Final report

EPDS- Predicting spring pasture growth

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Abstract

Soil moisture probes are gathering popularity in pasture paddocks across Victoria, albeit without clear understanding on the value in a grazing system. Research indicates that soil moisture at the beginning of spring can have a considerable impact on the pasture produced, which is utilised in software programs such AskBill (now Ag360), but this is not well known or utilised by producers. Early prediction of spring growth has the potential to help farmers make some early management decisions, particularly in the event of a poor spring.

Pasture cages were installed on four trial sites that had soil moisture probes, and cuts were taken over the late winter/spring period to estimate monthly pasture growth rates. Predictions for the spring period were produced using actual soil moisture at each site from 2019 to 2021. Regional climate forecasts were included in the predictions in 2020 and 2021. Actual growth rates were compared to the predictions to assess accuracy.

Trial sites experienced three good spring seasons, commencing with full soil moisture profiles in August/September, so all pasture predictions were for average or greater than average spring pasture production. Despite limited opportunity for farmer engagement over the project, most farmers involved felt predictions were realistic and that they could use soil probe data to make some early decisions in spring regarding stock sales; stocking rates, feed budgeting and pasture sowing decisions.

Benefits to industry include an increased understanding and use of the soil moisture probe data; an increase in confidence in pasture predictions; interest by the wider advisory and service industry in the technology and hence an opportunity for wider uptake and extension in the future. However, discussion and validation of pasture growth and predictions is critical for ongoing confidence and uptake. There is currently no simple and robust predictive system for Victoria. Farming Forecaster is an example of such a tool with a dashboard but is currently only supported in some regions, depending on funding.

Executive summary

Background

Seasonal variability of pasture growth has increased across southeast Australia in recent decades. Previous research has indicated that soil water content in early spring is a good predictor of pasture growth over the following months, which is crucial to better management of variable seasons. However, this research has been based on biophysical models (to produce predictive tools like AskBill and MLA Rainfall to Pasture tool) but is yet to be validated with real time data for farmers to have confidence to make changes. Farmers and consultants are looking at the probe data for direction on decisions based on soil temperature and the potential to boost winter growth, and how full the soil profile is for potential pasture growth. The knowledge to interpret these predictions could enable early management decisions to either reduce the impact of poor spring pasture growth or optimize the utilization of good springs.

Currently decisions to act and manage unknown and variable winter/spring pasture growth are made based on experience, best estimates given current dryness/wetness of soil, pasture condition and weather forecasts. This project offered a significant advance in management of seasonal climate variability by linking real time data collection to pasture growth forecasts to improve producers' decision making.

The target audience for the project were farmer groups based around soil moisture probes installed by Agriculture Victoria. Specific sites were targeted because they had groups associated with the sites that had an interest in pasture management and the coordinators were keen to be involved and drive this.

Objectives

The main objectives of the project were to:

- model and validate spring pasture production in four paddocks that have soil moisture probes installed, over three successive springs (2019; 2020 and 2021)
- demonstrate and promote the value of soil probe data in the local area for management decisions
- improve management of spring pastures through facilitated farm walks and discussions

Methodology

Pasture growth forecasts were made in the spring season of 2019, 2020 and 2021 at Baynton, Harrow and Dartmoor sites, using the actual soil water content at each site, historical climate data and seasonal forecasts in the Sustainable Grazing Systems (SGS) pasture model.

Pasture cuts were made under cages to make estimations of monthly spring pasture growth (when possible) to validate the predictions.

Farmer discussion groups were held at the end of 2021 to discuss the results and potential uses for the predictions.

Results/key findings

Due to full soil moisture profiles at all sites at the beginning of spring in all years, pasture predictions indicated average to above average spring pasture growth. Coupled with above average spring season climate forecasts in 2020 and 2021, an increase in the amount of feed was predicted and/or an increase in the length of the growing season. This was validated by actual cuts where possible, particularly in year three (2021).

A cost: benefit analysis was therefore not undertaken due to the good seasons over the project; limiting the ability to make and estimate any cost saving decisions. Whilst good spring conditions were predicted, none of the site hosts indicated any early decision making due to this (e.g., cutting hay or silage) but all aimed to utilise the feed with existing stock. Management changes identified by farmers involved for using the soil probe data in the future (particularly in the event of a poor forecast) included: stocking rate decisions; buying and selling of stock; fodder purchases and pasture sowing decisions. The cost: benefit from this range of decisions and cost; price range scenarios was too large an analysis for this project.

The results of the demonstration have increased the access and use of soil probe information for farmers involved (and potentially the wider service provider industry) for decision making in relation to both temperature (pasture sowing and winter boosting) and soil moisture (early spring warning and pasture sowing) so farmers and consultants involved are more likely to use the site for these decisions. Agriculture Victoria will use this information to target newsletter/warnings through its networks at more specific times as indicated by farmers involved. The confidence in the predictions will also likely provide more impetus for farmers involved (and outside the core group through the communications) to try and use future dashboards or software that do this.

Communication activities

Prediction reports (with 'actuals') were published on Agriculture Victoria's Feeding Livestock website and promoted through the Beef Sheep Networks monthly newsflash. Articles on the project have been produced in October Beef Central and in the September and December editions of the GSSA newsletter.

SMS snapshots were sent to site hosts and group co-ordinators over the spring to promote results. The Baynton GSSA group participated in a monthly pasture growth competition by email/text to encourage interest on local pasture growth rates over winter and spring.

Extension activities

Farmer discussion groups were held in year one for all three groups and this provided a base of knowledge and increased interest in both soil moisture probes and pasture growth rates. Pasture predictions were sent by email to the groups and their co-ordinators. Restrictions on field work and group meetings imposed by COVID-19 meant that few or no meetings were held during the spring of 2020 and 2021. The frustrations brought about by this also may have led to poor engagement and feedback from group co-ordinators as little or no communications (such as SMS or predictions) were passed on to group members over much of this period. A virtual meeting held with all co-ordinators and Brendan Cullen at the beginning of 2020, did do this but follow up did not occur. There were also issues regarding group co-ordination that occurred over this period that was outside this project.

A presentation was made at the Hamilton Digital Innovations and Smart Agriculture Festival to approximately 10 producers and 50 service providers. This led to a webinar on technologies used to predict pasture growth, which was attended by 85 producers and advisers (121 registrations with further requests for the recording). Of those who completed the poll, 100 percent said they would recommend the event and the average satisfaction rating was 9/10.

Two webinars were held in early 2022 to promote and discuss the project results and a presentation was given at a GSSA meeting in Penshurst in 2022.

Benefits to industry

The project highlighted the value that soil moisture probes can have in decision making in early spring for stock and feed decisions but also for pasture sowing decisions throughout the year. Engagement with producers at some level may be crucial to ensure confidence in the technology.

Given the increasing installation of soil moisture probes across the state, this project has provided more guidance on how they can be used to assist farmers in their farm management decisions.

Future research and recommendations

Extension is still required about of the benefits of knowing local pasture growth rates and potential pasture production so that the value of increasing production can be understood (e.g., cost benefit of changing pasture species; pasture boosting fertilisers; grazing management etc.

There is interest in the platforms and technologies that are available and emerging for assessing pasture availability and growth rates so there is a need for extension and evaluation of these so that farmers can adopt and use with confidence. There are currently no simple predictive pasture growth tools available in Victoria. For example, the Farming Forecaster platform developed in NSW provides similar predictive information with a simple dashboard and is currently available in NSW and some parts of Tasmania and Western Australia. Farmer discussions and validation is considered to be critical for wider confidence and uptake of tools if and when they develop.

Assisting farmers to set some relevant trigger dates and guidelines for early decisions relevant to their operation, will be critical to adoption in the future.

PDS key data summary table

Project Aim:
The aim of the project is to investigate if we can reliably predict spring pasture growth on a range of sites in Victoria, using real time soil temperature, moisture data and climate information linked together using farm systems models.

	Comments		Unit
Production efficiency benefit (impact) Animal production efficiency - kg LWT/ha; kg LWT/DSE, AE or LSU Pasture productivity – kg DM/ha Stocking rate – DSE, AE or LSU/ha Reproductive efficiency – marking %, weaning % Mortality rate (%)	More reliable pasture establishment	0	Insert unit
Reduction in expenditure Reduction in labour i.e. DSE/FTE, LSU/FTE, AE/FTE; Reduction in other expenditure	Saving in costs relating to stock feeding in a poor spring; saving in costs of 'failed pasture' establishment	0	
Number of core participants engaged in project		4	
Number of observer participants engaged in project		45	
Core group no. ha		5000	
Observer group no. ha		53000	
Core group no. sheep		10000	hd sheep
Observer group no. sheep		105000	hd sheep
Core group no. cattle		1700	hd cattle
Observer group no. cattle		9700	hd cattle
% change in knowledge, skill & confidence – core		0%	
% change in knowledge, skill & confidence – Core and observer	*Understanding of the data from soil moisture probes and how it might assist decision making.*	114% 61% 119% 72%	Knowledge Attitude Skill Confidence/ aspirations
% change in knowledge, skill & confidence – Core and observer	*Assessing pasture availability and growth rates*	44% 26% 40% 23%	Knowledge Attitude Skill Confidence/ aspirations
% practice change adoption – core & observer	*Increase in accessing soil moisture data*	55%	
% practice change adoption – core & observers	*Changed practices through use of soil probe data- not measured due to season*	0%	

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1 Background

The seasonal variability of pasture growth has increased across southeast Australia in recent decades. Previous research has indicated that soil water content in early spring is a good predictor of pasture growth over the following months (Cullen B 2012.; Court J. 2017), which is crucial to better management of variable seasons. However, this research has been based on biophysical models (to produce predictive tools like AskBill and MLA Rainfall to Pasture tool) but hadn't been validated with real time data for farmers to have the confidence to make changes. Soil moisture probes in pastures are creating wide interest but are yet to assist in making early decisions by improving predictions of seasonal conditions. Farmers, consultants and group members are starting to look at the probe data for direction on decisions based on soil temperature and the potential to boost winter growth, and how full the soil profile is for potential pasture growth (with or without rainfall). This would be useful to better predict variable springs and enable early management decisions to either reduce the impact of poor spring pasture growth or optimize the utilization of good springs to meet pasture and/or animal targets. In the less variable environments in southwest Victoria, early predictions of pasture growth in winter and spring may provide opportunities to calculate stock finishing times and weights and hence fill contracts or processor orders with confidence.

Currently decisions to act and manage unknown and variable winter/spring pasture growth are based on experience, best estimates given current dryness/wetness of soil; pasture condition and weather forecasts. This project offers a significant advance in management of seasonal climate variability by linking real time data collection to pasture growth forecasts to improve producers' decision making.

2 Objectives

The main objectives of the project were to:

1. **Model and validate spring pasture production in four paddocks that have soil moisture probes installed and over three successive springs (2019; 2020 and 2021).**

This included two sites at Baynton (different soil types); one at Harrow and one at Dartmoor.

2. **Demonstrate and promote the value of soil probe data in the local area for management decisions.**
3. **Assist local farmers improve management of spring pastures through facilitated farm walks and discussions.**

Spring pasture predictions were produced for four sites for each year using actual soil moisture and seasonal forecasts. Validation cuts were only achieved in 2019 and 2021, due to COVID restrictions preventing site visits. As pasture walks and discussions over spring were not possible in 2020 or 2021 (due also to COVID restrictions), improved management of spring pastures did not occur. Final group meetings and evaluation in the final year did indicate an increase in accessing soil moisture data and an increased understanding of its value for management decisions. The good seasons experienced across the three years also limited the ability to test and discuss options in the tougher years.

3 Demonstration Site Design

3.1 Methodology

3.1.1 Sites and resources

Four paddocks, at four locations with soil moisture probes, were monitored for pasture growth over the winter/spring growing seasons in 2019 and 2021. This included two sites at Baynton (on different soil types); one at Harrow and one at Dartmoor. These were modelled for pasture predictions in 2019, 2020 and 2021. A site at Coojar was added in 2021 to replace one of the Baynton sites. These sites represent a range of soil and pasture types (all perennial based) relevant to the local district. Each site is associated with a producer group (Grasslands Society of Southern Australia (GSSA); Bestwool/Bestlamb and/or BetterBeef) to enable wider group engagement and communications.

3.1.2 Pasture cuts

Pasture cages (three per paddock) were installed on two Baynton sites (basalt and granite soil types) and Harrow. These were cut (using quadrats) and moved monthly from September to the end of the growing season (generally November). Samples were cut to one to two centimetres in year one (as recommended for sheep paddocks grazing) but in year three, closer to paddock availability. Samples were weighed and dried in ovens to estimate kilograms of Dry Matter per hectare (kgDM/ha). Few or no cuts were made in 2020, due to COVID restrictions on field work.

At Dartmoor, cages were destroyed by cattle, so the methodology was changed to suit the farmer's management that included a combination of mowing and/or quadrant cuts, estimates of cattle intake when grazed, and weights of silage/hay harvested from the paddock to estimate pasture growth rate.

3.1.3 Pasture composition

Pasture composition assessments were made at the commencement of the project using the ProGraze stick measure.

3.1.4 Soil sampling

Soil sampling was taken as a random test across each paddock to provide average soil fertility estimates to 10 cm soil depth (standard tests by Nutrient Advantage) to include major nutrients; pH; exchangeable Aluminium and Electrical conductivity (EC). One 80 cm core was taken in each paddock and separated at each soil type/texture change for soil texture analysis. Depth of texture change was recorded to provide a texture profile for the pasture model.

AirTable was used as an online database for recording this data and photos.

3.1.5 Predictive pasture modelling

Pasture growth forecasts were made in the spring season of 2019, 2020 and 2021 at Baynton, Harrow and Dartmoor sites. The general approach was to use the measured Soil Water Content (SWC) on the forecast date for each site (from the Agriculture Victoria soil moisture sensor network, https://extensionaus.com.au/soilmoisturemonitoring/) to initialise the Sustainable Grazing Systems (SGS) pasture model, and then use historical climate data (1990-2019) to predict pasture growth.

SGS Pasture growth simulations

The SGS Pasture model was parameterised for each site by using the local soil type, pasture species and climate data (Table 1). Livestock grazing data was not available from each site, so a rotational grazing system was simulated with the paddock grazed when the biomass exceeded two tonnes DM/ha to a target residual of one tonne DM/ha.

Table 1. Summary of the soil texture, pasture species and weather station data used for in the SGS Pasture model for the Baynton, Harrow, and Dartmoor sites

Site	Soil texture	Pasture species	Weather station
Baynton	0-40 cm: loamy sand 40-60 cm: loam 60-80cm: clay	Phalaris, subclover	Baynton (88073)
Harrow	0-50 cm: clay loam 50-90 cm: clay	Phalaris, subclover	Balmoral (89003)
Dartmoor	0-50 cm: Sandy loam 50-150 cm: clay loam	Phalaris, lucerne, perennial ryegrass	Drik Drik (90036)

The soil water re-set in the SGS Pasture model on the pasture growth forecast dates was determined from the Agriculture Victoria in-field sensors (Fig. 1a). The individual depth sensors were used to determine the SWC in the SGS Pasture model using a relative scale between the historically ‘wet’ and ‘dry’ measurements made by the sensors. In the example in Fig. 1, the sensors show high SWC in late August 2021, reflecting that the soil moisture profile was full at that time, so the SWC was set to field capacity in the SGS Pasture model (Fig. 1b).

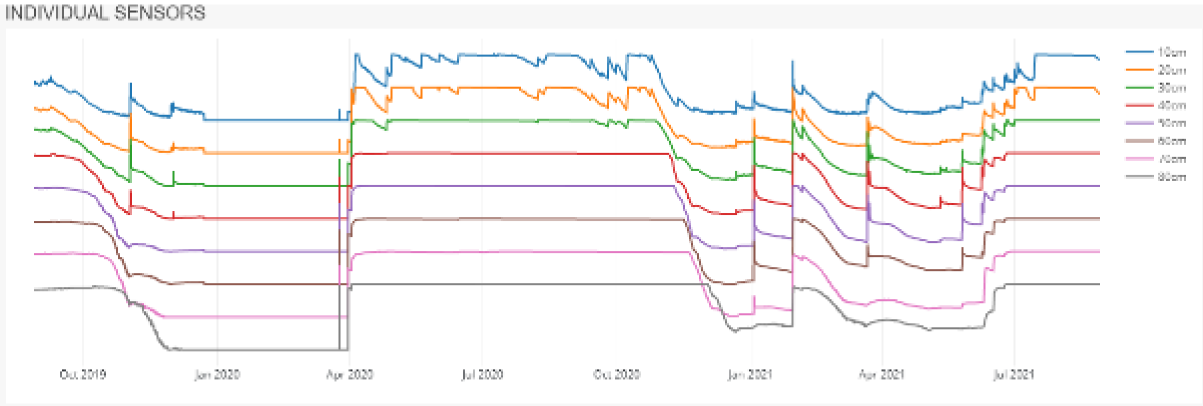
For the historically dry on 1 September simulations, the SWC in the SGS Pasture model was re-set to the predicted SWC on 1 September 1982 (Fig. 2). At Baynton and Harrow, the SWC was quite dry on this date, although Dartmoor was not as dry.

Data analysis and presentation

A long-term simulation (without soil water re-set) was run at each site to predict the pasture growth rate variability, and was used as a comparison with the pasture growth forecasts based on measured SWC. The ‘net positive pasture growth rate’ was used in the pasture forecasts and the data was summarised as the weekly average.

Figure 1. (a) Relative SWC at Banyton from October 2019 to late August 2021 from the Agriculture Victoria soil moisture sensors, and (b) the soil water re-set in 1 September showing that the 'actual' was re-set to close to field capacity (FC).

(a)



(b)

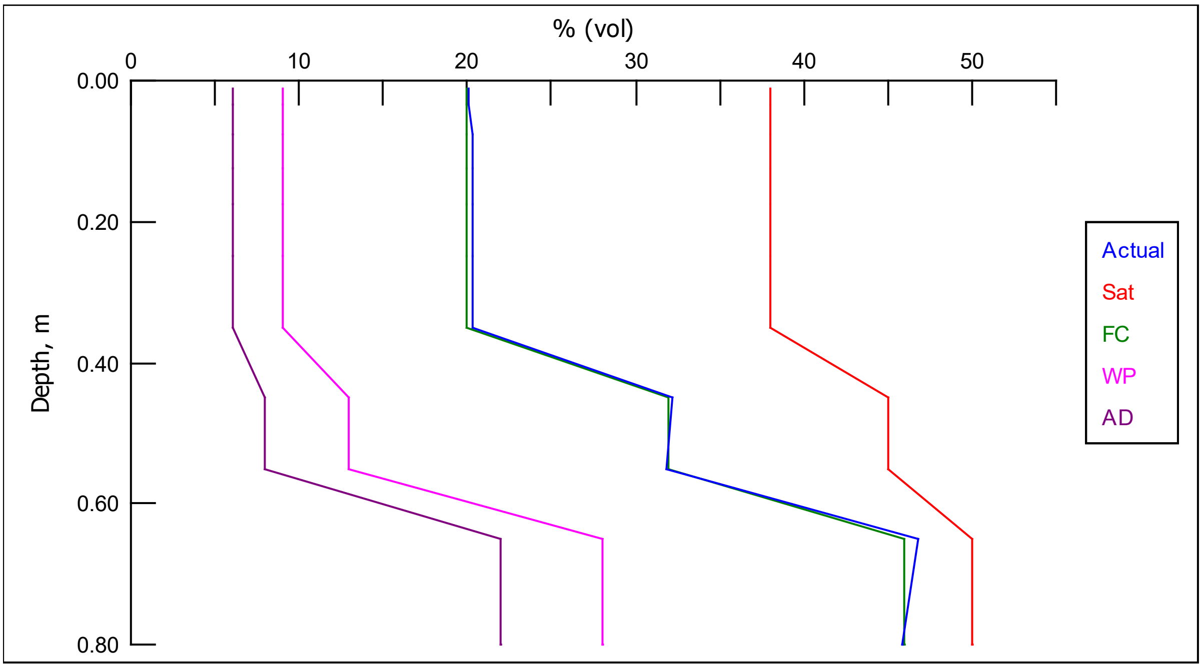
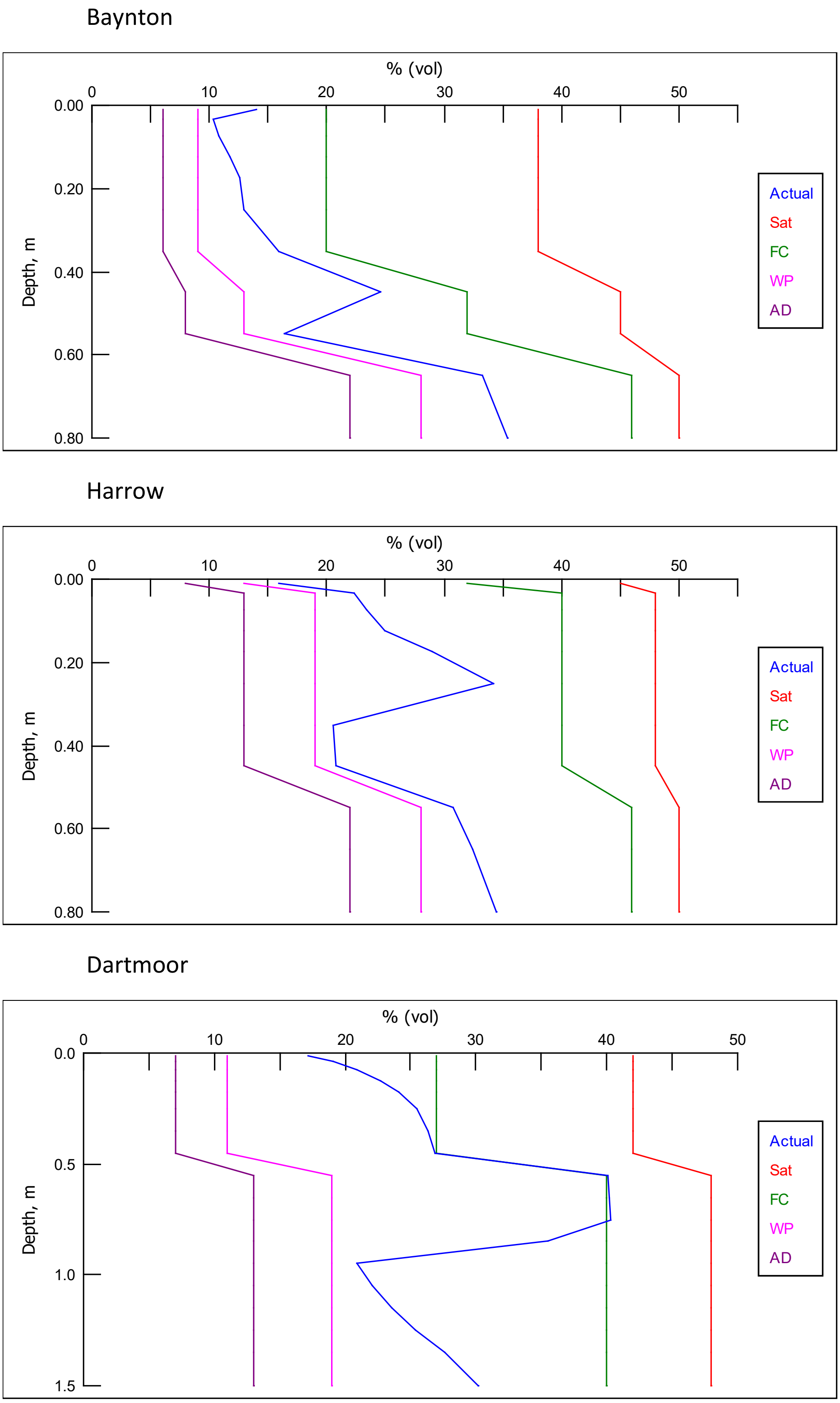


Figure 2. Predicted SWC (%) by soil depth on 1 September 1982 at (a) Baynton, (b Harrow and (c) Dartmoor. The SWC marked as 'actual' was used for the 'dry' 1 September scenario.



3.1.6 Assessment of results and impact

Two to three pasture walks were planned over each winter/spring season to match timing of pasture estimates and discuss modelling predictions and pasture management options pre and post meeting. Modelling predictions were compared to actual. Changes to modelling parameters were made to improve predictions if required. Options and impacts of management decisions were recorded and reported. The original plan was to use these decisions for economic analysis.

In addition, metrics such as number of site visitors, media and conference engagement and presentations at wider community field days were used to measure impact. Unfortunately, many of the planned activities did not occur however KASA surveys were conducted as group meetings (or post via Microsoft Forms) at the start and end. Webinars held collected registration details and some poll results.

3.2 Economic analysis

No economic analysis was completed due to the consistent good seasons that occurred over the project (and hence no management decision/changes made) and the complexity of analysing the range of price scenarios and potential decision options. The project was conducted over three good springs.

3.3 Extension and communication

Planned extension and communication activites included:

- Articles in the GSSA newsletter; Agriculture Victoria's SheepNotes and soil moisture newsletters; one article in Beef Central
- Presentations at field days and webinars
- Group meetings/ pasture walks each year

At the completion of the demonstration, it will include, as a minimum (over the next 12 months):

- Presentations of final results (face-to-face, phone seminar or webinar) for each group
- **1** Fact sheet
- **1** Final report

3.4 Monitoring and evaluation

Group walks were planned as part of the group's meetings, held as BWBL, BetterBeef, GSSA meetings. Table 2 outlines the scheduled timing of activities.

Table 2. Scheduled timing of activities

Month/ Year	Detail of activity	Evaluation
July 2019	Soil and texture sampling Pasture cages installed Composition assessment – farm walk and discussion SGS model set up and validation	Composition and KASA
September	Assess pasture growth Pasture prediction report	
October	Assess pasture growth Pasture prediction report	
September 2020	Assess pasture growth Pasture prediction report	
October	Assess pasture growth Pasture prediction report Farm walks and discussions	Feedback – decisions and validation
September 2021	Assess pasture growth- cuts at 3 sites Model predictions	
October	Assess pasture growth Model predictions Share predictions/ webpage & SMS	
November	Assess pasture growth Model predictions	
December	Assess pasture growth Review curves predicted V's actual Group meetings	Decisions and KASA

4 Results

4.1 Soil tests and pasture composition

All paddocks were sampled, and soil tested (Appendix 7.1) to a depth of 10 centimetres and tested for soil texture to a depth of 80 centimetres (Appendix 7.1). These were used to set up the SGS predictive model. Both the sites at Baynton were acidic (pH $CaCl_2$ < 5.5) and had an Olsen P of over 15. Pasture composition was assessed in winter in 2019 (Appendix 7.1).

Both the Baynton sites (basalt and granite) are phalaris based (most likely Australian cultivar) with other species present such as annual grasses and broadleaf species. The granite site had far less phalaris in the pasture (23 percent) but higher clover and these species will affect pasture growth rates. Figs. 3 and 4 show the pastures at the start of the demonstration at the basalt site and granite site, respectively. Both sites were also predominantly grazed by sheep, with some cattle grazing also, and were dense pastures.

Figure 3: Pasture under a pasture cage at Baynton basalt site with composition in 2019.

Figure 4: Pasture under a pasture cage at the Baynton granite site with composition in 2019.

The pasture composition in the Harrow site paddock had few weeds and a high percentage of balansa clover (Fig. 5).

Figure 5. High clover pasture spring 2019 Harrow.

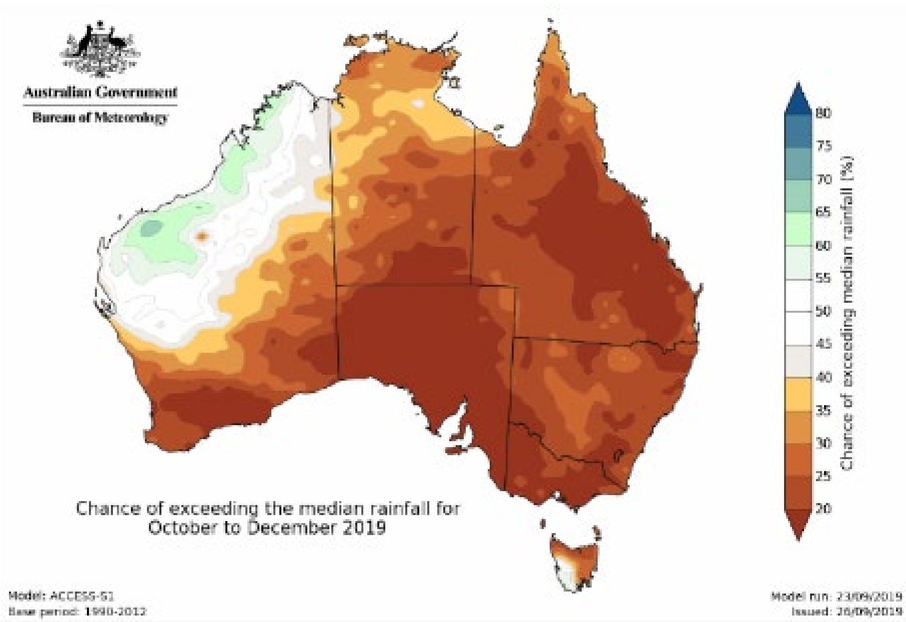
The pasture at the Dartmoor site is a lucerne/phalaris/ryegrass mix that was cut for hay and silage as well as grazed by cattle and so was a less dense pasture than the other sites. Figure 6 shows the pasture at the Dartmoor site in the spring of 2019. The cattle destroyed cages in the first year, so grazing days with pasture assessments in and out, plus fodder harvested (hay and silage) were used to estimate pasture production and growth rates.

Figure 6. Dartmoor pasture spring 2019.

4.2 The season and predictions Year 1 - 2019

Soil moisture at the beginning of spring in 2019 was wetter than 2018 however the soil profile was not quite full at Harrow and Baynton and close to full at Dartmoor. The pasture predictions for Harrow and Baynton were for an 'average' spring based on soil moisture on 1st September 2019 and using historic average rainfall. Climate predictions for a warmer and drier spring (Figure 7), were not included in the model in this year.

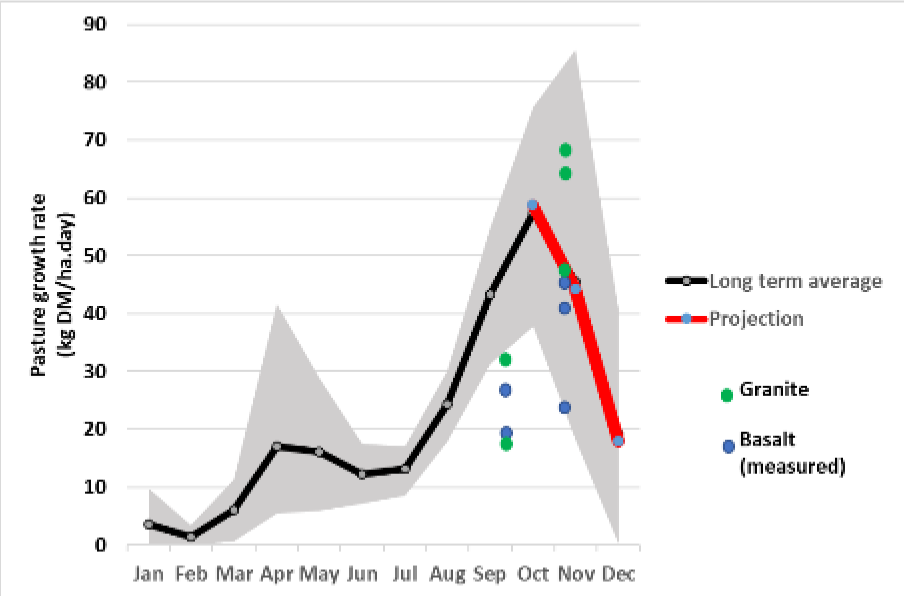
Figure 7. Seasonal rainfall outlook map for October to December 2019, Source BoM.



4.2.1 Baynton

The predictions for spring, based on soil moisture on 1st September, was for an average spring on both soil types as shown in Fig. 8. The line represents the long-term average (1990-2018) as predicted by the SGS model and the shaded area represents the range. The dots represent actual measures for each cage at the two sites, with the averages sitting close to the predicted lines for the granite site. The basalt measured growth rates were lower but generally within the shaded area.

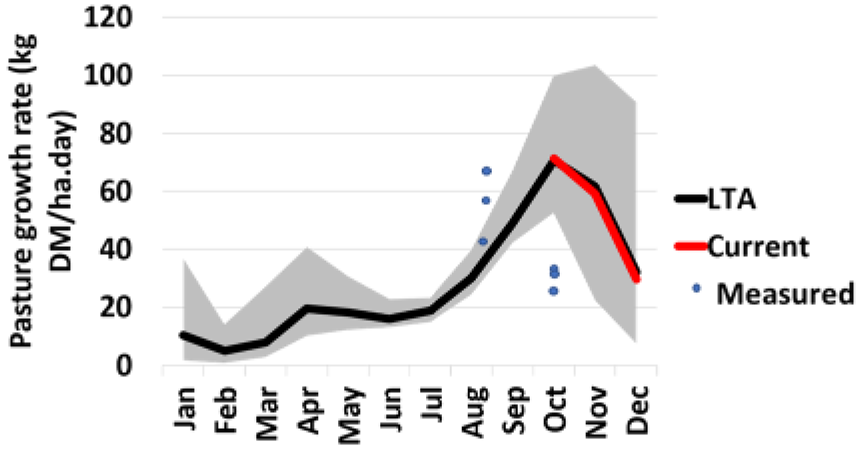
Figure 8. Long term average pasture growth rate at Baynton sites (1990-2018) with measured pasture growth under each cage at the basalt and granite soil site.



4.2.2 Harrow

The predicted pasture curve for Harrow shows that the actual growth was above average for August, but by September/October this pasture had peaked early and dropped to below average (Fig. 9). The August/September measured pasture growth of 60 kg Dry Matter (DM)/ha was in the higher end of the average predicted range and the 30 kg DM/ha/day from mid-September to mid-October was well below. The pasture cuts match the predicted pasture growth if the spring peak curve is moved about a month earlier. The likely reason for this, was that total potential yield may have been reached early. Yield was assessed at about six to seven tonnes of dry matter per hectare on the day of cutting and combined with earlier grazing, the pasture had probably produced at least eight tonnes of dry matter per hectare. It had been grazed with 50 lambs per hectare and they had kept up with pasture growth (which tallies with the growth rates of >60 kg DM/ha/day at that period). The balansa clover will have contributed to early growth and this may be a more feasible reason for the drop off in production in October, than moisture stress.

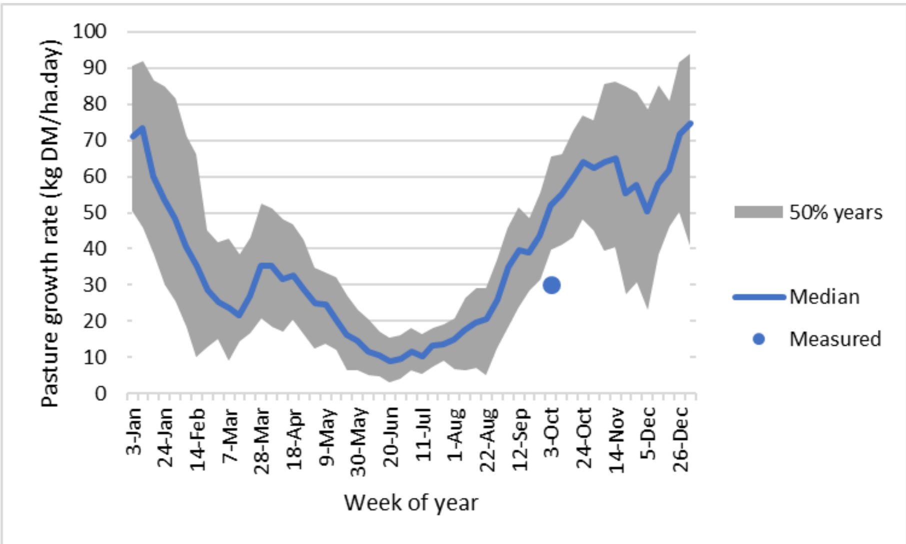
Figure 9. Long term pasture growth rates for Harrow with predictions for spring 2019 in red and measured pasture cuts.



4.2.3 Dartmoor

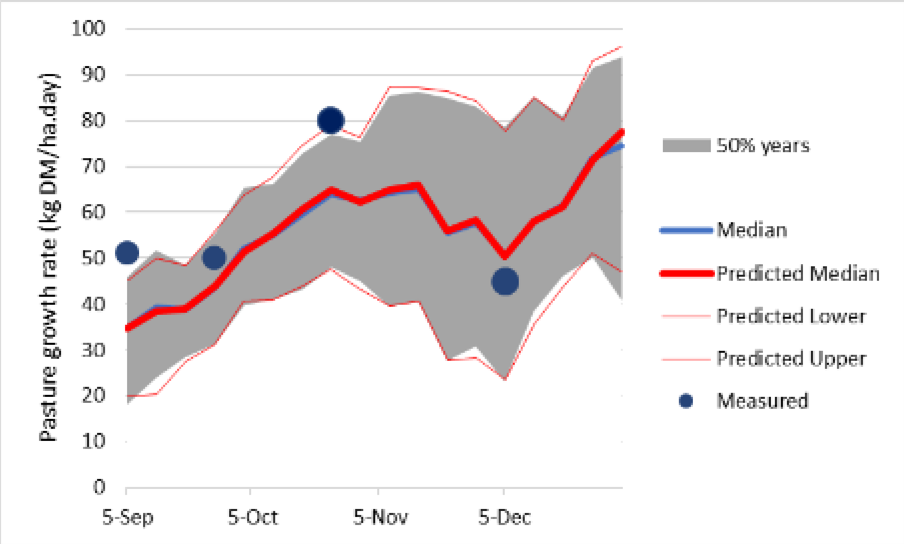
The measured growth at Dartmoor for October was well below average and predicted at 30 kg DM/ha/day (Fig. 10) and this was thought to be due to growth rate post silage removal. Future cuts also illustrated that the locking up and cutting of this paddock led to a lower density pasture than it appears and hence lower growth rates. For example, at one inspection, the pasture was visually estimated to be about seven tonnes DM/ha, but cuts indicated closer to three tonne DM/ha.

Figure 10. Long term average pasture growth rate at Dartmoor with one measured cut.



Given the extended growing season of the lucerne at this site, some measures/estimates (from silage or hay cuts) were made over summer (Fig. 11). The estimates are included in Table 15 in Appendix 7.1.3). The summer growth, driven by the lucerne (70 kg DM/ha/day over December and January) was not reflected in the initial modelled growth curves in 2019, but this was refined in 2020 leading to good agreement between the measured and modelled values (Fig. 11).

Figure 11. Average weekly pasture growth rates for Dartmoor for long term average (2012-2020) and 2019/20 and cuts.



4.2.4 Summary 2019

Overall, pasture cuts were generally within the predictive estimate variation, with some outliers that can be attributed to grazing management and pasture species. The Dartmoor growth curve required some refinement to reflect the later spring and summer growth from the lucerne.

There was little knowledge about local pasture growth rates and the reporting of growth rates was new to most farmers. Therefore, measuring and monitoring growth rates over a number of growing seasons will be required to build this knowledge. Long term annual average growth rates (as modelled through the SGS site) were therefore provided for each site in 2021.

4.3 Year 2 – 2020

The spring season forecast in 2020 was for a 70 percent chance above median spring rainfall across the state. All sites had full moisture profiles at the beginning of September and were predicted to have above average spring pasture growth.

A planning meeting was held with the project team (group coordinators and Brendan Cullen) before spring and started with good intensions for activities as planned. Due to restrictions brought on by COVID-19 in 2020, very few planned pasture cuts or estimates were made, and no farmer discussion groups were held. The predictions for 2020 are provided in Appendix 7.2.

The central ranges branch of GSSA managed to set up (run by local farmers/agronomist and contractor) trials on both the basalt and granite sites, to look at the impact of gibberellic acid (GA) and urea (as eziN or liquid Nitrogen) on pasture growth rates, as identified to be of interest by the group.

Given the interest, and lack of knowledge on pasture growth rates locally, long term pasture growth rates were provided from the SGS model.

4.3.1 Average annual growth rates 2020

Baynton

Long term average pasture growth rates were generated by the SGS model for both the basalt and granite soils (Figs. 12 and 13 respectively). The shaded areas around the median (blue line) represent the 25th to 75th percentiles.

Figure 12. Long term average weekly growth rates for Baynton basalt site.

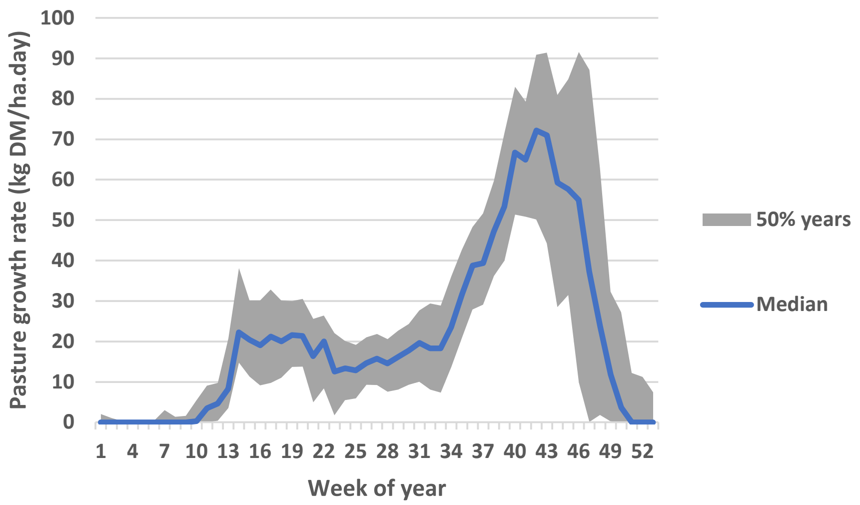
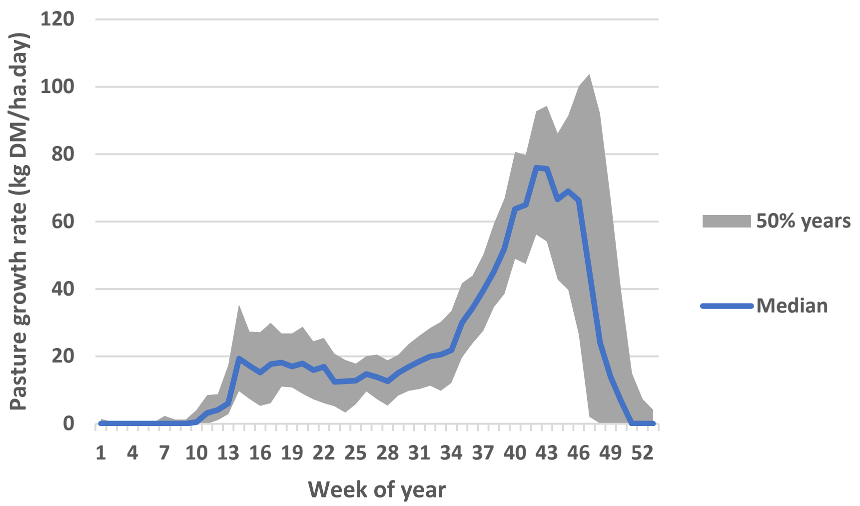


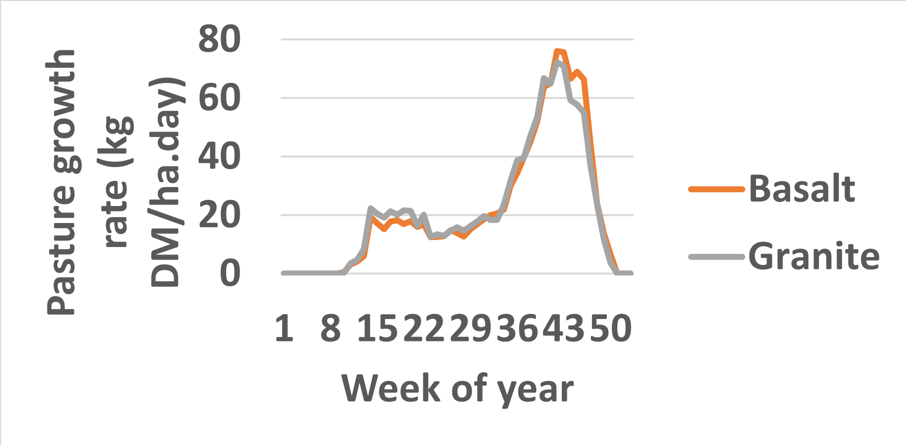
Figure 13. Long term average weekly growth rates for Baynton granite site with the 25-75th percentiles shown as shaded area.



Granite soil performance compared to basalt soil

Soil moisture probes were installed on both granite and basalt soil types as these soil type differences were considered locally to be the biggest differences in pasture growth rates and soil moisture storage/uptake. In the SGS model, the granite soil was shown to start better in autumn but has a shorter spring peak (Fig. 14). As the model didn't reflect the size of the differences observed by local farmers, it was decided to only make predictions for one site (granite) but include the pasture cut validations for both (when available).

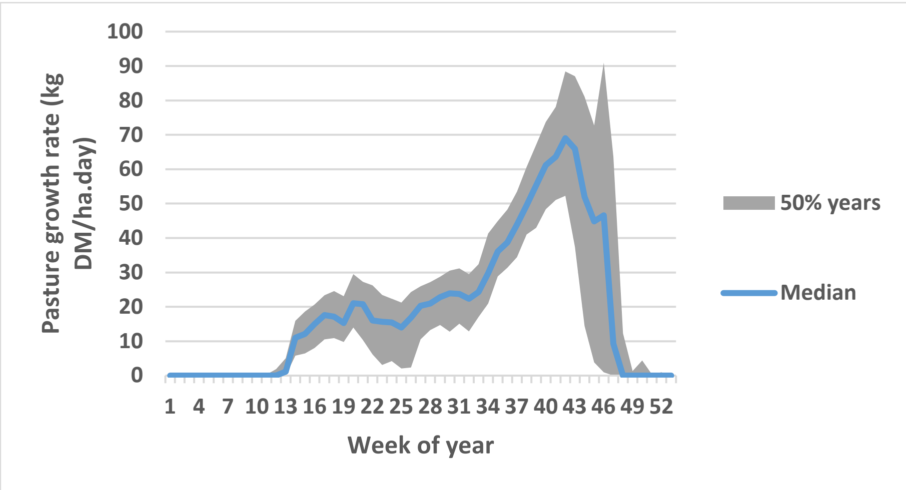
Figure 14. Long term pasture growth rates for the Baynton basalt and granite soils.



Harrow

No pasture cuts or farmer group discussions were held for Harrow in 2020. The long term average pasture growth rate was generated for this site and is presented in Fig. 15, with the 25th and 75th percentiles shown as the shaded areas.

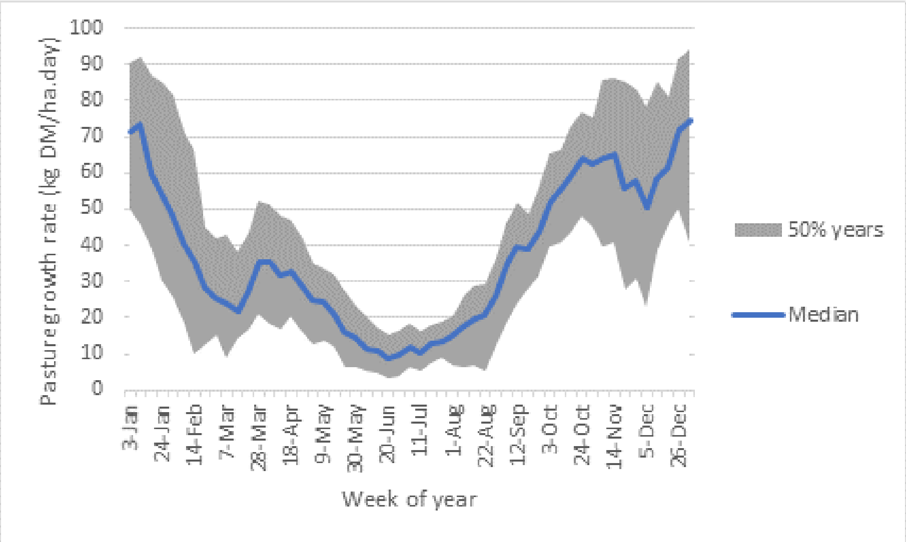
Figure 15. Long term average weekly growth rates at Harrow, with 25th to 75th percentiles shown as the shaded area.



Dartmoor

Given the modelled pasture growth rates for Dartmoor were underestimating summer and autumn, ryegrass was added to the model which lifted the autumn – winter growth but also extended into summer (Fig. 16). This was felt to be a better fit with the previous year's measurements and the local agronomist's experience.

Figure 16. Long term weekly pasture growth rates for Dartmoor.

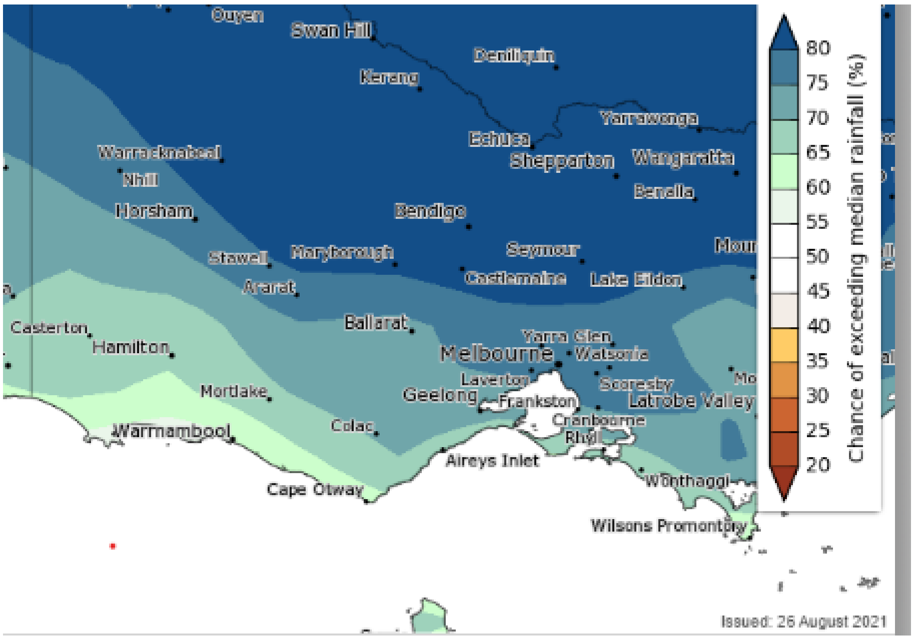


4.4 Year 3 – 2021

The situation at the end of winter in 2021 was almost precisely the same as at the end of winter in 2020. There was a full soil moisture profile at all sites and a seasonal forecast for above median spring rainfall. The BoM spring seasonal forecast (Fig. 17) showed a 75 percent chance of above medium rainfall at Baynton and 65 percent at Harrow, Coojar and Dartmoor. The Coojar site was included this year, (see below) given only one Baynton site was modelled.

The pasture growth forecasts therefore were the same and are reported here. Since the full soil water profile at end of august is 'usual' the growth forecasts based on it only are the same as the long -term prediction. With the seasonal forecast an extended spring season was predicted.

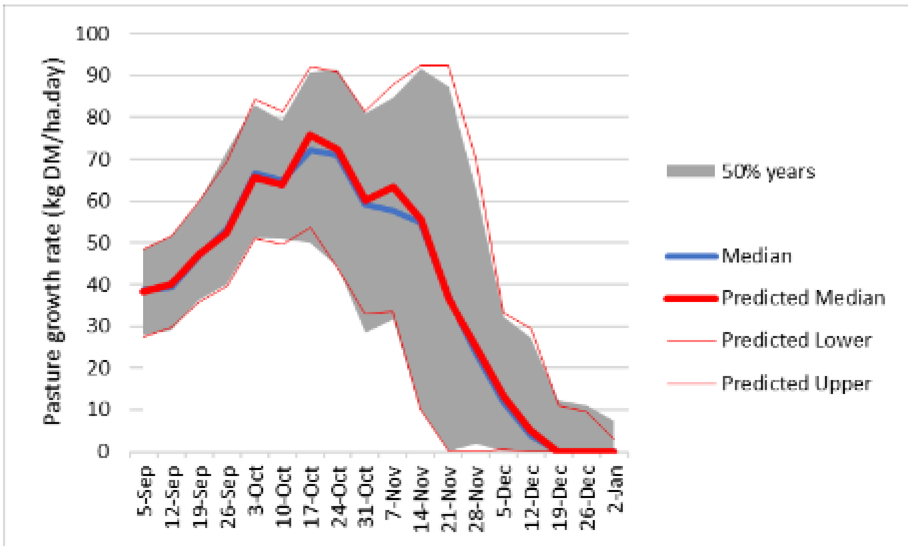
Figure 17. Bureau of Meteorology Spring (September-November) 2021 rainfall outlook for western Victoria. (Source: Australian Bureau of Meteorology http://www.bom.gov.au/climate/outlooks/#/rainfall/median/seasonal/0, accessed 26 August 2021).



4.4.1 Baynton

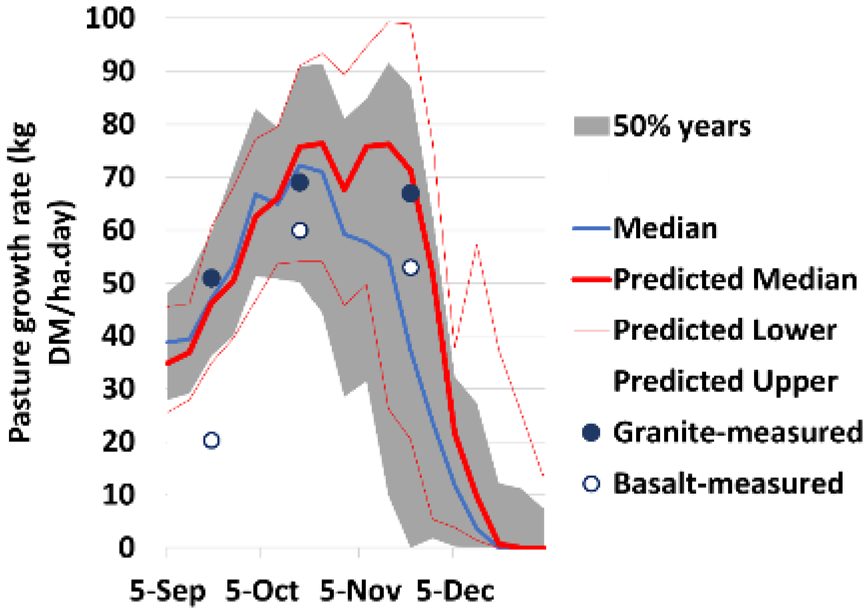
In general, the spring seasonal prediction was very similar to 2020 for the Baynton sites. Prediction based on soil water only was very similar to the long term average, with a slightly higher prediction in mid-October to mid-November (Fig. 18). With the projection for higher chance of above median spring rainfall, the growing season was predicted to extend for 3-4 weeks (Fig. 19).

Figure 18. Pasture growth prediction from 1 September 2021 based on soil water content only at Baynton.



Pasture cuts (Fig. 19) over the season at both the basalt and granite sites generally fitted well with the predictions, albeit a slow start on the granite in August (16 kgDM/ha/day) but a rapid increase in the following months. The basalt was slower to respond (as expected) and although the growth rate measured for November was slightly lower than the granite, the pasture was less advanced in maturity/reproduction than the granite site (as observed under the cages). Of note also was the large variation between cages, particularly at the granite soil paddock (Fig. 8 in 2019) and this recognizes the limitations of measuring pasture growth using cages in demonstration sites, with limited resources.

Figure 19. Pasture growth prediction from 1 September 2021 based on soil water content and seasonal forecast for 75% chance of above median spring rainfall at Baynton, with measured cuts.



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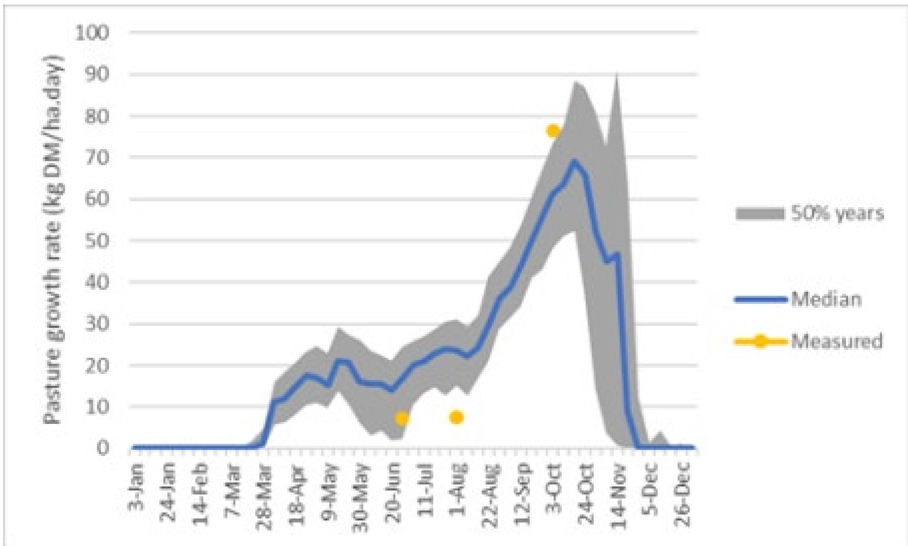
4.4.2 Harrow

The prediction for Harrow was very similar to 2020. Based on soil water on September 1st only, it was similar to long term spring pasture production, with a slightly higher prediction in early- mid November (Fig. 21). With the projection for higher chance of above median spring rainfall (65 percent at Harrow), the growing season was predicted to extend for 2 weeks (Fig.22).

Given the interest in winter pasture growth rates, cuts were included for June and July (marked on Fig. 20). Soil temperature was lower over the winter of 2021, and this was reflected in below average growth rates measured under cages compared to the long-term average shown in Fig. 20.

Figure 20. Long term weekly pasture growth rates for Harrow, with measured winter and early spring growth rates.



The early spring (September) growth rate measures were at the top of the modelled prediction, but within the range, taking into account the early season growth of balansa clover in this pasture, as noted in 2019 (Figs. 20 and 22).

Figure 21. Pasture growth prediction from 1 September 2021 based on soil water content only at Harrow.

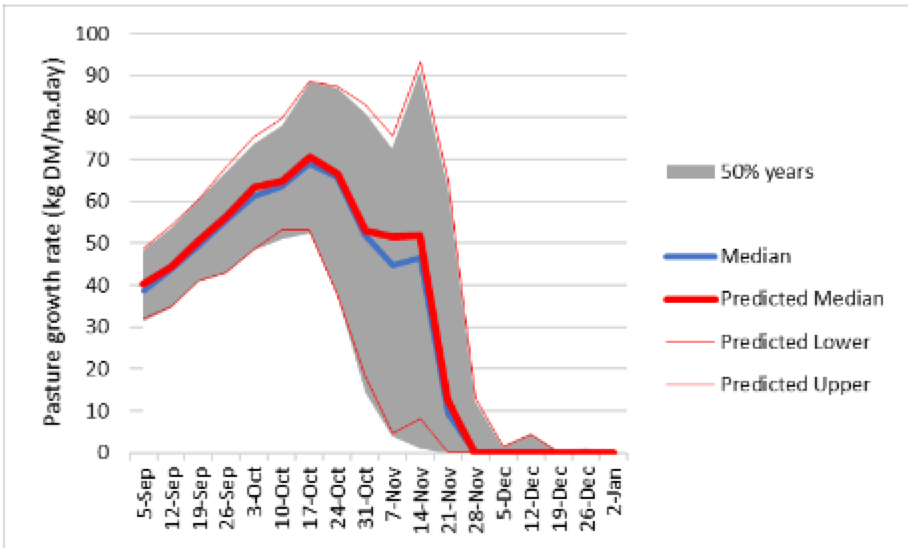
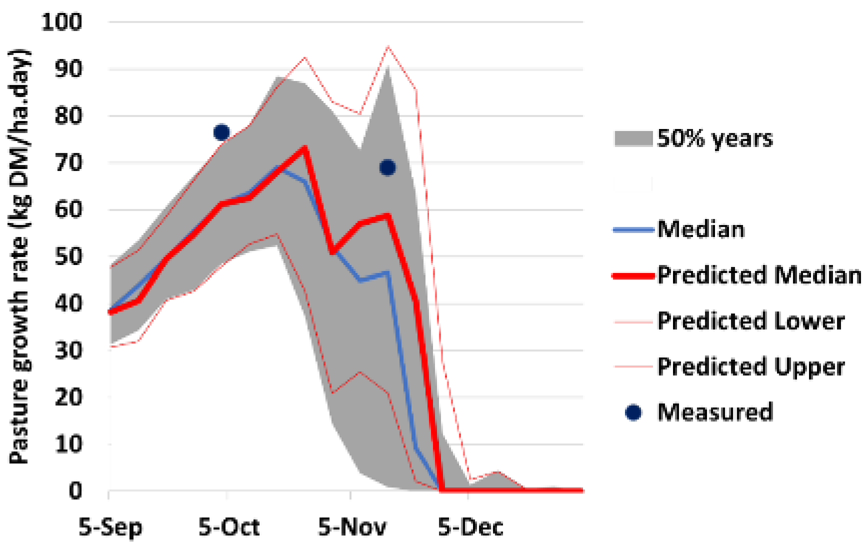
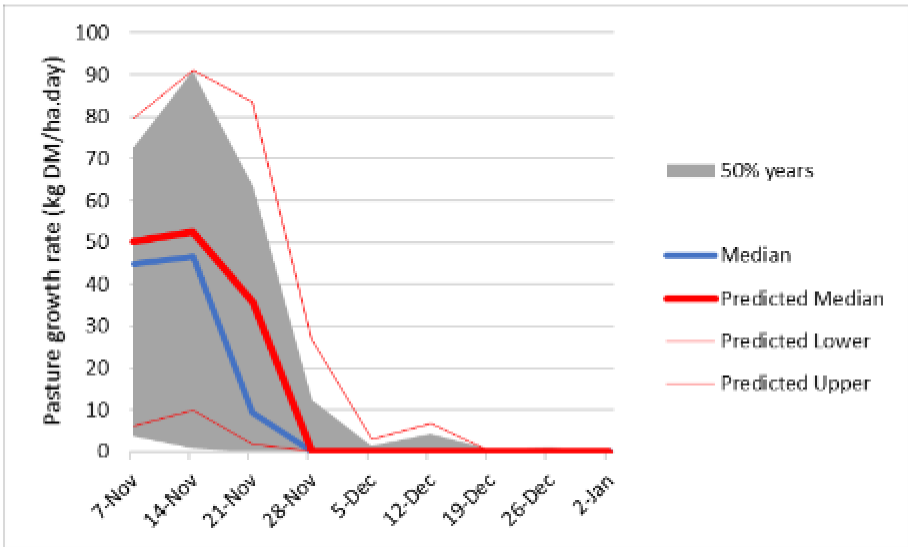


Figure 22. Pasture growth prediction from 1 September 2021 based on soil water content and seasonal forecast for 65% chance of above median spring rainfall at Harrow with measured pasture growth rates for spring.



Predictions were updated monthly (i.e., October and November) for each site, but as generally the season continued to be a good one, these are not included. In November, the soil water content was drier in the top 40 centimetres compared to early October when the profile was full. On the 8th of November 2021, soil water content was approximately 30 percent at Harrow, but the predicted growth based on November moisture, was still for above average growth rates (Fig. 23).

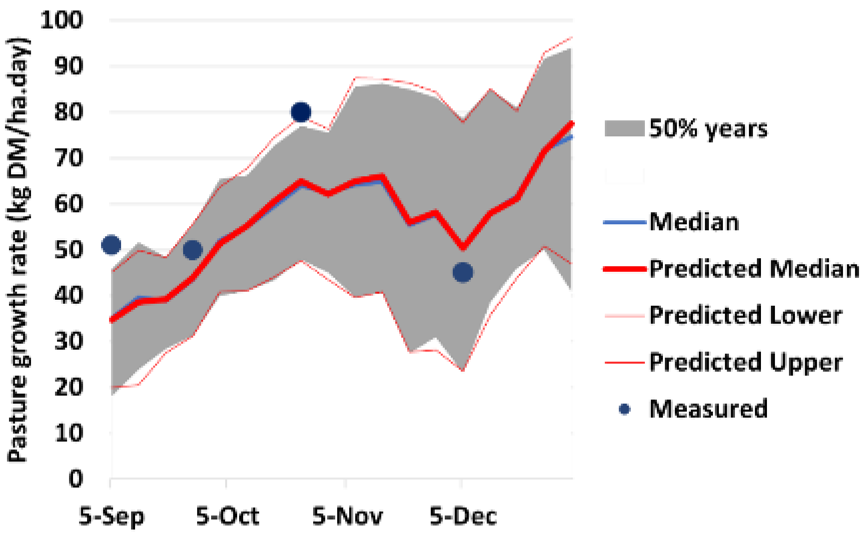
Figure 23. Pasture growth prediction from 8 November 2021 based on soil water content and seasonal forecast for 65% chance of above median spring rainfall at Harrow.



4.4.3 Dartmoor

The predictions for spring at Dartmoor, were close to the long-term average. The pasture cuts/estimations fitted within the predicted range (Fig. 24), recognizing that the locking up and cutting over spring was very different management compared to the other sites.

Figure 24. Pasture growth prediction for Dartmoor from 5th September 2021 based on soil water content and seasonal forecast for 65% chance of above median spring rainfall with measured growth.

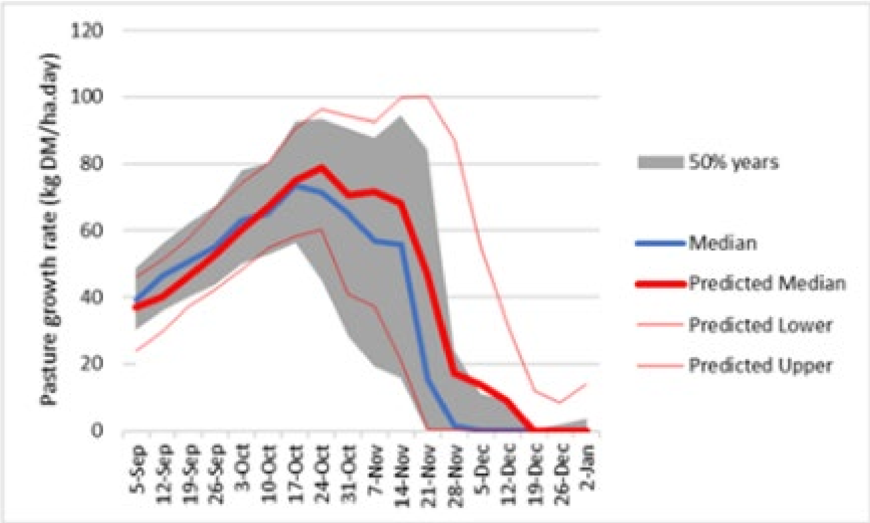


4.4.4 Coojar

A further site in southwest Victoria at Coojar was added for the final year. This site was part of Pastures from Space modelling with Southern Farming Systems (SFS), so it was considered a good opportunity to utilise their calibrations. Unfortunately, due to COVID-19 restrictions, few calibration cuts were made.

Coojar has a similar pasture growth pattern to Harrow but with a slightly longer spring growing season. Prediction based on soil water only was very similar to long term, just a slightly higher reduction in early- mid November. With the projection for higher chance of above median spring rainfall, the growing season was predicted to extend for 3-4 weeks (Fig. 25).

Figure 25. Pasture growth prediction from 1st September 2021 based on soil water and seasonal forecast for 75 percent chance of above median rainfall at Coojar.



4.5 Spring Whoosh

Whilst moisture was not limiting at any sites in the lead up to spring, low soil temperatures over winter were limiting at some sites. We therefore looked at when temperature (air temperature as the main limitation to photosynthesis) was likely to be 'non limiting.' The SGS model estimated the following dates when close to maximum (80%) photosynthesis was achieved, using climate data from 1990-2019 (Table 3) and non-limiting at 90% (0.9 on =15°C daytime temperature). To reach the 0.9 level, it was estimated to occur three to four weeks later.

Violet town was included as another soil probe site in the northeast, to illustrate the variation across the state. Baynton is significantly later to take off at the end of September compared to the other sites in late August to early September.

Table 3. Estimated dates for reaching maximum photosynthesis 0.8 (80%) and 0.9

	0.8	**0.9** **15°C**
Violet Town	29 Aug	22 Sep
Baynton	27 Sep	15 Oct
Pigeon Ponds	3-Sep	27 Sep
Coojar	3 Sep	2 Oct
Dartmoor	5-sep	22 Sep

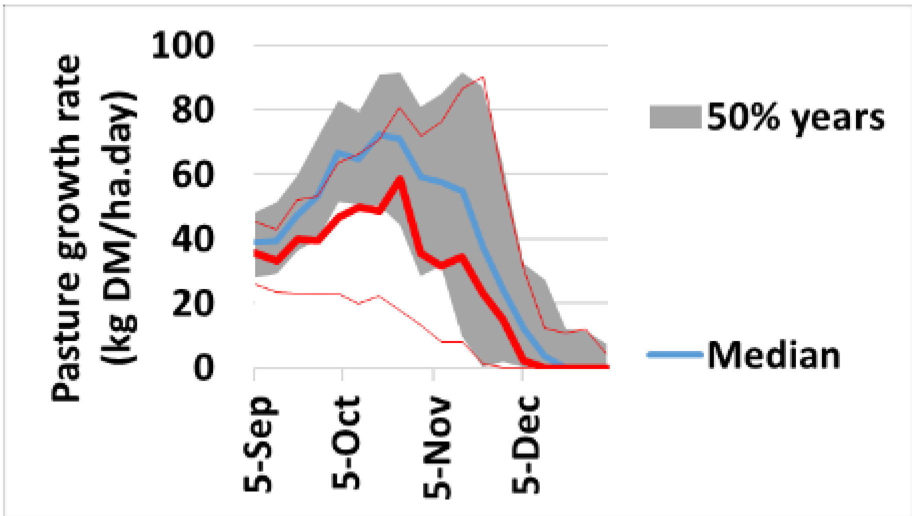
4.6 What if a dry start?

As the project did not experience a dry start over the three years, we looked at what the predictions would have been, given a low soil moisture at the start of spring (based on the soil moisture on September 1st as in 1982 (modelled) or in 2006 at Coojar site (with a half full moisture profile).

4.6.1 Baynton

At Baynton, using the granite soil type, if soil moisture was historically low on 1st September, then lower growth and a shorter growing season is predicted (Fig. 26). With no seasonal rainfall predictions included, the dry start was estimated as a loss of 1,450 kg DM/ha over the period from 1st September to 31st December, and a shorter season.

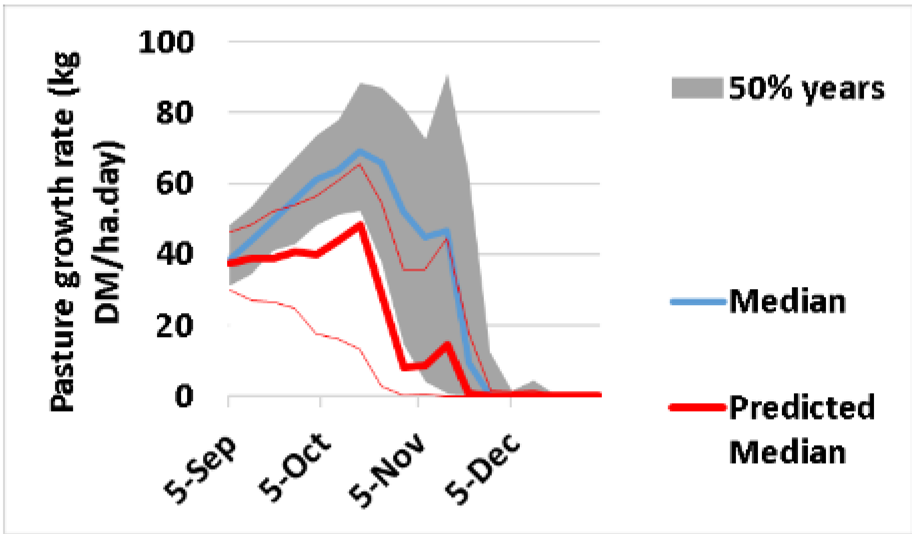
Figure 26. Predicted spring pasture growth with low starting soil moisture (as occurred in 1982) with long term median growth rates at Baynton (granite soil).



4.6.2 Harrow

Similarly, the low soil moisture as experienced in 1982, led to a significantly lower than average prediction for the spring (Fig. 27) and an estimated loss from 1st September to 31st December of approximately 1,750 kgDM/ha, without including a poor seasonal outlook.

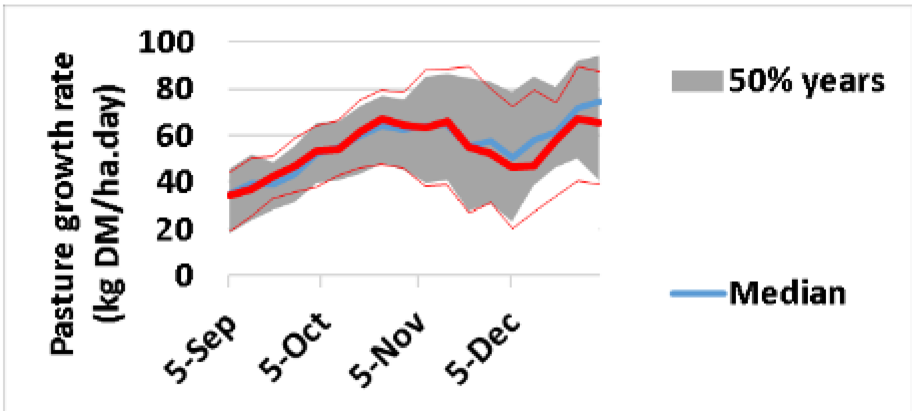
Figure 27. Predicted spring pasture growth with low starting soil moisture (as occurred in 1982) with long term median growth rates at Harrow.



4.6.3 Dartmoor

At Dartmoor, the rainfall is more reliable and even with a starting point as estimated for September in 1982, the predictions for the season were close to average with a slight drop off at the end of summer (Fig. 28).

Figure 28. Predicted spring pasture growth with low starting soil moisture (as occurred in 1982) with long term median growth rates at Dartmoor.

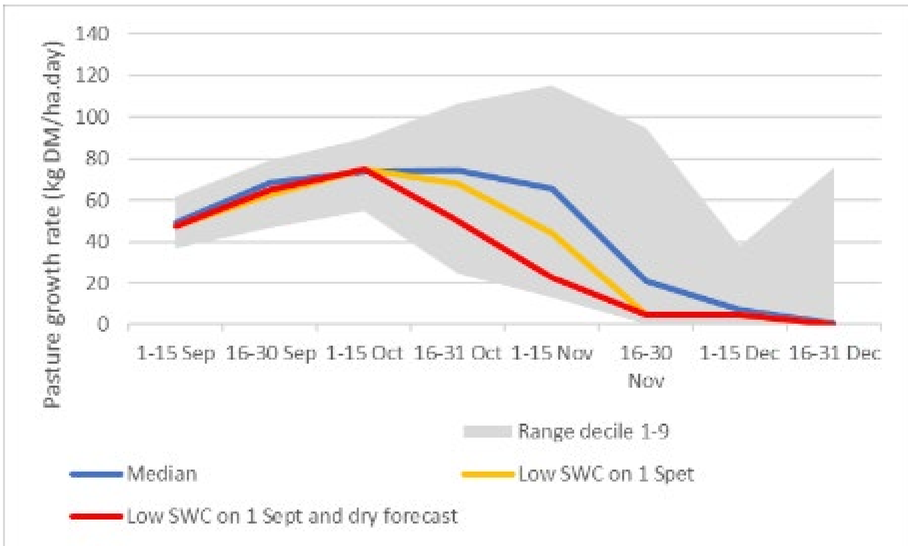


4.6.4 Coojar

The effect of historically low soil water content on spring pasture growth was simulated using the soil water content (from model) on 1st September 2006 as a starting point. The soil profile was approximately half full on this date.

The effect of historically low soil water content on 1st September on the predicted median spring pasture growth rates shows a contraction of the growing season by about two weeks compared with the long-term median (Fig. 29). When low soil water content on 1st September is combined with a seasonal forecast predicting 70 percent change of below median rainfall, there is a further contraction of the median predicted growth rate by about two weeks (Fig. 29).

Figure 29. Predicted spring pasture growth with low starting soil moisture (as occurred in 2006) on 1st September and coupled with a dry forecast compared to long term median growth rates at Coojar.



4.7 Cost: Benefit analysis

Previous work has studied the effect of early droughts (1982; 2002 and 2006) on prices over spring for livestock and fodder (Court, and Court et al., 2017). This study showed that mature livestock (as cows and wethers) dropped by 30 percent and 50 percent (respectively) by December compared to non-drought years. Hence the early sales of surplus or cull stock (also likely to be in better condition) had the potential to provide better returns (plus less feeding costs) if a decision was made early in the spring. The study also showed that hay and grain (as feed wheat) increased by over 100 percent in the 2002 and 2006 droughts (and carried on over the following year) and so provided further cost savings by early purchasing. This was reflected in the presentation by Tim Leeming in the final webinar through his experiences of making decisions in 2006 (Probing soil moisture – making early decisions).

A follow up study (unpublished) showed that the more recent drought in Victoria (2015/16) was different. Mature animals maintained value, but lambs fell over spring more than in other years. The many variables including enterprises, timing of management practices (e.g., lambing and shearing); size of operation and prices that could be used, mean that the potential outcomes and cost savings are numerous.

Given the numerous price and cost variations that have occurred in the past and the numerous enterprise and management scenarios that occur on farm, a modelled cost: benefit analysis was considered to be too large a task to be undertaken for this project. Some of the price scenarios were presented at the Probing Soil Moisture webinar as a stimulator for farmers in early decision making where a poor spring forecast is made.

Farmers in the three groups did generally identify that the soil moisture probes could assist with early decision making of selling stock or buying fodder if soil moisture was low in late winter. The Dartmoor group felt that this more unlikely i.e., they have a history of having full or close to full soil moisture at the beginning of spring, and pasture sowing decisions (e.g., in late spring) was a more likely, useful decision based on soil moisture at the time.

A current cost:benefit analysis was not undertaken due to the good seasons over the project; limiting the ability to make some cost saving decisions. Of note that whilst good spring conditions were predicted, none of the site hosts indicated any early decision making due to this (e.g., cutting hay or silage) but all aimed to utilise the feed with existing stock numbers.

A summary of the early decisions identified included:

- Buy or sell stock early – avoid stock price drops (as in 2002 and 2006) and reduce the numbers of stock to feed and water
- Buy feed early – avoid price hikes (e.g., $200/t for hay in 2002 and 2006 and approximately $35/t in 2016 and grain increases of over $150/t in 2002 and 2006), but also accessing/assuring supply and quality
- Pasture sowing decisions – optimising soil moisture and temperature, utilising additives like urea to boost growth

4.8 Communication and Extension

Farmer discussion groups were held in year one for all three groups and this provided a base of knowledge and interest in both soil moisture probes and pasture growth rates. Pasture predictions were sent by email to the groups/co-ordinators in 2020 and 2021 but given the poor interest and engagement by co-ordinators over the COVID-19 restrictions, it was doubtful that much of this was passed on to group members. The lack of co-ordinator engagement with groups over 2020, followed into the 2021 period, due to group meeting disillusionment/frustration but also due to issues with group leadership. Much of this has been resolved with renewed enthusiasm and activity in at least two of these groups. It did however make it difficult to share information over these last two years, as requests for feedback, information sent, etc were relied on to be forwarded by group co-ordinators.

SMS snapshots were sent to site hosts and group co-ordinators over the spring to promote results and encourage farmers to look at the local soil moisture probe on the ExtensionAus website. Figs. 30 and 31 show examples of texts sent.

The Baynton GSSA group have participated in a monthly pasture growth competition by email/text to encourage interest on local pasture growth rates over winter and spring.

Figure 30. Example of SMS snapshot for Dartmoor

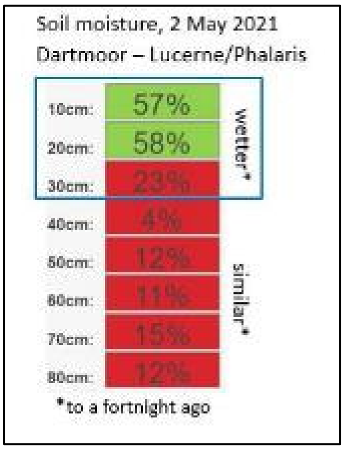
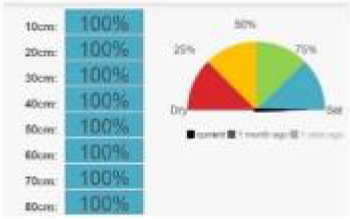


Figure 31. Example of SMS on 'spring whoosh'

Spring Whoosh!



Moisture is certainly not limiting at any PDS sites so we asked Brendan to look at when temperature (air temp. as the main limitation to photosynthesis and hence growth rates) and came up with the following dates (long term average) for when close to maximum (80%). These dates look comparable to the sharp increases on the growth curves.

Estimated dates for reaching maximum photosynthesis (80%)

Baynton	27 Sep
Pigeon Ponds	3-Sep
Coojar	3 Sep
Dartmoor	5-sep

Current soil Temperatures (10 cm)

Average 11-aug-17-1-aug

	2020	**2021**
Baynton	7.9°	7.6°
Pigeon Ponds	8.3°	8.0°
Harrow	8.2°	8.5°

Prediction reports (with 'actuals') were published on Agriculture Victoria's Feeding Livestock website and promoted through the producer network monthly newsflash.

Articles on the project have been produced in October Beef Central and in the September and December editions of the GSSA newsletter; the GSSA newsletter (by 2); the Agriculture Victoria soil moisture newsletter (x 2); BeefandSheep Newsflash (x3);

A summary of articles and extension activities are provided in Table 4.

Extension activities

Group meetings were held in 2019 and 2020 with the Baynton GSSA group and two south west Bestwool/Bestlamb groups to present and discuss results of 2019 predictions and growth rates.

A presentation (Brendan Cullen; Jane Court and Dale Boyd) on the project was made at the Hamilton Digital Innovations and Smart Agriculture (DISA) Festival to approximately 10 producers and 50 service providers in May 2020. Participants were invited through a QR code link to a Google Forms for follow up interest in the topic which led to a webinar on technologies used to predict pasture growth, attended by 85 producers and advisers (121 registrations with further requests for the recording). Of those who completed the poll, 100 percent said they would recommend the event and the average satisfaction rating was 9/10.

No face-to-face group activities were possible in the spring or summer of 2020 due to COVID-19 restrictions and related issues. Final wrap up meetings with groups was not possible until the end of 2021 and early 2022. The Hawkesdale BetterBeef group (centred around the Drik Drik site) met in February 2022, and as the first meeting for over two years, had a re-invigoration with a new co-ordinator, but would not have included all group members included initially. However, at the meeting, participants expressed interest in the use of soil moisture probes for making pasture sowing decisions (especially late spring/summer. This was followed up with a webinar and an article in SheepNotes including a presentation and paper from the Hawkesdale group co-ordinator, on critical soil moisture and temperature targets for pasture types. A summary of communication and extension tables are summarised in Table 4.

Table 4. Communication and extension activities carried out over the project

Date	Format	Place	Audience	Registrations or attendees subscriptions
08/08/2019	Farm walk	Sidonia	Central GSSA branch	13
03/10/2019	Presentation	Baynton	Central GSSA and other locals	25
October 2019	Article	Soil moisture monitoring newsletter	subscribers	
April 2020	Presentation	Hamilton	Glenelg and SW prime BWBL	47
October 2020	Article	Soil moisture monitoring newsletter	subscribers	
May 2021	Presentation	Hamilton	DISA conference	
14/07/2021	Webinar – Soil moisture pasture forecasting	online	General	121
August 2021	Article – spring whoosh	Soil moisture monitoring newsletter	subscribers	
August 2021	Web page	FeedingLivestock website		
September 2021	GSSA		GSSA members	Approx
December 2021	GSSA		GSSA members	
December 2021	Article	Beef Central	Beef farmers/advisers	Link
	Presentation and discussion	Pigeon Ponds	Glenelg BWBL	8
February 2022	Presentation and discussion	Drik Drik	Hawkesdale BBeef	9
May 2022	Presentation	Blackwood, Penshurst	GSSA SW	Approx 50
3/05/2022	Webinar – Probing soil decisions	online	All farmers	68
	Webinar – Probing soil decisions (Baynton)	online	GSSA Central	9
Autumn 2022	article	SheepNotes	All sheep farmers Vic (17000)	17,000
	3 Articles and link	Newsflash	Victorian network subscribers (3974)	3974

4.9 Monitoring and evaluation

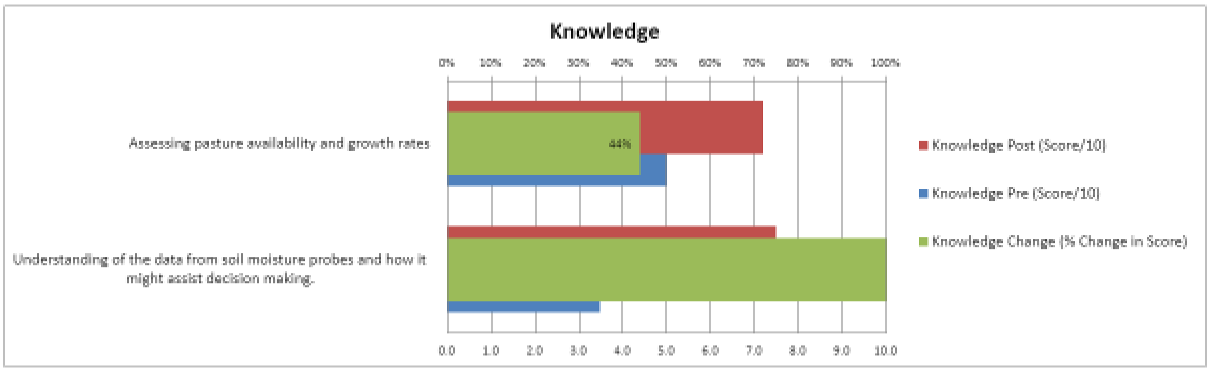
KASAA

A pre and post evaluation survey was completed by farmers involved in the three participating sites that attended a final workshop/meeting. A pre-evaluation was conducted with these groups at the beginning of the project, but as so few meetings and discussions were held throughout, the post evaluation survey asked farmers to consider their knowledge, attitudes, skills and aspirations associated with pasture growth and soil moisture data now (2022) and in 2019. This was completed by 20 producers. The survey involved producers rating their knowledge, attitude and skills from 1-10 and indicating practices they had adopted.

Knowledge

Producers were asked how much knowledge they had about spring pasture growth and/or pasture production in their area before and after the demonstration; and their understanding of data from soil moisture probes and how it might assist in decision making. Responses showed a 44 percent (change from a score 5 to 7.2) increase in knowledge about pasture growth and a 114 percent increase in knowledge about soil moisture probes (score 3.5 to 7.5) as shown in Fig. 32.

Figure 32: Knowledge changes about assessing pasture availability and growth rates and soil moisture probes.

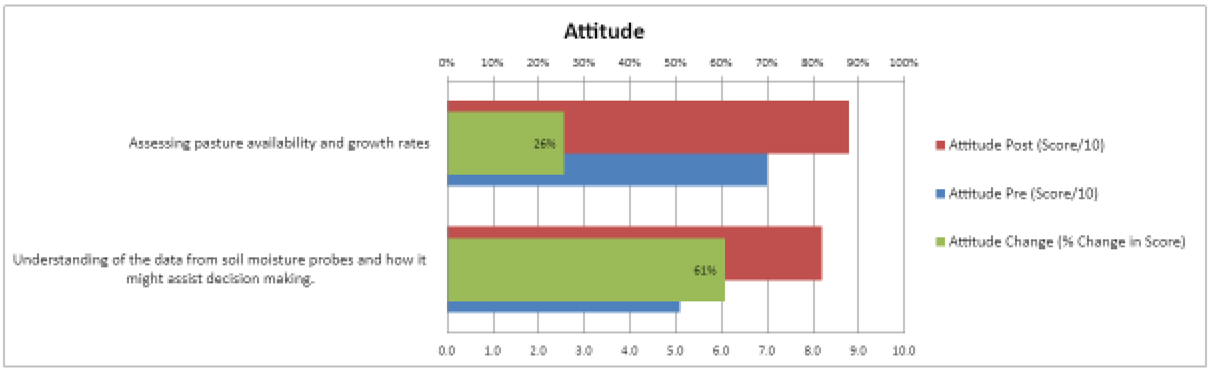


The starting knowledge on pasture growth rates was higher than that around soil moisture probe data. It still only started at a score of 5/10 but this ranged from a starting score of 2 to 10 showing the variability of starting knowledge.

Attitude

Producers were asked about their change in attitude toward the value of knowing pasture availability and potential pasture growth rates on their farm/area and to the value of having soil moisture probes in pastures. There was a 26 percent increase in attitude toward the value of knowing pasture growth rates (change from score 7 to 8.8) indicating that many farmers already thought this was of value at the start of the project. There was a 61 percent increase in attitude to the value of having soil moisture probes in pastures (score 5 to 8.2) as shown in Fig. 33.

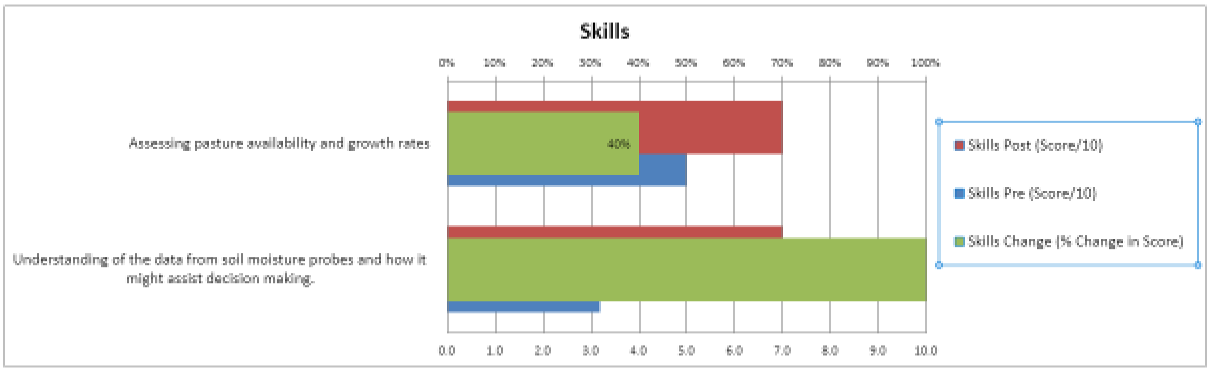
Figure 33. Attitude change pre and post project, towards the value of assessing pasture growth and of having soil moisture probes in pastures.



Skills

Participants were asked what skills they had in assessing pasture availability and growth rates on their farm, pre and post project and in interpreting the information from soil probe data. Fig. 34 shows that skills in assessing pasture growth rates and availability increased by 40 percent from a score of 5 to 8; and there was over two-fold (119 percent) increase in skills in interpreting data from soil moisture probes (score 3.2 to 7).

Figure 34. Skills change pre and post project, towards assessing pasture growth and availability and of interpreting soil moisture probes data.

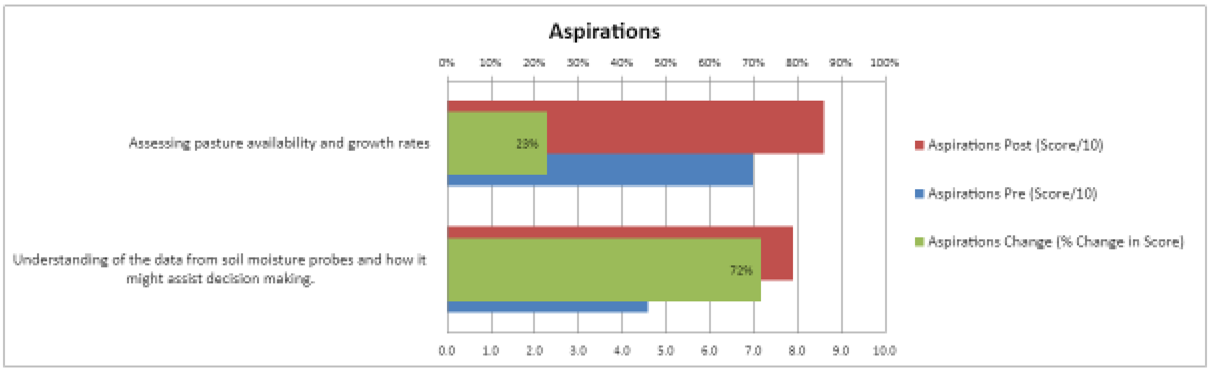


The start and end score for skills for both pasture availability and growth and soil probe data was very similar to that for knowledge of the same, which is not surprising given the similarity in the terms - skills and knowledge.

Aspirations

Farmers were asked how motivated they were to improve their skills in assessing pasture availability and growth rates and to monitor soil moisture and temperature for production purposes.

Figure 35. Aspirational change pre and post project, towards the improving skills in assessing pasture growth and availability and of monitoring soil moisture and temperature.



There was an increase in aspirations to improve pasture assessment skills from 7 to 8.6 (a 23 percent increase) and a 72 percent increase in motivation to monitor soil moisture probe data for temperature and moisture (Fig. 35).

Adoption

Eighteen out of twenty producers said they were planning to access pasture growth rates and/or pasture availability at key times of the year. As the project is now finished, there are currently no published local growth rates or pasture availability accessible, and this may account for the two who said they wouldn't.

Seventeen out of the twenty felt that early predictions of spring growth could be reliable enough to help them make decisions in the future and the remaining three were unsure.

Timing that this information would be most useful were recorded as late winter/early spring (15 people) and/or autumn (7). The decisions that farmers identified they would use soil moisture probes to assist with were:

- Stocking rates/ destocking/selling culls early
- Finishing/marketing stock
- Potential growth rates for fodder conservation
- Potential supplementary feeding/feed budgeting
- Buying in feed early
- Pasture planning
- Pasture sowing decisions – what and when

As the project did not experience conditions to trigger any early warnings for a dry spring, we cannot know how many farmers will enact these decisions (selling stock/buying feed) when the situation arises (i.e. a dry soil moisture profile in August). Critical levels of soil moisture and temperature for pasture sowing were provided at the end of the project via two webinars and a newsletter article. One farmer had already decided not to sow in late summer previously when alerted by a dry soil profile. Hence it will therefore be important for advisers and Agriculture Victoria (who host many soil moisture probes and their data on the website https://extensionaus.com.au/soilmoisturemonitoring/category/resources/meatwool/) to provide reminders and triggers for critical periods and potential decisions as identified by farmers involved in this project.

5 Conclusion

The indications from this project are that soil moisture probes look to be a useful predictor of spring pasture growth and farmers engaged felt that there was enough confidence in this to make some early decisions. For the red meat industry, this contributes to management through droughts or poor springs by making stock and feeding decisions early. The probe data was also considered to be useful in providing triggers for boosting winter growth in the colder areas of the state and in making valuable pasture sowing decisions to better ensure successful pasture establishment and consequent animal performance. Whilst only good seasons (full soil moisture profiles in spring) were experienced in this project, the model and farmers' feedback indicate that the probes would be useful in the years that this was not so, and there is a role for the advisory sector (including Agriculture Victoria) to provide reminders at crucial times/soil scenarios to assist in these decisions.

5.1 Key Findings

Spring pasture predictions were generally validated. In the first year, there were some outliers explained by pasture management (i.e., under and over grazing) or the pasture growth model.
All seasons (springs) started with full or close to full soil moisture profiles and pasture growth rates were average or above so no tough years or low starting moisture were tested.

Modelling indicated the value of soil moisture at the beginning of spring on potential pasture growth, emphasising the importance of this information.

In the area with higher occurrence of good soil moisture in August/September (participants claimed this was always the case) the group identified the value of soil temperature and moisture for making pasture sowing decisions, especially late in the season.
Farmers in other (less reliable) areas did indicate that looking at moisture in August would trigger decision options for selling stock early/buying in feed.
Soil temperature in pasture is an important limitation to pasture growth in some areas.
Competitions on estimating pasture growth for local area/soil types in Central Victoria created interest and increased knowledge and thinking about pasture growth rates.
Focus on growth rates inspired interest in increasing pasture growth in the Central GSSA branch.
SMS distribution lists with soil moisture snapshots could be useful to provide triggers at specific and critical times of the year/soil moisture profile.

A webinar held on pasture forecasting resources (what's out there) created the most interest with over 120 farmers and advisers registering and more requesting the recording post. This illustrates the interest in tools for estimating and forecasting pasture growth, by the wider audience.

5.2 Benefits to industry

The project results have indicated that soil moisture probes can be a reasonable predictor of spring pasture growth over the good seasons experienced. Of the 20 respondents to the evaluation survey at the end, three were unsure about the reliability of the probes to predict growth, but the remaining 17 replied that they did feel confident. This will aid in useful decision making as the number of soil moisture probes increases across dryland pastures in southern Australia. As software programs (e.g., Ag360) utilise this, validation with measured growth rates (albeit small numbers) will help to build confidence in modelling systems that may be available commercially or through other networks. However, the farmer discussions and pasture growth validation were considered to be critical for the confidence in predictions and currently no similar simple model or resource is available in Victoria.

Farmers involved did feel that the predictions were reliable enough for them to make early decisions (particularly in poor years, or springs that start with low soil moisture), despite not experiencing this scenario throughout the project. Making stocking decisions early and buying feed were identified as decisions they might make if soil moisture was low in August or September, and this was identified as a critical observation period at sites where seasonal variability occurs (i.e. Baynton and Harrow). Soil moisture later in the season was seen to be more useful for making summer sowing decisions at the site where winter soil moisture is reliably full.

The project also identified a lack of knowledge about and usefulness of local pasture growth rates, indicating it may take some time for producers to gain confidence in using predicted growth rates from satellite or other modelling tools. As the project did not have a 'poor' season or a dry start to a spring, it is difficult to know how quickly a response would be to such a situation when it does occur. Agriculture Victoria and other consultants, however, should be in the position now to use appropriate communication 'warnings' with confidence when they do occur which will be a more powerful way of early warning many producers. This is particularly valuable as the number of soil moisture probes in pastures increases.

6 References

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7 Appendices

7.1 Pasture Composition and Soil Tests

7.1.1 Baynton

Table 5 shows the pasture composition at the two Baynton sites. Both sites are phalaris based (most likely Australian but with other species such as annual species. The granite site has far less phalaris in the pasture (23 percent) but higher clover and these species will affect pasture growth rates. Both sites are also predominantly grazed by sheep, but cattle also.

Table 5. Pasture composition for the Baynton sites as percentages of occurrence

	Phalaris (%)	Sub-clover (%)	Annual weeds broadleaf (%)	Annual grass weeds (%)
Baynton (basalt)	68	12	20	
Baynton (granite)	23	28	9	37

Table 6 shows the soil fertility measures for both sites. Table c and d show the soil textures to depth for the basalt and granite sites respectfully, illustrating the soil differences with the basalt site being a clay loam over clay compared to the sandier granite soils. The texture data was used to set up the SGS model for all sites.

Table 6. Soil fertility (10 cm depth)

	Baynton basalt	Baynton granite
pH (water)	5.5	5.9
pH (CaCl2)	4.9	5.2
Phosphorus Olsen (mg/kg)	17.8	22.8
Phosphorus Colwell	76	56
Phosphorus Buffer index	220	72
Potassium Colwell	150	150
Sulphur KCl40 (mg/kg)	14	11
Aluminium KCl (cmol(+)/kg)	<0.10	<0.1
EC (dS/m)	0.31	0.13

Table 7. Texture to 80 cm at the basalt site

Soil depth (cm)	Silt (%)	Clay (%)	Sand (%)	Texture
0-30	16.7	25	58.3	Clay loam
30-50	13.1	25.1	61.8	Clay loam
50-80	6.3	42.5	51.2	Clay

Table 8. Texture to 80 cm at the granite site

Soil depth (cm)	Silt (%)	Clay (%)	Sand (%)	Texture
0-15	12.5	8.7	78.8	Loamy sand
15-35	12.3	9.8	77.9	Loamy sand
35-55	11.2	15	73.8	Loam
55-80	7.5	44.9	47.6	Clay

7.1.2 Harrow

The pasture composition in the Harrow site paddock had few weeds, a high percentage of clover (Table 9) and some bare ground when measured earlier in the year. Most of the sub clover is balansa. The soil is a loam above clay (Table 11) with an Olsen P of 21.6; Colwell K of 110 and pH ($CaCl_2$) of 4.3 (Table 10).

Table 9. Pasture composition for the Harrow site as percentages of occurrence

Perennial ryegrass	Phalaris	Sub-clover	Annual weeds broadleaf	Annual grass weeds	Lucerne	Other e.g. bare/dead
	28%	63%				8%

Table 10. Soil fertility and texture for the Harrow site (1to 10 cm)

Measure	
pH (water)	4.8
pH (CaCl2)	4.3
Phosphorus Olsen (mg/kg)	21.6
Phosphorus Colwell	64
Phosphorus Buffer index	190
Potassium Colwell	110
Sulphur KCl40 (mg/kg)	23
Aluminium KCl (cmol(+)/kg)	0.84
EC (dS/m)	0.22

Table 11. Soil texture to 80 cm at Harrow site

Soil depth (cm)	Silt (%)	Clay (%)	Sand (%)	Texture
0-10	11.2	19.9	68.9	Loam
10-50	7.4	35.7	56.9	Clay
50-80	6.1	52.9	41	Clay

7.1.3 Dartmoor

The pasture at the Dartmoor site is a lucerne/phalaris/ryegrass mix (Table 12) that is cut for hay and silage as well as some grazing by cattle. The soil is a sandy loam to depth (Table 14) and soil fertility results are provided in Table 13.

Table 12. Pasture composition for Dartmoor site as percentages of occurrence

Perennial ryegrass	Phalaris	Sub-clover	Annual weeds broadleaf	Annual grass weeds	Lucerne	Other e.g. bare/dead
15%	38%		3%	3%	27%	11%

Table 13. Soil fertility to 10 cm for Dartmoor site

Test	
pH (water)	5.9
pH (CaCl2)	5.3
Phosphorus Olsen (mg/kg)	14.5
Phosphorus Colwell	44
Phosphurus Buffer index	69
Potassium Colwell	210
Sulphur KCl40 (mg/kg)	13
Aluminium KCl (cmol(+)/kg)	<0.1
EC (dS/m)	0.17

Table 14. Texture measurements to 80 cm for Dartmoor site

Soil depth (cm)	Silt (%)	Clay (%)	Sand (%)	Texture
0-10	3.7	10	86.3	Sandy loam
10-50	3.6	14.3	82.3	Sandy loam
50-80	1.3	45.6	53.1	Sandy clay

Estimations for pasture growth rates using silage cuts and cattle grazing and pasture cuts are outlined in Table 15.

Table 15. Dartmoor Pasture growth rates estimated from cuts or fodder harvested over spring summer 2019/20

			Est growth rate/ha/day	Days	Comment
26-July		2000 kgDM/ha	36 kgDM	approx. 60	Visual estimate
12 Sep 2019	Cattle removed for silage	Visual 3033		60	Grazed and cages moved so couldn't estimate

1-oct	Cut for silage (42 rolls at 550kg) x 0.42 dry matter= 9702kgDM/8 ha	1213 kgDM/ha harvested		18	Depends on residual after silage cutting I only estimated 550 but looked 1000
1-oct-16-oct	Cut for growth since silage	1250 700 regrowth	23	16	Low because regrowth after cutting don't include
28-nov	28-nov Hay cut (40 rolls at 420kg)x 0.85 DM = 14280kgdm/8 ha	1785 kgDM/ha harvested	31-38	58	Quadrat cuts estimated 2178 kgDM/ha and looked well over 4000. I cut lower
28-nov to 28-jan 2020	Mowed cuts	4259 kgDM/ha	70	61	

7.2 Predictive modelling 2020

7.2.1 Baynton

In 2020 the seasonal forecast was for 65% chance of above median in November and early December. With full moisture profile at the beginning of spring, the prediction was for a longer spring at both the basalt site (Fig. 36) and the granite site (Fig. 37). The predicted growth rates are higher on the basalt soil than the granite and the season is longer.

Figure 36. Pasture growth projection (red) from 1st September to 31st December 2020 based on stored soil water and 70% chance above median spring rainfall at Baynton basalt site.

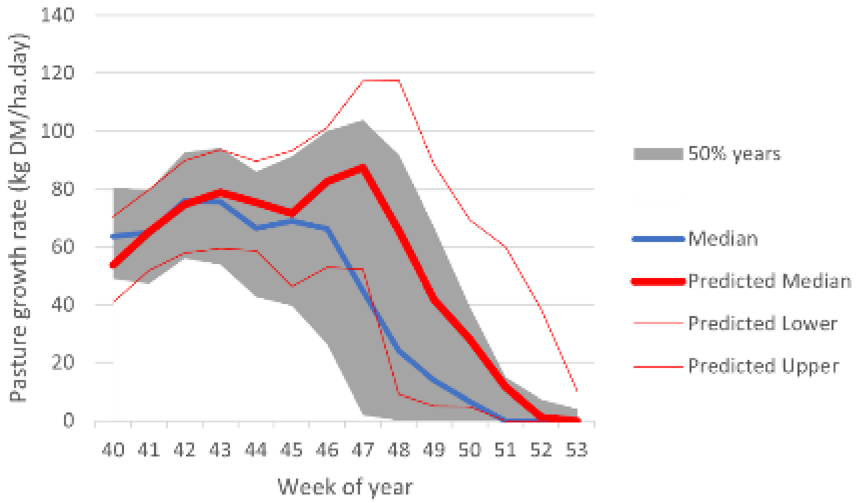
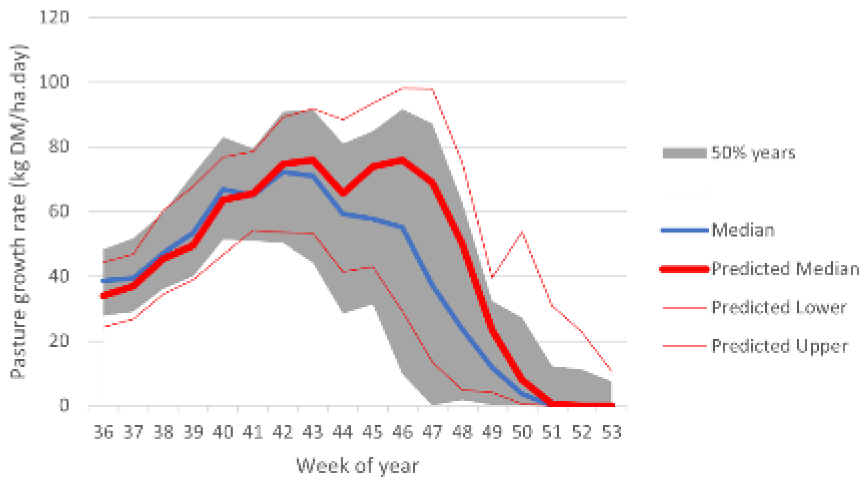


Figure 37. Pasture growth projection (red) from 1st September to 31st December 2020 based on stored soil water and 70% chance above median spring rainfall at Baynton granite site.



7.2.2 Harrow

Similarly at Harrow site the pasture growth projection from 8th October 2020 to 31st December based on stored soil water and 70% chance above median spring rainfall was for a longer spring (Fig. 38).

Figure 38. Pasture growth projection (red) from 8th October to 31st Dec based on stored soil water and 70% chance above median spring rainfall at Harrow.