Eutypa Impacts: Ground-truthing of Infrared Technologies

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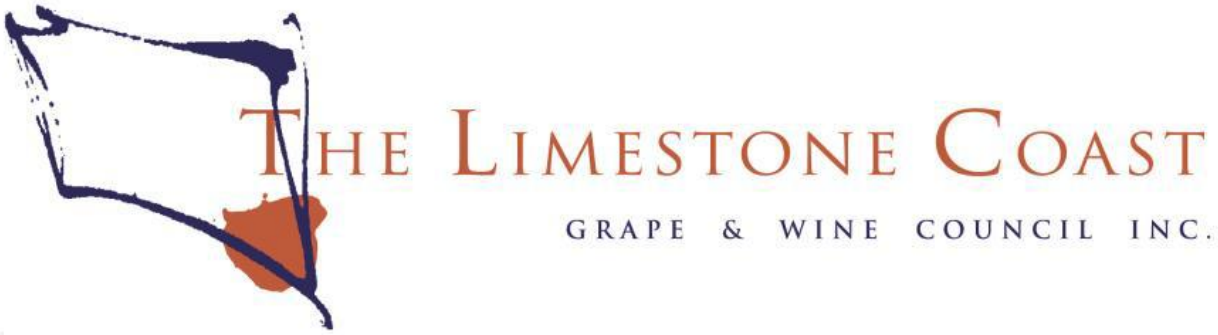
Limestone Coast Grape and Wine Council

Final Report



Executive Summary

The Limestone Grape and Wine Council investigated the use of Greenseeker® technology to determine if this technique would assist growers in being able to accurately quantify dieback caused by Eutypa in their vineyards when compared to the labour intensive 'ground truthing' technique.

The assessment was undertaken during the 2013/14 growing season on 6 Cabernet Sauvignon blocks located throughout the Limestone Coast. The Greenseeker® was run through each block in December with a follow up ground truth occurring within 2 weeks of the initial scan. Various amounts of each vineyard were ground truthed due to time constraints.

Results were variable with some vineyards producing higher degree of accuracy than others. This project identified a number of issues that would need further investigation before being confident that the technology is robust enough to be used by growers.

Introduction

Eutypa Dieback, caused by the fungus *Eutypa lata*, is a major trunk disease of grapevines (Sosnowski and Wicks 2012). Incidence of Eutypa in the Limestone Coast was recently assessed and the varieties Cabernet Sauvignon and Shiraz were observed with a mean incidence of 47% and 44% (Sosnowski et al. 2012). Disease incidence was greatest in vines 15+ years old increasing by 2% per year on average.

Vines infected with Eutypa often produce stunted shoots with chlorotic leaves; leaves may be cupped due to the toxins produced by the fungus and produce small, unevenly ripened fruit. Necrosis of wood results in wedge-shaped areas of stained tissue. The fungus grows slowly through the cordon and trunk eventually discolouring and killing the wood (Moller and Kasimatis, 1981, Sosnowski and Wicks 2013).

Ascospores infect grapevines through pruning wounds and germinate in xylem vessels. The mean rate of progression of wood staining due to Eutypa ranged between 12 and 18 mm per year in a study of eight cultivars, with a maximum of 50 mm per year recorded in individual Cabernet Sauvignon and Shiraz grapevines (Sosnowski *et al.*, 2007).

Identification of the disease has traditionally been through ground surveys during spring at critical time points of grapevine phenology (E-L stages 12-23). However, this method is laborious and as such is time restrictive on the area available to survey on a given day.

The Greenseeker® is a mobile system with an active lighting optical sensor which emits high intensity light 660 +/-10nm in red and 770+/- 15nm in NIR wavebands (Mazetto et al. 2009), operated at cordon height levels. The light is reflected by the leaves and is captured by a photo diode in front of the sensor. Greenseeker® gives back the index values NDVI and red/NIR in real time and is a measure of the vine vigour status through a measure of 'greenness' which reflects the amount of chlorophyll in the leaves. Historically this technology has been used in broadacre agricultural pursuits particularly to look at requirements for nitrogen application and spraying weeds.

One operator in the Coonawarra wine region has used this technology over the past few years to initially assess vine vigour for potential improvements in wine quality by identifying batch lots for

winemaking. It was identified during this process that the technology could be used for other uses including improving irrigation uniformity, vineyard biosecurity and identifying vine decline. For example, when Greenseeker® maps were analysed and compared on an annual basis, the change in vigour was identified and the information used to make a more informed decision on individual blocks long term viability (Figure 1).

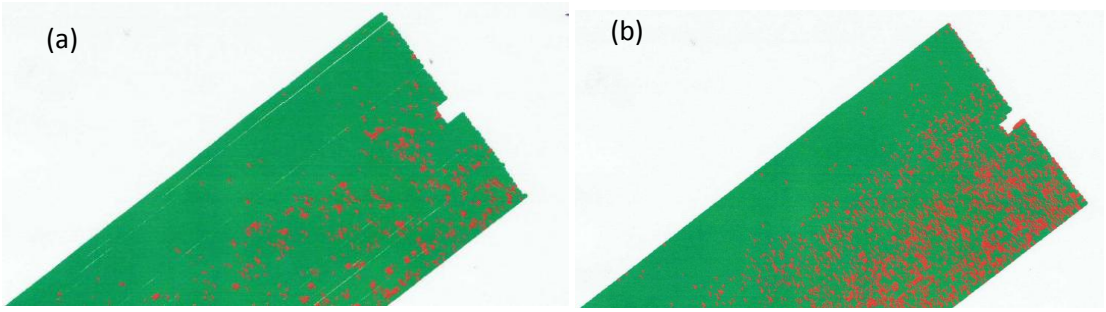


Figure 1. Comparision of the same block of grapes in January 2013 (a) and January 2014 (b) using Green seeker®.

For viticulture, there is potential to use the Greenseeker® as an early detection tool to measure vine decline associated with Eutypa. Currently very few operators within the viticultural industry have utilised this technology due mainly to a lack of confidence, knowledge and skills to adopt this type of technology along with the uncertainty in the accuracy of the data produced. It was the aim of this project to rapidly evaluate blocks for Eutypa decline and provide a quantitative assessment of Eutypa that is reproducible.

Materials and Methods

LSC Survey

Cabernet Sauvignon blocks were selected from various regions within the Limestone Coast as this was the variety deemed to be suffering the most from vine decline. Two blocks from each of the regions Padthaway and Coonawarra, one from Wrattonbully and one from Limestone Coast other, were chosen to represent the region as well as having different cordon structures to test the versatility in the Greenseeker® data collection (See Table 1). Prior to bunch closure, (mid-December) each selected block was surveyed with a Greenseeker® unit attached to tractor. The Greenseeker® unit used has two sensors located on either side of the tractor and data collected was averaged.

Table 1. Summary of Vineyards sampled

Vineyard/Region	Age	Cordon Type
Limestone Coast Other	16	Single wire
Padthaway Vineyard 1	16	Single wire
Padthaway Vineyard 2	45	T-Trellis
Wrattonbully	17	Two wire vertical
Coonawarra Vineyard 1	18	Single wire
Coonawarra Vineyard 2	20	Single wire

Ground truthing was undertaken within two weeks of the initial Greenseeker® survey. Each vine was visually assessed for percentage of bare cordon as well as noting obvious eutypa symptoms. The extent of ground truthing varied due to time constraints: the Limestone Coast other vineyard had every row assessed, Padthaway Vineyard 1 had half its block assessed, the Padthaway Vineyard 2 had four rows assessed, the Wrattonbully vineyard had eight rows assessed. Data collected from the Greenseeker® was also called NDVI value represented as two colours: red, indicating bare cordon and green indicating canopy was present. The NDVI value is between -1 and +1 and when used in agriculture they vary from 0.1-0.3 for bare soil, reaching to 0.8-0.9 where vegetation has a large dense canopy (Mazzetto et al 2009).

On further analysis of the data in January it was decided to revisit the Limestone Coast other vineyard to investigate the difference between averaging two rows of data versus one row. The vineyard was re-run in February with one camera being blocked off, so that only one row of data could be collected.

GPS Survey

The two Coonawarra vineyards were assessed differently from vineyards 1-4 with the intention to see how accurately the Greenseeker® can detect affected cordon. Using a hand held computer that had the respective Coonawarra Greenseeker maps loaded onto it and GPS activated, an operator randomly selected a row to walk down and selected sites within this row. At these sites four vines (two each side) were assessed for % missing or dead cordon and this data recorded on the computer with the corresponding GPS coordinates. In total 49 and 24 sites were visited at Coonawarra Vineyard 1 and 2 respectively (Figure 2). The following tables describe the information recorded at each site:

Coonawarra Site 1:

Vine 1	Vine 2
5	0
30	0
85	0
2	0
0	0
75	0
0	60
5	75
0	15
0	0
5	70
25	5
10	65
85	0
5	0
0	10
0	75
0	50
0	85
60	0
15	0
95	0
0	50
0	40
80	0
0	0
60	0
0	0
50	0
0	75
90	70
0	0
0	60
0	0
5	0
0	10
0	0
0	0
5	0
0	5
0	0
0	0
0	0
50	0
50	0
30	0
5	0
60	0
20	60

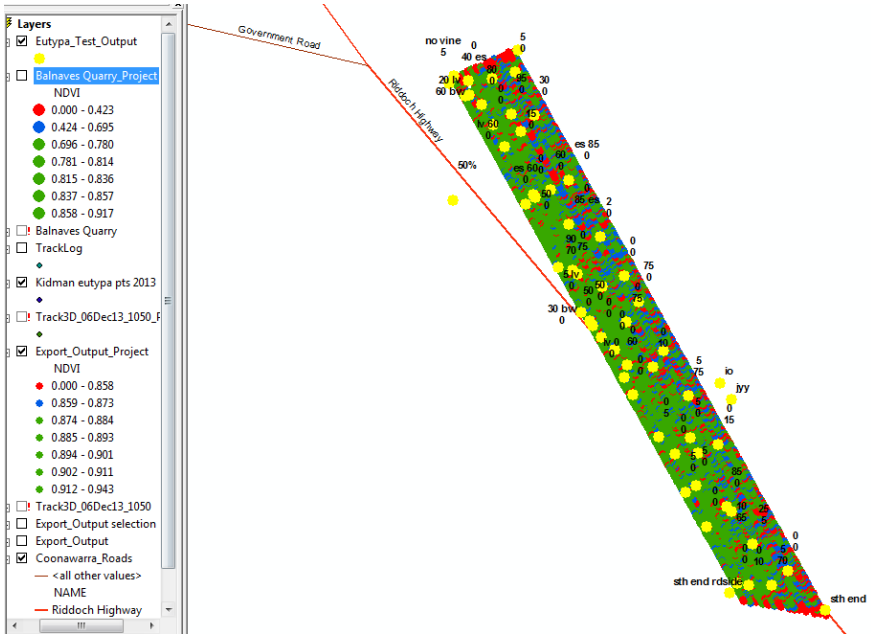
Coonawarra Site 2:

Vine 1	Vine 2
30	90
15	0
30	0
60	40
70	45
40	0
20	0
5	10
30	70
75	50
5	80
40	100
15	10
40	100
70	5
80	35
40	40
90	20
60	5
5	0
75	0
50	0
0	20
50	0

Figure 2 Percentage of missing/dead cordon at two sites in Coonawarra recorded by visual inspection. Vine 1 refers to left hand side of the row and vine 2 to the right hand side of the row. These were then averaged.

Figure 3 shows the Greenseeker® image that was displayed on the portable computer that ground truthing was based on:

Coonawarra Vineyard 1:



Coonawarra Vineyard 2:

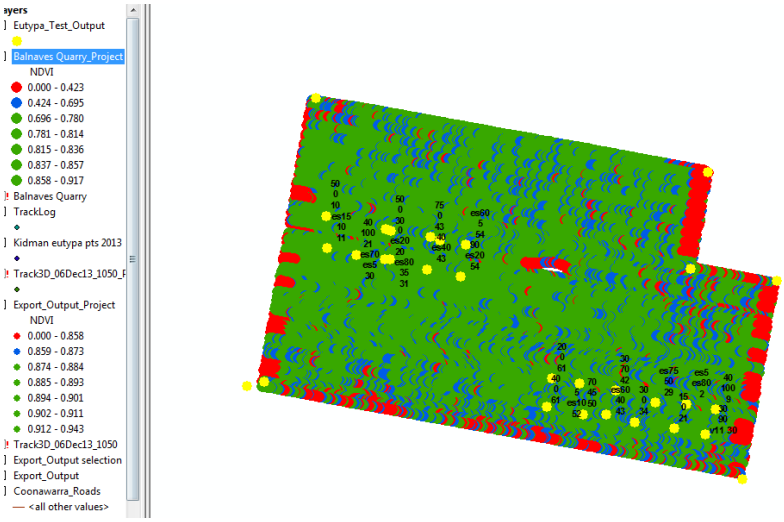


Figure 3. Diagrammatic representation of the ground truthing data overlaid on the Greenseeker® map both Coonawarra sites.

Results & Discussion

LSC Survey

Limestone Coast Other

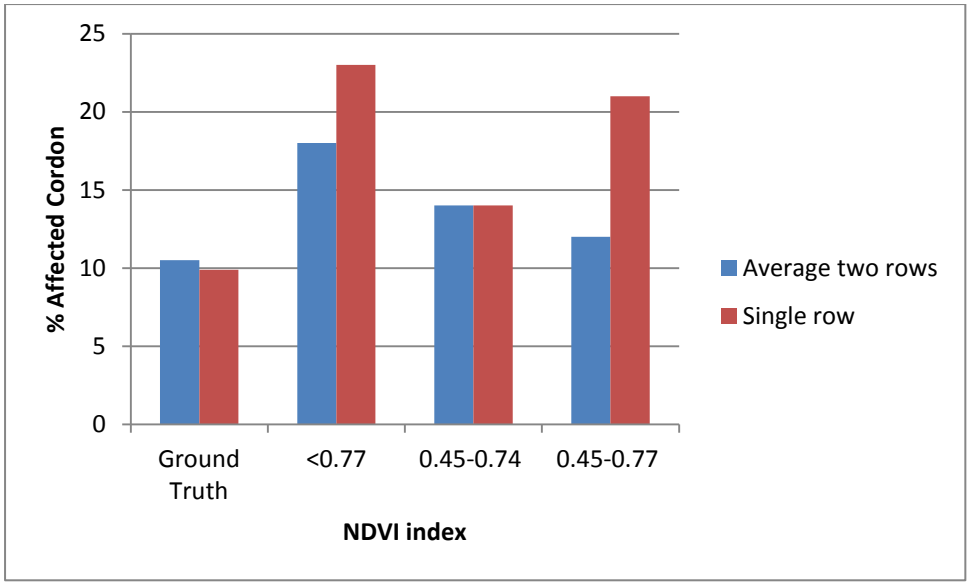


Figure 4. Limestone Coast Other vineyard comparison between the Greenseeker® (GS) and ground truthing on level of affected cordon with various indexing levels and the use of two row and single row data collection.

Limestone Coast Other was the only vineyard to have all rows ground truthed. The level of affected cordon was determined to be 10%, when averaging two rows (Figure 4). The default Greenseeker® NDVI indexing (0-0.775 Red, 0.776-1.00 Green –created by operator), determined the level of affected cordon to be 18.9%. When further manipulation of the indexing levels was undertaken (removal of anything under 0.45) it reduced the level of affected cordon to 12%, much closer to that of the ground truthed data. The decision to remove anything under the 0.45 level was made to exclude 'noise' as indicated with the 'bell curve' distribution created by the ARCGIS software (similar to those represented in Figure 8). This vineyard did have a small proportion of cordon that was just bare wire (where vines had not established) which would make up some of this noise.

This vineyard was re-run with a Greenseeker ® in February to assess differences that may occur from averaging two rows to that of every row being run separately, this is reflected in Figure 4. The default numbers actually increased the percent of affected cordon to 23%. Unfortunately, no ground truthing was done after this run so we cannot prove that the % affected cordon was due to the running of individual rows.

Padthaway Vineyard # 1

Padthaway Vineyard 1 had half of its block ground truthed (10 rows), and was found to have 7 % affected cordon (Figure 5a).

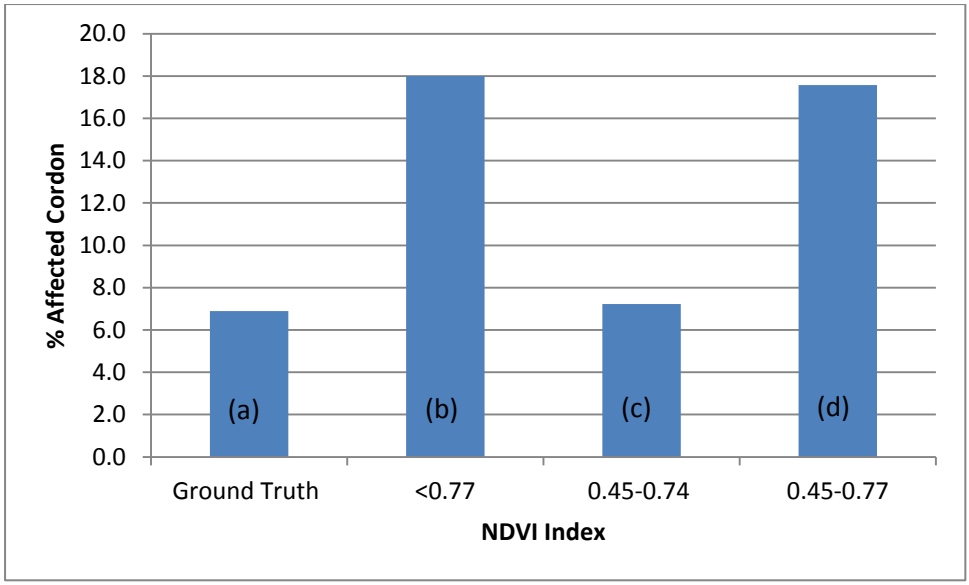


Figure 5. Padthaway Vineyard 1 comparison between the Greenseeker® (GS) and ground truthing on level of affected cordon with various indexing levels.

When using the default indexing level (Figure 5b) where the cut off between red and green is 0.77 it was determined that 18% of the vineyard had affected cordon. This is 11 % more than assessed by the ground truthing method. When the data was manipulated to eliminate any 'noise' below 0.45 this reduced to 7.2 % of the vineyard when the cut-off point was set at 0.74, but remained at 17.6% when the cut-off point was set at 0.77. This 3% difference may be accounting for the 'eutypa' affected vines where there is still green tissue but it is not reflecting on the 'green' scale like healthy tissue. This would need to be investigated further.

Padthaway Vineyard #2

The Padthaway vineyard 2 was the oldest of all vineyards surveyed and also had a t-trellis cordon structure. Due to the size of the vineyard only 4 rows were surveyed to determine if using a subsample of rows would be enough to represent the entire block. Figure 6 (a) shows that the 4 rows of ground truthing had 27% of cordon affected and the Green seeker® data 37%. When we tease out the individual rows, the rows 14/15 (Figure 6b) had a much higher % affected when compared to the Greenseeker® data (27% versus 16% respectively) and rows 29/30 (Figure 6c) the opposite (27% versus 34% respectively). When the data is averaged (Figure 6d) we return a very similar result, with 27% from the ground truthing and 25% from the Greenseeker®. Although this number is 10% lower than the Greenseeker® total assessment of the block it does suggest that sub sampling may be representative of the block. We were unable to manipulate the indexing like the previous two vineyards due to time constraints which may bring this % affected cordon in line with the ground truthing data. This would be an area to explore further.

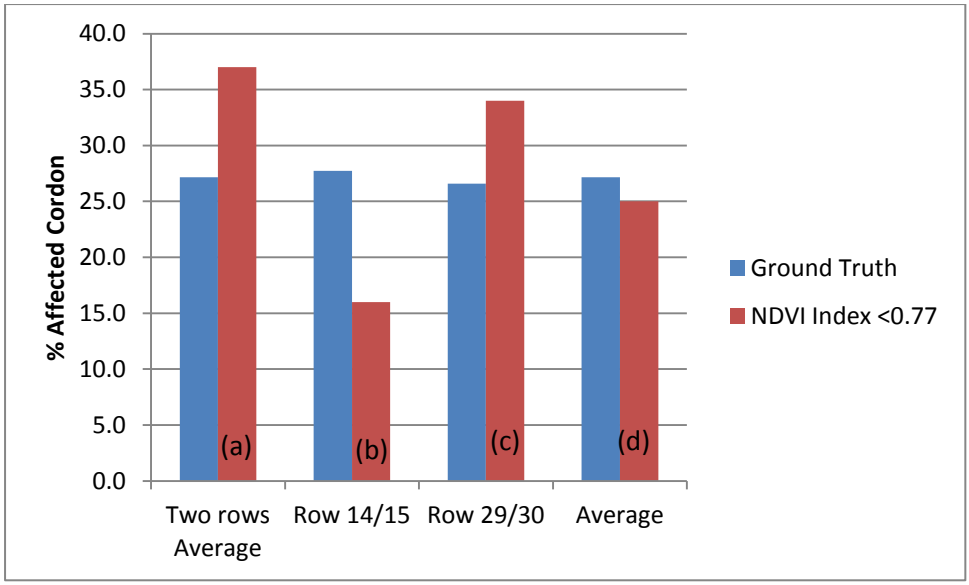


Figure 6. Padthaway Vineyard # 2 - comparison between the (a) ground truthing (b&c) Greenseeker® data using the surveyed rows only and (d) Greenseeker® data from the entire block

Wrattonbully vineyard

This vineyard is set up on a two wire vertical cordon system and visually is the most even of all vineyards visited, it also had the least % affected cordon. Eight rows were surveyed, resulting in 2.6% of affected cordon (Figure 7). When the individual rows were analysed using the same indexing scale as the other vineyards 2% of cordon was affected. The Greenseeker® data for the entire block indicated 1.5% of the block had affected cordon. Based on the data collected for this vineyard the use of subsampling rows to determine accuracy of the Greenseeker® data would be warranted, as results were very similar.

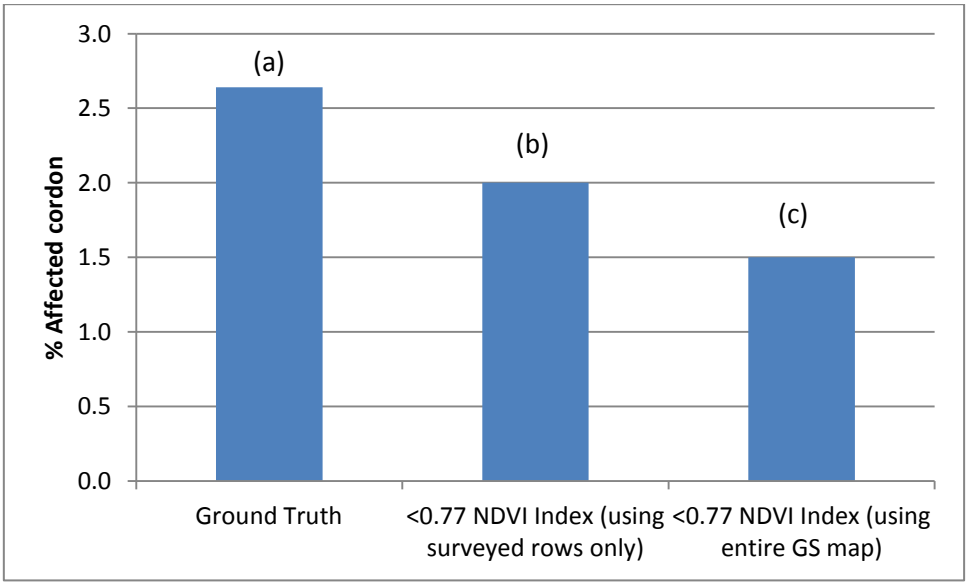


Figure 7. Wrattonbully Vineyard comparison between the (a) ground truthing (b) Greenseeker® data using the surveyed rows only and (c) Greenseeker® data from the entire block

Coonawarra Vineyards

Both vineyards in Coonawarra were devoid of ”noise” prior to assessment. Essentially, the quadrants were examined and levels of noise were excluded from the data set. Figure 8 shows the exclusion of noise. In the original quadrant data (Figure 8a), the lowest NDVI scale is at 0.545, however in figure 8b, you can see the bell curve has moved to now exclude this data, commencing at 0.423 NDVI scale.

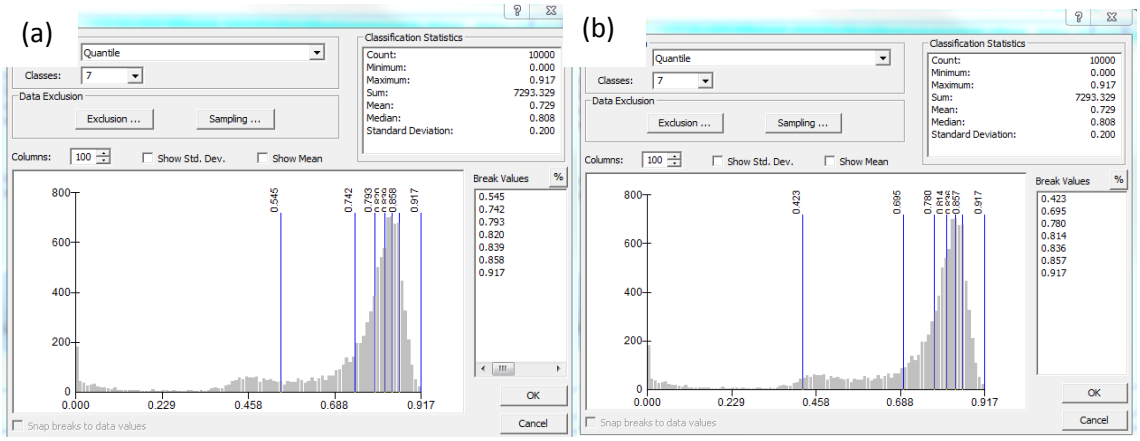


Figure 8. Bell curves indicating NDVI distribution (a) Original quadrant data with lowest NDVI break indicated at 0.545 (b) manipulated bell curve eliminating ‘noise’ by moving NDVI break to 0.423.

Coonawarra Vineyard 1.

A total of 5734 NDVI points were assessed for this vineyard. Of the points assessed by GS, 29% were found to be affected by Eutypa. Ground truthing results showed an incidence of 19%.

Coonawarra Vineyard 2.

A total of 17722 NDVI points were gathered within this vineyard and results identified a GS incidence of 21.5%, while ground truthing was higher at 35.7%.

Conclusions and Recommendations

- Historical data collection by Greenseeker® in Coonawarra has shown an ability to detect vine decline when used in successive years. It relies on the data being collected annually and using the same indexing levels. For a simple decision making tool this maybe all a grower requires , but does rely on a few years data collection before a decision is made on a the viability of a block.
- A better understanding of the accuracy of the Greenseeker® data that is produced was the aim of this project. The need to manipulate the indexing level to improve accuracy has been shown. The reason for needing to alter this level may be due to a number of reasons, including timing of assessment/growth stage (Padthaway vineyards more advanced that

vineyards further south), varietal differences, influences of rootstock, salinity etc. This could be investigated further and may have already been done in other crops.

- What level of accuracy is required? Is a 10% difference between what the Greenseeker® produces to that of a ground truth method bad (Padthaway vineyard # 2). This would require some statistical analysis, which is beyond the scope of this project.
- Averaging two rows worth of data versus individual row data collection would need to be investigated further. Do you increase your accuracy by running every row, and do you need to go down the same side of the row (obviously increasing the time required to complete the survey). This may vary depending on the cordon structure (ie t-trellis, single wire or two wire cordons).
- Is there a potential to ground truth in detail one vineyard and apply the NDVI scales to other vineyards within the same district. Or could this approach over or under predict incidence?
- What reflectance is provided by vines that are afflicted by the Eutypa disease? This may have been done in other crops and requires more investigation.

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