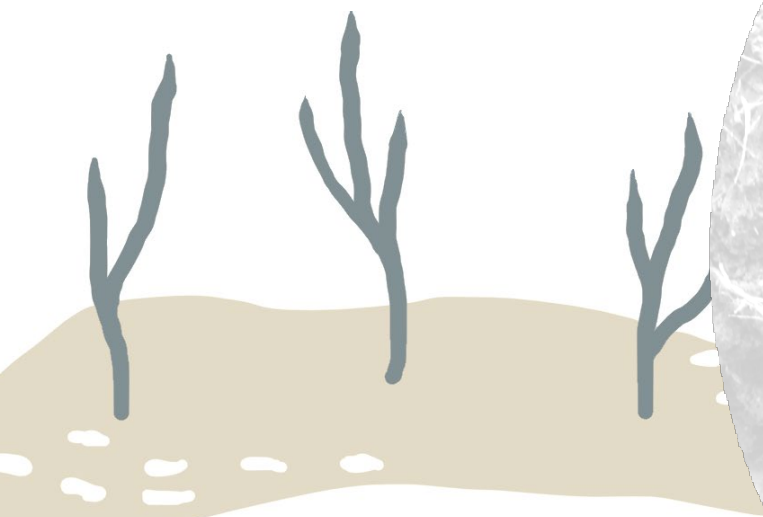


North Central Victoria Soil Health Action Plan



North Central Catchment Management Authority
PO Box 18
Huntly Vic 3551
T: 03 5448 7124
F: 03 5448 7148
E: infor@nccma.vic.gov.au
www.nccma.vic.gov.au

Acknowledgement of Country

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal and Torres Strait Islander people and organisations in land and natural resource management.

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EXECUTIVE SUMMARY

The *2013 North Central Regional Catchment Strategy*, identified the need for the development of Soil Health Action Plan. The *Soil Health Action Plan for North Central Victoria* was developed in partnership with Agriculture Victoria. The North Central Regional Sustainable Agriculture Steering Committee acted as the project reference committee and provided guidance and oversight in the development of the Action Plan.

A Community Consultation Plan for developing the Soil Health Plan was implemented in accordance with the *North Central CMA's 2017-2019 Engagement Strategy*, which focuses on achieving a more engaged and empowered regional community. The community and stakeholders were given numerous opportunities to be involved and provide feedback through a variety of consultation processes.

The community and stakeholders agreed that soil health is an important issue. Although there were some differences between the individual issues in each landscape area, many of the issues related to declining soil structure. The consultation also suggested that land-managers are aware of the significant changes that occur across the landscape and that there is a need to be resilient and adaptive. Land-managers are seeking help and support to improve their farming practices for production, sustainability and ecosystem services.

During the preparation of the Plan and based on the consultation with the community and stakeholders, the following were developed:

Soil health vision statement:

'Healthy soils sustaining prosperous communities and the natural environment in North Central Victoria.'

Guiding principles for soil health:

- *Adoption of sustainable practices for productivity outcomes (dryland and irrigation)*
- *Property planning, including a Soil Health Management Plan, involves a long-term vision which considers the whole of the property and its place in the catchment*
- *Preserve and protect natural features*

Regional soil health aims:

- *Agency and industry stakeholders are responsible for working collaboratively to ensure the delivery of best practice in soil health for north central Victoria.*
- *A high level of support is provided to existing (and proposed) soil health related projects/ programs being delivered in north central Victoria.*
- *Increase the skills and capacity of agencies and the community to provide soil health outcomes for the region.*
- *Improve soil health outcomes on public land in north central Victoria.*
- *Soil information is well managed, shared and easily accessible for the appropriate need.*
- *Maximise the Research and Development opportunities to improve the understanding and potential of the soils in north central Victoria.*
- *Monitoring, Evaluation, Reporting and Improvement processes and practice is applied appropriately and to a high standard across soil health programs in north central Victoria.*

The regional soil health aims relate directly to the seven *soil health actions* shown in Section 6. Each of the *actions* provide the basis for future soil health work programs to be developed and implemented within north central Victoria. Where appropriate, the actions will have business cases developed using the North Central CMA Project Management Framework, to further define the scope of the action/potential projects that could be delivered, and as a mechanism to attract funding.

The Soil Health Action Plan for North Central Victoria should be reviewed after five years with the list of actions to be annually reviewed by the North Central Regional Sustainable Agriculture Steering Committee.

INTRODUCTION

Background

Soil is vital for all of humanities existence. It provides the nutrients, water and the physical foundations to produce foods and fibres, and is the base resource for roads, homes and infrastructure. Soil also sustains the natural environment by cycling and storing nutrients and water, as well as assisting to regulate the climate by acting as a source or sink for important greenhouse gases.

Soil is largely a non-renewable resource (within human timescales) and Australia's soils are mostly ancient, weathered and infertile by world standards. While there are areas of highly fertile soil, soils in north central Victoria are often poorly structured and affected by salinity, sodicity, acidification, wind and water erosion.

There is a great need to understand and manage the soil if we are to increase agriculture productivity and profitability, we must reverse already existing degradation and improve soil conditions, for now and into the future (*Commonwealth of Australia 2014*).

Healthy soils are a prerequisite for delivering two important objectives throughout north central Victoria;

- To maintain and (where possible) enhance the health and quality of our soils in support of agricultural production for food security, economic viability and intergenerational equity.
- To optimise the range of soil related ecosystem services that influence the quality of natural capital including soil, air, water and biodiversity.

Recognising this, the *North Central Regional Catchment Strategy 2013*, identified the need for a regional soil health approach. The development of the Soil Health Action Plan for North Central Victoria provides a rationale and framework for regional stakeholders to better coordinate the many soil health related programs being implemented across the region. Efforts will be focused towards actions to maximise the soil health outcomes.

The Soil Health Action Plan was supported by the North Central Catchment Management Authority (CMA) Board and guidance was provided by the Regional Sustainable Agriculture Steering Committee, the Department of Economic Development, Jobs, Transport and Resources (DEDJTR) and Agriculture Victoria (Ag Vic). The Plan is a key component of the North Central Regional Sustainable Agriculture Strategy which guides current and future programs. The Plan identifies opportunities to improve soil health outcomes across the north central region.

The Plan was developed in accordance with an approved project plan and a consultation plan. These documents were endorsed by the Regional Sustainable Agriculture Steering Committee and the North Central CMA Board. They approved a template defining the opportunity for the community and key stakeholders to be involved in the development of the Plan via:

- An online Soil Health Survey, was launched at the Farming for Sustainable Soils Conference in March 2018.

- Three community workshops and an information session.

One of the initial tasks undertaken during the development of the Plan was for Agriculture Victoria to prepare a technical summary document to identify the available landscape, landform and soils data and information; as well as any potential gaps that may exist in expertise and knowledge. This document has been drafted and a hard copy is available upon request. The *Technical Review of the soil of the North Central Region, 2017*, needs to be taken through an internal review and approval process by DEDJTR before its full release and electronic publishing.

To enable the implementation of key regional priorities such as the improved health of the soils in the region, Victorian Catchment Management Authorities are required to develop a Regional Catchment Strategy (RCS) in accordance with the *Catchment and Land Protection Act 1994 (CaLP Act) (State)*.

A requirement of the *CaLP Act*, is that a regional catchment strategy must contain:

- An assessment of the region’s land and water resources, including;
- How they are being used within the catchment, as well as;
- The nature, cause, extent and severity of any land degradation that maybe occurring, and
- Identify priority areas for attention in terms of implementing the necessary actions designed to improve the quality of catchment land and water resources.

The *CaLP Act* directs CMAs to understand the physical causative processes that underpin land management and degradation through applied research and investigation programs. More specifically the Victorian Governments legislation requires reporting on changes in the regions soil condition under the *CaLP Act (1994)* by the Victorian Catchment Management Council and the *Commissioner for Environmental Sustainability Act (2003)* by the Commissioner for the Environment. Both reports are produced every five years.

To achieve progress towards sustainable agriculture, the North Central CMA has also developed the *North Central Victoria, Regional Sustainable Agriculture Strategy - 2015*. The aim of the Strategy is to achieve increased land protection by increasing the adoption of appropriate and sustainable agricultural practices. (See Figure 1. The interrelationship between the North Central CMA’s Regional Catchment Strategy’s implementation and the development and delivery of the Soil Health Action Plan).

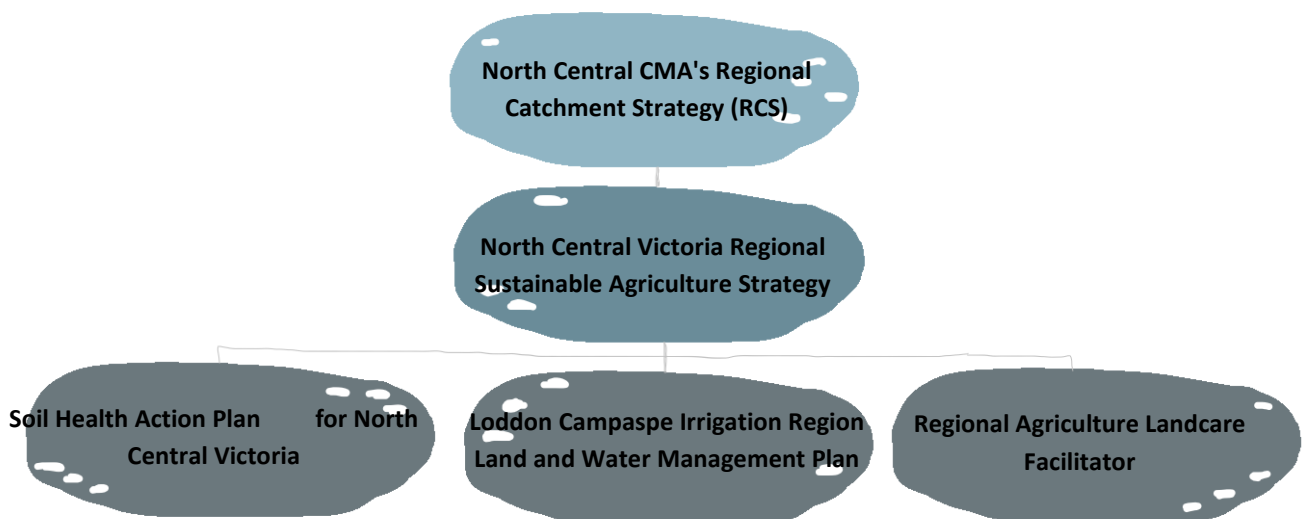


Figure 1: Interrelationship between the North Central CMA strategies and the Soil Health Action Plan for north central Victoria.

The Plan

The *Soil Health Action Plan for North Central Victoria* provides a rationale and framework for delivering soil health outcomes in the North Central CMA region of Victoria. The Plan recognises that soil health priorities may change over time and is structured so that it can evolve, as required. The completed Plan will be revised after five years while the individual actions (Section 6: Table of Actions), and progress against these actions will be reviewed annually by the North Central Regional Sustainable Agriculture Steering Committee (Table 1).

Table 1: Timeline and review processes of the Strategic Soil Health Action Plan

Timeline	Function	Responsibility
Quarterly	Review and target funding options for high priority actions recommended in the Plan	North Central Regional Sustainable Agriculture Steering Committee
Reviewed annually	All actions in the Plan (outcomes achieved recorded and reported)	North Central Regional Sustainable Agriculture Steering Committee
Reviewed every five years	Review, engage, revise and incorporate current priorities for soil health into an updated Soil Health Action Plan.	North Central Regional Sustainable Agriculture Steering Committee

SOIL HEALTH VISION

The following vision statement, guiding principles and aims were developed from the information gathered during the project development and the consultation process with communities and stakeholders.

Vision:

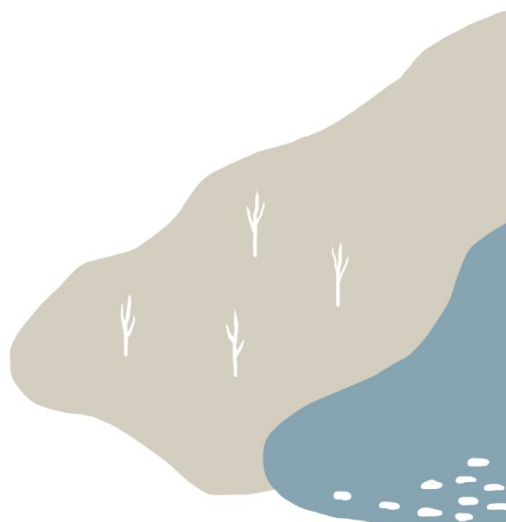
‘Healthy soils sustaining prosperous communities and the natural environment in North Central Victoria.’

This vision statement was compiled from key words provided by participants at the community workshops and confirmed by the Regional Sustainable Agriculture Steering Committee.

Guiding principles

The development of the Plan included the development of a set of guiding principles for soil health, relevant to north central Victoria. These were established after an extensive review of soil health literature and then confirmed through consultations with communities and stakeholders.

The overarching principles are listed below, with a detailed *Guiding Principles for Soil Health* document, (Section 10. Appendix i).



Adopt sustainable practices for productivity outcomes (dryland and irrigation):

- Implement farming practices to maximise photosynthesis, maintain and improve soil structure, improve water use efficiencies, nutrient use efficiencies, minimise soil losses with erosion, nutrient losses through gaseous exchanges and deep drainage and conserve water supplies in irrigation and dryland.
- Encourage the use of deep rooted vegetation.
- The adoption of grazing practices that monitor and match stocking to allow seed set, maximise groundcover, carbon sequestration and moisture retention in soils.
- Sustainable cropping practices such as; reduced tillage, stubble retention, rotational legume use, maintain stubble, soil testing and nutrient matching.
- Specifically, with irrigation, manage deep drainage and prevent run-off.
- Minimise compaction and excessive tillage.
- Build levels of organic matter / carbon in soils.

Property planning, including a Soil Health Management Plan, involves a long-term vision which considers the whole of the property and its place in the catchment:

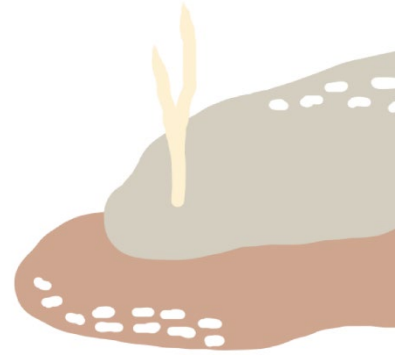
- Understand the landscape; geology, geomorphology, hydrology, soils and climate.
- Manage property according to the capability and the limitation of the land.
- Protect and rehabilitate areas that are degraded or at risk from degradation.
- Ensure the appropriate placement of infrastructure to minimise the soil impacts.
- Works with community; soil health is not an individual issue but a landscape issue.
- The prevention of soil degradation is nearly always substantially cheaper than the cost of restoration.

Preserve and protect natural features:

- Manage and protect native vegetation, including native grasslands as part of 'property planning'.
- Protect waterways and drainage lines with fencing, vegetation and land management strategies.
- Adoption of a strategic and coordinated approach to sustainable weed and pest control.

Management objectives for soil health:

- Maintain/improve groundcover and organic carbon.
- Improve soil physical properties.
- Maintain and enhance soil biota.
- Maintain nutritional fertility.
- Minimise soil loss.
- Reduce acidification and salinity.
- Manage wet soils.
- Prevent contamination.



Community and agency roles and responsibilities

The north central region soil health is ultimately the responsibility of farmers and farming communities, as they determine how the land is to be managed at a farm and paddock scale. The responsibility of agencies and industry is largely with the provision of the knowledge and support needed to assist farmers in making informed decisions. (See Section 5.i. Strategic Management & Action 2: Strategic Management Priorities). Continuing to foster partnerships with the wider community, especially the eleven Landcare Networks, these groups will also be vital in connecting and delivering high priorities in soil health for the region. (See Action 3: Community Engagement Priorities).

Overall, co-operation between community, business and agencies must be developed and supported. This will be achieved through:

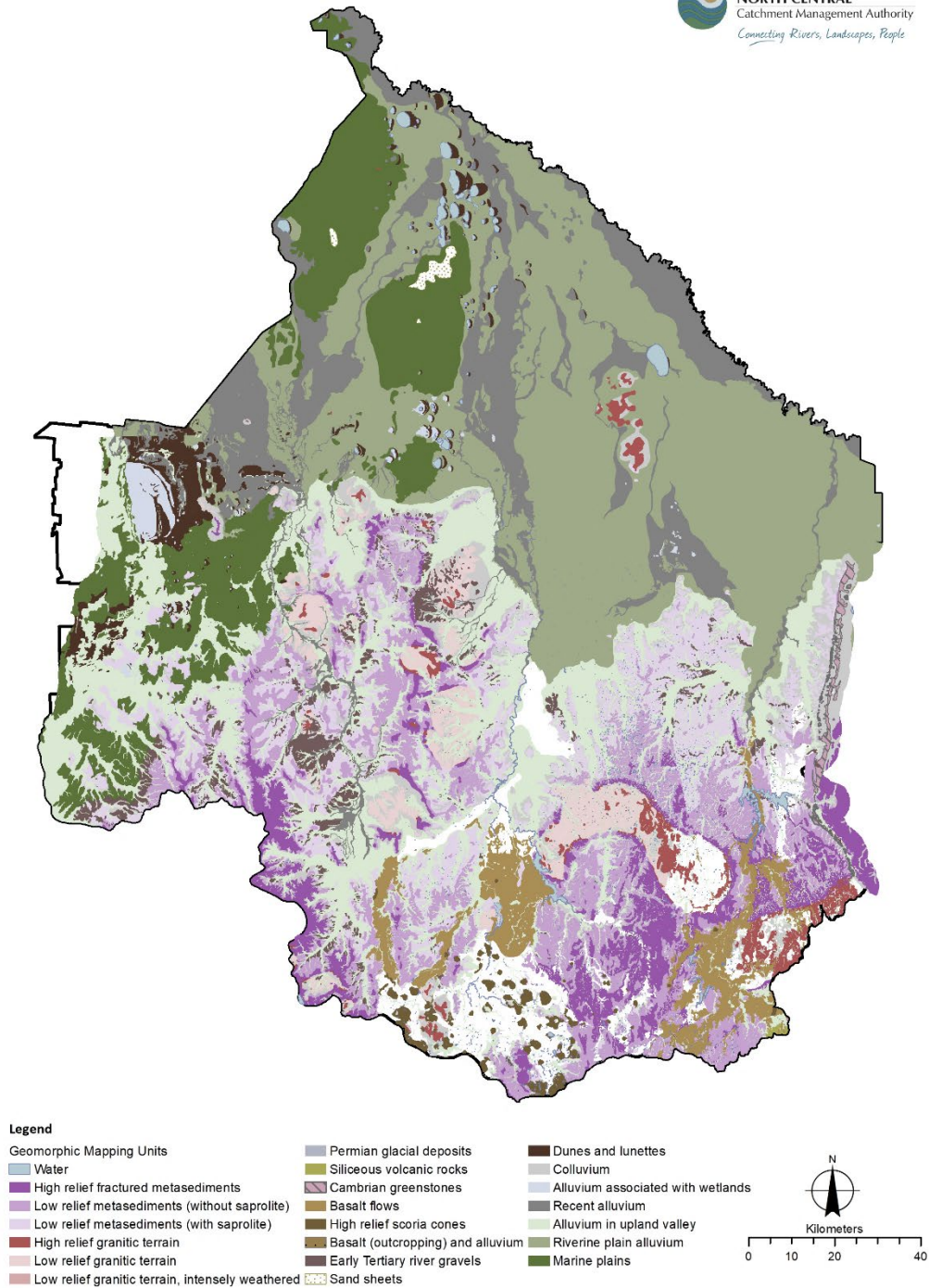
- Agency and industry stakeholders working collaboratively to support farming communities to develop and adopt best practice in soil health for north central Victoria.
- Ensuring that a high level of support is provided to existing (and proposed) soil health related projects/ programs being delivered in north central Victoria.
- Increasing the skills and capacity of agencies and communities to provide soil health outcomes for the region.
- Working with public land managers and Traditional Owner Groups to identify issues and develop appropriate management options.
- Agencies ensuring that soil information is well managed, shared and easily accessible for the appropriate need.
- Agencies and communities take advantage of the R&D opportunities to improve the understanding of regenerative soils management practices in north central and northern Victoria.
- Agencies establishing a monitoring and evaluation framework that informs collective understanding of the rates of adoption and the effectiveness of soil health programs in north central and northern Victoria.



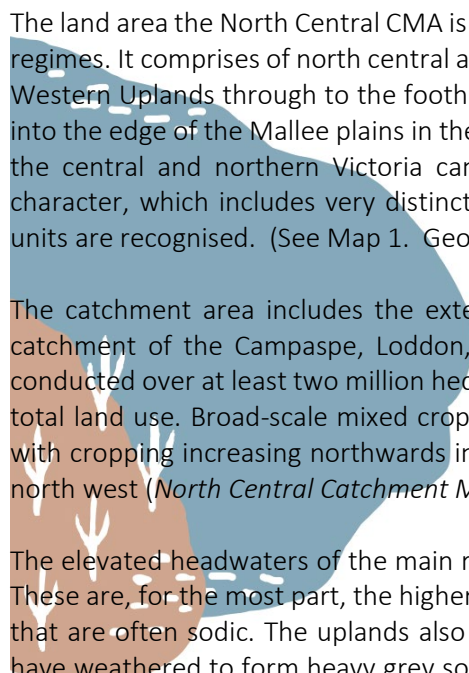
SOIL HEALTH IN NORTH CENTRAL VICTORIA

Regional context

The North Central CMA region covers 13% of the Victorian landscape. It is bordered by the Murray River in the north, the Great Dividing Range to the south and Mt Camel to the east.



Map 1. Geomorphic map of the North Central CMA region of Victoria



The land area the North Central CMA is responsible for has a wide range of soil / land types and climatic regimes. It comprises of north central and northern Victoria, extending from the northern slopes of the Western Uplands through to the foothills and onto the lowlands of the Riverine Plains in the east and into the edge of the Mallee plains in the north west. A broad consideration of the main terrain types of the central and northern Victoria can be subdivided in to units that have a distinct geomorphic character, which includes very distinct soil landscapes. At a scale of 1:1000,000, eighteen different units are recognised. (See Map 1. Geomorphic Map of the North Central CMA region of Victoria).

The catchment area includes the extensive cereal cropping and grazing lands in the mid to lower catchment of the Campaspe, Loddon, Avoca and Avon-Richardson river basins. Dryland farming is conducted over at least two million hectares of the region and accounts for approximately 66% of the total land use. Broad-scale mixed cropping and grazing enterprises are the most common land uses, with cropping increasing northwards into the Riverine Plains and onto the lighter Mallee lands of the north west (*North Central Catchment Management Authority, 2013*).

The elevated headwaters of the main river basins are formed on dissected marine sedimentary rocks. These are, for the most part, the higher rainfall grazing lands that carry yellow texture contrasting soils that are often sodic. The uplands also comprise of Quaternary basalt flows and in some areas these have weathered to form heavy grey soils and well structure red soils, that are extensively deployed in potato production. Areas of granitic terrain are also common in the uplands and they present highly silicic soils that are often very difficult to manage under agriculture.

Further north the steeper hill country gives way to gently undulating northern foothills. These older lands are formed from a highly weathered, marine based sedimentary rock and carry the red sodosols (sodic, clay subsoils). Historically they have been known as the 'marginal cropping lands'. They support a mixture of cropping and grazing enterprises and are often difficult to manage given their inherent issues with sodicity and in some places, dryland salinity.

Beyond the foothills lies the expansive Riverine Plains. These formed from the alluvium deposits of the main river systems over tens of thousands of years. This plains landscape carry red and grey sodosols with the area extensively utilised for cereal production, although mixed cropping and grazing enterprises are also common. In the far north and northwest, the Riverine Plains gives way to the marine and aeolian sediments of the Murray Basin. This is the interface between the alluvium of the Riverine Plains and the dune sands of the Mallee terrain. Dryland cereal cropping is the main land use in this area.

The lower portions of the Loddon, Avoca and Campaspe floodplains cover a large part of the region. Historically the floodplains played an integral role in mitigating the adverse impacts of flooding. However, today these floodplains have become highly modified with the arrangements of settlements and agriculture developments that have occurred throughout this part of the region. These modifications to the floodplains altered their hydraulic functions and connections to the natural waterways and wetlands across the Loddon Campaspe Irrigation Region (*North Central Catchment Management Authority, 2013*).

The irrigated land within the North Central CMA region occurs largely across the Loddon Campaspe Irrigation Region. The Loddon Campaspe Irrigation region comprises the northern half of the North Central CMA region and covers approximately 714,000 hectares. Some irrigation also occurs along the Loddon and Campaspe Rivers in the upper Loddon Catchment around Newlyn, Ascot and Waubra where groundwater is utilised in conjunction with surface waters. The intensity of irrigated production is greatest in the lower reaches and floodplains of the Campaspe and Loddon rivers (*North Central Catchment Management Authority, 2013*).

Traditional patterns of land-use are changing across the region and there is an ever increasing area of dryland within this irrigation region where water is no longer intensively applied due to irrigation system rationalisation, modernisation and the increasing costs of irrigation water. Adding to this, on-going adaptations to decade long droughts and subsequent flooding, are driving further changes to the established pattern of land use. This reduced water availability, combined with climate variability and the fluctuation commodity prices, has give rise to many landholders adapting their enterprises to be more opportunistic, resilient, and viable, aiming at maintaining or increasing their production (*North Central Catchment Management Authority, 2013*).

The Loddon Campaspe Irrigation Region Land and Water Management Plan considers the variability of the soils in the irrigation region as unrealised potential for diversification options, which could be leading to lost opportunities for economic gains. In such, having a plan that recognised these issues, allows for the development of a more considered approach to land suitability for irrigation developments and for the careful selection of crop / land uses to maximise the economic benefits without compromising the sustainability of the soils and the health of the landscape (*North Central Catchment Management Authority, 2013*).

The variabilities in the productive capacities of the soils of the North Central Victoria region, are the key considerations for *where* and *how* to best allocate resources to achieve soil conservation and land protection outcomes. At a broad scale, the landscape can be classified into six soil-landscape classes that are predominantly linked to various land use types (North Central Catchment Management Authority, 2013).

Table 2: Soil Landscapes and Land Use Correlations of the north central CMA region of Victoria (North Central Catchment Management Authority, 2013).

Soil landscape	Description	Principle agricultural land uses
Alluvial Plains of Northern Victoria	Alluvial sediments of the Riverine Plains and the Natte Yallock Basin	Mixed cropping and grazing
Victorian Riverine Plains	Mainly red and yellow duplex soils, with red and grey clays that are mostly suitable for agriculture	Grazing, irrigated pastures and crops
Eastern Mallee Plains	Aeolian sands over marine sediments in the semi-arid lands of Northern Victoria	Cropping with some grazing
Basaltic plains and Scoria cones	Soils formed on Quaternary basalts in the upper catchment	Grazing, cropping and horticulture
Foothills of the Western Uplands	Red sodosols on weathered meta-sedimentary rocks.	Mixed cropping and grazing
Hilly terrain of the Western Uplands	Red and yellow sodosols on moderate to steep hilly terrain	Grazing

Current programs and projects

Positive soil health outcomes are being achieved within the region through the delivery of past and current programs and projects. For example:

The **Land Health Program** delivered by *DEDJTR* offers training and advice in; farm planning, productive soils, farm water, grazing and pasture management, sustainable cropping and soil conservation.

The **Farming for Sustainable Soils project 2009-2018** managed by the *NCCMA* offered funding for geographical based groups to develop an approved schedule of activities that are developed by their own communities and then with a funded community facilitator, delivered against those scheduled activities.

The **Healthy Productive Irrigated Landscapes (HPIL) project**, encompasses the Loddon Campaspe Irrigation Region – Land and Water Management Plan. This plan undertakes a strategic and coordinated approach to land and water management, landholders and supporting organisations to increase their capacity in achieving a sustainable irrigated landscape.

Other inter-related regional deliveries have included the **Innovative Farming Program 2013**, which was targeting the irrigation region in developing resilience to the changing irrigation system, building advantages for farming in the region, increasing the diversity of agriculture products and the value chain and to enable communities to create opportunities.

An extension of the **Innovative Farming Program 2013** is the current **Plan2Farm project**. *Plan2Farm* provides specialist advice and support to help farmers to develop a strategy for their whole farming enterprise. Allowing forward planning with fully informed decisions based on good information such as on farm irrigation modernisation and connection to the irrigation backbone, how much land they will require, and the volumes of water they will need (*Rankin, 2017*).

The Programs and projects currently in place and being implemented within the region will continue to be supported.

Table 3: Australian programs relating to soil health improvement

Priority programs	Aspect in North Central CMA region	Status
National Soil R&D Strategy 2014	<i>Soils Constraints Project</i> (CSIRO & GRDC) https://soilstrategy.net.au/	Ongoing
National Landcare Program – Sustainable Agriculture	Regional Agriculture Landcare Facilitator, Regenerative Agriculture national-landcare-program/landcare-facilitators	Ongoing
National Landcare Program – Sustainable Agriculture	<i>Farming for Sustainable Soils</i> Groups Program / Regenerative Agriculture Program	NLP 2 Completed – Currently in funding negotiations for next round (August 2018)
National Landcare Program	Regional Landcare Coordinator – Landcare	Ongoing
Rural R&D for Profit Program	Numerous aspects available in region rural-research-development-for-profit	Ongoing
Agricultural Competitive White Paper	Numerous aspects available in region white-paper-at-a-glance	Ongoing

CRC for High Performing Soils	NCCMA Organisations http://www.soilcrc.com.au/	Partner/Participant	Ongoing
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Table 4: Victorian Government programs relating to soil health

Priority Programs	Aspect in North Central CMA region	Status
Victorian Soil Health Strategy	DEDJTR Land Health program	Ongoing
Sustainable Irrigation Program	Loddon Campaspe Irrigation Region Land and Water Management Plan (LWMP)	Ongoing
Irrigation Modernisation Project	GMW Connections	Ongoing
	Plan2Farm	Ongoing
Victorian Resources Online	Detailed central Victorian soil and land-use information available	Ongoing

Factors for consideration

With numerous influences including; increasing variable climate conditions, overall declining soil health, water reforms and irrigation modernisation, technological advances and consumers demands for quality food, organic products and the ever-increasing animal welfare standards, agriculture in north central Victoria continues to undergo change (*North Central Catchment Management Authority, 2015, b*). To achieve greater agricultural sustainability there will need to be the balance between increasing production, whilst protecting and enhancing the soils and investing in the capacity of the agricultural community.

Australian agriculture needs to improve the storage and the use of soil water for growing plants (from both rainfall and irrigation), improve soil nutrition and reduce the reliance on the high energy requirements for production of inorganic fertilisers. Agriculture will be expected to manage the soil to store more carbon and to reduce greenhouse gas emissions, such as those associated with inorganic nitrogenous fertiliser production and its uses (Commonwealth of Australia, 2014).

At a regional scale, soil surveying, monitoring and modelling holds the potential to provide an indication of the trends of a soils condition and health. But there are some sources of uncertainty in these approaches; spatial uncertainty, regarding the distribution of individual soil types; time-based uncertainties with regards to the use of past data sets and the associated limitations in changes of analytical and reporting methods; and the uncertainty of actual past practices that may have influenced the current soils' situation.

Due to past and current land management actions, different levels of information are required for the diverse range of land managers (*MacEwan et al., 2010*). The actual and most important limitations, remain a considerable uncertainty in terms of which sustainable practices we should best adopt to repair, regenerate and sustain the structure of an individual soil, in a distinct geomorphic based landscape.

A repository for a large portion of the Victorian soils data is *Victorian Resources Online (VRO)*, which is a gateway to a wide range of information and associated maps related to Victoria's soil and landscapes (*State of Victoria, 2018*). But gaps with public accessibility and importantly the comprehension and utility of the available data, remains an issue to be resolved.

In addressing this, the Corangamite CMA developed the *Soil Health Knowledge Base*, which is a comprehensive repository of soil health information. This portal has a spatial component (GIS) that allows users to focus on their locale and provide relevant and informative answers to their questions via an intuitive-to-use web-portal (Corangamite Catchment Management Authority, 2018).

A lot of knowledge and site information has been collected across north central Victoria by many entities over a long period of time. Access to this information is inconsistent, and in some cases almost impossible to find. To aid in the beneficial use of the plethora of knowledge and data, an Information management system is required to collate the information and provide an easy to use interface.

Climate

Climate and soil quality determines where agriculture and forestry can be productively undertaken in the landscape. Australian production systems are vulnerable to the effects of climate change with winter rainfall projected to decline and the rainfall patterns and evaporation rates changing, potentially altering the hydrological cycling of waterways and groundwater systems. The vulnerability of soils to climate change is again strongly linked to the type of soil and its inherent characteristics, but ultimately the vulnerability is determined by the lands use and the direct management (*North Central Catchment Management Authority, 2015 b*).

The North Central Climate Change Adaption and Mitigation Plan, 2015 b, assessed that the types of soils on freehold land as having highest potential vulnerability to a changing climate were those that were susceptible to wind and water erosion and some lighter textured soils in areas associated in higher parts of the landscape. The mass of soil lost in most years is reportedly much greater than the actual mass of food produced. Therefore, the potential loss of top-soils are the greatest threats to the productive and environmental values of the region.

Thus, adaption options for building a soils resilience to climate change need to be embraced by land managers and supported by agencies and agri-business, (Table 5: Climate Change Adaption Options for Soil).



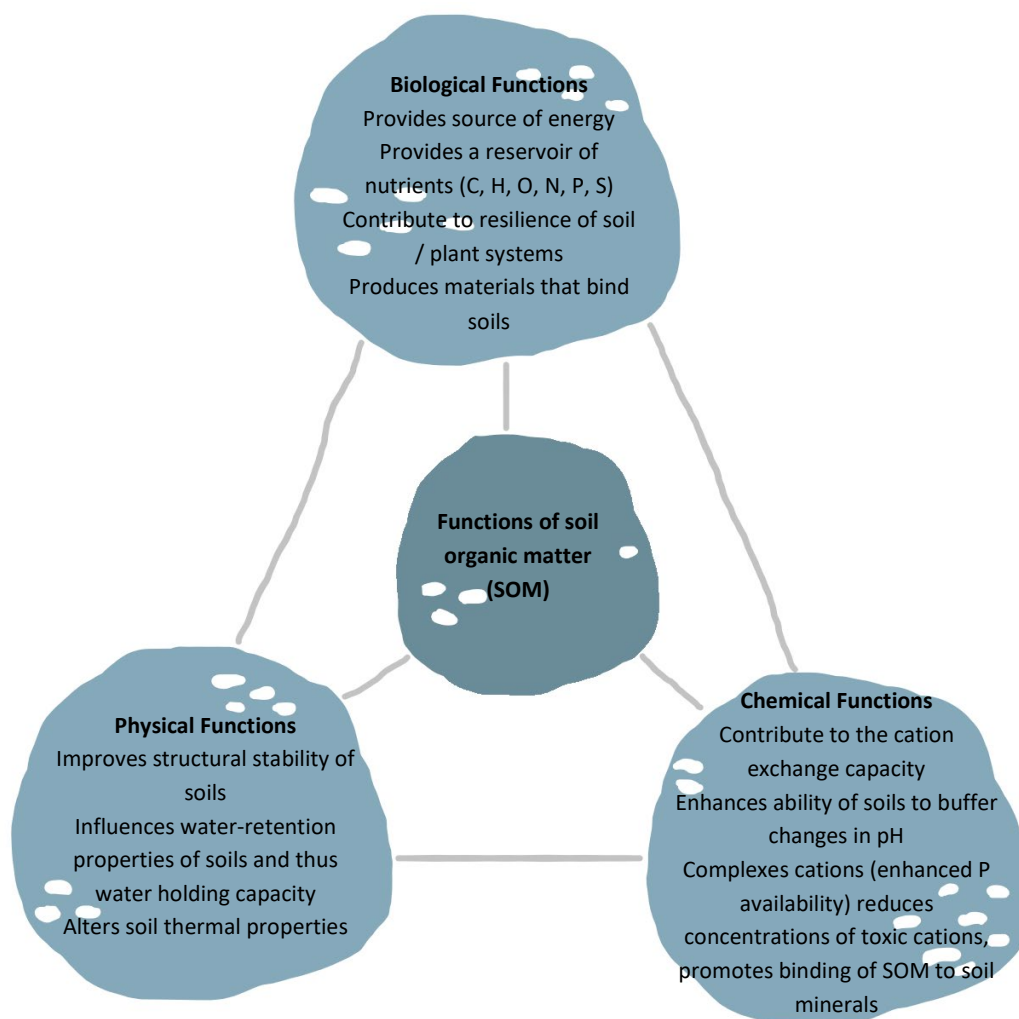
Table 5: Climate Change Adaption Options for Soil (North Central Catchment Management Authority, 2015 b).

Climate Change Variables – Adaptions Options for Soils			
Reduced and more variable rainfall	Increased temperature and extreme heat	Increased intensity and frequency of rainfall events (including flooding)	Increased frequency and intensity of fire
Soil management practices to reduce compaction, tillage and retaining stubble.	Provide shelter and shade from extreme heat, through vegetation establishment or the use of shade structures.	Maintain groundcover to mitigate against erosion. Adoption of alternative grazing systems.	On farm strategies to protect assets (firebreaks), fuel reduction burning.
Changes to a rotational grazing system to increase soil carbon and improve water retention.	Provision of sheltered watering points.	Consider timing of planned burns and the risks of rainfall events / flooding to reduce downstream impacts.	Property level fire management plan.
Increase on-farm water storage capacity, including soil water holding capacity with increases in organic matter.	Trial of new pasture and crop varieties.	Use ground cover crops to protect paddocks at flood risk during time of year when floods most likely.	Increase effort on invasive plants and animal controls, after fire.
Increase irrigation efficiency and re-use where applicable.	Increase groundcover through grazing management.	Increase effort on invasive plants, after flooding events.	
Spread production over a range of areas within the region to different irrigation or rainfall zones.			
New varieties more tolerant to water stress.			
Change crops to more water efficient varieties.			

Carbon

A soil's organic matter (SOM) consists of Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous and Sulphur, it is difficult to measure the SOM content, with most analysis methods determining the soil organic carbon (SOC) content and an estimate of SOM through a conversion factor. The functions of SOM relate to the; biological, physical and chemical and dynamic interactions between them. SOM varies in its chemical and physical properties, depending on that specific soils, developmental influences.

Figure 2: Functions of Soil Organic Matter and Carbon (Krull, et al. 2004).



It has been reported that a minimum of 2% SOC is necessary to maintain structural stability and that if a soil is only between 1.2 – 1.5 % SOC, structural stability can decline rapidly. The addition of SOM can not only reduce the bulk density and increase water holding capacity, but also effectively increases soil aggregate stability (Figure 2: above, *Functions of Soil Organic Matter and Carbon*). Carbohydrates are instrumental in a soils aggregate formation. Organic matter serves as the base for the microbial activity, which results in the production of microbial bonding materials, (cellulose, glucose, polysaccharides, exudates from roots and fungal hyphae), beginning the soil aggregation process. Therefore, most soils need to be at a minimum of 2% SOC, with variable organic matter and have good microbial activity, to even begin forming aggregates and to begin repairing the soils structure (Krull, et al. 2004).

Soils are the third largest storage of global carbon, currently storing about two and a half times the amount of carbon as the atmosphere and almost three times the amount that vegetation stores. Soil carbon occurs as two components – an **organic component** and an **inorganic component**. Only the **organic component**, which is derived from materials such as plant leaves, roots and stems as well as animal manure, is of relevance to soil carbon sequestration. Inorganic carbon consists of atmospheric carbon, carbonate rock, respiration by living organisms and the burning of fossil fuels (Krull, et al. 2004).

Soil carbon sequestration is defined as the long-term removal of carbon dioxide from the atmosphere into soils. Soil carbon sequestration can occur in two main ways:

- by increasing soil carbon levels and maintaining that increase;

- by converting organic matter that is easily decomposed into a form that is long-lived (for example - humus). Preventing the carbon contained in the organic matter from entering the atmosphere as carbon dioxide for a long period of time.

The amount of SOC that exists in any given soil is determined by the balance between the rates of organic carbon input (vegetation, roots) and output (CO₂ from microbial decomposition). An increase in some forms of carbon, may not result in soil carbon sequestration because those forms are very quickly decomposed into the soil and then subsequently released back into the atmosphere as carbon dioxide.

A range of factors influence inputs and losses and thus soil carbon levels, including:

- Plant productivity;
- Decomposition caused by micro-organisms;
- Climate, mostly temperature and rainfall;
- Soil types and soil depth;
- Plant roots and mycorrhizal fungi;
- Disturbances such as fire; and
- Land uses and management practices (Parliament of Victoria, 2010).

In Victoria, some broad trends in soil carbon levels are recorded, but information is lacking on soil carbon levels at a regional scale; across different climates and soil types; and under different land uses and management practices.

Table 6: Soil carbon levels under pasture and cropping regimes in low and high rainfall regions in Victoria. (Parliament of Victoria, 2010).

	Low Rainfall (<500mm)		High Rainfall (>500mm)	
	Crop	Pasture	Crop	Pasture
	Percentage by weight			
Low soil carbon level range	0.9	1.7	1.45	<2.9
Normal soil carbon level range	0.9 – 1.4	1.7 – 2.6	1.45 – 2.9	2.9 – 5.8
High soil carbon level range	> 1.45	>2.6	>2.9	>5.8

Naturally connected landscapes and ecosystems are generally healthier and can store carbon more effectively than degraded landscapes. Improving soil carbon stocks on agricultural land in the North Central region are strongly linked to the adoption of improved management practices, such as reduced tillage in cropping and horticultural systems or rotational grazing, as opposed to set-stocking, grazing sheep and beef cattle enterprises (*North Central Catchment Management Authority, 2015 b*).

The potential for Australia’s soils to store additional carbon are not well understood. Further knowledge is required to understand:

- The rate at which soil can accumulate and retain carbon under different management systems.
- The maximum carbon carrying capacity of soils.
- The permanence of any soil, as a carbon sink.
- The potential nutrient trade-offs in storing carbon.
- How to monitor changes in carbon levels.
- How to incorporate soil carbon sequestration in a national carbon accounting scheme. (Parliament of Victoria, 2010).

Land capability

Soils underpin the regions agricultural productivity and the ability to be a net exporter of food. Around 60% (volume) of Australia's total agricultural production are exported, currently supplying 1% of all the food eaten in the world (*Commonwealth of Australia, 2014*).

Achieving an improvement in agricultural productivity while protecting and even enhancing the environment, is indeed a balancing act. Productivity can often be driven by price and if circumstances prevail, for greater production. Then the abilities of the natural resources to hold up under these sustained pressures will depend on the level that farming practices match land use to the land capabilities (*Commonwealth of Australia, 2014*).

The productive capacities of the soil landscapes in North Central are very significant in considering where and how time and effort and resources are best invested in achieving regional soil conservation and land protection outcomes. (Table 2: Soil Landscapes and Land Use Correlations in the North Central Victoria Region).

The productive capacities of the soil are directly influenced by; soil types, climates, land-uses and the extent of the soil type throughout the region. If prioritising for soil health relative to the amount of food produced, the soils of the Riverine Plains and the adjacent foothills are the most important and are considered of the highest priorities (*Dyson, 2013*).

Agricultural technology

The global population is forecast to rise by almost a third in the next 30 years or so, from 7.55 billion people in 2017 to 9.77 billion by 2050, but at the same time resources like land and water are being squeezed by urban development, which means agriculture needs to do much more with less. It means Australian agriculture needs to become more sustainable and environmentally sensitive, but at the same time increasing productivity and this needs to be done quickly (*Trounson, 2017*).

Modern farms and agricultural operations work far differently than those a few decades ago, primarily because of advancements in technology, including sensors, devices, machines, and information technology. Today's agriculture routinely uses sophisticated and even 'out of the box' technologies such as robots, temperature and moisture sensors, aerial images, sensors mounted on drones to spot crop diseases or using microwaves to kill weeds and boost soil fertility and GPS technology. These advanced devices and precision agriculture and robotic systems allow businesses to be potentially more profitable, efficient, safer, and environmentally sustainable.

Farmers will no longer have to apply water, fertilizers, and pesticides uniformly across entire fields. Instead, they can use the minimum quantities required and target very specific areas, or even treat individual plants differently. These benefits could include:

- Higher crop productivity.
- Decreased use of water, fertiliser, and pesticides, which in turn keeps food prices down.
- Reduced impact on natural ecosystems.
- Decrease in runoff of chemicals into rivers and groundwater.
- Increased worker safety.



In addition, robotic technologies enable improved monitoring and management of natural resources, such as air and water quality. It also gives producers greater control over plant and animal production, processing, distribution, and storage, which will produce:

- Greater efficiencies and lower prices.
- Safer growing conditions and safer foods.
- Reduced environmental and ecological impact.

Evolving technologies in satellite diagnostics and controlled traffic farming are transforming precision farming (USDA, 2018).

COMMUNITY CONSULTATION

As part of the development of the Plan a consultation plan was developed, approved and implemented. An online North Central Soil Health Survey was undertaken over March and April 2018 with 37 respondents. This survey and the development of the *Soil Health Plan* was promoted widely; including radio, TV and newspaper. An article was also prepared and published in the *Landcare – North Central Chat* newsletter.

In April 2018, to support any survey results, three Community Soil Health Workshops were held with the aim of developing an understanding of the regions differing communities' priorities in soil health. The locations of the workshops were distributed within the three landscape zones of the region. Numerous media avenues were used to communicate the aim and location of the meetings including, regionally published public notices, personalised emails, radio, TV and numerous social media. Community stakeholders' attendances at the workshops was only a total of 25 participants. No participants attended the Charlton workshop, possibly as the meeting was held simultaneously as preparation for the sowing of crops was well underway.

The Charlton area has a very active Landcare and Farming for Sustainable Soils groups. Information on their landscapes soil health priorities, have therefore been acquired from their *Farming for Sustainable Soils* group schedules and priorities setting documents for that area (Cossar, 2017).

Table 7: Summary of the key soil health issues identified at the community meetings

Landscape zone	Key issues in priority order
Irrigated Farming Zone (Kerang)	<ol style="list-style-type: none"> 1. Soil compaction and lack of soil structure – Infiltration, low organic matter. Animals and wet ground. 2. Planned retirement of land needs to be done in conjunction with soil health assessments. 3. Lack of / uncertainty of resources to make changes; uncertainty of irrigation / amount of water, uncertain on how to repair their land. 4. People are not soil testing as much as they did in the past and are managing on historical evidence. 5. Abandoned land and assets – weeds. 6. Rate of land ownership changes are increasing so difficult to engage with some landholders.
Diverse Farming Zone (Kyneton)	<ol style="list-style-type: none"> 1. Erosion – maintain groundcover (any). 2. Soil structure – drainage and infiltration. 3. Excessive use of herbicides by Shire on roadsides.

	<ol style="list-style-type: none"> 4. Access to information – knowledge of their soils in general and how to develop a healthy soil (smaller landholders want to do the right thing). 5. Commercialisation and synthetic soil products – confusing amount of options.
Dryland Cropping Zone (Charlton)	No attendees.
Mixed Farming Zone (Newbridge – via the Mid Loddon Landcare Network meeting)	<ol style="list-style-type: none"> 1. Pasture persistence, including native pasture management. 2. Use of wastes as fertilisers. 3. Quality of limes and their effects. 4. Trace elements. 5. Art of cultivation - Knowledge of how to till and deep rip without damaging the soil, becoming lost with direct drill / stubble retention.

Other consultation

Murray Dairy

The Murray Dairy, Goulburn Murray Irrigation District (GMID) *Autumn Start Up Workshops - Technical Notes* topics, associated well with the bulk of the other consultation results, emphasising ‘soil structural’ issues. Murray Dairy produced tailored information to assist in their clients’ developments of an improved insight and then promoting the development of appropriate management options (Bannon, C. 2017).

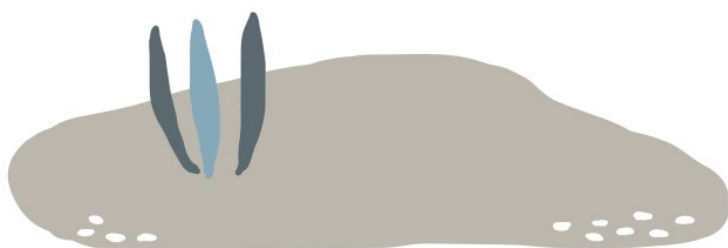
Farming for Sustainable Soil (FSS) groups

Priorities for each of the different landscape based FSS groups varied but the themes were very similar. The main themes from the groups are: understanding the inherent geomorphic landscape that produces their soil structural related issues, using local trials and demonstrations to inspire and educate their communities, targeting the trialling of management options for specific and sometimes very localised geomorphic based issues (RMCG, 2015, 2016, 2017).

Results of the community consultations

The following figures highlight the general issues raised during the community consultation processes across north central Victoria however, it needs to be noted that the importance of each aspect of the various issues does differ according to local observations.

Barriers to implementation – the top responses were; time, equipment, knowledge and then skills, capacity and confidence. Landholders were also concerned with the affordability and the uncertainty on a production return on a proposed investment from the time and resources invested in to a practice change for sustainability improvements.



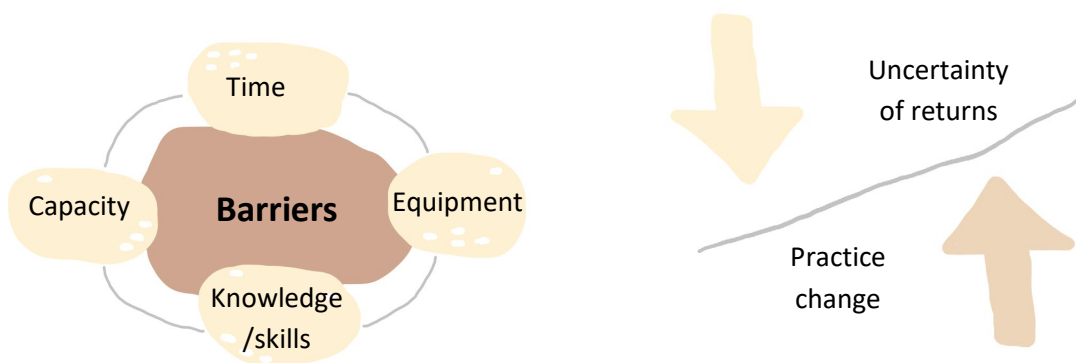


Figure 3: Community barriers to implement soil health management

- a) **Greatest concerns** - These are all linked with the **depleted levels of organic matter / soil carbon**. identified as; poor soil structures, sodicity, acidity, nutrient and fertility declines, salinity, alkalinity and low levels of soil biology.

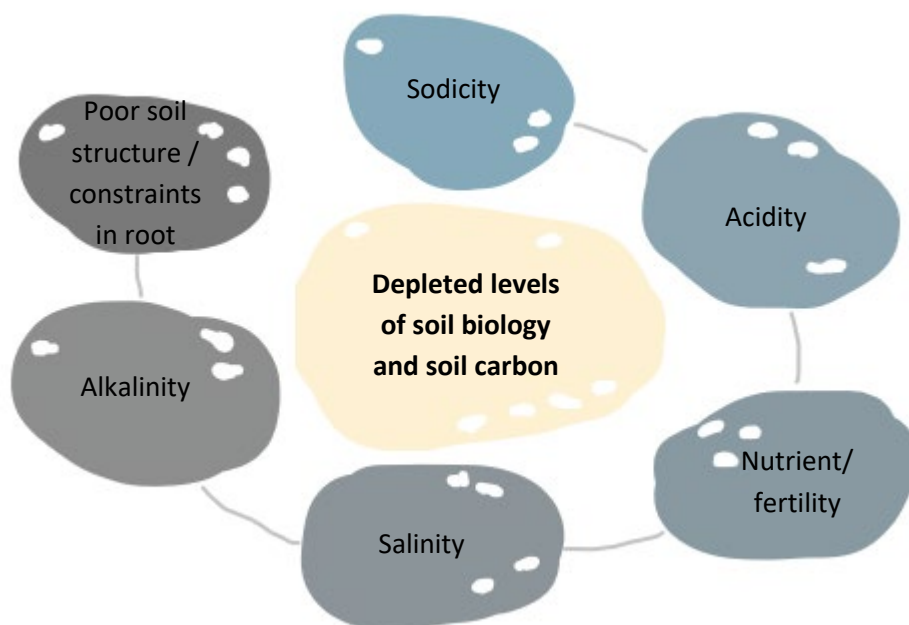


Figure 4: Community's greatest soil concerns

- b) **Information required** – management for the retention of groundcovers, impacts of alkalinity and salinity on groundcover retention and a desire to increase knowledge on nutrient cycling and soil biology.

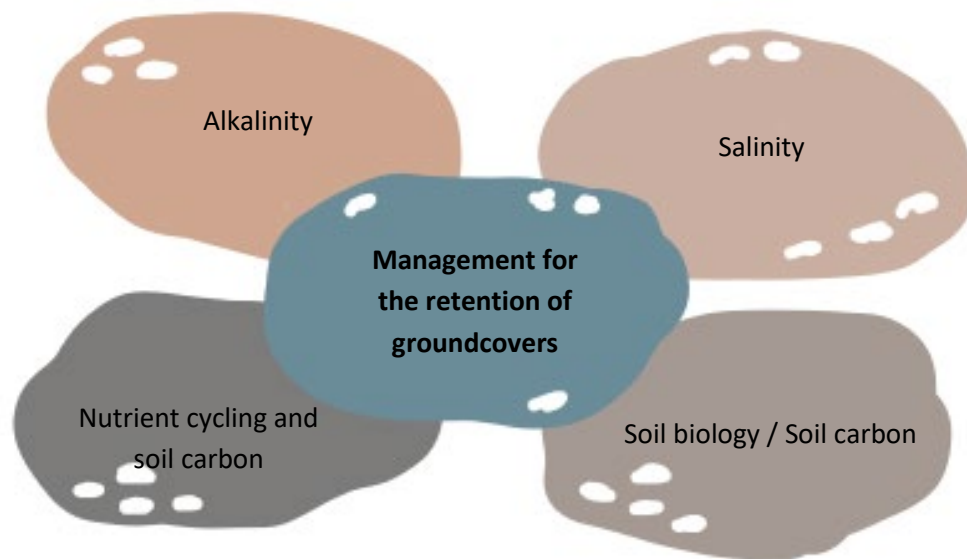


Figure 5: Community seeking further information

- c) **Issues impacting productivity** – how to improve the soils structure through: increase and protect top soils, increase rooting depths, increase groundcover persistence to increase the SOM and soil biology to improve infiltration and drainage that will result in an improved soil structure.

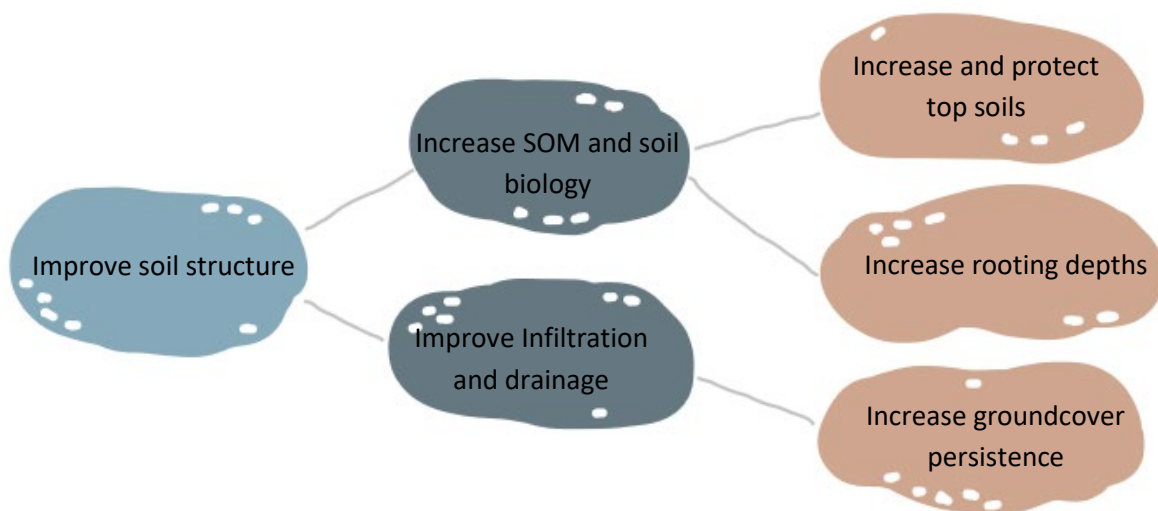


Figure 6. Impacts on productive soils – community issues

d) **Main themes** – the two main themes that were identified during community consultations;

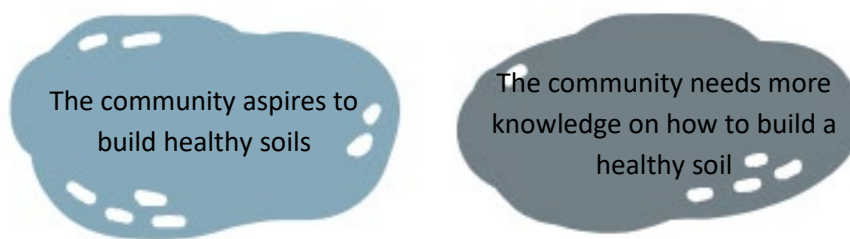


Figure 7: Main themes in Soil Health – community issues

e) **Preferred delivery mechanisms** - the delivery mechanisms suggested by the community to engage in soil health activities ranged from using the current Landcare and FSS group models to industry groups and commercial providers. It was suggested that Landcare groups are sometimes too environmentally focused with sustainable agriculture or soil health activities not a priority for them.

From the *2018 Soil Health Survey*, the community identified opportunities with the development of soil health activities and requested local demonstration sites, for confidence and skills building. It was also noted that their current '*usual source of soil information*' was private industry.

IMPLEMENTATION

Strategic prioritisation process

The challenge is to guide, support and implement soil health programs and projects that deliver both food security and ecological integrity to the region.

The North Central Regional Catchment Strategy 2013-2019, decrees that the following issues and principles will be used to set future priorities for land and soils.

Regional dispersed asset – Soil is a dispersed natural capital common to large areas of land. Thus, soil protection programs must encourage the adoption of sustainable practices at the sub-regional scale.

Community based – Investment strategies must be community driven and tailored to localised biophysical conditions and the social capacities.

Food security – Important to focus our efforts on areas of land that contribute to food security and ecosystem services. Especially the mixed cropping and grazing lands of the northern foothills, Riverine Plains and the Mallee Plains of the north-west.

Ecosystem services - Soils provide a wide range of services other than growing food. Soils and the plants they support may act together to limit sediments and soil losses to streams, minimize erosion, reduce flooding and many more instances.

Threat – Investment programs should consider the potential damage to the resource base that may occur into the future through the continued exposure of soils to the traditional land uses with the combination of climate change and production pressures (North Central Catchment Management Authority, 2013).

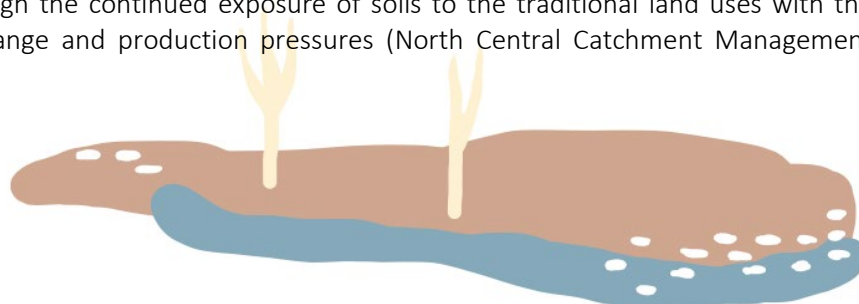


Table 8: Current soil related projects being delivered or in planning within north central Victoria.

Threat	Location	Impacts
Wind Erosion	Particularly in the north and north west (cropping zones).	Loss of productive top-soil. Sediment and salt loads - accumulation in waterways.
Water Erosion	Particularly in the higher elevations, on drainage lines or on waterways.	Loss of productive top-soils. Sediment and salt loads - accumulation in waterways.
Increasing groundwater table levels	Particularly in the north (irrigated zones).	Damage to productive top-soils. Hypersaline land discharging salt.
Salinity impacts to agricultural productivity	Particularly in the north (irrigated zones).	Ongoing salinisation of productive land will reduce regional productivity and cause deleterious environmental impacts and impact water quality in waterways.
Climate change resulting in below average rainfall and/or unseasonal rainfall	Whole of catchment.	Unviable farming will cause the abandonment of agricultural lands. Increase in summer weeds, wind and water erosion. Deleterious impacts on production and infrastructure.
Increased extent and frequency of flooding due to altered catchment hydrology	Particularly in the north (irrigated zones) but flooding can impact widely across the catchment.	Prolonged inundation of land causing salinisation and waterlogging.
Unsuitable drainage management	Particularly in the north (irrigated zones) but flooding can impact widely across the catchment.	Increased waterlogging and salinisation of productive land will reduce regional production and impacting on water quality in waterways. Artificial drainage can also have negative impacts on native vegetation.
Unsuitable land use change	Whole of catchment.	Land use unsuitable and this use is causing deleterious off site environmental impacts and a reduction in regional agriculture production. Increase presence of pest plants and animals across degraded (even abandoned) lands.

Threat	Location	Impacts
Increasing areas of sodic soils	Particularly in the north and north west (cropping zones) can occur at a range of depths.	Loss of soil structure, hard-setting and waterlogging, loss of infiltration, less plant-available water capacity, reduced leaching that can lead to an accumulation of toxic elements, poor seedling emergence and root development. Sodic soils are also often associated with tunnel and gully erosion (State of Victoria 2018).
Increasing areas of acidic soils	Areas of >400mm of annual rainfall and many top-soils in the lower rainfall areas are becoming increasingly acidic even though many of these soils have an alkaline sub-soil.	A reduced pH decreases the availability of vital nutrients ex: calcium, phosphorous, molybdenum and magnesium and increases the over-availability of others to toxic levels, ex; aluminium, manganese. A reduced pH also limits the soil complex biological components ex; Rhizobium, deleteriously effecting nodule initiation and the nitrogen fixation process. Further reducing the plants root and rhizosphere nutrient transfer and plant size. Effecting waterways' pH and aquatic ecosystems.
Unsustainable groundwater extraction	Particularly in the north (irrigated zones) but groundwater extraction does occur in localised upper catchment areas.	Unsustainable water resource management, with potential impact on groundwater dependent ecosystems.

(North Central Catchment Management Authority, 2013).

Investment principles

The *North Central Victorian Regional Sustainable Agriculture Strategy* utilises four key farming considerations as sustainability indicators. These indicators can be used at a program, project or an individual level to determine their level of sustainability.

The four sustainable agriculture indicators are:

- Profitable agriculture production.
- Environmental improvement.
- Enhanced social capacity.
- Climate change resilience.

Using all the criteria above, the **prioritisation processes** should then consider:

1. The current productive capacity of the soil.
2. The likelihood of soil damage if the threat is not abated.
3. The capacity to remediate (including the capacity of the community and the ability for actions that will address the threat/s).
4. Impact that proposed actions will have on improvements to climate change resilience.

At a broad scale the North Central CMA region has been divided into six soil landscape classes. (Table 2: Soil Landscape and Land Use Correlation of the north central CMA region of Victoria).

With the above criteria in mind, an initial analysis identifies the red sodosols and the grey vertisols of the northern plains and foothills are the most sensitive to damage and have the potential to suffer a reduction in production (Dyson, 2017).

To enable the prioritisation of any proposed works or interventions, a GIS based project layer is under development that will be populated with the known threats to soil health and assessed against the **prioritisation processes**, above.

Strategic management

In Victoria, soil health is a shared responsibility between the Victorian government bodies, DEDJTR / Ag Vic and DELWP in partnership with the CMA's. Other agencies involved also include; the Environment Protection Authority (EPA) and Parks Victoria (PV) (Pearson, 2010).

The North Central CMA operates as an *'agent of change,'* actively engaging with regional communities, industry and other government agencies, then working with, supporting and encouraging the adoption of improved practices in sustainable land management. The roles of the North Central CMA in sustainable agriculture and soils management, are to engage with the stakeholders to facilitate a **coordinated regional** approach to the protection and restoration of the natural resource base. **Action**

Strategic management priorities

commits the North Central CMA to coordinate the Regional Sustainable Agriculture Steering Committee and to involve regional stakeholders in soil health activities across the region.

Action 1: Strategic management priorities

Soil health:	Coordinating soil health across north central Victoria	Priority
Action 1:		
Aim:	Agency and industry stakeholders are responsible and working collaboratively to ensure the suitable prioritisation and delivery of best practice in soil health for north central Victoria.	High
Objectives:	<ol style="list-style-type: none"> 1. To utilise the <i>Regional Sustainable Agriculture Steering Committee</i> to provide oversight of soil health activities being implemented under the <i>North Central Victoria Regional Sustainable Agriculture Strategy</i>. 2. Agencies and stakeholders involved with soil health in the north central region participate, share, partner and collaborate with each other. 3. Prioritisation tool development (GIS based tool). 	

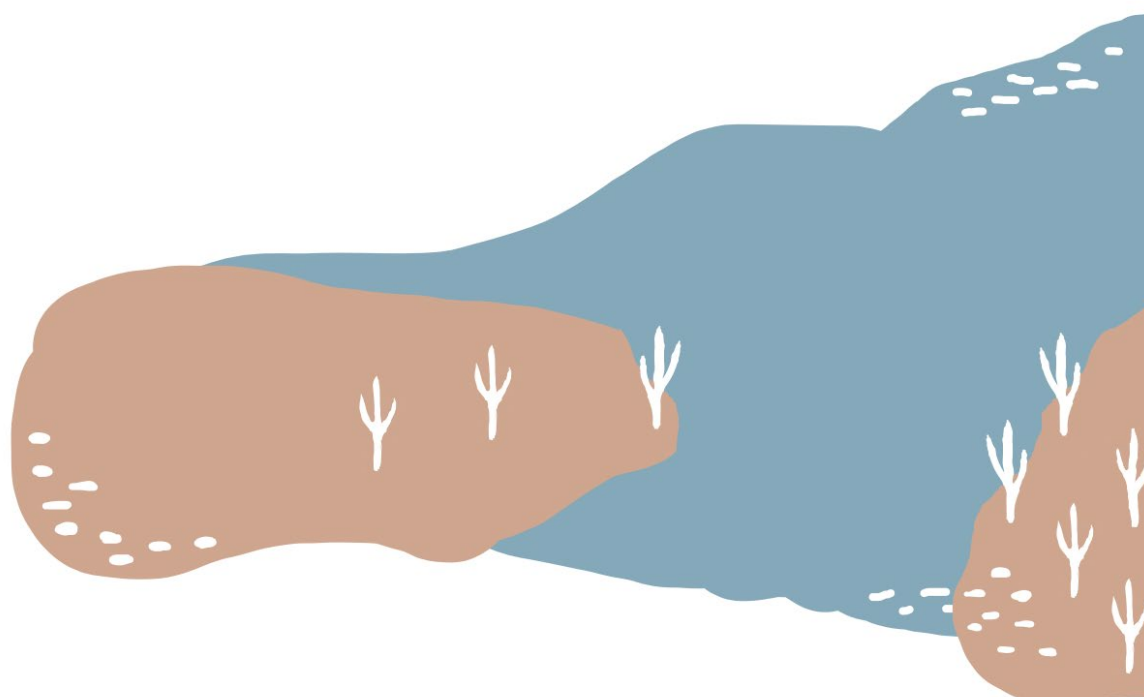
Project delivery

In the areas of soil management, the North Central CMA's major partners are; *DEDJTR, Ag Vic, DELWP, EPA, Landcare, Farming for Sustainable Soils* groups, Friends of Groups', Agricultural groups, local agricultural industries and individual community members.

There are many programs and projects that are currently delivering (and/or are already in the pipeline for funding and will soon be delivering) soil health outcomes in the north central region. It is therefore recognised that these programs and projects have undergone significant consultation and development to ensure they are consistent with the needs of the region and therefore need to continue to be supported and shared to achieve the greatest benefits to the region. (Action 2: Supporting Existing Soil Health Programs).

Table 9: Current soil related projects being delivered or in planning within north central Victoria.

Project	Status	Project owner	Funding
Farming for Sustainable Soils	Finished 30 June 2018	North Central CMA	Australian Government - NLP
Regional Landcare Facilitator	Finished 30 June 2018	North Central CMA	Australian Government - NLP
Regenerative Agriculture	Proposal	North Central CMA	Australian Government - NLP2
Regional Agriculture Landcare Facilitator	Proposal	North Central CMA	Australian Government – NLP2
Victoria Land Health Program	In progress	Agriculture Victoria	Victorian Government
Innovative Farming Workbook (dryland)	Proposal - unsuccessful	North Central CMA	Australian Government – NLP2 Smart Farms:
Plan2 Farm	In progress	North Central CMA	Victorian Government – SIP & RDV
Technical Notes development (Autumn Start-up Workshops 2017)	Seasonal	Murray Dairy	Murray Dairy, Agriculture Victoria, Dairy Australia
Pulse trials Pyramid Hill	In progress - 6 trials	Southern Pulse Agronomy – Ag Vic. BCG subcontracted to manage trials.	GRDC
Pulse Extension	In progress	BCG	GRDC



Action 2: Supporting existing soil health programs

Soil health: Supporting existing soil health programs	Priority
Action 2:	
Aim:	High
Objectives:	
<p>Continue to provide high levels of support to existing (and proposed) projects/programs being delivered in north central Victoria.</p> <ol style="list-style-type: none"> 1. To continue to implement the Ag Vic Land Health program 2. To develop and implement the Australian Governments. <i>National Landcare Program 2 (NLP2)</i> proposed projects. 3. To continue to implement and support other regional soil health activities being delivered across the region by industry and communities. 	

Traditionally extension and technical services were delivered predominantly by agencies, but more recently many individualised services are delivered by the private sector, which complements the agencies group-based activities. There is an opportunity for agencies to collaborate further to increase service capacity across the region, which will achieve efficiencies in the delivery of timely, relevant and targeted information as group- based training, to build the capacity of the farming community (Action 3: Community Engagement Priorities).

Action 3: Community Engagement Priorities

Soil health Building Capacity in Soil Health	Priority
Action 3:	
Aim:	High
Objectives:	
<p>To continue to increase the skills and capacity of agencies and the community to provide soil health outcomes for the region.</p> <p>Increase the availability of independent soil health advice and services in the region.</p> <ol style="list-style-type: none"> 1. To identify gaps and/or opportunities to increase soil health skills and capability for the community and agencies. 2. To implement community skills and capacity training programs via projects. 3. To undertake a Soil Health capability study for North Central Victorian (NCV) agency staff. 	

Public land and soil health

The focus for soil health has been predominated towards mitigating against the impacts of land management practices on privately owned land. Some areas of public land have also been disturbed in the past and may be impacting on the ecosystem and recreational service able to be provided.

Where soil health issues on public land are identified, a program to investigate and seek options to restore soil health should be developed. This would include engaging with the public land manager and Traditional Owner groups to determine appropriate methods of rehabilitation. (Action 4: Soil Health on Public Land).



Action 4: Soil health on public land

Soil health:	Soil health on public land	Priority
Action 4:		
Aim:	To improve soil health outcomes on public land in north central Victoria.	Low
Objectives:	<ol style="list-style-type: none"> 1. To identify areas of public land where there are soil health issues and assess the need for intervention (GIS prioritisation tool). 2. To involve Public Land Managers and Traditional Owner groups in determining appropriate rehabilitation methods where required. 	

Data, research and MERI - managing soil information

Condition reporting (as required under the *CaLP Act Section 11.1*), (State of Victoria, 2007), are important in providing the measurements of change in the regions soils' conditions. One of the main reasons for this is to generate government support in the form of policy and investment. Although there are these requirements for regular reporting, there are no systematic funding programs for the monitoring and measurement of soil condition. Hence, the methodologies utilised, and sites sampled are not necessarily consistent between reporting periods making valid comparison difficult, if not impossible (Fisher and Crawford, 2015).

To enable regions to effectively undertake programs of works to provide improved soil health outcomes, three important aspects need to be appropriately understood and resourced. These are:

Data capture

A lot of knowledge and site information has been collected by many entities over a long period of time. Access to this information is inconsistent, and in some cases almost impossible to find.

To aid in the beneficial use of the plethora of knowledge and data, a more effective Information management system is required that collates the information from most sources and provides an easy to use interface.

Action 5: Data capture priorities

Soil Health:	Data capture priorities	Priority
Action 5:		
Aim:	Soil information is well managed, shared and easily accessible for the appropriate need.	High
Objectives:	<ol style="list-style-type: none"> 1. To create a repository for all soils information collated for NCV. 2. To develop interface for easy access of information (e.g.: Extension Aus., website). 	

Research and development

As new technologies and information comes to hand, opportunities for innovation and improved understanding of mechanisms to improve soil health outcomes arise. Development of a R&D program to identify and investigate gaps in knowledge and understanding of the soils in NCV would provide benefits to the region. A significant component of any R&D program will include linking with existing R&D providers (e.g. CRC for soils) and regional partners so as not to duplicate effort (Action 6: Research Priorities).

Action 6: Research priorities

Soil health: Research priorities	Priority
Action 6:	
Aim:	Maximize Research, Development and Extension opportunities to improve the understanding and potential of the soils in NCV.
Objectives:	<ol style="list-style-type: none"> 1. To develop a GIS prioritisation project tool for soil health investment prioritisation decisions. 2. To undertake a knowledge audit on soil health issues and gaps relevant to NCV. 3. To identify R,D&E already in place that is covering off on any of the issues/gaps identified. 4. To develop a regional R,D&E program to investigate any outstanding issues.
	Medium

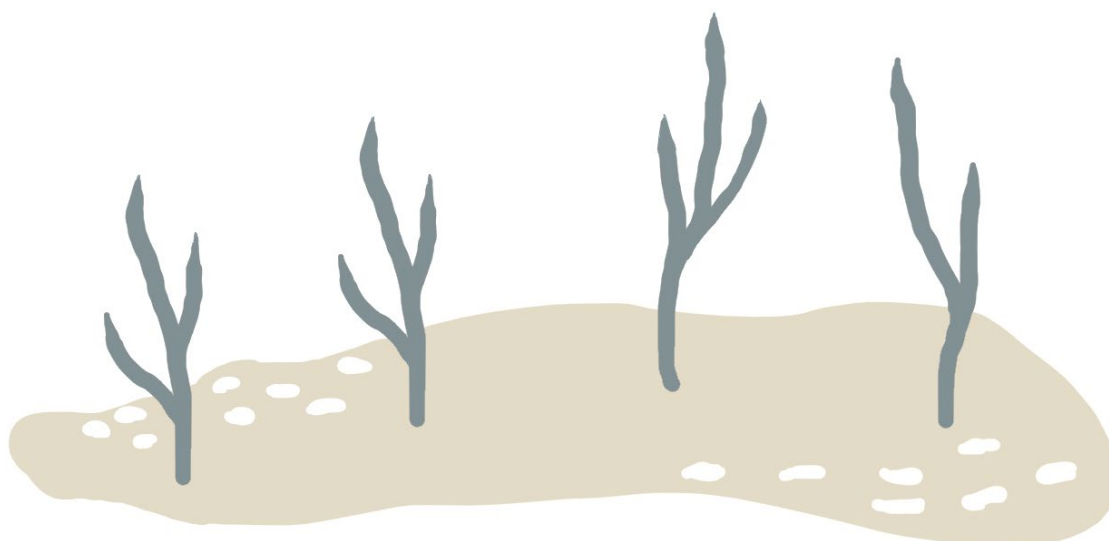
Monitoring, Evaluation, Reporting and Improvement (MERI)

Soil health is a complex and broad topic. Therefore, it is important that sound MERI processes are in place to:

- Continue to learn from the work we do in soil health.
- Build projects that are appropriate based on the knowledge and understanding gained from past activities. As well as;
- Being able to demonstrate to the community and potential funders of the value of the soil health actions we as a region are delivering. (Action 7: Monitoring, Evaluation and Reporting Improvements).

Action 7: Monitoring, evaluation and reporting improvements

Soil health Doing the MERI best for soil health	Priority
Action 7:	
Aim:	Monitoring, Evaluation Reporting and Improvement processes and practice is applied appropriately and to a high standard across soil health programs in NCV.
Objectives:	<ol style="list-style-type: none"> 1. To review current MERI processes for soil health projects in NCV. 2. To develop a consistent MERI standard to be used for all soil health programs/projects delivered under the Regional Sustainable Agriculture Strategy. 3. To develop a business case for the Actions.
	High



STRATEGIC SOIL HEALTH ACTION PLAN FOR NORTH CENTRAL VICTORIA – TABLE OF ACTIONS

The issues identified throughout the consultation process have been aggregated to a list of Seven Key Actions (Table 16 below). For each of the seven actions; soil health aims, a description of the action, key objectives, the likely action owner and proposed timeframe have been developed. The Plan will provide the basis for the future soil health work programs to be developed and implemented within north central Victoria. Where appropriate, the actions will have business cases using the North Central CMA Project management Framework prepared to further define the scope of the action/potential projects that could be delivered, and as a mechanism to attract funding.

Action	Title	Aim	Description	Objectives	Action owner	Timeframe	Priority (H,M,L)
1	Coordinating Soil Health across north central Victoria	Agency and industry stakeholders are responsible and working collaboratively to ensure the delivery of best practice in soil health for north central Victoria.	The community, key industry bodies and agencies have a forum that provides an opportunity to increase communication, development of new networks and create a culture of collaboration and sharing of soil health programs and information for north central Victoria.	<ol style="list-style-type: none"> To utilise the Regional Sustainable Agriculture Steering Committee to provide oversight of soil health activities being implemented under the North Central Victoria Regional Sustainable Agriculture Strategy. Agencies and stakeholders involved with soil health in the north central region participate, share, partner and collaborate with each other. To develop a prioritisation tool for prioritising action (GIS based tool) (See Research Priorities Action 6:). 	North Central CMA Manager Sustainable Agriculture to convene the meetings and coordinate appropriate representation from community, agencies and industry bodies.	In progress and ongoing.	High
2	Supporting Existing Soil Health Programs	Continue to provide high levels of service to existing (and proposed) projects/programs being delivered in north central Victoria.	<p>Programs and projects already in place and being implemented within the region will continue to be supported. New programs/projects that have been developed and are in the pipeline (such as the Ag Vic Land Health Program and NLP2 Regenerative Agriculture project) have already undergone significant consultation and development to ensure they are consistent with the needs of the region, will also be supported.</p> <p>This action ensures that these projects continue to receive the support and oversight required for successful delivery.</p>	<ol style="list-style-type: none"> To continue to implement the Ag Vic Land Health program. To develop and implement the NLP2 proposed Regenerative Agriculture and Regional Agriculture Landcare Facilitator projects. To continue to implement and support other regional soil health activities being delivered across the region by industry and communities. 	Each program/project delivery agent will be responsible for their program.	In progress and ongoing.	High
3	Building Capacity in Soil Health	To continue to increase the skills and capacity of agencies and the community to provide soil health outcomes for the region.	<p>Having appropriate skills, knowledge and capability in soil health is critical in achieving the vision of:</p> <p><i>‘Healthy soils sustaining prosperous communities and the natural environment in North Central Victoria.’</i></p> <p>This action focuses on improving the capacity in the community as well as in the government agencies to provide the appropriate responses to soil health.</p> <p>Assumed that industry bodies have their own programs in place.</p>	<ol style="list-style-type: none"> To identify gaps and/or opportunities to increase soil health skills and capability for the community and agencies. To implement community skills and capacity training programs via projects; (e.g.: RALF and Regenerative Ag). To undertake a Soil Health capability study for NCV agency staff. Increase the understanding and resilience to Climate Change. 	Agriculture Victoria and North Central CMA.	<p>Business case prepared by 30 June 2019.</p> <p>Implemented by December 2020.</p>	High

Action	Title	Aim	Description	Objectives	Action owner	Timeframe	Priority (H,M,L)
4	Soil Health on Public Land	To improve soil health outcomes on public land in north central Victoria.	To identify where there are soil health issues on public land and develop a program to investigate and seek options to restore soil health. This will include engaging with the public land manager and where appropriate, engage with traditional owner groups to determine appropriate methods of rehabilitation.	<ol style="list-style-type: none"> 1. To identify areas of public land where there are soil health issues and assess the need for intervention. 2. To involve Public Land Managers and Traditional Owner groups in determining appropriate rehabilitation methods where required. 	North Central CMA Manager Sustainable Agriculture to prepare project context and business case.	Business case prepared by 30 June 2019. Implemented by December 2021.	Low
5	Managing Soils Information	Soil information is well managed, shared and easily accessible for the appropriate need.	There is a broad range of types of soils information from reports, soils maps, site investigations etc. This action proposes to develop a 'one stop shop' for all available soils information in NCV. Noting that there may be some limitations on levels of access for privacy reasons.	<ol style="list-style-type: none"> 1. To create a repository for all soils information collated for NCV. 2. To develop interface for easy access of information (e.g. https://extensionaus.com.au/). 	North Central CMA Manager Sustainable Agriculture to prepare project context and business case.	Business case prepared by 30 June 2019. Implemented by June 2021.	High
6	Research Priorities	Maximize R&D opportunities to improve the understanding and potential of the soils in NCV.	Development of a R&D program to identify and investigate gaps in knowledge and understanding of the soils in NCV. This will include linking with existing R&D providers (e.g. CRC for soils) and regional partners so as not to duplicate.	<ol style="list-style-type: none"> 1. To undertake a knowledge audit on soil health issues and gaps relevant to NCV. 2. To identify R&D already in place that is covering off on any of the issues/gaps identified. 3. To develop a regional R&D program to investigate any outstanding issues. 	North Central CMA Manager Sustainable Agriculture to prepare project context and business case.	Business case prepared by June 2019. Implemented by June 2020.	High
7	Doing the MERI Best for Soil Health	Monitoring, Evaluation Reporting and Improvement processes and practice is applied appropriately and to a high standard across soil health programs in NCV.	With soil health being a complex and broad topic, it is important that we have sound MERI processes in place to continue to learn from the work we do in soil health, build projects that are appropriate based on the knowledge and understanding gained from past activities as well as being able to demonstrate to the community and potential funders of the value of the soil health actions we as a region are delivering.	<ol style="list-style-type: none"> 1. To review current MERI processes for soil health projects in NCV. 2. To develop a consistent MERI standard to be used for all soil health programs/projects delivered under the Regional Sustainable Agriculture Strategy. 3. To develop a business case for the Action. 	Agriculture Victoria and North Central CMA.	Business case prepared by 30 June 2019. Implemented by Dec 2020.	Medium

Table 10: North Central Victoria Soil Health Action Plan

APPENDICES

Appendix 1: References

In the development of the *Soil Health Action Plan for North Central Victoria*, the Department of Sustainability and Environment, 2012, *Soil Health Strategy*, directed that if Soil Health Plans are developed by a CMA, they must be consistent with the determined outcomes in the *Victorian Soil Health Strategy* and the CMAs, own RCS. These recommended references and therein outcomes, were utilised in the formation of the Plan.

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Appendix 2: Acronyms

Acronym	Description
Ag Vic	Department of Agriculture, Victoria
DEDJTR	Department of Economic Development, Jobs, Transport and Resources, Victoria
DELWP	Department of Environment, Land, Water and Planning
DSE	Department of Sustainability and Environment (now DELWP)
<i>CaLP</i>	<i>Catchment and Land Protection Act 1994</i>
CCC	North Central CMA's Community Consultative Committee
CMA	Catchment Management Authority
GRDC	Grains Research & Development Corporation
Mg/L	Megalitre (1 Mg/L = 1,000,000 litres)
NCV	North Central Victoria
<i>NCVRSAC</i>	North Central Victorian Regional Sustainable Agriculture Steering Committee
<i>NLP2</i>	National Landcare Program 2
NRM	Natural Resource Management
RCS	Regional Catchment Strategy
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
<i>ACTION</i>	Soil Health Action Plan for North Central
<i>PLANNC</i>	
<i>THE PLAN</i>	Soil Health Action Plan

Appendix 3: Guiding principles for soil health

GUIDING PRINCIPLES FOR SOIL HEALTH



The terms 'soil health' and 'soil quality' are becoming increasingly familiar worldwide. A modern consensus definition of soil health is "the continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals and humans" (Natural Resources Conservation Service –USDA-NRCS, 20122; Soil Renaissance, 2014). Doran and Parkin, in 1994, defined soil quality as "the capacity of a soil to function, within ecosystem and land use boundaries, to sustain productivity, maintain environmental quality, and promote plant and animal health."



Healthy soils:

- Supplies nutrients, water and oxygen for healthy plant growth
- Allow infiltration, and facilitate storage and filtration of water
- Retaining and cycling nutrients and supporting plant growth
- Suppresses pests, disease and weeds
- Large and diverse population of soil biota
- Resistant to degradation
- Resilient to impact of environmental stresses

Management objectives for soil health:

- Maintain/improve groundcover and organic carbon
- Improve soil physical properties
- Maintain and enhance soil biota
- Maintain nutritional fertility
- Minimise soil loss
- Reduce acidification and salinity
- Manage wet soils
- Prevent contamination

Principles for soil health:

Adopt sustainable practices for productivity outcomes (dryland and irrigation).

- Implement farming practices to maximise photosynthesis, maintain and improve soil structure, improve water use efficiencies, nutrient use efficiencies, minimise soil losses with erosion, nutrient losses through gaseous exchanges and deep drainage and conserve water supplies in irrigation and dryland.
- Encourage the use of deep rooted vegetation.
- Specifically, for irrigation, manage deep drainage to prevent off-site impacts.
- Adoption of grazing practices that maximise groundcover all year – monitoring and matching stock numbers to seasonal pasture availability, allow pastures to recover to set seed and maintain groundcover.
- Adoption of sustainable cropping practices – reduced tillage, stubble retention, legume incorporation into rotations, maintain stubble for groundcover, soil-testing and nutrient matching.
- Minimise compaction and excessive tillage.
- Build levels of organic matter / carbon in soils.



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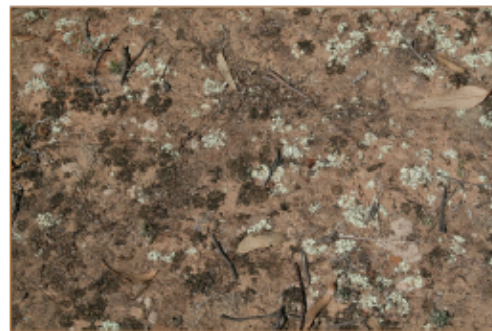
1. Property planning, including a Soil Health Management Plan – involves a long-term vision which considers the whole of the property and its place in the catchment.

- a) Understand the landscape; its geology, geomorphology, hydrology, soils and climate.
- b) Manage property according to the capability and the limitations of the land.
- c) Protect and rehabilitate areas that are degraded or at risk from degradation.
- d) Ensure the appropriate placement of infrastructure to minimise the soil impacts.
- e) Work with communities - soil health is not an individual issue but a landscape issue.

Prevention of soil degradation is nearly always substantially cheaper than the cost of restoration.

3. Preserve and protect natural features.

- a) Manage and protect native vegetation, including native grasslands, as part of property planning.
- b) Protect waterways and drainage lines with fencing, vegetation and appropriate land management strategies.
- c) Adoption of a strategic and coordinated approach to sustainable weed and pest control.



Biological soil crusts, a natural soil formation process
Photo credit: Robyn McKay (NCCMA)

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal and Torres Strait Islander people and organisations in land and natural resource management.

GUIDING PRINCIPLES FOR SOIL HEALTH



Further Readings:

Voluntary Guidelines for Sustainable Soil Management

<http://www.fao.org/documents/card/en/c/5544358d-f11f-4e9f-90ef-a37c3bf52db7/>

Sustainable Grazing – A producer’s resource

<https://www.mla.com.au/research-and-development/Environment-sustainability/Sustainable-grazing-a-producer-resource/>

Contamination

http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soil_health_mis7898_6#6.3

Groundcover

<http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/erosion/groundcovering-measuring-tool>

Carbon

http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_organic_carbon-cycle_transcript

Wet Soils

<http://agriculture.vic.gov.au/agriculture/dairy/managing-wet-soils/grazing-techniques>

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GUIDING PRINCIPLES FOR SOIL HEALTH



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Victorian Resources Online - What is a healthy soil

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Appendix 4: Soil health terms

“The continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal and human health” (Doran and Safley, 1997).

For the purposes of the *North Central Victorian Soil Health Action Plan*, Soil health, is the condition of a soil in relation to its inherent or potential capabilities, to sustain biological productivity, maintain environmental quality and to promote plant and animal health.

Soil quality, the capacity of a soil within a landscape to sustain biological productivity, maintain environmental quality and to promote plant and animal health.

Soil resistance, the capacity of the soil to continue to function without changes throughout a disturbance. Soil resilience, the capacity of the soil to recover its structural and functional integrity after a disturbance. (MacEwan, 2007).

Under the *CaLP 1994*, soil health; *avoiding causing or contributing to land degradation which causes or may cause damage to land of another owner; and (b) conserve soil; and (c) protect water resources.* The major challenge within sustainable soil management are to conserve ecosystem services delivery while optimising agricultural yields. (Kibblewhite et al., 2007).

The main soil qualities that can be considered as soil health indicators are; the nutrients and their availabilities, workability, oxygen availability at depths, nutrient retention capacities, toxicities, salinities and root zone conditions. (MacEwan, 2007).

Function

To support soil health, the functions of soil or what the transformations that result from soil ecosystems, needs to be defined and managed.

We depend on soil to perform many functions. Healthy soil gives us clean air and water, bountiful crops and forests, productive rangeland, diverse wildlife, and beautiful landscapes. Soil performs five essential functions.

Nutrient cycling functions

Soil stores nutrients, moderates the release of, and cycles nutrients and other elements. During these biogeochemical processes, analogous to the water cycle, nutrients can be transformed into plant available forms, held in the soil, or even lost to air or water.

Water functions

Soil can regulate the drainage, flow and storage of water and solutes, which includes nitrogen, phosphorus, pesticides, and other nutrients and compounds dissolved in the water. With proper functioning, soil partitions water for groundwater recharge and for use by plants and soil animals.

Biodiversity and habitat functions

Soil supports the growth of a variety of plants, animals, and soil microorganisms, usually by providing a diverse physical, chemical, and biological habitat.

Filtering and buffering functions

Soil acts as a filter to protect the quality of water, air, and other resources. Toxic compounds or excess nutrients can be degraded or otherwise made unavailable to plants and animals.

Physical stability and support functions

Soils have an ability to maintain their porous structures, allowing the passage of air and water, to withstand erosive forces, and to provide a medium for plant roots. Soils also provide anchoring support for human structures (NRCS, 2011).

Each of these soil functions are expressed as a collective of a variety of biological processes supported by a diversity of interacting soil organisms under the influence of the physical soil environment. (Kibblewhite et.al 2007).

Processes

The processes, are taking place in the soil in terms of the energy, nutrients and water cycling and interactions. The rate of these processes determines the soils', functional performances. There are six main ecological processes that moderate the release and cycling of energy, nutrient and water;

1. Providing a medium for plant growth.
2. Supplying a recycling system for organic wastes and nutrients.
3. Modifying the atmosphere.
4. Providing a habitat for soil organisms.
5. Offering a system for water supply and
6. Purification and providing an engineering medium (MacEwan, 2007).

Attributes

These are the measurable properties of the soil. They support or regulate the processes in the soil and the functions of the soil. Some properties are inherent to a soil and some properties are dynamic and can be influenced through the management of the soil. The attributes of a soil can be directly measured; physical, chemical and biological. Many attributes of a soil may in turn affect other soil attributes. For example, the hydraulic conductivity, a measurable attribute, influenced by many other properties, including; clay percentage, exchangeable sodium and by the fauna of the soil which produces micro and macro-pores (MacEwan, 2007).

Ecosystem services – soil functions – soil processes – soil attributes

The gross value of agricultural production (GVAP) in north central Victorian was around \$1.4 billion in 2012 up from \$1.1 billion in 2001. Grains are the largest sector by GVAP, followed by dairy, livestock and the intensive animal industries. Horticulture accounted for around 10% of GVAP in 2012. The industries where there has been highest growth in GVAP over the past decade are meat sheep, intensive animals and perennial horticulture. The relative proportions of the other sectors have remained relative steady (RMCG, 2015). But the productive capacity of existing agricultural land depends on the distribution, nature and the health of the soils.

Although not currently quantifiable for the region, the natural services or ecosystem services of the soils of the region are critical in providing many benefits that humans derive from them (Bennett, L. et al 2010). Ecosystem services have been broadly defined in numerous literature, but most of them have some relationship to soil and soil health. There are many ways in which soil health and environmental health are linked. Some examples include;

Ecosystem Service	Relationship to soil function and soil health
Pollination	Soil does not have a direct role in pollination, although undisturbed soil can provide habitat for many insect pollinators that pupate, nest or raise larvae underground.
Waste absorption and breakdown	The soil ecosystem, the single most important processor of waste in the environment and recognised in the soil quality literature through primary functions such as 'filter and absorb wastes' and 'store and recycle' nutrients.
Water filtration	'Filter' and 'absorb wastes', 'act as an environmental buffer', 'resists erosion', and 'partition and regulate flows of water' are all primary functions of soil that assist in the provision of the ecosystem services.
Provision of shade and shelter	Through supporting and maintaining vegetation, soil serves a primary function in the provision of shade and shelter.
Regulation of climate	Soil plays an integral role in the global climate, indirectly through supporting vegetation and C-fixation, and directly through C-sequestration in soil and gaseous emissions from soil. The latter are significant in some agro-ecosystems. Soil also influences the micro-climate close to the ground through reflection and heat storage which are affected by surface soil conditions, organic matter and moisture content.
Prevention of soil erosion	"Resist erosion", a primary function of soil described in soil health / soil quality literature. Soil structural stability and strength, groundcover, roots and vegetation all interact to provide these ecosystem services.
Maintenance and regeneration of habitat	Soil supports vegetation as habitat. A soil's health (or soil quality) are critical in the restoration of habitat. Management of soil for ecological restoration after mining operations, urban reclamation and post agricultural land use change are a critical area for the science of soil and soil health.

Table 11: Ecosystem Services and Relationships to Soil Functions and Soil Health

From Binning et al. 2001. (MacEwan, 2007)

Indicators of soil health

To measure a soil's health, an indicator or a measurable parameter of the soil, are used to represent the soil's condition or the soil's ability to perform functions. Indicators for soil quality or soil health cover a range of physical, chemical and biological soil properties. Some common examples include; crop production quantities of a certain area in relationship to rainfall received, water use to the conversion of dry matter of production, water stored in soil profile, pH, EC.

An index - usually a value on a relative scale that has no meaning unless you use as a comparative to gauge the change or the trend of the data.

Monitoring - the periodic and repeated measurement of a soil parameter to track the changes over time. Monitoring for changes, are necessary to provide the evidence for measuring the impact of management and to assess the need for a change in management. There are two main purposes for monitoring in respect to soil. Monitoring must be given context; which parameters are we monitoring and why.

- i. Reducing the risk in decision making.
- ii. Improving process understanding (MacEwan, R. 2007).

Organic carbon, the single most important soil health indicator. Increases in soil organic carbon (particularly biologically-available forms) are intimately linked to the size, composition and activity of

the soil microbial community; enhanced retention and cycling of nutrients; improved aggregate stability; and the increased water-holding capacity of soil (Stirling, G. 2016).

Appendix 5: Victorian Government priorities

The Victorian strategy focuses on the health of the soil asset and the ecosystem services that soil provides. The services that the Victorian strategy focuses on are;

- Water quality regulation
- Water yield and flow regulation
- Habitat provision and biodiversity support
- Carbon sequestration, and
- Remediation of wastes and pollutants

Four areas of soil health have also been identified, these include;

- Organic matter decline in erosion susceptible areas;
- Inadequate ground cover in erosion susceptible areas;
- Soil structure decline; and
- Soil contaminants (such as salt, acids, pollutants).

(DSE, 2012).

Victorian Government priorities for the immediate future

- Areas of large land slips, often triggered by heavy rainfall, that impact on waterways, water supplies, roads, buildings and productive farm land. These landslides impact the health of rivers and reservoirs, built infrastructure and reduce the area of land available for production.
- Soils which are dangerously acidic, impacting human health, vegetation and productive land.
- Wind erosion on cropping land, especially in the Wimmera and Mallee where a high risk of wind erosion exists. Impacting on air quality leading to health concerns and impacts to environmental assets. Agricultural productivity also declines.
- Movement of sediment and nutrient into rivers, lakes and estuaries, which can trigger algal blooms and eutrophication and compromise the health of these waterways.
- Salt affected soils decreasing agriculture productivity and leaking salt into downstream waterways.
- Sodic soils that are very unstable, prone to water logging and are highly erosive. These soils compromise vegetation, buildings and productive land.
- Low soil carbon levels undermine the fertility of productive land, indicate a low level of soil biodiversity, and contribute to high levels of carbon dioxide in the earth's atmosphere.
- Soil management following emergencies such as bushfire and flood to prevent land degradation.

(DSE, 2012).

Victorian Government goals

Protect and improve soil health by addressing current known threats to soils and improving soil resilience

- Improve the condition of high value soils currently at risk where they impact high value natural and other assets.

- Strengthened capacity of soils to resist and recover from environmental and management-induced events or shocks.

Methods:

- Develop rigorous investment assessment processes and viability of addressing threats with stakeholder and community partnerships.
- Support current projects that address current risks.
- Support research to identify soils at greatest risks.
- Integrate soil health works with other CMA issues, for joint benefits and to reduce conflicts.
- Publish guidance for local Soil Health Plans, to ensure their alignment with Victorian government and Regional plans.
- Support research to improve knowledge and the evidence on how to improve a soils systems resilience.
- Design and implement a robust system of monitoring soil health investments and to identify emerging issues.

Understand and value soil health and services

- Improved government, industry and community understanding of soil services and their benefits to environmental and agricultural systems.
- Improved knowledge on soil health to allow for more informed decisions by industry, government and communities.

Methods:

- Complete and implement a Soil Health Priority project that provides an assessment of soil values, threats and understanding of soil ecosystem services.
- Address knowledge gaps identified through the Soil Health Priority project and through other soil research.
- Support on-farm risk management by;
 - Identify trigger points for intervention.
 - Develop sets of decision points for under stressful conditions, for instigating intervention.

Maximise the efficiency and effectiveness of government investment in soil health for environment benefits

- Better targeted government action by increasing the focus on high value soil and natural assets at risk.
- Logical evidence-based intervention planning, including benefits focused investments.
- More effective government action by using innovative approaches to supporting provision of ecosystem services.

Methods:

- Enlist market-based research with land managers to support them to make positive practice changes for soil health.
- Develop key performance and appropriate monitoring indicators to assess impacts on priority environmental assets.
- Develop transparent and robust decision support tools for investment – to balance competing interests and set priorities and target soil health works.

- Explore market mechanisms to enhance the provision of ecosystem soil services – competitive tenders.
- Support other programs (River health & Biodiversity) to include an assessment of the benefits soil ecosystem services in their programs.

Build government, industry and community partnerships to manage for soil health

- A widespread understanding that soils provide important environmental services of benefit to Victorian communities.
- A culture of shared learning and partnerships with communities and local industry, business and government to promote soil health.
- Increased extent to land managers delivering the environmental benefits of soil from land use and management.
- Better coordination of government action and clearer lines of responsibilities.

Methods:

- Share knowledge and build partnerships with other government agencies including;
 - Dryland Managers forums.
 - Engaging Public Land managers in soil health projects.
- Share knowledge and build partnerships with community and industry groups.
- Support regional soil health strategic planning.
- Build community capacity in setting environmental stewardship standards.
- Develop measures of soil health for consistent reporting.
- Victorian government departments to work closely with its partners (DSE, 2012).