Healthy trees, healthy future

Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

scion
forests · products · innovation

Rebecca Ganley Scion, Rotorua

Stan Bellgard Landcare Research, Auckland

COMBATTING THE KAURI KILLER: KAURI DIEBACK AND OTHER *PHYTOPHTHORA* THREATS.

Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

scion
forests · products · innovation

Outline of presentation

- Overview of *Phytophthora* diseases worldwide
- Up-date on PTA and kauri dieback
- Diagnostics and beyond
- Healthy trees, healthy future

Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

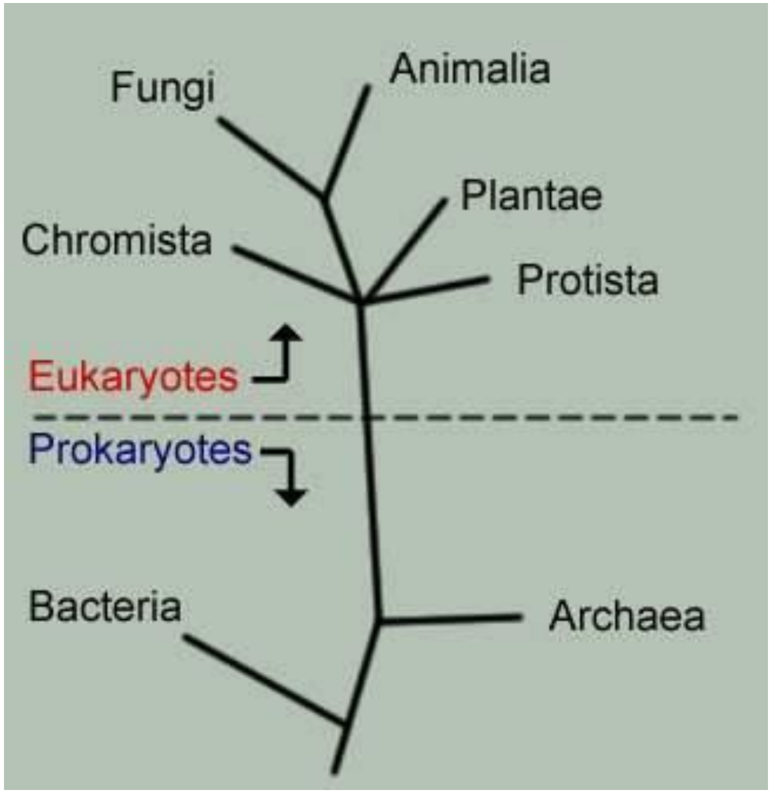
Landcare Research
Manaaki Whenua

SCION
forests · products · innovation

Phytophthora diseases world-wide

- Phytophthora = plant destroyer
  - φυτόν (phytón), "plant" and φθορά (phthorá), "destruction"; "the plant-destroyer"
- Genus of plant damaging, Oomycete (water moulds)
- Cellulose walls
- First described by de Bary in 1875
- One hundred species described, approx., 500 species thought to exist
- Best known example, cause of Irish potato famine.

Chromista – seven kingdoms of life



- Chromista (Chromalveolata)
- Brown algae
- Cellulose walls – fungicide resistant?
- Retain elements of aquatic origin, as water is essential for stages of its life-cycle, e.g. zoospores

World-wide impacts

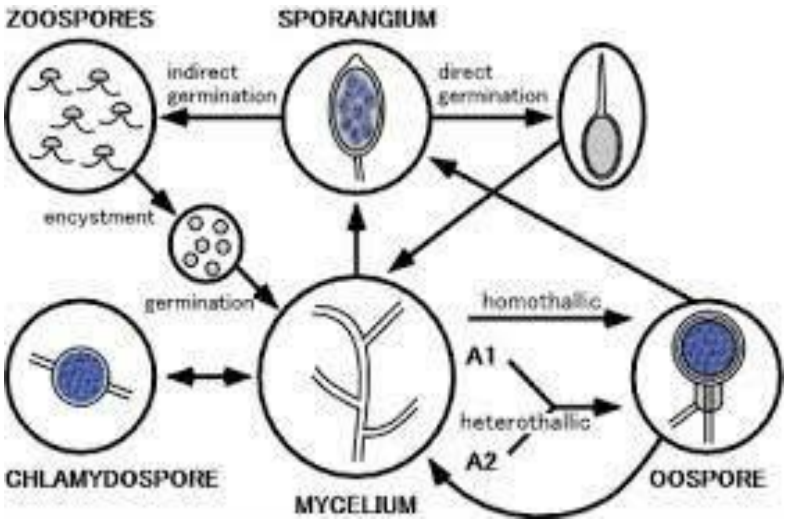
- USA – SOD
- UK;
  - *P. ramorum*
  - *P. kernoviae*
- EU;
  - Oak decline in Spain
  - Chestnut decline Italy
  - Alder decline Germany - *P. alni*
- AUS;
  - Jarrah dieback, WA
  - Button-grass heaths of Tasmania

Horticultural / forestry impacts

- Avocado root and collar rot
  - *P. cinnamomi*
- Crown rot of apples
  - *P. cactorum*
- Red needle cast
  - *P. pluvialis*

➢ *Managed with phosphite*

Importance of life-cycle in pathology and biology



- Foliar:
  - *P. infestans*, foliar, caducous sporangia
  - *P. ramorum*, SOD, alternation between foliar and soil phases
- Root- and collar-rots (soilborne):
  - *P. cinnamomi*, chlamydospores
  - PTA, oospores

Healthy trees, healthy future Enabling technologies to combat *Phytophthora* diseases

Landcare Research Manaaki Whenua

SCION forests · products · innovation

Kauri Dieback: historical perspective

- 1971 reported kauri dieback on Great Barrier Island (Gadgil)
- Identified as *P. heveae* (CMI-UK)
- 2006 recovered from Trounson Kauri park under dead kauri
- Identified using ITS-based gene analysis, as *P. castaneae* not *P. heveae*
- Oospore morphology not quite consistent
- Multi-gene analysis conducted

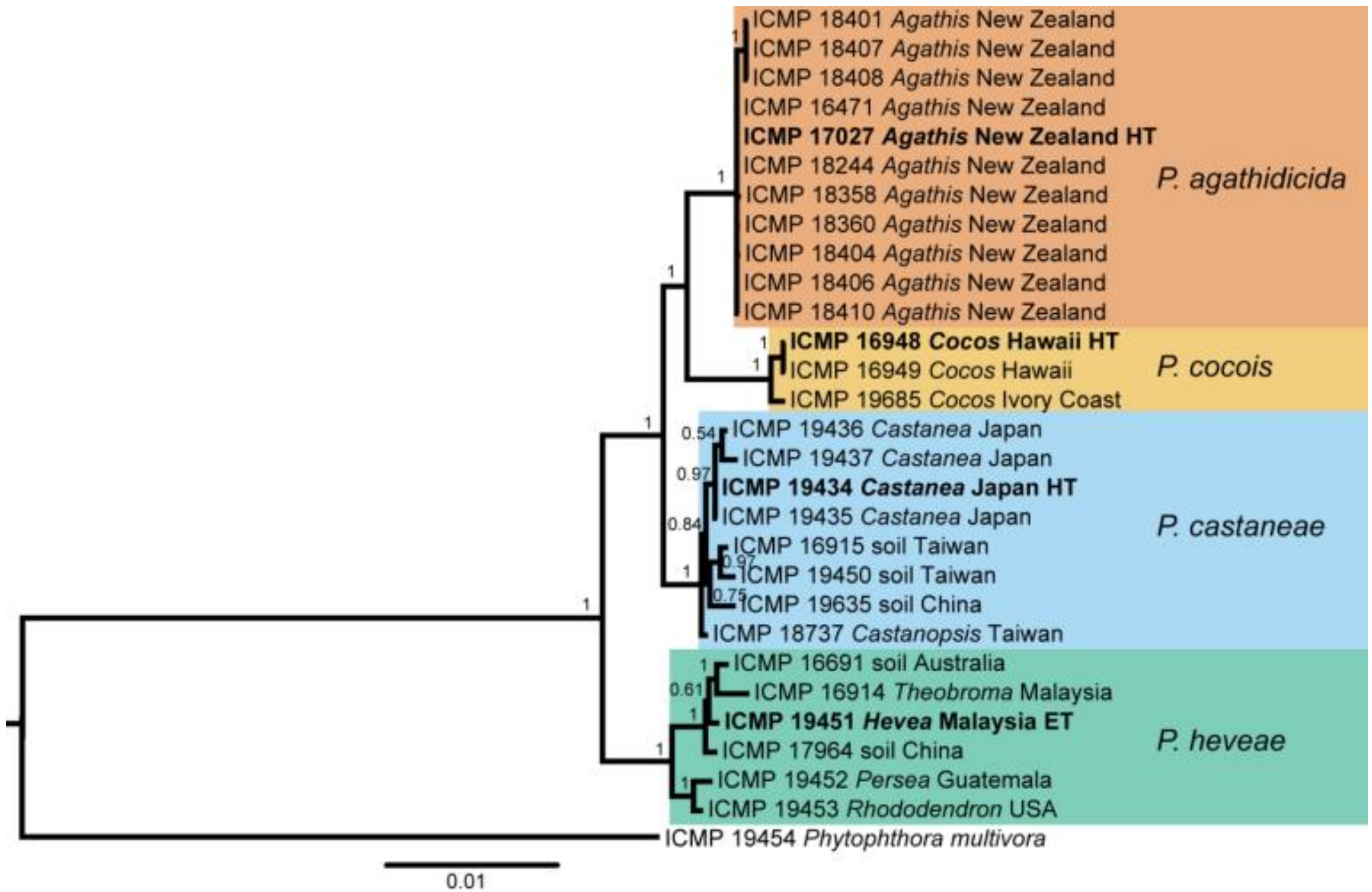
Foliage yellowing of planted ricker stand.
Kaiaraara, Gt. Barrier

Healthy trees, healthy future Enabling technologies to combat *Phytophthora* diseases

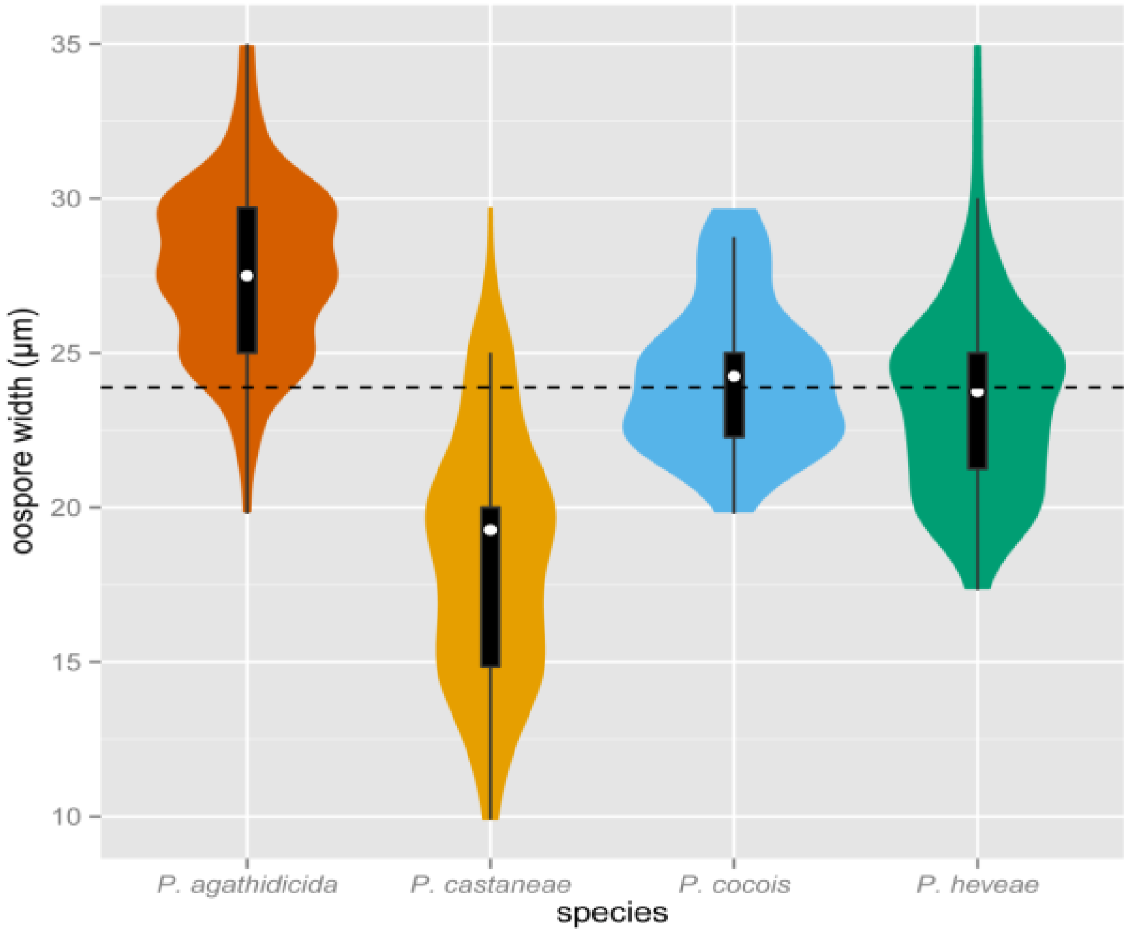
Landcare Research Manaaki Whenua

SCION forests·products·innovation

PTA: current taxonomy



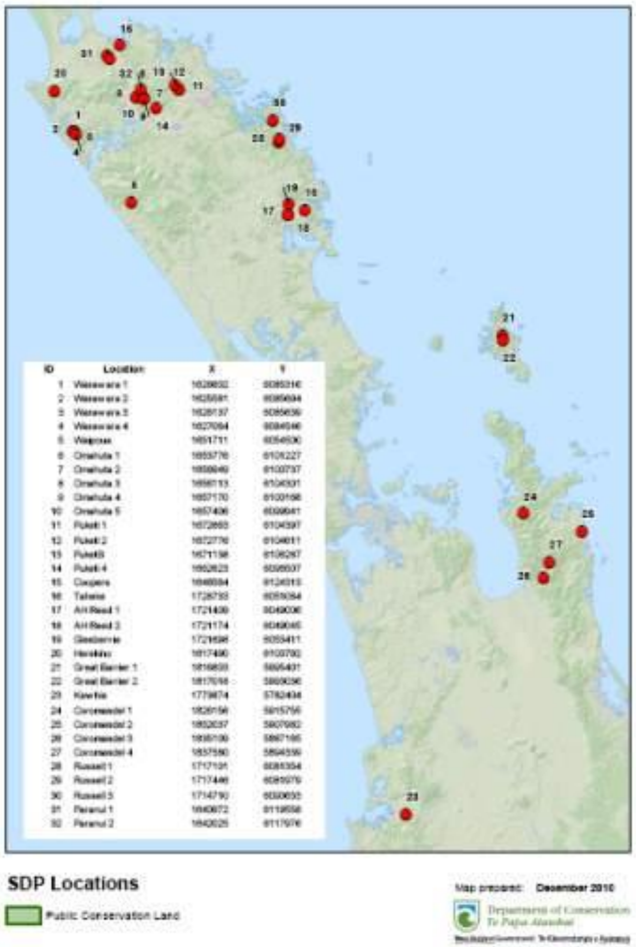
Size matters…



Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

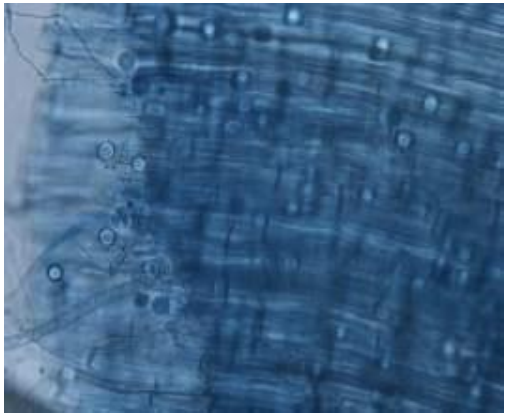
SCION
forests · products · innovation

Distribution



- Great Barrier Island
- Puketi / Omahuta
- Waipoua Forest
- Trounson Kauri Park
- Raetea Plantation
- Russell Forest
- Pakiri / Rodney
- Waitakere Ranges
  - Piha, Twin Peaks

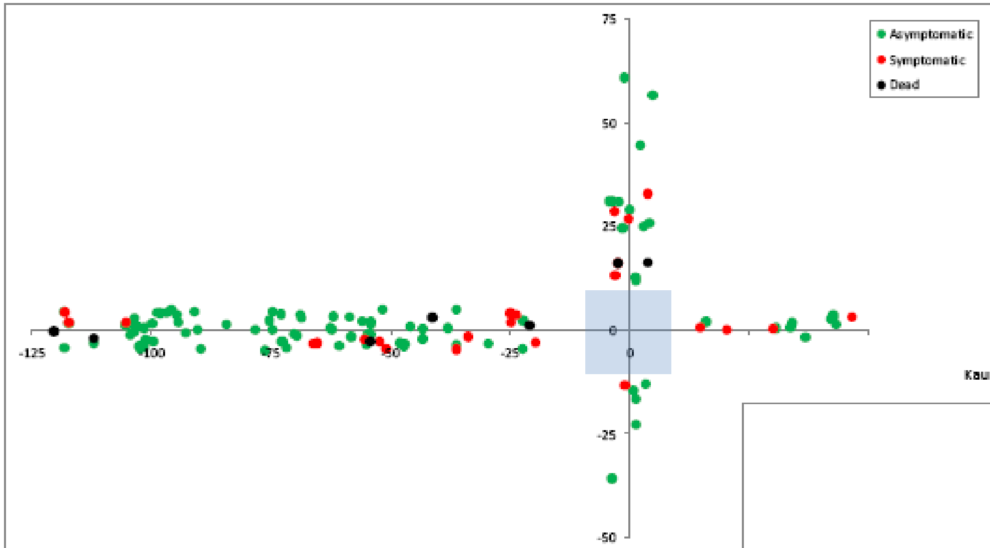
Transmission of infection



- Soilborne pathogen – so cannot eradicate without non-target impacts
- Root fragments from infected trees
- Survival structures in dead root tissue
- Thick-walled-oospores and stromata
- From which hyphae can grow and re-start the cycle of infection.

Rate of spread

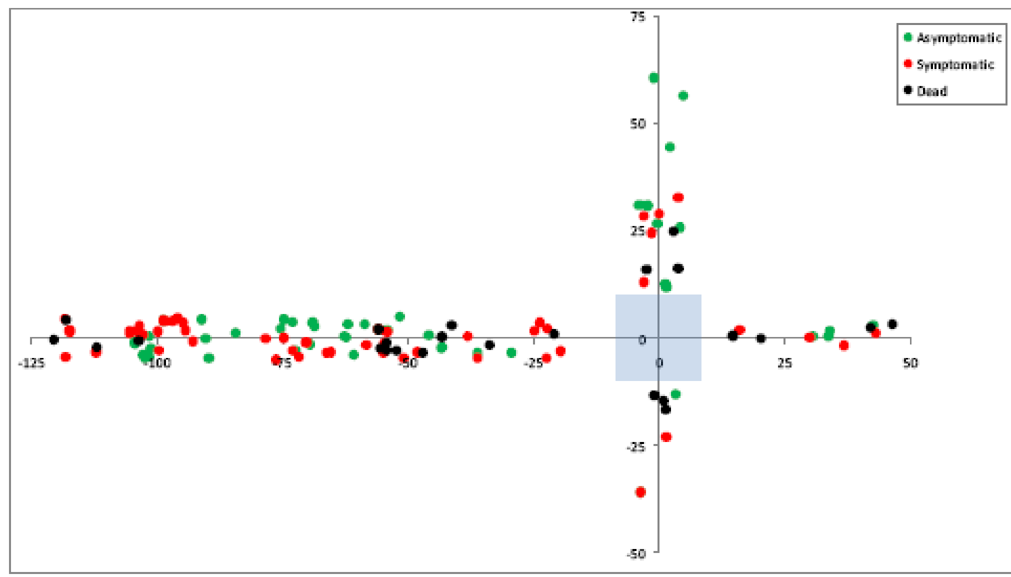
Kauri (*Agathis australis*) health status at Twin Peaks track, Huia along transects in 2006.



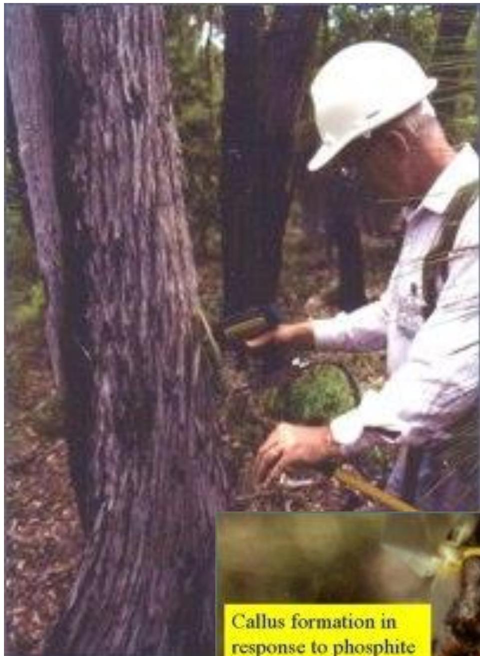
	2006	2012	Σ
AYMPTOMATIC	75	35	110
SYMPTOMATIC	28	53	81
DEAD	16	35	51
Σ	119	123	242

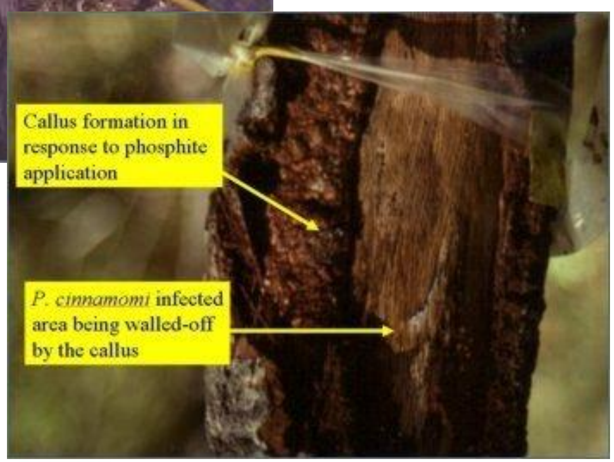
Linear distance of spread over 6 years	**3.41 ± 0.52 m**

Kauri (*Agathis australis*) health status at Twin Peaks track, Huia along transects in 2012.



Control: Phosphite experiments commenced





- Phosphite trunk injection-trials commenced (Ian Horner, 2012/13)
- Three infested sites at three geographic locations
- Initially phytotoxicity – dose response
- Mixed responses – positive, negative, no-response.

Healthy trees, healthy future Enabling technologies to combat Phytophthora diseases

scion forests · products · innovation

Meeting current research challenges: Kauri dieback and beyond …

- The importance of the Joint Agency approach for future incursion responses.
- Meeting the National Science Challenge: step-wise reversal in impact and distribution of *Phytophthora*
- Efficacy of phosphite trials?
- What else is there to know about current threats?
- What can this teach us about impacts of future threats?
- Lessons learnt to-date, and role of pragmatic, participatory and qualitative research.

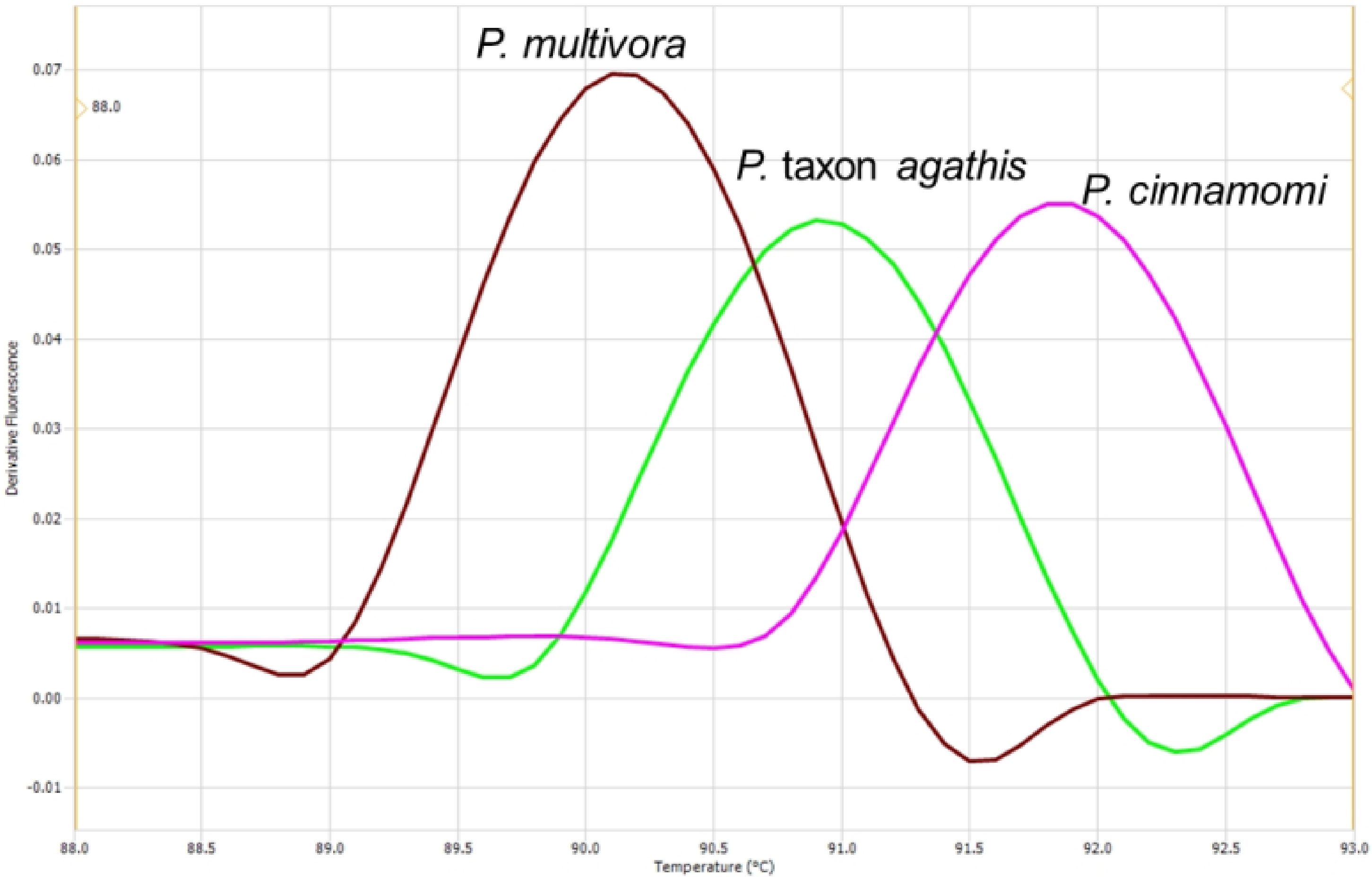
PTA diagnostics

- Bioassays vs molecular methods
  - Soil baiting – slow turnaround
  - PCR – results within several days

- Real time-PCR primers developed
  - Validated between labs

- Overall rate of detection or recovery similar between real-time PCR and bioassays
- Could improve RT-PCR assay through modifications to methods

Developed HRM diagnostic tool to distinguish PTA



Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

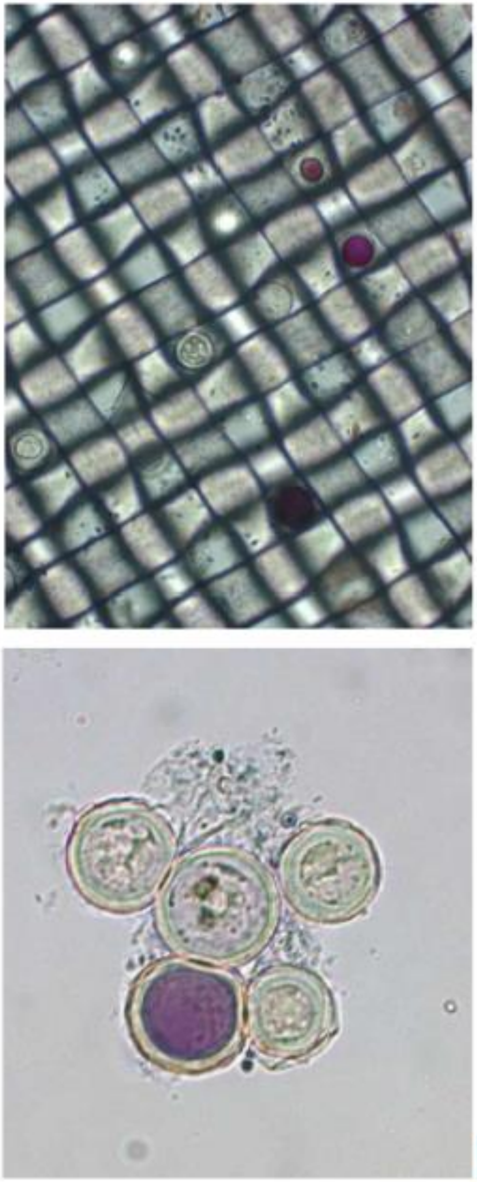
scion
forests · products · innovation

Efficacy of hygiene treatments

Determine the efficacy of a variety of treatments to deactivate oospores of PTA

- Trigene = not effective
- Salt water immersion = not effective
- Fumigation of soil = not effective
- Range of pH solutions = effective
- Temperature = most effective

➢ 60 - 70°C applied to wet soil or through a steam applicator for periods of 4 hours would result in total kill.



Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

scion
forests · products · innovation

Phytophthora species in New Zealand's trees and forests

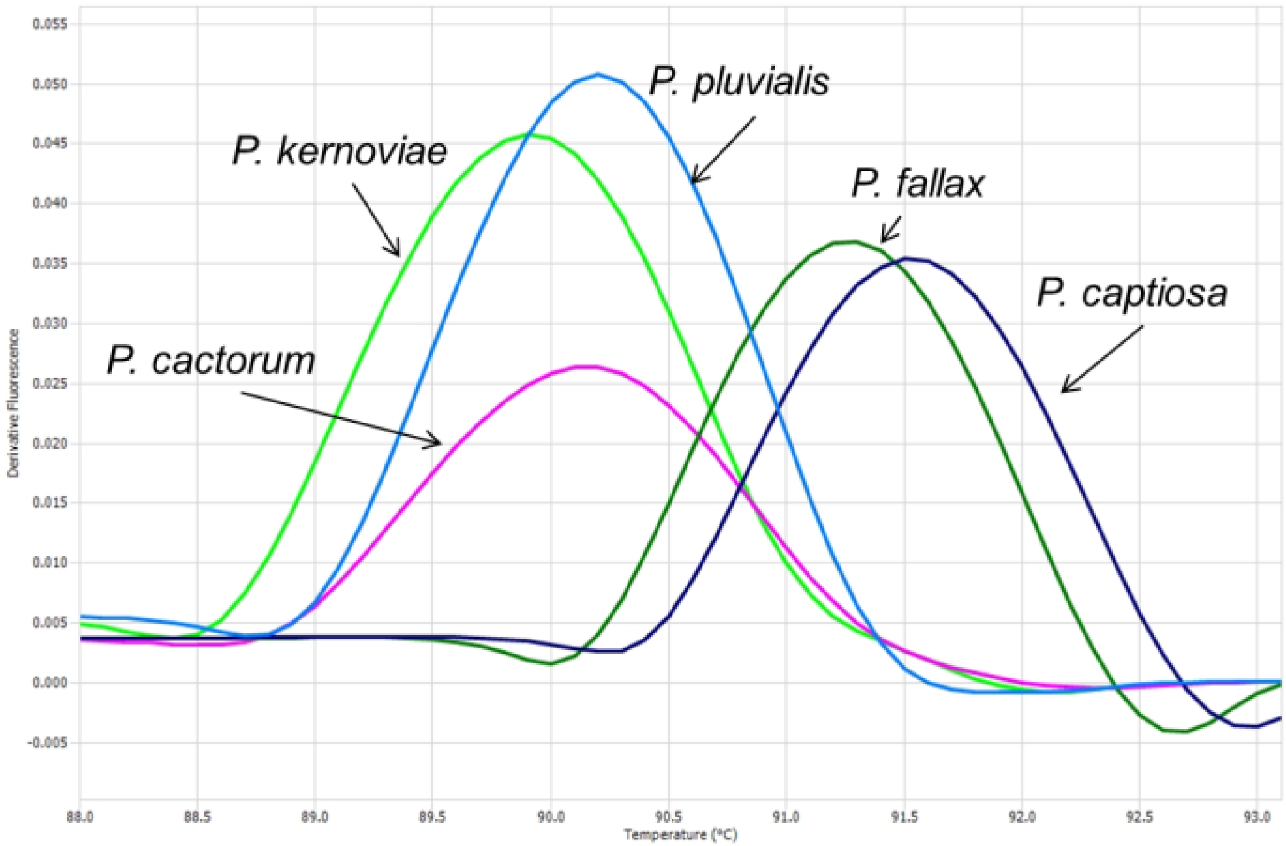
Species	Tissues affected	Mode of dispersal
P. t. Agathis	Roots Collar	Soil Water
P. cinnamomi		
P. multivora		
P. cactorum		
P. inundata		
P. cryptogea		
P. megasperma		
P. captiosa	Leaves/Needles	Aerial
P. fallax		
P. pluvialis		
P. kernoviae	Roots and Leaves	Aerial/Soil

Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

SCION
forests · products · innovation

Developed HRM diagnostic tool to distinguish *Phytophthora* spp.



Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

SCION
forests · products · innovation

Phytophthora pluvialis – red needle cast

scion

forests · products · innovation

Phytophthora cactorum – over 250 known hosts

Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

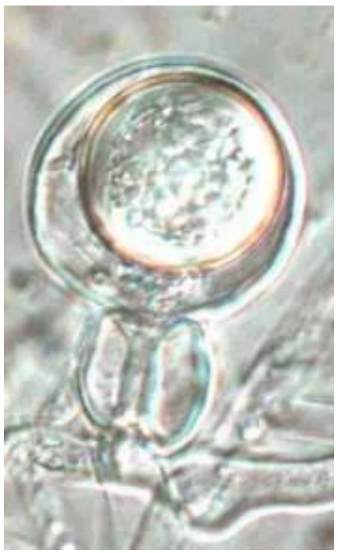
Phytophthora cinnamomi – over 2500 known hosts

Phytophthora cinnamomi - Australia

Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

scion
forests · products · innovation

Phytophthora kernoviae



Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

scion
forests·products·innovation

Healthy trees, healthy future:
Enabling technologies to combat Phytophthora diseases



Healthy trees, healthy future:
Enabling technologies to combat Phytophthora diseases

- Using a multi-host-pathogen model three tree species will be challenged by eight *Phytophthora* species to:
  - identify trees with broad resilience against a wide range of *Phytophthora* species
  - develop diagnostic tools
  - improve management of *Phytophthora* species
  - improve understanding of *Phytophthora*-host interactions

Healthy trees, healthy future Enabling technologies to combat *Phytophthora* diseases

Landcare Research Manaaki Whenua

SCION forests · products · innovation

The HTHF Enabling Technology Platform

PATHOGENS

***Phytophthoras* in New Zealand**

P. pluvialis

P. taxon *Agathis*

P. cactorum

P. multivora

P. cinnamomi

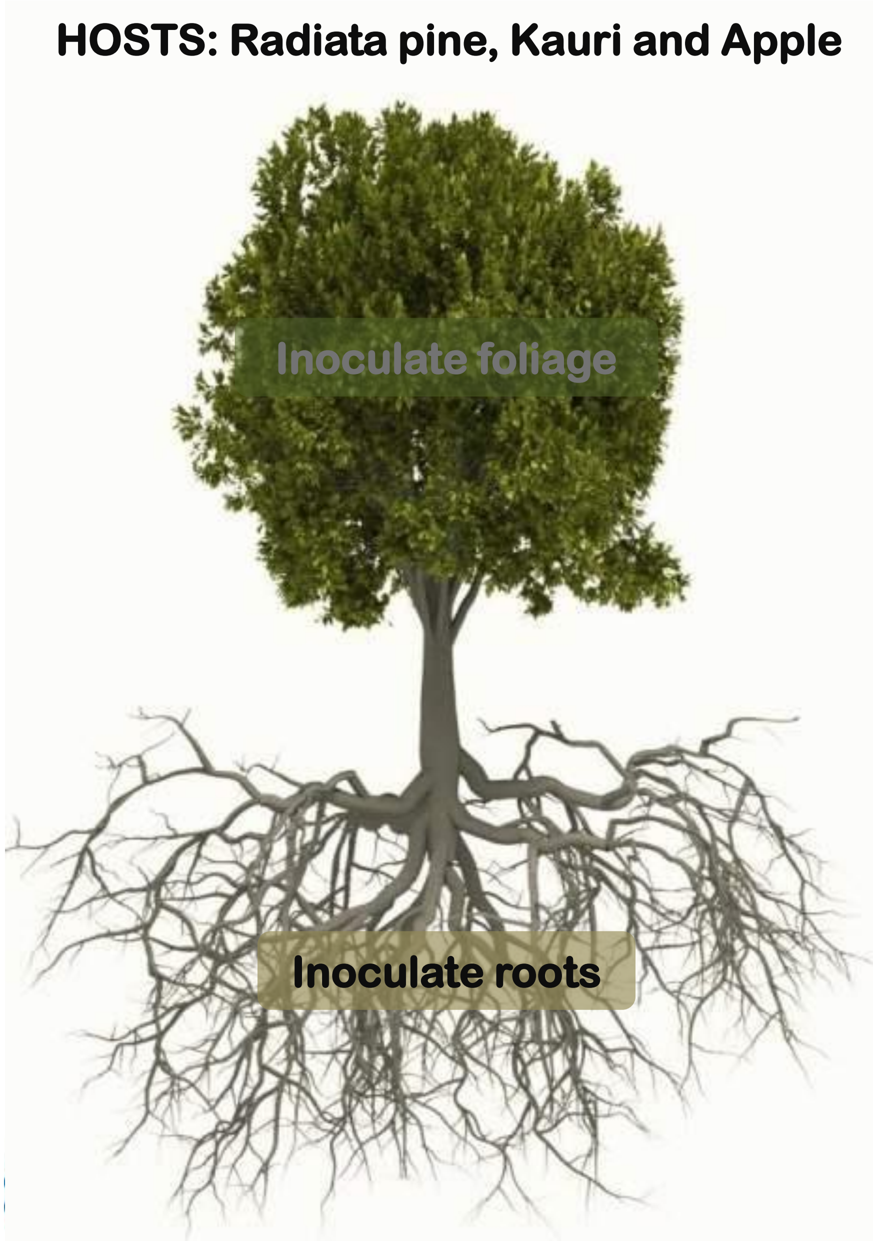
P. kernoviae

***Phytophthoras* Internationally**

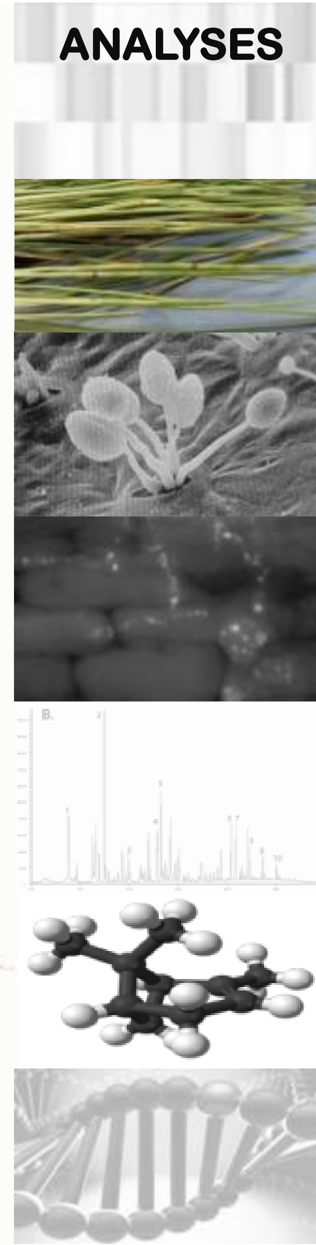
P. pinifolia

P. ramorum

HOSTS: Radiata pine, Kauri and Apple



ANALYSES



OUTPUTS

Improved breeding

Improved Diagnostics

Response to future incursions

Bio & Chemical control strategies

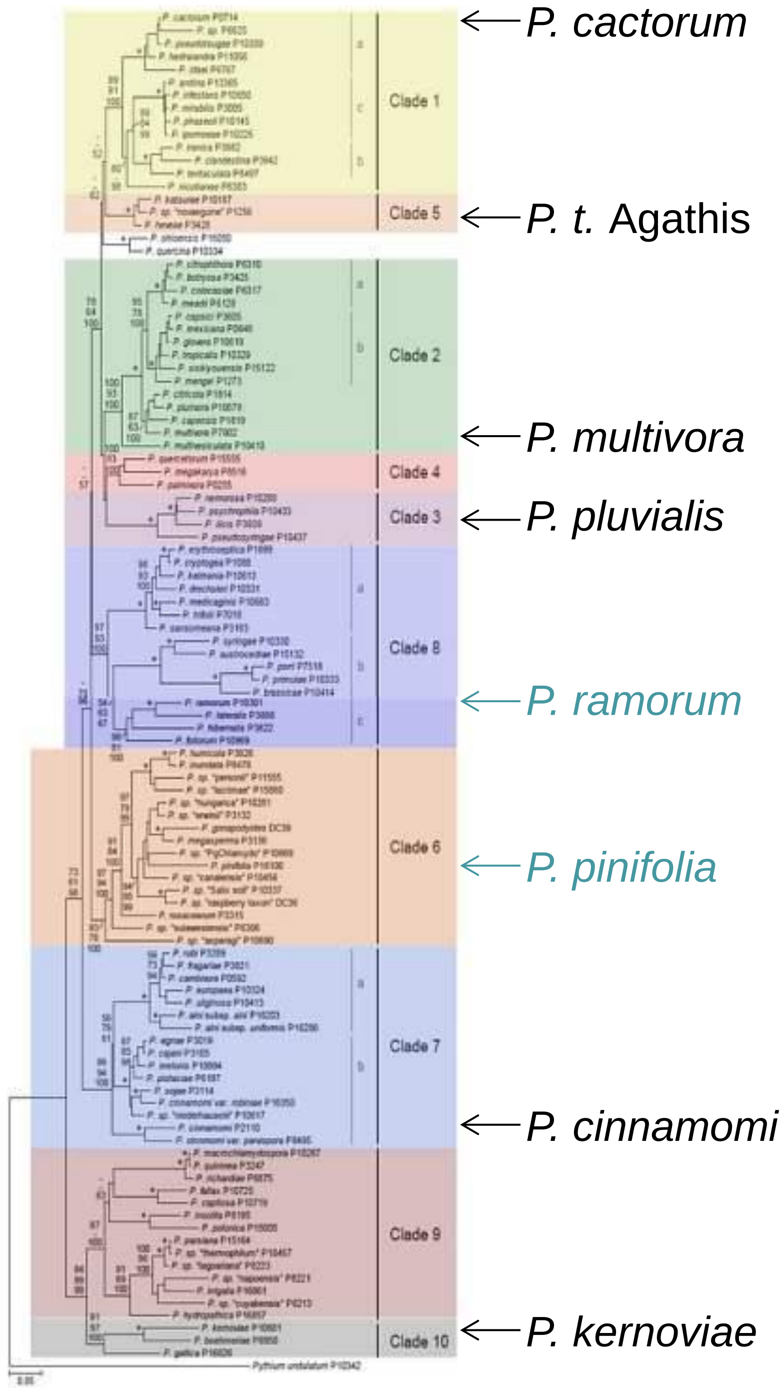
Chemical indicators of infection

Molecular indicators of infection

Resilient trees

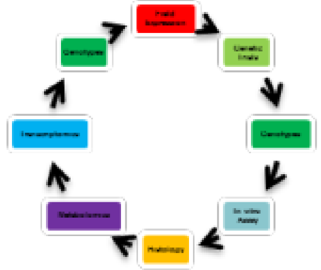
Understanding tree disease

Phytophthora phylogeny



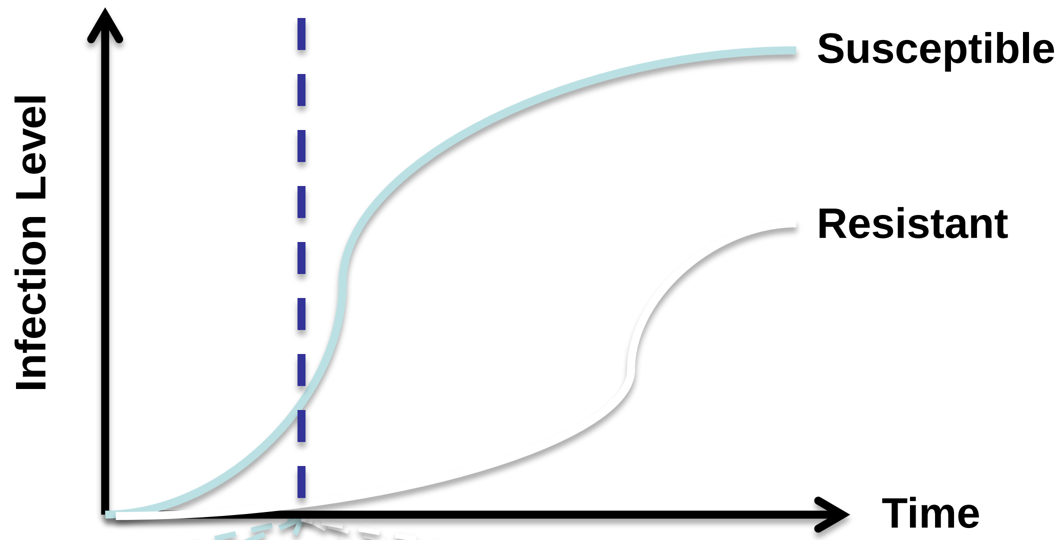
Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

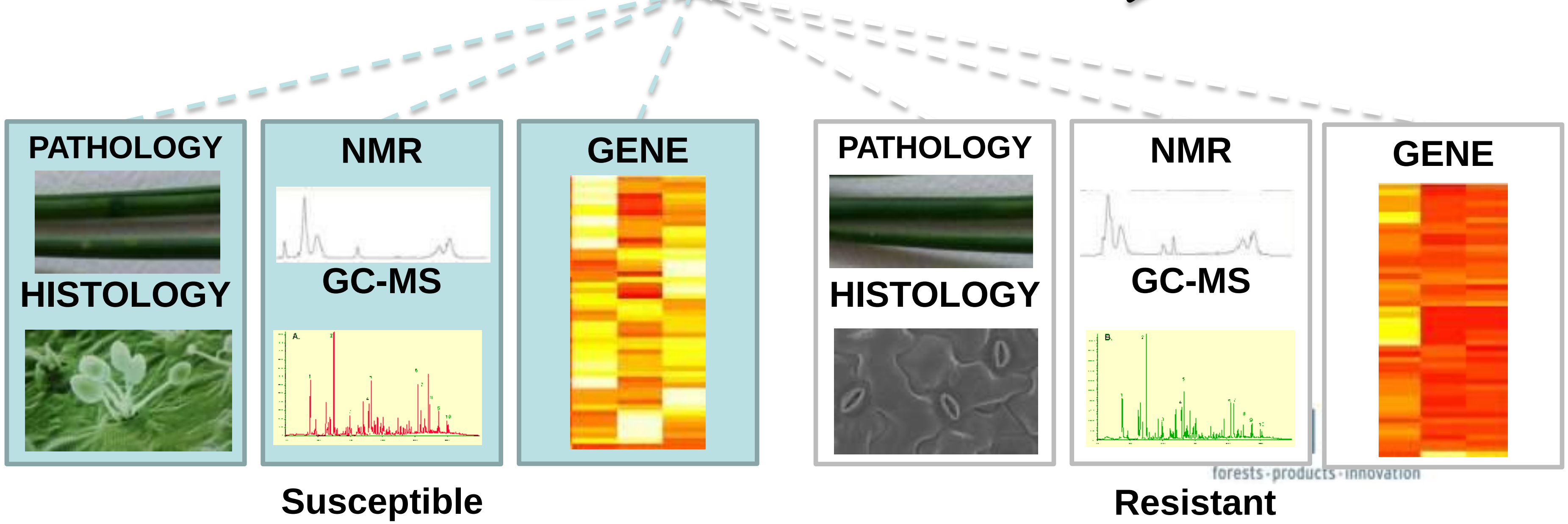
scion
forests · products · innovation



SYSTEMS BIOLOGY

Disease progression over time





A team effort - National and International Collaborators

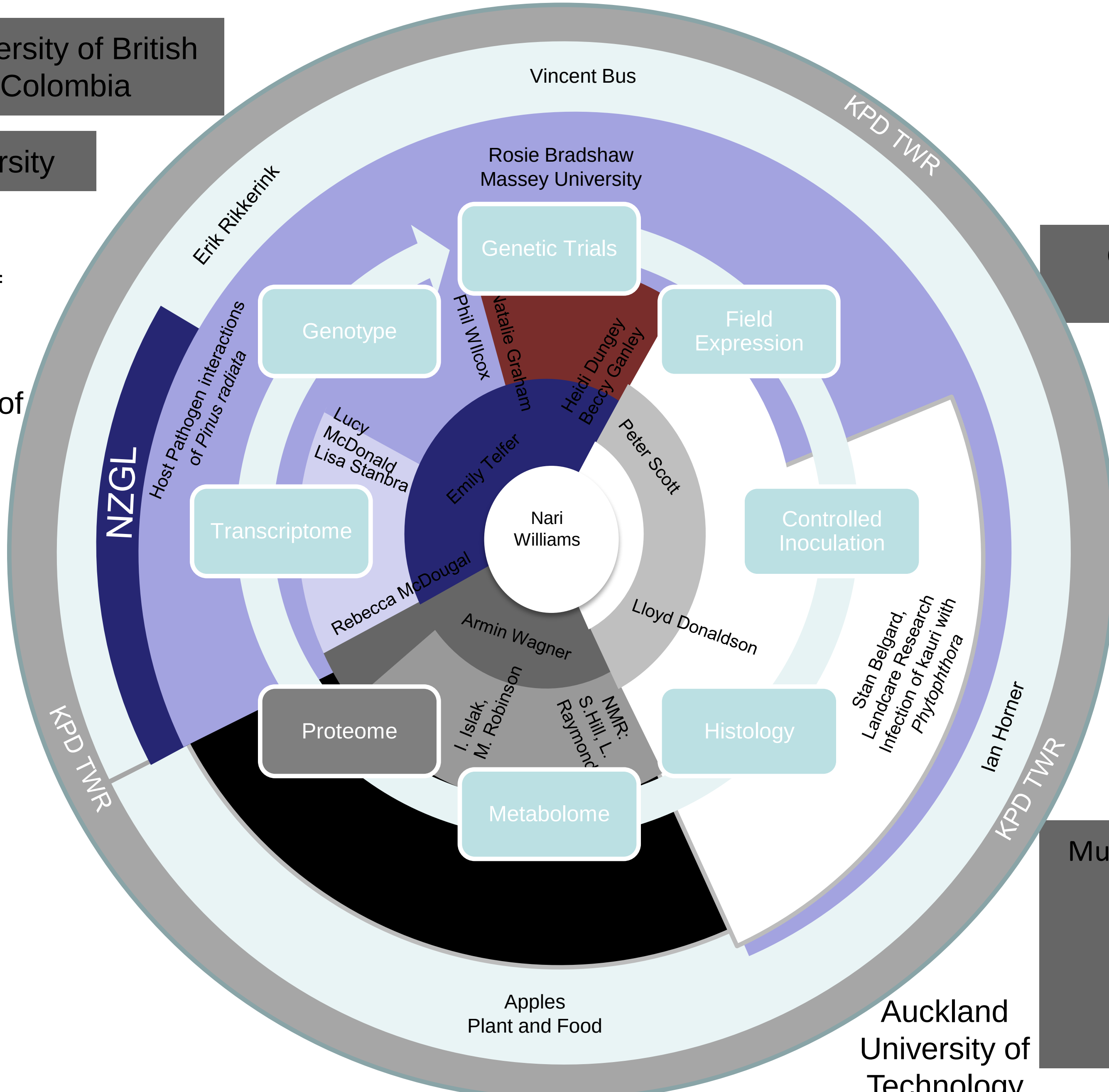
University of British Colombia

Exeter University

University of Canterbury

The University of Otago

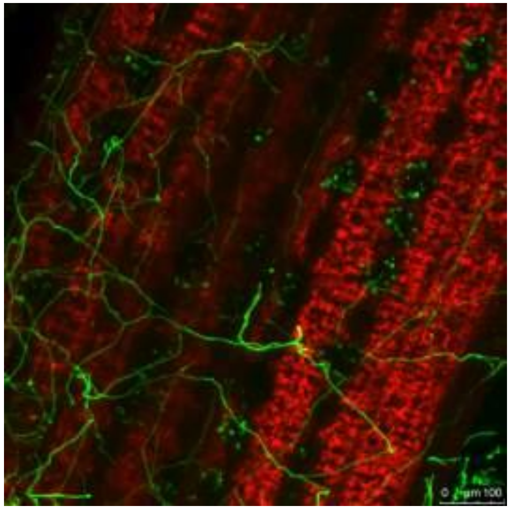
Oregon State University

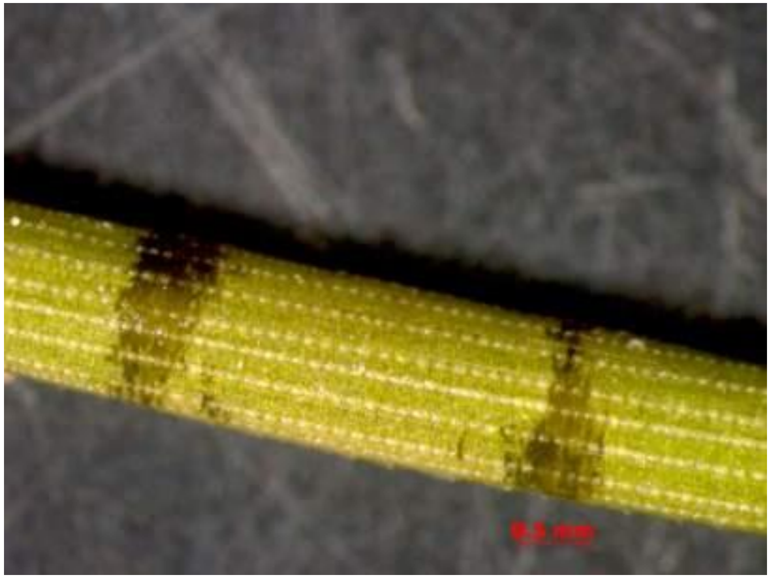


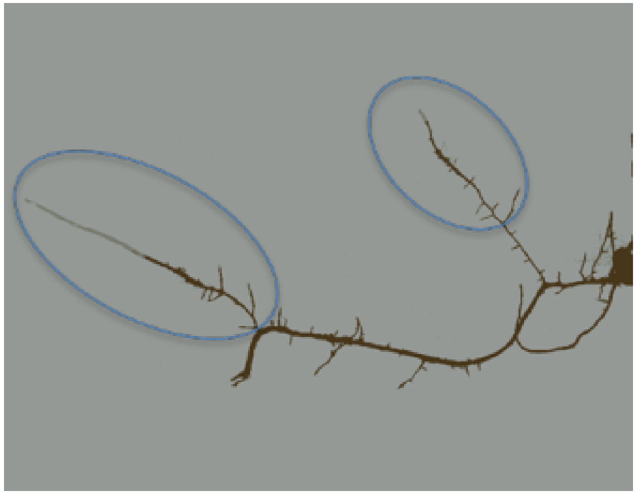
Auckland University of Technology

Murdoch University, Australia
Centre for Phytophthora Science and Management

Pathology/Histology

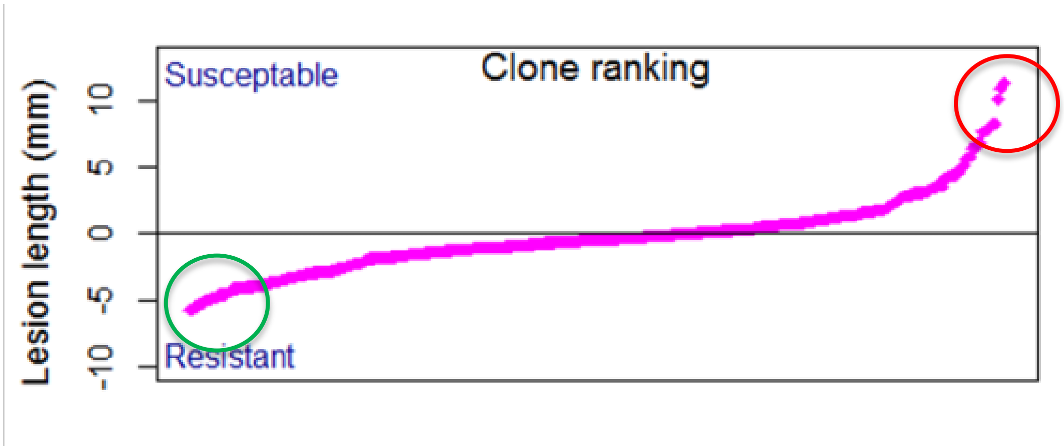


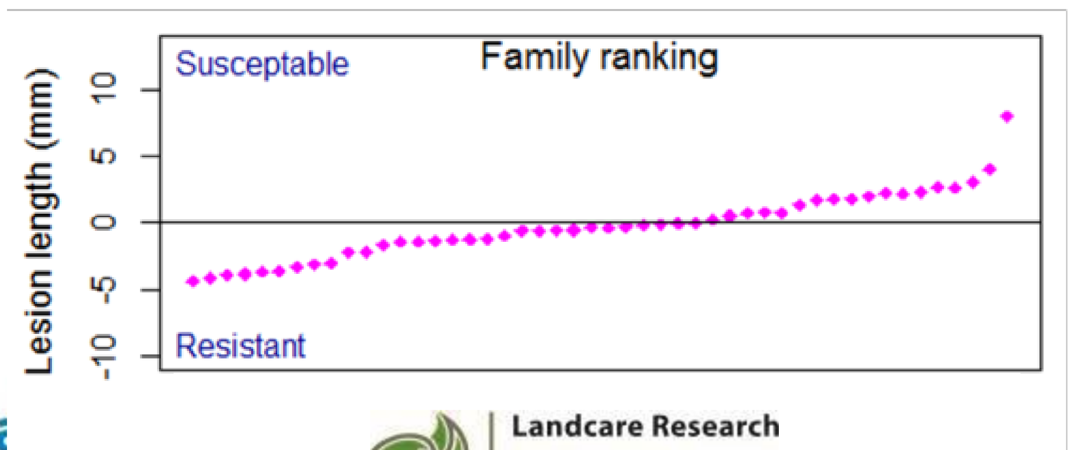




Screening for resistance

- Extremes of tolerance/susceptibility



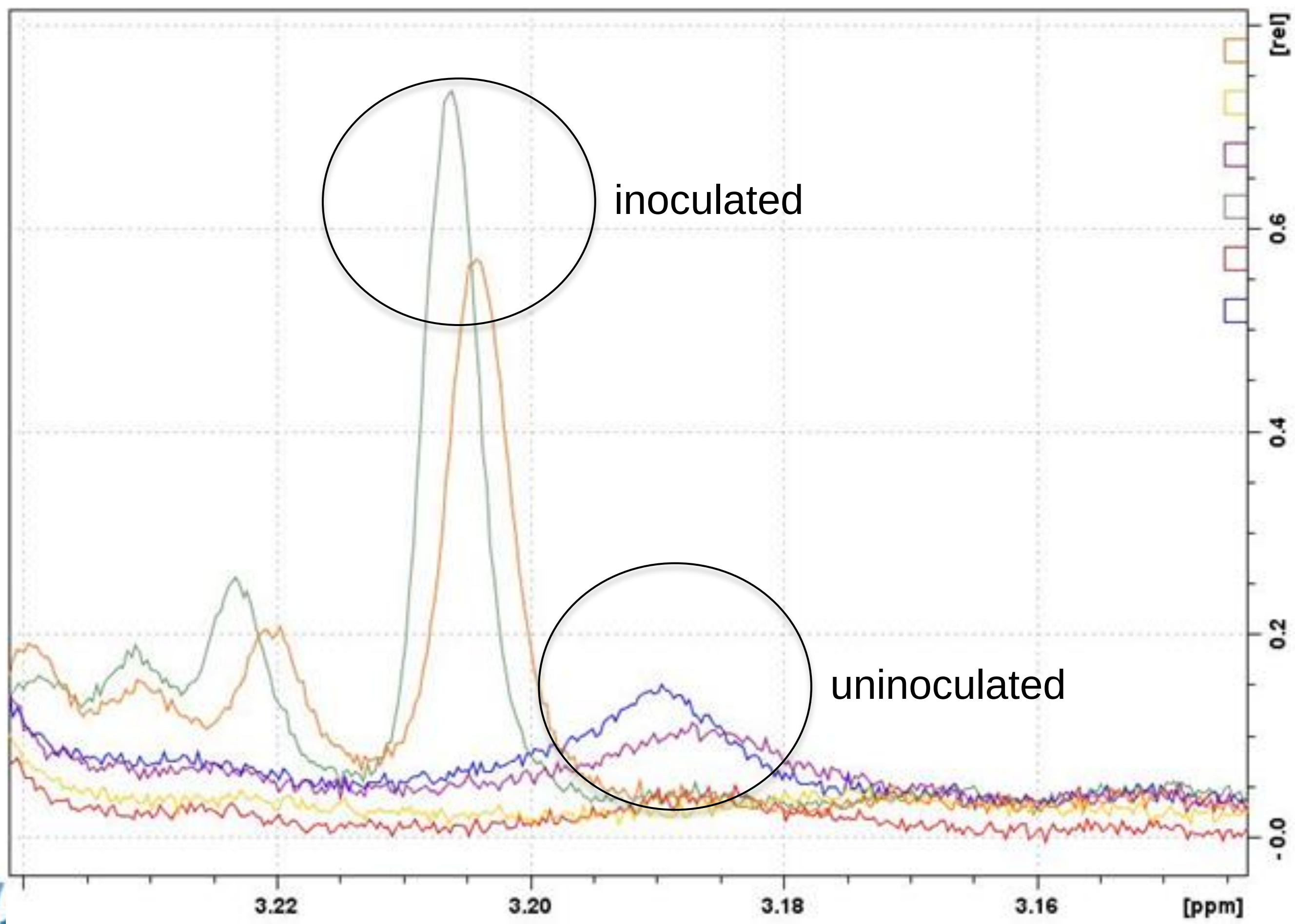


Healthy trees, hea[lthy] future Enabling technologies to combat *Phytophthora* diseases

Landcare Research Manaaki Whenua

scion forests·products·innovation

Metabolomics – looking for biological signatures



Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

scion
forests · products · innovation

Phytophthora genomes: what can they tell us?

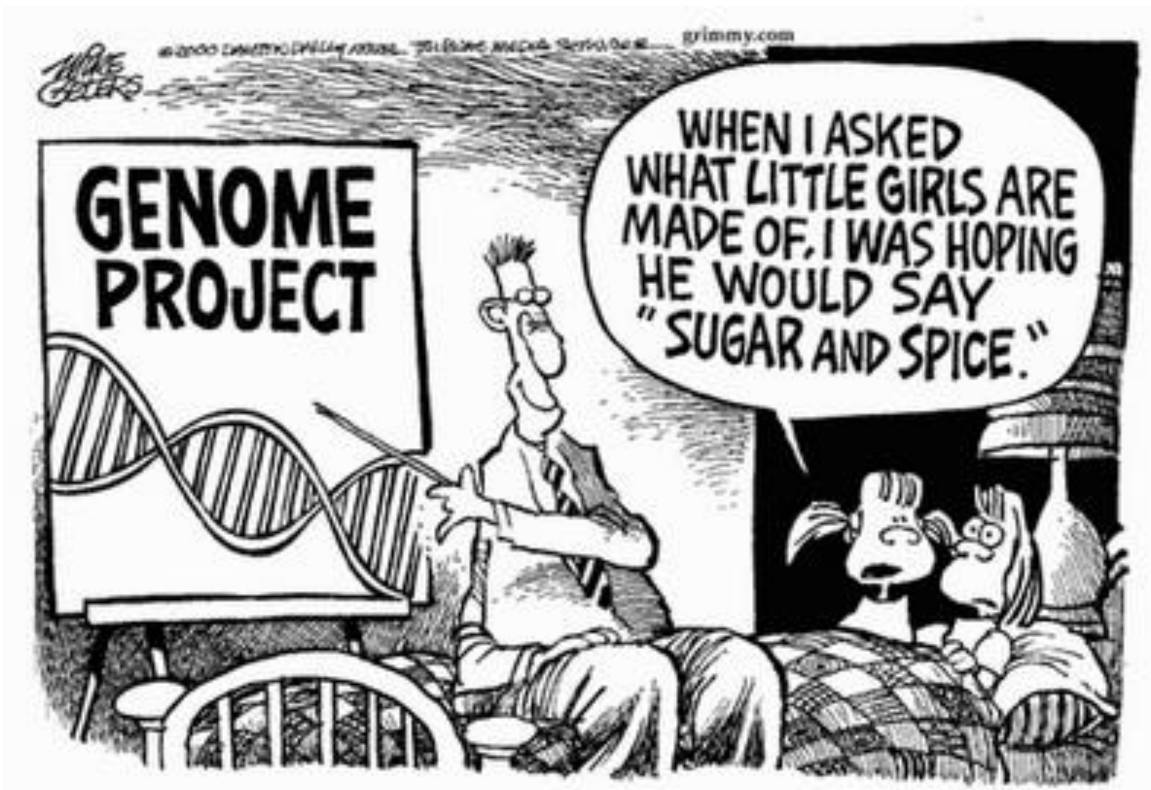
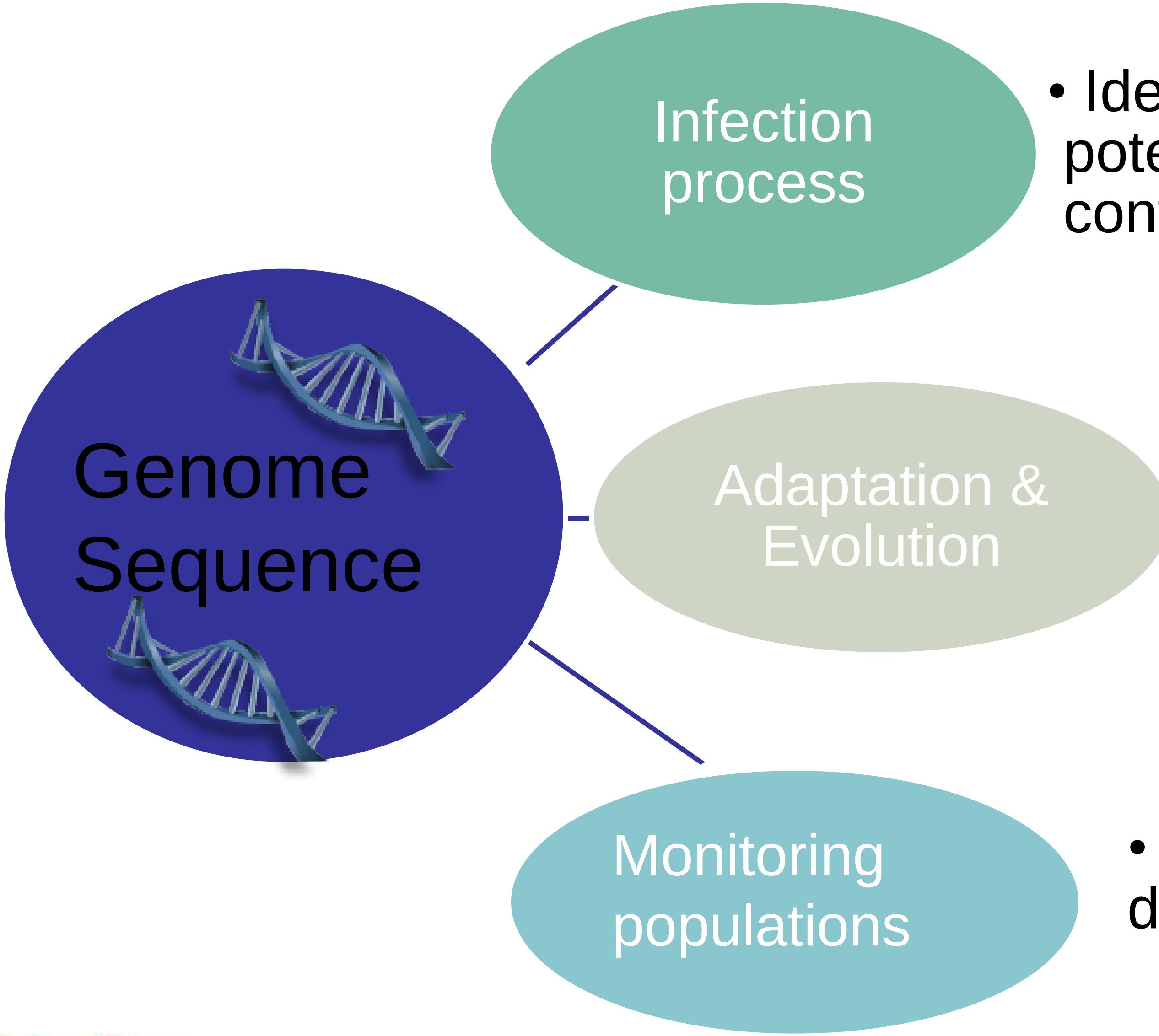


Image: mpnforum.com

Healthy trees, healthy future
Enabling technologies to combat *Phytophthora* diseases

Landcare Research
Manaaki Whenua

scion
forests · products · innovation



- Identify genes = potential targets for control

- Origin
- Why this host?
- How long have they been here?

- Fast & accurate diagnostics

Healthy trees, healthy future Enabling technologies to combat *Phytophthora* diseases

Landcare Research Manaaki Whenua

SCION forests·products·innovation

Phytophthora genomes: what's available?

Species	What's available	Genome Size
P. t. Agathis	2x NZ	42Mb
P. cinnamomi	NZ + Aus	78 Mb
P. multivora	2x NZ	In progress
P. cactorum	2x NZ	78 Mb
P. pluvialis	NZ + USA	62 Mb
P. kernoviae	2x NZ + lots UK	37-40 Mb
P. pinifolia	Overseas collaborators	132 Mb
P. ramorum	multiple	65 Mb
*P. infestans**	multiple	240 Mb

Conclusions

- *Phytophthora* species are the cause of epiphytotics throughout the world's forests, wildlands and productive sectors
- In NZ, *Phytophthora* species cause issues across landscapes and sectors (forestry, horticulture, conservation)
- More work needs to be done to contain and reduce impacts of *Phytophthora,* e.g. risk assessment of infested sites, increased surveillance efforts to prevent introduction of new overseas species e.g. SOD
- Systems biology approaches have replaced and extended species-specific responses, and the HTHF program (led by Nari Williams) brings CRI's, universities and industry together to combat the *Phytophthora* challenge
- Education programmes (schools, vocational, universities), public/community partnerships are needed to increase awareness around risks and up-take of management interventions.

Acknowledgements

SCION
forests · products · innovation

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Bio-Protection
Bioprotection science for New Zealand

Landcare Research
Manaaki Whenua

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

B3 Science Solutions for BETTER BORDER BIOSECURITY
www.b3nz.org

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo

AUT UNIVERSITY
AUCKLAND, NEW ZEALAND

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

KEEP KAURI STANDING
STOP KAURI DIEBACK DISEASE SPREADING
KIA TOITU HE KAURI

UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha

Healthy trees, healthy future
Enabling technologies to combat Phytophthora diseases

SCION
forests · products · innovation