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Abstract

Phalaris (*Phalaris aquatica spp*.) is a deep rooted perennial grass which has proven to be persistent and productive pasture species for grazing systems in the Upper Wimmera and Central regions of Victoria. It is also suited to other regions in Australia where average rainfall and summer temperatures reduce the persistence and therefore productivity of the more widely used perennial grass variety Ryegrass (*Lolium perenne*).

When combined with Subterranean Clover, phalaris based pastures provide high quality pasture feed for sheep and cattle and can increase carrying capacity by over 100% when compared with annual grass based systems. These increases combine with good environmental outcomes that are associated with deep rooted perennial systems such as increased ground cover, reduced nitrate leaching, greater water use and reduction in salinity risk.

While phalaris is a long lived perennial and can produce highly productive long term pastures, producers have variable results in maintaining the length of their phalaris stands. PPS members have a large number of phalaris based pastures with differing levels of persistence and it was considered that these provided a valuable resource in trying to ascertain the factors involved in maintaining long term phalaris based pastures.

The MLA PRS project B.FDP.0051 managed by Perennial Pasture Systems (PPS), conducted an in depth study of a selection of these pastures in an attempt to find the common factors that affect phalaris persistence. This report outlines the findings of the PRS research.

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

AGRICULTURE VICTORIA

EXECUTIVE SUMMARY

Phalaris (*Phalaris, aquatica*) is a deep rooted perennial grass which has proven to be persistent and productive pasture species for grazing systems in the Upper Wimmera and Central regions of Victoria. It is also suited to other regions in Australia where average rainfall and summer temperatures reduce the persistence and therefore productivity of the more widely used perennial grass variety Ryegrass (*Lolium perenne*).

When combined with Subterranean Clover, phalaris based pastures provide high quality pasture feed for sheep and cattle and can increase carrying capacity by over 100% when compared with annual grass based systems. These increases combine with good environmental outcomes that are associated with deep rooted perennial systems such as increased ground cover, reduced nitrate leaching, greater water use and reduction in salinity risk.

Phalaris based pastures can persist in a productive state for many decades but can also decline within a few years to become dominated by annual grasses resulting in a reduction of the productive capacity of the paddock. PPS identified the huge resource of multiple long term phalaris pastures within the group and decided to undertake an investigation of the factors involved in phalaris persistence.

Most persistence projects have a limited time span and usually commence with an establishment phase restricting the ability to make long term findings. PPS concluded that a project looking at long term pastures would provide information that would assist producers manage phalaris pastures for long term persistence.

While PPS entered the investigation with open minds, there were some preconceived ideas about phalaris persistence which did not end up being of high significance. The effects of phosphorus levels and annual rainfall are two examples where there was a poor relationship with persistence results.

It is important to note that phalaris persistence and productivity are not always mutual, phalaris can persist indefinitely in a fairly non productive state; roadside stands are an example of this. While recommended desirable phosphorus levels for achieving 95% of maximum pasture production (>Olsen P of 12 – 15 mg/kg) are not a requirement for phalaris persistence, they are for sub clover production which will provide the nitrogen fixation and supply N to the phalaris plants allowing them to achieve good production levels.

The four results that will allow positive on farm benefits in potentially increasing the persistence of phalaris pastures were; decreasing paddock size, raising soil acidity above critical levels, reducing the number of stresses phalaris is exposed to and accurately assessing state of the phalaris pasture. All of these can be used to improve the management of phalaris based pastures and increase persistence and long term productivity.

Paddock Size; A positive correlation was found in phalaris frequency with decreasing paddock size. The group suggests those over 20 Ha have a lower persistence rating than those under 20 Ha. The group speculates that grazing management through preferential grazing may be the reason for this, but other factors such as different soil types unsuited to phalaris may be another.

Soil Acidity: The results showed a positive correlation with an increase in phalaris content in surveyed paddocks as soil pH increased. The soil pH($CaCl_2$) range was 4.0 to 5.2 at 0-10 cm. Soil pH at 10-30 cm was found to be non- significant. Soil tests at this depth varied in pH from 4.2 to 6.8.

Combined stresses; The more stresses which the phalaris was exposed to; the more likely phalaris frequency declined. Stresses were; low pH ($p<0.05$), large paddock size, low P, low K, high aluminium and low decile rainfall in the year of establishment. The results showed a correlation between multiple stresses on the pastures and lower phalaris plant numbers.

Underestimating pasture quality; The project results showed that many producers underestimated the quality of old phalaris stands and the potential to rejuvenate them into productive pastures. This result is backed by observations made when favourable conditions, such as those experienced in the wet summer years of 2010 and 2016, allow phalaris plants to show up in pastures where they were thought to have died out. A phalaris pasture can still be productive with 5 plants/sq.m (Lisa Warn; personal communication) and there are many old pastures which could increase productivity with the application of fertilisers and weed control measures.

The increase in lamb production systems in the region has seen an increase in varieties such as lucerne, Brassicas and Arrowleaf clover but phalaris pastures still form the basis of profitable grazing systems. Identifying the factors that influence phalaris persistence will assist in reducing the rate of phalaris decline and allow the pastures to maintain a productive state for a longer period. This will increase producer's confidence in establishing perennial pastures as the costs of establishment and maintenance can be amortised over a longer period.

The balance between maintaining a phalaris pasture and having it produce at its potential requires a higher level of management to be implemented on farms. This may be a barrier in some cases and there are potentially infrastructure costs and annual inputs which must be addressed to maximise the pasture potential. It is important to note that **– Persistence doesn't equal Production.**

The main message that came out of the project was to reduce the potential stresses on the phalaris pasture, through improved management. Reducing the paddock size seemed to be one of the key methods in doing this, although the reasons are not clear, it is likely to improve grazing management and focus soil and nutrient management. It is difficult to estimate whether fencing larger phalaris paddocks is a good investment or whether other management changes such as grazing method may achieve a similar result.

It is clear from the results that reducing combined stresses on phalaris will result in better persistence of the pasture; these gains can also result in higher production. The use of containment areas for stock during autumn is being implemented on many PPS member farms to allow phalaris plants to produce adequate leaf recovery prior to grazing. This is expected to have a positive benefit on the persistence of the phalaris plants.

Further testing of the results found in the PPS project would be beneficial through a cost benefit analysis of subdividing existing large phalaris paddocks. The future development of "virtual fencing" would possibly allow this to be implemented at a more precise level.

The results show that finding the balance between maintaining phalaris persistence and maximising production is a complex task, but that it can be achieved with good information, planning and management.

In preparing the final report, the PPS project manager came across a quote from Yogi Berra, while it is unlikely that he ever grew pastures as he was a professional baseball player and manager in the U.S.A., he seemed to be able to put into words some of the issues that surround successful phalaris pasture management.

"In theory there is no difference between theory and practice. In practice there is!"

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Figure 1: Productive phalaris at the Greenfields, a project benchmark paddock, spring 2016

1 Background

1.1 The Perennial Pasture Systems Group (PPS)

The Perennial Pasture Systems (PPS) group was formed in mid 2007 at a meeting in Hall's Gap, reacting to concerns about the lack of research and extension into productive pastures in the Upper Wimmera and Central Highlands region of Victoria.

Since its inception in 2007, 144 farm businesses across the Southern Wimmera and Central Victoria have joined PPS. Members are heavily involved in prime lamb, mutton, wool and beef production. PPS also has 35 members involved in agribusiness and agronomic services. The total area farmed by producers who have joined PPS is 153,403 ha and they manage approximately 996,000 Dry Sheep Equivalents (DSE), made up of 596,000 sheep and 12,500 cattle; cropping and export hay operations are also conducted on many of the farms. The smallest farm in the group is 20 ha and the largest is 8,200 ha. The average farm size is 1,101 ha and an average of 7,010 DSE is managed by group member enterprises.

The aim of the group is to push the boundaries of perennial pasture research in the Upper Wimmera and Central Highlands region of Victoria, and to provide information on productive pasture management to PPS members.

The PPS group have actively engaged producers in multiple research projects since 2007 including the PPS/MLA PDS pasture variety trials which are full scale variety comparisons, two EverGraze supporting sites at Mooney's Gap and Tottington as well as demonstrations on Gibberellic Acid use, Cocksfoot comparison cultivars and a variable rate liming project.

The PPS/MLA PDS sites and the PPS/EverGraze Supporting Sites have a particular focus on pasture persistence and although they have officially been completed they will be monitored and measured by PPS for several years to come.

For the Producer Research Site program, a project advisory group of three PPS producers and the group co-ordinator oversaw the planning and implementation of the project and reported back to the wider group. About 15 producers were involved in the initial planning workshop and annual reviews to help interpret and provide feedback on the results for their farming systems.

Twenty three PPS members participated directly in the project contributing paddock data for the phalaris pastures that were investigated. Three PPS members; Wayne Burton, Mal Nicholson and Duncan Thomas were appointed to the project advisory group to assist the project manager and provide input for the duration of the project.

Figure 2: Project team members; Neil James (Agriculture Victoria, collaborative support), Duncan Thomas & Wayne Burton (PPS project advisory group), Lisa Miller (PRS coordinator), Mal Nicholson (PPS project advisory group); Absent, Rob Shea; (PPS Project Manager).

1.2 Motivation of the PPS to investigate phalaris persistence

The PPS group has an interest in persistent perennial pastures for economic and environmental reasons. They need the pastures to be productive long enough to provide them with a reasonable return on their investment back into their farm businesses. The use of phalaris gives them a longer window of quality feed compared to annuals and when combined with Subterranean Clover, phalaris based pastures provide high quality pasture feed for their grazing systems and can increase carrying capacity by over 100%.

The region’s producers are sowing pastures each year which is expensive and risky in this environment. The Upper Wimmera region would be considered a marginal area for perennial pasture due to areas of low rainfall and strongly acidic/infertile soils. They would like to save on costs and reduce inputs but if they do they are concerned this will affect both production and persistence.

Phalaris based pastures can persist in a productive state for many decades but can also decline within a few years to become dominated by annual grasses resulting in a reduction of the productive capacity of the paddock.

The PPS area contains many examples of productive perennial pastures including older and newer varieties, some over fifty years old. Most farmers now implement a form of rotational grazing having moved away from set stocking to improve persistence.

PPS concluded that a study of these pastures could provide information on the factors involved in successfully managing phalaris for long term persistence.

The group wanted to identify common factors for persistence from their large range of pasture resources. This would enable them to select persistent pasture species/cultivars and adopt tactical management decisions to ensure longevity of their pastures resulting in better economic returns from their pasture investments, particularly in dry seasons.

They are interested in knowing where is the defining line when the pasture has declined to a point that it is a better economic decision to resow.

Production increases would also achieve good environmental outcomes that are associated with deep rooted perennial systems such as increased ground cover, reduced nitrate leaching, improved water use and reduction in salinity risk.

PPS believes that successfully identifying the factors involved in phalaris persistence would have major production, economic and environmental outcomes in grazing systems in the region.

Figure 3: Ewe weaners in a productive phalaris pasture at PPS members Geoff & Aira Kemister’s; “Greenwood” property at Englefield.

2 Projective Objectives

The research projective objectives were:

1. Determine the key reasons for pasture persistence in the Upper Wimmera through a survey of PPS members who have existing new and old pasture varieties in their paddock.

2. Test key reasons for increasing the life of phalaris pastures identified through the survey.

3. Develop an understanding of the annual production of phalaris over its lifespan using data from survey results, economic benchmark paddocks and paddock trials to help identify the economic value of sowing phalaris pastures.

3 Methodology

3.1 Persistence and Production Survey

3.1.1 Paddock survey

A survey was designed to collect information on the paddocks covering pasture establishment, soil type, lime and fertiliser use, grazing systems, pasture management as well as producer views on reasons for any phalaris decline. The survey covered both phalaris persistence and production related questions because of the importance of both within the Upper Wimmera.

An in depth investigation of phalaris pastures greater than five years old formed the basis of the study. A complimentary trial looking at nutrient constraints in phalaris pastures in conjunction with Agriculture Victoria also formed part of the project.

Although the project advisory group were aware of several paddocks which would be suitable for the project, more were required and PPS informed members of the project and asked for them to submit suitable sites. There was a very positive response which showed members commitment to group projects as the study required pastures of poor quality as well as top performing ones. Forty pastures were identified as suitable for the project.

All paddocks started off as having good establishment with the exception of one paddock identified as Molans, which had the phalaris establishment affected by conditions in the year of sowing.

A rating system was devised which divided pastures into six levels of persistence and the PPS project manager conducted pasture inspections to identify the paddocks to include in the project. The investigation then commenced with a farmer survey, pasture composition count, phalaris plant counts and soil tests being conducted in 2014 -15.

Given 40 paddocks, calculations for the number of paddocks required were done from several past data sets to ensure that the sample size was reasonable. The calculations showed this number of paddocks provided a reasonable power (70 – 80% power) of achieving the objectives.

A rating table was devised to rank the paddocks into levels of phalaris persistence which formed the basis of much of the comparative analysis.

Table 1: Paddock ratings based on pasture composition

Rating	Description
A 1	Good phalaris persistence, >25% sub clover, >30% phalaris < 50% annuals & weeds
A 2	Good phalaris persistence, >20% sub clover, >25% phalaris with annual grasses & weeds
A 3	Good phalaris persistence, low clover; <15% sub clover, with annual weeds >25% phalaris, <30% weeds
B 1	Moderate phalaris persistence, could be brought up to a level A paddock with minor management changes e.g.: extra p, spray topping, minor changes to grazing management. >15% phalaris >40%phalaris & sub < 40% weeds
B 2	Moderate phalaris persistence, could be brought up to a level A paddock with major management changes e.g.: lime application, winter cleaning, major changes to grazing management. >15% phalaris. <40% phalaris & sub or >40% weeds or both
C	Poor phalaris persistence from a successful establishment. Too few phalaris plants to manipulate pasture to an A level. <15% phalaris

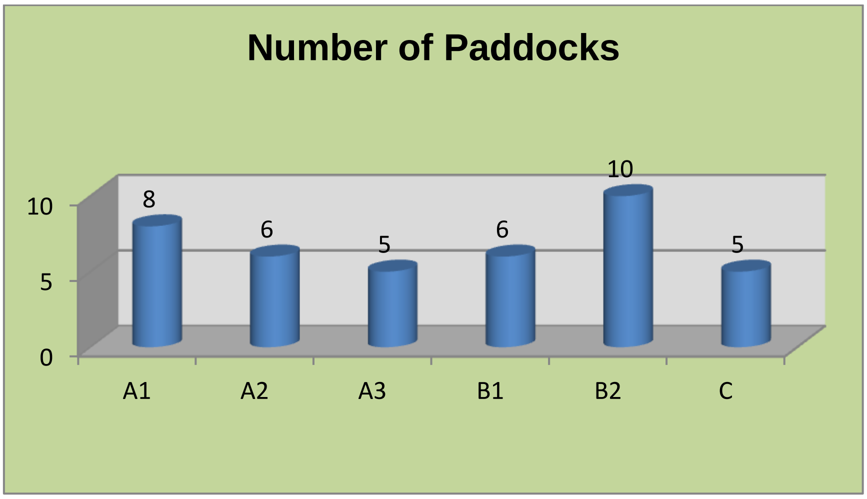

Figure 4: Number of Paddocks within each pasture composition assessment rating

Photographic examples of pasture ratings are shown on page 11.

Figure 5: A1 rated pasture; Millbanks, Elmhurst - PPS paddock

Figure 6: A2 rated pasture; Millbanks, Elmhurst - Long paddock

Figure 7: A3 rated pasture; Millbanks, Elmhurst - Dip paddock

Figure 8: B1 rated pasture; Ben Nevis Farms, Crowlands - Glenvale 5 paddock

Figure 9: B2 rated pasture; Karingal Elmhurst - Frasers Rise Paddock

Figure 10: C rated pasture; Overdale Concongella - Winery paddock

PPS analysed production of paddocks based on rating their current stocking against potential stocking rate related to rainfall (French Schultz).

The French-Schultz livestock carrying capacity was developed by two S.A. scientists, Reg French and Jeff Schultz in the 1980's. It calculates the potential stocking rate under ideal conditions in relation to rainfall.

The formula calculates the potential stocking rate as 1.3 DSE/ha for every 25mm of annual rainfall above 250 mm or in old terms 1 DSE/Acre for every inch rainfall above 14 inches

E.G. 500 mm rainfall; 500 mm – 250 mm = 250mm

250 mm÷ 25=10 10x1.3 = 13 DSE/ha.

Note the formula assumes optimum conditions and this needs to be taken into account when using the formula. (Personal communication – Reg French; circa 1994).

3.1.2 Survey Sites

Fifty paddocks on 23 PPS member farms were selected for the investigation which contained old phalaris pastures with varying levels of persistence. 43 of the paddocks were in the Upper Wimmera catchment region, five in the Upper Hopkins near Ararat and Balmoral and two were in the Avon River catchment near St Arnaud. The average annual rainfall varies from 600 mm at Ararat and Balmoral to 500 mm at Stawell and Tottington, although the rainfall was much lower during the study period. The phalaris pastures are in the sedimentary acidic duplex soils of the region with the oldest established in the 1950's and the most recent in 2009.

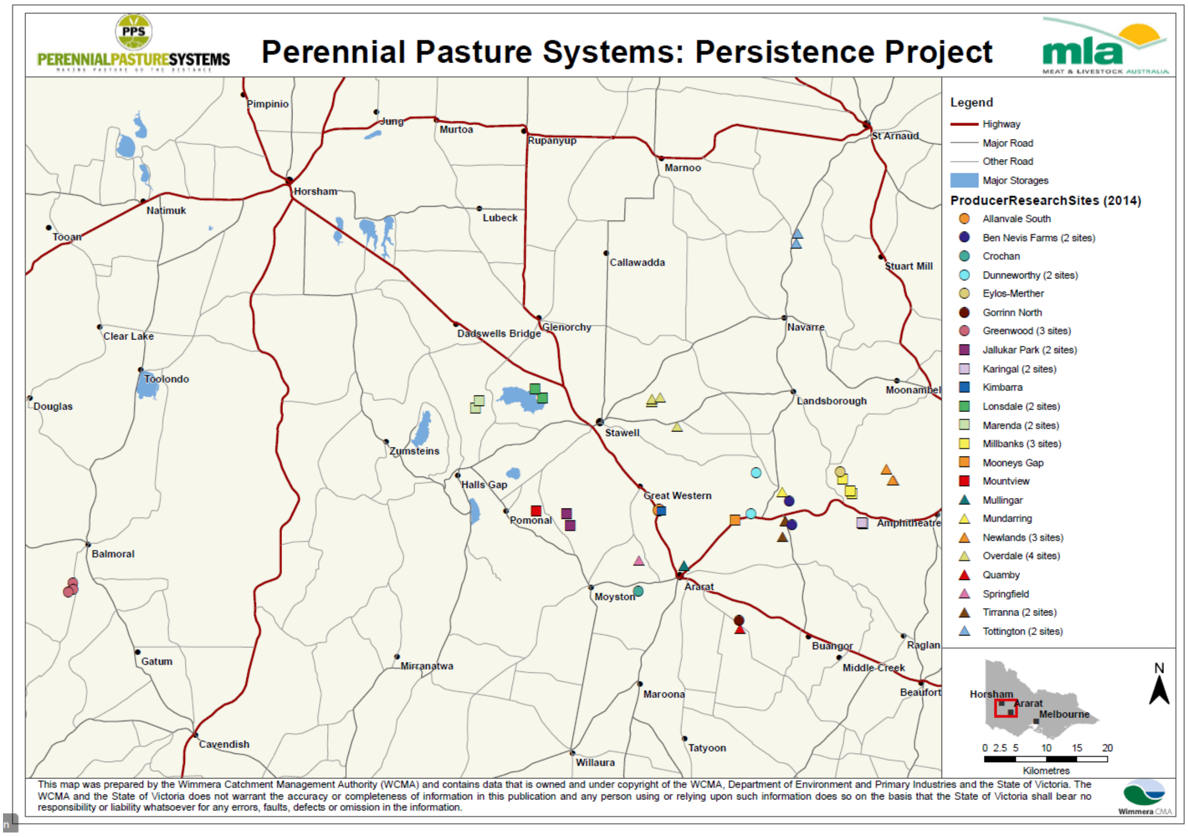

Figure 11: Map of paddocks used in the project

3.1.3 Monitoring within survey

Visual estimates of the pasture composition of each paddock were undertaken in the spring of 2014 and the results collated on a percentage basis of the species present in the pasture.

Assessments of the frequency of phalaris plants were carried out in the summer and autumn of 2015 using the EverGraze grid method, using a 1 m^2 quadrat within 6 fixed plots that were representative of different areas within the paddock.

All paddocks were soil tested in early 2015 with samples collected at 0 – 10 cm and 10 – 30 cm and sent to Nutrient Advantage soil testing laboratory for analysis. The 0-10 cm sample was tested for general fertility and condition and 10-30 cm tested for soil pH, exchangeable cations and CEC. Soil descriptions were also carried out on deep core samples by Agriculture Victoria.

3.1.4 Statistical analysis of survey results

Given multiple variables and some correlation between them, the parameters were analysed by the method of restricted maximum likelihood (REML). The process involved looking at all variables separately (one variable models) then all possible 2 variable models then all possible 3 variable models and so on. In all the models the variable/s were fitted as fixed effects while establishment year/farmer/paddock (paddock nested within farmer which was nested within establishment year) were fitted as random effects. All statistical analyses were performed using GENSTAT (18th Edition, VSN International Ltd, Hemel Hempstead, UK).

3.1.5 Molybdenum Trial Sites

PPS set up an investigation into the effect of molybdenum on phalaris and trials were set up to investigate any molybdenum response on phalaris.

PPS also instituted phalaris tissue testing on selected paddocks to investigate whether there were any trace element deficiencies or toxicities that may be affecting phalaris production or persistence, that were not apparent in the soil testing procedures.

(1) Two trials were set up to answer questions on whether molybdenum levels affect phalaris persistence:

- Allanvale South paddock at Great Western had molybdenum treatments applied in winter 2016, and pasture cages were installed to allow measurement of any DM differences. Tissue testing prior to application showed that molybdenum levels were not deficient for sub clover; no figures are available for phalaris.
- A new phalaris pasture at Marenda, East of Stawell had sections of the paddock treated with liquid molybdenum to investigate any molybdenum response. The response to a liquid molybdenum application on part of a newly established phalaris pasture at Marenda, Mt Dryden was compared with control sections of the pasture during spring. Pasture leaf measurements and tissue tests were taken to compare the + and - molybdenum treatments.

Tissue testing was on instigated in selected paddocks to test for Mo deficiency and also to look for any trace element deficiencies or toxicities that may be affecting phalaris production or persistence, that were not apparent in the soil testing procedures. Samples were taken from five higher rated paddocks and five lower rated paddocks.

Figure 12: Jim Caldwell from SFS conducting the soil tests in February 2015

Figure 13: Tirranna, Back Paddock Mt Cole Creek

SITE: PPSPP26 **Property:** Rod Vearing
Location: Dunneworthy **Geo. Ref:** 6890185E 5881193S
Aust. Soil Class.: Bleached-Mottled, Eutrophic, Brown DERMOSOL
Northcote Factual Key: 4.82

General Landscape Description: Hills
Site Description: Flat
Vegetation: Phalaris pasture

Soil Profile Morphology

A1 0 - 12 cm Dark brown (10YR3/3); hard setting surface condition; *sandy loam;* weak very fine subangular blocky structure; rough ped fabric; very weak consistence, dry; pH (field) 4.0; clear change to:

A2 12 - 40 cm Very pale brown (10YR7/3); *sandy clay loam;* weak apedal; sandy ped fabric; many fine to medium angular platy sedimentary gravel; pH (field) 4.0; abrupt change to:

Subsoil:

B21 40 - 75 cm Strong brown (7.5YR5/6), with a few medium distinct red mottles; *light clay;* moderate very fine angular blocky structure; rough ped fabric; firm consistence, dry; pH (field) 6.0; diffuse change to:

B22 75 – 90+ cm Strong brown (7.5YR5/6), with common medium faint red mottles; *light medium clay;* strong very fine to fine angular blocky structure; smooth to rough ped fabric; weak consistence, dry; common prominent manganese cutans evident; pH (field) 6.5; extending

Figure15: Soil samples from Back paddock at Tirrana

Figure 14: Example of soil description; Mooneys Gap. Described by Grant Boyle; Agriculture Victoria, Bendigo

3.2 Test key reasons

3.2.1 Nutrient extraction trials

The project was conducted in conjunction with Agriculture Victoria and their input involved the implementation of nutrient test strip trials. These trials sought to identify soil constraints (nutrients and acidity) that impact on phalaris production and persistence by undertaking nutrient subtractive trials on underperforming paddocks.

Two sites were selected from the survey paddocks and the trials were set up in “Lindells” paddock at Lonsdale Park near Stawell and “Metcalfes” on Allanvale South near Great Western. Methodology is reported in appendix (2).

3.2.2 In-depth surveys

In depth surveys were conducted on two of the PPS member participating properties which have exhibited long term phalaris persistence. The survey was conducted in an interview format by the PPS Project Manager. The purpose of these surveys were to test if key reasons for persistence identified within the survey held true on these farms and to get a better understanding of management. These were conducted at Greenwood; Englefield, near Balmoral and Millbanks near Elmhurst.

The in-depth surveys are presented as case studies in appendices (3) and (4).

3.3 Economic value of sowing phalaris

Benchmark paddocks were used to carry out an economic analysis on productive phalaris based pastures and the payback period when establishing them. The analysis used was a discounted cash flow analysis and is reported in appendix (1) titled; Economic analysis - prepared by Lisa Warn; Lisa Warn Ag Consulting Pty Ltd, May 2017.

The benchmark paddocks are existing PPS project sites which are:

- Greenfields – established 2014
- Mooneys Gap EverGraze support site – established 2009
- Elmhurst MLA PDS site – established 2009
- Jallukar MLA PDS site – established 2009

These paddocks have good production data sets and additional measurements were collected including:

- Pasture composition in winter and spring 2015 & 2016
- Plant persistence using frequency of occurrence of desirable sown perennial grass in autumn 2015 & 2016.

3.4 Extension and Communication

The PPS group had their first project meeting on 2nd April 2014, to discuss the project topic and to seek agreement with researcher Dr Kevin Smith on participatory R&D activities, what research questions were to be investigated and plan how the project might proceed.

Annual review meetings with the researchers and producers, focussing on the progress of the project, were held on the 25th of August 2015 and 18th July 2016. A project extraction meeting was held on 5th of December 2016 and the final review meeting was held on June 16th 2017.

Regular communication to the wider PPS group was through newsletters as well as annual conference presentation and posters.

The information was presented to other producers at a farm seminar at Edenhope in April 2015, to the SAMRC regional meeting in Horsham in July 2015 and the Glenthompson – Dunkeld BWBL group in April 2017.

The PPS newsletter is also distributed to agricultural extension contacts in Agriculture Victoria, Catchment Management Authorities, MLA, CSIRO and private agronomists as well as farmer groups in W.A., N.S.W. and N.Z.

Figures 16 & 17: PPS Annual conferences 2015 & 2016, where persistence project updates were reported.

4 Results

4.1 Persistence and Production Survey

4.1.1 Farmer Ratings

As part of the survey the participating farmers were asked to rate their phalaris pasture in accordance with the ratings set out in table 1. The farmer ratings were then measured against the objective measurement carried out by the PPS Project Manager.

The results showed that that 6 (15%) of the pastures were rated higher than the objective assessment, 25 (62.5%) were rated in accordance with the objective assessment and 9 (22%) were rated lower than the objective assessment.

Table 2: PPS objective assessment versus Farmer paddock assessment using defined paddock ratings.

		PPS Objective paddock assessment					
		A1	A2	A3	B1	B2	C
Farmer paddock assessment	A1	5	3				
	A2		3	1	2		
	A3			5			
	B1	1	1		4		
	B2			2	4	4	
	C		1				4

In table 2, the numbers in green show where farmers rated their pasture higher than the objective assessment, the numbers in red show where farmers rated their pasture lower than the objective assessment. The numbers in blue show where farmer and objective assessments were the same.

PPS noted that nearly a quarter of farmers underestimated the quality of their phalaris pasture and believes that this figure is reflected in the wider farming community. This finding suggests that farmers do not have the correct information to make informed decisions on management.

The consequence of this is that farmers are not realising the potential of phalaris pastures and may falsely believe the pasture to be poor and undertake unnecessary resowing when herbicide intervention may have been adequate.

4.1.2 Survey results investigating factors affecting persistence

There were twenty six variables or factors that were investigated to see if they negatively or positively affected phalaris persistence. The main factors that the project advisory committee considered to be the important in affecting phalaris persistence are shown in table 3. Not all were found to have a significant effect on phalaris content. Single, 2 variables and 3 variables models are shown in tables 3 to 5.

Table 3: The correlation and probability of a single variable's effect on phalaris counts i.e. persistence in a one way statistical analysis

Variable	REML approximate R^2	P (probability) of the first variable
Hectares (Ha)	43.8	<0.001
Rainfall	19.9	0.466
Sub clover	27.9	0.086
pH ($CaCl_2$) 0-10 cm	45.4	0.041
Colwell K	33.9	0.295
Aluminium Exchangeable %	36.2	0.117
Olsen Phosphorus	23.4	0.315

Grazing management data is not presented because it changed over time and records were generally unreliable and in 2016 nearly all the paddocks surveyed used a flexible rotation involving rest periods. In addition many parts of the system had changed from over 20 years ago. Phalaris used to be undersown with crops and grazed normally with wethers under set stocking, whilst now the system involves mainly ewes and lambs. Some paddocks had been in for 30 years and whilst systems had changed paddock size remained constant.

In the one variable analysis, there is very high confidence that there is an effect of paddock size on phalaris content and not a chance effect (p value is < 0.001). Paddock size has an R^2 of 44%, meaning that paddock size roughly accounts for 44% of relationship with phalaris content.

Figure 18 shows the negative correlation between paddock size and phalaris content. The slope of the regression line (0.7) indicates that for every 10 hectare increase in paddock size, phalaris content decreases by about 7%.

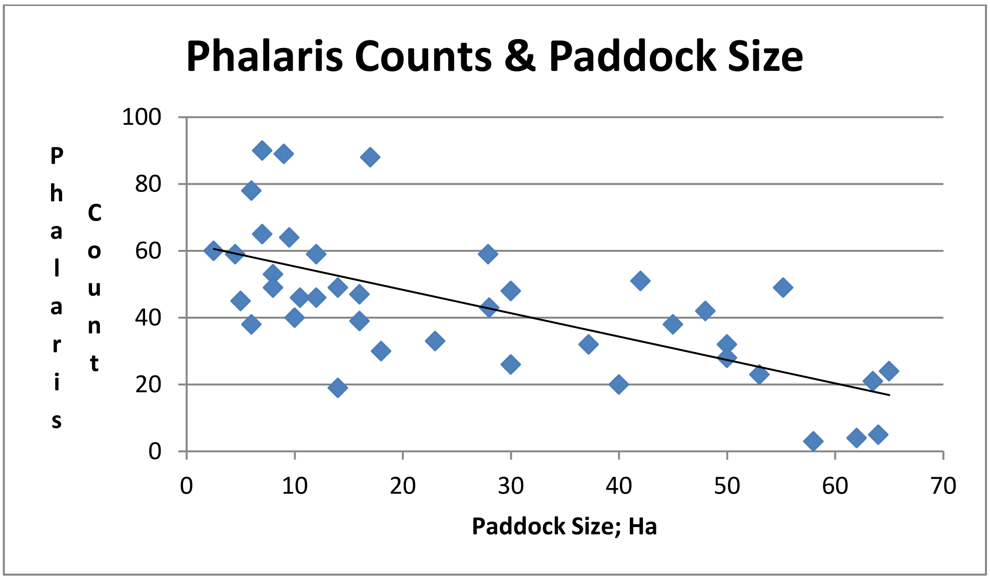

Figure 18: Effect of paddock size % on phalaris content (y=62.31-0.6996x)

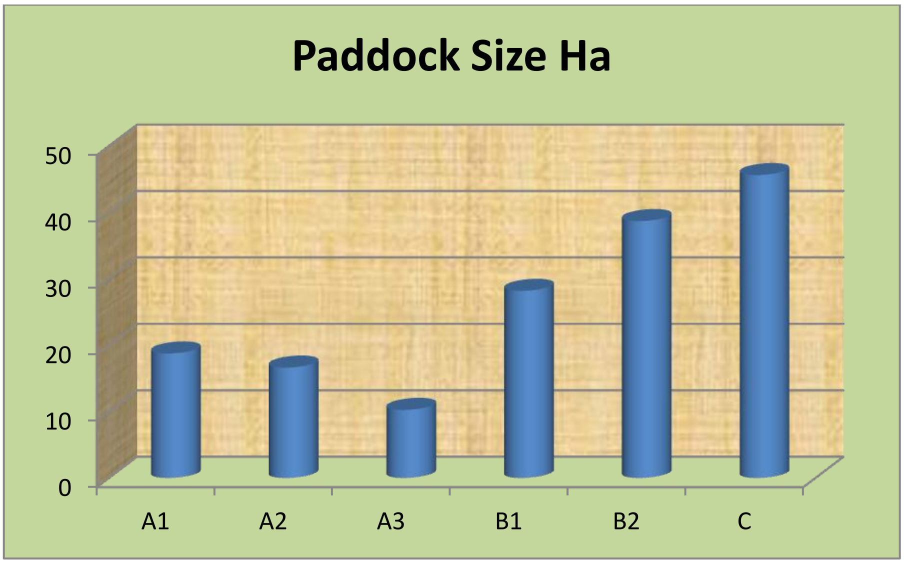

Figure 19: Paddock ratings and average paddock size

Paddock size statistics

- Paddock sizes ranged from 2.5 hectares to 65 ha
- 90% of paddocks with an area <20 Ha had a frequency count above 38 plants per square metre which is considered good content of phalaris.
- Only 20% of paddocks with an area > 20 Ha had a frequency count above 38 plants per square metre.
- Nineteen paddocks (47.5% of the total) had an area >20 Ha.

Other factors showing a significant effect ($p<0.05$) in the one variable analysis is soil pH. Figure 22 shows a positive correlation so that when soil pH increases so too does phalaris content. An increase in pH of 1 unit (e.g. 4.0 to 5.0) increased phalaris content by approximately 26%.

The range in soil pH results within the survey area was pH 4.0 to 5.2. Soil pH at 10-30 cm was found to be non- significant. Soil tests at this depth varied in pH from 4.2 to 6.8.

Only 8 paddocks were found to have pH greater than 5.0 and eleven paddocks had pH less than 4.5 indicating subsurface and subsoil acidity issues.

Exchangeable aluminium content is closely related to soil pH and soil type but it was found not to have a significant effect in the one model variable analysis. This is partly because of the leverage in the aluminium data meaning that there were three outliers or unusual data points where paddocks had very high exchangeable aluminium contents of around 45% compared to the majority of the aluminium (Al) results and so interpretation of any aluminium results should be treated with caution.

Sub clover is significant at a probability level of < 0.1 and so there is a 1 in 10 chance that this could be a false effect. Figure 20 shows the relationship with phalaris content to be negative and could be due to substitution. That is when sub clover percentage increased; it did so at the expense of phalaris content.

In this survey, one way variables not found to have a significant effect on phalaris persistence were rainfall, potassium and phosphorus.

There was no interaction found between any of the variables analysed in two and three way models meaning their response did not depend on the other and so the probability of each factor can be interpreted separately. In some cases, the use of two or three variables helped reduce some of the noise (unexplained variation) around a variable and so its significance increased. For example potassium became significant when combined with paddock size (hectares) in two variable models (see table 4). So that when some paddock size was reduced, it became apparent that phalaris content increased with higher contents of potassium. Aluminium also became significant when combined with paddock size and because of high leverage should be treated with caution although its effect is believable because of its link with soil acidity. Sub clover becomes significant when combined with pH at $P<0.05$ level, as phalaris is decreasing as a result of pH and being replace with sub clover which is more acid tolerant.

Paddock size and soil pH accounted for nearly 60% of the relationship with phalaris content in a two variable analysis.

Table 4: the correlation and probability of two variable's effect on phalaris counts i.e. persistence in a two way statistical analysis

Variable	REML approximate R^2	P probability of term/s in each model	
		first term variable	second term variable
Hectares & rainfall	43.6	<0.001	0.681
Hectares & sub clover	48.9	<0.001	0.155
Hectares & pH $CaCl_2$	59.4	<0.001	0.048
Hectares & Colwell Potassium	54.2	<0.001	0.036
Hectares & Aluminium %	56.8	<0.001	0.023
Hectares & Olsen P	42.8	<0.001	0.866
Sub clover & pH $CaCl_2$	53.8	0.034	0.014

Combinations of three factors that were significant at a $p<0.05$ level for each factor were hectares, pH and potassium and had an R^2 accounting for 66.5% of the variance.

Table 5: The correlation and probability of three variable's effect on phalaris counts i.e. persistence in a three way statistical analysis

Variable	Approx. R^2	P probability of term/s in each model		
		first term variable	second term variable	third term variable
HA & pH $CaCl_2$ & Al %	60.0	<0.001	0.443	0.121
HA & pH $CaCl_2$ & Colwell Potassium	66.5	<0.001	0.049	0.038
HA & Colwell Potassium & Aluminum%	60.4	<0.001	0.126	0.083
HA & Al % & sub clover	60.2	<0.001	0.016	0.092

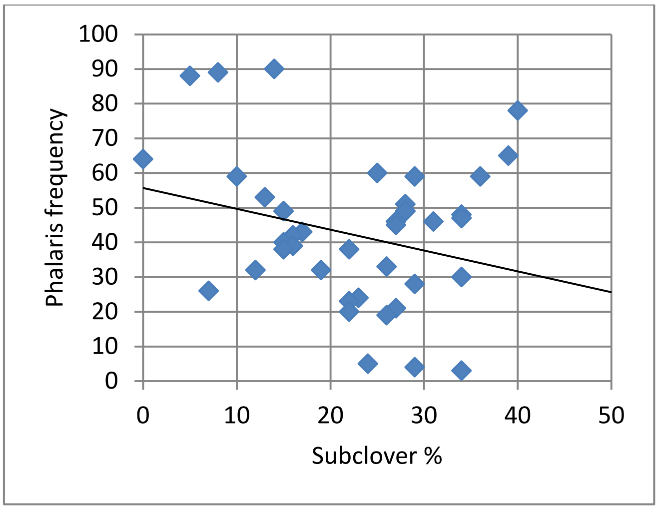

Figure 20: Effect of sub clover % on phalaris content (y=55.69-0.6015x)

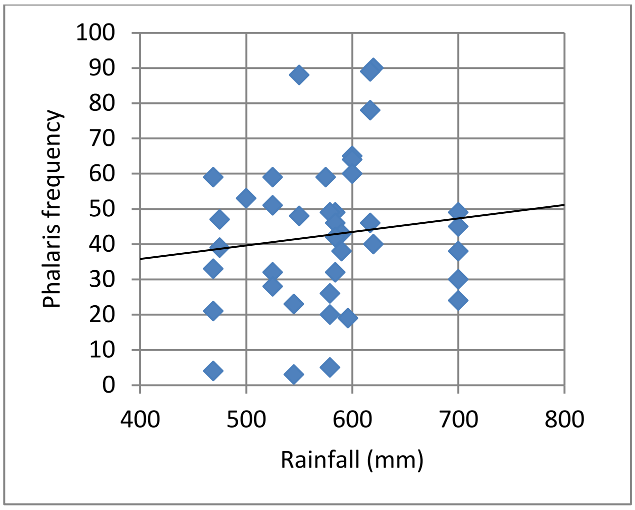

Figure 21: Effect of rainfall (mm) on phalaris content (y=20.5+0.03834x)

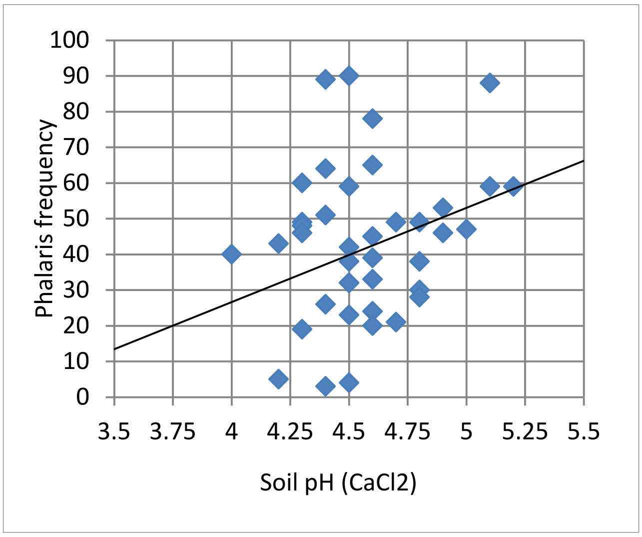

Figure 22: Effect of soil pH ($CaCl_2$) on phalaris content (y=-78.991+26.41x)

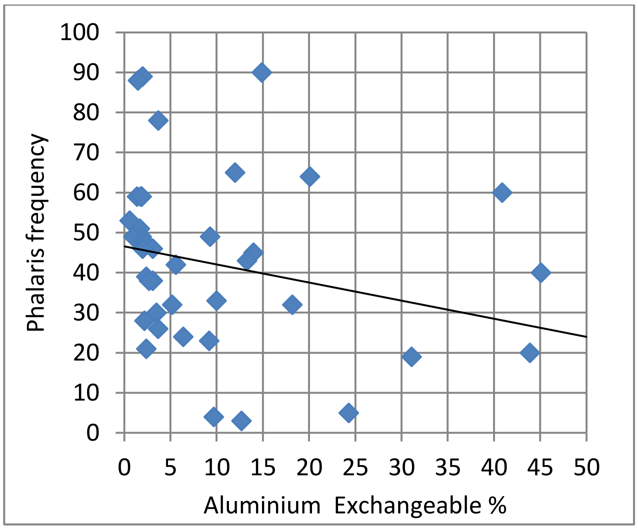

Figure 23: Effect of Al ex % on phalaris content (y=46.6-0.4521x)

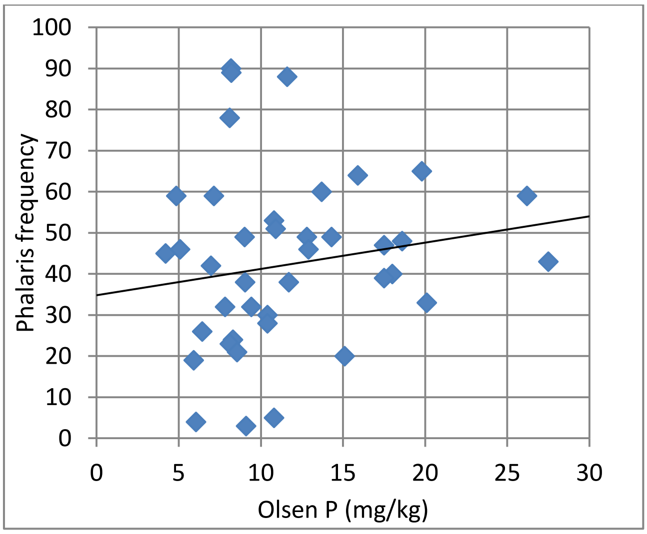

Figure 24: Effect of Olsen P on phalaris content (y=34.82+0.6388x)

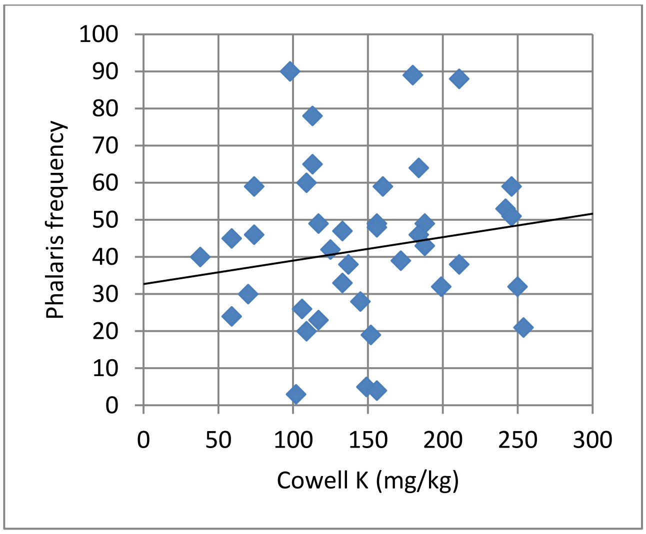

Figure 25: Effect of Colwell K on phalaris content (y=32.68+0.06316x)

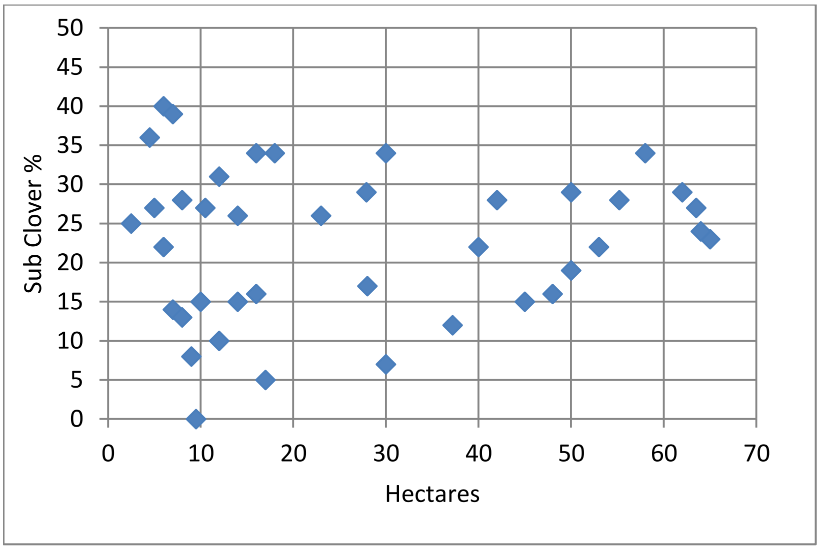

Figure 26: Scatter graph of Sub Clover % versus paddock size

Fig 26 shows that paddock size has little correlation with sub clover content within the pasture due to the scattered nature of data points. A separate analysis using excel found the R^2 was very small (<1 %).

The age of the phalaris stand did not appear to affect its persistence (see Fig 27). Some paddocks had been established in the 1950's and 1960's had good contents of phalaris being given Class A or B ratings.

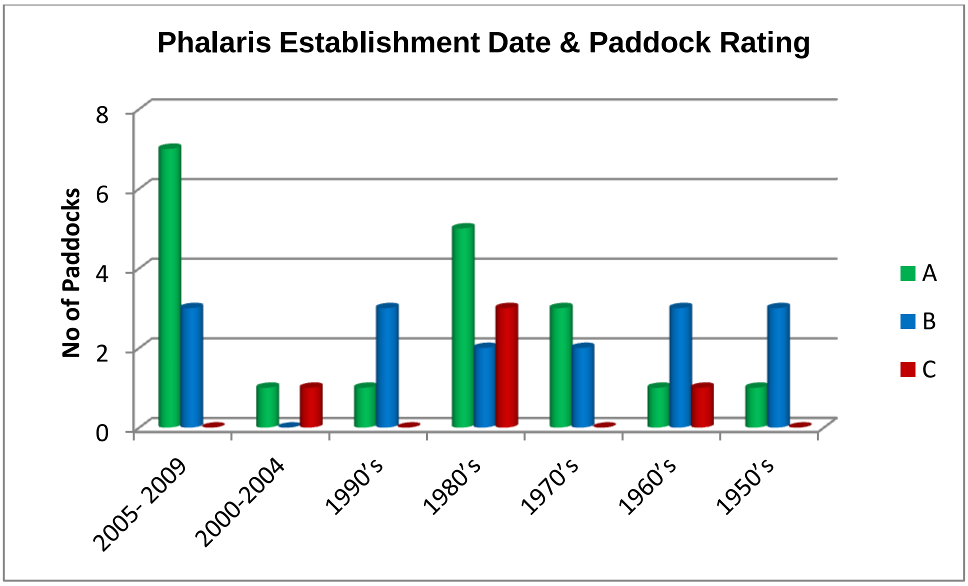

Figure 27: Establishment year of survey pastures

4.1.3 Multiple Stress Factors

PPS investigated the effects of multiple stresses on the survey paddocks and their influence on phalaris persistence. The stresses were recorded over the life of the phalaris pasture and did not necessarily occur concurrently. There is some evidence of this in the two way and three way models of factors decreasing phalaris content. For example combinations of three factors that were significant at a $p < 0.05$ level were hectares, pH and potassium which had an R^2 accounting for 66.5% of the variance.

Another method used by PPS to analyse stresses was to define what stresses are likely to impact on phalaris persistence and identify them within individual paddocks. These stress factors are defined in table 6.

Table 6: Major stresses on phalaris persistence defined from the group committee

	Paddock size	Soil pH (CaCl2)	Drought year	Olsen P (mg/kg)	Colwell K (mg/kg)	Al% Exch.	Grazing Method
Stress Factors	> 20 ha	< 4.4	Drought in first 2 years of pasture life	< 7	< 70	> 12%	Set stocking

Figure 28 shows that most of the C rated paddocks (inadequate phalaris) either had two or three stresses identified using the defined stresses in table 6. Most A rated paddocks (good phalaris content) had no stresses or only one stress identified.

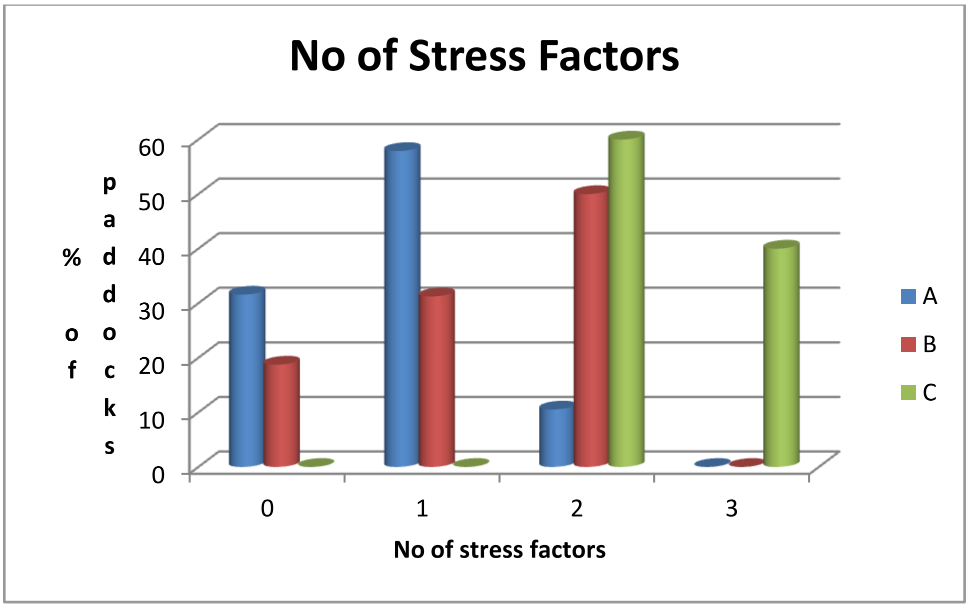

Figure 28: Effect of stress factors on paddock persistence rating

4.1.4 Survey results of factors affecting production

As expected the A1 paddocks had the highest production rating and the C paddocks the lowest (Fig 29).

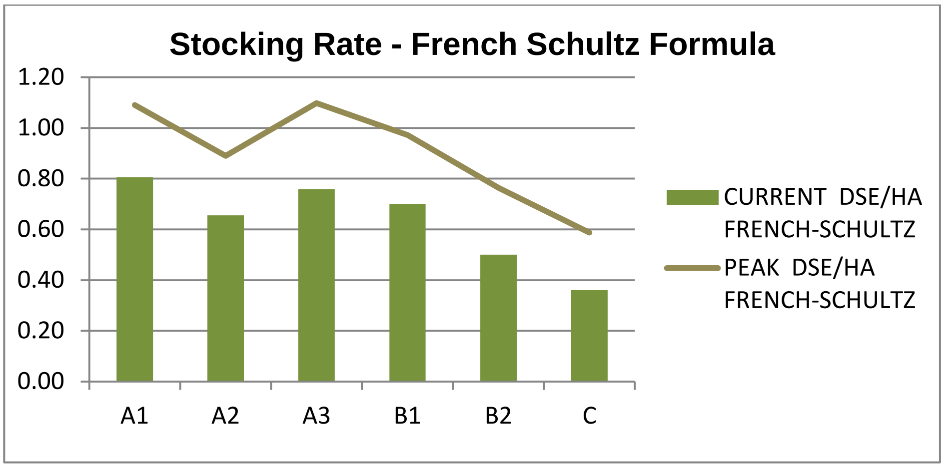

Figure 29: Comparison of average stocking rates between paddock ratings

As phalaris production was not the main focus of the investigation, factors that were significant are shown in tables 7, 8 and 9. Paddock size, soil pH and exchangeable Al were found to have a highly significant effect on production ($p<0.05$) as defined by French Schultz calculation. Olsen P had a significant positive effect on production at the $p<0.1$ level (see table 7).

The approximate R^2 relationships for hectares and pH are not showing very high relationships and this may be due to confounding from farmer (paddock location) which the models have tried to account for and remove. The slope of the relationship with pH indicates that as pH increases by 1 unit eg 4.0 to 5.0, the production is increasing by 30% (Fig 35). As paddock size increased by 10 hectares, production decreased by 5% (Fig 34).

The aluminium R^2 was very high but as mentioned previously the data contains outliers which could be unfairly influencing the effect.

Sub clover was found not to significantly affect production in any of the one, two or three way analysis. Sub clover assessment was done in the dry year of 2014 and its composition is known to fluctuate with seasons. Rainfall is not presented as it was already accounted for in the French Schultz formula.

Table 7: The correlation and probability of a single variable's effect on French Schultz calculation i.e. production in a one way statistical analysis

Variable	REML approximate R^2	P (probability) of the first variable
Hectares (Ha)	21.4	0.002
Sub clover	18.4	0.765
pH 0-10 cm $CaCl_2$	46.1	0.013
Colwell Potassium	17.4	0.223
Aluminium Exchangeable %	71.9	0.002
Olsen Phosphorus	16.9	0.062

Colwell K was not significant in a one way analysis but it was when combined with hectares in two and a three way analysis, with production increasing when potassium levels increased and when paddock size was also accounted for.

The significance of Olsen P became stronger when combined with combined with pH in the two way analysis. That is when pH was sufficient for growth (eg. pH 5.0), the production response to P became more significant.

Table 8: The correlation and probability of two variable's effect on French Schultz calculation i.e. production in a two way statistical analysis.

Variable	REML approximate R^2	P probability of term/s in each model	
		first term variable	second term variable
Hectares + pH (CaCl2)	63.3	0.004	0.025
Hectares + Colwell Potassium	28.5	<0.001	0.028
pH + Olsen Phosphorus	44.1	0.004	0.009

Table 9: The correlation and probability of three variable's effect on French Schultz calculation i.e. production in a three way statistical analysis

Variable	Approx. R^2	P probability of term/s in each model		
		first term variable	second term variable	third term variable
Hectares + pH + Olsen P	34.9	0.007	0.005	0.025
Hectares + pH + Colwell Potassium	57.3	0.001	0.052	0.051

Figures 30 & 31: Jallukar Park "Flat" paddock; which showed the highest French Schultz rating in the survey.

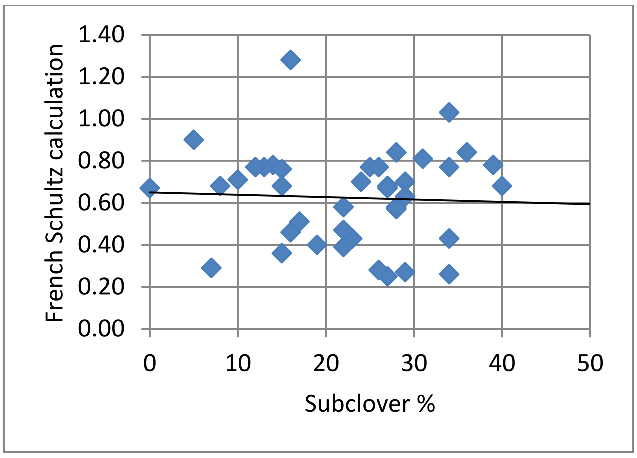

Figure 32: Effect of sub clover % on French Schultz rating (y=0.6499-0.001119x)

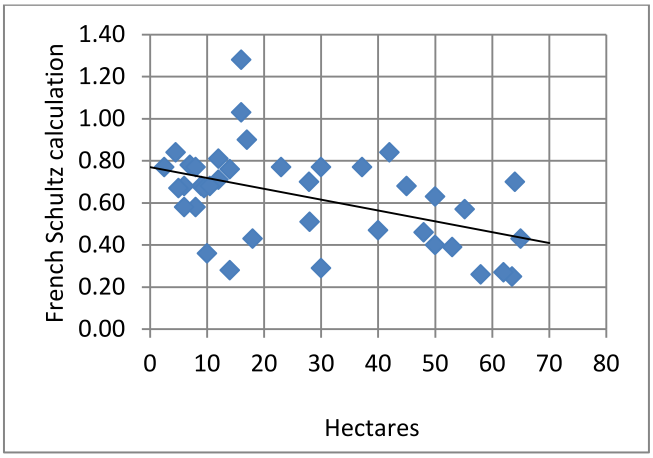

Figure 33: Effect of hectares on French Schultz rating (y=0.7694-0.005151x)

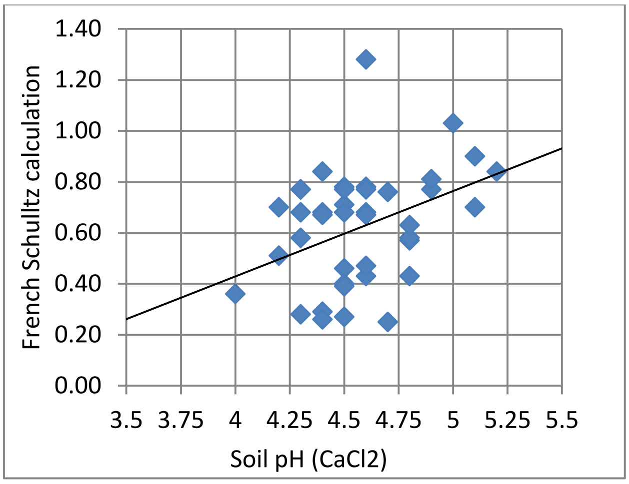

Figure 34: Effect of soil pH on French Schultz rating (y=-0.9097+0.3349x)

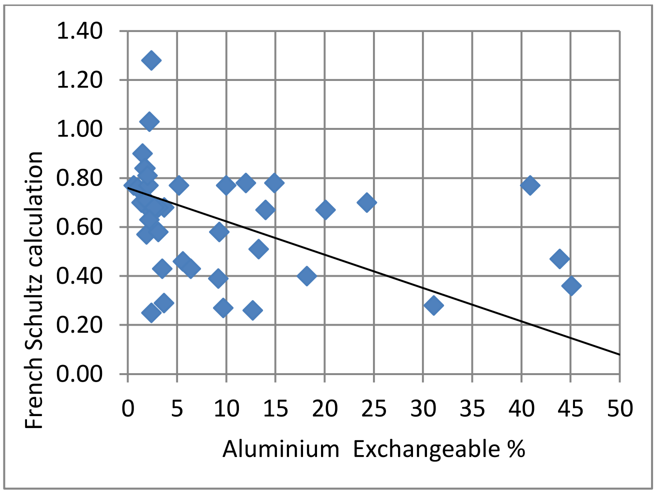

Figure 35: Effect of exchangeable Al% on French Schultz rating (y=0.7596-0.01363x)

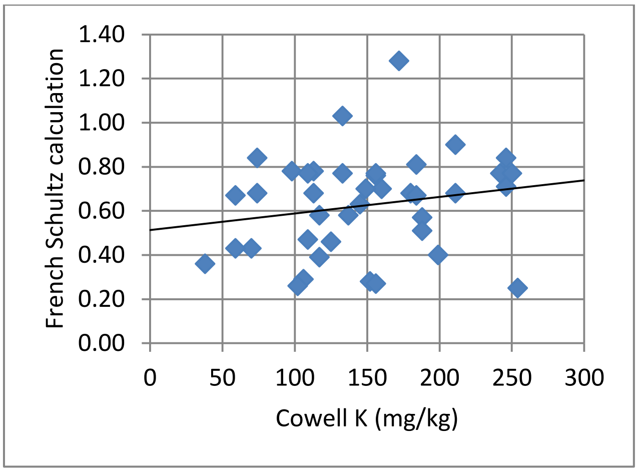

Figure 36: Effect of Cowell K on French Schultz (y=0.5130+0.0007518x)

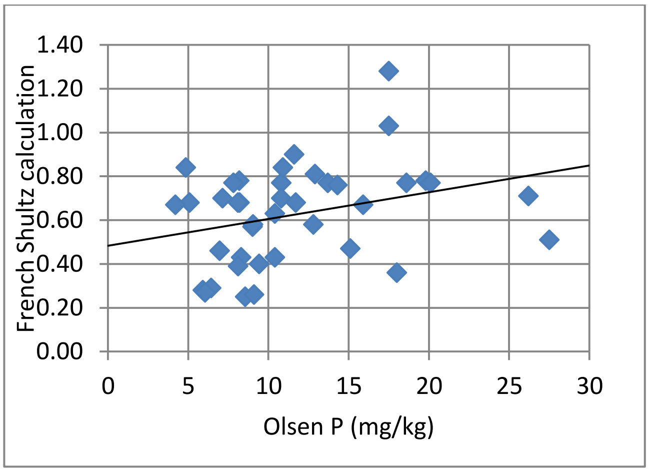

Figure 37: Effect of Olsen P on French Schultz (y=0.4825+0.01223x)

4.1.5 Molybdenum investigation as a factor in phalaris persistence

Molybdenum availability was also investigated as a factor that could affect phalaris production and persistence after feedback from researcher Dr Kevin Smith on a paper suggesting that molybdenum availability may have an effect on phalaris growth (Lipsett, 1973). A couple of extracts from the Lipsett paper are shown below. Molybdenum is required for the activity of the enzyme nitrate reductase for converting nitrates into ammonium and also converting inorganic P to organic forms.

TABLE 3

Dry matter yield and content of molybdenum of four species grown in pot culture with and without applied molybdenum (experiment 2).

Measurement	Wheat	Phalaris	Rye grass	Kikuyu
Dry matter (*g pot*$^{-1}$)				
With Mo	11.6†	10.0†	15.9	12.8
Without Mo	4.1	3.7	15.3	12.7
Mo content (*p.p.m.*)				
With Mo	0.19	2.15	2.91	0.62
Without Mo	< 0.01	< 0.01	0.05	0.01

† Significant at $P < 0.001$.

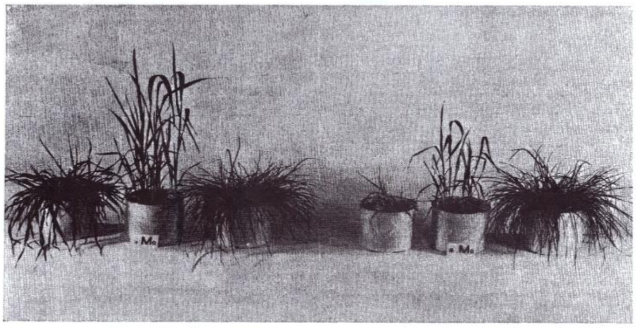

Figure 1—Appearance on day 110 of three species grown with and without molybdenum (experiment 2). Plants receiving molybdenum on left. Plants not receiving molybdenum on right. Left to right: phalaris, wheat, ryegrass.

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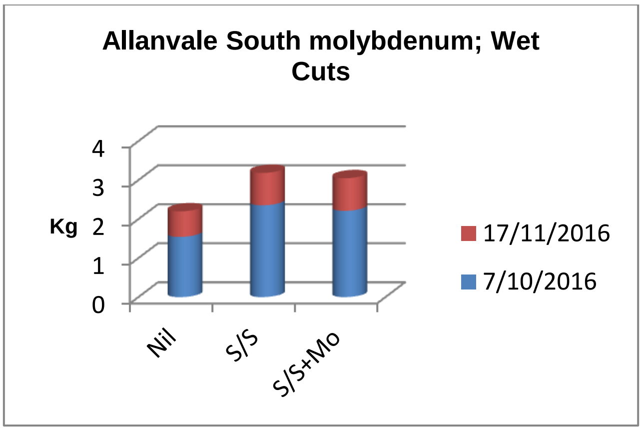
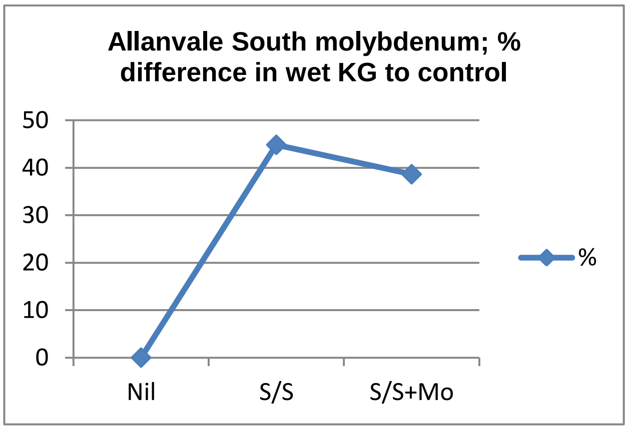
Figure 38: Extracts from the paper titled; "A comparison of the responses by six grasses, rape and subterranean clover to application of molybdenum by J Lipsett (1973)

At the Allanvale South site with a molybdenum application on mature phalaris pasture there were no significant differences found between the single superphosphate and single superphosphate + molybdenum treatments. Both single super treatments showed an increase in the amount of pasture from cage cuts when compared to the nil treatment; this confirms the findings in the subtractive fertiliser trial conducted in the same paddock (see appendix 1)





Figures 39 & 40: Results from replicated fertiliser treatments (s/s = single superphosphate)

Only minor differences between the treatments were found in the spring pasture composition estimates at Allanvale South.

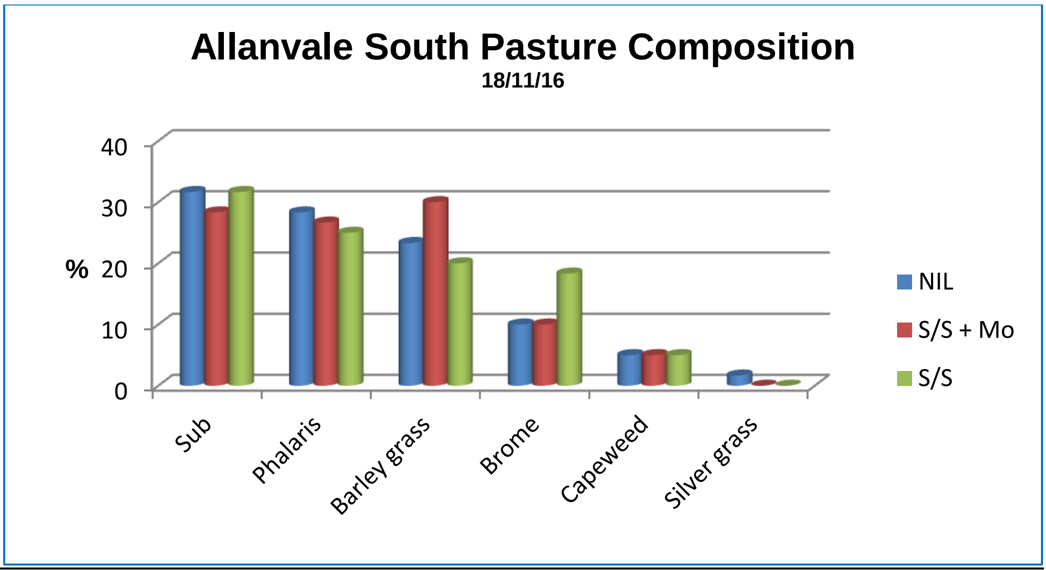


Figure 41: Molybdenum trial pasture composition, Spring 2016

At the Marenda Liquid Molybdenum Application site there was no significant differences found in the phalaris growth between the plus and minus liquid Mo treatments.

There were differences in plant survival counts but as the liquid Mo was applied as in conjunction with a weed control spray and the nil areas were established by turning off the boom spray. PPS suspects that the lower plant count was due to weed composition rather than an Mo effect. There was no opportunity to reapply Mo during the growing phase due to extremely wet conditions at Marenda in 2016.

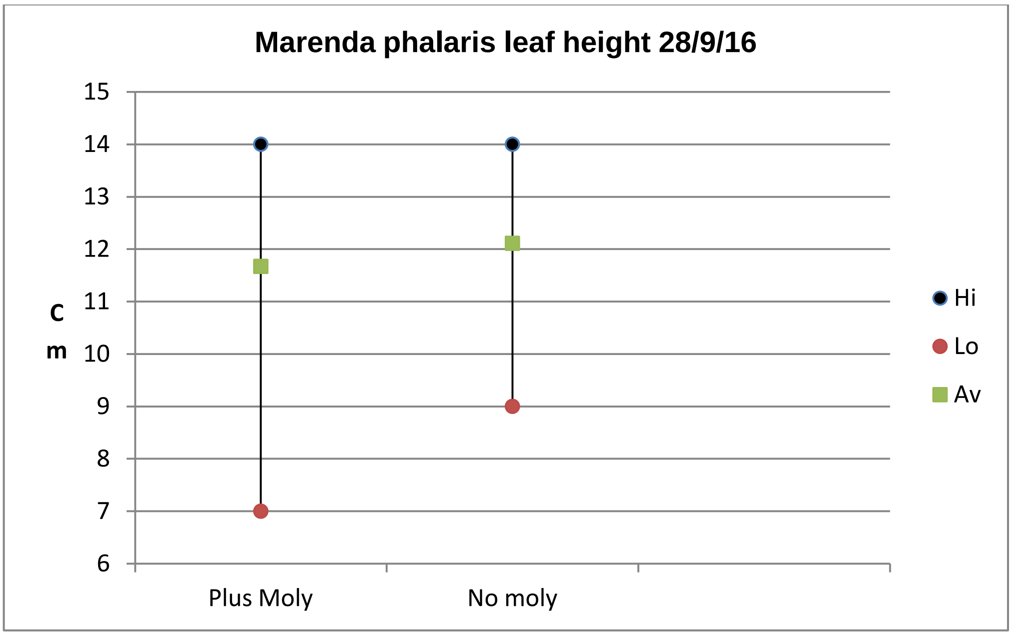


Figure 42: Liquid molybdenum trial measurements

The phalaris leaf tissue tests showed the plants in the + molybdenum replicates had a molybdenum result of 4.50 mg/kg which is regarded as high, while those in the control (no molybdenum) had a result of 0.25 mg/kg which is regarded as sufficient.

Plant tissue tests were taken from selected paddocks as part of the Molybdenum investigation.

Table 10: Results of tissue tests

Rank	Paddock	pH 0 – 10cm (CaCl2)	Soil Type	Molybdenum mg/kg
A1	7 Mile 3rd	5.1	L,GL	0.58
A2	3rd Peters	4.6	SL, L	0.56
B1	Allanvale South	4.8	CL	0.38
B1	Flat	4.6	CL	0.54
B1	Glenvale	4.7	CL	1.1
B2	McTavish W	4.7	L	0.51
B2	Rise	4.0	SL (granite)	0.45
B2	Stevens	4.6	L+Gravel Hill	1.3
C	Back	4.2	SL	1
Optimal levels for sub clover				0.5-10

The molybdenum investigation showed no results that suggest an effect on phalaris persistence. Further investigation would be needed to draw any conclusions on its' effect on phalaris production.

4.2 Tested key reasons

4.2.1 Nutrient Extraction trials

The nutrient extraction trials were conducted in conjunction with Agriculture Victoria which helped to identify production data.

These trials sought to identify soil constraints (nutrients and acidity) that impact on phalaris production and persistence by undertaking nutrient subtractive trials on old stands of phalaris.

Two sites were selected from the survey paddocks and the trials were set up in "Lindells" paddock at Lonsdale Park near Stawell and "Metcalfes" on Allanvale South near Great Western. The results are included in the discussion on page 34 and full results are shown in appendix (2).

4.2.2 In-depth surveys

Two in depth surveys were carried out on two properties which had long term persistent phalaris pastures. The properties were near Elmhurst and near Balmoral. The results are presented as case studies in appendices 3 and 4 and are in the discussion on page 34. Both explore the reasons why the properties have productive, persistent phalaris pastures and the case studies reflect the findings of the project.

4.3 Economic value of sowing phalaris

Economics of pasture establishment

The total cost of pasture establishment at each site ranged from $360 to $447/ha (Table 11). This is higher than for some other districts due to the need for capital inputs of lime.

Sowing phalaris pasture allowed producers to increase stocking rates from 100% to 150% compared with their unimproved/annual pastures (Table 11).

Table 11: Cost of pasture establishment and stocking rates achieved

Site	Cost of pasture establishment $/ha	Average stocking rate prior to pasture renovation DSE/ha	Peak stocking rate to date - after pasture renovation DSE/ha
Greenfields	406	6	13
Mooneys Gap	447	8	21
Millbanks	360	8	20
Jallukar	380	6	15

The Internal Rates of Return and the Payback period for each site are shown in Tables 12 and 13. Figures shown are before interest has been added on.

Table 12: Effect of Gross margins (commodity prices) on the Internal Rates of Return (IRR) for pasture establishment at each site.

Site	Internal rate of return (%)	
	Gross margin @ $30/DSE	Gross margin @ $50/DSE
Greenfields	21.6 %	32.1 %
Mooneys Gap	33.4 %	49.4 %
Millbanks	37.3 %	54.4 %
Jallukar	31.9 %	47.3 %

Table 13: Effect of Gross margins (commodity prices) on the Payback period for pasture establishment at each site.

Site	Payback period (years)	
	Gross margin @ $30/DSE	Gross margin @ $50/DSE
Greenfields	7	6
Mooneys Gap	5	4
Millbanks	5	4
Jallukar	5	4

At both Gross Margin/price scenarios, all 4 sites had a very good IRR, making pasture improvement a very worthwhile investment (Table 12). The average internal rate of return for pasture improvement at the 4 sites was 31.1% with an average payback period of 5.5 years, when the gross margin was $30/DSE (Tables 12 and 13). When the gross margin was increased to $50/DSE, to reflect current commodity prices, the average IRR was 45.8% and the average payback period was 4.5 years.

The Greenfields site had a slightly lower IRR and longer payback period than the other 3 sites. This was because the highest stocking rate achieved to date, relative to the stocking rate on the unimproved pasture, was lower than at the other sites. This site is still being monitored and the stocking rate has the potential to be higher than 13 DSE/ha.

4.4 Extension and communication

A summary of communication activities is shown in Table 14. Extension to the wider community was actively undertaken throughout the project. Twenty six extension activities were carried out involving a total 700 participants, with several farmers attending multiple events.

Table 14: Extension activities and communications delivered.

Date	Activity	No of people
2013		
12-13	PPS newsletter article - project announcement	300 Circulation
2014		
3-14	PPS newsletter article - project plans	300 Circulation
6-14	PPS newsletter article - project report	300 Circulation
01/8/14	Project planning initial meeting	16
3/9/14	PPS annual conference 2014 - project summary	110
11-14	Ararat/Stawell newspaper article Nov 14	
10-14	Update results sent to project participants	23
12-14	PPS newsletter article - project report	350 Circulation
2015		
3-15	PPS newsletter article - project report	350 Circulation
26/5/15	Presentation to CR GSSA producers visitors	9
27/5/15	Presentation to Yarram Landcare pasture group visitors	19
6-15	PPS newsletter article - project report	350 Circulation
7-15	Email updates to producers with surveyed paddocks	23
25/8/15	MLA Annual Review Meeting	21
12/8/14	PPS annual conference 2015 - project summary Aug 12	90
18/10/15	Benchmark paddock inspections, Mooneys Gap and Greenfields	18
10-15	Email updates to producers with surveyed paddocks	23
12-15	PPS newsletter article - project report	400 Circulation
12-15	5 MLA signs erected in Dec 2015	
2016		
3-16	External presentation; Farmers seminar; Edenhope	30
31/3/16	Project advisory group meeting at Ararat	5
23/5/16	Project advisory group meeting phone hook up	5
1/6/16	Workshop. National MLA PRS Attwood. 3 group members attended	65
June 2016	Paper: Project notes for national workshop. Real time biomass estimation using optical sensors. Author L Miller	Researchers workshop 60
23/6/16	Project advisory group meeting at Ararat phone hook up	5
6-16	External presentation; SAMRC meeting Horsham	12
18/7/16	Annual Review	20
24/7/16	PPS Winter farm tour	25
14/9/16	Project Update report at annual PPS conference	30
23/10/16	PPS Spring field day	40
25/11/16	PPS End of Year farm walk	40
6/12/16	Extension extraction meeting	8

2017	Activity	No of people
19/4/17	External presentation; Glenthompson - Dunkeld BWBL group	12
Various	PPS Facebook Group updates	72
19/6/17	Final Review Meeting	25

5 Discussion

5.1 Outcomes in achieving objectives

The group's research question was "*Can we improve productivity and longevity of perennial pastures in the Upper Wimmera through making informed tactical management decisions?"*

5.1.1 Key reasons for phalaris persistence & production

It is important to note that phalaris persistence and productivity are not always mutual, phalaris can persist indefinitely in a fairly non-productive state; roadside stands are an example of this.

The four results that will allow positive on farm benefits in potentially increasing the persistence of phalaris pastures were; decreasing paddock size, improving soil pH, reducing the number of stresses phalaris is exposed to and accurately assessing the state of phalaris pasture. All of these can be used to improve the management of phalaris based pastures and increase persistence and long term productivity.

Paddock Size; A positive correlation was found in phalaris frequency with decreasing paddock size. The group suggests those over 20 ha have a lower persistence rating than those under 20 ha. The group speculates that grazing management through preferential grazing may be reason for this, but other factors such as large paddocks containing different soil types and aspects may be another. In project review meetings it was also suggested that farmers may be less likely to look after larger paddocks when cost constraints need to be implemented, so they may be lower in fertility.

Most grazing management trials involving phalaris are generally small scale and so this effect of paddock size on persistence has not been identified as a potential factor previously.

Soil acidity; Soil pH was found to have a significant effect on phalaris content. As soil pH($CaCl_2$) declined phalaris content decreased. The trend line showed that as pH declined by 1 unit, phalaris content decreased by approximately 27%. The results confirmed previous knowledge of the effect of pH on phalaris. Aluminium was not found to have a significant effect but this may have been attributed to the leverage within the data.

The amount of toxic aluminium within the soil generally increases when soil pH falls below a pH of 4.8 but the amount is also influenced by the soil parent material. Most aluminium levels within the survey fell between 1% and 10%. Phalaris is considered sensitive to aluminium and it can reduce yields by reducing root growth and function restricting nutrient and water uptake. The yield of phalaris starts to decline at exchangeable cations levels of approximately above 10% (DPI, 2010). Culvenor *et al.* 2011 demonstrated where Al toxicity exists, phalaris can be increasingly sensitive to drought.

The sensitivity of aluminium varies with phalaris cultivar. The order of cultivar tolerance as tested by Song *et al*, 2016 who tested 20 perennial grasses and 4 legumes ranked Advanced AT 5th overall, followed by Landmaster 8th, Holdfast GT 11th, Australian 19th, Holdfast 20th, and Sirolan (23rd).
The survey contained only one paddock containing Advanced AT in a mix and one with Landmaster. Holdfast GT was used in 4 paddocks. There is opportunity to increase the use of more acid tolerant phalaris cultivars of Landmaster and Holdfast GT within low rainfall areas.

Combined stresses; The results showed evidence between multiple stresses on the pastures and lower phalaris plant numbers. The more stresses which the phalaris was exposed to; the more likely phalaris frequency declined. Stresses were defined in the results section and are low pH, large paddock size, low P, low K, high aluminium and low decile rainfall in the year of establishment.

Culvenor and Simpson, (2014) identified many more stress factors that influence pasture plant persistence (see figure 44 below) than what was investigated in this survey. They suggested that compounding stresses on plants can have adverse consequences on survival.

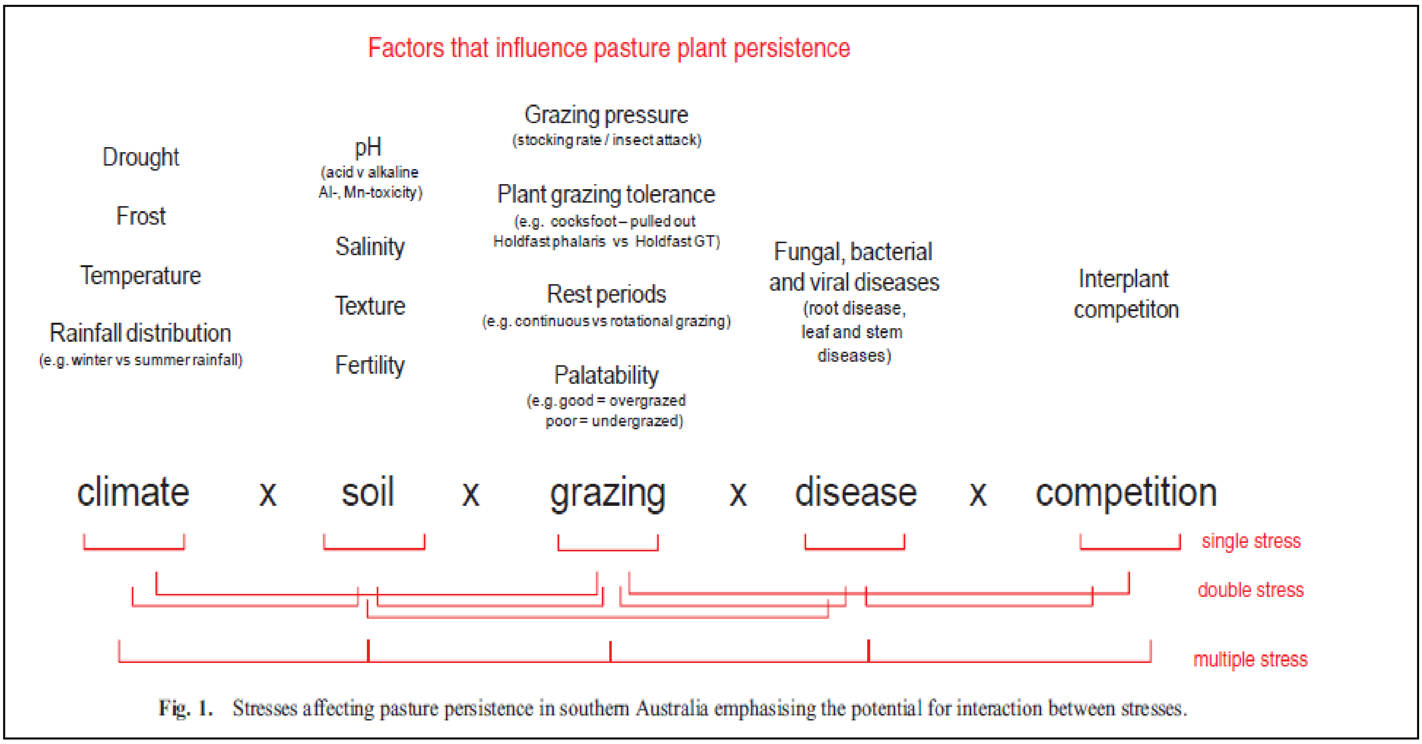


Figure 43: Stresses affecting pasture persistence in southern Australia (Culvenor and Simpson, 2014)

Underestimating pasture quality; The project results showed that many producers underestimated the quality of old phalaris stands and the potential to rejuvenate them into productive pastures. This result is backed by observations made when favourable conditions, such as those experienced in the wet summer years of 2010 and 2016, allow phalaris plants to show up in pastures where they were thought to have died out. A phalaris pasture can still be productive with 5 plants/ m^2 (Lisa Warn; personal communication) and there are many old pastures which could increase productivity with the application of fertilisers and weed control measures.

Olsen P wasn't found to be a key factor in persistence. This finding was unexpected although it is in agreement with AgVic's long term P trial which showed grass persistence affected when Olsen P< 6 (McCaskill, 2016). Productive phalaris based pastures normally have level of Olsen P >12 but it should be noted that the optimum phalaris production depends on the availability of N, normally provided by the sub clover component in the pasture.

Colwell K was found not to be significant in a one way analysis but it was when combined with hectares indicating that when some of the variation of large paddock size is accounted for, phalaris content increases with increasing potassium. Potassium is important for stomatal (pore) control and therefore is an important factor for controlling water loss in dry hot conditions.

Average rainfall was not found to be a key factor, indicating phalaris has the potential to persist in the varied annual rainfall zones in the Upper Wimmera.

Factors affecting persistence generally were also found to significantly affect production using the French Schultz rating. These included paddock size, soil pH and exchangeable Al% ($p<0.05$) and Olsen P ($p<0.1$). There was also evidence that Potassium influenced production when some of the variability around paddock size was removed in two way models.

The paddock size ($p=0.002$) confirms the Grasslands Productivity Project finding, (Bennison and de Fegely, 1998, where higher stocking rates (3 DSE/ha) could be carried in paddock sizes less than 20 ha.

Unexpectedly sub clover was found not to significantly affect the French Schultz model of potential stocking rate. This could be due to the 2014 year of the Spring assessment being a below average growing season rainfall and sub clover content varies with seasonal conditions.

5.1.2 Tested key reasons

One of the ways objective 2, (test key reasons for increasing the life of phalaris pastures identified through the survey), was achieved was through further in depth studies as the persistence of phalaris cannot be tested within one or two years.

In depth interviews were conducted on two of the PPS member participating properties which have exhibited long term phalaris persistence. The purpose of these surveys were to test if key reasons for persistence identified within the survey held true on these farms and to get a better understanding of management. These were conducted at “Greenwood”, Englefield and “Millbanks”, Elmhurst.

Greenwood was purchased by the current owners in 2003 and at that time consisted of large, set stocked paddocks with low fertility phalaris based pastures. Since then it has been fenced into paddocks averaging 7.5 Ha, had capital phosphorus fertiliser applied and has had a rotational grazing regime imposed. Production has increased by 60% and it stands as a great example of the effect of paddock size and other management techniques in maintaining productive, persistent phalaris based pastures.

Millbanks is an example of three generations of productive pasture management and the property has phalaris pastures dating back to the 1950’s. The system at Millbanks shows how the elimination of multiple stresses allows phalaris to persist for decades. As well as targeted fertiliser programs and rotational grazing strategies, Millbanks was one of the first farms in the region to use autumn stock containment as a method to enhance phalaris persistence. Strict management of newly established phalaris pastures are implemented to set them up for long term persistence.

The in-depth surveys are presented as case studies in appendices (3) and (4).

The effects of nutrients were studied at two properties, “Allanvale South” and “Lonsdale Park”. The nutrient extraction trial at Allanvale South showed that large increases in phalaris pasture production were achieved through the application of phosphorus above the recommended maintenance level. . There was little or no response to other nutrients suggesting that they were not limiting which was also reflected in soil test results. The starting Olsen P level was 10 which is below the optimum of 15 mg/kg for production and as the pasture was not constrained by potassium levels or soil acidity, it responded well to the extra P. The benefit to the phalaris plants is assumed to occur from the increased nitrogen made available through increased nitrogen fixation from improved sub clover growth.

The nutrient extraction trial at Lonsdale Park showed little or no response to the applied nutrients. At this site, P, K and soil acidity had soil test levels (8 mg/kg and 117 mg/kg) suggesting nutrient deficiencies and soil acidity (pH 4.5 with Al ex 9%). Lack of response may be due to the slow response of surface applied lime to address soil acidity which has constrained responses to both P and K.

5.1.3 Economic value of phalaris and its interventions to increase persistence

The high Internal Rates of Return calculated for the four trial sites indicate that pasture improvement is a very worthwhile investment. Large increases in stocking rate were achieved on the improved pastures, which meant the payback periods calculated are lower than in some other studies.

The payback period of 5 years was very quick which means that you could potentially sow phalaris more often. However the results of the survey show that phalaris once established has the capacity to maintain for a long period of time.

Phalaris wasn't found to necessarily decline over its lifespan (see fig 27; establishment year) and from the benchmark paddocks that were established in 2009 and one in 2014. This supports the Broadford grazing experiment (1998 – 2002) which showed that phalaris, if managed well, can maintain its productivity.

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

The value of the results for producers as identified in annual review meetings were:

- More productive and persistent phalaris
- Reduced supplementary feeding costs
- Improved ground cover
- Better persistence is desirable so that producers don't have to resow, which is risky in the Upper Wimmera environment and takes a long time to pay for the investment.
- Increased knowledge of phalaris management
- Adopting smaller paddock size for phalaris pastures will mean that there will be better utilisation and therefore improved production. It will also help to optimise mob size for lambing and may have spin off benefits for increasing lambing %. Having a smaller paddock size means more flexibility. If you have a 100 ha paddock you may be more inclined not to stock it correctly.

Environmental benefits
Productive perennial phalaris based pastures improve the level of summer ground cover when compared to annual systems. Productive phalaris pastures also have benefits in improved water use reducing run off and reducing the risk of salinity.

Productive perennial pastures also utilise stored nitrogen in the soil reducing the risk of nitrate leaching. Managing for persistence by reducing paddock size will also assist in managing differing land classes and improve grazing management.

5.3 Promotion of research results and its effectiveness

The phalaris persistence project created immediate interest both within and outside the PPS group as it was looking to address an issue that affects many producers in the grazing sector. Twenty three PPS member farms, which have around fifty people involved in the businesses, were directly engaged in the survey process and had soil and pasture measurements carried out on farm. Many other PPS members were engaged in formal and informal discussion regarding the project and its potential outcomes.

PPS used the project updates and findings as part of its overall extension and these were included in field day, annual conference and farm walk discussions. The project was also included in several external presentations by the PPS project manager.

The project and its progress were continually reported in the quarterly PPS newsletters, which are sent to PPS members as well as an additional 250 recipients. These include farmers and farmer groups in NSW, WA, SA and NZ as well as Dept Ag, CMA, CSIRO and agribusiness personnel.
The final report will be printed and distributed to the participating farmers as a record of their involvement and the report will be posted on the PPS website.

At the start of the project (initial workshop meeting) the group discussed their current knowledge about persistent perennial pastures. They had assumptions on reasons why pastures may or may not persist and some evidence but believed that it wasn't fully verified in their environment. Some of their observations included:

- They thought that there were stresses on the plant that play a role in the pasture's demise. They believed they got the soil condition right at sowing but wondered if soil condition a few years after sowing impacts on survival particularly pH at depth and aluminium.

- They knew that the amount and timing of moisture will place stress on the plant. But they didn't know when to put animals into containment and stop grazing good pastures so they survived. They indicated that the recommendations of containment were more about protecting soils than about plant survival. They were not sure how to judge when to stop grazing, kg DM/ha or use other factors.

- They recognised the value that a wet summer or spelling in spring may allow recovery of phalaris.

- They did question the influence of nitrogen on phalaris persistence; whether they should use urea if they can't get clover to fix enough nitrogen. It was unknown how much clover they needed to provide a balance with phalaris.

- They didn't know if and where the trade-off is between persistence versus production. Can they run pastures at 80% of their productive potential so they would persist indefinitely?

By the end of the project the group now knew the importance of paddock size, soil acidity and the effect of multiple stresses on phalaris persistence. Producers were also reassessing old phalaris pastures as a response to the finding that several of the project paddocks were rated lower by farmers than the objective measurement of the pasture indicated.

Examples of changes in knowledge mentioned by the group were:

- Know now about stresses and will pick stresses in those paddocks to manage them accordingly.
- Reduce paddock size.
- Payback period, didn't know what it was, but are interested in the results of the PPS Greenfields project which will produce quantifiable results for the region.
- Amount of production from phalaris and just how good it was.

Paddock size, in relation to phalaris persistence, is a completely new concept that has not been identified before to the knowledge of the PPS group or the project researcher. Other trials have shown an increase in productivity with smaller paddocks but PPS knows of no long term study into the effect of paddock size on persistence.

Practice change and likely adoption evidence collected as a result of the project included:

- There was a lot of interest noted in paddock size and one producer subdivided a large phalaris paddock and split up a 160 acre (65 ha) paddock into 3 (22 ha). An advisory group member combined the paddock size findings with annual rainfall to suggest the following for phalaris pastures.
    - Rainfall < 450 mm use 15-20 hectare paddocks
    - Rainfall > 500 mm use 10-15 hectare paddocks

- The host farmer with the fertiliser exclusion trial decided on a capital P fertiliser program for the paddock.

- The PPS Project Manager reported that anecdotally most farmers thought the autumn period was when they lost phalaris and many have implemented containment areas to protect phalaris pastures at the autumn break. This has been aided by the large uptake of stock containment areas in the region in response to the drought condition of 2014/15. This is contributing to improved phalaris growth and reduced soil erosion risk by resting the pasture at a crucial time.

- One member agreed that paddock size and set stocking in early autumn has been his downfall and he now leaves phalaris to reach about 1800 kg DM/ha before grazing it. He does this by grazing his unimproved hill country with large mobs of sheep and feeding them.

- One producer said they would find a system to allow phalaris to rest in autumn to reduce its stress. Another was going to try build enough autumn/winter feed (1200 to 2400 kg DM/ha) before grazing it and to do that, he recognised he was going to need smaller paddocks. He had also shifted lambing back a month to about July1st and had staggered lambing times with different classes to reduce autumn grazing pressure.

5.4 Effectiveness of the participatory research process

There wasn't an actual Feedbase Investment Plan research project on persistence but MLA had previously done a pasture persistence and establishment review which this project adds value to.

The two way discussion between the researcher and the group was highly valued. The annual reviews sought to get producer involvement and ask their opinions on the research findings and whether they made sense. Generally discussions with researchers are often one way the researcher does most of the talking and the producers ask questions mainly for clarification rather than stating their views. The discussions raised important issues on pasture management and paddock size.

The group also provided feedback to MLA on potential barriers to adoption and identified what's important to producers will be useful in development of extension products. The group have identified different strategies to overcome the paddock size and lack of grazing control issue including the awareness of avoiding grazing phalaris at sensitive times. Many strategies are already used by some members of the group. But there is more work required to identify which ones have a positive cost-benefit. Barriers to adoption and some potential strategies are listed below:-

- Mindset barriers:
    - Producers often wrongly assess the amount of phalaris within paddocks.
    - If farmers believe the phalaris paddocks are not that good, they don't invest in them. 22% of the paddocks surveyed were rated lower than the objective assessment.
    - There is still a lot of Australian phalaris sown as it is believed that new cultivars won't be as persistent.

- Paddock subdivision
  Subdivision of larger phalaris based pastures has commenced or is planned on several PPS member properties. Although there were barriers identified in implementing subdivision changes:
    - Cost of supplying water to the paddock and what to do about it. This was identified as a one off cost and the pay back of water infrastructure costs can be retrieved quickly
    - Cost of fencing. The development of new technologies such as virtual fencing would be a major advance in addressing this barrier to change.

- Productive phalaris pastures reduce water runoff which creates issues in planning new water supply dams.
- Water supply dams need a lot of planning and Water Authorities often will not approve large dams. Government policy needs changing – one member was quoted "I have been waiting 6 months for 7 dam approvals, 2 big dams (17 ML) for stock containment areas are holding up the approval."
- Putting in new dams is risky, if they are put it in the wrong place, they are not easily moved.

- Producer confidence in grazing management
  - Some producers aren't confident in applying the skills around managing a rotational grazing system, particularly around making grazing decisions in autumn or in poor springs.

- Managing multiple stresses in phalaris pastures
  - PPS expects that the key finding of the effects of multiple stresses on phalaris persistence will bring about practice changes in many aspects of phalaris management.

- Treating soil acidity
  - Low soil pH is being addressed on several pastures through the use of lime applications on PPS member properties. There are some barriers which affect the implementation of lime applications.
    - Cost of lime but it is a capital cost amortised over the medium term.
    - High cost of cartage and freight to local area.
    - Return on lime investment can be less than potential production returns.
    - Lime is a 10 year prospect to get money back.
    - Responses are variable and response time can be slow. One member said "I put on lime once and didn't see a response."

Possible future areas of research were identified from project review meetings. Producer thoughts included:

- Identify the optimum pasture mix for farms; one suggestion was 50-70% phalaris for lambing down on, 30-50% productive annual grasses, clovers or lucerne for autumn-winter feed when phalaris isn't growing or when it needs to be spelled to protect it.
- Quantify the benefit of locking up phalaris paddocks at various stages of the growth cycle to improve persistence and production.
- If paddock size is a key factor for phalaris persistence; do we contain stock at the plant's sensitive time or do we reduce paddock size and provide water infrastructure? Can virtual or temporary fencing be used?
- More research on the benefits of stock containment was thought to be needed; knowing when to spell and how much phalaris kg DM/ha needs to be present before re-grazing.

The PPS group was positive about and enjoyed being involved in the project and several members attended the review meetings. Others were positively involved throughout the project through discussions with the project manager. Many members were actively involved in the project through either supplying a survey paddock or being involved in a trial.

6 Conclusions/ Key Messages /Recommendations

6.1 Conclusions

Phalaris is a productive and persistent pasture species suitable for the Upper Wimmera rainfall environment. If well managed it can be productive in excess of 20 years and easily surpass the payback period of 5 to 7 years and produce internal rates of return of 22 to 37%, making it a very worthwhile investment. To achieve persistence of phalaris, the key factors found in this project that producers should consider are reducing large paddock sizes (optimum size is about 20 hectares), soil acidity by maintaining soil pH levels around 5.0 and avoiding compounding stresses which weaken the plants ability to persist. The factors found in this project that producer's should concentrate on to achieve good production were optimum soil levels of phosphorus and potassium and again reducing paddock size and soil acidity.

6.2 Key messages

The key messages for producers that came out of the extension extraction process were:

- Optimal paddock size to improve phalaris persistence is less than 20 ha.

- Identify which paddocks have stress factors and look to eliminate them so that the effect of multiple stresses on phalaris is reduced.

- Increase the phalaris asset by optimising macronutrients Phosphorus, Potassium and Sulphur with adequate fertiliser applications and Nitrogen by having a sufficient legume base in the pasture.

- Address soil acidity where necessary by liming to maintain soil pH above 5.0 and in limited circumstances by using acid tolerant cultivars.

- Assess phalaris content in mid spring to give a more accurate measure of phalaris content. Greater than 40% is considered good for production and persistence. Less than this can indicate phalaris may be declining due to compounding stresses.

- Continue to invest in the sown phalaris paddock and eliminate or manage stresses and phalaris can be productive for well in excess of 20 years.

6.3 Recommendations

The project identified that farmers thought their pastures were poorer than what they were so this potentially changed how they managed them. Therefore PPS recommends:

- Implementing a quantifiable assessment process which will assist in determining: What is an acceptable pasture level for phalaris productivity and persistence? Develop guides on how to objectively assess the pasture.

- A case study of splitting up large paddocks and supplying water to them – researching the best practice in implementing the process and the subsequent economic result as this is a big barrier identified by the group. The PPS Greenfields project, commenced in 2014, will partially answer this.

- Defining how much phalaris leaf recovery kg DM/ha should be present at key times for phalaris persistence (autumn, failed springs) before re-grazing.

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Project Participants
PPS members who supplied paddocks for the project and attended project review meetings.

9 Appendices

Note appendices can be obtained by contacting MLA at reports@mla.com.au

(1) PPS/DEDJTR Soil Constraints Trial
Prepared by - Rob Shea: Project Manager Perennial Pasture Systems (PPS), Ararat & Neil James: Land Management and Livestock Extension Officer Animal, Plant, Chemical Operations and Services Division DEDJTR, Ballarat; November 2015

(2) Economic analysis
Prepared by Lisa Warn; Lisa Warn Ag Consulting Pty Ltd; May 2017

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(3) *Greenwood, Englefield Vic; Aira and Geoff Kemister; March 2016*
(4) Millbanks; Elmhurst, Vic. Ben and Jodie Greene; April 2016

(5) PPS Phalaris Persistence Project; *paddock persistence & production survey template, November 2014*

(6) PPS Phalaris Persistence Project; P*addock Survey Summary,* April 2015