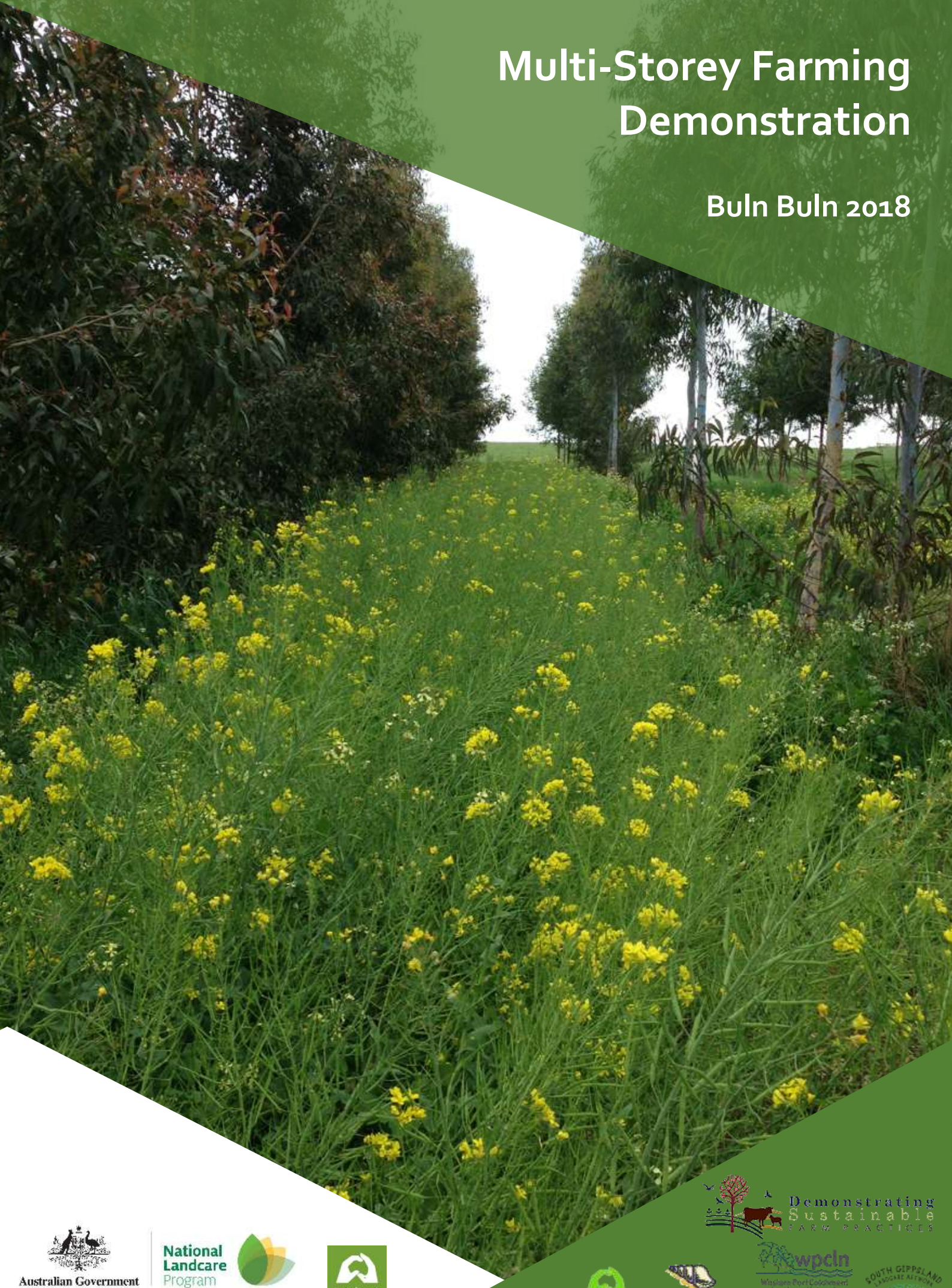
Multi-Storey Farming Demonstration

Buln Buln 2018



Australian Government

National Landcare Program

Landcare Australia

Demonstrating Sustainable Farm Practices

wpcln Western Port Catchment Landcare Network

Mornington Peninsula

South Gippsland Landcare Network

Background

Clinton and Michelle Tepper are fourth generation farmers on their 110 acre farm located just outside Warragul. Prior to owning the farm they lived on a 5 acre property in Trafalgar, never believing they'd have the finances to purchase a larger farm. In 2011 Michelle's parents decided to move from the family farm. Following discussions, arrangements were made for Clinton, Michelle and their 4 children to purchase and take over stewardship of the 110-acre farm. Michelle's parents initially stayed in the original homestead and 5 acres which was subdivided off the main farm, but eventually sold the house and land to Michelle's brother and his family – leaving 9 children living on 115 acres of Gippsland's lush green pasture.

Clinton studied Forest Science at University between 1991 and 1994 and has worked as a Forester since leaving University; in his own words '*trees were always going to play a part'* in their new farm. These ideas interested Michelle's father, who was delighted to see the farm staying in the family and keen to see further development of the farm business.

The motivation behind the demonstration

Clintons says '*I've been involved with planting millions of trees, a lot of different species and been on hundreds of different farms all over Victoria. I drew on that experience for the idea of the demonstration site'.* Clinton and Michelle had also owned a eucalypt and pine plantation in Woodside (since 2004) and a small acreage in Trafalgar where Clinton was able to trial his theories with tree plantings and design, but the 110 acre farm was their opportunity to use their experience on a larger scale.

The idea for the demonstration was also motivated by Clinton's trips overseas, in particular a trip with Beyond Subsistence to Africa. The trip opened Clinton's eyes to the innovative farming methods being employed by the subsistence farmers who lived on just 1 to 3 acres of land. Clinton recalls, '*I remember one of them visiting out here, we walked around the farm and I was embarrassed. I thought, "I've got 110 acres here, some of the best soils in Australia, fantastic rainfall and I'm not using the land to its*

potential. I'm only grazing cattle and feeding one family!". This was a turning point for Clinton and he realised how much more he could do with the farm.

Clinton admits multi-storey farming isn't an entirely new idea, he says he just used some existing concepts and meshed them together in his own unique way. He credits the Otway Agroforestry Network for their innovative approach to integrating trees onto land, but believes their ideas can be taken even further. Clinton's idea is fed by permaculture influences, his trip to Africa, the guidance of Rowan Reid in Master Tree Grower courses and influences from his job as a Forester – but primarily it was driven by a frustration with seeing people planting trees on farms that weren't fulfilling their full potential. Clinton was dispirited when he heard people complain about the trees they had planted - whether it was because they were falling over onto fences, harbouring pests or making it difficult to manage the area because there wasn't enough room. It was especially disappointing that people felt this way only 5-10 years into planting, and this made Clinton determined to find a method that would benefit the farmer and the land.

Creating the demonstration site

In response to a call for expressions of interest in the "Demonstrating Sustainable Farm Practices" project managed by the Westernport Catchment Landcare Network (WPCLN), Clinton contacted Peter Ronalds (Project manager) and proposed a design for planting trees that would make them easier to manage, and provide a sustainable and environmentally friendly return. The proposal was for trees to be planted with a larger space between them, which would allow pastures, crop and cattle to use the land around the trees. The proposal was assessed by the "Farmer Reference Group" (FRG) which is comprised of a number of highly successful and innovative farmers plus a soil scientist and a representative from AgVic. The FRG were very excited by the innovation and uniqueness of the proposal and gave it the green light to proceed. In 2014 Michelle and Clinton commenced the trial with the assistance of the WPCLN and input from experts such as Mark Roberts from the company Basix Trace Packs.

The designated trial area was 1.2 hectares (approx. 3 acres) and sited in a location that would provide shelter for livestock across an exposed location that was underutilised, due to cold conditions in winter.

The first task was to put fencing around the demonstration area and install a water trough to allow cattle to graze on the site. The tree rows were marked out and sprayed to control the weeds. Clinton then planted the trees in 13 rows – 5.25 metres apart. Trees were spaced 2 metres apart within the

row. Three species of tree were used – Silvertop Ash, Spotted Gum and Silver Wattle.

Work was then carried out between the tree rows to allow for the planting of crops and pasture.

Within one month of planting the trees, over 12 different blends of pasture and 1 type of cereal crop were planted in the area. Cattle were grazed on the site at 14 and 18 months after planting, which allowed enough time for the initial plantings to gain strength and height. Since the demonstration began in 2014 there have been over 70 different types of pasture and crops planted.

The results

Almost 4 years into the project, the results show that the system works – the trees have grown quickly and many varieties of crops and pasture have grown successfully. The cattle have happily grazed the pasture between the trees on several occasions, and are also more content on the pasture surrounding the demonstration area as it now offers shelter and warmth. During the dry summer months (including one of the driest summer/autumn periods on record) the demonstration area retained water and provided green feed for the cattle. This has increased the productivity of the land and improved income earning capacity. One of Clinton's initial concerns with planting the trees further apart was that they wouldn't gain enough shelter from each other in the critical early years, but the crops planted between the trees helped to provide adequate protection in the months following establishment.

Planting the trees further apart has given a more equal weighting between the trees and the agriculture. Clinton

stresses that multi-storey farming is about optimising soil use and photosynthesis, and that's what the system has achieved. This method of farming uses deeper reserves of soil, intercepts more sunlight and is creating a more robust and diverse system.

Lessons learned

As Clinton says '*making mistakes are worth their weight in gold if you learn from them. Learning from other people's mistakes is one thing, but when you make them yourself you learn with interest!*' Even with 25 years' experience, Clinton and Michelle admit that there are some things they would have done differently if they were to start the demonstration again. Here are their key learnings:

1. **Plant the trees further apart**. Once it became clear how well the first crops grew between the tree plantings Clinton realised that if the trees had enough room between them to accommodate agricultural machinery, the crop could make money - enough to offset the costs of planting the trees. The trees in the demonstration site had 5.25m by 2m spacing, but ideally the spacing would be 10-12m spacing between each tree row. The removal of two rows in July 2017, creating a 10.5m spacing between rows has confirmed these thoughts. The wider spacing places a more equal weighting between the trees and the agriculture and allows the system to integrate more naturally.

2. **Understand the site and suppress any weeds.** The demonstration site was plagued with Californian Thistle, which Clinton was aware of, but didn't realise how difficult it would be to control within a plantation containing a legume (i.e. silver wattle). Dealing with the issue retrospectively was a more complex and time-consuming process than if the weeds had been eradicated before the planting. Ideally problem weeds should have been controlled before planting took place.

3. **Prepare the soil.** All plantings require good soil nutrition, but this is especially true where there are multiple species planted in the same area and where trees, lucerne and other perennial crops are relying on water and mineral reserves up to 2 metres down. It's important to take soil samples before planting and link the nutritional requirements of plants with soil fertility. Armed with this knowledge, site nutrition can be

tailored to meet the needs of the system. Good soil health and fertility is vital for growing a long term timber crop.

4. **Use crops and pasture that integrate well with the trees.**

The demonstration site has trialed over 70 different crops and pasture, which has resulted in a wealth of knowledge about what works and what doesn't work. Clinton rated each crop as 1, 2 or 3 and has produced a table outlining the results. The key to producing a well-balanced system is using the right blend of crops and pasture around the trees, bearing in mind this may mean different crops and pasture throughout the lifecycle of the trees.

Multi-Storey Farming - about the name

The term 'multi-storey farming' came from Clinton's trade as a Forester where the top, middle and lower layers of a forest are referred to as 'storeys'. The idea for the name came after Clinton saw the results of the first planting – '*one crop we put in was huge with beautiful long seed heads. At this stage the trees were low, so the crop gave the trees fantastic protection'.* Clinton saw that the system was forever changing due to the different plantings throughout the site, but also in its physical appearance with the early crops initially towering over the seedlings, followed by the trees taking over in height and providing shade, warmth and cover for livestock and new crops.

That's when he realised what a dynamic system he was creating– one where what you put in at the start, isn't necessarily what you're going to end up with. A site might start with a particular crop but once the trees start to exert some shade influence, other crops will be better suited - with the final result being more shade-tolerant pasture and trees. The system also allows for livestock grazing and for the pasture between the rows to be harvested for hay, silage, grain, or a number of different crops.

Alternative options

The diverse system that Clinton and Michelle have created easily lends itself to other forms of farming. The theory behind multi-storey farming can be applied to other types of trees, including fruit and nut trees, and the grazing of chickens, pigs, sheep or other animals. Multi-storey farming can be adjusted to suit the objectives of most landholders, from a large-scale farmer to a hobby farmer.

Next steps

With the demonstration site proving so successful Clinton has already started preparation for phase two – the lucerne site. Lucerne grew well in the demonstration site and, with the assistance of Mark Roberts, Clinton has identified the triggers for its successful growth. To prepare the second site Clinton controlled problem weeds, then sowed the lucerne over the entire 7ha (18 acres). He will next plant trees at a 10-metre spacing over 60% of the area. Different pasture species will be planted on the site during the course of the tree lifecycle.

Clinton and his eldest daughter Hayley are also considering putting chickens on the demonstration site, with the idea of splitting the area into four sections and rotating the chickens on a regular basis. The chickens will fertilise the land, control insect populations and produce an income from egg production.

Conclusion

In Australia, forestry and agriculture are rarely integrated successfully whereby each system benefits from the other. In many cases, trees are planted in a fenced-off area and largely excluded from active pasture and livestock management during their lifetime.

Clinton's forestry design is relatively simple - plant the trees further apart and use the additional space between the trees for crops, pasture and/or livestock. This system allows a natural symbiosis to occur, with the result being a greater yield and ultimately, more productive land. Clinton says '*the demonstration site is changing the direction of where we're going with the farm'* and he's keen to share multi-storey farming with other local farmers. Clinton and Michelle are extremely grateful for the support provided by Peter Ronalds in his role with the Western Port Catchment Landcare Network.

TIMELINE OF ACTIVITIES SHOWCASING CONSTANT MANAGEMENT OF SITE		
Date	**Action**	**Rate**
Pre planting		
30/03/2012	Soil test	
15/10/2013	Fertiliser Traces - Basix Reset: high Zn, moderate B and Mo	15litre/ha
1/04/2014	Lime	2500kg/ha
1/03/2014	NPK 30:7:6 applied	200kg/ha
19/06/2014	Soil test - SWEP	
1/06/2014	Fencing	
1/07/2014	Pasture weed control and preplant weed control for trees	
At Planting		
Aug/Sep 2014	Trees planted	
Aug/Sep 2014	Slow release tablet fertiliser (eucs only)	
Aug/Sep 2014	Silver wattle guarded against hare damage	
Post Planting		
20/10/2014	Water trough installed	
1/10/2014	pasture/crop sowing	
12/11/2014	Snail/slug control for pasture establishment	
9/01/2015	Mow crops/pasture with sickle bar mower and take off site to remove weed burden	
1/02/2015	Californian thistle control	
1/04/2015	second year weed control	
26/05/2015	Second Soil test	
19/06/2015	NPK 30:7:6 applied	200kg/ha
9/10/2015	Second pasture/crop sowing	
14/06/2016	First pruning (silver wattle only to make more space for sowing)	
14/06/2016	Third pasture/crop sowing	
6/09/2016	NPK 30:7:6 applied	200kg/ha
28/12/2016	Fourth pasture/crop sowing	
2/05/2017	Fifth pasture/crop sowing	
8/05/2017	Third Soil test	
22/05/2017	First pruning of eucalypts with sawlog potential	
23/05/2017	Measure trees for height, volume, diameter & growth rates	
27/07/2017	Soil testing (moisture/biology/BD/chemistry)	
2/08/2017	Non commercial thinning and removal of 2 complete rows	
1/11/2017	Biology soil tests comparing mulch & unmulched areas	
1/11/2017	Soil testing (moisture)	
15/11/2017	Sow Dryland pumpkins	
27/02/2018	Soil testing (moisture)	
1/03/2018	Basix trace element application across site	15kg/ha
28/03/2018	Power harrow plots (23) to be sown	
19/04/2018	Pre-sowing weed control	
24/04/2018	2nd lift pruning to 4.5 metres of best trees within thinned area	
29/04/2018	Mulching prunings	
2/05/2018	Soil testing (moisture/biology/BD/chemistry)	
2/05/2018	6th pasture crop sowing and incorporation	
5/05/2018	Snail and slug control	
26/05/2018	Snail and slug control	
30/05/2018	Post sowing weed control in legume and cereal areas	
11/06/2018	Measure trees for height, volume, diameter & growth rates	
Grazings		
Nov-15	Grazing for 7 days with 20*200kg beef cattle	
Mar-16	Grazing for 7 days with 10*250kg beef cattle	
Aug-17	Grazing for 7 days with 10*300kg beef cattle	
Nov-17	Grazing for 1-2 weeks with 20 * 18 month old cattle	
Mar-18	Grazing for 7 days with 50 * 12 month old cattle	

Photo points over time

27/6/14

10/10/14

27/3/15

23/12/15

14/6/16

15/2/17

23/5/17

22/12/17

2/05/18

Lucerne tap root

Pruning silver wattles

Several of the early crops (note the lushness of some of them in late Dec)

Triticale Mar ‘15

Lucerne Dec ‘15

Brome Dec ‘15

Black Chia Dec ‘15

Fenugreek Dec ‘15

Canola Dec ‘15

Linseed Dec ‘15

Rye Dec ‘15

Several of the early crops (note the lushness of all of them in summer)

Tucano Oats Dec ‘15

Next Oats Dec ‘15

Silverado Lucerne Dec ‘15

Colossus Oats Dec ‘15

Olanda Sotaria Dec ‘15

Akurra Sulla Dec ‘15

Teff Dec ‘15

Feb ‘17

Some more recent crops

Turnip Oct ’17

Oats Nov ‘17

Red Clover Jan ‘18

Pumpkins Feb ‘18

Cocksfoot mix Feb ‘18

Multi Storey Farming Site Feb ‘18

Other Activities

Removing 2 rows of trees with mulcher on excavator Aug ‘17

Working seed into soil post sowing May ’18

Mulch cover after pruning

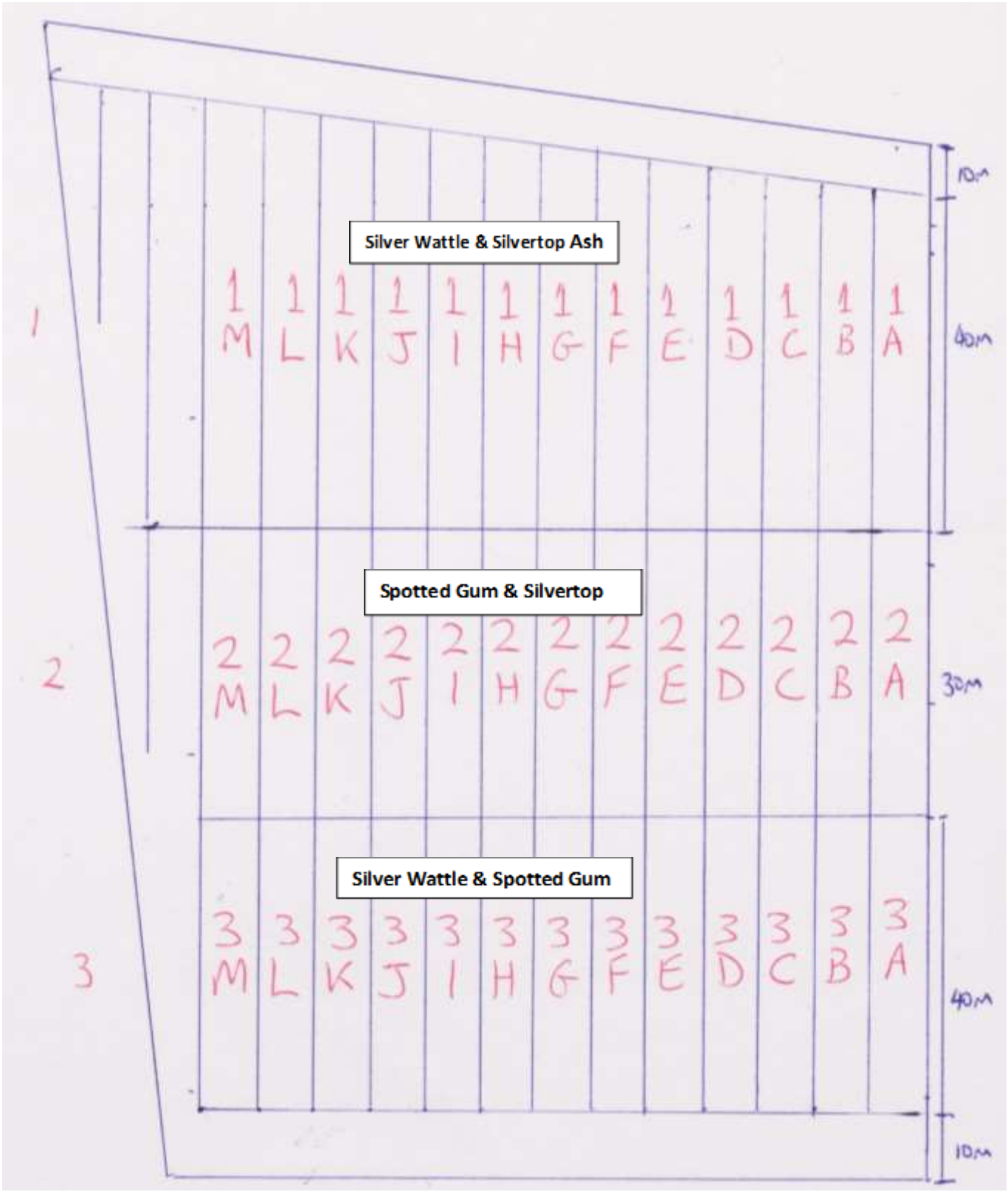
Mulch breaking down Nov ‘17

One of the several field days held on the farm

TEPPER DEMONSTRATION SITE

TRIAL SITE LAYOUT - PASTURE (row centres 5.25m)

N



Crop/Pasture results - sowing 1 (Oct 2014)

Pasture/Crop records - Sowing Date October 2014 - Rating (1=Excellent, 2=Satisfactory, 3=Poor)					
Plot #	**Blend/Variety**	**Species**	**Rating**	**Rank**	**Comments**
1A	Tall Legume	Blaza Crimson Clover, So this Eastern Clover, Elite II Berseem Clover, Flamenco Sulla	2		lower plant density than plot 3
1B	Lucerne+chicory	Manx lucerne blend/chicory	1		lower plant density than plot 3
1C	Rhodes+Chicory	Katambora Rhodes grass, Elite II Berseem Clover, ZululI Arrowleaf clover, Casbah biserrula, grouse chicory	2		lower plant density than plot 3
1D	Phoenix brome	Gala pasture brome, Bareno grazing brome and exceltas coloured brome	1		lower plant density than plot 3
1E	Triple Octane+ Legume 100	Barberia hybrid perennial rye grass. Awesome Italian rye grass, Ohua Italan hybrid ryegrass, Scimitar burr medic, Toreador hybrid medic, Jaguar strand medic, Jester barrel medic, Bolter balansa clover, Hycon rose clover, Casbah biserrula, Zulu II arrowleaf clover	2		lower plant density than plot 3
1F	Sulla	Sulla	2		lower plant density than plot 3
1G	Setaria	Setaria	2		lower plant density than plot 3
1H	Flatlands	Atlas Phalaris Perennial Grass, Charlton Timothy Perennial Grass, Choice Chicory, Elite II Berseem Clover, O'Connor Strawberry Clover, Leo Lotus	2		lower plant density than plot 3
1I	Legume 200 +Tonic plantain	Colenso red clover, Zulu II arrowleaf clover, Turbo II Persian clover, Cadiz pink serradella, Antas sub clover and Tonic plantain	2		lower plant density than plot 3
1J	Triple Octane	Barberia hybrid perennial rye grass. Awesome Italian rye grass, Ohua Italan hybrid ryegrass	3		
1K	Phoenix + Tall legume	Gala pasture brome, Bareno grazing brome and exceltas coloured brome, Blaza Crimson Clover, So this Eastern Clover, Elite II Berseem Clover, Flamenco Sulla	2		lower plant density than plot 3
1L	Setaria + Tall legume	Setaria, Blaza Crimson Clover, So this Eastern Clover, Elite II Berseem Clover, Flamenco Sulla	2		lower plant density than plot 3
1M	Triticale	Triticale	3		lower plant density than plot 3
2A	Existing pasture				
2B	Existing pasture				
2C	Existing pasture				
2D	Existing pasture				
2E	Existing pasture				
2F	Existing pasture				
2G	Existing pasture				
2H	Existing pasture				
2I	Existing pasture				
2J	Existing pasture				
2K	Existing pasture				
2L	Existing pasture				
2M	Existing pasture				
3A	Tall Legume	Blaza Crimson Clover, So this Eastern Clover, Elite II Berseem Clover, Flamenco Sulla	2		
3B	Lucerne+chicory	Manx lucerne blend/chicory	1	3	
3C	Rhodes+Chicory	Katambora Rhodes grass, Elite II Berseem Clover, ZululI Arrowleaf clover, Casbah biserrula, grouse chicory	2.5		Rhodes grass poor germination
3D	Phoenix brome	Gala pasture brome, Bareno grazing brome and exceltas coloured brome	1	2	
3E	Triple Octane+ Legume 100	Barberia hybrid perennial rye grass. Awesome Italian rye grass, Ohua Italan hybrid ryegrass, Scimitar burr medic, Toreador hybrid medic, Jaguar strand medic, Jester barrel medic, Bolter balansa clover, Hycon rose clover, Casbah biserrula, Zulu II arrowleaf clover	2		
3F	Sulla	Sulla	2	4	
3G	Setaria	Setaria	2		
3H	Flatlands	Atlas Phalaris Perennial Grass, Charlton Timothy Perennial Grass, Choice Chicory, Elite II Berseem Clover, O'Connor Strawberry Clover, Leo Lotus	2		
3I	Legume 200 +Tonic plantain	Colenso red clover, Zulu II arrowleaf clover, Turbo II Persian clover, Cadiz pink serradella, Antas sub clover and Tonic plantain	2		
3J	Triple Octane	Barberia hybrid perennial rye grass. Awesome Italian rye grass, Ohua Italan hybrid ryegrass	3		
3K	Phoenix + Tall legume	Gala pasture brome, Bareno grazing brome and exceltas coloured brome, Blaza Crimson Clover, So this Eastern Clover, Elite II Berseem Clover, Flamenco Sulla	2		
3L	Setaria + Tall legume	Setaria, Blaza Crimson Clover, So this Eastern Clover, Elite II Berseem Clover, Flamenco Sulla	2		Better in 2nd season
3M	Triticale	Triticale	3	1	
Notes: Weeds across this sowing were an issue in most row except for plot 2 (existing pasture) and plot 3 triticale and phoenix brome					

Crop/Pasture results - sowing 2 (Oct 2015)

Pasture/Crop records - Sowing Date 9th October 2015 - Rating (1=Excellent, 2=Satisfactory, 3=Poor)					
Plot #	**Blend/Variety**	**Species**	**Rating**	**Rank**	**Comments**
1A					
1B					
1C					
1D					
1E					
1F					
1G	Black Chia		1.5	8	
1H	Sensation Canola		2.5		Good germination, but attacked by insects in dry
1I	Cereal Rye		1.5	6	
1J	Tucano Oats		1.5	5	
1K	Ovalo Wheat		2.5		Good strike but remained prostrate. No erect growth
1L	Colussus Oats		1	2	
1M	Triticale		3		Poor germination - seed viability?
2A	Existing pasture				
2B	Existing pasture				
2C	Existing pasture				
2D	Existing pasture				
2E	Existing pasture				
2F	Existing pasture				
2G	Black Quinoa		2		
2H	Rubitas red clover		3		Poor germination
2I	Sardiruse clover		2		
2J	Purple clover		3		Poor germination
2K	Akurra sulla		2		Susceptible to weed comp early. Snails
2L	Silverado lucerne		1	3	
2M	Genesis lucerne		1	3	
3A					
3B					
3C					
3D					
3E					
3F					
3G	Fenugreek		3		
3H	Linseed		1.5	4	
3I	Spelt		3		
3J	Teff Grass		1.5		
3K	Solanda setaria		1	1	
3L	Pastoral fescue		3		Poor germination
3M	Stockman Phalaris		1	7	Slow colonisation, but after 12 months excellent
Notes:					

Crop/Pasture results - sowing 3 (Jun 2016)

Pasture/Crop records - Sowing Date 14 June 2016 - Rating (1=Excellent, 2=Satisfactory, 3=Poor)					
Plot #	**Blend/Variety**	**Species**	**Rating**	**Rank**	**Comments**
1A					
1B	Plantain		1	3	
1C	Persian clover		1.5	5	
1D	Balansa clover		1.5	6	
1E	Crimson clover		1.5	9	
1F	Red clover		1	2	
1G	White clover		3		Weedy
1H	Pink serradella		1.5	10	Great germination but weedy
1I	Causican clover		3		Weedy
1J					
1K					
1L					
1M					
2A					
2B	Annual rye grass		1	5	
2C	Perennial rye grass		1	4	
2D	Berseem clover		1.5	8	Significant weed competition
2E	Italian rye grass		1.5	6	
2F	Cocksfoot		1	1	
2G	Festulolium		1.5	7	
2H	Sulla		3		Poor germination
2I	Chicory		2.5		
2J					
2K					
2L					
2M					
3A					
3B					
3C	Arrowleaf clover		3		Poor germination
3D					
3E	Sub clover		3		Poor germination
3F	Rose clover		2.5		
3G	sulla		3		Poor germination
3H	Biserrula		3		Poor germination
3I	Strawberry clover		3		Poor germination
3J					
3K					
3L					
3M					
Notes:					

Crop/Pasture results - sowing 4 (Dec 2016)

Pasture/Crop records - Sowing Date 28th December 2016 - Rating (1=Excellent, 2=Satisfactory, 3=Poor)					
Plot #	**Blend/Variety**	**Species**	**Rating**	**Rank**	**Comments**
1A					
1B					
1C	Soy bean		3		
1D	Brazzil Canola		3		
1E	White Chia		2	2	
1F					
1G	Peas percy		2.5		
1H	Rice		3		
1I	Cereal rye		3		
1J	Grain sorghum		1.5	1	Good result. Best where less comp
1K	Maize		2.5		Good germ but sufferd from no follow up rain
1L	Oats		3		Sowed too late
1M	Triticale		3		Sowed too late
2A					
2B					
2C					
2D	Berseem clover elite		3		
2E	buckwheat		3		
2F	Rose clover		3		
2G	Biserrula		3		
2H	Sulla		3		
2I					
2J					
2K					
2L					
2M					
3A					
3B					
3C	Amaranth		2.5		Great germination but no follow-up rain
3D					
3E	Sunflower		2.5		
3F	Crimson clover		3		
3G	Fenugreek		3		
3H	Linseed - Golden		3		
3I	Spelt		3		
3J	Teff		2.5		
3K	Setaria		3		
3L	grass 2n		3		
3M					
Notes: Sowing too late for many species and no follow-up rain. Noticeable that cereals generally did not persist past early germination					

Crop/Pasture results - sowing 5 (May 2017)

Pasture/Crop records - Sowing Date 2nd May 2017 - Rating (1=Excellent, 2=Satisfactory, 3=Poor)					
Plot #	**Blend/Variety**	**Species**	**Rating**	**Rank**	**Comments**
1A	CT Patch up	Canola Brazzil, Aber gain Perennial rye, Charlem Fescue, Aber niche festol, rossi red clover, oconnor strawberry clover	1.5	5	no canola germ and minimial clover
1B					
1C	Field peas		3		Good germ but not incorporated into enough soil - snail & slug predation
1D	Gunyidi lupins		3		Good germ but not incorporated into enough soil - snail & slug predation
1E					
1F					
1G					
1H	Simple grass mix (BASIX)		1	1	Good germ and excellent persistance
1I	Simple grass mix (BASIX)		1	1	
1J	Simple grass mix (BASIX)		1	1	Good germ and excellent persistance
1K	Colussus oats		1.5	4	Best performance where less competition. Cattle love it. Good 2nd season germination as well
1L	NZDF grass + crimson clover		1.5	7	A compatible mix
1M	Barlock lupins		3		Good germ but not incorporated into enough soil - snail & slug predation
2A	CT Patch up	Canola Brazzil, Aber gain Perennial rye, Charlem Fescue, Aber niche festol, rossi red clover, oconnor strawberry clover	1.5	5	no canola germ and minimial clover
2B	Field peas				Good germ but not incorporated into enough soil - snail & slug predation
2C					
2D	Plantain/NSD grass/berseem clover		3		Poor strike
2E	Barley		3		Poor strike
2F					
2G	Simple grass mix		2		Good germ, but weedy - resow in May 18
2H	Simple grass mix		1	1	Good germ and excellent persistance
2I	Simple grass mix		1	1	Good germ and excellent persistance
2J	SS Turnip		1.5	3	Good germ and good result.
2K	TS Turnip		1	2	Good germ and excellent result. Superior survival over SS
2L					
2M					
3A	CT Patch up	Canola Brazzil, Aber gain Perennial rye, Charlem Fescue, Aber niche festol, rossi red clover, oconnor strawberry clover	1.5	5	no canola germ and minimial clover
3B					
3C	Tritacale		3		
3D					
3E	Colussus oats		3		
3F					
3G	Simple grass mix		1	1	Good germ
3H	Triple Octane		1.5	6	slower start but caught up to simple
3I	Simple grass mix		1	1	Good germ
3J					
3K	Setaria/persian clover/2N grass		1.5	7	Good coverage. Minimal clover
3L	Field Peas		3		Good germ but not incorporated into enough soil - snail & slug predation
3M					
Notes: Better results expected if site had been freshly harrowed prior and after sowing					

Crop/Pasture results - sowing 6 (May 2018)

Pasture/Crop records - Sowing Date 2nd May 2018 - Rating (1=Excellent, 2=Satisfactory, 3=Poor)					
Plot #	**Blend/Variety**	**Species**	**Rating**	**Rank**	**Comments**
1A					
1B					
1C	Brome/red clover	Exceltas Brome and renegade red clover			Good brome germ and reasonable clover germ
1D	Brome/berseem cl	Exceltas Brome and berseem clover			Excellent germ
1E	Brome/red clover	Exceltas Brome and renegade red clover			Good brome germ and reasonable clover germ
1F					
1G					
1H					
1I					
1J	Rye Grain				Reasonable germination
1K	Oats (2nd yr)	Colussus			2nd year germination. Orginally sown in May 2017
1L	Tritacale				Reasonable germination
1M	Buckwheat				
1N	Barley				Excellent germination and early growth
1O	Brown linseed				Good germination
2A					
2B	Field peas				Good germ and early growth
2C	Brome/berseem clover	Exceltas Brome and berseem clover			Excellent germ
2D	Brome/berseem clover	Exceltas Brome and berseem clover			Excellent germ
2E	Brome/red clover	Exceltas Brome and renegade red clover			Good brome germ and reasonable clover germ
2F					
2G	Brome/red clover	Exceltas Brome and renegade red clover			
2H	Simple grass mix				Good germination
2I	Simple grass mix				Good germination
2J	Brome/berseem clover	Exceltas Brome and berseem clover			Excellent germination
2K	Faba beans				Excellent germination & early growth
2L					
2M					
3A					
3B					
3C	Brome/berseem clover	Exceltas Brome and berseem clover			Excellent germination
3D	Brome/red clover	Exceltas Brome and renegade red clover			Good brome germ and reasonable clover germ
3E	Barley				Excellent germination and early growth
3F	Lupins				Good germination
3G					
3H					
3I					
3J	Lupins				Excellent germination and early growth
3K					
3L	Golden Linseed				Excellent germination
3M					

Soil investigations

The table below presents the results of soil analyses undertaken across the strips within the Agroforestry trial area (2018) and a control analysis on the south side of the trial site (May 2018).

Soil analyses over the Agroforestry Trial site - May 2018				
Nutrient	**Control no trees**	**SWSG (silver wattle & spotted gum)**	**SGST (spotted gum & silvertop)**	**SWST (silver wattle & silvertop)**
pH (1:5) water	5.41	5.52	5.7	5.48
Available Calcium mg/kg	750	802	929	738
Available magnesium mg/kg	124	125	125	114
Available Potassium mg/kg	85	85	89	94
Olsen P mg/kg	20	17	15	16
Colwell P mg/kg	62	53	47	46
Available nitrogen	5.54	9.8	6.9	8.5
Sulphur	27	34	24	24
Total Nitrogen %	0.46	0.44	0.46	0.44
Organic matter %	9.9	9.7	9.9	9.7
Total Carbon %	5.67	5.53	5.63	5.44
Effective Cation Exchange Capacity (ECEC) cmol+/kg	10.78	10.49	11.4	10.09
Calcium/Magnesium ratio	4.7	5.1	5.8	5
Calcium CEC %	70.4	73.3	76.8	72.3
Magnesium CEC %	14.9	14.5	13.1	14.4
Potassium CEC %	5.3	5	4.7	6.1
Sodium – ESP %	4.3	2.9	2.4	1.9
Aluminium CEC %	4	3.4	1.6	4.8
Carbon/Nitrogen ratio	12.3	12.5	12.2	12.5

The silver wattle/spotted gum area (9.8mg/kg) and the silver wattle/silvertop area (8.5mg/kg) have a higher available nitrogen level indicating a possible contribution from the leguminous wattles. The spotted gum/silvertop area (6.9mg/kg) also have slightly higher nitrogen levels.

An interesting observation from the analysis is that the Sodium CEC% has decreased across all three tree plots compared to the control (no trees). This could be due to the trees drawing sodium from the soil nutrient base.

Bulk density

Bulk density is the weight of soil in a given volume. As bulk density increases compaction also may increase. Soils with a bulk density of more than about 1.4g/cm3 may restrict oxygen penetration, water penetration and root growth.
The table to the right illustrates how bulk density is interpreted for a clay loam the soil type seen in the agroforestry trial area.

Interpreting bulk density	
Bulk density (g/cc, or g/ml)	**Clay loam**
<1.0	Satisfactory
1.0-1.2	Satisfactory
1.2-1.4	Some too compact
1.4-1.6	Very compact
Handreck & Black, 1984	

Bulk density in cores from the agroforestry area

Sample ID Depth cm	Bulk density 2017	Bulk Density 2018
Control 0-10	1.22	1.08
Control 10-20	1.22	1.17
SW SG 0-10	1.14	1.05
SW SG 10-20	1.19	1.13
SG ST 0-10	1.19	1.0
SG ST 10-20	1.25	1.17
SW ST 0-10	1.23	1.02
SW ST 10-20	1.24	1.06

The bulk density samples were obtained through taking soil cores to a depth of 800mm with a Christie hydraulic soil corer. Samples were taken from the control area and from within the tree alleyways in July 2017 and again in May 2018.

The bulk density samples were taken at a depth of 0-10cm and 10-20cm. The samples taken in 2018 have slightly lower bulk densities than the samples taken from the same depth in 2017 which is positive.

Bulk density in a sense is a reflection of soil structure with increased aggregation of soil particles as bulk density decreases. The lower readings may also be a reflection of the contribution of the expansive root systems of the trees working both physically and biologically, which will help to lower bulk density.

Moisture in cores from the agroforestry area

Monitoring moisture in the agroforestry plots was an important methodology for understanding the amount of moisture that the trees were taking from both the surface soil and the soil at depth.

Sample ID and Depth (cm)	Moisture % July 2017	Moisture % November 2017	Moisture % March 2018	Moisture % May 2018
Control 0-10cm	29.6	27.7	12.8	16.9
Control 80-90cm	23.3	21.4	19.1	19.2
SW SG 0-10cm	26.8	25.0	11.9	17.2
SW SG 80-90cm	20.0	21.1	19.0	20.4
SG ST 0-10cm	27.1	26.6	13.8	16.6
SG ST 80-90cm	21.0	23.9	20.8	19.4
SW ST 0-10cm	23.7	27.2	13.3	16.6
SW ST 80-90cm	21.5	21.6	20.1	18.8

Moisture readings taken in July 2017 and November 2017 over the depths 0-10cm and 80-90cm indicate reduced moisture as depth increases. This suggests that there is ample moisture available for the trees. All three agroforestry plots have slightly lower moisture levels than the control pasture area indicating the trees are utilising more of the 0-10cm surface moisture.

Readings taken in March 2018 and May 2018 tell a different story. Moisture levels at 80-90cm are higher than at the surface 0-10cm. This reflects the drier season and again the growth of the trees where increased moisture is being drawn from the surface soil.

Soil biology

Soil microbes play an important role in decomposing (cycling) organic matter such as grass, leaves and other organic wastes into nutrients such as carbon (C), nitrogen (N), phosphorus (P), and sulphur (S), and converting organic matter into stable humus compounds. They provide services such as nitrogen fixation, suppress plant diseases and produce products that stimulate plant growth and help solubilise nutrients from soil mineral particles.

It was therefore important to monitor biological activity to understand whether the contribution of increased carbonaceous material from the trees to the soil surface litter horizon may stimulate microbial populations thus enhancing the natural nutrient cycle.

The laboratory report for 2018 indicates significant increases in total microorganisms, total bacteria, fungi and mycorrhiza compared with the control. This indicates that the increased food source (litter) from the agroforestry plots is having a positive impact on soil microbial populations.

Microbiology Analysis												
Analysis	**Unit mg/kg**		**Control 2017**	**Control 2018**		**SWSG 2017**	**SWSG 2018**		**SWST 2017**	**SWST 2018**		**SGST 2017**	**SGST 2018**
Total micro-organisms	mg/kg		44.1	51.5		37.4	54.4		39.6	49.1		36.5	52.4
Total bacteria	mg/kg		10.9	13.8		10.1	13.4		10.2	12.2		9.9	12.7
Total fungi	mg/kg		31.1	35.4		25.4	39.7		28.1	35.5		25.3	38.3
Mycorrhiza fungi	mg/kg		3.81	4.51		3.45	5.56		4.52	4.88		3.51	5.69

Other Microbiological Testing - Soil biology of the phalaris mulch (3M) and cocksfoot pasture

The testing of the soil biology in the phalaris mulch area and the cocksfoot pasture area was an important part of the trial. The Multi Storey Farming system is attempting to replicate a natural systems approach to nutrient cycling as would be expected in a forest system. The natural Cycle of Life (life, death and decay) is a key parts of a natural forest system. The additional supply of organic matter is seen as contributing to the microbial food source and hence may be seen in soil biology tests.

The phalaris mulch area had a large quantity of prunings mulched onto the surface of the soil and this was breaking down. The Cocksfoot area had no mulch added, so was treated as a control comparison. Samples were taken from both areas for microbiology to monitor the differences in microbiology activity at a fixed point in time.

The phalaris mulch area supplied a good source of food for the microorganisms, which is reflected in the high number of total microorganisms compared with the cocksfoot area (with no mulch). Significantly bacteria, fungi and mycorrhiza are all present in greater numbers in the mulch than the pasture, with fungi numbers almost doubled. It is worth noting that soil chemistry analysis from the phalaris mulched area registered an 84.5% increase in ammonium nitrogen indicating that the nitrogen cycle was being stimulated by microbial action.

Analysis	**Unit mg/kg**	**Phalaris mulch**	**Cocksfoot pasture**
Total microorganisms	mg/kg	76.4	46.6
Total bacteria	mg/kg	18.3	14.7
Total fungi	mg/kg	54.6	29.4
Mycorrhiza fungi	Mg/kg	8.99	4.77

The laboratory (Microbiology Laboratories Australia) analysing the soil biology use indicator diagrams to illustrate the influence of microorganism activity on key soil functions such as nutrient cycling. The diagrams below reflect the higher level of nutrient cycling expected from the level of microorganisms detected in the phalaris mulched soil and the slightly lower level of nutrient cycling seen in the cocksfoot unmulched area.

Above: Nutrient cycling under phalaris mulch (left) compared to the cocksfoot with no mulch (right)

Key learnings

- To optimise early agricultural returns, trees should be established at wider than conventional forestry spacing's (>5m);
- Soil analysis shows positive trends to support the:
    - mulching of nutrient dense bark, branches and leaves generated from silvicultural operations;
    - inclusion of tree/pasture legumes to increase available nitrogen;
    - improvement of soil structure.

- Cattle grazing can be safely undertaken 15 months following planting of the trees;
- MSF can create a favourable microclimate for livestock and pasture/crop development within 12 months of planting;
- The system shows excellent potential to significantly close feed gap with several pasture/cropping varieties;
- Several grass, legume, cereal and fodder species can grow very well adjacent to rapidly growing trees;
- Several grass species show potential to grow significantly further into the dry season than conventional rye grass varieties;
- Establishing the pasture/crop before trees, offers income generation and can simplify MSF establishment;
- To attain the suite of benefits offered by MSF:
    - Access to a tractor mounted mulcher is advantageous;
    - Good design is essential. (e.g. consider species selection, livestock management, site type etc).
- MSF can be labour intensive. Available resources need to be considered in the planning phase to minimise the chance of overcommitting oneself;
- Prior to system establishment thought should to be given to pasture/crop succession planning because the trees will outcompete shade intolerant pasture/crop species that thrive in the open space that exists in the first few years following planting.

Economics for MSF Demonstration Site Project

Costs 2014-18 *(includes provision for landholder labor at $30/hr)*

Item	Timing	Units	Unit cost	Total+GST	Comments
Soil test	2014	1	$150	$150	
Fencing	2014	1	$2500	$2500	
Installation of stock trough	2014	1	$1050	$1050	Existing trough moved to opposition, pipe network expanded and fittings
Initial weed control	2014	1	$500	$500	For trees and pasture establishment
Seedlings, fertilizer tablet, tree guards and planting	2014	800	$3.50	$2800	
Pasture seed/sowing and fertiliser	2014	1	$1500	$1500	
Post planting/sowing weed control	2014/15	1	$750	$750	Mowing and physical removal of weed seed. Californian thistle control
Monitoring	2014-2018	1	$4000	$4000	2 hours per month * 4 years. Includes tree inventory
Further soil testing	2014 & 2018	2	$150	$300	
Fertiliser application	2015	1	$400	$400	200kg/ha
Subsequent pasture sowings * 5	2015-2018	5	$500	$2500	Weed control, power harrow, seed, sowing, snail and slug control
Fertiliser application	2016	1	$400	$400	200kg/ha
1st lift stem pruning	2017	2	$240	$480	Pruning ~300 stems/ha to 2.4m
Mulching	2017	1	$1000	$1000	Remove 2 complete rows plus bay thinning
Mulching prunings	2018	1	$500	$500	
Trace mineral fertilizer application	2018	1	$250	$250	
2nd lift stem pruning	2018	2	$250	$500	Pruning ~250 stems/ha to 4.5m
Total				**$19580**	

Returns 2014-2018

- 5 grazing periods – refer to activity guideline for details;
- firewood from silver wattle thinnings for domestic use.

Tree measurement summary - June 2018 at age 45 months

3 permanent sample plots (PSP). Each plot has an area of 420m2

Plot	Species	Stocking ha^{-1}	Mean dbh (cm) 5/17	Mean dbh (cm) 6/18	Inc. (cm)	Mean ht. (m) 5/17	Mean ht. (m) 6/18	Inc. (cm)	Mean tree vol (m^3) 5/17	Mean tree vol (m^3) 6/18	Inc. (m^3)	Form Score (1-3)
1N	Silver wattle	95	11.4	16.4	5.0	9.1	10.2	1.1	0.031	0.072	0.041	1.8
	Silvertop	143	7.8	11.4	3.6	7.1	8.4	1.3	0.011	0.029	0.018	2.3
2M	Silvertop	262	10	13.9	3.9	7.6	8.8	1.2	0.020	0.045	0.025	2.3
3S	Spotted gum	238	7.6	10.7	3.1	5.9	7.1	1.2	0.009	0.023	0.014	1.6
	Silver wattle	24	8.7	13.5	4.8	7.8	9.7	1.9	0.012	0.046	0.038	2

Notes:
dbh = diameter at breast height (1.3m)
MAI = mean annual increment. Calculates the volume of wood grown over the life of the planting
Form score: 1 = definite 6 metre sawlog, 2 = sawlog potential (2.7 - 6 metres), 3 = no sawlog potential

Summary

- This is not a replicated scientific trial. The PSP's are simply a mechanism by which diameter at breast height[1] (dbh) and tree height are measured at the same location and at regular intervals (e.g. annually);
- Plots were measured 4 times – May 17, Nov 17, Mar 18 and Jun 18;
- Silver wattle was easily the fastest growing tree on site, followed by silvertop and finally spotted gum;
- Spotted gum was only species to put on significant height during during Mar-Jun 18. The local species silver wattle and silvertop did not increase height during the Mar-June period. Observations during 2014-2017 show that this new growth in spotted gum is typically damaged by harsh winter weather (i.e. frost, hail, sleet). Silvertop and silver wattle have not incurred such setbacks through the winter period;
- Mean height increment across the trial in 2017-18 was similar for all species;
- Silver wattle has dominated both spotted gum and silvertop during early growth stages. This early competition requires careful management to encourage good growth increment in the initially slower growing species;
- Spotted gum showed better form than silvertop. This was to be expected given that improved seed was used to propagate the spotted gum;

[1] Only 1 silver wattle in plot 3S
[2] dbh = 1.3 metres above ground.

Soil samples were taken in May 2017 from inter-row areas to investigate the contribution of both plantation trees, and crops grown in these areas to soil nutrient levels and soil fertility. The following observations on the analyses are listed below												
Treatment	**pH 1:5 Water**	**Ammonium N KCl mg/kg**	**Nitrate N KCl mg/kg**	**Total N %**	**P Olsen mg/kg**	**K Morgan mg/kg**	**Ca Morgan mg/kg**	**Mg Morgan mg/kg**	**Total Carbon %**	**Organic Matter %**	**CEC**	**Comments**
Control (South End Easement)	5.32	8.6	54	0.45	23	86	430	244	5.80%	10.2	10.42	Good levels of nitrogen, phosphorus, potassium illustrating compound fertiliser applied
Wattle root zone (South third)	5.32	11	21	0.45	14	64	916	134	5.78%	10.1	11.59	Higher NH4 may indicate nitrogen cycling, Perhaps contribution from nodulation on acacias. Increase in available Ca. Slight increase in CEC.
Eucalyptus root zone (South 3rd)	5.58	7	19	0.46	17	52	591	85	5.99%	10.50%	10.66	
Euc root zone-no wattle influence (Mid 3rd)	5.53	6.2	20	0.46	18	90	806	111	5.95%	10.4	10.97	Increase in available Ca
Inter-row Eucs-no legume history	5.53	3.2	26	0.45	16	124	771	101	5.82%	10.20%	10.42	
Inter-row Wattle-no legume history (South 3rd)	5.72	4.7	21	0.45	18	98	885	131	5.99%	10.50%	11.8	Higher NH4 may indicate nitrogen cycling, Perhaps contribution from nodulation on acacias. Increase in available Ca, decrease in available and exchangeable K. Increase in CEC
Lucerne (plot B3)	5.55	6.5	53	0.49	19	82	935	139	6.19%	10.80%	12.14	High Nitrate N. Increase in available Ca, and K. Slight increase in organic matter organic carbon and CEC
Red clover (plot F1)	5.64	11	19	0.47	19	112	899	110	6.07%	10.60%	10.53	Higher NH4 may indicate nitrogen cycling. Increase in available Ca and K and CEC
Sorghum - no recent legume history	5.49	3.6	22	0.47	18	111	787	107	6.00%	10.50%	10.53	
Sorghum - with legume history	5.44	3.6	41	0.44	17	111	845	105	5.49%	9.60%	10.96	High Nitrate N, residual N from legume history. Increase in available and exchangeable Ca, slight increase in available K

References

1. The Center for Agroforestry at the University of Missouri http://www.centerforagroforestry.org/practices/ac.php

2. Practical Landcare Guide – Multi Storey Farming http://www.wpcln.org.au/wp-content/uploads/2018/05/MSF-Brochure_Print.pdf

3. Australian Centre for International Agricultural Research - Nitrogen fixation in acacias http://aciar.gov.au/files/node/619/mn115part1.pdf

4. Agriculture as a Mimic of Natural Ecosystems – RIRDC https://www.researchgate.net/publication/228606485_Agriculture_as_a_Mimic_of_Natural_Ecosystems

5. Alley Farming in Australia - Current research and future directions – RIRDC http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.594.4370&rep=rep1&type=pdf

This project is supported by Western Port Catchment Landcare Network through funding from the Australian Government's National Landcare Program and Landcare Australia