Precision Agriculture: what it is and what it isn't

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'Precision Agriculture' (PA), 'Precision Farming' and 'GPS' are terms gaining increasing usage in the Australian sugarcane industry - judging by a quick perusal of recent industry media, the conversations which can be overheard at shed meetings or in the bar after a hard day's work on the farm. However, it is increasingly clear that these terms can mean very different things to different people and can raise equally varying expectations.

With these thoughts in mind, an SRDC project[2] which draws on PA research expertise gained over many years in the grains, wine and sugarcane industries, is seeking to make sense of PA for the Australian sugarcane industry. In subsequent articles, we will consider issues such as the collection, management and analysis of the spatial data which underpins PA, the operation and effectiveness of component technologies, and how these might be used to optimise sugarcane farming systems. Here, the purpose is to present an underlying philosophy of PA, so that in discussing how to get the greatest value from it, the industry can progress from a common point of understanding.

LAND IS VARIABLE

Growers have been well aware for as long as farming has existed that land is variable. It is therefore well understood, for example, that the soils of the wet and undulating Tully district are quite different to those in the much drier and flatter Burdekin; or that in the Herbert district, the sandy soils of Upper Stone are naturally less productive than the more fertile and clayey soils close to Victoria Mill. Such knowledge also provides a part of the basis for SIX EASY STEPS. Most growers, especially those who also drive the harvester, also have a keen understanding of the fact that within individual farms and blocks, both crop yields (Figure 1) and soils (Figure 2) can vary markedly - although when presented with maps such as Figure 1, they are often surprised at the range of variation. Thus, without a means of accurately observing and measuring variation in land and its productivity, growers have operated on the assumption that the optimal strategy is to treat their management units (farms and blocks) as though they are uniform. The various technologies which we collectively refer to as the tools of PA allow us to see that this assumption is false (Figures 1-5). The adoption of PA is therefore driven by the idea that these tools can assist in optimising farm management with respect to production, profitability, or perhaps environmental goals.

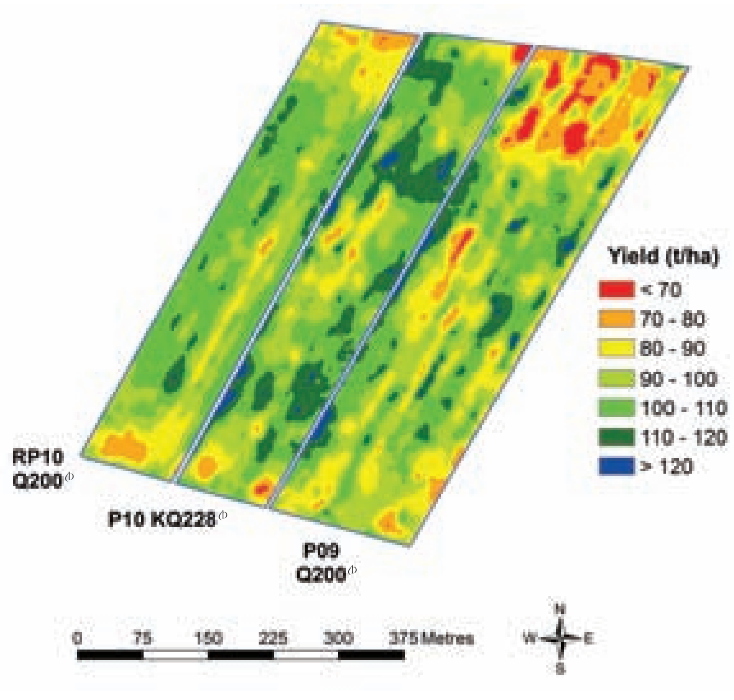
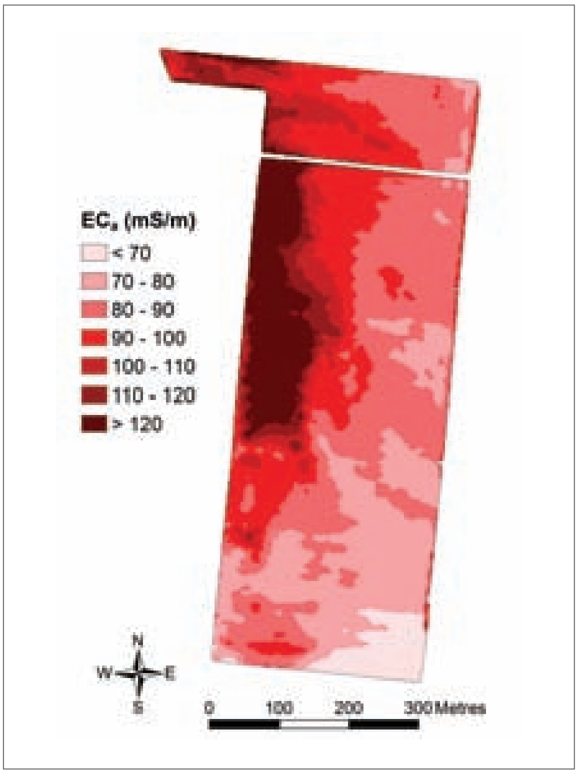


FIGURE 1 | Yield variation in 3 blocks totalling 22.9 ha in the Herbert district (Macknade Mill area), 2010. This map was produced using data collected on-the-go during harvest using a TechAgro yield monitor logging at 3 second intervals. Note that although the crop in each block was of differing age or variety, management was otherwise uniform for all practical purposes. The support and assistance of Santiago Marrero (Solinftec) and Mike Sefton (HCPSL) in providing data for this map is gratefully acknowledged.

[2]SRDC Project CSE022 is a collaborative project being undertaken by CSIRO Ecosystem Sciences/ Sustainable Agriculture Flagship, the National Centre for Engineering in Agriculture (University of Southern Queensland) and BSES Limited, and is funded jointly by these organisations in partnership with SRDC. The project is also critically dependent on the assistance of our collaborating farmers - Jay Hubert (Bundaberg), Denis Pozzebon (Burdekin) and Brian Tabone (Herbert), and other industry partners whose assistance is valued greatly. In addition to Rob Bramley, further information about the project or PA more generally may be obtained from Craig Baillie and Troy Jensen (NCEA), Bernard Schroeder and John Panitz (BSES Limited) or Tony Webster (CSIRO).



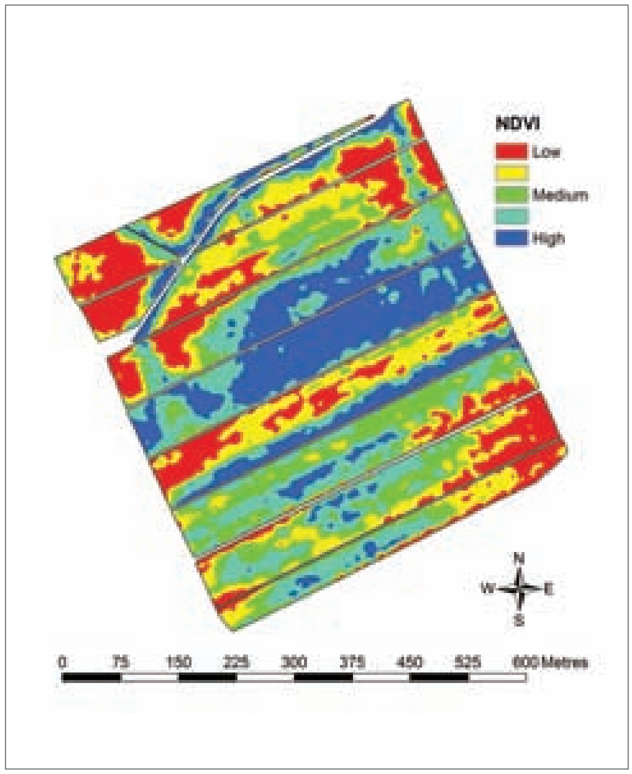


FIGURE 2 (ABOVE LEFT) | Variation in apparent electrical conductivity (EC_a) in the top 75 cm of the soil profile in a 26.7 ha block near Mt Kelly, Burdekin. This map was produced using data collected during an on-the-go survey with a dual dipole EM38 MK2 electromagnetic (EM) sensor during July 2011. Note that all that this map shows is variation in EC_a. Contrary to popular belief, such maps cannot be regarded as maps of particular soil properties until the appropriate calibration of the sensor against measured soil properties has been carried out for the particular site of interest. In order of effect, such sensors respond to salinity, moisture and the type and amount of clay - they cannot measure things such as soil pH or N status. Work to ground-truth this map is being undertaken presently. Uncalibrated EC_a maps can be valuable nonetheless. First, they can be used to direct soil sampling so that the likely full range of variation in soil properties can be assessed. Second, similarities in patterns of variation in soil and yield maps may suggest that yield is being limited by a soil constraint and that further investigation and possible remedial action is warranted.

FIGURE 3 (ABOVE RIGHT) | Variation in NDVI in a 24.7 ha section of a cane farm in the Bundaberg district, March 2011. The data underpinning this map were remotely sensed using the Ikonos satellite platform. NDVI is calculated from the reflectance of infrared (IR) and red (R) light by the crop (NDVI = (IR-R) / (IR+R)) and has been shown to be closely related to the amount of photosynthetically active biomass present (ie. canopy size and health). This image was kindly supplied by Andrew Robson and Chris Abbott (DEEDI) who, in collaboration with CSE022, are researching remote sensing applications for the sugar industry via SRDC project FPP818. As with proximally sensed data (Figure 2), remotely sensed imagery must be ground truthed for correct interpretation. However, through overlay with other data (eg. Figure 4), such imagery may give valuable insights to the understanding of within-block variation in crop performance.

WHAT PA IS AND IS NOT

The key technologies involved in PA are the global positioning system (GPS), yield monitors, remote sensing, proximal soil and crop sensors and geographical information systems (GIS). Whilst GIS is vital to the display and analysis of PA data, the GPS is arguably the most important enabling technology for PA since it allows measurements of the performance of the farm, and/or the land supporting it, to be geo-referenced and so transformed into maps (Figures 1, 2 and 3).

Taken individually, Figures 1, 2 and 3 are not necessarily anything more than pretty maps; some people have even referred to them as 'agro-porn' on the basis that they are good for little more than showing to your mates! However, when integrated together, they become very powerful management aids. Figures 4 and 5 therefore highlight the key idea that PA is about the use of high resolution spatial data for improved decision making.

Because the sugarcane industry is a late adopter of PA technologies by comparison with other cropping industries (the first Australian grains yield maps were produced in the early 1990s, whilst the first winegrape yield map was produced in 1999), we do not yet have sufficient data to produce sugar examples similar to those in Figures 4 and 5.

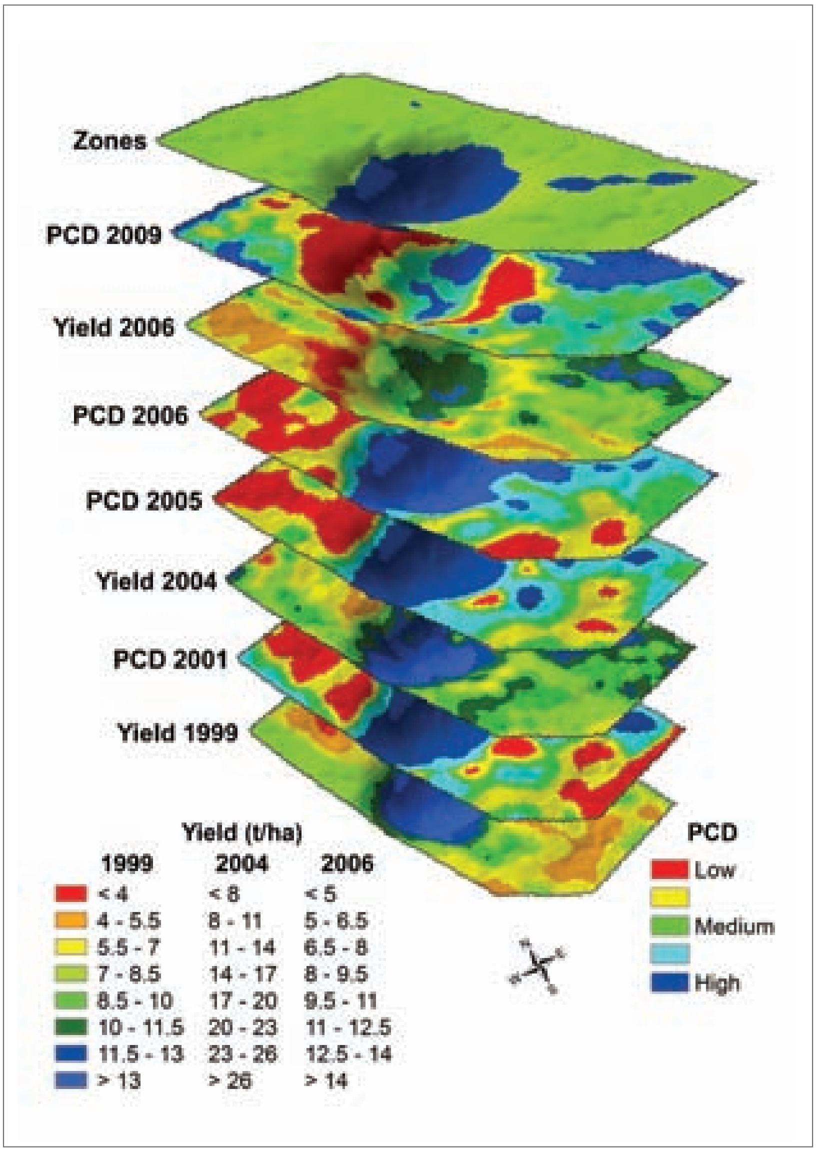
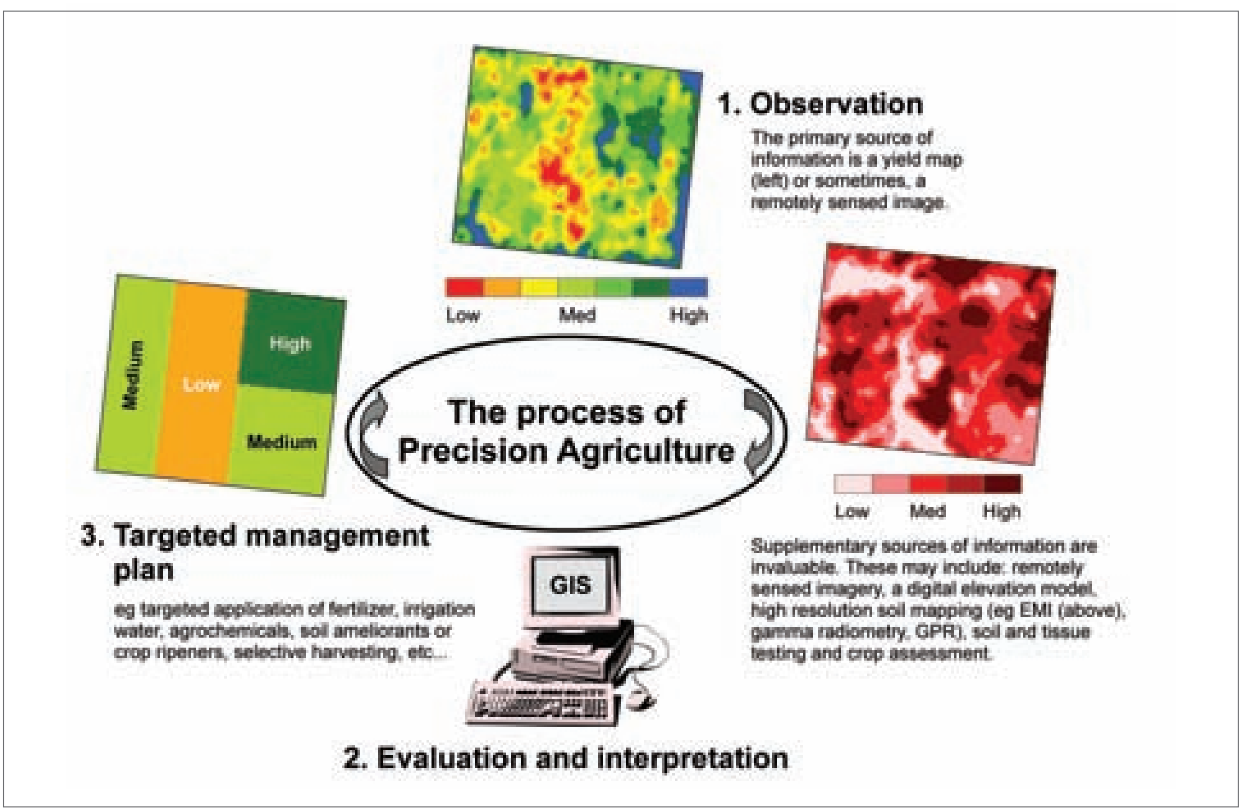


FIGURE 4 (LEFT) | Development of management zones in a 4.5 ha vineyard in the Padthaway region of South Australia over a 10 year period. Here, yield maps obtained in 1999, 2004 and 2006 have been clustered with remotely sensed imagery (PCD) and an elevation model to inform the delineation of management zones. PCD (the ratio of infrared:red reflectance) has been shown to relate very closely to vine vigour (ie. size and health). Note that even though the average yield (pale green) varies from year to year due to seasonal conditions, the patterns of variation remain stable.

FIGURE 5 (BELOW) | The cyclical process of PA. In this example, also from a vineyard (7.3 ha in Coonawarra), yield and soil data at high resolution have been used to inform the development of a targeted management plan. Note that because the process is cyclical, implementation of targeted management is followed by further observation and evaluation (was the plan any good, etc). This also means that PA lends itself to incremental adoption - there is no need to try and do everything at once!



However, the industry has been a rapid recent adopter of controlled traffic and GPS guidance so is well positioned to take the next step towards targeted or 'variable rate' management (Figure 5). But it is important at this point to highlight a key element of what PA is and is not.

As Figure 5 indicates, PA can be thought of as a cyclical process of *observation*, typically based on yield mapping (Figure 1) and supplemented by remote (Figure 3) and proximal sensing (Figure 2) of crops and/or soils, followed by *evaluation* and *interpretation* of the observed data leading to the development of a *targeted management plan*. As such, it is an 'information-rich' process which contrasts greatly with the traditional approach in which information about yield, for example, might be confined to a single block average measure made by the mill. By contrast, Figure 1 derives from several thousand measures of yield. Whilst the approach to PA illustrated by Figure 5 can be greatly aided by access to controlled traffic and GPS guidance, these latter technologies do not themselves either generate or require any information at all other than GPS coordinates. Thus, Figures 1-5 all represent information about the farming system in x, y and z format, where x and y are coordinates and z relates to a measure of farm performance (eg. yield) or of the land underlying it (eg. soil). Machine guidance and controlled traffic only involve x and y, and due to the absence of z, they are somewhat separate from what is otherwise regarded as PA or 'site-specific management'.

The cyclical nature of PA (Figure 5) is important for another key reason. A single yield map (eg. Figure 1) is simply a record of past crop performance. Whilst interesting, its power accrues when it becomes useful for determining what might happen in the future. In Figure 4, several such yield maps, along with remotely sensed imagery and an elevation model, have been used to demonstrate that the patterns of variation are stable in time - so the vineyard manager in this example can be confident that the low-lying hollow will be higher yielding (and in this example, also producing lower quality fruit) than in the remainder. In Figure 5, a similar integration of a yield map with proximally sensed soil conductivity data has been used to illustrate the delineation of management zones for some future management decision - in this example, a harvesting strategy (note that this example also made use of an elevation model, the recognition that the soil map was reflecting variation in soil depth, along with additional years of yield data). A key part of the present research effort is therefore aimed at demonstrating the patterns of sugarcane yield variation are stable in time and can be related to variation in identifiable aspects of the land supporting the crop such as key soil properties, elevation (ie. topography), and so on.

Overall, PA uses high resolution spatial data about land attributes and crop performance to inform improved decision-making. Rather than being beholden to the variability which traditional farming methods are affected by, PA seeks to use an understanding of variability to ensure that any given management decision results in the desired or expected outcome. That said, it is worth sounding a cautionary note: the use of yield mapping in the sugarcane industry has been extremely limited to date, in part due to significant concerns as to the reliability of the instruments used to measure yield. Indeed, it is only in the last few weeks that the CSE022 team have begun to have more confidence in the sensor used to produce Figure 1 and that after considerable post-processing of yield monitor data. Yet we are aware that many cane growers are already investing in variable rate equipment for the targeted application of fertilisers and other inputs. Unless these growers have access to data such as that shown in Figures 4 and 5, we think that this investment is premature, since the delineation of management zones cannot possibly be robust when based on a single map or data layer.

By following the PA path illustrated in Figure 5, and understanding that PA is about improved, information-rich decision making, rather than just being a question of driving in straight lines, PA should assist in making your sugarcane farming business a more profitable and sustainable one.

FURTHER INFORMATION

This is a large and growing research literature on PA, much of which can be accessed via internet search engines. More approachable information on PA can be found on the websites of SPAA-Precision Agriculture Australia (spaa.com.au) and the Australian Centre for Precision Agriculture (usyd.edu.au/agriculture/acpa/ - the training modules available at this site are especially recommended).

More sugar-focussed information is available at csiro.au/science/Precision-Agriculture-Sugar.html and in an SRDC report which can be accessed via srdc.gov.au/ProjectReports/ViewReports.aspx?ProjectNo=CSE018.

OVERALL, PA USES HIGH RESOLUTION SPATIAL DATA ABOUT LAND ATTRIBUTES AND CROP PERFORMANCE TO INFORM IMPROVED DECISION-MAKING.