Eucalyptus fastigata *seedlings growing in a nursery in New Zealand.* Insert: *Myrtle rust symptoms on* Eucalyptus globoidea, *detected in May 2017 in Northland New Zealand (MPI Plant Health and Environment Laboratory).*

Potential impact of myrtle rust (*Austropuccinia psidii*) on *Eucalyptus* species in New Zealand

Myrtle rust is a particularly damaging and invasive fungal pathogen, affecting species in the myrtle family, including *Eucalyptus* species in New Zealand. This document has been prepared to help New Zealand growers and plant producers understand how this fungal disease may impact *Eucalyptus*, how the disease develops, and current practices used to manage the disease.

Origin and spread. The disease myrtle rust, caused by the invasive fungal pathogen *Austropuccinia psidii*, affects plants in the myrtle (Myrtaceae) family. At least 480 myrtle species worldwide are known to be susceptible to the disease, including 98 taxa in the genus *Eucalyptus*[4]. The pathogen has spread from South and Central America into North America, Asia, South Africa and the Pacific[1]. Multiple genetic groups or strains of the pathogen associated with different hosts are present in South America. A distinct genetic group called the 'pandemic strain' is associated with a wide group of hosts and is found through most of the pathogens invasive range[2]. Another genetic group, is present in South Africa and is associated with a range of hosts[3]. The strains in South America associated with *Eucalyptus* are different from the pandemic and South African strains.

Signs and symptoms

Signs and symptoms of myrtle rust develop on young shoots and leaves, flowers and fruits. Red to purple lesions form before eruption of either bright yellow powdery spores or, more rarely, compact brown spores. Severe infection leads to necrosis and dieback. Repeated severe infection can result in reduced growth and potentially cause mortality[5].

Climate and seasonality

Environmental conditions have a key influence on myrtle rust development, with favourable conditions being warm and humid. The disease can be found throughout the year but follows a seasonal cycle in New Zealand, building up from October, peaking over the summer months and declining from April as New Zealand moves into winter. The known distribution of myrtle rust in New Zealand correlates well with the predicted climatically suitable areas in New Zealand (Figure 1), which include much of the North Island (particularly Northland, Auckland, Bay of Plenty and Taranaki regions) and the top of the South Island[6,7].

Known impacts on *Eucalyptus* around the world

New Zealand

In New Zealand, where the pandemic strain of *A. psidii* has been present since 2017[6,8,9], myrtle rust has been reported on *Eucalyptus* seedlings in two nurseries; one detection occurred in Northland at the first property where myrtle rust was detected in mainland New Zealand in May 2017 on *E. globoidea*[10], and another in May 2022 in the Bay of Plenty on *E. fastigata*, *E. regnans* and *E. globoidea*[11].

Outside of nurseries, myrtle rust has not been recorded on *Eucalyptus* in New Zealand. There is no targeted or systematic surveillance for myrtle rust in New Zealand and the host record and known distribution for the disease relies heavily on reports from members of the public (passive surveillance). While any significant damage in *Eucalyptus* stands or nurseries would likely have been reported, there may be low incidence and severity of disease occurring that is not being reported. Targeted systematic monitoring in nurseries and young plantations is recommended from November – March, particularly in regions with suitable climate for the disease.

Australia

In Australia, where the pandemic strain of *A. psidii* has been present since 2010[1], myrtle rust is yet to cause significant impact to *Eucalyptus* in nurseries or plantations. Extensive surveillance in New South Wales has found the disease only sporadically in young eucalypt plantations (<3 years old, species include *E. agglomerata*, *E. pilularis*, *E. cloeziana*, and *E. grandis*), at very low incidence (<1%), and often adjacent to remnant native forest. The disease is seen only sporadically in commercial eucalypt nurseries, in the subtropics[12 and A. Carnegie, NSW DPI, pers. comm. 2022] (Figure 2). In the natural environment in Australia, as of 2019 the disease had been reported on 14 *Eucalyptus taxa*, causing damage to seedlings and coppice[4,13].

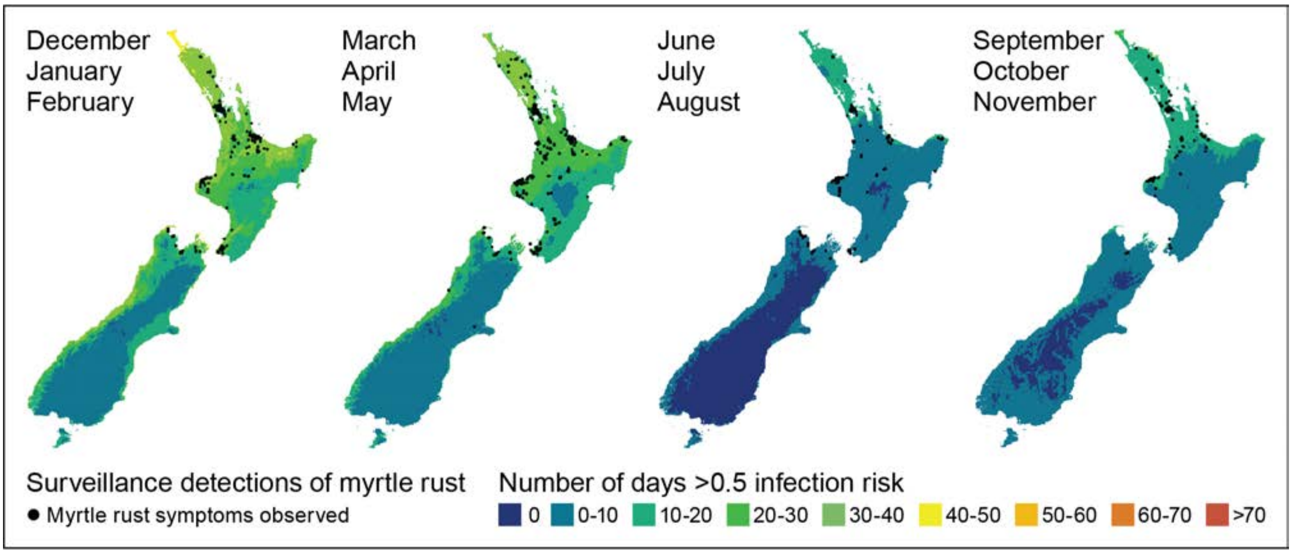

Image: Rebecca Campbell, Plant and Food Research and NIWA.

Figure 1. *Maps illustrating seasonal and spatial climatic risk of myrtle rust disease development overlayed with the distribution of myrtle rust records from all host species (represented by black dots). Infection risk is the likelihood that live spores will germinate and infect a susceptible host, when >0.5 likelihood of infection is moderate to very high. Seasonal risk was calculated from NZCSM September 2015 – August 2020 for three-month seasonal periods using the MRPM1. The surveillance records are for the same three-month seasonal periods from the composite surveillance data set May 2017 – July 2020.*

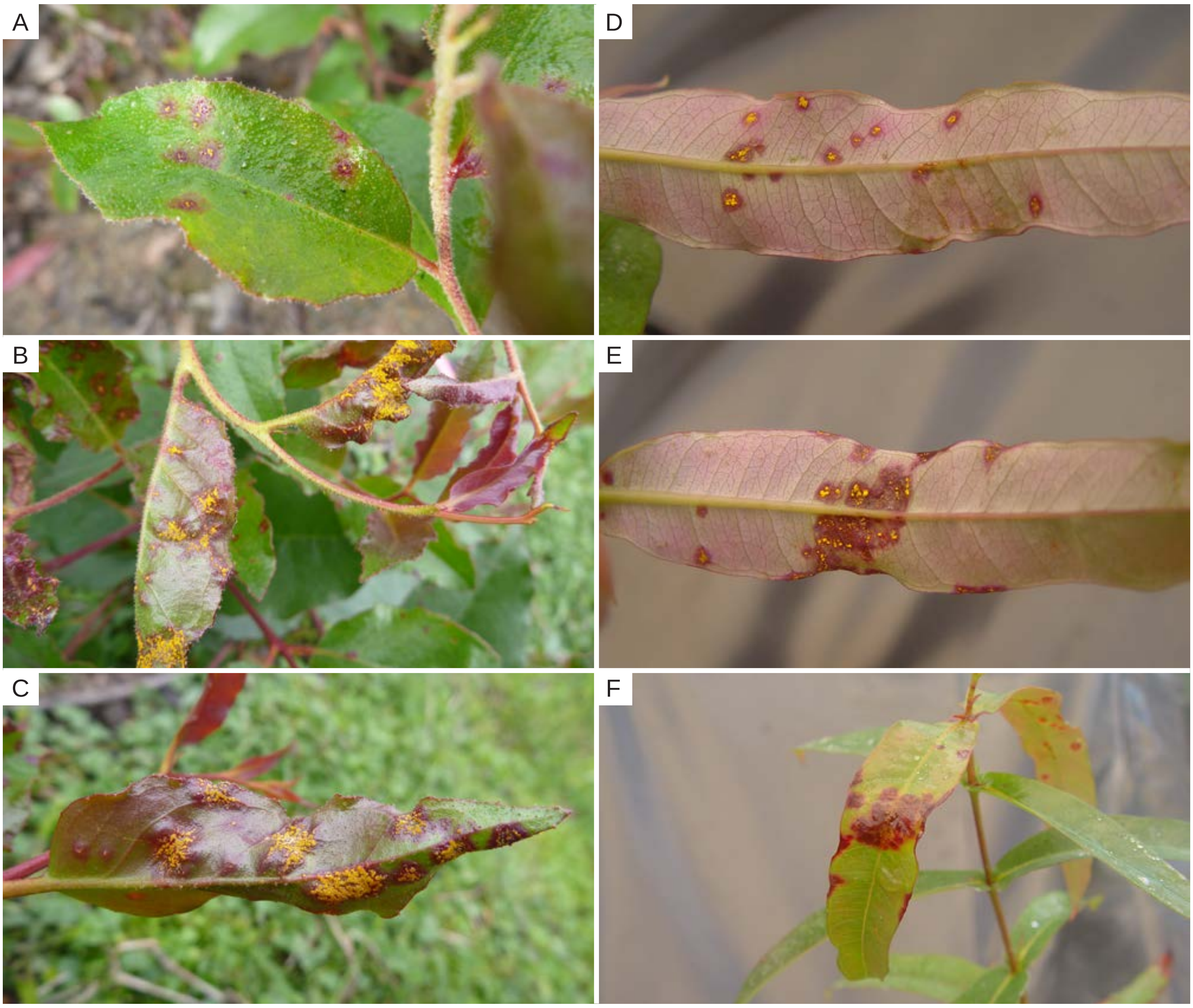

Image: A Carnegie, New South Wales Department of Primary Industries.

Figure 2. *Myrtle rust symptoms on A-C* Eucalyptus agglomerata *detected in 6 month old plantation in New South Wales, Australia and D-F* Eucalyptus pilularis *from inoculation trials*[47].

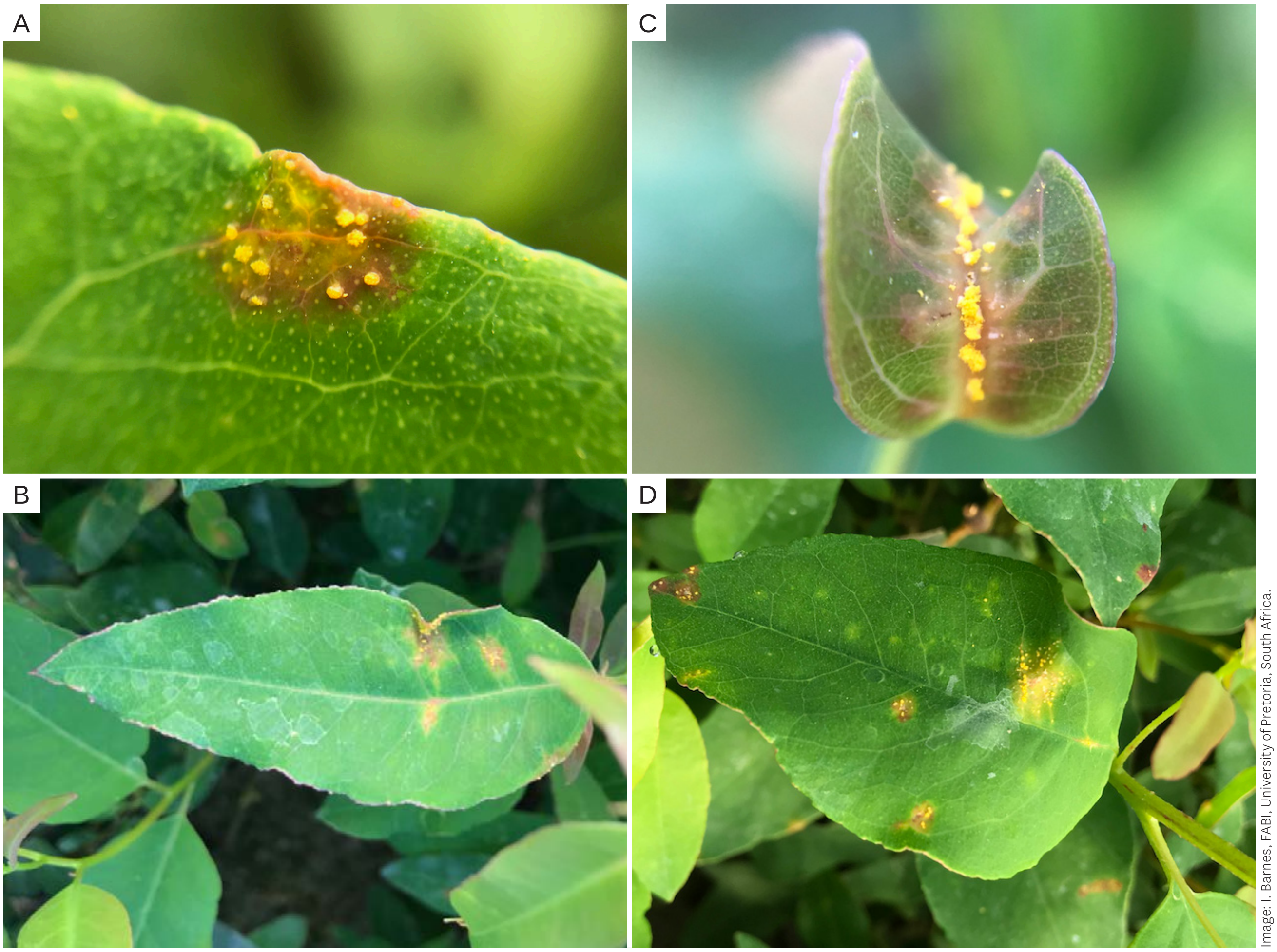

Figure 3. *Myrtle rust symptoms on* Eucalyptus pellita *detected in a nursery in North Sumatra, Indonesia.*

Indonesia

In Indonesia, the pandemic strain of *A. psidii* was reported on *E. grandis* x *E. pellita* hybrid in 2015[14] and on *E. pellita* in 2019[I. Barnes, FABI, pers. comm, 2022] (Figure 3). While detections have been made, the impacts to *Eucalyptus* in nurseries or plantations have not been reported.

South Africa

A distinct strain of *A. psidii* only found to date in South Africa has been present since 2013[3]. Myrtle rust has not been detected on *Eucalyptus* in nurseries or plantations[I. Barnes, FABI, pers. comm. 2022].

South America

In Brazil, where multiple strains of *A. psidii* are present, including strains associated with *Eucalyptus*[2], myrtle rust is a common and potentially severe disease. The disease affects seedlings in nurseries and young *Eucalyptus* plantings (0-2 years), that become less susceptible from 2-4 years and considered resistant from 4 years to harvest[15,16]. For susceptible genotypes of the main production species (*E. globulus*, *E. grandis*, their hybrids with *E. urophylla*, and hybrids between *E. saligna* and *E. camaldulensis*)[17], in areas where the climate is favourable for disease, it can cause significant impacts to harvest volumes and tree form[18,19].

In Uruguay, where multiple strains of *A. psidii* are present, including strains associated with *Eucalyptus*[2], myrtle rust has been reported on *E. globulus*, *E. grandis* and *E. dunnii*, with severe damage reported on 1 year old *E. globulus* trees and *E. dunnii* seedlings in a nursery[20–22].

In Colombia, where multiple strains of *A. psidii* are present, the pandemic strain of *A. psidii* has been reported on *E. grandis* in young plantations and a nursery, but the impact of the disease has not been reported[23–25].

Susceptibility of *Eucalyptus* species

A review of resistance/susceptibility responses for Eucalypts targeted for production forestry in New Zealand[26] is presented in Table 1. These range from resistant through to highly susceptible, often with a range of responses found for the same species. Resistance to disease depends upon a number of factors including the host genotype, the pathogen genotype/strain, spore concentrations and environmental conditions.

Field trials and surveillance in young plantings and nurseries where trees are exposed to natural infection can be used to monitor the risk in different areas and under field conditions. To provide an accurate picture of genetic susceptibility, industry would need to screen the genotypes of *Eucalyptus* species being deployed in New Zealand under controlled conditions (See **Breeding for resistance**).

The pandemic strain of myrtle rust currently in New Zealand has had low impact on *Eucalyptus* here and elsewhere. Greater impact could be seen if other strains invade New Zealand or populations of the current strain evolve greater pathogenicity towards *Eucalyptus* hosts. Deployment of multiple genotypes in the same stands is advised to minimise the selective pressure on the pathogen to evolve greater pathogenicity towards a particular host genotype, following the same approach advised for other rusts, for example poplar (*Populus*) and *Melampsora* rusts[27].

To understand the biosecurity risk posed by strains not currently present in New Zealand, seed of *Eucalyptus* species being deployed in New Zealand would need to be sent to South America for screening of host genotypes against those strains.

Disease management

The three main management practices for the disease in Brazil are breeding for resistance, fungicide application and planting in regions that are unfavourable for the pathogen[16].

Breeding for resistance

Should significant impact from myrtle rust on *Eucalyptus* arise in New Zealand the industry could consider breeding for disease resistance. Breeding programmes require screening for resistance, and will need contingencies to re-screen hosts if *A. psidii* populations evolve to defeat resistance as seen in Brazil[28,29].

Chemical control

Fungicide application in New Zealand is likely to be most effective in nurseries and may not be cost effective in the field. The most effective fungicides known to control *A. psidii* are those containing Triazoles and Strobilurins, particularly in combination. Method of application, rate and interval between applications, and climatic conditions are all important factors that influence the efficacy of fungicide control. Rotation of fungicides with different modes of action is also critical to prevent the evolution of fungicide resistance in *A. psidii* populations[16,17,30,31].

Pathogen avoidance

Climatic conditions have an important influence on disease development and will influence whether epidemics of severe disease can develop. Models have been developed to predict climatic risk zones for disease in Brazil[32] and New Zealand[6]. Nursery and forest managers can access current information about climatic risk for disease using the New Zealand Plant Producers (NZPPI) online disease management platform (https://nzppi.co.nz/disease-management/19881/) or the myrtle rust risk prediction tool (https://myrtlerust.com). These tools can help predict the best times to apply fungicide. Proximity to known sources of inoculum could also be considered when looking at locations to plant Eucalypts, the current distribution of the disease can be viewed using the interactive myrtle rust surveillance map (https://plantandfood.maps.arcgis.com/apps/webappviewer/index.html?id=db12ae762a0a4e3eb8c61b1f67120c3b).

Table 1. *Species of* Eucalyptus *targeted for production forestry in New Zealand and susceptibility to* Austropuccinia psidii.

Significant plantation species*	Natural distribution	Susceptibility rating given in source*	Susceptibility Standardised to Berthon *et al.*[33] scale*	Sample size (number of individuals screened)	Artificial/field inoculation; strain tested and location; Source	Recorded as a host in New Zealand
E. blaxlandii	New South Wales	Not known. Not listed in global host list[4]			No literature found	No
E. bosistoana	New South Wales and Victoria	Not known. Low seed germination and <10 plants tested/results questionable	NA	Exact number not given <10	Artificial: Pandemic strain (Australia)[34]	No
E. cladocalyx	South Australia	VR	Resistant	Exact number not given ≥10	Artificial: Pandemic strain (Australia)[34]	No
		VR to MS	Resistant to Medium	9	Artificial: Pandemic strain (Australia)[35]	
E. delegatensis	New South Wales, Tasmania and Victoria	VR to VS, 53% VS-S (ns across 3 Tasmanian populations)	Resistant to High	64	Artificial: Pandemic strain (Australia)[36]	No
E. fastigata	New South Wales and Victoria	R to VS	Low to High	Exact number not given ≥10	Artificial: Pandemic strain (Australia)[34]	Yes, May 2022 at nursery in BOP[11]
E. globoidea	New South Wales and Victoria	VS	High	Exact number not given ≥10	Artificial: Pandemic strain (Australia)[34]	Yes, May 2017 at nursery in Northland[10] and May 2022 at nursery in BOP[11]
		Medium to High	Medium to High	6	Artificial: Pandemic strain (Australia)[37]	
E. microcorys	New South Wales and Queensland	R to VS	Low to High	Exact number not given ≥10	Artificial: Pandemic strain (Australia)[34]	No
		All seedlings developed symptoms, but severity not scored	NA	10	Artificial: Pandemic strain (Japan)[38]	

*Species of interest mostly taken from Dungey et al. 2020[26], VR = very resistant, R = resistant, MR= moderately resistant S = susceptible, VS = very susceptible. Scale converted from source to scale developed by Berthon et al. 2018[33] Resistant = no infection, Low = infection but no sporulation, Medium = infection and limited sporulation, High = infection and abundant sporulation, ns = no significant difference.

Significant plantation species*	Natural distribution	Susceptibility rating given in source*	Susceptibility Standardised to Berthon *et al.*[33] scale*	Sample size (number of individuals screened)	Artificial/field inoculation; strain tested and location; Source	Recorded as a host in New Zealand
E. microcorys	New South Wales and Queensland	VR-VS 83% of seedlings did not develop symptoms, 1.4% developed severe disease.	Resistant to High	72	Field trials: natural exposure to unknown strain(s) in São Paulo (Brazil)[39]	No
		VR (over 9 assessments 6.8 % of plants had symptoms)	Resistant to Low	100	Field trails: natural exposure to unknown strain(s) in Minas Gerais (Brazil)[40]	
		VR to R	Resistant to Low	100	Field trails: natural exposure to unknown strain(s) in South Bahia (Brazil)[41]	
		Average severity of 12.8% leaf area with symptoms. Described as one of the more resistant species tested.	Low	10	Artificial: rust sourced from *E. urograndis* (Brazil)[42]	
		NSW 60%; Qld. 75% seedlings R or MR	60-75% Resistant to Low. Information about remaining percentages not given.	5-20	Artificial: rust sourced from *E. grandis* (UFV-2) (Brazil)[43]	
E. nitens	New South Wales and Victoria	VR to VS teliospores developed	Resistant to High	10	Artificial: Pandemic strain (Australia)[35]	No
		NSW 95%; Vic. 45% seedlings R or MR	65-95% Resistant to Low. Information about remaining percentages not given.	5-20	Artificial: rust sourced from *E. grandis* (UFV-2) (Brazil)[43]	
		R to VS	Resistant to High	50	Artificial: rust sourced from *E. grandis* (UFV-2) (Brazil)[44]	
E. obliqua	Lesser Sunda Is., New South Wales, Queensland, South Australia and Tasmania	VR to VS, 40% VS-S (ns across 4 Tasmanian populations)	Resistant to High	119	Artificial: Pandemic strain (Australia)[36]	No
		R to VS	Low to High	4	Artificial: Pandemic strain (Australia)[35]	
		VR to VS	Resistant to High	1073 (527 seedlots)	Artificial: Pandemic strain (Australia)[45]	
		VR to VS	Resistant to High	637 (each from different seedlot)	Artificial: Pandemic strain (Australia)[46]	
		NSW 73.8%; Vic. 79%; Tas. 70% seedlings R or MR	70-79% Resistant to Low. Information about remaining percentages not given.	5-20	Artificial: rust sourced from *E. grandis* (UFV-2) (Brazil)[43]	
E. pilularis	New South Wales and Queensland	R to VS	Low to High	Exact number not given ≥10	Artificial: Pandemic strain (Australia)[34]	No
		R to VS	Low to High	10	Artificial: Pandemic strain (Australia)[35]	
		MR – pustules developed after 6 weeks	Medium	3	Artificial: Pandemic strain (Australia)[47]	
		VR-VS 75% of seedlings did not develop symptoms, 4.2% developed severe disease	Resistant to High	72	Field trials: natural exposure to unknown strain(s) in São Paulo (Brazil)[39]	

Significant plantation species*	Natural distribution	Susceptibility rating given in source*	Susceptibility Standardised to Berthon *et al.*[33] scale*	Sample size (number of individuals screened)	Artificial/field inoculation; strain tested and location; Source	Recorded as a host in New Zealand
E. pilularis	New South Wales and Queensland	NSW 60-73.8%; Qld. 62.5% seedlings R or MR	60-73.8% Resistant to Low. Information about remaining percentages not given.	5-20	Artificial: rust sourced from *E. grandis* (UFV-2) (Brazil)[43]	No
		Assessment 1 = 99% asymptomatic assessment 2 = 97% asymptomatic low severity of disease on symptomatic plants	Resistant to Low	100	Field trials: natural exposure to multiple strains (Brazil)[48]	
		VR to VS High percentage of seedlings had resistant phenotype (80-95%)	Resistant to High	80	Artificial: rust sourced from *S. jambos* (Brazil)[48]	
E. quadrangulata	New South Wales and Queensland	Not known. Not listed in global host list[4]			No literature found	No
E. regnans	New South Wales and Queensland	VR to VS	Resistant to High	10	Artificial: Pandemic strain (Australia)[35]	Yes, May 2022 at nursery in BOP[11]
		VR to VS, 53% VS-S ($P<0.05$ across 4 Tasmanian populations)	Resistant to High	96	Artificial: Pandemic strain (Australia)[36]	
		Tas 85%; Vic. 7% seedlings R or MR	7-85% Resistant to Low. Information about remaining percentages not given.	5-20	Artificial: rust sourced from *E. grandis* (UFV-2) (Brazil)[43]	
E. saligna	New South Wales and Queensland	VR to VS	Resistant to High	10	Artificial: Pandemic strain (Australia)[35]	No
		VR to MR	Resistant to Low	12	Artificial: Pandemic strain (Australia)[49]	
		VR to S	Resistant to Medium	72	Field trials: natural exposure to unknown strain(s) in São Paulo (Brazil)[39]	
		VR to S	Resistant to Medium	200 (100/provenance)	Field trails: natural exposure to unknown strain(s) in Minas Gerais (Brazil)[40]	
		MS to S	Medium to High	100	Field trails: natural exposure to unknown strain(s) in South Bahia (Brazil)[41]	
		Average severity of 18% leaf area with symptoms. Described as one of the more resistant species tested.	Low to Medium	10	Artificial: rust sourced from *E. urograndis* (Brazil)[42]	
		NSW 50.8 - 83.5%; Qld. 60.5 - 75% seedlings R or MR	50.8-83.5% Resistant to Low. Information about remaining percentages not given.	5-20	Artificial: rust sourced from *E. grandis* (UFV-2) (Brazil)[43]	
		27–50% seedling susceptible from 2 seedlots tested	NA	Not given	Artificial: rust sourced in Brazil from unknown host (Brazil)[50]	
E. sphaerocarpa	Queensland	Not known. Not listed in global host list[4]			No literature found	No

*Species of interest mostly taken from Dungey et al. 2020[26], VR = very resistant, R = resistant, MR= moderately resistant S = susceptible, VS = very susceptible. Scale converted from source to scale developed by Berthon et al. 2018[33] Resistant = no infection, Low = infection but no sporulation, Medium = infection and limited sporulation, High = infection and abundant sporulation, ns = no significant difference.

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