Goulburn Broken Soil Health Action Plan

October 2006

Acknowledgments

This document was developed through funding provided by Incitec Pivot

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SECTION A: INTRODUCTION and BACKGROUND

1.1 The Goulburn Broken Regional Soil Health Action Plan

The Goulburn Broken Catchment, in northern Victoria, is part of the Murray Darling Basin. It takes in the catchments of the Goulburn and Broken Rivers and a small part of the Murray Valley, downstream of Bundalong. The Catchment covers 2,339,960 ha, or 10.5 per cent of the State, and is widely regarded as the "foodbowl" of Victoria and Australia. Soil health is the basis for maintaining agricultural production in the catchment.

There has been increasing concern that soil health in the Goulburn Broken Catchment has been declining. While this can be a natural process, farming practices and human impact have accelerated erosion, salinity, sodicity, acidity, soil structural decline, reduced soil biodiversity and lowered soil resilience. Declining soil health will affect agricultural production, and will also influence the success of revegetation efforts and erosion control.

A strategic approach to managing soil health is vital for the maintenance and rehabilitation of land in the catchment. In 2002, the Goulburn Broken Soil Health Steering Committee was formed to develop a draft Goulburn Broken Soil Health Strategy for the Goulburn Broken Catchment Management Authority (GBCMA). This Strategy forms a component of the Goulburn Broken Regional Catchment Strategy (2003).

In late 2005, it was agreed that an Action Plan was needed to stimulate and guide the implementation of the Goulburn Broken Soil Health Strategy. This Action Plan is intended to assist regional programs in the strategic management of soil health. The Plan will be used to inform funding and investment decisions. The Soil Health Action Plan will also assist the formulation of resource condition targets for the Regional Catchment Strategy, particularly targets for soil pH and soil organic carbon.

A Soil Health Action Plan is needed to assist in the strategic management of soil health in the Goulburn Broken catchment for the following reasons:

Water quality

While the Goulburn Broken Catchment covers only 2% of the Murray Darling Basin, it provides 11% of its stream flow. Declining soil health due to contaminants, acidity, erosion, salinity and poor soil structure can lead to increased levels of chemicals, sediment, nutrient and salt in waterways.

Loss of topsoil

Erosion on agricultural land in the region has caused a loss of valuable topsoil, resulting a decline in the productive capacity of the land, and threatening the quality and stability of terrestrial habitat**.**

The acid attack

Although soils in the Goulburn Broken region are naturally acidic, a rapid decline in pH levels has been recorded since land clearing began. For example, about 20 per cent of red duplex soils in the upper Goulburn Broken region have a pH level less than 4.5. Some 60 per cent of yellow duplex soils in the mid Goulburn Broken region have a pH level of 4.5-5.0.

Salinity control and acid soils

Acid soils are a major barrier for successful implementation of salinity control measures, mainly the establishment and persistence of perennial pastures. Acid soil management is crucial for the management of other land degradation issues such as biodiversity, river health and weed management.

Soil sodicity and soil structural decline
Soil structural decline (dispersive soils, hardpans, compaction, waterlogging) affects many of the region's cropping soils. Adopting management practices to improve soil structure is vital to prevent production losses and ultimately irreversible damage to the soil.

Urgent action is required as many of these issues may lead to irreversible damage to the soil. The focus of the Action Plan is on private land and the education of landholders.

1.2 History of soil health extension in the Catchment

A recent review of soil health activity in the Goulburn Broken catchment (appendix 1), has revealed much current activity and an emerging interest in soil health across the catchment. A review of past soil health extension programs has demonstrated a clear shift from the old approach of 'fixing up' single issues, to the more recent integrated holistic farm and catchment system approach. Key highlights from this historic review include:

- In 1912 the Victorian Department of Agriculture launched a major campaign to lime soils (Barr and Carey, 1992).

- In 1923 the Agricultural Societies of the Goulburn Broken Catchment were the first to run crop and fallow competitions (Barr and Carey 1992).

- In 1937 scientists at the Rutherglen experimental farm developed the clover ley system by sowing wheat into clover pasture plots (Barr and Carey 1992).

- In 1940 the Soil Conservation Act was passed by parliament which provided for the creation of a Soil Conservation Board (Thompson 1979). A major focus of the board was soil erosion.

- In the late 1950's and early sixties concern over declining soil fertility led to trial work to investigate pasture response to fertilizer in Victoria.

- In the early 1960's awareness of salt patches grew and the initial focus of extension was on management of discharge areas (Barr and Carey 1992). Management of recharge areas became the focus in later extension programs.

- In the late 1960's and 1970's the Rutherglen Research Institute developed the direct drilling technique for crop establishment that eliminated the need to cultivate (Barr and Carey 1992).

- In the early 1990's the Department of Agriculture and the Department of Conservation, Forests and Lands combined to implement an extension program called SoilCare in the dryland cropping area of the catchment. The SoilCare program recognized that farm sustainability requires complex and difficult changes in farm management – not just the adoption of a commercial product (Barr and Carey 1992).

- In 1994 the Catchment and Land Protection Act was passed by the Parliament of Victoria. The key purpose of the Act was to set up a framework for the integrated management and protection of catchments, and to encourage community participation in the management of land and water resources (CaLP Act). The Goulburn Broken Catchment Management Authority was established to maintain and enhance long-term land quality and productivity while also conserving the environment.

The challenge facing us is to learn from, and build on, the initiatives taken in the past, and to resist the temptations of denial, postponement, and tinkering with unsustainable designs (Hill, 2001). The quest for a more sustainable catchment system highlights the importance of soil organic matter and soil carbon in agricultural systems. This quest will continue to require complex and difficult changes to land management practices – not just the adoption of discrete pieces of technology or products. Public investment in programs that encourage local small groups to explore approaches for

conserving soil organic matter may bring about a deeper understanding of sustainability and a redesign of the farm system.

The review highlights the following key gaps for public investment in soil health:
- the need to assist farmers to develop sustainable, profitable, soil carbon conserving land management systems;
- the need for policies and programs that encourage the adoption of a stewardship philosophy of land management and ownership that includes the notion of soil health;
- the need to partner with industry and the private sector to promote soil health as an integral part of the production system.

1.3 Overview of our region's soils

In the Goulburn Broken Catchment, there is a range of soils with strong texture contrast between the surface and subsoil horizons. The majority of these soils are Sodosols (41%), occurring mainly on the lower slopes of the catchment. These soils are characteristically sodic in the subsurface, poorly drained, with dense subsurface clays. Chromosols are also common (15%) in the mid and lower GB. They also have dense clay subsoils and are often poorly drained. Dermosols dominate in the upper GB (22%). These soils do not have a strong texture contrast, are well drained, and are commonly acid in the surface and subsurface profile. Other soil types include Kandosols (10%), Vertosols (4%), and Kurosols (4%), with small areas of Calcarosols, Hydrosols, Rudosols and Tenosols.

1.4 Key soil health issues

Water and wind erosion – twenty one percent of Victoria's agricultural land is currently at a high to very high risk of erosion as a result of current practices. In the Goulburn-Broken Catchment much of this land occurs in the foothills and middle regions of the catchment.

Salinity – salinisation of soils impacts not only on production levels, but also the surrounding environment. About 0.2 per cent of land in the dryland catchment is affected by land salinisation. This area has been growing by five per cent each year. Particular areas of concern are the interface between the hills and plains along the Strathbogie Ranges. In the SIR, about nine per cent of the land is underlain by shallow, saline watertables. By 2020, that will reach 14 per cent of the SIR area.

Soil acidity – twenty three percent of Victoria's agricultural land is acidic. Much of the mid and upper regions of Goulburn Broken catchment are affected by acid soils. Soil acidity can affect crop or pasture choice and the productivity of the plants grown. The pH of a soil controls the availability of nutrients and toxic elements in soil. Many biological processes in soils are also influenced by soil pH, as soil organisms are sensitive to pH changes.

Soil sodicity – an excess of sodium cations can negatively affect soil structure and stability. Sodic soils can be prone to seasonally perched watertables, erosion, hardsetting when dry and crust formation at the soil surface. The Shepparton Irrigation Region (SIR), and the western fringes of the dryland, is likely to become increasingly sodic in the future. The riverine plain of the Goulburn Broken catchment has large areas of brown and yellow sodosols requiring careful management.

Soil structure deterioration – red and yellow duplex soil types are most prone to soil structure decline. Agricultural practices and reduced organic matter impact on soil structure, reducing infiltration, drainage, and aeration in soils. Areas of land in the riverine plains dedicated to cropping, horticulture and irrigated pasture are considered a high priority for addressing soil structure decline problems.

Soil fertility and organic carbon – soil organic carbon is an indicator of soil organic matter levels. Soil organic matter is vital for soil fertility, good soil structure, and soil biodiversity and biological activity. Soil organic matter will influence the overall resilience of soils.

Soil biodiversity - soil biodiversity refers to the flora and fauna in the soil. Agricultural practices in general can reduce soil biodiversity and this affects productivity, soil resilience, and fertility. This ultimately affects the sustainability of production.

Soil and water contaminants – the extent of contamination of soils by chemicals is not well documented. Studies of shallow well sites in the Kyabram/Tongala region have shown some contamination of groundwater with pesticides.

1.5 Linking land and water strategies

The Goulburn Broken Soil Health Action Plan complements the objectives of a number of regional and state land and water strategies. It is important to ensure the Soil Health Action Plan programs link into other existing programs under the Regional Catchment Strategy. Integration of soil health into other catchment programs will broaden the scope of these other programs, and ensure the objectives of the Soil Health Action Plan are met. Table 1 lists key regional catchment programs and indicates the nature of the links with the component programs of the Soil Health Action Plan.

Programs in the Soil Health Action Plan with proposed activities that are already occurring in existing key catchment programs, or which could be easily accommodated into existing programs, include:

- Coordination program
- Some activities in the Best management practice program
- Whole farm planning for soil health
- Local government linkages

Programs in the Soil Health Action Plan with activities that have the potential to align and complement existing catchment programs include:

- Staff training
- Community education program
- Research
- Some activities in the Best management practice program

The key gaps not covered by other programs/strategies are:

- Monitoring and evaluation program
- the small and lifestyle farm sector
- A focus on soil organic carbon

Table 1 Linkages to other catchment strategies and programs

Key GB Soil Health Action Plan Programs	**GB Salinity and Soils Program "GB Dryland Salinity Management Plan"**	**GB Biodiversity Program "A Strategic Plan for Integrating Native Biodiversity 2004-2007"**	**GB River Health and Water Quality Program "GB Water Quality Strategy" "GB River Health Strategy"**	**Agricultural Industries and LandCare extension programs in the GB**	**Relevant GB Soil Health Action Plan proposals**
Links to Strategy Targets	Soil health affects plant growth and hence recharge rates. In particular, acid soils limit the effectiveness of perennial pastures and recharge control.	Declining soil health affects the ability of vegetation to regenerate and the effectiveness of revegetation. Decline in soil health leads to decline in soil biodiversity.	Soil erosion affects nutrient and sediment inputs to waterways. Acid soil may also have potential impacts.	Soil health is a major factor in agricultural productivity and sustainability	
Coordination Program	Sustainable Landscapes Program management. Salinity/soils/ biodiversity extension network.	Biodiversity Integration Group.	Water Quality coordination Waterways Working Groups		Soil health extension network and soil health steering group
Community Education	Delivery of a comprehensive Whole Farm Planning program. Extension and incentives for revegetation, vegetation management, and establishment of lucerne on	Incentives for revegetation and vegetation management. Calendar of community biodiversity workshops (one event on soil biology last year)	Extension and incentives for revegetation and vegetation management on priority waterways. Promotion of 'current recommended practices for water quality'	BeefCheque PrimeLamb Best Wool Target10 TopCrop Horticulture Evergraze Fertilising grazed pastures course EMS	Soil health monitoring kits Soil health community workshops/forums Establish a network of best management practice sites Community awareness activity

	recharge sites. Promotion of 'best management practices.' Newsletters and media, community field days, workshops, pasture walks, forums, etc.			Biological farming Landcare projects: (eg. Balanced Productive Soils project, Dung Beetle project)	

Staff Training	Internal staff training program. Partnership with Landmark staff for delivery of staff training.	Internal staff training program Box-ironbark ecology course has soil health component.	Internal staff training program Annual staff training event	Internal staff training program	Soil health training for all extension staff including: CMA staff, DPI, Local Government and private
Promotion of Best Management Practice	General promotion of a wide range of 'best management practices'. Incentives for Lucerne on recharge sites require a pH test and lime application.	Promotion of direct seeding of appropriate sites in all programs. Promotion of perennials and understorey species, including native grasses. Promoting awareness of the need to improve soil biodiversity to facilitate better direct seeding.	Promotion of revegetation and stabilisation of soils in the riparian zone. Promotion of 'current recommended practices for water quality'. Erosion control works. Stream stabilisation works.	Promotion of deep-rooted perennials, native grasses, liming acid soils, revegetation, and fencing off drainage lines.	Promotion of: - soil testing - whole farm planning - land class fencing - rotational grazing systems - appropriate fertiliser use - liming of acid soils - inclusion of deep-rooted perennials into farming systems - retention and management of native grass pastures - appropriate cultivation and cropping practices

					- stubble management - erosion control works – stream and gully stabilisation works - fencing and management of native vegetation - fencing and revegetation of priority locations - options to improve organic carbon levels - options to improve soil biodiversity
Local Government Links	DPI involvement in strategic and statutory planning processes, eg. salinity overlay triggers referral to DSE/DPI.	Provides input into Municipal Strategic Statement reviews	CMA involvement in strategic and statutory planning processes		- process for assessing impact of development proposals on soil health - input of land capability assessments into the strategic plans of local Government.

Research	Linkages to soil health research undertaken by PIRVic and other research organisations.	GBCMA is working with CSIRO to Develop salt tolerant inoculants to improve the soil biodiversity and investigating other fungi and soil bacteria	Some linkages to research with soil or water quality focus	Projects funded by: - WI - MLA - GRDC Some LandCare projects have a research/demo.	Quantify the off-site impacts of soil acidification. Quantify the impacts of the 'do nothing' scenario for pH decline. Investigate the effects of using waste

		associations to help in direct seeding success. Develop a better understanding of the value of native biodiversity assets Do paddock trees conserve soil microbial diversity?"		component (eg. Dung beetles).	products as soil conditioners. Investigate the impact of land management on the diversity and function of soil biota.
Monitoring and evaluation	Limited monitoring of soil health parameters.	Soil health is not currently monitored through the Biodiversity program, however the Laying the Foundations project is looking at the "robustness of the Landscape Function Analysis scoring system in remnant, temperate woodlands by examining relationships between nominal and measured indicators of soil nutrient status" – this may provide future opportunities for gathering baseline data and monitoring		Incitec soil testing data Landcare survey of farmers attitudes to acid soils, lime and soil testing (2005) Soil care survey of cropping farmers attitudes to soil degradation, Direct Drill and stubble management (1989, 1992)	Link with community groups to collect soil health data from demo sites and a framework for data storage and evaluation Review existing data to build a soil inventory and develop baseline data for monitoring acidification, erosion, structure and carbon, salinity and condition targets Baseline data on landholder attitude, knowledge, and behaviour on soil health Network of sites to be monitored over time

SECTION B: DEVELOPING THE ACTION PLAN

PART 1: ACTION PLAN DEVELOPMENT PROCESS

The process of developing the Goulburn Broken Soil Health Action Plan has involved the following stages:

1. The development of a draft framework.

2. A Regional Soil Health stakeholders workshop held in late 2005 to review current activity in soil health in the region, and to identify gaps in the draft framework**.** This involved farmers, landcare, regional scientists, regional program leaders and extension staff, and Victorian Farmers Federation representatives. The workshop also identified key priority actions.

3. Appointment of a steering committee in early 2006 to oversee the project and an executive officer.

4. Identification of appropriate cross-linkages with other regional land and water strategies.

5. Identification of appropriate cross-linkages with other statewide and national initiatives and projects.

6. Development of draft action plan in consultation with the Steering Committee.

7. Consultation workshop for input from Implementation Committees and community representatives.

8. Set priorities for actions.

9. Develop an implementation timetable.

10. Presentation to the GBCMA Board for endorsement.

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PART 2: ACTION PLAN OBJECTIVES & PRINCIPLES

2.1 Objectives

The major objectives of the Goulburn Broken Soil Health Action Plan are:

1. To provide a framework for action to improve soil management in the Goulburn Broken Catchment.

2. To improve regional community awareness and knowledge of the agricultural and environmental impacts of soil health.

3. To maintain the long-term productivity and sustainability of the land in the region, and minimise poor soil management.

4. To provide land managers with the tools to monitor and manage soil health.

2.2 Basic Principles

1. Community education is the key to improving management of our region's soils.
The major priority of this Action Plan is to improve community awareness of the impact of soil health and to implement on-farm change. Developing the skill-base of current land managers to check, monitor, and evaluate soil health is a priority.

2. Soil health management will deliver community-wide benefits.
Soil health management delivers public and private benefits, and costs should be apportioned appropriately. Sharing of costs is needed between all beneficiaries, not just landholders.

2. Best Management Practice Approach.
The development of best practice guidelines for a range of industries will be a key approach. All land managers, private industry and local government have a duty of care to adopt Best Management Practices to manage land and water degradation.

4. A component of the Goulburn Broken Regional Catchment Strategy.
Priorities identified in the Regional Catchment Strategy will be recognised in the Soil Health Action Plan.

5. Co-operative approach.
The Action Plan will require a cooperative approach between all stakeholders in the development, implementation and monitoring phases of the Plan. The role of private enterprise is vital for the success of this cooperative approach.

6. Land and water degradation issues are linked within a catchment.
A holistic approach must be taken for soil health management, due to links with other natural resource management issues such as water quality, biodiversity, and productivity.

7. Monitoring and evaluation is fundamental to action plan success.
Monitoring of the implementation of the Action Plan and of the status of regional soil health is important to ensure Action Plan success and to identify changes in priorities. Monitoring and evaluation is important for reporting progress.

8. Adaptation of Action Plan programs in light of new research.
Current knowledge and understanding of soil chemical, physical and biological processes is limited. Action Plan programs will be reviewed as new research becomes available.

SECTION C: THE ACTION PLAN

The Goulburn Broken Soil Health Action Plan is made up of 7 key programs. These key programs contain priority actions vital for the success of the overall plan. The main focus of the Action Plan is community education, and the promotion of best management practices that control soil; acidification and conserve soil carbon.

PART 1: OVERVIEW OF THE ACTION PLAN PROGRAMS

1. Co-ordination Program

Co-ordination of all programs within the Action Plan is the key to the success of regional soil health management. Wherever possible, implementation will occur through other natural resource management programs within the region. Implementation of the Action Plan will be over-seen by the three Implementation Committees of the Goulburn Broken Catchment Management Authority.

- Linkages to other strategies and programs
- Establishment of extension staff network
- Provide technical information
- Reporting - quarterly and annually
- Coordinate the Community Education program

2. Community Education Program

This program focuses on developing the skill base of landholders and communities to assess, monitor and manage the soil resource in a profitable and sustainable way.

- Awareness programs promoting the importance of soil health and management systems for minimising soil acidification and improving soil organic carbon
- Community knowledge and capacity development programs
- Staff training in soil health
- Developing a Soil Health Monitoring Kit for the Landcare network

3. Best Management Practice Program

This program focuses on promoting current best management practices which will promote soil health. These practices include: whole farm planning, land class fencing, rotational grazing systems, appropriate fertiliser use, liming of acid soils, inclusion of deep-rooted perennials into farming systems, retention of native grass pastures, appropriate cultivation and cropping practices, stubble management, erosion control works, stream and gully stabilisation works, and fencing and revegetation of drainage lines and streams. There are also specific practices to improve organic carbon levels and improve soil biodiversity.

- Incorporation of a soil health component into existing extension programs
- Establishment of a network of existing Best Management Practice demonstration sites
- Development of a partnership with private enterprise to develop and promote a shared understanding of best management practices that minimise soil acidification and conserve organic carbon

4. Whole Farm Planning for Soil Health

A fundamental component of improving soil health in the region is through promoting soil-based property planning and sub-catchment planning.

- Incorporation of soils aspects into regional Whole Farm Planning activities
- Delivery of accredited courses for land managers in Property Planning for Soil Health and Soil Management
- Encourage Landcare groups to develop sub-catchment plans
- Pursue options for cost share arrangements for soil testing

5. Local Government Planning Program

Local governments play a vital role in planning land use in the shires of the Goulburn Broken region. Major actions in this program include:

- Assisting Local Government to incorporate soil health issues into strategic and statutory planning processes
- Training and information for Local Government staff on soil health issues as they affect planning
- Refinement of land capability mapping and assessment
- Developing options to encourage the adoption of a stewardship philosophy of land management and ownership that includes the notion of soil health

6. Monitoring and Evaluation Program

Long-term monitoring of soil health is essential to monitor trends over the years and to evaluate the action plan's success. This will be achieved via the following actions:

- Compilation of baseline data on landholder attitudes, knowledge, and behaviour on soil health
- Development of a database for compiling soil health information from regional demonstration sites and soil test data
- Review of existing soils data to develop a baseline for monitoring soil health - acidification, soil carbon, soil biota, soil structure, erosion, and salinity
- Establish appropriate regional Resource Condition Targets for soil health
- Long-term monitoring of the condition of our soils, using a network of sites, as part of monitoring implementation of the Regional Catchment Strategy

7. Research and Investigation Program

There are significant gaps in knowledge for both the soil health status of the region's soils and also the best ways to continue agricultural production whilst sustaining the soil resource. Priorities for further research include:

- Quantification of the off-site impacts of soil acidification
- Quantification of the impacts of the 'do nothing' scenario for pH decline
- Investigation of the role of soil carbon on agricultural production.
- Identifying the effects of agriculture on soil biota
- Studying the effects of using waste products as soil conditioners

PART 2: THE ACTION PLAN PROGRAMS AND PRIORITIES

The Action Plan programs are presented in Tables 2 to 8. These Tables list the key activities in each program, together with the priority ranking, the agency responsible for implementation, and the timeframe for implementation of each activity. The priorities were determined from the following criteria:

a. Public benefit – the extent to which benefits flow to the wider community.
b. Private benefit to land managers, as an indicator of the likelihood of landholder willingness to be involved in the programs.
c. Urgency, an assessment of how quickly action needs to be taken.
d. Compatibility with existing programs, as an indicator of whether or not additional resources are required to align with existing programs or whether new programs are required.

Each of the criteria were weighted, with public benefit being paramount (weighting of 0.4), followed by private benefit (weighting of 0.25), urgency (weighting of 0.25), and compatibility (weighting of 0.10).

The timeframe for implementation was developed by starting with the high priority actions first for implementation and then working on lower priority actions later.

Table 2: *Co-ordination Program (Program1)*

	Action	Priority	Imp. respon.	Timeframe	Comments
1.1	Coordinate linkages to other regional and statewide soil health programs	Mod High	DPI/ CMA	Ongoing	Build into current programs
1.2	Coordinate the development and implementation of staff training and community education, including the provision of relevant information	Mod High	DPI/ CMA	Ongoing	Build into current programs and explore the role of the private sector
1.3	Create an extension staff network for soil health (includes public agencies and private industry)	Mod Low	DPI/ CMA	06/07	Link with existing Salinity and Soils extension network
1.4	Facilitate funding for soil health programs, and develop joint funding bids	Mod High	CMA/ DPI	Ongoing	Build into current programs
1.5	Report quarterly and annually on implementation progress through normal regional reporting processes	Mod High	DPI/ CMA	Ongoing	Build into current programs

Table 3: *Community Education Program (Program 2)*

	Action	Priority	Imp. Respon.	Time frame	Comments
2.1	Provide training in soil health for agency extension staff, private sector staff, community groups, and local government staff	Mod High	DPI	06/07	Currently occurs in salinity and soils program, but requires a review of delivery package and links with the private sector
2.2	Incorporate a soil health module into existing landholder extension programs	Mod High	DPI	Ongoing	Currently included in many programs but requires an alignment of approaches
2.3	Develop soil health monitoring kits for the regional Landcare network. Organise field days and workshops to demonstrate the use of tools in kit	High	DPI	06/07	Currently being developed under the MYFOL program in partnership with the NE Soil Health program
2.4	Raise community awareness of soil health program. Organise and promote soil health awareness activities (eg. workshops, forums, field days, soil testing and mapping projects)	Mod High	CMA/ DPI/landcare		Will require additional resources

Table 4: *Best Management Practice Program (Program 3)*

	Action	Priority	Imp. respon.	Time frame	Comments
3.1	Establish and maintain a network of "Best Management Practice" demonstration sites across the region as a tool for farmers to learn from farmers	Mod Low	Landcare and landholder groups	Ongoing	Currently a part of many landcare projects and NLP funded projects and can be built into existing programs
3.2	Develop partnerships with private enterprise to develop and promote a shared understanding of best management practices that minimise soil acidification and conserve organic carbon	Mod High	CMA	06/07	Requires development of a specific proposal for engagement of the private sector

3.3	Promote current best management practices for soil health including: - soil testing and understanding test results - whole farm planning - land class fencing - rotational grazing systems - appropriate fertiliser use - liming of acid soils - inclusion of deep-rooted perennials into farming systems - retention and management of native grass pastures - appropriate cultivation and cropping practices - stubble management - erosion control works - stream and gully stabilisation works - fencing and management of native vegetation - fencing and revegetation of priority locations (eg. slopes, recharge areas, drainage lines, streams, habitat linkages) - options to improve organic carbon levels - options to improve soil biodiversity	Mod High	DPI/ CMA	Ongoing	Currently part of DPI and CMA core extension programs Effectiveness will depend on 6.1. Need to develop a partnership approach with the private sector

Table 5: ***Whole Farm Planning for Soil Health (Program 4)***

	Action	Priority	Imp. Respon.	Time frame	Comments
4.1	Incorporate soil aspects into regional Whole Farm Planning activities (MYFOL). Include a 'fit for purpose' notion of soil health	High	DPI	06/07	Build into current programs and include the private sector
4.2	Develop and deliver nationally-accredited training in Property Planning for soil health. Deliver courses to land managers in Soil Management (Natural Resource Management Training Package)	Mod High	DPI	Ongoing	Build into current programs
4.3	Encourage Landcare Groups to develop subcatchment plans	Mod Low	CMA/ landcare	Ongoing	Build into current programs
4.4	Explore the issue of "What is the Duty of Care for landholders concerning soil health?" and incorporate into programs	Low	CMA	08	Could be picked up as part of the development of the GB Dryland Landscape Strategy Eventually, and built into current programs

Table 6: ***Local Government Planning Program (Program 5)***

	Action	Priority	Imp. Respon.	Time frame	Comments
5.1	Assist Local Government to incorporate soil health issues into strategic and statutory planning processes	Mod High	DPI/ Shires	06/07	Currently occurring in the regional MYFOL program, and the Statewide Streamlining Property Management Systems project, but needs to develop specific soil health aspects
5.2	Provide training and information to Local Government staff on soil health issues as they affect planning	Mod High	DPI/ Shires	08	Will require additional resources
5.3	Review municipal planning schemes and procedures to provide a process for input of land capability assessments into strategic local Government plans	Mod High	DPI/ Shires	08	Will require additional resources
5.4	Assist Local Government to develop options which encourage landholders to adopt a stewardship philosophy of land management and ownership that includes the notion of soil health	Low	CMA/ Shires	08	Will require additional resources

Table 7: ***Monitoring and Evaluation Program (Program 6)***

	Action	Priority	Imp. Respon.	Time frame	Comments
6.1	Compile baseline data to allow monitoring and evaluation of changing landholder attitudes, behaviour, and understanding of soil health issues And landuse	Mod High	CMA/ Landcare	06/07	Have some past data but will require a new funding bid and additional resources
6.2	Link with Landcare groups to develop a database for compiling soil health information from regional demonstration sites and soil test data	Mod Low	DPI/ CMA	08	Will require additional resources Links with Actions 6.3 and 3.2
6.3	Review existing soils data to develop a baseline for monitoring soil health – current status for acidification, soil carbon, biotic activity, soil structure, erosion, and salinity	Mod Low	DPI/ CMA	08	Will require additional resources Link to the Better Fertiliser Decisions (PIRVic Ellinbank) project
6.4	Establish appropriate regional Resource Condition Targets for soil health (pH and Organic Carbon), including definition of methodology, sampling site network, and reporting process	Mod Low	CMA	08	Will require additional resources

6.5	Establish a network of sites to monitor the condition of our soils, as part of monitoring implementation of the Regional Catchment Strategy	Low	CMA/ DPI	Ongoing	Will require additional resources

Table 8: ***Research and Investigation Program (Program 7)***

	Action	Priority	Imp. Respon.	Time frame	Comments
7.1	Identify the public benefits of ameliorating acidic soils: - quantify the off site impacts of acidification - quantify the impacts of the 'do nothing'scenario for pH decline	Mod High	CMA/ Research bodies	06/07	Will require additional resources Some work has already been undertaken by PIRVic Rutherglen & others
7.2	Investigate the various roles of soil carbon and biology including impact on agricultural production	Mod	CMA/ Research bodies	08	Will require additional resources GBCMA role limited to support for research funding bids
7.3	Conduct further investigation into the impact of land management on the diversity and function of soil biota	Mod	CMA/ Research bodies	09	Will require additional resources GBCMA role limited to support for research funding bids
7.4	Identify and develop acid - tolerant perennial pastures which can be used as alternatives to lucerne and phalaris	Low	CMA/ Research bodies	09	Will require additional resources
7.5	Investigate the effects of using waste products as soil conditioners. Investigate capacity of bio-solids for increasing soil buffering capacity	Low	CMA/ Research bodies	08	Will require additional resources GBCMA role limited to support for research funding bids
7.6	Investigate definitions and measures of soil health	Low	CMA/ Research bodies	08	Will require additional resources

Section D: Priority Programs for 06/07

At a Regional Soil Health stakeholders workshop in 2005, participants reviewed current activity in soil health in the region and identified key priority actions. The steering committee has used these workshop outcomes to develop the focus for implementation of the soil health action plan for the next 2 years.

1. Coordination

Soil Health Action	What needs to be done?	By Who?	Status
Facilitate funding for soil health programs	• **Identify funding opportunities** • **Develop funding briefs with landcare coordinators for NLP** • **Work with the balanced productive soil project committee to develop new project**	**CMA/DPI**	
Report implementation progress to implementation committees	• **Advise on changes and amendments** • **Develop report requirements**	**CMA/DPI**	Implementation committees Consulted on soil health action plan
Create extension network for soil health	• **Integrate soil health with the salinity and soils program network**	**DPI/CMA**	
Coordinate the development and implementation of staff training and community education program	• **Integrate soil health training into the sustainable landscapes knowledge sharing network and other staff training programs**	**DPI/CMA**	Initial introduction training completed

2. Community education

Soil Health Action	What needs to be done?	By who?	Status
Develop soil health monitoring kits with Tools to help landholders, staff and industry people understand their soils	• **Develop the kit contents** • **Publication of instructions and recording sheets**	**DPI**	Kit contents develop Draft instructions complete
Field days and workshops to demonstrate use of tools in kit.	• **Develop training schedule for landcare staff** • **Develop program for landholder workshops/field days** • **Link with the Balanced productive soil project field days**	**DPI**	Some field days conducted
Training in soil health for extension staff, private sector, and local government	• **Training needs assessment** • **Review of salinity and soils program of staff training** • **Develop training package for local regional staff**	**DPI**	Training needs assessment complete

3. Best Practice Management Program

Soil Health Action	What needs to be done?	By Who?	Status
Develop partnerships with private enterprise to develop and promote a shared understanding of best management practices	• **Follow up with Ajax fertiliser on possible partnership opportunities** • **Explore possible expansion of the landmark partnership program**	**CMA**	Preliminary discussions with Ajax on subsidised soil tests in a pilot area
Promote current best practice	• **Incorporate soil health kit exercises with level one MyFoL farm visit**	**DPI/CMA**	

4. Whole Farm Planning

Soil Health Action	What needs to be done?	By Who?	Status
Incorporate soil aspects into regional whole farm planning activities	• **Strengthen the soil health focus in level 1**	**DPI**	Soil health currently included in level 2 whole farm planning course

5. Local Government Planning

Soil Health Action	What needs to be done?	By Who?	Status
Assist local government to incorporate soil health issues into strategic and statutory planning processes	• **Identify soil information needs** • **Digitise the land systems maps** • **Further develop regional land capability maps**	**DPI/Shires**	Kate Culley currently working with shires

6. Evaluation and monitoring

Soil health action	What needs to be done?	By who?	Status
Compile Base line data to monitor and evaluate Landholder needs, attitudes and perceptions, and knowledge gaps with soil health	• **Collate past studies/data** • **Seek linkages with the DPI practice change group** • **Seek external funding**	**CMA/Landcare**	

7. Research

Soil Health Action	What needs to be done?	By Who?	Status
Identify the public benefits of ameliorating acidic soils. quantify the off site impacts of acidification, quantify the impacts of the 'do nothing' scenario on pH decline	• **Collate past studies/data and workshop information** • **Seek opportunities to better understand public benefits of soil health including soil acidity**	**CMA**	

Section E: Funding Options

1. Utilising Existing Resources

The Goulburn Broken Soil Health Action Plan complements the objectives of a number of existing programs under the Regional Catchment Strategy. Integration of soil health into other catchment programs ensures the objectives of the Soil Health Action Plan are met using existing resources. Many of the proposed activities can be easily accommodated into existing programs or have the potential to align and complement existing catchment programs.

2. Private Sector partnerships

Some of the proposed activities in the soil health action plan will require additional resources. The CMA is keen to develop partnerships and alliances with the private sector and landcare to seek external funding for the soil health program. Key activities that have a clear role for private sector partnerships and alliances include:

- the development and implementation of staff training in soil health
- identifying best management practices that conserve soil organic matter and minimise soil acidification
- promoting best management practices

3. External Funding Sources

A key part of the soil health action plan is facilitating the development of soil health project proposals with key stakeholders such as landcare, private sector partners, and government agencies. Additional resources maybe sought from a range of external funding sources:

- National Landcare program-this program is sponsored by the Federal Department of Agriculture Fisheries and Forestry which supports the landcare movement and the sustainable use and management of natural resources. The NLP encourages landholders to undertake landcare and related conservation works by supporting collective action by communities to sustainably manage the environment and natural resources
- National heritage Trust - The Natural Heritage Trust is administered by Federal Minister for the Environment and Heritage and the Minister for Agriculture, Fisheries and Forestry. The Trust funds targeted approaches to environmental and natural resource management including improved water quality, less erosion, improved estuarine health, improved vegetation management and improved soil condition.
- Enviro Fund is a local action component of the NHT funding communities undertaking local projects aimed at conserving biodiversity and promoting sustainable resource use.
- Healthy soils sustainable farms program – is managed by Land and Water Australia and focuses on increasing practices which maintain and restore

farmland soils by involving agricultural industry groups, farmers and community groups in testing new methods in commercial conditions. This program aims to increase farmer understanding of soil management issues in their region and capacity to use techniques to improve soil health and farm productivity.

Glossary of Terms

Aluminum toxicity: Occurs when soil pH drops below 4.9. Aluminum is released into the soil below this pH and increases to more toxic levels as pH declines further. Aluminum toxicity stunt roots, reducing their ability to take up water and nutrients.

Best Management Practice: Describes an application of the best available method to deal with an issue or to improve the current practice, improving sustainability of soil, water and vegetation resources.

Compaction: Increased density of soils caused by tillage, stock and vehicle traffic, often causing ploughpans to form.

Discharge site: The area where there is upward movement of groundwater, discharging from the soil surface.

Dispersive soil: Clay particles separate and move about freely in wet soil conditions, resulting in soil structure decline.

Groundwater: Free water below the surface in the layers of the earth's crust.

Gypsum: A naturally occurring material containing 23% calcium and 18% sulphur, used as a soil ameliorant to reduce soil dispersion and improve structure. Typical rates are up to 5 t/ha.

Land class: Land classified according to one or more limiting factors of that land such as slope, drainage, rockiness, erosion potential etc. Appropriate uses of that land are allocated according to land class.

Land Capability: is a system of a ranking land according to the capability of an area of land to support a range of agricultural activities on a sustainable basis. Land capability ranking is determined by factors that represent the greatest limit to productivity and sustainability.

Land system: is a mapping unit that contains a pattern of land components each of which has little variation in climate, lithology (rock type), landform, soil and indigenous vegetation. A land system can be used to broadly group land under a common unit of management for broad-scale uses such as dryland farming or forestry.

Lime: a naturally occurring material containing calcium carbonate, used as a soil ameliorant to reduce acidity and aluminium. Typical rates are up to 3 t/ha.

Nitrate leaching: Nitrate nitrogen is the main form of nitrogen that is taken up by the plant. Nitrate nitrogen is produced in the soil through the mineralisation of organic matter and from certain fertilisers. Excess nitrate nitrogen that is not taken up by the plant leaches below the root zone, contributing to soil acidification.

Perched watertable: A watertable above the main watertable level where impermeable soil or rock prevents the water from percolating through to the main groundwater body.

Permeable: The capacity of soil or rock to allow water to pass through it.

pH: a measure of the acidity or alkalinity of a soil usually in 1:5 soil 0.01M calcium chloride suspension or a 1:5 soil water suspension. The calcium chloride method gives pH values approximately 0.7 units lower than the water method.

Ploughpan: A layer of compacted soil at the base of the plough layer caused by repeated tillage at constant depth over many years.

Porosity: Permeable by water or air through pores (small holes).

Pugging: Damaging soil structure due to trampling by stock in wet conditions.

Recharge: Water that drains below the root zone of vegetation and into the groundwater.

Remnant vegetation: Vegetation remaining after an area has been cleared.

Rhizobia: The bacteria that are found in the root nodules of leguminous plants that convert atmospheric nitrogen to a form that the plant can use as an essential food source.

Slaking: The breakdown of soil aggregates due to the swelling of clay and expulsion of air from pore spaces when soil wetting occurs.

Sodicity: A measure of the amount of exchangeable sodium in the soil. High levels of sodium increases the likelihood of soil structural decline.

Soil conditioner: A material which when added to the soil will measurably improve the physical characteristics of the soil, such as sawdust and compost.

Turbidity: A measure of how much suspended solids of silt and clay is in a waterway.

List of Acronyms use in this report

BMP	Best Management Practice
CMA	Catchment management authority
CSIRO	
DPI	Department of primary industry
DSE	Department of sustainability and environment
EC	Electrical Conductivity
GBCMA	Goulburn Broken catchment management authority
LPIS	Land Protection Incentive Scheme
MYFOL	My Farm our Landscape
NHT	Natural Heritage Trust
PIRVic	Primary Industries Research Victoria

Appendix

Trends and directions for Soil Health Programs in the Goulburn Broken Catchment

Paper prepared by Cathy Botta for the steering committee for the Goulburn Broken soil health action plan (2006).

The Goulburn Broken Catchment, in northern Victoria, is part of the Murray Darling Basin. It takes in the catchments of the Goulburn and Broken Rivers and a small part of the Murray Valley, downstream of Bundalong. The Catchment covers 2,339,960 ha, or 10.5 per cent of the State and is widely regarded as the "foodbowl" for Victorian and Australia. The total catchment production value is about $7.8 million. Soil health is the basis for maintaining this agricultural production in the catchment.

There has been increasing concern that soil health in the Goulburn Broken Catchment has been declining. While this can be a natural process, farming practices and human impact have accelerated erosion, salinity, sodicity, acidity, soil structural decline, reduced soil biodiversity and lowered soil resilience. A Soil Health Action Plan is vital for maintenance and rehabilitation of land in the catchment.

A recent review of soil health activity in the Goulburn Broken catchment revealed much activity and emerging interest in soil health in the catchment. The review identified the need for a coordinated framework for soil health activity. The steering committee for the soil health action plan identified the need for strategic management to ensure investment in 'public good' soil health programs in the catchment. This requires the identification of key gaps in current investment and activity and identification of 'public good' components for investment.

To assist this process, this paper reviews the history of soil health extension programs in the Goulburn Broken catchment and attempts to identify the key trends over time. The challenge facing us is to learn from and build on the initiatives taken in the past and to resist the temptations of denial, postponement, and tinkering with unsustainable designs (Hill, 2001). This paper proposes key gaps for public investment in soil health programs.

Potted History of soil health extension programs in the Goulburn Broken Catchment

In 1912 the Victorian department of Agriculture launched a major campaign to lime soils (Barr and Carey, 1992). The continual harvesting of crops was believed to 'sour' the soil. During this campaign the Rutherglen Experimental farm was established to run experiments on a range of soil management techniques. Annual field days were run to show local and regional farmers the results.

In 1923 the Agricultural Societies of the Goulburn Broken Catchment were the first to run crop and fallow competitions (Barr and Carey 1992). Department of agriculture advisers were the judges. Good fallow practices involved many cultivations of the soil leading to surface crusting, erosion, and waterlogging in winter.

In 1937 scientists at the Rutherglen experimental farm developed the clover ley system by sowing wheat into clover pasture plots (Barr and Carey 1992). Farmers were encouraged to change from the long fallow system to the clover ley system.

In 1940 the soil conservation act was passed by parliament which provided for the creation of a Soil Conservation Board (Thompson 1979). The Act also made provision for the appointment of Regional advisory committees. Eight committees were formed including the Upper Goulburn and Lower Goulburn advisory committees.

In 1942 The soil conservation board and the state rivers and water supply commission donated a trophy (the Hanslow Cup) to support a competition in the Goulburn region for erosion control and farm sustainability (Barr and Carey 1992). The competition encouraged grassed waterways, contour banks and other erosion control measures. This was modeled on the Mallee soil drift control competition (Thompson 1979).

Early in 1942 the principal of the Dookie agricultural college was concerned about erosion on the college farm (Thompson 1979). Contour furrows were constructed by students with advice from the Soil Conservation Board. This was the first official contour work for erosion control done by the board in Victoria (Thompson 1979). The contour works served for some years as a useful demonstration to farmers, students and advisers.

In 1943 the first Soil Conservation Board field day was held on a farm near Avenel on granitic country near Hughes creek (Thompson 1979). The farm had extensive contour furrowing to control surface water runoff over sloping land. This field day set the pattern for many field days run by the board (Thompson 1979).

In 1944 the soil conservation board accepted an offer by CSIR to undertake a soil and erosion survey in the Dookie district (Thompson 1979). R.G. Downes was appointed to head the survey. The survey report was published in 1949.

In 1950 the Soil Conservation Board was changed to become the soil conservation authority. In 1951 a demonstration site was established near Yea with the Yea Shire council and landowners all cooperating (Thompson 1979).

The Site involved erosion control structures, tree planting, contour furrowing and sowing improved pasture.

In 1955 scientists from the Rutherglen Experimental Farm, established on farm trials and demonstrations at Yarrawonga of the clover ley system as sustainability concerns with the fallow systems grew (Barr and Carey 1992).

In the late 1950's and early sixties much trial work was done to investigate pasture response to fertilizer in Victoria. Responses to superphosphate and examples of interactions with potassium, molybdenum, and lime application are reported and reviewed by Hosking (1986) that includes sites in the Goulburn Broken region.

In 1959 the Victorian Soil conservation Authority was directed to control the erosion for the new water supply dam at Lake Eppalock (Barr and Carey 1992). The authority focused on the degraded soils and pastures of the surrounding hillsides. The program developed a partnership arrangement with the farmers for the sowing of pastures, land capability fencing, and soil erosion structures (Barr and Carey 1992). Government funds were needed to encourage landholders to adopt erosion control measures (Roberts 1989). Government funded extension services developed landholder awareness of the issue and assisted landholders to develop practical solutions. This approach to soil conservation spread to other regions.

In the early 1960's awareness of salt patches grew and concern over the erosion risk of these bare patches increased (Barr and Carey 1992). Extension focused on the revegetation and erosion control on discharge sites. It was not until the late 1970's that investigators realized that salinity was coming from factures in underlying bedrock (Barr and Carey 1992). In the 1980's extension redirected management towards revegetation of recharge. In 1984 the Potter farmland plan project began that combined erosion control and salinity management into farm planning programs.

In 1967 the national Soil Fertility Project, established a large series of field experiments across Australia to develop fertiliser recommendation models, primarily for nitrogen and phosphorus, based on soil analysis for nutrient content (Cowlrick, Pluske and Wylie, 2005). The National Soil fertility Project involved 96 pasture experiments across Victoria, including sites in the Goulburn Broken catchment, One model developed from this work was 'superate'. This model was adopted and widely used in this region by department staff during the 1970's and 1980's.

In the late 1960's and 1970's Rutherglen Research Institute developed the direct drilling technique for crop establishment that eliminated the need to cultivate (Barr and Carey 1992). The scientists showed improved soil structure with this technique. The ICI chemical company developed 2 herbicides that enabled the

direct drill technique to control weeds without cultivation. In the 1980's ICI consultants worked with farmer discussion groups in the catchment to promote direct drill systems and assist farmers adopting the technique on farms (Barr and Carey 1992).

The soil conservation authority promoted the concept of conservation cropping not just direct drill (Barr and Carey 1992). Conservation cropping was a broader sustainability concept that included erosion and stubble management, water use efficiency and salinity and improving soil structure. The idea of conserving soil organic matter was emerging in rotation and stubble management research projects in the 1980's.

In the early 1990's the Department of Agriculture and the Department of Conservation, Forests and Lands combined in an extension program called SoilCare in the dryland cropping area of the catchment. The SoilCare program recognized that farm sustainability requires complex and difficult changes in farm management – not just the adoption of a commercial product (Barr and Carey 1992). The program worked with local farmers in discussion groups that explored practical options to improve farm sustainability. Groups established demonstration paddocks and monitored soil and plant properties. Shared decision making ensured success and failure was shared (Barr and Carey 1992). Many SoilCare groups developed into landcare or land mangement groups taking on a broader focus and involving the broader community.

In the mid 1990's much of the catchments lupin crop was affected by a soil borne fungus that devastated crops. Many farmers looked to canola as an alternative crop in the rotation. Canola focused farmer attention again on lime and soil structure. Research findings reported the biofumigation properties of Canola raising interest in soil health and soil biology.

The combined effects of changes such as reduced tillage, introduction of new crops, expansion of grain cropping to soils previously not included in the national Soil Fertility Project, reduction in soil research funding, increase in the number of fertilizer supply companies and decline in publicly-funded advisory services resulted in reducing in the perceived credibility of the original models for nutrient application (Cowlrick, Pluske and Wylie, 2005). This provided a space for the consideration and introduction of a range of other nutrient management approaches that at times are at odds with the approaches of the past. These include 'Maintenance/build-up', 'Base cation saturation ratio' and 'removal/replacement', which generally rely less on calibration and more on concepts with more intuitive and transparent methods of determining the requirement for nutrients and rates of nutrient addition (Cowlrick, Pluske and Wylie, 2005).

In the late 1990's the Department of Agriculture developed partnerships with industry in the application and promotion of these other nutrient management

approaches including high input, high yielding, and water use efficient systems. These programs included TopCrop, Pastures for Profit, and the triple P pasture program and involved input from private consultants and company agronomists. The result is that there are currently many approaches to nutrient management derived from many sources, ranging from detailed scientific investigation to cumulative observation and individual or group experience (Cowlrick, Pluske and Wylie, 2005).

In 1994 the catchment and land protection act was passed by the parliament of Victoria. The key purpose of the act was to set up a framework for the integrated management and protection of catchments and to encourage community participation in the management of land and water resources (CALP ACT). The Goulburn Broken Catchment management authority was established to maintain and enhance long-term land quality and productivity while also conserving the environment (CALP ACT).

In 1996 the Department of Agriculture and the Department of Conservation Forests and Lands merged to become the Department of Natural Resources and Environment. In the years following there has been a gradual shift away from a production and soil fertility focus and a loss of staff expertise in the areas of pasture and crop agronomy and soil health.

Concerns were raised by farmers about the longterm sustainability of high input high production pastures (Warn and McLarty 2000). In 1998 a pasture trial was established in the Broadford district to examine the effects of grazing method and soil fertility on pasture composition, economics and overall sustainability of the grazing system (Warn and McLarty 2000). The trial demonstrated large economic and environmental benefits of rotational grazing systems and perennial pastures. Research indicates that nutrients are more evenly distributed over the paddock of rotationally grazed pastures, perennial grasses were more persistent and there is greater ground coverage during summer and autumn periods (Sargeant, Nie, and McLarty, unpub).

The state government has now established a strong whole farm planning program in the catchment and works in partnership with the CMA to promote revegetation, establishment of perennial pastures, biodiversity and river health programs. There is an emerging landholder interest in soil health and in particular the role of soil biology and organic matter in agricultural systems.

Trends in soil Health extension

Much of the focus for government investment in the past has been on the soil physical health including soil structure to reduce the risk of erosion, waterlogging and poor crop and pasture establishment. Chemical soil health has primarily been concerned about soil fertility and acidity. This has increasingly been the focus of private consultants and fertilizer companies. However there has been a

long and sustained push from the Department to encourage liming on acid soils. There is emerging interest in soil biological health but as this is an area of recent research and there is little real understanding by farmers and extension staff.

One of the emerging trends is our understanding of soil carbon and soil organic matter as the key to soil health, soil resilience, and sustainable agriculture. Organic matter plays a vital role in soil physical, chemical and biological health. This vital component of soil is not picked up by the private sector and is often ignored and under resourced in the public sector.

These trends can be viewed as key overlapping stages in soil Health extension using Stuart Hill's (2005) synthesis of his work in agricultural systems:

1. awareness and acknowledgement of problems and issues (*recognition of emerging soil erosion, salinity, and fertility issues)*
2. definition, classification, and measurement *(mapping and measuring soil erosion, salinity, and fertility)*
3. understanding and competence with components of the system *(focus on structures and management practices to overcome single issue problems such as soil erosion, salinity, and fertility)*
4. localized project based initiatives that emphasize the systems nature of agriculture and natural resource management *(eg SoilCare, Landcare, whole farm planning*)
5. deeper understanding of sustainability and redesign of structures, policies, systems and processes (*possibly the emerging interest in soil biology and soil organic matter and possibly the whole farm planning program*)

Stuart Hill (2005) states that most rural areas in Australia have not yet progressed to the later stages of this progression and are suffering from many problems that indicate a breakdown in the system such as declining soil health. He suggests a focus on the redesign of agricultural systems and proactive management initiatives. Stuart Hill (2005)advocates the importance of small, meaningful projects that small groups can carry out in contrast to large mega projects that currently attract most attention and resources but rarely bring about positive sustainable change.

Key Gaps – Potential for public investment in soil health programs

The review of past soil health extension programs has demonstrated a clear shift from 'fixing up' single issues with soil health to taking a more integrated holistic farm and catchment system approach. The quest for a more sustainable catchment system highlights the importance of soil organic matter and soil carbon in agricultural systems. This quest will continue to require complex and difficult changes to landmanagement practices – not just the adoption of discrete pieces of technology or products. Public investment in programs that encourage local small groups to explore approaches for conserving soil organic matter may

bring about a deeper understanding of sustainability and a redesign of the farm system.

The key gaps for public investment in soil health are:
- the need to assist farmers to develop sustainable profitable, soil carbon conserving land management systems
- the need for policies and programs that encourage the adoption of a stewardship philosophy of land management and ownership that includes the notion of soil health
- the need to partner with industry and the private sector to promote soil health as an integral part of the production system

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