Figure 1. Phylloxera adults, nymphs and eggs Photo courtesy of Agriculture Victoria (Rutherglen)

Vigilance required in Phylloxera fight

Phylloxera, a major biosecurity pest of grapevines, was a buzz word 15 years ago. There was a 'keep our vineyards phylloxera free' sticker on the back of every ute. But industry focus on biosecurity has, in recent years, declined.

Vinehealth Australia is planning to turn things around. **Suzanne McLoughlin**, Vinehealth Australia; **Kevin Powell**, Agriculture Victoria; and **Inca Pearce**, Vinehealth Australia report.

INCA PEARCE, the new CEO of Vinehealth Australia (formerly known as the Phylloxera and Grape Industry Board of SA) is leading a renewed push to refocus industry attention on phylloxera prevention and management.

"I've worked in the viticulture industry for the past 19 years and I've seen the devastation that pests such as phylloxera can cause. I know how dangerous complacency can be," Pearce said. "Biosecurity and farm-gate hygiene may not be the most exciting things, but if we get those fundamental things wrong, then our industry will suffer."

WHAT IS PHYLLOXERA?

Grape phylloxera *Daktulsphaira vitifoliae* is a devastating pest of grapevines worldwide, affecting *Vitis* species (commercial grapevines and ornamental vines). Phylloxera is an insect native to eastern North America, first affecting native European *Vitis vinifera.* in the late 19th century.

There have been several hundred strains of the pest documented worldwide, of which Australia is known to have 83 endemic strains (Umina et al., 2007) (Powell and Korosi, 2014).

At present, these endemic strains are confined to parts of Victoria and New South Wales.

The phylloxera lifecycle involves egg, nymph and adult stages. Adult phylloxera are 1mm long and yellow to brown in colour (Figure 1). They feed on leaves and/or grapevine roots causing death of the European grapevine, *Vitis vinifera*, within five-to-six years on average; but dependent on which endemic strain is present.

The roots of *V. vinifera*, are extremely susceptible to attack by phylloxera but the leaves are resistant to strains present in Australia; endemic strains of phylloxera in Australia mostly feed on roots.

Root feeding on *V. vinifera* results in distinctive hook-shaped galls or nodosities on fleshy roots (Figure 2) or tuberosities on older roots. Depending on the phylloxera strain, leaf galls may occur on the leaves of suckers of American *Vitis* rootstocks. Grapevines grafted to phylloxera tolerant rootstocks or nursery plantings may show signs of phylloxera insects on the roots and damage in the form of nodosities, but not tuberosities, hovever visual symptoms in the canopy do not occur, which makes detection difficult. Grafted vines can sustain populations of phylloxera, which can spread to ungrafted vines. Some phylloxera strains which can feed on tolerant American rootstock leaves and/or roots cause neither vine decline nor economic damage. Phylloxera resistant grapevines are those on which phylloxera cannot develop to the adult stage so there is no egg production and no gall production (Powell and Krstic, 2015). Phylloxera tolerant rootstocks are those on which phylloxera can feed, reproduce and cause galling (nodosities) Rootstocks used commercially in Australia are considered to vary in their resistance, or tolerance, to different phylloxera strains, and research continues in this area.

Phylloxera can survive for up to eight days in warm weather and considerably longer in cooler conditions, without feeding on grapevines. They may be found in the vineyard throughout the year, with populations peaking both above

and below ground between December and February. Early signs of a phylloxera infestation include slow and stunted shoot growth and early yellowing of leaves as they lose function initially. Leaf yellowing will normally be seen in two to three neighbouring vines – usually, but not always, within the same row. In the mid stages of infestation, an infested vineyard area looks like an 'oil spot' in its spreading pattern as the phylloxera move from vine to adjacent vine and from row to row, spreading out from the roots of the vine where it was first introduced. Smaller satellite spots also occur when phylloxera has been accidentally moved on clothing, footwear or vineyard machinery.

Grape phylloxera causes considerable losses in both quality and yield of grapevines throughout many grape-producing areas around the world (PGIBSA, 2003; INRA, 2009). Crop losses range from no noticeable impact to almost total crop loss. The infestation rate and yield decline is significantly related to vine variety, seasonal temperatures, soil moisture levels and phylloxera strain. Vines planted on ungrafted *V. vinifera* rather than onto phylloxera resistant rootstock are most at risk to succumbing to phylloxera.

IMPACT IN AUSTRALIA

There is no proven chemical method to eradicate phylloxera on roots of ungrafted *V. vinifera* grapevines (Loch and Slack, 2007). Little information on biological control of grape phylloxera is available.

In 2007, approximately 80 per cent of Australia's commercial winegrapes were reported to be ungrafted *V. vinifera*, susceptible to phylloxera (Trethowan and Powell, 2007). From a South Australian perspective nearly 10 years on, 74 per cent of winegrapes are planted on own roots (Vinehealth Australia, 2016). These figures highlight the risk and potential impact of phylloxera to the Australian wine industry.

With the lack of available chemical or biological controls for phylloxera, the only proven cultural method to manage phylloxera is to pull out infested vines and replant with new vines that have been grafted onto phylloxera-resistant American rootstocks.

Figure 2. Galls on grapevine roots Photo courtesy of Agriculture Victoria (Rutherglen)

The cost of grafted material alone is three-to-five times that of own rooted vine material, notwithstanding costs of vine removal, ground preparation, planting, trellising, additional water and nutrition. Besides vine material costs of replanting a vineyard post-phylloxera infection, other secondary management costs may include extra machinery and infrastructure (such as heat sheds, washdown bays, etc), heightened farm-gate hygiene practices (including cleaning and disinfestation), people management, logistics and loss of production while a new vineyard is maturing.

WHERE IS PHYLLOXERA IN AUSTRALIA?

Phylloxera is a devastating pest that destroyed more than one million hectares of grapevines in Europe in the late 1800s. Movement of American propagation material into Europe was a fascination of the wealthy long before anyone began to understand the importance of biosecurity.

French viticulturists allowed importation of propagation material from north-eastern United States until the 1860s, unwittingly and inadvertently facilitating rapid phylloxera spread. In 1878, the 'Agreement of Berne' set international rules on phylloxera outbreak notification and border restrictions on movement of propagation material (Hamilton, 2012).

The first detection of phylloxera in Australia was near Geelong, Victoria in 1877. Once several vineyards were found to be infested, a policy of destroying vineyards and leaving them fallow for many years to eradicate the insect was implemented based on the French experience. Unfortunately, this early attempt at eradication was unsuccessful and phylloxera was later detected in other parts of Central and North East Victoria.

The first detection in New South Wales was in 1884 at Camden and further infestations were subsequently found nearby. Phylloxera was first found in Queensland at Enoggera, Brisbane, in 1910 and has not been detected in that state since the 1960s.

South Australia, which had not received infected material, banned movement of vine material under the powers of the Vine Protection Act of 1874. The first Phylloxera Act was enacted in 1899. Then in 1995, the Act became the Phylloxera and Grape Industry Act 1995 (http://www.vinehealth.com.au/biosecurity/phylloxera/) with government support for levies in order to undertake its duties under the Act.

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FOOTBATH REMINDER

Anyone who has already visited a vineyard before they enter yours could potentially carry phylloxera, weed seeds and other pests and diseases with them. An important step to protect your vines is to ensure that everyone coming onto your vineyard is wearing clean clothes and that their footwear is clean and disinfested.

The footwear disinfestation process is also recommended for disinfesting pruning snips, picking snips, shovels and other small hand tools that come into contact with soil and grapevine material.

The footwear disinfestation protocol has been updated and footwear must now be immersed for at least 60 seconds in 2% sodium hypochlorite solution. Do not rinse after immersion.

To view the footwear disinfestation protocol visit www.vinehealth.com.au

Currently, declared Phylloxera Infested Zones (PIZ) are confined to areas in Victoria (North East, Maroondah, Nagambie, Mooroopna, Upton and Whitebridge) and New South Wales (Sydney region and Albury/Corowa) – *refer to the maps on Page 37.*

Since December 2015, there has been an upsurge of new detections of phylloxera within the existing Maroondah PIZ, resulting in boundary adjustments to this zone.

"These outbreaks clearly demonstrate the need for greater awareness, vigilance and requirement for compliance with quarantine legislations. No one can afford to be complacent," Pearce said.

"It is critical that the wine industry maintains its investment in phylloxera research to ensure industry is armed with the most up-to-date knowledge in fighting phylloxera and that this knowledge strengthens the quarantine regulations.

"Vinehealth Australia acknowledges the proactive awareness campaigns that the Yarra Valley Phylloxera Management Working Group has implemented in an attempt to prevent further spread of phylloxera in and out of the Maroondah PIZ."

Through quarantine measures, implementation of farm-gate hygiene practices and continued vigilance, the major grape growing states of South Australia, Western Australia and Tasmania have not become infested with phylloxera; alongside large parts of Victoria and New South Wales. Queensland is thought to be free of phylloxera. For detailed maps of current phylloxera zones, refer to www.vinehealth.com.au/resources/maps/.

HOW DOES PHYLLOXERA SPREAD?

Movement of phylloxera can primarily be attributed to the transfer of first instar (crawler) or first instar lifecycle stages, which are associated with the movement of various human assisted vectors that can lead to unlimited spread if no control measures are practiced. Although phylloxera infestations in Europe in the late 19th century have been largely attributed to the movement of propagation material, grape phylloxera can be spread by numerous mechanisms including:

- Movement of vineyard machinery, equipment and vehicles:
- Soil from a vineyard;
- Footwear and clothing;
- Grapes – whole or harvested;
- Grape products such as unfiltered juice and pre-fermentation grape marc; and
- Grapevine material – rootlings, cuttings, potted vines, leaves and shoots.

Crawlers can also naturally spread from vine to vine by crawling along the soil surface and in the canopy or crawling below ground from root to root. They may also be carried by wind, with spread of up to 25 metres (Powell, 2000). Natural spread occurs at a rate of 100-200 metres per year within a vineyard (King and Buchanan, 1986). While crawlers are the most widely spread life-stage, other life-stages including eggs and wingless adults can be spread in soil, in leaves with leaf galls and on planting material.

In Australia Phylloxera adults are all female and are able to reproduce asexually. One adult female is capable of laying up to 200 eggs per cycle and can have several breeding cycles in its lifetime. This means only one insect is needed to infest a vineyard.

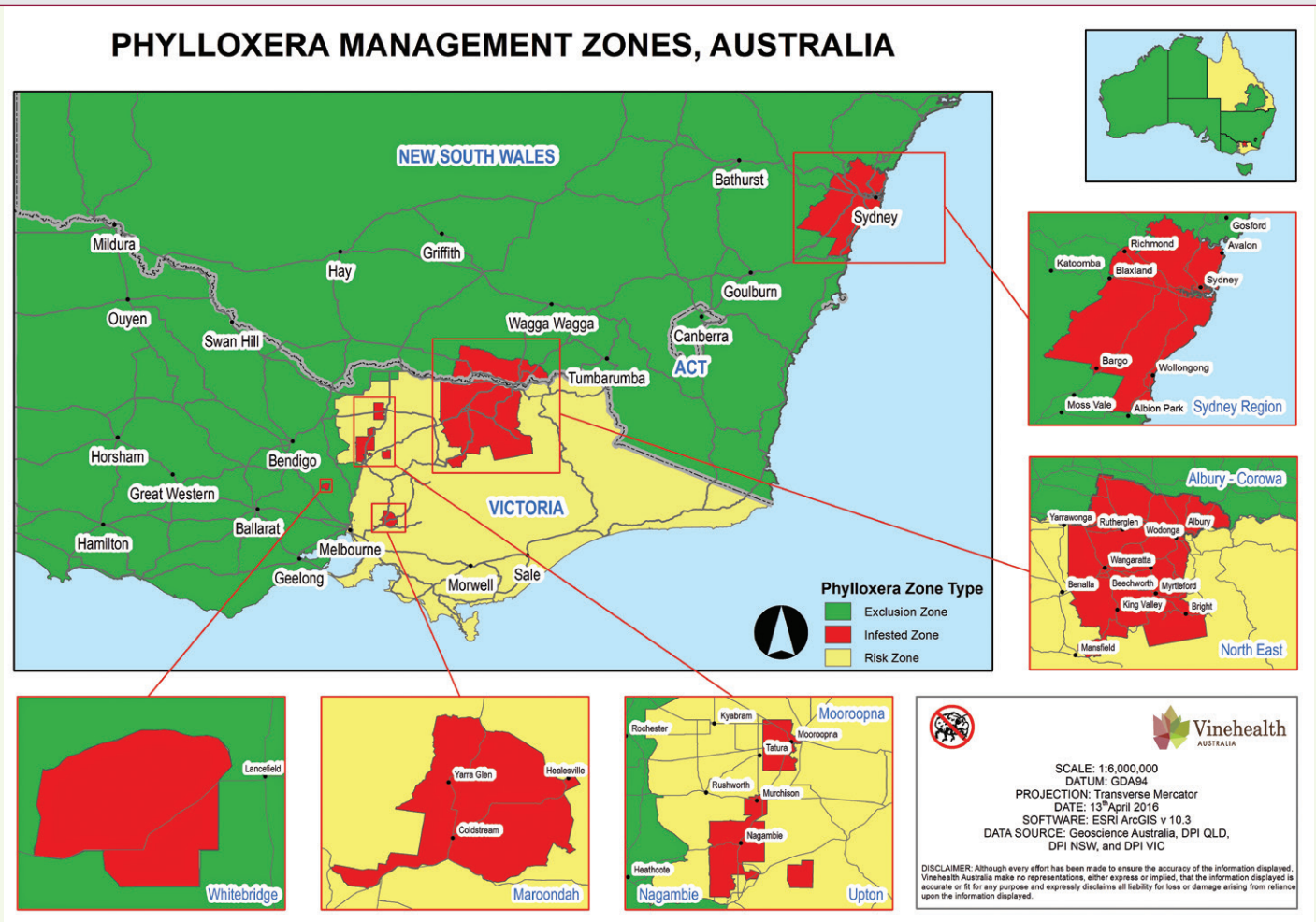
WHAT'S BEING DONE TO STOP ITS SPREAD?

In Australia, the Commonwealth Government is responsible for regulating the movement of plants and plant products into and out of Australia. However, each state and territory government is responsible for plant health controls within their individual jurisdiction (DAWR, 2016).

To prevent the spread of phylloxera from infested areas, each state has legislation and associated regulations, which restrict or prohibit the movement of 'phylloxera risk vectors'. These include grapevine material, grape products and vineyard or winery equipment and machinery (PIRSA, 2015).

These regulations are documented in Plant Quarantine Standards or equivalent, all of which are underpinned by the National Phylloxera Management Protocol, which allows for the delineation of grapegrowing regions by phylloxera status (http://www.vinehealth.com.au/media/National-Phylloxera-Management-Protocol.pdf).

Phylloxera Exclusion Zones (PEZ) are areas that have been surveyed and found free of phylloxera or are declared free historically, Phylloxera Risk Zones (PRZ) are areas that have not been surveyed for phylloxera and are of unknown status, and Phylloxera Infested Zones (PIZ) are areas that contain vineyards known to be infested with phylloxera. The boundaries of a PIZ must be a minimum of 5kms from the closest infested vineyard (NVHSC, 2009). Vinehealth Australia



has identified an opportunity to assist state governments to communicate these legal requirements around moving grape-related phylloxera vectors between states and between phylloxera management zones within states.

Demonstrating a coordinated approach to biosecurity, Vinehealth Australia has initiated the building of a simple, easy to use, online 'winegrape biosecurity legislation' tool with the potential to raise the awareness and understanding of these legal requirements and improve compliance with these requirements among users of the tool. Ultimately, to be successful in stopping the spread of phylloxera, we need to ensure that the surveillance methods we use in vineyards have the highest chance of detecting where phylloxera is and is not.

Since 2013, Vinehealth Australia has been the lead agency in a collaborative phylloxera research project, funded by the Plant Biosecurity Cooperative Research Centre (PBCRC) and Wine Australia, to develop an advanced early detection and surveillance system using phylloxera DNA extracted from soil samples. Once endorsed, the DNA method, which was first developed in 2006 by a collaboration between Agriculture Victoria and SARDI, will form part of an integrated approach for the detection and surveillance of phylloxera.

Favourable results to date indicate this method along with other primary surveillance methods of digging and emergence traps, will be able to support identification and verification of area freedom status to facilitate market access for growers, as well as improving proactive management strategies for phylloxera. For information about this project visit http://www.vinehealth.com.au/projects/dna-testing-early-accurate-detection/.

Other secondary methods of surveillance, such as aerial imagery, have been used since the early 2000s by Vinehealth Australia and even earlier by Agriculture Victoria, to look for weak vines using Normalised Differential Vegetation Index (NDVI), hyperspectral imagery and Plant Cell Density (PCD). Vinehealth Australia continues to use a system of routine aerial imaging followed by on-ground surveying, as a method to detect vine decline across South Australia. Researchers including Dr Kevin Powell have also investigated the potential for electromagnetic induction-based soil sensing (EM 38) and chemical fingerprinting to assist with phylloxera surveillance.

Phylloxera research in Australia is predominantly undertaken by Australia's authority on grape phylloxera, Dr Kevin Powell, a Principal Research Scientist – Invertebrate Sciences, for Agriculture

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Suzanne McLoughlin and Inca Pearce, Vinehealth Australia

Victoria based at Rutherglen. Kevin is working to improve our understanding of the comparative levels of virulence of the various phylloxera strains endemic to Australia and therefore the risk of spread of these strains in practice. His current research on phylloxera involves determining the effect of different disinfestation treatments on survival of endemic phylloxera strains, developing effective management options using rootstocks to restrict their further spread and testing of novel detection approaches.

In addition, several projects part of the PBCRC program, include the Vinehealth-led 'On-farm DNA surveillance for grape growers' mentioned above, as well as WA-based Michael Renton and Maggie Triska's 'Design and evaluation of targeted biosecurity surveillance systems' looking to design biosecurity surveillance systems that are more effective and economical, based on factors such as the number and location of traps or soil samples, and the frequency with which they are conducted or checked.

Importantly, Vinehealth Australia advocates for a national, coordinated approach to education and awareness of phylloxera and other priority biosecurity threats, to arm industry with information required to combat the introduction, establishment and spread of phylloxera and other pests and diseases in Australia.

WHAT ORGANISATIONS ARE INVOLVED IN PHYLLOXERA MANAGEMENT?

Biosecurity management must be viewed across a continuum from pre-border, at the border and post-border. The Australian Department of Agriculture and Water Resources and Plant Health Australia as its conduit to industry, are responsible for managing Australia's robust biosecurity system.

With regard to phylloxera post-border, responsibility for limiting the infestation and spread of phylloxera between states and within states, is a collective effort between industry, government-industry conduits and national and state-based regulators:

- Industry responsibility lies with grapegrowers, winemakers and others in the supply chain to adhere to legal movement requirements, plant with clean propagation material, implement farm-gate hygiene practices, maintain awareness of phylloxera and other pest and disease threats, monitor vineyards and verify anything unusual and to communicate the importance of being vigilant to all staff and visitors;
- National, state and regional grape and wine industry bodies have a key role in advocacy, communications and education. Australian Vignerons is signatory to the Emergency Plant Pest Response Deed and provides an industry voice if there is an exotic biosecurity incursion of importance to the wine industry;
- Research providers, such as Dr Kevin Powell (Agriculture Victoria) and the Australian Wine Research Institute, are involved in conducting research to support our quarantine legislation and knowledge of how to manage phylloxera in Australia, as well as communicating the importance of being vigilant to limit the spread of phylloxera;
- Vinehealth Australia operates under *The Phylloxera and Grape Industry Act (1995)* and is responsible to the South Australian Parliament through the Minister for Agriculture, Food and Fisheries. For more than a century Vinehealth Australia (formerly the Phylloxera and Grape Industry Board of SA) has protected South Australia's clean-green status by leading industry initiatives, education and influencing policy to keep vineyards free of phylloxera and other pests and diseases. Vinehealth Australia is a biosecurity regulator in SA and jointly manages biosecurity incursions in SA alongside Biosecurity SA. As phylloxera does not respect state borders, Vinehealth Australia understands it must enhance collaboration with interstate colleagues to prevent further spread of endemic strains of phylloxera in Australia and the potential introduction of exotic phylloxera strains into Australia; and
- State regulators such as Primary Industries departments are primarily responsible for surveillance and responses to incursions. They also have the responsibility of maintaining adequate quarantine standards and ensuring compliance to these standards.

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