Improving Grazing

Production increase through good environmental processes

A report for

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Executive Summary

The purpose of this report is to outline the exciting and new opportunities relating to the development of Northern Australia and the potential that the northern industry is presented with. This document has been compiled from experience as a manager using plan grazing in the northern environment for the last five years and encountering first-hand the improvement to the land and its ability to produce kilograms of beef.

Being accepted into the Nuffield community in 2017 has allowed the author to travel the world seeking new and proven ideas that can take the level of improvement even further and present the industry with tried and proven concepts in global agriculture. Potential implications or issues to making the intensive jump is the lack of knowledge, understanding and the fear of change. Arguments will arise from, and resistance encountered, however concepts that work in different environments will progress when the right plants are established.

Identified ecological tools with the support of strong planning assisted by technology, are also recognised and provide an insight to progress forward.

Progression can be encountered in different ways. This includes understanding ecological tools for progression, utilising advancements in technology to allow strong planning objects through development of fencing and water supported by stronger, more resilient pastures.

Among the recommendations of this report are developing required skills and knowledge to implement change, with the intent of intensification at the forefront, seeking professional and experienced guidance in required field, developing clear production outcomes, and increasing focus on potential gain through fertility, and improved pasture quality.

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Foreword

The topic of my Nuffield research is based on improved grazing techniques – focusing on good environmental practices to deliver strong production outcomes. Whilst investigating issues experienced in the northern agricultural industry, I noticed a large amount of land degradation occurring and biodiversity loss in soils.

Coming from the small country town of Mirriwinni in Queensland, I was raised on small scale grazing property. In 2002, after completing two years at agricultural college I was drawn to the bush for the vast volume of land and cattle numbers, soon realising the challenges that the producers of Northern Australia face. It produces low volumes of food for what the land mass covers. This presents great opportunity for growth, even withstanding the rainfall. Water is a vital ingredient that can be added via irrigation or managing soils to hold water for greater periods of time.

Over the last 17 years of working in the northern agricultural industry, I have witnessed and stumbled upon environmental issues both inside and outside my management that have had a strong impact on overall financial performance of the properties. In 2013, I was able to trial methods of improved grazing techniques on Manbulloo Station. Over five years I have not only noticed significant improvement in the land and its soil health, but it has proved to be an efficient way of putting kilograms (kgs) on the feeder cattle and position them for market at the desired time. We noticed increased desirable plants both native and improved, with reduction showing in non-desirable plants followed by an increase in ground cover.

With the potential positive impacts of improved soil health and land management, Northern Australian producers are faced with high development costs which limits their ability to grow.

When integrated livestock and cropping systems are applied, they add much needed value to producers with cash injection to upskill and upgrade. These systems can offer short-term gain that can be converted into long-term rewards.

As an employee of a large pastoral enterprise, it is my role to take advantage of every opportunity that presents itself. With the right management tools, we can deliver strong environmental outcomes that help communities thrive, and economic rewards in the long run.

On my travels, I certainly witnessed similar issues. These included topsoil soil loss, woody weed taking over, biodiversity loss, increased bare ground, and drops in productivity.

As stewards of the land, we have done our best with the knowledge available. As we progress forward, I hope we can grow and prove our value as very high-quality producers for future generations. The issue of productivity in agricultural in northern Australia needs to be addressed and acknowledged to benefit further generations and corporate investment future.

Acknowledgments

I would like to acknowledge and sincerely thank Nuffield Australia for the opportunity I was presented.

I would like to acknowledge ANZ Bank for their level of commitment to the process.

I would also like to acknowledge Australian Agricultural Company (AACO) for the guidance throughout the scholarship process.

I would like the acknowledge my employer Consolidated Pastoral Company (CPC) for full support to allow my participation in this scholarship. I would have not been able to commit to it if I did not have a good team at home, so I would like to thank the Manbulloo team for doing a fantastic job of keeping operations flowing in a standard of excellence whilst I was away.

I would like to thank all the newly found friends and their families for opening their homes and the sharing of their knowledge and hospitality, hopefully one day Tammy and myself can return the favour.

Finally, my wife Tammy and my three gorgeous girls Dakota, Kadence, and Billie May, for their love and support and the sacrifices they made so we could share this very incredible and unforgettable experience.

Abbreviations

AUS – Australia

CA – California

HA – Hectares

ILC – Integrated livestock and cropping

Kgs – Kilograms

MT – Montana

ND – North Dakota

NT – Northern Territory

NTNRM – Northern Territory Natural Resource Management

NZ - New Zealand

PDK - Paddock

Tech - Technology

TX - Texas

USA - United States of America

VF – Vertical fencing

Objectives

The objective of this report is to identify opportunities through change in grazing practices in Northern Australian grazing enterprises to increase productivity, while improving land fertility for future gain. In addition:

- To provide insight on ecological tools required to maximise production with the outlook to fulfil and deliver positive outcomes for both industry and consumers.
- Identify benefits to maximise opportunities in the Northern Australian environment.
- To outline role of integrated livestock and cropping systems.

Chapter 1: Introduction

With the development of Northern Australia at the forefront of mind, the need for strong ecological process will be essential to drive productivity in beef production. The author wants to see more strategic management implemented across the north, as climatic conditions present the opportunity of huge summer growth and implementing management guidelines that promote increased soil moisture and nutrient infiltration that will generate growth longer into the dry season, allowing plants to be in a more vegetative growth phase.

There are identified opportunities with good flexible planning with strong emphasis on soil fertility would be, but not limited to:

- Flexibility in operational process
- Delivering good outcome in productivity
- Provide endless opportunities in both land
- Greater operational efficiency
- Greater consistency in products turned off

The need for understanding the rotational grazing concept is critical to be successful when implementing a grazing process. Flexibility is needed when faced with adversity, which will help provide insight and understanding to make strong decisions. The decision to research improving grazing was to provide insight to a very valuable resource which is the soil. It is the author's belief that in the north, the soil is something that doesn't get enough focus. Therefore, a new grazing project commenced at Manbulloo Station using Alan Savory's 'Plan Grazing' technique to try and enhance soil fertility and transfer into valuable kilograms (kgs) of beef.

The project progress was immediate due to increases in efficiency from cattle moving onto fresh feed, not having to travel far for water and fodder. Reduction in labour handling costs per unit of cattle led to extinguished aerial support. Looking into nutrition, it was felt there was more that could be done to convert sunlight into energy produced by plants. This was encountered in New Zealand as part of the scholarship research. The need for critical planning will become a driving force in increasing productivity.

The Northern Australian climate provides great conditions for intensive grazing management, as discussed with producers from similar climatic zones around the world. Warmer climatic

zones along with reliable rainfall offer the perfect opportunity for growth. Pasture growth requires, moisture, sunlight, and nutrients. With two of the three available via the natural climate, the possibility of the third only requires management. Historically, nutrient requirements would be delivered either through synthetic fertiliser or feeding ruminates to deliver nutritional shortfall. Both processes address the nutrient requirement in the short term for production of ruminates at hand.

Figure 1: Paddock moves in grazing cell on Manbulloo Station (Source: C Kruckow)

The Northern Industry

The northern industry is mainly made up of large-scale conservative stock rates, livestock are let roam very large paddocks on generally mustered twice annually to remove culls and wean calves. Generally, teams of five to ten along with aerial support allow the movement of cattle from paddock to yard to carry out desired processes. This can be up to a week-long process which can have an impact on future production of all classes of livestock. Being a very vast and isolated environment logistically, this can be quite challenging and plays a role in endpoint production.

Extensive grazing management is most common, applying constant grazing pressure on watering points year in year out. With large-scale operations, access to capital can be one of the main constrains on expansion and continuous improvement. As more is learned,

producers are continuously asking questions and looking for opportunities to grow the businesses the best way they know how.

Fire is generally used as a source of delivering freshen and rejuvenating growth, as well as seen to the clear and tidy up woody encroachment. Understanding the environment and growth stage of pastures is critical to delivering desired production targets. Leaving cattle too long in an area will also be detrimental to animal performance as animals will often eat out sweeter areas reducing it to bare ground, as well as leaving and walking past messed plants. This is generally seen in the northern industry under set stock management.

Determining livestock numbers is generally decided by the stocking rate and how much feed is available in that paddock for long periods of time.

Chapter 2: Plan Grazing

Plan Grazing is the process originally designed by Andre Voisin, a French scientist that studied animal behaviour in the early 20th century. Andre called the process rotational grazing as it involved moving livestock from pasture to pasture allowing the livestock to always have fresh feed in front of them, motivated by the production of the best possible gain. This has been interpreted as exposing livestock to pasture at the right time for the right reason. When planning movements though a rotation, careful consideration is needed to be able to achieve desired outcomes. Alan Savoury borrowed the concept and developed it further after recognising the similarities with large bison herds in the USA and exotic herds in Africa. 'Mimicking nature' is the term used, where large herds of herbivores would move constantly from pasture to pasture, accessing water wherever available. This is also related to predator control movement.

In modern times, plan/rotation grazing is being widely used to treat degraded land and to restore soil health, manage water quality, as well as users of water downstream, and is used extensively in New Zealand. From a production standpoint, and in a trading situation to maximise production opportunities, delivering greater efficiency and the ability to meet market demand when required is vital. Uses in breeding require control mating so efficiency targets can be reached.

Spring Valley Enterprises, New Zealand

Spring Valley enterprises is owned but Matt and Lynley Wyeth, lamb, and beef producers in the Wairarapa region. This operation was well thought out and well planned. Integrated into their breeding program was strong environmental management. Low laying soft soil flats were able to be spelled until lambing, allowing high level of nutrition to be in abundance to meet ewe and lamb requirements. Hill country was used with ground cover left behind and put onto fresh pasture. Kgs of production wasn't measured on the hill country, as management was targeted at breeding females becoming fit for lambing, giving them best possibility of a smooth birthing process, so their production would be picked up at lambing time. Being strong sloping hills, the author expected strong sediment in water courses, but this wasn't the case. There was soil on the slopes, a good cover of used pasture and air rated soil due to high animal numbers which was steadily able to take water in. The minimal amount of run off was collected on grass and litter cover. Streams was clean and fresh and drinkable. This proved

that good land management practices by Matt and Lynley have led to good environmental outcomes.

There are many variations of fencing that can be used in planned rotational grazing, including cell grazing, strip grazing and break fencing, all which will optimise productivity opportunities.

In Northern Australia, pastoral properties can improve their grazing processes by implementing higher stocking rates. If this is not possible due to financial restraints, pastoralists can amalgamate segregated livestock together to graze in one paddock for half the year and the other for the other half of the year. This process could be repeated over and over. This would not require more immediate fencing, but gradually fencing could be implemented. As stated, planning is essential before implementing this process to be sure to know what stocking rates paddocks can handle and that there is sufficient water and watering points when increasing herd numbers.

Benefits of adapting to 'time control grazing' include greater flexibility in timing both for people and animals, the ability to improve soil quality while extracting valuable fodder to transfer into saleable product (beef or other desired protein).

Planned grazing practices have been utilised globally for very long periods of time, with the aim to manage environmental processes. However, with intensification this also allows increased production per unit of land through the practice of rotational, time control and cell grazing. When thinking of rotation, consideration should be given to the historic migrating herds. These animals were certainly managed, mostly by predators. Animals continued to move from available water to available water in large herds either grazing and tramping all in their path to their next destination for water or safety, allowing grazed and trampled vegetation to rest and recover.

Rotational systems are shown to have the same level of positive environmental impact as planned grazing. In Australia, different challenges are faced when it comes to predators, compared to the herds in Africa and the USA. However, fencing technology could be seen as controlling predators to control ongoing movement of herds for pasture to recover after utilisation. Intensification to a grazing system offers new opportunities to gain control of all aspects of operations including environmental, and economic management of a pastoral enterprise. This allows the ability to grow high quality feed to graze rested paddocks throughout drier periods.

Through intensification, measuring from the ground up is possible, starting with soil which is the main platform.

Introducing planned grazing won't change the amount of precipitation the land receives but will allow for better use of rainfall due to greater ground cover and regular disturbed (to a minimum) soil surface to prevent run off, allowing rain to be utilised where is falls – not across land – and finding its way into creek and rivers.

Plan grazing allow animals to be grazed at the right time for the right reason. When driving production, a plan needs to allow grazing when plants are at a high nutritional level.

Currently trending in regenerative circles is using long rest periods to allow plants to recover for longer. This puts plants into a reproductive stage rather than a vegetative stage and will start to use up root stocks to reproduce. This however will affect animal performance and a well-planned supplementary feeding program will be required to balance nutritional needs. Up to 60% of forage waste will take place. On the other hand, this will allow for great soil cover to be laid down.

Using an adequate rest period approach can allow grazing at the right time for the right reason, whether it be to maximise production, treat unhealthy soils or provide a maintenance diet for the desired class of stock. The shorter the period livestock spend on selected paddocks the shorter recovery period required. It also allows peak of animal performance as not exposed to already utilised or spoilt feed. A good example off this can be seen using a break fencing scenario where livestock only have their dietary requirement for the next 24 hours available. There is place for long rest periods when growth is slow in a rotational or cell grazing situation where recovery period will be longer due to long exposure. Grazing charts or apps are critical to the planning process. Good software and apps make this process more user friendly and helps with precise planning and decision making. In addition, different scenarios can be created by either adding fodder, reducing numbers, or recalculating desired outcomes.

Intensified systems allow greater control and efficiency in operational livestock tasks. Moving mobs of up to 1,000 head of cattle can be either moved to new area to graze or yarded for processing very easily using just one to three staff. Aerial assistance or mustering can be limited when delivering efficiency of this sort. Planning can be so precise that when processing, livestock can be at the yard gate, eliminating the need for traveling long distances to yards which can impact performance and or turn off weight dramatically.

A simple process that can be administered without difficulty is to amalgamate two paddocks together and running one mob and moving every 183 days. This process can be duplicated over and over until desired mode of fencing is require producing further improvement. However, ensure watering systems can serve double the amount of stock at anyone given time. An example is provided below in Figure 2.

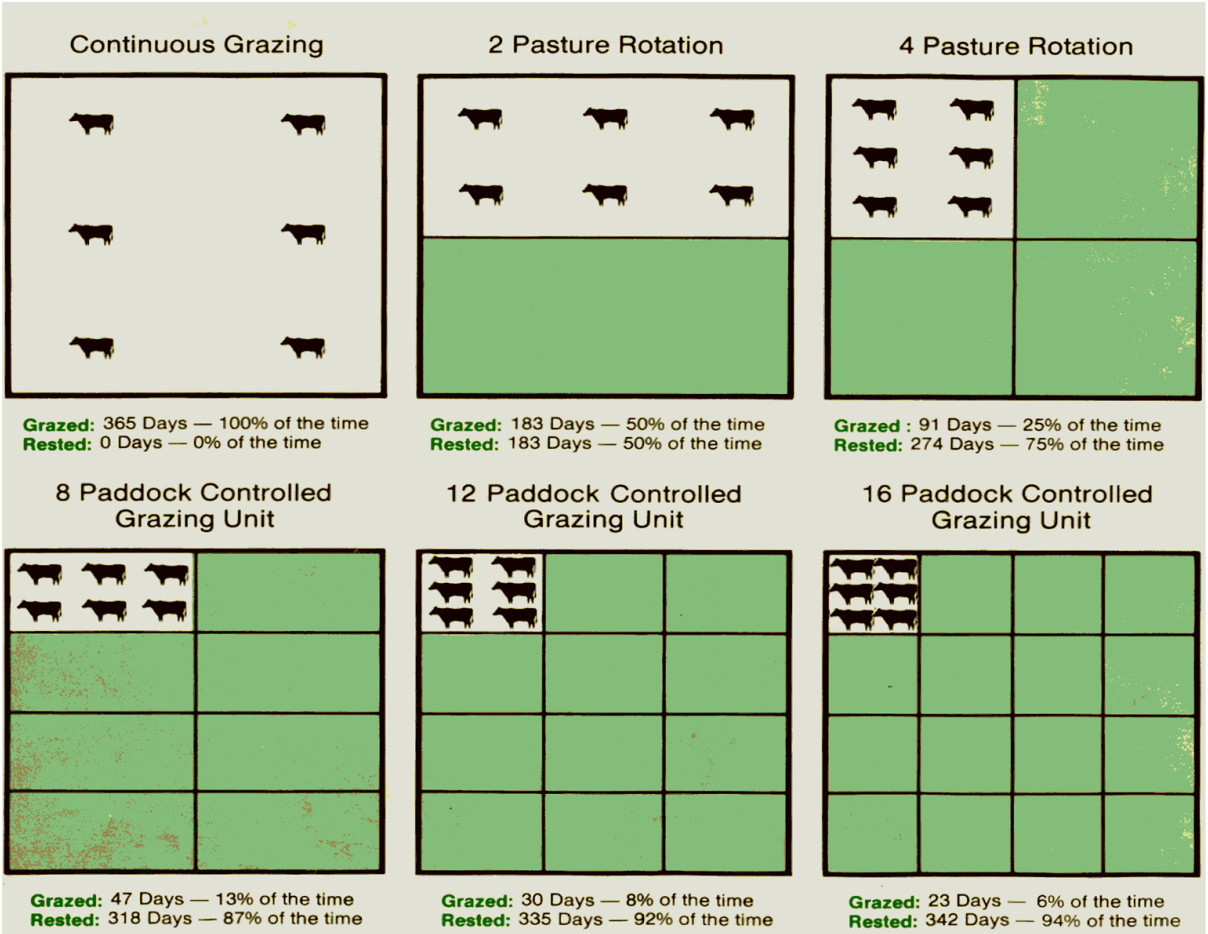

Figure 2: The cow and her grass: Rotational grazing - A manual of grass productivity
Source: Voisin, A (2015)

Integrated Livestock and Cropping (ILC)

ILC will bring multiple production opportunities. Income streams include, but are not limited to, meat production, cereal and grain crops, hay production, timber production and honey production.

The focus of this report is on meat production using cover crops. By applying five soil health principals creates resilience in a farm operation. These are:

1. Soil Armor (ground cover)
2. Minimal soil disturbance
3. Plant diversity

4. Continual live plant or root
5. Livestock integration

On a rotational basis, planting a multi species cover crop of both legume and non-legume plants to protect soil can be followed by livestock grazing providing perfect environmental and soil conditions to plant and harvest a cash crop. Residue from cover crops as well as nitrogen fixation from legumes and followed by herd effect puts soil in high nutritional value to convert to economic wealth. This is followed by converting back to perennial pasture to rotation with livestock and or deliver hay production.

Livestock performance will increase with report of up to 2 kgs average daily gain in integrated operations – achieved on pastures with a balance of protein and energy requirements. In a dryland situation, this would require grazing followed by harvesting a possible cash crop, which would be season dependent. Planting a crop such as oats into residue with the right plant species can allow further opportunities for increased average daily gain or boost cow calf condition individual analysis to deliver a return.

Figure 3: Friesian bulls on fodder beet at Marlborough, New Zealand (Source: C. Kruckow)

Irrigation

In many areas around the world, irrigation has brought life to soil and resulted in stronger economic performance to businesses. It should therefore be considered. Figure 3 above, taken in New Zealand, is part of a fodder beet integrated system at Bonavaree Farm in Grassmere, South Marlborough where the author met farmer Doug Avery. Doug explained how 2 kgs of average daily gain equates to 100 kgs in 50 days, average analysts read 18 % dry matter, 10% protein, 12.5 % ME.

DATE RECEIVED	20 September 2017
OUR SAMPLE NUMBER	S2017-34937
YOUR REFERENCE	Irrigated Oats
SAMPLE TYPE	Pasture Fresh
DESCRIPTION	
DATE SAMPLE COLLECTED	11 September 2017

TEST	Result
NIR Package (FT/003)	
Dry Matter (%)	88.8
Moisture (%)	11.2
Crude Protein (% of dry matter)	14.1
Acid Detergent Fibre (% of dry matter)	31.5
Neutral Detergent Fibre (% of dry matter)	53.0
Digestibility (DMD) (% of dry matter)	71.9
Digestibility (DOMD) (Calculated) (% of dry matter)	67.7
Est. Metabolisable Energy (Calculated) (MJ/kg DM)	10.7
Water Soluble Carbohydrates (% of dry matter)	9.3
Fat (% of dry matter)	3.4
Ash (% of dry matter)	8.2
Horse DE (NA)	
Horse DE (MJ/kg DM)	9.7

DATE RECEIVED	14 June 2017
OUR SAMPLE NUMBER	S2017-23838
YOUR REFERENCE	Cavalcade
SAMPLE TYPE	Hay
DESCRIPTION	
DATE SAMPLE COLLECTED	05 June 2017

TEST	Result
NIR Package (FT/003)	
Dry Matter (%)	92.4
Moisture (%)	7.6
Crude Protein (% of dry matter)	13.2
Acid Detergent Fibre (% of dry matter)	33.4
Neutral Detergent Fibre (% of dry matter)	45.2
Digestibility (DMD) (% of dry matter)	62.1
Digestibility (DOMD) (Calculated) (% of dry matter)	59.5
Est. Metabolisable Energy (Calculated) (MJ/kg DM)	9.1
Fat (% of dry matter)	3.7
Ash (% of dry matter)	6.4

Figure 4: Cavalcade and Oat Analysts provide by Dennis, M (2017) from Katherine, NT

As shown above, local producer Matt Dennis has made use of oats and cavalcade for hay production in Northern Australia. These crops can provide the desired increase in production. Established tropical feeds such as cavalcade and oats could be utilised in winter and spring period when plain of nutrition is falling and would boost kgs for quicker turn off. Careful consideration and risk assessments would be required to implement the right strategy. Carrying a higher plain of nutrition for longer certainly open the door to production increases, and even entering the market when demand is high. Cavalcade hay is already growing in the summer and could be utilised as a standing graze in from May through to August, to boost production outcomes.

Oats also play a role but would need to be irrigated. They provide desired outcomes and production in late winter. Varieties are being developed for earlier planting times to allow for grazing in early winter. Further development and research will be required here.

Timing and phase of growth can also deliver strong productive outcomes for longer into the season meaning plants remain in a productive phase rather then a reproductive stage. The standard four phases of growth are outlined below:

Phase 1

- Short first growth
- Growth is moderate
- High pasture quality but low yield
- High sensitivity to grazing
- High grazing pressure has a detrimental effect on root growth

Phase 2

- Increased volume of leaf
- Rapid growth stage
- High pasture quality
- Increasing yield
- Moderate sensitivity to grazing
- Peak vegetative stage

Phase 3

- Seed head and stem development

- Growth rate steadying
- Moderate pasture quality
- High yield
- Low sensitivity to grazing
- Entering reproductive stage
- Lignification developing

Phase 4

- Hayed off or dormant stage
- Little to no growth
- Declining pasture quality
- Low sensitivity to grazing pressure
- Lignification high
- Oxidisation process starting

Grazing at top of phase two and bottom of phase three is most productive for the profitability of grazing animals. Table below illustrates the growth and quality curve.

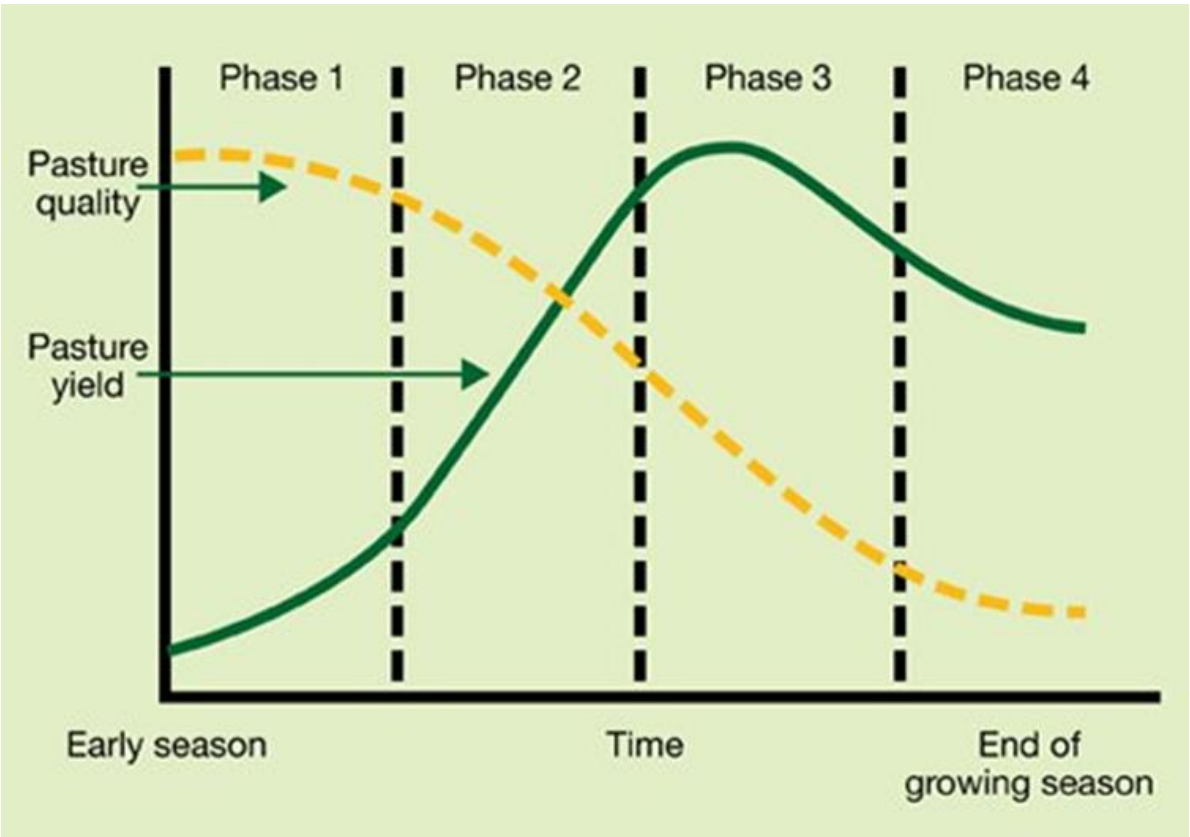

Figure 5: Pasture quality and growth curb (Source: Meat and Livestock Australia website)

Animal Behaviour and Performance

Animal behaviour is managed differently in traditional extensive systems, allowing them to roam wherever they want which lets them eat greater quality feed first which will increase productivity but has the opposite effect once only poor-quality pasture is left.

In an intensified system, cattle learn to balance their dietary needs and can remain stable in performance throughout the season. As they are rotated, it allows pasture to regenerate and develop into move productive plants over time. Supplementation programs will have greater effect on productivity and have greater impact on economic performance. Supplementation is only required when nutritional balance is not available. When introduced into intensive systems, learning, and changing habits can be quick if the right handling is applied. Good stockman ship methods deliver desired outcomes. Animals kept in the right frame of mind are happy to graze which effects performance positively. Livestock living in large mobs deliver some intimidation to predators and makes it difficult for predators to single out young stock. Livestock feel most comfortable when in mobs, which is witnessed when they take flight and look for a companion, as well as at water points. When cattle are being handled incorrectly, they will generally mob up or fight, so the logic of animals contained in restricted areas and being able to remain in designated area provides good animal welfare practice with protection from predators and better productivity.

Timing of grazing is critical to any animal's ability to perform. When pasture is in growing phase (1) animals will tend to struggle in performance due to a lack of bulk dry matter in the diet. When at grazing phase three and four, it also has as negative impact due to lignification of plants and protein and energy levels to decrease. Optimum time is being grazing in phase two of grow has plant has recovered and not far away from reproduction, has increase amount of quality leaf cover and protein and energy levels are at their maximum

Northern Territory Natural Resource Management (NTNRM)

The NTNRM did a report and trial at Manbulloo Station in the NT. Report number TNRM00511 stated 0.5 average daily gain increase in animal performance after a four-year period using plan grazing practices. Due to the efficiency of handling, an increase in pasture quality – both the profile of native C4 and improved C4 plants. The introduction of crops with high energy to convert to beef will allow producers to target average daily gains of up to two, 100kg in 50 days. This could lead beef production to 450kg produced per hectare (ha). Northern average daily gain is on average 0.3kg to 0.6kg so the potential for growth is there. The key

performance indicator of production per ha in the north of Australia is something not overly talked about in production circles. With estimated kgs produced per ha being from 3.5kg to 10kg per ha (NTNRM 2018). This is a simple formula that can be used to identify production on any extensive property. The NTNRM study using plan grazing on its measured 50kg per ha which is a vast improvement and the beginning of what may be possible. Putting the right ecological tools in place will increase production dramatically.

This project detail is outlined below and displays that with an increase in ground cover, desirable plant species increase. The most desirable data coming from this report is the decrease in undesirable species. This report was carried out from 2014 through to 2018 and focused on the link between production and environmental improvement.

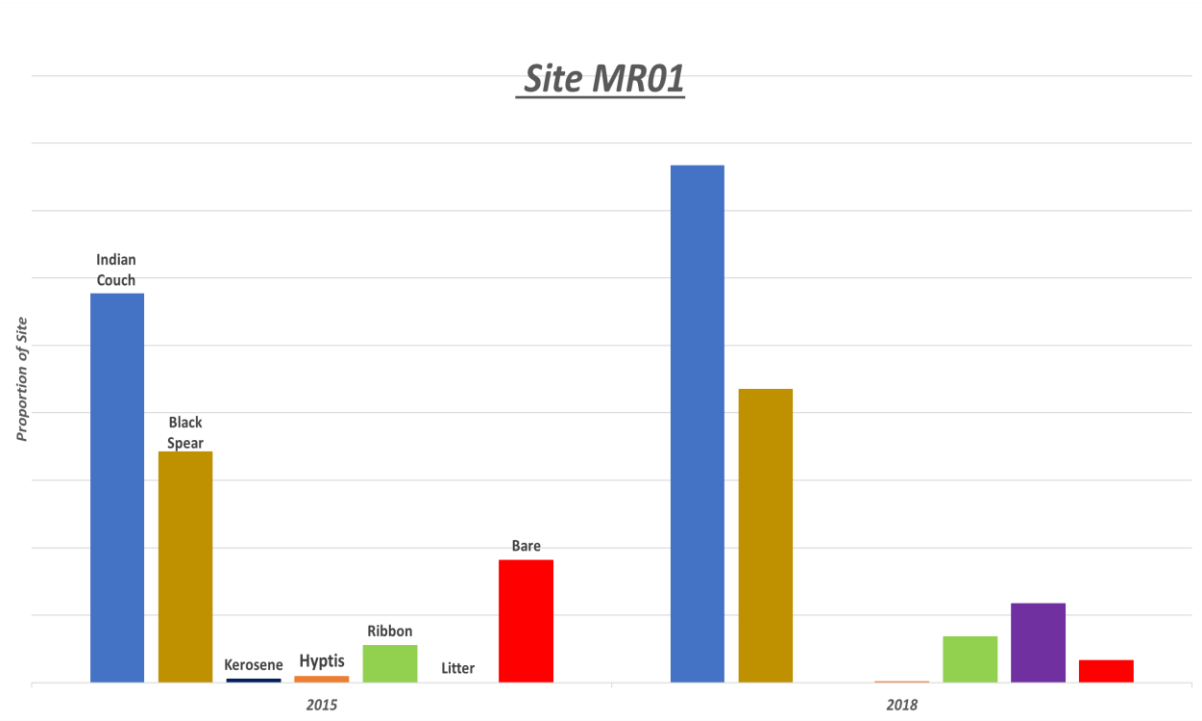

Figure 6: NTNRM report NTRM00511, showing increase in desirable perennials and litter (organic matter) and a decrease in undesirable species (NTNRM 2018)

Technology

Investing in technology such as piped water and electric fencing can be an expensive investment and sometimes a cash grab for technology companies. Electric fencing options can help with affordability in the right situation, but the best choice depends on economic availability, durability requirements and safety.

Virtual fencing (VF) can deliver the ability to intensify quite easily. In summary, livestock receive a tag that with a GPS tracker, which keeps them in the required boundary of the area

grazed. Animal location and movement can be monitored and moving animals can be achieved by using the devices. VF, however, could also remove the understanding of what is happening on the ground, and it is therefore important to maintain a presence around. Moves should be done with human engagement so continual learning and development can take place. This will become an easy process once moved a few times. VF can bring a whole new dimension to management of vast rangelands as it can allow livestock location to be always known. Mortality rates can also be managed as animal movement behaviour could be measured and allow treatment on control spread of disease.

The biggest opportunity VF presents is the ability to make paddocks as large or small as required. With this flexibility, density can have continual change to promote biodiversity. Operations can allow larger areas with less movement and then tighten up when calves are strong enough to be moved regularly. Cattle having to travel too far from water to find feed can be eliminated with closeness to water points being controlled. Vast areas of minimal use or lightly grazed area can be brought into greater production.

Management software and apps bring the ability to monitor all process and functions of an operation, with the ability to track live operational performance daily and remotely, giving great control on decision making and delivering outcomes as well as replanning being a quick easy process. Figure 7 below shows a virtual fencing dashboard overlay on Manbulloo Station in the NT, provided by Frank Wooten from Vence in California, showing the ability to track any operation from anywhere in the world.

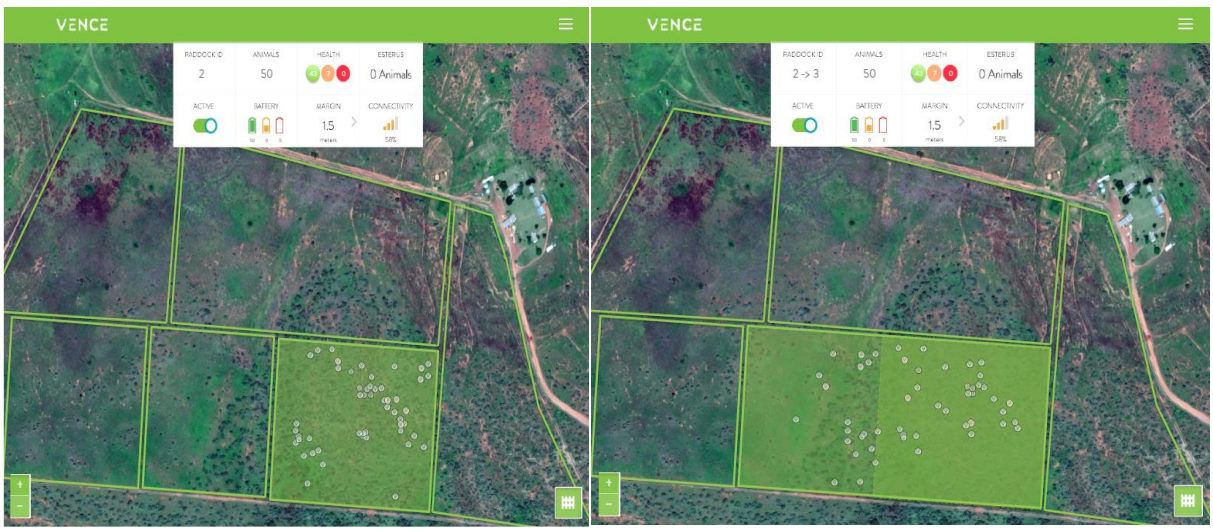

Figure 7: Virtual fencing dashboard at Manbulloo Station, provided by Frank Wooten from Vence, California

Walk over weighing systems also deliver the opportunity to be able to select livestock at right weight and to be moved on without processing entire classes of cattle. Data collection systems on watering points can also play a critical role in measuring water consumption and what effect behaviour could be having on production.

Ecological Tools for Change

1. Rest

Rest is a vital part of the ecological process as this allows plants to recover take in water and capture sunlight to photosynthesis and regenerate.

Figure 8: Hosts Jerry and Jayce Doan, with Jay Fuhrer, and the author at Black Leg Ranch, Bismarck, North Dakota

2. Grazing

Grazing is the process of which the pruning of plants to remove growth to allow for fresh growth and plants ability to regenerate and photosynthesis, grazing in which the process in which animals eat. (J. Fuhrer, Menoken Farm North Dakota). Grazing is also the fundamental process which allow livestock to eat grass to turn into kgs of desired protein e.g., beef. In Northern Australia there are several strategies in place but one of the most common is set stock grazing e.g., releasing cattle into a paddock and removing them at such time as to sell or wean calves or any other for any other task required.

Grazing timing is critical for an animal's ability to perform. When pasture is in growing phase one, animals may struggle in performance due lack of bulk dry matter in their diet, and in phase three and four there may also be a negative impact on performance due lignification of plants and protein and energy levels decreasing. As stated previously, optimum time for grazing is at the top of phase two, when the plant has recovered and in a vegetative stage at peak of nutrition, has increased amount of quality leaf cover and protein levels to deliver more balanced dietary requirement, to have a greater impact on production.

Figure 9: Demonstrating high animal impact (herd effect) at Birdwell Clarke Ranch in Texas. (Source: Debra Clarke)

3. Herd Effect (Animal Impact)

Herd effect is a critically important part of management, where animals break the soil surface to allow seed regeneration, which can be spread by wind, dropped by birds, or released from a plant where a grazing plan allows. This process lays down underutilised plants to protect the soil surface (see Figure 9), allowing precipitation to be trapped and used where rain falls, rather than running off. It also plays a role in regulating soil temperature to maintain soil and plant life. Herd effects also provide much need natural nutrient, through decaying plants, dung and urine. Soil infiltration rates can increase therefore making better use of precipitation as it falls and allow plants to remain growing for longer.

Figure 10: Profile change in black spear grass. (Source: NTNRM TNRM00511, NT)

4. Fire

Fire has been a critical tool in northern land management systems for thousands of years and is seen to be major tool to managing land by clearing woody encroachment, removing old oxidizing pastures and plants, and rejuvenating them. Also, it allows traditional hunting of native animals. However, research shows that in the long-term effects of fire increases woody and encroachment by setting seeds into reproductive stage. Undesirable plants will disappear after burning but will reappear very soon after, due to resilience and ability to try and provide

cover for bare ground. There is a glasslike hardening of soil surfaces as the heat of the fire passes over soils. Though burning soil is exposed directly to sunlight as Soil Armor is removed and soil remains bare until, this tool should carefully consider and only used if necessary.

Figure 11: Demonstrating effective water infiltration with J. Fuhrer from Bismarck in North Dakota (Source: C. Kruckow)

Four Ecosystem Processes, Critical for Production Performance

Using three ecological tools – recovery, grazing and herd effect – the four ecosystem processes can start to balance themselves. Making better use of rainfall results in higher moisture levels, better soil infiltration and increases in organic matter, for the mineral cycle to be revitalised, with increase microbiological life allowing decrease in soil leaching enhancing nutrient infiltration. The ecosystem process takes place with biodiversity increasing from plants to micro-organisms and small creatures that survive in thriving fertile soil. Diversification of species will occur when the right environmental conditions are in place, and diversification loss will occur when conditions become unsuitable for reproduction. Solar Energy Flow is a process enhanced by the volume of green leaf available to perform photosynthesis. The time of photosynthesis is negatively affected if water and mineral cycle is not effective therefore growth periods become shorter.

Livestock will graze and trample plants as they maintain a herd structure. Trampling pastures off aeration for topsoil allow for softer surface when precipitation falls, knocks down old and un-grazed plants to arm the soil surface with protection from wind and rainfall impact, as well as providing shade for soil surface to regulate soil temperate to maintain life for greater periods. Litter from the soil surface also provides food for soil and plant growth regeneration of future product plants, will also be enhanced by dung and urine in more concentrated forms to maximise plant opportunity to regenerate.

Conclusion

Australia's understanding of soil fertility seems to be lacking compared to other parts of the world. Northern Australia faces the greatest opportunity in global agriculture both in growth and overall improvement in production processes.

Ecological tools identified in this report will drive productivity for Northern Australian landholders. Australia's competitive advantage of being clean and green is being challenged. Management changes will reignite and place Australia firmly ahead of competitors who have already put soil at the forefront of their operations.

Northern Australian producers need to consider growth through intensification rather than expanding capital. This will deliver far greater outcomes and can extract more from less.

Intensification can come in many forms. It can consist of amalgamating two mobs of cattle together and moving them half yearly. This process can be continued over and over without major economic pressures.

Technological advances are certainly helping industry and allowing up-to-date information to be obtained from ground level. Water infrastructure will be increasingly required to open unutilised grazing areas, helping animals store energy they extract from pasture and turn to kilograms in place of using energy to travel to find enough fodder to get through the year.

Improving pasture quality through improved varieties and keeping in a more vegetative state will keep production higher through the dry end of the season, allowing animals to increase body mass at tougher periods of the year. Finding and establishing suitable plants to suit northern conditions will prove vital to the success of change in management practices.

It will be critical to gain better understanding of the environment and implement the use of ecological tools backed up by utilising good technology, to take advantage of new and emerging livestock markets as they are developed and presented. Population growth will increase. It will be critical for the north to adapt and evolve to play a role in feeding the world.

A critical well thought out planning process with the flexibility for change and with clear outcomes will allow northern producers new opportunities Further research and development will assist in evaluating every potential desired outcome.

Recommendations

Take simple steps to intensify the business. Have a clear starting point with planned potential for growth. In addition:

- Develop required skills and knowledge to implement change, with the intent of intensification at the forefront.
- Seek professional and experienced guidance in required field.
- Develop clear production outcomes.
- Increase focus on potential gain through fertility, and improved pasture quality.
- Consider opportunities to explore irrigation possibilities.
- Develop clear starting point, with clear objective for growth.

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Plain English Compendium Summary

Project Title:	Improving Grazing. Production increase through good environmental process
Nuffield Australia Project No.:	1706
Scholar:	Cameron Kruckow
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Objectives	The objective of this report is to identify opportunities through change in grazing practices in Northern Australian grazing enterprises to both increase productivity, while improving land fertility for future gains. In addition: • To provide insight on ecological tools required to maximise production with the outlook to fulfil and deliver positive outcomes for both industry and consumers. • Identify benefits to maximise opportunities in the Northern Australian environment. • To outline role of integrated livestock and cropping systems.
Background	Improving Grazing production in the Northern environment is a critical meeting demand from increase global population growth. The driving focus behind this scholar ship is outline opportunities using good environmental processes to in have Agricultural production opportunities.
Research	Environmentally driven Produces aimed strong production outcomes. Research was conducted in Brazil, North America, and New Zealand, using farm visits, personal study, interviews, conferences and research institute visits to collate information. Information all collected from Local grazing project, and farmers.
Outcomes	• Develop required skills and knowledge to implement change, with the intent of intensification at the forefront • Seek professional and experienced guidance in required field • Develop clear production outcomes • Increase focus on potential gain through fertility, and improved pasture quality • Consider opportunities to explore irrigation possibilities • Develop clear starting point, with clear objective for growth
Implications	• Ecological tool improved soil fertility • Importance of planning • Improved Production Opportunities • Reconsidering Strategy behind the use of fire • Efficiency enhancement through Technology
Publications	Nuffield Australia National Conference, Melbourne, Victoria, September 2018