The Integration of Livestock and Cropping in High Rainfall Zones

Jack of all trades, Master of none

A report for NUFFIELD AUSTRALIA FARMING SCHOLARS

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Foreword

For decades farmers from all over the world have experienced differing levels of success when integrating livestock and cropping. Recently in Australia there has been a suggestion to separate the two enterprises and focus on the one production system. Some people have it as an opinion, while several researchers are trying to quantify it. I strongly believe that with good management in the right environment, livestock can complement a cropping enterprise in a number of ways and vice versa. However if not managed correctly, then there is potential to jeopardise either one or sometimes both of the systems.

Over the last few decades as cropping systems have become more intensified, the traditional Australian mixed farm has disappeared. This change has been driven by higher returns from cropping, the decline of the wool industry and a changing climate. As growers strive for efficiencies in scale and management, integration becomes more of a challenge. This is a challenge we as producers, need to embrace, not shy away from.

The aim of this project was to find ideas, innovations and information that could be implemented into mixed farming systems in Australia. No two mixed farms are the same. There is no one ‘best fit’ model or blueprint on how to successfully integrate livestock and cropping. Mixed farms are often complex in both production and management but there are many common issues shared throughout the world.

In our family enterprise we are increasingly expanding our cropped areas, yet we are also running more livestock. We ask ourselves; how can we obtain more value from our livestock? Should we be value adding to our grain production through our existing livestock enterprises? But most importantly how we can ensure our sustainability into the future by integrating livestock production with crop production?

As farmers have intensified their cropping systems throughout the world they have created a number of serious issues that a well managed mixed farm is better positioned to handle. Declining soil structure and fertility, reduced organic matter, herbicide resistance, increased levels of pests and diseases are just a few of the monsters we have created. This is in a time of increasing volatile commodity markets.

Key Findings:

- An integrated farming system is a great risk management tool in this period of increasing volatility in our agricultural commodity markets.

- It is important that:

    - Each enterprise can be analysed independently to compare profitability between enterprises.
    - Strengths and weaknesses within the business are identified.
    - Management strategies are introduced that improve the performance of the business.

- A good rotation is the key to any integrated crop/livestock production system. Breaking up cycles of weeds, pests and diseases. A good rotation will improve soil structure and fertility.

- Cover crops play a role that benefits both the soil and a livestock enterprise.

- Information is now available on varieties suitable to graze our cereal crops with confidence. As long as best practice management is followed there will be no significant decrease in grain yield.

- Grazing canola will play an important role in mixed farming operations in the High Rainfall Zone (HRZ) in the future.

- Lucerne is a great tool for integrated farms in the HRZ. It is a great source of feed for livestock; it has flexibility for fodder production and provides benefits to both soil structure and fertility.

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Abbreviations

HRZ – High Rainfall Zone

DM – Dry Matter

LW – Live Weight

Ha – Hectare

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Executive Summary

• Background

The integration of cropping and livestock is not new in Australian farming systems, particularly the HRZ. However as growers justify the huge capital expenditure of machinery, strive for efficiencies in management skills and labour, livestock are been pushed out of the traditional mixed farm. We are seeing a move to intensive cropping monocultures. This is creating many challenges that include an increased reliance on chemical inputs and fertilisers and volatility in our agricultural commodity markets.

How do we find a balance in which the production of livestock adds value, not detriment, to a cropping system? We need to gain a greater understanding of how to better manage the integration of livestock and cropping in the HRZ and develop complementary practices that adds to the overall economic and environmental sustainability of our resources.

• Aims

To meet with some of the leading agricultural producers of mixed farming operations throughout the world. Examine their management, business structure and practices and find new ideas and innovations that could be implemented into our Australian farming systems.

To consultant some of the leaders in research and development and discuss new systems and technologies that may have a fit in our environment. To look at new dual purpose varieties and cultivars that may be utilised in Australian conditions.

To gain a better understanding of the integration of cropping and intensive animal production, such as piggeries, poultry, feedlots or dairies. Determine the benefits, implications and risks of these systems and how are they managed.

• Method

Throughout 10 weeks of extensive travel around the world, visiting countries such as England, Ireland, Canada, the United States (N^{th} and S^{th} Dakota, Nebraska, Iowa, Minnesota, Oklahoma and Texas) and New Zealand. Sourcing information and ideas from leading farmers, consultants, agronomist and researchers and observe how other areas around the

world integrate livestock with crop production. Also to look at issues, such as drainage and stubble management, related to crop production in high rainfall environments.

- **Findings**

  - There is no one 'best fit' or recipe as to how to successfully integrate livestock and cropping in the HRZ. Success and sustainability will come down to your available resources and level of management.

  - An integrated farming system is a valuable risk management tool in this period of increasing volatility in our agricultural commodity markets. It's all about balance. Have some flexibility in the system and change when change is required.

  - It is important that each enterprise can be analysed independently to compare profitability. Identify any strengths and weaknesses within the business. Can a change in management affect the performance of the business?

  - A good rotation is the key to any integrated crop/livestock production system. It breaks up cycles of weeds, pests and diseases. A good rotation will improve soil structure and fertility. Grow as many different types of crops as possible. Use warm and cool season grasses, and warm and cool season broadleaf species.

  - Cover crops have a role to play that will benefit both the soil and a livestock enterprise. Particularly in the HRZ where rainfall distribution is more even. Livestock will contribute to compaction of the soil however the benefits far outweigh the negatives.

  - We now have the information and varieties suitable to graze our cereal crops with confidence. As long as best practice management is followed there will be no significant decrease in grain yield.

  - Grazing canola will play an important role in mixed farming operations in the HRZ in the future. As the market grows and creates demand Australia should get access to some of the longer season European varieties, this will further improve options for this new dual purpose crop.

- Lucerne is a great tool for integrated farms in the HRZ. A great source of feed for livestock; it also has flexibility for fodder production and has benefits to both the soil structure and fertility.

Introduction

There are many pros and cons to operating a mixed farming system. Mixed farming systems require a greater level of management; however have less risk in volatile commodity markets. Environmental issues are present in all types of farming operations, something that has become increasingly important as we move towards a more sustainable future. The issues surrounding the environment will vary for every individual business and depend on a number of factors. Climate, soil, topography, water and land use a just a few of the vast amount of things we need to consider when assessing the impact our practices have on the environment.

In today's world, farmers are being pressured to produce more from less. As our land base declines due to population growth around the globe, food producers have to lift efficiencies and grow more food off any given area. This is combined with the fact that in some areas, farmers are also dealing with the challenge of repairing the land that has been degraded due to bad practices over time. Irrespective of the challenging climatic conditions we have to juggle from year to year and increasing market volatility, farmers still have a growing number of mouths to feed. It is estimated that the world's population will grow from 7 billion to 9 billion people by the year 2050. This means that we will have to increase grain output by half and meat production will have to double. Forty percent of the increase in world grain output now comes from increases in yields and the remaining 60% comes from increasing the area of land sown to crop. This is opposed to the 1960s when 25% came from increased land area and 75% from higher yields (Cremaq, 2010).

An integrated farming system could be any number of different combinations. The integration of livestock and cropping also has a wide definition. Farms visited were traditional mixed farms running wheat and sheep to the more intensive dairy, piggery and feedlot industries to the niche business of a turkey farm. No one individual system has a perfect model to pick up and place in a different environment. They have all been refined and finetuned over many years to come up with something that works for a particular situation, whether that be an environmental or climatic parameter or even to tailor a system to suit a certain market. The system also has to suit the individuals preferred style of management.

With the downturn in the wool industry in the 1990s, sheep producers were looking for an alternative source of income. This drove the expansion of cropping into more southern regions of Australia, traditionally used for fine wool production. This area is known as the High

Rainfall Zone (HRZ). The HRZ in Australia's northern, western and southern grain growing regions is increasingly recognised as an area of significant potential expansion for grain production.

Figure 1 Australia's High Rainfall Zone (HRZ). Source: Australian Natural Resource Atlas

Together with my family, we farm in Gippsland, in Victoria's south east. We operate a mixed farming enterprise running sheep, cattle and cropping. The beef cattle enterprise is focused on grass fed vealer production for the domestic market. We use Angus/Friesian or Murray Grey/Friesian cross cows joined to Limousin bulls to produce calves with a target carcass weight of 200kg. The sheep enterprise includes both merino and 1st cross ewes producing fine wool, averaging 19 micron, and prime lambs. Lambs are sold in both the domestic and export markets with carcass weights ranging from 18-24kgs. The cropping program consists mainly of a canola, wheat, barley rotation, along with a small area of triticale and peas. Long term average yields are 4t/ha for cereals and 2t/ha for canola.

Gippsland is not an area known for grain production. However there is huge potential for the industry to expand. The local dairy industry creates plenty of demand for grain at what is considered a premium price. Gippsland will never be self sufficient in grain production. While the industry is slowly growing, most of the growth is coming from understocked sheep/beef farmers. The cautious 'see how we go approach' will mean that very few farmers are going to sell all their stock and adopt a 100% cropping program. Because of this, integrated livestock/cropping farms are going to be where any growth in the industry comes from.

The region does have a long history of cropping dating back to the early 1900s. The Red gum plains located from Traralgon to Bairnsdale in a 500-600ml rainfall zone was where some of the first wheats were grown over 70 years ago. The construction of the Macalister Irrigation District (MID) in the 1940's saw a lot of former sheep/beef farms converted to dairy. The

dairy and poultry industries in Gippsland use approximately 1.3 million tonnes of grain per annum (Debenham Australia, 2008).

It is estimated that there is a potential for 200,000 ha of additional land suitable for crop production in the Gippsland area (Debenham Australia, 2008). It is unlikely that 100% of this land will ever be in crop at any one time. Therefore there is still going to be livestock in the area. With a run of dry seasons in the area, stock numbers have been reduced significantly. As the seasons improve, producers are looking for options to either restock their land back to somewhere near full carrying capacity, or look at diversifying into cropping as a method of spreading risk. With sheep prices at record highs, cropping is becoming a serious alternative. Many of these producers were forced to buy expensive grain during the drought to feed to breeding stock. If they had the ability to grow grain themselves, then this would reduce their exposure to high market prices. A number of challenges do confront these traditional stockmen; machinery, infrastructure and the limited amount of specialist knowledge in the area, just to name a few.

Australia's national sheep flock has dropped dramatically over the last 20 years. Current estimates of the national flock are 77 million head. This is down from 170 million head in 1990 (Sheep CRC, 2010). This trend had also occurred in our neighbouring country New Zealand, as they converted a lot of what were traditionally grazing properties into dairy farms. Now there is seen to be a shortage of sheep in the world. As demand for protein increases from countries like China, world sheep meat prices are skyrocketing. This is occurring at the same time global wheat prices continue to fluctuate.

A number of Australian farmers are reconsidering their position on livestock in their cropping systems after a continual run of below average yields, poor grain price and increased input prices. High returns for prime lambs and mutton, and a strong outlook for the future have some of the producers that switched their focus to 100% crop production reassessing their stance.

Objectives

The question is, “We grow grain and sell it to other businesses to value add to livestock – why aren’t we doing it ourselves?” or “How can we capture more profitability from our existing production?” With these burning questions - are other parts of the world asking the same questions and even better, do they have the answers? So began the investigation of the ‘Integration of Livestock and Cropping in High Rainfall Zones.’

Mixed farms will always have a place in Australian agricultural production and with the right management the systems can complement each other. The aim of my topic was to investigate some of the world’s leading producers and find ‘what are the successful management practices of an integrated farming system?’

This was achieved by;

- Visiting farmers that had diversified from a single enterprise into an integrated system and finding the answers to what were the main drivers for change and how successful had the transition been.

- Meeting with some of the leaders in research and development and questioning them on what is at the forefront of agricultural production with regards to new systems and technologies. And asking; what tools are available that will contribute to the prosperity of a mixed farming operation?

- Investigating some intensive animal production systems. Producers that were growing crops, feeding it to animals in a controlled environment and recycling nutrients back to the cropping system. What are the benefits to these styles of business structure?

Findings are targeted at farmers that are looking for the next challenge in their business. We need to embrace some of our perceived problems and find a way to make them benefit us. This report is not a single recipe as to how to successfully integrate livestock and cropping, as each individual system is uniquely different. Hopefully it encourages thoughts and ideas on what might work better for you in your particular situation and inspires you to ‘have a crack at it’.

Discussion

- **Business Structure**

It is important in any mixed farming business that all individual enterprises stand alone in profitability. The breakdown in the main cost structure and revenue from a business needs to be allocated to a section of the enterprise. This allows for the profitability of each enterprise to be analysed or benchmarked against each other. If an area of the business is running at a loss, then you should question why you would continue to operate in the same manner. Can a change in management or operational practice affect the bottom line of a business? Absolutely. However it is not until all areas of the business are individually analysed, that you will be able to identify the types of decisions that need to be made. Depending on whether the analysis is long or short term may also affect the outcomes. A business may be able to support an unviable enterprise short term but long term it is not sustainable, even if each enterprise does complement each other.

Every integrated business probably has some known benefits of integration that are hard to cost down to the last dollar. These may be referred to as ‘bonuses’ and include things such as environmental benefit, or a soil health benefit. A number of businesses integrate cropping with livestock through more intensive systems such as dairies, piggeries and feedlots. In this instance, if manure from the feedlot for example is used in the cropping program, the major elements like nitrogen, phosphorus or potassium can be calculated through a nutrient budget. However the benefit the manure has on the microbial activity of the soil is hard to accurately assess. Another ‘bonus’ benefit of cropping to a livestock enterprise, particularly sheep, is for worm control. Cropped paddocks are worm free and the stubbles provide a clean feed source for the summer months. Sheep are able to clean up any spilt grain, dropped heads and emerging summer weeds. Stubble grazing will reduce supplementary feeding costs in the summer. It also has a direct economic saving on drench plus the ‘bonus’ long term benefits of prolonging drench resistance. Stock that graze weeds in the stubbles also provide an economic saving on herbicides and again reduce the chances of herbicide resistance.

Intensive integration usually requires a significant level of capital investment to successfully set up and run these business structures. Many dairy farmers will have a portion of their land dedicated to crop production, either fodder or grain. This is all part of managing risk and buffering against potential spikes in grain and hay prices. These two enterprises complement each other very well. In the case of a crop being harvested for grain, the farmer also has the

option of baling straw to use as a roughage source, as a part of a feed ration. Straw can also be used for bedding in housed enterprises.

Figure 2: Hog Hill Farms, David Rourke, Brandon Manitoba, Canada, 2010.

David Rourke in Brandon, Canada runs one of the most integrated businesses in the country. In a nutshell he grows grain, uses it to produce ethanol, feeds the by-product to pigs, uses straw for bedding, and composts bedding material for fertiliser. This cycle allows him to extract more value from his grain to feed 14,000 pigs per year. David structures his business so each enterprise is run independently of each other. This allows for profitability to be calculated and compared between each section. His latest project is to establish a goat dairy. He feels his crop rotation is too tight and believes that by adding a ruminant into the system the farm will be more sustainable long term. The goats will be fed predominantly on lucerne grown on farm as part of the crop rotation.

A number of producers in the UK and US integrate livestock, particularly beef cattle, with cropping through feedlots. In the US, corn is the base of most feedlot rations. Due to the high demand for corn from either feedlots or for ethanol production, corn has become the major crop grown in many parts of the country. This has placed huge pressure on rotations as the majority of the crops are Roundup Ready. As part of the rotation they may grow soya beans – also Roundup Ready. Figure 3 shows an example of a Roundup Ready corn/soya bean rotation. Some growers have grown corn on corn for over 30 years. This is an unsustainable type of production system as there is no diversity in the rotation.

Figure 3: Roundup Ready® soya beans grown after Roundup Ready® Corn. Minnesota, USA 2010.

In the UK, farmers have access to a lot of waste vegetable products available to supplement their feeding rations. With population of over 60 million people in an area equivalent to 3% the size of Australia; they have a large amount of food waste to utilise. Usually sourced from a local area, the waste product may provide a source of energy or protein or sometimes both to the animal.

In many countries there are a number of farmers who have lost the necessary infrastructure to run livestock. As cropping farmers strive for efficiencies, they are turning to bigger machinery fitted with Global Positioning Systems (GPS) and are transforming their farm layout. Long, straight runs to minimise downtime turning corners and controlled traffic (CT) systems, where the wheel tracks of each implement only ever travel in the same spot are becoming more common. The increased incidents of herbicide resistant weeds along fence lines have also lead to changes in farm layout. As a result of these factors many kilometres of fencing and many sets of stock yards have been demolished and not replaced. Poor commodity prices greatly influenced this trend; infrastructure was becoming degraded anyway, and farmers could not justify the costs of replacement. However for a farmer that once had the livestock and infrastructure, to now go out and replace both would be a huge cost to any business. Probably one that is uneconomical. The world sheep flock won't build up overnight and the market predicts strong sheep meat prices for the short term. Even with this incentive, the loss of some of this infrastructure won't allow for some producers to efficiently return to a mixed farming model in a quick timeframe.

It is also important in the structure of a mixed farm to have some flexibility in the system. Land values in New Zealand have turned grass into so much of a precious resource that they

value every blade. Farms are so driven by high production rates, be it dairy or sheep, that they are fully stocked with high performing animals. This leaves no margin for error, especially if the seasons don't go to plan. Because of their reliable climate patterns they can calculate pasture budgets with more confidence than most Australian systems, however when things don't go as expected they are in trouble. In challenging times a strategy may be to sacrifice a percentage of livestock that require lower inputs, share less risk and would probably return less income, to reduce the burden of the system through these challenging periods. The part of the property they utilise can then be grazed by the mainstream animals. An example of this might be for a lamb producer to have a mob of wethers for wool production. Trading livestock as opposed to breeding also has advantages in this situation.

Figure 4: Intensive sheep grazing. Canterbury Plains, New Zealand 2010.

- **Minimum Tillage**

Developments in minimum tillage/zero tillage have made integrating livestock and cropping more sustainable due to the less time land is taken out of production for cultivation. Advances in herbicide technology have also contributed to this. Farmers are able to graze crops or stubbles right up until the time of planting the next crop. In this system the benefits of having a good rotation also stand out. In New Zealand farmers are able to spray out a ryegrass pasture, sow a crop of forage rape or peas for example, and then return the stock to the paddock as soon as the chemical withholding period has expired. The stock continue to graze the pasture up until the new crop starts to emerge; this typically extends their grazing period by about a week. Under a conventional cultivation program this would not be possible. Minimum tillage also allows timelier sowing of crops throughout the season; this is particularly important on limited soil moisture profiles in the autumn. Consequently grazing crops can be sown earlier in the season and therefore grazed earlier.

Conversely the rapid uptake of minimum tillage has also contributed to declining sheep numbers in Australia. There is research to suggest that stock contribute to soil erosion, soil compaction and increased weed pressure. These effects can be greatly reduced through better

management. Knowing your soil types is the key; rotationally graze your stubbles like you would a pasture, try not to set stock them and monitor feed availability. Once all the available feed is used, remove the stock from the paddock to avoid damage to the soil structure. Overgrazing stubbles can lead to erosion on light soils and compaction on heavy soils.

- **Rotations**

Having a good rotation is the key to any sustainable mixed farming system. A good rotation reduces the build up of weeds, pests and diseases that can be detrimental to crops. Pests and diseases are very selective about the crops they prefer, by rotating different crops around, cycles are broken and pest or diseases lose their hosts. A good rotation will consist of a mix of both broadleaf and grass species. Different species prefer different climates and there may be some limitations to what may work for you. Potential crops can be broken up into 4 different categories;

1. Cool season grasses
2. Cool season broadleaves
3. Warm season grasses
4. Warm season broadleaves

Table 1 shows a number of different crops from each of the four categories.

Cool Season Grasses	Warm Season Grasses
Oats	Millet
Barley	Sorghum
Wheat	Corn
Triticale	
Rye	
Cool Season Broadleaf	**Warm Season Broadleaf**
Canola	Buckwheat
Linseed	Chickpea
Peas	Soya Bean
Lentils	Safflower
Clover	Sunflower
Turnip	Lucerne
Forage Rape	Cow Pea
Mustard	Chicory
Lupins	

Table 1: Various plant groups and species

A good rotation will increase soil fertility through the addition of legumes. Soil structure will also benefit from the different root structures of different plants. There is no single cropping rotation that fits all enterprises. Depending on climate, soil type and management practices, the species and length of the rotation will vary. As long as you have a mix of cool season and

warm season broadleaf and grass species, you are on the right track. Organic farmers tend to have very good rotations in place as they rely on the natural synergies of the environment for their production. Instead of farmers waiting for the next 'silver bullet' to fix a problem we have created overtime through our current practices, we need to focus on soil health and natural biological processes. This will lift our production and improve our sustainability. This will also reduce our reliance on chemical inputs such as fertiliser, especially important in times of volatile price trends.

- **Intercropping**

Intercropping is a system being trialled by the Manitoba Zero Till Research Association (MZTRA) and the University of Manitoba, Canada. Intercropping involves growing more than one crop in the same paddock at the same time. The crops may be seeded at the same time (mixed intercropping) or they may be seeded at different times (relay intercropping). The benefits of intercropping include more diversity and possibly less inputs of fertiliser and chemicals. It ideally allows for improved resource use and beneficial biological interactions between crops (Natural Systems Agriculture, 2006).

Trials run by the University of Manitoba over 2001-2003 show intercropping produced higher yields than the same crops grown in monocultures 75% of the time. These crops include wheat, canola and peas and all possible combinations of them. The combination of peas and canola out yielded the monocultures 100% of the time. Management is more of a challenge in mixed stands and more research needs to be conducted to fully understand how intercrops function and to develop intercropping systems that are more compatible with current farming practices (Natural Systems Agriculture, 2006). Currently research seems to be focussed around intercropping peas and canola or lucerne and canola. If we grow summer active/winter dormant lucernes, over sown with canola, the canola should out compete the lucerne in the winter. If the lucerne gets away and starts to compete with the emerging canola then it can be suppressed chemically. Once the canola is harvested the lucerne will be actively growing, providing not only groundcover to the soil but valuable feed for livestock.

Figure 5: Intercropping Canola and Lucerne. Brandon Manitoba, Canada 2010.

- **Grazing Cereals**

Cereal crops can also be grazed by stock over the winter. Grazing cereals is a relatively new concept in Australia following the development of dual purpose cultivars bred for this purpose. By contrast, internationally some countries such as the USA have a long history of grazing dual purpose crops. Winter wheats are commonly used as a cool season pasture to graze cattle before entering the feedlots. Oklahoma grazes approximately 2 million 'stocker calves' on wheat each year with an economic value approaching $1 Billion US (Agricultural Research Services, 2007).

There are many true 'winter' varieties commercially available that require a vernalisation period. This allows for a much earlier sowing without the risk of the crop running to head. These varieties are commonly known as 'dual purpose' as they can be grazed and then harvested. Forage from dual purpose cereals has high nutritional values of DM digestibility 80-90^{+}% and crude protein contents of 20-26%. However the mineral composition of winter wheat is marginal for magnesium, deficient for sodium and has excessive concentrations of potassium. This creates an imbalance in the diet that means full potential of the feed is not utilised unless supplements are added. By giving stock access to a 1:1 salt/causmag supplement while grazing wheat, full potential is able to be captured very cheaply.

Very high weight gains in both sheep and cattle have been recorded from grazing dual purpose crops. Lambs can achieve growth rates of up to 300g/day and cattle up to 2kg/day. High stocking rates are also common.

- **Grazing Canola**

Grazing canola is something that is not commonly practiced throughout the world but I feel has potential for Australian farmers. Early sowing is a key to this system working. Our current varieties that are commercially available have a limited fit for grazing. If sown too early the crop won't remain vegetative and go into a reproductive phase (flowering). Growers around Harden and Delegate in NSW are having success with our current genetics, but this is only a small part of Australia. Caution must be taken until we have access to some of the European true winter type canola genetics.

Local trials of existing varieties will determine if dual purpose canola has a fit for your business. Currently hybrid varieties are best suited as a dual purpose crop as they are fast out of the ground and produce more biomass than conventional and triazine tolerant varieties. Crops can be sown 2-4 weeks earlier than normal and grazed from the 6-8 leaf stage. Selecting a variety with a good blackleg resistance rating is also important. Trials undertaken by the CSIRO have calculated gross margins $100-400/ha more than grain only crops. Liveweight gains in lambs grazing canola of 210-300g/day and biomass consumption of 2-4t/ha DM have been recorded (Kirkegaard, 2009).

If best practice is adopted yield penalties are minimised and oil contents are only slightly reduced. Removal of stock before buds have elongated more than 10cm is critical in avoiding yield reductions. Some of the additional benefits of grazing canola are shown to be a reduction in height/bulk which allows faster harvesting, grass weed control, value of winter pasture spelling, earlier income and risk management, provide a disease break, and management flexibility.

Some of these benefits are difficult to quantify but have been listed by consultants and growers as definite benefits of the system.

Figure 6: Grazing Canola. CSIRO Canberra, Australia 2010.

- **Other Options**

Another tool being trialled by farmers in Manitoba is to sow corn in a solid stand for grazing. This is done with a conventional seeder, like something used to sow a cereal crop, rather than a precision planter. Row spacings are narrower and plant placement is not as critical when the crop is only going to be grazed rather than harvested. Most farmers own a seeder but may not own a precision planter. This provides a significant cost saving if they are able to plant themselves rather than employ a contractor. Cattle strip graze the standing crop in the winter. The height of the corn acts as a natural shelter for the animals from the weather, while they have plenty of available high quality fodder close by.

A variety called Canamaize® has been purposely bred for this market. Canamaize® is an early maturing corn that is short in statue, meaning it can be planted at higher seeding rates to produce more DM/ha. It is cheaper to establish than hybrid corn varieties and has better utilisation for grazing. Canamaize® can also be swathed grazed.

Figure 7: 'Canamaize®,' Rourke Farms, Brandon Manitoba, Canada 2010.

A similar system is used in Texas; grazing forage sorghums in the summer months. This allows pasture growth to develop and provide a feed wedge to carry into the winter. Varieties have been developed to suit these systems. Figure 8 shows a 'Staygreen' sorghum variety. This is a dual purpose crop in that the plant stays green after the crop is harvested. The stubble has a higher nutritional value than that of conventional sorghum and has a good fit for integrated crop livestock farms. It also has a higher drought tolerance than conventional sorghum through the stay green trait.

Figure 8: Stay Green Sorghum, Bushland Texas, USA 2010.

Forage Soya beans are been grown in parts of the US to provide dairy and beef farmers with a home grown source of high quality and high protein feed. Originally intended for use as game cover for hunting, researchers are finding that they may have a fit for grazing.

The Noble Foundation in Oklahoma are trialling different varieties of forage soya beans and developing different management practices to see what sort of a fit they have in a mixed farming system.

Figure 9: Forage Soya Beans. Noble Foundation, Oklahoma USA 2010.

- **Cover Crops**

There is a lot of cropping research from around the world that shows benefits of rotations, break crops and cover crops. We have to move away from monocultures in cropping systems to capture the full potential of the soil biology. In parts of Manitoba Canada, and North and South Dakota USA, cover crops are growing in popularity. Growers were becoming frustrated with decreasing crop yields despite having to continually increase inputs. So they are using cover crops as a method of feeding the soil microbes, increasing organic matter, adding diversity to the systems and creating more nutrient cycling. This has lead to some growers grazing cover crops in an attempt to generate some income from them. Studies conducted by

the Burleigh County Soil Conservation District (BCSCD) USA show no significant additional moisture use and no yield penalty in corn following a grazed cover crop (Fulmer, 2008).

Cover crops have a number of other benefits other than feeding livestock. Cover crops provide surface residues or groundcover to help keep soil temperatures down as well as assist with weed control through crop competition. One of the main challenges in grazing cover crops is what North Dakota farmer Marlyn Richter calls the "Stockman's Challenge" (Richter, 2010). This refers to leaving enough residue or groundcover after grazing.

If the crop is overgrazed then in some ways it defies part of the logic for growing it, 'Graze your cover crops like you graze your pastures' (Brown, 2010). Another way of looking at a cover crop is that it is a dual feeding system. This refers to the fact that a cover crop feeds the animals above the ground as well as the soil microbes and biology below the surface. 'We spend too much time thinking about our stocking rates above the ground and not the one below' (Brown, 2010). Weight gains in steers have been recorded at 1.4kg/day grazing cover crops at Menoken, North Dakota (Fulmer, 2008).

The Dakota Lakes Research Farm is experimenting with cover crops consisting of up to 13 different species in a mix or a crop cocktail as they refer to it. With the addition of legumes in the mix there are also the additional benefits of adding nitrogen for the soil for the following crop.

Figure 10: Cover Crop Cocktail. Dakota Lakes Research Farm. Pierre, South Dakota USA 2010.

- ## Moisture Management

One of the problems typically encountered by grain growers in HRZ is high moisture content of the grain at harvest time. We need to change the way we look at moisture management and

view it as a friend, not an enemy. For example; for every 100 tonnes of grain, how many dollars is a grower losing, if he harvests at 10.5% moisture instead of the maximum allowable of 12.5%.

If grain is worth $275/t then it can be calculated as follows;

(Difference in moisture multiplied by grain price = $x.) E.g. 2% of $275 = $5.50/t.

(Total tonnage multiplied by $x.) 100t x $5.50 = $550.

The larger the tonnage; the greater the benefit. So while in the HRZ farmers often sit around waiting for the dry days to harvest, they should be pushing the limits more and speeding up the harvest period by stripping some grain with slightly elevated moisture. This is where blending has a fit. Why not blend high moisture grain with low moisture grain? In dry years, you may even add a small amount of water to raise the moisture content and still be at or below accepted levels. One large grain grower in the UK has fitted automatic controllers to his grain dryer; a reading is taken every 15 minutes to monitor moisture content so he is not over drying his grain. This saves fuel for the dryer, allows quicker turnaround time between batches and ultimately gives him the maximum amount of grain to sell. Although expensive to install, this technology will pay for itself quickly with the additional amount of grain sold.

Grain is at its peak nutritional value when its moisture content is between 35-45%. However Australian standards require grain to be delivered at 12.5% moisture. There are a number of risks growers in the HRZ face while waiting for moisture content to drop. Weather damage can cause sprouting, discolouration, shedding or lodging. Growers can alleviate some of these problems throughout the growing season through tools such as variety selection or growth regulators but come harvest time options are limited. Some of the options that are available as a means managing this risk are;

1. The first option, which is also the most common, is to do nothing. Wait for the right day with some wind and sunshine and the grain will dry. This has a high level of risk associated as it has the greatest risk of quality losses if weather damage occurs. Some varieties are more prone to sprouting than others and depending on target markets, growers need to consider the risk of weather damage at harvest.
2. Aeration. Ambient air can be used as a tool to manage grain moisture at slightly elevated levels. As long as temperature and humidity are at correct levels blowing air through grain can reduce moisture content. Cheaper alternative to drying but slower to achieve the same results.

3. Grain drying. By blowing heated air through grain, moisture content can be lowered to required levels. The required level will depend on the type and intended use of the grain. Grain drying is often expensive as an energy source is required to heat the air.
4. Crimping. With crimped grain, moist grain is harvested and run through a crimper that cracks and flattens the grain. Preservatives, molasses and sometime water are added to ensure the protection of nutrients and prevent spoilage. After three weeks in airtight storage it can be fed out as a supplement to a ration. Crimping is widely used in the UK.
5. Alkalage. Alkalage is a technique that some Australian farmers are using presently to conserve high energy forage made from mature cereal crops. Crops, typically wheat and barley are allowed to mature to a high dry matter – ideally in excess of 75%, to ensure the highest levels of starch and dry matter. The crop is cut with a forage harvester fitted with a grain processing mill which cracks the grain to ensure digestion by ruminants. Varying the cutting height of the crop can adjust the quality of the forage. The preserved crop is not silage – there is no fermentation so no energy is lost to the production of acids. Alkalage has increased digestibility of the straw and increases the protein content of the crop. It also increases the pH to approximately 8 by the production of ammonium salts. This is much friendlier to fibre digesting bacteria in the rumen. Alkalage is very stable and has a wide window for harvesting of approximately 30 days (Derrick, 2009).
6. Alkagrain. One of the most interesting systems was Alkagrain production. Similar to crimping, Alkagrain is produced from rolling mature (75-80% DM) cereal grain and mixing with specifically designed pellets that raise the pH into alkaline range (pH8-9). Alkagrain has a number of benefits including eliminating drying costs, allows more timely harvest, adds crude protein to the grain, and buffers rumen functions (Derrick, 2009). Grain is harvested with a conventional header. Although the grain is mature it can be harvested in damp conditions. The grain is then processed through a roller mill and pellets are added at the required rate. The grain is stored in a sealed environment and is stable once opened up. When fed to sheep it is not necessary to roll the grain. In New Zealand's Waikato district, contractor John Austin is using a silo bag system to process and store alkagrain. This system has big potential for mixed farmers in high rainfall zones. Education of the end user will be an important part of the success of alkagrain.

Figure 11: Alkagrain production in the Waikato district, New Zealand.

- **Lucerne**

Lucerne is one species that is grown right throughout the world in a huge variety of soil types and in multiple different climates. It is a perfect crop for any integrated livestock cropping farm as it has many benefits. It provides a break crop in the rotation to break up weed, pest and disease cycles. It is a source of nitrogen for the following crop. It also has benefits to the soil structure; it's deep tap root breaks up hardpans and drains the soil profile of excess moisture, helping alleviate water logging in following crops. Lucerne is a fantastic feed source for livestock. Rich in protein and energy it is perfect for growing or finishing stock. Lucerne can also be used for fodder production as it produces high quality fodder as either hay or silage. Lucerne can be challenging to establish but once established it is very hardy. It is reasonably drought tolerant but prefers a free draining soil. Lucerne also offers new chemistry for weed control in cropping rotations.

The Grain'n'Graze program run throughout Australia has initiated the use of over sowing cereals into established lucerne stands. The aim of this is to provide more feed during the winter months when the lucerne becomes dormant and production slows down.

- **The Environment**

Conventional cropping systems in the Central USA have low levels of biological diversity and rely heavily on synthetic fertilisers and herbicides. These are common contaminates of waterways and cause environmental degradation. Ecological theory suggests that diversified cropping systems integrated with livestock should have a reduced reliance on chemicals and fertilisers and should lower production costs and environmental pollution (Liebman, 2008).

An experiment run over 10 years by Texas Tech University USA, has shown that an integrated crop/forage/livestock system compared with a cotton monoculture has decreased nitrogen use by 40% and lowered irrigation water use by 25% whilst maintaining similar profitability between the two systems. It has also increased soil organic carbon, lowered soil erosion, lowered chemical use, improved soil health and microbial activity (Allen, 2009). Similar findings were also found in an experiment run by Iowa State University from 2003-2008.

- **Thinking outside the square**

Swath grazing was a system used in Brandon Manitoba as a method of feeding cows over the winter. It also had the flexibility of being used in the autumn as a tool to conserve pasture cover for the winter. The crop most commonly used is oats, which is windrowed or swathed at the milky dough stage and left on the ground for cattle to graze at a chosen time. The cattle are then 'strip grazed' with temporary electric fencing across the paddock to maximise utilisation and minimise wastage. Work is being conducted by the Agriculture and Agri-food Research Centre in Brandon, Canada to breed varieties with higher levels of wax in the leaf and stem. This is to assist with water shed in the swath and help minimise spoilage.

This system would not work in many Australian regions in the winter, due to the time the crop would be left on the ground**.** It may have a use for summer and early autumn when typically many grazing farms are low on pasture. If the crop was grown through the summer and then swathed in the autumn, then it may provide a source of winter feed. Consideration has to be given to each individual enterprise as to feed supply and demand at different times of year.

Figure 12: Swath Grazing, Brandon Agrifood Research Centre, Brandon Manitoba, Canada 2010.

- **Alternative forages**

Improvements in plant breeding particularly in New Zealand have created improved alternative forages that can fit into many cropping rotations. This has a number of benefits for the paddock when returned back in to the rotation. Disease and weed cycles are broken, soil benefits also occur from having a different root structure. Organic matter levels usually improve when in a pasture phase as well. Chicory, plantain and red clover are high energy, highly digestible forages that are showing some impressive results in New Zealand's sheep industry.

One of the new innovations in forage rape breeding is ALS Group B herbicide tolerant varieties. This allows for a wider range of weed control options. However caution must be taken. Australia already a number of incidences of Group B herbicide resistance and this will increase pressure on chemical rotations. As long as good chemical records are kept and chemical groups are rotated there won't be a problem.

Recommendations

- There is no ‘best fit’ or single recipe as to how to successfully integrate livestock and cropping in the HRZ. Success and sustainability will come down to your available resources and level of management.

- An integrated farming system is a great risk management tool in this period of increasing volatility in our agricultural commodity markets. It’s all about balance. Have some flexibility in the system and change when change is required.

- It is important that each section of the business can be analysed independently to compare profitability between enterprises. Identify any strengths and weaknesses within the business. Can a change in management affect the performance of the business?

- A good rotation is the key to any integrated crop/livestock production system. Breaking up cycles of weeds, pests and diseases. Keeps the environment guessing and adds diversity to the system. A good rotation will improve soil structure and fertility. Grow as many different types of crops as possible. Use warm and cool season grasses, and warm and cool season broadleaf species.

- Cover crops have a role to play that will benefit both the soil and a livestock enterprise. Particularly in the HRZ where rainfall distribution is more even. Livestock will contribute to compaction of the soil however the benefits far outweigh the negatives.

- We now have the information and varieties suitable to graze our cereal crops with confidence. As long as best practice management is followed there will be no significant decrease in grain yield.

- Grazing canola will play an important role in mixed farming operations in the HRZ in the future. As the market grows and creates demand, Australia should get access to some of the longer season European varieties that will further improve options for this new dual purpose crop.

- Lucerne is a great tool for integrated farms in the HRZ. A great source of feed for livestock; it also has flexibility for fodder production and has benefits to both the soil structure and fertility.

- Think outside the square, challenge yourself and don't be afraid to try new things! But most importantly - If you don't like it, don't do it! Because the chances are you are not going to do it well.

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Plain English Compendium Summary

Project Title:	The Integration of Livestock and Cropping in High Rainfall Zones (HRZ).
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Objectives	Mixed farms will always have a place in Australian agricultural production. The aim of my topic was to investigate some of the world's leading producers and find 'what are the successful management practices of an integrated farming system?' Additionally, investigate new technologies and innovations that can contribute to the prosperity of mixed farms.
Background	There has been a push in Australian mixed farming systems to separate enterprises and concentrate resources and skills into one area. This is increasing reliance on chemical and fertiliser inputs and creating risk in volatile commodity markets.
Research	Discussion and interviews with some of the world's leading farmers, researchers, consultants, agronomists and industry advisors on new technologies, ideas, or systems that may have a fit in Australian mixed farming systems. Review of current literature of the benefits of integrated systems.
Outcomes	Integrated farming systems offer a greater level of risk management, which is increasingly important in these days of rapidly changing climates and markets. Having balance and flexibility is the key to a successful integrated business. In any system our soil is the number one asset. We need to embrace best management practice in any enterprise to ensure maximum productivity is achieved from this valuable resource.
Implications	Integrated livestock and cropping systems do require a greater level of management. We need to embrace this, not shy away from it. Research and development needs to continue in the HRZ to identify new systems and techniques that increase the number of options available to growers. This will ensure the long term sustainability and growth of integrated livestock and cropping operations in the HRZ.
Publications	Nuffield Australia.