High Resolution Imagery for Forensic Agronomy

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Key Findings

1. High resolution imagery (pixel size <2.5m) will help determine the causes of spatial crop variability, unlike coarser spatial tools such as yield monitoring.
2. Good quality data is crucial.
3. The Near Infrared (NIR) band is the most critical in determining the crop variability, and crop vigour analysis (such as NDVI) adds value.
4. Four band images that look 'real' when presented in colour (like an aerial photo that growers and consultants can relate to) are essential. Many image types do not contain a blue band and cannot achieve a true colour image.
5. High resolution imagery is cost effective – less than 50c/ha (minimum areas required).
6. Combining imagery with farm operation logging will increase value.

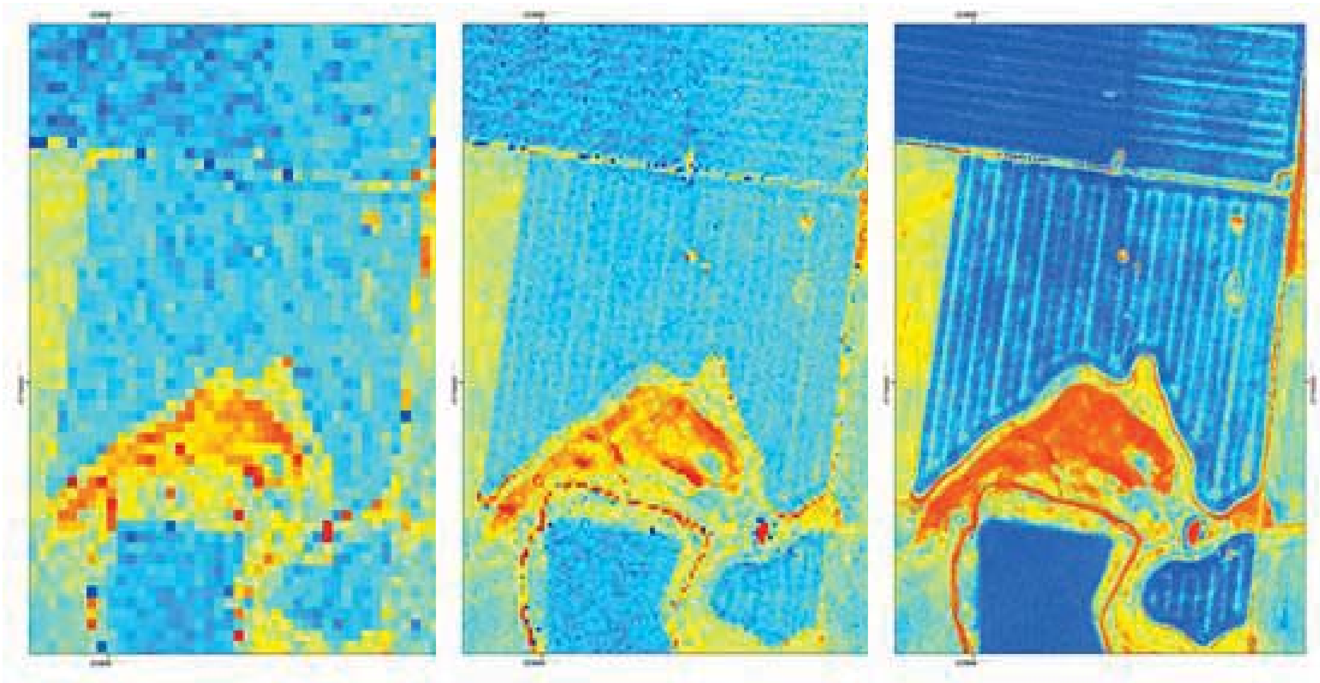
Introduction

CTF Solutions aims to help it clients identify, understand and manage crop variability occurring in paddocks and farms. Variability is spatially distributed and one obvious way to measure it is from above. The CTF Solutions team had experience with aerial surveys of erosion following heavy storms in central Queensland in 1997. Photographs recorded erosion and responses to improved management (controlled traffic and zero till) and the observers gained a profound experience of the devastation. However, the data was not digital or spatially accurate. The high resolution of the information showed that most of the variability was present at the 1 metre or less scale and that rilling was the dominant erosion process.

Research by Troy Jensen and Tim Neale on the Darling Downs in 1998-2001 used crop row harvests to show yields varying 4 fold within a 9m planter width in some situations. They identified that the process causing this variability was soil compaction by machinery wheels. Since crop growth was similarly affected, high resolution photographs in the near infra red band would also record this variability from above.

In late 2003, CTF Solutions purchased two metre pixel aerial imagery on five Inverleigh (near Geelong) clients. The results were astonishing. Growers saw things in the imagery that they had never seen in the paddock before. Growers and consultants now had a remote sensing tool to identify and quantify in-crop variability in their paddocks. And, due to the small pixel size, it was possible to identify causes of most of the variability.

This was a major breakthrough for Precision Agriculture as the typical PA tools (yield monitors, EM, soil sampling, soil types, LANDSAT imagery) could identify variability at a coarse scale, but not develop processes and causes. This is clearly shown below where the left image is 25m pixel, middle is 10m pixel and right is 1m pixel. Red/orange is poor growth and blue is good growth.



In 2004, our clients in Geelong decided to ramp up the data capture from paddock to whole farm and to get more people in the district involved. Due to the large capture area, and cost and unreliable availability of aerial imagery, we investigated 1m resolution imagery from the recently launched IKONOS satellite. 17 farmers became involved and a 40,000ha IKONOS capture was programmed. Subsequent captures in Geelong were in 2005 (x 2 dates), 2006, and 2007 with increasing areas and participants.

After the experiences with the Geelong growers, image captures have been conducted in other dryland grain growing areas, including Central Queensland (Duaringa, Wowan, Emerald), Southern Queensland (Warra, Macalister, Clifton), Northern NSW (Quirindi, Condobolin, Moree) and south-west Victoria (Lismore).

CTF Solutions has now captured over 800,000Ha of high resolution satellite imagery across Australia. The major driver has been the focus on high resolution data that led to better information and understanding and finally, to better decision making.

Overview

The presentation will focus on what high resolution imagery can see, and what value that has been to our farmers.

High resolution imagery has identified the following causes of variability:

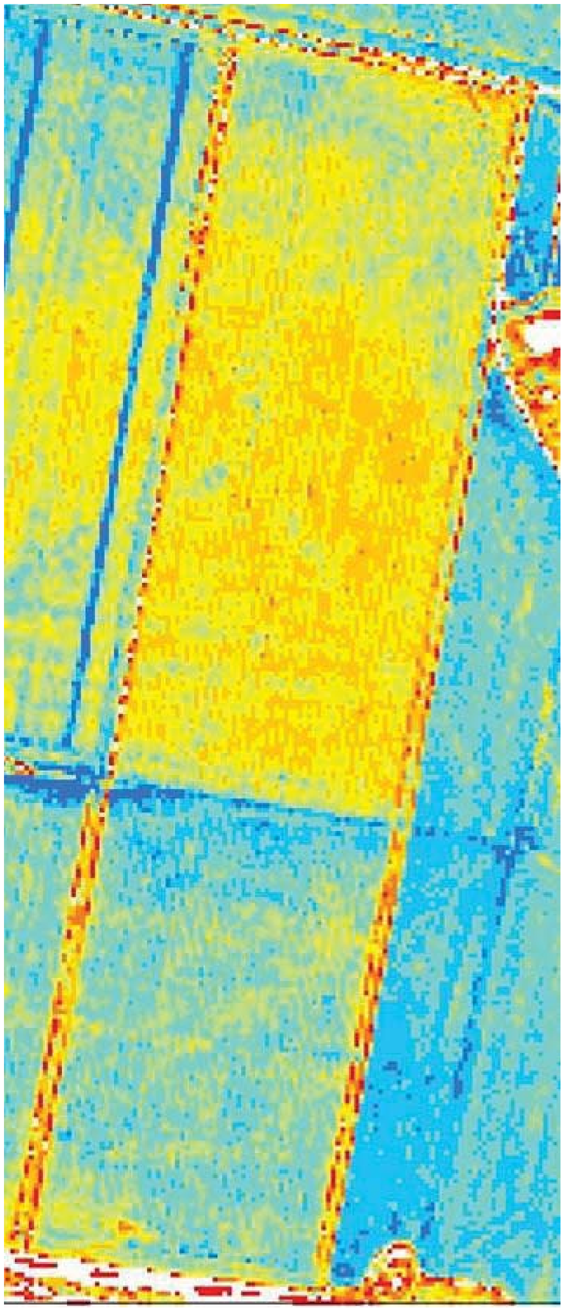
a) ***Variability caused by farmers***
- manure, gypsum and lime responses
- paddock history and previous management
- header windrow trails
- compaction and random traffic
- damage of crops from sprayer traffic
- planter problems
- variety differences
- missed fertiliser areas

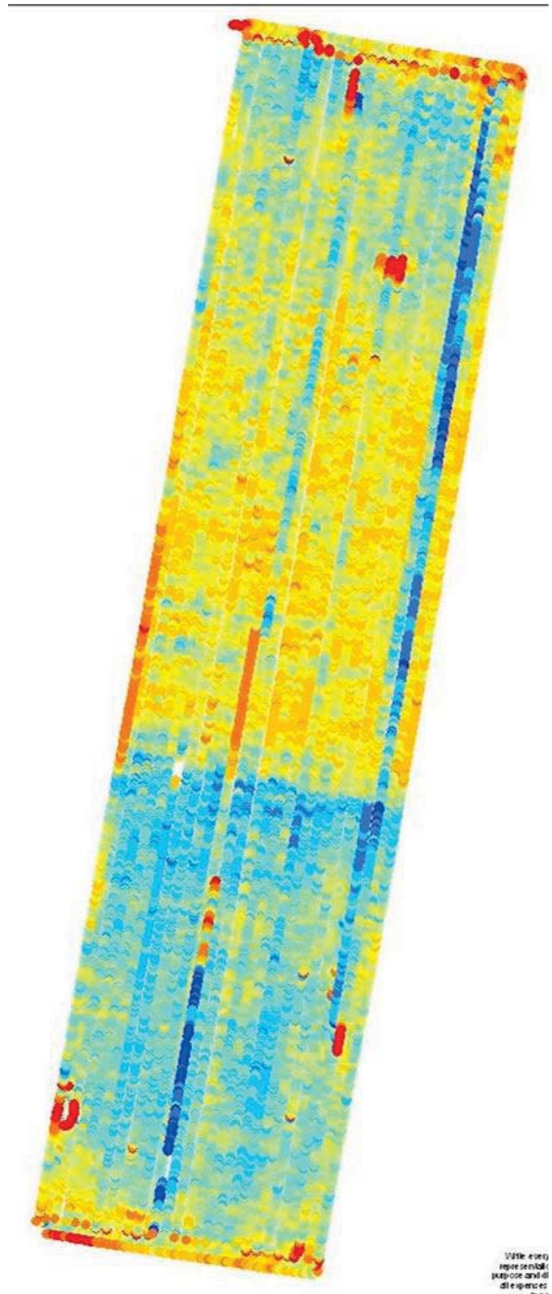
b) ***Variability that growers can manage***
- water logging (partial and complete crop loss)
- pest damage, weeds, and disease hot spots
- planter blockages
- nutrient deficiency symptoms and missed fertiliser strips
- effect of rock heaps/trees on efficiency
- paddock in-efficiencies
- growth regulator response

c) ***Variability due to basic resources***
- Soil differences
- Landscapes

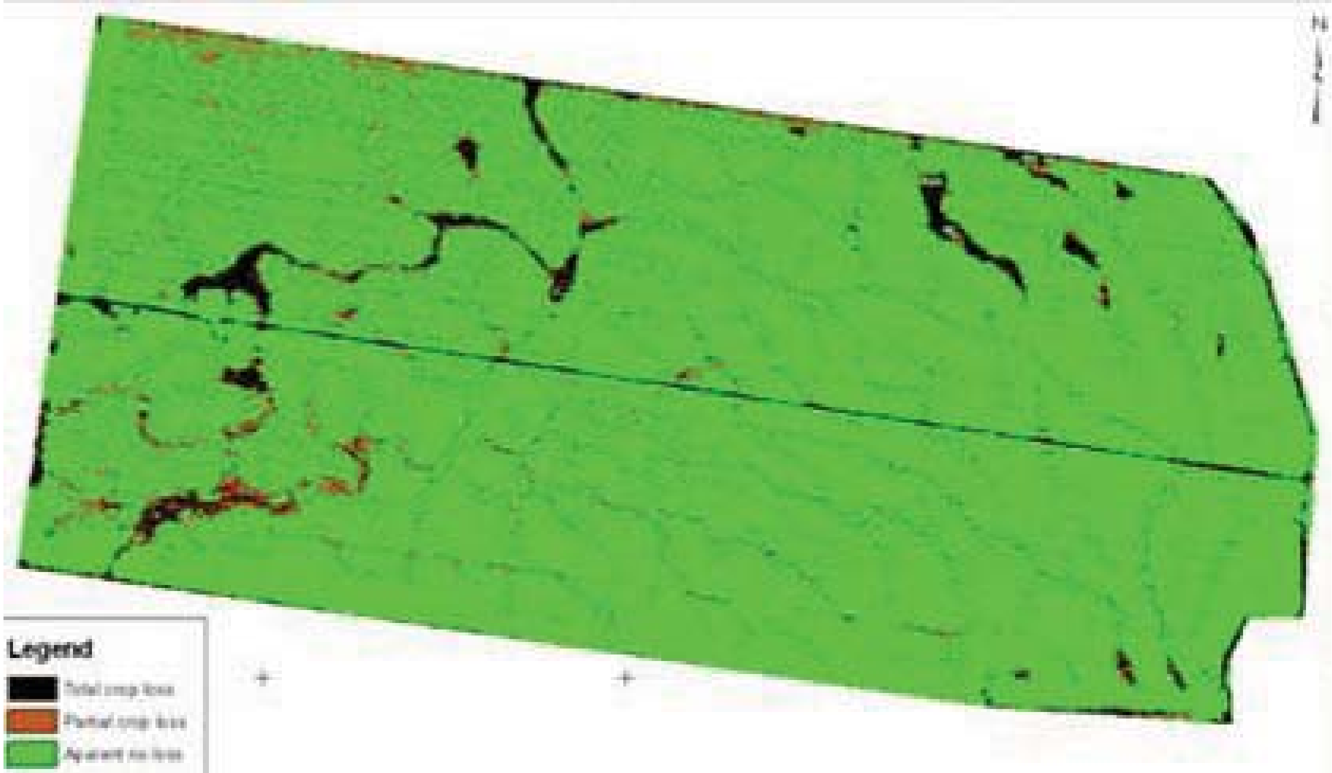
You will notice that variability due to basic resources is placed last. This is because most of the variability we see in imagery is as a result of actions by farmers or that farmers can manage. Most other PA tools focus primarily on soil differences.

Comparing high resolution imagery against other data layers in a GIS has provided additional value. High resolution NDVI image (left) shows good correlation with yield map (right).



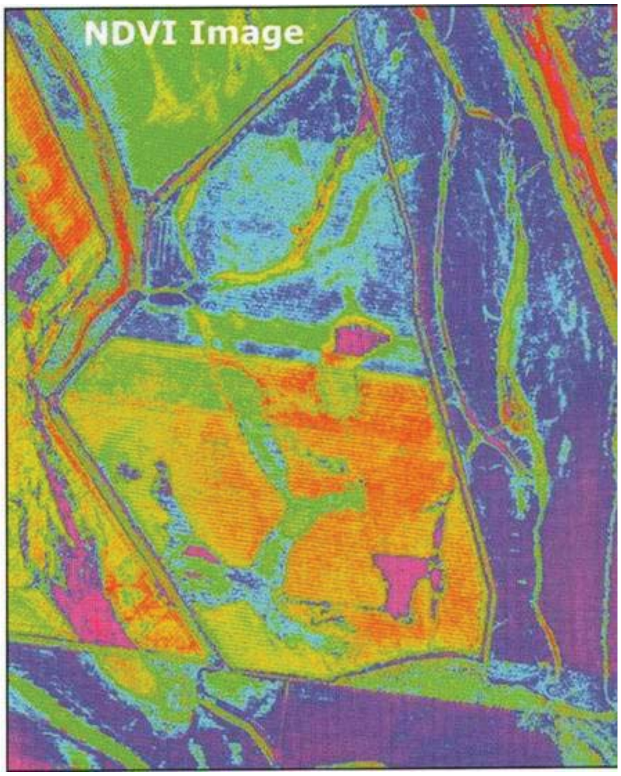


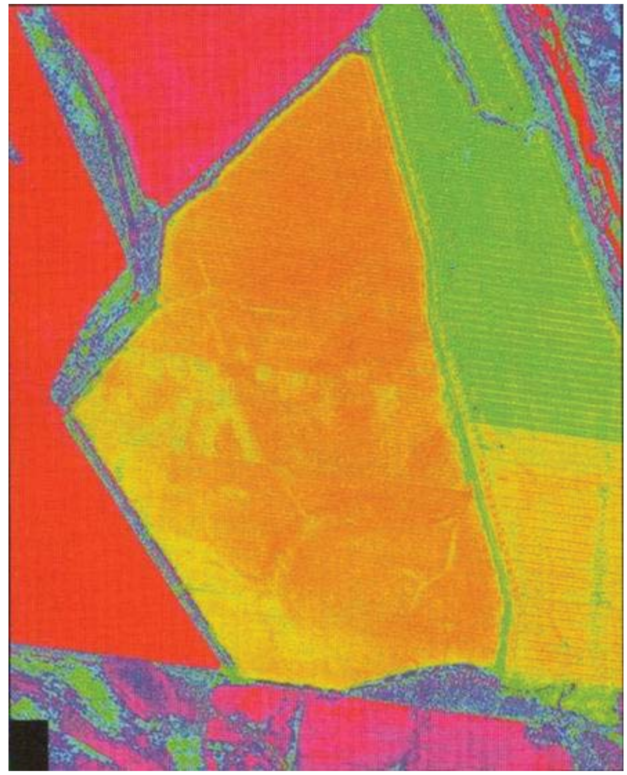
High resolution imagery has also identified water logging as a major production limiting factor, even though we have had significant drought periods over much of our clients growing areas. The image below is from Quirindi, and has been classified to separate completely waterlogged areas (black), partially waterlogged areas (brown) and unaffected areas (green).



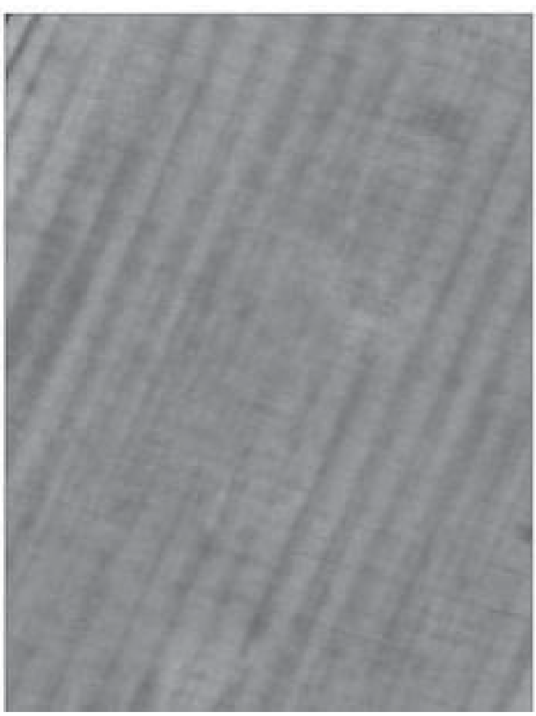
Economic analysis revealed that this water logging cost the farmer $25,000 in this paddock alone. The worst affected areas (black) were visible in the yield map, but the minor water logged areas (brown) were not very distinguishable in the yield map.

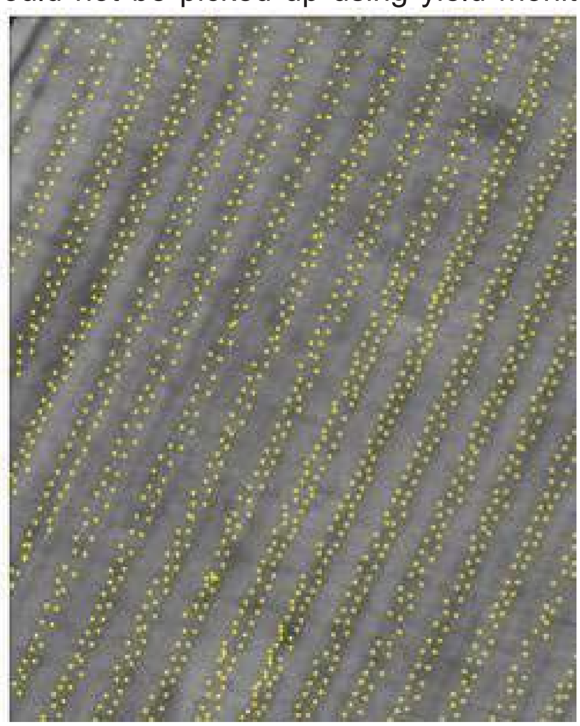
The NDVI images below show a 400ha paddock in Central Queensland with high variability in 2004 (left) and subsequent image in 2006 (right). After the 2004 image was captured, drainage work was conducted to minimise water logging, with the outcome being identified in 2006, which was a very wet winter. High definition topography mapping also made this possible by identifying the best options to drain the paddock. $5000 worth of drainage work yielded $53,000 extra income.



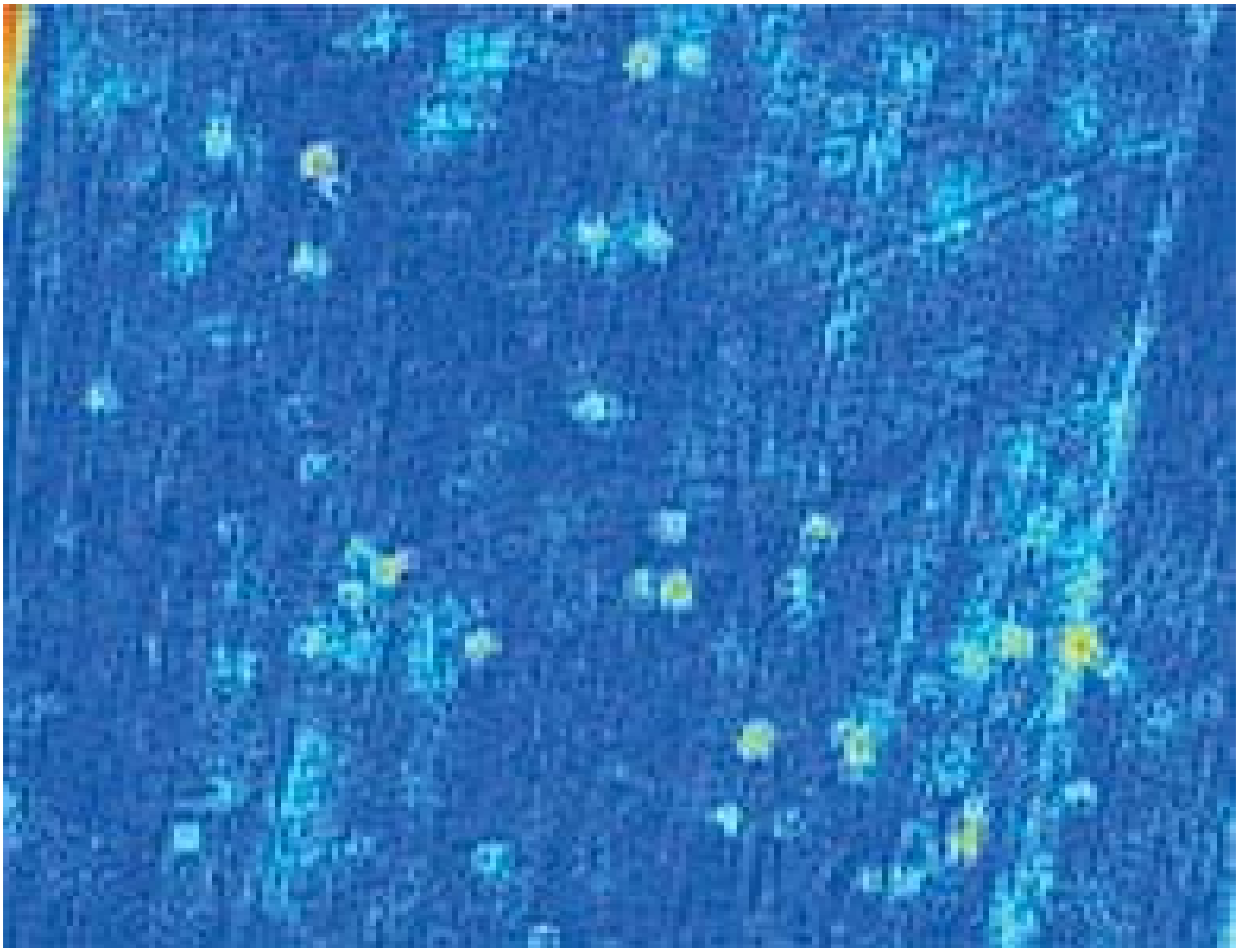


Harvest operations from previous years also cause significant crop variability. In a 2003 NIR crop image (below left) we noticed a major striping pattern that was across the planting direction (white is good and black poor growth). We had yield monitor data from 2002 which also showed where the harvester drove (yellow dots in below right overlying the image). Clearly, the reduced growth in ~50% of the paddock was in some way due to the harvester operations the season before. These effects would not be picked up using yield monitoring.

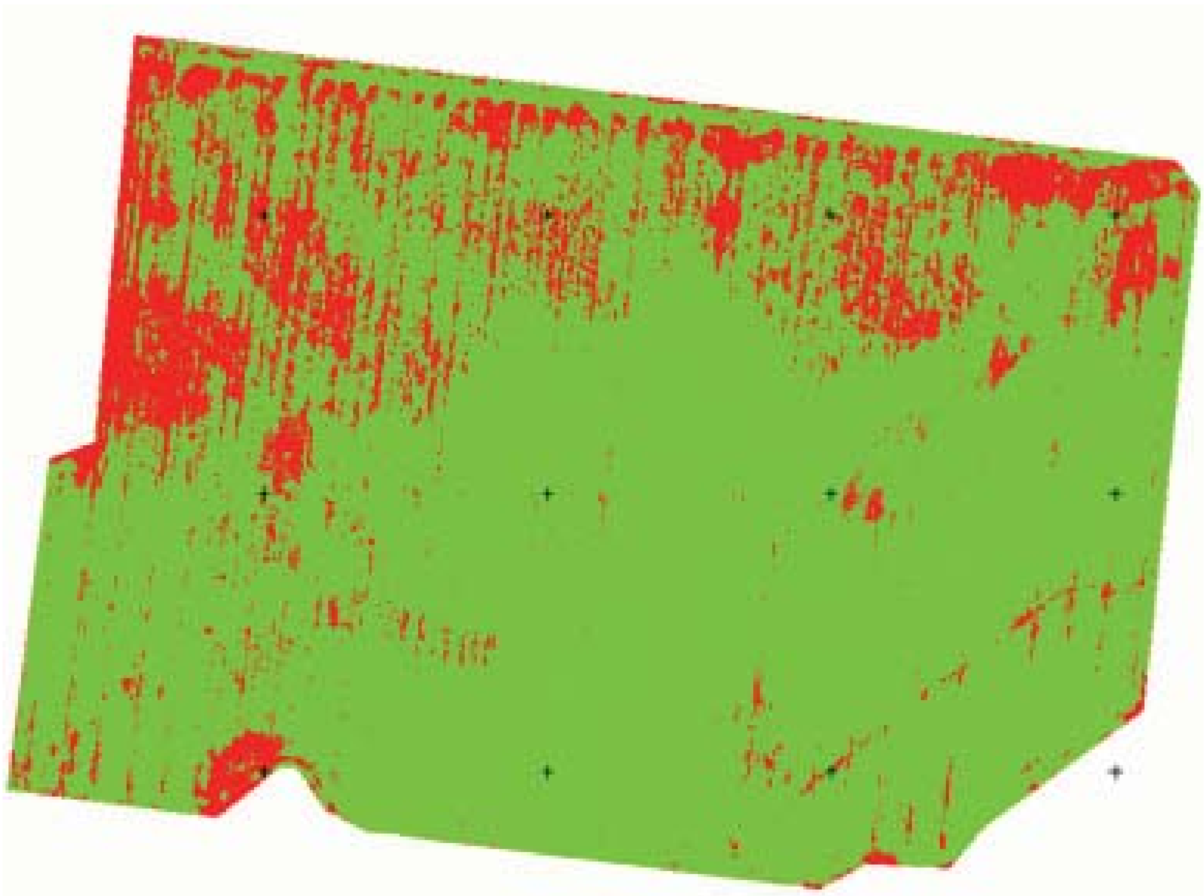




This NDVI analysis (below) from a 1m pixel satellite shows small red dots (poor growth) which are ‘hot spots’ of Rhizoctonia in barley. They are only 3-4m in diameter on the ground, and were not identified by the farmer or agronomist prior to image capture. The grower immediately changed his plans for this paddock to prevent massive crop losses in coming years.



A supervised classification has been conducted on an NDVI analysis (from a 1m pixel image) of this paddock below. Red areas related to earwig damage, whereas green areas represent no earwig damage. Originally, this was thought to be slug damage. Calculation of affected area identified approximately 20% of this paddock had been affected by the earwigs.



Conclusion

Work with our clients has shown that high quality data (1m and 2m pixel imagery) can identify and quantify paddock variability, can inform us on the likely causes and processes involved, and can suggest possible on-farm responses. This causal and process information is pivotal to knowing how to use precision agriculture. The imagery also provides products that farmers can relate to and understand, and the information is applicable to their farms. It facilitates better decision making and supports change.

The imagery has identified problems, indicated how to fix them, and suggested how to apply the options and engaged farmers in partnership with acceptance and relevance.

Our clients are among the best farmers and yet high resolution imagery has led them to significant change with significant positive impacts on the triple bottom line.