Transformative opportunities in plant breeding to cope with future climates.

Today's topics

- Intro to PGG Wrightson Seeds
- Where might we be in 20 years?
  - Recent investments in breeding
  - Deep rooted perennials
  - North West Spanish ryegrass – what can be achieved with 10x investment.
- Summary – ideas to push us forward.

Martin Harmer

Australian Research manager

Who are PGG Wrightson Seeds?

What is PGG Wrightson Seeds

- Specialist pasture and forage seed breeder and marketer
- 18 Plant breeders and 50 research staff (Australian, New Zealand and South America)
- $10 million annual breeding investment (~10 % of EDIT)
- We invest via long-term joint ventures

Breeding objective	Joint venture name	Joint venture partner
Grass and clover breeding	Grasslands Innovation Ltd	Grasslanz Technology
Endophytes discovery	Endophyte Innovations	Grasslanz Technology
Brassica and cereal breeding	Forage Innovations Limited	Plant and Food New Zealand

DLF purchase of PGG Wrightson Seeds

- In 2018 DLF purchased PGW Seeds for $420 NZD. DLF are a Danish Farmer owned cooperative.
- DLF have similar R&D investments in Europe and North America and bring functional and in-house technology platforms (Genomics) to accelerate PGW Seeds genetic gain.
- DLF invested for future revenue steams (innovations), not just todays.

Where do we undertake research?

Recent investments

Annual Legume Breeding Australia (ALBA)

- 2015 - PGG Wrightson Seeds awarded DPIRD (WA Gov) annual legume program in a competitive tender process
- 2017 - JV with University of WA and PGW
- UWA partnership offers PGW access to expertise and UWA access to commercial insights and a pathway to market
- Only sub clover breeding program in the world, led by Dr. Phil Nichols
- New products anticipated from 2024 which include:

  Sub clover Arrowleaf clover Balansa clover Persian clover

- $1m research funding annually
- **Challenges** – root disease and plant pathology

Recent investments

Annual Legume Breeding Australia (ALBA)

Recent investments

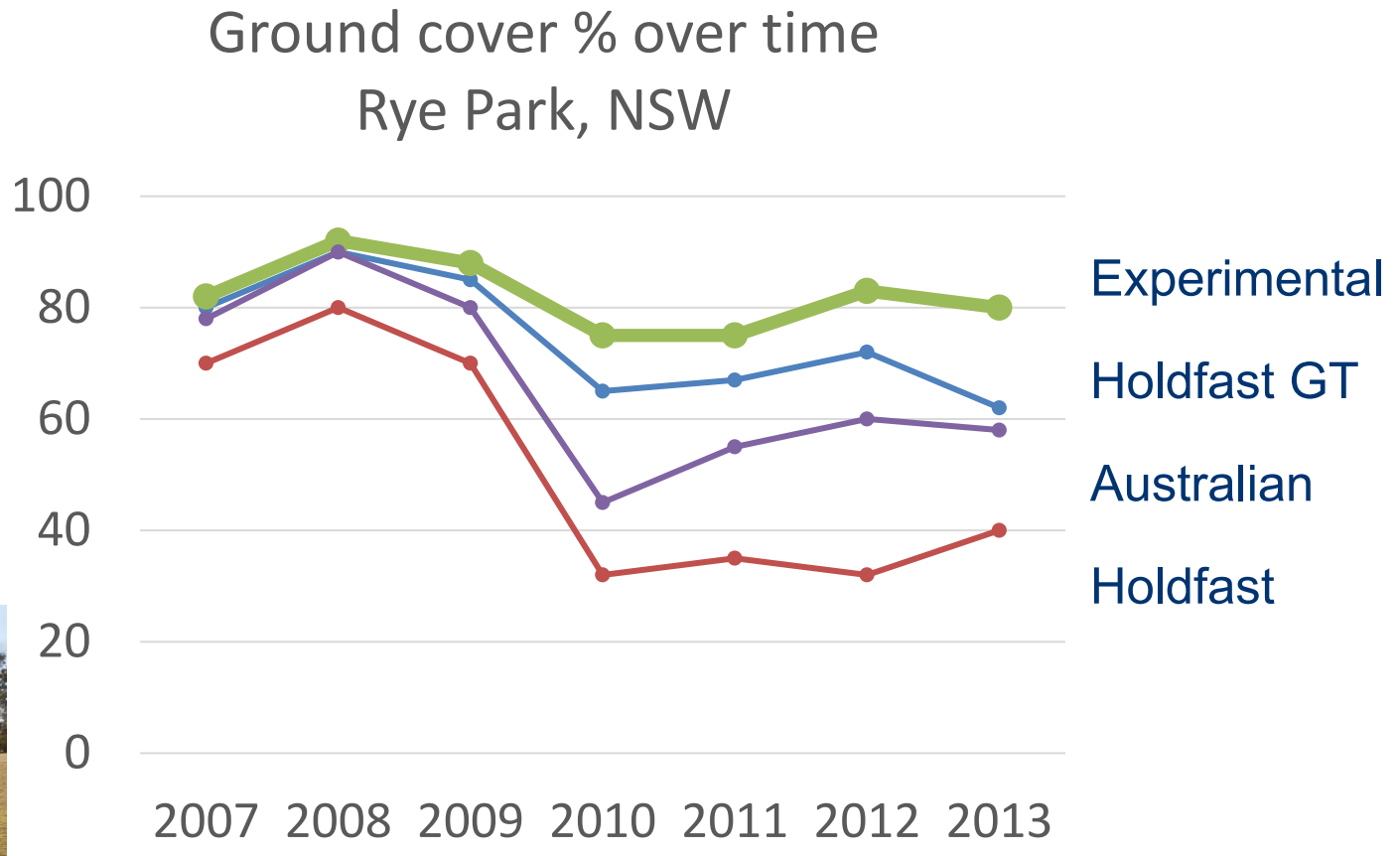
CSIRO – Phalaris

- CSIRO have a proud history of commercially consequential innovation in Phalaris; but have now elected to leave Phalaris breeding to the private sector.
- CSIRO and PGW Seeds partnered to utilise Phalaris germplasm and expertise after a competitive tender process.
- Breeding at scale recommenced in 2019.
- Exciting to leverage off the strong foundation build by CSIRO over 70 years.
- Critical to compliment annual legume breeding
- **Challenges** – what causes cardiac and PE-like sudden death?

Recent investments

CSIRO – Phalaris

- Persistence under challenging climates is a central pillar of our breeding program.
- Results from Rye park, NSW demonstrate further progress is likely.



Data from Culvenor and Simpson 2015

Experimental line bred by Richard Culvenor

Cocksfoot for increasingly stressed environments

Leveraging available natural diversity

- Only a fraction of the diversity available within cocksfoot had been exploited.
- Investment in understanding the extent of natural diversity via the establishment of a phylogenic frame work (PGW and AgResearch Collaboration).
- Systematic exploitation of the breadth of available natural diversity.
- 20 year + program, long-term investments require a stable investment environment.

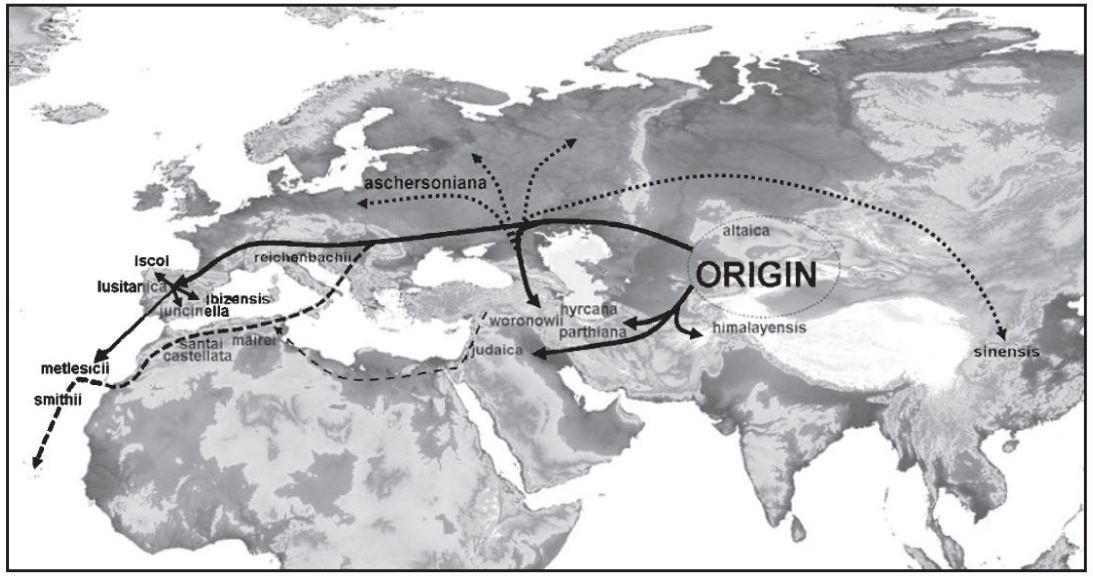


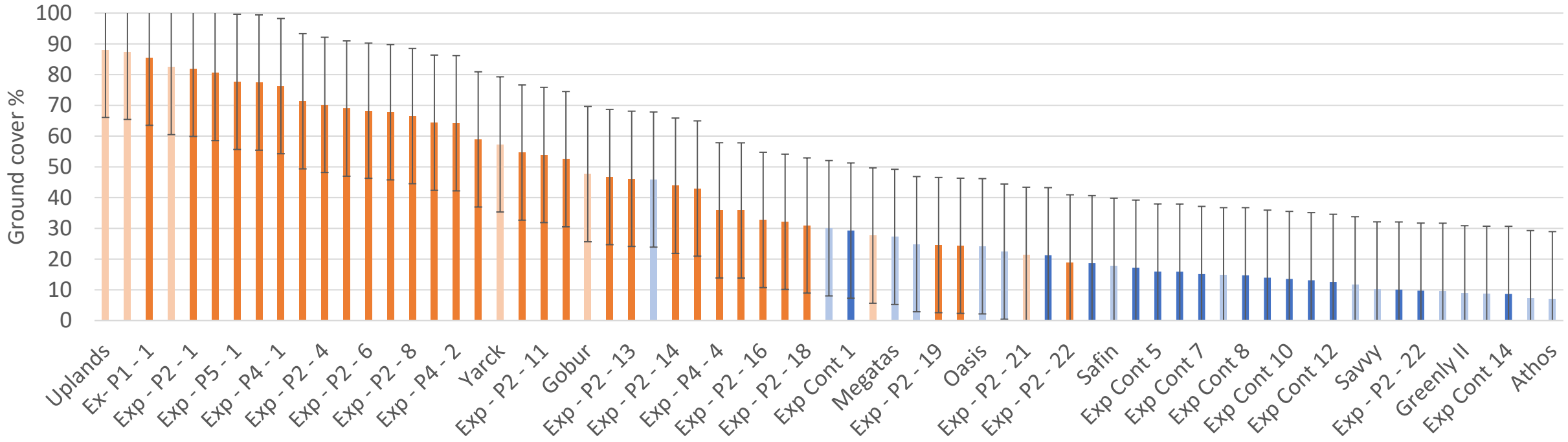
Fig. 2. Probable migration routes of diploid *Dactylis* based on molecular results of Stewart and Ellison (2011): —, before the last glaciation; – – –, North Africa during the glaciation; - - -, post-glacial, Northern Europe and China.

From Stewart and Ellison 2014

Cocksfoot for increasingly stressed environment

Leveraging available natural diversity

- Multiple long term trials in 350 mm summer dry Australian environments.
- Data indicates progress, but a long way to go. Future looks bright, but…. will they yield?

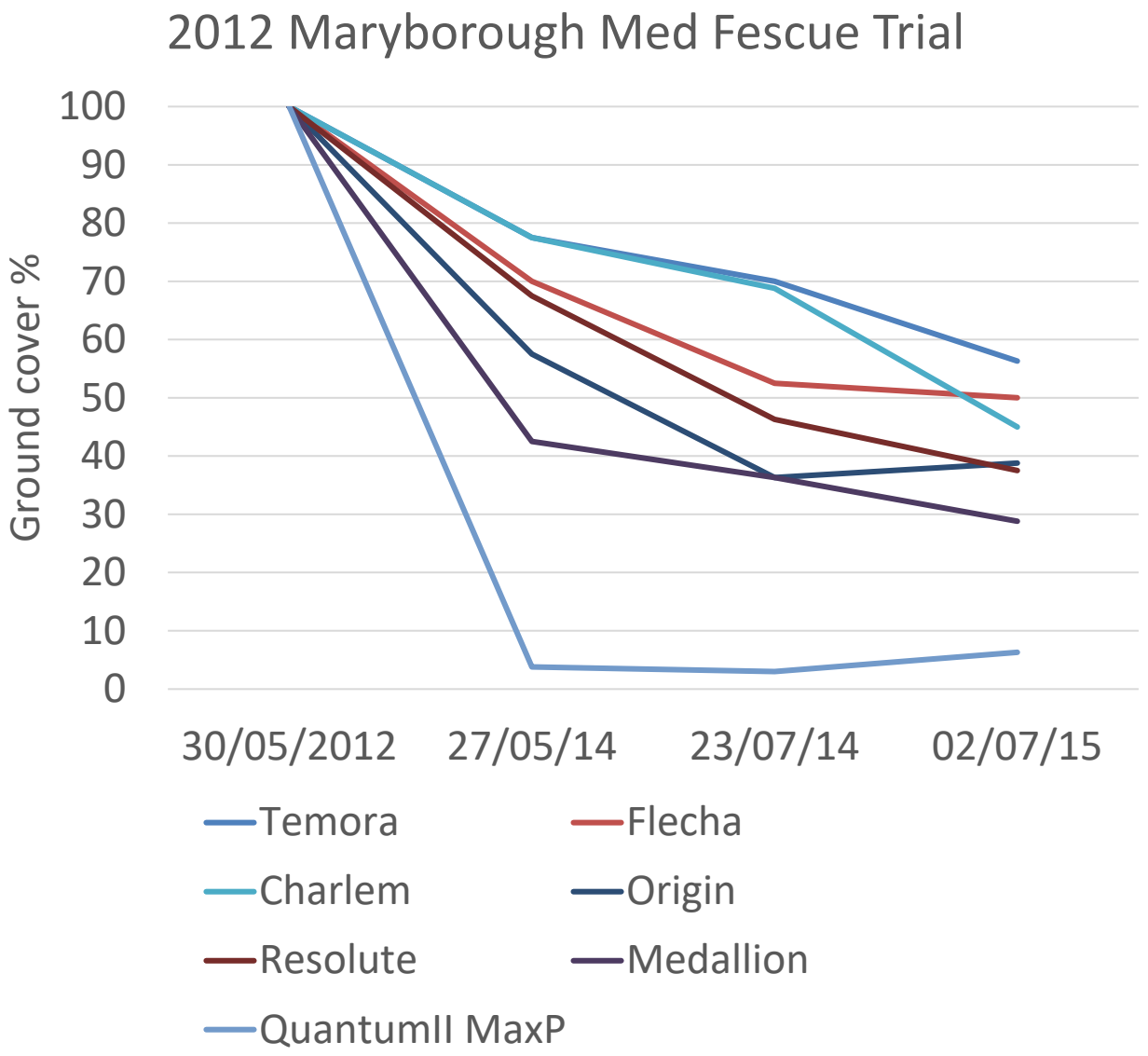


- Will farmers adopt the technology? PTN should evolve to consider persistence.

Mediterranean tall fescue

Perennial, drought tolerant, nutritious and non-toxic

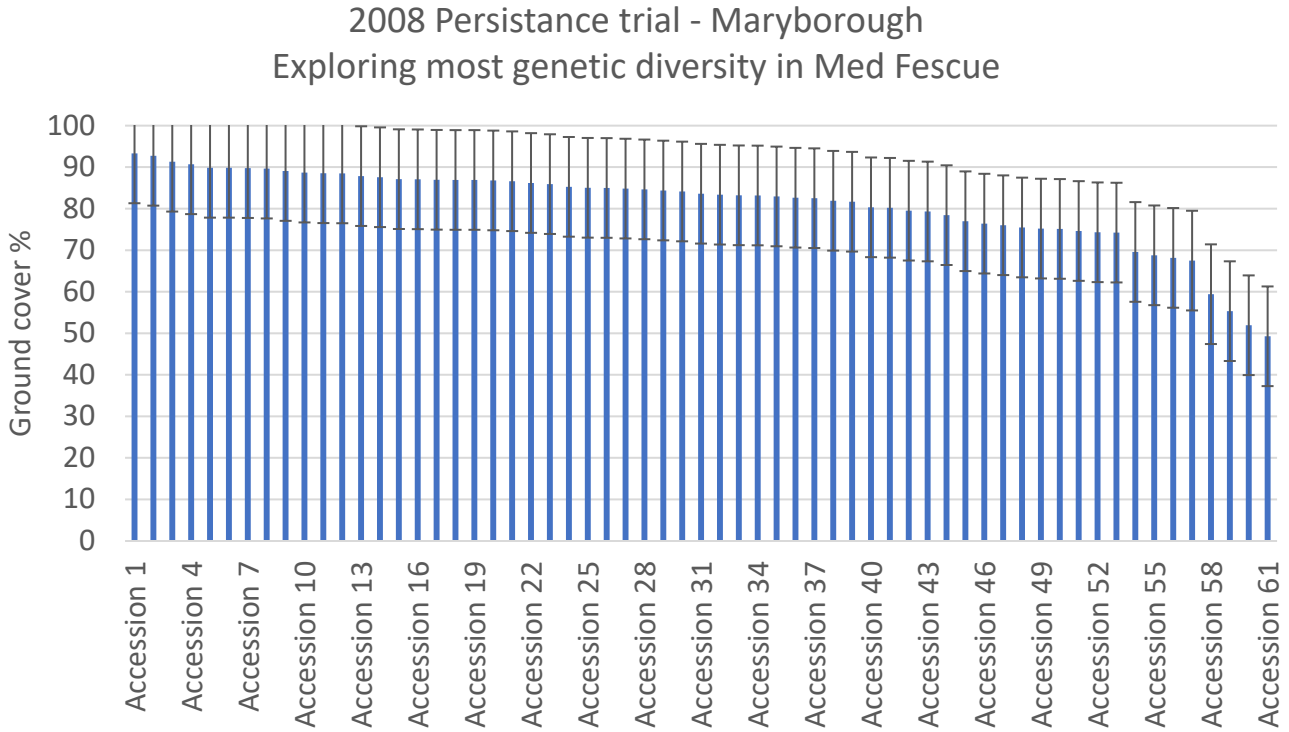
- The main Phalaris alternative?
- Astute farmers appreciate differences between cultivars and seek those that do well in their environments; but for many consider Med Fescue a ‘bag filler’ and are indifferent to variety.
- PTN educating farmers about persistence differences is critical to incentivising innovation.
- Spring management is the number one impediment to adoption of this species. Those that understand it plant large areas.
- Great to see Perenial Pasture Systems tackle a project on its system fit.



Mediterranean tall fescue

Perennial, drought tolerant, nutritious and non-toxic

- 2005-2020 - PGW Seeds have explored most diversity in available Med fescue germplasm in projects with our AgResearch JV. Trialling in multiple sites and years.
- Like cocksfoot, large diversity for persistence under drought conditions.
- Germplasm selected to add diversity for traits of value to Australian farmers and ensure products can handle future climate stress.
- Long term programs underway.



Perennial ryegrass – future ready technology from 10X investment.

North West Spanish germplasm with effective animal safe endophytes

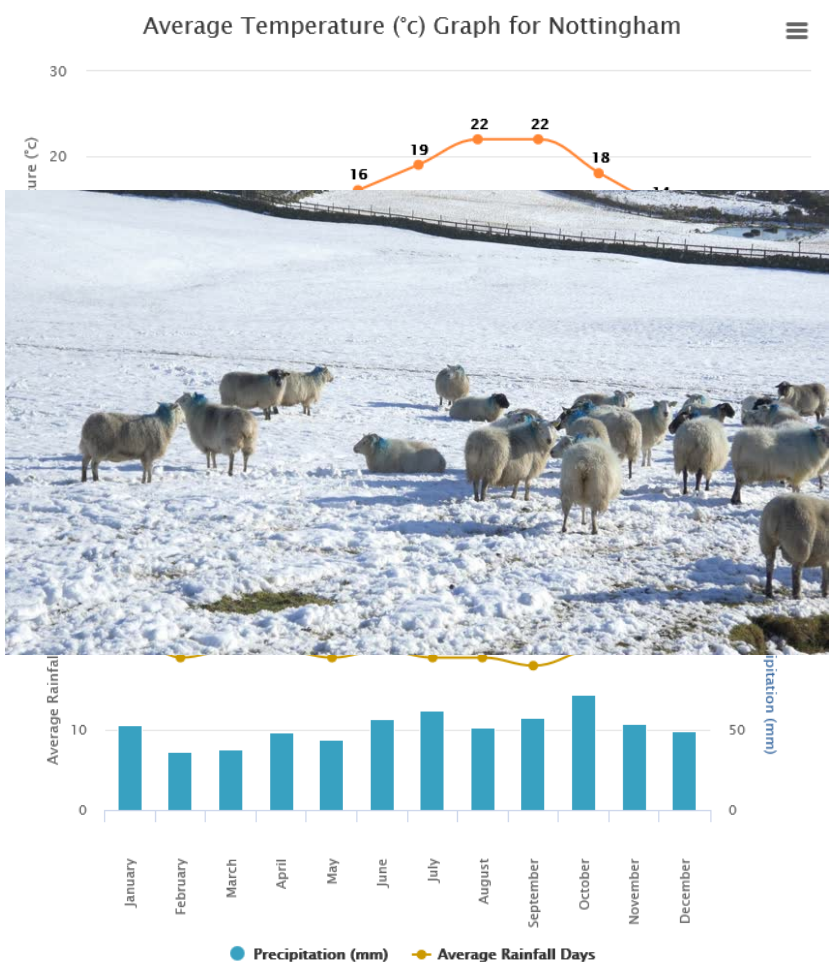
- Demonstrates what can be achieved when a large group of technology hungry farmers demonstrates a willingness to pay for superior technology.
- Adoption of this technology probably sits it ~30 % in the Australian sheep/beef market…

AR1 endophyte V AR37 endophyte

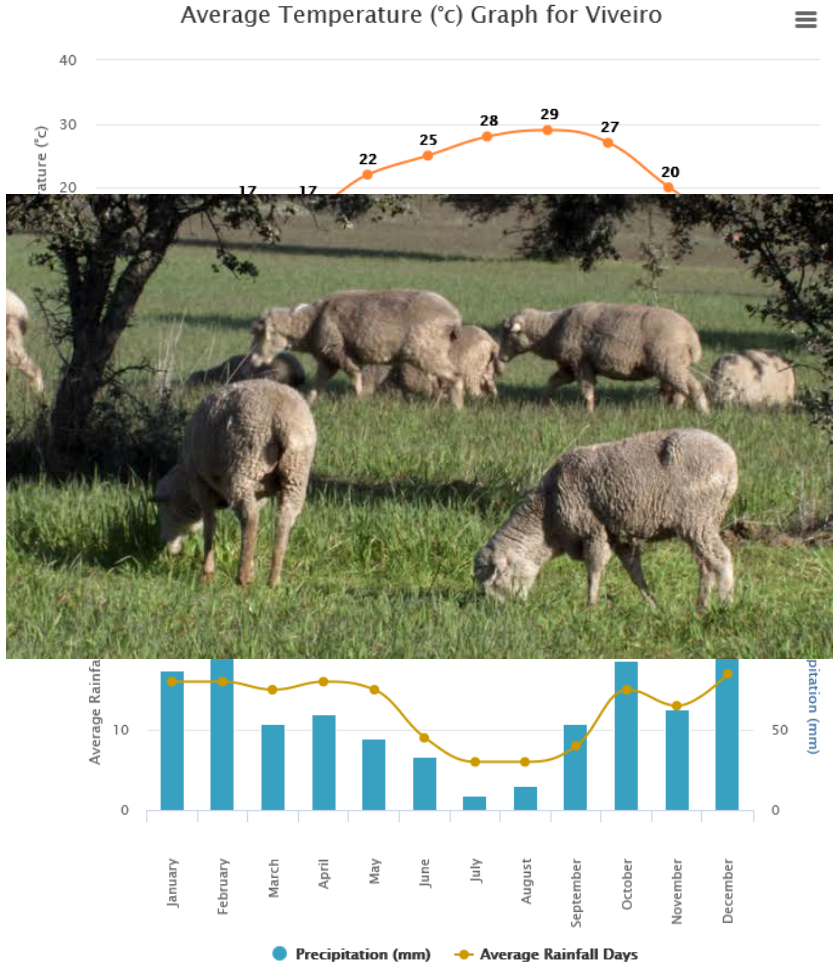
Autumn 2020, Terang, Victoria

Genetic origin of ryegrass drives winter growth

England



North West Spain



Seed Force Joule AR1 Halo AR37

Ballarat (June 13)

Base AR37 Camel

Lismore (Aug12)

Victorian SE Base AR37

(Ballarat – Jul12)

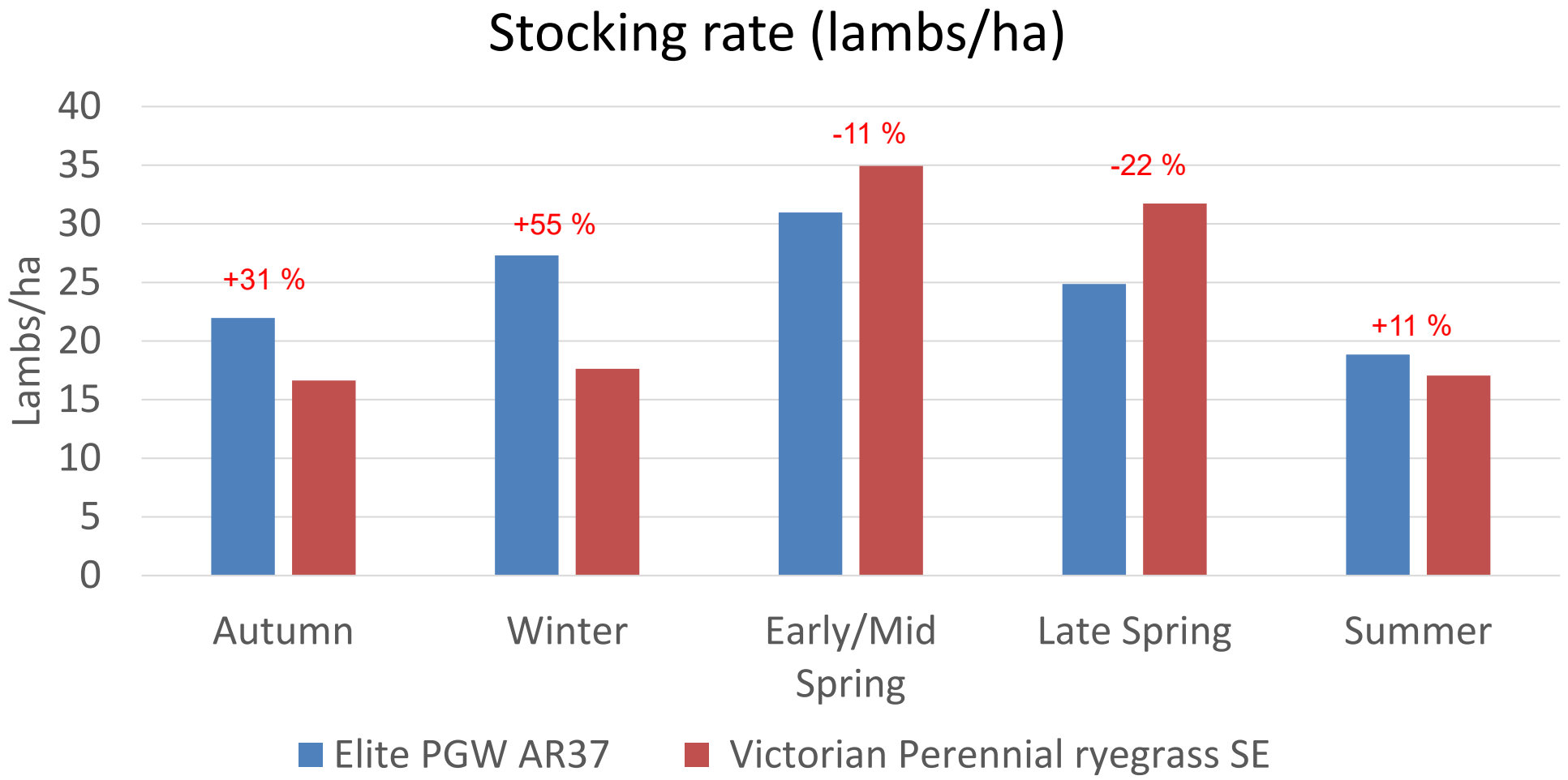
Elite perennial ryegrass
What is it worth 'on farm'?

- 3 year trial commenced 2014 comparing two varieties
- Outsourced to independent consultant in 2017 for further proof of concept testing in Hamilton, Victoria
- Repeated at 2 more locations in 2019

Elite perennial ryegrass
What is it worth 'on farm'?

	Elite cultivar AR37	Victorian Standard Toxic endophyte
Origin	North West Spain - well adapted to Australian conditions (Base AR37, Halo AR37)	England – brought out to Australia in the mid 1800's
Ploidy	Tetraploid	Diploid
Maturity	Late (+25 days)	Early to mid (-10 days)
Endophyte	AR37	Standard Toxic
Rust Susceptibility	Good tolerance	Very susceptible
Sowing rate	20/kg/ha	20/kg/ha
Price of seed	~ $12/kg	~ $4/kg

Increased out of season yield – autumn/winter



Increased late spring/summer forage quality Early December 2015

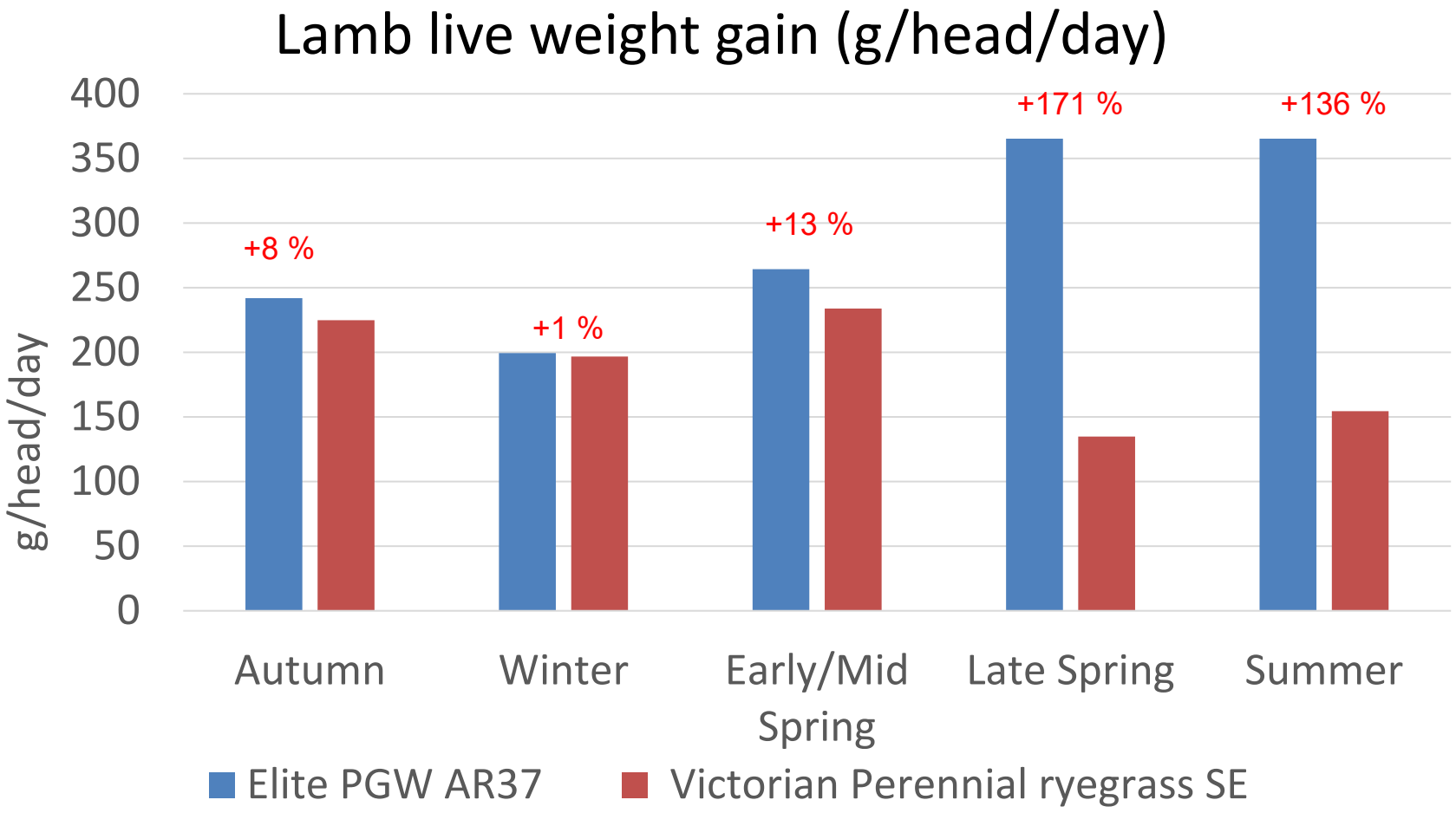
Victorian (or similar) Perennial Ryegrass
7.9 MJME/kg DM
9.3 % Protein

Elite PGGW Perennial ryegrass with AR37
9.8 (+1.9) MJME/kg DM
17.9 (+8.6) % Protein

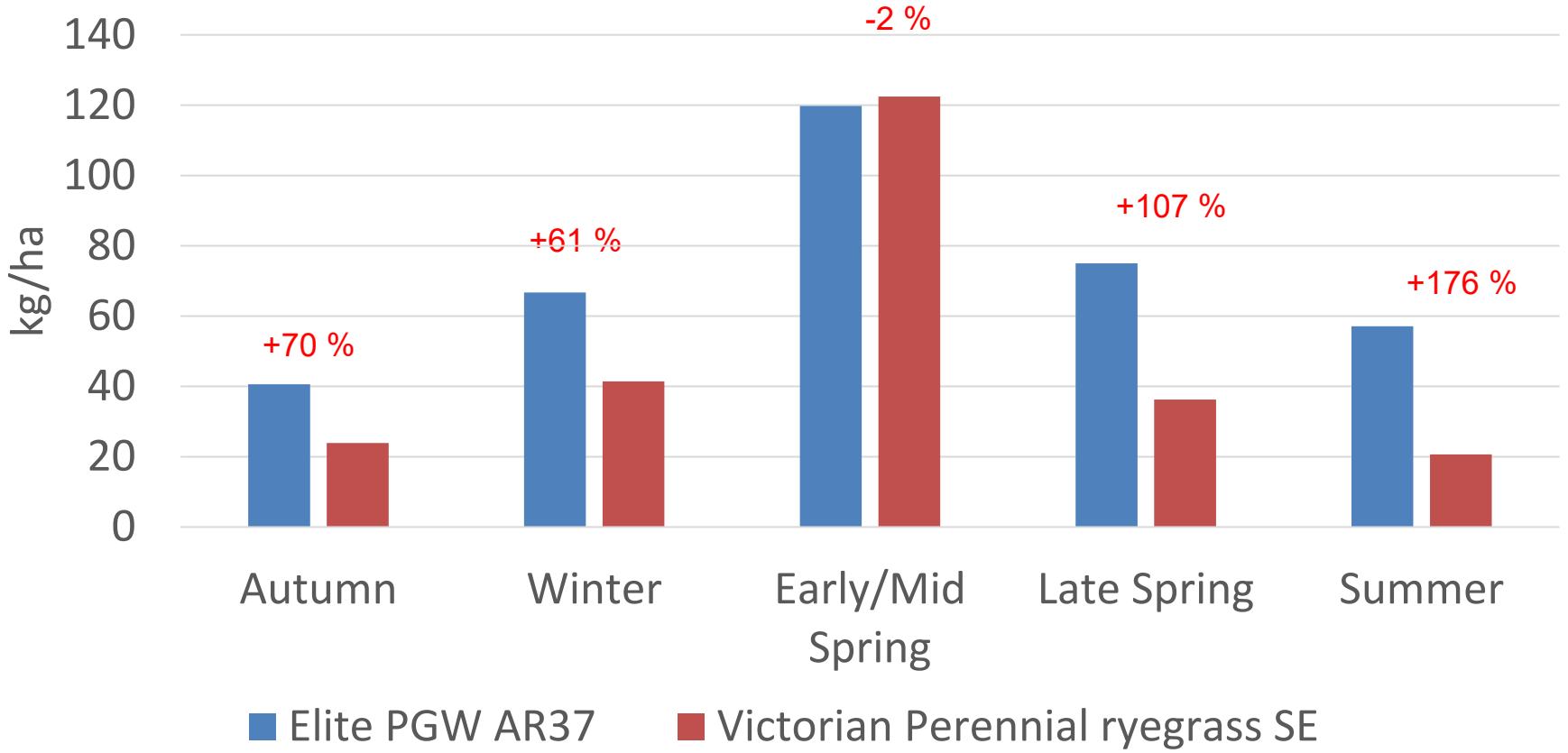
Late December 2015

Victorian Perennial ryegrass SE

Elite Perennial AR37


Lamb live weight gain (g/head/day)
400
350
300
250
200
150
100
50
0
g/head/day
+8 %
+1 %
+13 %
+171 %
+136 %
Autumn
Winter
Early/Mid Spring
Late Spring
Summer
Elite PGW AR37
Victorian Perennial ryegrass SE

Seasonal carcass weight production (kg/ha)



$600-800 more profit per hectare per year compared to status quo.

On-farm concept extension

- Managed by Meridian Agriculture
- 7.5 ha paddocks
- Hamilton Vic, sown 2016
    - Elite perennial ryegrass with AR37
    - Victorian perennial ryegrass toxic standard endophyte
- Sub clovers sown with ryegrass
- Twin bearing ewes stocked in early winter
- Lambs followed through to slaughter

12th Jan 2018

13th March 2018

Base AR37

Victorian SE

15th May 2018

Victorian SE

Base AR37

Results

	Total carcass weight (kg/ha)	$/kg	$/ha
Elite (Base) AR37	168	6.8	1,142
Victorian SE	69.7	6.8	474
Difference	**+ 98.3**	**-**	**+ $668**

- Annual profit increases of $700/ha
- Seed cost a one off additional $130
- 2 million ha of Australia is Perennial ryegrass
- Adoption of modern technology would be ~30 %
- The problem here isn't technology, it's adoption, and the upside is huge.

Summary – ideas to push us forward

- Long-term customer focused collaborations (international and local) have driven success.
- Most marketable species have international breeding programs accessing most diversity of available trait expression.
- Current investment in plant breeding is consequential and sustained; but investment at a species level is proportional to likely future market size and consumer's willingness to pay for a better solution.
- Governments left forage plant breeding to 'the market' without assuming responsibility for a functional market place:
  - 'Information market failure' hobbles pasture plant breeding investment, needs solving with sustained public (RDC) investment in market place transparency initiatives like MLA's Pasture Trial Network and DA's FVI.
  - Intellectual property rights (PBR) don't function as intended (if at all) for out-crossing species, with innovation rapidly misappropriated by cosmetic breeding.

Liebig's law of ~~the minimum~~ forage plant genetic gain

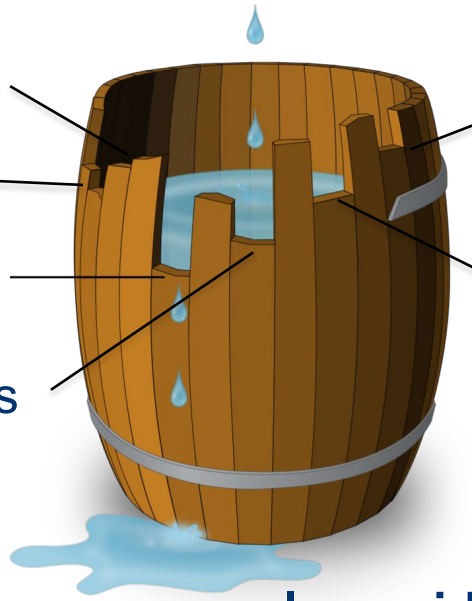
Innovation is not limited by total resource availability but by availability of the scarcest resource.

4. Plant science and farm systems research

3. Number of profit focused farmers per market segment

1. Information market failure/marketplace transparency

2. A lack of intellectual property rights for out-crossing species and over the fence trading of self-pollinated species



6. Human capital

5. – omics and modelling

In my day to day job allocating plant breeding and testing resources along side others, I see no evidence to contradict this theory.

What are the implications for efficient use of levy and tax payer resources if this is true?

Suggestion: a PhD (in economics not science) to investigate drivers of plant breeding investment and observed genetic gains. RMIT have an excellent group of innovation economists…