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New eucalypt pests and diseases: what is the risk and how should we respond?

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Report information sheet

Report title	NEW EUCALYPT PESTS AND DISEASES: WHAT IS THE RISK AND HOW SHOULD WE RESPOND?
Authors	Ian Hood, Lindsay Bulman
Client	NZFOA and NZFFA
Client contract number	
MBIE contract number	
SIDNEY output number	60108
Signed off by	
Date	29 December 2018 (revised)
Confidentiality requirement	Confidential (for client use only)
Intellectual property	
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Published by: Scion, 49 Sala Street, Private Bag 3020, Rotorua 3046, New Zealand. www.scionresearch.com

Cover figure: Defoliation in a young stand of *Eucalyptus regnans* afflicted by the disorder known as Barron Road syndrome (Scion image library reference 8068632).

Executive summary

The problem

Eucalypts have been grown in plantations in New Zealand since the late 1800s. Throughout this period they have been subject to incursions of exotic insect pests and fungal pathogens. A number of these organisms have impacted severely on eucalypt health and productivity leading to the elimination of some species from plantation forestry. Further introductions will undoubtedly occur, and an up to date assessment of the biosecurity risk to eucalypts is needed in order to minimise uncertainty and aid decision-making when a new insect or pathogen incursion occurs.

Client initiatives

The New Zealand Forest Owners' Association (FOA), the New Zealand Farm Forestry Association (FFA) and the Ministry for Primary Industries (MPI) have asked Scion to prepare a report evaluating the risk to eucalypt forestry from new introductions of pest and disease agents. In particular, they require information on the prospects for further incursions and their likely impact on the forest and non-forestry industries. They seek information on which to base recommendations on the probability of eradicating introduced insects and pathogens, whether or not eradication should be attempted, and if not, how incursions should be managed.

This project

This report addresses these questions. Its primary purpose is to provide MPI and forest growers with a basis for deciding whether or not it is realistic to attempt the eradication of a newly introduced eucalyptus pest or pathogen. It collates and reviews the information necessary to prepare for and manage a possible incursion using criteria such as the potential impact of the organism and the likelihood of successfully eradicating it.

The report begins with a discussion on the history of eucalypt plantation forestry in New Zealand, the way this has been affected by introduced pests and diseases and the potential for new introductions to occur. It also considers environmental, genetic and management factors that may influence the effects of new pest and disease organisms either beneficially or adversely. The future value and commercial prospects of eucalypts as forestry species are briefly included as an essential element when deciding on how to respond to a new incursion. Following a section summarising the eucalypt grower's perspective, a series of conclusions and recommendations are provided.

Key results

The reality of these biosecurity concerns, and the need to address them, is confirmed. Pre-1960s plantations of *Eucalyptus globulus*, *E*. *macarthurii* and *E*. *viminalis*, subsequent plantings of ash group eucalypts (*E*. *regnans*, *E*. *delegatensis* and to a lesser extent, *E*. *fastigata*), and ultimately young pulpwood stands of *E*. *nitens*, have all suffered in turn from insect pests and fungal infections. This has respectively curbed or completely terminated the role of these eucalypts as plantation species. The effects of pests and pathogens may be alleviated to some extent by management procedures such as suitable siting, genetic selection and for insects, the introduction of effective predators as biological control agents. The breeding programmes of *E. nitens, E. regnans* and *E. fastigata* may also mitigate future damage from existing pests by including health as a key selection criterion. Nevertheless, acquiring the necessary information requires investment and this knowledge is not immediately available for new, untried eucalypt species. Experience both overseas and within New Zealand indicates that introductions of harmful insects and fungi will occur on a regular basis with consequences that are unknown but potentially costly.

Implications of results for the client

- There is a strong likelihood of further incursions of eucalypt insect pests and fungal pathogens in the future.
- Based on precedent, there is reasonable probability that at least some incursions will have moderate or severe consequences.
- Eradication of new eucalypt incursions may be expensive in relation to the unknown (but possibly small) gains achieved by excluding the pest or pathogen, and with regard to the comparatively limited size of the estate; may be unsuccessful, especially if already moderately well dispersed when first detected. If successful, gains may be compromised by the effects of further incursions.
- The safest pest and pathogen risk management approach for eucalypt plantations is to employ a combination of good species selection, appropriate siting, sound management and proficient breeding. Achieving this will require investment, time and enthusiasm, but within a flexible, dynamic and responsive industry, may be effective for some species.

Recommendations

Based on the above, it is recommended that:

- Eradication of a new eucalypt pest or pathogen not be attempted, except in special circumstances.[1]
- Up to date information in written and other form on the management of pests and diseases be available to FOA and FFA members in the event of a pest or disease affecting their eucalypt stands.

[1] For instance, conceivably for a high value eucalypt species with a known background of successful, pest-free production, and a probable chance of effective eradication (e.g. incursion detected early, of limited distribution, and with an efficient operation put into place without delay).

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Table of Contents

Introduction

Eucalypts have been grown in New Zealand ever since the early days of European settlement, initially as ornamental or shelterbelt trees in urban and rural environments, and later also in commercial forest plantations. Interest has waxed and waned during the intervening years, with various species groups being tried at different times. The national eucalypt plantation area currently stands at around 22,300 ha (38). In recent years, attention has been directed towards "dryland" species for the production of naturally durable wood, partly in order to circumvent the use of toxic preservatives. This has once more raised concerns about the possibility of unwanted pests and diseases arriving from nearby Australia. The Forest Owners' Association (FOA), the Farm Forestry Association (FFA) and the Ministry for Primary Industries (MPI) have asked Scion to review the risk and produce a report to help prepare for possible incursions and to aid in decision making should an outbreak occur. The review was to be primarily for forest and woodlot growers, but a secondary objective is to provide information for other sectors as well. In scope it is wide ranging, with specific aims being to assess: (a) the likelihood of a pest or pathogen introduction; (b) the prospective impact of an incursion on commercial eucalypt production as well as on non-forestry industries; and (c) the potential for eradicating an incursion, with recommendations on whether eradication should be attempted, and if not, on how the incursion should be managed.

To set the context, the report begins by briefly outlining the history of eucalypt forestry in this country, in particular drawing attention to current species and those likely to be established in the near future based on present trends and motivations. There follows an account of important pests and pathogens that have significantly affected eucalypt plantation species in the past and which are still of relevance to contemporary eucalypt forestry. The next section conjectures about possible future threats by integrating information from international reviews and previous evaluations undertaken in this country, in order to consider the level of risk posed by the unwanted movement of exotic eucalypt pests and pathogens. The severity of a disease or insect infestation is generally affected by the local environment, so a discussion is included on how the effects of an incursion may be influenced by factors such as site, management activities or host genetics. This is followed by a short section that examines these issues in relation to the commercial outlook for eucalypt species from the viewpoint of several growers.

The concluding section to this report draws the threads together and sums up the perceived biosecurity risk for current and future eucalypt forests. It provides recommendations as to what are considered to be the best approaches to dealing with potential pest and disease introductions in the future.

Eucalypt plantation forestry in New Zealand

Eucalypts were first planted in New Zealand in the 1830s, with the beginnings of plantation forestry underway before the end of the century (25). Interest in different groups of species has occurred at successive intervals over the ensuing years. *Eucalyptus globulus* ("blue gum"), one of the first species planted, was subsequently joined by others such *E*. *macarthurii* and *E*. *viminalis* (all in section *Maidenaria* of subgenus *Symphyomyrtus*). Episodes of damage from frost and attacks by a range of insects occurred during the following decades (next section), and pulpwood plantings of "ash" species (*Monocalyptus*: *E*. *delegatensis*, *E*. *regnans*, *E*. *fastigata*) and *E*. *saligna* (*Symphyomyrtus*) were established as replacements from the 1960s (10,11,14,33). This was partly to substitute for decreasing quantities of indigenous tawa (*Beilschmiedia tawa*), which was still being harvested from residual native cutover being cleared for pine plantation, as a short fibre pulp resource, as well as to provide specialty timbers in their own right (sawnwood and roundwood;11,27). These species suffered attack from various forms of foliage fungi (next section) and in their turn declined in popularity in planting programmes (26,27; Fig. 1). With the biological control of the defoliator *Paropsis charybdis* (eucalypt tortoise beetle; 2,10), it became possible to set up numerous small plantations of *E*. *nitens* (section *Maidenaria*), along with *E*. *fastigata*, during the 1990s, also for short fibre pulp for higher quality paper (10,21,32). However, these stands have also suffered a similar fate (next section), although plantations of *E*. *fastigata* have remained comparatively free from attack by biotic agents.

As at April 2017, eucalypts comprised 0.8% of the total planted forest area of 1.2 million ha in the North Island and 2.7% of the 0.5 million ha in the South Island (38). Many of these stands are in the central North Island, with smaller quantities in areas such as Hawke's Bay and the Clutha district, besides ca. 10,000 ha of mainly *E. nitens* pulpwood stands in Southland. This species is better adapted to the cooler southern climate where it has not suffered as it has in warmer parts of the North Island. There is currently an initiative to promote the planting of “dryland” eucalypt species in order to supply “naturally ground durable” posts as replacements for environmentally unfriendly (e.g. copper chrome arsenate treated) radiata pine posts in vineyards (30,31,37,39,48). Species considered have included both monocalypt “stringybarks” (e.g. *E*. *globoidea*, *E*. *macrorhynca*) and symphyomyrt species (e.g. *E*. *argophloia*, *E*. *bosistoana*, *E*. *camaldulensis*, *E*. *cladocalyx*, *E*. *quadrangulata*, *E*. *tricarpa*).

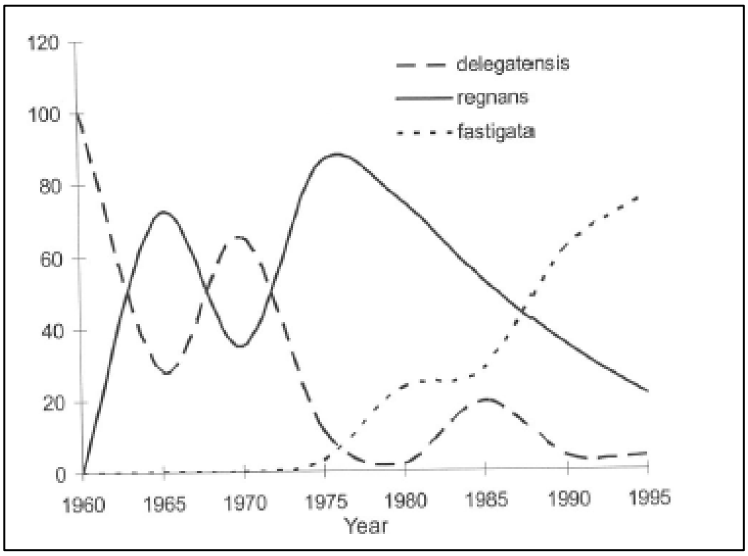

Figure 1: Relative percentage plantation areas of *Eucalyptus* species in the central North Island from 1960 to 1995 (27). Total area of the three species was 12,000 ha in 1980 (90% of the overall eucalypt plantation area) and 27,000 ha in 1993 (10).

Important pests and pathogens of the past and present

Insect pests

Eucalypts in New Zealand have been affected to a greater or lesser degree by a variety of introduced insect pests throughout the period they have been established in plantations (Table 1). Among the more significant have been *Cardiaspina fiscella*, *Paropsis charybdis*, *Phylacteophaga froggatti* and *Uraba lugens* (2, 53; Forest and Timber Insect Leaflets, Scion[2]). Table 1 is unbalanced in that greater numbers are recorded on species that have been more widely planted over a longer period, such as *E*. *nitens* and *E*. *fastigata*. But it appears that even less well known eucalypt species such as *E*. *bosistoana*, *E*. *camaldulensis*, *E*. *globioidea*, *E*. *quadrangulata* and *E*. *macrorhynca*, which have been sampled less intensively, already have their complement of pests.

Of the 15,000-20,000 insect species believed to feed on eucalypts in Australia, approximately 60 species are present in New Zealand, comprising mainly leaf chewers and sapsuckers, such as psyllids (16,53). Some insects specialise in only small groups of host species while others feed more generally on a wide range of species. Although not well studied in New Zealand, a trend is apparent for symphyomyrt eucalypts such as *E*. *botryoides*, *E*. *globulus*, *E*. *nitens* and *E*. *saligna* to be more palatable to these browsing and sucking insects than species in the *Monocalyptus* and *Corymbia* groups (16,46). Indeed, *E*. *globulus* was found early on to be susceptible to the gum tree weevil (*Gonipterus scutellatus*) and the gum tree scale (*Eriococcus coriaceus*). Probably the most serious impact by an insect pest in New Zealand eucalypts has been the severe defoliation in stands of the symphyomyrt species *E*. *globulus*, *E*. *viminalis and E*. *macarthurii* by the eucalypt tortoise beetle, *Paropsis charybdis* (11; Fig. 2; see box, page 4). Symphyomyrt eucalypts are among those favoured by the more recently introduced gum leaf skeletoniser (*Uraba lugans*; see box, page 5).

[2] https://cdm20044.contentdm.oclc.org/digital/collection/p20044coll11.

Table 1: Summary of some of the insect pests recorded on current and prospective *Eucalyptus* plantation species (Nº of records in Scion Forest Health Database).

	***Eucalyptus* (5)**							
	Subgenus *Eucalyptus* (monocalypts)				**Subgenus *Symphyomyrtus***			
	"Ashes" (series *Obliquae*)		**"Stringybarks" (series *Pachyphloius*)**		**Section *Maidenaria***		**Section *Exsertaria***	**Section *Adnataria***
	E. regnans	*E. fastigata*	*E. globoidea*	*E. macrorhynca*	*E. nitens*	*E. quadrangulata*	*E. camaldulenis*	*E. bosistoana*
Defoliators								
Acrocercops laciniella	4	13	1		18	1	2	2
Opodiphthera eucalypti	1	7			2			
Paropsis charybdis	3	11	1	1	25	4	2	
Paropsisterna variicollis						1	1	1
Phylacteophaga froggatti	9	16			31	2		1
Strepsicrates macropetana	4	18			27	2	1	2
Trachymela sloanei	1				14		1	
Uraba lugens	1	6			2		3	1
Sap suckers								
Cardiaspina fiscella	1				1		2	
Ctenarytaina eucalypti					46			
Ctenopseustis obliquana	1	3			7			
Eriococcus coriaceus	5	2			19			
Ophelimus eucalypti	5				16	1		
Wood borers								
Callidiopis scutellaris	14	8	1		5			
Tessaromma undatum	7	3			4			
Total	**56**	**87**	**3**	**1**	**217**	**12**	**12**	**7**

***Paropsis charybdis*, the eucalypt tortoise beetle.**

Paropsis charybdis was first recorded from the Port Hills in Christchurch in 1916. It is considered to be the most important insect defoliator of eucalypts in New Zealand as a result of its voracious feeding on adult foliage. It was primarily responsible for the demise of eucalypts such as *E*. *globulus*, *E*. *viminalis* and *E*. *macarthurii* as plantation species, and has hindered the establishment of *E*. *nitens*. Other *Eucalyptus* species are susceptible to varying degrees, with *E*. *fastigata* subject only to moderate attack.

The egg parasitoid, *Enoggera nassaui*, was successfully introduced as a biological control agent in the late 1980s, after several earlier attempts with other insect species had failed (2), and this led to renewed enthusiasm for the establishment of new plantations of *E*. *nitens* during the 1990s. However, in some young plantations in cooler regions such as the central North Island, control was not always successful, with outbreaks of *P*. *charybdis* occurring during late summer. In addition, the unintended appearance of a hyperparasite, *Baeoanusia albifuncle*, of *E*. *nassaui* further counteracted the benefits of this biological control agent. A second parasitoid of *P*. *charybdis*, *Neopolycystus insectifurax*, immune to the hyperparasite, was also found to have arrived naturally in New Zealand, giving new hope for better control of the pest.

A survey was undertaken during 2007 and 2008 in both the North and South Islands to investigate just what was happening (35). The picture that emerged was complex, but there were indications that the second parasitoid, *N*. *insectifurax*, might be providing control of *P*. *charybdis* during the late summer period when *E*. *nassaui* was less effective.

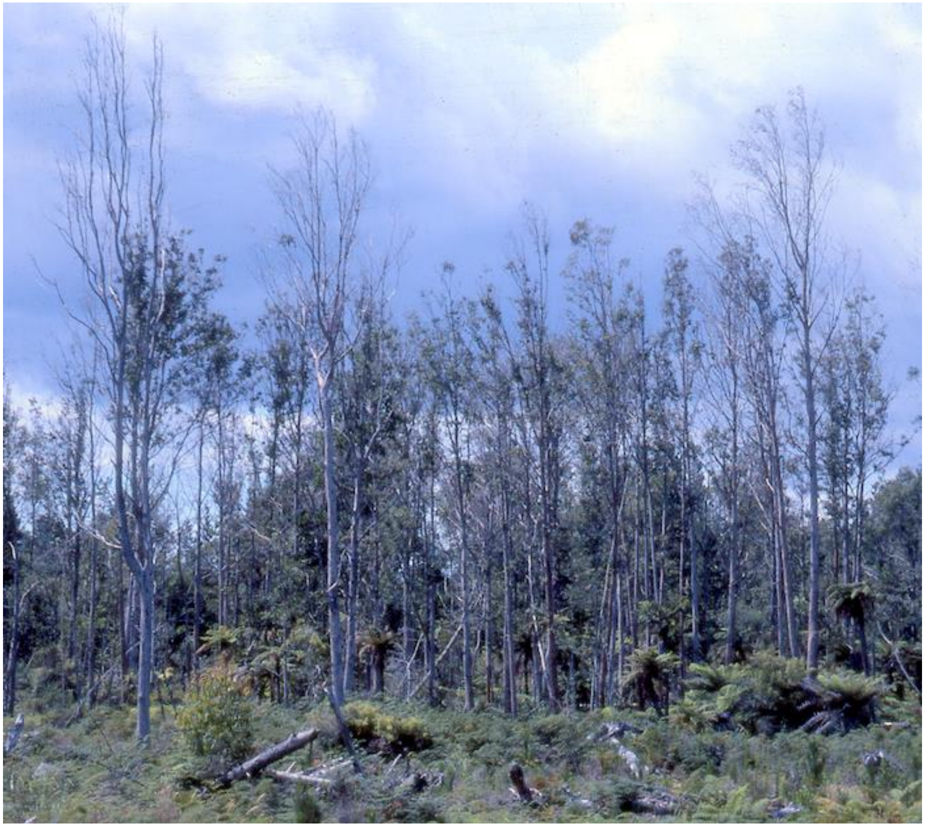

Figure 2: *Eucalyptus macarthurii* ravaged by the eucalypt tortoise beetle, *Paropsis charybdis*, on Matakana Island, Bay of Plenty (Scion image library reference 8048445).

***Uraba lugens*, the gum leaf skeletoniser.**

The gum leaf skeletoniser was first detected in New Zealand in 1992 at the Mount Maunganui Golf Course during a routine port environs survey. It was subsequently found in Auckland in 2001 and has now spread to the South Island. The insect occurs in Australia and is considered to be a serious defoliator of some species of eucalypt trees there.

In New Zealand the skeletoniser has been found on *Eucalyptus globulus*, *E. leucoxylon*, *E. macrocarpa, E. nitens*, *E. saligna* and *Corymbia ficifolia. Eucalyptus nitens* and *E. saligna* are important commercial plantation and farm forestry species in New Zealand and this insect has the potential to be a serious pest of these and other species of eucalypts, causing defoliation and loss of growth and even the death of smaller trees. It is not known how damaging this skeletoniser will be on *E. nitens* in Southland, or in cooler climates that limit the lifecycle of the pest.

The insect is also a human health risk. It produces hairs that can cause skin irritation and rashes on people.

Since its introduction is has not yet caused serious damage to plantations and its presence is mainly confined to trees growing in urban situations. This may be a "sleeper" pest that could increase in severity if plantations of suitable hosts expand.

Fungal pathogens

A catalogue of the more common pathogens found in New Zealand eucalypts as logged in the Scion Forest Health Database is presented in Table 2 (see also Fig. 3). As with insects, there are fewer records on less widely planted eucalypt species, which may be partly an effect of sampling intensity. Not all species are listed, and among those that are, some have had only minor consequences. However, others have impacted more seriously. The more important diseases and disorders caused by introduced pathogens have been reviewed periodically during the past two decades. This section briefly summarises our present knowledge.

Foliage diseases

In the 1970s serious discoloration and defoliation caused by *Teratosphaeria* (*Mycosphaerella) cryptica* led eventually to the abandonment of *E. delegatensis* in the central North Island (10,14,23,27). In like manner, the plantation area stocked in *E. regnans* steadily diminished during the 1980s mainly as a result of a disorder widespread in the central North Island known as "Barron Road Syndrome" caused by a complex of leaf-infecting fungi (14,26,27,44; cover image; see box, p. 8).

Since the mid-1980s there have been periodic localised outbreaks of a leaf spotting disease caused by two previously undescribed foliage-infecting species of *Phytophthora*. Petioles, twigs and small branches also become infected. *Phytophthora captiosa* occurs in stands of *E*. *saligna* and *E*. *botryoides* (symphyomyrts), while *P*. *fallax* attacks the ash group eucalypts *E*. *delegatensis*, *E*. *fastigata*, *E*. *reganans* as well as *E*. *nitens* (8).

During the 1990s and into the next decade, plantations of *E*. *nitens* were afflicted by a decline associated with the leaf blotch fungus *T*. *eucalypti*, which has been largely responsible for the abandonment of plantations of this species near the coast in the Bay of Plenty region (Fig. 4, p.9; see box, p.8).

Thus, during each decade since 1980 different introduced foliage pathogens have significantly impacted on eucalypt forestry.

Table 2: Summary of selected fungal pathogens recorded on current and prospective *Eucalyptus* species (N$^{os.}$ of records in Scion Forest Health Database)

Pathogens	*Eucalyptus* (5)							
	Subgenus *Eucalyptus* (monocalypts)				Subgenus *Symphyomyrtus*			
	"Ashes" (series *Obliquae*)		"Stringybarks" (series *Pachyphloius*)		Section *Maidenaria*		Section *Exsertaria*	Section *Adnataria*
	E. regnans	*E. fastigata*	*E. globoidea*	*E. macrorhynca*	*E. nitens*	*E. quadrangulata*	*E. camaldulenis*	*E. bosistoana*
Root disease								
Armillaria spp.	14	6			3			
Phytophthora cinnamomi	5	7			1			
Stem infections, dieback and sap rot								
Botryosphaeria dothidea					2			
Botryosphaeria sp.	2	3			18			
Chondrostereum purpureum	1	1			2			
Cytospora spp.	6	1			22			
Sarcostroma mahinapuensis					14			
Leaf spots and defoliation								
Aulographina eucalypti (anamorph: *Thyrinula eucalypti*)	68	74		1	52	1		
Fairmaniella leprosa	8	2	1		12			
Hainesia lythri	1	5			5			
Harknessia spp.	3				7			
Microsphaeropsis conielloides	6	4						
Mycosphaerella swartii (anamorph: *Sonderhenia eucalyptorum*)	16	7	4		1			
Mycosphaerella walkeri (anamorph: *Sonderhenia eucalypticola*)								
Pachysacca pusilla	4	2						
Phaeothyriolum microthyrioides	3	6			9	1		
Phytophthora captiosa								
Phytophthora fallax	1	2			2			
Pseudocercospora crousii	3	4						
Pseudocercospora eucalyptorum	22	19	1		49			
Pseudocercospora spp.	2	4			12			

Continued

Table 2 (continued):

Pathogens	*Eucalyptus* (5)							
	Subgenus *Eucalyptus* (monocalypts)				Subgenus *Symphyomyrtus*			
	"Ashes" (series *Obliquae*)		"Stringybarks" (series *Pachyphloius*)		Section *Maidenaria*		Section *Exsertaria*	Section *Adnataria*
	E. regnans	*E. fastigata*	*E. globoidea*	*E. macrorhynca*	*E. nitens*	*E. quadrangulata*	*E. camaldulenis*	*E. bosistoana*
Leaf spots and defoliation (continued)								
Readeriella mirabilis		11			3			
Sphaerotheca pannosa							1	
Teratosphaeria (*Phaeophleospora*, *Kirramyces*) *eucalypti*					172		3	
Teratosphaeria (*Mycosphaerella*) *cryptica*	60	16	2		94			
Teratosphaeria (*Mycosphaerella*) *nubilosa* (anamorph.: *Colletogloeum nubilosum)*	3	3			21			
Trimmatostroma bifarium	24	15			2			
Trimmatostroma excentricum	14	2						
Vermisporium obtusum	11	1			1			
Vermisporium spp.	6	2			2			
Total	**283**	**197**	**8**	**1**	**506**	**2**	**4**	**0**

Figure 3: Eucalypt leaf spot fungi. Left: *Trimmatostroma* sp. on insect-browsed *Eucalyptus regnans* foliage. Right: *Teratosphaeria cryptica* on *E. delegatensis* leaves. Scion image library references 8066092, 8065969.

Barron Road syndrome

Barron Road Syndrome (so named because of the location of the first study site in the early 1980s), is a condition of some ash group eucalypts that results in the upper crown becoming totally devoid of leaves. Small spots appear on new foliage and shoots and stems develop small galls. Barron Road Syndrome develops after extended periods of mild, wet weather. *Eucalyptus regnans* and *E*. *delegatensis* suffered badly from this disorder, which resulted in many moribund and dead trees in the worst affected areas. *Eucalyptus fastigata* showed similar symptoms but generally retained its foliage. A suite of fungi have been found associated with the affected tissues. These include known pathogens such as *Aulographina eucalypti*, *Elsinoe eucalypti*, *Teratosphaeria* (*Mycosphaerella*) *cryptica*, *Mycosphaerella swartii* and *Pseudocercospora eucalyptorum*.

Eucalyptus regnans and *E*. *delegatensis*, originate from areas in Australia with a distinct winter rainfall pattern, whereas *E*. *fastigata* comes from a winter-uniform, summer rainfall area, and is better adapted to withstand fungal attack on sites with moderate to warm temperatures and wet conditions (4).

The disease resulted in the gradual demise of *E*. *regnans* plantings in the central North Island during the 1980s.

Septoria leaf blight provides another text book example of a eucalypt disease putting paid to a prospective commercial enterprise. Disguised under a variety of synonyms (*Septoria pulcherrima*, *S*. *normae*, *Kirramyces eucalypti*, *Phaeophleospora eucalypti* etc.), *Teratosphaeria eucalypti* (its current name) was first found in New Zealand in the central North Island in 1981 and appeared to be just another of the many insignificant leaf spot fungi present on a variety of eucalypt species **(**9,13)**.** In the 1990s, following the successful biological control of the eucalyptus tortoise beetle (*Paropsis charybdis*), small plantations of *E*. *nitens* were planted onto pasture sites dotted through the Bay of Plenty and central North Island regions, with the intention of providing a fast growing resource of short fibre pulp additive for the manufacture of quality paper. Unfortunately many of these sites were not suitable for *E. nitens*. Concern was soon raised when the trees in many of these stands became spotted and defoliated by *T*. *eucalypti* associated with a persistence of juvenile foliage, a delay in the appearance of adult leaves and in reduced growth. Studies to understand and remedy the syndrome were commissioned and it became apparent that although the development of an aerial spraying procedure may have been possible, it would have been impracticable as an economical control measure (21,43). The stands were eventually felled and the blocks gradually sold off and returned to farmland or established in radiata pine. However, *E*. *nitens* remains healthy when grown on more suitable, cooler Southland sites (see “Mitigating factors”).

Stem disorders

Heavy defoliation due to some of the foliage diseases discussed above has also led to severe branch dieback and stem malformation (10). Besides this, sapwood decay was found to be a significant problem affecting wood production in some eucalypt species in the ash and *Maidenaria* groups as well as in *E*. *saligna* and *E*. *botryoides*. The principle cause was invasion through pruning wounds of the decay fungus *Chondrostereum purpureum*. An opportunist canker fungus, *Holocryphia eucalypti*, present in Australia and South Africa, was reported comparatively recently in New Zealand, but does not appear to be a serious issue here (15**).**

Figure 4: Septoria leaf blight on *Eucalyptus nitens* caused by *Teratosphaeria eucalypti*. Top left: young, healthy, central North Island stand. Top right: similar aged, Bay of Plenty, coastal stand affected by disease. Bottom: juvenile leaves with yellow spots due to early infection by *T. eucalypti* (spots later turn crimson and leaves then become brown before casting prematurely).

Root diseases

Armillaria root disease, caused by native species of *Armillaria*, has occurred only occasionally in eucalypt stands. However, stumps of previous-crop eucalypt species act as an efficient saprophytic food source for the pathogen, resulting in greater levels of mortality in subsequent pine stands that replace them. The less common root disease agent, *Junghuhnia vincta* behaves in a similar way on a minor scale. For instance, significant mortality caused by this pathogen was observed in a young radiata pine stand that succeeded a plantation of *E*. *nitens* in the Bay of Plenty region (18). Although *Phytophthora cinnamomi* is important in both Western Australia and South Africa it is generally of low significance in eucalypt stands in New Zealand (14). However, patches of mortality have been found in *E*. *fastigata* stands growing on wet or compacted sites in the Bay of Plenty (10,16). In Australia, monocalypt eucalypts (such as those belonging to the ash group, including *E*. *fastigata*, and "stringy bark" species) are more prone to attack by *P*. *cinnamomi* than symphyomyrt eucalypts and the genus *Corymbia* (bloodwood) (28,45; cf. Table 2).

Symphyomyrtus and Monocalyptus in terms of biological risk

It has been advocated that eucalypts in subgenus *Symphyomyrtus* are more susceptible to various insect pests than species in subgenus *Monocalyptus* such as the stringybarks *E*. *globoidea* and *E*. *macrorhynca*. While there appears to be support for this assertion from studies in Australia (46), the basis for susceptibility has not been well studied or understood. It should also be borne in mind that monocalypt eucalypts appear to be more susceptible to soil borne species of *Phytophthora* and that in New Zealand plantations of certain monocalypt species have historically been severely impacted by fungal pathogens.

It may be useful to consider this subgenus effect on susceptibility of the host species when deciding the appropriate response to a new incursion (for instance, is an attempt to eradicate a new insect pest likely to be more effective with a monocalypt eucalypt?). However, based on current knowledge, this aspect will not outweigh other key factors such as cost, probability of success and the risk of further incursions in the future.

Threats

Eucalypts have been cultivated around the globe in both the tropics and temperate zones, particularly in the southern hemisphere, for at least a century (51). In some regions species have become naturalised and even invasive (6). Part of the reason for their rapid growth in these new environments has been the absence during an initial "honeymoon period" of pests and diseases, which they have left behind in their native homeland in Australia and islands to the tropical north. However, new insects and pathogens have intermittently dispersed from this region reaching eucalypts in countries such as South Africa, Indonesia, Thailand, Viet Nam, China and other parts of the world. This movement has been encouraged by the expansion of the global plantation area during the last 3-4 decades (6,23,24,51). Introductions have accelerated in more recent years as international movement of people and goods has increased, assisted in some cases by the transfer of seed and rooted cuttings.

Although the predominant source of many exotic pests and pathogens such as species of *Teratosphaeria* (*Mycosphaerella*) and *Holocryphia* is Australia, some have originated elsewhere. Exposure to the myrtle rust pathogen, *Austropuccinia psidii*, for instance, first occurred when eucalypts were planted in tropical South America, allowing the pathogen to "shift" from its natural hosts (e.g. guava, *Psidium guajava*). This has facilitated the spread of pathogen strains from their South American home to eucalypts and other myrtaceous hosts elsewhere in the world, including Australia. In the same way, the canker forming fungus, *Chrysoporthe* (*Cryphonectria*) *cubensis*, may have first met eucalypts in Brazil, from where it has also spread globally (6,29).

Based on previous records there is no reason to believe that the appearance of new pests and diseases will not continue to occur as in the past. In their new environments they are in general no longer in climatic balance with their hosts, which may suffer as a consequence. They are also not held in check by hyperparasites that may be present in the indigenous habitat (6,51). There are more than 150 species of *Teratosphaeria* or *Mycosphaerella* leaf fungi, although so far only a small number have caused serious disease (6).

Perhaps the greatest risk from the dispersal of unwanted pests or pathogens is to plantations within Australia, itself (42). Planted eucalypts in that country are particularly vulnerable because indigenous pests and pathogens are right on their doorstep. Single-species stands on inappropriate sites have frequently suffered from, and at times succumbed to leaf diseases caused by *Teratosphaeria* and *Mycosphaerella* species. Plantations of *E*. *globulus* in Western Australia, where it is, in fact, an exotic species, have experienced disease or infection from strains of *T*. *nubilosa*, *T*. *suttonii* and *T*. *cryptica* that appear to have originated from specific locations back in eastern Australia (6). *Eucalyptus nitens* supports a variety of insect and fungal disorders in Tasmania, where it is also an introduced species (49).

It is only a step further to New Zealand, which in some ways is even closer to the natural populations of potential new pests and diseases than some locations in Australia, such as the biogeographically isolated western part of the country. For instance, both *T*. *eucalypti* and *T*. *cryptica* are so far known only from New Zealand and Australia (6,21). New Zealand has had the greatest numbers of eucalypt insect pest introductions of any country outside Australia (24). The ease with which air currents have carried these biological agents across the Tasman to New Zealand is well established (7,17,27). Even so, first detections of many pests and pathogens have actually been made in urban areas and around ports (Fig. 5), indicating that breaches of quarantine and introduction by means of imported goods particularly constitute a major risk (27,53).

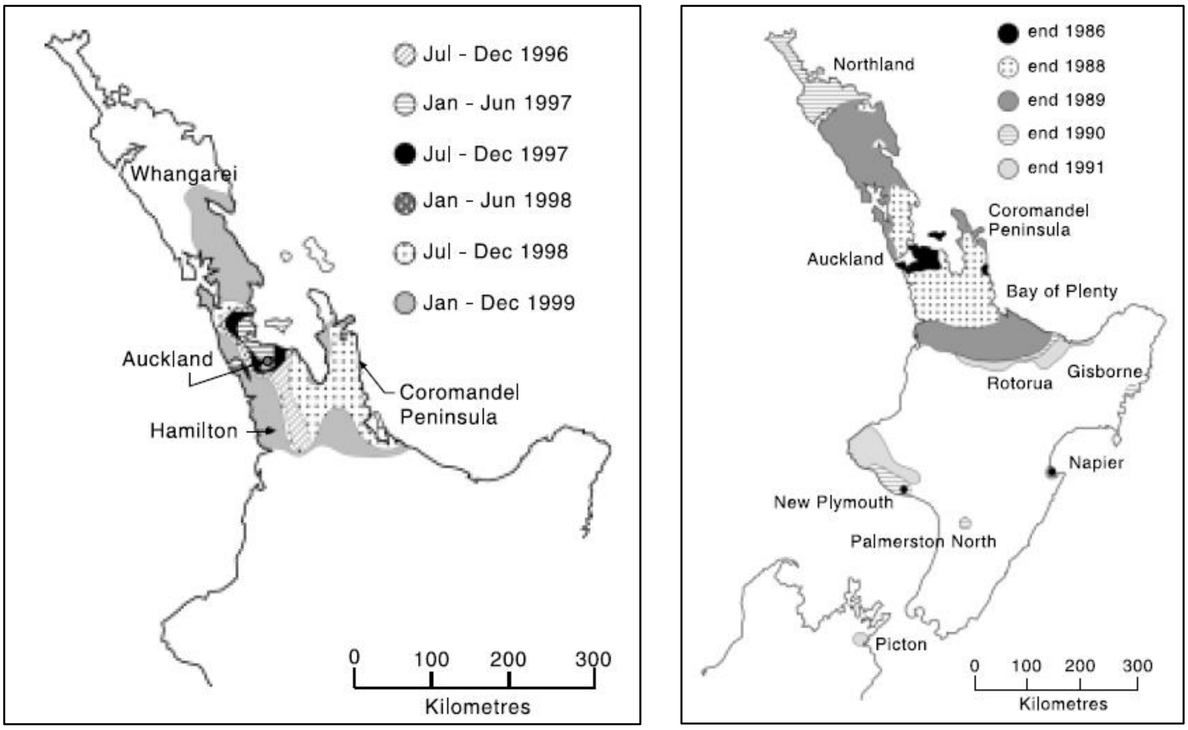

Figure 5: Spread of two eucalypt insect pests from first detection in Auckland (53). Left: brown lace lerp (*Cardiaspina fiscella*), July, 1996 to December, 1999. Right: leaf mining sawfly (*Phylacteophaga froggatti*), 1986 to 1992.

A time sequence of introductions of pests and pathogens since 1988 is presented in Fig. 6, based on the data in App. 1 (earlier first records are also available; 4,23). It is clear from this chart that New Zealand is no exception, and that further incursions can be expected. It is likely that some introductions from Australia may have been airborne by means of atmospheric currents. There is evidence of aphids and other small bodied insects, and even larger lepidoptera, being carried across the Tasman in this way (7,53). However, the majority of insect incursions have been with trade items, or by other human agency, through marine or air ports, despite border biosecurity protocols (27,53). The dominant insect invaders have been leaf chewers and sapsuckers, particularly psyllids. Some notable earlier pest introductions have included (53): the gum tree scale (*Eriococcus coriaceus*; first record, 1900), the eucalypt weevil (*Gonipterus scutellatus*; first record, 1890), the eucalypt tortoise beetle (*Paropsis charybdis*; first record, 1916) and the leaf blister sawfly (*Phylacteophaga froggatti*; first record, 1985).

There are major eucalypt pests in Australia that have not yet reached plantations in New Zealand. These include coreid bugs, external feeding sawflies, cup moths, autumn gum moths, cossid borers, seed feeders, the mutualistic nematode/*Fergusonina* fly galls and others (53).

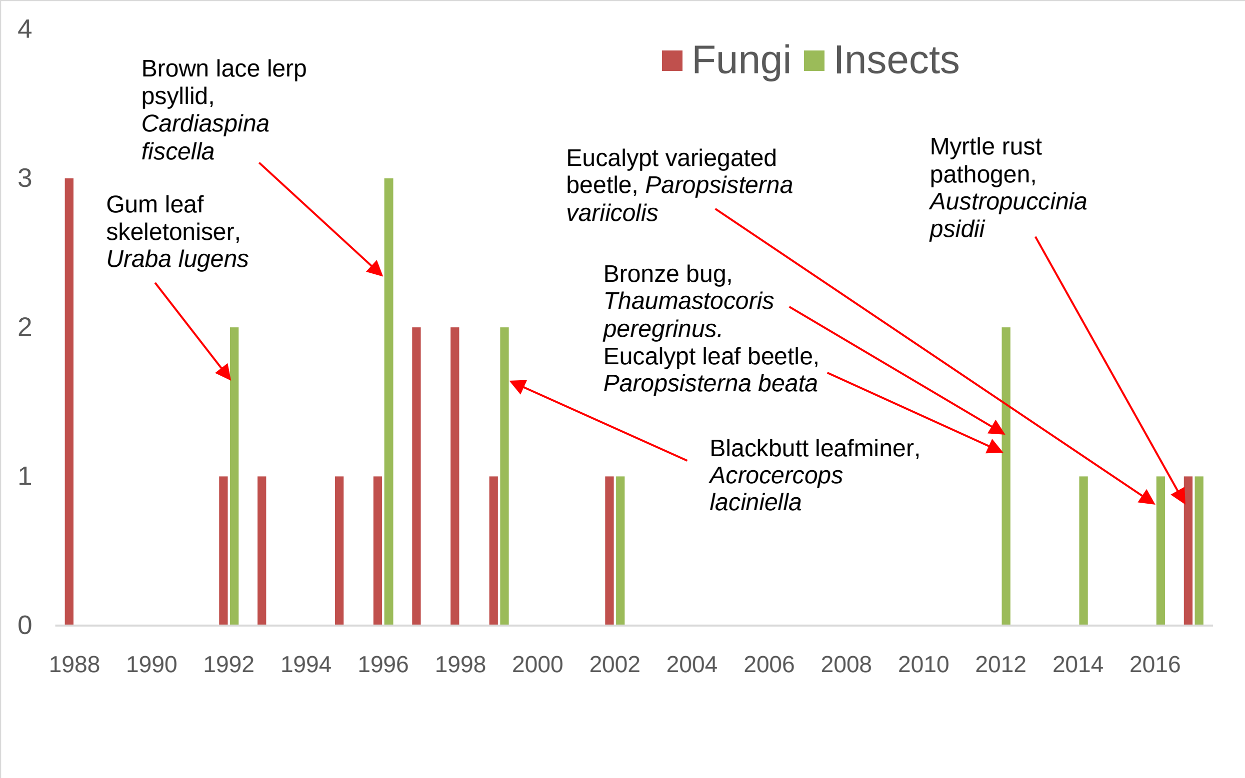

Figure 6: Three decades of eucalypt pest and pathogen introductions: numbers of first records of fungi and insects on eucalypt species by year since 1988. Introductions of significant pests are indicated. Source: Scion Forest Health Database (App. 1) and Ministry for Primary Industries (*A. psidii*).

New fungal pathogens have also continued to appear in eucalypt stands in New Zealand since the earlier introductions of species such as *Teratosphaeria* (*Mycosphaerella*) *nubilosa* and *T*. *cryptica* (4). In one study limited to material from a single trial stand of *E. globulus* near Kawerau, *T*. *nubilosa* was found to have a low genetic diversity and to belong to just one of three groups (Group B; now formally named *Teratosphaeria pseudoglobulus*: 40,41). However, it is possible that wider sampling may reveal greater diversity and it was suggested that a comparatively high genetic variation among *Teratosphaeria* species in New Zealand implies multiple introductions from Australia over the years that eucalypts have been grown in this country (6; cf. 47). In any case, with the close proximity of the two countries, there is clearly significant risk of further introductions.

Trying to anticipate which organisms may arrive in the future is a hazardous exercise. A number of known pathogens not present in this country include the stem canker fungus, *Chrysoporthe cubensis***,** foliage micro-fungi such as *Pseudocercospora basiramifera*, *Pachysacca eucalypti*, *Pachysacca samuelii*, *Sporothrix pusilla*, *Anthostomella eucalypti*, *Coniella australiensis*, *Coniella fragariae* and *Cylindrocladium quinqueseptatum* (a tropical species) and the root disease pathogen, *Armillaria luteobubalina*. There is also a variety of saprophytic wood decay fungi found on eucalypts in Australia but which are absent from this country such as *Amauroderma rude*, *Laccocephalum tumulosum* and *Piptoporus australiensis*. It is also worth remarking that a number of eucalypt mistletoes have remained behind in their native homeland apparently because of limited seed dispersal. But on the other hand, it is also possible that an insignificant organism that is harmless and even unknown in its own country may appear in eucalypt stands in this country. Insects that were virtually unknown as pests in Australia that have become pests in New Zealand include the psyllid, *Ctenarytaina spatulata*; the eulophid wasp, *Ophelimus eucalypti*; the chrysomelid beetles, *Paropsis charybdis*, *Trachymela sloanei* and *Trachymela catenata*; and the leafroller, *Strepsicrates macropetana* (53).The rust fungus, *Puccinia cygnorum*, found on *Kunzea ericifolia* in Western Australia, was unknown in its home country until intercepted on a shipment of cut flowers by New Zealand border security authorities (17). The most recent invasion, a strain of *Austropuccinia psidii*, agent of myrtle rust, reached the New Zealand mainland only in May 2017. Although now present it is still spreading throughout the country and its behaviour and ultimate impact on eucalypts have yet to be revealed (Fig. 7; see box).

Figure 7: Myrtle rust on *Eucalyptus wandoo* from Western Australia in the laboratory. The disease has not yet been found in this State. https://www.dpaw.wa.gov.au/management/pests-diseases/206-myrtle-rust**.**

Myrtle rust, caused by *Austropuccinia psidii*, was confirmed infecting *Metrosideros kermadecensis* on Raoul Island in the Kermadec group in early April, 2017, and was found on mainland New Zealand at Kerikeri several weeks later. During the ensuing cooler months it was discovered successively in Taranaki, Bay of Plenty and south Waikato, all finds being in urban gardens, nurseries or nearby rural settings. Despite eradication attempts by the Ministry for Primary Industries, infection has only recently (November, 2017) extended its range to the Auckland and Wellington areas. As warmer summer weather arrives more occurrences are anticipated, with potential spread onto myrtaceous hosts in indigenous vegetation.

Although it is still early days, experience in Australia suggests that eucalypts may not be seriously impacted by the present myrtle rust strain. While seedlings may be affected, severe disease in later juvenile and adult stages appears unlikely, although early infection could lead to around 10-20% of the trees in young stands becoming malformed (17). The persistence of juvenile foliage in coastal Bay of Plenty stands of *E*. *nitens* associated with infection by *T*. *eucalypti* could potentially favour attack by *P*. *psidii*. However, to date (7 December, 2017), infection has been found on only 0.03% of inspected eucalypt specimens[1] (MPI 2017; cf. 4.31% for susceptible *Lophomyrtus bullata* and 0.63% for native *Metrosideros* species). Prospects appear equally favourable for other industries based on myrtaceous hosts such as the manuka honey industry (0.01% of inspected *Leptospermum scoparium* specimens infected) and feijoa orchards (only one, recent infection).

Nevertheless, strains of *A*. *psidii* have severely affected plantations of *E*. *grandis*, *E*. *cloeziana*, *E*. *globulus* and *E*. *viminalis* from the 1970s in the native region of the pathogen in Brazil, where the disease is referred to as eucalypt rust (1). Although commercial plantations in this region are composed predominantly of eucalypt clones with a narrow genetic base, including genes selected for a resistance which is periodically overcome (29), the severity of the rust outbreaks suggests there is still a need for caution and vigilance in this country. A 2018-19 programme of research is carrying out inoculation studies testing overseas and local *A*. *psidii* strains.

[1]This situation had not changed by June 2018, well past the first summer, with still only one record reported by the Ministry for Primary Industries on a *Eucalyptus* sp.

Mitigating factors

Some of the problems with exotic pests and pathogens in eucalypt plantations might have been circumvented or lessened with a different management approach. However, the necessary information has been gained largely by hard experience over a period of time, and was not known when plantations were first established. This section discusses some of the various factors that need to be considered, but for which knowledge is still sparse with respect to eucalypt species that have yet to be tried in this country.

It has been demonstrated that eucalypts, in particular, must be planted on sites with suitable environmental conditions where they are not stressed and more likely to succumb to the effects of infestation by insects or infection by pathogens. Climate factors that have been found to be influential for different eucalypt species include temperature and rainfall. Knowledge of the original ecological niche of each eucalypt species in its natural habitat is important in understanding how to ensure it is planted on appropriate sites where any stress can be minimised.

Some eucalypt species originating from cooler, higher elevation sources in Australia may not do well when planted on sites where temperatures are generally warmer. *Eucalyptus delegatensis* was found to be more affected by mycosphaerella leaf disease (caused by *T*. *cryptica*) on warmer locations towards the coast such as at Rotoehu Forest in the Bay of Plenty region (36). During research into septoria leaf blight of *E*. *nitens* caused by *T*. *eucalypti* (refer earlier box), it became apparent that this disease was also very much climate related. Septoria leaf blight is virtually unknown in stands planted in the cool southern South Island whereas it was most severe in plantations in the warmer climate within 20 km of the coast in the Bay of Plenty region (19,20). Although infection also occurred further inland, the disease was uneven in its distribution, being present on flat tops and in valleys and hollows, but absent from slopes. In New Zealand *E*. *nitens* was found to produce new tender foliage continuously throughout a large part of the year. It was conjectured that even though *E*. *nitens* is a cool climate species in Australia, this phenology might make it vulnerable to the disease in frost prone sites, but studies to test this idea were not brought to fruition.

Rainfall, in particular, appears to encourage the development of some introduced pathogens. *Eucalyptus regnans*, especially, in contrast to *E*. *fastigata*, was found to be more susceptible to the effects of fungal infections in areas of uniformly distributed, high rainfall (>2000 mm/year; 14). Several thousand hectares were severely affected during an extremely wet spring in 1989-90, and highest disease levels occurred in humid gulley plantings (10).

It has been shown that provenances of many eucalypt species from different locations across Australia are genetically quite variable, and that the effects of pests and diseases can be minimised by selecting stock appropriate to the site. Research with *E*. *delegatensis* suggested that mycosphaerella (teratosphaeria) defoliation would be reduced if Tasmanian provenances were planted (36,50). Similarly, field trials indicated that provenances of *E*. *nitens* from New South Wales were less prone to septoria leaf blight in the coastal Bay of Plenty region than those from Victoria, though the latter produced faster growth (22). Potential for breeding increased resistance to mycosphaerella foliage disease has also been demonstrated internationally[3] as has resistance to stem canker caused by *Chrysoporthe cubensis*[4]. Hybrid clones (*E*. *grandis* × *E*. *urophylla*) are widely planted in Brazil, partly because of their greater resistance to chrysoporthe canker[5]. Breeding may help to cushion the impact of introduced pests and diseases, but it requires significant investment in both time and money, and may not be economically viable. However, where merited, it is one of the best approaches for reducing losses caused by introduced pests and diseases in the longer term. Disease resistance is a key criterion within all eucalypt breeding programmes currently in New Zealand, involving monitoring for health and selection for pest and disease resistance (Heidi Dungey pers. comm.). This approach may also mitigate the effect of future incursions if the genetic component of the breeding population is sufficiently diverse.

Silviculture may influence the effects of pathogens depending on how it is undertaken. Trials indicated that the level of stem decay caused by *Chondrostereum purpureum* could be reduced, though not eliminated, by pruning flush to the stem when branches were still small, by undertaking operations during

[3] For instance, in Australia (Carnegie and Ades 2005: doi.org/10.1515/sg-2005-0026; Milgate et al. 2005: doi.org/10.1071/AP04073) and Spain (Pérez et al. 2016: doi:10.3390/f7090190).
[4] da Silva Guimarães et al. (2010): doi.org/10.1590/S1415-47572010005000069.
[5] Zauza et al. (2011): https://ucanr.edu/sites/tree_resistance_2011conference/ (Abstracts, pp. 70-71).

autumn and winter and by treating with the fungicide captafol (12,14,33). Decay was considered unlikely if pruning could be avoided (10).

Chemical control is more likely to be successful against insect pests than fungal pathogens, which tend experimentally to require a greater number of applications during a season. However, this method has its limitations, particularly economic, and has not been employed operationally on a routine basis. Biological control, in effect an attempt to restore some of the natural balance by the safe introduction of predators from which insect pests have escaped in moving from their natural home, has more potential. Even here, however, the research and development costs have not been insignificant. Nevertheless, four attempts at biological control of eucalypt pests have generally had very good success in New Zealand (53): the gumtree scale ladybird (*Rhyzobius ventralis*) against *Eriococcus coriaceus*; the chalcid wasp egg parasitoid, *Anaphes nitens*, against *Gonipterus scutellatus*; and the parasitoid wasps, *Enoggera nassaui* against *Paropsis charybdis* (see earlier box), and *Bracon phylacteophagus* against *Phylacteophagus froggatti*. Other deliberate introductions have included the wasps *Cotesia urabae*, against *Uraba lugens*, and *Trigonospila brevifaces* against *Strepsicrates macropetana*. Some biological control agents have become unintentionally introduced with varying effectiveness, such as the parasitic wasps, *Psyllaephagus gemitus*, against *Cardiaspina fiscella*, *Psyllaephagus pilosus* against the blue gum psyllid, *Ctenarytaina eucalypti*, and *Psyllaephagus bliteus* against the red gum psyllid, *Glycaspis brimblecombei* (53). There are currently no biological controls for the *Ophelimus* wasps that occur on some eucalypts.

Past experience indicates that with eucalypts it is important to suit site to host species in order to minimise the effects of pests and pathogens. These conditions may not always be present when new introductions occur. For many eucalypts being grown as plantation species knowledge of the optimum conditions of site, site × provenance genetics and best pest and disease management procedures is not yet known. It may be possible to acquire this information only when a new incursion has become established.

Selected industry experts' views

It was felt important to incorporate some hands-on understanding of eucalypt cultivation. Grower views were sought and contributions were received from several. These are collated here without comment.

Biosecurity risks

Monocalypts appear to be less prone to insect pest attack. Biosecurity risk could be mitigated by planting species in that group. Symphyomyrtus are high risk, monocalypts are very low risk. The latter to date are safer than *Pinus radiata* and have better general health. Symphyomyrtus eucalypts are "bug magnets". This needs to be better understood by growers. It is becoming more difficult to grow them as time goes on.

Phytophthora species that cause root rot are a risk to *E. delegatensis* and *E. fraxinoiodes*, especially on wet soils. *Phytophthora cinnamomi* is a particular threat. Myrtle rust may be a threat, but it may not be important in cooler southern regions.

Commercial risks

Eucalypts can produce very good timber but there is a problem selling it. It needs marketing. Most retailers don't understand the wood. This could be overcome with hard work. The commercial risk to Class II durable species is very low. There is an unlimited market for blackbutt (*E. pilularis*) and stringybark eucalypts. The market wants hard, durable, high strength wood – stringybarks can provide that. It is unfortunate that there has been no effort put into improved breeding for stringybarks.

Willingness to contribute to an incursion response

Would "do our bit" and fund our share. Yes.

Outlook for *Eucalyptus*

We can certainly grow it; *E. microcorys* (tallowwood) is high value and durable, grows well in sand country. Stringybarks are good and we can process them. It is possible to get a significant premium over *P. radiata* and we need that – they are great for flooring and decking. There is enormous potential for stringybark and blackbutt, they grow well and are as healthy as *P*. *radiata*. They have everything going for them.

The small areas of established stands and higher risk of other pest issues mean that cost/benefit analysis will not generally support eradication efforts for new eucalyptus hosted pest introductions. However this situation is not yet universally proven for all groups of *Eucalyptus* species and some such as the stringybarks appear to have no more risk than other exotic species already included in NZ's repertoire of commercial plantation species. Careful consideration should however be given to pest risk factors in making any decisions to plant *Eucalyptus* species on a large scale.

Conclusion and recommendations

1. **Likelihood of a pest or pathogen introduction**

   Predicting the probability of an incursion for a specific organism is difficult and depends in part on a sound knowledge of likely pathways (51). Many factors are involved, for which we have little information that would enable some level of quantification. These include knowledge of the likelihood of passage to a new region, whether or not it will establish, and the rapidity of spread once it has done so. As noted, establishment and dispersal depend on factors such as host and provenance susceptibility, site, climate, and management.

   However, given the track record, both in this country and internationally, together with the proximity of Australia to New Zealand, there is every reason to expect further incursions of both insect pests and fungal pathogens. This is true both for existing species as well as for those that are as yet untried in plantations. There are no indications that weather trends, trade patterns or biosecurity protocols are likely to alter in any way that is likely to affect this conclusion in the foreseeable future.

   Introductions of new eucalypt insect pests and fungal pathogens can be expected to continue in the future.

2. **Prospective impact of an incursion on commercial eucalypt production as well as on non-forestry industries**

   The establishment of single species plantations on sites with environments that are potentially less than optimum creates new situations not realised in their natural habitats (27). Under such circumstances it is difficult to judge the potential impact of possible new insect or fungal incursions. Through harsh experience and a simple process of elimination, enough knowledge has now been gained for the successful cultivation of some existing species such as *E*. *nitens* and *E*. *fastigata*, and conversely for the complete avoidance of others. The hopeful viewpoint is that the effects of pests and diseases can be surmounted by judicious management procedures aided by research (36). But this takes time and does not account for potential new pest or disease introductions that may alter the balance. Even for existing eucalypts, but particularly for new and untested species, it is virtually impossible to anticipate whether or not the introduction of a new insect pest or fungal pathogen will cause serious devastation or become merely a mild, innocuous component of the local eucalypt biodiversity.

   However, the frequency and consequences of certain previous introductions warrants reflection. There is no doubt that introduced insects and pathogens have had a deleterious influence on eucalypt plantation forestry, resulting in the eventual failure of certain once favoured species (27). Perhaps only *E*. *fastigata* has so far remained relatively unscathed by serious pest and disease introductions. *Eucalyptus nitens* may be successful, with appropriate management, if sited where the climate is colder and there are now new selections of *E. regnans* with resistance to the Barron Road Syndrome.

   Non-forestry industries likely to be affected include the nursery and cut flower trades and honey production. Eucalypts form a significant and popular part of the landscape in parks and gardens in town, and in the country as shelterbelts and woodlots and for the supply of firewood. Such trees have suffered in the past as, for instance, in defoliation of species such as *E*. *botryoides* and *E*. *saligna* by the brown lace lerp, *Cardiaspina fiscella*. However, the diversity of species sold in nurseries means there is a range of alternatives and that the impact of an incursion is likely to be slight. A similar conclusion would apply to cut flowers, and probably the honey industry, although it is difficult to ascertain how important eucalypts are to beekeeping (eucalypts are not specifically referred to in the 2016 Ministry for Primary Industries apiculture report).

It is recommended that forest managers involved in incursion response decisions be aware of the history of past failures in eucalypt plantations due to biological agents. That in their familiarity with the eucalypt species under consideration they understand that there is some risk that a new incursion may have significant impact. That they also recognise that in the event of a new incursion, an attempt at eradication or assistance with disease management if the pest or pathogen becomes established, may not be forthcoming.

3. Potential for eradicating an incursion, with recommendations on whether eradication should be attempted, and if not, on how the incursion should be managed

a. To attempt an eradication

To be successful, an eradication attempt should only be considered if the incursion is found at an early stage when the organism's distribution is still limited and the affected area is readily accessible. Prompt identification is also necessary in order to be aware of its biology, including an understanding of its life cycle and dispersal behaviour. For fungi this may depend on the time of year (i.e. a knowledge of seasonal spore production), the type of dispersal (e.g. wind or insect borne or by means of rain splash), likely host range, and so on. For insects, reproductive biology, including specificity for eucalypts, and host range, distribution and abundance, are key factors (53). Only with this information is it possible to make the necessary rapid judgement as to whether or not there is a reasonable chance of actually achieving an eradication. Many factors are involved, biological, administrative, and economic. Administratively, there needs to be an infrastructure of specialist personnel and equipment ready to hand in order to provide the information to enable an appropriate decision to be made and to implement an efficient eradication attempt. To be undertaken effectively, it requires thorough planning. Ideally an incursion plan document should be prepared beforehand, which may need to be generic (the large range of potential incursion organisms of different kinds precludes a series of specific individual plans). To undertake this exercise comprehensively and realistically would give rise to significant expense.

Experience indicates that there is limited value in trying to effect the eradication of a new eucalypt pest or disease incursion because of the relatively small size and national value of the plantation estate, the expense it is likely to entail, the frequency with which further incursions are expected to occur, the uncertainty as to the level of damage the pest or disease will cause and hence the degree of benefit if successful, and the questionable likelihood of an eradication actually being achieved. A costly attempt to eradicate the gum leafed skeletoniser, *Uraba lugens*, was unsuccessful (53). An eradication attempt against a eucalyptus leaf beetle, *Paropsisterna beata* was also ineffective. Eradication was considered at the times of discovery of the eucalyptus leaf miner, *Acrocercops laciniella*, in January, 1999, and of the eucalypt variegated beetle, *Paropsisterna variicollis*, in March 2016, but not attempted when it was determined that they were already too widespread for the operation to be effective (3,52). The same was true of the red gum lerp psyllid, *Glycaspis brimblecombei*, in 2017.

In view of the various aspects itemised above an expensive eradication exercise should not be undertaken, except under special circumstances[6], in the event of the detection of a new eucalypt insect or pathogen.

b. To undertake pest or disease management

The management of a new eucalypt pest or disease, once it becomes established, may or may not be costly, depending on the effect of the incursion and the treatment needed, if any. FOA may feel some responsibility in facilitating the provision of advice and information to members

[6] For instance, logically the same rationale applies to "stringybark" eucalypts (e.g. *E*. *globoidea*, *E*. *macrorhynca*, *E*. *muellerana*) as to others, namely that there is a potential for damage from existing insects or pathogens, or from new incursions, if the planted area expands. However, the level of risk is unknown, and because of the current regard for these species, which at present sustain few records of pests or diseases, an eradication attempt may be deemed justifiable.

affected. The most effective approach is likely to be comprehensive, research-based and involve breeding, siting, silviculture, control options and particularly on-going integrated pest management. For full benefit, eucalypt breeding programmes will recognise and actively pursue pest resistance among their selection criteria.

It is suggested that in the event of the establishment of a new eucalypt pest or disease, the Forest Owners' and Farm Forestry Associations may wish to assist in the dissemination of pertinent pest or disease management information to members concerned e.g. in the form of prepared leaflets or brochures, oral advice, field visits and in other ways; this may include support for relevant research to supply pertinent knowledge not otherwise available.

Acknowledgements

All those contributing to the records held in the Forest Health Database are thanked as are Peter Berg and eucalypt growers Denis Hocking and Dean Satchell for their helpful discussion reflected in the industry views section. Heidi Dungey made many useful suggestions to the final draft.

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Appendix 1

First records of fungi and insects on eucalypts since 1988 as recorded in the Scion Forest Health Database

Year	Fungus /insect	Name of organism	Host[1]	Effect (low, medium, high)	Disorder	Location	Crosby region
1988	F	*Nothostrasseria dendritica*	*Eucalyptus globulus*	L	Leaf spot	Wellington (Port)	WN
1988	F	*Vermisporium brevicentricum*	*Eucalyptus* sp.	L	Leaf spot	Ongaroto	TO
1988	F	*Macrohilum eucalypti*	*Eucalyptus delegatensis*	L	Leaf spot	Rotoaira Forest	TO
1992	F	*Cryptosporiopsis eucalypti*	*Corymbia calophylla*	L	Leaf spot	Auckland (Port)	AK
1992	I	*Trachymela catenata*	*Eucalyptus macarthurii*	H	Defoliator	Gisborne (Port)	GB
1992	I	*Uraba lugens*	*Eucalyptus nitens*	H	Leaf damage	Mt Maunganui (Port)	BP
1993	F	*Coniothyrium ovatum*	*Eucalyptus leucoxylon*	L	Leaf spot	Napier (Port)	HB
1995	F	*Hainesia lythri*	*Eucalyptus regnans*	H	Leaf spot	FRI Nursery	BP
1996	F	*Seiridium eucalypti*	*Eucalyptus* sp.	L	Leaf spot	Mahinapua	WD
1996	I	*Eucalyptolyma maideni*	*Corymbia maideni*	M	Sapsucker	Auckland (Port)	AK
1996	I	*Cryptoneossa triangula*	*Corymbia maculata*	L	Sapsucker	Auckland (Port)	AK
1996	I	*Cardiaspina fiscella*	*Eucalyptus botryoides*	H	Sapsucker	Auckland Airport (Pt)	AK
1997	F	*Catenophoropsis eucalypticola*	*Eucalyptus nitens*	L	Leaf spot	TFI Gregory Blk	BP
1997	F	*Coleophoma oleae*	*Eucalyptus saligna*	L	Leaf damage	Rotoehu Forest, cpt 123	BP
1998	F	*Mycosphaerella intermedia*	*Eucalyptus saligna*	L	Leaf spot	Rotoehu Kohekohe Rd	BP
1998	F	*Septoria typica*	*Eucalyptus muelleriana*	L	Leaf spot	Kaikohe	ND
1999	I	*Acrocercops laciniella*	*Eucalyptus* sp.	M	Leaf miner	Aviation Golf Course (Pt)	AK
1999	I	*Nambouria xanthops*	*Eucalyptus nicholii*	L	Gall former	Carbine Rd, Auckland	AK
1999	F	*Vermisporium verrucisporum*	*Eucalyptus delegatensis*	L	Leaf spot	Catlins Forest, cpt 10	SL
2002	I	*Creiis liturata*	*Eucalyptus botryoides*	H	Sapsucker	Auckland Airport	AK
2002	F	*Leptomelanconium australiense*	*Corymbia ficifolia*	L	Leaf spot	Ahuriri Park, Napier (Pt)	HB
2012	I	*Thaumastocoris peregrinus*	*Eucalyptus nitens*	L	Defoliator	Auckland city	AK
2012	I	*Paropsisterna beata*	*Eucalyptus nitens*	L	Defoliator	Whiteman's Valley	WN
2014	I	*Phellopsylla formicosa*	*Eucalyptus saligna*	L	Sapsucker	New Lynn	AK
2016	I	*Paropsisterna variicollis*	*Eucalyptus* sp.	H	Defoliator	Te Pohue	HB
2017	I	*Glycaspis brimblecombei*	*Eucalyptus camaldulensis*	L	Sapsucker	North Canterbury	NC

[1]Note that genus *Corymbia* eucalypts differ taxonomically from those in subgenera *Monocalyptus* and *Symphyomyrtus*.