# The seven wonders of plants that may change our hill country

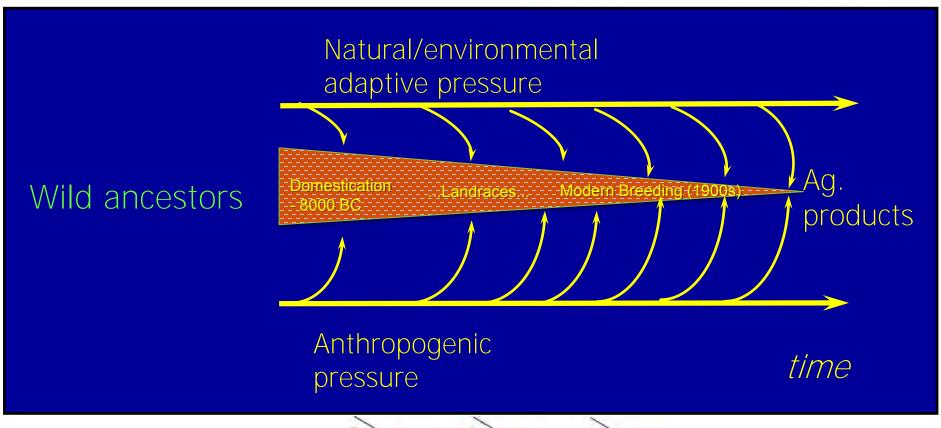


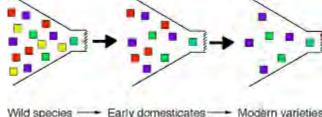
#### KIOUMARS GHAMKHAR

DIRECTOR
MARGOT FORDE FORAGE GERMPLASM CENTRE,
FORAGE IMPROVEMENT, AGRESEARCH



### Agriculture: fast and disruptive evolution



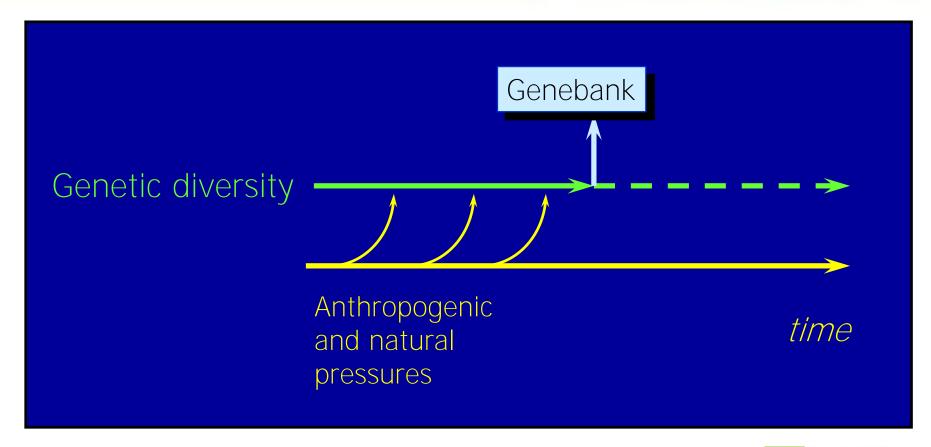






- 2,000 genebanks worldwide, 7 m accessions
- These are strategic global assets
- Safety net against the loss of valuable germplasm
- Conserve rich gene pools and help feed the world
- Priceless genes can be lost, even if only collection but no characterisation, regeneration and maintenance.

# Ex situ conservation: an evolutionary freeze





# Margot Forde Forage GC Holdings

- 113,000 populations of forage species
- Over 2,200 different species
- Sourced from over 100 different countries
- 390 named fungal endophyte populations
- Oldest population is from 1940
- Over 5000 wild populations collected in the last 5 years





#### MARGOT FORDE FORAGE GERMPLASM CENTRE

#### **Database**

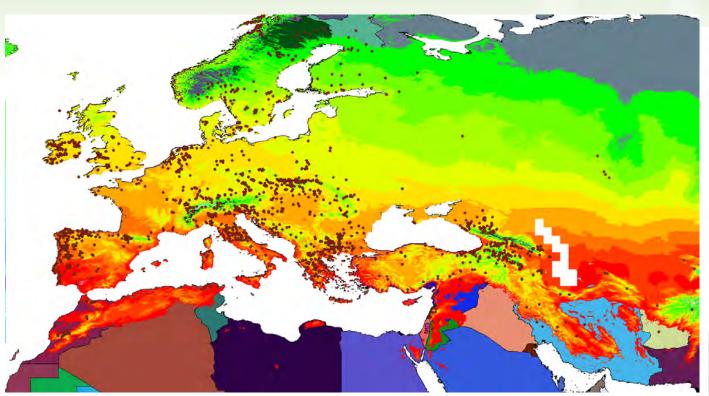
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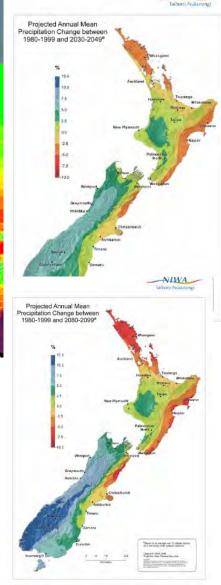
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#### **Current and future climate match studies**







### **Preparing for future**

#### **Change:**

- Incremental: doing better of what we are doing now (next 10 years),
  - New cultivars of current species
  - Hybrids of current and new species
- Transformational: meaning something has to give, change and there are consequences (next 10- 15 years).
  - Novel species/practice
    - Subterranean clover
    - Biserrula
    - Woody/hardy legumes



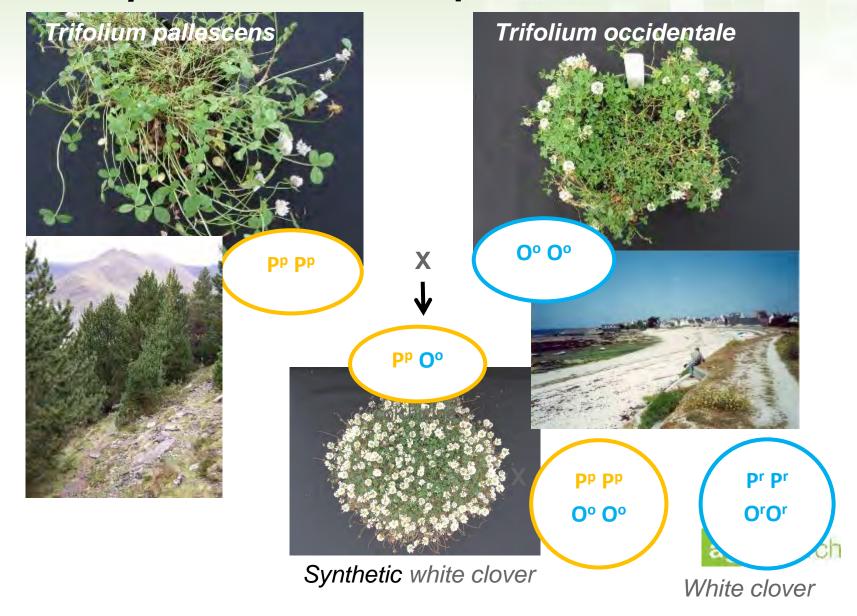
### Trifolium uniflorum







#### Trifolium repens is a natural alloploid. RRR'R' or Pr Pr OrOr



### Caucasian clover (T. ambiguum)

- Suited to high altitude
- More drought tolerant than white clover
  - Much deeper root system
- Six cultivars released by CSIRO in 1970 83
  - Seed production issues
- cv. Kuratas released in 2009 to overcome this issue





Rhizomes on cv. Kuratas

### **ALLOPLOID BREEDING**

#### **Present**

Hybrids of white clover with T. uniflorum and T.occidentale are entering mainstream breeding.

#### Future.

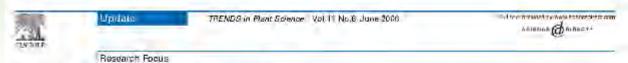
Great potential to screen within the wild related species for traits that white clover does not have and introduce them through Embryo Rescue





#### Same model for perennial ryegrass



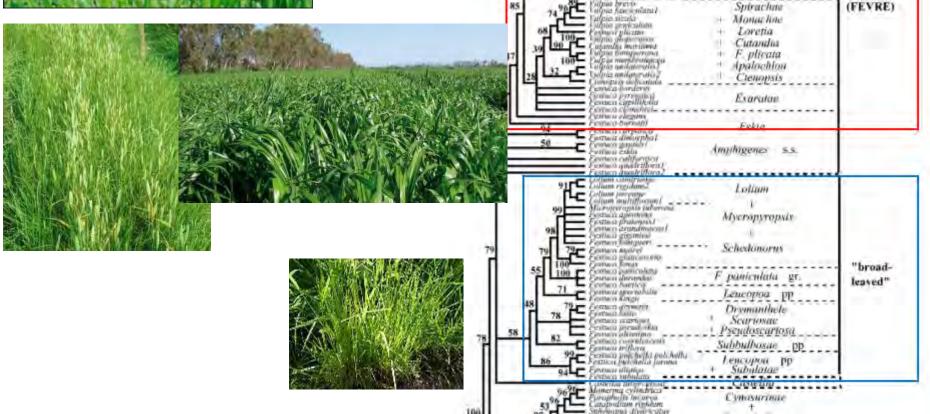


#### Wild sex in the grasses

#### Jason A. Able 1 and Peter Langridge2

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### Problem definition and analysis

- Identification of agronomic need or new opportunity
  - New agro-ecological niches that are not filled with existing species
  - New or changing farming systems that existing species are not well adapted to
- Setting broad plant improvement goals and objectives



#### #1 Subterranean clover (Trifolium subterraneum)

- Most widely sown species in Australia 29 mill. ha (Hill and Donald)
- •ssp. *subterraneum* For well-drained soils
- •ssp. *yanninicum*For poorly drained soils
  Both adapted to soil pH<sub>Ca</sub> 4.5-6.5
- •ssp. *brachycalycinum*For cracking clays and stony soils

pH<sub>Ca</sub> 6.0-9.0





Source: Nichols 2013 and DAFWA website

### Subterranean clover core :97 out of 10,000



### Screening sub clover for hardseededness

#### Plants:

- Parents of two F2 populations (360) + 16 sets of parents (32)
- 34 cultivars

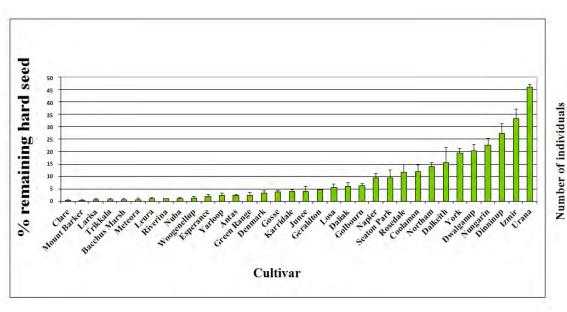
Character	Population 92S0	05 (size: 180)	Population 92S80 (size 180)		
	Denmark	DGI007	Woogenellup	Daliak	
Flowering time (days)	142	86	130	98	
Hardseededness (0-10)	2	8	1	7	

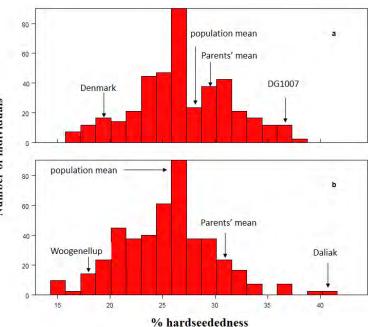


Cultivar	Subspecies	Н	FT
		S	
Antas*	brachycalycinum	4	134
Bacchus Marsh*	subterraneum	1	132
Clare	brachycalycinum	2	130
Coolamon*	subterraneum	7	132
Daliak*	subterraneum	7	98
Dalkeith	subterraneum	9	97
Denmark	subterraneum	2	142
Dinninup*	subterraneum	7	114
Dwalganup*	subterraneum	7	83
Esperance	subterraneum	5	120
Geraldton	subterraneum	8	93
Gosse	yanninicum	4	126
Goulburn	subterraneum	6	143
Green Range*	subterraneum	4	128
Izmir	subterraneum	10	78
Junee	subterraneum	6	126
Karridale	subterraneum	2	139
Larisa	yanninicum	2	140
Leura	subterraneum	2	147
Losa*	subterraneum	5	97
Meteora	yanninicum	6	148
Mount Barker	subterraneum	1	137
Napier	yanninicum	6	140
Northam	subterraneum	7	78
Nuba	brachycalycinum	4	146
Nungarin*	subterraneum	10	77
Riverina	yanninicum	4	119
Rosedale	brachycalycinum	8	114
Seaton Park	subterraneum	6	110
Trikkala	yanninicum	2	112
Urana	subterraneum	10	104
Woogenellup	subterraneum	1	130
Yarloop*	yanninicum	2	110
York	subterraneum	9	110
	000.0		

#### Results

- Multi-gene trait (relatively normal distribution and evident grouping)
- Population 2 more tendency towards softseededness
  - Softseedness a dominant trait.
- Broad range of hard or softseededness available

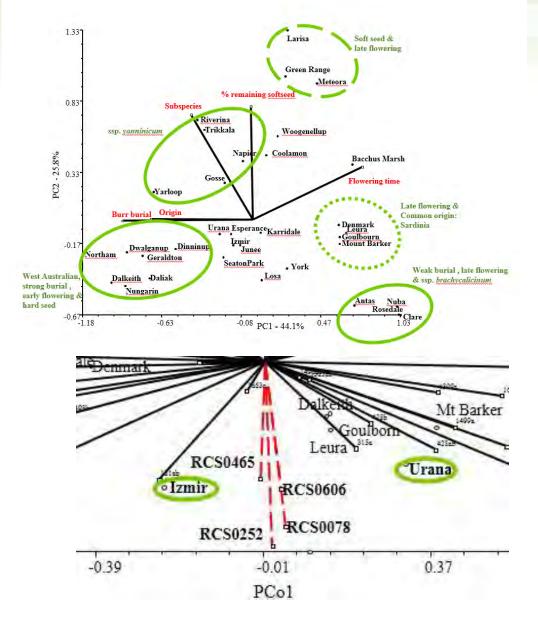




### Analysis of sub clover for hardseededness

- 34 cultivars
  - Flowering time
  - Burr burial
  - Origin (latitude and longitude)
- 2. Two mapping populations
  - Flowering time
  - Isoflavone content
  - •
  - QTLs identified
  - Candidate markers to be tested

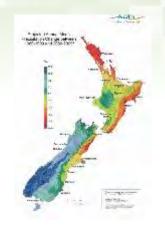
 Also a core collection of 97 accessions now available

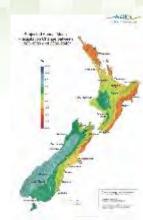


CORSE-DU-SUD Strait of Bonifacio

# Current and future climate match studies







# Trifolium subterraneum

cv. Goulburn

cv. York

cv. Leura

cv. Denmark

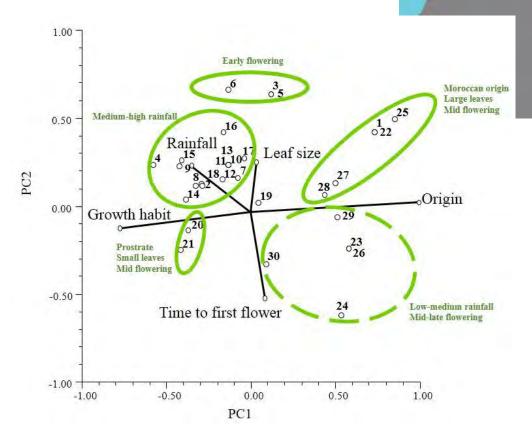


## # 2 Biserrula (Biserrula pelecinus L.)



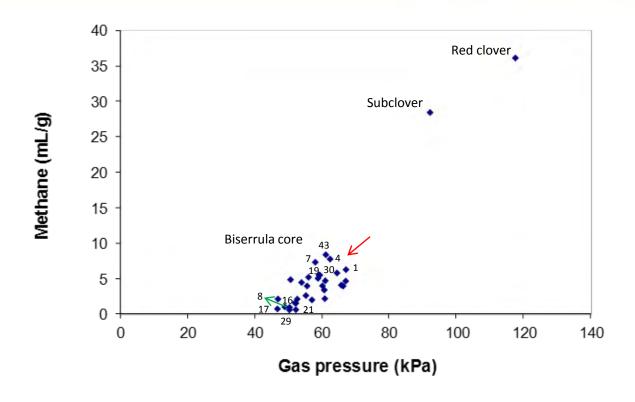
### Analysis of biserrula for relevant traits

- 30 accessions out of 280
  - Flowering time
  - rainfall
  - Origin (latitude and longitude)
  - Growth habit



- 2. Methanogenesis
- Lowest among the low range
- 3. Develop a mapping population
- Identify genes/QTLs for traits of interest

#### Methane mitigation



Methanogenic profile of biserrula and control species



### #3 Annual clovers for mid-high rainfall

- Rose clover
- Arrowleaf clover
- Purple clover



#### #4 Annual clovers for low-medium rainfall

- Gland clover (*T. glanduliferum*)
- Eastern star clover (*T. dasyurum*)
- Bladder clover (*T. spumosum*)



Gland clover



Eastern star clover



Bladder clover



# #5 Annual medics (Medicago species)

- Adapted to neutral-alkaline soils
  - Barrel medic (*M. truncatula*)
  - Strand medic (*M. littoralis*)
  - Disc medic (*M. tornata*)
  - Snail medic (*M. scutellata*)
  - Gama medic (*M. rugosa*)
  - Button medic (*M. orbicularis*)
- Acid tolerant species
  - Burr medic (*M. polymorpha*)
  - Murex medic (*M. murex*)
  - Sphere medic (*M. sphaerocarpos*)



Medic regeneration after crop

### #6 French serradella (Ornithopus sativus)

- Adapted to infertile, acid sands
- Rainfall 400- 600mm
  - Deep-rooted
  - More drought tolerant than sub
- cv. Cadiz released in 1996
- Soft-seeded at maturity (easy to establish)
- Seed yield (1 t/ha) (Manawatu)
- Forage yield 11 t DM/ha (Manawatu)
- Very fast winter growth ready for harvest early August





**#7 Next generation farming? Talish clover** 

#### Habit

- Woody base, rhizomatous, prostrate and perennial
- Below ground level growing point (grazing tolerant)

#### Rainfall

300- 700mm average annual rainfall (drought tolerant).

#### Soils

- Adapted to a range of soil types pH 5.0 to 8.5.
- Not suited to saline soils.
- Will tolerate moderate levels of aluminum.

#### Temperature

- Suitable for sowing in temperate or cool Mediterranean climates.
- Tolerant of cold winter temperatures.

Taproot of talish clover (*T. tumens*)



## #7 Next generation farming? Astragalus

spp.



A. cicer

Soil: Silty loams or fine clay loams,

pH: 7-8

Low-medium rainfall (400- 900mm)

Suited for mixture with cool season grasses

Suitable for summer grazing

#### A. adsurgens

- Prevents soil erosion
- Drought tolerant
- Grazing preference by wild (Canada) and domestic (China) herbivore

#### A. podolobus

- Grazing preference by wild (and domestic herbivore (Iran)
- Drought tolerant (<500mm).
- Deep root (>1m) and woody (grazing tolerant

#### A. onobrychis

Suitable for steep land



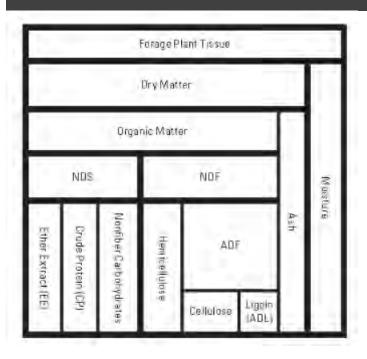
### Food for thought

- If genebanks don't have Information about the characteristics of the plants they contain they are of little value.
- Researchers are not monitoring enough new genes/alleles so farmers are not getting new cultivars or species.



### **Next challenges**

- Forage quality
- Greenhouse gases





### Future proof agriculture

- » Climate change
  - Drought tolerance genes
  - Disease resistance genes
  - New region specific species, e.g. for the hill country
- » Genetic erosion
  - Bringing the lost genes back to the breeding lines
  - Developing new crosses and cultivars from the collection
- » Lack of crop resilience/performance
  - Diversification of the endophyte choices
  - Developing region-specific cultivars
- » Biosecurity breaches/concerns
  - Coordination of seed import, compliance and quarantine activities
- » Funding limitations
  - Integration of all food crop, forage, horticulture, forest and vegetable collections
  - Public-private cooperation
  - International collaboration



### Applications to EPA and MPI: in progress

- Lolium spp.
  - » 20 species including the relatives: Festuca spp.
    - Returned by EPA but not rejected
    - Under internal and external review for resubmission
- Annual medics
  - MPI very keen to take this forward
  - Feedback to Kioumars by June 15th
- New legumes for hill country
  - Biserrula pelecinus
- Letters of support at the time of and after submission

