Applications of Precision Agriculture to Cattle: Is it all just hype and will digital technologies ever deliver value to the beef industry?

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Introduction

Precision Agriculture (PA) is synonymous with the cropping industries. Most people think of a farmer driving a GPS enabled combine across the field with yield map data being collected to enable improved efficiency through innovations such as variable rate fertiliser application. Whilst the plant industries are in no doubt leading the field in understanding and managing landscape variability, there is a similar revolution occurring in the grazing livestock sector. GPS enabled monitoring systems along with a range of other sensors and data management platforms are providing livestock managers with insights never before possible. Furthermore, technologies such as virtual fencing are enabling a complete re-think of the way in which animals are managed in extensive grazing landscapes.

This paper and presentation will review some of the currently available, and emerging technologies in the livestock industries. The focus will be on monitoring and managing animals in extensive grazing environments. This is a far greater challenge than in the intensive beef industries. The complexities of balancing variation in landscapes, feedbase, animal requirements and sustainability provide challenges but also opportunities.

One key challenges facing the livestock industries is the hype surrounding many of the technologies. In Australia at least, there is significant start-up investment being poured into companies attempting to develop these tools. While this may provide the solutions required, there is also a good chance that producers may be caught up in this hype cycle and become disillusioned as technologies fail to meet their expectations (Lamb et al., 2008). This presentation will focus on how some of these technologies actually work and what their current limitations might be. The hope is that by improving an understanding of how these technologies work, industry expectations might be better aligned with what can be delivered by the technology providers.

The components of PA in grazing systems

In many of the intensive animal industries PA is focussed on measuring and influencing individual animal productivity. The environment is important, but the focus is on identifying highly performing animals to breed from, or identifying why certain individuals are not performing and finding solutions to this.

In extensive grazing systems, the individual animal component is critical but so is monitoring and managing of the feed-base and landscape. This means that PA tools have been developed for both these applications, measuring and monitoring the animal as well as measuring and monitoring the landscape. Similarly, tools and systems have also been developed to manage both the landscape and

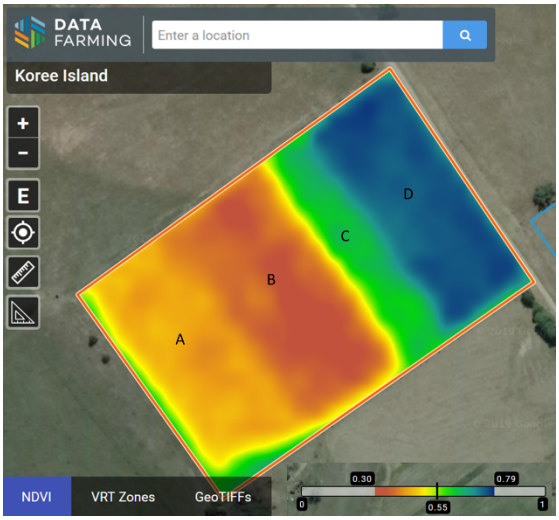

Figure 1 NDVI Image showing variability in pasture caused by electric fence strip grazing (A. Recovering Pasture; B. Just grazed; C. Being grazed; and D. Yet to be grazed pasture). The key innovation is that information is now freely available through web services from the Sentinel satellite (~5m pixel resolution) every 5 days).

the individual animal. This is the frame work in which PA in livestock will be discussed.

PA sensors and tools for monitoring the grazing landscape and feedbase

One of the key issues for animal managers in grazing systems is setting appropriate stocking rates. To do this well, a manager needs to understand exactly how much pasture will be available over the short, medium and long term. There have been a variety of sensor systems developed for measuring pasture (Trotter et al., 2010a). Some of the more recent advances include: the development of LiDAR based proximal systems (for vehicle based measurements - (Trotter et al., 2016)); and unmanned aerial vehicle based image analysis for vegetation volumetrics (Grüner et al., 2019). However, one of the most promising sources of information for grazing landscape assessment remains satellite data. While there are limitations with traditional multispectral imagery (particularly cloud cover), the development of new constellations that can collect imagery more frequently and at higher resolution is ameliorating this (Figure 1). Radar based satellite systems also provide some hope for regions in which cloud cover is frequent (e.g. New Zealand). These new active radar systems can effectively "see" through the cloud and have in, some situations at least, proven accurate (Schmidt et al., 2016). One critical feature of satellite derived data is that it is constantly being collected as opposed to on-ground sensor systems which require support from the producer.

There are also now a number of data platforms integrating remote sensed imagery with other data sources to provide the pasture biomass information sought by producers, for example: Pasture.io; Cibo Labs; GeoGraze and FarmMap4D.

Managing grazing landscape and feedbase variability

Collecting the data form all these sensors remains of little value if a producer cannot implement a management decision that drives production efficiency. There are numerous ways in which the data collected from sensors can be applied, as discussed earlier this information is most commonly used to adjust stocking rates to optimise pasture utilisation.

In addition to this some graziers are starting to consider how their fertiliser management might be impacted by spatial variability in the feed-base. Research has shown a large variation in soil nutrient variability in grazing landscapes (Trotter et al., 2014) and this is now beginning to be exploited

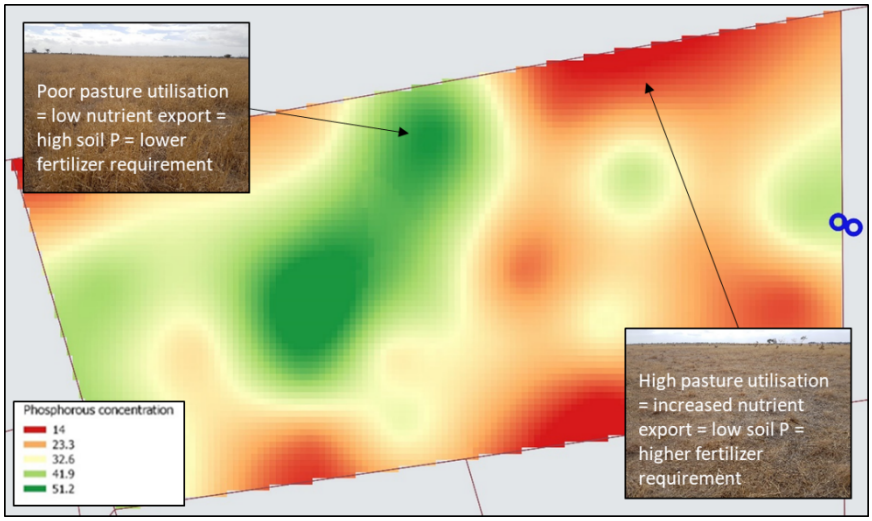

Figure 2 A soil Phosphorus (P) map developed from gridded soil sampling after reviewing GPS tracking data from livestock and variation in pasture biomass. These insights led this producer to develop and implement a variable rate fertiliser management strategy across this and other fields. This meant fertiliser was only spread in the areas that needed it and not in those parts of the field, it reduced fertiliser costs and will likely improve overall production.

by producers in the development of variable rate fertiliser prescriptions, a tool previously only used bin the cropping industry (Figure 2).

PA sensors and tools for monitoring the grazing livestock

There are numerous tools and sensor systems which have been adapted from the intensive livestock industries for use in the beef sector over the years. Individual animal performance recording is becoming increasingly common amongst commercial producers whereas it was once the domain of only seed stock breeders. Collecting the data on grazing animals is a key problem in extensive environments and has seen the development of a number of innovations.

In-field walk-over-weigh technology is now being used on a number of commercial beef properties in Australia (González et al., 2014). This innovation involves setting up weigh scales on a platform that cattle walk over on a daily basis to access an attractant (usually water). These systems provide producers with estimates of live-weight change without the need to bring animals into a central holding facility to weight them (Figure 3). The data can be used to monitor breeding animals to meet body condition score targets or for finishing animals to identify likely turn-off dates. There have also be a range of other applications found from these systems including: detection of parturition (Menzies et al., 2018); dam and calf matching (Menzies et al., 2017); and oestrus detection (Corbet et al., 2018).

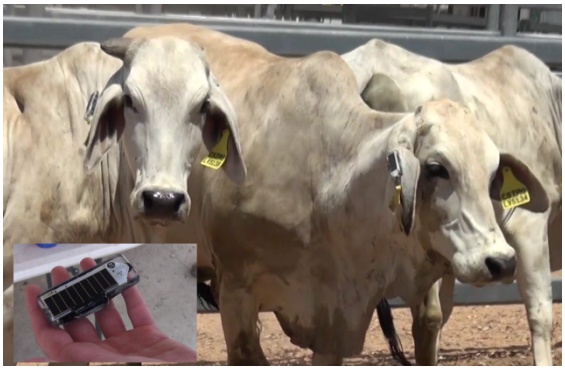

Figure 4 Cattle fitted with an early version of the Ceres Tag ™ GPS ear tag. Inset shows the approximate size and the prominence of the solar panels required to provide energy to power these devices (source Ceres Tag)

Figure 3 A Walk-over-weigh systems developed by DataMuster™. This systems enables collection of liveweight data on a regular basis while animals are located out in the pasture. This particular system has an "auto-drafter" attached which is being used to sort cows from calves automatically.

On animal sensor systems is another focus of research and commercial investment. This involves the deployment of some kind of sensor system on the animal, most commonly as a collar or ear tag (Figure 4 & Figure 5). The dairy industry has been using these sensors for decades with the feedlot industry now also exploring their value. The extensive grazing industries pose a more significant challenge in that connectivity to the sensor remains an issue when animals are located on a distant range.

In extensive landscapes, producers are keen to know both the behaviour of the animal as well as its location (whereas in dairy and feedlot, location is less important). As such, many technology companies are focussed on developing monitoring systems that use GPS to collect location data (Trotter et al., 2010b) and accelerometers to monitor behaviour (Barwick et al., 2018). These sensors, along with the radio connection all use energy that must be supplied by battery or some sort of energy harvesting device (usually a solar panel). This energy use and generation issue remains one of the key challenges for technology developers in this field. These sensors will provide data to enable producers to better understand their livestock behaviour and physiological state. There is good evidence to suggest that these systems can provide early

Figure 5 This heifer is wearing a Herddog™ ear tag (blue circular tag next to visual id tag). This device uses an accelerometer to detect activity patterns that can be associated with oestrus and other key behaviours of interest

warning to disease (Bailey et al., 2018), predation events (Manning et al., 2014), reproductive behaviours (Abell et al., 2017), and feedbase related behaviours (Roberts et al., 2015). They can also be used to develop landscape utilisation maps (Figure 6) similar to the yield maps currently used in the cropping industries.

There are now several commercial companies seeking to provide these tools to the industry, for example: Ceres Tag, Moovement and Smart Paddock.

Managing grazing animal variability

While the development of on animal sensor systems many benefits, the industry is also exploring opportunities to use technology to actively manage how animals interact with the landscape.

Perhaps one of the most anticipated technologies in the grazing industries is virtual fencing (Anderson, 2007). Using a collar born system (**Error! Reference source not found.**) this technology enables a grazier to set boundaries within which an animal can move. This enables a range of grazing management practices to be achieved where traditional permanent or electric fencing would never be feasible.

While this technology looks promising the specific value proposition around costs and likely benefits is yet to be fully understood. There is also some concern from the community in terms of social license. The RSPCA (peak body for animal welfare) does not currently support VF in Australia.

There are several companies currently in varying stages of commercial development, for example: Agersens; Vence and Halter.

A quick comment on technology use in genetic selection

The potential for improved genetic selection through automated phenotyping has been widely suggested. However, the potential for these technologies to provide key insights in some specific areas is worth noting. Using GPS tracking technologies to understand grazing distributions and then select for animals that display ideal habits (Bailey et al., 2015) holds significant promise for landscapes in which sustainability is a key issue. The ability to use

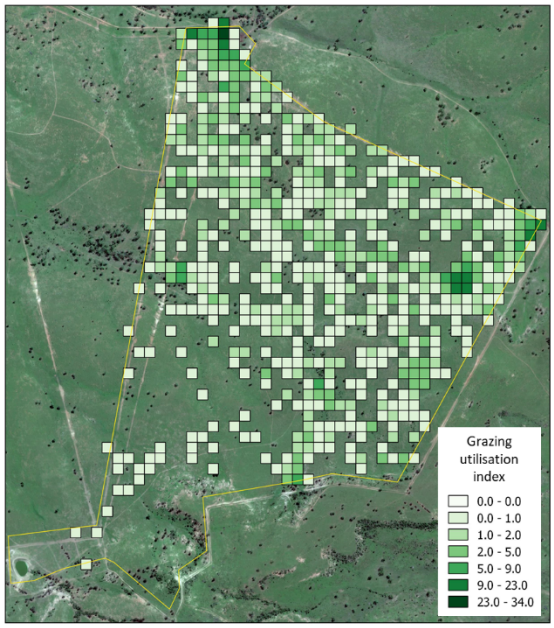

Figure 6 A grazing distribution map derived from GPS data. This information shows how animals prefer to graze in the northern parts of this field and avoid the south east corner. Producers can use this information to help guide paddock and water point design.

sensors to quantify feed use efficiency from pasture (Greenwood et al., 2018) is also of interest to many grass based production systems.

One key future issue may be the need for selection around new traits that enable improved compliance with the technologies. Virtual fencing is a good example of this, with a requirement for animals that respond favourably to this technology likely to be necessary and selected for in the future.

Conclusion

The development of digital technologies for monitoring and managing extensive grazing livestock systems has enormous potential. The ability to synoptically view the landscape in terms of feed-base characteristics along with monitoring the fine scale behaviours of livestock 24-7 is something that has never been possible before. The challenge remains operationalising these systems in the difficult and challenging environment of pasture and rangeland systems. If the industry can work closely with technology companies to guide the development so that valuable information that influences production efficiency decisions can be made, we will reduce the risk of producers becoming disillusioned. Even with this ideal situation, there will need to be a significant effort made in extension to facilitate successful and widespread adoption of these emerging technologies.

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