Kauri (*Agathis australis*) under threat from *Phytophthora*?

Landcare Research
Manaaki Whenua

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Introduction

The genus *Agathis* (Araucariaceae) includes about 13 species of tropical to warm temperate trees found from Malesia through Australia to New Zealand (Fig 1). Kauri (*Agathis australis*), is a dominant tree of lowland forests in northern New Zealand (Ecroyd 1982). Giant individual trees (Fig 2), which can reach over 4.5m in trunk diameter and exceed 1000 years age, are cultural icons.

In 1972, a *Phytophthora* was associated with dead and dying trees in a forest stand on Great Barrier, an island off the northern New Zealand coast (Gadgil 1974). We have now found this same *Phytophthora,* here referred to as *Phytophthora* taxon Agathis (PTA), is more widespread with isolates recovered from the Waitakere Ranges near Auckland and Trounson Park, near the Waipoua Forest in Northland.

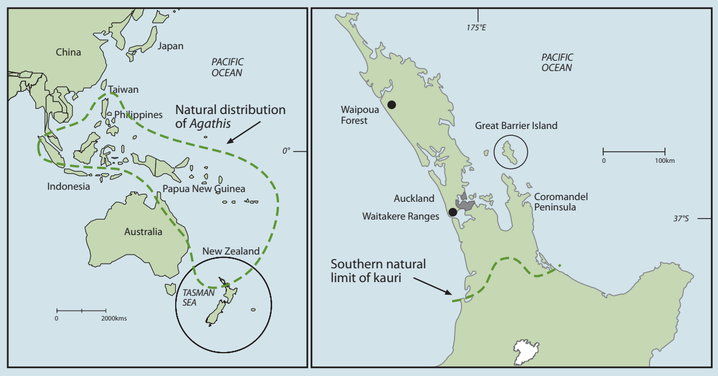


Fig 1 Map showing natural range of the genus *Agathis* (left) and that of kauri (*Agathis australis*), restricted to northern New Zealand (right).

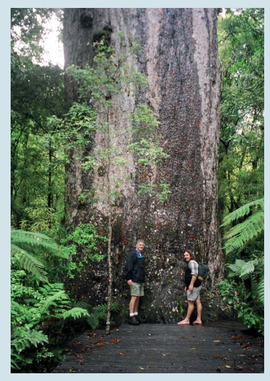


Fig 2 The Yakas tree, a giant kauri in Waipoua Forest

Symptoms

Affected trees show foliage yellowing, canopy thinning and tree death (Fig 3), associated with bleeding lower trunk lesions extending to the major roots and sometimes girdling the trunk as a 'collar rot' (Fig 4). PTA has been isolated from the margin of bleeding lesions (Fig 5) and from soil under affected and healthy trees. Additionally, giant trees have been observed with large collar rots extending around the circumference associated with large dead sectors on the trunk and dead 'stag heads'.

Fig 3 Kauri stand showing yellowing of crowns (circled left) and death (circled right) of young trees.

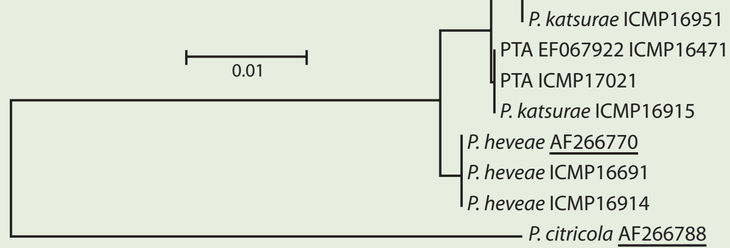
Fig 4 Bleeding resin ('kauri gum') associated with collar rot of the lower trunk.

Fig 5 Bleeding lesion exposed to show damage and staining in cambial region and outer xylem.

What species?

The organism was first identified as *P. heveae* (Gadgil 1974), but the recent revolution in *Phytopthora* taxonomy warrants a re-examination of its affinities. While our molecular studies (Fig 6) confirm it is related to this species, they suggest it is more closely related to *P. katsurae*, and indeed has an identical ITS sequence to an authentic strain of this species (ICMP 16915). However it differs from *P. katsurae* in the strict sense in its smooth, as opposed to strongly bullate (blister-like), oogonia (Fig 6). We propose that PTA is an as yet unnamed species. Further, we suggest that it is introduced to New Zealand, in view of its relatively recent recognition and the cultural and ITS sequence similarity of isolates recovered to date.

Fig 6 Neighbour joining phylogenetic tree of Clade 5 based on ITS sequences of selected *Phytophthora* strains obtained in this study (ICMP cultures using species names as supplied by depositors), along with representative GenBank sequences used by Cooke et al. (2000) (underlined), and gametangia of reprentative strains.



Host	Region
Cocos	Ivory Coast
Cocos	Hawaii
Cocos	Hawaii
Cocos	Hawaii
Agathis	New Zealand
Agathis	New Zealand
soil	Taiwan
Hevea	Malaysia
soil under *Eucalytpus*	Australia
Theobroma	Malaysia

Pathogenicity tests

Kauri seedlings and a selection of other woody species from kauri ecosystems were inoculated (5 replicates) by cutting a flap of tissue from the stem (c. 1–2 cm long), inserting an agar plug (colonised with PTA, *P. cinnamomi*, or with water as a control), folding the flap down, binding it with parafilm and covering with aluminium foil. Kauri inoculated with PTA showed severe wilting at 3 weeks and were were dead at 7 weeks (Fig 7), whereas those inoculated with *P. cinnamomi* and the controls appeared showed no external symptoms even after 4 months.

Stem lesion length was measured at 3–4 months (Table 1). None of the other woody species showed any response to PTA, whereas some showed a response to *P. cinnamomi*. *P. cinnamomi* is known to be common in kauri forests and has been implicated in occasional tree death (Beever at al. 2008) and may limit seedling recruitment (Johnston et al. 2003). The two species most affected by *P. cinnamomi* were *Knightia excelsa* (Proteaceae) (Fig 8) and *Coprosma robusta* (Rubiaceae).

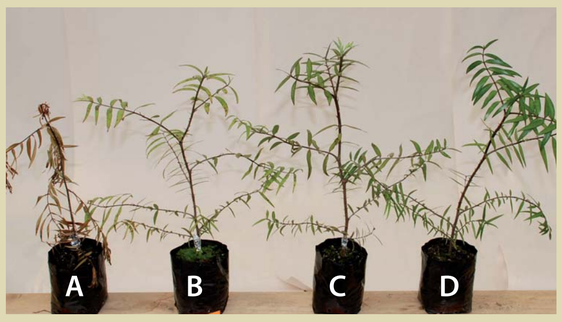


Fig 7 Plants inoculated with PTA (A), *P. cinnamomi* (B), water agar control (C) and unwounded control (D) at 3 weeks

Fig 8 Examples of lesions on *Knightia excelsa* inoculated 4 months previously with PTA (left) or *P. cinnamomi* (right).

Table 1. Responses of various woody tree species found in association with kauri to PTA and *Phytophthora cinnamomi*

	Lesion length ratio*	
Species	**PTA**	***P. cinnamomi***
Agathis australis (Araucariaceae) - Kauri	DEAD	++
Beilschmiedia tawa (Lauraceae) - Tawa	0	+
Beilshmiedia tarairi (Lauraceae) - Taraire	0	+
Coprosma robusta (Rubiaceae) - Karamū	0	+++
Corynocarpus laevigata (Corynocarpaceae) - Karaka	0	++
Dacrycarpus dacrydioides (Podocarpaceae) - Kahikatea	0	0
Dacrydium cuppressinum (Podocarpaceae) - Rimu	0	0
Hebe stricta (Plantaginaceae) - Koromiko	0	0
Knightia excelsa (Proteaceae) - Rewarewa	0	+++
Kunzea ericoides (Myrtaceae) - Kānuka	0	0
Leptospermum scoparium (Myrtaceae) - Mānuka	0	0
Metrosideros excelsa (Myrtaceae) - Pōhutukawa	0	++
Myrsine australis (Myrsinaceae) - Māpou	0	++
Olearia albida (Asteraceae) - Tanguru	0	0
Pittosporum tenuifolium (Pittosporaceae) - Kōhūhū	0	0
Podocarpus hallii (Podocarpaceae) - Tōtarakotukutuku	0	0
Podocarpus totara (Podocarpaceae) - Tōtara	0	0
Pseudopanax arboreus (Araliaceae) - Whauwhaupaku	0	++
Weinmannia racemosa (Cunoniaceae) - Kāmahi	0	+

*lesion length relative to water control: 0 ≤2.0, + >2≤4, ++ >4≤8, +++ >8

Impact of PTA

The health of kauri was assessed (Fig 7) in a natural forest stand in the Waitakere Ranges where symptomatic trees were abundant. PTA was obtained from both trunk lesions and apple baiting of soil. The vegetation at this site includes senescent trees of *Kunzea ericoides* (kānuka) and is interpreted as a seral successional site following timber extraction and fire about 100 years ago (Ogden 1983). The death of kauri at this site is likely to lead to a community shift towards dominance by podocarp tree species such as *Dacrydium cupressinum* (rimu). This species is present at the site, but appears unaffected and was not susceptible to PTA in our pathogenicity tests (Table 1).

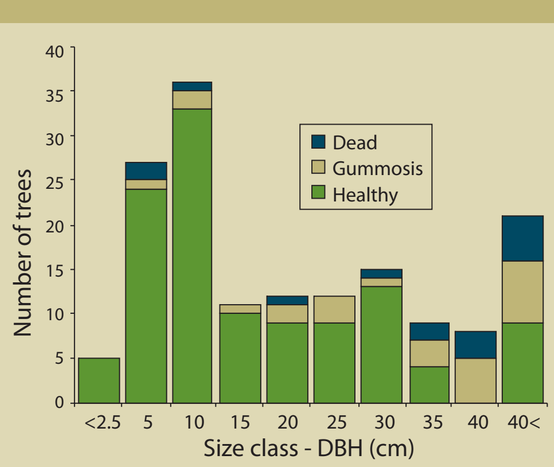


Fig 9 Size class distribution of *Agathis australis* (kauri) in a collar rot-affected forest stand in the Waitakere Ranges in 2007. In total, 156 trees were scored. Health status was assessed as: healthy, showing gummosis (lesions oozing gum) or dead.

Conclusions

Many questions remain to be answered about the biology of PTA. However, we conclude there is sufficient *a priori* evidence to propose that this pathogen poses a threat to kauri. Its long term effect may be to change the composition of kauri-dominated forests to forests dominated by podocarps, thus altering biodiversity values. Additionally, infection of giant kauri may lead to premature death and loss of these cultural icons.

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