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From the president

The second half of the year heralds the launch of the R&D investment plans for many organisations. I am pleased to report that SPAA has initiated and been invited to join discussions on a wide range of PA related projects. As plans are finalised we will bring you more details but I can say these potential projects cut across multiple industry sectors and some include unmanned aerial vehicles in one form or another. They will also help SPAA to promote the adoption of precision technologies in agriculture, viticulture and horticulture.

I can confirm that following the very successful series of Expos run in four states in 2014, there will be a follow up series in 2015. Reports from the Expos and other activities that SPAA has been involved in the past four months can be found in the SPAA news pages.

The Bureau of Meteorology reports that winter rainfall was 28% below the long-term mean when averaged nationally. Only the Kimberley and Cape York regions reported above average. Again rainfall will be the key limiting factor for all dryland systems.

In this issue read how one WA extensive livestock producer is harnessing technology to help him manage his very dry farming system.

Neale Postlethwaite
President SPAA
www.spaa.com.au
Since the Winter Issue of Precision Ag News, SPAA has run or been involved with seven events across Australia, which were attended by over 500 participants. These include two controlled traffic farming (CTF) workshops (Eyre Peninsula, SA and Croppa Creek, NSW).

We have run another three Precision Agriculture Expos (see page 6) that have been extremely well received and have supported speakers at the Esperance Downs Field Day, WA, which had a PA focus.

SPAA’s involvement with these events has meant that even more farmers and industries are aware of the role of SPAA and we are keen to continue to support producers in these regions as they embark in applying PA.

Many thanks to Alex Milner-Smyth for her work as event coordinator for these activities. Alex has also helped to keep the SPAA flag flying while I have been on maternity leave.

On pages 7 and 8 you can read about some of the highlights from this year’s very successful 17th Precision Agriculture Symposium in Australasia, which SPAA ran again in collaboration with the University of Sydney’s PA Lab.

In November, SPAA organised a precision viticulture event with support from the South Australian SE NRM Board and the Coonawarra Grapegrowers Association. Our workshop focussed on the use of remote and proximal sensing in vineyards. Next year SPAA will arrange a trial post harvest to assess vine water stress using images from several data sources.

All of these events are designed to help support the adoption of PA across all industry sectors and regions of Australia.

As with all our activities they could not occur without the generous support of our sponsors and funding bodies.

I am pleased to announce that Grain Growers and John Deere have committed to another year of silver sponsorship. This is the fifth year of John Deere working with SPAA and we look forward to continuing to build this relationship.
Committee out and about

The SPAA committee members put in considerable effort to help promote the adoption of precision agriculture. Many of the committee attended and helped at the 17th Symposium on Precision Agriculture in Australasia including Ed Cay, Todd Matthews, Sam Trengove and Frank D’Emden.

President Neale Postlethwaite welcomed everyone to the event and facilitated a session. Committee member Robin Schaefer shared his experiences, joys and frustrations of PA in his grain business. Sam Trengove provided an update on SPAA projects and has represented SPAA at several research project meetings.

Grant Pontifex and Jessica Koch hosted the international speaker Lucas Haag before the event and helped him tailor his presentation to an Australian audience.

Committee members have been instrumental as presenters and facilitators at two controlled traffic farming workshops. Chad Glover and Randall Wilksch ran the CTF workshop at Ungarra, Eyre Peninsula that was attended by 38 participants. Tim Neale presented at the Croppa Creek, NSW workshop which attracted a similar number. Tim also presented at the Quirindi PA Expo and at the World Congress on Conservation Agriculture in Canada. There he was addressing how PA will help feed the world’s growing population.

On a similar theme Craige Mackenzie will participate in a Global Farmer Roundtable in Iowa, USA to discuss the Truth About Trade and Technology - www.truthabouttrade.org. He also attended the International Conference on Precision Agriculture in California.

Neale Postlethwaite and Robin Schaefer both attended the Australian CTF Conference, and have hosted groups of interstate farmers looking at CTF and PA. Neale and I also attended a round table meeting with seven universities to discuss the development of a common approach to PA in education.

Frank D’Emden represented SPAA at the Esperance Downs Field Day and facilitated a session at the Moora Expo along with speaking at the Western Dairy Spring Field Day, the Far East Ag Research Group Spring Field Day and the Australian Fodder Industry Conference.

SPAA Research Projects

A new project funded by the Grains Research and Development Corporation and run by the Australian Controlled Traffic Farming Association is looking at the application of CTF in the low rainfall zone. SPAA is providing technical and research support as well as managing the communication. Other organisations involved include DEEPI, SARDI and a number of farming systems groups.

Working in collaboration with farming systems groups in the low rainfall region, the project will run four main trials on a calcareous sand (Eyre Peninsula, SA), red-brown earth (Upper north, SA), Mallee sandy loam (SA Mallee) and a deeper Mallee sand (Victorian Mallee).

In a second project, a trial looking at weed identification in the growing crop, has now started (see PAN 10.3). This work is supported by SA Grains Industry Trust for the next three years.

This research is looking at validating and developing Australian data for the H-sensor, which has been developed by a German company. The first sensor arrived in July. The trial will include crops and weeds not tested in Germany, for example, chickpeas, lentils and canola.

This project will also be about creating classifiers for key cropping weeds in no-till, stubble retention systems. The sensor has its own light source so it can be used day and night. It uses shape parameters to differentiate between crops and weeds.

Early experience has proved very positive in a range of crops and situations with different weeds. As information becomes available it will be shared through SPAA communications.
Over 380 delegates from across four states have had the opportunity to learn from farmers, agronomists and researchers about the latest developments and application in PA at the Expos.

Four of these events were supported by the Australian Government under a Community Landcare Grant. Other supporters have included the Grains Research and Development Corporation, NSW Local Land Services, WA NRM (NACC), NAB Agribusiness, Stock and Land, as well as SPAA’s key sponsors.

Presentations have related to dryland and irrigated agriculture, to a range of agricultural sectors including grains, cotton and rice as well as to pasture and livestock production, orchard crops and viticulture.

Copies of the proceedings from each of these events can be downloaded from the SPAA website – go to the communications tab and select event proceedings.

The first Expo for 2015 will be held in February on Yorke Peninsula, South Australia. Details will be posted on the web as available.

The SPAA Expo at Moora Western Australia saw a great turnout with 70 participants. A popular speaker was Christen Nansen from the UWA Institute of Agriculture.

Christen is seen here explaining his free app Snap Card. Available for iOS or Android through the usual channels, this app helps calculate/predict spray coverage based on spray settings and weather conditions. Using the app should help farmers optimise spray coverage and reduce risk of spray drift and pests developing resistance.


Other presenters looked at cost effective PA, farming to the soil bucket and PA in different industries including horticulture and livestock.

UAVs are the flavour of the month and at the Ballarat Expo Martin Peters explained the process and investment he has gone through to become a commercially accredited UAV pilot.

He also discussed the collection and processing of 800 images, from a paddock. Taken with 90 per cent overlap the images were processed with a 3D elevation model. This enabled differences in individual plant height to be recorded. It also showed differences in the depth of CTF wheel tracks and could be used to generate a track renovation map.

Pictured left to right - Martin Peters (Farming IT), Neale Postlethwaite, Josh Walters (Murnong Farming), Jade Killoran (Southern Farming Systems) and Andrew Whitlock (Precisionagriculture.com.au).

Other speakers looked at bringing precision to mixed farming systems and livestock, improving nitrogen use efficiency and plant and row spacing.

Participants at the Quirindi Expo learnt about the value of PA from several speakers including SA farmer Mark Branson (3rd from right). Mark has been using CTF for 10 years and eight years of full PA. He presented a breakdown of the cost savings these have brought him. He estimates an annual benefit of $57.17/ha

Pictured left to right - Angus Duddy - Warrawong Farming and Pastoral company, Greg Giblett - Agromax Consulting, Mark Kesby - Namoi regional Landcare facilitator, Mark Branson - Branson Farming, Dale Kirby - North West Local Land Services, George Truman - North West Local Land Services

Other presenters looked at precision irrigation, unmanned aerial vehicles (UAVs) and PA in the grazing industries.
At the 17th Symposium on Precision Agriculture in Australasia, international speaker Lucas Haag said his ultimate objective is site specific management. However, he encouraged the audience to answer the following questions before adopting variable rate.

1. Does it make sense agronomically?
   a. Is a factor that affects yield being addressed?
   b. Do I adequately understand the input versus yield response of what I am managing?
   c. Am I addressing the issue in an environmentally sound way?
   d. Do I have a way to evaluate this method of management?

2. Does it make sense technically?
   a. Can my method of application accurately apply my intentions?
   b. Do I have a way to evaluate the results e.g. as applied maps?

3. Does it make sense economically?
   a. What are the true costs of implementation, including my time?
   b. What is the probability distribution of years in which this will pay?
   c. Is there a better way to achieve most of the benefit with less cost?
   d. Am I collecting enough data in my agronomic and technical evaluations so that I can evaluate the economics of the practice?

He also cautions against dumbing down large datasets by accepting the average value for a zone. His aim is to create zones of yield potential (stable high, stable low, and average) generally using yield and soil type data and then running rate response trials within a zone. This data can then be used in a future season to create a graded prescription rate within the zone.

That is assuming going to variable rate for that input in that paddock meets the criteria set in the previous three questions. He emphasises that data should be aggregated to a spatial scale that best fits each set of data, be it zones or a continuous surface.

For more from Lucas Haag see pages 9-10.

At the 17th Symposium on Precision Agriculture, the PA Student of the Year Awards were presented to two students. This is the fifth year of this award for students studying at the University of New England (UNE).

The Undergraduate award went to Nicky Teroriero, while Ann Wallace was awarded the Post-graduate award.

Ann attended the Symposium and is pictured with UNE lecturer Dr Mark Trotter and SPAA President Neale Postlethwaite.

As part of her studies, Ann undertook a case study of a small but intensive stud operation in the Barossa Valley, South Australia running 300 breeding ewes on 51ha. Pedigree recording is an essential component of the enterprise with stud ram and ewe sales the key source of income.

Traditionally lambs were visually identified with their dams via a system of double tagging at marking. This method of identification was time consuming with on average 10% of lambs remaining unidentified at the end of a seven day observation period.

Implementation of the PA technology Pedigree MatchMaker was explored and potential labour savings and increases to the accuracy of pedigree capture (5%) were identified.

The Pedigree MatchMaker system takes advantage of normal animal behaviour where lambs follow their mothers to feed and water. The system works by recording eID tag numbers of ewes and lambs in sequence as they pass through a raceway which leads to an attractant, for example, water or supplementary feed.
Cheryl McCarthy, National Centre for Engineering in Agriculture, Queensland gave a fascinating presentation on a range of uses for machine vision that are being tested by members of this institute.

Machine vision based weed detection systems have been developed for the sugar, cotton and pyrethrum industries (last reported on in PAN 8.3). The systems analyse colour and depth, so are able to deal with more complex canopies much faster and can identify weeds under crop plants.

In cotton, machinery vision is also being used to estimate fruit count and yield and to adapt irrigation scheduling.

Grain growers may be interested to visit www.grainmonitoring.com to see the images of National Variety Trials that are being collected using remote mobile phones. These are being analysed to provide information on growth rates and maturity of different lines.

More details of these projects will be reported in future issues of Precision Ag News.

Co-organiser of the Symposium program Brett Whelan, Precision Agriculture Laboratory not only gave a good plug for Precision Ag News but also for a range of books, digital resources, websites and industry and university courses.

Check out his paper on the SPAA website for the details.

PA education resources

Western Australian farmer Simon Wallwork, pictured with delegate Greg Moorhouse, has extensively used electromagnetic and gamma-radiometric soil mapping across his Corrigin property. Having ground truthed the data, which included deep soil testing and digging lots of holes, he is now using this soil data to help direct the location of on-farm trials.

Simon has compared a DBS no-till tine seeding system with a disc on his two key soil types – sand and gravel. For his farm he found the tine resulted in about 750kg/ha yield difference.

He has also looked at the impact on yield of grazing or not grazing stubbles by soil type and compared mouldboard ploughing to deep ripping on grey and brown sands.
Working as a research and extension agronomist and being an active partner in his family’s mixed farming business puts Lucas Haag in a powerful position. Not only does he have the time, enthusiasm and resources to investigate the potential value of PA, he also can assess true on-farm benefits using data from the family’s operations.

Working across a territory of 65,000km², Lucas has plenty of opportunity to investigate the use of PA tools and techniques across a large number of farms running different systems.

While variable rate inputs are still the ultimate aim, Lucas is finding, as others before have also found, that PA is helping make better decisions on a paddock by paddock basis.

“Our goal has always been to manage the variability that exists, understand what is the cause of ‘stable low yielding areas’, and to fix the cause if economic, otherwise manage it as an area with inherently low yield potential,” explained Lucas at the PA Symposium.

A significant proportion of the family business is on leased land. Having a good understanding of production in relation to soil type is helping improve management decisions on newly leased land where historic data might not be available.

Drought can be a common feature in this region of the USA and crop yields of zero are not uncommon. Conserving soil moisture using crop residue in the zero-till system and the use of fallow are important tools. Comparing crop type/yield to the previous crop yield allows better decisions to be made. For example, the impact of fallow compared to a pea crop on the following year’s production can be assessed and used for future whole farm planning.

As Lucas explained during his presentation at the 17th Symposium on Precision Agriculture in Australasia much of the data required for the trial is already being collected via rate controllers etc, so why not put this data to use.

Indeed, as the agronomist for the Haag Land and Cattle Co., Lucas has found that mining the data that they are already collecting on their machines has provided the greatest return of all investments in PA tools.

“Detailed analysis of data that we collect automatically during most operations is helping us make more informed decisions.”

In 2001, the Haags ran two harvesters one with a stripper front, the other with a conventional front. They liked the stripper front but could they justify investing in another stripper front?

Lucas crunched the numbers and established that the conventional harvester was harvesting at a slower rate and was limited by the capacity of the harvester. The result was that the stripper front was harvesting 7.5t/ha compared to only 5.0t/ha for the conventional front. This resulted in a field capacity of 10.5t/ha for a stripper front.
front compared to 8.0 ha/hr with a conventional. This meant that the stripper front was reducing per hectare harvesting costs by up to 48%. At a harvesting cost of $150/separator hour this represented a huge pay-off and helped justify buying a second stripper front based on machinery economics alone.

Over time an additional un-costed yield benefit of up to 0.3 to 0.6t/ha has been gained in the following row crop (maize or sorghum) sown into standing stubble. This gain is due to improved residue cover preventing soil moisture evaporation. This response has been observed in both on-farm and university studies. The Haag’s farming land is spread over 35km from north to south and many paddocks are of an irregular shape. Lucas decided to look at the logistics of the seeding, spraying and harvesting operations.

“What is downtime costing us and is it most cost effective to seed or spray the next paddock with the same treatment or the nearest paddock even if that means changing inputs? These are the types of questions I want to address.”

Most of the data Lucas needed for this assessment is automatically gathered by tractor and implement monitoring systems already installed on their equipment.

“PA tools are not essential for this type of analysis but they ensure the data is gathered and recorded accurately, we just need to ‘mine’ the information.”

Across the 1100ha maize seeding program Lucas calculated how much of the difference between the hours on the seeder and the tractor represented down time due to filling.

If fill time could be reduced from half an hour to 20 minutes, that 10 minute saving would reduce costs by $1.68/ha, which equates to about $2000 across the program due to more of the tractor engine hours being used for planting. It also reduced the total time required for seeding by over a day. Mining the data not only helps to assess if an investment to save time is worthwhile, it can also help compare different options. In the example detailed in Table 1 Lucas and colleague Dr. Kevin Dhuyvetter, an agricultural economist at Kansas State University, looked at the potential savings from changing the spraying operation.

Questions they addressed included:

- How does distance between paddocks influence the area that can be sprayed in a year with the same boomwidth?
- How much would a faster speed of travel between fields change costs?
- Was it cost effective to invest in an auto-batch machine if tank fill time was reduced?

Table 1. Costs of spraying under alternative assumptions

<table>
<thead>
<tr>
<th>Distance between paddocks</th>
<th>Average road speed km/hr</th>
<th>Tank fill time minutes</th>
<th>Hectares sprayed annually</th>
<th>Total cost/ha (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 5</td>
<td>15 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance between fields</td>
<td>4.8km</td>
<td>45</td>
<td>12,000 14,323</td>
<td>$10.87 $9.81</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>12,144 14,532</td>
<td>$10.77 $9.71</td>
<td></td>
</tr>
<tr>
<td>Distance between fields</td>
<td>9.7km</td>
<td>45</td>
<td>11,342 13,394</td>
<td>$11.36 $10.30</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>11,599 13,751</td>
<td>$11.16 $10.10</td>
<td></td>
</tr>
</tbody>
</table>

Notes Table 1:

1 All modelled inputs were held constant except tank fill time, road speed and sprayer investment (assumed an extra $20K for faster fill time scenarios).
2 Sprayer engine hours are held constant at 500 for all scenarios (if area rather than spray hours held constant, gain to faster fill rate decreases).
3 Includes an estimate of ownership and operation of spray and fill equipment.
Telemetry for extensive livestock

Emma Leonard

Remote monitoring is enabling intensive management of extensive livestock systems, while saving time and resources.

Like most farmers, Tom Jackson is keen to apply the KISS principle to his farming – keep it simple stupid – but he is looking for simple methods to run complex biological systems.

“Complex biological systems are very resilient; they can adapt, simple ones collapse.”

“We need to maintain groundcover even in drought and to do this we need to allow hundreds of plant species to thrive,” explains Tom.

Tom has learnt this from firsthand experience. Austin Downs, in the Southern Rangelands of Western Australia was supposed to be able to carry 5000 ewes and 500 breeding cattle (11,000 dry stock equivalents, 1DSE/14ha). This was based on achieving five out of ten winters having good rain.

Since moving north in 2001, the Jacksons have experienced one good winter. Following two winters with no rain they had to completely destock, and eventually even the feral goats ‘went to the dogs’.

Virtually no stock were run between 2001 and 2010 and as a result groundcover doubled, perennial grasses returned and the effectiveness of intensive rainfall use increased from 20% to better than 60%. This is measured by a reduction in flood flows after heavy rainfall.

In order to maintain the gains in species diversity, groundcover and rainfall infiltration, even when grazed, Tom wanted to apply new management approaches. These approaches were influenced by the holistic thinking of Allan Savoury, the behavioural based landscape management of Fred Provenza as well as Prof Stuart Hall and Bruce Maynard’s philosophies of understanding what we do not know and livestock behaviour.

Movable network

In 2014, the Jacksons are rotating 200 head of cattle and no sheep through a series of 8000 hectare paddocks.

“As with all our neighbours, off farm income is keeping us going but this small stock number is allowing me to develop our new approach.”

Cost effective information gathering is one essential component of this approach. Tom is field testing and debugging the Taggle telemetry solutions to meet this need.

With the ability to communicate via satellite, Next G® or UHF radio this system offers huge potential for rural industries. Tom’s system is using the Next G® network via his four telemetry towers.

FARM DETAILS
Location: Austin Downs, Cue, WA
Farm size: 170,000 hectares
Rainfall: annual 200-210mm
Soil type: ancient, mostly shallow
Enterprises: extensive beef cattle

The great northern highway goes through the property, which surrounds the township of Cue, and hundreds of prospectors are attracted by old gold mines, so gates left open are a problem.

This telemetry system is being used to monitor livestock locations, 150km of electric fences, four to six water points and about 10 gates.

The terrain at Austin Downs is relatively flat with about a 1m/1000m fall from north to south but there are granite or iron stone outcrops that can block the Next G® signal. To overcome this, Tom has mounted the network of four receiver towers on trailers. Powered by solar, each telemetry tower can be towed behind a ute and easily relocated in order to maintain the best signal in relation to where the cattle are grazing. The cattle location is found by triangulation from at least three receivers.

The towers each have their own GPS locator and a Next G® data card. Information is relayed from the sensors to the towers and then
Mobile water tanks, troughs and telemetry monitoring systems provide Tom Jackson with alerts if water supply problems occur and enable him to move water to available feed. Photo: T Jackson

via the Next G® network to Sydney where it is processed. It is then delivered back to Tom’s computer or mobile.

Currently there is a 30 to 60 minute real time delay on positioning. New cattle tags will be transmitting every five minutes rather than every 20 minutes, so the lag time will reduce dramatically.

Remote monitoring
Fifty bores and windmills were located across the property. These have now been decommissioned and replaced with mobile watering points and solar pumps. Each watering point consists of a 5000 litre tank and integral trough (cup and saucer troughs). The solar pump with battery support can pump for 24 hours and sensors are located on the inlet (flow) and in the tank (depth). The sensor network relays information from the trough every 20 minutes and its reliability has meant Tom has gone from daily to weekly trough runs. These are in one paddock only so he has been able to cut his kilometres and travel time significantly.

“We currently run five mobile water points in the paddock and turn them on or off to draw the cattle to new pasture; this system is integral to our rotational grazing.”

The same types of sensors are used to monitor the electric fences. These sensors come with a 15 year life battery and count the pulses over 3000 volts, which is the minimum required voltage. Basically, if no count is received, Tom knows there is a problem with the fence.

A system of magnets and sensors on the gates is used to identify gates that have been left open.

Livestock tracking
While there are other remote water and fence management systems on the market, Precision Ag News is only aware of one tracking ear tag system.

Working with Taggle to ground test this system, Tom has tagged about 10% of the herd and the bull. While the ideal would be to have a tag on every animal, they are experimenting to establish the minimum ratio of tags to animals.

Current tags give a location accurate to about +/-20m. With a lag time up to 40 minutes, Tom is considering using a quadcopter to range across the location to find animals which have moved in that time.

Each tag costs about $20 and should have a three year battery life.

Tag design continues to evolve, with the current design being rather too brittle and prone to breakage. However, as the tag continues to transmit it can be retrieved and attached to conventional ear tags.

“The remote livestock monitoring system is giving us the confidence to run rotational grazing without degrading our land, even in dry years.”

Return on investment
The integrated remote monitoring systems are saving Tom time and resources. Where mustering used to require an aerial vehicle and three or four motorbikes, Tom can now move the water troughs and muster the cattle by himself over a period of about a week across the 8000ha paddock. The data from the ear tags enable him to track the animals moving in the right direction and their location from his office or mobile phone.

At this point Tom estimates he has invested less than $50,000 to achieve this system and is pleased with the payback.

“Although this is a very low stocking rate environment, it requires intensive management and these remote monitoring and data collection systems are enabling me to achieve more with less.”

Details: Tom Jackson, auspartom@gmail.com
Research is showing correlations in spatial variability between crop and pasture phases in mixed farming systems.

**Mixed farming**

Although precision farming techniques are widely used in Australian cropping enterprises, using the same tools to investigate interactions in mixed farming systems has been largely unexplored.

However, using PA techniques common to cropping in the pasture phase could offer a way to better understand how both phases interact, a means to follow different pasture management strategies and the opportunity to improve financial outcomes in both phases.

In a project to investigate spatial variation in mixed farming systems, data was collected at two dryland cropping sites, one in WA (with an annual pasture system) and one in north-eastern Victoria (with a perennial pasture system). On each property four paddocks were identified that had been in recent crop/pasture rotations.

Although both farms had historic cropping yield data, no equivalent data existed for pastures. As a measure of net primary production, and a way to compare the four paddocks’ total annual biomass productivity over time, accumulated annual MODIS normalised difference vegetation index (NDVI) data was used for the period 2004–2011. This data was supplied by Landgate in Perth.

At a pixel size of 250 metres by 250m, the MODIS data is relatively coarse, but it did confirm the initial research hypothesis - that at a sub-paddock scale, positive correlations in biomass production between the cropping and pasture phases exist (Figures 1 and 2).

To further investigate what was driving this correlation, the TIMESAT 3.1 software package was used to characterise vegetation life cycles and extract numerical observations related to vegetation dynamics using a pixel by pixel time series of the NDVI data.

Again, significant correlations were observed in spatial variation of biomass production between crop and pasture phases, for both annual and perennial pasture systems.

Buoyed by these results, the next step was to take the work to higher resolution pasture measurements by making use of a vehicle-mounted Crop Circle™ ACS-210 active optical sensor. It provided pasture data of similar resolution to the yield monitor (at a 10m scale).

**Future**

Although many farmers use PA tools in the cropping phase and their cropping paddocks, pasture phases are often then treated as one management zone, ignoring the existence of productivity gradients across the landscape. As a consequence, applying inputs uniformly across pastures can cause economic loss and subsequent degradation.

Pasture ‘zone maps’ that can identify how pasture growth potential is spatially distributed could allow poor performing areas to be identified for site specific management such as controlled grazing, selecting specific pasture cultivars or applying nutrients where needed. These management changes could also have flow-on benefits in the cropping stage.

In mixed farming situations, being able to do this in both the cropping and pasture phases could significantly enhance the capacity for implementing timely and spatially-efficient management strategies, including site specific fertiliser management.

The question will then be – will it help to produce better crops?

**Study sites**

Data was gathered at Milroy, a 2250ha cattle and cropping enterprise at Brookton, 120km east of Perth and at Grandview, a 2250ha cattle and cropping enterprise in north-eastern Victoria. On both properties, the main crops grown are wheat and canola.

**Biog.** Peter McEntee is completing his Grains Research and Development Corporation-funded PhD on the use of PA tools in mixed farming systems at Curtin University. Peter has a long history working in mixed farms and extensive experience on cattle stations in Northern Australia.

**Details:**

Peter McEntee, 0418 308 991, peter.mcentee@postgrad.curtin.edu.au
We get many business benefits from the AFS system, plus good backup from our local Case IH dealer.

Peter Doran, Southern Mallee, VIC

To see more genuine stories, scan the QR code or visit: caseihparts.com.au/genuine
Because PA gathers and uses spatial data along the value chain, it is seen as integral to the future of all food and fibre production. PA helps to support improved productivity, profitability and traceability and to reduce agriculture’s environmental footprint. These statements summarise comments made at the opening of the 12th International Conference on Precision Agriculture (ICPA), held in California in July.

Sharing knowledge between industry sectors and across the globe is important to help increase the application of spatial data across management systems in the whole value chain. Indeed, sharing knowledge across industries to increase adoption of PA is at the heart of SPAA-Precision Agriculture Australia objectives.

In Australia, one area where research in PA technology has been limited is the site specific management of pesticides, especially in relation to pathogens. Spatial management of pesticides is receiving much investigation in Europe and also in the USA. Some of this research is using commercial sensors, while new sensors are also being developed for specific applications. PA tools can help improve the targeting of pesticides, especially when we can sense specific weeds, pests and diseases, which in turn can lead to improved productivity, profitability and a reduced environmental footprint. They also provide on-the-go recording systems that support traceability across the value chain.

The adoption of spatial technology across all aspects of production offers opportunities to help Australian farmers to remain competitive in the world market. To capitalise on these opportunities, greater investment in evaluation of these techniques in an Australian context is encouraged.

Some of these and other projects reported at the 12th ICPA will be included as full articles in future issues of Precision Ag News.

**Herbicide rates by soil properties**

The efficacy of soil applied herbicides is known to decrease with increasing clay and organic matter content. At ICPA, researchers from Wageningen, Netherlands reported on the use of soil texture maps created from gamma-radiometric, electromagnetic and near infrared data, to vary rates of different herbicides in sugarbeet.

In on-farm experiments, herbicide rates were reduced by 15 per cent without reduced weed control.

While organic matter content is generally low in Australian soils, clay content can vary considerably. Tailoring soil applied herbicide rates to soil texture could offer Australian growers another tool to improve weed control and fight herbicide resistance.

**Mapping soil borne diseases**

In Sweden, researchers have been experimenting with mapping club root rot in brassica crops.

Using molecular-based soil tests, the team were able to rate whole paddocks for this root disease. In this case,
longer rotations without brassica were applied in paddocks with high disease ratings but for other diseases, target use of seed dressing, varying seed rate or variety might be alternative management strategies. These molecular tests are similar to those developed by the South Australian Research and Development Institute for soil borne diseases such as crown rot, pythium, bipolaris root rot and cereal cyst nematode. With more growers having the equipment to vary rates of seed and other inputs, perhaps it is time to revisit disease mapping in Australia.

Disease stability for cotton

Cotton root rot has been an ongoing problem in the US cotton industry. The recent registration of a fungicide to control the disease led researchers in Texas to look at the spatial distribution of the disease and the potential for patch application of the fungicide. They analysed airborne multispectral imagery that included visible and near-infrared wavebands taken in 2001 and again in 2011 and 2013. From this they confirmed that the spatial pattern of cotton root rot was relatively stable. It was calculated that only between 17 and 25 per cent of the 105 hectare paddock required fungicide treatment, depending on seasonal conditions. That represents a substantial input saving.

VR herbicides for potato desiccation

Potatoes are a major crop in the Netherlands and haulm killing herbicides are used prior to harvest. Researchers have been experimenting with varying herbicide rate by haul biomass. Crop biomass has been collected using ground based (proximal) biomass sensors as well as sensors mounted on an unmanned aerial vehicle (UAV) and from satellites. Varying inputs on-the-go and from a task map generated from previously gathered biomass data were both tested. Injection sprayers as well as section control sprayers were used for the application. Following eight years of research with different sensor and sprayer combinations, the team established that on average herbicide application was reduced by 31 per cent when matched to biomass. Greater reductions were achieved with biomass data gathered proximally compared to from satellites, and with conventional sprayers rather than injection sprayers that already had improved efficiency. When rates were reduced, haulm die-back time increased by about two days. A large part of this work was the development of dosing algorithms to appropriately vary spray rates in relation to biomass. In Australia, variable application of desiccants is being applied in cotton and could have potential in other crops. Much could be learnt on this topic from this large study already completed in the European potato industry.

Plant breeders use PA tools

Precision tools are becoming more widely used to support research trials, especially in plant breeding. For example, researchers at the University of Bonn have successfully used thermal imagery for the early detection of downy mildew in rose cultivars in a breeding program. This was achieved with scans of the canopy and from the side of the plant row. Many researchers are now using biomass imagery and remote sensing to identify differences in crop growth and stress factors between treatments.

Measurements combined for on-the-go control of cereal disease

A collaborative project between Leibniz Institute of Agricultural Engineering and the commercial companies, Agri Con and proPlant, is working to develop a real-time application system for precise fungicide spraying, initially in winter wheat. This work has highlighted the importance of sensing for leaf area index (LAI) and not purely biomass as the determinant of fungicide rate. An ultrasonic sensor is being used to measure LAI.

Biog. Emma Leonard runs the technical communication business AgriKnowHow and for the past eight years has been the editor of Precision Ag News.

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Hay is an important crop for many livestock and broadacre crop producers. Until now the lack of ability to map yield variation across the hay paddock has been a frustration.

To address this need, Nick Ross, Precision Agronomics Australia, with colleagues and grower Paul Hicks, Pingrup, Western Australia, have developed and validated a system to map hay yield across a paddock. This invention was subsequently awarded an Australian Fodder Industry Association’s (AFIA) Innovation Award.

Initially the team experimented with taking measurements on a square baler. Their aim was to map yield variation by measuring the rate at which compressed material accumulated, together with the weight of each bale. However, at the same time, a crop load sensing system was also tested on the mower conditioner. This system was found to gather accurate raw data, requiring less post capture data processing, even though it was weighing the wet forage.

“The main reason for the improvement in the mapping from the mower compared to the mapping from the baler was due to variation in the time lag between the hay entering and exiting the baler,” explained Nick Ross.

Measuring on the mower conditioner also provides the opportunity for producers using round or square balers to map yield variation.

The wet weight figures from the mower conditioner are calibrated against the total dry matter weight of hay carted from the paddock. This data is used to calculate hay yield variation across the paddock.

“Our goal is to develop a live map of hay yield on the John Deere GreenStar screen. This map will help growers make informed decisions regarding the correct management of their paddocks,” explained Frank D’Emden, Precision Agronomics Australia’s Technology Development Manager.

In a presentation to the Australian Fodder Industry Association, Paul Hicks noted several management benefits from mapping at cutting rather than baling.

- As the map is live you can relate the readings to what you are seeing in the paddock; when baling there is plenty of time to think about what is causing the variation and how it might be managed.
- With the yield data already collected we were better able to manage our resources at baling as we knew which paddocks were going to take longer to bale and cart and had a better indication of how much shed space to allocate.
- After harvest the hay yield map can be used in the same way as a grain yield map, for creating variable rate management zones.

The system was set up so that a live map was displayed on a John Deere GreenStar™ screen. While this could indicate variation in production, the live map does not provide actual yields.

Further research is being undertaken into rapid ground-truthing methods which would enable ‘first-pass’ estimation of final dry matter yields for planning purposes.

“Ground-truthing for initial estimations of dry yield would basically involve taking a small number of biomass measurements from known locations. These would then be used to enter a calibration coefficient, much like calibrating a yield monitor,” explained Frank D’Emden, Precision Agronomics Australia’s Technology Development Manager.

“We are working on developing a calibration coefficient which will enable us to map hay yields from the mower conditioner with as little as 1% error,” said Mr D’Emden.

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“Hay crops remove large amounts of nutrients, especially potassium; having a better understanding of yield variation provides another data layer in the development of replacement fertiliser maps for the following crops,” explained Nick Ross.

Paul found that the yield map from the mower (Figure 1) correlated closely with his soil type. Electromagnetic (EM) mapping (Figure 2) had identified the poorer areas of the paddock (coloured green to turquoise reading roughly 50 to 70). These consist of gravel over clay soils which have poor water holding capacity. In years with a dry, hot August and/or September these areas suffer from severe moisture stress, which in turn limits yield.

Paul felt that the system was cost effective to set up on his self-propelled mower conditioner, which was already fitted with GPS guidance, autosteer and suitable screen.

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The electromagnetic soil maps and associated soil water holding capacity show a strong correlation with hay yield maps.

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A weather station, carefully placed in the vineyard, is a useful tool to help understand seasonal conditions and their impact on growth in your particular location. The value of this data is enhanced by the number of years of past data that can be used to compare the influences of the current season on expected vine growth and fruitfulness.

When installing a new station it is useful to retrieve data from the local Bureau of Meteorology (BoM) network in order to compare the readings from other stations and start to understand what a regional forecast means for your location, in relation to the readings you are gathering on-site.

The recent introduction of MetEye, on the BoM website has taken this a step further by providing data from existing automated weather stations (http://www.bom.gov.au/australia/meteye/). MetEye data may then be integrated with a 7-day forecast for your current location.

The data for this service is stored in the Australian Digital Forecast Database (ADFD) with a 6km² grid from which maps are generated and forecasts overlaid. Comparison of your own station’s data with that from BoM sites and live MetEye data will help calibration of your station against forecasts.

For example, with frost forecasting, the elevation of your vineyard and its surrounding topography will influence the behaviour of pools of cold air. Once you have determined whether your site is equivalent, cooler or warmer than the BoM forecasts this calibration will aid decision making in response to frost warnings.

“MetEye data can be integrated with a 7-day forecast”

Local networks

Evolving technology is collecting local weather data that can support improved management decisions.

The availability of local networks of weather stations may further enhance understanding of the relativity of the data being collected on your vineyard. As an example, the Adelaide Hills Wine Region (AHWR) has a network of six stations placed over a regional footprint of 70km by 40km.

As for the BoM network, telemetry makes this data available to the region where the data is hosted by the Natural Resource Management Board’s Water Data services for the Adelaide and Mount Lofty Ranges (http://weatherstations.waterdata.com.au/).

There are many similar networks throughout Australia which make regional weather available. The formats range from a snapshot of current readings, daily averages through to 10-15 minute interval recordings from each station.

An analysis of aggregated data for average temperatures for the six AHWR weather station sites during the growing season proved useful in terms of understanding why the 2014 vintage was smaller than usual. Figure 1 shows comparison of the seasonal average temperatures for the past three growing seasons. Most notable is the warm start to the 2013/14 growing season which encouraged an early bud burst.

In contrast, conditions in November and December were unseasonably cool causing not only poor flower

Key points:

- Local networks of weather stations offer improved understanding of vineyard data
- New sensors are enabling temperature collection at multiple heights above the surface
- Models for disease forecasting have been developed but are not widely adopted in Australia
development but also conditions which slowed pollen tube growth resulting in poor fruit set. The heatwave in January 2014 resulted in a higher average temperature than in 2012/13 but not the long hot Indian summer seen that year.

This data helps us understand why the 2014 vintage for the Adelaide Hills was so small but with excellent ripening conditions for wine flavour and quality. The value of using the aggregated data from six sites is that the seasonality of the data is highlighted rather than site differences.

**Instrument set-up**

Another important step in helping make better use of weather stations includes the way in which instruments are arrayed (Figure 2). This illustrates a series of probes for measuring temperatures at a range of heights. This array has the capability of determining the height of warm air inversion layers where frost fans are available to protect against frost damage.

The introduction of new network sensors is offering significant opportunities. For example, Measurement Engineering Australia (MEA) has developed an instrument (Plexus) which is a field station in a stake. Currently, the channels are configured as three soil moisture probes and a soil temperature probe. Each unit is solar powered and transmits data to the cloud, according to parameters that are set by the owner. A Plexus network begins with two probes (one is assigned as the master data collector and sender unit) or as many as the owner can afford or has vision for.

MEA is looking at adding humidity and leaf wetness sensors, so rather than relying on a single point source for measurements (such as a weather station) this may be networked with sensors that will provide a detailed picture of conditions across the vineyard.

With understanding of the conditions conducive to pest and disease risk, this data could either be run through decision support software or simply be reviewed regularly and then examined in detail when conditions are conducive for an infection or risk period.


**Biog. Richard Hamilton has over 25 years of experience in viticulture in the public and private sectors and runs the consultancy Hamilton Viticulture servicing clients across south eastern Australia.**

**Details:**

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A number of commercial services are offering crop monitoring services based on satellite data. **Dr Andrew Robson** discusses the technology and industry-driven application with **Rebecca Thyer**.

### Key points:
- **Satellite imagery can improve understanding of on-farm variability**
- **By using vegetation indices, measures of crop reflectance can be converted into accurate predictions of yield, nutrition and a range of crop quality parameters**
- **Commercial satellites offer a wide range of spatial resolutions at varying costs**
- **New technology may provide even more information for farmers and researchers to work with**

Across Australia’s agriculture industries, remote sensing based applications are being developed for detecting crop damage from pests, disease and poor nutrition, as well as predicting yield over time.

### What is measured?
Passive remote sensing satellite platforms measure the amount of solar electromagnetic radiation (EMR) reflected, absorbed and transmitted by a plant canopy. In general, a healthy green leaf or canopy will exhibit low reflectance within the visible spectral range at 450 nanometres (nm) (blue) and 650nm (red) associated with chlorophyll absorption. The near infrared (NIR) region (700-1300nm) is associated with plant structure so varies in response to desiccation or stress influences while the mid-near infrared region (1300-2500nm) is associated with carbon, hydrogen, nitrogen, oxygen, starch, cellulose, water and lignin.

Vegetation indices derived from ratios of NIR and red reflectance such as normalised difference vegetation index (NDVI) or plant cell density (PCD) are commonly used because they provide an accurate measure of plant vigour and its spatial variability across a crop. In general, the more vigorous the plant, the higher the NDVI value.

### Platforms
The most common passive remote sensing platforms are satellite. However, the use of unmanned aerial vehicles (UAVs) is rapidly increasing.

The most common proximal sensors (ground based – e.g. GreenSeeker®, CropCircle™ and CropSpec) are active sensors that generate their own light source, so are less influenced by time of image capture or shadow.

### What is the best remote sensing platform?
Considerations include spatial resolution, spectral resolution, minimum capture area, repeat time and cost.

### What is the best spatial resolution?
Commercial satellites offer a wide range of spatial resolution - the size of the on-ground image picture element or pixel – from 0.31m² to 1.0km².

Optimum resolution is determined by the application being developed, whether it is at the individual tree or plant level, or at the farm or regional scale.

In general, very high-resolution imagery (less than 2m) such as Worldview2, Worldview3, GeoEYE, Ikonos, QuickBird, Pleiades, SPOT6 and SPOT7 are better suited for measuring individual tree health or localised plant stress, such as nematode damage, weeds and disease, and overall variability within smaller crops.

High-mid resolution imagery (5-25m), such as SPOT5, RapidEYE and Landsat are best for identifying variability trends across whole crops, farms and catchments, such as those arising from soil variability, topography or prior history.

Coarse resolution imagery (greater than 250m) such as MODIS is limited to regional and sub regional mapping.
Images cost more per hectare than in general, higher spatial resolution imagery cost? What does Table 1: Australian based commercial providers and on-sellers of satellite imagery include:

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The minimum capture area is also a consideration and ranges from 50km² for newly acquired imagery to greater than 1800km². If purchasing directly from an image provider, it may mean buying a much larger area than required; a compromise may be to purchase a more localised area from a commercial PA provider or banding together with others to purchase an image.

What is the best spectral resolution?
Commerciy available satellites offer a range of spectral resolution, that is the number of wavebands and associated bandwidths provided by each platform. The most common multispectral sensors - visible blue, green and red, and near infrared - allow for common vegetation indices such as NDVI to be derived.

More recent platforms provide additional bands, such as Coastal Blue (400-450nm), Red-edge (705-745nm) and mid-NIR (860-1040nm) with the launch of Worldview3 (August 2014 - http://www.satimagingcorp.com/satellite-sensors/worldview-3/) to provide eight short wave infrared bands (1195–2365nm). The additional bandwidths offer greater opportunities to map specific plant constituents, detect specific crop diseases or improve cultivar selection.

What does imagery cost?
In general, higher spatial resolution images cost more per hectare than lower resolution images, but require a smaller minimum capture area. These can range from around $1 per km² for the mid-resolution imagery through to more than $40 per km² for the very high-resolution imagery. Landsat 8 and MODIS imagery can be obtained freely, but require some image processing with the correct software before useful information can be derived.

What next?
Today’s satellite remote sensing technologies are evolving rapidly, with the launch of new platforms (BeiDou and QZSS – Quasi Zenith Satellite System), the rapid increase in UAVs, and the availability of new software and product delivery systems. It also involves the smart integration of this technology into existing agricultural systems, to ensure results are accurate, and most importantly affordable, simple and relevant to end users.

SRA-funded sugar research is a good example of how remote sensing applications are being developed with strong industry direction and collaboration and engagement with existing research. This includes extensive nitrogen screening trials; improved analysis techniques for cane grub detection; improved statistical methods for yield forecasting; and a strong integration with other sciences such as climate modelling.

Details:
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Industry applications of satellite imagery

Research applications for remote sensing technologies include:

- **Sugarcane**
  Sugar Research Australia funded work is developing applications to predict yield and foliar nitrogen uptake at a regional, farm and block scale; and to detect Yellow Canopy Syndrome and cane grub incursions.

- **Peanut**
  Peanut Company of Australia funded research is developing interactive maps that incorporate satellite imagery and real-time data (such as irrigation, pest and nutrient conditions) to analyse crops’ health and maturity and predict yield at crop and regional levels.

- **Avocado**
  Preliminary research funded by Horticulture Australia and Avocado Australia has found that very high-resolution satellite imagery combined with GIS and GoogleEarth are accurate tools for identifying trees affected by the pathogen Phytophora, predicting fruit quality and for tree auditing.

- **Pastures**
  Research funded by Meat and Livestock Australia and the CRC for Spatial information is evaluating the ability of active sensors to accurately predict pasture biomass across a range of species and geographical locations.

Bilog. For the past 12 years Dr Andrew Robson has been employed as a research scientist with Queensland Department of Agriculture, Fisheries and Forestry developing remote sensing/GIS applications across cropping systems. He has recently accepted a position as a research fellow with the University of New England's Precision Agriculture Research Group.
A natural resources management (NRM) project is testing the value and use of satellite imagery from both economic and environmental perspectives. Tying together these objectives makes sense, says Bernadette Lawson, Land Management team leader from Natural Resources SA Murray-Darling Basin.

“Satellite imagery is a tool that works well with natural resource management goals. We are working towards sustainable, productive landscapes where soils and other resources are protected against quality loss and erosion, and this relates directly to productivity on-farm.

“There are economic and environmental benefits from matching land use to its capability.”

The Focus Farm Project, being run by Rural Directions, uses the Geosys platform to:
• process historic satellite images;
• analyse inherent variations of biomass production; and
• identify areas in the paddocks that perform differently.

The project is working with 12 farmers located in the Mallee region of South Australia.

Rural Directions’ Patrick Redden says the grain and pasture farmers will then manage these zones differently, for example, by altering the urea rate on some strips to test the response. Subsequent yield maps and harvest counts will be used to evaluate the management plan chosen, and in time establish the value of satellite imagery for identifying management zones.

“We are trying to validate the technology for our region and bring it to a useful level,” Mr Redden says.

For some farmers, this project is about putting a toe in the water. For others who have used satellite imagery in the past, it is helping them to look at other ways to use it or to use it more regularly.”

To help achieve this, the project has also run workshops on satellite imagery and how it can be used to understand and manage variability.

Ms Lawson says Natural Resources SA Murray-Darling Basin will also assess whether the imagery can help better understand recharge problems facing the region.

Freshwater recharge at the base of sand dunes often limits both machinery movement across paddocks and their productive capacity.

“We would like to work out the point of impact and where recharge is likely to spread and we think imagery will help.”

This project is supported by the SA Murray-Darling Basin Natural Resources Management Board through funding from the Australian Government.

More information: Patrick Redden, 08 8841 4500, predden@ruraldirections.com

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