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Cultivating the next generation of pasture scientists in Australia

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Abstract. Current students coming through agricultural faculties in Australian universities have grown up in an era of low wool and meat prices, the introduction and acceptance of no-till farming as the norm and a general decrease in mixed farming landscapes in favour of continuous cropping. Since the collapse of the wool reserve price scheme in 1991, wool prices declined and income on wool producing farms followed suit. R & D during this period has also declined from 5-4% agricultural GDP in 1986 to only 3% in 2005 and has favoured research related to cropping rather than that related to pastures and livestock. How then do we convince students that mixed-farming enterprises provide the sustainable future of farming? This paper provides a background to farming practises over the last 20 years, along with the economic, environmental and social basis for the decisions that have been made. In view of a changing climate, peak oil, food security issues and changing trends for global food consumption, it will then set the scene and discuss why pastures and livestock should be an integral component of future farming systems. Finally, it will discuss how we can change a whole generation of future farmers and researchers to see the value of livestock and pastures in their farming landscapes. Current price increases for wool and meat, and the value of spreading risk on-farm in an increasingly variable climate will provide a basis for this decision.

Keywords: Sustainability, mixed farming, livestock, research and development, risk, climate change.

Introduction

The Australian agricultural landscape has gone through many changes since farming first commenced with European settlement around 1840 (Connor 2004). Initially farming was predominantly wheat with yields rapidly declining as soil fertility declined. The discovery of phosphorus as a fertiliser at the turn of the century and the release of the first Australian-bred wheat variety 'Federation' in 1902, led to an era of predominantly wheat-fallow farming rotations, which increased yields back above 1 t/ha, but not to original levels. At around the same time subterranean clover (*Trifolium subterraneum* L.) was introduced to Australia, with the release of the first variety 'Mount Barker' from South Australia in 1907 from a naturalised strain (Cocks and Phillips 1979). However, the use of pastures in farming systems was not widely adopted until wool prices increased in the 1950s and further pasture varieties were released that were better adapted to lower rainfall environments.

Mixed farming systems of wheat and sheep rotations, known as 'ley farming' systems then became more common, replacing the wheat-fallow rotations (Connor 2004). The benefits were clear as fertility accumulated during the pasture phase and was utilised by the subsequent crop, increasing wheat yields from 0.3 t/ha on average in 1900 to levels above those achieved when the land was first cleared (an average of 2.5 t/ha in 1985). Soil organic matter also increased, and soil erosion decreased. Wool prices were also high at this time (AU\$10/kg for market indicator fleece 21 μ m) to meet European demand and pasture scientists were busy developing new varieties of subclover

to fit all the ecological niches across the wheat growing areas of southern Australia. The 1980s and 1990s saw a period of success for pasture scientists as funding through the National Australian Pasture Legume Improvement Program (NAPLIP), by the Grains Research and Development Corporation, Australian Wool Innovation Ltd, CSIRO and state agricultural agencies, resulted in the rapid expansion of annual pasture species and varieties, increasing their potential from a few niches to across the majority of ecological niches within the wheatbelt. In total 30 new cultivars had been released by 2007, including 11 new subterranean clover varieties.

Wool prices peaked in 1987-88 when the Eastern Market Indicator Price averaged 1117 AUc/kg (clean) and in March 1989 sheep numbers peaked at 173 million (Ashton et al. 2000). By 1999/2000 wool prices had fallen to 625AUc/kg (wool) and sheep numbers had dropped to 115 million sheep. By 2010/11 sheep numbers had dropped to an all-time low of 71 million (AWPFC 2012). Despite this, wool is still one of Australia's most important agricultural commodities contributing around 10% of the gross agricultural production and in 2010/11 the value of Australian wool exports was AU\$3.047 billion (ABARE 2011). Since the 1990s the demand for lamb and mutton has risen internationally, which combined with falling sheep numbers in Australia, in response to falling wool prices, has led to a rise in the price of lamb and mutton. In 1990/1991 lamb prices were low, at approximately AU\$1.60/kg, and have since steadily increased to AU\$3.80/kg in 2003/4. Mutton has followed a similar pattern rising from approximately AU\$0.10/kg to AU\$2.00/kg over the same time period.

Decline in pastures and increase in cropping

The benefits of legumes, however, also led to their decline, with the added nitrogen in the soil contributing to the acidification of the soil and the subsequent decline in rhizomatous activity and N-fixation. The introduction and subsequent uptake of no-till farming in the 1980s, along with a collapse in the wool price, led to opportunities to reduce reliance on pastures and increase the cropping component on the farm. Farmers adoption of no-till farming is now between 70 to 95%, with arable land under no-till farming amongst adopters increasing around 45% over the last 10 years (Llewellyn *et al.* 2012). Perceived advantages of no-till farming with associated stubble retention including improved moisture retention, reduced weed emergence and fuel costs and increased reliability of wheat yield. Perceived disadvantages include reduced effectiveness of pre-emergent herbicides and increased disease in the crop (Llewellyn *et al.* 2012). There is also the issue of managing animals in the system in combination with a no-till system.

Global issues affecting farmers in Australia today and into the future

Climate Change

It is now widely accepted that the climate in Australia is changing. Climate change due to human activity has altered the earth's atmosphere, particularly the increase in the levels of greenhouse gases, such as carbon dioxide and methane, which has resulted in changes in the amount, distribution and intensity of rainfall across the globe. In Australia, cropping areas are experiencing drier conditions. Droughts are more frequent and the percentage of rain falling during the growing season is decreasing with a higher percentage falling as intense summer storms. Temperatures are also changing with the mean number of days of record temperatures increasing from 10 days/year in the 1960s to more than 20 days/year in the decade from 2000 to 2009 (Australian Academy of Science 2010). This latter decade was the warmest on record in Australia and showed the greatest rate of change since 1960.

Peak Oil

It has been said that global peak oil was reached in 2006. Since 1960 the global use of fertiliser has increased from 2t/km² of cropland, peaking in 2008 at over 11 t/km² of cropland (FAO 2008). Since then the figure has decreased, but is still far from sustainable. Oil prices during this time, have fluctuated greatly, but are currently on an upward trend as insecurity over availability of oil and phosphorus rises. Biofuels are one alternative to oil use on-farm, but are a competing source of land used to provide food. In 2008 food prices spiked, as combined with a major reduction in global food stocks and increasing land used to grow biofuels, food security became a very real issue. However, it has been estimated that to use biofuels to run farms and tractors would cut global food supply by 10% (FAO 2008).

Research and Development

Mullen and Cox (1995) showed that the returns to broadacre agriculture in Australia from research and

development spending were in the range of 15 to 40% between 1955 to 1988, with the impact on agricultural productivity growth from research flowing over many years (15 to 40 years). However agricultural productivity growth has slowed recently and now averages around 2.5%. This reflects the reduction in spending on agricultural R&D and a redirection of the funds away from farm productivity that began 20-30 years ago. During this time period there has also been a change in the percentage of public research and development investment and an increase in the percentage of private company investment. This reflects similar changes in the USA. However, Salim and Islam (2010) suggest that public investment in research and development may be an important catalyst in increasing farmer adaptation to climate change having showed that both R&D spending and climate change are having a similar impact on agricultural productivity growth in Australia.

Sustainable Farming Systems including pastures and livestock: spreading risk and preserving the landscape

Reeves and Ewing (1993) discussed their concerns over the sustainability of the change in farming systems from ley farming to phase farming and these concerns continue with the change from phase farming to continuous cropping. They did, however, point out that the rate of decline in soil organic matter in the cropping phase slowed down with reduced tillage or no-till systems and also by the inclusion of pulse legumes in the system. Pulses, or food legumes, are grown as a component of the rotation, but are often perceived to bring little profit and have a high risk of disease or crop failure. Lupins were introduced into the Western Australian farming system as an alternative to subclover in the 1980s and on the deep sandplain soils uptake was rapid. However fluctuations in the market and an increase in the value of canola, particularly with the requirements for biofuels, have seen canola take over as the main break crop in the cropping system.

A paper by Pannell (1995) examining the factors affecting farmer decisions on legume production showed that as well as the potential for short-term profit there are other sustainability and risk factors that influence the decision to include pastures in the system (Table 1). Farming systems that are not cropping dominant offer benefits in terms of risk, especially in times of drought or in heavy frost years, both of which are expected to increase under a changing and drying climate, and allow farmers to spread their business opportunities on-farm. These factors are as relevant today as they were 20 years ago, but also need to include decisions on potential profitability from cropping of land across the farm. For areas on-farm where cropping is no longer a viable option due to land degradation or marginal land that can only be cropped in a good season, pastures may be an attractive alternative and offer benefits beyond profit from wool and meat. The species available and farming systems have also changed in 20 years and there is a need to consider the use of perennial pastures and fodder shrubs in the system as well as new components of the system including pasture cropping and dual-purpose cereals. Soil health is an important benefit of these alternative systems. Under a mixed farming system

Table 1: Factors affecting decisions on legume production (adapted from Pannell 1995). Points in bold are those added to the original table

1.	<i>Short-term profit factors</i>
1.1	Legume grain yield (depends on weather, soil type, weeds and so on)
1.2	Legume crop stubble production and quality
1.3	Pasture production level, quality and timing
1.4	Yields of non-legume crops and pastures
1.5	Input costs
1.6	Output prices (for legume crops, livestock, livestock products and non-legume crops)
1.7	Opportunity for new farming systems – pasture cropping, dual-purpose crops, perennial pastures and fodder shrubs
2.	<i>Dynamic factors (short to medium term)</i>
2.1	Nitrogen fixation and yield boost from other factors (e.g. disease break, soil structure)
2.2	Pasture density
2.3	Legume crop disease
2.4	Stubble management
2.5	Weed control
2.6	Tillage method
2.7	Carry-over of fertilizer
2.8	Soil health
2.9	Carbon accumulation
3.	<i>Sustainability factors</i>
3.1	Herbicide resistance
3.2	Soil degradation (acidification, organic matter decline, erosion, nutrient decline, non-wettability, salinity, nutrient toxicity)
3.3	Pasture legume persistence –opportunities for incorporating perennial pastures and fodder shrubs
3.4	Pasture establishment costs
4.	<i>Risk factors</i>
4.1	Yield variability
4.2	Price variability
4.3	Yield/price covariance
4.4	Flexibility of the enterprise in response to changed conditions
4.5	The farmer's attitude to risk
4.6	Input price increases – fertilisers and fuel costs
4.7	Climate change – reduction in growing season rainfall and increase in out-of-season rain
5.	<i>Whole-farm factors</i>
5.1	Total crop area
5.2	Increase in marginal land or land becoming unproductive to crop
5.3	Machinery
5.3.1	Total capacity
5.3.2	Timing of requirements of different enterprises
5.4	Total feed supply (timing and quality)
5.5	Feed requirements of livestock on hand (timing and quality)
5.6	Finance availability and cost
5.7	Labour availability, quality and cost
5.8	The farmer's objectives (profit, risk reduction, sustainability, leisure)
5.9	The farmer's knowledge and experience

there are years when nutrients are put back into the soil, compared to a continuous cropping system where the majority of added nutrients are taken away with the crop, and there are opportunities for the accumulation of organic matter and organic carbon. Perennial pastures, including the use of fodder shrubs, pasture cropping, plus dual-purpose crops also increase feed availability outside that of the traditional annual pastures, reducing requirements and cost of supplementary feeding. The viability of perennials increases with increasing out-of-season rain as these plants are able to opportunistically utilise this rain, providing green feed over the traditional summer and early autumn feed gaps, and also as the percentage of poor soils or marginal land increases (Table 1).

Conclusion: The next generation of pasture scientists

The next generation of pasture scientists will need to improve knowledge through research, development and extension on incorporating perennial pastures and shrubs on-farm as part of the system. Although it is known that perennial plants provide green feed for livestock during the summer/early autumn in response to out-of-season rainfall events potentially increasing the condition score of sheep going into winter and reducing the amount and thus the cost of providing supplementary feed over summer/early autumn, there is still knowledge to be gained on how much feed is available at different times of the year and under

different systems. For the farmer, taking unprofitable land out of cropping enables them to spread risk and reduce loss in poor years, but pasture scientists are required to re-sell this message and in some cases it is an expensive message as fences have been removed and dams filled.

Increasing the amount of research and development funding targeted towards improving feed for animals across the year is vital. Pastures on-farm need to be viewed as an important component of the whole farm system; spreading risk, replacing nutrients on paddocks, providing a disease break between cropping years, providing quality feed for livestock, throughout the year where possible, and increasing the sustainability of the land for future generations.

Today's students have easy access to vast amounts of data through the internet. However, they still need skills in disseminating and interpreting that information and can get overwhelmed with the negative messages that are commonly presented in the media. It is the responsibility of lecturers, advisors and farmers to provide students with positive challenges for the future that include pastures and livestock in a sustainable farming system.

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