Characterizing the development of phylloxera infestation with multi-temporal colour infrared aerial photography

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Problem

Grape phylloxera (*Daktulosphaira vitifoliae*) is a major threat to the Australian grape and wine industry. The phylloxera aphid feeds on the vine root system causing extensive damage which results in reduced vine vigour and can lead to vine death. A program of early detection and monitoring the rate at which phylloxera spreads over time is vital for confining this pest to designated quarantine zones.

This study was undertaken on a vineyard set in the King Valley region of north eastern Victoria. The vineyard manager first noticed, in the 1994/95 season, phylloxera in a single block in the extreme north east of the vineyard (Figure 1). Over time phylloxera damage will require all the ungrafted sections (approx. 20 ha) to be replanted with phylloxera-resistant rootstocks.

Figure 1: Colour infrared photography from 1996 to 2001 documenting reduced vine growth due to the spread of phylloxera. White ellipses highlight the main areas of infestation

Discussion

Areas of low vine vigour were detectable primarily as areas of vines showing reduced NIR reflectance (less red) on the photograph. However, alteration to the distinctive vine row pattern as cover crop became dominant under dead or dying vines was also an important key for recognising areas of infestation. Because of the complexity of the interaction between incident visible and near-infrared light and vineyard land cover, it is unlikely that spectral information alone will allow for accurate detection and mapping of phylloxera infestations.

It is important to note that reduced vine vigour, similar to that caused by phylloxera may also be caused by other factors such as: soil variation; weed infestations; faulty irrigation systems; vine diseases; and other pests. Broad band multi-spectral data, such as those provided by aerial photographs, or airborne/satellite digital imaging systems are capable of detecting regions of reduced vine vigour within a vineyard block. However, attributing the reason for reduced vigour to a specific cause, such as phylloxera, will require additional information, ostensibly through field verification.

Aim

The aim of this project was to see if multi-temporal colour infrared aerial photography could be used to map and monitor phylloxera infestations; leading to concomitant increases in knowledge of the temporal dynamics of grape phylloxera.

Methods

A series of colour infrared aerial photographs captured annually from 1996 to 2001 was used to detect maximum growth differences between uninfested and infested vines (Table 1, Figure 1).

Table 1: Details of colour infrared aerial photography

Date stamp	Time	Approximate scale	Comments
27/3/96	09:24:10	1:11300	Over exposed print with red colour saturation. Significant shadow falling to the south. Smoke haze present.
11/4/97	10:39:47	1:11700	Clear print showing range of colours. Significant shadow falling to the south.
27/3/98	08:38:17	1:11000	Clear print showing range of colours. Significant shadow falling to the south west.
5/5/99	12:47:37	1:11300	Clear print showing range of colours. Significant shadow falling to the south south east.
22/3/00	09:41:45	1:11000	Over exposed print with red colour saturation, significant shadow falling to the south west.
20/3/01	14:07:59	1:8300	Clear print showing range of colours. Flown under a cover of high cloud, resulting in higher resolution and less shadow. South-west corner of vineyard is cut-off.

Each photograph was scanned at 300 dpi, converted into a TIF image and co-registered.

'Weak' vines were surveyed to confirm the presence of phylloxera.

Initial attempts to map the phylloxera affected areas using digital techniques failed due to the inherent variability in the photographic prints and the complexity of reflectance from vineyards.

As a consequence regions of phylloxera were investigated in this sequence of imagery using a combination of pattern, colour and shape image interpretation elements along with temporal variation between the photographs.

Results

Grapevine phylloxera was shown to spread throughout most of the ungrafted vines in the vineyard in the six year period from 1996 to 2001 (Figure 1). On the 1996 photograph, areas of visibly reduced vine vigour attributed to phylloxera had an area of 0.03 ha and were confined to a single block in the extreme north east of the vineyard. By 2001, areas of substantially reduced vine vigour totalled 1.88 ha and were spread across the entire vineyard. However, the area mapped as infested on the 2001 photograph did not include the removal of the 4 ha block in 1998 and 1999 that was the site of original infestation, nor a 0.6 ha block removed after the 2000 harvest.

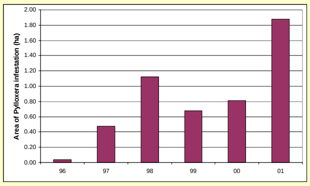

Figure 2: Temporal change in the area of phylloxera infestation.

The temporal pattern of phylloxera spread showed that existing sites of infestation grew outwardly each year and new nuclei of infection were established throughout the vineyard. Established sites of infestation increased monotonically in each subsequent year with the region of decreased vine vigour growing radially from the infected area of the previous year. New sites of infestation were visible on each of the annual photographs increasing from 3 identified sites of infestation in 1996 to more than 50 sites in 2001.

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