WHEATBELT NRM’S VISION
‘To bring exemplary natural resource management to the Wheatbelt to create healthy environments and livelihoods.’

ACKNOWLEDGEMENTS

Wheatbelt NRM would like to acknowledge the generous contribution of the following people:

Editors: Dr David Grasby
Dr Guy Boggs
Georgie Troup

Wheatbelt NRM Project Team:
Sally Sprigg, Jo Wheeler and Chris David for their contributions to the implementation of the Soil Conservation Incentive Program and case study material.

Thanks also to previous Wheatbelt NRM staff members, Daniel Ferguson and Rochelle Horlin.

The contribution of David Bicknell, DAFWA, to the issues and soil health issues section of the guide is gratefully acknowledged.

Maps created by Kathryn Horrocks, GIS Project Officer, Wheatbelt NRM.

Graphic design by Stylus Design.

Adoption of innovations survey analysis by Dr Dimity Boggs.

We would like to recognise the contribution of the following organisations directly to these case studies or indirectly through the support of the Soil Conservation Incentive Program (SCIP):

Delivery organisations including:
• AVONGRO
• Department of Agriculture and Food Western Australia (DAFWA)
• Oil Mallee Association (OMA)
• Western Australian No-Tillage Farmers Association (WANTFA)

Project support organisations including:
Local Government Authorities
• Shire of Kellerberrin
• Shire of Quairading
• Shire of Westonia
• Shire of Bruce Rock
• Shire of Trayning
• Shire of Mt Marshall
• Shire of Yilgarn

Individual Project Support Officers:
• Jade Dempster
• Linda Vernon
• Kezia Metcalf
• Samantha Pickering
• Tracey Hobbs

This project is supported by Wheatbelt NRM, through funding from the Australian Government.

DISCLAIMER

The views and opinions expressed in this publication do not necessarily reflect those of the Australian Government or Wheatbelt NRM.
**FOREWORD**

Is reliable, sustainable, management of Western Australia's Wheatbelt Agricultural soils of the utmost importance?

As the leading Natural Resource Management group, actively engaged in addressing a wide and diverse range of natural resource issues in the Wheatbelt, we think so.

Wheatbelt Natural Resource Management, (Wheatbelt NRM) is keen to see those involved in Agriculture adopt strategies to improve the health of the soils.

The ‘Soil Health Guide’, produced by Wheatbelt NRM, draws from the experience of farmers from across the region who are seeking to farm more sustainably.

The Soil Health Guide has been designed to demonstrate the feasibility of adopting agriculturally sustainable practices, by way of both case studies and the practical energies that will assist land management practitioners to explore farming practices to help them best manage this valuable natural resource.

Soil, its management and protection, is fundamental to the sustainability of agriculture in Western Australia.

Wheatbelt NRM has a very well developed Sustainable Agricultural program that assists farmers and all those involved in land management to maintain a productive and environmentally sustainable agricultural industry. The program works with Farmers, Grower Groups, Researchers and Industry Experts, to support the development and adoption of farming practices that will improve the condition of all soils and drive the sustainability and long term financial assurances of ‘whole farming’ enterprises.

The Wheatbelt has a number of challenges that relate to soils, and influences how they are managed.

Projects run through the Sustainable Agricultural Program, such as the Soil Conservation Incentive Program, are working with over 200 Farmers to trial and demonstrate innovative cropping, grazing soil manipulation and agroforestry practices that address issues ranging from soil acidity and salinity to non-wetting characteristics, depleted organic matter and erosion.

The case studies that form part of this guide have all been drawn from Wheatbelt NRM’s Sustainable Agricultural Program and are designed to show, in a practical way, how farmers and those involved can adopt the practices to their own properties.

Thank you,

Jim Sullivan
Chairperson, Wheatbelt NRM
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INTRODUCTION

Agriculture has a long and successful history in the Wheatbelt of Western Australia, beginning with the settlement of York in 1831. Today, agricultural production contributes 50% ($3.1b per annum) of the Avon region’s GDP and covers almost 6.6 million ha. However, the development of land for agriculture has had some negative effects on the region’s natural resources. Traditional cropping and grazing management practices have subsequently contributed to the development of a number of soil health issues in the region (Department of Agriculture and Food, 2013). There is a growing consensus that these issues need to be addressed to develop a sustainable agricultural sector and farmers are continuously investigating new and innovative practices to combat these problems (Wheatbelt NRM, 2013).

This guide has been developed to present some of the approaches Wheatbelt farmers are taking to address soil health issues in the region. More specifically, the guide presents the outcomes from a 5 year program that has worked with farmers and industry to explore innovative farming practices that address soil health issues in the Wheatbelt. The Soil Conservation Incentives Program (SCIP) invested over $4 million of funding from the Australian Government between 2009–2013 in projects undertaken by Wheatbelt farmers that demonstrate management practices that address soil health issues in the region, including soil acidification, soil loss through wind and water erosion, dryland salinity, soil biology and the carbon content of soils. There are now over 150 SCIP demonstration sites across the Avon River Basin (Figure 1).

The guide includes 24 case studies and fact sheets that discuss different grazing, cropping, agroforestry and soil management practices that Wheatbelt farmers have explored through the program. This booklet is not intended to be an exhaustive guide to addressing soil health issues in the Wheatbelt, but provides a snap shot of innovative agricultural practices that are currently being trialled in the region.
The Soil Health Guide has been designed with the farmer in mind with practical tips based on the real-life experiences of fellow-farmers. The Case Studies have been drawn from Wheatbelt NRM’s Soil Conservation Incentive Program (SCIP) and show, in a clear and practical way, how the practices can be implemented on other farms within the WA Wheatbelt with equally positive results.

The Soil Health Guide has been designed to describe issues that have been identified through discussions with farmers and which currently impact upon the sustainability of Wheatbelt farms. The issues are then linked to appropriate case studies to demonstrate how farmers have addressed the particular issues through changes in their farm practice.

**TO USE THE SOIL HEALTH GUIDE:**
1. Identify the issue of interest to you.
2. Use the table on the following page to direct you to case studies identified as addressing that particular issue.
### Table 1: Soil Health Issues and Relevant Case Studies

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WHAT IS SOIL HEALTH?

The health of a soil is an assessment of its ability to support plants, animals and other organisms, given its inherent characteristics and the environment in which it is found.

A ‘healthy soil’ has characteristics that allow it to reach its potential (for whatever land use is on that soil), and to resist disease or degradation.

An ‘unhealthy soil’ is a soil that cannot reach its potential because it is diseased, or degraded from its original condition, or it is a soil that contributes to negative off-site effects, such as the eutrophication of waterways.

Soil properties that influence soil health include soil physical, chemical, and biological properties, such as:
- soil texture;
- soil depth;
- soil organic matter content;
- cation exchange capacity;
- bulk density;
- porosity;
- plastic/liquid limit;
- aggregate stability;
- water content;
- water-holding capacity;
- hydraulic conductivity (permeability);
- infiltration; and
- soil respiration.

The concept of soil health focuses on those properties that are readily influenced by management. Soils with poor health often have inferior tilth, lower organic matter content, few living organisms, and show signs of soil erosion, crusting, and soil compaction. Eventually, poor soil health results in problems with crop establishment, root growth, and crop yields. Increasing amounts of fertilisers, pesticides, and tillage are needed to maintain yields on poor quality soil. That is why it is so important to maintain high soil quality.

We will now discuss some important soil properties that determine soil health.

The term soil health is used to assess the ability of a soil to:
- sustain plant and animal productivity and diversity;
- maintain or enhance water and air quality; and
- support human health and habitation.
**PRINCIPLES OF SUSTAINABLE LAND MANAGEMENT**

Sustainable land management has been defined quite simply by the United Nations Food and Agriculture Organisation (FAO) as ‘...about people looking after the land.’ (FAO, 2011). This is underpinned by the recognition that agriculture is dependent on the long term health of our natural resources as they provide the fundamental elements required to grow crops or graze livestock.

Natural systems are complex, and it is important to recognise and understand that it is the interaction of a number of different processes that provides a healthy environment for production. This means we need to take into account soil, water, vegetation and animal resources and their interactions when making decisions for sustainable land management. This is important as we begin to address some of the soil health issues facing our region, requiring us to consider why they have developed and how best we can manage them into the future.

A key aspect of sustainable land management is recognising and valuing, the ecosystem services provided by the environment relevant to agricultural production (Figure 2). Ecosystem services are defined as the benefits to humans from the environment, including both direct and indirect contributions to human wellbeing. In agriculture, this includes those services that enhance agricultural production (e.g. healthy, productive soils; nutrient cycling; pollination by insects; protection from pests etc) as well as those services to the broader community that agriculture impacts on such as water filtration, biodiversity or regulation of atmospheric gases. Many of these services are affected by land management decision-making but often require a medium to long term view to maximise the value obtained from the land.

![Ecosystem Services Model for Agriculture (from WNRM Strategy, 2013)](image)

**Figure 2: Ecosystem Services Model for Agriculture (from WNRM Strategy, 2013)**

The complexity of natural systems means that the best approach to sustainable land management is flexibility and adaptability. Adaptive management approaches, which cycle through planning, implementation, monitoring and learning phases, provide the flexibility and adaptability required for natural resource management. Furthermore, these approaches are commonly used by farmers, as they adjust their practices based on their own experiences. This is an incredibly valuable aspect of farming, and one readily embraced by Wheatbelt
farmers, which has led to a continual drive in innovation. However, adaptive systems require monitoring to inform future learning, and for too long this has focussed solely on productivity and economic measures. Monitoring must embrace natural resource indicators, such as soil health, to ensure long-term success. The concept of Adaptive Management can be illustrated by the following diagram:

---

**Figure 3: The adaptive management cycle (from CSIRO, Management Strategy Evaluation)**

http://www.cmar.csiro.au/research/mse/
SOIL HEALTH ISSUES IN THE WHEATBELT

The soils of the Wheatbelt have formed on one of the oldest and most stable land surfaces on earth, resulting in soils that are highly weathered and often have low fertility. Despite this, soil types are highly variable across the region, depending on the rock or substrate type, geomorphology, climate, hydrology and vegetation and can range from deep sandy soils, through duplex soils to heavy clay soils. The rapid development of agriculture across the Wheatbelt has revealed, exacerbated or caused a number of soil health issues relating to these soils. It is important to recognise that these issues are often associated with the soil type, meaning that understanding your soil types is an important starting point when considering soil health issues that may affect your production.

This section of the guide provides a summary of the soil health issues facing the Wheatbelt, including soil acidity, wind erosion, water erosion, soil organic carbon, soil biology, soil structure decline, soil compaction, water repellence, dryland salinity and nutrient status and nutrient export, based on the Department of Agriculture and Food Western Australia Report Card (DAFWA, 2013). Each summary documents the key points about the issue and the factors that cause it to occur. A range of management actions for these issues are then explored in the case studies presented in this guide. However, this should not be considered a comprehensive list of management recommendations and there are management options beyond those explored through SCIP.

The impact of these soil health issues on agricultural productivity, as well as the quality of ecosystem services, is gaining considerable attention within the farming community given their impact on production. For example, soil acidity has been estimated as costing $498 million annual from the opportunity costs of lost agricultural production (DAFWA, 2013). Survey data collected through the soil conservation incentive program highlighted soil health management issues as prioritised by farmer participants. Responses indicated that wind erosion, soil fertility, secondary salinity and soil acidity were the most pressing issues for land managers, but highlighted that there is a range of issues that are considered to be a high priority by Wheatbelt farmers.

Table 2: Priority management issues for farmers (n=51).
Data derived from Baseline Land Manager Surveys for SCIP rounds 1–3.

<table>
<thead>
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<td>Other (see below)</td>
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Other management issues

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<td>Maintaining or establishing perennial ground cover</td>
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<td>Weed control</td>
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SOIL ACIDITY

KEY POINTS
- An ‘acid soil’ is where the top 10 cm has a pH\text{Ca} of less than 5.5, and/or the subsoil (down to 30 cm) has a pH\text{Ca} of less than 4.8.
- Acid soils reduce root growth, increase aluminium toxicity to plants, reduce major nutrient uptake, and reduces nodulation in legumes.
- Liming to prevent or treat acid soils is practical, profitable and effective on most soils.
- Treating acid surface soils helps to prevent or treat acid subsoils
- Acidification is a natural consequence of agriculture.
- The two main causes of increased acidification are removal of plant material (pasture and crop), and leakage of nitrogen fertilisers.

DIAGNOSING ACID SOILS

VISUAL CLUES
- Plant growth is poor and usually worst on sandy surfaced soils.
- In dry seasons or dry finishes, acid soils are more likely than many soils to have poor yields (due to poor root depth and access to soil moisture).
- Plant roots look shortened and thickened, and end at a distinct layer in the soil (where the soil is too acid for root growth).
- Nodules on legume roots are reduced and not very active (not bright red).
- Plants have finished growing, but there is still plenty of soil moisture below the roots.

MEASURING ACIDITY TO IDENTIFY ACID SOILS
- Laboratory testing of samples collected using the standard recommendations.
- Soil from the top 10 cm with pH\text{Ca} of less than 5.5 are deemed to be acidic.
- Soil from the 10–20 and 20–30 cm depths with pH\text{Ca} less than 4.8 are deemed to be acidic.

WIND EROSION

KEY POINTS
- Any loose and dry soils are very susceptible to erosion.
- Wind erosion is a seasonal hazard in the south west of Western Australia, due to warm dry summers and reliance on annual crops and pastures.
- Maintaining more than 50% attached ground cover significantly reduces erodibility of soils.
- Late breaks to the season and reduced rainfall increase wind erosion hazard.

CAUSES OF WIND EROSION
For wind erosion to occur, three conditions have to be met:
1. Insufficient ground covers (less than 50% of the surface covered by stable stubble, pasture residues, or gravel).
2. Loose, dry soil at the surface.
3. Wind strong enough to move sand. Usually above about 28 kph.
SOIL ORGANIC CARBON

KEY POINTS

- Soils in the Wheatbelt have limited capacity for carbon storage.
- Recent seasons in the Wheatbelt have been characterised by generally variable and less reliable rainfall and an increase in summer rainfall.
- Soil carbon storage is largely dependent on soil type, climate and management practices.
- Changes in land management practices in recent years, particularly moves towards continuous cropping and away from pasture systems, have resulted in a reduction in carbon storage.
- Other factors contributing to a decline in soil carbon levels include summer weed control and chemical fallowing as nutrient conservation and water-use efficiency strategies.

FACTORS AFFECTING LEVELS OF SOIL ORGANIC CARBON

- Summer weed control.
- Chemical fallowing.
- Stubble burning.

SOIL BIOLOGY

KEY POINTS

- Soil is a complex and dynamic habitat for soil organisms.
- Soil organic matter provides a stimulus for biological activity within the soil.
- Soil biological activity is influenced by farm management practices.
- Soil biological function is currently low in the Wheatbelt.
- Soil meso-fauna and mycorrhizal fungi respond either negatively or positively to their surroundings.
- Soil biological health is indicated not only by the abundance of soil meso-fauna but also by the ratio between various species.
- Mites and springtails are indicator species of soil biological activity.
- Mycorrhizal fungi reflect processes associated with the efficiency of access of soil phosphorus, soil aggregation and protection of soil carbon.

FACTORS AFFECTING SOIL BIOLOGICAL FUNCTION

1. Soil acidity.
2. Soil organic matter management.
3. Tillage practices.
5. Herbicide and pesticide practices.
SOIL STRUCTURE DECLINE

KEY POINTS

- Soil structure decline ‘is a phenomenon of surface soil, caused mainly by excessive tillage’ (Moore, 1998).
- 30% of soils in the Wheatbelt are susceptible to soil structure decline (Carder and Grasby, 1984, cited by Moore, 1998).
- Soils with poor structure typically exhibit symptoms of ‘crusting’ and ‘hard-setting’ of the surface (Moore, 1998).
- Degraded soils are characterised by reduced infiltration, increased run-off and increased compaction (Moore, 1998).
- Soils suffering from structural decline often require more tractor power contributing to higher fuel consumption and an increased carbon footprint.
- The ideal soil structure has a large proportion of aggregates from 0.5 to 2mm which are not easily broken down (Moore, 1998).

FACTORS CONTRIBUTING TO SOIL STRUCTURE DECLINE

1. Excessive and/or poorly timed cultivation (especially of wet soils).
2. Stock trampling (especially of wet soils).
3. Loss of soil organic matter through excessive tillage or stubble burning.
4. Compaction due to farm vehicle traffic.
WATER REPELLENCE

KEY POINTS

- In Western Australia, up to five million hectares of soil are either affected or have the potential to be affected by water repellence.
- Soils most at risk of water repellence are sandy soils with less than 5 per cent clay content.

FACTORS CONTRIBUTING TO WATER REPELLENCE

1. Water repellence in soil is caused by dry coatings of hydrophobic material on soil particles or aggregates.
2. Hydrophobic organic matter, such as fungal strands and particles of decomposing plant material also have an effect.
3. Some legume crops, such as lupins, produce water repellence to a greater extent than cereal crops.
4. Microbial activity breaks down dead plant material in a way that contributes to the development of water repellence in susceptible soils.
5. Research continues for a biological solution to water repellence using similar principles to that of biological clean-up of crude oil spills.

DRIYLAND SALINITY

KEY POINTS

- Dryland salinity refers to all soils in non-irrigated areas that have become saline since being cleared for agriculture.
- Dryland salinity is a major cause of land degradation and remains a threat to 2.8–4.5 million hectares of highly productive, low-lying or valley soils in WA.
- More than one million hectares of agricultural land in the south-west of WA is severely salt-affected.
- Currently, 16% of the Avon River Basin is at high-risk of dryland salinity and this is expected to increase to 21% by 2050.
- Dryland salinity remains a potential threat to 2.8–4.5 million hectares of productive agricultural land (George et al. 2005) and depending on future climate, the area actually affected will increase.
- In some areas, salinity continues to expand despite lower than average rainfall since 1975 and particularly since 2000.
- The long-term extent of salinity may take decades to centuries to develop, especially in areas where clearing was staggered, the area cleared is small (<50%), or where watertables are deep (George et al. 2008b).
- Dryland salinity will only cease to expand when a state of ‘hydrological equilibrium’ is reached, which may take many decades to develop.
- Dryland salinity needs to be managed in a way which minimises off-site impacts and enables profitable use of affected land.
- Containing and adapting to salinity is feasible, though recovery is viable in only a few areas.
- The implications of dryland salinity to the agricultural industry are widespread and include reduced crop yield, reduced arable land and diminished land capability.
- Management to contain or adapt to salinity is technically feasible using plant-based and engineering options, though few, if any, degraded areas can be economically recovered.
FACTORS CONTRIBUTING TO DRYLAND SALINITY

1. Dryland salinity occurs when the concentration of soluble salts near the soil surface is sufficient to reduce plant growth.

2. Williamson (1998) points out that the fundamental requirements for dryland salinity to develop include:
   - a store of salt in the soil;
   - a supply of water; and
   - a mechanism to bring both of these into contact with the ground surface.

3. Clearing for agriculture over the last one hundred years and the replacement of perennial, deep-rooted native vegetation with the shallower rooted annual crops and pastures leading to increased groundwater recharge.

4. Groundwater recharge results in rising watertables, bringing naturally stored salts from depth to the surface.

5. In areas cleared and developed for agriculture after 1960, most watertables continue to rise, despite a decline in annual rainfall.
KEY POINTS

- On average, pasture soils and arable soils contained 1.3 times and 1.6 times respectively as much phosphorus (P) as is required for optimum production.
- The direct cost of excess P application in the agricultural areas of the south-west of WA is estimated to be about $400 million per year.
- Production in P-enriched soils is more likely to be constrained by soil acidity (50–60% of pasture and arable soils), potassium (K) (50% of pasture soils and less than 10% of arable soils), and sulphur (S) (30% of pasture soils).
- Reducing the amount of P to optimal levels could lead to economic benefits (reduced fertiliser costs or redirection of fertiliser costs to removing other constraints), and reducing the off-site impacts of agriculture (reduced leaching and run-off of P).
- Removing other nutrient and soil constraints (acid soils, K, S) is likely to increase productivity and profit of agriculture.
- Industry bodies, especially those providing fertiliser advice, need to be aware of the current nutrient status in the Wheatbelt and provide fit-for-purpose, element-specific fertiliser recommendations to derive optimal economic outcomes for producers and to minimise off-site impacts.

FACTORS INFLUENCING NUTRIENT STATUS AND NUTRIENT EXPORT

1. Applications of phosphorus-based fertilisers without prior testing to ascertain current levels of P.
2. Applications of P above recommended rates.
Agriculture is recognised as highly innovative, developing and adopting new techniques that have led to the rapid development of the industry. The land management practices used by farmers often have a direct impact on the condition of Wheatbelt soils, and there is a need to bring this innovation to develop and adopt farming techniques that both contribute to agricultural production while improving the condition of our natural resources.

These management practices need to be optimised for the conditions imposed by the biophysical environment, ensuring farming practices recognise the role of soil type, landform, climate and biodiversity. However, innovation in sustainable agriculture needs support from a range of stakeholders. As the Department of Agriculture and Food Report Card (DAFWA, 2013) points out:

*Achieving sustainable agriculture is the responsibility of all participants in the system, including land managers, farm businesses, policy makers, researchers, retailers, and consumers. Each group has its own part to play and its own unique contribution to make to strengthen the sustainability of our agriculture.*

(DFWA Soil Health Report Card pp. 4 & 8)

The case studies that form part of this guide are designed to highlight farming practices that address some of the issues raised in this guide, which are faced by farmers in the Wheatbelt. The case studies relate to trials and demonstrations that formed part of Wheatbelt NRM’s Soil Conservation Incentive Program (SCIP).

The trials were farmer-initiated and farmer-driven attempts to overcome problems that were being experienced with soil health and were leading to declining productivity, profitability and sustainability.

The innovative practices explored by participating farmers are summarised here and followed by a selection of case studies that explore individual stories more deeply. This section also describes some of the results obtained from surveys of participating farmers that highlight broad practice adoption rates and reasons for why farmers would or would not adopt particular practices.
AGROFORESTRY

The range of opportunities in agroforestry is continuously increasing with new industries emerging and a growing knowledge of how best to manage and integrate these systems into Wheatbelt farms. At the same time, we are recognising the value that these systems contribute to the health of our natural resources, with many biodiversity, soil and water benefits. This is particularly important given that the Wheatbelt forms part of an international biodiversity hot spot, but is largely cleared and remaining vegetation is highly fragmented.

The SCIP program received requests for support for 8 broad types of agroforestry based activities, with oil mallee and sandalwood based systems being the most popular.

Figure 4: Relative proportion of agroforestry based SCIP projects

TIMBER

Timber crops are an option for production in the higher rainfall areas of the Wheatbelt, although some species such as swamp sheoak (Casuarina obesa) are suitable in lower rainfall regions. Selecting the right species, provenance and site are essential to any successful planting, while on-going management (thinning, form pruning and clear wood pruning) requirements can be high.
SANDALWOOD
Sandalwood is a popular option for the Wheatbelt. It is a hemi-parasitic tree, dependent on nutrients from host plants to survive and grow. The best hosts are nitrogen-fixing trees, especially the wattles. Sandalwood shows great potential on soils that are unprofitable for cropping, and can provide significant economic returns. Although the long wait for such returns can be an issue, there is scope to develop systems that can provide grazing, carbon sequestration and bush food (from both the host or sandalwood trees) returns at an earlier date.

BRUSHWOOD
Brushwood or broombush is an agroforestry option on land that is not highly productive for conventional agriculture. Brushwood can be grown on sites that are marginally saline, and seasonally waterlogged, although as conditions decline productivity will be reduced. Harvested brushwood is used in the production of brushwood fencing panels. Established plantings provide excellent shade and shelter for livestock, particularly during lambing and off-shears.

OIL MALLEE
Oil mallees are commonly planted in the Wheatbelt, as they are largely unpalatable to sheep and so can be planted in paddocks without the need for fencing. Mallees coppice (re-sprout from the lignotuber) readily after harvest, fire or other damage. Oil mallees may be planted for a variety of production types, including; environmental services, harvested biomass, and carbon sequestration although there has been some uncertainty around the industry. Established plantings also provide excellent shade and shelter for livestock.

PLANTING FOR BIODIVERSITY
Biodiversity based revegetation activity is often incorporated into farming enterprises, often both for restoring environmental values and their potential to provide multiple benefits to the farm, for example wind breaks, soil protection, local ground water management, aesthetics and potential land values. For optimal biodiversity benefits from your revegetation use local species that are found on similar soil types and optimise structural characteristics by including ground cover, shrubs and trees.
CROP ROTATION
Crop rotations provide a number of benefits for soil health, supporting improvements in soil structure, fertility, and soil biological health as well as helping with weed, disease and pest management in cropping systems. The plant species and their sequence in the rotation will influence the potential gains, with rooting characteristics, nitrogen fixation and relationships with microbial species key factors influencing the success of a particular rotation.

STUBBLE RETENTION
The retention of stubble reduces erosion, conserves moisture and builds overall soil health. The value of stubble retention is well recognised in broadacre farming in the Wheatbelt and has now been adopted by almost all farmers. However, there are still improvements being made to this system, including weed and disease management, systems for seeding into thick and/or tall stubble and managing stubble and chaff to optimise soil health.

COVER CROPS
In a high quality no-till system permanent residue cover of the soil, crop diversity and integrated pest and weed management is vital. Cover crops can be part of the strategy to achieve this. Cover crops can also protect the soil from erosion, conserve moisture, provide a disease break, suppress weeds, provide an option for controlling weed seed set and promote soil health and fertility through biological activity, nitrogen fixation, nutrient cycling and organic matter accumulation.

OPTIMISING DRY SEEDING
Dry seeding is becoming an increasingly common practice in the Wheatbelt, driven by an increasing number of late starts to winter rainfall and opportunities arising from stored soil moisture following summer rainfall. However, dry seeding can increase the vulnerability of soils to wind erosion. Best practice dry seeding should adjust to soil type, aim to dry seed into soil with good stubble/ground cover and adjust sowing speeds to reduce wind erosion.
A key goal of sustainable grazing systems is to ensure that paddock ground cover levels never fall below 50%. This can be an issue on annual pasture systems during summer and autumn, particularly during drought years. SCIP survey data indicated that over 60% of project participants grazed paddocks with less than 50% ground cover, but that half of these only did this under drought conditions. There are a growing number of grazing options that can potentially address the summer feed gap.

**FORAGE SHRUBS**

Forage shrubs can provide valuable green feed for livestock during the summer/autumn feed gap, and during periods of drought. Research has shown that when 10–20% of the whole farm area is planted to forage shrubs, this can increase profitability of a mixed crop-livestock farm, based on unproductive cropping soils being planted to fodder shrubs. The list of species suitable for grazing is continually growing and now includes a range of plants suitable for a variety of soils, including saline soils. Breeding programs are also optimising productivity gains from individual species while plantings can provide important biodiversity gains, particularly through the use of local, native species.

**INTEGRATED SYSTEMS**

Many of the agroforestry and grazing options can be integrated to produce options that have multiple benefits. One example of this is the system proposed by Greening Australia that uses a mix of species to produce grazing, biomass and biodiversity outcomes. The system uses belts containing 4 to 6 rows of mixed fodder species from ground cover, small to medium shrubs and some larger small to medium trees. The inter-row is also important to supply high carbohydrate feed such cereal or dry pasture to complement the high protein feed available from the forage shrubs. The system design is very flexible and can be modified to meet farm management requirements however the technical team recommend that block plantings are avoided or restricted to small areas as experience indicates that stock can become difficult to muster in this style of design.

**PERENNIAL PASTURES**

Perennial pastures are increasingly being recognised as a viable and important part of a sustainable grazing system. This is for a number of reasons, including their ability to convert summer, ‘out of season’ rainfall into feed, the increased summer cover and perennial nature of the grass can make soils less vulnerable to erosion and their deep rooted nature can make better use of available soil moisture across the year. Perennial pasture species include both grass and legume based species that can be tailored across a broad range of environments, including warmer to cool climates and some salt tolerant species. There is also growing knowledge around native perennial pasture species.

**ANNUAL PASTURES**

Annual pastures are an important component of many Wheatbelt farming systems, but can lead to environmental issues due to their shallow rooted nature, when over grazed or pasture species selected cannot tolerate hostile soils. However, selecting annual pastures that are deeper rooted and nitrogen fixing (with appropriate inoculation) can lead to improvements in soil health while reducing input costs. Salt tolerant species can also protect the soil on these vulnerable components of the landscape.
INNOVATIVE SOIL MANAGEMENT

SOIL ACIDITY
Soil acidity is a big issue for the Wheatbelt of WA, causing significant losses in production and restricting crop or pasture selections. This has flow-on effects in terms of soil health through reduced cover and carbon cycling.

The application of lime is the most economical way of ameliorating low soil pH, and there is continuous improvement of methods of application and incorporation to ensure optimal outcomes. However, management practices that reduce the rate of acidification (e.g. through precision based fertiliser application) are also important in the long term management of soil acidity. Soil testing, both surface and subsoil, is important to inform the correct application of lime.

CLAYING AND/OR SUBSOIL CLAY MANIPULATION
The Wheatbelt’s sandy surface can be affected by water repellency or non-wetting, often caused by the build up of waxy, hydrophobic organic matter.

Clay, with a much larger surface area than sand particles, is less vulnerable to the build up of these waxes and soils with more than approximately 5% clay content are rarely non-wetting. The addition of clay, by spreading clay from elsewhere, or through delving by spading, mouldboard ploughing or deep delving systems can be used to correct these issues. However, they can be expensive and must be approached with caution to not exacerbate other soil health issues (e.g. spreading or bringing acid subsoils to the surface or increasing wind erosion).

BIOLOGICAL FARMING PRACTICES
Soil organisms have a number of important roles in soil that include the cycling and transforming of nutrients. They aggregate soil particles and improve the soil structure. They also assist plants to obtain nutrients from the soil and help with water penetration into the soil.

Many Wheatbelt farming systems are now using approaches that attempt to optimise soil biological function, through the use of nutrient, weed and pest management systems that work with the soil biology. However, the role soil organisms play in providing soil health in a Wheatbelt farming system is not yet fully understood.

SOIL CARBON
The management of soil carbon can improve soil quality through effects soil structure, water holding capacity and nutrient holding and cycling processes. Soil carbon is built through the management organic matter, however amount of soil carbon within a soil is often limited by rainfall and soil texture.

Practices such as stubble retention can increase soil carbon stocks, but recent findings indicate that the management of summer living cover (summer cropping, perennial pasture/forage shrub or weed management) is important in maintaining soil carbon, particularly during warm, wet conditions.

The addition of carbon, from external sources such as biochar, can also increase soil carbon.
ADOPTION OF SUSTAINABLE FARMING PRACTICES

The soil conservation incentive program (SCIP) supported farmers to explore sustainable farming practices with the goal that the practices trialled would be adopted into their on-going farming activities. The structure of the project was based on the Farm Practice Change model presented by Nicholson et al. (2003) that suggested that adoption ‘…follows a continuous and logical sequence that involves 3 key stages, with transition between the stages a conscious decision to progress.’ The 3 stages include motivation, exploration and trialling and farm practice change, with SCIP focussing on supporting farmers through each stage.

The Farm Practice Change model can be represented by the following model:

![Farm Practice Change Model](image)

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Figure 5: Farm practice change model (modified after Nicholson et al. 2003)

Project participants were surveyed throughout their interaction with the program, through base line, event and end of project surveys that assessed their knowledge and skills relating to the practice and information on the reasons for or against their longer term adoption of the practice. Overall, 91% of respondents indicated that they would go on to use the trialled management practice on broader scale on their farm. Adoption rates were lowest for the cropping practices trialled at 67% and highest for annual/mixed pastures at 100%.

Participating SCIP farmers were further asked to identify the reason(s) for their decision to adopt or not adopt the practice (Tables 3 and 4). The most commonly selected response related to the fact that the trialled practice could be reasonably simply integrated within the existing farming system. This was followed by the knowledge gained about benefits for the practice and increased technical knowledge gained through the program.

Interestingly, knowledge of the costs was not a big factor when the practice was adopted, but expense was cited as the most common reason for not adopting a particular farming practice. Lack of time was the other popular choice for why a farming practice was not adopted.
Figure 6: Percentage of farmers who will or will not adopt each sustainable farming practice

Table 3: The reasons why farmers/land managers will adopt the management practice trialled more widely.
Data derived from the SCIP End of Project Survey for rounds 1–6 (excluding round 4) and SCIP Round 4 Land Managers Survey.

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<td>Knowledge of benefits</td>
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<td>Increased technical knowledge</td>
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Table 4: The reasons why farmers/land managers would choose not to adopt the management practice trialled more widely.
Data derived from the SCIP End of Project Survey for rounds 1–6 (excluding round 4) and SCIP Round 4 Land Managers Survey.

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<td>More technical knowledge needed</td>
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<td>Didn’t fit with farming system</td>
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<tr>
<td>Lack of time</td>
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<td>Other</td>
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**CASE STUDIES AND FACT SHEETS FOR SUSTAINABLE LAND MANAGEMENT**

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<td>A decade of growing, observing and learning about sandalwood</td>
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<td>The story of Jogalong Downs: multiple benefits from a long term experience with tree planting</td>
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<td><em>Casuarina obesa</em> in the Avon Wheatbelt: Management of native stands and provenance trials</td>
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AGROFORESTRY

USING TREES TO PROTECT CROPS

PROJECT SNAPSHOT

Land Managers: Reece and Gina Boyne
Property size: 10,000 ha
Location: Koorda
Annual rainfall: 270 mm
Enterprise mix: Cropping and sheep
Soil types/Vegetation types: Red clay, wodjil sand, loam

KEY MESSAGES

• Be careful not to over clear because in the long run it won’t improve cropping efficiencies.
• Don’t let a landscape be lost to degradation. Seek advice and act quickly to maintain good soil health.
• Oil mallee belts provide excellent wind breaks which give annual pastures the opportunity to establish so they can be utilised by livestock.

WIND BATTERED SLOPES

Reece Boyne comes from a long line of farmers. His great grandfather started farming Tarapan, the family’s home farm, back in 1907. The Boyne family decided to expand the business in the 1970’s, purchasing Adrook.

In recent years the Boynes had seen some of the cropping paddocks being battered by the elements. They knew that replanting trees would be necessary to provide protection from further erosion.

‘Being on an upper slope in the landscape and having no wind breaks it was very exposed to wind and water erosion,’ Reece explained. ‘Less sheep could be stocked in the paddock and it was harder for the crops to establish due to the constant strong winds.’

Their local Natural Resource Management Officer was aware they were looking for funding to help them with the venture so when Wheatbelt NRM announced the Soil Conservation Incentives Program they were one of the first know.

The Boyne’s successful application meant they were able to plant 13,500 oil mallee (Eucalyptus loxophleba lissophloia) seedlings across the paddock. One belt was sown across the width of the paddock at mid slope (1590 m) and another two belts were positioned mid to upper slope (2025 m and 2040 m).

‘We were very pleased that we had the opportunity to revegetate the paddock with oil mallee belts. With less erosion and more feed on offer we have the possibility to increase stocking rates in the future as soil health improves,’ Reece said.

Using existing GPS lines allowed Reece and his wife Gina to plant the seedlings supplied by Koorda Tree Farm Nursery in the same direction as previous furrow lines. By planting the oil mallee seedlings into a sown crop they had some shelter from the wind and little weed pressure. Low rainfall (93 mm) during the growing season, however, did make establishment a little challenging.
LESSONS LEARNT

Not only did the Boynes benefit from the grant financially, they also gained knowledge along the way.

‘The Project Support Officer provided us with valuable information and advice on how to plan other revegetation projects in the future,’ Reece mentioned. ‘For example we now know what species are best suited to the certain soil types on our property.’

Although the Boyne family have been busy revegetating the farm (e.g. salt-affected and eroded country), the project also gave them more experience using modern technology which complemented the cropping program.

WHAT’S AHEAD…

The Boyne family look forward to planting more tree belts throughout the trial paddock and other paddocks at risk to reduce wind speed even more.

Reece said, ‘We have to protect our soil health or productivity will continue to be limited.’

As the oil mallees don’t need to be fenced off once established the Boynes also believe the tree belts will provide good shelter for their sheep grazing in this paddock.

‘We have to protect our soil health or productivity will continue to be limited…’

Reece Boyne
**AGROFORESTRY**

**FARMING WITH WINDROWS**

**PROJECT SNAPSHOT**

- **Land Managers:** Martin and Sheena House
- **Property size:** 3000 ha owned, 1200 ha leased
- **Location:** Ardath
- **Annual rainfall:** 320 mm
- **Enterprise mix:** 70% cropping, 30% pasture (sheep)
- **Soil types/Vegetation types:** Mixed, with a large portion of granite derived loams and rocky soils with associated clay flats

**KEY MESSAGES**

- Funding can help you take on that large revegetation project you have always wanted to do, but couldn’t finance.
- Integrating tree belts across a cropping paddock can protect crop seedlings from furrow infill.
- Preparation is important when planting windbreaks across paddocks to avoid complications with the cropping program.

**THEIR STORY**

Situated between Cunderdin, Merredin and Corrigin sits a small town called Ardath. Here Martin and Sheena House farm a large property comprised of mainly medium to heavy country.

Each year they plant trees on their property to create microclimates and protect the landscape from erosion. With funding available through Wheatbelt NRM they decided they would apply for some oil mallee seedlings to protect three low lying, flat paddocks (330 ha) which are susceptible to frost.

With the aid of their local Natural Resource Management Officer their submission was accepted and they received funding for 20,000 oil mallees.

Martin mentioned, ‘Without this project our budget limits the amount of trees that we plant each year.’

**INTEGRATING TREE BELTS INTO CROPPING PADDOCKS**

In July 2012 the House family planted the oil mallees in several two-row belts, in an east/west direction.

Martin explained, ‘The logic behind planting east to west was to minimise the shading effect on crops and to shelter the paddocks from damaging north-westerly winds.’

Using a Chatfield Tree Planter enabled them to rip, scalp and plant at the same time.

‘As the trees were planted after the cropping program was seeded, we used a grass spray to eliminate the crop within the belts,’ Martin said.
'The logic behind planting east to west was to minimise the shading effect on crops and to shelter the paddocks from damaging north-westerly winds…'

Martin House

‘We then used A–B lines to establish the tree belts [approximately 100 m apart] in accordance with our machinery widths.’

This approach significantly improved the efficiency of the extensive planting, during what can be a very busy time on the farm.

Unfortunately 2012 was a dry season and so the trees had a tough start. By the following summer Martin concluded that the oil mallees were well suited to sandy soils, but struggled to grow in the sodic grey clays. Yet he has since planted some more, and has found that the wet 2013 summer has improved establishment in these soils.

He intends to plant saltbush in areas that remain patchy.

‘I would like to incorporate saltbush into the tree lines, so they can serve as a shelterbelt as well as a feed source for sheep,’ Martin mentioned.

THOUGHTS IN RETROSPECT

Before the project the House family had limited experience planting trees in belts across cropping country. Therefore, encountering some issues during the first year was expected.

Martin said, ‘We will have to be careful not to overspray the oil mallees when spraying the crops with post-emergent.’ He added, ‘I will also have to reprogram my GPS to account for the tree lines.’

These teething issues haven’t deterred Martin however, and he will be accessing another 9000 trees via Wheatbelt NRM’s Soil Conservation Incentives Program to provide infills this season.
AGROFORESTRY

MT MARSHALL SANDALWOOD

PROJECT SNAPSHOT

Summary: $155,000 project. 13 farming families were able to protect 350 hectares of fragile wodjil soils using 111,880 seedlings and 85 kilograms of locally collected native host seed. As part of this funding, training sessions and workshops were also held and information resources developed.

Location: The Shire of Mt Marshall is situated in the North Eastern Wheatbelt with two major centres—Bencubbin and Beacon. The Shire borders the Shires of Trayning, Koorda, Mukinbudin, Yalgoo, Dalwallinu, Westonia, Yilgarn, Wyalkatchem, Sandstone and Menzies. The Mt Marshall Sandalwood Project includes neighbouring shires and communities.

Annual rainfall: Approximately 330mm

Soil types: There are a wide range of soil types in the region, however, the Mt Marshall Sandalwood Project has a focus on establishing biodiverse Sandalwood systems on wodjil soils which are marginally productive for agriculture.

BACKGROUND

The Shire of Mt Marshall officially became known as the Sandalwood Shire in February 2007. At the time of their centenary the Shire published a book on the history of the area. Local farmer, Bob Huxley, noted that according to this book the best sandalwood grew on wodjil soils in the district. As with a large part of the Western Australian wheatbelt, the majority of the landscape had been cleared for broadacre agriculture. Over time the wodjil soils in the North-Eastern Wheatbelt have proven problematic for these conventional farming systems due to their acidic nature and fragility.

When Bob read about the history he thought, ‘We have plenty of wodjil in this area and its mostly not used for growing crops, it blows away and acts as recharge areas. Maybe we should be putting these areas back into Sandalwood.’

And so began the journey. Bob gathered as much information as he could, actively encouraging others to plant sandalwood and helped them source grants, many through Wheatbelt NRM funding rounds.

Over time, biodiverse sandalwood systems were popping up all around Mt Marshall and surrounding regions thanks to the support from Bob and other leaders in the field such as Tim Emmott (formerly of Greening Australia) and researcher Dr Geoff Woodall.

Bob convinced many farmers over the subsequent years that Sandalwood could fit into their farming system, slowly building up a group of conventional farmers who could see what a sandalwood industry could bring back to their region.

Field days and site visits illustrated to the community how
well the biodiverse sandalwood system was establishing and growing on land that previously struggled to grow a crop.

‘Biodiverse plantings are all well and good,’ said one local farmer, ‘but then I still have an unproductive paddock. It’s the sandalwood that will give me production and an income in the future.’

In April 2011 a Wheatbelt NRM funded Master TreeGrower Program toured to the Mt Marshall area looking at biodiverse Sandalwood systems. Graeme McConnell of PlanFarm presented an economics spreadsheet which demonstrated the cost/benefit of sandalwood systems as compared to current practices. Wendy Dymond of ThinkScape facilitated the workshop. By the end of the workshop the local farmers had developed their vision, to plant 50,000 hectares of unprofitable wodjil soils to biodiverse sandalwood systems over the next 20 years.

The group of farmers then formed the Mt Marshall Sandalwood project steering committee under the auspices of the Australian Sandalwood Network (ASN) and approached Wheatbelt NRM for support. Wheatbelt NRM has since provided support for the project as one of their regional priority projects.

Wheatbelt NRM’s SCIP program aimed to fund the establishment of 100 hectares of biodiverse sandalwood systems, however, 350 hectares was established, consisting of 111,880 seedlings and 85 kg of locally collected sandalwood host seed. The seed was sown using the latest direct seeding techniques. This was made possible by a greater in-kind contribution from the farmers participating in the project and also by further funding provided by Wheatbelt NRM ($17,000).

SITE PREPARATION INSPECTION

Extending project information to the community, farmers and other stakeholders has been an important part of this project. Signage, a webpage, two newsletters, media releases and information sheets were also developed as part of the project.

Direct seeding mix: 95% MAP and vermiculite with 5% native seed mix (45 species).

13 farming families benefited from this funding over the two years of the project. Here is what a few of them had to say:

MARK AND MICHELLE FITZPATRICK

‘What makes it attractive is the mentoring from Bob and Ros. We first got interested when we went to a sandalwood field day at Hogan’s farm in 2010 and saw how well the site was doing in that drought year. We fenced off a 30 ha site where we had unsuccessfully tried to grow wheat and could not graze as it would just blow away.

‘In 2011 we received our first 8000 host seedlings through a Wheatbelt NRM SCIP project.

‘In 2012 we received assistance to plant another 6 ha through this funding round, which we used to connect up existing vegetation which provided valuable shelter. We used a combination of Bob’s direct seeding mix and seedlings.

‘The whole family was involved. We crawled under the old sandalwood trees on our property with the kids and collected the nuts, then Bob and Ros showed us how to prepare them.’

‘If the government can provide the funding for the seedlings, we are happy to do the rest. We did the weed, insect and vermin control as well as erecting the fencing…’

Mark Fitzpatrick

‘I like the fact that they are natural, part of our heritage. This project is about bringing back the livelihood that started Mt Marshall. The government granting us the trees allows us to take the area back to a sustainable and natural state…’

Michelle Fitzpatrick

Later in 2011, Mt Marshall Sandalwood (MMS), through the ASN, were successful in obtaining funding from Wheatbelt NRM under their Round 5 Regional Flagship Soil Conservation Incentive Program (SCIP) funding round. The project was granted $155,000 to:

- Officially launch the project on Friday September 9th 2011, by the Hon Mia Davies, MLC, Member for the Agricultural Region.
- Two further community workshops were held on Thursday and Friday September 8th and 9th modelled on the original April Master TreeGrower workshop. The result of these follow-up workshops were pledges of support from the Department of Agriculture and Food WA and Wescorp (the major exporter of Sandalwood in Western Australia). Several locals agreed to give talks at local schools, to hold women’s events to inspire others in the community and broaden the support base for the 50,000 hectare project.
- A technical workshop was held in Bencubbin on March 2nd 2012 focusing on establishment of sandalwood systems.
PETER SASCHE
‘We’re able to add value to worthless land.
‘I hate seeing bare soil so by establishing this sandalwood planting we get the environmental benefits of stopping the paddocks from blowing away. We have started planting sandalwood on our poorer country where we are not getting the returns we were 10 years ago.
‘I could not have spent that much time doing the whole project on my own so it was great that Bob could come in and do some of the work. I covered half the costs, did the fencing and all the spraying, but without Bob it just would not have happened. He has the knowledge, the machinery and the experience. He is the real driver here. ‘Without the funding we could not have done it.’

STUART CLARE
‘We are at a fork in the road, farming will not disappear but forestry can play a big part in farms becoming more sustainable.
‘I have doubts about how long conventional farming will last so I am diversifying our farming practices and sandalwood will be part of our future farming system. Trees, especially sandalwood, will be another form of income for us. We need different trees for different jobs in the landscape.
‘If we had a processing plant in the area it would produce jobs for the younger generation. The whole industry could be providing jobs; planting, harvesting, weed control contracts, processing etc.
‘I like to think outside the box, do different things that other people may not think about.’

GERALD SASCHE
‘I see sandalwood as an insurance against climate change. More summer rain suits the trees.
‘It was an easy decision to put in trees because of our salinity problem. If I can solve it with a commercial option that’s a win.’

For more information go to:
www.mtmarshallsandalwood.org.au
www.wheatbeltnrm.org.au

‘I see sandalwood as an insurance against climate change. More summer rain suits the trees.’
Gerald Sasche
PROJECT SNAPSHOT

Land Managers: Bruce and Bev Storer
Location: Gabbin in the Mount Marshall Shire
Property size: The Gabbin property is 387 ha and the Storers reside on another 687 ha property in Cunderdin
Soil types: There are a range of soil types on the property including gravel over clay, gimlet, salmon gum, red loam, clay, deep wodjil sands, and duplex where the sand meets the clay
Annual rainfall: Supposed to be 300 mm but it is erratic
Enterprise mix: A mixture of wheat and barley crops and sheep and, of course, the trees

TREE PLANTING PROGRAM

Planting since 2001
Species planted: Biodiverse sandalwood mix including a range of Acacia species.
Most recent tree planting project: In October 2010 Bruce and Bev Storer received funding through the Wheatbelt NRM Soil Conservation Incentives Program to plant 40,000 sandalwood hosts over 2.5 years. So far 16,000 hosts have been planted with another 6000 to 8000 to be planted in 2012. The sandalwood nuts will be planted in every second row 1 to 3 years after the hosts depending on host growth rate. So far 80–95% of the hosts have survived and are doing well.

WHAT SPARKED THE INTEREST IN TREE CROPPING?

Bruce started his journey with sandalwood over a decade ago when he began harvesting and selling the wild sandalwood growing on his property. Feeling it was wrong to harvest the wild trees without replacement, he began using the income to fund his own sandalwood plantations. Bruce then got to know other people interested in sandalwood, among them Tim Emmott who founded the Australian Sandalwood Network (ASN), of which Bruce became the founding chairman.

THE JOURNEY OVER THE YEARS

In 2001 the Storers put in their first sandalwood plantation, planting 2000 hosts, of which only 800 survived. Bruce puts this down to drought and inexperience and, taking these lessons on board, they put in another 2000 hosts the next year, this time with much greater success.
Around 2005 they did some experiments on species survival, planting mostly *Acacia acuminata* to research the survival rate, while in 2007 another Wheatbelt NRM grant was received and another 7000 hosts planted. In this manner they have been experimenting, researching and learning as they go which has been ‘a steep learning curve.’
Each year Bruce cuts some sandalwood out of the bush, sells it and invests the money in growing sandalwood again. He often recommends
to new growers to ‘start with a small amount of trees and see how you get on, because if you hit a bad season and that happens to be the year you ordered 100,000 trees and they all die, you can’t afford to do that too often.’

**SOME THOUGHTS ON PLANTATION DENSITY AND RATIO**

The Storers have been mostly working on a density of 1000 host stems per hectare, however Bruce says the jury is still out as to what density to plant and nobody has any conclusive data on the best host to sandalwood ratio. The sandalwood plantation industry is still young but with a decade of planting under his belt and his keen observations of the wild sandalwood he harvests, Bruce has a good idea of what works and what doesn’t, at least on his own property. Hence one of his key messages is the importance of trial, observation and learning when getting involved in sandalwood.

Through his involvement with the ASN, Bruce has seen a lot of plantations and feels that people can sometimes overestimate the density of their plantation. They might be concerned about thinning, which is important, however a plantation may not be as thick as one thinks. Looking back on his earlier plantations, Bruce can see that the density is a problem, however this is mainly in regards to harvesting, as it will be almost impossible to get into these dense thickets and he may have to basically clearfell once the time for harvest comes. The density does not seem to be a problem as far as tree growth, and in fact replicates what he sees in the bush, but it is just not practically viable.

The Storers keep going back to plantations and doing infills in order to try and maintain the density on average over the whole plantation. This is why they prefer to plant fairly densely to begin with, as it’s much easier to watch a few die because they’re too thick than to try and come back and infill.

**HOW ARE THE TREE PLANTING PROJECTS DESIGNED AND IMPLEMENTED?**

To achieve a density of 1000 host stems per hectare, rows are planted 3 metres apart with a tree planted every 2 metres. With this latest SCIP planting, the Storers used a GPS to get a very accurate planting, while in the past Bruce always estimated the spacings when making his run lines.

In April 2011 they deep ripped on the GPS line in order to capture some moisture down the bottom of the trench. Bruce emphasises that you need deep ripping prior to planting, especially in this environment, as it makes a huge difference to the survival rate.

They went on to plant the hosts in June and will wait for at least a year, possibly two, before planting the sandalwood. This gives the hosts time to really establish. The Storers like the host trees to be knee-high to a metre, whether that takes 1, 2 or 3 years to happen.

‘That’s just our theory—lots of people say plant the sandalwood in year 1 regardless.’

Since their first plantings in 2001, they have learnt to plant the sandalwood a bit further away from the hosts to give it room to come through. The roots will travel and attach to the hosts. Sometimes sandalwood seeds come up years later so you have to keep an eye on the plantation.

Once the sandalwood get a hold, and the seedlings are big enough, you can do your thinning. If there are three sandalwood to one host, two of them will come out once and you can be sure that one of them will take. You would take out the smaller ones and let the bigger one take hold.

The Storers have also learnt some lessons about plantation design. By planting in twin line GPS rows, Bruce has ensured that if seed were ever to become a mechanically harvested viable by-product, there is plenty of room to go up and down the rows with a street sweeper collecting seed.
Bruce has also been able to trial different hosts and their effectiveness with sandalwood. Four of the species he used for this latest SCIP project are *Acacia acuminata*, *A. lasiocalyx*, *A. neurophylla* and *A. assimilis* and these have been great. *A. resinomarginia* would be his first choice for wodjil soils but are not always available.

**WHAT BENEFITS HAVE THE TREES BROUGHT TO THE PROPERTY?**

According to Bruce, the most important change has been reducing wind erosion.

‘The wind used to tunnel around and you couldn’t drive across some of the country with a ute because the soil was all carved up.’

The land that is prone to blowing doesn’t grow a good crop, so trees are the best option to grow on that soil and much more economically viable.

‘It’s really a question of saying, that land is not productive wheat growing country so what else can I do with it that will make an income. Sandalwood can be established for minimum input and you do it once if you get it right and you shut the gate and all you’re waiting for is return on your capital land. There are thousands of acres of wodjil land around here and lots of people have gone broke trying to farm this land.’

Bruce is also doing a range of revegetation work on the property: ‘I’m going to try and put some remnant vegetation here to increase the buffer zone and protect this native vegetation. My mother is a bit of a plant guru and has done a lot of work identifying all these species. The local nursery will come and collect seed here and grow it for us to plant.’

The Storers have also seen evidence of lizards (sand-dragons) and echidnas in the plantations—great signs of the wildlife coming back into the area.

‘The land that is prone to blowing doesn’t grow good crop, so trees are the best option and much more economically viable.’
TIPS AND LESSONS LEARNT ALONG THE WAY

- Get to know your species and what works best for your particular soil types. Bruce has found that some species just don’t like sandalwood on them, they just won’t grow—for example Allocasuarina huegeliana. With some soil types it may be almost pointless planting sandalwood—for example in red loam over gravel. The Storers have tried many times and got very little survival.
- Choose your soil type and species very carefully. Each area and property has its own specific soil and characteristics, so sometimes the only way to learn is by experimentation and observation on your own soil.

‘Don’t have great expectations if the soil conditions are not right—do everything you can to time planting with the right soil conditions, because that’s critical.’

- Be very careful with how you handle your seedlings once you pick them up from the nursery. If you are planting all day and leave the trays out in the sun, they will be dry by the end of the day and this will affect your survival rate.
- Stay connected to funding opportunities and information through the ASN.
- There is great value in checkerboarding (i.e. planting some trees and then harvesting at different points) to spread the risk.
- Try new things but only try a little bit at a time. Share what you’ve learnt so everyone can benefit and the industry is not constantly reinventing the wheel.

‘When it comes to harvesting, think long term. I think you’re kidding yourself if you think you can grow commercial sandalwood in anything under 25 years.’

- Know your layout and your plan before you start, even if you mark it out with something, like dragging a tyre behind the ute along your run lines.
- Put your fence up afterwards, not before and leave room for access.
- Be aware of fire, and take steps to insure yourself.

Be quite clear about what you want to achieve, look around at what others have done as there are a few do’s and don’ts. Go and see someone planting some seedlings for example, get in touch with the peer mentoring network to connect with people who have done it and get as many tips as you can. Everyone starts off making the same mistakes so learn from others. Some people like to try and plant sandalwood on naturally occurring vegetation. While Bruce has not found much success with that, others have and it may be worthwhile to experiment.

FUTURE PLANS

Bruce plans to continue to expand his sandalwood plantations into the future. Acknowledging that wheat farming is becoming more and more difficult with the rising costs of production, Bruce feels it is really time to focus on sandalwood for the alternative income source and all the benefits it brings to the land.

‘With the wheat farming you don’t go far enough forward in the good year to make up for the giant leap backwards in bad years. But there is a ready market for sandalwood right now.’
THE STORY OF JOGALONG DOWNS:
MULTIPLE BENEFITS FROM A LONG TERM EXPERIENCE WITH TREE PLANTING

PROJECT SNAPSHOT

Land Managers: Tom and Donna Henning and their daughters Jodie, Sarah and Kirstie
Property: Jogalong Downs
Location: Wongan Hills in the Wongan–Ballidu Shire
Size: Approximately 3000ha in total with 2600ha arable
Soil types: A range of soil types on the property including red loams, gravel over clay, yellow wodjil sands and grey sands
Annual rainfall: 325mm
Enterprise mix: A mixture of wheat and barley crops and sheep; approx 1820ha of the arable land cropped with wheat and barley

TREE PLANTING PROGRAM

Biodiverse mix, mallees and sandalwood
Total trees planted on the property: 150,000
Year: 2011
Species planted: A mixture of saltbush, *Casuarina obesa*, brushwood and various types of Eucalypt including oil mallees.

Most recent tree planting project: In July 2011 the Hennings planted 60,000 trees in mixed species belts to reduce wind erosion with funding provided through the Wheatbelt Natural Resource Management ‘Soil Conservation and Incentives Program’ (SCIP).

WHAT SPARKED THE INTEREST IN TREE CROPPING?

For over a decade now, Tom and Donna Henning have had an interest in tree crops—both for the benefits trees bring to the land and for the long term commercial potential.

Ten years ago they were successful in applying for funding through the Saltland Pastures project and their tree planting mission began. Since that time, they have planted a total of 150,000 trees at various sites throughout their property—some with the help of grants and some out of their own pocket.

‘The primary reason we started looking at trees was the economic return; as well as doing something that would help us with management of low producing areas, we wanted to find something that would give an economic return, which is why we included the oil mallees and the brushwood in there as a harvestable long-term crop. If we had only planted saltbush it wouldn’t have been economically beneficial for us—we wouldn’t have done it.’

Tom and Donna with a mallee.
HOW ARE THE TREE PLANTING PROJECTS DESIGNED AND IMPLEMENTED?

Over the years, Tom and Donna have built a great working relationship with Shane Lyons and Deb Impiazzi at the local Kokardine Nursery. Shane and Deb provide advice on species and site selection, site design and tree establishment as well as practical help preparing and planting the sites.

Tom and Donna also access the technical advice and help provided through Wheatbelt NRM to ensure the best survival rates for their seedlings.

Additionally, Tom and Donna can now draw on the knowledge they have gained over 10 years of planting, and all the lessons learnt along the way. This gave them confidence in carrying out their most recent SCIP project—planting a massive 60,000 trees in mixed belts and fencing and managing the site for rotational grazing.

To undertake their SCIP project, the Hennings first sowed the paddock with barley and then established the belts over the barley crop a couple of months later. The land was sprayed and pre-ripped as part of the barley cropping work.

‘We find we get better weed management and survival rate if we plant the trees in existing crops.’

This way, the trees get buffered from the winds and are able to get well established, while also receiving the benefit of the fertiliser and weed control that the crops get.

A Chatfield tree planter was hired to plant the seedlings and help was provided by Tom and Donna’s three girls, Donna’s sister Anthea, and Shane and Deb from Kokardine Nursery. Trees were planted in 14 belts, with each belt consisting of 4 rows, with a total belt width of 10 metres. A different combination of species was used within each belt. Tom was able to identify the more saline land to be planted to saltbush, and on the better land the oil mallees and brushwood were planted.

Again, Tom and Donna credit Shane and Deb with providing excellent quality seedlings, tall and robust enough to make planting with a Chatfield easy, and delivered right on time.

‘We always request in our grants that the seedlings come from Kokardine.’
WHAT BENEFITS HAVE THE TREES BROUGHT TO JOGALONG DOWNS?

TRANSFORMATION TO LAND MANAGEMENT
The SCIP project has transformed the way Jogalong Downs is managed, by using fencing to divide the land into different management units. Before, it was just one very big unit that was difficult to manage. The fencing was a job that needed to be done on the farm anyway so by pulling down 6 kilometres of old fencing and putting in 8 kilometres of new fencing, the Hennings have been able to redesign a section of the farm, which separates the land use units into logical sections that are much easier to manage. The higher land is for wheat and barley, the low productive areas are for grazing and barley and harvestable tree crops.

LESS TIME AND MONEY SPENT ON SHEEP, MORE TIME FOR OTHER WORK
The Hennings believe that spending the time and money to fence paddocks according to the productive ability of the land is well worth the effort—it makes managing the farm a lot easier, there is more flow and there is a time saving, a huge factor in the life of busy farmers. Donna is involved in the local community of Wongan Hills, having a part time job at the local school and being involved in various community projects, including a planned community garden. Tom and Donna are also Wheatbelt NRM peer mentors, meaning they are available to provide farmer to farmer help and tips to others considering getting into tree crops.

With Tom doing the majority of the practical farm labour, having his time managed as efficiently as possible is crucial, to enable both of them to continue to contribute so much to their local community.

‘It’s made life a lot easier. The salt has been treed and fenced off. From doing this we’ll also benefit from having autumn feed at the break of the season. They’ll be locked into saltbush so the pasture can get away. Once it comes time to lamb, they’ll have lots of food in the paddocks they’re going to. So the grazing is deferred and you don’t need to excess feed them. This cuts down the amount of time you spend managing and handling the sheep system, and frees up time to do other farm work,’ says Tom.

NATURAL WEED CONTROL, LESS WIND EROSION AND SHELTER FOR THE SHEEP
Rotating the sheep in this way means they also help with weed control, reducing the need for chemicals, to which weeds can quickly build resistance.

All in all, you’re not having to constantly buy in feed or employ someone to feed the sheep and less money is spent on chemicals so ‘it does work out financially better for us in the short term’ say the Hennings.

In addition, having the trees there is reducing potential blow-outs in the low productive areas and providing shelter for the sheep.

‘The grazing is deferred and you don’t need to excess feed the sheep. This cuts down the amount of time you spend managing and handling the sheep system.’

ANY OTHER TIPS?
Over the years, the Hennings have learnt the importance of building good relationships, such as the ones with Wheatbelt NRM and Kokardine nursery. Having reliable people available to assist with the site and species selection and design or plantings is crucial to success.

As far as grazing the trees, Tom and Donna have found that the trees need a good 2–3 years to get established before they can handle grazing. With regards to the saltbush, they find that if it is grazed regularly, it makes better feed because the sheep prefer the younger, fresher coppice—it seems to be more palatable to them. They have also found that the sheep prefer the other trees in the winter, as the oil must get diluted, whereas in summer they tend to leave them alone.

In the future, Tom and Donna will continue with their tree planting work, with another 7000 planned to go in this year.

‘If it is grazed regularly, it makes better feed because the sheep prefer the younger, fresher coppice.’
AGROFORESTRY

CASUARINA OBESA IN THE AVON WHEATBELT
MANAGEMENT OF NATIVE STANDS AND PROVENANCE TRIALS

BACKGROUND

*Casuarina obesa* (swamp sheoak) is generally promoted as a landcare option on saline farmland that also has potential as a commercial tree crop across the Avon region. The timber of swamp sheoak is suitable for cabinetry, furniture or firewood and recent trials indicate that it can be used for CCA-treated fence posts.

This native species can be planted on a range of soil types but is preferred on duplex sand over clay to heavy wet clays. As a seedling it is heavily browsed by stock, kangaroos and rabbits, although, once more mature, it recolonises freely and is often seen as a dense stand of between 20,000–30,000 trees per hectare on farmland or reserves. In time, planted sites if unmanaged will also colonise the site.

**PARTICIPATING LAND MANAGERS, PROPERTY INFORMATION**

<table>
<thead>
<tr>
<th>Project</th>
<th>Landholders</th>
<th>Location</th>
<th>Project site (ha)</th>
<th>Rainfall (average annual in mm)</th>
<th>Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of native <em>Casuarina obesa</em> stands</td>
<td>Ian and Margaret Hall</td>
<td>Aldersyde</td>
<td>0.11</td>
<td>330</td>
<td>Shallow sandy loam over clay</td>
</tr>
<tr>
<td>Management of <em>Casuarina obesa</em> provenance trials</td>
<td>Tim and Jenine Powell</td>
<td>Goomalling</td>
<td>2</td>
<td>400</td>
<td>Shallow duplex sandy loam over clay</td>
</tr>
<tr>
<td>Management of <em>Casuarina obesa</em> provenance trials</td>
<td>Andrew and Lisa West</td>
<td>Meckering</td>
<td>2</td>
<td>350–400</td>
<td>Shallow duplex sandy loam over clay</td>
</tr>
</tbody>
</table>

**MANAGEMENT OF NATIVE CASUARINA OBESA**

**OBJECTIVES**

1. To demonstrate how the benefits of thinning native colonised stands of *C. obesa* can assist landowners.

2. To compare future growth rates of three stocking levels of thinned natural regenerated *C. obesa* and compare long term tree health with managed and unmanaged stands.

3. Establish demonstration sites for local landowners to learn about managing *C. obesa* in the Avon Wheatbelt region.

This site was planted with swamp sheoak seedlings in 1982 as part of a revegetation project to rehabilitate the saline land adjacent to an existing native stand of the species. These trees were fenced to protect them from browsing by stock and kangaroos. This protection allowed them to grow successfully but also allowed them to regenerate or colonise the site over time.

Prior to thinning the overall site average tree density was 17,407 trees per hectare ranging from 4444 trees per hectare in plot 1 to 30,000 trees per hectare in plot 3.

**BACKGROUND**

On farmland, native stands of swamp sheoak have often been left unmanaged and mostly used by landowners for stock shelter, shade or conservation purposes. There is little or no under-story of native species or pasture under these stands due to a lack of light or high tree competition.

Landowners have an opportunity to manage these native stands providing they meet legislative clearing protocols set out by the Department of Environment and Conservation.
Thinning dense stands of multiple small diameter swamp sheoak could have positive benefits for the landowner such as:

- Additional income from the production and sale of timber for tool handles, wood turning, firewood or fence posts.
- Fodder opportunities from thinned or new foliage (coppice) especially late autumn.
- Increased understorey of native or pasture species and therefore increased grazing land.
- Maintenance of long-term tree health and conservation/biodiversity values of the stand.
- Long-term opportunities for larger diameter sawlogs suitable for cabinetry or furniture timber.

Silvicultural management of these stands can produce all the benefits above. Unwanted trees are thinned and remaining bole sections pruned to minimise timber defects from knots.

SOIL SALINITY

An EM 38 salinity meter was used to determine soil salinity (ECE) differences across four plots. Measurements were taken on 18th August as two sub-samples per plot. Average salinity across the site was 90 mS/m in the vertical mode and 72 mS/m in the horizontal mode. Plot 1 (which was closest to the swamp) was more saline than other plots and registered 156 mS/m and 152 mS/m in the vertical and horizontal dipoles respectively.

Soil salinity at this site is not considered to be excessive as to impede adequate tree growth.

TREE GROWTH MEASUREMENT

Following thinning, all trees were measured for diameter at breast height over bark (dbhob) and total tree height. Measurement was carried out on 18th August 2011 on the three thinning treatments of 200, 400, 800 trees per hectare plus an unthinned control. Diameter was measured using a standard diameter tape and total tree height using a digital hypsometer.

SILVICULTURAL MANAGEMENT

Following thinning, all retained crop trees were pruned to 2.5 metres. At this stage all lower branches were dead to at least 5–6 metres and this is normal crown recession owing to the high tree density or lack of light. Pruning at age 29 is realistically ‘window dressing’ and considered far too late although it has potential as a future higher value timber option.

WOOD PRODUCTS

Firewood was the only commercial product that could be produced from the thinning operation.

All thinned material (logs) were measured by diameter over bark of the butt and crown (to a minimum stem diameter limit of 70mm), and log length. The volume for each log was calculated using Smalian’s (butt and crown) method. Conversion of this green volume to dry volume was calculated using a basic density of 649 kg/m³ (Siemon and Pitcher, 1996) and a valuation of potential firewood for sale was calculated using a local firewood price of $120/dry tonne.
MANAGEMENT OF CASUARINA OBESA PROVENANCE TRIALS

OBJECTIVES
1. To measure and assess tree form 8 year old established C. obesa provenance trials and recommend suitable provenances for future revegetation options on salt-affected Wheatbelt farmland.
2. To demonstrate the benefits of thinning planted stands of C. obesa to landowners.
3. Establish demonstration sites for local landowners to learn about managing C. obesa in the Avon Wheatbelt region.
4. Demonstrate pruning and thinning techniques and equipment for management of private forestry stands of all types.

In farm forestry revegetation, the selection of the best provenances is important for successful commercial activity. A key requirement is that planted provenances should have exceptional growth with a high number of straight trees with minimal forks or malformed trees. With these attributes, its commercial viability is much more secure for product utilisation in farm forestry or industry development. Therefore selection of poorly formed provenances may convert the planting into an uncommercial project (unless carbon sequestration is an objective).

Setting up regional demonstration sites is a useful extension activity as they show landowners how to manage swamp sheoak by thinning and pruning as useful land management practice. Providing real local data on tree growth and wood production is another way of giving landowners more confidence and getting more adoption of farm forestry.

BACKGROUND
Two sites were hand planted in 2003 as part of a Greening Australia revegetation program and included 15 Western Australian provenances consisting of 4 replicates that were planted on a 6 row x 6 tree grid pattern (0.032ha) at 3 x 3 metre spacing or 1111 trees per ha. The statistical design of both of these sites was a randomized complete block design with four replicates of each provenance and was designed by CSIRO.

Wild seed had been collected from the 15 native sites by numerous sources.

SOIL SALINITY
An EM 38 salinity meter was used to determine site differences. Measurements were taken in the centre of each plot in both vertical and horizontal dipoles. Salinity ranged between 107 mS/m and 161 mS/m across the two sites.

CHALLENGES
Goomalling site: The western replicate virtually failed due to waterlogging or stock browsing with only three provenances represented across the site. Waterlogging also encroached replicate three with a further two provenances not represented. Unfortunately this affected two provenances of the Meckering provenance. As a result of these factors a total of 46 plots were assessed.

There did not appear to be any parrot damage as was found at the Meckering site.

Meckering Site: In the early years Port Lincoln parrots caused significant form problems across the site. The form assessment indicated that 56% of the trial had forks or multi-forks. The damage caused by Port Lincoln parrots has affected the growth potential (diameter and height) and therefore compromised the comparison between provenances. This is obvious where many stems per tree are in competition with each other. Parrots have also affected the original growth tip at an early age causing many forks which has subsequently reduced height growth because the original growth tip was knocked out by ring barking.

TREE GROWTH MEASUREMENT
All trees were measured for diameter at breast height over bark (dbhob) and total tree height (age 8 years) and before any silvicultural work. Diameter was measured using a standard diameter tape and total tree height using 2 metre sectioned aluminium height sticks.

Total volume was calculated by the cone formula. This may not be an accurate method due to the multi-stemmed crowns of swamp sheoak.
**TREE FORM ASSESSMENT**

One of the main differences between provenances is tree form. As stem straightness is a key factor in commercial farm forestry, an 8 point assessment method was devised to assess tree form. This method has the advantage of indicating potential end use whether it be timber products, biomass production or non-commercial use (e.g. landcare). The assessment is also useful to show landowners how much pruning or workload is required to improve farm forestry potential or rather, to not manage them.

**Tree Form rating system used to assess 8 year old C. obesa**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Form description</th>
<th>Potential end use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Straight tree (butt log and crown)</td>
<td>Timber, post or biomass</td>
</tr>
<tr>
<td>2</td>
<td>Straight butt log of 1.8 m</td>
<td>Timber, post or biomass</td>
</tr>
<tr>
<td>3.1</td>
<td>Forked—pruning can turn it to Ranking No. 1</td>
<td>Timber, post or biomass</td>
</tr>
<tr>
<td>3.2</td>
<td>Forked—pruning can turn it to Ranking No. 2</td>
<td>Timber, post or biomass</td>
</tr>
<tr>
<td>4</td>
<td>Forked—cannot be fixed with pruning</td>
<td>Biomass</td>
</tr>
<tr>
<td>5.1</td>
<td>Malformed—bent or crooked stem</td>
<td>Biomass</td>
</tr>
<tr>
<td>5.2</td>
<td>Multiforked</td>
<td>Biomass</td>
</tr>
<tr>
<td>6</td>
<td>Stunted or poor growth and or multiforked,</td>
<td>Low value biomass or nil</td>
</tr>
</tbody>
</table>

**SILVICULTURAL MANAGEMENT**

Tree management such as pruning or thinning has the ability to turn swamp sheoak into a commercial product as long as it is done on time. We aimed to do this on plots that had at least 30% reasonable tree form.

With a high severity of early parrot damage at Meckering, only 18 plots or 30% (of all 60 plots) had at least 30% of tree form suitable for farm forestry when classes 1–3.2 are added together. This was the criteria used for plots that were thinned and pruned. There had been no attempt to form prune this site at an early age.

At Goomalling tree form was much better and a total 24 plots or 52% had at least 30% of tree form suitable for farm forestry when classes 1–3.2 are added together. Some form pruning had been carried out previously on some plots. This may have been why we saw a slightly overall improvement of tree form at this site although there was no evidence of parrot damage either.

These plots were thinned to half the initial tree density to 556 trees/ha after tree measurement and form assessment. 18 trees were retained on all thinned plots. All retained trees on these well-formed plots were low pruned to: 2–2.5 metres; pruned to retain half tree height of green crown; or were form pruned by removing large branches or forks in the upper crown. No more than 50% of total tree crown was removed at this time as growth would have been retarded.

**WOOD PRODUCTS**

By thinning from 1125 to 556 trees per hectare it indicated that there was about 3.6 dry tonnes per hectare on these provenance trial sites that could be suitable for firewood. This is not considered an economic yield.

**RESULTS**

The key findings from this work revealed that there were notable differences in tree form between the provenance trial sites and also between replicates.

At the Goomalling site the best growth was achieved by Murchison River and South Borden and for tree form, the Beaufort Inlet and Mullewa provenances.

At the Meckering site the best growth was the South Coast and Paynes Find provenances and for tree form, Lake Dumbleyung and Paynes Find.

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**Full details of the results of plot and provenance differences for these two sites can be found in the final report available from Wheatbelt NRM.**

A DVD was also produced as part of this project which explains in detail why, when and how to prune trees for commercial outcomes. The techniques can be transferred to any tree species. Copies of the DVD are freely available from Wheatbelt NRM and clips can also be found on YouTube at: www.youtube.com/wheatbeltnrm.
GRAZING PRACTICES: PASTURES

BULKING UP SERRADELLA FOR ON-FARM USE

PROJECT SNAPSHOT

- Land Managers: Anna and Colin Butcher
- Property size: 2730 hectares
- Location: Brookton
- Annual rainfall: 325 mm
- Enterprise mix: 65% crop, 35% stock
- Soil types: Duplex, sand and loams

KEY MESSAGES

- Plant serradella into clean paddocks to reduce weed burdens in crop.
- Choose small paddocks for bulking up serradella.
- Improve the harvesting of pods, remove any rocks and sticks.

THEIR STORY

Anna and Colin Butcher of Mail Rock Farm in Brookton got involved in Wheatbelt NRM’s project after receiving the SEAVROC newsletter to which they subscribe. They saw the funding as an opportunity to establish a 25 ha seed nursery paddock of Margurita pink serradella that could be harvested to enable economically viable plantings of serradella across the farm.

The Butchers view serradella as a better fit than lupins, which originally made up 25% of their cropping rotation.

‘We hope to make some major rotational changes within three years,’ Anna said. She added, ‘By using a year in year out rotation across 50% of our cropping area we anticipate we won’t have to reseed the annual legume pastures.’

Anna explains the major drivers for these changes by saying, ‘We will be growing our own nitrogen and expect minimal need for nitrogen fertilisers. We expect to be spending less money on weed issues too.’

In a drying climate Anna also expects deep rooted legumes, such as serradella, to be more productive and economically viable than current cropping legumes such as lupins.

MANAGING THE NURSERY PADDOCK

Prior to seeding the serradella, the Butchers applied a knockdown spray. They then spread 200 kg/ha of Super Potash 3:2 which was then followed by 8 kg/ha of Margurita pink serradella and 10 kg/ha of ALOSCA® Group 5 inoculant. A post spray pre-emergent (‘bare earth’) insecticide was used for RLEM control. Anna also pointed out the importance of closely monitoring and spraying for budworm if they are present.

Post seeding, all rocks and sticks were picked to ensure a good clean paddock for harvest. A grass selective herbicide was used to control grasses and volunteer cereals in crop and later in the season a weed wiper was used to control broad leaf weeds.
The serradella was then harvested for seed to be used on the farm to increase the area sown to serradella in the rotation. Anna recalled, ‘Harvesting height is very low, so harvesting is slow and can be a bit stressful.’

LESSONS LEARNT

The major change from this project for the Butchers has been rotation. Long being unsatisfied with lupins they got to the stage of only having 6% in their rotation. Conversely, they couldn’t be happier with their decision to introduce serradella into the system.

Anna and Colin were amazed at how green the serradella stayed so late in the season (until the end of the year) and believe that the deep rooted serradella will provide late feed for weaned lambs.

‘In a higher rainfall year than 2012, we expect to graze the serradella in late autumn, winter and early spring,’ Anna said.

In addition, the Butchers were also pleased at how well the sheep went on some of the serradella they cut for hay.

‘We will do this again, particularly on paddocks that can’t be winter grazed,’ Anna mentioned.

If the Butchers were to do the project again they would definitely sow the serradella into canola stubble as it will give them a clean paddock and protection to the emerging seedlings. They have also considered sowing after hay.

Anna stated, ‘We are going to try growing the serradella after a hay crop, but we will be making sure that we spray top the previous year.’

They however wouldn’t recommend sowing serradella into a pasture paddock unless it has been spray topped two years in a row as there is too much competition from weeds.

‘It is also very important to know the chemical history of a paddock; as some chemicals are residual and have a major impact on the serradella,’ Anna explained.

The Butchers found they learnt a lot of invaluable information from attending field days and by talking with other farmers. They wish to acknowledge the valuable assistance given to them by Angelo Loi, Brad Nutt and Ron Yates from Department of Agriculture and Food, Western Australia.

‘They assisted with paddock selection, agronomy, monitoring and successfully managing the serradella crop,’ said Anna.

LOOKING FORWARD

The Butchers plan on using their own scarified serradella seed to establish more nursery paddocks.

‘They will be sown after a break and post a knockdown to ensure that we have a clean paddocks for seed,’ said Anna.

‘We plan on grazing these paddocks with the potential of harvesting them depending on the season,’ mentioned Anna.

The Butchers are also going to grow some biserrula and seed it, after a knockdown. The biserrula will fit in other areas of the farm where they have heavier soil types, longer rotations and rocky hills.

‘It is also very important to know the chemical history of a paddock; as some chemicals are residual and have a major impact on the serradella…’

Anna Butcher
GRAZING PRACTICES: PASTURES

ATTEMPTING TO IMPROVE LAND USE AT SANDY AND SALTY SITES

PROJECT SNAPSHOT

- **Land Manager:** Doug Pease
- **Property size:** 2020 ha
- **Location:** Wyalkatchem
- **Annual rainfall:** 300 mm
- **Enterprise mix:** 70% crop, 30% stock (changes from year to year)
- **Soil types:** Medium loams

KEY MESSAGES

- Pasture species need to be matched to the right soil type and rainfall for optimal growth.
- To avoid disappointment and little economic return, new pastures should first be trialled on a small scale to better understand their suitability.
- Learn through the experiences of others by becoming a member of a grower group and/or by contacting field experts.

THE BEGINNING OF A NEW ENDEAVOUR

Doug Pease runs a mixed farming enterprise in Wyalkatchem and recently has been interested in growing summer active pastures and improving the pasture phase in his rotation by sowing annuals.

In 2011 Doug had the chance to experiment with several pasture varieties without the associated seed costs thanks to funding through Wheatbelt NRM’s wind erosion project. He set up two sites: Site 1 (40 ha of wodjil soil running along two adjacent paddocks) and Site 2 (30 ha of slightly saline, heavy loam within a paddock).

At Site 1 Doug established a perennial pasture of lucerne for summer stock feed alongside existing tree alleys. His motivation was to help maintain sheep numbers through summer months on sandy soil without baring-off paddocks. Lucerne was planted at 4 kg/ha with ALOSCA® Group AL inoculant in early August.

‘The site received 25 mm the day after planting, but rainfall was minimal thereafter,’ Doug said.

The lucerne seed was a mix of primarily Genesis but two other varieties were also used to make up the amount of seed required.

‘It germinated excellently, but within a week insects dominated the crop and, with little follow-up rain, establishment was poor across the site,’ said Doug.

At Site 2 Doug selected salt tolerant pasture varieties to try to increase biomass production to increase water use within the slightly saline and water-logging landscape. A mix of Rhodes grass (1 kg/ha), Tall Wheat Grass (1 kg/ha) and Ballards Ball-SalinA mix (which consists of Burr Medic–Cavalier (ALOSCA® Group AM), Balansa Clover (ALOSCA® Group C), Rocket Italian Ryegrass and Tetila Gold Ryegrass) was planted in early August.

Doug mentioned, ‘There has been patchy germination. Legumes germinated well in some areas and Rhodes grasses in others.’
It is too early to see how successful it will be but Doug commented that perhaps he planted the site too late for the clovers and medics to set seed successfully.

This point was reiterated by Natalie Hogg (Department of Agriculture and Food) who said, ‘Ultimately legumes should be planted no later than the second week in July, May/June is optimum.’

**LESSONS LEARNT**

Through the process of trialling Lucerne at Site 1 Doug now realises Lucerne is not suitable and now has plans to extend the alleys of trees within the landscape.

‘The project has made me consider other options and reconsider what we are doing there at the moment,’ says Doug.

It was unexpected for the lucerne to fail completely in patches. As Doug explained, ‘It turned around from good to shattered within a week.’

If Doug was to try lucerne again he would consider sowing it with a cover crop.

If Doug was to be involved in a project like the Soil Conservation Incentives Program again he would sow the annual pastures a little earlier, as well as consider the option of not sowing at all (because of the dry July that he experienced this year).

**LOOKING FORWARD**

A few changes have resulted due to Doug’s involvement in the project. He said, ‘I’ve lost money but have learnt a few things:

- It’s important to monitor lucerne closely;
- Lucerne is hard to grow;
- Timing of sowing is important; and
- Ballards salt seed mix at site 2 was impressive.

‘I guess the most important outcome of participating in the project is that I now know what works and what doesn’t work when trying to grow lucerne.’

Doug is considering extending the alleys with fodder shrubs at Site 1 as well as looking at alternative pastures to ensure cover on the sandy site.

At Site 2 Doug is going to wait and see how the pastures go over the next 12 months before making any judgement about the best way to manage the site long-term.
GETTING INVOLVED

Scott became involved in the project after he had attended a community forum in Trayning, that was organised by Dianne Haggerty as part of funding provided through Wheatbelt Natural Resource Management. After speaking with Wheatbelt NRM staff members Scott decided to become involved and put an application together.

WHAT HAS HAPPENED

Scott mentioned that he ‘knows a lot more people because of being involved in the project’, which he said has been good as they all have different areas of expertise that he can now access easily.

Scott conducted extensive research at the beginning of the project to decide what pasture species he wanted to grow, and says that ‘I have learnt a lot about pastures’. Once the on-ground works of the project were done Scott continued to learn a lot about what works and what doesn’t.

The most important change for Scott is what he has learnt about native perennial pastures especially that it is a long-term project.

‘A lot of the native perennial pastures didn’t germinate this year but they will germinate when the conditions are right,’ Scott stated. ‘It won’t happen in one year, it is going to take time.’

IN THE BEGINNING

When first deciding what native perennial pastures to plant Scott decided that it was best to know what it was that was growing naturally near his farm. To do this Scott collected seed from the side of the road.

‘I collected seven different types of seeds and sent them to the WA Herbarium to get them identified. From there I chose to sow windmill grass,’ recounted Scott.

The windmill grass was sown in early November of 2011 during a summer storm into a paddock that was cut for hay that year.

‘As the seed is so light I mixed it with a compost extract and rainwater and sprayed it out over the site. I then went over it with finger tyne harrows to ensure that I got good seed contact with the soil.’
WHAT WAS LEARNT

Scott will be making some changes on farm since his involvement in the project.

‘I will be trying time control grazing which is beneficial for the native perennial pastures (windmill grass). Over time I will manage to ensure 100% ground cover,’ said Scott.

‘I’m happy with what happened in the project. Hindsight is a great thing but I wouldn’t change anything, as I have learnt so much.’

LOOKING FORWARD

In the future Scott is going to plant some other native perennial grasses over the same area he planted the windmill grass.

‘I also plan to introduce fodder shrubs into the paddock where the windmill grass is as they too will benefit from the time control grazing.’

‘I am hoping that it works—which I am confident it will—it just takes time with native perennial pastures like windmill grass. I will be watching the site over the next few years to see what the windmill grass will do.’

‘It won’t happen in one year, it is going to take time…’

Scott McLean
PROJECT SNAPSHOT

- **Land Manager:** Nathan Davey
- **Property size:** 4523 ha
- **Location:** Konnongorring
- **Annual rainfall:** 330 mm
- **Enterprise mix:** 60% crop, 40% stock
- **Soil types:** Robbies—Tea tree; Grays—Salmon and York Gum

KEY MESSAGES

- Seeded pasture establishes better than seed that is spread.
- There are many salt land pasture options available to try.
- Slightly saline areas can be restored to provide a feed source to livestock.
THEIR STORY
Nathan became involved in the Australian Government-funded project when he saw an advert to apply for wind erosion funding in the Wheatbelt NRM newsletter. He decided to apply so that he could try out some new pastures on two of the farm’s paddocks, Grays and Robbies, which are slightly saline.

‘This funding allowed us to try a mixture of plants in order to determine which ones would be the most suitable stock feed options,’ Nathan said.

TRIALLING THE PASTURE OPTIONS
To ensure the paddocks were clean prior to sowing the pasture species, Nathan waited for a weed germination and then went in with a knockdown. At both sites he seeded the Ballards saline mix (BALL-SalinA) at 15 kg/ha. This pasture mix consisted of Burr Medic (Cavalier), Balansa Clover, Rocket Italian Ryegrass and Tetila Gold ryegrass, as well as ALOSCA® inoculant.

Eyres green was also planted in alleys in Robbies paddock as this site is a little more saline than Grays.

‘I was keen to see how the Eyres green compared to Old man saltbush,’ Nathan explained.

Overall establishment in Grays was extremely good, with the medics doing exceptionally well.

‘It’s had great production in such a short space of time [about 12 weeks],’ Nathan mentioned. He added, ‘It will be interesting to see how it persists over the next few years and whether the different pasture varieties find their niche in the paddock.’

The Eyres green also grew really well in Robbies.

‘It took off straight away,’ Nathan recalled.

These promising results have given Nathan some hope for his saltland pastures.

‘My newfound optimism has made me want to persevere with saltland pastures, especially for Robbies.’

LESSONS LEARNT
Previously Nathan spread seed across Robbies paddock rather than seeding it. The funding allowed Nathan to seed it and now he has converted his thinking.

‘It is definitely better to seed the pasture seed,’ he said.

Sown pasture seeds have a more favourable environment for growth and this is evident with Nathan’s surprise in how well the medics had gone. In all, Nathan was happy with how the project went and would not do anything differently in hindsight.

LOOKING FORWARD
In the future Nathan plans to graze the Grays paddock and see how it holds up for stock feed given it is a slightly saline site. As for the Robbies paddock, Nathan plans to dry seed in some Tall Wheat Grass to see how it compares with the Ballards saltland pasture mix. He will also monitor the paddock closely to see what the sheep do to the Eyres green.

Nathan believes that what he has done on his farm could be done by other farmers in other areas.

‘It will be interesting to see how it persists over the next few years and whether the different pasture varieties find their niche in the paddock…’

Nathan Davey
PROJECT SNAPSHOT

- **Land Manager:** Peter Whitfield
- **Property size:** 6300 ha
- **Location:** Konnongorring
- **Annual rainfall:** 350 mm
- **Enterprise mix:** Crop 70%, stock 30%
- **Soil types:** Grey sand, yellow sand in the trial paddock

KEY MESSAGES

- Even if something isn’t common practice, it is worth giving it a go on a small scale.
- Sub-tropical grasses can provide out of season feed and protect the soil from strong winds.
- Before planting a summer active crop ensure a good knockdown spray is applied.

THEIR STORY

Peter Whitfield found out about the Wheatbelt NRM project via a staff member from the group.

‘I wanted to try something different on unproductive soil types,’ he said. ‘Years of yield mapping had shown us how bad these soils really are and the funding was a chance to help me improve them.’

With some technical guidance provided through the project, Peter decided to establish 40 ha of sub-tropical grasses on part of a paddock that underperformed and was being wind eroded.

From the beginning Peter was hesitant about planting the sub-tropical grasses (active during the summer) saying, ‘I was sceptical that it wouldn’t work on my place. Traditionally sub-tropical grasses aren’t suited to the environmental conditions at Konnongorring.’

Given the funding opportunity however, he decided to go ahead and try the Evergreen Northern mix—Signal Grass (20%), Gatton Panic (60%) and Rhodes grass (20%). It was sown in spring at 5 kg/ha after a knockdown.

‘The trial area was sown in dry circumstances, but they happened to get some summer rainfall (late November and 40mm in January) and established fairly well.’ Peter also added, ‘We also had another 20 mm in March which has helped too.’

LESSONS LEARNT

Peter has learnt some things along the way but says that he hasn’t made many changes to his farming practices.

‘Forty hectares isn’t a big enough area to result in a change to my enterprise just yet.’

The trial that he was funded for was to reduce wind erosion on a sandy paddock that is unproductive.

Peter says that, ‘I am really happy to see that there is no wind erosion on the site as the pastures have established well.’
He explained another bonus from being involved in the project saying, ‘I am now getting some production off a paddock which I normally wouldn’t get, especially this time of the year.’

Peter is happy with the way the project went and says that he would do the same thing again if he had the chance, but emphasised the importance of a knockdown.

LOOKING FORWARD

By trialling the sub-tropical grasses successfully on this one paddock, it has now given Peter an option for these sandy soils. This season he plans to establish serradella to the paddock to provide a source of winter feed, but also nitrogen for the sub-tropical perennial grasses.

Peter plans to try out the mix of sub-tropical grasses on another area of about 40 ha. The main reason for this is because he now knows the benefits of the sub-tropical grasses and how they fit into his farming system.

‘I will eventually try to get my sandy, underperforming soils (200 ha) into some perennials,’ Peter stated.

He also plans to explore what perennial pastures may be suitable to land that at times is waterlogged in order to turn more unproductive land into productive land.

‘I am now getting some production off a paddock which I normally wouldn’t get, especially this time of the year…’

Peter Whitfield
Pasture cropping is the sowing of winter cereal crops between summer active perennial pastures as a means of integrating livestock and cropping enterprises, to the benefit of both systems.

The theory of pasture cropping is that livestock graze the pastures during summer and autumn, and the cereal crop during winter and early spring, then they are removed so the crop can regenerate and the grain harvested with minimal trade-off in yield. The system takes advantage of the different seasonal growth patterns of the summer-active perennial pastures and the winter-active crops (Figure 1). Often a herbicide is applied to the pasture before seeding to render it dormant until the crop is harvested, thus reducing competition between the pasture and crop and associated decreases in grain yield.

Advantages sought from pasture cropping include the management of seasonal risk through diversifying land use, production of green feed over summer, and managing marginal soils through maintaining protective ground cover throughout the year. The pasture component benefits the cropping system through improving soil health and stability, and preventing growth of summer weeds. From a livestock perspective, inclusion of the cropping component provides feed early in the season to supplement the perennial pasture. To make adoption of a pasture cropping system worthwhile, the extra green feed produced in summer and autumn must result in increased livestock production (higher stocking rates) to a level that offsets any resulting losses in grain production.

WHAT THEY DO IN THE EAST

The application of pasture cropping in the Eastern States has been thoroughly researched. Generally the perennial pasture used in the system is lucerne, as it is of high nutritive value and as a legume it also adds nitrogen to the soil, however in the Central West of NSW and the Mallee regions of South Australia and Victoria farmers have been sowing winter cereals directly into pre-existing native perennial pastures, such as Red grass and Warrego summer grass. Utilising native pastures means that input costs of re-sowing introduced pastures are reduced. Farmers have reported little decrease in grain yield, while observing an increase in pasture seedling growth, improved soil fertility and less dependence on fertiliser inputs for the same production level, which have all resulted in improved production and profitability.
WHAT IS WORKING FOR WA?

The Future Farm Industry CRC’s EverCrop project is exploring the potential value of pasture cropping as a viable system on the sandplain soils of the northern agricultural region in WA, substituting lucerne with the subtropical perennial grasses Rhodes grass (*Chloris gayana*) and Gatton panic grass (*Megathyrsus maximus*), which have proven to be productive pastures in this area. A perennial legume called Siratro is also being trialled as an alternative pasture.

In 2008 trial plots of Gatton panic, Rhodes grass and Siratro were established in Moora. Buloke barley was intercropped across the perennial plots in 2009. At a nitrogen fertiliser rate of 50 kg/ha, pasture row spacing of 36 cm and crop row spacing of 18 cm, differences in barley yield between pasture crop plots compared to the crop-only control plots were negligible (Table 1).

Table 1: Yield (t/ha) of barley sown over differing treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control – barley</td>
<td>2.8</td>
</tr>
<tr>
<td>Siratro</td>
<td>2.9</td>
</tr>
<tr>
<td>Rhodes grass</td>
<td>2.6</td>
</tr>
<tr>
<td>Gatton panic</td>
<td>2.6</td>
</tr>
</tbody>
</table>

In terms of pasture production, dry matter available six weeks after harvesting in the pasture cropping plots of Siratro, Gatton panic grass and Rhodes grass at the same fertiliser rate and row spacings as above were similar to the permanent pasture control plots (Table 2).

Table 2: Pasture dry matter (t/ha) available six weeks after harvesting

<table>
<thead>
<tr>
<th>Perennial pasture species</th>
<th>Dry matter in pasture crop (t/ha)</th>
<th>Dry matter in control pasture (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siratro</td>
<td>0.25</td>
<td>0.13</td>
</tr>
<tr>
<td>Gatton panic</td>
<td>0.82</td>
<td>0.72</td>
</tr>
<tr>
<td>Rhodes grass</td>
<td>2.61</td>
<td>2.52</td>
</tr>
</tbody>
</table>

IS IT VIABLE FOR THE AVON BASIN?

The WA Wheatbelt differs from the Eastern States areas where pasture cropping has been successfully implemented, not just in terms of rainfall patterns, but also in soil types, native pasture species and farming systems. The viability of pasture cropping in WA will be limited by the ability of farmers to establish a summer active perennial pasture base, as the pasture provides the backbone to the system. While early trials have demonstrated the successful integration of pasture cropping in the northern agricultural region, this is an area with sufficient summer rainfall to allow perennial pastures to persist. It remains to be proven if the practice is viable in other areas with less summer rainfall, and better soils types where crop yield penalties may be higher.

A Wheatbelt Natural Resource Management (WNRM) program, Soil Conservation Incentives Program (SCIP) is aimed at the widespread adoption of farm practices that maintain and improve soil quality. In particular the program attempts to address threats to the soil including wind and water erosion, soil acidity and soil carbon. As part of this program there are growers within the Avon Basin that are trialling summer active perennial grasses to determine whether there is the potential to practice pasture cropping on their marginal land. These grower trials are in the early stages but in some instances it looks promising.

To find out more about Pasture Cropping visit www.wheatbeltnrm.org.au or visit the Future Farm Industries CRC website: www.futurefarmonline.com.au/ and search ‘Pasture Cropping’ or contact David Ferris: david.ferris@agric.wa.gov.au.
For many of you, balancing your stock’s nutritional requirements with crop production is a constant challenge, with many relying on grazing crop stubbles to carry stock through the autumn feed gap. There is a need to maintain the health of cropping paddocks while allowing the use of stubbles as stock feed; relying on stubbles alone is not the answer.

**DON’T RELY ON STUBBLES ALONE**

Stubbles are a valuable feed source for livestock, however there are several limitations to stubbles as a feed source:
- Machinery leaves little grain behind.
- Only a small proportion is highly digestible (25% of dry matter).
- Young sheep only maintain live weight when spilt grain and green leaf material are available.
- The quality of the dry matter continually declines over time, with breakdown increasing after summer rainfall.
- Supplementing sheep with grain will be necessary to maintain live weight after stubble quality declines.

The feed value of stubbles varies greatly between crop species, with the most valuable being legume stubbles, followed by cereals and then canola. To ensure stock are not losing weight on stubbles, they should be removed when the grain content falls below 100 kg/ha. As a rough guide, in a 0.1 m² quadrant this threshold is equivalent to an average of 28 grains of wheat or oats, 25 grains of barley, 8 lupins or 5 field peas.

It is also important to note that:
- Paddocks should not be grazed when ground cover is 50%* or below.
- Excessive grazing damages soil structure, reduces soil fertility and results in poor crop root growth.
- With low feed availability, sheep will begin to deplete pasture seed banks, reducing biomass of subsequent pasture phases.

*50% ground cover is estimated to be 1000 kg/ha for cereal stubbles and 750 kg/ha for dry pastures.
ALTERNATIVE SUMMER GRAZING OPTIONS

The key to the profitable and sustainable integration of livestock with cropping is to use a range of alternative feeding strategies. Aside from hand feeding grain, alternative summer grazing options available are:

STANDING CROPS
- Sown in early autumn in small paddocks, they can provide high protein feed for early grazing at the break-of-season (e.g. oats and tetraploid ryegrass).

FORAGE SHRUBS—SUCH AS SALTBUSH AND TAGASASTE
- These are drought tolerant and can be rotationally stocked for short time periods.

PERENNIAL PASTURES—SUCH AS RHODES GRASS OR LUCERNE
- Used to provide out-of-season green fodder as well as maintaining ground cover in lighter country.

CONFINEMENT AREAS
- Small paddocks with adequate shade, feed and water to minimise energy expenditure and defer grazing of pastures.

FEEDLOTS
- Used for deferring grazing of pastures or maintaining stock during late breaks, particularly pregnant ewes.

SUMMER FODDER CROPS—SUCH AS MAIZE OR FORAGE SORGHUM
- Planted opportunistically in spring and wiped out with a herbicide before seeding the following year.

The suitability of each option for your system will depend on climatic conditions, and as the aim is to maintain adequate year-round ground cover several options can be utilised to allow livestock to rotate between systems.

For more information visit:
www.agric.wa.gov.au
www.futurefarmonline.com.au
or www.wheatbeltnrm.org.au
WHY INOCULATION IS IMPORTANT AND REASONS TO RE-INOCULATE

When sowing a legume pasture, it is vital to remember the importance of treating the seed with an effective rhizobial inoculant. The use of inoculants results in greater root biomass and an increase in nodulation, which increases plant vigour and yield. Compared to the relatively small cost of inoculation, nodule failure is very expensive, as without root nodulation with effective rhizobia, the plants will deplete soil nitrogen for their growth requirements.

The relationship between the rhizobia and host plant is very specific, and many rhizobial strains native to Australian soils are not effective in the pasture species cultivated. Therefore, to maximise nitrogen fixation and pasture production, seeds must be inoculated with a commercial strain of rhizobia prior to seeding. Before inoculation, make sure the rhizobial strain is effective for the legume species (Table 1), and be aware that if the pasture contains a mix of species, it may require inoculation with multiple rhizobial strains.

Table 1: Inoculant groups for pasture legume species
Adapted from DAFWA Farmnote 431/2010 ‘Inoculating Pasture Legumes’

<table>
<thead>
<tr>
<th>Inoculant Group</th>
<th>Pasture species</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Subterranean clover</td>
<td>Trifolium subterranean</td>
</tr>
<tr>
<td></td>
<td>Rose clover</td>
<td>Trifolium hirtum</td>
</tr>
<tr>
<td></td>
<td>Balansa clover</td>
<td>Trifolium michelianum</td>
</tr>
<tr>
<td></td>
<td>Arrowleaf clover</td>
<td>Trifolium vesiculosum</td>
</tr>
<tr>
<td></td>
<td>Crimson clover</td>
<td>Trifolium incarnatum</td>
</tr>
<tr>
<td></td>
<td>Gland clover</td>
<td>Trifolium glanduliferum</td>
</tr>
<tr>
<td>O</td>
<td>Persian clover</td>
<td>Trifolium resupinatum</td>
</tr>
<tr>
<td>S</td>
<td>Yellow serradella</td>
<td>Ornithopus compressus</td>
</tr>
<tr>
<td></td>
<td>French serradella</td>
<td>Ornithopus sativus</td>
</tr>
<tr>
<td>Biserrula</td>
<td>Biserrula</td>
<td>Biserrula pelecinus</td>
</tr>
<tr>
<td>AM</td>
<td>Burr medic</td>
<td>Medicago polymorpha</td>
</tr>
<tr>
<td></td>
<td>Barrel medic</td>
<td>Medicago truncatula</td>
</tr>
<tr>
<td></td>
<td>Sphere medic</td>
<td>Medicago sphaerocarpos</td>
</tr>
<tr>
<td></td>
<td>Snail medic</td>
<td>Medicago scutellata</td>
</tr>
<tr>
<td>AL</td>
<td>Lucerne</td>
<td>Medicago sativa</td>
</tr>
<tr>
<td></td>
<td>Strand medic</td>
<td>Medicago littoralis</td>
</tr>
<tr>
<td></td>
<td>Disc medic</td>
<td>Medicago tornata</td>
</tr>
</tbody>
</table>
OPTIONS AVAILABLE

Pasture seed can be custom-inoculated by seed retailers or prepared on farm just prior to sowing. There are four main inoculation techniques, described by the method in which the inoculant is carried. The methods vary in their cost ($5–25/ha) and labour requirements, which will determine the best technique for an individual situation. Also remember that the rhizobia contained within the inoculant are living cells and must be stored correctly. If seed is not sown within the specified shelf life of the inoculant, then it is highly recommended to re-inoculate the seed.

1. PEAT-SLURRY
The peat-rhizobia inoculant is added to water to form a slurry. Before coating the seed with the slurry, an adhesive solution is added to help stick the inoculant to the seed. Common methods of mixing include the use of a cement mixer, shovelling on a cement floor or using a revolving drum. If preparing a seed mix, different seed species must be inoculated separately before blending for sowing.

With the exception of serradella, the seed should be lime-coated after inoculation using agricultural lime. Peat-slurry inoculated seed cannot be treated with pesticides or fungicides. Once inoculated with peat-slurry the seed should be sown into moist soil within 12 hours, or 24 hours if pelleted with lime.

2. FREEZE-DRIED
Liquid is added to the inoculant powder to form a suspension which activates the rhizobia. A protecting agent is added to the suspension to increase rhizobial survival during seeding. Seed can be inoculated through spray application of the inoculant, and the dried seed does not need to be lime coated. Alternatively, the product can be directly injected into the furrow at seeding. Inoculated seed cannot be treated with pesticides or fungicides. Once inoculated, seeds should be sown into moist soil within five hours.

3. GRANULAR
Peat or clay granules containing rhizobia can be purchased as stand-alone products to be seeded alongside the seed. The granules can either be mixed with the seed before sowing, or run through a third seeder box. Granular inoculants can be dry sown, however this decreases the effectiveness of inoculation. Due to the physical separation of the inoculant and seed, the seed can be treated with pesticides or fungicides without damaging the rhizobia.

4. PRE-COATED SEED
An inoculant coating is applied to the seed before purchase. This method is commonly used for lucerne and medics. Along with rhizobia, the coating may contain insecticides, fungicides and micro-fertilisers. Seed inoculated by this method has a shelf-life of several weeks, with the exception of clover, serradella and biserrula which must be freshly pre-coated, as their rhizobia species have a short lifespan.

ADVANTAGES/DISADVANTAGES OF INOCULATION OPTIONS

<table>
<thead>
<tr>
<th>Inoculation method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peat-slurry</td>
<td>Lowest cost method</td>
<td>High labour and time requirement</td>
</tr>
<tr>
<td></td>
<td>Inoculant can tolerate fertilisers</td>
<td>Requires lime coating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cannot tolerate pesticides and fungicides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-flexible seeding</td>
</tr>
<tr>
<td>Freeze-dried</td>
<td>Lime coating not required</td>
<td>Cannot tolerate pesticides and fungicides</td>
</tr>
<tr>
<td></td>
<td>Long shelf-life of inoculant</td>
<td>Non-flexible seeding timeframe</td>
</tr>
<tr>
<td>Granular</td>
<td>Low labour and time requirement</td>
<td>Large bulk due to high application rate</td>
</tr>
<tr>
<td></td>
<td>Can tolerate pesticides and fungicides</td>
<td>Higher cost</td>
</tr>
<tr>
<td></td>
<td>Flexible seeding timeframe</td>
<td>Generally intolerant to fertilisers</td>
</tr>
<tr>
<td>Pre-coated seed</td>
<td>Can tolerate pesticides, fungicides and fertilisers</td>
<td>Some species have a short lifespan</td>
</tr>
<tr>
<td></td>
<td>Generally flexible seeding timeframe</td>
<td>Increases seed cost</td>
</tr>
</tbody>
</table>

For a detailed description of inoculation techniques, see the DAFWA Farmnote 431/2010 ‘Inoculating Pasture Legumes’ at www.agric.wa.gov.au/pastures
GRAZING PRACTICES: FORAGE SHRUBS

SALTBUSSH INSTEAD OF SAMPHIRE IN THE SALT FLATS

PROJECT SNAPSHOT

Land Managers: Dean and Tanya Butler
Property size: 4000 hectares arable
Location: Bruce Rock
Annual rainfall: 300mm
Enterprise mix: 75% cropping, 25% grazing
Soil types/Vegetation types: Mix of everything

KEY MESSAGES

• Unviable saltland has now become a valuable feed source for sheep.
• Zoning landscapes according to soil type and productivity can be a helpful way to reassess land use and isolate areas that require landcare.
• Soil properties have a direct effect on the types of vegetation that inhabit them.

THEIR STORY

Dean and Tanya Butler farm between Bruce Rock and Merredin in the Belka Valley.

In 2004 the family purchased a neighbouring farm which included saline water courses making up much of the non-arable land (approximately 100ha). Over the years the Butler family have actively sourced available funding to try and transform this salt-affected area to increase the health of the soil and its grazing potential. The land is characterised predominately by samphire (Halosarcia spp.) and bluebush (Maireana brevifolia) vegetation, interspersed with clay flats and deteriorating areas of York Gum bush.

‘If overstocked, the area is severely eroded by wind,’ Dean explained, ‘To make matters worse, secondary salinity was creeping into our cropping paddocks. Something had to be done.’
The Butlers were prompted to plant Old Man saltbush (*Atriplex nummularia*) for the first time in 2006 after observing salt starting to claim their arable country. They strategically planted the saltbush along a recharge zone and across cropping land where grain production had been lost to salinity.

A noticeable improvement was soon observed, as Dean explained, ‘The soil became stable and then grasses and clovers started to re-establish. The area had quickly become a valuable feed source for our sheep.’

Around the same time a trial site was also established through another funding scheme. This trial design was based on the Enrich Programme and its aim was to search for perennial forage shrubs which could cope with saline situations.

Dean mentioned, ‘We have planted saltbush in and around this site for the past five years and the transformation has been fantastic. What was a liability is now turning out to be a major grazing area and asset to our farm.

‘The saltbush has greatly improved the area’s carrying capacity—it provides shelter belts for ewes at lambing resulting in higher survival rates of lambs, and offers the opportunity to spell other areas of the farm.’

**TESTING THE TOLERANCE OF SALTBUSH IN 2012**

After observing the success of the trial, the Butlers wanted to keep going with the strategy of planting saltbush. Rather than just plant saltbush on unproductive cropping land however, they wanted to push into harsher environments.

Using a Chatfield one-pass tree planter approximately 10,000 Old Man saltbush seedlings were planted to augment prior plantings.

Weeds were not controlled in this instance as Dean and Tanya wanted to retain as much cover as possible to hold the site together.

Tanya said, ‘It’s a great feeling seeing the samphire flats being rejuvenated with the addition of all this new shrub land.’

**LESSONS LEARNT**

The most unexpected lesson Dean and Tanya learnt was in 2012 (the year of Wheatbelt NRM project), when they experienced one of the driest winters ever. With only 50 mm of rain recorded after establishment they still achieved 90% survival.

Dean boasted, ‘We were amazed at the ability of saltbush to survive and thrive in one of the most inhospitable environments there is, saltland.’

Survival rates like this give the family the confidence to keep on with the strategy. The only thing they may do differently is to increase the variety of forage shrubs.

Dean said, ‘Next time we will add more river saltbush, because they’re water-logging tolerant and the sheep like them. We look forward to seeing further results from the Enrich program as we’d like to include a greater variety of forage species for this environment.’

Through the Wheatbelt NRM project and others trials conducted on the property, the Butlers have learnt to better manage land of lower productivity.

‘We have identified those areas which consistently under achieve, and have changed the land use to perennial forage shrubs.’ Dean went on to say, ‘Trying to crop an unproductive area just makes it worse, and the sooner you can take it out of cropping production and convert it to shrubs the better.’
PROJECT SNAPSHOT

Land Managers: Keith and Sandie O’Brien
Tim Fleay and family

Property sizes: 1200 ha
3000 ha

Location: Wickepin Shire

Annual rainfall: 400 mm

Enterprise mix: Cropping and livestock

Soil types: Shallow clays to duplex loams

KEY MESSAGES

• Landcare projects have greater impact if done at a catchment level.
• Saltland can be transformed into productive agricultural land.
• Becoming part of a grower group can help support your business.

PROJECT DELIVERY THROUGH A GROWER GROUP

Facey Group is a community based farm productivity group that also encourages the integration of natural resource management activities on farm to protect and enhance nature-based assets. The Facey Group always try to have their ‘finger on the pulse’ so they can continue to provide a vital link between funding providers and landholders in their region. When they heard about Australian Government funding being delivered through Wheatbelt NRM they forwarded the information onto their grower membership.

Five willing participants put their names forward wanting to plant saltbush on their properties and so this formed the basis of their application.

Sustainable Agriculture Coordinator, Sarah Hyde, said, ‘By involving several growers in landcare activities we have a better opportunity to improve the health of the greater catchment. Government funded incentives can increase the scale of works and allow them to be achieved within just a short period.’

The group’s application was granted and in 2010 they were supplied with approximately 48,000 Old Man saltbush (Atriplex nummularia) and 12,000 River saltbush (Atriplex amnicola) to divide between the growers.

THE REHABILITATION PROCESS

The ground works of two of the growers are discussed below in detail.

Wheat and sheep farmer Keith O’Brien runs Lambton Downs a 1200 ha property north of Wickepin. In 2010 he machine planted 10,000 Old Man saltbush and 6000 River saltbush in a low lying area where a salt patch had been encroaching into the paddock.

‘I wanted to reduce erosion and offer the soil some protection from the wind,’ Keith said.

Similarly, Tim Fleay runs a mixed farming enterprise at Mannafield a 3000 ha property along the Yealering Rd north of Wickepin.

‘This salt land management tool has turned previous wasteland into productive land …’

Tim Fleay
He machine planted 10,000 Old Man saltbush along the edge of a paddock that had long been exposed to water erosion and had turned saline.

‘I wanted to be able to increase groundcover on the saline section of my paddock and make it productive,’ Tim explained.

Three years after the start of the project and after some infill (1520 saltbush at O’Brien’s and 8000 saltbush at Fleay’s) due to drought conditions, the growers started to realise the benefits the saltbush was having on farm productivity.

Keith explained, ‘At first I just wanted to stabilise the soil and get some cover back on the paddock. Since the saltbush is quick-growing, I now also have shelter for the stock and an alternative source of stock feed for my sheep.’ He added, ‘It’s like having a virtual haystack’.

Tim reiterated Keith’s sentiment saying, ‘This salt land management tool [saltbush] has turned previous wasteland into productive land.’

REFLECTING ON THE EXPERIENCE

Through their networks the Facey Group have been able to extend the experiences of the participating growers with the broader membership. In 2012 they held a bus tour that visited all the sites, and for those who couldn’t attend, descriptive case studies were presented in the group’s newsletter.

Sarah noted, ‘Keith O’Brien’s earnest participation in the project was clear and he promoted the use of saltbush as a productivity tool to other growers.’ In addition she said, ‘The Fleays have astutely recognised that each feature of the landscape can offer unique farm productivity outcomes. The family has a long history of landcare works particularly in the management of saline landscapes.’

Keith indicated that he would definitely like to apply for a bigger project of the same nature, having extensive valley flats and degraded drainage lines across the farm.

‘The recent plantings have enabled me to increase my sheep enterprise to 50%,’ Keith said.

The only thing the O’Briens feel they would do differently next time is to modify seedling width.

‘I feel the seedlings were planted too close and in hindsight would use a spacing that ensures stock can manoeuvre between plants.’

The Fleays had initially left their saltbush plantings unfenced but have since decided to fence them for improved grazing management.

Tim mentioned, ‘Isolation of soil types and site-specific features [salinity] makes management of paddocks easier.’

He also acknowledged that without family support a mass planting like theirs would be difficult. Tim plans to plant more saltbush and recommends locally sourced seedling where possible.

‘Seedling quality is also a very important requirement as it helps the project get away on a positive note.’

‘Since the saltbush is quick-growing, I now also have shelter for the stock and an alternative source of stock feed for my sheep…’

Keith O’Brien

‘I wanted to be able to increase groundcover on the saline section of my paddock and make it productive…’

Tim Fleay
PROJECT SNAPSHOT

Neighbouring farmers: Karen and Tom Williamson
Father and son team, Ron and Jamie Miller

Location: Between Wickepin and Kulin, in the Kulin Shire

Property size: The Millers are farming 5500 acres, while the neighbouring Williamson block is 842 acres. The Williamsons also have another property at Cuballing.

Enterprise mix: Both farm a mix of sheep and cropping

Soil types: 20% sand over clay.

LOCAL COMMUNITY GROUP

Both the Williamson and Miller families are members of the Facey Group, which is the regional farmer-run group working on research, information sharing, trials and experimentation aimed at improving farm practices to keep farms healthy and profitable and the region sustainable into the future.

The Facey Group was instrumental in coordinating this cross-boundary project. The Millers and the Williamsons had each approached the Facey Group separately about getting funding for planting Tagasaste trees on their sand plains, as these were no longer viable paddocks for cropping.

Recognising that they would be more successful if they joined forces, the Facey Group helped the neighbours in putting together their successful cross-boundary grant application to Wheatbelt NRM.

‘You had more chance of getting the funding if you were working across the boundary fence with neighbours, so the Facey Group took our applications and presented them together as a whole. The Facey Group has helped immensely in town, providing back up support and guiding people through those initial stages of funding applications and then the follow up and so on. The Facey Group has been enormously beneficial for this region,’ says Karen.

‘A lot of people have too many other things on their plate and don’t get around to taking advantage of the opportunities that come up; this is where the Facey Group is valuable,’ says Ron.
WHAT BENEFIT DO THE TREES BRING TO THE FARMS?

Obtaining this funding has allowed both families to plant significant blocks of tagasaste on sandplain that was going to continue to be degraded by wind erosion. Having the trees on both sides of the boundary provides further protection for the land, and is a win–win for the neighbours.

The Millers planted 17,000 tagasaste on their property in June 2011, while the Williamsons planted 15,000. Both families are planning to put in more this year—the Millers will put in another 13,000 and the Williamsons will put in 5000 mixed native trees.

While the grants are handy, both families would have done the plantings anyway, as they know very well the benefits the trees bring to their farms. The grant has meant that more farmers in the region have had the opportunity to see what has been done on this site and will encourage them to take action in managing sandy soil prone to wind erosion.

'We had planned to plant these trees ourselves, a little bit each year, but then this opportunity came up and this was a great help,'

The Williamsons

'In the past, we have just got in there and done it ourselves—we saw the paddock blowing away and decided to just do something about it.'

The Millers

The tagasaste provides excellent fodder for the sheep and can be grazed very early, less than a year after planting. The hardy young trees can be munched right down to the stalk, left for 2–3 months and then grazed again, which is excellent supplementary feed in the season break. The high protein in the tagasaste makes for better quality wool and happier sheep all round.

Once grown, the trees also provide great shade for the sheep and a place to comfortably lamb.

Both the Millers and the Williamsons have noticed a great improvement to their paddocks due to the buffer provided by the trees. Land that would previously have been basically beach sand if left unattended has returned to health and is now providing an economic benefit to the farm, as well as providing an aesthetic improvement too.

The Williamsons also feel that the trees allow the land to return to its natural state and return the life to the soil.

‘When I look at the patches of trees, to me it looks like it has gone back to nature—it’s flourished,’ says Karen.

‘It comes back to the dynamic of the individual farmers that are out there, and how you view running your business but, from my point of view, the trees do add value to the farm.’

HOW WAS THE PLANTING CARRIED OUT?

The Millers hired a Chatfields tree planter from the Corrigin Farm Improvement Group, which has a ripper attached to it. They came across a number of patches of gravel and ironstone and some large rocks, but just had to get around these as best they could. The Williamsons decided to hire a grader and pre-rip their lines to deal with the ironstone problem.

‘...from my point of view, the trees do add value to the farm…’

Karen Williamson

‘Land that would previously have been basically beach sand if left unattended has returned to health and is now providing an economic benefit to the farm.’
WHAT WAS NORMAL PRACTICE PRIOR TO THIS PROJECT?

THE MILLERS
Ron Miller’s father bought their property after the Second World War, securing it for a low price. Ron returned from boarding school at age 15 and helped his father and brother clear the land for grazing and cropping, an arduous task. Ron and his brother went on to split the farm and Ron acquired more land over the years, bringing the property size up to 5500 acres.

Small belts of trees were left on the property and around 25 years ago, Ron decided to do something about his sand plain and planted a dense thicket of tagasaste. These trees have brought enormous benefit over the years, and also gave Ron the advantage of experimentation and learning.

For this recent SCIP project, the Millers ensured there was more space between the trees, so the sheep can more easily move around and graze. Otherwise, the dense thickets cause the sheep to have to get a whole lot of unnecessary extra exercise, as they need to go to the very end of a row to get to the next grazing patch!

Twelve years ago the Millers also planted trees along their creek lines and, when they bought a neighbouring salt-affected farm, set about planting saltbush, which has proven to be another excellent fodder shrub option. Additionally, the creekline plantings provide more shelter for the sheep and stop the creek from washing away.

The Millers says that there is quite a bit of planting along creek lines happening around the area.

THE WILLIAMSONS
The Williamsonsons have another property at Cuballing and here they have planted a range of trees including saltbush and sheoaks. The Kulin block bordering the Millers’ property has pine tree belts planted by the previous owner. However these existing trees were not enough to prevent the blowing.

Karen and Tom Williamson recently made an interesting discovery when they used blue metal dust on a wind-blown paddock that was previously unable to produce a crop. The rock dust was obtained cheaply from a local quarry and enabled the paddock to retain moisture and hold the sand in place.

This previously unproductive paddock was able to produce a crop, much to their delight. They went on to use the dust when planting their trees as well, which they have found to be extremely beneficial.

THE BEAUTY OF CROSS-BOUNDARY PROJECTS
This kind of cross-boundary project provides a real win-win and could easily be replicated in other regions. Both families credit the Facey Group with being an excellent resource and link for farmers in the region. The two families are also able to share ideas about what they are doing on their farms, and benefit from the enhanced wind protection right across the boundary lines.
THE STORY SO FAR

Rod and Neil Carter initially became involved in the Soil Conservation Incentives Program following contact with the local Environment Officer and Wheatbelt Natural Resource Management Project Officer to discuss alternative management options for a highly wind-eroded site. The site chosen for revegetation is situated over deep yellow and grey sand plain country that has in the past been overgrazed by stock resulting in significant wind erosion and poor productivity. Based on recommendations received in the initial project consultation phase, it was decided that tagasaste (Chamaecytisus palmensis) would be a viable option to improve the grazing capacity, productivity and soil health within the 94 ha paddock. The tagasaste was planted in 2012 in alleys 110 m apart with 4 rows in each alley facing north–south. Weeds were controlled prior to planting using a knockdown herbicide and rabbits were controlled with 1080 poison. The seedlings were planted using a Chatfields tree planter and sheep have been kept off the paddock since planting to reduce the grazing pressure on the new seedlings. The establishment of the site is still in the early stages, however thus far has proved to be challenging for the tagasaste as a result of the dry season and degraded nature of the soil.

Rod and Neil plan to increase the number of fodder shrubs within the paddock in upcoming years to increase the grazing capacity at the site.

‘Production is limited so we hope the tagasaste will provide a feed source while improving the soil,’ Rod said. They plan to do more research on suitable fodder shrubs that would suit deep sandplain country to improve the establishment rate of seedlings in the future.

‘It is important for this paddock to be managed in a more sustainable and productive way,’ Rod mentioned.

LESSONS LEARNT

In hindsight, more research on the species chosen may have assisted in achieving better establishment of the seedlings, which only had about a 50% to 70% survival rate at the site. In addition, placement of the alleys in the paddock could have been planned better as some seedlings were planted on highly wind eroded and degraded areas within the paddock which hindered establishment.
The opportunity for farmers in marginal areas to include perennials in their production systems is brightening, with new plant species belonging to the genus *Rhagodia* being trialled for their suitability as alternative perennial fodder shrubs in the lower rainfall agricultural regions of WA.

The persistence of perennials in many WA agricultural regions is constrained by low rainfall and poor soils, with viable options being limited. However the inclusion of perennials in farming systems has several benefits as it:

- reduces supplementary feeding during the summer/autumn feed gap;
- allows deferred grazing of break-of-season pastures; and
- provides options for tackling salinity, wind erosion and biodiversity.

In some instances (as seen in the Enrich project) inclusion of 10–20% farm area of perennial forage shrubs on a typical central wheatbelt farm can increase total farm profit by 15–20%.

*Rhagodia* spp. are native perennials to WA, commonly found in salt-affected areas, and due to their tolerance of salt are collectively called saltbushes. *Rhagodia* species offer high value green feed during the summer-autumn feed gap, and have demonstrated high resilience to drought.

In some instances *Rhagodia* (*R. drummondii*) has been seen to contain 23% crude protein, and it also met animal requirements for phosphorus and copper, and exceeded dietary requirements for calcium, magnesium, sulphur and zinc. In general, *rhagodia* demonstrated high biomass production and good regrowth following grazing. Variation in palatability has been observed between different species.

So where can *rhagodia* potentially fit into your farming system? As a salt-tolerant shrub, *Rhagodia* spp. can be included in fodder shrub mixes for salt-affected areas, or alternatively planted in rows between annual pasture to provide year-round green fodder for livestock, manage salinity and combat wind erosion.

For more information on *Rhagodia* contact Dean Revell dean.revell@csiro.au or visit www.wheatbeltnrm.org.au
WASTELAND NO MORE

PROJECT SNAPSHOT

Land Manager: Tony Williamson
Property size: 3700 ha
Location: Belka
Annual rainfall: 330 mm
Enterprise mix: 85% cropping, 15% pasture
Soil types/Vegetation types: Mixed

KEY MESSAGES

- Utilise funding to give something new a try, the results may surprise you.
- Think about where you may be wasting inputs on your property and consider other options.
- Planting a mixture of perennial shrubs offers livestock a more balanced diet.
- Perennial forage shrubs can offer an alternative feed source to livestock during the summer and autumn months.

UNPRODUCTIVE COUNTRY ‘RICH’ AGAIN

Tony Williamson runs Morella Farms, a property between Merredin and Bruce Rock. Growing crops is his ‘bread and butter’. Like many farms in the wheatbelt however his soils are extremely variable. This means that some areas of the property are not suitable to cropping. Without help financially many of these areas would be either left unmanaged or cropped for the sake of it.

With the help of the Wheatbelt NRM funding Tony was able to plant an area of very rocky granite and shallow loamy country with the perennial shrub Old Man saltbush (Atriplex nummularia). This country was difficult to seed in the wet as Tony’s heavy seeding gear would turn it to slop—plus, due to the shallow soil, only poor yields could be achieved.

‘If it wasn’t for the funding on offer we wouldn’t have bothered to revegetate the area because of the cost to do so,’ Tony said. ‘The timing of the funding was great because the nearby creek was starting to show signs of salinity.’

With good preparation the 16 ha area established well. The site was initially sprayed with a knockdown, and then a scalper was used during the one-pass planting operation. This meant the saltbush was planted into a fairly clean site.

By transforming the area with saltbush (16,000 seedlings) Tony can now devote the fenced off area exclusively to stock, particularly when trying to establish other pastures early in the year.

‘Although it’s only a small area, it should be very productive saltbush country, because of its high fertility and efficient water-holding capacity,’ Tony believed.
‘Although it’s only a small area, it should be very productive saltbush country, because of its high fertility and efficient water-holding capacity…’

Tony Williamson

LESSONS LEARNT

Through this exercise Tony now looks at the landscape on his property in a new light.

Tony explained, ‘Cropping areas which are consistently unproductive, no matter what you do is counter-productive to the bottom line.

‘We have learnt to identify areas which are not returning a profit through normal farming practices.

‘Once identified, it is then up to us to find an appropriate use for it which is either not losing money or contributing to the profits of a different enterprise.’

He is very happy that through this project he was able to find a way to buffer the enterprise from the pressures of the autumn feed gap.

Tony would encourage other people to give it a go as the overheads are minimal and inputs are no longer being wasted.
KEY MESSAGES

- More frequently farmers are being faced with dry starts. More information is required regarding the implications of seeding conditions, seeder bar set up and application rates to improve crop yield potential in these years.
- Seasonal variability and soil type has a significant impact on crop yield results. There are also many other variables that impact crop development and these areas need further research.

THEIR STORY

The Bodallin Catchment Group was formed to bring farmers within the Yilgarn region together to discuss and trial areas of interest. Dry seeding, was one recent area of interest given the last few seasons have recorded below average rainfall and kicked off without sufficient breaking rains. So when the group heard about Wheatbelt NRM’s Soil Conservation Incentives Program they decided to apply for funding to conduct a project testing different dry seeding techniques.

A small group of willing farmers became a part of this project:

- Mark Granich from Moorine Rock who tested dry and wet seeding whilst testing different seeding speeds on light sandy soil;
- John and Tim Butcher from Noongar who tested dry and wet seeding whilst sowing inter- and intra-furrow on red clay soil;
- Toll Temby from Bodallin who tested dry and wet seeding whilst testing different press wheel pressures on grey clay/heavy red loam soils. The four weight settings were: 0 kg, 400 kg, 800 kg and 1000 kg; and
- Wayne and Clint Della Bosca from Southern Cross who tested dry and wet seeding whilst testing the use of a soil wetter (GLE Precision Wetter).

From this project the hope was to provide discussion points about the difficulties, benefits and risks of dry seeding techniques and set up at seeding.

TRIAL RESULTS

GRANICH: TESTING SPEED AND NITROGEN

Mark Granich dry seeded wheat on 4th May 2012 and wet seeded wheat on the 8th of June 2012. Nitrogen application occurred on both plots on the 5th July 2012 using a Flexi-Coil® 820, with 9 inch spacing, knife-point and press wheels.

During emergence the 12 km/h and 10 km/h sown strips looked better than the strips sown at 8 km/h. The possible reasoning is that the higher speed increased soil aeration, assisting seed growth. The plot dry seeded at 10 km/h yielded the largest tonnage, but this was not significantly different to the other dry sown wheat yields. On average, however, the dry sown treatments yielded 200 kg more than the wet sown treatment. This is likely due to the lack of finishing rains preventing the development of the wet sown crop.
### Soil Moisture Average Speed Yield (t/ha)

<table>
<thead>
<tr>
<th>Soil Moisture</th>
<th>Average Speed</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry seeded</td>
<td>8 km/h</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>10 km/h</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>12 km/h</td>
<td>1.00</td>
</tr>
<tr>
<td>Wet seeded (control)</td>
<td>10 km/h</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Also trialled by Mark were various nitrogen levels (50 kg/ha and 100 kg/ha) which were applied on the 5th of July 2012 and compared to a control (0 kg/ha N). For both the dry and wet sown treatments, the application of 100 kg/ha of nitrogen yielded the highest. In terms of the wet sown crop the high nitrogen application also seemed to allow the crop to compensate for the short growing season, as it yielded 1.15 t/ha, a 64% increase compared to the control.

<table>
<thead>
<tr>
<th>Nitrogen (N) rate</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry seeded</td>
</tr>
<tr>
<td>0 kg/ha</td>
<td>0.85</td>
</tr>
<tr>
<td>50 kg/ha</td>
<td>0.84</td>
</tr>
<tr>
<td>100 kg/ha</td>
<td>1.05</td>
</tr>
</tbody>
</table>

**BUTCHER: TESTING IN-ROW AND INTER-ROW SOWING**

John and Tim Butcher dry seeded wheat on the 28th of April 2012 and wet seeded wheat on the 26th of May using a DBS tyne seeder. The early sown, dry seeded wheat suffered from drought stress early on and therefore plant establishment and crop biomass was reduced. It should be noted that take-all root disease was present and stubble build-up on in-row treatments.

All the grain made grade AH1, though the early sown, dry seeded wheat had higher screenings (2.5%) than the late sown, wet seeded wheat (0.63%). There was little variance in yields, however, the in-row wet seeded treatment yielded the highest (0.38 t/ha).

### Soil Moisture Treatment Yield (t/ha)

<table>
<thead>
<tr>
<th>Soil Moisture</th>
<th>Treatment</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry seeded</td>
<td>In-row</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Inter-row</td>
<td>0.36</td>
</tr>
<tr>
<td>Wet seeded</td>
<td>In-row</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>Inter-row</td>
<td>0.35</td>
</tr>
</tbody>
</table>

**TEMBY:**

**TESTING VARYING PRESS WHEEL PRESSURES**

Toll Temby attempted to dry seed 45 kg/ha of wheat on the 3rd of June 2012, though approximately 10 mm fell the day prior. He then wet seeded 45 kg/ha of wheat on the 12th of June 2012 after an additional rainfall of approximately 25 mm. He used (parallelogram) press wheel pressures of 0 kg, 400 kg, 800 kg and 1000 kg on his JD1890 Air Hoe Drill to test crop performance in a paddock characterised by grey clay to heavy red loam.

The rainfall in June was enough to overcome any limitation by the press wheel pressure to maintain the soil to seed contact. This was verified by the plant density being similar over all plots. Although there was little variance in yields, the plots seeded in early June (referred to as having a wet soil profile in the table) with 800 kg and 1000 kg press wheel pressures produced the largest yields at 0.46 t/ha and 0.47 t/ha, respectively.

<table>
<thead>
<tr>
<th>Press wheel pressure</th>
<th>Yield (t/ha)</th>
<th>Average (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet soil profile</td>
<td>Saturated soil profile</td>
</tr>
<tr>
<td>0 kg</td>
<td>0.40</td>
<td>0.45</td>
</tr>
<tr>
<td>400 kg</td>
<td>0.43</td>
<td>0.40</td>
</tr>
<tr>
<td>800 kg</td>
<td>0.46</td>
<td>0.43</td>
</tr>
<tr>
<td>1000 kg</td>
<td>0.47</td>
<td>0.44</td>
</tr>
</tbody>
</table>
DELLA BOSCA:
TESTING VARYING SOIL WETTER RATES
IN-ROW AND INTER-ROW

Wayne and Clint Della Bosca seeded wheat into canola stubble on the 16th of May 2012 using a ConservaPak® after no April rain and only 13mm over three rainfall events in the first half of May. The trial site was made up of Kellerberrin/Goldfields clay and the total area harvested was 3.2 ha.

The wetting agent cost $6.75/litre and produced a yield increase across all treatments. For the dry in-row sown wheat the most effective application at the lower water rate (50L) was 2L/ha (100 kg higher than the control), while at the higher water rate (100L) the 1L/ha and 3L/ha rates were the most effective. Given the poor season (drought) the gross margin returns were minimal, though the in-row dry sown crop with 2L/ha 50L Vol had the highest return on investment ($17.40/ha) based on a $300 farm gate wheat price. This treatment also had an increased yield compared to the control of 42%.

<table>
<thead>
<tr>
<th>Soil wetter application</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In-row</td>
</tr>
<tr>
<td>Control (0L/ha)</td>
<td>0.25</td>
</tr>
<tr>
<td>1L/ha/50L Vol</td>
<td>0.92</td>
</tr>
<tr>
<td>2L/ha 50L Vol</td>
<td>1.12</td>
</tr>
<tr>
<td>3L/ha 50L Vol</td>
<td>0.95</td>
</tr>
<tr>
<td>Control (0L/ha)</td>
<td>0.79</td>
</tr>
<tr>
<td>1L/ha/100L Vol</td>
<td>1.13</td>
</tr>
<tr>
<td>2L/ha 100L Vol</td>
<td>1.00</td>
</tr>
<tr>
<td>3L/ha 100L Vol</td>
<td>1.08</td>
</tr>
</tbody>
</table>
Crop rotations are very important in a no-till system as they offer diversity and sustainability in a farming system. If only similar crops are grown (e.g. cereals), there is greater pressure on the system to perform on a long term basis. Break crops may not necessarily create high returns as a harvestable crop, but allow greater yields during the cereal phase (cash crops) due to carry-over benefits.

These carry-over benefits include:

**WEED CONTROL**
Reduced weed pressure in cash crop phase, by:
- More control option of grass and broadleaf weeds.
- Differences in competitive advantage (e.g. canola cabbaging).
- Ability to stop seed set (e.g. spray topping or cover cropping).

**HERBICIDE RESISTANCE**
Reduced risk of resistance, by:
- Using different herbicide chemistries and mode of action.

**DISEASE BREAK**
Reduced soil-borne and foliar diseases, by:
- Removing the host and breaking the life cycle.
- The release of biocidal chemicals (e.g. canola).
- Growing less susceptible crops or varieties.
- Changing the environment within crop canopies

**PEST CONTROL**
Reduced attack by insects and micro-fauna, by:
- Removing the host and breaking the life cycle.
- Growing less susceptible crops or varieties.

**FERTILITY**
Improved nutrient balance within the soil, by:
- Growing plants with the ability to fix nitrogen (e.g. legumes).
- Green manuring or sowing into sacrificial crops.
- Alternating between shallow and deep rooted plants.
- Retaining different crop residue types at the soil surface.

**SOIL STRUCTURE**
Improved soil structure, by:
- Alternating between shallow and deep rooted plants.
- Growing plants with thick tap roots (e.g. canola) to aerate soils.
- Different roots types attributing to soil aggregation and stability.
**ROTATION TYPES**

**Ley farming** is less commonly practiced today due to the adoption of pulse crops (e.g. lupins, field pea, chickpea and faba beans) enabling longer crop sequences. This mixed farming system generally has a greater focus on livestock and is used in areas where crop legume yields are unreliable or low.

**Phase cropping** is widely adopted in the Western Australia wheatbelt. This rotation is more focused on cropping than livestock as pastures require resowing and pasture phases are short term (one to three years). These phases are used to maintain livestock, reduce risk in poor cropping seasons and control high weed seed banks. Livestock can however have a negative impact on soil health and crop emergence when stocked in cropping paddocks over the summer and autumn period.

**Continuous cropping** has become more common recently due to poor long term wool prices, conflicts and work pressures in a mixed farming system and the introduction of canola into rotations. Long term cropping has lead to an increase in the adoption of large scale machinery, precision agriculture technology and paddock size. To replace the role of livestock, weed control options such as cover crops and chaff carts are utilised. Depending on soil type and rainfall crop types can include wheat, barley, oats, lupins, canola, field peas, faba beans and chickpeas. This crop diversity is the key to the system being sustainable long term.

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**CROP SELECTION**

It is always best to select a rotational sequence in order to have a long term approach to the farming system, although season conditions, soil type and changing markets have an effect on decision-making. Cash crops and high market prices can often drive tactical decisions about crop selection, though agronomic issues will be harder to tackle if break crops are not included at the right frequency.

Some tips to choosing the right crop to grow:
- Think about possible integrated pest management solutions a particular crop can offer.
- Soil test regularly to understand pH levels and rotational influences on nutrient supply.
- Observe agronomic shifts to foresee possible problem crops and come up with a strategy.
- Weigh up grain prices, although also focus on the indirect benefits for subsequent crops.
- Measure soil water prior to seeding and select a variety suitable to the growing season.
- Record yields on a yearly basis for each paddock to understand potential gross margins.

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**CROPPING PRACTICES**

Legumes, such as peas, are nitrogen fixers which help to reduce nitrogen inputs following cereal phase.

Canola helps to reduce soil-borne diseases via biofumigation and is able to aerate the soil with its large taproot.
WHY SHOULD STUBBLE BE RETAINED?

MINIMISATION OF EROSION
The minimum amount of ground cover required to minimise erosion is 50%, although sandy soils, exposed hills, slopes and grazed land require more cover (approximately 75%) to prevent wind and water erosion. Standing stubble is twice as effective as prostate stubble at reducing the erosion rate. Wind is slowed and kept away from the soil surface, while raindrops are deflected before hitting the soil surface. Unanchored stubble, chaff, other fine material and fragile grain legume stubble provides little protection of topsoil.

MOISTURE CONSERVATION
Stubble reduces raindrop impact on the topsoil, increases infiltration by limiting runoff and prevents moisture loss via evaporation by acting like a mulch layer. In low to medium rainfall areas where evaporative power is high and summer rainfall storage is advantageous the benefit of retaining plant residues is even greater.

BUILDING SOIL HEALTH
The retention of anchored stubble helps to hold the soil together and maintain soil aggregation. As plant roots decay they leave behind channels and deposit organic matter that helps to stabilise the soil. There are higher microbial populations and activity where stubble is retained as plant residues are a source of food/carbon for microorganisms. To build and maintain soil carbon levels, stubble retention needs to be ongoing.

MEASURING SOIL COVER
Visual assessments can be used to estimate total ground cover by comparing ground cover to photographs of known percentage cover. The difficulty with this method is that most assessments have only been designed for prostrate orientated stubble, not for standing stubble. Remember however that anchored, standing stubble is better than loose, trampled stubble.

Harvest yields can also be used to estimate stubble load. For cereal crops, grain yields can be multiplied by 1.8 to estimate stubble loads. A more accurate method to measure stubble load is to weigh plant residue within a 1 m² quadrat. To obtain stubble load (t/ha), convert the weight, that is, 100 g/m² equals 1 t/ha. 1t/ha cereal stubble load equates to approximately 50% cover. Keep in mind that at sowing approximately 50% cover is lost based on a tyne machine and that cover is still important at the early growth stages of a crop/pasture.

TOP: Long-term retention of stubble is vital to a no-till farming system.
CENTRE: Grazing fragile stubbles (e.g. peas) to a point where little remains limits the benefits of a no-till system.
LEFT: Stubble improves water infiltration by reducing runoff and losses from evaporation.
FACTORS THAT REDUCE THE ABILITY TO RETAIN STUBBLE

Cover can be lost by natural breakdown, grazing, tillage, burning and drought. The type of soil biota, number of soil biota, stubble composition and stubble orientation will determine the rate of breakdown. Careful monitoring of stubble over the dry season is crucial to avoid over grazing, while grazing of some paddocks should be avoided (e.g. pea stubble, sandy soils). The number of tillage passes and the type of implement used will determine stubble burial. Burning removes cover immediately and exposes the soil to erosion, so not preferable. Crop stubble loads and harvest heights are reduced in drought conditions.

MAKING STUBBLE RETENTION PRACTICAL

When managing stubble it is important to keep in mind the following:

- Handle stubble in a way that allows stubble flow through seeding machinery. For tyne machines the maximum stubble height should be two thirds the length of clearance under the lowest obstruction under the bar or match the row spacing. Disc seeders can handle higher cut stubble, although standing stubble is preferable to trampled stubble to reduce the frequency of hair pinning. Wind speed and direction should be considered during harvest to minimise concentration of straw/chaff. Time needs to be taken to ensure even spread of straw/chaff or redirection of straw/chaff onto tramlines.

- Ensure plant residues do not inhibit crop emergence by keeping the seeding row stubble free. Canola can be particularly sensitive to wheat stubble in the seeding row. Inter-row sowing and residue managers can be useful. Keeping plant residue in the inter-row will help suppress weeds and mulch the soil.

- There are alternatives to burning to control weeds, disease and manage stubble loads, such as diverse rotations, chaff carts, shielded sprayers, variety selection and harvest cutting heights. Spraying of summer weeds is important to avoid blockages at seeding and to remove the need to burn stubbles. The vines of melons in particular can be sliced by fitting coulters onto the seeder bar.

- Alternative feed sources over summer and autumn are necessary to reduce the stocking of stubble paddocks. Livestock numbers and/or carrying capacity can also be lowered to minimise erosion associated with stubble loss. Some areas of the property not suitable for cropping can be allocated to other land uses, such as perennial pastures, tree blocks, holding paddocks or saltbush.
In a high quality no-till system permanent residue cover of the soil, crop diversity and integrated pest and weed management is vital. Cover crops can be part of the strategy to achieve this. The primary function of cover crops is to produce biomass, thereby providing ground cover. Careful selection of cover crops can provide much needed diversity to the cropping system.

Cover crops can also protect the soil from erosion, conserve moisture, provide a disease break, suppress weeds, provide an option for controlling weed seed set and promote soil health and fertility through biological activity, nitrogen fixation, nutrient cycling and organic matter accumulation.

In Mediterranean climates such as southern Australia, cover crops have to be grown in place of fallow or a cash crop and, therefore, are unlikely to be grown more than once in about three to six years. The successful adoption of cover crops will only occur if costs are minimised and the benefits to the system are maximised.

Many crops/plants can be grown as cover crops and they should have the following attributes:
- cheap seed (harvest own seed);
- low inputs;
- easy to seed and manage;
- minimal interference on main cropping programme;
- provide good weed control; and
- have a positive carry-over effect on subsequent cash crops.

Plants that are tall with early maturity and good vigour are most suitable. Some examples of possible cover crops and their attributes are:

**NON LEGUME:**
- *Saia oats*—tall, high biomass, break crop, competitive for weed suppression.
- *Swan oats*—tall, high biomass, break crop, early maturing, competitive for weed suppression (other oats may also fit the criteria but have not been tested).
- Mustards—high biomass, break crop, nutrient cycling, drought tolerant, nematode control.
- *Oriental (daikon) radish*—high biomass, loosening soil, nutrient cycling.

**LEGUMES:**
- *Vetch*—high biomass, break crop, nitrogen fixation.
- *Pasture legumes* (serradellas, biserrula, bladder clover)—high biomass, break crop, nitrogen fixation, can establish cheaply.

**MIXES:**
- Mixtures of cover crops (e.g. legume vetch/oat mix, legume vetch/radish mix or field pea/oat mix) to suit requirements.
COVER CROP MANAGEMENT

The ideal time to sow cover crops in southern Australia is before seeding of the cash crops begins. A number of farmers consider seeding dry using relatively high seed rates to achieve this. Legume cover crops can be sown dry with relatively persistent inoculant delivery systems, such as the clay based ALOSCA® granules. Early seeded cover crops will maximise biomass production. In addition, vigorous cover crops grown at high seeding rates may out-compete weeds.

KILLING COVER CROPS

Generally, cover crops are killed prior to seed-set when they have reached maximum biomass, usually in spring. This can be done by spraying with a herbicide like glyphosate or by crimping the stems with blunt ‘knives’ on a roller, called a knife-roller. Plant height and maturity are important in determining the efficiency of knife rolling. Plants should be relatively tall and rolled between late flowering and soft dough. Rolling too early or too late is ineffective. Some farmers have found that knife rolling perpendicular to the direction of seeding is most effective, but this is not always the case. In many instances a herbicide like glyphosate should be used in combination with knife rolling as areas in the paddock are invariably weedy, or too small for effective knife rolling. The knife-rolled cover crop is left ‘in-situ’ until seeding the following autumn. Best results are achieved by disc seeding in the direction of knife rolling.

KNIFE ROLLER SPECIFICATION:

- Hollow steel cylinder, 6–8mm thick, welded at the ends so it can be filled with water if necessary (600–900mm in diameter).
- 2m wide, any wider may cause bridging on uneven ground. Larger working widths can be obtained by attaching in gangs.
- 12–20 blunt blades spaced evenly around the cylinder (15–19 cm apart).
- Blades 70–100mm tall and 10mm thick.
- Roller to be mounted in a frame so it can be pulled by a tractor.

TOP: Crimping of a vetch cover crop.
CENTRE: Rolled oats provide excellent ground cover and help to suppress weeds.
RIGHT: Care needs to be taken to move residue from the planted rows as this can affect establishment in high loads.
BELOW: The knife rolling of oat cover crops in progress.
CROPPING PRACTICES

TRIALLING BEST CROPPING PRACTICES FOR MAXIMUM SOIL COVER

PROJECT SNAPSHOT

Land Managers: Clint Della Bosca and Bodallin Catchment Group
Property size: 9800 ha
Location: South Moorine Rock
Annual rainfall: 290 mm
Enterprise mix: Cropping and livestock (sheep)
Soil types/Vegetation types: Loam, gumtrees

KEY MESSAGES

• Consider maintaining good groundcover to reduce topsoil loss particularly over the summer months. Cover crops offer a quick solution to maximise biomass.
• Brown manuring is a high return option in low rainfall areas; however remember seasonal variation can influence the financial outcomes of farming practices.
• Protect the soil; it is your main asset.
• Making trials locally relevant is important for community participation.

GETTING STARTED

The Bodallin Catchment Group is an innovative, community driven grower group that was formed due to farmers in the area wanting to come together to discuss localised agricultural issues and test practices with on-farm trials. The environment can be harsh when you’re farming east of Merredin and any farm practice that gives you ‘the edge’ in dry and windy conditions is worth adopting.

Wheatbelt NRM funding in 2010 provided another opportunity for the group to undertake a farmer demonstration.

Group leader Merrilyn Temby explained, ‘We wanted to raise awareness of wind erosion risks among Westonia and Yilgarn cropping farmers by promoting ‘best practice’ via field days.’

With the help of industry consultation the Bodallin Catchment Group designed a broadacre trial (10.5 ha) that compared four farming practices (full stubble retention, cultivation, brown manuring and cover cropping) and their effect on groundcover. After hearing about the concept of the project, South Moorine Rock grower, Clint Della Bosca willingly offered his time, equipment and paddock to the project.
Clint said, ‘Being directly involved in the project allows for better understanding of its findings.’

In 2010 a paddock was selected on the Della Bosca property which had good stubble cover after the 2009/2010 harvest. The soil type was medium loam. Pallingup oats were sown dry in 2010 and an area was left as a chemical fallow for the brown manure treatment, while the rest of the paddock was sown to wheat. A total of 177.5 mm was recorded in 2010.

Over the 2010/2011 summer either conventional weed control or WeedSeeker technology was used across the treatments (see Figure 1) and after a wet start to 2011 (129.5mm) wheat was sown across all treatments using either a disc seeder (Flexi-Coil® 500 on 225 mm spacings with Discamate® disc openers) or a tyne seeder (ConservaPak® on 300mm spacings) on the 13 May.

Figure 1: Trial design

**PRODUCTION RESULTS**

In Table 1 below are yields and protein levels of the 2011 Frame wheat crop, along with returns on a per hectare basis for the 2011 harvest. The analysis was based on a $185 farm gate/tonne feed wheat price. Clint points out however, that ‘Soil type and sub soil moisture plays a large determining factor in this project’. Growing season rainfall (1st April–1st Oct) was 188 mm and a total of 415.5 mm was recorded for the year.

<table>
<thead>
<tr>
<th>Seeder</th>
<th>Treatment</th>
<th>Yield (t/ha)</th>
<th>Protein (%)</th>
<th>Gross $/ha</th>
<th>Cost $/ha</th>
<th>Net $/ha</th>
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</thead>
<tbody>
<tr>
<td>Disc</td>
<td>1</td>
<td>1.78</td>
<td>10.3</td>
<td>$329</td>
<td>$204</td>
<td>$125</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.57</td>
<td>10.3</td>
<td>$290</td>
<td>$204</td>
<td>$86</td>
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<tr>
<td></td>
<td>3</td>
<td>2.05</td>
<td>10</td>
<td>$379</td>
<td>$204</td>
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<td></td>
<td>4</td>
<td>1.92</td>
<td>10.1</td>
<td>$355</td>
<td>$204</td>
<td>$151</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2.06*</td>
<td>10.5</td>
<td>$381</td>
<td>$219</td>
<td>$161</td>
</tr>
<tr>
<td></td>
<td>6 7</td>
<td>1.92</td>
<td>9.3</td>
<td>$355</td>
<td>$204</td>
<td>$151</td>
</tr>
<tr>
<td>Tyne</td>
<td>1</td>
<td>2.04</td>
<td>8.9</td>
<td>$377</td>
<td>$208</td>
<td>$169</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.64</td>
<td>8.8</td>
<td>$303</td>
<td>$208</td>
<td>$95</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.2**</td>
<td>9.2</td>
<td>$407</td>
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<td>$198</td>
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<td></td>
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<td></td>
<td>5</td>
<td>2.16</td>
<td>9.1</td>
<td>$399</td>
<td>$223</td>
<td>$176</td>
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<tr>
<td></td>
<td>6 7</td>
<td>2.02</td>
<td>8.3</td>
<td>$373</td>
<td>$208</td>
<td>$165</td>
</tr>
</tbody>
</table>
Interesting results were achieved from the trial, as Clint explains below:

In season 2011 the no-till tyne seeding on the brown manured early spray (treatment 3) was the highest gross margin producing crop of all treatments, producing $198.69/ha profit result. We can also say for this trial that tynes produced on average 12.8% better results than the Discamate® seeding system.

Another interesting result is the tyne seeded oats full cover late spray (treatment 2) recorded a falling number result of 222 which would have put that grain into General Purpose 1 segregation, thus making it worth more $/T.

FARMING: A CONSTANT LEARNING EXPERIENCE

To maximise the benefit of brown manuring Clint points out that subsequent weed control has to be undertaken, otherwise weeds can be difficult to control (e.g. windmill grass). At the end of the day the exercise of brown manuring is a sacrificial year of production, based on reducing water use so that the following year’s crop reaps a yield benefit.

As Clint says, ‘Brown manuring will work but timing is crucial. The earlier, the better, in my experience.’

Clint has only been able to implement brown manuring in a small way, given that his sheep enterprise requires more grazing area in the dry years.

A question that Clint asks himself is, ‘In the eastern wheatbelt can a system with fallow and cover crops reduce the risk of cropping enough for farmers to remove the grazing enterprise from their business?’

With more seasons incorporating these practices on-farm Clint hopes to get closer to answering this question. He is also interested to see if greater organic matter content and groundcover improves crop production and farm sustainability.

ACKNOWLEDGEMENTS

• Department of Agriculture and Food (Tim Scanlon, Dan Carter, Bob French).
• Landmark Merredin (Dave Meharry).
• WANTFA (Jade Dempster).

‘Brown manuring will work but timing is crucial. The earlier, the better, in my experience …’

Clint Della Bosca
The role soil organisms play in contributing to soil health in a Wheatbelt farming system is not yet fully understood.

It is known that the diversity of soil organisms is far greater than the diversity of plant communities anywhere on Earth. A square metre of soil contains millions of bacteria, kilometres of fungal hyphae and thousands of mites and springtails.

It is recognised that soil organisms have roles in soil that include the cycling and transforming of nutrients. They help aggregate soil particles and improve the soil structure. They also assist plants to obtain nutrients from the soil and help with water penetration into the soil.

Soil is a complex and dynamic habitat for soil organisms. Soil meso-fauna and mycorrhizal fungi respond to their surroundings, and many factors can influence them locally.

Scott McLean is a 100% biological crop and holistic livestock producer, who is already using biological stimulants on his soils. The McLeans no longer use any synthetic fertilisers and use only base rates of knockdown chemicals. Fertiliser that are added include NutraSoil®, a vermiculture extract, a compost extract and, when needed, a foliar spray.

Scott farms on soils that range from heavy red and grey clays to loam over clay.

### SOIL SAMPLING

Two soil samples were taken from two paddocks at Scott McLean’s property as part of a study that analysed 50 sites across the Wheatbelt.

The soil samples were sent to the University of Western Australia where soil meso-fauna and mycorrhiza fungi were assessed using glasshouse and laboratory conditions with standard methodologies. These methodologies can be replicated by farmers and further information can be found in the On Farm Soil Monitoring Handbook (www.wheatbeltnrm.org.au).

The soil samples were also sent to CSBP for standard chemical analysis.

### SOIL ANALYSIS

Soil Sample 1 was taken from a paddock that was sown to barley for the previous two years. Sample 2 grew barley in 2012 and had pasture in 2011. These soils were collected prior to seeding in 2013 in dry conditions.

The chemical analysis (Table 1) for these two samples varied in some characteristics but not all of their characteristics. The differences found with the soil fauna and mycorrhizas don’t appear to be strongly related to the soil chemistry.

#### Table 1: Chemical characteristics for the two soil samples collected from different paddocks on this farm

<table>
<thead>
<tr>
<th>Soil Characteristics</th>
<th>Soil Sample 1</th>
<th>Soil Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄ (mg/kg)</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>NO₃ (mg/kg)</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>P (mg/kg)</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td>PBI</td>
<td>29</td>
<td>125</td>
</tr>
<tr>
<td>%C</td>
<td>1.53</td>
<td>3.65</td>
</tr>
<tr>
<td>pH (CaCl₂)</td>
<td>5.1</td>
<td>5</td>
</tr>
<tr>
<td>EC (dS/m)</td>
<td>0.06</td>
<td>0.14</td>
</tr>
<tr>
<td>K (mg/kg)</td>
<td>302</td>
<td>1450</td>
</tr>
<tr>
<td>S (mg/kg)</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Mites and springtails are indicator species of soil biological activity. They reflect the diverse biological community within the soil. Mycorrhizal fungi reflect processes associated with the efficiency of access of soil phosphorus, soil aggregation and protection of soil carbon.

Although both soil samples had a history of barley in 2012, they differed in the number of mites at the time of sampling (Table 2). The number of mites in soil sample 1 was very high. Both soil samples had a similar number of springtails at this time (Table 2). The ratio of the number of mites to the number of springtails was very much higher in soil sample 1 than in soil sample 2.

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**PROJECT SNAPSHOT**

<table>
<thead>
<tr>
<th>Land Manager:</th>
<th>Scott McLean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property size:</td>
<td>1011 ha</td>
</tr>
<tr>
<td>Location:</td>
<td>Beverley</td>
</tr>
<tr>
<td>Annual rainfall:</td>
<td>400 mm</td>
</tr>
<tr>
<td>Enterprise mix:</td>
<td>50% cropping, 50% sheep</td>
</tr>
<tr>
<td>Soil types/Vegetation types:</td>
<td>Heavy red and grey clays to loam over clay</td>
</tr>
</tbody>
</table>
One theory given by http://ecoplexity.org/files//Coopete2009.pdf is that the ratio of mites to springtails is an indication of the amount of disturbance at the site. It has been suggested that springtails are opportunists that can take advantage of changed conditions and mites indicate a more stable, less disturbed environment. In theory, a higher mite to springtail ratio would indicate less disturbance of the soil. However there is a lack of understanding of exactly how these ratios respond to different farm management practices in the Wheatbelt and it is important to monitor these over time to build this knowledge.

Based on the theory, these results might indicate that the soil from sample 1 comes from an area that is less disturbed and more stable. This demonstrates the need to better understand the relationship between soil biology and land management. At this site, soil sample 1 was taken from beneath a summer active, native perennial grass that has been planted as a trial on the farm, while soil sample 2 came from a paddock with an annual pasture growing.

Scott has been taking a different path over the last 5 years using no synthetic fertilisers and only a base line of knockdown spray. He is not surprised that the rates of mites/springtails is so high but is happy that the differences that he can see in the groundcover and crop yield, is shown in the results.

The mycorrhiza bioassay measurement was slightly higher in roots grown in soil sample 1 than in roots grown in soil sample 2 (Table 2). The association between plants and mycorrhizal fungi are generally beneficial to both the plant and the fungus with nutrient exchange occurring between the partners. Other benefits include improvement in soil structure, protection of soil carbon and enhancing access to moisture in dry soil.

With ongoing monitoring, patterns in the occurrence and abundance of groups of meso-fauna in soil and mycorrhizal fungi in roots will emerge. The patterns in abundance and activity of soil organisms can be site-specific and may potentially be used to support land management decision-making for the site.

**COMPARISON WITH OTHER SOIL SAMPLES**

The abundance of mites and springtails (Figure 1) and of mycorrhizas (Figure 3) were compared across 50 sites in the Wheatbelt. The location of the two soil samples from this farm with respect to other farms is indicated below. The graph below shows the ratio of mites to springtails from the McLean’s property is above the average, with sample 1 showing the highest ratio over the 50 sites. The mycorrhizal colonisation in both samples is also above the average. The differences found in the soil fauna were not strongly related to the soil chemistry (Figures 2 and 4).

Figure 1: Ratio of mites to springtails for 50 sites across the Wheatbelt
SUMMARY

It is expected that the abundance of mites and springtails will differ during the growing season in parallel with the degradation of soil organic matter.

Mycorrhizal fungi depend on living roots and their abundance in soil will be reduced over time in the absence of plants. In addition, canola and lupins do not form mycorrhizas, so the presence of these crops in the rotation will decrease the capacity of the community of mycorrhizal fungi to colonise roots of subsequent crop and pasture plants. Nitrogen and phosphorus interactions in soil can also affect the level of colonisation of roots by mycorrhizal fungi.

By monitoring both meso-fauna and mycorrhizal fungi, their dynamics will become better known in relation to local soil conditions, rainfall events and specific agricultural practices used within and between seasons at a paddock level. When this information is combined with local knowledge of the farmer, patterns will emerge which can be combined with other information for a more complete analysis of the soil conditions for plant growth.

ACKNOWLEDGEMENTS

- UWA—Professor Lyn Abbott, Dr Zakaria Solaiman, Bede Mickan.

Figure 2: Plot of the ratio of mites to springtails against soil nitrate (A) and % soil organic carbon (B) for 50 sites in the Wheatbelt. Soil samples 1 and 2 from this farm are indicated by the numbered large circles.

Figure 3: Percentage of mycorrhizal colonization for 50 sites across the Wheatbelt

Figure 4: Plot of mycorrhizal colonisation (%) against soil phosphorus (A) and % soil organic carbon (B) for 50 sites in the Wheatbelt. Soil samples 1 and 2 from this farm are indicated by the numbered large circles.
SOIL IMPROVEMENT

WORKING OUT THE COST EFFECTIVENESS OF LIMING

PROJECT SNAPSHOT

Land Manager: Brian Bowey
Location: Kulin
Property size: 4500 ha
Annual rainfall: 320 mm
Enterprise mix: Cropping and Livestock
Soil types: Sandy loam, gravel and clay

KEY MESSAGES

- Limes aren’t limes: differences between lime products are important to know.
- Regular liming is essential to restore and maintain good pH levels for optimal crop growth.
- Low soil pH levels can cause boron and aluminium toxicity.
- If crop roots are not growing into the subsoil, test your pH levels at depth.

THEIR STORY

Brian Bowey is a young and enthusiastic farmer who helps to manage the family farm in Kulin. He was interested in gaining more knowledge about lime and lime efficiency and so he applied for Wheatbelt NRM funding in order to set up a broad acre trial.

‘I was driven to conduct an independent trial as it’s hard to get decent, trustworthy results on lime products,’ Brian explained.

The Boweys’ successful application helped to fund 100 tonnes of lime (mixture of lime sand, crushed limestone and chalk lime) that was spread in strips across a 100 ha paddock with a relatively uniform pH.

In order to work out the most cost effective lime application for the business, Brian utilised the help of local agronomist Ben Whisson (Consult AG, Kulin). Together they analysed the effect of crushed limestone (1 t/ha, 2 t/ha and 4 t/ha), lime sand (1 t/ha and 2 t/ha) and chalk lime (1 t/ha) against a control area (no lime).

The products were also sourced from different suppliers to provide an unbiased trial. Prior to the applications of lime, soil pH (average 4.8) and soil organic matter (average 0.72) was tested in each strip area.

Then, in 2012, these soil properties were tested again (average pH 5.0 and average soil organic matter of 0.75 (excluding an outlier) along with aluminium levels.

THOUGHTS SO FAR

Based on initial observations and soil analysis Brian has found crushed limestone better on the loamy soil.

‘The reason I think this product performed better was because of the higher level of super fines (<0.125 mm),’ he said.

Independent testing of lime product showed that crushed limestone at 2 t/ha especially, was more mobile than the other treatments. Unlike the other treatments, it reduced the sodium and magnesium levels of the sodic soil.
‘At this stage I believe 2 t/ha of crushed limestone seems to offer the best value for money, plus the product is easiest to handle,’ Brian mentioned.

The trial is still inconclusive due to the amount of time it has been established and the slight variation of pH across the paddock.

Brian said, ‘Independent tests on the lime pits showed the crushed limestone had twice the soluble calcium over the lime sand.’

He added, ‘This could account for the reason the crushed limestone showed a quicker result, however, with time this may not continue to be the case.’

To better understand the differences between the lime products and lime rates Brian is keen to gather more yield data and undertake more soil testing at the trial site over the next few years.

‘The project has encouraged us to increase the liming program,’ Brian said.
KEY MESSAGES

- Soil acidity levels can be vastly different at depth compared to what is on the surface.
- It is important to not only measure the pH of soil on the surface but also subsoil pH.
- Lime should be applied where it’s needed and a farmer can only know that through appropriate soil testing.
- It is only through measuring subsoil pH that a farmer can gain an accurate picture of soil quality.

THE STORY SO FAR

Kit Leake and his family are primarily wheat farmers and have been involved in farming for four generations. They have been involved with NRM activities over a long period of time and have planted in excess of 200,000 trees over the past 20 years.

While aware of and engaged in environmental and NRM issues, the Leake family’s primary focus is on production. They have a long term interest in maintaining soil quality and have been applying lime since the 1970s in an effort to reverse soil acidity that occurs as a result of farming practices.

The project involved soil-testing at depths of 10–30 cm to confirm the effectiveness and financial viability of applying lime.

As Kit himself said, ‘It’s all very well just testing the first ten centimetres but you need to know the subs, otherwise you’re just guessing… guessing with money.’

Soil testing was carried out at 120 sites across the property to depths of 30 cm with soil analysis being conducted by Soil Tech.
LESSONS LEARNT

The project has enabled the Leake family to see positive results of liming on soil acidity, improved soil quality and increased productivity. The Leake family is now convinced that applying lime over a long period has a demonstrable positive effect on soil quality and productivity.

ACKNOWLEDGEMENTS

- Tracey Hobbs—NRMO, Shire of Kellerberrin.
- Kit Leake, Ebony and Jason Syred.

‘It’s all very well just testing the first ten centimetres but you need to know the subs, otherwise you’re just guessing… guessing with money…’

Kit Leake
MANAGING WATER REPELLENT SOILS

PROJECT SNAPSHOT

Land Managers: Meag Soil Consultancy, Northam
Damien and Vanessa Leeson
Location: Goomalling
Annual rainfall 365mm
Enterprise mix: Cropping and sheep
Soil types: Water repellent yellow sands

KEY MESSAGES

- The inversion of water repellent topsoil and removing sub-compaction could result in significant improvements in crop productivity.
- Cultivated soil should be rolled or packed prior to seeding to improve establishment.
- Sending soil samples off for chemical analysis prior to any soil inversion lime and gypsum applications may be beneficial.
- Penetrometers are a great, inexpensive device that can measure strength and indicate depth of compaction layers.

THE DRIVE BEHIND THE PROJECT

Water repellency has been a hot topic of late, as unfortunately many farmers are facing water repellence problems across some proportion of their farm. H.F. De Wet, a farm consultant representing Meag Soil Consultancy, along with Goomalling grower Damien Leeson, was interested in determining the most appropriate means to manage sandy, water repellent soils.

As H.F says, ‘The wind erosion risk is increased by the forced delay in sowing, as well as by dry soil patches and poor cover. Also a crop’s water use efficiency is significantly reduced as a result of exacerbated evaporation and runoff.’

He therefore applied for some funding through Wheatbelt NRM’s Soil Conservation Incentives Program in 2012 to conduct a farmer demonstration at the Leeson property.
The following treatments were selected to investigate mechanical, chemical and biological methods for addressing water repellent soil across an 80ha paddock prone to wind and water erosion:

1. A commercial wetting agent (CWA) at 10 L/ha;
2. A biological ameliorant (BA) in the form of a seed treatment. This was included based on the hypothesis that specific micro-organisms were responsible for the breakdown of the hydrophobic materials introduced by the organic matter;
3. Dolomite (D) spread at 2 t/ha to increase the topsoil pH of 5.6 and the subsoil pH of 4.3 (120–300 mm). The general improvement of the soil condition should encourage water penetration, seed germination and root development and microbial activity;
4. A mouldboard plough (MP) was used to invert the hydrophobic wax-coated sand at the soil surface and the hydrophilic subsoil (a working depth of 350 to 400 mm);
5. A rotary hoe (RH) was used to invert the hydrophobic wax-coated sand at the soil surface and the hydrophilic subsoil (a working depth of 200 to 250 mm);
6. Dolomite incorporated by mouldboard plough (DMP);
7. Dolomite incorporated by rotary hoe (DRH); and
8. An untreated plot to serve as a control (C).

The site was divided into 8 plots to represent the eight treatments above. Each plot was 60 m wide and 450 m long allowing for a range of factors to be assessed.

**THE FINDINGS**

H.F. said, ‘One of the most effective ways to quantify water repellency is by doing a simple test where one measures the time it takes a water droplet to penetrate the soil.’

Table 1 shows that water droplet penetration time for untreated soil (control) reached 460 seconds, over 7 minutes.

Another useful measurement to take in the field is a penetrometer reading. This helps to get a better understanding of a plant’s capacity to access to nutrients and water.

‘Once a penetrometer registers a resistance of 600 psi, research indicates that root development is restricted,’ H.F. explained.

Not only did the mouldboard ploughing and rotary hoe treatments improve water infiltration, they also had an additional benefit of breaking-up a compacted soil layer at 180 mm. Roots were found at a depth of 450–460 mm on the mouldboard plough treatments and at 230–240 mm on the rotary hoe treatments (Table 1).

### Table 1: Water droplet penetration time (WDPT), penetrometer readings and root growth

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Water droplet penetration (seconds)</th>
<th>Depth penetrometer reading of 600psi recorded (mm)</th>
<th>Root effective depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWA</td>
<td>325</td>
<td>180</td>
<td>200</td>
</tr>
<tr>
<td>BA</td>
<td>475</td>
<td>180</td>
<td>190</td>
</tr>
<tr>
<td>D</td>
<td>135</td>
<td>180</td>
<td>190</td>
</tr>
<tr>
<td>MP</td>
<td>1</td>
<td>410</td>
<td>450</td>
</tr>
<tr>
<td>RH</td>
<td>10</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>DMP</td>
<td>1</td>
<td>400</td>
<td>460</td>
</tr>
<tr>
<td>DRH</td>
<td>8</td>
<td>250</td>
<td>230</td>
</tr>
<tr>
<td>C</td>
<td>460</td>
<td>180</td>
<td>200</td>
</tr>
</tbody>
</table>

Measurements taken revealed that the topsoil in all the treatments to a depth of 200 mm didn’t contain any moisture. However, to a depth of 300 mm higher moisture content was measured in the dolomite and dolomite incorporated by rotary hoe treatments.

‘Due to loss via trough evaporation the mouldboard plough treatment recorded a low moisture content at this depth and to 400 mm,’ H.F. said.

Interestingly, at 500 mm the moisture content on the mouldboard treatment is visibly higher (Figure 1).

‘One would assume that winter rain will fill the top half of the profile during the growing season and the reserve moisture in the mouldboard treatment should have a benefit at the finishing end of the season,’ H.F. mentioned.
There was a significant positive interaction between both the mouldboard plough treatments and grain yield (Table 2). In comparison with the control, mouldboard ploughing plus dolomite at 2 ton/ha increased the dry yield by 79 percent and mouldboard plough by itself by 67 percent. There was no significant difference in the number of plants per square metre of all the treatments where no cultivation was done.

‘The significant decrease in screenings on the plots that were mouldboard ploughed may be further prove that grain fill was improved due to plant roots accessing stored soil moisture at depth,’ H.F. said.

**Table 2: Plant density, grain yield and quality**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of plants/m²</th>
<th>Grain Yield (kg/ha)</th>
<th>Protein (%)</th>
<th>Hectolitre Weight</th>
<th>Screenings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWA</td>
<td>124</td>
<td>841</td>
<td>14.0</td>
<td>73.3</td>
<td>6.4</td>
</tr>
<tr>
<td>BA</td>
<td>135</td>
<td>766</td>
<td>13.8</td>
<td>74.6</td>
<td>5.1</td>
</tr>
<tr>
<td>D</td>
<td>137</td>
<td>852</td>
<td>12.9</td>
<td>75.3</td>
<td>4.8</td>
</tr>
<tr>
<td>MP</td>
<td>78</td>
<td>1413</td>
<td>11.6</td>
<td>77.5</td>
<td>0.9</td>
</tr>
<tr>
<td>RH</td>
<td>106</td>
<td>895</td>
<td>14.4</td>
<td>76.8</td>
<td>3.2</td>
</tr>
<tr>
<td>DMP</td>
<td>75</td>
<td>1518</td>
<td>12.5</td>
<td>76.9</td>
<td>1.3</td>
</tr>
<tr>
<td>DRH</td>
<td>110</td>
<td>875</td>
<td>13.7</td>
<td>76.3</td>
<td>2.7</td>
</tr>
<tr>
<td>C</td>
<td>130</td>
<td>846</td>
<td>14.2</td>
<td>70.9</td>
<td>7.1</td>
</tr>
</tbody>
</table>

**LESSONS LEARNT**

This project clearly demonstrated that the inversion of the water repellent topsoil and removing subsoil compaction could result in significant improvements in crop productivity. However, below are two points that were learnt during this project to be heeded by others.

Unfortunately, in this instance due to timing and the availability of equipment, the cultivated plots packed down. The poor crop establishment on the cultivated soft soil was a disappointment and emphasised the need to use heavy rollers or soil packers after mouldboard ploughing and rotary hoeing. There was evidence of sowing too deep and furrow infill, particularly in the mouldboard plough treatment. Some crusting on the soil surface was also observed in this treatment.

‘Ploughing was done when the soil was relatively wet, contributing to the crusting. Ploughing a dry soil profile won’t have the same outcome, but other consequences like wind and water erosion will cause a bigger headache.’

Through chemical analysis of the topsoil and subsoil it was revealed that the clay (deeper than 300 mm on this specific site) was highly acidic (4.3).

H.F. stated, ‘It is important to recognise that soil inversion, as part of managing water repellency, will bring the acid subsoil to the surface creating a soil fertility issue. Managing soil acidity through liming is essential in these circumstances.’

**ACKNOWLEDGEMENTS**

Specific thanks to Damien Leeson for making available the paddock to conduct the trial and for offering time and equipment to seed and manage the trial.
OVERCOMING NON-WETTING SOILS:
CLAY INCORPORATION 2010–2013

PROJECT SNAPSHOT

Land Managers: Trevor and Renae Syme
Property size: 4000 ha
Location: Bolgart
Annual rainfall: 397 mm
Enterprise mix: 80% cropping, 20% cattle
Soil types: Red clay to sandy soils

KEY MESSAGES

- Incorporating clay into sandy soils improves water penetration and improves yield.
- Deep ripping prior to claying can significantly improve crop yields by ameliorating physical soil constraints such as compaction.
- Soil testing is important before and after the claying process as soil nutrition can be greatly improved when clay is mixed with the profile.
- Depending on depth to clay, alternative methods can be used to eliminate the need for claying and bring existing clay to the soil surface (e.g. deep ripping, mouldboard ploughing, delving).

THEIR STORY

Trevor grew up on a farm in Coorow and moved to Bolgart in 1994 when he and his parents bought Waddi Park, which Trevor and his wife Renae have recently taken over managing.

They were aware that most of the farm had non-wetting problems and, in 1996, bought a DBS air seeder bar for furrow sowing. Unfortunately this wasn’t enough to combat the problem and with an increase in dry years the non-wetting problem became worse. Trevor first tried clay incidentally in 2001, after the neighbours dug out marron ponds and had some on offer. Trevor decided to spread it on the farm’s weakest soils.

‘We had to go over it three times with the mulipsreader to get 90t/ha,’ Trevor said.

With around 80 per cent of the farm having nonwetting issues Trevor turned to the services of a contractor for greater efficiencies (e.g. 250 t/ha in one pass). He also tried incorporating clay with offset discs; however this incorporation method seemed to create a constraint in the topsoil.

‘Plant roots would grow vigorously until about 100 mm due to additional clay, but then hit sand causing the crop to drought off,’ Trevor explained.

He added, ‘Claying is a pricey job [~$900/ha], especially when there is a lot to be done, so you want to do it right.’

Knowing that the application of clay was not as straightforward as one would think, Trevor sought funding in 2010 through Wheatbelt NRM’s Soil Conservation Incentive Program (SCIP). With this financial support he hoped to uncover a better method for spreading and incorporating clay.
**THE TRIALLING PERIOD**

With the help of the Western Australian No-Tillage Farmers Association (WANTFA) a uniform site was selected for a replicated trial in a paddock where Trevor had already intended to spread and spade clay. During the contracted spreading operation two rates of clay (260 t/ha and 520 t/ha) were spread (5 m wide) randomly in three 80 m long runs. Three runs with no clay were also included to act as controls.

Utilising owned and hired implements (offset discs, rotary hoe and spader) Trevor then incorporated the soil at a right angle to the spreading runs at different speeds.

**Table 1: Average yield (t/ha) results representing most of the treatments**

<table>
<thead>
<tr>
<th>Clay rate</th>
<th>Incorporation method</th>
<th>2010 Wheat</th>
<th>2011 Wheat</th>
<th>2012 Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil (0 t/ha)</td>
<td>Nil</td>
<td>0.7</td>
<td>2.0</td>
<td>0.55</td>
</tr>
<tr>
<td>260 t/ha</td>
<td>Nil</td>
<td>0.5 (-0.2)</td>
<td>1.6 (-0.4)</td>
<td>0.2 (-0.35)</td>
</tr>
<tr>
<td>520 t/ha</td>
<td>Nil</td>
<td>0.5 (-0.2)</td>
<td>1.7 (-0.3)</td>
<td>0.2 (-0.35)</td>
</tr>
<tr>
<td>260 t/ha</td>
<td>Offset Discs</td>
<td>1.0 (+0.3)</td>
<td>2.5 (+0.5)</td>
<td>0.8 (0.25)</td>
</tr>
<tr>
<td>260 t/ha</td>
<td>Rotary Hoe</td>
<td>1.4 (+0.7)</td>
<td>2.7 (+0.7)</td>
<td>0.55 (+0.0)</td>
</tr>
<tr>
<td>260 t/ha</td>
<td>Spader</td>
<td>1.4 (+0.7)</td>
<td>3.2 (+1.2)</td>
<td>0.9 (+0.35)</td>
</tr>
<tr>
<td>Bulk paddock 260 t/ha</td>
<td>Deep ripped and Spader</td>
<td>1.8</td>
<td>3.6</td>
<td>1.1 (+0.55)</td>
</tr>
</tbody>
</table>

**Table 2: Yield monitor readings (t/ha) for nil, spader and mouldboard plough with no additional clay application**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>0.15</td>
<td>0.70</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Spader</td>
<td>0.40</td>
<td>1.50</td>
<td>*</td>
<td>1.20</td>
</tr>
<tr>
<td>Mouldboard plough</td>
<td>0.50</td>
<td>2.70</td>
<td>2.90</td>
<td>1.50</td>
</tr>
<tr>
<td>Growing season rainfall (Apr–Oct)</td>
<td>178 mm</td>
<td>403 mm</td>
<td>188 mm</td>
<td></td>
</tr>
</tbody>
</table>

*No yield recorded as the spaded area was sprayed out due to weeds

NB. Where 250 t/ha of clay was added and spading was used for incorporation, yields of 1.41 t/ha and 4.60 t/ha was recorded respectively on sand and gravel areas of the paddock in 2010.

The Symes found (as shown in Table 1) that the rotary hoe and spader were better at dispersing the clay evenly through the soil profile, and in turn achieved the greatest production through better water availability. The treatment of the bulk area of the paddock also proved the added value of deep ripping. For example the 260 t/ha clay rate incorporated by the spader had a yield benefit of 0.7 t/ha versus 1.1 t/ha when deep ripping occurred prior to incorporation in the dry 2010 season. This yield advantage was also proven in the wet 2011 season and the 2012 season.

In a neighbouring paddock across an area with shallow clay, a mouldboard plough was hired to see if this cheaper alternative to claying could reduce the non-wetting problem.

‘I found it was less effective than spading clayed country and was sometimes damaging in sandy soils,’ Trevor mentioned. ‘I’ve learnt if the clay is deeper than 250–300 mm it needs to be dug up and spread before incorporation.’

‘The project has confirmed in my mind the viability of claying and has taught me that the method of incorporation is more important than the actual amount and spreading of the clay …’

Trevor Syme
The project has been a valuable experience for the Syme family. Without the funding from Wheatbelt NRM and support from WANTFA and the Department of Agriculture and Food, they wouldn’t have been able to explore the issue of non-wetting soils to such a degree. For example, the project drew Trevor’s attention to how soil nutrition and weed burdens change after soil is incorporated. Even more importantly other interested farmers facing similar problems with non-wetting soil had the opportunity to visit the Syme’s farm to see the results first-hand.

‘The project has confirmed in my mind the viability of claying and has taught me that the method of incorporation is more important than the actual amount and spreading of the clay,’ Trevor said.

FURTHER AREAS OF INVESTIGATION

Although the Symes have learnt a lot during this project, when it comes to addressing the big issue of water repellence there is much ‘untrodden ground’.

In 2012 Trevor trialled a new method to battle non-wetting soils. Trevor used a delver of his own design that was manufactured by a local Goomalling engineering firm. The Delver is used to bring clay to the surface.

Trevor explained, ‘By using this technique the spreading, smudging, ridging and deep ripping machinery operations shouldn’t be necessary, reducing the cost to around $350/ha.’

To help decide where it is most appropriate to use this technique Trevor has engaged Precision Agronomics Australia to survey 1300 ha of his land using Gamma and Electro Magnetic technology.

‘If the clay is not detected within 700 mm of the surface, I would have to spread clay as the delver wouldn’t reach it,’ Trevor said.

Trevor is currently trying different rates of lime and gypsum prior to delving. With the help of WANTFA’s Researcher Manager Dr Matthew McNee he is also investigating discs versus tynes in non-wetting soil.

ACKNOWLEDGEMENTS

- WANTFA: Jade Dempster and Lauren Celenza.
- DAFWA: Stephen Davies, Bill Bowden, Breanne Best and Craig Scanlan.
- CSIRO: Margaret Roper.
SOIL IMPROVEMENT

SOIL TESTING FOR LEVELS OF CARBON AND NITROGEN UNDER THREE LAND-USE REGIMES

PROJECT SNAPSHOT

Land Managers: Ian and Dianne Haggerty
Property size: 2000 acres
Location: Wyalkatchem
Annual rainfall: 200mm (5 year average)
Enterprise mix: 60% cropping, 40% sheep
Soil types: Light acidic (wodjil) sands; Morrel clay/loam; conglomerate gravels

KEY MESSAGES

• Preliminary findings suggest that the adoption of a biological farming system may have positive benefits for soil organic carbon storage when compared to a conventional farming system. However, further research is required to verify these findings.
• Improving soil structure can improve plant growth through enhanced water-holding capacity and water-use efficiency.
• To remain productive, soil fertility must be maintained. Farmers can enhance the fertility of their soil by adopting practices that stimulate biological activity thereby releasing nutrients that are important for plant growth and vigour.
• The C:N ratio of the soil can provide you with an insight into the nitrogen requirements of your crop.

THEIR STORY

Since 1994, Ian and Dianne Haggerty have been implementing an holistic and integrated program of broadacre, dryland cropping of cereal grains; cereal hay crops; and grazing with specially bred sheep for wool and premium grade fat lambs.

Their program is underpinned by their shared commitment to the regeneration of their property’s soil fertility. To achieve this they practice zero tillage, use biological fertilisers, such as worm juice and compost and have not used man-made phosphorus fertiliser for the last 10 years.

The Haggertys do not rely heavily on chemicals, instead adopting practices such as slashing paddocks with heavy weed infestations, maintain good levels of groundcover at all times and have adopted alternative grazing options (e.g. perennial fodder shrubs and sub-tropical grasses) to maximise soil moisture.

The Haggerty’s original property, Prospect Pastoral Co., lies on undulating semi-arid country in the north of Wyalkatchem, bordering on the Wallambin Salt Lake. When they first took over farming the land they were told by farm advisors to ‘get out’ before they got started, however this only challenged them to make a go of things. Initially, they implemented conventional best practice farming techniques around at the time but after a couple of dry seasons and declining production they realised the vulnerabilities of this farming system.

‘We observed cereal crops with shallow root systems, which contributed to poor growth particularly in short seasons,’ Di mentioned. ‘This made Ian and I want to know more about the limiting factors within the soil.’
Their ongoing pursuit of knowledge regarding soil health and productivity has lead the Haggertys to be involved with many Wheatbelt NRM projects over the years. The recent Soil Conservation Incentives Program gave them an opportunity to critically examine whether or not the practices they had adopted were having a demonstrable effect on soil quality. With the help of consultant agronomist, Andrew Wherrett of Living Farm, the Haggertys compared soil organic carbon and soil nitrogen within ‘biological farming’, ‘continuous cropping’ and ‘permanent pasture’ farming systems.

**THE IMPORTANCE OF THE CARBON: NITROGEN RATIO**

Regardless of where you are in the world, the soil microbial community is always searching for a C:N:P:S ratio of about 100:10:1.5:1.5. This is important for a couple of reasons:

1. It allows you to determine requirements for the breakdown of crop residues. Cereal crops have a high C:N ratio (60–90:1), therefore nitrogen is limiting when soil fauna and microbes try to break it down. Soil microbes as a community are much more competitive than a crop root at accessing that nitrogen and will take it before the plant has a chance to. This also explains why legumes provide nitrogen, they have a much lower C:N ratio.

2. In the period that you are increasing soil carbon storage, you will need more nitrogen inputs to maintain crop requirements. Once the upper limit has been reached, however, you will receive a larger N supply from the soil organic matter pool than previous. This is because you can assume a ball park figure of receiving 1–2% of the total soil nitrogen pool in any given year (e.g. if there is 20t/ha of soil nitrogen then you should get between 20 and 40kg/ha of N released from the organic matter).

NB. There is no statistically significant difference between nitrogen stock for biological farming and permanent pasture farming systems.

NB: There is no statistically significant difference between carbon stock levels for the continuous cropping and the permanent pasture farming systems.
THE FINDINGS
The graphs on the previous page show the difference between the farming systems for soil carbon storage and soil nitrogen storage at depth increments of 0–10 cm, 10–20 cm and 20–30 cm.

LESSONS LEARNT
Over the years the Haggertys have come to recognise the value of many practices such as using biological fertiliser and zero tillage to improve soil health and capture of soil organic carbon.
They have also benefited from revegetation, using fodder shrubs to limit the spread of salinity and stabilise soils, whilst increasing productivity for grazing.

LEGACY
Ian and Dianne will continue to implement biological farming practices on their family farm as they believe their crops are healthy despite meagre growing season rainfall, which can be as little as 100 mm.

The Haggertys believe that the increased microbial activity and associated improvement in soil structure that have resulted from Biological Farming principles are maximising the retention of soil moisture. (Dianne Haggerty, personal communication).

‘Farmers must be prepared to try things that might not necessarily work—we are having success now, but we also have had many failures along the way…’

Dianne Haggerty

There are many other aspects of their biological farming system the Haggertys would like to understand further.

It is only through continually testing and refining the biological farming system to suit local conditions that real improvements can be made towards reducing fertiliser usage and increasing soil carbon.

ACKNOWLEDGEMENTS
Dr Andrew Wherrett (Consultant Agronomist, Living Farm).
PROJECT BACKGROUND

For carbon sequestration, soil makes sense. It is the largest store of carbon on earth—larger than the atmosphere, biosphere and hydrosphere. A small increase in soil carbon across large areas has the potential to make a massive difference to atmospheric carbon. That is why there is so much interest in soil carbon sequestration, and encouraging farmers to change management strategies to improve soil carbon is one method of doing that.

But why is it so difficult to increase soil carbon in the Avon River Basin? Not only are soil type and climate major limitations to increased soil carbon storage (see How Much Carbon Can Soil Store factsheet at www.soilquality.org.au), but management practices like traditional summer weed control strategies may also be having a negative influence.

KEY MESSAGES

- Topsoil (0–10 cm) carbon has largely declined over the last five years in the Avon River Basin.
- High soil temperature and soil moisture during summer promotes increased microbial activity and organic matter breakdown.
- Summer active cover provides an important source of carbon during wetter conditions, with current weed control practices limiting the soil of a future carbon source.
- Detailed knowledge of preceding climatic factors are an important consideration for temporal measurement of soil carbon.

THE PROJECT

Soil was collected from 107 sites on farms throughout the Avon River Basin as part of a project to assess the capacity for change in soil carbon storage. Each of these sites were sampled previously between 2006 and 2008 as part of the W.A. ‘Soil Health Programme’ providing a unique dataset for the region.

Along with a range of other soil quality indicators, soil carbon stock was measured using a combination of bulk density and total carbon measurements.

SOIL CARBON LOSS?

The data collected in this project suggests a significant decline in topsoil carbon has occurred since the previous sampling times between 2006 and 2008 (Figure 1).

While some sites indicated an increase in soil carbon, those sites that showed major declines were particularly evident in soils that initially had relatively high carbon content. This change in carbon could be attributed to a combination of climatic factors and management changes over this period.

Detectable changes in soil carbon generally occur over longer time periods (e.g. > 10 years), so this result is surprising—and has potential implications for measurement protocols for ongoing audits.
ARE CURRENT MANAGEMENT STRATEGIES AFFECTING CARBON STORAGE?

Overall, the shifts in management over recent years are likely to favour conditions that result in a reduction in carbon storage. The drop in livestock profitability and therefore a subsequent shift away from pasture systems is likely to have contributed to an overall decline in soil carbon, however other factors appear to be influencing this change.

SUMMER WEED CONTROL

The push towards increasing cropping production benefits by preserving soil moisture from summer rainfall events particularly in the eastern Wheatbelt, means summer weed control has become a large part of many farms annual management cycling. This leads to paddocks having very little active cover during these months and removes this as a potential carbon input source.

WINTER FALLOWING

Decreased reliability of winter rainfall has seen many farmers adopt winter chemical fallowing for moisture conservation, and as a means of reducing investment risk over multiple seasons. While volunteer crops and weeds are allowed to grow during the winter season, herbicides are used to prevent seed set and reduce moisture loss. Anecdotal evidence suggests some farms have up to 20% of paddocks under chemical fallowing at any one time. Figure 3 shows the increase in chemical fallowing over the last ten years across the sites sampled in this project.

WHAT DOES THIS MEAN?

The control of summer weeds and high 2011/12 summer rainfall are likely to have contributed to the decline in topsoil carbon levels, as the resulting soil conditions may favour carbon losses due to:

1. Microbial activity increases significantly at higher soil temperatures. Organic nitrogen mineralisation has been found to be favoured over immobilisation, increasing the chance of leaching or gaseous loss. The same may be the case for carbon.

2. If allowed to grow, weeds will decrease topsoil moisture much quicker than evaporation. This will decrease the time period that soil microbes are active for, and therefore decrease total CO2 production.

3. The roots of weeds not only exude simple carbon compounds for soil microbes while growing, but will also leave behind a plant full of carbon for breakdown once it has died.

4. While microbes are not as active during winter, chemical fallowing during the growing season will still contribute to organic matter breakdown through retained topsoil moisture.

The research behind this factsheet is only the beginning of understanding how current management practices in the Avon River Basin might influence soil carbon storage. There is, however, a strong indication that high summer rainfall followed by weed control practices may increase the chance of carbon loss from cropping soils. This is particularly important given the observed increase in summer rainfall across the region. This suggests further work is needed to identify innovative management practices that maintain summer cover, while optimising yields in the subsequent crop.

ACKNOWLEDGEMENTS

Prof. Daniel Murphy (UWA) and Dr Andrew Wherrett (Living Farm Pty Ltd).
SOIL IMPROVEMENT

SIFTING THROUGH THE ‘GREY AREAS’:
LEARNING MORE ABOUT ALTERNATIVE FERTILISER OPTIONS

KEY MESSAGES

- Alternative fertilisers are still highly speculative for broadacre agriculture because little independent research has been conducted.
- Long term replicated trials are needed to better understand the impact of alternative fertiliser on crop growth and performance.
- After a one year trial, the LCDC have found ‘conventional’ and ‘conventional’ + manure fertiliser options the best for growing wheat.

CONTINUING THE GOOD WORK

The Quairading Land Conservation District Committee (LCDC) was formed in 1985 over concerns of salinity and erosion in the district. In 2011, the Quairading LCDC developed a strategic plan to achieve direction and motivation towards their key priorities in Natural Resource Management. The LCDC priorities are water, biodiversity, land, people and their community, and organisational capacity.

With the help of funding from Wheatbelt NRM, this not for profit organisation took part in the Soil Conservation Incentives Program to assist the group to trial alternative fertilisers for broadacre agriculture. The products used included compost, manure, worm juice and an Australian Mineral Fertilizers compound product.

This sustainable agriculture focused trial was designed to benefit farmers in the Quairading district by attempting to address the ‘grey areas’ surrounding the topic. The trial was developed in collaboration with a York-based consultancy Living Farm to explore alternative cropping inputs that were perceived to have an influence on soil health.

‘Soil health is an essential part of all farming landscapes. Our goal is to ensure landholders have access to information and research that covers an array of techniques from alternative to conventional…’

Rowlie Mellor (Quairading LCDC Secretary and Treasurer).
Table 1: The fertiliser treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control</td>
</tr>
<tr>
<td>2</td>
<td>‘Conventional’ 100 kg/ha Gusto Gold</td>
</tr>
<tr>
<td>3</td>
<td>Compost 2t/ha</td>
</tr>
<tr>
<td>4</td>
<td>Manure 2t/ha</td>
</tr>
<tr>
<td>5</td>
<td>Worm Juice 10L/ha</td>
</tr>
<tr>
<td>6</td>
<td>‘Conventional’ + Worm Juice 10L/ha</td>
</tr>
<tr>
<td>7</td>
<td>‘Conventional’ + Manure 2t/ha</td>
</tr>
<tr>
<td>8</td>
<td>WMF NPK Crop Plus (100 kg/ha) with microbes (750 g/1000 kg/seed) + oil (4L/1000 kg/seed)</td>
</tr>
</tbody>
</table>

THE TRIAL

The replicated ‘alternative fertiliser’ trial was set up in 2012. Each plot was 12 m long by 1.83 m wide. See Table 1 for a description of the treatments used. All treatments (except Worm Juice, applied 31st May) were applied at seeding with Cobra wheat, sown on the 20th of May at a rate of 75 kg/ha. Table 2 gives a breakdown of the nutritional make-up of each of the fertiliser treatments.

NB. Data was statistically analysed to understand the effect treatments had on wheat yield and quality, as well as soil nutrient changes in the first year.

Table 2: Nutrient concentration of each treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N%</th>
<th>P%</th>
<th>K%</th>
<th>Ca%</th>
<th>S%</th>
<th>Mg%</th>
</tr>
</thead>
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These results and other observations are explained in more detail below:

- ‘Conventional’ 100 kg + Manure 2 t had significantly higher crop vigour than all other treatments.
- Assessment of crop vigour in September also found ‘Conventional’ fertiliser 100 kg/ha and ‘Conventional’ 100 kg + Manure 2 t to have significantly higher crop vigour than the untreated control.
- It was observed that the protein concentration of ‘Conventional’ 100 kg + Manure 2 t was higher than all other treatments.
- Composite soil samples collected post-harvest showed Manure 2 t had a higher concentration of ammonium, nitrogen and sulphur and Compost 2 t had high nitrate nitrogen. Gross margins of treatments containing conventional fertiliser were much higher than other treatments.

**TRIALLING INTO THE FUTURE**

The group intends to continue testing each trial plot for a number of years so they can gain a more comprehensive perspective about the long term effects of the alternative fertilisers used in this project.

As Living Farm research agronomist Richard Devlin explained, ‘Compost and manure based fertiliser may take a longer time to break down and release nutrients that are available to the plants, inhibiting the ability to compare it to conventional or AMF fertilisers in the first year of application.’

Obviously different results may occur under different seasonal conditions and so multiple season will help to test whether conventional fertiliser alone and also with the addition of manure are still the most successful options over the long term.

**If you are interested in viewing the complete set of results from this trial, a report written by Living Farm Research is available through the Quairading LCDC, phone Rowlie Mellor on 9645 1439.**
REFERENCES


Weaver DM and Summers RN (2013). ‘Nutrient status (phosphorus)’. In: *Report card on sustainable natural resource use in agriculture*, Department of Agriculture and Food, Western Australia.

The health of our soils underpins the success of the Western Australian Wheatbelt’s agricultural industry, covering almost 6.6 million ha of the Avon region and contributing 50% ($3.1b per annum) of the region’s GDP.

This guide has been developed to present some of the approaches Wheatbelt farmers are taking to address soil health issues in the Avon region of WA. The guide summarises some of the key soil health issues facing our region and findings from the Wheatbelt NRM Soil Conservation Incentives Program (SCIP), which saw over $4 million of funding from the Australian Government invested between 2009–2013 in over 150 on-farm projects that explored innovative and sustainable land management approaches.

The guide includes 24 case studies that present different grazing, cropping, agroforestry and soil management practices that Wheatbelt farmers have explored through the program. This booklet is not intended to be an exhaustive guide, but provides a great introduction to the range of options available to farmers to improve the health of their soils and boost productivity. These are presented in an easy to read and practical format, with farmers and industry experts sharing the lessons they have learnt when addressing soil issues on farm.

“THE NATION THAT DESTROYS ITS SOIL, DESTROYS ITSELF.”

FRANKLIN D. ROOSEVELT