Appendix 1: Kauri Dieback – Literature Summary

1. What we're protecting

Situational data: Kauri Sites

The areas where Kauri are located and the typical characteristics of those sites (size, location, ownership, management and access).

"Kauri is a much loved tree species and has a special place in New Zealand's northern ecosystems and history. It shapes the character and function of forests where it occurs, is a taonga tuku iho of the Māori ancestral spiritual world and is of significant cultural importance to all New Zealanders."[1]

Kauri (*Agathis australis*) is a coniferous tree of Araucariaceae in the genus Agathis, found north of 38°S in the northern districts of the North Island. After heavy logging, starting from 1820 until approximately 1970, only small pockets of kauri forest remain in New Zealand.

The largest area of mature kauri forest is Waipoua Forest in Northland, although mature and regenerating kauri can also be found in other National and Regional Parks such as Puketi and Omahuta Forests in Northland, the Waitakere Ranges near Auckland, and Coromandel Forest Park on the Coromandel Peninsula. It is these areas of iconic kauri, comprised of both kauri forests and individual trees and all other kauri, that we want to protect.

2. What we're fighting

Data on *Phytophthora agathidicida*

Any relevant data on the disease which may influence how we manage it – including vectors, its spread and identification.

About the disease

With the movement of people and goods around the world, plant pathogens have been introduced to new countries, and so, new hosts. The hosts have little to no natural resilience, allowing the introduced pathogens to cause devastation.

"*In New Zealand the discovery of diseased kauri (Agathis australis) in Northland in 2003 was a huge blow. When kauri trees in the Waipoua Forest started showing symptoms of disease a decade ago Phytophthora was the prime suspect. Species of Phytophthora (which literally means "plant destroyer") have been responsible for many serious plant diseases, including the Irish famine when potatoes became infected in the 1840s, but also more recently affecting a range of trees*

[1] New Zealand's strategy for managing kauri dieback disease

worldwide including oak, chestnut, alder and jarrah. Phytophthora is a soil-borne microbe (or water mould)….further investigations showed … the pathogen was… Phytophthora 'taxon Agathis' or PTA."[2]

Research to date indicates that PTA (*Phytophthora agathidicida*[3]) has been in New Zealand since the 1950s, but it was not formally identified until 2008, when it was declared as an Unwanted Organism under the Biosecuirty Act 1991.

P.agathidicida is a microscopic, fungus-like organism which has the ability to kill kauri of all ages, from saplings to huge trees that are over 800 years old. It can infect single trees or cause dieback of entire stands, and nearly all infected trees die. There is no known cure, although research is currently being undertaken to develop treatment tools.

P.agathidicida infects kauri roots and damages the tissues that carry nutrients and water within the tree, effectively starving it to death. Symptoms include yellowing foliage, canopy thinning, appearance of dead branches and tree death. Affected trees frequently show bleeding lesions on the lower trunk extending down the major roots.

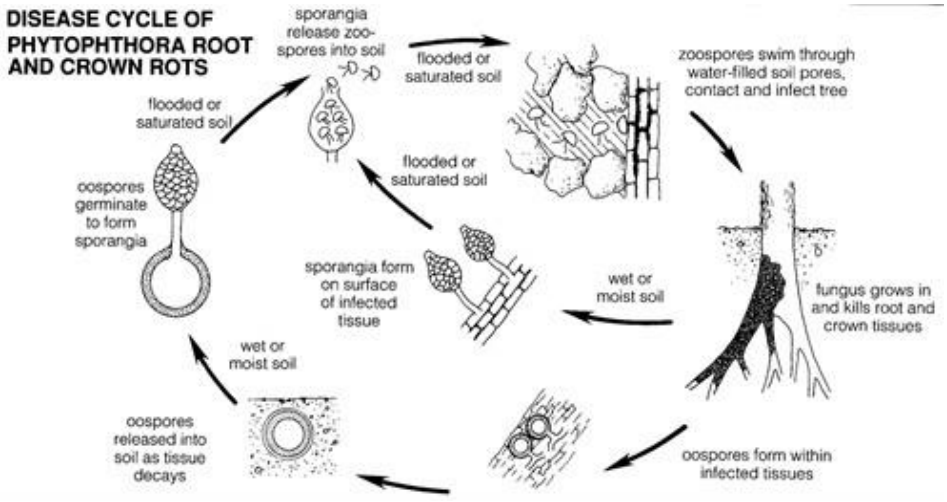

Diagram 1: Lifecycle of P.agathidicida

The disease does not have airborne spores so is unlikely to travel by wind and airflows. Motile waterborne spores (zoospores) are produced in wet conditions and move through water films in soil. Waterborne spores have a short life span once released. Resting soil-borne spores (oospores) can survive for at least three years and possibly much longer periods - more research is needed to determine the life span of these spores.

The primary vector for kauri dieback appears to be movement of soil between forests on human assisted pathways such as footwear, bikes and equipment.

"Results of mapping Kauri in Auckland show greater amounts of infected areas along track networks than in other areas, indicating the spread of Kauri Dieback within contaminated soil on footwear.[4]*"*

If left unmanaged, the disease has the potential to kill all kauri, which would dramatically alter our nation's northern forest ecosystems forever.

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[2] Landcare - http://www.landcareresearch.co.nz/publications/newsletters/biological-control-of-weeds/issue-67/kauri-dieback

[3] Originally labelled as PTA - *Phytophthora taxon agathis,* but now given the name *Phytophthora agathidicida.*

[4] Auckland Council – Kauri Local Sports Park draft Report.

Where it is has spread to

The disease has been found in parts of the Northland, Auckland and the Coromandel regions, but it has a highly patchy distribution, including:

- A number of forests in the Northland region (e.g. Trounson Kauri Park, Omahuta, Glenbervie, Mangawhai, Kaiwaka, Raetea, as well as Waipoua);
- Forest remnants in the Auckland Region (Waitakere Ranges, Awhitu Peninsula south of Manukau Harbour, North Shore/Albany, Waimauku/Muriwai) as well as Great Barrier Island.
- Coromandel Peninsula i.e. Whangapoua and Hukarahi.

"PTA has not been detected in a number of the larger areas of kauri forest. It appears that it was transported from Waipoua Nursery to three other sites between 1954 and 1956, 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 are infected with PTA, which is now having a substantial impact on ricker (<100-year-old trees). PTA has spread on farms between Auckland and the Northern Kaipara Harbour since the 1970s. 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." [5]

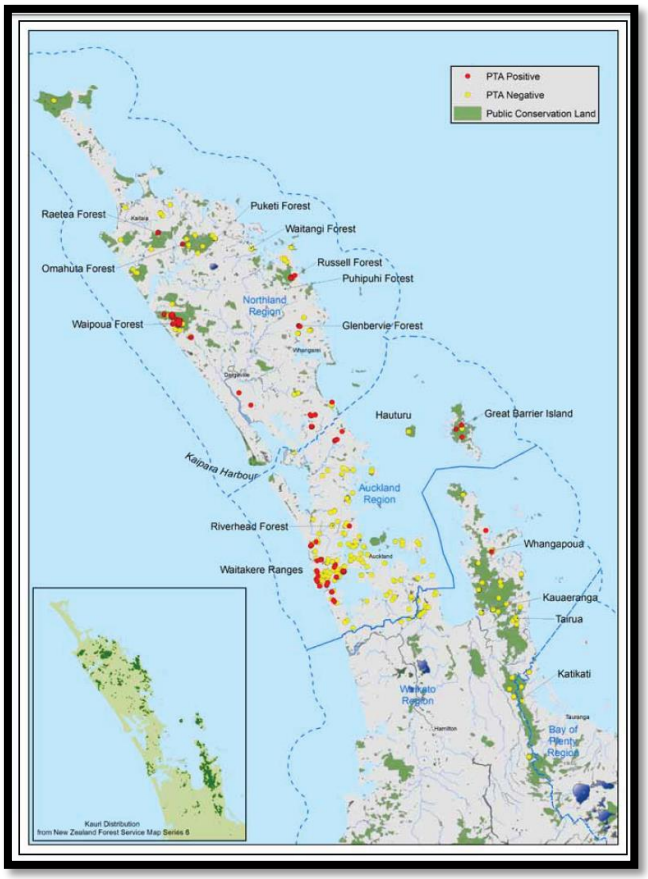

Diagram 2: Spread of P.agathidicida

[5] Surveillance and management of kauri dieback in New Zealand

3. Who we need

Stakeholders

The various stakeholders involved in protection of our Kauri – Councils, government, landowners, management and the programme partners.

The Kauri Dieback Joint Agency Response was initiated after the discovery of *P. agathidicida*. It involved a multi-agency response to a widespread problem, involving tāngata whenua, central government and local government. All partners to the programme are crucial to its success. The ICANZ review in 2013 noted that "*A number of people in crucial roles work extremely hard and work outside their roles. This energy has got the programme where it is… People have focussed on getting things done….Each delivery partner has done its best within its allocated resources.*"

The programme's partners work together and individually to prevent the further spread of *P.agathidicida*, and have produced New Zealand's strategy for managing kauri dieback disease. This includes:

1. Delivering effective operations.
2. Building knowledge and tools.
3. Engaging and enabling people and communities.

However, when actively planning and undertaking action to prevent the spread of *P.agathidicida,* each partner works within its own unique context. This includes particular challenges and issues on the frontline - whether it be funding, varying agendas, or the fact most kauri is on private land.

In order to make this project a success, we need to understand each partner - their key drivers, and the particular issues and challenges they face, which impacts on decision making. During workshops with the key stakeholders (those actively involved in the programme), we will explore and the key drivers and primary challenges faced. We will also gather information on how these challenges and drivers affect decision making (i.e. whether it changes the priorities for the areas of intervention, or the choice of intervention).

4. How we're currently fighting it

Managing *P.agathidicida*

The current forms of management intervention in use - "what" we are doing.

Types of interventions

As there is no cure for *P. agathidicida*, programme partners are currently focused on containing the disease – preventing spread to areas it is not present. These interventions include:

1. Cleaning of footwear: Encouraging people to clean their footwear, equipment and vehicles – by scrubbing and spraying with trigene ("phytosanitary stations").

   "*Soil collected from boot-wash stations contained three Phytophthora species, demonstrated the need for phytosanitary measures to contain the disease. "We were surprised to find that the Phytophthora remained viable within the soil for at least a year.*

Chemicals such as Trigene Advance II are effective against the mycelium of Phytophthora, so we are encouraging the public to clean their boots and bikes with a 2% solution"[6].

"Trigene is a broad spectrum disinfectant which is non-toxic, noncorrosive, biodegradable and environmentally friendly. The properties of this disinfectant prevent it penetrating skin so its use is safe for all mammals, amphibians, reptiles, fish and humans. To effectively kill any kauri dieback spores on footwear, try to remove as much soil as possible first, spray footwear with disinfectant then wait for one minute before entering kauri areas."[7]

2. Upgrading current tracks: Reducing the risk of spread along high-use tracks by upgrading high use forest tracks, includes installing boardwalks and improving drainage.

   "DOC has invested significant resources into building boardwalks around some of the most famous and best loved kauri trees, such as Tane Mahuta, which attract a continuous stream of tourists."

3. Closing or relocating lower-priority tracks.
4. Controlling the animals/organisms that can spread the disease (vector control).
5. Conducting surveillance to determine the distribution of the disease.
6. Engaging with communities: An extensive public awareness campaign has been launched in the Auckland and Northland regions. Signage and foot-wash stations have been established at the start and finish of popular walking trails.
7. Planting of the rootzone of Kauri and buffer area with kauri associated plants: In open areas (where there is no defined track), Auckland Council planted an area of 30m around trees to restrict the ability to enter the zone and reduces the need for ground staff to carry out maintenance.
8. Inter-regional holding periods of at least 3 months before planting of Kauri.
9. Implementation of Standard Operating Procedures for Council staff.
10. Establishing programme management structures and systems.

5. How we choose our interventions

Current kauri dieback management practices in New Zealand

The decision frameworks influencing how we select interventions – the "which, where and why" related to intervention choice.

We have considered the management frameworks of Auckland Council and DOC, as well as identifying aspects of management decision making in the literature. We first describe approaches to prioritising sites (either for intervention, or for surveillance), and then the frameworks for intervention choice from Auckland Council.

Prioritising sites

1. From Landcare "Management of Kauri Dieback":

   Sites for surveillance were prioritised in areas with:

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[6] Landcare - http://www.landcareresearch.co.nz/publications/newsletters/biological-control-of-weeds/issue-67/kauri-dieback

[7] http://www.kauridieback.co.nz/media/20081/the%20science%20kauri%20dieback%20v2.pdf

a. High conservation value;

b. Iconic trees;

c. High levels of soil disturbance, such as tracks intersecting kauri root zones;

d. Reports from landowners and the public regarding sick kauri trees occurring on private and reserve lands were responded to by a site visit.

2. From "Surveillance and management of kauri dieback in New Zealand":

Sites were then selected for surveillance both randomly and based on structured decisions that assessed likely vectors from PTA positive sites. Surveillance targeted:

a. Former New Zealand Forest Service (NZFS) plantations;

b. Sites considered to be contaminated only with P. cinnamomi;

c. Iconic large kauri trees;

d. Stands important to Māori

e. Stands 100–1000 years old

f. Large areas of forest;

g. Kauri on islands; and

h. Infected kauri and other sites on farmland.

3. From the Department of Conservation:

The goal for DOC was to deal with spread issues on the tracks in order to protect the remaining 1% of the terminal kauri forest that tracks run through, and forest in high "Ecological Management Units" (a DOC ecosystems ranking).

When deciding on the assessment "fields" for prioritisation (i.e. the topics they would consider when deciding priority), key issues considered were:

a. Whether the site was contaminated;

b. The location of the tracks: Whether the tracks were located in old kauri areas (old growth kauri and kauri associates);

c. How the sites rank ecologically

d. Recreational and other use;

e. Cost of upgrade.

Other fields were identified (but were not used by DOC in an initial prioritisation exercise:

f. Vectoring issues;

g. Whether the track was part of a network.

The key fields defined in the first round were:

Prioritisation field	**Considerations/factors for assessing establishing increased priority**
Contamination: Whether the site PTA positive	• PTA positive site • Symptomatic trees present in forest somewhere

Old kauri areas: Whether the forest had old kauri	• The presence of Dracophyllum in the understory (being an indicator of ancient community) • Large Kauri
DOC EMUs: Ecological ranking	• Ecological Management Unit ranking (2013)
Recreational use: Recreation indices regarding upgrades due to recreation capital investment policy	• Icon/gateway • Recreation OK with cost / visitor • Total visitor number at FLOC
Cost	Cost per visitor rank

DOC then assessed priority by identifying "concern factors" within each field at sites – and gave sites a priority ranking based on the number/combinations of factors.

Priority ranking went from 1-10. DOC then selected against provisional costing to get to the required level of expenditure.

Priority	**Factors**
1	Positive sites
2	Suspect kauri + high recreation value + kauri Dracophyllum + high EMU
3	Kauri Dracophyllum + high EMU + high recreation values + recreation important considerations.
4	Kauri Dracophyllum + icon/gateway
5	Large kauri + icon/gateway + high visitor numbers
6	Large kauri + icon/gateway + medium visitor numbers
6a	Rickers + icon/gateway + high visitor numbers
7	Large kauri + local treasure + high visitor number + low cost per visitor
8	Large kauri + local treasure + high visitor number + medium cost per visitor
9	Large kauri + local treasure + medium visitor number + low cost per visitor
10	Large kauri + local treasure + medium visitor number + medium cost per visitor

In this exercise, DOC did not consider specific track related vectoring issues. These will be part of considerations in future prioritization once there is consultation, however, the "priority factors" for each field are set out below.

Future prioritisation field	Considerations/factors for assessing establishing increased priority
Vectors: Potential	• Is there off-track use by hunters? • Other considerations e.g. TAT
Network Is the track part of a network?	

Intervention choice

1. From Auckland Council:
    a. Auckland Council assessed and surveyed 95 local and sports parks, then made recommendations based on:
        i. Size of park;
        ii. Approximate number of Kauri;
        iii. Health of Kauri;
        iv. Diameter at breast height (DBH) and Canopy health information;
        v. Presence of heritage trees;
        vi. Ecological value, representativeness, density;
        vii. Level of use;
        viii. Whether it is a dogs off leash or exercise area;
        ix. Risk factors:
            1. Roots exposed
            2. Demonstrable human injury (carved initials, graffiti)
            3. Surrounding areas (e.g. rail/bus stations, schools – where off track use probable, farmland with moving animals)
            4. Maintenance at site (weeding, mowing pest management);
        x. User group interest.

    Council mapped all Kauri and indicated a 30m buffer around Kauri – being the distance deemed necessary to defend the whole present and potential rootzone of a kauri, plus an intermediary area – informed management of the areas.

Intervention	When to use	Associated considerations	Benefits
Buffer Zone Planting	In open areas (where there is no defined track).	Planting of the rootzone of Kauri and buffer area (Auckland Council deemed it to be 30m) with kauri associated plants.	Restricts ability to enter the zone and reduces the need for ground staff to carry out maintenance.
Track closure	In areas of dense bush with	Best if an alternative track is present within the park – and	The most effective and efficient way of

Intervention	When to use	Associated considerations	Benefits
	ecologically significant kauri along a defined track, track closure should be considered (either permanent or temporary).	should be accompanied by signs explaining the closure, reasons and alternative routes (with maps) at park entry points and start of the closed track. Barriers should then be erected and planting to fill the closed track if it is permanent. The users of the track should be evaluated and a communications plan put in place. Will need to be accompanied by compliance monitoring.	protecting high risk/high value kauri, however, it is important that user experience is considered.
Track rerouting	In situations where current track networks are high risk but track closure not feasible – rerouting to be considered.	Any rerouting must be evaluated to ensure it does not come within 30m of the protected kauri. The design and construction of rerouted tracks need to be planned to minimise the disturbance to kauri and forestry hydrology – drainage to be diverted away from kauri to prevent water logging or other hydrological effects. Should be located downslope of kauri. Track designs to take into account where visitors may stop (e.g. to take photographs and discourage from visitors to leave the track).	
Track upgrades	Where possible without being detrimental to the natural, healthy growth of the kauri and without changing the hydrology of an area	Track material should be assessed on the number of visitors, and type of use, as well as the health status of the kauri. The most effective track structure is boardwalks (recommended for high visitor use or high risk areas), alternatively gravel and bark mix is a cheaper option, though it requires more maintenance.	Little or no transference of soil or debris by normal visitor use when maintained.
Phytosanitary stations	In instances where a track is within 30m of a kauri	Stations include a mechanism of removing dirt and debris from shoes and equipment and an application of disinfectant. Replenishment and maintenance	Trigene (broad spectrum, non-toxic, non-corrosive disinfectant) has been known to kill dieback spores.

Intervention	When to use	Associated considerations	Benefits
		is required. Visitor attitude to the importance of kauri dieback and the hygiene procedures can be negatively affected by poorly maintained stations.	
Signage and interpretation	In high use areas where visible to public	Signage is important for engaging with the public. Assessment of signage and its effectiveness is required.	Effective signage will bring awareness to public.
Future planting		A site management and risk assessment plan should be carried out prior to planting and any measures to reduce the risk of kauri dieback introduction must be in place. Planting is not recommended within close proximity of visitor access points.	

Issues with interventions

1. Issues with community willingness to undertake cleaning:

   "Community-led efforts to inform hunters, mountain bikers and trampers about the importance of cleaning footwear to prevent soil transfer between forests have been initiated but the gravity of the situation does seem to be lost on some forest visitors. A recent survey of people using the kauri forests for recreation conducted by Auckland Council found that despite numerous public meetings and media messages, engagement with the public was poor and that compliance rates were below 40%. Better public support is needed to prevent further spread of the disease."[8]

   "Reported motivations for and against compliance were more likely positive (n=220) than negative (n=116) with most participants referencing a desire to protect kauri and New Zealand's natural heritage. Negative motivations were varied, but participants cited a lack of information, difficulties with stations, feelings of restriction, effort, doubt and uncertainty. Of particular concern, participants expressed feelings of frustration and resignation with control efforts. Self-reported intentions to comply with cleaning stations and track usage were high and attitudes about the recommendations were largely positive. However, perceptions about the effectiveness of cleaning and the likelihood of others complying were areas of weakness."[9]

2. Issues with kauri on private land:

[8] Landcare

[9] Factors Influencing Public Responses to Kauri Dieback Control Measures, Simon Wegner

The greatest challenge in the next phase is to help manage PTA on private land. Support, incentives and regulation will be required. A nationally consistent approach is necessary.[10]

3. Translating planning into action:

   The programme attempts to work in partnership with tangata whenua and communities. But, for a number of reasons, this does not always translate into consistent action on the ground.[11]

4. Resourcing:

   Current resources are struggling to meet current activities. And they will be inadequate to meet the challenges of regulating PTA on private land or co-funding long-term research.[12]

5. Stronger planning and practical business systems are urgently required.[13]

6. What can we learn from internationally?

Other international pathogen management techniques

Management interventions for other plant pathogens which we are currently managing – can we learn from the way sites are prioritised or managed?

Literature regarding management plans for other plant pathogens was reviewed – and any salient points, relevant to either prioritisation techniques, or interventions (where the pathogen was a soil-dispersed *Phytophthora* species) was recorded.

The purpose of this exercise was to understand how other countries are managing spread of *Phytophthora*, in order to identify any decision making frameworks/tools which could inform New Zealand's approach. A reading list is attached as Appendix A, however, the points of interest (generally excerpts from the document) are set out below.

The literature summary is organised by pathogen:

1. *Phytophthora cinnamomi*
2. *Chalara fraxinea.*[14]

We have produced a table for each document – with points relevant to either prioritisation of sites, or choice of intervention separated. We reproduce what the document said, then comment on how this could be relevant to producing a framework in New Zealand.

[10] IQANZ Report
[11] Ibid
[12] Ibid
[13] Ibid
[14] Other pathogens were considered, but are not reproduced here – please see Appendix A.

Phytophthora cinnamomi

Document: Victoria *P. Cinnamomi* management strategy[15]		
Strategy	**Approach**	**Relevance**

Prioritisation	• Prioritisation should be based on maintaining the viability of key environmental assets and optimising outcomes for asset protection and management.
	• Assets should be ranked according to their significance. Uninfected areas of significant and vulnerable ecosystems, and the species they contain, are the highest priority for greater levels of protection and management. Priority will also be given to species currently or potentially threatened with extinction as a result of *P. cinnamomi*. Where two ecosystems of the same conservation value are being compared, generally intact ecosystems will have priority for management over degraded ecosystems and ecosystems at higher risk will have priority over those at lower risk.
	• *Phytophthora* Management Plans would include an analysis of the range of values, the level of risk, and the practicality of control, including cost (i.e. a cost/benefit analysis). Values that should be considered include:
	  • biodiversity
	  • other social and economic assets potentially at risk.
	Knowledge of these impacts on biodiversity is limited and support in terms of modelling capability is likely to be required.
	Until such time as agencies have the capacity to undertake site appraisals and cost/benefit analyses these should be done by persons with specialist knowledge. In some instances, relying on expert opinion may be necessary as an interim measure.
		Prioritisation was based on significance (with ecosystem significance being the primary "field" of consideration).
		Although we will have additional/different fields – use of a "significance" test is a running theme.
		Here, it was about risk to an ecosystem/ biodiversity, but other social and economic considerations were at play.
		It noted that practicality of control could also be a factor – and cost was a consideration here.
		It recommended data modelling to better understand risk – which we are unlikely to have/get.
		The need to get professional appraisal on whether sites are infected or not was noted. This could be a consideration within our framework.
		Note: *The Kauri Dieback Programme P&I work stream are currently developing criteria to help define an area 'free from PTA'. Once the criteria have been*

[15] Department of Sustainability and Environment (2008). Victoria's Public Land *Phytophthora cinnamomi* Management Strategy. Department of Sustainability and Environment, Melbourne.

		finalised they will be tested in selected areas. Areas deemed free of the disease are likely to inform the actual decision making on the ground in terms of prioritisation and selecting the most appropriate intervention.
Intervention	Zonation • Regional *Phytophthora* Management Plans should identify *P. cinnamomi* management zones based on the significance of the asset and level of risk. Zones should be tiered with highly significant sites at high risk given the highest level of protection. For example: o Zone 1 — Routine Phytophthora Management Zone The objective is to adopt routine measures to safeguard areas of low to medium biodiversity significance that are susceptible to moderate impact. Routine measures entail active hygiene efforts to clean plant and equipment, vehicles and footwear as necessary. Other measures may entail track or road closures, or scheduling works in relation to weather and infestation status. Measures may also need to be taken to safeguard against importation of contaminated gravel and plant materials. o Zone 2 – Intensive Phytophthora Management Zone The objective is to adopt both routine measures and intensive efforts to safeguard areas of medium and high value asset significance that are at high risk. Intensive measures include use of physical barriers to protect clean areas, installation of hygiene infrastructure, road and track modification (such as re-routing, addition of passive road and trail hygiene elements as outlined	Using an assessment on priority (based on significance etc.), "Zones" were identified, and particular plans implemented within the Zones. In these zones, categories of interventions were identified – this could guide stakeholders on use of interventions, while allowing some flexibility? Potentially the Zones could have different "purposes" – e.g. zones with infestation are about "response", while zones without are about "preparedness". Other associated points of interest: • A program of regular assessment and soil testing should be developed for these important sites. ***Note:*** *The Kauri Dieback Programme will be investigating the definition of a 'management unit' this financial year and what criteria should be used to define it. The final*

	below, or water diversion), monitoring and disease awareness programs and, possibly, chemical intervention.
	• Phytophthora Management Plans can be used to indicate the level of management effort that is required in particular zones. For example, they can guide when it is necessary for road making materials to be tested for the pathogen prior to use and where road drainage water diversion measures are warranted.
	• Preparedness: Land managers should make arrangements to prepare for management of *Phytophthora cinnamomi*. This includes acquiring the appropriate equipment and materials to effectively implement procedures for hygiene, surveillance and quarantine viz:
	  • Chemical (i.e. potassium phosphonate) and wash-down facilities
	  • Materials and structures for passive hygiene, road and trail control
	  • Signage for vehicles or pedestrians
	  • Barriers for track closures etc.
	  Further work is needed to standardise the apparatus and infrastructure. These need to build on and integrate with weed hygiene initiatives.
	  Action 12: Phytophthora Regional Working Groups to determine local preparedness requirements and implement procedures for hygiene, surveillance and quarantine.
	• Response: Where hygiene and quarantine procedures fail to prevent infestation, and in some already infected communities, a management response may be required to control the pathogen.
	  Chemical intervention: The most promising agent for controlling *P. cinnamomi* is potassium phosphonate, a systemic fungicide thought to also trigger and/or enhance intracellular barrier formation to resist the pathogen's passage through a plant. The effect may last for up to five years. Potassium phosphonate is being
		'prioritisation and optimisation' framework that will be developed is likely to add value to future discussions around the definition of a 'management unit'.

	applied routinely in high value areas in Western Australia both through tree injections and spraying foliage by hand, and by aircraft.	

Document: Threat abatement[16]		
Prioritisation	• A risk assessment process has been developed for assessing the risk of P. cinnamomi to threatened species, ecological communities and areas, and ranking them as the basis for setting management priorities. • The models identify the source of risk, the likelihood of occurrence and the magnitude of the consequences. The models are semi-quantitative (i.e. qualitative criteria are assigned scores), based on current scientific knowledge. However, where significant knowledge or data gaps exist, expert opinion will be required. The semi-quantitative scoring system used in developing the models enabled a ranking of assets according to the risk posed by *P. cinnamomi* and the perceived ability to manage the risks. Indicative assessments are produced when the models are run. • Examples of risk assessment: o Bayesian based risk mode o A preliminary risk assessment methodology has been developed that guides decisions concerning implementation of hygiene measures during operational works. Studies have identified high, moderate and low risk zones within the World Heritage Area Implementation of hygiene measures is recommended for works within high and moderate risk zones in order to prevent transfer of the pathogen from infested catchments.	A useful approach regarding risk assessment as a means of prioritisation, where "risk" is a combination of: • source of risk • the likelihood of occurrence • the magnitude of the consequences. Notes concerns about how to assess each of these factors- and the need to bring in qualitative/judgment based assessments. At these times, expert opinion should be obtained so subjectivity has credibility. ***Note:*** *A semi-quantitative model e.g. Bayesian modelling or similar may be considered as a potential research topic in the future by the Kauri Dieback Programme P&I work stream.*

[16] Background: Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi,* Commonwealth of Australia, 2014

	○ The Victorian Department of Environment and Primary Industries (Vic DEPI) used known sites of impact to produce a Species Distribution Model (SDM) for *P. cinnamomi*. This model factors in relevant climate and terrain variables and may be used to determine the risk to individual taxa. To determine the risk to vegetation communities Vic DEPI combined the *P. cinnamomi* SDM with a vegetation impact model to produce a risk map showing the relative risk of impact across Victoria. ○ Tasmania has undertaken a project which established a set of priority areas for management of *P. cinnamomi* for threatened species and ecological communities that are at risk from *P. cinnamomi*. This rated vegetation community susceptibility due to frequency of susceptible species and environmental susceptibility. The largest disease-free areas or areas most manageable (considering factors such as disease proximity, landscape features and ease of access etc.) were selected for priority management. ○ In New South Wales, the *P. cinnamomi* threat to Royal National Park through modelling the probability of infection as a function of environmental variables (soil, landscape, topographic position, aspect and slope) and mapping plant communities in which susceptible species are most abundant. This data provided maps showing the risk of plant diversity loss to *P. cinnamomi*.	
Intervention	See Appendix B.	

Document: Chapter 11: Risks and Priorities, Biodiversity values and threatening processes of the Gnangara groundwater system

Prioritisation	• The use of frameworks/tools to determine what conservation actions to invest in was encouraged – so that the benefits, constraints and uncertainties and trade-offs are explicitly stated. • Could be either quantitative or qualitative (e.g. mathematical optimisation tools, or multi-criteria decision analysis). Allows assessment of the worth of diverse conservation outcomes at both macro and micro scales – in order to distinguish among and integrate various goals held by stakeholders. However, it is important to specify constraints and uncertainty by being clear about what we don't know. • In the example provided, risk assessment was a product of likelihood and consequence (with standard semi-quantitative descriptors of likelihood and consequence). It was noted that: o Likelihood was defined as the likelihood an area was infested with *Phytophthora* dieback – when usually risk assessments assess the likelihood of a hazard affecting biodiversity assets in future. However, no reliable spatial information relating to the future likelihood of *Phytophthora* infection currently exists. o Consequence related to the loss of biodiversity in this context. o Risk was then calculated for each 100m grid cell. • This is particularly relevant to our situation. Where risk of spread is unlikely to be considered, so much as risk of infection.

Chalara faxinea

Document: Chalara Management Plan (UK) and Socio-economic Framework		
Prioritisation	• Prioritising of areas (to look at the impact of any action which could be taken to slow the spread) occurred by combining 2 models: o Modelling of the potential spread of the disease (based on evidence); and o Modelling the relative hazard (a calculation of the area of ash that would become infected by an isolated new focus of infection in an otherwise uninfected area). Then weighted by an estimate of ash value for recreation etc. This size of the hazard is based on how much ash is present and whether there are gaps in distribution. • Therefore, trace forward activity will be focussed on areas we believe the removal	Although risk of spread was modelled, other factors or "fields" to consider in a risk assessment to establish priorities may be relevance, like societal benefit etc.

	of newly planted ash trees will deliver the most benefit i.e. where the likelihood of airborne infection is relatively small, but the potential impact of the disease could be high. • The Government's approach to managing the disease recognises the wide range of potential values at stake, and the importance of taking a proportionate approach to managing the disease in a cost-effective way, particularly in view of substantial scientific uncertainty. • When estimating value (non-uniform), the value of ash in delivering certain ecosystems services will vary significantly across the country. In a mixed woodland used for recreation, the loss of ash trees may have relatively little impact and substitution by other species could offset losses. By contrast, the loss of ash trees in an established hedgerow could result in complete loss of the hedgerow as a landscape feature, a valuable habitat and a source of habitat connectivity. • Finally, the value of societal benefits depends directly on population distribution and therefore woodlands and ash trees close to large population centres will have higher use-values than more remotely located woodlands. These locations include: o Special Areas of Conservation (SACs) where ash is a significant component of a habitat feature notified under the EU Habitats Directive. o Sites of Special Scientific Interest (SSSIs) where ash is a significant component of the site including sites where it is a notified feature. o Ancient woodland (continuously wooded since at least 1600) where ash is a significant component. o Veteran ash trees (trees in middle or late stages of life providing a diversity of habitat related to their structure and rot status) which can occur within woods	

	but also in agricultural, park and urban landscapes where they provide connectivity. o Ash supporting a high proportion of the species that exclusively depend on it as a host, substrate or food source. • Loss of benefits (and cost) was considered: o Previous UK studies have focused on landscape, recreation, biodiversity, air quality, carbon sequestration and any human health impacts as the non-market costs of tree disease.	

APPENDIX A: Kauri Dieback – Documents reviewed

Document	Author	Description	Reviewed
Documents regarding the Kauri Dieback Programme and management of the disease			
Kauri Dieback Strategy (2014)	Kauri Dieback Programme Partners	Strategy for the programme.	✓
Management of Kauri Dieback	Landcare Research	Mostly about surveillance of Kauri	✓
Landcare – Overview from the Website	Landcare	Introduction to the fungus, background, history, detection and management summary.	✓
Surveillance and management of kauri dieback in New Zealand	Tony Beauchamp and Nick Waipara	Information on spread and surveillance of kauri dieback.	✓
Kauri dieback management plan in place by Auckland Regional Council	Auckland Council	Management plan in place by Auckland Regional Council – talks about spread, risks and interventions – and when to use particular interventions.	✓
Kauri Dieback Programme – ICANZ Independent review of the programme and recommendations for its next phase (2013)	ICANZ	Review of the programme and recommendations for the future	✓
Factors Influencing Public Responses to Kauri Dieback Control Measures (2014)	Simon C Wegner	Review conducted on the rate of awareness, compliance and attitudes to phytosanitary stations.	✓
Auckland Council Draft LSP strategy	Auckland Council	Set out Auckland Council's approach to deciding on interventions in Local and Sport Parks	✓

Department of Conservation email to Travis Ashcroft	Department of Conservation	Email setting out DOC's approach to prioritisation (could not open attachments)	✓
International papers on tree pathogens and their management			
Chalara Management Plan (2013)	Department for Environment Food & Rural Affairs (UK)	Overview/description of Chalara and its infection, spread, history, prevention in Ash. Sets out the 4 primary objectives of the prevention programme (the 1st being preventing the spread of the disease) and what is being done under each.	✓
Chalara in Ash Trees: A framework for assessing ecosystem impacts and appraising options (2013)	Department for Environment Food & Rural Affairs (UK)	An analytical discussion paper that has been produced by Defra's Plant Health Evidence and Analysis team. It develops a possible framework for assessing the economic, environmental and social risks and impacts of Chalara. Such a framework could be used for assessing the effects and value for money of the options set out in the Interim Control Plan and subsequently the Chalara Management Plan.	✓
Victoria's Public Land *Phytophthora cinnamomi* Management Strategy	Department of Sustainability and Environment (Australia)	This Strategy sets out the objectives, management principles, priorities, legislation and proposed management approaches for protecting biodiversity from this significant threat.	✓
A review of the catchment approach techniques used to manage *P.cinnamomi* infestation of native plant communities of the Fitzgerald River National Park on the south coast of Western Australia	Chris P. Dunne, Colin E. Craig, Maria Lee, Tile Massenbauer, Sarah Barrett, Sarah Comer, Greg J. C. Freebury, Deon J. Utber, Malcolm J. Grant, Bryan L. Shearer	A description of the techniques used at the Fitzgerald River National Park to manage *P.cinnamomi.* An initial Bayesian model to determine the probability of success of different management techniques. A series of 4 programmes was implemented, aimed at preventing spread.	✓

Background: Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (2014)	Commonwealth of Australia	This background document complements the statutory *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi* (TAP) (Department of the Environment, 2014). The TAP outlines the actions proposed to abate the threat and addresses statutory requirements. This document provides supporting information on matters such as the biology of the pathogen, its population dynamics, spread, diagnosis and impacts on biodiversity and management measures.	✓
Chapter 11: Risks and Priorities, Biodiversity values and threatening processes of the Gnangara groundwater system	Department of Conservation (Australia)	This excerpt (amongst other things) provided an overview of ways assess conservation risk and prioritise conservation assets. *Phytophthora cinnamomi* was used as a case study.	✓
Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia: Part 3 – Risk Assessment for Threats to Ecosystems, Species and Communities: A Review (2005)	B Wilson, K Howard, E O'Gara and GESTJ Hardy	Sets out the benefits of, and current processes for, risk assessment and setting priorities for *Phytophthora cinnamomi* threats – summarises each and assesses benefits/merits.	✓
Progress of the *Phytophtora ramorum* eradication programme in south-western Oregon forests, 2001 - 2009	Alan Kanaskie, Evertett Hansen, Ellen Michaels Goheen, Nancy Osterbauer, Micheael McWilliams, Jon Laine, Michael Thompson, Stacy Savona, Harvey Timeus, Bill Woosley, wendy Sutton, Paul Reeser, Rick Schultz and Dan Hilburn	Description of the efforts to quarantine and treat *Phytophtora ramorum* in Oregon through felling and burning.	✓

APPENDIX B: Approach to control of *Phytophtora Cinnamomi*

Intervention	When to use	Difficulties
Access prohibition or restriction	Prohibiting access or quarantining an area is generally used to protect biodiversity assets of high conservation value from P. cinnamomi. For sound management of access to uninfected areas, it is necessary to delineate the boundaries between infected and uninfected areas. A number of elements that are essential to operational planning include: • recognition of the boundaries between infected and uninfected areas • mapping of the boundaries between the two areas as a basis for future access • demarcation of the boundaries on the ground, so that machinery operators are forewarned and avoid crossing into infected areas • regular inspection to ensure that entry controls are being followed • regular testing to ensure that the disease has not spread past the boundaries put in place • assessment of the efficacy of controls.	Difficulties with these sorts of quarantine measures can arise for social and resource-related reasons, such as: • opposition to changes in land use/access • level of public education required • lack of resources necessary to enforce quarantine and hygiene processes.
Hygiene	Where access is permitted, hygiene refers to specific procedures designed to prevent the spread of P. cinnamomi by ensuring that infected soil, water and/or plant material are removed from machinery, vehicles, equipment and footwear before entering uninfected areas. Management options include: • postponing activities during wet weather • beginning activities with clean vehicles and equipment • avoiding wet or muddy areas during activities • leaving heavy equipment in infected area where they are regularly used.	Where access is permitted, hygiene refers to specific procedures designed to prevent the spread of P. cinnamomi by ensuring that infected soil, water and/or plant material are removed from machinery, vehicles, equipment and footwear before entering uninfected areas. Management options include: • postponing activities during wet weather

	Permanent or semi-permanent vehicle wash-down facilities may be constructed where machinery and vehicles require routine cleaning for fixed activities. Portable wash-down systems enable machinery, vehicles and any item that comes into contact with the ground, to be cleaned at the point of risk for activities that do not have a fixed location. Where high conservation values are at stake, activities such as bushwalking, horse riding and cycling may pose a risk of introduction and may also be subject to hygiene. Disinfection of footwear, small tools and equipment against P. cinnamomi is required to maintain disease-free status in these instances.	• beginning activities with clean vehicles and equipment • avoiding wet or muddy areas during activities • leaving heavy equipment in infected area where they are regularly used. Permanent or semi-permanent vehicle wash-down facilities may be constructed where machinery and vehicles require routine cleaning for fixed activities. Portable wash-down systems enable machinery, vehicles and any item that comes into contact with the ground, to be cleaned at the point of risk for activities that do not have a fixed location.
Potential further introductions through revegetation	Revegetation of much of the landscape is occurring on a broad scale across the vulnerable envelope for P. cinnamomi and the threat of continued spread of P. cinnamomi from infected stock and nurseries is potentially significant. A key objective for much of the revegetation work is to enhance or restore the landscape; however, this may be nullified if P. cinnamomi is introduced in the process. Managing the threat will require targeting both producers and consumers of products.	
Monitoring and surveillance	Effective monitoring and surveillance for the presence of P. cinnamomi is essential to allow timely management. Monitoring and surveillance of plant communities provides information on disease outbreaks, as well as on distribution, prevalence and incidence of P. cinnamomi. It also provides information necessary for evaluating the risk P. cinnamomi poses to biodiversity and the effectiveness and efficiency of management and risk mitigation measures. The purpose of monitoring ranges from determining long-term patterns of pathogen spread and disease impact, to determining the effectiveness of management	

	measures and/or surveillance of pathogen movement where high conservation values are under imminent threat. Surveys can be one-off to determine if a site is infected with the pathogen, or they can be systematic and ongoing. Systematic ongoing surveys focused on key sites provide data on the epidemiology of the disease over time. Information about pathogen occurrence, susceptible species, climate and topography can be employed to develop predictive maps for potential future occurrence and risk of introduction of the disease.	