MEAT & LIVESTOCK AUSTRALIA

final report

Project code: B.FDP.0050

Prepared by: Peter Schroder
Meat & Livestock Australia

Date published: July 2017

PUBLISHED BY
Meat and Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Kelly Gang Real time biomass estimation

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

Cutting green pasture to ground level, and washing and drying it, is the most reliable way of measuring the pasture biomass, but this method is very slow.

Active Optical Sensors (GreenSeeker) have been successfully used to quickly measure a wide range of diverse situations but has never been used to measure green pasture.

The Triple M BWBL group on 27 sampling campaigns (3 properties/paddocks in SW Victoria by 3 times during the growing season (autumn, winter, spring) by 3 years (2014-2016)) measured the amount of green grazed perennial pasture using a GreenSeeker. The pasture height was also measured using a falling plate meter.

The results were analysed using a linear regression model. The residual deviation (R^2) was the key output from this. In 16 out of 25 (2 campaigns not used) samplings, pasture height had the highest association (R^2) with the actual dry matter yield (DMY). The GreenSeeker had the highest association with the actual dry matter yield in only 6 out of 25 cases.

From this project, developing a tool which measures pasture height before converting it into green dry matter yield while driving across green pastures needs to be a priority.

This project received additional collaborative support from Agriculture Victoria, allowing the group to increase the scope of the research undertaken.

Executive Summary

Being able to measure green pasture dry matter yield (DMY) is important for both research and developing profitable livestock feeding programs. The method commonly used to do this involves cutting the pasture to ground level and washing, drying and weighing it. While the results are accurate the method is very slow and very tedious. This limits its use.

Active Optical Sensor technology, in the form of a GreenSeeker or Crop Circle, is a hand held tool which has been used to successfully and quickly measure a range of things in a wide range of diverse situations. It has not been used to measure green pastures. The aim of this project was to assess their capacity to quickly and accurately measure green pasture biomass.

The project involved one pasture on each of three properties (Mountjup, Woorndoo and Coojar) in SW Victoria. All the pastures were at least 25 years old and were within 65 km of Hamilton, Victoria. All the pastures were grazed from time to time. Phalaris was the perennial grass in two of the paddocks and perennial ryegrass was the main grass in the other.

The green pasture was measured on these three properties on three occasions (autumn, winter and spring) in each of three years (2014-16). On each occasion 12 or 15 points were measured and sampled. The aim was to select points with a similar botanical composition but the DMY range was to be as wide as possible.

The procedure followed at each sampling point was -

- Visual estimation of DMY, clover percent and percent of standing dead pasture.
- Falling plate meter to measure pasture height (cm).
- GreenSeeker and Crop Circle measurements.
- Photograph the pasture.
- Cut pasture in the quadrat to ground level using a shearing hand piece. Wash, sort into botanical components, and dry.

It soon became clear that the GreenSeeker only partly told the story; pasture height appeared to be far more important. Because of this it was included in future measurements.

Both the GreenSeeker and Crop Circle were used in the early stages of this project but continuous problems with the operation of the Crop Circle led to its use being discontinued.

Only GreenSeeker data is reported here.

The results have been analysed on two levels, one (reported here) involving an analysis of local results and a second (reported in B.GSM.0010) more complex analysis combining data from all the sites involved in the broader project (see bibliography) including the botanical composition.

The local data was analysed using a simple regression

$Y = a + bx$ with y = DMY, x = GreenSeeker reading or pasture height, and a and b being constants.

The residual deviation (R_2) was the outcome of most interest. The higher the R_2 the better the association between DMY and the GreenSeeker reading, or pasture height.

In comparing the R_2 for pasture height and DMY, and GreenSeeker and DMY, at each campaign pasture height, while not perfect was the highest in 19 out of 25 cases, well above the GreenSeeker figures of 6 out of 25. Any future plans to develop tools to measure green pasture biomass must include pasture height.

Producers involved in the project were enthusiastic about the project goals and took a keen interest in the projects progress.

Producers, reflecting on what IT has done for their businesses in recent years, were excited at the thought of being able to measure the amount of green biomass in a paddock as they drove from gate to gate and on reaching the second gate tapping an iPad to get the details about the pasture, and the implications of them for the stock grazing the paddock. A whole farm assessment within half a day was looking a reality and the tools required to do it would find a ready market. Cost will not be a barrier to adoption.

The initial enthusiasm for using the GreenSeeker for measuring pasture mass was proven to be unfounded. Height was a better indicator of pasture biomass than NDVI and that measuring NDVI using the GreenSeeker didn't add much to improve the calibration than just measuring height in Western Victoria.

Table of Contents

1 Background

1.1 The Triple M Bestwool Bestlamb group

The group involved in this project is the Triple M Bestwool Bestlamb group. The current mailing list covers 13 businesses. The group members run a total of about 60,000 sheep and about 2700 cattle. The main pasture types are phalaris sub clover, and perennial ryegrass sub clover. The group has been active for 22 years. The ongoing aim of the group is to run a sustainable profitable (average ROI >6% per annum) grazing business. With a history of over 100 meetings spread over the life of the group just about every imaginal topic has been covered. In recent times the topics covered have included labour efficiency, infrastructure improvements, financial benchmarking and visiting other farming businesses.

1.2 Issues faced by group members

The producers in this group are in the business of turning pasture into dollars. Measuring biomass is a natural part of this. They believe more accurate measures would improve business outcomes.

Green pasture is in most cases high quality and in most cases drives the grazing system. Knowing how much green pasture is in a paddock should be a high priority however an issue identified by the group is the widely recognised inaccuracies associated with the current visual assessment method.

Accuracy counts. An ongoing daily challenge for the producers is to strike a favourable balance between the feed(s) required and the feed(s) available for stock. If feed budgeting calculations are based on accurate figures the final answer will be accurate. There is an awareness in the group that they are not confident in their visual estimates of green feed. If figures are incorrect so are any calculations. Accuracy, especially in tough seasons, means higher $ returns to management. Accuracy can be improved through pasture cuts but group members are reluctant to do them because they are very time consuming and they don't have a drying oven.

Most group members are stocking at close to optimum levels. Decisions to reduce stock numbers during tough times are critical and the pasture assessment tool coupled with sensible whole farm feed budgets would be valuable for giving producers the confidence to make decisions during stressful periods.

1.3 Producer management practices

Although the group are aware of the potential benefits of making better decisions by having accurate measurements they do not actively seek to measure pasture accurately. One member uses Pastures from Space to try and assess if the pasture is growing, so they can make feed management decisions, but most producers just visually assess their pastures.

In most cases in January group members work out the number of stock they want to run for the year then stock accordingly. They know in some years they will get the balance between supply and demand correct and not have to feed while in others the season results in things being under done and feeding will be required. Generally it is when extra feed is required that producers will actively assess, usually visually, the amount of feed on offer.

1.4 Motivation of the group

New technology offers an opportunity to objectively assess pasture biomass and thus improve the accuracy of pasture budgeting. The group has access to the whole farm feed budgets but not to a practical tool to objectively assess pasture biomass.

The group is always on the lookout for new things that will improve their productivity and profitability. They don't have to be big things but they must be reliable and sustainable.

2 Project Objectives

This project forms part of MLAs Producer Research Site program that is part of the southern Feedbase Investment Plan. In particular, this project supports the MLA-funded project *B.GSM.0010 – Real time pasture biomass estimation.*

The PRS project objectives were to:

1. Develop accurate AOS (Active Optical Sensors) predictions, using a GreenSeeker, for typical phalaris/sub clover pastures at the key times of the year including.
   a. Post autumn break (April – June), with the exact timing depending on environmental conditions.
   b. July (pre lambing)
   c. October – November (peak of the season).
2. Compare the different pasture mass estimations of the AOS to the methods currently used by producers.
3. Establish the benefits for producer's decision making through the use of the AOS real time biomass measurements using optical sensors.

3 Methodology

3.1 Research Sites

This project involved three sites (Mountajup, Woorndoo, Coojar), which were each sampled three times (autumn, winter, spring) in each of three years (2014-16). The sites were considered "typical" of the paddocks on the properties and were accessible. The pastures contained sub clover and either phalaris and/or perennial ryegrass. Additional details of the sites are:

1. Mountajup. About 8 km west of Dunkeld. Phalaris pasture. Vertosol soil. Annual rainfall 696 mm (Dunkeld). Sheep grazing only. Soil fertility Olsen P 10.4 mg/kg. Pasture mainly set stocked.
2. Woorndoo. About 60 km east of Hamilton. Phalaris sub clover pasture. Chromosol soil. Annual rainfall 560 mm. Soil fertility Olsen P 18.1 mg/kg Sheep grazing only. Pasture mainly set stocked.
3. Coojar. About 20 km north of Coleraine. Perennial ryegrass sub clover pasture. Chromosol soil. Annual rainfall 611 mm (Coleraine). Soil fertility Olsen P 12.9 mg/kg. Sheep and cattle grazing. Pasture mainly set stocked.

All three pastures were at least 25 years old. The paddocks were selected from a wide area in the expectation that this would provide the best chance of any geographic differences showing up.

All three sites are in a Mediterranean climate zone. The average annual rainfall in Hamilton is 680 mm with the autumn being 159 mm, winter 222 mm and spring 275 mm.

In 2014 the rainfall in autumn and winter was about average but in spring it was very dry. In 2015 the rainfall in autumn was about average but in winter and spring it was below average. In 2016 the rainfall in autumn and winter was about average but in spring it was well above average.

3.2 Treatments

Four treatments tested in the project were:

- GreenSeeker – measuring Near Infrared and red light (NDVI).
- Crop Circle – measuring NDVI and other combinations of wavelengths.
- Pasture height – falling plate.
- Visual assessment of the pasture biomass.

At each sampling time 12-15 sampling points were identified within the paddocks. The aim was for the pasture composition to be similar at each point. After this, the range in pasture dry matter yield (DMY) was to be as broad as possible in the hope of getting a clearer definition of the relationships between the variables.

Both the GreenSeeker and Crop Circle sensors were used in this project. Both measure NDVI. NDVI stands for Normalised Difference Vegetation Index) which is a measure of the amount of near infrared (NIR) and red light reflected back from the plant. The NIR light is thought to predict plant structure/density. The red light predicts the amount of chlorophyll or greenness and may be a good predictor of dead material.

The bands measured by the GreenSeeker can not be separated to work out which has the best relationship with biomass but the Crop Circle provides separate information on 4 different light bands and is therefore an important additional measurement for this project. It costs about $6,000 and was borrowed from AgVic.

There were operational issues with the use of the Crop Circle which includedfaulty wiring which required it to be sent to UNE Armidale for repairs and difficulty in trying to share the device amongst the two groups and AgVic field officers. There was also a lack of consistency of which wavelengths gave the best correlations and this led to its use being discontinued after the winter 2014 measurements. Only GreenSeeker data is reported here but Cropcircle data is contained in the accompanying metadata file.

It became very clear within two sampling sites that pasture height needed to be included in the measurements if useful results were to be obtained.

3.3 Monitoring

The plan was, weather permitting, to measure the selected pastures about 4 weeks after the autumn break, in the second week of August (about lambing time) and in the first week of October (peak of the spring season). The dates when the sites were actually sampled are detailed in Table 1.

The procedure carried out at each sampling point was –

- Select sampling site. Position yellow stand.
- Visual estimation of DMY, clover percent and percent of standing dead.
- GreenSeeker measurement. The GreenSeeker is fixed to the stand which always positioned one meter above the ground.
- Crop Circle measurement: As for positioning the GreenSeeker.
- Falling plate measurement (cm). A broom stick was positioned in the sampling area three times. A plastic disc, about 500 mm in diameter and 3 mm thick, was slid down the stick and markings on the stick enabled the height of the disc above ground level to be measured.
- Sampling quadrat in place.
- Photograph pasture.
- Remove stand.
- Cut pasture in the sampling quadrat to ground level using a shearing hand piece.
- Reposition the stand
- Photograph quadrat again.
- Wash, sort into botanical components, or green, dead or green clover.
- Dried at 80^0 C for 16 hours in a fan forced oven.

Data collected was converted into kilograms DM/ha and is presented as green or total or both. Green kg DM is the measurement of the green component of the biomass only because the green proportion has higher feed quality and is selectively eaten by stock and so is used in feedbudgeting throughout the growing season to predict animal performance. Total biomass is the combined measure of the green and dead component of the pasture which is commonly used in summer feed budget calculations.

The visual assessments were made by a skilled agronomist who did all the visual assessments in the project.

All data once collected, including the photographs, were sent to UNE researchers for detailed statistical analysis.

3.4 Statistical analysis

The results were analysed using a simple linear regression ($y = a + bx$) where

- Y = total available dry matter yield cut to ground level (kg/ha), washed, sorted and dried.
- X was either NVDI (GreenSeeker or Crop Circle) readings, or height in centimetres.
- a and b are constants.

The measure of fit (R^2) of the harvested DMY to NDVI, or DMY and height, was the key outcome from the analysis. An R^2 of 1 reflects a perfect correlation/association. An R^2 greater than 0.7 is considered desirable.

A more comprehensive analysis of the data, including elimination of outliers and transformations of some data, was completed by Karl Anderson (2017). See bibliography.

3.5 Extension and Communication

The Triple M group had their first project meeting on 14/2/2014 to discuss the project topic and to seek agreement with UNE researchers (Mark Trotter) on participatory R&D activities, what research questions were to be investigated, and plan how the project might proceed.

Annual review meetings with the researchers and producers, focussing on the progress of the project, were held on 18/2/2015, 14/4/2016 and 31/1/2017.

A key objective of the project was to establish the benefits to producer's decision making through using the GreenSeeker. The constraint to this was the GreenSeeker was not accurate enough to carry out an evaluation of if and how producers change their decision making following the use of the GreenSeeker. Instead the group investigated how using the biomass measurements in general can assist in making useful decisions leading to potential financial gains.

This was done through surveying three group members using the following survey questions.

1. How and when are you currently measuring pasture biomass?
2. Why are you measuring at that time?
3. How does it change what decisions you might make?
4. What do you think is the value of measuring pasture biomass?

4 Results

4.1 Pasture calibration results

The differences in DMY between cutting and weighing the biomass in this project, and the visual estimation of the biomass, were so variable and erratic it made the figures from any visual estimation unsatisfactory for any research (see Table 1). This is consistent with similar comparisons in other places.

Table 1. The comparison of the average actual DMY (kg/ha) and the average visual estimated DMY (kg/ha) of 27 pastures.

Year	Season	Site	Actual DMY kg/ha	Estimated DMY kg/ha	Difference DMY kg/ha
2014	Winter	Mountajup	638	1093	-455
		Woorndoo	1136	1183	47
		Coojar	394	863	-469
	Spring	Mountajup	1104	2164	-1060
		Woorndoo	2521	2183	338
		Coojar	1198	1490	-292

2015	Autumn	Mountajup	291	348	-57
		Woorndoo	588	390	198
		Coojar	756	850	-94
	Winter	Mountajup	357	383	-26
		Woorndoo	537	388	149
		Coojar	1107	796	311
	Spring	Mountajup	2250	1112	1138
		Woorndoo	2059	1031	1028
		Coojar	2500	2788	-288
2016	Autumn	Mountajup	66	257	-190
		Woorndoo	1301	929	372
		Coojar	344	160	184
	Winter	Mountajup	966	571	395
		Woorndoo	1852	2633	-781
		Coojar	2131	929	1202
	Spring	Mountajup	2386	1258	1128
		Woorndoo	1301	929	372
		Coojar	2652	3408	-756

The average actual pastures sampled ranged from 66 to 2652 kg DM/ha, averaging 1072 kg DM/ha. The average pastures assessed visually ranged from 137 to 3408 kg DM/ha yield. The number of pastures which were overestimated using the visual method was about equal to those under estimated. Using visual estimation of the pastures sampled 12 out of 25 were overestimated. Overall the trend was to underestimate the actual DMY with this being more marked in 2015 and 2016, than in 2014. In 10 out of 24 of the comparisons the difference between the actual and estimated DMY was less than 300 kg DMY/ha, 25% of the average actual DMY.

The results of the linear regression analysis for all the sampling sites in this project are shown in Table 2.

Table 2. The residual deviation (R^2) following the linear regression analysis between the actual DMY and pasture NDVI, and the actual DMY and pasture height (cm).

Year	Season	Sampling site.	Green Harvest DMY kg/ha	GreenSeeker NDVI R^2	Height R^2	Sampling date
2014	Autumn	Moutajup		Project training		
		Woorndoo	908	0.85	0.91	30/6/14
		Coojar		0.64	0.93	7/7/14
	Winter	Moutajup	638	0.55	0.87	7/8/14
		Woorndoo	1136	0.76	0.85	7/8/14
		Coojar	394	0.43	0.80	9/8/14
	Spring	Moutajup	1104	0.70	0.85	1/10/14
		Woorndoo	2521	0.51	0.97	2/10/14
		Coojar	1198	0.88	0.76	1/10/14
2015	Autumn	Moutajup	291	0.03	0.03	9/6/15
		Woorndoo	588	0.53	0.71	10/6/15

		Coojar	756	0.37	0.50	24/6/15
	Winter	Moutajup	357	0.30	0.02	27/7/15
		Woorndoo	537	0.62	0.44	28/7/15
		Coojar	1107	0.35	0.62	9/9/15
	Spring	Moutajup	2250	0.48	0.69	7/10/15
		Woorndoo	2059	0.40	0.56	7/10/15
		Coojar	2500	0.53	0.62	13/10/15
2016	Autumn	Moutajup	66	Pasture too short		17/5/16
		Woorndoo	194	0.80	0.22	19/5/16
		Coojar	344	0.04	0.71	25/5/16
	Winter	Moutajup	955	0.55	0.85	15/9/16
		Woorndoo	1852	0.96	0.96	26/9/16
		Coojar	2131	0.64	0.59	24/10/16
	Spring	Moutajup	2386	0.19	0.46	9/10/16
		Woorndoo	1301	0.58	0.45	17/10/16
		Coojar	2652	0.81	0.83	22/11/16

The average DMY on each sampling occasion ranged from 66 to 2652 kg/ha, the range expected on grazed pastures during a growing season. The R^2 figures are compared in horizontal pairs. The highest figure of the two is the best correlation between the DMY and either the GreenSeeker reading or the pasture height. Findings were:

- For the 25 sampling sites pasture height was the highest R^2 in 16 out of 25 of the comparisons. GreenSeeker R_2 was highest on 6 out of 25 sites. Pasture height clearly gives the better measure of DMY.
- Pasture height was the highest in all but one of the sampling sites in 2014. It was highest in 6 out of 9 of the sites in 2015 and in 2016 4 out of 9 of the heights were highest. While this looks like a significant trend there are not enough points to be confident that this was the case.
- 20 out of the 46 of the individual measurements had an R^2 >0.7, the level considered acceptable. Of these 20, on 13 occasions the height readings were the highest while on 7 the GreenSeeker readings were the highest.
- For any sampling time, when the R^2 figures for the NDVI and height were compared, the R^2 figures for height were highest in 17 out of 25 cases while for the NDVI this was the case for only 6 out of 25 cases.

Clearly the decision to include height in the measurement and analysis in this project was correct.

This data will be combined with a number of other sets which have a similar design and used similar procedures. It will then be subjected to a complex analysis the results of which will be reported in UNE's project report (B.GSM.0010). An example of the initial analysis by UNE is shown in table 3 below, which was presented at the final review in January 2017.

Table 3 shows combined calibrations of measurements made locally. RMSE is the random mean standard error. For example in SW Victoria the best correlation was height x NDVI with plus or minus 479 kg green DM/ha. N is the population sample or how many samples were taken. Table 3

allows for comparison between operators within a district with the Triple M group generally having a lower RMSE than AgViv.

Table 3. Summary of interim UNE analysis of the Triple M and AgVic data presented at the final review February 2017 by Karl Anderson (Miller, 2017)

Sites including Coleraine, Woorndoo, Mountajup, Croxton East, Penshurst East (2014) and Tabour (2015, 2016)		Height x NDV R^2	NDVI R^2	Height R^2
SW Victoria combined 36 campaigns N = 448	R^2 RMSE	0.72 479	0.61 642	0.69 503
Ryegrass, Ryegrass clover AgVic 5 campaigns N= 46	R^2 RMSE	0.87 393	0.48 702	0.87 389
Ryegrass , ryegrass Triple M campaigns N = 49	R^2 RMSE	0.89 222	0.2 607	0.84 271
Phalaris + rye AgVic N = 98	R^2 RMSE	0.68 520	0.59 629	0.65 544
Phalaris + Rye Triple M N = 228	R^2 RMSE	0.84 240	0.56 421	0.80 269

The most significant result is finding that pasture height is more important than the GreenSeeker (AOS) measurements in measuring green pasture DMY.

Future developments need to include height in any plans to design and manufacture relevant hard ware or tools.

Producer comments indicate that any new tools to measure green pasture biomass accurately will quickly find a good market.

While this project has not developed any new practices that producers can use immediately producer comments tell us that the thinking behind the project is attractive to them and will result in changes to farm practices as new tools are introduced.

4.2 Survey results

All group members involved in the survey had participated in short courses such as Prograze and had a good understanding of the principles involved in growing and utilising pastures. One person included in the survey had tried using a Grass master Pasture meter and commented it was OK but seemed to be no better than the pasture stick.

All had chosen slightly different enterprises to utilise their pastures – wool sheep, cross bred lambs and wool sheep and growing out dairy and beef cattle. They were chosen because they believed the enterprises best suited their farm and their skills and interests.

One used the Prograze stick to measure their pasture mass, plus used these measurements to calibrate their mind. The results of the latter were used every day that they were in paddocks. The remaining two had used the Prograze stick when it was first introduced and believed that this training was accurate enough to get them through the pasture growing season.

All three had a clear targets for their mid winter and lambing goals. This was as expected given the lambing times and stocking rates being run. This was the time they took the most interest in the pasture mass in their paddocks and is the time they would measure the pastures most often if there was a quick and easy way to accurately measure it in a number of paddocks.

On one occasion one person had used the results of measuring pasture to apply urea with the aim of boosting winter pasture growth.

Stocking rate was mentioned by all three and how they manipulate it during the growing season. An early break to the season meant that extra stock were commonly brought in by two of them while the third considered they had an optimum stocking rate and used their supplementary feeding program to manipulate their grazing pressure.

All three were interested in being able to measure their growing pastures more accurately but they all had clear criteria that any tools had to meet.

All three bench marked the performance of their businesses and so would know better than most about the dollar return from having more accurate measurement of their pastures. All three admitted they were only making guesses at the additional profit they mentioned which ranged from $100 to $250/ha. They all mentioned that in winter their management had to strike a reasonable balance between the condition of the stock, the green pasture and any supplementary feeding.

All three included in the survey said that developments in IT must surely mean that being able to accurately measure pasture quickly will not be far away.

4.3 Extension and communication results

A summary of communication activities is shown in Table 4. Extension to the wider community was not actively undertaken while trying to verify the accuracy of the GreenSeeker. Thirteen extension activities were engaged in involving 61 people. It includes providing email and verbal updates to group meetings.

Table 4. Extension activities and communications delivered.

Date	Activity	Number of people
February 2014	Workshop. Initial planning.	15
2014	Factsheet snapshot. Testing the GreenSeeker for real time biomass estimation for MLA website.	Circulation 5000
February 2015	Workshop annual review. Hamilton.	12

March 2015	Article. Warrnambool Standard.	Circulation 1500
2015	Article in MLA Feedback magazine.	Circulation 5000
April 2016	Workshop Annual review. Hamilton.	15
June 2016	Workshop. National MLA PRS Attwood.	65
June 2016	Paper. Project notes for national workshop. Real time biomass estimation using optical sensors.	Researchers workshop 60
January 2017	Workshop Annual review. Hamilton.	17

4.4 Participant reactions

Knowledge

At the start of the project the groups understanding of biomass sensors was limited with some not knowing anything and others having heard of producers who had used different types of sensors to measure height and density. They had also heard of Pastures from Space.

By the end of the project they were familiar with the GreenSeeker optical sensor and NDVI measurement. The group had knowledge that visual assessment was generally inaccurate. Height was an important measurement but the Green Seeker was not consistently better
than just taking a height measurement.

Attitude

The group was optimistic at the start of the project but by the end they had no great confidence in the use of the Greenseeker as the error was too high (greater than + or - 200 kg DM/ha and early season needed refinement).

Producer comments indicate that any new tools to measure green pasture biomass accurately will quickly find a good market. Some producers indicated they would pay up to $10,000 for a tool to get accuracy.

However the device had to be easy to use or it won't be used. The group also indicated they wanted a mobile unit for producers to use whilst driving across paddocks. They don't want to have to measure height via a plate meter.

While this project has not developed any new practices that producers can use immediately producer comments tell us that the thinking behind the project is attractive to them and will result in changes to farm practises as new tools are introduced. The progress being made will be followed with interest.

Producer practice change

Producers are likely to be wary of visually estimating pastures but it's unlikely they will take pasture cuts to calibrate their eye. One producer mentioned he had purchased a rising plate meter 12 months ago which he hadn't used yet but would get it out and calibrate it for his phalaris pastures.

4.5 Producer Research Site Program

The objectives of the PRS program were to:

- Add value to the existing FIP new research.
- Test if and how new research fits or could fit within farm systems if modified.
- Speed up the development and adoption of new research.
- Involve innovative information seeking producers in research funded by MLA.
- For producers to influence future research agendas.

The project contributes findings to MLA's national project B.GSM.0010 Real Time Pasture Biomass estimation.

The group added value to the PRS program by providing:

- 27 campaigns of data collection for UNE to analyse.
- Data on the accuracy of visual estimation which the GreenSeeker could be compared to.
- Feedback on what was important to producers for the device to do:
    - It must be accurate at key times and the level of acceptable accuracy is + or – 200 kg DM/ha.
    - It must be easy to use and mobile.
    - Want to be able to make decisions out in the paddock rather than having to go back to the office (Initial planning workshop.)
    - Their preparedness to take cuts to calibrate their farm to improve efficiency and willingness to spend more than $600 to get a useful device.
- Feedback on what they would potentially like the device to do.
- Need to measure both dead and green material.
- The need to potentially indicate quality.
- Feedback on the use of app (details of feedback are provided in the final review workshop notes).
- Intellectual property.
- Access to DEDJTR staff for additional sampling
- Access to dollars for feed testing samples to determine the detection of quality.

The group tested the optical sensor but found it added no further value than just measuring height and therefore the modification that was suggested was their preference to use height and find practical and easy ways to measure height.

By providing data for Victoria the group have helped to direct research away from the use of the GreenSeeker potentially saving producers from investing in it and directing further development towards methods of measuring height.

5 Discussion

5.1 Outcomes in achieving objectives

The group's research question was "*Can we make better grazing decisions that maximise opportunities and minimise disasters by using real time biomass sensors?''*

The key question was investigated through 3 key objectives which are shown in table 5.

Table 5. Project objective and outcomes.

Project objective	Outcome
1. Develop accurate AOS predictions for typical pastures at key times.	Process worked. AOS predictions were not very accurate. Modified to include pasture height.
2. Compare different pasture mass estimations of the AOS to methods currently used.	Completed. Current method used visual estimation. Accuracy consistently poor.
3. Establish the benefits for producer decision making through the use of AOS and real time biomass measurements.	This objective was modified. Making grazing decisions using a phone, iPad and a touch on the touch pad excited producers. Demonstration limited by brands of phones and other parts yet to be made. Encouraging.

Project objective one was achieved but was found to be of limited value because it focussed on AOS (GreenSeeker). Its association with DMY was poor (reflected by the number of low R_2 values). In response an extension was added to the objective, adding pasture height. This proved to be a valuable move. Height was found to be more highly correlated to green biomass. The conclusion is that pasture height gives a better measure of the available DMY than NDVI. This was clearest in the 2014 data (Table 2).

Overall the project ran to plan with only a couple of small exceptions. The measurements to be made in winter and spring 2016 were delayed by flooding after well above rainfall in September and October. This meant the pasture was more mature than it was aimed for but this probably had no effect on the results. The Crop Circle which was to be used alongside the GreenSeeker largely failed because of frequent break downs and demands for its use in other locations around the state. It was thought that the Crop Circle information to hand was insufficient to get any useful data and so was not included in any results and reports. The boundaries for sorting cut pasture into categories changed during the project so limiting the value of this data. The effect of this will not be clear until the secondary analysis is completed (B.GSM.0010).

The project had a relatively simple design with two treatments and a large number of replicates. This makes the analysis and interpretation of the data simple and straight forward. The secondary analysis that will be completed by UNE using the national field work is expected to show some additional details.

Objective 2 was completed. The main current method used to measure pasture mass, looking and guessing (visual estimation), has been shown many times to not be reliable enough to give results of a satisfactory standard. The accuracy of visual estimation varies amongst operators which is why

producers were keen to get an objective measuring device. They tend not to account for decreasing moisture contents at the end of the growing seasons and so underestimate what is present or kid themselves that there is enough feed early in the season to avoid supplementary feeding. This provides the benchmark for the accuracy of any future new measuring devices. That is they must be better than what visual estimation can achieve.

The group only used a roughly handmade device to measure pasture height. In New Zealand rising plates meters are used with monthly calibrations for ryegrass only pastures. John Cayley (ex AgVic) researched the best falling plate meter for use in research projects. The best meter was heavier and more robust than the meter used in this project. UNE has someone trying electronics currently used in boom sprays which have become cheaper in price but have a 2 cm wobble which could be equivalent of + or – 500 kg DM/ha. MLA has focussed on cheaper devices but the group expressed that they would spend thousands of dollar to find an easy to use accurate tool and thought they would recoup the funds.

The results of the project clearly show that the AOS used (others may use different wavelengths) is not adequate for measuring the green pastures used in this project. It was very clear that pasture height as measured by the falling plate meter had higher R^2 correlations.

The world of electronics and IT is complex and moving at a rapid pace and it is likely that on the move affordable and accurate sensors are likely to be developed which can measure height. UNE is also investigating the use of photos to generate heat maps which may be able to detect density. Connecting devices to bureau of meteorology data may be able to account for moisture content of pastures to give more accurate and practical applications.

The producers were encouraged by an early model phone app to convert calibration data into kg DM/ha which was originally used for NDVI conversions but could be used for height. This app excited producers at the meeting. They will be keen to try improved models once they are available. Making grazing decisions using a phone, iPad and a tap on the touchpad is appealing. The demonstration of the app was limited to analogue phones but was to be made for iPhones.

Objective 3 was about answering if the group could make better decisions based on using AOS. As the technology proved inadequate there was nothing the group members could try to test this. Therefore the objective was broadened to establish the benefits for producer decision making through the use of accurate biomass assessments. This objective was met through the use of questioning of producers at annual workshops and through a survey were:-

- It was very clear that if producers had accurate measurements they are certain they would make better decisions.
- All producers said the better decisions would centre around increasing or reducing winter stocking rate on a paddock by paddock basis. Decisions about annual property stocking rate were generally made in January but in some cases were adjusted in autumn depending on the timing of the autumn break and the amount of available feed. Better planning of adjustments to the winter feeding programs was also mentioned. There was a wide range of benefits mentioned flowing from these changes - financial gains, gives more confidence, helps sleep at night, better lamb survival.

- The Prograze Pasture stick was used occasionally to measure pasture mass. Using these results, along with observations on livestock and pasture conditions, producers seemed to build up pasture benchmarks in their minds which they referred to regularly. No written records of these benchmarks were kept. While the accuracy of the benchmarks is known to be challengeable producers find their system useful.
- All producers considered the current recommended method of measuring pasture mass to be too slow and tedious. If these problems can be addressed a lot more pastures will be measured.
- Once some easy to use and accurate hardware becomes available it will be quickly taken up. Time and quality research will determine how quickly this will happen.

Full consideration and interpretation of any results is required demonstrating what it means for the producer group and producers outside the core group and region to take up any new technology.

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

There will be no immediate benefit with optical sensor usage as new practices and ideas have not been finalised. Comments by producers indicate that benefits will be considerable once the practices are finalised and are accurate. If a longer term view is taken, the value of this project and what continues, is considerable.

Some of the beneficial research results include:

- GreenSeeker has been shown to not be effective in measuring mixed green biomass in Victoria and this is a result from this project. It means it will not be promoted and producers use an inaccurate device.
- Height has been confirmed as a useful measurement of biomass.
- Visual estimation has proven again to be consistently inaccurate for producers and agronomists that are likely to train them.
- A better understanding of how producers measure or don't measure pasture biomass and how accurate measurements could help them make better decisions.

Producers have identified how having accurate measurements that are easy to take will benefit them in the following ways:

1. Better Decisions

The results of this project focus on the time between the autumn break and when the pasture starts to dry off.

- Better decisions during this time means better lamb survival, less livestock deaths, more advantageous movement of stock between paddocks, more focused supplementary feeding.
- Being able to pick when the pasture starts growing helps make management decisions.
- Possibly to determine the autumn pasture mass so you could hold off on grazing which would lead to environmental benefits.
- Better decisions about livestock nutrition and management during the pasture growing season will lead to improved production and marketing plans.

Producer's commented:

"It will give me extra confidence in decision making especially around when you are starting to hit critical points. Stock may not be doing well and are slowly declining which you may not pick up."

"It's useful to know when you are under 1,000 kg DM/ha in autumn and winter and that you have enough for maintenance. Spring is not having as much financial impact."

2. Objective accurate measurements

Producers thought a major benefit for the development of tools to measure pasture biomass was that they could make better use of employed staff by being able to give more objective and better instructions.

Producers commented:

"A big benefit of the technology related to its objectiveness and that anyone on the farm will be able to use it."

"It gives better control of management decisions, objective assessments versus subjective assessments where you hope there is enough feed."

3. Confidence in making decisions

Producers felt that a tool would give them confidence in their decisions. There comments included:

"It will help give information to make decisions and then you are not under pressure to correctly estimate biomass by eyeballing."

"It will give confidence to make decisions under stress."

"Take out the uncertainty around decision making."

4. The costs and expected benefits

Producers are reluctant to put a value on the benefits but one producer believed it will be tens of thousands of dollars as he thought he could get a 20% increase in feed utilisation through better allocation.

Some comments included:

"Opportunity cost in losing lambs by not making the right decisions because we don't know how much pasture is there. You assume we underestimate but probably overestimate when feed is short and try to run a few too many."

"Running a few extra lambs would soon pay for any device."

A useful measurement of the benefits would be the dollar value of decreased mortality compared with baseline.

The cost of making any changes could potentially be minimal (new phone, iPad, feed budgeting tool, feeding out equipment) to considerable if the current feeding programs need major upgrading and

the device is expensive. For most producers the main cost will be management. Where there is a better match between feed supply and feed requirements. There are many height measuring devices on the shelf ready for purchase and use. Although few are able to measure pasture height on the go which is keenly sought after by producers e.g. Drones. When will this happen? This depends on the dollars invested in getting the research ideas up to a point of being ready for use and purchase. IT ideas and hardware are coming at a phenomenal rate and their expense is dropping

The benefit cost sensitivity can range from very low to very high if measuring pasture height as there will likely to be a range of devices that could be used e.g. ruler, pasture meter or LIDAR type sensor. Most producers will be at the low end of the scale. However for producers who have heavy stocking rates, it makes good sense to farm well and to operate with minimal risk.

Unintended/unexpected benefits or consequences included:-

- Improved IT skill as learning to use one device makes adoption of others easier. Big flow on effect.
- New IT skills may mean additional training to use it well. Benefit costs can be very high.
- Finding that consultants training producers to assess pasture might not themselves be very accurate.
- Opportunity to measure FOO across the farm is exciting and producers being able to connect to tools for feed budgeting.
- Optical sensors may be useful to infer quality changes by potentially picking up changes in biomass structure (seed heads, amount of green) at the point when the pasture becomes reproductive and quality starts to decline.
- Opportunity to add it to the Lifetime Ewe program as it covers mainly interpretation of results rather than assessment.
- Potentially there are environmental benefits through better management of water and soil run off in years of very high rainfall. May help with planning major issues around wind erosion when pasture growth and availability is well below target.

5.3 Promotion of research results and its effectiveness

Engagement of producers

There were approximately 15 repeat producers engaged throughout the project. The results of the project were not promoted more widely because it was a national project and the group did not want to promote mixed messages, especially without understanding the full set of results. For example optical sensors didn't work well in Victoria but may have been working in WA and the reasons for this were speculated rather than proven.

Practice changes

Promotion of the GreenSeeker is not relevant at this stage. Once accurate devices are available they will walk off the shelf. Extension will potentially be needed to raise awareness, especially about how and when to measure biomass.

The feedback from annual views suggested this project has increased producer's interest in measuring pasture but the increase is not to the point where pasture cuts will be keenly taken. Producers admitted that they may be under valuing the benefits of being able to measure pastures accurately.

After analysis of 3 years of data collection there were two key messages the group felt comfortable to promote for future extension and they were:

- Calculate green biomass by measuring height using the most cost effective and accurate method.
- Visually assessing pasture is not a sufficiently accurate way of assessing biomass unless you are regularly calibrating your eye through pasture cuts.

Barriers to change

No producers in the group routinely measured pasture. The survey helped pick up some reasons why. Getting accurate measures (height) using current methods is slow and tedious and may not be sufficiently accurate. The barriers are mentioned continually. Time is precious when running a grazing business. The demands from using existing methods are currently not considered worthwhile however this could change quickly if suitable tools become available (currently work is being done on this). There has been no whole farm study which clearly demonstrates the value of routinely measuring green pasture mass.

Barriers to change that were identified in the annual reviews and surveys were:

- Not shown / proven the value of measuring pasture.
- Haven't established the need. Need has to drive the technology.
- The appeal of the GreenSeeker was that you could do it whilst driving across the paddock. It was going to be easy to use. If taking height was used you might have to get out of the ute and walk and this isn't as appealing.
- Any additional farm calibration needs to be made easy as producers rarely take pasture cuts.

Enablers to change identified in producer discussions were:

- Having an accurate device that is easy to use.
- Future research is important to find accurate, mobile and easy ways to measure height and account for density and moisture change throughout the year.
- Demonstrating the extra dollars producers can make by taking biomass measurements at critical times to make better decisions.

5.4 Effectiveness of the participatory research process

Producer engagement

Producers were kept engaged by the quality presentations and the opportunity to enter the engagement at any point during the process. All participants have been in many discussions like this and are comfortable with it. All were very happy to be involved in the process.

The facilitator needed to be well prepared but not over prepared and prepared to be interrupted and engaged in discussions. Measurement of biomass was the topic the producers focussed on as they became more and more impressed with what has been done the more they entered into the discussion.

All up it was very positive they are a very mature group which enters into discussions readily. Controlling of the group only ever needs to be minimal. They are an easy and very good group to work with.

Working with the researcher and their support

Working with Karl Anderson, and researchers before him, was always helpful. They were always accessible and answered all group queries. Having made trips to this location the researchers were familiar with the situation the group was working in which made it easy to give good advice when faced with difficulties.

Researchers attended all the annual group review meetings. This added considerably to the quality of the meetings and the quality of the project. There were always questions which were better answered face to face.

Speed up adoption of technology

The project hasn't sped up the adoption of the technology but helped to speed up the research into proving that NDVI technology did not work as effectively as just measuring pasture height and that it was the group's recommendation that the height calibrations developed could be used in conjunction with AgVic calibration data to measure height and could be included in the phone app.

The group provided additional sites in Victoria and therefore increased the geographic spread of the project.

Feedback to the researchers

The group acted like a market focus group for the researchers and provided feedback on what they needed and what they wanted the tools to do. Examples included:

- Victorian pastures are very different from those in Armidale where the researchers were from and whose pastures stay green all year round as opposed to Victorian pastures having dry feed from December until the autumn break. Therefore there was also a desire from producers to also measure total feed.
- The group advised the researchers when the best times were to measure pasture biomass in their environment.
- They would be prepared to take on farm calibration cuts to improve predictions if necessary.

App feedback was provided at the final annual review meeting and this included:

- Require one registration code for each phone, so that multiple workers on the property can use different phones and know what paddocks have been measured.
- Must be able to download data to excel or be exportable.
- Needs to be basic not extensive, apps try to do too much.
- Has to work on iPhone and android.
- Good if it could calculate basic growth rate from last reading (even if stock grazing).
- Could it be predictive and tell you what you could have in 4 weeks.
- The group would like the order to be feed data entry first, so you can get in and out.
- Don't think there is anything useful on the market in terms of an App. Agriwebb was on this track but it's not useful for this.
- High appeal for dairy farmers who measure biomass weekly.
- Can load your data into a computer program and it produces a growth curve.

Is the mapping feature necessary?

- Have to have a mapping feature, so you can return to your transect to measure.

- Mapping on a phone is no fun.
- With large fingers, drawing on an iPad would be better.
- We have already mapped paddocks, maybe 3 times; can it be linked so we don't have to draw them again?
- Have found the GPS on the phone not to be good. Might be better if you wait for satellite bars to improve and then take.
- Could you enter size of the paddock rather than have to map?
- Grazeable areas, sometimes only parts of the paddock are grazeable, e.g. they go under water.
- Need to be able to calculate how many stock to put in and for how long.
- Seeing maps on phones is necessary but not map on phone.
- Pull maps in from google earth, or shape files, there are lots of different datum accuracies.
- Link data through to iCloud.

Is the heat map of biomass worthwhile or gimmicky?

- It's like a yield map, may be good for identifying poor areas which you could fix with VRT. That is at the start of season you could work out which areas were growing the fastest.

Group paid to take measurements

- Farmers have appreciated that they haven't had to collect the data. One farmer commented he has it in his business plan never to carry out trials again due to the high amount of time taken having participated previously in trials.

Research influence

The group are keen for this topic to be further pursued and invested in to develop easy to use tools that can measure pasture height.

6 Conclusions/ Key Messages /Recommendations

Every producers dream is to be able to drive from gate to gate measuring how much green pasture is in the paddock as he goes. This is then entered into an app which with the tap of a button does the calculations required and shows how much pasture is present.

There are several ways of measuring pasture but the two tested in this project are an Active Optical Sensor (GreenSeeker) and pasture height. They were compared with cutting pasture to ground level and weighing it and producer's current method of visual assessment.

Three perennial pastures/paddocks were measured late autumn/early winter, late winter and spring in 2014 to 2016 using three assessment methods. Pasture height gave the most accurate measure in 16 out of 25 of the situations tested. GreenSeeker only gave satisfactory results on 6 out of 25 occasions. Visual assessment was generally inaccurate with the trend being to underestimate biomass.

The conclusion is pasture height has to be included in any tool which attempts to measure green pasture biomass in Western Victoria.

7 Bibliography

Anderson, Karl (2017) Biomass Business 2. Tools for Real Time Biomass Estimation in Pastures. Available at https://www.crcsi.com.au/assets/Resources/Project-4.18-Biomass-Business-II-Tools-For-Real-Time-Biomass-Estimation-in-Pastures.pdf

CRC Project number 4.18. Biomass business 2. Available at http://www.crcsi.com.au/research/4-1-agriculture-natural-resources-and-climate-change/4-18-biomass-business-2/

MLA Project number. B.GSM.0010 Real time pasture biomass estimation

Miller L, (2017) MLA Kelly Gang group final review notes, Southern Farming Systems, Inverleigh