Soil Health Management Plan

Concept, Process and Pilot Study with Mid Loddon Sub Catchment Management Group

DEPARTMENT OF PRIMARY INDUSTRIES | future farming systems research

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Richard MacEwan, Principal Research Scientist, Future Farming Systems Research Division, DPI.

Acronyms and Glossary

ArcMap Proprietary GIS software marketed by ESRI (www.esri.com)

CfoC Caring for our Country (Commonwealth government funding initiative)

CPRS Carbon Pollution Reduction Scheme - subject of federal parliamentary papers regarding carbon emissions.

DPI Department of Primary Industries

DSE Department of Sustainability and Environment

EBMP Environmental Best Management Practices - a DPI farm planning program used in south west Victoria.

eFARMER A web-based system used in Victoria to provide access to and record spatial data for farm planning.

EM Electromagnetic (induction) - used in EM31 and EM38 instruments to map subsurface differences in conductivity.

EMAP Environmental Management Action Plan - landcare based process funded by DPI, DSE and MCMA.

EMS Environmental Management System

ESAS Environmental Sustainability Action Statement (Victorian Government funding initiative).

FFSR Future Farming Systems Research - Division of DPI conducting innovative research for farming systems.

FSV Farm Services Victoria - Division of DPI that is focussed on support and regulatory services to farm businesses.

GIS Geographic Information System - computer based mapping software.

GPS Global Positioning System

GRS Gamma radio spectrometry (a type of remotely sensed data used to distinguish surface geological and soil materials)

ISO International Standards Organisation. ISO 14001 - standard governing environmental compliance.

MCMA Mallee Catchment Management Authority

MLSC Mid Loddon Sub Catchment Management Group

SHMP Soil Health Management Plan

VRO Victorian Resources Online - web pages managed by the DPI to provide natural resource information

WFP Whole Farm Plan

Soil Health Management Plan Concept

Introduction

The Soil Health Management Plan (SHMP) is a paddock by paddock, farm scale plan. It should be created by farmers for farmers. The SHMP is not an end in itself — it will only make sense and be applied if it is tied to business plans for the farm enterprise. Soil health interacts with crop type, climate and management to deliver dollars on farm from the sale of agricultural products.

Background

The DPI is significantly engaged in research, training and demonstration for various aspects of soil health. Most recently, funding from the Commonwealth Government[1] and the Victorian Government[2] has been used to deliver a project known as *Healthy Soils*. This project has been conducted in partnership with farmer groups in Western Victoria and South East South Australia.

A primary objective of the Healthy Soils project has been to increase the knowledge and skills for soil management amongst farmers and their advisers. Two important outputs from the project are a series of training modules for different aspects of soil science and management, and a review of tools that can be used to assess soil health.

The Soil Health Management Plan (SHMP) was conceived during the *Healthy Soils* project as an effective endpoint in which the information and tools could be applied on farm. The concept of a SHMP became the litmus test for relevance of information incorporated in the training modules - 'if it cannot be applied to management, it may be interesting but is useless'. Similarly, in the review of tools for soil assessment these were rated for their ease of use and their value to decision making.

A pilot for soil health management planning commenced with members of the Mid Loddon Sub Catchment Management Group (MLSC) in 2008. The group received Commonwealth funding for 12 months under the Caring for our Country (CfoC) program and chose to incorporate the SHMP pilot within their CfoC project. DPI has worked in partnership with the MLSC to explore the capacity of two farmers to develop SHMPs for their farms.

This report describes the SHMP concept and proposes a process for implementation based on progress with the pilot group so far.

[1] Land and Water Australia: Healthy Soils, Sustainable Farms project. 2006-2008
[2] Environmental Sustainability Action Statement (ESAS) 2006-2010

Soil health and the farming system

Soil health is not an end in itself. Soil, water, sunlight and air are the primary natural resources for agricultural production. Of these four, soil is the most complex component and is also highly sensitive to management. The term 'soil health' conjures up the sense of soil as living, productive and, by implication, something that can at times be unhealthy, incapacitated and unproductive.

Soil is a finite resource on the farm. The farm enterprise is adapted to this resource in terms of the total land area of the farm and soil quality. These factors combine with season temperatures and water availability to determine the choice of produce, the production system, and the productive potential of the enterprise. Figure 1 illustrates some of these biophysical factors and relationships.

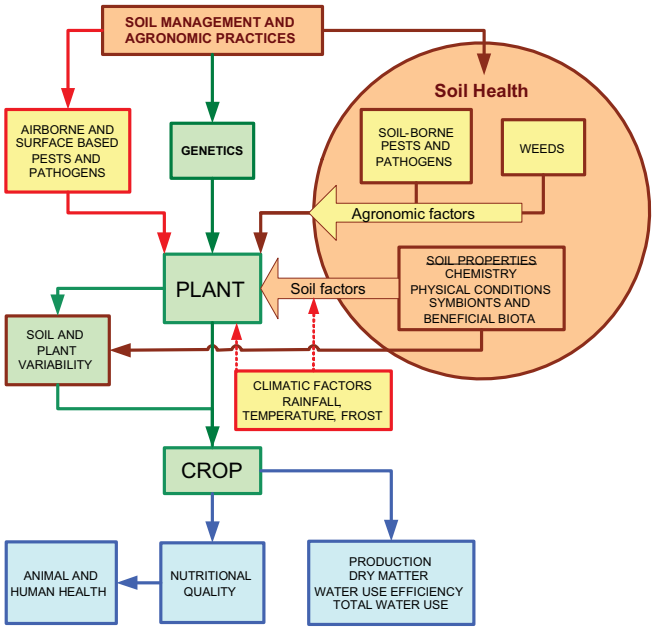

Figure 1. Soil Health in the Agro-ecosystem

The central vertical pathway in Figure 1 (green boxes) represents the primary agronomic choice (the crop or pasture that is to be grown) and the end result (blue boxes) as food quality, animal and human health, total production and production efficiency. Farming practices are applied to achieve the best result by managing soil conditions and weeds (brown circle) whilst responding to seasonal invasions of pests and pathogens and the vagaries of the climate and weather (yellow boxes not included in the soil health circle). Other important inputs associated with production, such as energy, labour, fertilisers, chemicals, machinery and infrastructure depreciation, are not represented in Figure 1.

The success of the farming system may be indicated by gross production, the quality of the product and the

efficiencies in production. Most of the annual enterprise decisions centre on the economics of production; machinery operation and replacement costs, seeds, fertilisers, chemicals and labour. These decisions are largely driven by experience of what has been successful in the past and the market opportunities for the coming season.

Management of soil health is generally not an explicit part of this planning process but there are many aspects of the seasonal farm operations that have an impact on soil condition. Conversely, there are many soil related factors that have impacts on a successful outcome for the enterprise.

Adopting soil health as another indicator of success is an important step in demonstrating a sustainable farming system that can also help achieve the bottom line business goals.

Lessons from the past

Why should a landholder bother?

We have no previous experience of farm scale soil health planning, although there are similarities with whole farm planning. Whilst it is possible to create a framework for such a plan, implementation is the responsibility of the land manager.

The challenge is to find or provide a driver that will motivate a land manager to adopt the ideas in the framework and make them part of the farm business planning activity. Economic benefits are not always clear enough for economics to be, at this time, a major driver, although many of the 'alternative' farming philosophies stress soil health as an objective that can benefit the economics of production through lowering the costs of inputs and raising the value of produce for specialised markets.

There are considerable costs involved in changing farm equipment to adopt controlled traffic systems, for example, and there may be economic risks in reducing tillage or adopting zero till systems. We can point to successful examples that demonstrate the long term improvements to soil structure, and there are now some research results that show production benefits. In addition, lower fuel usage may be one of the most powerful drivers for change in traffic and tillage and this is likely to increase as oil becomes scarcer and more costly.

An ecological conscience (caring for soil) and economics both play their part as drivers, but, at the present time, economics is the weaker of the two.

How should a soil health management planning framework be promoted?

There are many examples of programs to encourage farmers to adopt new practices. Some are more successful than others. The issue of drivers already discussed is an important one affecting success, but failure may occur because of the intellectual and emotional distance between the developer/s and the recipient/s. A 'back-room' approach to reviewing knowledge of a topic can produce credible output, but development of the knowledge into an application or tool to be used by others who have not been involved in the knowledge review is another matter.

Recent examples[3] of soil quality and soil health knowledge extension stress the need to involve the farmers from the beginning. Unless the farmer 'owns' the plan it will never fully translate into enduring management.

SHMP and other farm plans

There are many other initiatives and projects driven by DPI that include soil management as an issue but not as the single focus. Some of these and their relationship to soil health management planning are described below.

SHMP and whole farm plans (WFP)

What is the difference between whole farm planning and a soil health management plan?

Whole Farm Planning has been conducted for several decades and has its origins in the days of the Soil Conservation Authority[4]. The primary focus in whole farm planning is on farm layout, land class fencing, access and water reticulation. A WFP provides a sound approach to the natural resource 'infrastructure' of the farm. It should take account of water flow across the landscape, management of any erosion hazard, establishment of shelter belts and protection of native vegetation remnants.

SHMP and FarmPlan21

The most recent DPI advice on whole farm planning is part of the FarmPlan21 program conducted by Farm Services Victoria Division (FSV).

FarmPlan21 is described as 'Whole Farm Planning for the 21st Century' and defines a WFP in the following way:

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[3] Lobry de Bruyn LA, Abbey JA (2003) Characterisation of farmers' soil sense and the implications for on-farm monitoring of soil health. Australian Journal of Experimental Agriculture 43, 285 – 305. Full text doi: 10.1071/EA00176

[4] The Soil Conservation Authority was a Victorian government department that existed from 1940 to 1984.

"A Whole Farm Plan develops short term and long term goals based on the aims of the farming family or operation. Primarily the plan is to simplify management, improve productivity and include biodiversity and ecological issues in farm decision making. It takes into account livelihood, lifestyle and landscape to ensure sustainability of all three."

Using this definition as a model, we can define a SHMP:

"A Soil Health Management Plan (SHMP) develops short and long term goals based on the purposes of the farm business and the capacity to invest in improving soil management and thereby soil health. Soil is recognised as the primary natural resource supporting the farm business. The plan should take account of soil capability on the farm, current soil condition and requirements for management. A SHMP integrated with the farm business is used in consideration of crop choices, tillage, traffic, grazing management, machinery purchases, and inputs to maintain soil fertility (chemical, biological and physical), manage disease and reduce weeds."

SHMP and environmental management action planning (EMAP)

Another project that can provide a platform for development of SHMPs is environmental management action planning (EMAP) that has been delivered to farmers in a partnership between DPI, DSE and the Mallee region catchment management authority (MCMA). The EMAP process is also described as 'environmental whole farm planning'.

SHMP and eFARMER

eFARMER is a web-based application which supports the capture, viewing and sharing of natural resource management information across farms, landscapes and catchments. It has been developed by DPI and DSE working closely with a number of CMAs.

Because of its links to Victorian government datasets eFARMER has a lot of potential for use in building soil health management plans, at least in providing some context for soils and geology. The scale of available soil maps is too coarse for farm planning and can only provide a regional indication of a soil inventory.

Access to aerial photography, property boundaries and satellite data are the most useful aspects of eFARMER for development of SHMPs but not many farmers in the pilot group have equipment or confidence to take advantage. However, as computer literacy in the farming community grows and internet connectivity becomes faster and cheaper eFARMER may be more readily adopted. At this stage in the *Healthy Soils* project no single computer based system has been advocated.

SHMP and environmental best management practices program (EBMP)

The environmental best management practices program (EBMP) is a system used for self-auditing of practices on the farm. Participants rate themselves against management of a range of practices that include soils, water, vegetation, animals, chemicals, waste, etc. The SHMP would fit well into the EBMP by fulfilling the high level 'tick' for soil management practices. EBMP workbook can be a component in an environmental management system (EMS).

SHMP and environmental management systems (EMS)

The elements of an EMS are really the same as those found in WFPs, EBMPs and a SHMP. The difference between a true EMS and the other approaches is compliance to any documented industry standards under ISO 14001. This entails record keeping, monitoring, and auditing by a third party. Legal obligations for soil management are fairly limited but have been documented for Victoria in a DPI publication *Soil Management*, one of a series of 6 publications for EMS[5].

The soil health management plan and the bigger picture

Soil health is important for sustainable farming because a healthy soil performs the functions that are expected of it. Annual maintenance costs to restore soil to a functionally healthy state can be avoided - e.g. changing from cultivation practices to zero tillage and controlled traffic systems reduces fuel costs and maintains soil structure. The costs of substituting management interventions for services that soil could provide can also be reduced or eliminated - e.g. soil-borne disease management.

There is also a bigger picture, beyond the farm. Environmental impacts of inadequate soil management include groundwater contamination, surface water quality degradation (nutrients and turbidity), and destruction of infrastructure (e.g. erosion and deposition). On the positive side, a soil health management plan for a farm potentially enhances property value, provides evidence that can be used in environmental accreditation for 'clean and green' products, and even a basis for auditing practices against Carbon Pollution Reduction Schemes (CPRS).

At the state level, the number of farms, or land area, governed by SHMPs would be a worthy indicator of effective practice change in farm and soil management.

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[5] Environmental Requirements For Victorian Farmers
www.dpi.vic.gov.au

Basic elements for a soil health management plan

A SHMP can be as simple or as complex as the knowledge, skill and time of the farm manager allow. The main elements of the SHMP are soil inventory, monitoring, planning and management.

The elements

The basic elements of a soil health management plan answer three questions:

1. What do we have? = Soil inventory and interpretation.
2. How are things going? = Assessment and monitoring.
3. What needs to be done? = Planning and management.

Soil inventory and interpretation

This is the primary representation of soils on the farm and should include:

- Identification of major soil differences across the farm.
- Soil profile descriptions for full depth of major soils.
- A record of the critical differences between them.
- Ranking — best to worst (could depend on purpose).
- Any special considerations for management.

Identifying the major soils

Surface soil colour and textural differences are fairly obvious features, particularly when the soil is bare or is cultivated. Farmers will often use terms such as 'gray loam' or 'black clay' to describe their soil. Presence of cracking soils, stony areas, land subject to inundation, and general landform also provide indicators of soil differences. History of the farm, the order in which land was cleared, and the original vegetation cover can provide clues to the underlying soil and land quality. Recent technological innovations, particularly yield mapping, the use of ground based sensors (EM38) and interpretation of satellite imagery are proving invaluable for identifying soil-based production issues and for zoning paddocks for precision agriculture. The SHMP provides a framework for properly documenting these soil differences and issues.

Soil profile descriptions

Soil investigations must go deeper than the surface 10 cm. Total soil depth available for water storage and root growth can be extremely variable. Subsoil properties may restrict growth in ways that can be overcome by management or may be permanent features of the soil that have to be recognised and adapted to. If irrigation water is to be applied on the farm then knowledge of soil properties for the full profile (depth ~1-1.5 m) is essential. A soil auger or post hole digger may give sufficient information, particularly for confirming soil properties, but, ideally, a soil pit excavated by backhoe will give the best indication of soil horizons and structure (Figure 1). The main horizons should be sampled and sent away for chemical and physical analysis if funds permit. A well described soil profile supplemented by chemical and physical data provides a good reference site for the farm and for other landholders in the district.

Figure 2. Full soil profile information is necessary.

Critical soil differences

Soil health (or soil quality) is described in terms of the capacity of the soil to perform critical functions such as: retain and store water for plant growth, resist erosion, and support traffic (animals and vehicles)[6]. Critical soil differences are the soil properties that affect these functions. Some of these properties are inherent to the soil and determine the soil quality, soil type or class of soil. These properties may change but only very slowly over decades, centuries or millennia (e.g. soil texture). It is these enduring inherent soil properties that should be described and

[6] DPI report "Soil health for Victoria's Agriculture" available online at http://www.dpi.vic.gov.au/vro/soilhealth

mapped as part of the soil inventory. Other soil properties are changeable over the short term, during a season or over several management cycles. Such properties are dynamic, respond to management and also affect the soil's capacity to perform key functions (e.g. pH and soil structure affect availability of nutrients, soil air and water). The soil condition with regard to dynamic properties indicates soil 'health' and is therefore important for the assessment and monitoring elements in the SHMP.

Some important critical soil properties for the inventory are: surface soil colour and texture, subsoil texture, total soil depth (or rooting depth), stoniness (rocks, gravels, buckshot), topsoil or A horizon thickness, surface drainage status, etc. The assistance of a soil specialist and training of farmers in some simple field methods to assess soil is necessary support for the development of a farm soil inventory.

Ranking the soil types

During the process of creating a soil inventory, comments should be recorded concerning the history and performance of different paddocks. A simple ranking of the soils from best performers to worst can do two things: it can indicate inherent differences in soil and land quality, and it may also highlight some management issues that have arisen in the past.

Special considerations for management

Special considerations for management will arise during the initial soil inventory and ranking. Issues for consideration include: erosion hazard, waterlogging and inundation, dispersive (sodic) soil, soil acidity, and structurally degraded soil.

Using available soil information

A large amount of soil information exists on the DPI website, particularly in the Victorian Resources Online (VRO) pages[7]. Scanned soil survey reports and maps are available for download and are useful to gain a general idea of local soil types. However, most of the soil and land surveys have been conducted at regional scales that have insufficient spatial detail to be used to map soil at a farm scale. In addition to the soil survey reports there are several hundred examples of regional soil types complete with images, profile descriptions and analytical data. The VRO pages also include information on soil degradation processes and soil management. The web pages provide support for anyone developing a SHMP but direct consultation of a soil scientist will be needed for local interpretation and planning.

The *Healthy Soils* module 'Understanding soil types' is designed to deliver basic information to farmers and their advisers to provide skills in recognising and recording soil differences. Each delivery has been tailored to include information on regional soils and issues depending on the training venue.

Figure 3. Sometimes expert help may be needed.

[7] http://www.dpi.vic.gov.au/vro

Local farm knowledge and investigation will be required to complete a farm soil inventory and to create a soil map. Ultimately, this should be a fine scale soil map that has been interpreted in relation to management requirements for the different soil map units. Some whole farm plans (WFP) may already include a soil map. A SHMP can take this information to the next stage by assessing soil condition and managing soil health.

Assessment and monitoring

The farmer needs to know how farming practices are affecting the soil. The soil inventory answers the question 'what's out there?' Assessment and monitoring should answer the question 'How well are things going?' A balanced program will include all of the following:

- Soil and plant sampling and laboratory analyses.
- Paddock walks and soil condition assessment.
- Evaluation of crop and animal production, quality and health.

What factors should be monitored and how often should monitoring occur?

There is no 'one size fits all' design for assessment and monitoring that can cover all soil and all farming systems. An appropriate assessment and monitoring routine depends on: land use, the practices and changes in practice, critical issues such as erosion, and the expected rate of change (e.g. soil carbon is slow to change whereas soil nitrogen changes rapidly).

Guidelines for soil and plant sampling for analysis are provided by DPI and commercial laboratories. Consideration should be given to timing, soil depth, tillage and fertiliser practices (e.g. banding, zero tillage). To monitor soil change, consistent methods must be applied in the field and laboratory from year to year. Surplus from large soil samples taken (more than is sent to the lab) can be held at the farm as reference samples in case methods or laboratories are changed. Samples for archiving should be thoroughly air dried and stored in water tight and vermin proof containers.

Figure 4. Paddock walks to inspect soil and crop condition.

Paddock walks are opportunities for systematic visual and tactile assessment of soil to develop a familiarity with differences between paddocks, soils and seasons (Figure 4). These walks can be incorporated into crop monitoring and animal husbandry activities. Useful observations can be made of soil surface condition such as crusts, evidence of erosion, ponding of water, surface compaction etc. and supported by taking reference photographs.

Figure 5. A simple penetrometer indicates soil strength and moisture content.

A simple penetrometer can easily be carried during a paddock walk to serve as a useful indicator of soil moisture conditions and subsoil physical strength (Figure 5).

Figure 6. Training in use of equipment will be needed.

Farmers are increasingly adopting technology to assist in crop management. Yield monitors, satellite data, soil moisture sensors, and electromagnetic induction surveys are all examples of readily available technology. As with any new approach, expert help may be required for proper set up of equipment, training in applications, and interpretation of data. Site or farm specific calibrations should also be considered because soils are so diverse and variable.

Soil moisture sensors may be deployed as portable meters to collect readings from many access points or as

permanently installed sensors fitted with loggers to collect continuous soil moisture data. Efficiency in data collection can be supported by remote telemetry and directly downloading data from the loggers to the home computer.

Crop yield, nutritional quality, animal production and animal health are seasonal indicators of the success of the farming system - soil management plays a significant role in these but there are other factors too. However, they can be used to guide soil investigations particularly if there is variation across the farm, or the outputs are less than expected given the season and the inputs used.

Further information for soil health monitoring

A soil health check ideally includes an assessment of soil physical condition, chemical fertility and biological functions. The *Healthy Soils* project's review of soil health tools provides a summary of useful methods. Also, the *Healthy Soils* training modules on understanding soil testing, soil structure, soil biology, organic matter, and soil water, are available for delivery to farmers and their advisers. Much of the material is available online through the DPI website.

Planning and management

Knowledge of soils, soil differences and soil condition needs to be translated into action - what management actions are required to maintain or improve soil condition and get the best from the soil?

Crops and livestock

Profitable production of food and fibre is the primary business goal. The aim of a SHMP is to align soil management with this goal. Decisions about crop type, rotations, and stock management all have an impact on, and are affected by, soil health. Crops are not all equal in terms of their fertility requirements, rooting depth or potential to protect soil. Hard hoofed animals can readily cause damage to soil that will impact subsequent plant growth (Figure 7 and Figure 8).

Figure 7. Hard hoofed animals can readily cause damage to soil. Compaction by sheep treading on moist unprotected ground.

Grazing and cropping combinations must be carefully managed. Timing and sequencing of crop and stock operations, paddock by paddock, must not be left to chance but should be planned to achieve triple benefits for crop, stock and soil.

Figure 8. Impact on following crop along a stock track created during the pasture phase.

Soil amendments

Amendments such as fertilizers, lime, gypsum, composts, and feed supplements are major business expenses. It is essential to know where and when these amendments are needed, the amounts that should be applied, and their potential economic benefits. Conversely, the cost and penalties should also be known for not using appropriate amendments at the right time, in the right place and at the best rates. The business strategy for amendments must be based on good knowledge of the soil inventory, crop history, and soil testing.

Tillage and traffic management

There are many different operations that can be included under the general term, 'tillage'. Any action associated with *mechanical disturbance* of soil in the preparation of ground for growing crops, burial of weeds, or incorporation of organic matter is tillage[8]. Worldwide, the evidence is mounting that soil health benefits are greater where disturbance is kept to a minimum.

Decisions regarding tillage are critical for the business and for soil health. Fuel, machinery depreciation and implement wear are significant costs. A SHMP should account for differences in soil conditions and how tillage affects soil structure. It is much easier to degrade soil structure with tillage than it is to build good structure. Evaluation of existing equipment, condition, purpose and performance is an essential component of the SHMP.

[8] Ploughing, ridging, harrowing, rolling, rotavating (rotary ploughing), discing, aerating, scarifying, drilling, deep ripping, bed forming, humping and hollowing, draining.

Control of traffic across soil is also an important management tool for soil health. Soil becomes strong enough to support the loads imposed on it. Dry soil is strong - moist soil is weak. Dense soil is strong - loose soil is weak. Loose moist soil is good for plants, dense dry soil is good for supporting wheeled vehicles. A healthy soil for supporting traffic is not a healthy soil for growing crops, and vice-versa.

The simplest form of controlled traffic is to only put traffic on paddocks when soil structural damage is likely to be low. Fully developed controlled traffic confines traffic to consistent routes or tramlines, is managed by GPS guidance systems, and has machinery axle widths optimised to minimise the trafficked area. Changing from uncontrolled to controlled traffic farming is therefore costly and needs to be planned in the business time frames for machinery replacement.

Adoption of minimum tillage and even zero tillage systems is increasing in Victoria. Controlled traffic farming has not yet been widely adopted but the efficiencies in fuel usage, management of inputs, and demonstrated yield benefits should serve to encourage rapid change in traffic management.

Changes in the NSW Cotton industry - a SHMP model

In the NSW irrigated cotton industry, as many as 14 different tillage operations per year used to be involved. Soil compaction and other aspects of soil structure decline were recognised as having a severe impact on cotton production and the costs of production. In the late 1980s considerable effort was devoted to simultaneously solving the soil and business problems. Now reduced tillage, controlled traffic, paddock zoning and soil monitoring are all integrated and provide a good model of a SHMP for that industry[9].

SHMP planning cycle

The principal elements of the SHMP can be summarised diagrammatically (Figure 9) as an application of a standard planning cycle (plan-implement-review-improve). Knowledge of soil differences on the farm, and their responses, may change as experience is gained through implementation of the SHMP. The original inventory of soils and map may therefore also be modified.

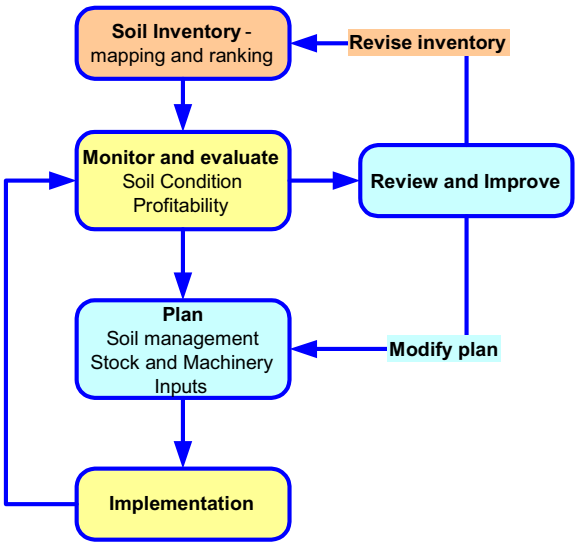

Figure 9. SHMP Planning Cycle

Business tools to assist the SHMP

There are many products on the market that can assist in planning farm business activities, in particular for maintaining financial records and for financial planning. The DPI's AgriGater[10] software is useful for running a variety of scenarios across the farm to evaluate costs and potential gross margins. It allows paddock by paddock analysis and is therefore well suited to incorporation in a SHMP and management of different soils or soil zones in a paddock. Machinery replacement costs are incorporated in the program, so plans for conversion of sowing equipment or standardisation of axle widths in a move to controlled traffic can be included in a scenario.

Mapping software that can incorporate data layers (land parcels, air photographs, geology, soil, etc.,) is an essential tool. There are many products available that can be used. These may be served via the web such as the DSE's eFarmer, or they may be standalone products with different degrees of functionality. At this time, most farmers would require a level of training to use such software and would be best served by having access to a provider who is able to process GIS data and supply appropriate hard copy maps.

[9] SOILpak first published in 1991 by the NSW government for the cotton industry has subsequently been adapted for dryland cropping and for vegetable growers in NSW.

[10] AgriGater is free http://www.AgriGater.com.au/

The SHMP Process and Pilot

Priming the SHMP process

A balanced program of activities including education, engagement and experience provides the focus for different aspects of the soil health management plan. The starting point and expectations will vary between individuals — some one to one or small group discussion is essential.

Group readiness

A baseline level of knowledge and interest in natural resource management on the farm is desirable. This is something that can be engendered over time with groups at field days (e.g. soil pit days), seminars and training sessions.

The MLSC had already built a strong interest in soil through other funded projects that focussed on 'biological farming' and on compost trials. Seventeen soil pits had been excavated, sampled and described for the group as part of the DPI support to these projects and to their 2008-09 'Caring for our Country' project[11]. Additionally, trial sites managed by the group had been surveyed by DPI using farm quad bike mounted remote sensing equipment[12]. These surveys highlighted soil variability at the trial sites, in particular demonstrating differences in subsoil quality. Several field days and presentations to the MLSC group occurred in the two years prior to the SHMP pilot. Two farms were selected for participation in the pilot. These will be referred to as HH and DC.

Farmer engagement

A clear enduring commitment by participants in the SHMP is needed. This cannot be achieved in an afternoon. The SHMP process involves documentation of existing and historic conditions, discovery of new knowledge, adoption of new tools, changes in perspective and consequent changes in practice.

The initial meeting was held in the kitchen at the HH farm. The MLSC group facilitator, owner of the HH farm and his nephew, and father and son from the DC farm attended the meeting. The whole morning was set aside for this.

An introduction to the SHMP pilot was given, emphasising that:

- the SHMP should be their plan - it was only going to be facilitated, and not created, by a third party,
- commitment to the whole the process was a requisite and that time and 'homework' would be required,
- the SHMP does not need to be complex, but should be a level that can and will be acted on, and
- it should be central to the farm business, and some new business habits may be needed particularly for record keeping.

A series of prepared questions was used to lead the conversation (Appendix A - Questions):

- the farm business and planning (10 questions),
- soils, soil knowledge and soil management (24 questions), and
- machinery and stock (6 questions).

Copies of the questions were given to the participants and interviews for the two farms were conducted. This process led to much open discussion about comparisons and differences of experience at the two farms. Emphasis was on the farmers and letting the conversation run. It's their business and it has to be their plan, so it was important not to dominate or lead too much at the inception of the project. The interviews and conversations throughout the morning were audio recorded with the permission of the participants. The farmers were also asked to complete written answers to the questions in their own time as homework and to return them to the SHMP project manager at DPI.

Figure 10. Kitchen table discussion kicking off the soil health management plan process - two farms and two generations.

[11] Commonwealth funding program www.nrm.gov.au

[12] The quad bike carries differential GPS, GRS, EM31 and dual EM38 (horizontal and vertical dipole).

GIS and property documentation

Landholders were engaged in an interactive GIS session to identify their properties and to view the available geographic data layers. Maps showing paddocks on each farm were prepared. Additional paddock scale property information was used to run farm business scenarios in DPI's AgriGater software.

Office GIS Session I (with farmers)

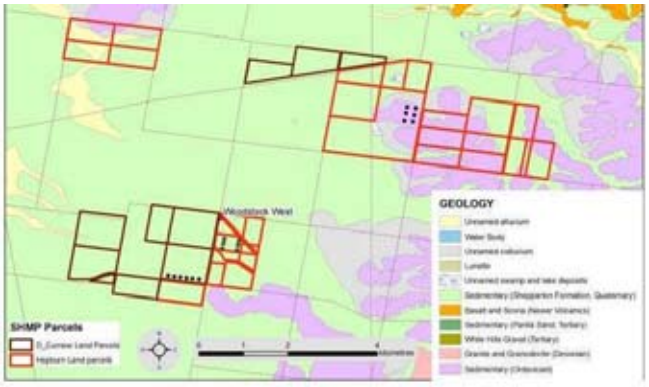

Figure 11. SHMP land parcels overlain on regional geology.

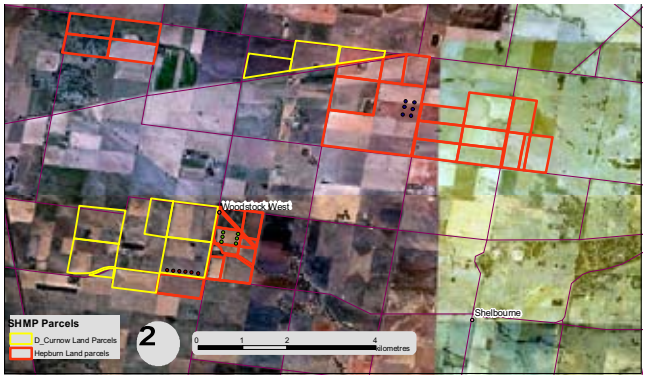

Figure 12. Air photography overlain with land parcels owned by the SHMP pilot farms.

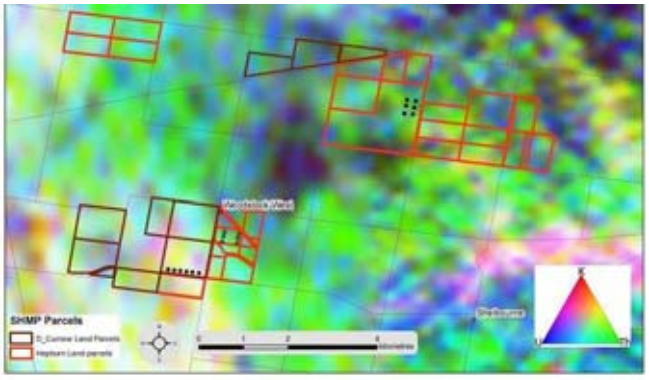

Figure 13. SHMP land parcels overlain on the airborne gamma radiometric map.

Farmers involved in the pilot SHMP came into the DPI Bendigo office for half a day for an interactive session using the GIS running in ArcMap. The corporate data layer for land parcels was used to identify the land owned by the participants. Other layers were viewed to gain a general understanding of the sub catchment landscape, e.g. geology, soils, and airborne gamma.

Office GIS Session II

Using air photo mosaic a draft paddock layer[13] was created for each farm. The draft paddock maps were printed and sent to the farmers for checking, numbering and naming.

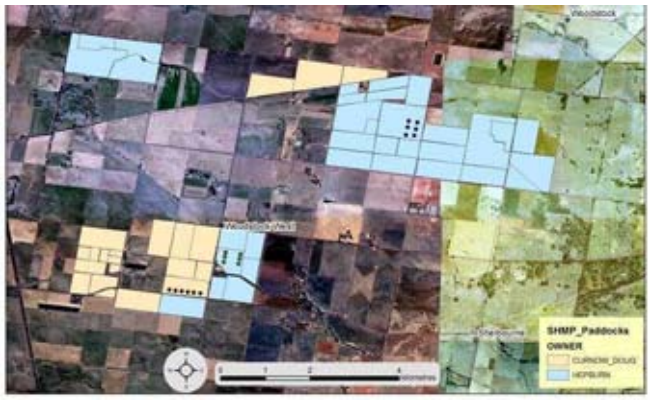

Figure 14. Paddock boundaries within land parcels are delineated from air photographs and used for checking, numbering and naming.

Office AgriGater training session

Paddock information and farm management scenarios were entered into DPI's AgriGater program during a training session. (N.B. There is no soil component in AgriGater but this level of planning of the farm business is crucial to building SHMP.

Figure 15. Farmers engaged in training to enter their farm data into AgriGater.

[13] Corporate geospatial layers exist for land parcels and fences but not for paddocks. Differences in management within parcels can be seen on recent air photography.

Paddock walks

Paddock walks on each farm enabled closeup examination of soil and conditions, to discuss the management issues and future actions.

A time was arranged for one to one engagement with each of the pilot farms. Three to five hours was spent with the farmer visiting paddocks that they elected to examine – ten to twelve per farm. This was an opportunity for more considered conversation and interchange of ideas.

Hardcopy A4 maps and a clip board were provided to each of the farmers. Four maps were printed:

- Plain map with paddock boundaries.
- Paddock boundaries overlain on air photograph.
- Paddock boundaries overlain on airborne gamma image.
- Catchment scale map of geology overlain with paddock boundaries.

The maps were used to record information and for general context and discussion about particular features.

A penetrometer and soil auger were taken into the paddock and used to (a) determine the achievable depth of penetration, and (b) examine the soil to and beyond that depth. This took time but really forced engagement between farmer and soil to a degree that is never achieved by driving a tractor or just simply looking at surface tilth and conditions.

Figure 16. During the farm walk, the auger and penetrometer were given to the farmer to use.

During the walk, the topic of the conversation was broad but included essential information about the use of the paddock, soil condition, pasture quality, this year's and recent crop, production history, plans, issues, and variability. This was very effective for really getting behind some attitudes, and there were some 'sartori' moments for the farmers.

All the paddocks had a reasonably long history of crop and pasture rotations and most showed evidence of compaction.

The degree to which compaction is a feature of these soils had not been appreciated previously by the owners.

It is easy to talk about compaction in presenting information to groups but there is nothing to beat real observation of soil conditions (e.g. penetrometer resistance, cloddiness, root deformation) to bring the message home. In both pilot cases the farmers had plenty of previous exposure to the ideas, but it was only in visiting the paddocks, on a one to one basis, that the messages really came home.

Figure 17. Three examples of differences in soil condition that were observed during the paddock walks: (top) dense and cloddy; (centre) surface sealing and compaction; (bottom) beneficial fungi (white) in soil pore space.

Conversation about practice change and how to achieve it over the medium or long term, rather than all at once, is needed. Without gaining an achievable perspective on time and economics, radical changes can appear to be too difficult.

Figure 18. An example of how sealed and hard-set the soil surface has become, and hence the need, in this case, for tillage.

Figure 19. Old rip lines created during establishment of shelter belt show advantages to grass growth in an area of compacted soil.

Figure 20. There is nothing quite like a lucerne root to tell you what a plant might be experiencing below the surface.

The paddock walks were followed by a debriefing session back at the farmhouse to discuss main findings and how they might affect plans. Some 'homework' was left in the form of a table for each paddock with columns to be filled out for:

- when paddock soil was last tested,
- what the results were and the management response, and
- when the paddock soil will be next tested.

This is as far as the pilot project progressed within the timeframe and funding. At the annual gathering of the MLSC group both farmers described to the group what they had been doing in the SHMP pilot and spoke very positively about. On the day following this gathering, there was a full day of presentations for group members. Presentations were given on soil water, soil biology and soil organic matter. A separate evaluation report of that day has been prepared by DPI.

Three months after this an evaluation was carried out over the telephone with the farmers in the two pilot farms. This is reported in the following section.

Evaluation and future work

The SHMP pilot has been successful in engendering an enthusiasm for understanding and managing soil. It has resulted in change in attitude and brought forward some planning and management that was not previously as a high a priority as it is now. Follow through is still needed with the pilots and there is opportunity to adopt the approach with more members of the MLSC group. DPI's Farmplan21 project could provide the extension vehicle to reach large numbers of Victorian farmers. However providers with appropriate knowledge and expertise will need to be found in DPI and externally.

Evaluation

The leader of the Mid Loddon Sub Catchment Management Group projects, Judy Crocker is engaged in diverse activities with this group ranging from mapping and managing native vegetation to introducing new technology for soil management. When asked about the SHMP pilot, Judy had this to say:

"A farm soil health inventory has the potential to greatly increase the success rate of revegetation projects. The detailed soil structure and farm landscape knowledge gained from an individual farm SHMP has already shown to provide valuable farm surface and sub-soil information to enable more precise planning of direct seeding paddock positioning, methods of ground preparation and seasonal timing."

(J.Crocker MLSC group facilitator)

The two principal participants in the SHMP were interviewed on the telephone by a DPI Farm Services Victoria officer, three months after completion of the pilot. The officer asked five questions and the responses are summarised here.

Has the experience been useful?

HH: “Yes It is part of the overall plan.” "it is a bit big to do all at once - each paddock will be taken on its merit" HH found it “really exceptional spending the whole day with RM”. Part of the day was "learning Richard" that is “getting to know the person as well as the information”.

DC: "Quite Beneficial" Taken on a lot of what RM said. Now doing EM 38 looking at carbon levels in soils and chook manure "Working on the soil we have got"

Will you be changing any practices as a result? (i.e. what have you learned that you want to incorporate into farm management SHMP)

HH: “No doubt it will be part of the changes depending on the finances and the other parts of the business. Yes more gypsum and to less of an extent lime and chook manure.”

HH also plans to increase the areas treated so there will be fewer small (treated) areas as he understands what they should be doing and where they will have an affect.

DC: "Reformation of what we were doing" “Direct drill.” “It will come down to there being a long term financial benefit for things to be applied.”

Do you require more help and, if so, what is the most important thing for you to have further help with

HH: “Not sure at the moment. Not sure until we use it more to found out what the issues or obstacles are.” "He is entertaining"

“Need to do more with AgriGater.”

DC: After the EM38 has been done would like some help interpreting the maps and advice on management or clarification on what it shows up.

Would you have made any of the proposed changes (if there are any) without the SHMP engagement.

HH: “Not in the same detail as we do now having done the work.” “We look more in depth now.” (Looking below the surface to 60 cm or more) HH thought the soil auger and the penetrometer were good. “Have had a soil corer out (on the farm) …we looked at the cores and could see and understand the clay layers and the sodic areas.”

DC: "fast tracked the direction we were going already". "The workshop on organic matter and soil biology was a light bulb moment."

How much of this do you think could be done in a group and how much is needed as personal attention to you and your farm?

HH: “Paddock stuff needs to be one on one with no distractions.” “Group discussions help share the understanding.”

DC: “Should be half and half - good day with RM.” "Nothing brings it home more than walking your property." (This was referring to being able to see where soils are in the landscape e.g. old water courses and other features.)

“Information (delivered) at workshops after (a) one on one paddock walk as you can (then) relate it to your own property.” “The hand auger and the penetrometer (are) useful when you have an experienced operater or person with you.” “Getting to know RM not just as an ivory tower person.” “Richard seems to be trying to take what he knows and help put it into some thing that can be applied to farms.”

Future work

The SHMP pilot needs to be followed through with the two initial participants. A taste has been given and the response is positive and enthusiastic. In particular the paddock walks were effective in getting the landholders themselves to see that there are real physical constraints that could be resolved through some management changes.

A system of record keeping has not been introduced or imposed during the pilot, but the participants do need a system if there is to be long term value and monitoring of the SHMP. They should now be in a position to recognise this and be receptive to adopting a system - but it will need to be simple and effective. It will be very valuable if the participants can augment their existing farm business accounts with more detailed documentation of fuel use, tractor hours and area covered. The latter will help to refine inputs into the AgriGater package but should, over time also show whether changes in soil management are reducing the mechanical costs of crop production.

Key issues to follow through with are:

- Record keeping - paddock by paddock and crop by crop record of inputs including tractor hours and fuel.
- Plan for monitoring and soil testing.
- Machinery audit and possible long term plan for unifying wheel spacing to support controlled traffic (e.g. 3 metre spacing).

Both the pilot SHMPs were on mixed cropping and sheep farms. One important improvement to soil condition is management of soil structure and dealing with compaction. There is an increasing body of evidence to support the benefits of zero till and controlled traffic systems. The success of these systems has been on cropped land without livestock. A major challenge to an SHMP then is how to design a system that can adopt the principles and practice of zero till and controlled traffic but to include sheep in the system.

Conclusion

Pressures on the farm sector increase annually for a variety of reasons. Costs of production, seasonal hazards, climate change and prospective incorporation of agriculture into national and global CPRS are just some of the factors. Soil productivity and health are always going to be important in the farm business. It is crucial that, where business activities may affect the soil or be affected by the soil, the right questions are asked and appropriate decisions are made. Some actions in a SHMP may require years of investment to achieve (e.g. changing machinery over to allow complete controlled traffic).

A SHMP has the potential to focus the farm business on the soil – it will only be successful if this is the approach – soil health is not an end in itself.

The process of developing a sound SHMP needs strong support, both from the technical side and the social side. From a DPI perspective this would require building a team between Future Farming Systems Research Division and Farm Services Victoria Division. The Departmental approach ‘Better Services to Farmers’, particularly concerning ‘wholesaling’ versus ‘retailing’, raises questions about capability and consistency if the SHMP (perhaps as a component of Farmplan21) is delivered. One of the main issues that came from the participating farmers was that of the trust they developed during the pilot.

Appendix A - Questions

Questions used to seed discussion at the introduction of the SHMP process (kitchen table discussion). After the round table discussions these were left as 'homework' for the participants. The real value was in the conversation and engagement rather than the particular responses.

The Farm Business – planning and management

1. Describe the Farm Business (size, type of enterprises, history)
2. What are the primary business goals?
3. How far ahead do you plan? Is there a long term plan / goal?
4. How much of your time is spent managing the farm business (planning, record keeping etc.)
5. What tools do you use to help you manage the farm business?
6. Do you use a computer to manage the farm business records and plans?
7. Have you ever done a whole farm plan?
8. If yes, when was it done and how useful was it? Is it still useful?
9. Are there any tools or skills that you think you need to help make the farm business more effective?
10. How much time per year would you be prepared to put into developing and implementing a soil health management plan?

The Soil

1. How important is the consideration of soil in short and long term planning?
2. Why is this so?
3. What business activities and decisions are affected by the soil or soil condition, and affect or might affect soil condition?
4. Do you have a definition of soil health?
5. What is it?
6. Do you have a goal for soil health?
7. What is it?
8. How often would you walk in most paddocks during the year?
9. Do you look at, handle or sample the soil during any of these visits?
10. Do you have different soils on your farm?
11. Describe the main characteristics of the soils on your farm?
12. Do you have a good appreciation of where the soil differences are?
13. Do soil differences affect any management decisions?
14. Are there any things about your soil that you find difficult to manage?
15. Have you adopted any management practices that are specifically to help soil condition or health?
16. How often have you or do you sample soils for chemical analysis?
17. Do you always use the same laboratory for soil analysis?
18. Who gives you advice with regard to managing your soil fertility?
19. What is your practice with regard to soil fertility management (major nutrients NPK)
20. What fertility aspects do you deal with besides NPK?
21. Have you ever used lime? Why, when, how much and what was the result?
22. Have you ever used gypsum? Why, when, how much and what was the result?
23. Have you ever used organic manures? Why, when, how much and what was the result?
24. Have you ever used any 'biological' products? Why, when, how much and what was the result?

Machinery and stock

1. If you have stock how do you manage paddocks with regard to cropping, pasture and stock?
2. How many different machines and implements do you use to manage your crop or stock?
3. Do you know what they weigh?
4. Do you know their wheel spacings / axle width?
5. Do you determine tyre pressures within any particular range? Why or why not?
6. Do you have any plans for new machinery in the next 5-10 years? What?

Appendix B - Program

Through the DPI's *Healthy Soils* project, seminars and training modules were delivered to the MLSC. A summary of activities is shown in Table 1.

Table 1. Timetable of activities in the Soil Health Management Plan pilot project.

Date	Event	Duration	Who
Pre September 2008	Pits excavated, sampled and analysed. Geophysics surveys for trial sites. Field days, trials, pit days, seminars.	15 days	DPI staff MLSC group
September 2008	Pits excavated, sampled and analysed for Lucerne trial sites and SHMP participating farms.	8 days	DPI staff MLSC farmers at Lucerne trial sites
October 2008	'Understanding soils and soil structure module' (group) Hands on activities and field visits (soil pits).	1 day	DPI staff MLSC group
December 2008	Half day kitchen table discussion - soil health planning and the farm business. (2 participating farms)	0.5 day plus 0.5 day preparation	DPI staff SHMP pilot participants MLSC facilitator
January 2008	Half day in DPI - GIS session to identify land parcels for the 2 farms.	0.5 days plus 1.5 days support	DPI staff SHMP pilot participants MLSC facilitator
January 2008	GIS output returned to farmers with paddock boundaries for validation and naming.	0.5 days	DPI staff
February 2009	Half day in DPI - AgriGater training and collation of paddock information from 2 participating farms.	0.5 days plus 0.5 days support	DPI staff SHMP pilot participants MLSC facilitator
March 2009	Understanding soil tests - module delivery (group)	1 day	DPI staff MLSC group
June 2009	Demonstration of moisture monitoring probe and logger (Martin Peters)	0.5 day	Consultant MLSC group
June 2009	Paddock walks with participating farms	2 days plus 0.5 day map preparation	DPI staff Landholder
July 2009	Presentation to group and feedback provided by SHMP farmers	1 day	DPI staff MLSC group
July 2009	Understanding soil water Soil organic matter Soil biology Module delivery (group)	1 day plus preparation	DPI staff Consultant MLSC group
July - Sept 2009	Report production (including pit report for Lucerne sites	10 days	DPI staff