final report

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Abstract

In this project, the Muchas Gracias producer group looked at the viability of using the Greenseeker tool to enhance and refine information that would assist with feed budget planning for livestock.

Over a three-year period, green biomass measurements were collected from a host farm that allowed for analysis via the Greenseeker tool that could further refine and enhance paddock pasture production for grazing.

The results indicate that the use of the Greenseeker tool was superior to previously used technology (such as satellite imaging) in gathering relevant data. These findings generated a lot of discussion as to how the Greenseeker could progress to the next step of being available as Mobile Device Application. Usage of the Greenseeker App would allow for greater clarity, accuracy and information when making important feeding decisions relating to grazing livestock.

Executive Summary

PROJECT SUMMARY

The use of technology to inform and assist farmers with planning is nothing new and farms and agriculture have benefited from this usage enormously in recent years, particularly in cropping. However, with any technology, there is always room for improvement and refinement. This paper seeks to highlight how this further refinement was identified, investigated and implemented specifically to a livestock grazing system.

BACKGROUND

This research was implemented by the “Muchas Gracias” group (Muchas), having liaised with other groups such as Landgate, Pasture Watch and LITE, whom have previously used satellites to monitor and plan for Food On Offer (FOO). The information provided by this technology was used by this group to guide decisions affecting feed budgeting and monitoring of FOO levels. The next stage was to enter the data into Pastures from Space Plus software which became the basis to develop a predictive tool that estimated stocking rate potential based on seasonal informational and requirements. It became apparent, however, further analysis highlighted and quantified the gap between a farm’s actual and potential productivity.

Issues associated with this satellite imagery information are now becoming more problematic and limiting in its use. With data being affected from areas such as resolution, time limitations, accuracy and cloud cover, it became quite evident that the information provided by this technology was proving to be quite narrow in its scope of evidence that it could provide regarding farm planning, in particular the ability to factor in the impact of frost on pasture growth and how this affects FOO at a later stage of the seasons. With acknowledgment to these difficulties within the current system, a Greenseeker device was introduced for investigation.

The use of a handheld Greenseeker device was trialled to obtain accurate real time biomass measurements to assist in stocking rate decision as critical times of the year, and how these compared to the past results of using satellite only imagery.

This research was led by Mark Trotter and Professor David Lamb as part of MLA’s Southern Feedbase project to investigate whether real time biomass was an accurate way to measure biomass in pastures and how this could be converted into an easy to use smartphone application (App) for farmers and relevant stakeholders. The Muchas Gracias group provided the facilitation of on farm research, user networks and an interest in investigating new technologies.

OBJECTIVES

The initial objectives of the MLA project were refined from the original proposal once the project commenced as the initial objectives were too broad. The new objectives were articulated and clearly defined whilst still adhering to the original protocols of the project. The ***new objectives of the project*** were to:

i Determine the influence of pasture type, location and seasonal conditions on the relationship between Greenseeker readings (normalised difference vegetation index – NDVI) and green biomass.

ii Develop calibrations between Greenseeker NDVI readings and green biomass produced from key pasture species relevant to the sampling area at critical animal production time if the year (Autumn/Early Winter)

iii Test how the handheld Greenseeker tool can be used to improve decision making regarding pasture and stubble use through Summer periods

iv Assess the value of a mobile application device using Greenseeker information output for the red meat industry.

PROCESS

The project ran for three years in duration, commencing in 2014, initially at two sites in the South West of Western Australia to allow for a cross section of results. After the first year, the decision was made to continue research on just one of these sites, as extended travel was adding a large time component that people could ill afford.

The group meet four times annually to discuss relevant issues concerning the research, such as seasonal conditions, project relevance and project updates.

Primarily, the focus was on collecting biomass cuts to determine the application and viability for the use of the Greenseeker tool on mixed species pasture. From then, each preceding year's data was utilised to inform farmers of feed availabilities and feed budgets. The final year of the project the group provided critical feedback on a feed budgeting App that drew from the Greenseeker data.

The timing of measurements occurred mainly in June, July, September and November to represent the seasons accordingly. Each year the cuts, measurements and calibrations were added to and refined as required to assist with accuracy of data.

Guided by our research collaborator, Mark Trotter, we were able to reflect and refine some of the issues that arose during the course of the project, such as; problems with cut pasture samples, cumbersome steel stands and time constraints, in ways that were effective but did not deviate from project protocols.

FINDINGS/CONCLUSIONS

The research has laid the foundation that the Greenseeker tool, accompanied by an application device, is a vital step towards assisting farmers estimate their in-paddock feed availability and subsequent management processes. This will ultimately benefit the grazing industry to whom the farmers support and supply. It is important to note that there are several factors that will greatly influence the potential of this technology, which will need further exploration. Variations that will need to be considered include;

- The accuracy of the green dry matter
- The allowance of an offset algorithm of the mobile device to allow for broader calculations
- The ability to share data between handheld units.

Research results indicate there is potential wide-ranging benefits that Greenseeker can deliver to farmers. It is the belief of all parties involved that the use of Greenseeker devices will check all the boxes regarding the necessity for accuracy, precision, clarity and simplicity with the design of Mobile Device Application outputs in mind.

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1 Background

1.1 Muchas Gracias

Muchas Gracias was formed in 2013 as a group of producers who came together to improve the way they exchanged learnings and mentored each other. Members of the group have worked with Landgate's satellite imaging since 2000, originally in Pasture Watch and over the past 7 years with LITE (Land Imaging for Technical Evaluation). Initially the PGR information was used for feed budgeting, for in season strategy and monitoring of FOO levels. Lately the group and Dr Norm Santich of Landgate have used the Pastures from Space Plus (PfS+) software for the analysis of historical data and developed a predictive TDM tool that estimates stocking rate potential for the season based on the week of seasonal break and the use of analogue seasons. Further analysis has quantified the gap between a farm's actual and potential productivity.

The issues with satellite imagery are now beginning to limit further on farm use of this technology. Resolution and accuracy, cloud cover, timeliness of information, narrow spectrum for further analysis. The current PGR and TDM values are model derived from NDVI and have no input that allows for the impact of frosts on pasture growth rate values. At the peak of the winter feed gap when FOO is at its lowest and ewes are lambing, a series of frosts will stop actual pasture growth, this is not reflected in the model output, so at the most feed critical time of the year the current information is too inaccurate to use in feed budgeting. An app that allowed real time TDM information would bridge this gap.

Currently members of the group are liaising with Landgate while they write new spatial analysis software. The group members were selected for their long-term involvement in the facilitation of on farm research, dialog with researchers and adoption of research outcomes as well as their own on farm research projects.

Muchas members have extensive experience in the presentation of information to the wider farming community and to industry through key events such as MLA Meat for Profit Days, Crop, Pasture and Sheep updates. Members hold key roles in WA's largest geographical farmer group, Southern DIRT. This provides significant advantage for being at the forefront of industry development and extension. Key relationships exist with DAFWA and Landgate software development personnel. Experience in social media setup and project promotion using blogs and platforms such as Twitter are used to extend information to the community.

2 Projective Objectives

The objectives of the project initially were too:

1. Test the hand-held Greenseeker tool and assess how the data may be able to help producers make more informed decisions about their pasture use through the autumn and early winter period

2. Test how the Greenseeker tool can be used to improve decision making regarding pasture and stubble use through the summer period

3. Determine the value of a smartphone application using Greenseeker information output for the red meat industry

The early stages of the project determined these objectives needed to be refined without changing the protocols of the project. The objectives therefore became:

1. To determine the influence of pasture type, location and seasonal conditions on the relationship between Greenseeker readings (normalised difference vegetation index – NDVI) and green biomass.
2. To develop calibrations between Greenseeker NDVI readings and green biomass produced from key pasture species relevant to the sampling area at critical animal production times of the year (autumn and early winter).
3. To test how the hand Greenseeker tool can be used to improve decision making regarding pasture and stubble use through summer period.
4. To assess the value of a mobile application device using Greenseeker information output for the red meat industry.

3 Methodology

Originally the trial sites were to be based in two locations in the great southern region of the south-west of WA. This was to establish a cross section of pastures and reduce risk of seasonal conditions. This decision was reviewed in Year 2 of the project, once it was understood how time consuming on ground data collection (biomass cuts, sorting and weighing) was, when added to the time-constraints imposed by the project’s extensive travel requirements. In year 2 the trials focused on one property, that of Brad & Tracey Wooldridge. The Wooldridge’s should be applauded for their drive and commitment to the success of this project.

In 2014 the focus was on collecting measurements to determine if the Greenseeker (GS) tool can be accurately calibrated for measurement of biomass in a mixed species pasture. The GS takes readings of the Normalised Difference Vegetation Index (NDVI), which can be correlated to green dry biomass. But before correlations are made, a better understanding of the influence of different pasture species, mixed swards, pasture nutrition and seasonal conditions on the readings is required.

To calibrate the GS active optical sensor (AOS), the following will occur:

1. Visual assessment of feed on offer (FOO) was performed by the host farmer, group members and the project coordinator. The producer group were invited to attend the collection of FOO measurements to compare the accuracy of visual FOO measurements and actual biomass. Most of this was completed by host farmers, Brad & Tracey Wooldridge.
2. Biomass assessment was completed by taking pasture cuts from quadrats, recording fresh weight and dry weight. Species composition was recorded.
3. The cuts taken were planned to be analysed for metabolic energy (ME) value through Independent Lab Services (WA). This occurred only twice as costs for cutting, sorting and weighing samples was expensive for the project.
4. NDVI readings from the GS were collected as part of the calibration process to determine whether or not the GS can be accurately calibrated to the true biomass for a mixed species pasture. The GS used was also calibrated against

the base from UNE and initially the UNE Crop Circle tool to obtain the maximum amount of information from a range of hand held devices.

5. Digital photos were also taken from a camera mounted on the hand-held device to visually capture the pasture sampled as it appeared in the paddock.

Group members used actual biomass measurements to develop feed budgets, with the key assistance of Brad Wooldridge. Biomass and corresponding Greenseeker measurements were taken across a number of farms and a number of species. These included representative pastures types of the region. Within each trial paddock, initially 14 sampling locations were selected that represent a graduation from high, medium to low pasture biomass. In 2015 after consultation with Dr Mark Trotter and a clear and accurate set of protocols established, the group reduced the number of cuts per set to five (5). This significantly reduced the time and cost of doing the cuts.

The calibrations developed in 2014 were used in 2015 to convert the GS NDVI values into feed availability and to develop feed budgets. These were then compared to biomass results from the pasture cuts to determine the accuracy of feed availability assessments from the GS NDVI values.

In late 2015 and throughout 2016 the group trialed and provided feedback on a feed budgeting App for mobile devices that draws upon Greenseeker data.

Early in the project the plan was to use a methodology popular within the industry to cut pasture samples, that resulted in the use of a shearing handpiece. Our research collaborator, Mark Trotter, expressed reservations with this methodology, but allowed us to trial the method. His concerns soon became reality, with major issues arising as a result of needing to cut biomass as low to the ground as possible. These include:

I. A shearing hand piece does not cut gravel/stones well - it will reliably jam.

II. By cutting low the residual may be constant - but a percentage of the total biomass varies. This means the NDVI to biomass correlation is poor.

III. Recutting lower to get more biomass will:

   a. add a lot of soil

   b. mix the soil with small pieces of plant material which cannot be separated

   c. increase the time required to sort samples to pasture species

Hence, very early in the project after these initial poor results, the methodology was reassessed and using a scalpel to do all calibration cuts became standard practice.


Photo 1 & 2: Muchas Gracias group members get involved in the first biomass measurements with researcher Mark Trotter in July 2014 (left) and in the field sampling (right).

Cuts were then done to ground with a scalpel, one plant at a time and the samples sorted for soil and plant species. One set of 14 cuts took 50 labour hours. The suggested protocol was a subset sort, but the group decided to do the whole sample as so much effort had gone into cutting samples up to that point. Also, given that a high R^2 (>0.85) was important and was being achieved, the 'whole sample' cuts were used as the reading was more likely to be used in the App.


Photo 3 & 4: Biomass sampling with a scalpel (left) and the master sorter Brad Wooldridge and team sorting samples at DAFWA Katanning (right).

To obtain a range of NDVI values, cages were deployed each week so that sample pastures would not be grazed, this meant that cuts had to be done with the utmost precision as it took months to obtain the range required.

With this precision in cut and sort protocol, the original 14 cuts per set was reduced to 5 cuts per set. This allowed the same resources to cover may more pasture types and seasons.

Due to the need for a range of values and that correlation will change over time, the project was unable to calibrate any values for pastures very early in the season.

Photo 5 & 6: Pasture cages set at different Feed on Offer levels to assist calibration of biomass cuts to GS readings.

Once a quadrant was selected for its uniformity and its position in the range of NDVI values, it was first measured with the crop circle, then the GS, then cut to ground and the bare soil had readings taken again (Photo 7 & 8).

Photo 7 & 8: Pre (left) and post (right) cut with sample bag visible with reference numbers on it allows results to be referenced to any outlier samples.

The original steel stand was designed to provide a static platform to provide the same positional sensing of both the crop circle 210 and the GS and the same height from one site to another.

Once the crop circle to GS correlation was satisfied only the GS was used. The original stand had its limitations, including:

i) transport and handling difficulties

ii) it did not ensure correct GS orientation to quadrant on sloping land

iii) the quadrant was larger than required

iv) the height stick was another item to carry around

So, a ‘Mark II’ stand was designed from PVC. This stand gave height and orientation and allowed a quadrant without "wings" to be used. The stand also included the height stick, significantly reducing items to be carried.

The extension in SA required a set of quadrants, a stand, a height stick and a plate meter. The new design allowed everything required to fit in a single duffle bag and accompany us on a plane easily. Additionally, the gauge of the steel rod used in the quadrant was reduced from 10mm to 8 mm. This made them lighter and to reduce the reflectance interference.

We made a set of 5 quadrants and height stick for each person so all cuts were done the in the same manner.

Photo 9 & 10: Original ‘clunky’ stand (left) and Mark II stand (right).

In the field, placing 5 quadrants on a range of NDVI values pre-cutting was the easiest way to ensure a good range for the calibration. This method is fraught with risk of losing quadrants, so we made wire stands with flags to assist identify their position. These then fit inside the height stand when moving from one site to another. The GS comes in a bag for storage and transporting, which is important to protect the lens from being scratched, as this would change the sensor values. It is recommended the GS bag is used, then placed in a plastic tool box with foam on the base for long term storage and transporting.

3.1 Research Sites

The project was conducted on two properties in the great southern region of the south-west of Western Australia (Katanning and Arthur River).

Paddocks were managed according to normal farmer practice. Key activities that influence pasture growth are recorded in a farm diary. Sheep grazed the paddocks from July to December when stubbles become available.

3.2 Treatments

Greenseeker NDVI measurements and calibrations to biomass were conducted on a range of pasture species during this trial in WA. Species calibrated included:

- Sub clover dominant
- Mixed clover, grass and broad leaf
- Capeweed dominant
- Annual ryegrass dominant (Wimmera)
- Lucerne
- Chicory
- Mixed Lucerne, Chicory & Phalaris
- Kikuyu

3.3 Monitoring

The timing of measurements was seasonally dependent and occurred mostly in June, July, September and November. These timings represented autumn, winter, spring and summer.

In year 1 of this project (2014), the measurements provided feedback to the research team and the group to use for the duration of the project. The actual biomass assessments were used by the group to develop precise feed budgets. These were used to raise awareness of the value of precise biomass measurements compared with visual assessment.

In year 2 of this project (2015), the calibration developed in year 1 were added to by further calibration cuts which were then used by the group to convert the NDVI values into feed availability and develop feed budgets based on these readings. These were compared to the biomass cuts to determine the accuracy of the feed availability assessments when compared to the calibrated NDVI readings.

In year 3 of the project (2016), further biomass cuts and calibrations were completed on different species of pasture. This helped determine the value of the GS to provide accurate data for feed budgeting. The group trialed (and provided strong feedback) about the value of the smartphone App.

3.4 Statistical analysis

See results section.

3.5 Economic analysis (if applicable)

There was no economic analysis for this project.

3.6 Extension and Communication

The producer group met 4 times annually to discuss updates on the project, but mainly to discuss the relevance of the project outcomes on their business with the current season in mind. Most members are eagerly awaiting the decision on a mobile device application (MDA) as they have the evidence this will make feed budgeting quick, timely, simple and accurate.

A wide range of extension methods were undertaken (see section 4.2 for detail) including articles in local grower group newsletters, presentation at field days, and interstate travel to assist other producers and consultants with biomass measurements and protocol.

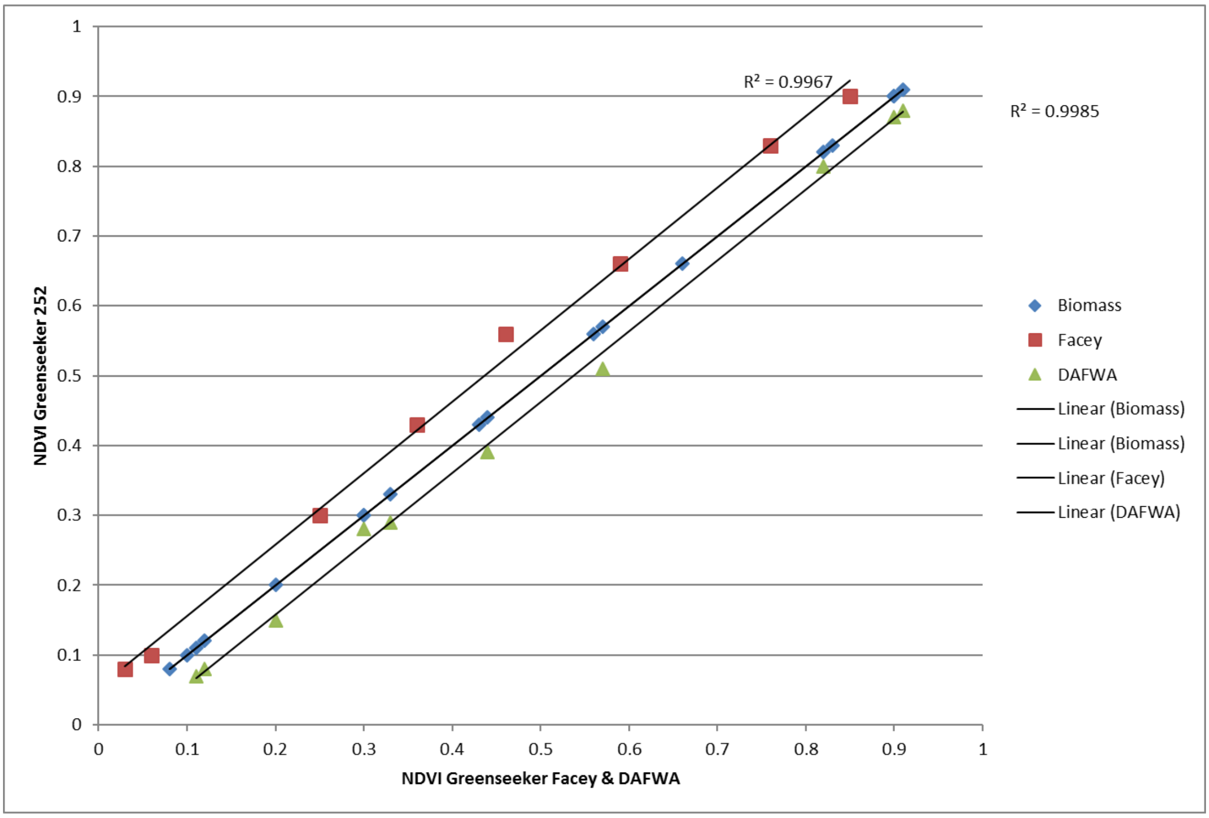
4 Results

Early in the project there was concern from researchers and producers that there was variation between the Greenseeker (GS) units that would need to be accounted for. This concern was offset by the affordability of the GS at $700/unit vs $5000/unit for the crop circle which was much heavier and the next in the affordability scale.

The effect of the error results in deviation of the crowd sourced cut and weighed input NDVI to biomass data. This then also alters the App output values because the GS is the tool used to measure NDVI and feed values into the App to derive estimated biomass results.

To counter this, all GS units are calibrated against a known GS source, being GS252 at UNE (252 being the last 3 digits of the serial number)

To achieve this the static height stand (standard height to rest the GS tool), developed in WA, was used to read an NDVI value, then the GS units are swapped and the same area sensed and value recorded. The aim is to test as large a range of NDVI values as possible (0.1 to 0.91) with a total of 8 readings taken. This is then graphed to allow the formula to be calculated so that when the app is released, the user will enter the GS serial number and the App will automatically calculate the offset for the GS (Graph 1).

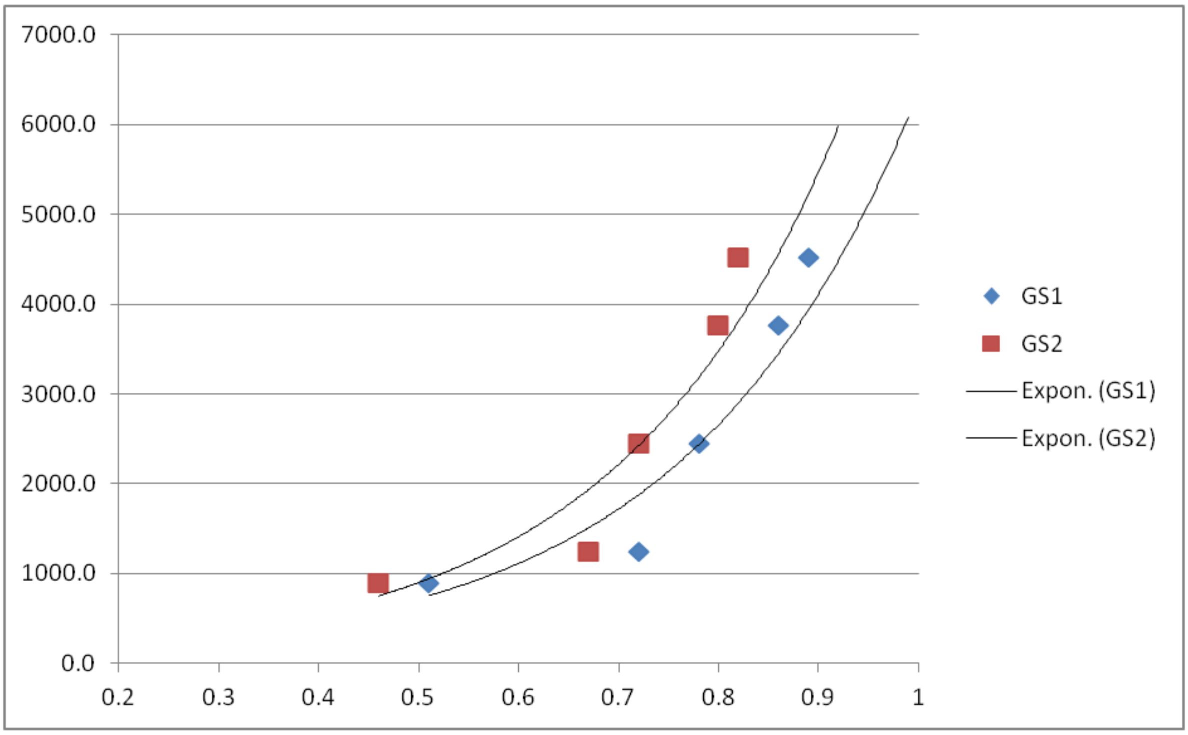


Graph1: Calibration curves of different Greenseeker units used against the UNE supplied Greenseeker tool which is calibrated against Greenseeker 252 from UNE.

Though the slope in the variation is linear, often the relationship of NDVI to biomass is exponential (Graph 2 below).

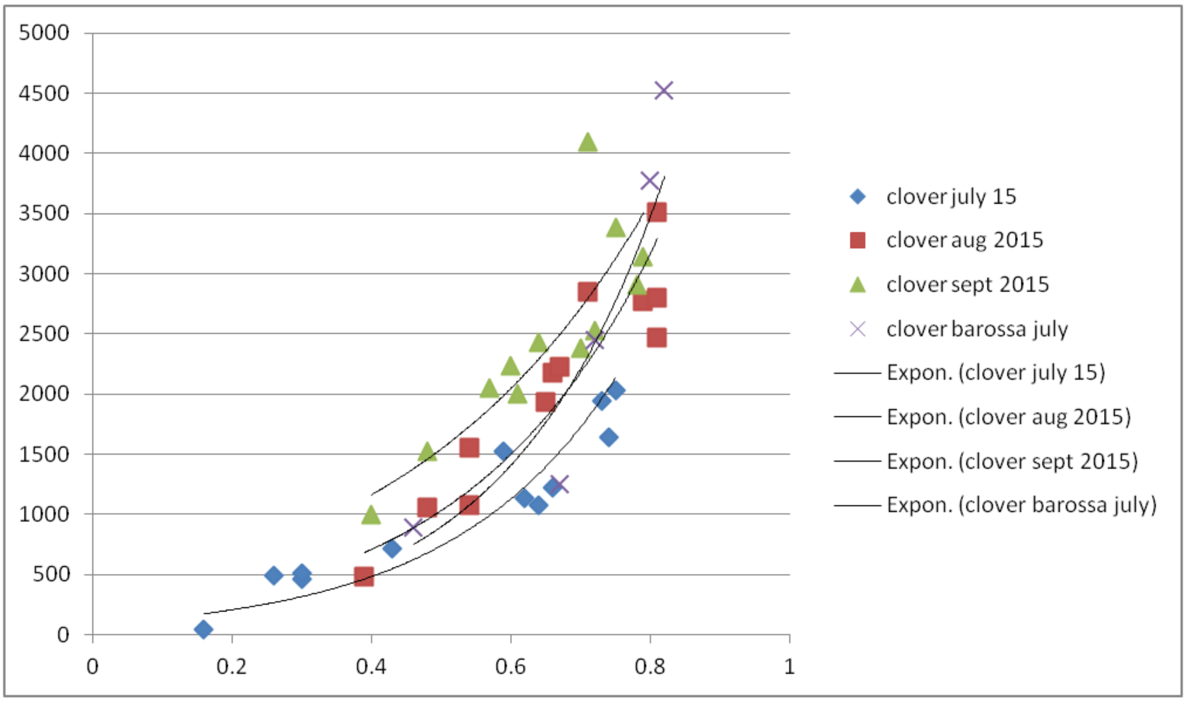
In Graph 2 we used two GS units purchased in SA to take NDVI values for a series of cuts in SA (as part of the extension, showing producers and consultants how to do cuts for GS calibration). The graph shows a small variation at low values, but at the higher end of NDVI values the error is magnified significantly.

This error is a problem when unit GS1 entered vales into the app and unit GS2 used it's NDVI values to enter into the app.

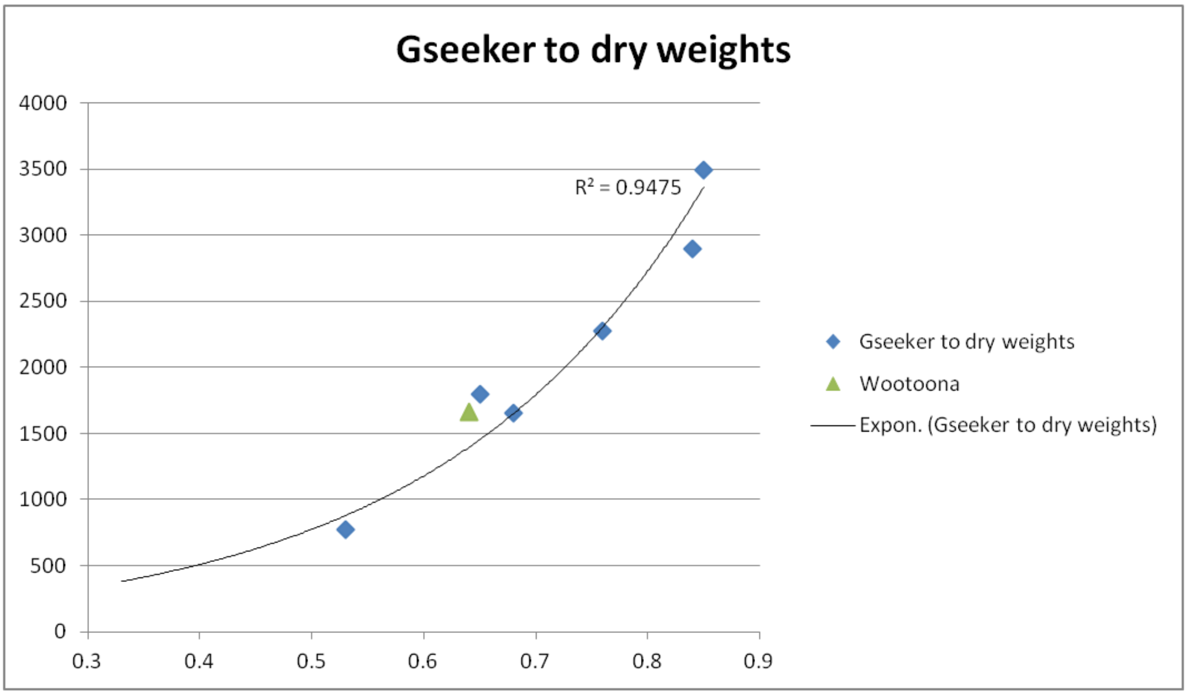


Graph2: Biomass (kgs DM/ha) on Y-axis and NDVI readings on X-axis showing calibration curves of two different Greenseeker units.

Graph 3 is a composite curve showing sub clover cuts from WA and SA. It is important that the results fit closely to the same curve so the calibrations can work well in both states. Note also that the curve shifts to the left as the plant ages. This finding is in line with researcher, Mark Trotter's expectations from the start of the project and supports the suggestion that building the App with the ability to derive biomass for different seasons is critical to its success.



Graph 3: Biomass (kgs DM/ha) on Y-axis vs Greenseeker NDVI readings on X-Axis. A range of biomass vs GS NDVI readings from clover based pasture in WA (Jul, Aug & Sep 2015) as well as a clover based pasture in the Barossa in SA in July 2015.



Graph 4: Capeweed biomass (kgs DM/ha) on Y-axis vs Greenseeker NDVI readings on X-Axis showing the very close fit.

Capeweed had been an issue for results in the early part of the project. Samples in cuts do not sit on the composite curves and once it starts to flower it changes again.

A series of capeweed plots were cut, being from hard grazed stalks to lush dense stands. An outlying sample from SA that was also capeweed was taken (Wootoona) and the results showed it to sit on the same curve. This result was very pleasing with all the capeweed cuts showing an excellent fit ($R^2 = 0.95$).

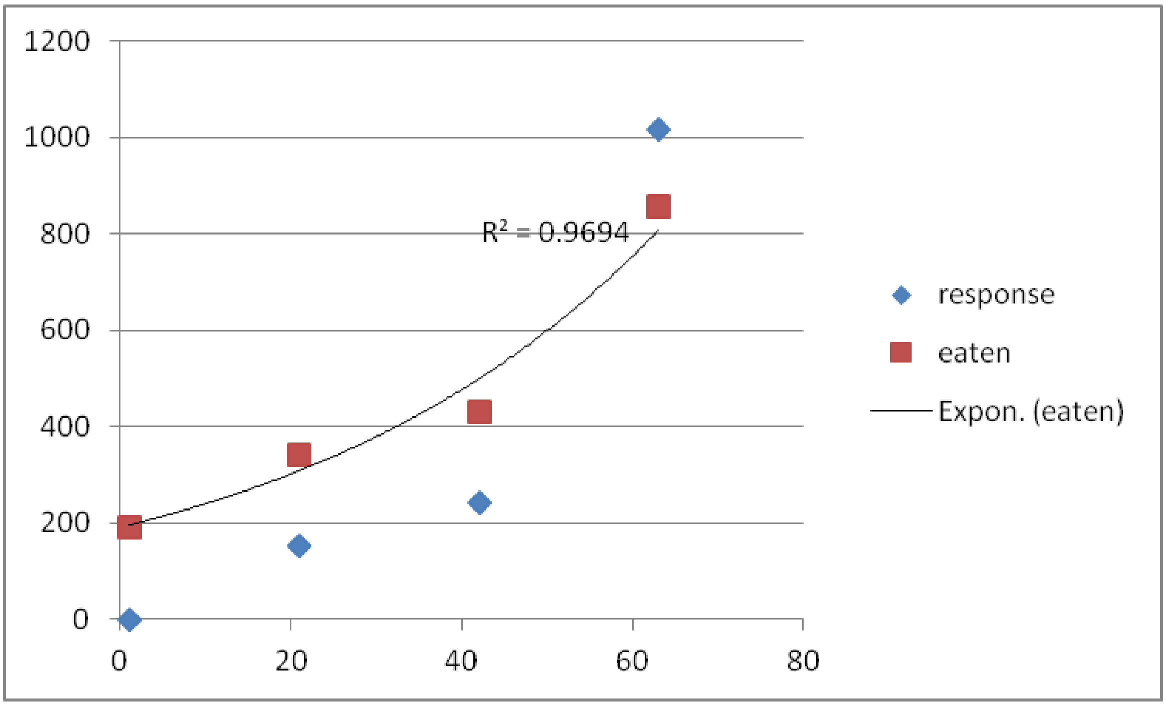
4.1 Measured trial results

4.1.1 Trying to break the R^2

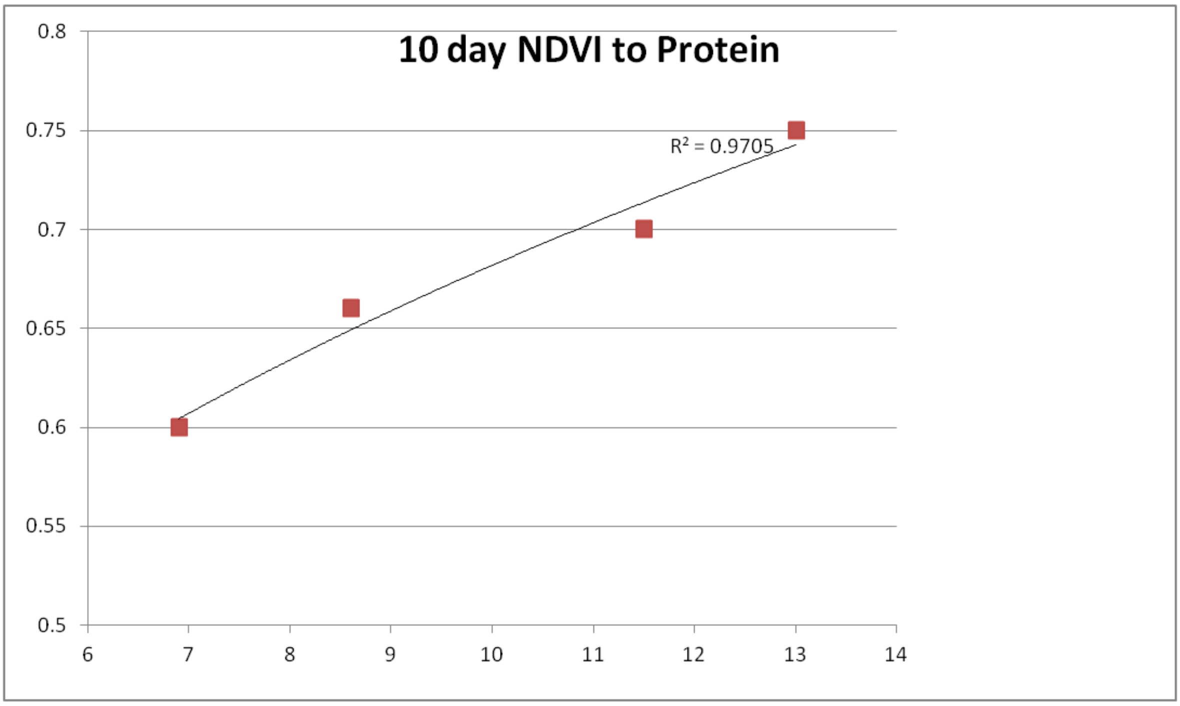
The application of nitrogen (N) will alter the NDVI before the biomass increases because NDVI is the capacity of the plant to grow, rather than the physical biomass which is measured as the result of that capacity. We applied N in varying rates (Phot 11) of 0, 20, 40 & 60 kilograms per hectare and then planned to plot changes in NDVI. Unfortunately, only one measurement was done and that was at 10 days' post application - so this was analysed for biomass and GS calibration.

Photo 11: Randomised demonstration of N applications rates.

The plots were scanned by the GS and measured for biomass. The plots were measured with the GS in a transect across the plots to measure residual post grazing and calculate intake. An excellent R^2 result was achieved but the area needs further research.



Graph 5: Biomass (kgs DM/ha) on Y-axis vs N applied (kgs N/ha)on X-Axis. Calibrated nitrogen response and dry matter eaten.



Graph 6: NDVI on Y-axis vs Protein (%) on X-Axis. A 10-day NDVI to 30-day Protein curve showing the prediction of GS measurements 10 days after application of N can closely predict Protein of green feed 30 days later.

Samples were assessed for biomass 30 days after application of N and sent away for quality testing (metabolisable energy and protein). The 10-day post-nitrogen application NDVI results were then compared with the 30-day sample testing for quality (i.e. a 10-day NDVI reading to protein comparison). The GS allowed us to measure an N response of 15 kg DM per unit of N applied (which is a common response I previous N rate trials). It also supported recommendations that higher rates give a better response, resulting in more dry matter being consumed (Graph 5).

The surprise result (from this limited data) was that 10 days post application of N, the GS appears to be able to predict pasture protein at 30 days with an R^2 of 0.97 (Graph 6). This has large implications when designing N application for a predictive green feed budget as it gives both quantity and quality predictions. This area is of primary interest and certainly needs more research in our view.

4.2 Extension and communication

Over 600 producers and industry personnel have been extended the information on this project and its accuracy of results from measurements in WA.

Date	Activity	Number of people
July 2014	Meeting with researcher and full Greenseeker measurements and biomass cuts completed.	8 producer group members
August 2014	Presentation to GGA annual event in Perth	45 industry people
February 15	Darkan crop updates	25 producers
May 15	Curtain Uni student visit	22 students
June 2015	West Wagin Top Crop group	5 producers
July 15	SA farmer groups visit	25 producers
September 2014	Article for Southern DIRT newsletter	Circulation 80 producers and 60 industry consultants and sponsors
August 2015	Wickepin pasture updates	35 producers and industry
September 2015	Southern Dirt field day	50 producers and industry reps
September 2015	Murdoch Uni visit	23 students and teachers
November 2015	Article for Southern DIRT summer newsletter	Circulation 80 producers and 60 industry consultants and sponsors
November 2015	Article for MLA Feedback magazine with Red Pen	Large circulation
April 2016	Planfarm advisor's PD day	21 consultants
May 2016	Curtin Uni visit	22 students and teachers
July 2016	Planfarm client day	25 producers and consultants
August 2016	Manjimup Pasture Group pasture updates	41 producers and industry people
August 2016	WA DAFWA Sheep updates	52 producers and industry people
September 2016	Muresk Institute seminar	42 producers, students and industry people
September 2016	Albury, GrowAg Conference	150 producers and industry
September 2016	Murdoch Uni visit	23 students and teachers

4.3 Participant reactions

Grower to grower learning is a key driver in adoption, so having a local demonstration site along with cross pillar research was a significant aid for information delivery on the GS technology.

Participants at a field day in June 2017 were astounded by the amount of work completed by hosts Brad and Tracey Wooldridge for the benefit of industry, with no direct reward, probably not even covering the cost of their hourly time commitment.

Producers indicated the importance of analysing feed on offer more accurately, rather than just going on gut feel or visual assessment because of the extreme variations achieved. Producers also took notice of the high accuracy this project has achieved in estimating biomass using the Greenseeker, a relatively cost-effective tool. At the field day in June 2017, producers were starting to discuss how and where they would mount a Greenseeker tool on mobile vehicles. Though, there was still some slight apprehension from producers as to what they will do with the data they collected, and whether they would construct feed budgets or just 'get a feel' for the biomass on offer and then make decisions based on the Greenseeker results. This area requires further extension work, focussing on how producers can use this information in the real world of mixed farming.

An additional, indirect benefit of this project, is an improved demand for consistent group meetings, with demand increasing from producers themselves very early in the project. On average, the group met at least four times per year. In 2015 it met five times to discuss both the project outcomes, and the seasonal implications.

4.4 Producer Research Site Program

While the group did not change the overall research topic, it did use opportunities for 'cross pillar' research and extension work. An excellent example of this partnership was the DAFWA and CSIRO trial site on Wooldridge's property in the second year of the Biomass Project. The 1 ha Tedera trial site was set up with 48 automatic soil probes to 1.2m logging each 15 minutes along with 40 neutron probes and soil testing to 2m. It has replicated Tedera, Lucerne, sub clover and kikuyu plots.

On the same site Heritage seeds established Margurita serradella, arrowleaf clover, Losa sub clover and chicory. With multiple species and high density of site specific data it was decided to do cuts on all the varieties. This allowed rigorous testing of the GS and associated calibrations, with an added option to analyse soil nutrients and soil water data to clarify any anomalies. This also demonstrated the new technology to site partners so we could use the method as part their biomass measurements. This gave us a rare opportunity to calibrate multiple species from one site.

The opportunities to meet with researchers on other PRS projects (pillars) meant that when root disease hit the Tedera trial site we were able to liaise directly with Daniel Real and Martin Barbetti about root disease and it's impacts on different species. These discussions were highly effective, as they ruled out chemical application responses, allowing us to successfully trial foliar nutrient applications instead.

Though this was not directly part of the biomass project, the Southern Feedbase design enabled the linkages to solve problems on another site. This result is set to be further investigated.

5 Discussion

The project allowed the Muchas Gracias group to compare a range of pasture species for biomass production in both regenerated annual pastures and re-sown annual pastures, and calibrate these comparisons to Greenseeker NDVI measurements. Greenseeker NDVI measurements to actual biomass production were very accurate in WA with all annual species measurements of NDVI vs Biomass providing an R^2 of over 0.9: an excellent result.

Additionally, countless cuts and Greenseeker NDVI measurements confirmed that a ‘Greenseeker Unit Offset’ is required for each different Greenseeker unit. This will enable Greenseeker NDVI measurements to be used in any potential mobile device application (MDA). This affords confidence to producers outlaying the capital to purchase a Greenseeker unit (approximately $500) when measuring green biomass on farm.

We believe this WA research project will allow producers to confidently use the Greenseeker unit to measure NDVI and then provide this data into an MDA and predict green pasture biomass. This is a simple, efficient and accurate method to derive pasture biomass estimations and feed budgets. We are confident that this project has assisted MLA with the future extension of ‘out with the old and in with the new’.

5.1 Outcomes in achieving objectives

5.1.1 Outcomes vs Objectives

Project objective	Outcome
1. Test the hand-held Greenseeker tool to assess how the data may be able to assist producers to make more informed decisions about their pasture use through the autumn and early winter period	The hand-held Greenseeker tool is an accurate way to relate NDVI measurements to actual green biomass. The influence of pasture type, location and seasonal conditions were also tested and showed a strong relationship between Greenseeker NDVI readings and biomass. The project also produced calibrations between Greenseeker tool NDVI readings and green biomass produced from key pasture species relevant to the sampling area at critical animal production times of the year (autumn and early winter).
2. Test how the hand Greenseeker tool can be used to improve decision making regarding pasture and stubble use through the summer period	The Greenseeker tool can be used to improve decision making in pasture budgeting and utilisation even without an MDA as the base calibration curves have now been created for WA. However, an MDA would make the whole process extremely efficient and user friendly for producers and industry. The Greenseeker also appears to be a useful tool in predicting protein increase in green feed following nitrogen fertiliser applications. This area requires further research. The objective of improving decision making regarding stubble use over summer was not achieved directly. However, we believe that using Greenseeker and App derived biomass

	data during spring that spring management of pastures will indirectly assist stubble grazing decisions.
3. Determine the value of a mobile device application (MDA) using Greenseeker information output for the red meat industry.	This project has highlighted the urgent need for fast tracking of an MDA for the industry. This project has determined the requirement for a 'Greenseeker Unit Offset' which will enable any Greenseeker unit readings to be used accurately within the App. Feedback at field days regarding the App's value to individual businesses has been overwhelming. Producer perception however is that development may be stifled. This would be highly disappointing for producers actively engaged in the project and the broader industry.

5.2 The value of the research results (Benefits/Costs)

Having produced high accuracy calibrations of Greenseeker NDVI measurements to pasture biomass, the benefits to producers are wide ranging. From a renewed understanding and invigoration of technology advancements in pasture feed budgeting to a renewed interest in pasture species for mixed farming systems. In respect to the MLA demonstration site, the end result for producer practice change and industry benefit has been:

- involvement in cross pillar research
- renewed enthusiasm for biomass estimate adoption for deriving feed budgets
- awareness of technology advancements in biomass estimation
- understanding of biomass differences between species

A renewed interest in pasture species for mixed farming systems has also been generated from this project. In particular, the *Braccia* species of clovers have had some outstanding success throughout the project and biomass production have also been calibrated with the Greenseeker NDVI measurements.

5.3 Promotion of research results and its effectiveness

Table 1 shows a sample of a crowd sourced biomass estimates from our 'FOO auctions' at a Southern DIRT grower group event and a group of Murdoch University students. The group was told the biomass of each quadrant prior to the next quadrant estimate to see if knowing a previous value was enough information to improve their estimates. Only a slight improvement resulted which shows that individual biomass estimation has large variation.

The group from the Southern DIRT day were given the previous quadrant biomass and the NDVI of the next quadrant, this improved the error rate significantly.

	Southern Dirt farmers				Murdoch students		
	site 1	site 2	site 3	site 4	site 5	site 6	site 7
NDVI	0.83	0.74	0.69	0.36	0.68	0.49	0.15
clover %	80	0	0	0	100	100	100
height	4	2	3	1	3	2	2
FOO Range (kgs DM/ha)							
300				2			
400				5			
500				10			
600				3		2	4
700						9	8
800					1	7	3
900					1	2	1
1000			2		1		
1100		2	2		4		
1200			2		4		
1300					3		
1400		1	5		1		
1500		3	2				
1600		2	1		1		
1700		1					
1800		4	2				
1900		1	1				
2000		3	1				
2100	2	1			1		
2200	1	1					
2300		1					
2400	2						
2500	3						
2600							
2700	3						
2800	1						
2900	1						
3000	4						
3100							
3200							
3300							
Total Estimates	17	20	18	20	17	20	16

Table 1: A record of FOO estimates by participants at two separate field days comparing the 'old' way of estimating biomass vs the Greenseeker. The green highlighted cells are the actual GS estimate and measured cut and weighed biomass (kgs DM/ha). Note the range in variation of producer estimates.

5.4 Effectiveness of the participatory research process

Producers have been largely captivated by the range of pasture species tested with the Greenseeker NDVI and biomass measurements. Brad Wooldridge presented at field days and is highly knowledgeable in this field of biomass analysis. This was an important step to complement his work on his own farm and provide ‘peer to peer’ background to the research.

Demonstrations of the Greenseeker and App were timed in with other events and participant feedback and interest was always high. There was 100% involvement of biomass estimation games at all field days attended.

“There are a lot of growers talking about this technology and the development of a phone App. I haven’t heard so much discussion on technology improvements in feed budgeting in years.” (E Hall pers comm 2017).

While growers were interested in seeing pasture cuts and physically completing a demonstration cut or a biomass estimation, they were not keen to donate their time to do cuts over the whole project. The extent of biomass cuts and calibrations to Greenseeker NDVI measurement is totally due to the efforts of Brad and Tracey Wooldridge, the host farmers. Without the effort of these two, the outstanding results would not have been achieved. The Wooldridge’s. motivation and drive was greatly support by DAFWA staff from Katanning.

The design of the app will allow producers do their own cuts and personally input the dry matter biomass results. However, having now done many cuts, our opinion is that producers will not do cuts - and few that do within the industry will do them properly. Our recommendation is therefore to train additional industry participants already familiar in the cut and weigh process or keen to do cuts in the protocol required to progress the implementation. Groups then could contribute to employing these trained cutters to do series of cuts for use in a district.

The Participatory Research Process has very strong merits for the sharing of ideas and having an industry researcher to support the producer group. The success of this project would not have been possible without the collaboration between producers, consultants and researchers.

6 Conclusions/ Key Messages /Recommendations

The Greenseeker (GS) tool and mobile application device (MDA) represents the first important steps towards an in-paddock feed estimation and management process, which ultimately will be of high value for the grazing industry. This project has shown that the value of the MDA will depend on a number of factors, not least the accuracy of the green dry matter estimates from the Greenseeker.

A ‘device off-set’ algorithm is a required feature in future development plans for the MDA, and these are aimed at broadening data calculations and increased data sharing to address the variations between handheld Greenseeker units.

This project has assisted with the key issue in the design of MDA outputs, which is the requirement to meet the needs of industry users for accuracy/precision, clarity, simplicity and utility. We believe this project has signficantly contributed to future development of the MDA.