microPublication BIOLOGY

11/17/2026 - *Open Access*

Community-led surveillance of *Phytophthora agathidicida*: A pilot study on Te Hikutu land in Whirinaki, Aotearoa New Zealand

Emily MG Hocking[1], Wayne M Patrick[1], Monica L Gerth[1§], Ian Mitchell[2,3]

[1]School of Biological Sciences, Victoria University of Wellington, Wellington, WGN, New Zealand

[2]Te Uri Taniwha, Te Hikutu, and other hapū of Ngāpuhi, Aotearoa, New Zealand

[3]Taniwha Research and Production Limited, Kaikohe, New Zealand

[§]To whom correspondence should be addressed: monica.gerth@vuw.ac.nz

Abstract

Kauri are ecologically and culturally significant trees in Aotearoa New Zealand. Maintaining forest health requires proactive monitoring of *Phytophthora agathidicida*, the causal agent of kauri dieback. We report a surveillance study initiated by Te Hikutu hapū (sub-tribe) on their land in Whirinaki, Hokianga, in response to visibly declining kauri and cattle disturbance at the site. Ten soil samples were screened using a DNA-based diagnostic; four tested positive, confirming the presence of *P. agathidicida* around kauri at the site. These findings highlight the value of Indigenous-led surveillance for early, locally informed detection and management of kauri forest health.

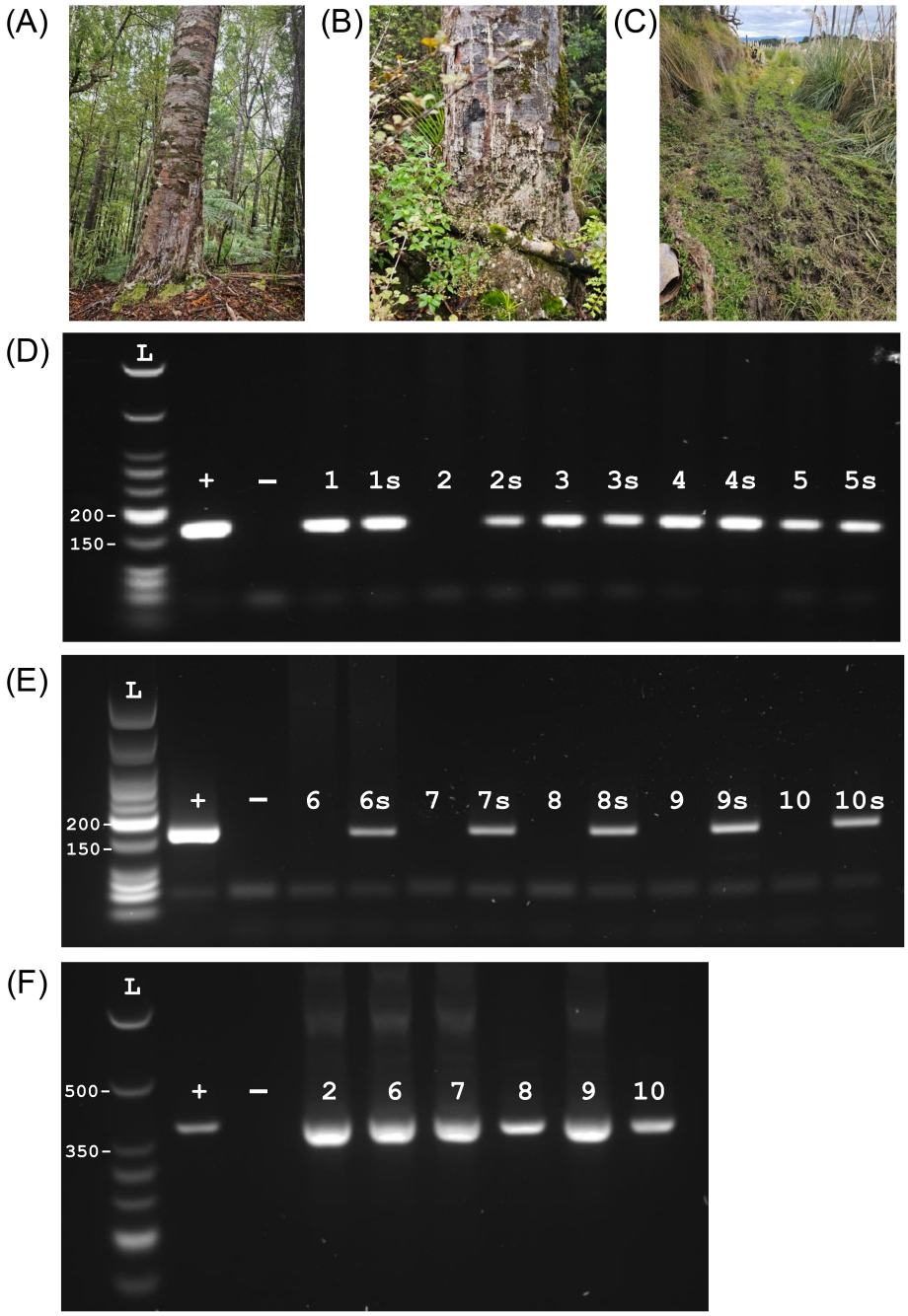


Figure 1. Field sampling sites at Whirinaki and PCR detection of *Phytophthora agathidicida* (PA) in soil samples:

(A) Kauri #1 (source of Sample 1), showing trunk lesions consistent with advanced kauri dieback symptoms. **(B)** Close-up of trunk lesions on Kauri #4 (source of Sample 4). **(C)** Cattle track at the first entrance point to the bush. **(D, E)** PCR amplification using PA-specific primers. Amplicons of the expected size (~161 bp) were detected in Samples 1, 3, 4, and 5. Inhibition control reactions (each sample spiked with 10 fg PA genomic DNA; labelled "s") produced target bands across all samples, confirming an absence of significant PCR inhibition. Positive control (5 pg PA genomic DNA; "+") and no-template control (water; "–") reactions performed as expected. **(F)** Extraction control PCRs using 18S universal eukaryote primers for PA-undetected samples (2, 6, 7, 8, 9, and 10), yielding expected amplicons of ~350–400 bp. PCR products were resolved on 2% agarose gels stained with GelGreen. L: Low Molecular Weight DNA Ladder (New England Biolabs).

Description

Kauri (*Agathis australis*) are among the largest and longest-lived trees in Aotearoa New Zealand, forming ecologically important forests and holding deep cultural significance for Māori (Indigenous people), particularly those whose ancestral lands lie within kauri's range (Ecroyd, 1982; Bradshaw et al., 2020; Hill et al., 2021). Kauri conservation depends on early detection of threats, particularly infection by *Phytophthora agathidicida*, the pathogen that causes kauri dieback (Bradshaw et al., 2020). Early indicators of ill-thrift, such as mild canopy thinning or yellowing, are non-specific and can be triggered by abiotic stressors (e.g. drought, physical root damage, or nutrient stress). As a result, visual scoring alone cannot reliably confirm infection at early stages. Trees with more advanced symptoms, such as canopy thinning combined with trunk lesions or resinous bleeding, are more readily recognisable in the field (Figure 1A, B). However, by this stage they are likely already shedding *P. agathidicida* oospores (long-lived survival spores) from their infected roots into the surrounding soil (Palmer et al., 2026). Soil containing these oospores can be dispersed (e.g. by footwear, vehicles, and livestock), so molecular surveillance is vital not only around trees of varying health status but also along potential dispersal pathways. Livestock represent one such potential pathway. In Aotearoa New Zealand, remote forested boundaries frequently lack stock fencing, allowing domestic cattle from neighbouring farms and/or unmanaged feral cattle unrestricted access to native forest remnants. These roaming cattle can trample the forest floor, transport topsoil on their hooves, and damage root systems (Parkes, 2001; Smale et al., 2008; Niebuhr et al., 2024).

Here, we report a targeted surveillance study on Te Hikutu hapū (sub-tribe) land in Whirinaki, Hokianga, following community-initiated sampling in response to declining kauri health and cattle disturbance. The subtropical kauri-broadleaf forest comprises land reserved for food, medicinal, weaving, timber, and other uses; however, cattle from at least two neighbouring farms have had free access for over 20 years (Figure 1C). Te Hikutu hapū members collected ten soil samples, mainly around mature kauri showing a range of health conditions, including canopy thinning, trunk lesions, and tree death, as well as along the access track and its associated drainage ditch. Cattle disturbance, including hoof-pugging and root damage, was evident on the track and around some sampled trees. Seven samples were associated with individual kauri trees ranging from dead (Sample 2) through symptomatic (Samples 1 and 4) and possibly symptomatic (Samples 5, 6, and 8) to apparently healthy (Sample 3). Of the other three soil samples, two were from the heavily disturbed access track (Samples 7 and 10), and the third was from its associated drainage ditch (Sample 9).

Four of the seven kauri-associated samples (Samples 1, 3, 4 and 5) tested positive for *P. agathidicida* by endpoint PCR (Figure 1D, 1E). *P. agathidicida* was undetected in the remaining six samples, including three of the kauri and all of the track and drainage samples. Notably, *P. agathidicida* detection did not correspond straightforwardly with visible symptom severity. *P. agathidicida* DNA was detected in the soil around a visually healthy kauri (Sample 3) but not in the soil from a dead kauri (Sample 2). Both symptomatic trees tested positive (Samples 1 and 4), along with one of the three classified as possibly symptomatic (Sample 5). Together, these results reinforce the limitations of visual assessment alone for confirming infection status.

All controls performed as expected: negative controls produced no PCR amplicon; positive and inhibition controls produced the expected ~161 bp product (Figure 1D, 1E); and 18S extraction controls produced the expected ~350–400 bp product (Figure 1F). Quantitative PCR of positive soil samples revealed substantial variation in *P. agathidicida* DNA concentrations, spanning a ~170-fold range between trees. Sample 1 yielded the highest concentration at 640 ± 70 fg *P. agathidicida* DNA/g soil, while the remaining positive sites ranged from 3.8 to 150 fg *P. agathidicida* DNA/g soil (Sample 3: 3.8 ± 1.1 fg/g; Sample 4: 60 ± 4 fg/g; Sample 5: 150 ± 10 fg/g). Because our extraction method enriches for oospores before DNA purification, these values provide a relative proxy for *P. agathidicida* oospore abundance, but not a direct or absolute measure of oospore or inoculum numbers in soil (Palmer et al., 2026).

This patchy distribution is consistent with localised *P. agathidicida* shedding dynamics, in which oospores accumulate around infected root systems as roots die back (Palmer et al., 2026). Crucially, non-detection along the cattle tracks (Samples 7 and 10) and in the drainage ditch (Sample 9) should be interpreted with caution and does not rule out a role for cattle in dispersing contaminated soil. Movement along access corridors may involve transient, low-density transfer of contaminated soil that falls below our assay's limit of detection of 1 fg *P. agathidicida* DNA/g soil (Palmer et al., 2025). In short, this study shows we can detect *P. agathidicida* where infection is established and pathogen DNA concentrations are high, whereas low levels of *P. agathidicida* in soil carried along tracks may evade detection.

These findings highlight an urgent need for targeted management. Trees with high concentrations of *P. agathidicida* DNA in the oospore-enriched fraction may represent localised pathogen reservoirs. Allowing cattle continued access to such sites may increase the risk of further spread, as stock can transport contaminated soil on their hooves and cause root damage that may facilitate new infections. Stock exclusion and fencing around positive trees or stands, in alignment with national biosecurity rules (Tiakina Kauri, 2022), should be prioritised to reduce the potential for further soil-borne dispersal.

Admittedly, this pilot study has some limitations. The set of seven tree and three non-tree samples is small. Sampling was also confined to a single access corridor, so the findings should be treated as indicative rather than representative of the wider Whirinaki area. Furthermore, without a matched control site free of livestock, this study cannot determine whether

cattle contributed to *P. agathidicida* dispersal at this site; nonetheless, the extensive pugging and soil disturbance observed support precautionary stock exclusion to reduce the potential for soil-borne dispersal.

Despite these limitations, this study highlights the value of place-based knowledge in disease surveillance. People with a long-standing connection to a place are often best placed to notice how it changes and to guide where sampling is targeted. In this case, it was Te Hikutu hapū members who noticed declining kauri health and initiated sampling. Neighbouring farmers also had regular access to the site, which suggests that proximity alone is not what prompts this kind of attentiveness; rather, it arises from the active relationship of kaitiakitanga (guardianship) that hapū hold with their land, grounded in mātauranga (Indigenous knowledge). This is why Indigenous-led surveillance is an essential part of kauri disease management.

This form of surveillance differs from current statutory practice. Statutory agencies often rely on broad-scale visual surveys, which can miss localised outbreaks until canopy decline is severe and cannot distinguish *P. agathidicida* infection from general abiotic ill-thrift. Indigenous-led surveillance brings together place-based mātauranga, such as knowledge of historical stock movements, land boundaries, and subtle changes in kauri stand vigour, with rapid molecular tools. Mana whenua (the hapū holding customary authority over the land) are uniquely positioned to identify emerging high-risk sites, carry out rapid targeted sampling on their own land, and implement immediate management actions such as fencing, stock exclusion, or treatment without administrative delay. Empowering hapū to lead monitoring in this way helps ensure early, action-oriented biosecurity interventions where they are needed most.

Methods

Sampling was conducted on Mangatapere, Whirinaki 6G Block (19 ha), Māori land held by Te Hikutu hapū with 324 individual owner/shareholders, in Whirinaki, Hokianga, Northland. The block has gentle, north-facing slopes with kauri, and steep, kauri-free cliffs along the south and west boundaries. Sampled trees were classified in the field into three symptom severity categories: non-symptomatic, possibly symptomatic (i.e. signs of ill-thrift, but no lesions), and symptomatic (i.e. signs of ill-thrift and visible lesions) using standard visual indicators such as canopy condition and lesion presence. One tree (#2) was classified as dead due to a complete absence of leaves or bark.

A total of ten soil samples were collected using a clean, inverted plastic bag to gather a large handful of soil from the top 5 cm of the soil. Seven samples were tree-associated, and three were from the track and associated drainage ditch. For each sample, four sub-samples were collected and pooled into a single bag. Samples were sealed, double-bagged, and transported via courier to the laboratory, where the samples were stored at 4 °C until processing.

Soil DNA extraction used the double-filter bag technique (Palmer et al., 2025). Briefly, each sample was mixed thoroughly by shaking and breaking up soil aggregates without opening the original sample bags. Then, 5–10 g of each sample was sealed within a 90 µm nylon mesh pouch, enclosed within a secondary 25 µm nylon mesh pouch, then placed in 50 mL of sterile water and vortexed to concentrate *P. agathidicida* oospores. After removing debris >90 µm, the residual soil–oospore suspension retained by the 25 µm mesh was centrifuged at 3000 × g for 2 min. The pellet was resuspended in 800 µL of Solution CD1 from the DNeasy PowerSoil Pro Kit (Qiagen) and transferred to a Precellys SK38 soil-grinding bead tube; cells were lysed by mechanical homogenisation for 10 min. DNA was purified using the DNeasy PowerSoil Pro Kit following the manufacturer's protocol, with one modification: final elution was performed in 100 µL of low-EDTA TE buffer (10 mM Tris-HCl, 0.1 mM EDTA) to improve storage stability.

Endpoint PCRs were performed in 40 µL reactions comprising 1× HOT FIREPol Blend Master Mix (Solis BioDyne), 0.5 µM of each primer, 5 µL template DNA and PCR-grade water. For the PA-LTR primer pair, thermal cycling was as follows: 95 °C for 12 min; 40 cycles of 95 °C for 15 s, 63 °C for 40 s, and 72 °C for 7 s; and a final extension at 72 °C for 5 min. PCR-grade water served as a negative control, and purified *P. agathidicida* genomic DNA (5 pg) as a positive control. To monitor for PCR inhibition, parallel reactions were spiked with 1 µL of *P. agathidicida* genomic DNA at 10 fg/µL. For samples in which *P. agathidicida* was not detected, an additional extraction control was performed using universal eukaryote 18S primers (Machida & Knowlton, 2012): 95 °C for 12 min; 30 cycles of 95 °C for 15 s, 63 °C for 30 s, 72 °C for 60 s; and a final extension of 72 °C for 5 min. PCR products were visualised by electrophoresis on 2% agarose gels pre-stained with GelGreen (Biotium).

For samples testing positive by endpoint PCR, the amount of *P. agathidicida* DNA was quantified by qPCR following Palmer et al. (2026) on a QuantStudio 3 Real-Time PCR System (Applied Biosystems). Samples were run in triplicate alongside no-template controls and a 3 fg *P. agathidicida* genomic DNA spike control per sample to monitor for inhibition. Quantification of *P. agathidicida* was calculated using a 10-fold serial dilution standard curve of *P. agathidicida* genomic DNA (amplification efficiency 97–98%), with results expressed as fg *P. agathidicida* DNA per gram of soil (fg/g).

Reagents

Primers

Name	Sequence (5′–3′)	Reference
PA-LTR-for	ACGCGCTCTGTTTCTTTAGC	Palmer et al., 2025
PA-LTR-rev	GCGGGCTTCCATTCAATTCA	Palmer et al., 2025
18S #3	GYGGTGCATGGCCGTTSKTRGTT	Machida & Knowlton, 2012
18S #5RC	GTGTGYACAAAGGBCAGGGAC	Machida & Knowlton, 2012

Kits and Reagents

Name (Supplier)	Catalogue Number
DNeasy PowerSoil Pro Kit (Qiagen)	47016
Soil grinding SK38 2 mL tubes (Bertin)	P000915-LYSK0-A
5× HOT FIREPol Blend Master Mix Ready to Load, 10 mM $MgCl_2$ (Solis BioDyne)	04-25-00120-5

Acknowledgements: This study was conducted as a partnership between Te Hikutu hapū members and university researchers. Co-author Ian Mitchell (Te Hikutu) provided cultural and scientific leadership throughout the project. We gratefully acknowledge the wider mana whenua of Te Hikutu for their contributions — in particular, community members Joseph Wynyard, Whiu Waata, Veronica Wynyard, Warren Morunga, and other kaitiaki who initiated and guided the sampling efforts, and whose commitment to the protection of the whenua was central to the success of this project.

References

Bradshaw RE, Bellgard SE, Black A, Burns BR, Gerth ML, McDougal RL, et al., Horner. 2020. *Phytophthora agathidicida*: research progress, cultural perspectives and knowledge gaps in the control and management of kauri dieback in New Zealand. Plant Pathology 69: 3-16. DOI: 10.1111/ppa.13104

Ecroyd CE. 1982. Biological flora of New Zealand 8. *Agathis australis* (D. Don) Lindl. (Araucariaceae) Kauri. New Zealand Journal of Botany 20: 17-36. DOI: 10.1080/0028825X.1982.10426402

Hill L, Ashby E, Waipara N, Taua-Gordon R, Gordon A, Hjelm F, et al., Jesson. 2021. Cross-cultural leadership enables collaborative approaches to management of kauri dieback in Aotearoa New Zealand. Forests 12: 1671. DOI: 10.3390/f12121671

Machida RJ, Knowlton N. 2012. PCR Primers for metazoan nuclear 18S and 28S ribosomal DNA sequences. PLoS ONE 7: e46180. DOI: 10.1371/journal.pone.0046180

Niebuhr CN, Warburton B, Latham ADM. 2024. Managing feral pigs to mitigate kauri dieback disease in the face of ecological and epidemiological uncertainty. New Zealand Journal of Zoology 52: 349-366. DOI: 10.1080/03014223.2024.2345328

Palmer JTT, Vink JNA, Castro LM, Craig OJS, Davison EE, Gerth ML. 2025. Improved isolation and PCR detection of *Phytophthora agathidicida* oospores from soils. Microbiology Spectrum 13: 10.1128/spectrum.00135-25. DOI: 10.1128/spectrum.00135-25

Palmer JTT, Hocking EMG, Gerth ML. 2026. Vertical distribution of *Phytophthora agathidicida* oospore DNA in kauri forest soils: implications for optimized sampling and disease monitoring. Microbiology Spectrum 14: 10.1128/spectrum.01025-26. DOI: 10.1128/spectrum.01025-26

Parkes J. 2001. Advances in New Zealand mammalogy 1990–2000: Feral livestock. Journal of the Royal Society of New Zealand 31: 233-241. DOI: 10.1080/03014223.2001.9517651

Smale MC, Dodd MB, Burns BR, Power IL. 2008. Long-term impacts of grazing on indigenous forest remnants on North Island hill country, New Zealand. New Zealand Journal of Ecology 32(1): 57-66.

Tiakina Kauri. 2022. *National Pest Management Plan for Phytophthora agathidicida*. Ministry for Primary Industries / Biosecurity New Zealand. https://www.kauriprotection.co.nz/national-plan

Funding: This research was supported by the Mātauranga Māori Research Fund at Te Herenga Waka—Victoria University of Wellington and Te Kaunihera ā-Rohe o Te Taitokerau—Northland Regional Council.

Conflicts of Interest: The authors declare that there are no conflicts of interest present.

Author Contributions: Emily MG Hocking: investigation, writing - review editing. Wayne M Patrick: writing - review editing, investigation. Monica L Gerth: conceptualization, project administration, resources, supervision, writing - review editing, writing - original draft. Ian Mitchell: conceptualization, investigation, methodology, writing - review editing.

Reviewed By: Anonymous

History: Received August 19, 2026 **Revision Received** September 26, 2026 **Accepted** November 8, 2026 **Published Online** November 17, 2026 **Indexed** December 1, 2026

Copyright: © 2026 by the authors. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International (CC BY 4.0) License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Citation: Hocking EM, Patrick WM, Gerth ML, Mitchell I. 2026. Community-led surveillance of *Phytophthora agathidicida*: A pilot study on Te Hikutu land in Whirinaki, Aotearoa New Zealand. microPublication Biology. 10.17912/micropub.biology.002362