Mitigating risk in a dry and variable climate

Investigating rotations and techniques to achieve and maintain profitable Eastern Wheatbelt farming businesses in our current cycle of dry and variable seasons

A report for:

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Executive Summary

Over the past 40 years the south-west land division of Western Australia has seen a 10-15 per cent decline in winter rainfall and an increase in seasonal variability. When coupled with a long-term decline in terms of trade, this changing rainfall pattern has created serious challenges for farm businesses, especially those in the drier Eastern Wheatbelt of Western Australia (WA). On many Eastern Wheatbelt family farms the ten-year wheat average has dropped 250kg/ha since the end of the 1990s to today. This Nuffield Scholarship study examined ways to produce the same grain yield with fewer costs and, in doing so, reduce production risk in the Eastern Wheatbelt.

This report focuses on three ways to better manage production risk:

- crop rotation and diversity;
- reducing input costs, and
- benefitting from economies of scale.

Crop rotation and diversity

Crop rotation and diversity are powerful tools in managing cereal production costs because they lower disease and weed burdens in a paddock whilst enhancing cereal yields. While legumes still hold a central place in many of the international farming systems visited, they have fallen from the typical Eastern Wheatbelt crop programs in the past decade due to the drying climate, salinity, acidity, sodicity and constraining weed control options. As a result, canola (once deemed risky for the Eastern Wheatbelt) has replaced lupins as the main rotation crop.

A canola rotation trial at Ag Canada in Lethbridge, Canada, demonstrated that after six years of continuous canola the plot yielded 16 per cent less than the ideal three-year rotation of canola following field peas and barley. In the Eastern Wheatbelt growing continuous cereals is often district practice, so a viable alternative to reduce weed and disease burdens and costs could be to grow two continuous canola crops in a rotation before a cereal phase.

Canola is the dominant brassica oilseed grown in Australia and worldwide. However, mustards such as oriental mustard (Brassica juncea) and Ethiopian mustard (Brassica carinata) are more drought, heat and shatter tolerant than canola and could be more suitable for dry cropping regions of Australia. In marginal areas of Canada, canola and condiment mustard are achieving yields up to 3t/ha when grown following fallow. In Australia mustards are generally only competitive with canola in areas where the yield base is low. Canola breeding has a considerable head start with the research and development invested in comparison to mustard over the past 20 years. This gap will be difficult to bridge without a significant investment focus through organisations such as the Australian Grains Research and Development Corporation (GRDC).

Research by the Bioceres R&D business unit in Indear, Argentina, on the drought and salinity-tolerant gene HB4 currently being tested in wheat could be applied in the future to canola; such a trait could potentially benefit canola in WA cropping systems and make it a more resilient break crop in the Eastern Wheatbelt. Many farms in the Eastern Wheatbelt are affected by salinity with shallow water tables on valley floors. The addition of a gene like HB4 could help improve production on these soils by improving salt tolerance of wheat or canola.

There is a potential role for perennial crops, wheat and oilseeds in our Eastern Wheatbelt system to reduce costs and take advantage of our increasing out-of-season rainfall. A dual-purpose perennial wheat could be grazed in poorer seasons or allowed to set grain in high rainfall years. However, whilst perennial crops are promising, it will be a long time before they are commercially viable and suitable for the Western Australian low rainfall cropping system.

Input costs

Lowering input costs lowers the required yield to make a break-even income while maintaining the flexibility to capitalise on good seasons as they unfold. Lime and associated freight is a costly input but its application can significantly increase yield and improve nutrient and herbicide efficiency. High freight costs to the Eastern Wheatbelt make it crucial to apply lime where it's most needed to raise the pH of our naturally acidic soils. Technology is now becoming increasingly available to generate very detailed soil maps across a paddock, which can then be used for variable rate applications, enabling growers to generate the highest return on lime dollars spent.

Crop rotation can help to use and prolong the life of off-patent herbicides rather than using newer more expensive herbicides covered by patents that significantly increase input costs. For example, in Western Australia, key ryegrass control herbicide trifluralin (off-patent) at 2L/ha costs $11/ha compared to Sakura (under-patent) at 118g/ha costing $39/ha for ryegrass control. With a cost saving of $28/ha it significantly reduces costs and risk.

Economies of scale

Strong appreciation in land values both in Australia and around the world has meant growers have to intensify production to compete with other land uses. A major advantage in the Eastern Wheatbelt is that land values are relatively low and have not appreciated as strongly by Australian and international standards. This aids business expansion to achieve economies of scale and reduce costs per hectare. For example, land values of $750/ha in Kalannie, Eastern Wheatbelt are about a fifth of those to the west in the higher rainfall zone around Moora. R. Nixon & Co has a current five-year wheat average of 1.75 t/ha resulting in a land value of $428 per tonne of wheat produced compared with Moora where the five-year wheat average is about 3.2 t/ha resulting in a land value of $1250 per tonne of wheat produced.

Comparatively low land values are a major advantage in gaining economies of scale. When coupled with good management, economies of scale will continue to be a key profit driver in the WA Wheatbelt.

Without the subsidies and crop insurance safety nets that underpin the USA grains industry, it is critical that growers in the Eastern Wheatbelt lower rather than increase their production risk. Multi-peril crop insurance may not be a viable solution to mitigate production risk without government subsidised premiums because the premiums will be unaffordable. It is an expensive option for our low rainfall area and over time can add another cost.

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Foreword

I am a fourth generation farmer on a family owned and operated broad acre cropping and livestock business at Kalannie, 260 kilometres north-east of Perth in Western Australia (WA). Kalannie is situated in the low rainfall area of the central WA Wheatbelt with an annual rainfall of 300mm.

WA produces about 13 million tonnes of grain each year, making it the largest grain producing state in Australia. Grain exports generate more than $4 billion for the WA economy each year, making it the largest agricultural sector in the state (Wilkinson, 2016).

In 2016 our family business, R. Nixon & Co Kalannie, planted 13,350 hectares of wheat, barley and canola with two sets of sowing machinery. We currently have 1,200 Merino ewes, which represent about 25 per cent of our stocking rate 10 years ago. The property will be fully destocked in 2017 after running livestock for 92 years. (This trend out of livestock is being replicated across WA as the number of Merino sheep in the State continues to decline). The WA sheep flock peaked at about 38 million in 1990 but has since fallen to 14 million head (Pritchett, 2015).

As we transition out of livestock we are converting pasture to chemical fallow in order to store moisture and accumulate mineralised nitrogen for following crops. On our farm, pasture or fallow is often followed by a canola ‘second break’ to reduce disease and weed pressure and improve canola performance. The double break enables two years of very effective weed and disease control, which then leads into a low-cost cereal phase. We have found canola to be the superior break crop for our farm. We stopped growing legumes as a break crop in 2010 due to their poor performance, low economic return and poor weed control outcomes compared to canola.

We have removed banks, fences, trees (including oil Mallee plantations) and rock piles to improve machinery efficiency and weed hygiene. Banks and trees shorten machinery passes and result in more turning and wasteful overlap. Unseeded areas around banks, fences and trees also allow weeds to grow without crop competition, adding to the weed seed bank and increasing the risk of herbicide resistance. Removing trees was initially a difficult concept as I had personally pushed for the planting of trees during the wetter years of the 1990s. However, annual tree planting is still part of our program but is now concentrated on poor performing soil types that are unprofitable for cropping.

If the seasons continue to become drier and more variable, it is likely we will continue to take poor performing soil types (heavy clays and poor sands) out of cropping. Such areas could be planted with trees or fodder shrubs to allow confined feeding if livestock continues to be a part of the business.

The decline in autumn/sowing rainfall has focused our recent land purchases on more flexible light-to-medium textured soil types. These require less moisture to establish crops and produce grain. Figure 1 displays the arable hectares we have accumulated since 1988 along with prices paid. The purchase of Greens in 1989 put our business under significant pressure with interest rates reaching 18 per cent and three siblings at boarding school. The purchase of McPharlins occurred before the 2002 drought, which was so severe that we were not even able to harvest seed for the following season. However, we have gradually grown our business over time to achieve economies of scale. Kalannie land values are around $250-$300 per acre, which is low by Australian and international standards and makes the area a financially attractive place to farm with great opportunities when risk is managed appropriately.

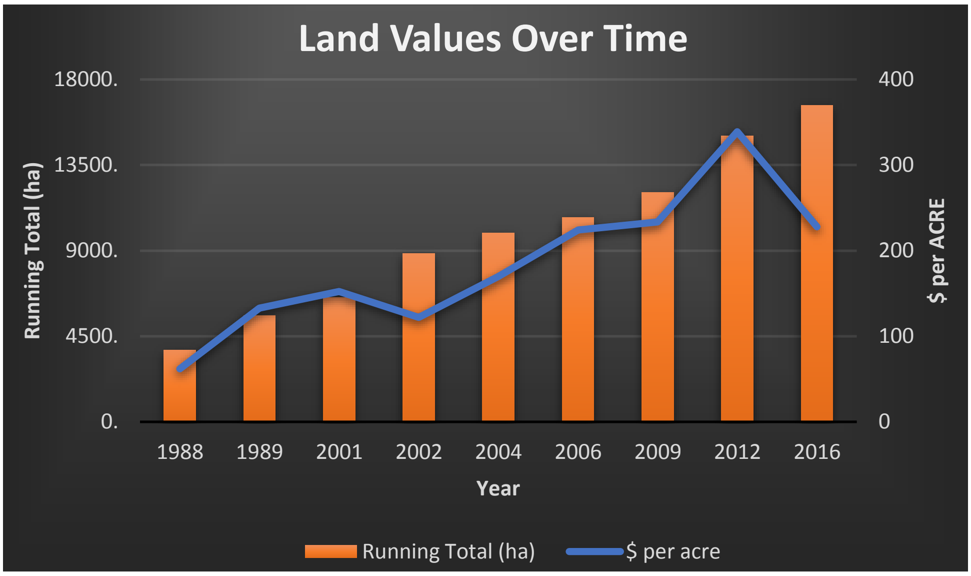

Figure 1 Accumulated arable hectares and prices paid since 1988 by R. Nixon & Co (Nixon collection, 2016)

The first crop planted on R. Nixon & Co, Kalannie was in 1927. Since 1999, we have experienced our driest and wettest seasons and our poorest and most profitable seasons. Figure 2 shows our wheat yield over time and the five-year rolling average, which varies from 1.93t/ha after 2001 down to 1.24t/ha after 2006. Our ten-year wheat average has dropped 250kg/ha since the end of the 1990s to today (1.58t/ha). During this same period, we conservatively estimate we should have received a 10 per cent increase in yields via new genetics and technology. It is therefore critical that we continue to adapt our business and use the latest research and development to remain profitable.

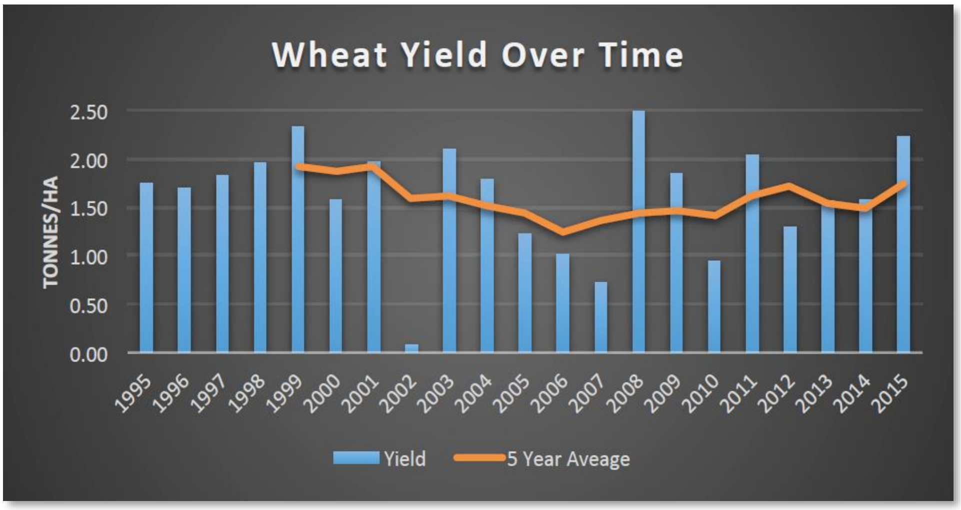

Figure 2: R. Nixon & Co wheat yields over time and the 5-year rolling average (Nixon collection, 2015)

Figure 3 and Figure 4 illustrate the extremes of seasonal variability possible in the Eastern Wheatbelt. It was these extremes that motivated me to apply for a Nuffield Scholarship to study 'Mitigating risk in a dry and variable climate'. The drought of 2002 (Figure 3) resulted in us failing to even get our seed back for the following season. In contrast, the 2008 season (Figure 4) was our best season on record resulting in a return on capital of 43 per cent.

During the 1990s profitability was driven by increasing inputs to drive production. However, under a constrained climate we cannot continue to drive production by increasing inputs. My Nuffield Scholarship travels examined ways to produce the same yield with less expense and, in doing so, reduce production risk.

Figure 3: (Nixon Collection, Nov 2002)

Figure 4: (Nixon Collection, July 2008)

My travels began in 2014 with a seven-day Contemporary Scholars Conference in Sydney and Canberra which led into the Brazilian Global Focus Program where we gained a perspective of agricultural trends on a worldwide scale. Our group travelled through New Zealand, Brazil, Mexico, the USA and the UK. It was amazing to witness the contrast of the emerging economies of Brazil and Mexico to the productivity of the central valley of California, which produces 90 per cent of the world's almonds and 50 per cent of global processing tomatoes. I was able to appreciate the heritage of the United Kingdom and the farming constraints of the regulated systems within the European Union. Despite their sometimes-stark differences, similar issues ran through all the farming systems I encountered; managing scarce water resources and producing more from fewer resources under the backdrop of a fragile social licence.

After returning home for seeding I then embarked on my personal studies. In Argentina I attended AAPRESID, the largest no-till conference in the world and visited Bioceres Indear to examine their work in developing a genetically-engineered drought and saline tolerant wheat. In the American states of Oklahoma and Kansas I examined the cropping and grazing systems relevant to their dry seasons, a large Farm Progress show and automatic soil testing equipment manufactured by Veris. Oil seeds and crop rotations were my focus in Canada. The farming issues faced by the Special Areas of Central Eastern Alberta were most similar to the issues we face in the Eastern Wheatbelt of Western Australia.

In Kenya, I travelled with Victorian 2014 Nuffield Scholar and professional fisherman Wayne Dredge where we looked at both the grains and fishing industry and gained that all important social perspective. My stint in a Nairobi hospital is something that I will not quickly forget. My family met me in Italy to finish my travels, where in typical Nuffield style, we peppered our tourist adventures with visits to places such as the Italian Cereal Quality Institute in Rome and I had the privilege of introducing agricultural gentlemen like Norberto Pogna to my 16 year old son. My whole family and business invested and sacrificed a lot for my Nuffield experience; it was great that they got to share the journey and some of the learnings along the way.

Acknowledgments

In the past 12 months, I have learned the value of information sharing and giving back to an industry I love. I would like to extend my thanks to the following people:

Thank you to my wife Amanda, my children Jacob, Samuel and Isabel for their encouragement and support. I couldn't have completed the journey without the tireless support and hard work of Amanda.

To my brother Daniel: your professionalism and capability while I was away illustrates that I am dispensable. Cheers.

To my parents Robert and Helen for your generosity and tolerance. Both my brothers and loyal staff, thank you.

Thank you to Nuffield Australia for believing in my potential from my initial interview to the evolving industry presentations. To Jim Geltch; a true industry beacon.

Thank you to Janet Paterson and Nuffield editor Kelly Manton-Pearce for your editorial input.

To all the doors that were opened and the generous hospitality from those I met and stayed with during my travels, thank you.

Thank you to the Grains Research and Development Corporation for your sponsorship. To Mike Ewing from the GRDC Western Panel; your guidance is greatly appreciated.

I feel proud to be sponsored by the GRDC, as my agricultural passion is crop agronomy and research and development. The opportunities the GRDC has afforded me since my travels in industry involvement and sharing my experiences has facilitated my growth in an industry I am passionate about.

To my fellow Nuffield Scholars; cheers for the adventures.

Figure 5: Photo of the author with Aapresid staff and Tony Fischer on the Pampas, Argentine province of Buenos Aires, Argentina (Nixon Collection, August 2014

Abbreviations

AAPRESID	la Asociación Argentina de Productores en Siembra Directa
AEGIC	Australian Export Grains Innovation Centre
AHRI	Australian Herbicide Resistance Initiative
CARA	Chinook Applied Research Association
DAFWA	Department of Agriculture and Food, Western Australia
EONR	Economic Optimum Nitrogen rates
EC	Electro conductivity
EW	Eastern Wheatbelt
g/ha	grams per hectare
GM	Genetic Modification
GRDC	Grains Research and Development Corporation
ha	Hectares
IWM	Integrated Weed Management
L/ha	Litres per hectare
NV	Neutralising Value
R&D	Research and development
SANTFA	South Australian No-Till Farmers Association
T/ha	Tonnes per hectare
Tn	Tonnes
WA	Western Australia
UK	United Kingdom
USA	United States of America

Objectives

This report investigates the role of crop rotation and other technology to mitigate production risk in the low and variable rainfall region of the Western Australian Wheatbelt. This study will examine the following issues connected with risk mitigation:

- Managing input costs so that break-even yield is minimised in the best way to manage seasonal risk and to examine what are the best ways to achieve this without compromising the farming enterprise?
- Does adding crop diversity to the cropping system lower production risk in a low and variable rainfall environment?
- Do livestock fit the Eastern Wheatbelt farming system? Does the need for ground cover and soft friable soils to enable dry seeding and conserve soil health outweigh the need for income diversity generated by a mixed cropping-livestock system?
- Does multi-peril crop insurance have a role to play in low rainfall areas or are there better ways to manage risk?
- Do the extra costs associated with genetically-modified crops outweigh their potential benefits in the Eastern Wheatbelt of Western Australia?
- What are the social and economic impacts of economies of scale on Eastern Wheatbelt farming businesses?

Chapter 1: Introduction and context

Dryland cropping in the south-west land division of Western Australia (WA) makes WA Australia's largest grain producing state. It is characterised by a Mediterranean climate supporting a winter cropping system and traditionally has had the most reliable winter rainfall pattern in the world. However, WA is now experiencing a drier and more variable rainfall pattern (Figure 6). (Stephens, (2016) states that since the year 2000, WA has settled into a new climate characterised by less winter and more summer rainfall. The annual inflow into Perth dams in the hundred years between 1911-2011 (Figure 7) has seen a step-wise decline over time, with inflows during the period 2006-12 less than a fifth of those during 1911-1974 (Water Corporation, 2012). Discussion with the US Drought Mitigation Centre in Lincoln, Nebraska about this graph revealed they use the same figure to teach their students about urban planning. This indicates that the south-west of WA has a drying climate that is not just significant in Australia but on a world scale.

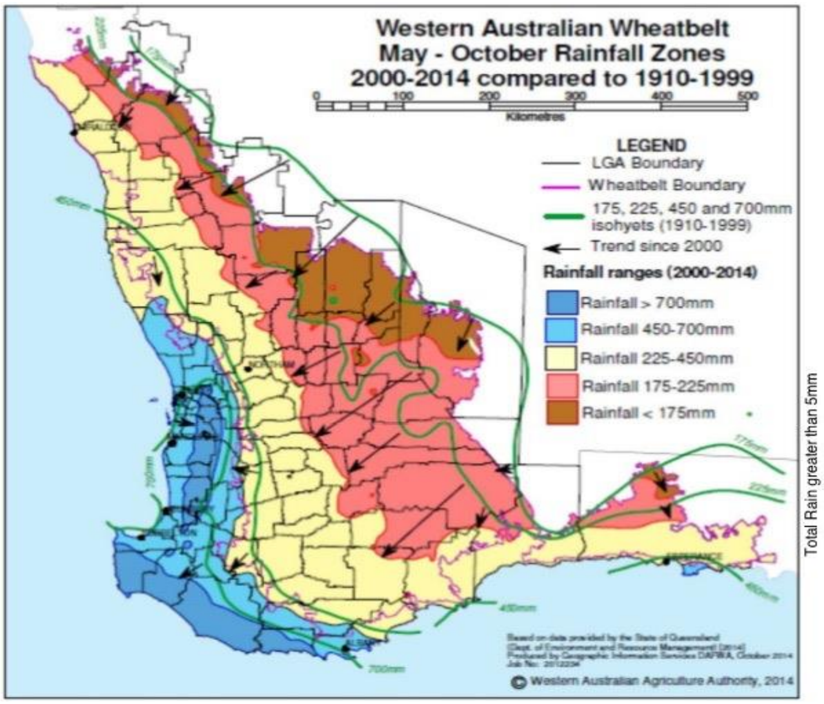

Figure 6: Western Australian Wheatbelt rainfall zones 2000-2014 compared to 1910-1999 (WA Agricultural Authority, 2014)

The Eastern Wheatbelt of WA has a historically low rainfall of 250-300 mm per annum and the impact of this changing rainfall pattern will reduce this region's low yield potential even further. In contrast, cropping in the historically high rainfall areas of the western and southern cropping zones has been favoured by the reduction in winter rainfall and reduced incidence of waterlogging. The long-term drying trend has caused the average crop yield at R. Nixon & Co to drop by 250 kg/ha since the end of the 1990s. In the 1990s the general production philosophy by WA farmers was to produce more using higher inputs, but with the drier climate the focus is now on producing the same yields with fewer inputs. Despite this change in rainfall, by keeping a careful eye on inputs and generating efficiencies like scale, most Eastern Wheatbelt farm businesses have remained profitable.

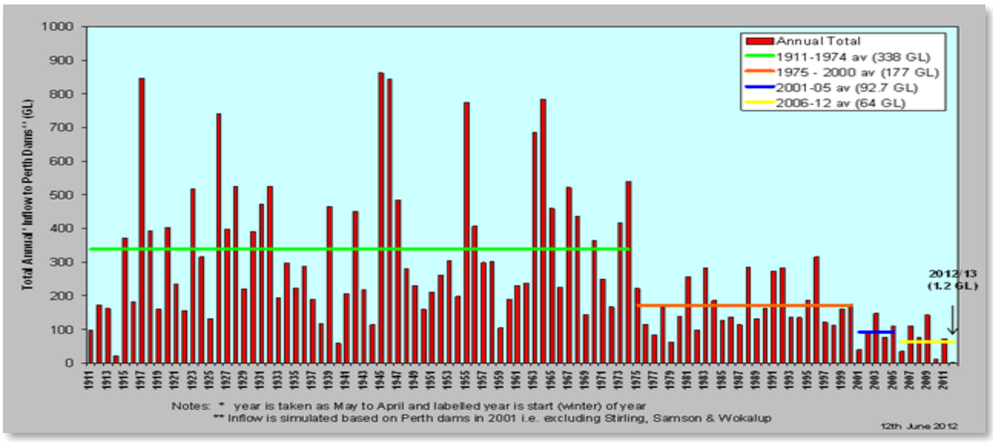

Figure 7: Annual inflow to Perth dams 1911-2012 showing stepwise declines (Water Corporation, June 2012)

This report investigates the following ways to mitigate risk for Eastern Wheatbelt farming businesses:

- crop rotation using canola and alternative oilseeds;
- the uses of chemical fallow and crop rotations to better manage weeds, disease and soil moisture;
- perennial grains: could perennial wheat and oilseeds be used as a low-input alternative to conventional annual crops?
- livestock: do their benefits of integrated non-chemical weed management and perceived income diversity outweigh their impact on soil compaction, ground cover removal and labour and managerial effort?
- soil health: by using liming to maximise production on lighter soil types;
- multi-peril crop insurance: would insuring against production failure from drought or frost increase or decrease production risk in the Eastern Wheatbelt?
- GM technology: assessing production benefits vs. cost of the technology in a low yield/financial margin cropping context, and
- using economies of scale to reduce costs per hectare.

Broadacre arable farming is a complex business with many variables and a systems approach is imperative to remaining profitable in a low rainfall environment. It is critical to get every part of the system right, especially when coupled with increased scale.

Chapter 2: Crop Rotation

WA is a world leader in herbicide resistance management using integrated weed management (IWM) (AHRI, 2015). While travelling on this Nuffield Scholarship the author noted that the recurring theme across all systems was diversity. However, when it comes to crop diversity options for WA producers the variety of choice is limited and underutilised.

Lawes and Anderson (2015) demonstrated the value of crop rotation in improving returns in the cropping system. A break in the repeated sowing of cereals with a break crop such as canola or lupins helps to reduce disease, weed and pest burdens in a paddock resulting with a yield boost in the following year when cereals are resown. Despite this evidence, the dominant rotation in the Eastern Wheatbelt has become continuous cereals (wheat and barley), as this is perceived to be the less risky than growing a break crop such as canola or lupins. This practice has led to a significant build up in soil borne pathogens as demonstrated by the recent Grains Research and Development Corporation (GRDC)-funded Focus Paddock Project. Between 2010 and 2015 crown rot increased across the WA Wheatbelt from 13 to 37 per cent; rhizoctonia detection increased from 16 to 48 per cent and root lesion nematodes increased from 21 to 60 per cent (Harries and Anderson, 2015)

Legumes versus canola as a break crop

After hearing that many Eastern Wheatbelt producers no longer grew legumes, Canadian researcher Bob Blackshaw (Ag Canada Lethbridge Research and Development Centre, Alberta, Canada) (Figure 8) commented, "You'll be broke in ten years if you don't grow legumes". He also said that chemical fallow was bad for soil health because 'you need something growing for soil biology'. Nearly 50 per cent of Canadian farmland in the 1950s was fallowed and now only 10 per cent is due to adoption of practice change such as no-till and growing break crops. Field research carried out by Blackshaw and colleagues concluded that growing legumes for seed before a wheat-canola cropping sequence in conventional cereal cropping systems can increase crop yields, reduce economic optimum nitrogen rates and improve the long-term sustainability of cereal cropping systems. (St. Luce et al, 2015)

Figure 8: Photo of "The two Bobs". With Bob Blackshaw standing in a wheat/fallow rotation trial that has been running since 1910 at Ag Canada Research Centre (Nixon Collection, August 2014)

The Eastern Wheatbelt has fewer available legume crop options than other Western Australian (WA) cropping regions due to its lower rainfall along with similar soil constraints like acidity, salinity and sodicity. A similar lack of crop diversity was noted in drier areas of Oklahoma and Kansas, USA.

Over the past decade, canola has replaced lupins to become the dominant break crop across WA, not just the Eastern Wheatbelt. Lupin production peaked in WA in 1997 at 1.2 million hectares and then declined to less than 300,000 hectares by 2014. During the same period canola increased in production with 1.1 million hectares sown in 2014 (DAFWA, 2015). The reasons for this shift towards growing canola as a break crop are more variable and declining rainfall, the nitrogen added from legumes is potentially no longer as valuable as the superior weed control options from canola and the higher economic returns from growing canola. Weed control has become more difficult with legumes due to their uncompetitive nature and limited herbicide options. The GRDC-funded Focus Paddock Project in WA has identified no adverse wheat production impacts from expanded canola plantings at the expense of legumes in crop and pasture sequences (Martin Harries Department of Agriculture and Food, WA research officer, 2015).

Canola has been considered a higher-risk crop for the drier Eastern Wheatbelt than the medium and high rainfall areas. However, canola can be a profitable crop in low rainfall areas if costs are minimised to achieve a low break-even yield.

Other ways to manage costs while growing canola include:

- sowing using retained open-pollinated seed;
- delaying application of nitrogen and use conservative application rates (Bucat and Seymour, 2016);
- using low cost off-patent herbicides (for example; clethodim, atrazine) that often still have good activity in the Eastern Wheatbelt, and
- harvesting by direct heading rather than swathing followed by harvesting windrows. When compared to cereals, direct heading of canola is expensive because the slow harvest speed increases harvesting cost per hectare. However, this can be overcome by using Vario fronts that increase harvest speed and reduce canola seed losses compared to draper-type platforms. Luke Marquis (2016) of South East Agronomy Services Esperance WA, found that there is an average difference of 36 kg/ha loss in favour of the Vario front with a per hectare difference of $18.40 (based on Canola at $500 per tonne) compared to a draper front.

Alternative break crop strategies

A one-year break in the continuous growing of cereal crops is often not sufficient when diseases and weeds have increased under a continuous cereal regime, or when purchasing new property with large weed and disease burdens with unknown history. An alternative strategy is using a double break. This involves growing two break crops in a row or growing a break crop after pasture or chemical fallow. It is an effective way of resetting the system for disease and weeds as it enables two years of effective weed and disease control, leading into a low-input continuous cereal phase. The fallow phase also allows some moisture conservation making canola yields more reliable in Eastern Wheatbelt conditions.

A canola rotation trial at Ag Canada in Lethbridge Canada demonstrated a 16 per cent decline in yield after six years of continuous canola compared to the ideal three-year rotation of canola following field peas and barley (Figure 10). Compared to WA, Canada has many well-adapted crop types due to its favourable climate and soil types. In Canada, canola yields up to 80 per cent of potential wheat yield while in WA a 50 per cent yield comparable to wheat is considered normal. Even after six years and a 16 per cent reduction in yield, the continuous canola plot at the Ag Canada rotation trial was producing acceptable yields. In the Eastern Wheatbelt growing continuous cereals is often district practice, so could growers consider growing two canola crops in a row?

Figure 9: The author next to seven-year trial plots of continuous canola. Lethbridge, Alberta, Canada (Nixon Collection, July 2014)

Finding low-risk resilient break crops is a difficult proposition given the limited crop options available for the Eastern Wheatbelt region. Two canola crops in a row could be a suitable alternative double break strategy for the Eastern Wheatbelt. After visiting Ag Canada in 2014, the author trialed a stacked rotation of canola on canola in seasons 2014 and 2015 (Figure 10). Following on from growing canola in 2014, the same paddock was split in half in 2015 with half the paddock put back into canola and the other half into wheat. In 2016 the entire paddock was planted to wheat. The standard rotation of canola-wheat-wheat was compared to the double break of canola-canola-wheat. Yield was measured along with weed numbers and disease incidence such as rhizoctonia.. The canola-canola-wheat double break rotation yielded 10 per cent higher compared with canola-wheat-wheat with lower weed and rhizoctonia pressure. Importantly, with lower disease and weed pressure the double break treatment can continue to be planted to cereals for at least another year where canola-wheat-wheat rotation needs another break in the rotation. This is an un-replicated farmer trial and needs further investigation by industry.

An alternative double break canola rotation strategy is to grow a conventional triazine-tolerant canola followed by a GM Roundup Ready canola. This would result in the use of herbicides atrazine and propyzamide in the first year followed by glyphosate and trifluralin in the second, meaning that no herbicide group is used in-crop twice in two years. Alternating herbicide use is a valuable tool for managing herbicide resistance. The GM canola is grown in the second year so there is no risk of GM seed contamination while also making use of GM varieties' improved blackleg resistance compared to commonly grown triazine-tolerant ATR-Bonito (GRDC Spring Blackleg Management Guide, 2016). In higher rainfall areas further west and south where the canola disease sclerotinia is prevalent, a stacked double canola rotation may not be viable.

Figure 10: Left - wheat after canola. Right - canola after canola. R. Nixon & Co, Kalannie WA. (Nixon Collection, 2015)

Alternative oilseeds

Canola is the dominant brassica oilseed grown in Australia and worldwide. However, the mustards are more drought, heat and shatter tolerant than canola and could be more suitable for dry cropping regions of Australia. Some examples of mustards include:

- Brassica juncea (oriental mustard). This is grown in Australia as either juncea canola or condiment mustard. Condiment mustard has much higher levels of glucosinolates, which are responsible for the hot and spicy taste of table mustard.
- Brassica carinata (Ethiopian mustard). Agrisoma in Canada has developed Resonance Carinata, which is used to produce a high quality biodiesel for bio-jet fuel. Bio-jet fuel produced from plants is approved up to a 50 per cent blend with conventional jet fuel. Resonance Carinata will be a suitable alternative to traditional canola for the semi-arid growing areas of the southern prairies of Canada and northern plains of the United States (Figure 11).

Figure 11: Resonance Carinata (Ethiopian mustard) at Chinook Applied Research Association, Alberta, Canada (Nixon Collection, 2014)

Of all the areas visited on this Nuffield study, south-east central Alberta in Canada was the most similar to the Eastern Wheatbelt of WA. The Chinook Applied Research Association (CARA) in Oyen, Alberta, carries out a broad range of applied research and demonstration projects in an area with an annual rainfall of 322 mm with long dry cold winters and hot summers when cropping takes place. The current research program is evaluating many cereal, oilseed and pulse crops, annual and perennial forages, agronomic practices of annual and perennial crops, pasture and grazing management as well as methods of conserving and reclaiming fragile soils (CARA, 2016).

CARA is in an area known as the Special Areas. During the dust bowl years of the Dirty Thirties, drought forced many ranchers to walk off the land and ownership reverted back to the government to be rehabilitated to prairie grasslands, which were then leased back for grazing (Gorman,1988). The Special Areas is one of the few areas in Canada where fallow is still consistently practiced; with a chemical fallow normally followed by two crops. In this area canola and condiment mustards are achieving yields up to 3 t/ha when grown following fallow. CARA is trialing the alternate oilseeds including Agrisoma's Resonance Carinata (Figure 11) with the aim of finding a more resilient oilseed for the region's dry environment.

In Australia, mustards are generally grown in areas where the yield potential of canola is low. Canola breeding has a considerable head start with the amount of R&D invested in comparison to mustard over the past 20 years. This gap will be difficult to bridge without a significant investment focus through organisations such as the GRDC. A key recommendation from this report is that more R&D on canola and alternative oilseeds is needed to improve their adaptability to the Eastern Wheatbelt and other low rainfall cropping zones.

Off-patent herbicides

Significantly reducing weed numbers reduces the selection pressure on herbicides and lowers the onset of herbicide resistance (Norsworthy, 2012). Prolonging the life of out-of-date, off-patent herbicides can significantly lower costs compared to the new herbicides covered by patents. For example, in WA, trifluralin (off-patent) at 2L/ha costs $11/ha compared to Sakura (under-patent) at 118 g/ha costing $39/ha for ryegrass control (Hathway, 2015). A saving of $28/ha significantly reduces costs and risk (especially in a poor year). Crop rotation also helps to prolong the life of cheaper off-patent herbicides in the WA Wheatbelt. The reduction in cost of off-patent herbicides is one of the big wins growers have had in controlling input costs over the past decade.

Chapter 3: Perennial Grains

Irrespective of whether our climate is in a long-term drying trend or a temporarily drier and more variable cycle, grain growers from marginal areas of Australia will need to examine different cropping systems from those currently being used. The south-west land division of Western Australia (WA) has had a 29 per cent increase in summer rainfall and a 20 per cent reduction in winter or growing season rainfall (Stephens, 2016). Perennial grains have a large root system compared to annual crops so can capture nutrients and moisture at depth (Figure 12). Could perennial crops more effectively capture this increasing out-of-season rain than the traditional system of winter grown annuals?

About 70 per cent of WA cropping land is planted to annual grains, pulses and oilseed crops. There is general agreement that we will need to produce 50-100 per cent more crop yield to meet the needs of a projected global population of nine billion people by 2050. An increasing number of researchers (Cassman, 1999) are suggesting that future crop production cannot come from input intensification but will rather have to come from ecological intensification using perennial crops.

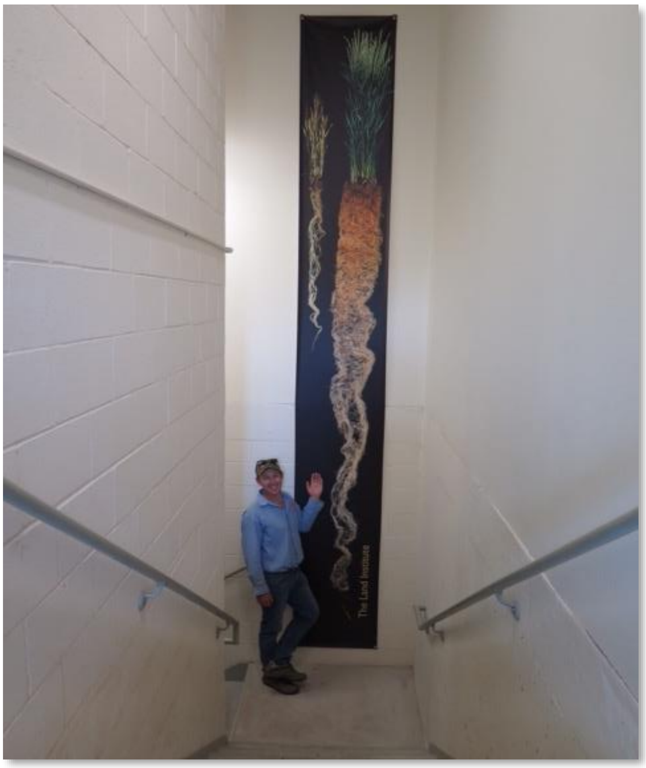

Figure 12: The root system of conventional wheat vs Kernza perennial wheatgrass (Thinopyrum intermedium) at The Land Institute, Salina, Kansas (Nixon Collection, Sept 2014)

Current research on perennial grains

The Land Institute in Salina, Kansas, is working on ecological intensification through the development of perennial wheat, wheatgrass, sunflowers and sorghum. Their breeding efforts focus on improving perennial grain quality and yield while also developing traits to combat disease and insects. Disease and insect pressure is higher in perennial stands than annual crops as perennials are grown for an extended period of time. The Land Institute researchers have developed Kernza perennial wheatgrass which is a cross between domestic wheat and wild perennial wheat, and current research is focusing on selecting for several traits including yield, shatter resistance, free threshing ability, seed size and grain quality. In the next decade the researchers aim to have a seed size that is 50 per cent of annual bread wheat seed size with improved bread baking quality (Land Institute, 2014).

Challenges to overcome include the grain's small seed size and gluten level; which is currently too high to be gluten free yet too low to make bread. Perennial grains produce a lower proportion of grain to biomass ratio than annuals. However, perennials can produce significantly more biomass than annuals, leading to a similar grain yield per hectare as the size of the pie increases (Figure 13).

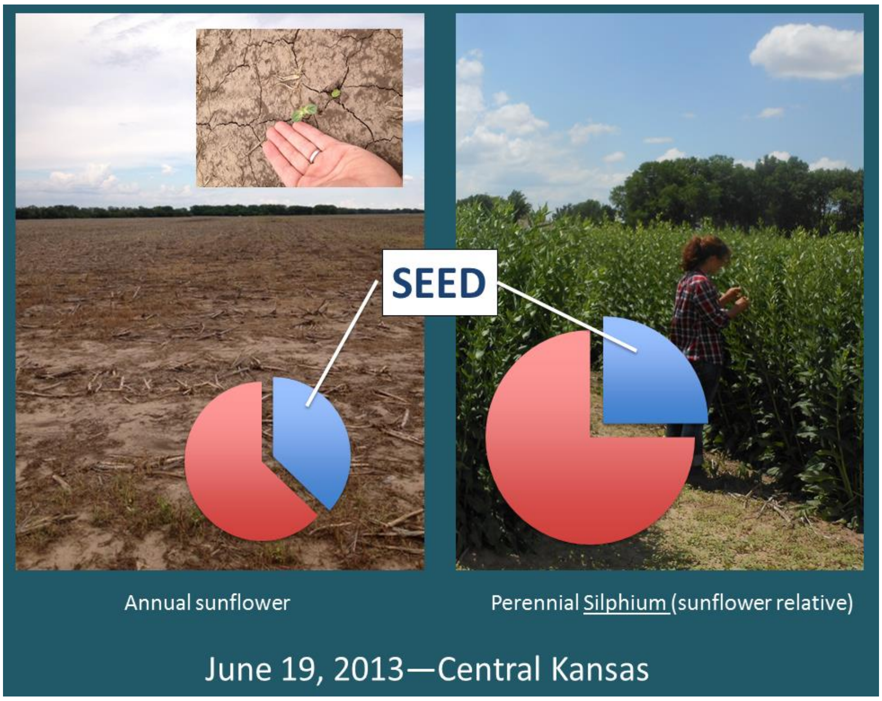

Figure 13: Total seed to biomass ratio in an annual vs perennial sunflower (Source: Sprunger, C. The Land Institute, Kansas, Presentation Sept 2015)

Perennials in the Eastern Wheatbelt

Low annual rainfall, shallow soil depth and subsoil constraints such as acidity and salinity in the Eastern Wheatbelt may mean there is insufficient soil moisture available for perennial grains to fulfill their promise in the Eastern Wheatbelt. Crews (2014) asserts if rainfall is low year-round and the soil reserve is not recharged, then shallow rooted annuals with shorter growing seasons are likely to be favoured. Perennial grains would certainly offer potential in areas of

WA with higher annual rainfall and deeper soils than the Eastern Wheatbelt . However, many areas of the Eastern Wheatbelt have a transient salinity problem which should be viewed as opportunity. The excess moisture and in turn nutrients that are moving through the soil profile unused by current annual cropping systems could be used by perennials.

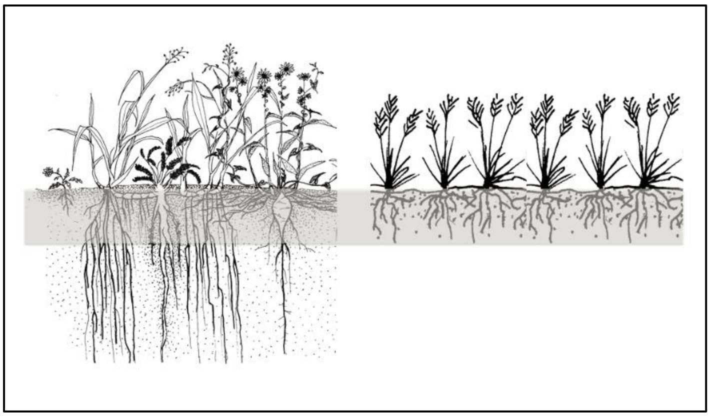

Figure 14: When rainfall is low year-round and the soil reserve is not recharged, shallow rooted annuals with shorter growing seasons are likely to be the better option. (Source: Crews, T. The Land Institute, Kansas, Presentation 2014)

Michael Trammell from the Samuel Roberts Noble Foundation, Ardmore, Oklahoma does not believe that perennial cereals can achieve the yields of annuals as too much of their energy goes into the root system. This implies that value in a perennial system would also need to be gained from grazing, carbon sequestration, reduced inputs or salinity control to compete economically with our current annual based cropping system. In taking perennial wheat research forward in Australia, GRDC Western Panel member Dr Mike Ewing (2015) suggests using dual-purpose perennial wheat for grazing and opportunistic grain. Grazing revenue could offset the revenue losses resulting from poorer grain yield and quality (Bell, Wade and Ewing, 2010).

Researchers from CRA Italian Cereal Quality Institute in Rome have developed a perennial wheat grain that more closely resembles conventional grain, however, it is less hardy resulting in a reduced ability to survive the summer and subsequent years (Gazza, Pogna 2014). Murphy (2010) found that despite the potential for bread making and disease resistance, few of the lines were developed from adapted wheat species and, as a result, their grain yields were generally low and declined with time. The available germplasm did not meet the standard required for robustness of the perennial habit or the consistency of grain yield from one season to the next. Murphy, Cox and Jaikumar (2010) concluded that for the Australian environment, better-adapted and more productive germplasm was required.

In conclusion, perennial grains offer great potential for the Eastern Wheatbelt but are a long way off commercial reality. Batello (2014) questioned whether perennial survival could be enhanced via better agronomy such as rotation with brassicas or via soil type, pH or drainage, or through better tolerance of particular diseases such as root and crown rots. By understanding why breeding material fails in different situations, sustained breeding and agronomic progress is more likely to result.

Chapter 4: Livestock

Producers in the Eastern Wheatbelt region are encouraged to run livestock as a risk management strategy to help mitigate the seasonal and climatic impact on farm profitability. The positives of running sheep are that they add income diversity and offer another tool in integrated weed management. The negatives include livestock that reduce ground cover and degrade and compact soil structure, which interferes with seeding processes and reduces water use efficiency. The weed Matricaria (Oncosiphon spp.) has been identified by the GRDC Kwinana East Regional Cropping Solutions group as a major problem as it is infesting pastures and building up seed banks in the pasture rotation.

Dry seeding is common practice in the Eastern Wheatbelt and involves starting seeding based on a calendar date rather than soil moisture conditions. Dry seeding can be the largest driver of machinery utilisation and water use efficiency in low rainfall cropping systems. Successful dry seeding requires soft friable soil with crop or pasture residue to aid moisture conservation. Some pre-emergent herbicides like Trifluralin are compromised if the seedbed or soil is cloddy and compacted together by livestock. Compacted heavy clay soil also causes issues with seeder penetration. Livestock are less compatible with these dry seeding requirements. In the current cycle of dry and variable seasons it has been observed (in the Eastern Wheatbelt) that the soil moisture and nitrogen benefits of fallow for the following crop can provide a greater return than that gained from running livestock. Stocking rate is a key profit driver with livestock. High stocking rate is not compatible with the fragile soils and the variable climate of the Eastern Wheatbelt.

With the decline in autumn rainfall/sowing rainfall (Figure 15) and increasing farm size, dry seeding has become more important for effective crop establishment. Figure 15 highlights the significant reduction in May and June or autumn rainfall since 2000 in Koorda, Eastern Wheatbelt. This has reduced the early germination and establishment of pasture for livestock meaning that Eastern Wheatbelt sheep producers are more reliant on supplementary feeding and agistment to manage feed requirements for sheep through the winter, which is an additional cost to the farm business.

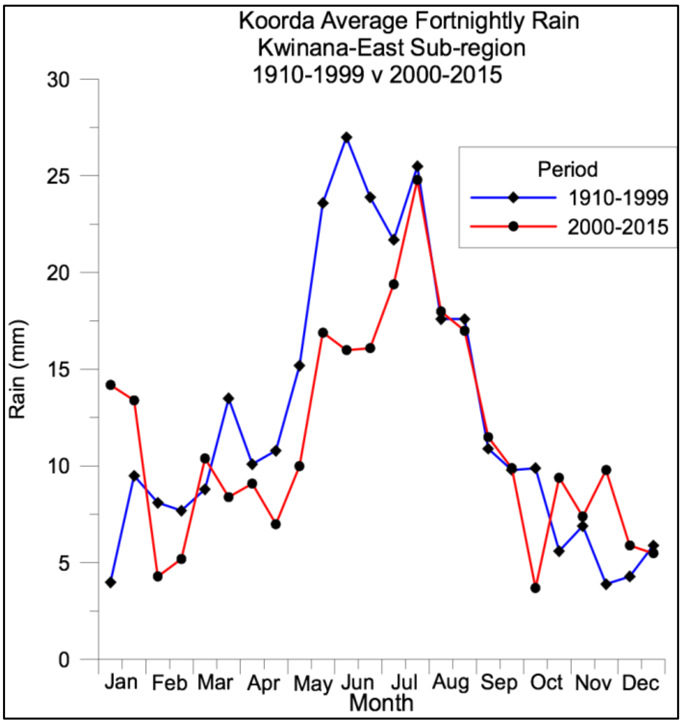

Figure 15: Koorda average fortnightly rainfall 1910 – 1999 vs 2000 – 2015. (Source: Stephens, 2016)

Increasing paddock size to drive machinery efficiency and removing fences for weed hygiene for herbicide resistance management does not always complement the need of livestock systems for smaller paddocks to enable effective grazing management and manage ground cover on erosion-vulnerable soil types. Livestock run counter to achieving large cropping paddock scale and also absorb management time while compromising the conditions required for dry seeding. Livestock's fit in Eastern Wheatbelt farming systems varies from north to south depending on soil type, frost risk, farmer attitude and skill set with livestock.

Trading, feeding, grazing

A typical farming system in Oklahoma as observed at Oklahoma State University in the US is based on trading cattle and grazing winter wheat to effectively manage seasonal risk. Oklahoma is currently in a drying cycle climatically and because of this, has strong similarities to the Eastern Wheatbelt. Grazing cereals can recoup the costs of production enabling grain to be harvested for profit in favourable years. In Oklahoma winter wheat incurs about a 15 per cent reduction in yield from grazing (Hunger 2014 Oklahoma State University). With strong beef prices in recent years this yield decrease has been more than offset by grazing value. This is an excellent system for diversity and seasonal risk mitigation.

The author also visited Hope and Brian Pjesky who run a winter wheat cropping and cattle grazing business in Goltry, Oklahoma. Pjesky told me how his grandfather had experienced a bad drought in the 1950s during which they fed all their hay and feed to their cattle, then harvested their wheat and used the proceeds to buy more hay. This hay was then fed to the cattle, which they ended up having to sell as the drought continued. 'Grandfather Pjesky' vowed to never have breeding stock again. This position has continued ever since by trading rather than breeding cattle. Trading rather than breeding removes the emotional attachment and adds the flexibility to react to seasonal conditions as they unfold.

For livestock to be viable business in the Eastern Wheatbelt three strategies are suggested:

- Trade stock rather than breeding. Breeding should take place in the reliable higher-rainfall areas, using the Eastern Wheatbelt to run traded ewes and wethers and finish lambs for slaughter. This would make it easier to react to seasonal conditions and would remove the emotional attachment and investment in breeding ewes that makes it difficult to destock when necessary.
- Confined feeding offers another way to remove livestock from fragile cropping areas when seasonal conditions dictate. Fodder plants such as saltbush plantings on poor performing saline zones can be used for confined livestock feeding. Poor performing soil types can be identified through yield mapping, taken out of production and used instead for fodder production.
- Grazing cereals. Often this is not viable in the low production zones of the Eastern Wheatbelt because the yield reduction often out-weighs the grazing value. In dry seasons crops struggle to recover from grazing.

Chapter 5: Soil Heath

Liming

With the decrease in autumn rainfall in Western Australia (WA) over the past 30 years (Figure 15) lighter soil types are playing a larger role in generating farming profit, as they require less moisture to germinate and produce a crop. Soil acidity is the largest soil constraint affecting agriculture in WA costing $1,574 million/year (Petersen, 2016). Reducing acidity of these lighter soil types using lime is therefore crucial.

One positive outcome from the past practice of increased inputs to drive production was the high application of phosphorous. This has resulted in a significant phosphorous bank that farmers can now use, provided we raise soil pH to make it more available to plants. By redirecting the dollars spent on phosphorous into lime, producers have been able to generate higher yields and improve herbicide efficiency.

Technology and mechanisation

Variable rate application enables lime to be applied to areas that most need it. With the high cost of transporting lime to the Eastern Wheatbelt, variable application can deliver the highest return on dollars spent. Precision agriculture technology is now available to assist in developing variable rate applications. For example, Veris Technologies in Salina, Kansas, has developed a mobile unit called the Veris 3000 that maps pH, electrical conductivity (EC) and organic carbon in the field. The machine generates the data required to make very detailed soil maps across a paddock, which can then be used for variable rate applications of lime and other fertilisers (Figure 16).

Figure 16: Photo of the author (left) with Veris 3000. pH, EC and organic matter testing. Machine manufactured in Salina, Kansas. (Nixon Collection, March 2014)

An interesting observation during Nuffield studies in Kenya is that liming is recognised as an important agricultural practice, although the country lacks the liming technology and mechanisation used in the developed world. While the lime used in WA is formed from shell and coral fragments, the lime used in the Rift Valley of Kenya is calcium carbonatite - a rare igneous rock formed in the Rift Valley. The calcium carbonatite lime is crushed, then manually screened and bagged before being spread by hand onto small farming plots (Figure 17). The lime is also burnt in kilns after which it is used in the manufacture of road base.

Figure 17: Photo of manually screened and bagged calcium carbonatite; an igneous rock formed in the Rift Valley. Time to Lime, Kenya. (Nixon Collection, September 2014)

On-farm sourced inputs

WA has significant sources of high quality, low cost limesand on the west coast, however, there is a significant cost to freight the lime to the Eastern Wheatbelt (Chris Gazey, 2015). Low operating margins and high transport costs makes fixing acidity problems on Eastern Wheatbelt properties financially difficult.

R. Nixon & Co, Kalannie is now using an on-farm lime source for treating acid soils which has led to significant cost savings (Figure 18)). The alternative lime source is a calcium magnesium soil type (known as Morrell) with a neutralising value (NV) of 45-50 per cent, which is about half that of the coastal limesand traditionally used. Due to its lower NV the Morrell sand is applied at 4 t/ha, which is double the rate of limesand. No mining lease or royalty payment is required to extract the Morrell soil as it is similar to digging a gravel or claying pit for on-farm use only. The Morrell soil type is very fertile but is subject to salinity because its fine texture enables capillary rise to bring salts to the surface. It contains high potassium levels (>600mg/kg in Colwell). In low rainfall years, the Morrell is a poor producing soil type, however, by using it as a lime source it has been turned into an asset.

In the last two years the author has observed other Wheatbelt growers starting to test and use similar soil types as alternative lime sources. Transport costs for coastal lime increases significantly with distance from the coast. This means the quality (NV) of the local lime source can be significantly lower than limesand and still be economically viable. For example, on farms 350 km east of Perth (Southern Cross) an NV of just 25 per cent could be a viable alternative to limesand. It is possible to find liming sources with economic levels of potassium included and requires further investigation by growers and industry. This could also extend to potassium in claying resources, gypsum and anything that could help to control farm input costs. When trying to identify on-farm liming sources pour vinegar on a sample and it will fizz if alkaline with neutralizing value. Further testing is available through Agrifood Technology in Western Australia and Victoria.

Figure 18: Photo of Kalannie lime mining extracted from a Morrell soil type. Nixon's Dalmeny East Farm (Nixon Collection, November 2014)

Minimum-tillage and the incorporation of lime

The majority of grain producers in WA have been practising no-till (one pass seeding with minimal soil disturbance) for 20 years. Along with countries like Brazil and Argentina, Australia is a world leader when it comes to no-till, however, there are low adoption rates of no-till in places like Tuscany, Italy, and Oklahoma, USA. One of the main drivers of no-till in Australia is the efficiency it brings to a one pass seeding operation of large scale cropping businesses. In addition, no-till improves soil structure and health.

The author observed that only 20-30 per cent of Oklahoma farmers practise no-till; with the majority instead using tillage and accepting the subsequent erosion as part of the system. Tillage is preferred because it creates bare soil, which raises soil temperature to aid plant growth in the winter wheat grazing rotation. In Oklahoma canola is planted in autumn after which it generates vegetative growth and then shuts down over winter. The canola finishes its development in the spring before the onset of the harsh dry summer. When stubble is retained in canola fields the reduction in soil temperature leads to significant canola death over winter because the stubble causes the canola growing point to rise above the soil surface making it more vulnerable to frost damage.

In the Eastern Wheatbelt of WA there has been a revival of tillage after many years of minimum tillage. A key reason is because tillage helps with soil acidity management as lime reacts more quickly when mixed through the soil and to depth to manage subsurface acidity rather than left on the soil surface. The most common ways to incorporate lime are by ploughing with offset discs and deep ripping with inclusion plates. Inclusion plates are fitted behind deep ripper tines and hold soil open at depth so limed topsoil falls down behind the tine to the subsoil. This speeds up the return on the investment in lime, improving grower returns.

Figure 19: The author with Aapresid staff on field with wheat following 16T corn residue. Argentina (Nixon Collection, August 2014)

Figure 20: Photo of Fabio mouldboard ploughing. "No No-Till in Tuscany. Good reasons or historical inertia?" Tuscany, Italy. (Nixon Collection, October 2014)

Chapter 6: Multi-Peril Crop Insurance

Multi-peril crop insurance has been promoted by the Australian grains industry as a strategy to manage the production risks associated with seasonal variability. Crop production insurance is central to the grains industry in the United States (US) and is the corner stone of the U.S. Farm Bill, with the premium subsidised by government. In Australia crop insurance premiums come at a significant cost to growers.

Producers in the US see value in insuring for events that affect production rather than providing assistance for crop failure post an event. With Australia's relatively low level of government assistance and subsidies it is unlikely the grain industry here will receive significant funding for multi-peril crop insurance premiums and post-event aid.

The author visited Steve Larocque (2008 Nuffield Scholar) in Alberta, Canada, who said that Canadians pay a 7-13 per cent premium for multi-peril crop insurance to insure 80 per cent of average production x price, with the premium differing across Alberta depending on historical claims. Provincial and federal governments provide some assistance with premiums. In 2015, 78 per cent or 14.7 million of provincial crop acres valued at $3.68 billion Canadian were covered (Canadian Underwriter, 2015).

Australian growers traditionally insure for events that do not happen regularly. The system for calculating premiums is based on the likelihood of occurrence. An example is farm buildings where a 0.2 per cent premium covers an event likely to occur every 70 years. Traditional fire and hail insurance incurs about 1 per cent premium in the Eastern Wheatbelt.

Insurance premiums for events that happen more regularly and align more closely with the likelihood of frost and drought events in cropping are:

- a rate of 5 per cent means the insurer expects the loss to occur every 26 years;
- a rate of 10 per cent means the insurer expects the loss to occur every 14 years.

Should farmers insure knowing the insurer loss estimates are much higher than 14 to 26 years? (Peter Burtenshaw, Australian Reliance February 2016).

Multi-peril crop insurance for the Eastern Wheatbelt

In the Eastern Wheatbelt of WA the current dry cycle has made difficult years more frequent, perhaps at least one in every five years. The cost of insurance for this frequency becomes prohibitive. Insurance has a better fit for the one in 15- or 20-year shock event. The premium for more regular events may not reduce risk over time but become another cost that increases the overall risk to the farm business. Without doubt there are areas and times in Australia where multi-peril crop insurance could have a fit, such as after a property purchase.

Due to variable growing seasons farm businesses in the Eastern Wheatbelt may not have the positive consecutive yield history to obtain a premium that is financially viable. Committing to another insurance premium would remove another slice of an already small operating profit.

Large industry uptake of multi-peril crop insurance is going to be a difficult proposition without some form of government intervention (e.g. removal of stamp duty on the premium). The harsh reality is that the areas that most need insurance do not have a yield history to obtain a premium that is affordable to protect a meaningful yield.

Australian crop insurance specialist 'Ag Guard' is working with several Nuffield scholars to develop an innovative insurance product that may be available as a pilot in the 2017/18 season. The current product offerings encourage growers to opt in and out on an annual basis, making insurance premiums very high. An alternative strategy is for growers to average their production across a number of years, to help remove the current volatility that is difficult to avoid on a year-by-year approach. Ag Guard's focus is also on aggregating production at a farm level rather than a crop or paddock level. If average production can be diluted across multiple seasons, the cost of the insurance premiums will drop and farmers will be protected when they need it most (Cohn, 2016).

The following may be valuable or used in combination with multiperil crop insurance to reduce variability and manage risk through lowering breakeven yield:

- Banks recognising that multi-peril crop insurance reduces their risk, then passing this on to growers in the form of reduced rate margins.
- Government removal of stamp duty on the premium.
- Directing more levy spending on increasing R&D to fix the cause not the effect, eg breeding more frost-tolerant cereal varieties rather than insuring for frost events.
- Increasing geographical diversity in farming locations to vary rainfall distribution and the range of soil types to reduce the chances of a poor year. This does not have to be for different rainfall zones but could also work within a rainfall zone.
- Controlling costs and reducing the break-even point. For example, investing in and retaining open pollinated canola seed at $2/ha rather than using Roundup Ready hybrid canola seed and tech fee at $50/ha. This equates to an effective $48/ha of crop insurance by reducing the band required to be insured to cover break-even yield.
- Investigating alternative ownership structures to improve business equity and/or scale to reduce costs. For example, Nuffield Scholar John Gladigau's (2006) collaborative farming model.
- A farm management deposit scheme that does not just use the tax incentive of deferring income to encourage deposits.

Chapter 7: GM Technology

GM technology could provide solutions to many issues within Australian farming systems such as drought, salinity and pesticide tolerance while also generating products of health benefit to consumers. In addition, incorporating traits like Omega-3 into grain would add value to end products and consumers, which in turn, would lift the value of grain received at the farm gate.

R. Nixon & Co, Kalannie has grown GM canola for the past three years but has found that it can increase costs and in turn, risk in poor years. The reason for growing GM canola is to manage weeds and resistance and to protect the grass herbicide clethodim from resistance to use in lupins if they are grown again in the future. However, whilst non-GM canola continues to work well because costs can be controlled by retaining seed and using low cost off-patent herbicides and conservative nutrient application, the role of GM canola in low rainfall cropping systems will be limited until further yield and agronomic benefits can be added to lower risk.

Reward vs. risk

In the future, for GM crops to fit our Eastern Wheatbelt system we would need crops with multiple traits so the rewards outweigh the risk associated with the large upfront cost. Producers would require end point royalties to replace upfront seed and technology fees so that the risk of adopting GM is shared with seed and technology providers. Reduced regulation is also needed to lower the cost of bringing new traits to commercialisation. There is also the concern that with the majority of plant breeding focused on GM hybrids, the yield gap between conventional triazine-tolerant open pollinated lines and GM lines will continue to widen.

Leading GM crop breeding firm Monsanto is not pursuing GM traits for tolerance to stressors like low rainfall or frost (Chris Anderson, North American canola breeder, 2014). Instead, the focus is on shortening time to maturity to enable crops to finish before the onset of the cold part of the growing season begins. According to Anderson, GM hybrids in Canada had significant uptake in dry areas and delivered the largest yield increase compared to higher rainfall areas. However, this has not been the case for GM uptake in the Eastern Wheatbelt of WA where the uptake of GM is low and potential possibly unrealised.

A topical issue in the US is the current cycle of low corn prices. Of the direct costs for growing corn in the US, per acre seed costs on a percentage basis increased the most between 2006 and 2014, increasing by 164 per cent (farmdoc daily September 1, 2015). This highlights the risk in adopting and becoming dependent on a system using GM hybrids in Australia; they can add cost and risk.

Genes – what's out there

The Bioceres R&D business unit, Indear, in Argentina investigates crop technologies for managing stress events and crop herbicide susceptibility. Indear has identified the drought and salinity tolerance gene called HB4, which is ready for development in wheat once regulation permits (Marianna Chiozza, 2014). Indear is not going to introduce their HB4 technology into canola or mustard as these crops are not in their core group; instead they are looking to outsource the technology which may allow the transfer to happen.

The salinity tolerance of conventional wheat and wheat incorporated with HB4 technology is shown in Figure 20. After 25 days of exposure to a 0.1 per cent NaCl solution there was an 80 per cent reduction in biomass in the conventional wheat compared to a 20 per cent reduction in wheat with the HB4 gene trait. The addition of a gene like HB4 could help improve productivity on crops grown under both drought and saline conditions in the Eastern Wheatbelt.

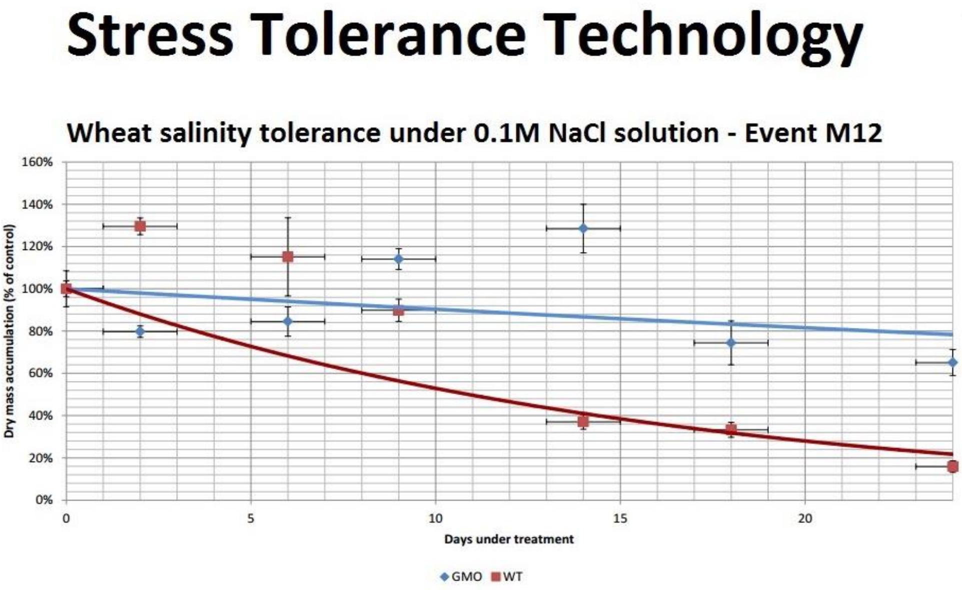

Figure 21: Wheat salinity tolerance under 0.1M NaCl solution – Event M12 (Indear, Bioceres, August 2014)

In collaboration with the GRDC and Nuseed, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is developing canola with the long chain fatty acid Omega-3. This will provide a new and sustainable source of Omega-3 and take the pressure off wild fish stocks. A GM trait with consumer and environmental benefits developed by a leading scientific body could help get public and political support for the use of GM technology and shift the current perception that GM only benefits large multi-national companies and growers.

Another trait that would benefit from GM technology development is shatter tolerance in canola. Current conventional breeding for improved shatter tolerance is seeing an associated yield penalty. Improving shatter tolerance would reduce shedding losses and aid in direct heading canola resulting in significant cost savings over conventional swathing.

GM technology faces many hurdles through regulatory costs and commercialisation of traits. In addition, the technology must gain market, social and government acceptance. GM could bring exciting agronomic and consumer benefits, however, as with perennial grains, the solutions will not come quickly or easily. Will GM wheat be accepted as milling grade and at what price penalty? Human consumption of GM wheat is different to other GM crops. Canola and soy are crushed and the meal that contains the protein and GM material is largely fed to animals along with GM corn. Will consumer backlash be greater towards GM wheat than GM soy and canola?

The industry would be better to focus on developing multiple traits in canola rather than GM wheat. It will be a difficult proposition to get political and social acceptance of GM milling wheat. As demonstrated earlier the Eastern Wheatbelt is lacking in resilient break crops. Multiple GM traits in canola could offer such resilience.

Chapter 8: Economies of Scale

Economies of scale are the cost advantages that enterprises obtain due to size, output, or scale of operation, with cost per unit of output generally decreasing with increasing scale as fixed costs are spread out over more units of output. This doesn't mean a grower attempting to own and farm half the Eastern Wheatbelt but trying, to for example fully use one set of machinery to minimise the cost per hectare.

Alongside rainfall and yield reliability, farm size and good management are the most important determinants of farm profitability in the Western Australian Eastern Wheatbelt. Scale allows producers to increase income at a faster rate than costs; the performance of grain farms increases with cropping intensity (degree of focus on cropping) and size (total area cropped). A positive relationship has been found to exist between farm operating size, productivity and other indicators of performance in the United States (US) and European Union (Hallam 1991; Chavas 2001; Mundlak 2005; OECD 2012). Local WA data demonstrates the relationship between return on capital increases and farm size (Planfarm Bankwest 2015 farm business analysis, 2015). Importantly, no business over 8,000 hectares showed a negative return on capital suggesting no negative effect as business size increased.

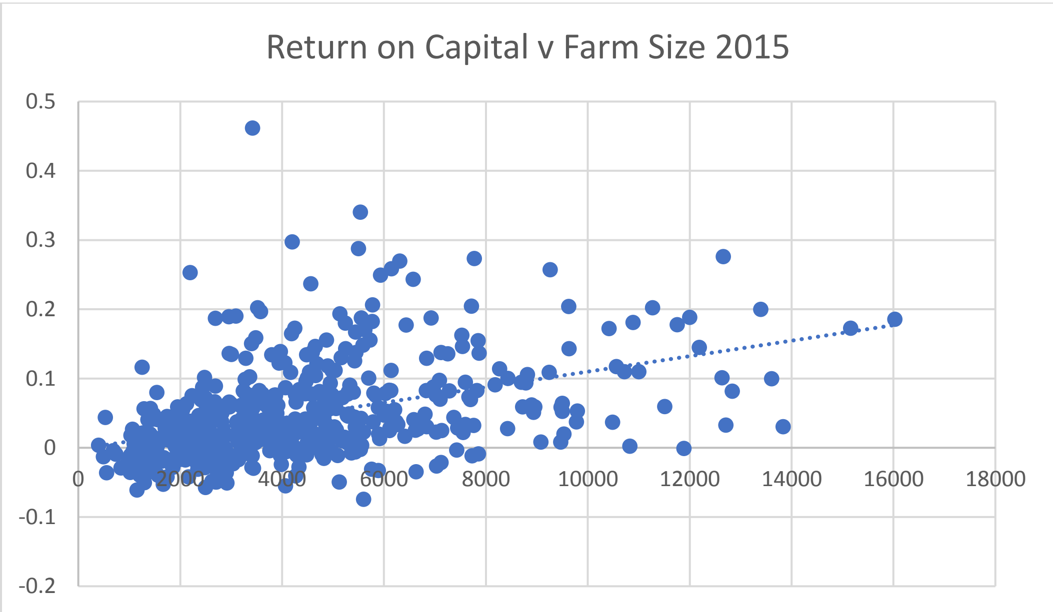

Figure 22: Return on capital vs farm size. (Planfarm, 2015)

Strong appreciation in land values both in Australia and around the world has meant growers have to intensify production to compete with other land uses. Intensifying or increasing inputs adds more risk to farming businesses when seasonal conditions or commodity prices are poor. A major advantage in the Eastern Wheatbelt is that land values are relatively low and have not appreciated as strongly as other Australian and international markets. The region has also experienced limited external influences like foreign investment. This means farmers in the Eastern Wheatbelt do not have to intensify production to compete, and expansion has been possible at lower cost. Farmers can often be their own worst enemy when expanding and can pay too much for land without pricing risk adequately into the price paid.

An example of how land in different zones is valued is as follows:

- **Low Rainfall Eastern Wheatbelt**: Author's farm (300 mm low rainfall zone) valued at $750/ha for a current five-year wheat average of 1.75 t/ha. This amounts to $428 of land value per tonne of wheat produced.
- **High Rainfall**: Moora (450 mm higher rainfall zone in WA) land valued at $4,000/ha for a five-year average of 3.2 t/ha. This amounts to $1250 of land value per tonne of wheat produced.

Fallow is an important tool for reducing seasonal variability in the Eastern Wheatbelt. It works to reduce risk with the right soil type and when land values are low. However, the lack of income in the year of fallow is difficult to justify financially when land prices are high.

Expansion and the scalable unit

Machinery costs are rising at a faster rate than the price of the commodities we produce. Scale is an effective way to keep machinery costs under control, because it spreads the capital cost over a larger area and lowers the cost of production per hectare. R. Nixon & Co has expanded from 2,700ha in 1987 to its current 16,000 ha arable (Figure 1) and now fully uses two sets of sowing and harvesting machinery or scalable units. The business has changed its focus from increasing inputs to drive production to the present focus of producing the same amount for lower cost.

Families farming together

Farming families are able to achieve and maintain scale by farming together as a family unit in partnership rather than separate entities. This can also be achieved by collaborative farming. Nuffield Scholar John Gladigau (2006) investigated the topic Collaborate to survive and thrive, which involves combining the resources of farming businesses to achieve what our family farm has achieved through farming in partnership. Scale brings advantages that contribute to supporting the management of family relationships, both professionally and personally.

During this study, the author visited the Mountain View Hutterites Community an ethno-religious group near Alberta Canada that farms and lives in a collective and vertically integrates within the colonies. Mountain View grows crops and has a dairy, piggery and poultry enterprise, carries out shed building and cold pressing of canola and packs and brands canola-cooking oil. The community was a real eye opener and showcased the strengths and associated efficiency gains that come from diversifying and working together as a collective.

Scale – understand the cost

Large-scale farming can have a negative social effect because it results in fewer people in small regional towns. For example, in 2000 WA's Cooperative Bulk Handling system, responsible for storing and handling the state's crop, had 10,000 grower members. By 2015 there were just 4,200 members. The declining rural population has lead to the loss of infrastructure and critical services like primary schools, sporting clubs and health services.

As the area of land farmed per labour unit increases there is real pressure on the farm business to manage farm staff and technology application as best as possible. The remoteness and isolation of the Eastern Wheatbelt in particular makes it difficult to attract rural staff.

Studies examining the characteristics of high-profit farms relative to low-profit farms show that management and attention to detail are key factors. As an industry we need to focus on up-skilling management through encouraging participation in grower groups and programs, agribusiness qualifications and recognising the capacity of the business team and building it with expertise and skills from outside sources.

As farm size increases there becomes a loss of time and management capability to pay attention to detail. Growers need to be able to identify the tipping point when attention to detail is compromised by expansion and scale stops working for them. Agriculture is a complex business. Scale is an incredibly useful tool in spreading the costs per hectare but must be coupled with close attention to detail to be successful. Paying attention to detail while managing scale is the largest stumbling block for many farm businesses.

Conclusion

It is possible for low rainfall farming businesses to remain profitable even under the current pattern of dry and variable seasonal conditions. In fact, because of low land values the low rainfall area can probably adapt to variable seasons more readily than the medium rainfall zone. However, to achieve this we need our farming system to be profitable in decile 3 & 4 rainfall years (rainfall range from 200 to 250 mm). The best way to mitigate risk is to manage costs to generate a low break-even yield. We need to drive all efficiencies without compromising the production outcome.

Business diversification and value adding are difficult to achieve in the Eastern Wheatbelt due to lack of water, high labour costs and limited product range for value adding. We have no choice but to rise to the challenge to be the most efficient, lowest cost producers in the world with the flexibility to adapt to change. High input prices will most likely be here to stay so the goal is to achieve the same yield with more efficient use of inputs.

Recommendations

1. Rotational diversity provides a tool for achieving success in low rainfall cropping systems. Crop rotation coupled with improved oilseed variety performance will underpin ongoing success in Eastern Wheatbelt farm businesses.
2. Rotation using low-cost canola and chemical fallow increases profit and reduces risk in the short and medium term.
3. Continued industry investment breeding open pollinated canola varieties is critical to controlling costs and managing risk.
4. Increased R&D/breeding efforts of alternative oilseeds will improve their adaptability to the Eastern Wheatbelt.
5. Evaluating the use of livestock. Sheep can compromise rather than complement dryland cropping systems. There is a need to retain ground cover to protect soil and keep soil soft and friable to support dry seeding. Dry seeding is the main driver of improved machinery and water use efficiency in the Eastern Wheatbelt. The decline in autumn rainfall has lengthened the autumn livestock feed gap and supplementary feeding.
6. Ameliorating soil pH using lime or limesand takes full advantage of available nutrients and maximises the size of the soil moisture bucket, increasing water use efficiency on our lighter more favourable soil types in dry seasons.
7. Identifying and using on farm resources like Morrell lime can help significantly lower soil amelioration costs. This could also extend to potassium in claying resources, gypsum and anything that could help to control farm input costs.
8. The industry should focus on developing multiple GM traits in canola rather than GM wheat to make canola a more resilient break crop with added consumer benefits.
9. The agricultural industry needs to focus on up skilling management and employee capacity to manage economies of scale in the Eastern Wheatbelt successfully.
10. Perennial grains offer potential solutions to a low input cropping system, however, there are many breeding challenges and industry should concentrate on solutions that are more likely to succeed.

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Plain English Compendium Summary

Project Title:	Mitigating risk in a dry and variable climate
Nuffield Australia Project No.: Scholar: Organisation: Phone: Email;	1404 Bob Nixon Robert Nixon & Co. Dalmeny East Farm 103 Nixon Road Kalannie, Western Australia 6468 + 61 429 662 150 bobnixon11@gmail.com
Objectives	To achieve and maintain profitable Eastern Wheatbelt farming businesses in our current cycle of dry and variable seasons by understanding and managing risk.
Background	How can Eastern Wheatbelt farmers continue to be successful in the face of reduced winter rainfall and increased seasonal variability? If the answer is in the detail, what are the key elements that require our attention and implementation to mitigate risk and ensure our future profitability?
Research	Included the 2014 six-week Global Focus Program; including travel to New Zealand, Brazil, California, Mexico, Washington DC, UK. My independent study took place in Alberta Canada, Argentina, Iowa Kansas, Nebraska USA and Kenya. Time was spent at agricultural conferences, research facilities, with university R&D personnel, industry R&D officers, political lobbyists, machinery manufacturers and most importantly, farmers.
Outcomes	To investigate and endorse practices that can be implemented in the unique farming districts of the Eastern Wheatbelt, for the benefit of economic, environmental and social viability.
Implications	The Eastern Wheatbelt is expansive, characterised by large variations in soil types, rainfall, and land demography. Quantifying business variables is most valuable at a local and regional level. Flexibility to adapt to change is an ongoing farming and R&D task.
Publications	• 2016 GRDC Business Updates – Munglinup, Narrogin, Dalwallinu • 2016 Moora Miling Pasture Improvement Group • 2016 Merredin Crop Updates • 2015 GRDC & Western Panel Presentation • 2015, 2016 Liebe Field Day Dalwallinu • 2015 Beacon Soil Acidity Workshop • 2015 Mukinbudin Regional Cropping Solutions Network • 2015 Nuffield State Lunch • 2015 Nuffield National Presentation • 2015 CSBP Fertiliser Consultant Workshop • 2015 Mullewa Crop Updates • 2014, 2015 GRDC Perth Crop Updates • 2014 (Whilst Traveling) Nobel Foundation, Oklahoma US / The Land Institute, Salina Kansas / Oklahoma State University / Italian Cereal Quality Institute, Grains Research Centre, Rome, Italy.