History of forest health research in New Zealand

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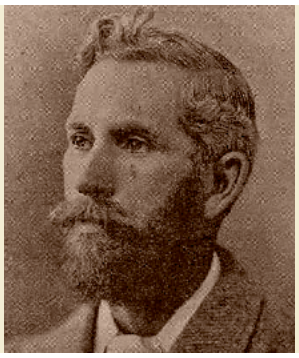
Introduction

Exotic forest trees have been planted in New Zealand since the mid-1880s, initially as shelterbelt trees in treeless areas such as Canterbury and later on a wider scale with the establishment of Whakarewarewa State Forest in the 1900s and Kaingaroa State Forest in the 1920s. As the plantation area grew, so did the awareness of the risks posed by pests and diseases to the forest estate. The purpose of this paper is to outline the long history of forest health research in New Zealand, which began over 100 years ago, and of the significant events that have shaped the course of the research.

1919 to 1947 – the establishment period

Very little forest health research was carried out in New Zealand before the formation of the State Forest Service in 1919. A notable exception was the work of Thomas Kirk, a biologist and chief of the Division of Biology and Pomology in the Department of Agriculture. In 1908, he reported on the biocontrol of gum-tree scale (*Eriococcus coriaceus*) by the ladybird *Rhizobius ventralis*. However, Kirk's main focus was on pests and diseases of fruit trees.



Thomas Kirk, the first person to undertake research on forest pests in New Zealand. Cyclopedia of New Zealand (Wellington Provincial District)

Shortly after its inception, the State Forest Service was renamed the New Zealand Forest Service (NZFS). In the 1920s, David Miller, an entomologist, became an honorary zoologist to the Forest Service and also taught at the School of Forestry established at Auckland University in 1924. Miller published *Forest and Timber Insects in New Zealand* in 1925, and in 1929 he established the Forest Biological Research Station at Nelson. However, this was short lived and closed in the early 1930s – a victim of a lack of funding.

The first attempt at biocontrol of a pine pest in New Zealand occurred at around the same time. The parasitic wasp *Rhyssa persuasoria* was deliberately introduced from Europe to control the sirex woodwasp (*Sirex noctilio*). Miller had a long and distinguished career culminating with the publication of the widely-read *Common Insects in New Zealand* in 1971. His efforts contributed to New Zealand becoming a world leader in biocontrol.

Arthur F. Clark was seconded to the Cawthron Institute in Nelson as a forest entomologist in 1927. He worked with Miller on control of the sirex woodwasp and also on bark beetles, wood borers and insects of eucalypts. Also at Cawthron were two mycologists. In 1926, Kathleen Curtis was the first to report dieback caused by *Diplodia pinea* in *Pinus radiata* and Jean Murray described several fungi associated with species of *Salix* and *Rubus*.

Gordon Cunningham, who was employed by the Department of Agriculture to work on diseases of fruit trees, also acted as a part-time forest pathologist for the Forest Service. His 1923 report on fungi found on timber trees, ornamental woody plants and timber in use was the first of its kind in New Zealand. Cunningham was placed in charge of the Mycological Laboratory at the Plant Research Station in Palmerston North in 1927. Like Kirk, his main interest was in fruit trees, but recognising the need for forest pathology research he requested the transfer of Tom Birch to his newly-formed team of plant pathologists.

Although he had a degree in forestry from Oxford, Birch at that time was employed in Invercargill as a forest guard, an appropriate title given that Scion's forest health research is led by the Forest Protection Team. Cunningham, son of a West Otago farmer, was not one to let matters rest and Birch received a summons dated 17 December 1930 from the director of the Forest Service instructing him to leave Invercargill and report to Palmerston North in eight days' time – on Christmas Day! Birch managed to delay his start until late January 1931. As the first full-time dedicated forest pathologist in New Zealand he carried out pioneering work on armillaria root rot, cypress canker, phomopsis dieback and decay fungi that has stood the test of time.

Birch also wrote a guide to forest fungi. Cunningham developed an interest in wood-decay fungi, and added a section to the Plant Diseases Division (PDD) of the Department of Scientific and Industrial Research (DSIR) in the 1940s to carry out timber preservation research. Forest health research from the 1930s to the late 1940s was primarily focused on finding out what pests and pathogens we had in our forests and what damage they were doing.

Joe (G.B.) Rawlings was appointed as an entomologist and pathologist by the Forest Service in 1938 and continued in that role until his retirement in 1962. Rawlings was a true generalist, a forest ecologist who worked and published on insects and pathogens in

both native and planted forests. Rawlings established the Pathology Branch, consisting of himself and two others, when the Forest Research Institute (FRI) – initially known as the Forest Experiment Station – was formed in 1947.

Interestingly, at least for the authors whose background is in pathology, the organisational chart from that same year shows entomology to be a sub-section of the Pathology Branch, a structure that continued until 1967. In the late 1940s, the pathologists were housed in a prefabricated corrugated iron hut left over from the war, described by mycologist Joy Osborne as, 'spacious, airy and very suitable for the purpose.' Entomology research was carried out in a weatherboard building, but this was cramped and it leaked. In fact, it would be better described as a small leaky hut. Treatment of forest entomology as a lesser discipline no longer prevails.

Late 1940s to 1960s – the development period

For 20 years most forest health research in New Zealand was undertaken by the Forest Research Institute, now Scion. However, some research concerning pests and diseases of forest trees was still carried out by the Plant Diseases Division and at the University of Auckland. The significance of *Phytophthora cinnamomi* as a primary pathogen of forest trees became the subject of vigorous and sometimes acrimonious debate between a pathologist at the Plant Diseases Division, and later the University of Auckland, and a pathologist from the Forest Research Institute.

Two events in the late 1940s and early 1950s guided the research approach over that time. Sirex woodwasp populations had built up in overstocked pine plantations in the central North Island and had caused considerable mortality by 1949. In 1951, the native looper caterpillar *Pseudocoremia suavis* caused severe defoliation of several plantation forests in Canterbury. These events triggered an expansion of the entomology section, with increased effort allocated to the impact and control of sirex woodwasps in particular, and more generally to the monitoring of insect populations, especially lepidopterous defoliators.

These outbreaks also prompted the Forest Service to engage a Canadian biologist, J. de Gryse, to evaluate the forest health research programme and recommend measures to be taken to protect forests from pests and diseases. Forest health surveillance was to be a special focus. His report was completed in 1955 and contained a number of recommendations, the main one being that a surveillance system should be established. The Forest Biology Survey, modelled on the Canadian system, started full-time in February 1956. The survey had three aims:

- to inspect forests for detection of new pests and pathogens or outbreaks of existing pests or diseases

Some of the original Forest Research Institute buildings with administrative offices – with red roofs – in the foreground. Part of the Quonset hut housing the Pathology laboratory is just visible

- to collect data to support research programmes
- to disseminate forest health information to foresters.

During the 1950s and 1960s, a number of new pests and pathogens/diseases were found:

- peniophora root rot caused by *Gloeopeniophorella sacrata*
- terminal crook (*Colletotrichum acutatum* f.sp. *pineum*)
- Swiss needle cast (*Phaeocryptopus gaeumannii*)
- burnt pine longhorn beetle (*Arhopalus ferus*)
- most notably, dothistroma needle blight (*Dothistroma septosporum*).

Along with pest detection, the Forest Biology Survey focused on nursery surveys and the monitoring of sirex, looper caterpillar and tortricid populations in pine plantations.

From 1947 to 1961, the Forest Research Institute was led by a senior Forest Service administrator. The appointment in 1961 of Denis Richardson, a weighty forestry scientist, as a director of research led to a major change in direction. He insisted on research based on experimental work, backed by work plans, not mainly on observation as had been the practice at the Institute. Most scientists who worked there welcomed the change and thrived; some could not and left. Rawlings was one of those who left.

During the 1950s and early 1960s, forest pathology research continued to be concentrated on observation and data collection, as well as understanding the significance of new diseases such as Swiss needle cast, peniophora root rot and terminal crook. Another achievement in the early 1960s was the prevention of chlorosis in Douglas fir planted in Otago and Southland by the recognition that some nursery stock did not have adequate mycorrhizal fungi.

The mid-1960s stand out in the history of forest pathology research in New Zealand. The confirmation of dothistroma needle blight (caused by *Dothistroma septosporum*) in 1964 led to a major expansion in the research effort. Concentrated effort led to an understanding of the infection process and, more importantly, to practical chemical control of the disease. This was the first and only major forest disease to be controlled by aerial application of a fungicide, and all credit to John Gilmour for achieving this. Aerial spraying to control the disease has now become a part of routine forestry operations. The need for a concerted response to deal with this significant forest health event brought together researchers and forest growers for the first time. The Dothistroma Control Committee was founded in 1965 and is still going strong.

Entomology research in the 1960s was principally on biological control of sirex. A major advance was the discovery and subsequent propagation of a nematode *Deladenus siricidicola*, which renders female sirex wasps sterile. The success of other sirex control agents prompted requests from Australia and the first consignments were sent there in 1962. The need for a diagnostic service arose following the establishment of the Forest Biology Survey. By the mid-1970s, over 500 specimens a year were being dealt with. Major surveys of insects in beech forests and pine plantations were conducted along with studies of insects on timber in use.

1970s to 1986 – expansion, consolidation and then decline

The number of forest health science staff, particularly pathologists, increased during the 1970s, followed by consolidation, and then in the mid to late 1980s declined as shown in Table 1. Research was carried out in response to the needs of the Forest Service and to requests from other tree growers. In the latter part of this period, research was reviewed at a high level by a Research Advisory Committee composed of senior foresters and researchers.

Table 1: Scientists and technical staff employed by the Forest Research Institute and Scion on forest health research[1]

Year	1970	1980	1987	1994	2004	2014
Entomology	5	6	3	4	6	7
Pest management[1]	1	1	2	2	5	4
Pathology	3	7	4	3	7	8
Technical	7	18	11	9	8	17
Total	16	32	20	18	26	36

[1] Includes modellers, biometrician

In the 1970s and 1980s, considerable work was done on achieving chemical control of terminal crook, then a serious disease of *P. radiata* seedlings. Research was also carried out on Swiss needle cast, which by then had spread over most of the North Island and parts of the South Island. The effect on growth of armillaria root disease, dothistroma needle blight and cyclaneusma needle cast was determined and site preparation methods for the control of armillaria root disease were investigated.

A major research project on cyclaneusma needle cast (caused by *Cyclaneusma minus*) was established, culminating in 1984 in a series of papers on the biology of the fungus and chemical and silvicultural control. The many fungi causing leaf spots in species of *Eucalyptus* were studied, in particular *Mycosphaeralla nubilosa, M. cryptica* and *Phaeophleospora eucalypti*. The kauri dieback pathogen *Phytophthora taxon Agathis* was isolated from dying kauri rickers on Great Barrier Island in 1972 and was shown to cause the death of kauri seedlings.

In the mid-1970s, the death of shelterbelt trees, mainly *P. radiata*, was shown to be caused by waterlogging leading to root mortality aggravated by infection by *Phytophthora* spp. Silvicultural control of cyclaneusma needle cast was found experimentally to

be successful. It was shown that removing 25 per cent or less of the crown in a single lift and avoiding pruning in the summer months successfully controlled diplodia whorl canker and top dieback.

Timing of pruning was also found to be crucial in controlling stem rots in eucalypts. Further work on chemical control of dothistroma needle blight resulted in reducing the amount of fungicide needed, and the application volume per hectare was also lowered. The effect of spraying of copper compounds on the environment was studied and found to be negligible. The possibility that dothistromin, the toxin produced by *Dothistroma septosporum*, was a carcinogen was explored and it was shown that the quantities produced were so small as to be harmless.

A long study in mortality in beech was concluded in the late 1970s. It was shown that a fungus (*Sporothrix nothofagi*) transmitted by platypodid pin-hole borers could kill merchantable trees if the insect attack followed a long period of drought. Pathogenicity of the fungus was experimentally proved in 1977. Biocontrol of the bark beetles *Hylastes* and *Hylurgus* was attempted. The bark beetles were shown to be of no consequence in plantations, but they were important quarantine pests.

A predator of *Paropsis*, a major pest of some eucalypts, particularly *E. nitens*, was released. An analysis of forest insect interceptions at the border and establishment showed that Australia posed the greatest risk. Of the forest insect species established, 46 were likely to have come from there, 12 from North America, and only two from Asia despite interceptions from North America vastly outnumbering those from Asia or Australia.

Operations of the Forest Biology Survey were reviewed, and in the early 1970s surveillance was extended to cover environs of main seaports and airports and other high-risk areas such as de-vanning depots and major construction sites. Aerial surveillance, in addition to ground surveys, became routine in 1981. In 1985, forest health inspection and construction records over the past 25 years were entered into a computerised database. This was the foundation of the forest health database used to this day.

1987 to present – further decline, restructuring, then growth and expansion

In 1985, the government decreed that it would progressively decrease funding for forest research and that the shortfall should be made up from commercial revenue. The requirement for 1987/88 was that 10 per cent of Forest Research Institute funding would come from commercial sources. This change in policy had significant ramifications for forest health research in New Zealand. A second major change was brought about by the demise of the New Zealand Forest Service in 1987. A consequence of these changes was that industry played an increasingly important role in the setting of research priorities, as would be expected given they were funding part of it.

The Forest Health Advisory Committee was formed in 1988 to advise the Minister of the Ministry of Forestry on issues concerning the health of New Zealand's trees and forests. Government funding became contestable and in 1990 the Foundation for Research, Science and Technology (FRST) was formed to administer this through the Public Good Science Fund. The Forest and Forest Products Research Organisation (FAFPRO) was created at the same time as the Foundation to coordinate research programmes, enhance the relationship between researchers and their clients, and to promote investment in forestry research by industry and government.

Further science reform led to the Forest Research Institute becoming a Crown Research Institute in 1992, with its own board of directors reporting to the Minister of Finance. The advent of contestable funding encouraged a competitive environment and for research providers other than the Institute to become involved in forest health research. Industry visionaries were openly critical of the process. In 1994, Peter Olsen stated in *New Zealand Forestry* that, 'The annual round of bidding … has again demonstrated the problems associated with this contestable process and the stifling of truly cooperative use of research resources.'

In 1996, the Forest Health Research Collaborative (FHRC) was formed by the Forest and Forest Products Research Organisation with the joint aims of facilitating improved interaction between researchers and industry and broadening the base of research providers. A sum of about $55,000 per year was raised from a voluntary levy on Forest Owners Association members. This was used for initiation of small projects or to supplement larger ones. The Forest Biosecurity Research Council (FBRC) was established in 2004 as an unincorporated joint venture between the Forest Owners Association, the Ministry of Agriculture and Forestry, the Forest Health Research Collaborative, the Forest Research Institute and the Bio-Protection Research Centre at Lincoln University.

Another voluntary levy on Forest Owners Association members raised about $300,000 per year. A 2011 review of biosecurity research recommended consolidation of the Forest Health Research Collaborative and Forest Biosecurity Research Council into the Forest Biosecurity Committee (FBC). In 2014, a compulsory levy was imposed on all forest growers and this resulted in forest health research being overseen by a high-level research and development committee, the Forest Biosecurity Committee, plus specific technical sub-committees. For instance, a foliar disease technical sub-committee was recently formed.

The amount of funding, and consequently forest health staff numbers at the Forest Research Institute, increased as a result of these changes in research funding and administration. The mid-1990s had marked a near low when the Institute employed 18 staff working on forest health, but 20 years later that number had doubled to 36 as shown in Table 1.

Research has become more collaborative and the breadth of capability has increased. Over one-third of

government funding for Scion's two major forest health programmes is sub-contracted to external collaborators comprising other crown research institutes, universities and private organisations or individuals. Scion is the primary provider of forest health research to the forest sector, although the Bio-Protection Centre at Lincoln University is a significant contributor. National collaborations such as Better Border Biosecurity, which has five research partners and three end-user partners, are providing vehicles for integrated solutions to forest health issues.

The first new major research project carried out in the post-Forest Service era involved the design of a new forest health surveillance system. This combined three main survey methods undertaken in forests and high-risk sites. A model, named after its developer Peter Carter, was used to allocate effort based on risk and cost-benefit. This surveillance system was described by two international reviewers in 2007 as a programme that, 'deserves commendation as part of a progressive approach to forest biosecurity that exceeds the sophistication level attained by forest health surveillance programs elsewhere in the world.' Put in place in the early 1990s, it is currently under review and will be updated. Major studies were undertaken to quantify the quarantine risk to forestry posed by imported containers at the major seaports at Auckland, Wellington and Christchurch and at Auckland airport.

In general, forest health research over the last 20 years has been aimed at reducing risk, protecting the plantation forest asset value and improving productivity. Compared with the Forest Service days, Scion's research on native plant health has reduced significantly as responsibility has shifted to Landcare Research, another Crown Research Institute, and some universities.

Notable achievements

Achievements over this period have included:

- The combined use of new molecular tools and traditional techniques to detect pitch canker in plant material held in quarantine. This one detection, and the consequent avoidance of the disease becoming established in New Zealand, has saved hundreds of millions of dollars.
- The contribution of entomologists and aerial spray application specialists to two spray programmes in Auckland and one in Hamilton. This has been vital for the successful eradication of three different economically significant moth incursions.
- Success with biocontrol, which has continued with the release of agents to control the eucalypt sawfly and the gum-leaf skeletoniser.
- In 2003, the discovery of nectria flute canker caused by a fungus not considered a pathogen that had never before been recorded in the southern hemisphere or on radiata pine raised initial alarm. A research programme incorporating a mix of fundamental and operational research was developed in close association with industry and government as a response to this threat. It led to the successful control of this disease based on modified forest management.

Further changes

In 2005, the privatisation of the Forest Biology Survey, at the time named Vigil, marked the end of an era that started in 1956. Fortunately, this capability in forest health surveillance was retained by two of the principal forest health advisors who bought the group and formed their own company, SPS Biosecurity.

Watching briefs were kept on overseas pests and diseases. The discovery of the *Phytophthora* foliage disease Red Needle Cast in New Zealand pine plantations in 2008 drew parallels with a similar disease in Chile. For the first time, forest health research was undertaken to find out if pathogens were present on export logs and if so whether they posed any risk to trading partners. The results showed that the *Phytophthora* in question posed a minimal threat because of its inability to colonise wood and survive on log surfaces.

The discovery of this *Phytophthora* increased attention on foliar diseases. A major programme started in 2013 focused on combating these diseases and identifying trees with broad resilience, not only to pathogens already present but also those yet to arrive. This involves collaboration among three Crown Research Institutes – Scion, Plant and Food, and Landcare Research – plus Massey, Lincoln and Auckland Universities and others. The second largest current forest biosecurity programme is seeking alternatives to methyl bromide fumigation for the control of forest insects on export produce.

Summary

In summary, forest health research has been carried out in New Zealand for over a century. The first group formed to undertake this work was established well before most readers of this review, including the authors, were born. The research effort has been influenced by a number of factors – visionary and dedicated people, circumstances (including changes in funding sources, policy and biological invasions), industry requirements and trade patterns – but its intent has not changed in the slightest. To this day, research is carried out to help to protect New Zealand's trees and forests from biotic threats.

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The authors – Lindsay Bulman, science leader of the Forest Protection Group at Scion and Peter Gadgil, former research field leader of Forest Health – have between them over 50 years of first-hand experience of forest health research in New Zealand.