

Cross validation of pasture biomass predictions from handheld NDVI sensor measures

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Introduction

- Visual pasture estimates are critical in helping graziers match stocking rates with forage supply. However, they are subject to operator bias¹.
- Normalised Differential Vegetation Index (NDVI) sensors offer an objective method for assessing pasture yield. Pasture reflects near infrared (NIR) and absorbs red light. $NDVI = \frac{NIR - Red}{NIR + Red}$
- This paper develops prediction equations for actual green biomass from NDVI values, then cross validates them to assess whether the handheld NDVI sensor would be a suitable option for predicting green biomass of mixed pastures in northern Queensland.

Data description

- Pasture measurements were recorded for 191 quadrats of mixed pasture types over 12 months (Wet & Dry seasons), on two properties in the Burdekin grazing region in North Queensland.
- Initial pasture measures included: visual estimate green biomass, height, NDVI using a Trimble GreenSeeker^R (Figures 1 & 2).
- Quadrats were then cut and dried to calculate actual pasture measures (e.g. green biomass, protein).



Figure 1. Visual estimation



Figure 2. Hand-held NDVI sensor

Statistical methods

- Predicted actual green biomass from NDVI and NDVI x pasture height (NDVI_Ht) for Wet and Dry seasons.
- Prediction models were obtained by choosing the optimal significant linear and curvilinear regression.
- Cross validated these best models via:
 - Independent data set (Dry season only)
 - k-fold (Wet season only)
 - divide data into k random groups,
 - fit the model format to k-1 groups, validate on the remaining group;
 - repeat k times so every group is in the validation group exactly once
 - n-fold (leave-1-out) (Wet season only)
 - as for k-fold with k=n
- Main assessment measures:
 - Root mean square error (RMSE) - to quantify the error of prediction (on the original scale of the data - kg/ha)
 - Mean absolute error (MAE%) - to assess % error

Results

- Green biomass ranged from 10 - 2,776 kg/ha and NDVI readings from 0.15 to 0.58, providing a good distribution of data points for predictions.
- A mix of linear and curvilinear models were appropriate (Table 1, Figure 3).
- RMSE and MAE for each validation are shown in Table 2.

Table 1. Prediction models

Season	Equation	n	p	adj R ²
Wet	$\log_e GB^{\#} = 7.9 - 0.14 \times (0.13)^{\log_e NDVI}$	137	<0.001	66.7
	$\log_e GB = 7.4 - 3.8 \times (0.77)^{NDVI_Ht}$	137	<0.001	68.8
Dry	$\log_e GB = 13.7 + 5.3 \times \log_e NDVI$	54	<0.001	49.5
	$\log_e GB = 8.4 - 5.2 \times (0.90)^{NDVI_Ht}$	54	<0.001	29.1

GB = Green Biomass

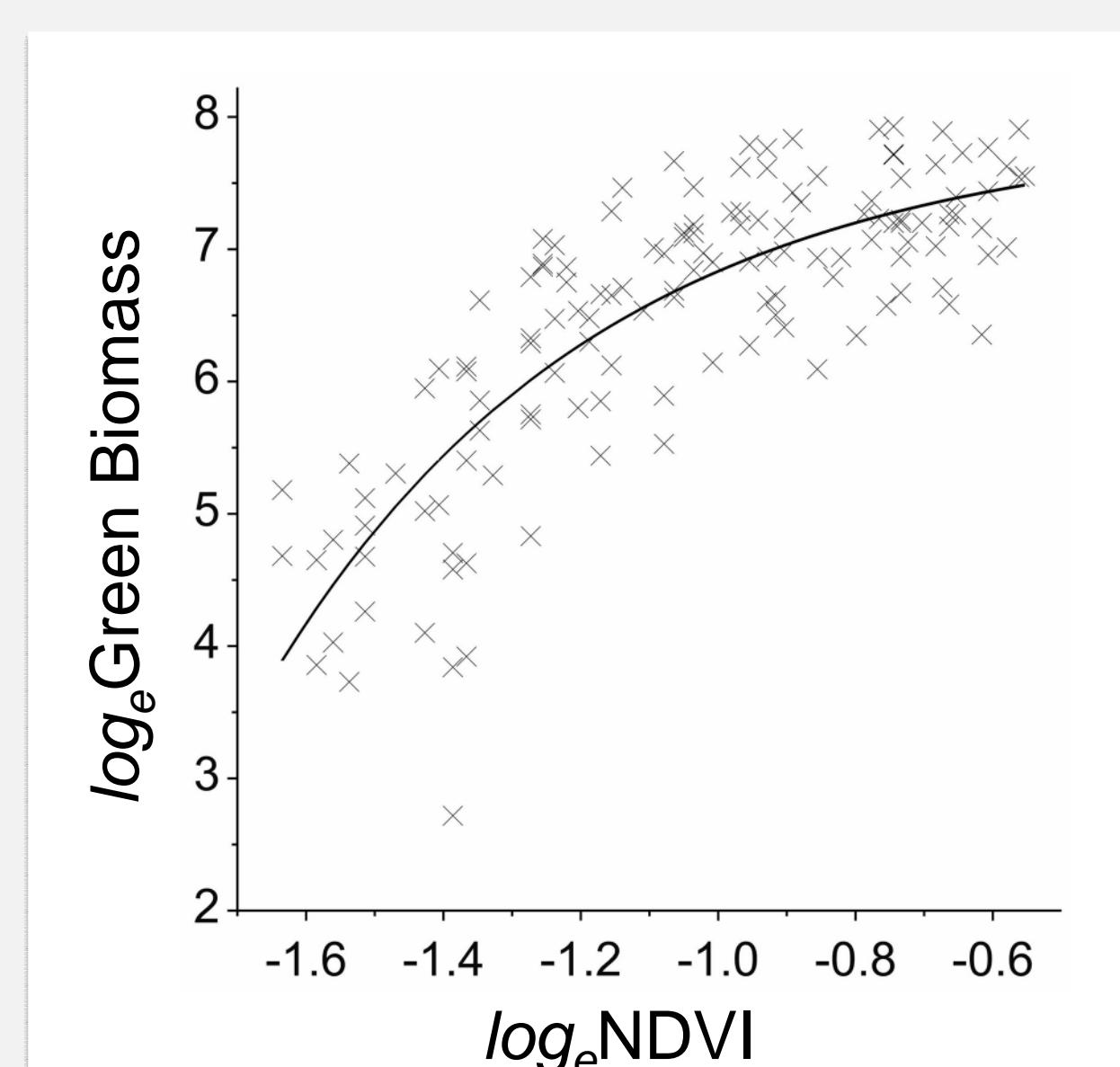


Figure 3. Fitted curve for \log_e Green Biomass (Wet season)

Table 2. Cross validation results (RMSE kg/ha, MAE %)

Measure	Wet				Dry	
	k-fold (k=5)	n-fold	Independent data		RMSE	MAE
RMSE	MAE	RMSE	MAE	RMSE	MAE	
NDVI	505	7.6	509	7.5	742	13.4
NDVI_Ht	456	7.2	461	7.2	464	12.3

Conclusions

- Prediction error for NDVI was large, especially in Dry – too large for practical use
- Height improved predictions of green biomass in the Wet and Dry (although, Dry model was poor).
- There was minimal difference in results between the k-fold and n-fold validation methods.
- Improving predictions using a model sensor that enables the calculation of a modified NDVI index² needs to be investigated.

References

- Spiegel N., O'Reagain P., Anderson A., Willis M. (2015) Estimating pasture yield: More than meets the eye? Proceedings of the Australian Rangeland Society Biennial Conference, Alice Springs.
- Trotter M.G., Lamb D.W., Donald G.E. and Schneider D.A. (2010) Evaluating an active optical sensor for quantifying and mapping green herbage mass and growth in a perennial grass pasture. Crop & Pasture Science 61 389-398.