Recommended Case Definition and Design of a Baseline Monitoring Methodology for Kauri Dieback

May 2020 FINAL

(Updated: September 2020)

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A report for the Ministry for Primary Industries on behalf of the Kauri Dieback Programme

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Reference as: Stevenson, M., Froud, K., 2020. Recommended case definition and design of a baseline monitoring methodology for Kauri Dieback. A report for the Ministry for Primary Industries on behalf of the Kauri Dieback Programme, 41 pp.

Biosecurity New Zealand
Ministry for Primary Industries
Manatū Ahu Matua

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

1 Contents

2 Introduction

Kauri (*Agathis australis*, Araucariaceae) is a native conifer distributed extensively in the North Island of New Zealand, north of Kawhia. Kauri are of cultural significance for Māori and a national icon for all New Zealanders (Lambert et al. 2018).

The disease known as kauri dieback is caused by the fungal-like chromist, *Phytophthora agathidicida* (Weir et al. 2015). While the first records of kauri dieback were from Great Barrier Island in the early 1970s (Gadgil 1974) the disease was not reported on the mainland until 2006, although it may have been mis-identified earlier. It is suspected that the disease had been present on the mainland for many years before first detection in 2006. Kauri dieback has been confirmed in kauri stands in Auckland, Northland and the Coromandel Peninsular.

In 2008 *P. agathidicida* was declared an Unwanted Organism under the New Zealand Biosecurity Act (1993). Kauri is currently managed by the National Kauri Dieback Programme (National Programme), a partnership with Biosecurity New Zealand (part of Ministry for Primary Industries), Department of Conservation, Auckland Council, Waikato Regional Council, Northland Regional Council, Bay of Plenty Regional Council, and the Tangata Whenua Roopu (representative body for hāpu/iwi with an interest in kauri lands).

To limit the impact of disease, an epidemiological approach is expected to provide a rational, cost-effective and time-efficient approach to guide the deployment of interventions designed. In brief, an epidemiological approach involves:

1. Establishment of a case definition, allowing cases to be recorded consistently over place and time;
2. Enhancement of surveillance for disease;
3. Descriptive analyses to describe the distribution of disease over place and time;
4. Development of hypotheses relating to why some trees are at greater risk of infection, compared with others;
5. Application of intervention measures based on the hypotheses developed in the previous step; and
6. Continued surveillance to record incident cases post application of control measures to determine if control measures have been successful.

This is an adaptive management approach with steps (1) to (6) repeated, if necessary, over time. Adjustments to interventions can then be made as additional information is accumulated over time.

This report provides details of a workshop held in May 2019 to achieve consensus among stakeholders on two key aspects of an epidemiological approach to kauri dieback control outlined above:

1. Development of an appropriate case definition for classifying kauri as either dieback-positive or dieback-not detected; and,

2. Selection of an appropriate spatial unit of interest that will allow stakeholders to: (a) describe the frequency of disease over time; and (b) monitor responses to interventions.

Additional questions posed by Biosecurity NZ, Ministry for Primary Industries (on behalf of the Kauri Dieback Programme) include:

1. What data are required to describe the prevalence of kauri dieback before the onset of formal control measures ('baseline project')?

2. How would baseline monitoring inform decision making and measure intervention success over time?

3. What is the best way to measure and report the prevalence and incidence of kauri dieback? How many kauri trees need to be sampled to estimate the prevalence of disease?

4. How should baseline monitoring outputs be reported against the Kauri Dieback Programme or the proposed National Pest Management Plan?

Section 5 provides definitions of technical terms used in this report.

3 Methods

A workshop for kauri dieback stakeholders was held at the Ministry for Primary Industries, 17 Maurice Wilson Avenue, Mangere, Auckland from 10 am to 3 pm on Wednesday 29 May 2019.

A copy of the workshop agenda and a list of workshop participants is provided in Section 6.1. Minutes from the meeting are provided in Section 6.2.

Following introductions from Bronwyn Mullions and Travis Ashcroft, Karyn Froud and Mark Stevenson led attendees through a presentation and group discussion of the steps involved in complex disease outbreak management, the elements of a good case definition and why a case definition is important for effective disease control.

In the afternoon, Mark Stevenson facilitated development of group consensus regarding the criteria and symptoms that should comprise a case definition for kauri dieback. While Karyn Froud led attendees through the principles of selection and definition of a spatial unit of interest for recording and reporting of kauri dieback case events. A draft kauri dieback case definition was developed using notes made during the early afternoon session. This draft was then presented back to the group for comment and editing. A copy of the case definition agreed-on by participants is provided in Section 3.1.

Following the workshop a consultation report with a draft case definition was drafted and released for feedback on 25/07/2019 to 53 people due to their previous interest in Kauri dieback, their attendance at the Kauri Dieback Programme 'Baseline workshop' on the 29 May 2019 in Auckland

and the members of the Kauri Dieback Strategic Science Advisory Group and Biological Heritage Rapid Implementation Group. A reminder was sent on the 19/08/2019 to the entire group and individual reminders were sent up until mid-September to people who had indicated they wanted to respond but hadn't yet done so.

The following people provided written feedback on the consultation document:

Murray Fea, You Chin Chew, Chris Green, Tony Beauchamp, Kim Parker, Lee Hill, Gavin Clapperton, Philippa Stevens and Lindsay Bulman (in part).

This report was then finalised based in the feedback received.

4 Results

4.1 Consultation

Most responses for feedback on the draft case definition were from members of the KDP planning and intelligence team and two members of the kauri dieback Strategic Science Advisory Group. In all cases there was support for developing an agreed case definition and baseline methodology for kauri dieback. Based on this feedback modifications were made to the draft case definition. Changes in terminology and clarification were made to the definition of a *P. agathidicida* site versus kauri dieback trees. Minor changes were made to the symptomatic criteria. Significant change was to the epidemiological criteria (as below). We added clarification to the wording of the baseline monitoring methods and examples based on feedback and change to the epidemiological criteria. We also clarified and extended the recommendations based on feedback and confirmed that a further round of consultation was required.

4.2 Case definition

Distinction is made between *P. agathidicida* sites based on pathogen presence in samples (soil, tissue etc.) and kauri dieback trees based on disease presence (i.e. visible symptoms of disease).

P. agathidicida sites are useful data points for measuring disease spread and risk management.

Kauri dieback trees are useful data to document the prevalence and geographic extent of disease and to monitor disease progression and responses to controls or interventions.

4.2.1 *P. agathidicida* sites

P. agathidicida sites are geospatial locations where the pathogen is confirmed or suspected to be present. How inclusive management agencies are with suspect *P. agathidicida* sites will be dependent on their objectives. For measuring disease spread into new regions only confirmed cases are likely to be acceptable, whereas for risk management, agencies may include suspect *P. agathidicida* sites to enable site management under the Biosecurity Act.

A ***confirmed P. agathidicida site*** is a point location where the presence of *P. agathidicida* has been confirmed (from a tree, soil or other substrate), using a National Programme approved test at an approved laboratory.

A ***suspect P. agathidicida site*** is a point location, where the presence of *P. agathidicida* is suspected on the basis that probable or suspect cases of kauri dieback (disease) have been recorded. Suspect *P. agathidicida* sites are recorded at the same point locations as probable or suspect cases of kauri dieback.

4.2.2 Kauri dieback cases (3 classes)

A kauri dieback tree is a kauri (*Agathis australis*, Araucariaceae) that meets the symptomatic criteria and may meet the epidemiological criteria, as described below, of having kauri dieback (disease). There are three classes of kauri dieback-trees: confirmed, probable or suspect depending on agreement with the epidemiological criteria. These are summarised in Table 1.

How inclusive management agencies are with suspect cases will be dependent on their objectives.

4.2.3 Symptomatic criteria

The symptomatic criteria for kauri dieback on a kauri tree is meet if a National Programme approved trained observer detects one or more of the following symptoms that are consistent with kauri dieback: bleeding lesions on the basal trunk, lesions on roots, the presence of canopy thinning, yellowing of the foliage, tree death.

4.2.4 Epidemiological criteria

The **epidemiological criteria** for kauri dieback are meet if the tree is located within a radius of 50 m of a **confirmed *P. agathidicida* site** (point location).

The epidemiological criteria differ significantly from the draft criteria based on feedback during consultation. The draft criteria and consultation responses are detailed in the Appendix.

4.2.5 Case classification – Kauri dieback cases

4.2.5.1 Confirmed case

A kauri dieback ***confirmed*** case is a tree that meets the symptomatic criteria **and** *P. agathidicida* has been confirmed from the tree or from soil sampling specifically around the tree using the National Programme approved soil sampling protocol and approved test at an approved laboratory.

4.2.5.2 Probable case

A kauri dieback ***probable*** case is a tree which meets the symptomatic criteria AND the epidemiological criteria (i.e. a tree that has symptoms, no laboratory confirmation (either no test or an undetected test) but is within 50m of a confirmed *P. agathidicida*-positive site.

4.2.5.3 Suspect case

A *suspect* case of kauri dieback is a tree that meets the symptomatic criteria listed above but DOES NOT meet the epidemiological criteria (i.e. a tree that has symptoms, no laboratory confirmation (either no test or an undetected test) and is not within 50m of a confirmed *P. agathidicida* site).

4.2.6 Case classification – Non-cases

Note a non-case relates to absence of disease NOT to presence or absence of the pathogen.

Unhealthy kauri – other causes, is a tree that may meet the symptomatic criteria, and possibly even the epidemiological criteria, but in the expert opinion of the trained observer the cause of ill-health is not kauri dieback related and rather is associated with other causes such as lightning strike, drought, flooding etc.. It is useful to classify these trees separately to non-cases.

Non-cases – are kauri trees that **do not** meet any of the symptomatic criteria but may meet the epidemiological criteria.

Table 1: Proposed criteria for *confirmed, probable, suspect* case and non-cases (*unhealthy* and *non-cases*) of kauri dieback.

Case	Test positive	Symptomatic	Epidemiological	Approved observer
Confirmed	Yes	Yes	Yes or no	Yes
Probable	No	Yes	Yes	Yes
Suspect	No	Yes	No	Yes
Unhealthy kauri	No	Maybe	Yes or no	Yes
Non-cases	No	No	Yes or no	No

4.2.7 Use of case classifications

For disease management, *confirmed, probable* and *suspect* cases may be grouped together. For analyses designed to determine the influence of environmental factors that are contributing to disease development (e.g. soil type, moisture retention) there would be interest to identify the characteristics of kauri that made them more likely to show signs of disease by grouping *confirmed, probable* and *suspect* cases together and comparing them with *unhealthy* kauri and *non-cases*.

It is important to note that the existing canopy health score system is not intended to be replaced by the proposed case definition. Canopy health scores contribute to the case classification (within the symptomatic criteria) and separately provide information on the severity of disease within a site. For disease management it is anticipated that a map showing disease prevalence (case classification) of trees will be presented alongside a map describing disease severity (canopy score) for the same site.

4.3 Spatial unit of interest

The case definition of a kauri dieback-positive tree refers to individual trees and data are collected relating to individual trees. For this reason, it is recommended that the spatial unit of interest is an individual kauri tree for seedlings, saplings, rickers and mature trees.

Given widespread access to global positioning system (GPS) enabled hardware (i.e. hand-held GPS devices) it is recommended that the coordinates of point locations of suspect, probable and confirmed case trees are recorded using hand-held GPS devices in New

Zealand Transverse Mercator (NZTM). In addition to location, the approximate diameter of the trunk of the affected tree should be recorded as well as the canopy score and trunk diameter at breast height. Along with environmental and management variables.

Recording case locations at the finest level of spatial detail possible will ensure it is possible to carry out detailed geospatial analyses to determine the influence of local (micro) environmental effects (e.g. slope, aspect) on kauri dieback risk in the short to medium term future (Nguyen et al. 2011).

Case locations recorded at the point level can be aggregated up to the small area level for reporting to policy makers or stakeholders, as individual circumstances dictate. This may include a spatial polygon for biological zones (the canopy range or estimated rootzone of trees, hygiene zones, risk zones such as uphill and downhill water flow, watersheds and catchments) or for land management zones (conservatory, forest, rohe, takiwā or territorial authority boundaries).

The extent of the drip line for individual trees has been excluded from our definition of the spatial unit of interest for the following reasons: (1) the soil area is only relevant for those trees where a soil sample has been taken; (2) defining the boundary of a drip line would increase the amount of data to be collected by field staff; (3) data collected on the population of trees at risk is at the individual tree level (see below); and (4) drip lines will overlap with other trees that may have a different disease status.

4.4 Baseline monitoring methodology considerations

4.4.1 What data are required to describe the prevalence of kauri dieback?

We recommend that the following data are collected to estimate the prevalence of kauri dieback before the onset of formal control measures (based on the comments made in Section 3.3.3):

1. Details of the point location of confirmed, probable, at-risk and suspect cases. Existing data which uses a range of different disease status classifications can be re-classified for this purpose.

2. Raster maps showing the geographic distribution of kauri density. Which we understand are available.

4.4.2 How would baseline monitoring inform decision making?

The following comments and suggestions are made in relation to how baseline monitoring can be used to inform decision making and measure the success (or otherwise) of disease control interventions.

1. Numeric estimates of kauri dieback prevalence at the forest, catchment or regional park level can be used to prioritise (rank) areas, allowing control and investigative resources to be allocated accordingly to optimise the effectiveness of interventions.

2. Prevalence estimation conducted at regular intervals (say) every 12 to 24 months after a base-line prevalence study will provide an indication of how quickly disease is spreading in areas of interest and if control measures are slowing disease spread and reducing the impact of the disease over time.

3. Disease prevalence mapping techniques provide the opportunity to identify specific locations within an area of interest in which the frequency of disease is relatively high.

4. Presentation of prevalence maps to technical stakeholders (such as those that attended the May 2019 meeting) will allow hypotheses to be generated regarding disease spread. These hypotheses can then be tested by collecting the appropriate data followed by application of appropriate statistical techniques.

5. Quantitative evidence of the success (or otherwise) of disease control interventions will be provided by prevalence estimation and changes in severity of disease over time.

4.4.3 What is the best way to measure the frequency of kauri dieback?

Objective comparisons of the frequency of disease can only be made if case numbers are reported as a fraction of the total number of kauri trees that are at risk. When the entire population of trees cannot be enumerated with ease, calculations can be carried out to determine how many trees need to be sampled to estimate prevalence at a given precision and level of confidence, allowing statements such as 'sufficient numbers of trees were assessed to be 95% confident that our estimate of the prevalence of kauri dieback was within 5% of the true population value' to be made. This is important for defining areas that are free from disease.

Figure 1 is a line plot showing the number of kauri to be sampled to be 95% confident that the prevalence of kauri dieback within a given study area is within 5%, 10% and 20% of the true population value for prior prevalence estimates ranging from 5% to 95%. In summary, required sample sizes reduce as: (a) the estimated prior prevalence of disease increases; (b) the relative error increases; and (c) the level of confidence in the prevalence estimate decreases. The data presented in Figure 1 are shown in tabular format in Table 2.

Table 2: Number of kauri trees to be sampled to be 95% confident that the prevalence of kauri dieback is within 5%, 10% and 20% of the true population value for prior prevalence estimates ranging from 5% to 95%.

Prior estimate of prevalence	Precision		
	5%	10%	20%
5%	7246	3233	1821
15%	2172	967	544
25%	1151	512	288
35%	713	317	178
45%	469	209	117
55%	314	140	79
65%	207	92	52
75%	128	57	32
85%	68	30	17
95%	20	9	5

Numerous online tools are available for calculating sample sizes to estimate a prevalence, see http://252s-epi.vet.unimelb.edu.au:3838/epi/sample.size/ for an example.

4.4.4 Options to measure kauri dieback frequency

Several options are available for estimating the prevalence of kauri dieback against the population at risk.

Option 1. The most accurate way to estimate the frequency of kauri dieback is to:

(a) define the boundaries of an area of interest;

(b) count the number of confirmed, probable and suspect cases of kauri dieback within the area of interest at a single point in time (the numerator); and

(c) count the total number of kauri trees in the area of interest (the denominator).

Kauri dieback prevalence for the area of interest equals the number of (confirmed, probable or suspect) cases divided by the total number of trees at risk.

Option 2. Given the difficulties in enumerating every kauri present in an area of interest a second option for quantifying disease frequency would be to:

(a) define the boundaries of an area of interest;

(b) count the number of confirmed, probable or suspect cases of kauri dieback within the area of interest at a single point in time (the numerator), as shown in Figure 2; and

(c) use remote sensed imagery to enumerate kauri forest density. Given knowledge of the size of the area of interest and size of areas within the area of interest with a non-zero density of kauri, the total number of trees within an area of interest could be approximated.

Kauri dieback prevalence for the area of interest equals the number of (confirmed, probable or suspect) cases divided by the approximate number of kauri trees at risk. While development of host recognition remote sensing is still in development, it is sufficiently accurate to estimate a population, excluding non-emergent life stages (seedlings and saplings).

Option 3. For the situation where observations are made on trees adjacent to walking tracks the approach would be to:

(a) define the boundaries of an area of interest;

(b) count the number of confirmed, probable or suspect cases of kauri dieback within a defined distance from specified walking tracks (the numerator); and

(c) count the total number of kauri trees within the same distance from the same walking tracks.

Kauri dieback prevalence for the area of interest equals the number of (confirmed, probable or suspect) cases divided by the number of kauri trees at risk. This approach could also be applied where transects are taken or where randomised swathes of forest are flown, visually assessed and then ground-truthed (i.e. when the number of cases of kauri dieback directly observed are divided by the total number of kauri trees that are directly observed). In some situations, suspect cases may be excluded from analysis.

Option 1 provides the most accurate measure of the frequency of kauri dieback, but there is no guarantee that all stakeholder groups will be able to enumerate every tree in every area of interest accurately. In addition, it is possible that while some stakeholders might be very accurate at enumerating trees others may be far less accurate. This will lead to over- and under-estimates of the true frequency of disease in different areas (i.e. misclassification bias), making the ability to carry out objective area-level comparisons difficult.

Option 2 allows stakeholders to focus on their immediate area of interest and concern: identifying and enumerating kauri dieback cases. Use of remotely sensed images as a proxy for the size of the population at risk will provide less biased estimates of kauri dieback prevalence across different areas of interest and over time.

With Option 3, there is some evidence that kauri associated with tracks are at higher risk of disease and therefore option 3 would give an estimate of disease prevalence within the track network, but could not be used to extrapolate disease prevalence to the wider forest, or be used to test the hypothesis that tracks are associated with higher risk or that track closures are an effective intervention.

However, Option 3 applied to transects or swathes where these are representative of the study area will give an estimate of kauri dieback prevalence which should be an unbiased estimate of the true prevalence in the wider area of interest.

4.4.5 How should baseline monitoring outputs be reported?

There are two complimentary options for reporting the prevalence of kauri dieback at baseline:

1. Numeric estimates of prevalence at the area level (e.g. a forest, watershed or regional park).

2. Raster maps showing the spatial distribution of kauri dieback prevalence.

For each of these methods, we assume that the point locations of confirmed, probable or suspect kauri cases and raster maps of kauri density are available. In the absence of actual kauri dieback case data, data presented in a similar format are used for illustration of the recommended techniques for this report.

Future development of disease prevalence maps of kauri dieback should abide by good practice for image development for colour blindness.

The example data set provides details of the location of foot-and-mouth disease (FMD) positive villages in Peninsular Malaysia in 2011 to 2017 (OIE 2016) as the numerator and raster maps of the density of villages in Peninsular Malaysia as the denominator.

Numeric estimates of prevalence at the area level

A map of the point locations of FMD-positive villages in Peninsular Malaysia for the period 2011 to 2017 is shown in Figure 3a. Figure 3b is a raster map of Peninsular Malaysia showing the density of villages or townships for the same time frame.

We assume that Peninsular Malaysia corresponds to an area of interest for estimation of kauri dieback prevalence (e.g. a regional park).

Numeric estimate of kauri dieback prevalence at the area level:

Step 1. Count the number of confirmed, probable and suspect kauri within the boundaries of the area of interest.

Step 2. Take the density of kauri in each raster cell and multiply it by the area of each cell to return the approximate number of kauri per cell. Sum the estimated number of kauri in each raster cell to return the approximate total number of kauri at risk in the area of interest.

Step 3. Prevalence equals the number of disease-positive kauri (confirmed, probable and suspect) divided by the estimated total number of kauri trees at risk. Quote prevalence as the number of disease-positive kauri per 100 kauri at risk. Provide exact confidence intervals for the prevalence estimate (Collett 1999). Numerous on-line tools are available for calculating the confidence interval for a prevalence, for an example see: http://252s-epi.vet.unimelb.edu.au:3838/epi/conf.int/.

Example calculations for the Peninsular Malaysia FMD example and the equivalent metrics for kauri dieback are shown in Table 3.

Table 3: Analytical procedures to estimate the prevalence of disease using the point location of disease-positive sites (e.g. confirmed, probable and suspect kauri dieback cases) and a raster map of site density.

Procedure	Peninsular Malaysia FMD	Kauri dieback
Define the area of interest.	Peninsular Malaysia.	XYZ forest
Count the number of disease-positive sites within the boundaries of the area of interest.	For the period 2011 to 2017 there were 113 FMD-positive villages in Peninsular Malaysia.	In a baseline cross-sectional study carried out in 2019, there were N confirmed, probable and suspect kauri in XYZ forest.
Take the density of sites in each raster cell and multiply it by the area of each cell to return the approximate number of sites per cell. Sum the estimated number of sites in each raster cell to return the total number of sites in the area of interest.	Based on a raster map of village density, there are approximately 11,517 villages (i.e. populated places) in Peninsular Malaysia	Based on a raster map of kauri density, there are approximately M kauri in XYZ forest.
Prevalence equals the number of disease- positive sites divided by the estimated total number of sites at risk. Quote prevalence as the number of disease-positive sites per 100 sites at risk.	The [period] prevalence[1] of FMD in Peninsular Malaysia for the period 2011 to 2017 was 0.98 (95% CI 0.81 to 1.17) FMD-positive villages per 100 villages at risk.	The prevalence of kauri dieback in XYZ state forest in 2019 was (N÷M) x 100 (95% CI CC to DD) kauri dieback-positive trees per 100 trees at risk.

[1] Period prevalence equals the number of FMD-positive villages at the start of the follow-up period plus the number of incident FMD villages that occurred during the follow-up period, divided by the size of the village population at risk. Period prevalence is used for the Malaysian FMD data because FMD cases were accumulated over several years, 2011 to 2017.

Raster maps showing the spatial distribution of kauri dieback prevalence

For disease mapping, two options are available.

1. Plot the prevalence of confirmed, probable and suspect kauri per 100 trees per square kilometre (Pfeiffer et al. 2008) as shown in Figure 4a.

2. Plot the odds of confirmed, probable and suspect kauri, as shown in Figure 4b. Plot a raster map showing the density of confirmed, probable and suspect kauri, a raster map of kauri dieback-non-case (non-cases and unhealthy kauri) trees and divide the kauri dieback-positive raster map by the kauri dieback-negative map to return the odds of kauri dieback. When the density of kauri dieback-positive trees equals the density of kauri dieback-negative trees the odds will equal 1. When the density of kauri dieback-positive trees is greater than the density of kauri dieback-negative trees the odds will be greater than 1. When the density of kauri dieback- positive trees is less than the density of kauri dieback-negative trees the odds will be less than 1.

While prevalence maps (Figure 4a) have the advantage of being relatively easy to understand it can be difficult (when the prevalence of disease is highly skewed) to show the subtle features of the geographic distribution of disease using equal interval legend colour scales.

Taking the logarithm of an odds map, on the other hand (Figure 4b), has the advantage of being able to show a higher level of spatial detail. The disadvantage is that disease prevalence expressed in terms of log odds is a metric that is not familiar to lay audiences (e.g. the general public, decision makers).

4.4.6 Reporting against the proposed National Pest Management Plan

The proposed National Pest Management Plan lists the following objectives:

1. To maintain kauri dieback free areas.
2. To significantly reduce the spread of kauri dieback.
3. To significantly reduce the impact of kauri dieback.
4. To protect iconic trees.

The procedures and recommendations provided in this report specifically address each of the objectives listed above. Numeric estimates of kauri dieback prevalence and the production of prevalence maps will allow the geographic extent of disease to be objectively described. This will identify kauri dieback free and kauri dieback low prevalence areas, allowing interventions to be put in place to ensure that this status is maintained.

Numeric estimates of prevalence and prevalence maps developed on an annual or biannual basis will allow stakeholders to make objective assessments of disease spread and, over a much longer time period, provide a means for assessing the effectiveness of control measures. Based on this knowledge, control measures can be adapted accordingly to reduce both the rate of spread and the impact of kauri dieback.

5 Recommendations

1. Following feedback, we propose a new case definition for 'kauri dieback' based on slightly modified symptomatic criteria and an adjustment to the epidemiological criteria to a proximity measure of within a 50 m radius of a 'confirmed *P. agathidicida* site'.

2. Following feedback with KDP representatives we added a ***suspect P. agathidicida site*** as a point location, where the presence of *P. agathidicida* is suspected on the basis that probable or suspect cases of kauri dieback (disease) have been recorded.

3. The case definition provided as part of this report refers to individual trees. For this reason, it is recommended that the spatial unit of interest for monitoring is an individual kauri tree for all age classes (seedlings, saplings, rickers and mature trees).

4. We recommend that the existing surveillance data within the National Programme and other agencies reclassify their data to meet the definition of a) a *P. agathidicida* site, classified as confirmed or suspect, and b) kauri dieback cases classified as confirmed, probable, suspect and non-cases following final agreement.

5. We recommend that the proposed case definitions be tested by KDP partners in an operational based workshop using existing data that has been reclassified to the proposed case definitions to test operational decision-making requirements by the partners.

6. Because of the magnitude of change to the original proposed case definition, we recommend further consultation with stakeholders to provide the opportunity for the new case definition proposed in this report to be accepted or modified, if necessary. The importance of this step cannot be over emphasised. Put simply without stakeholder endorsement the ability to objectively document the occurrence of new cases of kauri dieback over time and to monitor responses to disease control interventions over time will be compromised.

7. It is recommended that all *P. agathidicida* sites and kauri dieback cases are recorded in a centralised database where possible, both from within the National Programme partners and from other sources e.g. research, community groups, mana whenua. This needs to abide by appropriate cultural IP practices, and clearly state the source of the data and whether the data is from an 'approved observer' (i.e. trained sufficiently to classify kauri dieback as per the case definition).

8. Aerial imagery is available to be used to provide estimates of the geographic density of kauri in forest areas. It is recommended that kauri density estimates be tested for accuracy when setting up long term monitoring plots and updated over time as kauri are lost to disease. Using this approach, reports can be generated for both biological and management agency spatial zones.

9. Numeric estimates of kauri dieback baseline prevalence at the management unit of interest such as forest, watershed or regional park level can be used to prioritise risk areas, allowing control and surveillance resources to be allocated accordingly. Ongoing incidence (refer to terminology) estimation conducted at regular intervals (say) every 12 to 24 months after a baseline prevalence study will provide an indication of how quickly disease is developing in areas of interest. Prevalence and incidence mapping techniques (described in detail in this report) provide the opportunity to identify specific locations within an area of interest in which the frequency (incidence or prevalence) of disease is relatively high.

10. We support the recommendation to carry out long-term demographic modelling of kauri populations (Black & Dickie 2016; Kauri Dieback Strategic Science Advisory Group 2018). In addition baseline prevalence data and ongoing monitoring of incidence (and other biotic and abiotic risk factors) would enable the expected timing of responses to interventions to limit the spread or impact of kauri dieback to be estimated and communicated to stakeholders and quantify the impact of other factors on disease development.

11. There remains a need for a training module for the National Programme to standardise assessment of the agreed symptomatic criteria for approved observers, as an approved observer in one area might take yellowing foliage by itself as diagnostic and classify thousands of trees as diseased on that basis, while another wouldn't. It is also recommended that a register be kept of who has meet the approved observer training so that this can be matched with the database. i.e. it is a component of meeting the case definition.

6 Terminology

Case definition	In epidemiology a case definition lists the criteria by which health professionals determine whether an individual's illness is included as a case in an outbreak investigation.
Drip line	In horticulture a drip line is the area directly located under the outer circumference of a tree's branches.
Incidence	The number of new cases of disease in a defined population within a defined period of time.
Index case	In a disease outbreak the index case is defined as the first individual identified as disease positive.
Misclassification bias	Deviation of the observed result from the true result arising from measurement error.
Odds	The ratio of the number of case events to the number of non-case events.
Period prevalence	Period prevalence is defined as the number of disease-positive individuals in a population at a given point in time plus a count of the new cases that occur over a defined follow-up period, expressed as a proportion of the size of the population at risk.
Precision	Precision is a description of random error, a measure of statistical variability.
Prevalence	Prevalence is the proportion of individuals in a population having a disease at a given point in time.
Relative error	Relative error is the discrepancy between a variable's true value and an estimate of the variable, usually based on a sample.
Sensitivity (Se)	Proportion of trees with the disease that will test positive.

i.e.

$$\frac{True\ positives}{True\ positives + false\ negatives}$$

Where false negatives are trees that test negative but do have disease. Highly sensitive tests can be used to rule-out disease because they will have few or no false negatives e.g. if we fail to detect *P. agathidicida* from the leading edge of a fresh lesion where the lateral flow device has indicated phytophthora, it is most likely that it truly isn't *P. agathidicida*. Less sensitive tests such as soil samples may fail to detect *P. agathidicida* even when it is present. Typically, if a test has high sensitivity it will have lower specificity (i.e. you will find almost all

cases of disease (high SE), but you will also call lots of things diseased that are not (low Sp).

Specificity (Sp) Proportion of healthy trees that will test negative

i.e.

$$\frac{True\ negatives}{True\ negatives + false\ positives}$$

Where false positives are trees that test positive but do not have disease. Highly specific tests will have very few or no false positives e.g. if we detect *P. agathidicida* in a soil sample using culture and sequencing it is almost certainly *P. agathidicida*. Less specific tests may detect '*P. agathidicida'* but actually be a cross-reaction detecting a different species of *Phytophthora*. Typically, if a test has high specificity it will have lower sensitivity (i.e. the cases you find are truly diseased, but you will miss quite a few cases of disease).

Surveillance The systematic ongoing collection, collation, and analysis of information related to health and the timely dissemination of that information to those who need to know so that action can be taken. Includes long-term monitoring.

Symptoms Physiological or structural changes in a plant that indicate the presence of disease.

7 References

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8 Figures

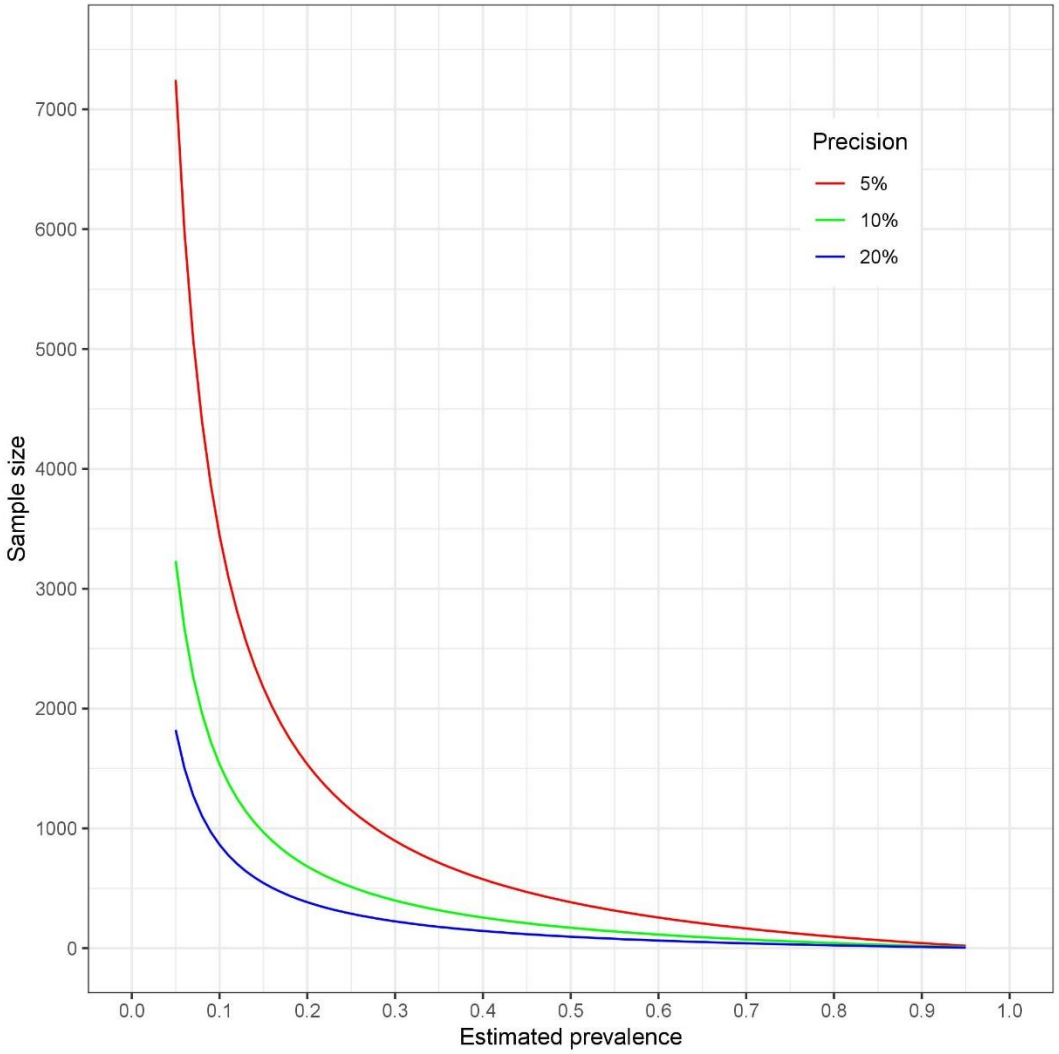
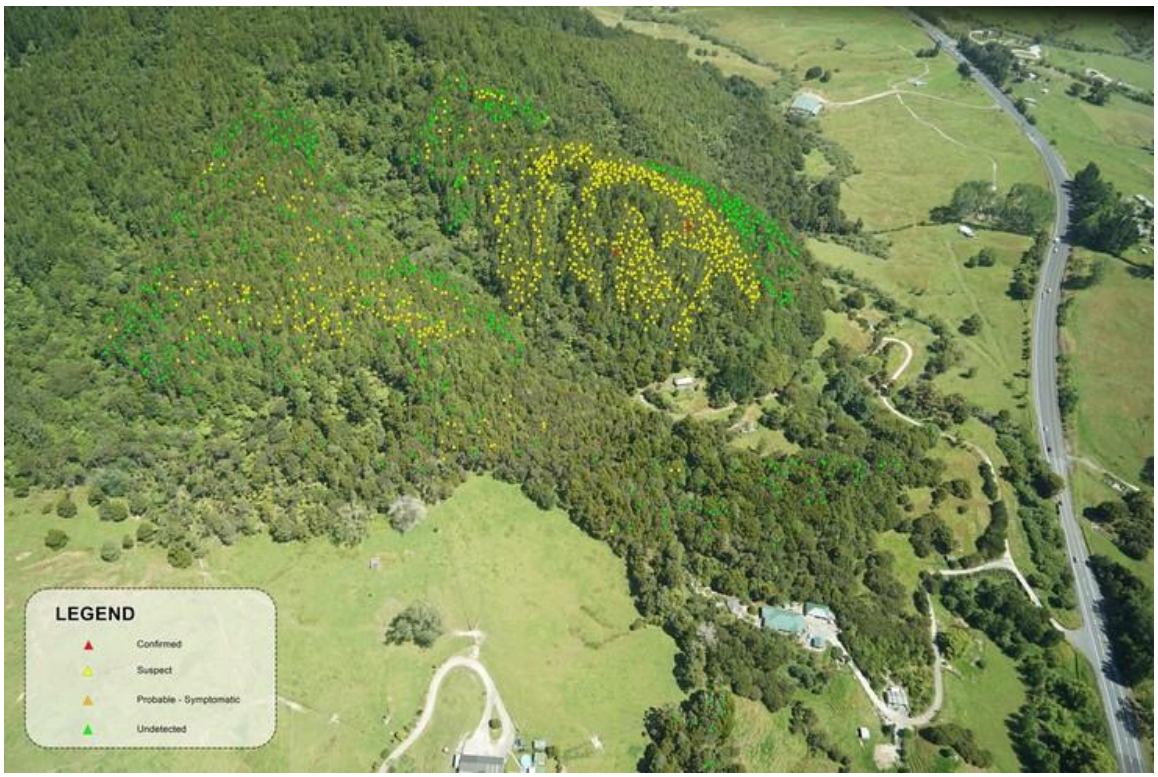
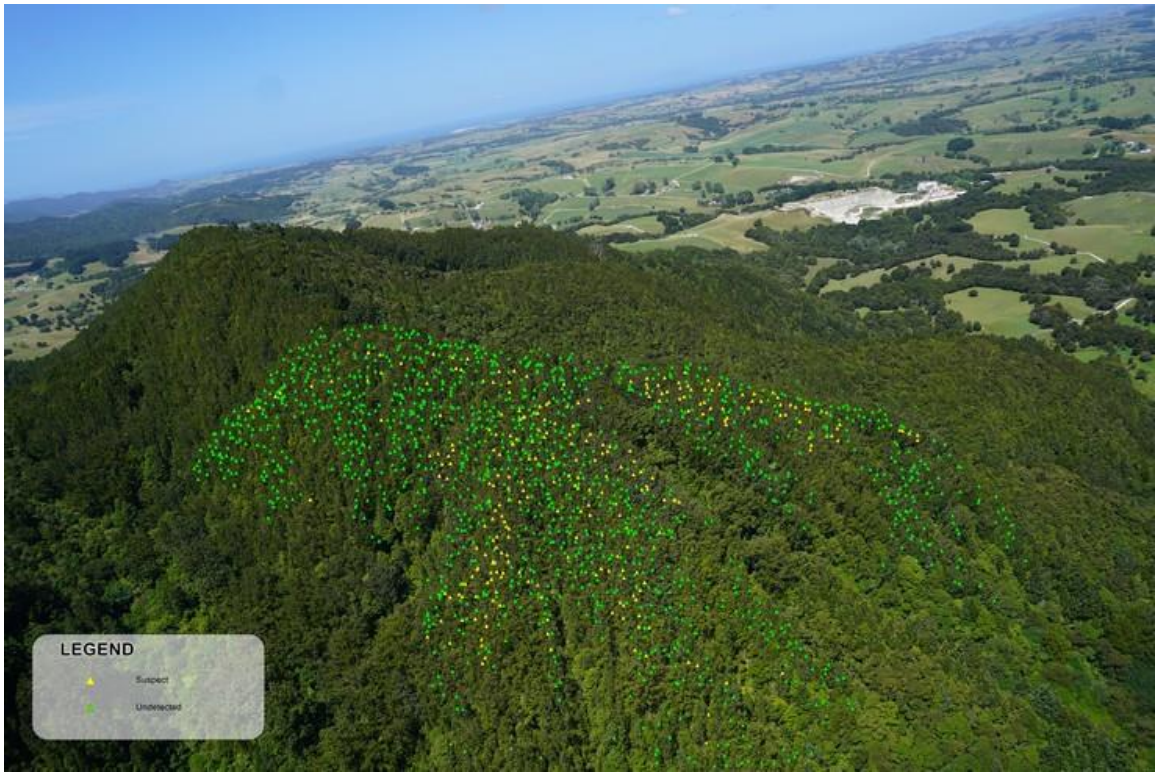


Figure 1: Line plot showing the number of kauri trees to be sampled to be 95% confident that the prevalence of kauri dieback is within 5% (red), 10% (green) and 20% (blue) of the true population value.

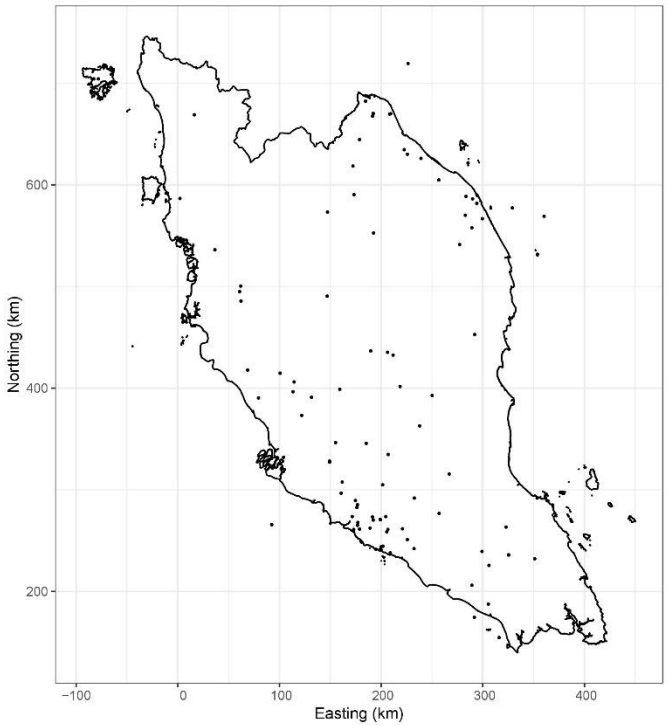


(a) High prevalence area

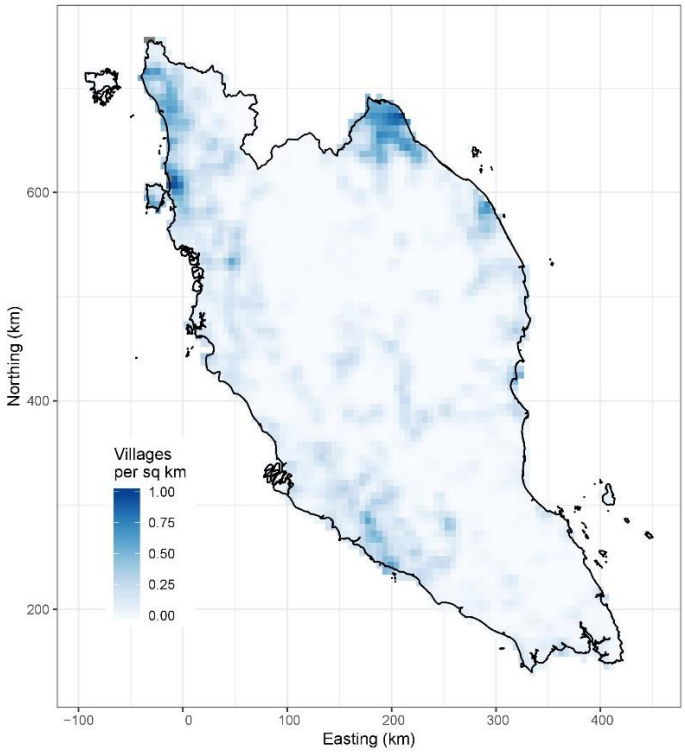


(b) Low prevalence area

Figure 2: Aerial photographs of the type that would be suitable for prevalence estimation Option 2 for: (a) an area of high kauri dieback prevalence; and (b) an area of low kauri dieback prevalence. Acknowledgements: A. MacDonald (Biospatial Ltd. Photoblique Software). Note these examples use the epidemiological criteria of 3x the dripline to classify cases.

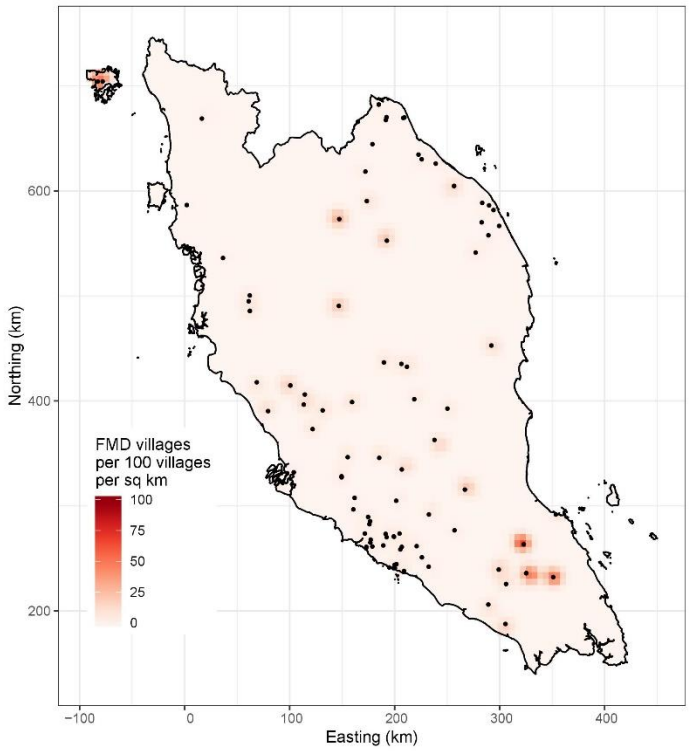


(a) Point location of FMD-positive villages

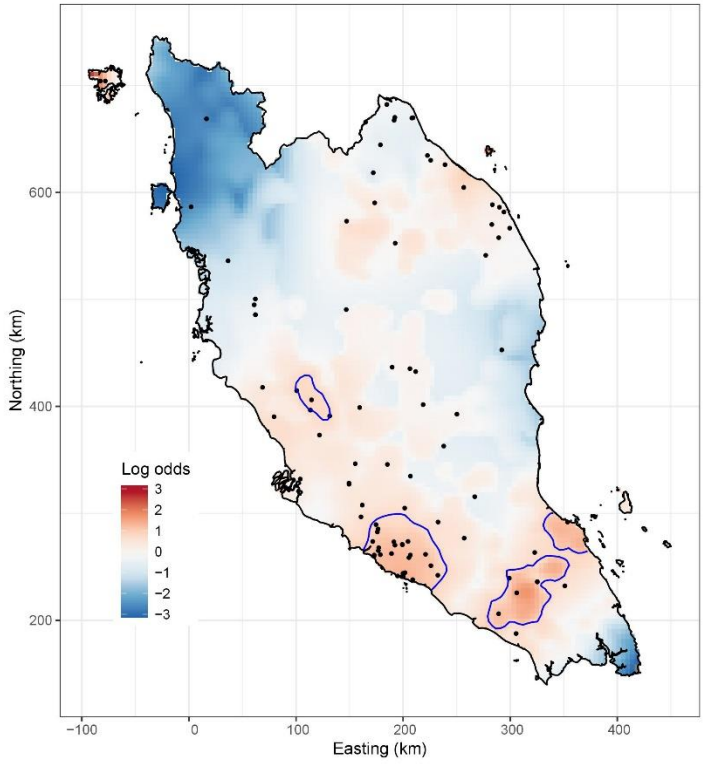


(b) Density of villages

Figure 3: Maps showing: (a) the point location of FMD-positive villages in Peninsular Malaysia in 2017; and (b) the density of villages and townships (expressed as number per square kilometre) in Peninsular Malaysia for the same time frame.



(a) Period prevalence



(b) Log odds

Figure 4: Maps showing: (a) the [period] prevalence of FMD in Peninsular Malaysia, expressed as the number of FMD positive villages per 100 villages per square kilometre; (b) the log odds of FMD. In (b) contour lines have been included to show the top 5% of log odds estimates.

9 Appendix 1 – Draft epidemiological criteria

Draft epidemiological criteria

The draft epidemiological criteria prior to consultation was:

A kauri tree meets the epidemiological criteria for having kauri dieback if it is located within a radius three times the length of the drip line of a confirmed case of kauri dieback (defined below) (Figure 5.)

This did not seem a pragmatic option and a consultation question was posed:

Acknowledging that drawing a drip line around all confirmed cases might be a laborious and time-consuming task (subject to measurement error and subjective), a more operationally workable epidemiological criteria for kauri dieback might be kauri trees located within the same watershed or water catchment area of a confirmed case. We request feedback on the most practical proximity criteria for the epidemiological criteria component of the case definition.

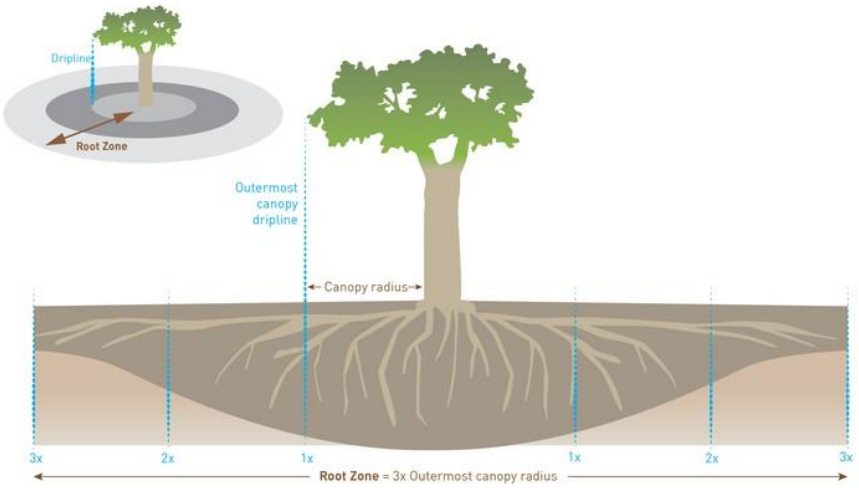


Figure 5: Diagram explaining the spatial extent of a tree's drip line and estimation of the extent of a tree's root zone as three times the length of the drip line.

Based on consultation feedback the use of watershed or water catchment area was considered far too large to be practical or biologically meaningful. Key comments that support this were:

- While broadening the epidemiology criteria to include all trees within a catchment/watershed would save a lot of time, it would clearly have a major impact on the case classification results. A much higher number of trees would potentially be classified as Asymptomatic high risk.
- If your watershed definition is linked back to the …draft epidemiological criteria… then all of your highlighted "or" statements in each of the "probable" "asymptomatic high-risk" and "suspect' cases mean that **every kauri tree in the catchment** of a "confirmed" tree will be included in each of these cases. Essentially the "or" statements make it a catchment by catchment distribution, i.e. more of a landscape scale assessment.

- For finer scale, tree by tree monitoring of population trend, which is the level I interpret your later sections, I think your epidemiological criteria make it too coarse scale for a soil borne pathogen because natural spread is a lot slower than a catchment by catchment approach.
- This definition is not well tied into the sampling of a kauri in surveillance which could be a tree within 15 to 50 m of the index tree.
- If you were to use a wider definition than 3 times the radius of the dripline then I would move to 50 m.
- Because bush is often fragmented, we wouldn't say an entire catchment (or watershed) is infected.
- Disagree, as what we might consider a watershed could be very large and have ambiguous edges in non-hilly terrain.
- I do not agree with this as watersheds can be hundreds of hectares.
- Down slope, within landscape boundary yes but not watershed.
- Soil samples are taken around the most symptomatic tree, using the 4 cardinal points method described in Waipara et al. (2013) with four samples within 1.5 m of the tree trunk and in many cases, four more samples extending out to the dripline are included. This dripline is often shared by other kauri in the vicinity.
- The best estimate for disease extent would to my mind be the root zone extent of the kauri stand from which the pathogen has been isolated.
- I don't think it's possible to define an area. I think that's where the workshop landed, and where we ended up referring to trees again.
- I think your epidemiological criteria make it too coarse scale for a soil borne pathogen because natural spread is a lot slower than a catchment by catchment approach.
- This could be over a ridge from a confirmed case and in my opinion would require further sampling before being classified or at least show multiple symptoms
- A water catchment is too big (and WRC would oppose that description) to say yes to having dieback, and I've been trying to think how else you can describe and I'm not sure how else you would describe this. How are they doing it Australia / California?

10 Appendix 2 – Workshop Agenda, minutes and presentations

Kauri Dieback: Baseline Project Workshop (Stage 1)

AGENDA

Date: Wednesday 29th May 2019
Venue: 17 Maurice Wilson Avenue, Mangere, Auckland.
Room: M1.07
Time: 10am to 3pm

Facilitators: Professor Mark Stevenson, University of Melbourne; Karyn Froud, Biosecurity Epidemiologist, Biosecurity Research Limited.

Purpose of the meeting: (1) Define appropriate case definitions for measuring kauri dieback presence & absence against programme outcomes, and; (2) Identify the appropriate unit of interest (e.g. management units) to enable end-users to monitor outcomes.

Out of scope: Development of a baseline methodology (Stage 2).This will be developed at a later date. Stage 1 (this workshop) will inform Stage 2.

Decisions and Actions: Will be noted during the meeting, as meeting minutes.

Time	Item	Agenda Item	Lead
10.00	1	**Welcome/Introduction**	Bronwyn Mullions
10.20	2	**Purpose**	Travis Ashcroft

10.30	3	**Case Definition**
		• What is it?
		• Examples
		• Why is it useful for kauri dieback?
		  ○ Management Decisions
		  ○ Linkages with the National Pest Management Plan
			Mark Stevenson
			Karyn Froud

11.30	4	**Case Definition Workshop** • What is a case definition for kauri dieback? • Draft and agree on a case definition.	
12.30	5	**Lunch (to be provided)** **Note:** *There will be an opportunity to discuss the sensitivity/specificity project with Massey University Researchers during lunch for those of you who are involved or interested.*	

1.00	6	**Management Unit of Interest**
		• Introduction / relevance
		• Why is it useful for kauri dieback?
		  ○ Management Decisions
		  ○ Linkages with the National Pest Management Plan
			Mark Stevenson
			Karyn Froud

	7	**Unit of Interest Workshop** • What is a unit of interest for kauri dieback and over what scale? • Draft and agree on a unit of interest	
2.55	8	**Wrap up & Next Steps**	Travis Ashcroft
3.00		**Meeting Close**	

AGENDA VERSION: Oct 2013

1 of 1

Kauri Dieback : Baseline Project Workshop (Stage 1)

Minutes of Meeting

Date: Wednesday, 29th May 2019
Venue: Ministry for Primary Industries, Maurice Wilson Avenue, Auckland
Facilitators: Mark Stevenson (University of Melbourne); Karyn Froud (Biosecurity Research Limited).

Attending			
•	Bronwyn Mullions, Ministry for Primary Industry	•	Travis Ashcroft, Ministry for Primary Industry
•	Ian Horner, Plant & Food	•	R.C Winkworth, Massey University
•	Lindi Eloff, Department of Conservation	•	Kim Morgan, Department of Conservation
•	Nari Williams, Scion	•	Chris Green, Department of Conservation
•	Kim Parker, Waikato Regional Council	•	Peter Scott, Plant & Food
•	Yue Chin Chew, Auckland Council	•	Andrew McDonald, Biospatial
•	Adrian Peachy, Northland Regional Council	•	Murray Fea, Auckland Council
•	Lee Hill, Biosense	•	Randy Lacey, Victoria University
•	Stanley Bellgard, Landcare Research	•	Emilie Vallee, Massey University
Observers/Support			
•	Shruti Mewara, MPI		

Meeting Minutes

PURPOSE:

(1) Define appropriate case definitions for measuring kauri dieback presence and absence against programme outcomes and
(2) Identify the appropriate unit of interest (e.g. management units) to enable end-users to monitor outcomes.

OUT OF SCOPE:

Development of a baseline methodology (Stage 2). This will be developed at a later date. Stage 1 (this workshop) will inform Stage 2.

INTRODUCTION (Mark Stevenson)

Presentation (Appendix 1) which encapsulates the following topics:

- Recent examples (BSE, avian influenza, bovine tuberculosis)
- Key factors for success (look for patterns, not perfection)
- Do we have a problem » define identify and count cases » describe outbreak in term so animals places and time »develop hypotheses »test hypotheses » implement control measures » monitor responses to control measures
- A structured approach to problem solving.
- Case definition (probable cases and confirmed cases, with examples)
- Unit of interest for Kauri
- Stop the impact of the pathogen and prevent on-going spread of pathogen
- We need to start finding the pathogen in absence of symptoms

WORKSHOP – KAURI DIEBACK (Karyn Froud)

Presentation (Appendix 2) on Kauri Dieback which encapsulates the following topics:

- Draft (April) Kauri Dieback National Pest Management Plan (primary objective and secondary objective)
- What are we measuring?
- Should focus be on the disease (KDB) or on the pathogen (PA)?
- Maintaining currently kauri dieback-free areas
- Significantly reducing the spread
- Managing diseased forests
- Prevalence and incidence
- Incidence is better for measuring success of interventions (Cases vs time graph for tree interventions and impacts of current interventions)
- Psa case definition example
- Myrtle rust case definition

Current process for soil collection and testing (Appendix 3-1):

- Currently kauri dieback assessment is done via aerial surveillance (visual/high resolution photography). Each symptomatic tree identified is classified according to their canopy health state (canopy score 1-5 = 1 being healthy; 2-5 being unhealthy). Symptomatic trees are then assigned a Priority level for ground truthing. This is based on canopy rating; lesion presence/absence; vector risk and current disease status of the area.
- High priority sites are soil sampled first (minimum 3 soil sample collection) (1-4 meters or within the drip line).
- Soil samples are sent to lab for soil testing (Plant & Food and Scion).
    - 1.5% likely that one lab test has positive result and one lab test has negative results
    - How often does "No detection" lab result from both lab are false negative (3-10%)?
- Soil sample results:
    - Positive-presence of PA
    - Negative- absence of PA
    - Not Detected- Lab result pending or inconclusive result

What is the case definition for Kauri dieback (Appendix 3-2)?

- **Probable case**- reasonable grounds to suspect on unwanted organisms is present:
    - Symptoms vs aerial survey (healthy vs unhealthy trees)
    - Canopy score
    - Ground thruthing and visual symptoms
- Lab test/soil test with positive results- "confirmed case" within tree/stand/site
- Genetic test with positive results?
- Legal case definition?
- Asymptomatic indicators
- Primary indicators currently used (need to be included as part of the case definition) based on symptomology and proximity to confirmed sites:
    - Bleeding lesions- basal trunks and roots and/or
    - Canopy thinning
    - Yellowing foliage

- Dead tree
- Proximity to other trees with similar symptoms
- Soil test positive
- Kauri Tree
- Vector risk

- Secondary Indicators
  - Alternate host symptoms (indicator species) and/or
  - Epicormics growth
  - Moss/Lichen on bark
  - Bark shedding
  - Root discolouration
  - Timing- mostly expressed during summer drought stress
  - Seedling loss
  - Loss of fine feeder roots
  - Forest health indicators
  - Cultural health indicators
  - Multiple age class

Starter for 10

- Probable cases of Kauri Dieback:
  - Part 1: Forest environment
    - A Kauri tree with symptoms (below) that is contiguous with other Kauri trees that exhibit Kauri Dieback symptoms or have a positive soil test
  - Part 2: Describe the symptoms
  - Part 3: Classification system of individual trees
- Confirmed cases of Kauri Dieback
- Confirmed cases of PA

UNIT OF INTEREST (Karyn Froud):

- Positive symptom expression– Tree (+/– 30 meter) and positive symptomatic mates/ stand (how big is the stand) / site (how big is the site)/ Forest (0.5 hector)/ Geospatial/ property
- Types of sites:
  - Suspect site (symptoms but not positive)
  - Probable site (symptoms and non-symptoms with positive result)
  - Confirmed site (symptoms and positive)

MANAGEMENT UNIT OF INTEREST (Karyn Froud):

- Protectable unit (land owner, community, region, Rohe)
- Biological based – buffer / probable definition (might include topography)
- Forest level
- Rohe- territories or boundaries of Iwi

- Contagious symptoms linked to a positive soil test
- High risk slope topography

FINALISE CASE DEFINITION FOR KAURI DIEBACK (Mark Stevenson):

We distinguish between Phytophthora-positive sites and kauri dieback positive trees.

A Phytophthora - positive site is a location where the presence of *Phytophthora agathidicida* has been confirmed following collection of soil sampling using an approved sampling protocol and tested at an approved laboratory using an approved diagnostic test.

A kauri dieback positive tree is one that meets the epidemiological and symptomatic criteria as defined below.

Phytophthora- positive sites are used for disease spread risk management. Kauri Dieback positive trees are used to document the geographic extent of infection and to monitor responses to controls.

Epidemiological criteria:
A kauri located in close (i.e. within contagious proximity) of another kauri that meets the confirmed case of kauri dieback. This criteria is not valid for index cases of Kauri Dieback within a given site.

Symptomatic criteria:
A kauri showing one or more of the following symptoms following examination by an approved (accredited) trained observer:

Bleeding lesions on the basal truck or roots, the presence of canopy thinning, yellowing of the foliage, the presence of epicormics growth, tree death

DRAFT CASE DEFINITION FOR KAURI DIEBACK

A **suspect case** of kauri: symptomatic, or dead but not contiguous to a confirmed case (laboratory confirmation)

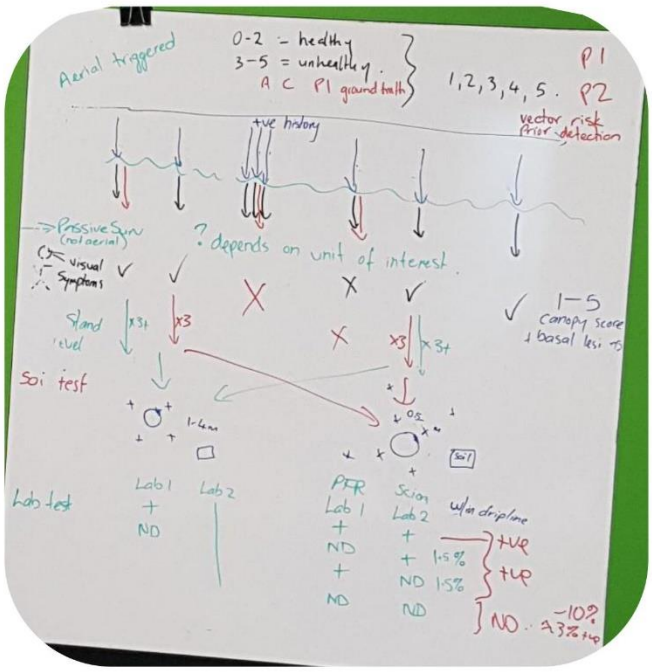
A **probable case** of kauri dieback is a tree which meets the epidemiological and symptomatic criteria listed above.

A **confirmed case** of kauri dieback is a kauri tree (dead or alive) which tests PA positive to an approved diagnostic method (of 100% assumed specificity) or other approved methods (Management Agency) and testing of that sample at an approved laboratory using an approved test.

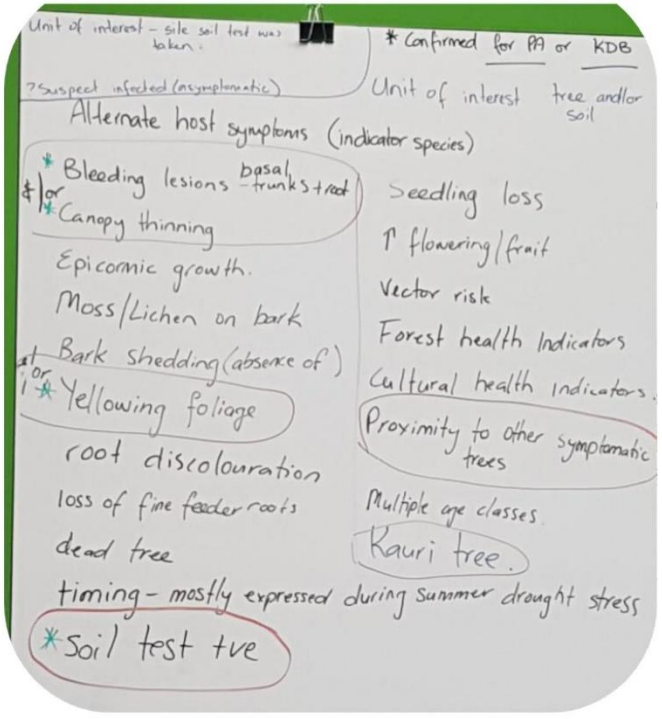
Where we state approved we mean by the Management Agency.

DRAFT UNIT OF INTEREST - Kauri tree (including x3 the dripline)

Appendix 1: Whiteboard sessions
Whiteboard #1



Whiteboard #2



Solving difficult problems in [animal] health

Mark Stevenson

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The University of Melbourne, Parkville Victoria 3010 Australia
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Faculty of Veterinary and Agricultural Sciences
The University of Melbourne
OIE Collaborating Centre
Diagnostic Test Validation Science

OIE

My background ...

- A veterinarian
  - 1987 to 1995: private practice NSW, Australia
  - 1994 to 2014: veterinary epidemiologist, Massey University
  - 2014 to present: veterinary epidemiologist: University of Melbourne
- Many war stories
  - foot-and-mouth disease (UK 2001, South Korea 2002, 2011, Japan 2010), Varroa destructor (New Zealand 2000), bovine spongiform encephalopathy (UK 1986-2017, Japan 2001-2006), highly pathogenic avian influenza (Vietnam 2002-), bovine tuberculosis (New Zealand 1990-), bluetongue (Australia 2017) ...

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Road map

- Recent examples
- A structured approach to problem solving
- Case definition
- Units of interest

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Road map

- Recent examples
- A structured approach to problem solving
- Case definition
- Units of interest

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Recent examples

- Bovine spongiform encephalopathy (mad cow disease)
- Highly pathogenic avian influenza H5N1
- Bovine tuberculosis

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Recent examples

- BSE
  - fatal, nervous disorder of cattle first identified in the United Kingdom, November 1986
  - consumption of meat from BSE-positive cattle believed to be the cause of variant Creutzfeldt Jacob disease in humans
  - ~38,000 cases of BSE detected in the United Kingdom in 1992
  - 4 cases of BSE detected globally in 2017

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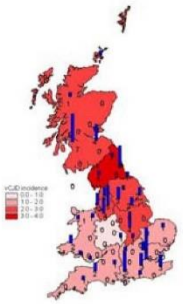
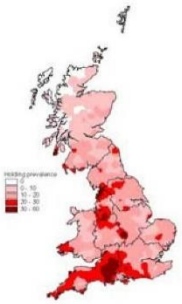
1

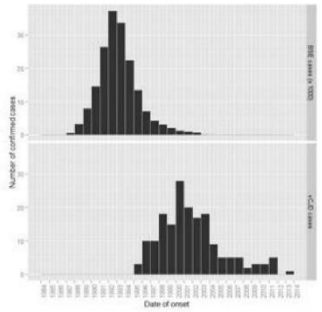
Regional-level vCJD cases per million.



Percentage of cattle herds BSE positive to June 1993.



Frequency histograms showing counts of confirmed BSE (×1000) and vCJD cases per year to 31 December 2013.



Recent examples

- Bovine spongiform encephalopathy (mad cow disease)
- Highly pathogenic avian influenza H5N1
- Bovine tuberculosis

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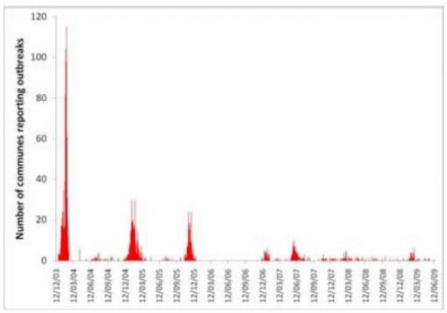
Frequency histogram showing counts of confirmed highly pathogenic avian influenza-positive communes per month in Vietnam, 2003 to 2009.



Recent examples

- Bovine spongiform encephalopathy (mad cow disease)
- Highly pathogenic avian influenza H5N1
- Bovine tuberculosis

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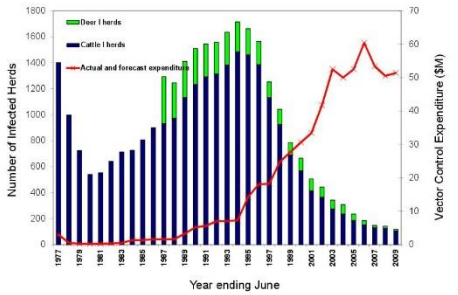
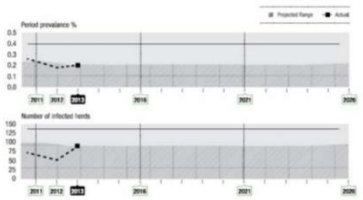
Number of bTB infected herds and annual expenditure on bTB wildlife vector control in New Zealand, 1977-2009.



Anonymous (2014) Animal Health Board Annual Report 2012-2013. New Zealand Animal Health Board, Wellington, New Zealand.

Period prevalence of bTB (expressed as the number of herds per 100 herds at risk) and the number of bTB infected herds in New Zealand, 2011-2013.

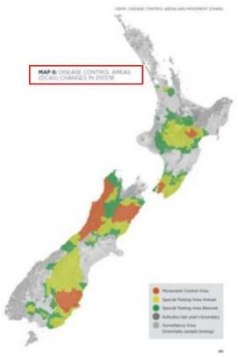


Anonymous (2014) Animal Health Board Annual Report 2012-2013. New Zealand Animal Health Board, Wellington, New Zealand.

Maps showing the location of bTB infected beef, dairy and deer herds in 2018.

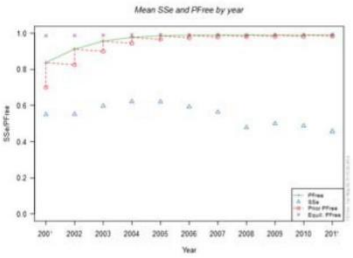
Anonymous (2018) Animal Health Board Annual Report 2017-2018. OSPRI New Zealand, Wellington, New Zealand.

bTB disease control area changes, 2017-2018.



Anonymous (2018) Animal Health Board Annual Report 2017-2018. OSPRI New Zealand, Wellington, New Zealand.

Annual prior probability of bTB freedom and estimated sensitivity of the surveillance system to detect bTB in cattle and deer herds in the Tokirima control area.



Anderson D, Ramsey D, Nugent G, Bosson M, Livingstone P, Martin P, Sergeant E., Gormley A, Warburton B (2013) A novel approach to assess the probability of disease eradication from a wild-animal reservoir host. Epidemiology and Infection 141, 1509-1521.

Key factors for success

1. Consistency in what you're calling a case
   - allows extent of the problem to be clearly reported to stakeholders
   - allows resources for controls to be allocated appropriately
2. Look for patterns, not perfection
3. Be prepared to adapt management plans in light of new information

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Recent examples

- Bovine spongiform encephalopathy (mad cow disease)
- Highly pathogenic avian influenza H5N1
- Bovine tuberculosis

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Road map

- Recent examples
- A structured approach to problem solving
- Case definition
- Units of interest

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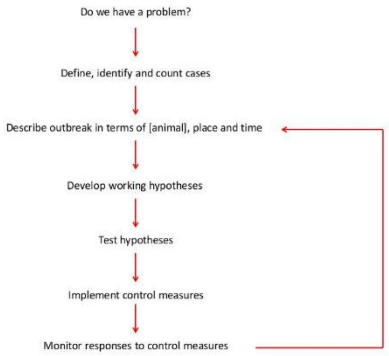

A structured approach to problem solving

- A case definition ensures consistency in what's defined as a 'case'
  - over space (e.g. from one jurisdiction to another)
  - over time (e.g. BSE)
- Allows you to confidently describe the frequency of disease
  - over space
  - over time
  - so funding agencies can allocate resources for control appropriately

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A structured approach to problem solving

- Monitoring an essential part of the outbreak investigation process
- Monitoring allows you to identify what's working and what's not working, so control measures can be modified accordingly
- A process of 'adaptive management'

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Road map

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Case definition

- A case definition is comprised of clinical criteria and (sometimes) epidemiological criteria
- Legionnaires' disease:
  - the clinical criteria required that a person have onset between 1 July and 18 August 1976, an illness characterised by cough and fever and chest x-ray evidence of pneumonia
  - to meet the epidemiologic criteria, a patient either had to have attended the American Legion Convention held 21-24 July 1976 or had to have entered Hotel A between 1 July 1976 and the onset of illness

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Case definition

- Not all cases will have the benefit of laboratory testing, so [post data collection] we often distinguish between probable and confirmed cases
- Probable case: *a [herd, animal, tree, forest] with signs-symptoms consistent with the clinical criteria listed above*
- Confirmed case: *a [herd, animal, tree, forest] with signs-symptoms consistent with the clinical criteria listed above and the listed laboratory criteria for diagnosis*

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New Zealand Veterinary Journal (First article, 1, 2012 1

Correspondence

A case definition for acute salmonellosis in dairy herds in New Zealand

This letter proposes a case definition for identifying and reporting cases of acute salmonellosis in dairy herds in New Zealand. We request veterinary practitioners in New Zealand use this case definition when identifying and reporting herds affected by salmonellosis.

By way of background: on 19 December 2011 Dr. Katie Owen (Ministry of Agriculture and Forestry, MAF) reported that the National Animal Health Information Surveillance programme had detected a change in the pattern of diagnosis of salmonellosis in dairy cattle in New Zealand, viz an increase in the incidence of uncommonly reported *Salmonella* serotypes in cattle and a moderate increase in laboratory case counts for *Salmonella* spp. in cattle (Anonymous 2011).

To deal with what appears to be an emerging disease syndrome in dairy cattle in New Zealand, a liaison group was formed in early January 2012 that comprised of representatives from MAF, the Dairy Companies Association of New Zealand, dairy veterinarians from Taranaki and the Waikato, the New Zealand

The clinical description includes acute onset of diarrhoea and debility affecting more than 5% of the milking herd over a 10–14 day period. In affected animals there is initially high fever (rectal temperature 40–41°C) that subsides with the onset of diarrhoea. Diarrhoea is severe and accompanied occasionally by dysentery and tenesmus. The crude mortality rate in affected herds is less than 2%.

The laboratory criteria for diagnosis include isolation of *Salmonella* ser. Typhimurium, *Salmonella* ser. Mbandaka, and/or *Salmonella* ser. Bovismorbificans from faecal samples from clinical cases.

The case classification for a probable case herd is a herd with clinical signs consistent with those listed above; for a confirmed case herd is a herd meeting the prescribed clinical description and laboratory criteria for diagnosis.

On behalf of the Salmonellosis Liaison Group I request that

Case definition

- Probable cases
  - no reliance on laboratory testing, therefore inexpensive
  - likely that some of the probable cases we accumulate won't actually be cases, i.e. false positives
- Confirmed cases
  - relies on laboratory testing; not all cases will be tested
  - we can be confident (given the characteristics of the diagnostic test) that a confirmed case will actually be a case
  - essential to define the characteristics of your diagnostic test

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Case definition

- An analysis of *probable* cases will give you the worst case scenario; an analysis of *confirmed* cases will give you the best case scenario
- The truth will be somewhere between these two extremes
- Perfectly OK to use probable cases for monitoring; relative changes in disease frequency critical for decision making

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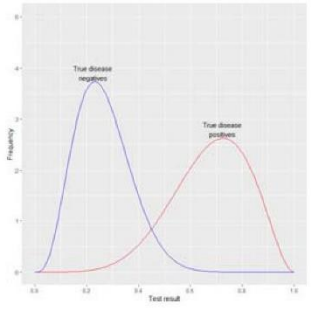
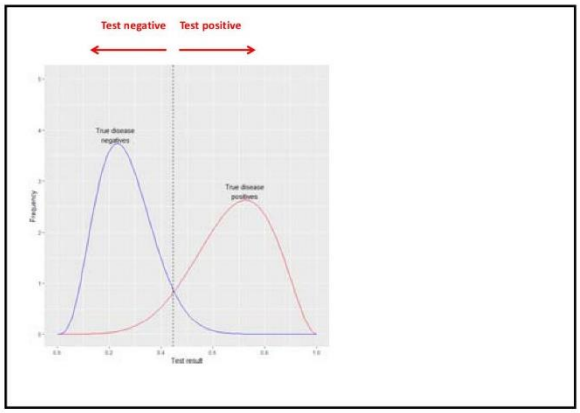
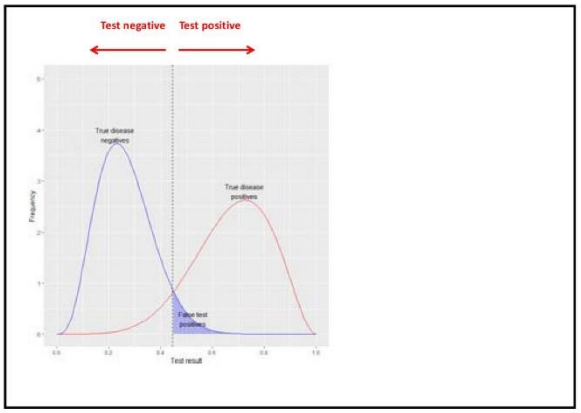
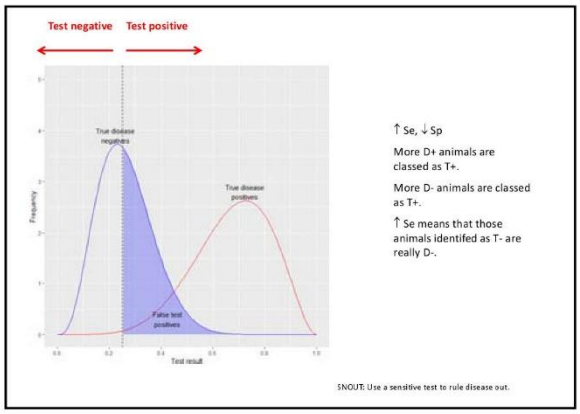








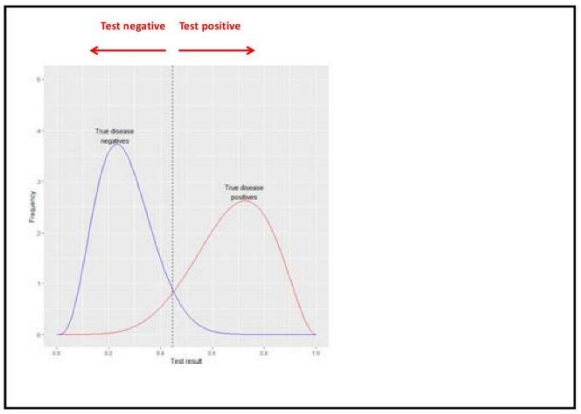
↑ Se, ↓ Sp

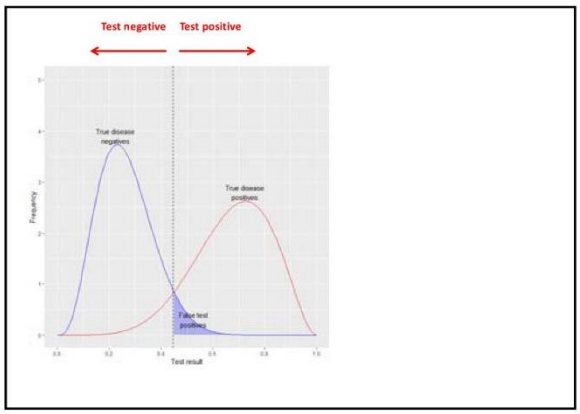
More D+ animals are classed as T+.

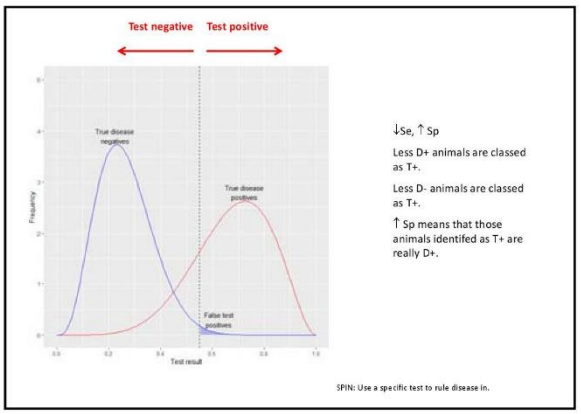
More D- animals are classed as T+.

↑ Se means that those animals identifed as T- are really D-.

SNOUT: Use a sensitive test to rule disease out.







↓Se, ↑ Sp

Less D+ animals are classed as T+.

Less D- animals are classed as T+.

↑ Sp means that those animals identifed as T+ are really D+.

SPIN: Use a specific test to rule disease in.

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Road map

- Recent examples
- A structured approach to problem solving
- Case definition
- Units of interest

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Units of interest

- Veterinary epidemiology
  - individual animals are managed within groups called herds, flocks, or mobs
  - observations, analyses and interventions can be carried out either the individual animal level or the herd level
  - if we can't observe [assess] all animals within a herd we take a sample; sampling theory allows us to calculate the required number of animals to sample to detect disease if it is present or to determine the prevalence of disease in the herd population

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Units of interest

- Kauri
  - need to define the geographic 'extent' of each forest (similar to OSPRI's bTB control areas), i.e. define your 'herds'
  - may need to quantify die-back frequency at both the forest level and the individual tree level
  - using the individual tree as the unit of interest gives you the greatest flexibility for reporting; aggregating data 'up', if requited is easy

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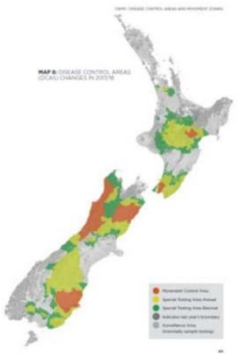
bTB disease control area changes, 2017-2018.



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Road map

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Biosecurity Research

Kauri dieback

Kauri dieback National Pest Management Plan primary objective

- To reduce the harmful effects of PA by preventing the spread of PA and minimising its impacts on kauri forests, culture, communities and economy
- Secondary objectives:
- Reduce spread of KDB
- Maintain KDB free areas
- Reduce impact of KDB within infected sites
- Locally eliminate KDB within infected sites
- Protect kauri trees and stands with special values form KDB
- Facilitate controlled access to kauri forests without compromising kauri protection or future
- Provide for Māori knowledge, values and approaches to manage KDB and prevent it spread

What are we measuring?

- What is a 'case'?
  a) P.a. positive test?
  b) P.a. positive test and disease symptoms?
  c) Disease symptoms?
- Selection will differ depending on the question you are asking
- For "reducing the spread" you are interested in detecting new cases of disease associated with the pathogen *P. agathidicida* and therefore b) could be your case definition
- For measuring "maintaining currently kauri dieback-free areas" c) will be most appropriate, followed by b) if disease is detected.
- For managing disease c) should be sufficient

Should focus be on the disease (KDB) or on the pathogen (*P. agathidicida*)?

- The KDB NPMP aims are based on managing the disease
- This is landscape scale not pathogen scale.
- All disease in Kauri is bad, not just that caused by P.a.
- If you manage disease factors you may manage multiple phytophthora's
- Will it be important if some symptomatic trees are miss-classified as P.a. positive based only on symptoms?

Maintaining currently kauri dieback-free areas

- Need targeted surveillance and/or passive surveillance to detect disease (case definition c)
- We need to understand the sensitivity and specificity (Se/Sp) of the detection method (aerial or visual inspection)
- We need to know the unit of interest – tree, stand, watershed, forest?
- Knowing these we can calculate the search effort (sample size) for confidence that disease is present or absent from an area.
- E.g. *"Based on visual assessment of disease we need to inspect 380 trees per watershed to be 95% confident that an area is free of disease and requires expenditure for ongoing preventative management."*

Significantly reducing the spread

- Detecting new cases either when surveying disease-free blocks or measuring spread
- Needs surveillance to detect disease (case definition c) and follow-up testing to detect P.a.
- We need to understand the sensitivity and specificity (Se/Sp) of the P.a. detection method (soil sampling)
- We need to know the unit of interest – tree?
- Knowing these we can calculate the search effort (sample size) for confidence that P.a. is present or absent from an area.
- E.g. *"Based on visual assessment of disease and follow-up sampling we need to take 8? soil samples from 5 symptomatic trees to be 95% confident that a area has P.a. and requires expenditure for disease management"*

Managing diseased forests

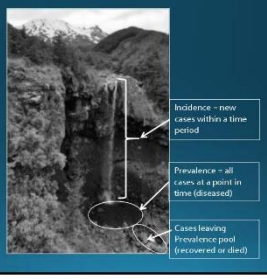
- Need to know the baseline prevalence of disease
- Need to know the unit of interest (tree, stand, watershed, catchment, forest) for the question you are asking
- E.g.
  - does phosphorous acid work = tree level or stand level
  - Do hygiene stations work = watershed or catchment
  - Do track upgrades work = forest
  - Are pigs an issue = forest
- Need to monitor the incidence rate of disease following intervention (or no intervention)

Prevalence and Incidence

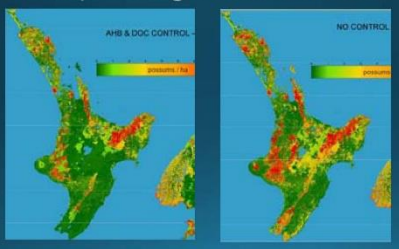
- Prevalence is how many cases of disease are there in a given population at a point in time
- Incidence is how many new cases of disease develop over a period of time
- If you know the baseline prevalence of disease you can calculate how many new cases occur (incidence) in areas where interventions are made versus in areas where no interventions are made.

Incidence is better for measuring success of interventions.

- Prevalence can increase by increasing survivorship of diseased trees



Monitoring interventions: Example using Possum control



Ebola example