# Cross validation of pasture biomass predictions from handheld NDVI sensor measures

Angela Anderson[A], Nicole Spiegel[A], Heather Jonsson[B], Bob Shepherd[A]
[A]Queensland Department of Agriculture and Fisheries; [B]Dalrymple Landcare Committee
*angela.anderson@daf.qld.gov.au*

## Introduction

- Visual pasture estimates are critical in helping graziers match stocking rates with forage supply. However, they are subject to operator bias[1].
- 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 asses 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 asses % 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

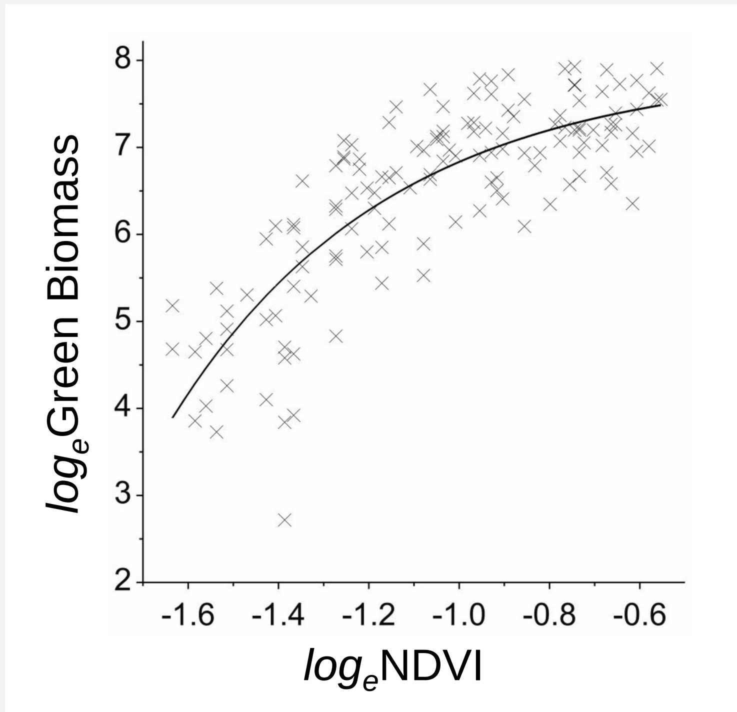


Figure 3. Fitted curve for $log_e$Green Biomass (Wet season)

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 |
| 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 index[2] needs to be investigated.

## References

1 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.

2 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.

REEF ALLIANCE
Growing a Great Barrier Reef
AGFORCE
Queensland Government