# Atlas OF Biosecurity SURVEILLANCE

JANUARY 2020

New Zealand Government

Biosecurity New Zealand
Ministry for Primary Industries
Manatū Ahu Matua

**Acknowledgements**

The *Atlas of Biosecurity Surveillance* is a publication of the Surveillance and Incursion Investigation Group, Biosecurity New Zealand. We are grateful to all in the Surveillance Group for their patient assistance and participation in compiling this atlas. We also wish to thank Dr Craig Stewart, NIWA, for his assistance in data cleaning and contribution to figures, and MPI's Publications team and Words & Pictures for editing and formating this document.

Cover images: Ants in pottle by Flybusters/Antiants, Auckland, New Zealand; Native trees by Rory MacLellan; Hoiho (Yellow-eyed penguin) taken on Rakiura (Stewart Island) © Robert Sanson (www.myfathersworld.net.nz)

**Enquiries**

All enquiries should be addressed to the Surveillance and Incursion Investigation group of the Diagnostic and Surveillance Services Directorate of Biosecurity New Zealand.

**Citation**

Acosta H, Earl L, Growcott A, MacLellan R, Marquetoux N, Peacock L, Phiri BJ, Stanislawek W, Stevens P, Tana T, van Andel M, Watts J, Gould B (2020).

**Published by**

Ministry for Primary Industries
34-38 Bowen Street
PO Box 2526
Wellington 6140
New Zealand
Tel: 64 4 894 0100 or 0800 008 333 (within New Zealand)
Fax: 64 4 894 0731

Web: www.biosecurity.govt.nz



First published – January 2020

ISBN 978-1-99-001785-8 (Print)

ISBN 978-1-99-001786-5 (Online)

**Disclaimer**

While every effort has been made to ensure the accuracy of the information depicted in this atlas, no guarantees can be made as to quality, performance and usefulness of the maps or data for the user. The atlas should be considered as a dynamic document that is responsive to the surveillance priorities of Biosecurity New Zealand. Specific questions regarding features of the atlas should be referred to Biosecurity New Zealand Surveillance Group. This atlas remains copyright of Biosecurity New Zealand – Surveillance Group.

# Contents

# Preface

In 2011 we produced our first Atlas of Biosecurity Surveillance to communicate the majority of our surveillance programmes, showing what we do, where we do it and why we do it. We were extremely happy with the positive feedback received from a range of stakeholders and members of the public, indicating the Atlas increased their knowledge and understanding of the Biosecurity New Zealand's surveillance programmes. For this version we have expanded the Atlas to describe the full range of Biosecurity New Zealand's active and general surveillance programmes. We also aim to provide a deeper insight into these programmes. Hence, the reader will find that this version includes more detailed explanations of the sampling methods, information on the biological features of some of the target organisms, or details of previous incursions. We hope this will provide further context to the importance of biosecurity surveillance and the outcomes that these programmes achieve.

A main aim of our surveillance programmes is early detection of new or exotic organisms which may impact our environment, economy, our access to fresh produce, and/or the health and wellbeing of our people and animals. Early detection enables the opportunity to minimise this impact and sometimes eradicate the organism. Quite often the only time that the public become aware of the surveillance system is when it identifies the presence of a potential threat in the country. However year after year the majority of our surveillance programmes are also quietly fulfilling another purpose of biosecurity surveillance: creating and sustaining valuable export markets for New Zealand produce and animal products. This is because zero detections in a well-designed surveillance programme help provide confidence to our trading partners that our exports are free from the pests and diseases that may impact their country. Trade is also enabled by trust, and we must therefore demonstrate transparency in our programmes, as well as fulfil international reporting requirements to organisations such as the World Organisation for Animal Health (OIE) and the International Plant Protection Committee (IPPC). This Atlas aims to both increase transparency and spark interest in our programmes for New Zealanders and international stakeholders.

Our surveillance programmes span the length of the country and involve multiple agencies, specialists and everyday New Zealanders: including sampling for marine pests in harbours, baiting ants around ports and transitional facilities, trapping fruit flies in backyards, surveying forests and coastal environments, blood sampling cattle in abattoirs, capturing pathological findings from veterinary laboratories. Our general surveillance system also encourages all 4.7 million New Zealanders to phone a specialist or MPI's Exotic Pest and Disease hotline (0800 80 99 66) when they come across a pest or disease they have not seen before. In this way biosecurity surveillance becomes everyone's responsibility, a key message of Biosecurity 2025's Ko Tātou This Is Us campaign. In our work we continuously witness the passion of New Zealanders for protecting our natural resources, our people and our way of life, and we are fortunate to be part of this. We hope this Atlas helps communicate the large amount of work being undertaken in biosecurity surveillance and inspires further participation in this system.

Brendan Gould
Biosecurity Surveillance and Incursion Investigation Group Manager
Diagnostic and Surveillance Services Directorate
Biosecurity New Zealand

# 1 Introduction

## 1.1 Biosecurity: What it is and why we should bother

Biosecurity is the protection of the economy, environment and people from the risks[1] associated with and consequences of, the introduction of damaging risk organisms[2], and the mitigation of the effects of risk organisms that are already present.

## 1.2 The biosecurity system in New Zealand

The biosecurity system in New Zealand is coordinated by the Ministry for Primary Industries (MPI) and comprises three sequential, equally important and highly interactive sections: pre-border, border and post-border (Figure 1). It is a complex system based on commitments and synchronised interactions between government agencies, industries and members of the New Zealand public.

Biosecurity surveillance activities occur pre-border, at the border, and post-border. Post-border surveillance increases the likelihood of detecting pests and diseases early enough to conduct effective containment and eradication programmes.

## 1.3 Surveillance: an essential component of post-border biosecurity

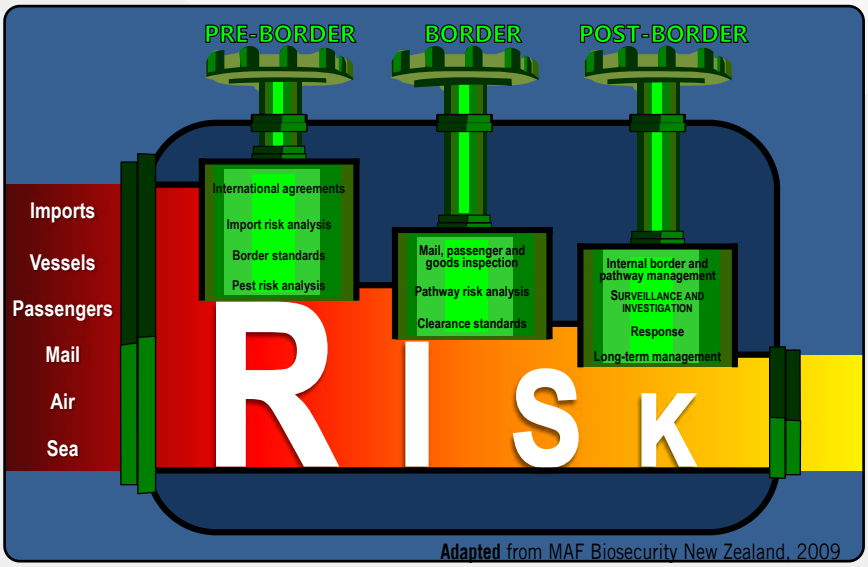
Biosecurity surveillance is "the collection, collation, analysis, interpretation and timely dissemination of information on the presence, distribution or prevalence of risk organisms and the plants or animals that they affect" (MAF Biosecurity New Zealand, 2009). It is an essential component of post-border biosecurity (Figure 1).

Post-border surveillance is undertaken for a variety of reasons, some of the most important being:

- to provide evidence that a pest or disease is absent from a country, region or defined area, thus enabling access to particular export markets;
- to detect new pests and diseases early enough to enable cost-effective management;
- to establish the boundaries of a known pest or disease incursion;
- to monitor the progress of existing containment or eradication programmes.

Biosecurity surveillance in New Zealand is undertaken across the four functional areas of animals, plants, environment and marine using active and passive, targeted and non-specific surveillance techniques in continual, seasonal and periodic programmes.

**Figure 1: The biosecurity system**




**Adapted** from MAF Biosecurity New Zealand, 2009

**1** "Risk" is a measure of the probability of a harm multiplied by the consequence of such harm.
**2** "Risk organism" is an organism either already present in, or new to, New Zealand that poses a potential biosecurity risk.

## 1.4 Risk and how it varies

The arrival in New Zealand of imports, vessels and passengers, as well as the connectivity that the air and sea creates with other regions of the world (Figures 2–7), has the potential to generate risks that, if unmanaged, could have serious impacts on New Zealand's economic, environmental, human health, socio-cultural and Māori values. These risks are highly dynamic and can vary in space and time.

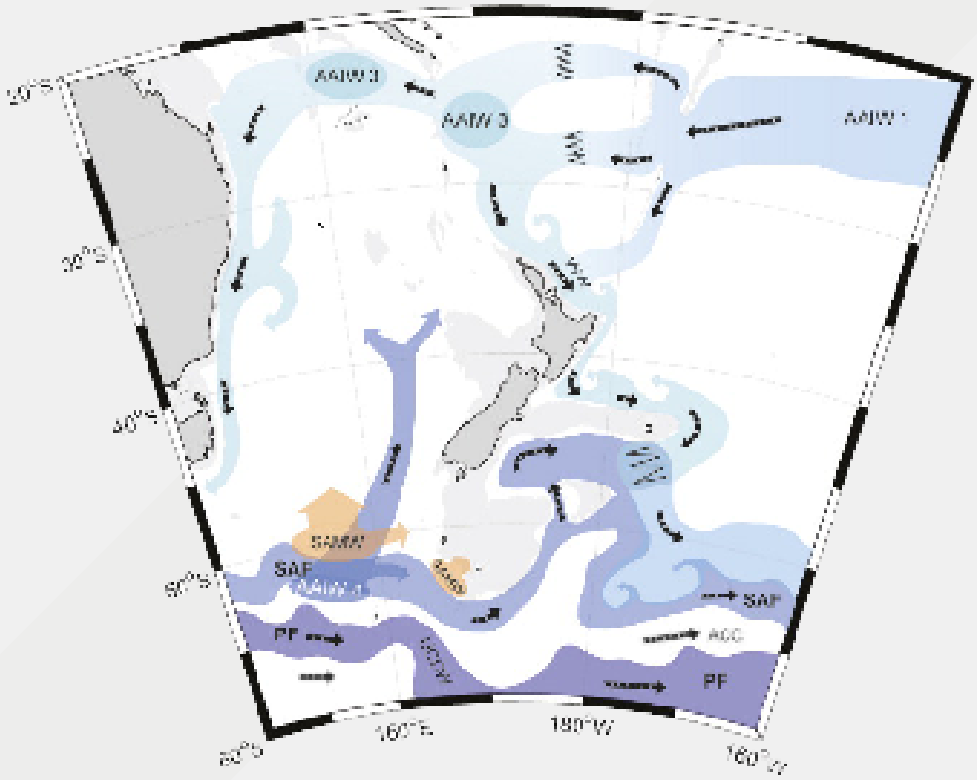
For example, larvae of coastal marine species may be transported across oceans, predominantly in surface currents which are strongly influenced by deep ocean currents (Figure 2) and other factors such as wind conditions, seawater temperatures, salinity, and upwelling.

The risks also vary across the country. This is clearly shown in the map of New Zealand airports, commercial seaports and transitional facilities (Map 1). These localities are the most likely points of entry and spread for many new organisms. Similarly, the risks vary over time. For example, Figures 4–7 show a seasonal pattern of arrival numbers of people and vessels, thus risks, at airports and seaports over time. Figure 4 also shows a steady increase in the number of arrivals by air during recent years, which suggests an increase of the risk level.

A similar seasonal pattern is observed for people arriving at the airports of Hamilton, Rotorua, Palmerston North, Queenstown and Dunedin, which received international passengers only from Australia between 2000 and 2018 (Figure 5). This figure shows how risks associated with arrivals can appear or disappear, depending on the dynamic of the airports across the country. Before 1995 for example, Queenstown did not receive any direct flights from Australia, but today it is one of the busiest airports for flights from there. Similarly, although Rotorua does not now have any passenger flights from Australia, there were Australian flights to this city from 2009 to 2015.

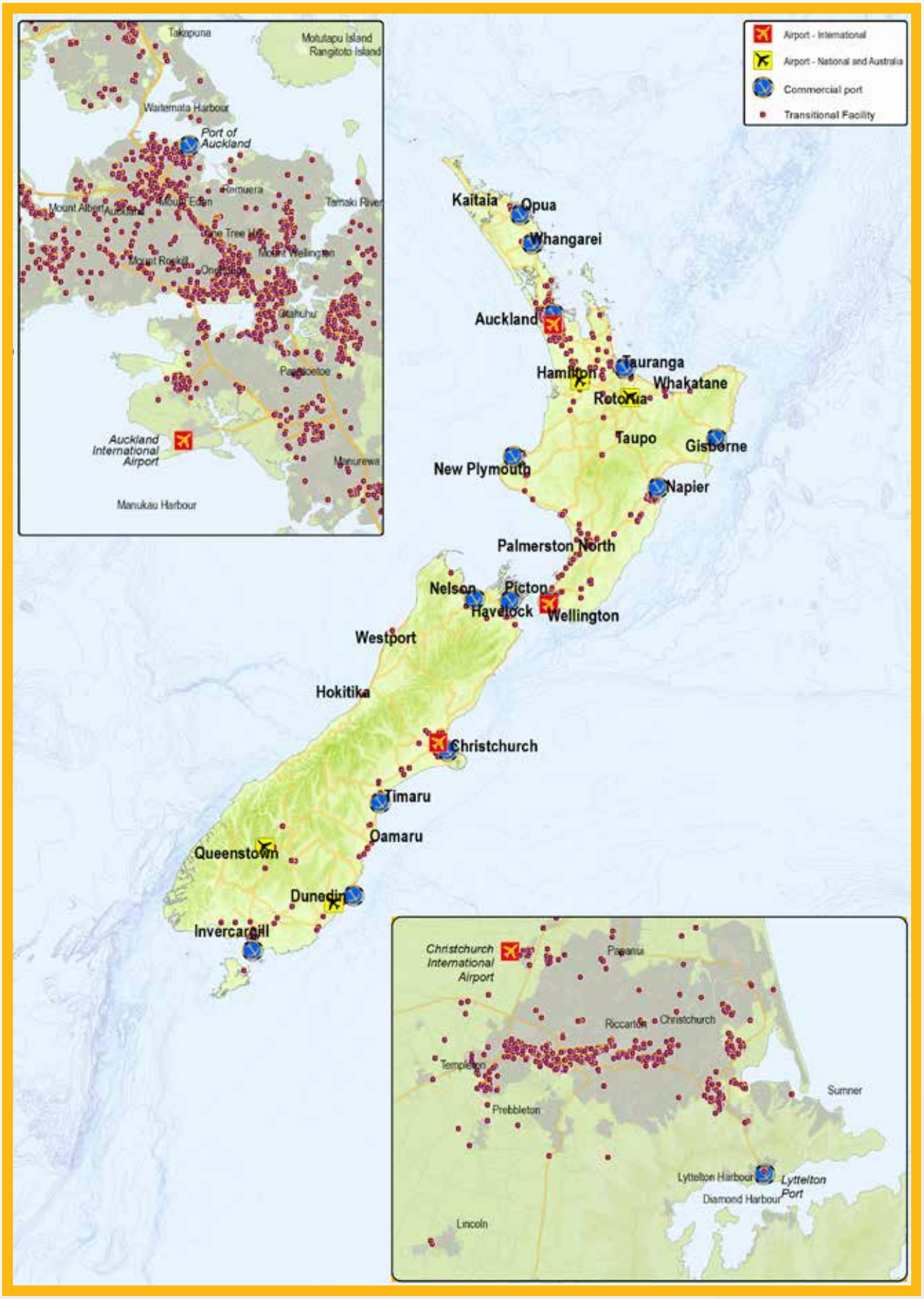
Risks associated with passengers and cargo vessels also vary in space and time. Figures 4 and 7 show a seasonal pattern of arrivals, with more people arriving on passenger vessels during summer. Similarly, Figure 6 shows that Auckland and Whangarei have been always the ports most visited by international container vessels. The sudden drop for the Port of Wellington in November 2016 coincides with the Kaikoura earthquake, which caused significant damage to the port and temporarily suspended operations.

**Figure 2: Ocean currents in New Zealand region at approximately 1000m depth**




**Source:** National Institute of Water and Atmospheric Research: Chiswell, SM et al (2015)

## Map 1: International airports, commercial seaports and transitional facilities

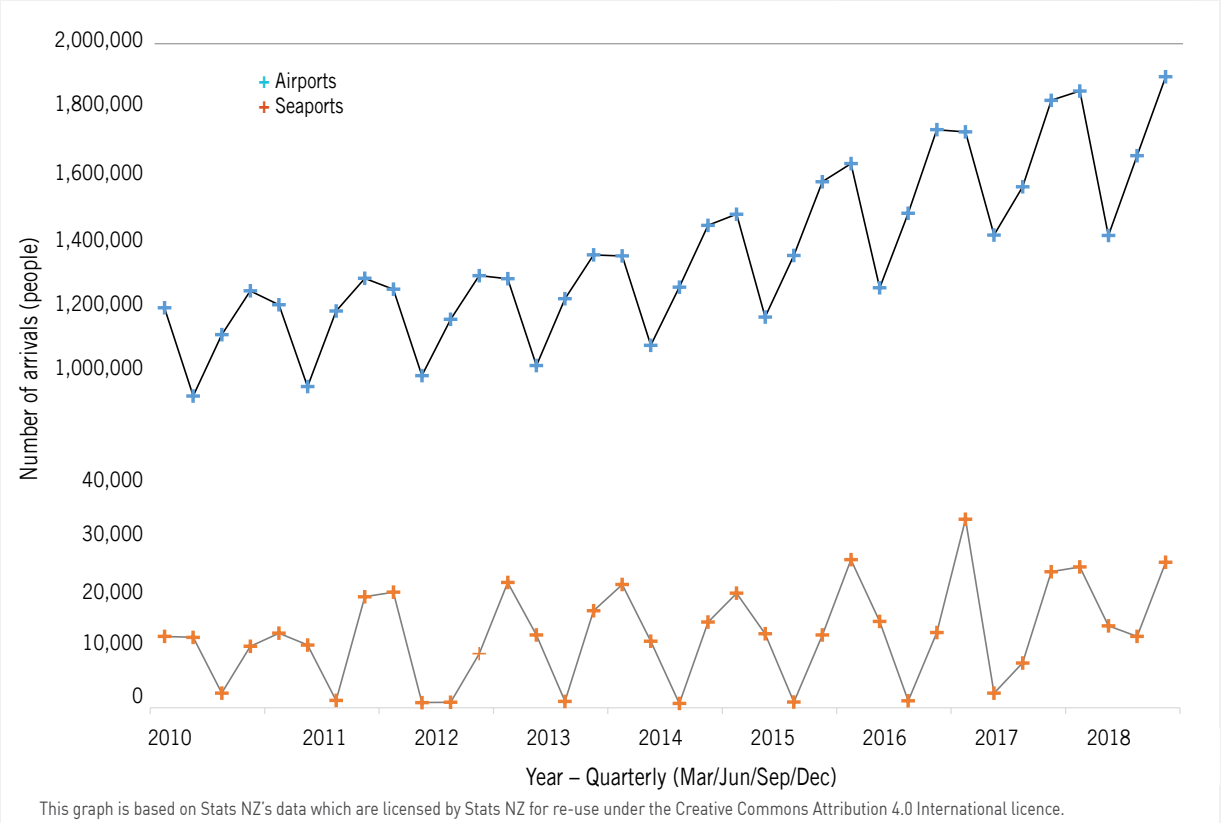



**Locations** of transitional facilities are approximate and as at 2015.

**Figure 3: International flight arrivals into New Zealand in 2014**


**Data** source: https://openflights.org/data.html – downloaded 18/3/18

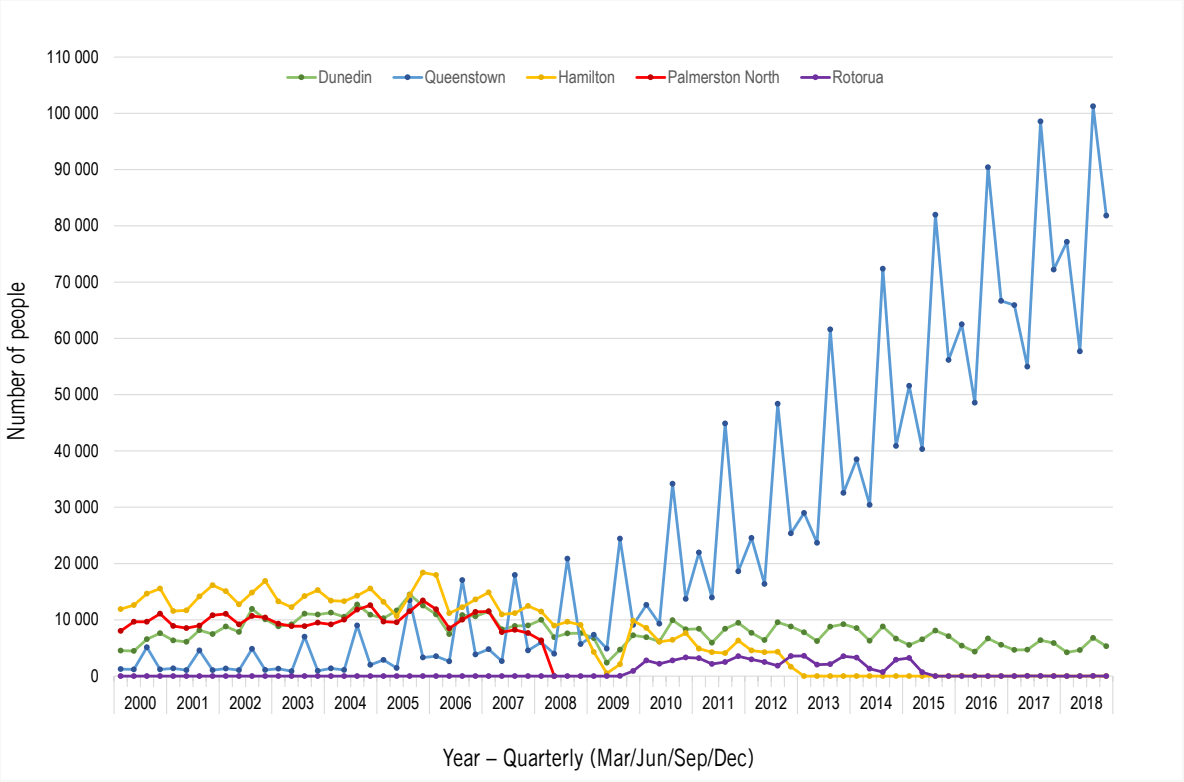
**Figure 4: Quarterly arrivals at New Zealand airports and seaports between 2010 and 2018**






Risks associated with passengers and cargo vessels also vary in space and time. Figures 4–6 show a seasonal pattern of arrivals, with more people arriving on passenger vessels during summer. Similarly, Figure 6 shows that Auckland and Tauranga have been always the ports most visited by international container vessels. This figure also shows a remarkable drop of visits for the Port of Wellington between November 2016 and September 2017.

## Figure 5: Arrivals from Australia at regional airports between 2000 and 2018






## Figure 6: Visits of international container vessels to six ports between 2013 and 2018

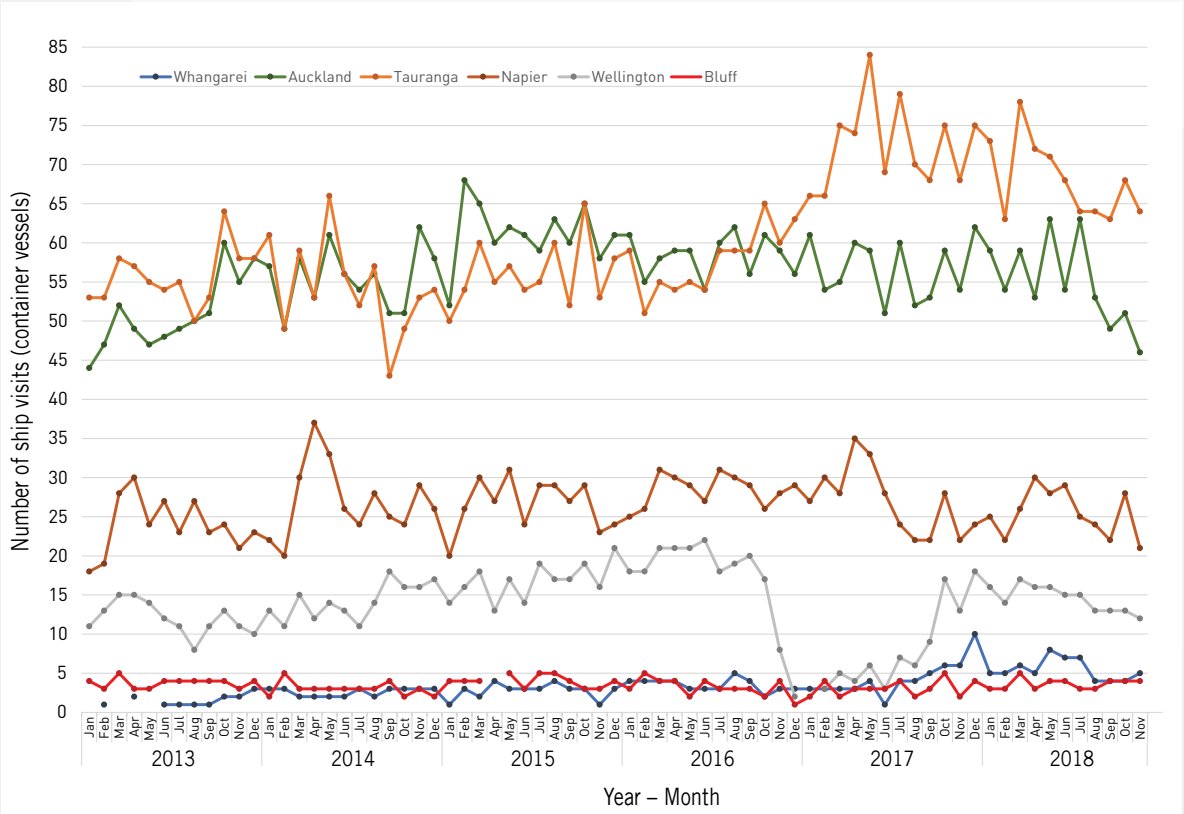
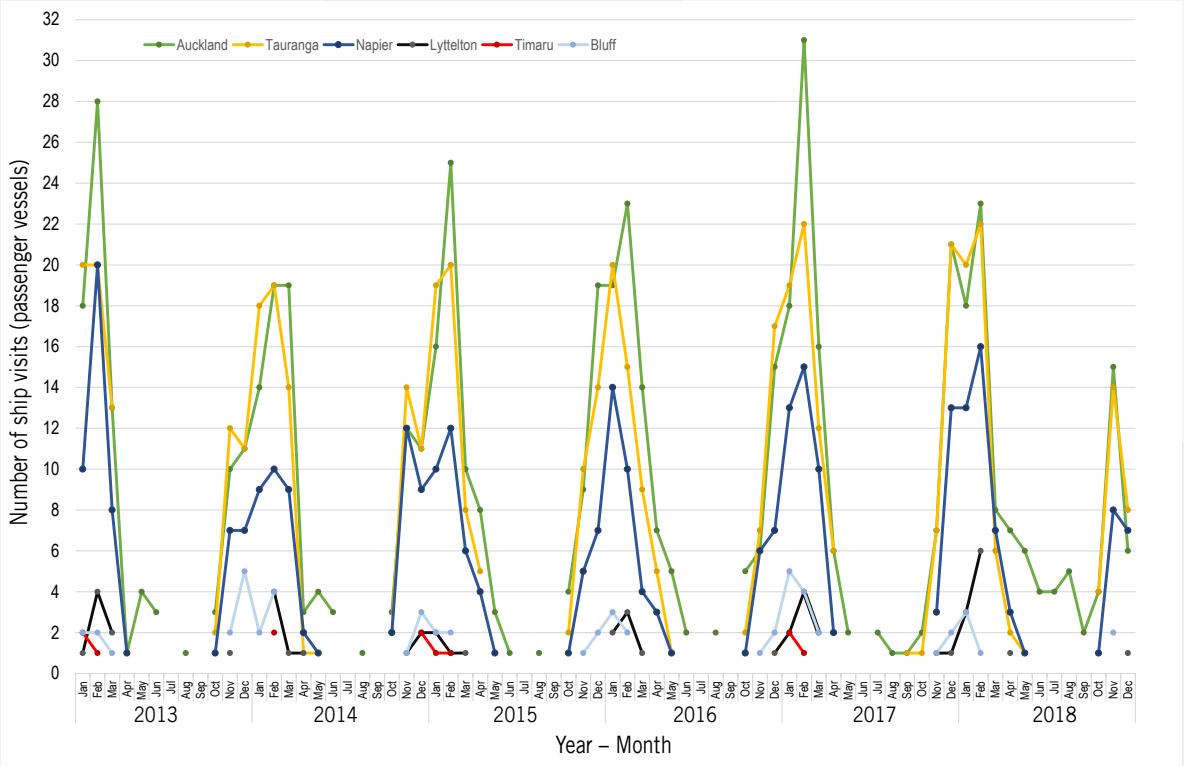


**Figure 7: Visits of international passenger vessels to six ports between 2013 and 2018**






## 1.5 Atlas layout

Each programme begins with an introductory page with the following headings:

### Name of the programme

**Target organism/s:** The organism/s of concern for that particular programme.

**Potential impacts:** A summary of the potential impacts that the target organism/s could have in New Zealand.

**Introduction mechanisms:** The means by which the target organism/s could arrive and spread in New Zealand.

### Surveillance programme

**Objectives:** The main objectives of the programme.

**Start:** The year when the programme officially began.

**Methodology:** The surveillance methods used to detect target organism/s.

**Sampling period:** The period of the year when sampling is conducted.

**Status:** Whether the target organism/s are currently present or not in New Zealand.

**Incursions:** Known incursions in New Zealand of target organism/s.

The introductory page is followed by a map of New Zealand depicting the usual sampling locations of the programme. For several programmes, additional large-scale maps have been included to give the reader an idea of sampling density.

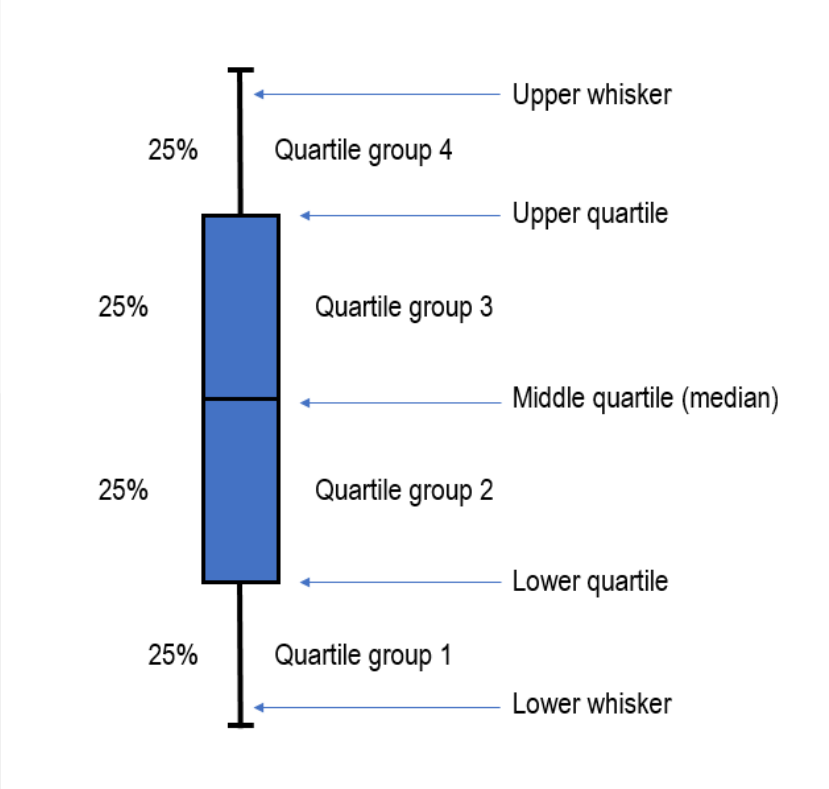
**Complementary information:** This includes a summary of the sampling effort and findings of the programme during the past few years, as well as complementary information on the identification, biology and world distribution of some of the target species.

## 1.6 Boxplots

Some of the information on surveillance sampling activities, effort and results in this Atlas are presented in boxplots. The box-and-whisker plot, or boxplot, is commonly used in statistics. They represent datasets using ranked vales to generate a five-number summary: minimum, first quantile, median, third quantile and maximum (Figure 8). The five-number summary makes presenting, interpreting and comparing datasets easy and straightforward, especially when comparing distributions between many groups of data. Boxplots are more compact than histograms and density plots – they are still highly effective at visually conveying information on the symmetry (skewness) and extreme values (outliers) of the data.

The "split box" in the plot is referred to as the Interquartile range (IQR) and represents the middle 50 percent of the ranked values – all the values between the lower quantile value (25 percentile) and the upper quantile value (75 percentile). The height of box is proportional to the spread of the values within the IQR. The whiskers represent values out of the IQR and their length is proportional to the spread of such values within a minimum and the 25 percentile (lower whisker) and the 75 percentile and a maximum (higher whisker). There is no standard definition for the minimum and maximum. For example, Massart et al. (2005) calculate the minimum as the lower quantile – (1.5 * IQR) and the maximum as the upper quantile + (1.5 * IQR), Cleveland (1985) defines them as the 10th (minimum) and 90th percentile (maximum), and McGill et al. (1978) uses the actual minimum and maximum values of the whole dataset. The latter is the approach used throughout this Atlas to define these values.

**Figure 8: The anatomy of a bloxplot**



# 2. Surveillance Programmes

## 2.1 Biosecurity New Zealand Exotic Pest and Disease Hotline (0800 80 99 66) – general surveillance

### Target organism/s

All exotic and emerging organisms and diseases across all environments (land, freshwater and marine) in New Zealand, including wildlife and native flora, production and customary crops, and farmed and domestic animals.

### Potential impacts

The potential impacts of exotic and emerging organisms and diseases on New Zealand's human health and Māori, socio-economic and environmental values are species-specific and vary from minor and unnoticeable to devastating and irreversible, including:

- international trade restrictions (even potentially a complete ban) on New Zealand's exports such as dairy, honey and forestry products;
- altered ecosystems and affected native fauna and flora;
- socio-economic burdens associated with control and eradication programmes;
- restricted movement of animals, plants and their products, affecting domestic markets;
- degrading New Zealand's image of a pristine and healthy tourism destination.

### Introduction mechanisms

Potential routes of introduction for exotic organisms include natural introduction by wind and marine currents, illegal importation of animals and plants or their products, inadvertent introduction via legal trade, and as hitchhikers on planes, vessels, or passengers and their belongings. There is also the potential for new mutations of existing pathogens, which alter their virulence and epidemiology, resulting in increased disease, reduced productivity or new human health risks.

### Surveillance programme

**Objectives:**

- to facilitate the early detection of exotic or emerging disease in New Zealand;
- to support New Zealand's statements of freedom from specific pests or diseases;
- to investigate to a point of diagnosis any cases of unusual disease that could possibly be new or emerging;
- to support the fulfilment of New Zealand's international reporting obligations.

**Start:** 1998

**Methodology:** Reporting of suspected emerging or exotic diseases is a responsibility of all New Zealanders under the Biosecurity Act 1993. All calls to the Exotic Pest and Disease Hotline (staffed 24 hours a day) are triaged by trained call centre staff and passed onto the appropriate investigation team at Biosecurity New Zealand: Animal Health, Plant Health or Aquatics and Environment Health (Figure 9). In addition, low-risk notifications regarding plant health are first passed onto Biosecurity New Zealand's Plant Health and Environment Laboratory to screen, with only suspicious notifications passed on to Investigators. Investigation teams include veterinarians, marine biologists, ecologists, pathologists and epidemiologists, all trained in biosecurity investigations and exotic pest and disease recognition. Investigators follow each report directly with the caller and, if warranted, an investigation plan is developed. Investigation teams work closely with private veterinarians, private veterinary laboratories, universities, research groups and other parts of Biosecurity New Zealand, including the Animal Health Laboratory (Wallacevile) and the Plant Health and Environment Laboratory (Auckland and Christchurch). Most notifications do not result in anything more than a detailed investigation to rule out exotic or emerging diseases and to establish an endemic diagnosis, but occasionally a new organism or disease is detected. Sometimes, such as when detected at the border, these detections can be eradicated immediately. At other times the detection will result in a biosecurity response.

**Sampling:** Sampling varies from case to case and ranges from submission of organisms in the case of suspect new pests to blood or tissue sampling of animals or post mortem examinations. Strategies are adapted to each case to make the most robust assessment possible.

### Status

Not applicable

### Incursions

In 2017 the Exotic Pest and Disease Hotline received 13,600 notifications, of which 2,800 were initially screened by the Plant Health and Environment Laboratory and 1,700 were immediately sent to Investigators. In total, 800 notifications were investigated, resulting in 200 positive detections of which 11 led to a biosecurity response.

**Figure 9: Exotic Pest and Disease Hotline notification process**

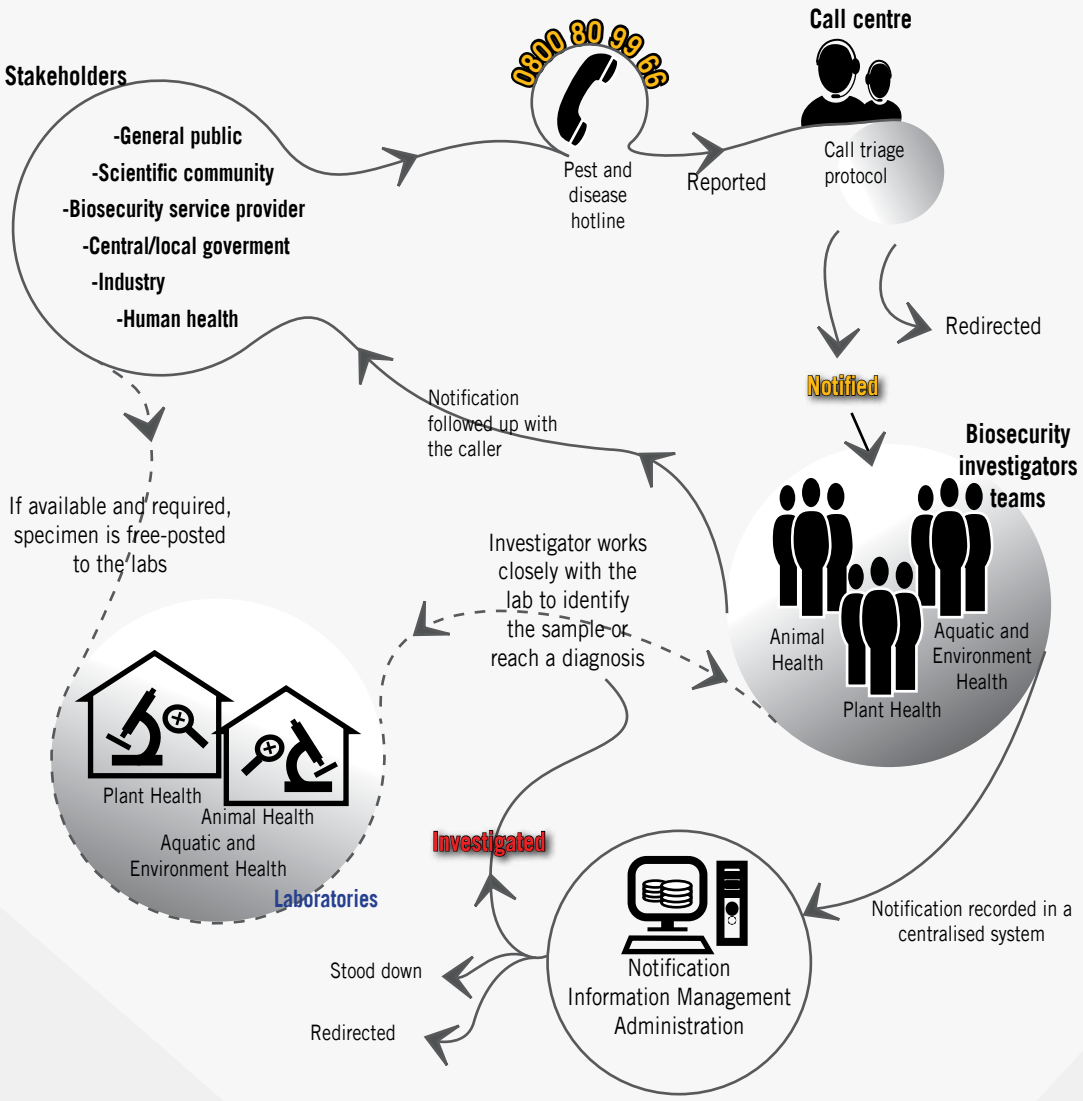


**Figure 10: Number of notifications to incursion investigators per year by sector at risk, 2012–2017**

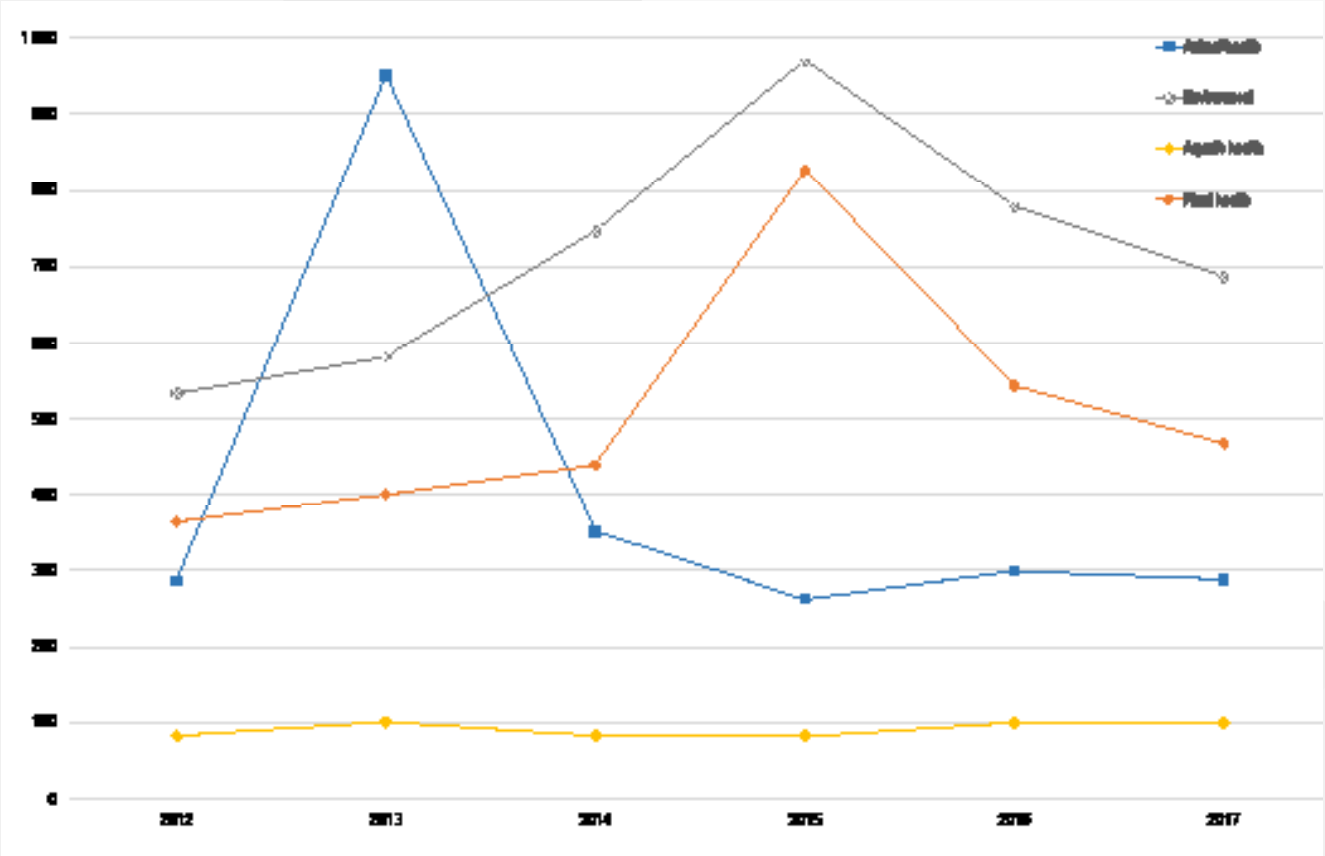


**Figure 11: Number of annual notifications and investigations by month between 2012–2017**

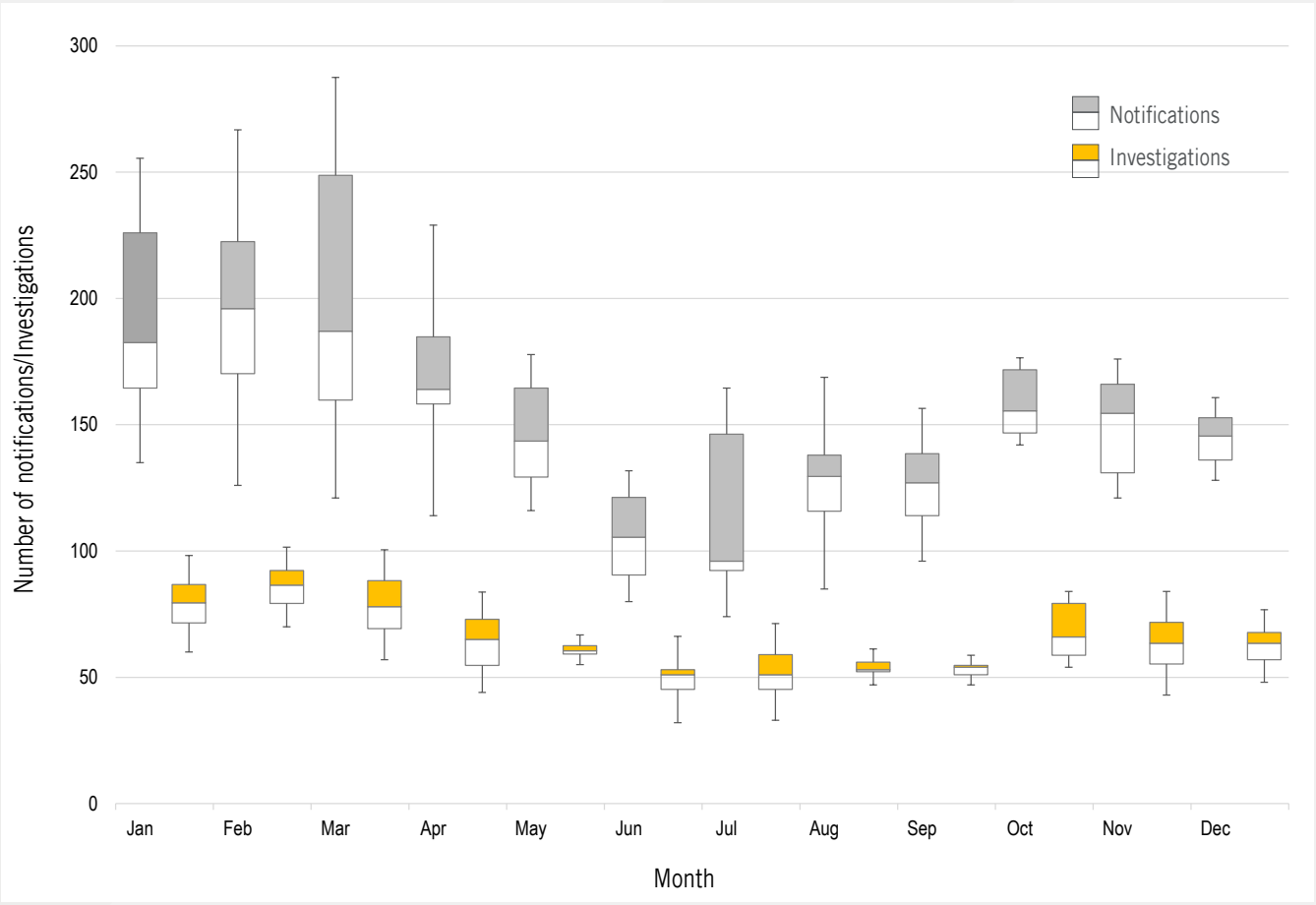


**Figure 12: Total number of notifications and investigations by sector and region between 2012–2017**

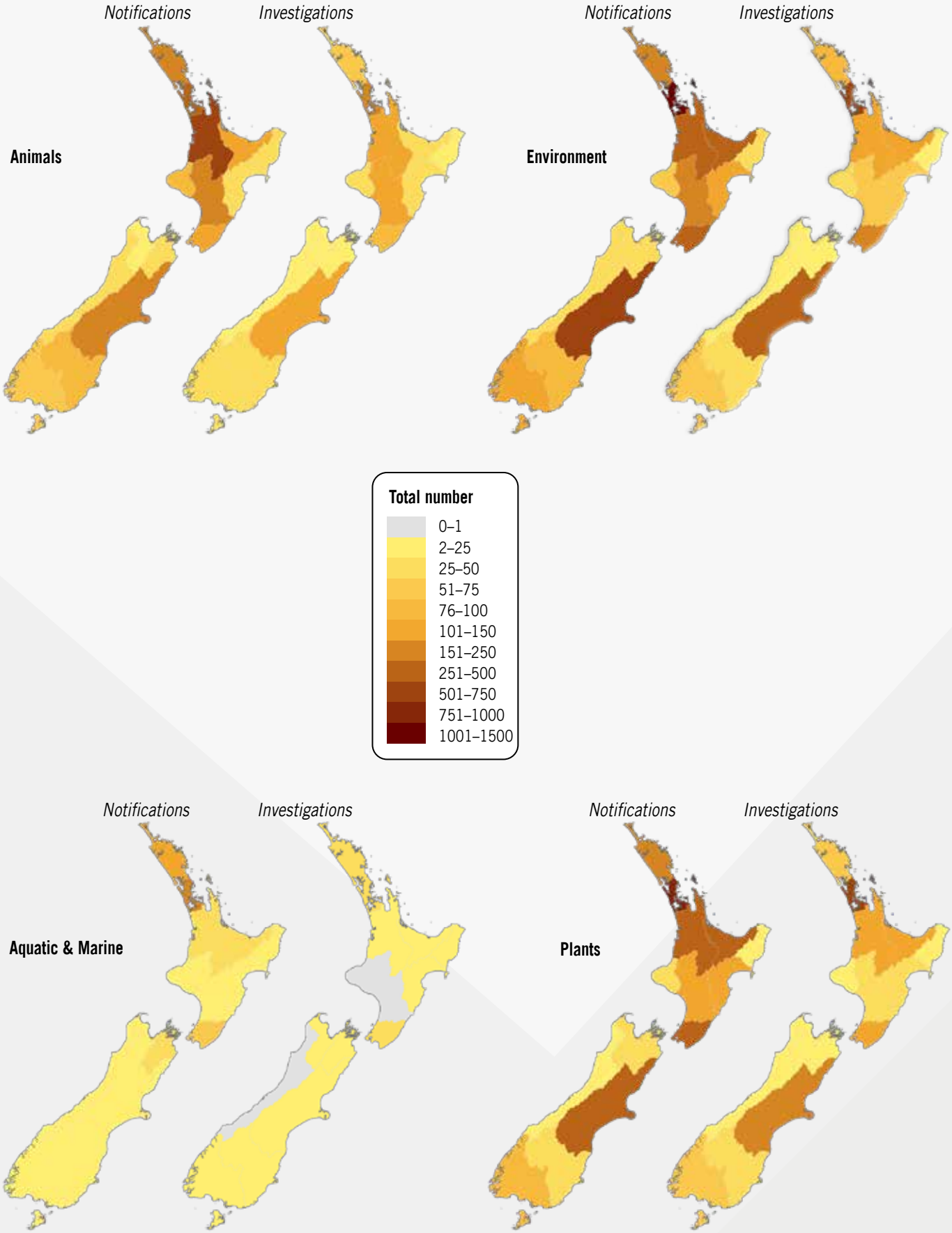
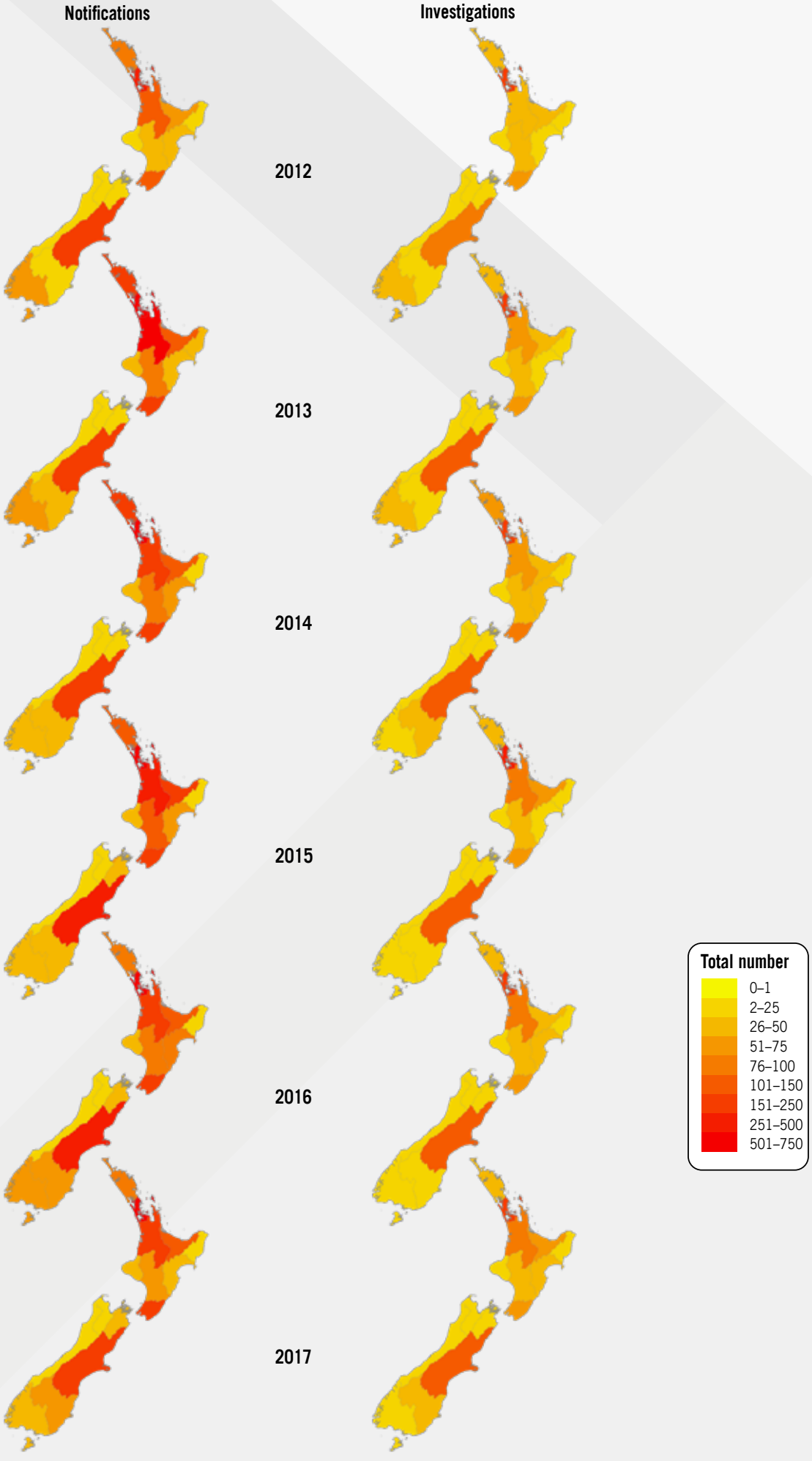


Figure 13: Total number of notifications and investigations by region between 2012–2017



## 2.2 Animal health information

### Target organism/s

No specific organism is targeted but scanning surveillance techniques are used to watch for organisms of interest and to monitor and measure submissions to veterinary diagnostic laboratories.

### Potential impacts

Potential impacts range from the very minor to extremely severe, depending on the organisms. Organism/s of high interest to the surveillance programme could have dramatic economic or human health impacts if they became established in New Zealand. For example, *Coxiella burnetii*, the causative agent of Q fever, would have a significant human health impact.

### Introduction mechanisms

Commonly recognised introduction mechanisms for exotic organisms include carrier animals, international travel by humans and winds. Sometimes an arthropod[1] vector[2] is also involved. In addition, there is the potential for new mutations of existing pathogens, which alter the epidemiology and can result in increased wastage, reduced productivity or new zoonotic[3] risks.

### Surveillance programme

**Objectives:**

- to provide early detection of exotic or emerging diseases to facilitate containment and eradication;
- to provide assurance of country freedom from specified diseases;
- to describe distribution and occurrence of endemic diseases;
- to demonstrate and quantify the veterinary infrastructure and submission patterns.

**Start:** Evolved from original government veterinary diagnostic services provided many decades ago.

**Methodology:** The programme has two main components:

1. Submission of animal health data:

a. Veterinary practitioners submit samples to veterinary diagnostic laboratories as part of disease investigations for their clients' animals. The investigating veterinarian requests the tests. Where a case meets specific MPI criteria the veterinary diagnostic laboratory provides MPI with anonymised case data. This data is then loaded into the MPI Surveillance Information Management System database where it can be retrieved, analysed and published as needed (Map 2).

b. Samples are collected across all species and across the entire country.

c. In 2017 approximately 28,000 case records were submitted to MPI.

2. Demonstration and oversight of veterinary laboratory network:

a. MPI maintains contracts with the private veterinary diagnostic labs with specific requirements related to biological containment and quality control within the laboratory.

b. MPI stipulates criteria for notification of suspected exotic or emerging organisms via the Exotic Pest and Disease hotline.

c. MPI carrieds out regular audits to ensure compliance with the requirements.

### Status

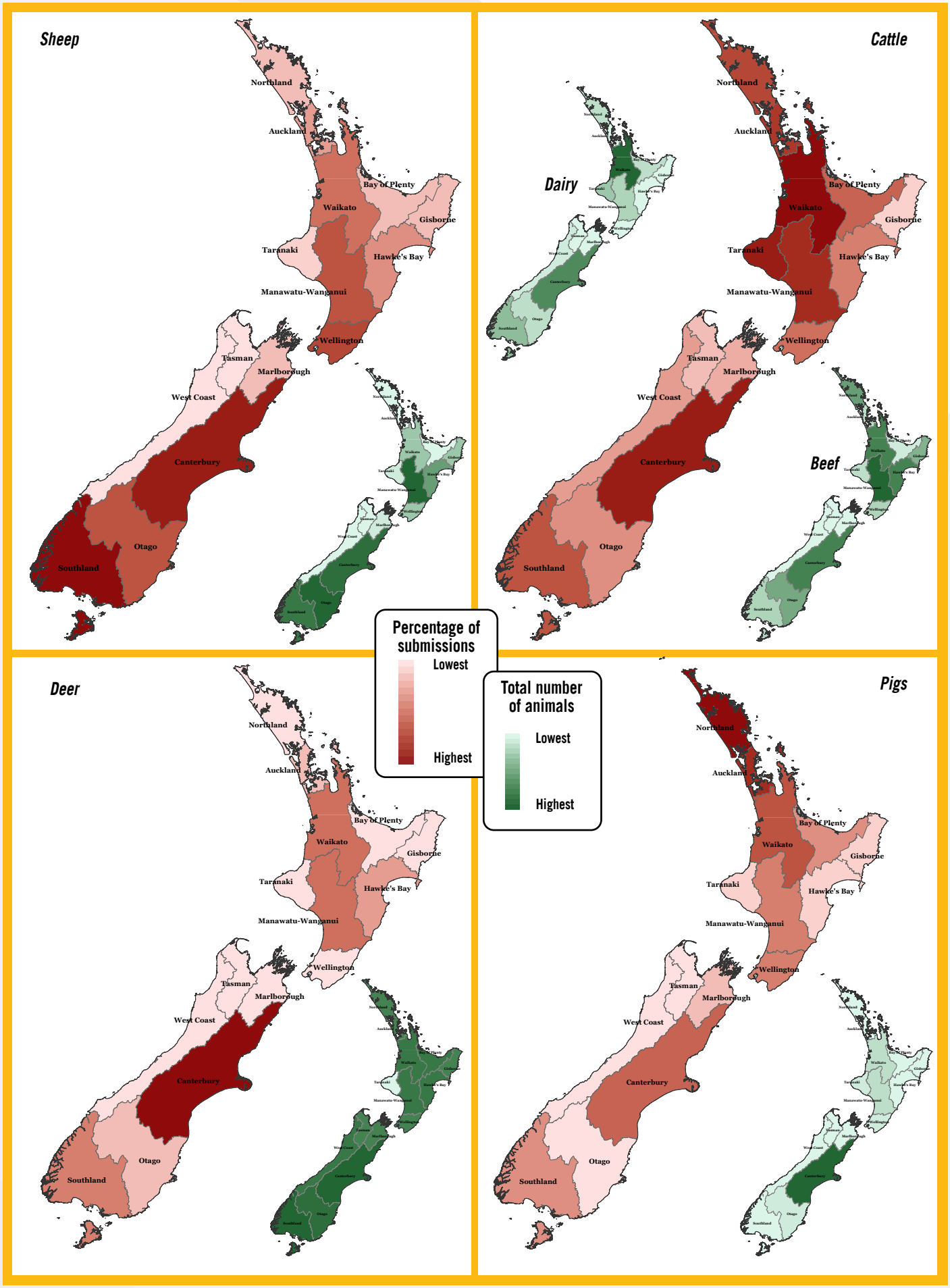
Not applicable

### Incursions

There are several notifications from veterinary diagnostic laboratories each month to the Exotic Pest and Disease Hotline as a direct result of veterinary practitioner submissions. Most of these do not result in anything more than a detailed investigation, but occasionally a new organism or disease is detected, such as *Theileria orientalis* (Ikeda) in 2012.

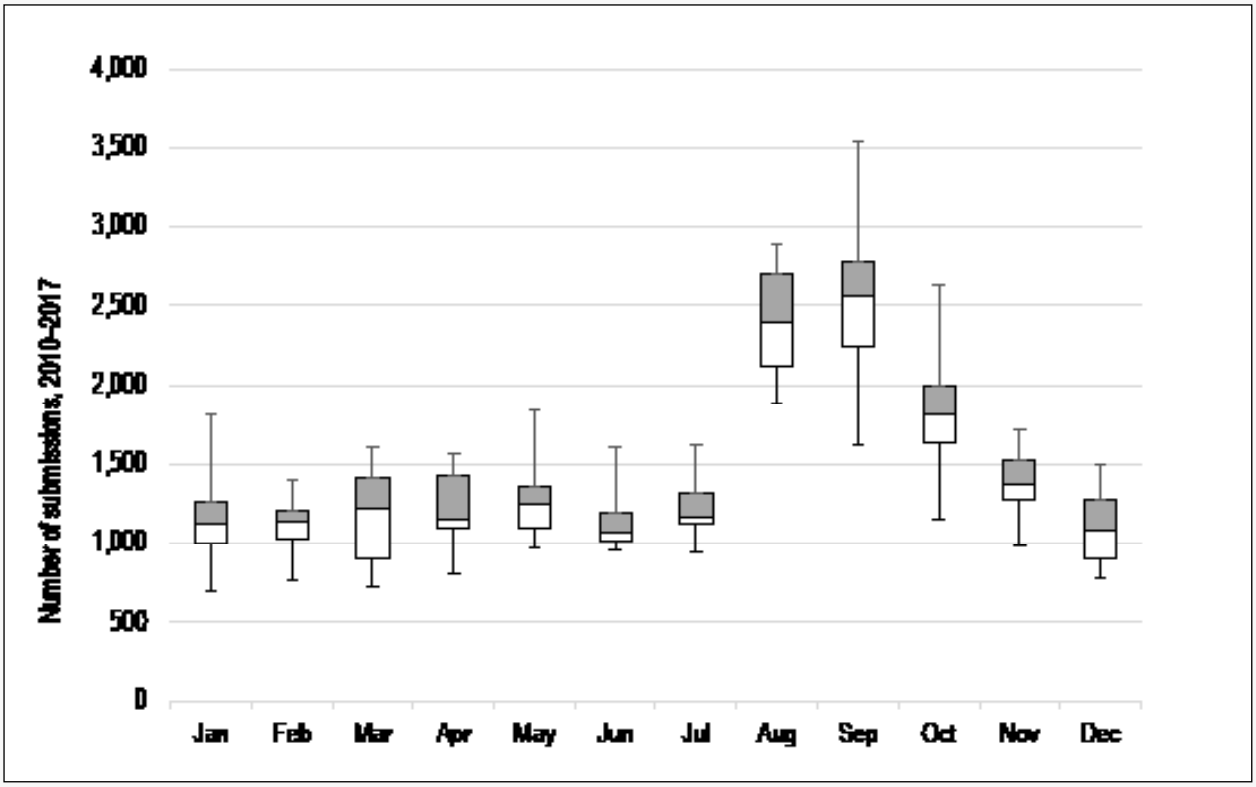
**1** Invertebrates that have a segmented body, jointed limbs and an exoskeleton.
**2** Organisms that carry and transmit a disease from one host to another.
**3** Refers to diseases that can be transferred between animals and people.

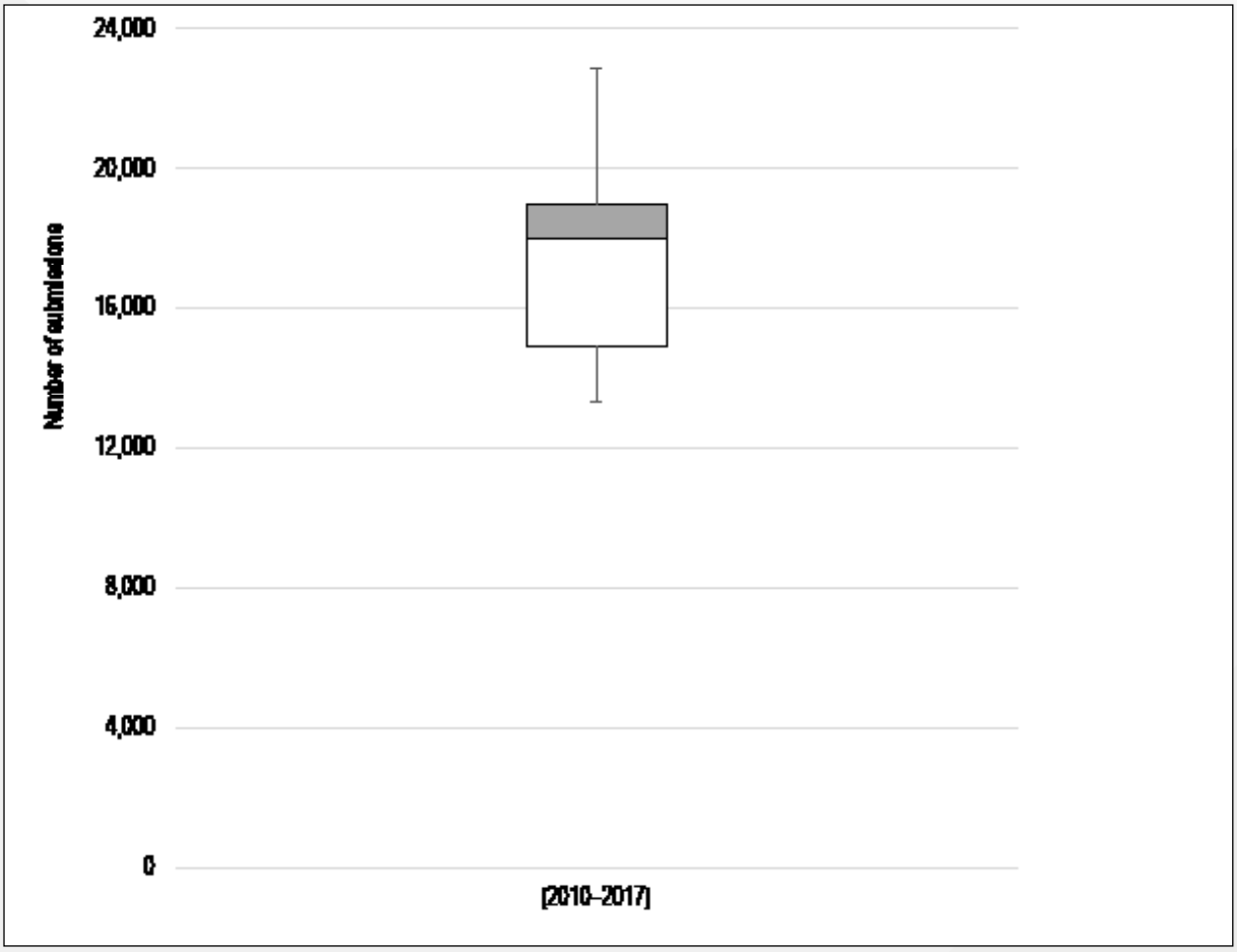
**Map 2: Animal health information 2017 – sheep, cattle, deer and pig submissions 2016**




**Data sources**: MPI Surveillance Information Management System database (Animal submissions); Agriculture Census data Stats ZN 2013 (Total number of animals).

**Figure 14: Animal health information – monthly and yearly total submissions of cattle, sheep, pigs and deer, 2010–2017**



## 2.3 Detection of *Theileria orientalis* (Ikeda) in New Zealand

In September 2012 a new-to-New Zealand organism, *Theileria orientalis* (Ikeda), was notified to MPI by a veterinary pathologist via the Exotic Pest and Disease hotline. The pathologist had detected the organism in blood smears of anaemic cattle from a Northland dairy herd that was experiencing high mortalities. This organism was subsequently detected on a number of farms in Northland in late 2012 and in Waikato in 2013.

Theileria orientalis (Ikeda) is a blood-borne parasite in cattle. It causes anaemia by infecting and destroying red blood cells (Figure 15). The signs of the disease are therefore due to anaemia, and include lethargy, pale mucous membranes, increased heart rate and respiratory rate, and sometimes death. It does not infect humans and is treatable. Other *Theileria* species exist worldwide with the *Theileria orientalis* (Ikeda) strain affecting Pacific rim countries (Figure 18). New Zealand has also had another strain of this species, *Theileria orientalis* (Chitose), since the early 1980s, however, this strain does not commonly cause disease.

Theileria orientalis is transmitted by the cattle tick, *Haemaphysalis longicornis*, (Figure 16) which was already established in New Zealand. Movements of infected cattle can also spread the disease, however the tick is required to be present to infect other cattle. The known distribution of this tick in New Zealand are in regions with warmer climate, mainly in the North Island, the top of the South Island and Canterbury (Figure 17). The disease is therefore only expected to be found in these regions. However suitable habitat for this tick may increase in the future with climate change, and thus may cause further spread of *Theileria orientalis*.

**Figure 15: Theileria-infected red blood cells in an affected cow**

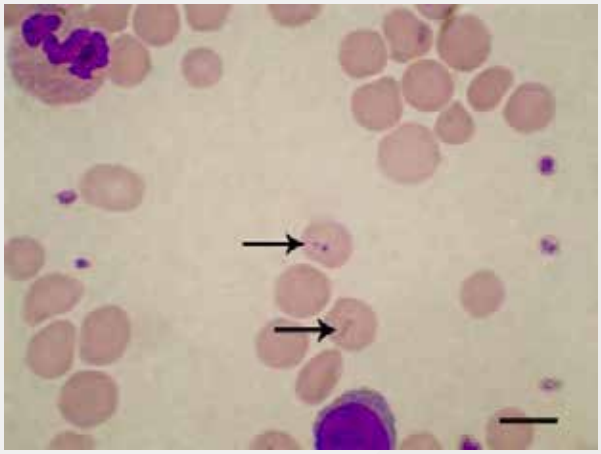
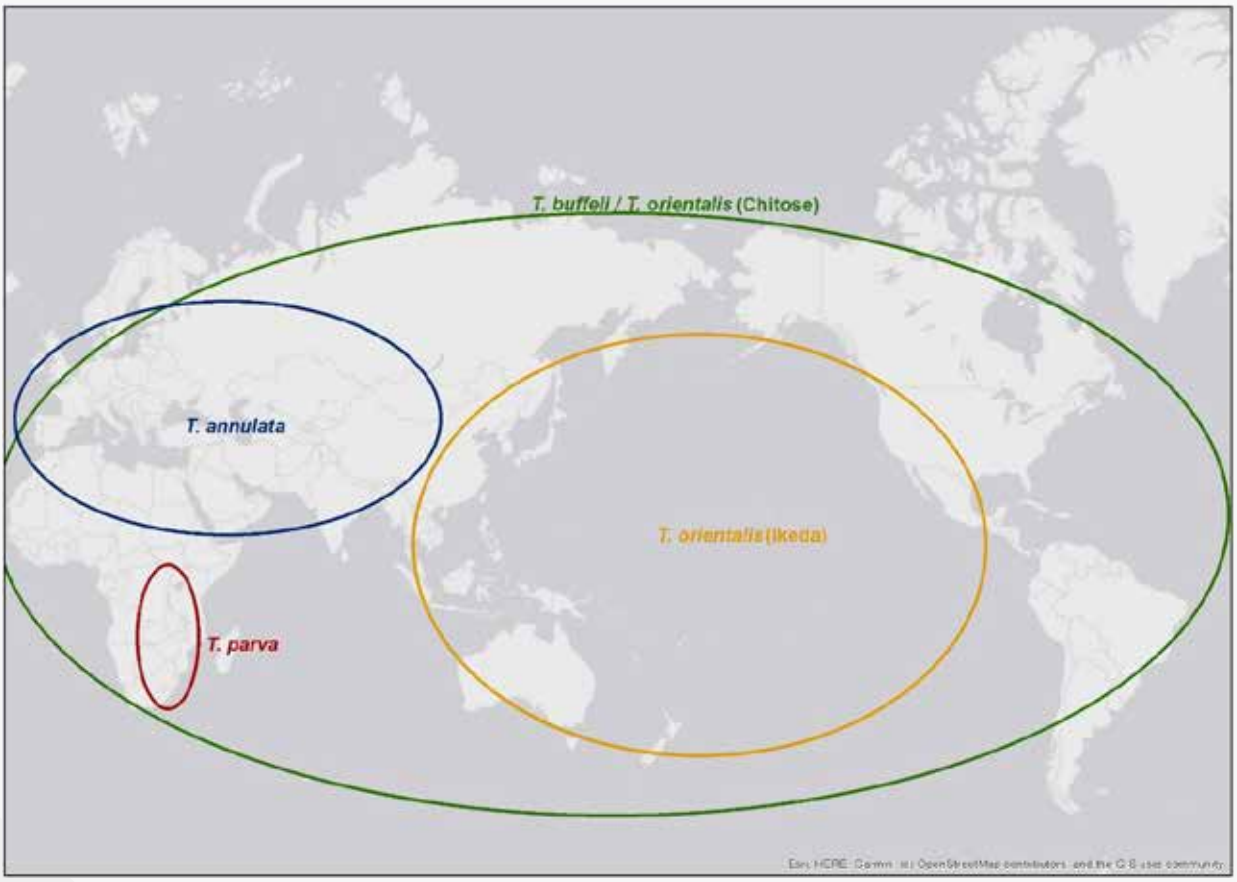


**Figure 16: Cattle tick (*Haemaphysalis longicornis*)**


Image: Qing-Hai Fan, MPI

**Figure 17: Distribution of the cattle tick (*Haemaphysalis longicornis*) in New Zealand as at 2016 (Heath, 2016)**

**Figure 18: Figurative distribution of Theileria species worldwide (does not depict exact distribution)**




Reproduced from DairyNZ Technical Series, February 2014.

## 2.4 Avian influenza surveillance programme

### Target organism/s

All Type A avian influenza viruses with high-pathogenicity[4] and low-pathogenicity avian influenza viruses of subtype H5 and H7, that are responsible for avian influenza (bird flu).

### Potential impacts

High-pathogenicity avian influenza can cause serious damage to multiple internal organs of infected birds, leading to a mortality rate up to 90–100 percent in less than 48 hours. Although the risk from avian influenza to most people is low, since 1997 cases of human infection with high-pathogenicity avian influenza have been reported overseas (Map 4). The presence of high-pathogenicity avian influenza in New Zealand could:

- have a devastating effect on the domestic market for poultry and poultry products;
- lead to international trade restrictions on New Zealand's poultry and poultry products;
- negatively impact populations of domesticated birds and wild birds, which is of particular concern for critically endangered species;
- bring a socio-economic and ecological burden associated with control and eradication programmes;
- have a health impact on the human population.

### Introduction mechanisms

Avian influenza viruses could enter into New Zealand via inadvertent importation via legal trade movements or the illegal importation of risk items, for example, eggs, unprocessed poultry products, contaminated equipment, packaging, clothing and other commodities from infected areas (Map 5). There is also the potential for avian influenza viruses to be carried by migrating birds, whose interaction with local species could lead to spill-over infection.

### Surveillance programme

**Objectives:**

- to provide early detection of avian influenza for containment and eradication;
- to provide assurance of country freedom from high-pathogenicity avian influenza viruses;
- to provide assurance of country freedom from other avian influenza viruses;
- to monitor endemic avian influenza viruses.

**Start:** 2004 (Previously, surveillance had been conducted since 1975).

**Methodology:** Throat[5] and cloacal[6] swabs are taken from healthy resident mallard ducks *Anas platyrhynchos* and tested for avian influenza virus. Positive or suspected positive samples are then tested for H5 and H7 subtypes.

**Map 3: Avian influenza surveillance programme, 2017**


**Sampling:** The programme samples healthy resident wild mallard ducks mainly in mid-to-late summer. In addition, any reports to MPI's Exotic Pest and Disease Hotline related to sick or dead wild and domestic birds are assessed by a veterinarian and if required, the event is further investigated with birds tested for avian influenza (Figure 20). Sampling is targeted principally to coastal areas where non-migratory waterfowl are likely to have had contact with migratory shorebirds. Initially the programme also included migratory birds such as the bartailed godwit (*Limosa lapponica*) and red (lesser) knot (*Calidris canheutus*), but this changed as findings from surveillance from 2004 to 2010 indicated the risk of introduction of avian influenza to New Zealand by migratory birds was very low.

### Status

New Zealand is considered free from highly pathogenic avian influenza (high-pathogenicity avian influenza viruses).

### Incursions

New Zealand has never had a case of high-pathogenicity avian influenza, but low-pathogenicity avian influenza viruses have been detected in wild mallard ducks. Cases of low-pathogenic avian influenza subtypes H5 have been detected in the North Island and subtypes H7 in the South Island (Map 3).

**Figure 19: Active surveillance for avian influenza viruses in wild birds, 2010-2017**

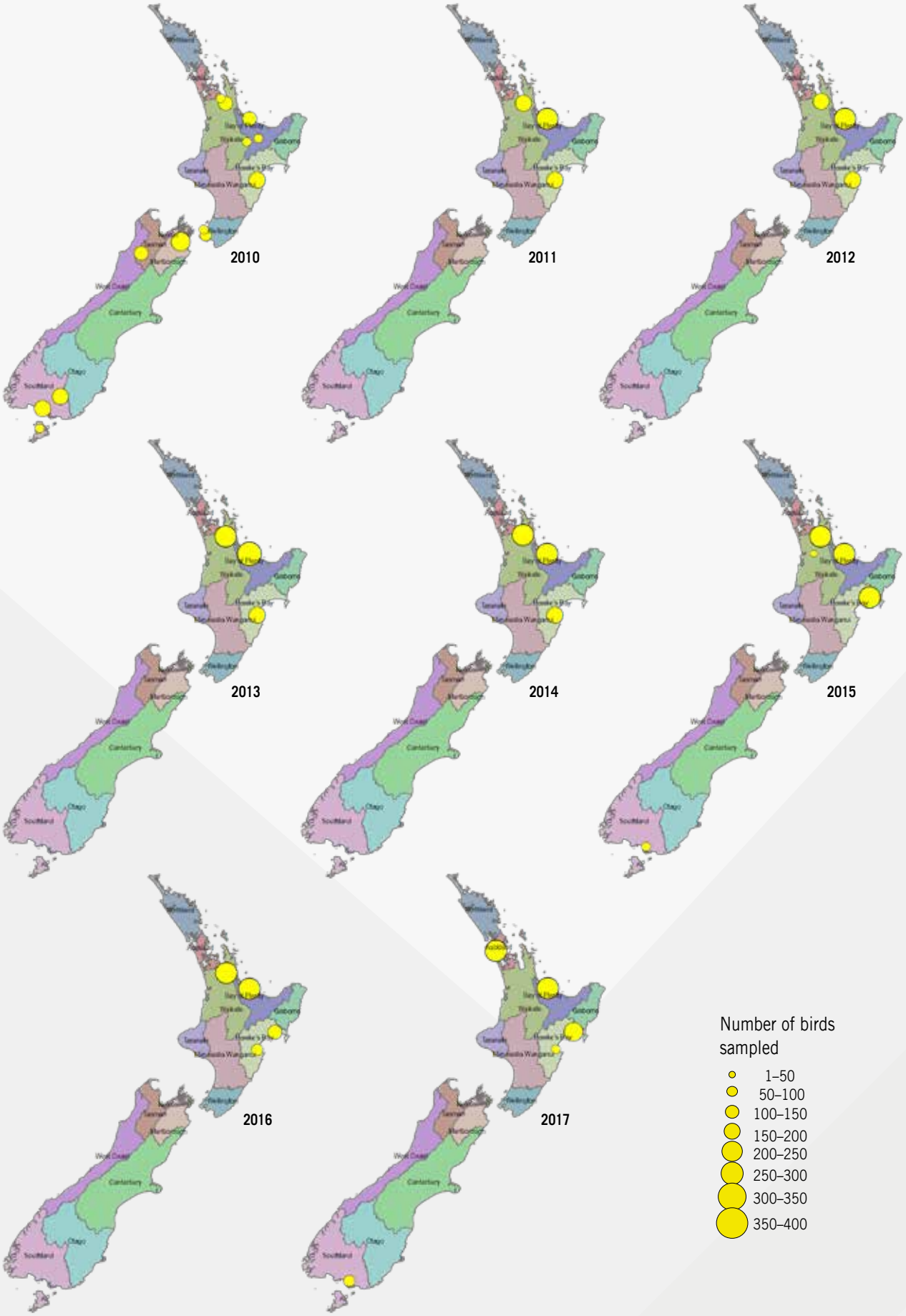
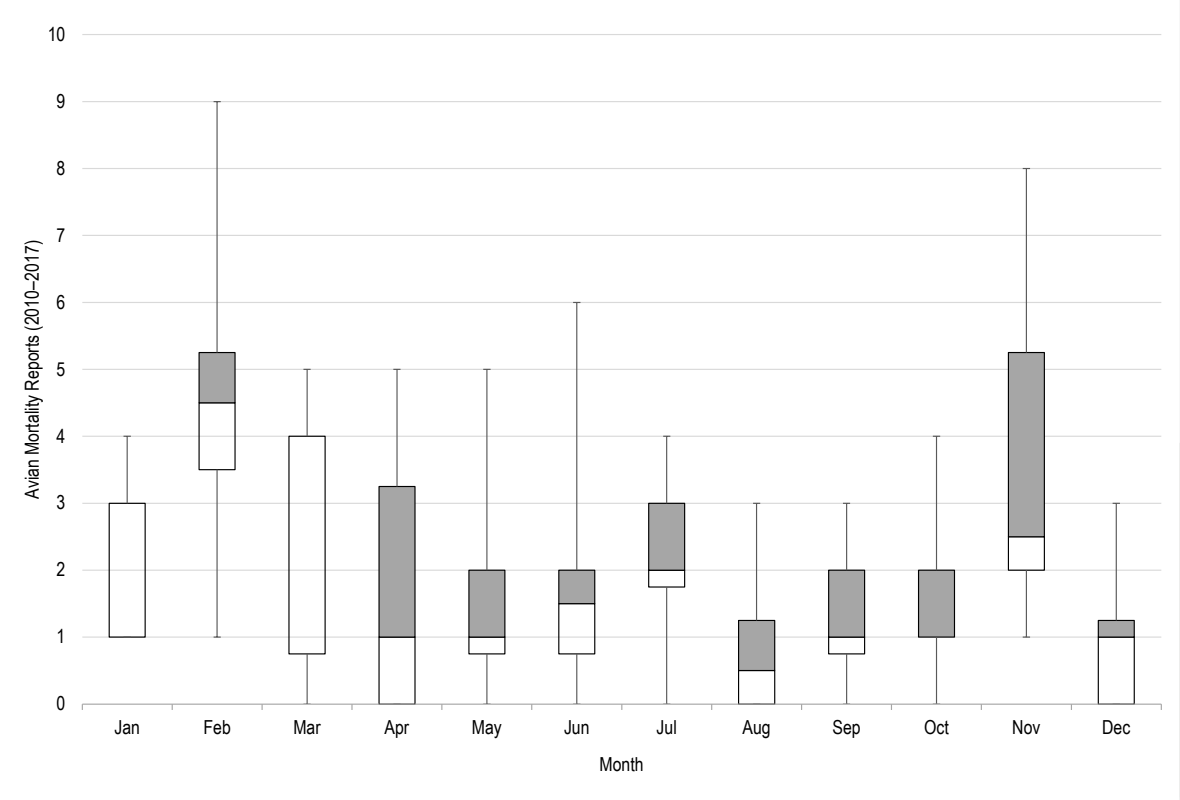


**Figure 20: Monthly avian mortality reports, 2010–2017**



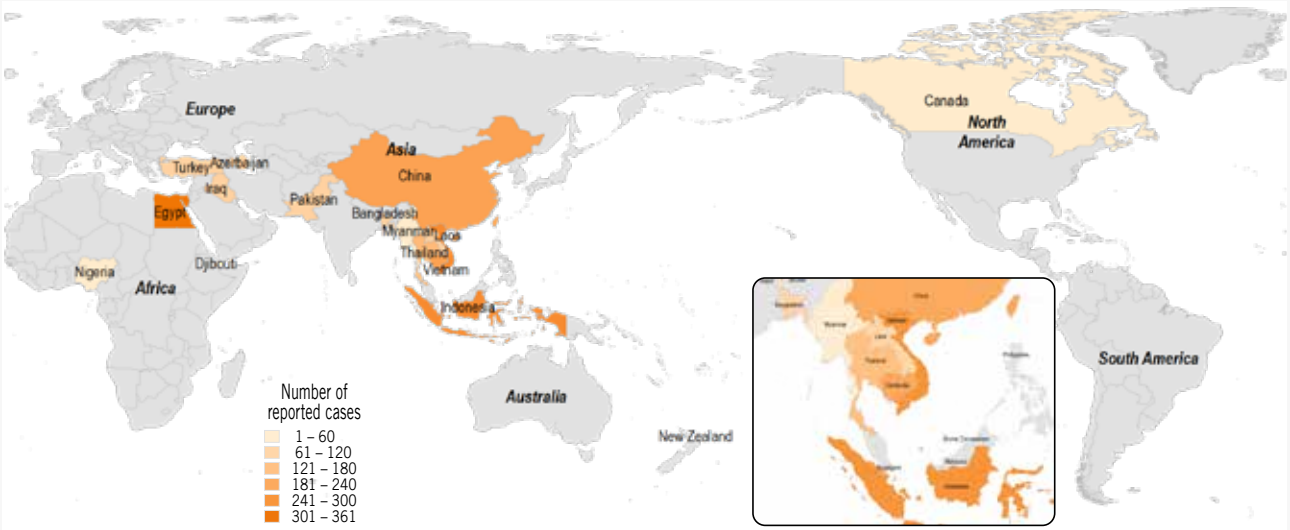

## 2.5 Avian influenza

Avian influenza, which is caused by Influenza A, is a viral disease that can infect domestic poultry (chickens, turkeys and ducks) and wild birds such as waterfowl, gulls and shorebirds (CIDRA 2013). Avian Influenza viruses are divided into H type and N type based on the configuration of their haemagglutinin (HA) and neuraminidase (NA) proteins. These H and N types are at the same time classified as low-pathogenicity or high-pathogenicity viruses mainly based on their ability to cause disease and mortality in chickens under laboratory conditions. For example, the epizootic bird flu that started in Southeast Asia in late 2003 was caused by a high-pathogenicity H5N1 strain: a highly pathogenic avian influenza virus subtype that has an HA5 protein (H5) and an NA1 protein (N1) (Martin et al. 2006). This outbreak affected not only domestic and wild birds but also humans. Since then, more than 10 countries have reported human H5N1 influenza cases (Map 4).

Birds infected with low-pathogenicity avian influenza virus strains may not develop clinical disease, and show only mild symptoms or no symptoms at all (Swayne and Suarez 2000, Swayne et al. 2003, Peng et al 2013). Low pathogenicity avian influenza viruses often occur naturally in wild birds, particularly waterfowl, without causing illness. In contrast, high-pathogenicity avian influenza virus strains are highly infectious, commonly lethal to domestic poultry, and can spread rapidly between flocks. High-pathogenicity avian influenza virus has been recorded in most continents (Map 5).

Avian influenza is transmitted mainly through direct contact with infected birds via saliva, nasal secretions and faeces (CIDRAP 2013). Birds can also become infected through contact with contaminated objects such as feed, water, equipment and clothing. Faecal contamination of drinking water as well as houseflies (Wanaratama et al. 2013) and blowflies (Sawabe et al. 2006) have also been linked to the transmission of avian influenza.

**Map 4: Countries with confirmed human cases of avian influenza A (H5N1) between 2003–2019**




**Data source:** www.who.int/influenza/human_animal_interface/H5N1_cumulative_table_archives/en/ (visited 3 March 2019)

**Map 5: 23 countries that have reported high-pathogenicity avian influenza subtype H5N1 in poultry to the OIE between 2013–2017**


**Data source**: www.oie.int/animal-health-in-the-world/update-on-avian-influenza/ (visited 21 Nov 2017)

## 2.6 Arbovirus surveillance programme

### Target organism/s

The programme targets the following diseases through a combination of blood sampling and trapping for the *Culicoides* biting midge:

- bluetongue virus;
- epizootic haemorrhagic disease;
- Akabane disease;
- bovine ephemeral fever.

The *Culicoides* genus is not present in New Zealand.

### Potential impacts

By causing significant health problems (for example, illnesses of the central nervous system and haemorrhagic fevers) in cattle, sheep, goats and deer, the incursion of these diseases into the country would:

- lead to international trade restrictions on New Zealand's animals and animal products;
- impact the domestic market for animals and animal products;
- impose a socioeconomic burden associated with control and eradication programmes.

### Introduction mechanisms

These diseases are transmitted by arthropods, for example midges of the *Culicoides* genus. Although regarded as a very low-probability event, there is a risk that infected midges could arrive in New Zealand from Australia via wind currents, the main form of dispersal for these species.

### Surveillance programme

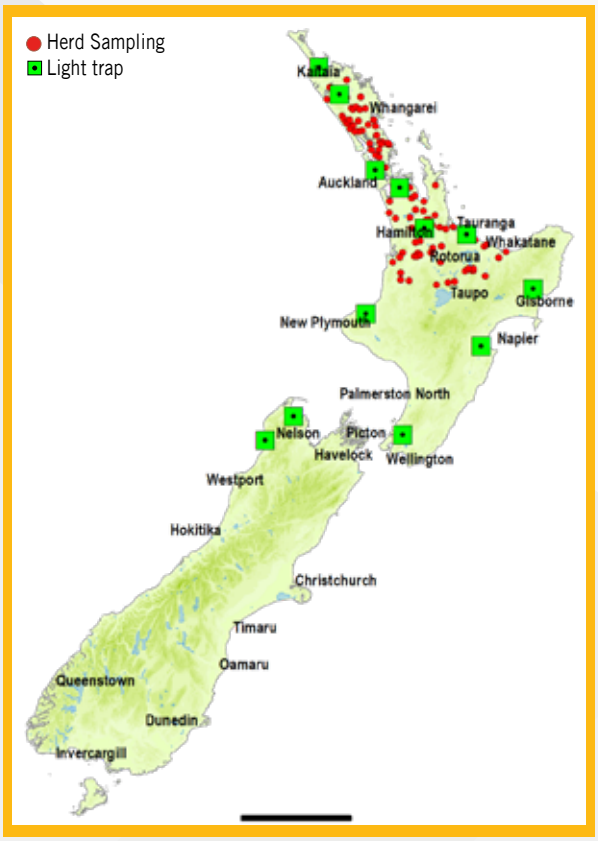
**Objectives:**

- to provide early warning of selected arboviruses to facilitate eradication;
- to provide assurance of country freedom from selected arboviruses.

**Start**: 1991

**Methodology:** 640 blood samples are taken from 32 farms from four districts (Northland, Auckland, Waikato and Bay of Plenty) that are considered suitable for *Culicoides* species for survival and establishment (Maps 6 and 7). Light trapping of *Culicoides* is undertaken at 12 cattle farms in areas where *Culicoides* species are likely to arrive via wind currents from Australia. The traps use green light-emitting diodes to attract *Culicoides* (Figure 21). These traps were introduced in 2012 to replace the incandescent white light traps previously used because of the demonstrated greater trapping efficiency of green light traps (Bishop et al., 2004 and 2006).

**Map 6: Arbovirus surveillance programme, 2018**




**Sampling:** Blood testing is conducted after the possible period of virus transmission from onset of arrival and establishment of *Culicoides*. Trapping is undertaken in all sites from February to April each year, as environmental conditions during this period are most favourable for survival of midges.

### Status

New Zealand is considered free from these selected arboviruses and their vectors.

### Incursions

There have been no detections of the selected arboviruses or the genus *Culicoides* in the country.

**Map 7: Arbovirus herd testing and light trapping surveillance programme, 2008–2018**

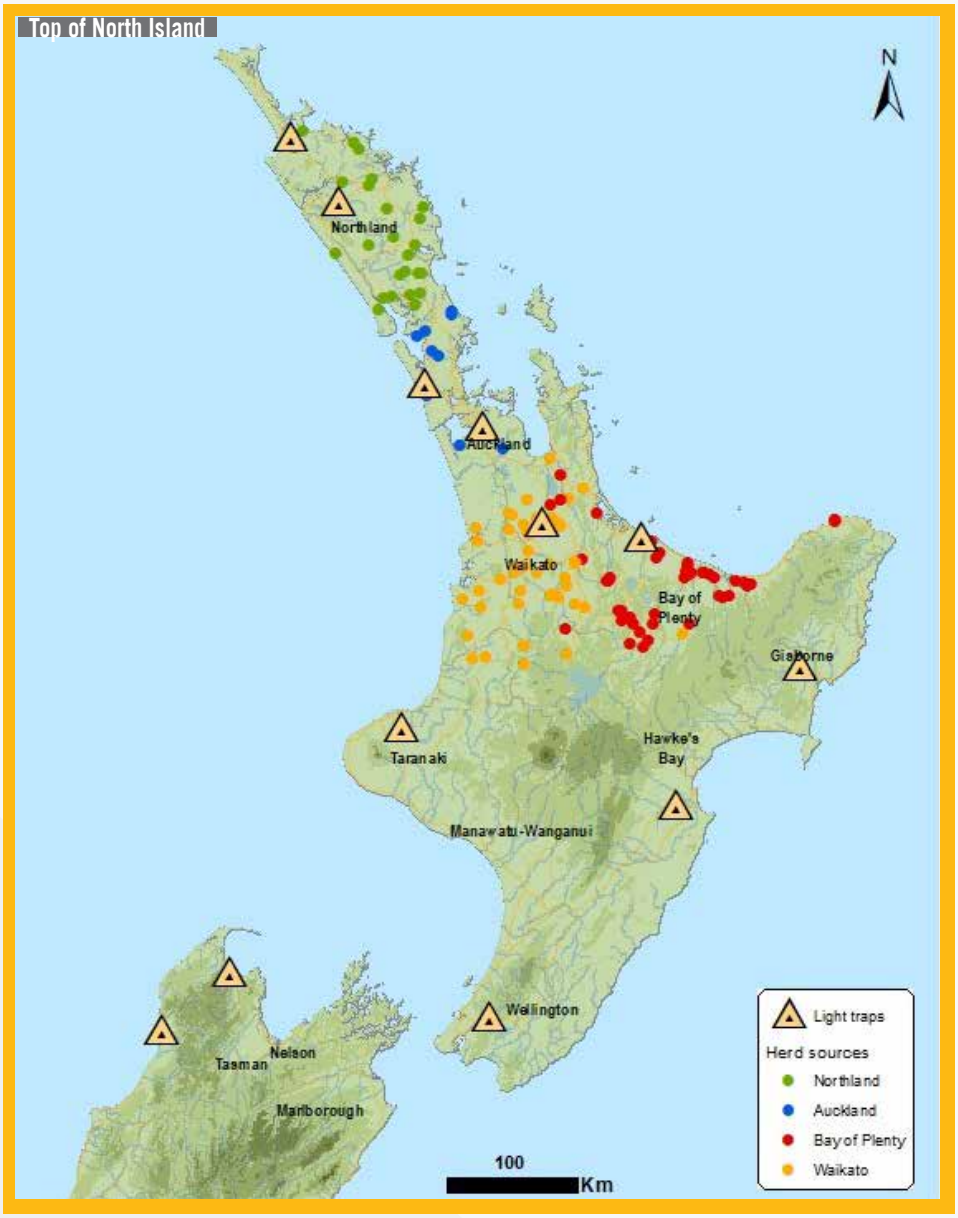



**Figure 21: Traps for *Culicoides* midges**

Traps used in the surveillance programme attract midges with light emitting diodes, luring them close to the sheltered part of the trap where an air current from a battery fan vacuums them into a collection pot with ethanol. The arbovirus surveillance programme places light traps close to cattle whose dung offers suitable habitat for the development of immature stages of *Culicoides*. Light traps are not used during full moon weeks as the increased luminosity is likely to reduce their effectiveness (Bowden and Church 1973). The programme initially used white-light traps but in 2012 changed to green-light traps because of their demonstrated greater trapping efficiency (Bishop et al. 2004 and 2006).

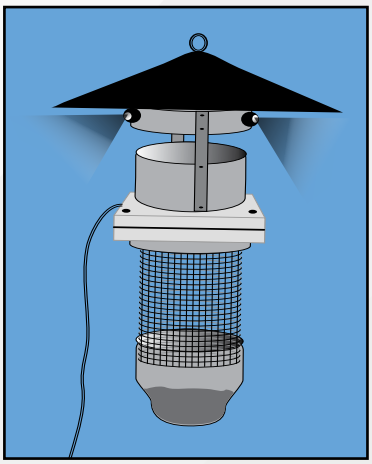
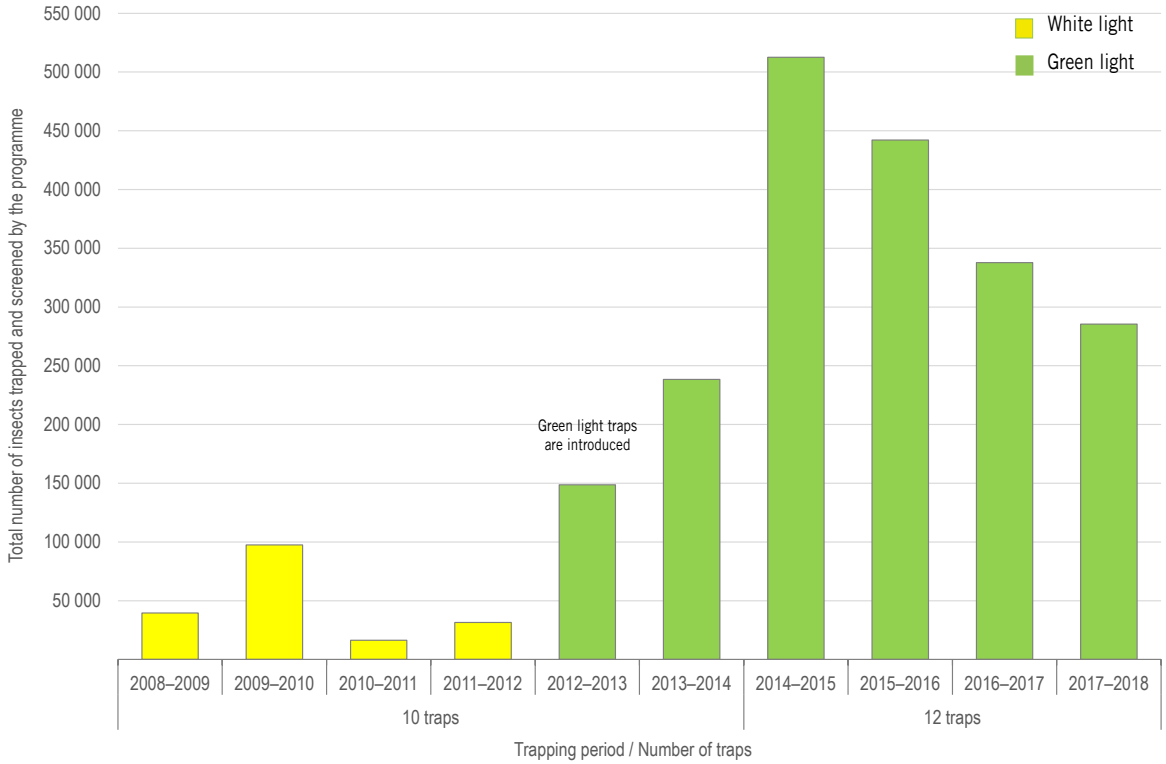


**Figure 22: Arbovirus surveillance light trapping programme, 2010–2018**

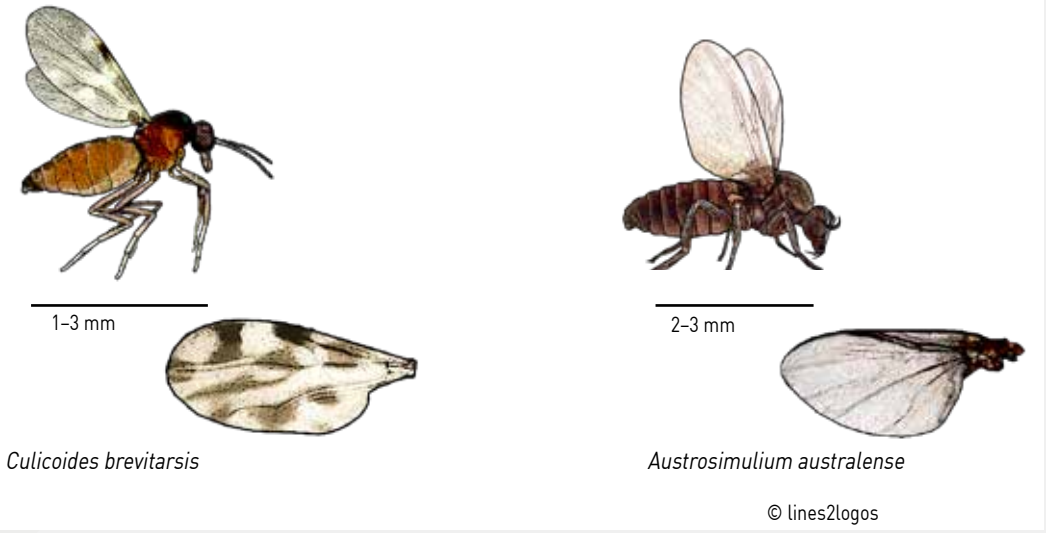



The programme has detected native midges (*Ceratopogonidae*) in all trapping seasons, which suggests the traps would catch *Culicoides* sp. if present in the area. In 2012, white light traps were replaced with green light traps because of their greater trapping efficiency.

## 2.7 Biting midges are not sandflies

Biting midges, including *Culicoides* species, are sometimes incorrectly referred to as sandflies. They are both insects but belong to different biological groups. New Zealand has 13 species of sandflies and only two of them bite: the New Zealand blackfly (*Austrosimulium australense*) and the West Coast blackfly (*A. ungulatum*). Biting midges and sandflies are small, so would look the same to the naked eye. The wing pattern is commonly used to differentiate taxonomic groups even at the species level (Figure 23). The genus *Culicoides* has never been present in New Zealand.

**Figure 23: Biting midge (*Culicoides brevitarsis*) vs. Sandfly (*Austrosimulium australense*)**

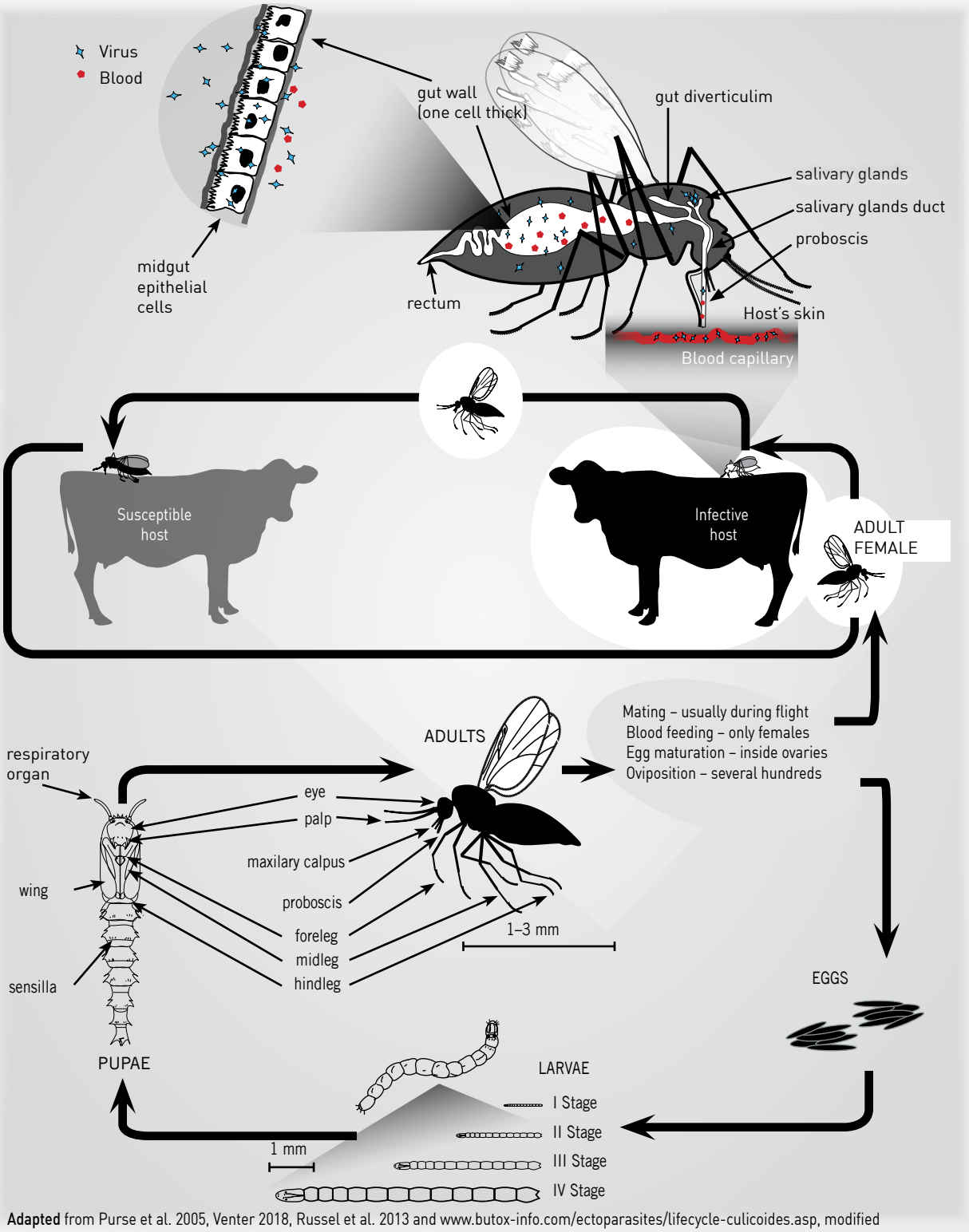


## 2.8 *Culicoides* life cycle and arbovirus transmission

Most *Culicoides* species undergo anautogenous development, characterised by female midges requiring to take a bloodmeal after mating to ensure the fertilised eggs have access to nutrients (Figure 24). Once eggs mature, the female lay them in suitable habitat – cattle dung in the case of *C. brevitarsis* (Kelso and Milne 2014) – where they go through four larval stages before turning into pupae and then adults. Male midges do not bite and feed only on nectar (Mellor et al. 2000).

Female midges can uptake the virus during a blood-meal when feeding from an infected host. The virus initially infects and replicates in the epithelial cells of the midgut before spreading into other organisms via haemolymph (Venter 2018). Once the virus is present in the salivary glands, the female is capable of transmitting it to a susceptible host during a blood-meal.

**Figure 24: Life cycle and arbovirus transmission**




**Adapted** from Purse et al. 2005, Venter 2018, Russel et al. 2013 and www.butox-info.com/ectoparasites/lifecycle-culicoides.asp, modified

## 2.9 National apiculture surveillance programme

### Target organism/s

All honey bee diseases, pests and undesirable genetic strains non-indigenous to New Zealand, but in particular:

- external mites (*Tropilaelaps* spp. and *Euvarroa* spp.);
- tracheal mite (*Acarapis woodi*);
- small hive beetle (*Aethina tumida*);
- European foulbrood (*Melissococcus plutonius*);
- parasitic fly (*Braula coeca*);
- Asian honey bee (*Apis cerana*);
- Africanised honey bee (*Apis mellifera scutsellata*);
- Cape honey bee (*Apis mellifera capensis*).

### Potential impacts

The introduction and spread of any of these pests or diseases is likely to affect honey production and severely reduce the number of bees in managed hives and wild colonies, which could:

- affect pollination of commercial crops, pasture legumes and native flora;
- lead to international trade restrictions for New Zealand's honey and bee products;
- impact the internal market of honey and bee products;
- bring a socioeconomic and ecological burden associated with control and eradication programmes.

### Introduction mechanisms

Introduction mechanisms are species-specific but often associated with apiculture products and equipment (including honey) and the transport of plant products or inanimate objects such as machinery, personal effects, used vehicles and shipping containers.

### Surveillance programme

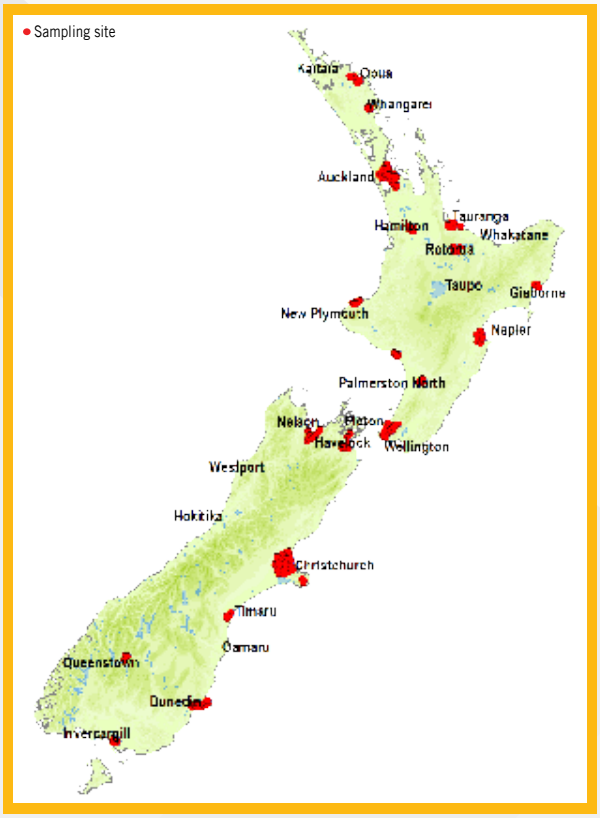
**Objectives:**

- to provide early detection of apiary-related pest and diseases for containment and eradication;
- to provide assurance of country freedom of notifiable bee diseases such as European foulbrood;
- to promote biosecurity awareness and education within commercial and recreational beekeepers.

**Start:** Evolved since the detection of American foulbrood in 1877.

**Methodology:** Every year warranted inspectors survey a minimum of 350 apiaries randomly selected from 19 areas considered high risk because of their proximity to ports, Transitional Facilities, urban areas, tourist destinations and areas of high hive concentration (Maps 8-12). High-risk areas include commercial and recreational apiaries. All the hives of the selected apiaries are visually inspected and adult bees tested for external mites using miticide strips. Opportunistic testing is also conducted from consignments of live bees from apiaries sourcing live bees for exports. Bee keepers wanting to export bees are required to provide

**Map 8: National apiculture surveillance programme, 2018**




samples of bees from up to 25 of their apiaries. The total number of exporting apiaries and export events are then determining factors in the number of samples received and processed by the programme (Figures 26 and 27). Samples are tested for external and internal mites.

**Sampling:** Beehive inspection and collection of samples for laboratory examination are conducted between February and May. Opportunistic sampling can occur at any time through the year.

### Status

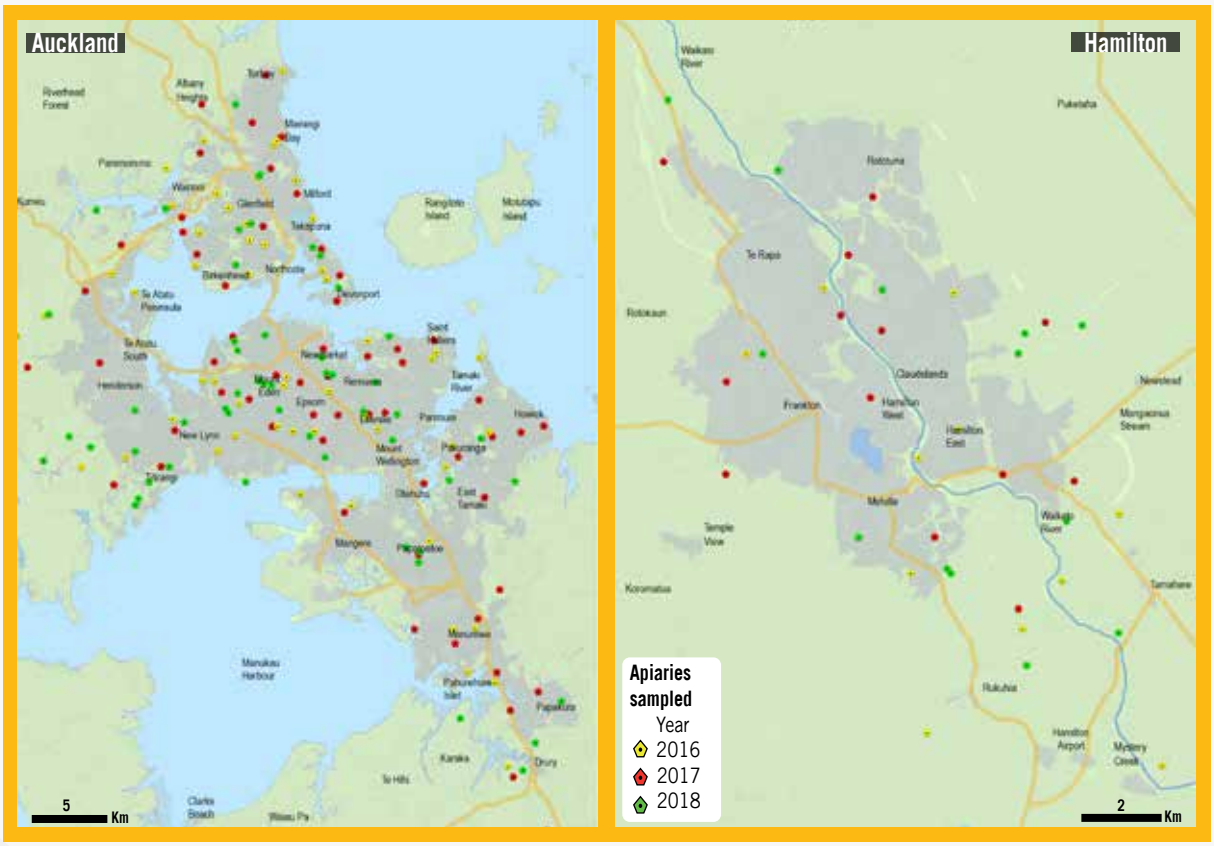
New Zealand is considered free from all notifiable bee pest and diseases except American foulbrood (AFB) and the mite *Varroa destructor* which are both classified as controlled.

### Incursions

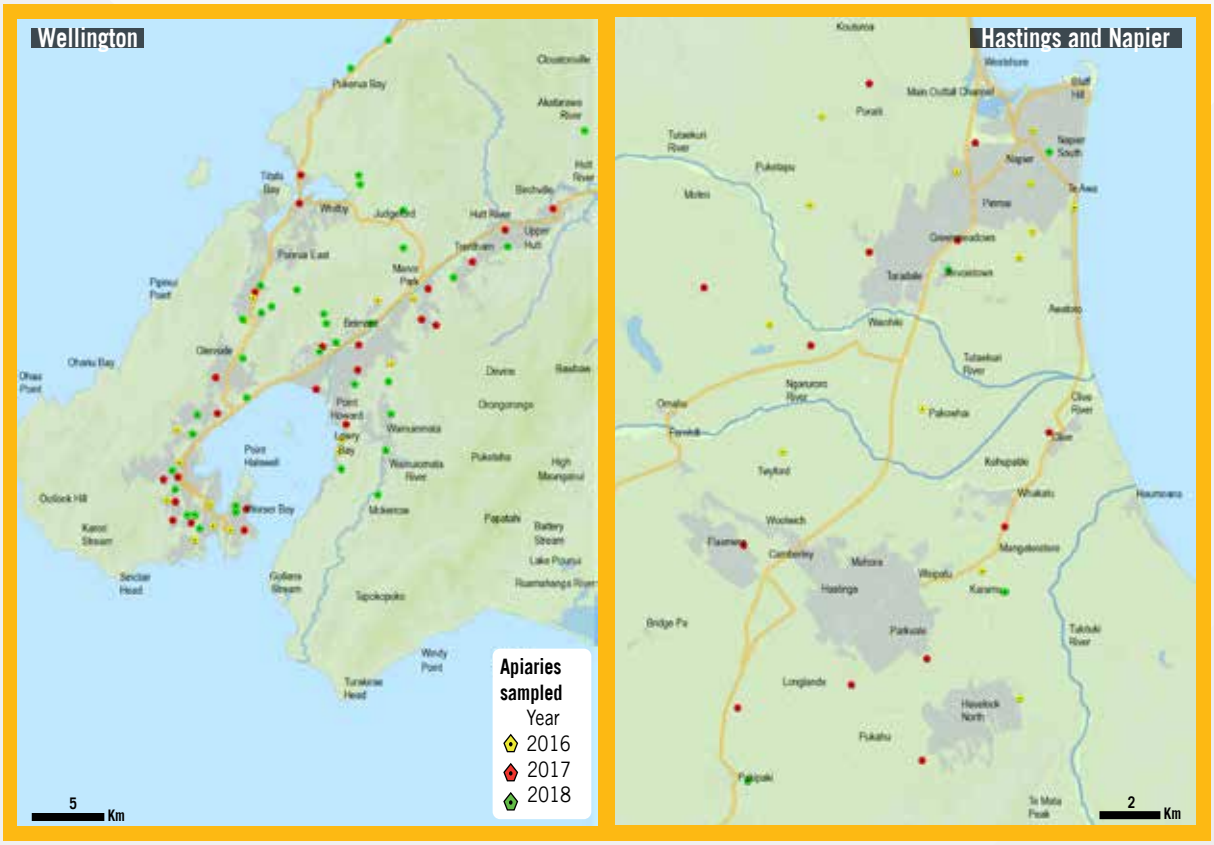
The only two high-profile introductions in New Zealand are AFB, first detected in 1877, and the Varroa mite, first detected in Auckland in April 2000. The presence of these organisms has significantly changed apiculture practices in the country. The industry previously promoted itself as relying mainly on natural products. New Zealand apiculture had to accept the use of chemical products as the only effective method to control the Varroa mite. The use of antibiotics to control AFB and other endemic diseases is still prohibited.

The spore-forming parasite *Nosema apis* has been also considered established in New Zealand since 2010 when an investigation found it in apiaries from Coromandel and northern Bay of Plenty. This parasite is of concern to beekeepers because it can kill colonies in winter and spring, but it is not a notifiable disease.

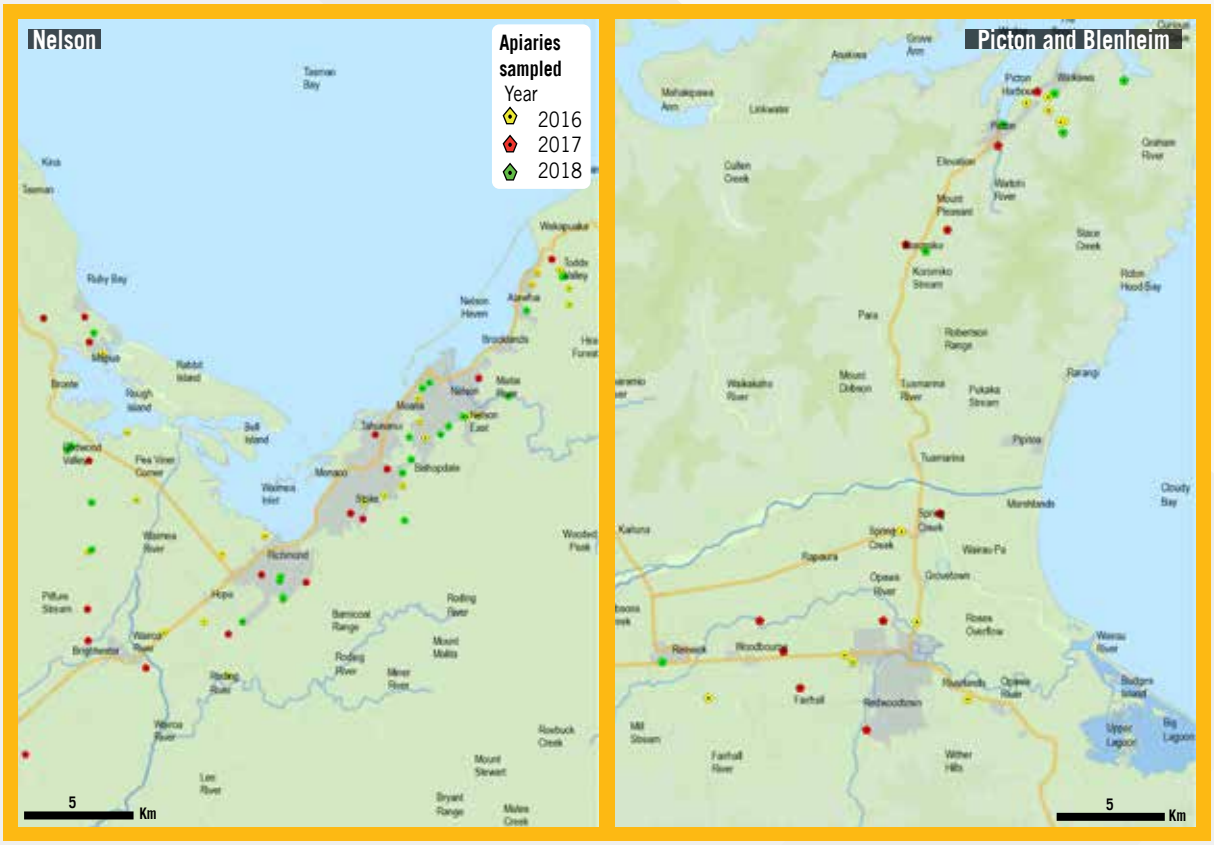
**Map 9: National apiculture surveillance programme – Auckland and Hamilton, 2016–2018**




**Map 10: National apiculture surveillance programme – Wellington, Hastings and Napier, 2016–2018**



**Map 11: National apiculture surveillance programme – Nelson, Picton and Blenheim, 2016–2018**




**Map 12: National apiculture surveillance programme – Christchurch and Dunedin, 2016–2018**

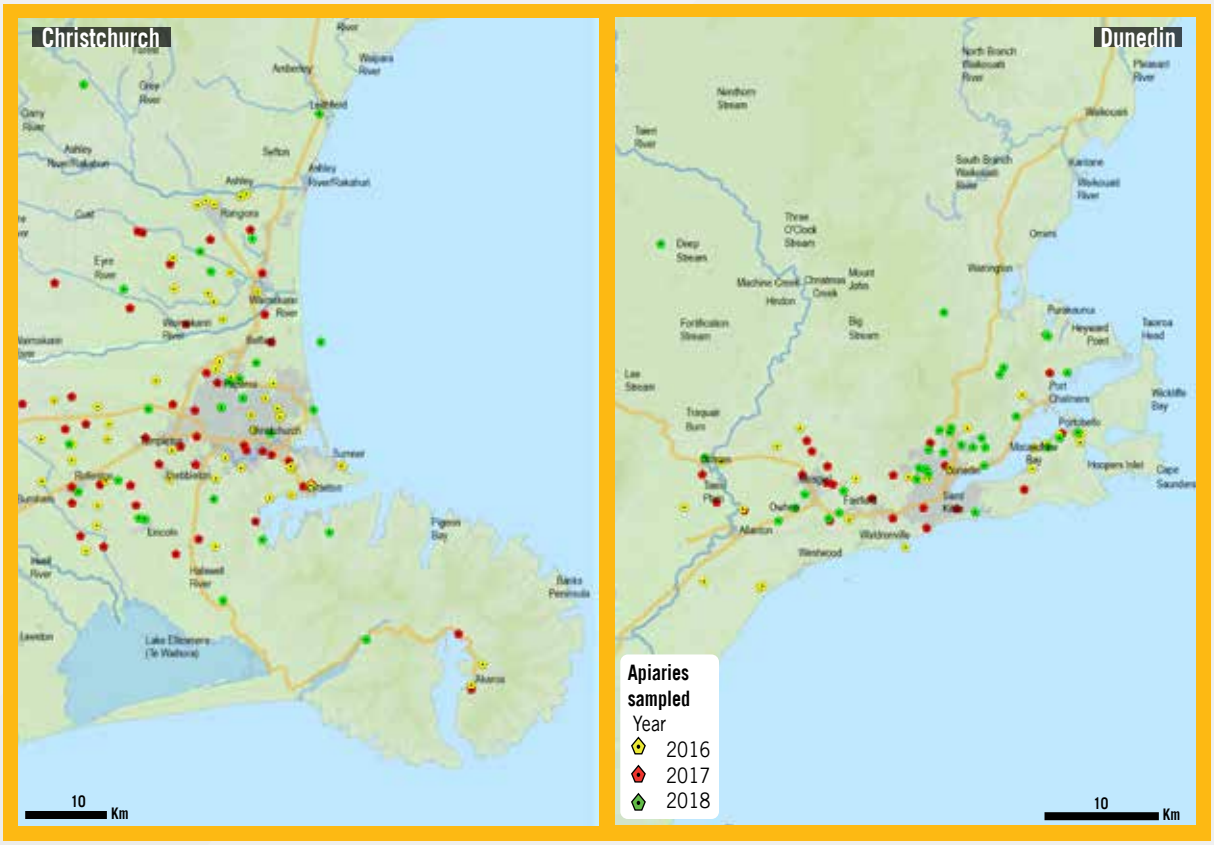
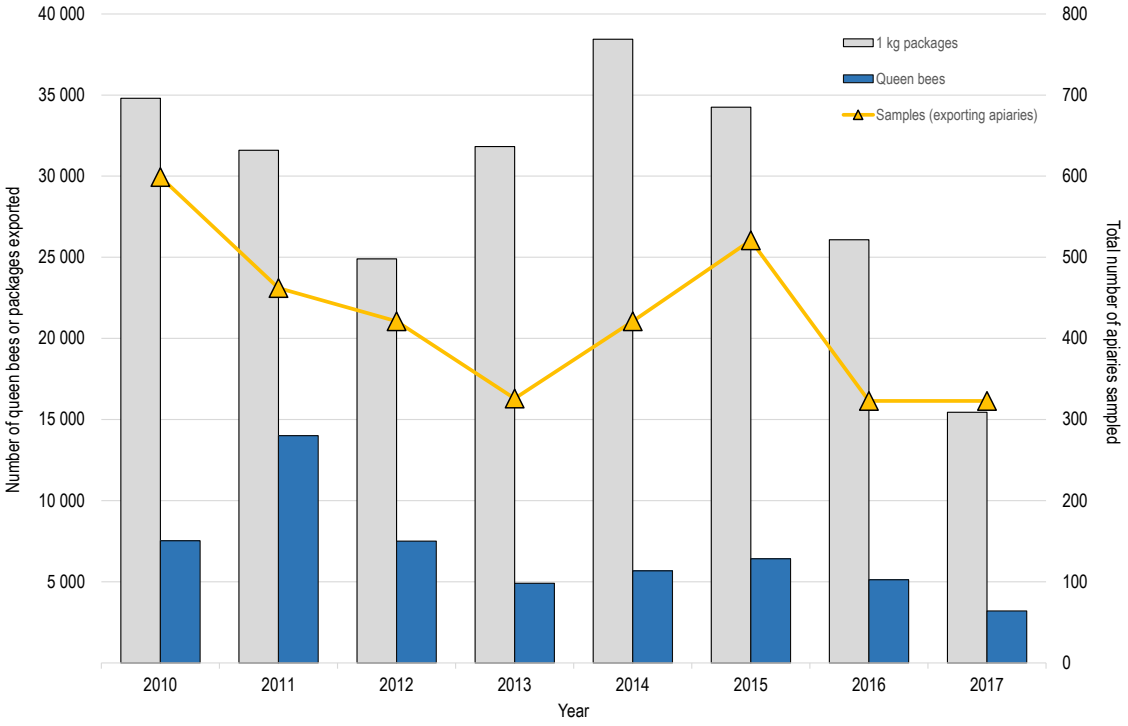
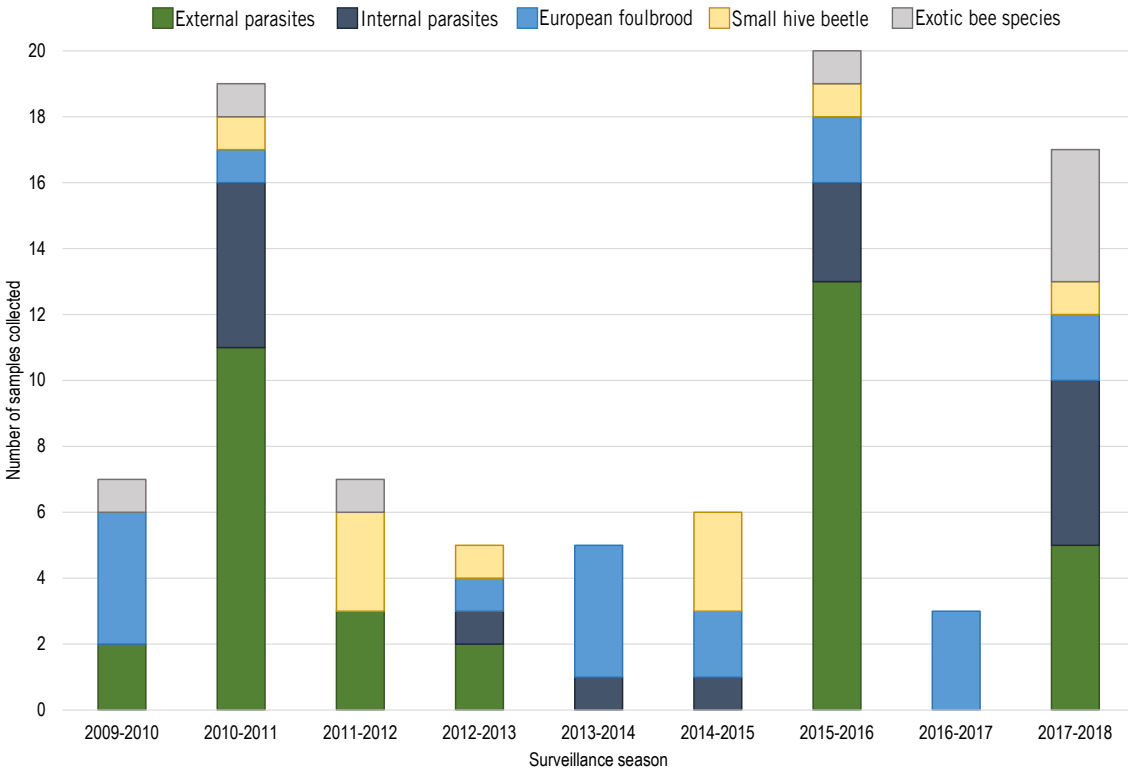


**Figure 25: Exports of live bees and number of exporting apiaries supplying sampling bees, 2010–2017**




The total number of exporting apiaries and export events are detetermining factors in the number of samples received and processed by the programme. Samples are tested for external and internal mites. 1kg package = 1kg of bees.

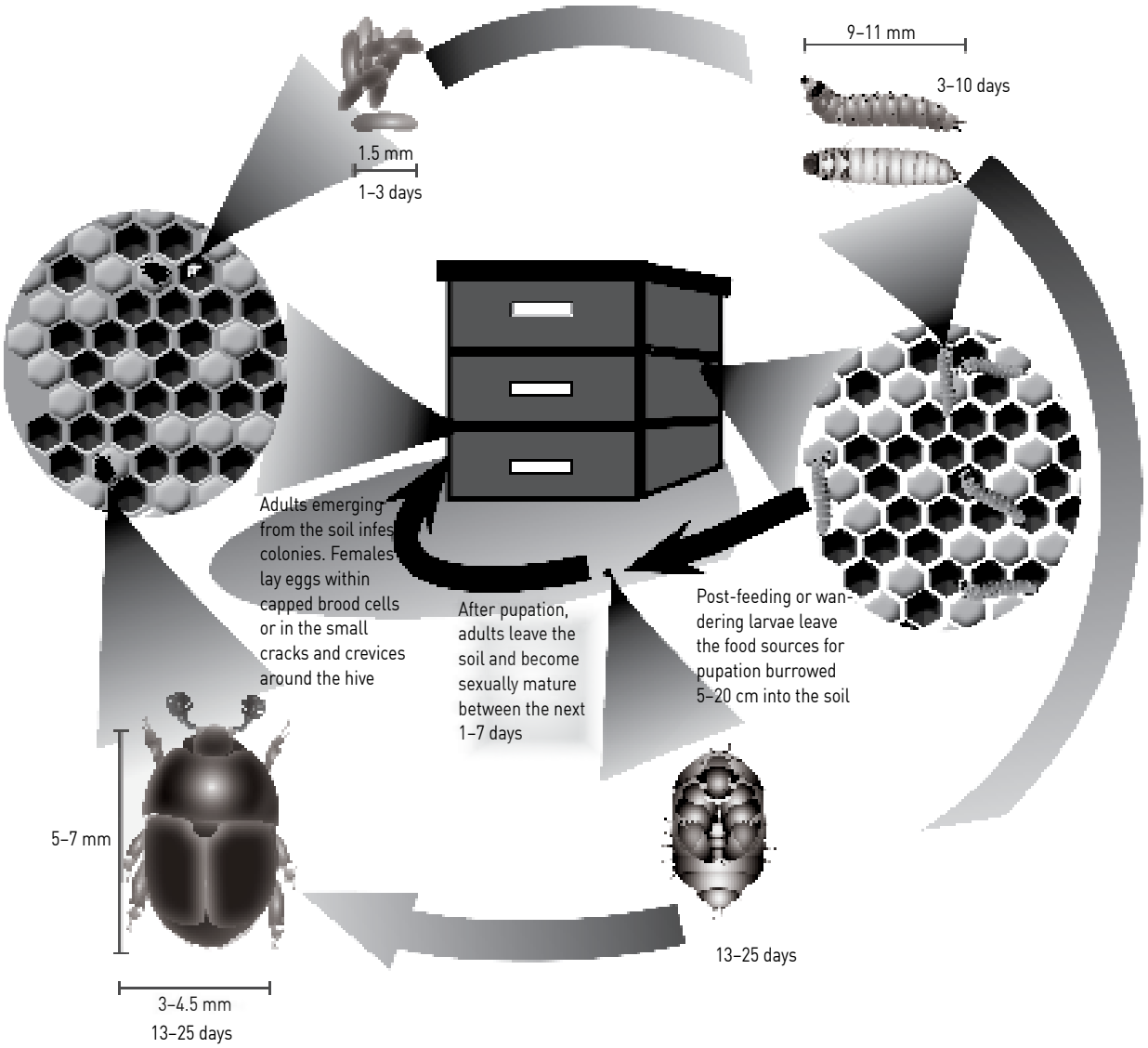
**Figure 26: Number of suspected samples taken by the programme, 2010–2018**



## 2.10 Small hive beetle (*Aethina timida)*

Small hive beetle (SHB), *Aethina tumida*, is a well-known invasive pest of beehives. Adults of this pest lay eggs in hives, where emerging larvae feed on honey comb, bee eggs, brood, honey and pollen (Figure 27). Larvae also defecate throughout the comb, releasing the yeast *Kodamaea ohmeri* that contaminates the honey. Under suitable conditions *A. tumida* can produce five generations per year, with females producing about 1,000 eggs in 4-6 months of life (Cuthbertson et al., 2008). The development and length depends mainly on humidity, temperature and food availability (De Guzman et al 2009). The actual risk and impact on the survival of the affected colony is highly dependent on the number of larvae present. Surveillance for SHB is particularly important as it might take a few years for the impacts of the pest to become obvious in the industry and before this time, the pest could establish in multiple places.

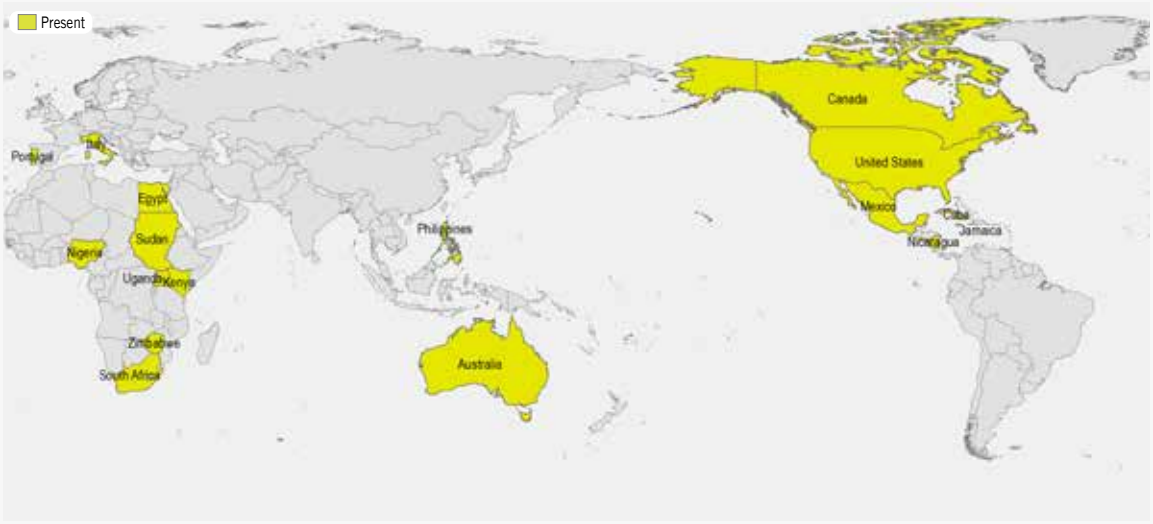
**Figure 27: Life cycle of small hive beetle *Aethina timida***




**Adapted** from Sheridan et al 2019 with information from Neumann et al 2016 and Cuthbertson et al 2013)

Originally from South Africa, the SHB has spread across the world and is now present in the United States, Canada, Mexico, Jamaica, Australia and Italy (CABI 2018) (Figure 28). It has also been reported in other countries such as Portugal, Egypt, El Salvador, Nicaragua and the Philippines (Neuman et al. 2016). The SHB has never been detected in New Zealand.

**Figure 28: Global distribution of small hive beetle *Aethina timida***




**Data source**: CABI, 2019. *Aethina tumida*. In: Invasive Species Compendium. Wallingford, UK: CAB International, https://www.cabi.org/isc/datasheet/3459#toDistributionMaps. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 2.0 UK: England & Wales Licence.

## 2.11 Fruit fly surveillance programme

### Target organism/s

Economically important fruit flies of the family *Tephritidae* such as:

- Queensland fruit fly (*Bactrocera tryoni*) (Map 19);
- Oriental fruit fly (*Bactrocera dorsalis*);
- Mediterranean fruit fly (*Ceratitis capitata*) (Map 18);
- melon fly (*Bactrocera cucumis*).

### Potential impacts

Collectively, fruit flies are considered the world's worst fruit crop pests by laying eggs in ripening and ripe fruit and vegetables. Their larvae then damage the pulp of fruit and vegetables, leaving them inedible and unmarketable. The presence of economically important fruit flies in New Zealand could therefore:

- damage commercial and home crops;
- generate trade restrictions on horticulture exports;
- affect native flora;
- impose an economic and ecological burden associated with control and eradication programmes.

### Introduction mechanisms

Fruit flies could enter New Zealand as eggs or maggots in fruit and vegetables imported commercially or brought in by travellers from overseas.

### Surveillance programme

**Objectives:**

- to provide early detection of fruit fly incursions to facilitate eradication;
- to provide assurance of country freedom from economically important fruit flies.

**Start:** mid 1970s

**Methodology:** Pheromone-lure traps are placed in potential host trees and arranged in a specific pattern to cover areas identified as likely points of entry and detection because of their vicinity to international sea/air ports, presence of host material, habitat suitability (in particular temperature), population, and first night of stay (Maps 13–16). The effective range of action of a fruit fly trap is determined by the pulling capacity of its lure. The surveillance programme uses three main lures:

- methyl eugenol to attract Oriental fruit fly and other lure-responsive oriental fruit flies;.
- Cuelure to attract Queensland fruit fly and other lure-responsive tropical fruit flies;
- Trimedlure to attract Mediterranean fruit fly.

**Map 13: Fruit fly surveillance programme, 2018**


The methyl eugenol lure has a pulling capacity of approximately 600 metres. In contrast, the pulling capacity of Cuelure and Trimedlure is approximately 200 metres (Map 14).

**Sampling:** October to July annually. This programme deploys about 7,800 traps throughout the country. Methyl eugenol traps are spaced 1,200 metres apart, while Cuelure and Trimedlure traps are spaced 400 metres apart. All traps are placed at the same site where alignment and host availability allows, but are at least 3 metres apart from any other pheromone trap to prevent cross contamination.

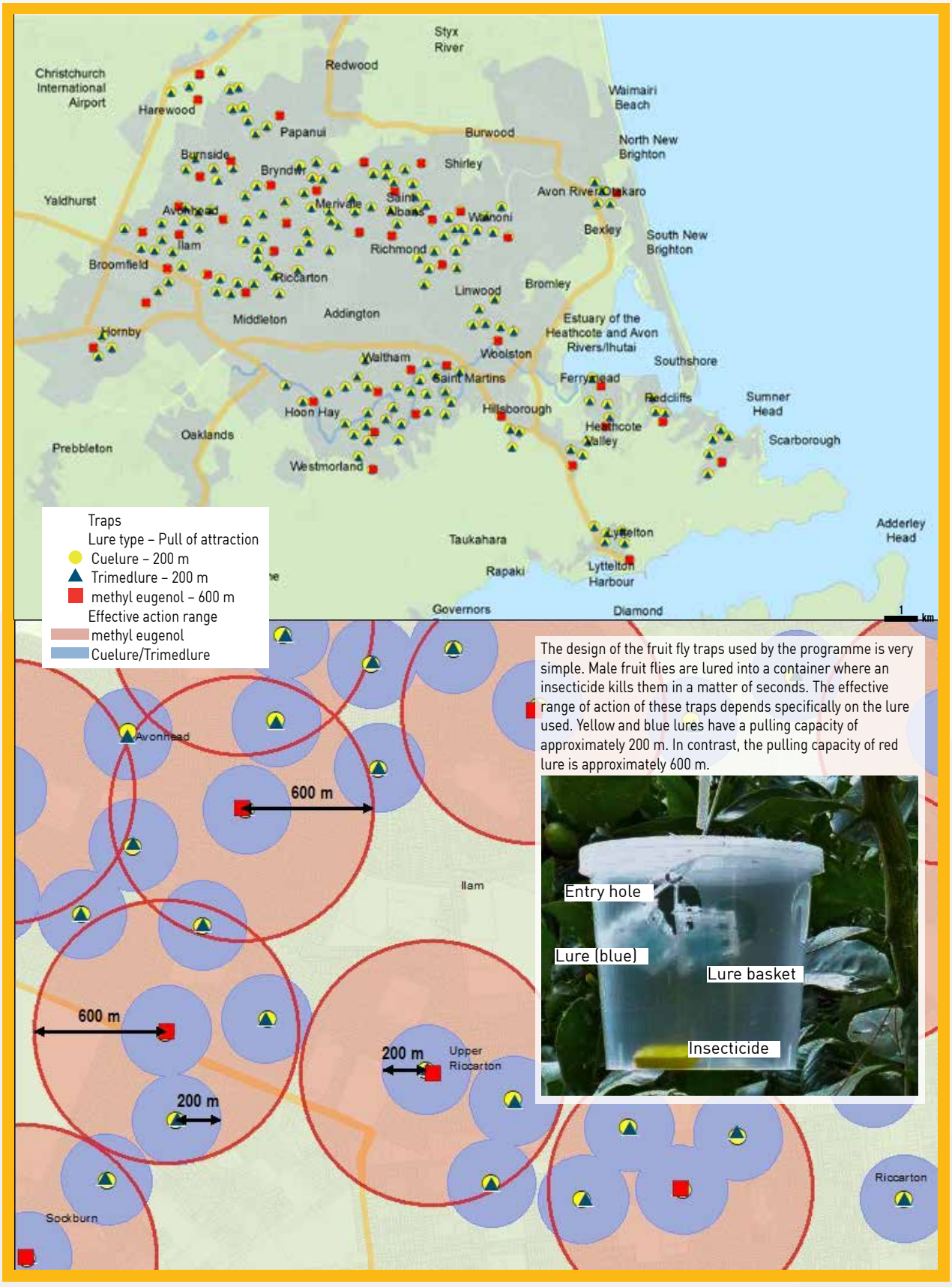
### Status

New Zealand is considered free from economically important fruit flies.

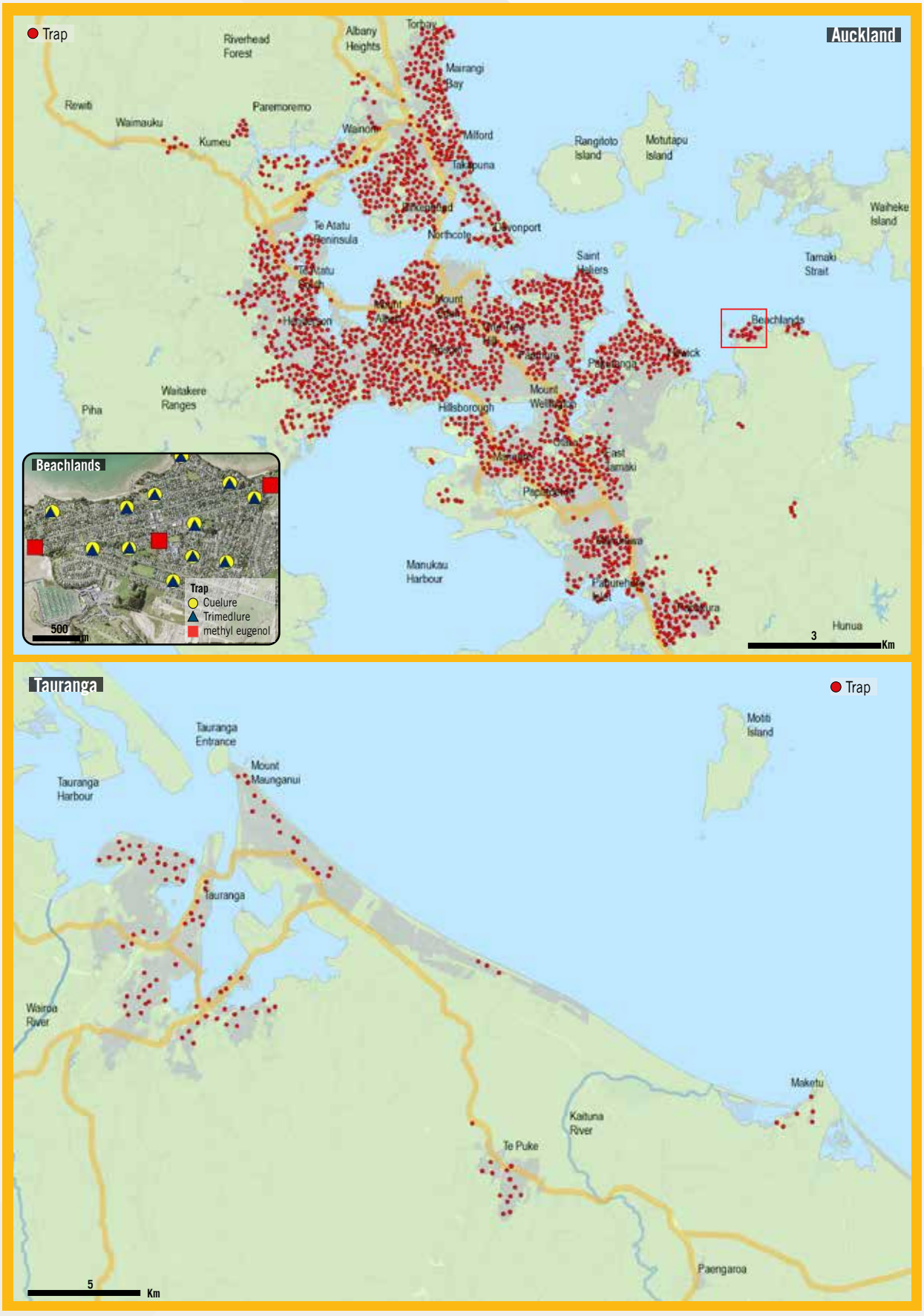
### Incursions

There have been ten incursions in Auckland and Northland between 1996 and 2019 (Map 17). Only two of these incidents (Mediterranean fruit fly and Queensland fruit fly, found in Auckland in 1996 and 2015, respectively) detected a breeding population, which triggered an eradication programme using intensified trapping, fruit collection and monitoring, and a bait spraying programme. These actions were also used for the Queensland fruit fly incursion of 2019 in Northcote as a precautionary measure due to a number of adult males detected. This response is ongoing at the time of publication.

**Map 14: Fruit fly surveillance programme traps – Christchurch, 2018**

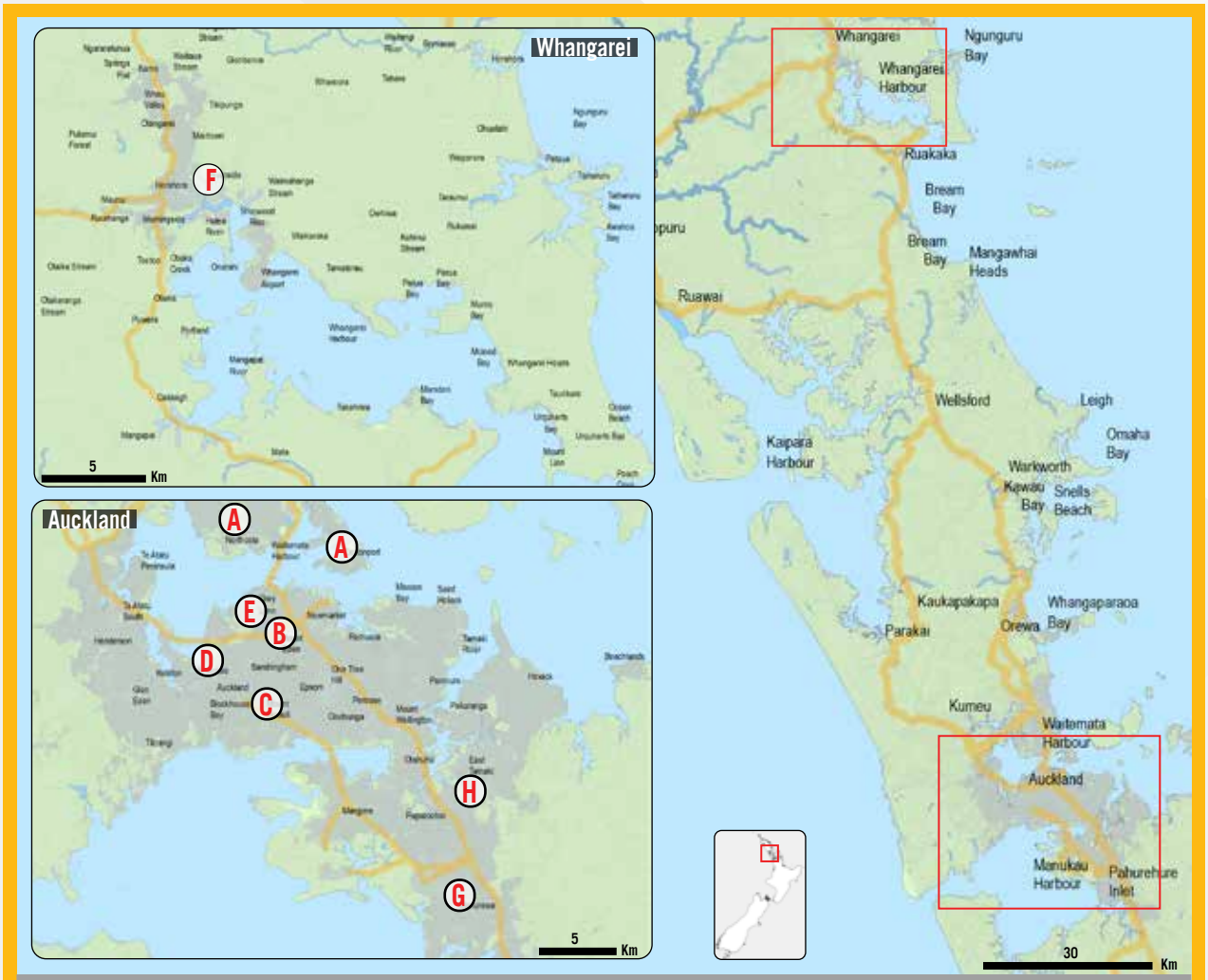


**Map 15: Fruit fly surveillance programme – Auckland and Tauranga, 2018**



## Map 16: Fruit fly surveillance programme – Nelson and Dunedin, 2018

**Map 17: Fruit fly incursions in New Zealand, 1996– 2019**




| Species | Location | | Date | Finds | | | Actions |
|---|---|---|---|---|---|---|---|
| | City | Suburb | | ♂ | ♀ | Larvae | |
| Queensland fruit fly (*Bactrocera tryoni*) | Auckland | North Shore (A) | 04 / 1996 | 2 | | – | Increased surveillance. No further finds |
| Oriental fruit fly (*Bactrocera dorsalis*) | Auckland | Mount Eden (B) | 04 / 1996 | 1 | – | – | Increased surveillance. No further finds |
| Mediterranean fruit fly (*Ceratitis capitata*) | Auckland | Mount Roskill (C) | 05 / 1996 | 41 | – | Numerous | Local larval population delimited and successfully eradicated |
| Queensland fruit fly (*Bactrocera tryoni*) | Auckland | Avondale (D) | 05 / 2012 | 1 | – | – | Increased surveillance. No further finds |
| | Auckland | Grey Lyn (E) | 02 / 2015 | 13 | 1 | Numerous | Local larval population delimited and successfully eradicated |
| | Whangarei | Riverside (F) | 01 / 2014 | 1 | – | – | Increased surveillance. No further finds |
| | Whangarei | Riverside (F) | 04 / 2014 | 1 | – | – | Increased surveillance. No further finds |
| Tau fruit fly (*Bactrocera tau*) | Auckland | Manurewa (G) | 01 / 2016 | 1 | – | – | Increased surveillance. No further finds |
| Queensland fruit fly (*Bactrocera tryoni*) | Auckland | North Shore (A) | 02 / 2019 | 1 | – | – | Increased surveillance. Response ongoing. |
| Facialis fruit fly (*Bactrocera facialis*) | Auckland | Otara (H) | 02 / 2019 | 3 | – | – | Increased surveillance. No further finds |

**Map 18: World distribution of Mediterranean fruit fly (*Ceratitis capitata*)**


**Data source:** https://gd.eppo.int/taxon/CERTCA/distribution – visited 10/02/2019

**Map 19: World distribution of Queensland fruit fly (*Bactrocera tryoni*)**

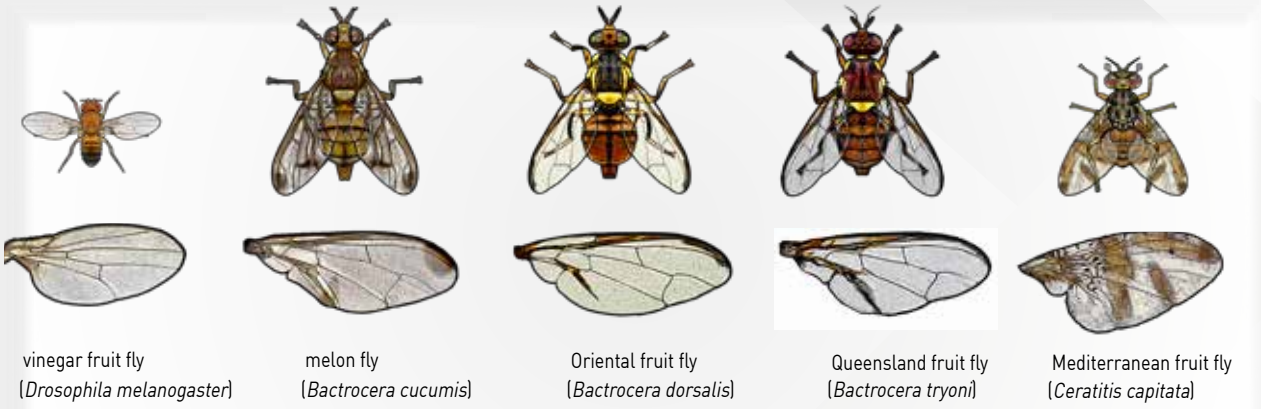

**Data source:** CABI, 2019. Bactrocera tryoni (Queensland fruit fly). In: Invasive Species Compendium. Wallingford, UK: CAB International, https://www.cabi.org/isc/datasheet/17693#toDistributionMaps. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 2.0 UK: England & Wales Licence.

## 2.12 Fruit flies

### Identification

The pattern of the wings, overall colour and colour pattern, presence and shape of thoracic vitae (yellow bands), and presence or absence of various setae (longer bristle-like hairs) are key morphological characteristics used to differentiate fruit fly species (Plant Health Australia 2018). All identifications of potential pest fruit flies in New Zealand are conducted by experienced entomologists and sometimes include genetic profiling, especially as they have sex dichotomy (males and females look different). The vinegar fly (sometimes referred to as the common fruit fly) *Drosophila melanogaster*, a cosmopolitan species with a long history in laboratory studies, is well known worldwide. Hence, it is not uncommon for people to think about this species when the term 'fruit fly' is used, even under a biosecurity context. This species, although a nuisance in some households, lays eggs in ripening and ripe fruit and does not have the devastating impact on horticulture that characterises true pest fruit flies. The vinegar fly is also considerably smaller than most economically important fruit flies (Figure 29).

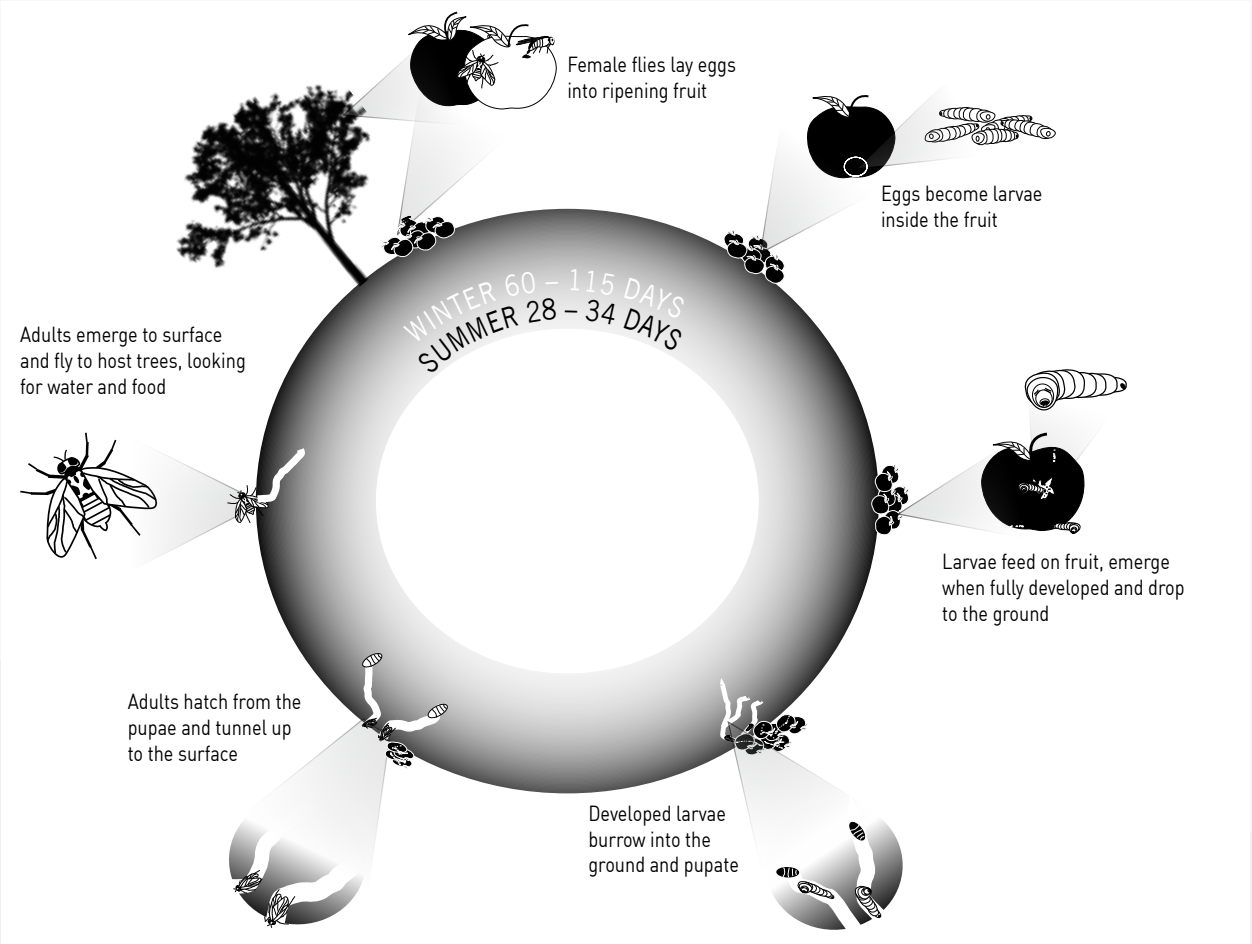
**Figure 29: Vinegar fruit fly vs economically important fruit flies – males**



## Life cycle

All the fruit fly species go through the same four life stages: egg, larva (maggot), pupa and adult (Figure 30). The duration of the stages however varies among species and is highly determined by environmental conditions such as temperature and soil moisture (Quesada-Moraga et al. 2012).

**Figure 30: Life cycle of the Mediterranean fruit fly (*Ceratitis capitata*)**




**Adapted** from Department of Agriculture and Food (n.d.). Mediterranean Fruit Fly. https://www.agric.wa.gov.au/sites/all/modules/custom/seed_tools/pestweb/981692564.html

## 2.13 Gypsy moth surveillance programme

### Target organism/s

All moth species of the genus *Lymantria*, including the Asian gypsy moth (*Lymantria dispar asiatica*) and the European gypsy moth (*Lymantria dispar dispar*). The Asian species is regarded as a higher risk due to the numbers of containers and cars imported from Asia. It also presents a greater biological risk because it feeds on a wider range of hosts and the female and male can fly, unlike the European species where only the male flies.

### Potential impacts

The larvae of the gypsy month can strip trees of their foliage, damaging and exposing them to diseases. The presence of the gypsy moth in New Zealand could therefore:

- damage forestry and horticulture tree species (for example, pines and apple trees);
- generate restrictions on forestry, horticultural and industrial exports;
- affect grasses, weeds, herbs and garden crops;
- damage native bush, including the endemic black beech (*Nothofagus solandri*);
- impose an economic and ecological burden associated with control and eradication programmes;
- caterpillar hairs can provoke allergenic reactions in some humans and the larvae can contaminate water with their frass.

### Introduction mechanisms

Gypsy moths could enter New Zealand as egg masses, larvae or adults in vessels, shipping containers, imported cars, goods carried by travellers and immigrants' personal effects.

### Surveillance programme

**Objectives:**

- to provide early detection of gypsy moth incursions to facilitate eradication;
- to provide assurance of country freedom from gypsy moth.

**Start:** 1992

**Methodology:** Pheromone-lure traps placed in potential host trees and arranged in a grid pattern designed to cover areas identified as likely points of entry for gypsy moth. The lure of the traps has a pull of attraction of about 375–800m$^2$ so traps are spaced at about 750 metres to ensure adequate coverage. Traps attract male moths.

**Map 20: Gypsy moth surveillance programme, 2018**


**Sampling:** October–April each year. The programme uses more than 1,500 traps across the country (Maps 21–25, Figures 32 and 33). The programme replaces all lures once during the season, after they have been in the field for 12–14 weeks.

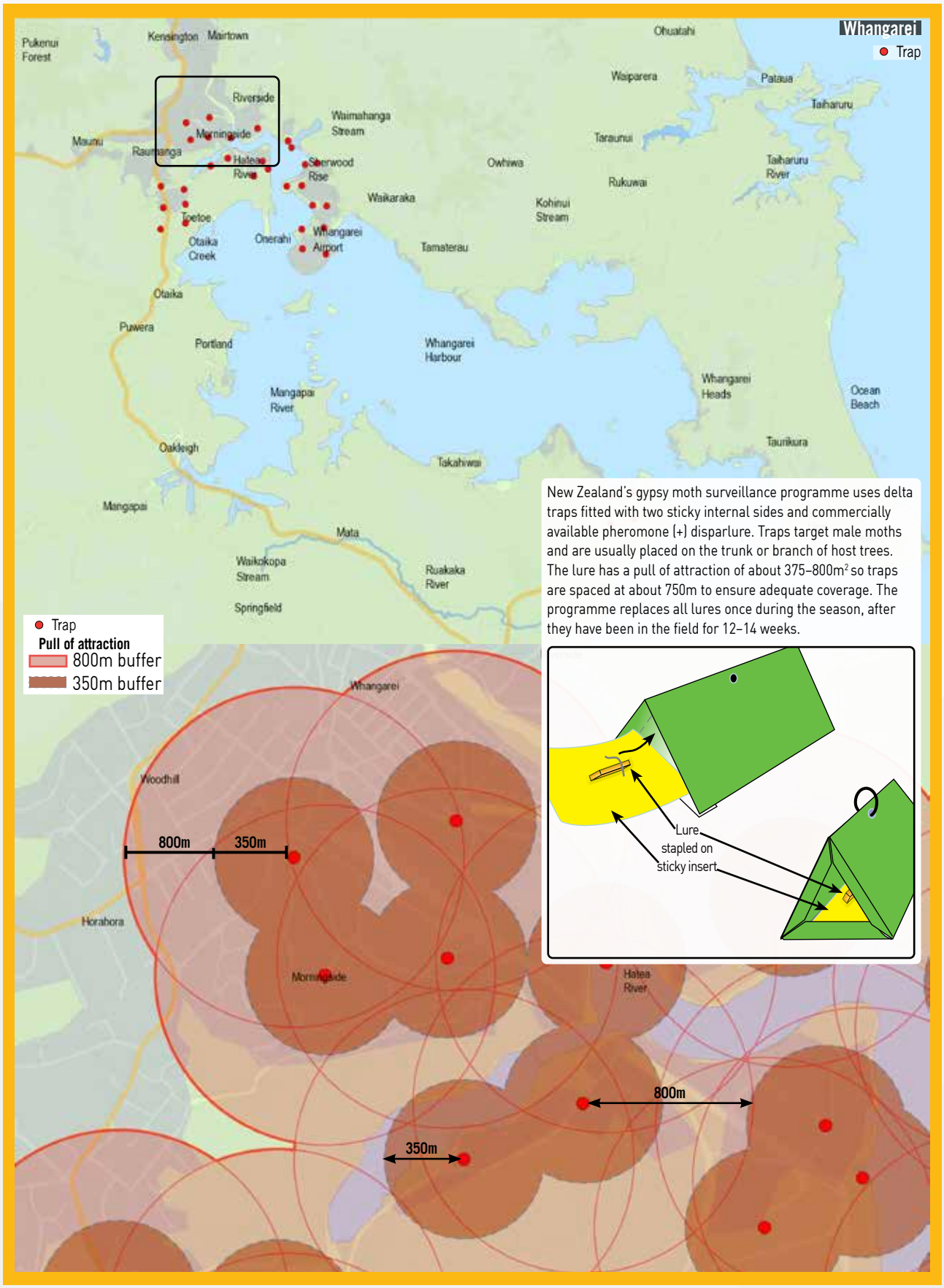
### Status

New Zealand is considered free from Asian and European gypsy moth.

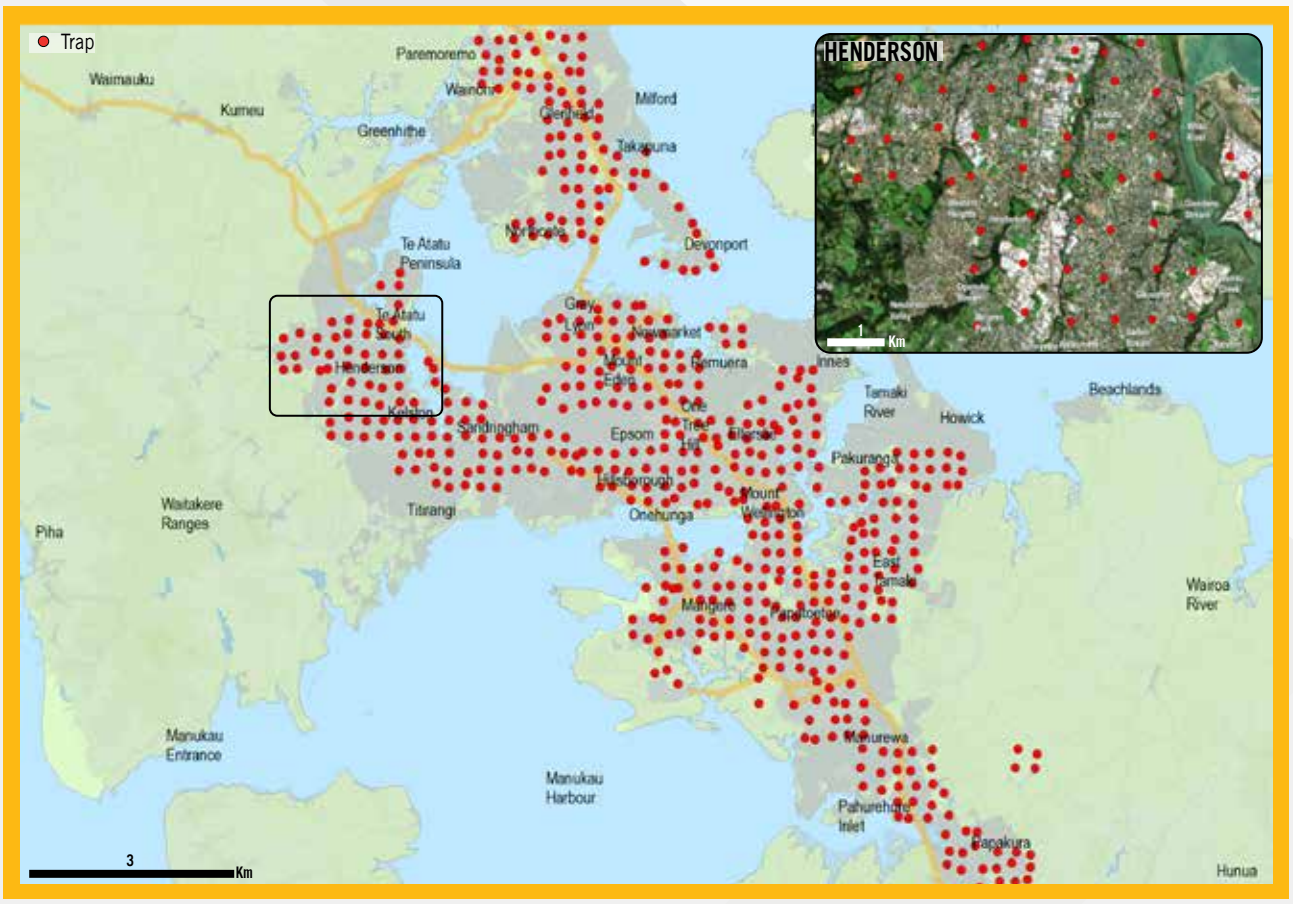
### Incursions

There has been only one incursion, in Hamilton in 2003. After an intensive eradication programme (including aerial treatment) the moth was declared eradicated in 2005.

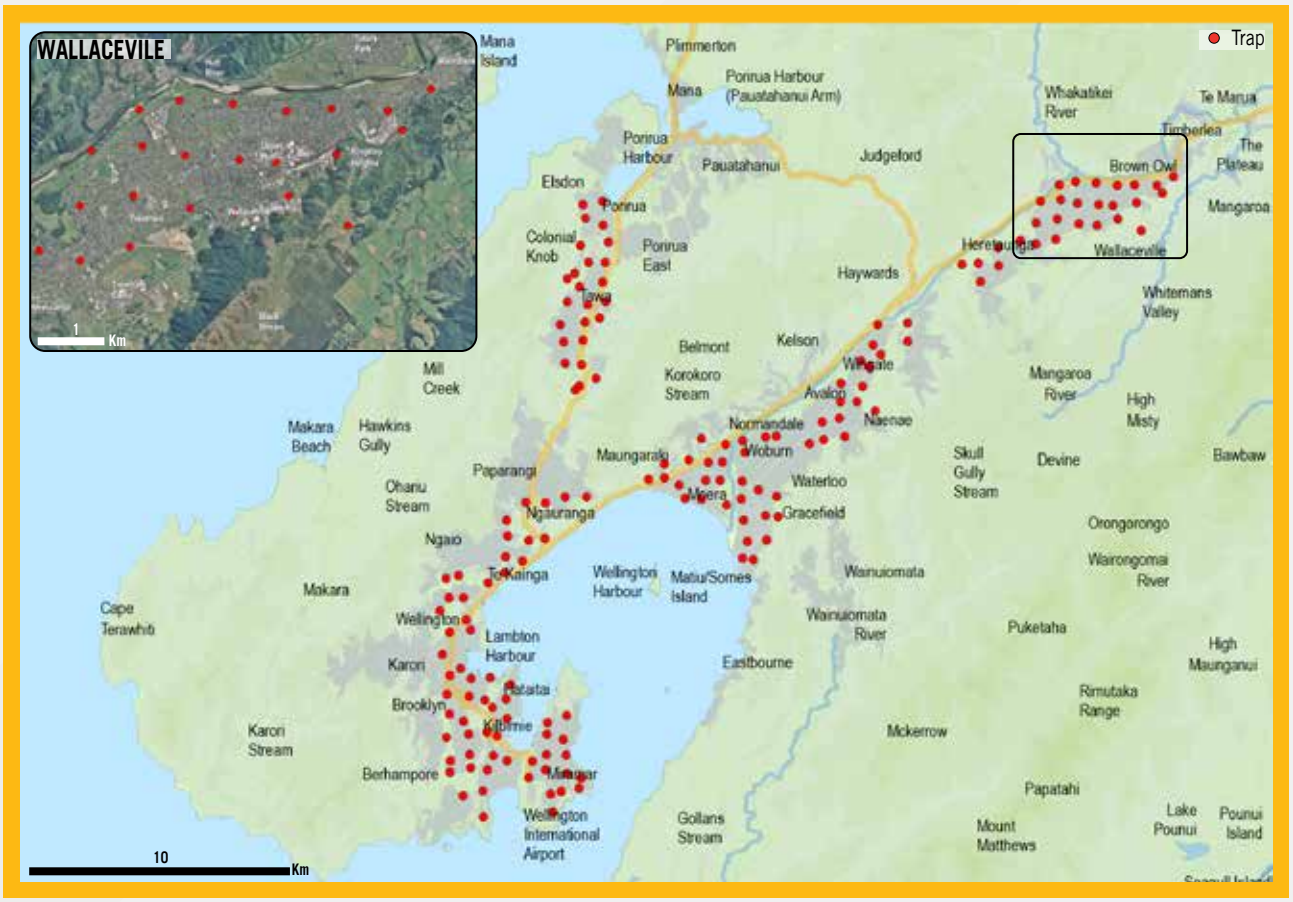
## Map 21: Gypsy moth surveillance programme – Whangarei, 2018



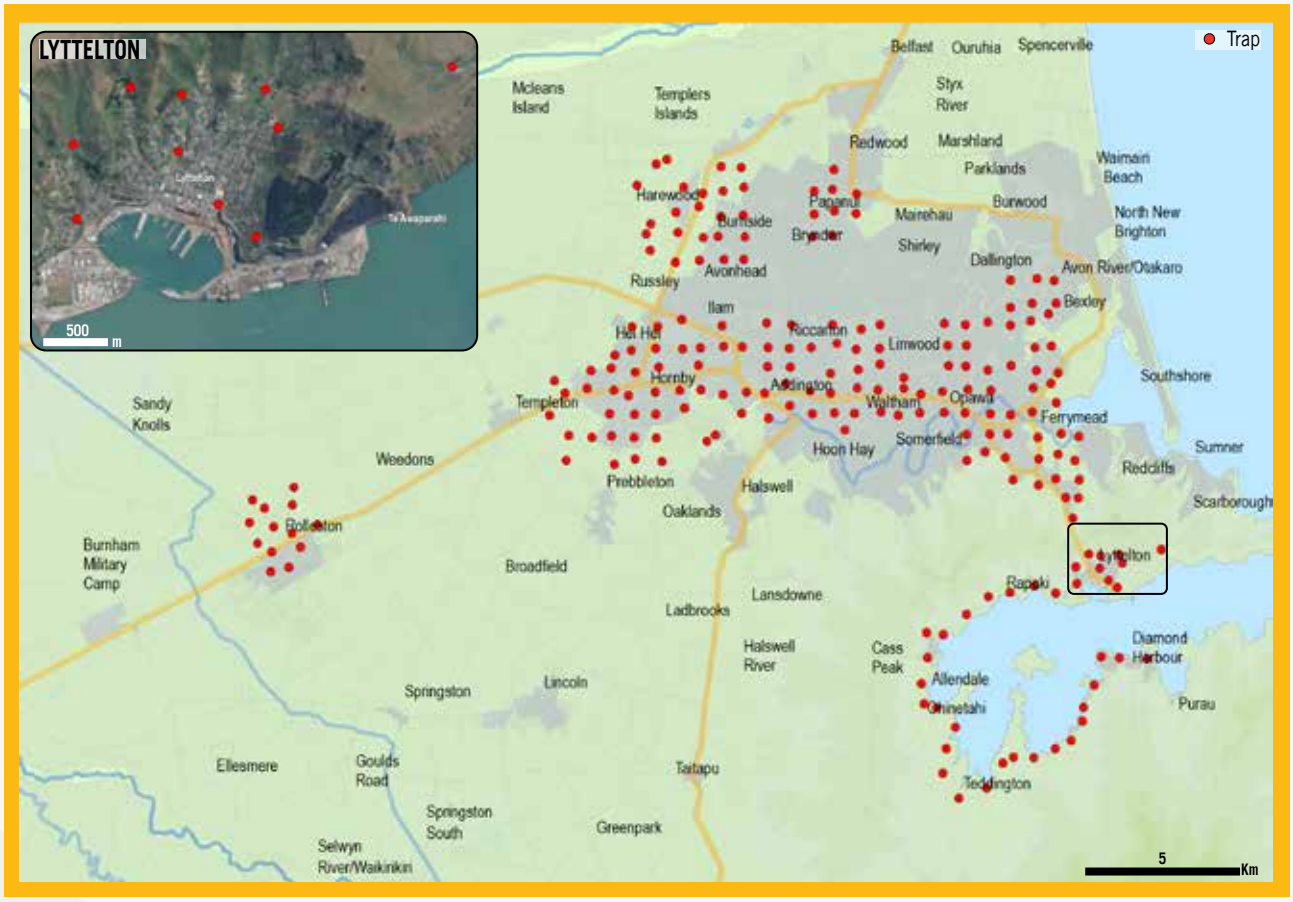
**Map 22: Gypsy moth surveillance programme – Auckland, 2018**




**Map 23: Gypsy moth surveillance programme – Wellington, 2018**



**Map 24: Gypsy moth surveillance programme – Christchurch, 2018**




**Map 25: Gypsy moth surveillance programme – Dunedin, 2018**

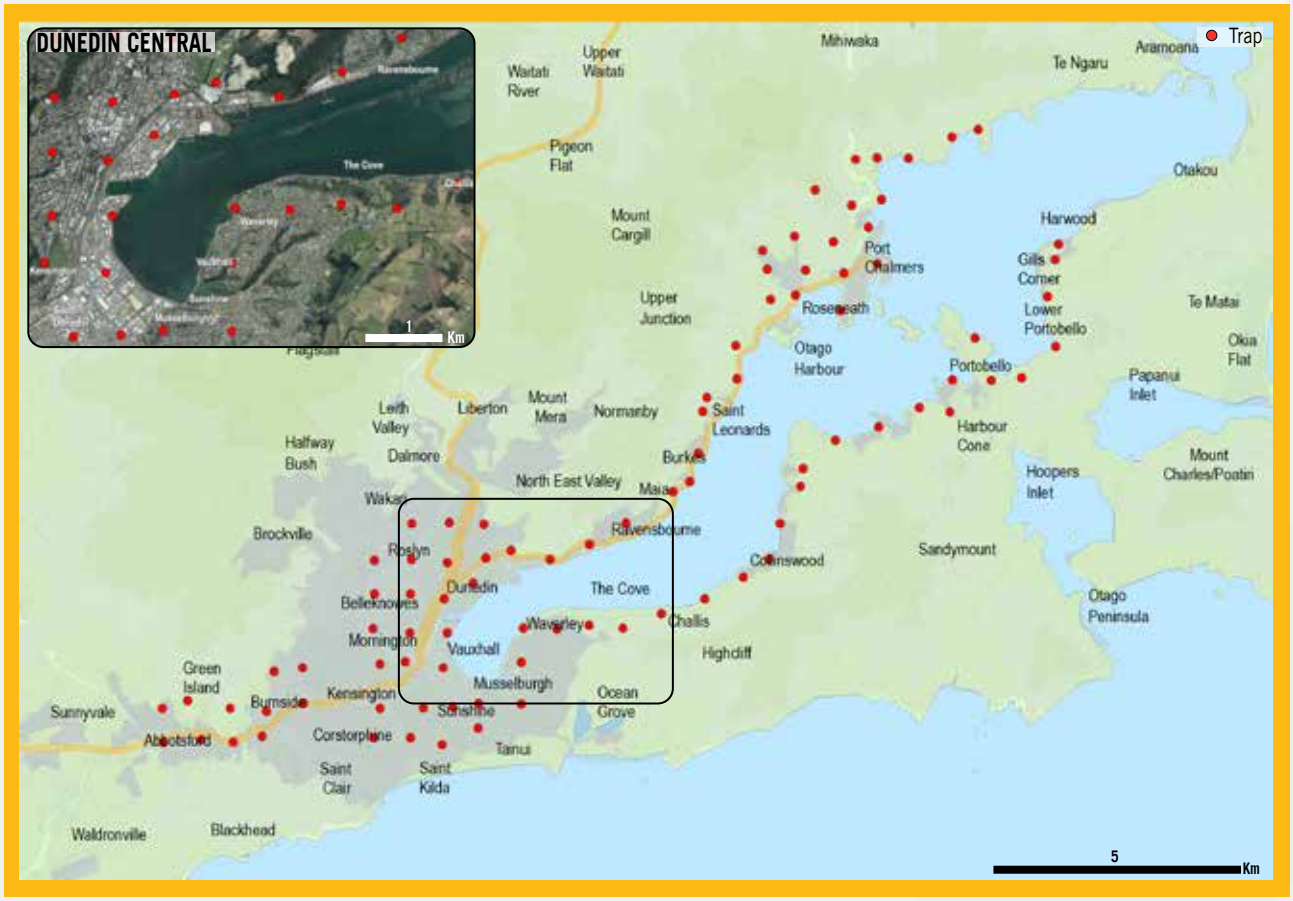


**Figure 31: Number of samples submitted per month between the 2010–2018, by region**

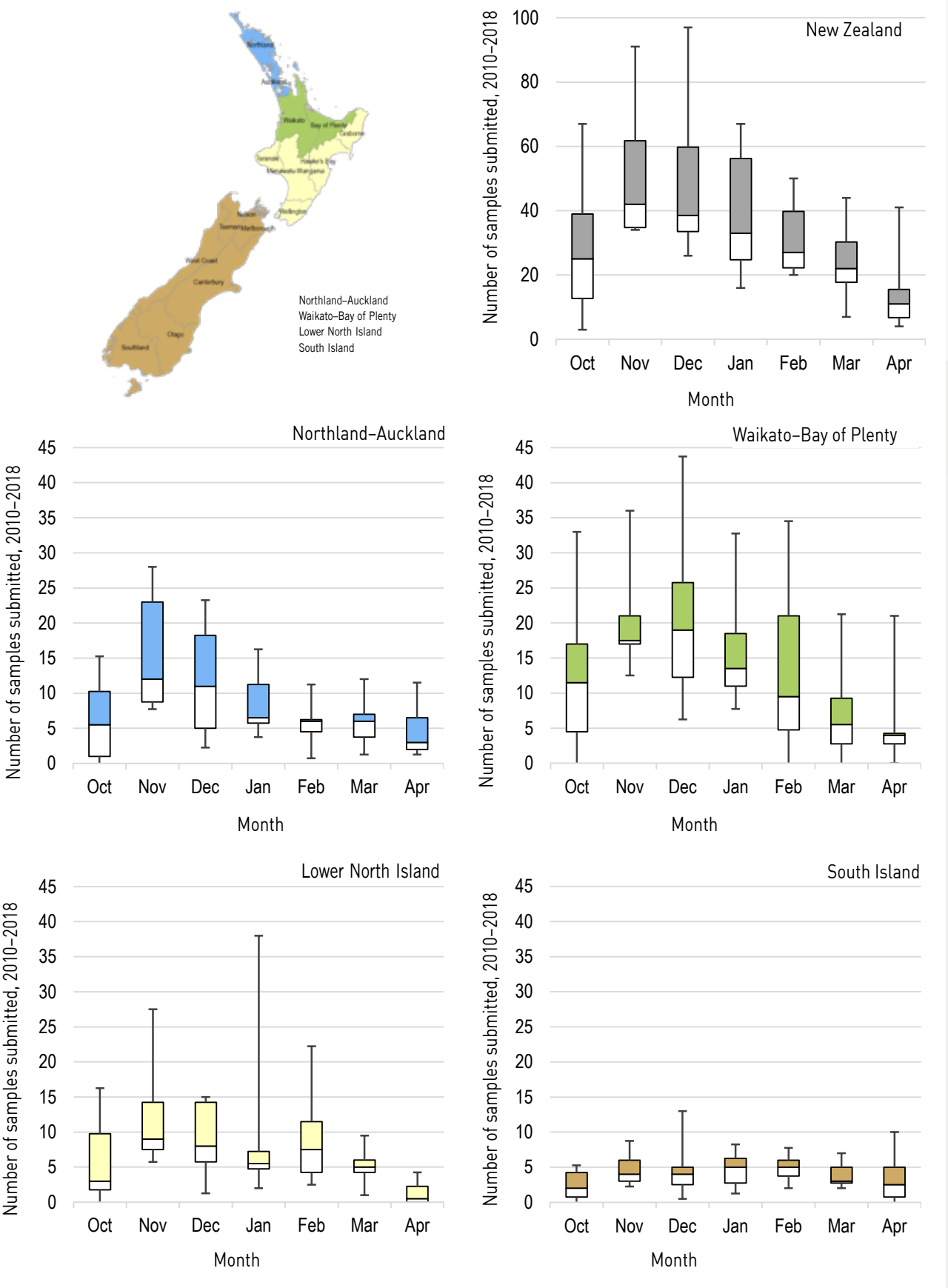
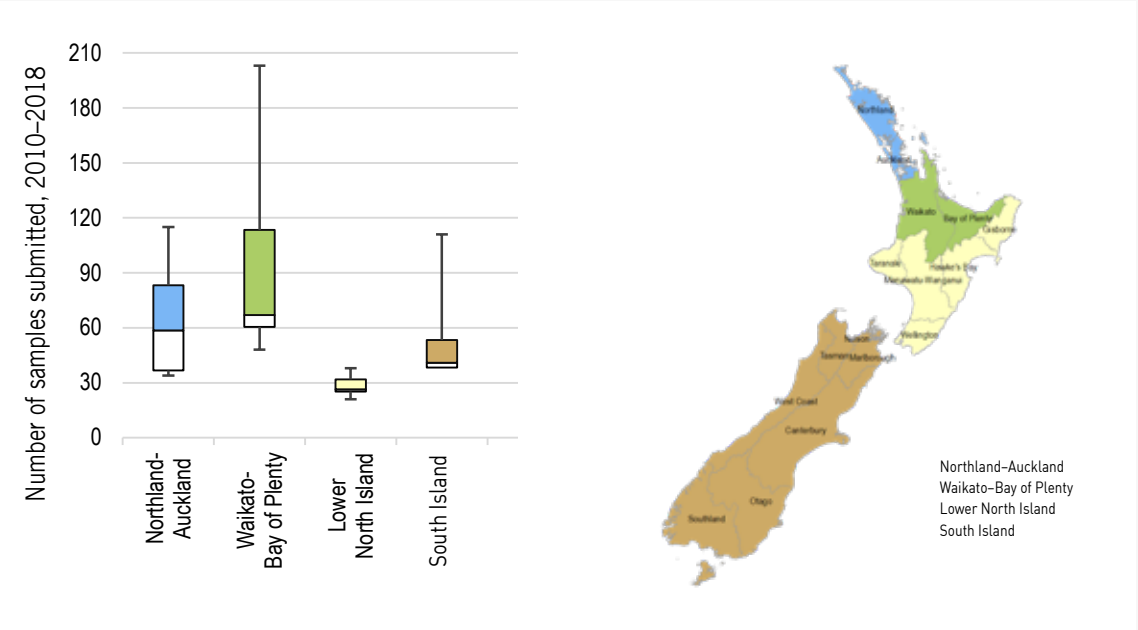


**Figure 32: Number of samples submitted per year between 2010–2018, by region**



## 2.14 Gypsy moth (*Lymantria dispar)*

The gypsy moth, *Lymantria dispar*, is one of the most significant insect pests both in its native and introduced regions (FAO 2009) (Map 26). It is a polyphagous species known to feed on hundreds of different trees species. Gypsy moth populations usually remain at low densities but occasionally they reach high densities (outbreaks). Feeding caterpillars can defoliate trees completely and during outbreaks the foliage of every tree in a forest can be stripped (Weseloh 2003).

### Life cycle

Gypsy moths have a 4-stage life cycle (Figure 33). Female moths lay eggs masses indiscriminately on living or inanimate objects. Egg masses, that can contain 100 to 1,000 eggs (Wallner 2000), are the most important stage when it comes to human-mediated dispersal. After hatching, gypsy moths grow through six larval stages or instars. First instar larvae can disperse by ballooning, usually in the direction of prevailing winds (Weseloh 1997). Late-instar larvae can disperse by crawling from tree to tree. Larvae pupate for about two weeks before adults emerge (Campbell et al. 1975).

### Identifying the gypsy moth *Lymantria dispar*

Gypsy moths have distinctive features. Adult males are brown to grey with dark markings in a scalloped pattern along the wing edge (Figure 34). They also have feathery (plumed) antennae. Female adults are white with small brown markings and are much larger than the males. Most New Zealand native moths that might show wing colour patterns and shapes similar to gypsy moths, such as *Dasypodia cymatodes*, are usually considerably smaller (Figure 34). Wing colours and shapes of larger New Zealand moths such as *Pantydia sparsa are* considerably different to those from gypsy moths.

**Figure 33. Life cycle of the gypsy moth *Lymantria dispar***

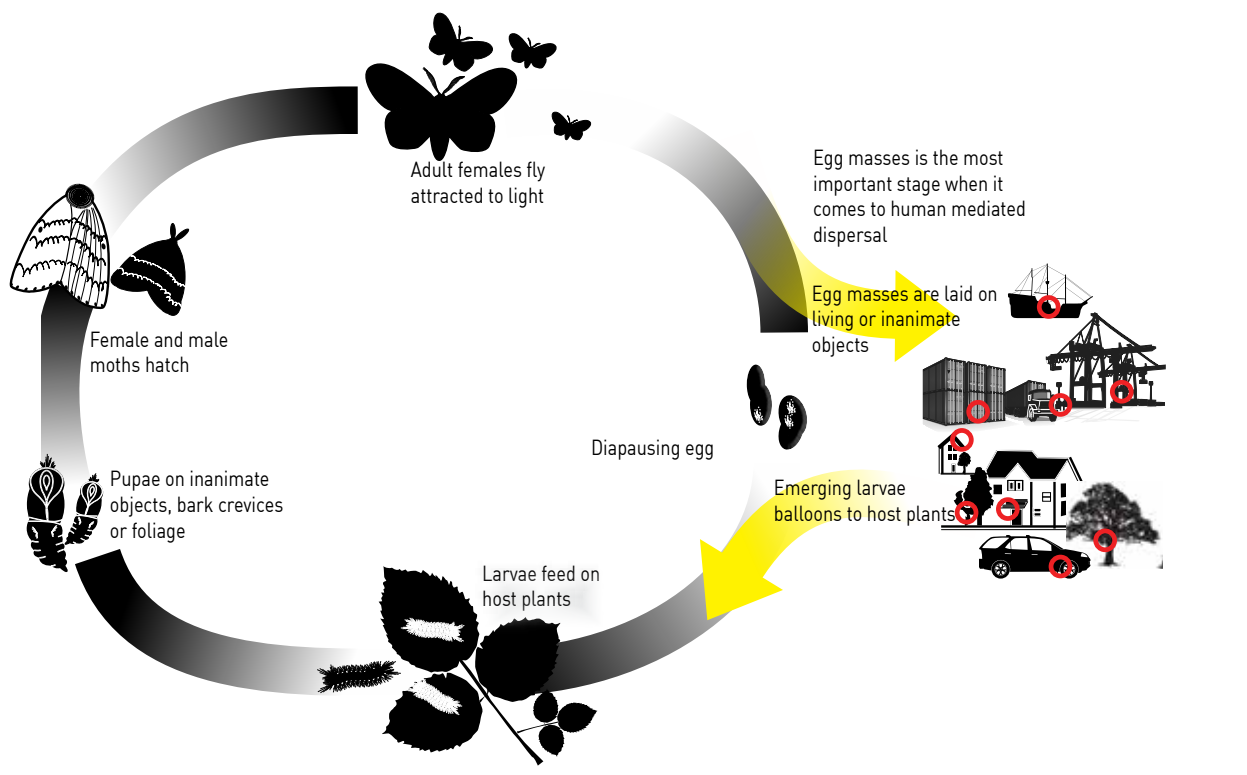
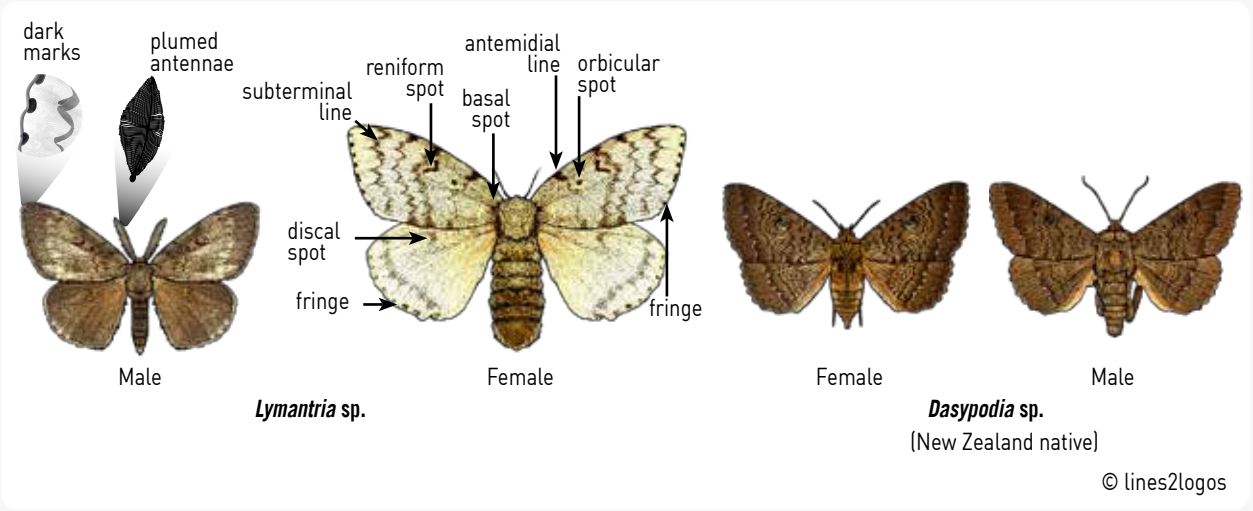
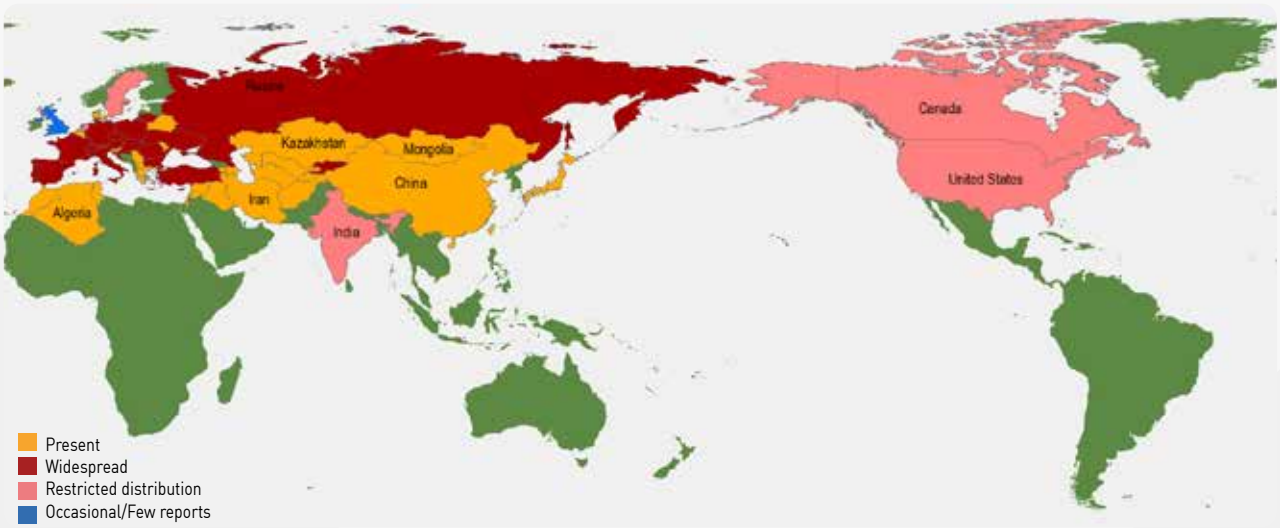


**Figure 34: Gypsy moth *Lymantria dispar* – identification features**




**Map 26: World distribution of *Lymantria dispar***




**Data source:** CABI, 2019. *Lymantria dispar* (gypsy moth). In: Invasive Species Compendium. Wallingford, UK: CAB International https://www.cabi.org/isc/datasheet/31807#toDistributionMaps. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 2.0 UK: England & Wales Licence.

## 2.15 High-risk site surveillance programme

### Target organism/s

All organisms that may pose a threat to exotic plantation forestry, urban and indigenous forest trees and shrubs, and tree fruit crops.

### Potential impacts

The range of potential impacts is species-specific but in general terms the presence of these pests could:

- have a devastating impact on the forestry and tree crops industries;
- lead to international trade restrictions (even potentially a complete ban) on New Zealand's forestry exports;
- affect vegetation including urban and rural trees, and native forest;
- impose a socioeconomic burden associated with control and eradication programmes.

### Introduction mechanisms

As with the impacts, the introduction mechanisms are species-specific but are mainly associated with shipping containers, passengers, international mail, aircraft and vessels.

### Surveillance programme

**Objectives:**

- to provide effective detections of pests of trees or shrubs;
- to assist with providing evidence of pest-free status or area freedom to trade partners;
- to monitor pest distribution and spread;
- to collect urban tree records to facilitate future host-specific surveys.

**Start**: 2005

**Methodology:** A set of transects has been defined around sites regarded as high risk because of their proximity to international airports, commercial seaports, transitional facilities, first-night tourist campsites and areas with a wide range of plants and tree species (Maps 27–31, Figure 35). Woody vegetation along these transects is visually inspected for presence and signs of non-indigenous organisms and diseases. Samples of all suspect organisms or vegetation showing signs of disease that could be new are collected and sent to the laboratory for identification (Table 1).

**Sampling:** All sites are sampled from September to May each year, as these are the times when new organisms are more likely to be growing and spreading. About 7000 transect inspections are carried out each year.

**Map 27: High-risk site surveillance programme, 2015**

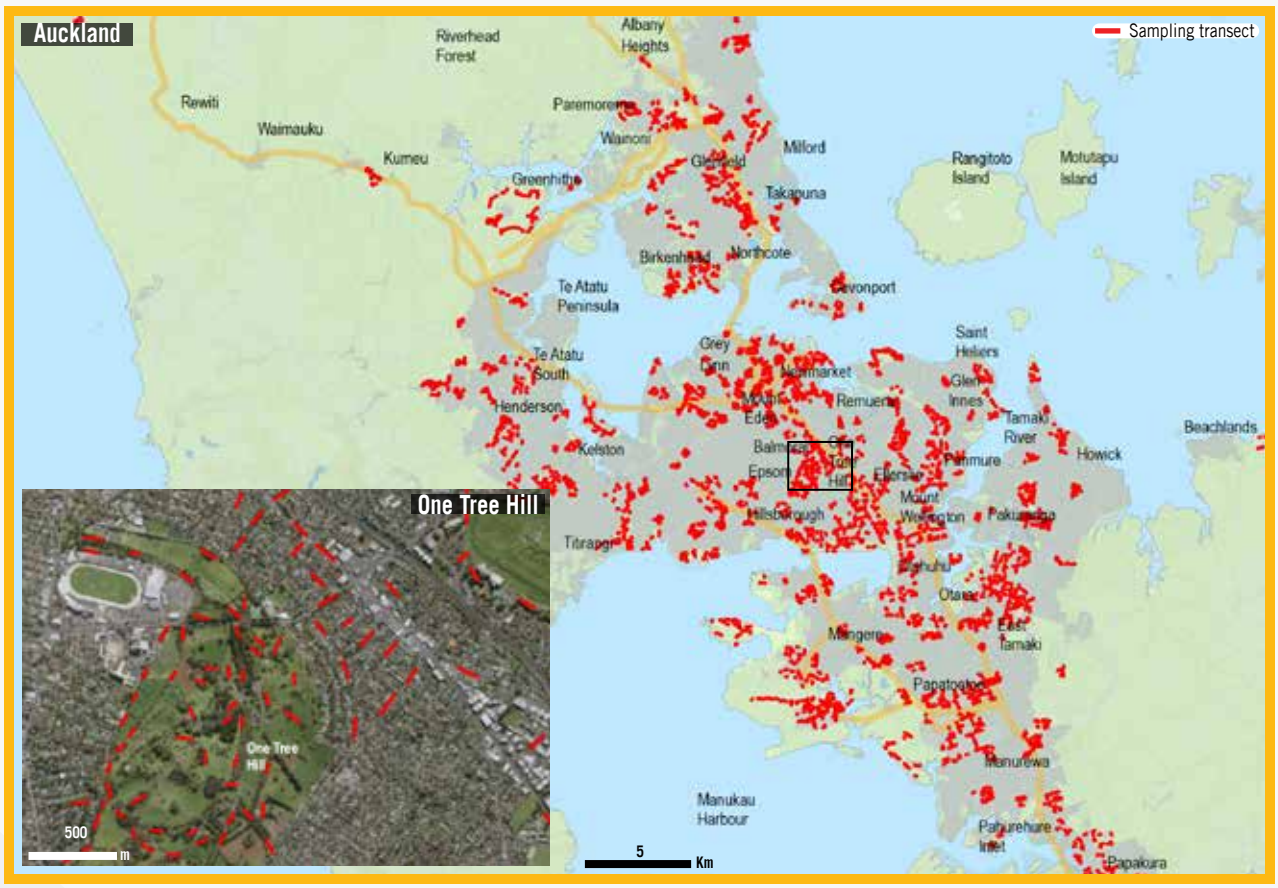

### Status

New Zealand is considered free from many diseases and pests of trees and forests that would be found by the programme if they entered the country. These include sudden oak death disease (caused by the oomycete *Phytophthora ramorum*), white-spotted tussock moth (*Orgyia thyellina*), painted apple moth *(Teia anartoides*), *Xyella fastidiosa* bacterium, and pine wilt nematode (*Bursaphelenchus xylophilus*).

### Incursions

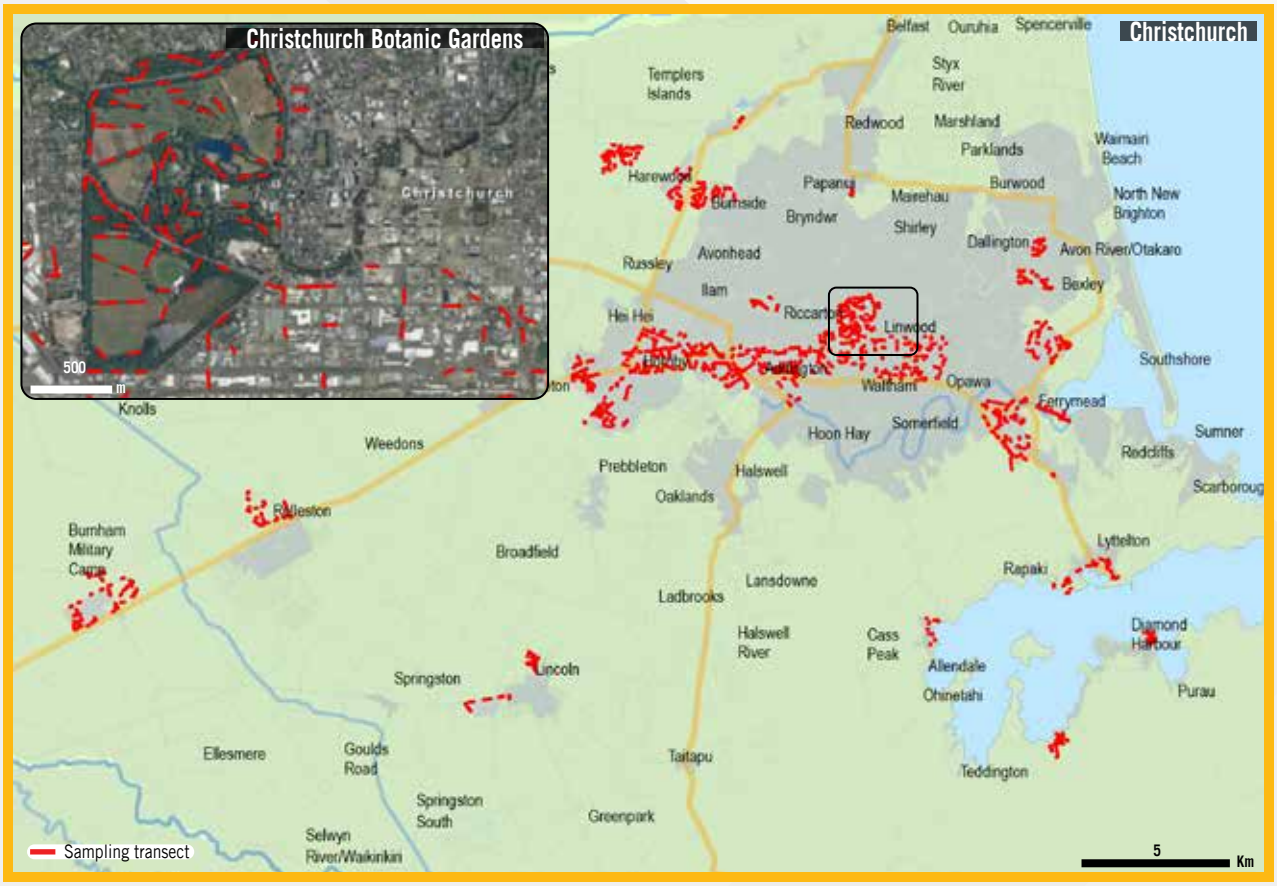
Each year at least two organisms new to New Zealand are found by the programme, which has also assisted in monitoring the spread of gum leaf skeletoniser (*Uraba lugens*) around the country. In addition, hundreds of new host and new bioregion reports on already-established organisms are made annually (Table 1). In 1999, before this programme started, the painted apple moth (*T. anartoides*) was found established in Auckland. This triggered an intensive control and eradication programme that lasted several years and cost New Zealand $65 million. In 2006 New Zealand was declared free from this pest.

**Map 28: High-risk site surveillance programme – Auckland, 2015**




**Map 29: High-risk site surveillance programme – Wellington, 2015**

**Map 30: High-risk site surveillance programme – Christchurch, 2015**




**Map 31: High-risk site surveillance programme – Dunedin, 2015**

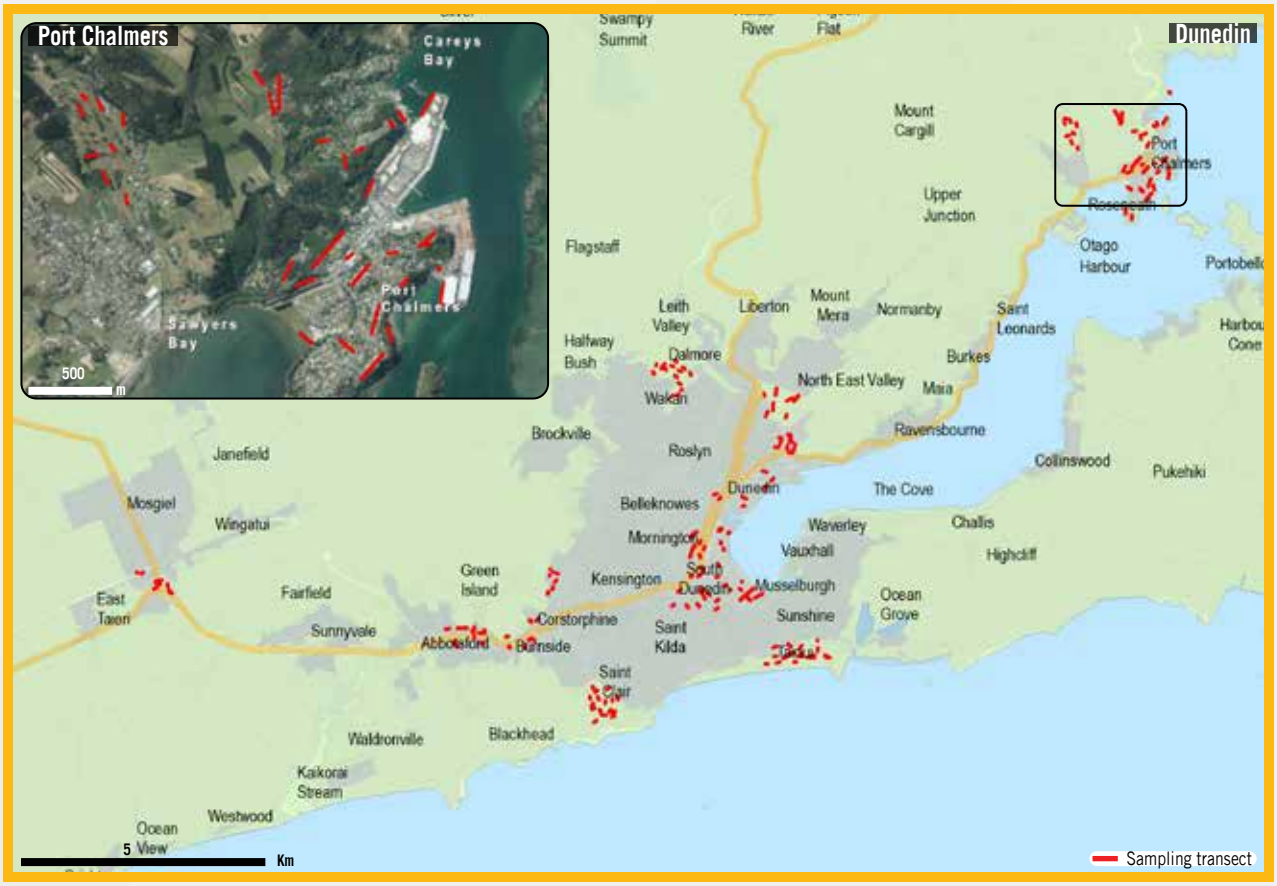


**Figure 35: Sampling transects**

At each sampling site, specially trained personnel conduct visual inspections of all the trees and shrubs present along the transects for signs or symptoms of diseases. The length of the transects varies between 9 metres and 370 metres, with most of them (>70 percent) within the 50–100 metres range.


## Table 1: Number of species and individual plants sampled by the programme between 2017 and 2018

Each year the high-risk site surveillance programme samples more than 1,000 species and nearly 250,000 specimens across New Zealand. Sampled specimens are classified in five groups based on their origin (native/non-native), use (production/not production) and type and size (tree/shrub).

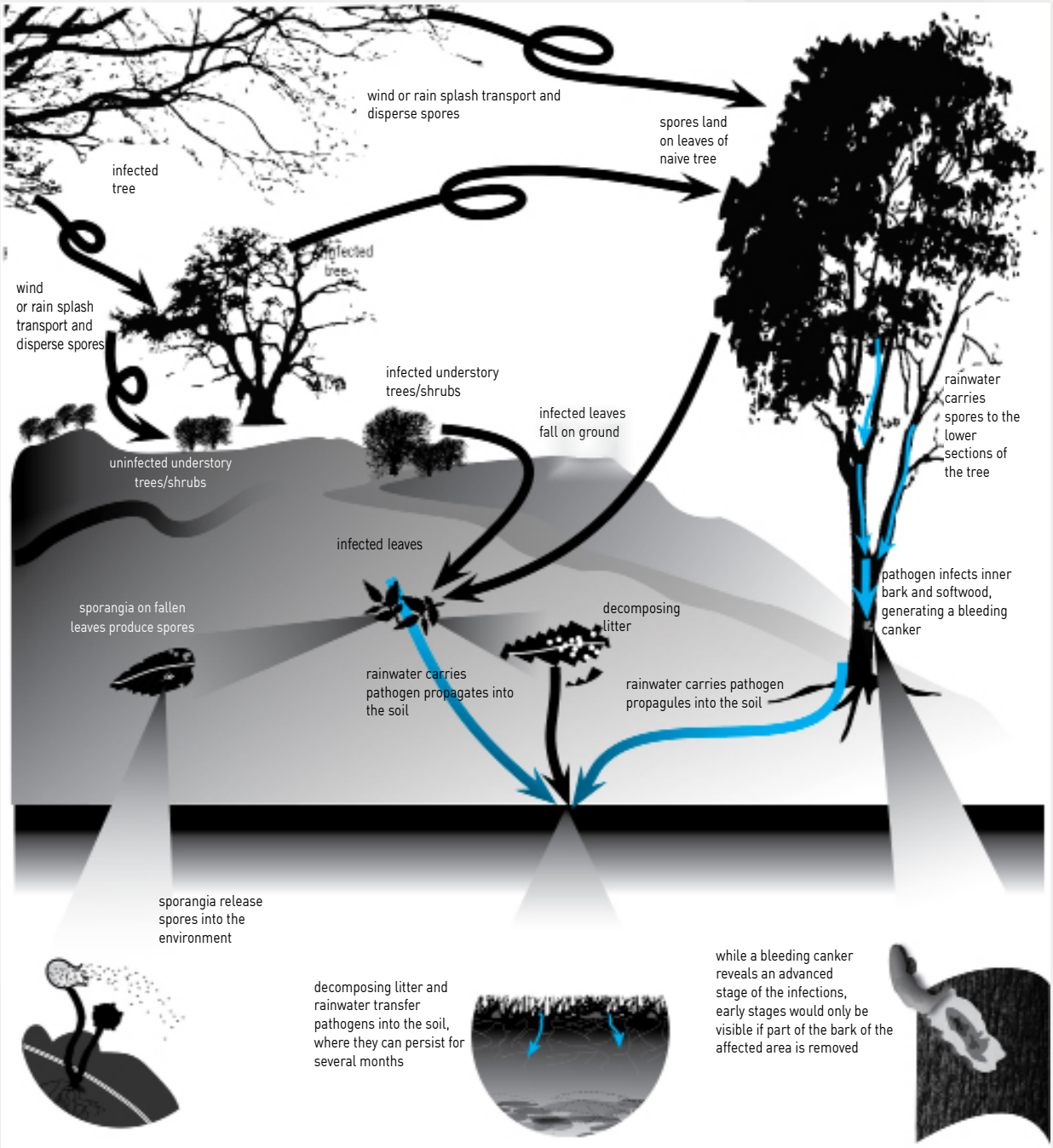
| Vegetation type | Number of species | Number of specimens | Examples |
|---|---|---|---|
| Production species<br>All species related to production forests, including *Pinus* and *Eucalypt* genera. | 75 | 9,177 | Macrocarpa (*Cupressus macrocarpa*)<br>Douglas fir (*Pseudotsuga menziesii*)<br>Cypress (*Cupressus lusitanica*) |
| Fruit trees<br>All tree species related to production of fruit for consumption. | 52 | 6,428 | Peach (*Prunus persica*)<br>European plum (*Prunus domestica*)<br>Feijoa (*Acca sellowiana*) |
| Native trees<br>All native species excluding production species. | 116 | 62,225 | Rimu (*Dacrydium cupressinum*)<br>Totara (*Podocarpus totara*)<br>Hard beech (*Fuscospora truncata*) |
| Native shrubs<br>Native ground cover to small trees. | 259 | 85,630 | Karamau (*Coprosma robusta*)<br>Red kaka beak (*Clianthus puniceus*)<br>Rangiora (*Brachyglottis repanda*) |
| Exotic trees<br>Non-native trees excluding production species. | 396 | 43,920 | Horse chestnut (*Aesculus hippocastanum*)<br>Balsam fir (*Abies balsamea*)<br>Sweet chestnut (*Castanea sativa*) |
| Exotic shrubs<br>Non-native ground cover to small trees. | 292 | 36,346 | Australian fireweed (*Senecio bipinnatisectus*)<br>Bindweed–black (*Fallopia convolvulus*)<br>Brush wattle (*Paraserianthes lophantha*) |

## 2.16 Sudden oak death

Sudden oak death (SOD) is a tree disease caused by the oomycete plant pathogen *Phytophthora ramorum*. This organism causes disease in more than 150 species of trees, shrubs, herbs and ferns, and prefers cool, wet climates. It could therefore establish in New Zealand and harm many of our introduced and native species. SOD has killed hundreds of thousands of oak trees in northern California and thousands of hectares of larch in the United Kingdom. It is also present in other parts of Europe and some parts of Asia (Map 32).

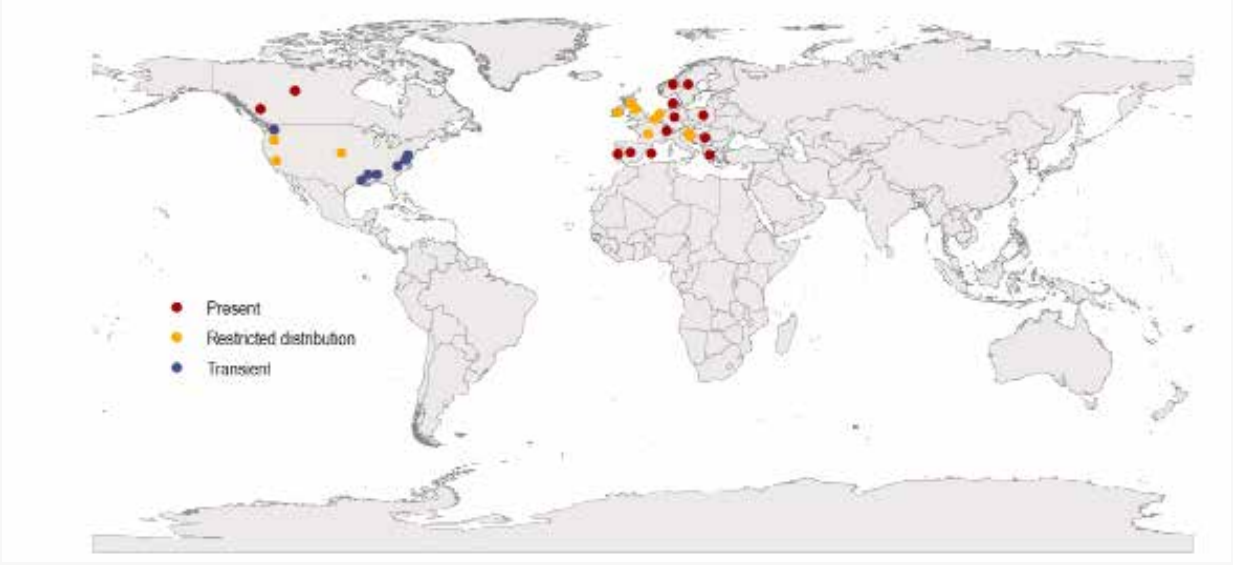
Signs of SOD depend on the tree species affected and it either causes trunk cankers and bleeding (Figure 37) or damage to the foliage (blight, spots and scorch) and branch dieback. Despite its name, death of the tree may take at least two years and affected trees do not always die. The fungus-like organism spreads by producing sporangia on infected leaves which are able to disperse to other trees via wind and rainwater (Figure 36). Rainwater carries the sporangia to lower parts of the tree where it can infect and damage the inner bark and sapwood. Infected leaves also fall to the ground, where the organism can persist in decomposing leaf litter and soil for several months. Wild animals and human activity, such as hiking and mountain biking, can therefore spread the disease further to other parts of the forest. Humans can also spread the disease by transporting infected plant material.

**Figure 36: Dispersal of sudden death oak disease caused by the oomycete *Phythopthora ramorum***




**Adapted** from Westchester Tree Life (2016) and Cave et al (2008).

**Map 32: Global distribution of sudden oak death**




**Data sourced** from CABI, 2019. Phytophthora ramorum (sudden oak death (SOD)). In: Invasive Species Compendium. Wallingford, UK: CAB International, https://www.cabi.org/isc/datasheet/40991#toDistributionMaps. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 2.0 UK: England & Wales Licence.

**Figure 37: Examples of trunk and foliage symptoms of sudden oak death**


**Photographs** by Joseph OBrien, USDA Forest Service, Bugwood.org. Licensed under a Creative Commons Attribution 3.0 License.
Sourced from: https://www.forestryimages.org/browse/detail.cfm?imgnum=5040082

## 2.17 Marine high-risk surveillance programme

### Target organism/s

Non-indigenous marine organisms listed on the Unwanted Organism Register. This includes five primary species that have never been recorded in New Zealand and four secondary species that currently have a restricted distribution in New Zealand.

Primary species include:

- Asian clam (*Potamocorbula amurensis)**
- Chinese mitten crab (*Eriocheir sinensis*)*
- European shore crab (*Carcinus maenas*)*
- Northern Pacific seastar (*Asterias amurensis*)*
- marine aquarium weed (*Caulerpa taxifolia*)*

Secondary species include:

- Asian date mussel (*Arcuatula senhousia*)
- Australian droplet tunicate (*Eudistoma elongatum*)
- clubbed tunicate (*Styela clava*)
- Mediterranean fanworm (*Sabella spallanzanii*)*

### Potential impacts

The introduction of non-indigenous marine organisms has the potential to affect values in coastal and marine environments as a result of:

- increased predation and competition for food, habitat and space;
- alteration of habitat and nutrient cycling;
- introduction of new diseases;
- reduced endemic biodiversity.

### Introduction mechanisms

Introductions of non-indigenous marine organisms is predominantly through the entry of international vessels with hull biofouling[7] being the major pathway followed by ballast water[8]. Other pathways include used marine and aquaculture equipment, fish bait and the ornamental fish trade.

*Notifiable organisms under the Biosecurity Act 1993.

**Map 33: National marine high risk site surveillance programme**


### Surveillance programme

**Objectives:**

- to detect incursions of new-to-New Zealand non-indigenous organisms listed on the Unwanted Organism Register;
- to detect incursions of new-to-New Zealand non-indigenous organisms or cryptogenic[9] organisms not listed on the Unwanted Organism Register;
- to detect range extensions of established non-indigenous or cryptogenic organisms that exhibit characteristics of pests and diseases.

**Start:** 2002

**Methodology:** Underwater dive searches, crab condos, crab box traps, benthic sled tows and shore searches are used to detect suspect organisms at 11 locations throughout New Zealand (Maps 33–36, Table 2). These locations were selected as they are the ports of first entry for international vessels and are at highest risk of introduction of non-indigenous marine organisms.

7 Accumulation of organisms (for example, algae, invertebrates) on wetted structures of vessels (for example, hull, intake pipes).
8 Fresh or salt water stored in special tanks for stability purposes. Ballast water is usually taken in or released during loading operations at ports.

9 Species whose origin cannot be clearly classified as either indigenous or non-indigenous.

**Sampling:** All locations are surveyed using a systematic rotational approach to ensure appropriate spatial and temporal replication. Each location is surveyed twice every 12 months (winter and summer sampling periods), totalling around 6,000 sites sampled per survey year (Figures 39 and 40). Sites are selected using environmental modelling relevant to target organisms.

## Status

One notified organism on the Unwanted Organisms Register has been introduced to New Zealand: the Mediterranean fanworm (*Sabella spallanzanii*). It was first detected in Lyttelton Harbour in 2008 and later in the Waitemata Harbour as an established population. *Sabella* has also been detected from Opua, Whangarei, Coromandel Peninsula, Tauranga, Gisborne, Wellington, Nelson and Picton (Figure 40).

## Incursions

Over 350 non-indigenous species have been identified across New Zealand, with more than 180 of these considered established (Ministry for the Environment & Statistics New Zealand, 2016). These include other high profile species such as the Asian kelp *Undaria pinnatifida*, Asian paddle crab *Charybdis japonica* and the Australian droplet tunicate *Eudistoma elongatum* (Figure 40).

**Table 2: Sampling methods used by the national marine high risk surveillance programme**

The National Marine High-Risk Site Surveillance programme uses a range of sampling methods that ensure potential habitats for the target species are surveyed. Sampling methods are habitat, organism and life stage specific.

| | | Sampling methods | | | | |
|---|---|---|---|---|---|---|
| Target | | Epibenthic sled tows | Crab (box) traps | Crab condos | Diver searches | Shoreline searches |
| Species – Primary | Asian clam (*Potamocorbula amurensis*) | ■ | | | | |
| | Chinese mitten crab (*Eriocheir sinensis*) | | ■ | ■ | | ■ |
| | European shore crab (*Carcinus maenas*) | ■ | ■ | ■ | ■ | ■ |
| | Northern Pacific seastar (*Asterias amurensis*) | ■ | ■ | | ■ | ■ |
| | Marine aquarium weed (*Caulerpa taxifolia*) | ■ | | | ■ | |
| Species – Secondary | Asian date mussel (*Arcuatula senhousia*) | ■ | | | ■ | ■ |
| | Australian droplet tunicate (*Eudistoma elongatum*) | ■ | | | ■ | ■ |
| | Clubbed tunicate (*Styela clava*) | ■ | | | ■ | ■ |
| | Mediterranean fanworm (*Sabella spallanzanii*) | ■ | ■ | | ■ | ■ |

**Figure 38: Total number of sites for all locations sampled by season by the marine high-risk site surveillance programme, 2010–2018**

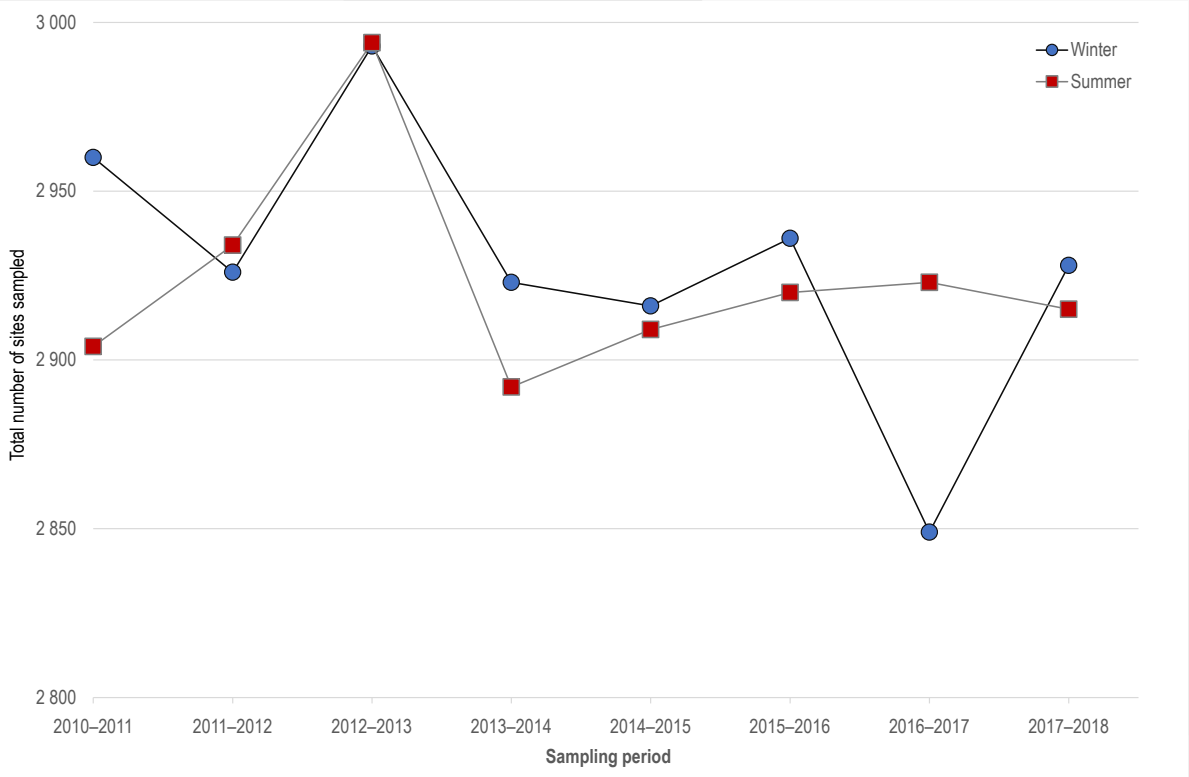
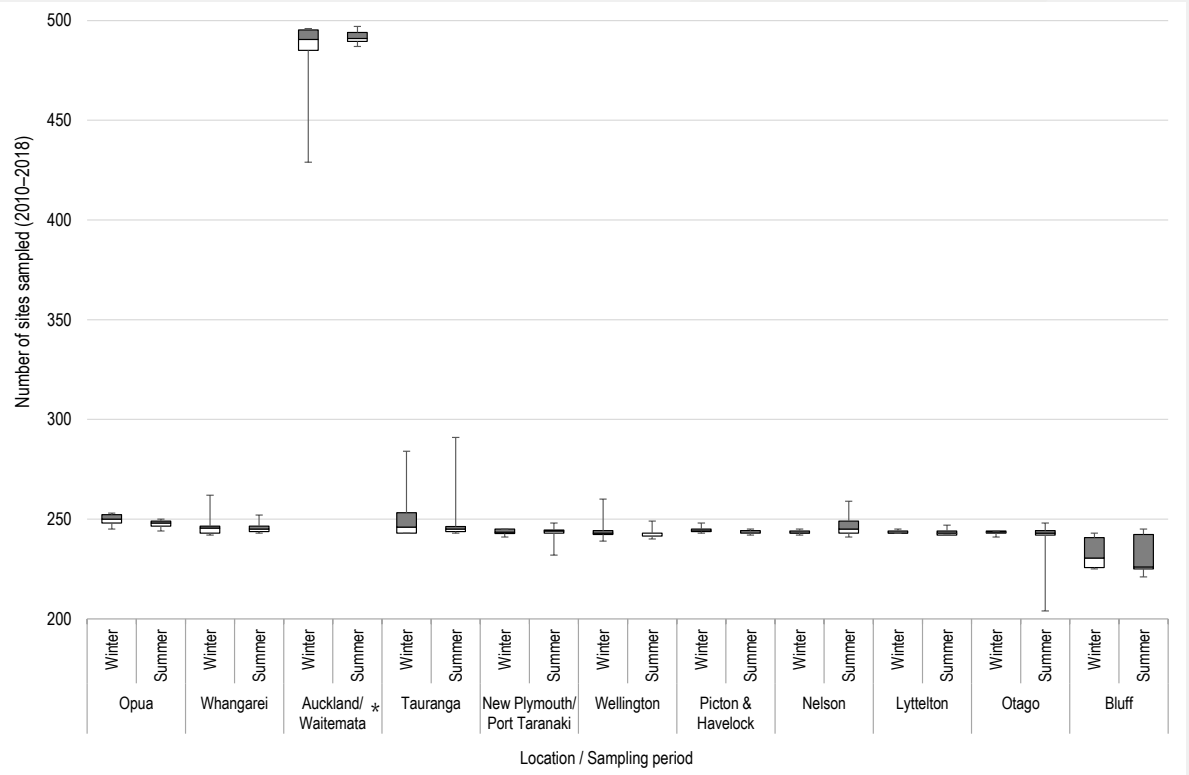
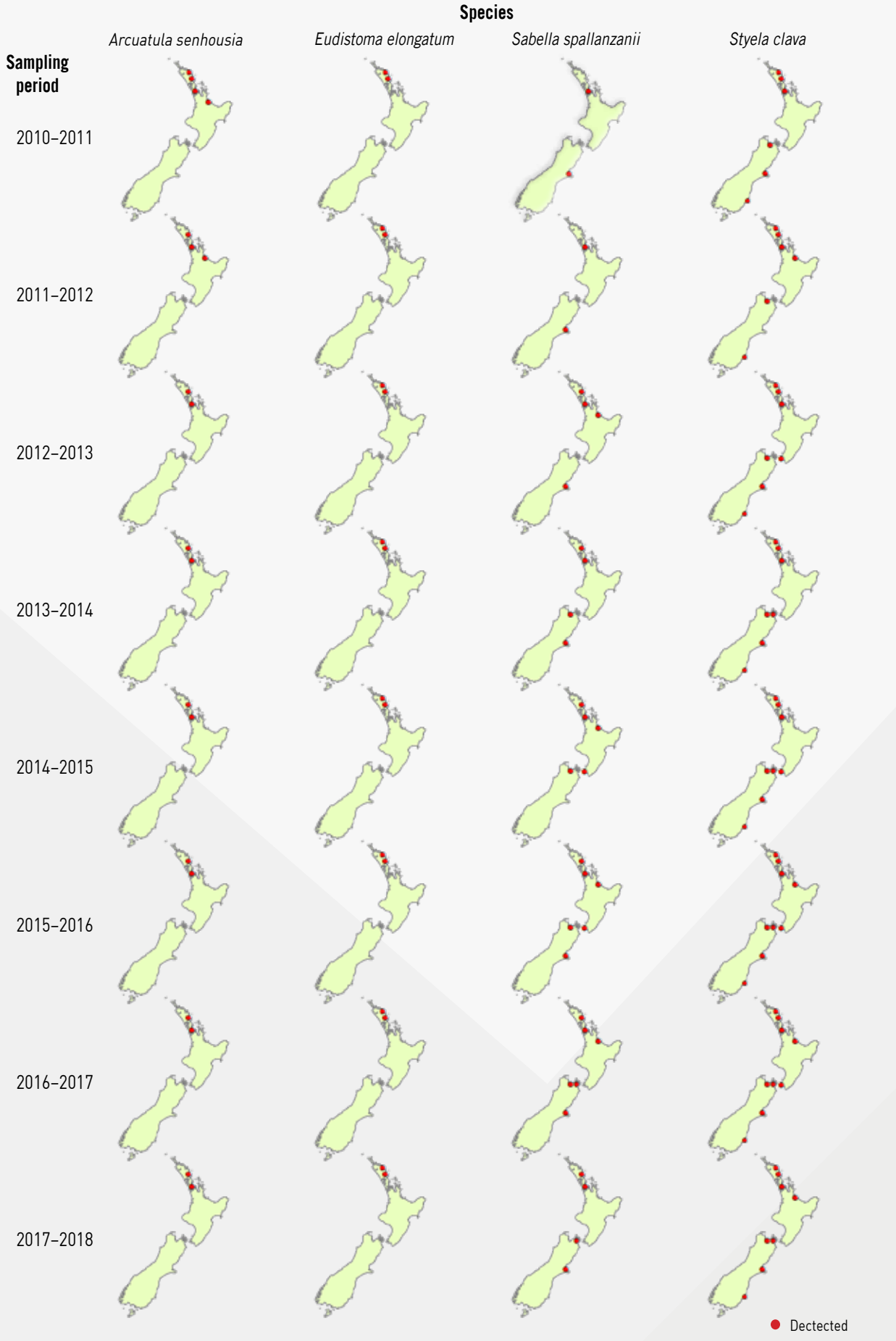



**Figure 39: number of sites sampled by the national marine high-risk site surveillance programme by season at each location, 2010–2018**

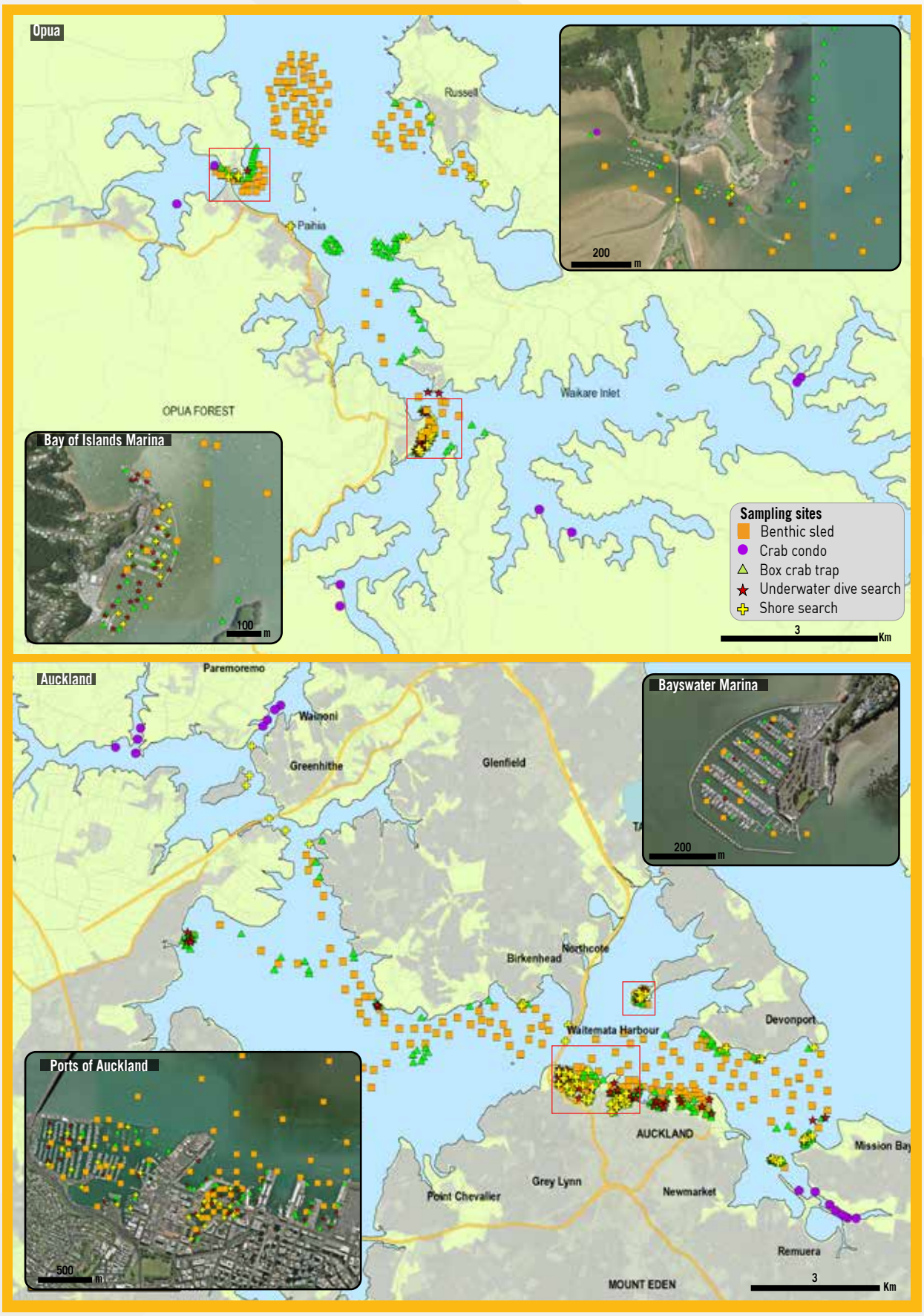



*The survey effort here is double compared with all other locations due to the high number of international vessel arrivals

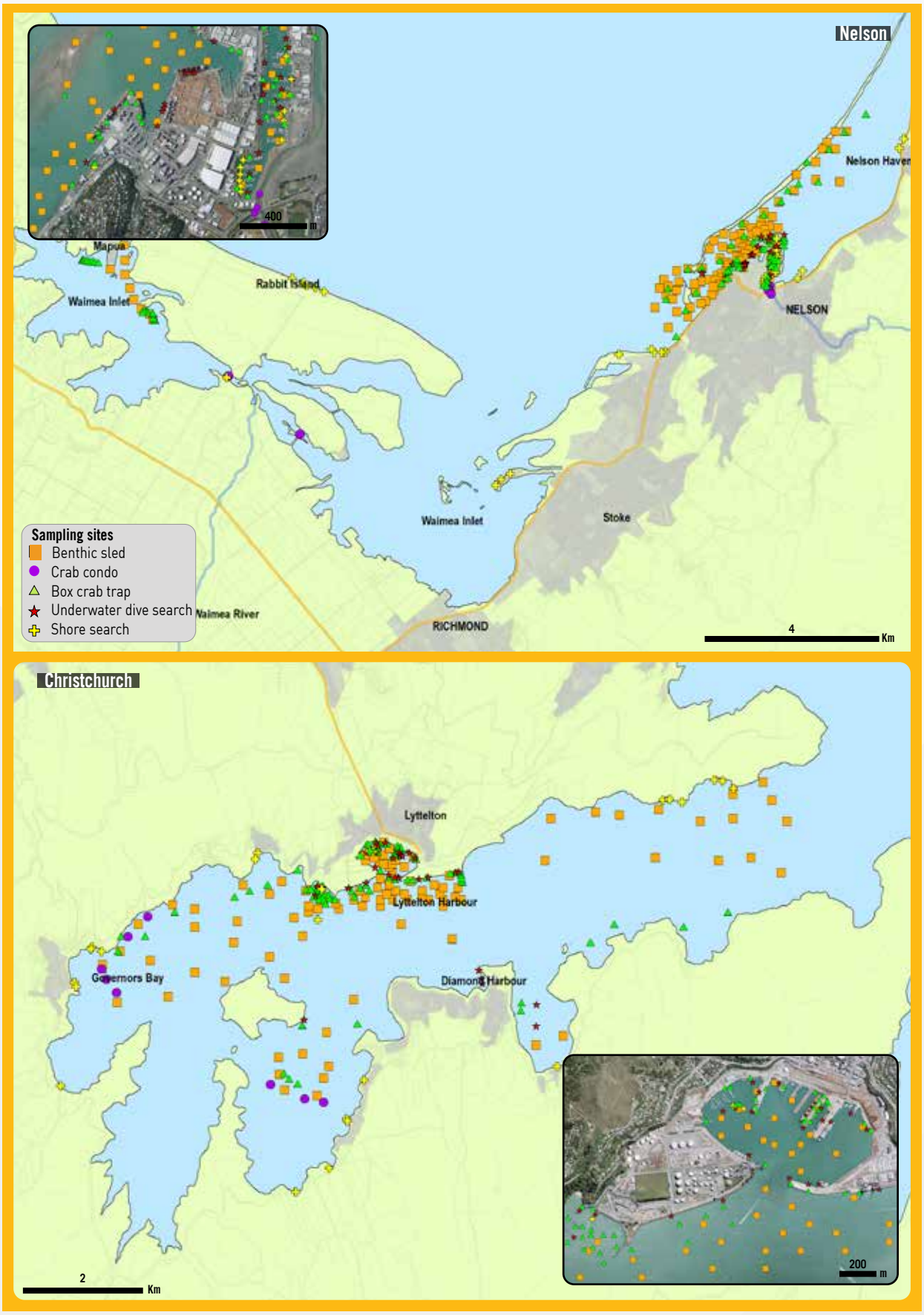
**Figure 40: Secondary target species detected by the marine high risk site surveillance programme, 2010–2018**



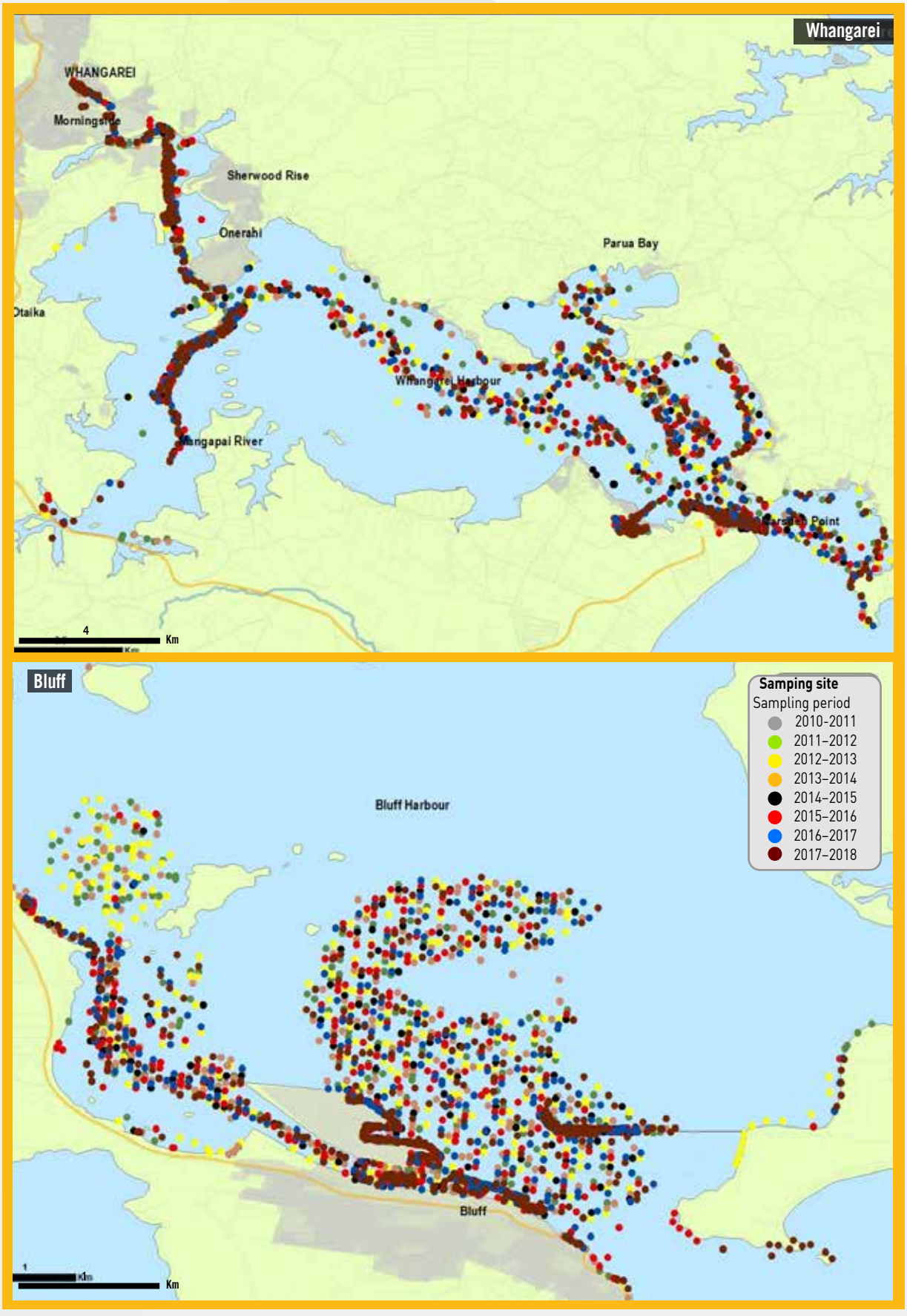
**Map 34: National marine high-risk site surveillance programme – Opua and Auckland, winter 2018**



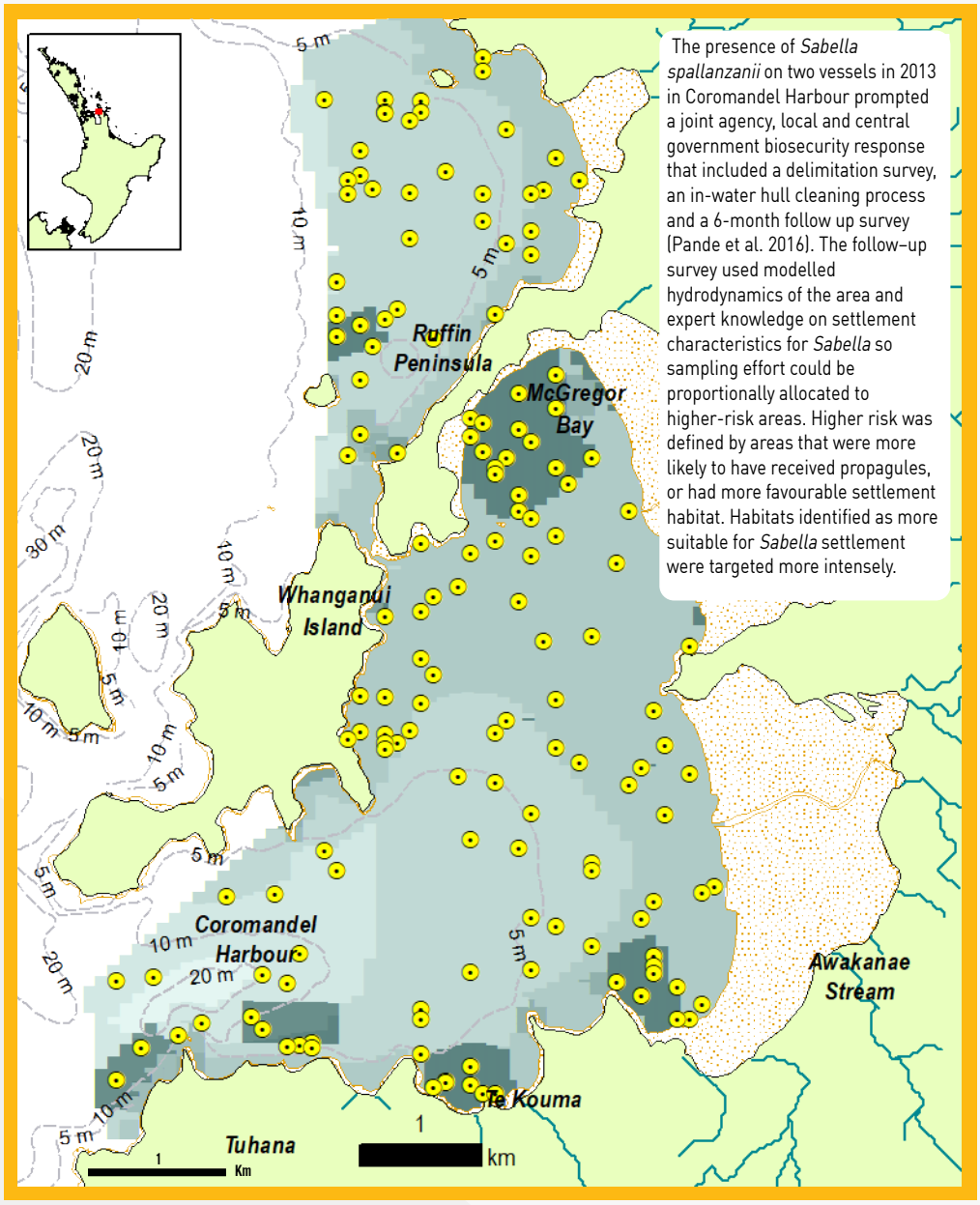
**Map 35: National marine high-risk site surveillance programme – Nelson and Christchurch, winter 2018**



**Map 36: National marine high-risk site surveillance programme – Whangarei and Bluff, 2011–2018**



**Map 37: Follow–up survey for *Sabella spallanzanii* in Coromandel peninsula, 2013.**




The presence of *Sabella spallanzanii* on two vessels in 2013 in Coromandel Harbour prompted a joint agency, local and central government biosecurity response that included a delimitation survey, an in-water hull cleaning process and a 6-month follow up survey (Pande et al. 2016). The follow–up survey used modelled hydrodynamics of the area and expert knowledge on settlement characteristics for *Sabella* so sampling effort could be proportionally allocated to higher-risk areas. Higher risk was defined by areas that were more likely to have received propagules, or had more favourable settlement habitat. Habitats identified as more suitable for *Sabella* settlement were targeted more intensely.

## 2.18 National invasive ant surveillance programme

### Target organism/s

All non-native ants, but in particular those known to be invasive such as the:

- red imported fire ant (*Solenopsis invicta*);
- tropical fire ant (*Solenopsis geminata*);
- black crazy ant (*Paratrechina longicornis*);
- yellow crazy ant (*Anoplolepis gracilipes*);
- little fire ant (*Wasmannia auropunctata*);
- ghost ant (*Tapinoma melanocephalum*);
- carpenter ant (*Camponotus* spp.);
- Singapore ant (*Trichomyrmex destructor*).

### Potential impacts

A number of ant species are known to be invasive and are environmental, economic and nuisance pests. Impacts are species-specific but include:

- ecosystem disruption;
- impacts on native fauna;
- impacts on horticulture;
- damage to electrical wiring and machinery;
- house infestation;
- bites and stings, especially when nests are disturbed.

### Introduction mechanisms

Ants are very good "hitch-hiker" species and are often transported on inanimate objects including machinery, personal effects, used vehicles and shipping containers.

### Surveillance programme

**Objectives:**

- to detect newly established nests of exotic or non-native ant species at high-risk sites around New Zealand;
- to identify changes in distribution of non-indigenous ant species already established in New Zealand, for reporting purposes.

**Start:** 2003

**Methodology:** Annual targeted surveys are conducted in sites identified as likely points of entry for exotic ant species such as seaports, marinas, international airports and transitional facilities (Maps 38–40). Pottles with attractant baits are laid at sites where ants are likely to be present. Attractant baits contain both a carbohydrate (sugar solution) and protein source (peanut butter and sausage meat). The use of both carbohydrate and protein maximises the chances of catching foraging exotic ants of different species. Ants caught are sent to the laboratory for identification.

**Sampling:** All sites are sampled during summer, when ants are more likely to be foraging.

**Map 38: National invasive ant surveillance programme, 2018**


### Status

None of the above targeted ants are present in New Zealand.

### Incursions

Over 15 years of operation, the programme has detected numerous ant incursions from several species at ports and transitional facilities around the country (Table 3, Map 41). In each case, early detection by the programme meant eradication has been easily achieved without the need for a full-scale response.

**Map 39: National invasive ant surveillance programme – Auckland and Wellington, 2018**

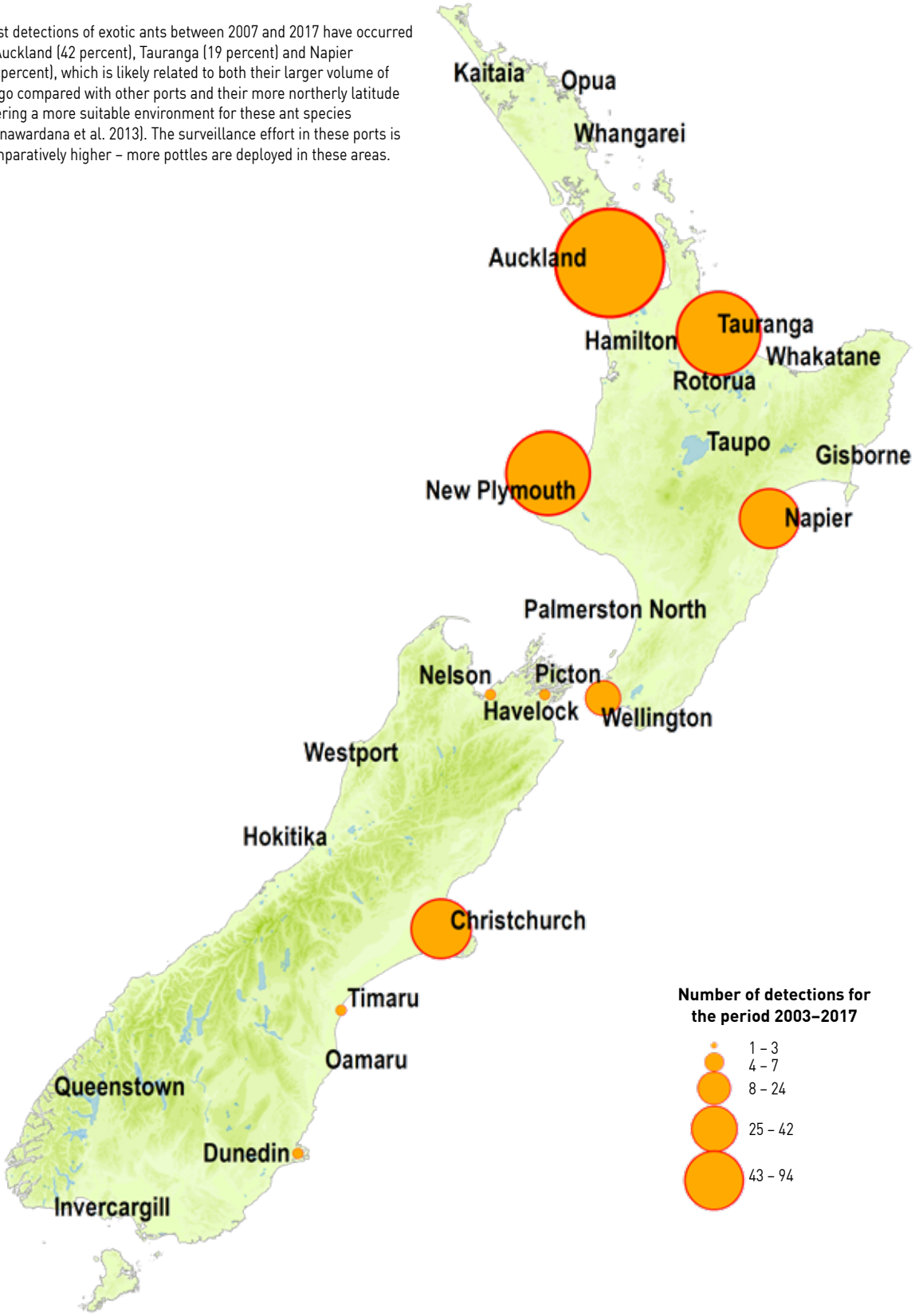
**Map 40: National invasive ant surveillance programme – Christchurch and Dunedin, 2018**

**Table 3: Exotic ants detected by the programme, 2003–2018**

| | LOCATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Opua | Auckland | Tauranga | Napier | New Plymouth | Nelson | Wellington | Picton | Christchurch | Timaru | Otago |
| *Anoplolepis gracilipes* | | ■ | | | | | | | | | |
| *Brachymymex obstructor* | | ■ | | | | | | | | | |
| *Camponotus* sp. | | ■ | | | | | | | | | |
| *Iridomyrmex* sp. | | | | ■ | ■ | | | | | | |
| *Trichomyrmex destructor* | | ■ | ■ | ■ | | ■ | ■ | | ■ | ■ | ■ |
| *Monomorium dichroum* | | ■ | ■ | ■ | | | | | ■ | ■ | ■ |
| *Monomorium floricola* | | ■ | | ■ | | | | | | | |
| *Monomorium indicum* | | | | | | | | | ■ | | |
| *Monomorium smithii* | | | | | | | | | ■ | | |
| *Monomorium* sp. | | ■ | ■ | ■ | | | | | ■ | ■ | |
| *Ochetellus glaber* | | ■ | | | | | | | | | |
| *Pachycondyla castenicolor* | | | | | | | | ■ | | | |
| *Paratrechina longicornis* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | | ■ |
| *Paratrechina* sp. | | ■ | ■ | | | | | | | | |
| *Pheidole rugosula* | | | ■ | | | | | | | | |
| *Pheidole vigilans* | | ■ | | | | | | | | | |
| *Solenopsis invicta* | | | | ■ | | | | | | | |
| *Solenopsis geminata* | | ■ | ■ | ■ | | | | | | | |
| *Solenopsis* sp. | | ■ | | | | | | | | | |
| *Tapinoma melanocephalum* | ■ | ■ | ■ | ■ | | ■ | ■ | | ■ | | |
| *Tapinoma sessile* | | | | ■ | | | | | | | |

## Map 41: Number of exotic ants detected by the programme, 2007–2017

Most detections of exotic ants between 2007 and 2017 have occurred in Auckland (42 percent), Tauranga (19 percent) and Napier (15 percent), which is likely related to both their larger volume of cargo compared with other ports and their more northerly latitude offering a more suitable environment for these ant species (Gunawardana et al. 2013). The surveillance effort in these ports is comparatively higher – more pottles are deployed in these areas.



## 2.19 Red imported fire ant *Solenopsis invicta*

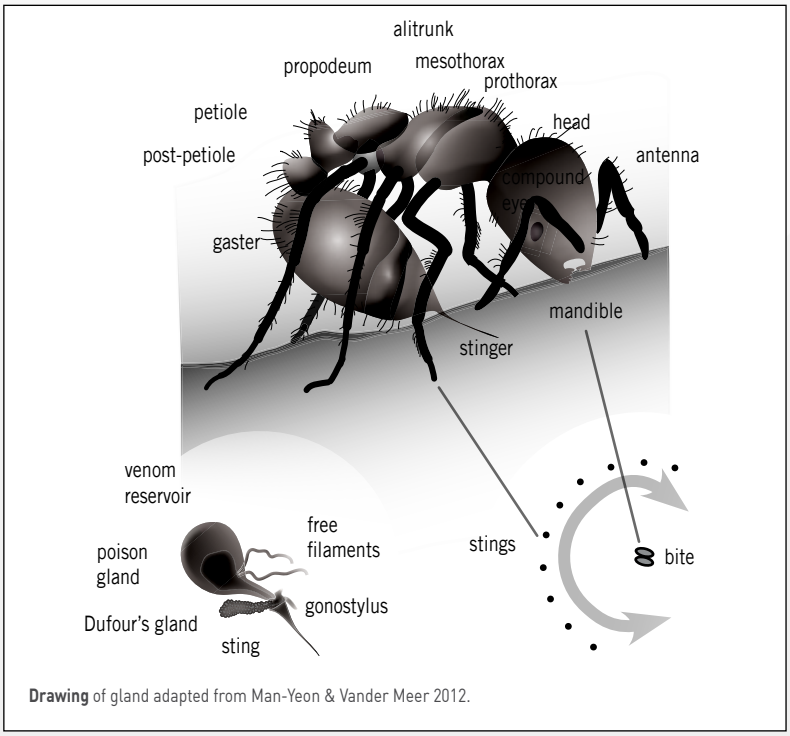
Fire ants belong to the genus *Solenopsis* and are well-known for their aggressiveness and potent sting. Despite the large variation in size among its species, the *Solenopsis* genus is relatively easy to identify. Key identification features include: four-tooth mandible, antennae with 10 segments (last two elongated in a club shape), no protuberances or spines on the alitrunk, a well-developed sting, and sculpture absent or restricted to rugulae or striae on the head, alitrunk, petiole, and postpetiole (MacGown and Whitehouse 2016) (Figure 41). In contrast, identification of fire ants to species level is challenging, especially as hybridisation between populations is known to occur (Tschinkel 2006, Ross et al. 2010).

The red imported fire ant (RIFA) *Solenopsis invicta* is a generalist predator and scavenger that forms colonies that can become extremely invasive. Mature colonies can have one queen (monogyne) or many queens (polygyne) and between 200,000 – 300,000 workers (Klotz et al. 2003). RIFA is highly aggressive and have painful bite and a sting capable of producing anaphylaxis and on rare occasions even death (Lofgren et al. 1975). In areas where RIFA become established and abundant, such allergic reactions are likely to pose a serious public health problem, as it has been determined in some southern provinces in mainland China (Xu et al. 2012). RIFAs can sting more than once without dying or losing their sting as is the case with bees (Nunnelee 2005). When stinging, the worker first uses its mandibles to bite and anchor its body to the tissue, causing a pricking sensation (Figure 41). The ant then arches its back and stings repeatedly in a circular pattern, pivoting around the anchored head (Hedges 1998).

The complete lifecycle of *S. invicta* takes between 22 and 38 days and follows four stages: eggs, larvae with four instars, pupae and adults (Hedges 1997). The body of this species is usually red to brown with a black gaster (Figure 41). Males and females are winged ('reproductive alates') and mating occurs above the ground during mating flights at between 90–250 m of altitude. Males die soon after mating. Ant workers have a stinger at the tip of their gaster and show polymorphism, with their size varying between 2.4 to 6 mm.

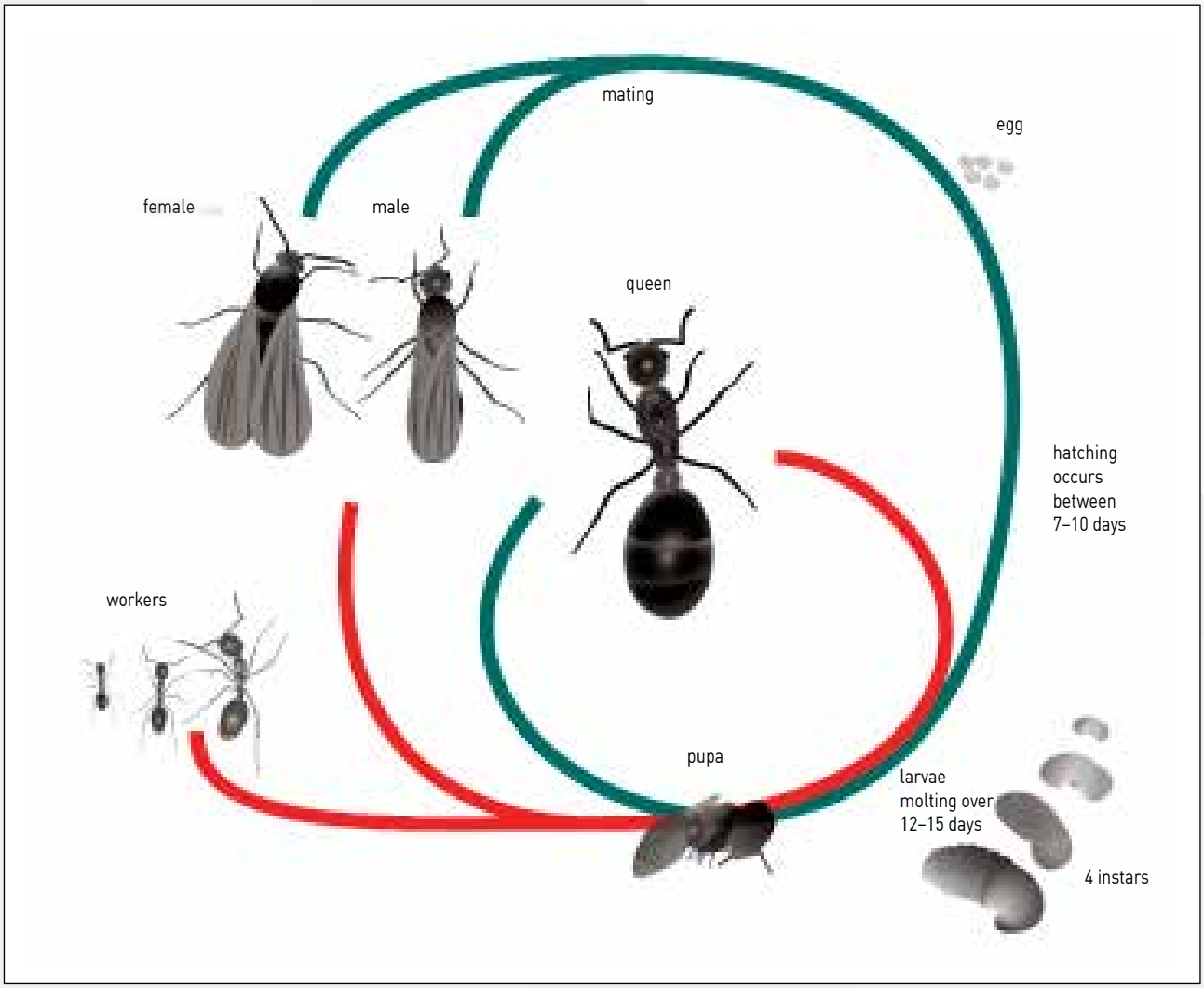
Native to Brazil, along the Paraguay and Parana Rivers (Allen et al. 1995), RIFA has been introduced to the United States, Australia and several countries from Southeast Asia (Map 42). RIFA is not present in New Zealand, but it has been detected. In 2001, a member of the public reported a single nest at Auckland International Airport. In 2004, the National Invasive Ant Surveillance Programme caught about 200 workers in a bait trap at the Port of Napier and in 2006 a single nest was found in the plant of forest products company about 10km from the same port (Cristian 2009). In all cases, early detection and effective eradication plans, which included increased surveillance, prevented the species from establishing in these areas.

**Figure 41: Red imported fire ant *Solenopsis invicta***

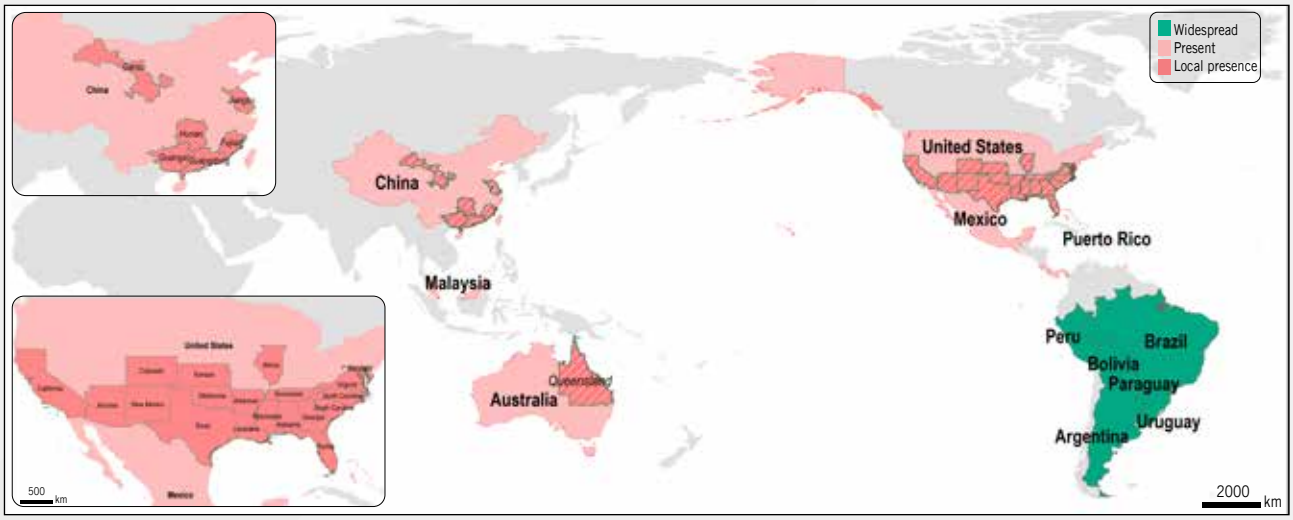



**Drawing** of gland adapted from Man-Yeon & Vander Meer 2012.

**Figure 42: Life cycle of red imported fire ant *Solenopsis invicta***




**Map 42: World distribution of red imported fire ant *Solenopsis invicta***




**Data source:** CABI, 2019. Solenopsis Invicta (red imported fire ant). In: Invasive Species Compendium. Wallingford, UK: CAB International,https://www.cabi.org/isc/datasheet/50569#toDistributionMaps. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 2.0 UK: England & Wales Licence.

## 2.20 National saltmarsh mosquito surveillance programme

### Target organism/s

All exotic saltmarsh mosquito species. The programme also monitors the distribution of introduced species, such as *Aedes (Finlaya) notoscriptus*.

### Potential impacts

Saltmarsh mosquitos are known vectors for diseases of medical and veterinary importance. The establishment of exotic saltmarsh mosquitos in New Zealand could:

- have a serious health impact on the human population;
- have a severe effect on the domestic livestock market;
- lead to international trade restrictions on New Zealand's livestock;
- disrupt outdoor activities and impact New Zealand's tourism industry;
- affect property values on land adjacent to areas where mosquitoes are present;
- bring a socioeconomic and ecological burden associated with control and eradication programmes

### Introduction mechanisms

Saltmarsh mosquitoes could enter in New Zealand as adults on sea and air containers, imported cars and tyres, machinery, aeroplanes, ships, yachts and personal luggage.

### Surveillance programme

**Objectives:**

- to provide early detection of exotic saltmarsh mosquitoes;
- to identify changes in distribution of endemic and introduced saltmarsh mosquitos species already established in New Zealand, for reporting purposes.

**Start:** In 2005 to complement the Southern Saltmarsh Mosquito Eradication Programme (December 1998 – June 2010).

**Methodology:** Sampling for larvae is carried out across New Zealand around high-risk entry points and in all the habitats identified as suitable for the establishment of saltmarsh mosquitoes (Maps 43–47, Figure 43). Light traps for adult trapping are also used in these areas. In order to increase the likelihood of detecting new introductions, sampling effort is determined through a statistical algorithm that takes into account habitat size, receptivity, proximity to ports and transitional facilities and urban centres, and climate.

**Sampling:** All areas are surveyed annually but the actual number of sampling hours for each site is based on the allocated sampling effort derived by the statistical algorithm.

**Map 43: Saltmarsh mosquito surveillance programme, 2018**

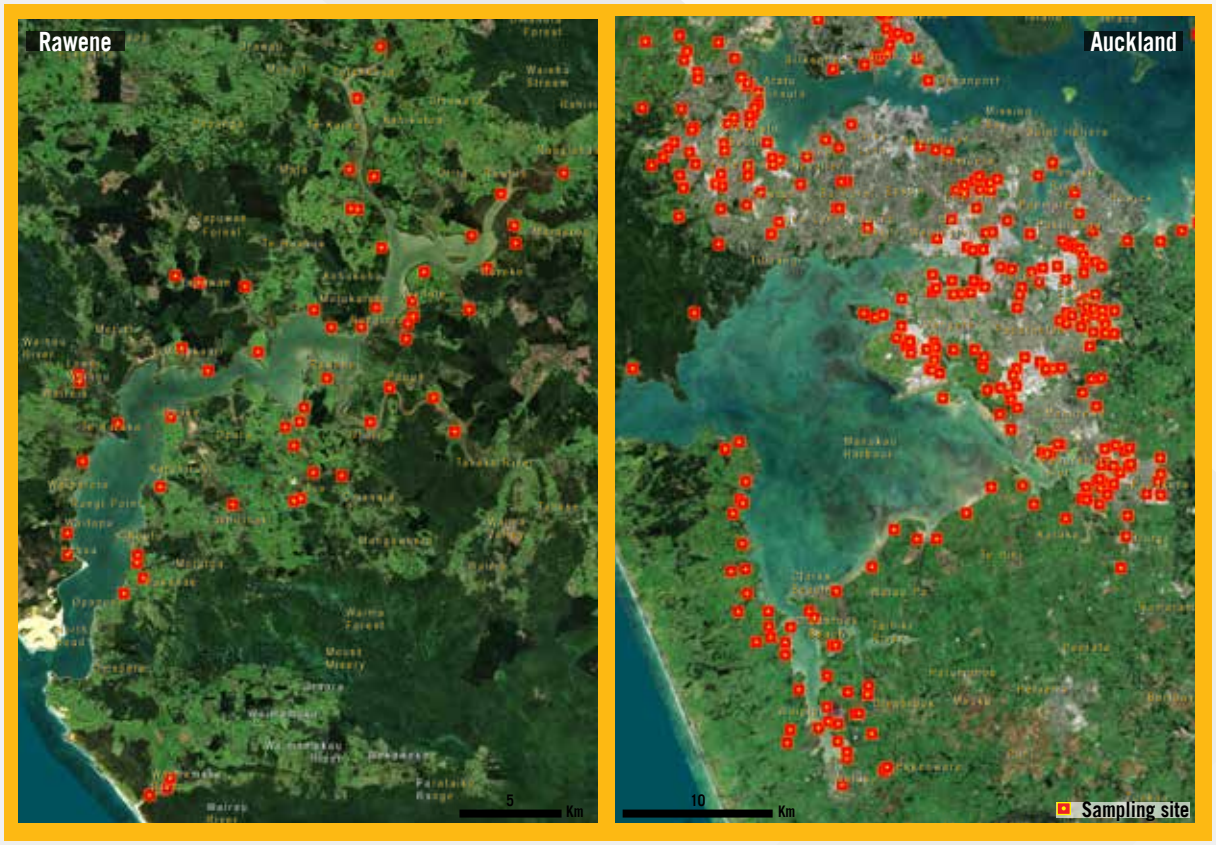

### Status

New Zealand is considered free from mosquitoes that transmit diseases of medical and veterinary importance.

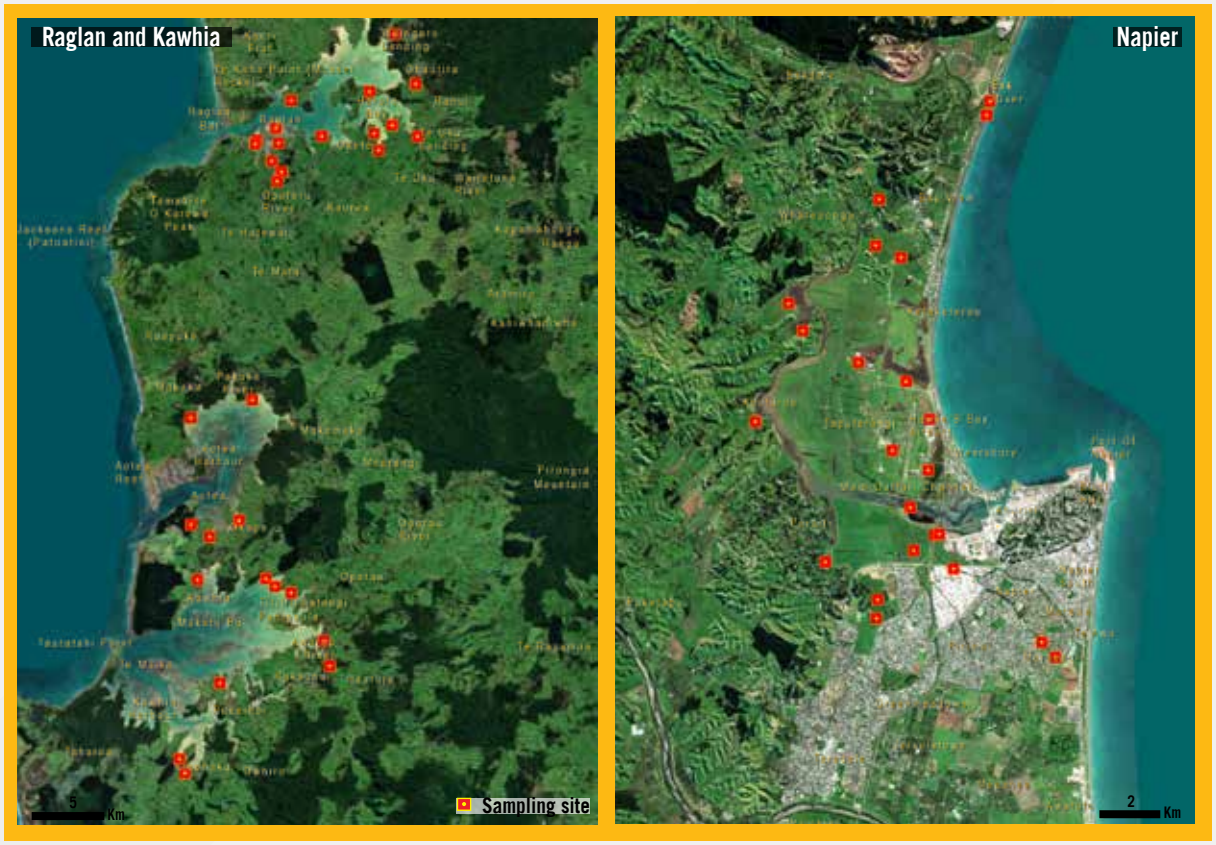
### Incursions

The detection of *Aedes* (*Ochlerotatus*) *camptorhynchus* in Napier in December 1998 triggered the Southern Saltmarsh Mosquito Eradication Programme that ended in June 2010, when the species was declared eradicated. Over the past eight years, the saltmarsh mosquito programme has collected approximately 87,000 suspect larvae needing to be identified (Fig 44). In 2018 an exotic detection of *Culex sitiens* was made near Auckland and is currently undergoing eradication.

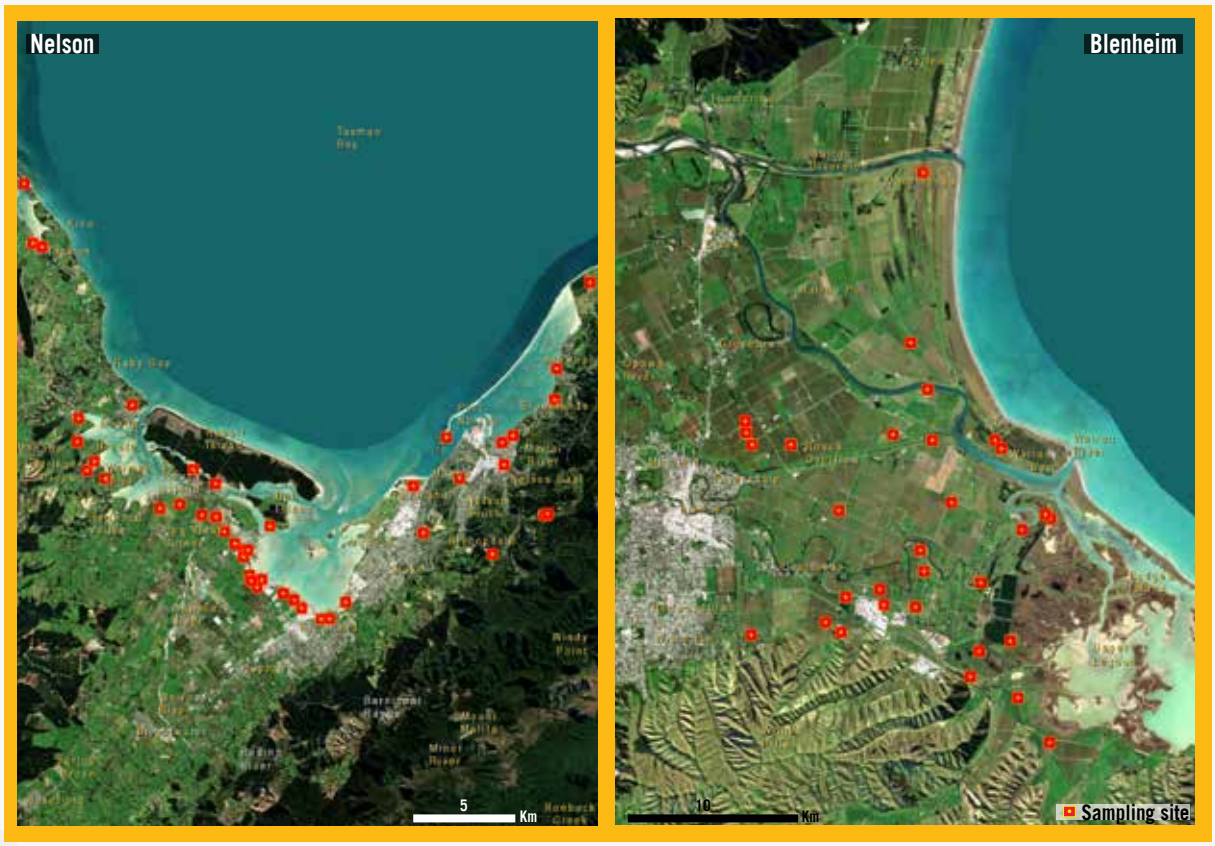
**Map 44: Saltmarsh mosquito surveillance programme – Rawene and Auckland, 2018**




**Map 45: Saltmarsh mosquito surveillance programme – Raglan, Kawhia and Napier, 2018**



**Map 46: Saltmarsh mosquito surveillance programme – Nelson and Blenheim, 2018**




**Map 47: Saltmarsh mosquito surveillance programme – Christchurch and Bluff/Invercargill, 2018**

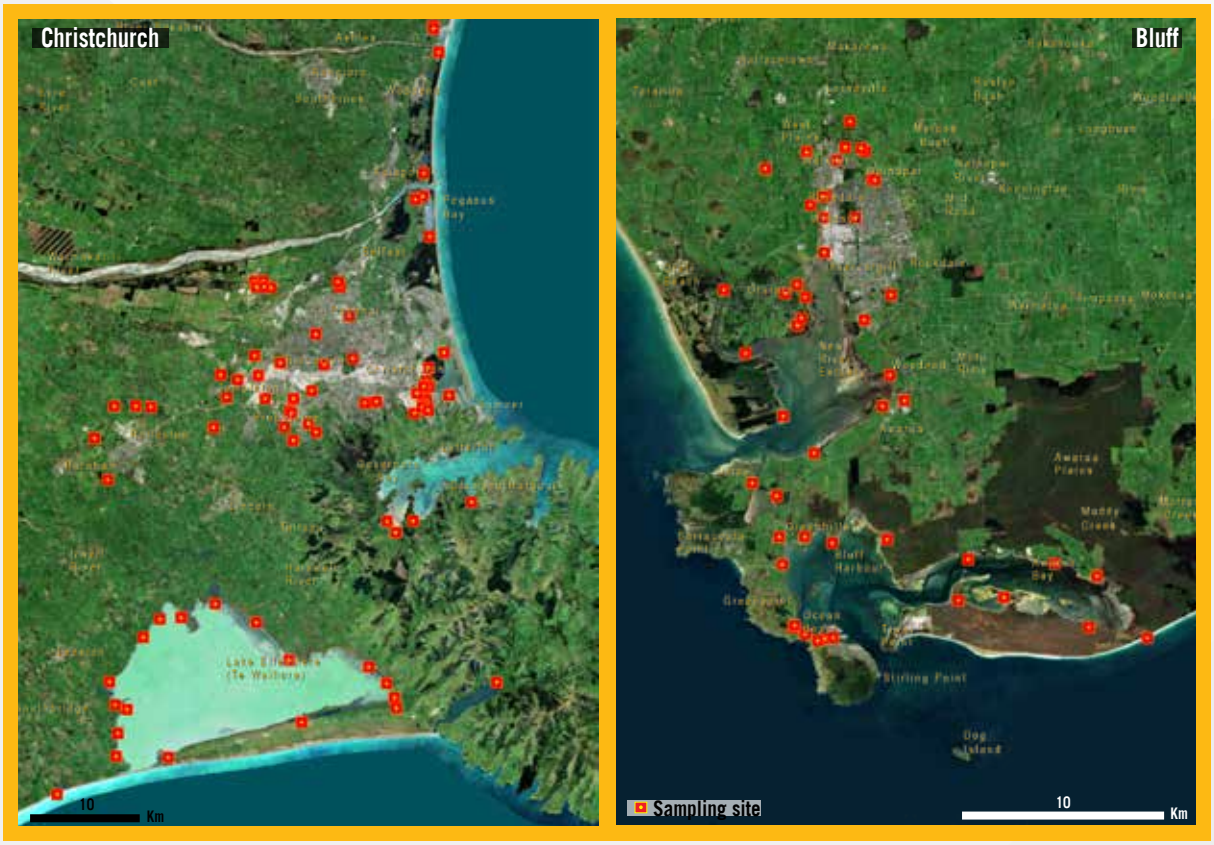
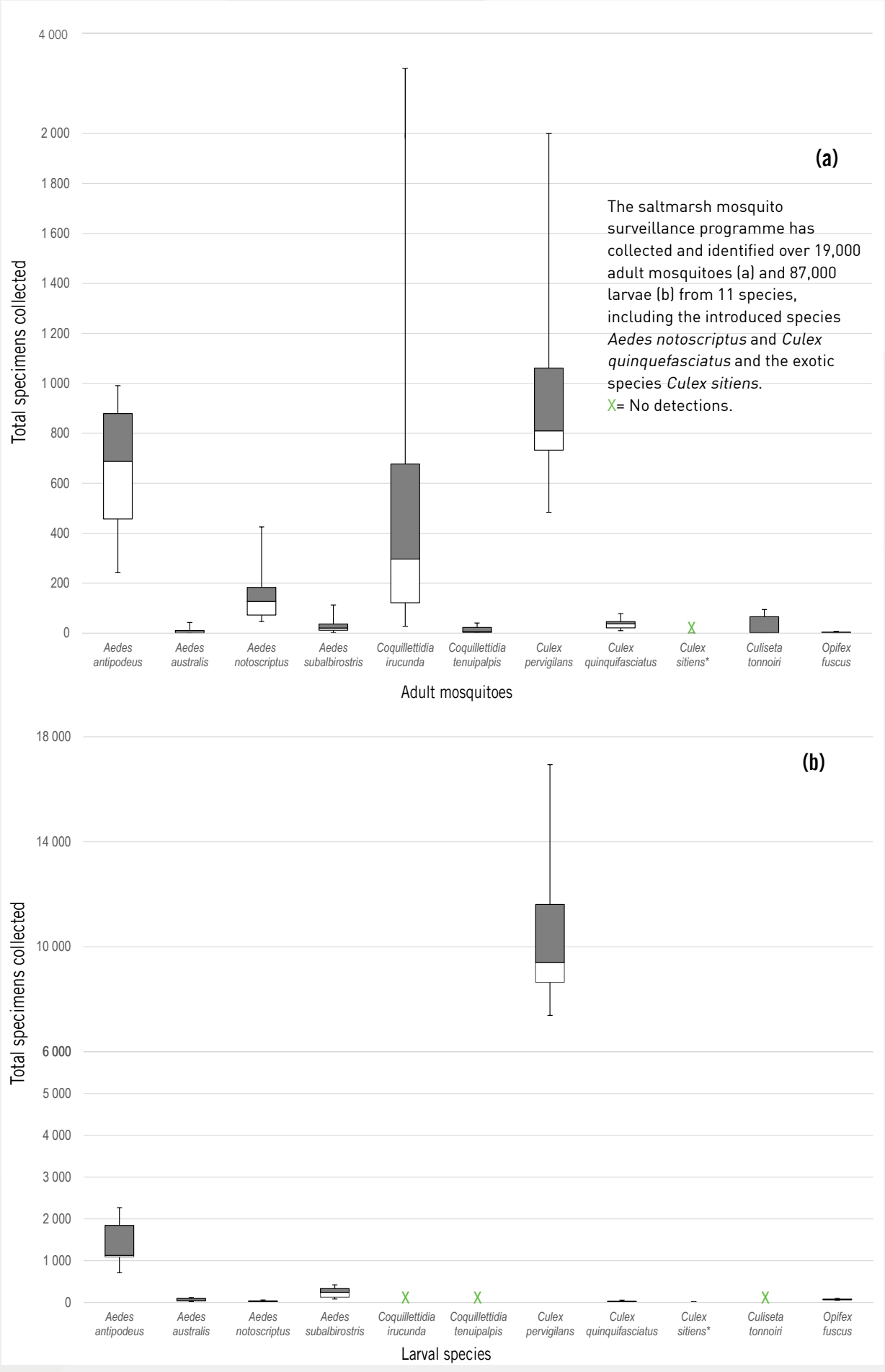


**Figure 43: Larval mosquitoes collected and identified by the programme, 2011–2018**



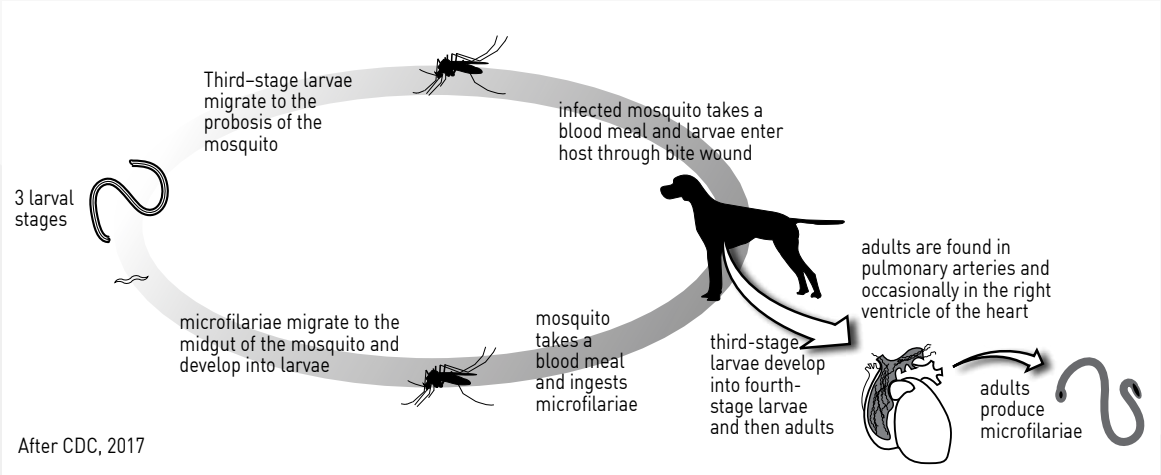
## 2.21 Dog heartworm *Dirofilaria* sp.

Dirofilariasis is a disease caused by a diverse group of long and thin parasitic roundworms known as Dirofilaria. It is transmitted by mosquitoes (for example *Culex* spp., *Aedes* spp., *Anopheles* spp.) to a range of mammals. Humans can be accidental hosts of two canine *Dirofilaria* species, *D. immitis* and *D. repens*, and occasionally of other non-canine-associated species such as *D. tenuis* (from racoons), *D. urse* (from bears), *D. subdermata* (from porcupines) and *D. striata* (from bobcats) (To et al. 2012). Humans, however, do not contribute to the transmission of the disease – Dirofilariasis is not transmitted person-to-person or person-to-mosquito-to-person (CDC 2012).

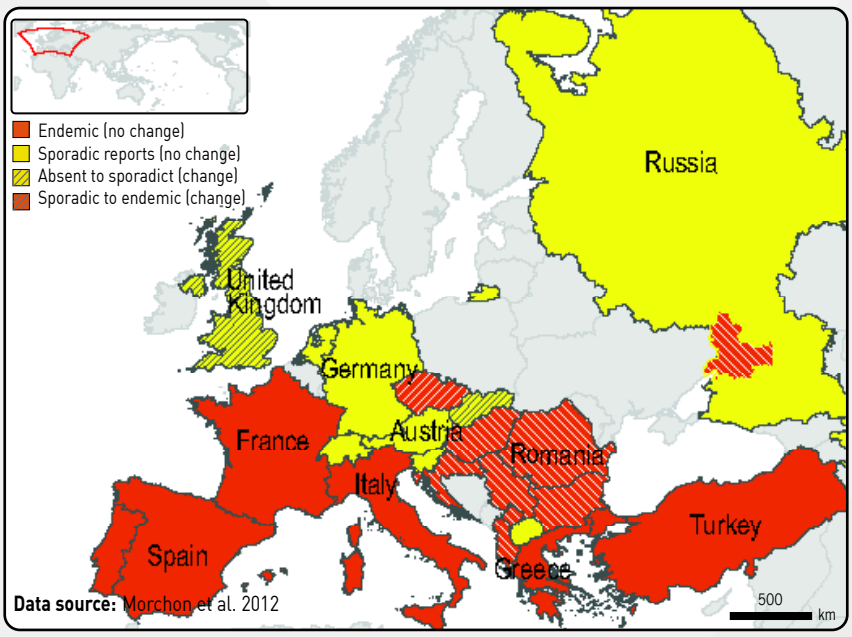
*Dilofilaria immitis* is commonly known as "heartworm" and responsible for canine and feline cardiovasculary dirofialariosis, a severe and life-threatening disease. Adult worms block pulmonary arteries of their hosts (for example domestic dogs and cats, wolves and foxes) causing signs such as coughing (sometimes with blood), exercise intolerance, fainting, and severe weight loss (Aiello and Mosses 2016). Several techniques, including radiology, echocardiography and laboratory tests can help diagnose dirofialariosis but no single test can confirm the presence of heartworm at all stages (Nelson 2008).

Dirofilariasis is present where *Dirofilaria* species are common. The increase and spread of the number of cases of canine and feline Dirofilariasis in Europe observed between 2001 and 2011 (Map 48) has been linked to new introductions of mosquito species (specifically those able to be competent vectors, such as *Aedes aegypti* and *Ae. albopictus*), movement of infected animals (people travelling with their dogs for holidays and commerce of dogs across regions), human activity in new areas and climate change (Morchon et al. 2012).

**Figure 44: Life cycle of *Dirofilaria imitis***




**Map 48: Changes in the distribution of *Dilofilaria imitis* in Europe between 2001–2011**



## 2.22 Transmissible spongiform encephalopathies (TSEs) surveillance programme

### Target organism/s

TSEs are a group of progressive and ultimately fatal neuro-degenerative diseases affecting humans and animals. They are caused by the proliferation in the central nervous system of a prion, an altered form of a normal intracellular protein. The main TSEs are bovine spongiform encephalopathy (BSE) of cattle, classical scrapie affecting sheep and goats, and chronic wasting disease (CWD) affecting deer.

### Potential impacts

An incursion of a TSE in New Zealand could:

- lead to international trade restrictions on live animals and animal products;
- have a devastating financial effect on the market for the concerned livestock industry of New Zealand;
- bring a socioeconomic and ecological burden associated with control and eradication programmes;
- raise questions about the status of other TSE diseases.

### Introduction mechanisms

Prions are resistant to heat, desiccation and disinfectant treatments, and persist in the environment by binding to inorganic soil constituents. This implies that any product derived from or contaminated by an infected animal could potentially transmit the disease. Transmission of BSE in cattle involves feeding ruminant-derived meat and bone meals contaminated with a prion protein. The feeding of ruminant protein, such as meat and bone meal, to ruminants is prohibited in New Zealand. Scrapie in sheep is transmitted from dam to lamb around lambing and through pasture contaminated with infectious material (placental tissues and associated fluids). Like scrapie, CWD is contagious and persistent in the environment and thus can be transmitted between farmed and wild populations via direct or indirect contact with infected animals. The main pathway for introduction in New Zealand for scrapie and CWD would be through import of live animals or their products. Countries where these species can be imported from are restricted. Owners are legally required to report the location and death of imported ruminants.

### Surveillance programme

**Objectives:**

- to provide assurance of country freedom from TSEs;
- to provide early warning in the event of an incursion of TSEs to facilitate containment and eradication.

**Start:** 1990.

**Methodology:** Passive (incentivised) surveillance is performed in New Zealand for all three TSE diseases. The passive component was incorporated in 2007 and consists of a targeted, incentivised scheme where veterinary practitioners submit brain material from animals showing neurological signs. In addition, brain tissue samples from all imported cattle, sheep, goats and deer are also collected after they die or are culled.

**Map 49: Transmissible spongiform encephalopathies surveillance programme, 2017**


In addition, an active surveillance component supports the passive surveillance for scrapie and CWD, whereupon samples are routinely collected from clinically healthy adult animals sent to meat processing plants. The number of animals sampled is calculated to establish freedom from disease in the population at a 95 percent confidence level. As with most surveillance programmes in New Zealand, the TSE surveillance programme evolves to respond to both changing risks and advances in sampling and diagnostic techniques to ensure the programme is as effective and efficient as possible.

**Sampling:** All samples collected through passive and active surveillance are tested using a rapid screening test (The EU approved HerdChek BSE-scrapie ELISA IDEXX) at AHL. In addition, brains submitted via passive surveillance are also examined via histopathology. Passive surveillance occurs year-round with a seasonal increase between August and October.

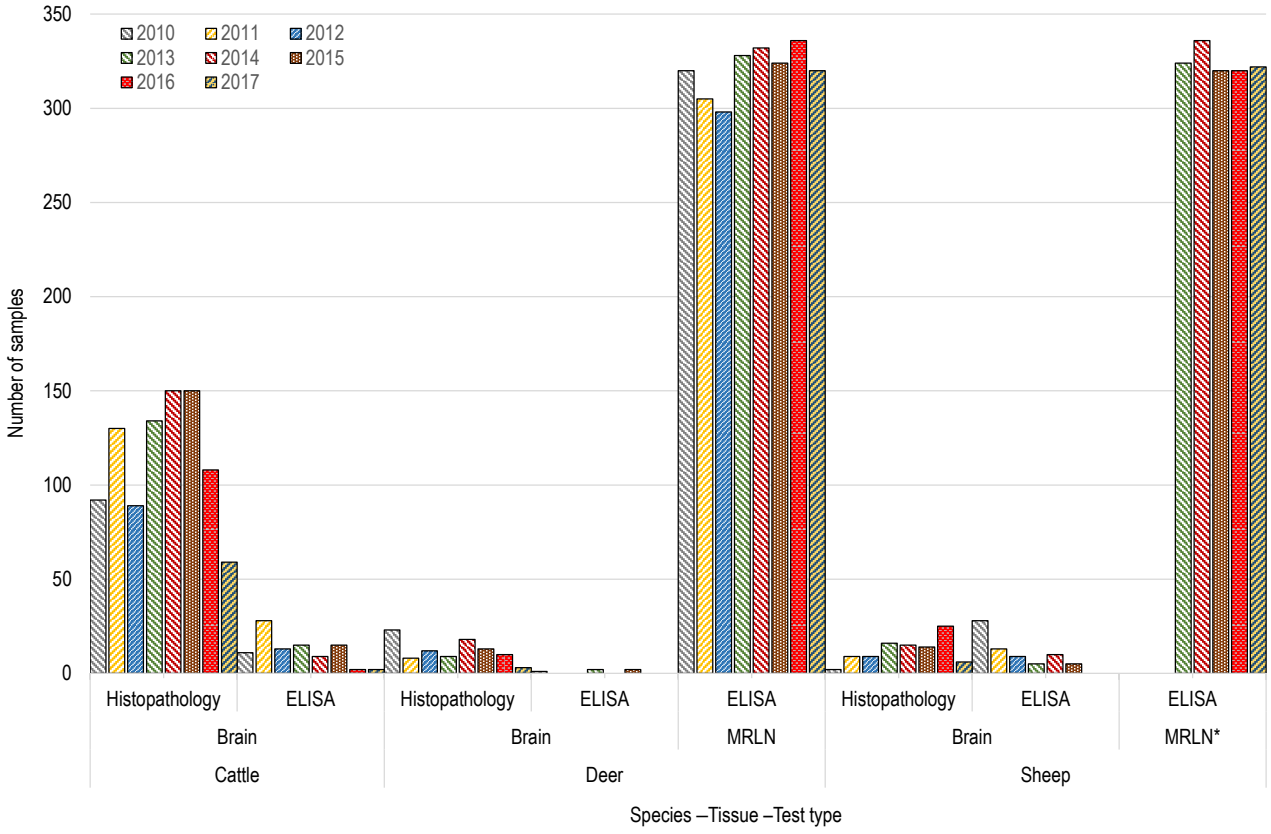
### Status

New Zealand is considered free from BSE of cattle, classical scrapie of sheep and goats, and CWD of deer and elk.

**Map 50: Location of farms submitting deer samples for chronic wasting disease, 2015–2017**

**Map 51: Location of farms submitting sheep samples tested for scrapie, 2015–2017**

**Figure 45: Number of annual samples tested for TSEs by passive and active surveillance, 2010–2017**




**MRLN:** medial retropharyngeal lymph node.
† The graph does not include 165 and 528 sheep tested (MRLN) as part of a research project in 2010 and 2011, respectively.

## Incursions

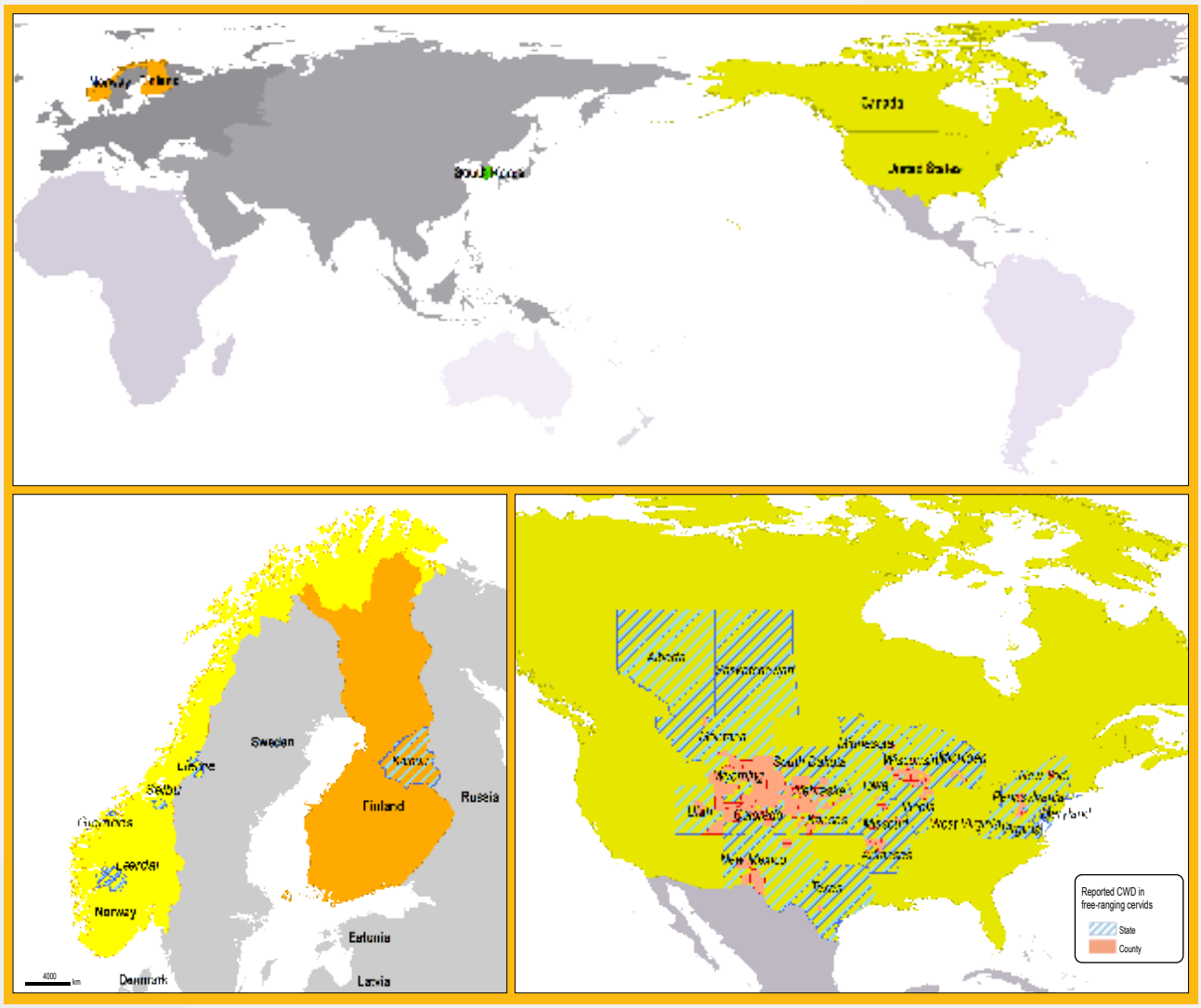
No TSE incursions have been detected in New Zealand since 1954 when classical scrapie was stamped out from a group of sheep imported from the UK. After this date, scrapie was occasionally diagnosed in imported sheep in quarantine up until 1977. However the disease did not spread further (Bruère, 2003). Despite this, more rigorous importation and quarantine measures were put in place and no further detections were made (Bruère, 2003). In October 2009, a case of atypical scrapie was detected in a New Zealand-born sheep. Atypical scrapie is unrelated to 'classical' scrapie, may not be contagious and is believed to spontaneously occur in older sheep (World Organisation for Animal Health, 2019). Atypical scrapie is thus considered a negligible biosecurity risk.

## 2.23 Chronic wasting disease (CWD)

CWD was first detected in 1967 in captive mule deer in northern Colorado, United States. Since then, the disease has been diagnosed in other states and in Canada in wild and farmed elk, mule deer, white-tailed deer, black-tailed deer, and moose (Map 52). In 2001 South Korea reported the disease in a male elk imported from Canada (Sohn et. al., 2002). In 2016, Norway confirmed the discovery of CWD in a free-ranging reindeer and to date, the disease has also been detected in moose and red deer in that country (Benestad et al. 2016). CWD has also been recently detected in a free-ranging moose in eastern Finland near the Russian border (Finnish Food Authority 2018). As of November 2019, the United States had reported 281 counties in 24 states with CWD in free-ranging cervids (CDC 2018).

Signs of chronic wasting disease include progressive weight loss, behavioural changes, loss of awareness, loss of fear to humans, increased drinking, urination and excessive salivation. Most, if not all, CWD signs can have other causes and lead to misdiagnosis of the condition if the affected animal is not tested specifically for CWD.

**Map 52: Occurrence of chronic wasting disease across the world – April 2018**




**Data source**: http://www.oie.int/en/animal-health-in-the-world/official-disease-status/bse/en-bse-carte/ – visited 3 April 2018.

## 2.24 Wildlife disease surveillance programme

### Target organism/s

Exotic and emerging pathogens across all wildlife species (native, non-native and feral) in New Zealand. No specific organism is targeted but scanning surveillance techniques are used to watch for organisms of interest and to monitor testing results to veterinary diagnostic laboratories.

### Potential impacts

Impacts would vary depending on the organisms detected. Importance would be determined by the organism's disease-causing potential in wildlife and whether it is also an important pathogen in domestic animals or humans. Some organisms affecting wildlife have the potential for significant economic, environmental, or human health impacts if they were introduced or became established in New Zealand. For example, the introduction of West Nile Virus could kill native bird species and affect the health of humans, horses and farmed species, also affecting New Zealand's international market for animals and animal products.

### Introduction mechanisms

Potential mechanisms for the introduction of new pathogens include: migratory animals such as birds and mammals and via inadvertent importation through legal trade, or illegal importations of animals or other risk items (for example bird or reptile trafficking). Increased global trade and passenger movements have increased the risk of introducing and spreading exotic agents affecting wildlife. The occurrence of an unwanted organism in New Zealand could also result from mutations of organisms already present in New Zealand. These mutations could alter the organisms' disease-causing ability, for example through increased severity of disease, expanded host range, or becoming a new zoonosis.

### Surveillance programme

**Objectives:**

- to facilitate the early detection of exotic or emerging disease in New Zealand;
- to support New Zealand's statements of freedom from specific pests or diseases;
- to provide baseline information on endemic disease occurrence in New Zealand's wildlife;
- to support the fulfilment of New Zealand's international reporting obligations.

**Start:** New Zealand has a long history of a comprehensive general passive surveillance system that provides coverage of all animal species in New Zealand, free-living or captive, wild or domesticated. The MPI Pest and Disease Emergency Hotline (0800 80 99 66), available since 1998, assists New Zealanders to report suspected exotic or emerging pests or diseases (section 2.1). The necropsy of wildlife mortalities was initiated by the Department of Conservation in 2002. MPI receives high-level information from this programme to complete biannual OIE wildlife reporting and an annual wildlife surveillance report and notifications when exotic OIE-listed diseases and pests are suspected.

**Methodology:** The wildlife programme is multifaceted general passive surveillance and incorporates the following:

- The animal pest and disease notification and investigation system. An organised system of maintaining public awareness of the importance of reporting unusual pests or diseases, assisting notification of observations in the field, and the investigation and veterinary diagnostic testing of suspected cases of exotic or emerging diseases (Section 2.1).
- Wildlife submissions to veterinary diagnostic laboratories. Samples submitted by clinical veterinary practitioners to veterinary diagnostic laboratories are tested by the laboratory according to the intentions of the practitioner investigating the case. For wildlife cases that meet particular sick animal criteria, MPI is provided with anonymous summary data (Figure 47).
- Alongside MPI's wildlife activities, causes of mortalities of threatened or critically endangered native species are monitored by the Department of Conservation (DOC). Certain species found dead in the wild or in captive facilities are sent by DOC to Wildbase Pathology (part of the School of Veterinary Science at Massey University, Palmerston North) for post-mortem examination by veterinary wildlife pathologists to determine their cause of death (Figure 46). MPI is advised of detections of exotic or emerging diseases.

**Sampling:** Sampling is primarily opportunistic, focusing on sick or dead animals.

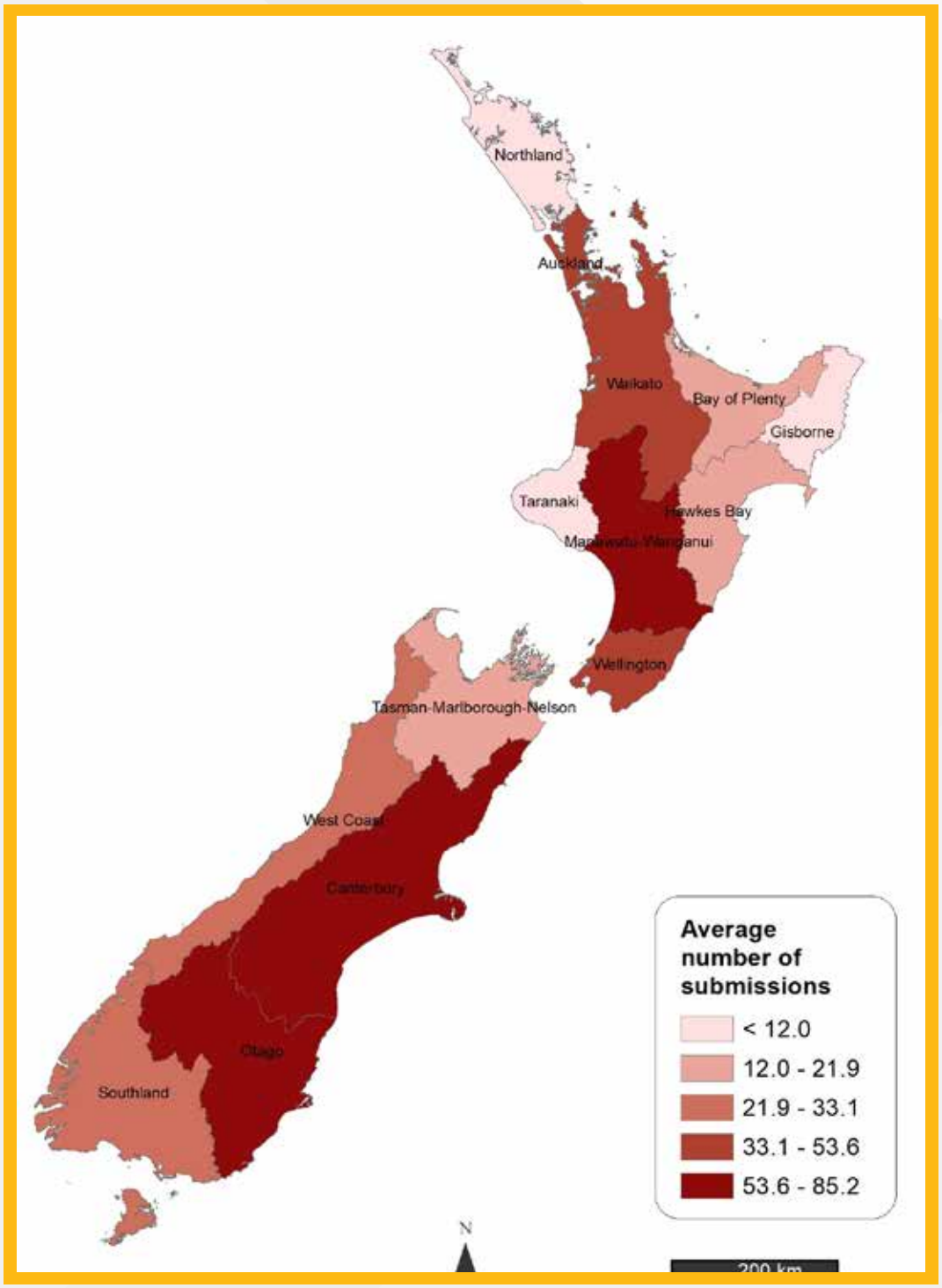
### Status

Not applicable

### Incursions

Approximately 1,500 calls are received every year from members of the public, researchers, veterinarians and laboratories. About 10 percent of calls relate to wildlife pests and diseases, but most of these do not warrant more than a detailed investigation. Since the start of this programme there have been a number a wildlife cases of special interest and occasionally the detection of a new organism or disease has generated an incursion response.

**Figure 46: Average number of avian cases submitted to Wildbase Pathology by region, 2010-2017**




**Data** courtesy of Wildbase Pathology, Massey University, Palmerston North and Professor Maurice Alley.

**Figure 47: Cases processed by veterinary laboratories, 2010–2017**

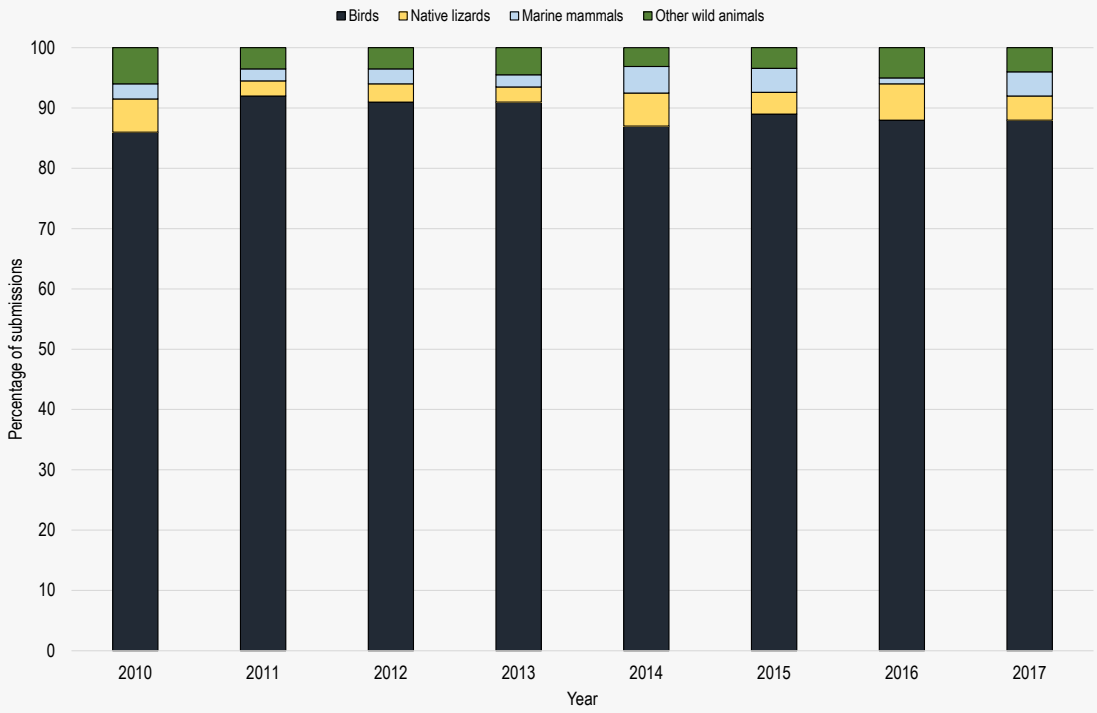
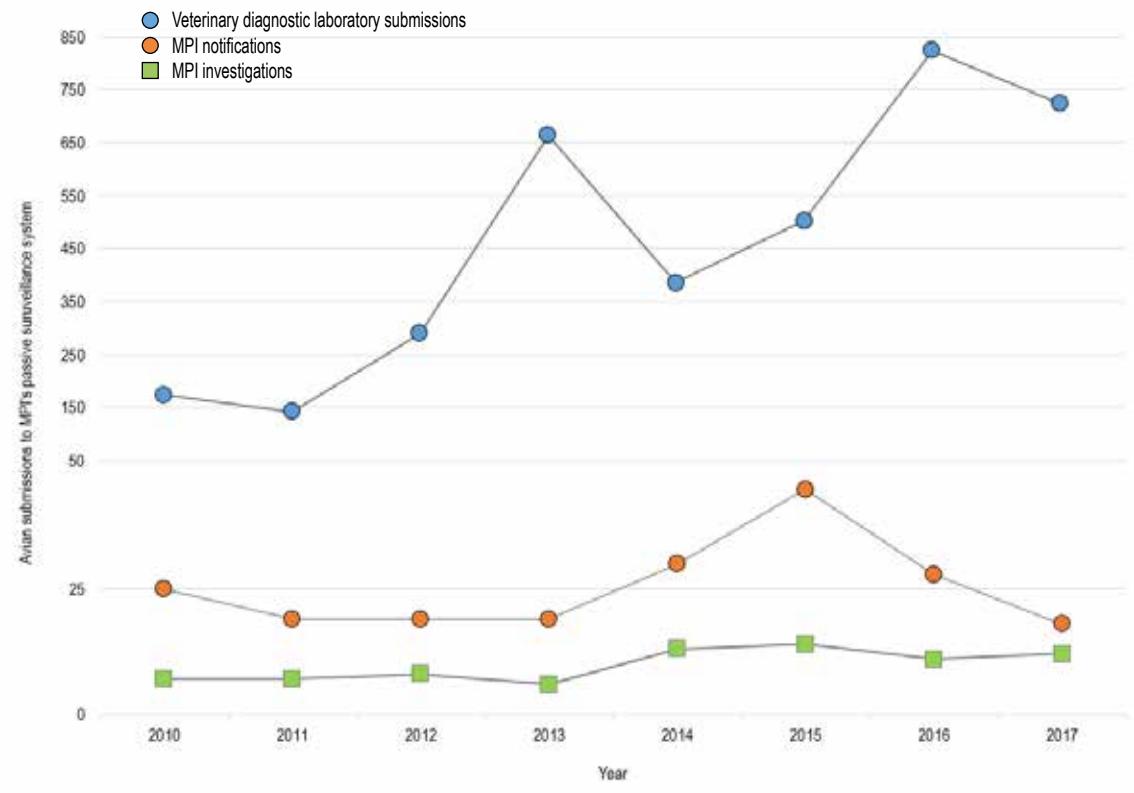



**Figure 48: Avian submissions to MPI's passive surveillance system, 2010–2017**

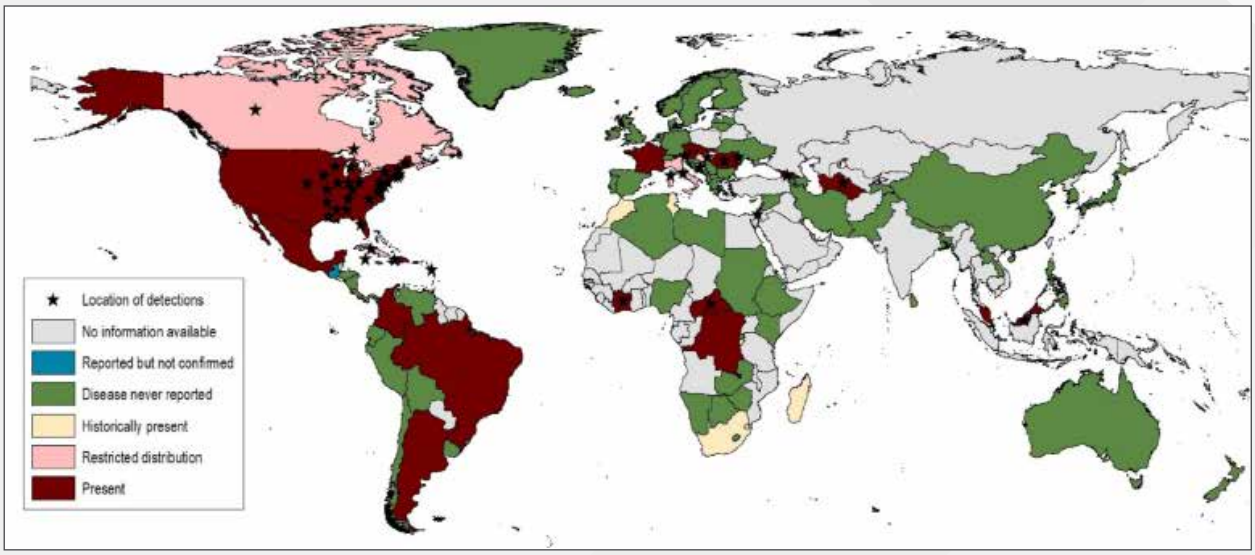


## 2.25 West Nile fever

West Nile fever could cause mortalities in wildlife and has the potential to infect a wide range of species, particularly birds, horses and humans. It is caused by West Nile virus (a flavivirus) which circulates in wild birds via mosquitoes, primarily *Culex* species. Humans and other mammals can be infected when bitten by mosquitoes that have fed on infected birds. However they are not known to pass the infection on to others and are therefore known as "incidental hosts". The majority of infected people will have no signs of disease, while others will experience flu-like symptoms. However it can lead to encephalitis or meningitis in humans and horses, with signs including partial paralysis, convulsions, impaired vision and sometimes death. There is no vaccine available.

The virus was first found in Uganda in the 1930s and appeared in the Middle East and Europe in the 1950s. It was first found in the American continent in New York in 1999 following coinciding outbreaks of high mortalities in crows, and encephalitis and meningitis in humans and horses. It subsequently spread across the United States and into Mexico and South America. It has never been detected in New Zealand but could potentially have a similar impact as it did in the United States. If detected, New Zealand must report it to the World Organisation for Animal Health (OIE).

**Map 53: Global distribution of West Nile virus**




Data for this map has primarily been sourced from(CABI (2018). West Nile virus. In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc, licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 2.0 UK: England & Wales Licence. Some countries showing as "present" in this map may have only had serological detections without recorded disease outbreaks. Australia has reported "Kunjin disease" which is a subspecies of West Nile Virus.

# 3 References


Aiello, S and MA Mosses (2016). The Merck veterinary manual. 11th ed. / Whitehouse Station, N.J. [Great Britain]. Online version (https://www.merckvetmanual.com/circulatory-system/heartworm-disease/overview-of-heartworm-disease) accessed on 10 Jan 2019.

Alexandersen S, Zhang Z, Donaldson AI, Garland AJM (2003). Review: The pathogenesis and diagnosis of foot-and-mouth disease. *Journal of Comparative Pathology*. 129, 1–36

Allen CR, Lutz RS and Demarias S (1995). Red imported fire ant impacts on northern bobwhite populations. *Ecol. Appl.* 5 (3), 632–638.

Benestad SL, Mitchell G, Simmons M, Ytrehus B and Vikøren T (2016). First case of chronic wasting disease in Europe in a Norwegian free-ranging reindeer. *Veterinary Research*, 47(1), 88.

Bishop AL, Worrall R, Spohr LJ and Barchia IM (2004). Improving light trap efficiency for *Culicoides* spp. with light-emitting diodes. *Veterinaria Italiana* 40, 266–269

Bishop AL, Bellis GA, McKenzie HJ, Spohr LJ, Worral RJ, Harris AM and Melville L (2006). Light trapping of biting midges *Culicoides* spp. (Diptera: Ceratopogonidae) with green light-emitting diodes. *Aust. J. Entomol.* 45: 202–205.

Bowden J, Church B (1973). The influence of moonlight on catches of insects in light-traps in Africa. Part II. The effect of moon phase on light-trap catches. *Bull Entomol Res.* 63 (01): 129-142. 10.1017/S0007485300050938.

Bruère AN (2003). Scrapie freedom-the New Zealand story. *Surveillance*, 30(4), 3–7.Prevalence of *Solenopsis invicta* (Hymenoptera: Formicidae) Venom Allergic Reactions in Mainland China Author(s): Yijuan Xu, Jun Huang, Aiming Zhou and Ling Zeng Source: *Florida Entomologist*, 95(4):961–965. Published By: Florida Entomological Society

Campbell RW, Hubbard DL and Sloan RJ (1975). Patterns of gypsy moth occurrence within a sparse and numerically stable population. *Environmental Entomology* 4:535-542.

Cave GL, Randall-Schadel B, and Redlin SC (2008). Risk analysis for *Phytophthora ramorum* Werres, de Cock & Man in't Veld, causal agent of sudden oak death, ramorum leaf blight, and ramorum dieback. US Department of Agriculture, Animal and Plant Health Inspection Service, Raleigh, NC.

CDC (2012, February 8). Dirofilariasis FAQs. www.cdc.gov/parasites/dirofilariasis/faqs.html

CDC (2012). Parasites—Dirofilariasis. www.cdc.gov/parasites/dirofilariasis/ accessed 3 Sept 2018.

CDC (2018). *Chronic Wasting Disease Occurrence*. www.cdc.gov/prions/cwd/occurrence.html

CDC (2019). *Dirofilariasis*. www.cdc.gov/dpdx/dirofilariasis/index.html

Chiswell SM, Bostock HC, Sutton PJ and Williams MJ (2015). Physical oceanography of the deep seas around New Zealand: a review. *New Zealand Journal of Marine and Freshwater Research*, 49(2), 286–317.

Choi M and Van der Meer R (2012). Ant Trail Pheromone Biosynthesis Is Triggered by a Neuropeptide Hormone. PloS one. 7. e50400. 10.1371/journal.pone.0050400.

CIDRAP (2013). *Avian Influenza: Agricultural and Wildlife Considerations*. www.cidrap.umn.edu/infectious-disease-topics/avian-influenza-agricultural-and-wildlife-considerations

Cleveland WS (1985). *The Elements of Graphing Data*, Hobart Press, 297 pp

Cristian S (2009). *Red imported fire ants eradicated from Napier*. MAF Biosecurity New Zealand.

Cuthbertson AGS, Mathers JJ, Blackburn LF, Marris G, (2013). Lifecycle of the Small hive beetle, *Aethina tumida*. *Bee Craft*, 95(5):32–33

Cuthbertson AGS, Mathers JJ, Blackburn LF, Wakefield ME, Collins LE, Luo W, Brown MA (2008). Maintaining *Aethina tumida* (Coleoptera: Nitidulidae) under quarantine laboratory conditions in the UK and preliminary observations on its behaviour. *Journal of Apicultural Research*, 47(3):192–193. www.ibra.org.uk

De Guzman LI, Prudente JA, Rinderer TE, Frake AM, Tubbs H (2009). Population of small hive beetles (*Aethina tumida Murray*) in two apiaries having different soil textures in Mississippi. *Science of Bee Culture* 1: 4–8.

Detection and isolation of highly pathogenic H5N1 avian influenza A viruses from blow flies collected in the vicinity of an infected poultry farm in Kyoto, Japan (2004). *Am J Trop Med Hyg*. 75:327–332

Donaldson AI and Alexandersen S (2003). Predicting the spread of foot and mouth disease by airborne virus. *Revue Scientifique et. Technique de l'OIE*. 21(3): 569–575.

Donaldson AI. (1987). Foot-and-mouth disease: the principal features. *Irish Veterinary Journal*. 41:325-327

FAO (2009). Global review of forest pests and diseases. FAO Forestry Paper 156. 222p

Finnish Food Authority (n.d.). *Chronic wasting disease (CWD) and other TSE diseases in cervids*. www.ruokavirasto.fi/en/farmers/animal-husbandry/animal-health-and-diseases/animal-diseases/wildlife/chronic-wasting-disease-cwd-in-cervids/

Grubman MJ and Baxt B (2004). Foot and mouth disease. *Clin Microbiol Rev*. 17: 465–93

Gunawardana DN, Peacock LR, Flynn AR, Ashcroft TT and Green OR (2013). Why is Napier sea port a hot spot for invasive ants? *New Zealand Plant Protection*, 66, 10–16.

Gutiérrez RA, Naughtin MJ, Horm SV, San S, and Buchy P (2009). A(H5N1) Virus Evolution in South East Asia. *Viruses*, 1(3): 335–361. doi:10.3390/v1030335

Heath ACG (2016). Biology, ecology and distribution of the tick, *Haemaphysalis longicornis* Neumann (Acari: Ixodidae) in New Zealand. *New Zealand Veterinary Journal*, 64(1): 10–20.

Hedges SA (1997). *Handbook of Pest Control*, 8th Ed. (Moreland D, ed.) pp. 531–535. Mallis Handbook and Technical Training Company.

Hedges SA (1998). *Field Guide for the Management of Structure Infesting Ants*, 2nd Ed.(Moreland D, ed.) pp. 202–216. GIE Publishers, Cleveland, Ohio.

Kelso J and Milne G (2014). A spatial simulation model for the dispersal of the bluetongue vector *Culicoides brevitarsis* in Australia. PLoS One. 9, 8, p. 1-16

King D and Henstock H (2016). OIE-FAO FMD Reference Laboratory Network Report 2016.www.foot-and-mouth.org/sites/foot/files/user-files/research-paper/pdf/07-17/FMD%20Laboratory%20Network%20Report%202016.pdf. Accessed on 18 December 2019.

Klotz JH, Jetter KM, Greenberg L, Hamilton J, Kabashima J and Williams DF (2003). An insect pest of agricultural, urban, and wildlife areas: the red imported ant, pp. 151–166. In D.A Sumner [ed.] *Exotic pests and diseases: biology and economics for biosecurity*. Blackwell Publishing Professional, Ames, IA.

Knowles NJ and Samuel AR (2003). Molecular epidemiology of foot-and-mouth disease virus. *Virus Research*, 91:65–80

Lofgren CS, Banks WA and Glancey BM (1975). Biology and control of imported fire ants. *Annual Review of Entomology*, 20(1), 1–30.

MacGown, JA and Whitehouse RJ (2016). Ants Formicidae from the Southeastern United States. https://mississippientomologicalmuseum.org.msstate.edu/Researchtaxapages/Formicidaepages/genericpages/Solenopsis.invicta.htm Accessed 21 Nov 2018

MAF Biosecurity New Zealand (2009) *Biosecurity surveillance strategy 2020*. MAF Biosecurity New Zealand, Wellington, New Zealand

Martin V, Sims L, Lubroth J, Kahn S, Domenech J and Begnino C (2006) History and evolution of HPAI viruses in southeast Asia. *Annals of the New York Academy of Sciences* Oct; 1081:153–62.

Massart, DL, Smeyers-Verbeke J, Capron X and Schlesier K (2005). Visual presentation of data by means of box plots. *LC-GC Europe*, 18(4), 2–5.

McGill R, Tukey JW and Larsen WA (1978). Variations of box plots. *The American Statistician*, 32: 12–16.

Mellor PS, Boorman JP and Baylis M (2000). *Culicoides* biting midges: their role as arbovirus vectors. *Annual Review of Entomology*, 45: 307-40

Ministry for the Environment and Statistics New Zealand (2016). New Zealand's Environmental Reporting Series: Our marine environment 2016. Available from www.mfe.govt.nz and www.stats.govt.nz.

Morchón R, Carretón E, González-Miguel J, Mellado-Hernández I (2012). Heartworm disease (*Dirofilaria immitis*) and their vectors in Europe – new distribution trends. *Front Physiol*. 3:196.

Nelson, CT (2008, July). *Dirofilaria immitis* in cats: diagnosis and management *Compend Contin Educ Vet*. 30(7): 393–400; quiz 400.

Neumann P, Pettis JS and Schäfer MO (2016). Quo vadis *Aethina tumida*? Biology and control of small hive beetles. *Apidologie*, 47: 427–466.

Nunnelee J (2005). Summer injuries: Bites and stings. *RN*. 68: 56–8, 60–1.

Pande A, Acosta H, Brangenberg NA and Knight B (2017). A risk-based surveillance design for the marine pest Mediterranean fanworm *Sabella spallanzanii* (Gmelin, 1791) (Polychaeta: Sabellidae) – a New Zealand case study. *Management of Biological Invasions* 8: 257–265

Peng Y, Xie ZX, Liu JB, Pang YS, Deng XW, Xie ZQ, Fan Q and Luo SS (2013). Epidemiological surveillance of low pathogenic avian influenza virus (LPAIV) from poultry in Guangxi Province, Southern China. PloS one, 8(10), e77132. doi:10.1371/journal.pone.0077132.

Plant Health Australia (2018). *The Australian Handbook for the Identification of Fruit Flies*. Version 3.1. Plant Health Australia. Canberra, ACT.

Purse BV, Mellor PS, Rogers DJ, Samuel AR, Mertens PPC and Baylis M (2005). Climate change and the recent emergence of bluetongue in Europe. *Nature Reviews Microbiology*, 3: 171–181.

Quesada-Moraga E, Valverde-García P and Garrido-Jurado E (2012). The Effect of Temperature and Soil Moisture on the Development of the Preimaginal Mediterranean Fruit Fly (Diptera: Tephritidae), *Environmental Entomology*, 41(4): 966–970.

Ross KG, Gotzek D, Ascunce MS and Shoemaker DD (2010). Species delimitation: A case study in a problematic ant taxon. *Syst Biol* 59: 162–184.

Russell RC, Otranto D, Wall RL (2013). *The Encyclopaedia of Medical and Veterinary Entomology*. CAB. International, Oxfordshire, UK.

Sawabe K, Hoshino K, Isawa H, Sasaki T, Hayashi T, Tsuda Y, Kurahashi H, Tanabayashi K, Hotta A, Saito T, et al. (2006). Detection and isolation of highly pathogenic H5N1 avian influenza A viruses from blow flies collected in the vicinity of an infected poultry farm in Kyoto, Japan, 2004. *The American Journal of Tropical Medicine and Hygiene*. 75(2): 327-332.

Sheridan AB, Fulton H and Zawislak J (2019). Small Hive Beetle Management in Mississippi. https://bee-health.extension.org/wp-content/uploads/2019/08/SHB-Mgt-in-MS_2012_Sheridan-Fulton-Zawislak-1.pdf (20 August 2019. Accessed 1 Sept 2019)

Sohn HJ, Kim JH, Choi KS, Nah JJ, Joo YS, Jean YH and Balachandran A (2002). A case of chronic wasting disease in an elk imported to Korea from Canada. *Journal of Veterinary Medical Science*, 64(9), 855–858.

Swayne DE and Suarez DL (2000). Highly pathogenic avian influenza. *Revue Scientifique et Technique*. 19(2): 463–82.

Swayne DE and Halvorson DA (2003). Influenza. In: Saif YM, Barnes HJ, Glisson JR, Fadly AM, McDougald LR, Swayne DE, editors. *Diseases of poultry*. 11th ed. Ames (IA): Iowa State University Press. p135–60.

Thomson GR. Foot-and-mouth disease (1994). In: Coetzer JAW, Thomson GR, Tustin RC and Kriek NPJ (eds). *Infectious diseases of livestock with special reference to Southern Africa*. Vol. 2. Cape Town: Oxford University Press; p. 825–852.

To KK, Wong SS, Poon RW, Trendell-Smith NJ, Ngan AH, Lam, JW, Tang TH, Ah Chong AK, Kan JC, Chan KH, Yuen KY (2012). A novel *Dirofilaria* species causing human and canine infections in Hong Kong. *Journal of Clinical Microbiology*, 50(11).

Tschinkel WR (2006). *The Fire Ants*. Belknap Press of Harvard University Press, Cambridge, MA.

Venter G (2018). *Culicoides*. www.afrivip.org/sites/default/files/01_culicoides_complete_lv.pdf
Accessed 2 March 2016.

Wallner WE (2000). *Lymantria dispar*. NAFC-ExFor Pest Report. www.spfnic.fs.fed.us/exfor/data/pestreports.cfm?pestidval=11&langdisplay=english

Wanaratana S, Amonsin A, Chaisingh A, Panyim S, Sasipreeyajan J and Pakpinyo S (2013). Experimental assessment of houseflies as vectors in avian influenza subtype H5N1 transmission in chickens. *Avian Diseases*. 57: 266–272.

Webster RG and Rott R (1987). Influenza virus A pathogenicity: the pivotal role of hemagglutinin. *Cell*. 50(5): 665–6.

Weseloh RM (1997). Evidence for limited dispersal of larval gypsy moth, *Lymantria dispar L*. (Lepidoptera: Lymantriidae). *The Canadian Entomologist* 129: 355–361.

Weseloh, RM (2003). People and the gypsy moth: A story of human interactions with an invasive species. *American Entomologist*. Fall. 180–190.

Westchester Tree Life, INC. (2016) Sudden Oak Death Life Cycle Westchester Tree Life. http://westchestertreelife.com/2016/08/sudden-oak-death/ Accessed 7 October 2019

World Organisation for Animal Health (OIE) (2019). Scrapie. In *Terrestrial Animal Health Code*, Chapter 14.8, 24th Ed. OIE, Paris. www.oie.int/en/international-standard-setting/terrestrial-code/access-online/ (accessed on 20 August 2018)

Xu Y, Huang J, Zhou A and Zeng L. (2012) Prevalence of *Solenopsis invicta* (Hymenoptera: Formicidae) venom allergic reactions in mainland China. *Florida Entomologist*. 95(4): 961–5.

# Ko Tātou This Is Us

BIOSECURITY 2025