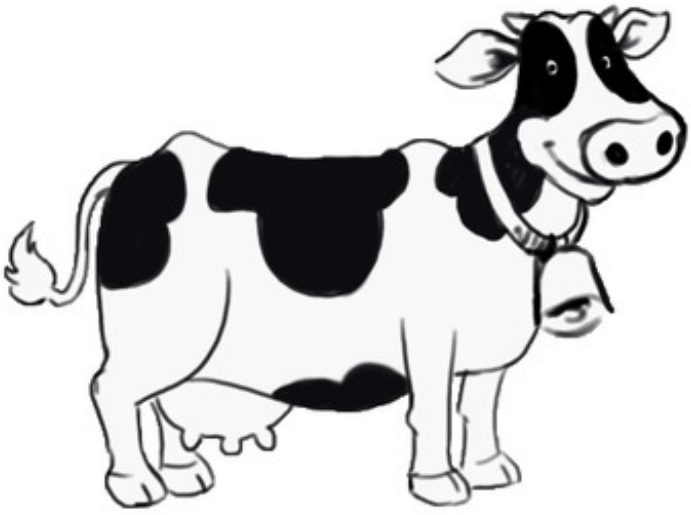
THE SPREAD OF SEEDS THROUGH CATTLE



~ To determine what plants, if any, are capable of germinating after being passed through the digestive tract of a bovine animal ~

Jade Moxey - Year 10

ABSTRACT

The concept of using livestock as an economic and environmentally friendly control in the fight against weeds is becoming a more common approach within farming communities. However, we have observed contradictions to this theory on our farm. I decided to test whether livestock are capable of spreading weeds through their manure, possibly compounding the weed problem.

Every month, for the period of 11 months, a manure sample was randomly collected (in duplicate) from the Bega Saleyards. The manure sample consisted of 15 individual collections from separate pens within the yards. These samples were then brought back to our farm, located in Numbugga north of Bega, where they were prepared for potential germination. Each sample was given the opportunity to germinate from the time it was collected until the completion of the trial.

The results supported the hypothesis that seeds do survive the digestive system of a ruminant and are then capable of germinating in the manure. A limited number of species beneficial to a farming operation germinated, such as Ryegrass, Kikuyu, Clover, Paddock Lovegrass and Medic. Fireweed was the only listed noxious weed to germinate. A variety of other seeds also germinated, including plants such as Chickweed, Flaxleaf Fleabane, Stinging Nettle, Verbena, Vulpia, Couch, Crab Grass, Marshmallow Weed, Carrot Weed, Dandelion and Flatweed. The germination rate over the life of the trial ranged from one or two plants in some species to 880 in another.

INTRODUCTION

Certain types of livestock are thought to be a reliable form of weed control, but is this true; and more importantly, could they instead turn a weed problem into a weed catastrophe?

I live on a 750 acre beef and sheep farm in the Bega Valley where we use our sheep as an aid in weed control, particularly the noxious weed known as fireweed. However, we have noticed two things:

1. fireweed seems to be most prominent where the sheep camp in concentrated numbers; and
2. fireweed is spreading across the farm, becoming established in paddocks that once contained little or no infestation.

We have also found a few completely isolated African Lovegrass plants (also listed as noxious) on the farm in paddocks where we agist locally sourced dairy heifers. We have often wondered how these plants established themselves, considering it is documented that the seeds can only be spread short distances by wind and there are no known plants on our farm. It is suspected that such seeds have been brought in with the dairy heifers that have recently been introduced to our farm.

The local private veterinarian, Peter Alexander, has found certain weed species growing only in the area where they treat horses at the veterinary practice, again raising the question, why only where the horse manure is found?

My Grandfather collects manure from a local dairy for his veggie garden and now struggles with the many “unwanted plants” that are competing with his vegetables. Before the introduction of the manure there were no signs of such plant species.

The above observations clearly challenge the concept that livestock can be an effective form of weed control; instead suggesting they may even be compounding the problem. What if the seeds that an animal consumes are capable of germintating after passing through the animal’s digestive tract … consequently spreading the unwanted plant further?

This is of particular interest to me because, if this is a known fact, not only would it be beneficial to weed management strategies implemented on my family farm, but also to the control and management of weeds throughout the Bega Valley and wider farming community.

AIM

To determine what plants, if any, are capable of germinating after being passed through the digestive tract of a bovine animal.

BACKGROUND RESEARCH

The Oxford Dictionary states that a weed is “a plant growing where it is not wanted”; therefore, any plant may be a weed in context. Plants considered to be beneficial to one area may be detrimental when spread to a region where they are not wanted, or not yet introduced. For the purpose of the trial, I will be classifying a plant as either ideal or as a weed, based upon the plant’s impact on a farm grazing operation.

Pasture plants within grazing operations across the Bega Valley are predominately based around Ryegrass, Kikuyu, Clover, Paspalum, Oats, Millet, Fescue, Cocksfoot, and certain native grasses. On the other side of the spectrum, there are 145 plant species listed as significant weeds that are known to occur, or have the potential to occur, in the Bega Valley. Those of most concern to the local community at present are African Lovegrass and Fireweed. These two species are considered to be extremely problematic due to their rapid spreading ability and negative impacts on livestock and pasture conditions. The spread of these two weeds in particular needs to be controlled, as there are significant consequences should these species be allowed to spread into non-infested areas. Action groups are being established in the Bega Valley to help address the ever increasing issues associated with the management and eradication of these two noxious weeds.

To determine whether animals are in fact capable of spreading plants via their manure, first the animal must consume the seed. “Weed seeds commonly enter livestock systems from forages, grain and palletized feed products. Cash et al. (1998) estimated that for palletized products, less than 1% of weed seeds survive feed grinding and palletizing. Though small in number, feed pellets can be a source of introduction of new weed species to a farm, and if one considers the volume of palletized feed fed, can be a significant source of weed seed.”

It is interesting to note that *NSW Department Of Primary Industries* states that cattle will normally avoid eating fireweed and the pasture below it and the *QLD Department Of Agricultue, Fisheries and Forestry* suggests that African Lovegrass will only be consumed once all other pasture has been consumed. This would then lead us to believe

that cattle are not likely to spread these particular plants as they do not willingly ingest them.

Contradicting this however is the fact that the plant itself does not have to be consumed. Instead, it is possible that the cattle could ingest the seed of these plants if they were placed in a heavily infested paddock. Therefore, African Lovegrass and fireweed, although not likely to be consumed by the animal directly, still possess the ability to be spread through the ingestion and excretion of seed.

Due to the manure samples being collected from cattle within and surrounding the Bega Valley, it is expected that African Lovegrass (Eragrostis Curvula) and Fireweed (Chamerion Angustifolium) would be particularly prominent due to their concentrated abundance in this area. Ryegrass, clover and kikuyu are the most dominant pasture species in the area due to the number of local dairy farms and seed from these species should also be available in abundance. Therefore, it is assumed that ample seeds are being ingested by cattle in the Bega Valley, either from ideal or problmeatic species. However, it is vital that the seed survives the digestion process if there is to be any chance of the seed being able to germinate once excreted.

Kerry Barringer, curator of the herbarium at the Brooklyn Botanic Garden said, “Many seeds have an impermable outer layer that protects the seed and allows the delicate embryo to survive the trip through an animal’s digestive system.” A study conducted in New York (Mt Pleasant and Schlather 1994) demonstrated that manure with low amounts of weed seeds are from cows subjected to feed containing low numbers of weed seeds, and manure with high amounts of weed seeds are from cows subjected to feed containing high numbers of weed seeds. Seeds are most definitely able to pass through the bovine digestive tract, but whether or not these seeds are capable of germination is unanswered.

HYPOTHESIS

From my observations and research I am of the opinion that seeds are capable of germinating after passing through the digestive system of cattle, which challenges the concept that livestock may be an effective form of weed control. I expect that different varieties of seeds will germinate, with the abundance of each seed being dependent on the time of year in which the sample is collected and the conditions in which the sample is grown.

RISK ASSESSMENT

Five risks have been identified as potential hazards in the running of this experiment. These, along with the techniques to overcome the risks, are listed below:

1. Potting Mix – The collected manure samples are being mixed with potting mix in order to establish a suitable seed bed that is considered sterile. The hazards associated with Potting Mix are clearly labelled on the bag:

   > "Inhalations of dust and/or liquid mists, produced by potting mix may irritate, inflame or sensitise the nose, throat and lungs resulting in illnesses ranging from Hayfever or Asthma, to Pneumonia (eg: Legionnaire's Disease) or Pneumonia like illnesses. Direct contact with the potting mix or its dust and/or liquid mists (bioaerosis) may cause skin irritation (dermatitis)."

   To prevent these risks, the potting mix bag states:

   > "Avoid contact with eyes and skin. Avoid breathing dust and/or liquid mists (bioaerosis). Wear suitable protective clothing and standard duty gloves. If exposed to dust and/or liquid mists also wear dust resistant eye protection and particulate respirator. Wash thoroughly immediately after handling. wash work clothes regularly. Clean up by wet sweeping or vacuuming."

   I have furthered these safety precautions by ensuring I mix the potting mix with the manure in a well ventialted area.

2. Bovine Johnes Disease (BJD) – The potential introduction of BJD onto our farm through the collected manure samples would be disastrous to our farming business; therefore, it is vital that I do not dispose of any collected manure samples on our property, due to the potential risk of contaminating the ground with BJD bacterium. My Grandfather has kindly offered to take all the plots and use the manure on his vegetable garden, which is located on a suburban block and poses no risk to livestock or farming enterprises.

3. Injury at the saleyards – There is always the risk of injury when moving within and around livestock, particularly when the stock are subjected to stressful conditions such as those found at the saleyards. Therefore, all manure samples will be collected once the sale has concluded and only from empty pens, with all collections being done under the supervision of a responsible adult.

4. Zoonotic Diseases of Cattle – There are 12 known Zoonotic diseases that spread from cattle to humans, some of which are spread through manure. Therefore, disposable gloves will be worn at all times whilst handling the manure samples and hands will be thoroughly washed with a disinfectant soap at the completition of each manure handling.

5. Animal Ethics – Even though the manure is sourced from cattle, I will not be running any trials on animals; therefore, I do not believe there to be any animal ethical issues associated with this experiment.

EXPERIMENTAL DESIGN

Randomisation

An important part of this experiment is to provide a broad and fair representation of plants grazed within the Bega Valley. To ensure this occurrs, fifteen individual samples will be randomly collected from within the Saleyards every month, with each individual collection being taken from a different and random pen of cattle.

Replication

Due to the varying lifecycles of different plant species found in the Bega Valley it is most important that the monthly samples be replicated over an 11 month period. This will ensure that no plant varieties are excluded simply because they were not seeding at the time of collection, or able to germinate at a particular time of year.

It is also important that two identical samples be collected each month as this will help identify any sources of variation or experimental errors, ensuring the results of the experiment remain unbiased.

Control Group

A control will need to be prepared to ensure the growing medium that is mixed with the manure in no way contributes to seed germination through its own contamination. This will be done by running a plot containing only potting mix which will be treated the same as the manure plots. The same potting mix will be mixed with the manure throughout the entire trial. Should any weeds germinate in the control plot they will be excluded from the experimental findings.

Experimental Variables

In order to prevent biased data, a number of variables need to be controlled. Some of the variables can be controlled by the management of each plot; therefore, all the plots will:

- consist of the same sample size, dried to the same consistency
- be kept in the same location
- be grown in the same type and depth of soil
- be watered at the same time using the same type of water

To ensure plots are not contaminated from either seeds or plants from sources other than the manure, the following measures will be implemented:

1) Ensure the plots are watered with rain water and not creek water, as there is no guarantee the creek water does not contain seed.

2) Keep the plots off the ground to ensure invasive plants, such as kikuyu and couch grass, do not enter and grow up through the plots from underneath. Therefore, all plots will be placed on top of our large farm trailer.

3) Keep the plots in a protected area so as to avoid contamination from wind bourne seed. The trailer will be kept within our farm's large machinery shed which is covered and enclosed 3 sides, with the open side facing east. Most of the wind on our farm comes from the west or south; therefore, it is hoped that the easterly aspect will protect the plots from outside contamination.

4) Ensure the manure is being mixed with sterile potting mix. Only good quality potting mix will be used and the control plot will identify any plants that germinate from the potting mix. Should this occur, the germinated plant species will be excluded from the results.

It is also important to protect the plots from the "natural" hazards found within the farm environment. Placing the plots on the trailer and in the shed will help control potential impacts from some of these hazards, which include:

1) Being consumed by livestock – the shed is in an area where livestock are excluded.

2) Damage from pests and vermin – being raised off the ground will prevent birds and rabbits from consuming any of the germinated plants. Should any insect pests be found within the plots, they will be treated as necessary.

3) Damage from the elements – considering the trial is being run over a 12 month period the experiment will be subjected to all sorts of potential damage from the elements. The shed will ensure the plots are protected from damage associated with wind, rain, storms, hail, intense heat and frost. All these forces have the potential to either remove the seed from the plot or damage seedlings and more established plants before they have been identified.

4) Competition from already established plants – each manure sample will be grown in its own polystyrene box and as the plants are identified they will be removed from the plot. This will ensure each seed has every opportunity to germinate and grow without being compromised through competition associated with already established plants.

5) Soil temperature changes – The shed and polystyrene boxes will help insulate the manure mix from rapidly changing soil temperatures, which could impact the germination of certain plant species.

Materials

- 125mL measuring container
- 2 x 2 Litre Containers with lids
- Trowel
- Gloves
- Fabric for drying manure
- Wooden Spoon
- 24 Polystyrene Boxes (52cm x 34cm)
- Knife
- 12 bags Sterile Potting Mix
- 10 L bucket for mixing manure with potting mix
- Ruler
- Permanent Marker
- Watering Can

Method

The trial had to be carefully prepared to ensure that all plots had the same growing conditions, in order to guarantee the accuracy of the final results. The process followed is detailed below:

- Collect the manure sample –
    a. Enter a random cattle pen containing fresh manure that has not been trampled
    b. Whilst wearing gloves, collect a sample from the middle of a manure sample with the trowel, ensuring the trowel does not scrape the concrete.
    c. Place the sample into the 125 mL measuring container, level the top of the manure sample with the trowel, removing any excess
    d. Place the 125 mL sample in th first 2 L container
    e. Repeat steps (b) and (c) above, collecting manure from the same sample source, this time placing the sample in the second 2 L container
    f. Move onto the next random cattle pen and repeat steps (a) to (e) another 14 times
    g. Put the lids on the two containers and wash up the trowel and measuring container
    h. Repeat this process monthly for the duration of 11 months

- Dry manure –
    a. Use the wooden spoon to evenly spread the manure from the first sample until it is approx 1cm thick
    b. Repeat the above step with the second sample, ensuring the two samples are kept separate
    c. Place the spread samples in a raised and enclosed area to avoid contamination
    d. Check the samples daily until they are crumbly in nature, but not too hard. The duration in which the samples are left to dry with depend on the manure moisture when collected, along with humidity and temperature at the time of drying.

- Prepare polystyrene boxes –
    a. Using a small knife, cut three small wedge-shaped holes in the bottom of a polystyrene box, approximately 10cm apart.
    b. Repeat the step above in a second polystyrene box.
    c. Fill the two boxes with approximately 6cm of sterile potting mix each.

- Prepare the manure –
    a. Remove one dried manure sample from the fabric and place in a 10L bucket
    b. Whilst wearing gloves, break the manure into small pieces.
    c. Add approximately 650g of sterile potting mix to the broken up manure.
    d. Spread the manure / potting mix mixture over the prepared potting mix in the polystyrene box
    e. Repeat steps (a) to (d) for the second sample
    f. Water the two plots evenly

- Water –
    a. Water all plots evenly every 2 to 4 days depending on weather conditions, obviously more frequently in summer and less frequently in winter.

Collecting The Results

Once old enough to be identified, each plant species will be tallied and tabled before being removed from the trial in order to prevent overcrowding and inaccuracies with future counts. Photos are to be taken of the identified plants.

RESULTS

The combined tally of each plant species for the individual samples, collected each month throughout the trial, are shown in Table 1 below. It can be quite clearly seen that a total of 1,557 plants from 19 different species germinated. No plant species needed to be excluded from the trial as no plants germinated in the control plot. Only 2 plants were unidentifiable.

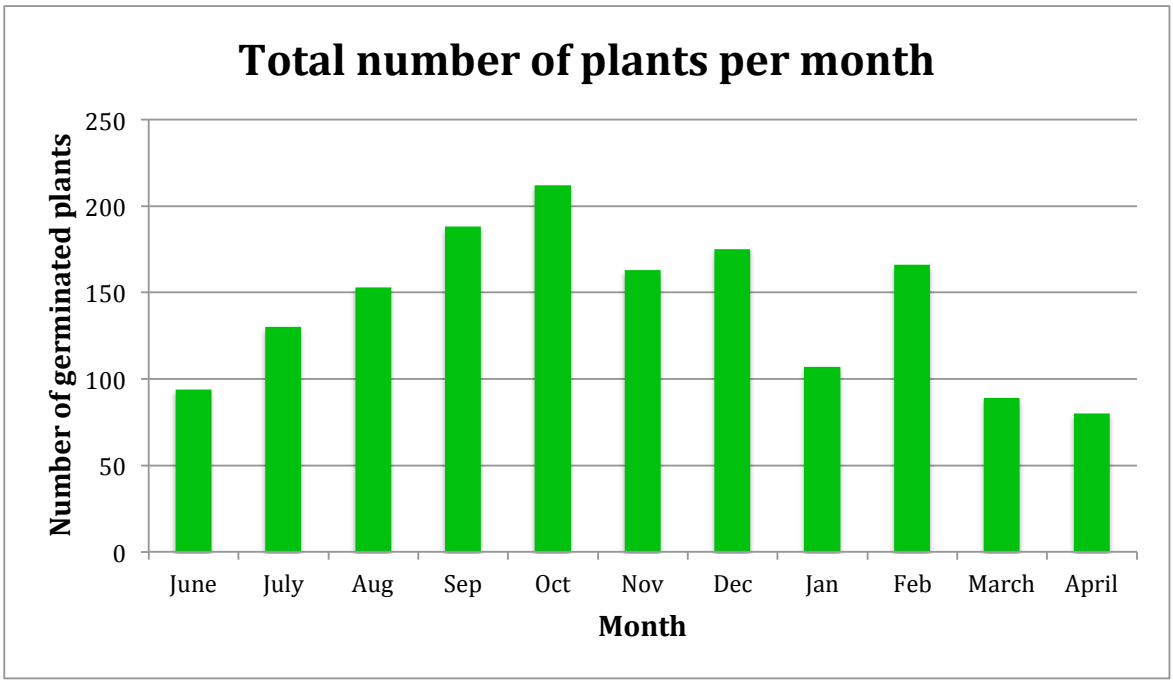
	Control	Clover	Chickweed	Nettle	Ryegrass	Couch	Kikuyu	Fireweed	Flaxleaf Fleabane	Crabgrass	Marshmallow Weed	Paddock Lovegrass	Verbena	Medic	Carrot weed	Vulpia	Dandelion	Flatweed	Unidentified	**Total**
Jun		2	8		55	1	3	1	20	3			1							**94**
Jul 1			7		34				13	35										**89**
Jul 2					16			3	22											**41**
Aug 1			35	4	13				16	4					1					**73**
Aug 2			34	7	15		2	1	11	8		1					1			**80**
Sep 1			32		59				5											**96**
Sep 2		3	29		58				2											**92**
Oct 1			79		16				1											**96**
Oct 2			81		32			1	2											**116**
Nov 1		5	20	1	32		4		5						1					**68**
Nov 2			31	3	50		2		6				1		1	1				**95**
Dec 1		3	4		53		1	2	13		1			1		2				**80**
Dec 2		4	5		72				8			1	1	1		2			1	**95**
Jan 1		1	7		38			1	7		1					2		1		**58**
Jan 2			3		40				4	1						1				**49**
Feb 1			5		65			2	1											**73**
Feb 2		1	6		83		1		1										1	**93**
Mar 1			1		37															**38**
Mar 2			7		44															**51**
Apr 1			3		30															**33**
Apr 2			7		38			2												**47**
TOTAL	**0**	**19**	**404**	**15**	**880**	**1**	**13**	**13**	**137**	**51**	**2**	**2**	**3**	**2**	**3**	**8**	**1**	**1**	**2**	**1557**

Table 1 – Plant Tally for Each Monthly Plot

Table 1 highlights two distinct observations. The first being the variation in germination numbers between the different species. 10 of the species had total germination numbers of less than 10 plants each, with many species showing only 1 or 2 germinations throughout the course of the trial. These low germinating species accounted for 52.6% of the total species identified, yet they only contributed 1.1% of the total number of germinated plants. This is significantly less than the 3 plant species, or 15.8% of the

species overall, that had germination numbers exceeding 100 plants each. These 3 high germinating species accounted for 91.3% of the total plants germinated. Ryegrass was the most abundant of all species, totalling 880 plants, which is more than double any other species and accounted for 56.5% of the total plant population.

The second observation is the germination patterns of certain species. It can be seen quite clearly that some species, such as Ryegrass and Chickweed, are capable of germinating from manure collected at any time of the year. However, other species portray more seasonal germination patterns, either germinating only at a certain time of year, such as Vulpia; or increased germination numbers at a certain time of year, such as Flaxleaf Fleabane. Graph 1 below shows the overall plant numbers per month tending to follow a spring germination pattern.



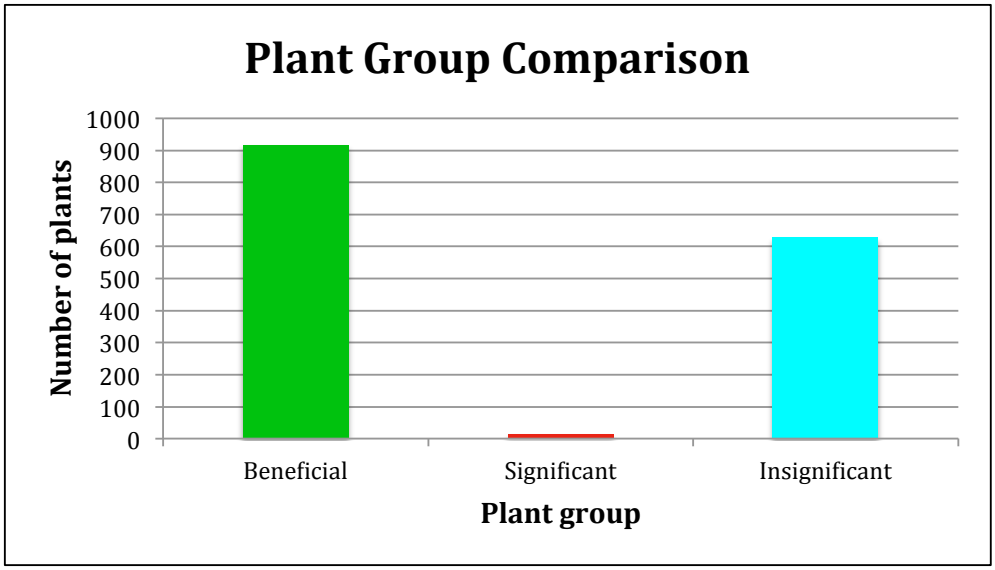
Graph 1 – Total Number of Plants Per Month

I have broken the plant species into 3 different categories dependent on their impact to a farm grazing enterprise. The plant type can be considered either beneficial, significant or insignificant. Graph 2 shows the breakup of the total number of plants into these 3 groups, whereas Table 2 details the species, including their abundance, within each category. The 3 groups have been categorised as follows:

1) **Beneficial Pasture** - Suitable for Pasture Grazing (Shaded Green in Graph 2)
Ryegrass, Kikuyu, Clover, Medic and Paddock Lovegrass are all listed as suitable plants for grazing pastures in NSW. These 5 plant types accounted for 916 of the total number of plants. This equates to 58.83% of the total plant population. Ryegrass was the most adundant of all plant species, germinating at more than double any other plant. Ryegrass was also the only plant to germinate in every collection. Photos of plants shown in Appendix 1.

2) **Significant Weeds** - Unsuitable for Pasture Grazing (Shaded Red in Graph 2)
Fireweed was the only listed noxious weed to germinate, resulting in 13 established plants over the 11 month period. Table 1 shows that the fireweed did not germinate seasonally, but instead was able to develop at all seasons throughout the year. However, this noxious weed only accounted for 0.83% of the total number of plants. Photos of plants shown in Appendix 2.

3) **Insignificant Weeds** – Not Ideal for Pasture Grazing (Shaded Blue in Graph 2)
11 species of insignificant weeds germinated, including Chickweed, Flaxleaf Fleabane, Stinging Nettle, Verbena, Vulpia, Couch, Crab Grass, Marshmallow Weed, Carrot Weed, Dandelion and Flatweed. These are considered to be insignificant due to their small impact on livestock and/or pasture conditions, along with their limited effect to grazing farm enterprises. The combination of these insignificant species contributed 40.3% of the total number of germinated plants. Photos of plants shown in Appendix 3.



Graph 2 – Plant group comparison breakup

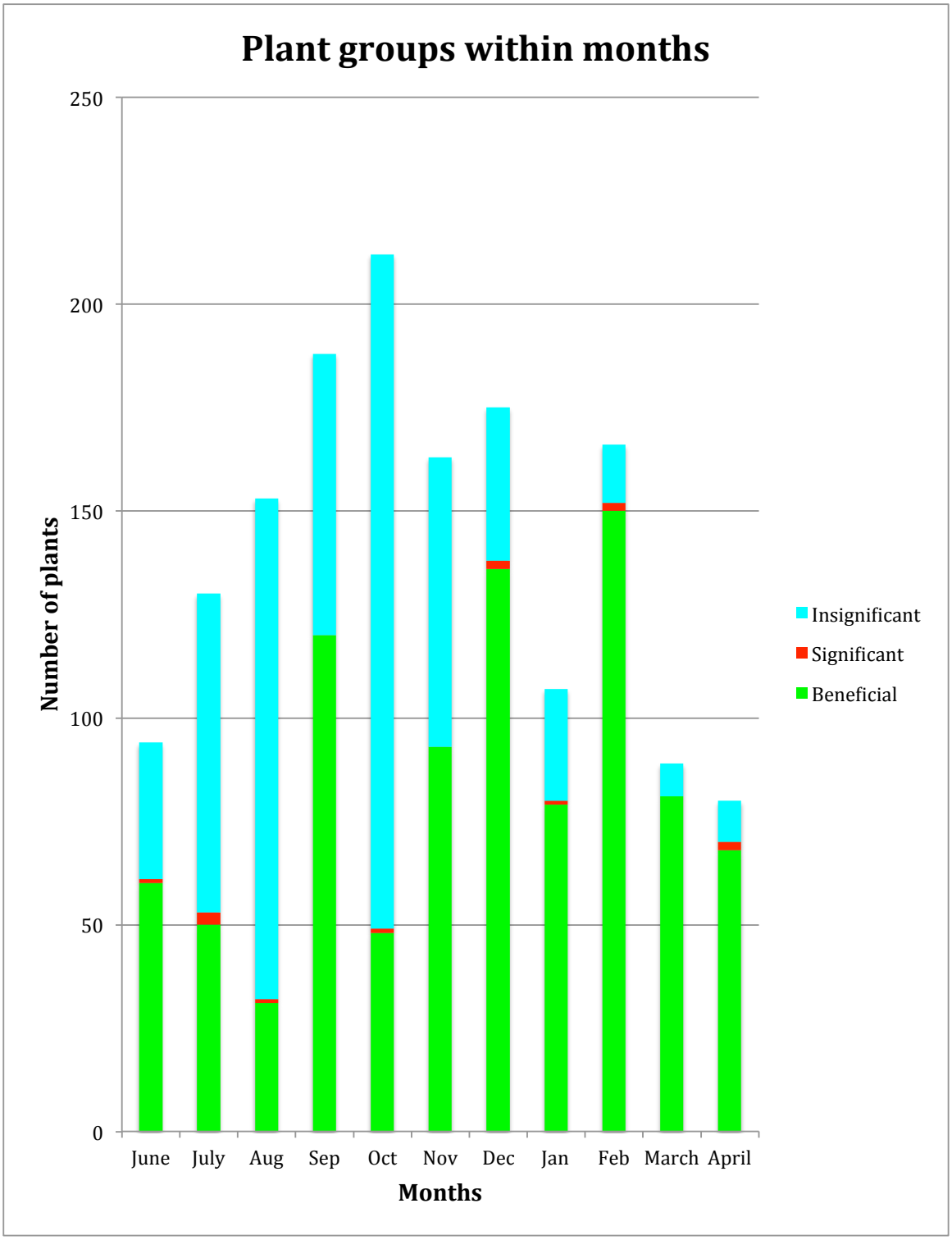
BENEFICIAL GROUP	Total Plant Numbers	% Of Group Population	% Of Total Population
Clover	19	2.07%	1.22%
Kikuyu	13	1.42%	0.83%
Ryegrass	880	96.07%	56.52%
Medic	2	0.22%	0.13%
Paddock Lovegrass	2	0.22%	0.13%
Total Beneficial Plants	**916**	**100.00%**	**58.83%**

SIGNIFICANT GROUP	Total Plant Numbers	% Of Group Population	% Of Total Population
Fireweed	13	100.00%	0.83%
Total Significant Plants	**13**	**100.00%**	**0.83%**

INSIGNIFICANT GROUP	Total Plant Numbers	% Of Group Population	% Of Total Population
Chickweed	404	64.33%	25.95%
Nettle	15	2.39%	0.96%
Couch	1	0.16%	0.06%
Fleabane	137	21.82%	8.80%
Crabgrass	51	8.12%	3.28%
Marshmallow	2	0.32%	0.13%
Verbena	3	0.48%	0.19%
Carrot weed	3	0.48%	0.19%
Vulpia	8	1.27%	0.51%
Dandelion	1	0.16%	0.06%
Flatweed	1	0.16%	0.06%
Unidentified	2	0.32%	0.13%
Total Insignificant Plants	**628**	**100.00%**	**40.33%**

Table 2 - Plant Groups and Abundance

Graph 3 on the next page displays the total plant numbers for each of the 3 plant categories on a monthly basis over the course of the trial. There does not appear to be any significant relationship between the abundance of plants within each category and the month in which they germinate.



Graph 3 – Total Group Plant Numbers Per Month

DISCUSSION

From the data shown in **Table 1** it can be seen that 19 different plant species are capable of germinating and establishing themselves into fully productive plants, after having passed through the digestive system of cattle. This supports the hypothesis, suggesting that not all seeds are broken down during the digestion process.

Graph 2 categorises these 19 different species into groups, based on whether the plants are beneficial, significant or insignificant to a farm grazing enterprise. **Table 2** shows that the beneficial group contributed 58% to the total plant polpulation, thanks to the 880 ryegrass plants that germinated.

Ryegrass was one of five species to be categorised as a beneficial plant, making up a massive 98% of the total plant population in this group. The abundance of ryegrass is most likely due to the large number of dairy farms located in the Bega Valley, as ryegrass is the preferred pasture for most of these farming operations.

Kikuyu and clover were also beneficial pasture species that germinated throughout the trial; however, they only contributed 13 and 19 plants respectively. This is significantly less than that of ryegrass and raises the question as to why their germination numbers were so much lower, especially considering these two species are incorporated throughout most pasture management programs within beef and dairy enterprises in the Bega Valley. It would be interesting to know whether the germination numbers were low due to:

1. only a small number of seed being consumed in the first place, or
2. only a small percentage of seed surviving the digestive system of cattle.

Measuring the input versus output of these species would clarify the reason for low germination numbers.

Based on the findings of this trial, livestock could be used as a host for spreading beneficial pasture species, as it has proved that such species survive digestion. Simply changing the order in which paddocks are grazed could quite easily change the plant population of a paddock, particularly if a paddock lacking beneficial species is grazed immediatley after a paddock containing mostly beneficial species.

Provided it was economically viable, the strategy of using livestock to introduce, establish or change plant populations within a paddock could be taken even further. Feeding the seed of beneficial species directly to cattle could have the following advantages:

1. Considering manure provides an ideal growing medium, due to its moisture retention and fertility, seeds germinating in manure may have a higher survival rate than those germinating in soil
2. Seeds could be spread across an area without the intervention of machinery, which may prove more cost and time effective
3. Beneficial plants could be established in areas that are inaccessible to machinery
4. A targetted approach to weed control could be implemented, where beneficial species are used to target and compete with weed populations. An example of this would be to introduce kikuyu where african lovegrass is dominant.

Altering grazing management strategies to get the most out of beneficial species is important. However, it must also be acknowledged that 42% of the plants that germinated throughout the course of this trial were considered undersirable. Within these undesirable plants, noxious weeds were classed as significant, with all other species being classed as insignificant, as shown in **Table 2**.

Fireweed was the only noxious weed to germinate and contributed to only 0.83% of the total germination overall. This may seem an insignificant number; however, cattle tend to avoid grazing fireweed; therefore, it could be assumed that only a small number of seeds were ingested by cattle that grazed pastures contaminated with fireweed seed. This suggests fireweed seed may be relatively resilient against the digestive system of a ruminant. Sheep have a similar digestive system to cattle and readily graze fireweed; thereby, challenging the notion that sheep are an effective form of fireweed control. Instead of controlling fireweed, are sheep in fact spreading fireweed? Further studies targetting the input versus output of fireweed in sheep would provide more definitive answers to this question.

Once again, knowing that livestock spread noxious plant seeds can assist with the implementaiton of suitable grazing management strategies, aimed at minimising potential impacts from such plants. Management systems can be altered to prevent and control the spread of noxious species through the adoption of the following processes:

1. Quarantining new livestock brought onto the property in a “sacrifice” paddock before introducing them into the grazing management system. This will allow livestock to excrete any undesirable seeds in an area where weeds can be more easily contained and controlled. Ideally, cattle should be quarantined before coming onto the property; however, this is not always practical.
2. Controlling movement of stock within a property to ensure noxious species are not spread from an infested paddock to a non-infested paddock.

These management strategies would also assist in controlling plants listed in the insignificant category; however, it is unlikely that plants in this category would have any significant productive, economic or environmental impacts on a farm grazing system.

The variation in the quantity of seeds germinating each month, as shown in **Graph 1**, also supports the hypothesis regarding the abundance of each seed being dependent on the time of year in which the sample was collected and grown. This may be one of a number of reasons as to why only 19 different species of plant germinated throughout the duration of the trial. This is quite a limited number when considering the plant diversity across the Bega Valley, which is significantly greater than these 19 species. It would be inconclusive to meerly assume that the seed of the plants that did not germinate throughout the trial were destroyed during the digestion process. Other possible reasons as to why these plants did not germinate are listed below:

1) the seed of these plant species may not have been consumed by cattle in the first place,
2) the timing of the trial may not have suited the reproductive cycle of these plant species,
3) the growing conditions provided throughout the trial may not have been ideal for the successful germination of these plant species.

A targetted approach designed specifically to meet the germination requirments of individual species would need to be undertaken in order to determine whether these particular plants are able to survive the bovine digestive tract. This approach may be of benefit when applied to African Lovegrass. No African Lovegrass seeds germinated throughout the course of the trial, which was an unexpected finding, especially considering the large abundance of this plant within the Bega Valley.

It appears that my trial has unintentionally excluded African Lovegrass from the results due to the plants seeding cycle not falling within the period in which the trial was conducted. African Lovegrass develops ripe seeds over the months of January through March; therefore, the samples I collected during these months could have contained seed. However, African Lovegrass seed has an inherent dormancy of around 5 to 6 months, ensuring the plants don't germinate until spring. Unfortunately, the final identification of plants in my trial was conducted early August, well before the African Lovegrass seed had the opportunity to germinate. Had my trial instead run from January through to December, I may have seen very different results in the types of species that germinated.

Graph 3 shows that beneficial and problematic plant species are both capable of germinating each and every month, therefore farmers would benefit through the

implementation of permanent pasture management startegies that take the results of this trial into consideration.

There were, of course, some experimental errors within this trial. These are listed below:

1. Plot sizes differed between certain months as I was unable to acquire 24 evenly sized polystyrene boxes.
2. Some plants were damaged by insects, possibly affecting the final results.
3. The period of time in which the manure was left to dry varied depending on weather conditions at that time. Therefore, the ideal consistency had to be estimated, as there was no way to best measure the consistency of the manure.
4. A shadow was cast in each plot by the edge of the polystyrene box, affecting the amount of sunlight received. Consequently, there was a very low germination rate at the front edge of each box.

CONCLUSION

In conclusion, 19 species of plants within the Bega Valley are capable of germinating after passing through the digestive tract of a bovine animal. Five of these species were considered to be ideal in a farm grazing enterprise, contributing to over half of the total plants that germinated. 13 fireweed plants established themselves within the trial; however, this was the only noxious weed to germinate, contributing 0.83% to the total plant population. This is still of significance considering cattle do not graze fireweed, yet sheep readily ingest the plant and are used as an aid in its control. The remaining thirteen species were considered to be insignificant due to their small productive, economic and evnironmental effects. The abundance and germination rates of the plants within all three of these categories was dependent on the time of year, with most species demonstrating seasonal patterns throughout the course of the experiment. This trial has provided data which could assist farmers in implementing grazing management strategies in a beneficial manner whilst minimising the introduction, establishment and spread of unwanted plant species. A number of areas have been identified where further research would be of benefit.

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APPENDIX 1 – BENEFICIAL SPECIES

Ryegrass

Paddock Lovegrass

Kikuyu

Medic

Clover

APPENDIX 2 – SIGNIFICANT SPECIES

Fireweed

APPENDIX 3 – INSIGNIFICANT SPECIES

Chickweed

Flaxleaf Fleabane

Stinging Nettle

Verbena

Vulpia

Couch

Carrot Weed

Crabgrass

Flatweed

Marshmallow Weed