final report

Project code: L.PDS.1705

Prepared by: Georgia Reid and Edward Riggall
AgPro Management

Date published: 20 March 2020

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Manipulating pastures for mixed enterprises

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

Executive summary

The project aimed to demonstrate the advantages of pasture manipulation to the sheep enterprise, to enhance producer understanding of the tool. The objectives were to do so by demonstrating the impact of pasture manipulation and its timing across three properties in the Moora-Miling region of W.A.'s northern Wheatbelt, running for three years. It was expected that manipulation would show the most profitable time to manipulate pastures, through livestock productivity and impact on feed quality and quantity. Economic analysis was conducted to show the impact on the enterprise overall.

The project was run because grasses such as barley and brome grass provide early season feed for livestock, but challenge sheep producers later in the season. These grasses do not provide good quality spring feed and set seed heads early, limiting livestock productivity and impacting sheep health. This is an issue producer's address with combinations of herbicides and grazing management. Manipulating pasture species composition is a common practice, yet producers are often unsure if, or when, to apply this treatment.

Producers who do not manipulate are faced with many issues such as diminished spring pasture quality, which leads to lower stock growth rates, as well as less clover seed set, lower clover nodulation (and therefore lower soil fertility) and increased grass-based disease carrying over into crop phases, which impacts cereal crop production. Such grasses and weeds also crowd out legume clovers, which in spring deliver higher growth rates to livestock. Having higher density clover pastures in spring also leads to greater clover seed set, so improves the following years' pastures. In contrast, seed set from grasses negatively impact on lamb skins, eyes, and overall profitability.

The solution to this issue is to manipulate these grasses & weeds with chemicals during winter, while limiting the impact on clover and ryegrass. The timing of this manipulation is important - it has to be early enough to limit grass seed set and promote clover production, while late enough to not impact feed production. This is what the project addressed- comparing the impact of late and early pasture manipulation to unmanipulated pasture.

The demonstration sites commenced at the break of the season, with paddocks stocked with producers' usual stocking rate. At each of the three properties, 'strips' of different manipulation treatments were created. Grass-selective herbicides were applied either early or late in the season, or not at all, to create the early, late and control treatments. The control treatment was spray-topped with Glyphosate as grasses set seed in spring as per usual farmer practice. Each strip had an exclusion area to prevent grazing, so that pasture species, quality and quantity could be measured without grazing pressure. Exact spray dates depended on the timing of the season break and germination patterns.

Feed tests were taken throughout the season to determine the impact of manipulation timing on pasture species composition, feed quality and quantity. Germination data was collected in the project's third year, with part of the sites having been sprayed out in year two to mimic a cropping cycle. This showed the impact on the seed bank and subsequent pastures.

The feed data was then used to model sheep productivity and combined to create the overall economic analysis.

Feed test results showed that manipulating pasture did not have huge impacts on spring Feed On Offer. Feed quantity decreased after manipulation, before increasing throughout the season. Early manipulation had the least impact on spring feed availability, however the biggest impact on feed quality. The feed test results varied across the three years, however the results on species

composition were very clear. Pasture manipulation led to an increase in the percentage of clover present in pastures, and decreased grass content. Early manipulation resulted in the highest clover composition, followed by late manipulation. The control treatments had significantly higher levels of barley, silver and rye grasses when compared to the manipulated pastures in spring. This difference in spring feed quality led to the ability to extend the season in spring, as pastures with lower levels of grasses did not need to be spray topped to prevent grasses setting seed. This was an extremely valuable result, creating up to 16 days of additional grazing. The value of this was calculated to be on average $42 per hectare.

However, manipulation did come at a cost- the value of feed removed by manipulation. The value varied based on the time during the season, with early season feed being much more valuable than late, due to pasture being in short supply. The feed removal cost averaged $108/ha for early manipulated pastures, while the value of feed removed by late manipulation was $59/ha.

GrazFeed modelling based on the feed test results showed that sheep productivity is very closely linked to pasture quality in terms of species composition. Pastures with high clover content led to the highest meat and wool growth in ewes, lambs and wethers, with indications that species content may be just as important as FOO. However, feed availability was still a significant driver of productivity over winter, but not in spring where feed quality was the key driver.

To give the impact on profitability, the cost of removing feed was combined with the sheep productivity benefits, and the value of being able to extend the season in spring. This overall profitability modelling showed that over the project's three years, late manipulation led to an average impact of -$17/ha and early manipulation -$66/ha. It should be remembered that overall profitability showed some positive economic results, and some significant negative financial impacts. This variability is partly due to the project having run over a series of late break seasons. Further research should be conducted to clarify results, and include other outcomes of manipulation such as:

- Soil nitrogen and soil disease impacts
- Increased clover content in subsequent pastures, therefore assumed decreased grasses in seed bank.
- Increased carrying capacity
- Decreased need to re-sow pastures after a cropping cycle

Producers were still interested in adopting pasture manipulation control despite the average negative impact on profitability, seeing value beyond the economic analysis conducted. This was due to the project showing positive financial impacts at some sites, the strong link between species composition and sheep productivity, as well as improving following years' pastures. Overall, knowledge and skill change, confidence and satisfaction with the project was high. Producers have been equipped with the knowledge and skills required to make the decision about if, and when to manipulate pastures.

Table of contents

1 Background

The problem that prompted this project is that grasses such as barley & brome grass provide early season feed for livestock, but challenge sheep producers across Western Australia later in the season. These grasses do not provide good quality spring feed and set seed heads early, limiting livestock productivity and impacting their health. This is an issue that producers address most commonly with a combination of herbicides and grazing management. Manipulating pasture species composition is a common practice, yet producers are often unsure if, or when, to apply this treatment.

Producers who do not manipulate are faced with many issues such as diminished spring pasture quality, which leads to lower stock growth rates, as well as less clover seed set, lower clover nodulation (and therefore lower soil fertility) and increased grass-based disease carrying over into crop. Barley grass is a particular carrier of grass-based diseases such as 'take all' which impacts cereal crop production. Such grasses and weeds also crowd out legume clovers, which in spring deliver higher growth rates to livestock. Having higher density clover pastures in spring also leads to greater clover seed set. In addition, early seed set from grasses such as barley and brome significantly and negatively impact on lamb skins, eyes, and overall profitability.

The solution to this issue is to manipulate these grasses & weeds with chemicals during winter while limiting the impact on clover and rye grass. The timing of this manipulation is important - it has to be early enough to limit seed set and promote clover production, while late enough to not impact feed production, as feed is in short supply early in the season.

While approximately 30% of the MMPIG members are manipulating pastures in some form regularly (which is representative of the rest of the state), many farmers lack knowledge and confidence to regularly manipulate pastures and are concerned they will remove too much pasture and impact profitability. The key concern is that the remaining pasture's growth (predominantly clover) will not be adequate to support a high stocking rate through winter, with significantly lower Feed on Offer.

The project aimed to demonstrate to producers the impact of different pasture manipulation timing compared to not manipulating. This will be assessed visually as well as supported by feed tests and livestock profitability modelling. The aim is to increase understanding of the benefits and costs of manipulation, so producers are better equipped to make decisions regarding its use and timing.

2 Project objectives

The project aimed to demonstrate the advantages of pasture manipulation to the sheep enterprise. To achieve this by December 2019, three producers in the Moora-Miling region of W.A.'s northern Wheatbelt implemented and demonstrated the advantages of pasture manipulation. This was on the quantity and quality of Feed On Offer (FOO) available for sheep, and the impact on farm profitability. The project and its activities were expected to lead to 60% of observer producers that attended field days (60+) adopting the practice as well as 90% of the project's core members.

Over three seasons, on three different demonstration sites hosted on different properties, 3 producers, with the help of the other 10 core members of the producer group, will demonstrate to the 70 members of the wider producer group and others, through field walks, newsletters and Facebook and Twitter posts, the advantages of pasture manipulation. The producer group will:

- Demonstrate the impact that manipulation has on the quantity and quality of feed, allaying fears that are currently preventing farmers from using the tool.

- Use discussion on these results to reinforce farmer understanding of the effects of quantity and quality of FOO on sheep productivity.

- Model the effect of increased quantity and quality of feed on sheep productivity and profitability.

- Show the difference between early and late manipulation on feed quantity and quality at key times during the season.

3 Methodology

3.1 Demonstration site set up

Three producer demonstration sites were run in Western Australia's Northern Wheatbelt, with sites located in Moora, Walebing and Miling. These were replicated each year from 2017 to 2019. The identified host properties were known as: Lefroy, Mike and Richard.

At each property, there were three adjacent treatment plots, known as 'strips'. These strips are the three treatments: early manipulated, late manipulated and control. Each strip is the width of the producer's spray rig and continue for the length of the paddock or at least 500 metres. Each strip has an exclusion area to prevent grazing, so that pasture species, quality and quantity could be measured without grazing pressure.

The treatments were as follows:
- The control strip did not receive any manipulation but were spray topped just before the barley grass went to seed in spring, mimicking usual practice.
- The early manipulation strip was sprayed with a barley grass selective herbicide in early winter.
- The late manipulation strip was sprayed with a similar herbicide in late winter.

Exact spray dates were dependent upon the season - the timing of the season break and germination.

The control strip was spray topped at the end of the season as per usual farmer practice, to control grass seeds. This timing was recorded as was the time of early and late manipulated strip senescence.

In the project's second year, we looked at pasture species germination at the beginning of the season, to demonstrate the longer-term effect of manipulation on pasture composition. Also in year two, a band going across the three strips was sprayed out with Glyphosate to mimic cropping. In year three, germination was examined across this band, mimicking what happens when cropping goes back into pasture.

The demonstration sites commenced at the break of the season in 2017, with the exclusion areas put in place before grazing began. The paddocks were stocked at the producers' usual stocking rate, with pregnant ewes. Paddocks were chosen based on what could remain in pasture for 3 years. This resulted in paddocks with slightly varying pasture composition, treatment history, topography and soil types, providing a cross section of typical pastures in the area.

The demonstration sites were completed in late spring of 2019, when the final feed tests were collected.

3.2 Demonstration site measurements

Measurements were undertaken by core and observer producers, overseen and assisted by a technician in order to reinforce measurement techniques, as well as maintain the reliability and validity of results.

3.2.1 Feed quality and quantity

In order to quantify the difference between the quantity and quality of pasture in each treatment, members of the grower group took 0.1m2 pasture cuts from each strip just before each manipulation, as well as regularly between this date and the end of the growing season. These cuts were sent for analysis of dry matter (kg/ha), digestibility, (%DM), crude protein (%DM) and metabolisable energy (MJ/kgDM). The grower group members who carried out this work will also took photographs of their quadrats, to visually show the difference in pasture species combination and ground cover for comparison between strips and compare across the season within the same strip.

3.2.2 Pasture species composition

Composition of pasture species was estimated at the same time the cuts are conducted. This was recorded as species' percentage of pasture/0.1m2. For the first measurement in year 1, the sample was separated into individual species in order to accurately identify and measure composition. Due to the time-consuming nature of this analysis, subsequent composition was estimated.

3.2.3 Soil nitrogen

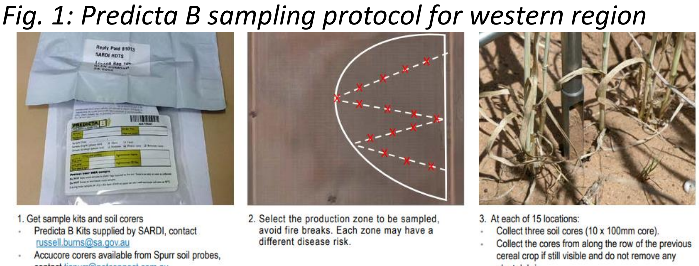
Total soil nitrogen, nitrate and ammonia was tested in after year 1 and 2. After the end of the growing season, the producers took soil samples from each strip, following CSBP's soil sampling protocol, as soil samples were sent to CSBP for analysis.

3.2.4 Predicta B analysis

Predicta B testing was undertaken for soil-borne pathogens and disease risk, using the sampling protocol as outlined by PIRSA: (https://pir.sa.gov.au/__data/assets/pdf_file/0008/291248/Sampling_protocol_Predicta_B_South_and_West_V2.pdf). A visual of this protocol is available in Fig. 1.

This involved 15 locations per treatment strip, selected in a zig-zag pattern. At each of these 15 locations, three soil cores were taken (10x100m core), which included plant debris, adding in one 5cm piece of cereal or grass stubble which includes the crown (if present).

Fig. 1: Predicta B sampling protocol for western region



3.2.5 Germination (mimicking cropping year)

In the second year of the project, a band was sprayed out horizontally across the strips to mimic what would occur if the paddock was cropped. This occurred at the break of the season, removing all germination.

In the third year of the project, the band was analysed for germination. This occurred at the break of season and was monitored throughout the year. Germination data was collected with the producers, taking visual estimates of the percentage of clover compared to grasses and weeds as well as overall ground cover of each treatment strip. This was undertaken after the break of season.

3.3 Economic analysis

GrazFeed and MIDAS modelling was used to calculate the impact on sheep profitability. This focused on the most significant impacts - the value of early season feed and extending the growing season at the end of spring. John and Mike Young from Farming System Analysis Services conducted this modelling.

3.3.1 MIDAS

The MIDAS modelling included the impacts of stocking rate, supplementary feeding requirements, soil nitrogen, soil disease, removal of early season feed and extended spring feed. This analysis calculated the impact of removing each 100kg of pasture at a range of timings over winter and early spring, and the value of extending the growing season. The values of early pasture and of extending the growing season was multiplied by the measured reductions (kgDM/ha) in early pasture production and the observed extension in the length of the growing season. This combined value gives an estimate of the impact on sheep profitability for implementing the practice on a typical farm.

The full economic analysis methodology can be viewed in Appendix 1, within the Economic modelling report.

3.3.2 GrazFeed

GrazFeed modelling looked at the impact of pasture manipulation on wool and meat growth, milk production, and pasture intake. This was more feasible than collecting condition score data for the season duration due to the need to rotate stock. Modelling was done for ewes and their lambs as well as 1-year old wethers. Wethers were also modelled as the impacts of manipulation are clearer without the influence of lactation or pregnancy, while lamb growth is indicative of lamb survival to reach weaning. Period 1 was July to August; Period 2 August to mid-September and Period 3 mid-September to mid-October.

3.4 Extension and communication activities

Involvement of the core and observer producers was at the heart of this project, as well as involvement from the MMPIG group. This provided the platform to conduct extension activities, and further the reach of any communications and outcomes of the project.

Extension and communication activities included two field walks per year: one held four to six weeks after the early manipulation, and the second at the end of the season when the control had been spray-topped. This way, members of the producer group could see the visual results at different stages and discuss the quantitative results available at the time.

These days were advertised through social media, with Facebook, Twitter and WhatsApp, as well as the MMPIG email list. Summary sheets of current results were shared at these days. Annual summaries of the project and its findings were distributed through the same channels. However, the project and its findings were shared as widely as possible, with AgPro Management & MMPIG seeking out presentation slots.

At the start of each year, core producers met to discuss the project, review results and plan the years' activities. This was an opportunity to review key skills such as pasture cuts.

4 Results

4.1 Feed test results

Feed quality and quantity varied significantly across sites and treatments, with few clear trends. Data has been displayed as averages each year in Figures 3-5, with full results available in Appendix 2 to 4.

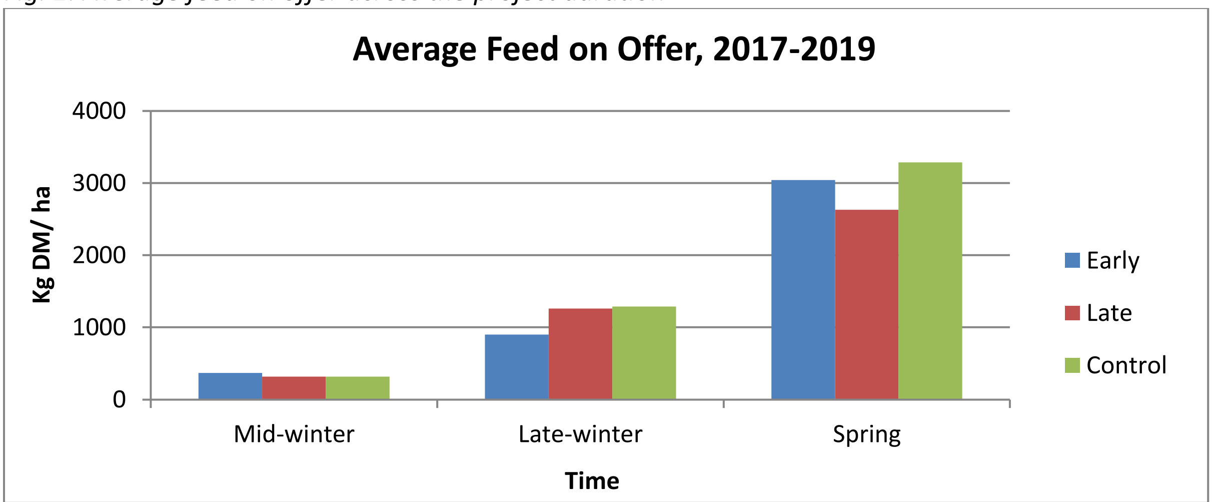
4.1.1 Feed on Offer

Feed on Offer (FOO) was measured in kilograms of dry matter per ha (kgDM/ha). It varied between sites, ranging from 591kgDM/ha to 6,197 kgDM/ha. Average FOO across the project is shown in Fig. 2. All sites saw a slight increase in FOO by the end of July/August when the second cut was taken, and then a rapid increase in production in late winter/early spring. Manipulating pastures led to initial decreases in FOO, however this was compensated for with abundant spring FOO and feed quality.

Appendix 2 shows the performance of each year, at each site. 2018 had higher FOO levels than 2017 due to a good season, as did 2019. This was particularly evident early in the season, however, 2019 saw lower FOO in spring compared to 2018 which will be addressed in the discussion.

Manipulation had varying impacts on the amount of spring FOO. Early manipulation led to higher spring FOO compared to late manipulation every year, as shown in Figures 2 to 5. These figures also show conflicting results: in 2019, control treatments had the highest spring FOO, in 2018 the lowest, and in 2017 it was higher than the late but less than the early.

Fig. 2: Average feed on offer across the project duration

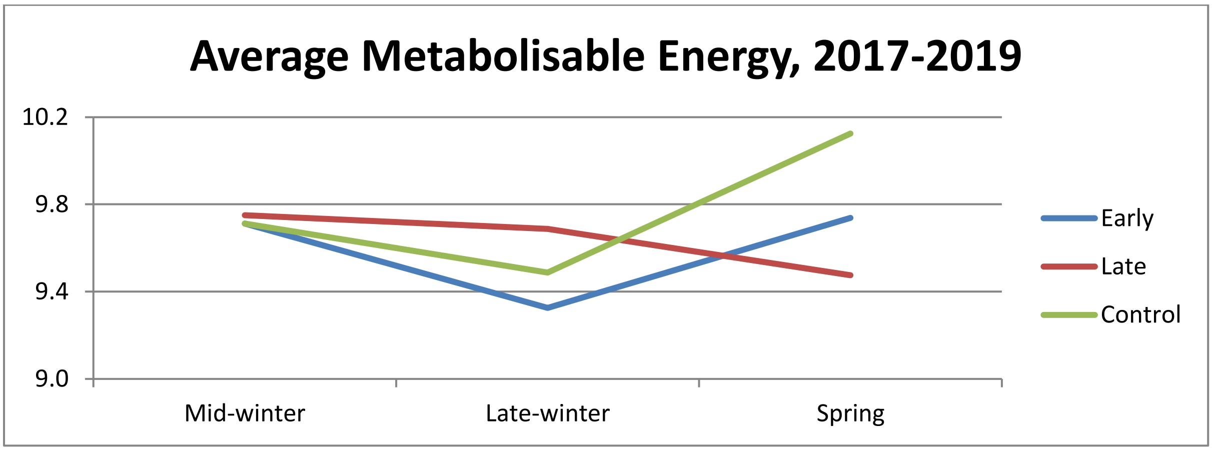


4.1.2 Feed quality: energy, protein and digestibility

Feed quality varied across years more than feed quantity, so a break-down of each year has been included. Metabolisable energy, measured as megajoules per kilogram of dry matter (MJ/kgDM), had varying trends each year, but did not have huge variation. Full results are available in Appendix 3 to 5, showing this variability between 9.1 and 11.8MJ/kgDM.

2017 saw ME decrease in winter at all sites before peaking in spring. One site followed this trend in 2018, while the other sites showed very different results. One site showed steadily declining ME, and the other recorded an increase in winter before a decrease in spring, which was repeated in 2019. On average, energy decreased from mid to late winter, before increasing in spring. Fig. 3 shows this pattern, with each treatment responding differently. However, this is not a clear, reliable result of impact of spray timing on the energy content of pastures, with the sites, and years, having conflicting results. This should be kept in mind when viewing the average performance in Fig. 3 below.

Fig. 3: Average metabolisable energy for project duration



Crude protein was measured as percentage of dry matter (%DM). Fig. 4 below shows the average crude protein of pastures throughout the season, across the three-year project. It should be kept in mind that there were extremely variable results, with crude protein ranging between 11.4% and 29.9% throughout the season as shown in Figures 5 to 7.

Protein levels declined over the season, as expected and seen in Fig. 4. It is also worth noting that 2019 saw spring protein in early manipulated to increase at every site, shown in Fig. 7.

On average, early manipulated pastures had the highest spring protein, while late manipulation had the highest winter protein. The unmanipulated treatments had the lowest protein compared to any manipulated pasture. There were no further clear trends, with conflicting results each spring. This can be seen in Figures 8 to 10, with varying results. In 2017, spring protein was highest in the early manipulated pastures, as it was in 2019. 2018 saw late treatment to have the highest spring protein.

Fig. 4: Crude protein for project duration

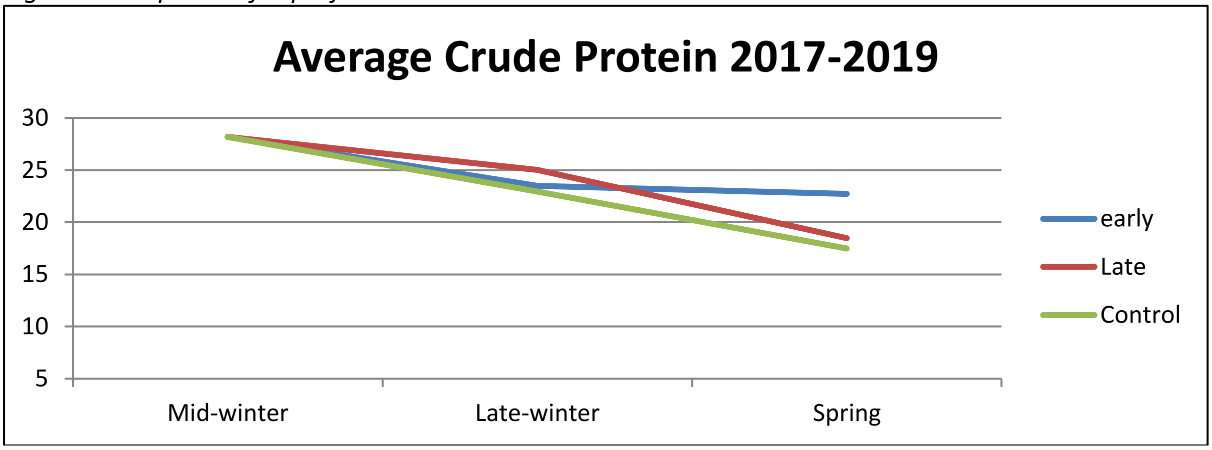


Fig. 5: Crude protein for 2017

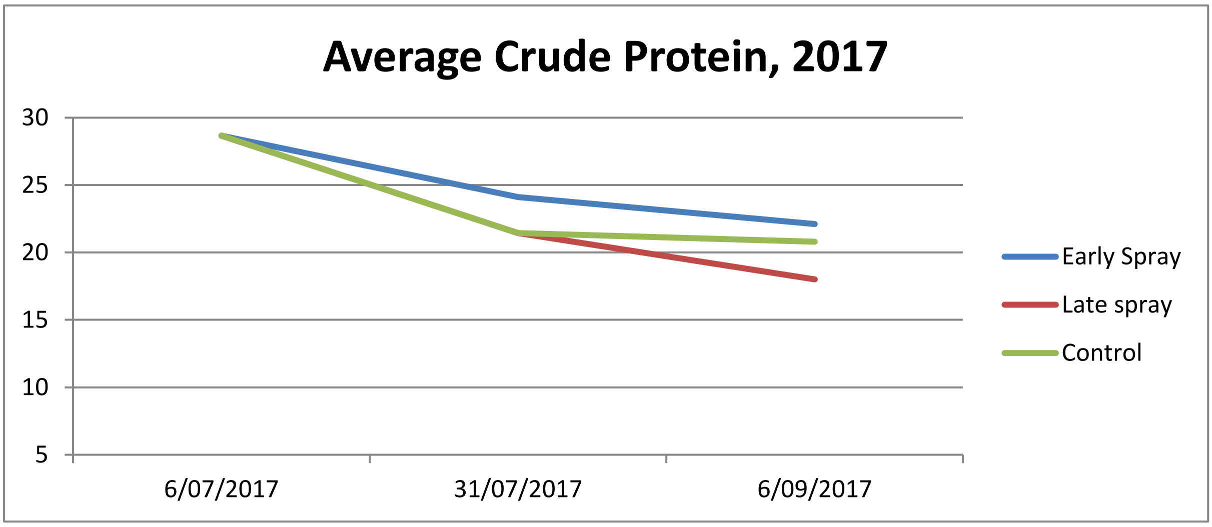


Fig. 6: Crude protein for 2018

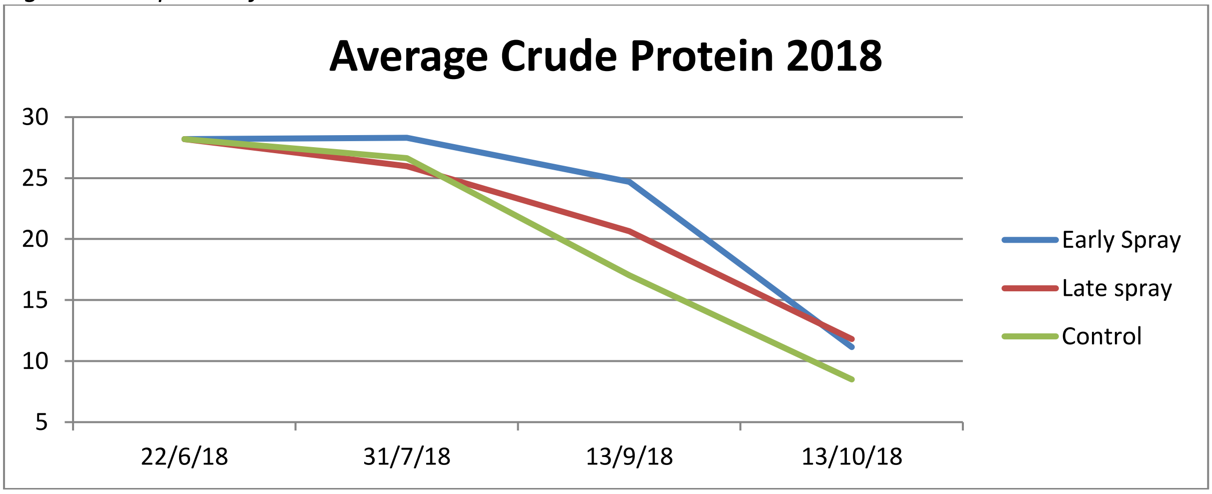
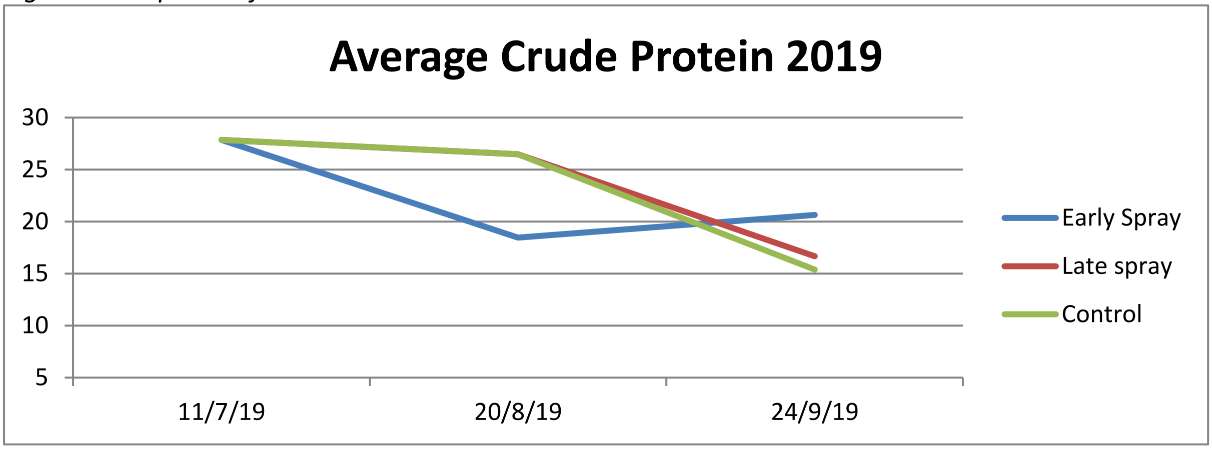


Fig. 7: Crude protein for 2019



Dry matter digestibility (percentage dry matter) produced conflicting results across sites and years, but similarly to energy did not have huge differences due to treatment or site, being between 61.1% and 77.8%. This is demonstrated in Figures 8 to 10.

To begin with, 2017 saw digestibility decrease in winter, compared to 2018 and 2019. There were conflicting results across the 2017 and 2019 treatments regarding the impact of manipulation as seen in Fig. 8 and Fig. 10, however both reported the unmanipulated control strip to have the highest digestibility in spring. Compared to 2017 and 2019, 2018 results (Fig. 9) clearly showed early and late manipulated pastures to have higher average digestibility in spring compared to unmanipulated pastures.

Overall, the early manipulated treatment was more digestible in spring than the late manipulations.

Fig. 8: Average metabolisable energy for 2017

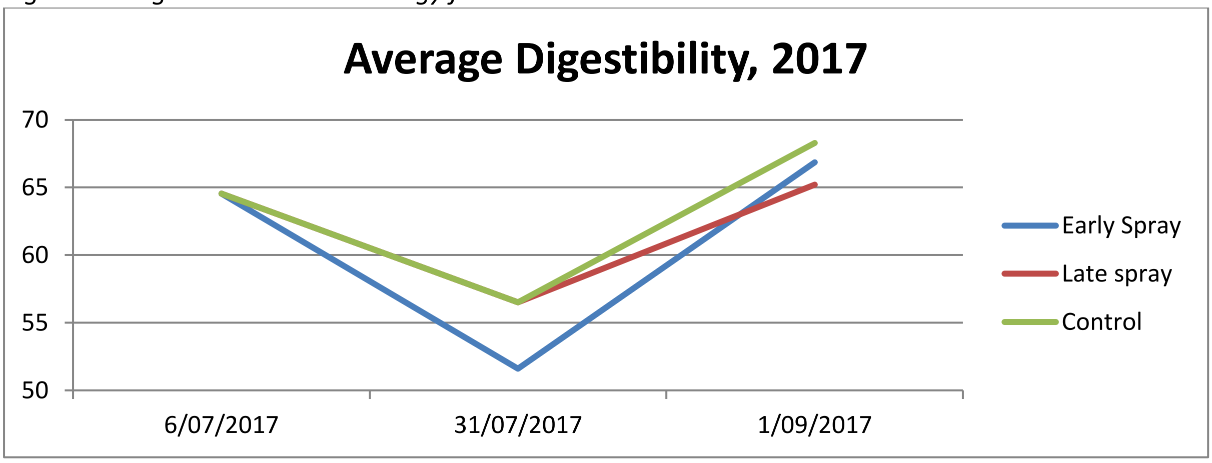


Fig. 9: Average metabolisable energy for 2018

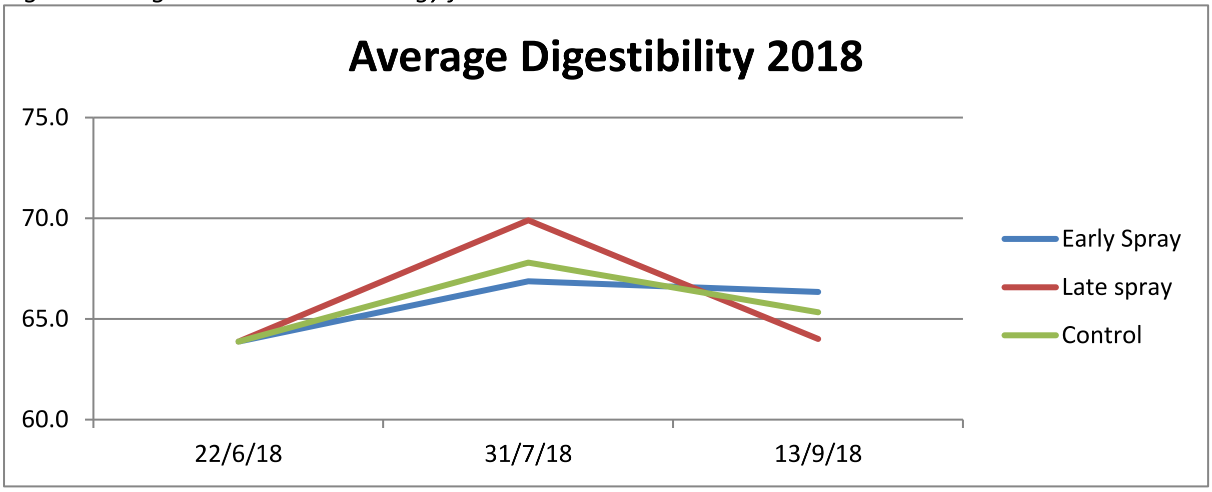
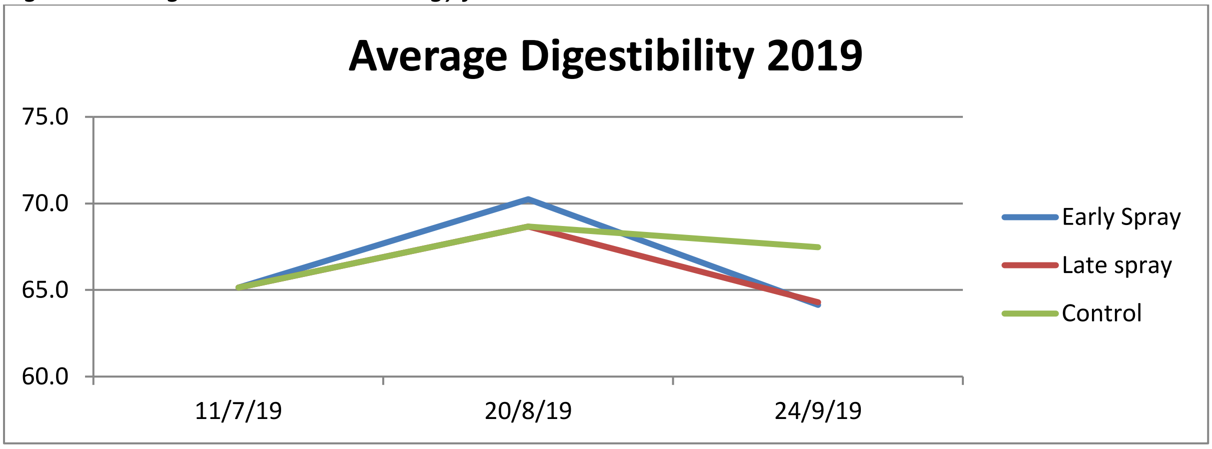


Fig. 10: Average metabolisable energy for 2019



4.2 Difference in species composition

Differences in pasture species composition was the clearest result gained across the three years of the project, with manipulation leading to higher clover content and fewer grasses in spring compared to the control strip. Full results from each site can be seen in Appendix 5.

As seen in Table 1, average species composition varied in response to treatment timing. Late manipulation resulted in initial decreases in clover content, and then significant increases after manipulation occurred. This was linked to a huge decrease in barley, rye and silver grass after manipulation.

Early manipulation led to increased clover content and decreased grasses, with higher clover content in the early manipulation compared to the late strip.

Unmanipulated pastures, the control, had higher levels of weed and grasses compared to any pasture that had been manipulated, at either mid-winter or spring.

Table 1: Average species composition for project duration

Time of pasture cut	Manipulation timing	Species composition (%)				
		Barley grass	Silver & rye grass	Clover	Cape weed	Other
Start of Season	All treatments	43	8	36	11	4
Mid-winter	Early	21	13	52	14	9
	Late	33	14	30	21	10
	Control	39	13	23	21	9
Spring	Early	12	16	57	13	13
	Late	13	18	48	23	9
	Control	34	21	29	16	14

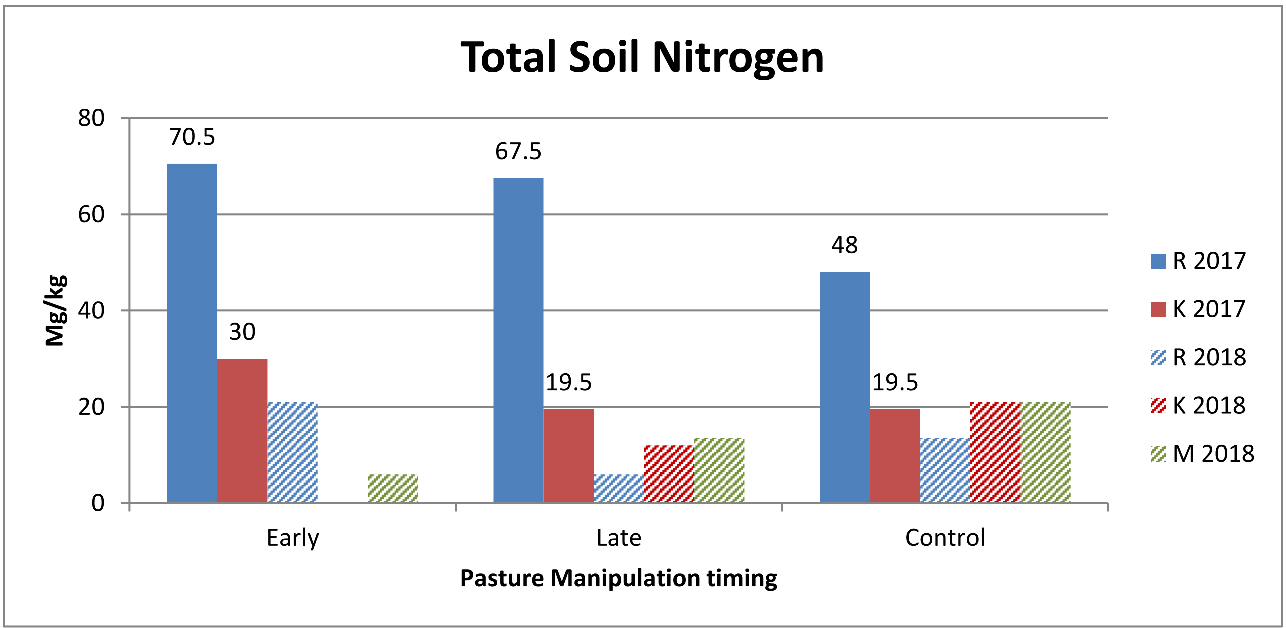
4.3 Soil test results

4.3.1 Soil nitrogen

Soil nitrogen results ranged, with levels varying between each site as seen in Fig. 11. There is conflicting data, so no conclusive results gained. For example, in 2017, early manipulated strips had the highest nitrogen, while in 2018 it was highest in the control treatments.

Overall, nitrogen was significantly lower in 2018 compared to 2017 results. Full results can be viewed in Appendix 7 and 8, with a breakdown of ammonia and nitrate levels.

Fig. 11: Total soil nitrogen patterns throughout the project



4.3.2 Soil Disease

Predicta B testing for soil disease risk was conducted after the 2017 and 2018 seasons, with few clear trends across the 3 properties or treatments. As seen in Fig. 12 and Fig. 13 below, both years show no consistent relationships between treatment and disease risk. 2018 did see an increased risk of P. Neg, Take-all and Charcoal rot at all sites compared to 2017.

Fig. 12: Cereal disease risk, 2017

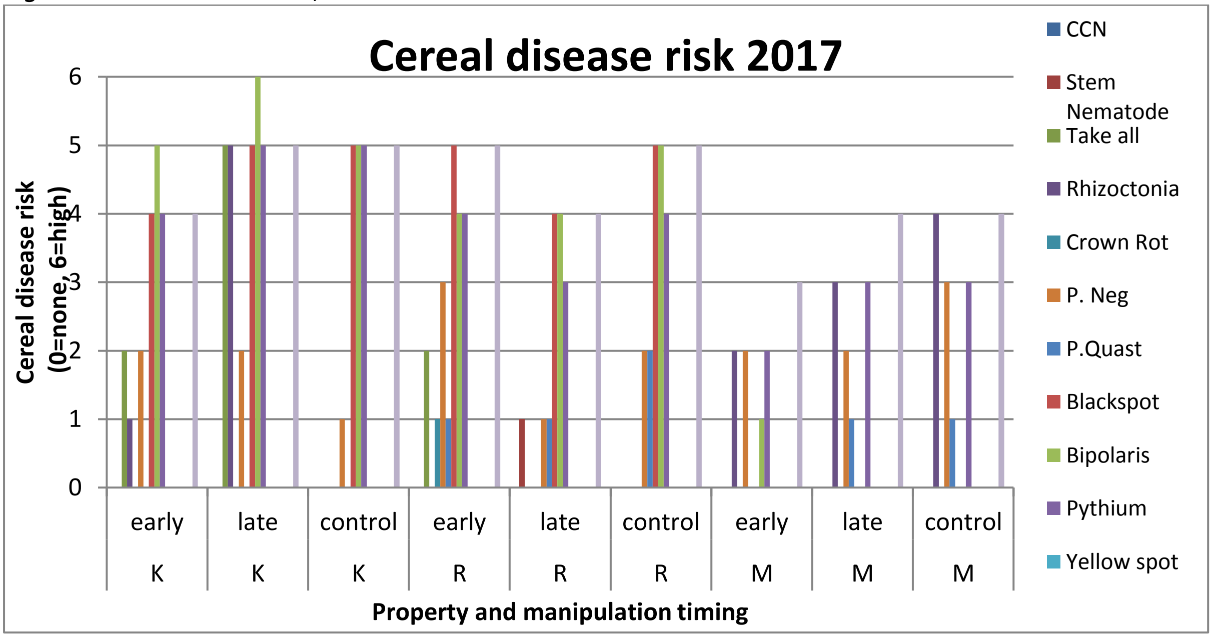
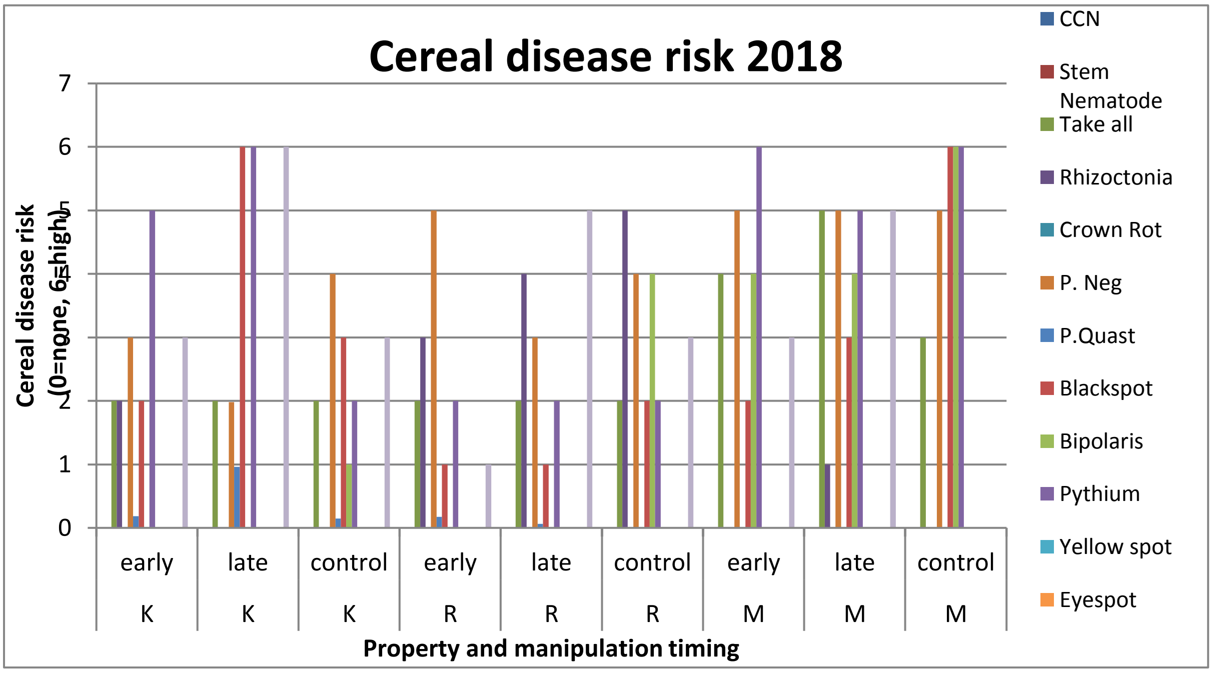


Fig. 13: Cereal disease risk, 2018



4.4 Germination data

Species germination was assessed at the break of the season, by calculating percentage ground cover and percentage of clover in each strip. Table 2 shows there were visually noticeable differences in the treatment strips, with early manipulation having a higher percentage of clover and the control strip the highest ground cover and the lowest clover content. The late and early treatment had mixed results when it came to species composition and ground cover but had less ground cover and weeds than the unmanipulated control strip. Full results for each site can be seen in Appendix 9.

Table 2: Germination data: species composition and ground cover

Treatment	Clover (%)	Weeds (%)	Ground cover (%)
Early	65	35	28
Late	38	63	25
Control	25	75	78

4.5 Economic analysis

4.5.1 Overall profitability: MIDAS modelling

Overall profitability focused on the most significant impacts- value of early season feed and extending the growing season at the end of spring. Soil nitrogen and disease risk was not included in the profitability analysis, as the trends were not clear enough across all three demonstration sites. Table 3 and 4 use the financial impact of removed feed at different times during the growing season to calculate overall profitability. This was calculated as the value of extended season minus the feed removal cost, compared to not manipulating pastures. The full breakdown of results and calculations can be seen in the economic modelling report in Appendix 1.

The modelling showed that early manipulation severely impacts profitability at the beginning of the season, further reducing feed when it is most limited. Impacting stocking rate and increasing supplementary feeding requirements, the removal of early season feed cost between $0 and $207/ha.

Removing feed during late manipulation was calculated to have a much lower financial impact, at -$195 to -$0.6/ha (Table 4). This was expected to be lower due to feed being in less demand at this time. The average financial impact of removing feed can be seen in Table 3 below, with a full explanation of results and calculations available in Appendix 1.

Table 3 further shows the value of extending the season, which was worth between $68 and $28/ha. On average, it was worth $42/ha each season in meat & wool growth and reduced feed costs.

On average, late manipulation outperformed early manipulation, leading to profit losses of $17/ha compared to $66/ha, due to the differences in feed removal costs. However, despite the overall average being a financial loss from any manipulation timing, the modelling showed that manipulation can lead to overall profitability increases due to the high value placed on extended season feed. Table 4 shows this was seen three times with late manipulation and once with early. It is believed that the 2019 results are skewing the average.

Table 3: Overall average of financial performance

Treatment	Feed removal cost ($/ha)	Extended season value ($/ha)	Overall profitability ($/ha)
Early	-$108	$42	-$66
Late	-$59	$42	-$17

Table 4: Average of each year's financial performance

Year	Treatment	Feed removal cost ($/ha)	Extended season value ($/ha)	Overall profitability ($/ha)
2017	Early manipulation	-5	28	23
	Late manipulation	-23.7	28	3.75
2018	Early manipulation	-$142	$68	-$74
	Late manipulation	-$68	$68	$0
2019	Early manipulation	-$177	$30	-$147
	Late manipulation	-$85	$30	-$55

The modelling was extended to farm scale as discussed in the methodology. Extending the growing season for three weeks was valued at $65,000 per farm. Part of this result is due to supplementary feeding requirements reducing by 25% (0.6kg/DSE) without altering stocking rate.

4.5.2 GrazFeed modelling: overview

GrazFeed modelling was undertaken looking at the impact of pasture manipulation on wool and meat growth, milk production (in lambing ewes) and pasture intake. These results were built into the economic modelling discussed above in Tables 3 and 4. While using the GrazFeed model to evaluate the impact on sheep condition, we found better results could be obtained by determining wool and meat growth for different sheep classes impacted by the changes in feed- wethers, pregnant/lactating ewes and their lambs, born in July, rather than condition score.

The modelling showed that most of the growth occurred in the period around the second pasture cut (Late August-September) and continued significantly into October. This is where the value of extending the growing season was clear, with significantly lower sheep growth rates as a result of the control pasture, with no extended feed. Over all sheep classes the clearest trend was that manipulation led to higher pasture intake and therefore increased meat and wool production.

4.5.3 GrazFeed modelling: pasture intake

Across all stock classes it is clear that manipulated pastures had higher feed intake in winter and spring. Early manipulation led to the highest pasture intake in winter and spring, while severely impacting intake in Period 1 (Figures 14 & 15). Pasture intake varied from 0.3kg/wk in lambs to

15.2kg/wk in ewes. This intake peaked in Period 2 for ewes and wethers, reaching their highest intake for all pasture treatments. Across the project, ewes had a much higher intake than wethers at any time, which shows the impact of pregnancy and lactation on feed intake. This is clearest when looking at the intake during Period 1, where ewe intake on early manipulated pastures nearly double's wether intake.

Lamb data in Fig. 16 indicates increased feed intake as the season progresses, and the animal ages. This will be explored in the discussion, as the change from 0.3kg/wk to 6.6kg/wk is significant.

Fig. 14: Pasture intake for wethers, average over 2017-2019

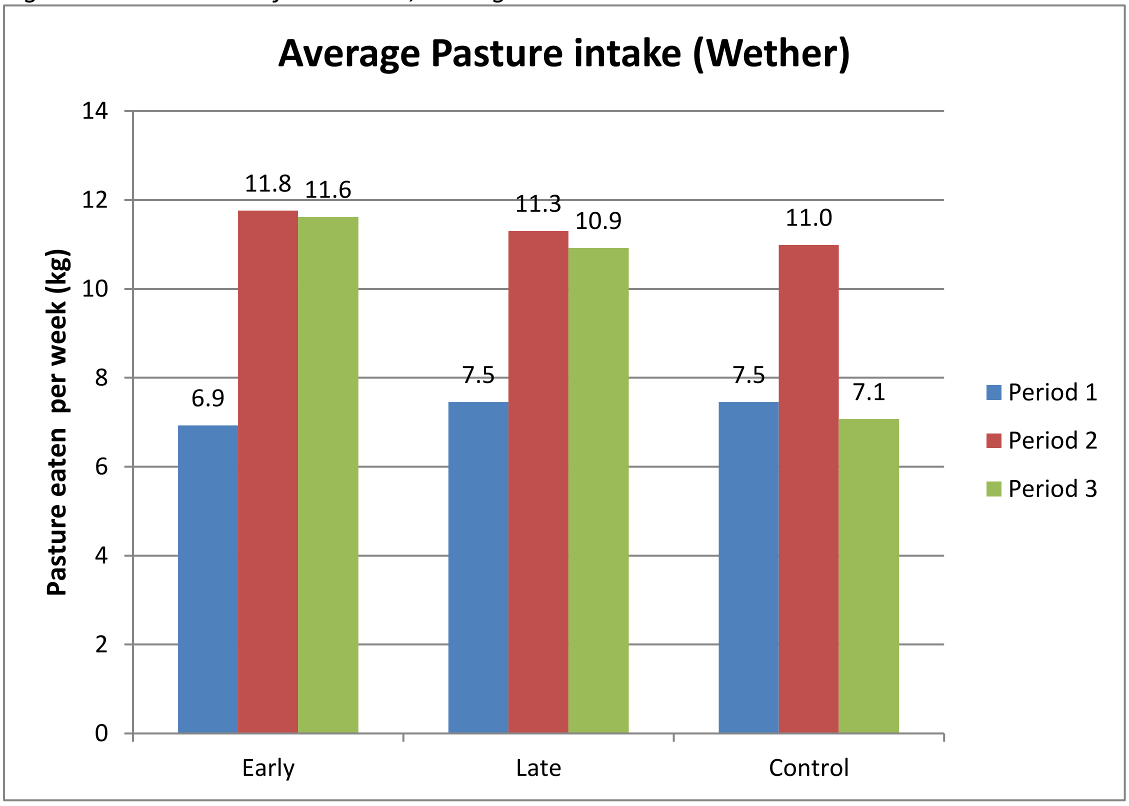


Fig. 15: Pasture intake for ewes, average over 2017-2019

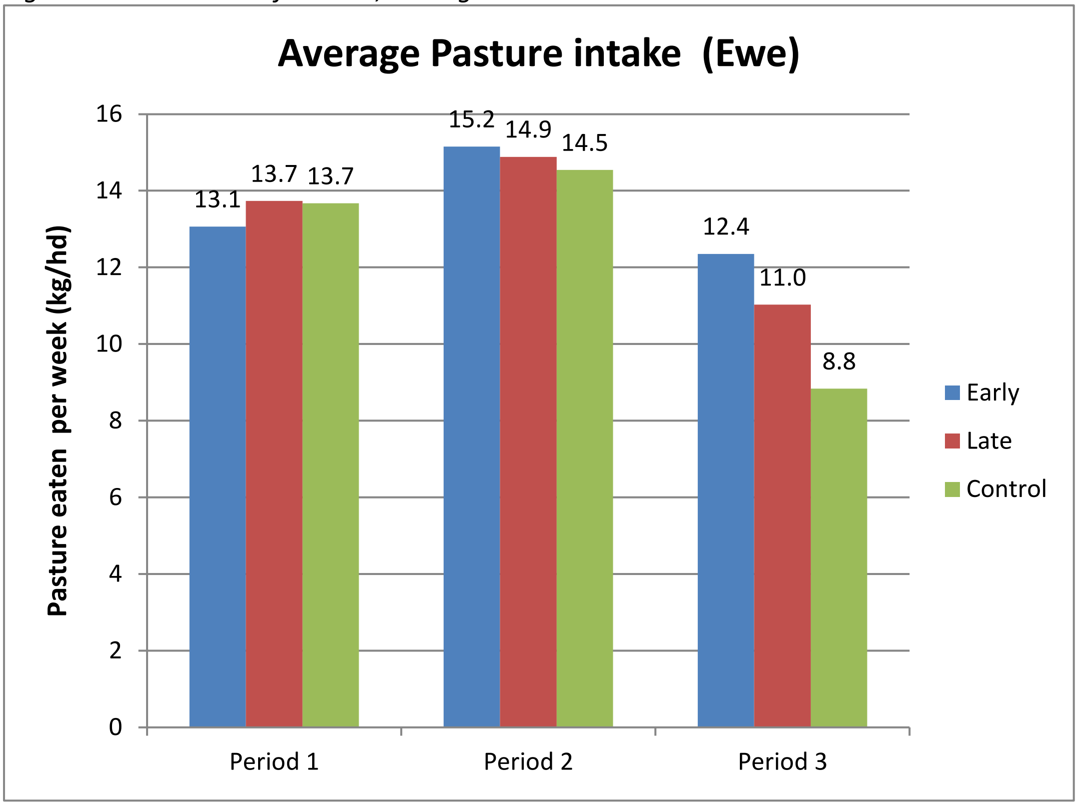
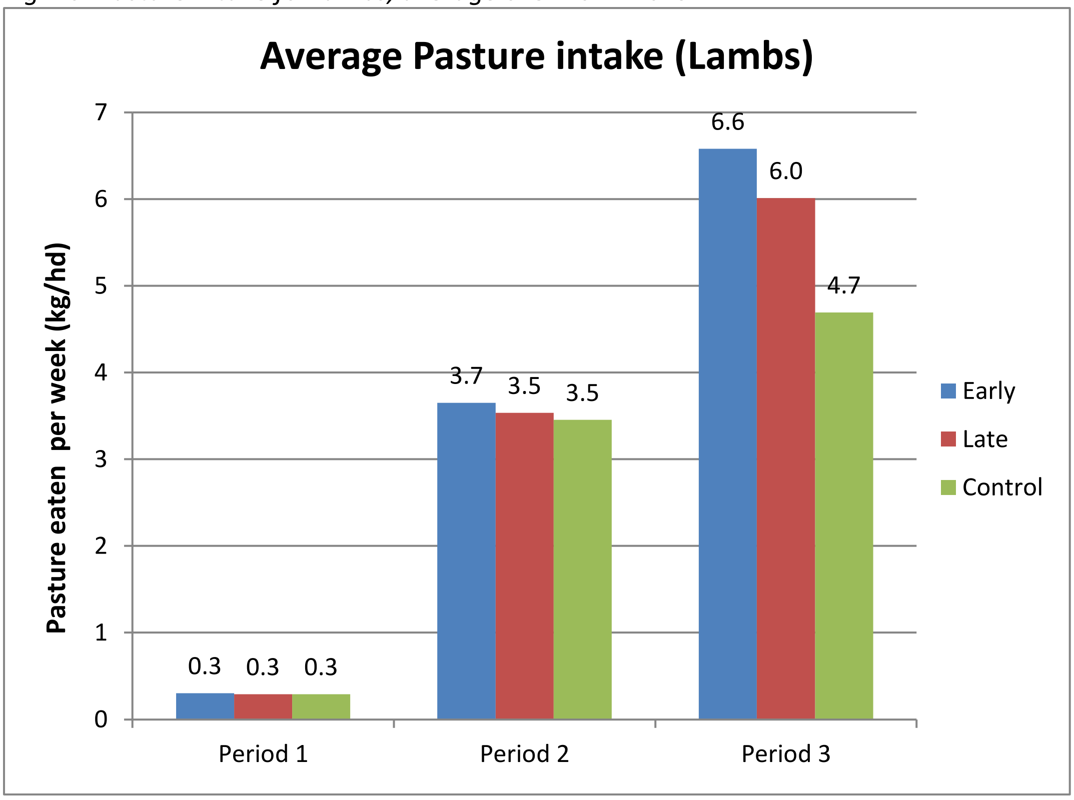


Fig. 16: Pasture intake for lambs, average over 2017-2019



4.5.4 GrazFeed modelling: meat growth

Animal growth was measured in terms of meat and wool growth. This was because we saw that different stock classes partitioned energy into the two differently due to varying nutritional demands such as pregnancy and lactation.

Meat growth followed pasture intake patterns closely, as shown in Figures 17 to 18. Highest growth rates were seen in Period 2, no matter the treatments, and early manipulated pastures had the highest average meat growth in Period 2 and 3, and the lowest in Period 1. This indicates a very strong link between intake and meat growth. This is clearest in Fig. 17, showing the impact on wethers. Fig. 18, impact on ewes, shows negative meat growth in Period 1 from all treatments, as well as the control treatment in Period 3.

Fig. 17: Meat growth for wethers, average over 2017-2019

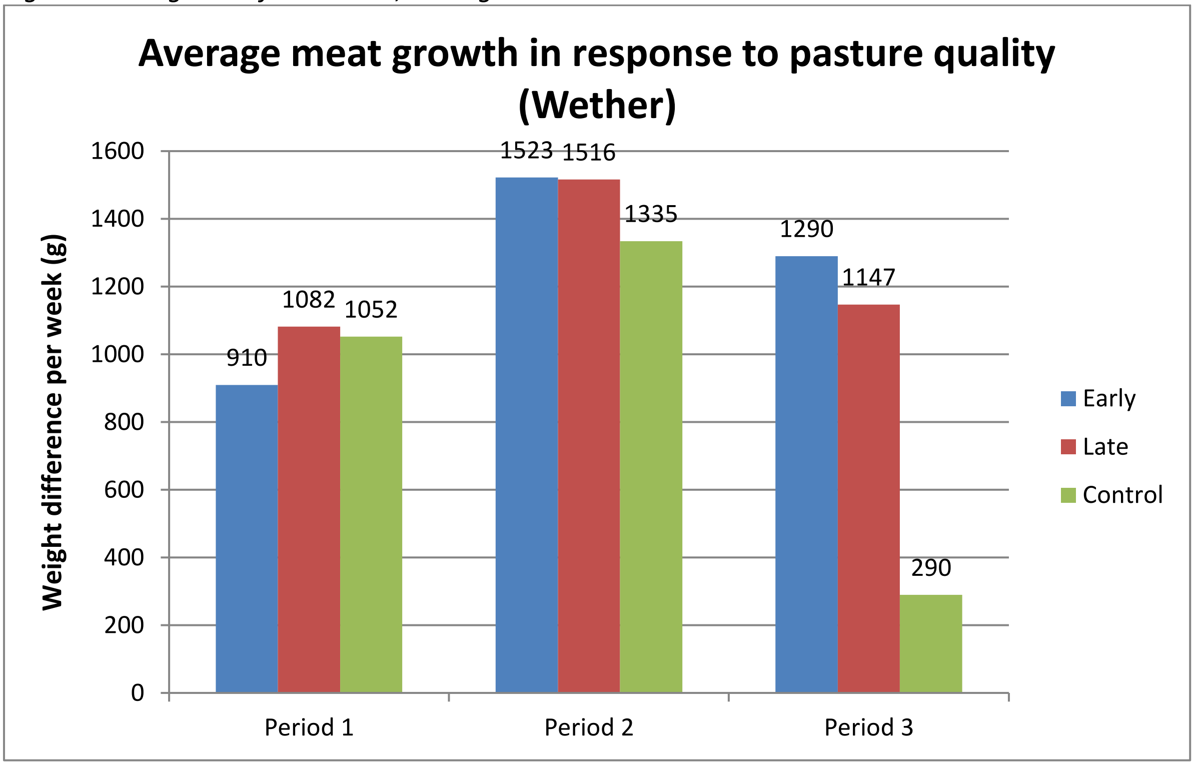
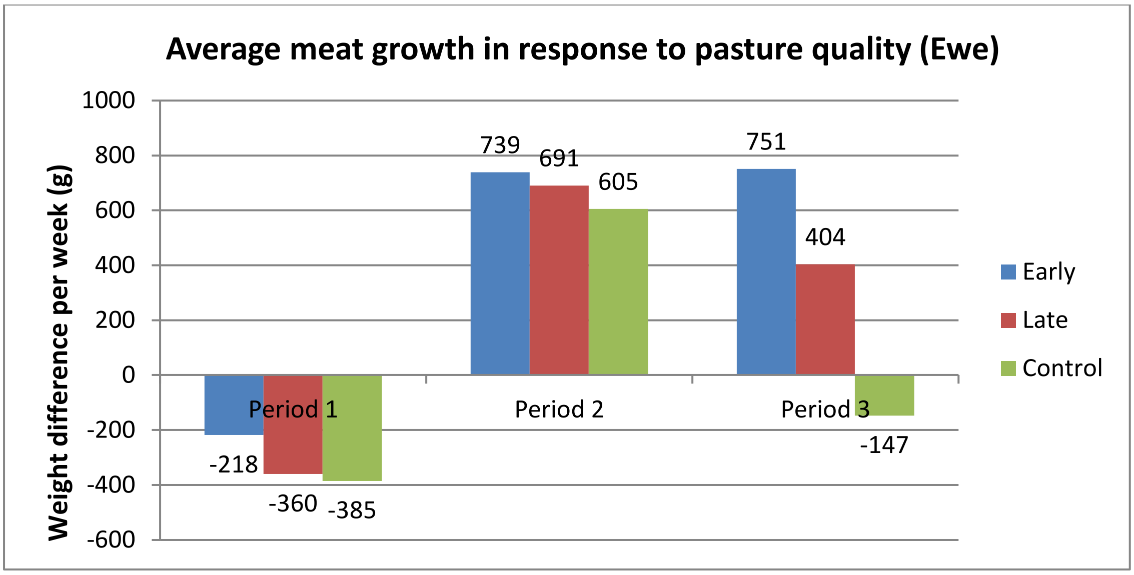


Fig. 18: Meat growth for ewes, average over 2017-2019



4.5.5 GrazFeed modelling: wool growth

Average wool growth varied from 66g/wk to 564g/wk and was very responsive to both treatment and period. This indicates that wool growth is very closely linked to pasture intake. The trend of peak production seen in Period 2 continues with wool growth in both ewes and wethers. Despite this, the data in Figures 19 & 20 show a much larger decline in performance over Period 3 compared to the decrease in meat growth and pasture intake.

Once again, early manipulation led to the highest growth rates in Periods 2 and 3, while the late and control treatments led to the highest growth in Period 1, (as had not had any feed removed yet). It is interesting to note the performance of wethers in Period 2 compared to the ewes, which clearly shows the partitioning of energy required in reproduction. Very interesting to note is that compared to ewe's negative meat growth in Period 1, wool growth is positive in Fig. 20.

Fig. 19: Wool growth in wethers, average over 2017-2019

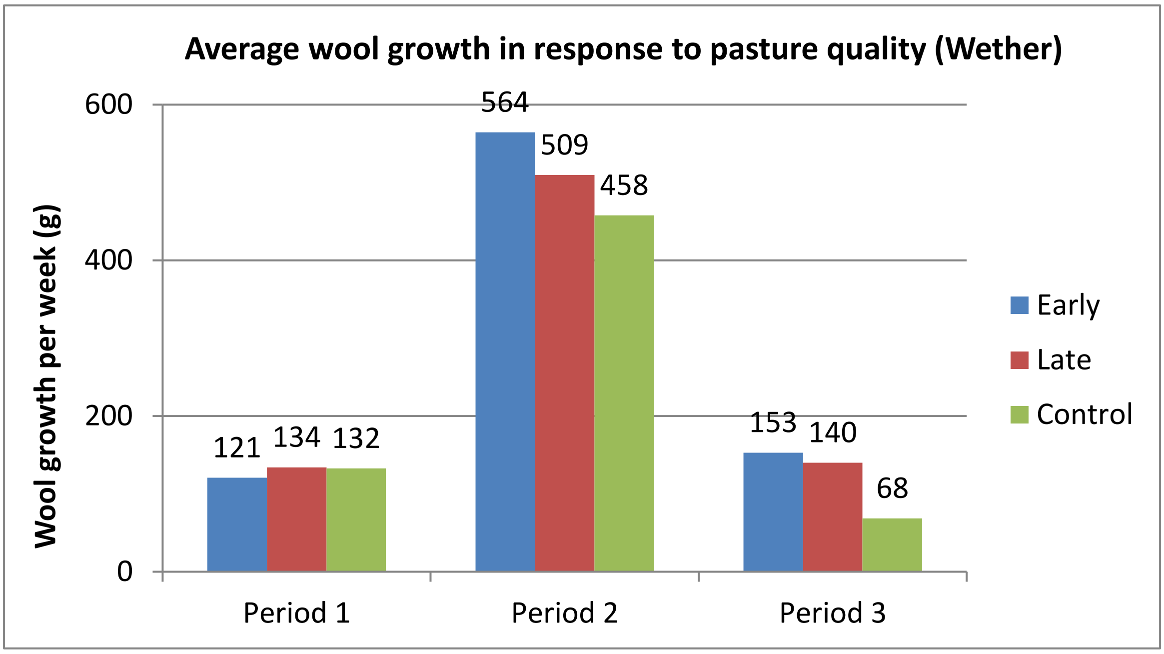
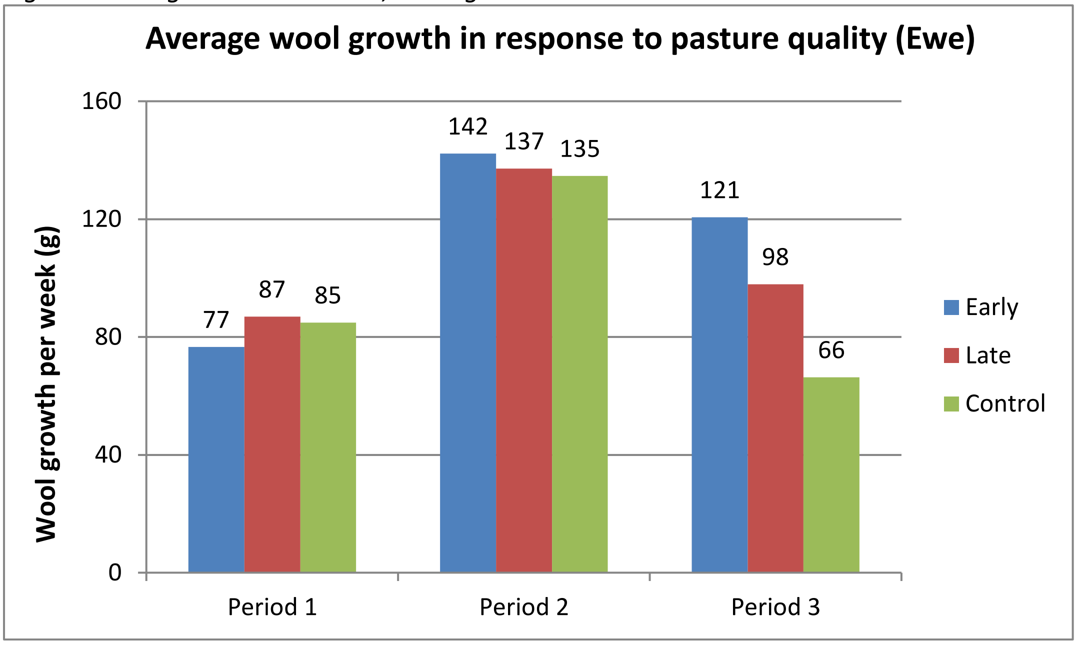


Fig. 20: Wool growth in wethers, average over 2017-2019



4.6 Outputs: extension and communications activities

Two field walks were held each year, with an average of 16 producers in attendance at each event. This ranged from 10 to 25 attendees. Discussions at the field walks were as follows, focusing on the complexity of pasture manipulation and the many factors to consider:

- Species feed quality and seasonal growth patterns
- Importance of manipulation regarding seed set, and following cropping cycle
- Preference for late manipulation in most years due to shortages of early season feed, and the impact on sheep productivity and management.
- Chemical options for pasture manipulation and pest management, e.g. importance of Time Rite
- Impact of timing on composition and feed quality, and therefore profitability
- Impact of grazing timing on seed set, and the value of additional spring feed from delayed spray topping
- Potential impacts of the spray-out band, mimicking cropping.
- Impact of manipulation and species composition on soil disease & nitrogen levels.
- Value of early season feed and the cost of early manipulation in terms of tonnes of FOO sacrificed and comparing to the likelihood of being able to extend the growing season.
- Appropriate stocking rates and increasing carrying capacity through pasture improvement.

As well as the previous year's figures and composition, challenges the project had faced so far, and looking at the future of the PDS sites.

Annual reports were produced for the MMPIG newsletter and were also distributed to the AgPro network and interested grower groups. Each report can be seen in Appendix 10. In addition, summary sheets, with facts about pasture manipulation, were shared with attendees at the field walks (Appendix 11).

The project and its findings were also presented at the MLA Pasture & Livestock Updates in 2018, The Sheep's Back Autumn and Spring Optimisers in 2017 and 2018.

4.7 Adoption and practice change

4.7.1 Changes in knowledge, skills and confidence

The project led to an increase in producers' knowledge, skills and confidence in pasture manipulation, and selecting its timing. This was measured by the responses to the pre and post project survey questions, as outlined in Appendix 12, as well as anecdotal data reported in the discussion. All 30 producers surveyed for the closing data agreed that they found the project to be valuable and recommended the PDS program, ranking both satisfaction and project value as 7 out of 10. Their responses can be seen in Appendix 13. Confidence in manipulating pastures was also ranked as 7 out of 10, having increased from 5.6 out of 10. This is likely linked to the increase in knowledge and skill, with 100% of producers responding to questions asked in the final survey, compared to the original survey where 40% of producers selected the response 'not sure'.

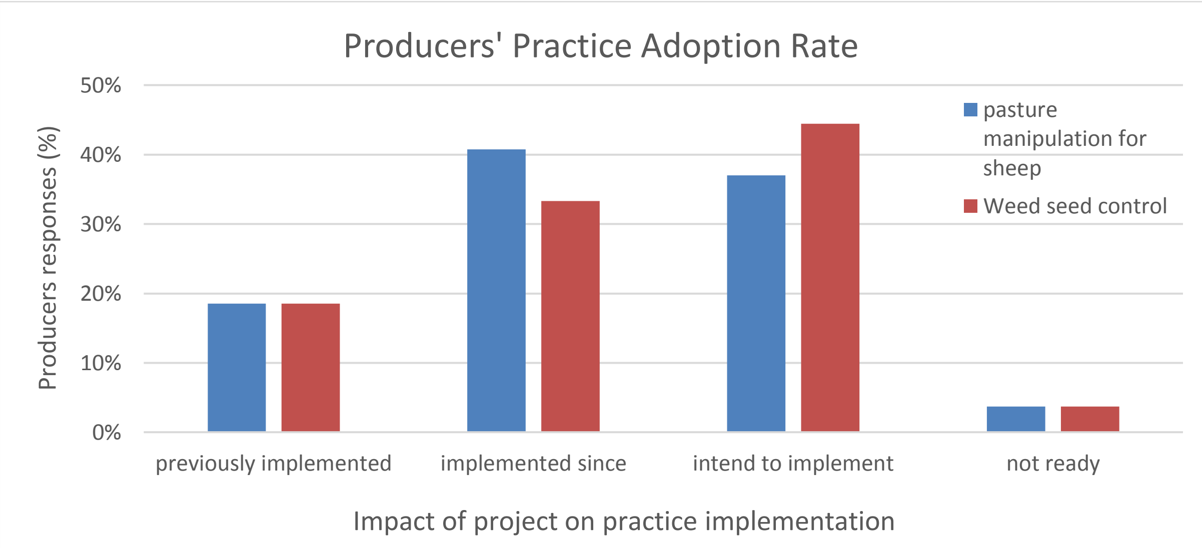
90% of producers initially surveyed believed pasture manipulation is a valuable tool for the sheep enterprise. Overall, 41% of producers said the project had increased their likelihood of adopting pasture manipulation for their sheep enterprise, 26% said it decreased the likelihood, and 33% were unsure. It was discussed that this is likely due to the very short feed in autumn-winter, as the late breaks meant pastures could not get away before the temperatures dropped and pasture growth rates slowed, which increased the value of removed feed. It was suggested that the project needed to run in more 'typical' years, to better reflect average performance of the area.

4.7.2 Adoption Rate

Adoption rate was measured similarly to changes in knowledge, skills and confidence, in the survey responses. As seen in Fig. 21 below, most producers intend to adopt some form of pasture management- whether this be weed seed control or manipulating the pasture for sheep feed. 33% of producers adopted grass seed management as a result of this project, and 44% intend to. Of the 30 producers surveyed, 4% do not intend to adopt, and 19% had 'previously implemented', meaning they already regularly used the practice.

We also measured adoption rate of chemical pasture management, when manipulating was being conducted for sheep. This did not discriminate between manipulation timings or chemical used. 19% of producers already regularly used pasture manipulation for sheep and 41% have adopted manipulation for sheep since the project began. A further 37% of producers intent to adopt.

Fig. 21: Adoption rate of practices post project



5 Discussion

5.1 Data reliability and validity

The project ran during a string of late season breaks. This meant that early and late manipulation occurred much later in the year than usual, as pasture germination was delayed. There have also been uncharacteristically long springs in 2017 and 2018, and a very short spring in 2019 which may have impacted results. This variability in seasons, seen in the different timing of pasture cuts each year, severely impacted manipulation and feed test timing. Variability in rainfall patterns may have also impacted the soil test data, of both nitrogen and soil disease risk. The lack of congruency in these results led to exclusion of expected benefits from the economic analysis, which could mean that our calculation of pasture manipulation is skewed. Pasture germination and the impact on seedbanks were also excluded, as were deemed too difficult to accurately measure or model. Ideally the project would be repeated in order to get more reliable data over consistent seasons.

5.2 Feed impacts

Pasture manipulation had very clear results on feed quality and quantity throughout the season, as expected. Manipulation led to initial decreases in feed availability, but improved quality. Species composition clearly shows this result, with manipulation leading to a higher proportion of clover and less grass compared to unmanipulated treatment at every site. Overall early manipulation led to clover making up over half of the pasture species, while late manipulation was not as successful at removing barley, silver and rye grass, perhaps due to plant growth stage.

Manipulation clearly impacted Feed on Offer- immediately after manipulation, FOO fell as pasture was removed, before increasing as the season progressed. The most important result gained regarding feed quantity was that early manipulated pastures could regain substantial biomass after being manipulated, meaning that spring feed was of high quality and abundant. The second important result is that early manipulation had higher spring FOO compared to late, indicating that late manipulation has more impact on spring FOO levels than early manipulation did. When looking at manipulation vs no manipulation, there were conflicting results, showing unmanipulated pastures to have the highest, and lowest, FOO in spring in different years. Unmanipulated pastures would be expected to have the highest feed available due to not having any plants removed, while having the lowest feed quality. This is one aspect of the project producers are disappointed about, as there was not a clear result. However, the impacts of neither manipulation in spring effected profitability- profitability was driven by feed removal timing.

The impact of manipulation on FOO influenced producers as they are aware of how much feed is removed through manipulation, and what this means for feed availability at different points in the season. The biggest impact of manipulation on feed availability is the extended spring feed, with up to 2 more weeks of green feed compared to the unmanipulated pastures, which needed spray topping for seed control.

Also an important impact is how removing feed early in the season eliminates a large percentage of feed, particularly as there is insufficient pasture to meet animals' requirements. Pasture removal at this time is costly and can mean more supplementary feeding. The project has shown early manipulation is most effective at removing grass species and does not mean lower spring feed. In comparison, late manipulation removed a higher quantity of feed at a time that was less critical and did not control grasses as successfully. However, if grass control is producers' main aim, spray topping in early spring could achieve the same result for the following year, by not allowing seed set.

This is why manipulation is a complex practice, as there are multiple ways to achieve goals, and multiple goals.

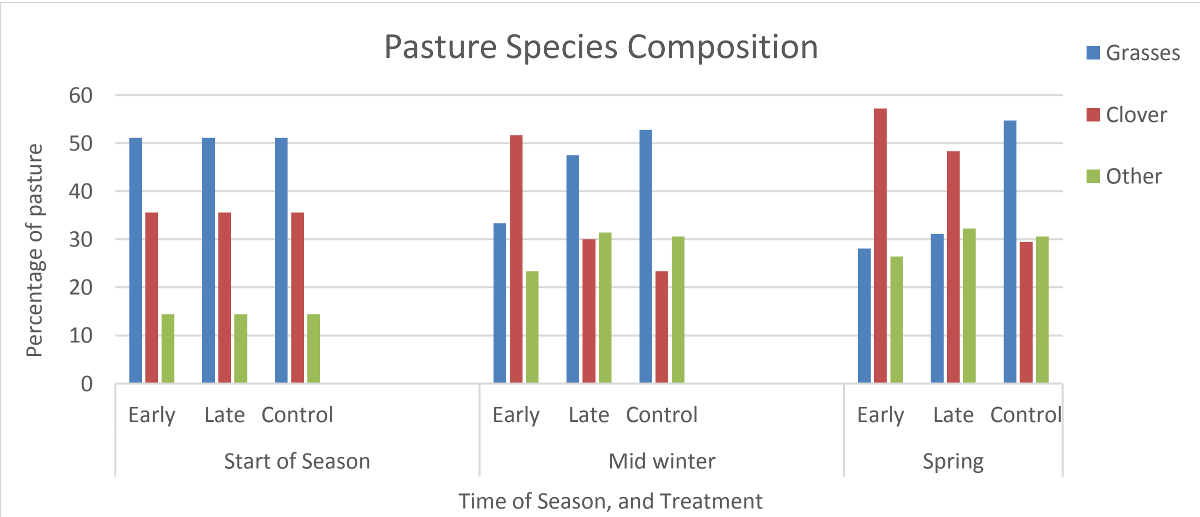
When it came to feed quality, the results are not as clear compared to feed quantity. Species composition shows relatively consistent trends, but these differences were not reflected in the feed test results. Metabolisable energy did not vary clearly due to treatments as expected. For example, pasture quality usually declines over winter as plant growth slows, but even this basic pattern had conflicting results within the project. It has been determined that this may be due to different germination timings between properties. Overall, the results did not clearly show the impact of manipulation timing on the energy content of pastures, only that treatment did not have a significant impact.

Crude protein shows the expected pattern in most years, declining as the season progresses. We are not sure why 2019 showed a spring increase in protein at all sites. Species composition links into crude protein results, with those with the higher clover composition having higher protein levels. On average, early manipulated pastures had the highest spring protein, while late manipulation had the highest winter protein. The unmanipulated treatments had the lowest protein compared to any manipulated pasture. This is important to remember for young sheep, who need high protein diets. Most pastures, no matter their treatment, had protein levels much higher than required for young sheep with high protein demands. There were some sites that dropped below 14% crude protein in late spring, which could limit lamb and weaner growth.

It was expected that prostrate clover pastures would be more digestible than upright grasses, due to the lignin content required from upright growth. This was supported to a point- overall, the early manipulated treatments were more digestible in spring than the late manipulations. But, the unmanipulated treatment had the highest digestibility in 2017 and 2018. This could be due to the grasses having less water content than the clover, or due to various plant growth patterns.

Despite the feed test data not supporting feed quality increases due to improved species composition, the differences in pasture species across each treatment remains one of the clearest and most important findings of this project, as seen in Fig. 22. Improved species composition due to manipulation shows producers the impact of manipulation at various times, which extends into the ability to delay or even eliminate spray topping, increasing grazing time in spring. It also clearly showed reduced grasses and therefore grass seed issues with lambs skin and eyes, which is another profitability impact we were unable to capture or model.

Fig. 22: Species composition as a result of manipulation timing



5.3 Soil impacts

The impacts on soil borne disease were not conclusive, with contradicting results across and between the sites. This may have been due to sampling error, but further investigation is required, as decreased grass content should theoretically lead to decreased disease carry over. Overall, the project showed that manipulation does not strongly impact soil disease risk.

Nitrogen results were also expected to reflect difference in species composition, due to increased clover content meaning increased nitrogen fixation. The results showed few trends - the only pattern was the consistently higher 2017 nitrogen levels. 2017 also showed early manipulated treatments to have the highest total nitrogen, followed by late and control at both sites. 2018 results contradict this, with the sites each demonstrating different patterns.

The difference between sites and years is most likely due to differences in soil type, geographic location and initial soil nitrogen. Ideally, soil testing would have been conducted before and after treatments, despite difficulties regarding mineralisation.

Both impacts on soil characteristics are valuable components in the economic analysis, which unfortunately we have been unable to include due the inconclusive soil results.

5.4 Germination impacts

Species germination looked at the impact manipulation timing had on germination two years later, mimicking the paddock going into a cropping rotation. This was done to see the impact on the seedbank, to see if manipulation was successful at influencing grass levels in later years. There were very noticeable differences between the strips, even when driving 300metres away. Early manipulation had significantly higher clover content and less grasses compared to the late and control treatments, however the control treatment had much higher ground cover compared to the manipulated strips. Manipulated strips also had significantly less weeds and grasses. This shows that manipulation, rather than spray topping, was most successful at increasing clover content and decreasing weed seed content in subsequent years. This is due to eliminating spray-topping, which allows clover to set seed. This is an important impact in WA's mixed enterprise systems, meaning that paddocks coming out of crop don't necessarily need to be reseeded. This is a massive cost saving in seed, clover, machinery costs and labour, and supports a self-sustaining rotation. Increased clover content, and clover seed set, means more clover burr over summer. This a valued sheep feed source, providing feed even when paddocks appear bare.

5.5 Impact on sheep productivity

The GrazFeed data showed that manipulation has huge impacts on sheep productivity. Sheep productivity showed very clear responses to manipulation, with strong trends. It indicates that productivity is driven by pasture availability, especially early in the season. However, Period 2's results, in mid-winter, showed early manipulated pastures led to the highest feed intake, and therefore meat and wool production, despite having the lowest FOO. This indicates that feed quality, in the form of species composition, influences feed intake and sheep productivity. Early manipulated treatments at this point had lower FOO but a higher clover component, with varying feed quality test results.

This is a valuable result, as producers can clearly see the impacts of manipulation at certain points of the season on their animals. This tool could be very helpful in determining optimal stocking rates, targeting better growth rates, or managing ewes. The lamb data is also of immense value, showing that feed quality massively impacts pasture intake at the early stages of lambs grazing. Fig. 16 showed that unlike the wethers and ewes, lamb pasture intake increased as the season progressed, due to their rumen developing and their main feed source becoming pasture. This is a little alarming when considering that by the time their diet consists of solely pasture, these pastures have stopped growing. This is a reminder to producers to actively manage lambs in spring and give them the best quality pasture available to ensure high growth rates, therefore survival.

Looking at the differences between ewe and wethers performance is very interesting, as it shows producers the impact of reproduction. Ewes, with higher energy demands due to lactation, did not respond in wool growth as significantly as wethers, but did have higher pasture intake throughout the project. Ewe's weight gain was much lower, particularly in Period 1 where it is assumed their energy demands were not being met, leading to negative impacts on weight gain. Interestingly, weight gain was negative, but wool growth remained positive.

Overall, the productivity modelling showed that pasture manipulation has huge impacts on sheep productivity and health compared to not manipulating. Across the three years, early manipulation led to the highest overall meat and wool growth for the season in ewes and lambs, due to increased clover levels in the pastures.

5.6 Profitability impacts

The MIDAS modelling data showed that the biggest impacts on profitability was the cost of removed feed and the benefit of being able to extend the season due to being able to delay or eliminate spray-topping.

Early manipulation severely impacted profitability at the beginning of the season, further reducing feed when it is most limited. This is what producers fear- that this removal outweighs any gained benefits. Impacting stocking rate and increasing supplementary feeding requirements, the removal of early season feed was between $0 and -$207/ha. This is a big cost for producers, and impacts sheep management, with aspects such as rotation and supplementary feed requirements. It can also lead to logistical challenges, like increasing the need to hand feed or spell pastures.

Removing feed by late manipulation had a lower financial impact, as feed was not in short supply at this time of the season. This was calculated to be losses of between -$195 and -$0.6/ha. Producers noted that while this had less of a financial impact, manipulation at this time was not as effective at removing problematic silver grass. Being able to remove certain grasses is extremely valuable if manipulating for paddocks going into crop, or if trying to get on top of grass problems. This highlights the challenge of balancing the need to control weeds with sheep feed availability, the common issue with pasture manipulation timing. The pasture composition results showed that early manipulation leads to better weed control, and higher clover content. Beyond these results, producers said that visually, early manipulation led to significantly less silver grass in the pastures in following years, particularly when looking at the sprayed-out strip from Year 2.

Despite feed removing having a high cost, manipulation allows spring feed to be extended. Manipulation removes grasses such as barley, silver and rye grass, which impact lamb's wool and eyes in late spring, and often require the pastures to be sprayed out in spring to stop seed set. This end of season feed is extremely valuable as wool and meat growth, to both lambs and ewes facing the dry summer. This ability to further extend the season was calculated to be a benefit of between $28 and $68 per hectare, varying due to the additional amount of time spring feed was available. This addition was due to either spray topping being delayed, or eliminated- in this case, the extended season was recorded until pasture senesce. On average, extending the season was worth $42/ha in meat & wool growth (calculated using GrazFeed) and reduced feed costs.

When combining the value of extending the growing season with cost of pasture removed, mixed financial outcomes were achieved due to the difference in seasons and demonstration sites. On average, late manipulation outperformed early manipulation, leading to average losses of $17/ha compared to early manipulation's $66/ha. This was due to the higher cost of early manipulation's feed removal. Despite the project's average performance showing negative financial impacts on profitability, this was not the case each year. In 2017, all sites saw increases in overall profitability due to manipulation. 2018 also showed late manipulation to have no impact on profitability, with the sheep benefits negating the costs. This shows that there is potential to manipulate pastures without financial impacts, which should reassure producers. The key financial trend seen each year was that late manipulation was most likely to lead to positive overall profitability, or lower financial losses. This shows that late manipulation is likely to be producers' preferred manipulation timing.

5.7 Meeting project objectives

The project objectives and deliverables have been met, as outlined in the table below.

<table>
<tr><td colspan="2">By December 2019, three producers in WA will implement and demonstrate the clear advantages of pasture manipulation on the quantity and quality of FOO available for sheep and the impact on farm profitability, leading to 60% adoption of the technology by the producers attending the field days (60+), on top of 90% of the core members.</td></tr>
<tr><td>Over three seasons, on three different demonstration sites with different properties, 3 producers, with the help of the other 10 core members of the producer group, will demonstrate to the 70 members of the wider producer group and others, through field walks, newsletters and Facebook and Twitter posts, the advantages of pasture manipulation. They will:</td><td>Demonstrated across three sites over three years in the Moora-Miling region:</td></tr>
<tr><td>Demonstrate the impact that manipulation has on the quantity and quality of feed that is left behind, allaying fears that are currently preventing farmers from using the tool.</td><td>Demonstrated varying results on feed quality, but clear impacts on species composition. Shown that manipulating early does not have significant impacts on spring feed on offer. Shown that manipulation successfully leads to decreased grasses.</td></tr>
<tr><td>Use a discussion on these results to reinforce farmer understanding of the effects of quantity and quality of FOO on sheep productivity.</td><td>Results discussed at field walks, the WhatsApp group, presentations, and meetings of MMPIG members and the wider agricultural industry.</td></tr>
<tr><td>Model the effect of increased quantity and quality of feed on sheep condition score, using existing data and extend this to weaner survival, again using existing models.</td><td>Modelled impact of differences in feed quality and quantity on sheep productivity and growth, which is indicative of weaner survival.</td></tr>
<tr><td>Show the difference between early and late manipulation on feed quantity and quality at key points throughout the season, giving farmers confidence in the best timing for manipulation in difference years, on different sites</td><td>Demonstrated varying results on feed quality, but clear impacts on species composition. Shown that manipulating early does not have significant impacts on spring feed on offer. Shown that manipulation successfully leads to decreased grasses.</td></tr>
<tr><td>Visually show farmers the difference between manipulated areas and areas that have had to be spray topped early to demonstrate the extra length of season that manipulation can achieve.</td><td>Field walks held to coincide with this point, and photographs distributed in annual reports and through the WhatsApp group.</td></tr>
</table>

Expose other advantages of manipulation to grower group members. o Demonstrate the impact of manipulation on soil N levels as clover fixes N through soil samples from each strip o Validate the impact on cereal disease risk, using Predicta B soil testing. o Show the longer-term impact on seed banks, evidenced by germination.	Inconclusive soil nitrogen and soil disease results were shared with the group. Germination data recorded as species composition and percentage ground cover in year 3 with producers in attendance.
Model the economic impact of pasture manipulation using supplementary feed costs and time costs at the same quantity and quality as the increase available in the paddock following pasture manipulation. An estimate of the economic impact of the other advantages of manipulation (soil N levels, impact on cereal disease, pasture germination) will also be made.	Modelled the economic impact as $-66/ha from early manipulation and $-17 for late manipulation, due to the high cost of removing early season feed in late break years. Economic analysis did not include soil nitrogen, disease or germination as data was wither inconclusive or was not able to be incorporated into models.
Overall objective is to increase the use of pasture manipulation as a tool up to 60% adoption over the wider group (70 producers) and 90% amongst the core group members, over the three years of the demonstration.	33% of producers adopted grass seed management as a result of this project, and 44% intend to. Of the 30 producers surveyed, 4% do not intend to adopt. Adoption rate of chemical pasture management: 19% of producers already regularly used pasture manipulation for sheep and 41% have adopted manipulation for sheep since the project began. A further 37% of producers intend to adopt. 41% of producers surveyed more likely to use pasture manipulation, 26% less likely and 33% unsure.

6 Conclusions/recommendations

Future research should focus on soil impacts, in particular disease risk and calculating an economic benefit. Large, paddock scale plots would provide better representation, and would allow sheep to graze, giving actual sheep performance data for each treatment rather than modelled. This would improve the accuracy of the economic analysis. Ideally, additional research (not demonstration sites) would be conducted or included before further development and adoption activities.

The project has shown that manipulation may not be profitable, with large costs in removing feed especially early in the season. The cost of removing early season feed averaged $108/ha, while removing late in the season was a $59/ha cost. These impacts varied each year, and manipulation was shown to be beneficial beyond financial impacts.

Manipulation demonstrated high benefits to sheep productivity, in meat and wool, potential stocking rates and pasture intake. This linked very closely with pasture species composition and FOO changes due to manipulation. FOO was significantly impacted, decreasing pasture because it was directly removed by manipulation. It then increased as the season progressed. The most important result gained regarding feed quantity was that early manipulated pastures could regain substantial biomass after being manipulated, meaning that spring feed was of high quality and abundant. The second important result is that early manipulation had higher spring FOO compared to late, indicating that late manipulation has more impact on spring FOO levels.

Early manipulation led to the highest clover content throughout the project, and lowest level of weeds and grasses. Late manipulated pastures had improved clover content in spring, with grass content being reduced post-manipulation. This still did not match the quality of early manipulated pastures.

Improved pastures due to manipulation led to valuable additional grazing time at the end of spring, with the need to spray top to control grass seed set being delayed or eliminated. On average, there was 16 days additional grazing, providing a financial gain of $42/hd. When this was combined with the cost of removing pasture, to show that late manipulation led to an average impact of -$17/ha and early manipulation -$66/ha over the project's three years of late season breaks.

Producers were still interested and adopting manipulation or weed control despite the findings, seeing value beyond the economic analysis conducted. Knowledge and skill change, confidence and satisfaction with the project was high.

The project and its findings have better equipped producers with knowledge and skills regarding pasture manipulation. The data collected, and host producer experiences, can be used to help inform and guide producers' decisions, and decide on their pasture manipulation or weed management plan: are they doing it to benefit sheep productivity, reduce grass seed impacts, or for the cropping enterprise? Knowing their aim means that they can choose from the demonstrated practices (early, late or no manipulation having to spray top in spring) and know the economic impacts, as well as expected impact on species composition and sheep productivity.

7 Bibliography

https://pir.sa.gov.au/__data/assets/pdf_file/0008/291248/Sampling_protocol_Predicta_B_South_and_West_V2.pdf

8 Appendix

8.1 Economic analysis

8.1.1 Value of pasture

Values to help calculate impact of timing of Pasture manipulation and extending the growing season. By John Young, Farming Systems Analysis Service

Abstract

A component analysis was carried out using the MIDAS model to estimate the impact on profitability of the sheep enterprise associated with using pasture manipulation to delay spray topping. This analysis calculated the impact of removing 100kg of pasture at a range of timings in winter and early spring and the value of extending the growing season. The values of early pasture and of extending the growing season can be multiplied by the measured reductions in early pasture production and

the observed extension in the length of the growing season. This combined value gives a best bet estimate of the impact on sheep profitability for implementing the practice on a typical farm.

Background

On-farm trials have measured the impact of pasture manipulation treatments and spray topping treatments on pasture production early and late in the season and the length of the growing season. A component analysis was carried out with MIDAS to value each component so that the economic impact of the trial measurements could be estimated.

Method

The Central Wheatbelt version of MIDAS was used for this analysis. It represents a typical farm in the 350-400 mm rainfall zone near Cunderdin. Which is the nearest model for the Miling Area

MIDAS was selected as the appropriate modelling tool because it can value pasture quantity and quality at different times of the year. It models the whole flock and includes a powerful feed budgeting module that optimises animal and pasture management across the whole farm through the entire year and accounts for the changes in feed demand of stock through the year. The feed budget and pasture growth in the model is divided into 10 periods (Table 1), periods 1 to 5 are growing season and periods 6 to 10 are dry. For a simple analysis, pasture removal and extension of the growing season must occur at the beginning or end of these periods.

The model represented a self-replacing flock based on a merino ewe lambing in July with a lambing percentage of 90% and producing 5.5kg of 20.5µ wool. A proportion of the ewes are mated to a terminal sire to produce cross bred lambs that are turned off as suckers. The merino wether lambs are turned off as merino prime lambs.

Table 1: Feed periods used in the CWM feed budget.

Period	Start date	Description
1	10-May	Break of season
2	24-May	
3	14-Jun	
4	19-Jul	
5	13-Sep	End of growing season
6	11-Oct	Dry pasture
7	01-Nov	Harvest occurs mid period
8	06-Dec	
9	01-Mar	
10	26-Apr	

The prices used in the analysis are summarise in Table 2.

Table 2: Prices used in this analysis

Meat Prices	Units	Value
CFA Ewes	$/hd in saleyards	85
Lambs	$/kg DW	5.00
Wool Price (20.5µ)	c/kg greasy STB	7.50

To represent an extension of the growing season, period 6 was converted to a growing period and pasture growth was assumed to occur at the same rate as in period 5. Digestibility of feed was increase by 4% (0.7MJ of ME/kg) for the remainder of the season. Period 6 is a 3-week period, so the value generated is for a 3-week extension of the growing season.

Pasture removal was valued for at the beginning of periods 3, 4 and 5, 100 kg/ha was removed at each time. To estimate the value in the target region at the times when the pasture manipulation occurred, a weighted average of these values was calculated.

The value of the pasture early in the season is predominantly as it could be used to increase farm carrying capacity. The value of extending the growing season, which increases the quantity and quality of dry feed available is predominantly through reducing the costs of filling the feed gap that occurs after pasture senescence and before stubbles become available and is valued in the model as reduced supplementary grain required.

The area of pasture on the farm was fixed at 1565ha (49%) to reduce the complexity in interpreting the analysis. By fixing the pasture area the analysis concentrates on the shorter-term implications of the pasture strategies rather than including the longer-term implications of changing the sheep/crop balance.

There is an interaction between removing pasture and extending the growing season. Early manipulation and delayed spray topping leads to greater spring pasture growth which would be expected to increase the value of extending the growing season. However, because early manipulation reduces pasture early in the season this reduces carrying capacity and therefore there are fewer sheep available to utilise the extra high-quality spring feed. In some scenarios the extra feed is more valuable and in others the reduced early feed is more valuable. The actual impact on-farm will be affected by on-farm management decisions particularly decisions like time of lambing and grazing crops which both alter the relative grazing intensity within the season. Valuing these factors is beyond this component analysis.

In the calculations presented, the middle ground is taken and it is assumed that there is no interaction, i.e. that the value of extending the growing season is not effected by when the pasture manipulation occurred (and hence how much feed is accumulated by the end of spring).

Results & Discussion

Extending the growing season by 3 weeks increases profitability by $65 000 or $41.50/ha of pasture (Table 3), stocking rate is unchanged and supplementary feed is reduced by 0.6kg/DSE (a 25% reduction).

Removing pasture during the growing season reduces profitability by between $10 000 and $45 000 or $60 to $275/t of feed. The reduction in profit is greater when pasture is removed early because the impact on stocking rate is greater with early removal.

Table 3: Profit, stocking rate, supplementary feed required and wool production per hectare for the standard farm and with altered pasture production.

	Profit $/farm	Stocking rate DSE/ha	Supplement kg/DSE	Wool Growth kg/ha

Standard Farm	135 400	8.6	2.3	24.6
Extend growing season	200 600	8.6	1.7	24.6
Remove pasture P3	89 900	7.2	1.8	20.4
P4	116 500	8.0	2.1	22.8
P5	124 850	8.3	2.2	23.6

The above model results have been manipulated to generate the value of extending the growing season by one week and the value of reducing pasture at the times that pasture was manipulated in the trials (**Error! Reference source not found.**).

2017

Table 4 : 2017 Value of extending the growing season by 1 week and removing 100kg of pasture at the 2 times that pastures were manipulated in the trial.

	Change evaluated	Change in profit ($/ha)
Extend the growing season	1 week	14
Remove pasture early	100 kg	20
late	100 kg	6

The above figures can be combined with the trial results to estimate impacts of the trial results on whole farm profit and production.

For example, in Trial 1 in 2017 an early spray reduced FOO by 50kg and extended the growing season by 2 weeks.

Early feed value = MIDAS value x reduction in feed / 100

= 20 x 50 /100

= $10/ha reduction

Extend growing season = MIDAS value x weeks extended

= 14 x 2

= $28/ha increase in value

Net result is an increase in profitability of $18/ha for trial 1.

Following the above methodology allows calculation of the breakeven reduction in the feed associated with the pasture manipulation that would exactly offset the extension in the growing season.

Breakeven = Value of extension of the growing season / value of early pasture

In 2017 the growing season was extended by 2 weeks at each trial site and the breakeven values are presented in Table 5. Note: the ranges presented are based on the value of extending the growing season and the value of extra early pasture that was calculated with a sensitivity analysis of +/- 30% on wool and meat prices. The low level of variation indicates that price level is not a major variable in this decision.

Table 5: 2017 The breakeven reduction in early pasture that would exactly offset the value achieved from a 2-week extension of the growing season.

Manipulation time	Average value	Range
Early removal	165	110 – 175
Late removal	275	190 – 300

Potential to improve the analysis

This analysis has not included the impact of the increased clover content of the pasture on

1. the growth rate of the pasture during spring.
2. any variation in the requirement for ground cover on the pasture paddocks due to the lower grass content of the pastures.

The impact of the pasture control strategies on crop costs, crop yields and stubble availability. These impacts could be due to:

1. Variation in weed control required
2. Levels of root disease associated with grass in the pasture phase
3. Level of nitrogen required by the crop associated with N fixation by the clover.

This analysis could be improved with measurement of the increased digestibility of the pasture at the end of the growing season, because the results are sensitive to this parameter.

A more detailed analysis could also be carried out at the end of the project accounting for the factors outlined above and valuing the system for farms with different animal growth targets.

2018

Table 6: 2018 Value of extending the growing season by 1 week and removing 100kg of pasture at the 2 times that pastures were manipulated in the trial.

	Change evaluated	Change in profit ($/ha)
Extend the growing season	7 days	14
Remove pasture: Early (End June)	100 kg	-20
Late (Mid-August)	100 kg	-9

The above figures can be combined with the trial results to estimate impacts of the trial results on whole farm profit and production.

For example, in Trial 1 in 2018 an early spray reduced FOO by 1085kg and extended the growing season by 34 days.

Early feed value = MIDAS value x reduction in feed / 100

= 20 x 1034 /100

= $207/ha reduction

Extend growing season = MIDAS value x days extended / 7

= 14 x 34 / 7

= $68/ha increase in value

Net result is a decrease in profitability of $139/ha for early Spray in trial 1.

Following the above method, the value of pasture manipulation can be calculated for each trial

Table *11: 2019 Feed quality of the different trials comparing early and late manipulation with control (Digestibility).*

Manipulation	Trial 1	Trial 2	Trial 3	Overall
Early	63.7	65.3	69.1	66.0
Control	65.4	66.6	69.2	67.1
Late	65.0	64.4	70.1	66.5

Table 12, there is large variation in the results due to the variation in FOO measurements. The individual trial values can be averaged to give the overall profit from early and late pasture manipulation, shown in Table 13.

Table 7: The value of early and late pasture manipulation for each trial in 2018.

		Extended season value ($/ha)	Feed Value ($/ha)	Overall profit ($/ha)
Trial 1	Early	68	-207	-139
Late		68	-3	65
Trial 2	Early	68	-78	-10
Late		68	-144	-76
Trial 3	Early	68	-140	-72
Late		68	-56	12

Table 8: The average overall value of pasture manipulation from the three trials in 2018.

	Extended season value ($/ha)	Feed Value ($/ha)	Overall profit ($/ha)
Early (End of June)	68	-142	-74
Late (Mid-August)	68	-67	1

Conclusion

The 2018 results showed that pasture manipulation added a month onto the growing season, compared to just 2 weeks in 2017. However, this was offset by the larger FOO reductions associated with the manipulations in 2018. Leaving the average net profit of early pasture manipulations across all trials to be negative compared to the standard non-manipulation method. Nevertheless, the reduction in FOO associated with pasture manipulation varied significantly between trials, with some trials recording smaller reductions and net positive profits associated with pasture manipulation

Late manipulation was significantly more profitable than earlier manipulations because the value of pasture is much greater earlier in the season (June/July) compared to later (August). A FOO reduction early in the season has a much greater effect on stocking rate than a reduction in the middle of the season.

2019

Table 9: 2019 Value of extending the growing season by 1 week and removing 100kg of pasture at the 2 times that pastures were manipulated in the trial.

	Change evaluated	Change in profit ($/ha)
Extend the growing season	7 days	14
Remove pasture: Early (Mid July)	100 kg	-15.5
Late (Mid to late August)	100 kg	-8.8

In 2019 the trial results showed that both the early and late manipulations had a significant effect on foo. However, there was a little bit of inconsistency with one trial recording an increase in foo after the manipulation, this was recorded after the late manipulation and is likely due to the clover taking off. The manipulations were done later in the season compared to 2018 and 2017, so although the reduction in foo was more, the cost of reducing foo later in the year is less as indicated from the MIDAS findings. Both the early and late manipulated pastures were able to grow for an extra 15 days. This equated to an estimated gain of 30 $/ha. However, it should be noted that the MIDAS calculation assumed an increase in quality of 4% however the results in 2019 showed a very minimal change in quality, possibly due to the later manipulation timings. This may mean the benefits of pasture manipulation in 2019 are overstated. Overall, however the cost associated with the reduction in foo was greater than the gain from the longer growing season and increased feed quality. Even with the later manipulation the calculated profit reduction over the model farm was 55 $/manipulated ha.

Table 10: The recorded foo reduction for each trial in 2019.

		Change in foo
Trial 1	Early	-820
	Late	-2200
Trial 2	Early	-1380
	Late	530
Trial 3	Early	-1220
	Late	-1230

Table 11: 2019 Feed quality of the different trials comparing early and late manipulation with control (Digestibility).

Manipulation	Trial 1	Trial 2	Trial 3	Overall
Early	63.7	65.3	69.1	66.0
Control	65.4	66.6	69.2	67.1

Late	65.0	64.4	70.1	66.5

Table 12: 2019 The value of early and late pasture manipulation for each trial in 2019.

		Extended season value ($/ha)	Feed Value ($/ha)	Overall profit ($/ha)
Trial 1	Early	30	-127	-97
	Late	30	-195	-165
Trial 2	Early	30	-214	-184
	Late	30	47	77
Trial 3	Early	30	-189	-159
	Late	30	-109	-79

Table 13: The average overall value of pasture manipulation from the three trials in 2019.

	Extended season value ($/ha)	Feed Value ($/ha)	Overall profit ($/ha)
Early (End of June)	30	-177	-147
Late (Mid-August)	30	-85	-55

Conclusion

The 2019 results showed that pasture manipulation added 15 days onto the growing season and surprisingly had a very little effect on pasture quality. The reduction in foo from the manipulations was significant and the cost of doing so more than outweighed the benefits on the longer season from a profit point of view. Although as seen in trial 2 when foo reduction is minimal pasture manipulation can become quite profitable.

Much like 2018 late pasture manipulation was significantly more profitable than earlier manipulations because the value of pasture is much greater earlier in the season (June/July) compared to later (August). A FOO reduction early in the season has a much greater effect on stocking rate than a reduction in the middle of the season.

8.1.2 Financial impacts of pasture manipulation compared to cControl, 2017 - 2019

2017Financial impact of pasture manipulation compared to control (unmanipulated) $/Ha		
	Site 1	**Site 2**

	Feed removal cost	Extended season value	Overall profitability	Feed removal cost	Extended season value	Overall profitability
Early manipulation	-10	28	$18	0	28	$28
Late manipulation	-48	28	-$20	0.6	28	$27.50

2018Financial impact of pasture manipulation compared to control (unmanipulated) $/Ha						
	Site 1			**Site 2**		
	Feed removal cost	Extended season value	Overall profitability	Feed removal cost	Extended season value	Overall profitability
Early manipulation	-$207	$68	-$139	-$78	$68	-$10
Late manipulation	-$3	$68	$65	-$144	$68	-$76

	Site 3		
	Feed removal cost	Extended season value	Overall profitability
Early manipulation	-$140	$68	-$72
Late manipulation	-$56	$68	$12

2019Financial impact of pasture manipulation compared to control (unmanipulated) $/Ha						
	Site 1			**Site 2**		
	Feed removal cost	Extended season value	Overall profitability	Feed removal cost	Extended season value	Overall profitability
Early manipulation	-$127	$30	-$97	-$214	$30	-$184
Late manipulation	-$195	$30	-$165	$47	$30	$77

	Site 3		
	Feed removal cost	Extended season value	Overall profitability
Early manipulation	-$189	$30	-$159
Late manipulation	-$109	$30	-$79

8.2 Feed on offer results

Fig. 1: Average feed on offer for 2017

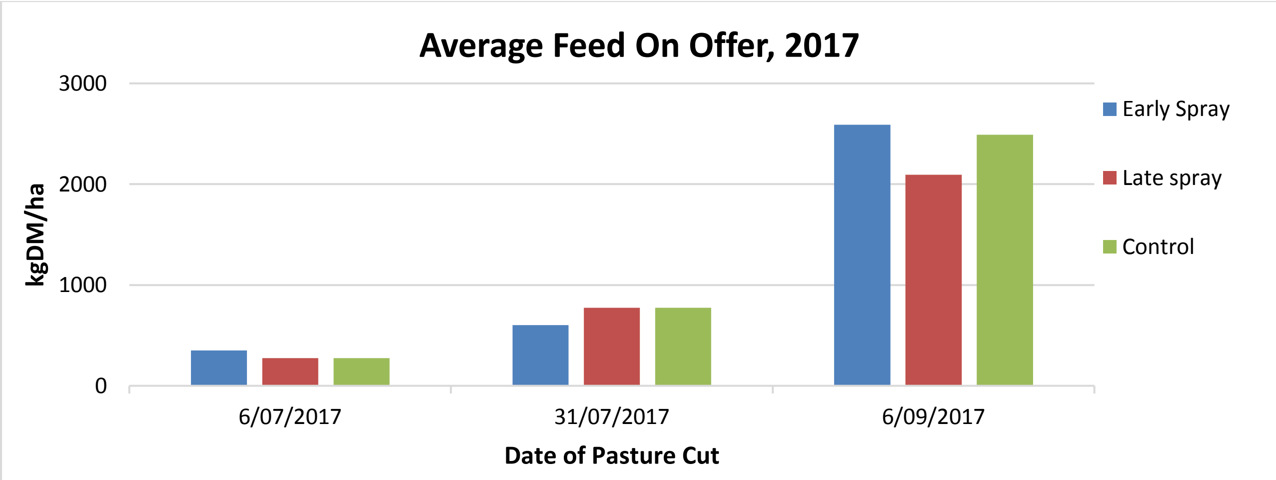


Fig. 2: Average feed on offer for 2018

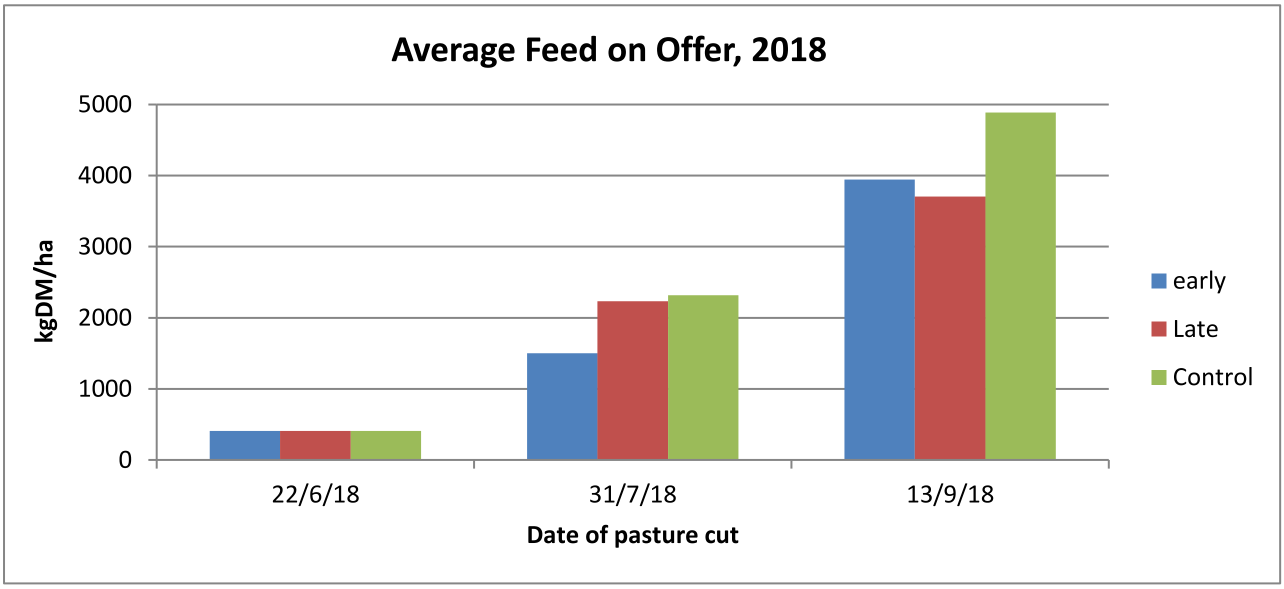
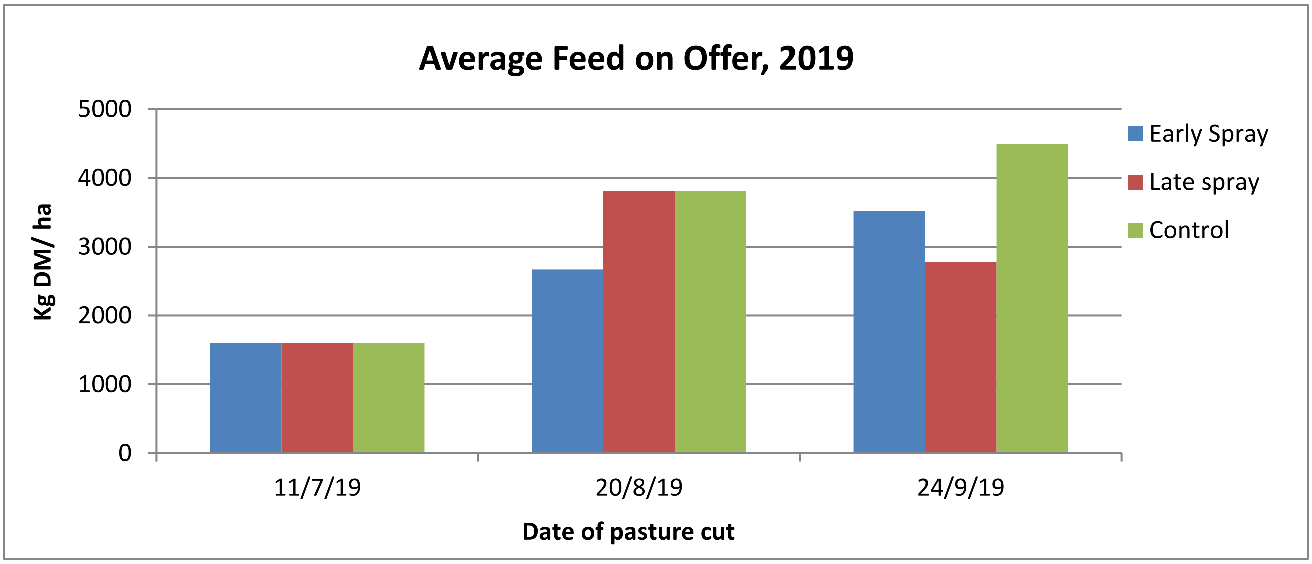


Fig. 3: Average feed on offer for 2019



8.3 2017 Feed test results

FOO DM

Lefroy

	6/07/2017	31/07/2017	1/09/2017
Early Spray	300	400	2950
Late spray	300	450	2100
Control	300	450	2900

Richards

	6/07/2017	31/07/2017	1/09/2017
Early Spray	400	800	2230
Late spray	250	1100	2090
Control	250	1100	2080

Average

	6/07/2017	31/07/2017	6/09/2017
Early Spray	350	600	2590
Late spray	275	775	2095
Control	275	775	2490

CP %

Lefroy

	6/07/2017	31/07/2017	1/09/2017
Early Spray	26.9	23.3	17.5
Late spray	26.9	24.7	14
Control	26.9	24.7	19.6

Richards

	6/07/2017	31/07/2017	1/09/2017
Early Spray	30.4	24.9	26.7
Late spray	30.4	18.2	22
Control	30.4	18.2	22

Average

	6/07/2017	31/07/2017	1/09/2017
Early Spray	28.65	24.1	22.1
Late spray	28.65	21.45	18
Control	28.65	21.45	20.8

ME

Lefroy

	6/07/2017	31/07/2017	1/09/2017
Early Spray	9.2	7.1	10.4
Late spray	9.2	9.1	9.3
Control	9.2	9.1	10.6

Richard

	6/07/2017	31/07/2017	1/09/2017
Early Spray	9.8	7.4	9.4
Late spray	9.8	7.1	9.9
Control	9.8	7.1	9.7

Average

	6/07/2017	31/07/2017	1/09/2017
Early Spray	9.5	7.25	9.9
Late spray	9.5	8.1	9.6
Control	9.5	8.1	10.15

DMD

Lefroy

	6/07/2017	31/07/2017	1/09/2017
Early Spray	62.8	50.7	69.8
Late spray	62.8	62	63.54
Control	62.8	62	71.1

Richard

	6/07/2017	31/07/2017	1/09/2017
Early Spray	66.3	52.5	63.9
Late spray	66.3	51	66.9
Control	66.3	51	65.5

Average

	6/07/2017	31/07/2017	1/09/2017
Early Spray	64.55	51.6	66.85
Late spray	64.55	56.5	65.22
Control	64.55	56.5	68.3

8.4 2018 Feed test results

FOO DM

Lefroy	22/6/18	31/7/18	13/9/18	13/10/18	Richards	22/6/18	31/7/18	13/9/18	13/10/18	Mike	22/6/18	31/7/18	13/9/18	13/10/18	Average	22/6/18	31/7/18	13/9/18	13/10/18
Early Spray	472	1364	3761.928	2960.743	Early Spray	292	2672.004	3274	2363	Early Spray	460.9415	1011	4792	3700	Early Spray	408.3	1682.5	3741.8	3007.9
Late spray	472	2398	4343.047	3252.603	Late spray	292	2282	2868	2200	Late spray	460.9415	1713	3901	3201	Late spray	408.3	2131.0	3508.6	2884.5
Control	472	2398	4373.742	2001	Control	292	2282	4463	2108	Control	460.9415	1713	4520	2100	Control	408.3	2131.0	3725.2	2069.5

CP %

Lefroy	22/6/18	31/7/18	13/9/18	13/10/18	Richards	22/6/18	31/7/18	13/9/18	13/10/18	Mike	22/6/18	31/7/18	13/9/18	13/10/18	Average	22/6/18	31/7/18	13/9/18	13/10/18
Early Spray	27.6	31.2	23.6	10.2	Early Spray	28.5	27.2	25.6	12.1	Early Spray	28.5	26.5	24.9		Early Spray	28.2	28.3	24.7	11.2
Late spray	27.6	24.1	17.9	9.3	Late spray	28.5	26.7	27.2	14.3	Late spray	28.5	27.1	16.8		Late spray	28.2	26.0	20.6	11.8
Control	27.6	22.8	19.2	7	Control	28.5	31	22.7	10	Control	28.5	26.1	9.2		Control	28.2	26.6	17.0	8.5

ME

Lefroy	22/6/18	31/7/18	13/9/18	13/10/18	Richard	22/6/18	31/7/18	13/9/18	13/10/18	Mike	22/6/18	31/7/18	13/9/18	13/10/18	Average	22/6/18	31/7/18	13/9/18	13/10/18
Early Spray	10.4	9.7	9.1	9.3	Early Spray	8.3	9.6	9	8.7	Early Spray	11.2	9.4	11.2		Early Spray	10.0	9.6	9.8	9.0
Late spray	10.4	10.1	9.4	9.1	Late spray	8.3	10.6	9.1	8.1	Late spray	11.2	10.1	9.7		Late spray	10.0	10.3	9.4	8.6
Control	10.4	10.1	9	6	Control	8.3	9.4	9.7	6	Control	11.2	9.7	12.1		Control	10.0	9.7	10.3	6.0

DMD

Lefroy	22/6/18	31/7/18	13/9/18	13/10/18	Richard	22/6/18	31/7/18	13/9/18	13/10/18	Mike	22/6/18	31/7/18	13/9/18	13/10/18	Average	22/6/18	31/7/18	13/9/18	13/10/18
Early Spray	66	65.6	62.5	60.4	Early Spray	55.5	65.1	61.9	57.4	Early Spray	70.1	69.9	74.6		Early Spray	63.9	66.9	66.3	58.9
Late spray	66	68.3	63.9	59.4	Late spray	55.5	71.1	62.4	54.9	Late spray	70.1	70.3	65.7		Late spray	63.9	69.9	64.0	57.2
Control	66	68	61.9		Control	55.5	64.2	59.9	45	Control	70.1	71.2	74.2		Control	63.9	67.8	65.3	45.0

8.5 2019 Feed test results

FOO DM	11/7/19	20/8/19	24/9/19												
	Kristen's			Richards				Mike				Average			
	11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19
Early Spray	1555	3278	992	Early Spray	2374	1736	1565	Early Spray	866	2985	6048	Early Spray	1598.3	2666.3	3520.0
Late spray	1555	4097	591	Late spray	2374	3120	2891	Late spray	866	4208	4967	Late spray	1598.3	3808.3	2779.0
Control	1555	4097	2793	Control	2374	3120	2361	Control	866	4208	6197	Control	1598.3	3808.3	4495.0

CP %															
Lefroy				Richards				Mike				Average			
	11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19
Late spray	25.5	21.4	18.8	Late spray	28.5	29.9	11.4	Late spray	29.6	28.1	19.8	Late spray	27.9	26.5	16.7
Control	25.5	21.4	13.8	Control	28.5	29.9	14.8	Control	29.6	28.1	17.5	Control	27.9	26.5	15.4
Early Spray	25.5	15.8	23	Early Spray	28.5	13.7	21.6	Early Spray	29.6	25.9	17.3	Early Spray	27.9	18.5	20.6

ME															
Lefroy				Richard				Mike				Average			
	11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19
Late spray	9.9	9.1	9.3	Late spray	9.6	10.3	9	Late spray	9.6	11.1	10.1	Late spray	9.7	10.2	9.5
Control	9.6	9.1	10.1	Control	9.6	10.3	9.6	Control	9.6	11.1	10.2	Control	9.6	10.2	10.0
Early Spray	9.6	9.7	9.4	Early Spray	9.6	9.9	9.4	Early Spray	9.6	11.8	10	Early Spray	9.6	10.5	9.6

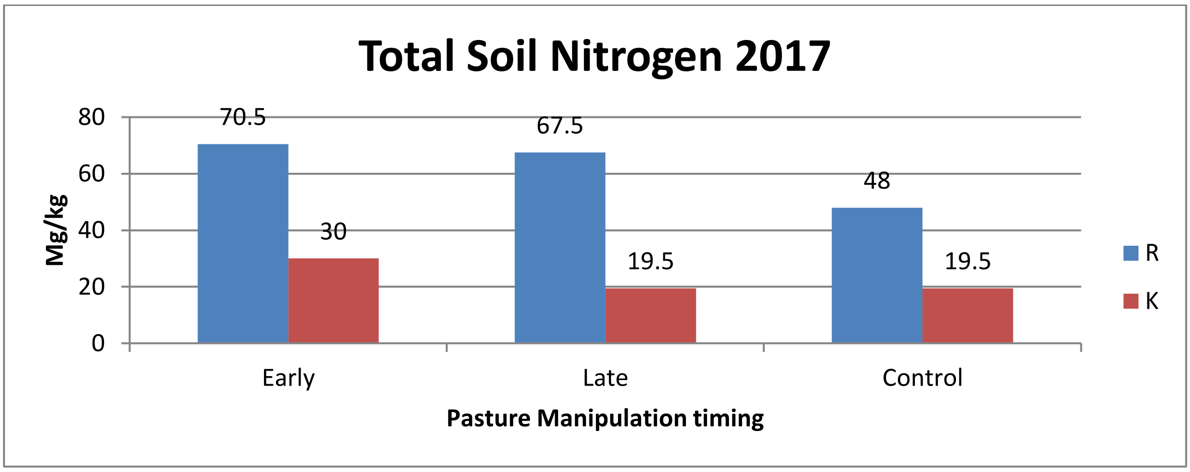
DMD															
Lefroy				Richard				Mike				Average			
	11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19		11/7/19	20/8/19	24/9/19
Late spray	65.4	62.5	63.3	Late spray	65	69.5	61.4	Late spray	65	74	68.2	Late spray	65.1	68.7	64.3
Control	65.4	62.5	68.3	Control	65	69.5	65.4	Control	65	74	68.7	Control	65.1	68.7	67.5
Early Spray	65.4	65.7	63.8	Early Spray	65	67.2	61.1	Early Spray	65	77.8	67.5	Early Spray	65.1	70.2	64.1

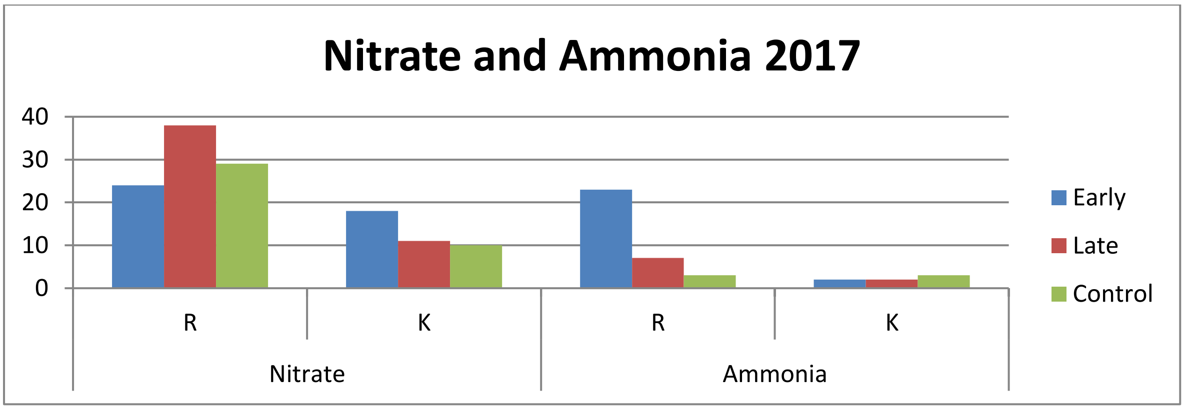
8.6 Pasture species composition

Pasture species composition 2017			Percentage of different species				
Site	**Sample date**	**Manipulation timing**	BG	SG	C	CW	Other
K	6-Jul	all	70	0	30	0	0
R	6-Jul	all	40	0	60	0	0
K	31-Jul	E	40	15	40	0	5
K	31-Jul	L	40	20	20	10	10
K	31-Jul	C	40	20	20	10	10
R	31-Jul	E	5	0	90	5	0
R	31-Jul	L	30	0	50	20	0
R	31-Jul	C	30	0	50	20	0
K	1-Sep	E	0	20	60	0	20
K	1-Sep	L	0	30	50	10	10
K	1-Sep	C	50	20	10	10	10
R	1-Sep	E	0	0	90	10	0
R	1-Sep	L	10	0	80	10	0
R	1-Sep	C	20	0	60	20	0
Pasture species composition 2018							
Site	**Sample date**	**Manipulation timing**	BG	SG	C	CW	Other
K	22-Jun	all	15	20	50	10	5
M	22-Jun	all	65	0	10	10	15
R	22-Jun	all	20	0	60	20	0
K	31-Jul	E	0	0	70	20	10
K	31-Jul	L	30	0	30	30	10
K	31-Jul	C	30	0	30	30	10
R	31-Jul	C	40	0	20	40	0
R	31-Jul	L	40	0	20	40	0
R	31-Jul	E	5	0	70	25	0
M	31-Jul	E	30	0	20	30	20
M	31-Jul	L	50	0	5	25	20
M	31-Jul	C	50	0	5	25	20
K	13-Sep	E	0	5	65	20	10
K	13-Sep	L	0	25	50	20	5
K	13-Sep	C	20	25	30	20	5
R	13-Sep	E	5		85	10	
R	13-Sep	L	20		20	60	
R	13-Sep	C	40		35	25	
M	13-Sep	E	40		20	20	20
M	13-Sep	L	30		10	45	15
M	13-Sep	C	40		5	5	50
Pasture species composition 2019							
Site	**Sample date**	**Manipulation timing**	BG	SG	C	CW	Other
K	*11-Jul*	all	40	30	15	15	

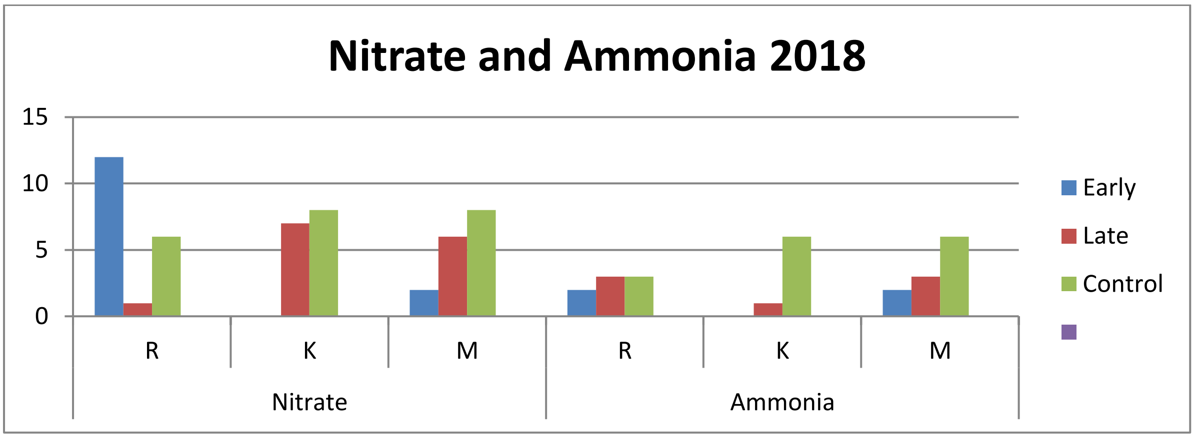
M	*11-Jul*	all	40	5	20	30	5
R	*11-Jul*	all	40	20	30	10	
K	20/08/2019	E	25	55	20		
K	20/08/2019	L	25	55	20		
K	20/08/2019	C	50	25	15		10
R	20/08/2019	E	20	5	70	5	
R	20/08/2019	L	10	10	70	10	
R	20/08/2019	C	45	35	10	10	
M	20/08/2019	E	40		20	25	15
M	20/08/2019	L	40		20	25	15
M	20/08/2019	C	35		25	25	15
K	24/09/2019	E	25	55	20		
K	24/09/2019	L	20	20	50		10
K	24/09/2019	C	20	20	50		10
R	24/09/2019	E	10	10	70	10	
R	24/09/2019	L	10	10	70	10	
R	24/09/2019	C	45	35	10	10	
M	24/09/2019	E	30		30	25	15
M	24/09/2019	L	20		40	25	15
M	24/09/2019	C	35		30	25	10

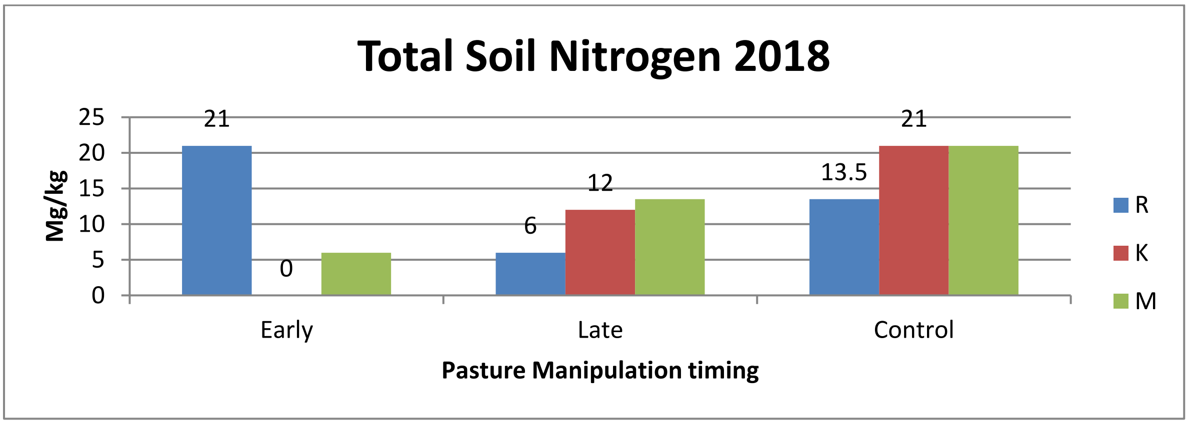
8.7 2017 Soil nitrogen results: nitrate, ammonia and total nitrogen





8.8 2018 Soil nitrogen results: nitrate, ammonia and total nitrogen





8.9 Germination data: species composition and ground cover

Site	Treatment	Clover (%)	Weeds (%)	Ground Cover (%)
R	**Early**	70	30	25
R	**Late**	45	55	25
R	**Control**	30	70	70
M	**Early**	60	40	30
M	**Late**	30	70	25
M	**Control**	20	80	85

8.10 Summary articles

8.10.1 MMPIG Summary article 2019

MLA Producer Demonstration Site: Advantages of Pasture Manipulation 2017-2019

Grass-selective herbicides were applied to pastures either early (June-July) or late (July-August), with a control strip left untreated at each of the three properties.

At each site, there was little difference in spring feed on offer, however manipulation led to immediate decreases in feed on offer after treatment which was most significant early in the season. This lack of major impact on **spring** FOO levels indicates flexibility in when manipulation can happen, and that clovers' growth can make up for grasses removed through manipulation, so timing will not reduce spring feed or winter pastures significantly.

Pasture species composition had clear results- with higher levels of clover in the early manipulated pastures (60-90%) compared to the late manipulated (50-80%), with unmanipulated pastures showing as little as 10% clover content. Feed quality (energy, protein and digestibility) surprisingly did not have any link to pasture composition and manipulation timing.

Manipulation also led to additional weeks (2-4) of green pasture at the end of spring, with spray topping being delayed as grasses were removed earlier in the season. This meant more feed, resulting in increased sheep weight gains, without the risk of grass seeds to lambs' eyes and skin.

The impact on sheep production, potential stocking rate, value of early season feed and extending the season was used to produce an overall economic profitability model using MIDAS and GrazFeed. Data is yet to be assessed determining impact of manipulation on the follow year's seed set, where a cropping cycle was mimicked. Other excluded data is disease risk & soil nitrogen, as soil results were inconclusive. This meant that soil & germination impacts were not included in the economic analysis.

The most important economic values were the cost of feed removal. Feed early in the season was calculated to be worth $15.5 per 100kg. Removing feed later in the season cost less, at -$8.8 per 100kg. Extending the season in spring was worth $14/ha/week. Combining these numbers with the removed FOO gave us the below overall averages per hectare for the three-year project. Despite the negative profit impact of removing feed, the modelling showed that manipulation can lead to overall profitability increases, with a modelled $23/ha profit. The biggest loss was -$147/ha. Late manipulation was more profitable than early, due to the value of early season feed.

	Feed removal cost	Extended season value	Overall profitability
Early manipulation	-$108	$42	-$66
Late manipulation	-$59	$42	-$17

In each image, the unmanipulated pasture is on the left and early manipulated on right.

8.10.2 MMPIG Summary article 2018

MLA Producer Demonstration Site: Advantages of Pasture Manipulation

The MLA funded project looking at advantages of pasture manipulation has shown that mid-season manipulation impacted species composition, but not feed on offer. Feed quality (energy, protein and digestibility) surprisingly did not have any link to pasture composition.

Grass-selective herbicides were applied either early or late in the season, with a control strip of pasture left untreated at each of the three properties. At each location, there was little difference in amount of winter and spring feed on offer, or pasture quality. However, the difference in pasture species composition was significant between each strip, at each site. There were higher levels of clover in the early manipulated pastures (60-90%) compared to the late manipulated (50-80%), with the unmanipulated pastures showing as little as 10% clover content.

Higher clover content should lead to reduced soil disease risk and greater soil nitrogen, as well as better clover seed set and livestock growth rates.

The demonstration site results have shown that the timing of pasture manipulation can have some impact on feed quality and certainly on species composition throughout the season, while generally having minimal effect on feed available to livestock (except late manipulation at one site).

This lack of significant impact on FOO levels is a great result, indicating that there is flexibility in when manipulation can happen, and that the clovers' compensatory growth can make up for the grasses removed through manipulation. This is significant, as it shows that manipulation will not reduce spring feed or winter pastures.

Summer Soil tests have been taken from each strip to review nutrients levels and disease risk, while economic analysis will show the impact of pasture quality/quantity on lamb/weaner survival, stock growth rates, stocking rates and supplement feeding requirements.

This was a good year to begin the trial, as one of the great fears with manipulating is removing sheep feed, which was in short supply this year. The challenge is to remove grasses before seed set, without affecting the amount of feed on offer for sheep.

Another significant impact is that manipulation led to an additional 2 weeks of green pasture at the end of spring, with spray topping being delayed as early flowering Barley grass were removed earlier in the season.

This means more feed of a higher quality for sheep resulting in increased weight gains without the risk of grass seeds to lambs' eyes and skin. There will also be a higher clover seed set, leading to better pastures in the future.

Over the next three years, the impacts of manipulation timing will continue to be demonstrated- everyone is welcome to view the sites at the field days next winter and spring. The sites will also look at the impact of cropping on pasture germination, as well as the effect of pasture legume levels on soil health, nitrogen and disease risk.

8.10.3 MMPIG Summary article 2017

<u>MLA Producer Demonstration Site: Advantages of Pasture Manipulation</u>

The MLA funded project looking at advantages of pasture manipulation has shown that mid-season manipulation impacted species composition, but not feed on offer.

Grass-selective herbicides were applied either early or late in the season, with a control strip of pasture left untreated at each of the three properties. At each location, there was little difference in amount of winter and spring feed on offer, or pasture quality. However, the difference in pasture

species composition was significant between each strip, at each site. There were higher levels of clover in the early manipulated pastures (60-90%) compared to the late manipulated (50-80%), with the unmanipulated pastures showing as little as 10% clover content.

Higher clover content should lead to reduced soil disease risk and greater soil nitrogen, as well as better clover seed set and livestock growth rates.

The demonstration site results have shown that the timing of pasture manipulation can have some impact on feed quality and certainly on species composition throughout the season, while generally having minimal effect on feed available to livestock (except late manipulation at one site).

This lack of significant impact on FOO levels is a great result, indicating that there is flexibility in when manipulation can happen, and that the clovers' compensatory growth can make up for the grasses removed through manipulation. This is significant, as it shows that manipulation will not significantly reduce spring feed or winter pastures.

Summer Soil tests have been taken from each strip to review nutrients levels and disease risk, while economic analysis will show the impact of pasture quality/quantity on lamb/weaner survival, stock growth rates, stocking rates and supplement feeding requirements.

This was a good year to begin the trial, as one of the great fears with manipulating is removing sheep feed, which was in short supply this year. The challenge is to remove grasses before seed set, without affecting the amount of feed on offer for sheep.

Another significant impact is that manipulation led to an additional 2 weeks of green pasture at the end of spring, with spray topping being delayed as barley grasses were removed earlier in the season.

This means more feed of a higher quality for sheep resulting in increased weight gains without the risk of grass seeds to lambs' eyes and skin. There will also be a higher clover seed set, leading to better pastures in the future.

Over the next two years, the impacts of manipulation timing will continue to be demonstrated- everyone is welcome to view the sites at the field days next winter and spring. The sites will also look at the impact of cropping on pasture germination, as well as the effect of pasture legume levels on soil health, nitrogen and disease risk.

8.11 Field day handouts

8.11.1 Field day factsheet 2017

Advantages of Pasture Manipulation: Trial Year 1

Field day 2, 18/7/17

RESULTS

Feed quality

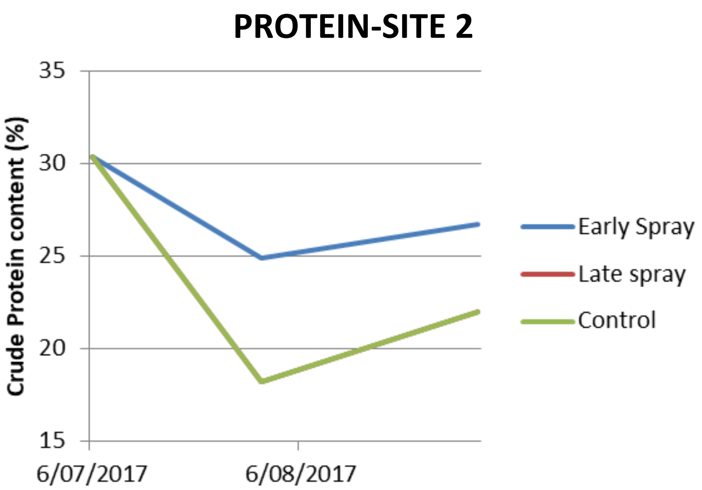
Crude Protein (%) declined at both sites in all spray treatments. This could be due to young growth being highly concentrated early in the season. At site 2 however, crude protein declined and then increased, but not to the original level. There is no clear trend regarding the spray timing, with mixed results across the sites. The early spray outperformed the late and control at site 1, the opposite occurred at site 2, with the late and control spray having identical levels of crude protein.

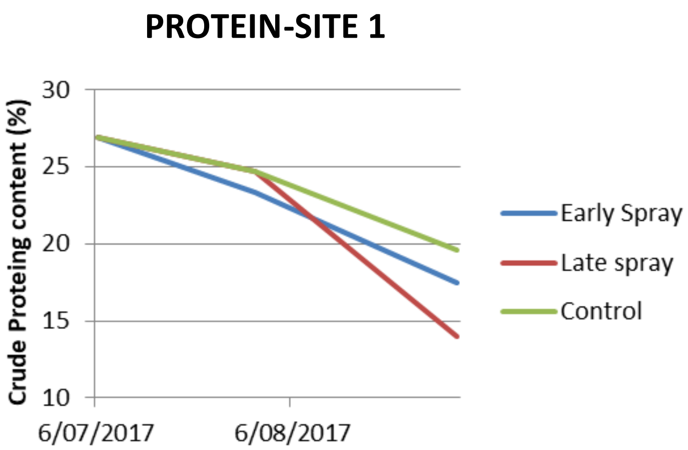
Metabolisable energy (MJ/kg DM) declined across all strips after the first cut was taken, falling most significantly at Site 2. Originally 9.8MJ/kgDM, the early spray fell to 7.4MJ/kgDM, and the late and control strips to 7.1MJ/kgDM. With conflicting results, ME at Site 1 was the lowest in the early spray strip. The results were also conflicting, with the lowest total ME in Site 1's late spray, and highest in control, compared to Site 2 with the highest in late spray and lowest in the early manipulation.

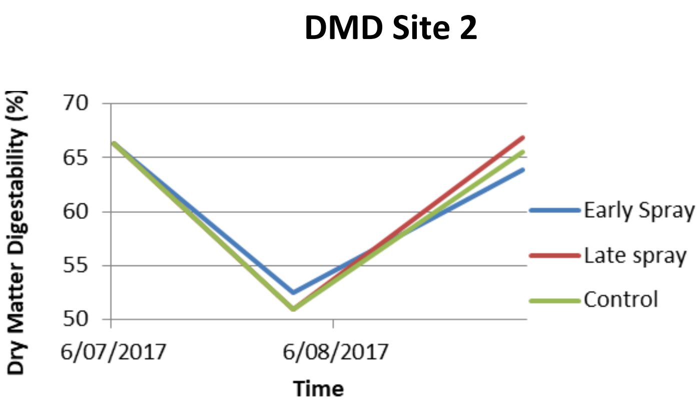
Site 1			
	6/07/2017	31/07/2017	1/09/2017
Early Spra	9.2	7.1	10.4
Late spray	9.2	9.1	9.3
Control	9.2	9.1	10.6

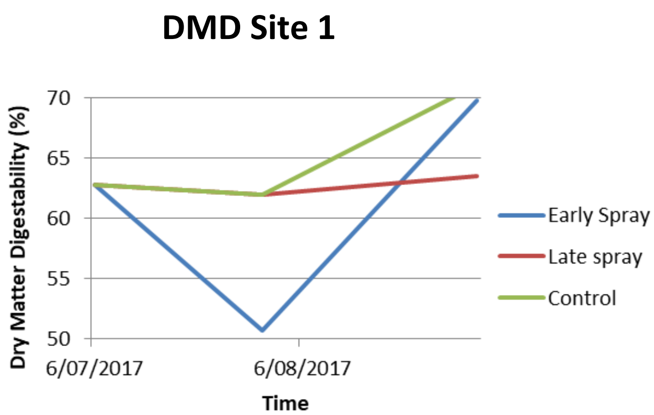
Site 2			
	6/07/2017	31/07/2017	1/09/2017
Early Spra	9.8	7.4	9.4
Late spray	9.8	7.1	9.9
Control	9.8	7.1	9.7

Digestibility followed the same trends as ME across the sites, with curve shapes nearly identical to ME at that site. Overall, the Site 2 pastures had the highest kg/DM per hectare in each strip despite having lower ME compared to Site 1.

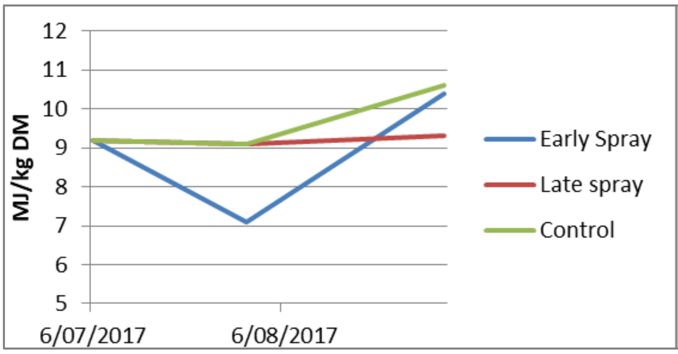




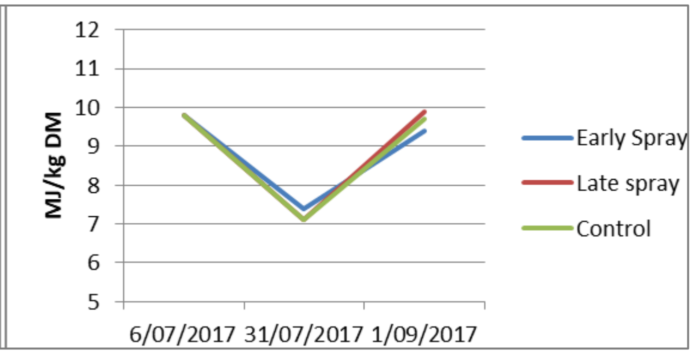




ME SITE 2



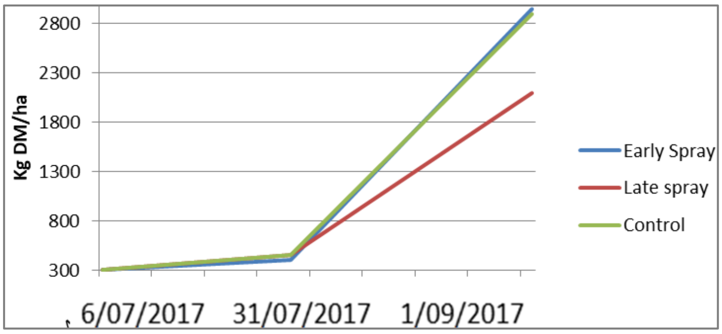
ME SITE 1



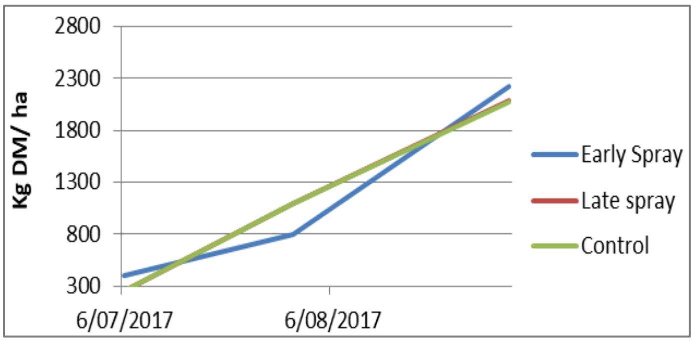
Feed quantity

Kilos of dry matter per ha (DM kg/ha) began quite low at around 300kg/ha across both sites.
The early manipulated sites had the highest DM by the end of the period, with 2950kg/ha at site 1 & 2230kg/DM at site 2. The control strips followed, with 2900 and 2080 respectively, this could be due to the high level of barley grass heads at site 1. Late manipulation was the lowest, around 2100 at both sites. The late and control DM curves at Richards were very similar which is understandable with a late spray just dying off, as were the early spray and control at site 1 despite having very different pasture compositions.

Feed on offer: Site 2



Feed on offer: Site 1



Issues/ Challenges

- Late season break
- Barley grass heads influencing final cuts
- Mike's application/timing
- Potential early finish
- Poor pasture growth rates

Next steps

The control strips need to be sprayed to control barley grass, and economic modelling undertaken in *GrazFeed* to determine the impact on the livestock enterprise, and a webinar produced once we have all the data analysed.

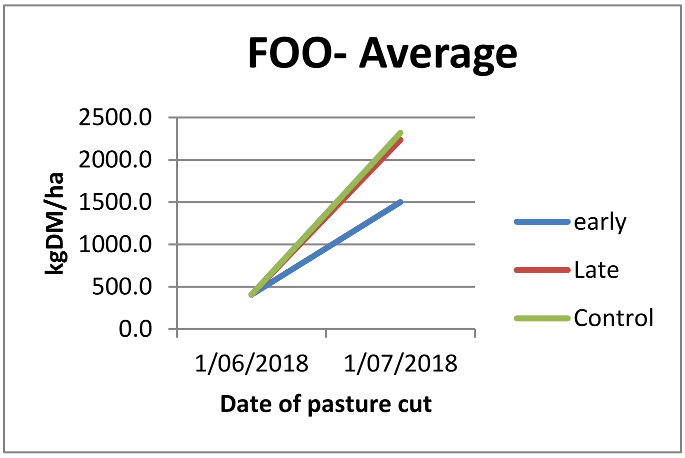
Question to YOU: Who is planning to manipulate their pastures next year?

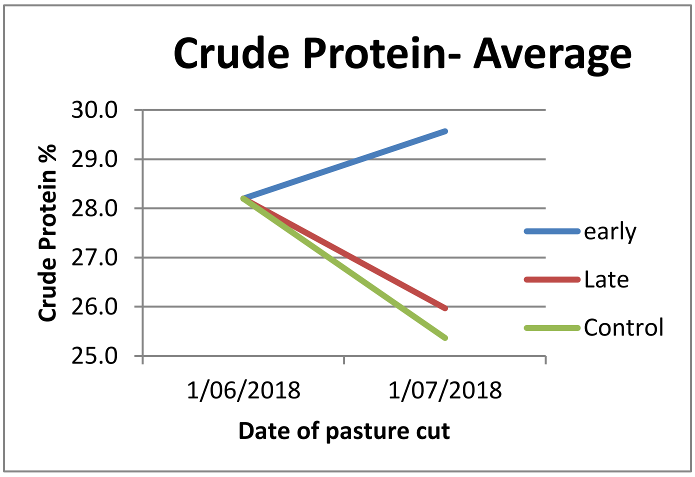
2018: Replicate the trials, same farm but different strips. Trial will also look at germination in the existing 2017 strips. A band will be sprayed out across the existing strips to mimic cropping rotation, so we can see clover germination levels in 2019.

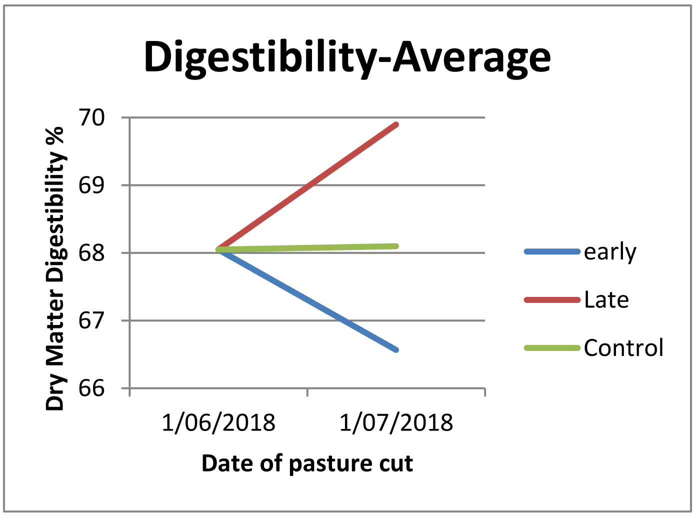
8.11.2 Field day factsheet 2018

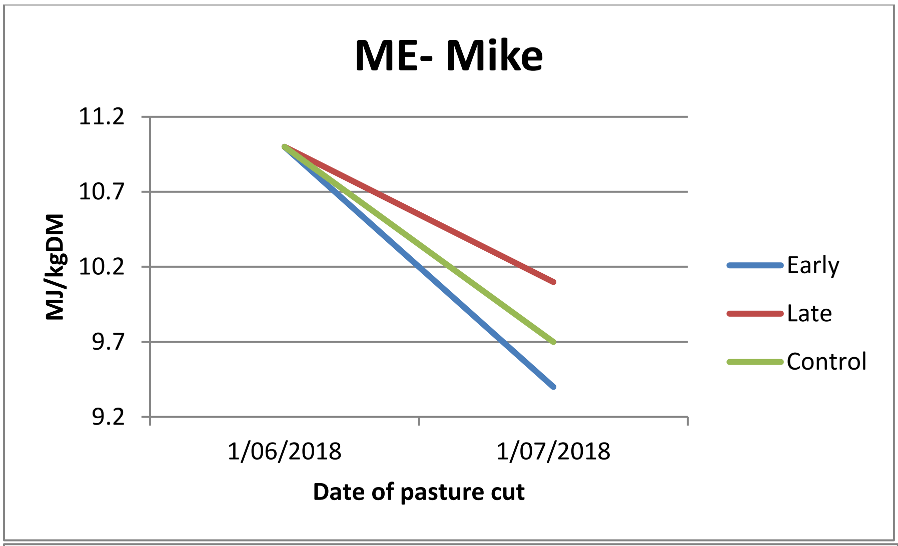
Advantages of Pasture Manipulation: Timing

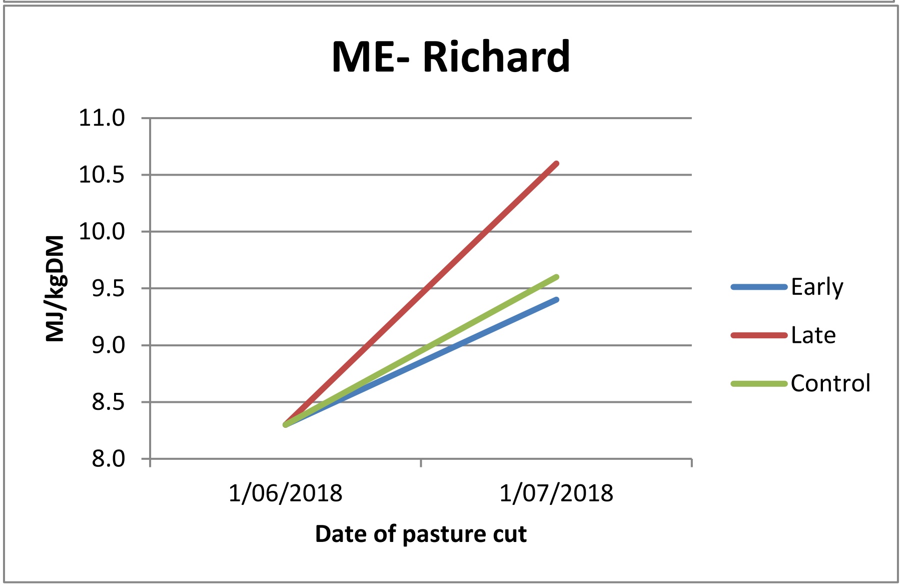
These measures do not consider spring feed, as cuts are yet to be taken. Nor does it consider late manipulation impact: Only early manipulation and no manipulation can be seen in these results.








ME- Mike
11.2
10.7
10.2
9.7
9.2
MJ/kgDM
1/06/2018
1/07/2018
Date of pasture cut
Early
Late
Control


ME- Richard
11.0
10.5
10.0
9.5
9.0
8.5
8.0
MJ/kgDM
1/06/2018
1/07/2018
Date of pasture cut
Early
Late
Control

8.11.3 Field day factsheet 2019

This page was distributed at the first field day to all attendees.

Producer	Treatment	Cut date	ME (MJ/kgDM)	FOO (kgDM/ha)	Protein %	Digestibility %	Species composition	APPLICATION
K	Initial (no treatment yet applied)	11/07/2019	9.6	1555	25.5	65.4	30%BG, 30%SG, 15%C 15%CW	
K	*Early*	*20/08/2019*	*9.1*	*3278*	*21.4*	*62.5*	*55% SG, 20% c, 25% BG*	*500g simazine*
K	*Control*	*20/08/2019*	*9.7*	*4097*	*15.8*	*65.7*	*50%bg, 25%SG, 15% c 10% geranium*	-
M	Initial (no treatment yet applied)	11/07/2019	9.6	866	29.6	65	35% BG, 25% CW 15%C	
M	*Early*	*20/08/2019*	*11.1*	*2985*	*28.1*	*74*	*40% BG 20% clover, 25% CW,15% G&WW*	*500g simazine, 140ml chlorpyrifos*
M	*Control*	*20/08/2019*	*11.8*	*4208*	*25.9*	*77.8*	*35% BG 25% clover, 25% CW,15% G&WW*	-
R	Initial (no treatment yet applied)	11/07/2019	9.6	2374	24.9	65	40% BG 30%C, 20% SG, 10%CW,	
R	*Early*	*20/08/2019*	*10.3*	*1736*	*29.9*	*69.5*	*70% C, 10%SG, 10% BG*	*500g simazine, 400ml Targa, 100ml roger?*
R	*Control*	*20/08/2019*	*9.9*	*3121*	*13.7*	*67.2*	*45% BG, 35% SG, 10%CW, 10%C*	

SUMMARY:

As late sprays went on without the second pasture cut being done, it is assumed that the control strip would have had the same feed as the late strip before it was sprayed. Late strip when discussed below is assumed to be pre-manipulation.

- Digestibility has increased, on average highest in late and control strips

- Energy highest at Mike's, On average ME highest in unmanipulated strips
- FOO highest in unmanipulated strips.
- Protein highest early in the season, but now Protein highest in early manipulated strips
- Third pasture cut to be done in next 2 weeks!

Composition:

BG= barley grass

C =clover

CW= cape weed

8.12 Survey questions

8.12.1 Pre-project survey questions

1. In your view, is pasture manipulation a valuable tool for the sheep enterprise?
2. Do you utilise pasture manipulation for your sheep enterprise?
3. Why/why not?
4. Is managing grass seeds an issue for you?
5. If you currently manage grass seeds, how?
6. Do you think lamb growth rates in spring could be improved through pasture manipulation?
7. Which pasture species do you think lead to the highest sheep growth rates?
8. Would you describe your attitude towards the tool as positive or negative?
9. What do you think the positives of pasture manipulation are?
10. What is your biggest concern regarding pasture manipulation
11. Is there more you would like to know about pasture manipulation?
12. If so, what and why?

8.12.2 Post-project survey questions - core participants

MLA Producer Demonstration Sites

Skills Audit template – Post-PDS-Core Participants

PDS Name Advantages of Pasture Manipulation

PDS Code L.PDS. 1705

Event name (to fill out by PDS coordinator):

The following questions are used to determine your level of understanding of Advantages of Pasture Manipulation. The knowledge and skills audit is used at the start and completion of the program to allow individuals to track their skill development and adoption of new practices. It will also be used:

1. To improve the content of future projects; and
   As part of the evaluation process for the project

The information will be completely confidential, and individuals will not be identified in the analysis of data.

Name: ____

Date: / /

MLA may contact me to further assess the impact of their programs? ☐ Yes ☐ No

MLA may send me newsletters and inform me of future events? ☐ Yes ☐ No

The information you are providing to Meat & Livestock Australia Limited ABN 39 081 678 364 ("MLA") may be personal information under the Privacy Act. We will collect, hold, use and disclose the email address you have given us and the personal information you provide in the manner set out in MLA's privacy policy (located at http://www.mla.com.au/General/Privacy). If you provide a telephone number, you consent to MLA contacting you for an indefinite period about future products and services that may be of interest to you.

Section A – Your Thoughts on the PDS

A1. Overall, how **satisfied** are you with this PDS?

1	2	3	4	5	6	7	8	9	10
Poor									Excellent

A2. How **valuable** was this PDS in assisting you manage your livestock enterprise?

1	2	3	4	5	6	7	8	9	10
Poor									Excellent

A3. Would you **recommend** MLA's PDS program to others? ☐ Yes ☐ No ☐ Not Sure

A4. General Feedback

Please provide feedback to help us improve the PDS program:____

____

Section B – Knowledge and Skills (If you do not know, please select the 'Unsure' option)

B1. Do you utilise pasture manipulation for your sheep enterprise? *(Tick one of the options below)*

a. Yes, in past .... ☐

b. Yes, currently .... ☐

c. No ☐

B2. In your opinion, what is the main benefit of pasture manipulation? *(Tick one of the options below)*

a. Weed control .... ☐

b. Increased feed quality .... ☐

c. Increased animal growth rates .... ☐

d. Grass seed control .... ☐

B3. How would you determine when to manipulate pastures? *(Tick the answer that applies to you)*

a. Grass burdens (anticipated grass seed issues) .... ☐

b. Feed availability.. ☐

c. Pasture quality.. ☐

d. Unsure.. ☐

B4. Has your involvement in this PDS project increased or decreased the likelihood of you manipulating pastures in the future? *(Tick the answer that applies to you)*

a. Increased…………………………………………………… ☐

b. Decreased …………………………………………………… ☐

c. Has had no impact…………………………………………… ☐

Section C – Confidence and Practices

C1. How confident are you in manipulating pastures for the sheep enterprise?

(please rate out of 10, with 1 being poor and 10 being excellent, by circling your choice below)

1	2	3	4	5	6	7	8	9	10
Poor									Excellent

C2. Have you begun implementing changes regarding the following practices, as a result of participating in this PDS?

	Already used before PDS	Implemented this Practice (please indicate on what % of your enterprise this practice has been adopted e.g. 50%)	Intend to implement	Not ready yet (need more training, advice)	Not needed on my property / not relevant
Manipulate pasture for sheep					
Grass seed management					

C3. If you have implemented changes, what impact did they have on feed availability? e.g. Feed on offer (FOO) *(Please do not answer if you are unsure)*

____
____

C4. If you ticked "not ready yet', please indicate what additional information, training or advice you require

____
____

If you ticked "not needed on my property", please indicate why

____
____

8.12.3 Post-project survey questions – observer participants

MLA Producer Demonstration Sites

Skills Audit template – Post-activity: Observers

PDS Name Advantages of Pasture Manipulation

PDS Code L.PDS. 1705

Event name (to fill out by PDS coordinator):

The following questions are used to determine your level of understanding of Advantages of Pasture Manipulation. The knowledge and skills audit is used at the start and completion of the program to allow individuals to track their skill development and adoption of new practices. It will also be used:

To improve the content of future project meetings, and is part of the evaluation process for the project

The information will be completely confidential, and individuals will not be identified in the analysis of data.

Name: ____

Date: / /

MLA may contact me to further assess the impact of their programs? ☐ Yes ☐ No

MLA may send me newsletters and inform me of future events? ☐ Yes ☐ No

The information you are providing to Meat & Livestock Australia Limited ABN 39 081 678 364 ("MLA") may be personal information under the Privacy Act. We will collect, hold, use and disclose the email address you have given us and the personal information you provide in the manner set out in MLA's privacy policy (located at http://www.mla.com.au/General/Privacy). If you provide a telephone number, you consent to MLA contacting you for an indefinite period about future products and services that may be of interest to you.

Section A – Your Thoughts on the Event

A1. Overall, how **satisfied** are you with this event?

1	2	3	4	5	6	7	8	9	10
Poor									Excellent

A2. How **valuable** was this event in assisting you manage your livestock enterprise?

1 2 3 4 5 6 7 8 9 10

Poor Excellent

A3. Would you **recommend** this event to others? ☐ Yes ☐ No ☐ Not Sure

A4. General Feedback

Please provide feedback to help us improve the PDS program:____

Section B – Knowledge and Skills

B1. Do you utilise pasture manipulation for your sheep enterprise? *(Tick one of the options below)*

d. Yes, in past .... ☐

e. Yes, currently .... ☐

f. No ☐

B2. In your opinion, what is the main benefit of pasture manipulation? *(Tick one of the options below)*

e. Weed control .... ☐

f. Increased feed quality .... ☐

g. Increased animal growth rates .... ☐

h. Grass seed control .... ☐

B3. How would you determine when to manipulate pastures? *(Tick the answer that applies to you)*

a. Grass burdens (anticipated grass seed issues) .... ☐

b. Feed availability .... ☐

c. Pasture quality .... ☐

d. Unsure .... ☐

B4. Has your involvement in this PDS project increased or decreased the likelihood of you manipulating pastures in the future? *(Tick the answer that applies to you)*

a. Increased .... ☐

b. Decreased .... ☐

c. Has had no impact .... ☐

Section C – Confidence and Practices

C1. How confident are you in manipulating pasture?

(please rate out of 10, with 1 being poor and 10 being excellent, by circling your choice below)

1 2 3 4 5 6 7 8 9 10

Poor Excellent

C2. For the following practices, do you plan to make changes to your business as a result of attending this event?

	Confirmed what I'm already doing	Intend to implement	Not ready yet (need more training, advice)	Not needed on my property / Not relevant
Manipulate pasture for sheep				
Grass seed management				

C3. If you ticked "not ready yet', please indicate what additional information, training or advice you require

____

____

If you ticked "not needed on my property / not relevant", please indicate why

☐ Not a producer

☐ Other (please provide details)

____

____

8.13 Pre and post-project survey results

8.13.1 Pre and Post-Project Survey Results

	Yes/Positive	No/Negative	Both/Maybe	Average written response
1	18	2		
2	18	2		
3				Timing difficult. For weed control and sheep.
4	13	7		
5				Spray top, graze
6	18	1	1	
7				grasses
8	8	6	6	
9				Improved feed less grass seed
10				Remove feed, timing
11	20			
12				economics

8.13.2 Pre and post-project survey results

	Yes/A/Average	**No/B**	**Unsure/C**	**D**
A1	6.8			
A2	7.2			
A3	30	0		
A4				
B1	7	11	9	0
B2	10	9	3	3
B3	7	7	7	6

B4	11	7	9	0
C1	6.9			
C2.1	5	11	10	1
C2.2	1	9	12	1
C3	Written responses			
C4	NA			
C5	NA			