Breeding Climate Change Resilient Pastures

Prof Kevin Smith

THE UNIVERSITY OF MELBOURNE

FACULTY OF VETERINARY & AGRICULTURAL SCIENCES

Some Inconvenient Truths

- Plant Breeding is Slow
- Plant Breeding is Big
- Plant Breeding is Expensive
- Selection Environment
  - Influences response
  - As real as possible
- You get what you select for (usually)
- Market realities

Typical Plant Breeding Program

- 10 – 30 years
  - Define traits
  - Measure
  - Select
  - Cross
  - Evaluate
  - Adoption

Breeding Programme Outline
Perennial Ryegrass

Year 1	X F_1 Seed	50 crosses
Year 2	F_2 Seed production	50 lines
Year 3/4	Selection under grazing	120,000 plants
Year 5	Clonal rows	2000 rows
Year 6	Seed production	50 varieties
Year 7-9	Multi location small plot trials	50 varieties
Year 9-11	Large plot trials	6 varieties
Year 12	Potential Variety Release Farmer Demonstration Trials	1? variety

Predictions

- **Lower Yield**
- **Changed Seasonal Growth Patterns**
- **Reduced Digestibility**
- **More Variability**
- **Change to Crops with Less Yield Volatility**

- **Displacement of Meat Production Systems**
  - Marginal Environments
  - More Abiotic Stress
  - Current Species Poorly Adapted

- **These Changes are Already Creating Challenges for Breeders**

Land Use Change - Argentina

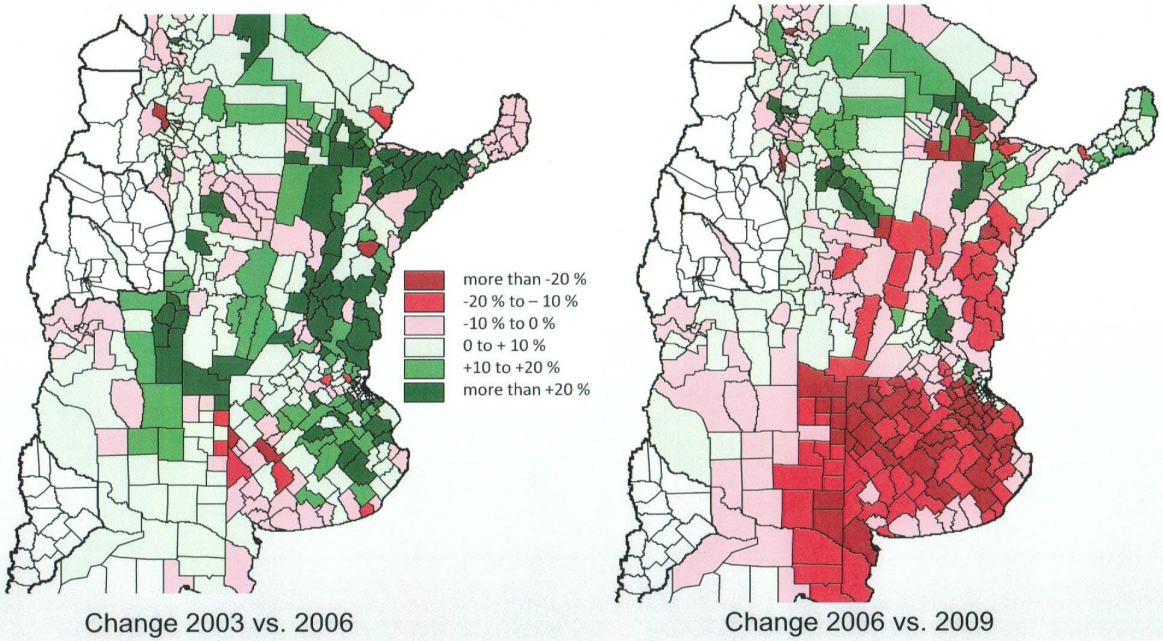
- The Humid Pampas
  - 6 Million Ha
  - 2/3 Argentine Economy
- Home of the Gauchos
  - Traditional cattle farmers
  - 98.4kg beef per annum (1958)
  - 3rd highest exporter of beef

Land Use Change Argentina

- Cattle herd dropped by 12M in 5 years
  - 58M to 46M
- No longer in the top 10 exporters
- 30,000 farmers left industry
- Beef consumption per capita 53.4kg
- Soy bean, soy bean, soy bean…….

Land Use Change Argentina

Change of cattle stocks in Argentina



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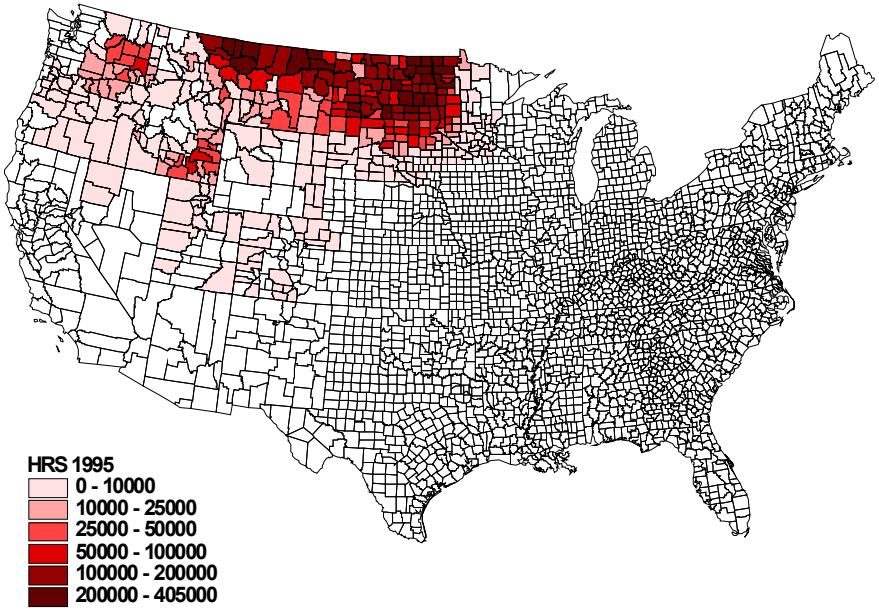
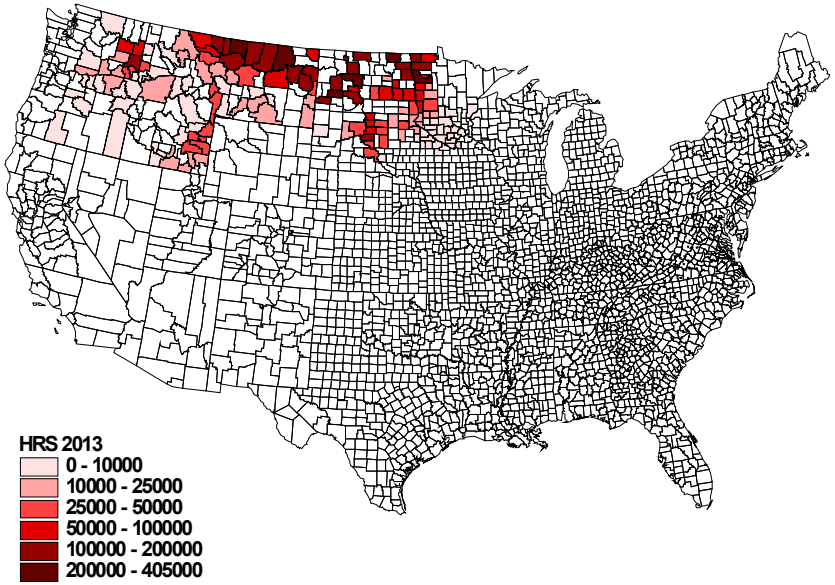
Land Use Change USA

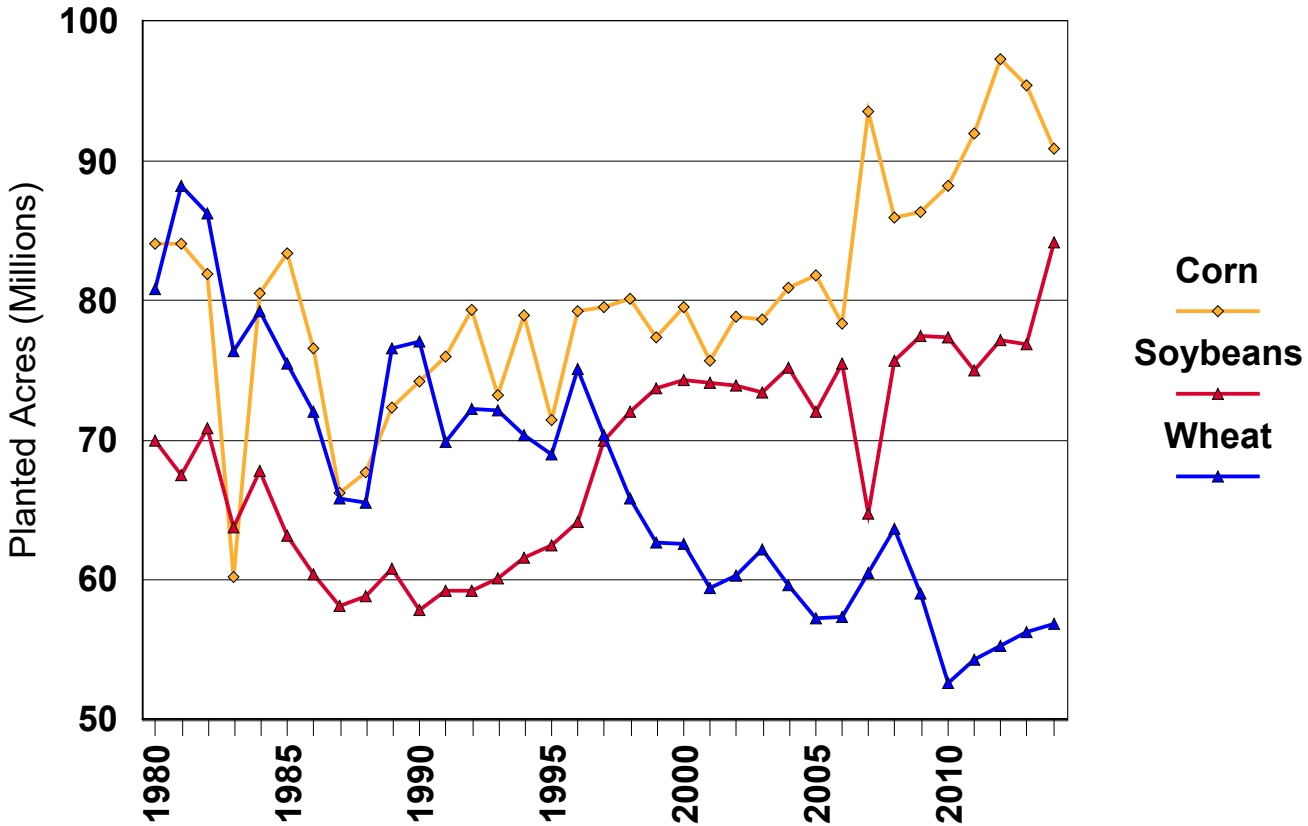
HRS Wheat Planted Area 1995



HRS Wheat Planted Area 2013



Land Use Change USA



Challenges for Breeders

- Water Availability
- Temperature Extremes
- Changed Pest and Disease Pressures

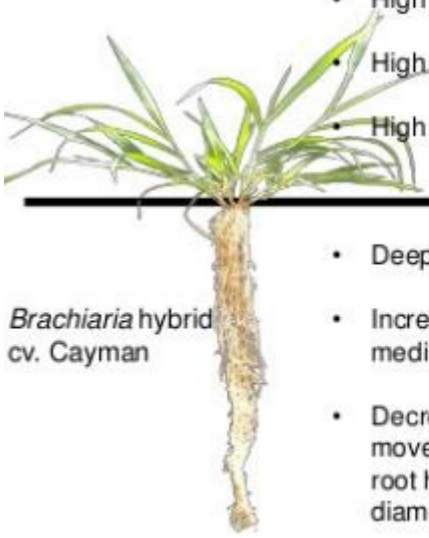
- Maintain and/or Increase Yield
- Maintain Functional/Nutritional Quality

- Climate Resilient Crops

Drought Tolerant Grasses

- Seasonal yield
  - Winter, Summer, Autumn
- Persistence
  - Production and survival over time
- Disease and pest resistance
  - Rust, viruses, nematodes
- Forage quality
  - Digestibility, WSC, protein
- Endophyte toxins

Drought



Brachiaria hybrid cv. Cayman

Drought resistance (avoidance/tolerance)	Assessment methods
• High stomatal conductance	• Leaf gas exchange/porometry • Infrared thermometry • Carbon isotope discrimination???
• Delayed leaf senescence	• Chlorophyll content (SPAD)
• High quantum yield	• Chlorophyll fluorescence
• High osmotic adjustment	• Relative water content in leaves
• High transpiration efficiency	• Weighing each container on a regular basis
• Deep root systems	• Vertical distribution of roots in soil cylinders (120 cm height x 22 cm width; 80 cm height x 7.5 cm width)
• Increased root length density in medium and deep soil layers	
• Decreased resistance to water movement from soil by increasing root hair growth and xylem diameters	• Micrographs from root cross sections

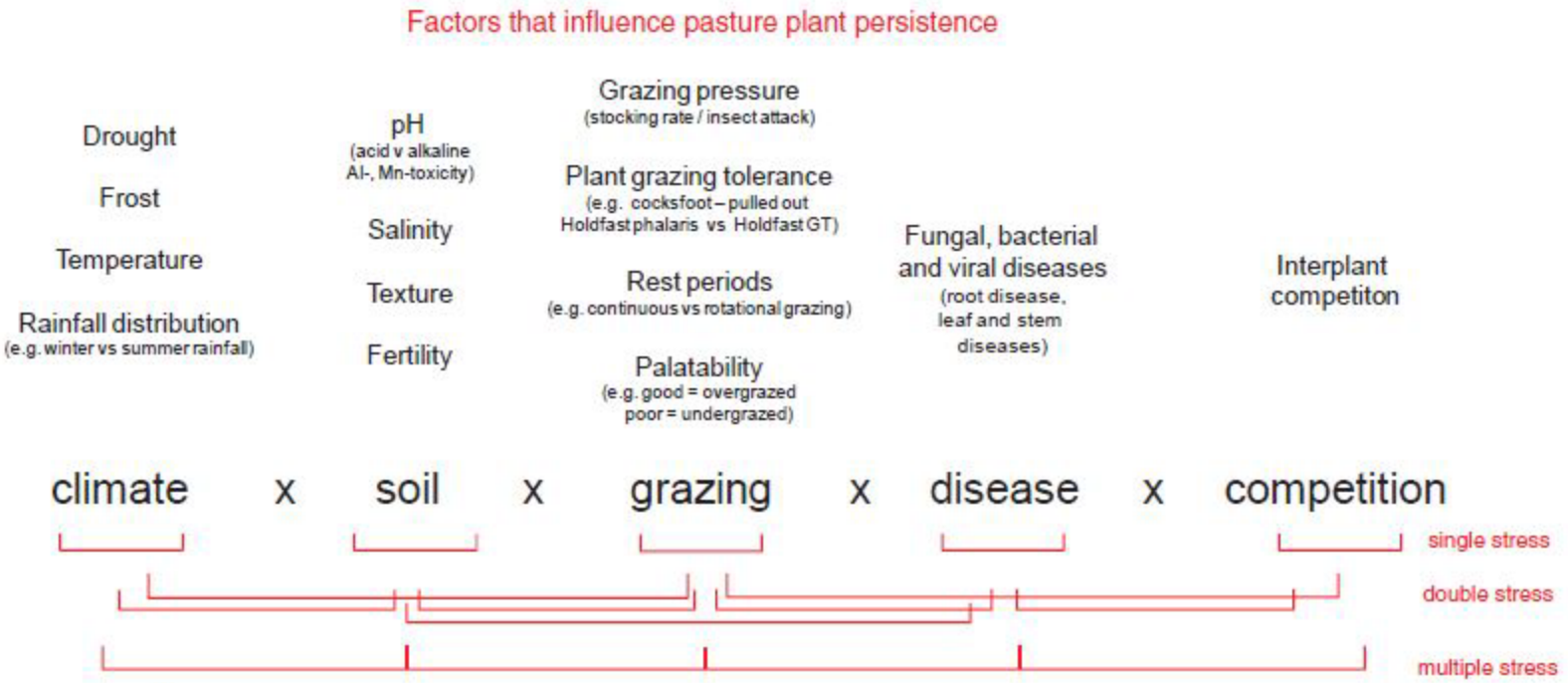


Fig. 1. Stresses affecting pasture persistence in southern Australia emphasising the potential for interaction between stresses.

Paspalum

- C4 grass
- Drought tolerant
- Heat tolerant
- Flood tolerant

- A great replacement for ryegrass

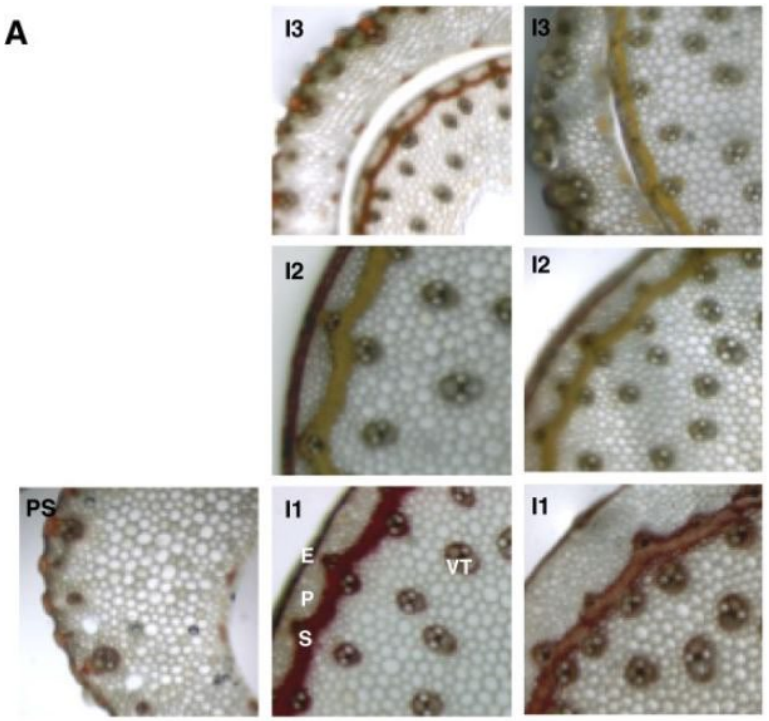
- But ……

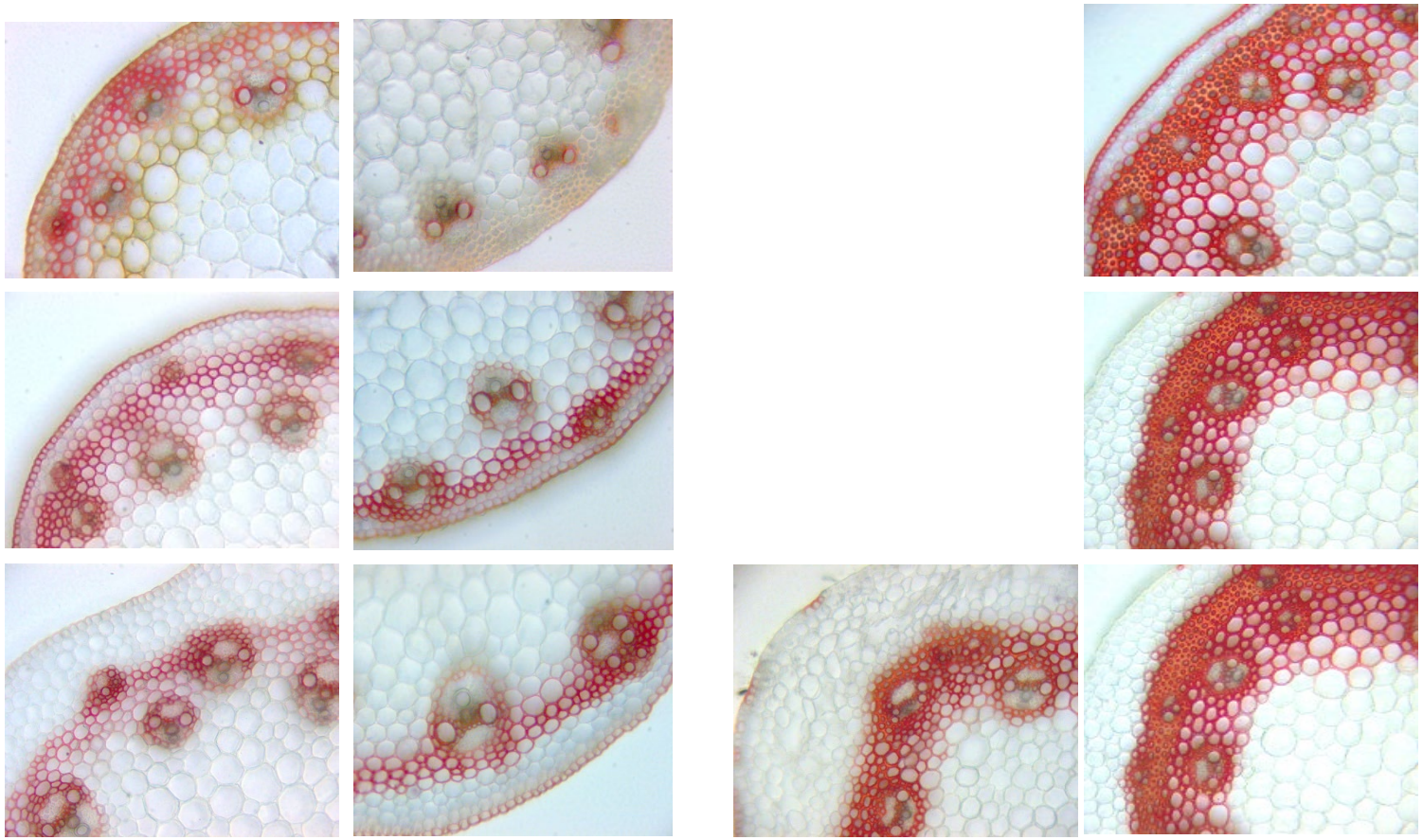
C4 grasses are less digestible

- Lignin
  - Cell walls
  - Vascular tissues

- Lower animal performance

- Increased methane production





Ubi::dsRNAi-CCR1-3 Ubi::dsRNAi-CCR1-2 Ubi::1-SST Control

Improved Forage Quality

- Pathway well characterised
- Exemplified in many species
  - C3, C4, Legumes
- 5 - 15% unit increase in DMD

- Delayed leaf senescence, enhanced lipids, frost tolerance

New Technologies

- Genome Editing
  - Could provide this opportunity free of the regulatory burden that applies to GM crops
  - Do you have commercial freedom to operate?

- Genomic Selection
  - X3 increase in rate of gain
  - Set up costs
  - Genomic and Phenomic Characterisation

Concluding Remarks

- We can do things that were not possible 20 years ago.
- Plant introduction/new species?
- Understand the ‘market’
- Is there an option already out there?
- Partnerships

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An idea that is not dangerous is unworthy of being called an idea at all.