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Climatic suitability of Australia's production forests for myrtle rust

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Summary

Many tree species in the family Myrtaceae, including eucalypts, melaleucas, and a variety of Australian rainforest trees, are susceptible to myrtle rust disease caused by the fungus *Puccinia psidii* s.l.. Myrtle rust was first detected in Australia in 2010, and since then its geographic distribution in Australia has progressively widened. The disease is now present in New South Wales, Queensland, Victoria, Tasmania and the Northern Territory, although detections outside New South Wales and Queensland may be restricted to nurseries and gardens.

Myrtle rust has caused severe defoliation, dieback and death of trees of some rainforest species in Australia, and its impact has been assessed by CSIRO as a potential 'megashock' for Australia's forests. The same or related rusts have damaged commercial eucalypt plantations in Brazil and Uruguay. Myrtle rust is denoted as a quarantine pest in Australia.

The work reported here used climatic suitability modelling with Climatch software to predict areas of Australia's production forests that are highly suitable climatically for myrtle rust. The work has three novel aspects. First, the climate suitability modelling was based on the locations where myrtle rust has been detected in Australia as well as the locations where myrtle rust and related rusts have been detected overseas. Second, the climate modelling results were intersected with spatial coverages of Australia's eucalypt plantations and public production native forests in the National Plantation Inventory and the National Forest Inventory, to allow description of the extent of these production forests in areas highly suitable climatically for myrtle rust (private native forest available for wood production was not considered in this work). Third, results were then combined with ABARES regional forecasts of Australia's wood availability for the period 2010-54, to calculate the proportion of forecast future plantation and public native forest wood availability that is predicted to derive from areas highly suitable climatically for myrtle rust.

Climatic conditions predicted to be highly suitable for myrtle rust are found in coastal and subcoastal regions of eastern Australia, from approximately Cooktown in northern Queensland to far eastern Victoria, including some areas a few hundred kilometres inland in southern Queensland and northern New South Wales. Modelling that used the Australian locations of myrtle rust predicted a larger area highly climatically suitable for the disease than did modelling that only used overseas locations of this and related rusts.

The area of Australia's eucalypt plantation estate used in this analysis, 812 thousand hectares, is that for which spatial data were available in the National Plantation Inventory as at 2011 excluding minor or unknown eucalypt plantation species, and fallow land.

- Within this plantation area, 63 thousand hectares (7.8 per cent) is predicted to be highly suitable climatically for myrtle rust. This is all the eucalypt plantations in Queensland and most of the eucalypt plantations in New South Wales, and includes approximately 41 thousand hectares of *Eucalyptus dunnii* (Dunn's white gum), 9.5 thousand hectares of *E. grandis* (flooded gum or rose gum), 7.4 thousand hectares of *E. nitens* (shining gum) and 4.3 thousand hectares of *Corymbia maculata* (spotted gum) plantations.
- Over the period 2010-54, 1.0 million cubic metres per year of eucalypt logs are forecast to be available from these plantation areas highly suitable climatically for myrtle rust. This is 9.1 per cent of Australia's total forecast available volume of plantation eucalypt logs, and comprises mostly logs from the Wood Supply Regions of North Coast NSW, Northern Tablelands NSW and South East Queensland.

The area of multiple-use public native forest used in this analysis, 5.7 million hectares, is the area of the five Eucalypt forest subtypes used for wood production in the National Forest Inventory as at 2011.

- Within this area of public native forest, 1.6 million hectares (27 per cent) is predicted to be highly suitable climatically for myrtle rust. This mainly comprises Eucalypt medium and tall open forest, from central Queensland southwards through New South Wales, with a small area in East Gippsland, Victoria.
- Over the period 2010-54, 0.79 million cubic metres per year of eucalypt logs are forecast to be available from these public native forest areas highly suitable climatically for myrtle rust. This is 22 per cent of Australia's total forecast available volume of public native forest eucalypt logs, and comprises mostly logs from the Wood Supply Regions of North Coast NSW, Southern Tablelands NSW, East Gippsland Bombala NSW, Western Queensland and South East Queensland.

The results indicate the proportion of Australia's forecast future wood availability that derives from production forest areas predicted to be highly suitable climatically for myrtle rust. However it is important to note that the analyses are based solely on the climatic component of the potential risk of myrtle rust. A number of other factors need to be taken into account before making any assessment of the potential impact of myrtle rust on wood production, and so this report does not attempt to predict the risk of myrtle rust outbreaks or the possible impact of such outbreaks on future wood availability.

First, the results assume that the distribution of the myrtle rust pathogen will extend over time to the full area modelled in this work as highly suitable climatically for the disease. The results will overestimate potential impact if full occupancy of this area by the pathogen does not occur. Alternatively, the potential impact may be higher if the disease is able to establish in additional areas that are here rated as only 'suitable' climatically for myrtle rust.

Second, the impact of myrtle rust on wood availability may be low even when the pathogen is present in areas highly suitable climatically for the disease. Many eucalypt species are resistant to moderately resistant to myrtle rust. Further, the myrtle rust pathogen generally infects only the young growth stage of susceptible eucalypts. Infection therefore needs the coincidence of susceptible species at a susceptible stage of their life cycle, with appropriate climatic conditions. A significant outbreak would also need a sufficiently large inoculum of spores from previous consecutive years of suitable temperature and rainfall.

Plantations generally contain contiguous areas of younger age-classes of trees, with a lesser range of genetic variety compared to native forest. This suggests that the most likely situation in which myrtle rust might impact wood availability would be in eucalypt plantations in northern New South Wales and southern Queensland. However, a range of silvicultural options and management actions are available to mitigate the risk of the disease impacting on eucalypt plantations. These include the use of fungicides on young, rust-susceptible trees, and planting genotypes or species resistant to myrtle rust, as has been done in Brazil.

Myrtle rust has already impacted on the health of rainforest stands in eastern Australia. In the long term, myrtle rust could also affect regeneration of native eucalypt forests through death of seedlings and young plants of susceptible species, thereby impacting on native forest wood availability. Myrtle rust infection can affect tree form through a loss of apical dominance, and thus could also affect wood product recovery from trees that survive infection. Few practical options are available to mitigate damage to native forests in areas where myrtle rust is established. However, domestic quarantine measures may reduce the spread of myrtle rust to areas currently free of the pathogen.

1 Introduction

The myrtle rust pathogen and its hosts

The fungal pathogen *Puccinia psidii* sensu lato[1], the causative agent of the disease commonly known in Australia as myrtle rust, has been reported as a significant plant health threat to a wide range of Australia's native forests and hardwood eucalypt plantations (Glen et al. 2007, Plant Health Australia 2009, Carnegie et al. 2010, Carnegie and Cooper 2012, Pegg et al. 2012, 2014a,b, Morin et al. 2012, MIG and NFISC 2013, Makinson 2014a,b, Carnegie 2015, Carnegie et al. 2016). The myrtle rust pathogen has a wide host range in the family Myrtaceae (Giblin and Carnegie 2014), including eucalypts[2], melaleucas and other characteristically Australian tree species, and is a quarantine pest for Australia[3]. Eucalypt species reported as hosts of the myrtle rust pathogen overseas and in New South Wales and Queensland are listed in Appendix A (Tables A1 and A2 respectively).

Myrtle rust is considered distinct from guava rust and eucalypt rust (Graça et al. 2013), which are also part of the *P. psidii* s.l. complex. However, the taxonomy of these rusts is not completely resolved, and various scientific names have been used for myrtle rust by different workers. At this stage, only a single strain of *P. psidii* s.l. has been recorded in Australia (Carnegie 2015), and it is believed that Australia remains free from many strains present overseas. Simpson and Srinivasan (2014) identified myrtle rust as a potential 'megashock' for Australia's forests[4], if and when more highly virulent strain(s) of *P. psidii* s.l. with a wider host range within the Myrtaceae than the strain currently in Australia arrive in this country and spread across multiple ecosystems.

Eucalypts are generally most susceptible as hosts when young trees less than two or three years of age, although some species such as *Eucalyptus carnea* and *E. curtisii* can be susceptible at all ages. Recent detections of myrtle rust in eucalypt plantations in New South Wales are restricted to stands less than three years of age (Carnegie 2015). However, mature trees of some species of *Melaleuca*, *Rhodamnia* and *Rhodomyrtus* can be killed by the pathogen in native forest ecosystems (MacLachlan 1938, Rayachhetry et al. 1997, Pegg et al. 2014b, Carnegie et al. 2016).

Commercial impacts of the myrtle rust pathogen overseas

P. psidii s.l. causes necrosis, deformation of infected organs, prolific branching, galling, and death of apical portions, and thus reduces growth of infected susceptible plants (Lana et al. 2012). It can cause severe symptoms on susceptible eucalypt species, and has caused significant damage to *E. grandis* and *E. globulus* plantations in South America (Tommerup et al. 2003, Glen et al. 2007, Xavier and da Silva 2010, Graça et al. 2011b, Masson et al. 2013, Silva et al. 2013). The

[1] Sensu lato, s..l.: in the broad sense, thus including a broad range of races and strains of the pathogen. C.f. sensu stricto, s.s: in the narrow sense.
[2] The term eucalypt refers to species in the genera *Eucalyptus*, *Corymbia* and *Angophora*.
[3] A quarantine pest, as defined by the International Plant Protection Convention of the Food and Agriculture Organization of the United Nations, is a pest of potential economic importance to the area it endangers and not yet present there, or present but not widely distributed and being officially controlled. A pest is any species, strain or biotype of plant, animal or pathogenic agent that is injurious to plants or plant products.
[4] Megashock: An important event resulting from multiple trends (patterns of change) and shocks (sudden and hard-to-predict events) with far-reaching implications and leading to irreversible change, senso Hajkowicz & Roy (2013).

pathogen has also had severe impacts on guava production in Brazil, and the allspice industry in Jamaica.

The myrtle rust pathogen is one of the most significant pathogen threats to eucalypt plantations in Brazil, where ongoing selection and breeding for rust resistance is necessary for its control (Cannon 2011, Lana et al. 2012, Santos et al. 2014). Disease outbreaks caused by the myrtle rust pathogen occurred in Brazil in 1973 in nurseries and young plantations of flooded gum (*E. grandis*), with large-scale death of heavily infected plants (Ferreira 1981), and the pathogen has since caused almost entire loss of some plantings in Brazil (Commonwealth of Australia 2006, Glen et al. 2007, Invasive Species Council 2011). Damage to *E. grandis* across 160,000 hectares of eucalypt plantations along the Rio Doce Valley, Minas Gerais, Brazil triggered research in Brazil on rust resistance in eucalypts (Ferreira 1981, Dianese et al. 1984). High levels of infection have also been found in commercial plantations of blue gum (*E. globulus*) and manna gum (*E. viminalis*) in Brazil, and the pathogen has been a limiting factor in the expansion of plantations of Gympie messmate (*E. cloeziana*) in the south-east of Bahia, Brazil (Ruiz et al. 1989; Carvalho et al. 1994). The pathogen is also commonly found on *E. grandis* in Argentina, and its impact on *E. globulus* in Uruguay has heightened concerns for the extensive plantations of this species in Chile (Glen et al. 2007).

The periodic epidemics of myrtle rust in Brazil have caused significant losses in wood production, and even in normal (non-epidemic) years declines in wood production of up to 20 per cent have been estimated for a number of states within Brazil (Masson et al. 2013). Higher proportional losses of wood yield have occurred in susceptible *E. grandis* clones (Takahashi 2002).

Distribution and spread of the myrtle rust pathogen in Australia

The myrtle rust pathogen *P. psidii* s.l. is primarily spread by windblown spores and movement of infected nursery plants, as well as potentially by insect vectors, and thus can move easily to rust-free areas within and across countries (CABI 2014). Since its first detection in Australia on a commercial plant production property on the central coast of New South Wales in 2010 (Carnegie et al. 2010), myrtle rust has spread rapidly along coastal areas of New South Wales and Queensland (Carnegie and Cooper 2012, Pegg et al. 2014b, Carnegie et al. 2016). The pathogen has also spread to nurseries and gardens in Victoria (MIG and NFISC 2013, Kriticos et al. 2013), Tasmania[5] and the Northern Territory, including the Tiwi Islands[6], but to date has been contained in these jurisdictions by management measures including chemical sprays and destruction of infected plants. The Australian Capital Territory, Western Australia and South Australia currently remain free from myrtle rust. Myrtle rust has also been detected in a small number of young eucalypt plantations in New South Wales (Carnegie 2015). A map of myrtle rust locations as at 2015 has been published by the Plant Biosecurity CRC[7].

Warm, humid conditions suitable for myrtle rust occur in most years in eastern and north-eastern coastal areas of Australia, but as infrequently as one year in 10 in other parts of Australia (Magarey et al. 2007). In areas where *P. psidii* s.l. has established, the level of infection

[5] dpipwe.tas.gov.au/biosecurity/plant-biosecurity/pests-and-diseases/myrtle-rust.
[6] abc.net.au/news/2016-01-27/myrtle-rust-spread-costs-nt-nursery-business/7116764; nt.gov.au/d/index.cfm?Header=Myrtle%20rust
[7] pbcrc.com.au/news/2016/pbcrc/myrtle-rust-threat-australian-landscape-and-plant-industries; this map excludes detections in plant nurseries, but does not appear to exclude garden detections potentially associated with plant nurseries.

also varies from year to year depending on environmental conditions, host species and the fungus strain. Infection is promoted by moderately warm temperatures and high relative humidity (Ruiz et al. 1989, Carvalho et al. 1994) as well as a high concentration of airborne spores (Blum and Dianese 2001). Epidemics of rust pathogens generally require the coincidence of a sufficient inoculum of spores, susceptible hosts at a susceptible age, and appropriate climatic conditions across at least two adjacent years; 'rust years' are naturally infrequent.

Some potential host species (including many *Eucalyptus* and *Corymbia* species) show variable levels of resistance to the myrtle rust pathogen, while others (such as *E. grandis*, *Melaleuca quinquenervia*, *Rhodamnia rubescens* and *Rhodomyrtus psidioides*) are susceptible (Zauza et al. 2010, Pegg et al. 2012, 2014a,b, Carnegie & Lidbetter 2012, Carnegie et al. 2016). Pathogenic variation in *P. psidii* s.l. is common overseas (Loope 2010, Graça et al. 2011a, 2013, Carnegie 2015), with host-specific strains infecting certain species of eucalypts; emergence or local appearance of new strains of the pathogen can break down the resistance of commercial eucalypt clones (Graça et al. 2011a, Quecine et al. 2014). Introduction of new strains of *P. psidii* s.l. into Jamaica and Florida resulted in severe impacts not seen with the strains previously present in these countries (Carnegie et al. 2016).

As the causative agent for myrtle rust, *P. psidii* s.l., has been denoted as a quarantine pest for Australia, and attempts to eradicate it from Australia have not been successful. Domestic phytosanitary measures are in place to prevent or delay its spread, and include restrictions on movement of susceptible plant species (including nursery stock) to minimise the risk of entry of rust-infected materials into areas free of the disease. Furthermore, there is the potential for introduction into Australia of strains of *P. psidii* s.l. that are more virulent or aggressive, have a wider climatic range, or have an increased host range, with greater potential impacts on species, ecosystems and production forests. Quarantine restrictions are thus in place at the national level to minimise the risk of introduction of further exotic rust strains to Australia.

Modelling the potential distribution of myrtle rust in Australia

A number of studies have been conducted on the potential geographic distribution of myrtle rust or its pathogen in Australia. These have generally used CLIMEX[8], MaxEnt[9] and NAPPFAST[10] modelling tools and expert models developed based on the available knowledge of *P. psidii* s.l. biology and epidemiology (Magarey et al. 2007, Kriticos and Leriche 2008, Booth and Jovanovic 2012, Hanna et al. 2012, Elith et al. 2013, Kriticos et al. 2013).

This report takes a simpler and more correlative approach, using climatic suitability modelling with the Climatch tool to assess the potential future distribution of myrtle rust in Australia. However, in addition to data from international locations of *P. psidii* s.l., this work also incorporates climate data from recent Australian distribution records of myrtle rust.

These distribution records are generally of the myrtle rust disease as assessed by its symptoms, and only sometimes of an identified causative pathogen. Further, locations where the myrtle rust pathogen may be present without causing symptoms are not included in the analysis. The

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[8] CLIMEX is a process-oriented model used to predict the likely distribution and abundance of species in relation to climate.
[9] Maximum Entropy Modelling.
[10] North Carolina State University (NCSU) Animal Plant Health Inspection Service (APHIS) Plant Pest Forecasting System.

work can thus only be used to deduce areas climatically suitable for the myrtle rust disease, but not areas where its causative fungal pathogen may be present.

Modelling production forest areas that are highly suitable climatically for myrtle rust

This study then intersected the areas predicted to be highly suitable climatically for myrtle rust, with the spatial extent of those components of Australia's plantation estate and public native production forests potentially susceptible to myrtle rust. These components are eucalypt plantations, and the five individual Eucalypt forest subtypes used for wood production on multiple-use public forests.

Finally, this study intersected these areas predicted to be highly suitable climatically for myrtle rust, with regional forecasts of future wood availability from eucalypt plantations and public production eucalypt native forests. This enabled estimation of the proportions of Australia's forecast future plantation and public native forest eucalypt wood availability that are predicted to derive from areas highly suitable climatically for myrtle rust.

Despite predictions to the contrary (Morin et al. 2011, Elith et al. 2013, Kriticos et al. 2013), the myrtle rust pathogen has had no impact to date on wood availability from Australia's forests. Epidemics of rust pathogens require the coincidence of a number of pathogen, host and climatic factors, and so occur irregularly. Potential host species are abundant in many locations in Australia, and the myrtle rust pathogen thus has the potential to appear in epidemic proportions in locations where climatic conditions are favourable across consecutive years. However, not all myrtaceous species are equally susceptible to myrtle rust, and some susceptible species only appear to be susceptible as young plants, with both these factors acting to reduce the likelihood of outbreaks of the disease impacting production forests, even in areas predicted to be highly suitable climatically for the disease.

This report therefore investigates only the climatic determinants for myrtle rust in Australia, and does not attempt to predict the risk of myrtle rust outbreaks or the possible impact of such outbreaks on future wood availability. However, as Booth (2011) notes, it will be important to remain vigilant about the long-term potential impacts of myrtle rust on Australia's hardwood plantations and native forests.

Aims of this work

This work had three novel aims:

- to use data on both Australian and overseas locations of myrtle rust to predict areas of Australia that are highly suitable climatically for this disease
- to use ABARES spatial forest coverages to predict areas of Australia's production forests that are highly suitable climatically for myrtle rust
- to use ABARES data on forecast regional wood availability to predict the proportion of Australia's forecast wood availability that derives from areas highly suitable climatically for myrtle rust.

2 Methodology

Climatch modelling

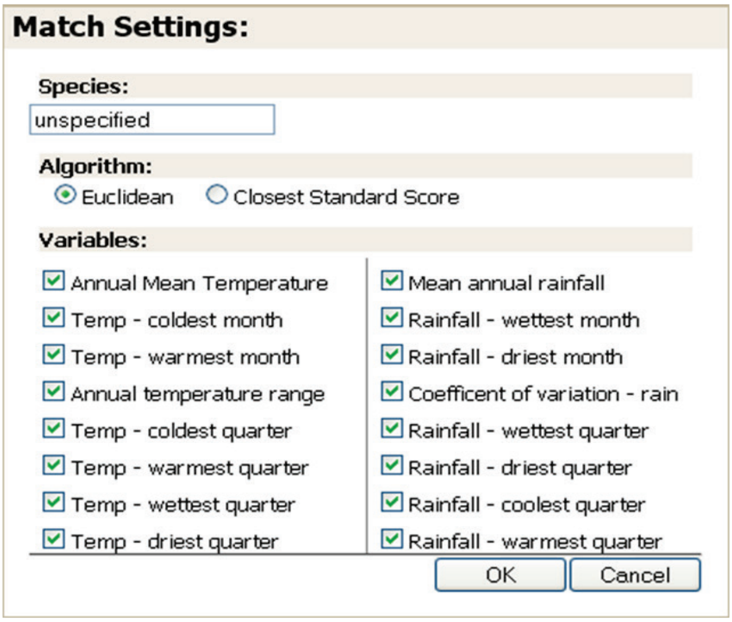
Climatch modelling software, a free online application available at data.daff.gov.au:8080/Climatch/, predicts the likely geographic distribution range of a species (including pests and diseases) based on climatic requirements derived from a set of known locations where the species has been detected. A simple matching algorithm compares the climate in locations where the species is known to occur (the source region), with that in locations under investigation (the target region) (Crombie et al. 2008). Climatch is recognised by the Australian and state and territory governments as a national tool for predicting potential distribution of pests under the National Environmental Biosecurity Response Agreement[11], is simple to use, and has been applied relatively widely in pest risk assessments (Froese 2012).

The geographic distribution data input to Climatch were locations where myrtle rust has been recorded, either overseas or in Australia (listed in Appendix B, Tables B1 and B2 respectively). The data were of detections of the disease (symptoms observed in the field), with only some of these detections identified to the level of the specific pathogen. Overseas locational data were from the dataset 'Puccinia_94' of Elith et al. (2013), which includes all non-Australian records of both *Puccinia psidii* and *Uredo rangelii*[12] available to those authors, in both native and invaded ranges, and which comprises records of myrtle rust as well as related rusts such as guava rust or eucalypt rust (Elith et al. 2013; see Table B1). Australian location data for myrtle rust were from New South Wales and Queensland state agencies (Department of Primary Industries, and Department of Agriculture and Fisheries, respectively; see Table B2, and links at anbg.gov.au/anpc/resources/Myrtle_Rust.html), as these are believed to be the detections of myrtle rust in Australia away from nurseries and gardens. The Australian dataset was taken as representing detection locations as at 2012, and was the dataset also used to underpin the Case Study on myrtle rust in *Australia's State of the Forests Report 2013* (MIG and NFISC, 2013).

The analysis was developed using the 'Euclidean' climate match algorithm for all 16 temperature and rainfall climatic parameters (Figure 1), which calculates the 'climate distance' between the set of input sites and each output location based on the 'average' of all climate variables considered together[13]. Australian records used the Australia 20k Albers Grid dataset (Crombie et al. 2008). The output of the Climatch model was saved as an ASCII file and converted to an ESRI Grid to depict the spatial distribution of Climatch scores using ArcGIS. This work also explored using only four (annual mean temperature, annual temperature range, mean annual rainfall, and coefficient of variation-rain) or three (annual mean temperature, annual temperature range, and mean annual rainfall) climate variables.

[11] Available at coag.gov.au/node/74 (accessed 21 January 2016).
[12] *Uredo rangelii* is the name for the 'anamorph' or asexual reproductive stage of myrtle rust; *Puccinia psidii* is the name for the 'teleomorph' or sexual reproductive stage of myrtle rusts and related rusts.
[13] In contrast, the 'Closest standard score' algorithm is based on the match of the least close climate variable (Crombie et al 2008).

Figure 1 Temperature and rainfall parameters used for Climatch modelling



Note: All temperature and rainfall variables were selected in this study.
Source: Crombie et al. (2008)

Higher Climatch scores imply a closer match of local climate to the climate of sites where the myrtle rust has been detected. Areas with Climatch scores of 6 and above were considered climatically suitable for myrtle rust establishment in the Australian context. Within those areas, areas with Climatch scores of 8 and above were considered climatically highly suitable for myrtle rust.

Plantation and native forest areas

The locations of hardwood eucalypt plantations and native forests were taken from the National Plantation Inventory (NPI) and the National Forest Inventory (NFI), respectively.

Hardwood eucalypt plantation areas were sourced from the ABARES National Plantation Inventory 2010-11 spatial layer used in Gavran and Parsons (2011). Only plantation data available in both tabular and spatial form were included; data for *Acacia* species and other non-eucalypt species not susceptible to myrtle rust were excluded; and fallow land and unidentified or minor eucalypt plantation species (as defined in the National Plantation Inventory) were excluded (except that data for the regionally important eucalypt plantation species *Corymbia citriodora* ssp. *variegata* were retained). The eucalypt plantation area used in this study is thus less than the total hardwood plantation area reported by Gavran and Parsons (2011).

Native forest areas were taken from the ABARES National Forest Inventory 2011 spatial layer used in *Australia's State of the Forests Report 2013* (ABARES 2014, MIG and NFISC 2013). Areas investigated were multiple-use public forest with native forest types containing or dominated by myrtaceous species (forest types Eucalypt, Melaleuca and Rainforest). The major productive Eucalypt forest subtypes (medium closed and open forest; tall closed, open and woodland forest) were also investigated. 'Medium' and 'tall' refer to forest height; 'closed', 'open' and 'woodland' refer to forest canopy cover.

Forest area data in this report are presented as an exact number of hectares. However, these data should be taken as accurate only to the nearest 100 hectares.

Determining the climatic suitability of plantation and native forest areas for myrtle rust

The spatial layer containing Climatch output for myrtle rust across Australia was intersected separately with the appropriate plantation and native forest spatial layers, and the areas of forest with each Climatch score were calculated. Full output area statements and associated maps are provided in Appendix C for eucalypt plantations, and Appendix D for multiple-use native forests.

Assessing potential vulnerability to myrtle rust of Australia's forecast wood availability

Burns et al. (2015) constructed a number of Wood Supply Regions for the purposes of forecasting Australia's wood availability over the period 2010 to 2054. For the present analysis, the proportions of forecast future wood availability that derives from areas modelled to be climatically highly suitable for myrtle rust were determined separately for native forest and plantations, using forecast wood availability figures from the 'business-as-usual' scenario of Burns et al. (2015).

The native forest analysis considered only hardwood logs from eucalypt species on multiple-use public forest; cypress pine logs were excluded. The plantation analysis considered only hardwood logs from eucalypt species; softwood logs and logs from other hardwood species (such as *Acacia*) were excluded. Within the categories analysed, all log types were included (high-quality sawlogs, low-quality sawlogs, pulplogs, domestic veneer logs and export veneer logs).

Native forest production areas were restricted to the major productive Eucalypt forest subtypes (medium closed and open forest; and tall closed, open and woodland forest) on multiple-use public forest. No such forest areas exist in the Wood Supply Regions of Goldfields WA, Green Triangle SA, Green Triangle VIC, Northern Territory, Northern Territory Other, Other WA, Pilbara WA and Wheatbelt WA, and hence these regions were omitted from the native forest analyses. The small amount of native forest logs projected to be available from multiple-use forests in the Northern Tablelands NSW Wood Supply Region was incorporated into the wood availability figures for the North Coast NSW Wood Supply Region.

Hardwood plantation areas were restricted to species considered susceptible to myrtle rust by excluding areas of *Acacia*, fallow, unidentified species and minor species; areas for which only tabular data were available were also excluded. After these exclusions, there was no hardwood plantation area in the Wood Supply Regions Central Tablelands NSW, Dubbo NSW, Goldfields WA, Northern Territory, Northern Territory Other, Other WA and Southern Tablelands NSW, so these regions were omitted from the plantation analyses. The North & Central Queensland Wood Supply Region was also excluded as it contains only a small area of potentially susceptible productive plantations (of *E. dunnii*) against a larger area of plantations of species not susceptible or not commercially productive.

With the above area exclusions, analyses were conducted with the assumption that the availability of wood from public native forests in each Wood Supply Region is evenly distributed across the public production native forest areas within that Wood Supply Region; and that the availability of plantation eucalypt wood in each Wood Supply Region is evenly distributed across the plantation eucalypt areas within that Wood Supply Region. Full output area statements by Wood Supply Region, and associated maps, are given in Appendix E.

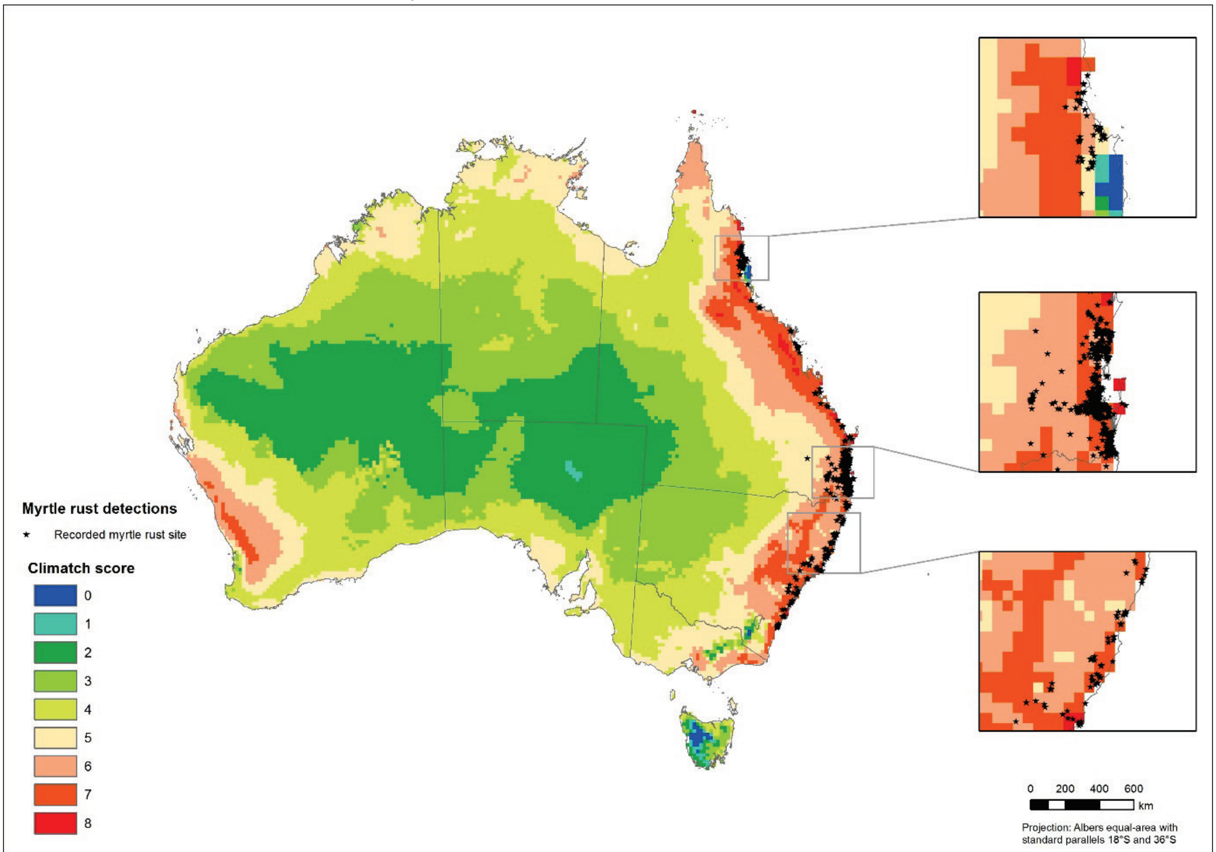
3 Results

Climatic suitability of areas of Australia for myrtle rust

Modelling using climate data from overseas locations

Climatch modelling software was first used to predict the potential distribution of myrtle rust in Australia based on climate data for areas where myrtle rust and related rust diseases had been detected overseas at as 2012. The modelled climatic suitability map was then compared to the locations of myrtle rust detections in Australia as at 2012 (Figure 2). Only detections in New South Wales and Queensland are shown, as these are believed to be the only detections of myrtle rust away from nurseries and gardens.

Figure 2 Climatch modelling of potential distribution of myrtle rust in Australia based on recorded distribution overseas, and locations of detection in Australia



Notes: Climatch modelling used data on overseas locations of *Puccinia psidii* s.l. (Appendix B). No areas had Climatch scores 9 and 10 in this modelling. Areas with scores of 6 and higher are considered climatically suitable for myrtle rust development, and areas with scores of 8 and higher are considered climatically highly suitable for myrtle rust development. Only detections in Queensland and New South Wales as at 2012 are shown.

Higher Climatch scores imply a closer match of local climate to the climate of the sites used to parameterise the modelling. Areas with Climatch scores 6 and above, which are climatically suitable or highly suitable for myrtle rust, are located in the eastern and southwestern coastal and subcoastal regions of Australia (Figure 2). Establishment of myrtle rust outside these areas would be limited by dry climates or cold climates. Only small areas with Climatch scores 8, and no areas with Climatch scores 9 and 10, were predicted by this modelling using climate data from overseas locations.

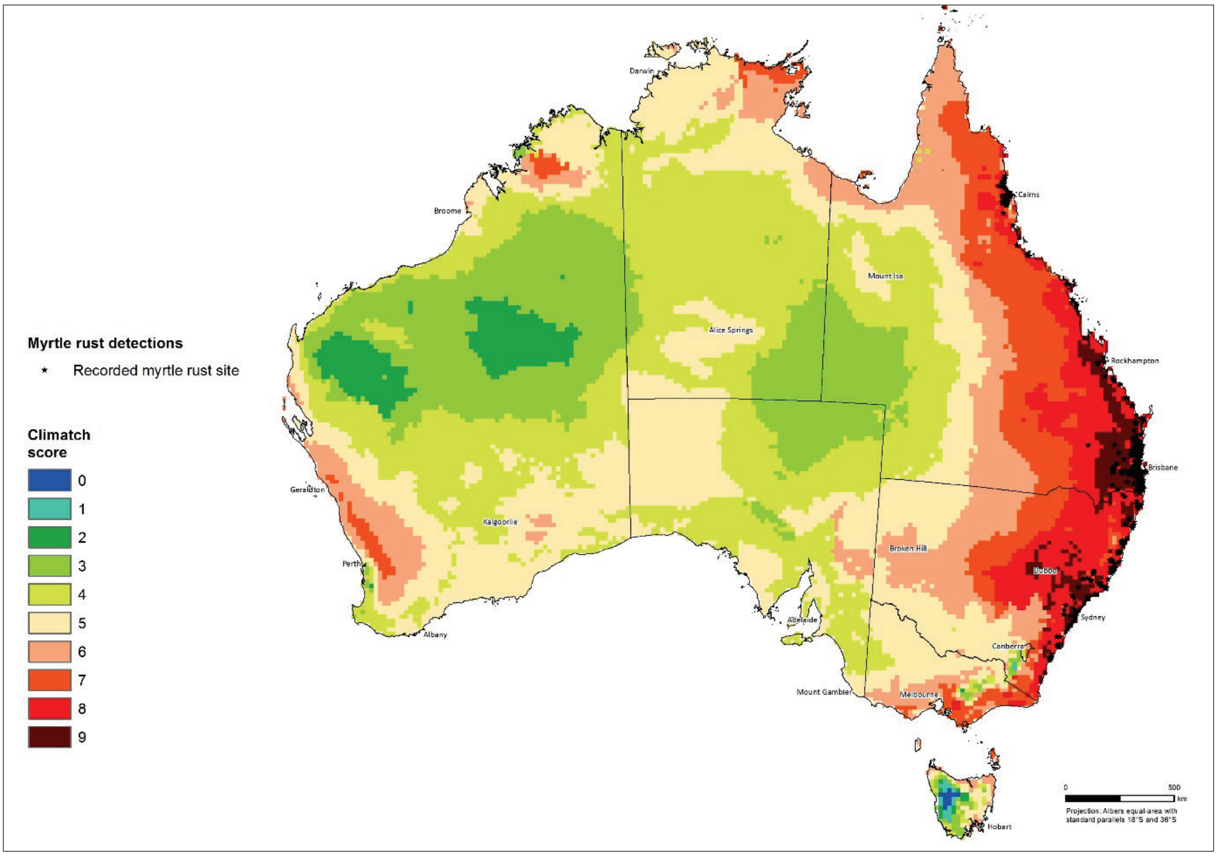
The New South Wales and Queensland locations in which myrtle rust has been detected are concentrated in areas of higher Climatch score (Figure 2). No detections of myrtle rust had occurred in areas of Australia with a modelled Climatch score below 5, with most detections in areas with Climatch scores 6 or 7 (noting the very small areas with Climatch scores above 7 in this modelling). This demonstrates that Climatch modelling makes reasonable predictions about the relative climatic suitability of areas of Australia for myrtle rust even when parameterised only with climate data on overseas detection locations.

This modelling also predicted large areas of Climatch score 7 and above where the disease has not been detected. Assuming suitable hosts are present in these areas, this is consistent with myrtle rust not yet having reached its full climatic range in Australia.

Modelling using climate data from overseas and Australian locations

The Climatch analysis was therefore repeated, incorporating in the model climate data from the locations in New South Wales and Queensland where myrtle rust has been detected as well as data from detection locations overseas (Figure 3). Data from detections in Australia but outside New South Wales and Queensland were excluded because it is believed that myrtle rust does not occur elsewhere in Australia outside nurseries and gardens.

Figure 3 Climatch modelling of potential distribution of myrtle rust in Australia based on recorded distribution overseas and in Australia



Note: Climatch modelling used data on both overseas and Australian locations of *Puccinia psidii* s.l. (Appendix B). Data from detections in Australia but outside New South Wales and Queensland were excluded. No areas had Climatch score 10 in this modelling. Areas with scores of 6 and higher are considered climatically suitable for myrtle rust development, and areas with scores of 8 and higher are considered climatically highly suitable for myrtle rust development.

Modelling using climate data from international and Australian locations again showed that areas with higher Climatch scores are located in the eastern and southwestern coastal and subcoastal regions of Australia. Analyses using just the Australian location data without the international data produced very similar results to those obtained using the combined international and Australian data (not shown). These distributions of climatic suitability are again are consistent with myrtle rust not yet having reached its full climatic range in Australia.

However, incorporation of climate data from Australian locations increased the Climatch score of most regions of Australia by 1 or 2 score units, and led to prediction of larger areas with Climatch scores 6 and above that are climatically suitable for myrtle rust, and importantly led to prediction of larger areas with Climatch scores 8 and above that are climatically highly suitable for myrtle rust. Areas of Climatch scores 8 and 9 predicted by the modelling incorporating the dataset of Australian locations are located in eastern Australia, from coastal northern Queensland (approximately Cooktown) to coastal and subcoastal southern New South Wales, and include some areas a few hundred kilometres inland in central-northern New South Wales and central Queensland. There were no areas predicted to be climatically highly suitable for myrtle rust in the Northern Territory, South Australia, Tasmania or Western Australia, although relatively small areas of these jurisdictions were given the lower rating of climatically suitable.

There are a number of possible reasons for the modelled climatic suitability distributions showing similar overall geographic patterns across the two sets of input locations, but with higher Climatch scores in models that include climatic data from Australian locations. Firstly, the international location data are dominated by detections of *P. psidii* s.l. that represent guava rust or eucalypt rust rather than myrtle rust (Elith et al. 2013, Kriticos et al. 2013), whereas the Australian location data all represent detections of myrtle rust (and specifically of the strain of myrtle rust present in Australia). Secondly, the characteristics of the Australian climate, including its seasonality, are better captured when values of climate variables from Australian detection locations are used in the modelling, leading to a closer match of climate between detection locations and modelled regions, and higher Climatch scores.

The prediction of areas a few hundred kilometres inland with Climatch scores 8 and 9 was not driven by the occasional inland detection record in the input dataset. Removing the inland records (and even all Queensland records) from the input dataset had minimal effect on the Climatch output (not shown). The prediction of climate suitability for areas a few hundred kilometres inland is similar to that derived by Elith et al. (2013) for modelling using the 'Uredo_27' dataset of overseas detection locations, which is a dataset containing only the overseas detections definitively identified as the causative agent of myrtle rust.

Reducing the number of climate variables from 16 to four or three progressively increased the climatic suitability ratings broadly across Australia, both for modelling using only international detection locations and for modelling using only Australian detection locations. Using these significantly reduced sets of climate variables, the areas modelled to be climatically suitable or highly suitable for myrtle rust expanded substantially beyond the current or expected potential distribution of the disease in Australia (not shown). This suggests that, within the full set of 16 climatic variables used, variables covering seasonal variation in rainfall and temperature describe climate features that restrict the distribution of myrtle rust.

Taken together, these results give confidence that the geographic distribution of areas highly suitable climatically for myrtle rust (Climatch scores 8 and 9), as predicted from modelling using climatic data including Australian locations where myrtle rust has been detected, is neither very conservative nor very liberal. The results presented subsequently in this report are therefore based on modelling using both overseas and Australian detection locations.

Climatic suitability of eucalypt plantation areas for myrtle rust

The area of Australia's eucalypt plantation estate for which spatial data were available in the National Plantation Inventory (NPI) as at 2011, and determined by excluding non-eucalypt hardwoods, minor and unknown eucalypt plantation species and fallow land from the total hardwood plantation area, was 812 thousand hectares. The distribution of areas of different climatic suitability for myrtle rust as modelled by Climatch (Figure 3) was combined with the NPI data on areas of eucalypt plantations, to give the areas of eucalypt plantations by their climatic suitability for myrtle rust (Table 1).

Table 1 Eucalypt plantations in Australia by climatic suitability for myrtle rust

Climatch score	Climatic suitability for myrtle rust	Eucalypt plantation area a (ha)	Proportion of total eucalypt plantation area (%)
0	Less suitable	175	0.0
1	Less suitable	35,021	4.3
2	Less suitable	4,771	0.6
3	Less suitable	39,834	4.9
4	Less suitable	114,787	14.1
5	Less suitable	366,045	45.1
6	Suitable	150,163	18.5
7	Suitable	37,715	4.6
8	Highly suitable	37,877	4.7
9	Highly suitable	25,559	3.1
10	Highly suitable	0	0.0
Total 0-10		**811,947**	**100.0**
Total 8-10	**Highly suitable**	**63,436**	**7.8**

a Eucalypt plantation area is the hardwood plantation area available spatially from the NPI, excluding area of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species.
Notes: Climatch modelling used data from overseas and Australian locations where myrtle rust has been detected. Minor differences in total area of plantations between tables are due to the differences in the scale of the boundary data used in the spatial analysis. Totals may not tally due to rounding.

A total of 63 thousand hectares (7.8 per cent) of Australia's eucalypt plantation area is in areas predicted by this modelling to be climatically highly suitable for myrtle rust establishment (Climatch scores 8 and above).

The eucalypt plantation areas highly suitable climatically for myrtle rust are almost entirely in Queensland and New South Wales, with a very small area in Victoria (Table 2). All the eucalypt plantation area in Queensland, and 88 per cent of the eucalypt plantation area in New South Wales, is predicted to be highly suitable climatically for myrtle rust. Approximately two-thirds of the eucalypt plantation area in Victoria were given the lower rating of suitable climatically for myrtle rust. Only a small proportion of the eucalypt plantation areas in Tasmania and Western Australia, and no eucalypt plantation area in South Australia, were predicted to be suitable climatically for myrtle rust.

Table 2 Eucalypt plantations by climatic suitability for myrtle rust, by state and territory

State	Total eucalypt plantation a	Less suitable (Climatch scores 0-5)		Suitable or highly suitable (Climatch scores 6-10)		Highly suitable (Climatch scores 8-10)	
	Area (ha)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)
ACT	0	0	0	0	0	0	0
NSW	50,997	10	0	50,987	100	44,824	88
NT	0	0	0	0	0	0	0
Qld	18,296	0	0	18,296	100	18,296	100
SA	54,577	54,577	100	0	0	0	0
Tas.	222,704	187,298	84	35,406	16	0	0
Vic.	200,341	68,323	34	132,018	66	316	0.2
WA	264,987	250,380	95	14,607	5.5	0	0
Total	**811,902**	**560,588**	**69**	**251,314**	**31**	**63,436**	**7.8**

a Eucalypt plantation area is the hardwood plantation area available spatially from the NPI, excluding area of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species.
Notes: Climatch modelling used data from overseas and Australian locations where myrtle rust has been detected. Minor differences in total area of plantations between tables are due to the differences in the scale of the boundary data used in the spatial analysis. Totals may not tally due to rounding.

The areas of plantations of various species by climatic suitability for myrtle rust, organised into plantations of temperate species and plantations of subtropical species, are given in Table 3. The myrtle rust climate suitability map overlaid with the distribution of temperate and subtropical eucalypt plantations is shown in Figure 4.

Approximately 1 per cent of the area of plantations in Australia containing temperate species such as *Eucalyptus globulus* and *E. nitens* is modelled to be highly suitable climatically for myrtle rust (8.3 thousand hectares out of 753 thousand hectares), almost all of this being plantations of *E. nitens* in New South Wales. By contrast, 93 per cent of the area of plantation containing subtropical species such as *E. dunnii*, *E. grandis*, *Corymbia maculata* and various eucalypt hybrids is modelled to be highly suitable climatically for myrtle rust (55 thousand hectares out of 59 thousand hectares), and is located almost completely in northern New South Wales and southern Queensland. *C. citriodora* subsp. *citriodora* plantations in Queensland, which were not included in this analysis, are also located in areas highly suitable climatically for myrtle rust. Some of these major subtropical eucalypt plantation species are species that are susceptible to infection by myrtle rust (see Appendix A)

The modelled climatic suitability for myrtle rust for eucalypt plantations of individual species is given nationally and by state in Appendix C, Tables C1-C7. The modelled myrtle rust climate suitability map overlaid with the location of plantations of the major eucalypt plantation species is shown in Figure C1.

Australia's plantations are classified in the National Plantations Inventory (NPI) into a number of regions. Eucalypt plantation areas in various NPI regions are shown in Table 4 analysed by their modelled climatic suitability for myrtle rust. Area figures for North Queensland and Northern Territory NPI regions are zero as areas of *Acacia* species were excluded from the analysis (because they are not susceptible to myrtle rust). Eucalypt plantations in areas highly suitable climatically for myrtle rust are located in the NPI region South East Queensland (100 per cent of the plantations in this region being in areas highly suitable climatically for myrtle rust) followed by the North Coast (93 per cent) and Northern Tablelands (57 per cent) in

New South Wales, and Bombala-East Gippsland (26 per cent) straddling the New South Wales/Victoria border. Appendix C, Table C8 gives data on the climatic suitability for myrtle rust of areas of individual eucalypt plantation species by NPI region.

Climatic suitability of multiple-use public native forest for myrtle rust

Analysis of native forest areas climatically suitable for myrtle rust focussed on multiple-use public forest tenure; some areas of private native forest are also suitable climatically for myrtle rust but have not been considered here. The analysis also focussed on the Eucalypt, Melaleuca and Rainforest forest types as these contain or are dominated by species in the family Myrtaceae (myrtaceous species) potentially susceptible to myrtle rust (see Appendix A, Tables A1-2). The distribution of areas of different climatic suitability for myrtle rust as modelled by Climatch (Figure 3) was combined with National Forest Inventory (NFI) data on areas of native forest, to give the areas of myrtaceous forest types by their climatic suitability for myrtle rust (Table 5). The distribution of these forest types is mapped in Figure 5, overlaid on the mapped modelled climate suitability for myrtle rust.

The total area of Eucalypt, Melaleuca and Rainforest forest types on multiple-use public forest was 9.4 million hectares, of which 95 per cent is Eucalypt forest, 4.6 per cent Rainforest, and 0.3 per cent Melaleuca forest. Approximately 6.0 million hectares (64 per cent) of the total area of Eucalypt, Melaleuca and Rainforest forest types is predicted to be suitable or highly suitable climatically for myrtle rust, and 3.5 million hectares (37 per cent) to be highly suitable climatically for myrtle rust. The area proportion of Rainforest (45 per cent) and Melaleuca forest (73 percent) that is predicted to be highly suitable climatically for myrtle rust is greater than the proportion of Eucalypt forest (37 per cent).

The areas of these forest types on multiple-use public forest highly suitable climatically for myrtle rust establishment are largely in Queensland (2.2 million hectares) and New South Wales (1.2 million hectares), comprising 84 per cent and 69 per cent of the area of these forest types on multiple-use public forest in these states (Table 6). The remaining small area is in Victoria.

A full analysis across Melaleuca forest, Rainforest and the range of sub-types of Eucalypt forest on multiple-use public native forest is presented in Appendix D, Table D1 (for Australia) and Tables D2-8 (for individual states and territories, excluding the Northern Territory which has no multiple-use public forest).

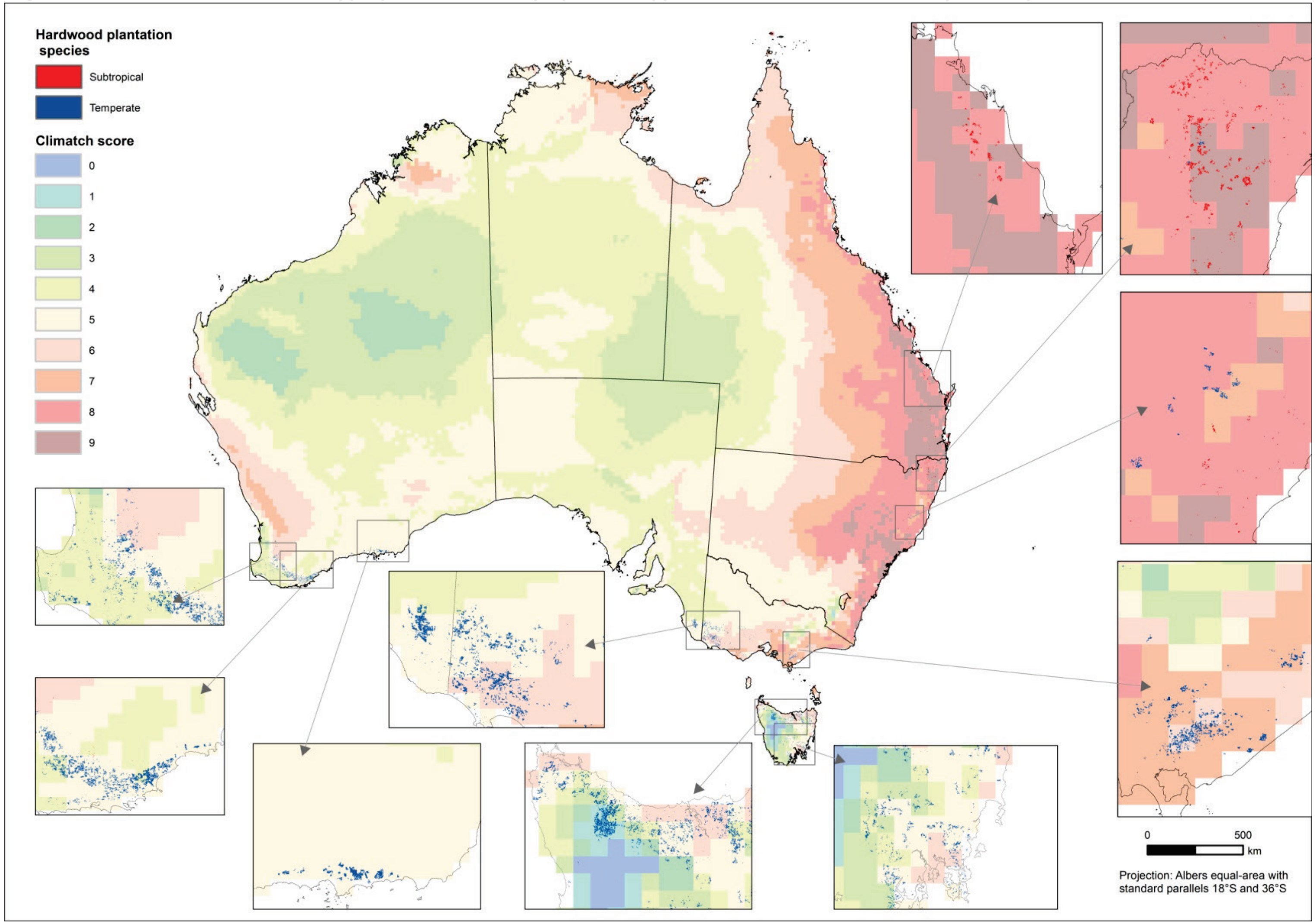
Only certain Eucalypt forest sub-types are commonly used for wood production in Australia, namely medium closed and open forest, and tall closed, open and woodland forest (medium and tall refer to height; closed, open and woodland refer to canopy cover). Restricting the analysis further to just these native forest production Eucalypt sub-types gives a total of 1.56 million hectares of potential production forest that is climatically highly suitable for myrtle rust, which is 27 per cent of the total area of these forest sub-types on multiple-use public forest (Table 7). The majority of this area climatically highly suitable for myrtle rust comprises Eucalypt medium open forests (1.01 million hectares) and Eucalypt tall open forests (0.50 million hectares).

Table 3 Plantations of temperate and subtropical eucalypt species by climatic suitability for myrtle rust

Species	**Total eucalypt plantation** a	**Less suitable (Climatch scores 0-5)**		**Suitable or highly suitable (Climatch scores 6-10)**		**Highly suitable (Climatch scores 8-10)**	
	Area (ha)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)
Temperate species							
Eucalyptus globulus	507,190	378,071	75	129,119	25	185	0
E. globulus ssp. *globulus*	8	0	0	8	100	8	100
E. globulus ssp. *maidenii*	3	0	0	3	100	3	100
E. globulus x *E. camaldulensis* and *E. dunnii*	669	0	0	669	100	669	100
E. nitens	205,004	151,856	74	53,148	26	7,300	3.6
E. nitens x *E. globulus*	189	0	0	189	100	125	66
E. regnans	7,503	22	0	7,481	100	0	0
Hardwood spp. (Hardwood in Tasmania)	32,347	29,806	92	2,541	7.9	0	0
Total temperate species	752,913	559,755	74	193,158	26	8,290	1.1
Subtropical species							
Corymbia maculata	5,167	652	13	4,515	87	4,313	83
E. dunnii	38,163	1	0	38,162	100	36,301	95
E. dunnii and *E. globulus* x *E. camaldulensis*	3,975	0	0	3,975	100	3,975	100
E. dunnii and *E. grandis*	573	0	0	573	100	573	100
E. dunnii x *E. grandis*	442	0	0	442	100	442	100
E. grandis	8,078	97	1.2	7,981	99	7,209	89
E. grandis x *E. camaldulensis*	244	0	0	244	100	244	100
E. grandis x *E. camaldulensis* and *E. dunnii*	2,007	0	0	2,007	100	2,007	100
E. grandis x *E. camaldulensis*	79	0	0	79	100	79	100
E. grandis x *E. pellita*	1	0	0	1	100	1	100
E. grandis x *E. tereticornis*	2	0	0	2	100	2	100
E. grandis x *E. camaldulensis* (Saltgrow)	292	128	44	164	56	0	0
E. grandis x *E. globulus*	11	0	0	11	100	0	0
Total subtropical species	59,034	878	1.5	58,156	99	55,146	93
Total	**811,947**	**560,633**	**69**	**251,314**	**31**	**63,436**	**7.8**

a Eucalypt plantation area is the hardwood plantation area available spatially from the NPI, excluding area of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species.
Note: Species names are taken from the National Plantation Inventory Categories. Minor differences in total area of plantations between tables are due to the differences in the scale of the boundary data used in the spatial analysis. Totals may not tally due to rounding.

Figure 4 Distribution of eucalypt plantations by species type and climatic suitability for myrtle rust



Note: Climatch modelling used data on both overseas and Australian locations of *P. psidii* s.l. (Appendix B). Data from detections in Australia but outside New South Wales and Queensland were excluded. No areas had Climatch score 10 in this modelling. The allocation of eucalypt plantation species to temperate or subtropical groups is given in Table 3.

Table 4 Eucalypt plantations by climatic suitability for myrtle rust, by National Plantation Inventory region

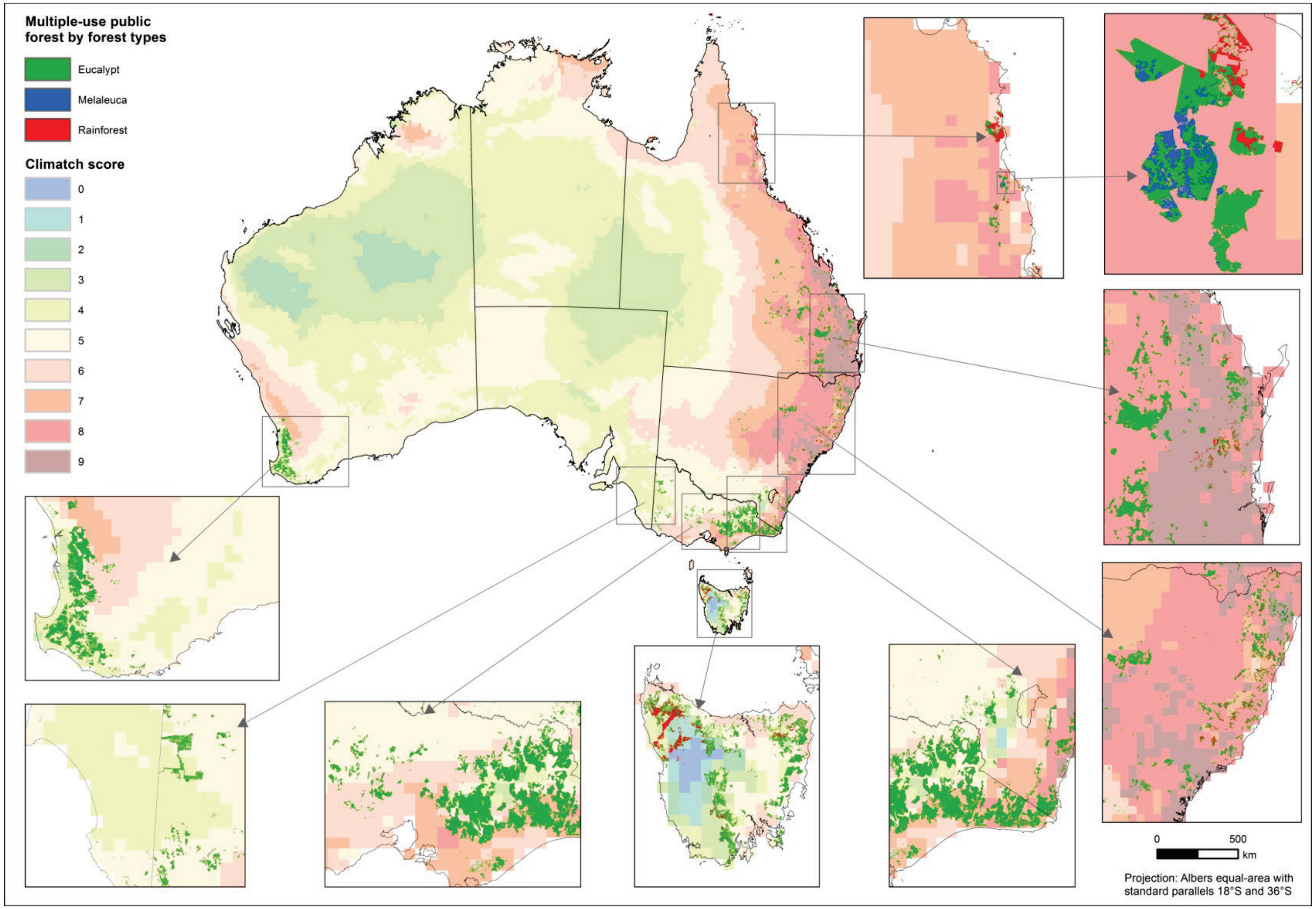
NPI region	Total eucalypt plantation a	Less suitable (Climatch scores 0-5)		Suitable or highly suitable (Climatch scores 6-10)		Highly suitable (Climatch scores 8-10)	
	Area (ha)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)
Western Australia	265,017	250,410	94	14,607	5.5	0	0
Northern Territory	0	0	0	0	0	0	0
Mount Lofty Ranges and Kangaroo Island	12,529	12,529	100	0	0	0	0
Green Triangle	162,445	98,190	60	64,255	40	0	0
North Queensland	0	0	0	0	0	0	0
South East Queensland	18,656	0	0	18,656	100	18,656	100
Northern Tablelands	5,382	0	0	5,382	100	3,076	57
North Coast	43,481	0	0	43,481	100	40,414	93
Central Tablelands	0	0	0	0	0	0	0
Southern Tablelands	0	0	0	0	0	0	0
Murray Valley	6,250	1,031	16	5,219	84	0	0
Central Victoria	34,950	11,152	32	23,798	68	0	0
Central Gippsland	35,674	0	0	35,674	100	2	0
Bombala-East Gippsland	4,805	0	0	4,805	100	1,257	26
Tasmania	222,704	187,298	84	35,405	16	0	0
Total	**811,893**	**560,610**	**69**	**251,283**	**31**	**63,405**	**7.8**

a Eucalypt plantation area is the hardwood plantation area available spatially from the NPI, excluding area of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species. Approximately one thousand hectares of *E. dunnii* plantation in northern Queensland are also not included on this table.
Notes: Minor differences in total area of plantations between tables are due to the differences in the scale of the boundary data used in the spatial analysis. Figures may not tally due to rounding. These NPI regions differ from the Wood Supply Regions used to describe areas of native and plantation forest for wood availability forecasts.

Table 5 Multiple-use public native forest containing or dominated by myrtaceous species by climatic suitability for myrtle rust

Climatch score	Suitability for myrtle rust	Forest type				Proportion of total area of these native forest types (%)
		Eucalypt	Melaleuca	Rainforest	Total	
		Area (ha)				
0	Less suitable	11,443	0	6,559	18,002	0.2
1	Less suitable	42,847	53	25,446	68,346	0.7
2	Less suitable	81,665	519	21,073	103,257	1.1
3	Less suitable	392,663	645	58,425	451,733	4.8
4	Less suitable	1,090,524	2,773	35,037	1,128,334	12
5	Less suitable	1,631,324	2,745	21,174	1,655,243	18
6	Suitable	781,135	657	18,069	799,861	8.5
7	Suitable	1,613,963	1,036	50,827	1,665,826	18
8	Highly suitable	2,716,424	14,540	155,544	2,886,508	31
9	Highly suitable	591,833	8,819	40,325	640,977	6.8
10	Highly suitable	0	0	0	0	0
Total 0-10		**8,953,821**	**31,787**	**432,479**	**9,418,087**	**100**
Total 8-10	**Highly suitable**	**3,308,257**	**23,359**	**195,869**	**3,527,485**	**37**

Figure 5 Distribution of multiple-use public native forest containing or dominated by myrtaceous species and climatic suitability for myrtle rust



Note: Climatch modelling used data on both overseas and Australian locations of *P. psidii* s.l. (Appendix B). Data from detections in Australia but outside New South Wales and Queensland were excluded. No areas had Climatch score 10 in this modelling. The allocation of hardwood plantation species to temperate or subtropical groups is given in Table 3.

Table 6 Multiple-use public native forest containing or dominated by myrtaceous species by climatic suitability for myrtle rust, by state and territory

State	Multiple-use public native forest containing Eucalypt, Melaleuca or Rainforest forest types	Less suitable (Climatch scores 0-5)		Suitable or highly suitable (Climatch scores 6-10)		Highly suitable (Climatch scores 8-10)	
	Area (ha)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)
ACT	2,612	1,390	53	1,222	47	0	0
NSW	1,774,621	165,140	9.3	1,609,481	91	1,226,843	69
NT	0	0	0	0	0	0	0
Qld	2,591,778	13	0	2,591,765	100	2,168,320	84
SA	20,012	20,004	100	8	0	0	0
Tas.	853,171	741,518	87	111,653	13	0	0
Vic.	2,908,374	1,439,837	50	1,468,537	50	132,322	4.6
WA	1,267,519	1,057,013	83	210,506	17	0	0
Total	**9,418,087**	**3,424,915**	**36**	**5,993,172**	**64**	**3,527,485**	**37**

Table 7 Area of multiple-use public native forest containing Eucalypt sub-types used for wood production by climatic suitability for myrtle rust

Forest subtype	Total	Less suitable (Climatch scores 0-5)		Suitable or highly suitable (Climatch scores 6-10)		Highly suitable (Climatch scores 8-10)	
	Area (ha)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)
Eucalypt medium closed	72,228	32,277	45	39,951	55	6,806	9
Eucalypt medium open	3,319,272	1,467,027	44	1,852,245	56	1,016,862	31
Eucalypt tall closed	105,715	42,925	41	62,790	59	16,134	15
Eucalypt tall open	2,063,398	850,639	41	1,212,759	59	501,198	24
Eucalypt tall woodland	149,750	91,928	61	57,822	39	21,871	15
Total	**5,710,363**	**2,484,796**	**44**	**3,225,567**	**56**	**1,562,871**	**27**

Potential impacts of myrtle rust on wood availability

ABARES has published outlook forecasts for Australia's future wood availability over the period 2010-54. These forecasts are based on summing the potential production of a range of wood products under a number of scenarios for 34 defined Wood Supply Regions (Burns et al. 2015). These Wood Supply Regions apply across both native and plantation forests and therefore differ from the NPI regions used to describe areas of plantation concentration (see above). Several Wood Supply Regions are located entirely or partially in the area highly suitable climatically for myrtle rust in Queensland and New South Wales.

Plantation production

Appendix E, Figure E1, shows the mapped climatic suitability for myrtle rust overlaid with these Wood Supply Region boundaries and areas of eucalypt plantation. Of the 63 thousand hectares of eucalypt plantation nationally in areas highly suitable climatically for myrtle rust (Table 4), 98 per cent is in the three Wood Supply Regions of North Coast NSW (38 thousand hectares, comprising 89 per cent of the eucalypt plantations in that region), South East Queensland (18 thousand hectares, 100 per cent) and Northern Tablelands NSW (5.5 thousand hectares, 91 per cent) (Table 8). The North & Central Queensland and Northern Territory Wood Supply Regions contain no hardwood plantations in the spatial coverage used in this work, and thus are not included on these tables: with the exception of a small area of E*. dunnii* in the North & Central Queensland Wood Supply Region, their hardwood plantation comprises *Acacia* and other non-eucalypt species not susceptible to myrtle rust. Appendix E, Table E1, gives a more detailed breakdown of plantation areas by Wood Supply Region and Climatch score category.

The total forecast eucalypt plantation log availability from each Wood Supply Region for the period 2010-54 is also given in Table 8. The proportion of the long-term plantation log availability in each Wood Supply Region deduced to be sourced from areas highly suitable climatically for myrtle rust was taken as the proportion of eucalypt plantation area in that region that was modelled to be highly suitable climatically for myrtle rust. In this way, a national total of 1.0 million cubic metres per year of plantation eucalypt hardwood logs was deduced to derive from areas highly suitable climatically for myrtle rust (Table 8), comprising mostly logs from the three Wood Supply Regions of North Coast NSW, South East Queensland and Northern Tablelands NSW.

This figure of 1.0 million cubic metres per year of plantation hardwood logs deduced to derive from areas highly suitable climatically for myrtle rust (Table 8) is 9.1 per cent of Australia's total national forecast plantation eucalypt log availability. This is slightly higher than the 7.8 per cent of Australia's eucalypt plantation area modelled to be in areas highly suitable climatically for myrtle rust (Table 8; see also Tables 1-4, E1), because plantations modelled to be in areas highly suitable climatically for myrtle rust are, on average, slightly more productive than plantations modelled to be in areas not highly suitable climatically for myrtle rust (not shown).

Native forest production

Appendix E, Figure E2, shows the mapped climatic suitability for myrtle rust overlaid with these Wood Supply Region boundaries, as well as areas of Eucalypt forest subtypes used for wood production on multiple-use public forest (medium closed and open, and tall closed, open and woodland forest). Of the 1.56 million hectares of Eucalypt forest subtypes used for wood production on multiple-use public forest that are in areas highly suitable climatically for myrtle rust (Table 7), 77 per cent is in the four Wood Supply Regions of North Coast NSW (505 thousand hectares, 84 per cent of the area of these native forest subtypes in that region), Western Queensland (378 thousand hectares, 88 per cent), South East Queensland (191 thousand hectares, 100 per cent) and Northern Tablelands NSW (122 thousand hectares, 80 per cent) (Table 9). Appendix E, Table E2, gives a more detailed breakdown of public production native forest areas by Wood Supply region and Climatch score category.

Table 8 Forecast log availability from eucalypt plantations, by Wood Supply Region, and proportion from areas climatically highly suitable for myrtle rust

Wood Supply Region a	Eucalypt plantation b			Average annual eucalypt log availability from plantations 2010-54		
	Total	Highly suitable (Climatch scores 8-10)		Total	From climatically highly suitable areas	
	Area (ha)	Area (ha)	Proportion of area (%)	m³/year	m³/year	Proportion of total log availability (%)
Bass	59,598	0	0	844,636	0	0
Central Gippsland	34,440	2	0	373,465	22	0.0
Central Victoria	23,323	0	0	282,953	0	0
Derwent	40,792	0	0	352,063	0	0
East Gippsland Bombala NSW	1,723	943	55	32,422	17,744	55
East Gippsland Bombala VIC	4,316	314	7.4	68,886	5,012	7
Green Triangle SA	41,979	0	0	653,293	0	0
Green Triangle VIC	132,101	0	0	1,864,911	0	0
Huon	10,398	0	0	185,919	0	0
Mersey	39,759	0	0	585,917	0	0
Mildura VIC	172	0	0	0	0	-
Mt Lofty & Kangaroo Is SA	12,529	0	0	116,916	0	0
Murchison	72,157	0	0	1,326,533	0	0
Murray Valley NSW	10	0	0	148	0	0
Murray Valley VIC	6,075	0	0	73,843	0	0
North Coast NSW	43,173	38,374	89	767,606	682,281	89
Northern Tablelands NSW	6,073	5,499	91	92,496	83,753	91
Other SA	8	0	0	0	0	-
Pilbara	1,514	0	0	37,405	0	0
South Coast	109,683	0	0	879,861	0	0
South East Queensland	18,279	18,279	100	221,769	221,769	100
Swan	4,852	0	0	61,311	0	0
Warren	79,191	0	0	1,346,949	0	0
WA South West	51,050	0	0	677,875	0	0
Western Queensland	25	25	100	0	0	-
Wheatbelt WA	18,727	0	0	302,496	0	0
Total	**811,947**	**63,436**	**7.8**	11,149,673	1,010,581	**9.1**

a Of the 34 Wood Supply Regions, this table excludes 6 regions (NSW Southern Tablelands, Central Tablelands NSW, NSW Dubbo, WA Goldfields, WA Other and NT Other) that contain no eucalypt plantation area and no forecast eucalypt log availability, and excludes 2 further regions (NT, North and Central Queensland) that contain also no eucalypt plantation area and for which all or the majority of the forecast hardwood plantation wood availability derives from *Acacia* and other non-eucalypt species. A small volume of pulpwood was modelled to derive from *E. dunnii* plantations in areas likely to be highly climatically suitable for myrtle rust in the North & Central Queensland Wood Supply Region, but is not shown on this table.
b Eucalypt plantation area is the hardwood plantation area available spatially from the NPI, excluding area of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species.
Notes: Minor differences in total area of plantations between tables are due to the differences in the scale of the boundary data used in the spatial analysis. Figures may not tally due to rounding.

Table 9 Forecast log availability from multiple-use public native forest, by Wood Supply Region, and proportion from areas climatically highly suitable for myrtle rust

Wood Supply Region a	Eucalypt forest sub-types used for wood production, on multiple-use public forest b			Average annual eucalypt log availability from public native forest 2010-54		
	Total	Highly suitable (Climatch scores 8-10)		Total	From climatically highly suitable areas	
	Area (ha)	Area (ha)	Proportion of area (%)	m³/year	m³/year	Proportion of total log availability (%)
Bass	103,349	0	0	315,595	0	0
Central Gippsland	530,879	20,690	3.9	571,320	22,266	3.9
Central Tablelands NSW	23,857	14,875	62	0	0	-
Central Victoria	179,566	0	0	18,344	0	0
Derwent	147,769	0	0	236,491	0	0
Dubbo NSW	5,577	4,684	84	2,100	1,764	84
East Gippsland Bombala NSW	121,812	61,609	51	269,178	136,142	51
East Gippsland Bombala VIC	816,742	104,164	13	237,992	30,353	13
Green Triangle VIC	42,864	0	0	17,701	0	0
Huon	60,270	0	0	224,133	0	0
Mersey	53,953	0	0	86,349	0	0
Mildura VIC	14,996	0	0	855	0	0
Mt Lofty & Kangaroo Is SA	226	0	0	0	0	-
Murchison	108,226	0	0	181,871	0	0
Murray Valley NSW	112,161	0	0	106,603	0	0
Murray Valley VIC	912,252	0	0	250,578	0	0
North & Central Queensland	119,926	95,802	80	25,260	20,179	80
North Coast NSW	601,362	505,256	84	366,359	307,810	84
Northern Tablelands NSW	152,580	122,267	80	0		-
Other SA	491	0	0	0	0	-
South Coast	4,301	0	0	0	0	-
South East Queensland	190,681	190,681	100	60,697	60,697	100
Southern Tablelands NSW	85,250	64,606	76	180,861	137,064	76
Swan	248,550	0	0	29,506	0	-
WA South West	392,131	0	0	76,934	0	-
Warren	248,919	0	0	322,514	0	-
Western Queensland	431,656	378,237	88	81,357	71,289	88
Total	**5,710,346**	**1,562,871**	**27**	**3,662,599**	**787,564**	**22**

a Of the 34 Wood Supply Regions, this table excludes 7 regions (WA Wheatbelt, WA Goldfields, WA Pilbara, WA Other, SA Green Triangle, NT and NT Other) that contain no area on multiple-use public forest of the five eucalypt native forest sub-types used for wood production.
b Eucalypt forest sub-types used for wood production comprise the Eucalypt medium closed, Eucalypt medium open, Eucalypt tall closed, Eucalypt tall open and Eucalypt tall woodland forest sub-types.
Note: Figures may not tally due to rounding.

The total forecast public native forest eucalypt log availability deduced to derive from areas highly suitable climatically for myrtle is also given in Table 9. The proportion of the long-term native forest eucalypt log availability in a Wood Supply Region deduced to be sourced from areas highly suitable climatically for myrtle rust was taken as the proportion of the area in that region of the multiple-use public native forest containing Eucalypt sub-types used for wood production that was modelled to be highly suitable climatically for myrtle rust. In this way, a national total of 0.79 million cubic metres per year of eucalypt logs from multiple-use public native forest was deduced to derive from areas highly suitable climatically for myrtle rust (Table 9), comprising mostly logs from the five Wood Supply Regions of North Coast NSW, Southern Tablelands NSW, East Gippsland Bombala NSW, Western Queensland and South East Queensland. The small amount of native forest eucalypt logs projected to be harvested from multiple use forests in the Northern Tablelands NSW Wood Supply Region were incorporated into the wood availability figures for the North Coast NSW Wood Supply Region.

This figure of 0.79 million cubic metres per year of public native forest eucalypt logs is 22 per cent of Australia's total national forecast public native forest eucalypt log availability. This is lower than the 27 per cent of the area of Australia's multiple-use public native forest containing Eucalypt sub-types used for wood production that is modelled to be in areas highly suitable climatically for myrtle rust (Table 7, E2), because native forest modelled to be in areas not highly suitable climatically for myrtle rust (such as Tasmania) is, on average, slightly more productive than native forest modelled to be in areas highly suitable climatically for myrtle rust (not shown).

4 Discussion

Myrtle rust, a disease caused by *Puccinia psidii* s.l., has recently become established in Australia, and has been responsible for deaths of rainforest trees of susceptible species. This paper uses Climatch modelling — a tool developed for pest risk assessments — to assess which areas of Australia have a climate that matches the climate of areas where myrtle rust has been recorded. Modelling based on datasets that include the Australian locations of myrtle rust was considered to give the best predictions of the climatic suitability of different areas of Australia for the disease.

The modelling output showed that areas climatically highly suitable for myrtle rust are located in coastal eastern Australia, from northern Queensland to southern New South Wales and small areas in eastern Victoria, and including some areas a few hundred kilometres inland from the coast in southern Queensland and central New South Wales. There were no areas climatically highly suitable for myrtle rust in South Australia, Tasmania, Western Australia, the Australian Capital Territory or the Northern Territory. Myrtle rust is currently not present in all the areas predicted to be climatically highly suitable for the disease in Australia.

Intersection of the climate modelling with spatial data on Australia's forests and forecast wood production showed that 7.8 per cent of Australia's eucalypt plantations and 27 per cent of Australia's public production native eucalypt forests[14] occur in areas highly suitable climatically for myrtle rust. A total of 9.1 per cent of Australia's future eucalypt plantation log availability and 22 per cent of Australia's future eucalypt public native forest log availability are forecast to derive from these forest areas, comprising logs mostly from the Wood Supply Regions of North Coast NSW, Northern Tablelands NSW, South East Queensland and East Gippsland Bombala NSW.

These results are based solely on the climatic component of the environmental requirements of myrtle rust, and assume that the distribution of myrtle rust will extend over time to the full area modelled as climatically highly suitable for the disease. The results will overestimate potential consequences if full occupancy of this modelled area does not occur. Alternatively, the potential consequences may be underestimated if the disease is able to establish in additional areas that are rated here as only 'suitable' climatically for myrtle rust.

However, for a number of reasons the impact of myrtle rust on future wood availability may be low even in areas that are predicted to be climatically highly suitable for the disease. Firstly, many eucalypt species are resistant to moderately resistant to myrtle rust. Secondly, the myrtle rust pathogen generally infects only younger age-classes of eucalypts. Thirdly, an outbreak needs the coincidence of susceptible species at a susceptible stage of their life cycle, with appropriate climatic conditions, as well as a sufficiently large inoculum of spores from previous consecutive years of suitable temperature and rainfall. Lastly, a number of management actions designed to prevent or mitigate rust outbreaks can be taken, at least in regard to plantations. For these reasons, this report discusses the climatic suitability of areas of Australia for myrtle rust, but does not attempt to predict the risk of myrtle rust outbreaks or the possible impact of such outbreaks on future wood availability.

[14] Defined as the five native forest Eucalypt subtypes on multiple-use forest tenure from which hardwood is predominantly sourced (medium closed and open forest, and tall closed, open and woodland forest)

Climatic suitability modelling

The data input to Climatch modelling in this work were the climate at the locations of current detections of myrtle rust overseas and in Australia. These data were used to predict the climatic determinants of the potential future distribution of myrtle rust in Australia.

Climate modelling approaches to disease distribution use relatively simple, correlative modelling tools acknowledged to be less sophisticated than other approaches, particularly whe compared to mechanistic expert models that seek to model the fundamental niche of a species (the total range of environmental conditions suitable for the species). However, such mechanistic modelling needs additional input data on pathogen biology and host interactions, data which are not always available or accurate. Froese (2012) provides a useful comparative review of the various approaches.

Climate modelling of disease distribution assumes that the current distribution of disease detections correctly defines the potential climatic envelope of the pathogen, and does not take account of the extent to which the current distribution reflects the locations of initial establishment of the disease in a region or country. Furthermore, no account is taken of the possibility that races of the pathogen differ in their climate requirements, or of the possibility of future climate change. Possible differences in climatic preference between races of the myrtle rust pathogen have not been formally investigated (Kriticos et al. 2013), although the results of Elith et al. (2013) do suggest differences within the *P. psidii* s.l complex. Lastly, climate suitability alone does not determine the extent and impact of disease outbreaks, which also depend on the relative susceptibility of different host species (Zauza et al. 2010, Pegg et al. 2012, 2014a,b) in combination with the relative virulence of different pathogen strains (Graça et al. 2013) and available inoculum size. The outputs of Climatch modelling can thus be useful for regional or national planning, but are not useful for the accurate prediction of disease risk at local scales.

In addition, the Australian locations used in this study did not arise from a systematic survey, and have been collected at a relatively early stage of the establishment and spread of myrtle rust in Australia. The modelling thus could usefully be repeated in a few years as the progress of spread of the disease continues.

Climatch scores 5 and above are generally taken as indicating a suitable climate for a pest species ("Bomford modelling": National Environmental Biosecurity Response Agreement[15]). This work uses Climatch scores 6 and above to indicate a suitable climate for myrtle rust, and Climatch scores 8 and above to indicate a highly suitable climate for myrtle rust. This allocation of categories was made to take account of a number of potential mitigating factors that may reduce the impact of the disease broadly in Australia: firstly, eucalypts have a diverse genetic base, giving the potential for various forms of resistance to the pathogen; and secondly, both native forest stands and plantation estates often contain trees of a range of ages, while at least for eucalypts susceptibility is confined to young individuals.

The results of this study are broadly consistent with the results of other modelling of the potential geographic distribution of the myrtle rust pathogen in Australia with the CLIMEX, MaxEnt and NAPPFAST models (Magarey et al. 2007, Booth and Jovanovic 2012, Hanna et al. 2012, Elith et al. 2013, Kriticos et al. 2013), but with some differences.

- Compared to the MaxEnt modelling of Elith et al. (2013) that used the complete ('Puccinia_94') dataset of overseas detection locations, the Climatch modelling using the

[15] Available at coag.gov.au/node/74 (accessed 18 November 2014)

same overseas detection locations plus the Australian detection locations shows greater climatic suitability along the eastern coast and adjacent subcoastal regions of Australia, but less climatic suitability in the Northern Territory and south-west Western Australia. Results more similar to those of Elith et al. (2013) were obtained when the Climatch modelling was performed using only the overseas detection records and a limited set of climate variables similar to those used by Elith et al. (2013).

Further, the modelling of Elith et al. (2013) that used just those overseas detection locations considered to represent definitive detections of myrtle rust (their 'Uredo_27' dataset) predicted climate suitability extending somewhat inland from coastal Queensland and New South Wales. This is more consistent with the results of the climate suitability modelling in this work using Australian detections of myrtle rust. This in turn suggests that the climatic suitability distribution predicted in this work using the Australian detections locations of myrtle rust, including the extension inland from coastal Queensland and New South Wales, more correctly represents the climatic suitability of areas of Australia for the form of *P. psidii* s.l present in Australia.

- Kriticos et al. (2013) also performed climate modelling using Climex, based on overseas detection locations of *P. psidii* s.l. (and including detections locations for guava, eucalypt and myrtle rust. Areas modelled by Kriticos et al. (2013) to have an Ecoclimatic Index for *P. psidii* s.l. of 46-100 for *P. psidii* s.l. were broadly similar to areas modelled by Climatch to be highly suitable for myrtle rust. However, Kriticos et al. (2013) then combined hardwood plantation areas with the area modelled to have an Ecoclimatic Index of >0 for *P. psidii* s.l., which explains why that work predicted that 76 per cent of Australia's hardwood plantation area, and greater than 90 per cent of the plantation areas in all jurisdictions other than Tasmania and the Northern Territory, to be in the climatic potential range for *P. psidii* s.l.. Our work, which focusses on plantation and public native forest areas highly suitable climatically for myrtle rust (Climatch scores 8 and above) provides a more targeted description of plantation and public native forest areas where wood production may be at risk from this pathogen.
- The possible extension of the distribution of myrtle rust to inland regions west of the Great Dividing Range under certain climatic conditions was also suggested by Glen et al. (2007) and Booth and Jovanovic (2012).

In summary, the Climatch modelling conducted in this study included the locations of detection of myrtle rust in Australia (New South Wales and Queensland), as well as the locations of detection of myrtle rust (and related rusts) overseas. The modelling of Elith et al. (2013) and Kriticos et al. (2013) used a small set of climate variables, but inclusion in this study of climate data from the locations of detections of myrtle rust in Australia is likely to have given a more accurate measure of the range of climates (that is, of the range of different combinations of climate variables) in which the disease could establish in this country. Additionally, the overseas distribution data used in other modelling studies (Elith et al. 2013, Kriticos et al. 2013) included data for a range of rusts in the *P. psidii* s.l. complex such as guava rust and eucalypt rust, not just myrtle rust, thus reducing the accuracy of their predictions for myrtle rust in Australia: the climatic suitability for myrtle rust deduced from this set of overseas locations is likely to have been an imperfect predictor of the climate suitability of areas within Australia for myrtle rust. Incorporation of the locations of Australian detections of myrtle rust, climate data from these locations, and the full set of climate variables, as in this work, maximises the chance of including key climate variables for the interaction of the strain(s) of myrtle rust present in Australia with hosts present in Australia, and maximises the chance of accurately predicting the climatic bounds of the potential range of the myrtle rust pathogen in Australia.

Wood production from areas of Australia’s production forests climatically highly suitable for myrtle rust

This study indicates that, nationally, approximately 63 thousand hectares (7.8 per cent) of Australia’s eucalypt plantation area are highly suitable climatically for myrtle rust. The climatically highly suitable areas are mostly in south-east Queensland and northern New South Wales, with 100 per cent of the eucalypt plantations in the South East Queensland Wood Supply Region and 84 per cent of the eucalypt plantations in the North Coast NSW Wood Supply Region being in areas highly suitable climatically for myrtle rust. In contrast, plantations in the Green Triangle region of SA and Vic., Tasmania and south-western Western Australia are not located in areas highly suitable climatically for myrtle rust. Incorporating the wood availability forecasts of Burns et al. (2015), the eucalypt plantations in areas highly suitable climatically for myrtle rust were forecast to produce 1.0 million cubic metres per year of plantation eucalypt logs over the period 2010 to 2054, which is 9.1 per cent of Australia’s total national forecast plantation eucalypt log availability over this period.

Plantations generally contain large contiguous areas of younger age-classes of trees, with a lesser range of genetic variety compared to native forest. The causative agents of myrtle rust and related rusts have led to major damage in *E. grandis* plantations in Brazil (Alfenas et al. 2004, Coutinho et al. 1998, Xavier and da Silva 2010) and *E. globulus* plantations in Uruguay (Telechia et al. 2003, Pérez et al. 2011). The major impact on wood production species has been through loss or growth impairment of young eucalypts (usually at less than two years of age), resulting in loss of stocking, uneven growth, and loss of wood volume and quality. Myrtle rust also has the potential to disrupt wood availability from hardwood plantations in areas of Australia modelled as highly suitable climatically for the disease.

Based on the modelling of Kriticos et al. (2013), Cannon (2011) estimated potential losses in hardwood plantation wood production of 20 per cent (equivalent to 449 thousand cubic metres) in NE New South Wales/Queensland, 13.2 per cent (510 thousand cubic metres) in Gippsland, Green Triangle, Kangaroo Island and Central Victoria regions, and 6.6 per cent (538 thousand cubic metres) in Western Australia and Tasmania. However, as only a small proportion of the hardwood plantation estate is at a susceptible age at a given time (Gavran 2012), impact on wood availability from susceptible stands in climatically highly suitable areas may not be immediate, even during outbreaks. Furthermore, some eucalypt species such as *Corymbia citriodora* and *E. cloeziana*, as well potentially as *E. grandis* and *E. tereticornis*, have some degree of resistance to myrtle rust (Zauza et al. 2010, Pegg et al. 2012, 2014a,b).

Native forest susceptible to myrtle rust was taken to be the forest types Eucalypt, Melaleuca and Rainforest. Approximately 3.5 million hectares of these forest types on multiple-use public native forest, including 3.3 million hectares of Eucalypt forest, are present in areas highly suitable climatically for myrtle rust. These areas are largely in coastal and subcoastal regions of Queensland and New South Wales. Within this overall area, approximately 1.56 million hectares carry one of the Eucalypt forest sub-types commonly used for wood production. Incorporating the wood availability forecasts of Burns et al. (2015), these public production eucalypt native forests in areas highly suitable climatically for myrtle rust were forecast to produce 0.79 million cubic metres per year of public native forest wood logs over the period 2010 to 2054, which is 22 per cent of Australia’s total national forecast native forest eucalypt log availability over this period. In the long term, myrtle rust may cause significant problems for native forest regeneration and consequently wood production through death of seedlings and young plants of susceptible or highly susceptible species.

Limitations of this work

This work assumes that the values of climatic variables determined from the current locations in which myrtle rust has been detected, including from current Australian locations, are appropriate for predicting the range of future potential locations that the rust could inhabit. The pathogen may in fact have different climatic limits to those described by the set of current detection locations.

The estimates of forest areas highly climatically suitable for myrtle rust, and wood volumes forecast to derive from these areas, are also only relevant estimators of potential impact if the myrtle rust pathogen is distributed over the full area modelled as climatically highly suitable, which is not currently the case. They are also only relevant estimators of potential impact if no management action is taken following any future detection of myrtle rust in production forest.

In addition, this work only considers the annual climatic parameters that may limit the future potential distribution of myrtle rust in Australia. It is possible that the current Australian range of the pathogen is not related to climatic factors, in which case the future range could be wider or narrower than that predicted here. In addition to climate, variables known to determine impacts of this pathogen and other rusts include species susceptibility or resistance, plant growth stage, and the presence or otherwise of a suitably large inoculum of spores resulting from favourable climatic conditions over adjacent seasons; there may also be other, unknown variables. Because outbreaks of rust are rare even in areas climatically suitable for the disease, this work does not estimate potential losses due to future outbreaks of myrtle rust.

It is also not clear whether predicted future climate change will make regional forests more or less susceptible to myrtle rust. In Tasmania and Western Australia, the modelled potential distribution and severity of myrtle rust vary significantly depending on the choice of models, the potential effects of climate change on temperature and rainfall, and the strain of rust pathogen modelled (Kriticos et al. 2013). Myrtle rust could become a problem in Tasmania under predicted climate change (Kriticos et al. 2013). However, Hanna et al. (2012) predicted almost no or only a slight increase in the climatic suitability for myrtle rust in Australia by 2050. A recent study has indicated that increases in atmospheric concentration of carbon dioxide may limit the development of rust epidemics directly (Ghini et al. 2014). The virulence and aggressiveness of strains of rust pathogens can vary under different climatic conditions (Singh and Heather 1982a,b), as well as across the range of hosts, but possible differences in climatic preferences between strains of *P. psidii* s.l. have not been investigated (Kriticos et al. 2013). Lastly, there is an on-going risk that new strains of myrtle rust with different climatic limitations will either evolve in Australia, or will be introduced from overseas.

Utility of this work

This work showed that the ABARES spatial forest coverages can be used to allow prediction of the areas of Australia's plantations and native production forests highly suitable climatically for the forest pathogen myrtle rust. Moreover, ABARES data on forecast regional wood availability can be used to allow prediction of the proportion of forest wood availability that derives from areas highly climatically suitable for myrtle rust.

The results of this work can:

- assist forest managers to target surveillance to particular regions in advance of implementing management measures

- allow planning for selection of rust resistance in eucalypt plantation species for planting in areas highly climatically suitable for myrtle rust, or planning for planting different (less susceptible) species

- assist industry and policy-makers to decide on domestic restrictions on plant movement, designed to reduce the risk of myrtle rust establishment in areas that are highly suitable climatically for the disease.

The lack of noticeable impact to date of myrtle rust on wood production from Australia's plantations and production native forests gives a window of opportunity to understand the future vulnerability of these forests to myrtle rust, and potential mitigation options. The range of silvicultural options available to mitigate the risk of myrtle rust in Australia's plantations include the use of fungicides (Plant Health Australia 2009, Pegg et al. 2012, Masson et al. 2013) on young, rust-susceptible trees, and planting genotypes resistant to myrtle rust as has been successfully done in Brazil (Office of the Chief Plant Protection Officer 2010, Graça et al. 2011a, Pegg et al. 2014a,b). Fewer practical options are available to mitigate damage to native forests in areas where myrtle rust is already established, but domestic quarantine measures may reduce the spread of myrtle rust to areas currently free of the pathogen. Loope (2010) has described approaches to prevent the introduction of additional strains of *P. psidii* to Hawaii. Continued quarantine restrictions to prevent introduction of new, more virulent strains of *P. psidii* s.l. into Australia (Simpson et al. 2006, Cannon 2011, Carnegie 2014) would also help in managing any further threats to Australia's native production hardwood forests and eucalypt plantations.

Future work on the potential impacts of myrtle rust on Australia's forests, and on the wood availability from different wood production regions, could usefully:

- review differences in the responses to the myrtle rust pathogen of various hosts, including plantation eucalypts and key native forest species, to assess potential susceptibility or resistance

- assess the potential risks to eucalypt plantations and native forests due to changes in the virulence of the rust pathogen population already present in Australia, or the introduction of new, more virulent or host-specific strains from overseas

- assess the viability under Australian conditions of the various management options used overseas.

Appendix A: Eucalypt species reported as hosts of myrtle rust

Table A1 Eucalypt species on which myrtle rust has been reported overseas

Host species	Reference (in addition to Giblin & Carnegie 2014b)
Angophora costata	Zauza et al. (2010)
Corymbia citriodora	Joffily (1944), Zauza et al. (2010)
C. gummifera	Zauza et al. (2010
C. intermedia	Zauza et al. (2010)
C. maculata	Zauza et al. (2010)
Eucalyptus acmenoides	Zauza et al. (2010)
E. alba	Zauza et al. (2010)
E. amplifolia var. *amplifolia*	Zauza et al. (2010)
E. brassiana	Zauza et al. (2010)
E. camaldulensis	Dianese et al. (1984)
E. camaldulensis ssp. *obtusa*	Zauza et al. (2010)
E. camaldulensis ssp. *simulata*	Zauza et al. (2010)
E. cloeziana	Dianese et al. (1984), Zauza et al. (2010)
E. deglupta	
E. diversicolor	
E. dunnii	Zauza et al. (2010), Pérez (2014)
E. elata	
E. globulus	
E. globulus ssp. *globulus*	Telechea et al. (2003), Zauza et al. (2010), Pérez et al. (2011)
E. grandis	Ferreira (1981), Zauza et al. (2010), Pérez et al. (2011)
E. guilfoylei	Zauza et al. (2010)
E. melanophloia	Zauza et al. (2010)
E. microcorys	Dianese et al. (1984), Zauza et al. (2010)
E. moluccana ssp. *moluccana*	Zauza et al. (2010)
E. nitens	Zauza et al. (2010)
E. obliqua	Zauza et al. (2010)
E. paniculata	Dianese et al. (1984)
E. pellita	Dianese et al. (1984)
E. pilularis	Zauza et al. (2010)
E. phaeotricha	Dianese et al. (1984)
E. punctata	Dianese et al. (1984)
E. pyrocarpa	Dianese et al. (1984)
E. regnans	Zauza et al. (2010)
E. resinifera	Zauza et al. (2010)
E. robusta	Zauza et al. (2010)
E. rudis	Kawanishi et al. (2009)
E. saligna	Ferreira (1983)
E. scias subsp. *scias*	Zauza et al. (2010)
E. tereticornis	Dianese et al. (1984)
E. urophylla	Dianese et al. (1984), Zauza et al. (2010)
E. viminalis ssp. *viminalis*	Kawanishi et al. (2009)

All species listed at anpc.asn.au/myrtle-rust (Giblin & Carnegie 2014b); data current as at 24 Sep 2014. See also links at anbg.gov.au/anpc/resources/Myrtle_Rust.html. May also include detections of related rusts in the *Puccinia psidii* complex.

Table A2 Eucalypt species on which myrtle rust has been reported in New South Wales and Queensland

Host species	Common name	NSW	Qld	Response to rust
Angophora floribunda	Rough-barked apple	Y	-	-
Angophora subvelutina	Broad-leaved apple	Y	-	-
Corymbia citriodora subsp. variegata	Spotted gum	Y	Y	RT
C. ficifolia x *C. ptychocarpa*	'Summer red'	-	Y	RT
C. henryi	Large-leaved spotted gum	-	Y	MS
C. torelliana	Cadagi	-	Y	RT
E. agglomerata	Blue-leaved stringybark	Y	-	-
E. argophloia	White gum	-	Y	-
E. camaldulensis	River red gum	-	Y	-
E. carnea	Broad-leaved white mahogany	-	Y	MS
E. cloeziana	Gympie messmate	Y	Y	RT
E. curtisii	Plunkett mallee	-	Y	MS
E. deanei	Mountain blue gum	Y	-	-
E. elata	River peppermint	Y	-	-
E. gomphocephala	Tuart	-	Y	-
E. grandis	Flooded gum, rose gum	Y	Y	RT, MS
E. olida	Strawberry gum	Y	-	-
E. pellita	Red mahogany	Y	-	-
E. pilularis	Blackbutt	Y	-	-
E. planchoniana	Bastard tallow wood	-	Y	RT
E. robusta	Swamp mahogany	Y	-	-
E. siderophloia	Northern grey ironbark	-	Y	-
E. tereticornis	Blue gum, forest red gum	Y	Y	RT
E. tindaliae	Tindale's stringybark	Y	Y	MS
E. urophylla	Timor white gum	-	Y	-
E. xerothermica		-	Y	-

Host detections: Y, reported as host in that state; -, not found to be reported as host in that state. Response to rust: RT, relatively tolerant; MS, moderately susceptible; -, not reported or no data.
All species listed at anpc.asn.au/myrtle-rust (Giblin & Carnegie 2014a); data current as at 24 Sep 2014. Primary sources for rust response are Pegg et al. (2012, 2014a,b) and Queensland Government (2015). See also links at anbg.gov.au/anpc/resources/Myrtle_Rust.html

Appendix B: Geographic distribution of myrtle rust

Table B1 Locations of detection of myrtle rust and related rusts outside Australia

Latitude	Longitude	Location
-27.00	-65.50	#Tucuman, Argentina
-27.45	-58.98	# Resistencia, Argentina
-27.40	-56.10	# Encarnacion, Argentina
13.17	-59.53	# Bridgetown, Barbados
-15.80	-43.32	# Janauba, Brazil
-14.18	-44.67	# Itaguai, Brazil
-18.10	-41.10	# Espirito Santo, Brazil
-18.10	-40.10	# Teixeira de Freitas, Brazil
-5.08	-42.82	# Teresina, Brazil
-20.40	-42.90	# Pomte Nova, Brazil
-19.82	-40.27	# Aracruz, Brazil
-22.95	-43.33	# Sao Francisco, Brazil
-22.90	-43.23	# Rio de Janeiro, Brazil
-26.93	-49.05	# Blumenau, Brazil
-9.67	-35.72	# Maceio, Brazil
-27.10	-48.93	# Brusque, Brazil
-8.05	-34.90	# Recife, Brazil
0.72	-51.38	# Porto Grande, Brazil
-0.12	-51.28	# Mazagao Novo, Brazil
0.03	-51.05	# Macapa, Brazil
6.25	-75.58	# Medellin, Colombia
6.24	-75.59	# Medellin, Colombia
9.93	-84.10	# Ciudad Colon, Costa Rica
21.80	-79.98	# Trinidad, Cuba
22.82	-82.77	# Artemisa, Cuba
20.35	-74.50	# Baracoa, Cuba
19.22	-70.52	# La Vega, Dominican Republic
19.38	-70.52	# Moca, Dominican Republic
18.47	-69.90	# Santo Domingo, Dominican Republic
19.73	-70.72	# Puerto Plata Cupey, Dominican Republic
-2.28	-78.98	# Huigra, Ecuador
-1.40	-78.42	# Banos, Ecuador
18.53	-72.33	# Port-au-Prince, Haiti
18.00	-76.80	# Kingston, Jamaica
18.38	-77.45	# Stewart Town, Jamaica
18.03	-77.37	# Mandeville, Jamaica
18.27	-77.12	# Moneague, Jamaica
18.03	-76.72	# Gordon Town, Jamaica
18.17	-77.48	# Christiana, Jamaica
18.25	-77.72	# QuickStep, St Elizabeth,Jamaica
18.07	-76.72	# Newcastle, Jamaica
-24.50	-57.00	# Rosario, Paraguay
18.12	-66.17	# Cayey, Puerto Rico
18.40	-66.00	# Bayamon, Puerto Rico
18.05	-66.08	# Guayama, Puerto Rico
18.23	-66.39	# Orocovis, Puerto Rico
18.17	-67.08	# Mayaguez, Puerto Rico
18.18	-66.98	# Maricao, Puerto Rico
18.17	-66.70	# Adjuntas, Puerto Rico
10.65	-61.52	# Lady Chancellor Hill, Trinidad
11.20	-60.80	# Plymouth, Trinidad
10.50	-66.90	# Caracas, Venezuela
19.16	-96.13	# Veracruz, Mexico

Latitude	Longitude	Location
23.98	121.60	# Hualien, Taiwan
33.24	-117.02	# San Diego, USA
20.57	-156.57	# Makiki, USA
21.30	-157.85	# Manoa, USA
27.93	-82.45	# Tampa, USA
26.63	-81.87	# Fort Myers, USA
21.35	-157.72	# Waimanalo, USA
27.77	-82.67	# St Petersburg, USA
27.43	-80.32	# Fort Pierce, USA
20.88	-156.50	# Wailuku, USA
21.97	-159.37	# Lihue, USA
25.77	-80.18	# Miami, USA
26.70	-80.05	# West Palm Beach, USA
26.12	-80.13	# Fort Lauderdale, USA
-34.60	-58.45	# Buenos Aires, Argentina
-26.40	-54.63	# Eldorado, Argentina
-22.72	-47.63	# Piracicaba, Brazil
-21.27	-48.32	# Jaboticabal, Brazil
-20.75	-42.88	# Viçosa, Brazil
-23.42	-51.92	# Maringa, Brazil
-22.90	-47.08	# Campinas, Brazil
-22.87	-48.43	# Botucatu, Brazil
-19.92	-43.93	# Belo Horizonte, Brazil
-21.23	-45.00	# Lavras, Brazil
-23.53	-46.62	# Sao Paulo, Brazil
-15.78	-47.93	# Brasilia, Brazil
-21.23	-43.77	# Barbaccena, Brazil
-30.10	-51.32	# Guaiba, Brazil
-25.28	-49.23	# Colombo, Brazil
-29.83	-51.17	# Sao Leopoldo, Brazil
-31.40	-58.00	# Concordia, Uruguay
-34.47	-58.52	# Acussuso, Argentina
-33.25	-58.08	# Paysandu, Uruguay
-34.67	-56.33	# Canelones, Uruguay
-32.42	-57.37	# Rio Negro, Uruguay
-31.68	-55.95	# Tacuarembo1, Uruguay
-31.58	-55.95	# Tacuarembo2, Uruguay
-31.55	-55.95	# Tacuarembo3, Uruguay
-34.32	-54.73	# Maldonado, Uruguay
-34.55	-55.15	# Lavalleja, Uruguay
18.08	-76.72	# Hardwar Gap, Jamaica

Source: Elith et al. 2013, dataset 'Puccinia_94'. This dataset includes all available *Puccinia psidii* s.l. and *Uredo rangelii* records, in both native and invaded ranges, and thus includes detections that may be guava rust or eucalypt rust as well as detections of myrtle rust.

Table B2 Locations of detection of myrtle rust in Australia

Latitude	Longitude
-33.75815012	150.9655833
-29.45975	153.0738333
-28.96486111	153.4058333
-28.99080556	153.4081389
-28.797	153.3844167
-28.59538	152.70779
-28.52013	152.57143
-33.81111111	151.2002778
-31.22405181	152.5743498
-31.67018154	152.7361276
-30.82934601	152.9087683
-30.82274596	152.9163654
-32.24110723	152.2011881
-32.3630713	152.2346606
-33.57333333	150.6277778
-33.77	150.645

Latitude	Longitude
-28.35583333	153.3827778
-33.83305556	151.2094444
-30.94141237	152.8128437
-31.56967995	152.5884891
-32.90833333	151.7297222
-35.46829934	150.3375977
-29.4925	153.1027778
-31.29036053	152.5968939
-30.86557151	152.7951565
-31.28443568	152.519111
-31.27940057	152.5070867
-31.2645649	152.5256401
-31.54572355	152.7341923
-31.37121534	152.7413938
-32.18388889	151.7022222
-32.23527778	151.7297222

Latitude	Longitude
-31.76166667	152.5977778
-31.35222222	152.7516667
-32.55638889	151.1702778
-31.71155594	152.6912825
-30.88916667	152.9138889
-28.81972222	153.3283333
-28.84222222	153.3572222
-28.84138889	153.4391667
-28.8425	153.5416667
-28.692	153.295
-33.7356889	151.1549682
-32.9379992	150.9137474
-33.45383281	151.1090166
-32.19875	151.3221944
-32.20072222	151.3263056
-32.20477778	151.3203333

Latitude	Longitude
-32.20038889	151.3253889
-33.0487493	151.0565961
-32.40087589	152.4587563
-32.45335117	152.4956811
-32.05841068	152.5465902
-32.43452713	152.5266342
-32.37859939	152.5274575
-34.18074738	151.0188503
-29.57382293	153.3356171
-29.6737786	153.3270814
-29.6775471	153.3286749
-29.75855995	153.2918375
-29.82195012	153.2919697
-29.75956897	153.2926369
-29.69414392	152.9466933
-34.22793975	150.974034
-31.2539769	152.9663908
-33.37525417	150.6731342
-34.41438283	150.8548385
-35.04569353	150.5951117
-35.04559058	150.5899696
-34.68594891	150.6175741
-35.68130114	150.2663182
-35.68849469	150.2858707
-35.60632779	150.276179
-35.61118352	150.2784646
-35.62635975	150.3193482
-35.62360623	150.3163161
-35.56994851	150.3239548
-35.55884016	150.3306889
-34.30170065	150.9334961
-34.3021452	150.933659
-34.30274748	150.9319494
-35.01287705	150.65372
-35.0529047	150.5972034
-35.06704846	150.528591
-34.30050735	150.9247795
-34.71506972	150.4623884
-33.63063183	151.2797111
-32.93630706	151.6705867
-32.92754985	151.7619673
-30.40440723	153.0666185
-30.40530939	153.0676561
-30.40260096	153.0686937
-30.39899035	153.0718064
-30.40169493	153.0759872
-30.36470407	153.0613843
-30.3638019	153.0603467
-30.3638019	153.0603467
-30.36199564	153.0624371
-30.35939647	153.0624778
-30.36019131	153.0603314
-30.37282359	153.06555
-30.59482899	153.0083334
-30.59392492	153.0072958
-30.58219477	153.0072804
-30.48611674	152.9149651
-30.45139195	152.8906273
-30.38120747	152.9203652
-30.42472466	153.02093
-31.80135761	151.7951813
-31.64586026	152.6276529
-31.6378327	152.6132268
-31.6341167	152.6047638
-31.89931125	151.7735889
-31.90803006	151.7872107
-31.91113604	151.793177
-31.89893689	151.7712569
-31.53522431	152.7339713
-32.14939581	151.5114388
-31.66908973	152.7346874
-31.67112505	152.7121902

Latitude	Longitude
-32.36090581	152.3415448
-31.51630168	152.685167
-31.56299576	152.7818265
-31.5663011	152.7538097
-32.3086276	152.1169007
-26.399820	153.068920
-27.410490	153.009590
-27.113520	152.950170
-27.585100	153.283360
-26.682420	153.056050
-27.473020	153.096840
-26.650740	152.896050
-26.640960	152.939780
-26.498400	152.853390
-26.634360	152.977160
-27.218360	153.064270
-26.795920	153.104950
-26.651370	153.079650
-26.648980	152.897960
-26.401890	153.061160
-26.397520	153.061850
-27.107660	152.901820
-27.332240	153.010080
-27.362080	153.013980
-27.113300	152.903430
-26.0419167	152.7899333
-27.2871500	153.0643700
-27.4693600	153.0609300
-27.5107300	152.9609900
-27.9279700	153.3948800
-27.5804000	153.2712900
-27.2999700	153.0209800
-27.3158000	153.0193800
-27.6391600	153.2510110
-26.7051100	152.8079900
-27.6132500	152.9635200
-27.4534600	152.9506400
-27.6078400	153.0682300
-27.4934200	153.0730400
-27.4680600	153.1708700
-25.9645500	152.9774200
-27.6016100	153.0958200
-24.8536800	152.3370700
-20.2767400	148.6926700
-27.5359500	152.9984167
-27.5363167	152.9994333
-27.5380167	153.0031500
-27.5386333	153.0043500
-27.5252900	152.9434500
-27.4795000	153.1590000
-27.6581600	153.1798400
-27.3039200	152.0852200
-26.4196700	153.1032000
-25.2975100	152.8888000
-26.4018700	153.0674500
-27.8271900	153.4136400
-27.9023100	153.2102600
-26.4097400	153.1082200
-28.0708100	153.4247700
-27.5328300	152.8267400
-27.3744557	152.9756888
-27.3535700	153.0353900
-26.7748400	152.9134800
-27.5100700	153.0463300
-27.4690600	152.9842400
-26.5294300	152.6933100
-26.9339310	152.9811860
-27.4877000	153.2373400
-26.3278000	152.8375900
-27.5194900	153.2592600
-26.6845000	153.0143700
-26.8280200	153.1093700

Latitude	Longitude
-27.4191400	152.9738200
-27.4651660	153.1862680
-27.5261600	152.9655600
-23.3379100	150.5202300
-28.0070900	153.3411200
-28.0808400	153.3537100
-28.0791700	153.4139200
-27.6057100	151.9605100
-28.0786300	153.4132600
-26.1822000	152.6621000
-27.5139300	153.2076000
-27.9029500	153.2562600
-28.2363090	153.3548280
-28.2057140	153.3950900
-27.5148750	152.9805690
-17.3495900	145.5786100
-27.6671600	153.1402200
-27.5299400	153.0519400
-27.5082400	152.9734300
-26.4028500	152.8727300
-26.6154000	152.9549100
-28.0086700	153.3861700
-27.4894400	153.0745200
-28.1349600	153.4879200
-27.4089800	153.0522400
-27.6243200	153.0487200
-27.5486900	152.9295000
-28.0633700	153.4079000
-28.1809900	153.3615500
-27.6598900	153.2169200
-27.4847800	151.9494700
-27.4730000	152.9774600
-27.2529900	153.0238000
-26.7032600	152.9512800
-26.6805700	153.0588600
-26.5568600	152.9915800
-27.6144800	153.0664700
-27.5161400	153.0677100
-26.4003500	153.0268600
-28.0655400	153.4011500
-26.3981600	153.0679700
-26.6024900	152.9010700
-26.4755200	152.9524000
-26.4053000	153.0526000
-27.3381300	152.8713700
-27.5088400	152.9507800
-28.0973700	153.3368800
-26.4171600	152.9100600
-26.6927500	153.0463300
-28.1601300	153.5121100
-27.5031900	151.9641700
-27.8108900	153.2790500
-28.0107100	153.3973100
-26.9037000	152.9508700
-27.0920000	152.9859500
-28.0800300	153.3786400
-27.5349200	153.2682700
-26.6618700	152.8649100
-26.7248700	153.0623100
-26.7741700	152.8691700
-26.4328500	152.9325100
-27.4878000	152.9418000
-27.5661600	153.2714400
-26.3986600	153.0603300
-26.4060800	153.0532600
-27.5770000	151.9301000
-27.3200200	153.0360100
-26.7244800	153.0505100
-27.4403400	153.0058700
-27.9941400	153.0286200
-27.3010800	153.0639000
-26.2482500	152.7695500

Latitude	Longitude
-26.4407900	152.8972500
-26.6513900	152.9946800
-27.5045900	153.2211300
-26.6275100	152.9500300
-27.2502800	153.0334700
-27.5611480	153.0509560
-27.3620800	153.0139800
-16.9321500	145.7685700
-27.1135200	152.9501700
-16.8826400	145.7106400
-27.2183600	153.0642700
-27.5851000	153.2833600
-26.6824200	153.0560500
-27.4730200	153.0968400
-26.6507400	152.8960500
-27.5674000	152.9810800
-19.2797000	146.7568100
-18.9617700	146.2659000
-19.3162600	146.8210900
-27.3322400	153.0100800
-27.1133000	152.9034300
-27.8899800	153.3962900
-26.6805100	153.0496000
-27.8583400	153.3629700
-28.1573700	153.4295300
-26.7728800	152.9591000
-28.1564400	153.4293800
-26.4407300	153.0256000
-28.1478200	153.4272300
-28.0718480	153.3816180
-26.4128700	153.0608800
-27.6146800	152.7590400
-26.6971800	152.8134700
-27.8853630	153.3190530
-28.1498500	153.4989800
-26.4447300	152.8356600
-27.3081700	152.9360400
-26.3845900	152.8506900
-26.2124300	152.7218200
-27.4011900	152.9605100
-27.5885000	153.0850000
-26.4299400	153.0027300
-26.7614600	152.8730400
-26.2477700	152.8933100
-26.3762200	152.9911600
-25.3039100	152.8785900
-26.3998200	153.0689200
-27.5247100	152.9619800
-26.6297700	152.9433500
-26.4081500	152.9227200
-26.4045800	153.0494400
-26.3804800	152.8580600
-27.5496000	153.0317400
-27.6426600	152.9193600
-27.2518100	152.9952200
-28.0716600	153.3364100
-26.3227500	152.8264000
-27.1533700	152.9291900
-27.4037100	153.0329600
-27.6156500	152.7587700
-26.6233200	152.9546300
-26.4423100	152.9580600
-26.7893300	153.1021000
-26.6817000	153.0329100
-26.4102100	152.9848700
-28.0935800	153.3896800
-28.1815500	153.2591400
-27.4632000	153.0178600
-26.5587700	152.9883400
-26.7884400	153.1062900
-26.4098800	152.9431600
-27.1290800	152.9445900

Latitude	Longitude
-26.6718200	152.8624300
-26.7596600	152.8636000
-27.9798800	152.6924600
-26.6637500	152.9523500
-28.1876600	153.4246600
-27.6231000	153.3035700
-26.4984000	152.8533900
-26.6343600	152.9771600
-27.6548100	153.1174300
-28.1842300	153.4197900
-26.6206200	153.0406800
-27.4953400	153.2417000
-27.5468100	152.9694500
-27.4953600	153.2418200
-28.0940800	153.4392500
-27.3713400	153.0192600
-27.4762500	153.0650300
-27.5633600	152.7020400
-27.6368400	153.1472700
-27.6443700	153.1675700
-27.4075300	153.0285800
-23.3645200	150.5157400
-26.6546200	152.9574900
-27.6077800	151.9525400
-27.6044800	152.8060300
-27.3508600	152.9862500
-26.6818100	153.0441600
-26.6950800	152.8072000
-27.9949200	153.3906400
-27.4924100	152.9245100
-27.4929100	152.9252800
-28.1896810	153.2684990
-27.5801500	152.8883400
-27.1425500	152.9472700
-27.4503300	152.9750100
-27.4513000	153.1738300
-26.2109500	152.7274000
-26.9639200	152.9518700
-28.1565500	153.4588800
-26.9058600	152.6629500
-26.7398000	152.8957300
-26.4131800	153.0705100
-27.5913900	153.0863000
-26.4446300	152.9824900
-26.3880900	152.8616900
-27.5810800	153.3606100
-26.6858900	153.0442800
-28.0869100	153.3398400
-26.8002200	152.9735900
-27.5322000	153.0623200
-27.5622400	152.8901400
-26.6821700	153.0548900
-26.8199700	152.8186300
-26.4471500	152.8884400
-26.7628200	152.7844700
-27.8757300	153.3111800
-27.8214300	153.2875500
-27.5326200	153.2791500
-27.6384200	153.0355300
-27.0514900	152.9423700
-27.4023500	152.9636100
-26.6851300	153.0920900
-26.5527600	153.0854900
-26.6277900	152.9748700
-26.4055100	153.0861100
-28.2306689	153.1358900
-27.5080400	153.1464000
-26.6113400	152.8155200
-28.1081300	153.4436500
-27.6566800	153.0746900
-26.6203500	153.0406800
-27.5750000	153.0838500

Latitude	Longitude
-27.9751000	153.4037600
-27.5348100	152.9742100
-26.8949300	152.9483800
-26.2019200	152.6714300
-27.9747400	153.3924800
-26.2618800	152.8726400
-27.4027800	152.9436300
-27.4144500	153.0520400
-27.0448200	152.9311100
-27.6700200	153.1414400
-27.4371100	153.0201500
-27.9537200	153.3519400
-27.6030700	151.9317800
-27.8624300	153.3163100
-27.9923000	153.3598700
-27.3931500	153.0372700
-27.4214300	153.0265200
-27.8872880	153.2804880
-28.0266000	153.3714200
-27.4971800	152.9401900
-26.6512200	152.9356600
-28.0935000	153.3914600
-28.1409900	153.3988000
-28.0981500	153.4096400
-27.5154400	153.0694100
-17.2059900	145.4374000
-25.5395300	152.6956800
-27.3791030	153.0008280
-16.9473800	145.4249900
-20.3072900	148.6232900
-27.4234700	153.0169300
-17.2532240	145.6027290
-17.2229850	145.4781030
-28.0515500	153.4255100
-21.1504700	149.1916100
-27.4219600	152.9710600
-26.8303400	152.9441500
-27.3199900	152.8660900
-27.3564500	153.0574600
-26.9002200	152.9504700
-26.7143580	152.8998430
-27.4692500	153.0717400
-26.4980760	153.0663620
-27.6310400	153.2937100
-25.8557500	152.6347000
-27.3769000	153.0216200
-27.4941400	153.0025000
-27.4757500	153.0300200
-27.4748900	153.0597400
-27.2141100	153.0217500
-26.3975200	153.0618500
-17.0034600	145.4223100
-16.8055900	145.6824900
-16.6595800	145.4826600
-16.7826600	145.6173600
-27.5228400	152.9170100
-16.1372000	145.4376500
-27.6507500	153.1649700
-17.2585600	145.4848800
-27.5340600	152.8053900
-27.5040400	153.1705000
-16.5857500	145.4531400
-16.5864800	145.4519700
-16.8189500	145.6822100
-27.4737300	152.8570900
-16.9032700	145.6043000
-27.4983200	153.2308000
-27.4454200	152.9562200
-27.3984200	152.9916000
-27.5503500	152.5103500
-27.2386500	152.9947000
-27.7961100	153.2528200

Latitude	Longitude
-27.6209800	152.7632800
-27.6610710	153.1739670
-27.5114500	152.9443400
-27.4991500	153.0335400
-27.5509600	152.9806300
-27.3980600	153.0000200
-24.8575100	152.3739500
-27.2596500	152.9385000
-27.4308900	152.9936500
-27.4946800	153.0972700
-27.5253900	152.9895100
-27.6374450	152.7697850
-27.4978300	152.9561300
-26.4627800	153.0707100
-23.2633500	150.8066300
-27.1076600	152.9018200
-26.5593500	151.8403600
-27.9891400	153.2460300
-17.2459900	145.6414600
-27.4351650	152.9653930
-27.5097750	152.9901230
-16.1383000	145.4395000
-16.5813000	145.4525000
-17.1296000	145.6066700
-17.1736600	145.6404400
-17.0738400	145.5916400
-16.8854100	145.7364800
-16.9038400	145.7522300
-17.2901570	145.6294495
-17.3245413	145.6318009
-17.2849058	145.6293660
-16.9879630	145.4260090
-16.9059900	145.7383000
-27.8740100	153.3169000
-27.4181500	153.0048500
-27.4091800	153.0266800
-27.2584600	152.9430000
-27.8320900	153.2236400
-26.6817900	153.0710100
-26.5530700	153.0810800
-27.5519500	151.9388300
-27.5538800	152.9708300
-27.2743200	153.0318100
-26.7610600	153.1026400
-16.4783300	145.3780100

Latitude	Longitude
-27.4299560	152.9447980
-27.5792600	152.3065700
-27.5368000	153.0861800
-27.5547500	151.9636800
-27.0588900	153.1458500
-27.4737400	152.9899800
-27.5190600	152.9739800
-23.8347400	150.9213800
-16.4620000	145.3710400
-27.9429400	153.3564100
-27.6200300	152.8664900
-27.6870200	153.1051400
-26.6879700	152.9782800
-27.6171550	153.1590270
-16.5784060	145.1877970
-25.2839530	152.8878240
-27.4998000	153.2003300
-16.9517200	145.7079300
-25.3918000	153.0304740
-26.6333180	153.0850250
-16.5795220	145.3265690
-17.0103500	145.4159700
-16.9883990	145.4268940
-16.9955720	145.4164020
-16.9826900	145.4215100
-27.1585500	153.0024600
-27.4871200	153.0101400
-27.3705600	153.0379200
-27.3690700	153.0120100
-27.5904000	152.7392200
-27.5556800	152.9680100
-27.6393400	152.4463900
-27.0841900	152.3755300
-27.5314500	152.9811400
-26.6409600	152.9397800
-26.6558590	153.0016140
-16.5073430	145.3804060
-19.3041700	146.7275500
-16.9047300	145.7268000
-21.3713400	149.3167800
-17.6753870	145.5215550
-18.1474830	145.9907910
-27.4282800	153.0119600
-23.3292800	150.5355600
-27.3133380	153.0617970

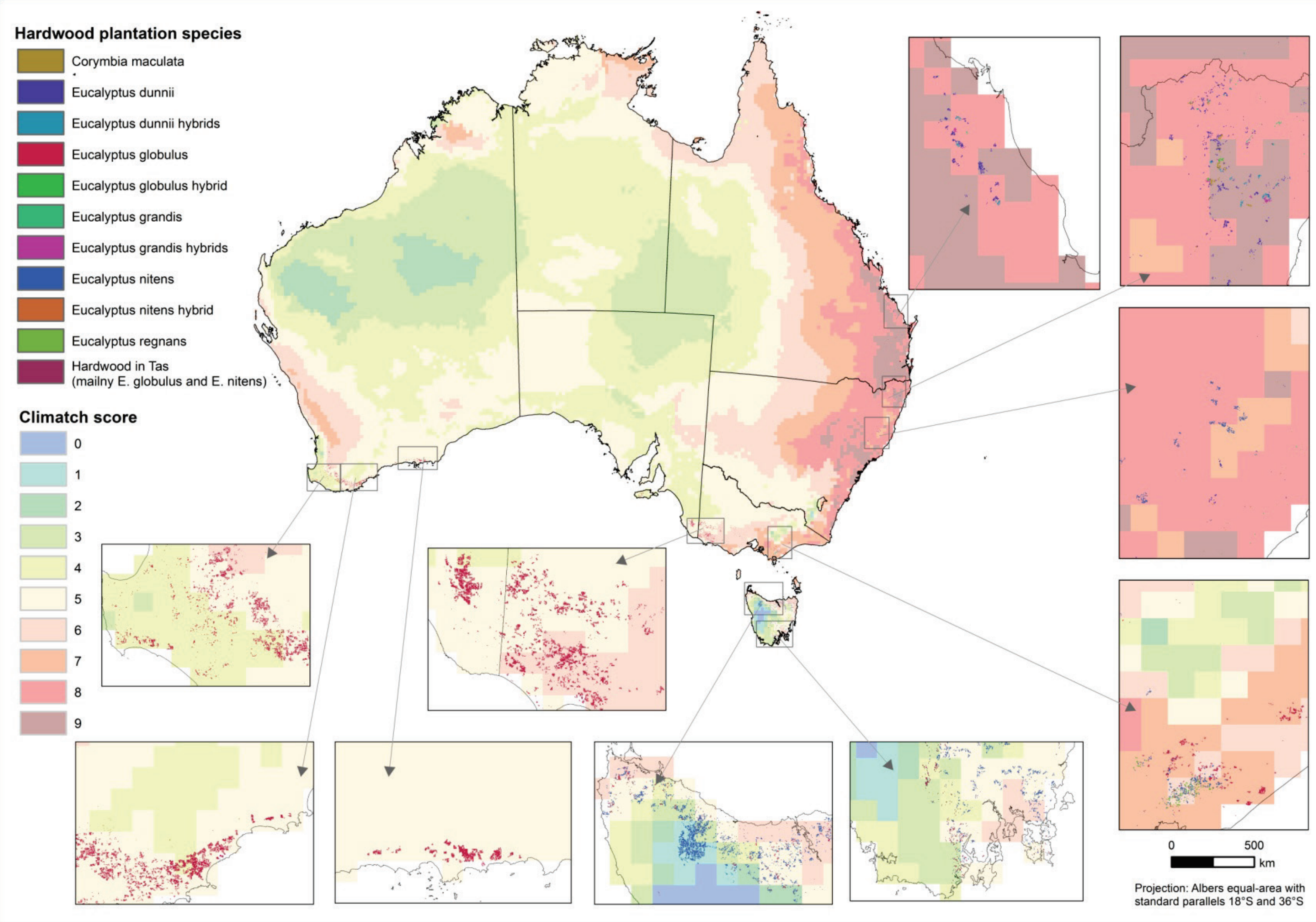
Latitude	Longitude
-26.4152200	153.1054600
-27.4681200	153.0428800
-26.4795000	152.9533200
-27.5487000	151.9720900
-27.6416000	153.2477000
-27.4243700	153.0255400
-28.0550500	153.3962300
-27.5052100	152.9049700
-26.6599200	153.0624200
-23.0899000	150.7363900
-27.5509500	152.3495800
-26.6810600	153.0687100
-26.6248800	152.9471300
-27.4622800	153.0856500
-27.0420200	153.1466700
-28.1743500	153.4342200
-26.4415800	152.9336600
-26.6782400	153.0744800
-26.8292000	152.8983500
-28.0915100	153.3592300
-26.8611500	152.0938300
-27.5097600	153.0941600
-26.7976700	153.0824600
-26.6962700	153.0808300
-27.6113000	152.9687200
-27.4652200	153.0821100
-27.5141300	153.1826100
-26.6609700	152.9858300
-26.1798200	152.6767300
-26.6382330	152.6480980
-26.6280200	152.9244100
-26.5651800	153.0893000
-27.5093500	152.9736700
-27.4943500	153.0293300
-23.8974800	151.2681900
-27.5492600	153.0778300
-27.3645740	153.0158290
-26.7721700	153.1279600
-26.4049300	153.1119000
-26.4323600	152.9943900
-27.0650200	153.0233700
-26.8057600	152.7046300
-26.6864050	153.0427670

Note: data supplied by state agencies (Angus Carnegie, New South Wales Department of Primary Industries; Geoff Pegg, Queensland Department of Agriculture and Fisheries) for the locations of detections of myrtle rust as at 2012. Location names were not available. Location data outside New South Wales or Queensland were not used, because outside those states myrtle rust is only found in nursery situations, gardens, and areas where misting is used and there is uncertainty as to whether the rust occurs there under natural conditions.

Appendix C: Climatic suitability for myrtle rust of Australia's eucalypt plantations

Eucalypt plantation areas are from the NPI 2010–11 spatial layer used in Gavran and Parsons (2011), and are determined by excluding from the total hardwood plantation area the areas of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species; data for regionally important eucalypt species, such as *Corymbia citriodora* subsp. *variegata* in Queensland, was retained.

Figure C1 Distribution of eucalypt plantations by species and climatic suitability for myrtle rust



Note: Climatch modelling used data on both overseas and Australian locations of *P. psidii* s.l. (Appendix B). Data from detections in Australia but outside New South Wales and Queensland were excluded. No areas had Climatch score 10 in this modelling.

Table C1 Area (hectares) of eucalypt plantation by species and climatic suitability for myrtle rust, Australia

Species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Corymbia maculata	0	0	0	1	374	277	148	54	1,507	2,806	0	5,167	4,313
Eucalyptus dunnii	0	0	0	0	1	0	17	1,844	19,587	16,714	0	38,163	36,301
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	1,507	2,468	0	3,975	3,975
E. dunnii and *E. grandis*	0	0	0	0	0	0	0	0	573	0	0	573	573
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	442	0	442	442
E. globulus	0	0	157	1,000	84,624	292,290	108,140	20,794	185	0	0	507,190	185
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	8	0	0	8	8
E. globulus subsp. *maidenii*	0	0	0	0	0	0	0	0	2	1	0	3	3
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	229	440	0	669	669
E. grandis	0	0	0	0	43	54	35	737	5,862	1,347	0	8,078	7,209
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	244	0	244	244
E. grandis x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	973	1,034	0	2,007	2,007
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	16	63	0	79	79
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	1	0	0	1	1
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	2	0	0	2	2
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	128	164	0	0	0	0	292	0
E. grandis x *E. globulus*	0	0	0	0	0	0	11	0	0	0	0	11	0
E. nitens	3	33,934	3,684	30,093	22,191	61,951	35,037	10,811	7,300	0	0	205,004	7,300
E. nitens x *E. globulus*	0	0	0	0	0	0	0	64	125	0	0	189	125
E. regnans	0	0	0	1	14	7	4,070	3,411	0	0	0	7,503	0
Hardwood spp. (Hardwood in Tasmania)	172	1,087	930	8,739	7,540	11,338	2,541	0	0	0	0	32,347	0
Total	**175**	**35,021**	**4,771**	**39,834**	**114,787**	**366,045**	**150,163**	**37,715**	**37,877**	**25,559**	**0**	**811,947**	**63,436**

Note: Species groups and group names are from the National Plantation Inventory.

Table C2 Area (hectares) of eucalypt plantation by species and climatic suitability for myrtle rust, New South Wales

Species	**Climatch score**											**Total 0-10**	**Total 8-10**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
Corymbia maculata	0	0	0	0	0	0	0	0	1,507	2,806	0	4,313	4,313
Eucalyptus dunnii	0	0	0	0	0	0	15	1,841	13,758	8,230	0	23,844	21,988
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	342	2,448	0	2,790	2,790
E. dunnii and *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus	0	0	0	0	0	0	0	3	3	0	0	6	3
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus subsp. *maideni*i	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	229	440	0	669	669
E. grandis	0	0	0	0	0	0	0	737	5,611	594	0	6,942	6,205
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	244	0	244	244
E. grandis x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	280	1,034	0	1,314	1,314
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens	0	0	0	0	8	2	41	3,526	7,298	0	0	10,875	7,298
E. nitens x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. regnans	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardwood spp. (Hardwood in Tasmania)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**8**	**2**	**56**	**6,107**	**29,028**	**15,796**	**0**	**50,997**	**44,824**

Note: Species groups and group names are from the National Plantation Inventory.

Table C3 Area (hectares) of eucalypt plantation by species and climatic suitability for myrtle rust, Victoria

Species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Corymbia maculata	0	0	0	0	0	0	32	41	0	0	0	73	0
Eucalyptus dunnii	0	0	0	0	0	0	2	3	0	0	0	5	0
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii and *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus	0	0	0	0	1,294	65,909	88,694	20,706	182	0	0	176,785	182
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus subsp. *maidenii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis	0	0	0	0	0	22	20	0	7	0	0	49	7
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	8	1	0	0	0	0	9	0
E. grandis x *E. globulus*	0	0	0	0	0	0	11	0	0	0	0	11	0
E. nitens	0	0	0	0	92	998	7,326	7,285	2	0	0	15,703	2
E. nitens x *E. globulus*	0	0	0	0	0	0	0	64	125	0	0	189	125
E. regnans	0	0	0	0	0	0	4,070	3,411	0	0	0	7,481	0
Hardwood spp. (Hardwood in Tasmania)	0	0	0	0	0	0	36	0	0	0	0	36	0
Total	**0**	**0**	**0**	**0**	**1,386**	**66,937**	**100,192**	**31,510**	**316**	**0**	**0**	**200,341**	**316**

Note: Species groups and group names are from the National Plantation Inventory.

Table C4 Area (hectares) of eucalypt plantation by species and climatic suitability rating for myrtle rust, Queensland

Species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Corymbia maculata	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus dunnii	0	0	0	0	0	0	0	0	5,829	8,484	0	14,313	14,313
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	1,165	20	0	1,185	1,185
E. dunnii and *E. grandis*	0	0	0	0	0	0	0	0	573	0	0	573	573
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	442	0	442	442
E. globulus	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	8	0	0	8	8
E. globulus subsp. *maidenii*	0	0	0	0	0	0	0	0	2	1	0	3	3
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis	0	0	0	0	0	0	0	0	244	753	0	997	997
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	693	0	0	693	693
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	16	63	0	79	79
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	1	0	0	1	1
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	2	0	0	2	2
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. regnans	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardwood spp. (Hardwood in Tasmania)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8,533**	**9,763**	**0**	**18,296**	**18,296**

Note: Species groups and group names are from the National Plantation Inventory.

Table C5 Area (hectares) of eucalypt plantation by species and climatic suitability for myrtle rust, South Australia

Species	**Climatch score**											**Total 0-10**	**Total 8-10**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
Corymbia maculata	0	0	0	0	14	0	0	0	0	0	0	14	0
Eucalyptus dunnii	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii and *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus	0	0	0	0	15,029	39,523	0	0	0	0	0	54,552	0
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus subsp. *maidenii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis	0	0	0	0	5	6	0	0	0	0	0	11	0
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. regnans	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardwood spp. (Hardwood in Tasmania)	0	0	0	0	0	15	0	0	0	0	0	15	0
Total	**0**	**0**	**0**	**0**	**15,048**	**39,544**	**0**	**0**	**0**	**0**	**0**	**54,592**	**0**

Note: Species groups and group names are from the National Plantation Inventory.

Table C6 Area (hectares) of eucalypt plantation by species and climatic suitability rating for myrtle rust, Western Australia

Species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Corymbia maculata	0	0	0	0	360	273	114	13	0	0	0	760	0
Eucalyptus dunnii	0	0	0	0	1	0	0	0	0	0	0	1	0
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii and E. grandis	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus	0	0	0	540	67,483	181,582	14,228	85	0	0	0	263,918	0
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus subsp. *maidenii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis*	0	0	0	0	38	26	15	0	0	0	0	79	0
E. grandis x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	95	152	0	0	0	0	247	0
E. grandis x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. regnans	0	0	0	0	12	0	0	0	0	0	0	12	0
Hardwood spp. (Hardwood in Tasmania)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**540**	**67,894**	**181,976**	**14,509**	**98**	**0**	**0**	**0**	**265,017**	**0**

Note: Species groups and group names are from the National Plantation Inventory.

Table C7 Area (hectares) of eucalypt plantation by species and climatic suitability for myrtle rust, Tasmania

Species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Corymbia maculata	0	0	0	1	0	4	0	2	0	0	0	7	0
Eucalyptus dunnii	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii and *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus	0	0	157	460	818	5,276	5,218	0	0	0	0	11,929	0
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus subsp. *maidenii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	25	11	0	0	0	0	36	0
E. grandis x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. nitens	3	33,934	3,684	30,093	22,091	60,951	27,670	0	0	0	0	178,426	0
E. nitens x *E. globulus*	0	0	0	0	0	0	0	0	0	0	0	0	0
E. regnans	0	0	0	1	2	7	0	0	0	0	0	10	0
Hardwood spp. (Hardwood in Tasmania)	172	1,087	930	8,739	7,540	11,323	2,505	0	0	0	0	32,296	0
Total	175	35,021	4,771	39,294	30,451	77,586	35,406	0	0	0	0	222,704	**0**

Note: Species groups and group names are from the National Plantation Inventory.

Table C8 Area (hectares) of eucalypt plantation by species in NPI regions and climatic suitability for myrtle rust

NPI region/species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
1 Western Australia													
Corymbia maculata	0	0	0	0	360	273	114	13	0	0	0	760	0
Eucalyptus dunnii	0	0	0	0	1	0	0	0	0	0	0	1	0
E. globulus	0	0	0	540	67,483	181,582	14,228	85	0	0	0	263,918	0
E. grandis	0	0	0	0	38	26	15	0	0	0	0	79	0
Eucalyptus grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	95	152	0	0	0	0	247	0
E. regnans	0	0	0	0	12	0	0	0	0	0	0	12	0
Total	0	0	0	540	67,894	181,976	14,509	98	0	0	0	265,017	0
3 Mount Lofty Ranges and Kangaroo Island													
C. maculata	0	0	0	0	12	0	0	0	0	0	0	12	0
E. globulus	0	0	0	0	9,429	3,087	0	0	0	0	0	12,516	0
E. grandis	0	0	0	0	0	1	0	0	0	0	0	1	0
Total	0	0	0	0	9,441	3,088	0	0	0	0	0	12,529	0
4 Green Triangle													
E. globulus	0	0	0	0	6,815	91,347	64,166	0	0	0	0	162,328	0
E. grandis	0	0	0	0	0	5	0	0	0	0	0	5	0
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	8	0	0	0	0	0	8	0
E. grandis x *E. globulus*	0	0	0	0	0	0	11	0	0	0	0	11	0
E. nitens	0	0	0	0	0	0	42	0	0	0	0	42	0
Hardwood spp.	0	0	0	0	0	15	36	0	0	0	0	51	0
Total	0	0	0	0	6,815	91,375	64,255	0	0	0	0	162,445	0
6 South East Queensland													
C. maculata	0	0	0	0	0	0	0	0	17	0	0	17	17
E. dunnii	0	0	0	0	0	0	0	0	6,196	8,484	0	14,680	14,680
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	1,165	20	0	1,185	1,185

NPI region/species	Climatch score 0	1	2	3	4	5	6	7	8	9	10	Total 0-10	Total 8-10
E. dunnii and *E. grandis*	0	0	0	0	0	0	0	0	573	0	0	573	573
E. dunnii x *E. grandis*	0	0	0	0	0	0	0	0	0	442	0	442	442
E. globulus subsp. *globulus*	0	0	0	0	0	0	0	0	8	0	0	8	8
E. globulus subsp. *maidenii*	0	0	0	0	0	0	0	0	2	1	0	3	3
E. grandis	0	0	0	0	0	0	0	0	244	753	0	997	997
E. grandis x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	693	0	0	693	693
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	16	39	0	55	55
E. grandis x *E. pellita*	0	0	0	0	0	0	0	0	1	0	0	1	1
E. grandis x *E. tereticornis*	0	0	0	0	0	0	0	0	2	0	0	2	2
Total	0	0	0	0	0	0	0	0	8,917	9,739	0	18,656	18,656
7 Northern Tablelands													
E. dunnii	0	0	0	0	0	0	0	0	40	0	0	40	40
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	1	0	1	1
E. nitens	0	0	0	0	0	0	0	2,306	3,035	0	0	5,341	3,035
Total	0	0	0	0	0	0	0	2,306	3,075	1	0	5,382	3,076
8 North Coast													
C. maculata	0	0	0	0	0	0	0	0	1,490	2,798	0	4,288	4,288
E. dunnii	0	0	0	0	0	0	15	1,841	13,351	8,230	0	23,437	21,581
E. dunnii and *E. globulus* x *E. camaldulensis*	0	0	0	0	0	0	0	0	342	2,448	0	2,790	2,790
E. globulus x *E. camaldulensis* and *E. dunnii*	0	0	0	0	0	0	0	0	229	440	0	669	669
E. grandis	0	0	0	0	0	0	0	737	5,611	594	0	6,942	6,205
E. grandis x *E. camaldulensis*	0	0	0	0	0	0	0	0	0	244	0	244	244
E. grandis x *E. camaldulensis* and *E. du nnii*	0	0	0	0	0	0	0	0	280	1,034	0	1,314	1,314
E. nitens	0	0	0	0	0	0	41	433	3,323	0	0	3,797	3,323
Total	0	0	0	0	0	0	56	3,011	24,626	15,788	0	43,481	40,414

NPI region/species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
11 Murray Valley													
C. maculata	0	0	0	0	0	0	16	0	0	0	0	16	0
E. globulus	0	0	0	0	63	614	3,107	1,877	0	0	0	5,661	0
E. grandis	0	0	0	0	0	22	15	0	0	0	0	37	0
E. nitens	0	0	0	0	100	232	193	11	0	0	0	536	0
Total	0	0	0	0	163	868	3,331	1,888	0	0	0	6,250	0
12 Central Victoria													
C. maculata	0	0	0	0	0	0	13	7	0	0	0	20	0
E. globulus	0	0	0	0	0	10,384	17,454	4,457	0	0	0	32,295	0
Eucalyptus grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	0	1	0	0	0	0	1	0
E. nitens	0	0	0	0	0	768	1,427	334	0	0	0	2,529	0
E. regnans	0	0	0	0	0	0	105	0	0	0	0	105	0
Total	0	0	0	0	0	11,152	19,000	4,798	0	0	0	34,950	0
13 Central Gippsland													
C. maculata	0	0	0	0	0	0	3	13	0	0	0	16	0
E. dunnii	0	0	0	0	0	0	2	3	0	0	0	5	0
E. globulus	0	0	0	0	0	0	3,967	14,067	0	0	0	18,034	0
E. grandis	0	0	0	0	0	0	5	0	0	0	0	5	0
E. nitens	0	0	0	0	0	0	5,582	4,654	2	0	0	10,238	2
E. regnans	0	0	0	0	0	0	3,965	3,411	0	0	0	7,376	0
Total	0	0	0	0	0	0	13,524	22,148	2	0	0	35,674	2
14 Bombala-East Gippsland													
C. maculata	0	0	0	0	0	0	0	21	0	0	0	21	0
E. globulus	0	0	0	0	0	0	0	308	185	0	0	493	185
E. grandis	0	0	0	0	0	0	0	0	7	0	0	7	7
E. nitens	0	0	0	0	0	0	82	3,073	940	0	0	4,095	940
E. nitens x *E. globulus*	0	0	0	0	0	0	0	64	125	0	0	189	125
Total	0	0	0	0	0	0	82	3,466	1,257	0	0	4,805	1,257

NPI region/species	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
15 Tasmania													
C. maculata	0	0	0	1	0	4	2	0	0	0	0	7	0
E. globulus	0	0	157	460	818	5,276	5,218	0	0	0	0	11,929	0
E. grandis x *E. camaldulensis* (Saltgrow)	0	0	0	0	0	25	11	0	0	0	0	36	0
E. nitens	3	33,934	3,684	30,093	22,091	60,951	27,670	0	0	0	0	178,426	0
E. regnans	0	0	0	1	2	7	0	0	0	0	0	10	0
Hardwood spp.	172	1,087	930	8,739	7,540	11,323	2,505	0	0	0	0	32,296	0
Total	175	35,021	4,771	39,294	30,451	77,586	35,406	0	0	0	0	222,704	0
Grand Total	**175**	**35,021**	**4,771**	**39,834**	**114,764**	**366,045**	**150,163**	**37,715**	**37,877**	**25,528**	**0**	**811,893**	**63,405**

Note: Species names and group names are taken from the National Plantation Inventory Categories.

Appendix D: Climatic suitability for myrtle rust of Australia's native forest

Table D1 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climatic suitability for myrtle rust, Australia

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Eucalypt mallee open	0	0	0	0	0	887	93	548	37	0	0	1,565	37
Eucalypt mallee woodland	0	0	0	0	48,638	130,159	354	2,983	5,386	2,149	0	189,669	7,535
Eucalypt low closed	0	0	3	437	269	2,124	2,581	2,729	793	0	0	8,936	793
Eucalypt low open	79	467	679	3,561	11,022	14,551	10,473	12,093	5,883	931	0	59,739	6,814
Eucalypt low woodland	166	548	588	2,894	9,747	8,453	2,660	14,256	7,199	38	0	46,549	7,237
Eucalypt medium closed	0	0	1,421	4,268	6,212	20,376	15,108	18,037	6,278	528	0	72,228	6,806
Eucalypt medium open	338	3,366	30,582	108,317	563,883	760,541	338,488	496,895	788,218	228,644	0	3,319,272	1,016,862
Eucalypt medium woodland	386	6,656	7,759	39,728	147,937	327,932	215,004	468,628	1,453,994	268,976	0	2,937,000	1,722,970
Eucalypt tall closed	0	0	1,328	8,943	9,868	22,786	16,882	29,774	15,763	371	0	105,715	16,134
Eucalypt tall open	8,457	25,656	33,114	213,309	262,099	308,004	166,755	544,806	417,312	83,886	0	2,063,398	501,198
Eucalypt tall woodland	2,017	6,154	6,191	11,206	30,849	35,511	12,737	23,214	15,561	6,310	0	149,750	21,871
Eucalypt	11,443	42,847	81,665	392,663	1,090,524	1,631,324	781,135	1,613,963	2,716,424	591,833	0	8,953,821	3,308,257
Melaleuca	0	53	519	645	2,773	2,745	657	1,036	14,540	8,819	0	31,787	23,359
Rainforest	6,559	25,446	21,073	58,425	35,037	21,174	18,069	50,827	155,544	40,325	0	432,479	195,869
Total	**18,002**	**68,346**	**103,257**	**451,733**	**1,128,334**	**1,655,243**	**799,861**	**1,665,826**	**2,886,508**	**640,977**	**0**	**9,418,087**	**3,527,485**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D2 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climatic suitability for myrtle rust, New South Wales

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
Eucalypt mallee open	0	0	0	0	0	417	93	548	37	0	0	1,095	37
Eucalypt mallee woodland	0	0	0	0	42	433	292	2,983	5,386	2,149	0	11,285	7,535
Eucalypt low closed	0	0	0	0	0	0	0	7	1	0	0	8	1
Eucalypt low open	0	0	0	0	0	0	263	109	2,306	931	0	3,609	3,237
Eucalypt low woodland	0	0	0	0	2	1	1,510	9,275	444	11	0	11,243	455
Eucalypt medium closed	0	0	0	0	0	0	0	8	355	528	0	891	883
Eucalypt medium open	0	0	0	10,649	25,178	73,230	28,974	83,854	261,129	79,986	0	563,000	341,115
Eucalypt medium woodland	0	0	0	417	8,127	46,312	24,064	97,182	313,221	55,402	0	544,725	368,623
Eucalypt tall closed	0	0	0	0	0	0	0	1,608	9,991	371	0	11,970	10,362
Eucalypt tall open	0	0	0	14	211	107	7,991	95,082	335,106	81,501	0	520,012	416,607
Eucalypt tall woodland	0	0	0	0	0	0	33	379	3,547	805	0	4,764	4,352
Eucalypt	0	0	0	11,080	33,560	120,500	63,220	291,035	931,523	221,684	0	1,672,602	1,153,207
Melaleuca	0	0	0	0	0	0	0	29	1,204	5,706	0	6,939	6,910
Rainforest	0	0	0	0	0	0	2,804	25,550	61,201	5,525	0	95,080	66,726
Total	**0**	**0**	**0**	**11,080**	**33,560**	**120,500**	**66,024**	**316,614**	**993,928**	**232,915**	**0**	**1,774,621**	**1,226,843**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D3 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climatic suitability for myrtle rust, Victoria

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Eucalypt mallee open	0	0	0	0	0	429	0	0	0	0	0	429	0
Eucalypt mallee woodland	0	0	0	0	47,930	128,928	14	0	0	0	0	176,872	0
Eucalypt low closed	0	0	3	437	269	2,124	2,581	2,720	717	0	0	8,851	717
Eucalypt low open	0	0	11	2,961	4,738	10,811	8,419	10,009	1,693	0	0	38,642	1,693
Eucalypt low woodland	0	0	0	381	771	2,440	1,146	2,905	335	0	0	7,978	335
Eucalypt medium closed	0	0	1,247	3,943	3,676	18,440	14,954	18,029	5,923	0	0	66,212	5,923
Eucalypt medium open	0	0	10,873	47,409	89,707	463,849	222,775	339,262	32,232	0	0	1,206,107	32,232
Eucalypt medium woodland	0	0	684	5,991	10,699	98,502	21,955	26,953	3,593	0	0	168,377	3,593
Eucalypt tall closed	0	0	1,328	8,943	7,704	22,710	16,882	28,166	5,772	0	0	91,505	5,772
Eucalypt tall open	0	0	17,797	100,007	94,136	211,471	132,712	445,610	75,986	0	0	1,077,719	75,986
Eucalypt tall woodland	0	0	426	2,189	5,109	9,195	10,711	22,808	4,920	0	0	55,358	4,920
Eucalypt	0	0	32,369	172,261	264,739	968,899	432,149	896,462	131,171	0	0	2,898,050	131,171
Melaleuca	0	0	0	0	0	549	506	794	0	0	0	1,849	0
Rainforest	0	0	237	228	187	368	1,472	4,832	1,151	0	0	8,475	1,151
Total	**0**	**0**	**32,606**	**172,489**	**264,926**	**969,816**	**434,127**	**902,088**	**132,322**	**0**	**0**	**2,908,374**	**132,322**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D4 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climatic suitability for myrtle rust, Queensland

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
Eucalypt mallee open	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt mallee woodland	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low closed	0	0	0	0	0	0	0	2	75	0	0	77	75
Eucalypt low open	0	0	0	0	0	0	154	1,931	1,884	0	0	3,969	1,884
Eucalypt low woodland	0	0	0	0	0	13	0	2,076	6,420	27	0	8,536	6,447
Eucalypt medium closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt medium open	0	0	0	0	0	0	2,959	70,405	494,857	148,658	0	716,879	643,515
Eucalypt medium woodland	0	0	0	0	0	0	3,345	305,607	1,137,180	213,574	0	1,659,706	1,350,754
Eucalypt tall closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt tall open	0	0	0	0	0	0	38	4,114	6,220	2,385	0	12,757	8,605
Eucalypt tall woodland	0	0	0	0	0	0	0	27	7,094	5,505	0	12,626	12,599
Eucalypt	0	0	0	0	0	13	6,496	384,162	1,653,730	370,149	0	2,414,550	2,023,879
Melaleuca	0	0	0	0	0	0	89	213	13,336	3,113	0	16,751	16,449
Rainforest	0	0	0	0	0	0	12,040	20,445	93,192	34,800	0	160,477	127,992
Total	**0**	**0**	**0**	**0**	**0**	**13**	**18,625**	**404,820**	**1,760,258**	**408,062**	**0**	**2,591,778**	**2,168,320**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D5 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climatic suitability for myrtle rust, South Australia

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Eucalypt mallee open	0	0	0	0	0	41	0	0	0	0	0	41	0
Eucalypt mallee woodland	0	0	0	0	666	355	0	0	0	0	0	1,021	0
Eucalypt low closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low open	0	0	0	0	18	157	0	0	0	0	0	175	0
Eucalypt low woodland	0	0	0	0	3,206	774	0	0	0	0	0	3,980	0
Eucalypt medium closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt medium open	0	0	0	0	491	226	0	0	0	0	0	717	0
Eucalypt medium woodland	0	0	0	0	2,740	11,195	8	0	0	0	0	13,943	0
Eucalypt tall closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt tall open	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt tall woodland	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt	0	0	0	0	7,121	12,748	8	0	0	0	0	19,877	0
Melaleuca	0	0	0	0	134	1	0	0	0	0	0	135	0
Rainforest	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**7,255**	**12,749**	**8**	**0**	**0**	**0**	**0**	**20,012**	**0**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D6 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climatic suitability for myrtle rust, Western Australia

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Eucalypt mallee open	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt mallee woodland	0	0	0	0	0	443	48	0	0	0	0	491	0
Eucalypt low closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low open	0	0	0	0	5,796	3,480	1,637	44	0	0	0	10,957	0
Eucalypt low woodland	0	0	0	3	3,942	5,053	0	0	0	0	0	8,998	0
Eucalypt medium closed	0	0	174	325	2,536	1,936	154	0	0	0	0	5,125	0
Eucalypt medium open	0	0	18,816	45,776	444,924	214,819	76,225	2,609	0	0	0	803,169	0
Eucalypt medium woodland	0	0	4,054	17,117	107,464	92,272	90,941	38,848	0	0	0	350,696	0
Eucalypt tall closed	0	0	0	0	2,164	76	0	0	0	0	0	2,240	0
Eucalypt tall open	0	0	0	3	73,441	1,624	0	0	0	0	0	75,068	0
Eucalypt tall woodland	0	0	0	0	8,258	41	0	0	0	0	0	8,299	0
Eucalypt	0	0	23,044	63,224	648,525	319,744	169,005	41,501	0	0	0	1,265,043	0
Melaleuca	0	0	0	0	2,023	453	0	0	0	0	0	2,476	0
Rainforest	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**23,044**	**63,224**	**650,548**	**320,197**	**169,005**	**41,501**	**0**	**0**	**0**	**1,267,519**	**0**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D7 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climatic suitability for myrtle rust, Tasmania

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Eucalypt mallee open	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt mallee woodland	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low open	79	467	668	600	470	103	0	0	0	0	0	2,387	0
Eucalypt low woodland	166	548	588	2,510	1,826	172	4	0	0	0	0	5,814	0
Eucalypt medium closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt medium open	338	3,366	893	4,483	3,527	7,176	7,256	0	0	0	0	27,039	0
Eucalypt medium woodland	386	6,656	3,021	16,203	18,847	79,618	74,571	0	0	0	0	199,302	0
Eucalypt tall closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt tall open	8,457	25,656	15,317	113,285	94,311	94,802	26,014	0	0	0	0	377,842	0
Eucalypt tall woodland	2,017	6,154	5,765	9,017	17,482	26,275	1,993	0	0	0	0	68,703	0
Eucalypt	11,443	42,847	26,252	146,098	136,463	208,146	109,838	0	0	0	0	681,087	0
Melaleuca	0	53	519	645	616	1,742	62	0	0	0	0	3,637	0
Rainforest	6,559	25,446	20,836	58,197	34,850	20,806	1,753	0	0	0	0	168,447	0
Total	**18,002**	**68,346**	**47,607**	**204,940**	**171,929**	**230,694**	**111,653**	**0**	**0**	**0**	**0**	**853,171**	**0**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D8 Area (hectares) of multiple-use public native forest containing or dominated by myrtaceous species by forest type and sub-type and climate suitability for myrtle rust, Australian Capital Territory

Forest Type and Sub-type	Climatch score											Total 0-10	Total 8-10
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
Eucalypt mallee open	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt mallee woodland	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low open	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt low woodland	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt medium closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt medium open	0	0	0	0	56	1,241	299	765	0	0	0	2,361	0
Eucalypt medium woodland	0	0	0	0	60	33	120	38	0	0	0	251	0
Eucalypt tall closed	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt tall open	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt tall woodland	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypt	0	0	0	0	116	1,274	419	803	0	0	0	2,612	0
Melaleuca	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainforest	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**116**	**1,274**	**419**	**803**	**0**	**0**	**0**	**2,612**	**0**

Note: The 11 Eucalypt forest sub-types together comprise the Eucalypt forest type. The Eucalypt, Melaleuca and Rainforest forest types together comprise native forest containing or dominated by myrtaceous species potentially susceptible to myrtle rust.

Table D9 Area (hectares) of multiple-use public native forest of Eucalypt sub-types used for wood production, by Wood Supply Region by climatic suitability for myrtle rust

Wood Supply Region by Forest Sub-type	Climatch score											Total 0-10	Total 8-10
	0	1	2	3	4	5	6	7	8	9	10		
Bass													
Eucalypt medium open	0	0	0	173	164	2,070	6,574	0	0	0	0	8,981	0
Eucalypt tall open	0	0	0	12,742	14,955	24,148	19,944	0	0	0	0	71,789	0
Eucalypt tall woodland	0	0	0	2,035	1,123	18,168	1,253	0	0	0	0	22,579	0
Total	0	0	0	14,950	16,242	44,386	27,771	0	0	0	0	103,349	0
Central Gippsland													
Eucalypt medium closed	0	0	0	2,147	1,186	2,921	2,281	2,877	625	0	0	12,037	625
Eucalypt medium open	0	0	0	23,769	16,898	43,859	40,206	136,451	2,701	0	0	263,884	2,701
Eucalypt tall closed	0	0	0	3,923	2,605	4,218	5,280	2,082	4,226	0	0	22,334	4,226
Eucalypt tall open	0	0	0	47,550	23,321	37,108	44,289	54,191	12,166	0	0	218,625	12,166
Eucalypt tall woodland	0	0	0	1,297	736	2,553	4,240	4,201	972	0	0	13,999	972
Total	0	0	0	78,686	44,746	90,659	96,296	199,802	20,690	0	0	530,879	20,690
Central Tablelands NSW													
Eucalypt medium open	0	0	0	0	0	0	8,471	511	10,760	4,115	0	23,857	14,875
Total	0	0	0	0	0	0	8,471	511	10,760	4,115	0	23,857	14,875
Central Victoria													
Eucalypt medium closed	0	0	0	0	0	3,137	8,510	0	0	0	0	11,647	0
Eucalypt medium open	0	0	0	0	0	98,966	43,350	10	0	0	0	142,326	0
Eucalypt tall closed	0	0	0	0	0	643	4,345	0	0	0	0	4,988	0
Eucalypt tall open	0	0	0	0	0	2,535	16,001	7	0	0	0	18,543	0
Eucalypt tall woodland	0	0	0	0	0	34	2,028	0	0	0	0	2,062	0
Total	0	0	0	0	0	105,315	74,234	17	0	0	0	179,566	0

Derwent													
Eucalypt medium open	0	1,185	280	1,268	2,225	1,025	259	0	0	0	0	6,242	0
Eucalypt tall open	0	5,809	1,269	33,120	51,151	15,701	833	0	0	0	0	107,883	0
Eucalypt tall woodland	0	1,735	2,783	5,262	15,720	7,423	721	0	0	0	0	33,644	0
Total	0	8,729	4,332	39,650	69,096	24,149	1,813	0	0	0	0	147,769	0
Dubbo NSW													
Eucalypt medium open	0	0	0	0	0	0	126	620	2,927	564	0	4,237	3,491
Eucalypt tall open	0	0	0	0	0	0	0	102	1,192	0	0	1,294	1,192
Eucalypt tall woodland	0	0	0	0	0	0	0	45	1	0	0	46	1
Total	0	0	0	0	0	0	126	767	4,120	564	0	5,577	4,684
East Gippsland Bombala NSW													
Eucalypt medium open	0	0	0	375	1,313	0	1,394	38,625	37,552	4,703	0	83,962	42,255
Eucalypt tall open	0	0	0	0	0	0	1,490	17,006	18,350	1,004	0	37,850	19,354
Total	0	0	0	375	1,313	0	2,884	55,631	55,902	5,707	0	121,812	61,609
East Gippsland Bombala VIC													
Eucalypt medium closed	0	0	0	0	8	1,431	1,727	13,097	5,298	0	0	21,561	5,298
Eucalypt medium open	0	0	0	0	146	19,024	29,215	185,601	29,538	0	0	263,524	29,538
Eucalypt tall closed	0	0	0	0	51	1,904	3,354	20,767	1,546	0	0	27,622	1,546
Eucalypt tall open	0	0	0	0	226	15,345	39,941	359,349	63,834	0	0	478,695	63,834
Eucalypt tall woodland	0	0	0	0	0	102	3,521	17,769	3,948	0	0	25,340	3,948
Total	0	0	0	0	431	37,806	77,758	596,583	104,164	0	0	816,742	104,164
Green Triangle VIC													
Eucalypt medium closed	0	0	0	0	0	1,085	1,072	0	0	0	0	2,157	0
Eucalypt medium open	0	0	0	0	5	19,462	21,013	0	0	0	0	40,480	0
Eucalypt tall closed	0	0	0	0	0	0	1	0	0	0	0	1	0
Eucalypt tall open	0	0	0	0	0	7	212	0	0	0	0	219	0
Eucalypt tall woodland	0	0	0	0	0	7	0	0	0	0	0	7	0
Total	0	0	0	0	5	20,561	22,298	0	0	0	0	42,864	0

Huon													
Eucalypt medium open	0	0	0	367	93	487	0	0	0	0	0	947	0
Eucalypt tall open	0	0	0	31,603	5,282	22,249	0	0	0	0	0	59,134	0
Eucalypt tall woodland	0	0	0	107	62	20	0	0	0	0	0	189	0
Total	0	0	0	32,077	5,437	22,756	0	0	0	0	0	60,270	0
Mersey													
Eucalypt medium open	231	956	513	758	311	960	371	0	0	0	0	4,100	0
Eucalypt tall open	7,395	8,722	9,357	4,903	1,927	5,026	2,077	0	0	0	0	39,407	0
Eucalypt tall woodland	1,981	3,091	2,969	1,165	577	644	19	0	0	0	0	10,446	0
Total	9,607	12,769	12,839	6,826	2,815	6,630	2,467	0	0	0	0	53,953	0
Mildura VIC													
Eucalypt medium closed	0	0	0	0	0	87	0	0	0	0	0	87	0
Eucalypt medium open	0	0	0	0	0	8,227	144	0	0	0	0	8,371	0
Eucalypt tall closed	0	0	0	0	0	96	4	0	0	0	0	100	0
Eucalypt tall open	0	0	0	0	0	6,228	71	0	0	0	0	6,299	0
Eucalypt tall woodland	0	0	0	0	0	139	0	0	0	0	0	139	0
Total	0	0	0	0	0	14,777	219	0	0	0	0	14,996	0
Mt Lofty & Kangaroo Is SA													
Eucalypt medium open	0	0	0	0	0	226	0	0	0	0	0	226	0
Total	0	0	0	0	0	226	0	0	0	0	0	226	0
Murchison													
Eucalypt medium open	107	1,225	100	1,917	734	2,633	52	0	0	0	0	6,768	0
Eucalypt tall open	1,062	11,125	4,691	30,916	20,996	27,664	3,159	0	0	0	0	99,613	0
Eucalypt tall woodland	36	1,328	13	448	0	20	0	0	0	0	0	1,845	0
Total	1,205	13,678	4,804	33,281	21,730	30,317	3,211	0	0	0	0	108,226	0
Murray Valley NSW													
Eucalypt medium open	0	0	0	10,274	23,921	74,460	2,407	765	0	0	0	111,827	0
Eucalypt tall closed	0	0	0	0	0	1	0	0	0	0	0	1	0
Eucalypt tall open	0	0	0	14	211	91	17	0	0	0	0	333	0
Total	0	0	0	10,288	24,132	74,552	2,424	765	0	0	0	112,161	0

Murray Valley VIC													
Eucalypt medium closed	0	0	1,247	1,796	2,482	9,779	1,364	2,063	0	0	0	18,731	0
Eucalypt medium open	0	0	10,873	23,640	72,658	274,322	88,848	17,341	0	0	0	487,682	0
Eucalypt tall closed	0	0	1,328	5,020	5,048	15,848	3,898	5,323	0	0	0	36,465	0
Eucalypt tall open	0	0	17,797	52,457	70,589	150,264	32,200	32,249	0	0	0	355,556	0
Eucalypt tall woodland	0	0	426	892	4,373	6,360	922	845	0	0	0	13,818	0
Total	0	0	31,671	83,805	155,150	456,573	127,232	57,821	0	0	0	912,252	0
North & Central Queensland													
Eucalypt medium open	0	0	0	0	0	0	2,959	17,013	80,118	6,155	0	106,245	86,273
Eucalypt tall open	0	0	0	0	0	0	38	4,114	5,414	0	0	9,566	5,414
Eucalypt tall woodland	0	0	0	0	0	0	0	0	193	3,922	0	4,115	4,115
Total	0	0	0	0	0	0	2,997	21,127	85,725	10,077	0	119,926	95,802
North Coast NSW													
Eucalypt medium closed	0	0	0	0	0	0	0	0	355	528	0	883	883
Eucalypt medium open	0	0	0	0	0	0	703	22,959	140,441	64,012	0	228,115	204,453
Eucalypt tall closed	0	0	0	0	0	0	0	1,599	9,960	371	0	11,930	10,331
Eucalypt tall open	0	0	0	0	0	0	6,478	64,135	215,496	70,204	0	356,313	285,700
Eucalypt tall woodland	0	0	0	0	0	0	33	199	3,084	805	0	4,121	3,889
Total	0	0	0	0	0	0	7,214	88,892	369,336	135,920	0	601,362	505,256
Northern Tablelands NSW													
Eucalypt medium open	0	0	0	0	0	0	0	16,529	50,991	2,612	0	70,132	53,603
Eucalypt tall closed	0	0	0	0	0	0	0	3	31	0	0	34	31
Eucalypt tall open	0	0	0	0	0	0	0	13,653	67,806	365	0	81,824	68,171
Eucalypt tall woodland	0	0	0	0	0	0	0	128	462	0	0	590	462
Total	0	0	0	0	0	0	0	30,313	119,290	2,977	0	152,580	122,267
Other SA													
Eucalypt medium open	0	0	0	0	491	0	0	0	0	0	0	491	0
Total	0	0	0	0	491	0	0	0	0	0	0	491	0

South Coast													
Eucalypt medium open	0	0	0	0	0	4,282	0	0	0	0	0	4,282	0
Eucalypt tall open	0	0	0	0	0	19	0	0	0	0	0	19	0
Total	0	0	0	0	0	4,301	0	0	0	0	0	4,301	0
South East Queensland													
Eucalypt medium open	0	0	0	0	0	0	0	0	74,173	113,292	0	187,465	187,465
Eucalypt tall open	0	0	0	0	0	0	0	0	429	2,385	0	2,814	2,814
Eucalypt tall woodland	0	0	0	0	0	0	0	0	0	402	0	402	402
Total	0	0	0	0	0	0	0	0	74,602	116,079	0	190,681	190,681
Southern Tablelands NSW													
Eucalypt medium open	0	0	0	0	0	0	16,171	4,469	18,451	3,978	0	43,069	22,429
Eucalypt tall open	0	0	0	0	0	0	4	0	32,249	9,928	0	42,181	42,177
Total	0	0	0	0	0	0	16,175	4,469	50,700	13,906	0	85,250	64,606
Swan													
Eucalypt medium closed	0	0	147	20	86	846	12	0	0	0	0	1,111	0
Eucalypt medium open	0	0	14,992	687	88,694	114,769	25,688	2,609	0	0	0	247,439	0
Total	0	0	15,139	707	88,780	115,615	25,700	2,609	0	0	0	248,550	0
WA South West													
Eucalypt medium closed	0	0	27	305	1,829	967	142	0	0	0	0	3,270	0
Eucalypt medium open	0	0	3,824	45,089	201,049	86,697	50,537	0	0	0	0	387,196	0
Eucalypt tall closed	0	0	0	0	10	0	0	0	0	0	0	10	0
Eucalypt tall open	0	0	0	3	952	0	0	0	0	0	0	955	0
Eucalypt tall woodland	0	0	0	0	700	0	0	0	0	0	0	700	0
Total	0	0	3,851	45,397	204,540	87,664	50,679	0	0	0	0	392,131	0
Warren													
Eucalypt medium closed	0	0	0	0	621	123	0	0	0	0	0	744	0
Eucalypt medium open	0	0	0	0	155,181	9,071	0	0	0	0	0	164,252	0
Eucalypt tall closed	0	0	0	0	2,154	76	0	0	0	0	0	2,230	0
Eucalypt tall open	0	0	0	0	72,489	1,605	0	0	0	0	0	74,094	0
Eucalypt tall woodland	0	0	0	0	7,558	41	0	0	0	0	0	7,599	0
Total	0	0	0	0	238,003	10,916	0	0	0	0	0	248,919	0

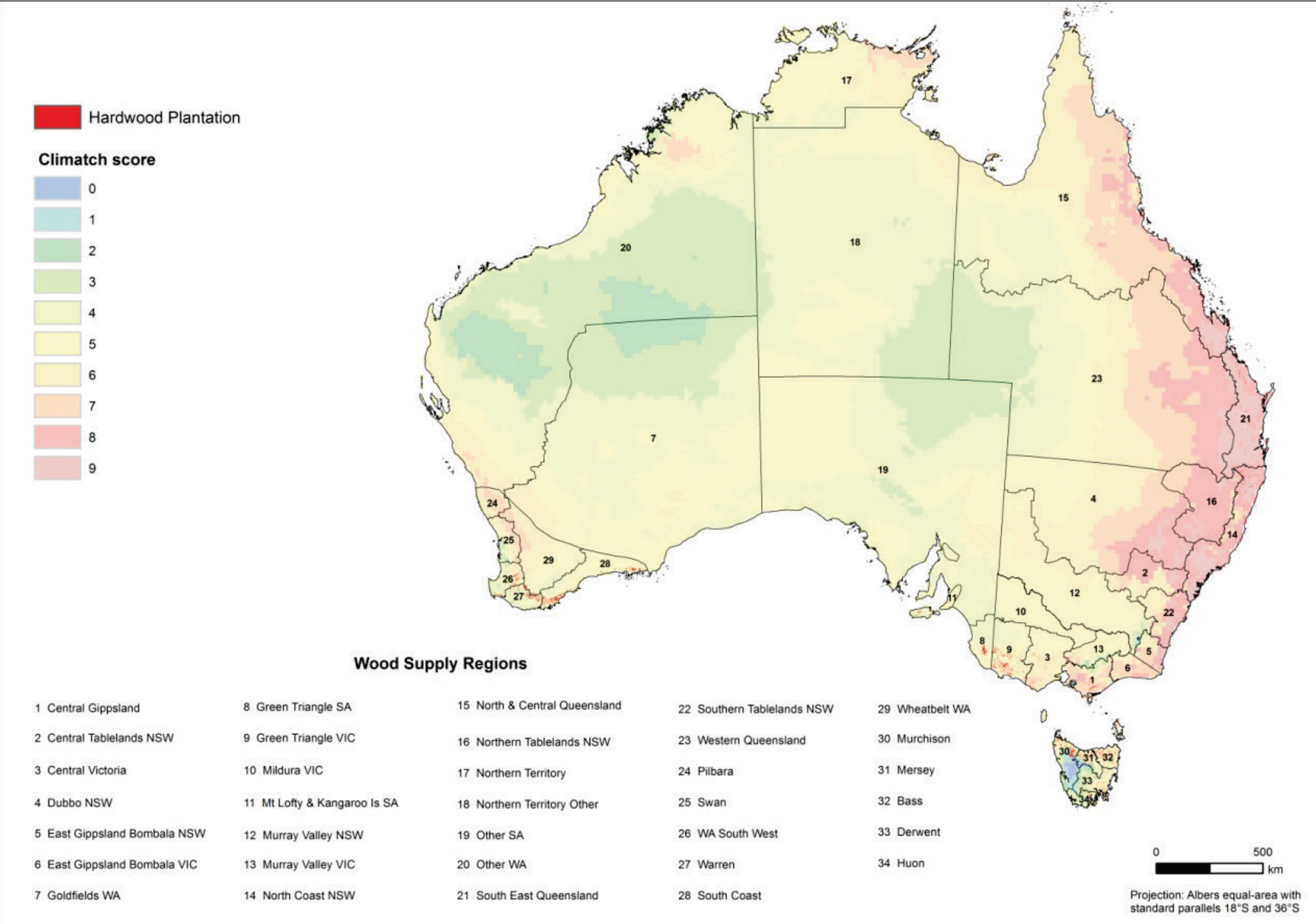
Western Queensland													
Eucalypt medium open	0	0	0	0	0	0	0	53,392	340,566	29,213	0	423,171	369,779
Eucalypt tall open	0	0	0	0	0	0	0	0	376	0	0	376	376
Eucalypt tall woodland	0	0	0	0	0	0	0	27	6,901	1,181	0	8,109	8,082
Total	0	0	0	0	0	0	0	53,419	347,843	30,394	0	431,656	378,237
Grand Total	10,812	35,176	72,636	346,042	872,911	1,147,203	549,969	1,112,726	1,243,132	319,739	0	5,710,346	1,243,132

Notes: Forest sub-types containing or dominated by myrtaceous species and predominantly used for wood production are listed in each Wood Supply Region where they occur. Wood Supply Regions of Goldfields WA, Green Triangle SA, Green Triangle VIC, Northern Territory, Northern Territory Other, Other WA, Pilbara and Wheatbelt are omitted as forest sub-types containing or dominated by myrtaceous species and predominantly used for wood production do not occur on multiple-use public native forests in these regions.

Appendix E: Climatic suitability for myrtle rust of eucalypt plantations and public production native eucalypt forest in Australia's Wood Supply Regions

Eucalypt plantation areas are from the NPI 2010–11 spatial layer used in Gavran and Parsons (2011), and are determined by excluding from the total hardwood plantation area the areas of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species; data for regionally important eucalypt species, such as *Corymbia citriodora* subsp. *variegata* in Queensland, was retained.

Figure E1 Distribution of eucalypt plantations by climatic suitability for myrtle rust, and Wood Supply Regions



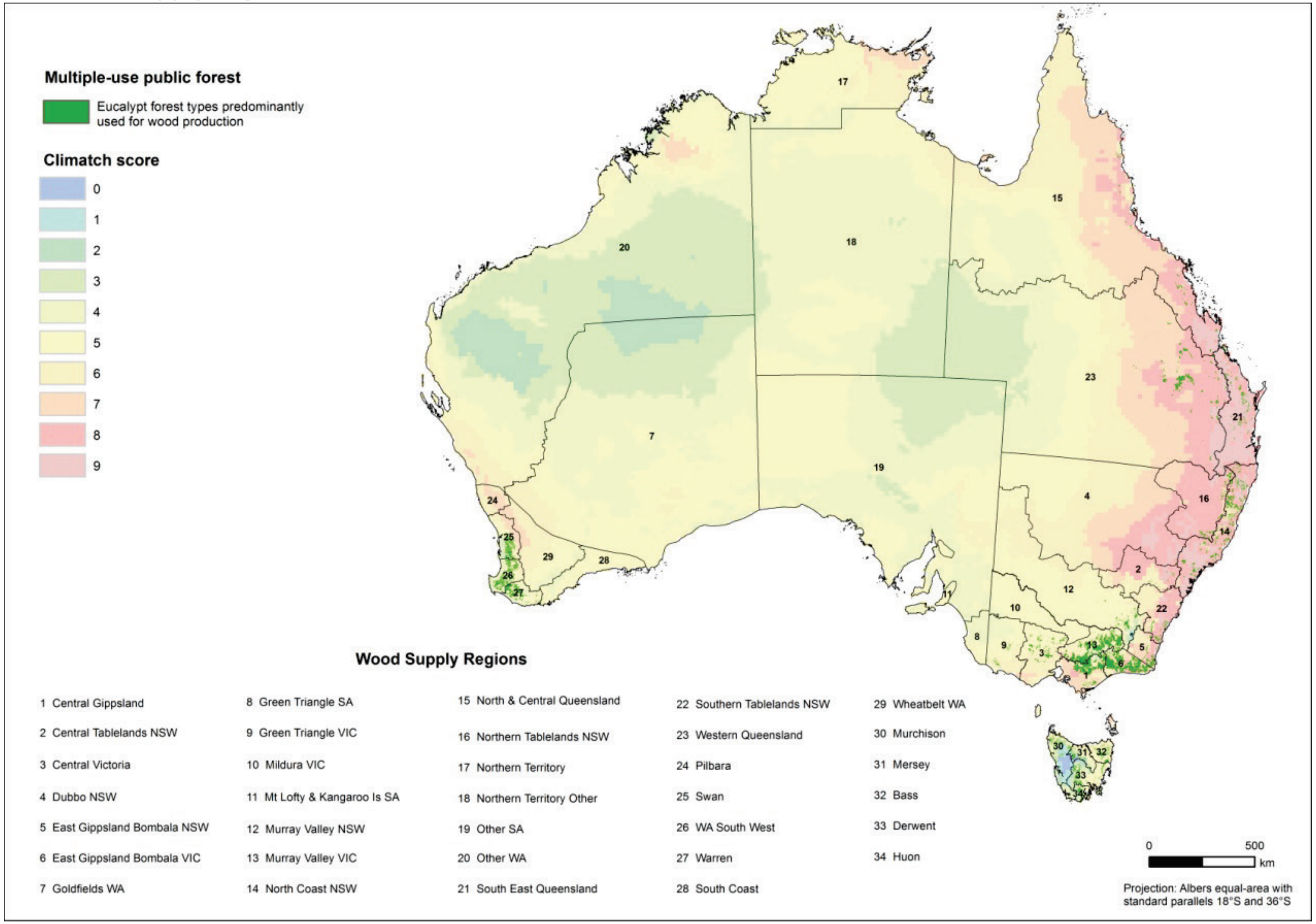
Note: Rust rating category S10, where the area was zero, is not included in this Figure.

Table E1 Eucalypt plantation by climatic suitability for myrtle rust, by Wood Supply Region

Wood Supply Region a	**Total eucalypt plantation** b	**Less suitable (Climatch scores 0-5)**		**Suitable or highly suitable (Climatch scores 6-10)**		**Highly suitable (Climatch scores 8-10)**	
	Area (ha)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)
Bass	59,598	35,850	60	23,748	40	0	0
Central Gippsland	34,440	0	0	34,440	100	2	0
Central Victoria	23,323	6,580	28	16,743	72	0	0
Derwent	40,792	36,785	90	4,007	10	0	0
East Gippsland Bombala NSW	1,723	0	0	1,723	100	943	55
East Gippsland Bombala VIC	4,316	0	0	4,316	100	314	7.4
Green Triangle SA	41,979	41,979	100	0	0	0	0
Green Triangle VIC	132,101	60,801	46	71,300	54	0	0
Huon	10,398	10,398	100	0	0	0	0
Mersey	39,759	35,827	90	3,932	10	0	0
Mildura VIC	172	157	91	15	8.7	0	0
Mt Lofty & Kangaroo Is SA	12,529	12,529	100	0	0	0	0
Murchison	72,157	68,438	95	3,719	5.2	0	0
Murray Valley NSW	10	10	100	0	0	0	0
Murray Valley VIC	6,075	861	14	5,214	86	0	0
North Coast NSW	43,173	0	0	43,173	100	38,374	89
Northern Tablelands NSW	6,073	0	0	6,073	100	5,499	91
Other SA	8	8	100	0	0	0	0
Pilbara	1,514	0	0	1,514	100	0	0
South Coast	109,683	109,683	100	0	0	0	0
South East Queensland	18,279	0	0	18,279	100	18,279	100
Swan	4,852	1,446	30	3,406	70	0	0
Warren	79,191	79,191	100	0	0	0	0
WA South West	51,050	41,512	81	9,538	19	0	0
Western Queensland	25	0	0	25	100	25	100
Wheatbelt WA	18,727	18,578	99	149	0.8	0	0
Total	**811,947**	**560,633**	**69**	**251,314**	**31**	**63,436**	**7.8**

a Of the 34 Wood Supply Regions, this table excludes 8 regions (North and Central Queensland, NSW Southern Tablelands, Central Tablelands NSW, NSW Dubbo, WA Goldfields, WA Other, NT and NT Other) that contain no hardwood plantation eucalypt area. Hardwood plantations in the Wood Supply Regions NT, and North & Central Queensland, completely or mainly comprise *Acacia* and other non-eucalypt species.
b Eucalypt plantation area is the hardwood plantation area available spatially from the NPI, excluding area of *Acacia* and other non-eucalypt species, fallow land and unidentified or minor eucalypt plantation species.
Note: Minor differences in total area of plantations between tables are due to the differences in the scale of the boundary data used in the spatial analysis. Figures may not tally due to rounding.

Figure E2 Distribution of multiple-use public forest with Eucalypt sub-types used for wood production by climatic suitability for myrtle rust, and Wood Supply Regions



Note: Rust rating category S10, where the area was zero, is not included in this Figure. Eucalypt forest sub-types used for wood production are Eucalypt medium closed, Eucalypt medium open, Eucalypt tall closed, Eucalypt tall open and Eucalypt tall woodland forest subtypes.

Table E2 Multiple-use public native forest of Eucalypt sub-types used for wood production by climatic suitability for myrtle rust, by Wood Supply Region

Wood Supply Region a	**Total Eucalypt forest sub-types used for wood production, on multiple-use public forest** b	**Less suitable (Climatch scores 0-5)**		**Suitable or highly suitable (Climatch scores 6-10)**		**Highly suitable (Climatch scores 8-10)**	
	Area (ha)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)	Area (ha)	Proportion of area (%)
Bass	103,349	75,578	73	27,771	27	0	0
Central Gippsland	530,879	214,091	40	316,788	60	20,690	3.9
Central Tablelands NSW	23,857	0	0	23,857	100	14,875	62
Central Victoria	179,566	105,315	59	74,251	41	0	0
Derwent	147,769	145,956	99	1,813	1.2	0	0
Dubbo NSW	5,577	0	0	5,577	100	4,684	84
East Gippsland Bombala NSW	121,812	1,688	1.4	120,124	99	61,609	51
East Gippsland Bombala VIC	816,742	38,237	4.7	778,505	95	104,164	13
Green Triangle VIC	42,864	20,566	48	22,298	52	0	0
Huon	60,270	60,270	100	0	0	0	0
Mersey	53,953	51,486	95	2,467	4.6	0	0
Mildura VIC	14,996	14,777	99	219	1.5	0	0
Mt Lofty & Kangaroo Is SA	226	226	100	0	0	0	0
Murchison	108,226	105,015	97	3,211	3.0	0	0
Murray Valley NSW	112,161	108,972	97	3,189	2.8	0	0
Murray Valley VIC	912,252	727,199	80	185,053	20	0	0
North & Central Queensland	119,926	0	0	119,926	100	95,802	80
North Coast NSW	601,362	0	0	601,362	100	505,256	84
Northern Tablelands NSW	152,580	0	0	152,580	100	122,267	80
Other SA	491	491	100	0	0	0	0
South Coast	4,301	4,301	100	0	0	0	0
South East Queensland	190,681	0	0	190,681	100	190,681	100
Southern Tablelands NSW	85,250	0	0	85,250	100	64,606	76
Swan	248,550	220,241	89	28,309	11	0	0
WA South West	392,131	341,452	87	50,679	13	0	0
Warren	248,919	248,919	100	0	0	0	0
Western Queensland	431,656	0	0	431,656	100	378,237	88
Total	**5,710,346**	**2,484,780**	**44**	**3,225,566**	**56**	**1,562,871**	**27**

a Of the 34 Wood Supply Regions, this table excludes 7 regions (WA Wheatbelt, WA Goldfields, WA Pilbara, WA Other, SA Green Triangle, NT and NT Other) that contain no area on multiple-use public forest of the five eucalypt native forest sub-types used for wood production.
b Eucalypt forest sub-types used for wood production comprise the Eucalypt medium closed, Eucalypt medium open, Eucalypt tall closed, Eucalypt tall open and Eucalypt tall woodland forest sub-types.
Note: Figures may not tally due to rounding.

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