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# Disease Dynamics in Wild Plant-Pathogen Associations

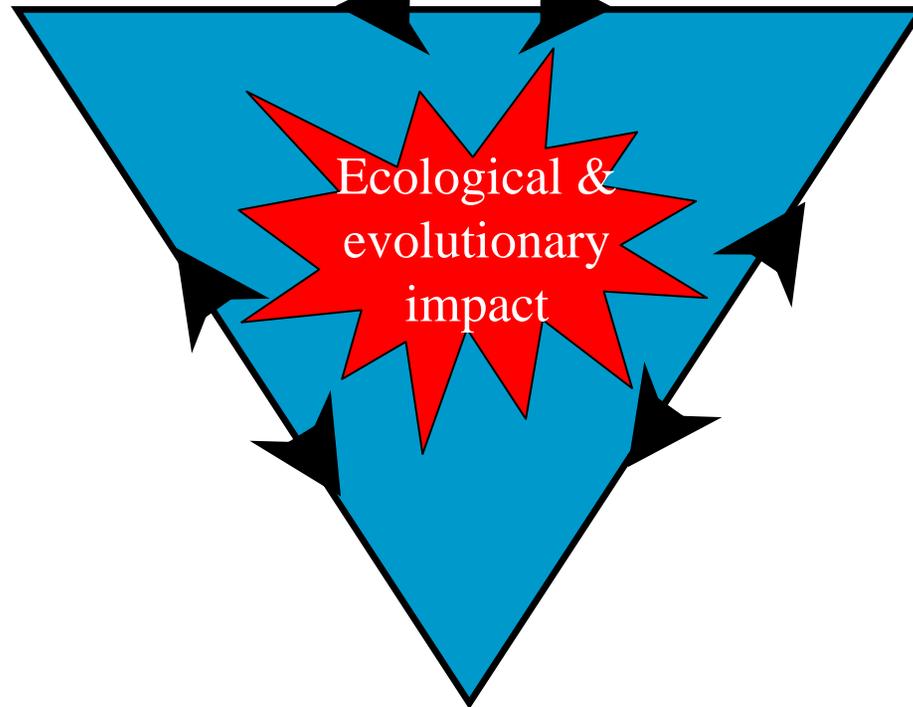
**Jeremy Burdon & Pete Thrall**  
10 March 2011



# The ecological & evolutionary triangle

- ◆ Genetics
- ◆ Phenology
- ◆ Pathogenicity
- ◆ Propagule production
- ◆ Parasitic mode
- ◆ Target tissue
- ◆ Dispersal mechanisms
- Etc

**Pathogen**



**Host**

- ◆ Genetics
- ◆ Phenology
- ◆ Resistance & its distribution
- ◆ Propagule production
- ◆ Population size
- ◆ Dispersal mechanisms
- Etc

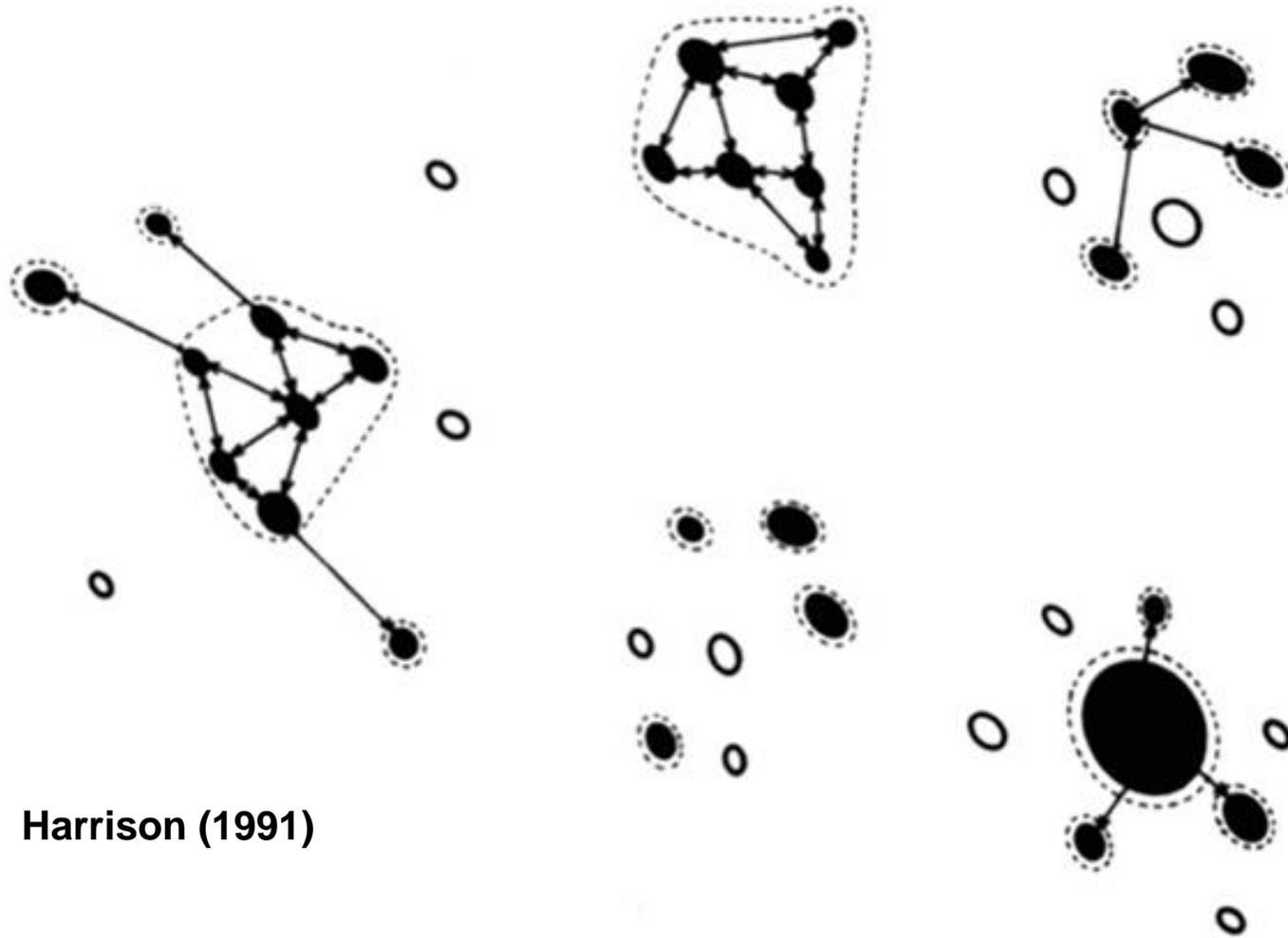
**Environment**

- ◆ Temperature;
- ◆ Moisture;
- ◆ Season length;
- ◆ Host nutrition; Etc

# Pathogen behaviour in natural ecosystems

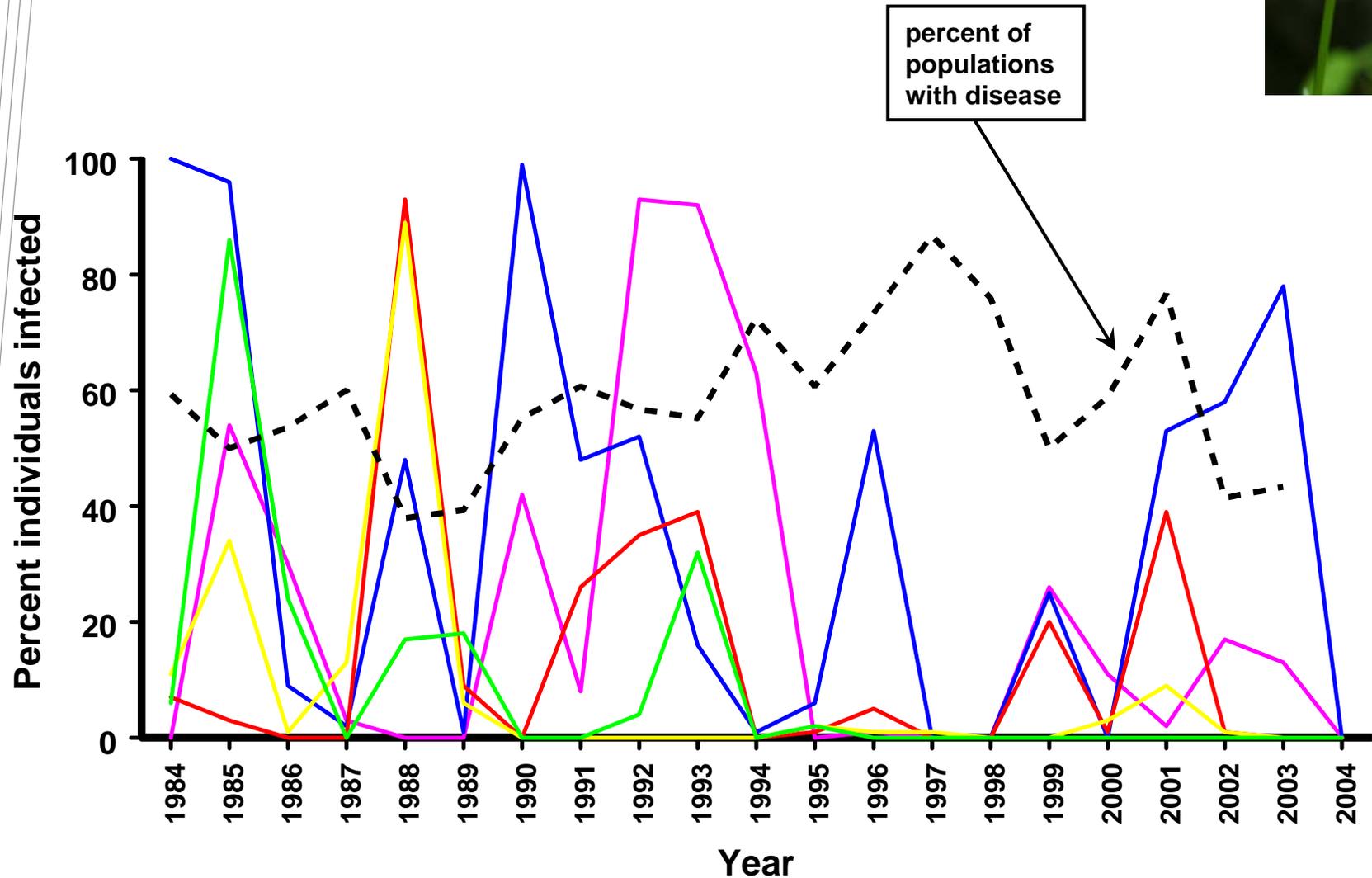
- Wild host-pathogen interactions are genetically and environmentally variable
- Pathogens are much less predictable in natural ecosystems than in agricultural systems.
- Our understanding of host-pathogen interactions in nature comes primarily from two sources: a) long-standing (co-evolved) native associations; and b) invasive situations.
- In native associations, disease typically 'comes and goes' (i.e. is unpredictable in space and time) requiring a metapopulation approach.

# Metapopulation studies: spatial structure



Harrison (1991)

# Local vs. regional persistence in the *Valeriana-Uromyces* interaction



# Life history plays a key role in determining dynamics and disease outcomes

*Anthracoidea heterospora*



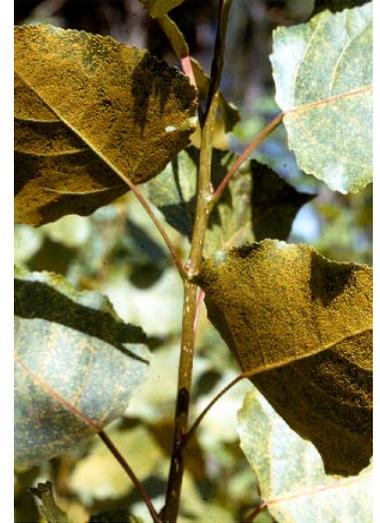
*Microbotryum violaceum*



- Host range
- Mode of attack and fitness effects (mortality vs. fecundity)
- Transmission mode (e.g. aerial, vector)
- Life cycle (e.g. saprotrophs, necrotrophs, biotrophs)
- Systemic vs. local infection

Life history influences both ecological and evolutionary outcomes

*Melampsora medusae*



*Puccinia psidii*



# Introduced pathogens: importance of host range



## ■ Pathogens with a narrow host range:

- Likely to be more predictable in terms of broad geographic distribution and likely ecological impacts...
- But perhaps less predictably present locally, esp. for those which exhibit epidemic cycles
- Host-specific pathogens can have major impacts (e.g. chestnut blight in N. America), but often may not (e.g. *Puccinia lagenophora* on *Senecio* sp.)



## ■ Pathogens with a wide host range:

- Will more likely be buffered from 'boom and bust' dynamics
- The likelihood of ecosystem and trophic effects is greater but...
- Perhaps less predictable overall, given potential for spatial variability in host community structure and susceptibility, and variation in fitness effects across environments
- Will have significant impacts in some, but not all ecosystems



# What can we learn from overseas examples?

May 2008

Research into natural and induced resistance in Australian native vegetation of *Phytophthora cinnamomi* and innovative methods to contain and/or eradicate within localised incursions in areas of high biodiversity in Australia



Cape Riche, Western Australia

Photos: WA Dunsen

Eradication of *P. cinnamomi* infections in Western Australia

Murdoch LINK

## Probably not very much...

- We only hear about invasive pathogens with dramatic effects (what % of invasions do these represent?)
- Incursions of *P. psidii* in Florida and Hawaii represent an exotic pathogen largely attacking introduced hosts, likely representing low genetic diversity in both.

**EXOTIC PEST ALERT**  
*Phytophthora ramorum*  
Sudden Oak Death

USGS Forest Commission

*Phytophthora ramorum* is a new species of *Phytophthora*. It was first identified in and then later in Oregon, USA, in both these states it causes a highly damaging tree Sudden Oak Death. The same *Phytophthora* has also been found to cause a new disease and wilt syndrome, which was first reported in Europe from the Netherlands and Great Britain of *P. ramorum* in North America is of a different sexual mating type to the one in Europe.

*P. ramorum* has since been found in nursery stock in a number of other European countries, the Czech Republic, Denmark, France, Ireland, Italy, Spain (including the Balearic Islands) and the UK. The main hosts are rhododendrons and viburnum, but other plants including Camellia, Galium, Ficus, Hamamelis and Ilex. It has also been seen on young pine plants (*Pinus taeda*) growing close to infected viburnum in a US nursery of *P. ramorum* on a mature tree outside the USA occurred in the UK in 2002. The affected tree was a 150-year-old *Quercus robur* (pedunculate oak). Also oak infected *Q. rubra* (northern red oak) was reported in the Netherlands. Subsequently, *P. ramorum* was found on *Quercus robur* (pedunculate oak) in the UK and a single *Q. robur* (pedunculate oak) has been found in Scotland. It is to raise awareness of the disease and describe the symptoms on potentially susceptible hosts.

**Known hosts**  
Disease symptoms caused by *P. ramorum* can vary markedly depending on the host. On some hosts the infection is lethal to the tree, but on other hosts only damage and dieback are affected. In the USA infected plants have been found in both Europe (Fig 1) and where planted. They include:

- Rhododendron (Rhododendron sp.)
- Sweet birch oak (*Q. nigra*)
- Black oak (*Q. velutina*)
- European larch (*Q. pedunculata*)
- Leaves of:
  - Bay laurel (*Laurus nobilis*)
  - Honeysuckle (*Lonicera xylosteum*)
  - Dogwood (*Cornus canadensis*)
  - Sweet gum (*Lygodium complanatum*)

Apart from forest trees, nursery stock can be burnt through of infection. In all, around 40 plant families in the susceptible list are affected. Details of these host plants are available on [www.usgs.gov/forest](http://www.usgs.gov/forest).

In Europe known hosts include ornamental rhododendrons, the most susceptible tree species there takes the form of colonies on the ground. Infected rhododendrons (Fig 2) and sweet chestnut have been found in the UK. With some ornamental species, dieback and trunk rot have been reported in the UK. In the USA, *P. ramorum* was first reported to a host in Poland in 2002.



Fig 1. Sudden Oak Death on oak in California



Fig 2. Infected rhododendron in the UK

USGS

**A Summary of Information on the Rust *Puccinia psidii* Winter (Guava Rust) with Emphasis on Means to Prevent Introduction of Additional Strains to Hawaii**

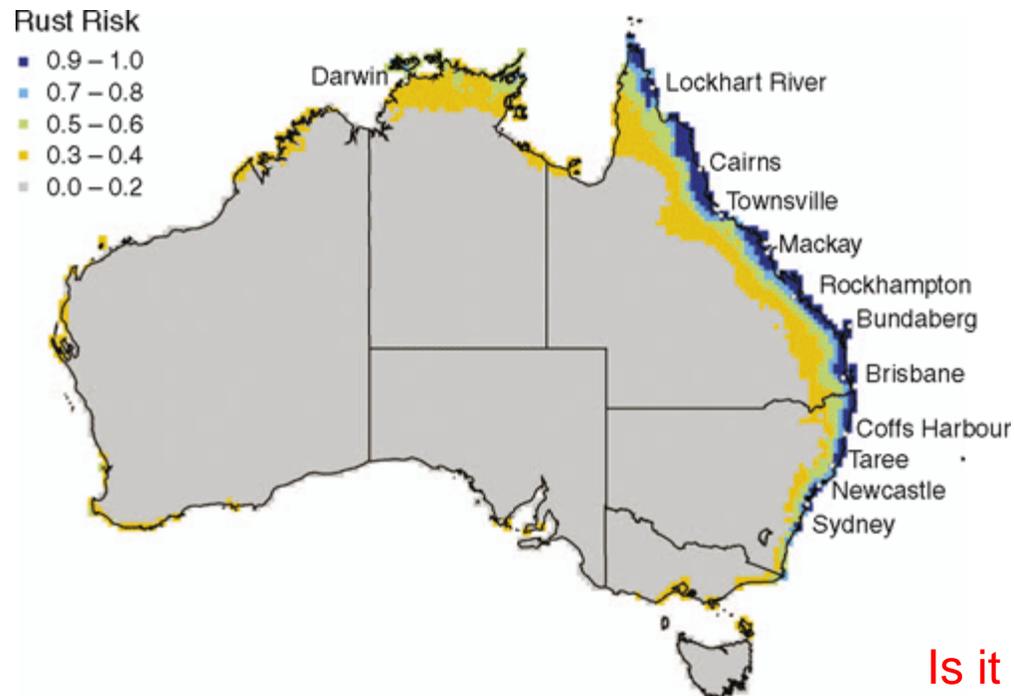


Open File Report 2010-1062

U.S. Department of the Interior  
U.S. Geological Survey



# Predicted spatial distribution of myrtle rust in Australia: what's missing?



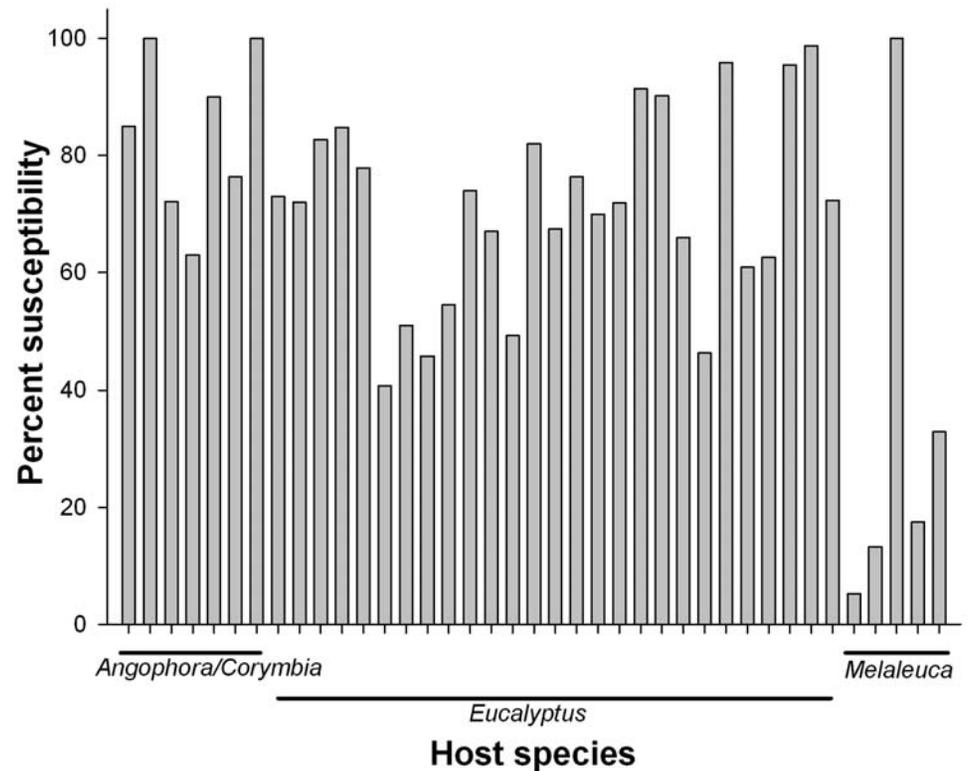
- Predicted distribution based on existing knowledge of climatic conditions conducive to rust
- Climatic information was derived from disease occurrence on eucalypts in exotic plantations – how representative?
- Map does not include host susceptibility or variation in myrtaceous community structure in Australia

Is it possible to develop a predictive map for likely disease impacts?

Glen et al. Aust. Plant Pathol. 2007;36:1-16

# Variation in susceptibility to guava rust in Australian Myrtaceae

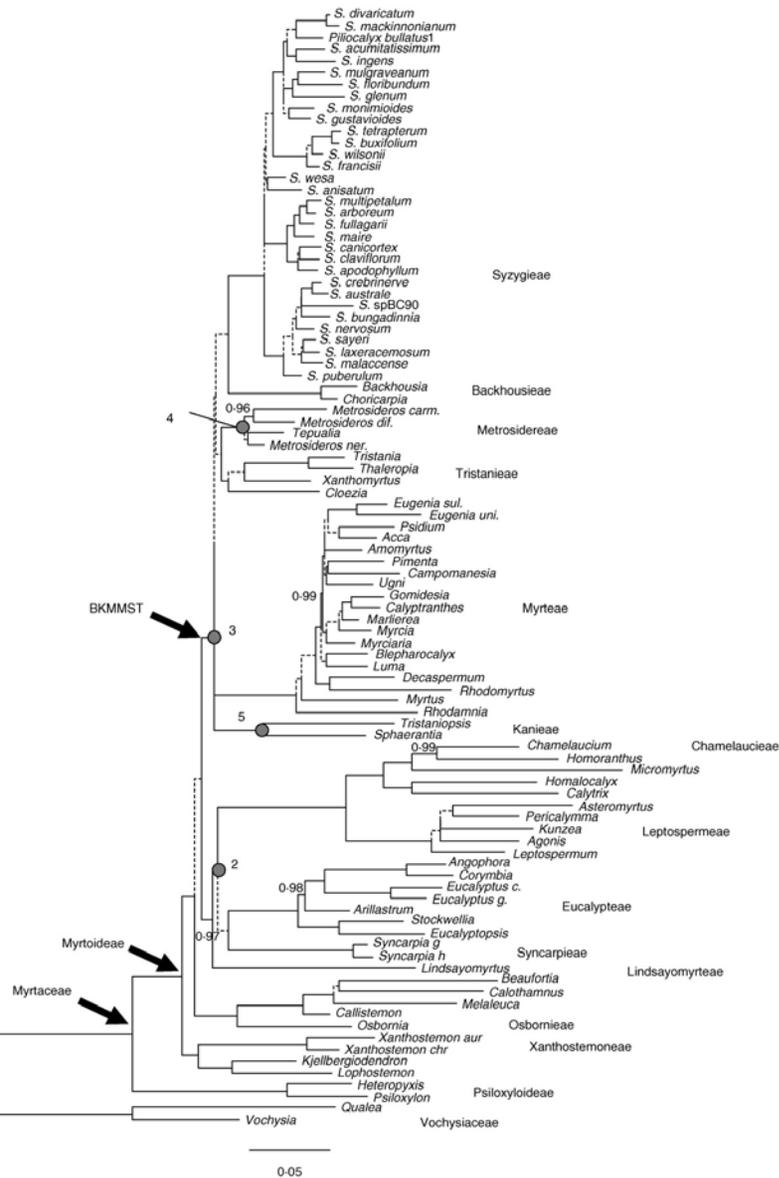
- Earlier work suggests susceptibility may vary considerably across the Myrtaceae
- Some evidence for variation within species (but insufficient to draw broad conclusions)
- Preliminary indication of variation in susceptibility in hosts from geographically different regions of Australia



Zauza et al. Aust. Plant Pathol. 2010;39:406-411

# What role does host phylogeny play in determining patterns of susceptibility?

Biffin et al. Ann Bot 2010;106:79-93



# Some major unanswered questions...

- What are the patterns of susceptibility within ecologically and economically important host spp. across geographic ranges?
- How does variation in susceptibility interact with environmental factors to determine host fitness effects?
- Is there heritable genetic variation for resistance and what is the underlying genetic basis of resistance?
- Do evolutionary (phylogenetic) relationships among hosts provide any predictability with regard to likely resistance?
- Is there genetic variation among Australian isolates of myrtle rust and what is the potential for further invasions to: a) increase diversity, and b) facilitate sexual reproduction?
- How does community structure (relative abundance and diversity of Myrtaceae) influence disease incidence and prevalence?
- Are some communities types likely to be more at risk (e.g. in terms of ecosystem impacts, including trophic effects)?

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