


Grain & Graze™

Profit through knowledge








Managing Complex Systems:

Preliminary findings from Grain & Graze

mla MEAT & LIVESTOCK AUSTRALIA

australian wool innovation limited

GRDC Grains Research & Development Corporation

Australian Government

Land & Water Australia

Published by: Land & Water Australia
Postal address: GPO Box 2182 Canberra ACT 2601
Office Location: Level 1, 86 Northbourne Avenue, Braddon ACT 2612
Telephone: 02 6263 6000
Facsimile: 02 6263 6099
E-mail: land&wateraustralia@lwa.gov.au
Internet: www.lwa.gov.au

Grain & Graze is a collaboration between four leading research and development corporations: Meat & Livestock Australia (MLA), Australian Wool Innovation (AWI), the Grains Research & Development Corporation (GRDC) and Land & Water Australia (LWA) – along with more than 60 farmer and landcare groups, research providers and regional management authorities.

For more information about the Grain & Graze Program, contact:
Telephone: 02 6263 6000
E-mail: info@grainandgraze.com.au
Internet: www.grainandgraze.com.au

Publication data: Managing Complex Systems – Preliminary findings of the Grain & Graze program
Product Code: PR081463
ISBN 978-1-921253-96-6

Final Report Project Team:
Peter Day – Peter R Day Resource Strategies Pty Ltd
Julian Cribb – Julian Cribb & Associates
Robert Hannam – RJ Hannam & Co Pty Ltd
Phil Price – Mackellar Consulting Group Pty Ltd
Michael Krause – Applied Economic Solutions Pty Ltd
Peter Wylie – Horizon Rural Management
Anne Burgi – SUBStitution Pty Ltd
Dave Riches – Riches Communications Pty Ltd
With assistance from the Grain & Graze program team

Layout by: SUBStitution Pty Ltd, Melbourne
Printed by: DPA, Melbourne

June 2008

SUBS/DPA/08-06

Contents

Foreword

Dr Richard Price

Grain & Graze has been a unique and rewarding experience for all involved.

Between 2003 and 2008, more than 4,000 producers across Australia were involved, with hands-on engagement, in a wide variety of mixed-farming research and extension activities conducted on approximately 240 sites.

Many thousands more took interest in the activities by seeking information about Grain & Graze results.

This overall engagement has led to an average 9% increase in profit for the 2,000 or so people who either adopted the practices advocated by Grain & Graze, or ceased practices that the program's research had found to be not beneficial.

This is quite remarkable given that during this period all nine Grain & Graze regions experienced severe, and in some cases, unprecedented, drought conditions.

Perhaps even more remarkable has been the discernible improvement in soil and vegetation health and management on participating farms, evidenced by fewer dust events traditionally associated with high erosion during drought.

Grain & Graze has been unique in other ways. It has explored from production, environmental and social perspectives the complexity involved in managing multi-enterprise farms. Crop, pasture and animal management research sat comfortably alongside studies on biodiversity, risk management, decision-making and work-life balance.

This report is a synthesis of the interim findings of Grain & Graze, attempting to come to grips with managing complex systems and providing guidance to producers and their advisers on those practices and decision-making processes that will help lead to better profits, better farms, better catchments and better lifestyles.

I commend this report to you and invite your feedback to ensure its next iteration capitalises on the complete lessons of Grain & Graze.

Dr Richard Price
National Operations Coordinator
Grain & Graze

June 2008

Introduction

Purpose

This report distils the experiences and findings of mixed farmers and scientists involved in the nine regions and four national projects of the nationwide Grain & Graze program. It aims to help Australian mixed farmers analyse their systems and make better decisions in an increasingly complex operating environment.

Mixed farming occurs across a wide array of soils, landforms and climates in Australia. In response to that variability, Grain & Graze has developed local as well as national solutions to a range of production and management issues. This information is available through local, regional and national reports which are available on the Product Directory. These reports and information guides offer tactical assistance and 'how to' advice to farmers in solving practical problems.

This report explores strategic matters of interest to mixed farmers, teasing out the options and exploring how the pros and cons vary in different circumstances. It doesn't seek to provide precise answers; it highlights issues and options to be considered and gives more insight into how they can be tackled by individuals seeking to develop solutions to their own unique set of circumstances.

It isn't an encyclopedia of mixed farming nor does it pretend to have 'silver bullet' answers. Mixed farming isn't that simple. Rather, Grain & Graze aims to offer ideas and ways of thinking about complex issues.

The individual Grain & Graze projects began at different times and many have been affected by drought. When this report was produced some had been completed, some had preliminary results and some were just starting to analyse their findings. This report distils findings into the main themes and ideas that have emerged so far.

The report is a strategic companion that complements the array of problem-solving material generated by Grain & Graze that is available through regional projects. It deals with issues such as deciding the appropriate balance between livestock and crops, designing farming systems that cope with variability, finding better ways to manage the complexity of modern farming, and understanding how to keep farms and their rural landscapes healthy and productive.

To get the most from this report, try 'browsing'. Thumb through to sections of most interest, have a read and ponder how the issues discussed apply to your farm. Consider following up one of the leads for more information or discuss it with a local adviser or farmer group. When next you want to reflect on an aspect of mixed farming browse another topic.

Most of Australia's mixed farms are family owned and most owner-managers have grown up on a farm. They have wide experience and expertise to draw upon and they know that skill in production (managing crops, pastures and livestock) is critical to their business performance.

They are vulnerable to global commodity price swings, to seasonal variability, and to changes in the value of the Australian dollar, interest rates and farming input costs. Farmers can do little or nothing to alter these off-farm issues – but they can plan for them and factor them into their strategic decisions for the mixed farming enterprise.

This report begins by examining some of the issues that are inherent in mixed farming enterprises and the key strategic challenges that arise. It then considers the available management responses and the relevant Grain & Graze findings.

Readers will see how different farmers and different regions deal with common issues and be able to consider whether there are new ways they can tackle those issues on their own property, drawing on local advice for more technical assistance.

What is a mixed farm?

The Australian Bureau of Agricultural and Resource Economics (ABARE) defines 'mixed livestock–crop producers' as being 'engaged in the production of sheep and/or beef cattle in conjunction with substantial activity in broadacre crops'. Mixed producers are classified as 'Australian broadacre industries' along with 'wheat and other crops', 'sheep', 'sheep-beef' and 'beef producers'.

To be counted by ABARE, mixed producers had to have an estimated value of agricultural operations above $40,000 a year in 2005/06. In terms of national broadacre production, mixed livestock-crop producers make up:

- 25% of all farms;
- 25% of grain production;
- 30% of sheep and wool production; and
- 10% of beef sales.

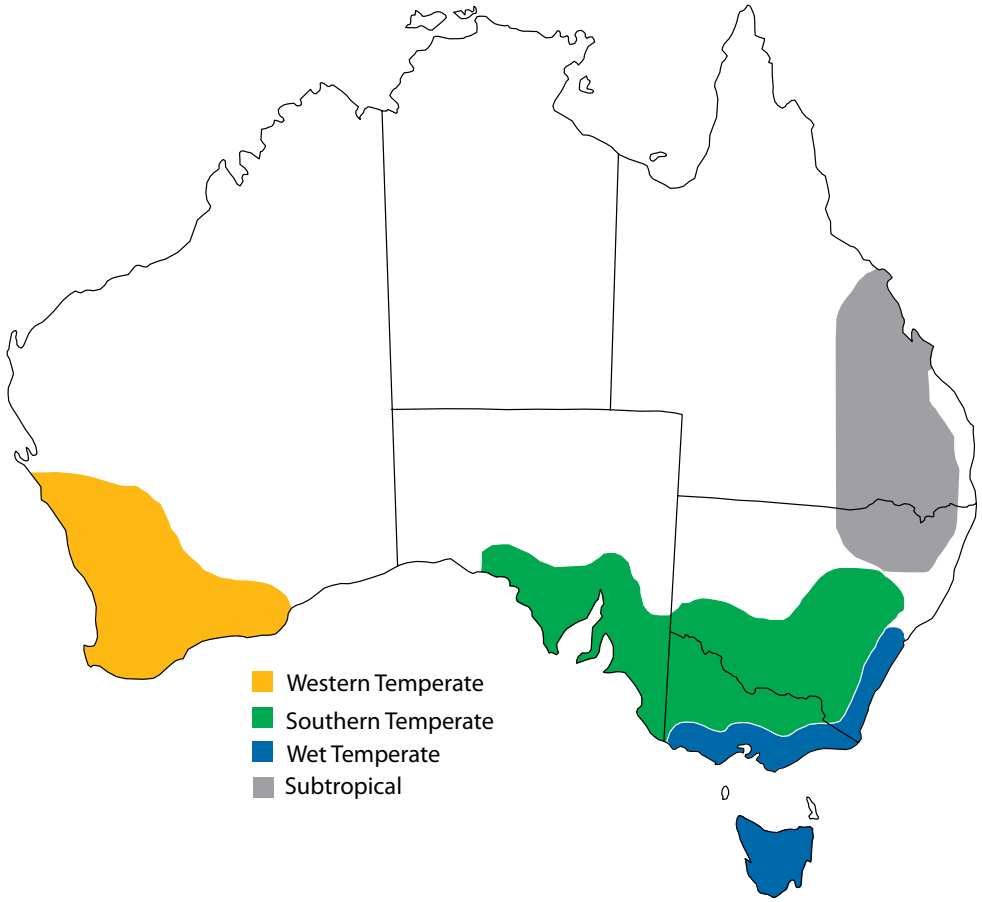
It is estimated that in 2005/06, mixed producers ran 30 million sheep and two million cattle. They produced more than 140 million kilograms of wool and seven million tonnes of wheat.

Many mixed producers focus on a major enterprise such as cattle or cropping and see themselves as a single-commodity producer, although they also produce other commodities: "I'm a cattle producer – but I grow a bit of grain as well". Other

graziers grow grain purely for on-farm use. These farmers may fall outside the ABARE definition but they are still 'mixed farmers', producing more than one commodity on their property and making decisions which involve multiple enterprises.

Mixed farming is traditionally associated with the wheat-sheep zone but nowadays more and more cropping is being done in the high rainfall zone, usually in conjunction with livestock enterprises. This trend may persist under climate change if the outer grain belt becomes drier.

The findings of Grain & Graze are intended to be useful to all these different kinds of mixed farmers.



Where does mixed farming occur?

The following zones present a geographic context for Grain & Graze information. They are based on agro-ecological zones and regional Natural Resource Management (or catchment) boundaries.

- *Western Temperate: Mediterranean climate, unreliable spring rainfall, generally lighter soils (tending to be acidic) and large properties.*
- *Southern Temperate: Generally Mediterranean climate with hot dry summers, ranging to uniform rainfall throughout the year in parts of NSW. Soils vary from sandy Mallee to deep loam soils (alkaline in the west, becoming more acidic to the east). Traditional wheat-sheep country.*
- *Wet Temperate: Higher, winter dominant, rainfall and cooler seasons. Feature increased grain production in what were more livestock-oriented districts.*
- *Subtropical: Transitional climate with rainfall likely to permit cropping in summer and winter, and relatively fertile soils in which rainfall conservation will drive yields. Beef production has been the historic mainstay of production with grains, including sorghum, increasing more recently.*

Mixed farming in Australia

The historical success of mixed farming lay in its versatility and its ability to cope with climate fluctuations and maintain a reliable supply of varied food for a large number of people.

The hunting and gathering that had preceded it could only sustain small groups. The ability of early farmers to produce far more than was needed to support themselves and their families freed others to develop new skills and industries and enabled the rise of cities – and civilisation as we know it.

Australian farms have been 'mixed' since the First Fleet arrived. Various combinations of livestock and crops have stood the nation in good stead, enabling it to cope with drought, flood, fire, storm, war and disease when more specialised farming systems struggled or failed. As a result, at no time in the past two centuries has the nation as a whole gone hungry.

While specialist livestock and cropping enterprises have also been a feature of the landscape, especially in the arid and subtropical regions, the mixed family farm has been the backbone of Australian rural industry and the cornerstone of thousands of regional communities.

Responding to the continent's varied soils and climate, Australian farmers have developed their own unique forms of mixed farming. One of the best-known is the pasture ley ('sub and super') system, in which legume-based pasture – particularly subclover fertilised with superphosphate – was combined with cereal crops and other grains, the nitrogen fixed by the pastures enriching the soil for subsequent cereals and the stubbles providing nutrition for the stock. Australians also have a proud history of developing tillage and harvesting equipment to suit their environment, dating from the stump jump plough and early grain strippers.

In recent decades, a marked shift towards refined cropping systems – such as minimum till, no till, continuous cropping and precision farming – has increased the options and flexibility in the cropping phase. In some cases this, and the relative profitability of cropping, led to a decline in the livestock enterprise and to some mixed farms moving out of livestock altogether. However, several factors, such as herbicide resistance in weeds and a succession of droughts and poor finishes, are causing many producers to reconsider the role of livestock within the mixed enterprise, with an eye to their ability to maintain a more regular income and their place in a resilient farming system.

Mixed farming in human history

Mixed farming is one of humanity's oldest, most important and successful activities. It developed in response to the dying-off of the great game herds at the end of the last Ice Age and the deliberate cultivation of grasses such as wheat and barley in the Middle East or rice and beans in China. Latest archaeological findings suggest crops may first have been grown as long ago as 23,000 years, but did not become farming as we know it until about 8,000 years ago. As wild herd numbers dwindled towards the end of the Ice Age, hunting communities took to following their seasonal migrations and gradually evolved into nomadic herding with a degree of deliberate management, including the use of domesticated dogs. By around 7,000 years ago large livestock – cattle, sheep, goats – had been domesticated for their meat, milk, hides, wool and dung and rapidly became an integral part of a system of mixed crop/livestock farming that has thrived ever since in every inhabited continent.

In recent times, the problems of dryland salinity and the failure of exotic pastures during droughts have driven a push to perennials. This has led to the reintroduction of perennial and native pastures, shrubs and trees – for grazing, browsing, timber, fuel and carbon storage – interspersed with more traditional cropping and annual pastures. The developing global market for carbon storage, combined with a desire for a more sustainable landscape, is accelerating the introduction of agro-forestry and native revegetation into the traditional enterprises of the Australian mixed farm. At the same time, rising energy prices are likely to drive up the costs of the cropping enterprise, especially fuel, fertilisers and chemicals, relative to livestock costs.

The cost/price squeeze has been a feature of farming for more than a century and reflects the worldwide increase in farm productivity. It is, in a way, a tribute to the efficiency of modern producers. Today, mixed farmers must plan for an average 2% increase in productivity every year to stay in front and remain competitive against livestock and grain specialists, both in Australia and in other nations. One of the advantages of mixed farming is that it offers a wider choice of options for achieving this, while remaining resilient in the face of seasonal, climatic and market variation.

With the rise of consumer power and global supermarket chains, external factors are dictating as never before how the farm is run. Issues such as deregulation, animal welfare, food purity and safety, resource management regulations, reduced availability of local labour, the sustainability of production systems and, of course, price and quality are now part of the complex web of factors that mixed farmers have to consider.

Being a good manager of an enterprise is no longer enough on its own; the mixed farmer now has to navigate a host of considerations related to what society, consumers and customers are demanding. Increasingly, the farming game is about finding the premium returns by meeting these highly specialised requirements.

In the longer term, demand for Australian food looks secure: the world is running out of water and good arable land, it is losing nutrients to erosion and waste, and food crops to biofuels, while the climate is becoming drier and more variable in the mid-latitudes. At the same time, economic growth in India and China is boosting demand for high protein diets. Overall food demand is expected to more than double by 2050, from a position in 2008 when global food stocks were at their lowest in half a century.

The changing role of farmers

The role of the farmer is changing rapidly, becoming more complex, more demanding and more strategic.

It is no longer simply about being an excellent producer of crops or livestock, but increasingly about the ability to integrate a wide range of factors from markets and climate to social demands, environmental pressures and family wishes into a well-thought out plan for the farm itself.

This is not easy but, as work in Grain & Graze shows, Australian farmers are finding new and original ways to come to terms with complexity and to make better decisions.

They are demonstrating the wisdom, relevance, resilience and success of mixed farming. The new technologies becoming available for mixed farming in turn present fresh opportunities to evolve new farming systems.

Climate change

Australia is already experiencing the effects of climate change: increased stresses on water supply and agriculture, changed natural ecosystems and reduced seasonal snow cover. The CSIRO told the Greenhouse 2007 conference that the ongoing vulnerability to extreme events is demonstrated by substantial economic losses caused by droughts, floods, fire, tropical cyclones and hail.

There has already been some adaptation to climate change in sectors such as water, natural ecosystems, agriculture and coasts.

The climate of the 21st Century is virtually certain to be warmer. There will be more heat waves, fires, floods, droughts and storm surges, more intense cyclones and hail storms, and less snow and frost. Large areas of mainland Australia are expected to have less soil moisture

Water security problems are projected to intensify in southern and eastern Australia:

- 0-45% less flow in Victorian catchments by 2030
- 14% less flow in south-western Australia by 2030
- 10-25% less flow in the Murray Darling Basin by 2050

Production from Australian agriculture and forestry is projected to decline by 2030 over much of southern and eastern Australia due to increased drought and fire. By 2070, the south-western wheat regions are likely to experience significant yield reductions while north-eastern wheat regions are likely to have moderate increases. Where water is not limited, warming will extend the growing season in southern Australia, but this may be offset by pest damage, reduction in average run-off and increased fire risk. Greater rainfall intensity is likely to exacerbate soil erosion.

By 2030, CSIRO's best estimate for warming is around 1.0°C with a range of 0.6 to 1.5°C. By 2070, under a low-emission scenario it is around 1.8°C (1-2.5°C); under a high-emission scenario it reaches around 3.4°C (2.2-5°C). Warming is likely to be least in coastal areas and Tasmania.

Rainfall decreases (up to 40%) are expected to be strongest in winter-spring, in the south-west and under the highest emission scenario. Increased rainfall is unlikely, with the possible exception in the north and east in summer and autumn. There may be wide variations in local rainfall.

Extreme daily rainfall is expected to increase in many areas but not in the south in winter and spring. An increased frequency of drought over most of Australia is likely, particularly in the south-west, accompanied by higher fire danger. There may be fewer but more intense tropical cyclones.

Estimated changes in rainfall under different climate change scenarios.

	2030	2070 low emission	2070 high emission
Southern areas	0 to -10%	0 to -20%	+5 to -30%
Eastern and northern areas	+5 to -10%	+10 to -20%	+20 to -30%

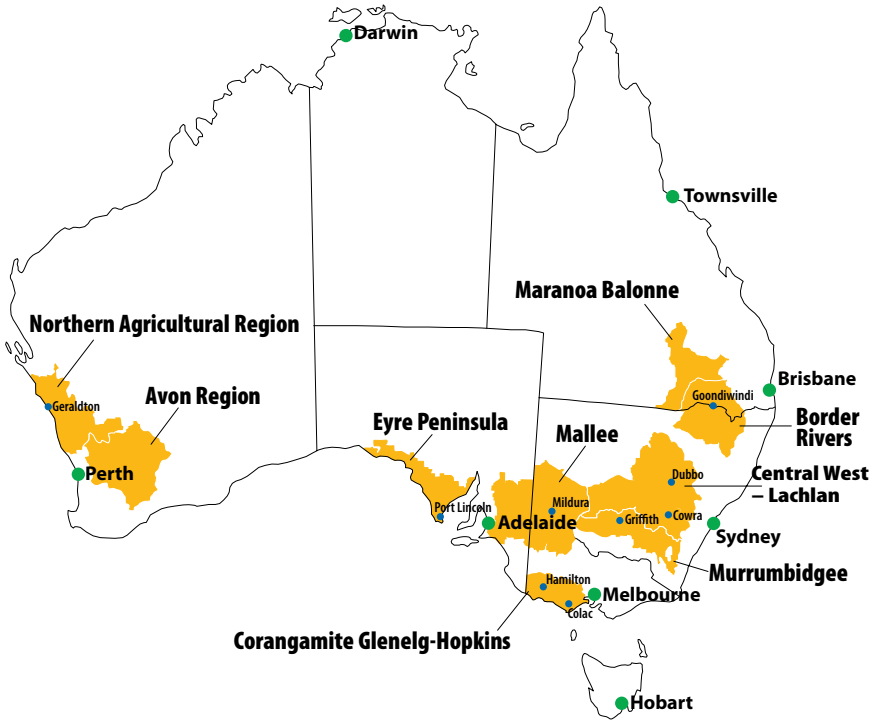
Source: CSIRO 2007

About Grain & Graze

Grain & Graze is a collaboration between Meat & Livestock Australia, Australian Wool Innovation, the Grains Research & Development Corporation, and Land & Water Australia, in conjunction with grower groups, research institutions and Natural Resource Management bodies across Australia. It has worked in nine focus regions and in four national projects.

The program invests in research to improve the profitability and sustainability of mixed farms, focusing on cropping, pastures, livestock, profitability, whole-farm economics, farming systems, social issues and natural resources such as soil, water and biodiversity.

Among its strengths are the direct involvement of farmers in local trials, development and extension activities – testing new farming practices on more than 200 research and demonstration sites across Australia – and the links that regional projects have established between industry and Natural Resource Management bodies. Appendix 1 gives information on the partners in the program.



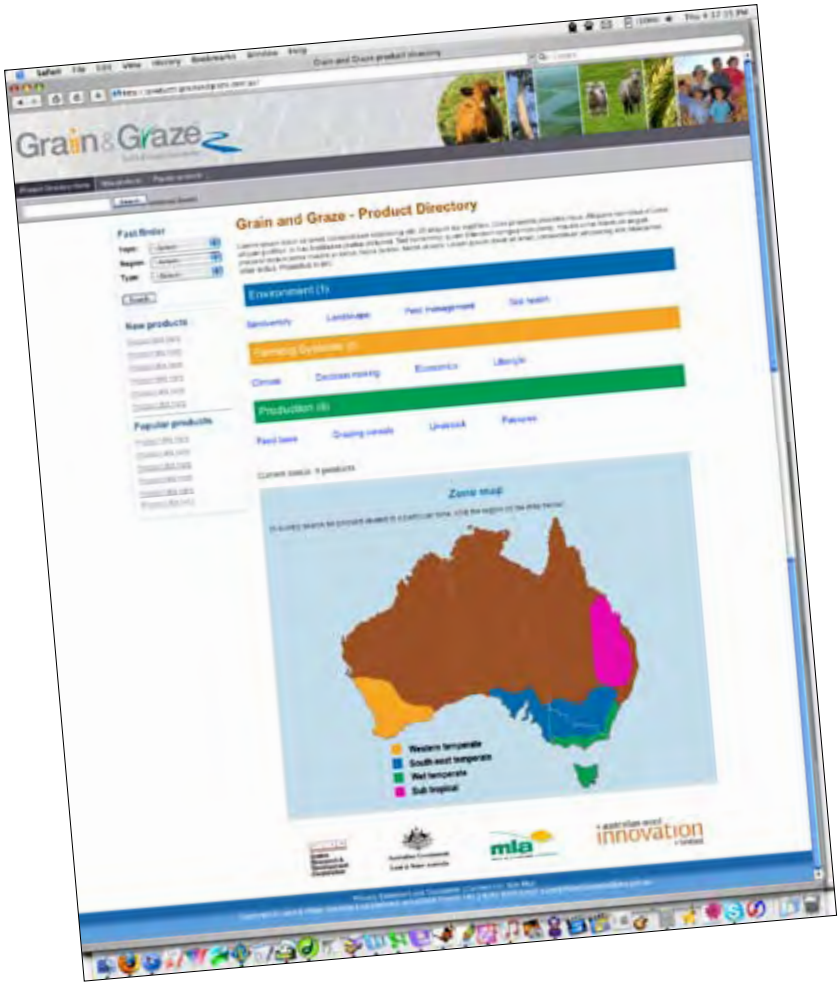
GRAIN & GRAZE PROGRAM REGIONS

- *Northern Agricultural Region (WA)*
- *Avon Region (WA)*
- *Eyre Peninsula (SA)*
- *Mallee (SA, Victoria, NSW)*
- *Corangamite/Genelg-Hopkins (Victoria)*
- *Murrumbidgee (NSW)*
- *Central West / Lachlan (NSW)*
- *Border Rivers (NSW, Queensland)*
- *Maranoa Balonne (Queensland)*

NATIONAL PROJECTS

- *Biodiversity and Productivity*
- *Feedbase Management*
- *Social Influences*
- *Whole-Farm Economics*
- *National Database*

Grain & Graze Product Directory



The Grain & Graze program has produced a virtual library of valuable publications for farmers, advisers, researchers and natural resource managers.

An on-line directory has been developed to provide information about, and ready access to, all these products. It is at products.grainandgraze.com.au, or access via the Grain & Graze home page, www.grainandgraze.com.au.

Products can be found by searching based on:

- Topic (e.g. Production, Farming Systems or Environment),
- Region (based on agro-ecological zones), or
- Type (General Information, Management Information, Technical Information or Case Studies).

A summary of each product is available along with the ability to download a copy.

More information

- The Grain & Graze program: www.grainandgraze.com.au

  Grain & Graze partners:

  - Land & Water Australia: www.lwa.gov.au
  - Meat & Livestock Australia: www.mla.com.au
  - Grain Research & Development Corporation: www.grdc.com.au
  - Australian Wool Innovation: www.wool.com.au

Summary

A question of balance

Balance

One of the basic questions for a mixed farmer is: "What is the right mix of crop and stock for my property?"

The message from Grain & Graze is that, from an economic perspective, there is likely to be a wide range of 'optimal' mixes for any individual farm. Farmers can, and should, look at a range of factors such as land capability, system interactions, personal preferences and skills, natural resource management, and long-term business, farm and family goals.

Grain & Graze research has confirmed that (subject to commodity price changes) mixes with more livestock are less likely to incur serious losses in dry seasons, while those skewed to cropping can make bigger profits in bumper years. These are likely to be significant factors in a climate that is predicted to become more variable and extreme.

See: 'Finding the right balance' (page 31)

Complexity

There is no simple answer to the question of whether a specific mix of enterprises is optimal. It may be reassuring for farmers to hear that Grain & Graze has reinforced the belief that mixed farming is 'complex': there are many interdependent variables to be considered and numerous alternative, equally 'correct', solutions.

There are universal principles that can be incorporated in complex decisions (such as the importance of maintaining soil cover), and it is often possible to break decision-making down into less complex parts, but there are few standard recipes that apply beyond the region or district where they evolved.

Grain & Graze has shown that time-honoured practices like yarning with a neighbour, chatting with different advisers and contributing to discussion groups can all be useful mechanisms to help make complex mixed-farming decisions. Farmers have often been applying 'best practice' in complex decision-making without knowing it.

See: 'Making complex decisions' (page 37)

Grain & Graze identifies issues for mixed farmers to consider and ideas to try

Systems that are profitable in average years, that can survive harsh seasons without heavy financial or environmental losses, and that can minimise crop production costs tend to prove more viable in the longer run.

Enjoyment

Enjoyment is a big part of any job – especially when the workplace is also your home. Grain & Graze has highlighted that it is an important part of getting the balance right for individual farms.

That is not to suggest that farmers should only do the things they enjoy (or to belittle the fundamental importance of running a profitable business) but it does stress the value of acknowledging what is personally enjoyable and optimising the parts of farming you are best at.

Farmers are encouraged to factor enjoyment and satisfaction into their thinking about farming systems, and to actively seek methods and technologies that make work easier, simpler and more pleasurable.

Prices, and advances in technology that have made cropping 'easier', have influenced a strong trend towards cropping in temperate Australia (and increasingly in wet temperate and subtropical areas). However, factors such as drought, climate change and herbicide resistance in weeds are causing some to reconsider the crop-livestock balance and – especially in temperate regions – to re-introduce more livestock. Managing feed availability for stock without interfering with crop management will be critical.

See: 'Enjoying farming' (page 45)

Managing feed supplies

Feedbase

Any enterprise involving livestock has the challenge of maintaining suitable feed supplies year round. An important first step in managing feed supply, livestock numbers and the cropping requirements is to prepare a feed budget – a 'cash flow' of feed production and consumption.

Preparing a reliable feed budget depends on being able to predict:

- the feed requirements of livestock at different times of the year;
- the feedbase that will be available at different times of the year; and
- the alternatives available to manage the gaps (and their relative cost).

See: 'Feedbase management' (page 55)

Grazing cereals

For many temperate areas, one option to increase the availability of feed in a time of shortage is to graze cereal crops at an early growth stage – then grow the crop to maturity for grain harvest. This old practice has re-emerged with modern varieties and has been trialled through Grain & Graze in

Below: Grazing cereals can provide a 'free lunch' for livestock according to Grain & Graze.

several regions, helping to give a deeper understanding of management principles and the conditions required for it to be successful.

Grazing cereals intended for harvest is not feasible in subtropical regions and is risky in dry regions with poor soil water storage and where an assured finish to the growing season cannot be relied upon. However, in temperate regions which normally receive reliable finishing rains, it is possible to graze cereal crops without significantly reducing grain yields. In certain cases, provided seasonal conditions are favourable, the grain harvest may even be increased.

Some keys to effective grazing of cereals:

- sow early (as soon as temperature and soil moisture allow for successful establishment and early growth) and increase sowing density;
- graze crops as soon as individual plants are 'anchored' and able to remain rooted when given the 'twist test', i.e. they will break off instead of pulling out when grasped half-way along the leaf and given a pull and a twist;
- don't graze crops too late; remove stock no later than growth stage 30 (stem elongation) and ensure there is time for recovery and grain maturation;
- fertilise adequately and ensure N is not limited in the crop's later growth stages; and
- keep an eye on animal nutrition: watch out for symptoms of inadequate mineral intake, especially magnesium and sodium which may reduce livestock growth rates.

See: 'Grazing cereals' (page 63)

Pastures

Pasture selection and management is important in managing a feed budget as well as in working with cropping cycles and caring for the environment. Besides selecting species that will contribute as required to the feedbase, pasture selection also includes factors such as:

- ground cover and erosion control;
- biodiversity and integrated pest management;
- soil health and fertility (higher nitrogen);
- disease management in cropping rotations;
- stock health and condition; and
- opportunities for new income.

The use of different pastures can bring about important changes in farming systems overall. Their incorporation into systems such as alley farming and pasture cropping is being tested across Australia, while the growing interest in energy production from plants and carbon sequestration also appear to hold new pasture opportunities.

See: 'Pastures' (page 77)

Below: Mixed farmers are typically engaged in sheep and/or beef livestock production in conjunction with broadacre cropping.

Crop, stock and environment

Biodiversity

There are countless interactions between farm production and the environment. Environmental resources, such as soils and water, drive production. Other components, such as areas of native bushland, are affected by adjacent production, while also providing services to it (e.g. surface run-off, shade and shelter, and promoting pollination of crops). The trick is to optimise positive interactions wherever possible.

Grain & Graze has highlighted some key biological interactions where biodiversity benefits production (e.g. soil biology and pest management) and shown that farmers have a valuable role to play in arresting and reversing the decline of native species and ecosystems – especially through their management of areas of remnant vegetation and native grasslands.

See: 'Natural assets' (page 89)

Pest management

Grain & Graze has shown that biodiversity can help to lower farm costs of production and reduce the risk from chemicals used in pest control. Projects in wet temperate areas have shown that it is possible to put biodiversity to work to control many crop and pasture pests. Indeed, past chemical use may even increase the risk of pest outbreaks by also killing off predatory insects that normally keep the pests in check.

Referred to as Integrated Pest Management (IPM), the main features are:

- monitoring the presence and abundance of pests and 'beneficial' predators that prey upon them;
- giving these predators time to build up in numbers and control the pests;
- managing farms to maintain populations of beneficial predators and suppress pests; and
- strategic use of selective pesticides – instead of broad-spectrum chemicals that kill predators along with the pests they prey upon.

Adopting IPM requires time to be spent monitoring pest and beneficial populations and the ability to identify invertebrates – often to the species level. It also requires a degree of faith and patience. Instead of spraying pests as soon as they are identified (or as 'insurance' to prevent them becoming a problem), it is necessary to allow time for nature to take its course by allowing predator numbers to build up and get on top of the pest.

See: 'Managing pests' (page 101)

A refuge for native flora and fauna

Mixed farms provide important refuges for native flora and fauna, which offer a range of benefits to farms and farming families as well as to the nation.

Many of Australia's mixed farming landscapes have been extensively cleared, and species that relied upon them (such as woodland birds, mammals and reptiles) have declined in number.

In some parts of the country this loss is continuing. This makes on-farm remnant vegetation of national value and significance, especially when it forms stepping stones between larger blocks of vegetation or refuges from which native populations of plants and animals may be able to recover.

Soil management

Another productive aspect of 'biodiversity' considered by Grain & Graze has been soil biology.

All farmers know that good soil management underpins mixed farming. Soils hold and release the water and nutrients essential for plant growth; provide a substrate in which plants can grow; and host soil biota (insects, worms, protozoa, fungi, microalgae and bacteria) that break down organic matter (such as stubbles and leaf litter) and recycle their nutrients into forms that the next year's crop or pasture can use.

Soil carbon levels are a mainstay of biological activity in soils. Keys to having high levels of biologically available carbon are:

- having high crop and pasture production to begin with; and
- retaining and recycling as much plant matter as possible.

Maintaining the soil's nutrient status is also of fundamental importance. Elements such as nitrogen, phosphorus and potassium, and micronutrients which are removed in grain, wool or livestock sales, or lost through leaching or erosion, must be replaced, either from soil stores, natural sources such as nitrogen fixation by legumes or by applying fertiliser.

In mixed farming systems, pasture-crop rotations, grazing period and intensity, tillage and other aspects of management can be used to obtain biological benefits for the soil. These practices promote higher levels of organic matter in the soil, as well as high nutritional status, soil structure and water infiltration. Having good levels of soil carbon can also reduce the need for fertilisers, cut costs and lower the greenhouse contribution from farming.

Besides lowering production costs (by reducing inputs such as fertiliser and fuel) many of the management measures used to improve soil function also serve to protect land from further loss of nutrients and carbon from wind and water erosion.

See: 'Managing soils' (page 115)

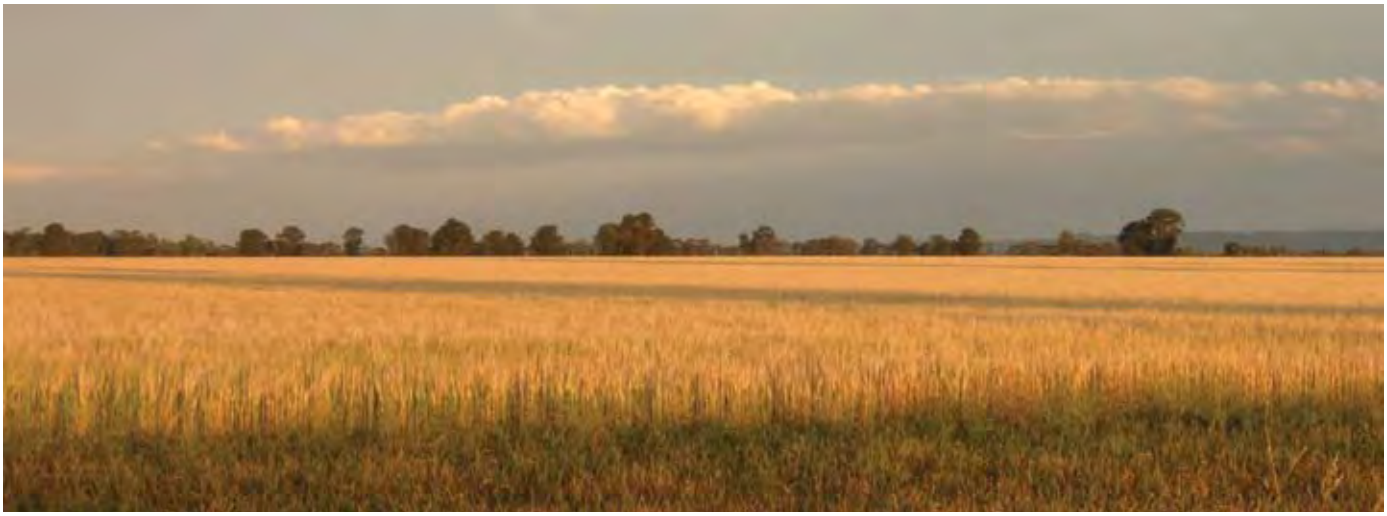
Good soil management is of fundamental importance.

Having a go

To make sense of the complexity, synergies and conflicts inherent in mixed farming it can be handy to:

- Do an audit of farm resources (the farm plan is a useful place to start):
  - identify arable land – within this, segregate the most productive and poorer soils, and any that need special management; and
  - identify non-arable land – determine which parts are most suitable for grazing, which have high conservation value, and which are vulnerable and require special protection.
- Develop a list of possible enterprises most suited to each land class or soil type under probable rainfall patterns based on the best-adapted native and exotic plant and animal species or varieties – and with due consideration of current and projected demand, prices and gross margins.
- Acknowledge the aspirations of those involved in the management of the property – identify their long-term goals, attitudes to risk, etc, and their specific skills, knowledge and interests.
- Select appropriate strategic options – the enterprises or commodities to be produced and the appropriate mix in terms of land capability, profitability, preference, aspirations, synergies, conflicts and trade-offs, existing infrastructure, capital and acceptable investment levels, etc.
- Tactics – talk it over with advisers or respected farmers and devise action plans for each enterprise choice to achieve agreed factors deemed critical to success, such as:
  - maintaining or improving soil resources as measured by soil organic carbon levels and balanced nutrient budgets;
  - optimising water use efficiency for maximum profit across all enterprises;
  - maintaining a healthy net profit (e.g. a rolling five-year average) through variable seasons and commodity prices;
  - being able to take annual leave each year; and
  - protecting iconic native species on the property.
- Reflect on any synergies or conflicts and trade-offs in the proposed actions and consider how successful they would be in alternative future scenarios (e.g. changing commodity prices or different seasonal conditions such as drought and floods).
- Get started. Taking the first step can be the hardest part. Making a small, achievable first step can be a great way to start implementing a bigger plan that seems daunting, risky and expensive when viewed in total. Tackling it in parts reduces risk, retains flexibility for considered changes to plans and increases the likelihood of success.

Below: A farm audit is a good starting place to identify farm resources.



Benefits and risks

Farm businesses with both crop and livestock components have advantages and disadvantages. The main pros and cons of the Australian mixed farm are discussed in this chapter under:

- Managing risks
- Production
- Diversity and skills
- Complexity
- Livestock
- Healthier landscapes

This discussion aims to draw out some of the potential benefits and risks inherent in mixed farming. It does not 'sell' any particular approach but explores some facets and considers their implications. It raises questions that farmers face and indicates how they could go about finding their own unique answers to them.

Managing risks

Having more than one enterprise gives farmers the opportunity to spread the production risks associated with seasonal variability and the financial risks caused by fluctuating markets and exchange rates. If prices for one commodity are poor, they may be better for another. Similarly, crops may fail in a dry year but, if perennial feed, affordable hay or grain is available and stock are managed to avoid damage to the land, then stock can still generate income, helping to add stability to the farming enterprise.

Expenditures and income associated with crop and livestock commodities occur at different times of the year, which helps smooth cash flow. This can make the farm business easier to manage.

Being diversified doesn't guarantee success. Mixed farms must still be well managed to perform well. They also require more equipment (tractors and harvesters) and infrastructure (stock yards, fencing and shearing sheds) to cater for several production systems and this can add to the capital costs of the enterprise.

Mixed farming helps spread risk and smooths cash flow

"It's no good being a 'Jack of all trades and master of none'. You have to be on top of all aspects of the business ... but in 2006 my Northern Mallee Breakthrough Group (farm discussion group) completed its benchmarking. Being a drought, I would have expected businesses with a spread of livestock and crop would have minimised their expenses. In fact, it was a continuous cropping farm that provided the best financial results ... 'good' managers, no matter what the system, can manage climatic ups and downs, and still perform."

Mike Krause, Farm Business Economist

Livestock offer farm productivity gains

In contrast, specialist producers can focus all their energies on one or two commodities and are under less pressure to compromise the management of one component of the system (e.g. grain) to accommodate the needs of other enterprises (e.g. stock). They can use alternative ways to manage financial risks, such as off-farm investments or Farm Management Deposits.

In any farming system it pays to take a long-term view. Performance can vary significantly from year to year. Systems that can survive poor years (in terms of production, market prices or increased input costs) as well as returning sound profits in better years may be good options even if they don't deliver the spectacular returns offered by other systems in a big year. There is value in the adage that slow and steady wins the race.

*** PEAK OIL**

The time when the rate of production of oil will peak before declining as global reserves are drawn down. Predictions are that humanity is now at, or nearing, 'peak oil' and that scarcity and irregularity of supply will force prices up as availability declines and demand rises. This is likely to cause increases in the price of many farm inputs, including fuel, fertiliser and pesticides and in the cost of transporting farm produce.

Production

Mixed farming enterprises are, by nature, more resilient than monocultures, offering farmers a greater array of choices in dealing with market and climate variation. There are also important synergies between different enterprises. For example, using stock to break down heavy stubbles or graze out weeds saves on pasture and costs less than tillage or spraying. Weeds that are resistant to herbicides are still highly susceptible to sheep and, with the rise in resistance, grazing is becoming an increasingly important part of the strategy for controlling weeds in following crops.

With the world facing 'peak oil' * and rising energy prices likely to affect the cost of fuel, fertilisers and chemicals used in cropping, the livestock enterprise offers a means to balance income, limit costs and still lift overall farm productivity.

In many areas, farms include different types of country and soil types, so mixed farming is a way to optimise total production. Using land to its capability (e.g. cropping on flats while grazing hilly country) enables the whole property to be productive while also getting the best financial return for all inputs (e.g. not wasting fertiliser on less responsive land).

Having livestock in the system is also a potent way of managing, or bringing back, less productive or degraded lands, like salt-affected areas. Once the capital costs of establishing pastures in these areas are covered, they can again be profitable components of the farming system.

On farms with high physical variation it may make more sense to use the quality land exclusively for high-input farming, and adopt a very different management approach in the rougher country, using few inputs and grazing stock strategically.

Risk and uncertainty

Uncertainty is a lack of confidence that an event will occur or what the outcomes may be. There may be uncertainty about what will result from a particular action or just no feeling for the likelihood of different outcomes.

Risk involves both the probability of an adverse event occurring and the likely size of the impact if it does.

A risk can be considered as an uncertainty for which there is some understanding of the chance (or probability) of different outcomes. Working out the odds (even roughly) converts an uncertainty into a risk – and helps make it more manageable.

Sometimes there may be a trade-off between risks or a transfer of risk. A production risk (such as not having sufficient nutrient available for optimal crop growth) may be overcome (by applying fertiliser) and could then generate an environmental risk (such as excess nitrate leaching into groundwater below the crop). People may accept a higher production risk if it offers the opportunity for increased profit.

A risk is also a matter of perspective: one person's risk may be another's opportunity. For example, grazing stubbles may increase the risk of ryegrass seeds being trampled into the ground and emerging in next season's crop. That's a risk – unless the decision is deliberately taken to profit from it by boosting the rye grass and harvesting it as hay.

On farms where the country and soils are relatively uniform, stock and crops can be closely intertwined, taking full advantage of the way they support one another and using the benefits of rotating between pasture and cropping phases, such as:

- nitrogen build up from pasture legumes;
- increased soil organic matter from grass-legume pastures;
- benefits to disease and weed control from rotations; and
- using cropping as a step in renovating pastures.

Some producers have reduced their grazing activity to focus on cropping, because it can deliver the highest return in a good year. On some soils, there may be issues about soil compaction from stock and, if poorly managed during drought, stock can cause erosion and loss of fertility. However, there are equivalent concerns about soil compaction from heavy machinery and erosion from tilling sloping soils, which can, in turn, be addressed by precision agriculture and controlled traffic cropping, etc. These illustrate the complexity of issues and options that surround even basic questions in mixed farming.

Diversity and skills

Farming different combinations of crops and livestock provides opportunity for greater diversity within the management structure of the farm. In family businesses, one family member may specialise in livestock management while another handles the cropping and a third manages marketing or keeps the books. This shares the load, takes best advantage of the family's individual ideas and skills, and satisfies the needs of individuals by allowing each to follow their passion. It can also be effective in succession planning – gradually increasing the knowledge and responsibility of the next generation in a staged transition.

The inherent diversity of a mixed farming business enables its managers to position themselves to take advantage of changing circumstances and emerging opportunities. As markets or input costs vary, or as different seasonal conditions emerge, a diverse enterprise has the potential to scale up production of a commodity that will make the most of the opportunities to hand. There will be transition costs such as buying stock but mixed systems are intrinsically more flexible and adaptable than a single commodity system.

Match land use with land capability

Below: Mixed farming offers options to match skills and opportunities.

Case Study: The Smiths,* South West Slopes, NSW

Four families live off the farm business, making a strong focus on profit vital. The family runs six main enterprises on their 1,490 ha, based on the idea that business diversity can provide stability:

1. Merino sheep: joining 3,000 ewes of 20 micron, aiming at high weaning percentages.
2. Dairy heifers: contract growing out 80-160 dairy heifers each year and joining them for return to coastal dairy farmers on the point of calving.
3. Cattle feedlotting: finishing around 130 head of cattle.
4. Lamb feedlotting: the family finishes its own lambs – up to 2,000 at a time – in order to run more ewes and maximise profits from each lamb drop.
5. Contracting: in 1999 the family started a windrowing business, which has recently been sold. They still carry out contract harvesting.
6. Cropping: rotations of wheat, lupins, triticale and some barley. The rotation includes a six-year cropping phase with a five-year pasture break. The family produces some straw bales and operates a lucerne seed enterprise.

The four families involved are: Jack and Jill and their three sons (and their families). The family has farmed near Canberra for the past five generations. In the '70s they gradually shifted operations to Young and West Wyalong on the South West Slopes of NSW.

There is a strong cropping orientation to the enterprise but family members also enjoy the grazing side. Their stocking rates now range from 10 to 13 dry sheep equivalents (DSE) per hectare, well above district averages.

In 1996, the family did Allan Savory's Holistic Management® course, which helped them to look for new ideas and shape their existing business. While initially drawn to the grazing components, they realised that the program offered a framework for running an integrated farm business.

"There is a local saying 'Enterprises doubled, management squared' so we are aware of the time and skills needed to run a diverse enterprise mix and develop new enterprises," one of the boys says.

The family plans out the sheep enterprise 12 months ahead and the cropping enterprise 10 years ahead, but this is flexible. Each year they examine enterprises in the light of seasonal conditions and prices and the least profitable are removed. The range also gives a good risk spread. The farm is structured so that each family member is responsible for an enterprise, which helps in planning regular holidays during enterprise 'down time'.

In such a diverse and integrated family farm business there are ongoing challenges. Working out the family partnership direction in the long term is becoming important. While the family gets on well and works well together, as children's education, retirement and other individual decisions arise, the structure of the business needs to be reviewed.

"The production stuff is easy, it's the goals and people stuff that is the hardest. Having family members who are good 'generalists' helps pull the operation together. Good communication and relationships are essential if all the enterprises and people are to work well together."

** This case study uses pseudonyms, but the details are drawn from a real property.*

Complexity

The diversity of a mixed farming system offers more opportunities – but it can also make things more complex. It holds more options to consider, a range of interactions (often not clearly understood – some offering synergies while others require a trade-off), and different ways to integrate them.

In the northern temperate and subtropical areas, where summer and winter growing seasons are possible, the range of options and complexity is even greater.

Analysing the financial performance of a mixed business can be tricky: understanding where the real costs and real profits come from is challenging, especially in systems where there are good synergies between different components.

Often, there is no one right answer for managers. What works in one season, or on one soil type, won't work in another. What works for one manager and their mix of skills and assets, won't work for a neighbour.

Decisions that involve lots of different variables, and for which several potentially 'right' answers exist, are known as 'complex decisions' – and mixed farmers face many.

They are difficult to work through and, especially if being considered in a time of stress, can be 'all too hard' – resulting in no decision being made at all. This can be a worse outcome than making a 'wrong decision'. It can result in the same thing being done over and over again, even though it's not working.

Recognising that some decisions are 'complex' and that they need to be tackled in special ways is a big step toward making them easier to deal with. Many mixed farmers are adept at that, even though it is a skill they do not think consciously about. Making complex decisions requires the acquisition of considerable specialist knowledge and mixed farmers often under-rate their aptitude at that.

Successful farmers have considerable technical expertise in a wide range of fields and they are very competent in the difficult art of making complex decisions.

Livestock

Livestock. Sheep especially. Some farmers love them, others hate 'em. Many just put up with them.

Having livestock can mean less free time and it can be harder to leave the farm on weekends or to take holidays. A constant eye must be kept on the animals' health and on their water and feed; and they must be 'parked' somewhere during intensive cropping phases. Then there is the challenge for sole-farmer businesses of mustering and drenching and the problem of finding and managing the additional labour required for shearing and other labour-intensive tasks.

However, for those who like stock and the joy that comes from working and breeding them, these are small costs for the rewards they receive.

Besides the benefits that stock may bring to an enterprise, there is the personal enjoyment of interacting with them – and, for some, pride in maintaining an element of a traditional lifestyle that has been at the heart of Australia's self-image for two centuries.

In some enterprises, the inclusion of livestock in a cropping system results in sufficient additional work to justify a full-time farm hand. This makes many farm operations easier while also giving flexibility for holidays and the security of knowing that while the owner is away there is someone

More options means greater complexity

Below: Streamlined management techniques can make many aspects of livestock handling easier.

Building resilient farms and landscapes

keeping a watch not just on the stock but the property over all. It is also a small step toward countering the declining population faced by many rural communities, and there are opportunities for neighbours to share an additional labour unit as well.

There are also many measures farmers can take to make stock handling easier. They range from adding laneways to make moving stock easier to adopting labour-saving technologies such as portable electric fencing, low-stress stock handling, auto-drafting, three-way drafting and walk-over weighing.

Increasing automation is heralding concepts such as 'self-managing sheep' and fenceless paddocks.

Recognising the importance of promoting innovations that make the management of livestock easier, Grain & Graze has partnered in a competition, *Raising the Baa*, to showcase the gains that are possible.

Healthier landscapes

The diversity of mixed farming offers many opportunities to retain and enhance quintessentially Australian features of the environment. The range of native and introduced plants on a mixed farm provide different habitats that suit various forms of animal life, from insects and spiders, through birds and lizards to kangaroos and possums.

Some of these species can be valuable to farmers. Natural predators of crop and pasture pests like red legged earth mite can be sufficient to control the pest, reducing the need for chemicals and lowering costs. Soil microbes similarly play an important role in improving the structure and function of soils, controlling soil-borne diseases, unlocking and recycling nutrients and boosting plant yields.

In many mixed farming regions, few tracts of native vegetation remain, raising their importance. Many farmers appreciate this and feel they have a significant role to play in helping populations of birds and animals that rely on native trees and grasslands. Native vegetation is not only for conservation purposes; many producers use native species as a fodder reserve in a drought, as windbreaks, as a barrier to prevent nutrients or livestock entering the creek, as a way to bring degraded or saline

Raising the Baa

Raising the Baa challenged Australian sheep and wool producers to showcase their innovations with livestock farming. The competition encouraged producers to submit their innovations and explain how they improved efficiency, ease of management, and enterprise development as well as environmental impact and benefits.

It was funded and partnered by Australian Wool Innovation (AWI), Meat and Livestock Australia (MLA), Sheep CRC, Grain & Graze, Kondinin Group and supported by Rural Press.

See: 'Enjoying Farming' and the Case Study on the Raising the Baa national winner, Andrew Dufty, page 51.

Opposite: Weaners on Andrew Dufty's property.

land back into production, and, in some cases, even as a tourist attraction.

As livestock can make the management of saline lands worth the effort, and as perennial pastures can help reduce the loss of water below root-zones, mixed farms are helping to deal with landscape-scale problems, such as salinity that owe their origins to land clearing in the first place. While farming has caused changes in the balance of the Australian landscape in the past 100 years, today it is also helping to re-stabilise it.

Management of livestock is a critical element in looking after the landscape. Strategic grazing can retain and promote native pastures whereas over-grazing may soon degrade them – and reduce the biodiversity of the district. Inadequately managed stock also cause erosion, especially during drought. Over-grazing can lead to a loss of nutrients, loss of soil fertility and structure (compaction) and harm to water quality (soil erosion). That stock can be both a benefit and a threat, depending on how they are managed, is further evidence that there are few simple answers for mixed farmers. It is a complex business, requiring a wide range of skills and understanding.

Complex decisions

Mixed farming decisions can be simple, complicated or complex. Working out what sort of decision it is helps to select the best way of making it.

- ***Simple** decisions have few variables, one right answer and generally do not require deep thought. They can be assisted by getting the right information, e.g. how much drench to give a 45 kg wether – the label shows the recommended dose.*
- ***Complicated** decisions have more variables, whose relationship is usually clear. They have a right answer, but it is not easy to arrive at and usually requires expert knowledge of the issue, e.g. what weed control system is the best one for a particular wheat crop?*
- ***Complex** decisions bring together a number of complicated decisions, often with many variables and where the different factors are not easy to compare with one another. There may be several 'right' answers to choose among, e.g. what is the right balance between livestock and various crops on my farm for the goals you have in mind and foreseeable circumstances? The degree of complexity increases with the number of variables to be considered.*

Often there is no obviously 'right answer' to a complex problem. It depends on the farmer's unique circumstances and personal preferences. What's certain is that such decisions cannot be delegated to someone else and, in the long run, there's no avoiding them.

This Grain & Graze work draws upon the Cynefin decision making framework developed by Dave Snowden, a leader in the applied theory of sense-making and knowledge management.

	One right solution	Many right solutions
Many variables	Complicated	Complex
Few variables	Simple	Complex

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Livestock require more constant time and labour to manage and their needs may conflict with optimal crop management.	▪ The benefits of rotations (e.g. soil health and disease suppression) may be mirrored at a landscape level due to the diversity of land uses in mixed systems (e.g. better pest control).
▪ Livestock may compromise soil health and grain yields (e.g. surface compaction and consuming organic matter at the expense of recycling it into the soil).	▪ Land being used according to capability, with each component contributing to the overall farm profit and enhanced production is the essence of a successful mixed farming business.
▪ Multiple enterprises are more complex and time consuming to manage.	▪ The flow of funds in mixed farming businesses can help smooth the variability of income between seasons and years.
▪ Different enterprises may compete for attention and result in sub-optimal management skill in any; compromising potential profit.	▪ Multiple enterprises provide more opportunity for diverse interests and skills among family members to work together to optimise profit and lifestyle.
▪ Dual enterprises require dual infrastructure, plant and equipment. It may be a trade-off between buying a new tractor or renovating fences, while smaller paddocks may suit stock management but disadvantage cropping.	

More information

- Low input, strategic grazing methods: the Sustainable Profit report from the Land, Water & Wool program, at www.landwaterwool.gov.au
- The Cynefin decision-making framework: en.wikipedia.org/wiki/Cynefin
- Raising the Baa: www.kondinin.com.au

Strategic challenges

The benefits and risks of mixed farming give rise to a number of strategic challenges for farmers. These are 'high level' challenges about how they structure and manage their operations and involve:

- getting the balance right between the different enterprises;
- managing a variable feed supply and demand;
- managing biodiversity; and
- keeping it simple.

These challenges have driven much of the Grain & Graze program which has developed ideas, options and solutions based on research and the experience of its farmer participants. The challenges and the questions they raise for mixed farmers are discussed in this chapter, with pointers to where some solutions and insights may be found elsewhere in the report.

Getting the balance right

'Finding the right balance' is often said to be the big challenge faced by mixed farmers.

There are a number of factors to consider, such as the right mix between cropping and livestock from a farming system perspective. If there are synergies to be had, how much crop and how much livestock will give the optimal outcome? Or, if there is a role for stock in optimising the use of dry matter produced, what is the right number of stock to run? There can be a trade-off between feeding livestock and feeding the soil (building up nutrients and organic carbon); will changing the number or type of stock change that relationship?

From a business perspective, how does profit vary with changes in the balance between stock and cropping? Is it the same for all seasons? What mixes have the least risk or the most potential profit? What mixes will best 'drought proof' the farm, make best use of the land types, or best lower production costs, or give most potential to reap opportunistic profits?

From an operational perspective, what mix is easiest to manage? What numbers

It's a balancing act: stock/crop and profit/risk

There is no 'right mix' and few rules of thumb to help decision making, but there are some, and there are certainly some tools and analysis that can be performed to help individuals make these complex decisions.

Know your feed supply; know your feed demand

and types of stock will best fit with a cropping regime? What changes to stock management (e.g. the time of year chosen for joining) will influence the outcome? How easy is it to co-ordinate, or shift, activities between commodities?

What level of capital investment is appropriate for different mixes of stock and cropping, and how much does it change with different mixes? Cropping is easier in big paddocks, but stock management can be better in smaller paddocks – what's the right size, or mix of paddock sizes?

For some, the question of balance may be about the emphasis on high-input agriculture compared with low-input production, or the balance between promoting natural systems and technology-intensive ones.

And, there is always the fundamental issue of farming land to its capability – the varied capacity of different classes of land will set boundaries in which the questions above may be considered.

All these factors need to be considered with a long-term view, and the 'answer' to many of the questions will depend on a mix of personal preferences, particular skills, the circumstances of the property and the business plan.

There is no 'right mix' and few rules of thumb to help decision making, but there are some, and there are certainly some tools and analysis that can be performed to help individuals make these complex decisions.

More information and ideas on how to answer these questions:

- ***Finding the right balance (page 31)***
- ***Making complex decisions (page 37)***
- ***Managing soils (page 115)***

Strategic and tactical decisions

Strategy – from the Greek word for a general – is about large-scale, 'big picture' plans, often involving interactive components.

Strategies tend to be long-term, incorporating a wide range of factors, both internal and external. They identify the overall goal/s and map out the broad means of getting there.

To be successful, strategies depend on good 'intelligence' – knowing what is going on in the wider world as well as on the farm itself, and having an idea how these trends are likely to play out over time.

Strategic decisions may involve things like:

- *shifting the balance between livestock and crop;*
- *shifting the balance between farming and conservation;*
- *adding saltland pastures to a production system and increasing the emphasis on livestock;*
- *deciding to bring livestock into a cropping system;*
- *identifying a market niche and tailoring production to it; or*
- *committing to an integrated pest management system.*

Managing variable feed supply and demand

Matching the supply and demand for feed is a challenge in all mixed farming operations, as neither is static during the year.

The volume and quality of feed available varies and can be supplemented in various ways. Stock numbers may also vary (with births, deaths, sales and purchases) as will their dietary requirements. There will be times of feed gap (deficit) and surplus.

Having a good understanding of the quantity and quality of feed available, and of the volume and nature of demand, is critical to ensuring good stock condition and to optimising the value of the feed available.

Just like a cashflow budget, a 'feed budget' is required, although it is not always straightforward to prepare and analyse.

What is the best use of the feed available? Is it to feed stock or to be 'recycled' to feed the soil? Is it needed to maintain ground cover and control erosion; or perhaps to harbour beneficial insects that will control other insect pests? Perhaps the carbon present should be incorporated into the soil (carbon sequestration) – or, there may be feed available, but does the quality match the nutritional requirements of stock at that time?

In many regions – especially the temperate zone – there are opportunities to graze crops being grown for grain, without affecting yield. The experience of Grain & Graze has shown clearly that this option is redefining what farmers regard as feed. Providing there is sufficient available moisture, the calculated grazing of crops in their early stages can provide a vital boost to the livestock enterprise during a feed gap, without a significant impact on the ultimate yield of grain harvested.

While there are variations in the supply and demand for feed during the year, there are also significant variations between years. The scope of these has to be incorporated in long term planning. Drought management is a critical consideration, with contingency plans needed to reduce demand and provide alternative feed in a cost effective manner, which also cares for the environment.

More information and ideas on how to answer these questions:

- ***Enjoying farming (page 45)***
- ***Feedbase management (page 55)***
- ***Grazing cereals (page 63)***
- ***Pastures (page 77)***

CARBON SEQUESTRATION

The capture and storage of carbon. Oceans, soils and plants can all sequester carbon. Soils store carbon in soil organic matter but release it as CO_2 following oxidation.

BENEFICIAL INSECTS

Ones that help farmers by preying on crop or pasture pests.

THE FEED GAP

The availability of feed (referred to as 'feed on offer') and the demand for feed from livestock both vary during a year. By comparing them it is possible to see when they are well aligned, when there is a surplus of feed and when there is a deficit – referred to as a 'feed gap'.

Tactics are more about short-term situations and actions. ('Tactics' is also a military word – the art of out-manoeuvring an opponent to win a battle.) They tend to be chosen from a set of options to deal with specific problems.

Tactical responses involve measures such as:

- *electing to graze a poorly finishing crop instead of harvesting it;*
- *managing degraded native pastures as a fodder input;*
- *buying in feed to maintain stock during a drought; or*
- *buying additional stock to take advantage of an exceptional season of pasture production.*

This report aims to bring out the strategic aspects of mixed farming as assessed in the Grain & Graze program and, in doing so, it makes numerous references to tactical options. These references draw on projects within Grain & Graze which should be consulted for detail of locally relevant options.

Biodiversity also provides benefits for farm management

Managing native plants and animals

Farms are often important refuges for native plants and animals, adding to the mosaic of reserves or roadside bush where they still survive.

These areas of vegetation offer advantages for farming (such as providing shelter, assisting with the control of pests and controlling watertables) but can also have disadvantages (harbouring vermin, competing for water and providing obstacles for large farm machinery).

Communities have expectations about how natural assets will be managed and governments have introduced various regulations and policies to protect native flora and fauna.

The first challenge for farmers is to develop a good understanding of the type and extent of the natural assets they have.

The second is to appreciate how they can be managed to complement their farming system, to protect the native species, and not introduce management difficulties.

Given the broader community interest (and benefit), there are also opportunities to engage wider support (e.g. grants for fencing or revegetation services) that must be balanced with the associated administrative responsibilities.

More information and ideas on how to answer these questions:

- ***Pastures (page 77)***
- ***Natural assets (page 89)***
- ***Managing pests (page 101)***
- ***Managing soils (page 115)***

Keeping it simple

The need to factor in enjoyment, easier management and better ways to make complex decisions has already been discussed. It is evident that social factors must be incorporated into planning and managing farming systems and that mixed farms present their own unique mix of issues and opportunities.

More information and ideas:

- ***Finding the right balance (page 31)***
- ***Making complex decisions (page 37)***
- ***Enjoying farming (page 45)***
- ***Natural assets (page 89)***
- ***Managing pests (page 101)***

Below: Natural assets are an important part of the farm balance sheet.

Finding the right balance

Summary

There is no single mix of crops and livestock that delivers optimal profit for a given location. Evidence from Grain & Graze suggests that mixed farmers usually have a range of alternative mixes that can perform equally well in average seasons, as long as the management is good.

Mixes with more livestock are less likely to incur serious losses in dry seasons, while those skewed to cropping can make bigger profits in bumper years. This is likely to be a significant factor to consider as the climate becomes more variable and extreme, as it is forecast to do under climate change. The challenge lies in anticipating what the season will be like and having the capacity to change the mix of crop and stock to suit.

Managing risk, working with the opportunities provided by different soil types and landforms, personal preferences, management skills and land management priorities all influence the chosen ratio of crops and livestock on mixed farms.

Systems that are profitable in average years, survive harsh seasons without devastating financial or environmental losses and minimise crop production costs, tend to prove most viable in the longer term.

There is considerable scope to adopt a range of enterprise mixes, and personal attitudes to risk will influence the outcome.

"There isn't an ideal mix of crop and stock – it can come down to management preference and other factors."

Mike Krause, Farm Business Economist.

Information and ideas

Finding the best profit

Working with an agricultural consultant on Eyre Peninsula, SA, Grain & Graze used a financial model to analyse the performance of farm businesses using different ratios of cropping and grazing. The results in the graph below show how mixed farming profits and costs vary according to the amount of cropping in the farm mix. In this region, when cropping makes up half or less of the enterprise, costs are fairly low and profits rise with the proportion of cropping activity. However, above 60% cropping, profits flatten out and then decline as costs climb steeply.

The analysis is based on an 'average' year and doesn't account for the different types of soil or landforms that could be present across a property, but it does highlight that there is a broad range of cropping and grazing mixes, from 50% to 80% crop, that provide 'near optimal' profit.

It is important to note that this data may vary considerably in a drought, an exceptionally good season (see information from the Mallee, opposite) and with different commodity prices. For example, in a bumper year crop profits would climb sharply, offsetting the higher costs. Similarly, changes in commodity prices will also influence the outcome – and have been a factor in farmers swinging toward cropping and beef production. The challenge is working out how different crop/livestock mixes respond to changing circumstances for the individual farm.

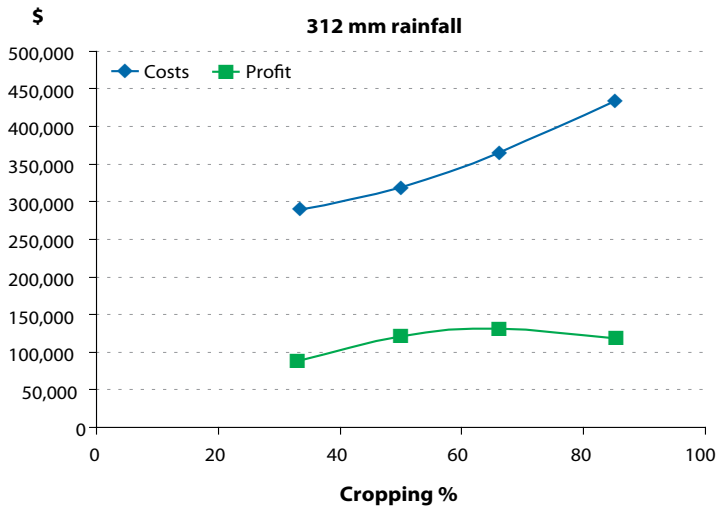
In support of this work, 26 farmers joined in a detailed analysis of their farms' performances. Analysis of their data showed that nearly 90% were viable. Most generated more than 75% of their total income from cropping, but farms which had more sheep (35-45% of gross income from sheep) were also viable.

There was little evidence of 'economies of size'. Smaller, well-managed farms were just as profitable as larger farms. It was also interesting that farmers with a higher proportion of their income from livestock could also be efficient grain producers.

The cost of production per tonne of wheat was the key driver of profitability and controlling the input costs of fertilisers and chemicals in cropping was critical. One of the most important findings confirmed that maximum inputs did not result in maximum profit (see Managing pests for information on low cost pest control options). The cost

Profit and cost relationships for different crop and stock mixes on the Eyre Peninsula.

Source: Ed Hunt (Ed Hunt Agricultural Consultancy)



of production per kilogram of wool was not a key profit driver but that may have been because of the relatively smaller commitment to sheep as compared to cropping.

This exercise suggests that the choice of enterprise mix can be freely influenced by the managers' preference and other factors, once a threshold of cropping is achieved. It also showed that in this region, conservative, lower-risk approaches (more livestock) can be more profitable over time and given 'average' seasons, than higher risk (more cropping) approaches that hold out the prospect of very high profits in a good year.

Changing prices – changing mixes

From an economic perspective, the optimum enterprise mix on a farm will change as the relative prices of livestock and grain change, as illustrated by examples from the Western Downs, Queensland. Several years ago the price of beef went up from $1.10 to $1.90/kg making pastures more profitable than grain on many farms (see the table below comparing wheat production in 2006 and improved pasture). Since then the price of wheat has more than doubled, making wheat more profitable in 2008.

Managing risks to maximise profit

A study in the Murray Mallee investigated how farms with different mixes of cropping and grazing fared in different seasons. A 'traditional' system (50% cropping and 50% grazing) was compared with a 'new' system (75% cropping to 25% grazing) – across the full range of seasons.

The results from the Mallee Sustainability Project show that the traditional 50:50 system performs better in poorer seasons by limiting losses. However, a 75:25 balance achieved greater profits in above-average seasons. While cropping specialists make big money in above-average seasons, those with a stronger livestock component lose less in dry years. The choice of mix depends very much on the farmer's personal attitude to how much risk they are willing to incur.

In the case of the Mallee farmers, the big challenge was that they had not experienced a good cropping season for the eight years up to 2007. Farms which were more livestock-orientated thus tended to outperform those with more crop. If greater seasonal variability is one of the consequences of climate change, farmers will need to think carefully how to structure their enterprise for risk, as bumper years may become more infrequent.

Specialised farms face more seasonal risk but can make higher profits in good years

Profits from grain, forage crop and pasture – Western Downs, Queensland

	Wheat 2006	Wheat 2008	Sorghum 2008	Grazing Oats[1]	Improved pasture[2]
Yield kg/ha	2800	2800	3200	200	168
Price $/t or kg	175	410	220	$2.00	$2.00
Return $/ha	490	1148	704	400	336
Fuel and repairs	54	68	68	70	30
Fallow spray	40	55	45	35	0
Seed cost	24	34	22	45	14
Fertiliser	74	90	80	32	0
Herbicide	11	14	25	0	4
Harvest, misc.	44	52	52	70	38
Growing costs[3]	247	313	292	252	83
Overhead costs[4]	145	160	160	140	80
Profit $/ha	98	675	252	8	170

1. Grazing oats: 2 steers/ha, 100 days = 200 kg beef.
2. Pasture income: 1 steer: 1.6 ha, 0.75 kg/day x 360 days = 168 kg beef.
3. Growing costs include a portion of cattle costs of freight, commission on sales, etc.
4. Includes labour $64/ha, machinery overheads $52/ha, administration $44/ha.

Source: Peter Wylie

LeyGrain – Moving between crops and pastures

In the subtropical northern grainbelt of Queensland and northern NSW, there has been a trend to include more pastures in what have traditionally been regarded as cropping soils. This has been supported by commodity prices and has occurred in response to rising costs of nitrogen fertiliser and fuel, herbicide-resistant weeds and an increase in crop disease, particularly crown rot.

The Queensland Department of Primary Industries and Fisheries (QDPI&F) and the NSW Department of Primary Industries (NSW DPI) developed LeyGrain, a participatory action-learning workshop and decision-support process, to assist producers in integrating pastures into their cropping land. It helps farmers make decisions about moving paddocks into and out of pasture.

LeyGrain consists of four workshops, followed by on-farm planning, monitoring and evaluation. Participants receive a PRECaPS decision-support model, which enables whole-farm economic analysis. It is a steady-state interactive model with many worksheets based on Microsoft Excel, which enables the whole-farm economic comparison of systems over rotation cycles of up to 10 years.

PRECaPS is able to compare crop and crop/pasture rotation scenarios set by the operator on a site-specific basis based on seasonal conditions, market strategy and individual farm management. It incorporates risk analysis based on yield (or production) and price-risk probabilities, producing outputs that enable the operator to view the range of outcomes associated with different seasonal and price variables. PRECaPS enables farmers to quantitatively assess the economic impact of changing farm management systems.

In 2005/06, LeyGrain was accepted as a pastures extension tool in the Border Rivers and Maranoa/ Balonne Grain & Graze projects. It has now been modified for use nationally through Grain & Graze projects in southern and western Australia. The project team at QDPIF worked with NSW DPI, South Australian Research and Development Institute and the Department of Agriculture and Food, WA to fine-tune the package according to the farming and grazing systems in those areas.

'Weather risk' plays a vital part in influencing the profitability, and indeed survivability, of different farming systems. With climate change predicted to become part of the farm management landscape, the issue of striking the right balance between crops and livestock needs to factor the resilience to stand up to a run of poor seasons into consideration.

Other factors and preferences

The Eyre and Mallee economic assessments suggest there is considerable scope to adopt a range of enterprise mixes and that personal attitudes to risk will influence the outcome. There are other factors to consider as well – as systems that suit the personal skills of the manager will also perform best.

Individual expertise and preferences will be important (e.g. a love of livestock or pride in delivering a good clean crop). Similarly, there will be questions about the capability of different soils and landforms on individual properties to perform best for different purposes and there will be 'whole system' issues to consider (e.g. the role of pastures in building organic matter in soils, managing ground-cover during a drought or the ability of perennials to use water and reduce recharge to groundwaters in wet years).

BELOW: An early feed trial on the Eyre Peninsula.

Having a go

Many farm advisers have their own 'mini-models' of production and profitability, and models such as MIDAS (see page 81) can be used to explore the outcomes of different commodity mixes under different seasonal conditions. Farmers interested in seeing how their figures look when analysed in this way could talk with an adviser or make contact with a Grain & Graze group.

As there is a range of 'near optimal' mixes, it can also be rewarding to contemplate the other issues that influence the 'right' mix for an individual property; things like land capability, available capital and equipment, and management expertise and preference.

Consider the implications if climate change occurs as predicted. Assuming that seasonal rainfall will become more variable:

- select an enterprise mix compatible with your attitudes to risk;
- develop and prepare plans for good, average and dry seasons, and early or late starts in your area;
- manage drought by optimising profits in the good years to help survive the poor; and
- develop a calendar of farm actions for each scenario – including triggers for a change in plans.

Case Study: Matt & Amanda Cook, Eyre Peninsula,SA

Matt and Amanda Cook usually crop some 1,300 ha and run a 900-head Merino ewe flock, in which the top ewes maintain the purebred female line for wool production and the remainder are mated to terminal sires for prime lamb production.

They had begun to seriously question the balance between their cropping and sheep enterprises after a difficult season in 2006, when grain yields fell as low as 0.2 and 0.4 tonnes to the hectare.

After taking part in Grain & Graze farm profitability workshops, the pair are now using the Plan2Profit computer program, taking advantage of its 'what if' capability to calculate the most profitable crop and stock options after factoring in the timing and quantity of autumn break rain and the likely prices for grain and sheep.

Traditionally, they expect to make around three-quarters of their farm income from cropping and one-quarter from the stock, but in 2005 and 2006, when crop income dropped right away, returns from the wool and lambs remained about the same as they were in a good year.

"There's no arguing that, if you have a significant debt, cropping will pay it off a lot faster, and a lot of people have got right out of stock," Matt says. "But livestock are more stable, and people sticking with them often work on the basis of splitting their land area 50/50 between cropping and sheep. We've normally been on a 65/35 split."

In 2007, the pair did their sums and decided to stick with the higher cropping percentage because of high world grain prices and likely strong returns.

"We are reasonably well-hedged, but do have the capacity to change quickly, reacting to the season or if wheat prices go down and cropping looks like being less profitable," Matt says.

"In that scenario we would go more into sheep, possibly buying some in. Livestock require so little capital investment, while in cropping large equipment is a necessary evil. Once you are set up, with good fences, yards, piping and troughs, livestock are a lot easier to manage."

Discussion groups provide opportunities to explore options.

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ The most profitable enterprise mix may be in conflict with management skills and preferences.	▪ Success in mixed farming involves physical matters such as water use efficiency, balanced nutrient budgets and the addition of soil carbon, in synergy with the key profit drivers, such as: – adjusting crop and livestock according to relative profitability; – minimising production costs; – marketing strategies to lift average price; – planning for seasonal rainfall variability and risks (frost, hail, dry periods, etc); and – undertaking key management actions at the right time.
▪ Flexibility to change enterprise type and scale may be limited by the time required for change, available resources, infrastructure and land capability.	▪ Under-performing crop paddocks may benefit from a well-managed, productive pasture phase to increase soil carbon and reduce soil-borne cereal disease for long-term benefit.
▪ Changing enterprise mix and scale in response to prevailing commodity prices increases the complexity of management and planning.	
▪ The availability and demand for labour may be in conflict between enterprises when peak activity coincides within a season.	

More information

- Grain & Graze regional projects at www.grainandgraze.com.au
- Plan2Profit: www.appes.com.au
- LeyGrain: www.grdc.com.au/director/events/groundcover and follow the links to Issue 62 and the article, 'The LeyGrain package: integrating pastures into cropping land profitably'

Making complex decisions

Summary

Making decisions for a mixed farm is a complex and demanding process: factors such as money, family and farm environment must be taken into account and weighed against one another to reach a viable decision.

Mixed farmers face layers of complexity in this process because there is more than one enterprise to consider and many options are available, especially in areas that can grow both summer and winter crops.

Typically, there are three sorts of decisions encountered on the farm: simple, complicated and complex. These are all solved in different ways. Working out what sort of decision it is first can help in selecting the best way of tackling it. Social factors like personal or family preferences also play a big part in the complexity of decision-making on mixed farms.

This section contains some tips derived from farmer experience in Grain & Graze for making better complex decisions. It looks at the growing role of local discussion groups as a valuable place for farmers to debate, discuss, dissect and share the complex decisions they face.

Complex decisions involve evaluating and balancing competing options

"Rather than always making rational decisions, humans make decisions by matching the information they are getting with their own (or collective) experience and expectations. They also do things according to habit (rather than conscious reflection), while observing and copying others, and tend to go out of their way to avoid losses without accurately assessing the probabilities and risks."

Nigel McGuckian, National Social Influences Research Coordinator for Grain & Graze

Information and ideas

Complexity

One reason mixed farming decisions are so complex is that there are many factors in each major decision that are hard to quantify or to relate to one another. The mixed farmer must weigh up the influence of all these factors and make a decision that matches their goals.

Farmers are constantly making decisions, for the most part extremely sound. Daily decisions are made about handling stock in relation to feeding and various other husbandry issues. Medium-term decisions include managing pastures for greater productivity and how best to improve or maintain infrastructure on the farm. Grain growers make decisions about varieties, timeliness of sowing, soil preparation, weed control and suitable rotations. Each of these decisions lies on a spectrum between simple and complex.

Farmers make many decisions based on a combination of intuition, experience, lifestyle and cultural factors, and their own personal or family goals. Big management changes are unlikely to be contemplated unless farmers are convinced these changes fit in with their goals.

As a result, most farmers seldom rely on financial analysis alone to determine enterprise mix. Factors such as soil type, labour requirements, family and personal preferences frequently outweigh purely financial considerations in arriving at the 'right' mix.

Making complex decisions

Mixed farming is all about making good, complex decisions – about balancing the needs of the various enterprises with those of the farm, the farmer and the family as a whole.

Typically, the sorts of decisions encountered on the farm are of three kinds: simple, complicated and complex (see below for their characteristics). These are all solved in different ways and working out what sort of decision it is first can help in selecting the best way of tackling it.

Types of decisions in mixed farming

Simple decisions

- *Few variables*
- *One right answer*
- *Are assisted by accurate information*
- *Can delegate the decision to someone else*

Complicated decisions

- *Many variables*
- *One right answer*
- *Can be assisted by advice (can delegate the decision)*

Complex decisions

- *Many variables (often non-comparable)*
- *Many 'right' answers (depending on personal preferences, values, context)*
- *Many simple and complicated parts (some of which can be delegated)*
- *Decision making is intuitive as well as rational*
- *Can be assisted by hearing and telling similar stories about decision making*
- *Ultimate decision rests with farming family (can't delegate a complex decision)*

Social factors

Social factors play a big part in the complexity of decision-making on mixed farms – although this is not always fully acknowledged by farmers and their advisers.

Often the fundamental reasons a family keeps on farming are social drivers such as lifestyle preference, being independent, flexibility, the opportunity to work with their children, attachment to the land or simply because they like the work. Money isn't always the dominant factor.

Strong drivers of farmer's decisions include:

- whether they enjoy or dislike a particular enterprise;
- labour availability and skill levels;
- the need to find time off for family and recreation; and
- the wish to keep a system simple and avoid complexity.

Ways to enhance decision making on mixed farms identified during Grain & Graze interviews with farmers include:

- Farmers have been making complex decisions for years and have much experience in their own enterprise. Advisers and extension officers will find more traction with farmers if they understand how their advice fits into a much larger picture.
- Advisers and researchers can help farmers make complex decisions by clarifying the complicated parts of the decision through a greater understanding of its variables.
- Farmers can delegate complicated parts of their complex decisions to advisers. For example, agronomy decisions can be made by a consultant agronomist with little input from the farmer. This allows farmers to focus on the complex decisions.
- Farmers may make better complex decisions if they have a forum for 'story telling', sharing experiences and bouncing ideas off colleagues. Discussions groups are proving popular with Grain & Graze farmers, where they share their stories and challenges and compare approaches.

Below: Field days and farm walks are good places to discuss complicated and complex issues.

Tips for better decision making

- ***Be clear about your goals.*** *Everyone in the business must know why they are there and what they are trying to achieve. It is important to make time to sit down and work out what everyone wants.*
- ***Be objective with separate parts of the decision.*** *Complex decisions involve many complicated parts. Some have a quantifiable relationship which is known; other parts have relationships which are unknown. Where the relationships are quantitative or logical, make sure you know what they are.*
- ***Trust gut feelings in making complex decisions.*** *Where the relationships are known, you need to use a combination of gut feeling and experience to put together all the inputs and make a good decision. Your gut feelings are usually a guide to your goals and motivations.*
- ***Don't delay big decisions.*** *Delaying a decision due to uncertainty can be bad. Drought and the uncertainties it creates often cause people to fall into the trap of continually watching and waiting when they should be acting. (The Land, Water & Wool program highlighted the importance of setting 'trigger points' – dates by which critical decisions had to be made – and then getting on with it.) Have a documented plan that specifies the dates big decisions need to be taken by.*
- ***Be simple, be smart.*** *Because everything is becoming more complex, it is important to simplify your system. Simple uniform systems are a characteristic of many successful farming businesses. At the same time, these systems most allow the enterprises to work together in the best way.*
- ***Story telling helps.*** *By comparing stories about complex decisions, farmers find they can improve your decision making. It helps them to understand their goals, motivations, fears, experiences and biases. To tell your story effectively you need to trust others – and be prepared to talk openly about profitability.*

Talking things through

Discussion groups have become a powerful learning tool for mixed farmers in Australia and are likely to be even more valuable in years to come to debate and discuss the complex decisions they face in mixed farming systems.

The Grain & Graze experience suggests the most effective groups have:

- a small number of members (no more than 10) who commit to about four meetings a year;
- eight farm decision makers and two advisers;
- meetings held at a member's farm with a focus on the farmer's business;
- details of financial performance presented to the group;
- farmers clearly stating their farm goals to the group;
- agreement to be open and honest with one another and to treat what they hear with complete confidentiality – trust is a big part in the group's success;
- meetings facilitated by someone with experience in mixed farming businesses;
- advisers who both listen and reflect back what they learn; and
- discussion about trade-offs, risks, decisions and future plans.

Below: Discussion groups and farm walks are valuable ways to share knowledge.

The value of failure

Traditionally, researchers and advisers illustrate the adoption of new farming systems with 'case studies' – stories about farmers who have taken up the new technology. These often contain an inspiring account featuring 'best practice' about how well it is fitting into a particular farm family's operations and lifestyle.

While these have much value, they are sometimes less instructive than stories of struggle, difficulty or failure encountered in trying to adopt the innovation.

In farming, learning what can go wrong and what not to do is as important as learning what to do. Nobody likes admitting 'failure' or a mistake, but if seen in the light of a valuable lesson well-learned, it becomes an essential ingredient for success.

This wider and more truthful approach allows farmers to better weigh up their own situation (in terms of money, farm physical characteristics, personal and social factors) by identifying potential pitfalls, as well as the benefits of a new system or technology from the experiences of others like themselves.

An important learning from Grain & Graze is that farm case studies and farmer discussions should contain accounts of difficulty, challenge and failure as well as partial and complete success.

Case Study: The Bakers,* south-west Victoria

Simon and Louise Baker reached a turning point in their farming lives when the bank started to ask difficult questions. They took the opportunity to have a hard look at what they were doing and 'bit the bullet': how were they going to make a profit? Were they running the right kind of sheep? Should they get out altogether and do something else?

Rather than selling, they made some major changes, simplifying the enterprise to just one type of sheep and a simple crop rotation. Then they changed their own approach to run the farm in a much more businesslike way – basing each decision on its business impacts, rather than just what felt right. Under this new approach they bought additional land and increased their equity.

The sheep and grain sides of the 681 ha mixed farm are roughly equal in terms of land area used and income earned. Although Simon makes many day-to-day decisions himself, the couple make all the big decisions together. Louise manages the finances and keeps a close eye on progress by keeping an up-to-date budget and tracking actual income and expenditure each month. The Bakers keep an open mind about the future and regularly review their plans.

The cropping rotation is canola-barley-clover-hay-wheat. Although most of the property is arable, the Bakers only crop 58% of the area. They direct sow, don't burn stubbles and have introduced canola into the rotation. Although they considered raised bed cropping, they decided against it. Their paddocks run in a range of directions, making it more difficult to manage, and they believe direct sowing minimises the problems with waterlogging, although they admit a very wet year could cause problems. Raised bed farming could also have a negative impact on the sheep enterprise.

Including a clover paddock in the crop rotation is a great benefit to both cropping and sheep. It provides an excellent disease break, is profitable and provides a fodder reserve and valuable clean grazing on regrowth in spring.

The improved pastures and stubbles allow the Bakers to run 1,600 Coopworth/East Friesian cross ewes at 12 dry sheep equivalents (DSE) per hectare for specialist meat production. The self-replacing flock averages a 132% lambing percentage and produces fast-growing lambs. Ewe lambs are joined at seven months and about 60% of lambs are dropped at 12 months. This reduces the cost of replacing ewes and allows fast genetic improvement.

Simon and Louise believe their farming system is successful because the enterprises work well together. Grazing sheep on crop stubble gives the pastures a three-month spell in autumn and stubbles aren't burnt because they are grazed hard. Growing barley after canola is low cost because the ground is clean and spring barley gives more room for sheep in winter. Ewes lamb in spring onto growing fresh pastures and selling lambs in late spring/summer means they are off the farm before the harvest.

The Bakers have made several decisions that spread their workload through the year. They moved shearing from late autumn to January (after harvest) This also fits well with joining, as the ewes are bare shorn at joining in February/March. Lambing was moved to spring to increase fertility.

** This case study uses pseudonyms, but the details are drawn from a real property.*

Decisions in drought times

Making confident decisions during a drought is difficult. The decision-making process is made even harder because of the extra stress and uncertainty.

Grain & Graze experience suggests farmers can be more confident by following these steps:

- Remember that there is no one right answer – but there is an answer which best suits your situation. It is essential to know where you are at. Calculating the profitability of the business over the past five years will give a good guide. A simple model can then be used to calculate the farm's sensitivity to varying commodity prices and production levels, and used to compare different enterprise mixes.
- Estimate the profitability of the chosen farming system into the future. Consider the effect of varying price and yield.
- Look at the effect of each option on labour requirements.
- Consider the effect of things getting drier and make allowances for this. How long will it be until you can reasonably expect rain and pasture growth? How much feed do you have on hand and how long will that last? What are the critical dates by which you must decide to sell stock or buy in feed?
- Ask yourself what you prefer to do, what strategy is most appealing?
- Discuss the above with other family members who are affected.
- Have a pre-determined strategy, with trigger points for decision making or actions.
- Discuss all these factors (warts and all) with someone you trust who is objective.

Using advisers

Advisers are a major source of information about new systems and technologies and can help in making both complicated and complex decisions. Grain & Graze has found that:

- *farmers can learn how to make complex decisions and test out their ideas by discussing them openly with other farmers and advisers;*
- *farmers can learn more about their own farming system by sharing stories with other farmers facing similar challenges; and*
- *farmers rely on past experience and tend to be conservative.*

Advisers need to recognise they are only a part of the decision-making process and there will be many factors of which they are unaware. Some advisers may find this frustrating but, if they recognise the other social factors involved, they will work with and respect the farmer's decision making.

The role of agricultural research is to inform the overall decision – not recommend 'best bet' systems. Extension officers should be aware that every mixed farming system is different and designed by the farmer to suit a set of unique conditions. Systems research that compares systems can be useful for describing their benefits and costs.

Having a go

Reviewing your goals, and the assumptions on which they were originally based, is an important place to start in making a complex decision.

The key to making a good complex decision lies in breaking it down into its main components and exploring them, one by one.

The 'simple' decisions can be resolved by doing one's homework to gather the necessary facts, or by delegating this to an expert (a partner skilled in crops or livestock, or a specialist farming adviser). There is usually only one right answer here.

Complicated decisions often have a quantifiable relationship to one another. For example, a decision to increase cropping at the expense of grazing is likely to have a broadly predictable effect on grazing and cropping income streams, and on probable farm performance in dry, average and wet years. These decisions can be explored and outcomes compared using some of the newer farm modelling software and the use of a broad-based farm adviser.

Decisions which help to simplify parts of the farm management usually make both complicated and complex decisions easier.

Complex decisions involve balancing these more definable factors with ones that are much harder to quantify, like changing family preferences, balancing the needs of biodiversity with those of the farm business, external consumer or regulatory factors or possible climate changes.

It is here that, after doing the basic homework, gut feeling and experience still offer the most reliable guide as to what should be done. The main thing to remember is not to put off a complex decision, simply because it is complex – but to chip away at it, testing its components, until the path forward becomes clearer.

Having some decent 'anchor points' – fundamentals that are important to a sustainable farming outcome – will also help. Examples include:

- Soil organic carbon levels should be stable or increasing. These are a key driver of the stability of farming systems which underpins production potential through nutrient holding and cycling, water holding capacity, soil stability and biological health.
- Water use efficiency – optimal efficiency is the key to productivity and is a handy diagnostic benchmark when looking for system problems.
- Match enterprises to land capability – optimise production, care for vulnerable lands and optimise the conservation of native biodiversity.
- Minimise transaction costs and optimise synergies in switching between enterprises on 'shared' land.
- Enjoyment – profit alone may not be enough; acknowledge and factor in the other rewards you seek from farming.
- Resilience and flexibility – position your farm to withstand climatic extremes or have the flexibility to work around them.

Testing likely outcomes against key factors for profitable and sustainable farming such as these can help deal with competing options in complex decision making.

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Effective decision making in a complex farming business may be constrained by differing views within a management team or a lack of skill and knowledge related to specific enterprises.	▪ Anchor points (such as improving soil organic carbon and water use efficiency) help with complex decision making and are valuable goals for sustained profitability.
▪ Comparing options and mulling over alternatives can fly in the face of the need to take immediate action. Procrastination can lead to lost opportunities and missed or delayed critical management action – seek advice, be proactive in planning scenarios and set firm trigger points (deadlines) for key decisions.	▪ Defining the enterprises suited to different land classes helps develop clear goals for decision making; reducing complexity and locking sustainability into production decisions.
▪ Lack of information or sound economic evaluation can lead to decisions based too much on personal preference and not on profit and environmental grounds.	▪ Small-scale trials can help decision making and learning about new farming options.
	▪ Maintaining or improving carbon and reducing energy use have synergies with reduced greenhouse gas output and also help cut farm costs.

More Information

- Making complex decisions: the discussion papers at the Grain & Graze website www.grainandgraze.com.au:
  – Decision Making on Mixed Farms – Managing Complexity
  – Mixed Farming Decisions – Doing the Sums
  – Farmers and the Triple Bottom Line
  – Confident decision making in drought
- Making risk management decisions: www.makingmorefromsheep.com.au/plan-for-success/procedure_1.4.htm

Enjoying farming

Summary

Enjoying work is at the heart of any successful business – especially when you live and work in the same place.

Grain & Graze has explored how farmers across Australia feel about the importance of enjoyment in their work and how it is factored into their planning, businesses and production systems.

Being profitable is a key to sustainability, but so is enjoyment.

It is important for farmers and researchers to consider how any proposed changes will make management easier – and not merely chase increased production without considering whether it demands additional labour and complexity which may lead to reduced enjoyment.

The management of livestock, especially sheep, could be considered less innovative than cropping in recent decades and has been a factor in decisions about enterprise mix, but this is changing.

There are opportunities to simplify and automate stock management, all of which helps make mixed farming more enjoyable. Grain & Graze has highlighted the importance of such innovations.

'Enjoyment' is a valid part of measuring farming success

"Many farmers, just like everyone else, are looking for ways to make life simpler and easier. Cropping systems have used innovative technologies over the past 20 years to make life simpler and easier for farmers. The sheep industry must investigate or promote ways to make running sheep simpler and easier. Some technologies have been available for many years but not adopted, e.g. bugle sheep yards, sheep handlers and good sheep dogs!"

Nigel McGuckian, National Social Influences Research Coordinator for Grain & Graze

Information and ideas

Balancing business and lifestyle

Enjoyment is central to the whole business of mixed farming, indeed to any career on or off the farm. It is what gives us the reason to keep going when the going gets tough. It provides the motivation to develop the farming enterprise as well as the individuals who work in it. It provides the 'buzz' of success, the honest pride in accomplishment, the pleasure in hard work and in caring for the land.

Farming is both a business *and* a lifestyle, and the two go hand-in-hand. People who run businesses from which they derive little enjoyment seldom do well, and this is especially true of farming where there may be long periods of drought or low prices to contend with, when farmers need to remind themselves about the reasons they farm and draw on their reserves and sense of enjoyment and satisfaction to see them through periods of worry, stress or doubt.

Farmers do run businesses and, like most business people, one of the main reasons they do so is in order to enjoy their lives more fully. Because of its diversity, versatility and challenges, a mixed farm has many opportunities for enjoyment – perhaps more than many other kinds of business offer.

In Grain & Graze, the farmers who took part agreed that enjoyment in farming comes from a range of factors such as:

- independence, flexibility and the freedom to make one's own decisions;
- the pleasure afforded by the farm landscape and nature, the peace and quiet, of being in a special place that means much to one;
- the ability to be with children and family far more often and flexibly than can most office or factory workers;
- the ability to work alongside one's children as they take their share of the farm chores and share their delight in aspects of the farm;
- the quiet satisfaction and fulfilment of watching things grow or of working with animals;
- the sense of purpose and self-respect that comes from being a producer of things valued by society and seen as essential to its wellbeing;
- the pleasure of creating a farm that will pass to ensuing generations in better shape than when you acquired it;

Farms provide families with the chance to work together and share experiences in a way not available to most non-agricultural workers.

- the enjoyment of working hard with both mind and body, of maintaining one's physical health and mental wellbeing;
- the satisfaction of solving complex problems and thinking through new challenges; and
- running a sound business and making money.

Farmers are fortunate in being able to perform their life's work in generally peaceful and rewarding surroundings, in being able to work at their own pace and according to their own priorities. When things have been tough for a long time, it is sometimes easy to forget or overlook this enjoyment. At such times it is vital to remind oneself of it, to keep up morale and motivation.

Farmer case studies in Grain & Graze show that farmers do, indeed, plan their farms and make decisions for enjoyment as well as sound business and agricultural reasons. For example, a decision to introduce a new technology may be motivated by a desire to make a laborious task easier or to free up the farmer for things she or he enjoys doing more. A shift from sheep to cattle may be influenced by easier management as well as by better returns.

However, because enjoyment is qualitative, it can be hard to compare against money and other quantitative measures; this makes the big decisions complex and often hard. It is not unusual for farmers to become anxious or confused when trying to weigh up the value of a course of action in a purely business sense against their own personal preferences. There can be a guilty sense, or anxiety, that one is indulging one's private inclinations instead of taking the hard-headed business decision.

Because enjoyment is so fundamental a part of farming, it needs to be acknowledged as an important, if not central, factor in any big decision. Everyone tends to be better at what they enjoy most and less skilled at the things they dislike – and this is an argument for playing to your strengths. It may mean not forcing yourself to carry out tasks that give you little pleasure – especially if the task can be taken on by another member of the family, a partner, an employee or simply made easier and less wearisome through intelligent use of modern technology.

Knowing what you enjoy and what you don't is an important part of making sound mixed farming decisions and should be acknowledged as a valid part of the process.

On the other hand, enjoyment has its pitfalls, such as becoming over-specialised or neglecting other tasks. On a mixed farm there is a risk of not developing the farm to its full potential by favouring one enterprise and neglecting others. Being aware of these tendencies is key to acknowledging the important part enjoyment plays in the complex decision making involved in mixed farming, positively and negatively.

Below: It's easy to take a farm's natural assets for granted and so overlook a key factor in many farmers' enjoyment of their workplace.

A farmer may conclude, from a purely fiscal perspective, they are better off moving out of livestock and into a zero-till system – but their enjoyment and skill in working with livestock contradicts that logic. Being conscious of the tension will enable the mixed farmer to more rationally consider the options, for example: "I want to keep some cattle: the question now is how many do I need to maintain my skills and enjoyment?"

Grain & Graze also found that an area that is bringing many farmers profound satisfaction is environmental sustainability and landscape rehabilitation. In an evolution from the time when the farming ethos called for native vegetation to be almost all cleared, many farmers today say they obtain great delight in restoring its richness and diversity while at the same time finding ways to use it profitably and sustainably. In many ways, the management and care of native plants and animals has become a part of the mixed farming enterprise, whether it makes money or not, and another thing which needs to be factored into its complex decisions.

Another area of enjoyment is new technology, which many farmers see as being not only about ways to work more efficiently and profitably, but also about making life easier, reducing stress and injury risk and creating opportunities for greater enjoyment and fulfilment both in the task at hand and elsewhere. For those with a technical bent, it offers new challenges.

Sheep: not always hard labour

In the Avon region of WA, Grain & Graze helped run a series of Sheep Innovator Forums which showcased a number of commercial options that can help make stock handling simple.

The field days showed that sheep no longer have to be hard work. Some of the innovations on display were:

- low stress stock handling: strategies to make stock handling easy and less stressful on 'man and beast',
- walk over weighing: combining electronic auto-identification with auto-weighing;
- three way drafting: combining electronic identification with automatic three way drafting;
- New mulesing technologies such as skin traction; and
- BioClip; injecting a protein that causes a break in wool fibres for easy, effective de-fleecing; a practical alternative to shearing.

Farmers at the Lake Grace Sheep Innovator Forum looked at a range of labour-saving ideas.

How much are you enjoying farming?

Farming life and the business of farming are closely tied together. Enjoyment is important to success in both and plays a big part in the decisions we make.

The simple test at right, distilled from the Grain & Graze experience, allows farmers to assess their current levels of enjoyment, and monitor them from time to time, to see if they are rising or falling. You can add your own personal criteria for enjoyment. Keep a record and compare your feelings now with how you feel in six months, a year or in five years. What has changed?

Rate your answer to each question on a scale of 1 to 5 where *5 is strongly agree* and *1 is strongly disagree*. Add up your score and check where it falls on the scale.

How much are you enjoying farming?

When I get up in the morning I am excited about the days farm work ahead.

1 2 3 4 5

When I am out on the farm I appreciate the natural landscape.

1 2 3 4 5

It gives me pleasure when I harvest my crop/shear the sheep/sell animals.

1 2 3 4 5

It is great to have the freedom to manage my time as I wish (be my own boss).

1 2 3 4 5

I enjoy having the family involved in the farming business.

1 2 3 4 5

I enjoy seeing the condition of the land improve.

1 2 3 4 5

I like mixing with other farmers and talking about farming decisions.

1 2 3 4 5

Farming gives us the freedom to get away as a family each year.

1 2 3 4 5

I enjoy the practical side of farming e.g. working with machinery, livestock, building things.

1 2 3 4 5

I like making decisions and solving problems.

1 2 3 4 5

TOTAL: ___

Scoring:

40 – 50	*You love farming. Celebrate this and stick with it.*
30 – 39	*Farm life is good to you*
20 – 29	*Life isn't bad but think about making changes*
10 – 19	*You aren't enjoying farming. Is it really for you?*
0 – 9	*Strongly consider a change*

Source : Nigel McGuckian

Farming easy

Like most Australians, farmers are looking for ways to make life easier. Over the past 20 years many innovative cropping systems such as minimum till have been developed that contribute to this aim. As a result, some farmers are thinking about moving out of livestock because it means less work, less employed labour, less stress and frustration – and more holidays or time for other things. The challenge for the livestock sector is to match the advances in simplicity and easy management achieved in cropping.

Mixed farmers have a preference for simple systems because less can go wrong, they generally have lower costs and are easier to manage with under-skilled labour.

Farmers sometimes avoid a new technology because it adds to the complexity of the system, even though it may also promise greater profits. As farms become larger and are run by a smaller labour force this is becoming more of an issue.

Extension programs commonly focus on increasing the profitability of mixed farming systems by increasing livestock numbers and therefore stocking rate. However, Grain & Graze social research explains why many farmers avoid this: higher stocking rates increase workload, worries and risk and may conflict with personal and family goals.

Technologies which reduce labour and simplify the farm work are likely to have the most success in mixed agriculture, e.g. efficient new fencing layouts, handling and laneway systems, sheep dogs and wool harvesting systems.

The new systems or technologies most likely to succeed on the Australian mixed farm will:

- make life easier for the farmer;
- offer significant financial benefits;
- reduce risk to the enterprise;
- lead to a simpler, more streamlined system;
- show how a whole system works, or can be improved;
- answer questions which are important to the individual farmer; and
- increase one's overall enjoyment of farming.

Farms can provide a great environment for the whole family.

Case Study: Dufty Family, western Victoria

The national winner of the Raising the Baa competition, Andrew Dufty, has achieved his goal to be a part of Australia's top 1% of wool producers in terms of volume. The goal called for the production of 300 bales of wool annually and was set when the family, Andrew his wife Kim and children, bought their property, 'Melville Forest', Hamilton, during 2000. The mission was accomplished when the Duftys' 2006/07 clip totalled 308 bales at an average 18.5 micron.

The Duftys run 13,500 Merinos on the 1,450 ha property and are working to increase grown sheep numbers to 15,000 during the next five years.

For Andrew, the increased volume opens avenues to market his clip in a more creative way. For example, a 40-bale consignment of the 2007/08 clip is headed to the Merino Company for inclusion in active sportswear. Andrew has had pleasing results with forward contracts and intends to continue to forward sell when the price is right.

Sheep numbers have increased during the past seven years. As a result, areas traditionally sown to crops have increasingly been transferred to pasture. The plan is to sow 100 ha annually over the next 10 years.

Andrew says the combination of improved pastures and sheep genetics puts the family on track to reach their goal of at least 50 kg/ha clean wool within the next five years.

A key to the Duftys' success and their efficient operation is having a written business plan with clearly defined goals and milestones. All management decisions and planning are made by Andrew and Kim, with input from Andrew's parents.

Benchmarking has been instrumental in increasing the Duftys' labour efficiency from 6,126 dry sheep equivalents per person during 2003 to 8,983 DSE/person in 2007. Comparative analysis has been used since 2003/04 with the Victorian Department of Primary Industries Wool Industry Farm Monitor Project.

The Duftys have made extensive improvements to the property, including extending and improving laneways, updating sheep handling systems (new easy-flow covered yards), pasture improvement programs and better water supplies where dams supply tanks that reticulate to troughs. Most paddocks directly access the laneway system, of which most have been gravelled to allow for year-round access.

Andrew Dufty: Raising the Baa national winner.

Fencing-off all creeks has also helped mustering and pasture management – as well as the environment. Difficult-to-manage areas have been either revegetated or planted to blue gums under long-term forestry leases that provide a current annual return of about $300/ha.

Environmental development has been ongoing since the Duftys established themselves at Melville Forest. More than 150,000 trees have been planted to address stream health, soil erosion and increased pasture use. Funding for these plantings has been a mix of both private and grant money.

Andrew has planted 70 ha to native tree species suitable for carbon sequestration. He has been in talks with CO2 Australia but admits he is still trying to "get his head around the process" and is happy to sit back and see how this new industry develops. The Duftys are also on a share basis with Timbercorp for any credits generated as part of the blue gum lease.

The Duftys have made extensive improvements to the property.

Case Study: Brian & Tracy McAlpine, WA wheatbelt

Brian and Tracy McAlpine are on a quest to find a mixed farming system that suits their lifestyle. The solution forming in their minds – after much experiment and thought – is a predominantly cropping enterprise with some form of low maintenance livestock to turn spring green feed into profit.

"I am a passionate crop farmer who needs to include some livestock in the farming system. We don't want to lose the farming lifestyle itself, because it's the best ever," Brian says.

"Work never stops on a farm, particularly when you have livestock, and we want to be able to take holidays and go to the football on weekends. We ran no stock for a number of years and it was only when we came back into them that we realised what was involved in managing them."

The McAlpines' unusual approach to mixed farming emerged during a national Grain & Graze study of the social influences on decision making by Australia's mixed farmers.

Grain & Graze Social Influences Project co-ordinator, Nigel McGuckian, says the McAlpines are an excellent example of the mixed farmers identified in the study. They are balancing considerations of profit, environment and people in the very complex decisions required in mixed farming.

"We have a 10-year plan in which we try to see where we are heading," Brian says. "We continually look to the future for our children and the viability of our business, the rural community we live in, population and isolation issues and lifestyle.

"A number of farms have adopted the drive-in, drive-out management of farms; not always successfully. The successes have been where the farm owners have had good managers, policies, procedures and communication. The trouble starts when those good managers move on and you find it difficult to replace them with the right person."

The McAlpines believe owning and breeding livestock requires an enterprise of some scale. They think agistment, trading or backgrounding of stock should prove a more flexible system.

Tracy & Brian McAlpine.

They admit to be "still learning" about these more flexible options, all of which they tried in 2006. "It was a dry, difficult year," Brian says, "and made all the more difficult because we took on too much.

"We learned that you need to keep the job simple, and one key to that is having the infrastructure right. We had been out of stock for a while, so the yards had been let go a bit, along with the watering system. Stock work can be pleasant if you have the infrastructure right, and I find the people who like stock always have good infrastructure."

Brian wants to include stock in future because he believes rainfall in an already marginal area seems to be getting less and that he and Tracy need to have the ability to be reactive to the seasons and opportunities that may present with livestock.

Climate change is their biggest concern, more than herbicide resistance and the loss of profitability in grain legumes.

Salinity is also an ever-increasing problem affecting some very productive farming country in the district.

"I maintain a lot of damage has been done to country by over-grazing, often just by grazing, because I have seen the impact sheep can have on fragile soils like these," Brian says. "Yet, if we don't run stock on the unproductive county we can't get a return from it, and I am positive strategic grazing can be a profitable answer to salinity.

Employing farm labour

There is considerable reluctance to employ labour on Australia's mixed farms due to the difficulty in finding sufficiently skilled employees (especially in livestock), suitable accommodation for them, and the need to comply with increasingly complex employment, taxation, superannuation, insurance and Occupational Health and Safety regulations. This has led to:

- a preference for reducing employed labour on the farm by selecting enterprise activities which have a low labour demand or suit available family labour;
- a concern about whether the decision to employ labour is cost-effective; and
- a concern about the loss of people from rural communities.

These findings imply that many mixed farmers will tend to (i) reduce sheep numbers and increase cropping, in some cases moving out of sheep altogether and (ii) reduce sheep numbers in favour of cattle. It also implies that, as farmers reduce their labour demand, mixed farming areas will continue to experience skilled labour shortages and population decline. These, in turn, may limit the scope for Australian mixed farming businesses to grow and diversify.

Having a go

If you haven't already had a go at filling out the "How much are you enjoying farming?" questionnaire, do it now. Why not do it with the family and talk over how accurate you think the results are – and if there is anything you can do together as a consequence? If there is something you particularly enjoy, are you spending enough time doing it? Where are the greatest areas of enjoyment for all the individuals in the family? Which of them can be shared?

It's okay to look for easier ways to manage livestock. Find out more about two or three of the technologies mentioned above and see if any fit your farming operations.

Using labour more efficiently

One way to tackle labour issues is to hold on-farm workshops featuring creative ideas for using labour more efficiently, such as:

- *demonstrating labour-saving stock handling equipment;*
- *case studies of how people have gained efficiencies in labour;*
- *sharing experiences in the cost/benefits of employing labour and how to manage employees;*
- *understanding and working with OH&S systems;*
- *sharing skilled or task-specific labour between farms, perhaps by forming labour co-ops; and*
- *better time management, leading to a clearer understanding of how best to use labour across multiple enterprises.*

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Lifestyle and production preferences may be in conflict with the most profitable enterprise choices or relative scale. Can you be happy going broke?	▪ Being profitable can underpin enjoyment, leaving farmers emotionally free to innovate, indulge in lifestyle preferences and take time off. Enjoying farming can underpin profit as farmers doing what they love are more likely to do it well.
▪ Production preferences may be in conflict with the capacity of the land to support them, leading to long-term degradation.	▪ Management which enhances the natural resources that drive production (e.g. soil and vegetation) and enhances native flora and fauna, give satisfaction in 'leaving the property in good shape' as well as being productive.
▪ A desire for simplicity may be in conflict with complex options that are more profitable, better suited to the farm's natural resources, and more resilient through variable seasons.	▪ Well-designed and maintained infrastructure gives added pride to a farmer and makes it easier and more efficient for handling livestock.

More information

- Examples of farmers enjoying mixed farming: 'Insights into Mixed Farming in Australia', www.grainandgraze.com.au
- Strategic grazing: the Sustainable Profit report: www.landwaterwool.gov.au
- Hi-tech stock management solutions: www.sheepcrc.org.au

Feedbase management

Summary

Aligning feed supply and the livestock enterprise is the best way to convert feed into saleable product and so improve farm production efficiency.

Farmers can choose from an array of tools that help do that by preparing a feed budget. The tools prompt consideration of alternatives that either vary the amount of feed on offer or the demand from stock for fodder. These options often interact and may have implications for the management of the whole farm.

Preparing a reliable feed budget depends on knowing:

- the feed requirements of livestock at different times of the year;
- the feed that will be available (the feedbase) at different times of the year; and
- the alternatives available to manage the gaps (and their relative cost).

Putting plans from a feed budget into practice requires well-honed skills in calculating the amount of feed on offer and condition scoring of livestock.

For those wanting to top up their skills, courses that cover those topics as well as the basics of feed budgeting are available from various industry sources such as Prograze or Making More from Sheep.

An effective feed budget will improve both the supply of feed to stock through the year and its conversion into saleable product

"Three key questions link feed supply and demand:

1. ***What is the cost of the current situation? How severely is feed supply limiting the profitability of the animal production system?***
2. ***If I improve the feed supply, how will I use it to ensure that I can more than cover the cost of implementing the change?***
3. ***Might it be easier and/or cheaper to alter animal demand, rather than fighting against environmental (or climatic) constraints to pasture growth?"***

The National Feedbase Project Team

Information and ideas

Know pasture production phases as well as you know crop production phases and stock accordingly

Feed budgets

An effective feed budget matches the quality and volume of food on offer with the energy and nutritional requirements of the livestock. It will improve both the supply of feed to stock through the year and its conversion into saleable product. It can be used to plan grazing over the entire year or to help with short-term (tactical) grazing decisions.

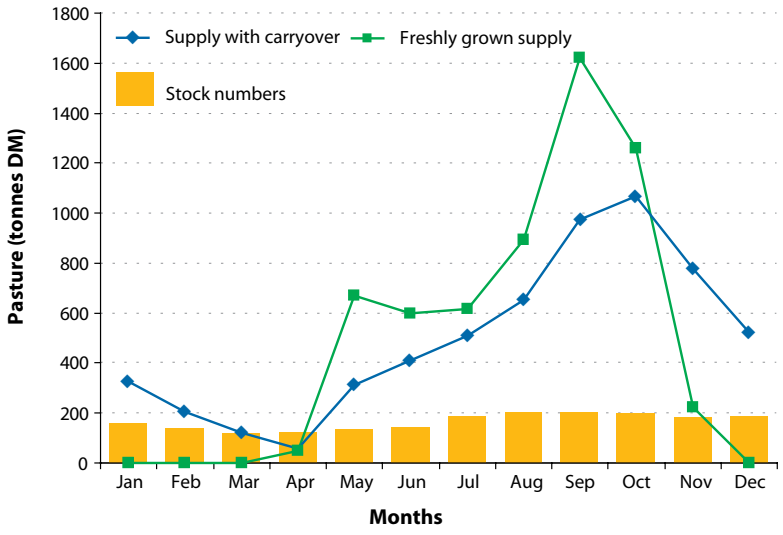
As the graph below shows, there are periods when the supply and demand for feed is out of kilter. That imbalance can be addressed with a good feed budget.

The alternatives include buying in extra feed, boosting feed production with additional fertiliser, storing excess feed as hay or silage, shifting lambing or calving times, weaning early, particularly under drought conditions, agisting stock, purchasing or selling stock, or adding new feed sources to the farm (e.g. by grazing cereals or developing saltland pastures). The choices consist of a mix between altering supply and modifying demand and should be treated as interacting options rather than as stand-alone choices.

A feed budget can not only help to optimise production, but also help maintain natural resources (avoiding losses caused by over-grazing). It helps to manage business risk, but may involve trade-offs such as the risk of having to buy or sell stock in unfavourable markets against the risks involved in changing feed supplies.

Having a good plan with sound alternatives is always a recipe for avoiding stress.

It is important to keep approaches to feed budgeting in context. As the chart on the next page shows, solving a feed imbalance may lead to significant changes in an entire farming system. While that might be easy to do on paper, in the real world it can be hard to achieve as it can involve major shifts such as shearing or calving times. Feed budgeting cannot be considered in isolation from other aspects of management. Seasonal variability must also be factored in. It is one thing to understand how demand and supply perform 'on average' – but variability between years must be included in the farm plan. Maintaining sufficient flexibility to deal with variable seasons is essential to a successful livestock enterprise.



Typical feed supply and demand curves for a temperate climate.
Source: Grain & Graze Feedbase Project Team. Ten Issues Discussion Paper

Feed management keys

To get the most from feed budgeting the focus should be on achieving or providing high-performance feeds, sustainable pastures that keep going in the face of seasonal variability and livestock that are known to convert feed to meat or wool very efficiently. It is also necessary to vary stocking pressure according to feed availability: the Grain & Graze experience indicates set stocking is less effective.

Some keys to high-performance feeds are:

- Use pasture species that are adapted to local conditions and have high digestibility (75%) energy and protein levels. Include legumes in the mix; they fix nitrogen which is, in turn, converted to protein in livestock or grain.
- Manage pastures and grazing so as to provide young, leafy forage to stock, rather than aged, rank fodder.
- Try to maintain plant mass between 1,000 and 2,500 kg dry matter/ha. The MLA 'pasture ruler' can be used to estimate plant mass.
- Provide feed at times that coincide with demand for high-priced produce.

An example of how various options involving both feed supply and livestock demand interact in a WA wheat-belt context:

Supply **Demand**

Baseline – annual pasture; autumn lambing, 85% lambing percentage, Merinos

↘ Change lambing time for better alignment between animal demand and spring feeding supply.

↓ With a focus on using the spring feed surplus, consider modifying the animal system to a prime lamb enterprise (e.g. terminal sire, 100% lambing percentage).

↙ Improve feed distribution over the year by incorporating lucerne, or consider the use of forage shrubs (e.g. saltbush) to improve autumn feed supply.

↓ Consider combining the options of annual pasture, lucerne and saltbush in different proportions in different parts of the farm – what does this do to our supply curve? Is the extra feed being used?

↘ With the annual pasture base, plus lucerne for an extended growing season and saltbush for autumn, can we support a higher demand? (i.e. higher annual average stocking rate).

↙

Improved supply curve and modified demand curve.

Source: Grain & Graze Feedbase Project Team. Ten Issues Discussion Paper

Metabolisable Energy (ME):

This is the energy derived from digested feed to maintain body functions and to produce wool, foetal growth, milk or body weight and is measured as MJ/kg (megajoules per kilogram). It is the energy value of feed and is closely related to digestibility. Feed energy is a major requirement and is normally the first limitation during a drought.

Dry Matter (DM)

Feeds consist of dry matter (DM) and water. If you feed out a grain that is 90% dry matter and has 13 MJ/kg ME then for each kilogram fed the actual ME consumption is 12 MJ/kg ME, as 10% is water. Grains and hay are quite similar in dry matter or water content and so can generally be compared without taking this into account. However, this must be assessed when considering feeds that are quite different in dry matter and comparing costs of supplying energy.

Crude Protein (CP)

Protein is measured as % crude protein (CP) and is calculated from the total nitrogen content of feed. If protein concentrations in poorer grass hays and oaten grain are below requirements, the animals' appetites may drop. This is because the feed is unsuitable for rumen micro-organisms and will break down at a slower rate.

Source: Drought Feeding and Management of Sheep. A guide for farmers and land managers (Victorian DPI) 2006

To maintain good pastures:

- Manage grazing pressure (stocking rates, grazing duration and the frequency of grazing) to facilitate regrowth and pasture persistence.
- Remove stock before over-grazing: retain 60-70% of plant mass (biomass) for native grasses, 45% for perennial leys, and 20% for annual forages.
- Maintain a minimum ground cover of 70% and 800 kg dry matter/ha to avoid erosion, or a level appropriate to your district.

The profitability of livestock enterprises rests on pasture production and use, stocking rates and production per animal, the cost of production, and the prices received. For profitable livestock:

- Monitor stock and score their body condition.
- Maintain mineral supplements, worm control, etc, to optimise stock health.
- Select livestock for high feed conversion efficiency.
- Manage stock to meet market specifications and demand.

Livestock offer gains

Farmers in the Avon region of WA found that, of the options available to them, getting more livestock back into well-managed mixed farming systems was most likely to give the greatest gain in overall performance. Many accepted they hadn't kept up with livestock production methods to the same degree they had with advances in cropping technology and systems – and that they needed training in techniques such as assessing 'feed on offer', condition scoring of livestock and preparing a feed budget. Without these skills they felt it would be difficult to generate the gains they were after.

To complement these skills Grain & Graze also explored ways to make more feed available. For example, analysis showed that in dry years it was more profitable to graze poorly performing crops than it was to carry them through to harvest. It was also found that establishing improved pastures dramatically extended the period they could be grazed, compared with naturally regenerating pastures. At Ngaree, in the second year after pasture renovation, grazing was extended from 310 to 1,219 grazing days/ha (a four fold increase), while at Tooravee it was extended from 946 to 1,447 grazing days/ha.

Assessing pastures is part of feed budgeting.

Weighing-up the options

Deciding how to fill a feed gap involves weighing up alternatives or making trade-offs. A good example of this is the management of feed shortages during dry times. Stocking rates can be reduced or supplementary feed can be purchased (e.g. hay or grain), with stock held in a feedlot to avoid the risk of over-grazing and erosion.

In the Central West Lachlan region of NSW, a mini-MIDAS model (see page 81) was used to assess these options in different seasons. As many farmers would expect, it showed that reducing stocking rates to match feed supply in dry (25th percentile) and very dry (10th percentile) years is more profitable than maintaining median stocking rates with supplementary feeding.

These decisions involve financial aspects such as capital expenditure and potential profit, changes in exposure to risks (e.g. buying or selling stock may be a higher risk than changing feed production systems), environmental consequences, personal preference and compatibility with other farming operations and assessing how each may change in different seasonal conditions. They are complex decisions and are easier to make when there is good information and a range of tools available to help.

Case Study: Brendon Tierney, Moora, WA

Brendon Tierney's mother's kitchen microwave has become one of his most important farm management tools.

When he returned to the family property in 2006 after a stint as an agricultural consultant, Brendon felt instinctively that there was scope to emulate the fantastic technological progress of the cropping sector in the farm's Merino wool enterprise.

One of his first challenges was to better understand condition scoring in sheep. Most research results were linked back to having sheep meet certain condition targets and he needed to find out what these targets looked like on real sheep. The 'Look 2 Grow' Grain & Graze workshop provided the hands-on training he was looking for.

Brendon says he needed to be able to objectively assess the amount of feed available in his pastures to ensure that sheep met the condition targets for optimum production. This involved cutting samples from different pastures and drying them in a microwave to calculate a dry matter yield per hectare.

Armed with this information, he is able to forecast the number of sheep than can be grazed for a specified time in a paddock while meeting the condition score targets.

"Feed budgeting allows us to anticipate likely shortages or surpluses of paddock feed and act accordingly," Brendon says.

"This includes adjusting sheep numbers and setting aside an appropriate amount of grain and hay to feed over summer and autumn. By planning ahead we can ensure our livestock enterprise runs at optimum profitability, regardless of whether we have an early or late break to the season."

What's a percentile?

The 25th percentile is the value below which 25% of all records fall. For example, if annual rainfalls from a long period were kept, the 25th percentile would be the rainfall below which the driest 25% of all records lies.

Similarly, the 10th percentile is the annual rainfall below which the driest 10% of years lie. There is a 1-in-4 chance of being drier than the 25th percentile and a 1-in-10 chance of being drier than the 10th percentile.

Feed budgeting tools

All the main farm commodities have tools that can assist producers with feed budgeting. These include Lifetime Wool (AWI), Making More from Sheep (AWI and MLA), More Beef from Pastures (MLA) and LeyGrain (GRDC).

MLA and AWI also provide tools and advice for drought management, through Making More from Sheep.

A Feed Demand Calculator is available from MLA to help design feeding strategies. The Calculator was originally designed for temperate systems but, thanks to a Grain & Graze project in the Border Rivers and Maranoa-Balonne regions, it now includes subtropical data as well. It can deal with a mix of forage sources and includes growth rate and pasture quality data for native grasses, sown grass pastures, lucerne, oats, lablab and forage sorghum.

To cater for the variable seasons in subtropical locations it can generate pasture growth curves for poor, average and good seasons.

Calculating feed demand

"The real advantage of the Feed Demand Calculator is moving producers away from thinking about a fixed stocking rate for the year and into stocking rates as they change from month to month during the year," according to Dr David McNeil, principal of DJM Livestock Consultants, who has advised on the modification of the Feed Demand Calculator for northern NSW and southern Queensland.

"In a reproducing herd that also includes trading stock there will be a particularly big variation in animal demand for pasture at different times of the year," he says.

"Livestock producers in the north generally rely on a mix of native pastures, stubble, possibly lucerne or tropical legumes such as lablab and short-term fodder options such as forage sorghum rotated with grain crops.

"What's needed is a quick and easy way of combining these in an overall feed supply package that also takes into account the highly variable rainfall pattern."

To find the calculator, visit: www.mla.com.au and search for 'Feed Demand Calculator'.

Practical demonstration of a pasture photo guide.

Having a go

A first step in feed budgeting is to note, on a seasonal basis, when a farm is in feed surplus and when it is in feed deficit. This can be done purely from experience.

The next step is to jot down the alternatives available to remedy any imbalances – considering changes to supply and demand, their interactions and the implications for property and business management overall.

If this proves a useful exercise, it may be productive to add some further detail, such as assessing seasonal feed quality by testing the feed sources you commonly use.

Look at the various feed budgeting tools available (e.g. use GrazFeed to predict potential livestock production on different feed sources), talk with an adviser or another farmer who prepares a feed budget, or get a group together and arrange some training for your district through programs such as the EDGEnetwork or Making More from Sheep.

Once a feed budget has been prepared it is possible to test alternative scenarios.

See how the system would cope with average, wet and drought years, and also assess how critical benchmarks may respond, for example:

- Ground cover – maintain 70% ground cover to protect soil and keep soil carbon up.
- Weediness – a sign of pasture run-down and a higher risk of soil-borne disease carrying over to crops.
- Proportion of legumes – in improved pastures legumes drive pasture soil health and crop productivity.

Below: Budget to use surplus feed to help fill the gaps when a farm is in feed deficit.

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Feed can always be supplied (at a cost) but farms, or the farming system, may not have sufficient flexibility to adjust grazing pressure.	▪ Well-managed, high-quality pastures with legumes underpin feed availability, long-term productivity, soil quality and carryover benefits to crops.
▪ Stock numbers may be mismatched with available feed and fodder reserves.	▪ Having a mix of annual, perennial and woody perennial pasture species matched to the landscape can extend feed availability into 'gap' periods and improve the environment (e.g. increasing biodiversity and reducing dryland salinity).
▪ Energy requirements of different animal classes (e.g. pregnancy, lactation, age, or sale) may be mismatched with the feed on offer.	▪ Woody perennials can have multiple production and environmental benefits and also offer secondary metabolites to add unique quality factors to the feed mix for livestock.
▪ Over-grazing can have a long-lasting impact on production (pasture productivity, species mix and increased weediness) and the environment (soil loss and reduced soil organic carbon).	
▪ High grain prices can give a double relative advantage to cropping; increasing the profitability of the cropping enterprise and the cost of feed supplements for livestock.	

More information

- More Beef from Pastures and GrazFeed: www.mla.com.au/TopicHierarchy/IndustryPrograms/SouthernBeef/Morebeeffrompastures/default.htm
- LeyGrain: www.grdc.com.au/director/events/groundcover.cfm?item_id=publication-issue62&article_id=482BDA28D46CA2E4F751836B6DB65341
- StockWise: www.ruralrdc.com.au/Page/Drought+/Feeding+Livestock.aspx
- MLA Pasture Ruler: www.mla.com.au/TopicHierarchy/InformationCentre/TipsandTools/Feedbaseandpastures
- MLA Feed Demand Calculator: www.mla.com.au/TopicHierarchy/IndustryPrograms/SouthernBeef/Morebeeffrompastures/MLA+Feed+Demand+Calculator.htm
- Prograze: www.mla.com.au/topichierarchy/informationcentre/learning/producertraining/feedbaseandpastures/prograze.htm
- EDGEnetwork: www.mla.com.au/topichierarchy/informationcentre/learning/producertraining/producer%2Btraining.htm
- Making More from Sheep: www.makingmorefromsheep.com.au/index.htm
- Feedbase Management Fact Sheet: www.grainandgraze.com.au/Publications/Fact_Sheets
- For easy searching of livestock-related information on the web: www.livestocklibrary.com.au
- Lifetime Wool: www.lifetimewool.com.au/index.aspx

Grazing cereals

Summary

In most temperate regions of Australia it is possible to graze cereal crops without significantly reducing their grain yields. In some seasons, the grain harvest may even be increased.

Crops to be used for both grazing and grain should generally be sown as early as practicable, although in higher-rainfall areas crops seeded later in the sowing window may still be grazed. The key is to remove stock in time to allow the cereal to recover and mature.

Grazing cereals can also help increase pasture production by allowing pastures to be rested during their early growth phases, making them more vigorous and productive, with benefits for the stock that graze them later on.

The season finish is critical to the success of this strategy. Having enough soil moisture left to fill the grain and finish off the crop is essential. The risk in grazing cereals is higher in regions with less-reliable rainfall or soils with poor water-holding capacity.

Seasons in subtropical areas finish quickly and tend to have relatively little spring rain. This may make grazing cereals in the subtropics a risky option, needing careful thought.

Some keys to effective grazing of cereals:

- Sow early (as soon as temperature and soil moisture allow for successful establishment and early growth), and increase sowing density.
- Crops can be grazed as soon as individual plants are 'anchored' and will break off instead of pulling out when grasped half-way along the leaf and given a pull and a twist (the 'twist test').
- Don't graze crops too late: remove stock no later than growth stage 30 (stem elongation), and ensure there is time in the season for recovery and grain maturation.
- Fertilise adequately, and ensure nitrogren is not limited in the crop's later growth stages after the removal of stock.
- Keep an eye on animal nutrition: avoid symptoms of inadequate mineral intake by making mineral supplements available.

In temperate areas, crops can often be grazed without reducing grain yields

"Grazing cereals is a great way to give your pastures 'a spell', especially for spring lambing ewes which can graze the cereals when pregnant then lamb down on the pasture."

Neil Vallance, Chairman,
Streatham branch of Southern Farming System

Information and ideas

Opportunities

Many mixed farmers have traditionally grazed cereals as stubble. Stock are used to knock down stubble, control summer weeds and avoid the use of burning, while taking advantage of an otherwise potentially under-valued resource. Cereals have also been cut for hay (oats especially) or silage, and grazed in that manner as well. However, there are other options.

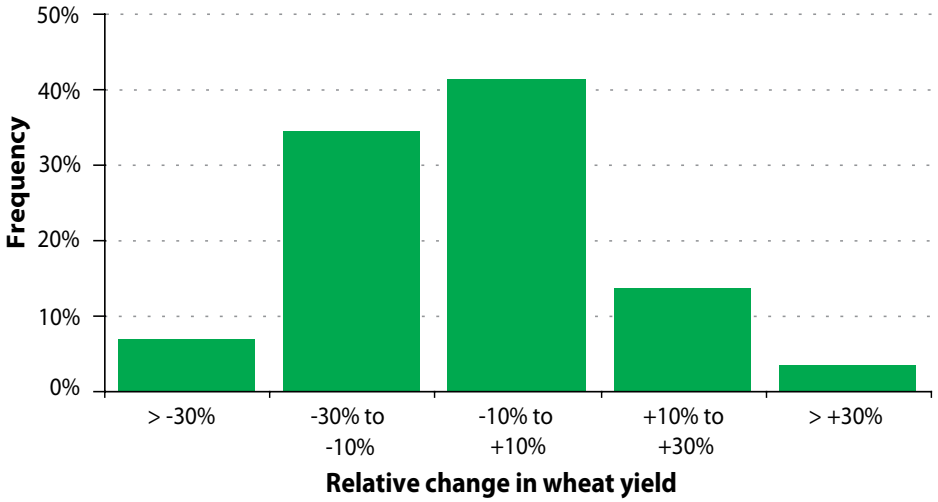
Grain & Graze has put the spotlight on the ability to graze crops in the early stages of development – up to growth stage 30, the beginning of stem elongation once tillering is complete. Depending on the season, crops in temperate climates can be grazed for feed in early winter without the risk of lowering grain yields. This approach can get more production from the same land (both crop and livestock) and increase profit. It can contribute to maintaining higher stocking rates for a property – a key driver of profit for livestock enterprises. Livestock benefit from the extra grazing available and have extra liveweight gain.

The data in the graph below come from 13 trials conducted by CSIRO or NSW DPI at eight sites between 1999 and 2006. In the majority (40%+) of cases, the impact of grazing on wheat yield was between plus and minus 10%. It shows that grazing cereals can have a variable impact on wheat yields and this is thought to be heavily influenced by management – things such as the time of sowing and the growth stage of the crop when grazing is terminated.

A graph from the Corangamite region of Victoria (wet temperate climate) (see page 66) demonstrates the importance of not grazing cereals beyond growth stage 30. It is evident that prolonged grazing (beyond growth stage 30) has a significant impact on yields – but earlier grazing doesn't and may even be beneficial. The worst results occur in drought years, highlighting the importance of having sufficient soil moisture left over for crops to mature.

In medium to high rainfall zones, there is generally little, if any, negative impact on grain yields, as long as there is sufficient soil moisture for flowering and grain fill. There is even some evidence that early grazing can be beneficial to final grain yield. It is suspected that grazing reduces the amount of water taken up by the crop in its early growth stages, leaving a reserve in the soil to boost later yields – but more research is needed to confirm this.

The effect of grazing on grain yield for dual-purpose wheats in NSW.
Source: A. Moore and H. Dove, CSIRO (2007)



In the drier mixed farming areas, where spring rainfall may be unreliable and a dry finish is common, grazing cereals is inherently more risky and it is harder to achieve the optimum balance between liveweight gain and grain harvest.

Similarly, in subtropical areas where seasons finish early and spring rainfall may be low, there is limited chance of crops recovering from grazing in time to produce good grain yields.

In temperate areas, putting stock onto a growing cereal crop that is still intended for harvesting can fill an early winter feed gap cheaply, using the vigour of the young crop to extend grazing time. It also rests pastures for that period, which is thought to improve their performance – helping them get away better in late winter and early spring.

Careful fertiliser management – a late application of nitrogen when soil moisture is adequate – can help optimise grain yields and ensure they overcome any impact from grazing.

Case Study: Neil and Helen Vallance, south-west Victoria

Grazing 204 ha of Mackellar winter wheat made a big difference to 2007 gross margins for Neil and Helen Vallance on their Lake Bolac property, in Victoria's south west.

"Grazing the Mackellar wheat increased liveweight gain, produced a grain yield and reduced the need for supplementary feed," Neil says.

"In previous years we would have had to sell sheep early because of the dry winter conditions and poor pasture growth. It would have been a struggle just on pasture and would have involved hand feeding as well as reducing numbers."

Neil, in partnership with his brothers, Max and Graeme, run 3,200 Merino ewes on the 2,040 ha 'Braebrook'. Some 65-70% of their country is under crop in the popular local rotation of barley, canola and wheat over six or nine years; with the balance under pastures of phalaris, subclovers and ryegrass.

Half the ewes are joined to Dorset rams to lamb in May; the others are joined to Merinos for an August lambing. Crutching is in October and shearing in February.

As Chairman of the Streatham branch of Southern Farming Systems, Neil has been involved with grazing cereals for the past four or five years and has gained information from Grain & Graze.

His first choice was Tennant wheat, initially sown in February, but it was discarded because Neil believed "it was a bit too slow to get going" for his property. Like his grain crops, the Mackellar paddocks were sown dry and no-till around Anzac Day in 2007, with 1.5 litres each of Treflan and Diuron incorporated for early season control of annual ryegrass – Neil's biggest problem.

The sheep went onto the winter wheat in early July, with one mob of 1,300 Merino ewes and their autumn drop Dorset cross lambs moving into a 45 ha paddock because feed was running out on the pastures.

These ewes and lambs were rotated across three paddocks of winter wheat, moved every 10-14 days and the mob grazing each paddock twice.

Neil Vallance

Another mob of 650 pregnant spring lambing ewes went into a rotation over two 45 ha paddocks of wheat, but were in each paddock for a longer time because of the smaller mob size.

"It's better to graze with big mobs for a shorter time because you get more even grazing of the crops, which makes it easier to apply nitrogen later on and leaves the crops better to harvest," Neil says.

"All sheep were in very good condition and had no animal health issues when they came off the cereals, although the ewes with lambs appeared slightly daggier; probably because of the high-quality grazing those paddocks provided."

Mineral nutrition

Grain & Graze trial work revealed that growth rates in sheep of well over 200 g/day and up to 360 g/day, can be achieved by grazing dual-purpose cereals such as Tennant, Wedgetail, Whistler and Mackellar wheats and Blackbutt oats.

Liveweight gains can vary significantly, but lambs grazing dual-purpose wheats have grown more than 20% faster than those on oats.

The Grain & Graze study supported earlier findings that the performance of stock grazing cereals can be very variable and went on to investigate possible causes.

It is known that the nutritional value of grazed wheat is very high, as it has both a high protein content and high digestibility. Lamb liveweight gains can be high, but they can also be as low as 140 g/day. Investigations in the Murrumbidgee region examined the mineral content of wheat forage and whether mineral deficiencies or imbalances may be to blame for variability in stock growth rates.

A survey of wheat forages across NSW, Victoria, Tasmania and WA indicated that they are generally adequate for calcium (Ca), marginal for magnesium (Mg), deficient in sodium (Na), but contain excessive potassium (K) (often 5-10 times the daily requirements for growth in young stock).

Soils that have a low pH and are high in K may impede the uptake of Mg by plants, leading to lower Mg levels in the forage.

A high K:Na ratio in the feed, together with the high protein and low sugar content also leads to reduced Mg absorption from the rumen.

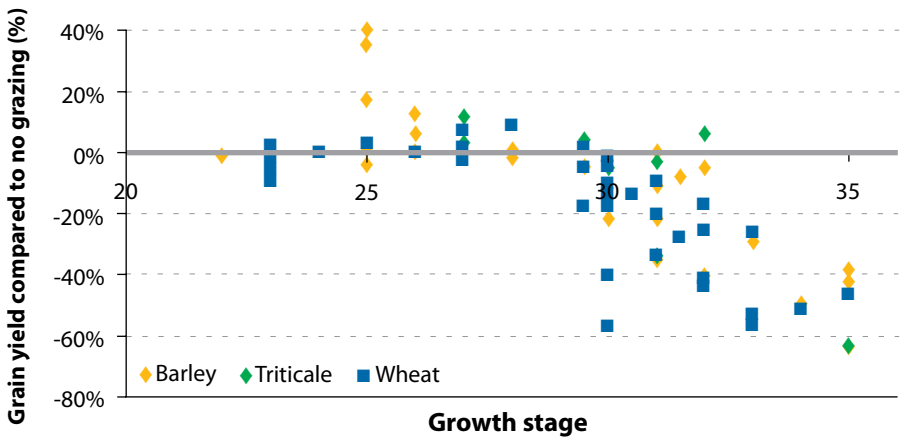
Mg problems can be transient as roots grow through acid soils (low Mg uptake) to more alkaline sub-soils where Mg availability is usually greater.

Lambing ewes require higher levels of Ca for milk production and when they graze cereals any shortfall in its availability in feed will be an issue.

Stock grazing cereals may need mineral supplements or access to salt licks to perform optimally. The responses to Mg and Na may interact but it seems that responses to both may be expected where K levels are high.

Ratios, based on K:Na and K: Mg+Ca, may be good indicators but thresholds are yet to be defined.

When supplemented with Causmag:lime: salt (2:2:1), lamb liveweight gains increased 54% when grazing Wedgetail dual-purpose wheat at Harden, NSW, in 2005. The value of the extra weight gain was more than 15 cents/day/lamb, for a supplement cost of only one cent/day/lamb.



Percentage impact of grazing on grain yield.

Each symbol represents the difference in grain yield of a grazed crop compared to no grazing. Where the symbol is above 0, grazing has increased yield. Where it is below 0, grazing has reduced yield. This represents wheat, barley and triticale in south-west Victoria over four years of trials.

Source: Cam Nicholson (2007)

Combined supplementation with salt: causmag mixtures (1:1) to sheep grazing forage wheats should improve liveweight gains and reduce the risk of grass tetany.[1]

The good news in grazing grain crops is that standard local grain varieties, selected for optimal grain yield, are suitable for grazing.

Producers do not have to use specialty forage wheats. Indeed, trials indicate that even canola can be grazed and still yield well, as long as stock are removed before the buds appear.

The important issues to consider here are things like available soil moisture and time of sowing, the varieties selected, sowing rates and fertiliser applications, stocking rate and the financial benefit to the livestock enterprise compared with any loss to the grain enterprise. Getting these factors right means that current rotations can be retained while still obtaining the feed benefits from a cereal crop intended for harvest. The livestock enterprise must also be flexible enough to graze cereals when seasonal conditions are suitable – and have alternative feed sources if they turn dry.

[1] *Source: Dove, H., McMullen, G., and Kelman, W.M., (2007) Growth rate responses to magnesium or sodium supplements in lambs grazing dual-purpose wheats, Journal of Animal and Feed Sciences, 16, Suppl.2, 465-470.*

Case Study: Wayne Johnstone, south-west Victoria

Warrambeen is a 4,000 ha property and a 500 ha lease block. A total of 2,000 ha are cropped (including all the leased areas). Half is in raised beds and half is flat. The balance of the land is in pastures that are in the process of being developed. The property runs 7,000 Merino ewes of which 5,000 are joined to Merino rams and 2,000 are joined to Border Leicesters. Lambing starts on August 20.

Manager Wayne Johnstone was part of a Grain & Graze trial that grazed 148 ha of triticale with Merino wethers. The sheep were fed through the drought after weaning and were likely to be sold because of the lack of suitable pasture going into winter. This meant selling sheep – which had cost money to get though the drought – into a falling livestock market. Grazing the triticale meant the sheep would be grown out and sold when market conditions improved.

A mob of 1,000 unshorn Merino weaners were put on a crop of Kosiuszcko triticale on June 4. It soon became clear that there was plenty of feed, so a further 500 weaners were added to the mob. Kosiuszcko (a short season variety) was chose because of concern that the season may cut short. It hit growth stage 30 in early July, so the sheep were moved onto a red wheat paddock and grazed until early August before being sold. The sheep weighed about 28 kg when they began grazing cereals and 38.5 kg at sale on August 3. They sold for $1.45/kg.

"The challenge was to find some feed for the stock and get them off the pasture. Grazing cereals meant we had the feed to value-add to the weaners by increasing their body weight," Wayne says.

David Watson, an agricultural consultant involved with the trial, recorded that there were fewer weeds in the grazed triticale than in an ungrazed comparison. Another benefit was getting the stock off the pasture, which meant more pasture was available in the lead-up to lambing.

On reflection what was initially seen as a problem – the triticale finishing early – was also a benefit for Wayne.

"The triticale had good early establishment and grew a bulk of feed early that we could use before we put the stock on the red wheat, which was slower to establish but grew the bulk of feed later," he says. "By using the triticale then the wheat, we were able to stagger our grazing and graze cereals for longer."

Wayne Johnstone. *Source: The Herald and Weekly Times Photographic Collection*

Case Study: Troy & Paula Missen, south-west Victoria

Troy and Paula Missen farm 335 ha at Werneth, lease 60 ha and share crop 140 ha. The home farm is roughly 50:50 cropping and pasture; all the other land they farm is cropped.

Until recently, they ran 850-1,000 autumn lambing crossbred ewes. Troy is changing the farm enterprise mix and is getting rid of the ewes, ripping up the pasture on the home farm and incorporating winter active lucerne into their cropping rotation. He then plans to trade store sheep opportunistically to graze feed over winter if there is a profit to be made.

The reason for getting rid of the ewes is the workload required to manage sheep and the clash with cropping activities, such as harvest. Troy has been grazing cereals for nine years with mixed results.

While he admits that grazing early doesn't harm the cereals, he has found that hard, early grazing of red wheat can mean that the plants take more time to recover and get going and this is a problem if the season doesn't finish as well as hoped.

"The whole point of grazing cereals is to utilise a bulk of feed before the plant reaches growth stage 30. Up until that point the feed is essentially free," he says.

"I've found the best way to get the bulk is to delay grazing red wheats until July/August."

Most of the paddocks Troy grazes are around 20 ha and his aim is to put as many sheep on a paddock as possible so it is grazed as quickly as possible. The high stocking rate creates more even grazing and the short grazing period reduces the trampling of feed.

In the past, Troy lost a few ewes grazing cereals either just pre-lambing or with young lambs at foot. In recent years he has fed a loose lick containing calcium and magnesium (ProV min) and has had no mortalities since.

Another challenge is the difficulty of predicting exactly when plants are going to reach growth stage 30 and when the sheep will need to be removed.

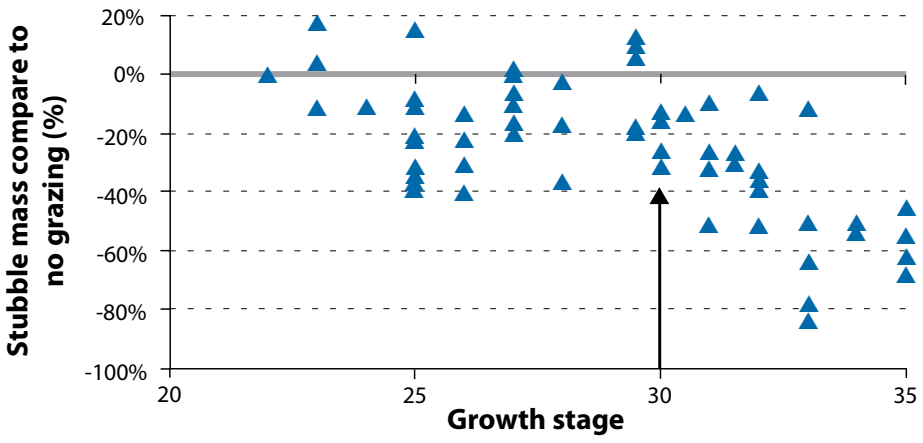
Management issues

Grazing cereals in this manner can be profitable and help overcome a feed scarcity problem. However, it is not without risk – and may not be feasible in all regions and all seasons.

Early sowing is required in many regions. Depending on the cereal and variety being used, this may mean sowing in March or early April in southern temperate Australia. In regions with reliable spring rain that usually enjoy a 'soft' finish, cereals sown in May can also be grazed early. However, even if it is feasible to sow early there may be other factors that conspire against it, such as exposing the crop to pests or diseases that are less prevalent later in the season (such as wheat streak mosaic virus).

If there is a late break there may be insufficient time in the remaining growing season to permit grazing and still allow the crop to recover, flower and ripen. Seasons finish quickly in subtropical areas and rainfall is less likely late in the growing season. Both are factors which limit the grazing of cereals in that environment.

In regions where yields do not suffer significantly from grazing, there may be less dry matter produced. This may be an issue if the crop is to be cut for hay or silage, or if building up soil organic matter is the



Percentage impact of grazing on stubble mass.

Each triangle represents the difference in stubble mass of a grazed crop compared to no grazing. Where the triangle is above 0, grazing has increased stubble mass. Where it is below 0, grazing has reduced stubble mass.

Source: Cam Nicholson (2007)

farmer's long-term goal – but it can be a blessing if heavy stubbles are a problem. A reduction in dry matter is likely to occur if crops are grazed beyond growth stage 30.

Weed management is also an issue – and may be a positive or negative, depending on the weed. If crops selected for grazing already contain weeds, then grazing may worsen the situation. However, where the weeds are more palatable than crops (such as wild radish) there is evidence that stock will graze them out of the crop. If herbicides are used for weed control in crops being grazed then any withholding period will have to be factored into the timing of grazing events.

The grazing of crops must also be compatible with other farming operations. For example, if livestock are carried through on early cereals and total numbers allowed to build up, care must be taken to ensure will there be sufficient feed available from other sources once that phase of grazing is completed. If stock are purchased to graze cereals and will then be traded, will sufficient livestock still be available when needed to achieve the desired stocking rate, and will purchase and sale prices be suitable? Does the quality of the feed available from the cereals match the needs of the stock on hand? Are there concerns about stock contributing to the spread of cereal diseases?

Crops must be monitored during grazing and grazing pressures managed. The season will dictate the frequency and duration of grazing and additional fencing (e.g. electric fencing) may be needed to adequately manage stock for the best results. Stocking rates and the type of stock will also influence how well crops respond.

The choice of stock is another consideration. Cattle do not graze as closely as sheep and may be more uniform in their grazing. If sheep are not grazed intensively, they may leave the crop with uneven growth – and the more heavily grazed patches may require more time to achieve an even recovery.

An early finish to the season may mean that grain yields from grazed crops suffer, as the plants have insufficient time to recover and yield well.

On the other hand, in NSW there have been instances of grazed crops yielding better than ungrazed when there is a dry finish, which is thought to be due to the grazed plants using less soil moisture earlier in the season, leaving more available at grain fill. Generally, however, a good finish is critical to a profitable outcome from grazing cereals, especially in the drier zones and soils with poor water-holding capacity. A poor finish can result in significant financial loss from grazing.

Grazing crops can maximise returns for each hectare cropped

Case Study: Gary Butcher, WA wheatbelt

In the Liebe area of WA, oats are being planted in mid-April for grazing 3-4 weeks after germination, as a feed source and to help control weeds.

Leibe farmer, Gary Butcher, says the first great value of Pallinup oats sown in April is production of feed that – however short the crop might be – can be grazed to give improved pastures of Caliph medic and serradella pastures time to bulk up.

"The longer you can keep sheep off pastures after germination, the better grazing you get later on," Gary says.

"Then, when Pallinup oats gets to the stage of ear emergence, we've found it is somewhat unpalatable to sheep, and they will clean up the radish and ryegrass.

"You can then harvest the oat grain as an opportunity crop."

Grazing cereals may shift the optimal balance between stock and crop

Trying to predict seasonal outcomes adds further complexity and stress to management, except in areas of reliable rainfall and deep soil profile where there is good moisture-holding capacity.

Paradoxically, Grain & Graze modelling indicates that grazing cereals may shift the optimal economic mix of crop and stock in favour of cropping – by using livestock to generate greater value from cereal production.

Using whole-farm economic models, Grain & Graze researchers have concluded that grazing cereals can improve farm profit. Some general messages can be drawn from an analysis of grazing cereals in the Murrumbidgee region, even though the results will not be the same on every farm.

The model farm near Coolamon in NSW includes lucerne in the pasture mix. It is assumed that: there is an average yield loss in grazing wheat of 10%; a wheat price of $150/t; canola at $314/t (farm gate); and a wool price of 750 ¢/kg clean.

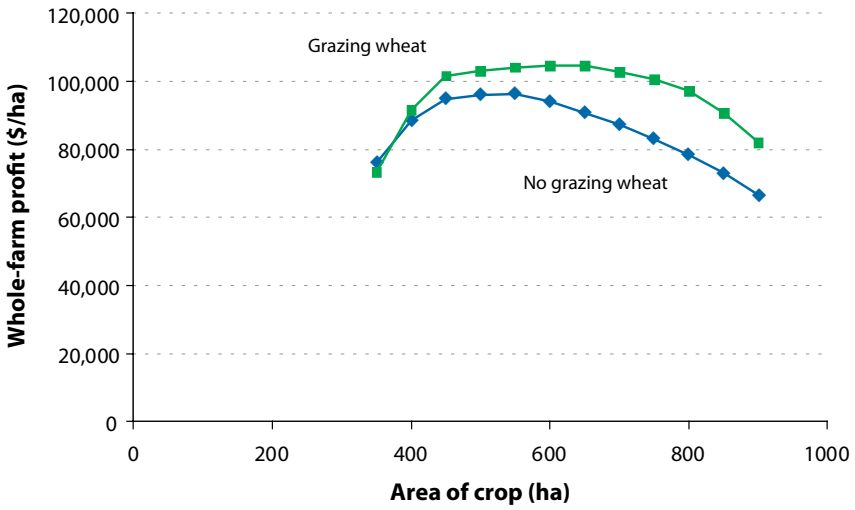
It should be noted that rainfall and soil type mix will lead to different results. For example, the optimal crop area will be typically less in higher rainfall areas. However, the general shape of the profit curves will be similar to those in the graph below.

The graph indicates that under a non-grazing situation for crops, the profit on the model farm changes by less than $10,000 as the cropped area is increased from 400 to 700 ha; which is not that significant given the variability in prices and yields in any given season. However, by grazing wheat the optimal cropping range is extended from 400-700 ha to 400-850 ha. That is, the profitability of sowing a larger area of crop is increased through the introduction of grazing wheat.

A farmer who is already in the optimal range can assess whether the potential overall increase in profit outweighs any additional risks in changing their farming system, and whether it is feasible in their mixed system.

Running the same model on a property without lucerne yielded different results. In this situation, the optimal range of crop is 450-950 ha, and in contrast to the earlier example, the optimal range of crop is reduced to 550-850 ha when grazing wheat is adopted (see graph opposite page) .

This implies that some farmers who do not grow lucerne may have an incentive to increase the area of crop subsequent to the adoption of grazing wheat, where the area is less than 50% of the total farm area. Conversely, farmers with very high



Responses of farm profit to area of crop, with and without grazing wheat, where lucerne is included in the pasture mix.
Source: Andrew Bathgate

crop areas may have an incentive to reduce their crop area after adopting the grazing of cereals. Both modelled farms would be better off financially if they adopted lucerne and grazing wheat.

Running the model with an assumed yield loss of 20% due to the impact of grazing lowered the profitability of grazing wheat, indicating that the benefits of grazing were outweighed by the higher losses in grain production. Analysis has also shown that although the benefits of grazing wheat are markedly reduced if stocking rates are not increased, the profit equation is influenced more by yield loss than it is by improved carrying capacity.

The broad conclusion of the work to date suggests the focus of management should be on grain yield. If wheat can be grazed with no or only a small yield loss it will be very profitable. However, if yield losses are greater than 10%, the loss can only really be made up by increasing livestock production through an increased stocking rate.

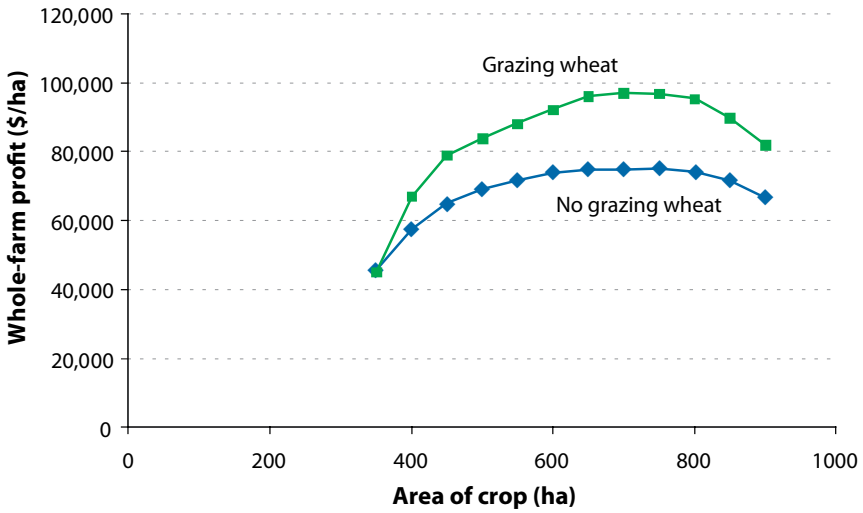
Sacrificial grazing

Regardless of whether they have been grazed in early growth stages or not, if crops are performing poorly and are unlikely to provide a grain yield worth harvesting, it may be better to graze them than grow them through to maturity.

Grain & Graze findings suggest that it may be more profitable in poor seasons to sacrifice the grain and use crops as stock feed, especially those seasons with little prospect of a good finish.

From a longer-term and environmental perspective, the relative advantages of feeding stock and feeding the soil will need to be considered, along with the ability to retain ground cover until the next growing season. These considerations will also have to factor in spot grain prices. If drought is pushing up the price of grain then the relative advantage of harvest versus stock feed will vary. However, the real difficulty is in applying this knowledge – the outcomes depend on how seasons finish and that is hard to determine in advance.

Grain & Graze conducted three main analyses across its regions: WA regions (Northern Ag and Avon), subtropical regions (Border Rivers and Maranoa-Balonne) and a cross-regional analysis. A crop growth model was used to simulate the biomass at flowering and the grain yield for wheat using 100



Whole farm profit at different areas of crop with and without grazing cereal, in the absence of lucerne.

(Assumptions: A yield loss in grazing wheat of 10%; Wheat price $150/t; Canola price $314/t (farmgate); Wool price 750 cents/kg clean) .

Source: Andrew Bathgate

Likely final crop yield dictates whether to harvest or graze

years of meteorological data, at a series of locations varying in mean annual rainfall, on different soil types – and with different starting soil water in the subtropical regions. The economic value for grazing and grain production was estimated from biomass at flowering and final grain yield according to current commodity prices and livestock production assumptions.

It emerges that cereal crops were most regularly more profitable for sacrificial grazing rather than continuing on to harvest grain under the following circumstances:

- in the drier environments in each region;
- on the poorer soil types; and
- when relative commodity prices favour livestock.

In general there was a good relationship between final grain yield and the relative economic value for either grain or grazing purposes, with higher grain yields making harvesting more profitable, as would be expected. Below a critical grain yield, sacrificial grazing was likely to be more profitable in certain situations.

The graphs below were developed using WA data, and here the critical anticipated grain yield below which sacrificial grazing was likely to be more profitable was about 2 t/ha. This critical level will vary with commodity prices, availability of alternative feed, enterprise net values, etc. However, the analysis shows that crop models with long runs of rainfall data can be used to explore the relative values of crops for grazing or grain.

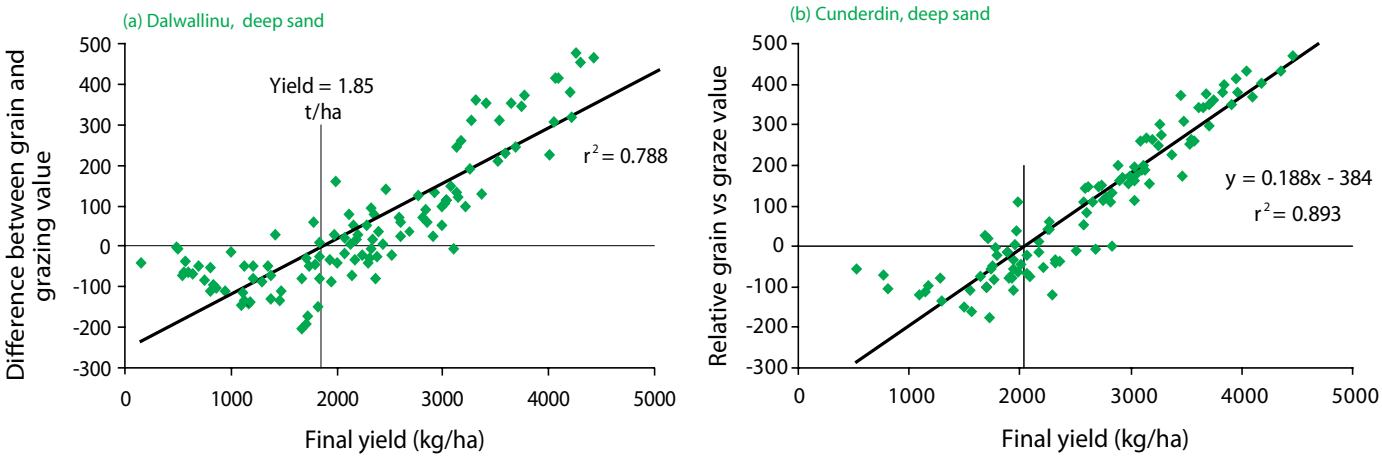
The difficulty in applying this understanding is being able to predict likely final grain yields before the season concludes.

Tools such as Yield Prophet have been developed to help farmers determine likely yield, based on starting soil moisture and rainfall received to date. They provide probabilities of final yield reaching or exceeding set levels, and are being used to help guide post-emergence fertiliser decisions. They could also be used to assist decisions whether to graze some crops, based on commodity prices, seasonal conditions to date, and availability of other feed.

A similar simulation for subtropical areas, using the APSIM wheat module, showed that (at then commodity prices) the critical grain yield was 800 kg/ha. Above that yield, harvesting is more profitable. Analysis such as this also allows consideration of how sensitive the outcome is to grain and livestock prices. The table on the opposite page shows the critical yield for winter grown crops in northern NSW and southern

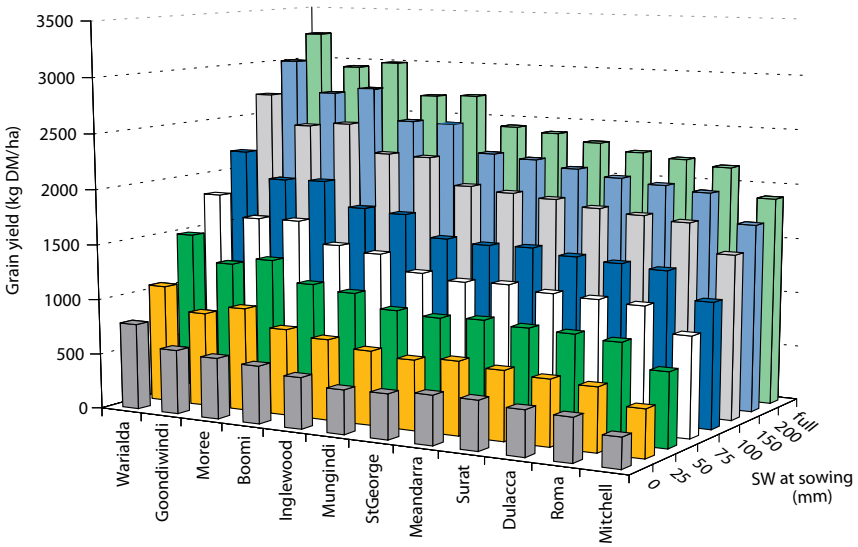
Below: Differences in profit between harvesting and sacrificial grazing as a function of grain yield.

Source: Lindsay Bell, CSIRO



Soil moisture reserves influence final yield

In subtropical environments, the amount of starting soil moisture was also a vital factor. The greater the soil water content at the time of sowing, the higher the crop yield. Crops grown on drier soil profiles were often better used for grazing than for grain production.



Simulated grain yields of wheat sown at eight levels of soil water on a grey vertosol at 12 locations throughout northern NSW and southern Queensland wheat-growing region.

Source: Lindsay Bell, CSIRO

Critical yields (kg/ha) that grazing a crop is more profitable than harvesting in subtropical areas.

Livestock Price ($/kg LW)	Grain Price ($/t)			
	$300	$250	$200	$150
$1.00	336	411	530	744
$1.20	385	473	614	873
$1.40	436	539	704	1,015
$1.60	489	607	799	1,170
$1.80	545	679	901	1,341
$2.00	602	755	1,011	1,530

Source: Lindsay Bell, CSIRO Sustainable Ecosystems, Toowoomba

Case Study: Allen Buckley, South Australian Mallee

Allen Buckley has spent a lifetime looking for better ways to manage his 5,000 ha mixed farm 12 km south of Waikerie. He has been no-till continuous cropping and grazing his crops with Merinos for many years but it wasn't until he attended a Grain & Graze Free Food for Thought – Grazing Winter Crops Roadshow that all the parts to his latest plan for a whole new grazing strategy fitted together.

"The researchers speaking at the workshop put into perspective what I'd been doing for years. But they actually put values on cereal grazing opportunities so I could calculate what potential there was in grazing my cereals," Allen says.

The workshops showed farmers the possibility that if cereal crops are grazed early and the stock are removed at the right growth stage, then weeds will be contained and there will be limited yield loss at grain harvest. When the seasons allow, this creates the opportunity for additional winter stock feed without compromising a grain harvest.

Allen's problem has been areas of rocky soil within his paddocks that are difficult to manage. The soil is difficult to sow with the no-till points used on his softer country and it dries out quickly without in-season rain. These areas sometimes have a large bulk of green feed early in the season but limited grazing or harvesting potential if the season doesn't finish well.

Allen's new strategy is to sow them separately and use them as his grazing country. This may not sound too revolutionary except that Allen is calculating that by grazing the crops and harvesting them he will be able to feed all his ewes, lamb them down and supply grain to his on-farm feedlot all from the rocky areas. It means he will be able to make the most of green feed when it is available in the rocky areas without grazing his better cropping country. If it doesn't rain late in the season and the crop fails at least he will have had the benefit of the good feed when it was available and will still have had the ground cover.

Allen runs a 1,200 head Merino breeding flock with culls joined to SAMMs (South African Mutton Merinos). Non-replacement and crossbred lambs are put through an on-farm feedlot.

"I've always asked myself the question: how can I run my sheep and continuously crop my farm at the same time?" Allen says.

"We're talking about 50-80 kg dry matter feed value out of cereals per day. If one dry sheep equivalent (DSE) consumes 1-1.5 kg of dry matter equivalent per day then at 25–50 DSEs/ha/day I can run my sheep operation on the stony area and still reap grain afterwards for the feedlot."

Allen is always searching for ways to do things better in his low-rainfall (250 mm) environment, including reducing the risk of erosion and preserving and enriching his topsoils. When he started no-till cropping with 6 inch rows it didn't work as well as he hoped – the stubble wasn't breaking down and it was clogging up the machinery at sowing. Allen had to use cultivation and prickle chains to break it up. The stubble was then using the nitrogen to break down and taking it away from the sown crop. Analysis of other farms, showed that 12 inch rows were the answer.

"In the 12 inch rows, much of the stubble is left standing and the inter-rows create a mini-ecosystem. There is a watershed effect where the water runs off the inter-rows thatched with straw and chaff and into the seeded rows."

Allen believes he will run more sheep using this new approach than with conventional farming. The sheep have always preferred the stony areas for grazing but these areas now need more careful monitoring because of the extra pressure on them.

Lambing and shearing times have been changed to fit in with the continuous cropping system. "We now shear at the end of March and lamb in July/August when there is more chance we will have green feed.

"We may need to be careful of the type and amounts of fertiliser we use. We will be monitoring because it may be taking more out of the soil. Perhaps we will need to apply micro-nutrients. We will find this out as we go along."

Allen hasn't kept to the suggestions of removing stock at precise times in the growing phase but he has still managed to harvest grain off his grazed cereals every year except the drought years of 2002, '04 and '07. He says this is partly to do with the fact that parts of the crop always grow faster than the sheep can eat them. The plants then get too tall and stalky for the sheep. Those areas eventually go into head and yield grain.

Allen uses triticale and cereal rye as his grazing crops but believes that some barley varieties may be suitable. He considers cereal rye to be very good at weed control and breaking disease cycles.

Having a go

In temperate areas with the right season and suitable stock available, it is possible to experiment with grazing cereals without much additional effort.

The decision should take into account relative prices of grain and stock, soil moisture, rainfall outlook and anticipated yields, and the value to the livestock enterprise of the additional forage and rapid liveweight gain.

If this seems overly complex, it is possible to start by grazing a small area of cereals and assessing the costs (grain foregone) and benefits (reproductive success, liveweight gain, market readiness, spelling of pastures).

As with all innovations, it may pay to test the approach before making wholesale changes to farming operations. Either give it a go in a small paddock or use electric fencing to isolate part of a bigger one.

Management, such as sowing rates and sowing times, will also be important so look for local advice before getting started.

Assessing the overall impact on farm operating surplus and profit is vital in deciding whether cereal grazing is a technique that can be adopted over a wider area.

Case Study: Ray Brown, south-west Queensland

The Brown family of Moonie, have 2,000 ha of grain cropping country and some 1,600 ha of Bambatsi grass pasture.

Wheat is the main winter crop, followed by triticale, which has replaced oats for grazing and can be carried on for a grain harvest in the right season.

"We moved away from oats because there is just too much rust in it and also because of the seasons. We probably only had one or two good oat crops in 10 years," Ray Brown says.

"With triticale, you can sow at the end of March or in early April and get good feed, with no rust problems until at least October, when you can shut the paddock up for grain.

"One year we harvested triticale grain on Australia Day. We'd had two grazings from the paddock and it still stayed green. Not a big yield but not bad at six bags (1.3 t/ha).

"The other advantage of triticale is that you can use residual chemicals such as Glean and Ally for broadleaf weed control."

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Grazing cereals will decrease crop yields if grazing continues too long or there is insufficient soil moisture available for crops to finish. This compromises profit to fill a feed gap.	▪ Grazing cereals can fill a feed gap and help spell pastures when moisture availability is adequate. It is a 'free feed' and increases total farm production and water use efficiency.
▪ Sowing early in order to graze cereals may expose crops to diseases.	▪ Stubble retention and zero cultivation enhances soil organic carbon levels and helps protect soils from trampling by stock. This reduces compaction and poor water infiltration – and subsequent declines in yields.
▪ Livestock can damage soil structure and formed beds if grazing occurs when susceptible soils are wet, compromising yield, necessitating rehabilitation and inviting soil erosion.	▪ Organic matter retention can help soils suppress soil-borne diseases.
▪ Small paddocks are preferred for optimal management of stock grazing cereals, but bigger paddocks are better from a cropping perspective.	
▪ Extra human resources are required to monitor and manipulate grazing timing and pressure. It is a more complex system.	
▪ Having enough stock to optimise the grazing value of cereals can be a problem; a feed budget is essential for management.	

More information

- Crop growth stages: www.sfs.org.au/Publications/Hi%20Grain%20Updates/HiGrain1.pdf
- Minerals and grazing cereals: www.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/AAP/Dove_GrazingWheat_v2.pdf
- Yield Prophet: www.bcg.org.au/yield_prophet.php
- Grazing cereals: 'Free food for thought', a detailed report on grazing winter crops available through the Grain & Graze network.
- Grazing Cereals Fact Sheet: www.grainandgraze.com.au/Publications/Fact_Sheets

Pastures

Summary

Having different pastures offers mixed farmers a variety of options for filling feed gaps, as well as a great many other benefits. Besides providing feed, a variety of pastures can improve:

- ground cover and erosion control;
- biodiversity and integrated pest management;
- soil health and fertility (higher nitrogen);
- disease management in cropping rotations;
- stock health and condition; and
- opportunities for new income.

The use of different pastures can also bring about important changes in farming systems overall.

Their incorporation into systems such as alley farming and pasture cropping are being tested across Australia, while the growing interest in energy production from plants and carbon sequestration may generate even more pasture opportunities.

Grain & Graze farmers have found that new ways of looking at pastures are opening exciting opportunities

"In many situations, a mixture of annual and perennial pastures will be desirable. A useful tactic is to grow a pasture mixture containing species with complementary growth patterns; such as combining warm-season perennial grasses with temperate annual legumes."

National Feedbase Project Team

Information and ideas

Pastures – more than a 'feedbase'

Pastures are fundamental to the grazing component of a mixed farming system and provide a wide range of 'services' that are of value to the farm as a whole.

Grain & Graze farmers have found that new ways of looking at pastures are opening exciting opportunities for mixed farming.

Pastures, especially those with perennial features, significantly enhance the farm's ability to withstand dry spells and drought. They give farm businesses a degree of climatic resilience, enabling them to endure periods of low rainfall and to bounce back quickly when normal seasons return.

They also provide 'environmental services', including:

- transpiring moisture to reduce 'leakage' into the soil causing dryland salinity;
- providing ground cover to protect soils from erosion;
- creating favourable conditions for soils and enhancing biological activity and nutrient levels (e.g. legumes);
- providing a disease break in cropping rotations;
- providing food and shelter for all manner of fauna as an aid to landscape biodiversity;
- contributing to integrated pest management; and
- depending on the type of pasture, providing shelter to create favourable micro-climates for crops, other pastures and livestock.

This section examines pastures with regard to their primary role as a feedbase but also in the context of their wider roles.

The value of pastures as a feedbase to the mixed enterprise can be enhanced by:

- increasing pasture productivity by irrigating, fertilising or increasing stocking rates;
- adding cereal crops to the pasture base by grazing crops intended for later harvest, growing crops (e.g. oats) specifically for feed, or pasture cropping (sowing a crop into pasture as an adjunct to it);
- feed conservation as hay or silage;
- perennial plants, ranging from certain grasses to shrubs from temperate and subtropical climates;
- annual pastures used as productive 'break crops' in a cropping cycle; and
- grazing stubbles and crop residues.

Pastures as water pumps

There are several factors that influence the effectiveness of plants and farming systems with respect to water use:

- ***Water Extraction Effectiveness**: A plant's ability to extract water from soil. Perennials are usually better at getting water from dry soils than are annual plants.*
- ***Water Use Efficiency (WUE):** A plant's ability to convert water into dry matter. Annuals are usually very good at producing high levels of dry matter in a short time and have good water use efficiency. Perennials, though longer lived, are often slower to grow and may have periods of dormancy which lower their overall WUE.*
- ***Water Input Efficiency:** Also referred to as 'consumptive water use' – a plant's ability to capture available water. In a dryland situation this is the percentage of rainfall used by plants. Perennials are more likely than annuals to be able to use water when it falls as they are around all year – unlike annuals. They often also have extensive root systems that enable them to extract water from depth, if it should get there past the shorter roots of annual plants. Perennials tend to use a greater percentage of rainfall than do annuals.*

Source: Perennial Species Fact Sheet No 1. Central West/Lachlan Grain & Graze

All these options have been explored to some extent by farmers in Grain & Graze but, in recognition of their many system-wide benefits and their ability to provide summer feed in temperate zones, perennials have received the most attention, including:

- perennial grasses – subtropical and temperate, native and introduced;
- perennial legumes – subtropical and temperate; and
- shrubs, such as old man saltbush used in alley farming.

Introducing new pasture options can bring about change in the entire farming system, including the design of new systems that combine traditional crops and livestock with enterprises based on native species to enhance the farm's sustainability. With access to reliable water reaching its limits in many areas, Australia is falling back on rain-fed agriculture, and the name of the game today is maximising both crop and livestock yields for every drop that falls.

As a result, farmers are experimenting with better ways to use rainfall before it sinks deeper into the soil profile. They are trying new combinations of different crops, grown together both for grazing and harvesting, and they are keen to understand carbon sequestration and carbon cycles as part of that. Pastures have key roles to play in this broader perspective.

Perennial grasses

Perennial grasses offer the prospect of an extended growing season, making feed available through summer and autumn.

Grain & Graze research in WA's Northern Agricultural Region (see below) investigated the suitability of perennial subtropical (summer growing) grasses in temperate mixed farming enterprises. Local farmers took part in trials of Rhodes grass, panic, setaria and signal grasses.

Rhodes, Gatton and Green panic were the stand-out species, followed by signal grass. They provided consistent year-round feed quality in terms of metabolisable energy (ME) and crude protein (CP) levels (ME: ~8.5-10.5MJ/kg; CP: ~8.5-22.5%) compared with more variable annual pastures (ME: ~5-13.8MJ/kg; CP: ~2.7-28%).

This work showed that subtropical grasses were best suited to sandy soils in the higher rainfall (450+ mm plus year) western half of the Northern Agricultural Region. The grasses extended the growing season in late spring/early summer and in late autumn/early winter, smoothing the feed-on-offer profile within and between seasons. Surprisingly, the trials indicated that pastures including perennials out-performed annual pastures in winter and spring when the subtropical grasses were least active. The higher stocking rates supported at these times are thought to be due to enhanced performance by the

Perennial pastures: profitable, productive and sustainable

METABOLISABLE ENERGY

Metabolisable energy (ME) is measured as MJ/kg (megajoules per kilogram). It is the energy value of feed that can be used by the animal (See page 57).

annuals in the presence of perennials. This may possibly result from higher soil fertility from nutrient recycling.

The partial filling of an autumn feed gap and extended growing season provide more flexibility for stock trading – giving a wider 'window' for decisions about sales and purchases. Using additional perennials (such as tagasaste on deep sands) or feedlotting can supplement the subtropical grasses and give even greater flexibility to the stocking component of a mixed farm.

Replacing cropping/annual pasture systems on poor sand plain soils with subtropical perennial grasses offers several environmental benefits. The perennials use more of the rain that falls and so reduce the groundwater recharge that can lead to salinity. They provide better ground cover and reduce erosion over summer, and they host beneficial insects that help with the farm's integrated pest management (see 'Managing pests' for more information). Deep rooted perennials also help capture and recycle leached nutrients and so assist in managing soil acidification.

Using the poorer soils for livestock permits more focus on cropping the higher-yielding country, and opens the opportunity for tighter rotations or continuous cropping. Overall productivity may be increased while retaining a preferred crop/pasture balance.

Perennial legumes

Legumes hold a special place in pasture and cropping systems because of their ability to extract nitrogen from the air and make it available in the soil for other plants. Besides being a source of stock feed or a crop they also improve the organic carbon and nutrient status of the soil. As an example, a good stand of lucerne can add in excess of 140 kg of nitrogen/ha in one year. A 'rule of thumb' is 25 kg of nitrogen/tonne of legume dry matter.

Annual legumes such as peas or lupins are regularly used as break crops, but perennial legumes such as lucerne and tagasaste are also being considered.

Lucerne

Grain & Graze research in the Avon Region of WA investigated using lucerne to solve a feed gap problem and manage dryland salinity. A version of MIDAS was used to model profitability under different price and production conditions. The analysis concluded that lucerne can be a profitable option for the region.

Small changes in commodity prices can lead to large changes in profit but, for any given pricing scenario, the profitability of lucerne is driven by the bulk and quality of feed produced and the value of the additional

C3 and C4 plants

Plants convert CO_2 in the air to stored energy using sunlight. The terms C3 and C4 refer to two different biochemical pathways used by most plants.

C3 is the most common (and most ancient) form, using water and drawing CO_2 from the air to produce energy in the form of sugars. It is used by most plants, including wheat and clover.

C4 plants use a more complex process of photosynthesis that requires more energy but is more efficient overall. The C4 process was only discovered in 1966, by two Australian researchers – M.D. Hatch and C.R. Slack. The C4 pathway is thought to be an advantage in warm environments limited by water, nitrogen or CO_2. It is used by some subtropical grasses and plants such as sugarcane, maize, millet and sorghum.

The C4 plants (such as summer growing grasses) are better adapted to hot climates and lower CO_2 levels (warm climate or tropical plants, such as subtropical grasses), while C3 plants thrive in atmospheres with higher CO_2 levels, and more moderate temperatures and sunlight (cool season or temperate plants).

In a temperate to subtropical environment, the advantage of having both kinds of plants in a pasture is that they grow at different times and rates, and so make better use of the total water, sunlight and nutrients available.

From a farming perspective, this means a mixed C3/C4 pasture or cropping system has the potential to be more productive.

production it generates. The results indicated that increasing the area sown to lucerne to support a self-replacing Merino flock had little impact on profit, but the benefits increased if some lambs were sold as prime lamb. Most profit was generated by running cross-bred lambs.

Although lucerne may be grown targeting a summer feed gap, additional winter feed produced was of even greater value to overall profit as it met a gap in the energy demands of livestock. It was also evident that maximising profit from the additional feed available meant increasing stocking rates and supplementary feeding to carry additional stock through the autumn-winter period.

While this higher investment in livestock increased profits, it also increased the variability of income – and risk – as well as demanding good management of stock and pastures at higher stocking rates. The risks from variable income could be partly offset by using standard financial options such as Farm Management Deposits.

From a management perspective, the introduction of lucerne may lead to environmental benefits but could also complicate property management and increase demand for farm labour.

Lucerne pasture – forage crop trade-offs

Lucerne has been used as a short-term pasture in subtropical areas. It has potentially greater profit than most forage crops due to its lower cost and similar production potential – but it's not all straight forward.

Benefits of lucerne include:

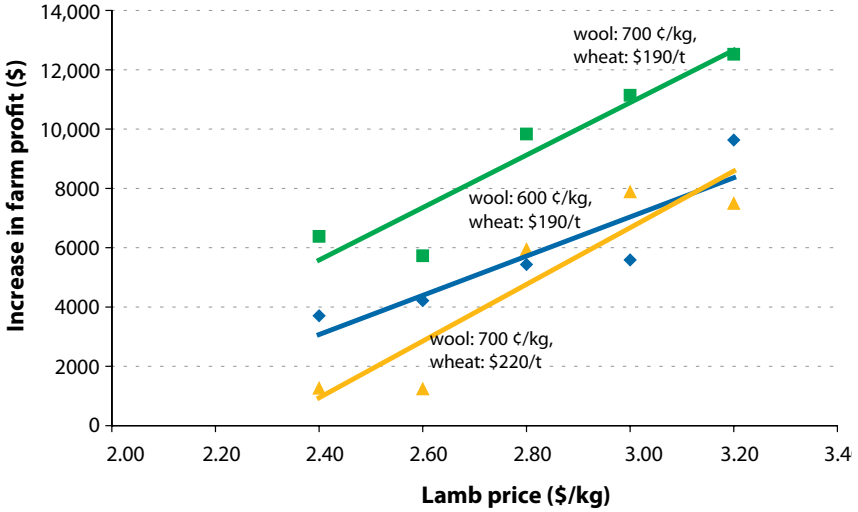
- a significant gain in soil nitrogen during the growth of a lucerne pasture;
- the quality of the pasture is relatively high; and
- lucerne can respond to rain at any time of the year and can make good use of both the winter and summer rain in subtropical regions.

Drawbacks with lucerne include:

- the need to manage bloat in cattle;
- there may be less of a forage reserve than a grass pasture because cattle will graze lucerne at a higher utilisation rate, meaning that the feed supply runs out faster in a dry season;
- killing-off lucerne to return to crop can be difficult; and
- the storage of moisture in soil after lucerne is usually less than after a grain crop, although depletion of moisture beyond the normal crop rooting depth is not an issue in shallow soils.

MIDAS

MIDAS (Model of an Integrated Dryland Agricultural System) is a computer model incorporating the economics and biology of mixed farming. There are regionally specific versions available and each model includes components for crops, pastures, sheep, stubble, grain feeding, machinery and finance. They are strongly based on soil types and rotations and will calculate optimal farm management practices including rotations, flock structure, stocking rate and feeding strategies.



Increase in farm profit resulting from lucerne establishment for the production of cross-bred prime lambs at different wheat prices ($190 and $220/t) and wool prices (600 and 700 cents/kg).
Source: Andrew Bathgate, Farming Systems Analysis Service

Case Study: Aubrey & Lisa Panizza, WA Wheatbelt

Establishing 560 ha of subtropical perennial grasses has enabled the Panizza family in WA's northern wheatbelt to run 1,600 more sheep.

Aubrey Panizza

Aubrey and Lisa Panizza run an extensive sheep enterprise on two properties, 'Yerramullah Park' and 'Stone End', about 200 km north of Perth, WA. Annual average rainfall is 600 mm, with variable summer rainfall and sandy soils with gravel ridges.

The 2,400 ha on these two properties – of which 2,000 ha is arable – supports 9,000 sheep. About 200 ha is cropped annually to a mix of oats and lupins to meet the grain needs of their sheep.

Aubrey crosses 70% of ewes to AMS rams and the balance to terminal sires for the prime lamb market. Ordinarily, Merinos lambs are dropped in May and cross-bred lambs in April. Lambing rates are currently 93% but Aubrey is aiming to boost this to 100%.

"The problem relates to the period between birth and marking. We started feeding lupins and oats at 1 kg/head/day 10 days before lambing and then for six weeks, but it only lifted our numbers by 3%," he says.

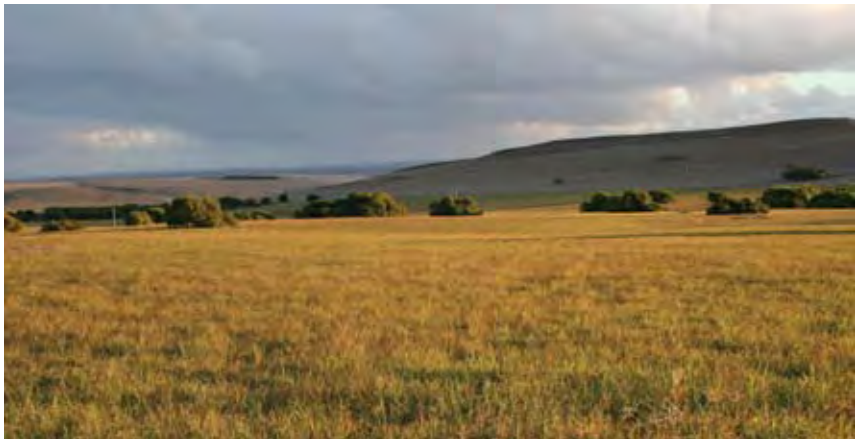
He is now looking to run his ewes in smaller mobs of about 400.

Perennial grasses have been established on the least-productive sandy country and have transformed these areas. The grasses are grazed during winter and up until November, then spelled over summer, unless there are summer rains.

"We had three inches of rain in the summer of 2006 and if we didn't feed the grasses off, they would go rank and be wasted," Aubrey says.

This grazing regime has resulted in a thickening of the stands of perennial grasses, presumably with some grasses self-seeding. In addition, Aubrey has noticed regeneration of annuals such as *Cadiz serradella* that had been sown previously. The grasses are fertilised annually with 80 kg/ha of Coastal Super.

"Having transformed the sandy areas with the perennial grasses, this permanent ground cover has to go a long way toward long-term sustainability," Aubrey says.



Some 560 ha on Yerramullah Park and Stone End has been established to subtropical perennial grasses.

Tagasaste

Fodder shrubs are also used as feed supplements to fill feed gaps and make good use of lower-fertility soils. They provide shelter from the elements (for stock and adjacent pastures or crops) and host a range of fauna, from insects to lizards and birds.

Tagasaste has the added advantage of being a legume. It is well suited to deeper sands and work in the Northern Agricultural Region shows that it is successful in filling the autumn and summer feed gap – though it is better as cattle feed than for sheep.

The shrubs need to be well-grazed or periodically trimmed to keep growth at a height that is accessible to stock and grazing can be timed to limit the flowering and seed set of the plant, which has the potential to escape as a roadside or bushland weed in some regions, if unmanaged.

Case Study: Bob and Anne Wilson, Midwest WA

Bob and Anne Wilson farm just 25 km from the coast in a 650 mm rainfall zone, but they are effectively dealing with drought for six months of the year. They run 850 breeders of their own, plus another 200 heifers and agist up to 1,500 head during the growing season. They aim to finish heifers and young bulls for the tail end of the shipping season in March.

Soils on the leased 2,000 ha property, 'Tagasaste Farm', near Lancelin, 150 km north of Perth, are predominantly grey sand over yellow sand.

Having established perennials over the past 20 years – initially the fodder shrub tagasaste and more recently subtropical perennial grasses – they have been able to extend their growing season and carry more stock over summer.

Initially, the Wilsons cropped Tagasaste Farm as a means of cleaning up new country but yields were poor and the sand was prone to erosion. They switched from sheep to cattle in 1990 when the wool market slumped.

Bob's strategy to drought-proof the property began in 1985 when, with support from the late Jim Mazza, the owner of the property, he planted tagasaste seedlings. About half Tagasaste Farm is now planted to tagasaste in 28 paddocks ranging from 20 ha (the ideal area) to one paddock of 50 ha.

The initial plantings were set up on single rows, 5 m apart. Nowadays, as a tagasaste contractor, Bob establishes tagasaste in a double row with 8-10 m in the inter-row.

Tagasaste is rotationally grazed year round, but with greatest intensity during the growing season. It serves a critical role at the break of the season, allowing Bob to defer grazing his emerging annual pastures.

The tagasaste is fertilised with 100 kg/ha of Super/ Potash 5:1, but recent soil tests have shown that while the phosphorus levels are adequate, the potassium levels have dropped over time.

In recent years, Bob has opted to supplementary feed lupins to some of his cattle grazing the tagasaste and adjacent annual pasture paddocks over the summer. "We would see their weight gain slow up over summer when they were only feeding on 'tag', " he says.

Bob says the tagasaste has in the past provided an alternative feed source in the event of summer rain. "But it is some time before stock feeding the tagasaste actually put on weight," he says. "We wanted to incorporate subtropical perennial grasses as an alternative feed source, knowing that they would respond extremely quickly to summer rain."

He first planted subtropical perennial grasses in one 60 ha paddock in September 2003, sowing a mix of Rhodes grass, Gatton panic and signal grass using a triple disc drill. These grasses were first grazed in the following February and then rotationally grazed. Plant density remains good and there is now a diverse mix of perennial grasses and annuals in that paddock, including blue lupins.

Bob Wilson

Bob sowed a 70 ha paddock to the perennial grasses in the spring of 2005 and a further 90 ha to the Rhodes grass, panic and signal grass mix in 2007. The subtropical grasses proved their worth at the break of the season in 2005 and again in the summers of 2006 and 2008.

"In 2005 we had two inches of rain at the start of April but nothing to follow it for a month," Bob says. "It was one of the worst years we have had for subclover – the annual pastures were dominated by capeweed. While it was a false break for the annual pastures, the perennial pastures powered away."

In the summer of 2006 Tagasaste Farm received three inches of rain in January, with some more in February, and the subtropical perennial grasses showed their true potential, with massive growth.

"To have mobs of cattle grazing green feed half a metre high in February was a sight to behold," Bob says.

Subtropical perennial grasses provided opportunistic feed following rain in January 2006.

Saltbush alley farming

A Grain & Graze project in the Central West /Lachlan region of NSW investigated a farming system using old man saltbush as both a fodder reserve and as shelter in an alley farming project. The system was considered to offer potential benefits in terms of better matching feed supply with demand, providing a wind shelter, promoting better ground cover to reduce erosion, and improving the local and regional biodiversity.

Preliminary results from trials have indicated that, over a six-week period, lamb weights increased more in mobs that had 20% of the paddock sown to saltbush alleys than they did for those without saltbush. In addition, ewes lost less weight over summer if saltbush was present. There also appears to be less variation in liveweight in stock grazing the saltbush sites. If confirmed, these early insights have positive implications for the stability of livestock production, profit and the environment.

Alley farming can be adopted as one component of a farming system and matched with other 'between alley' options, ranging from traditional pasture/crop rotations to pasture cropping. In the Grain & Graze trials old man saltbush has been used as a fodder source, but other options are available for the alleys (such as oil mallee, plants grown for energy production or carbon sequestration or for native bush revegetation).

Old man saltbush, and other woody perennials, may be used in other situations as well. A perennial shrub paddock may be established as a solid block for periodic grazing (especially as a means of resting other pastures) or as a means of restoring saline land to productive use.

Saltbush in the Central West / Lachlan region.

Old man saltbush

Old man saltbush is native to Australia. It is a deep-rooted perennial that is very tolerant of drought, and moderately tolerant to salinity and waterlogging. It grows in regions with 175-600 mm of rainfall.

It is palatable to livestock but not to kangaroos and helps prevent grass fires. It provides high-protein green feed year-round but requires supplementation with good-quality pasture or stubble for adequate energy intake. Due to its high salt content, grazing stock require access to good water.

Old man saltbush should be grazed regularly, not just as drought forage, to keep it productive. Grazing can be quite intense for short bursts, but needs to be followed by an adequate break to permit the bush to recover.

Pasture cropping

Pasture cropping is the practice of sowing cereal crops into degraded native perennial pastures. In a good year, the grain may be harvested (and either stored for feed or sold) while in less-favourable seasons the crop is grazed. The approach suits regions with evenly distributed annual rainfall and perennial grasses that are active in summer and dormant in winter. An even rainfall distribution throughout the year – as occurs in the Central West of NSW – avoids shortfalls in either crop or pasture production due to seasonal rainfall deficits. The winter dormancy of the native grasses allows sown crops to grow with little competition.

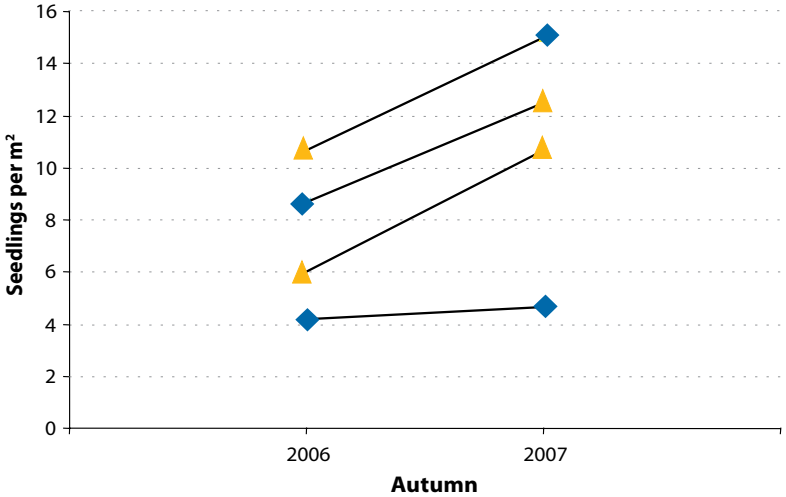
Pasture cropping is a useful option on soils that do not store water efficiently, as it allows moisture to be used when it falls, rather than being lost over time. However, summer-active perennials consume water and nitrogen, making it unavailable to subsequent crops, which may suffer yield losses as a consequence. For pasture cropping to improve profit over conventional cropping or grazing requires a livestock system that uses the additional forage produced in summer/autumn (through the absence of conventional fallowing) to compensate for reduced crop yield due to moisture limitations. The system must also be able to use the forage resulting from crop failures and the gains from stock must exceed any losses from crops. This, in turn, may necessitate a change in the livestock component of the farming system, such as increased trading.

There are several environmental benefits from pasture cropping in degraded pastures. It improves ground cover and prevents erosion, it improves biodiversity and may be more resilient through drought. Pasture cropping can also be used as a pasture regeneration technique since, for reasons not yet understood, direct drilling into a degraded pasture can encourage perennial grass recruitment, which enhances pasture composition without foregoing production.

Pasture cropping is not suitable in good stands of native grassland, where it would harm the integrity and environmental value of the native system. In some States it may also be an offence under native vegetation protection laws.

Initial investigations into the effect of pasture cropping on red grass *(Bothriochloa macra* – a native perennial) seedlings at Wellington, NSW, indicate an increase in seedling numbers after pasture cropping as compared to a continuous pasture phase (see graph below). This effect appears to persist the following year after a pasture cropping phase, but requires further research.

Pasture cropping is not appropriate in good stands of native grassland



Red grass (Bothriochloa macra) seedlings recorded the following autumn after being pasture cropped (yellow triangle) or untreated as pasture (blue diamond) at Wellington, NSW. Pasture cropping has increased the number of perennial seedlings compared to a continuous pasture phase.

Source: Geoff Millar, DPI NSW

Case Study: Kim and Wendy Muffet, Central West NSW

Kim and Wendy Muffet, from Wirrinya near Forbes, incorporated pasture cropping into their holistic management approach to farming in response to the problems they see with a high-input system financially, ecologically and socially.

"We've come from a system of Merino sheep and 'no till' annual winter cropping, where we were using high inputs to achieve high yields. It wasn't working for us – it was boom or bust financially, stressful and negatively affecting the health of our land.

"We believe there is a better way to farm that's more in tune with our variable climate. This alternative system also allows us, as farmers, to be part of the solution to the threat that climate change poses, and to benefit from the carbon trading opportunities now appearing."

Grain & Graze, in partnership with the Lachlan CMA and Stipa Native Grasses Association, have supported much of the training the Muffets have done. "Through this support we have been able to attend workshops and short courses run by Holistic Management consultant Mark Gardiner, Grazing for Profit's Terry McCosker, and the pasture cropping pioneer, Col Seis – all of them inspirational educators," Wendy says.

"The resulting changes in our beliefs and practices have transformed the way we feel about the future of family farming.

"We feel confident that we can adapt our farming system to deal with the challenges that climate change and spiralling input costs are throwing at us."

The Muffets now use a holistic management system to run 2,000 Dohne-based sheep in one mob on 'Taroona'. They grow wheat, oats and barley in their pasture cropping system but no longer grow canola and field peas.

Pasture cropping is a system where crops are sown directly into perennial native pastures when those pastures are dormant. Herbicides are used to kill annual weeds prior to sowing and fertiliser is applied at sowing. Livestock are an essential part of the system and benefit from the fact that the paddock is able to be grazed right up to sowing and then again as soon as the crop is stripped when the pasture is off and running.

The Muffets consider the number one benefit of this sort of farming is year-round living ground cover. They have seen the topsoil loss from wind erosion and know the benefits ground cover can supply through moisture retention, soil temperature regulation, healthier soils and increasing biodiversity.

Dougal Muffet with his parents, Kim and Wendy.

"We are now managing our existing pasture base to encourage the native perennial grasses back. We have done a pretty good job of killing them off over many years of high herbicide use," Wendy says.

"That left us with a lucerne/annual grass pasture base, which in this area equates to a lot of bare ground over summer and all of the problems that brings.

"With a combination of time-controlled grazing and pasture cropping, we have begun to re-establish a strong native perennial base and we are pretty excited about the pace at which this is happening!

"We plan to try sowing some native perennials this year although understand that it is not always wildly successful."

The Muffets sow into native grasses such as Windmill and panic after a heavy graze and a burn down by Spray Seed. They have used glyphosate to kill weeds but are moving away from summer spraying except for Bathurst Burr infestations.

"I've been farming since the '70s and there is always the promise of high prices – the big year. Lately, inputs have risen so much that prices and yields will need to be very good to justify using them. We don't think that's a good way to go. We need to get to a biological farming system that delivers a profit year-in-year-out and improves the health of our land," Kim says.

He doesn't have any concrete data yet to quantify how pasture cropping has improved their operation, but will be collecting data on all key areas in conjunction with the DPI and Grain & Graze.

Having a go

Farmers interested in trying out new approaches to pasture management are encouraged to talk with someone who has already put a 'toe in the water', to get their view of the pros and cons of management.

Talking with an experienced researcher or farm adviser and reading up is also recommended to get a feel for what may work in local situations and complement the desired farming system.

When ready to put theory into practice it pays to plan for success and how it will fit the overall farming operation, e.g. what changes are required to the whole farm plan? To test a new approach, manage the risk by using a paddock that has good prospects for success, but isn't too big for starters.

Some things to remember:

- Pastures need to be managed to permit seed set, seedling recruitment and post-grazing recovery. This needs to leave the roots healthy and enough leaf area for photosynthesis to occur.
- Sheep and cattle have different grazing behaviour and have different feed preferences (although 'training' is possible). Sheep graze lower and have a greater impact on pasture composition – they tend to go for clovers first in green pastures – whereas cattle are less selective and better at taking in less palatable, rank species.
- 'Improved' pastures should be well fertilised and legume components maintained to build nitrogen-rich organic matter for higher fertility and long-term resilience.
- Weediness in pastures is a sign of decline or inadequate management – a key management benchmark. Competitive preferred pasture species and matched grazing tactics are keys to higher input systems.
- Grazing should be used prevent a build up of tall, rank material in perennial grass species in pastures.

Below: Fodder options field day in the Mallee.

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Synchronise grazing with the critical growth stages of preferred pasture species to ensure their vigour and persistence. Native pastures are susceptible to over-grazing and need to set seed for natural recruitment; most perennials require resting with sufficient leaf cover and root health to drive renewal.	▪ Productive pastures containing legumes provide high-quality soil organic matter to enhance soil biology, fertility and structure for long-term resilience and production.
▪ High pasture protein levels can cause bloat in livestock.	▪ Deep-rooted perennials recycle leached nutrients and help manage recharge (improving water use efficiency) as well as providing feed throughout the year and in drought.
▪ Cropping and fallow phases may reduce populations of root fungi that are essential for some native and perennial pasture species.	▪ Perennial pasture species can extend feed availability and grazing days.
▪ The conservation value of native pastures can be compromised by cropping, introduction of exotic species, application of fertilisers and inappropriate grazing.	▪ Astute grazing management can help manage weeds, improve production, lower chemical use and reduce input costs.
▪ Weedy pastures can host soil-borne diseases that affect rotational crops.	▪ Managing grazing to maintain adequate ground cover protects soil from erosion, enhances soil biodiversity and sustains future yields.
▪ Summer grasses and weeds can provide a 'green bridge' carrying pests and diseases from one year into the next.	▪ Woody perennials can provide fodder, beneficial feed compounds for stock, shelter, habitat for birds and insects (which eat crop and pasture pests), plus help in managing recharge and preventing soil erosion.

More information

- Grain & Graze pasture trials:www.grainandgraze.com.au/Publications/Publications/indexdl_7076.aspx
- Grazing saltland pastures and native pastures: Land, Water & Wool – www.landwaterwool.gov.au/
- The feed value of crops: 'grazing management of sheep' at: www.agric.wa.gov.au
- Plants and options for new farming systems: Future Farm Industries CRC and its predecessor, CRC for Plant Based Management of Dryland Salinity,www.crcsalinity.com/index.php and www.futurefarmcrc.com.au
- Making the most use of pastures through profitable livestock: www.makingmorefromsheep.com.au/index.htm

Natural assets

Summary

Mixed farms can provide important refuges for native flora and fauna, offering a range of benefits to farms and farming families, as well as to the nation.

Many of Australia's mixed farming landscapes have been extensively cleared and the species that rely on them (such as woodland birds, mammals and reptiles) have declined in number – in some parts of the country this loss is continuing. That makes on-farm remnant vegetation of considerable national value and significance, especially when it forms stepping stones between larger blocks of vegetation or refuges from which vestiges of native populations of plants and animals may be able to recover.

Programs such as Grain & Graze help farmers appreciate the role they can play in arresting and reversing the decline of native species and ecosystems, while also raising awareness that without good management we will see continuing long-term declines in the Australian character of the landscape.

The program has operated across a wide range of ecosystems, from native grasslands, to mallee, to open woodlands and brigalow. Throughout that range, Grain & Graze is clarifying the real benefits that farms and farmers gain from biodiversity, such as:

- an alternative or emergency feed source available;
- a cheap pollination service to optimise crop yields;
- a low-input way to control pests;
- shade and shelter for stock;
- a way to improve soil health and productivity;
- a means of controlling salinity, water tables and water quality in local creeks and rivers;
- a source of pleasure and refreshment for the farm family; and
- the satisfaction of caring for important native habitats.

Grain & Graze also found that many farmers take a real interest in biodiversity and a pride in their role in maintaining and enhancing it. It has highlighted a desire among farmers to know more about biodiversity and how best to look after it.

Biodiversity: the variety of life – from ecosystems, to species, to genes

"I know I have to do a lot more to protect my remnant vegetation. I'm trying to do my little bit and make things work better, I guess. If you are re-vegetating your creek lines and the birds are coming back, that must help the environment."

Gene Stone,
Avon, WA

Information and ideas

"Biodiversity provides the best opportunity we have of utilising a natural mineral cycle and removing the need for chemical fertilisers."

Angus Maurice, Central West/Lachlan, NSW

What is 'biodiversity'?

Biodiversity is a complex subject. There are many variables, lots of questions and any number of equally correct answers, which often depend on personal objectives.

Some considerations are emotionally charged. Natural areas and wildlife can be an important component in helping define a farmer's 'sense of place' – the sense of 'belonging' they have with their farm as they gaze upon a high-yielding crop, survey a mob of stock in prime condition, reflect on their thriving revegetation efforts, enjoy a bush barbecue with family and friends, or simply take in the view from the verandah.

Biodiversity covers a range of scales. It is about whole systems – ecosystems (their structure, function and composition), species (the number of species present and the abundance of individuals) and genes.

It includes farms, livestock and crops, and the landscapes in which they exist.

However, the term is often used to refer primarily to native systems and species; natural settings in which native plants provide food and shelter for a diverse range of native fauna.

To examine biodiversity is to consider:

- Composition – what species are present and how big are their populations given the habitat available.
- Structure – where are they and how are they arranged in the landscape; both laterally and vertically.
- Function – what do they do? What services do they provide, such as pollination or nutrient recycling?

In a mixed farming context, biodiversity can be critically important to production. For instance, healthy life in the soil (known as biota) makes nutrients readily available to plants and combats root diseases. A native or saltland pasture can provide valuable out-of-season or standby feed. It can also harbour beneficial insects and birds that help control crop and pasture pests, which reduces pesticide costs and risks. Farms and their biodiversity can be critically important to conservation at a regional and national, as well as farm, level – supporting vestiges of rare native grasslands or threatened species of woodland birds.

Grain & Graze has made a major effort to better understand just how much biodiversity is on mixed farms, and how healthy it is, as a step to forming a deeper

Below: Monitoring biodiversity helps with an understanding of farm ecology.

understanding of its value as a farming, as well as an ecological, asset, and the factors that may be important to its future management.

The Biodiversity in Grain & Graze (BiGG) project has been one of the largest on-farm biodiversity projects ever run in Australia and has measured aspects of biodiversity in nearly 200 paddocks across the nation.

Biodiversity in Grain & Graze – the BiGG project

The BiGG project assessed biodiversity indicators on 47 farms across Australia, twice each year (spring and autumn) for two years. It measured plants, invertebrates (beetles, ants and spiders), birds and soil microbes (fungi and overall biological activity).

Separate data were collected on each farm from:

- a cropped paddock;
- a paddock under rotation, as a break crop or pasture phase;
- perennial pasture; and
- native vegetation.

The size and location of the sampled paddocks was mapped and farmers interviewed about farm size and enterprise mix, paddock history and management. Besides providing an inventory of how mixed farming systems support biodiversity, the project also explored how the arrangement of paddocks on farms, and farms in the landscape, support or affect native biodiversity. The project ran from 2005 to 2008.

The BiGG project was Australia's first trial aimed at collecting a national set of data about the biodiversity found on farms. It has been unique in examining a range of biodiversity indicators and operating at a range of scales from paddock to continent, and has focused on the following questions:

- What biodiversity continues to exist on mixed farms?
- Is there a difference in native biodiversity between different land uses (crops, pastures, native vegetation)?
- Do farms that are close to large reserves have more native biodiversity than those isolated from large areas of native vegetation?

The active support of the participating farmers was vital to the project.

They showed a strong interest in finding out exactly what biodiversity was present on each farm, and there was often considerable surprise at the large numbers of species recorded.

Many farmers said they found involvement in the BiGG project to be a real eye-opener, as they were not aware of the many native species present, some of which performed functions vital to agriculture, such as watertable management or control of pests.

"Biodiversity is an investment in the future, for the sustainability of the farm into the future."

Steve Wilkins,
Border Rivers, Queensland

To read the Thinking BiGG case studies and listen to audio from Talking BiGG, visit www.grainandgraze.com.au

Mixed farmers manage important national biodiversity assets

As well as collecting, analysing and interpreting a vast amount of data, the project helped build the Grain & Graze regions' capacity to collect and interpret ecological data, and established links between farmers, catchment bodies and researchers.

Native biodiversity on mixed farms

The BiGG project was still under way when this report was prepared, but it was already evident that Australia's mixed farms support an immense amount of native biodiversity.

The sheer number of species and the range of life forms present is significant. It highlights the potential importance of biodiversity to healthy farming systems – and the tremendous contribution to conservation by modern farms and farming families.

Early results from BiGG confirmed that biodiversity was alive and well in mixed farming systems. It found:

- More than 500 species of beetles, 860 genera of ants and 330 groups of spiders, most of which were native. More than 230,000 individuals were counted from the samples taken in 2006 and the autumn of 2007.
- One hundred and eighty-one (181) species of birds – 174 of them native, 33 listed as 'threatened' and 23 noted as declining in abundance nationally. Some rare species were also recorded, including sightings on farmed land outside areas of native vegetation (such as brolgas in Victoria and mallee fowl in NSW). One hundred and fifteen species (64%) are known as predators on invertebrates – providing a service to farm production.
- Soil microbial activity is affected by rainfall, soil temperature, pH and nutrient levels. It was highest in cropped paddocks and lowest in remnant vegetation through all seasons. Soil fungal diversity was not related to measures of activity and was generally highest in remnant vegetation.

Some early insights are beginning to emerge from the data, which confirm and extend existing knowledge, as well as adding new elements of understanding. They are best regarded as 'hunches' at present, pending further data collection and analysis, but some themes are:

- There are large differences in the total number of species and in the species recorded from different regions.
- This probably reflects historical differences in development, and in climate and soils, but some differences appear to be related to land use and management – and small changes in management (e.g. planting native grasses) can boost overall biodiversity.
- Biodiversity occurs in all land use types studied, but the highest values are found in remnant vegetation and then

Below: Wetlands and seasonal flooding can provide valuable habitat.

perennial pastures with lower values for crop and rotation paddocks.

- Farms with a greater proportion of remnant vegetation record higher species richness for birds, invertebrates and vegetation.
- Many birds use the entire farming landscape. Bird species richness is affected by the presence of remnants on and off farm (within 5 km of the farm boundary) and by the condition of the habitat on farm.
- Bird species richness was higher where habitat was more complex, i.e. the presence of more than one structured layer (trees, tall shrubs, small shrubs).
- Species richness of birds and spiders was lower on farms recording high wheat production (t/ha).
- The data suggest that soil and microbial activity can be used as an indicator of paddock inputs and soil disturbance. Land uses with more inputs and disturbance have fewer ant species than those with lower inputs and disturbance.

While strengthening existing understanding of how farms interact with biodiversity, Grain & Graze is adding significant amounts of data regarding the role of farmed land in supporting biodiversity, and extending the knowledge base of ecologists and farmers alike. It is beginning to take 'biodiversity' out of the realm of misunderstood jargon and making it real and meaningful to farmers.

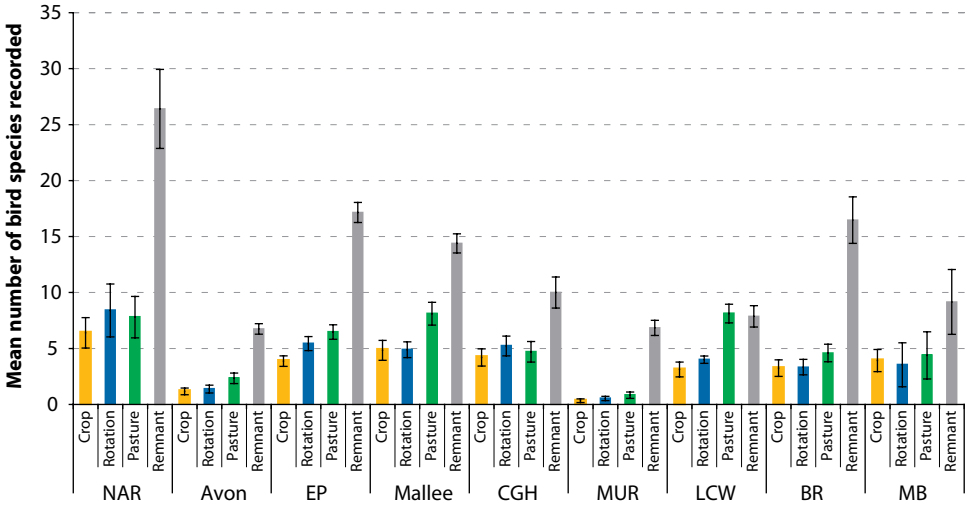
Land use and biodiversity

Preliminary results indicate that different forms of biodiversity respond differently to alternative land uses (i.e. cropping, pasture, rotation or native vegetation). The type of vegetation present, its condition and health, and hence the food and shelter it provides, is a key influence on the fauna and food chains supported in any area, but some generalisations are emerging from Grain & Graze investigations.

- **Invertebrates**: At a regional scale, the presence of different species of beetles, ants and spiders is influenced more by land use and management than geographic location. Carabid beetles are one of the predator groups used in Integrated Pest Management (IPM). Beneficial carabids were found in all regions. They are generally smaller on farmed land than in remnant native vegetation, a sign of environmental stress. The beetles in paddocks also tend to be winged (flighted) species; wingless species are the norm in remnants.
- **Birds**: At a regional scale, the number of species of birds is heavily influenced by geographic location and proximity to other areas of native vegetation and habitat provision (especially the 'structure' of vegetation – the presence of different layers, such as ground cover, shrubs and trees).

"It is important for us to understand the role biodiversity plays in our farming and grazing practices."

Geoff Chase,
Central West/Lachlan, NSW



More species of bird were found in remnant vegetation than any other land use type. These data were collected over autumn and spring 2006 and 2007.
NAR = Northern Agricultural Region; Avon = Avon; EP = Eyre Peninsula; Mallee = Mallee; CGH = Corangamite/ Glenelg-Hopkins; Murr = Murrumbidgee; LCW = Lachlan/Central West; BR = Border Rivers; MB = Maranoa Balonne

Source: Janet Smith and Kerry Bridle (unpublished data)

Case Study: Craig Forsyth, Northern Wheatbelt, WA

Craig Forsyth wishes farmers had known the value of biodiversity decades ago. He, for one, would have "done things a bit differently, left far more trees for shelter belts and for wildlife corridors. We know now how important biodiversity is in the system".

The Forsyth family is still well placed for biodiversity on the 3,600 ha 'Avoca', outside Dongara, 360 km north of Perth, with about a fifth of their country still covered by remnant vegetation. Predominantly carrying coastal blackbutt, grevilleas and banksia woodland with tussocky undergrowth, the 700 ha of undisturbed vegetation is home to the rare Arrowsmith's stilt lily. The endangered Carnaby's white tailed cockatoo also nests there.

He accepts that the remnant vegetation remained undisturbed largely because the soils underneath it are "gutless" and not worth clearing.

In the production side, Craig has decided to commit all of Avoca's cropping land to pasture for cattle.

"Up to six years ago we cropped 1,400 ha. We had water-logging problems in 1998 and 1999, and then serious disease problems in lupins, which are a very important part of the cropping system here, providing nitrogen for the wheat," he says.

"All the arable country is pasture improved to some degree now. We started seriously with the subtropical, perennial grasses in 2001, though we had dabbled in them since the early 1990s. Then we had no grasp of the rotational grazing they need, but we've planted 800 ha of them now – Gatton panic, fine cut Rhodes and signal grass – and they have a sort of symbiosis with our established annual legumes, blue lupins, sub-clovers and serradella.

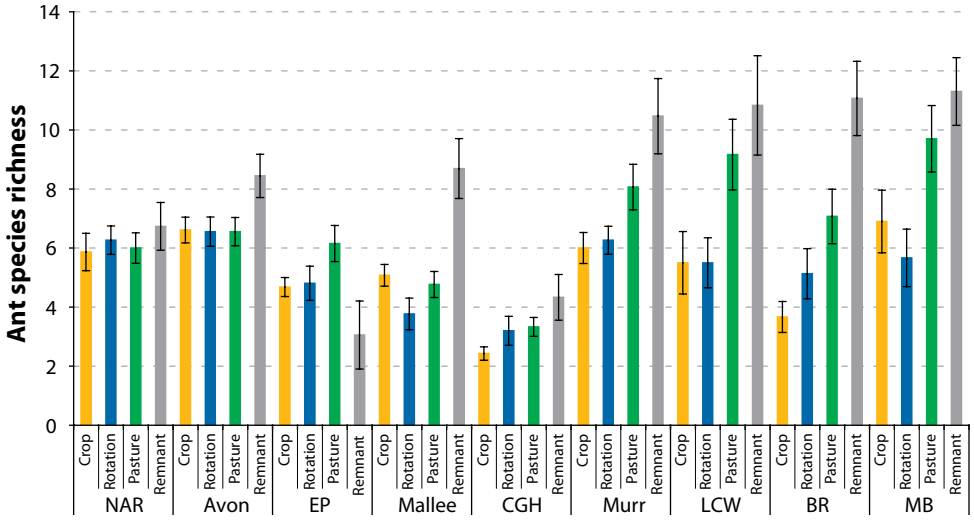
The Forsyths run a Santa Gertrudis / Droughtmaster breeder herd, backgrounding progeny for feedlots, and have an alliance with pastoral stations in the west Pilbara, taking young cattle to prepare for the live export market.

Extra paddock feed comes from 400 ha of tagasaste, planted in rows 18-20 m apart. Craig says the wind protection provided by the tagasaste is creating an evolving ecosystem, with annual legumes such as blue lupins, grasses and what he calls "the three "r's" – ryegrass, radish and rubbish – all highly palatable to cattle.

"We'd been playing around with tagasaste for 25 years, but over the past 10 we've learned how to handle it and have cranked the system up. We're making sure we keep a cover on the soil and keep an area set aside for endangered species.

"Like anything in life, there needs to be a balance."

Craig Forsyth examining rhagodia seedlings planted in an area where tagasaste and saltbush have been unsuccessful.



Mean ant species richness for land use types. Data from three seasons (autumn, and spring 2006, and autumn 2007) were used to calculate these means. Generally there are more species of ants in remnants and pasture paddocks than in crop and rotation. This pattern does not hold for the western states.

NAR = Northern Agricultural Region; Avon = Avon; EP = Eyre Peninsula; Mallee = Mallee; CGH = Corangamite/Glenelg-Hopkins; Murr = Murrumbidgee; LCW = Lachlan/Central West; BR = Border Rivers ; MB = Maranoa Balonne

Source: Peter McQuillan, Margy Fitzgerald and Kerry Bridle

Significantly more bird species were found in the remnant vegetation in most of the regions surveyed. Initial analyses indicate that the number and area of adjacent remnant patches has more influence on the number of species present than the configuration of remnants in the landscape.

- **Soil microbes**: Land use and management (such as grazing pressure) affect soil microbial communities during periods of average rainfall. Low rainfall periods reduce microbial activity in soils, making management differences hard to detect. The diversity of soil microbial and fungal populations was higher under remnant vegetation, but the level of microbial activity was highest under cereal crops. The 'Soils' section provides more information.

Autumn monitoring of farms in the Avon (WA) showed that different groups of invertebrates respond differently to land use. More ant species are found in remnant vegetation, more beetle species are found in pastures (annual and perennial) and spider species richness is similar across the four land use classes. However, different species of spiders are found in the different land use types.

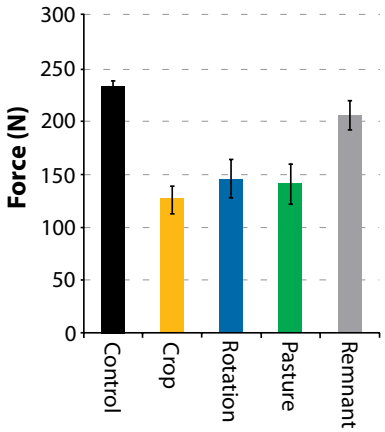
Different farming systems and land uses provide different benefits for biodiversity. Having a mosaic of systems and management across a landscape can promote a more diverse range of habitats and host a larger total number of species, but it may also present challenges to the long-term viability of some populations.

Although lower in autumn than winter, the number of bird species was higher throughout the year in remnant vegetation.

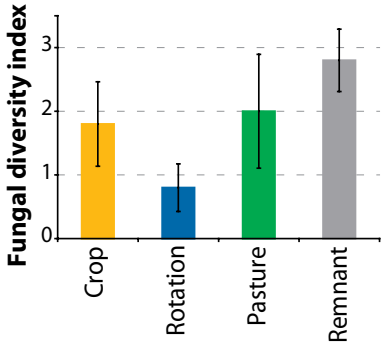
Soil microbial activity is assessed by the degree to which cotton strips decompose when buried in soil. The graph at right shows how much force is needed to tear a strip after being in place for two weeks – including a control that has not been buried. It appears that the soils in farmed paddocks (which are often chosen for their soil quality) have more biological activity (less force is needed to tear a cotton strip) than do those under remnant native vegetation (which may have been left uncleared due to poor soil characteristics). It should be noted that biological activity is not the same as biological diversity.

Soil microbial activity (decomposition) was highest in the crop paddock in autumn 2006. However, soil fungal diversity was lowest in 'rotation' paddocks and was higher in less-disturbed land use types (remnant vegetation and perennial pasture). This demonstrates that biological activity is not the same as soil biological diversity.

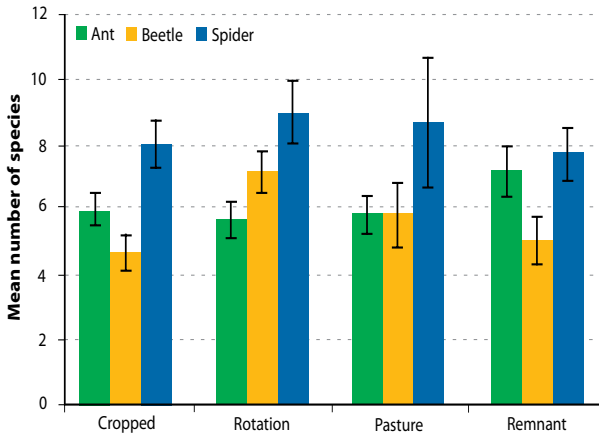
It is interesting to contemplate the possible interactions between different land uses. It may be that remnant vegetation, with higher numbers of species but lower population sizes, functions as a refuge from which species can migrate until they find a niche that suits (such as a fertile paddock), where they can grow into large populations.



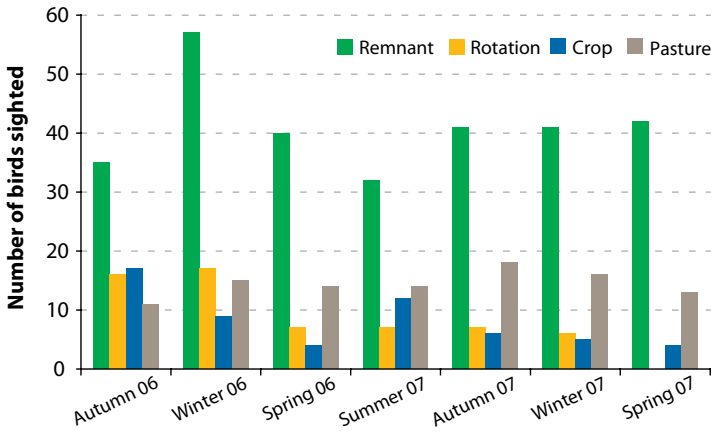
'Cotton strip' results, Avon 2006. Higher microbial activity in cropped soils is indicated by less force being required to tear cotton strips that have been buried for two weeks.
Source: Kerry Bridle



Soil fungal diversity was higher in remnant vegetation in Avon than in rotation paddocks. This contrasts with microbial activity.
Source: BiGG database (Jason Hon, Martin Lane and Kerry Bridle)



Avon invertebrate species diversity, Autumn 2006.
Source: Kerry Bridle



Avon bird species diversity.
Source: BiGG Project.

Case Study: Lawry Pitman, WA Wheatbelt

Lawry Pitman became involved in BiGG when he saw an advertisement about the project in the local newsletter. He phoned Avon's regional biodiversity officer, Susie Murphy White, and asked if his property at Corrigin could be used as one of the project's survey sites.

Lawry is well known to WA researchers as an avid amateur naturalist and he spends a lot of time photographing the numerous plants and animals found on his farm.

In November 2007 the BiGG national project team met Lawry as he took time out from his busy harvesting schedule to talk about biodiversity and what it means to him. He has spent many years involved in wildlife and habitat restoration projects on his farm and in the region.

"In 1984, we were planting trees on farms. My neighbours were planting 200 a year and I told them that that wasn't enough, that it should be 5,000 trees a year. I initiated a farm improvement group in Corrigin in 1988 and developed a Landcare group in 1990. I chaired the group for five years and then thought someone else should have a go," he says.

"I have 65 different species of birds on my farm. The revegetation has helped the red-capped robin. I instigated the 'Save the Curlew' program in Corrigin on a points system, 15 points for a cat's tail and 10 points for a fox's. The program started in 1990 and people are still sending their numbers in.

"Between 1997 and1999 we had a big splurge and planted 300,000 trees, 120 different species all collected from the farm. The trees were planted in corridors that were 1-2.5 km long and 55 m wide, with more than 80 different species in each. The development of corridors means that kangaroos are all over our farm now and some of the results of the 'Decade of Landcare' are now in the path of our controlled traffic layout – but we'll learn to live within it."

Birds are not Lawry's only interest. He has photographed moths, ground invertebrates and aims to have everything, including soil fungi, named on his property.

He observes species populations and manages his farm accordingly. For example: "We noticed a decrease in the spotted burrowing frog, so we fenced off all gullies and planted trees. The wheatbelt frog is prolific now. Every time we get summer rain, they come from all over the paddock," Lawry says.

The remnant patch used for the BiGG project is 29 ha. "The soil is generally too sandy, the land too light, so it was left there. It was fenced off in 1984, as were all our remnants. There are many species of orchids in there and the roos were eating it out.

"There are lots of theories about the benefits of bushcare, but I don't know. Most of it is feeling good – and it feels good to me, when you're coming over a hill from a barren paddock," Lawry says.

Source: Dave Green, Susie Murphy White and Lawry Pitman

Lawry Pitman spends many hours photographing the numerous plants and animals on his farm, including at right, from the top, a Jewel beetle, Common Grass Blue butterfly, Hornet, Katydid, Striated Pardalote and Dragon fly nymph skin.

Farms make landscapes

A Grain & Graze project in the Central West /Lachlan region of NSW explored the links and contributions between individual farms and the biodiversity at a regional (or 'landscape') level.

Native vegetation was assessed in terms of quality or condition, total area and configuration – the degree of 'connectedness' between patches.

The work showed that past clearing had had a heavy impact on native ecosystems (more than 80% of most systems had been cleared) and that the condition of remnants was generally very poor. This was signalled by the presence of weeds, little regeneration of native species, few ground cover species and dieback in the trees.

Six farms were studied in detail, which had from 2% to 18% native cover remaining. They supported 74 different species of bird, including:

- 38 species that depend on woodlands for survival;
- four woodland species that are declining in numbers in the NSW wheatbelt (emu, rufous whistler, white-browed wood swallow and dusky wood swallow); and
- three 'threatened species' (bush stone-curlew, superb parrot and grey-crowned babbler).

Even though the remnant vegetation may not be in good condition, it is still playing a vital role in conserving threatened species in the region.

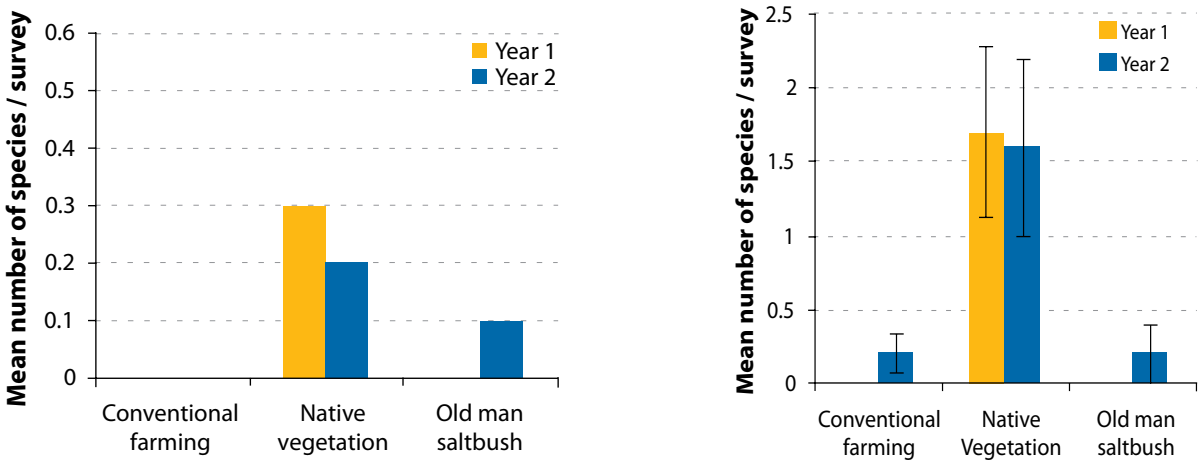
It was noted that more species were found in larger patches of vegetation but that species numbers overall did not vary significantly between the six farms.

The project also looked at biodiversity values in newly planted old man saltbush established for alley farming near Condobolin. These plantings are still young, but already they are showing an increase in native biodiversity when compared with conventional farming – although still well short of the levels found in native vegetation.

The saltbush plantings play a role as habitat for woodland birds in general and, importantly, for some bird species that are declining in abundance elsewhere.

"Biodiversity continues, even when we've altered the landscape."

David Lewis, Avon region, WA



The number of decliner (left) and woodland (right) bird species. Source: Seddon et al (2006) Grain & Graze Progress Report

Case Study: Steve Wilkins, Border Rivers, Queensland

Steve Wilkins

Steve Wilkins manages 'Kioma', a mixed farm in the Toobeah district owned by J.H. Fairfax and Son. The property supports 1,500 Merino sheep, a 500-head cattle breeding herd and nearly 2,500 ha of wheat.

Kioma is one of the largest collaborating farms in the BiGG project. Steve says its involvement reflects the commitment of J.H. Fairfax and Son to improving biodiversity.

"Before we were involved in Grain & Graze, we had a straight-down-the-line approach, where we developed the country in the aim of profitability," he says. "Now we're looking at a bit of everything for the future."

Steve has adopted a number of sustainable farming practices that aim to improve biodiversity values on the property while helping make it sustainable for the long term. For example, he uses a rotational grazing system for cattle and sheep that retains ground cover, ensuring that diverse pasture species survive and thrive.

"With rotational grazing, we expect to see the return of more native grass species that tend to become over-grazed and eventually die out in set stocking situations," he says. "The rotational grazing system retains ground cover, which I am sure in turn encourages the build up of biodiversity."

Increased levels of soil organic matter should increase the amount of rain stored in the profile rather than running off. No- and minimum-till cropping techniques also play a role in increasing the amount of ground cover and organic matter.

Steve first thought that becoming involved in the BiGG project was an opportunity to gather some data on Kioma's biodiversity status – both to set a benchmark for the property and to compare it with how other farmers were doing. He was heartened to find that BiGG surveys indicated that the farm supported a wide range of living creatures and confirmed observations that they had high levels of active dung beetles.

Overall, Steve says it is important to balance farm profitability with biodiversity needs. "You shouldn't need to sacrifice farm profitability when encouraging and increasing populations of biodiversity. Biodiversity is an investment in the future, for the sustainability of the farm into the future."

Swathing Bambatsi panic for seed production.

Benefits of biodiversity

Projects such as those run through Grain & Graze are adding to our knowledge of the importance of vegetation condition, size and connectivity in maintaining bird species and other fauna – and how these factors vary in importance for different species, depending on the range they require (e.g. are they territorial within a small patch or do they roam over extensive areas) and their mobility (how easily can they move within and between vegetation patches). Generally it is the larger, better-conditioned and better-connected patches of vegetation that support higher numbers of native birds and animals, but even small patches of poorer-quality remnant vegetation can be important.

Grain & Graze also explored the benefits of biodiversity to farms in areas such as watertable management (salinity), shelter (for stock and crops), ground cover (reducing erosion), crop pollination, pest management (habitat for beneficial insects, birds and other insectivores), improved soil health, and as a source of aesthetic pleasure and enjoyment for people.

By working with farmers, sharing data and understanding with them, and looking at how property management influences biodiversity, Grain & Graze is continuing to add to our understanding and giving 'biodiversity' a practical significance.

Having a go

Farmers interested in better understanding and managing the biodiversity on their farms can:

- Find out what is on their property. A range of tools and methods are available to help get farmers started but measures such as the area and condition of remnant vegetation and the number of bird species are a good guide.
- Consider the potential benefits of having a variety of native invertebrates, birds and native vegetation types, such as being able to reduce pesticide use by Integrated Pest Management, access to out-of-season native pastures and drought reserves, and improved control over farm and catchment watertables.
- Consider management strategies that will be profitable and help to maintain areas of remnant vegetation.
- Find out how your property contributes to catchment-scale biodiversity targets. Check your local CMA or NRM plan.
- Find out what incentives and funding are available for you to retain, maintain and enhance natural values on your property. Check with your local CMA, NRM body or Council or State Government departments.
- Seek assistance in deciding what to do first, where to get started – talk with neighbours, Landcare members or local NRM advisers.

Case Study: Doug and Roma Parker, Mid West, WA

After Doug and Roma Parker attended the January 2008 BiGG forum in Hobart, they came home with a good dose of enthusiasm for the future of farming. They needed it. Like other farmers in their part of WA, they have been through some tough years recently.

'Pri-inga' has around 1,600 ha of arable land and 600 ha of remnant vegetation on rough uncleared or partially cleared country, including the South Irwin River that runs through the property. The Parkers normally crop 1,000 ha of wheat and 600 ha of lupins and barley for sheep feed. At one stage their sheep flock was up to 1,800 ewes producing replacement ewes and first cross lambs. Droughts in recent years have meant they haven't delivered any grain for two years and are down to about 700 Merino lambs.

But the challenging conditions haven't dimmed the couple's enthusiasm for farming in the long term. They've taken advantage of the lull in normal farming activities to get involved in BiGG and fence out most of their remnant vegetation.

"The BiGG team had documentation from 1928 that gave bird counts for the area and our bird count now in the remnant vegetation very closely matches what they observed back in 1928. We're lucky because we've got natural corridors between the Coalseam Conservation Park, the river and our property that the birds use to move between the park and our place," Doug says.

BiGG also gave Doug and Roma the opportunity to examine some living creatures they hadn't looked at before – and to see what benefits they were providing.

"We got to look down a microscope at a lot of bugs that had been trapped on our place," Doug says. "We found that there are natural insect predators in the remnant vegetation and we didn't realise that they are keeping other problem insects under control, such as red legged earth mites and lucerne fleas. Some of the results are showing us that maintaining biodiversity is having a good effect on our pastures, as well as giving us a 'feel good' feeling."

Roma and Doug Parker.

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Remnant stands of native vegetation are usually on less-productive and non-arable areas of mixed farms. For optimum conservation outcomes some more productive land should also be retained under native vegetation.	▪ Native vegetation can promote a farm's contribution to nature conservation, instil pride and enjoyment in farming families and assist production by: – protecting land from degradation in vulnerable areas (e.g. river banks); – reducing salinity through recharge management; – providing 'ecosystems services' – clean air and water, carbon sequestration and pest management; – providing alternative fodder sources, some with compounds beneficial to animals; – providing windbreaks for livestock and crops; and – offering business opportunities – forestry, ecotourism.
▪ Native vegetation areas may harbour weeds and pest animals (including over-abundant native herbivores). Introduced crop and pasture species (e.g. phalaris) can become weeds in native vegetation.	▪ Farming to land capability can lead to high input intensive farming in some areas and natural systems for production and biodiversity gains in others (lower input but still profitable). This increases total farm profit, as well as environmental performance.
▪ Strategic grazing (managing the timing, frequency, duration and intensity of grazing) can retain or improve biodiversity in native pastures, but inappropriate grazing will degrade it and invite invasive species and soil erosion.	▪ Improving on-farm environmental performance (e.g. protecting vulnerable streams or rehabilitating saline lands) can reduce the off-farm impacts of farming as well (e.g. nutrient and sediment losses).
▪ Fencing is usually required for effective strategic grazing.	
▪ Nutrients from stock camps may promote exotic species and weeds at the expense of native plants.	

More information

- General information: MLA Fact Sheets – Tips & Tools. Encouraging biodiversity benefits, and Assessing the condition of remnant vegetation, www.mla.com.au/default.htm
- Vegetation management guides: www.live.greeningaustralia.org.au/nativevegetation/pages/index1.html
- Strategic grazing: the Land, Water & Wool Sustainable Profit report, available via www.landwaterwool.gov.au
- Methods used in BiGG to monitor biodiversity: www.environment.utas.edu.au/documents/BiGGFieldDataManual.pdf
- Biodiversity & Productivity Fact Sheet: www.grainandgraze.com.au/Publications/Fact_Sheets

Managing pests

Summary

Grain & Graze projects in wet temperate areas have showed that it is possible to control many crop and pasture pests through natural means, without relying solely on chemical pesticides.

The approach, referred to as Integrated Pest Management (IPM), puts biodiversity to work for farmers and, consequently, increases the value of natural habitats on farms. The main features are:

- monitoring presence and abundance of pests and their predators (e.g. carabid beetles, predatory mites, native earwigs, lacewings, ladybirds, wasps and other insects that kill pest insects);
- giving these predators time to build up in numbers and control the pests;
- managing farms to maintain populations of beneficial predators and suppress pests; and
- strategic use of selective pesticides instead of broad-spectrum chemicals.

Without compromising production, IPM can significantly lower chemical costs and the danger of product contamination and residues in the food chain. It can also reduce the risk of chemical resistance in pests and any negative impact of chemicals on the environment and people.

Traditional broad-spectrum pesticides kill beneficial species as well as pests. Reducing their use can improve the natural resilience of farms.

Adopting IPM requires time to be spent monitoring pest and beneficial populations and the ability to identify invertebrates – often to the species level. It also requires a degree of faith and patience. Instead of spraying pests as soon as they are identified (or as 'insurance' to prevent them becoming a problem), it is necessary to allow time for Nature to take its course – a measure that has a less-certain outcome than spraying.

Training programs and commercial services are available to help build the skill and confidence needed for success.

IPM can lower costs and chemical use without loss of production

INVERTEBRATES

All animals without a backbone, including insects, mites, worms, snails and spiders.

"We were worried that over time 'spraying the hell out of everything' probably wasn't the best thing to do. We were concerned about a pest, in this case aphids, building up a resistance to the chemical and the chemical residue levels that may be passed on the consumer of the grain. We didn't think that we could continue farming using these practices. We also liked the idea of less work – letting Mother Nature do some of the work for me, so I could have the weekend off."

Stephen Menze, cropping manager,
Charles IFE Piggeries, Ballarat, Victoria

A ladybird 'managing' aphids.

A brown lacewing attacking aphids.

Information and ideas

Pests and beneficials

All crops, pastures and areas of native vegetation have a range of invertebrates living in them. Most cause no significant economic damage to the crop or pasture and are part of the 'web of life' that makes up the on-farm ecology.

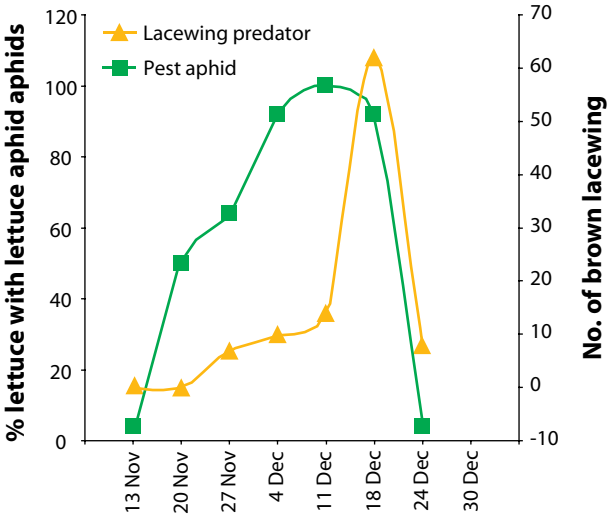
Among the useful, even vital, roles they play are building the soil by breaking down old plant matter or timber, pollinating crops, and feeding the lizards and birds that prey on farm pests. Some invertebrates become pests when they:

- dramatically increase in numbers and attack crops or pastures, e.g. lucerne flea or red legged earth mite;
- are present when the plants are at a vulnerable stage in their life cycle, such as at germination or flowering, e.g. slugs;
- change their feeding habits during their life cycle, e.g. black headed cockchafer; and
- transmit viral diseases, e.g. Barley Yellow Dwarf Virus (BYDV) transmitted by aphids.

Invertebrates (beneficials and pests) can be 'residents' or 'transients'. Resident insects such as slugs, earwigs and red legged earth mites live in the crop or pasture from one year to the next. They cannot normally move large distances, usually because they are flightless. Transients can arrive over night, after breeding up in other locations (e.g. locusts). As a rule, residents are easier to control through IPM, as it is possible to disrupt their life cycle and control their subsequent abundance.

Successful breeding is the primary reason for an increase in pest populations. Predatory species that feed on pest species usually build up in numbers after their prey do, as they need abundant food before their population can boom. It is common to see rapid rises in pest populations followed by similarly large increases in beneficial predators a short time later. Population increases (and their later decline) can be dramatic, especially in species with short breeding cycles.

For example, aphids can produce young within days of maturing and have a generation time of less than two weeks, allowing them to breed up very quickly within a single cropping season. Beneficial species, such as parasitic wasps and lacewings, that specialise in eating aphids usually have generation times that are



Predator – Prey cycle, 2007 data.
Source: Dr Paul Horne, IPM Technologies Pty Ltd

short, like their prey. Slugs can also breed quickly, with some species able to produce 1,000 eggs per individual and have two generations per year. Others, like some carabid beetles and spiders, have multi-year life cycles and so are slower to respond to a change in the management approach.

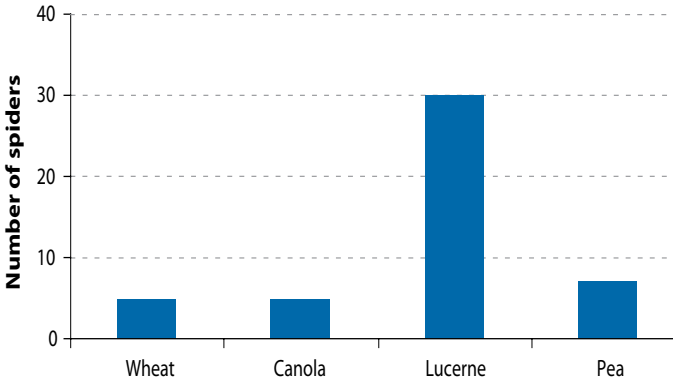
Many predators feed on more than one species of prey and do not depend on just one pest to survive. However, a small population of pests is usually required to provide food and sustain a residual population of predators and parasitic wasps, etc.

Little is known about the specific benefits spiders provide to an IPM approach. However, spiders are the tigers of the insect world – voracious predators – and research suggests that significant populations of spiders exist in cropped land. By inference, the presence of spiders in crops or pasture can be expected to help control both resident and transient pests. Research in progress via Grain & Graze is shedding new light on the importance of spiders. It indicates that:

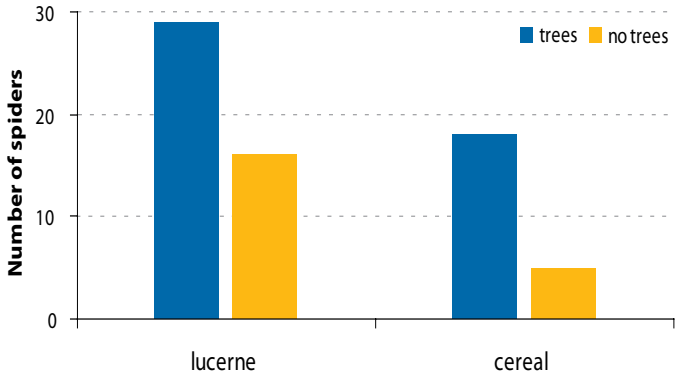
- spiders (most commonly medium to large and ground dwelling) are present all year round, although their numbers fluctuate with the seasons, and hence they may be able to control pests before the pest population expands;
- many spiders are nocturnal, so they may not be seen in daylight inspections;

Some common pests of crops and pastures and beneficial species that prey on them.

Common pests of crops and pastures	Type	Beneficials that help control the pest
Aphids	Transient	Brown lacewings (*Micromus tasmaniae*), Ladybird beetles (*Harmonia, Coccinella, Hippodamia*), Parasitic wasps (*Aphidius* species)
Black headed cockchafers	Resident	Carabid beetles (*F. Carabidae*)
Blue oat mite	Resident	Predatory mites (*Bdellidae* and other species), Native earwigs (*Labidura truncata*), Possibly predatory beetles *(Carabidae)* and true bugs (various *Hemiptera*)
Diamondback moth	Transient	Damsel bugs (*Nabis kinbergii*), Parasitic wasps (many species), Ladybird beetles (*Harmonia, Coccinella, Hippodamia*).
European earwigs	Resident	Carabid beetles (*Geoscaptus*)
Heliothis caterpillars	Transient	Damsel bugs (*Nabis kinbergii*), Shield bugs (*Oechaelia schellenbergii*), Parasitic wasps (many species)
Lucerne flea	Resident	Predatory mites (*Bdellidae* and other species), Native earwigs (*Labidura truncata*)
Red legged earth mite	Resident	Predatory mites (*Bdellidae* and other species), Native earwigs (*Labidura truncata*)
Rutherglen bugs	Transient	No known beneficial predators
Slugs (*Deroceras reticulatum, Milax gagates*)	Resident	Carabid beetles (*Rhytisternus, Notonomus*)
Wireworm, false wireworm	Resident	Carabid beetles *(F. Carabidae)*



Lucerne had significantly more spiders than other types of crop sampled. Source: A Cutler et al.



Crops with tree belts appear to have more spiders than those without trees. Source: A Cutler, P Horne, A Yen, M Elgar (2007) 'Spider populations in broadacre crops and pasture'

Native earwig

- spiders kill flies, crickets, Lucerne flea, aphids, caterpillars and moths and, in a laboratory, ate more than 3½ times their weight in five days (e.g. one spider captured 55 blowflies in five days; another killed 90 lucerne fleas in one day);
- spiders were evenly spread across cereal paddocks, but were more common in fields with adjacent belts of trees and were in even higher numbers in grassy edges around crops;
- more spiders were found in lucerne than in crops; and
- the history of chemical use on a property did not appear to significantly affect spider numbers.

IPM principles

IPM is about ensuring there are enough beneficial insects to reduce pest populations to a level where they do not cause significant economic damage to a crop or pasture. It is about maintaining a productive balance – a balance influenced by a range of factors.

Some people suspect that management practices such as minimum till and stubble retention also create an environment that harbours some pests, such as slugs. However, scientists also think that the widespread use of broad-spectrum pesticides and baits, which remove beneficial predators as well as pests, creates a predator-free environment in which surviving pests can reproduce and rapidly build up their numbers, potentially causing heavy damage.

Targeted use of pesticides can reduce pest populations, while retaining beneficial predators. While insecticides are still used in IPM, the chemical type, along with how and when it is applied, is chosen with the beneficials' survival in mind. This could involve delivery techniques such as baiting and using seed dressings, rather than broad-acre boom spraying.

Mixed farms can also use practices that favour beneficials and reduce the opportunity for pests to survive and breed. Cultivation, burning, weed control and grazing influence how many beneficial insects and pests are present.

Mixed farmers and IPM

Mixed farmers are becoming a lot more interested in IPM techniques because of:

- increasing consumer demand for products grown with minimal or no pesticide use;
- a wish to avoid creating insect resistance to current pesticides;
- a reduction in the health hazard to farm families posed by insecticides;
- triggering unintended insect problems in other species as a result of targeting one pest;
- the scope to reduce farm costs;
- a desire to protect benign Australian native insect species and biodiversity in general;
- a desire to reduce the impact of pesticide use on the environment, waterways and species such as birds, reptiles, etc; and
- a desire for a healthier soil biota.

"I have slowly come to realise that, in the main, killing bugs with a boom spray doesn't work. When you start to think that some insects are eating other insects and not your crop you have a whole different outlook! Balance is the key and you will not achieve it with a boom spray."

Robert Meek, 'Strathleigh', Shelford, Victoria

Encouraging beneficial insects

Through Grain & Graze, a survey was undertaken across south-west Victoria in 2005 and 2006 to analyse the distribution of beneficial insect species in four different vegetation types:

- winter crops, such as wheat, barley and canola;
- improved pastures, based on exotic (non-native) species;
- 'native pastures', as identified by the participating farmers; and
- native grassland on roadsides that had minimal disturbance through cultivation or grazing.

A selection of five carabid beetles and one native earwig were chosen for analysis. These are regarded as key species that prey on many common agricultural pests, such as caterpillars, aphids, European earwigs, slugs and possibly mites.

In 37% of the crop and pasture sites few or no carabid species or native earwigs were recorded. The larval stages of these beetles live below ground and only the adult insects, moving on the soil surface, were trapped, which may explain why the recorded populations at some sites were low. However, expert opinion suggests that previous paddock history is likely to have a greater influence on the current population

Case Study: John & Janet Leigh, Central West/Lachlan, NSW

John Leigh first heard of the possibilities of Integrated Pest Management (IPM) when he heard Dr Paul Horne, from IPM Technologies, talking about the effects of insecticides on canola and lucerne.

John Leigh and Dr Paul Horne keep an eye on the insects.

"I talked with some of the other members of the region's Grain & Graze Steering Committee. We decided we didn't know enough about IPM and if we looked into it we might come up with something useful for our region."

As a result, an IPM scoping trial was set up in four paddocks – grazing oats, lucerne, wheat and canola – on 'Nandewah', Cowra. Each week the insects collected in a variety of traps were sent to NSW Department of Primary Industries' Orange Agricultural Institute for identification.

John believes canola is one of those crops that has high inputs and plenty of things that can go wrong, including slugs, cockchafers, aphids, red legged earth mite and lucerne flea – "and that's only the insects".

"This is our seventh year of below average rainfall. There's a lot of cost pressure. If you can do something positive to minimise your inputs and not jeopardise your outputs then it's worthwhile," he says.

"With canola, many of the problems arise when the crop is tall. So you either aerial spray, which is expensive, or you trample the crop, which is another cost. Traditionally, we sprayed lucerne and canola several times every year. For a crop like canola that is expensive to establish, spraying allowed you to sleep at night for a relatively small cost."

The report on the Nandewah scoping study says that withholding insecticide sprays resulted in no significant economic loss. To the contrary, it has saved application costs and allowed numbers of beneficial insects to build up.

"It takes a lot of courage to decide not to spray. I couldn't have done it without experienced and knowledgeable people working with me and providing advice. When I told my neighbours that I wasn't going to spray they looked at me like I was a bit strange. I wondered if I was. Luckily, the predators came in sufficient numbers to do their job," John says.

The study showed large numbers of pests were seen initially but in the absence of any spray, beneficial insects started to build up and pest numbers eventually declined to a negligible level without any obvious damage to the crop.

John, in conjunction with the Grain & Graze project, is planning to expand IPM on the farm. A one-year-old lucerne paddock and a new lucerne paddock will be incorporated into the IPM program in 2008.

"We are certainly not suggesting that we will never spray pesticide again. If we have to, we will. But we'll start with seed dressing to get some protection in the establishment phase and only spray later as a last resort. In the long run we may even be able to do away with the seed dressing but I don't think I've got the courage to go that far yet," John says.

Native vegetation may harbour a wide range of beneficial insect species

than the timing of the survey. Carabid beetles have a long reproductive cycle. Following the loss of a population (e.g. through an application of a broad-spectrum insecticide), they may take years, if ever, to recover, especially if the breeding habitat is less than ideal.

From this work, there is a suspicion that some herbicides may have insecticidal properties and plans are afoot to investigate this.

In the remaining 63% of the sites where beneficial species were captured, the relative proportion of each carabid subspecies varied depending on the ecosystem.

The native grassland contained four of the five carabid subspecies, but the total number of these beneficial insects was low in contrast to collections from the pasture and crop paddocks. For example, one grassland site had a total catch of 35 carabid beetles and earwigs, compared to 364 in the adjacent cropping paddock.

The cropping paddocks were dominated by one subspecies of carabid and the beneficial native earwig, and all sites had significant populations of these two species. In contrast, the improved pasture paddocks were dominated by a different subspecies of beetle that was found at all sites that had carabids and ranged between 17% and 92% of the total beneficial carabid and earwig populations.

Similar to the cropping sites, the abundance of beneficial species in a pasture was up to 10 times higher than that in nearby native grassland.

The third ecosystem type identified by participating farmers was an unimproved grassland paddock (referred to as a 'native' paddock). The abundance profiles of beneficial species more closely matched the numbers and proportions found on improved perennial pastures, rather than the roadside native vegetation sites.

The large differences in beneficial insect numbers found across these sites implies that effective IPM may be achieved more quickly on some farms than others because of the existing resident population of beneficial species.

The data also suggests that populations of beneficial species can survive in numbers believed to be sufficient to achieve the biological component of an IPM program.

Results showed that native grasslands contained a greater diversity of carabid beetles. but in numbers much lower than the cropping or improved pasture paddocks.

Ground beetle.

Carabid beetles

Commonly known as ground beetles, carabids have a hard shell-like covering on their backs. There are more than 20,000 species of carabid across the world.

They are long lived and take a year to move from eggs, to larvae, to pupae, to adult beetles, and are generally nocturnal.

Both the worm-like larvae and adults are predators to a wide range of invertebrates, including caterpillars, slugs and snails. In turn, they are preyed upon by birds, lizards, spiders and small mammals.

Most are a shiny black; although some are brightly coloured – warning of their ability to discharge a foul-smelling liquid.

The results have three important implications:

- The number of beneficial insects present in native vegetation is unlikely to be enough to provide direct, immediate biological control in adjacent paddocks; they are simply outnumbered by the pests in the crop or pasture.
- Based on the finding that at least one species of resident carabid beetle and earwig found in native grassland are favoured by the environment created by cropping or pasture, these species are most likely to move out of the native vegetation areas and breed successfully in the crop or pasture (assuming action is also taken to avoid killing them in the crop or pasture). Their numbers in the crop or pasture will eventually build up to a level sufficient to provide some natural pest control.
- Retaining native grasslands, or establishing new areas, may be important for providing a reservoir of beneficial insects to repopulate crop and pasture areas and help control potential pest populations.

Making IPM work

For IPM to work, farmers require knowledge about the life stages, timing and population dynamics of both pests and their predators – and the ability to tell one species from another. Based on this knowledge, strategies can be developed to favour the beneficial species and suppress the pests.

The successful introduction of IPM involves farmers taking a significantly different approach to pest management, including:

- appreciating the role beneficial species play in regulating pest numbers and treating these as the primary pest control mechanism;
- understanding the life cycles of pest and predatory species and what conditions need to be created to discourage pests and encourage beneficial species;
- replacing the historic approach that dictated if a pest was present in a crop or pasture it needed to be controlled, with an understanding of pest:predator ratios and the timing in population build-ups;
- knowing how and when to monitor for pests and beneficial species to support decision making; and
- recognising that a single management decision (e.g. to spray or not) can have long-term ramifications for achieving on-going pest control.

Netelia – a parasitic wasp, that lays eggs in caterpillars.

Scarab grubs

Scarab, or white curl, grubs are the larval stage of scarab beetles. They live in the soil and feed on humus and plant roots. Their life cycles range from one to two years and the beetles emerge from pupal chambers in the soil when conditions suit – often in the morning or at dusk on a warm day.

Mass swarmings can occur, with the beetles flying to nearby eucalypt trees (within a kilometre or two) to feed and mate. The larvae go through three stages, each becoming more destructive to plant roots, before pupating in a chamber below the soil's surface.

Scarab grubs are naturally regulated by weather (both droughts and 'drowning' during extreme wet periods), disease (fungal, bacterial and viral), parasites and predation by birds and insects. Some flower wasps (that rely on certain flowers, scale insects or aphids for feed) lay their eggs in the third larval stage of scarab grubs. After hatching from their eggs the wasp larvae feed on the scarab grub. Parasitic flies also attack scarabs, at both the grub and beetle stages. Insectivorous birds, such as magpies and straw-necked ibis, are other predators of scarab grubs, and the adult and larval stages of carabid beetles also prey on them.

Black headed cockchafer.

Case Study: Making sense of IPM

A Grain & Graze project in south-west Victoria involved farmers, consultants and IPM experts learning from each other so as to develop skills in IPM. They used a mixture of on-farm trials and surveys, workshops and field days, and even the development of a training package and course.

The interest in IPM arose from a local perception that slugs were becoming more of a problem as a result of minimum till and stubble retention. Accepted practice had been to bait for slugs and spray a synthetic pyrethroid or organophosphate insecticide for any other pests present, either at a predetermined time or with other chemical (e.g. herbicide) applications.

Working with a commercial IPM service provider (IPM Technologies), 11 sites were surveyed, showing predatory carabid beetles at all sites but in numbers (and subject to spray regimes) that meant they were unlikely to be effective in controlling slugs.

In the next phase, a private agronomy firm and a leading farmer ran an on-farm trial of IPM in three paddocks. Regular monitoring indicated that European earwigs were also a significant pest – contrary to previous perceptions. The trial led to a reduction in insecticide use and no chemicals were used during crop establishment.

Another component of the project involved farmers and agronomists in a series of one-day workshops (run by the Southern Farming Systems network) to introduce and explain the concepts behind IPM. Following the workshops, 15 farmers accepted an offer from agronomy consultants AgVise to have three paddocks monitored fortnightly. This work reaffirmed the importance of European earwigs as a pest (causing similar damage to slugs) and resulted in reductions in chemical use. It also highlighted the knowledge gap surrounding the important step between monitoring pests and beneficials and making commercial decisions about pest control.

Through Grain & Graze, a series of field experiments observed pest/beneficial interactions under a range of different management situations. A total of 30 paddocks were involved and a series of further workshops focused on the farmers telling their stories about IPM and what they had learnt from the trials. Some themes and 'hunches' were emerging (e.g. there looked to be a link between beneficial species diversity and native vegetation) but still there was a lack of confidence in abandoning the 'insurance' controls offered by insecticides and adopting IPM strategies.

In response, Grain & Graze initiated the development of an IPM training course. It presented the theory behind IPM and combines it with field observations in commercial crops over a cropping season. Twenty-two people enrolled in the course, half of them district agronomists. The course has given participants more confidence to adopt IPM and is part of a significant move in regional approaches to pest management.

The program is an example of both the inherent difficulty of introducing an apparently 'risky' approach into established farming systems and the excellent results that come from involving farmers, consultants and IPM experts in the joint development of their understanding and management skills.

– Cam Nicholson, Grain & Graze Coordinator

A switch to IPM requires changing to a practice that many farmers have never used before, and a move away from an approach (spraying of pesticide) that had appeared to work well in the past.

It requires a change in mindset from trying to exterminate pests to trying to control them so as to minimise the damage to the farm enterprise.

This 'leap of faith' poses a challenge to any mixed farmer considering adopting IPM, but can be assisted by seeing what others have achieved, by obtaining expert technical advice and training, and by testing IPM initially on one part of the farm.

IPM has been widely practised in various forms of monoculture for many years, including orchards and cotton, and is no longer as experimental a technique as is sometimes thought.

Monitoring invertebrates

Monitoring pest populations and their impact, and the presence and population trend of beneficials, is crucial to an effective IPM strategy.

The fundamental role of monitoring is to correctly identify the pest(s) involved. Many apparent control failures are due to inappropriate treatment stemming from misidentification of the pest.

An important part of this monitoring is timing – monitor well in advance of when action will be needed.

The monitoring needs to take into account not only the number of pests but also the number and type of beneficial species and the trends in their population. It is not enough to say 'slugs' or 'earwigs' are present, as the crop damage caused by different species of pest varies widely. For example, some slugs are far more damaging per individual than others. Also, larger individuals cause more damage than newly hatched individuals. A plain count of slug numbers is not a sufficient base for an IPM strategy.

The same applies to beneficials. A farmer needs to know the life stage, species and relative numbers of pests compared to the appropriate beneficials. In addition, the monitoring needs to look at trends rather than absolute numbers of pests. Are they increasing or decreasing in relation to the predator?

Specialist services are available to undertake the detailed monitoring required to design an effective IPM strategy, but farmers can undertake some simple monitoring of their own to help determine the abundance of certain pest in different paddocks of the farm. If large quantities of target pests are identified through this monitoring, preventative actions are likely to be needed. This monitoring is only intended to identify the high and low-risk paddocks for the specified pest.

If some of the target species are observed or found in the traps, then it is wise to get them accurately identified.

The most difficult part of an IPM strategy is the correct identification of pest and beneficial species from monitoring and the ability to distinguish them amid the thousands of similar-looking species that are neither pest nor beneficial in the cropping system. This is a specialist skill, but growers can take the first step and build up their skills through experience and training.

Monitoring for pests and beneficials

Common monitoring methods used by farmers to look for pests are:

- **Slugs** – Use tiles or sacks placed in the paddock as shelter traps to check for the presence of slugs in September to October.
- **Earwigs** – Check under tiles or sacks in October for pest earwigs.
- **Wireworms** and **false-wireworms** – Check under tiles or pitfall traps during the season before the one you intend to crop in. Testing once or twice a year is usually sufficient.
- **Aphids** – Monitor in autumn (if there is an early break) and in early spring with yellow sticky traps. This should be done weekly during flight times. Avoid winter.
- **Red legged earth mite** and **predatory mites** – Check on broad-leaf plants (capeweed and clover) from mid-winter until mid-spring. Once or twice a year will be adequate. Checking puddles after rainfall is also useful.
- **Beneficial species** – Monitor with shelter traps (tiles and sacks) after the season's break, but avoid cold times (winter) and before the onset of summer. Once or twice a year is sufficient. Pitfall traps can also be employed, but they are not easy to use.

Developing a pest management strategy

After monitoring, deciding what course of action to take is the most difficult part of IPM and one that cannot be predicted simply from pest numbers or spot checks of beneficial species.

Decisions need to be made based on population trends for pests and beneficials, not just the numbers of the pests and beneficials present at a particular time.

The adoption of IPM also means accepting a longer time frame to achieve control. If control of the pest problem is required, or can only be addressed, in the year of sowing, the options (and ability to minimise the effect on beneficials of the pest treatment) are greatly reduced.

If a three-year time frame, for example, can be adopted, then the options to control pest populations while minimising the effect on beneficials are greatly enhanced.

The steps, in sequence, are:

- plan your monitoring strategy ahead of when any action may be needed ;
- assess the risk of damage per paddock;
- consider seed dressings rather than sprays, if possible;
- baits are more suited to an IPM strategy than broad-spectrum sprays;
- do not apply unnecessary insecticides – they can create problems;
- if using broad-spectrum pesticides on one paddock, flush the tank before moving to the next paddock;
- choose pesticides for their impact on beneficial species, as well as their effects on pests;
- the cheapest pesticide (per ha) may not be the cheapest if it creates other pest problems; and
- consider the potential to use border sprays only where a pest is spreading in from surrounding areas.

Special care is required in selecting chemical control agents:

Pesticide group or insecticide	Examples from the group	Typical toxicity to beneficials	Factors affecting efficacy
Synthetic pyrethroids	Ambush, Fastac, Dominex, Cymbush, Karate	High	Easy to use and apply
Organophosphates	Lorsban, Malathion, LeMat Rogor	High	
Organochlorine	Endosulfan	High	
Pirimicarb	Pirimor	Low Kills adult wasps	Best used on sunny days Temperature sensitive
BT	Delfin, Dipel, XenTari	Very low	Specific to caterpillars Sensitive to UV degradation and wash-off

Case Study: John Hamilton, south-west Victoria

Farming at John Hamilton's 'Leighview' in wet temperate country near Geelong is based on 2,000 ha of crop and about 1,500 Merino wethers. Cropping is generally about 500 ha of canola, 700 ha barley, 400 ha milling wheat, 300 ha red wheat and a few peas and linseed. About half the area is owned and the rest leased and share farmed.

The country owned by Leighview is continually cropped, with some paddocks now up to 28 crops in a row. Sheep are run on non-arable areas and used as 'stubble crunchers' after harvest.

"I'm not a Greenie," John says, "My previous approach has been that the only good bug is a dead bug. We have done much preventive insecticide work in the past that may or may not have been necessary. Our normal approach has been to add an insecticide to any application of Round-up and Endosulfan with any Simazine or Atrazine. Slug-baiting post sowing of any canola crop had become routine. These cost about $25/ha.

"After observing the amount of herbicide resistance happening in farming, I decided a new approach was necessary. Frequent applications of insecticides would lead to a similar situation in our pests. Weeds don't have predators, but insects do, so it seemed a natural progression to try and harness these wherever possible.

"We have ceased much preventive spraying and now prefer to see insects before spraying. Many times, as pest populations build up so do beneficial populations, so by not spraying we are increasing these beneficial populations. This is sometimes very hard on the nerves, as there is a delay of several days while the predator builds up to controlling levels. If you go in and spray immediately, you will also kill the beneficials, creating problems, perhaps later in the season, that require another insecticide application."

John has been monitoring a wheat, a barley and a canola paddock each year for the past three years with expert assistance, and building more knowledge of IPM. Paddocks are monitored fortnightly by a farm consultant; when a problem is suspected John inspects it alternate weeks. If a problem arises, it is monitored every day or second day.

"Last year we had problems with earwigs in canola, which we may have been blaming on slugs. This gets very involved because the native earwig is not a problem, but the European earwigs is and believe me, one earwig looks just like another earwig – even with my glasses on!

"There is no recommended bait for earwigs, but IPM Technologies found some information from Western Australia,

John Hamilton: "IPM requires a lot more time to see exactly what is happening in the paddock."

so we tried it. The bait consisted of an insecticide, vegetable oil and attractant mixed with wheat, and was very successful," he says.

"In late October we had a rapid build up of aphids in the canola. We normally would have sprayed immediately, however, it was recommended that we wait a few days to see if we had a build up of beneficials, because there were a few in the paddock. Within a week the predators had control of the aphids. We monitored the paddock daily to see what was happening. This is very difficult for someone who wants to act on a problem immediately.

"IPM requires a lot more time to see exactly what is happening in the paddock. It is a slow process and requires getting on your hands and knees."

John believes IPM has led to savings in costs, but has required more time. It requires more planning of what crop is going into the paddock the following year and what pests and beneficials are there now; but it has been surprising how good a job the beneficial insects have done.

"An IPM approach is not always possible. You must be prepared to use insecticides if necessary, although the choice of insecticide becomes very important. Often insecticides can be selected that are soft on beneficials and hard on the pest. Concern for the beneficial population is a priority and may require a more expensive chemical to be use," he says.

"IPM has become a fundamental part of our farming practice and it is our intention to expand its application across our entire cropping operation as our knowledge and confidence grows."

Having a go

The first step in adopting IPM is to review past and anticipated pest problems, consider the effectiveness of current control methods, and whether IPM could prove more effective.

The next step is to become skilled in the identification of pests and beneficials and to consider trialling an IPM approach in a couple of paddocks. This is a risky business for anyone on their own, so think about engaging an IPM expert or getting enough local interest to warrant the organisation of a local training course and perhaps some on-farm trials.

The IPM course developed through Grain & Graze recommends a 'paired paddock' approach to begin experimenting with IPM. Start by adopting IPM on part of a paddock, while managing the rest as normal, and observe what happens. Monitor pests and beneficials in both areas and compare final production levels.

The range of beneficial predators, farm practices and insecticides makes it impossible to use a 'recipe book' approach to pest control. The alternative is to identify the range of practices and approaches that are likely to have success in a certain crops or pasture and then, depending on the circumstances, adopt appropriate actions.

Suggested steps for developing a crop pest strategy, from the Grain & Graze IPM course, are:

Step 1: Choose a crop.

Step 2: List the common pests for the crop.

Step 3: Identify the beneficial species that can help control the pest.

Step 4: Identify farm practices that discourage pest populations and encourage beneficial species. A description of insect life cycles is valuable in formulating appropriate actions, both for the pest and beneficial species. Be aware that some actions may need to be taken in the season *before* establishment.

Step 5: List the insecticides that can be used in conjunction with the application method and possible timing, e.g. boom spray, bait or seed dressing.

Step 6: Identify the appropriate monitoring techniques and timing for the pests and beneficial species.

Case Study: Steve Dickson, South-West Victoria

Steve Dickson is a consulting agronomist at 'The Falls', near Inverleigh, and has been involved in learning about IPM through Grain & Graze.

"In November a flight of armyworms flew in, which was one of the largest for some years," Steve says.

"We decided to treat all but 18 ha of the property by including an insecticide with a fungicide application in November. The untreated IPM area (the 18 ha) was sprayed with fungicide only and no insecticide was included. It was later discovered that the treated area had no beneficial insects, the chemical had destroyed them, whereas the untreated IPM area had ample numbers of brown lacewings, predatory wasps and mites.

"These natural predators were able to build in numbers to fight off the armyworm invasion, which I found amazing. The armyworm numbers built up again in

Pest control strategy: Barley.				
Pests commonly found in target crop	**Beneficial predators of the identified pests**	**Possible farm practices to discourage pests and/or encourage beneficial species**	**Possible insecticide to use (as support)**	**Monitoring methods**
Resident pests				
Slugs – Grey field slug Slugs – Black keel slug	Carabid beetles	Burning Cultivation Treat fence lines (burn, cultivation, baits) Rolling Time of sowing Sow larger seed (seedling vigour) Actions to get the crop growing rapidly and out of the vulnerable stage (seed size, variety = vigour, nutrition = N, sowing depth)	EDTA (e.g. Multiguard) to gain control for next year's crop	Ceramic tiles or sacks, ideally in September and October Direct search after the autumn break
Lucerne flea Red legged earth mite (RLEM) Blue Oat mite	Predatory mites, Native earwigs	Control of broadleaf weeds the winter before the crop is sown Timerite for RLEM (as a once off if populations are very high, but may increase other pest mite problems)	Seed dressing with Imidacloprid (e.g. Gaucho) Barrier spray if pests are migrating from adjacent paddocks	Signs of damage on crops – from mid-winter to mid-spring On broadleaf plants Look in puddles of water – from mid-winter to mid-spring
Armyworm	Parasites	Windrowing	Bacillus thuringiensis) (e.g. BTK) on small armyworms	Sweep nets in autumn and early spring
Transient pests				
Aphids	Brown lacewings, Ladybird beetles, Parasitic wasps, Hoverflies	Plant late to avoid aphid flight Select resistant variety	Pirimicarb (e.g. Pirimor)	Yellow sticky traps attached to the fence, done weekly during flight times. Conducted in autumn (if break early) and early spring Direct search after autumn break
Source: 'IPM in cropping and pastures' Grain & Graze				

the treated area, but it was not able to be re-sprayed with insecticide as it was close to harvest by the time the adults had started doing damage, and the insecticide withholding period prevented it.

"IPM had certainly hit home as to its worth and the understanding of how habitats and creatures live in the bug world.

"The understanding of natural predators and that there exist more options than just mixing up an insecticide and killing the first pest that we see has now been replaced by a better understanding and the need to think about sustainability in our agricultural system.

"It is not only the money spent on insecticides, ranging from $27 to $36/ha, that we could save, but also the thought in the back of the mind regarding development of resistance to insecticides."

RIGHT: Steve Dickson sees the need to consider sustainability within agricultural systems.

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Using broad-spectrum pesticides can solve immediate pest problems, but increase the risk of their recurrence, as predators are also killed off. Effective control may be achieved, but at the risk of higher costs and greater environmental harm.	▪ IPM can control pests and maintain production at a lower cost, less environmental impact and less risk to human health.
▪ IPM is complex and time consuming to manage, as it requires an understanding of beneficial and pest organisms, their critical vulnerabilities and how to change management. Advice is needed as new systems are developed.	▪ Areas of native vegetation can harbour predators of pasture and crop pests, ranging from insectivorous birds to beneficial insects.
▪ IPM requires patience and trust that it will work. Pest species must first build up to a level that will sustain high populations of predators.	

More information

- The IPM Course: the Rural Industries Skill Training Centre www.rist.com.au/
- Integrated pest management for cereals: the National Invertebrate Pests Initiative, www.csiro.au/partnerships/NIPI.html
- The type of IPM services available: www.ipmtechnologies.com.au
- Integrated Pest Management Fact Sheet: www.grainandgraze.com.au/Publications/Fact_Sheets
- IPM Technologies: www.ipmtechnologies.com.au/

Managing soils

Summary

Crops and pastures depend on healthy soils for sustained, profitable production, so good soil management underpins the success of mixed farming.

Soils hold and release the water and nutrients essential for plant growth; provide a substrate in which plants can grow; and host soil biota that break down organic matter – such as stubbles and leaf litter – and recycle its nutrients into forms that the next year's crop or pasture can use.

Having high crop and pasture production to begin with and then retaining and recycling as much plant matter as possible is a key to having good organic matter and biologically available carbon levels. This helps maintain high nutritional status, soil structure and water infiltration as well.

Soil carbon levels are the mainstay of biological activity in soils. Good levels of soil carbon can reduce the need for fertilisers, cut costs and lower the greenhouse contribution from farming.

In mixed farming systems, pasture-crop rotations, grazing period and intensity, tillage and other aspects of management can be used to obtain biological benefits for the soil. For example, spelling grazed paddocks toward the end of the growing season can help promote higher levels of soil organic matter.

Maintaining the soil's nutrient status is also of fundamental importance. Elements such as nitrogen, phosphorus, potassium and micronutrients removed in grain, wool or livestock sales, or lost through leaching or erosion, must be replaced, either from soil stores, 'natural' sources such as nitrogen fixation by legumes, or by the application of fertiliser.

Many of the management measures used to improve soil function also protect land from wind and water erosion and the loss of nutrients and carbon.

Soil biota: insects, worms, protozoa, fungi, micro-algae and bacteria

"I like the thought of microbial activity below our feet. Healthy soils breed healthy people."

BiGG farmer, Craig Forsyth, Northern Agricultural Region, WA

Information and ideas

The importance of farming carbon

Carbon is the basis of all life as we know it. The carbon in organic matter provides the energy needed by the insects, worms, protozoa, fungi and bacteria (soil biota) that convert plant (organic) matter back into nutrients that are taken up by crops, pastures or natural vegetation.

The more carbon present as organic matter in a soil, the higher the levels of biological activity – and the more nutrients that will be available for plant growth, providing there are no other constraints to growth, such as soil compaction or very high or low pH.

Soil carbon is the total amount of carbon in a soil. It is measured as a percentage by weight in g C/kg soil (e.g. 10 g/kg = 1%). Soil Organic Carbon (SOC) is the measure of carbon within Soil Organic Matter (SOM).

Soil Organic Matter (SOM) is the sum of organic compounds in the soil, including micro-organisms, decaying plant and animal matter, and the resultant organic compounds (humus). It is closely related to Soil Organic Carbon and can be approximated by multiplying SOC by 1.72.

In desert loams, SOM can be less than 1%, while across Victorian soils it is generally from 1.3% to 10.5%. Levels decline rapidly with the onset of cultivation for farming before becoming more stable.

Increasing SOM and biological activity can improve yields. This is especially important in the low-fertility soils and low-input mixed farming systems of the eastern states' Mallee region and similar low rainfall areas, including SA's northern Eyre Peninsula, and parts of the WA coastal sand plains.

The long-term objective is to increase the amount of plant material returned to the soil, in the form of crop stubbles or pasture leaf litter, together with decaying root systems. This increased organic matter helps bind soil particles together, thereby improving structure and the infiltration of rain, making more water available to plants. It also makes more nutrients available for use by the next crop or pasture, and augments the biological activity which performs this recycling.

The more carbon a farming system returns to the soil the better, and Grain & Graze projects have collected data about how different cropping and grazing systems influence the soil.

Below: Increasing the amount of plant material – through stubble or pastures – returned to the soil increases soil organic matter.

Minimal tillage aids soil health

In the subtropics, zero-tillage has become accepted as the most profitable and sustainable method of grain farming with significant improvements in grain yield and soil health. It is the most important method of erosion control and will also stop the decline in soil organic matter (SOM).

SOM has declined by around 50% over the 50-70 years of cropping in subtropical regions, affecting soil structure and nutrient supply. The resultant increase in runoff and reduced crop production can set off a cycle of decline, which returns less biomass to the soil and speeds up a rundown in SOM.

Tillage trials on clay soils in northern Australia show that zero-tillage is able to halt the decline in SOM, while one or more cultivations a year (minimum tillage) is likely to result in a continuing decline.

Ten long-term studies of no-tillage in the US measured an increase in SOM of 1.1 t/ha/year, compared to a decline of 0.3 t/ha/year where ploughing was used. Controlled traffic farming takes zero-tillage to another level, where all traffic is restricted to defined lanes. Soil compaction from heavy machinery is minimised and farmers say they see additional benefits from more friable, better-drained soils which also allow water to enter more easily.

Soil microbes make nutrients available to plants

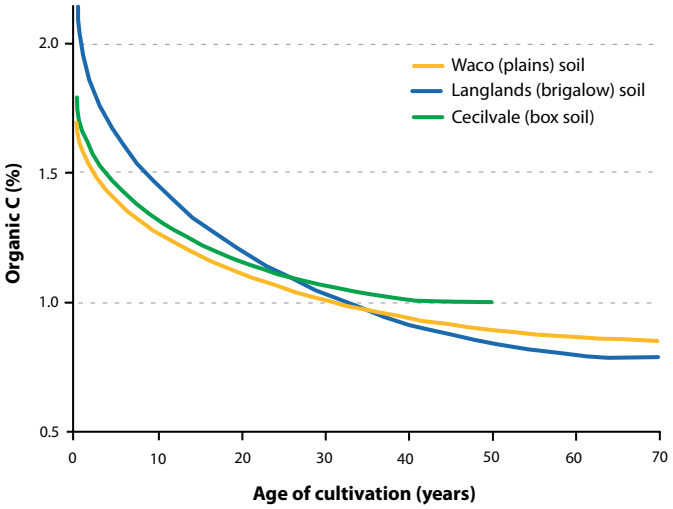
Soil nutrients come from decomposition of plant residues such as stubble, dead leaves, old root systems and root exudates, as well as the weathering of naturally mineral-rich rocks.

In addition, some soil biota, both free-living (e.g. blue-green algae) and in legume root nodules, can fix nitrogen from the atmosphere (as much as 20 kg N/ha/year for free living organisms and 25 kg N/ha/t of dry matter for fixation associated with legumes). These nutrients are 'stored' as organic compounds, including as the biota themselves, in a form that plant roots generally cannot take up directly. However, biota can transform this organic matter (mineralising the nutrients) into forms that plants can take up.

Soil biota can recycle nutrients, and some can fix nitrogen, but if nutrients are removed in produce or via erosion, etc, they must be replaced (or drawn from deeper layers in the soil) to maintain a balance.

In agricultural systems, applied fertiliser is often a major source of soil nutrients; although this is becoming increasingly expensive and, with rising energy costs, that trend is likely to continue.

Heavy use of fertilisers also increases the 'greenhouse footprint' of farming (the total



Decline in organic carbon with cultivation.
Source: Redrawn from Dalal and Probert 1997

generation of greenhouse gases by farming and ancillary activities), due to fertiliser manufacturing and distribution processes. Optimising the amount of nutrients available through natural recycling is one way to keep costs down, increase profit and reduce the greenhouse footprint of farming. It is especially important in low-fertility soils in the drier mixed farming regions.

Building soil carbon

There are several ways to increase the amount of carbon being returned to soils and to slow or reverse the decline in soil organic matter caused by the removal of agricultural products and certain farming practices. The following techniques help increase the amount of organic matter returned to the soil:

- retaining stubble and no-till seeding;
- optimising the return of plant material and avoiding tillage that destroys organic matter;
- increasing the proportion of time land is under pasture, under sowing pastures and crops, using green or brown manuring of crops or pastures for a year within a rotation, and removing livestock while there is still soil moisture available for plants to recover;
- improving above- and below-ground levels of dry matter;
- maintaining soil fertility – replacing nutrients removed in produce or by leaching and fertilising the pasture phase to optimise its production (especially with phosphorus, to boost production and ensure that nitrogen fixation by legumes contributes its full potential);
- growing high-yielding, high-biomass crops and pastures, and optimising agronomy to enable crops to reach their water-limited potential and decreasing the frequency of fallow; and
- increasing the amount of plant material returned to the soil.

Pastures build organic matter

Many soils in subtropical southern Queensland and northern NSW have soil organic matter levels of close to 3.6% (2% SOC) when first cultivated, but decline to around 1.8% (1% Soil Organic Carbon [SOC]) after 50 years of cultivation.

During this process there is a loss of 2,000-3,000 kg of nitrogen/ha, worth around $4,000/ha if applying fertilisers at 2008 prices.

Comparisons of soil carbon for nearby cultivation and pasture are shown in the table below, for three soil types and situations on the Darling Downs.

Soil carbon levels with pasture and crop.

Site	Comparison	SOC* crop	SOC* pasture
Ryeford sand	30 years of cultivation vs 4 years pasture	0.5	0.8
Ryeford basalt	50 years of cultivation vs 10 year pasture	0.9	1.9
Moola	50 years of cultivation vs 20 year pasture	1.0	5.2

** Soil Organic Carbon – top 10 cm (%).*
Data from G. Lambert, Condamine Alliance, Toowoomba

Maximising plant production can improve soil biology

As the accompanying tables show, growing more crop or pasture improves the status of soil biota.

To maximise production, soil pH must also be monitored to ensure it stays within the range that best suits plant growth, especially in cases where nitrogen addition or cation (calcium, magnesium) removal is high as, for example, in hay crops.

Soil compaction is another issue that affects productivity on mixed farms. Both livestock and machinery can cause severe compaction of topsoil and subsoil, respectively, when the soil is moist. This compacted soil severely restricts crop or pasture root growth.

These problems can be avoided by adopting a controlled traffic system for cropped paddocks and ensuring that livestock are not grazed on susceptible soils when they are wet.

Grain & Graze explored the interactions between plant cover, soil biology and grazing. It looked at the level of soil microbes present, the diversity of their communities (as measured by their ability to use different forms of carbon), and their potential to perform useful functions such as mineralising nitrogen and making it available to plants.

Assessments of soils under crops, permanent pastures and native vegetation showed that native vegetation had the lowest levels of soil biota, but the greatest diversity, while crops had the lowest diversity but highest level of microbial activity.

Other Grain & Graze studies investigating the soil biology of double-sown, single-sown and volunteer pastures showed the double-sown pasture to have the highest plant biomass, the highest levels of soil biota and the greatest potential to mineralise nitrogen. The volunteer pastures were lowest in each category.

Further experimentation (including incubating soils for six weeks as a proxy for grazing) indicated that heavy grazing of systems with low plant biomass resulted in the loss of microbial diversity and their ability to mineralise nitrogen.

In the trials, a range of carbon sources are made available to soil microbes. Their average use and the variety of sources used indicate the variety and level of activity of microbes within the soil.

Microbial biomass in surface soils, Waikerie (SA) 2002.

Treatment	Microbial biomass	
	mg C/kg soil	mg N/kg soil
Low input pasture / wheat	205	21
High input canola / wheat	275	34

Source: Gupta Vadakattu and David Roget, CSIRO

Microbial nutrient status of Mallee soils.

Treatment	Microbial biomass	
	mg C/kg soil	mg N/kg soil
Double sown pasture (high biomass, 5.3 t/ha)	265	35
Volunteer pasture (low biomass, 2.7 t/ha)	182	24

Source: Gupta Vadakattu

Microbial property	Double-sown pasture	Single-sown pasture	Volunteer pasture
Average carbon-substrate use	0.16	0.13	0.08
Microbial biomass (mg C/kg soil)	265	260	162
Microbial biomass after Incubation – grazing simulation (mg C/kg soil)	312	234	195
Microbial biomass (mg N/kg soil)	35	34	24
N Mineralisation potential (mg N/kg soil/21 days)	23	22	9

Source: Gupta Vadakattu

The impact of different land use and management on soil microbial properties.

Over-grazing can harm soil biology

Another permanent pasture site monitored by Grain & Graze had less total plant material (1.6 t/ha) than adjacent crop/pasture (2.2 t/ha) or pasture/crop sites (2.1 t/ha), but higher levels of microbial N and a higher N mineralisation potential. This suggests that the quality of plant material available for microbial decomposition is as important as its quantity.

Soil microbial diversity and activity depends on the quality and quantity of carbon inputs from plants. These studies built on previous work in the Mallee region of NSW, Victoria and SA, which showed that higher microbial biomass resulting from intensive cropping increased the amount of nitrogen held in the soil by more than 40% and that mineralisation of the N into plant-available forms increased by 50%.

The ability of microbial communities to convert a wide range of complex molecules (such as proteins) into energy was greater in soils under intensive cropping systems (0.54) compared to a low-input pasture/wheat system (0.31). The intensive system was also more profitable when assessed over several years.

In the graph below, the rise in gross margin with intensive opportunity cropping is correlated with increasing SOM (and hence nutrient and water retention) and soil biological activity. There has been an increase in the amount of plant matter returned to the soil in the high input system.

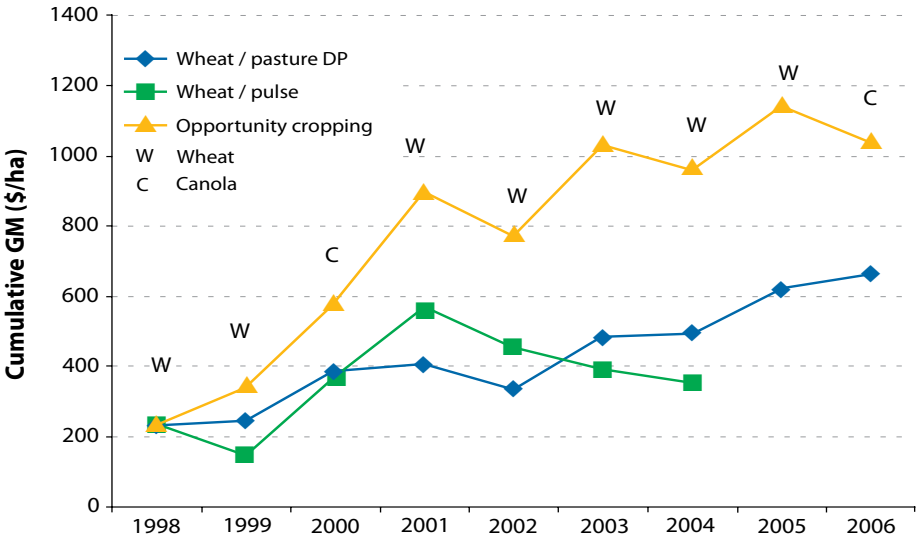
Better soils and better profits

To avoid loss of vital organic matter and nutrients, soil needs to be protected from loss by wind or water erosion, and this can be achieved by ensuring adequate levels of plant cover are maintained throughout the year, particularly during periods when intense rainfall or wind events are likely (e.g. summer storms).

At least 70% of the ground area should be covered by vegetation, and this usually requires at least 1,000 kg/ha of dry matter.

Higher levels of microbial biomass can also promote stronger soil aggregates, which help to reduce wind erosion.

Intensive opportunistic cropping increased soil organic carbon and gross margins.
Source: David Roget, CSIRO. Mallee Sustainable Farming Inc



Case Study: Malcolm and Kerrie Plum, Wagga Wagga, NSW

Plenty of four-legged creatures were born on Malcolm and Kerrie Plum's sheep and cereal property 'Burradool' after they started farming there during the 1970s. But after some special two-legged newborns came along, the Plums took a hard look at their farming practices.

"In the early 1980s we became a little reckless with our farming and were a bit off track," Malcolm says. "We started to notice a few health problems within our family and began to question whether this was connected to our increased use of commercial fertilisers and chemicals."

Now their mission statement says: 'Healthy soils mean healthy plants, which lead to healthy livestock and healthier humans'.

Burradool runs around 1,000 first cross Merino/Border Leicester ewes and 70 cows, with cropping on one-third of the property. In a key step for their farm management, Malcolm and Kerrie became collaborating farmers in BiGG.

While they are not certified organic farmers, the Plums have been practising 'biofarming' for about 15 years. Biological preparations provide trace elements for the soils and plants and also feed the living micro-organisms in the soil.

Malcolm uses a rolling prickle harrow to flatten and bend the standing cereal straw, giving the microbes a larger surface area to work on during the decomposition process. He also sprays his stubble with a mix of molasses and urea to help break it down and encourage soil biota populations to thrive.

Direct drilled crops, strategic spraying, stubble management and managed grazing are some of the other tools in the Plums' quest for more sustainable soils.

"We're working from the soil up. In the past three years we've changed to set stocking for eight weeks of the year during lambing and then rotational grazing for the rest of the year."

The rotational grazing pattern involves stocking paddocks for short periods and then allowing them to recover. The Plums

Malcolm and Kerrie Plum believe healthy soils lead to healthy animals and people.

bought a soil aeration machine to help them overcome soil compaction problems from large stock numbers.

"We've found the benefits of rotational grazing have gone beyond our expectations. It allows legumes and grasses to regrow and replaces old roots with new ones, creating more organic matter for the soil."

In the animal husbandry side of the business, Malcolm and Kerrie have a strong focus on nutrition. They give the sheep nutritional oral drenches and supplements of calcium, magnesium and salt. Any sheep or lambs brought onto the property are given a quarantine drench of Ivermectin, mixed with white and clear drenches.

Since early 2007, the Plums have been using an organic nutritional supplement called Preobiotic, which contains probiotics, minerals, vitamins, enzymes and selenium in a base of apple cider vinegar.

"In the end it comes down to the food chain. Whatever you feed something, be it animal or plant, will influence how it performs," Malcolm says.

A rolling prickle harrow bar used to knock down stubbles and improve the decomposition potential for soil microbes.

Prime lambs grazing a crop of millet. In the background, the tree line provides shelter for livestock and a haven for birds.

Case Study: Geoff and Diana Chase, Central West NSW

Geoff Chase is becoming interested in bugs – and the smaller the better. After his trip to the BiGG forum, he is keen to reduce his reliance on artificial fertilisers by building up organic and bacterial matter in his soil to increase the nutrients that are available to his plants.

The Chase family property 'Waitara', Trangie, is a 5,250-ha mixed cattle (commercial and stud Angus) and cropping business growing oilseeds, legumes and winter cereals including canola, chick and field peas, wheat, barley and oats.

When he became a BiGG participant, Geoff discovered he was already on the right track for increasing microbial activity and creating healthier soils. Some years back the family started using conservation farming techniques, including reduced tillage and retained stubble. Now, about 80% of their cropping country is direct drilled and 20% is minimum tilled with less than two passes by cultivation equipment.

"Our land is becoming softer and we have been able to sow crops in some years where it would have been impossible with a conventional approach," Geoff says.

The Chases have also stuck to a policy of not over-stocking so as to maintain good ground cover. While the past few years have been tough, they made a commitment to not wait until the last minute to look for agistment.

"One of the things I've learned is that you need to have that rest period, otherwise you are taking out what I call the 'ice cream plants', which are the good ones the stock really like. Instead you're letting low succession plants come through, which we don't want," Geoff says.

His management strategy now involves working out how to increase beneficial creatures in the soil.

"The majority of plant nutrients are in the roots of the old crop, so we're looking at moving even more into conservation tillage and leaving more plant roots in the ground," he says. "We'll also be trying to keep ground cover on top of the soil as much as possible.

"I want to reduce our reliance on artificial fertilisers and make sure that microbes are available all the time for the plants."

One tip Geoff picked up through BiGG is spraying crop stubbles with a molasses and urea mix to improve decomposition and increase the health of the soil.

Geoff's interest in soil extends to using new technology to manage it better. The Chases are using a hand-held global positioning satellite (GPS) unit to more precisely understand the variability of soil health and its productive potential

Diana and Geoff Chase: using old man saltbush to boost cattle performance.

both within and across paddocks. A yield monitor fitted to the header as well as yield mapping can pinpoint higher and lower yielding zones within a paddock. The monitoring has identified variations in crop yield from 3 t/ha to 9 t/ha in a single run by the header.

"In some paddocks the majority of the wheat comes from just 25% of the area. This gives us enormous opportunity for gains if we can work out the reason through soil testing."

Geoff is interested in the role of vegetation in biodiversity and would like to eventually link remnant vegetation on farm with vegetation on roadsides and neighbouring properties.

He is also looking at how he can use vegetation to promote species diversity in pastures. The family has planted 150 ha of old man saltbush. The area is divided up into 10 ha blocks and rotationally grazed by the cattle, which prevents the saltbush becoming too tall and rank for feed. Experimentation has led to relatively wide spacing between saltbush rows to maximise the amount of feed between them.

The family has calculated the stands of saltbush could pay for themselves in three years, through better cattle performance and better quality pastures due to the introduction of longer recovery periods for the grazed blocks.

"We think monitoring our biodiversity might help us pick up any problems early so that we can treat the causes rather than the symptoms. BiGG has given me some answers, but it has created about three or four times more questions!" Geoff says.

"Being involved with the project has made me happy that some of the decisions we are making are heading in the right direction. It has also enabled us to be able to talk to a mix of like-minded people."

Trade-offs and synergies

The complex interactions between soil processes, production and management generate an array of options to be considered by farmers. In some cases there will be trade-offs to consider; in others there will be synergies to be had – and win/wins all round. Typical of complex systems, there are few simple answers.

As an example, because plants are the major source of carbon (energy) that drives biological activity in the soil, there may be a trade-off between using all plant material for short-term income (e.g. cut for hay or eaten by livestock) and leaving behind sufficient residues to feed the soil and underpin future production. The tradeoff: feed the soil or feed the animals?

However, putting this in context, cropping usually removes more nutrients than livestock enterprises.

Cropping removes 32 kg N/ha for a 2 tonne/ha wheat crop compared with 5 kg/ha for wool from 8 wethers/ha and 4 kg clean fleece/head or lambs at 6/ha and 40 kg live weight. While a full stubble retention and no-till cropping system may return carbon and nutrients to the soil, it is generally at a lower rate than with good grazing of permanent pastures.

Grazing livestock can add to the losses from a cropping system but they also recycle nutrients – even though they may redistribute them unevenly in stock camps and urine patches.

Then there is another consideration. While carbon may drive short-term biological activity, the nutrient status of soils may be more important in the long term.

Running a highly productive system that produces high levels of carbon and nutritious plant material (crop or pasture) may mean that apparent trade-offs between returning dry matter to the soil or using it as stock feed are not that significant after all.

Happily, there are numerous obvious synergies that are exploited by mixed farming operations. They range from the use of legumes to boost nitrogen levels to manipulating soil biota with break crops to manage root diseases, and the use of deeper-rooted pastures to improve soil structure.

Retaining good practices in the cropping and pasture establishment phase (e.g. minimum till) is important to ensure the soil health advantages of mixed farming are not lost.

Crops and livestock can offer different and often synergistic benefits.

Having a go

A first step is to understand the current status of the farm's soil health, by monitoring key indicators like soil organic matter (SOM) and pH. Results can be compared with district benchmarks or other farms and plans made to improve any aspects of concern.

Farmers can assess the organic matter content of their soils and relative level of biological activity using the cotton-strip method (see page 95), and monitor the trend in organic matter over time.

Some farming regions have established benchmarks for SOM and wherever possible, these local benchmarks should be used for comparisons, as SOM content varies with soil type and climate, as well as with management.

Likely benefits from increasing SOM can then be incorporated into the farm plan and budget over time. Feed and grazing management can be planned to allow plant material to build up for return to the soil. Cropping systems can include a pasture phase or a periodic green or brown manure crop (which may also assist with weed control), if the potential long-term benefits outweigh the short–term cost of crop or grazing foregone. Moving to a conservation farming system, with all stubbles retained and not burnt, together with minimum or zero tillage (use of disc or narrow knife point seeders) will help maximise the input of plant residues into the SOM pool. This is lost by cultivation due to its rapid decomposition and oxidation when exposed to microbial activity.

Even with full conservation farming methods, the build-up of organic matter under cropping is slow: for each extra 2 t/ha of organic matter applied and retained for 10 years the SOM content can be expected to increase by about 0.5% (depending on rainfall and temperature variations).

Farmers can also undertake an on-farm trial by increasing the fertiliser input for a crop or pasture (e.g. in a strip trial), and/or green or brown manuring to return more plant biomass to the soil, and monitoring its impact over succeeding seasons. There are guides available for such on-farm trials from GRDC.

National, State and industry guides are available to help monitor and maintain soil nutrient and pH levels, and provide practical ways to minimise soil erosion.

There are also many guides to help farmers avoid or repair soil problems such as compaction.

The Healthy Soils for Sustainable Farms program is preparing a 'knowledge bank' of key management principles.

Key points to remember

- *Soil health is a fundamental point of connection between crops and pastures, driving production in both. Higher levels of soil organic carbon are good for soil biology, structure and nutrient availability.*
- *Mineral nutrients used in production must be replaced. Nutrient budgets can be used to help plan fertiliser programs.*
- *Special measures may be required to deal with limiting factors within soils such as hard-pans, poor pH and sodicity. Deep-rooted pastures and once-off tillage can be part of the solution, together with soil improvers like lime or gypsum.*
- *Plants suffering from mineral deficiencies are more vulnerable to soil-borne diseases but increased soil organic carbon levels can favour organisms which suppress diseases.*

Conflicts and synergies

Mixed farming systems present win-win options (synergies) but there are often potential conflicts.

Conflicts	Synergies
▪ Short-term boosts to production can be detrimental in the longer term if they leave depleted soils. The level of soil organic carbon in soil drives the physical, chemical and biological health of soil – and future production. 'Mining' soils and over-grazing limit future productivity and profitability.	▪ Tactics that add organic matter to soils also benefit the environment, production and profit by promoting: – soil structure and resistance to erosion; – soil biological health and diversity; – suppression of soil-borne cereal diseases; – nutrient cycling and supply to crops and pastures; and – water infiltration and water use efficiency.
▪ Mineral nutrient inputs are usually required to drive production from crops and pastures but low inputs are usually best for native pastures. The high cost of chemical fertilisers can be a barrier to optimum productivity and profitability.	▪ Growing healthy productive crops and pastures is a first step toward lifting soil organic carbon levels.
▪ Improved water infiltration, promoted by zero till and stubble retention, will reduce erosion but may also reduce run-off into streams and stream health.	▪ Productive, legume-based pasture leys provide high quality organic matter to soils and increased soil nitrogen for crop production; as well feed for livestock.
	▪ Reducing tillage reduces the cost of production and decline in soil structure while adding organic matter to soils – and reducing greenhouse contributions.

More information

- General soil health information and key management principles: www.healthysoils.gov.au
- Designing Your Own On-Farm Experiments: How Precision Agriculture Can Help: www.grdc.com.au
- Soil compaction: www.dpi.qld.gov.au
- Conservation agriculture: Conservation Agriculture Association of Australia and New Zealand www.wantfa.com.au
- Mallee Sustainable Farming practices: www.msfp.org.au/media.php?page=farmtalk
- A Carbon Farming program: www.horizonrural.com.au

Pulling it together

Grain & Graze has shown there are few simple answers for mixed farmers. There are lots of synergies but also a lot of conflicts and trade-offs. How do you pull it all together?

Pros & cons

How do you assess the pros and cons of different farming systems when they differ between regions and even individual properties?

Every farm has its own unique combination of land types, ecosystems and environmental assets, personal skills and preferences, as well as capital, infrastructure and machinery. Adjusting the balance of grain and grazing will depend not only on external factors such as market prices of crops and livestock, but also on those internal aspects that make every property and its managers one-of-a-kind.

Some points to ponder are provided here.

Mixed enterprise systems

- The risks associated with seasonal production (such as during a drought and commodity price variations) are spread over more enterprises.
- Rotations of crops and pastures produce synergies, such as improved soil health and disease control, that benefit all enterprises.
- Income and expenditure is spread more evenly throughout the year, making it easier to manage finances.
- Workloads are spread through the year; leaving less opportunity for holidays but, if a threshold of work is reached, it may justify employing (or sharing) a farm worker.
- A wider range of enterprises appeals to a wider range of skills, interests and expertise among several partners in a family farm; it offers more options for succession planning.

Synergies

Rotations of crops with legumes and pastures can:

- ***provide yield-boosting nitrogen at no additional monetary cost;***
- ***help prevent herbicide resistance and control weeds and diseases (which can require grass-free pastures for good results);***
- ***increase the level of soil organic matter (enhancing nutrient availability, soil structure and water infiltration); and***
- ***include deep-rooted perennials that help combat dryland salinity.***

- Mixed systems enable production to be optimised from different land classes – such as making a profit from grazing saline land which could not otherwise be used.
- More diverse production systems offer a broader range of habitats and micro-environments that cater for a more diverse mix of species. This enhances biodiversity conservation and pest control.

Single enterprise systems

- Farmers can specialise and become expert in a single commodity, its production and marketing.
- Production can focus on high-profit commodities without hindrance from other farm activities; maximising returns in 'good years' when price and production peak together, but also sustaining heavier losses in poor years.
- Capital equipment and infrastructure costs are lower.
- They are less complex to manage, with fewer interacting variables to worry about and more chance to 'take time out'.
- It is easier for non-arable land on cropping properties to be managed for nature conservation.
- Soil structure can be better protected through zero till and controlled traffic farming, without the risk of damage from livestock.

Having diverse land uses can:

- ***increase the potential to adopt Integrated Pest Management (relying on natural predators to prey on pests) and reduce chemical costs;***
- ***improve the nature conservation value of a property ;***
- ***provide fodder and grazing reserves for dry seasons;***
- ***manage groundwater and nutrient leaching better;***
- ***build pride in a property and the enjoyment of living there; and***
- ***offer potential opportunities to utilise adapted plant biodiversity for multiple purposes.***

Pulling it together

Sustained farm well-being

Some of the keys to a sustainable farming business are:

- **A profitable mix of enterprises**. Ensure land is farmed to its capability, and adjust crop and livestock ratios according to shifts in their relative profitability.
- **Maximum yields and productivity**. Focus on the drivers of production, such as high water use efficiency and healthy soils (high levels of soil organic carbon and maintaining nutrient budgets). Consider management options such as the time of lambing or calving.
- **Lower costs of production**. Consider low-cost management solutions instead of higher inputs. For example, use legumes to provide nitrogen, use rotations and grazing to control weeds and soil-borne diseases, and adopt Integrated Pest Management to reduce pesticide use.
- **Low relative overheads**. Apply strategies such as economies of scale, contract labour and services, or leasing land to reduce overhead costs.
- **Increased sale prices**. Focus on marketing and timing of sales to optimise sale prices.
- **Managed risks**. Climate risks, such as drought, can be managed by spreading production risks over different seasons (e.g. via different commodities), selecting appropriate crops, pastures and livestock, having a drought response plan, using seasonal climate risk assessments and planning tools, and optimising soil moisture storage. Environmental risks can be handled by sensitive management (e.g. using perennial plants to reduce recharge or protecting biodiversity assets, maintaining ground cover to avoid erosion and using vegetation to provide shelter and shade for stock).
- **Timeliness**. Do the right thing at the right time. Plan critical activities in advance and choose trigger points (set dates) for making key decisions. Make sure equipment and infrastructure is up to scratch and well maintained, and hire contract assistance when required.
- **Enjoyment**. Take time to savour achievements in production or environmental care, plan for the lifestyle you seek and search out technical solutions to save time and make management easier. Accept that mixed farming is complex and make decisions in that context.

Based on key profit drivers described by Peter Wylie (Horizon Rural Management) and supplemented with conclusions from Graze & Graze.

Conflicts & trade-offs

Grazing livestock on cropping soils can:

- ***result in livestock trampling formed beds and increasing surface compaction, especially if vulnerable soils are grazed when wet;***
- ***decrease the amount of organic matter returned to the soil (or concentrate nutrient redistribution in stock camps) through grazing stubbles (in contrast, stock may also be used to break down heavy stubble to make sowing the next crop easier);***
- ***increase the risk of soil erosion during drought by over-grazing stubbles; and***
- ***reduce returns when grain prices favour cropping over livestock.***

Cropping unsuitable land can:

- ***destroy native pastures and harm the land's contribution to nature conservation;***
- ***promote soil erosion; and***
- ***yield poor returns compared to the cost of production.***

Grain & Graze regional stakeholders

Avon

Avon Catchment Council
CSIRO
Department of Agriculture and Food, WA
Facey Group
Freebairn Group

Border Rivers

Border Rivers Catchment Management Authority, NSW
CSIRO
Gwydir Catchment Management Authority
NSW Department of Primary Industries
Queensland Department of Primary Industries and Fisheries
Queensland Murray Darling Committee
University of New England

Central West / Lachlan

Central West Catchment Management Authority
Central West Conservation Farming Association (CWCFA)
Central West Farming Systems (CWFS)
Lachlan Catchment Management Authority
NSW Department of Environment & Climate Change (DECC)
NSW Department of Primary Industries
Stipa Native Grasses Association

Corangamite Glenelg Hopkins

Corangamite Catchment Management Authority
Department of Primary Industries Victoria
Glenelg Hopkins Catchment Management Authority
Melbourne University
Southern Farming Systems

Eyre Peninsula

CSIRO
Eyre Peninsula Agricultural Research Foundation
Eyre Peninsula NRM Board
Rural Solutions, SA
South Australian Research and Development Institute (SARDI)
University of Adelaide

Mallee

CSIRO
Department of Primary Industries Victoria
Lower Murray Darling Catchment Management Authority
Mallee Catchment Management Authority
Mallee Sustainable Farming Inc
NSW Department of Primary Industries
Rural Solutions, SA
SA MDB NRM Board

Murrumbidgee

Charles Sturt University
CSIRO
Farmlink Research Ltd
Murrumbidgee Catchment Management Authority
NSW Department of Primary Industries

Northern Agricultural Region

CSIRO
Department of Agriculture and Food, WA
Evergreen Farming Group
Liebe Group
Mingenew Irwin Group
Northern Agricultural Catchments Council
Victoria Plains Group

Maranoa Balonne

CSIRO
Natural Resources & Water Queensland
Queensland Department of Primary Industries and Fisheries
Queensland Murray Darling Committee

Photographic acknowledgements

The authors thank the many people and organisations involved in Grain & Graze projects who have generously supplied photographs for use in this report.

Rachel Charles
Alison Cooke
Denis Crawford
Jodie Dean
Katrina Durham
Holly Hanlon
David Heinjus
Sarah Knight
Brian & Tracy McAlpine
Mallee Sustainable Farming Inc.
Cam Nicolson
Lawrie Pitman
Malcolm & Kerrie Plum
Esther Price Promotions
Rural Press Ltd
Sefton & Associates
Zubair Shahzad
Kathryn Taylor
Neil Vallance

Grain & Graze program teams

Program Management Committee

Current Members

Ian Donges – Chairman
Robert Banks – MLA
Cameron Allan – MLA
Ken Baldry – MLA producer rep
Martin Blumenthal – GRDC
Stuart Kearns – GRDC
Bill Yates – GRDC producer rep
Lu Hogan – AWI Ltd
Renelle Jeffrey – AWI Ltd
Peter Ralston – AWI Ltd producer rep
Anwen Lovett – LWA
Catherine Viljoen – LWA
Jack Speirs – LWA producer rep

Past Members

Ben Russell – MLA
Ian Rogan – AWI Ltd
John Childs – LWA board rep
Mike Logan – LWA board rep
Ian Blayney – GRDC producer rep
Mike Wagg – LWA

Operations Team

National Operations Coordinator	Richard Price – Kiri-ganai Research
National Extension Coordinator	Gillian Stewart – LWA
National Communication	Merryn West (LWA) and Sefton & Associates
Executive Officer(s)	Tom Dennis (* Melanie King, Catherine Viljoen, Joanna Pinkas, Vanessa Place, Joanne Blair – LWA)
Administration Support	Michelle Smith – LWA

Partner Communications support

Michael Goldberg – MLA
Megan Ball – formerly AWI Ltd
Helen Weldon – formerly GRDC
Lynne Sealie – LWA
Tim Lester – formerly LWA
Stuart Kearns – GRDC

Regional Coordinators

Avon	David Kessell	(* Wendy Dymond, Linda Leonard)
Border Rivers	Kathryn Taylor	(* Rachel Charles)
Central West/Lachlan	Jodie Dean	(* Libby Roesner, Ron Hacker)
Corangamite Glenelg / Hopkins	Cam Nicholson	
Eyre Peninsula	Naomi Scholz	(* Alison Frischke, Sophie Keen)
Mallee	Lance Brown	(* Zubair Shahzad)
Maranoa / Balonne	Nick Christodoulou	(* Jay Singh, Stephen Ginns, Scott Cawley)
Murrumbidgee	Katrina Durham	(* Kirrily Condon, Felicity Gummer)
Northern Agricultural	Phil Barrett-Lennard	

National Project Leaders

Feedbase Management	Michael Robertson & Andrew Moore – CSIRO
Whole-Farm Economics	Andrew Bathgate – Farming Systems Analysis Service Mike Krause – Applied Economic Solutions
Social Influences	Nigel McGuckian & Lauren Rickards – RMCG
Biodiversity	Kerry Bridle – University of Tasmania
Database	Jim Scott – University of New England
Ley Grain	David Lloyd – QDPI&F
Monitoring and Evaluation	Viv Read & Liz Peterson – Viv Read & Associates
Benchmarking	Martin Andrew & Don Burnside – URS
National case studies	Nigel McGuckian & Simon McGuiness – RMCG

** former holders of the position.*