DEVELOPMENT AND APPLICATION OF PASTURE CROPPING BY FARMERS IN NORTH EAST VICTORIA

Trials by the Gecko CLaN

This book is a record of the Pasture Cropping project funded by the Federal Government's Caring for our Country initiative and coordinated by the following committee members.

Chairperson: David Dore
Project Officer: Jacci Campbell
Landcare Project Officers: Charlie Sexton, Dave Cleeland and Kerri Robson

Cam Barrett-Lennard, Tony Burke, Russell Ellis, Bob and Marj Falconer, Bill Hill, Doug James
Kevin Mitchell & Belinda Steers

Acknowledgements

The contents of this booklet resulted from the 'Pasture Cropping Project,' funded by the Federal Government's 'Caring for our Country' initiative and coordinated by the following steering committee members of the Broken Catchment Landcare Network (Gecko CLaN):
Project Officer: Jacci Campbell
Landcare Project Officers: Charlie Sexton, Dave Cleeland & Kerri Robson
David Dore (Chair)
Cam Barrett-Lennard
Tony Burke
Russell Ellis
Bob and Marj Falconer
Bill Hill
Doug James
Kevin Mitchell
Belinda Steers

The Gecko CLaN wishes to thank the following people and organizations for their contributions towards the project and this publication:

<u>Trial Participants:</u>
Cam and Kathy Barrett-Lennard,
Tony and Trish Burke,
David Dore,
Russell and Helen Ellis,
Bob and Marj Falconer,
Doug and Steve James,
Kevin and Pat Mitchell and
Belinda Steers and Mark Goodman

<u>Members of the Pasture Cropping- No Kill Cropping Company:</u>
Colin Seis: Gulgong NSW
Bruce Maynard: Narromine, NSW
Angus Maurice: Wellington NSW

<u>Presenters:</u>
Colin Seis
Dr Ash Martin: Creation Innovation Agriculture and Forestry Pty Ltd, St. Marys, SA
Dr Christine Jones: Founder- Australian Soil Carbon Accreditation Scheme (ASCAS), Armidale NSW
Graeme Hand: Holistic Management Training, Branxholme Victoria

<u>Gecko CLaN would also like to thank the following for their contribution to the project:</u>
Cath Botta
Don Cook – Farmright [Kyabram]
Alan Johns [Elmore], Konigs [Shepparton], Farm Tech [Wodonga] and Agroplow [Colin Hercott].
John Moore: Permanent Memories
Native Seeds Pty Ltd
Smyth Seeds [Benalla]
Goulburn Broken Indigenous Seedbank

FOREWORD

This book summarises progress by the Broken Catchment Landcare Network (Gecko CLaN) in developing pasture cropping as a technique for application on our farms. The results raise as many questions as they answer, and we look forward to continuing the Pasture Cropping project thanks to the support of a third grant from Caring For Our Country and the support of the Goulburn Broken Catchment Management Authority.

We have been delighted with the response of a diverse group of farmers who have found that the technique offers something to their farm businesses.

The project has also stimulated interest in the benefits of retaining and managing native grasses, and has enabled us to get to know some of these species.

Not withstanding the calibre of the presenters at our field days and presentations, one of the best outcomes of the project has been the encouragement and open exchange of information between farmers. Thanks go to Gecko CLaN, and our Landcare facilitators Kerri Robson and Dave Cleeland, supported by staff from Goulburn Broken Catchment Management Authority, in particular Charlie Sexton and Tony Kubeil, for creating the situation where this could happen.

Finally, the biggest thanks must go to Jacci Campbell, the project officer for this project, who continues to bring a great level of commitment to finding solutions for farmers to improve both their farm business and the health of the landscape.

We hope that you will be encouraged to apply some of these ideas on your farm!

David Dore
Chair

Doug James

Marj and Bob Falconer

Dave Dore

Back Row: Dave Cleeland, Tony Burke, Cam Barrett-Lennard, Bill Hill, Kevin Mitchell, Russell Ellis
Front Row: Belinda Steers, Kerri Robson and Jacci Campbell.

SOILS FORUM PROGRAMME

WHAT IS GOING ON IN YOUR SOIL?

UNDERSTANDING YOUR GREATEST ASSET

MONDAY 21ST NOVEMBER 2011 AT

BENALLA LAKESIDE COMMUNITY CENTRE

PROGRAMME:

9.00 – 9.30	**REGISTRATIONS**
9.30 – 9.45	**WELCOME**
	BOOK & VIDEO LAUNCH – MURRAY CHAPMAN
9.45 – 10.30	**COLIN SEIS – CHANGES TO SOILS AT WINONA**
10.30 – 11.00	**MORNING TEA**
11.00 – 11.30	**CASE STUDIES**
11.30 – 12.30	**CATH BOTTA – WHAT CAN CARBON DO FOR YOUR SOILS?**
12.30 – 12.45	**CHARLIE SEXTON – CARBON FARMING INITIATIVE**
12.45 – 1.30	**LUNCH**
1.30 – 2.00	**CASE STUDIES**
2.00 – 2.30	**DR BRUCE COCKROFT – SUPER SOILS – WHAT CAN YOU DO TO IMPROVE SOIL STRUCTURE?**
2.30 – 3.00	**AFTERNOON TEA**
3.00 – 3.45	**DR ASH MARTIN - UNDERSTANDING YOUR SOIL MICROBIOLOGY TESTS**
3.45 – 4.15	**QUESTIONS & ANSWERS**
4.15 – 4.30	**WHERE TO FROM HERE/CLOSING REMARKS**
4.30 – 5.30	**DRINKS & NIBBLES**

CONTENTS

PASTURE CROPPING PROJECTS IN THE BROKEN CATCHMENT

In 2003 two local landholders attended the Stipa Native Grasses Conference at Cooma to learn more about managing native grasses which had proved resilient in the drought of 2002. They also attended another Stipa conference at Burra in South Australia in 2005 where the concept of Pasture Cropping was presented by Colin Seis. As a result they convinced the Farm Table Discussion Group, a joint project run by the Goomalibee and Sheep Pen Creek Landcare groups, to invite Colin to speak at the Caniambo Hall in November 2007.

Rosie Sheather [Landcare Facilitator for the Goulburn Broken Landcare Network] attended a Pasture Cropping Field Day in the Culcairn region and came away very impressed. She initially organized a seminar at Glenrowan football grounds, featuring both Colin Seis and Peter Andrews. This day appealed to dryland and higher rainfall area farmers alike and over 100 people travelled from far and wide to attend. Due to interest generated from this day, Rosie then organized a two day Pasture Cropping and No Kill Cropping course at Doug James' shearing shed at Bungeet in March 2008. Rosie obtained a grant from the Goulburn Broken Catchment Authority which subsidized the cost of bringing the presenters, Colin Seis and Angus Maurice, from New South Wales. 18 producers attended this course and several have been the backbone of the following projects. She also obtained a substantial CFoC grant to fund the first stage of the Pasture Cropping project referred to below.

Gecko CLaN funded a presentation by Colin Seis and Meredith Mitchell in Benalla in August 2008, followed by a bus tour in October of that year to several properties, including Colin Seis' property in Gulgong, NSW. The interest in both these events was the catalyst for initiating Project 1: 2008-2009: Profitable, sustainable cropping and grazing systems using Pasture Cropping Principles.

Activities held during this project included:

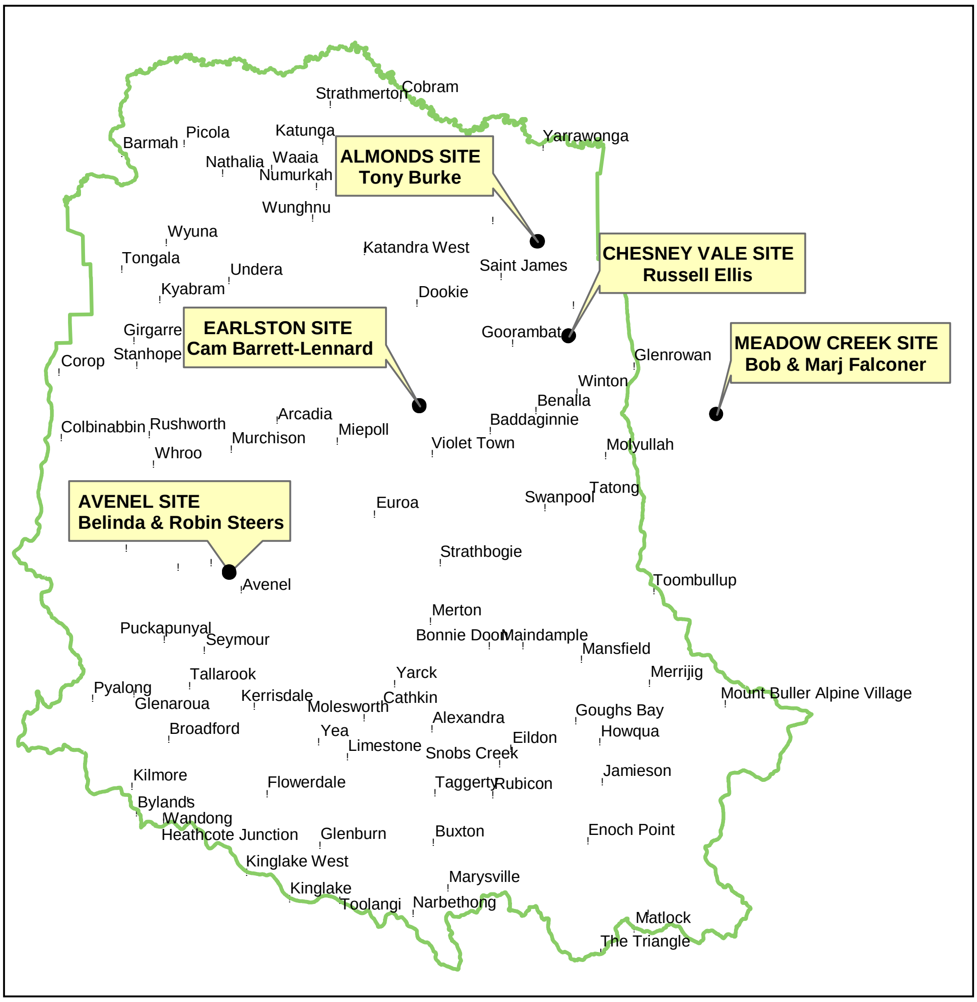
- **Farm Walk: Opportunity for participants to visit a trial site.**
- **Soil Testing on Trial Sites in December 2008**
- **Soil Food Web test and site inspection by Gerhard Grasser of Agrisolutions in August 2009**
- **Two Advanced Pasture Cropping and No Kill Cropping Courses: These two day courses were held in Warrenbayne and Thoona.**
- **Bus Trip: A visit to 'KoWarra Seeds', near Echuca to discuss the production of native pastures.**
- **Discussion Forum: Trial participants participated in this forum held in Benalla.**
- **Field Day: 'Soil Health and Monitoring Pasture' Guest speakers: Sonia Lee and Graeme Hand**
- **Field Day: 'Improving Biodiversity and Monitoring Soils' Guest speakers: Christine Jones and Colin Seis. Also included field walks and trial participant presentations.**
- **Production of a 'Pasture Cropping' DVD.**

In 2009 a second project entitled “Improved Soil Organic Carbon and Ground Cover using Pasture Cropping Principles” was successful in receiving a Caring for Our Country grant.
The Gecko CLaN oversees the project with an executive member as chairperson of the Pasture Cropping Committee. This committee is comprised of farmer members, trial participants, Landcare Project Officers and a Pasture Cropping project officer employed by the Gecko CLaN. This committee meets bi-monthly. This project has built on the work done in Project 1.

Activities held during this project included:

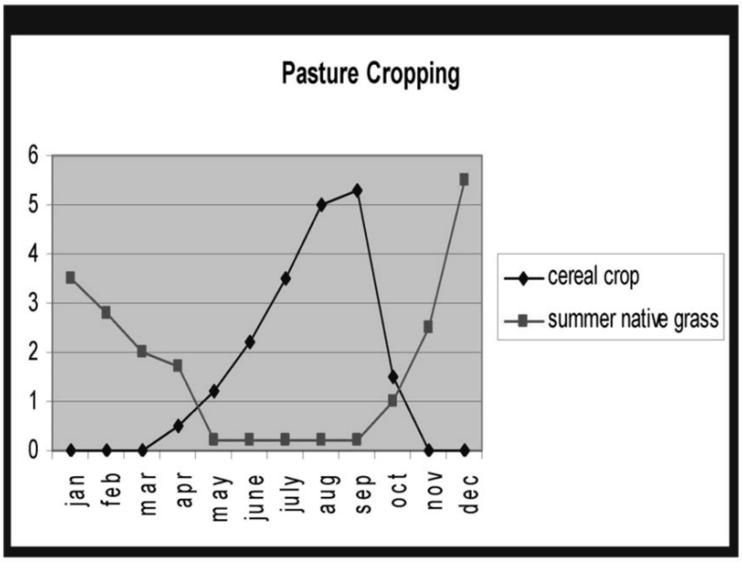
- **A farm machinery field day at Benalla**
- **An Introductory 2 day Pasture Cropping Course at Euroa**
- **2 grazing management field days at Violet Town and Lake Rowan**
- **A field day at Avenel**
- **13 on farm consultations with Colin Seis**
- **A soil microbiology seminar at Warrenbayne**
- **A bus trip to 4 of our trial sites**
- **A grazing management field day with Graeme Hand**

The five new trial sites that have been established were chosen to provide a site that was relevant to most areas within the Gecko CLaN’s area. They vary with soil type, topography, rainfall and previous land use.



WHAT IS PASTURE CROPPING?

Pasture Cropping is a technique of sowing zero-till annual crops directly into living perennial pastures. Generally winter cereal crops are sown into summer-growing native perennial pastures. The pasture can be grazed right up to the point of sowing and the stock can be put back on the pasture after harvest to graze stubble and green perennial grasses. Using this technique cropping and grazing are combined into one land management system and each enterprise enhances the other both economically and environmentally.



The guidelines for Pasture Cropping are:

- Never Plough!
- Never kill perennial species.
- Perennial pastures can be native or introduced - better results are achieved from native grass species.
- Weeds are controlled by creating large quantities of thick litter and by using correct grazing management of livestock.
- Weeds can also be controlled with very careful herbicide use.

Colin Seis and Daryl Cluff are the pioneers of Pasture Cropping in Australia. Studies of Pasture Cropping on Colin's property have shown that sowing a crop into native perennial pastures actually stimulates the native seedlings to grow. The consequent greater tonnes/hectare of plant growth provides more stock feed after the crop is harvested. Up to six months' extra grazing can be achieved in comparison to traditional cropping methods where there is loss of grazing due to ground preparation and weed control. A three year trial was conducted by the CSIRO on Colin Seis' property in Gulgong NSW which showed positive outcomes in water use efficiency, weed control, nitrogen use efficiency and soil health (Bruce et al., 2005). Pasture Cropping is now being practiced throughout Australia as well as in USA and Scandinavia with good results.

"It should always be remembered that pasture cropping is a restoration technique. As well as growing crops, importance should be placed on using the technique to improve soil health including structure, nutrient cycling and increasing soil carbon." *Colin Seis February 2011*

ACTIVITIES

1. Farm Machinery Field Day

The Field day that was held at David Dore's property in February 2010, was well attended and highlighted the issues with many of the machines that are on the market and for the need to be careful in selecting an appropriate machine if you wish to get the best results from Pasture Cropping. The spacing between the rows should be at least 8 inches, preferably 12, and the machine needs to be able to deal with trash. Disc machines can deal with more trash than tynes and are more suitable for use in existing perennial pastures. Tynes provide greater soil disturbance and are better when you are requiring recruitment of grasses. The purpose of the day was to explain how to sow grain and native seed into an existing pasture. Pasture cropping can successfully retain perennial grasses and ground cover while still producing profitable cropping and grazing compared with continuous pasture.

Colin Seis, who first tried this method in the 1990s at Winona near Gulgong NSW, was present to explain the necessary steps that are needed to optimize success. Various machines were on site to compare their suitability for different conditions. Alan Johns from Elmore provided valuable information regarding the conversion of existing machines to be suitable for Pasture Cropping. One of the major differences is the need to plant at a wider spacing than conventional cropping so that the crop gets a good start. The pros and cons of dry sowing were also discussed.

Participants listen to Colin Seis speak on the benefits of the John Shearer disc machine at the Demonstration field day in February 2010

2. Introductory Course at Euroa

The Gecko CLaN as part of their Pasture Cropping Project provided 19 farmers with the opportunity to learn about Pasture Cropping and No Till Cropping principles and techniques at a 2 day course held in Euroa in April 2010 by the Australian Pasture Cropping Company.

This practical course covered the theory and practice of both Pasture Cropping and No Kill cropping. The course was presented by Colin Seis and Bruce Maynard and showed how to slash the cost of production of cropping operations, how to gain crop income from livestock operations, as well as improving grazing techniques.

Some of the topics covered in the course were:

. Pasture cropping principles
. No kill cropping (Advance sowing) principles
. Economic Analysis
. Cutting pasture establishment costs
. Improving grassland and soil health
. Grazing management and techniques
. Best management of native grasslands
. Farm planning for perennial profit
. Holistic integration of grazing/cropping and natural resources.

3. Grazing Management Field Days

Two very successful grazing management days were held at Violet Town and Lake Rowan on 5th and 6th July 2010 with Colin Seis and Graeme Hand doing the presentations. It is very important to the success of Pasture Cropping that good grazing management is practiced as the two components of Pasture Cropping – grazing and cropping - must be understood and managed for their mutual benefit. 67 farmers from nearby areas attended. Following lunch on each day we visited one of our trial sites – Cam and Kathy Barrett-Lennard's at Earlston and Tony and Trish Burke's at Almonds - where practical exercises in observing pasture and soil conditions took place.

4. Advanced Pasture Cropping Course

Nine members of the Gecko ClaN Pasture Cropping group attended the 2 day Advanced Pasture Cropping Course - Cropping Solutions in a Changing Climate on 6th -7th-8th October 2010 in Central West NSW. The course was delivered over 3 days at Col Seis, Angus Maurice's and Bruce Maynard's properties at Gulgong, Wellington, and Narromine. This event allowed us the opportunity to see the machinery, livestock and crops on each property. It re-enforced the message that there is no one answer and that you are the best person to make the right decisions for your farm.

Topics that were covered in the course included an in-depth look at grasslands, strategies to improve results with Pasture Cropping, decision making and analysis tools, machinery choices, paddock evaluation, crop selection and sequencing for maximum production, strategies for improving water use efficiency and the benefits of trees and shrubs on farms for stock shelter, biodiversity and carbon storage.

Oat crop at Colin Seis' farm.

Angus Maurice's crop.

Saltbush at Bruce Maynard's farm.

5. Field Day at Avenel

Can Pasture Cropping work for you?

Pasture Cropping is a cropping system that works with grassland without destroying it. It is an ideal system for use in a mixed grazing and cropping enterprise as animals are an integral part of the system. Crops are sown into an existing pasture without killing the existing plants – animals are used to heavily graze the pasture prior to sowing rather than using a herbicide. The crop is direct drilled using tynes or coulter discs at a wider spacing than in conventional cropping. The crop yield may be less than traditional cropping but there are added benefits of greater continual biomass and improved sequestration of carbon in the soil. There are no pasture re-establishment costs and, with lower input costs, it may be a system for your enterprise.

This field day was held at the Steer's property, Nagambie Road, Avenel on Friday October 22nd 2010. Colin Seis explained the necessary steps required for successful Pasture Cropping. After lunch a sowing demonstration took place using an Agroplow seeder and then time was spent at the Pasture Cropping trial site discussing the practical issues of Pasture Cropping.

Farmers inspecting the oats sown at the Steer's Trial Site at Avenel

6. On Farm Consultations with Colin Seis

The Gecko ClaN offered an opportunity for those who had completed the Introductory Pasture Cropping Course to meet with Colin Seis on farms on 22nd, 23rd and 24th October 2010 to discuss issues encountered with Pasture Cropping. Colin and Jacci visited all trial sites plus 4 other farms and met with 19 farmers. Colin also provided a written report to all the owners which contained advice on how to deal with the issues they had on their farms.

7. Soil Microbiology at Warrenbayne

A Soil Microbiology Seminar was presented (2nd February 2011) by Dr Ashley Martin, the Principal of Creation Innovation Agriculture and Forestry a microbiology laboratory service in South Australia where we have had our testing done.

Session 1 'An Introduction to Microbiology in Agriculture' covered what soil microbiology [Bacteria, Archaea, Fungi and other microbes] consist of, what they do and what influences their populations in agricultural systems.

Steps to managing microbiology outlined some of the strategic points needed to manage microbiology to increase agricultural profitability and sustainability.

This Session also covered:

- Why measure soil microbiology?
- What can microbiology do?
- How do you measure it and how do you sample?

After lunch Session 2 covered Stubble digestion and Session 3 analysed the test results from some of our trial sites and addressed issues raised in them.

62 participants attended and found the presentations very informative. There is so much going on in the soil and how we farm has a major impact on microbial populations.

Dr Ash Martin looking at soil at Warrenbayne

8. Bus Trip to Trial Sites

Dave Cleeland

March the 10^{th} 2011 saw quite a bit of rain falling around the district yet it failed to dampen the spirits of “Pasture Croppers” on the bus trip put on by the Gecko CLaN. A large coach was filled with participants old and new from across the state and even Tasmania!

Four of our trial sites were visited throughout the day looking at a range of issues regarding Pasture Cropping. At the Barrett-Lennard’s, participants were asked to focus on ground cover yet discussion was vibrant and enthusiasm high this early in the morning so a great deal was covered. We then called in to the Mitchell’s where we were treated to look at a brilliant Lab-lab, Millet and Cow-pea crop as well as Kevin’s converted International drill.

Ellis’ farm was next and discussion focused on native grass recruitment. Participants were thrilled to be able to identify countless species of native perennials. Falconer’s at Meadow Creek was the finale of the day with some flighty fillies and a rogue bull giving participants a thrill! There was yet another great example of Millet and Cow-peas and a passionate talk from Marj stressing what can be achieved even in the most trying circumstances with a little ingenuity.

A big thank you to Colin Seis for again offering expert opinion and advice, Colin Hercott for coming all the way from Pyramid Hill with his Agro-plow that added yet another facet to the day as well as our trial participants that opened their farms for the day - Cam Barrett-Lennard, Kevin & Pat Mitchell, Russell Ellis and Bob & Marj Falconer.

In Plot 2 at Cam and Kathy Barrett-Lennards at Earlston

9. Pasture Cropping Discussion Group session “Reading your pasture”

Dave Cleeland

The first day of spring was the perfect time to hold the initial Pasture Cropping Discussion Group session at Cam and Kathy Barrett-Lennard's property, Earlston and the weather certainly didn’t let us down.

“Reading your Pasture” was the topic of the day and who better than the CEO of Stipa, Graeme Hand, to delve into the mysteries of grazing management and pasture regeneration?

Graeme has been involved in the Pasture Cropping project and was keenly anticipated by participants as he was not only full of information but extremely entertaining.

The day consisted of a short presentation in Cam’s machinery shed (kindly cleaned out by Cam and Cathy!) and then a walk into a couple of paddocks including the Pasture Cropping Trial Site. It seemed a very valuable exercise as people broke into small groups and worked together to identify pasture species and indicators that reflected management options that were available. Graeme insisted that landholders could make grazing decisions simply by looking at the plants and soil surface as they tell a story as to whether the paddock is receiving enough recovery time to encourage perennial species and promote nutrient and water cycling through a composting litter layer.

Assessing pasture & surface soil conditions

10. Pasture Cropping Survey

PASTURE CROPPING SURVEY DECEMBER 2010 NAME [OPTIONAL]
DISTRICT

	YES	NO
QUESTION 1: Have you attended a PC Course? If Yes what year? If No would you be interested in attending a course?		
QUESTION 2: Have you attempted any Pasture or No Kill cropping? If No go to question 3 If yes go to question 4		
QUESTION 3: What are the reasons for not trying the technique?		
QUESTION 4: Did you use the Pasture Cropping or No Kill technique?	Pasture Cropping	No Kill
QUESTION 5: When did you sow?		
QUESTION 6: What seed did you sow?		
QUESTION 7: What area have you sown?		
QUESTION 8: What type of machine have you used?		
QUESTION 9: Did you use any herbicides? If Yes what type and at what rate?		
QUESTION 10: Did you apply any fertilizers? If Yes what type, when and at what rate?		
QUESTION 11: Has there been any recruitment of native grass species? If Yes, what species?		
QUESTION 12: Did you graze the crop? If yes, how many times, type of stock?		
QUESTION 13: Do you intend to sow any crop in 2011? If yes, What area, type of crop?		
QUESTION 14: Have you attempted to sow native grass seeds? If Yes, what are the results?		
EXTRA COMMENTS		

Thank you to the 63 respondents to the survey that was sent in January 2011.
The information has been very important to us.

Survey Results

The results:
Of the 63 replies 20 have not used the PC or No Kill techniques. Reasons included lack of appropriate equipment, inability to find contractors, no need for feed and still learning about the techniques.

The total area sown in 2010 is 4250ha and it is anticipated that 4200ha will be sown in 2011.

18 have used herbicides, mostly for the control of broadleaf weeds.

8 have not used any fertilizer when sowing and did not report any downside.

7 have not grazed the crop that they sowed.

28 have noticed recruitment of native grasses –particularly wallaby grass species.

From these replies it has shown that many of you are using the techniques and have also commented on the change in grazing management – in particular rotational grazing.

Bulk Density Testing May 2010

11.Visitors

European Union Agricultural Committee Delegates and Victorian Parliamentary Committee

Charlie Sexton

In May 2010 the Gecko ClaN was asked by the Federal Government to show our PC trials to a delegation from the European Parliament's Agriculture and Rural Development committee. We were honored to welcome two Irish Members of Parliament, one Romanian member and an agricultural advisor to the committee from Belgium. They are pictured below.

L to R: Jacci Campbell, Pasture Cropping Project Officer, Charlie Sexton, Landcare Project Officer, Rares Niculescu (Romania), Stephen McMillan (DFAT), Liam Aylward (Ireland), Russell Ellis, Andrew Ellis, Kerri Robson, Landcare Support Officer, Andreas Schneider (Belgium), EU Ag Committee advisor James Nicholson (Ireland) and Doug James.

The delegation was very interested in the concept of providing dual enterprises and the opportunity to sequester carbon at the same time. The European members were particularly interested in the erosion benefits through increased ground cover and the take up of perennial plants over summer. On a parting note they left with the words "we need to seriously look at this in the arid areas of Italy and Spain". What a pleasure to hear!!!

This visit complemented another visit that we have had from the Victorian Parliament's NRM and Environment Committee earlier in April where we gave evidence to their Inquiry into Soil Carbon Sequestration in Victoria on our PC project and the community model we have adopted.

Caring For Our Country Visit

On Tuesday 7 December 2010, Bill Woodruff, who was the Assistant Director of Australian Government Land &Coasts, Victorian division, visited Russell Ellis's property at Chesney Vale. It was a great opportunity to explain our Pasture Cropping project to him and to talk about funding issues.

PASTURE CROPPING

1. Pasture Cropping

Colin Seis

Reproduced with permission from Colin Seis

Pasture Cropping can be used for a variety of reasons:

- It can be used to produce good grain crops (80 - 85% of conventional yields) at very low risk.
- It can be used to produce winter or summer stock feed with a possibility of grain.
- It can be used to restore grassland function by increasing the numbers and diversity of perennial plants.
- It can be used to improve soil with poor structure.
- It can be used to improve the health and organic carbon levels of soil.

Pasture Cropping works better, in relation to crop yield and recruitment of perennial grass species, if the crop is sown into areas where there is some perennial grass species to regenerate. Further improvement to the property can be achieved by improving the species diversity and plant numbers in your pastures and encourage it to function like the original grassland.

Pasture Cropping Methods

With Pasture Cropping it is extremely important to focus on leaving the existing perennial plants alive. This is usually achieved with careful, selective herbicide use and correct zero till seeding equipment. When pastures start to function like grasslands and there is more surface litter and fewer weeds, it is possible to Pasture Crop with reduced herbicides or even no herbicides.

If crops are sown when the majority of the grass species are dormant or not actively growing it is usually not necessary to use a herbicide.

It is very important, if grass is high during the 2 or 3 months leading up to sowing the crop, that the pastures are grazed short to decrease the bulk of leaf material to prevent shading of the emerging crop. This grazing method also prunes roots which add organic matter to the soil and removes competition from the crop.

Grazing management is also very important to conserve moisture by managing annual weeds and more importantly to reduce the root mass of the perennial species, which will reduce competition as well as conserve moisture and reduce "nitrogen tie-up." This method is even more important where no herbicides are to be used. The paddock that is to be sown should be grazed short one or two weeks before sowing, herbicides can then be used to shut down the perennial plant, if necessary (enforce an early dormancy) as well as control weeds.

Slashing a paddock to reduce weeds and plant mass can be another option that works well if there are not enough animals or the paddock is too large to graze it effectively.However the loose plant material can create blockage problems with tine seeding equipment, but is usually not a problem with disc seeders or tine seeders with disc openers.

It must be noted that grazing short to deliberately advantage the crop is not the way plants should be normally grazed, where green leaf material is left on a plant to encourage fast plant recovery after the grazing event.

This technique is used specifically as part of the "Pasture Cropping" technique. *Colin Seis, 2011*

Where there is not any native glycine or lucerne present broad leaf weeds can be controlled by using a selective herbicide such as MCPA without killing grass species. It is recommended that you seek advice from an agronomist in your choice of herbicide but please tell him that the perennial grass species are not to be killed.

- **Do not use Roundup for summer weed control.** It will kill summer growing species if used while the plants are actively growing, it will also kill winter growing species like wallaby grass if used pre-sowing the crop.
- A better option of knock- down herbicide is Sprayseed or Gramoxone.
- Gramoxone is a cheaper option.

They usually will not kill, well-established perennial plants, but care needs to be taken with both these herbicides, and they can be dangerous to human health if not used correctly.

- If only broad – leaf plants are present use a broad – leaf herbicide. That usually will not affect most grass species.
- Start to think of weeds as potential litter.
- **<u>Remember</u>-seek agronomy advice on the use of herbicides, but inform the agronomist that you do not want any perennial plants killed.**

Timing of crop establishment

The timing of crop establishment is important. Sowing early is important to achieve good winter feed with the crop. Shutting down, but not killing the perennial plants with a herbicide (Sprayseed not roundup) is more critical at that time than it is in late April or early May where it may be possible to sow crops without herbicides because the summer growing perennial species have become dormant because of the cold weather conditions (frosts). However late sowing of forage cereal crops may not produce the quantity of winter feed that is required and the crop may not develop until later in the season.

In Victoria, where there are not many C4 summer growing perennial grass species the main times to sow crops to avoid competition from existing perennial plants are:

- Late spring (October- November) to sow summer forage crops. The winter growing C3 plants are slowing down and in some years may be dormant.
- Late summer (early to late February). The winter growing C3 pasture plants have not started to grow yet because the temperature is too hot. The main type of crop that can be sown at this time would be oats. Crops sown at both of these `times may not require a herbicide treatment if the pasture grass species are dormant.

  Crops sown at this time could be sown dry to get the crop up before the weeds but remember this is an element of risk in using this technique.
- Oats, barley, wheat, triticale, field peas, could all be sown after the autumn break from March – May but the paddock may require spraying with a herbicide to manage weeds and perennial pasture grass if they have germinated. Sprayseed or gramoxone are the better knock down herbicides to use at this time.
- When sowing a crop the addition of a legume will always benefit lighter soil.

The types of legumes that can be sown are cow peas in the summer and field peas in the winter. Both of these can be sown with another crop like millet or oats.

Note: *Cow peas require ground temperature to be 18 degrees at sowing.*

The crop should be sown with a zero till seeder, which creates as little soil disturbance as possible. Row spacing on the seeder should be 10 – 12 inch and over to decrease the chance of perennial grass removal, and weed germination.

The seeding rates should be whatever is normally used for your district and soil type, but for sowing forage crops, the rates are usually better if they are higher to give thicker plant density.

Fertiliser rates and type with the crop should be a rate that would be normally used with traditional cropping methods.

Pasture Cropping works better, in relation to crop yield and recruitment of perennial grass species, if the crop is sown into areas where there is some perennial grass species to regenerate.

Further improvement to the property can be achieved by improving the species diversity and plant numbers in your pastures and encourage it to function like the original grassland.

Improvement in perennial grass species usually happens within one to two years.

A Pasture Cropped paddock, Doug James October*2011*

Pasture Cropping without chemicals

Sowing crops organically using Pasture Cropping techniques is possible, but when paddocks are first Pasture Cropped organically there are some things to be aware of:

- Weeds in the crop will affect crop yield
- Low nutrient soil will not produce good crop yields.

There are some ways of controlling weeds and supplying nutrients to the crop organically.

Weed Control

- Sow a vigorous growing crop at a higher that usual sowing rate. This will create more competition for weeds. Crops like cereal Rye, triticale, oats, and barley are usually good for out-competing weeds.
- Sow the variety of crop at the recommended time (too late or early will give disappointing results).
- Create as little ground disturbance as possible, to reduce weeds.

- Sow with a seeder that will create very little soil disturbance. A seeder with 12 inch row spacing and very narrow points like knife points or disc seeders are both suitable.
- Sowing dry will allow the crop to germinate at the same time as weeds (This gives the crop the competitive edge over weeds).
- Excess nitrogen, in nitrate form, will encourage weeds.
- Ground cover and litter are the best way of controlling weeds. Create as much ground cover as possible by good grazing management and Pasture Crop into the litter.
- When Pasture Cropping into thick summer growing native grass species, wait until the grass has become dormant before sowing (around April- May).

Grazing Management

"Time control" grazing is a grazing method where the animals are combined into a larger mob, or mobs and rotated around a property, with the main purpose being, to give plants time to recover from being grazed. The time given to the grazing of any one paddock can vary from 2 to 14 days and that is used to calculate the rest period or the time given for the plants to recover.

It must be noted that a paddock should **not** be over-grazed otherwise individual plants can be killed by over-grazing.

The rest period should be varied with differing seasons. For example in a period of declining plant growth (a dry season or during winter) the rest period should be longer to give plants more time to recover from being grazed. It is usually better to give long periods of rest rather than short (100 – 120 days is usually better than 50 days).

It is important to remember the recovery time of the plants and the graze time of the plants when planning your paddocks and paddock numbers.

This type of grazing management encourages perennial species and discourages annual weed species and used in conjunction with Pasture Cropping will increase the speed of perennial grass recruitment.

Pasture Cropping will enable you to rest some paddocks longer in the winter by grazing forage crops (oats, barley etc.) and will also produce more winter or summer feed to enable you to "fatten" animals.

You should be aware that Pasture Cropping and "time control grazing" go hand in hand, and animals should be used to prepare a paddock to crop by mulching the grass on the paddock and controlling weeds. The other benefits such, as nutrient cycling by the animals, is another important advantage.

It is very important when using animals to prepare a paddock to Pasture Crop to be aware of the potential soil compaction that they can cause if they are grazing on wet soil. This problem becomes less as more surface litter and root mass is created.

These 2 methods, when used together will restore your property to functioning grassland; however it is important to use both techniques well, to achieve that result.

If the focus is placed on creating 100% groundcover 100% of the time, most things like reducing weeds and increasing perennial species happen fairly quickly.

Colin Seis, 2010

2. Machinery

“The Pasture Croppa”

Charlie Sexton & Bill Hill

We all have some whacky ideas now and then but how many of them produce our most handy tools? The minds of Bill Hill, Colin Seis, an unnamed engineer and a little ingenuity have produced the “Pasture Croppa”!!!

The "Pasture Croppa" is a versatile mounted "chisel seeder" which was made by combining an 18 run (9 ft) Connor Shea series 2 seeder with a 9 tyne Shearer chisel plough. Bill said “this machine was inspired by Col Seis, when I said to him that I could not justify spending $30,000, plus, on an Agrodrill or similar to start to pasture crop effectively. He knew of other similar conversions and assured me that it would be a very effective machine for our needs. A local self-taught engineer was engaged in the possibility of bringing our dream into reality; unfortunately he wants to remain nameless. He spent a couple of weeks creating the "Pasture Croppa" with many parts made from scratch. This unique machine will be used to sow cereals and grasses on the key line (contour). Using Pasture Cropping principles, we expect to grow more feed for our livestock enterprise, while building soil and biological activity, sequestering carbon, harvesting rainfall runoff and stimulating grass growth (especially native perennial species!). We may even harvest grain or at least make some silage! I believe that purpose built machinery like the "Pasture Croppa" can revolutionize our farming systems, allowing the combination of proven methodologies and techniques.

“Simple to use, effective machines will enable us to farm successfully and with increasing confidence into the future.” *Bill Hill, 2010*

Bill Hill’s “Pasture Croppa” A little ingenuity and some spare parts can go a very long way!

Leigh Stubb's Seeder

"I have attached the photos of my seed drill that l have built over the past few months. As you will see, l started with a Davimac small seeds box that l bulked up by increasing the bin size. Then l purchased 8 x Alan Johns tynes with knife points and designed a frame from 75x75x5mm RHS to space the tynes at 300mm spacings over two rows. I wanted to incorporate a liquid fertilizer injection, so l researched and made my own Green Drop system that runs off a 12V diaphragm pump, which injects the liquid into the manifold via a hollow cone nozzle and then is gravity fed down the tube to the tyne, where l fitted a 16mm steel tube to the back of the seed tube to protect the plastic tube and drop the fertilizer as a concentrate at the point of the seed placement. I have also fitted some Manutec press wheels to ensure good seed/soil contact.

To keep it simple, l used two ratchet rams to adjust the tyne height from 100mm clearance to 100mm tilth depth, which adjusts from behind the wheels.

I have a contractor cutting silage next week, so we can sow millet the following weekend. I will be using a product from local company called Hybrid-Ag to inoculate the seed with. The product is called Micro Start & Micro Feed (Bacteria, fungi, protozoa, and other microbes) providing the seed with a high concentration of beneficial organisms in the seeding zone. I am excited to see how the whole thing goes!!"

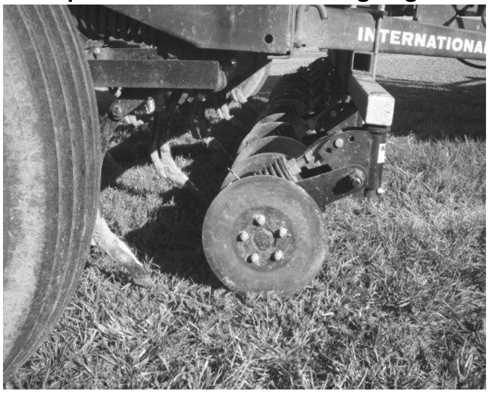
Leigh Stubbs, 2010

Leigh Stubb's Seeder

Kevin Mitchell’s Machine

Set up with double edged plain coulter discs
4mm thick X 14” circumference.
Some prefer fluted coulter discs going into crop stubbles.

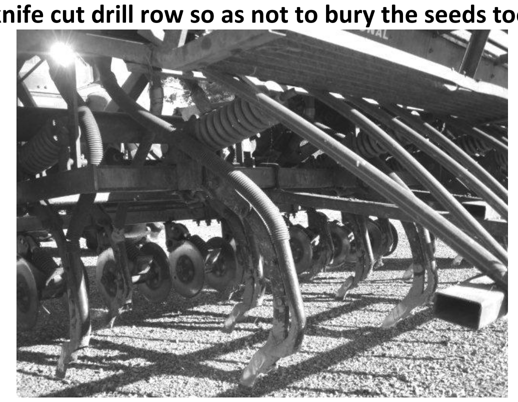
These double coulters swivel easily and corner well.



Good adjustment and spring pressure available.

Small seedbox facility. Poly pipe delivering small seeds on top of the knife cut drill row so as not to bury the seeds too deep.

When sowing Lab Lab and Cowpeas – sow with approx. 30” row spacings eg. Blocking off 2 outlets and sowing on the 3rd.



Good clearance for trash. Tynes on 3 rows. In very heavy trash I have removed 2 centre tynes. Higher lift off the ground would be preferable.

Press wheels from an old vegetable roller.

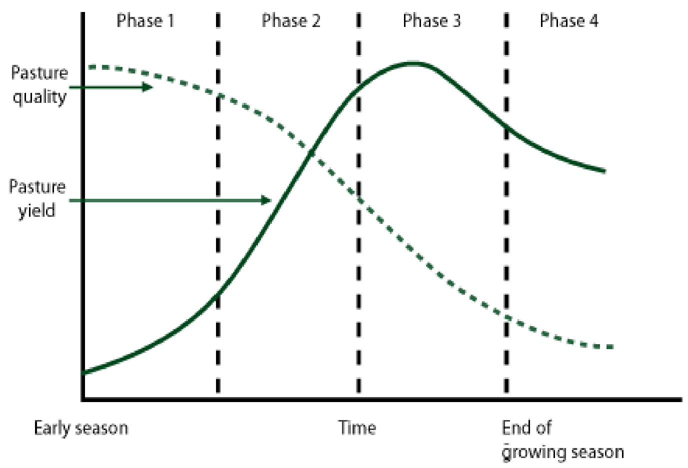
Sowing through heavy trash. This conversion (Johns) is excellent but the main limitation being the lift of approx. 10cms above ground - would be better in heavy trash at 30-40cms.

3. Grazing– The Key to Pasture Management

Grazing is important in an agricultural enterprise that is using Pasture Cropping; it is the way in which animals are used to convert grass into meat, milk and other products.
There are a number of environmental effects derived from grazing, and these may be either positive or negative. Negative effects of grazing (or more usually *over*-grazing) include increased erosion, loss of ground cover, adverse water quality impacts from increased runoff and loss of biodiversity.
Different pasture species respond differently to grazing so it is necessary to understand the growth cycle of the species in your pasture so that you can maximize your productivity. Some varieties may become less productive as they mature and stocking rates need to be adjusted accordingly. Overgrazing at critical stages may lead to damage and the loss of some species.

Pasture growth

Understanding the growth patterns of plants will help you to understand how grazing can effect plants at different times in their life cycle



The figure above shows the changes in quality and yield through the growing season through Phase1 [short leafy], Phase2 [well developed tussock] Phase three [seeding] to Phase 4 [dormancy]
Timing of activities such as joining, lambing, and weaning should be identified and planned in accordance with pasture growth cycles. Planning the grazing will help to ensure animal nutrition requirements are met and animals are in adequate condition to maximize conception, lambing or calving and weaning rates. Once identified, those paddocks planned for a specific use should be set aside well in advance to ensure feed quality and quantity is available to meet stock requirements during these critical periods.
There are two considerations in grazing management:

1. The aim should be to convert the greatest quantity of grass [energy and nutrients] into product that you can sell while also leaving the pasture in the best condition for re-growth
2. To manage the amount of ground cover and root growth which impact on the soil fertility and structure, you need to understand your soils and manage them accordingly.

So what grazing strategies can you employ? Successful grazing management needs to be flexible and reflect the needs of the animals, the soil and the pastures. There will be different objectives at different times of the year and with different seasonal conditions. The enterprise that you are running will also influence the decisions that you will have to make.

Good grazing management balances pasture growth and use, so that the condition of the land is improved. To do this you will need to be able to accurately assess pasture quality and quantity and match that to the needs of the animals. Identifying the stocking rate and stocking density that your enterprise can sustain to maximize pasture utilization without any detrimental effects, is important in increasing profitability. Uneven grazing is both wasteful and harmful to the pasture. The most common reasons for this are distance to water, land type preference, and plant species preference.

A safe utilization rate is the maximum rate of average annual use that maintains or improves the condition of the land. This will vary with land type, soil type, climate and animal type. Long-term carrying capacity is the average number of animals that a paddock can be expected to support over a period of say 5 years. You are able to set your own targets which could be ground cover percentage or amount of dry matter.

These are the key categories in assessing pasture condition:

1. **Available feed (kilograms of dry matter per hectare)**
2. **Ground cover (%)**
3. **Diversity of perennial grass species**
4. **Perennial grass contribution to available feed (% of available feed)**
5. **Legume contribution to available feed (% of available feed)**
6. **Annual grass contribution to available feed (% of available feed)**
7. **Herbs contribution to available feed (% of available feed).**

Grazing perennial grasses

If a perennial grass plant is grazed —and to keep it healthy, grasses need to be grazed — it needs time to recover before it is grazed again. When the top of the plant is eaten by an animal, the stores of starch in the roots provide the energy for new shoots to be produced. If the plant is grazed again before the roots have had time to recover, the whole plant is weakened because it does not have a renewed store of energy in its roots from which to fuel new leaf re-growth. If this happens continually the perennial plants gradually get smaller and smaller and so weak that they eventually die. This is why planning for appropriate recovery (rest) periods are the most important part of successful grazing management.

"ANIMALS SHOULD NOT BE RETURNED UNTIL THE GRASSES ARE FULLY RECOVERED." *Graeme Hand, 2010*

Planned grazing management

Planned grazing is the use of a range of management tools to create a particular landscape that meets the goals of the land manager. For example, a goal might be to maintain ground cover at more than 80% year round. There are a range of grazing management tools available to use including rest period, graze period, stock density, soil fertility, animal supplements, watering points and access, and fire. Grasses are nature's selection of plants that are well adapted to grazing. Grasses can be perennial, which means they live for many years, or annual, which means they grow from a seed, flower and die, all in one growing season. Annual plants respond quickly to rainfall and grow quickly before dying off, while slower growing perennial grasses provide a greater bulk of feed that can carry stock through dry periods and they can use water that falls at any time of the year, not just through winter. Perennial grasses grow from a long lived base of roots and growing tips which can last for many years. The plant may have dead material standing above the ground with the growing tips at the base of the plant just waiting for moisture so that they can grow. Removing the dead material through grazing allows sunlight to reach the base of the plant and enables rapid response of the new young growth tips to moisture. Established perennials produce new leaf material more quickly after rain than annuals which have to grow from a seed.

A successful grazing management strategy will manage pasture use effectively, reduce uneven grazing and will match the animal's needs to the feed that is on offer. It can also be used to improve the condition of the soil and the perenniality of the pasture. It is irrelevant whether it is a native or exotic grass based pasture. You have the opportunity to reduce weeds by maintaining ground cover, to increase the proportion of specific species by managing for them and to improve your bottom line by matching animals to feed on offer and avoiding the cost of supplementary feed.

Sheep grazing Russell Ellis's Pasture Cropped paddock, Chesney Vale, VIC, 2010

Cattle grazing a trial plot at Cam Barrett-Lennard's property, Earlston, VIC, October 2011

4. Weed Control Without Herbicides

There are many ways to conduct a weed control program that will work. Unfortunately, there are even more ways that will not work. Prevention is much better than dealing with an established weed. Weed control in pastures can be a very difficult challenge.

Pasture weed management requires maintaining a balance of pasture species, maximizing the number of desirable species while deterring weeds. Most weeds are susceptible to grazing. When and how you do it can have a major effect on weed populations. Grazing management of weeds is achieved through a reduction in seed set and the competitive ability of the weed whilst encouraging the domination of desirable species particularly perennial grasses. To achieve the maximum impact grazing should coincide with the vulnerable stages of the weed's life cycle.

1. **Tactical grazing pressure:** Use high-density, strategic grazing pressure for a short period to reduce seed production capacity and to weaken the plant.

2. **Grazing palatable weeds:** Vary grazing frequency and density to encourage livestock to consume non-toxic vegetative weeds.

3. **Reduce weed germination by groundcover retention:** Maintain greater than 1500kg/ha of dry matter [including litter] and at least 80% groundcover at the autumn break to reduce weed germination and seedling establishment.

4. **Slashing:** Cut the pasture in spring before flowering to reduce seed production. This could be for the making of hay or silage.

All strategies must be timed to the weed's and desirable species' life cycles. Weed removers and pasture improvers should integrate and complement one another and must be employed at the optimum time to achieve desirable outcomes. Producers must continue to monitor paddocks annually to assess botanical composition and detect changes in the pasture.

Sources: www.mla.com.au/livestock production/ weed control

www.agric.wa.gov.au/Tactic 3.5 Grazing – actively managing weeds in pastures

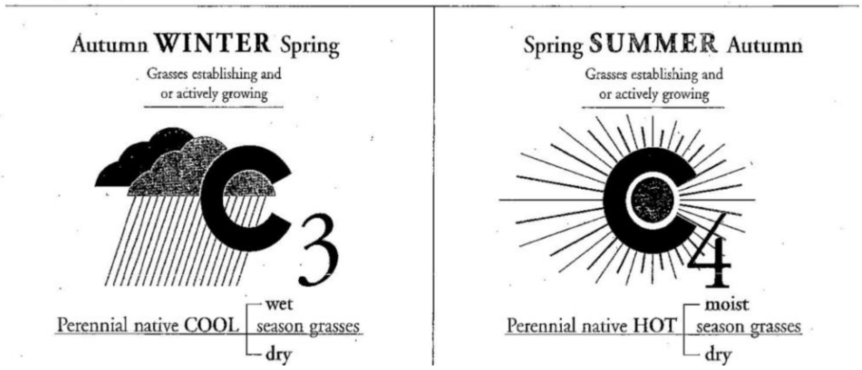
NATIVE GRASSES

For your information here is a list of the most common indigenous grass species in our area. This was compiled by Sally Mann for the Native Grasses day that was held by Sheep Pen Creek Land Management Group at Caniambo in November2010.

C3 Grasses: Winter-Spring					
	Common Name	Natural Habitat areas	Soil	Likely to find where?	Grazing tolerance
Austrodanthonia carphoides	Short Wallaby-grass	all	dry, shallow	paddocks, wad sides	high
caespitosa	White Top, Common Wallaby	plains	dry, loamy to heavy	paddocks, road sides	medium
duttoniana	Brown-back Wallaby-grass	plains, drainage lines	moist loamy to heavy	paddocks, road sides	high
eriantha	Hill Wallaby-grass	hills	dry	rough paddocks, bush	medium
fulva	Copper-awn Wallaby-grass	all	dry, loamy or lighter	road sides, bush	medium
setacea	Bristly Wallaby-grass	all	dry loamy to heavy	paddocks, road sides	high
Austrostipa geniculata	Yanganbil	plains	loams to heavy	rough paddocks, roadsides	medium
densiflora	Fox-tail Spear-grass, Dense Spear-grass	hills	dry, shallow or light	rough paddocks, roadsides, bush	medium
elegantissima	Feather Spear-grass	plains	dry loamy or lighter	road sides, bush	low
scabra	Rough Spear-grass	all	dry	all	high
Amphibromus nervosus	Swamp Wallaby-grass	swamps, dams	Moist, heavy to loamy	paddocks, road sides, bush	medium
Aristidabehriana	Brush Wire-grass	plains	dry, loamy to light	rough paddocks, roadsides	medium
Dichelachne crinita	Long-hair Plume-grass	All?	dry loams	rough paddocks, roadsides,	low
Elymus scaber	Common Wheat-grass	all	all	rough paddocks, roadsides,	medium
Joycea pallida	Red-anthered Wallaby-	hills	dry loams	road sides, bush	low
Microlaena stipioides	Weeping Grass	drainage lines, south slopes	moist loamy or lighter	rough paddocks, creek banks	medium
Poa fordeana	Forde Poa	plains drainage lines	moist, heavy	rough paddocks, roadsides,	medium
labillardieri	Common Tussock-grass	creek and river banks	moist	rough paddocks, roadsides,	medium
sieberiana	Grey Tussock-grass	all	dry loams	rough paddocks, roadsides,	low
Whalleya proluta	Rigid Panic	plains, drainage lines	moist, heavy	rough paddocks, roadsides	medium
C4 Grasses Spring-Summer					
Bothriochloa macra	Red Grass, Red Leg	all	loamy to light, shallow	road edges, paddocks	medium
Chloris truncata	Windmill Grass	all	loamy to light, shallow	road edges, paddocks	high
Dicanthium sericeum	Silky Blue-grass	low rises to north	dry loams, red soils	Dookie hills paddocks, road sides	low
Enteropogon acicillaris	Spider Grass	plains	dry loamy to heavy	rough paddocks, roadsides	medium
Eragrostis brownii	Brown's Love-grass	plains, drainage lines in hills	dry loamy to heavy	paddocks, rough paddocks, roadsides	medium
Themeda triandra	Kangaroo Grass	all, including creek banks	all but not poorly-drained	rough paddocks, roadsides, bush	medium

SIMPLY EXPLAINING C_3 AND C_4

The terms C_3 and C_4 refer to aspects of the carbon fixation in photosynthesis. The first product of carbon fixation in the C_3 pathway is a molecule with three carbon atoms; hence the name. The enzyme which initially fixes carbon has a relatively poor affinity for CO_2. The first product in C_4 plants is a molecule with four carbon atoms and the equivalent enzyme has a much higher affinity for CO_2. A feature of C_4 plants is their Kranz* leaf anatomy. They have bundle sheath (Kranz) cells containing chloroplasts as well as the mesophyll-chloroplast cells[4,6]. Frost susceptibility is a feature of nearly all C_4 species and so perennials are dormant in the winter in frosty climates. Many C_3 plants are frost tolerant and so they remain green in the winter, even though their major growth period may be in the summer if soil water is available. *Kranz = wreath in German.



Queensland Blue Grass

SCIENTIFIC NAME: *Dichanthium sericeum*

CATEGORY: C4 perennial

GRAZING & NUTRITIONAL VALUE

- Moderate grazing value
- Digestibility ranges from 38-62 %
- Crude protein 2-7%

MANAGEMENT STRATEGIES

- Highly palatable and nutritious when young and actively growing; stalky and low quality at flowering
- Possibly more suited to cattle enterprises as it appears to be less palatable to sheep, allowing it to become tall and rank
- Growth responds well to increased fertility. Declines under set stocking systems as cattle selectively graze it (sheep less so); better suited to rotational grazing
- Will easily re-establish from seed, so spell during flowering and seed set to increase or maintain populations

Red Grass

SCIENTIFIC NAME: *Bothriochloa macra*

CATEGORY:C4 perennial

GRAZING & NUTRITIONAL VALUE

- Moderate grazing value, but low when frosted
- Digestibility ranges from 48-69 %
- Crude protein 4-15 %

MANAGEMENT STRATEGIES

- Tolerates disturbance; one of the first native plants to return to drought affected sown pastures
- A valuable coloniser of degraded areas and for useful for stabilising waterways
- Can produce a large amount of material, the majority of which is stem. However, it can provide quality feed after summer rain and is best utilised at this time
- Responsive to fertiliser and increased grazing pressure, but grows well in unfertilised areas
- Best kept green and leafy as it has a high stem to leaf ratio when flowering and stock tend to avoid it once it goes to seed; rotational grazing helps maintain larger plants
- Maintain heavier grazing from late winter to mid spring to avoid clover and annual grass dominance in spring or red grass populations can thin out dramatically
- To increase density, allow to seed in summer and rest pastures in late summer to aid seed germination if conditions are suitable
- Seed can be sown by spreading seed-bearing hay or broadcasting and harrowing in spring or early autumn

Kangaroo Grass

SCIENTIFIC NAME: *Themeda triandra*

CATEGORY: C4 perennial

GRAZING & NUTRITIONAL VALUE

- Low to moderate feed quality, but this is highly variable across the region
- Digestibility ranges from 54-75 %
- Crude protein 3.3-10.6%

MANAGEMENT STRATEGIES

- A highly variable species that is moderately productive with most growth being produced over summer; many of the more palatable varieties have been grazed out
- Leaves tend to have low phosphorus level and are relatively palatable to cattle, but not sheep
- A well-managed stand provides excellent competition against weed invasion
- Although it is frost sensitive, heavy grazing in late summer/autumn can produce new growth that is more frost resistant and will remain green well into winter
- Abundance declines with increasing phosphorus or nitrogen applications
- Avoid heavy continuous grazing as its buds and storage organs can be depleted, leading to thinning of stands. Heavy grazing just prior to stem elongation can also severely inhibit flowering. However, heavy short-term grazing can be useful in preventing the build-up of dead material, which creates a fire hazard and lowers feed quality
- Its abundance can be encouraged by grazing systems that provide long rests or continuous grazing at low stocking rates
- In conservation areas, the use of cool burns in autumn will promote the grass, although this is not recommended as regular practice on farms
- Seed can be sown by spreading kangaroo grass mulch immediately after harvest in summer. If the mulch is burnt in late winter when the soil is still moist, the seed will germinate as the soil warms up

Curly Windmill Grass

SCIENTIFIC NAME: *Enteropogon acicularis* and *E. ramosus*

GRAZING & NUTRITIONAL VALUE

- Low to moderate grazing value
- Digestibility ranges from 37-62%
- Crude protein 5-13%

MANAGEMENT STRATEGIES

- Produces good growth after rain from spring to autumn
- Young growth is moderately palatable, but flowering plants are harsh and left ungrazed
- Produces some winter growth, but this is ignored by stock if other palatable species are present
- Seedling recruitment is infrequent
- Can increase under light to moderate stocking rates, but is eliminated under heavy stocking
- Rest pastures when there are good prolonged summer rains to aid seedling establishment

Windmill Grass

SCIENTIFIC NAME: *Chloris truncata*

CATEGORY: C4 perennial

GRAZING & NUTRITIONAL VALUE

- Low to moderate grazing value
- Digestibility ranges from 35-68%
- Crude protein 7-12%

MANAGEMENT STRATEGIES

- A useful coloniser of bare or degraded areas, germinating after spring and summer rains
- Most feed is produced in spring and summer, but leaves are fibrous and not very palatable; must be kept green and leafy to maintain quality
- Growth increases with improved fertility, but it will often decline in abundance due to shading unless pastures are kept short
- Heavy grazing pressure in late spring and summer increases the abundance of windmill grass by increasing bare ground and reducing competition
- Probably best grazed by sheep, as it grows close to the ground

Common Wheat Grass

SCIENTIFIC NAME: *Elymus scaber*

CATEGORY: C3 perennial

GRAZING & NUTRITIONAL VALUE

- Moderate to high grazing value
- Digestibility ranges from 63-90 %
- Crude protein 10-36%

MANAGEMENT STRATEGIES

- Produces high quality, palatable green feed in the cooler months on fertile soils in moister areas
- On shallower soils and drier western areas, it tend to have harsher leaves and is of lesser value
- Generally only a short lived plant, but can recruit well from seed if needed
- Growth is better under increased soil fertility and increased grazing pressure (if not selective)
- Often preferentially grazed, but is avoided after it runs to head in spring
- Rotational grazing to reduce selective grazing and providing strategic rests in spring to allow flowering and seed set will aid persistence
- Seed can be direct drilled at 5-20mm deep using a cone seeder in autumn

Weeping Grass or Microlaena

SCIENTIFIC NAME: *Microlaena stipoides*

CATEGORY: C3 perennial

GRAZING & NUTRITIONAL VALUE

- High grazing value
- Digestibility ranges from 56-80%
- Crude protein 11.3-26.9 %

MANAGEMENT STRATEGIES

- High quality species that produces most feed from spring to autumn; winter growth is slow in cold areas
- Tolerant of moderate to heavy grazing pressure and should be kept short to maintain quality, especially over summer. However, heavy grazing in spring may reduce summer growth
- Will tolerate heavy shading from annuals in spring
- Responds strongly to increased soil fertility and the use of legumes, but needs to be kept short in autumn to allow clover establishment
- Rotationally graze for better leaf production and to allow seed set in spring and/or autumn
- Seed can be sown by broadcasting, mulching and using a crocodile planter in spring or autumn

Wallaby Grass

SCIENTIFIC NAME: *Austrodanthonia* species (formerly *Danthonia)*

CATEGORY: C3 perennial

GRAZING & NUTRITIONAL VALUE

- Low to high grazing value
- Digestibility ranges from 45-82%
- Crude protein 10.1-25%

MANAGEMENT STRATEGIES

- Feed value is dependent on the species and location; plants growing on very shallow poor soils show little response to fertiliser and often form low quality, unproductive plants. In more fertile areas, plants respond to fertiliser and tend to produce larger quantities of higher quality feed
- Species on more fertile soils mostly increase with increased (to quite high) grazing pressure as their buds and storage organs are at or below ground level and frequent defoliation removes shading from taller plants. Species on infertile soils are generally only suited to light grazing pressure
- Spell to allow seeding in spring or summer after good rainfalls
- Does not tolerate heavy shading in early spring, so maintain grazing pressure to avoid dominance by sub clover and other annuals. Seed can be sown by broadcasting and using light harrows in spring or autumn. Coverage should be no deeper than 3mm and reliable moisture is essential.

Ringed Wallaby Grass or White Top

SCIENTIFIC NAME: *Austrodanthonia caespitose*

CATEGORY: C3 perennial

GRAZING & NUTRITIONAL VALUE

- Moderate to high grazing value
- Digestibility ranges from 37-60% from one semi-arid trial at Cobar
- Crude protein 10.1-14.9%

MANAGEMENT STRATEGIES

- Produces good amounts of very palatable and nutritious forage that still provides reasonable quality hay or roughage when hayed-off
- Most growth occurs in late winter and spring. Produces little forage after summer rain, but is more likely to do so if plants have been grazed short
- Persists unless very heavily and continuously grazed and will tend to decline if not grazed for a long period
- Abundance increases with increased (to quite high) grazing pressure as it is very tolerant of grazing and trampling and frequent defoliation removes shading from taller plants
- Maintain moderate grazing in late winter and spring to reduce competition from medics and clovers
- Seeds prolifically unless heavily grazed, so spelling to aid seed set is generally not required. However, reducing stocking pressure or resting the pasture following good rains in spring or autumn will aid seedling establishment
- Seed can be sown in spring by broadcasting onto disturbed surfaces, followed by light harrows in spring or autumn. Coverage should be no greater than 3mm, with reliable moisture and low weed burdens being essential.

Silvertop or Red Anther Wallaby Grass

SCIENTIFIC NAME: *Joycea pallida* (formerly *Danthonia pallida*)

CATEGORY: C3 perennial

GRAZING & NUTRITIONAL VALUE

- Low to moderate feed quality
- Digestibility not measured
- Crude protein not measured

MANAGEMENT STRATEGIES

- Forms a valuable summer feed in harsher environments if kept short and green
- Generally avoided by stock due to its tough leaves and the high proportion of dead leaves in the tussock
- It is an important “indicator” species of light, infertile soils that need special management
- A valuable species for protection against erosion on slopes and ridges
- Conservatively graze to maintain populations, as it will often rapidly decline if frequently defoliated.
http://www.dpi.nsw.gov.au/agriculture/field/pastures-and-rangelands/species-varieties/native-grasses

SOIL MICROBIOLOGY

Microbes in your soil as an asset

Seminar notes from Warrenbayne presentation - February 2011

Dr Ash Martin PhD BSc (For) Hons, Dr Maria Manjarrez-Martinez PhD MSc BSc
Creation Innovation Agriculture and Forestry (CIAAF)

The Importance of Soil Microbes.

If we were to consider how precious soil microbes were to the success of ancient food and fibre production we would be able to appreciate them more in our current era. Ancient Chinese, Romans and Hebrews relied on them for successful cropping but also for soil classification in terms of taxation purposes (money). As the “Green Revolution” era arrived (1970’s) food and fibre production became increasingly distant from the basic principle that kept humans alive: Sustainability. As the effects of ignoring sustainability in food and fibre production have become increasingly apparent in recent years, food and fibre producers have started to rediscover the basics of successful, profitable, sustainable food and fibre production: Soil biological, chemical and physical ‘health’.

You will learn from Part 1 of our introductory presentations that soil microbiology plays an important function in soil and plant health, and through the various roles of different microorganisms in nutrient availability and disease suppression they give soils a tremendous capability of sustaining life. Importantly, fungal, bacterial and many other microbial communities are there to be used for free. Just to set an example, 1g of soil contains:

- More than 100,000,000 bacterial cells
- More than 11,000 species of bacteria
- Fungi and larger animals.

How Soil Microbiology, Food and Fibre Producers and Sustainability are Linked.

Of these, the majority would be carrying out activities such as releasing phosphorus (P), fixing and cycling nitrogen (N), capturing carbon (C) and directly or indirectly promoting plant growth. Other soil microbes would be predating on insects, nematodes and also plants to keep the balance.

Balance is essential when describing sustainability. Food and fibre production are sustainable when they are profitable and the natural resources of the farm are maintained or increased. Soils in the farm must create and maintain an active and balanced microbial population that can produce healthy plants, animals and humans.

In order to be able to manage soil microbiology to create and maintain a healthy balance that results in productive soils, food and fibre producers need to measure it to gain information that can be used to make management decisions. After all, it’s very difficult to manage what you can’t measure. Measurements are particularly important before and after implementing new practices, so you can see what effect the practice has had on soil microbiology. Measuring microbial populations is not easy because different factors contribute to error. However, new techniques had allowed scientists and farmers to get a good view of what is happening with the more important groups of soil microbes.

Part 2 of our introductory presentations will show you why is important to measure microbial groups and how the results can help to improve farm management. Examples from real farms and basic sampling instructions will give you the tools to take and understand your own microbiology tests.
By the end of the session you will see that there is no general rule to create a healthy balanced soil, but a number of factors that you can be empowered to manage by having the right information, which can be used to create a more productive, profitable, sustainable farming system.

Can any of the following be achieved on your farm?

- **Inoculate the soil with a balanced population of microbes**
- **Increase soil organic matter to greater than 2% and preferably 4-5%.**
- **Minimised tillage (i.e., minimal tillage)**
- **Sustain a perennial grass cover (even on cropping areas) and avoid bare soil**
- **Avoid excessive use of inorganic or chemical fertilisers and sprays**
- **Avoid burning stubble and grasses**

Start today!

CIAAF Education and Training Seminars – Gecko CLaN February 2011 – Seminar Notes Prepared by Creation Innovation Agriculture and Forestry © February 02-2011

MANAGING MICROBIOLOGY

Step 1:

- **Measure them**

  Measurement needs to be
  - **Accurate**
  - **Cost-effective**
  - **Easy to understand**

Step 2:

- **Find out whether levels are 'good' or 'bad'**

Step 3:

- **Employ management practices to improve them**

General Microbiology Tests (for soil, compost, liquids etc.)

<u>Test F1 – Microbiology Suite</u> ***This is the test that we have used in the project.***

This test can identify and quantify the biomass of 10 different groups of microbes in your sample, and provides you with detailed information that can help you manage your microbiology to increase the microbial health and productivity in your soil or compost.

Unlike many other agricultural microbiology tests, the CIAAF test uses molecular markers unique to each different species of microbe to accurately measure what and how many microbes are in your actual soil samples. The measurements are taken directly from the actual sample you send in.

The 10 microbial groups measured in Test F1 are:

- Total microorganisms
- Total bacteria
- Total fungi
    - Prokaryotes
        - Pseudomonas
        - Actinomycetes
        - Anaerobic bacteria
        - Gram positive bacteria
        - Gram negative bacteria
- Eukaryotes
    - Protozoa
    - Mycorrhizal fungi

Two useful ratios are also included in the report:

- Total to Anaerobic bacteria
- Fungi to Bacteria

The report also includes the CIAAF Microbial Diversity Indicator, a measure of the microbiological diversity, or species richness, present in your sample.

The mass of 7 nutrients held in the biomass in your sample are also reported:

- Nitrogen
- Phosphorus
- Potassium
- Sulphur
- Calcium
- Magnesium
- Carbon

You may want to perform this test if you want to know:

- What is the biomass of the different microbial groups in my sample?
- What level of microbial diversity do I have in my sample?
- How have my management practices affected the different microbial groups and diversity in my sample?

Soil Fertility

SOILS ARE ALIVE! http://www.soilhealth.com/

THE COMPLETE SOIL HEALTH REFERENCE FOR FARMERS, CONSULTANTS AND RESEARCHERS

Question 1: What is soil biological fertility?

Soil fertility is the combined effects of three major interacting components. These are the **chemical, physical** and **biological** characteristics of the soil. The physical and chemical characteristics of soil are far better understood than that of the biological component; therefore we know quite a lot about the desired chemical and physical status of soils. It is still difficult to define the desired biological status of soil because they are so dynamic and changes occur in much shorter time periods than physical and chemical changes. Biological fertility, while difficult to define, provides us with great opportunities for land management and monitoring because of its dynamic nature. It is thought the biological state of soils may be able to provide early warning of land degradation, therefore enable us to employ more sustainable land management practices. The biology of soil is complex and we need a better understanding of the mediatory effect that biological components have on chemical and physical fertility. We have yet to determine desirable levels of activity, numbers and diversity of soil organisms to maintain a fertile and productive soil.

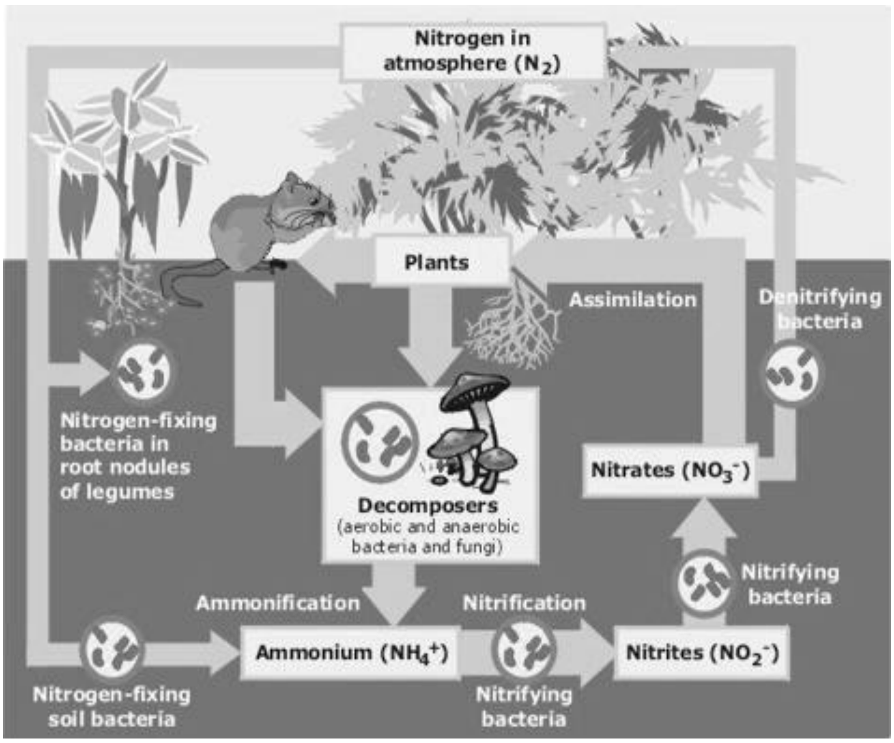
Question 2: What are the ten key principles of soil biological fertility?

The biological components of soil perform a number of important processes, soil biological fertility:

1. Soil organisms are most abundant in the surface layers of soil,
2. Soil organic matter is necessary for nutrient cycling and soil aggregation,
3. Maximum soil biological diversity depends on the diversity of organic matter and habitats,
4. Nitrogen fixing bacteria form specific associations with legumes under specific conditions ,
5. Nitrogen is released during organic matter breakdown, either into soil or into the soil microbial biomass,
6. Arbuscular mycorrhizal fungi can increase phosphate uptake into plants in P-deficient soils,
7. Soil amendments can alter the physical and chemical environment of soil organisms,
8. Some crop rotations and tillage practices decrease the suitability of soil for plant pathogens,
9. Production systems based on soil biological fertility can be profitable,
10. Soil biological processes develop slowly, and the time required will differ for different soils, environments and land management practices.

Question 3: What are the corresponding land management guidelines relating to these ten key principles of soil biological fertility?

1. Soil erosion should be controlled to minimise loss of soil organisms.
2. Plant organic matter should be retained to maximise nutrient cycling and soil aggregation processes.
3. Some disturbance of soil is necessary to maximise soil biological diversity.
4. Nitrogen fixing bacteria should be selected that match the host, soil characteristics (such as pH) and environmental conditions.
5. Inputs of nitrogen fertiliser should be calculated to complement nitrogen cycling from organic matter.
6. Inputs of phosphorus fertiliser should be calculated to complement and enhance the activities of arbuscular mycorrhizal fungi.
7. Any substance added to soil should be assessed in terms of its effects on soil biological processes and soil biological diversity.
8. Crop rotations and tillage practices should be selected to avoid development of soil conditions that enhance the growth and survival of plant pathogens.
9. The capacity of a management practice to produce a commercial product should be considered in parallel with its capacity to maintain and/or increase soil biological fertility.
10. Sufficient time should be allowed for establishment or restoration of a level of soil biological fertility appropriate for particular soils and land management.



The Nitrogen Cycle - Mike Jones - macroevolution.net

PAPERS

Soil Changes on “Winona” – Colin Seis

After 50 years of high input agriculture Colin Seis’ 2000 acre property “Winona”, had become a degraded farm dependent on high inputs and lacking production and profit as well as having ongoing problems of insect attack and fungal disease in crops.

The granite soil on “Winona” had become compacted, lacking structure, acidic, high in aluminium and had organic carbon levels below 1.5%. The top soil had declined to less that 100 mm deep and the sub soil had become sodic.

The poor structured soil allowed very little water to infiltrate and consequently very little nutrient cycling.

Small saline areas were first noticed on Winona in the 1920’s and by the 1970’s the saline area had expanded to cover over 100 acres.

Over a 50 year period, introduced pastures like sub clover and rye grass, were sown annually in an effort to maintain production. These pastures were maintained with increasing amounts of fertiliser to a point where 125 kg/ha of superphosphate was applied to pastures annually and 100 kg/ha DAP applied to annual crops like wheat and oats. The advice in 1970 to apply 200 kg/ha of superphosphate to pastures was thankfully, not adopted.

From the early 1990s Colin Seis started to look for other ways of practicing agriculture on “Winona”, that did not require high levels of fertiliser and pesticides to maintain, and would restore the property to a regenerative grassland.

The restoration of Winona was achieved with a combination of “pasture cropping” “time control grazing” and reduction of fertilisers, fungicides and insecticides.

Fungicides and insecticides are no longer used and fertiliser is used sparingly.

“Pasture Cropping” combined with “time control grazing” changed “Winona” from a farm dominated by introduced annual plants that required high levels of fertiliser to maintain, to a grassland dominated by native perennial plants that improved soil structure, increased organic carbon levels and increased soil nutrient cycling.

The data and photo below are the result of using these techniques

The “Winona” paddock was “pasture cropped” in 2000 (wheat), 2004 (oats) and 2009 (cereal rye). A large mob of merino ewes is time control grazed on the area with a graze period of 2-3 days and allowed to recover from the graze for 90 – 120 days before re-grazing. This grazing technique has been used over all of Winona for almost 20 years.

The large mob was also used to prepare the paddock pre “pasture cropping” by mulching and manuring the grass.

The results of this management technique are:

- Almost double soil organic carbon
- Winona’s paddock is dominated by 82.9% native perennial grass species. *(82.9% compared to 11%)*. The adjoining paddock is dominated by 88.1% annual introduced species.
- Improved ecosystem and landscape function on Winona.
- Production has increased, with the number of sheep carried on Winona at 8 dse/ha compared with 3.7dse/ha on the adjoining paddock.
- Improved water infiltration
- Improved nutrient cycling.
- Almost double soil nitrogen.
- Soil microbial counts showed that the Winona soil had significantly higher counts of Fungi *(46% increase)* and actinomycetes bacteria *(over 100% increase)*

Note: The above data is the result of a “communities in landscape” project by Peter Ampt, Rebecca Cross, and Sarah Doornbos from the University of Sydney NSW in 2010.

The soil photo and samples (below) were taken 15 meters apart on 28th September 2010 The soil on the left is from Colin Seis property “Winona” the other sample from the adjoining property. (Fence line comparison) *(The same paddocks as the data above)*
The difference in soil and nutrients are the result of a change in land management over a 10 year period. The difference in land management has been, “Pasture Cropping” and “Time Control” grazing, compared to set stock grazing and traditional cropping techniques.

- The cropping frequency is approximately the same for both paddocks, with crops sown 3 times during the last 10 years.
- The adjoining paddock management is set stock grazing and traditional sowing of crops by ploughing, scarifying and cultivating pre sowing, and herbicide application in crop.
- The only fertiliser applied on the paddocks during the last 10 years has been with the crops. 40 kg/ha DAP on Winona and 60 kg/ha DAP on adjoining property.
- No lime has been applied to either property.

The list below shows the percentage increase in the Winona soil in available and total nutrients over a 500 ml soil profile.
There has been a reduction in available Sulphur, Iron, sodium and aluminium

- The average increase in total nutrients in the Winona soil is 162 %
  E.g. Calcium: 12768 kg/ha on Winona and 4602 kg ha adjoining property (277% change)
  Phosphorus: 837kg/ha on Winona and 554 kg/ha adjoining property (151% change)
- Soil organic carbon has increased by 203.5% over the 10 year period
  There is 90.1 ton/Ha on Winona, and 43.41ton/Ha on the adjoining area
  This is 168.5tonnes of CO_2/Ha sequestered to a depth of half a meter.
  78% of the newly sequestered carbon is in the non-labile (humic) fraction of the soil.
- A “pasture crop” of cereal rye was sown in 2009. The soil carbon increased by 16.2 ton / Ha or 54.95ton/Ha of CO_2 sequestered in two years. (to 30 cm depth)
- The following increases in soil minerals have occurred-
  Calcium 227%, magnesium 138%, potassium 146%, sulphur 157%, phosphorus 151%, zinc 186%, iron 122%, copper 202%, boron 156%, molybdenum 151%, cobalt 179% and selenium 117%
- The average increase in total nutrients in the Winona soil is 162 %

e.g. Calcium: 12768 kg/ha on Winona and 4602 kg ha adjoining property (277% change)Phosphorus: 837kg/ha on Winona and 554 kg/ha adjoining property (151% change)

Winona paddock
Pasture cropped and time control grazed

Adjoining paddock
Traditional Cropping and set stock grazed

Carbon that counts – Dr Christine Jones

Failing a cataclysmic collision with an asteroid or a volcanic explosion of earth-shattering proportions, the thin layer of weathered rock we call soil will have to feed 50% more people before this planet gets much older. The bproblem has not gone unnoticed. Learned men and women have gathered, books have been written and conferences convened. What has been discussed? How to build new topsoil? No. Everything but.

The collective knowledge of the human species on almost every subject from sub-atomic particles to distant galaxies is extraordinary, yet we know so little about soil.
Is it too common, this world beneath our feet? This stuff of life that sustains us?

Failure to acknowledge/ observe/ measure/ learn how to rapidly build fertile topsoil may emerge as one of the greatest oversights of modern civilisation. Routine assessments of agricultural soils rarely extend beyond the top 10 to 15 centimetres and are generally limited to determining the status of a small number of elements, notably phosphorus (P) and nitrogen (N). Over-emphasis on these nutrients has masked the myriad of microbial interactions that would normally take place in soil; interactions that are necessary for carbon sequestration, precursor to the formation of fertile topsoil.

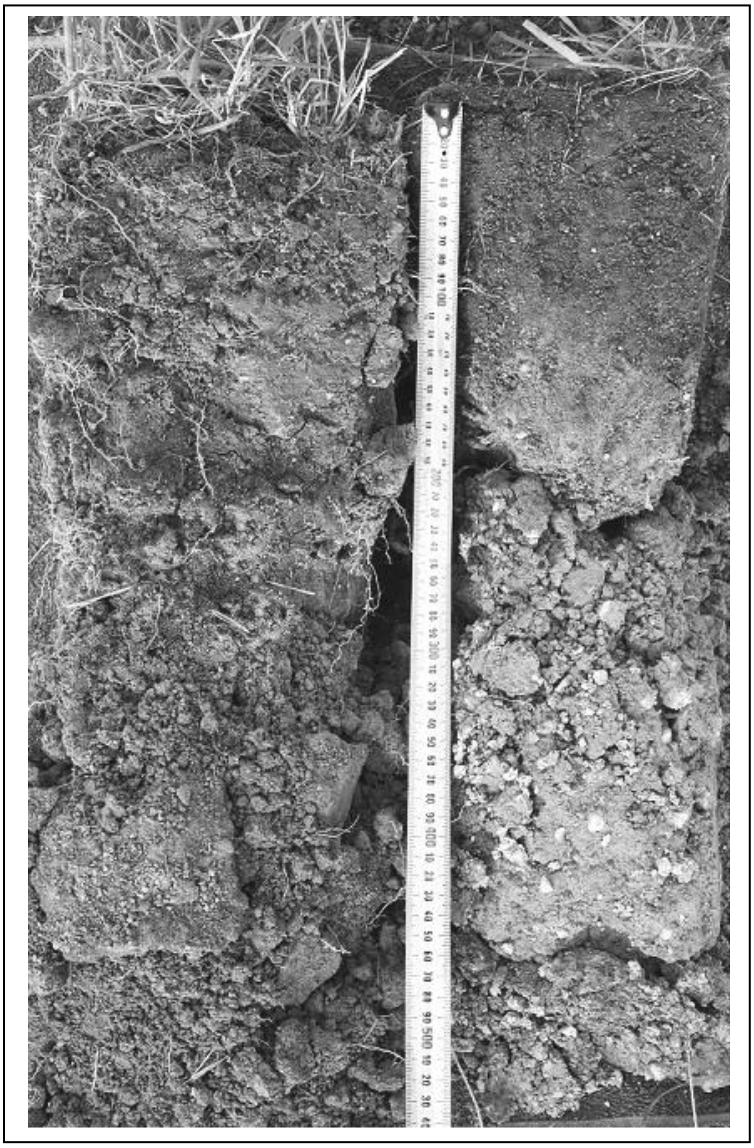


Fig.1. In this paired site comparison, parent material, slope, aspect, rainfall and farming enterprise are the same. Levels of soil carbon in both paddocks were originally the same.

LHS: 0-50cm soil profile from a paddock in which groundcover has been actively managed (cropped and grazed) to enhance photosynthetic capacity.

RHS: 0-50cm soil profile from a conventionally managed neighbouring paddock (10 metres through the fence) that has been set-stocked and has a long history of phosphate application.

NOTES:

i) The carbon levels in the **0-10cm increment** are very similar. This surface carbon results from the decomposition of organic matter (leaves, roots, manure etc), forming short-chain **unstable 'labile'** carbon.

ii) The carbon **below 30cm** in the **LHS** profile has been sequestered via the **liquid carbon pathway** and rapidly incorporated into the humic (**non-labile**) soil fraction. Long-chain, non-labile carbon is highly STABLE.
Photo: Christine Jones
Property: 'Winona', operated by Colin and Nick Seis

Land management and soil carbon

The **RHS** soil profile has formed under conventional grazing, intermittent cropping and standard practice fertiliser management. On the **LHS,** 50 centimetres of well-structured, fertile, carbon-rich topsoil have formed as a result of the activation of the 'sequestration pathway' through cropping and grazing management practices designed to maximise photosynthetic capacity. Superphosphate has not been applied to the **LHS** paddock for over thirty years. In the last 10 years the **LHS** soil has sequestered 168.5 t/ha of CO_2.
The sequestration rate in the last two years (2008-2010) has been 33 tonnes of CO_2 per hectare per year.

Due to increased levels of soil carbon and the accompanying increases in soil fertility, the **LHS** paddock now carries **twice** the number of livestock as the **RHS** paddock.

Levels of both total and available plant nutrients, minerals and trace elements have dramatically improved in the **LHS** soil, due to solubilisation of the mineral fraction by microbes energised by increased levels of liquid carbon. In this positive feedback loop, sequestration enhances mineralisation which in turn enhances humification.

As a result, the rate of polymerisation has also increased, resulting in 78% of the newly sequestered carbon being non-labile. The stable, long-chain, high-molecular weight humic substances formed via the plant-microbe sequestration pathway cannot 'disappear in a drought'. Indeed, the humus now present in the **LHS** profile was formed against the back-drop of 13 years of below-average rainfall in eastern Australia.

A major cause of soil dysfunction, as illustrated in the **RHS** soil profile in Fig.1, is the removal of perennial groundcover for cropping and/or a reduction in the photosynthetic capacity of groundcover due to set-stocking. In the post-war era, a range of chemical fertilisers have been applied to soils in an attempt to mask reduced soil function, but this approach has merely accelerated the process of soil carbon loss, particularly at depth.
The net effect of inappropriate management practices has been compromised landscape function, loss of biodiversity, markedly reduced mineral levels in plants and animals and an increase in the incidence of metabolic diseases. This will no longer do.

Australia is not the only country in which subsoils - and hence landscape function - have deteriorated as a result of inappropriate land management and fertiliser practices. In New Zealand, a country blessed with vast tracts of inherently fertile topsoil, carbon losses are occurring at depth under heavily fertilised pastures, due to the inhibition of the sequestration pathway. To date, alternative management practices have been either dismissed or ignored by establishment science in that country.

It is important to note that the rapid improvements to soil fertility and soil function recorded in the **LHS** soil profile in Fig.1 are dependent on the enhanced photosynthetic capacity that accompanies regenerative forms of cropping and grazing management.

Not just any carbon - and not just anywhere

The soil surface increment, 0-10cm, generally contains the highest levels of short-chain, labile carbon, indicative of rapid turnover. While this 'active' carbon is important for the health of the soil food-web, the surface increment is not where one would be looking to safely 'store' atmospheric CO_2. The deeper in the soil profile that carbon is sequestered, and the more humified the carbon, the better.

Over the last 10 years, the amount of long-chain, non-labile soil carbon (i.e. the humic fraction) in the **LHS** profile has doubled in the 10-20cm increment, tripled in the 20-30cm increment and quadrupled in the 30-40cm increment. In future years, it is anticipated that the most rapid sequestration of stable soil carbon will take place in the 40-50cm increment, then later still, in the 50-60cm increment. That is, over time, fertile, carbon-rich topsoil will continue to build downwards into the subsoil.

Deeply sequestered carbon alleviates subsoil constraints, improves farm productivity, enhances hydrological function and improves mineral density in plants, animals and people.
The Kyoto Protocol, which relates only to carbon sequestered in the 0-30cm increment, completely overlooks this 'sequestration of significance' in the 30-60cm portion of the soil profile.

Building new topsoil

The formation of fertile topsoil can be breathtakingly rapid once the biological dots have been joined and the sequestration/ mineralisation/ humification pathway has been activated.

The positive feedback loops render the liquid carbon pathway somewhat akin to perpetual motion. You can almost see new topsoil forming before your eyes.

The sun's energy, captured in photosynthesis and channelled from above-ground to below-ground as liquid carbon, fuels the microbes that solubilise the mineral fraction. A portion of the newly released minerals enable rapid humification in deep layers of soil, while the remaining minerals are returned to plant leaves, facilitating an elevated rate of photosynthesis and increased levels of production of liquid carbon, which can in turn be channelled to soil, enabling the dissolution of even more minerals.

The levels of acid-extractable minerals in the **LHS** soil profile are higher than those on the **RHS** soil in the following proportions, calcium 277%, magnesium 138%, potassium 146%, sulphur 157%, phosphorus 151%, zinc 186%, iron 122%, copper 202%, boron 156%, molybdenum 151%, cobalt 179% and selenium 117%.

Levels of inorganic plant nutrients have increased to a similar extent.

Where do the 'new' minerals come from?

A standard soil test provides very little information about the bulk soil and the minerals potentially available to plants. Most lab reports list 'plant-available' nutrients (that is, nutrients not requiring microbial intermediaries for plant access) and if requested, acid-extractable minerals (misleadingly quoted as 'totals').

With respect to phosphorus, for example, the 'plant-available' levels are usually estimated using an Olsen, Colwell, Bray 1, Bray 2, Mehlich 1, Mehlich 3 or Morgan P test. These tests provide information on the relatively small pools of inorganic soil P. Where a figure for Total P is provided, it refers only to the quantity of P that is acid-extractable, not the actual 'total' amount of P in the soil.

Other techniques, such as x-ray fluorescence (XRF) are required to determine the composition of the insoluble, acid-resistant mineral fraction, which comprises 96-98% of the soil mass and contains far more minerals than are shown in a standard soil test.

Indeed, the top one metre of soil contains thousands of tonnes of minerals per hectare. Specific functional groups of soil microbes have access to this mineral fraction, while others are able to fix atmospheric N, provided they receive liquid carbon from plants.

The newly accessed mineral, particularly iron and aluminium, plus the newly fixed N, enable rapid humification of labile carbon. However, the liquid carbon needed to drive the process will not be forthcoming if high analysis N and/or P fertilisers inhibit the formation of a plant-microbe bridge.

The 'classic' models for soil carbon dynamics, based on data collected from set-stocked conventionally fertilised pastures and/or soil beneath annual crops, where the plant-microbe bridge is dysfunctional, fail to include nutrient acquisition from the bulk mineral fraction and hence cannot explain rapid topsoil formation at depth.

The puzzle is that establishment science clings to these out-dated models, inferring real-life data to be inconsequential. Measurements made outside of institutionalised science are branded 'anecdotal' and largely ignored.

Making the world a better place

When pastures (including those grown in association with crops) are managed to utilise nature's free sunlight, air and soil microbes - to rapidly form new, fertile, carbon-rich topsoil, the process is of immense benefit to farmers, rural communities and the nation.

Property owner, Colin Seis, has no wish to revert to former management practices, as he can now carry twice the number of stock at a fraction of the cost. Nevertheless, if the land management were to change for some unforeseeable reason, the increased levels of humus (non-labile carbon) now present in his soil would remain for considerably longer than the average lifespan of carbon in trees.

In addition to reducing levels of atmospheric carbon dioxide, the activation of the soil sequestration pathway results in the release of plant nutrients from the theoretically insoluble mineral fraction, which comprises by far the largest proportion (96-98%) of the soil mass. This increased mineral availability improves the health of pastures, crops, livestock and the people consuming agricultural produce. Everyone benefits when food is more nourishing.

Mineral availabilities are determined more by the rate of carbon flow from plants than by the stock of carbon in the soil. The 'key' to mineral management is appropriate groundcover management.
When the plant-soil sequestration pathway has been activated, it is possible to feed more people from less land.

Taking action on soil carbon

Those who persist in maintaining that soil carbon comes at a 'cost' and/or disappears during a drought and/or requires applications of expensive fertiliser and/or necessitates forgone production - had better 'please explain'. The on-farm reality is that when the sequestration pathway for non-labile carbon has been activated, the opposite is true.

How much longer will the farming community have to endure the myths, misconceptions and misleading models put forward by the people currently employed to solve the problem of declining soil carbon, dwindling soil fertility and losses in soil function?
Will government show some initiative, seek the truth and act on it?

<u>Here's the data</u>

2000-2010: 168.5 tonnes CO_2 sequestered per hectare.
2008-2010: Sequestration rate 33 tonnes CO_2 per hectare per year.
Permanence: 78% of the newly sequestered carbon is in the non-labile (humic) fraction of the soil - rendering it highly stable.
Location: The greatest increases in soil carbon have occurred at depth, overcoming subsoil constraints. Non-labile soil carbon has doubled in the 10-20cm increment, tripled in the 20-30cm increment and quadrupled in the 30-40cm increment.
Minerals: The following increases in soil minerals have occurred - calcium 277%, magnesium 138%, potassium 146%, sulphur 157%, phosphorus 151%, zinc 186%, iron 122%, copper 202%, boron 156%, molybdenum 151%, cobalt 179% and selenium 117%.
Cash benefit: At a carbon price of $20 per tonne, and assuming payment for non-labile (permanent) carbon only, the value of 33 tCO_2/ha/yr would be $660 x 78% = $515/ha/yr. A price on carbon would provide worthwhile incentive for progressive farmers to rebuild our precious agricultural soils.

Building soil carbon with Yearlong Green Farming (YGF) – Dr Christine Jones

Founder, Amazing Carbon
www.amazingcarbon.com

The capacity for appropriately managed soils to sequester atmospheric carbon is enormous. The world's soils hold around three times as much carbon as the atmosphere and over four times as much carbon as the vegetation. **Soil represents the largest carbon sink over which we have control.**

When atmospheric carbon is sequestered in topsoil as organic carbon, it brings with it a wealth of environmental, productivity and quality of life benefits. An understanding of the 'carbon cycle' and the role of carbon in soils, is essential to our understanding of life on earth.

Building soil carbon requires green plants (such as crops and pastures) and soil microbes.

There are 4 steps to 'turning air into soil':

i) Photosynthesis
ii) Resynthesis
iii) Exudation
iv) Humification.

Photosynthesis

The miracle of **photosynthesis**, which takes place in the chloroplasts of green leaves, is a two-step endothermic reaction (i.e. a **cooling process)**. Incoming light energy (sunlight) is captured and stored as biochemical energy in the form of a simple sugar - glucose ($C_6H_{12}O_6$), using carbon dioxide (CO_2) from the air and water (H_2O) from the soil. Oxygen is released to the atmosphere.

Photosynthesis requires 15MJ of sunlight energy for every kilogram of glucose produced. If the same 15MJ of incoming light energy makes contact with a bare surface, such as bare ground, it is reflected, absorbed or radiated - as **heat**, usually accompanied by moisture. Thus the respective area of the earth's surface covered by either actively growing crops and pastures, or bare ground, has a significant effect on global climate.

Resynthesis

Through a myriad of chemical reactions, the glucose formed during photosynthesis is resynthesised to a wide variety of carbon compounds, including carbohydrates (such as cellulose and starch), proteins, organic acids, waxes and oils. Carbon atoms can link together to form long chains, branched chains and rings, to which other elements, such as hydrogen and oxygen, can join.

The energy captured during photosynthesis and stored in carbon compounds serves as 'fuel' for life on earth. Carbohydrates such as cellulose provide energy for grazing animals, the starch in grains provides energy for livestock and people – and carbon stored in previous eras as 'fossil fuels' (hydrocarbons) such as coal, oil and gas – provides energy for vehicles, machinery and industry.

Exudation

Around 30-40% of the carbon fixed by grass plants during photosynthesis is exuded into soil to form a microbial bridge – that is – to feed the microbes that enhance the availability of essential plant nutrients. In this way, actively growing crops and pastures provide ‘fuel’ for the soil engine.

Carbon compounds and the microbial populations they support are essential to the creation of topsoil from the structureless, lifeless mineral soil produced by the weathering of rocks.

Organic carbon additions are governed by the volume of plant roots per unit of soil and their rate of growth. The more active green leaves there are, the more healthy roots there are (Fig 1), the more carbon is exuded. It’s as simple as that. The breakdown of fibrous roots pruned into soil through rest-rotation grazing is also an important source of carbon in soils.

Humification

Adding organic carbon to soil is one thing. Keeping it there is another. Organic carbon moves between various ‘pools’ in the soil, some of which are short lived while others may persist for thousands of years. Carbon additions need to be combined with land management practices that foster the conversion of relatively transient forms of organic carbon to more stable complexes within the soil.

In the humification process, soil microbes resynthesise and polymerise labile carbon (exuded from plant roots or accessed by mycorrhizal fungi) into high molecular weight stable humic substances. Humus, a gel-like substance that forms an integral component of the soil matrix, is the best known of the stable organic fractions.

Humification cannot proceed unless there is a continuous supply of ‘fuel’ for soil microbes. If humification does not occur, the carbon exuded from plant roots at Step 3 (or added to soil as plant residues or manure) simply oxidises and recycles back to the atmosphere as carbon dioxide.

Humic substances have significance above and beyond the relatively long-term sequestration of atmospheric carbon. They are extremely important in terms of pH buffering, inactivation of pesticides and other pollutants, improved plant nutrition and increased soil-water-holding capacity. By chelating salts, humic substances can also effectively ameliorate the symptoms of dryland salinity. Increasing the rate of humification therefore has highly significant effects on the health and productivity of agricultural land.

Importance of soil fungi

Most perennial grasses are excellent hosts for mycorrhizal fungi. Around 100 metres of microscopic fungal hyphae can form per gram of soil under healthy grassland (with several kilometres of total hyphae per gram of soil in the rhizosphere). Glomalin is a glycoprotein (contains both protein and carbohydrate) produced by arbuscular mycorrhizal fungi living in association with plant roots. Glomalin can persist for several decades and may account for one third of the stable organic carbon stored in agricultural soils. The glomalin molecule also contains quite high levels of iron which are thought to help protect plants from soil pathogens. Enhanced glomalin formation may partly explain the success of **Pasture Cropping**, a technique in which annual grain crops are sown into dormant perennial pasture.

Inhibitory factors for mycorrhizal fungi and glomalin production include bare soil, intensive tillage, the application of phosphorus fertiliser and the presence of plants from the Brassica family, such as canola, which do not form mycorrhizal associations.

Maintaining soil structure

'Aggregation' is part of the humification and soil carbon building process. It is essential for maintaining soil structure. Glues and gums from fungal hyphae in the rhizosphere enable the formation of peds or lumps (which can be seen with the naked eye, often attached to plant roots). The presence of these aggregates creates macropores (spaces between the aggregates) which markedly improve the infiltration of water. After rain, less water sits on the soil surface, waterlogging is reduced and vehicles are less easily bogged. As structure continues to improve, smaller and smaller aggregates are formed, along with soil mesopores and micropores. The reinstatement of the complete range of aggregate sizes and soil pore sizes dramatically improves soil function, aeration, levels of biological activity and resilience.

Soil structure is not permanent. Aggregates made from microbial substances are continually breaking down and rebuilding. An ongoing supply of energy in the form of carbon from the rhizosphere exudates of actively growing plant roots and mycorrhizal fungi will maintain soil structure. If soils are left without green groundcover for long periods there is no energy source for soil life. Soils lose structure and can become compacted – or in the case of light soils – blow or wash away.

Under conventional cropping or set-stocked annual pastures, the stimulatory exudates produced by short-lived species are negated by bare earth in the non-growing season. The inevitable result is a decline in levels of soil carbon, soil structure and soil function.

Soil building requires green plants and soil cover for as much of the year as possible. In seasonal rainfall environments, a mix of perennial groundcover species enables response to rain at any time. In grazing enterprises, rest-rotation grazing is absolutely essential. For broadacre cropping, the presence of out-of-season groundcover ensures stability, long term productivity and soil building – rather than soil destruction.

Any farming practice that improves soil structure is building soil carbon. When soils become light, soft and springy, easier to dig or till and less prone to erosion, waterlogging and with less dryland salinity - then organic carbon levels are increasing. If soils are becoming more compact, eroded or saline – organic carbon levels are falling.

Water, energy, life, nutrients and profit will increase on-farm as soil organic carbon levels rise. The alternative is evaporation of water, energy, life, nutrients and profit if carbon is mismanaged and goes into the air.

Yearlong Green Farming (YGF)

Yearlong Green Farming is any process, technique or practice that turns bare soil into soil covered with green plants. Yearlong Green Farming increases the quality, quantity and perenniality of green groundcover in broadacre cropping, horticultural, silva-pastoral and grazing enterprises.

Many of the benefits of Pasture Cropping, for example, can be attributed to having perennial grasses and cereals together, side by side in space and time. The ongoing carbon additions from the perennial grass component evolve into highly stable forms of soil carbon, while the short-term, high sugar forms of carbon exuded by the roots of the cereal crop stimulate microbial activity.

As a bonus, regenerative farming practices such as Pasture Cropping result in the production of food much higher in vitamin and mineral content and lower in herbicide and pesticide residues than conventionally produced foods.

Rewarding landholders for Yearlong Green Farming practices that build new topsoil and raise leve[49] organic carbon would have a significant impact on the vitality and productivity of Australia's rural industries. Yearlong Green Farming would also reduce evaporation and heat radiation from bare soil surfaces, reduce the incidence of dryland salinity and counteract soil acidity.

Under **regenerative** regimes, soil carbon and soil life are restored, conferring multiple ecological and production benefits in terms of nutrient cycling, soil water storage, soil structural integrity and disease suppression. Benefits extend well beyond the paddock gate. Improved soil and water quality are the 'key' to catchment health, while Yearlong Green Farming represents the most potent mechanism available for mitigating climate change.

It's about turning carbon loss into carbon gain. Getting started in lifeless, compacted soils where the soil engine has shut down is the hard part. The longer we delay, the more difficult it will be to re-sequester soil carbon and re-balance the greenhouse equation.

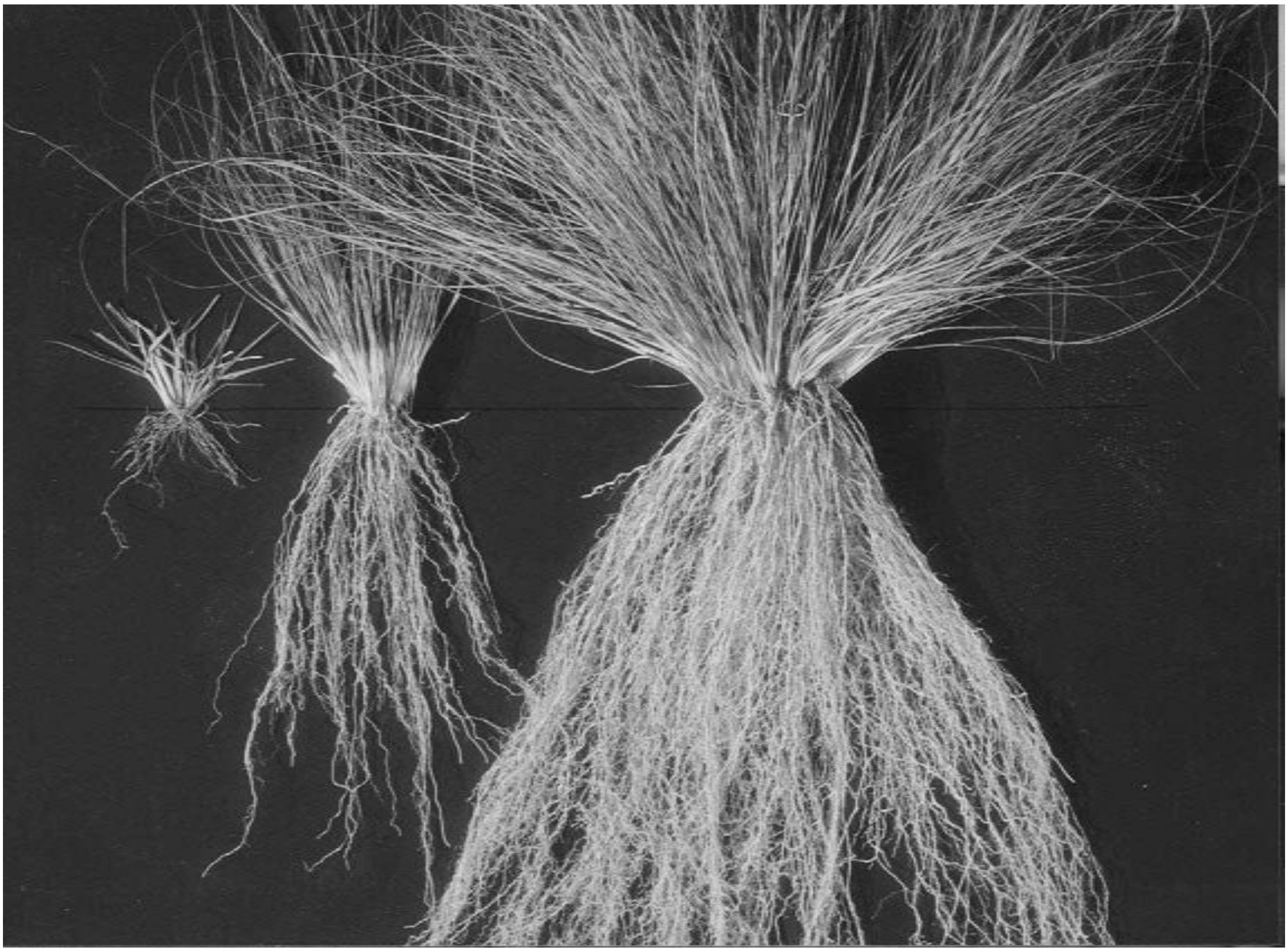


Fig 1. Root volume, rhizosphere surface area, exudation of carbon, presence of mycorrhizal fungi, levels of biological activity, humification and soil building are all highly correlated with the perenniality and vigour of groundcover plants.

Super Soils - Dr Bruce Cockroft

Background

Irrigated agriculture in Australia performs rather poorly in the dollars it generates. This is because the yields of nearly all crops and fodder are very low compared with potential; but also because low cost, low return (per ha and per Ml) grazing industries dominate. For example, irrigated Victoria produces $430 per ha per year, California $3,500 and Israel $13,700. Examples of actual and best overseas yields include maize 10t/ha v 35, grapes 4 v 20 and pears 35 v 180.

To consider potential productivity we should not only compare our results with what others can achieve: the ultimate limitation to plant productivity is the available solar radiation. This is expressed as the conversion of incoming energy to plant dry matter: 6% conversion is possible on farm, 12% has been achieved. A 4% conversion in southern Australian irrigation areas to plant dry matter would give 64t/ha which is 15 times the current yield of, for example, perennial pasture. Cockroft and Mason (1987) discuss this and give examples of a range of crops, especially horticulture.

This, and comparisons with very best yields overseas, indicate that irrigated horticulture could generate far more than current. The important issue is that it is possible to greatly improve the total economic value of our irrigate agriculture.

Causes of Low Productivity

Australian irrigated agriculture has many advantages and thus real potential:
Ample land, easily irrigated, mostly high quality water, good climate, clean and green, year round production, good local infrastructure, experienced and able farmers, soils with few difficult nutritional problems. An important cause of low productivity is soil structure. Australian soils rapidly deteriorate when put under crops - they go hard, then restrict crop roots, yield falls off disastrously and the crops become uneconomic. Soil hardening causes the low yields of most annual and perennial crops; it also forces animal industries to grow pastures and graze in order to sustain feed production.

In the early days of irrigated agriculture, many areas including northern Victoria and southern NSW, farmers grew crops: in the late 1800's crops occupies 100% of irrigated land; by 1910 they occupied 70%, 1925 it was 50%, and currently it is 20%. This swing to pastures is not seen anywhere else in irrigation areas around the world and was caused here by our hard setting soils. In NSW the proportion of soils under crops is higher but most of this is either rice which requires soils of low permeability, or wheat which is grown in winter.

However, poor soils should not be looked on as a given. We have improved soil nutrients and water and we can improve soil structure too.

Properties of Productive Soils

I have studied the properties of some of the best soils in the world, by visiting them, examining them in the field, discussing with local soil scientists, reading the literature relevant to them, including soil surveys; in California, Nebraska, Iowa, Holland, Sweden, Italy, Kent, China, Northern Syria and New Zealand. The very best soils in each country showed similar properties to each other. Their yields of nearly all crops are two to three times the highest in Australia. In Madera County, California, the soil survey in its comments on the best soil type, says, "This soil is much prized in Californian agriculture." I call them Super Soils. They are extremely rare in all areas. They do not exist in Australia.

Table 1 sets out some of the properties of a super soil in Kent and contrasts it with a Class 1 soil in Shepparton. The important differences are, in the super soil: light textures, deep, loose, soft, porous, very high available water, high OM, young (1000yr).

Table 1. Comparison of Properties of Barming in UK and Class 1 Soil in Shepparton

Property	**East Shepp. fsl**	**Barming sl**
Macroporosity (%)	11	20
Mesoporosity (%)	9	18
Microporosity (%)	24	33
Total porosity (%)	47	71
Water Stable Aggregation (%)	75	100
Dispersion (%)	2	0
Slaking (%)	9	0
Coalescence (%)	100	0
Infiltration (mm/ha)	20	50
Hydraulic conductivity (mm/hr)	9	36
Available water capacity (%)	8	25
Penetrometer resistance (MPa)	3.6	0.8
Bulk Density (glee)	1.4	0.8
Coarse sand (%)	27	12
Fine sand (%)	48	48
Silt (%)	12	24
Clay (%)	13	16
Organic Matter (%)	2.7	9.4
pH	6.5	6.3
Fine Roots (cm/cc)	4	30

THEORETICAL ASPECTS

Super Soil and Super Aggregates

Our aim is to find how to produce super soil for horticulture and have growers produce it and maintain it thus. A super soil yields two to three times the best current orchards and continues the high yield under zero tilled fruit trees and tilled vegetable crops. The very best soils in the world are super soils.

Super soils are also characterised by:

- Completely stable to wetting and drying
- Stable to overburden pressures and other stresses.

Loose, not massive. i.e. not coalesced. Soft.

- Macroporosity at least 15%.
- Mesoporosity at least 30%.
- Bulk density less than 1.0.

We assume that the soil is properly managed for crops - nutrition, waster supply, drainage, no soil-born disease.

The concept of the "super soil" is a new approach to our research on irrigated soils. This soil is rare around the world and non-existent in Australia.

After many years of research I have at last produced a super soil; this is a first in the world and represents a lot of progress. However, my most recent measurements indicate that in all pots and plots the soils are slowly deteriorating - they are going hard and losing the all important water conducting pores. I am convinced that we have the chemistry correct (lime, gypsum, fertilizer, etc), also the physics (water application, drainage, etc), and the mechanics (no traffic, overburden, slumping, etc). We are left with the biology of the soil.

Soil Biology

The soil science literature tells us that the important biological agents in the production of good soil structure tend to be associated with roots, especially the roots of grasses which are extensive, branching and vigorous growers. The agents involved are roots, fine, very fine roots <0.01mm), fungal hyphae, actinomycetes and bacteria. The actinomycetes are very fine <0.01mm) organisms that live on root surfaces. All these have the ability to entangle with soil particles and bind them into aggregates. They also exude gums that bond particles to make the aggregates stable. The whole biological system within soils is very complex and soil scientists have not yet sorted out the details of binding and bonding, nor the mechanisms involved in maintaining looseness between the aggregates, nor the mechanisms involved in the formation of the water conducting pores within the aggregates.

If we grow a grass plant in loose soil then pull the plant out of the soil we find that each root supports a layer of soil that is adhering to the surface of the root. The adhering soil is up to 3mm across, is attached by exudates (gums) from the root and by the mass of very fine roots, root hairs and fungal hyphae. The rhizosheath has a huge population of biological agents and is the main centre of the biological activity involved in developing and maintaining the soil structure that we are aiming for.

Water Supply to Root

Some of the reasons why the super soil produces such high yields are obvious -
good infiltration and drainage of water, loose and soft for crop root activity, up to two feet depth and never losing these properties. Not quite so obvious is the need for more mesopores. We need a study to discover how the mesopores develop as the original soils of the experiments gradually change to super soils. Some scientists believe the mesopores form as the larger (1/4 to 10mm) aggregates develop under the influence of the biological agents. Others believe that the larger aggregates change to more porous structures in the presence of these agents. One can imagine that when we irrigate, water flows down the channel created by the old roots, carrying fine soil particles, fine organic debris and other materials, and down the large pores; these could become entangled in the crowded roots/hyphae. With enough biological entanglement a larger aggregate could develop that would be very porous and spongy. As it becomes stable it remains full of mesopores.

Organic Matter and Microbial Biomass

Recently I discussed these subjects as applicable to this project, with Dr Jan Skjemstad of CSIRO Division of Land and Water in Adelaide. He agreed with our results and he was very encouraging. He then made several points:

- He explained the success of high initial organic matter pot treatments (virgin soil and OM added initially) in spite of soil organisms digesting organic matter quickly in soils.
- He explained the success thus: when we add OM then grow high concentrations of rye grass roots, the

roots protect the OM from digestion; the roots add organic matter as the older ones die; the roots exude soluble organic matter; the roots grow fungal hyphae out into the surrounding soil; the roots develop the "rhizosheath" which is highly active biologically; the roots rearrange soil particles into more stable aggregates.

• His most important point was his argument that the vital issue for really excellent soil structure was the turnover of "microbial biomass". The microbial biomass includes bacteria, fine filamentous fungi (hyphae), other microscopic organisms, fine roots (0.2 – 1 mm diameter), very fine roots <0.2mm diameter), and root hairs. All these develop, function, then die in soils and Skjemstad thinks that it is the total amount of this microbial biomass that drives the production of aggregates that are stable and will not collapse into a hard mass when farmed. The higher the microbial biomass, the more structure building that goes on.

• Also of great importance is the "carbon turnover". This is the cycle of organic matter into the soil, its dynamic changes to various compounds and its ultimate respiration as CO_2, In the soil we have many different such pathways, some very slow and some very quick. The amount of turnover is the crucial issue.

• The fuel for all this activity is organic matter. Clearly, also needed are moisture, aeration, warmth, nutrients especially nitrogen, lime and gypsum. The micro-organisms live on the organic matter and the fine grass roots proliferate when the structure starts to improve.

• When we set up beds with normal orchard soil, the level of organic matter is low because in old orchards the organic matter is concentrated in the top 5 centimetres and is very low below; the same with pasture soil. In the new plantings that growers set up, if they grow rye grass the grass roots start to add organic matter but this results in only a very slow OM build up. Skjemstad suggested that it would take 50 years to get to the desired level.

• When I added high amounts of OM initially in the pots, Skjemstad argued that the soil received a kick-start and the concentrated rye grass rooting which developed, was able to maintain the organic matter, and the desired soil structure developed.

• We have to maximise the microbial biomass. Needed are: plenty of OM added initially - not less that 4%, or 40t/ha to raise the soil OM from the normal 2% to 4%. This OM must be high quality and not resistant to microbial activity. Heavy rye grass. High nitrogen fertilizer. Moist, warm, well-drained soil.

Skjemstad suggested that reaggresizing could be a real effect. The changes to a soil that will remain loose, soft and porous are not immediate and some coalescence will develop; the reaggresizing, by gentle tillage, breaks up this incipient welding of aggregates and after a few cultivations the aggregate stability becomes high.

• The success of lime in the pots could be a real effect. He suggested that the lime not only provides calcium, important in bonding soil particles into aggregates, but also raises the pH to a level where silica in the soil becomes a bonding agent also.

Although irrigation by buried pipes to capillary wet the soil, had no spectacular result in soil structure, the fact is that when we find (very rarely) loose soft soil in mature orchards it is always in tree line banks that are wet from below when the orchard is flood irrigated and never in spray irrigated orchards. Capillary wetting may have a much better effect when we achieve higher OM. In the rare loose soils in older orchards the organic matter is over 6% compared to newly set up orchard beds where the soil has only 1 to 2% OM.

Powdered original soil and fine clay added originally, gave the poorest results because they were low in organic matter and the fine particles cemented the aggregates together rather than form up new aggregates. The original tomato soil was low in OM.

Building Super Aggregates

Introduction

In our path to building highly productive soils, the key hurdles that remain are how to make permanent a loose soft porous structure and how to develop a porosity that conducts water to the crop roots at very high rates. This describes a super soil.

We have achieved such a soil in several pots in our pot experiments on Stuart Pickworth's orchard; however the original soil was virgin; also we do not know how long the structure would last under commercial farming. To develop a farm system of soil management that will produce and maintain super soil is such a complex task of research that it is essential for us to develop a detailed understanding of the changes involved. Hence our cooperation with CSIRO at Canberra. Here I describe our most recent advances in this understanding.

Porous Aggregates

When a grower cultivates, the soil breaks up into a mixture of fragments and powder. Under irrigation the soil then rapidly coalesces into a hard mass that restricts root growth. In addition, this soil can conduct water to the roots only at a very slow rate. Our crops need soil that is permanently loose and porous. If we were to examine the best soils of all, we would see that they consist of loose aggregates, not fragments, and on close inspection we would see that the aggregates are rounded (unlike fragments which are angular) and that the aggregates are porous (unlike fragments which are dense and non porous).

The Soil Aggregates that Produce High Yields

In our experimental plots and pots some of the treatments have resulted in soil that has remained loose, soft and porous for up to eight years thus far. The aggregates are rounded with no sign of the original fragments. Our question is how did the soil change from hard dense angular fragments and powder, into soft porous rounded aggregates?

This change is brought about by the soil's biology - especially the roots of rye grass, but also the fungi, actinomycetes, bacteria and other soil organisms associated with the root.

Professor McCully of CSIRO in Canberra has studied the soil around roots and especially in the rhizosheath, the soil that adheres to the roots. She has developed the concept that the building of ideal soil structure is very mud-centred in this rhizosheath.

Recently Professor McCully came to our area and took samples of soil from our pots and plots. She has now studied these under the electron microscope in her laboratory in Canberra. One of the important observations that she has made is that in the very best soils of our large number of plots and pots, the aggregates are high in mesopores.

Professor McCully made thin sections of the rounded aggregates that are about 5mm in diameter to study the mesopores. She collected the aggregates, froze them with liquid nitrogen then cut very thin slices with a special slicer. This technique allowed her to study the interior of different aggregates from different soils and different treatments. In doing so the aim is to study the gradual changes and eventually understand the process of formation of the ideal aggregates, including the pores within them.

Time-Lapse Photography

Tips of roots grow so very slowly that we find it difficult to observe what they are doing to the soil. However we can speed up our view of root growth by time-lapse photography, and thus view what is happening.

Dr Michelle Watt, a very experienced scientist who specialises in soil biology and who works with John Passioura and Margaret McCully, has developed a technique that looks promising for examining aggregate formation. Recently she has grown roots along a glass plate. She photographs the root every five minutes. When she then runs the film at normal speed we can see the movement of the root tip as it grows through the soil and the root hairs developing behind the tip; we can also see the effect of the root tip on the soil particles adjacent and the action of the root hairs in stabilizing the aggregates that they have been formed into.

All fleshy, growing root tips exude a sticky glue-like substance that lubricates the tip as it pushes through the soil. The exudate also assists the plant in taking up nutrients and in other ways. In Michelle's film we can see the actual movement of the root tip as it grows through the soil. We see the sticky tip picking up very small pieces of soil and collecting them into a bundle, until the bundle has become sufficiently large that it detaches from the root tip and is left in the soil. The root tip grows on and picks up more pieces, to develop more bundles. Inside each bundle the fine pieces of soil are spaced in the exuded gel, like currants in a bun. The gel dries, shrivels and is digested by microorganisms, leaving an aggregate, transformed from the bundle, that is rounded and porous. Michelle is suggesting that it is possible to imagine how in this way, the grass roots slowly change the original cultivated soil into the crumb structure that we desire. Once we positively know the mechanism of super aggregate formation, we can start devising ways to achieve the best results on-farm.

A NEW SYSTEM OF SOIL MANAGEMENT

Introduction

The aim of our research is a better system of soil management. We know that soil type and also the type of soil management both have large effects on fruit yields. But we are still a long way from the potential top yields of our crops. Our research of the last 15 years has produced sufficient data to try out a new system of soil management. The results of this research were outlined earlier (see Table 1).

The Eleven Practices

We can suggest from the total of all results from the last 15 years that it is possible to prevent coalescence and its resulting hardening of the soil and in fact, produce and maintain soil equal to the best overseas.

To do this, we need to avoid certain practices and use others:

Practices for Super Soil

Practices to Avoid	Practices to Use
Traffic compaction	Rye grass
Clay contamination	Capillary irrigation
Powdering	Organic matter
Ex-cropping soil	Reaggresizing
Ex-pasture soil	Lime
Poor drainage	

I need to comment on each of the eleven:
Practices to Avoid

1. Traffic compaction. An example is driving the tractor onto the bed when forming the bed.
2. Clay contamination. Caused when ripping, land forming, etc.
3. Powdering. Over-cultivating of the soil when it is dry.
4. Ex-cropped soil. Soil deteriorated from constant cropping.
5. Ex-pasture soil. Bad because of many years of compaction by stock and by machinery.
6. Practices to Use
7. Poor drainage. Continued wetness causes breakdown of OM plus surface viscous flow and welding at points of contact (see Lanyon Orchard Soil Management No. 42 and Tomato Technology No. 32).
8. Rye grass. Reduces the amount of coalescence by supplying OM into the soil, improving bonding and binding within aggregates and providing binding between aggregates.
9. Capillary irrigation. When soil wets upwards like a wick, the water comes under a suction and this provides a tension that holds the particles within each soil aggregate into an entity.
10. Organic matter. Bonds the soil particles within each aggregate to their neighbouring particle.
11. Reaggresizing. Breaks up any initial welding that has developed since the final bed cultivation.
12. Lime. Can give a bonding within the soil aggregates, possibly by interacting with OM.

Application of the Practices On-Farm

It seems to me that it should be quite simple to apply all eleven practices on our orchards.

- Traffic compaction. Ensure no traffic compacts the soil in the bed at any stage.
- Clay contamination. Prevent clay from the subsoil coming into the surface soil.
- Special tillage equipment may be necessary.
- Powdering. Avoid cultivating a soil when it is dry and avoid excessive cultivation.
- Ex-cropped soil. Rejuvenate it with six months or more under grass with no grazing, prior to planting.
- Ex-pasture soil. Ditto.
- Poor drainage. Provide effective drainage.
- Rye grass. Aim at 365 days per year when the soil benefits from active root growth - rye grass or tree roots. Avoid fallow - i.e. where no roots growing.
- Capillary irrigation. Tomato growers already do this; orchardists are starting to develop effective systems of capillary irrigation.
- Organic matter. Cultivating into the soil, such material as residues, has little beneficial effect unless the OM is protected by subsequent grass roots. The grass roots also add OM themselves.
- Reaggresizing. Tomato growers already do this by cultivating for the next crop.
  Orchardists can sow grass and incorporate it after six months prior to planting.
- Lime. Tomato growers in the western irrigation districts tend to have lime in their soil. The rest should consider applying suitable lime.

A Soil Management System

It seems that we are now in a position to try out, on farm, a new system of soil management. This new system of soil management should give very high yields, good fruit quality and will be cheap and easy to set up and manage. Clearly, soil quality would be much improved. We are now at a stage when we should try it in commercial plantings, at least in a small way. Although it is early days, all the evidence indicates that it will work.

We have identified eleven practices in orchards and tomatoes, that reduce soil deterioration by coalescence and lead towards ideal soil. Orchardists normally use 1 or 2 of the practices, tomato growers 2 or 3. Their soils are always hard.

• Several growers have included up to 6 or even 7 in recent plantings and here the soils are much softer than normal.

• Ross Turnbull has succeeded in setting up a block of peach trees where he was able to include 8 practices. Here the soil is the best I have seen in a commercial property; however, the soil is deteriorating after several years.

I have many plots in orchards and tomatoes where I have reached 10 practices; in these the soil is really first class and improving, not deteriorating.

• In a very few very best plots where I have included, just by good luck, all eleven practices, the soil has now changed to a super soil. That is to say, a normal orchard soil had changed to equal the best in the world.

REFERENCES

Cockroft, B., and Mason, W.K. (1987) Irrigated Agriculture. In "Agriculture in Victoria" by DJ.Connor and D.F. Smith.AlAS

Hall, D.G.M., Reeve, M.J., Thomasson, AJ., Wright, V.F. (1977) Water retention, porosity and density offield soils. Soil Survey of British Soils. Tech. Monograph No.9

Olsson, K.A., Cockroft, B., Rengasamy, P. (1995) Improving and managing subsoil structure for high productivity from temperate crops in beds.In "Subsoil Management Techniques" Ed. N.S. Jayawardane&B.A. Stewart. Lewis

Winteroo oats at Falconers Trial site September 2010

PASTURE CROPPING TRIALS

TRIAL DESIGN

TREATMENTS

TREATMENT	PLOT 1	PLOT 2	PLOT 3	PLOT 4
AUTUMN 2010	CONTROL Pasture only	Autumn crop plus C4 native grasses# sown together (Mar-Apr sowing) Fertiliser optional	Autumn crop (Mar-Apr sowing)Fertiliser optional grazed heavily in spring	Nil
SPRING 2010	CONTROL Pasture only	Nil	Summer crop, cow peas, lab lab and C4 native grasses# (Oct-Nov sowing) Fertiliser optional	Summer crop, cow peas, lab lab and C4 native grasses# (Oct-Nov sowing) Fertiliser optional
AUTUMN 2011	CONTROL Pasture only	Self Sown Oats	Oats, Seed Mix * Fertiliser optional	Oats, Seed Mix* Fertiliser optional
Disturbance Events	0	1	3	2

#Native grass species: Red grass, Wallaby Grass, Queensland Blue Grass, Microlaena, Paspalidium distans

* The seed mix to sow 2 plots [4ha] was: 1Kg Gatton Panic, 1Kg Premier Digit Grass, 2Kg Warrego grass [Paspalidium distans], 1 Kg Plantain, 2.5 Kg Arrow leaf Clover and 2 Kg of Lucerne.

GRAZING has been at the discretion of the owners and has been hampered by the lack of a water supply in the individual plots. Our original design included an ungrazed section in each plot but this has proven to be difficult to implement as it has created issues for machinery at sowing times.
Everyone had decided to try Pasture Cropping due to drought, but last year was the opposite which caused a different set of problems and raised many questions.
Two points have stood out:

- Lack of summer active feed.
- Grazing management.

Our trials continue to face many challenges but all have managed to get their crops sown.
The tests that we will be doing include species identification, % ground cover, Soil Microbiology test,% Soil carbon– 0-10cm,10-20 & 20-30cm, Standard soil test-0-10cm.Participants could choose what fertilizer they used if any.

Deep Soil Testing – May 2010

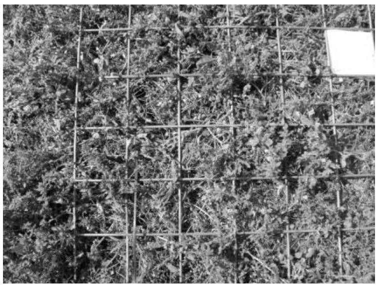
On Farm consult – October 2010

GROUND COVER

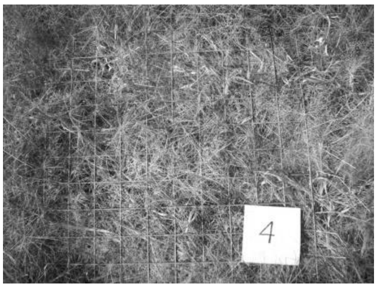
SITE	YEAR	PLOT 1	PLOT 2	PLOT 3	PLOT 4
BARRETT-LENNARD	2010	40%	80%	40%	65%
	2011	98%	95%	75%	70%
BURKE	2010	40%	80%	60%	30%
	2011	70%	70%	80%	75%
ELLIS	2010	95%	90%	85%	85%
	2011	100%	100%	70%	100%
FALCONER	2010	95%	90%	50%	95%
	2011	75%	75%	80%	85%
STEERS	2010	40%	70%	100%	60%
	2011	60%	75%	85%	100%

Ellis Control

2010

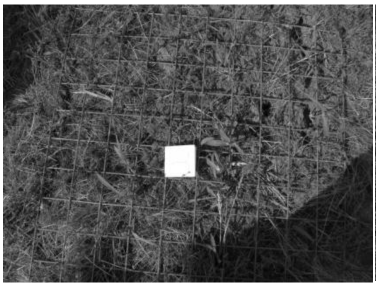


2011

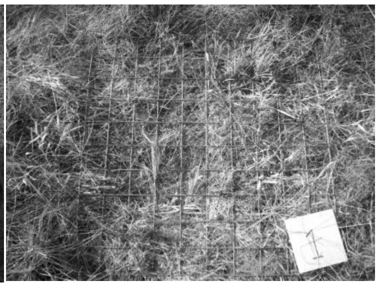


Burke Control

2010

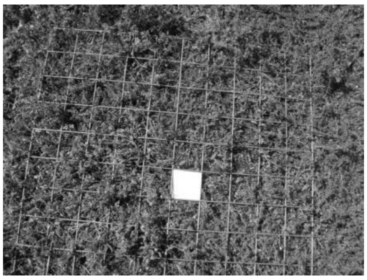


2011



Falconers Control

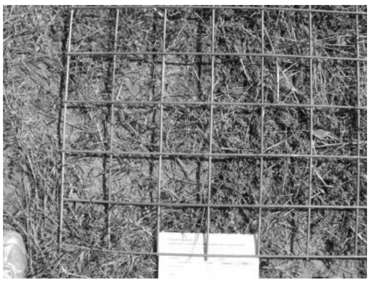
2010



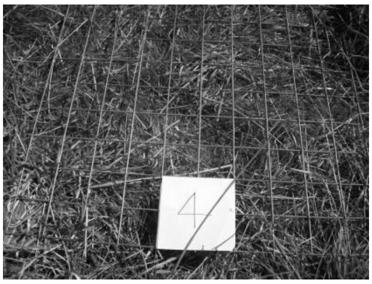
2011

Barrett-Lennard Control

2010



2011



CAM AND KATHY BARRETT-LENNARD

Cam showing a Salisbury West Landcare Group member his Trial Plot

Farm Address:

536 Gellibrand Tonks Rd Earlston

Farm Enterprise:

Fat lambs, cattle and some crop for fattening

Machinery Used:

Inter 20 rows 511 with John’s undercarriage at 7 inch spacings

Crop Varieties Used:

Bimble oats

OBSERVATIONS:

SUCCESSES –

- Noticeable improvement in recruitment of C3 and C4 grasses on what was previously bare ground and prone to waterlogging.

DIFFICULTIES–

- Working out how to get the bulk down without spraying or burning. Mulching seems to work well. Perhaps need to go to wider spacings on the seeder.

OTHER COMMENTS–

- Can see the benefits of smaller paddocks, in our case maybe 10 Ha each and rotate stock gives you time for winter oats and summer plantings to keep bulking up pastures.

- Will try molasses on stubbles in future to help break down of straw and digestibility.

- Very happy with results so far.

Tony Burke and Russell Ellis at PC Discussion Group day at Earlston

TONY & TRISH BURKE

Farm Address:
"Limerick", 275 Almonds Road, Lake Rowan Vic 3727 – North East Victoria - 24kms south of Yarrawonga

Farm Enterprise:
405ha Self replacing prime lamb flock. Cereal crops for grazing and grain

Reasons For Pasture Cropping:
- Colin Seis & Peter Andrews were initial instigators – after listening to them speak and reading Peter's books
- Move away from traditional mind set of continuous cropping
- Cost of chemical/ fertilisers – particularly prohibitive in drought years
- Like the idea of returning biology to soil and relying less on artificial inputs
- We were already unknowingly "pasture cropping" by sowing cereals into degraded pastures

Machinery Used:
Shearer 28 run trash drill (initially 7" rows now 12" rows to get through trash) knife edge points

Crop Varieties Used:
Cereals Wheat – Whistler: Barley – Gairdner: Oats – Eurabbie
Spring/Summer forage crops Brassica - Leafmore: Shirohie – Millet
Although the above are preferable, whatever we have or have access to at the right price is considered.

OBSERVATIONS:

SUCCESSES –
- Reduced input costs significantly
- Starting to see some varieties of native perennials coming back
- Getting more ground cover

DIFFICULTIES–
- Weed control particularly silver grass& barley grass
- Soil structure
- Mice & grasshoppers
- Establishing pastures without destocking
- Fencing & water
- The amount of trash to be handled when sowing
- Chemical selection so as not to harm native(finding a good agronomist that has an open mind to work with our ideas).

OTHER COMMENTS–
- We are looking into a disc and press wheel unit so we can go back to 7" spacing & still handle the trash
- After the last 2 years we will need to use more chemicals than I would like to keep on top of prolific weed grasses (Silver & Barley Grass)
- May have to use some fertilizer to help emerging crops. Sometimes you just can't do the things the way you would prefer and have to go back to some old ways to get out of a tough spot.

RUSSELL AND HELEN, ANDREW AND ALLY ELLIS

Farm Address:

"Hawk Hill", Chesney Vale, North Eastern Victoria

Farm Enterprise:

1000 hectares, merino sheep for both wool and first cross ewe production, prime lambs and cattle.

Reasons For Pasture Cropping:

Due to dry years the annual pastures ground cover was virtually nil in the autumn which allowed weeds to dominate pastures. We saw the need for more ground cover and when we listened to Colin Seis at Glenrowan in 2008, it immediately seemed that the principles would fit within our aims of both financial and environmental sustainability.

Machinery Used:

The International 511 spring release combine was not robust enough to direct drill into our pasture paddocks so we purchased a John's undercarriage for this machine which converted the 24 run combine to a 14 run combine with 30 cm spacings and high pressure breakout tynes, being 2 rows of 5 tynes and 1 row of 4 tynes creating wide spaces between - all are sowing tynes.

Crop Varieties Used:

2008: Our first pasture cropping using Bulban oats- grain yield on most paddocks was reduced (0.5 tonne per hectare) and most crops were grazed heavily due to the dry conditions. The recruitment of native grasses was significant (mainly varieties of Wallaby grass, red grass and windmill grasses) numbers increasing by at least 50%.
2009: Due to dry conditions and lack of feed for stock we sowed 200 hectares of oats and 100 hectares of wheat – most crops again heavily grazed with the yields of those crops taken through to grain being improved (1.5 t/ha oats and 1.2 t/ha wheat). Stubble grazing was very good and recruitment of natives again extensive.
2010: Summer rains resulted in good grazing of summer growing natives in last years' stubbles. Pasture crop 150 ha oats and 150 ha wheat- all crops heavily grazed. Crops taken through to grain looked better until extensive rain in November/December/January and late arrival of contractor in early February (by which time the oats had mainly shed) devastated the yields. Stubble grazing was excellent.
2011: Sowed 50 ha oats and 25 ha wheat. Less crop due to excellent feed carryover from summer rains and good ground cover. Crops again grazed due to increased stock numbers and the desire to use the available feed to maximise prime stock production.

DIFFICULTIES–

- Competition from annual grasses is difficult to control in the crop due to the limited number of sprays which kill annual grasses while leaving the native grasses. We are trying to control annual grasses in the winter prior to cropping.
- Allowing the seeding of native summer grasses limits the time available to reduce the amount of ground cover allowing the combine to pass through, especially in this establishment phase.
- Managing rotational grazing (getting the timing and intensity of grazing correct) with a breeding flock and varying stock classes is an ongoing problem.

BOB AND MARJ FALCONER

Farm Address:

107 Wards Lane, Meadow Creek   Victoria 3678 35 Km south east of Wangaratta in North East Victoria]

Farm Enterprise:

We farm 195 ha of grazing land in the King Valley.We run a Murray Grey beef herd producing about a 100 weaners per season and also operate an Arabian horse stud with three stallions for visiting mares and the production of transported chilled or frozen semen.

Reasons For Pasture Cropping:

Our farm is basically run on organic principles although we are not certified organic. We were attracted to pasture cropping after hearing Col Seis talk at Glenrowan in 2008 and then enrolling in his Pasture Cropping introductory course in Doug James' woolshed. The ideas seemed so common sense, 'do-able' and with low input costs that we purchased seed oats on our way home from the course and began sowing the next day. We had been in drought conditions for a number of years so had nothing to lose and with no ground cover bar some weeds we were sowing in early March into ground that was ideal for a cereal crop devoid of competition. The crop was a huge success reaching fence height and supplying us with four grazings to December and to our astonishment a variety of perennials which we hadn't seen in the paddock for years. We had produced a successful feed wedge and improved our pasture at little expense.

Machinery Used:

We used a converted Wallace plough to aerate prior to sowing and a 14 run Connor –Shea disc linkage seeder. We used an old chook feed mixer to inoculate the oat seed with Nutri-soil.

Crop Varieties Used:

We used Saia black oats and have since tried triticale. The oats have proved superior for the pasture result we require. For a cropping /sheep operation this may not be the case.

OBSERVATIONS

SUCCESSES-

- In our first year of Pasture Cropping we sowed several paddocks all successful but quite different for many reasons – soil type, timing, rain events, and soil preparation and the amount of disturbance before we direct drilled.
- All paddocks have responded very well in terms of native perennial recruitment, ground cover and diversity.   Over subsequent years we have used Pasture Cropping in several other paddocks and have been impressed with the results. However in 2010 with an extremely wet spring summer and autumn we have not had the same results but we did not need to as we had heaps of feed but still think the low cost of the method has been worthwhile for the diversity of species and perennial grass recruitment both native and exotic.

DIFFICULTIES

- We have difficulty in reading the amount of disturbance required prior to sowing using the seed drill we have. We are still learning and maybe one of the new double disc /press wheel drills would obviate this dilemma, however we plan to continue with our present equipment.
- We do not use a spray fallow and in a wet year like we just had, we had competition from grasses such as couch which meant we didn't have a good strike. We are working on it!

OTHER COMMENTS;

- Pasture Cropping is an excellent method of low cost pasture renovation and supplies a huge increase in fodder in spring. The cereals stimulate perennial C4 grasses through Summer/Autumn which is normally when we struggle for feed leading up to the autumn break.

MARK GOODMAN AND BELINDA STEERS

(Running the trial for Robin and Carolyn Steers)

Farm Address:

"Broxbourne Park", Nagambie Rd, Avenel.

Farm Enterprise:

Commercial Dorper sheep production

Reasons For Pasture Cropping:

Moving from extensive cropping back to pasture based sheep production

Machinery Used:

Massey Ferguson tractor and Connor Shea disc seeder
Trialed an Agroplow disc seeder with great success at completion of Field Day held in October.

CROP VARIETIES USED:

Echidna Oats

OBSERVATIONS

SUCCESSES:

- Planting Gatton Panic with Oats and Lupins in October 2010. Provided massive growth via the Panic over Jan –Feb.

DIFFICULTIES:

- Weed control with silver grass, barley grass and sorrel.

OTHER COMMENTS:

- We cannot decide whether it's the pasture cropping or changes to grazing management that has had the greatest success in improving the diversity of what is in the trial plot.

KEVIN AND PAT MITCHELL

Lab Lab nodulation

Farm Address:
'Muttaburra South", Devenish, Victoria

Farm Enterprise:
Prime Lambs ,Cropping

Reasons For Pasture Cropping:
To increase plant species, especially more perennials, while at the same time achieving a cereal crop for grain or grazing. I consider improving the pasture is of 60% importance compared to cropping 40%.

Machinery Used:
An International 511 combine with John's modification with knife points, 9 ½" spacings, also K-Line coulters (from Cowra NSW) and reused roller sections as press wheels.

CROP VARIETIES USED:
Matika Oats and Wedgetail wheat for winter crops
Shirrohie Millet, Lab Lab and Cowpeas for summer crops.
Sometimes undersown with Plantain, Chicory and *Paspalidium distans* grass.

OBSERVATIONS

- Much better cover over soil with plant material, reducing erosion and assisting moisture retention.
- Improving soil life eg. fungi, worms etc has meant the soil is becoming more friable near surface.

SUCCESSES:

- Cereal crops productive with useful undercrop plant species for grazing or start for next season. Last year's wet summer grew excellent millet and Lab Lab.
- Both were grazed and some millet harvested. Lab Lab would have added to soil nitrogen with excellent nodulation.
- Warrego and Prairie grass are showing promise.

DIFFICULTIES:

- Intensive cropping history here with high chemical usage means it's hard to achieve a good clean crop without chemicals.
- Also difficult to establish native perennials and clovers.
- Summer pasture cropping shows potential to grow feed for sheep when it is needed but also establishes couch grass, sorrel and noxious weeds like loosestrife.

.

OTHER COMMENTS:
Producing prime lambs requires quality feed to finish them for market. Cannot see a big place for native plants for this and expect to sow perennials like Lucerne, Chicory and Plantain along with Rye grass in with our Oat crops. We are likely to produce grain for our own livestock and not sell the grain. Some work yet to be done re safety of chemicals on the pasture under the crops as chemicals will be needed to harvest any crop on our property.

SOIL TEST RESULTS March 2010

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 105532 / 5
Address:	DOUG JAMES	**Received:**	29 Mar 2010
	98 JAMES ROAD	**Despatch:**	12 Apr 2010
	BUNGEET 3726	**Submitted:**	Jacci Campbell
		Email:	Charlie Sexton
Job Comment:	**TRIAL PADDOCKS**		

ANALYSIS		UNITS	Laboratory Identification: CAM BARRETT LENNARD	FS 105532 - 105536 TONY BURKE	RUSSELL ELLIS	BOB & MARJ FALCONER	ROBIN & BELINDA STEERS	
Phosphorus	(Olsen)	mg/kg	15.3	20.9	17.5	9.1	11.7	
Phosphorus	(Colwell)	mg/kg	43.0	67.0	52.0	19.0	34.0	
Potassium	(Colwell)	mg/kg	298.0	371.0	202.0	189.0	311.0	
Sulphur	(KCL40)	mg/kg	14.3	4.4	9.9	7.3	7.1	
pH	(1:5 water)		5.0	5.5	5.4	5.1	5.3	
pH	(CaCl2)		4.3	4.6	4.5	4.4	4.5	
Salinity (EC)	(1:5 water)	dS/m	0.09	0.04	0.09	0.15	0.09	
Soil Texture			Loam	Loam	Loam	Loam	Loam	
Organic Carbon		%	2.75	1.48	1.91	2.55	1.78	
Nitrate		mg/kg	38.0	4.0	28.0	65.0	38.0	
Ammonium		mg/kg	22.0	4.0	15.0	3.0	3.0	
Calcium	(Exch)	meq/100 g	2.50	3.98	3.50	2.82	2.10	
Magnesium	(Exch)	meq/100 g	0.80	1.32	1.23	0.80	0.45	
Sodium	(Exch)	meq/100 g	0.15	0.22	0.48	0.18	0.07	
Potassium	(Exch)	meq/100 g	0.70	0.92	0.46	0.43	0.78	
Aluminium	(Exch)	meq/100 g	0.44	0.20	0.25	0.13	0.18	
Calculations								
Sum of cations	(CEC)	meq/100 g	4.59	6.64	5.92	4.36	3.58	
Calcium/Magnesium ratio			3.1	3.0	2.8	3.5	4.7	
Sodium % of cations	(ESP)		3.3%	3.3%	8.1%	4.1%	2.0%	
Aluminium % of cations			9.6%	3.0%	4.2%	3.0%	5.0%	

Comments:

The test(s) reported have been performed in accordance with the terms of registration with the Australian Soil and Plant Advisory Council, Australia.
This document shall not be reproduced except in full without the prior approval of Farmright.

Authorised signature:

3

SOIL TEST RESULTS April 2011

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 114923 / 4
Address:	DOUG JAMES	**Received:**	14 Apr 2011
	98 JAMES ROAD	**Despatch:**	03 May 2011
	BUNGEET 3726		
		Submitted:	Jacci Campbell
Job Comment:	**BARRETT - LENNARD - PASTURE CROPPING TRIAL**		

ANALYSIS		UNITS	**Laboratory Identification:**			FS 114923 - 114926		
			BAR - LEN PLOT 2 OATS	**BAR - LEN PLOT 3 OATS / MILLETT**	**BAR - LEN PLOT 4 MILLETT**	**BAR - LEN PLOT 1 CONTROL**		
Phosphorus	(Olsen)	mg/kg	18.3	17.1	15.1	10.8		
Phosphorus	(Colwell)	mg/kg	46.0	36.0	35.0	26.0		
Potassium	(Colwell)	mg/kg	282.0	264.0	276.0	175.0		
Sulphur	(KCL40)	mg/kg	8.0	6.9	8.3	9.8		
pH	(1:5 water)		5.2	5.2	5.0	5.1		
pH	(CaCl2)		4.3	4.3	4.2	4.3		
Salinity (EC)	(1:5 water)	dS/m	0.06	0.06	0.05	0.05		
Soil Texture			Loam	Loam	Loam	Loam		
Organic Carbon		%	2.42	2.13	2.36	2.46		
Total Carbon		%	2.69	2.44	2.60	2.59		
Nitrate		mg/kg	5.0	4.0	6.0	5.0		
Ammonium		mg/kg	4.0	3.0	7.0	7.0		
Calcium	(Exch)	meq/100 g	2.89	2.09	2.22	3.72		
Magnesium	(Exch)	meq/100 g	0.83	0.51	0.57	1.25		
Sodium	(Exch)	meq/100 g	0.13	0.10	0.06	0.19		
Potassium	(Exch)	meq/100 g	0.68	0.67	0.54	0.39		
Aluminium	(Exch)	meq/100 g	0.61	0.50	0.62	0.56		
Calculations								
Sum of cations	(CEC)	meq/100 g	5.14	3.87	4.01	6.11		
Calcium/Magnesium ratio			3.5	4.1	3.9	3.0		
Sodium % of cations	(ESP)		2.5%	2.6%	1.5%	3.1%		
Aluminium % of cations			11.9%	12.9%	15.5%	9.2%		

Comments:

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK		**Sample :**	FS 114915 / 4
Address:	DOUG JAMES		**Received:**	14 Apr 2011
	98 JAMES ROAD		**Despatch:**	02 May 2011
	BUNGEET	3726		
			Submitted:	Jacci Campbell
Job Comment:	**BURKE - PASTURE CROPPING TRIAL**			

Laboratory Identification: **FS 114915 - 114918**

ANALYSIS		**UNITS**	BURKE PLOT 1 CONTROL	BURKE PLOT 4 MILLET	BURKE PLOT 3 OATS / MILLET	BURKE PLOT 2 OATS		
Phosphorus	(Olsen)	mg/kg	21.7	22.4	21.7	23.0		
Phosphorus	(Colwell)	mg/kg	65.0	61.0	56.0	63.0		
Potassium	(Colwell)	mg/kg	316.0	289.0	371.0	345.0		
Sulphur	(KCL40)	mg/kg	3.1	3.6	3.6	3.4		
pH	(1:5 water)		5.6	5.6	5.5	5.5		
pH	(CaCl2)		4.6	4.6	4.5	4.5		
Salinity (EC)	(1:5 water)	dS/m	0.03	0.03	0.03	0.03		
Soil Texture			Loam	Loam	Loam	Loam		
Organic Carbon		%	1.19	1.17	1.36	1.38		
Total Carbon		%	1.46	1.37	1.62	1.59		
Nitrate		mg/kg	2.0	1.0	1.0	2.0		
Ammonium		mg/kg	2.0	2.0	1.0	2.0		
Calcium	(Exch)	meq/100 g	3.56	3.62	3.84	3.49		
Magnesium	(Exch)	meq/100 g	1.25	1.22	1.19	1.08		
Sodium	(Exch)	meq/100 g	0.20	0.19	0.15	0.13		
Potassium	(Exch)	meq/100 g	0.81	0.74	0.95	0.88		
Aluminium	(Exch)	meq/100 g	0.34	0.38	0.38	0.45		
Calculations								
Sum of cations	(CEC)	meq/100 g	6.16	6.15	6.51	6.03		
Calcium/Magnesium ratio			2.8	3.0	3.2	3.2		
Sodium % of cations (ESP)			3.2%	3.1%	2.3%	2.2%		
Aluminium % of cations			5.5%	6.2%	5.8%	7.5%		

Comments:

The test(s) reported have been performed in accordance with the terms of registration with the Australian Soil and Plant Advisory Council, Australia.
This document shall not be reproduced except in full without the prior approval of Farmright.

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 114908 / 7 Page 1
Address:	DOUG JAMES	**Received:**	14 Apr 2011
	98 JAMES ROAD	**Despatch:**	03 May 2011
	BUNGEET 3726		
		Submitted:	Jacci Campbell
Job Comment:	**ELLIS - PASTURE CROPPING TRIAL**		

ANALYSIS		**UNITS**	**Laboratory Identification:**			**FS 114908 - 114913**		
			ELLIS GRAZED PLOT 2 OATS	**ELLIS GRAZED PLOT 3 OATS**	**ELLIS GRAZED PLOT 4 MILLET**	**ELLIS GRAZED PLOT 1 CONTROL**		
Phosphorus	(Olsen)	mg/kg	18.4	19.6	22.4	22.7		
Phosphorus	(Colwell)	mg/kg	52.0	51.0	60.0	63.0		
Potassium	(Colwell)	mg/kg	175.0	177.0	204.0	172.0		
Sulphur	(KCL40)	mg/kg	6.6	4.3	4.8	4.4		
pH	(1:5 water)		5.5	5.7	5.7	5.6		
pH	(CaCl2)		4.7	4.7	4.7	4.6		
Salinity (EC)	(1:5 water)	dS/m	0.10	0.05	0.06	0.05		
Soil Texture			Loam	Loam	Loam	Loam		
Organic Carbon		%	1.96	1.42	1.82	1.85		
Total Carbon		%	2.18	1.83	2.19	2.12		
Nitrate		mg/kg	24.0	2.0	2.0	3.0		
Ammonium		mg/kg	13.0	8.0	1.0	4.0		
Calcium	(Exch)	meq/100 g	3.57	3.50	4.00	3.59		
Magnesium	(Exch)	meq/100 g	1.20	1.07	1.18	1.21		
Sodium	(Exch)	meq/100 g	0.37	0.29	0.32	0.38		
Potassium	(Exch)	meq/100 g	0.36	0.39	0.51	0.41		
Aluminium	(Exch)	meq/100 g	0.41	0.36	0.31	0.41		
Calculations								
Sum of cations	(CEC)	meq/100 g	5.91	5.61	6.32	6.00		
Calcium/Magnesium ratio			3.0	3.3	3.4	3.0		
Sodium % of cations	(ESP)		6.3%	5.2%	5.1%	6.3%		
Aluminium % of cations			6.9%	6.4%	4.9%	6.8%		

Comments:

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 114900 / 8 Page 1
Address:	DOUG JAMES	**Received:**	14 Apr 2011
	98 JAMES ROAD	**Despatch:**	02 May 2011
	BUNGEET 3726		
		Submitted:	Jacci Campbell
Job Comment:	**FALCONER - PASTURE CROPPING TRIAL**		

ANALYSIS		UNITS	FALCONER GRAZED PLOT 4 MILLET	FALCONER GRAZED PLOT 2 OATS/MILLET	FALCONER GRAZED PLOT 2 OATS	FALCONER GRAZED PLOT 1 CONTROL		
			Laboratory Identification:			**FS 114900 - 114905**		
Phosphorus	(Olsen)	mg/kg	6.8	6.2	6.3	5.7		
Phosphorus	(Colwell)	mg/kg	15.0	14.0	15.0	14.0		
Potassium	(Colwell)	mg/kg	185.0	98.0	136.0	101.0		
Sulphur	(KCL40)	mg/kg	5.0	2.6	4.2	3.9		
pH	(1:5 water)		5.5	5.5	5.6	5.5		
pH	(CaCl2)		4.7	4.7	4.7	4.7		
Salinity (EC)	(1:5 water)	dS/m	0.07	0.04	0.05	0.05		
Soil Texture			Loam	Loam	Loam	Loam		
Organic Carbon		%	2.24	2.11	2.04	1.85		
Total Carbon		%	2.61	2.63	2.42	2.35		
Nitrate		mg/kg	13.0	5.0	7.0	7.0		
Ammonium		mg/kg	5.0	3.0	5.0	6.0		
Calcium	(Exch)	meq/100 g	2.66	2.41	2.44	2.65		
Magnesium	(Exch)	meq/100 g	0.64	0.55	0.65	0.74		
Sodium	(Exch)	meq/100 g	0.16	0.12	0.10	0.13		
Potassium	(Exch)	meq/100 g	0.42	0.23	0.32	0.23		
Aluminium	(Exch)	meq/100 g	0.29	0.24	0.20	0.20		
Calculations								
Sum of cations	(CEC)	meq/100 g	4.17	3.55	3.71	3.95		
Calcium/Magnesium ratio			4.2	4.4	3.8	3.6		
Sodium % of cations	(ESP)		3.8%	3.4%	2.7%	3.3%		
Aluminium % of cations			7.0%	6.8%	5.4%	5.1%		

Comments:

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 114919 / 4
Address:	DOUG JAMES	**Received:**	14 Apr 2011
	98 JAMES ROAD	**Despatch:**	02 May 2011
	BUNGEET 3726		
		Submitted:	Jacci Campbell
Job Comment:	**STEERS - PASTURE CROPPING TRIAL**		

Laboratory Identification: **FS 114919 - 114922**

ANALYSIS		**UNITS**	**STEERS GRAZED PLOT 1 CONTROL**	**STEERS GRAZED PLOT 2 OATS**	**STEERS GRAZED PLOT 3 OATS / MILLET**	**STEERS GRAZED PLOT 4 MILLETT**		
Phosphorus	(Olsen)	mg/kg	11.1	11.6	11.0	10.7		
Phosphorus	(Colwell)	mg/kg	27.0	27.0	28.0	27.0		
Potassium	(Colwell)	mg/kg	181.0	143.0	178.0	207.0		
Sulphur	(KCL40)	mg/kg	2.2	2.4	2.5	3.9		
pH	(1:5 water)		5.5	5.5	5.6	5.4		
pH	(CaCl2)		4.6	4.6	4.7	4.4		
Salinity (EC)	(1:5 water)	dS/m	0.03	0.03	0.03	0.05		
Soil Texture			Loam	Loam	Loam	Loam		
Organic Carbon		%	1.19	1.26	1.39	1.53		
Total Carbon		%	1.38	1.57	1.64	1.69		
Nitrate		mg/kg	4.0	5.0	5.0	4.0		
Ammonium		mg/kg	4.0	2.0	3.0	3.0		
Calcium	(Exch)	meq/100 g	1.42	2.22	2.24	1.43		
Magnesium	(Exch)	meq/100 g	0.31	0.28	0.28	0.49		
Sodium	(Exch)	meq/100 g	0.02	0.02	0.03	0.11		
Potassium	(Exch)	meq/100 g	0.43	0.36	0.42	0.54		
Aluminium	(Exch)	meq/100 g	0.22	0.17	0.17	0.44		
Calculations								
Sum of cations	(CEC)	meq/100 g	2.40	3.05	3.14	3.01		
Calcium/Magnesium ratio			4.6	7.9	8.0	2.9		
Sodium % of cations	(ESP)		0.8%	0.7%	1.0%	3.7%		
Aluminium % of cations			9.2%	5.6%	5.4%	14.6%		

Comments:

The test(s) reported have been performed in accordance with the terms of registration with the Australian Soil and Plant Advisory Council, Australia.

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 114895 / 5
Address:	DOUG JAMES	**Received:**	14 Apr 2011
	98 JAMES ROAD	**Despatch:**	03 May 2011
	BUNGEET 3726	**Submitted:**	Jacci Campbell
Job Comment:	**TRIAL PADDOCKS**		

ANALYSIS		UNITS	ELLIS	FALCONER	DORE (DAVE)	MITCHELLS	JAMES	
			Laboratory Identification:				**FS 114895 - 114899**	
Phosphorus	(Olsen)	mg/kg	16.2	8.1	11.0	20.8	11.7	
Phosphorus	(Colwell)	mg/kg	45.0	20.0	32.0	57.0	25.0	
Potassium	(Colwell)	mg/kg	279.0	337.0	174.0	417.0	177.0	
Sulphur	(KCL40)	mg/kg	5.7	11.1	6.3	6.0	3.4	
pH	(1:5 water)		5.2	5.3	6.4	6.5	5.4	
pH	(CaCl2)		4.2	4.5	5.7	5.6	4.6	
Salinity (EC)	(1:5 water)	dS/m	0.06	0.09	0.09	0.08	0.04	
Soil Texture			Loam	Loam	Clay loam	Loam	Loam	
Organic Carbon		%	2.34	2.23	2.54	1.45	1.08	
Total Carbon		%	2.69	2.58	2.87	1.86	1.20	
Nitrate		mg/kg	3.0	14.0	4.0	4.0	6.0	
Ammonium		mg/kg	9.0	27.0	4.0	14.0	3.0	
Calcium	(Exch)	meq/100 g	2.94	2.85	8.68	4.02	2.40	
Magnesium	(Exch)	meq/100 g	1.58	0.78	3.19	1.13	0.33	
Sodium	(Exch)	meq/100 g	0.27	0.07	0.32	0.04	0.02	
Potassium	(Exch)	meq/100 g	0.69	0.75	0.42	1.01	0.39	
Aluminium	(Exch)	meq/100 g	1.08	0.44	< 0.01	< 0.01	0.33	
Calculations								
Sum of cations	(CEC)	meq/100 g	6.56	4.89	12.61	6.20	3.47	
Calcium/Magnesium ratio			1.9	3.7	2.7	3.6	7.3	
Sodium % of cations	(ESP)		4.1%	1.4%	2.5%	0.6%	0.6%	
Aluminium % of cations			16.5%	9.0%	< 0.1%	< 0.1%	9.5%	

Comments:

Authorised signature:

DEEP SOIL TESTS May 2011

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 106416 / 30 Page 1
Address:	DOUG JAMES	**Received:**	21 May 2010
	98 JAMES ROAD	**Despatch:**	29 Jun 2010
	BUNGEET 3726	**Submitted:**	Jacci Campbell
		Email:	Charlie Sexton
Job Comment:	**TRIAL SITES**		

ANALYSIS		UNITS	Laboratory Identification: BARR / LENN PLOT 1-2-3-4 10 -20 cm	BARR / LENN PLOT 1-2-3-4 20 -30 cm	BARR / LENN PLOT 1-2-3-4 COMPOSITE 10 - 60 cm	FS 106416 - 106421 BOURKE TRIAL PLOT 10 -20 cm	BOURKE TRIAL PLOT 20 -30 cm	BOURKE TRIAL PLOT COMPOSITE 10 - 60 cm
pH	(1:5 water)		5.6	6.0		6.7	8.0	
pH	(CaCl2)		4.6	5.2		5.8	7.2	
Salinity (EC)	(1:5 water)	dS/m	0.03	0.08		0.05	0.22	
Soil Texture			Clay loam	Clay loam		Clay loam	Clay loam	
Organic Carbon		%	0.34	0.20		0.33	0.18	
Total Carbon		%	0.39	0.25		0.39	0.19	
Nitrate		mg/kg			4.0			1.0
Ammonium		mg/kg			1.0			1.0
Calcium	(Exch)	meq/100 g	2.17	3.30		4.10	6.29	
Magnesium	(Exch)	meq/100 g	1.47	3.21		2.92	5.73	
Sodium	(Exch)	meq/100 g	0.24	0.55		0.68	1.66	
Potassium	(Exch)	meq/100 g	0.23	0.25		0.50	0.72	
Aluminium	(Exch)	meq/100 g	0.16	0.07		< 0.01	< 0.01	
Calculations								
Sum of cations	(CEC)	meq/100 g	4.27	7.38		8.20	14.40	
Calcium/Magnesium ratio			1.5	1.0		1.4	1.1	
Sodium % of cations	(ESP)		5.6%	7.5%		8.3%	11.5%	
Aluminium % of cations			3.7%	0.9%		< 0.1%	< 0.1%	

Comments:
Note: Composite taken from 10-20 cm & 20-30 cm & 30-60 cm depths.

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 106416 / 30 Page 2
Address:	DOUG JAMES	**Received:**	21 May 2010
	98 JAMES ROAD	**Despatch:**	29 Jun 2010
	BUNGEET 3726	**Submitted:**	Jacci Campbell
		Email:	Charlie Sexton
Job Comment:	**TRIAL SITES**		

ANALYSIS		**UNITS**	**Laboratory Identification:** DORE TRIAL PADDOCK 10 -20 cm	DORE TRIAL PADDOCK 20 -30 cm	DORE TRIAL COMPOSITE 10 - 60 cm	ELLIS TRIAL PADDOCK 10 -20 cm	ELLIS TRIAL PADDOCK 20 -30 cm	**FS 106422 - 106427** ELLIS TRIAL COMPOSITE 10 - 60 cm
pH	(1:5 water)		5.5	6.2		5.6	6.9	
pH	(CaCl2)		4.7	5.3		4.8	6.1	
Salinity (EC)	(1:5 water)	dS/m	0.07	0.09		0.06	0.13	
Soil Texture			Clay loam	Clay loam		Clay loam	Clay loam	
Organic Carbon		%	0.32	0.27		0.45	0.19	
Total Carbon		%	0.38	0.35		0.53	0.22	
Nitrate		mg/kg			3.0			4.0
Ammonium		mg/kg			1.0			1.0
Calcium	(Exch)	meq/100 g	2.80	3.21		2.98	2.64	
Magnesium	(Exch)	meq/100 g	2.93	5.49		2.90	3.49	
Sodium	(Exch)	meq/100 g	0.57	1.25		0.92	1.54	
Potassium	(Exch)	meq/100 g	0.19	0.27		0.21	0.21	
Aluminium	(Exch)	meq/100 g	0.18	0.01		0.10	< 0.01	
Calculations								
Sum of cations	(CEC)	meq/100 g	6.67	10.23		7.11	7.88	
Calcium/Magnesium ratio			1.0	0.6		1.0	0.8	
Sodium % of cations	(ESP)		8.5%	12.2%		12.9%	19.5%	
Aluminium % of cations			2.7%	0.1%		1.4%	< 0.1%	

Comments:
Note: Composite taken from 10-20 cm & 20-30 cm & 30-60 cm depths.

Authorised signature:

3

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 106416 / 30 Page 3
Address:	DOUG JAMES	**Received:**	21 May 2010
	98 JAMES ROAD	**Despatch:**	29 Jun 2010
	BUNGEET 3726	**Submitted:**	Jacci Campbell
		Email:	Charlie Sexton
Job Comment:	**TRIAL SITES**		

ANALYSIS		**UNITS**	**Laboratory Identification:**			**FS 106428 - 106433**		
			ELLIS PLOT A-B-D-E 10 -20 cm	**ELLIS PLOT A-B-D-E 20 -30 cm**	**ELLIS PLOT A-B-D-E 10 - 60 cm**	**FALCONER TRIAL PADDOCK 10 -20 cm**	**FALCONER TRIAL PADDOCK 20 -30 cm**	**FALCONER TRIAL COMPOSITE 10 - 60 cm**
pH	(1:5 water)		5.6	5.6		5.4	5.3	
pH	(CaCl2)		4.6	4.9		4.2	4.3	
Salinity (EC)	(1:5 water)	dS/m	0.08	0.21		0.02	0.02	
Soil Texture			Clay loam	Clay loam		Clay loam	Clay loam	
Organic Carbon		%	0.44	0.20		0.55	0.27	
Total Carbon		%	0.47	0.27		0.61	0.29	
Nitrate		mg/kg			2.0			2.0
Ammonium		mg/kg			1.0			1.0
Calcium	(Exch)	meq/100 g	1.88	1.66		1.01	1.06	
Magnesium	(Exch)	meq/100 g	3.16	3.65		0.35	0.33	
Sodium	(Exch)	meq/100 g	1.00	2.78		0.05	0.03	
Potassium	(Exch)	meq/100 g	0.23	0.35		0.44	0.39	
Aluminium	(Exch)	meq/100 g	0.29	0.11		0.67	0.58	
Calculations								
Sum of cations	(CEC)	meq/100 g	6.56	8.55		2.52	2.39	
Calcium/Magnesium ratio			0.6	0.5		2.9	3.2	
Sodium % of cations	(ESP)		15.2%	32.5%		2.0%	1.3%	
Aluminium % of cations			4.4%	1.3%		26.6%	24.3%	

Comments:
Note: Composite taken from 10-20 cm & 20-30 cm & 30-60 cm depths.

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK
Address:	DOUG JAMES 98 JAMES ROAD BUNGEET 3726
Job Comment:	**TRIAL SITES**

Sample :	FS 106416 / 30 Page 4
Received:	21 May 2010
Despatch:	29 Jun 2010
Submitted:	Jacci Campbell
Email:	Charlie Sexton

ANALYSIS		UNITS	**Laboratory Identification:** FS 106434 - 106439					
			FALCONER PLOT 1-2-3-4 10 -20 cm	FALCONER PLOT 1-2-3-4 20 -30 cm	FALCONER PLOT 1-2-3-4 COMPOSITE 10 - 60 cm	JAMES TRIAL PADDOCK 10 -20 cm	JAMES TRIAL PADDOCK 20 -30 cm	JAMES TRIAL COMPOSITE 10 - 60 cm
pH	(1:5 water)		5.5	6.6		5.2	5.6	
pH	(CaCl2)		4.4	5.3		4.2	4.6	
Salinity (EC)	(1:5 water)	dS/m	0.02	0.03		0.03	0.01	
Soil Texture			Clay loam	Clay loam		Loam	Loam	
Organic Carbon		%	0.32	0.16		0.34	0.07	
Total Carbon		%	0.37	0.18		0.37	0.11	
Nitrate		mg/kg			2.0			3.0
Ammonium		mg/kg			1.0			2.0
Calcium	(Exch)	meq/100 g	1.07	1.78		0.94	0.87	
Magnesium	(Exch)	meq/100 g	0.64	2.48		0.17	0.18	
Sodium	(Exch)	meq/100 g	0.14	0.78		0.03	0.03	
Potassium	(Exch)	meq/100 g	0.09	0.14		0.26	0.18	
Aluminium	(Exch)	meq/100 g	0.27	0.06		0.42	0.27	
Calculations								
Sum of cations	(CEC)	meq/100 g	2.21	5.24		1.82	1.53	
Calcium/Magnesium ratio			1.7	0.7		5.5	4.8	
Sodium % of cations	(ESP)		6.3%	14.9%		1.6%	2.0%	
Aluminium % of cations			12.2%	1.1%		23.1%	17.6%	

Comments:
Note: Composite taken from 10-20 cm & 20-30 cm & 30-60 cm depths.

Authorised signature:

Client:	BROKEN CATCHMENT LANDCARE NETWORK	**Sample :**	FS 106416 / 30 Page 5
Address:	DOUG JAMES	**Received:**	21 May 2010
	98 JAMES ROAD	**Despatch:**	29 Jun 2010
	BUNGEET 3726	**Submitted:**	Jacci Campbell
		Email:	Charlie Sexton
Job Comment:	**TRIAL SITES**		

Laboratory Identification: **FS 106440 - 106445**

ANALYSIS		**UNITS**	**MITCHELL TRIAL PADDOCK 10 -20 cm**	**MITCHELL TRIAL PADDOCK 20 -30 cm**	**MITCHELL TRIAL COMPOSITE 10 - 60 cm**	**STEERS PLOT 1-2-3-4 10 -20 cm**	**STEERS PLOT 1-2-3-4 20 -30 cm**	**STEERS PLOT 1-2-3-4 10 - 60 cm**
pH	(1:5 water)		5.5	5.7		5.3	6.1	
pH	(CaCl2)		4.5	4.7		4.3	5.2	
Salinity (EC)	(1:5 water)	dS/m	0.02	0.02		0.02	0.03	
Soil Texture			Clay loam	Clay loam		Loam	Clay loam	
Organic Carbon		%	0.39	0.15		0.32	0.12	
Total Carbon		%	0.44	0.16		0.39	0.15	
Nitrate		mg/kg			2.0			1.0
Ammonium		mg/kg			1.0			1.0
Calcium	(Exch)	meq/100 g	2.20	3.46		0.86	0.66	
Magnesium	(Exch)	meq/100 g	0.74	1.37		0.34	0.70	
Sodium	(Exch)	meq/100 g	0.04	0.06		0.09	0.21	
Potassium	(Exch)	meq/100 g	0.52	0.46		0.19	0.16	
Aluminium	(Exch)	meq/100 g	0.26	0.16		0.23	< 0.01	
Calculations								
Sum of cations	(CEC)	meq/100 g	3.76	5.51		1.71	1.73	
Calcium/Magnesium ratio			3.0	2.5		2.5	0.9	
Sodium % of cations	(ESP)		1.1%	1.1%		5.3%	12.1%	
Aluminium % of cations			6.9%	2.9%		13.5%	< 0.1%	

Comments:
Note: Composite taken from 10-20 cm & 20-30 cm & 30-60 cm depths.

The test(s) reported have been performed in accordance with the terms of registration with the Australian Soil and Plant Advisory Council, Australia.

Authorised signature:

3

SUMMARY OF RESULTS

NAME	PLOT	CROP SOWN	HERBICIDE	FERTILISER	RATE	GR	GR	BULK	PENETROMETER	PH	PH	org C	org C	TOTAL
						COVER	COVER	DENSITY		1:5 WATER	1:5 WATER	%	%	C%
YEAR		2010				2010	2011	2010	2011	2010	2011	2010	2011	2011
BARRETT-LENNARD	1	CONTROL				40%	98%	1.15	10/900	5.0	5.1	2.75	2.46	2.59
	2	OATS		VICMILL	150 Kg/H	80%	95%	1.35	7.5/900		5.2		2.42	2.69
	3	OATS / MILLET				40%	75%	1.34	7.5/900		5.2		2.13	2.44
	4	MILLET				65%	70%	1.22	7.5/900		5.0		2.36	2.60
BURKE	1	CONTROL				40%	70%	1.55	2.5/1000	5.5	5.6	1.48	1.19	1.46
	2	OATS				80%	70%	1.52	10/900		5.5		1.38	1.59
	3	OATS / MILLET				60%	80%	1.41	5/800		5.5		1.36	1.62
	4	MILLET				30%	75%	1.45	4/700		5.6		1.17	1.37
ELLIS	1	CONTROL				95%	100%	1.14	5/700	5.4	5.6	1.91	1.85	2.12
	2	OATS				90%	100%	1.28	5/600		5.5		1.96	2.18
	3	OATS				85%	70%	1.33	5/700		5.7		1.42	1.83
	4	MILLET				85%	100%	1.29	7.5/800		5.7		1.82	2.19
FALCONER	1	CONTROL				95%	75%	1.34	10/800	5.1	5.5	2.55	1.85	2.35
	2	OATS				90%	75%	1.15	7/600		5.6		2.04	2.42
	3	OATS / MILLET				50%	80%	1.29	11/700		5.5		2.11	2.63
	4	MILLET				**95%**	85%	1.2	8/700		5.5		2.24	2.61
STEERS	1	CONTROL				40%	60%	1.32	40/900	5.3	5.5	1.78	1.19	1.38
	2	OATS	Spray seed	map/ lime	100	70%	75%	1.29	40/900		5.5		1.26	1.57
	3	OATS / MILLET	Spray seed	map/ lime	100	100%	85%	1.33	20/900		5.6		1.39	1.64
hand broadcast	4	MILLET	nil	nil		60%	100%	1.41	10/900		5.4		1.53	1.69

Summary of Key Issues from the soil test results

Comments Prepared by Cath Botta 21/6/2011

Phosphorus - Low phosphorus results at Falconers and Steers maybe an issue for introduced pasture species but possibly not an issue for native grass species. Pasture growth responses to phosphorus fertilisers are very likely at these sites and perhaps should be considered.

Sulphur - low sulphur levels at Burkes maybe an issue for legume species such as clover but possibly not as much of an issue for grasses.

pH and Aluminium - all sites have low pH levels. Low pH and high Aluminium maybe an issue at the Steers and Barrett-Lennards as the Aluminium levels increase with depth. This can affect plant root growth and particularly affect germination of species. Possibly not an issue for native grass species but perhaps some consideration of lime application should be made.

Organic Carbon - all sites have reasonably low levels of organic carbon particularly Burke, Ellis and Steers. This may reflect a past cropping history on these paddocks.

Soil Structure - all sites except for Falconers have poor soil structural issues caused by low Ca/Mg and high exchangeable sodium percentages. This is particularly the case in the 10 - 30cm zone. This has the potential to create a zone of very hard setting soil with poor porosity. This was confirmed by the bulk density results (and my arm ache!). This can become a barrier to root growth and induce temporary water logging issues in this zone. Deep ripping may not be an option due to the potential for dispersive soil.

How to Calculate Gross Margin on Crops

INCOME	NO TILL SHORT FALLOW	PASTURE CROPPING					
CROP			Yield [t/ha]]	$/tonne	$/ha	PC 25% less than NT	
GRAZING			Days	$/dse/day	dse/ha	dse/days/ha	$/ha
TOTAL INCOME							
COSTS							
			Seed	This will be the same for both			
			Sprays	PC may only require a pre-emergent spray for broadleaf weeds and MCPA			
			Fertilizers	This will be the same for both			
			Harvest	This will be the same for both			
			Pasture establishment	Required in No Till rotation			
			Machinery	This will be the same for both			
			Harvest	This will be the same for both			
DIRECT COSTS							
GROSS MARGIN							

The only thing that you have control over is your costs.

REFERENCES

Advanced Pasture Cropping Company. (2009). *Pasture Cropping and No Kill Croppping: The two Day*

Course in Profitable Regenerative Agriculture. The Advanced Pasture Cropping Company.

Bruce, S. A. (2005). Lift ground cover and reduce drainage with pasture cropping. *Farming Ahead, 1-2.*

Ham, I (2009) Pasture Cropping: Trials by the Gecko CLaN in the Goulburn Broken and North East Catchments of Victoria. Published by Gecko Catchment Landcare Network

Pasture Cropping and No-Kill. (2009). *Cropping for a Changing Climate.* Retrieved from Pasture Cropping and No-Kill Cropping: http://www.pasturecropping.com

http: www.mla.com.au/livestock production/ weed control

http:www.agric.wa.gov.au/Tactic 3.5 Grazing – actively managing weeds in pastures

http://www.dpi.nsw.gov.au/agriculture/field/pastures-and-rangelands/species-varieties/native-grasses

http:www.mla.com.au/Livestock.../Grazing-and-pasture-management

Useful Information:Websites

Advanced Pasture Cropping Company:	www.pasturecropping.com
Amazing Carbon!	www.amazingcarbon.com
Creation Innovation Agriculture & Forestry	www.ciaaf.com.au
EverGraze:	www.evergraze.com.au
Goulbum Broken Indigenous Seedbank:	www.dookie.unimelb.edu.au/research/seedbank.html
KoWarra Native Grasses	www.nativegrasses.com.au
Native Seeds Pty Ltd:	www.nativeseeds.com.au
Soil Health	www.soilhealth.com
Stipa:	www.stipa.com.au

Useful Information: Books

Cluff, D. (2003) Farming Without Farming. 63 pp. Stipa Native Grasses Association Inc ..

Cunningham, G.L., Mulham, W.E., Milthorpe, P.L. and Leigh, J.H. (1981). Plants of Western New South Wales. NSW Soil Conservation Service, Sydney. ISBN 0409306878

Gibbs, J. and Gibbs, R. (2005). Grass Identification Manual - for Everyone. Native Grass Resources Group Inc. - South Australia. ISBN 0-646-41619-7

Lamp, C.A., Forbes, S.J. and Cade, J.W. (1990). Grasses of Temperate Australia. Inkata Press, Melbourne and Sydney.

Lunt, I., Barlow, T. and Ross, J. (1998) Plains Wandering: Exploring the grassy plains of southeastern Australia. Victorian National Parks Association and the Trust for Nature (Victoria).

Marriott, N & J. (1998). Grassland Plants of Southern-Eastern Australia. Bloomings Books, Melbourne.

Mitchell, M. (1996) Native Grasses: Identification Handbook for Temperate Australia Agmedia, Melbourne

Scarlett, N.H., Wallbrink, S.J. and McDougall, K.(1992) Field Guide to Victoria's Native Grasslands. Victoria Press, Melbourne.

Waters, C, Whalley, W. and Huxtable, C. (2000) Grassed Up: Guidelines for revegetating with Australian Native Grasses. NSW Agriculture, Dubbo.