The New Zealand Douglas-fir breeding programme: proposed adjustments to address Swiss needle cast and climate change.

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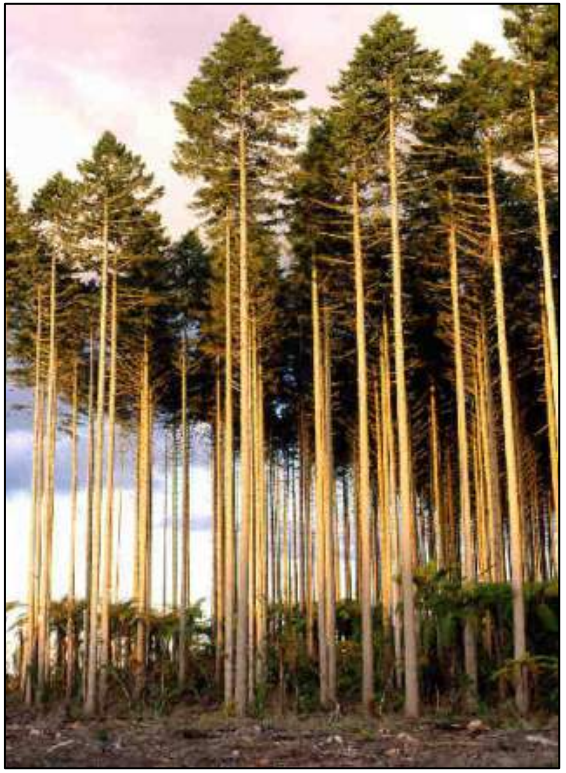
Douglas-fir in New Zealand

- Annual production D.-fir
  - ~3.5 % of New Zealand production timber
    - 155,000 m^3 rough-sawn timber
    - ~6% of planted forest
- Higher wood quality than radiata pine
- MAI up to 40 m^3/ha/year
  - NZ average 18.4 m^3/ha/year
  - Pacific Northwest Max 17.4 m^3/ha/year
- Establishment costs high and growth losses to needle disease



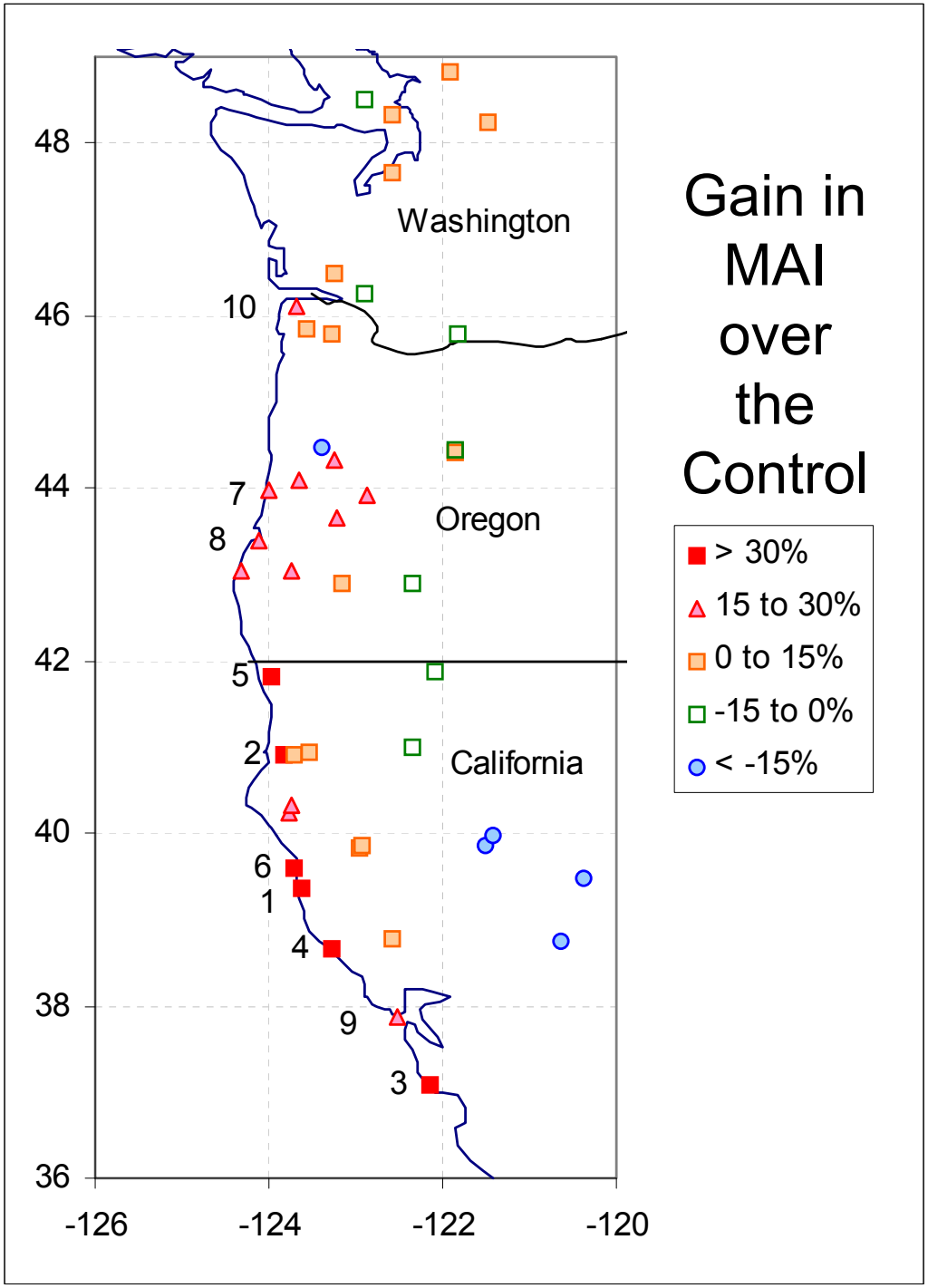
1st series: ~1955

- 1957-9 provenance tests
- 19 sites

- 44 provenances
- 1 control (Wash)
- ~10 fams/prov

- Analysis 6 sites
  - Survival, poor reps, uneven prov representation

- Best provenances
  - coastal California
  - southern Oregon

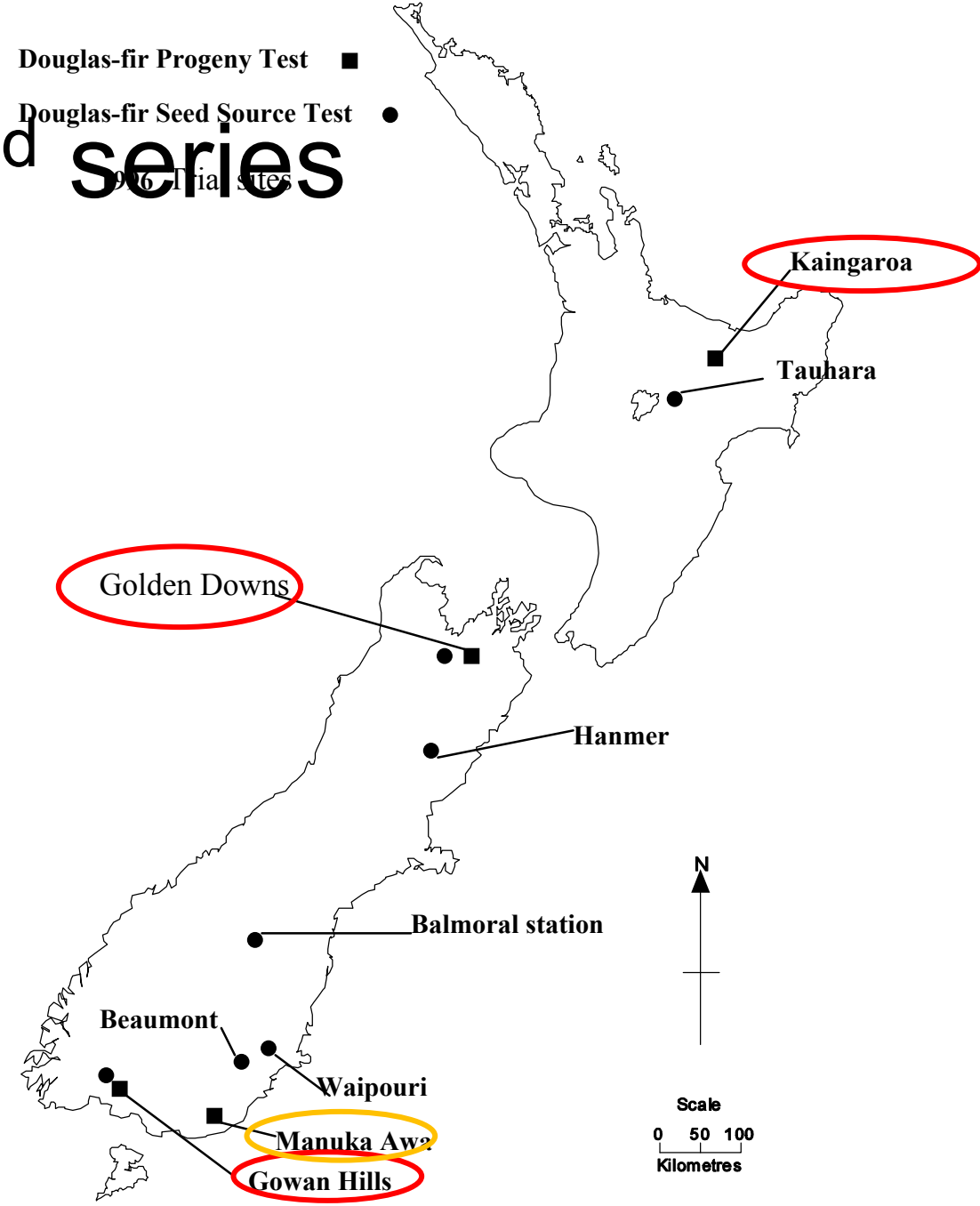


2nd series

- California, Oregon provenances
- 238 families from 22 provenances
- 3 breeding trials established 1996
- 1 smaller trial

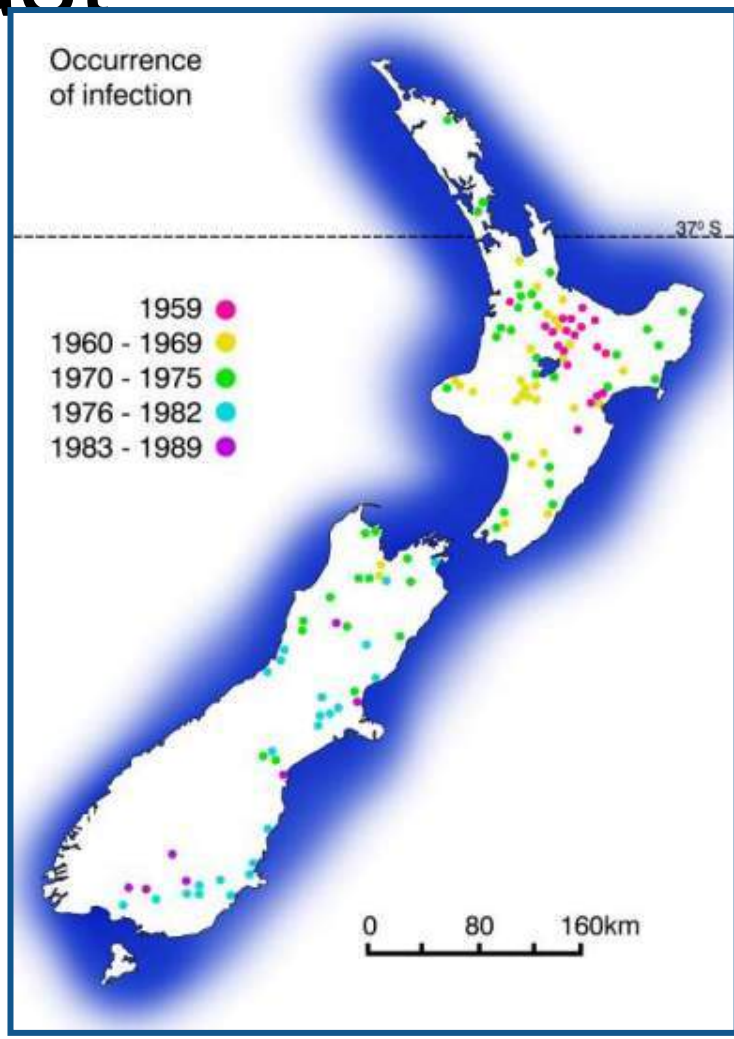
Sets-in-Reps design

- 7 sets, 34 fams/set
- Single-tree plot design

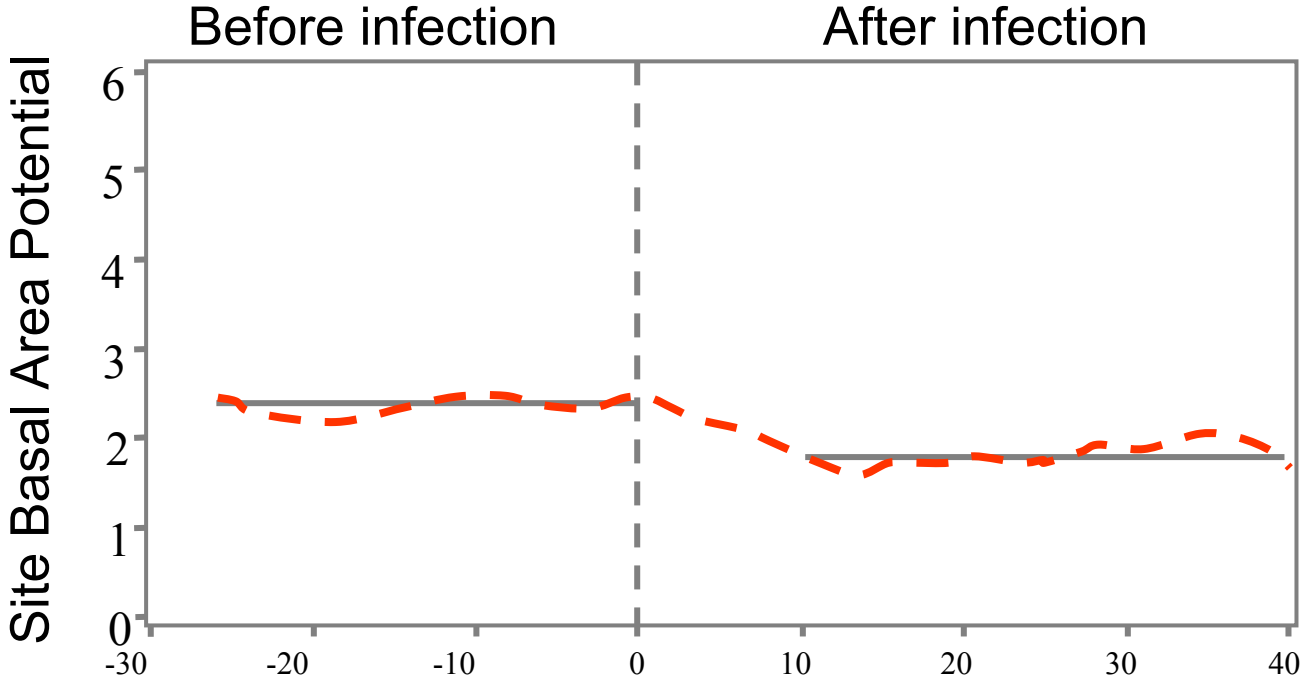


Swiss needle cast

- *Phaeocryptopus gaeumannii*
- First noticed in NZ in 1959
- Develops in warm winters, wet spring
- Significant disease of Douglas-fir
- Can cause up to 50% volume reductions



Swiss needle cast



Average national volume growth decline ca. 29%
Down from 2.5 m^2/annum to 2.0 m^2/annum

Kimberley, M.O.; Hood, I.A.; Knowles, R.L. 2011. Impact of Swiss needle cast on growth of Douglas-fir. *Phytopathology* 101:583-593.

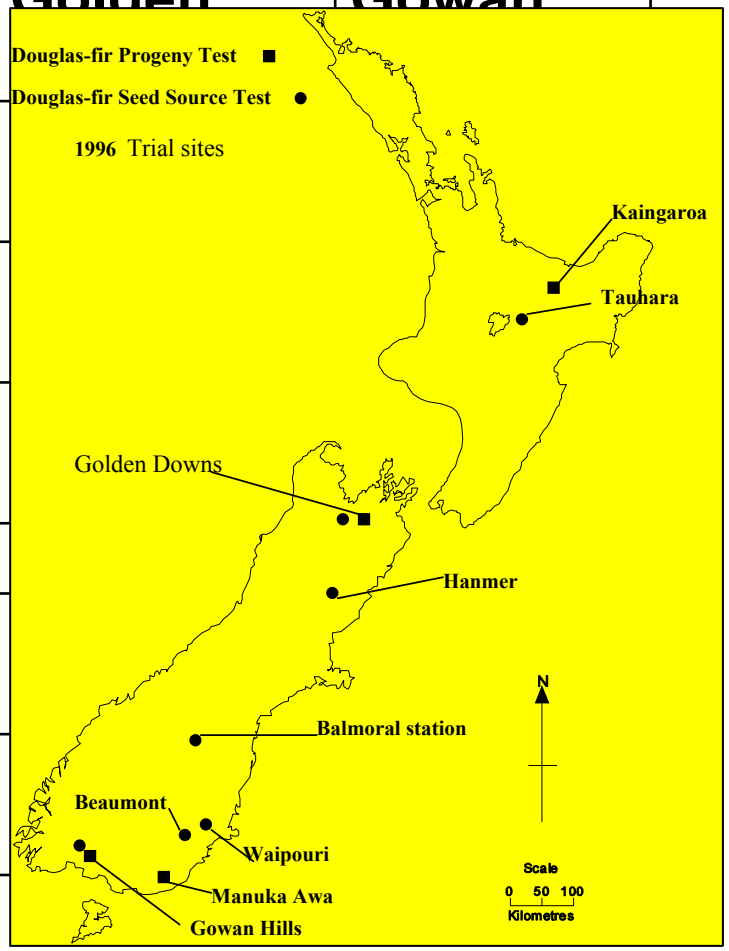
Douglas-fir breeding – current objectives

- Growth
- Form
- MoE/Stiffness

- Swiss Needle Cast
  - Needle retention score on a 1-6 scale

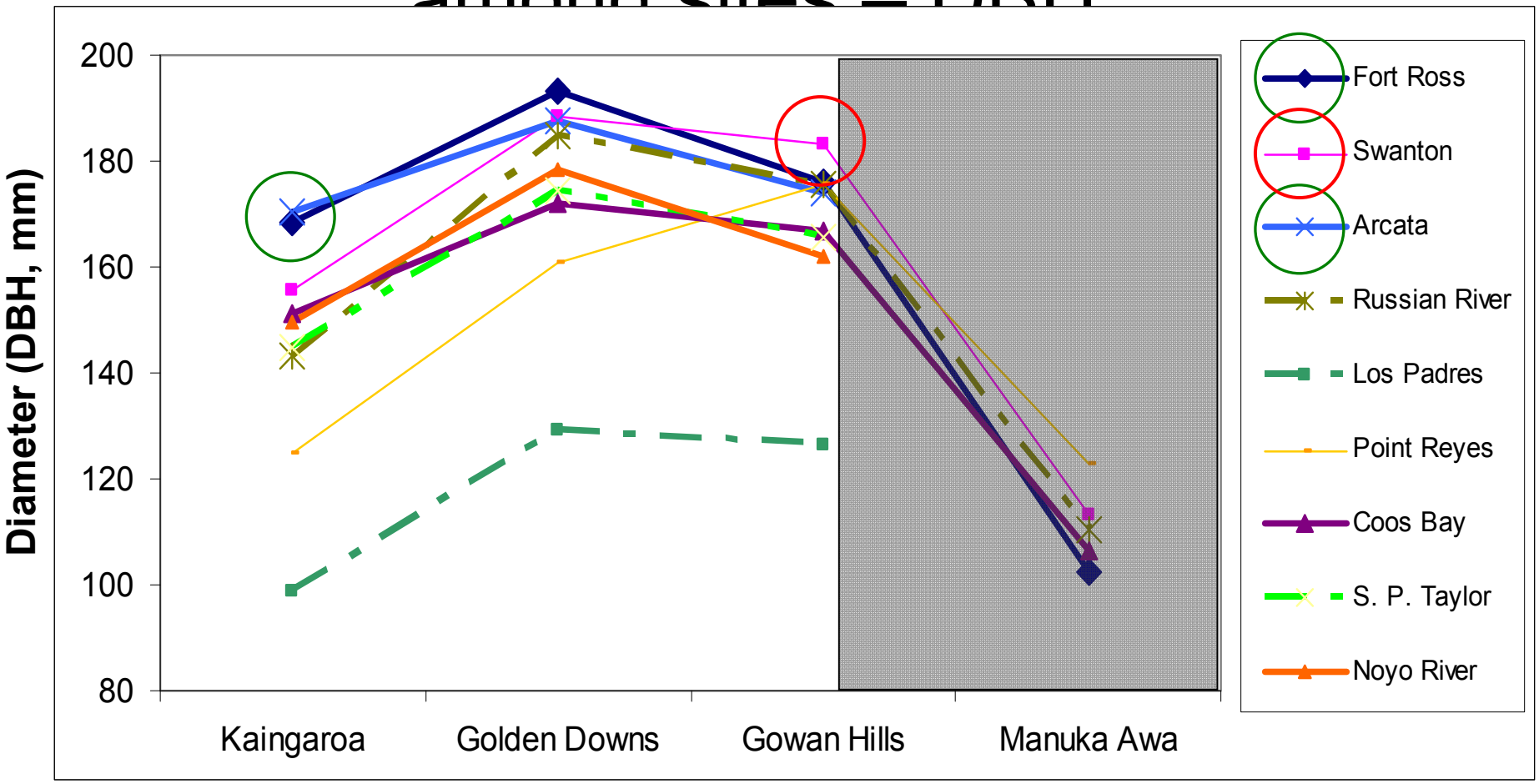
Genetic correlations estimated across sites for the same trait (type-B genetic correlations) for the provenance effect.

		Kaingaroa*	Golden	Gowan
DBH (9-13 years)	**Golden**	0.77±0.15		
	Gowan Hills	**0.55±0.17**		
	Manuka Awa	0.63 ±0.14		
STR (11-13 years)	**Golden**	0.49±0.31		
	Gowan Hills	0.43±0.26		



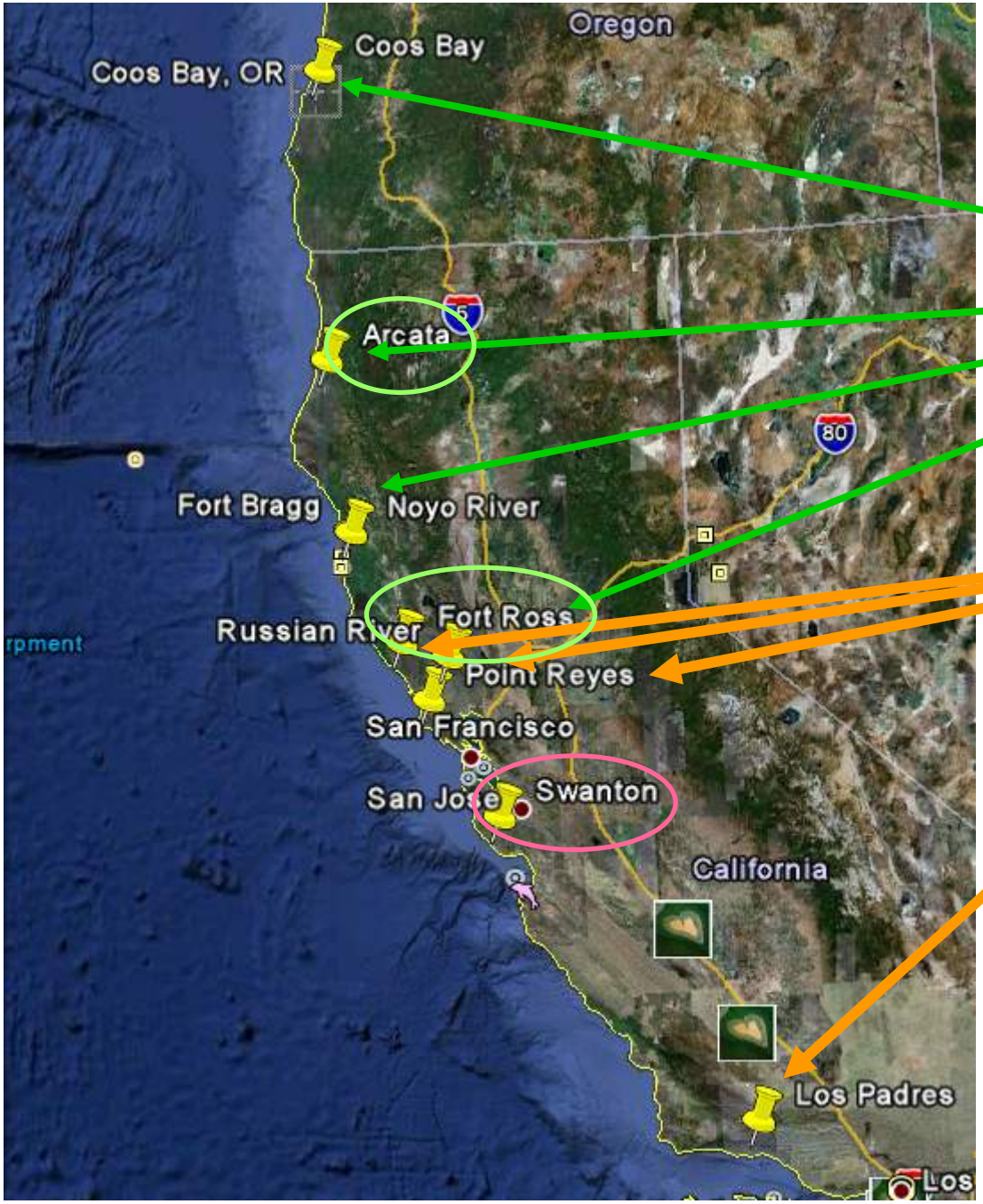
* Site with significant SNC present

Provenance performance (9 of the 22) among sites – DBH



Top needle retention – solid lines

Lowest needle retention – broken lines



Best needle retention

Worst needle retention

Heritabilities....at ages 7-13

ASReml model: $Y_{ijklm} = \mu + Site_i + Prov_j + Rep(Site)i_k + Fam(Prov)_{jl} + Prov \times Site_{ij} + Fam(Prov) \times Site_{ijl} + \varepsilon_{ijklm}$

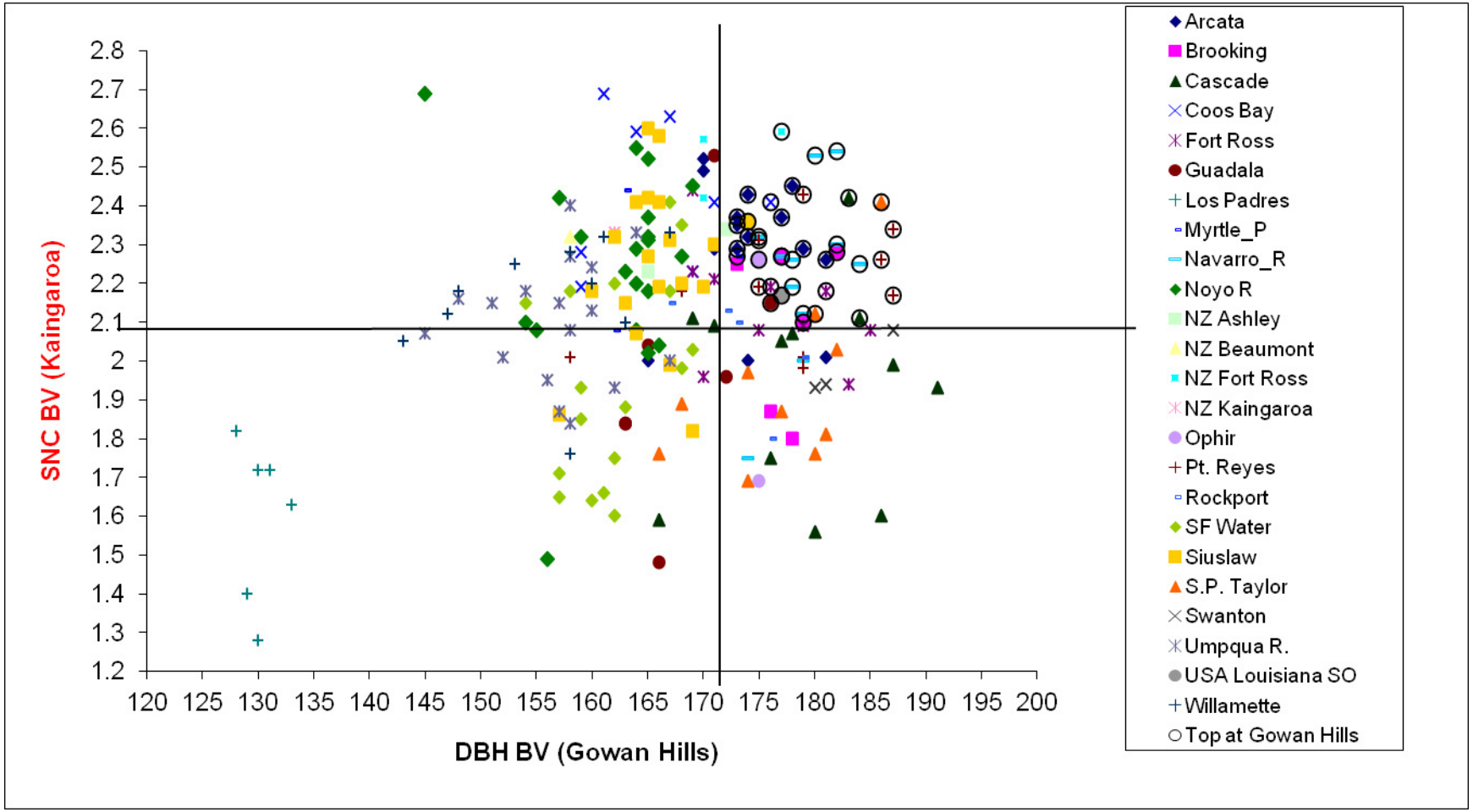
- Diameter 0.17± 0.02
- Straightness 0.20± 0.03
- Malformation 0.04± 0.01
- Acoustic velocity 0.49± 0.11
- Needle Retention (0.37±0.06)(@Kaingaroa)

Genetic correlations estimated across sites for the same trait (type-B genetic correlations) for <u>families-within-provenances</u>.

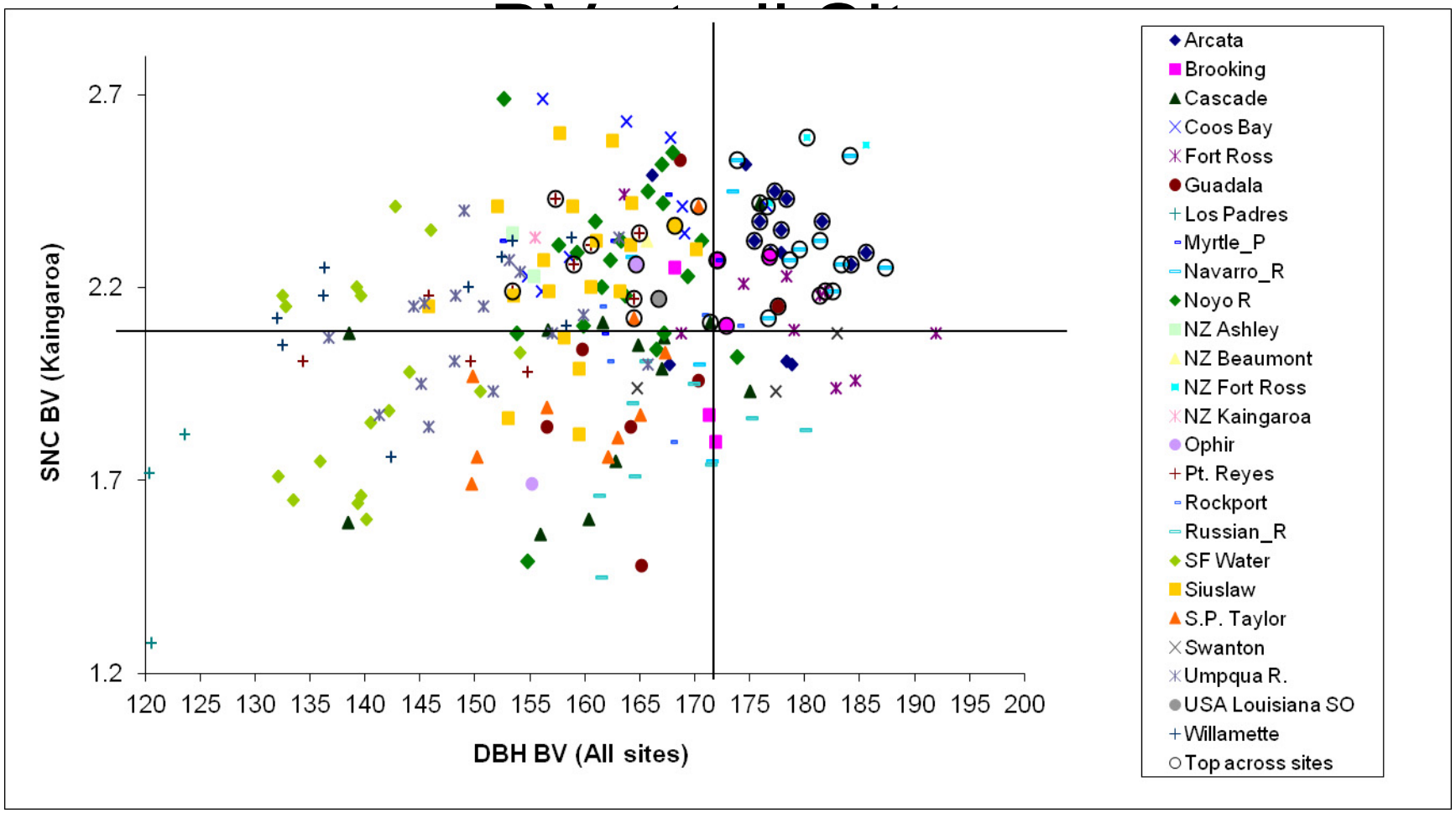
		Kaingaroa	Golden Downs	Gowan Hills
DBH (9-13 years)	**Golden Downs**	0.75±0.09		
	Gowan Hills	**0.61±0.08**	0.72±0.08	
	Manuka Awa	0.68±0.14	0.69 ±0.15	0.73±0.18
STR (11-13 years)	**Golden Downs**	0.91±0.08		
	Gowan Hills	0.82±0.08	0.85±0.07	
VEL (11-13 years)	**Golden Downs**	NE		
	Gowan Hills	0.97±0.30	NE	

NE = reliable estimates were not able to be calculated.

Breeding Values (BV) for Swiss Needle Cast (SNC) at Kaingaroa vs Diameter BV at Gowan Hill only (SNC 'free' site);



Breeding values (BV) for Swiss Needle Cast (SNC) at Kaingaroa vs Diameter



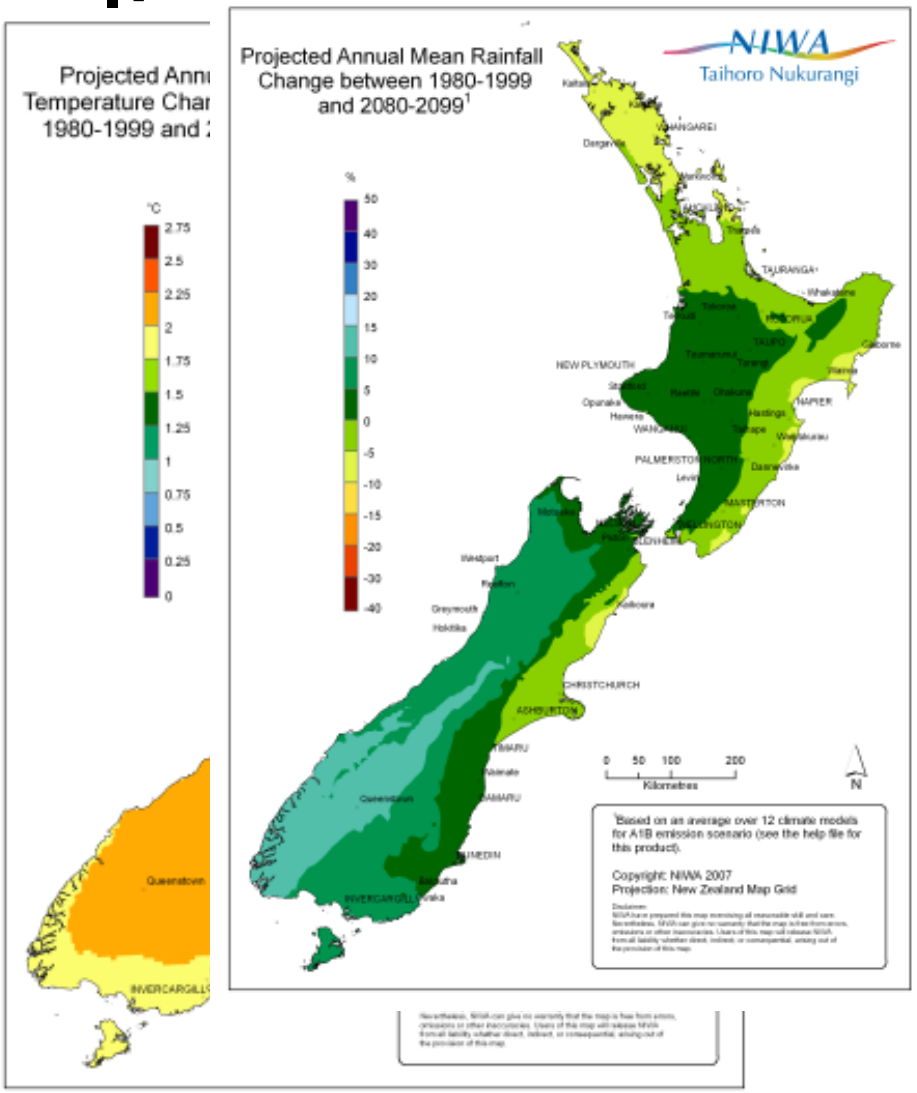
Genetic gain – DBH (%)

- Overall gain – smaller on a pooled site analyses
- Due to ~1/3 of families changing in the selection process

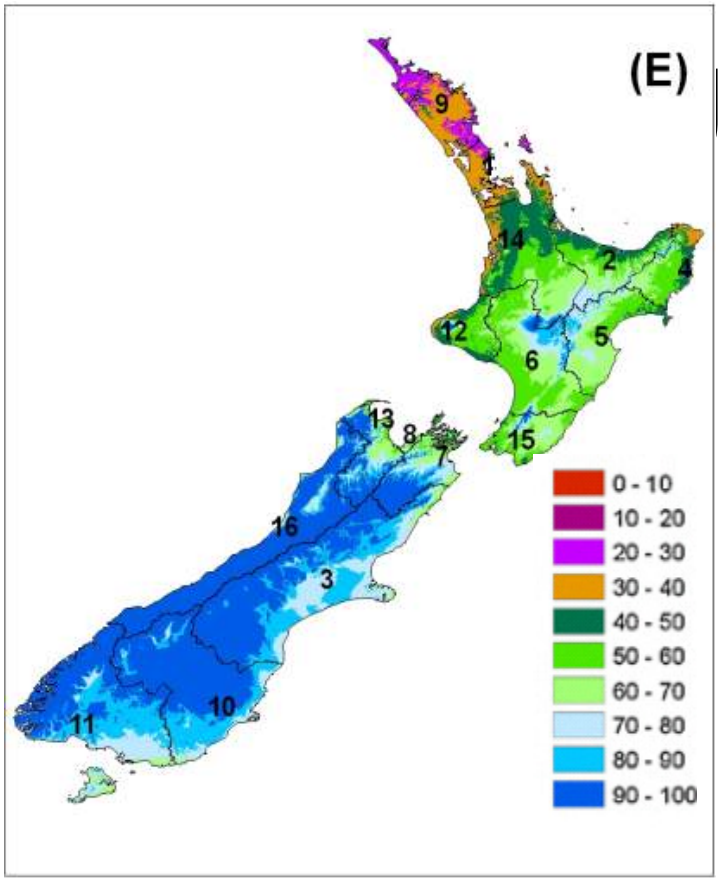
	Kaingaroa	Golden Downs	Gowan Hills	Across sites
Top 40	18.1	13.9	14.4	12.3
Top 100	10.8	10.1	11.3	8.2

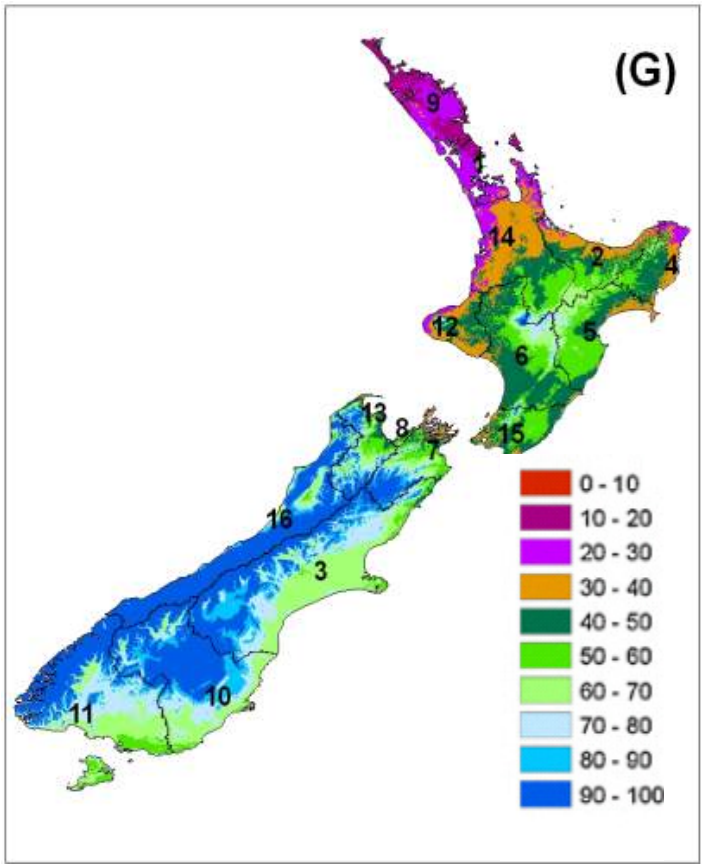
What are the projected changes in

- Temperature rises
  - +0.6 to 0.7 in 2030
  - +1.6 to 2.0 in 2080
- Rainfall changes
  - +/- 5% in 2030
  - +15% in 2080
- High variability, uncertainty



Swiss needle cast - future





Foliage Retention (%)

Current climate

2090

+1.9% °C (0.88-3.01);
-2.6 mm (-18.1-14.1)

average from 12 GCMs, averaged across 3 emission scenarios

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Projecting the severity of Swiss needle cast on Douglas-fir under current and future climate in New Zealand
Michael S. Watt, Jeffrey K. Stone, Ian A. Hood, David J. Palmer. Forest Ecology and Management (2010)

Breeding – where to from here?

- **Deployment: (i) handle through custom seedlots from orchards, or (ii) two different orchards?**
- **Consider SNC climate model predictions over time**
- Breeding;
  - Forward 2nd generations selections underway
  - All selections screened for wood stiffness
  - Pedigree reconstruction from fingerprinting (in development)

South Island breed

- growth and exposure
- 2 sites
- 100-120 trees

North Island breed

- SNC and growth
- 2 sites
- 100-120 trees

Acknowledgements

- Future Forests Research
- Nelson Forests, Rayonier
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- NZFHRC (Forest Health Research Collaborative)
- B.C. Forest Service

FUTURE FORESTS RESEARCH

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