Spatio-temporal movement of livestock in relation to decreasing pasture biomass

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Abstract

The use of spatio-temporal livestock monitoring to investigate animal behaviour in relation to available biomass has the potential to improve pasture utilisation in rotational grazing systems. The aim of this study was to examine if movement metrics derived from GPS monitoring could identify variations in animal behaviour in response to decreasing pasture availability. GPS tracking collars were deployed on six cattle grazing for 46 days and data analysed to determine grazing time and spatial variation in utilisation. Unexpectedly, grazing time did not seem to be affected by decreasing pasture biomass. However, spatial utilisation of the paddock appeared to increase as biomass decreased.

Key words

GNSS, GPS, cattle tracking, spatio-temporal analysis, Crop Circle.

Introduction

There are several spatio-temporal livestock monitoring systems being developed for commercial deployment (Stassen 2009). Monitoring livestock behaviour in relation to available biomass is one potential application with the aim of increasing the utilisation efficiency of pastures and better matching the needs of livestock to the available biomass. Pasture utilisation increases of up to 20% may be realised (Monk 2010) using these spatial monitoring technologies to assist in scheduling livestock movements in rotational grazing systems. The aim of this preliminary study was to examine if movement metrics derived from GPS monitoring devices can identify variations in animal behaviour in response to decreasing pasture availability. To do this we used ‘time spent grazing’ and the recently developed ‘Livestock Residence Index (LRI)’ mapping tool (Trotter et al. 2010a) to examine variations in the spatial distribution of livestock in response to dynamic changes in available pasture biomass under grazing.

Methods

The study site was located at the Douglas McMaster Research Station, a 1500 ha mixed cattle and cropping enterprise located in the Northwest slopes region of New South Wales, Australia (150^{o}36’0”, 29^{o}17’6” WGS84). A 51 ha paddock was sown to oats on 9 May 2008 and grazed by a herd consisting of 99 small steers (mean weight 244 kg), 22 large steers (mean weight 450 kg) and 30 in-calf cows (mean weight 569 kg). Initial calculations suggested that at this stocking rate there would be a net decrease in biomass over the monitoring period. The herd was managed as a ‘normal commercial system’ during the study period. The monitoring period was interrupted by management operations (31 August to 5 September 2008) in which the herd was variously removed and returned to the paddock. This period, hitherto referred to as ‘the exclusion period’, coincided with a major rainfall event (43 mm, Figure 1). Prior to the exclusion period cattle had access to a water trough located in the south eastern corner of the paddock and following the exclusion period an additional water trough was made available in the north eastern corner of the paddock. As a consequence of the break in the natural grazing cycle, the variation in paddock management and the rainfall events, the total grazing duration was divided into four periods; periods 1 and 2 before, and periods 3 and 4 after the exclusion period.

Biomass mapping

Two biomass surveys were undertaken; at the beginning of the study prior to period 1 and at its conclusion following period 4 (13 August 2008 and 24 September 2008, respectively) using an Active Optical Sensor (AOS) platform (Crop Circle™) linked to a GPS mounted on a quad bike (Trotter et al. 2010b). The Normalised Difference Vegetation Index (NDVI) generated by the AOS was calibrated to green dry matter (GDM) by scanning and harvesting, drying and weighing 25 pasture samples from a 1 by 0.7 m quadrat on 30 July 2008 (Whelan et al. 2001). The calibration curve was applied to the paddock scans and data interpolated using Vesper to a 10 m grid. Block Kriging was used with an exponential variogram, a block size of 50 m and a neighbourhood for interpolation of between 80 and 100 points. The data were then mapped (Figures 2 and 5) using ArcGIS (ESRI, California, CA, USA).

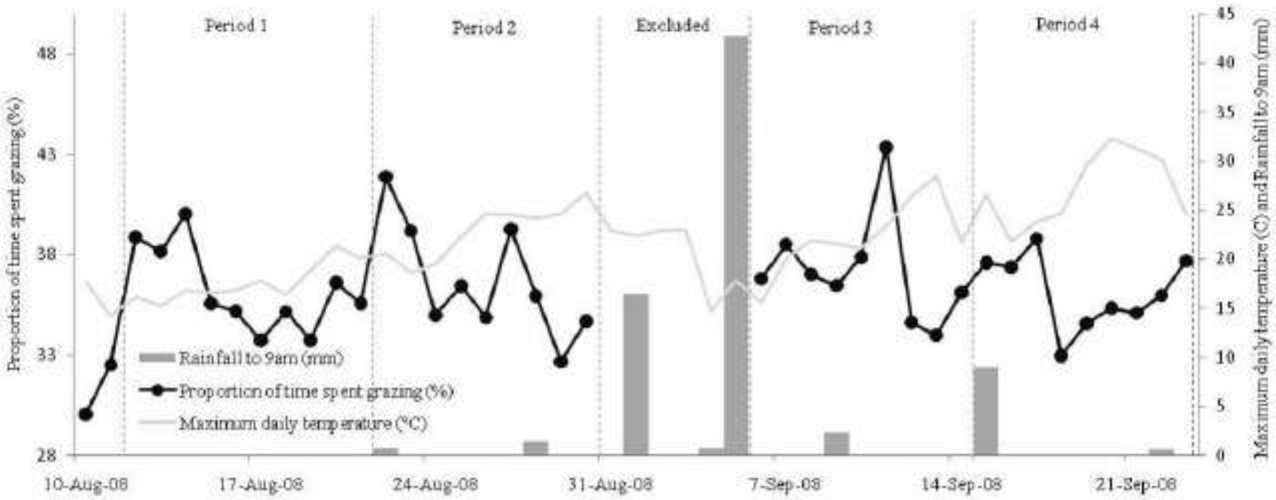

Figure 1. Daily variation proportion of time spent grazing (dark line), maximum daily temperature (grey line) and rainfall events (shaded bars) for the period of monitoring.

GPS tracking

Six UNEtracker GPS collars (Trotter and Lamb 2008) were deployed on animals in the herd from 9 August to 23 September 2008. Collars were programmed to collect positional records every 10 minutes. Raw GPS log data were analysed using ArcGIS (ESRI 2006) and Microsoft Excel. Movement metrics were derived using 'Hawth's Tools', an add-in for ArcGIS (Beyer 2004). Following the behavioural model proposed by Putfarken et al. (2008) each point was subsequently classified based on velocity (derived from distance travelled and time between previous logged position) as either stationary (<0.02 m/s), grazing (>0.02<0.33 m/s) or travelling (>0.33 m/s). The mean proportion of time spent grazing by all six animals being monitored was then calculated for each day for the deployment period and graphed against climate data (Figure 1). The deployment period was subsequently divided into four periods for further investigation. Grazing positions were also mapped as a LRI (Trotter et al. 2010a) for each of these periods (Figures 3, 4, 6 and 7). As no local climate data were available, this information was obtained from the Australian Bureau of Meteorology for a weather reporting location approximately 40 km east of the study site.

Results and discussion

Biomass mapping

Calibration of AOS NDVI to GDM showed a good correlation (r^2= 0.80) using a log transformation of the biomass values (prediction equation: GDM = $23.2e^{5.3NDVI}$). This result was better than that reported by other researchers for similar forages (Trotter et al. 2008). Mean GDM for the survey on 13 August 2008 was 928 kg/ha (sd = 296 kg/ha) and on 24 September 2008 it was 279 kg/ha (sd = 109 kg/ha). The spatial variation in the distribution of GDM is apparent in Figures 2 and 5, with higher GDM evident in the central and northern parts of the paddock at the start of the study. At the conclusion of the monitoring period there was a net reduction in GDM with the western areas of the paddock retaining relatively higher levels compared with the eastern parts.

Livestock grazing activity

The proportion of time spent grazing (Figure 1) ranged well below the 48% reported by Putfarken et al*.* (2008); however, it was within the range reported in several other studies (29-50% - as reviewed by Vallentine 2001). Other studies have also demonstrated an inverse relationship between mean daily temperature and grazing time (Shaw and Dodd 1979; Thomas et al*.* 2008). However, in our study it was difficult to isolate the effects of temperature from other variables, particularly progressively diminishing GDM. This highlighted the challenge in attempting to ascribe behavioural changes to individual variables. We expected daily net grazing time to increase over time in line with diminishing pasture availability (Chacon et al. 1978; Gibb et al*.* 1999). In contrast, we found that there was little difference between the time

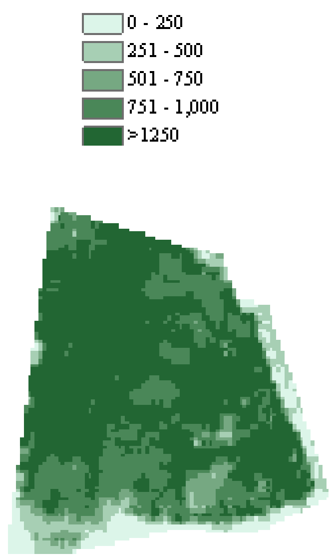

Figure 2. Green dry matter map (kg/ha) for 13 August 2008.

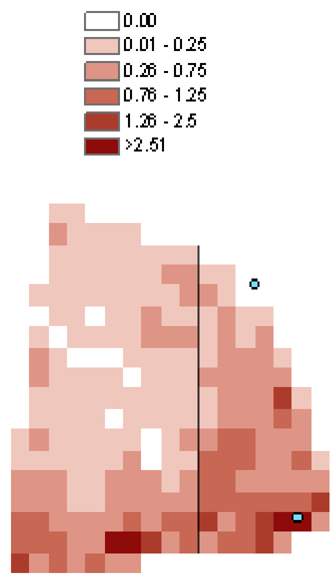

Figure 3. Livestock Residence Index (x100) for period 1.

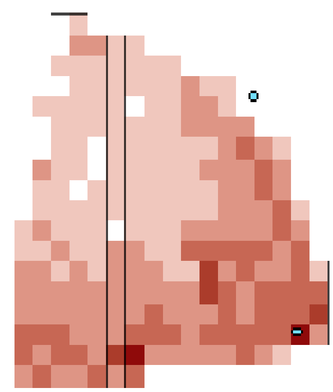

Figure 4. Livestock Residence Index (x100) for period 2.

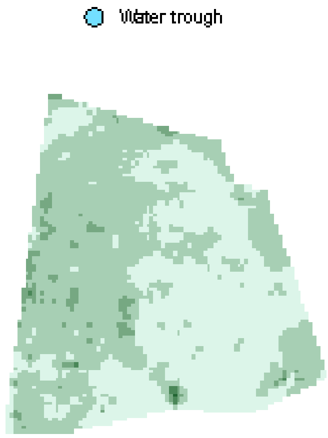

Figure 5. Green dry matter map (kg/ha) for 24 September 2008.

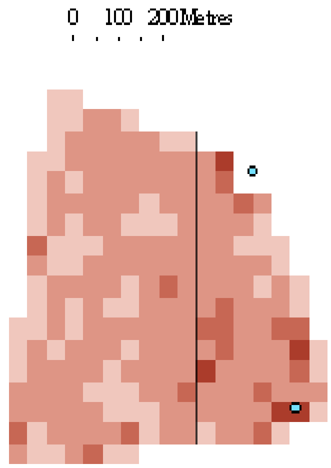

Figure 6. Livestock Residence Index (x100) for period 3.

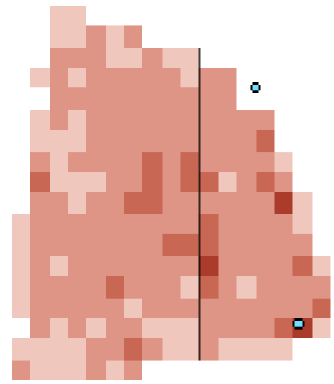

Figure 7. Livestock Residence Index (x100) for period 4.

spent grazing for periods 1-4 (means of 36.3, 36.7, 37.2 and 36.2, respectively), although there was a large amount of variation between days (Figure 1). In a much shorter study, Chacon and Stobbs (1976) found grazing time initially increased over 1-2 days, but then gradually decreased in response to a diminishing pasture biomass over the next 10 days. The initial pattern of behaviour demonstrated for the first 12 days of the Chacon and Stobbs (1976) study appeared to almost mirror the trends demonstrated in the first 12 days of our study. Chacon and Stobbs (1976) suggested that the reduction in grazing time was a result of declining leaf availability in pastures causing fatigue, which in turn resulted in a lack of desire to harvest and so compensate for the reduced quantity and quality of the diet. However, it is unlikely that this was the case in our study, as the GDM and LRI maps showed considerable areas of largely unutilised pasture that were still available in this period. The LRI map for period 1 (Figure 3) demonstrated the initial utilisation of the paddock which avoided much of the higher GDM areas apparent in the north western quarter. An increase in spatial utilisation as the monitoring period progressed was expected, in line with a decrease in available pasture GDM in grazed areas (Bailey et al. 1996). The LRI map for period 2 (Figure 4) showed some dispersal of grazing pattern as livestock forage for new feed, however, they continue to under utilise the high GDM in the northern and western areas of the paddock. The LRI maps for periods 3 and 4 (Figures 6 and 7) demonstrate a remarkable increase in the spatial utilisation of the paddock as a whole, compared with periods 1 and 2. However, as this followed the exclusion period and rainfall it is difficult to determine the dominant influences affecting alterations in behaviour. Certainly, the decline in available forage would have contributed, but so to may have the introduction of the second watering point as well as rain (Bailey et al*.* 1996).

Conclusion

The results of this preliminary study suggested that there is opportunity to utilise spatial monitoring technologies to understand livestock and pasture interactions and enable producers to better schedule livestock movements in rotational systems. Whilst traditional measures such as grazing time may not provide sufficient information alone, the integration of spatial measures of utilisation are promising. This study highlights the complexities faced in developing these types of systems. A large body of research remains to be undertaken in this field, with particularly detailed temporal studies required to examine the pasture and animal characteristics in question.

Acknowledgements

This work was conducted within the CRC for Spatial Information (CRCSI), established and supported under the Australian Government Cooperative Research Centres Programme. The authors acknowledge the support of Simon and Corrine Jasper (McMaster Research Station). The senior author was awarded an Australian Society of Agronomy Travel Bursary sponsored by Australian Wool Innovations Ltd.

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