How well does NDVI correlate with green biomass, cover and diet quality?

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Abstract

Livestock producers desire improved tools to assess the quality and quantity of pasture on offer to adjust stocking rates and provide timely protein and energy supplementation. The NDVI (Normalised Differential Vegetation Index) has been used in environmental and agricultural monitoring for over 40 years to estimate photosynthetic activity, leaf area index and plant biomass accumulation. This paper presents preliminary findings of 12 months assessment of relationships between ground-based NDVI and visually estimated green biomass, green cover and faecal estimates of forage crude protein. There was a strong linear regression between NDVI and green biomass and cover, but NDVI was a poor surrogate for diet quality. NDVI has the potential to be used as a forage budgeting tool within Mitchell grass pastures.

Introduction

Forage biomass and diet quality are key determinants of livestock stocking rates and performance (McDonald *et al*. 1985). Consultation with landholders in western Queensland has shown they desire improved tools to assess the quality and quantity of pasture on offer, to adjust stocking rates and provide timely protein and energy supplementation. NDVI has been used in environmental and agricultural monitoring since the early 1970s to estimate photosynthetic activity, leaf area index and plant biomass accumulation (Clevers 1988). If there is a strong relationship between NDVI and Mitchell grass pasture biomass, then commercially available hand-held NDVI sensors and remote sensing products could be useful tools for adjusting stock numbers through forage budgeting. Historic datasets of remote sensed NDVI have potential to derive probabilities of the start and duration of growing seasons at paddock or property scales and aid in planning longer-term stocking rates and breeding calendars. To be useful, NDVI would need to indicate both the timing and magnitude of growth pulses .Underpinning this application of NDVI is that green pasture is of higher diet quality for livestock than senesced or moribund pasture (Meyer and Brown 1985). Could NDVI be used as a surrogate for pasture quality and inform supplementary feeding decisions? This paper presents preliminary results of field testing the relationship between NDVI, green biomass, green cover, faecal estimates of forage crude protein and sheep live-weights during 2014 in Mitchell grass pastures of western Queensland.

Methods

Two sites of 100 x 100 m size were established within the Open Downs land type on Dunblane, 10 km west of Barcaldine in central-western Queensland. Land Condition was moderate (B condition score, Hunt *et al*. 2014), being dominated by Mitchell grass (*Astrebla* spp.) but also having a high frequency of feathertop (*Aristida latifolia*). The sites were representative of two paddocks, grazed by Merino hogget wethers with mixed age-class cattle as a single area over 2014 at 1 dse/ha. NDVI, biomass and ground cover were estimated nine times over 2014, every 3-6 weeks. Fifty NDVI recordings were made along fixed transects using a hand-held French-built sensor coupled with an OM-DAQPRO-5300 logging multimeter at the same time as 10 BOTANAL recordings (within 0.5x0.5m quadrats, Tothill *et al*. 1992) to estimate total and green biomass and cover. Sheep and cattle diet quality was assessed using faecal NIRS (Dixon *et al*. 2010) and 100 sheep were weighed monthly. Data were prepared, graphed and linear regressions conducted in Microsoft® Excel as site averages for each recording date.

Results & Discussion

Green biomass ranged from 120-1325 kg Dry Matter per ha (DM/ha) and NDVI from -0.23 to 0.14 (on a scale of -1 to +1) throughout the year. The highest were values recorded over January-February following above-average rain (Table 1), prior to declining under drying conditions (Fig. 1).

Table 1. Monthly rainfall totals and number of rain days in 2014 for Barcaldine Post Office, 10 km to the East of Dunblane.

Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rain (mm)	100.2	252.5	5.1	0.8	0.0	19.4	0.6	51.5	25.4	9.2	10.6	79.4
Rain days	6	9	4	2	0	1	1	5	5	3	3	10
Mean rain (mm)	86.6	79.4	59.5	36.0	30.3	24.2	22.5	16.0	15.9	28.6	39.6	63.7

NDVI increased over September-October following winter rain, whilst green biomass estimates did not alter; either the changes were too small to detect via visual estimates or NDVI was responding to increased plant photosynthetic activity independent from biomass changes. There was a strong linear regression relationship between NDVI and green biomass (R^2 = 0.7365, Fig.2). Linear regression relationships were comparable for green biomass and green cover (R^2=0.8281) and NDVI and green cover (R^2=0.8645, data not presented). These data suggest NDVI is a good predictor of green biomass for Mitchell grass pasture in moderate land condition. Overall, these data suggest remote sensing based NDVI should accurately detected the timing and magnitude of green biomass changes pulses, although this was not specifically addressed within the current study.

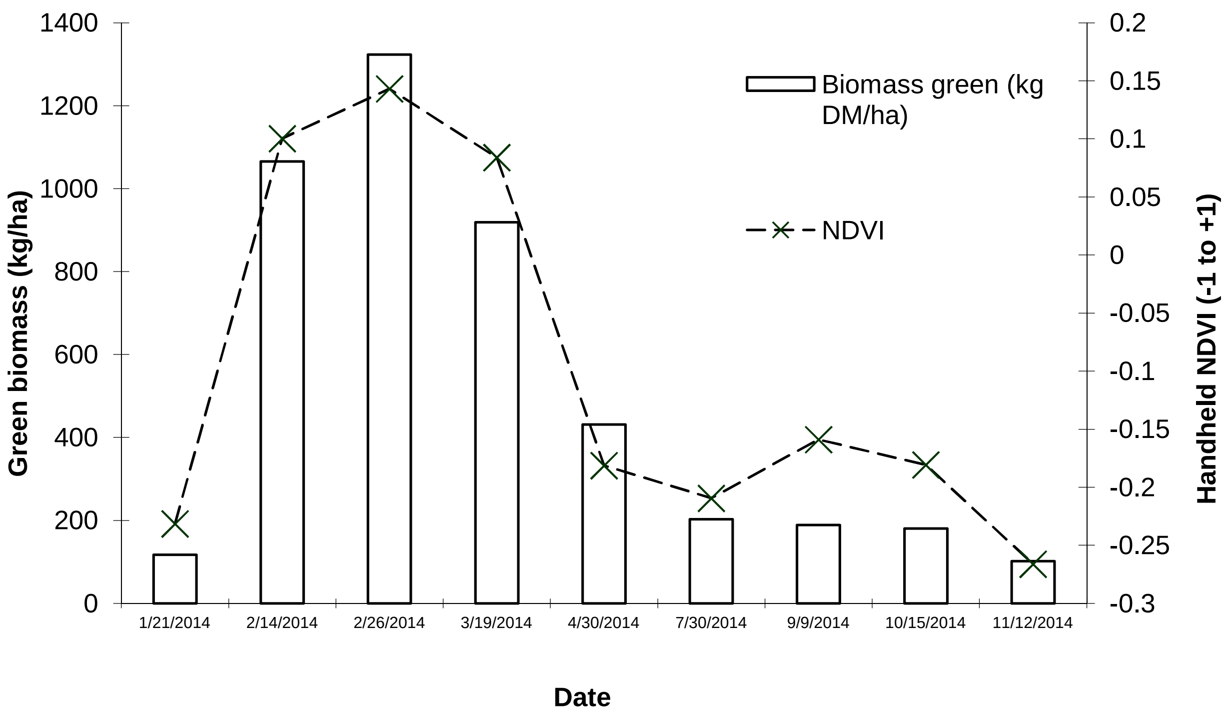

Fig. 1. Green biomass (kg DM/ha, bars) and NDVI (hashed line) profiles between January and November 2014

Forage crude protein was highest in January 2014 (21%) when NDVI and green biomass were low (-0.23 and 120 kg DM/ha respectively). Crude protein concentration is highest in early grass growth dominated by leaf and dilutes as tillering commences (Parsons and Penning 1988, Hunt *et al*. 2014). The simple linear regression of NDVI and crude protein was relatively weak (R^2=0.2351) with the January data included, but improved when removed (R^2=0.7572). This suggests NDVI is generally not a good surrogate for diet quality due to the poor relationship between protein and biomass during leaf growth yet may improve in later growth stages. The patterns in NDVI and protein were similar from March onwards, including the small NDVI increase in September following winter rain (Fig.3). There may be value in using NDVI as a guide once the initial pasture growth phase is completed.

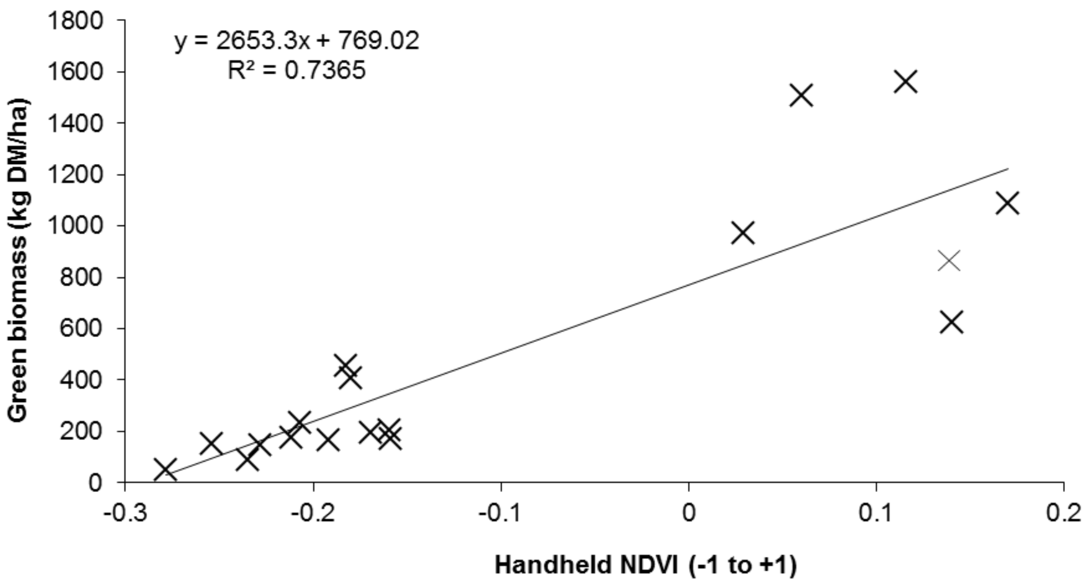

Fig. 2. Simple linear regression of average NDVI and green biomass (kg DM/ha) from two sites at nine recording times throughout 2014

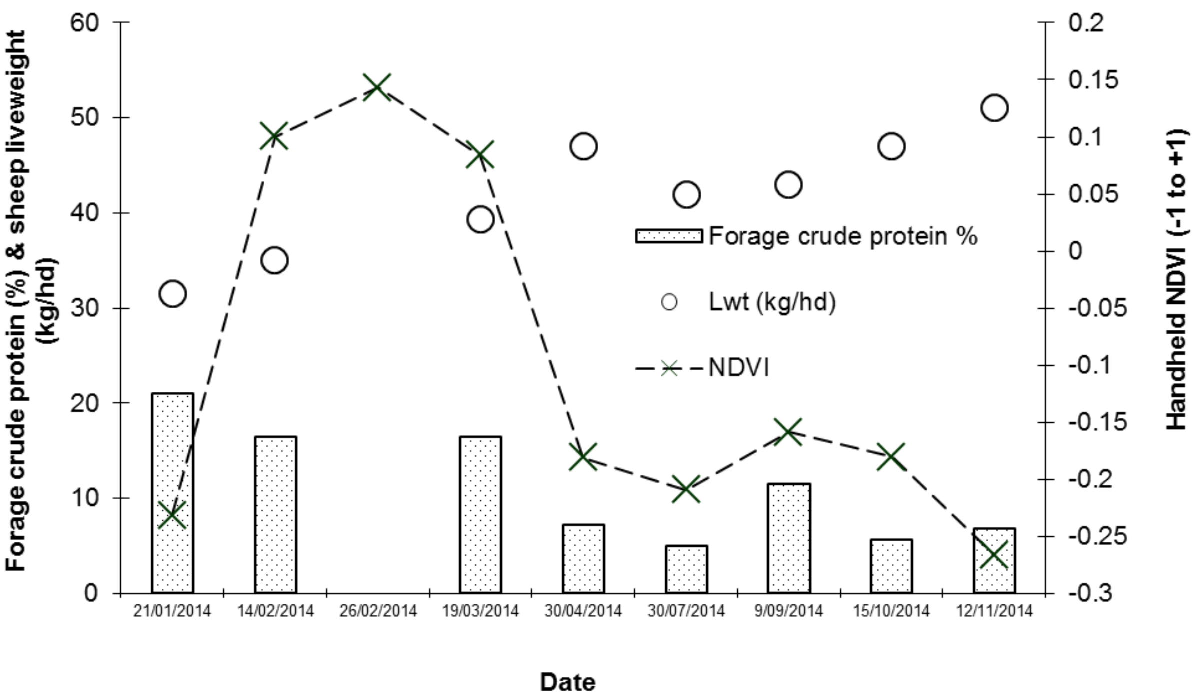

Fig.3. Forage crude protein (%, bars), sheep live-weight (kg/hd, open circles) and NDVI (dashed line) profiles between January and November 2014

Sheep live-weight increased from 31.5 kg/hd in January to a final weight of 51 kg/hd in November as these hoggets matured towards adult weights, despite NDVI, green biomass and crude protein declining from March onwards (Fig.3). NDVI and green biomass may be useful tools to help adjust live-stock numbers but would be a poor predictor of live-weight change for sheep which are still maturing. This information could guide supplementary feeding decisions when considered in conjunction with faecal NIRS reports (which includes forage crude protein and digestibility, and the implications for live-weight gain or loss) and/or direct measurement of sheep live-weights, but appear to be a poor surrogate for animal performance.

Conclusion

Overall, these preliminary data suggest NDVI derived from a hand-held device is a useful predictor of green biomass in Mitchell grass pastures with the potential to be used in forage budgeting activities. Similarly, remote sensed NDVI may offer useful tools at the paddock or property scale, but this was not tested directly within the current study. NDVI was a poor surrogate for diet quality, as inferred through a poor relationship with crude protein. However, NDVI values from later in the growing season may offer information to help guide supplementation decisions. Further investigation in the applied use of NDVI within Mitchell grass pastures is warranted.

Acknowledgments

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