Surveillance and management of kauri dieback in New Zealand

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Introduction

Kauri (*Agathis australis*) is a conifer endemic to northern New Zealand. In recent years, kauri trees have been found to be suffering from a disease given the common name of ‘kauri dieback’. The causative organism of kauri dieback is *Phytophthora* taxon “Agathis” (PTA), which affects the feeder and structural roots and kills trees of all ages. Kauri dieback has been identified as a significant threat to kauri-dominated ecosystems (Beever et al. 2009).

In 2009, three regional councils (Northland, Auckland and Waikato), central government (Ministry of Primary Industries, Department of Conservation (DOC)) and representatives of local Māori set up a joint agency which has managed a substantial programme of science, public engagement and surveillance to determine the extent of the problem and to mitigate transport of PTA to other areas (see www.kauridieback.co.nz).

Forest name	Forest, PTA status (+ve or –ve)	PTA status of nearby kauri (+ve or –ve)	Year plantation established and area planted (acres)										
			1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Great Barrier Island													
	+ve	+ve	1				1.8	2.8		2.4 +ve			
Coromandel													
Katikati	Plantation failed	–ve									8		
Kauaeranga	–ve	–ve	5	17									
Whangapoua	Sick, destroyed	+ve	5	7									
Tairua	–ve	–ve											
Northland													
Raetea	+ve	n/a							0.8	8.5 +ve			2.5 +ve
Waipoua	+ve/–ve	+ve				2.5			5	5.7 +ve	2.5	2.7	
Omahuta#	Plantation failed +ve/–ve	–ve		66	32	37		10					
Puketi	Plantations failed	–ve						19	28				
Waitangi	Plantations failed	–ve	3										
Russell	+ve	+ve		8									
Puhipuhi	Plantations failed	n/a	1.3	10									
Glenbervie	+ve	–ve	6 +ve	6 +ve					13 +ve				
Riverhead	–ve	–ve	2	31.5									

Table 1. Distribution and area (acres) of kauri plantings sourced from Waipoua nursery in the 1950s and the resulting locations of transported PTA contamination.

Amenity planting of unknown date.

RED text Indicates a transfer of infection between plantations.

YELLOW shading indicates the consignment of plants most likely to have been contaminated with PTA.

GREEN shading indicates areas that may have been contaminated through forest management activities and/or pigs and cattle.

Figure 5. The originally contaminated (1956) part of the Raetea plantation is in the middle of the photo. The kauri on the hills above were planted in 1981–85 and are now also contaminated.

Figure 9. Track reconstructions using wooden rafts placed over bags filled with locally collected leaf litter.

Developing detection techniques and surveillance

In 2010, sites identified from genetic analysis as being positive for PTA in the Waitakere Ranges and three other forests were used to refine existing field site collection and soil bioassay methods to improve PTA detection techniques (Beever et al. 2010).

Sites were then selected for surveillance both randomly and based on structured decisions that assessed likely vectors from PTA positive sites. Surveillance targeted former New Zealand Forest Service (NZFS) plantations (Table 1), sites considered to be contaminated only with *P. cinnamomi* (Podger & Newhook 1971), iconic large kauri trees, stands important to Māori, stands 100–1000 years old, large areas of forest, kauri on islands and infected kauri and other sites on farmland.

Two active, ground-based methods and aerial surveillance were used. Auckland Council conducted a detailed assessment of the distribution of kauri dieback throughout its region using symptomology, and one laboratory for testing soil at ‘positive’ sites. The Joint Agency tested all other areas using a differently structured approach and three laboratories (including that used by Auckland Council). The aim was to consistently improve detection and refine test methods (Table 2).

Data were collected on tree canopy and lesion status (Figs 1 and 2), and soil was collected from near the trunk and drip line (Waipara et al. 2013). Aerial surveillance was used to review the contamination at very infected sites, assess where we need to look in places of high conservation value (Fig. 3), identify at-risk sites and obtain a photographic record of the current status of kauri forests. We are now testing RT-PCR in parallel with the soil bioassay, and improving the guidelines for selecting the soil collection sites for more intensive field sampling (Than et al. 2013, McDougal et al. 2014).

Public engagement and reporting has been substantial, and reports from the public of diseased trees have been followed up.

Surveillance results

PTA has not been detected in a number of the larger areas of kauri forest (Fig. 4). It appears that it was transported from Waipoua Nursery to three other sites between 1954 and 1956 (Table 1, Fig. 5), probably in consignments of trees that were grown in plots containing forest-collected leaf litter and then shipped in reusable planting tubes. At two sites, the disease has spread to other neighbouring plantings. Cattle and feral pigs are likely to have spread the disease more widely in nearby forests.

In the Waitakere Ranges, sites thought to have been degraded by *P. cinnamomi* in the late 1960s (Podger & Newhook 1971) are infected with PTA, which is now having a substantial impact on ricker (<100-year-old trees) (Fig. 6). PTA has spread on farms between Auckland and the Northern Kaipara Harbour since the 1970s (Fig. 7). It is well distributed on Great Barrier Island and in parts of Russell forest, which were NZFS kauri management areas with substantial canopy release and under-planting activity up until 1985.

Management

Currently, people, cattle and, possibly, wild pigs are regarded as being the principal vectors of PTA. Both Auckland Council and DOC are carrying out multi-million-dollar programmes to improve walking tracks by removing muddy soil contact areas and restoring the surface hydrology of kauri ecosystems (Figs 8 and 9). Five contaminated areas have been closed to the public through existing legislation or by Māori enacting traditional rahui.

Pigs are being controlled in contaminated forests and their elimination is proposed for some areas. The role of farm activities and livestock movement has emerged as an important issue in the spread and distribution of kauri dieback. Rural communities are being engaged to define the extent of the PTA problem and to implement measures to stop its spread.

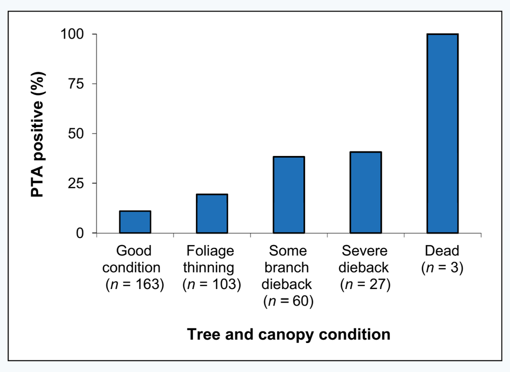

Figure 1. Proportion (%) of trees indentified as PTA positive (n = no. trees assessed) by canopy condition in joint agency surveillance.

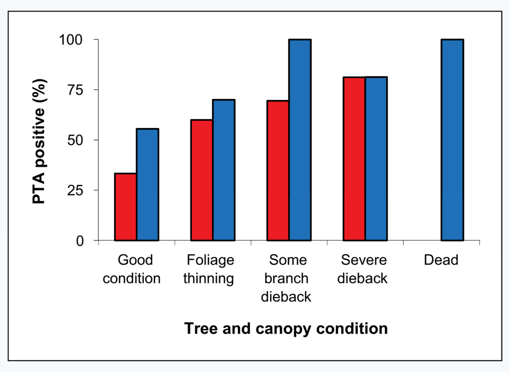

Figure 2. Proportion (%) of PTA positive trees with different canopy conditions that displayed fresh (red) and old (blue) cork cambial lesions.

PTA positive trees						
Lab	Surveillance 1 (n = 15)		Waipoua (n = 29)		Surveillance 2 (n = 21)	
	Mean	SE	Mean	SE	Mean	SE
SCION	0.27	0.13	0.49	0.10	0.60	0.16
Landcare	0.67	0.14	0.76	0.09	1.00	0.00
Plant & Food	0.60	0.13	1.00	0.00	0.82	0.17

PTA positive sites						
Lab	Surveillance 1 (n = 24)		Waipoua (n = 34)		Surveillance 2 (n = 26)	
	Mean	SE	Mean	SE	Mean	SE
SCION	0.22	0.12	0.41	0.11	0.56	0.16
Landcare	0.56	0.18	0.65	0.11	1.00	0.00
Plant & Food	0.40	0.14	1.00	0.00	0.77	0.14

Table 2. Probability of detecting PTA positive samples and sites in the three laboratories as surveillance rounds have progressed (Surveillance 1 in 2011, Waipoua 2011,and Surveillance 2 in 2012).

Figure 3. Sites identified and photographed from a helicopter survey on Te Hauturu-o-toi/Little Barrier Island for assessment and possible follow-up soil sampling.

Figure 6. Kauri dieback in regenerating (100-year-old) kauri stands.

Figure 8. Track construction using large-cell perforated plastic moulds at a site that is muddy for part of the year. The cells are filled with mixed bark and gravel and the structure is then capped with gravel to allow water movement and root development in the cells.

Conclusion

Kauri dieback remains undetected in many large areas of kauri forest. Development of cheaper and more accurate detection tools is needed to fully assess the kauri dieback status of forests and improve monitoring. Risk assessments are being used at each contaminated site/forest to refine management and reduce spread of the disease.

References

Beever, R.E.; Waipara, N.W.; Ramsfield, T.D.; Dick, M.A.; Horner, I.J. 2009. Kauri (*Agathis australis*) under threat from *Phytophthora*? pp 74–85 in Goheen, E.M.; Frankel, S.J. (tech. cords): Phytophthoras in forests and natural ecosystems. Proceedings of the forth meeting of IUFRO Working Party S07.02.9, General Technical report PSW-GTR-221, USDA Forest Service, Albany, CA, USA.

Beever, R.E.; Bellgard S.E.; Dick, M.A.; Horner; I.J.; Ramsfield, T.D. 2010. Detection of *Phytophthora* taxon “Agathis”: Final report: Ministry of Agriculture and Forestry report. Wellington. 76 p.

Podger, F.D; Newhook, F.J. 1971. *Phytophtoroa cinnamomi* in indigenous plant communities in New Zealand. *New Zealand Journal of Botany* 9: 625–638.

McDougal, R.; Bellgard, S.; Scott, P.; Ganley, B. 2014. Comparison of a real-time PCR assay and soil bioassay technique for detection of *Phytopthtora* taxon “Agathis” from soil. Kauri Dieback response, MPI contract report 53789. SCION. 22 p.

Than, D.J.; Hughes K.J.D.; Boonhan, N.; Tomlinson, J.A.; Woodhall, J.W.; Bellgard, S.E. 2013. A TaqMan real-time PCR assay for the detection of *Phytophthora* “taxon Agathis” in soil, pathogen of Kauri in New Zealand. *Forest Pathology* 43(4): 324–330, doi:Doi 10.1111/Efp.12034.

Waipara, N.W.; Hill, S.; Hill, L.M.W.; Hough, E.G.; Horner, I.J. 2013. Surveillance methods to determine tree health, distribution of kauri dieback disease and associated pathogens. *Plant Protection* 66: 235–241.

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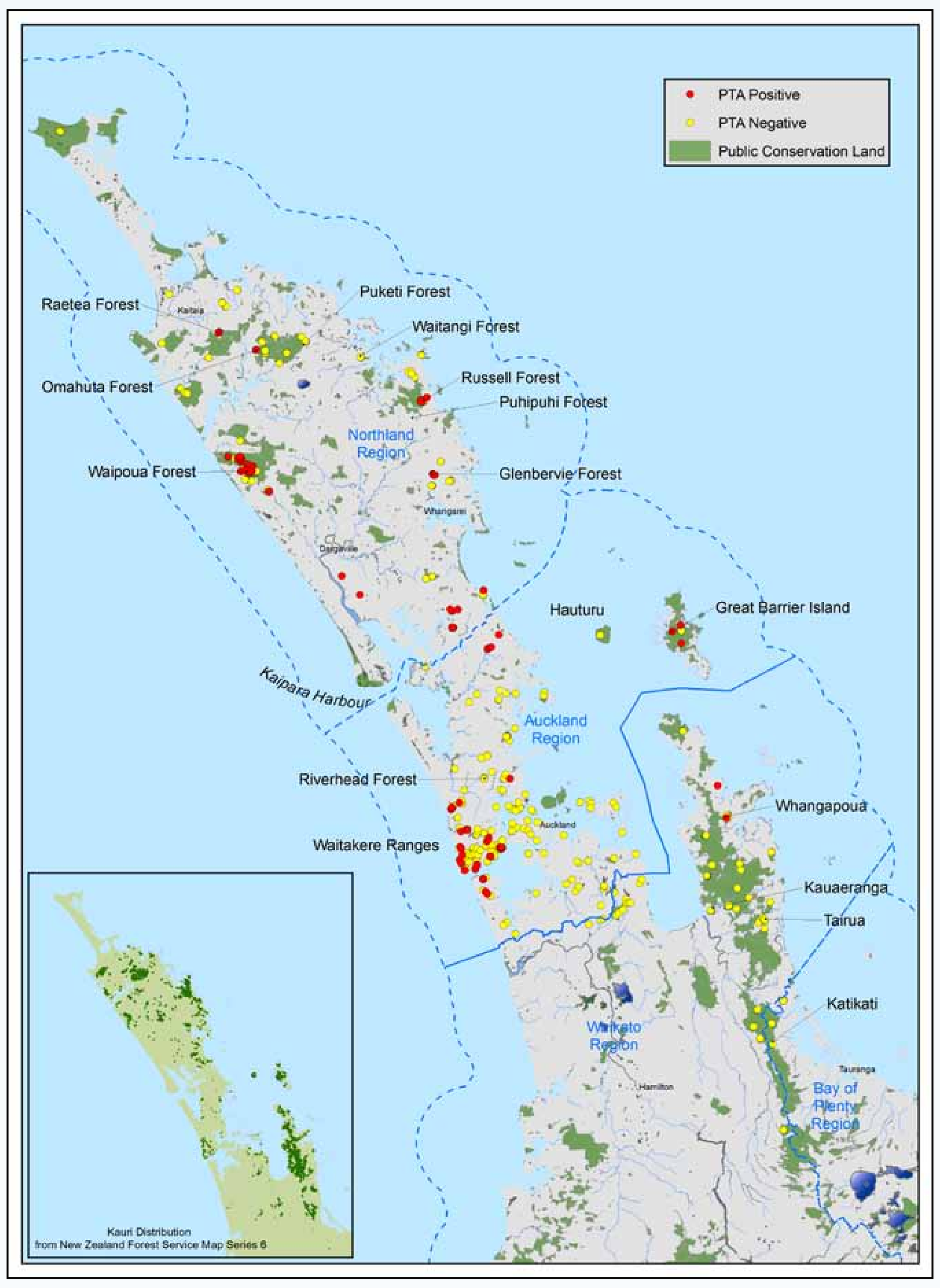

Figure 4. Map showing PTA status of sites/forests assessed during kauri dieback surveillance, along with regional boundaries. The insert map shows the location of the remaining large areas of kauri forest in northern New Zealand. in 1954.

Figure 7. Kauri dieback in farmland, with trees showing the full range of canopy collapse conditions