



Soil Carbon and Pasture Trials

Increasing soil carbon through species-diverse pastures

Key Findings

- *Highly diverse pastures usually produced more feed, compared to two-species pastures.*
- *Where ground cover was maintained and deep-rooted perennial species not sprayed out, large differences in soil carbon were observed within two years of sowing.*
- *Crude protein, energy and fibre were similar between the diverse and simple pastures.*

Introduction

In 2019, NRM North partnered with four farmers to develop long-term soil carbon trials aligned with the Regional Land Partnerships funding priority: Soil Carbon. These trials feature species diverse pastures alongside standard grass and clover blends. The aim is to increase farmers' confidence in using diverse pastures to build soil carbon by investigating and demonstrating this in real-world situations over a four-year period.

Trial Setup and Method

Trial preparation began in autumn 2019, where a uniform paddock from each farm was halved. Diverse pastures were sown on one half and a simple pasture sown on the other.

The simple pastures were sown with various perennial ryegrass cultivars, short-rotation ryegrasses and either red or white clover species.

The diverse pastures were sown with a range of grasses, including ryegrass, cocksfoot, fescue, brome, phalaris, mixed perennial and annual clovers, chicory, and most sites included plantain.

Due to the dry conditions in autumn 2019, some sites had problems with establishment.

Management of grazing and weed control was left to the participating farmers. New fences between the pasture types were not erected, except for later at the Rosevale site.

Pasture performance was monitored through ongoing dry matter (DM) estimations using a rising plate meter and feed testing. The rising plate meter was used to collect the pre-grazing (production) and post-grazing (consumption) DM measurements. This relied on communication with the participating farmers, and therefore sampling efforts varied across farms.

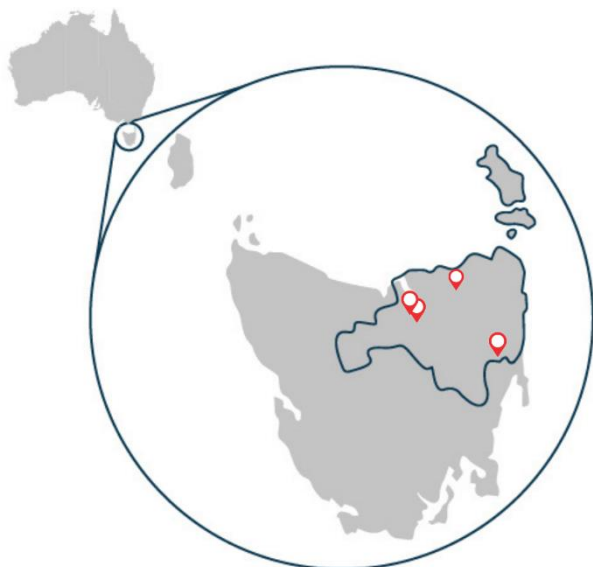


In August 2021, soil was sampled to 30 cm with a hand auger - 20 sub-samples were taken from each plot (160 sub-samples overall) in a grid pattern. Samples were then sifted and combined to be sent away for Soil Organic Carbon testing by Agvita, Tasmania.

Due to the poor condition of the Westwood diverse plot at the time of sampling, NRM North staff hand-spread red and white clover seed and chicory seed in patches of bare ground in August 2021.

Trial Location

The four demonstration sites located in northern Tasmanian are in Jetsonville, Mangana, Rosevale and Westwood.



Results

Pasture composition

Between sowing in 2019 and observations in 2021, pasture composition had changed at all sites except Jetsonville.

Pasture composition of each plot from August/September 2021 is shown in Table 1.

The loss of chicory at three sites was attributed to broadleaf weed sprays applied post-sowing and preferential grazing. A broadleaf herbicide registered for chicory was not available in 2019. Some chicory has since re-appeared at the Mangana site, without additional sowing.

Feed Tests

Standard feed test results showed only marginal differences between the diverse and simple pastures. Averaged feed test results across the diverse and simple pastures are summarised in Table 2.

Dry Matter

Since establishment in 2019, almost an additional 6,500 kg/DM/ha was produced from the diverse pastures compared to the simple pasture blends. The pre and post grazing plate meter readings estimate an additional 4,500 kg/DM/ha was consumed on the diverse plots measured. It should be noted, these numbers do not factor in wastage from livestock trampling. The difference was most noticeable on the diverse pasture plot at Jetsonville.

See dry matter data in Table 3. Dry matter production data was not collected from the Mangana site.



Soil Carbon

Soil organic carbon test results from samples taken in August 2021 show both large and small differences between the diverse and simple pastures.

The soil carbon results from each site are presented in Table 4.

Discussion

Pasture composition

Of the four farms sown with chicory, only two had chicory remaining in 2021 (Jetsonville and Mangana). As the trial sites were required to be set up quickly, the pastures were not sown following best practice methods of fodder cropping weed control for two years. With that considered, and the very dry period at sowing, weed issues quickly appeared at all sites. With the absence of chicory-registered herbicides like Thistrol Gold in 2019, chicory succumbed to the thistle and flatweed sprays. Weeds at the Jetsonville site were largely controlled through grazing pressure rather than herbicide, so it retained chicory.

The Rosevale site, with chicory sprayed out and no plantain sown, became a comparison of a few types of grass and clover (simple) vs many types of grass and clover (diverse).

The Mangana site retained plantain in the diverse-sown plot and maintained clovers and ground cover. The plantain has started spreading to the simple-sown plot as well. Chicory is present again despite sprays used in 2019.

The Westwood site has had a range of challenges with groundcover and persistent

capeweed. Ground cover is higher in the simple-sown side, though it consists almost entirely of grasses and capeweed. The diverse-sown side has lower groundcover, and increased presence of weeds. Plantain is retained and has bounced back from heavy grazing over two years, though clover was almost absent from both sides until Spring 2021. Soil fertility and pH may be contributing factors in that paddock.

Feed Test

Overall, the differences in metabolisable energy, crude protein and neutral detergent fibre between the two pasture types were very small on each of the farms. It may be that other measures are more appropriate for detecting any differences. Sap tests of mineral concentration could be sampled in future.

Dry Matter

For each individual farm there was an increase in dry matter consumed for the diverse plots. In terms of red meat production and financial return, this consumption equates to approximately 305 kg/ha of extra liveweight gain produced (at 15:1 feed conversion ratio) for the diverse pastures over the life of the project.

Soil Carbon

The soil carbon results are the complete profile to 30 cm deep, so will most likely have lower carbon percentages than 10 cm or 7.5 cm samples. Unfortunately, the original soil tests from 2019 were obtained from a range of depths and are not comparable to the standard 30 cm depth used for this report in 2021. This new depth standard was chosen as



it is a minimum used in soil-based carbon market projects.

The clear link between those diverse-sown pastures that have more soil carbon is that they both have high levels of groundcover and deep-rooted perennial herbs (plantain and chicory). The lush pasture at Jetsonville did not improve soil carbon as much as the pasture at Mangana, probably due to soil structure. The Mangana site's soil was a free-draining loam to 20-25 cm and the clay below had a relatively high sand content. The Jetsonville site, on the other hand, had compaction issues and a hardpan at depth due to many years of root vegetable cropping. So, it appears that even though the lush, high-rainfall diverse pasture increased soil carbon a lot, relative to the simple pasture, root activity and hence, carbon inputs, were limited by soil structural issues. This was not a problem at the Mangana site, which had the highest soil carbon result relative to the simple pasture.

The two sites where the diverse-sown pasture had lower soil carbon compared to the simple-sown pastures was due to a range of issues. Firstly, sprays killed the chicory and only the Westwood site had a backup deep-rooted perennial herb (plantain).

The Westwood site's small difference in soil organic carbon can be explained by the poor pasture cover and weediness. Bare ground does not put carbon into soil, and the weedy annual grasses like wintergrass have very shallow root systems, low dry matter production and hence low carbon inputs. We hope that the additional seeding of clover and chicory from August 2021 will allow the soil

carbon levels to increase again by trial's end in 2023.

The Rosevale site, which became a comparison of grasses and clovers only, gave a surprising, much lower carbon result under the diverse-sown plot. In trying to interpret this result, it was important to consider the sampling conditions. The diverse-sown plot has poorer drainage than the simple-sown plot, and when sampling the site in August, large areas of the site had to be ignored due to waterlogging. This also meant favouring better-drained areas, such as with higher gravel content. The farmer also later informed us that we had sampled along the buried pipeline route and were likely sampling much higher concentrations of deep subsoil. The final deep soil sampling in 2023 will occur in early autumn, when the site is likely to be much drier, and will avoid the pipeline route. Comparing those results again will be of interest.

When comparing changes in percentages of soil organic carbon to quantities, such as tonnes per hectare, soil bulk density must be considered. However, for the purposes of comparing results, if we assume soil bulk density is 1 (one litre of dry soil weighs one kilogram), the two sites with increased soil carbon under diverse-sown pastures have experienced big increases.

Jetsonville – 25 tonnes of carbon per hectare between autumn 2019 and winter 2021

Mangana – 32 tonnes of carbon per hectare between autumn 2019 and winter 2021

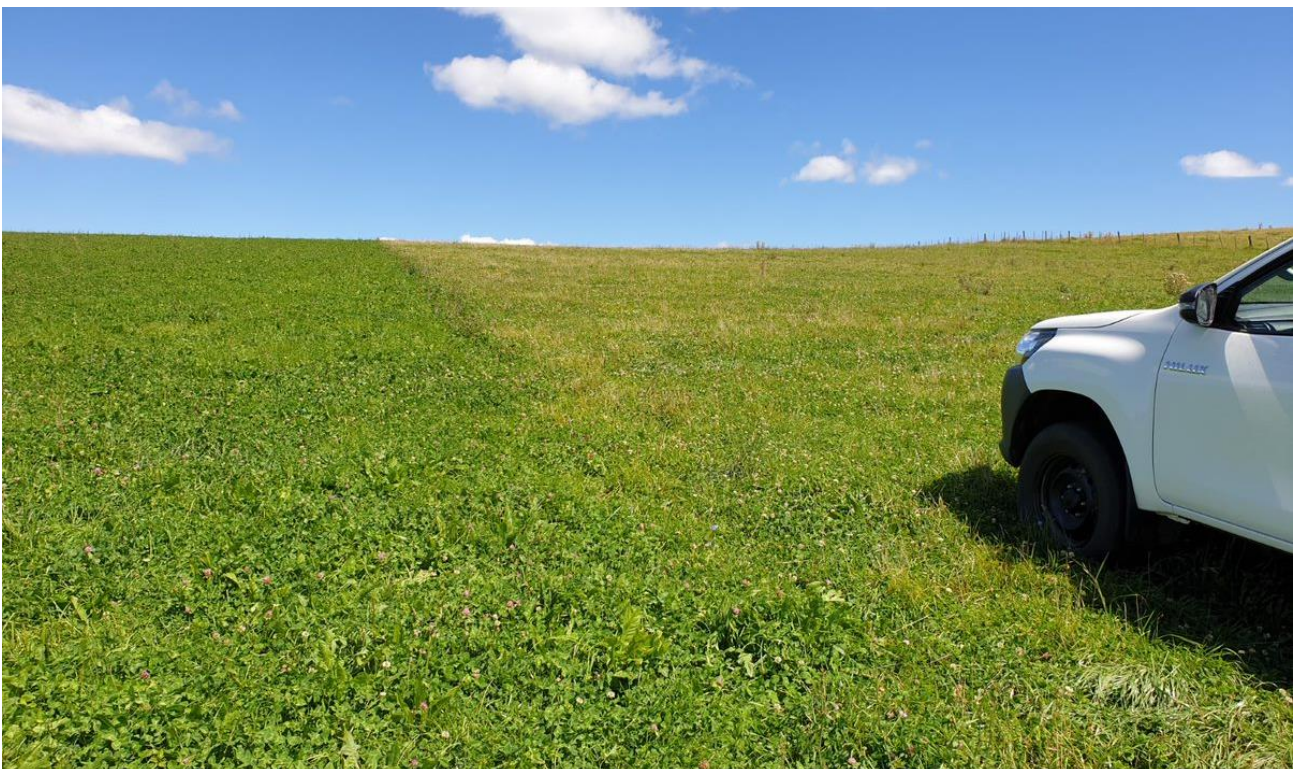


Many would be surprised at the size of these increases, so we should remember two things. Firstly, the difference is a result of a big change in pasture diversity. Secondly, this is from the first two years only, and soil carbon increases are expected to slow down and plateau out in later years.

Conclusion and Key Points

From these four sites, over two years, we are confident in saying that in northern Tasmanian conditions of recent years:

- Highly diverse pastures produce more feed over a year than simple pastures, though not in every month, in the first few years;
- The feed value of highly diverse pastures, when measured in ME, CP, NDF, is equivalent to simple pastures;
- Weed control is particularly important when establishing highly diverse pastures, though less problematic than in 2019 due to new herbicide availability;
- Deep-rooted perennial species are important in increasing soil carbon to 30cm depth;
- The ability of a diverse pasture to increase soil carbon is partly limited by soil quality, including fertility, drainage, and structure/compaction;
- Bare ground does not help increase soil carbon; and
- Compared to simple pastures, a well-managed and productive, highly diverse pasture can give large increases in soil organic carbon to 30 cm depth in the first two years, where previous pastures were mainly shallow rooted.



The Jetsonville site consistently maintained all sown species through to 2021, providing a stark visual difference.



Farmer Responses

Farmers hosting trial sites were asked to provide a statement.

Mangana

“We hosted the trial because whilst monocultures ryegrass have been most productive, as things get drier, ryegrass needs support from other species to provide continuous feed – so we’re looking at mixed species and increasing water holding capacity by increasing soil carbon.

The paddock was sown to pasture nearly 30 years ago and pasture had run out, so in 2016-17 we put two lots of cereal through it and it was going back to pasture when the trial opportunity came up. We had no issues with the diverse pasture – a very subtle difference – the diverse side seems to stay a bit greener for a bit longer.

Poly tape was put up between the two trial sites, each side grazed for three days, but we didn't see much difference in recovery.

It was surprising to see the big difference between treatments in terms of soil carbon, because the two plots are so similar, only explanation is deeper rooted species.” – Humberston McKenzie



Mangana sown as simple pasture



Mangana sown as diverse pasture



Westwood

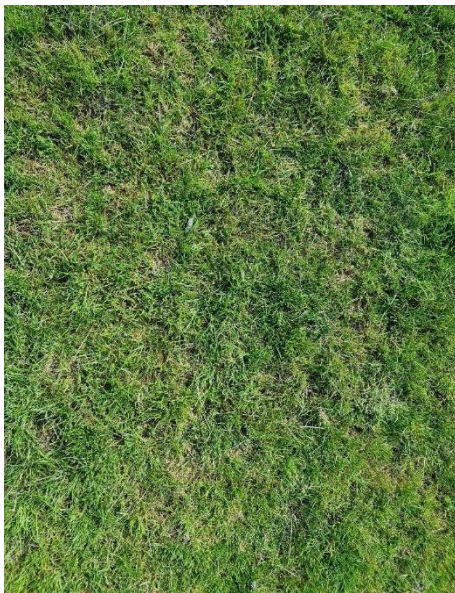


Westwood sown as simple pasture

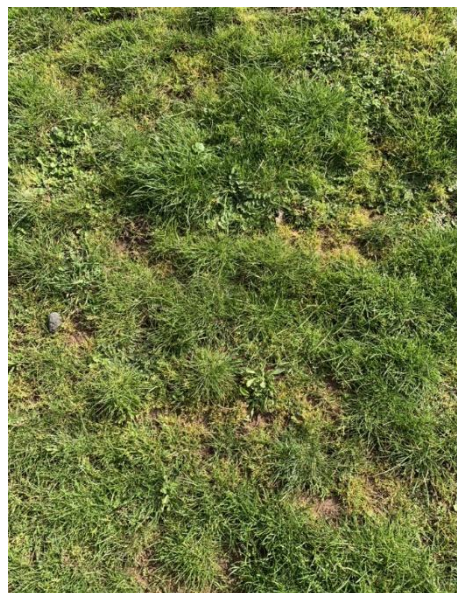


Westwood sown as diverse pasture

“We got involved with the trial because we were intrigued with the idea of building up more carbon through pastures. That little paddock has never been cropped, it’s traditionally been a ryegrass and clover paddock. It gets a bit neglected and overgrazed sometimes, so maybe we should have tried the carbon trial on a bigger paddock. The grazing seemed pretty even between the two pasture types, and it’s disappointing the broadleaves weren’t as thick on the ground as they should have been. Anyway, the carbon result makes sense – the side with less groundcover had less soil carbon.” Andrew Archer.



Westwood sown as simple pasture



Westwood sown as diverse pasture



Rosevale sown as simple pasture



Rosevale sown as diverse pasture

Rosevale

“We had two paddocks of similar size that needed renovation. These paddocks had been used for hay production by us the last 4 years running and from what we know every year prior to us buying the farm.

I have always used diverse species pastures and this seemed like a good way to get proof that what we did had merit, not only financially, but also environmentally. It was a bit rushed with the set up of the pasture as normally I use a diverse fodder crop the season prior which adds to the soil and also helps get weeds under control.

We had a flat weed issue that when sprayed killed out the chicory. I would love to reintroduce chicory etc but as this is a trial I will wait until it has finished to do this.

Animals always prefer to graze the diverse pastures and camp on this side prior to installing the dividing fence. Fodder production last season for silage was 50% more on the diverse side.

Colour difference visually is more appealing on the diverse and we noticed even with good seasons the ryegrass-based pasture has struggled in the summer and has areas the rye has died out.

In regards to the soil carbon - it's an interesting result. Full tillage of the soil releases a large percentage of the soil carbon that was already there. But this wasn't taken into account just a pre tillage and 12 months post establishment.” - Tim Reed



Jetsonville

"I hosted the soil carbon trial at my farm because I thought I had a perfect paddock for the topic. The paddock has a strong soil type but its productivity wasn't good. I wanted to see what experts in this field would recommend compared to my own ideas. Soil carbon is of high interest to me, and an opportunity to learn about this was a perfect opportunity.

The paddock has had a heavy cropping history and I wanted to trial different plant types to improve the soil structure. In my opinion the soil structure was the limiting factor of this paddock and I knew that with time and different plants it could be improved. We have lots of ryegrass pasture and over time we don't see the improvement in productivity and soil structure needed for long term sustainability. The different plants in the trial seem to complement each other, and having some deep-rooted varieties is the key for our farm into the future.

The bonus of soil carbon is the factor needed for the structure, so they go hand in hand. The results from the trial have been amazing, to see the production from the diverse mix of plants has been impressive. The increase in soil carbon is good. Especially to see an improvement at 30 cm soil depth. Something that I would like to learn more about.

Establishment of the trial wasn't without some problems. Pink weed dominated the slow establishment of the trial but grazing and a light spray has remediated this. The concept of being carbon neutral for my farm and what is needed for me to achieve this has been of high interest, thanks to Peter for all his efforts and Adrian and NRM North for their time and help." - Clint Lette.



Jetsonville sown as simple pasture



Jetsonville sown as diverse pasture


Table 1
2021 Pasture composition for each plot

LOCATION	DIVERSE	SIMPLE
Mangana	Perennial grasses, clovers, plantain and chicory	Perennial grasses and clovers, small amount of plantain spreading
Westwood	Perennial and weedy annual grasses, capeweed, areas of bare ground	Perennial and annual weedy grasses, capeweed
Rosevale	Perennial grasses and clovers	Perennial grasses and clovers, annual clovers
Jetsonville	Perennial grasses, clovers, plantain and chicory	Perennial grasses and clovers

Table 2
Averaged feed test results

LOCATION	DIVERSE	SIMPLE
Est. Metabolisable energy (Mj/kg)	11.42	11.50
Crude protein (%)	22.66	22.54
Neutral detergent fibre (%)	40.51	42.09


Table 3

Averaged Dry Matter consumed over the trial to date (kg/DM/ha)

LOCATION	DIVERSE	SIMPLE
Westwood	9 550	9 032
Rosevale	25 883	24 497
Jetsonville	19 892	17 220

Note: As these measurements are reliant upon stock rotation, the number of measurements to calculate the averages for each farm varies.

Table 4

Soil organic carbon tests (%) from 0-30cm of the soil profile in August 2021.

LOCATION	DIVERSE	SIMPLE
Mangana	4.47	3.60
Westwood	2.10	2.36
Rosevale	1.12*	1.84
Jetsonville	3.56	2.87

*see notes in Discussion

