Maintaining Groundcover in Mixed Farming Systems

Understanding livestock grazing behaviour in large Mallee paddocks

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Executive Summary

Livestock are an integral component of Mallee farming systems. However, the integration of cropping and grazing remains a major management challenge as paddock sizes tend to be large to benefit efficient cropping practices at the expense of optimising grazing management. Furthermore, Mallee paddocks are also characterised by extreme soil variability and these variable soil types support different levels of feed availability and have different susceptibilities to soil erosion. As a result, farmers report that they are not able to utilise all of the feed on offer within a paddock without reducing groundcover below critical levels. In situations in which farmers are forced to extract maximum productivity, soil erosion often results on the most vulnerable soil types such as sand dunes. Advances in technology such as portable fencing systems and virtual fencing potentially offer a solution to the issue of grazing large Mallee paddocks with high soil variability. However, to effectively design and deploy these innovative grazing techniques, the grazing behaviour of livestock in these paddocks needs to be understood and quantified. This project has begun to address this knowledge gap by quantifying livestock (sheep) grazing habits in a large Mallee paddock with variable soil types.

A flock of two-year-old merino ewes (approximately 200) was monitored over a summer and winter grazing period during 2015 using Global Positioning System (GPS) tracking collars. Prior to the commencement of grazing, 25 animals within the flock were fitted with UNE Tracker II GPS collars. Livestock monitoring data was supported with on-ground assessment of vegetative soil cover and feed quantity over both grazing periods. The project was undertaken in a 107 ha paddock near Nandaly in the Victorian Mallee which had a range of soils (deep sands to clay loams) commonly associated with Mallee paddocks. The summer grazing period commenced on 14 January 2015 and concluded on 24 February 2015. The paddock was sown to barley in 2014, and livestock grazed the stubble and grain from lodged heads and grain spilt during harvest. No green plants (volunteer barley or summer weeds) were present when the livestock were introduced into the paddock. The paddock was sown to a vetch pasture in autumn and the flock was re-introduced into the paddock on 28 July 2015. The sheep grazed the paddock until 17 September 2015. At the conclusion of each grazing period, the collars were removed and the data downloaded from the GPS devices. Data was then analysed for the purpose of quantifying spatial variability in grazing pressure. A behavioural model was developed using speed thresholds to identify when sheep were grazing ravelling or camping. This allowed isolation and measurement of the location of grazing, the key behaviour of interest.

When in the stubble paddock over summer, the sheep initially spent most of their time grazing the lighter soil types in the paddock before moving on to the other zones. However, by the end of the summer period, paddock utilisation was relatively even. Grazing speeds and distance travelled were very high as the sheep constantly searched for spilt grain and this would have resulted in large energy expenditure. The amount of spilt grain declined from around 80 kg/ha when the sheep were introduced, to approximately 20 kg/ha when they were removed 40 days later. Very little green pick was available during the grazing period and as a result ewes lost condition over this time. There was a very slight decline in groundcover over the summer grazing period, but on average, groundcover levels remained well above critical levels of 50%. However, there were already some parts of the paddock at the critical 50 percent groundcover when the sheep were introduced to the paddock. In contrast to the summer grazing period, there was a substantial decline in both the median and minimum groundcover level across the winter grazing period with groundcover reaching 50 percent at some individual sites in less than 30 days. In both instances, the sheep had free access
to these low groundcover sites as the farmer sought to extract grazing value from the wider paddock area. The ability to prevent grazing these areas within the paddock could significantly minimise the impact of grazing practices on soil health on dryland Mallee farms.

Grazing intensity was much more spatially variable on the sown vetch pasture in winter than on the cereal stubble in summer. The sheep concentrated grazing on the western end of the paddock during the first 10 days after which paddock utilisation by the livestock slowly increased over time. However, during any 10-day period, livestock spent 50% of the time grazing only 25% of the paddock and a further 25% was not utilised. Spatially variable grazing led to under-utilisation of pasture on the eastern end of the paddock. This represents a significant under-utilisation of the feed base with a subsequent loss of potential income from either increased stocking rates or harvest of the excess feed for fodder.

Currently there is no easy solution to overcoming the problem of uneven grazing by livestock in large paddocks. Rapid fencing systems such as portable electric fencing have been used effectively by some Mallee farmers, but require resources to erect and dismantle. The development of such new technologies as virtual fencing could drastically improve the utilisation of large Mallee paddocks and the data from this project has demonstrated economic case for investing in more flexible fencing technologies.

This project has clearly demonstrated that within-paddock grazing management in large Mallee paddocks has the potential to both increase farm production and profitability by improving feed utilisation and to minimise the impact of grazing practices on soil health on dryland Mallee farms. Therefore, the following recommendations are provided for further work to advance this management practice following this project:

- This study was limited to a single paddock and two grazing rotations. Whilst it has provided significant insights additional replicated trials would provide more data on which economic analysis of the value of managing the spatial variation in grazing pressure might be undertaken.
- In future, trials investigating these issues should be resourced to include evaluation of the prevailing environmental conditions at a sub paddock scale. This study did not have this information and it is thought to have influenced grazing pressure and as such warrants further investigation.
- Future studies could consider the application of virtual fencing however consideration should be given to exploring issues such as optimum paddock size which might be achieved with currently available fencing systems.
- Future studies would benefit from the integration of farmer knowledge surveys to explore the indigenous knowledge currently held by experienced livestock managers. It would be particularly beneficial to examine how new technologies might be integrated with the experience and understanding held by generations of producers currently managing livestock.
- Whilst technologies such as virtual fencing for application to sheep might be several years in development there are innovations such as real-time location and behavioural monitoring which might provide immediate benefit and are closer to commercialisation. Future studies could be focussed on the testing and evaluation of real-time system to provide Mallee livestock managers with improved understanding of animal nutritional status to increase production efficiency.
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1. **Background**

Livestock are an integral component of Mallee farming systems, however, the integration of cropping and grazing remains a major management challenge. In these mixed farming systems, livestock and cropping enterprises normally occupy the same land, where livestock graze the stubbles of winter crops over the summer fallow period and paddocks are rotated between crops and pastures. Consequently, farm infrastructure is not optimised for grazing enterprises and paddock sizes tend to be large to promote efficient cropping practices.

Mallee paddocks are also characterised by extreme soil variability and within a short distance the soil types can changes from deep sands to clay loams. These variable soil types support different levels of feed availability and have different susceptibilities to soil erosion. As a consequence, farmers report that they are not able to fully utilise all of the feed on offer within a paddock without reducing groundcover below critical levels. Furthermore, in situations where farmers are forced to extract maximum productivity from grazing these paddocks, soil erosion often results on the most vulnerable soil types, such as sand dunes.

In low rainfall farming systems such which have substantial within paddock soil variation such as the Mallee, there is potential for in-paddock spatial grazing to greatly improve both cropping and livestock productivity. As well as increasing grazing, utilisation of crop residues while reducing the risk of overgrazing in parts of the paddock, spatial grazing could also make crop grazing more profitable and less risky by targeting grazing to areas where the risk of subsequent grain yield loss is lowest.

Technology such as portable fencing systems and virtual fencing potentially offer a solution to the issue of grazing large Mallee paddocks with high soil variability. To gain insight into the perceived value of virtual fencing among crop-livestock farmers, a survey of 573 Australian grain growers with livestock was conducted across 12 major southern and western grain growing regions in 2012. Growers were asked how beneficial they thought technology that could control where livestock grazed using electronic collars or eartags (virtual fencing) would be on their farm. Overall, of crop-livestock farmers 31% said very beneficial; 17% moderately beneficial and 19% slightly beneficial with producers with large farm sizes were more likely to expect the technology to be very beneficial (R Llewellyn 2015, pers.comm., 21 October 2015).

To effectively design and to efficiently deploy these innovative grazing technologies, the current grazing behaviour of livestock in large Mallee paddocks needs to be understood and quantified. This project has begun to address this knowledge gap by quantifying livestock (sheep) grazing in a large Mallee paddock with variable soil types.
2. Methodology

2.1 Project site

The project site was a 107 hectare paddock near Nandaly in the Victorian Mallee (54 H 651011.21 m E 6088990.15 m S) (Figure 1). The paddock has the wide range of soils (deep sands → clay loams) commonly associated with Mallee paddocks. The paddock had one centrally located watering point and shelter was limited in the paddock with only one small tree located next to the watering point (Figure 2). However, there are shelter belts in adjacent paddocks and roads along the northern and southern edges of the paddock.

Figure 1. Location of the project site

Figure 2. The paddock at the end of the winter of grazing period looking towards the watering point in the paddock.
The site was intensively mapped to determine the extent of spatial variability and define soil type zones within the paddock (Figure 3). The spatial layers captured for the site include using electromagnetic mapping (EM38), Normalised Differential Vegetation Index (NDVI) (using both Historic Landsat and Crop Circle Sensor) and elevation. The zone maps were then used to determine 29 sites across the paddock to be used for on-ground monitoring activities during the grazing period (Figure 4). Soil sampling was then undertaken at nine of the monitoring points to determine the variation of important soil properties across the project site.

**Figure 3** Soil type zone map of the paddock with soil zones classified as light, moderate or heavy

**Figure 4** Location of the 29 sampling points within the project site. The highlighted point between points 18 and 23 is the location of the water point.
### Table 1 - Variation in key soil properties across the project site

<table>
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<th>Sample Point</th>
<th>pH (CaCl₂)</th>
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<th>Colwell P mg/kg</th>
<th>EC 1:5 dS/m</th>
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<td>0-120 cm</td>
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</tr>
</tbody>
</table>

#### 2.2 Livestock monitoring

A flock of two year old merino ewes (approximately 200) were monitored over a summer and winter grazing period during 2015. The same sheep were used during each grazing period, however the ewes had lambs at foot during the winter grazing phase. This project was conducted with the approval of the UNE animal ethics committee, authority no: AEC14-121.

The summer grazing period commenced on the 14th January 2015 and concluded on the 24th February 2015. The paddock was sown to barley in 2014, therefore barley stubble and barley grain from logged grain heads and grain spilt during harvest were available to livestock. No green plants (volunteer barley or summer weeds) were present when the livestock were introduced into the paddock. No livestock grazed the paddock between the summer and winter grazing period. The paddock was sown to a vetch pasture in autumn 2015 and the flock was re-introduced into the paddock on the 28th July 2015. The sheep grazed the paddock until the 17th of September 2015.

Prior to the commencement of grazing, 25 animals within the flock were fitted with UNE Tracker II GPS collars (Figure 5). These collars were set up to collect locations using a burst log, whereby every 7 minutes 4 locations are collected in rapid sequence. GPS data was downloaded and analysed using ArcMap 10.2. The live weights of the sheep fitted with collars were recorded before each collar was fitted. At the conclusion of each grazing period, the collars were removed and the live weights of the sheep were again recorded.

*Figure 5 - A sheep fitted with a UNE Tracker II GPS collar*
2.3 On ground monitoring

On ground monitoring of vegetative soil cover and feed quantity was undertaken at five equal
intervals over both grazing periods including prior to and post grazing. Monitoring occurred at
29 locations within the paddock (Figure 4). At each point four quadrats (0.316 m x 0.316 m) were
placed across a 12 metre transect, perpendicular to the sowing and harvest direction. A photograph
was then captured from a camera mounted on a fixed height frame (approximately 1.5 metres)
looking directly down at each quadrat. Vegetative groundcover was assessed in each photograph by
classifying 100 pixels as either bare ground, dead vegetative material or green plant material.
Percentage groundcover was then calculated as the percentage of pixels with vegetative cover (dead
plus alive vegetative material). From each quadrat all above ground plant material was removed and
sorted as dead or alive. The dead and alive vegetative components were placed in separate paper
bags which were then dried at 70°C until constant weight. Following drying samples were weighed to
calculate kilograms of dry matter per hectare. Once all vegetative matter was removed from the
quadrat, the number of barley grains inside the quadrat were recorded. A standard grain weight of
35 grams per 1000 seeds was used calculate the quantity of grain per hectare.

One of the limitations of the measurement of stubble biomass during the summer grazing period
was that a destructive sampling strategy was required. This resulted in a highly variable
measurement of stubble quantity as the sampling sites needed to shift each monitoring time.
Furthermore stubble load at each monitoring site was highly variable due to factors such as harvest
cut height and straw spread across the harvester width. Therefore, the on-ground monitoring
methodology was modified for the winter grazing period to measure biomass using a calibrated
Normalised Differential Vegetative Index (NDVI) measured with a handheld Trimble Greenseeker.
This methodology not only allowed for repeated sampling at each monitoring point but also a much
larger area of pasture to be measured at each location, counteracting small scale variability at each
monitoring site.

Pasture biomass and groundcover was assessed immediately prior to the sheep entering the
paddock on the 28th of July 2015 (monitoring time 1) and subsequently on the 5th and 20th of August
2015 (monitoring times 2 and 3 respectively) and the 8th and 23rd of September 2015 (monitoring
times 4 and 5 respectively). To assess dry matter a white fibreglass peg was installed at each of the
29 monitoring points and then the Greenseeker (held at approximately 1.5 m height) was then used
to measure average NDVI for four separate 20 m transects which were walked in a north, east, south
and west direction out from the peg. At a distance of 1.5 m out from the peg on each transect, NDVI
was again measured by holding the green seeker over the fixed site for 10 seconds. Pasture height
was also recorded and a photograph was captured to measure groundcover using the same method
as the summer grazing period for each of the four sites.

To calibrate NDVI to kilograms of dry matter per hectare, one destructive sampling measurement
was taken at each monitoring point but not on transects used for repeated measurements. A
specially designed frame was located over what was deemed an average pasture for that site. The
hand held Greenseeker was locked into position on the frame and NDVI was recorded for that site
over a 10 second period. Pasture height was then recorded 3 times across the Greenseekers NDVI
scan width. A quadrat of equal size to the Greenseeker NDVI scan footprint (0.7 x 0.3 m) was then
placed over the scanned pasture area and a photograph was then taken of the quadrat. Using hand
shears, as much vegetative material as possible was removed to ground level within the quadrat and
placed in a paper bag. A post-cut photograph of the quadrat was taken and NDVI was re-measured
with the Greenseeker over 10 seconds. The wet weight of each sample was recorded back in the
laboratory. The sample was split multiple times until a subsample of approximately 30 grams was obtained and then sorted into dead and green fractions. The wet weights of both the fractions was recorded individually and then dried separately at 60°C. The data was then used to generate a calibration curve between NDVI and dry matter in kilograms per hectare.
3. Results

3.1 Summer Grazing

3.1.1 Paddock utilisation

The time sheep spent grazing in each area of the paddock for four periods (10 day intervals) during the summer period is shown in Figure 6. While there were areas of high activity on the northern and southern edges along shelter belts as well as around the water point, across the whole grazing summer period no one cell within the paddock was overrepresented. Grazing times per cell were quite low which was probably due to limited feed availability in the paddock. Furthermore as the summer grazing period progressed, the amount of time the sheep spent grazing the paddock declined.

Figure 6 - Time spend grazing (hours per cell) in 30 x 30 m cells in four 10 day intervals over the summer grazing period
While paddock utilisation was relatively even by the end of the summer grazing period, there was spatial variability in grazing time between 10 day periods. Figure 7 compares the utilisation of paddock zones at 5-day intervals over the summer grazing period. Initially the sheep spent most of their time grazing the lighter soil types in the paddock before moving on to the other zones. This may suggest preferences for certain zones or soil types before feed became limiting and utilisation of other areas became necessary. Figure 8 also highlights a bias in grazing intensity towards some parts of the paddock where sheep spent around 40 percent of their time grazing just 50 percent of the paddock during any 10-day interval over the summer grazing period.

Figure 7 - Cumulative utilisation of the three soil type zones (light, moderate, and heavy) over the summer grazing period

Figure 8 - Percentage of grazing time in the 10, 25, 50 and 75 percent most utilised 30x30 m cells across the paddock during four 10 day intervals over summer
3.1.2 Feed quantity

Barley stubble and grain spilt during the harvest operation were the two most significant feed sources measured in the paddock at the beginning of the grazing period. No green feed (volunteer cereals or summer weeds) was measured in the paddock for the duration of the summer grazing period. The level of stubble dry matter measured was highly variable with no clear trends visible over the grazing period (Figure 9). This is most probably a result of high variability in the amount of standing stubble present owing to the harvest operation such as highly variable harvest heights and straw spread across the width of the harvester. Furthermore, as a destructive sampling technique was required to assess stubble load, the relocating of sampling transects each sampling also contributed to sampling variability. A clear trend in declining spilt grain levels was visible over the summer grazing period (Figure 10). The average level of grain across the paddock at the commencement of grazing was 80 kg/ha with a near linear decline in the amount of grain to 20 kg/ha at the end of the grazing period observed. The limited availability of feed during the summer period was reflected with the ewes losing condition ewes were pregnant prior to entering the paddock, however the average weight of the ewes fitted with collars at the commencement of grazing was 52.5 kg. At the conclusion of the summer grazing period the average weight of these same sheep was 43.6 kg representing a 17 percent decline in body weight over the 6-week period.

![Figure 9 - Stubble dry matter levels measured over the summer grazing period. Error bars are standard error of mean.](image)

![Figure 10 - Barley grain on soil surface measured over the summer grazing period. Error bars are standard error of mean.](image)
One of the unexpected results generated by this study was the relationship found between animal behaviour and the feedbase (Figure 11). Although this data is unreplicated and needs to be treated with some caution there does appear to be a relationship between time spent grazing and the amount of surface grain present. When spilt grain levels reached 40 kilograms per hectare (approximately day 25) there was a noticeable decrease in time spent grazing. The average time spent grazing before day 25 was 28 percent and after was 24 percent. Given the significant weight loss observed in this trial and the difficulty in quantifying the feed base available to sheep one potential application of the GPS tracking might be to provide producers with warnings around animal nutrition issues when grazing stubbles. This would require the development of real-time GPS tracking systems that could report the data on a daily basis.

![Figure 11 - Relationship between time spent grazing (five day moving average) and barley grain on soil surface over the summer grazing period.](image)

**3.1.3 Groundcover**

Figure 12 shows that there was a very slight decline in groundcover over the summer grazing period, however, on average groundcover levels remained well above critical levels of 50% (Leys et al, 1994) over the entire grazing period. As cereal stubble was the major source of livestock feed in the paddock, a lack of change in groundcover levels supports that little of the stubble was being utilised by the livestock over the grazing period. However, there were already some parts of the paddock at 50% when the sheep were introduced, with groundcover further degrading at these sites as the grazing period progressed. In an ideal system, grazing would have been avoided in these zones to reduce the risk of erosion.
Understanding livestock grazing behaviour in large Mallee paddocks

3.2 Winter Grazing

3.2.1 Winter grazing

The time sheep spent grazing in 10 day intervals during the winter period is shown in Figure 13. The maps show that grazing was concentrated on the western end and in particular the north western area of the paddock. This is especially obvious during the first two 10 day grazing periods. Grazing also concentrated on the southern boundary which is similar to what occurred during the summer grazing period. It is possible that the location of a sheltered ridge and/or the water point were acting as attractants to this area. Grazing behaviour during the winter period was much more typical of Merino sheep, with an abundance of feed slowing grazing speeds and allowing grazing to concentrate on certain areas of the paddock. Grazing times were also elevated compared to the summer period as feed was not limiting.

Figure 12 - Vegetative groundcover levels at 29 monitoring locations at five sampling times across during the summer grazing period. The boxes represent the median and the 25th and 75th percentile and the whisker represent the range.
Figure 13 - Time spent grazing (hours per cell) in 30 x 30 m cells in five 10 day intervals over the winter grazing period
Figure 14 highlights that grazing intensity was highly variable across the paddock during the winter period, where during any 10-day period livestock spent 50% of the time grazing just 25% of the paddock. Furthermore 25% of the paddock was not grazed which represents a significant opportunity forgone to extract economic value from these regions with the paddock.

3.2.2 Feed quantity and quality

There was an average of 500 kilograms per hectare of vetch dry matter across the paddock when the sheep commenced the winter grazing period (Figure 15), however this varied from as low as 175 to as high as 1250 kilograms per hectare across all monitoring sites (Appendix 1). By the end of the winter grazing period, an average of 1840 kilograms per hectare of vetch pasture remained with a range of 1300–3000 kilograms of dry matter per hectare not utilised across the paddock. This accumulation of pasture biomass indicates that grazing pressure was insufficient to utilise all of the pasture on offer.
Grazing time at each of the 29 monitoring locations (within a 50 metre radius) was compared to pasture accumulation rate at that site (Figure 16). There was a significant correlation between pasture accumulation and grazing time during the first three monitoring periods but not for monitoring period four. The data shows that at some locations within the paddock grazing pressure exceeded the growth rate of the pasture for that period (negative pasture accumulation) while other points were under grazed. There was an apparent spike in pasture growth rate between monitoring times four and five (Figure 15) which exceeded grazing pressure at all sites during period 4.

Figure 16 - Correlation between grazing time and pasture accumulation for the four monitoring periods at 29 sampling locations.

Feed quality was analysed for each monitoring time over the winter grazing period to see if there were significant differences between over and under grazed regions of the paddock (Table 2). Only two points were selected, point 17 which represented a heavily utilised part of the paddock on the western side and point 20 which represented an area which was underutilised on the eastern side. The results show that the underutilised area (point 20) had higher quality feed, with significantly higher crude protein and digestibility. It is apparent that the sheep did not preferentially seek out the higher level quality areas. The increase in Netural Digestible Fibre (NDF) between the sites could be explained by the removal of green leafy material and more cell wall material remaining at point 17. It may be that sheep were selectively grazing the leaf component of the low biomass areas and as such the effective quality of the feed available between the two sites was not actually different from the animals perspective.
Table 2 - Pasture quality indicators at sites 17 and 20 at five monitoring times during the winter grazing period

<table>
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<tr>
<td></td>
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</tr>
<tr>
<td>Moisture (%)</td>
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<td>Crude Protein (%)</td>
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</table>

### 3.2.3 Groundcover

In contrast to the summer grazing period (where there was little change in groundcover) there was a substantial decline in both the median and minimum groundcover level across the winter grazing period (Figure 17 and Appendix 3). When sheep were introduced to the paddock, vegetative groundcover at all sites was more than 60 percent, however following just 30 days of grazing, groundcover at some sites had reached minimum levels (50%). Minimum groundcover did not continue to decline from this point, probably due to the accumulation of vetch dry matter (Figure 15). However, if the paddock had continued to have been grazed once pasture growth had ceased, it is likely that the minimum level of groundcover would have decreased beyond the critical minimum recommendations.
Figure 17 - Vegetative groundcover levels at 29 monitoring locations at five sampling times across during the winter grazing period. The boxes represent the median and the 25th and 75th percentile and the whisker represent the range.
4. Discussion

Farmers report that livestock graze large Mallee paddocks unevenly, however this project has begun to verify on the extent of the variability in spatial utilisation of a paddock. During summer, the stubble paddock was fully utilised however large areas were very lightly grazed, with animals travelling long distances across the field. The animals also grazed the summer stubbles at high speeds which were almost double those observed during the winter grazing period. The extent and speed of grazing during the summer period suggests little feed was present and that they were driven to search for nutrition.

Robinson (2006) showed that the grazing value of stubble is determined by the amount of residual grain and green material present and that the standing straw and trash has minimal value. With the presence of both spilt grain and summer weeds, sheep were able to maintain live weight until early autumn where sheep condition declined it was due to the nutritional stress of late pregnancy and parturition in autumn lambing flocks (Robertson, 2006). In the current study the sheep lost 17% live-weight over the six week grazing period when no green weeds were present and sheep were only extracting spilt grain. While we are uncertain over what timeframe livestock weight declined, a change in animal grazing behaviour, where time spent grazing declined from 28 percent to 24 percent, was detected when surface grain levels reach around 40kg/ha. This level corresponds with other observations which have found livestock will lose weight when the stubble offers anything below 40 kg/ha of spilt grain or 40 kg/ha of green weeds dry matter (GRDC, 2011).

Real time monitoring systems could make use of this type of data to improve the grazing management of livestock. For example, where the feed value of spilt grain is difficult to determine, detecting a change in time spent grazing could be the trigger point to remove the livestock from the paddock before condition is lost. Such systems could also provide other benefits such as identifying animal health and welfare issues.

During the winter grazing period sheep concentrated 50% of their grazing time on just 25% of the paddock while a further 25% of the paddock was left unutilised, representing a significant economic opportunity foregone. Two hundred ewes with lambs at foot grazed the paddock, or 5.6 Dry Sheep Equivalent (DSE) per hectare. However, as grazing occurred on only 75% of the area, the stocking pressure on the utilised part of the paddock was 7.3 DSE/ha. It is logical that, with improved grazing management an additional 65 ewes with lambs could have been fed. Alternatively, a quarter of the paddock could have been cut for hay. If 1.5 t/ha of vetch hay were cut from 25% of the paddock, an additional $150/ha of profit would have been made on a quarter of the paddock or the equivalent of approximately $4000 additional profit.

Similar improvements in profitability have been reported by farmers who have used portable electric fencing systems to manage grazing in Mallee paddocks. South Australian Mallee farmer Allen Buckley has used the Rappa portable electric fencing system to concentrate grazing low production soil types within crop paddocks while harvesting the more productive soil types for grain. Two separate economic analysis of this system in 2009 and 2010 has shown that grazing these zones produced respective gross margins of $140 – $250 per hectare while gross margins from harvesting grain from these soil types is typically negative (A Buckley 2016, pers.comm., 8 March).

Despite the demonstrated benefits of using portable electric fencing systems, adoption of such systems is low as considerable labour is required to erect and dismantle the fences. Technology such as virtual fence systems could address the limitations of the physical fencing systems and allow for widespread implementation of within paddock grazing management for which this project has
demonstrated a strong economic case for. Many Mallee farmers have voiced their support for the development of such technology including Walpeup farmer Jim Wakefield. He states that “the benefit of such a system for me is the ability to get greater production and efficiencies where broadacre cropping and livestock coexist. The prime example in our scenario is the grazing of fodder crops, where effective virtual fencing could provide greater utilisation of feed in areas that were highly productive, without allowing livestock to degrade the less productive areas more prone to erosion” (J Wakefield 2016, pers.comm., 22 February 2016).

As highlighted above, such technology would not only improve farm productivity and profitability but could also provide environmental benefits. This project showed that some areas within the paddock (typically erosion prone sandy soils) were at the critical groundcover level when sheep where introduced into the stubble paddock in summer, while grazing during winter rapidly brought groundcover levels to the critical threshold limits at isolated sites. In both instances, the sheep had free access to these low groundcover sites as the farmer sought to extract grazing value from the wider paddock area. The ability to prevent grazing these areas within the paddock significantly minimise the impact of grazing practices on soil health on dryland Mallee farms. Furthermore additional environmental benefits from such technology could also include preventing livestock from entering and damaging important habitats such as remnant vegetation, waterways and wetlands and preventing native animal injury by minimising the number of physical fences in the landscape.

Australian company Agersens (http://agersens.com/home-2/) is currently developing the eshepard system which utilises animal friendly patented training software developed by the CSIRO. The system trains livestock to respond to an audio sound that signals the fence boundary. Furthermore the technology will allow farmers can create a fence or set up a controlled grazing program using their smart phone, tablet or PC which will then relay Instructions wirelessly to each animal’s GPS enabled collar. The eshepard system is designed for cattle and significant research and development is required before similar commercial systems would be available for sheep. Furthermore, the current Victorian Prevention of Cruelty to Animals Regulations 2008 prevent the use of electronic containment collars on animals other than dogs and cats, therefore using this technology on livestock (including for trials) is currently illegal.
5. Conclusion and recommendations

For the first time sheep grazing behaviour in a Mallee paddock was monitored and mapped using GPS tracking technology. During summer, when feed was limited, the paddock was fully utilised but large areas were very lightly grazed, with animals travelling long distances across the field. This contrasted with the winter grazing period in which sheep concentrated 50% of grazing on 25% of the paddock. A further 25% of the paddock was left unutilised which represents a significant economic opportunity foregone that could be addressed using cost-effective within-paddock fencing or virtual fencing. Furthermore, low groundcover sites were identified within the paddock during both the summer and winter grazing periods.

This project has clearly demonstrated that within-paddock grazing management in large Mallee paddocks has the potential to both increase farm production and profitability by improving feed utilisation and to minimise the impact of grazing practices on soil health on dryland Mallee farms. Therefore, the following recommendations are provided for further work to advance this management practice following this project:

- This study was limited to a single paddock and two grazing rotations. Whilst it has provided significant insights additional replicated trials would provide more data on which economic analysis of the value of managing the spatial variation in grazing pressure might be undertaken.
- In future, trials investigating these issues should be resourced to include evaluation of the prevailing environmental conditions at a sub paddock scale. This study did not have this information and it is thought to have influenced grazing pressure and as such warrants further investigation.
- Future studies could consider the application of virtual fencing, however, consideration should be given to exploring issues such as optimum paddock size which might be achieved with currently available fencing systems.
- Future studies would benefit from the integration of farmer knowledge surveys to explore the indigenous knowledge currently held by experienced livestock managers. It would be particularly beneficial to examine how new technologies might be integrated with the experience and understanding held by generations of producers currently managing livestock.
- Whilst technologies such as virtual fencing for application to sheep might be several years in development there are innovations such as real-time location and behavioural monitoring which might provide immediate benefit and are closer to commercialisation. Future studies could be focussed on the testing and evaluation of real-time system to provide Mallee livestock managers with improved understanding of animal nutritional status to increase production efficiency.
6. Acknowledgments

This project was supported by the Mallee Catchment Management Authority, Mallee Sustainable Farming, University of New England and BCG through funding from the Australian Government’s National Landcare Programme.

Thank you to the Sam, Joseph and Matt Brady for allowing us to use their livestock and paddock for this project and for their assistance throughout the project.

7. References


8. Appendices

Appendix 1 – Animal ethics approval

ANIMAL ETHICS COMMITTEE
ANIMAL RESEARCH AUTHORITY
And Approval for Animal Experimentation

RESEARCH TEAM: Mr Zachary Economou, Dr Mark Trotter, Mr Jamie Barwick & Mr Derek Schneider

EMERGENCY CONTACT Dr Mark Trotter
0447 441 841

Are authorised to conduct the following research:

TITLE: Quantifying Livestock Grazing Behaviour and the implications for groundcover in the Victorian Mallee

LOCATION(S): Bragee, 723 Nyarrin-Nandaly Rd, Nandaly VIC 3533

ANIMALS:

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This authority remains in force from 05/01/2015 to 05/01/2016 unless suspended, cancelled or surrendered.

This statement must be read in conjunction with the Conditions for Animal Experimentation at UNE as stated on the reverse.

Jo-Ann Sozou
AEC Secretary and UNE Research

05/01/2015
Appendix 2 – The change in vetch dry matter at 25 monitoring sites during the winter grazing period
Appendix 3 - The change in vegetative groundcover at 25 monitoring sites during the winter grazing period