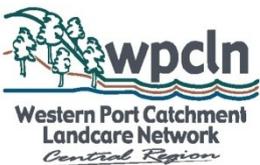


Final Report for Farmers and Partners and Funders

Funder – Caring for our Country via PPWCMA

Project Manager – Western Port Catchment Landcare Network / CEC

Partner Organisations - Tarago Catchment Sustainable Farms (TCSF), Department of Environment & Primary Industries Ellinbank (DEPI), Bass Coast Landcare Network (BCLN), South Gippsland Landcare Network (SGLN), Port Phillip & Western Port Catchment Management Authority (PPWCMA)



Acknowledgement

This report is the culmination of a three year project coordinated by the Western Port Catchment Landcare Network and partnered by Tarago Catchment Sustainable Farms, Department of Environment and Primary Industries (Ellinbank), Bass Land care Network, South Gippsland Landcare Network and Port Phillip and Western Port Catchment Management Authority.

I would particularly like to thank Peter Ronalds, Coordinator for the Western Port Catchment Land Care Network who skilfully managed, contributed and drove the project, Dr Jess Horton and David Shambrook, DEPI, who provided expert advice and interpretation skills where required, and the Farmer Advisory Group consisting of Jim Armstrong, Sandra McPhee, Ray Boys, Graeme Wood, and Chris Alenson who provided technical expertise, guidance, community ownership and rigour to the project.

To all farmers involved in the project who had the foresight to see that this project was ultimately designed to provide assistance for their on-farm management and to improve their soil health and knowledge we are most grateful.

The “Healthy Soils - Linking Soil Carbon and Soil Acidification with Farm Management Practices” project was funded through the Australian Government's Caring for our Country Program

Chris Alenson, June 2013

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1. Executive Summary

The Healthy Soils, Soil Carbon and Soil Acidification project's major objective was to link soil carbon and soil acidification with farm management practices, building the knowledge and skills of farmers leading to increased uptake of sustainable farming practices.

736 farmers have been involved in the Healthy Soils – Linking Soil Carbon and Soil Acidification project, participating in small group mentoring, field days, discussion and training, forums, and farm planning. Carbon benchmarking also took place on 109 farms. This has culminated in an increased understanding of soil acidification and soil carbon processes and the link with farm productivity and land management actions.

109 farmers have undertaken farm planning programs including FarmPlan21 and iFarm incorporating farm scale mapping, along with soil training courses, and all participants received 1 on 1 assistance and guidance from experienced project staff across the region.

Over 100 soil cores were taken throughout the region benchmarking soil carbon levels and pH across multiple soil types and land uses, relating this information to land management practices. A Farmer Advisory Group provided leadership and technical expertise to the project assisting in the interpretation of on-farm observations and soil analyses, the planning of field days and forums and communication strategies for the engagement of farmers.

Further information was imparted through educational activities (soil workshops), the dissemination of defined handbooks and factsheets, project defined web sites, field days, demonstration sites and the development of individualized property management plans.

The provision of this information assisted individual farmers in understanding the complexity involved in managing their soils, and in particular in planning for the dual objectives of moderating pH and sequestering carbon with the ultimate aim of improving soil health.

Two alternative fertiliser trial sites have continued to be monitored, for a further period of 3 years (6 years total), to provide high value scientific data including pasture productivity, nutrition and soil biology counts to draw out the linkages between soil microbiology and soil carbon.

Three Soil Carbon Forums and eight field days were held, attracting participants from more than 25 Landcare groups. The final forum provided results from the soil core logging and coupled with informative talks from soil carbon and soil health experts and case stories from commercial farmers, ensured the day was an outstanding success.

The integrated nature of the project encompassing soil carbon benchmarking, soil analysis, and educational activities such as workshops, field days, forums and discussion groups has not only assisted in increased farmer learning, but resulted in significant changes to on-farm sustainable management and an increased level of community engagement.

1.1 Project Objectives

The project's underlying focus was to link soil carbon and soil acidification with farm management practices, leading to increased knowledge and skills of farmers and an increased uptake of sustainable farming practices.

This was achieved through:

- An extensive learning program that improved land manager skills and knowledge, focusing on soil carbon retention and soil acidification reduction, and linking these learning's with farm management changes and farm productivity
- Benchmarking soil carbon levels across multiple soil types and land uses, and relating this information to land management practices,
- The utilisation of current soil acidification knowledge across the region, the review of management practices at a local farm scale level through training, monitoring and mapping.

1.2 Overview of Findings

736 farmers have been involved in the Healthy Soils – Linking Soil Carbon and Soil Acidification project, participating in small group mentoring, field days, discussion and training, forums, and farm planning. Carbon benchmarking also took place on 109 farms. This has culminated in an increased understanding of soil acidification and soil carbon processes and the link with farm productivity and land management actions.

Many of these farmers have adjusted their land management practices based on soil observations and analytical data to improve soil carbon and reduce soil acidification leading to an improvement in soil health.

The project has delivered information that has assisted individual farmers and also provided pH and soil carbon data across a range of soil types that may assist further researchers in understandings the complexity involved in sequestering soil carbon while accommodating enterprise productivity.

Although no definitive trends were observed or relationships found between carbon and the other major nutrients research does indicate that high labile carbon is active in mobilising a range of important plant nutrients (Pettit, Dalton,1952, Jensen, 1917, .DE Koch,1955)

Nutrients were found to be highly variable amongst the different enterprises and this could be influenced by both the nature of the enterprise in terms of demand on nutrients but also more importantly dependant on the soil type with its historical geochemistry. Farmers tended to manipulate pH and the major nutrients nitrogen, phosphorus, potassium and sulphur to suit their particular enterprise.

The carbon levels were fairly consistent across similar soil types.

It is reported that soils under pasture have higher organic carbon than cropped soils due to the less disturbed state of pastures and the slower decomposition of pasture roots (DPI, NSW, 2010). Perennial pastures with higher shoot to root ratio (S/R) have higher levels of organic carbon. Results from the Healthy soils carbon sampling are consistent with this research with dairy and beef properties demonstrating high levels of organic carbon across the sampled profile.

In the same way that cropped soils generally have decreased organic carbon over time, it is also evident that heavily over grazed pastures that do not allow significant root development also have decreased soil carbon levels.

Building soil carbon levels takes considerable time. Where the use of green manures, legumes and compost additions can add organic matter to horticultural and cropping soils, grazing enterprises rely on rotational strategies, the addition of root biomass through growing hay or silage and the application of organic manures like poultry litter.

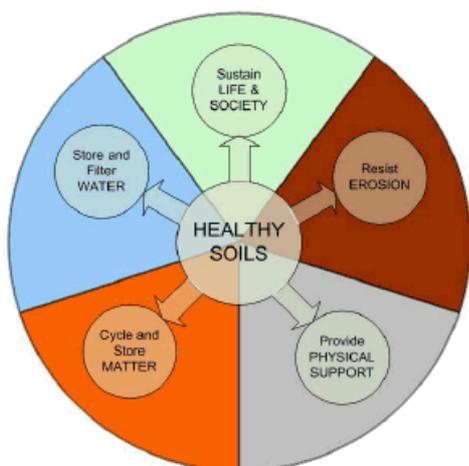
2. Background to the Healthy Soils, Soil Carbon and Soil Acidification project

The Healthy Soils, Soil Carbon and Soil Acidification project integrates knowledge across key soil characteristics that determine both productivity and long-term sustainability. Understanding how on-farm management practices affect soil carbon and soil acidification will assist in the implementation of strategies that through the modification of these soil characteristics will improve soil health and as a consequence productivity.

Soil quality and soil health are terms that are used almost interchangeably in discussions on agricultural production. Soil quality takes on a more scientific approach in its more precise characterisation of the soil's productive capacity (USDA 2001), where as soil health takes on a more sensory level of understanding (Kirschenman, 1997).

Parr et al. (1992) describes soil quality as perceived in a sustainable agriculture "as the capability of soil to produce safe and nutritious crops in a sustained manner over the longer term and to enhance human and animal health, without impairing the natural resource base or harming the environment".

The Victorian Department of Environment and Primary Industries (DEPI, 2007) have indicated the five major functions that they perceive as being seen in a healthy soil.



They include:

- The storage and filtering of water
- Cycling and storage of organic matter
- The provision of physical support for plants
- Ability to resist erosion
- Sustaining life and society

Although there is debate on the range of characteristics which maybe illustrative of a healthy soil the following are seen to be associated with it:

- Adequate organic matter levels
- Optimisation of plant root depth and development
- Good earthworm populations
- No obvious soil compaction
- Good soil structure
- Good aggregate stability
- Soil pH in the vicinity of 6-6.5
- A medium to high Cation Exchange Capacity
- Adequate levels of macro and micro nutrients

It is changes in these characteristics that may reflect changes to the functions of a healthy soil impacting on productivity and health of crops and livestock.

2.1 Management effects on soil pH and soil carbon

Given that more than 75 percent of Australian farming soils have organic carbon contents less than 1.75 percent (CSIRO 1983) the challenge to manage Australian soils in a more sustainable manner is at the forefront of scientific endeavour.

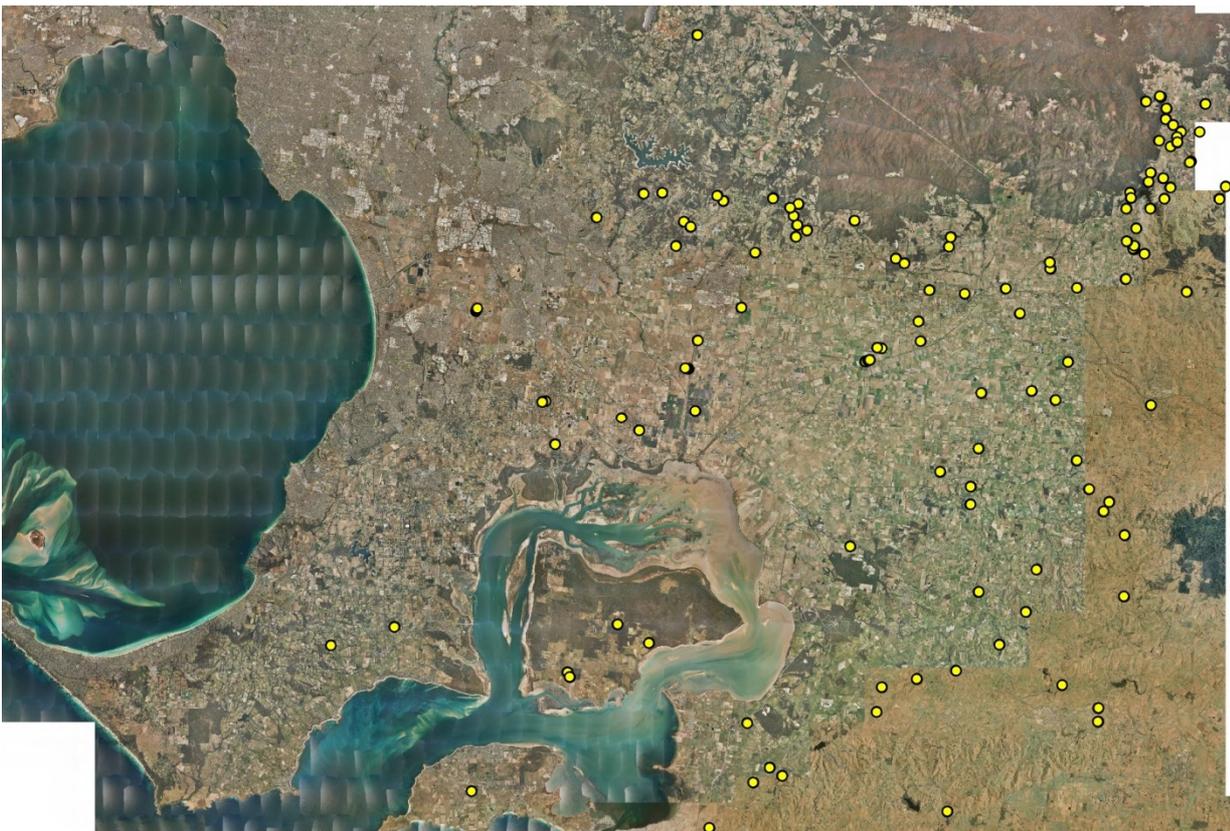
Over the last century agricultural practices have depleted Australian soils of their carbon stocks to the tune of approximately 40% from our cropping soils (Wentworth Group of Concerned Scientists 2009). They indicate that this loss of soil carbon is the primary cause of land and water degradation, acidification and soil structure decline.

Soil acidity in high rainfall areas (>600mm) has become a high priority in terms of amelioration for many farmers (Hughes 2001). Landcare estimates that strongly acid soils have affected 1.2 million ha of Victoria's soils costing \$15 million in lost production. It is considered that the major cause of acidity in Gippsland is leaching of the major base cations from the soil colloid and the removal of product from the farm. The increasing use of nitrogen fertilisers which can have an acidifying effect on the soil is also a cause for concern (Rowell, Wild, 2007, Barak, Jobe, Krueger, Peterson, Laird, 1997).

It is well documented how soil pH and soil carbon can be affected by management activities (Reganold, 1987, Cornish, 1992, Gatehouse, 1995, Small and McDonald, 1993).

Data gathered during this project has allowed management strategies to be developed that can affect positively the pH and carbon that historically in Australia has trended in a downward direction. The Wentworth Group of concerned scientists suggest that not only does raising soil carbon improve soil health and as a consequence agricultural production, but it will lead to the sequestration of atmospheric carbon contributing to the fight against climate change.

Map - Location of Carbon Benchmark properties



3.

Project methodology

As the project developed, the relationship between soil carbon levels and soil acidification with productivity was explored, as previous research programs including the “Healthy Soils, Stock & Pasture”, and “Tarago Catchment Sustainable Farms” projects have suggested that linking sustainable farm management practices with farm productivity, leads to the adoption of improved farm management practices

The project expanded the above learning’s into broad scale land management actions, across a minimum of 100 sites within the Westernport region, encompassing multiple soil types and land uses.

After base line data had been collected and analysed, whole farm behaviour change and learning was facilitated through training workshops, mentoring & discussion groups. Information was disseminated via defined handbooks and factsheets, project defined web sites, field days, demonstration sites, continuation of the current trial sites, development of individualized property management plans (through FarmPlan21 and iFarm).

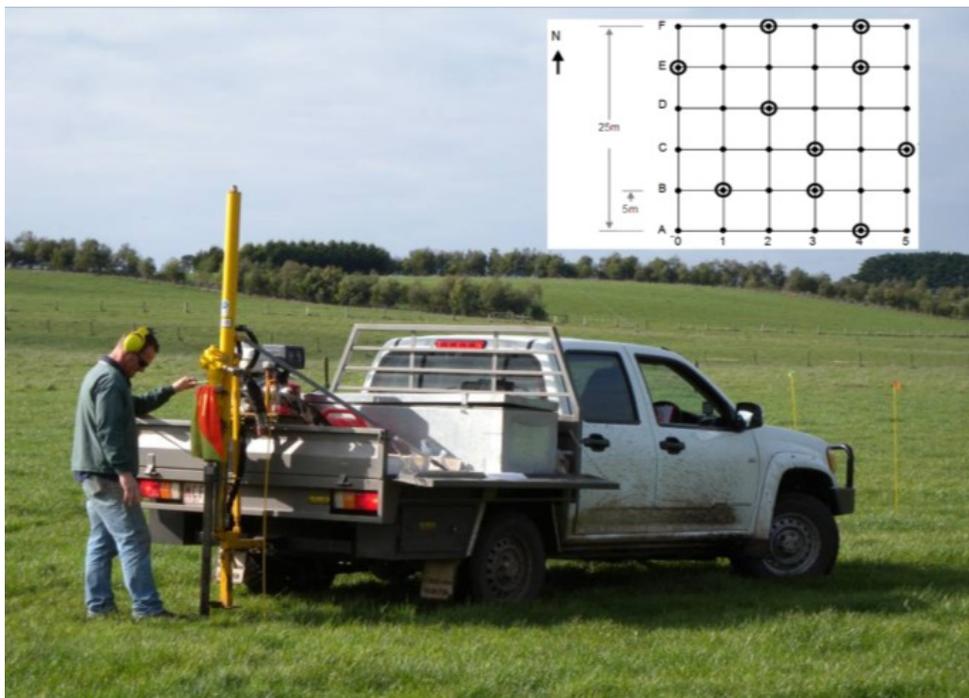


At the completion of the project:

- 736 landholders had participated, and each had gained a better understanding of soil acidification & soil carbon processes and the link with farm productivity and land management actions.
- 109 landholders had undertaken farm planning courses and mapped their current soil carbon & soil pH levels, and incorporated change into their land management practices.

- 109 sites have had Soil Carbon benchmarking undertaken on multiple soil types and land uses
- 140 soil tests had been taken throughout the region to measure soil acidification

- Soil Carbon benchmarking data had been collected across 2 scientific replicated trial sites with 14 different fertiliser regimes, (with 6 years data). These 2 trial sites provided accurate soil carbon data so that different management regimes can be measured against a control, providing farmers with information that links specific management practices with soil carbon results.



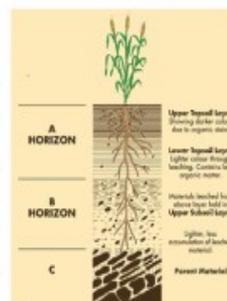
- annual soil tests had been taken on 2 existing trial sites with 14 different fertilizer regimes to monitor soil acidification trends over the longer term. (6 years total)
- 2 existing trial sites have continued to be monitored, with existing management regimes continued to provide high value data for a further period of 3 years (6 years total)
- Annual Soil Biology counts had been taken on 2 existing trial sites to draw out linkages between soil microbiology & soil carbon
- Information had been disseminated via “Land manager Hand Booklets”, discussing specific actions which can be implemented on farm whether they be beef, dairy, horticulture, cropping, small or large landholders.
- This Final Report will be placed on a Web Site www.wpcin.org.au data results will be made available to the regions landholders - thus being able to disseminate information across the greater region of Westernport.
- 3 Soil carbon forums with a target audience of 300 farmers had been held

Healthy Soils – Linking Soil Carbon and Soil Acidification with Farm Management Practices

In Field Analysis for project id SCBAR01

Soil Type as per DPI website – Strzelecki (S2)
 Soil Type as per Australian Soil Classification – Dermosol

HORIZON ID	DEPTH (cm)	pH	TEXTURE
A	0-20	5.5	Light clay
B	20-47	5.5	Medium clay
B	47-80	5.5	Medium heavy clay
C	80-94	5.5	Decaying bedrock



- 8 field days and educational events, with participants from more than 25 Landcare groups over 3 Landcare Network areas across the region, have had exposure to these learning's, and have been able to participate in changed land management practices focused on soil carbon increases and retention, and acidification reduction.



- Over 130 farmers attended the final Soil Carbon Forum at Lardner Park, Warragul, where results of the project were discussed and key speakers advised participants on that latest research on soil carbon.



3.1 Training workshops, mentoring & discussion groups.

Training workshops targeting soil health were conducted at a range of locations. Information on the physical, biological and chemical aspects of the soil was covered along with interesting hands-on activities which enabled participants to get a better understanding of soil texture and soil structure and what that meant in the context of their on-farm management strategies. Attendance at these training workshops was excellent and illustrated the depth of learning that farmers were prepared to take on.

The issue of understanding soil analysis was another well attended workshop series where the range of issues and reliability concerning soil analysis was covered. Soil analysis remains an important tool for farmers but it was emphasised that the farmer's own observations of pasture growth and animal health should not be underestimated and that decision making on the farm required a significant range of observations to ensure appropriate actions were taken.

Evaluation question - What did you like most about the workshop day?

Typical comments from farmers included:

"Learning about the use of different limes so that not only pH is raised but to enhance or otherwise trace elements".

"Looking at 2 different soil tests & comparing results or even just finding different test results and measurements and making sense of those was useful".

"A good intro to soil management".

"Being with people of like minded interests in land management"

3.2 Field days

The 8 field days with good attendances were held with varying enterprises and activities highlighted. The opportunity to hear from practicing commercial farmers, to walk their paddocks and to hear discussion about their soil and animal management practices was appreciated by participants.

Evaluation question - What did you like most about the field day?

Typical comments from farmers included:

"Farmers speaking about their experiments with alternatives & workbook summary for future bedtime reading".

"Workshops on farm where you can have a walk around is excellent".

"Practical information and real farmers presenting their observations - excellent catering also!

"The opportunity to see and discuss what others have done"

3.3 Forums

Three soil forums were held highlighting the project and results from a range of activities. Alternative fertiliser trials were discussed along with results from the soil carbon benchmarking.

Key note speakers with scientific expertise provided up to date information on soils and soil carbon. 5

3.4 Case Studies

5 Case studies of farmers were written which demonstrated the importance of practicing farmers transferring their knowledge and experience to interested participants. As has been the case throughout this project it is the practicing commercial farmer's views and experiences which seem to attract the most attention. Case studies are valuable tools to assist farmers to learn from other farmers. Farmers can use case studies acquire knowledge and transfer this learning to active research on their own property.

3.5 Methodology – how were targets delivered?

The Project was designed and delivered collaboratively, by Western Port Catchment Landcare Network, Tarago Catchment Sustainable Farming Project, Department of Primary Industries (Frankston and Ellinbank), Bass Coast Landcare Network and South Gippsland Landcare Network.

The project team was made up of a farmer from each of the 4 participating Landcare Networks, a representative from DEPI and a soil specialist. The project team was called the Farmers Advisory Group (FAG). The FAG provided technical expertise, guidance community ownership and rigour to the project. The FAG also assessed the on-farm management strategies for the 109 participating farmers. Their proposed actions were carefully considered and vetted by the FAG and decisions were made based on farm observations and soil analytical data.

The input from this Farmer's Advisory Group cannot be underestimated nor can the learning and knowledge that was acquired as a group through their involvement in the project. The examination and critical analysis of soil analysis reports and suggested management improvements by the farmers involved in the project taxed the expertise of the committee to the highest degree. The benefit of having both on-the-ground farmers and soil technical experts on the committee nurtured a symbiosis that allowed healthy discussions and informed decision making.



Comments from some of the FAG demonstrate the beneficial and stimulatory working relationship that was enjoyed by all members.

Jim Armstrong, FAG Member – “As a member of the FAG for this program, I think it is great that we can get some baselines on carbon levels on a lot of different farming enterprises. It also gives us a challenge to improve our level of understanding and hopefully we could get some funds in 5 years time to re-test”.



Sandra McPhee, FAG Member, “The healthy soils project has been a terrific project to be involved in - both as a landholder and as a member of the advisory committee. I really enjoyed the combination of hands on learning and the sharing of knowledge at the field days. It certainly demystified much of the science behind soil carbon and a particular highlight was individual attention each property was given. I would really like to see a continuation of this type of project engagement - so vital in a learning community”.

Chris Alenson, FAG Member, “Through my involvement in the Farmer Advisory Group I have been able to share in significant information and learning while using my particular expertise to hopefully contribute to the desired outcomes and decision making of the group”

Ray Boys, FAG Member, “This project has been the best project ever delivered in the catchment. It was really worthwhile for farmers”

The 736 farmers were engaged through advertising in local papers advertising in industry magazines, Landcare networks, flyers newsletters, farm industry bodies and via web sites.

The Carbon benchmarking on the 109 sites, was conducted to Australian standards. Samples were collected at 0-10cm, 10-20cm, 20-30cm depths, and EAL Norsearch through analysis, fractionised the carbon. Collection was across 8 strategic soil groups, with multiple land uses and management practices situated throughout the Westernport Catchment (central, eastern & southern areas). These soil types comprise 68% of all soils within the whole of Westernport catchment. (calculated using data from Soil Survey Westernport Bay Catchment I.J Sargeant Soil Survey report No. 52). Soil acidification was also monitored on each of these 109 sites

In addition to this, soil carbon benchmarking, as detailed above, also took place on 2 existing trial sites that had 14 alternative fertiliser regimes in place. These scientifically validated replicated trial sites were set up 6 years ago under the ‘Healthy Soils, Stock & Pasture’ project. The sites have been monitored over 6 years for soil microbiology, pasture nutrition, soil chemistry and pasture yield. These sites were utilised to provide valuable long term data on the effects that different management regimes have had on soil acidification and carbon. Annual soil microbiology counts were also continued to monitor linkages between different management regimes, microbiology counts and soil carbon results.

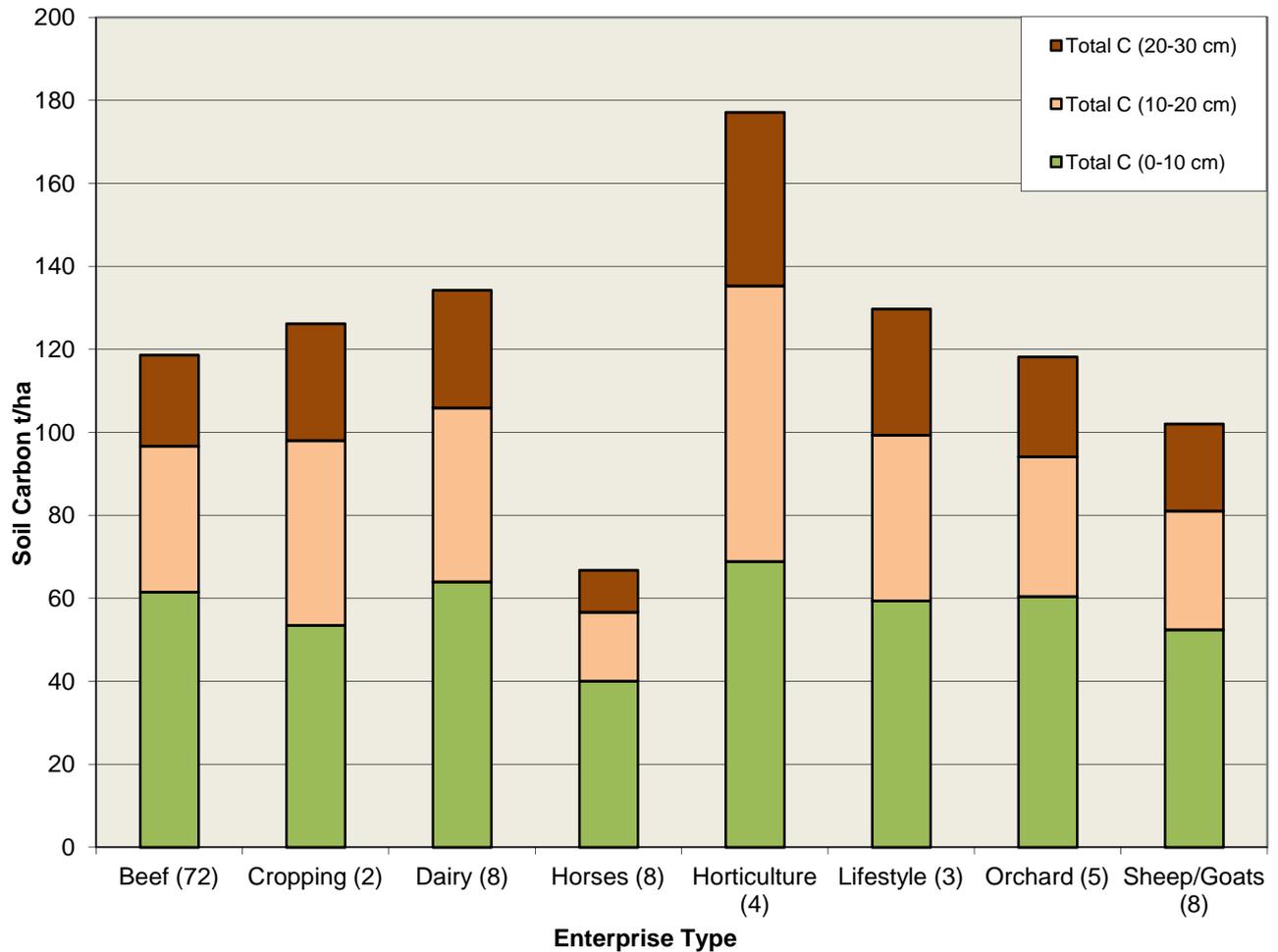
The sites formed the basis of developing land management practises developed for this project - that drive increases in soil carbon and reduction in soil acidification. These land management actions, were further trialled on larger scale demonstration sites, and monitored, evaluated and documented against farm productivity, and sustainable farm management practises. The resulting data and evaluation, enabled the development of targeted “how to” programs, tailored to specific farm types, soil types and management regimes, which then provided farmers with the knowledge and tools to implement management practices leading to an improvement in soil carbon and a reduction in soil acidification.

These land management practices have already resulted in real landscape scale change throughout the Westernport catchment resulting in a significant improvement in the overall health of the catchment, and increased productivity in the agricultural sector.

The overall data collected can be used widely across the entire catchment, as the results and information provided outline the steps which landholders of any “land use” need to take, with specific tailored practices, to improve their farm management.

4. Results- Benchmark

Enterprise and Total Soil Carbon



Comments

Results for total organic carbon are benchmark results only and do not reflect management over time. These levels of soil carbon however, may over time (5 years or more), indicate the effect that the enterprise activity has had on them.

In order of abundance highest carbon levels from 0- 10cm were noted in horticulture->dairy->beef-> orchards->lifestyle->cropping, sheep/goats-> horses

Slightly lower levels of carbon from 0-10cm occurring in cropping may indicate the disturbance of soil aggregation through ploughing and oxidation of organic matter.

In order of abundance highest carbon levels from 0-30cm were noted in horticulture->dairy & lifestyle->cropping->beef->orchards->sheep & goats-> horses

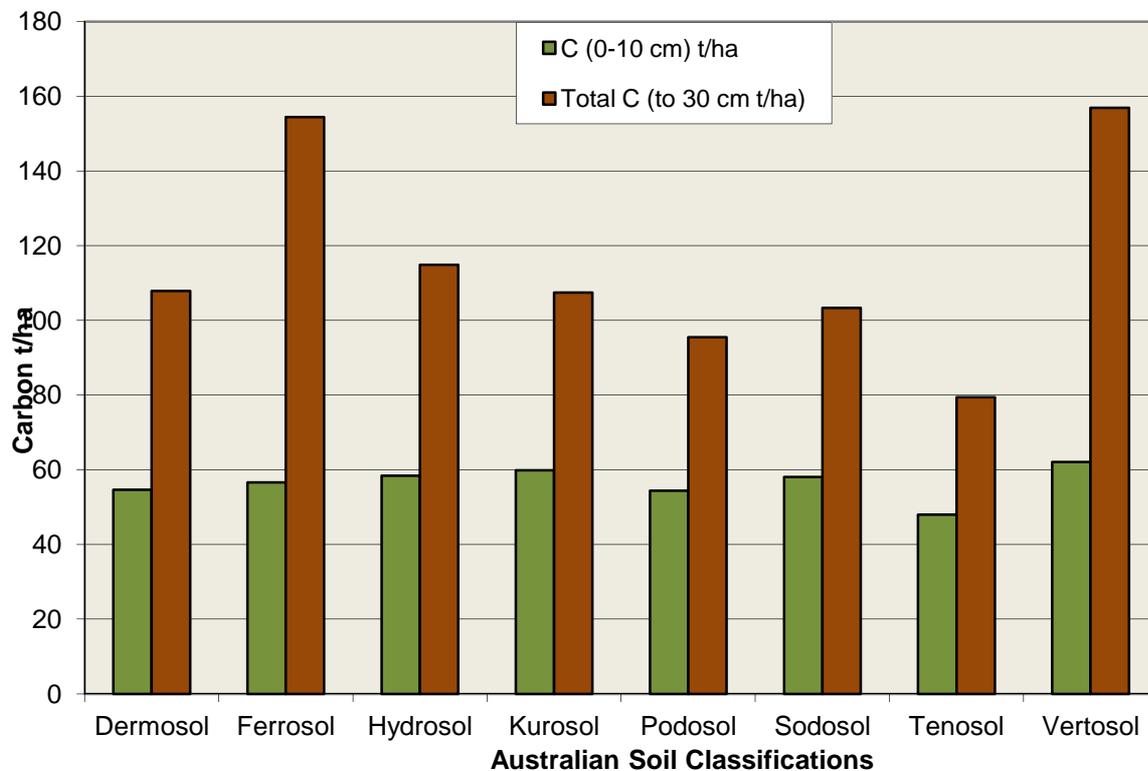
Other than the horse enterprises all other enterprises had similar organic carbon levels from 0-10 cm.

What perhaps is interesting is that the highest levels of organic matter are seen in the horticultural enterprises. Almost all research indicates that cultivation depletes organic matter (Hunt 1980, Burke, Yonker, Parton, Cole, Flach, and Schimel, 1989). The suggestion is that soil mixing through cultivation and or site selection on an organic carbon rich soil (Kooweerup soils), may explain such results.

The lowest levels of organic matter are seen in horse enterprises. Does this reflect a lifestyle property where perhaps poorer quality land class may have been available or is it illustrative of an overgrazed poorly managed enterprise? As this is a benchmark figure for organic carbon only retesting over time would perhaps indicate a positive or negative trend in carbon levels.

Given that more than 75 percent of Australian farming soils have organic carbon contents less than 1.75 percent (CSIRO) which equates to levels of 63 tonnes per hectare the levels seen across most enterprises in Gippsland compare quite favourably.

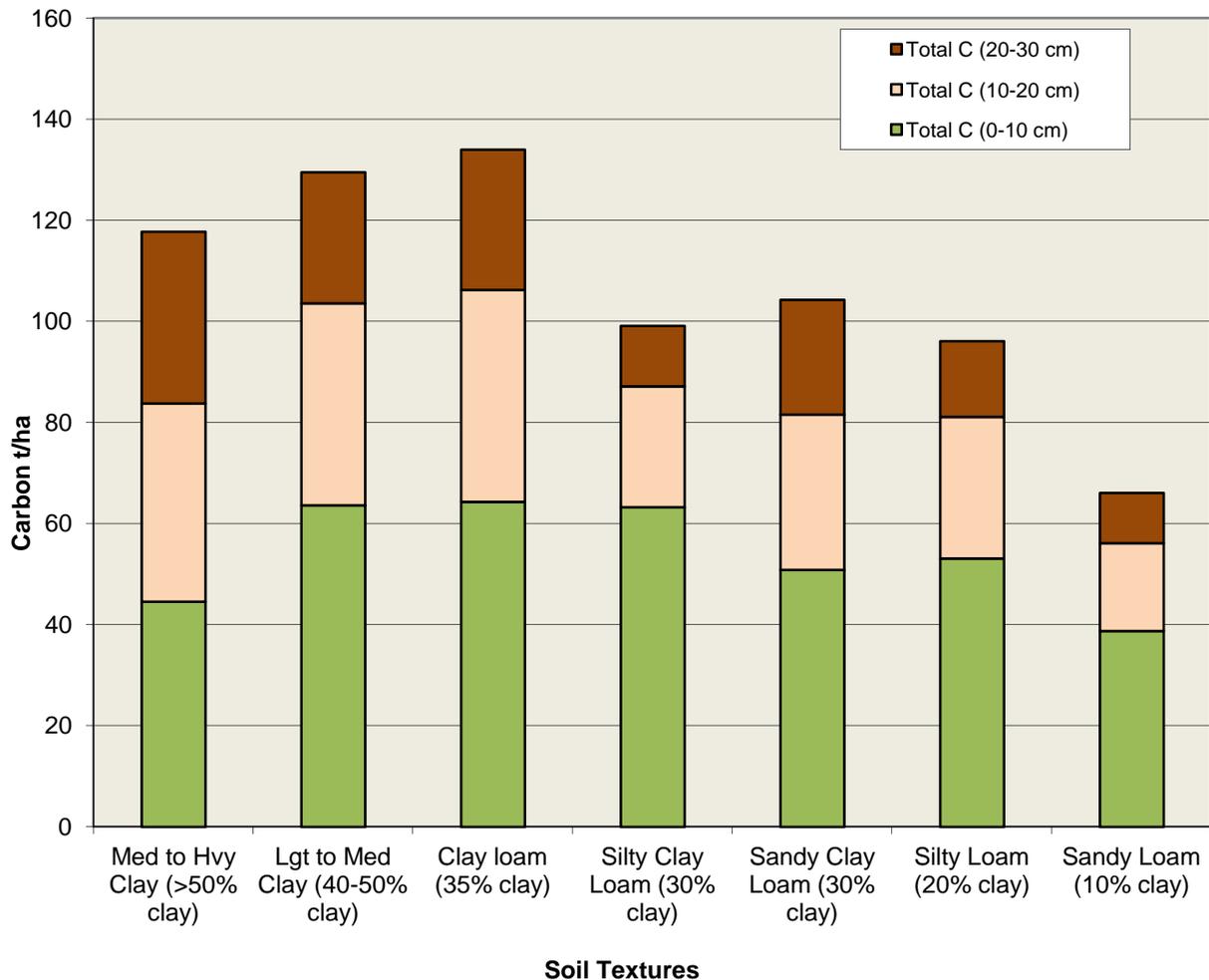
Australian Soil Class and Total Carbon



The above graph indicates that the highest levels of organic carbon were to be found in the Ferrosols and Vertosols. This is to be expected as Ferrosols (Krasnozems) generally have strong crumb structure and moderate to high organic matter contents and although Vertosols have variable organic matter content the soils analysed illustrated high organic carbon.

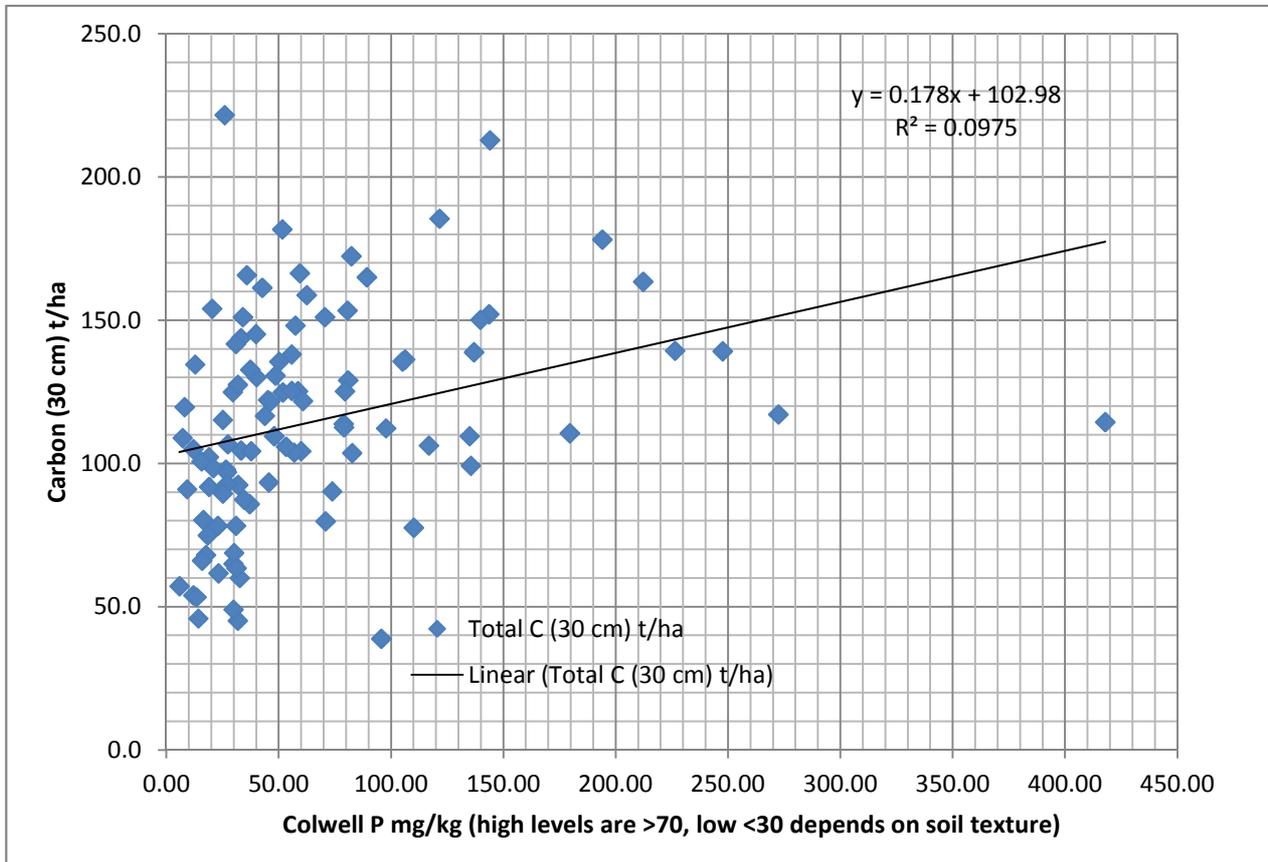
Tenosols in Gippsland tend to occur on rolling to steeper slopes over granite geology and are less developed. They are usually strongly acid throughout with weathered parent material usually encountered above 1 metre depth. They had the lowest total levels over the 30cm with carbon declining rapidly from 10-30cm.

Soil Type and Total Carbon



The graph above shows that the more clay dominant soils, i.e. light to medium clays and clay loams are some of the better structured soils with good aggregation allowing root penetration illustrating the accumulation and retention of organic matter over the 30cm profile. In comparison the sandy loams tend to be more compact soils with poorer structural development and although accumulating reasonable organic carbon in the 0-10cm profile have difficulty allowing plant root access deeper in the profile hence negating organic matter build-up. The geochemistry of sedimentary derived soils would also indicate lower pools of essential plant nutrients.

Total organic carbon and phosphorus levels



Although it is hard to reach conclusions on the relationship between total organic carbon and phosphorus from the above scatter diagram, research does indicate that not only is organic matter a major contributor to the phosphorus pool but it plays an important role in mobilizing this phosphorus (Dalton, Russell & Seiling, 1951). Given that organic matter is an important food source for earthworms it may also be likely that earthworm populations are larger where higher levels of total organic carbon are to be found and hence may play an important role in mobilising phosphorus from the soil pool (Mackay, Syers, Springett & Gregg, 1982).

5. Project conclusion

The following key objectives were realised:

- Soil C was benchmarked with soil pH on 109 farms
- 11 field days and forums, 5 training courses with 752 participants
- 5 soil training courses with most farmers participating
- Each farmer received 1 to 1 support from project staff & DEPI
- Management change or trial on each farm – these included
 - Innovative - compost, alternative fertilisers, scallop shells (CaCO_3)
 - More conventional - increasing pasture cover and sowing more productive pasture species
- Farmers Advisory Group – guided delivery of the project, planned field day themes, assessed and approved the management action plans for each of the 109 participating farmers

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