Healthy trees, healthy future

Enabling technologies to combat *Phytophthora* diseases

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

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Outline of presentation

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

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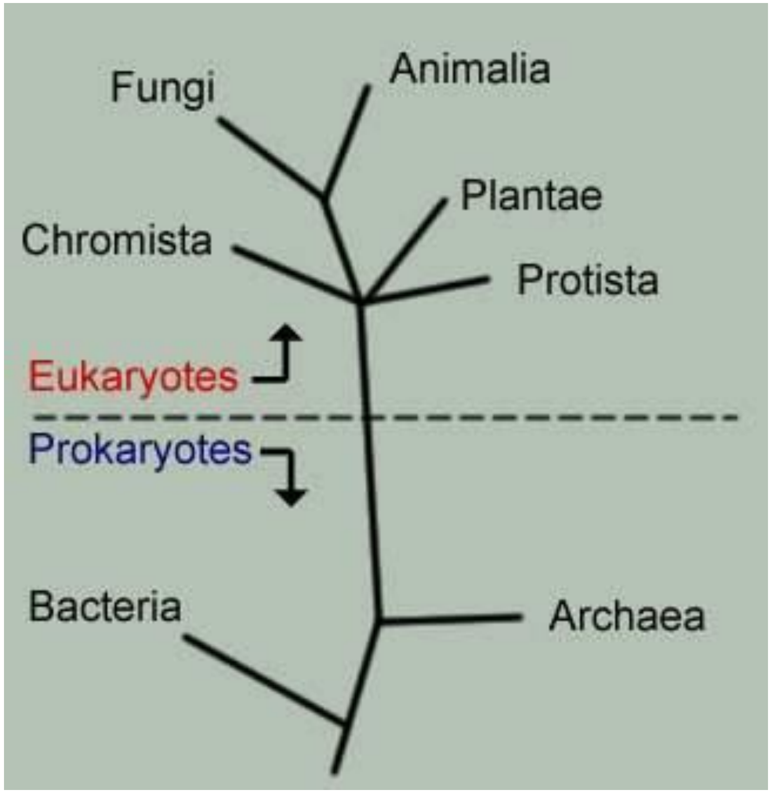
Phytophthora diseases world-wide

- 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*

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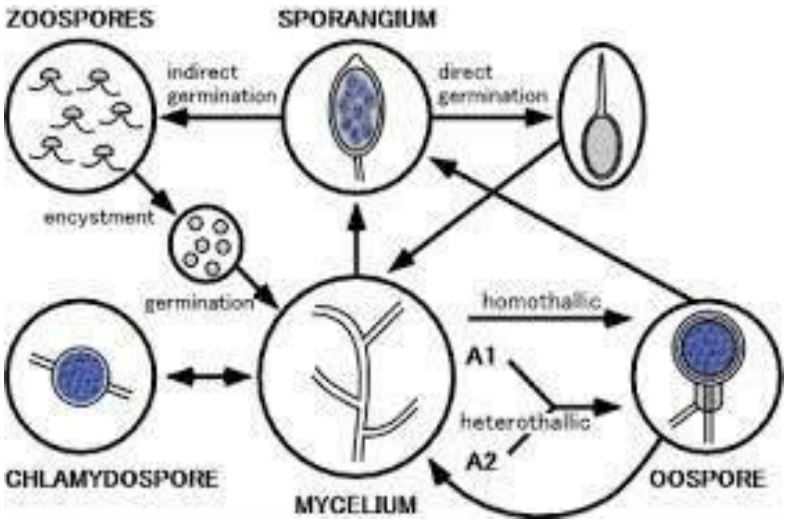
Importance of life-cycle in pathology and biology



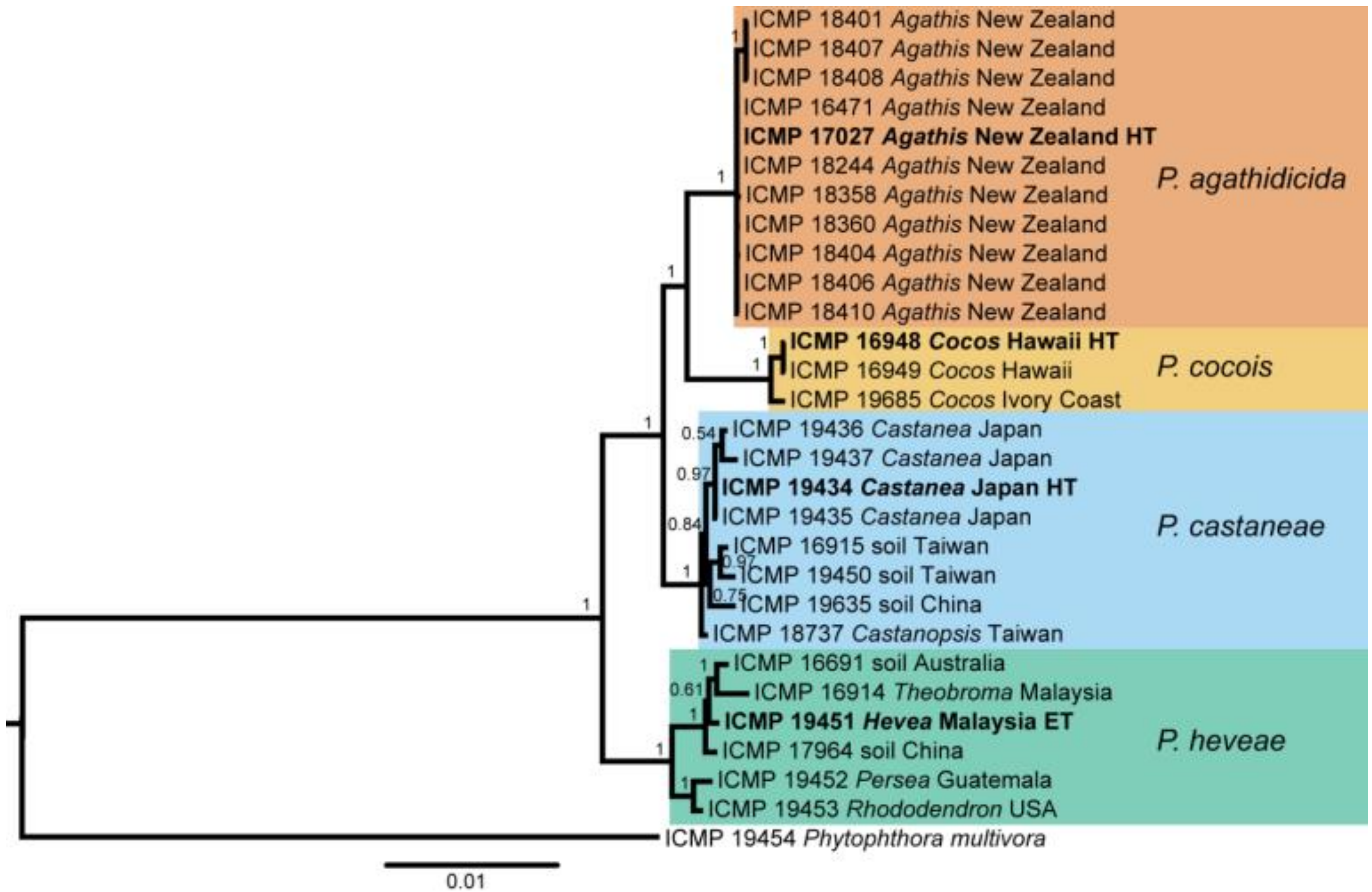
- Foliar:
  - *P. infestans*, foliar, caducous sporangia
  - *P. ramorum*, SOD, alternation between foliar and soil phases
- Root- and collar-rots (soilborne):
  - *P. cinnamomi*, chlamydospores
  - PTA, oospores

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

PTA: current taxonomy



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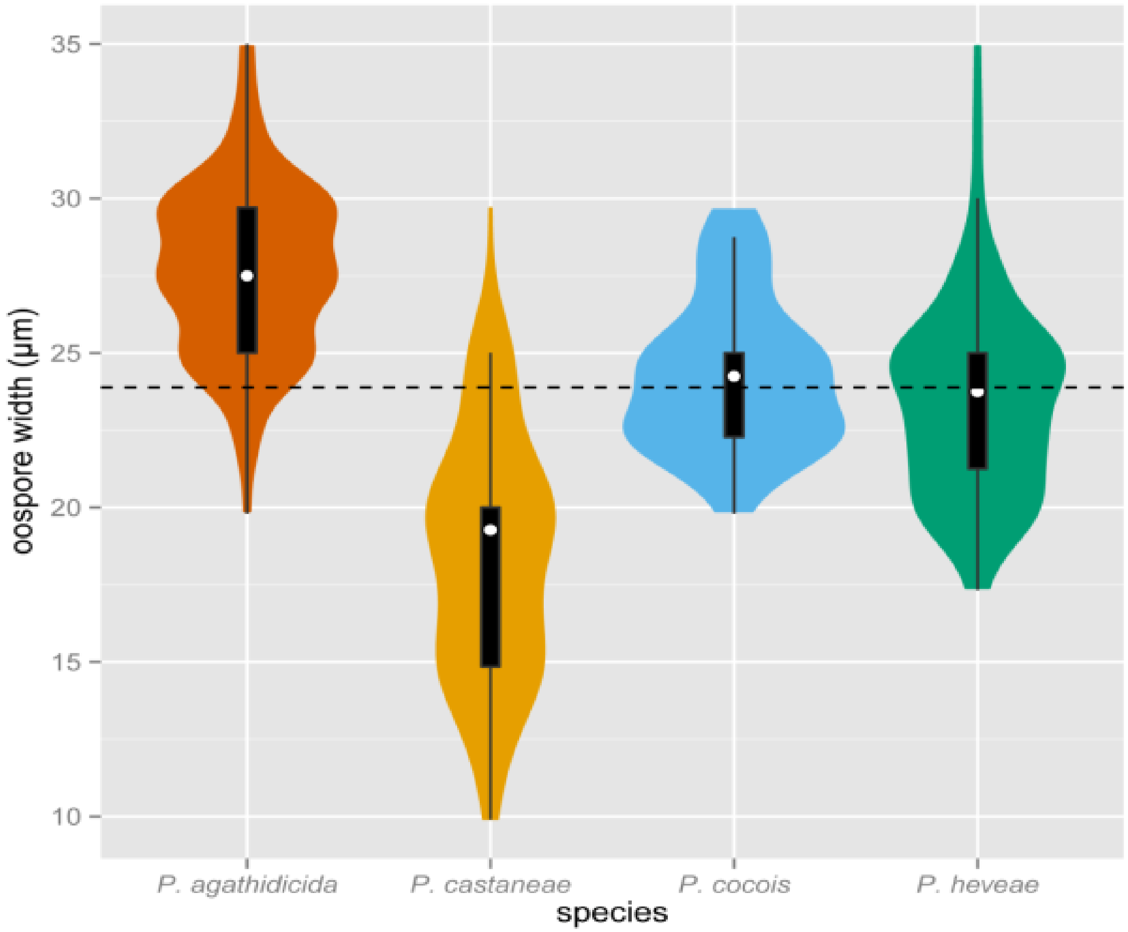
Size matters…



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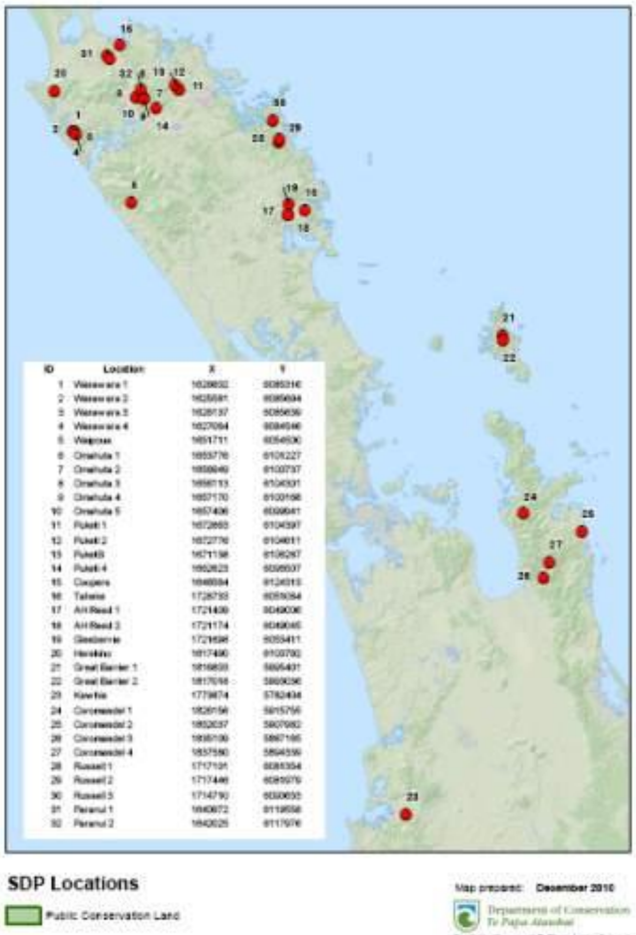
Distribution



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

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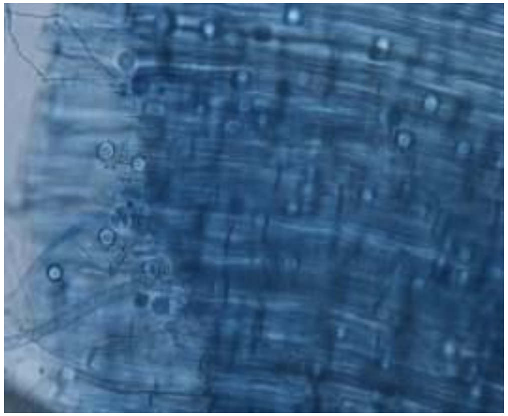
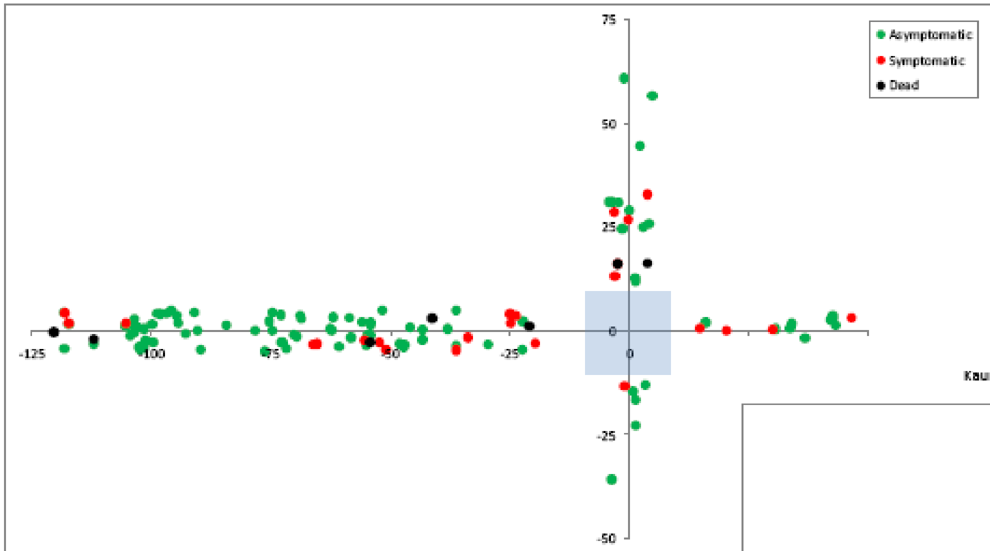
Transmission of infection



- 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

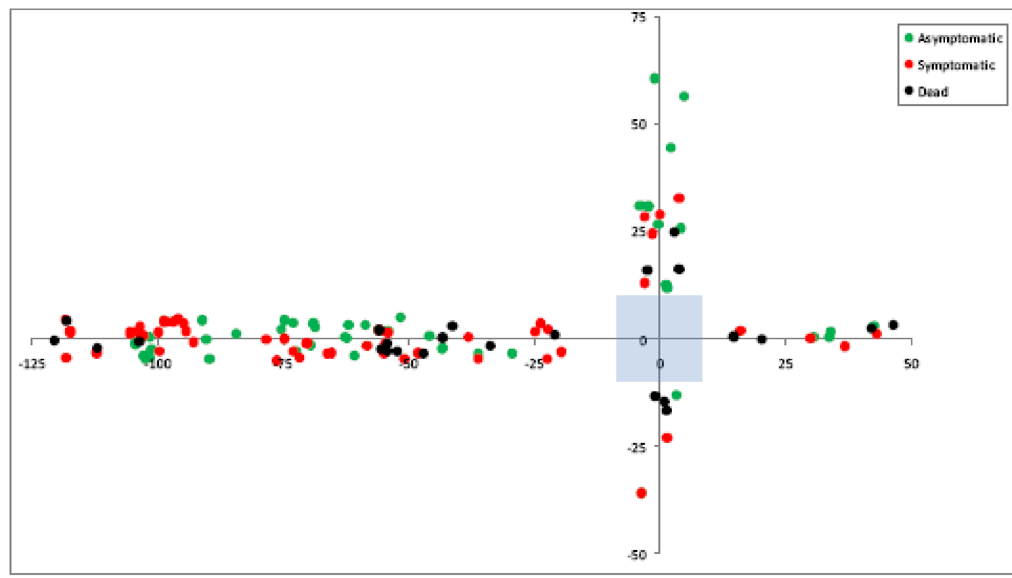
Kauri (*Agathis australis*) health status at Twin Peaks track, Huia along transects in 2006.



	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.



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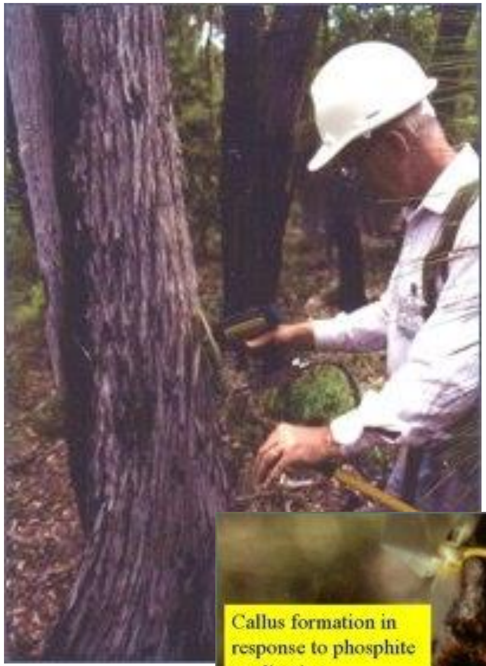
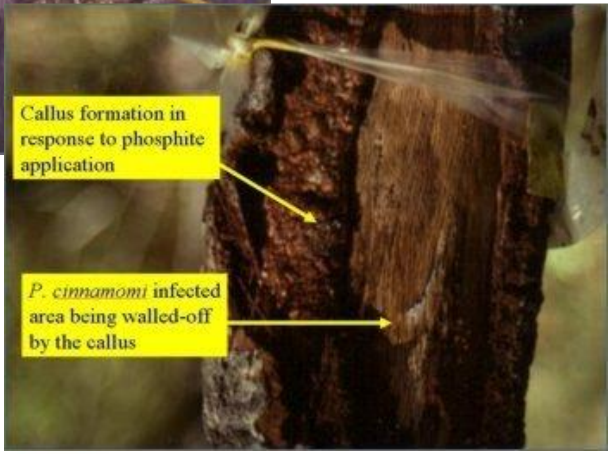
Control: Phosphite experiments commenced





- 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.

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

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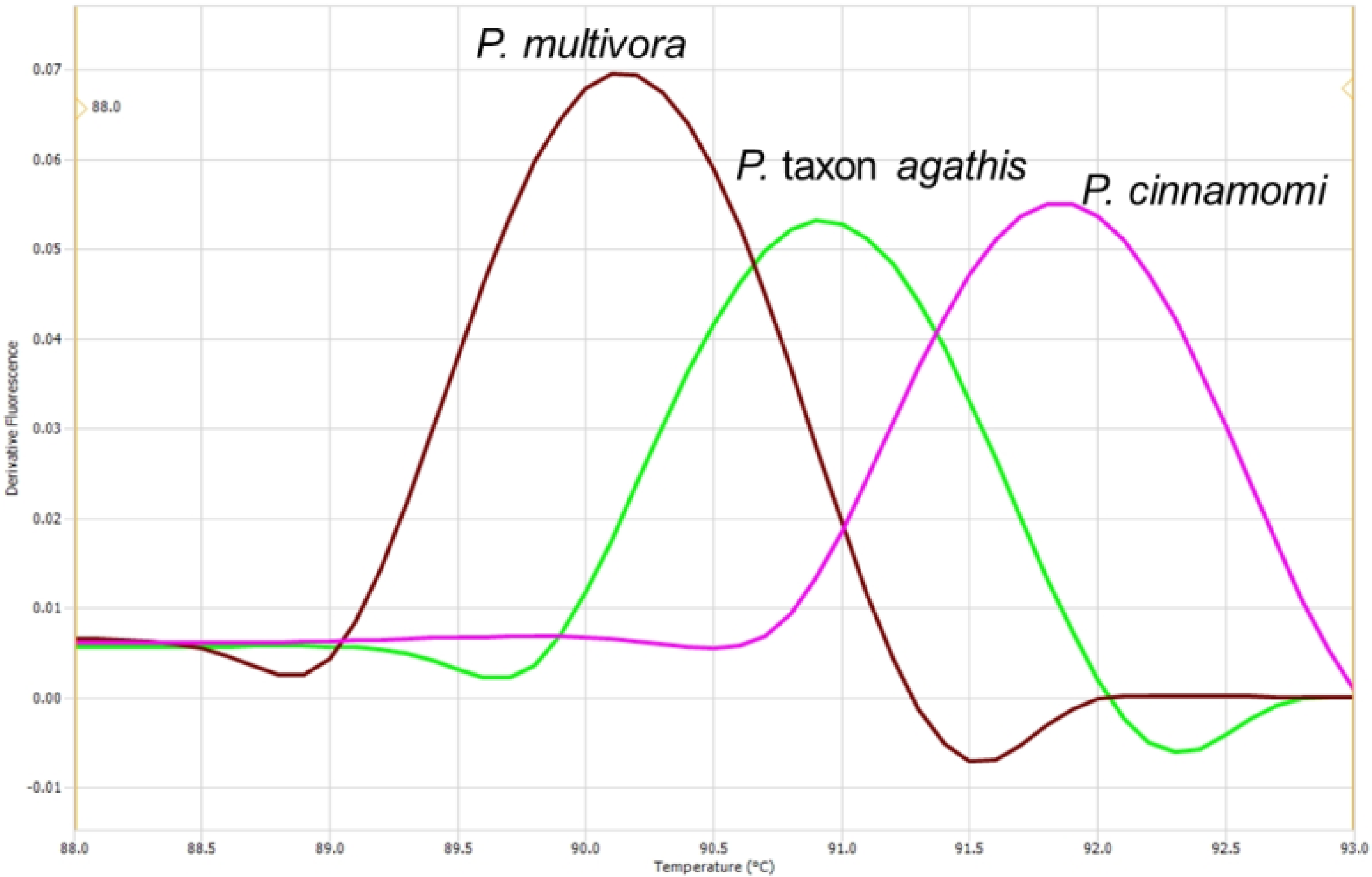
Developed HRM diagnostic tool to distinguish PTA



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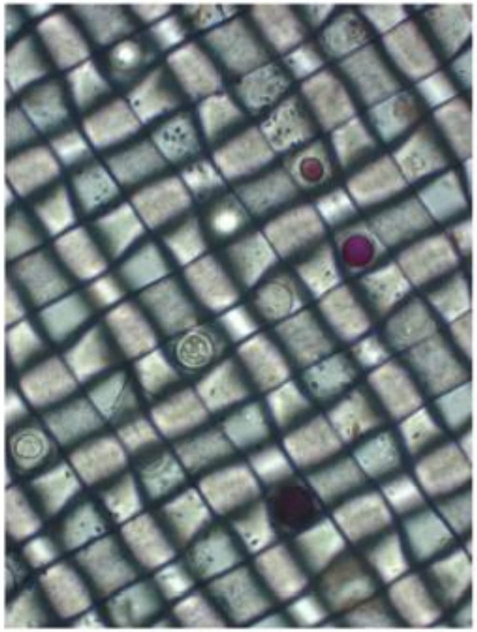
Efficacy of hygiene treatments

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

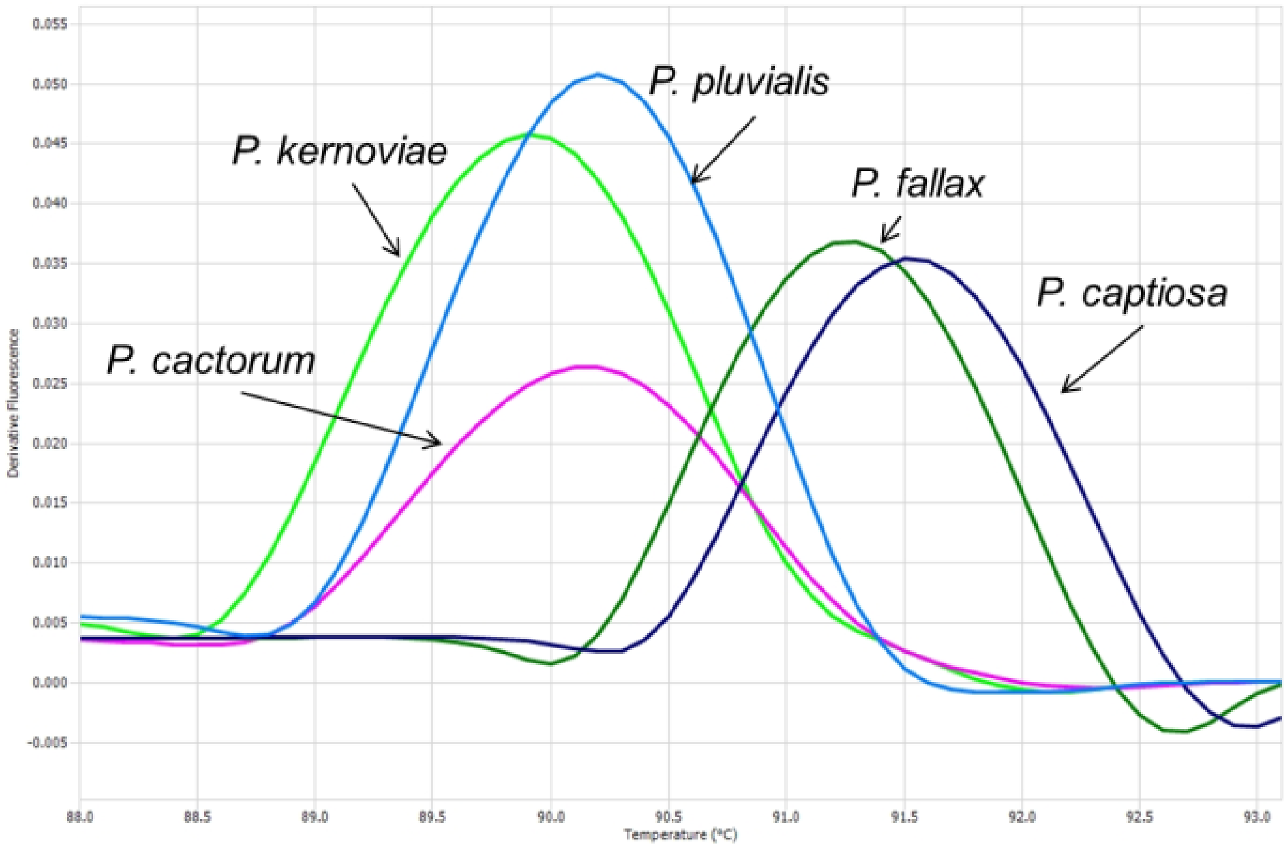
➢ 60 - 70°C applied to wet soil or through a steam applicator for periods of 4 hours would result in total kill.



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

Developed HRM diagnostic tool to distinguish *Phytophthora* spp.



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Phytophthora pluvialis – red needle cast

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Phytophthora cactorum – over 250 known hosts

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Phytophthora cinnamomi – over 2500 known hosts

Phytophthora cinnamomi - Australia

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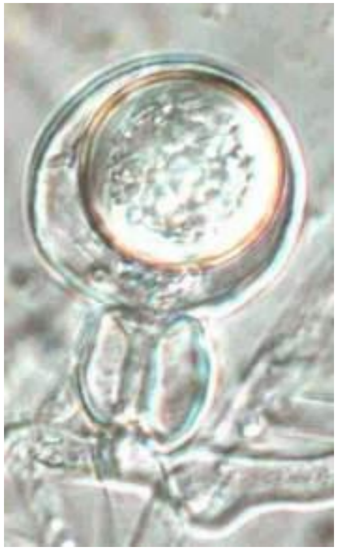
Phytophthora kernoviae



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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

The HTHF Enabling Technology Platform

PATHOGENS

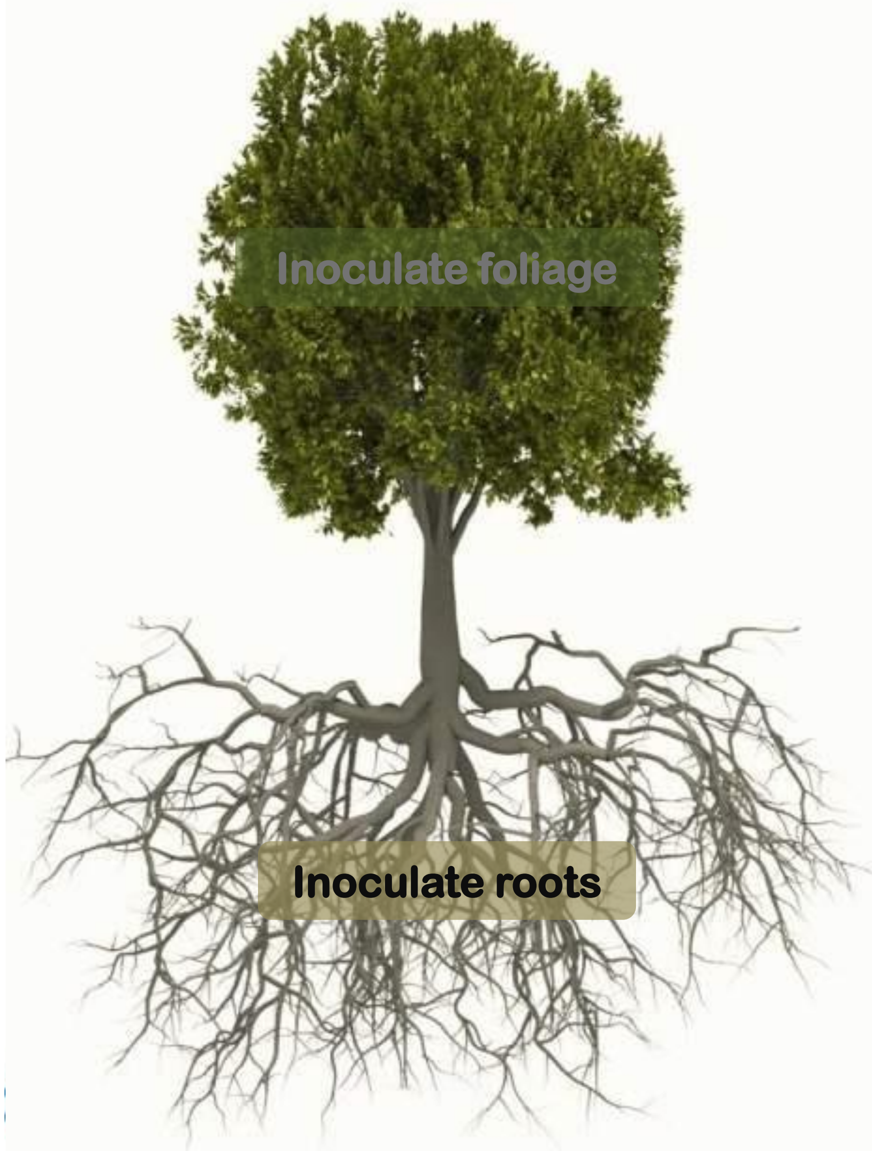
***Phytophthoras* in New Zealand**

- ***P. pluvialis***
- ***P.* taxon *Agathis***
- ***P. cactorum***
- ***P. multivora***
- ***P. cinnamomi***
- ***P. kernoviae***

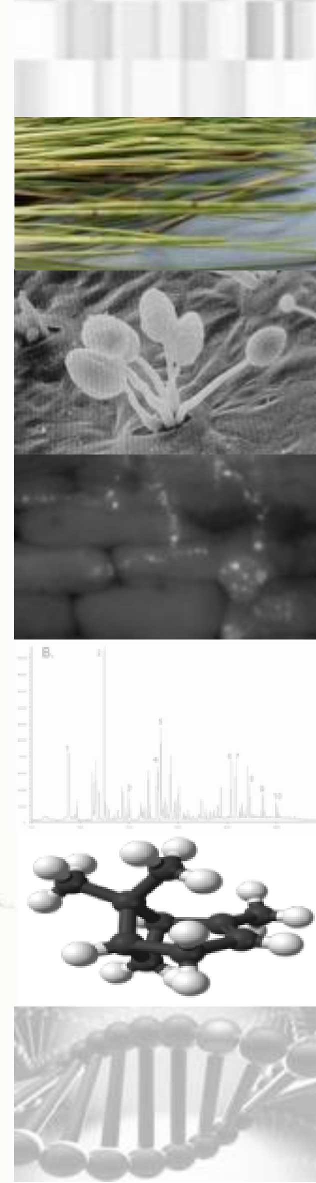
***Phytophthoras* Internationally**

- ***P. pinifolia***
- ***P. ramorum***

HOSTS: Radiata pine, Kauri and Apple



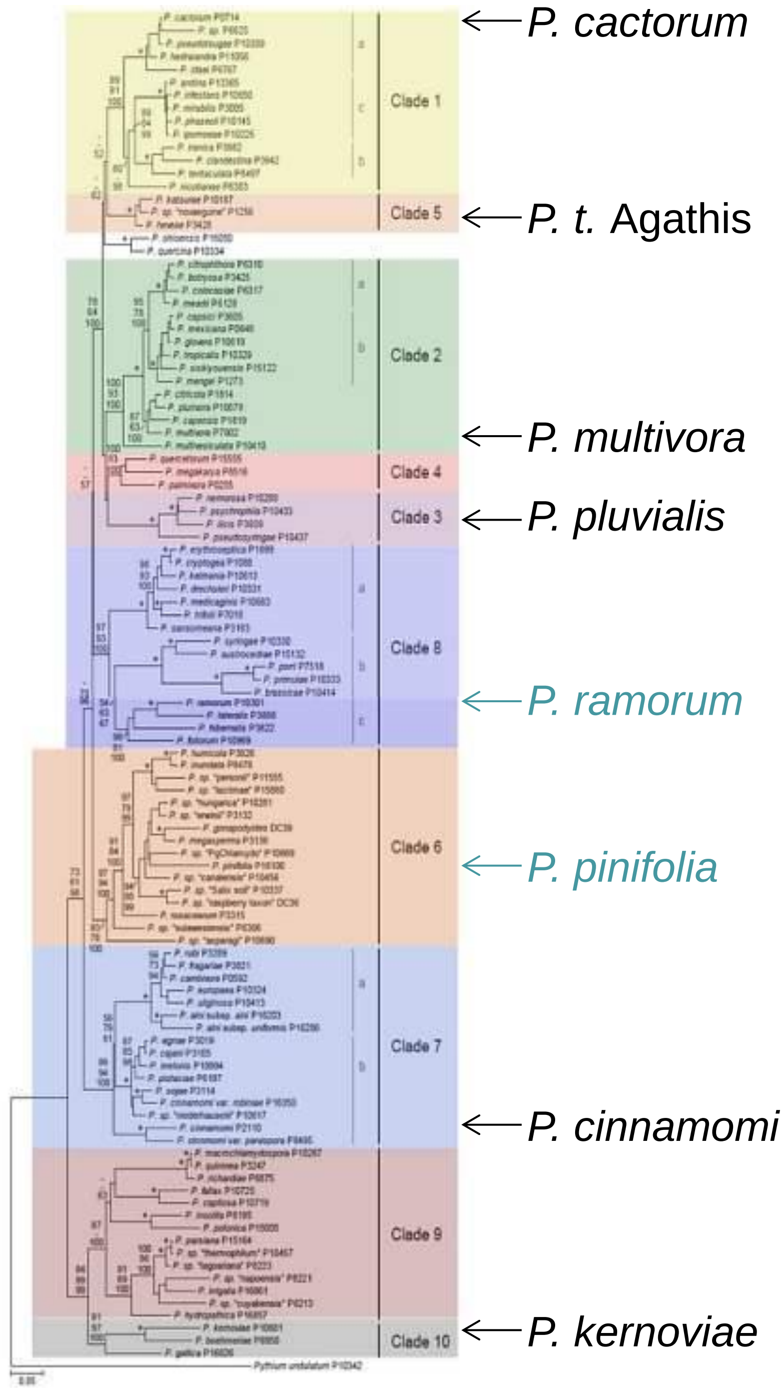
ANALYSES



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



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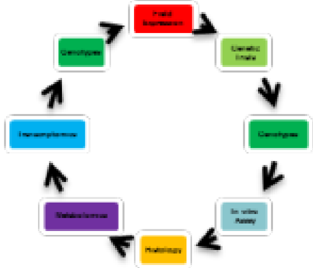
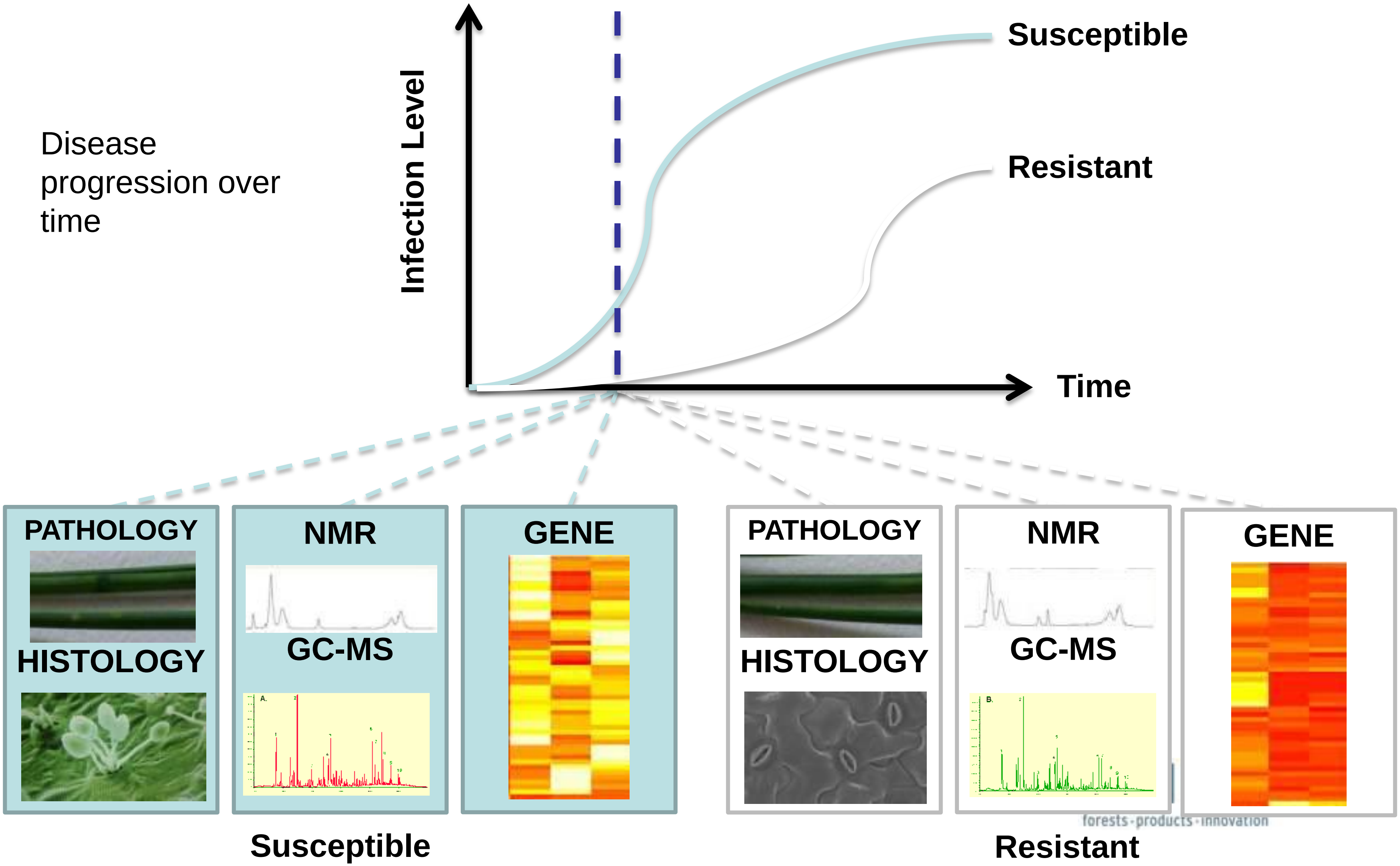
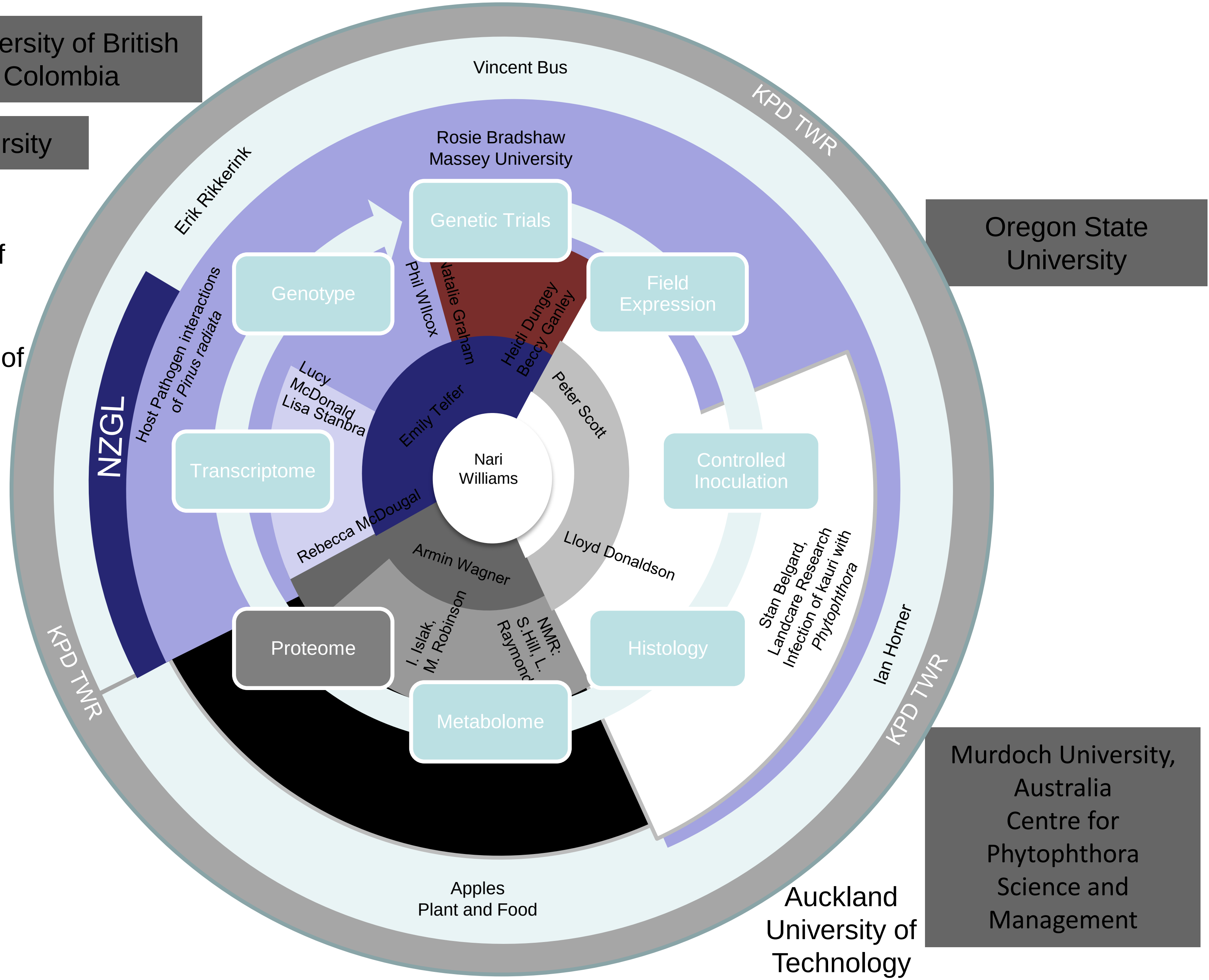


SYSTEMS BIOLOGY

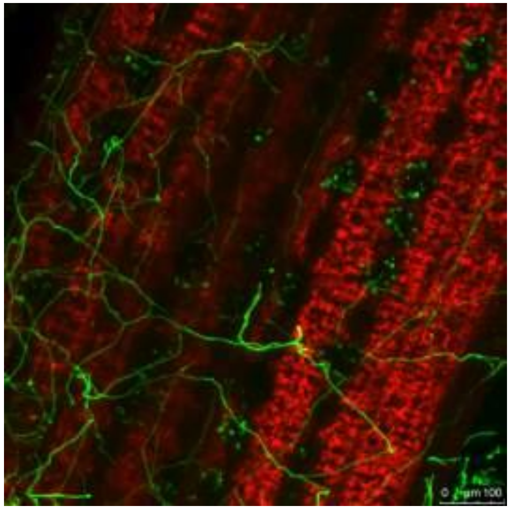
Disease progression over time

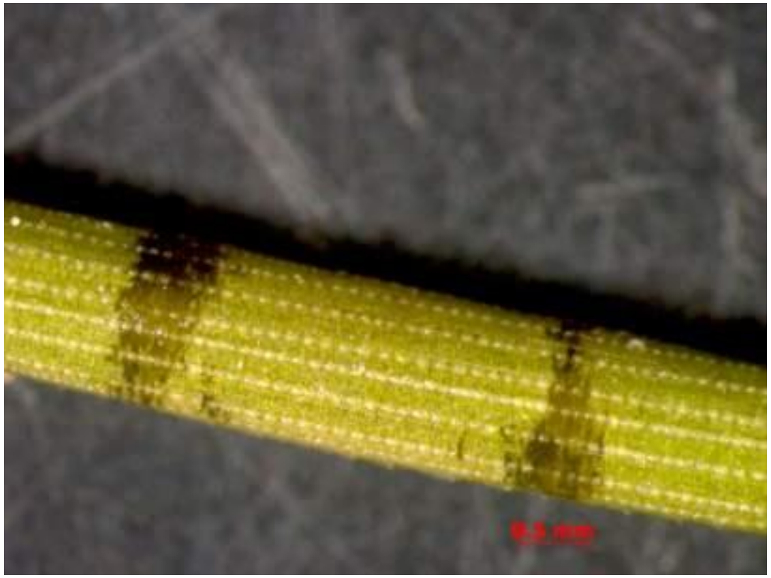


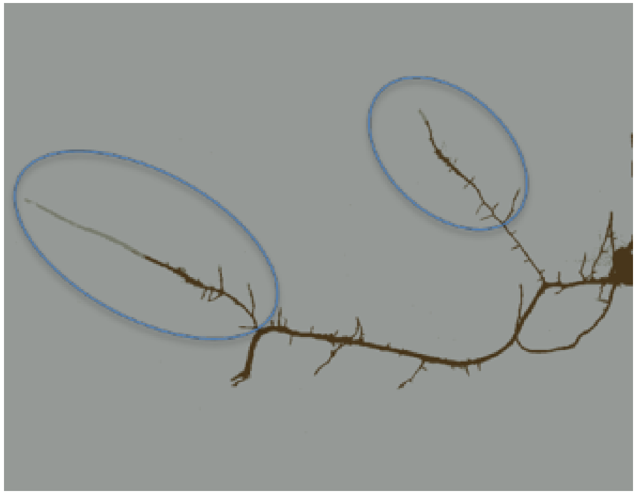
A team effort - National and International Collaborators



Pathology/Histology







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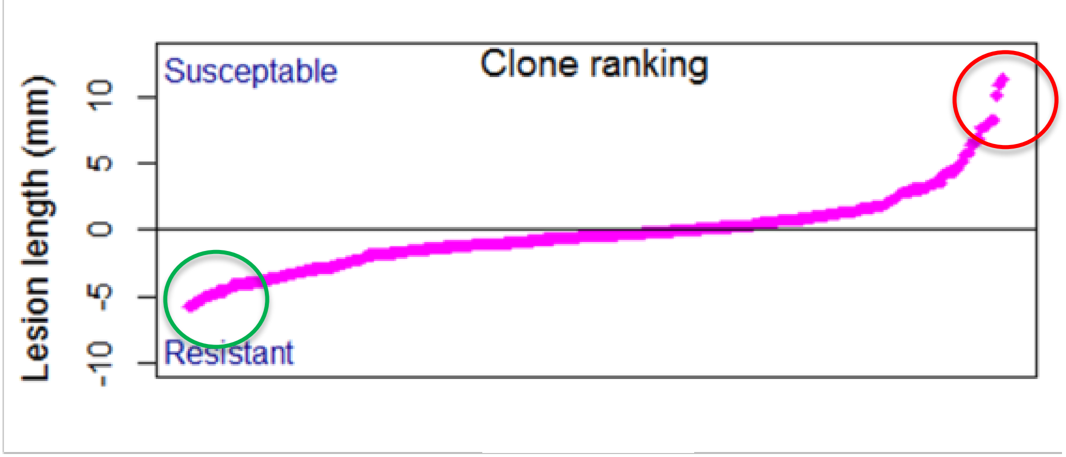
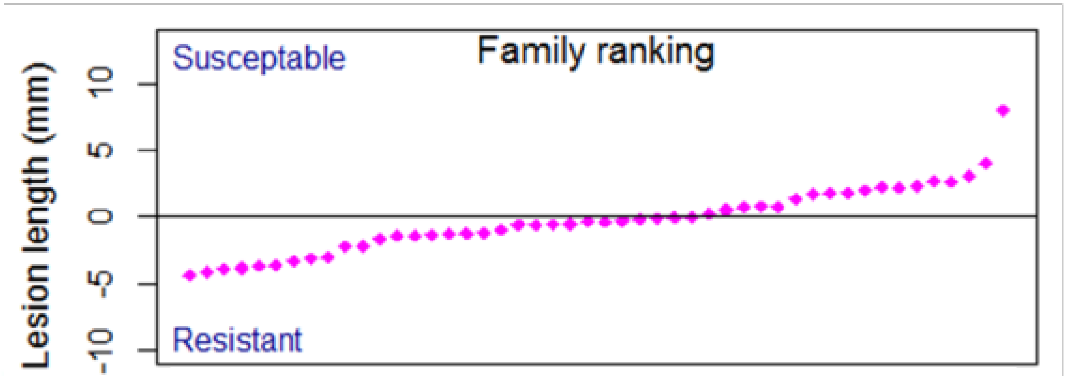
Screening for resistance

- Extremes of tolerance/susceptibility





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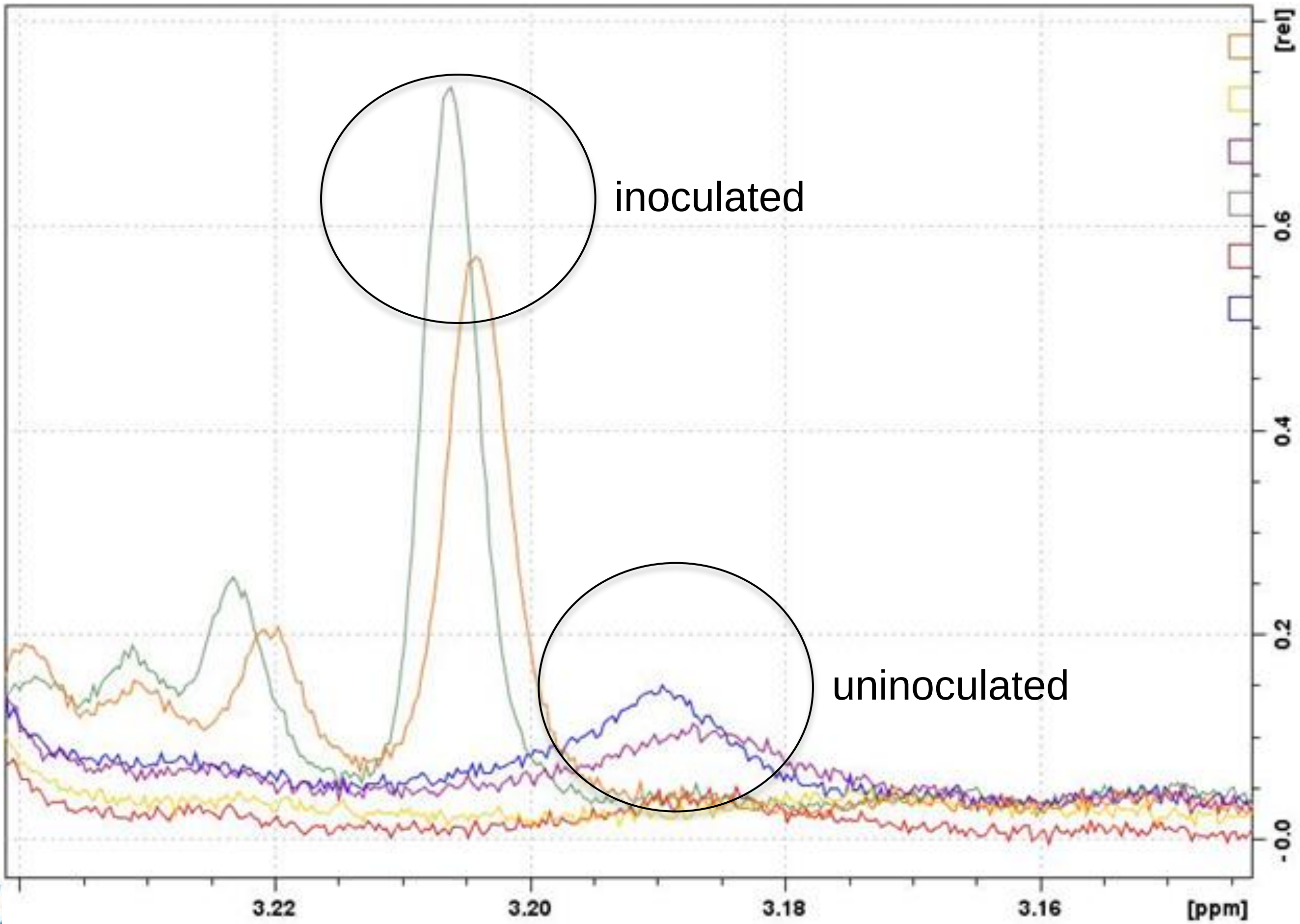
Metabolomics – looking for biological signatures



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Phytophthora genomes: what can they tell us?

Image: mpnforum.com

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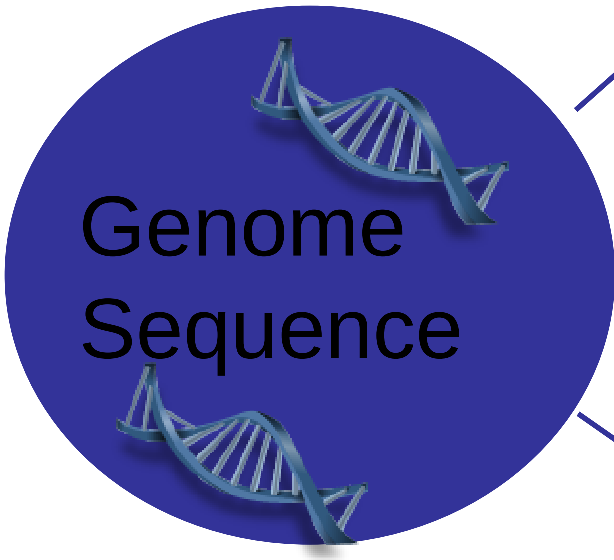

Infection process

- Identify genes = potential targets for control

Adaptation & Evolution

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

Monitoring populations

- Fast & accurate diagnostics

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.

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RESEARCH
RANGAHAU AHUMĀRA KAI

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

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