Revolutionising big data to help grain growers answer on-farm questions.

Roger Lawes, Gonz Mata, Yang Chen, Joanne Chai, Randall Donohue, Roger Butler, David Factor, Tim Pitman, Chris Sharman, Zvi Hochman
CSIRO, 147 Underwood Avenue, Floreat, WA 6014

Key messages

- CSIRO has constructed digital infrastructure to capture agricultural information from soil water sensors, satellites, soil types, crop models, economics and commodity prices. These data are used to create new digital products for the agriculture industry.
- Crop yields can be monitored in near real time across the Western Australian wheat belt using the next generation of crop models.
- Crops can be monitored as the season progresses with a suite of satellites and crop type identified.
- Apps are being created to help farmers access information about the yield potential of their crops and current status of plant available water in their paddocks.
- Digital safeguards are being constructed to enforce high standards of human ethics and privacy.

Aims

The explosion of sensors, satellites, and computational models in agriculture has brewed up a whirlwind of data for the modern agricultural business. Making sense of these vast data sets in fast, accurate ways to make important decisions is not trivial. However it would be unwise to ignore these new technological advances, as they will help agricultural businesses remain competitive and make decisions in a timely manner.

Yet this smorgasbord of digital and data products take time to process, often provide information that is difficult to interpret, and require substantial investments in time to derive anything of value. We know that growers will not take up complex information technologies if they are difficult to use or take lots of time to derive value from. For example, the complexity of using yield monitors and variable rate controllers has contributed to the lack of uptake of precision agriculture technology by producers (Robertson et al 2012). The adoption of digital technology by the agricultural sector has plateaued because, in part, it is too difficult and time consuming to engage with the technology.

Digital infrastructure needs to be reimagined and new analytical methods developed to deliver fast, intuitive answers.

CSIRO (https://research.csiro.au/digiscape/) is taking on this challenge, constructing a one stop shop for data storage, access and analysis. We are building one platform that can house information about soils, captures information from satellites, and can deploy outputs from these information sources through user friendly products such as an app. The objective is to allow agricultural businesses to quickly acquire information about production in real time, without the hassle of identifying soil types, calibrating models, or searching for satellite information.

As we bring new data products to the agricultural sector, we also consider how to protect the privacy of individuals, and provide opportunities for individuals to choose whether to engage with these digital products, with full disclosures.

This paper describes the new digital capability CSIRO has created for agriculture and some of the products emanating from this research. These products include a near real time system for identifying what crops are growing where across the grain belt, a yield forecast for those paddocks, the current plant available water status in that paddock, and an historical record of the water-limited potential yield in those paddocks going back in recent seasons. We envisage this capability will have widespread application for growers, advisers, bulk handlers, marketers, commodity forecasters, insurers, and research funders and providers.

Method

CSIRO is using a multidisciplinary approach comprising social, economic, biophysical, analytical, remote sensing, user experience and software engineering components to build digital outputs for Australian agriculture. New crop modelling architectures have been developed with satellite information. Soil grids have been created with a multitude of data-layers and climate surfaces are being generated with the next generation of climate forecasting models. These frameworks have been constructed to deliver information about crops at the paddock, farm, regional and national scales.

Understanding grower's needs and use of digital technology

We sent our team across southern Australia to chat to growers about their thoughts on digital information, technology, computers, data, useability and sources of information. We asked about their interests in a range of digital products that could potentially be built, such as crop yield forecasting, crop rotation management, pest management, planting practices, soil water estimation, nutrient management and crop marketing. The objective was to simply identify what farmers liked about farming and what they would like from a digital product. We also talked about privacy, security and ethical issues surrounding the use and creation of data products about agriculture. The objective of the conversations were to identify the issues that farmers considered important, and discover how they would like information packaged for them. The survey was not exhaustive, but was considered instructive as it provided the team with an insight into what useful packages could be produced for farmers with today's technology.

It was no surprise that farmers wanted information packaged in a highly accessible manner. They did not wish to spend time at a computer, had a preference for accessing relevant information while driving around the paddock. Farmers expressed an interest in all the topics discussed, but in the first instance, we decided to focus on producing outputs about plant available soil water, historical yield potential and the current yield forecast. These pieces of information were operationally tractable from a software engineering perspective.

Google ventures model

In five short days we harnessed our cross disciplinary advantage to build an app to deliver information about crop yield and plant available water in real time to a farmer on a mobile device. A team of software engineers, user experience, legal, social, biophysical and crop modelling backgrounds convened and followed the google ventures methodology (http://www.gv.com/sprint/) to discuss every page and aspect of the App. The user experience team then constructed this app and it was evaluated by four growers. As we engaged with growers we pivoted twice by redesigning and adapting the product in response to user feedback.

Assembling and creating data layers

We created a number of static and dynamic layers of information relevant from paddock through to national scale that can be used to estimate the identity of what is growing in each paddock, crop yields (back through history and forward into the future), soil water dynamics and with the potential of much more (Figure 1).

The first layer identifies the crop species growing in each paddock, using a combination of satellite images from Landsat, Sentinel 2 and SAR, depending on availability. The images used vary with location and time, as many paddocks are obscured when it is cloudy. Adaptive learning algorithms identify crop species.

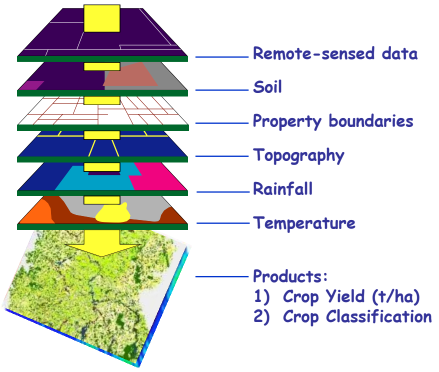

Figure 1. Layers of information used to create digital products

A second layer creates an estimate of yield potential and plant available soil water for the current season. Such information can be used for tactical management of crop inputs, risk management and marketing decisions. This layer is calculated with the APSIM crop model. The most likely soil type, and climate are selected for each paddock in the grainbelt without the need for the user to have local knowledge of these inputs. This is achieved by using the Soil and Landscape Grid of Australia (90m resolution) (Grundy et al. 2015) and the SILO datadrill 5 km grid for climate information (https://www.longpaddock.qld.gov.au/silo/). Because the APSIM simulation of crop growth under current season conditions needs to estimate the daily dynamics of plant available soil water, the system can be used to provide an estimate of plant available water (PAW) in real time, without the need for local knowledge of the actual soil type in each paddock. Such estimates of plant available water often provide better estimates of soil water than a single poorly calibrated stand-alone soil water sensor (Freebairn et al. 2018).

A third layer creates an historical series of water-limited potential yield estimates for a particular paddock. This information can assist with benchmarking, diagnosing yield constraints and setting yield targets.

The fourth layer monitors the growth and expected yield of the crop in real time and can provide a forecast for that season. These new satellite-driven crop models integrate information from multiple MODIS and LANDSAT scenes to build a yield prediction from the observed NDVI signal (Donohue et al. 2018).

Collectively, we have now housed these layers of information on soil type, climate, climate forecasts, crop yield and crop species in a new digital architecture that allows us to develop fit-for-purpose digital products. We envisage this capability will have widespread application for growers, advisers, bulk handlers, marketers, commodity forecasters, insurers, and research funders and providers.

Results

Crop yield forecasts

In 2017 crop yield forecasts and crop area estimates were generated for the entire Western Australian wheatbelt. Identification of what crops were growing in each paddock improved as the season progressed, as more cloud free images became available, and the spectral differences (i.e. differences in colour) between crop species increased. An example of the classification output generated on October 31 2017 with the actual crop is presented in Figure 2. This figure is a subset of information generated for the entire state.

The crop yield estimate, generated from remote sensing, and estimated on October 1 is presented in Figure 3 for the same region, while Figure 4 illustrates the capacity to generate crop yield maps for the entire state at this time.

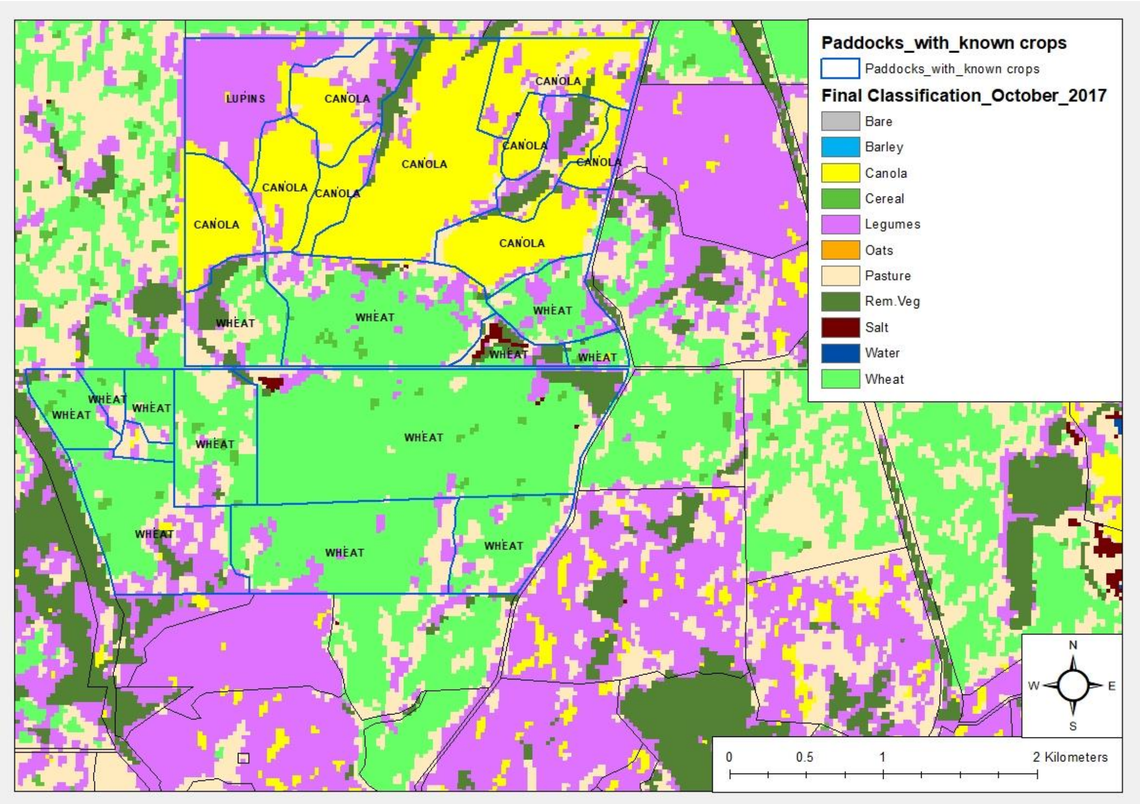

Figure 2. Output for crop classification in Western Australia for the 2017 growing season, for a farm, where data was not used to train the classification. Paddock labels were provided by the farmer after the analysis.

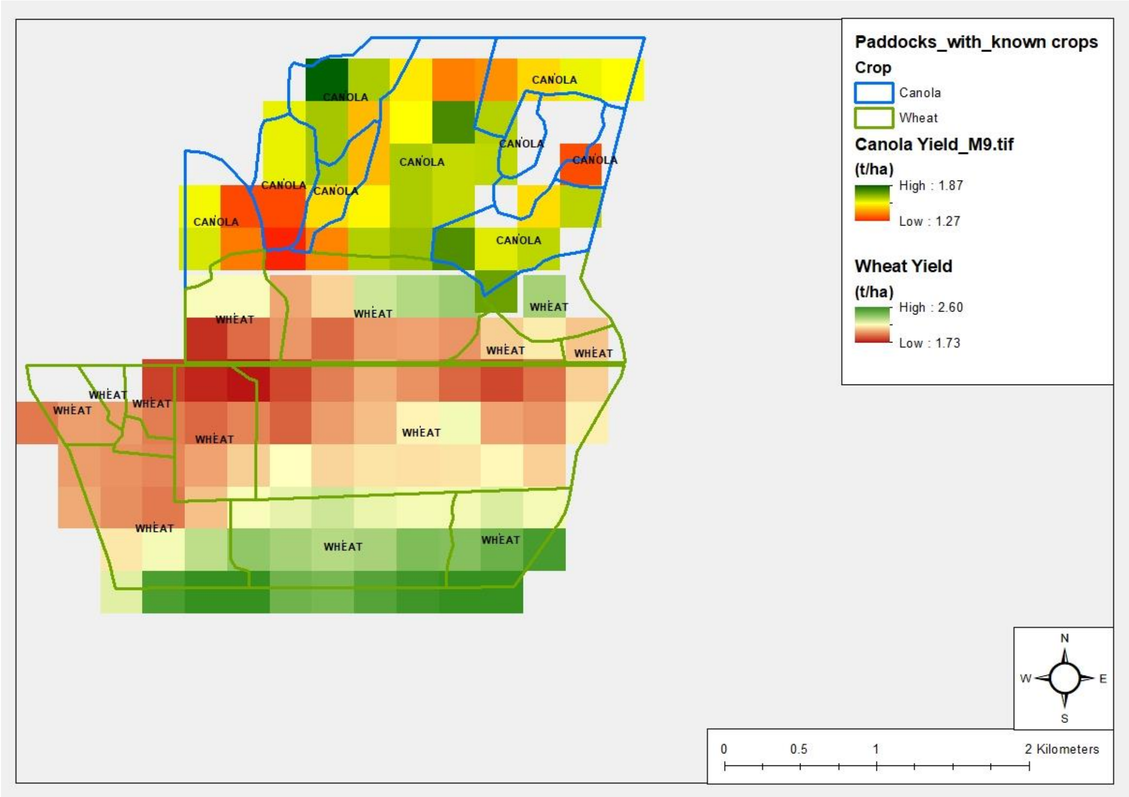

Figure 3. Forecast yields for wheat and canola, as estimated by remote sensing in late September 2017.

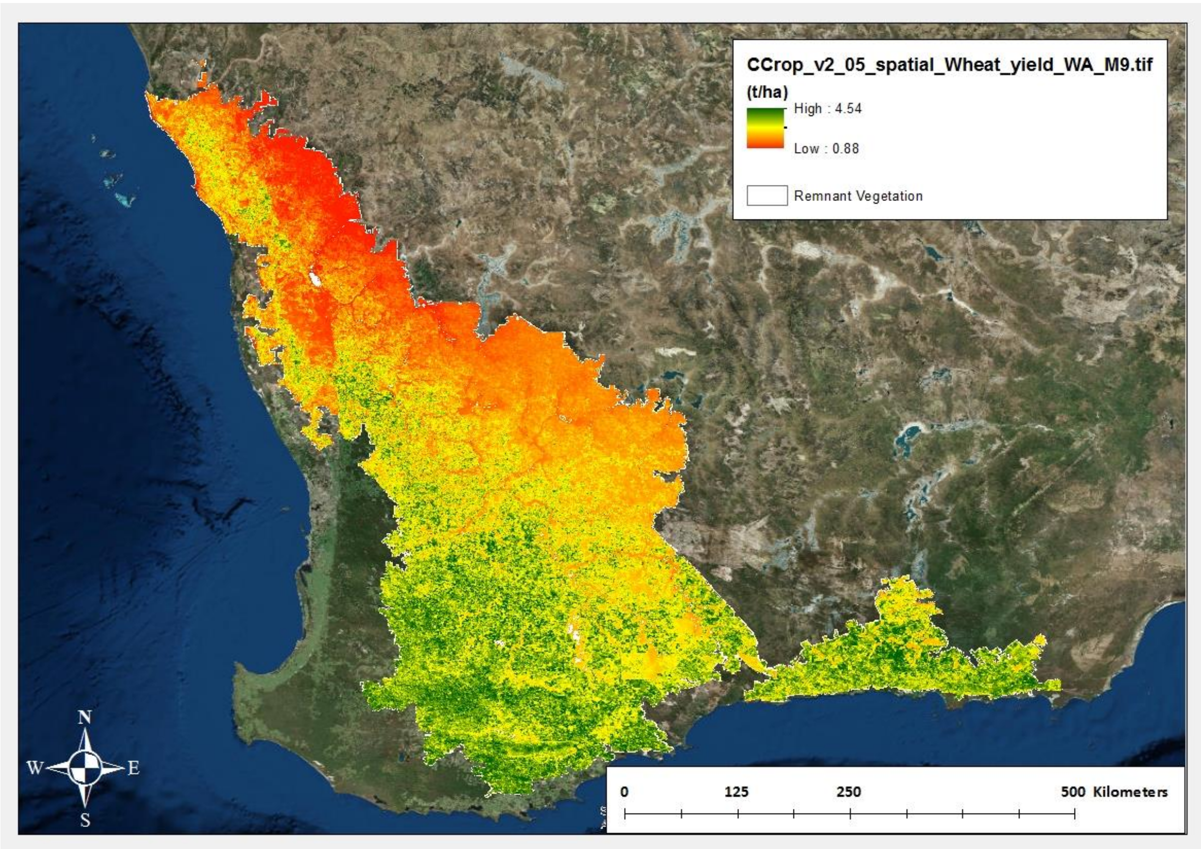

Figure 4. Wheat yields forecast in late September of 2017 for every paddock across the WA grainbelt.

Crop yield and soil water dynamics

From listening to the needs and concerns of growers, the app was constructed to be paddock specific providing insights about historical yield potential, plant available water in real time and yield potential for the season. Our early beta versions (Figure 5) are likely to evolve with more grower consultation.

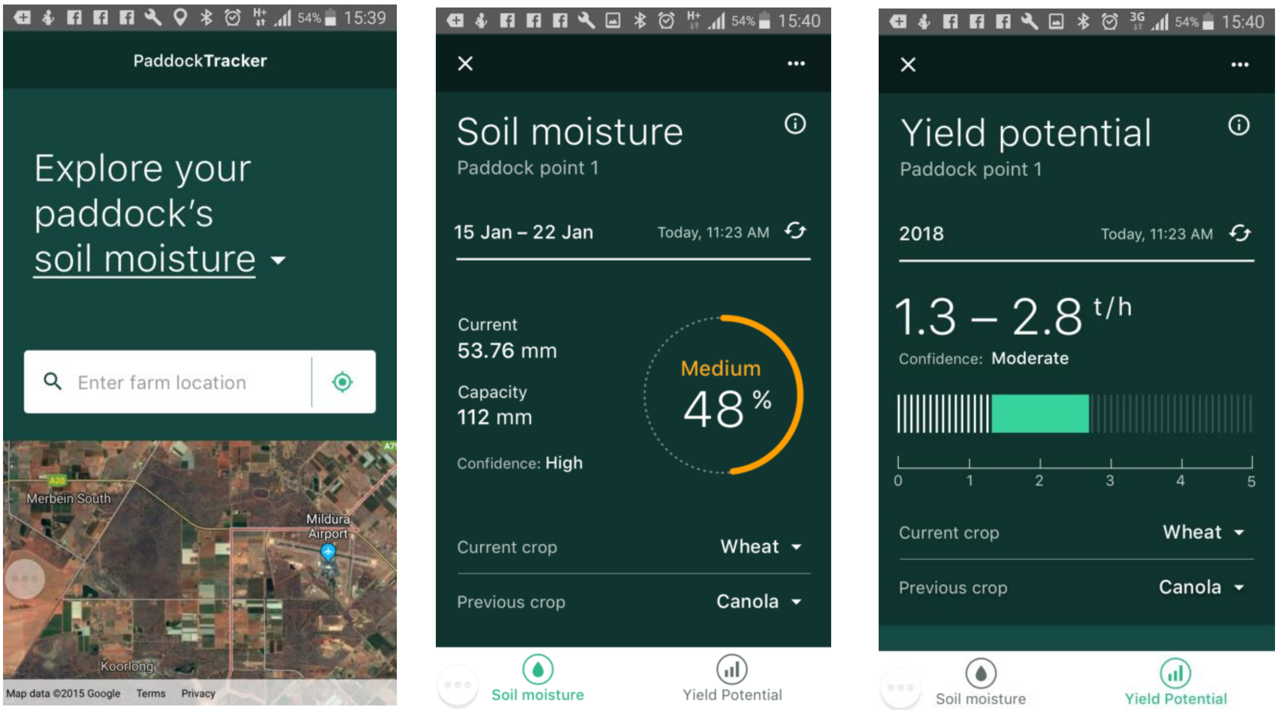

Figure 5. Examples of output generated in real time using data layers about agricultural production. These are beta versions, and are used for industry engagement only. Production app output will change, based on grower feedback.

Conclusion

The digital revolution won't allow us to stand still in providing information to Australian Agriculture. CSIRO have created new digital products for agriculture about crop production, crop species, crop yield, soil moisture and soil type. Outputs from these digital products can be delivered at paddock, farm, regional and national scales, in near real time. These products mean farmers will be able to quickly and seamlessly understand and monitor a crop, like never before. The challenge is to engage the agricultural industry and explore how they can best use these sources of data and package that information into a useful format.

Key words

Crop yield mapping, Soil water, On-farm monitoring, Digital Farm Products

References

Donohue RJ, Lawes RA, Mata G, Gobbett D, Ouzman J (2018) A national, remote-sensing-based model for predicting field-scale crop yield. International Journal of Remote Sensing. (In review)

Freebairn DM, Ghahramani A, Robinson JB, McClymont D (2018) A soil water monitoring tool using modelling, on-farm data and mobile technology. Environmental Modelling and Software. (In review)

Grundy, M., Viscarra Rossel, R., Searle, R., Wilson, P., Chen, C., Gregory, L. (2015) The Soil and Landscape Grid of Australia. Soil Research 53, 835-844.

Robertson MJ, Llewellyn RS, Mandel R, Lawes R, Bramley RGV, Swift L, Metz N & O'Callaghan C. (2012) Adoption of variable rate fertiliser application in the Australian grains industry: status, issues and prospects. 13, 181 -199.

GRDC Project Number: CSIRO internally funded