

DOTHISTROMA NEEDLE BLIGHT (DNB) (*D. septosporum*)



HISTORY OF UK DNB EPIDEMIC

1997 -



2006 -



2010 -



Corsican pine
(England)



Lodgepole pine
(Scotland)



Native Scots pine
(Scotland)

What is the origin of DNB on Native Scots pine?

Dispersal from Corsican pine?

Dispersal from lodgepole pine?

Endemic origin in native pinewoods?

NATIVE PINE SITES

PAIRED SAMPLING FROM:

Native Scots pine



Lodgepole pine



+

NURSERY SAMPLES
(North and South Scotland)

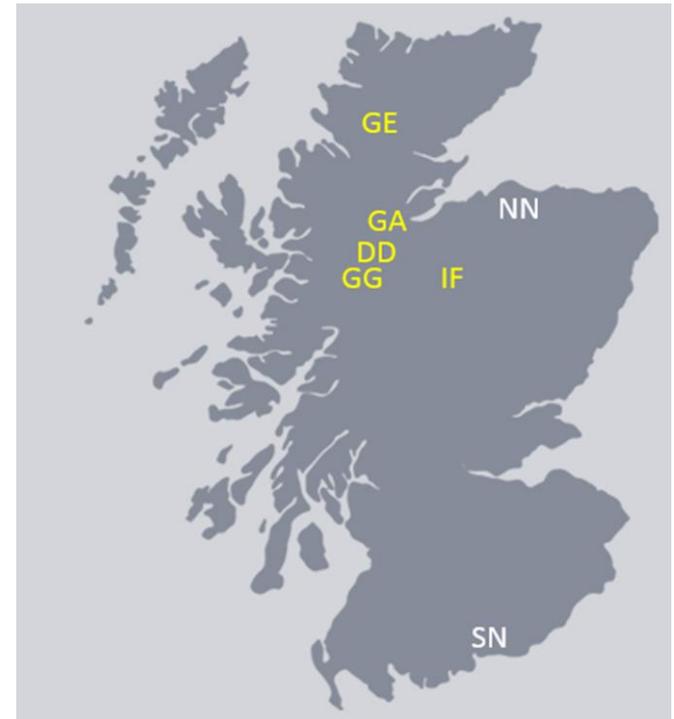
LABORATORY ANALYSIS

A. DNA FINGERPRINTING

Related individuals have similar fingerprint

B. MATING TYPE (MT1 and MT2)

Mating only between MT1 and MT2



GE - GLEN EINIG

GA - GLEN AFFRIC

DD - DUNDREGGAN

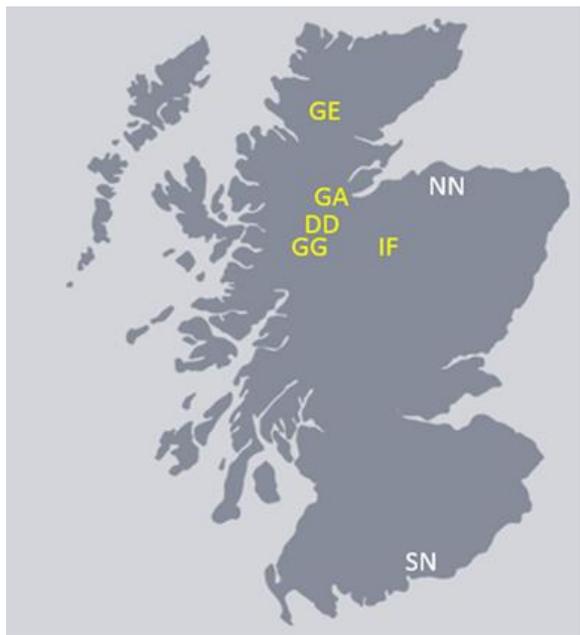
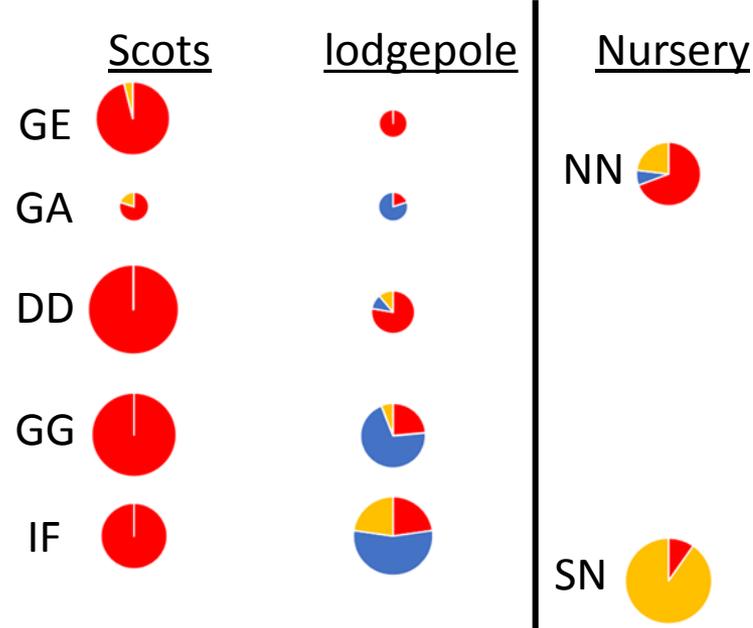
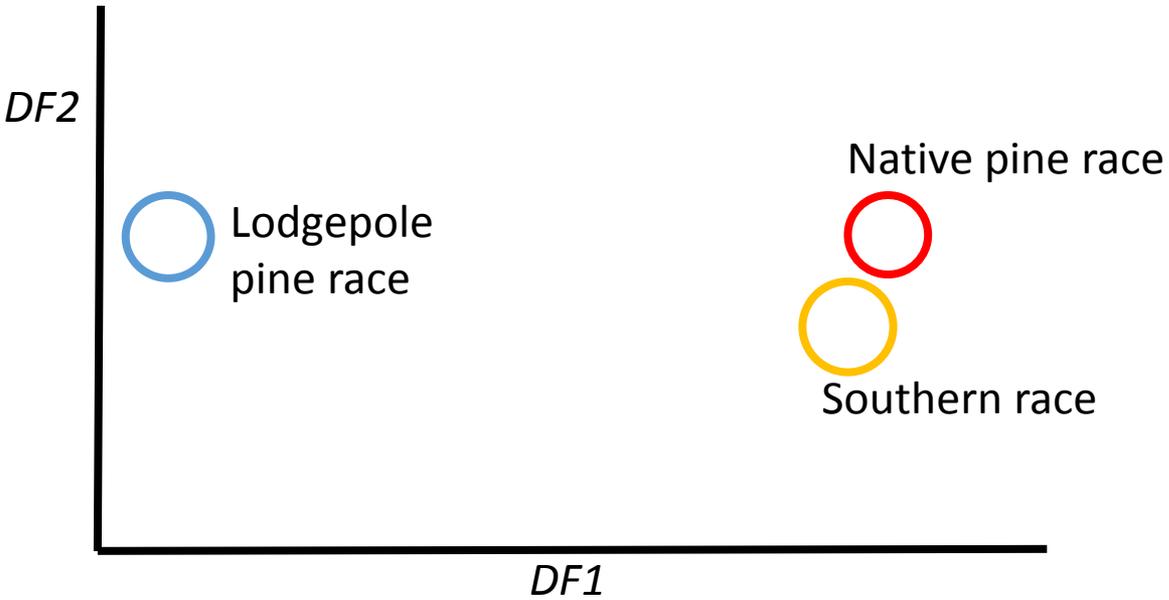
GG - GLEN GARRY

IF - INSHRIACH FOREST

NN - NORTHERN NURSERY

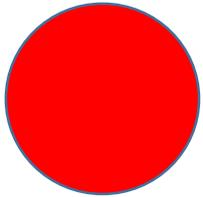
SN - SOUTHERN NURSERY

THREE DISTINCT RACES OF DOTHISTROMA IN SCOTLAND



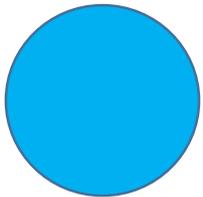
CHARACTERISTICS OF THE THREE DOTHISTROMA RACES

Native pine race



Resident race on native pine populations
Moderately variable
Low frequency of sexual reproduction

Lodgepole pine race



Found only on lodgepole pine
Little variation
Sexual reproduction absent
Introduction from North America?

Southern race



Predominantly southern distribution
Highly variable
High potential for sexual reproduction
Dispersing north from outbreak on Corsican pine?

PRACTICAL IMPLICATIONS

- A. Native Scots pinewoods harbour a resident *Dothistroma* race
 - the pathogen is not a novel threat to native Scots pine populations
- B. A novel (southern) race of *Dothistroma* is invading native Scots pinewoods

Southern race is highly genetically variable

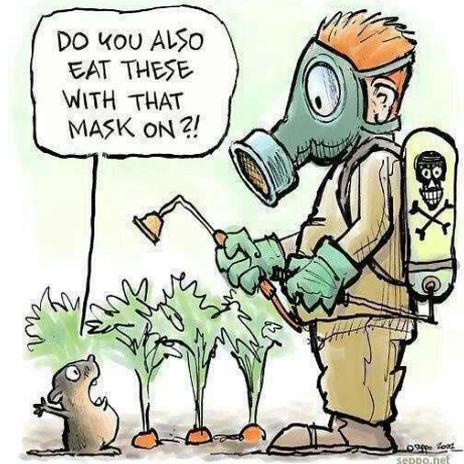
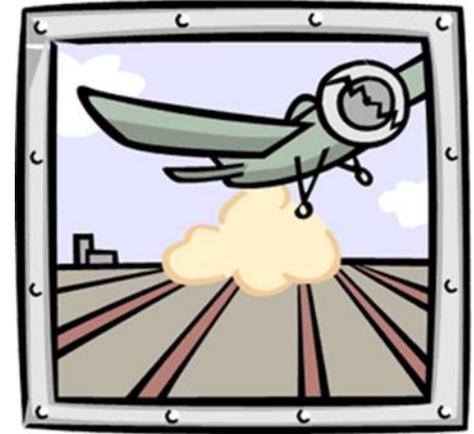
Southern race has potential for sexual reproduction

There is the potential for hybridisation between southern and native pine race

- C. A distinct, possibly exotic, race of *Dothistroma* is present on lodgepole pine but does not appear to transfer onto Scots pine
- D. Nurseries can harbour all three races of *Dothistroma* and movement of infected plants will hasten spread of novel races
- E. Susceptible exotic tree hosts increase problems caused by native pathogens

Chemical control

- No detailed information on fungicide efficacy against DNB
- Copper-based fungicides used to prevent DNB infection- both kill conidia and reduce sporulation in established lesions
- In New Zealand, aerial application of copper fungicides used when disease reaches 25% or more
- In the UK, chemical control is used on nursery stocks



Chemical control



Fungicides

Contact inhibitors
i.e. Copper-based fungicides etc.

Mostly multisite inhibitors

Resistance uncommon



Contact Fungicides

Systemic fungicides
i.e. QoIs, DMIs, SDHIs etc.

Single site inhibitors

Documented cases of resistance in pathogenic fungi

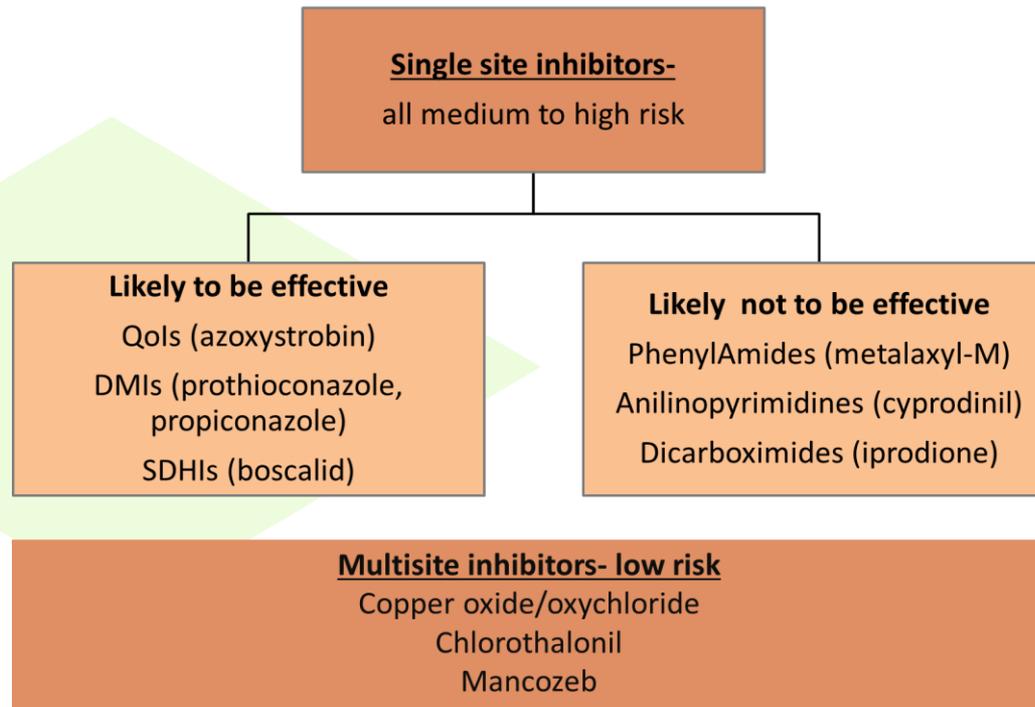


Amphimobile Fungicides

Chemical use survey



- Looking for fungicide resistance to approved modes of action used in the nurseries



- Isolates from native forests (baseline range) vs isolates from DNB outbreaks in the nurseries (received from Richard Baden from Alice Holt)

Fungicide assay



EC₅₀ values for native forests and nursery isolates from year for single site inhibitors applied commonly in the forest nurseries.

Fungicide	Native forest	Nursery isolates
Azoxystrobin (Qols)	0.003-0.017	0.006-0.042
Prothioconazole (DMIs)	0.001-0.004	0.001-0.004
Propiconazole (DMIs)	0.006-0.016	0.005-0.043
Boscalid (SDHIs)	0.121-0.514	0.147-0.598
Cyprodinil (AP)	8.398-100	-
Iprodione (Dicarb.)	100	-
Metalaxyl-M (PA)	100	-

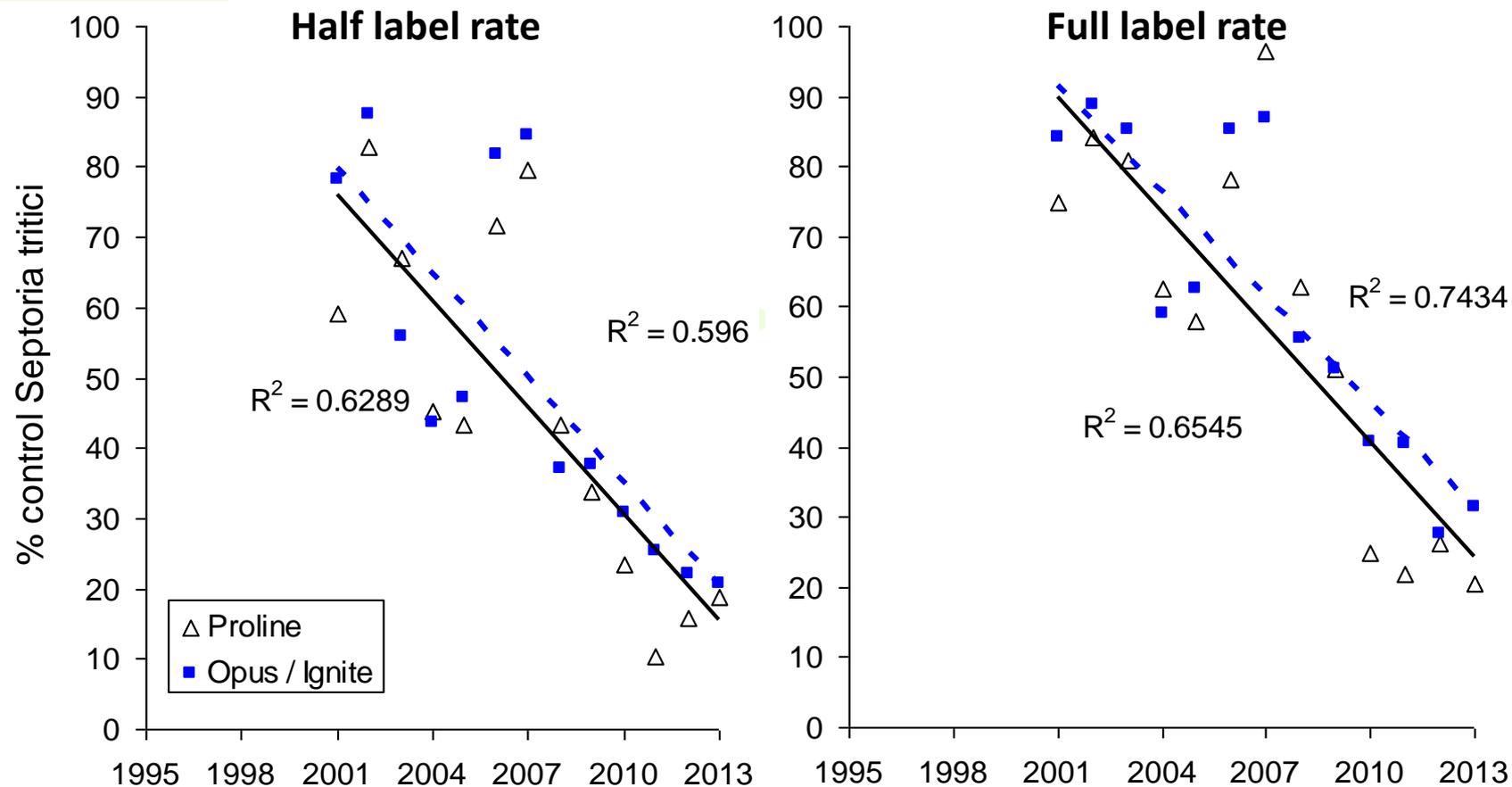
- No resistance development so far- GOOD JOB!

BUT..

DMIs- declines in efficacy over time



Significant shifts in the sensitivity of *Zymoseptoria tritici* to triazoles since 1990s

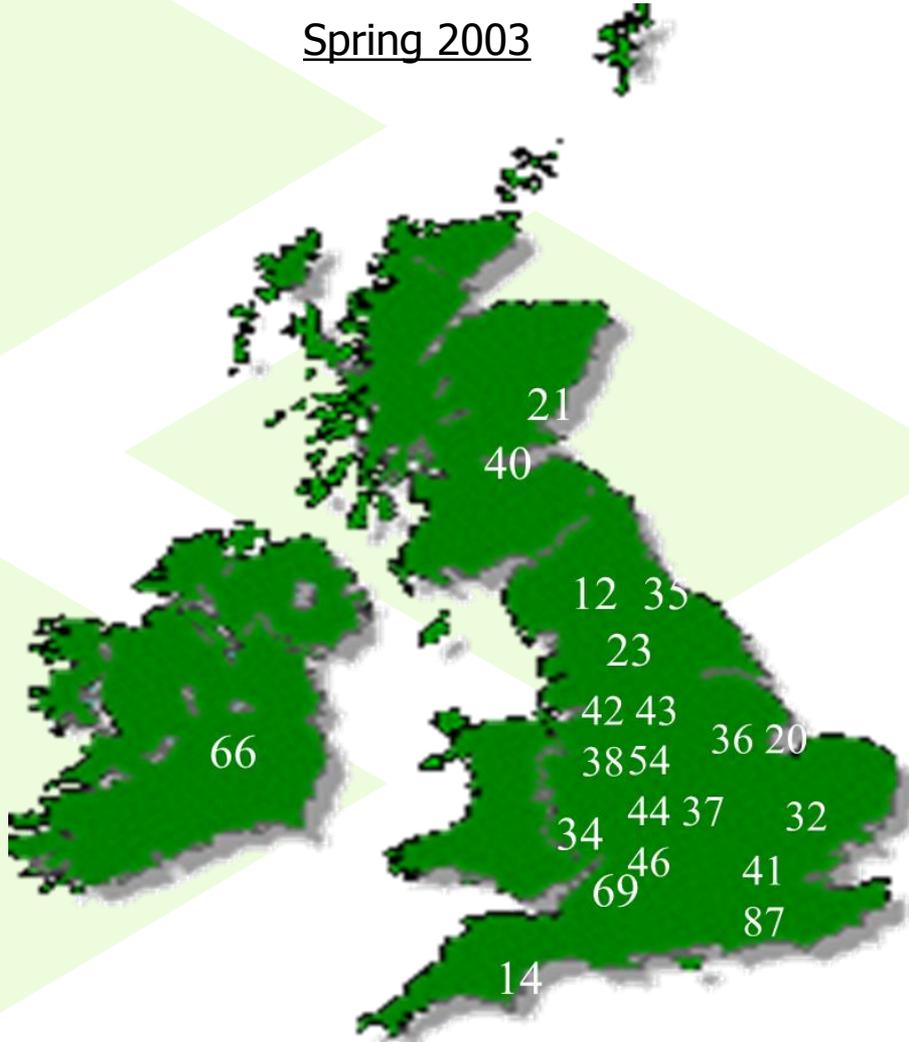


Proline- prothioconazole, Opus/Ignite- epoxiconazole

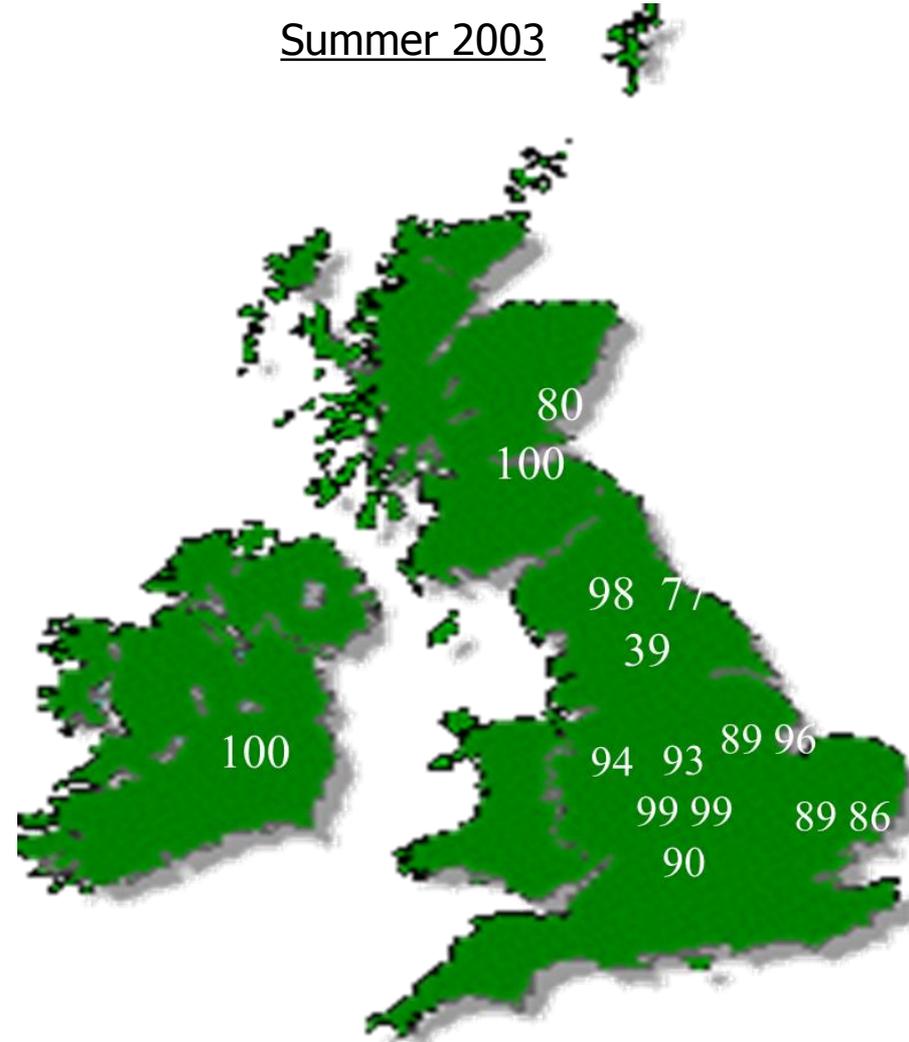
QoIs- one step shift in *Zymoseptoria tritici*



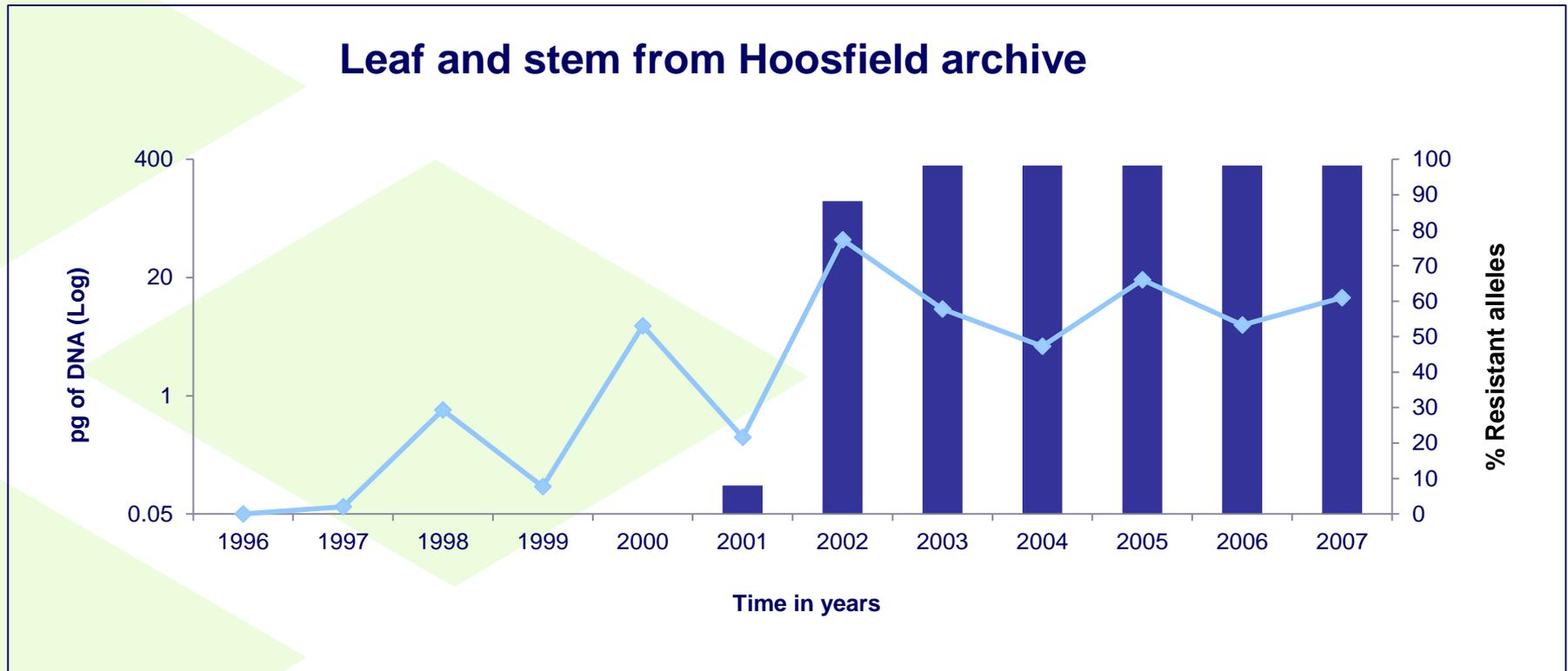
Spring 2003



Summer 2003



QoIs- one step shift in *Ramularia collo-cygni*

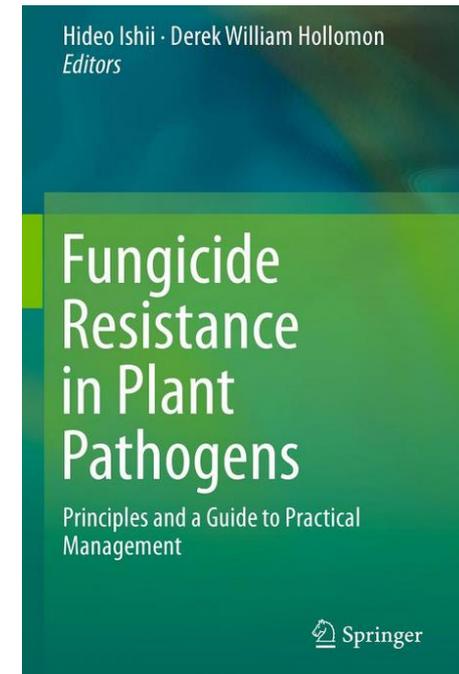


Rapid increase in the frequency of genetic individuals resistant to the QoI fungicides

Why fungicide resistance matters?



- Reduced crop yield and quality
- Loss of compounds with high activity and improved environmental profile
- Fewer options for effective disease control
- Fungicide resistance is an issue for sustainable production
- Recently became more topical because of likely losses through EU legislation. Fewer options would increase selection pressure on remaining actives



What can we do?- Apply anti-resistance strategies



- Limit the number of applications, apply when required
- Avoid frequent application of same mode of action
- Make use of multi site fungicides
- Make use of mixtures/alternations
- Include good agronomic practices/
/integrated control measure

High risk fungicides used in the nurseries-
i.e. QoIs!



What can we do?- Regular screenings and KT



- The baseline range of sensitivity established for DNB- can be used in future monitoring programs
- Similar studies on other pathogenic fungi
- Examples from FRAG UK

Fungicide Resistance Management in Apple and Pear Pathogens

March 2015



Integrated Control and Resistance Management Guidelines

Disease profiles

Apple Scab (*Venturia inaequalis*)

Current fungicide resistance situation in apples and pears in the UK

Pathogen	Disease	Crop	Fungicide performance affected by resistant or less sensitive strains
<i>Venturia inaequalis</i>	scab	apple	DMIs, dodine
<i>Venturia pirina</i>	scab	pear	none
<i>Podosphaera leucotricha</i>	mildew	apple and pear	DMI
<i>Neonectria ditissima</i>	canker and fruit rot	apple and pear	none
<i>Monilinia laxa</i> f.sp. <i>mali</i>	blossom wilt	apple	none
<i>Phytophthora cactorum</i>	collar or crown rot	apple	none
<i>Botrytis cinerea</i>	fruit rot	apple and pear	dicarboximides
<i>Monilinia fructigena</i>	brown rot	apple and pear	none
<i>Phytophthora syringae</i>	fruit rot	apple	metalaxyl-M
<i>Penicillium expansum</i>	fruit rot	apple and pear	none
<i>Gloeosporium</i> * spp.	fruit rot	apple and pear	none

Fungicide Groups for control of apple & pear pathogens

Fungicide Group (FRAC Code)	Active ingredient(s)	Product names (examples)	Apple/ Pear	Diseases controlled (or partially controlled) in absence of resistant strains		
				Mildew M	Scab S	Nectria canker N
Orchard Sprays						
Anilinopyrimidine (9)	pyrimethanil	Scala, EAMU on pears (0295/2011)	A	-	S	-
Anilinopyrimidine (9) + phenylpyrrole (12)	cyprodinil + fludioxonil	Switch	AP	(M)	(S)	(N)
DMI (3)	difenoconazole	Difference	AP	-	S	-
	penconazole	Topas	A	M	-	-
	myclobutanil	Systhane 20 EW	AP	M	S	-



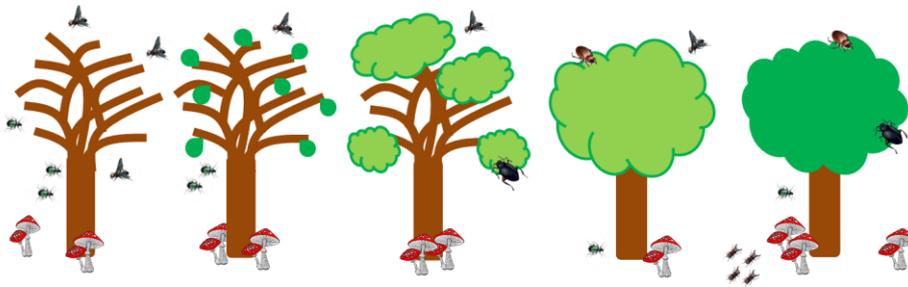
Glen Affric National Nature Reserve, Scottish Highlands

Resilience of native Scots pine to *Dothistroma* needle blight

Annika Perry

What is needed for resilience?

Adaptive potential



Heritable
Evolvability

Common garden trial



$$V_P = V_G + V_E$$

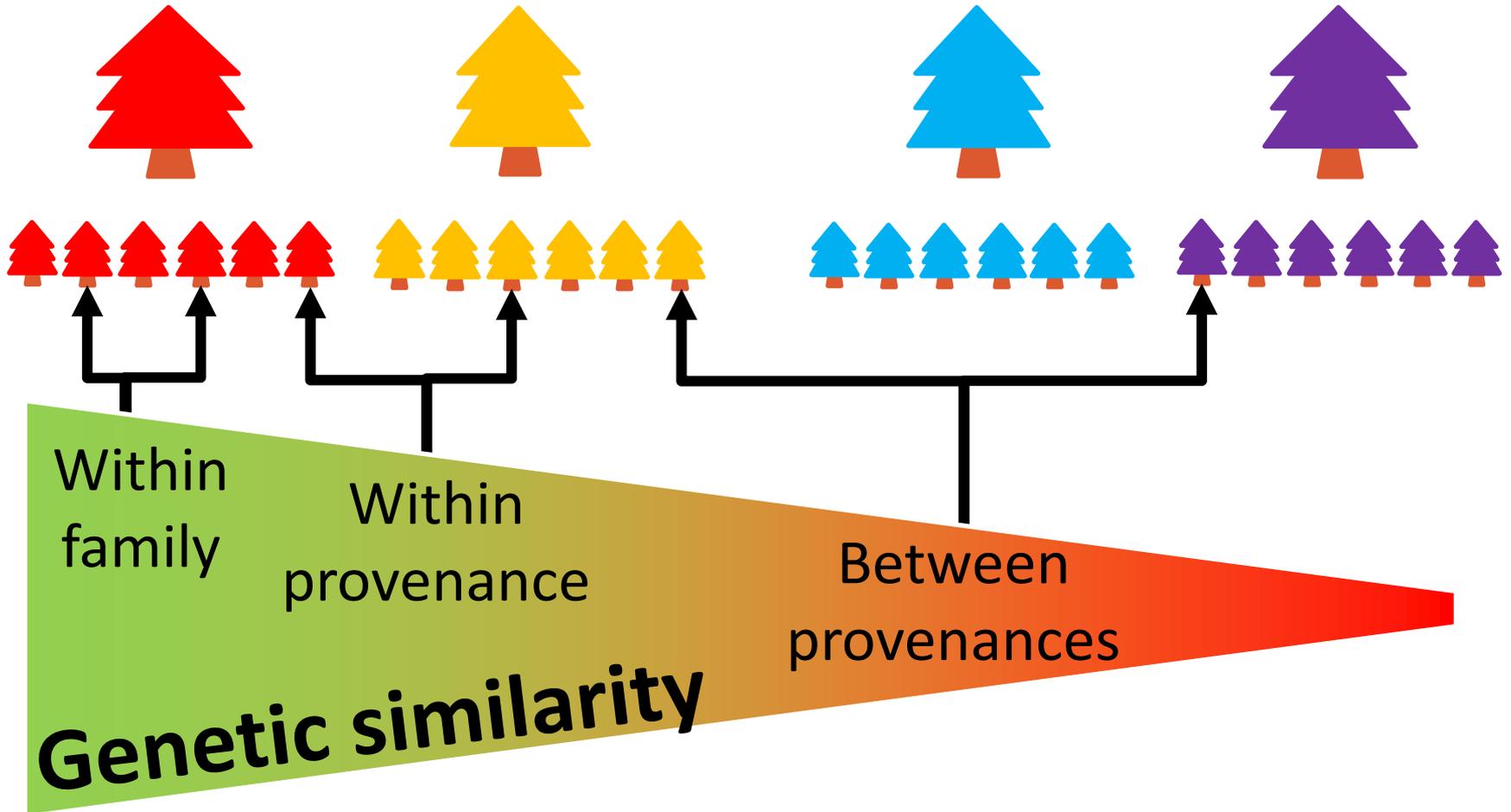
The equation $V_P = V_G + V_E$ is shown inside a black oval. A large red 'X' is drawn over the plus sign and the V_E term, indicating that this equation is incorrect or being rejected.

 = Mean annual precipitation 1961-1990

Progeny-provenance trial

Provenance A

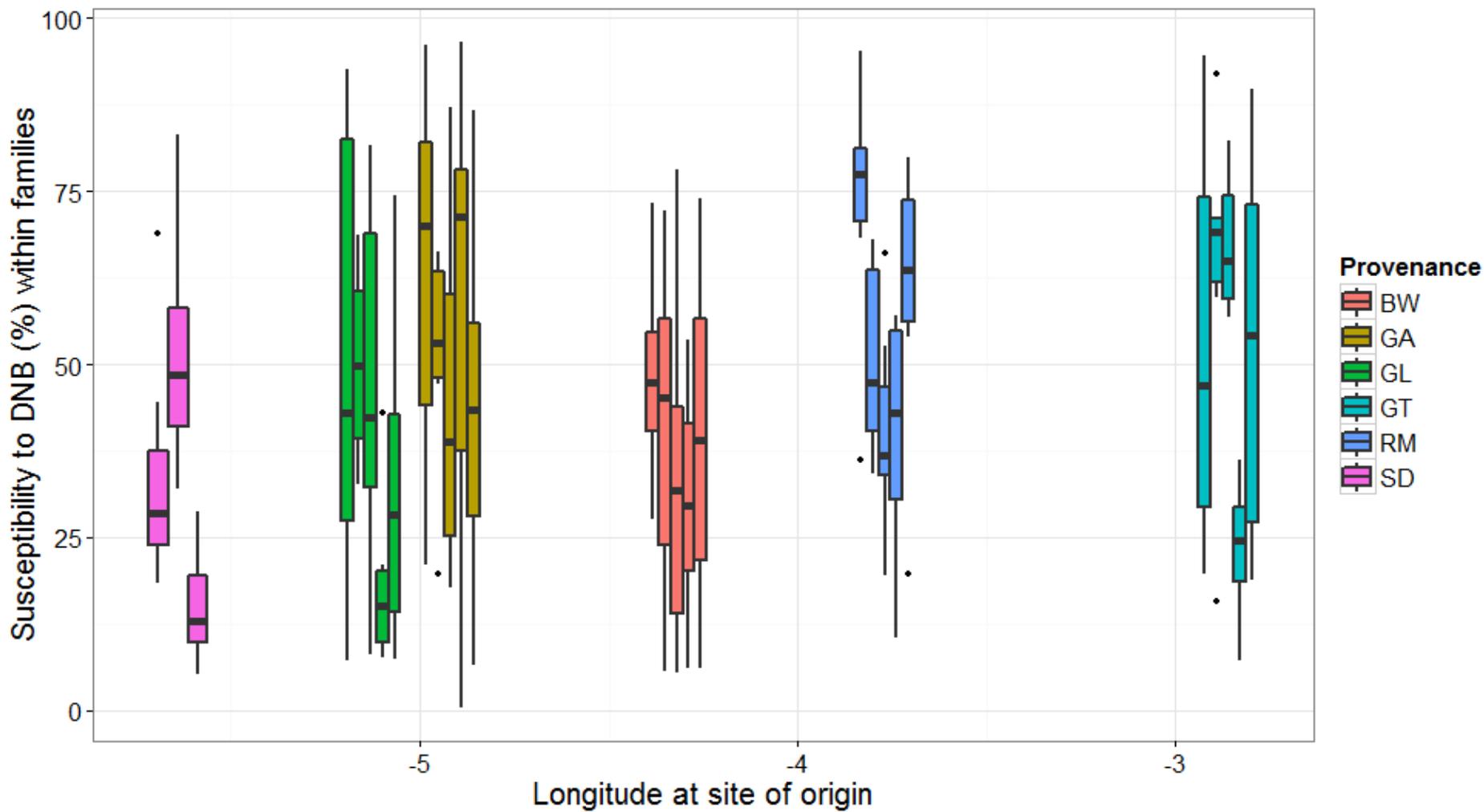
Provenance B



Artificial and natural inoculation trials



Distribution of variation in susceptibility



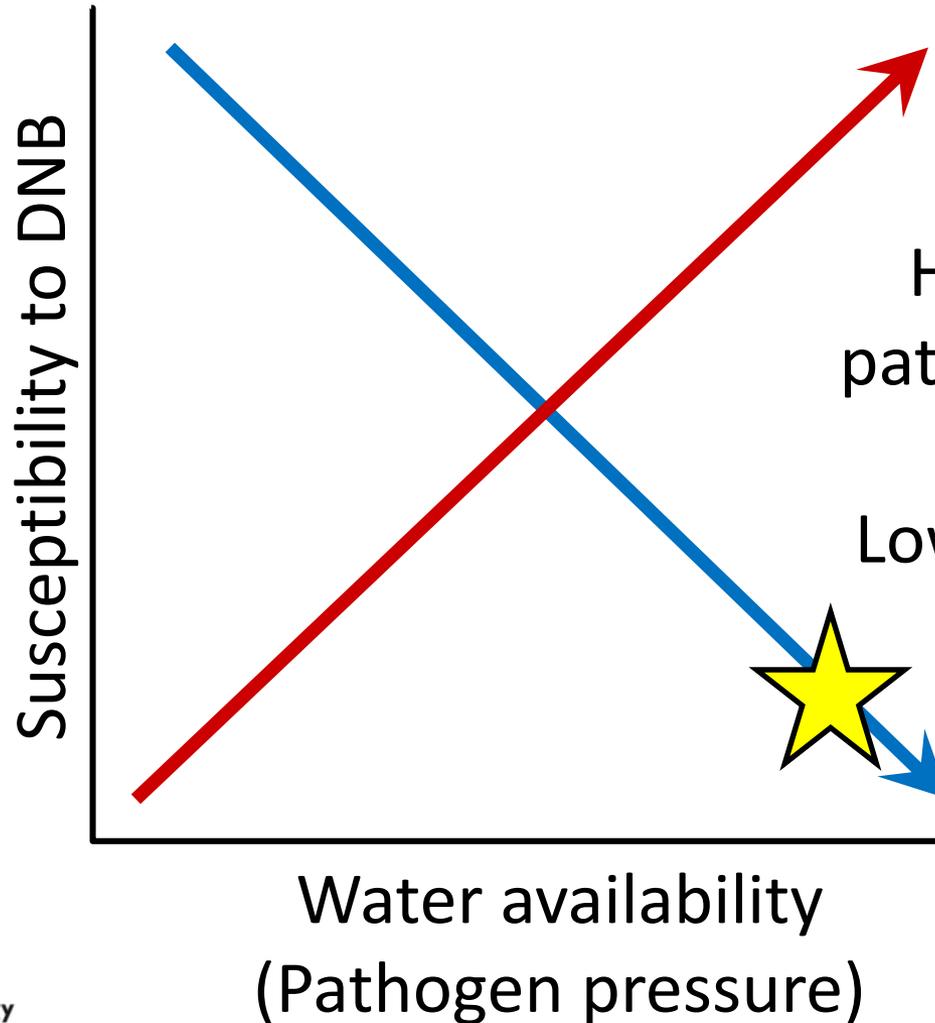
Heritability and evolvability

Variation in susceptibility due to genetic effects



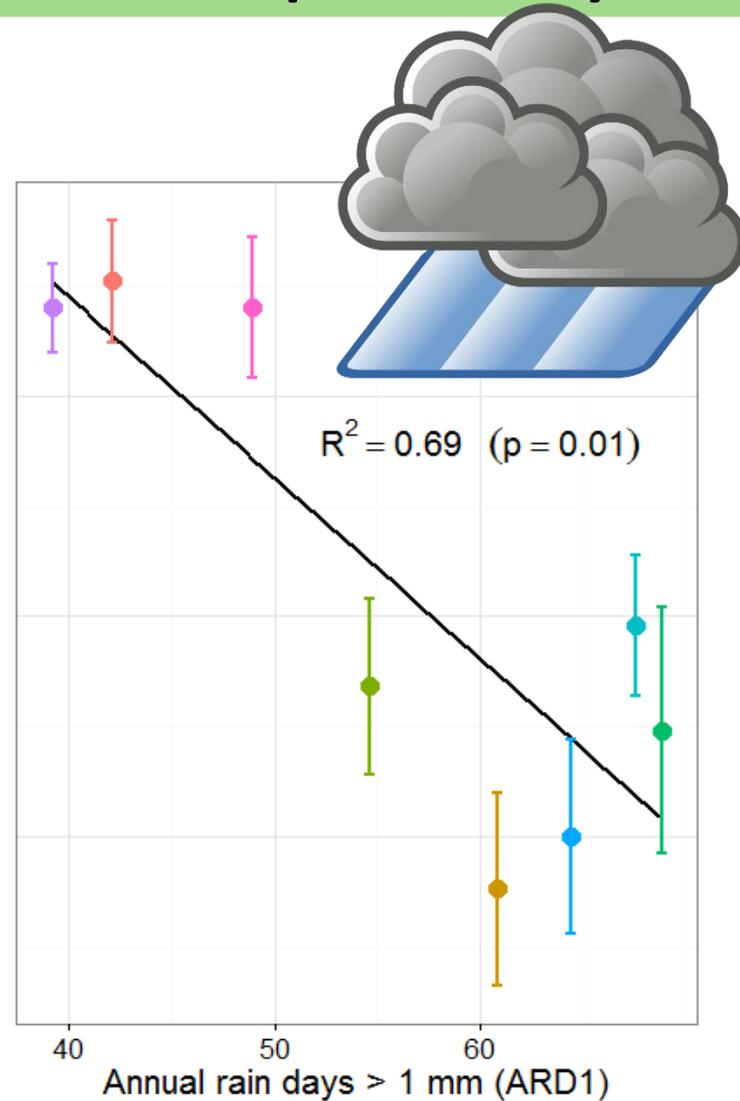
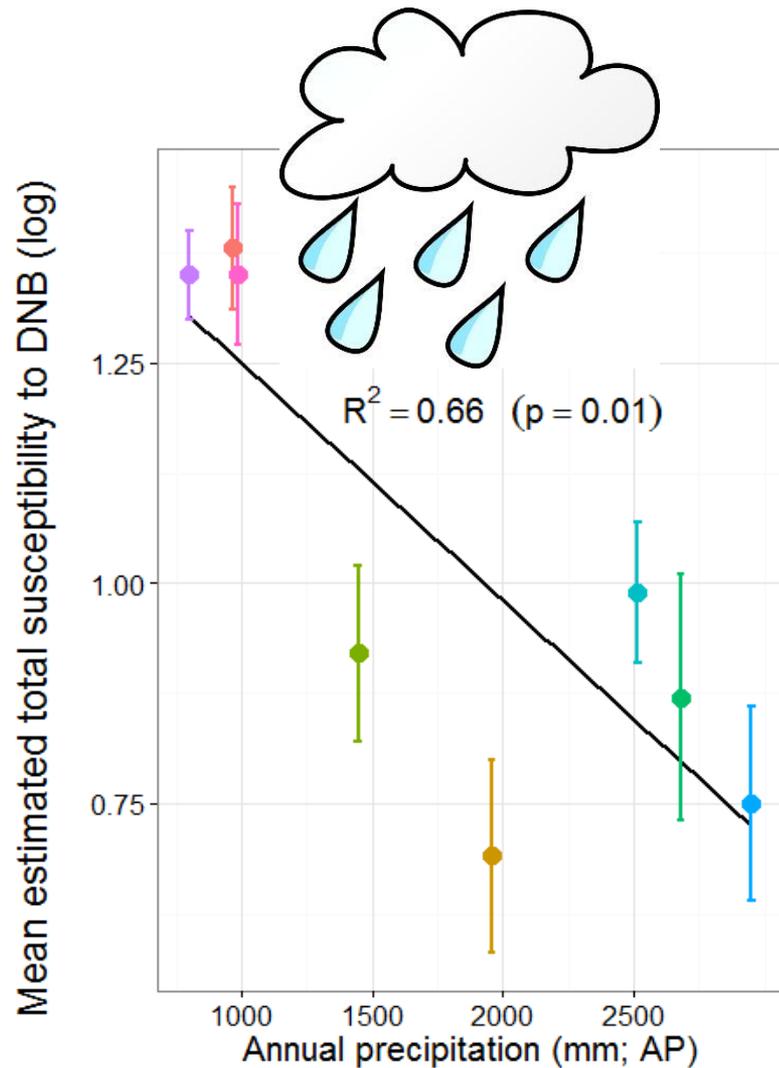
Evidence for *co-evolution*?

Hypothesis:



High historical
pathogen pressure
=
Low susceptibility

Evidence for *co-evolution* of pathosystem?



Management strategies

Facilitate adaptation in native Scots pine:

- Natural regeneration
- Assisted regeneration



Thank you



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