Managing Pastures for Seasonal Variability

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Executive Summary

Droughts have increased in both severity and duration over the past 30 years. Alongside this, stocking rates have been slowly declining and the need to supplement or substitute feed stock has risen accordingly. Australia's climate is not unique with similar environments around the world however, many of our grazing methodologies and pasture management theories are derived from Europe which does not share our climate traits.

Most primary producers believe they are doing right by their land as they want to leave it in a better shape than it was when they took over. It is this same inspiration the author uses to convey an out-the-box solution to managing our native environment, in a way that is more suitable to its varied climate. Humid environments are more forgiving in terms of under grazing or over grazing pastures and that is a luxury only a few parts of Australia get to enjoy.

To allow livestock producers to return to stock production in a similar capacity to early colonial days, we need to understand the brittle environment in which we graze, observe the delicate combination in which the soil, plants and animals coexist and maximise the full potential of our free natural services; rainfall, and sunlight.

Large areas of the landscape have been (unknowingly) mismanaged for generations, in turn lowering soil organic moisture and soil organic carbon levels and reducing water absorption rates. This in turn has seen a proliferation of woody weeds grow and a reduction in nutritious edible plants in the broader pastures. A large reduction in trees has seen an imbalance of shade and shelter throughout the paddock, impacting on stock comfort and their overall productivity. Then finally, a failure to understand the flow on effects from plant to animal have seen livestock under or overgraze paddocks to the detriment of the soil.

Animals are the most important tool in a grazier's tool box for soil fertility and pasture management and with their help, all the above can be reversed. How they are grazing a paddock determines the Soil Organic Matter (SOM), the water absorption rates and plant exposure to the sun to name a few. Managing grazing intensity and time is up to us to get this balance right.

This report aims to give not just confidence to primary producers managing for excessive seasonal conditions. At a time where there is increasing scrutiny from consumers on how we manage our production, this report also, importantly, shines a light on the awareness farmers have on the environment that they rely so much on.

Keywords: grazing management, brittle, soil health, grasses, pasture,

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Foreword

I grew up in the semi-arid environment of Cunnamulla, South-West Queensland which is a region that has traditionally been known for its sheep and wool production. A summer dominant rainfall area, that typically got late autumn rainfall, it was also a 'sweet' spot for lamb production. My family has grown wool there for five generations and when I returned in 2011, it was a trend I wanted to continue. Being a large pastoral holding (138,000ac / 55,757ha) meant a lot of time was spent on motorbikes rounding livestock and it was during these times that I was able to observe the subtle differences in our pastures and the correlating effects these differences had on the sheep and the overall business.

When I first left for school in 2002, we were in the grips of the "millennial" drought, one that lasted for seven years with varying degrees of intensity in that time. Upon coming back in a wet 2011, it was not long before we were back in drought. This one lasting eight years, with a lot more severity. Despite the compatibility of the Merino sheep to the landscape; we were virtually substitute feeding and given the scale of our operation, it was not a financially-viable scenario long term.

When it did rain, our holding paddocks appeared to yield more pasture per acre than the external paddocks (which was even more noticeable in the Mulga country) and I remained curious until I enrolled in an RCS (Resource Consulting Service) Grazing for Profit course, where these questions started to get answered. I then started investigating different grazing theories to see what could be done to ensure viability for pastoral Australia given the increasing severity and changes of the seasons.

Since the year 2000, the 17 years of drought experienced in South-West Queensland have highlighted the vulnerable state our businesses exist in, and how reducing the risks associated with a grassland-based enterprise in this Australian environment is the only logical way forward. With land asset prices rising, there is increasing pressure on primary producers to grow more with less and this is being passed onto the soils on which we are completely reliant.

The Nuffield scholarship has allowed me to sift through conventional, regenerative, sustainable, innovative and any other type of "agriculture" out there to determine a balanced system that works for any grazing environment within the Australian climate. It has highlighted to me, the commonly 'brittle' nature of our climate, and how it is imperative that more observation is taken in our approach to land management to determine what suits the functionality of our environment.

During this scholarship, I married my wife Rhiannon, bought, and developed 151ha of country in Tenterfield, traded merino wethers, managed breeding stock for my family, contracted off-farm, bred in excess of 10,000 rangeland goats and moved properties twice. Over the last two and a half years, I have travelled to eight different countries (Argentina, Canada, Israel, Japan, Netherlands, Singapore, United Kingdom and the United States of America) as well as throughout Australia. The scholarship has given me the knowledge and in turn, the confidence to work within the confines of our environment with a more risk adverse yet, profitable approach.

I would like to thank Rabobank for all their support throughout this scholarship. None of this would have been possible without their assistance in the last two and a half years.

Table 1. Travel itinerary

Travel date	Location	Key visits/contacts
1st – 20th March 2022	United Kingdom	Pre-Contemporary Scholars Conference and CSC Week (Half of it).
11th September 2022	Australia, Tenterfield, NSW	Dick Richardson - Natures Equity
23rd February 2023	Argentina, Buenos Aires, BA	Gustavo Benoit, Rabobank
27th February - 4th March 2023	Argentina, Rio Gallegos, SC	Gregory and Brian Aldridge – Laguna Colorada Gonsalez Sanchez – Chali Aike Juan Zavalia – La Realidad
5th - 6th March 2023	Argentina, Concordia, RE	Manual and Maria Esteves-Buchanan – La Gloria
7th - 18th March 2023	Canada	Pre-Contemporary Scholars Conference and CSC Week
22nd - 5th May 2023	Singapore	Global Focus Program (GFP), Andrew Cox, MLA, various meetings (ANZ).
26th May – 3rd June 2023	Japan	GFP – Various Meetings
4th – 8th June 2023	Israel	GFP – Various Meetings (Water security, Agro-Tourism)
10th – 13th June 2023	Netherlands	GFP – Various Meetings
14th – 22nd June 2023	USA	GFP – Various Meetings
13th July 2023	Australia, Toowoomba, Qld	Ian Moss – F.A.R.M Consulting
11th – 15th September	Australia, Tamworth, NSW	Nuffield Australia Conference
12th – 16th February 2024	Australia, Clare Valley, SA	Australian Wool Innovation – Breeding Leadership – Corporate Governance
19th - 21st March 2024	Australia, Dubbo, NSW	Nic Kentish – Resource Consulting Service (RCS)

Acknowledgments

Starting with a chance encounter with 2012 scholar, James Walker, at a rugby match in Longreach, I never envisaged the journey Nuffield would take me on for the next three years. The support I received from Nuffield Australia, along with my mentor, 2014 scholar, Simon Mattsson and the global network I have cultivated has been phenomenal and has helped drive me through this wonderful experience.

My sponsor Rabobank Australia has been hugely supportive from the get-go with managers around the country offering assistance through their international contacts. Most notably, Nicolas Mihura from Rabobank Geraldton, WA. helped me considerably in planning my trip to Argentina, which was no easy task.

Thank you to all the 2021, 2022 and 2023 scholars both locally and internationally who I have been able to share this experience with. Your support has been excellent and they are friendships I will hold dear for a long time.

To my wife, Rhiannon, who has kept the fires burning while I have been away for weeks at a time, dealing with the constant crisis that has plagued us, thank you. It has not been easy. Thank you to our extended family for all your help - Rhi and myself certainly appreciated it.

Abbreviations

ANZECC	Australia and New Zealand Environment and Conservation Council
ARMCANZ	Agricultural Recourse Management Council of Australia and New Zealand
PAW	Plant Available Water
PAN	Plant Available Nutrients
NSW	New South Wales
QLD	Queensland
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SW	South West
WUE	Water use efficiency

Objectives

To highlight and understand issues in the Australian grazing environment to then help mitigate the high variability of our domestic climate. These will include:

- Water function and its implications on soil health.
- The importance of biodiversity in the landscape within a grazing enterprise.
- Grazing management processes and their impacts.

Chapter 1: Introduction

Pastoral leasehold land is used primarily for the grazing of livestock in Australia and currently accounts for 44% (338 million hectares) of the total mainland area as shown in Table 1 below. Australia and New Zealand Environment and Conservation Council (ANZECC) describes it as 'the low rainfall and variable climate arid and semi-arid areas and, north of the Tropic of Capricorn, some seasonally high rainfall areas' (Australian Government Productivity Commission, 2002).

Table 2. Pastoral Leasehold land (Source: Australian Government Productivity Commission, 2002)

Pastoral leasehold land, by jurisdiction, 2001

Jurisdiction[a]	*Pastoral lease area*	*Pastoral lease area/ total mainland area*
	million hectares	%
Queensland[b]	107	62
New South Wales[c]	30	37
South Australia	42	43
Western Australia	96	38
Northern Territory	63	47
Australia total	**338**	**44**
New Zealand[d]	**2.2**	**8.1**

[a] ACT, Victoria and Tasmania have negligible areas of pastoral lease. [b] Pastoral holding term leases and grazing homestead perpetual leases. [c] Grazing leases only but includes some land where cultivation permits are in force. [d] There are also 0.25 million hectares of short-term pastoral occupation licences.

Based off this interpretation, a large percentage of the Australian climate could best be described as a brittle environment where humidity is low for most of the year. A great example of this can be seen by comparing the climate between Sydney, Australia and London, England. Sydney, despite receiving 1175mm per year compared to London's 585mm per year is the more brittle region due to its comparatively low humidity. The reason for identifying brittleness is important to understanding how our flora naturally breaks down and therefore, how we manage the livestock grazing those pastures to work within the boundaries of our local environment.

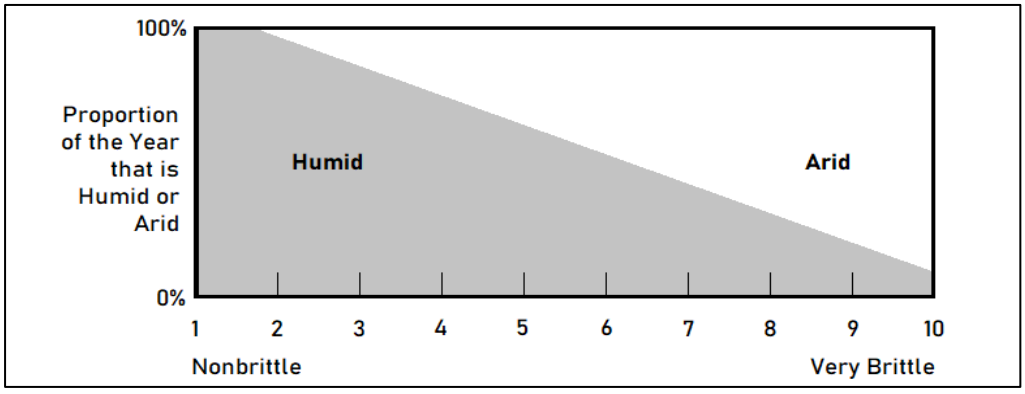

Figure 1. Brittleness Scale (Source: Savoury & Butterfield, 2016)

While identifying climatic conditions is important for pasture management, it is crucial that graziers consider the range of other influential factors. The plants available, the variety of plants at any given amount of time, their growth stage, and the plant available water (PAW) that is present in the soil at any one time should all be considered. In addition, managing fluctuating livestock numbers (by matching stocking rate to carrying capacity) year-round and stock placement throughout the property will have a large impact on productivity.

Figure 2. The effects of different seasons in 'brittle' SW QLD, 2016 & 2018 (Source: Author)

Given that grazing land in Australia is very arid, considered a '*brittle*' environment and is the recipient of highly variable weather conditions, it creates a challenge for producers trying to get the most out of their land. Too much rest in such an environment and the grasses will oxidise the soil causing desertification. To little rest, and you expose your soil to the elements (wind – top soil loss, sun – lack of temperature control (too hot and too cold), rain – soil compaction, poor water infiltration and excessive run off) also causing desertification. This report aims to help the reader get the balance right within their grazing enterprise and highlight tools (both artificial and natural) that primary producers are using, to manage this variability and ultimately create financial stability in their business.

"*To be a successful farmer one must first know the nature of the soil*." – Xenophon, Oeconomicus, Ancient Greek philosopher and historian, student of Socrates, Circa 430 - 354 BC

Chapter 2: Water Function

Just because a farm/property might receive 25mm of rain, does not mean that the plants receive 25mm of rain. With climate variability playing such a major role in both farming and grazing enterprises, using rainfall patterns more efficiently should be a high priority. Over grazing, under grazing, over tillage and potentially the under tillage of soils all contribute to the slow destruction of soil structure and in turn, its ability to collect and retain rainfall. How animals are managed alone, can greatly determine the soils infiltrating abilities.

The benefits of livestock include:

- Maintaining ground cover – protecting the surface from wind, rain, and temperature fluctuations.
- Stirring of the soil - aerating, and mixing organic matter in.
- Podding (deep hoof prints) - allowing water to pool and soak in.
- Dung and urination – increased micro biological function and increased plant available nutrition.

2.1 Soil Organic Carbon (SOC)

Key to the development of improved soil structure is soil organic matter and SOC (the measurable component of Soil Organic Matter (SOM)). Increasing the total organic carbon in soil may decrease atmospheric carbon dioxide and increases soil quality (Carson, 2023). An intrinsic relationship exists between the water holding capacity and organic carbon. As soil organic carbon rises or falls, its water holding abilities follow. According to data collected by Glenn Morris and Dr Christine Jones, in the soil matrix, one part of soil humus, (a stable form of soil carbon) can retain four parts water (Morris, 2004). From this they deduced an increase of 16.8 litres/m2 (in the top 30cm of soil) for every 1% increase (in absolute terms) in the level of soil organic carbon. This equates to 168,000 litres per hectare (Jones, 2010).

2.1.1 Soil Organic Matter (SOM)

Core to increasing SOM is a biodiverse pasture. While being significantly influenced by soil type (clay type soils have better SOM retention than sandy soils), a biodiverse pasture brings with it increased biomass and biological activity which in turn allows for an increase in decomposing organic matter to enter the soil. As part of the SOM cycle, there are 3 phases of SOM as seen below in Figure 3.

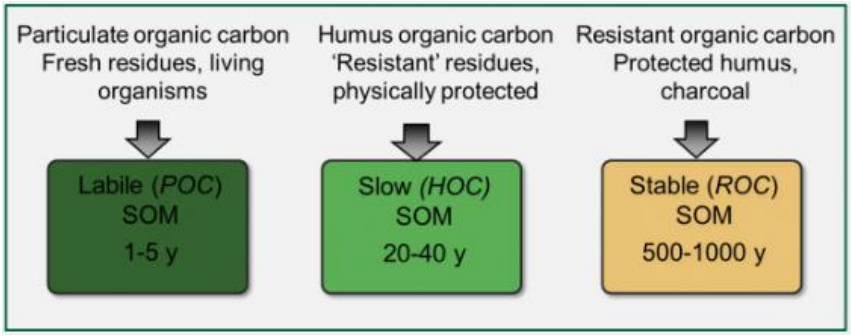

Figure 3. Different Phases of SOM decomposition over different time frames (Source: Edwards, 2022)

Following the initial inputs from plant break down and assorted animal by-products, soil and other microorganisms break down and consume the organic matter, reducing it to a biologically stable material, adequate to enter the humus pool. Any nutrients not required by the microorganisms are then made available to the surrounding plants. Overtime, as the organic matter continues to decompose, the organic matter stabilises becoming resistant to added change, essentially locking the carbon into the soil.

These soil and microorganisms also respire carbon dioxide back into the atmosphere despite their ability to digest up to 90% of organic carbon entering the system, reducing the amount of carbon being retained in the soil. Regardless, up to 30% of organic inputs can be converted into humus, although this is rarely achieved in Australia. Figure 4 below illustrates the influences that determine the retention of SOC.

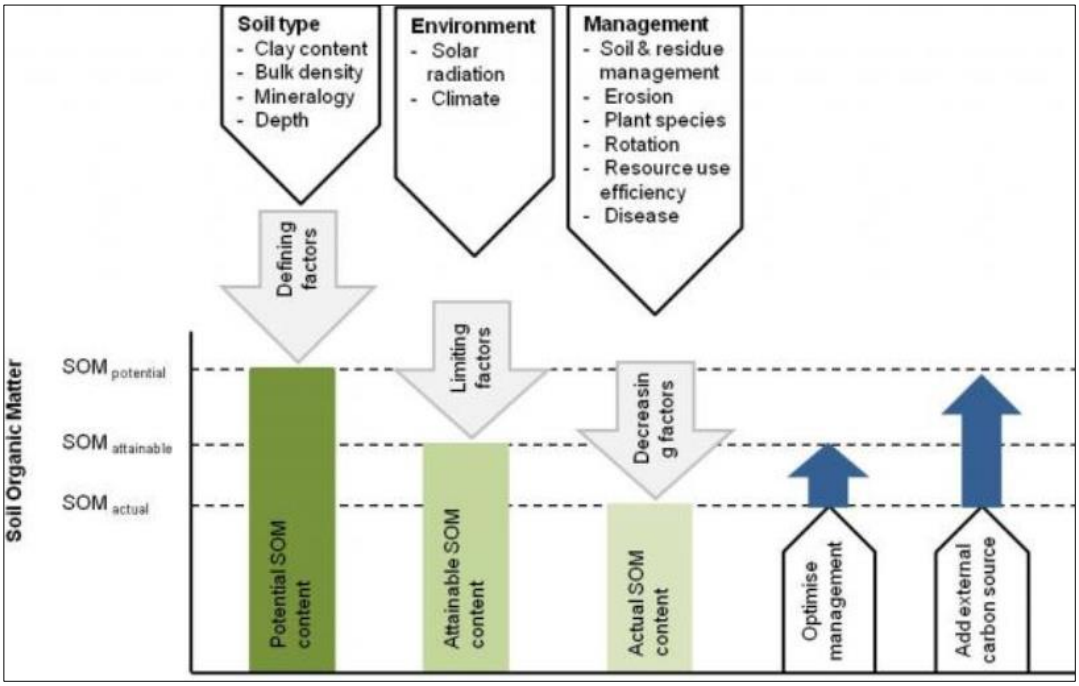

Figure 4. SOC Influences (Source: Edwards, 2022)

2.2 Rainfall Efficiency

Over the summer of 2012, Yarmouth Station, Cunnamulla, Qld received 650mm of rain, double the rainfall it normally receives. Despite all this extra rain, vast areas remained bared of pastures while others turned into large lakes. This proved to be a direct reflection of the soil and its WUE (Water Use Efficiency). A combination of traditional grazing methods and a bare soil surface area had contributed to severe capping and hardening of the soil.

2.2.1 Artificial Methods

Highlighted below in Figure 5, many graziers have carried out ‘ponding’ or ‘water banking’ projects on their properties in South-West Qld. While not a new concept, this ‘ponding’ while accompanied with adequate rest from livestock, is a tool used increasingly by graziers in rural and remote Australia as it slows the flow of water across the landscape, allowing it to soak in and improve germination results.

Figure 5. Early ponding on Harriman Park (left) and established pastures from ponding on Avondale (right), Cunnamulla Qld, March 2021 & May 2023 (Source: Author)

“The Eumana Creek used to flow after every storm, with all my rain going into the neighbours. That does not happen anymore now that it is being allowed to soak in. Being ‘black country’, you wouldn’t think it would make much difference but it is surprising, the amount of run off that you lose. It has significantly increased our ground cover too” (Schmidt 2023).

Chapter 3: Biodiversity

Getting the balance right in an ecological environment is a crucial aspect of primary production. If there is a monoculture of one plant or animal, there is more competition for the same resources. To add to this, where there is mix of shrubs and trees, the soil will be fungi dominant, whereas in an area proliferated with grasses, the soil tends to be more bacterially dominant. These different microbes will affect plant breakdown and nutrient distribution in different ways which can have a significant effect on production. It is for this reason that it is important to have a healthy mix of plants in the grazing pasture.

The same can be said for livestock. Cattle favour grass over scrub and herbages and in drier, more brittle areas, graziers will see more woody weeds and trees start to proliferate areas, especially those under constant grazing pressure. Similarly, sheep prefer herbages over other plants types and constant grazing with these animals can potentially see a monoculture in C_4 grasses appear. In areas with high grass growth, they will be more susceptible to worm infestation compared with those grazing in conjunction with larger ruminants. Goats, however, prefer scrub and woody weeds to the softer grasses and herbages making them a helpful tool in restoring a balanced grazing system.

A holistic understanding and approach to the environment and its conditions is critical to enjoying its full benefit. That way it can be improved using plants and animals that suit the environment parameters in the region without negative side effects.

3.1 Plants

The community of plant in a pasture is representative of the soil type, the climate and ultimately management. Combined, this highlights the successional stage the soil is at and will determine the nutrient access the livestock will ultimately receive from that soil (via the plants). As shown below in Figure 6, as the soil progresses (and becomes more friable), the plants evolve accordingly and this allows increased nutrient access through an improved and deeper root system.

A pasture that has been tilled or overgrazed will result in a bare area, the start of the plant successional cycle. The outcome of such will see hardy pioneer species (woody weeds, burrs (e.g. cats/goats head, galvanised burr, Bathurst burr) and low nutrient grasses) proliferate. As these plants break down and more organic matter enters the

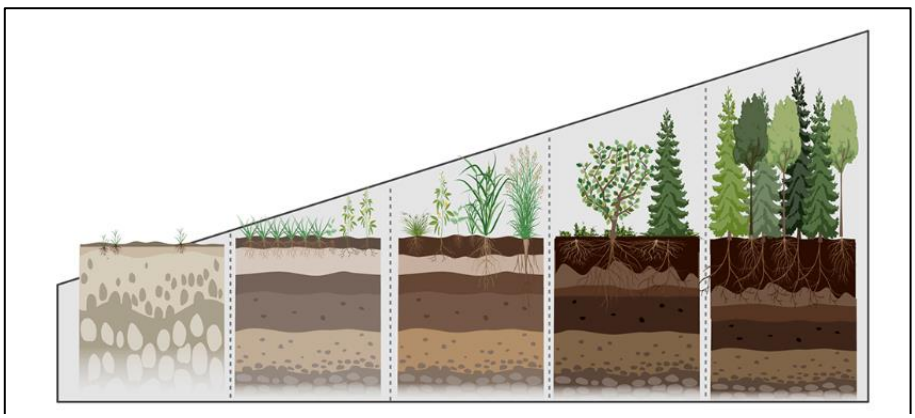

Figure 6. Plant Successional Stages (Source: Moseley, 2023)

soil, the plants will gradually become replaced by those better-suited species (perennials, annuals, legumes, etc.) and they will bring with them a stronger root base that can dig further down. The cycle witnessed above the ground is reflected below with the plants root base both aerating the soil (along with the soil biology coexisting) and feeding micro-organisms, creating an exchange in nutrients. This combination increases the soil's ability to sequester carbon, allow more water to be stored and become more resilient over time.

Not all soil types can physically reach the final forest stage of plant succession. The brittleness of an environment can play a limiting role in this and this is evidenced in 40% of the terrestrial world being grassland (70% in Australia). In the arid and semi-arid environments of Australia, the use of indicator plants is a very helpful tool in identifying which stage the pasture is at and an understanding of which plants belong where is crucial to this being utilised successfully. For example, in the mulga regions of Australia (and despite being a tree); Mulga is a low successional plant. Not only does it have a relatively shallow root base, it is quick to emerge after soil disturbance, flourishes if under grazed and cannot handle excessive grazing pressure (especially at a young age).

3.1.1 Woody Weeds

A classic case of an ecological imbalance (and a low successional plant) is the strong encroachment of woody weeds (namely Green/Charleville Turkey Bush – Eremophila gilesii) in sandy/rocky pastoral zones of Western Queensland and Western New South Wales. Despite a paper being released in 1971 on the subject, it has been a long-considered belief of graziers that over grazing has been the cause of the issue.

Figure 7. Turkey Bush dominated pastures, Wyandra Qld, February 2021 (Source: Author)

In the semi-arid mulga (Acacia aneura) shrublands of South-West Queensland the presence of unpalatable or little utilised woody weeds over considerable areas of potentially useful grazing land poses a serious threat to land productivity. Chief among these is green turkey bush. Population studies over a five-year period have shown that E. gilesii is increasing in density under both light grazing pressure and where stock are excluded. The evidence suggests that the plant is favoured (relative to most grasses) by cool season (March-September) rainfall. Pattern analysis of the vegetation at one site indicated that E. gilesii forms monospecific stands in A. aneura scrub. (Burrows, 1971).

In southern Argentina, ganaderos (graziers) are having similar issues with Mata Negra, a plant with similar properties to Turkey Bush. Gonsalez Sanchez of Chali Aike has started mulching the plant (with a 110hp tractor and a 3.5m wood mulcher) in conjunction with a rotational grazing system. He believes it both protects (ground cover) and feeds the soil. Along with ploughing or high volume sprays, slashing and grazing management techniques were found to be an effective means of killing Turkey Bush (Burrows, 1971) and it would appear that the same applies to the Mata Negra of Santa Cruz Argentina. This highlights both the artifical and natural methods that can be utilised by farmers and graziers looking to achieve a balanced ecosystem with these issues.

Figure 8. Mata Negra dominated pastures with a mulched track (left) at Chali Aike, Esperanza, Argentina, March 2023 (Source: Author)

3.1.2 Grasses

Grasslands cover a greater percentage of the land than any other plant type on earth. In warmer seasons, C_4 grasses, particularly in Australia are abundant whereas in the cooler seasons, C_3 grasses come into the fore, ensuring that a living plant is growing all year round in that soil.

C_4 grasses are better adapted to high-temperature and high-light environments. Because of their greater photosynthetic efficiencies, they have lower photosynthetic enzymes and lower protein levels as compared to C_3 grasses. Added with this, most studies suggest the C_4 grasses are typically higher in silica and fibre (decreasing digestibility) whereas C_3 grasses are higher nonstructural carbohydrates, protein, and water, increasing their palatability (Barbehenn et al. 2004).

Despite most grasses being palatable to grazing livestock, an imbalance of these can create significant issues not only in the soil and the pasture but in the nutrient cycle of livestock, creating an increased reliance on mineral supplements that otherwise might not be required. Grasses like African Love Grass (Eragrostis curvula) and Buffel Grass (Cenchrus ciliaris) are such introduced grasses ideal for the variable, dry Australian climate. Both highly palatable to stock when young, the plants quickly grow thick (if not grazed adequately enough), lose most of their nutrition value, invade and choke out native vegetation and burn hotter than most the surrounding native vegetation, creating further issues (Teague, 2014).

Seasonally, C_4 grasses when used in conjunction with C_3 grasses like perennial ryegrass, cocksfoot or even annuals like oats and capeweed, the mix can help provide

excellent ruminant function in grazing animals. In cool seasons, the highly palatable C_3 grasses becoming the source of nutrition while the dormant C_4 grasses provide the silica and fibre required for a balanced system. Meanwhile in the warmer seasons, the C_3 grasses provide this fibre while being supplemented from the extra fibre of the C_4 grasses. The sheer bulk provided from the C_4 grasses should also cover their typically lower nutrition value. This year-round plant life, along with the decaying leaf litter from the dormant grasses also benefits the soil by providing a constant source of food and nutrition to organisms in addition to the improved soil structure and increased ground cover.

3.1.3 Legumes, Pulses and Medics

A meta-analysis study suggested that the legumes have the capacity to store 30% higher SOC when compared to other species; this is because of their N-fixing ability (Kumar, et al, 2018). Besides sequestering nitrogen (and carbon) from the atmosphere (a form of "free" protein from the atmosphere) legumes are an excellent source of nutrition for livestock, especially when compared to grass. An extract from the '*The Nutritive Value of Legumes'* tell us that

> "legumes are of higher nutritive value than grasses. The reasons for such differences are explored using evidence from indoor feeding experiments. In particular, the superiority of legumes over perennial rye-grass appears to be due to a higher intake and a higher ratio of protein/energy absorbed. The mechanisms by which tannins in legumes such as Lotus and sainfoin can reduce bloat and improve nutritive value are also considered. Finally, the management of legumes in relation to their higher feeding value is discussed. It was considered that, because of agronomic factors, the superior nutritive value of legumes is not being exploited in agriculture". (Ulyatt, et al. 1976).

Even as a monoculture, legumes (along with other pulses and medics) appear to have few negatives in the way of soil health however, given their high nutrition and palatability this can present a few problems for grazing animals. Particularly when young, these plants are especially sweet and livestock will "gorge" themselves on the plants, creating an imbalance in the gut, leading to poor digestibility, poor weight gains and diarrhea. To compensate for the impacts of this plant species, roughage in the form of dry hay (grass) is highly advised and will allow the ruminant to function as normal. That is why this summer grown plants would work well if planted as a mix with other plants, particularly C_4 grasses.

As with Legumes, grazing herbages provide added benefit to both the soil and the animals with increased biomass and mineral production (cobalt, copper, and selenium).

3.1.4 Trees

Timber throughout the grazing landscape offer a range of solutions to primary producers, especially those with seasonal extremes as witnessed in Australia. Most significant though is that simply through the increased shade from the sun and shelter from the elements (wind, rain, etc.), where there is the potential to increase production by 5-15% through increased comfort to the animals (Taylor, 2024). 2022 Australian Farmer of the Year, Michael Taylor of Kentucky in the New England, North East NSW, mentioned this was the driving force behind his family's ability to increase production along with timber milling added as a sideline income and, suggested the ideal balance

of tree cover (not clumped together) was 30% for pastures requiring adequate sunlight and shade as anything otherwise would be disruptive to production. A tipping point to a nice compromise.

With respect to the right tree (e.g. fibrous rooted trees) being selected (and being planted in the correct locations), they also offer effective erosion control in areas including creeks, gullies, and washouts. The author has observed that the native she-oak is particularly good for this as it not only holds the soil in place but it provides shelter through all seasons (e.g. preventing frost in winter), doesn't break up as easily as willows and provides a consistent high output of organic material that breaks down easily. Not only is timber good for above the ground but also below as graziers will see higher organic matter readings, more notable at the drip zone, which encourages higher successional grasses due to the increased Plant Available Nutrients (PAN) in the soil; a result of increased nutrient cycling.

3.2 Animals

The three most common grazing ruminants in Australia, sheep, cattle, and goats all graze pastures differently and therefore have a different impact. While not all areas are suitable for all three, where possible, they can provide a better outcome for each other and the environment.

3.2.1 Cattle

Grass dominated pastures are ideal for cattle as they have a higher fibre requirement than other ruminant animals and are considered kinder on pastures as they use their tongues to eat the grass rather than gnaw it with their teeth. This restricts them to a grazing height of 3-5cm, allowing good ground cover to be maintained. This comes to roughly 1,500/2,000kg of residual grass per ha if efficiently grazed (Earle 2024).

Figure 9. Kikuyu grass with a high proportion of Arrow Leaf Clover, Tenterfield, NSW, October 2022 (Source: Author)

Given the high fibre requirement of grass, pastures with active growing legumes that constitute 30% or more of the total pasture can present a significant risk of bloat. This is where sheep are typically used to conduct an initial graze, eating most of the legumes, making it safer for cattle to graze. Alternatively, cattle would graze a paddock before sheep if there is more grass. Pastures with higher grass populations prevent sheep from exploring more of the paddock, increasing their susceptibility to intestinal worms. Given that different parasites affect different animals, cattle are not adversely affected.

They are also useful in the form of spreading seeds as 27% of hard coated seed remain viable for successful germination after passing through the rumen (Modderman, 2022). Given the seed is in the manure of the animal, there is an increase in PAN (plant available nutrients) during germination allowing for a stronger, healthier plant.

3.2.2 Sheep

Given too much rest in a grass growing season, sheep will start “patch” grazing (as they are uncomfortable with taller grasses), increasing their chance of intestinal

worms. Given to little rest and the sheep will graze to the ground, also increasing their chances of intestinal worms and other diseases like scabby mouth. They are a good representation of pasture management in this regard and arguably a reflection of well managed soil. Having the taller grasses (e.g. Love Grass) getting away stifle's competition in pasture, encouraging a monoculture (and restricts nutrient intake to micro-organisms) and grazing to the ground has a similar effect with atmospheric nutrient intake and offers a restricted nutrient exchange between plants and micro-organisms in the soil. It is partly for these reasons that they are considered very harsh on the soil.

Their diet is 30% grass and 70% legumes/herbages due their reduced risk of bloat and sheep prefer C3 grasses like ryegrass and cocksfoot over C4 grasses such as kikuyu and Rhodes (Charlton and Stewart, 2006). Having a pasture with a matching mix to their diet would be both incredibly nutrient dense for the animal and biologically powerful for the soil.

Unfortunately, the rumen of the sheep is a lot harsher on seeds than that of cattle with only 7% of hard coated seed passing through and remaining viable for germination however, like cattle, the seeds coat is softened with the pericarp removed, allowing for quicker and faster germination.

When combined with cattle in a grazing system, the two ruminants complement each other well and add further benefit to the biodiversity in the paddock. The cattle removed the excess grass and make useful seed spreaders, whereas sheep manage the biomass through the legumes and herbages while adding a richer, more concentrated form of (slow release) fertiliser through their manure. Given their diets, their manure typically reflects the nutrient intake and delivers that in a manner that is more accessible to the plant.

Three key mineral elements of plant growth include nitrogen (important for growth and plant development and is key for chlorophyll production), phosphorus (assists in plant reproduction and resilience) and potassium (it works conjunction with the other two minerals and helps regulate water uptake and drought tolerance) which are measurable in most compost, manure, or soil enriched bags. When reading the N (Nitrogen)-P (Potassium)-K (Potassium) it is indicated with three numbers, usually in the fashion of 0.50% - 0.50% – 1.0% (Yan, 2022). When comparing sheep to cattle it follows:

- SHEEP: 0.70% – 0.30% – 0.90%
- CATTLE: 0.25% – 0.15% – 0.25%

This indicates sheep are better for enriching poorer soils due to the high mineral concentration, whereas cattle could be considered a low-risk source of fertiliser. This also helps explain why seeds are more likely to germinate in cattle dung than that of sheep.

3.2.3 Goats

Natures bulldozers, while potentially destructive to landscapes if allowed to overgraze a pasture, the goats strength is they typically like to eat the weeds and shrubs avoided by sheep and cattle. They browse pasture but as opposed to grazing grasses and herbages like sheep and cattle, they prefer assorted shrubs and plants with typically higher tannins and only graze other plants species occasionally, depending on their needs. They do present a risk in winter dominant rainfall areas as they will tend to

leave behind smaller legumes, and could potentially leave behind clover dominant pastures, creating issues for cattle producers.

Given their indiscriminate browsing patterns, goats provide an extremely nutrient dense manure, significantly more so than sheep and cattle. In some regions chicken manure is spread over pastures to improve PAN in the soil, given its high N-P-K scores and this offers a healthy comparison to goats.

- GOATS: 1.34% – 0.54% – 1.56%
- CHICKENS: 0.7% - 0.45% - 1.45%

Given the nature of goats and the high nutrient content of their manure, it is not as easy to spread fertilizer like that of chickens. In non-brittle, smaller browsed areas, their droppings are more likely to carry pathogens and parasites. Other than this, if in the wrong environment, the dung can ferment, burning the surrounding plant roots. Composting is one way around this.

Figure 10. Cooling yard following summer rains and a goat yarding. Wyandra, Qld, January 2024 (Source: Author)

The author observed exceptional plant growth in a newly built cooling yard that has only held goats only once. The yard had a high population of turkey bush which was quickly eradicated from the sheer numbers in the yard (over three days). It is now thick with diverse grasses and herbages after one summer. While this is common in and around stock yards, given the high nutrient mix in goat manure, it was surprising to see the feed grow like this compared to sheep or cattle manure and surprising that fermentation of the manure did not occur, stalling growth.

Chapter 4. Grazing Management

The author's grandfather used to quote, "*A good manager can make poor livestock look good and a bad manager can make good livestock look poor*." The same logic can be applied to our pastures through the way they are grazed. A manager can inherit either a property that is teeming with biodiverse environment or a monoculture and it is how these pastures are managed that will determine both their long-term viability and their tolerance to seasonal viability.

Animals mirror the health of the landscape on which they graze and good livestock managers will identify this and correct it with the right supplementation. Unfortunately, an unhealthy landscape being exacerbated by dry climatic conditions can blow this supplementation into total substitute feeding which can have a detrimental effect on the financial return of a business if sustained for long periods of time. The dung of livestock is a clear indictive response to the grass being grazed and a rich diverse pasture suited to the animals grazing it will result in healthy, normal looking faecal matter.

Some of the main indicators from dung include:

- Hard "pellets" (sheep/goats) and firm cow pads from dry, high fibre pastures lacking essential nutrients.
- Diarrhea / Scours in livestock can be the result of highly nutritious pastures lacking fibre.
- Mucus on the dung can also be related to pastures lacking essential nutrients to help break down carbohydrates creating an inflamed gut with a low ph. level.
- Clumps of soft sheep "pellets" or pads with a "porridge-like" consistency about 2.5 – 5cm high are signs of a healthy diet and a healthy environment.

An environment with less variety within it will require more supplementation to maintain the health and wellbeing of an animal, in comparison to pastures with a more vibrant mix. If left to their own devices, the observer will see that livestock will favour areas of the paddocks with a greater mix than those that are monocultures. These are typically described as "sweeter" areas but depending on the grazing regime, they are probably an area that has slightly more carbon and biodiversity in it than the rest of the paddock. To manage livestock and ensure a productive environment, graziers (ranchers/farmers) typically use one of three styles of grazing management.

- Continuous/Set Stocking – The most common form in pastural areas given the size and scale of properties.
- Cell/Timed/Rotational – A method adopted in regions with higher stocking rates to help manage parasites and dry fodder for non-growing seasons.
- Holistic – Similar to cell grazing, except grazing times vary due to several factors. Initially adopted in closely settled areas, this grazing method is starting be used in more remote regions.

Getting the balance right in your grazing setup is a challenge for all livestock producers. Too many 'mouths' and you can chew yourself into a drought. Too few and the lignified pasture will oxidise the soil, preventing green grass. Graziers in remote pastoral zones tend to use conservative numbers in their grazing setup as the next rainfall event is unknown and it is seen as feed banking for hard times. Unfortunately,

this practice can have a negative effect on the soil biology, effecting their long-term productivity.

4.1 Set-stock Grazing

One of the most common grazing methods employed by graziers in Australia, set-stocking or continuous grazing is a method in which a select number of animals are placed in a paddock where they stay for the remainder of the year. The authors father often discussed the method of placing 2,000 merino wethers in an 18,000ac paddock each year, only removing them for crutching and shearing.

4.1.1 Benefits

Talking to a range of landholders, set-stocking has several positives for landholders:

- Less stress on the animals through reduced handling.
- It is time efficient due to reduced handling.
- Livestock weight gains are increased through less walking between paddocks and reduced handling.
- A safe approach to managing land, taking into account both dry and wet seasons.

The increased weight gains are an argument commonly used to justify this method and could be akin to ‘paddock feed-lotting’ in that the animal are not wasting energy by the process of being moved to a new paddock continually. While it has its merits, it can also be seen as a way of ‘mining’ your soils as the plants are under constant grazing pressure and can assist in the creation a monoculture, with all favourable grass species being chewed out.

4.1.2 Drawbacks

The plant function and growth are hugely important for nutrient cycling in the soils and what is observed above ground is normally reflected below in its roots (plant type depending). With a plant constantly being chewed, the lack of leaves available for photosynthesis restricts the plants’ ability to cycle nutrients and sugars with the micro biology in the soil. This creates an imbalance in the microbiology present and reduces PAN. This reduction in PAN, ultimately starves that plant and creates and environment that is no longer suitable for that plant species.

By allowing this to occur, the animals are in effect reversing the order of plant succession and reducing the population of favourable plants in the environment. By reversing the primary succession (as seen in Figure 10.) graziers are unintentionally creating an environment that is not conducive to animal health. Supplementation or even substitute feeding may be required to maintain the condition of these animals.

Set-stocked paddocks develop a lop-sided pasture with areas constantly under grazing pressure while other less favoured sections are underutilised. This under utilisation (especially in more brittle environments) allows the grass to lignify and ultimately oxidise the soil. This creates a reactive and often toxic reaction in the soil, restricting plant growth.

Additionally, following a dry season, the pastures will struggle to grow back with constant grazing pressure, allowing more favourable conditions for your pioneer

species in the order of plant succession (woody weeds, assorted burrs, etc.). The grazier will require more water given the reduced ground cover resulting from this method of grazing management.

Animal health, despite having weight gain benefits, could also be put in a vulnerable position through the lack of monitoring and handling. Should a worm or fly or other health outbreak occur, the response time by the grazier could be significantly delayed resulting in severe fatalities. In other grazing management styles, through merely moving the herd/flock, the weaker animals typically fall to the tail of the mob allowing the stockman to check on their health status whereas this is simply not possible in set-stocked paddocks. In pastoral zones where livestock are grazed over large areas (400ha/1000ac or more), the mobs disperse more, the drier it gets. When the time comes to mustering, getting a 'clean' muster can be challenging. Weak or sick sheep don't 'travel' and hide, the dispersal through the paddock means the stockman needs to check every area of the paddock and then some animals must travel significant distances before they have even left the paddock. With regular moves, the paddock stays fresher, meaning the livestock are more likely to stick together and allowing improved mustering in the future.

To summarise, to improve the tolerance of soils against both excessive wet and dry years, this management style would not suffice. While the argument for improved weight gain is valid, it comes at a cost. The land suffers via understocking the paddocks and overgrazing preferential plant species, the animals potentially suffer through a lack of thorough routine checkups and livestock movements can be more challenging, depending on the season.

4.2 Timed Rotational Grazing

4.2.1 Benefits

Timed/ rotational grazing is a crash grazing approach where large mobs of animals are rotated through a series of paddocks for a select amount of time. This process allows better paddock rest and improved plant succession. The crash grazing effect allows for a more even graze of the paddock and a denser concentration of dung in a small area. This improves PAN incredibly and if the stocking density is high enough, the results will be more pronounced.

Combined, the improved photosynthesis, the trampling effect of undesirable plants, the removal of lignifying grasses and increased fecal matter combine to improve the SOC (as seen in Figure 3.). This ultimately will improve the water holding capacity of the soil and lead to an increased tolerance of dry periods and will allow the pasture to respond more readily to rainfall events.

4.2.2 Drawbacks

The risks with timed grazing are the animals soon learn which days they are to be moved, which can become problematic (Richardson, 2022). If the livestock are not moved on the day they are required too, this can increase stress amongst them and a reduction in weight gains. In addition, while stock water will need to be accessible to all paddocks grazed, there also needs to be sufficient water availability (Stacey, 2022) along with reliable flow rates (for water troughs) as dropping water levels can add to stress levels in livestock. Often this can be identified with damaged water

infrastructure, resulting from the stress. A flow rate of 5L+ per second for a trough is adequate.

Given each paddock is given a similar grazing time, paddock size may not be taken into consideration resulting in some paddocks being potentially either under or over grazed. This can have a degenerative effect on the pastures for the same reasons as those listed under set stocking.

To summarise, timed rotational grazing has significant advantages over set-stocking due to the land being allowed to rest, the animals getting a regular check-up during moves and the mustering of stock being substantially easier with animals becoming trained to the regular moves. The drawback is that differing paddock sizes, weather conditions and even rest periods for worm burden, etc. are not always considered in this grazing approach as it is time based and this can have an adverse effect on both livestock and soil health.

4.3 Holistic Grazing

With similarities to timed grazing, rotational grazing and cell grazing, holistic grazing is often dumped under the same category. It is often assumed that holistic grazing comprises of quick rotations through numerous small paddocks (cells) with heavy stocking rates. Critics of this argue that there would then be no grass (particularly in more brittle environments) when the stock return to the first paddock. Holistic grazing is a rotational grazing strategy that considers all the interconnecting attributes surrounding soil health, pasture quality, animal health, time management requirements and our own social well-being, along with numerous other qualities the landholder takes into consideration.

4.3.1 Benefits

As with timed rotational grazing, rest of pastures to ensure correct plant function (photosynthesis, nutrient cycling, etc.) however the duration of the graze period is more fluid with differing factors influencing this aspect. Most commonly, season (winter/summer, wet/dry), feed quality, animal class, parasite control, animal weight, and rolling rainfall have the most impact on this determination, however other aspects including social aspects (holidays, etc.), water reliability, market trends, etc. could come into play. As its name suggests, this grazing strategy places equal importance on a range of aspects in land management to create an equilibrium between the land, the animals and the business and allow room for sustainable growth. In set-stocking, an imbalance is created with more pressure put on animal performance at the expense of the land and in timed rotational grazing, this imbalance alternates between the animal and the land depending on seasonal variances and potentially market trends. In both scenarios, the business is more exposed, restricting fluidity of trade and in turn putting more pressure back onto the land and the animals.

4.3.2 Drawbacks

The drawbacks in any system that requires large groups of animals to be corralled together and rotated through a series of paddocks or cells are similar. As with timed rotational grazing, animal stress can be induced when water pressure is not sufficient to maintain adequate water supply or, if a paddock/cell move becomes too regular and the animals are getting out sync with the process.

The health and well-being for different animal classes (especially sheep and goats) also needs to be considered as each class has its own unique grazing pattern and this can impact both them and the pasture differently.

Goats, namely rangeland goats do not function well in small confined paddocks with large numbers for an extended period of time. They are browsers and typically favour grazing and are also very susceptible to parasites when forced to graze to low. The same occurs to sheep and when forced into such an environment with excessive numbers. Ovis21 conducted a trial with producers in Chile and Southern Argentina where they collectively graze 50,000hd of sheep together to see the results on both the landscape and the animals. Despite seeing a sharp improvement in ecological health, the health of the livestock caused significant concern. Intensive grazing suits cattle better than sheep, conceded one Ovis21 client (Sturzembaum, 2023) who was unsure why. It was determined that flock sizes of 3000hd was an ideal size for pasture rotation (Sanchez, 2023) but would require occasional separation during certain periods (joining, lambing).

While it is not as important as with sheep, most farmers observe that cattle do not often graze shoulder to shoulder (Richardson, 2022) (encouraged by some in the industry, to promote PAN and to trample any unwanted plants into the soil). It is argued that systems like this might be handy as a one-off, just like the spraying or tillage of pastures (Richardson, 2022) but should not become a consistent pattern as new problems will arise from it.

Figure 11. Single wire division fences used by the Buchanan's at La Gloria, Concordia, Argentina to reduce capital expenditure. March 2023 (Source: Author)

Weight classes play a crucial role in the hierarchical structure of livestock and it's for this reason that this can come into play when determining your grazing plan. In sheep it is more prominent as larger, strong sheep bully the weaker, lighter animals creating a tail in the flock. As they progress through the paddocks/cells, this tail will grow and as it did in South America, become an increasing issue. This can be resolved by periodically removing the tail and putting them in reconditioning paddocks before allowing them back into the flock (de Mestre, 2024).

The capital requirements can be one of the more overwhelming components of a rotational grazing system given each paddock/cell requires adequate shade, water, and fencing. To get around these obstacles, people practicing holistic grazing often use electricity to reduce fencing costs (Buchanan & Buchanan, 2023) and instead of placing multiple water troughs at great expense throughout the property, having multiple plug-in points for temporary water troughs (Earle, 2024) or allowing water

access to several paddocks at once are other solutions around reducing these high capital inputs. In addition to this, technological capital may also be required in the form of auto-handling equipment given the blending of flocks/herds. Should joining, pregnancy testing or other such animal management situations arise, a system that removes human error (e.g. Auto-drafting equipment) from such a program is advised.

In summary, holistic grazing is both the most complex form of grazing management for pasture and livestock management and the most complete as it takes all matters of influence, into consideration. As with timed rotational grazing, it provides rest required for correct plant function but unlike this, it does this on a customisable basis, allowing ecological function to grow to its full extent. Animal health and management is also an important part of the function and prioritised alongside the pastures.

The system can also be overwhelming and costly (especially without proper planning). Capital invested in water and fencing infrastructure will be higher than that with a set-stocked regime but, long term ecological growth should be guaranteed as the stocking rate is considerably increased every time a paddock is split (Moss, 2024). It is advised that data is collected on all animals in this scheme to improve the outcomes of any animal handling that is completed (e.g. drafting) given the blending of livestock that can occur. Mixed ages, mixed sexes and mixed breeds/wool types (sheep) can occur and technologies like simple auto-drafters are ideal for cleaning it up while also adding financial benefit through better selection pressure.

Conclusions

The livestock grazing industry in Australia exists in a volatile and brittle landscape and as such, needs to learn to work within the confines of such a fragile and seemingly unforgiving ecosystem. Systemic issues in the environment are slowly highlighting issues with increasing severity to such a degree that they need repairing at a fundamental level. To do this, we need to better understand the balancing act that co-exists between, our water, our soil, our plants, and our animals.

Producers are starting to become more aware of the importance of improved rainfall absorption over high rainfall totals and are chasing ways to increase this. From artificial methods which slow the flow across the landscape to naturally increasing SOC, getting more water into the ground increases the resilience of our pastures for drier times. In conjunction with improving WUE, an understanding of the biodiversity within your working environment is critical to achieving long term growth. Growing the right mix grasses, herbages, and trees to suit both the brittleness of your environment and the animals being grazed determines the viability of the business long term. If this imbalance is out, then costly issues will increase.

Lastly, our grazing management is key to bringing everything together. Our animals are the defining feature that breathes life into both the soil and the air. Producers need to remember that they represent the health of our soils and our pastures and a sick or poor animal will reflect the environment they are grazing as much as a fat and healthy animal will. Band-aid solutions (like substitute feeding) will only mask this for so long. Matching the stocking rate to the carrying capacity in a holistic system will go a long way to maintaining the pastures for a variable climate and therefore, preventing an ecological imbalance. As graziers, we need to remember that in essence, we are pasture farmers and our livestock output is simply a reflection of our yields.

Figure 12. Brian and Gregory Aldridge, (La Colorada) with the author, Juan Zavalia (La Realidad) and Gonsalez Sanchez (Chalia Aike), Argentina and the authors Global Focus Group in Israel. (February to June, 2023) (Source: Author)

Recommendations

The following recommendations are to assist in providing a framework for anyone in the livestock grazing system looking to create more consistency in their business, regardless of the seasonal conditions that are faced.

- Adopt a more holistic approach to how your animals graze their environment.
    - Read the animals condition, their excrement, the amount of feed on offer before they enter the paddock and the growth rates of the feed going forward.
    - The carrying capacity of your property will vary through the year. It is essential that the stocking rate never exceeds this.
- Reduce set-stocking paddocks where possible.
    - In the event of this being deemed financially unviable (e.g. pastoral holdings), try to split paddocks in half so that half the country can be rested for a time after major rain events. Then when the pasture has come away sufficiently, allow stock to resume grazing in the entire paddock again.
- Collect data on your animals and the pastures.
    - This can be used to measure performance on your livestock, allowing producers to manage stocking rate fluctuations with more ease.
    - Data collecting on the pastures will provide constant feedback on property performance, while also providing a visual tool on your feed bank going forward.
- Understand your climate for what you want to grow.
    - Some regions are better suited to different animals, so select the region best suited to your enterprise.
- Implement strategies to hold both water on your property and improve the water absorption rate.
    - Erosion means you not only lose water to your neighbours but soil too.
    - Plant trees where required, commit to ponding if your landscape is flat enough and graze for more friable soils (soils with a better SOC).
- Encourage plant growth in your paddocks year-round.
    - Living plants means more life in the soil and more nutrients being cycled.
    - Livestock are growing year-round and need constant sustenance. Plants with life in them will provide this and reduce the need for supplementary feeding.
- Maintain variety in the pasture.
    - More variety for the livestock will result in increased yields.
    - Also encourages a greater diversity of nutrients to be present in the soil and the plants.
    - Lessens the chance of undesirable plants growing.

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