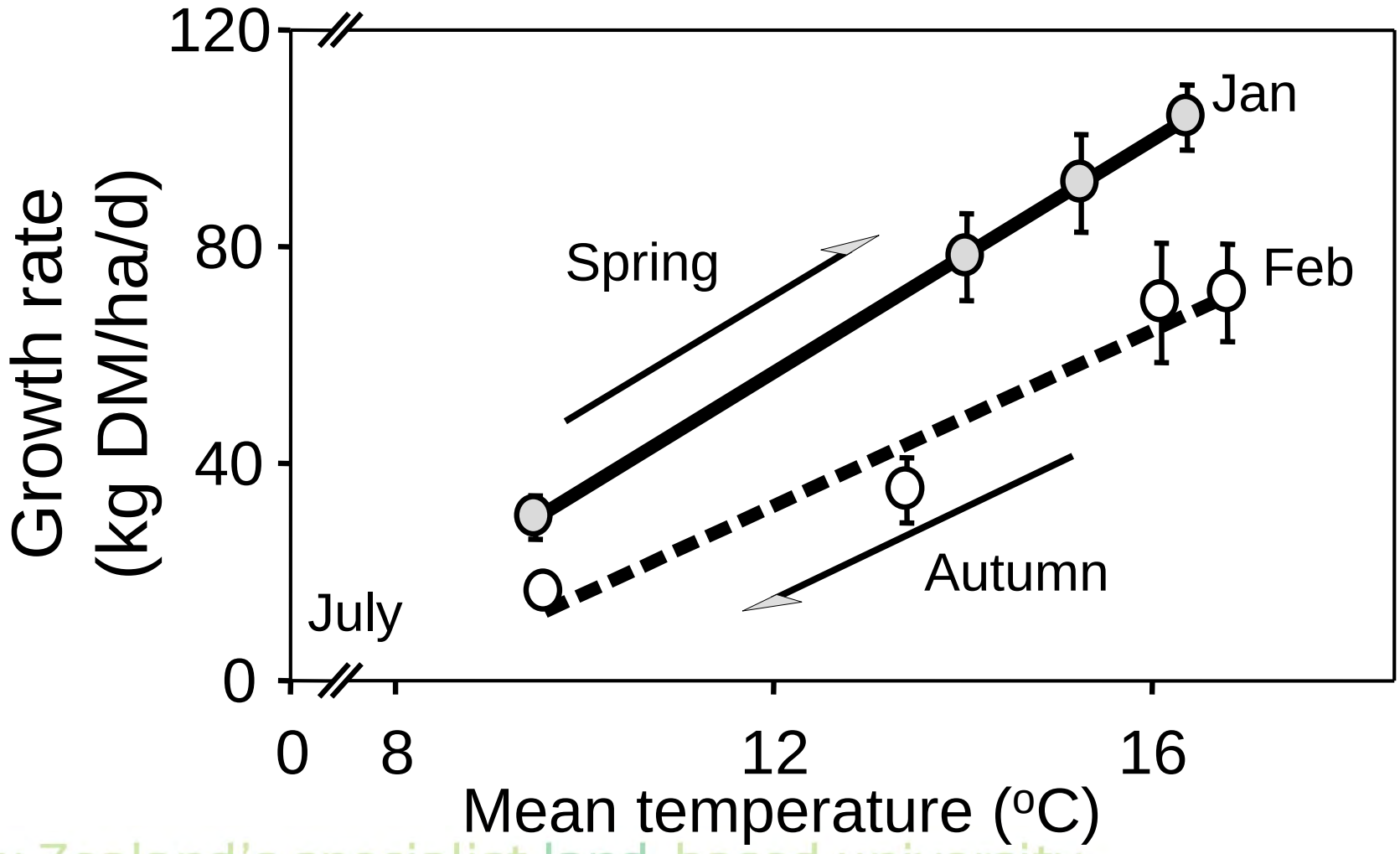
is the ‘age’ or maturity of the regrowth crop

e.g. leaf appearance, flowering

Growth and development are both influenced by environmental signals

The canopy:
the energy capture device

Vegetative growth



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Source: Moot *et al*. 2003

Experiment 2 flexible grazing

38 days resting

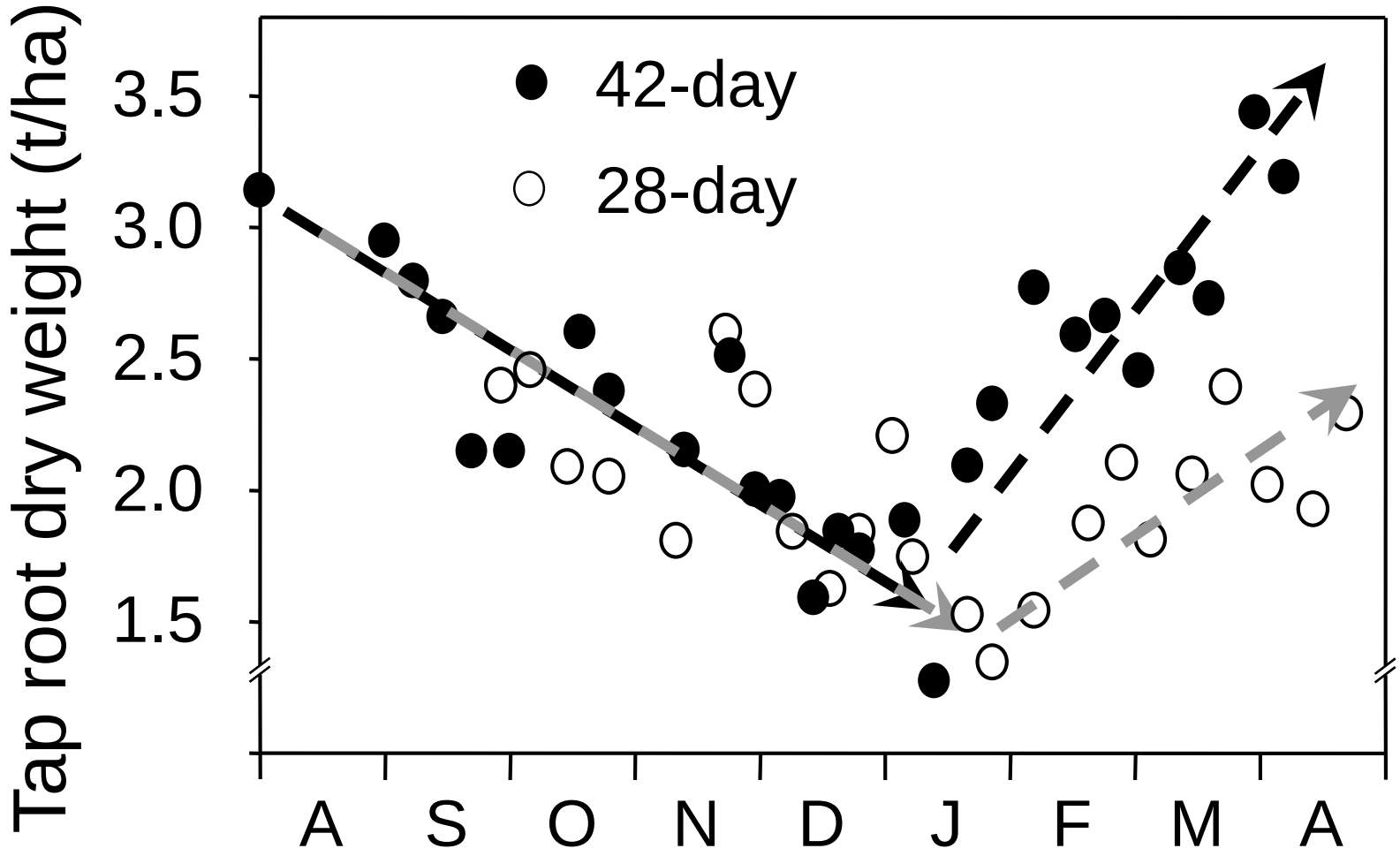
4 days grazing

25 days resting

3 days grazing

What's going on down there?

Partitioning to roots



Source: Moot *et al*. 2003

Seasonal grazing management

Spring

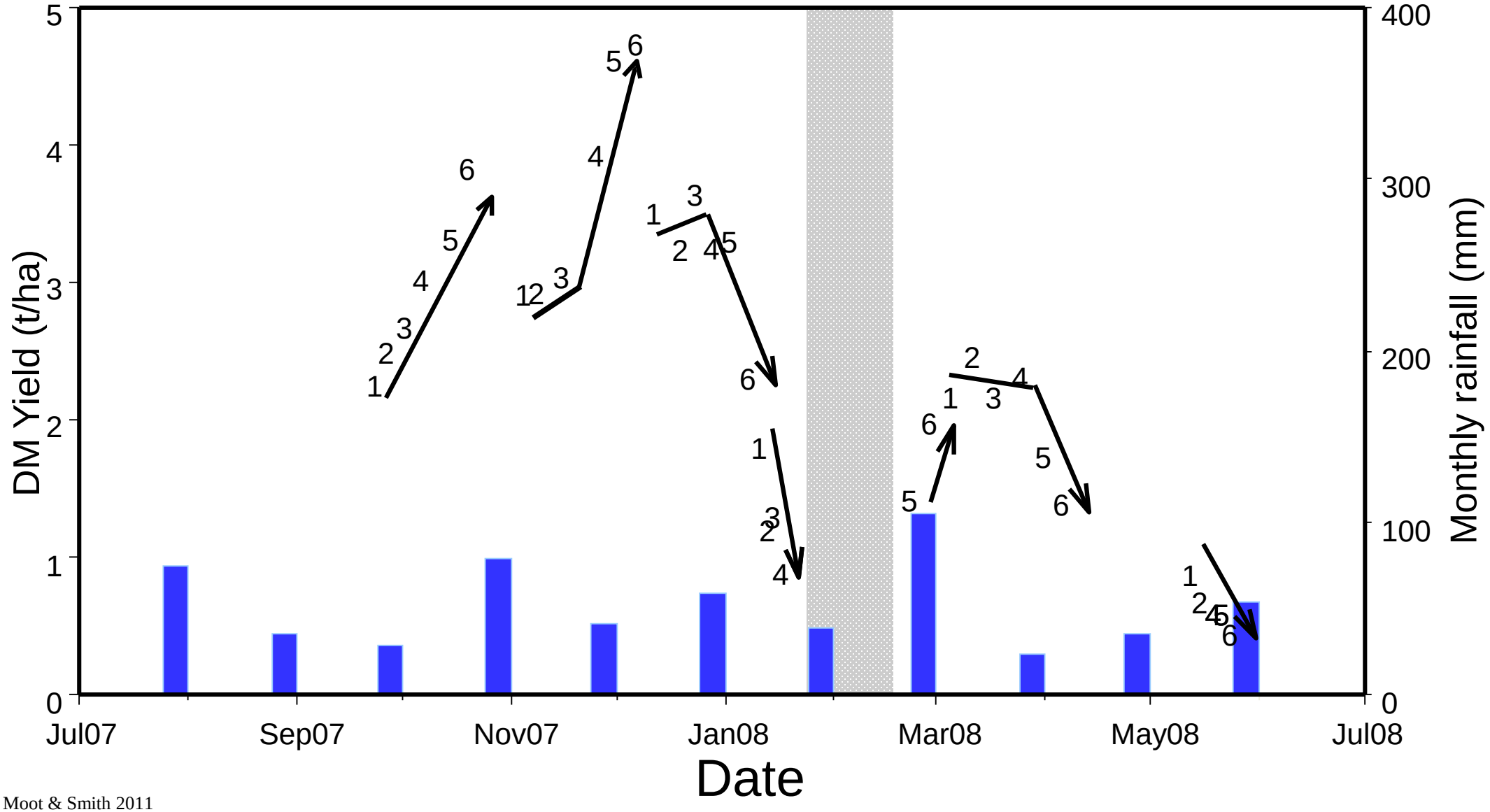
- 1st rotation aided by root reserves to produce high quality vegetative forage.

- 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

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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

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

Early autumn (*Feb-April*)

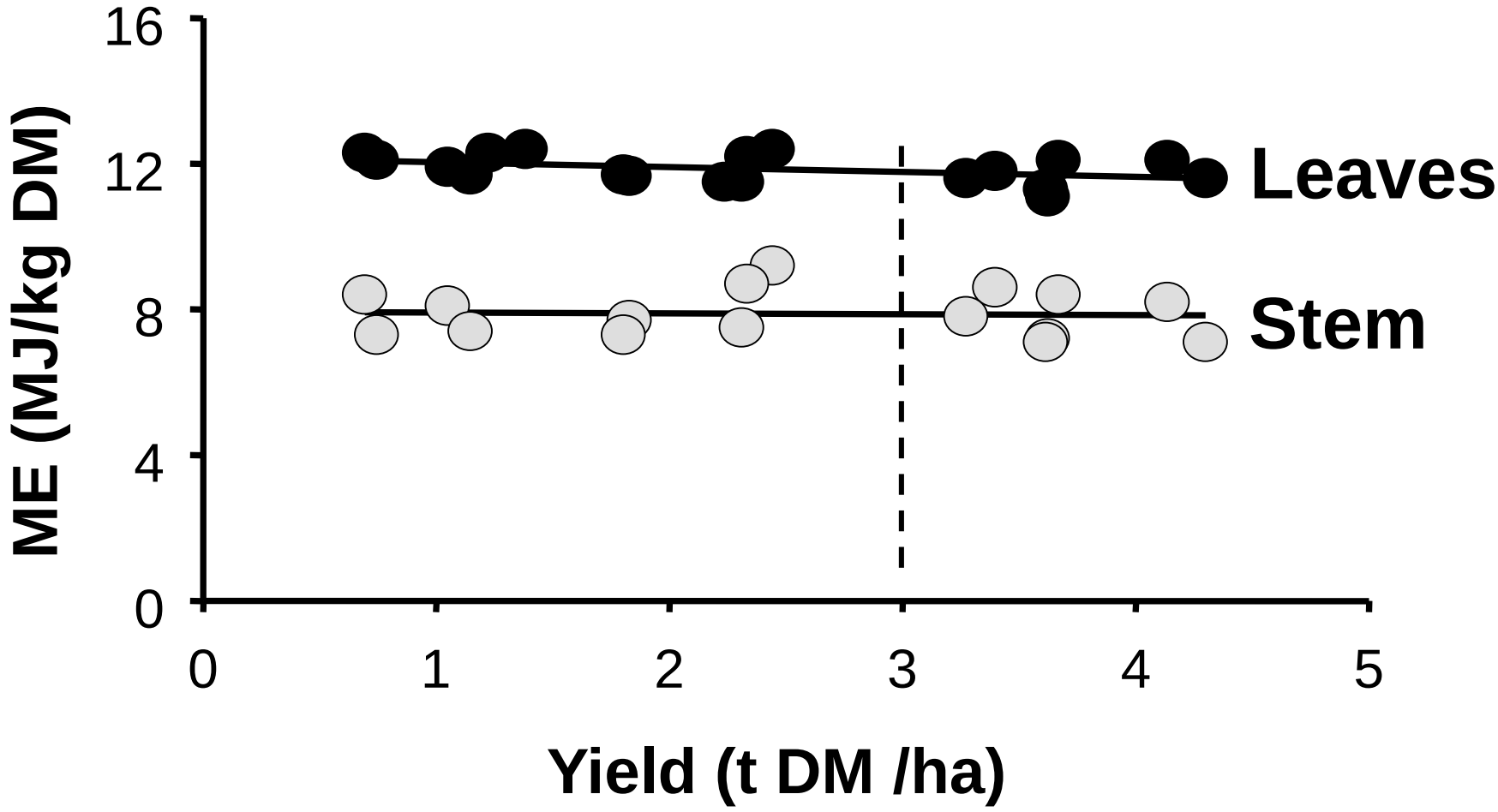
- terminal drought ⇒ graze standing herbage
- allow 50% flowering
- long rotation (42 days) somewhere between Jan and end of May.

⇒ **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

Metabolisable energy of lucerne



Source: Brown & Moot 2004

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 grazing options
- Rotational grazing
- Set stocking
- Grass mixes

Pastoral 21 BLNZ funded programme

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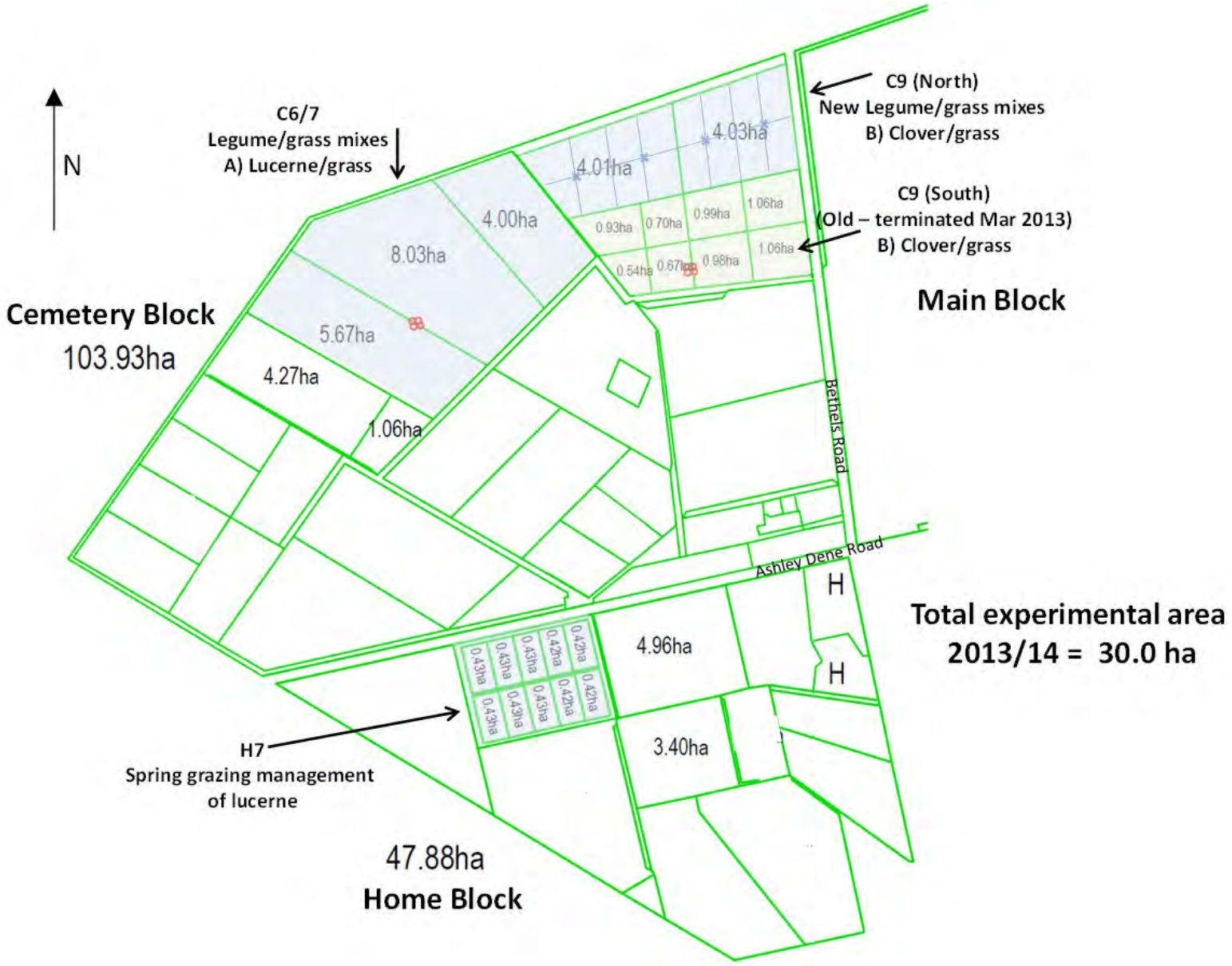

Total experimental area
2013/14 = 30.0 ha

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beef+lamb new zealand

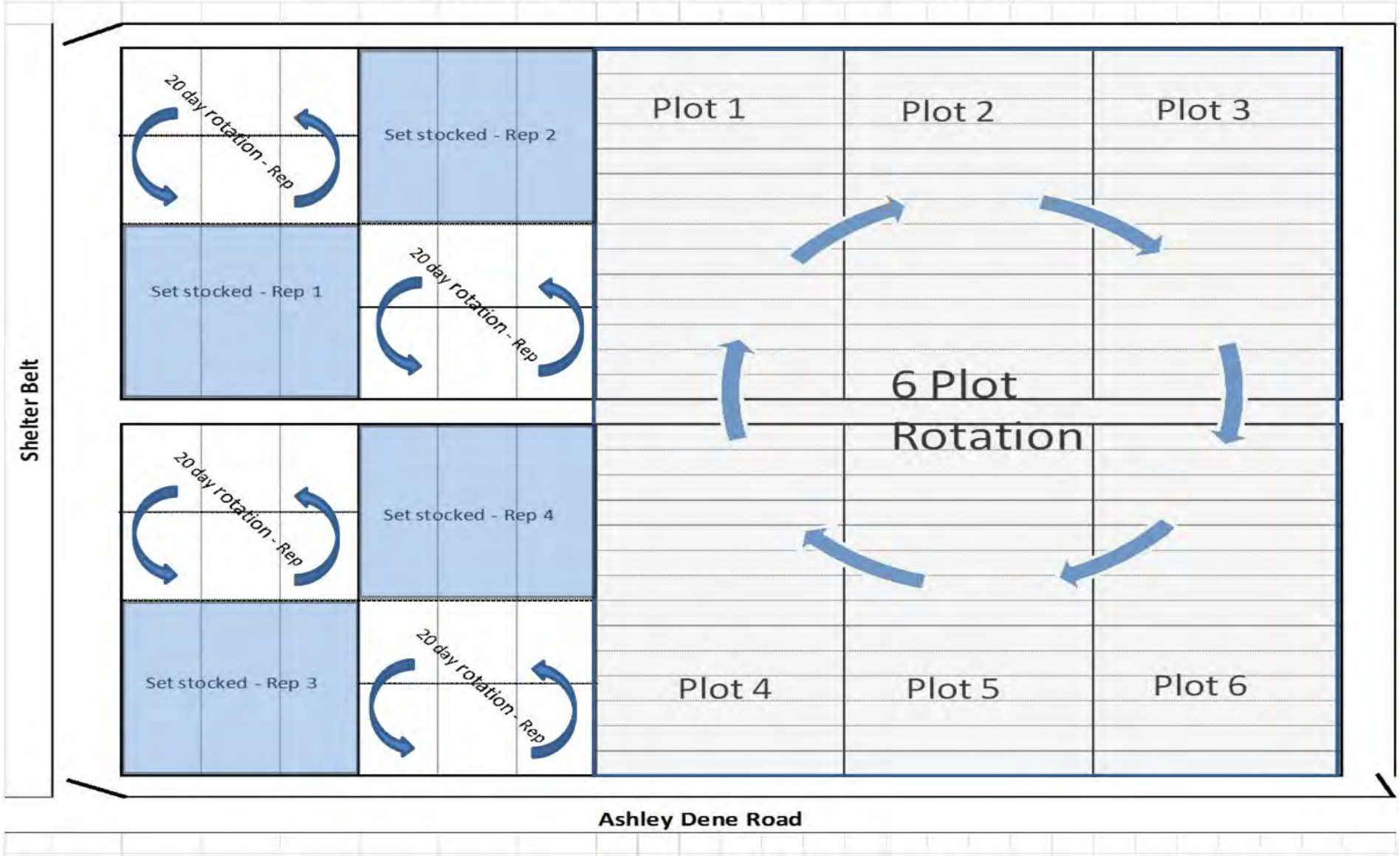
Objective

- Evaluate three spring grazing management strategies for lucerne monocultures
  - Rotational grazing (6 paddock system)
  - Set stocked (SS) until weaning
  - Semi set stocked (SSS) until weaning (10 day shifts)

- After weaning SS and SSS lambs mobbed up and moved to an 8 paddock rotational grazing system (RECOVERY PHASE)

Contributes to: Critical measures A & B

Ashley Dene Lucerne - H7 – Grazing Treatments



Project 3 –
Spring grazing management of lucerne

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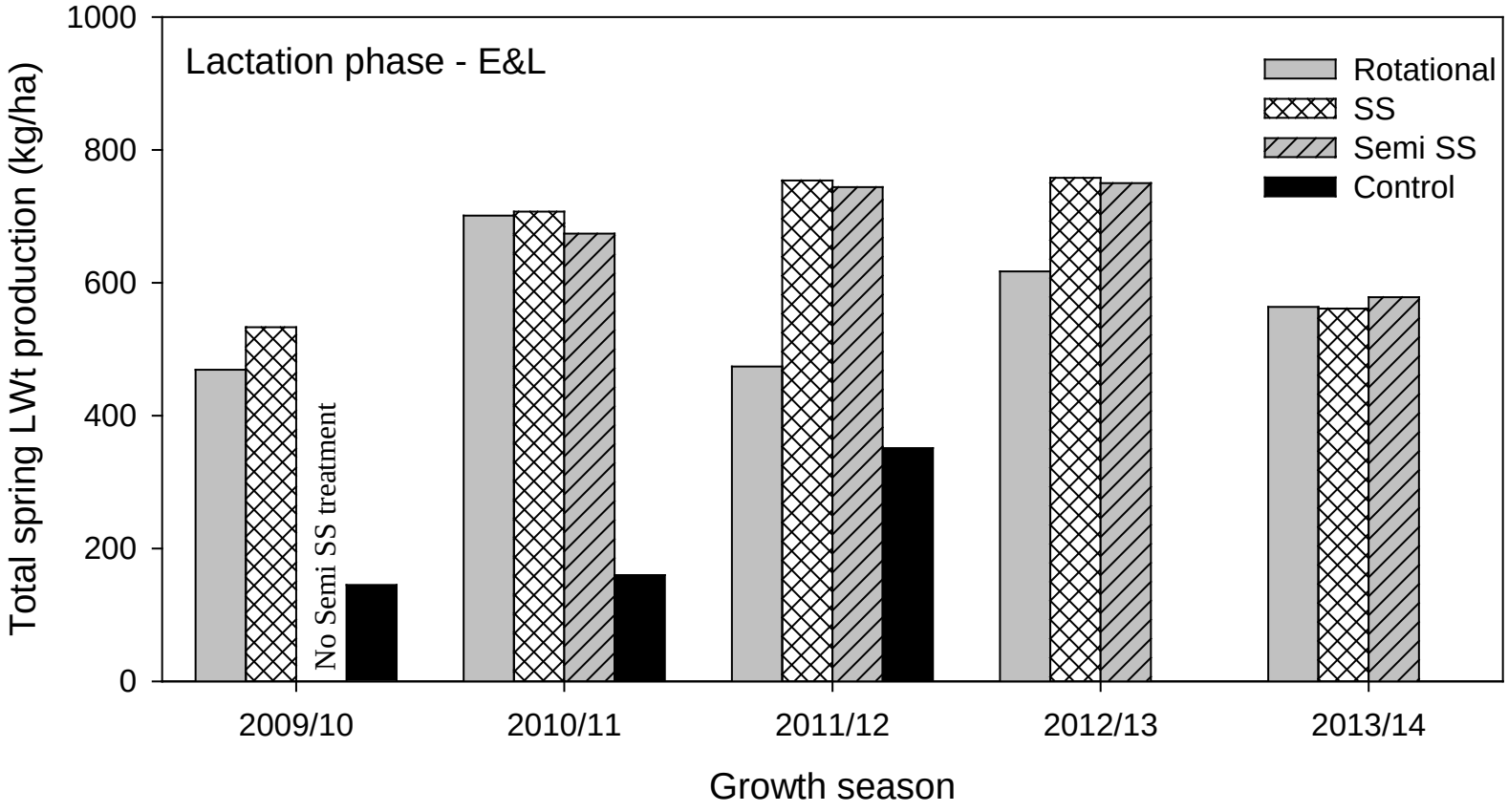
Total LWt produced



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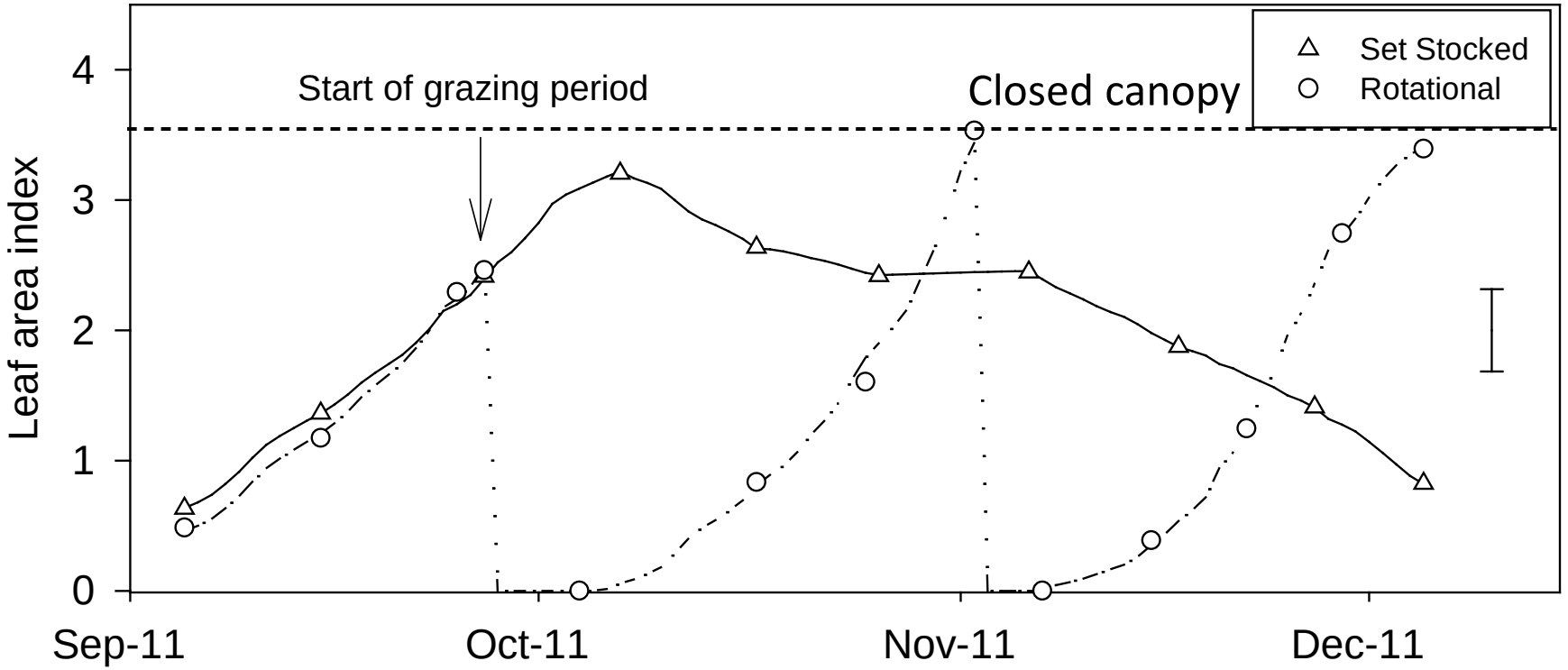
Crop canopy


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

RULES FOR SET STOCKING LUCERNE

1. Manage lucerne pure swards first.

2. Choose paddocks to lamb on early in autumn
   – shelter, older, early clean-up graze and winter herbicide application.

3. Lucerne grass mixes – grass transition.

4. Early and late for condensed lambing (1 cycle).

5. Drift onto lucerne ~14 d prior to lambing

6. Lucerne ~20 cm tall and keep it there.

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beef+lamb new zealand

RULES FOR SET STOCKING LUCERNE (CONT.)

7. Stock at about half the rotational grazing rate
8. SS for 4-5 weeks – then rotate
9. SS lambs use the taller feed as shelter.
10. Stocking rate to keep closed canopy!
11. Canopy gets taller over 4-5 weeks not shorter
12. Once canopy reduces begin rotational grazing
13. Open canopy = twitch, yarrow, dandelions.
14. Paddocks need autumn (6 wks) recharge.

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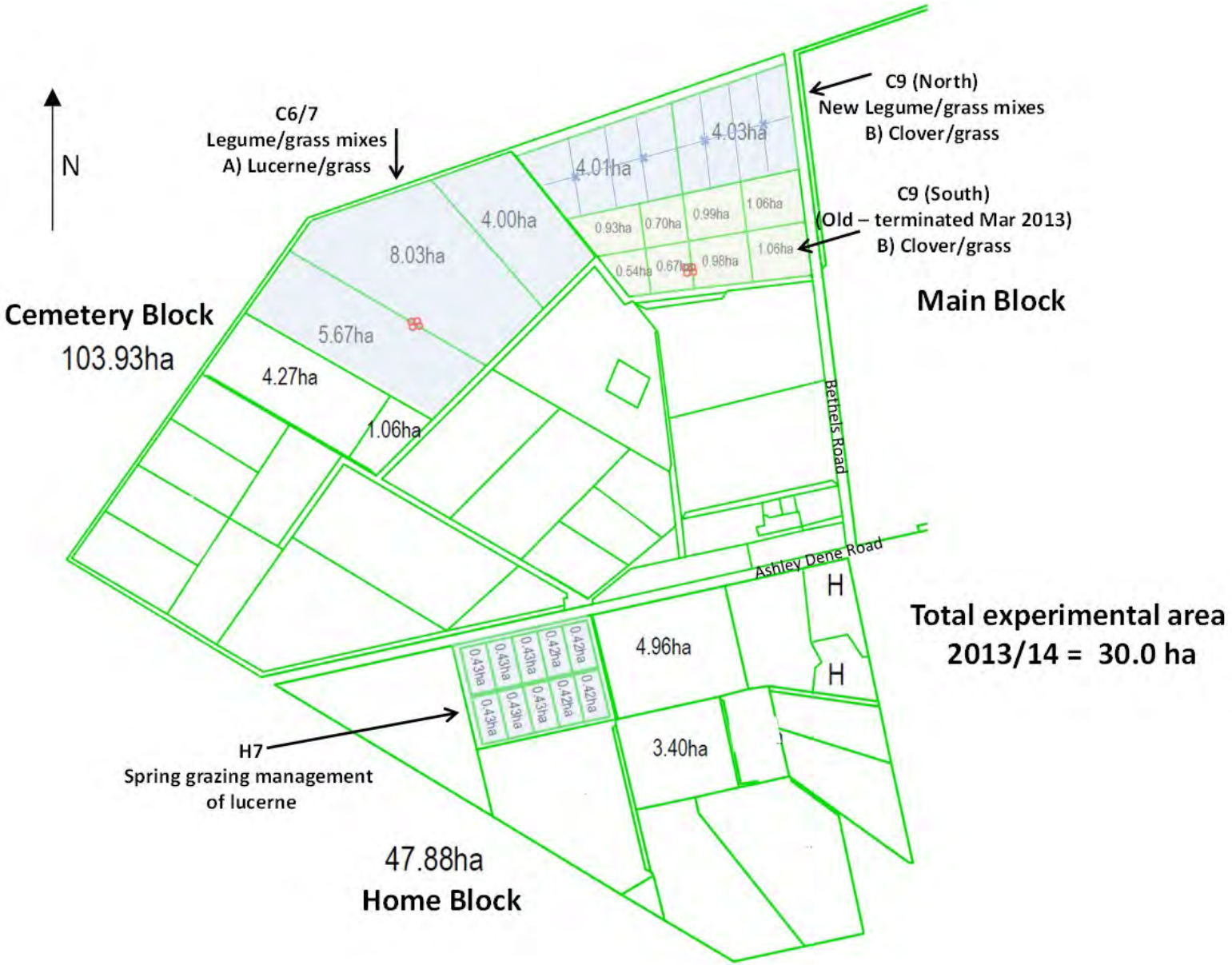

Total experimental area
2013/14 = 30.0 ha

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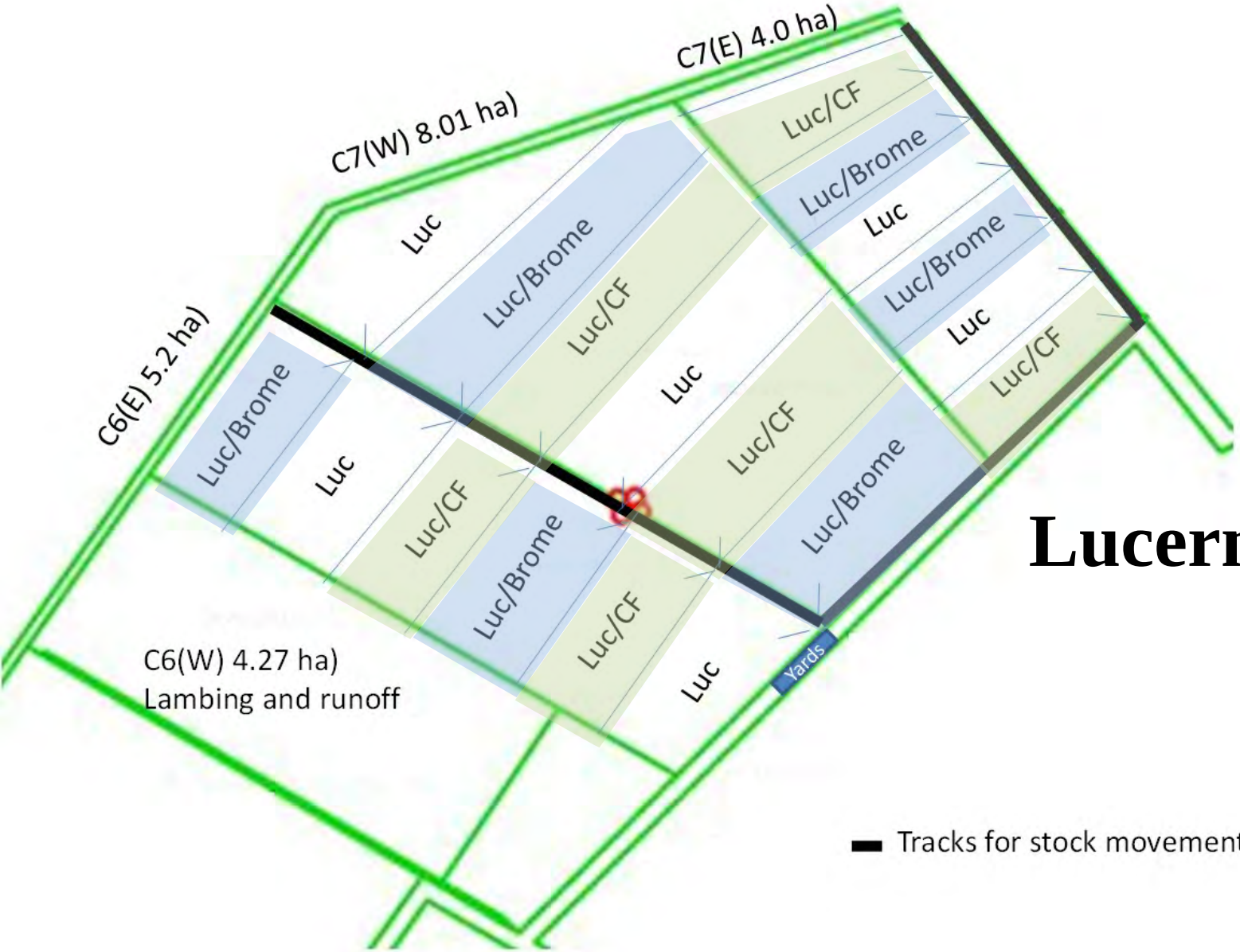
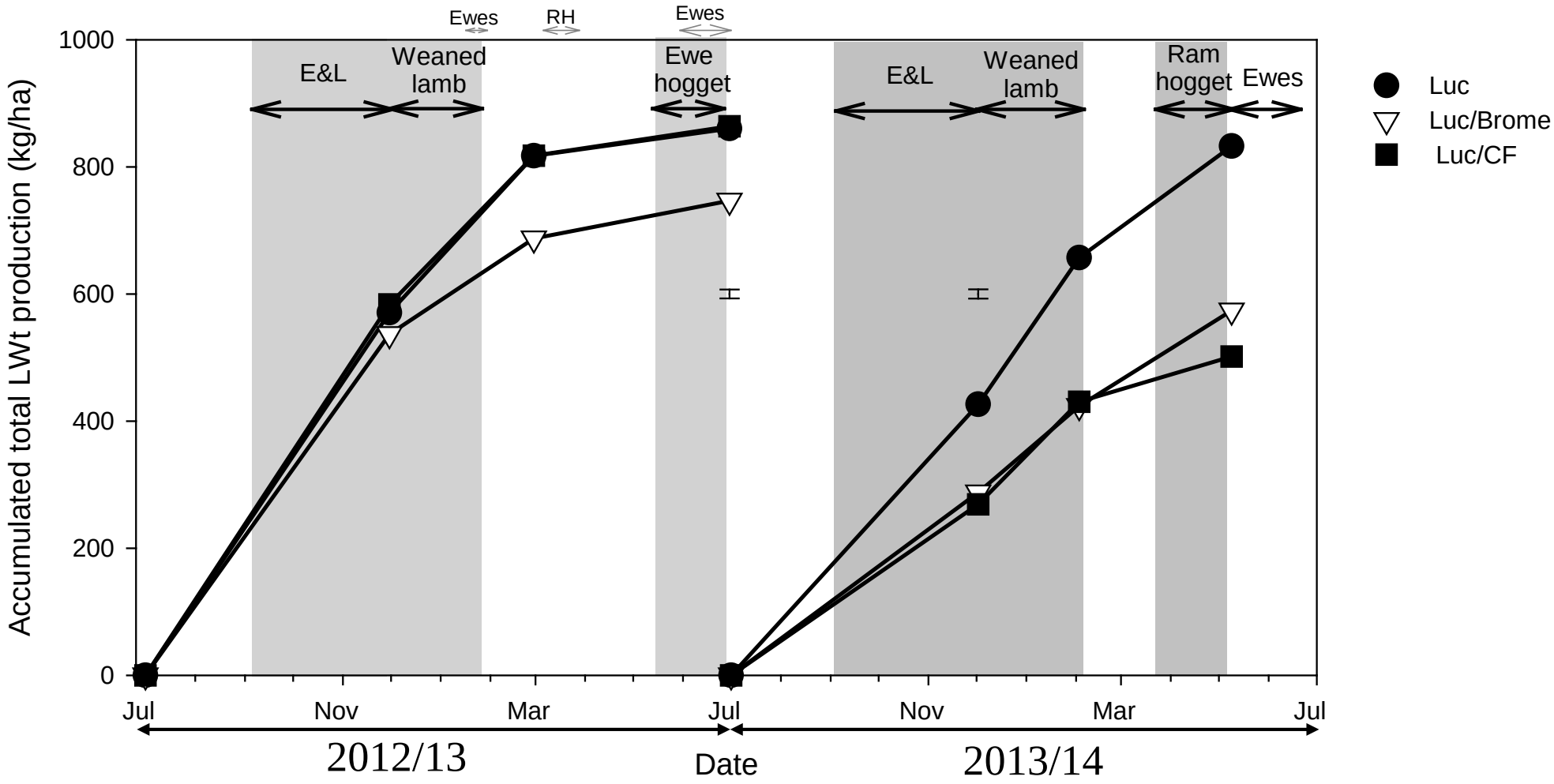
Lucerne/grass mixes

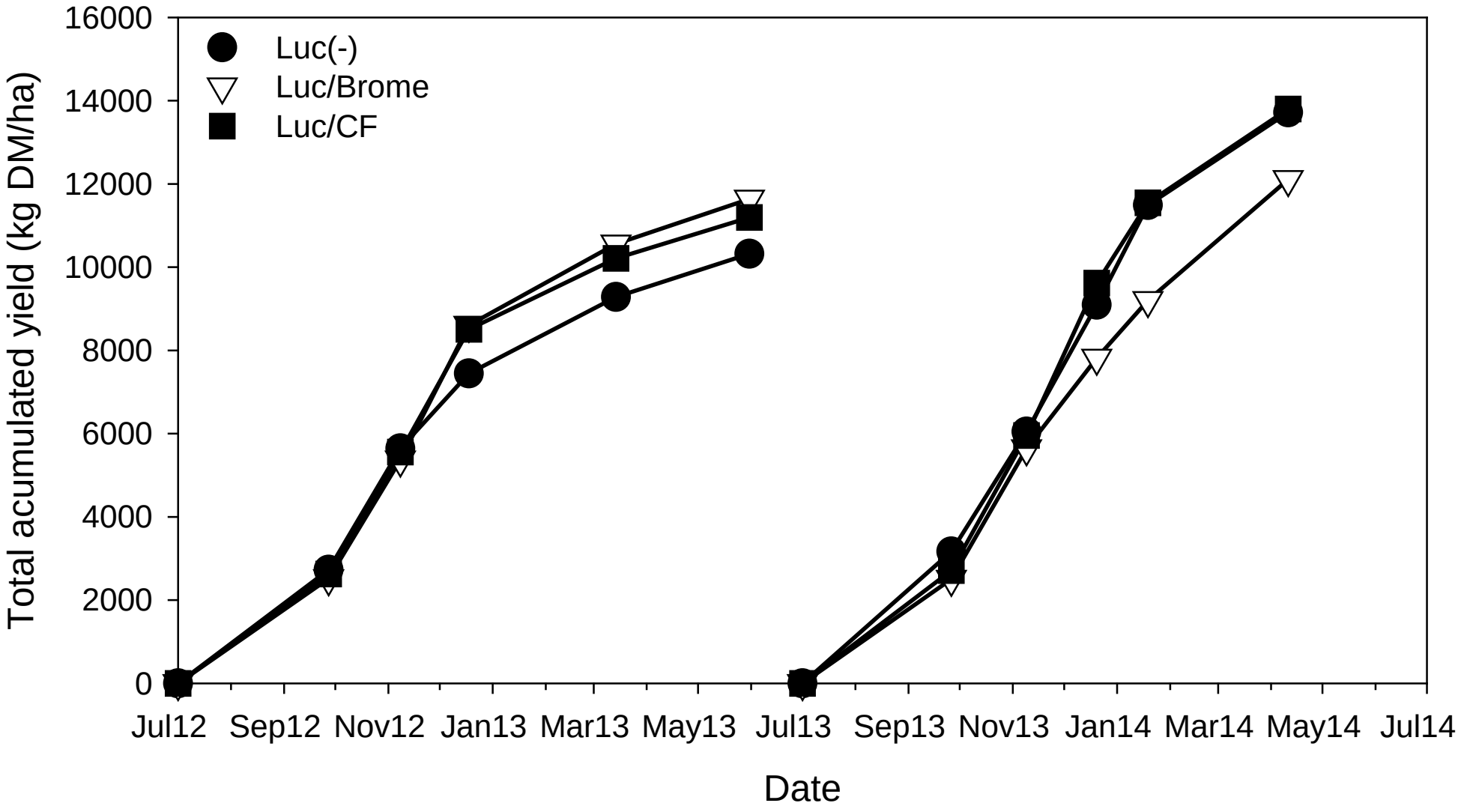


Early spring

Total Accumulated LWt production



DM Yield


Luc(-)
Luc/Brome
Luc/CF
Total acumulated yield (kg DM/ha)
16000
14000
12000
10000
8000
6000
4000
2000
0
Jul12
Sep12
Nov12
Jan13
Mar13
May13
Jul13
Sep13
Nov13
Jan14
Mar14
May14
Jul14
Date

Plot 2
Luc/CF
24 Oct 2012

Plot 10
Luc/CF
17 Oct 2012

Lucerne/cocksfoot mix – Sept 2013

Plot 3
Luc/brome
24 Oct 2012

Plot 11
Luc/brome
17 Oct 2012

Plot 7
Luc/brome
11 Oct 2013

Plot 17
Luc/brome
14 Nov 2013

3 Feb 2014

3 Feb 2014
Luc/CF

3 Feb 2014
Luc/brome

3 Feb 2014
Luc

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Integrating lucerne into a high country merino system

D. Anderson, L. Anderson, D.J. Moot and G.I. Ogle

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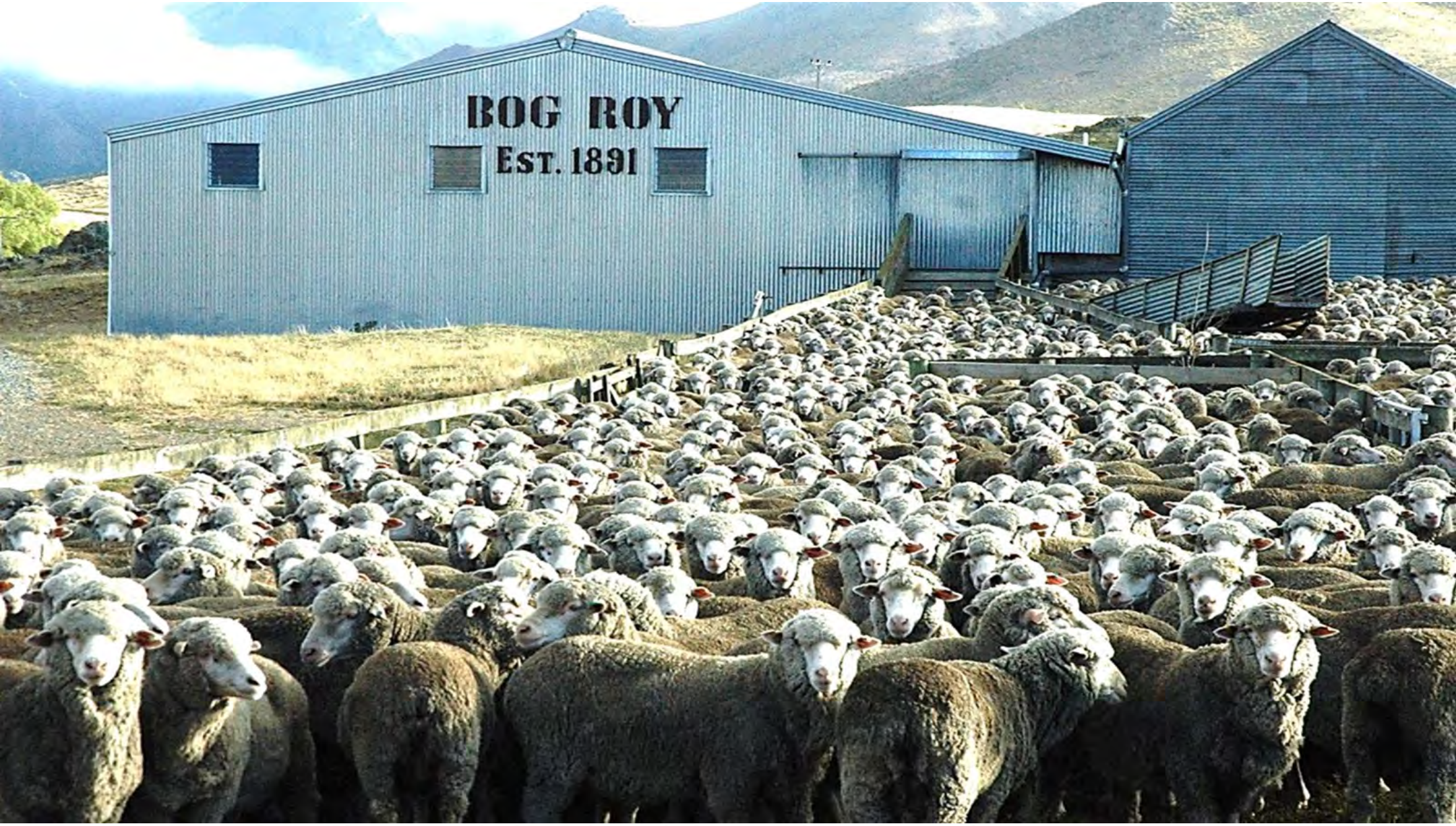

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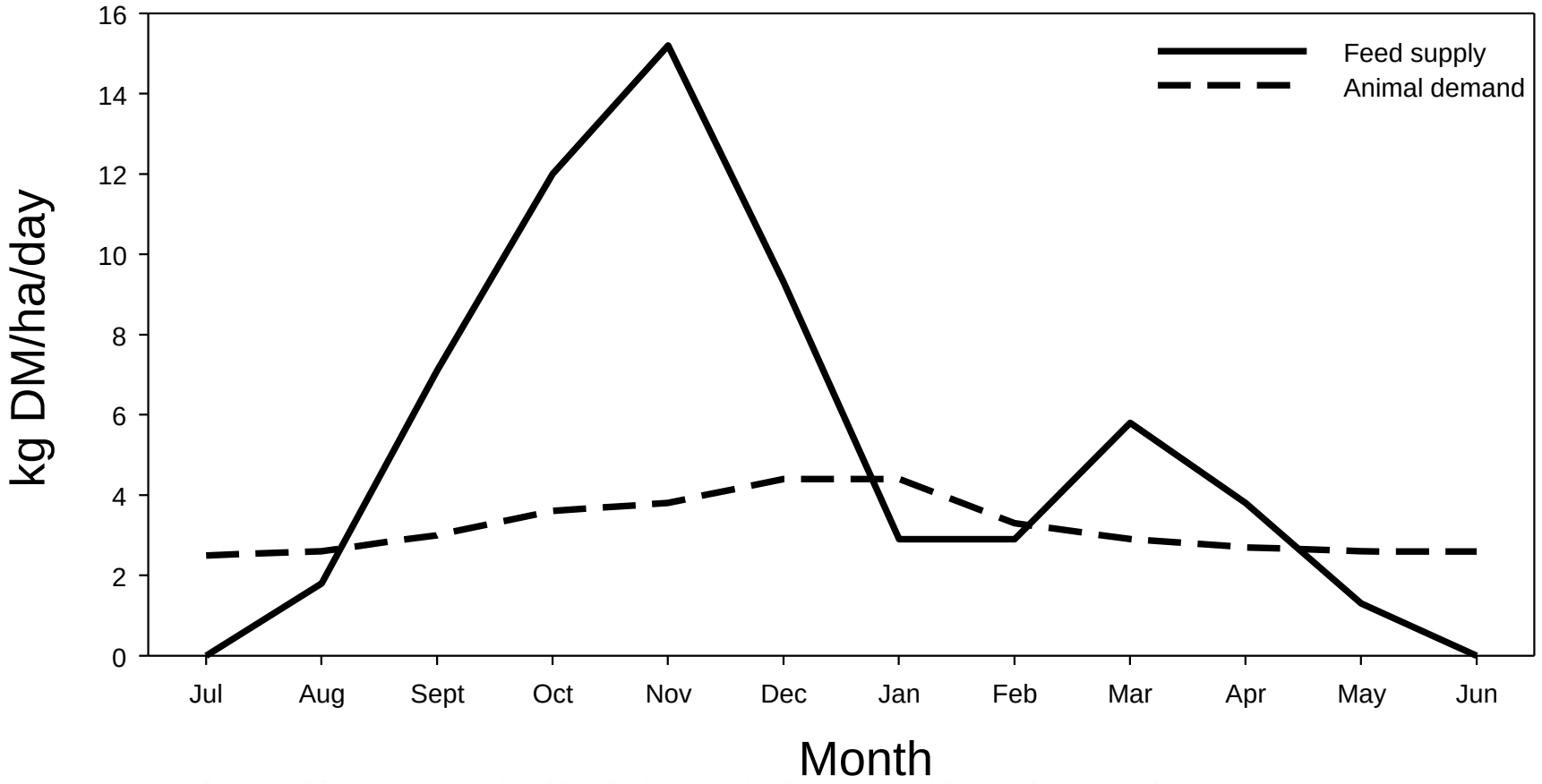
Landscape farming

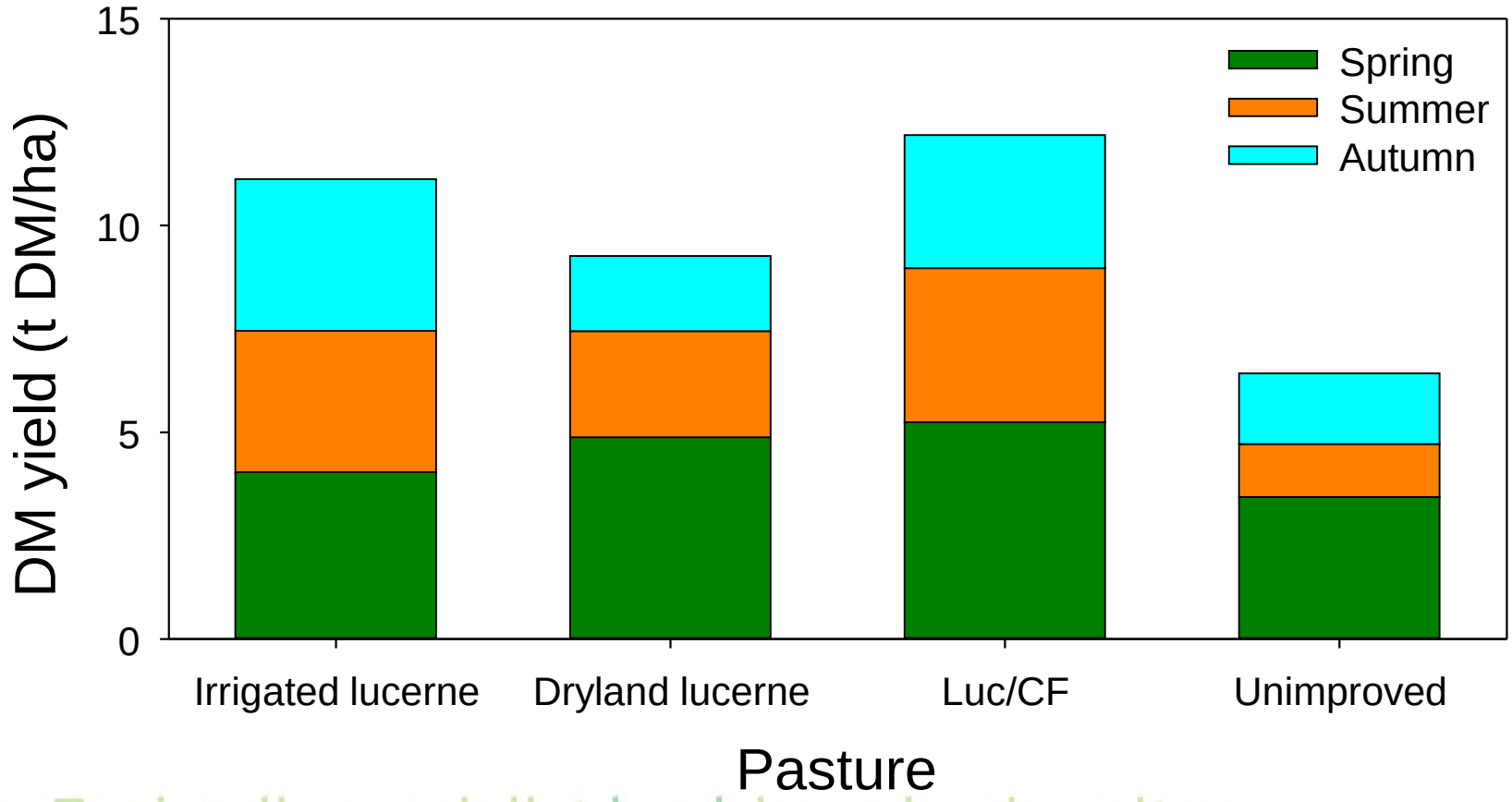
Pasture supply & Animal demand



New Zealand's specialist land-based university

Anderson *et al*. 2014

Seasonal pasture production (3-yr average)



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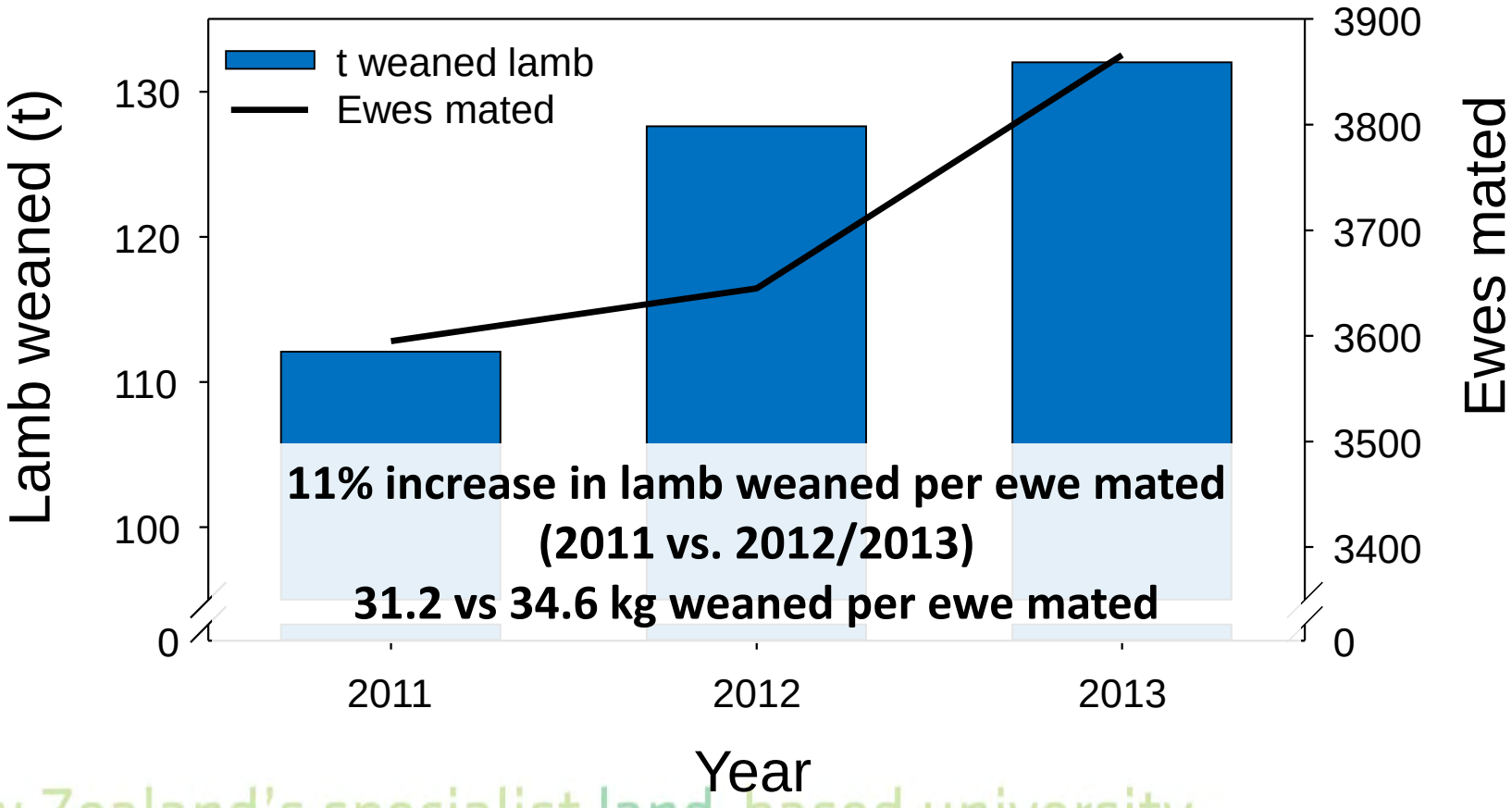
Anderson *et al*. 2014

Lamb weaned and Ewes mated



New Zealand's specialist land-based university

Anderson *et al*. 2014

Bog Roy change in system performance

	Historic (Pre 2010)	Year 3 (target)	Year 3 (actual)	% Change
Mixed age ewes				
Tupping weight (kg)	57.0	60.0	59.5	↑ 4.3
Ewe scanning (%)	165	165	165	-
Ewe weaning (%)	115	125	130	↑ 13.0
Ewe lamb mortality (%)	30.0	25.0	21.0	↓ -30.0
Lamb weaning weight (kg)	27.0	29.0	29.0	↑ 7.4
Lamb growth rate (g/hd/day)	205	235	235	↑ 14.6

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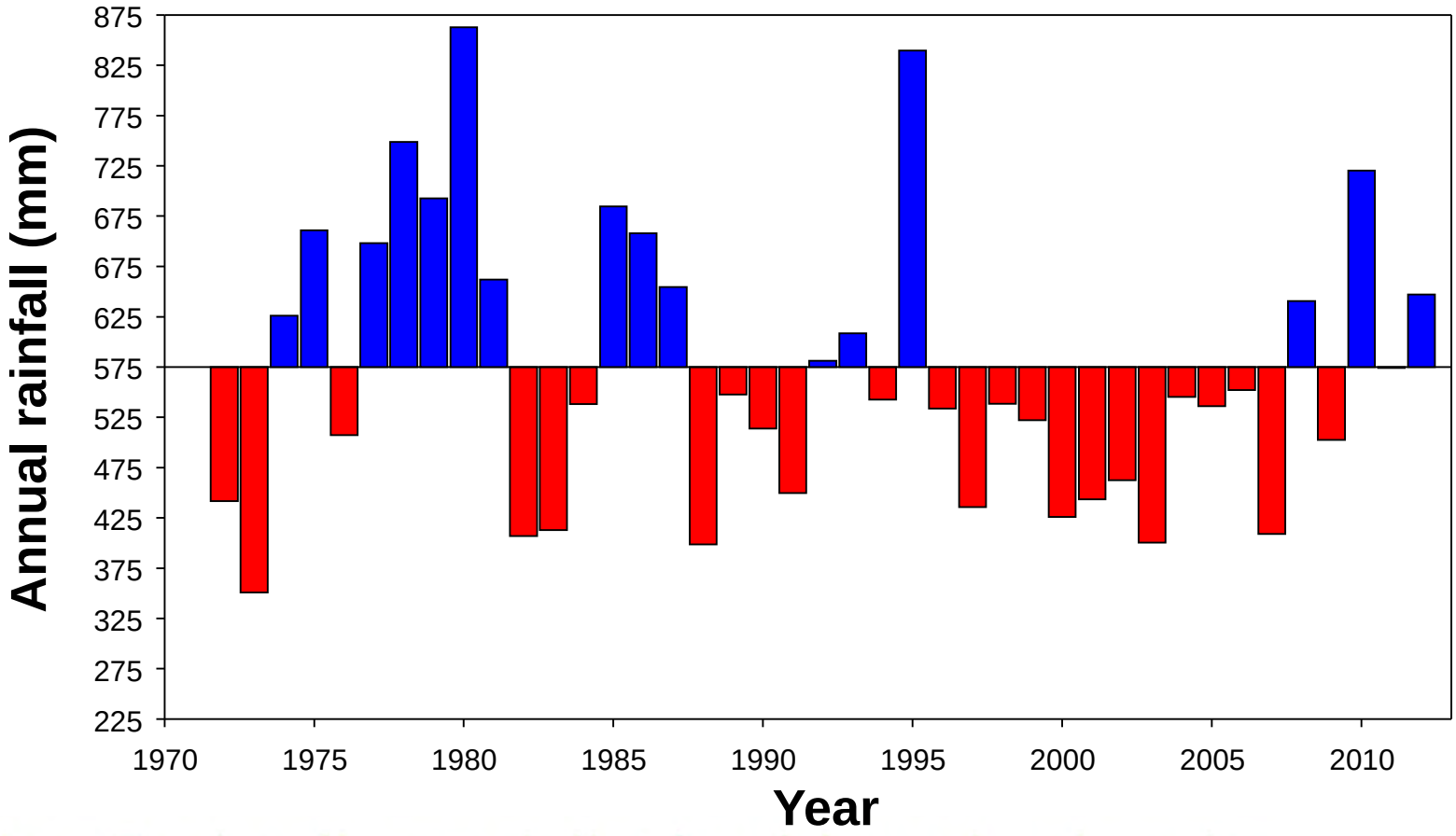
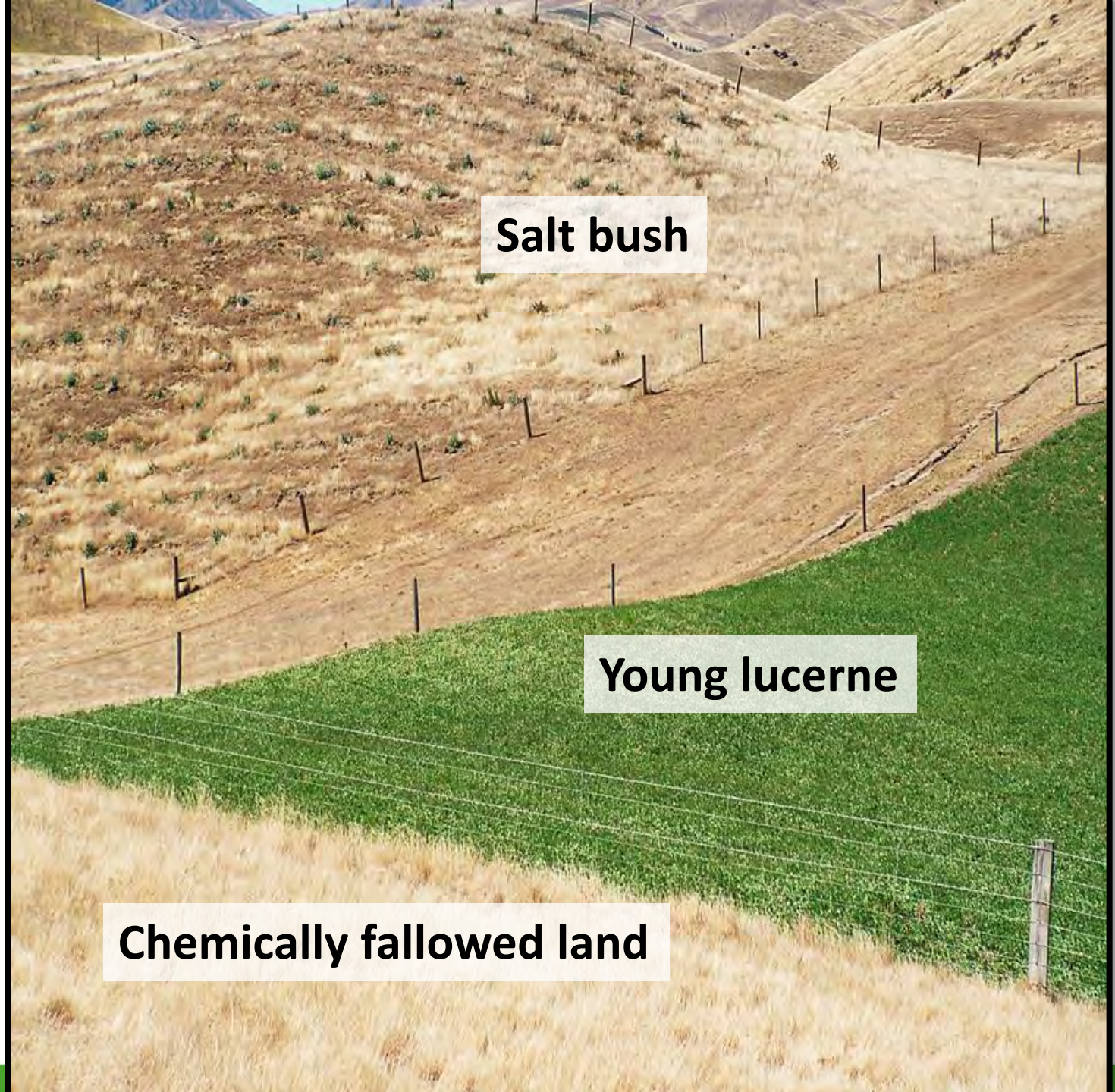
Anderson *et al*. 2014

Case study – Bonavaree farm, Marlborough
Over grazed – high erosion risk

Annual rainfall at ‘Bonavaree’




Salt bush
Young lucerne
Chemically fallowed land

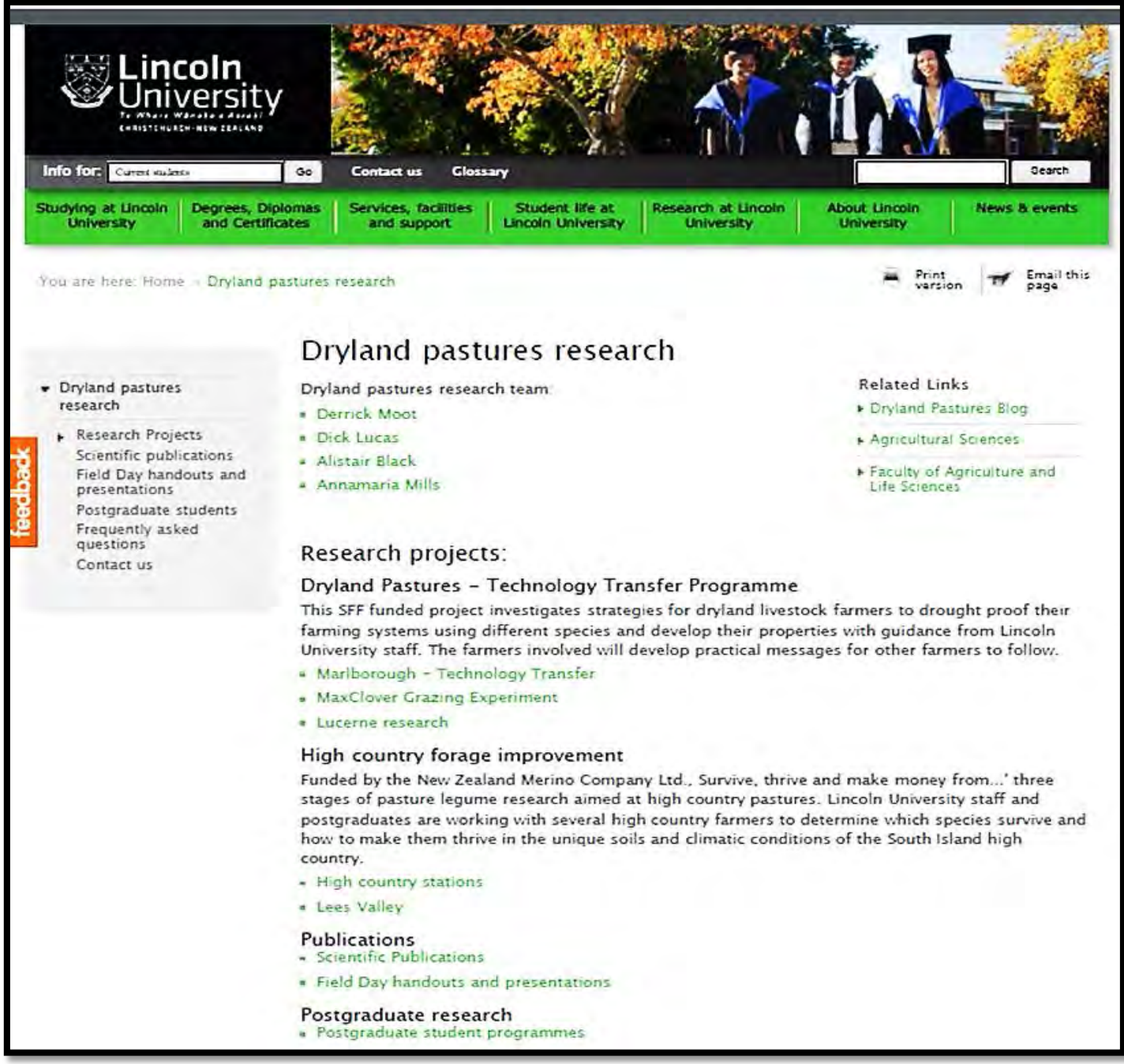
‘Bonavaree’ production change over 10 years

	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)	$317	$792	↑ 149%

The website…

Info on:

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



www.lincoln.ac.nz/dryland

Conclusions

- Lucerne growth rate is seasonal based on storage and remobilization of reserves
- Lucerne can be grazed or cut and carried based on yield – not time of flowering
- Replace nutrients removed through cut and carry (K)
- Minimize soil evaporation by timing of irrigation

References & Links

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

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

MaxClover Photo Diary (18 MB; PDF File)

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