Managing Australian Soils

a policy discussion paper

National Committee on Soil and Terrain

final draft 8 May 2008 (layout incomplete) for NRPPC meeting 16 May 2008

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April 2008

Australian Government

Department of Agriculture, Fisheries and Forestry

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Publication Details

Disclaimer

Acknowledgments

This report was commissioned by the Natural Resources Policies and Programs Committee (NRPPC), comprising representatives of all Australian jurisdictions, on the recommendation of the National Committee on Soil and Terrain (NCST). The project was managed on behalf of the NRPCC through the National Land & Water Resources Audit by Blair Wood, with a steering committee chaired by Noel Schoknecht. Valuable feedback on earlier drafts of the document was received from Len Banks, Greg Chapman, Kimberley Green, Jason Hill, Mark Imhoff, Andrew Kennedy, David Maschmedt, Declan McDonald, Neil McKenzie, Bernie Powell, Noel Schoknecht, Mirko Stauffacher, Brian Vandersee and Blair Wood, and from meetings of the NCST and the Audit Advisory Committee. The final draft includes inputs from the members of the Natural Resources Policies and Programs Committee, the National Committee for Acid Sulfate Soils via the Marine and Coastal Committee, the National Water Initiative Committee and the Industries Development Committee. Those inputs are gratefully acknowledged.

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April 2008.

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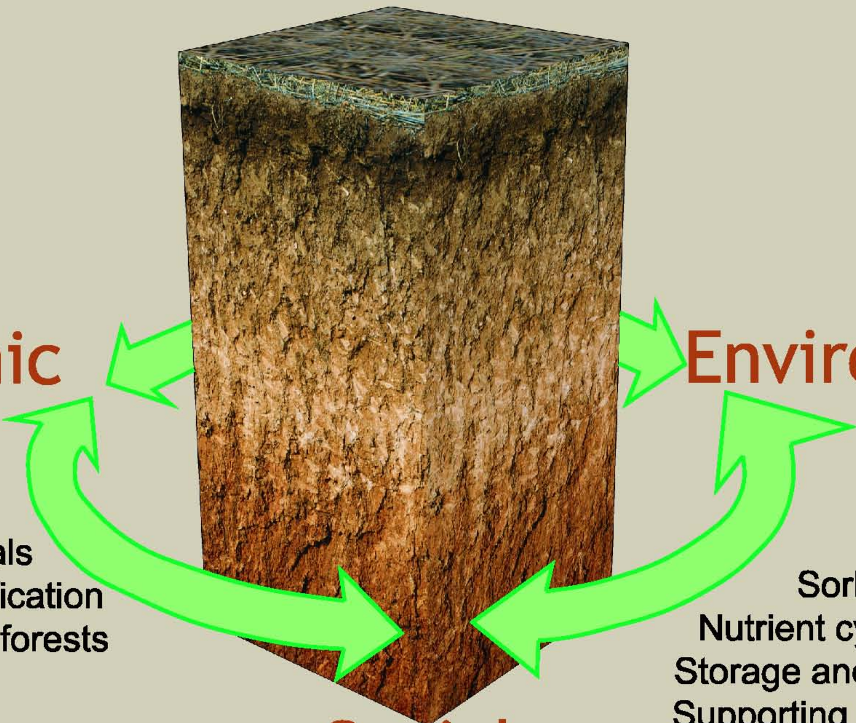
SOIL

A pivotal resource for healthy communities



Economic values

Building materials
Sanitation /purification
Food, fibre and forests

Environmental values

Carbon sink
Sorbant for chemicals
Nutrient cycling and storage
Storage and filtration of water
Supporting the diversity of life

Social values

Archive of human and natural history
Gardens and lawns
Sport and recreation

"A nation that destroys its soils destroys itself". Franklin Roosevelt

Soil image: David Maschmedt
Graphic: Noel Schoknecht

Purpose

This discussion paper was commissioned by the National Committee on Soil and Terrain (NCST) to investigate the key soil resource and management issues and opportunities in Australia, with a view to developing a national soil strategy.

To address the Terms of Reference (listed in Appendix D) the paper provides perspectives on:

- a vision and guiding principles for soil management
- the policy context, including current issues and needs, policy drivers and roles and responsibilities,
- options for a way forward

The paper identifies sustainable soil management as a fundamental requirement for the future prosperity of this nation. It also acknowledges that it can't be dealt with alone — it must be part of a broader and integrated NRM package that encourages and supports sustainable land management.

This paper is not setting policy, although it hopes to influence it. Its primary purpose is to encourage a genuine public debate on the role of soil management in our future and the policy needs and opportunities for a better integrated and coordinated national investment in the management of this most important resource.

The NCST invites comments from all areas of the community on all aspects of the discussion paper, and most importantly on the options for a way forward. Many important groups, including academia, professional bodies, government, industry, NRM and community groups and individuals are yet to have a formal input into this process and their input is especially welcome. The final paper, once comments have been incorporated, will be published and hopefully form a springboard for new investment in the long-term sustainable management of soils.

Comments, by (tba) should be sent to

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National Committee on Soil and Terrain
April 2008

Executive Summary

Soils play a fundamental role in the carbon cycle and the water cycle, as well as being the engine room of food production, an archive of human and natural history and host to extraordinary biodiversity.

Australia will struggle to meet its greenhouse objectives, manage its water supply crisis or improve the resilience and profitability of its farming systems without a renewed focus on and re-energising of efforts to improve soil management. That will require reinvestment in the underlying infrastructure of data, information and professional capacity, and the rebuilding of soils literacy among natural resource management (NRM) professionals in the field. There has been an overall increase in public concern about NRM issues, allied with a significant increase in public investment to tackle those issues. However soil management has been overshadowed by seemingly more urgent issues like climate and water. The connection between these issues and the soil is largely being forgotten or ignored.

That is a clear consensus among soils professionals working in state and federal government agencies in policy, research and management roles. This discussion paper has been commissioned by the National Committee on Soil and Terrain, one of the National Coordinating Committees of the National Land & Water Resources Audit, with the endorsement of the Policies and Programs Committee under the Natural Resource Management Ministerial Council. It seeks to explain the significance of good soil management in meeting broader NRM goals like reducing net greenhouse gas emissions and improving water yields and quality, and also in meeting broader social and economic goals like food security and export income. It outlines why prevention of soil degradation is a strategic, economically rational investment, and works through some of the ingredients needed to underpin better soil management in Australia.

The broader policy context for soil management in Australia is introduced. International developments are referenced as a backdrop to the development of possible new measures in Australia. By 2050, the world will need to be producing around twice as much food as it does now, from less water, less soil and less healthy soil if current degradation trends continue. Moreover, if soil and water resources are diverted from food production to energy production, and/or if climate change impacts and responses lead to declining land and water availability or productivity — and both seem very likely — then the pressure on remaining soil and water resources will intensify even further.

Australia is one of the countries most affected by climate change. Australian agriculture is among our most exposed and vulnerable sectors. Increasing world demand for food and energy in the face of tightening supply will create major economic opportunities for exporting countries like Australia. We will be able to capture those opportunities only if we rapidly improve the productivity and resilience of our farming systems, in the face of an increasingly variable and difficult climate and declining overall water availability. This will require exceptionally good soil management. Such management will also increase soil water storage, improve water quality, build soil carbon and reduce greenhouse gas emissions from agricultural soils.

The guiding philosophy behind this paper is to be clear about the overall objective — more sustainable soil management. Soil science, soil classification, mapping and monitoring systems and resources are not ends in themselves, they are means to an end. The objective is more sustainable management of Australian soils. This paper tries to look at soil science, soil policy and soil information from the demand perspective — what is needed to assist in getting better management on the ground.

Significant good work has already been done, but momentum has been lost, despite the need. The required outcomes can't be achieved by the current model of piecemeal, short-tem and sporadic funding, despite the commitment and enthusiasm of individuals and groups. It requires national commitment, coordination and cooperation.

In order for individual people, families, firms, industries or institutions to change, three essential elements are required: they must want to change (commitment); they must know how to change (knowledge); and they must be able to change (capacity). Practical measures that would rebuild commitment, knowledge and capacity for better soil management in Australia are outlined. Some of these are relatively quick and easy to bring about. Others will take a concerted, sustained and well-organised effort to guide strategic national investment on a critical natural resource issue.

Such an investment is urgently needed, and will generate big dividends for current and future Australians.

1. Introduction

Soil, along with air and water, is one of the essentials of life and among our most fundamental natural resources. It contains and/or supports the overwhelming majority of our terrestrial biodiversity and vast quantities of carbon and water. Soil health and soil management profoundly influences our food production and our water quality and quantity. Healthy soils grow healthy foods, which grow healthy communities — urban and rural. Yet we tend to take soil for granted. Poor soil management generates significant greenhouse gas emissions, it diminishes food production and threatens food security, it damages water quality, it limits economic options, and through dust it directly affects human health.

Figure 1 below illustrates the centrality of soils in meeting basic human needs and dealing with the main environmental issues of our time.

Figure 1. Soil linkages and key ecosystem services (after European Commission 2006)

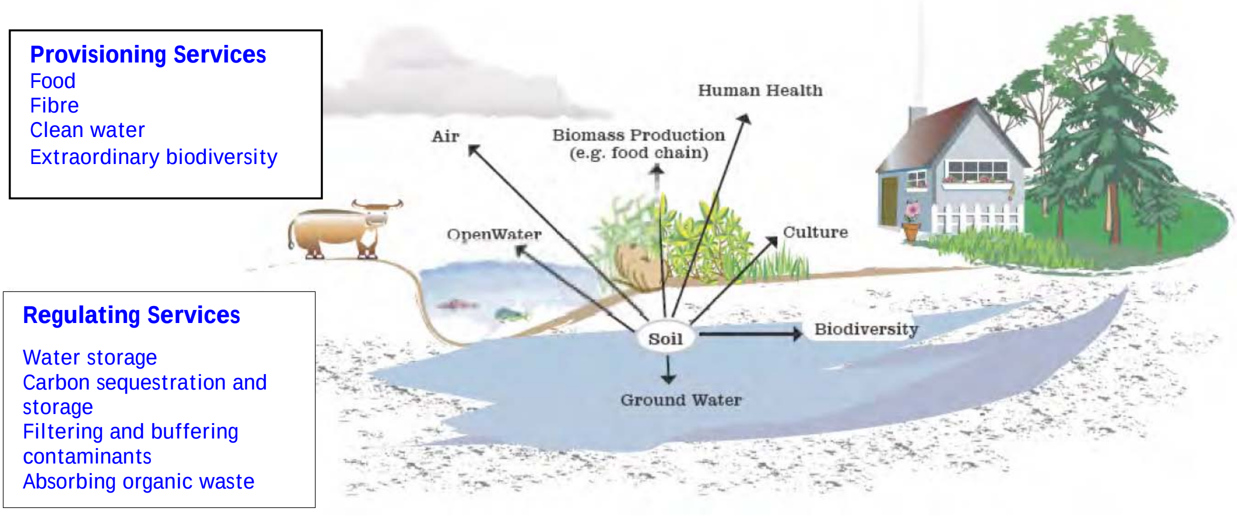

Figure 1. Soil linkages and key ecosystem services (after European Commission 2006)

Gretchen Daily and colleagues describe six key ecosystem services supplied by soil: buffering and moderation of the hydrological cycle; physical support of plants; retention and delivery of nutrients to plants; disposal of wastes and dead organic matter; renewal of soil fertility; and regulation of major element cycles including carbon, nitrogen and sulfur (Daily, Matson and Vitousek 1997). They provide some estimates of the marginal cost of soil degradation and hence loss of these services. While extremely difficult to quantify with any precision, the global costs of soil degradation are significant[1] and the replacement value of the ecosystem services supplied by soil is enormous. For example, taking just the functions of providing physical support for and supplying nutrients to plants: substituting hydroponic culture for soil, the construction cost of a modern hydroponic system is around $US850,000 per hectare (FAO 1990). The energy and other running costs for the technologies and expertise required to regulate complex interactions between factors (including nutrient concentrations, pH and salinity of the nutrient solution; air and solution temperature; humidity; light; pests and plant diseases) is prohibitive for all but the most expensive, specialised crops (Daily, Matson and Vitousek 1997).

In practice, the services provided by soils are irreplaceable and invaluable.

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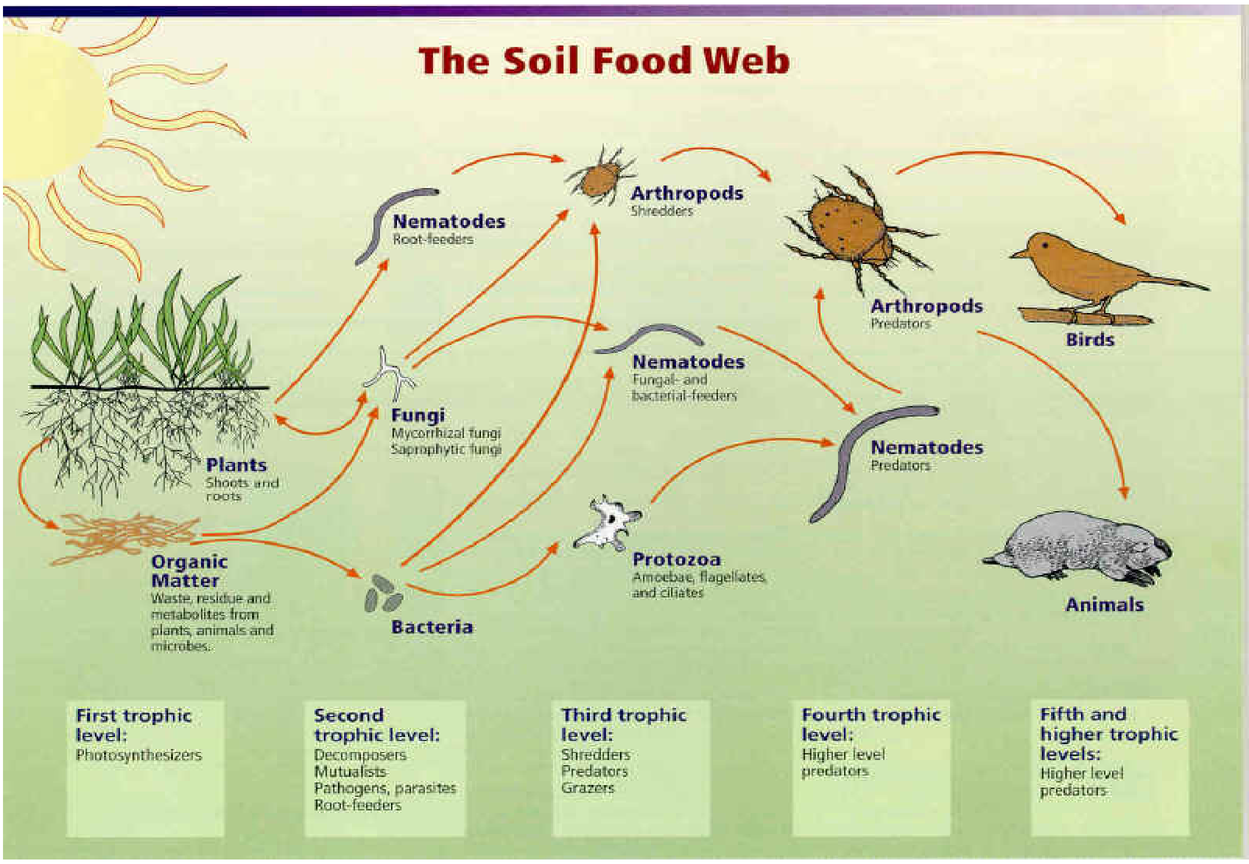
[1] Pimentel et al (1995) estimated that the direct costs of soil erosion, measured just by the cost of replacing lost water and nutrients on farmlands, amounted to US$250 billion annually. Some Australian data are presented in section 3.3.

However the soil is far more than just a multifaceted service provider for humans, or an enormous asset in our inventory of natural capital. Although not generally visible to the naked eye, soil is one of the most diverse habitats on earth and contains one of the most diverse assemblages of living organisms (Giller et al., 1997). The soil plays host to a significant proportion of the world's biodiversity, containing a huge range of organisms of extraordinary diversity, abundance and complexity.[2] It is one of nature's most complex ecosystems: it contains thousands of different organisms, which interact with and contribute to the global cycles that make all life possible.[3] Nowhere else in nature are species so densely packed (Hågvar, 1998). For example: over 1000 species of invertebrates may be found in a single cubic metre of soil from a European beech forest (Schaefer and Schauermann, 1990); many of the world's terrestrial insect species are soil dwellers for at least some stage of their life-cycle (Bater, 1996); a single gram of soil may contain millions of individuals and several thousand species of bacteria (Torsvik et al., 1994); and a typical, healthy soil might contains several species of vertebrate animals, several species of earthworms, 20-30 species of mites, 50-100 species of insects, tens of species of nematodes, hundreds of species of fungi and perhaps thousands of species of bacteria and actinomycetes.



The complex physical and chemical nature of the soil, with a porous structure, immense surface area, and extremely variable supply of organic materials, food, water and chemicals mean that various animal, plant and microbial worlds can co-exist simultaneously and find appropriate niches

2 Much of the material in this section, including the diagram above, is drawn from the FAO's excellent soil biodiversity portal http://www.fao.org/AG/agl/agll/soilbiod/index_en.stm

3 After the oceans, the soil is the earth's biggest carbon store (European Union 2006). Of the estimated 3,060 gigatonnes of carbon in the terrestrial biosphere, 82 per cent is in soils (Lal 2004, cited in Porteous and Smith 2008). Nearly 60 Gigatonnes (Gt) of Australia's total continental carbon is stored as soil carbon (55%) and plant biomass (45%) (NLWRA 2001). Australia's National Greenhouse Gas Inventory estimates that on-farm activities (excluding energy use) produce around 18 per cent of overall national emissions, making the agricultural sector the second largest Australian source of greenhouse gases. Nitrous oxide (N2O), the second significant greenhouse gas from agriculture after methane (CH4), represents around 3 per cent of Australia's overall greenhouse gas emissions. Most of Australia's nitrous oxide emissions come from agricultural soils, particularly following the application of nitrogenous fertilisers. Carbon dioxide emissions from the burning of fossil fuels for farm power and transport, and land clearing and soil organic matter decomposition, represents another form of greenhouse gas emissions from agricultural activity (NRM Ministerial Council 2006a).

for their development. This provides a range of habitats for a multitude of fauna and flora ranging from macro- to micro- levels depending on climate, vegetation and physical and chemical characteristics of the given soil. The species numbers, composition and diversity of a given soil depends on many factors including aeration, temperature, acidity, moisture, nutrient content and organic substrate. Soil biodiversity tends to be greater in forests compared to grasslands and in undisturbed natural lands compared to cultivated paddocks. However the number and types of organisms vary from one system and environment to another and this is strongly influenced by agricultural practices. Soil biodiversity can be used as an indicator of soil quality and stable ecosystems.

The community of soil organisms depicted in the diagram above incorporates plant and animal residues and wastes into the soil and digests them, creating soil humus, the organic constituent so vital to good physical and chemical soil conditions, and recycling carbon and mineral nutrients. This decomposition process includes the release of carbon dioxide (CO_2) to the atmosphere where it can be recycled through higher plants, and the release of essential plant nutrients in inorganic forms that can be absorbed by plant roots or leached from the soil. All soil organisms have important effects not only on soil properties but also on the functioning of the ecosystem.

Weathered and leached over aeons on this ancient continent, many Australian soils are effectively non-renewable. As with most natural resource management issues, prevention of soil degradation is much cheaper than trying to restore the productive capacity of degraded soils and/or managing the off-site impacts of soil degradation.

Now, more than ever before, we need to be managing soil resources very wisely.

If we don't, the consequences are dire. We will struggle to meet our own needs for healthy food in a changing climate, let alone to capture the enormous export opportunities from feeding a hungry world, we will exacerbate our water shortage problem and we will fail to meet our greenhouse targets.

This document is overwhelmingly focused on Australia, however the international context is important. The two graphs below, from the International Water Management Institute's Comprehensive Assessment of Water Management in Agriculture (2007), illustrate a picture of rapidly intensifying global pressures on soils and water resources. Figure 2 below shows that meat consumption in East Asia is projected to double by 2050. This has huge implications for water consumption, and for the pressures on soil resources.

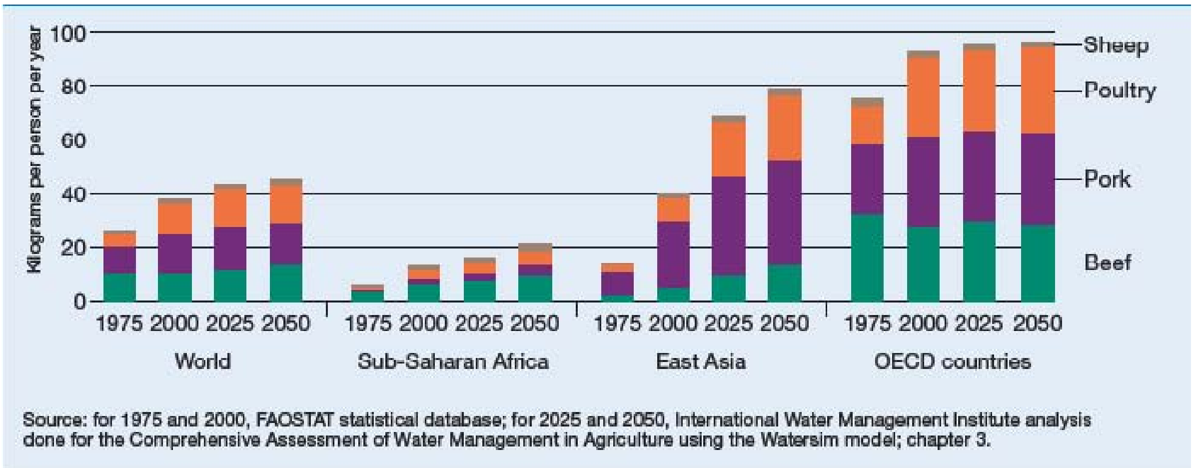


Figure 2. Growth in meat consumption by region, 1975-2050

Figure 3 below illustrates future demands for grains. The huge growth in grain consumption in East Asia is directly related to the changing consumption pattern towards a higher proportion of meat in the diet as illustrated in Figure 2 above. This change in food consumption patterns, coupled with population growth, means that global demand for food effectively doubles from 2000-2050 (Comprehensive Assessment of Water Management in Agriculture 2007). Added to these pressures, many countries, driven by rising energy prices and concerns about energy security, are investing in biofuels. India, for example, has set a goal of meeting ten percent of its gasoline needs from biofuels by 2030, which will involve the reallocation of significant soil and water resources from food production to energy production (Comprehensive Assessment of Water Management in Agriculture 2007).

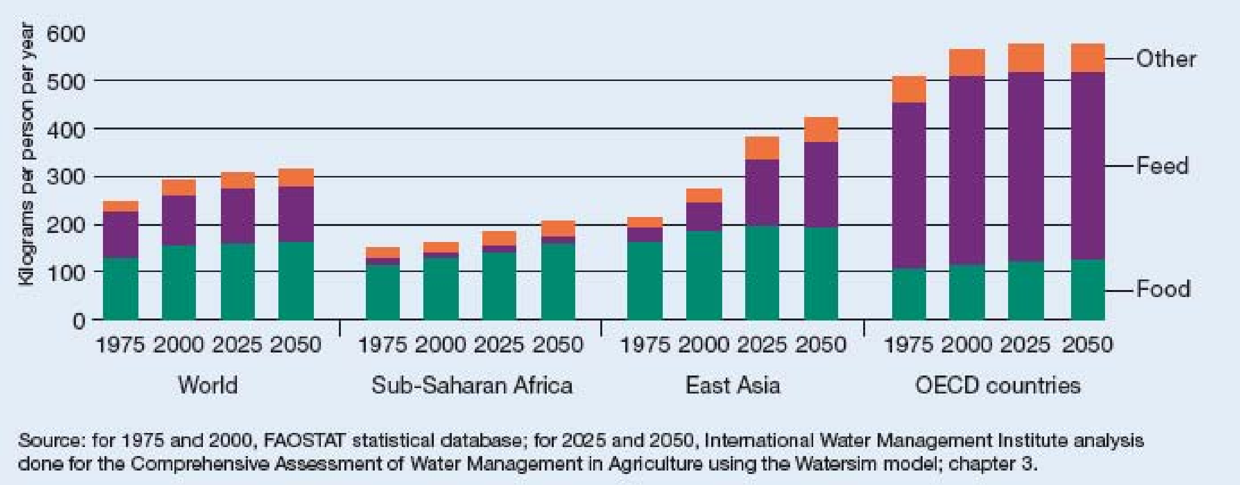


Figure 3. Growth in grain consumption by region, 1975-2050

Traditional responses to increase agricultural production have been to clear and/or irrigate more lands. However the Comprehensive Assessment's analysis is that opportunities to expand irrigation globally are very limited — most of the world's great food production basins are effectively 'closed', with existing water resources already fully utilised or over-allocated. That analysis identified that the main opportunities for the world to meet its future food needs lie in making better use of existing irrigation water, and better soil and water management in rainfed agriculture. Opportunities to clear more forests to convert to agriculture are also limited, and there are considerable pressures from a greenhouse perspective for reforestation as opposed to deforestation.

This combination of increasing demands intensifies the pressures on soil and water resources, and the urgency of improving soil and water management everywhere. In essence, by 2050 the world will need to be producing twice as much food as it does now, from about the same amount of soil and water. If soil and water resources are diverted from food production to energy production, and/or if climate change impacts and responses lead to declining land and water availability or productivity, then the pressure on remaining soil and water resources will intensify even further.

The global situation has several implications for Australia. It suggests that major food exporters like Australia will have expanding markets, particularly in Asia, which is a big opportunity. It is also likely that there will be a resurgence in demand for more sustainable and productive soil management practices worldwide, in both dryland and irrigated farming systems. Australian firms and scientists have considerable expertise that will be in growing demand. On the other hand, Australia is one of the countries most affected by climate change (Pittock 2003), and may have its own pressures to allocate land and water resources to energy production. The National Land and Water Resources Audit has revealed that soil degradation problems in Australia remain very significant. Salinity has been widely publicised, but erosion, acidification, acid sulphate soils, declining fertility and soil structure decline are equally important, both environmentally and economically (NLWRA 2001).

The economic opportunities and the environmental challenges underline the importance of good soil management for Australia.

Despite increasing public and private investment in natural resource management (NRM) generally, there has been a loss of focus on knowledge, people, systems and agencies dedicated to soil management in Australia over the last fifteen years or so. In the words of one senior official, *"disinvestment creeps up on you"*. If we allow the attrition of data, knowledge, expertise and people to continue, we will lose critical capacity that will be very expensive and difficult to replace — impossible in the case of some historical data. Notwithstanding the erosion of soils capacity in Australia recent times, there is a strong demand for soils information and soils-focused activities.[4]

This discussion paper is intended to propose ideas and options, and to stimulate discussion about ways in which Australia's NRM policies and programs can better promote and support, in a more durable way, more sustainable management of the nation's soil resources. At the time of writing, the new federal government has yet to announce the detail of its NRM policies. This paper sets out to explain the importance of soils as the engine of food production, as a fundamental element of most ecological and hydrological processes, and to underline the key role that soils play in the national carbon accounts. It puts forward ideas that could improve existing policies and programs to lift the profile of soils within Australia's integrated NRM approach, and the regional investment model in particular.

There are several drivers behind this paper:

- The need (and opportunity) to rethink soil management in Australia given the growing understanding of the importance of soil carbon, both as a store of carbon and as a source of emissions depending on management practices;
- The critical role of soil health and structure in the overall water balance[5], both in the context of the current extreme drought and the likelihood that such conditions may become more frequent, widespread and intense;
- The importance of soil management for food health and food security in Australia and worldwide;
- Long term climate shifts and rising energy prices will place increasing pressures on existing land uses and soil management practices, probably making sustainable soil management more difficult in some regions. They will also lead to increasing demands for assessments of soil and land suitability for new enterprises and land uses;
- Rising energy prices and shortages of phosphate resources will also contribute to increasing costs of external inputs such as fertilisers, underlining the importance of soil management practices and leading to greater scrutiny of the sustainability of high-input farming systems;
- The tendency for a generic issue like soil management to get lost in the shift to a more integrated approach to natural resource management at a landscape scale, and to become overshadowed by seemingly more urgent problems such as salinity, weeds, water quality or climate change impacts;
- The widespread erosion of specialist soils expertise within NRM agencies and universities, increasing the risk that Australia will soon suffer from critical capacity gaps on a key basic issue — gaps that will be difficult and expensive to fill after key expertise has been lost;

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4 In the Northern Territory alone, there are around 1,000 separate requests for land resources information in an average year (Jason Hill *pers comm*. 2007). More than 12,000 people participated in workshops, training courses, field days and soil pit days under Land & Water Australia's Healthy Soils for Sustainable Farms program, which has not been able to meet demand in all regions (Catherine Viljoen *pers comm*. 2008). The Healthy Soils for Sustainable Farms program received $75m worth of credible proposals (against its modest $5m budget) from a wide range of research and extension agencies and industry bodies.

5 Farmers in central west NSW who have adopted conservation farming techniques report increases in the order of 50 mm of extra soil profile water storage for their crops, which is very significant when total annual rainfall is in the order of 350-650 mm.

- The incomplete development of the soils information base, coupled with on-going disinvestment, means that the overall national knowledge base for sustainable soil management is depreciating. This increases the risk associated with policy and management responses to issues such as climate change, water security, food security and drought resilience;
- The acknowledgement that management of the soil resource is more than an agricultural or rural issue as it is recognised that the soil provides important ecosystem services to the whole community. The competition for land uses other than food or fibre production is increasing on the coastal fringe and new issues are arising in urban and peri-urban areas including contamination, leaching of nutrients into groundwaters or waterways and the potential effects of acid sulfate soil disturbance;
- The need and opportunity for careful planning of developments in northern Australia as the focus shifts to these less developed areas with perceived favourable soils and climate.
- The piecemeal approach to soils research nationally, where significant innovations in areas such as soil biology and soil carbon management outside government-funded research are not well known. The recent Healthy Soils for Sustainable Farms program has already made a significant contribution to coordinating research and extension in soil health and especially soil biology, but also has highlighted the need for a long-term strategic national approach in this area. A better coordinated approach to soils knowledge management and research would also accelerate development of a soil carbon market; and
- The chance to turn a problem into an opportunity by looking at the issue holistically, thinking about how new technologies can be exploited, building on the momentum of climate-change responses, and identifying practical measures that could fit relatively easily into existing policy and investment frameworks.

This is not a *cri de coeur* lamenting the demise of soil conservation agencies, nor a call for dedicated, single issue soils programs to be reinstated within the NRM regional investment model. Rather, it calls for more explicit attention on soils and their management, within an integrated approach to NRM and related policies and institutional arrangements. This needs to be reflected in our investment mix so that we can rebuild the commitment, knowledge, skills and systems we need to manage Australian soils more sustainably.

2. Vision and Guiding Principles for soil management

There is a tension throughout this document between a narrower focus explicitly on Australian soils and their management, and the knowledge that such management occurs within the context of a more integrated approach to managing land, water, vegetation, biodiversity and whole landscapes, in their social and economic settings. At the farm level, the catchment level, and at state and national policy levels, people rarely consider soil management in isolation. Yet in a continual focus on integrated management of natural resources, with all its inherent complexities, the particular requirements for the long term sustainable management of soils often gets lost. The treatment here tends to oscillate between soils *per se*, and the wider NRM context, attempting to articulate how soils can be given greater emphasis **within** an integrated NRM framework.

2.1 Envisaging sustainable soil management

Each generation of Australians has defined its relationship with the land consistent with its own aspirations, understandings and technologies. For the first European settlers, the Australian bush was unfamiliar, even bizarre, and was often seen as something to be fought, tamed and displaced in order to 'civilise' landscapes into something more familiar and, it was assumed, more productive. Land was cleared and soils were ploughed accordingly, even in areas where sustainability concerns were raised from the outset. In many districts the condition of Australian soils has been altered profoundly. In these regions and many others the current intense and prolonged drought and the prospect of on-going, rapid, climate-driven environmental change are raising new questions about the long term sustainability of current land use systems and practices. At the same time, most Australian citizens and voters are urban and disconnected from their sources of food and fibre.

For the current generation, our challenge is to develop more sustainable ways of:

- managing our soils in the face of environmental change and increasing demands upon soil resources;
- restoring the productive capacity of degraded soils; and
- putting in place robust and resilient systems of land use and management that prevent the further degradation of Australian soils and landscapes.

Looking forward a generation and beyond, it is interesting to envision where further development in our attitudes, knowledge and behaviours could lead us in terms of how we manage Australian soils. The vision sketched here sees *Australian landscapes in which soil is conserved for its ecological values and the ecosystem services soils provide, and soil health is enhanced for sustainable production.*

The concept of 'landscape' informs this vision. Landscape is an integrating term that connotes not just the biophysical elements of the countryside, but also the people and communities who live in and depend upon that countryside. Landscape is an inherently, explicitly value-laden, subjective concept — interpreted differently by different people in different places at different times. Landscape connotes spatial scales that are necessarily fuzzy and fluid, but generally bigger than individual properties. Thus managing landscapes implies social processes. Further, the concept of landscape should not imply a static snapshot, a visual image, but rather an evolving context shaped by ecological, hydrological and climatic processes and human activities. These dynamic human, spatial and temporal dimensions are fundamental to the challenge of adaptive management of the countryside to achieve individual, community and national goals. Many regions in southern Australia and along the eastern seaboard are becoming less dominated by agriculture, and we need to recognise that soil management is just as central to infrastructure, urban and peri-urban planning issues.

Within a generation, the current tendency to see conservation of vegetation and soil, and agricultural productivity as competing objectives to be 'balanced' and 'traded off' will be much less pervasive. Natural resources — soil, water, vegetation and animals — are the life-blood of agriculture. Our attitude to natural resources and how we manage them will determine the capacity of primary industries to produce, and ultimately survive. Conservation of soil and the maintenance and improvement of soil health are inextricably linked with sustainable agriculture. A healthy natural environment is crucial for primary producers, who are dependent on fertile soils and clean and adequate water supplies for their income. Conservation is neither an alternative land use nor an opportunity cost — it is an investment in natural capital, which underwrites material wealth. Soil conservation is crucial to the sustainability of all primary industries, as it is for the conservation of native species and ecosystems, and the processes they support; the flows and quality of rivers, wetlands and groundwater. As the world confronts the need to dramatically reduce greenhouse gas emissions and to substantially increase carbon sequestration, soil management assumes even greater importance, given the enormous capacity of soils both to release and store carbon.

Soil conservation in its broadest sense is about being able to foresee and understand the consequences of human actions. It is about keeping options open. Soil conservation is an inherently economically rational objective for Australia, as elsewhere.

Many of the land degradation issues and processes in Australian rural landscapes stem from the on-going attempt to adapt essentially European agricultural systems to Australian landforms, climates, soils and water supplies. The vision sketched here does not for a moment assume a return to some pre-European Arcadia and/or the replacement of all the native vegetation that has been cleared or modified since European settlement. However it implies that maintaining or improving soil health, restoring some hydrological balance, restoring wildlife habitat, protecting freshwater resources, increasing carbon storage and sequestration in the landscape, and rehabilitating degraded lands, will require the development of land use systems that are more distinctively Australian — tailored to land attributes and local conditions. Such systems, in their structural and functional composition; in their cycling of water, energy and nutrients; in their storage of carbon and in their resilience in the face of climatic variability; will draw inspiration from the ecosystems which evolved *in situ*.

At present a range of approaches to land and soil management, each with their passionate advocates, compete for attention and support in Australia, including organic, biodynamic and biological farming, holistic resource management, time-controlled grazing, pasture cropping, natural sequence farming and keyline farming. More mainstream practices such as conservation farming, raised beds, fixed beds, minimum tillage, no-till farming and precision agriculture are also in the mix. All of these approaches claim to improve soil structure and fertility, reduce soil erosion and compaction and increase soil carbon and water holding capacity.

Landholders could be forgiven for feeling confused in the face of sometimes competing claims and a fragmented, haphazard extension effort.

Well-understood core metrics around soil structure, fertility, carbon storage and water balance, with associated user-friendly assessment tools, would enable relatively objective independent evaluation of the performance of diverse farming systems in a given location, or of existing farming systems in new locations. Soil pH is probably the only such metric at the moment. Such assessment tools would support soil conservation extension activities delivered by various combinations of state agency staff, specialist consultants and contractors, grower groups, industry associations and catchment bodies; with various degrees of public support according to the wider public benefit and the potential for commercial returns.

There will be calls for new Goyder Lines, just as there are already calls for agriculture to move north, or cereal cropping to move further south. Existing management practices that may be marginal in some regions in some seasons may become much more marginal, over larger areas in a higher proportion of seasons. Now is the time to be establishing some ground rules based on well-understood core parameters of soil health and resilience. This would help landholders and their advisers to evaluate the likely sustainability and inherent risks associated with new development proposals, or with continuing current practices in a changed environment. Many landholders and their support organisations realise that soil management based on soil type and natural processes is a cost effective means of running sustainable and profitable enterprises.

Complementing such an extension effort would be a major environmental education effort to make soil more sexy in public environmental debates and in NRM policy. Climate change offers a great opportunity to re-engage significant sections of the Australian community in land literacy activities (Campbell 1995), as was done very effectively with programs like SaltWatch 25 years ago. These should aim to educate people about the fundamental role of soils in the carbon and water cycles, as the engine room of food production systems and as the foundation for terrestrial biodiversity.

The 'wider public benefit' would be understood in reference to robust, regionally specific articulations of the duty of care of land users not to degrade natural resources — soil health in particular. *Duty of care* would be widely accepted and understood as setting out the responsibilities which are inseparable from the privilege of managing land, regardless of its tenure. *Duty of care* would be defined in regulation where appropriate, but would be more commonly used in industry codes of practice, industry-based environmental management systems, and voluntary incentives programs. These would all be informed by comprehensive, nationally consistent assessments of Australia's soil resources, kept constantly up to date through on-going monitoring of key parameters in a consistent way across the country, and made easily accessible at all levels through a range of web-based services and tools, backed up by high level technical expertise strategically located across the NRM and agricultural systems.

In a commercial sense, land uses generating insufficient returns to enable land users to fulfil their duty of care, would by definition be unsustainable, and hence unsuitable, uses of land[6]. Land users however may decide to provide inputs and resources from other sources to enable them to fulfil their duty of care whilst conducting land uses that may not be commercially sustainable.

Markets would be informed and constrained by the understanding that the human economy is a subset of human society, which in turn is a subset of, and utterly dependent upon, the biophysical environment. Market forces would work to use natural resources more efficiently, discriminating against products, production systems and processes that degrade or deplete soils and other natural resources unsustainably. Linkages between well-informed consumers and all stages of production cycles would be fostered and direct feedback encouraged. Environmental externalities (positive and negative) would be internalised in market prices wherever possible. National accounts would account for natural capital stocks and flows in key parameters such as soil carbon, offering a truer reflection of the relative sustainability of apparent economic performance. The role and limitations of market forces in questions of long-term sustainability would be well understood, and the conditions under which intervention in markets is justified, well accepted.

Comprehensive incentive regimes would complement markets in encouraging and delivering more sustainable approaches. Management actions seen to be in the public interest, for example through positive externalities such as the delivery of off-site ecosystem services, and which are clearly over and above what would be expected under *duty of care*, would be supported by a wide range of direct and indirect incentives and disincentives. Such incentives would be derived and delivered at a range of scales: for example nationally through the carbon market (subject to carbon measurement and security issues being sorted out), the taxation system and major targeted grants for national priorities; sub-nationally through revolving funds, industry codes of practice, accreditation systems, planning schemes and regulatory approaches; and regionally through regional grants, stewardship payments, planning, zoning and rating systems.

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6 This does not mean that soil conservation practices such as de-stocking in poor seasons or taking riparian lands out of production are unsustainable. Rather, sustainable land use systems are able to do just that, because they generate sufficient returns at an enterprise scale over the 'normal' run of seasons (i.e. including a significant proportion of very bad seasons depending on the region) to enable land users to re-invest in measures that conserve the long-term productive capacity of the resource base, minimise negative off-site impacts and maintain ecosystem function at a landscape scale.

The incentives regime would be designed to attract private-sector funding into soil, water and nature conservation at property and landscape scales: through tax measures encouraging philanthropy; through rewards at an industry-level for best-practice and corporate citizenship; and through tax and other incentives for the individual or firm to go above and beyond their *duty of care* in managing for long-term conservation in the public interest.

The general principles informing the design and delivery of incentives would include the principle that natural resource management and resource allocation decisions should be made at the lowest practicable level; that incentives systems should connect people as directly as possible with the consequences of their actions; that management and policy interventions should be based on the best available knowledge; and that local ownership of problems and solutions is most likely to be genuine when revenue-raising and resource allocation operates at the same level.

Consistent with provision of a sound knowledge base to inform extension, education, management and policy interventions, the comprehensive and consistent soil monitoring framework would be complemented in two key areas. Firstly, a number of strategically located long term research and monitoring 'sentinel' sites would enable much more detailed assessments of trends in key soils parameters in major agroecological zones, and would provide critical research infrastructure. Ideally, such sites would be networked within an Australian Ecosystem Observation Network established at a continental scale to monitor environmental change and support long-term research activities. This would combine the best elements of the National Ecological Observatory Network (NEON) in the US, and the Environmental Change Network in the UK.

Secondly, the currently fragmented and often uncoordinated soil research effort in Australia would be transformed into a more comprehensive, coherent and cohesive national research and land resource assessment effort, with leading standards of knowledge management across the sector to maximise the return on that investment.

This is a vision, far from a depiction of current reality in many regions of Australia. The first step towards making this picture more real in most places is to improve our knowledge base, in both theoretical and practical terms, on how to conserve, manage, enhance and restore soils for various combinations of objectives at various scales.

This attempt to envisage Australian soil management over the next generation is not driven by extrapolating current trends. Rather, it is based on a premise of the need for profound change in the management of Australian rural landscapes and consequently for soils — towards more distinctively Australian land use systems that are resilient in the face of rapid environmental change.

2.2 Guiding principles

A comprehensive suite of actions and investments will need to be implemented by a wide range of governments, industries, communities and individuals if this vision is to be realised. This document attempts to flesh out some of those actions, but first it is important to set out the principles that should guide policy development, legislative reform, public investment and action at all levels. These principles have been distilled from a wide range of sources, including the World Soil Charter (FAO 1982) and the IUCN guidelines for soil legislation (Hannam and Boer 2004), and Australian strategies such as the National Weeds Strategy (**http://www.weeds.gov.au/publications/strategies/weed-strategy.html**), the National Strategy for the Conservation of Biodiversity (DEST 1996) and the National Water Initiative (NWC 2006).

Recognising that:

1. Soil is a crucial natural resource and a key element of terrestrial ecosystems. It provides a wide range of provisioning services for humans including food and fibre production, and of regulatory services as it acts to filter, store or transform many of the chemicals passing through it, preventing them from polluting water or air. Good soil management is very important. Global demand for food will double by 2050 (Comprehensive Assessment of Water Management in Agriculture 2007). That food will need to be produced from about the same amount of land as

is in production today (or less as land is reallocated to biofuel production), yet in Australia as in most countries, soil degradation is still a significant problem.

2. Soil degradation means partial or total loss of productivity and biodiversity (reducing capacity to provide eco-services from the soil) as a result of such processes as soil erosion by water or wind, acidification, salinisation, waterlogging, depletion of nutrients and organic matter, deterioration of soil structure, desertification and contamination. Such processes are often insidious. In addition, significant areas of soil are lost daily to non-agricultural uses such as urban encroachment. Soil degradation directly affects agriculture and forestry by diminishing yields and upsetting water regimes. Other sectors of the environment and the economy as a whole are also affected through, for example, dust impacts on human health, declining water quality, and silting up of waterways.

3. Prevention of soil degradation is nearly always substantially cheaper than the cost of restoration, and in most cases is a much better investment. Where there are threats of serious or irreversible damage to the soil environment, lack of full scientific certainty should not be used as a reason to postpone measures to prevent soil degradation.

It behoves people, communities, industries and governments not to knowingly degrade soil resources.

4. Soil management and policy decisions at all levels should be based on the best available knowledge. This requires: a) awareness of soil as a key consideration; b) readily available soil information; c) sufficient expertise to interpret soil information in ways that assist management and policy decisions; and d) trust in the quality of the information.

5. Sustainable soil management is most likely to be achieved through integrated approaches to sustainable agriculture and NRM where long term soil condition is built in as a core consideration.

6. Governments have a responsibility to provide an institutional framework that encourages and supports sustainable management of soil resources through:

   a) Provision of comprehensive, regular and consistent assessment and inventory of soil resources and land capability, and monitoring of trends in soil condition, made readily accessible in forms designed to facilitate their use in management and policy;
   b) Ensuring that the community is aware of the importance of soil and its management and increasing commitment towards more sustainable soil management through broader community education activities, and through an extension framework that involves the people whose decisions and actions most influence soil condition;
   c) Ensuring that the community, and land users in particular, have access to sufficient skilled professionals with high level expertise in soil management (whether in the public or private sectors), and opportunities to build their own expertise, through provision of a range of technical training opportunities;
   d) Provision of incentives to encourage and reward exemplary behaviour in managing soils, in particular measures that ensure the sustained provision of soil ecosystem services that go beyond landholders' duty of care to look after the resource;
   e) Investment in research to inform better soil management and policy;
   f) Establishing a coherent and cohesive system for collating, managing and making accessible, knowledge about Australian soils and their management.

7. Governments also have a responsibility to provide an institutional framework that constrains and discourages unsustainable management of soil resources through:

   a) A planning regime that takes soil characteristics into account in determining land use capability, in particular by identifying risks such as acid sulfate soils and assets such as high quality agricultural lands, with the aim of ensuring that use of soils for any purpose should not lead to their degradation and must therefore be within the bounds of their inherent capability to ensure continued utility, stability and, as appropriate, productivity and improvement;
   b) A regulatory regime that defines inappropriate soil management and provides for sufficient penalties to discourage such practices;

c) Laws that require anyone whose activities cause or are likely to cause a loss of the ecological integrity of soil to bear the cost of preventive or restorative measures;
d) A compliance regime that enforces regulation rigorously and fairly, while maintaining a clear separation between regulatory and extension functions.

8. Industries that depend on soils have a responsibility to inform themselves about their impact on soil condition, and to promote and support sustainable soil management practices within their industry.
9. With the right to own, manage and use land and soil, landholders accept a duty of care to prevent soil degradation that affects others, and to implement management practices that maintain or improve soil condition and productive capacity.
10. Sustainable management of soil resources across the country requires coordination, cooperation and collaboration among all levels of government in partnership with industry, land and water managers and the community, regardless of land tenure.

3. The policy context

Australia has a wide range of national, State and Territory level strategies, policies, frameworks, legislation, initiatives and programs that have a bearing on soil management. These are reviewed briefly in this section to establish the backdrop against which any new soil-focused effort would need to be pitched.

Since the National Soil Conservation Program was absorbed into the National Landcare Program in the early 1990s, and since the NSW Soil Conservation Service was absorbed into the Department of Land and Water Conservation in 1995 in a process of reorganising, restructuring and renaming natural resources agencies that continues to this day, there have been no dedicated, comprehensive soil conservation programs or agencies in Australia. There have been more recent initiatives with a narrower focus, such as on acid sulfate soils in Queensland and NSW. There has also been a significant effort on salinity, commencing in Victoria and Western Australia in the early 1980s and culminating in the $2 billion National Action Plan for Salinity and Water Quality (NAP) in 2000.[7]

In commissioning this project, the National Committee on Soil and Terrain was spurred by the drivers listed in the introduction and the need for a better coordinated and more focused national effort to ensure that what it sees as a critical issue gets sufficient attention. Similar sentiments are sprinkled throughout the international soils literature. The soil science and policy community has set out its objectives through calls to action such as the World Soil Charter (FAO 1982), the IUCN soils law work (Hannam and Boer 2004), and the World Soils Agenda of the International Union of Soils Sciences (Hurni and Meyer 2002). The draft resolution for the US Senate recently proposed by the Soil Science Society of America (see Appendix B section 8.2) is a classic example of the soils science community trying to raise the profile of this issue at the highest levels. There have also been efforts (reviewed by Hannam 2004) to gain support for a new United Nations framework convention on soils, complementing those on climate change, biodiversity and desertification, that would establish an international legal framework for conservation and management of the world's soil resources.

To the soils science community, the needs seem obvious. The world, and countries like Australia in particular, face a greater need than ever to be conserving soil resources, making the best possible use of existing knowledge, reinvesting in both new knowledge and in soil assessment and monitoring systems, and in the skills and capacity to maintain and interpret them. Yet dedicated soils expertise, systems and know how are depreciating, and the rate of attrition seems likely to accelerate as the current generation of senior soils people approaches retirement. Downsizing in many areas, not least in tertiary soils courses, has reduced the number of their successors and the capacity to rebuild.

3.1 The loss of focus on soil conservation

Before elaborating a comprehensive suite of potential 'fixes' it is important to try to understand why soil conservation has seemingly fallen through the cracks, and why governments in particular have shifted focus. Without tackling the factors reinforcing the status quo, this document risks adding to the pile of 'supply push' prescriptions for reinvestment in soils that have not been very influential.

This is an inherently subjective analysis. Before embarking on any major national reinvestment in soils it would be prudent to undertake a more comprehensive and systematic study of these and other factors, and to survey a wider range of expertise across the policy, science, public administration, primary industries and landholder sectors. But for the purposes of this discussion

7 Responsibility for Soil Conservation in NSW has recently been transferred from the Department of Environment and Climate Change to the NSW Lands Department under former Soil Conservation Service commissioner Warwick Watkins.

paper it suffices to postulate some of the reasons why soils may have become a lower priority for public and private investment, in Australia at least, over the last two decades.

At the risk of crude generalisation, there seem to be two broad categories of factors: generic factors that are not really about soils *per se* but rather about other more compelling issues getting greater attention; and specific factors that appear to be related to perceptions of soils and soil conservation.

Generic factors include:

- Issues such as climate change, salinity, water quality and quantity, old growth forests, charismatic endangered species, weeds and feral animals have all become the focus of greater public concern, political attention and consequently public investment. Urban citizens expect that soils are being looked after and assume that government has a handle on soil stewardship. Lack of media attention to soils means these assumptions are not tested.
- The plethora of issues, and the fact that many of them and their solutions are interconnected, has underlined the need to develop a more integrated model for dealing with NRM issues. The Regional NRM Investment Model ('the regional model') is described later, but it is fair to say that its design and implementation over the last decade has absorbed a significant amount of attention and effort from policy makers, program administrators, community leaders and the science community.
- In line with broader trends in public policy towards smaller government, rationalisation and out-sourcing of public services (Dovers 2001), there has been widespread reform in the delivery of agricultural extension services in Australia (Roberts et al 2005). This has seen a downscaling of state agency extension services, with greater reliance on private sector service provision and on delivery through the regional model. Soil conservation agencies, and soil conservation elements within agencies with a broader focus, have been caught up in this shift along with everyone else. The private sector has not seen much profit to be made from provision of soil conservation extension services, yet there is a strong demand for those government services remaining.[8]
- There has been a trend in education policy over the last decade towards user-pays, particularly at tertiary level, which has caused universities to concentrate resources in those areas where there is a demand from students and prospective students. Soil science (as with agriculture and many areas of science) is not in high demand (possibly because of some of the negative perceptions outlined below as well as perceptions about modest salary levels for graduates). Consequently there has been a marked decline in provision of dedicated soils courses at undergraduate level, and courses have also collapsed or removed vital but expensive components such as field work. The net result has of course been declining student enrolments, continuing the vicious cycle. This of course ties in to the difficulty of rebuilding expertise and capacity in soils.
- The most recent Australian State of the Environment Report (http://www.environment.gov.au/soe/2006/index.html) found that it was unable to report with any authority on trends in resource condition across Australia because of the inadequate state of monitoring, assessment and inventory systems and efforts across all jurisdictions. While at the headline level there has been increasing public investment in NRM programs, in the background there has been widespread disinvestment in the basic monitoring systems and effort that are needed in order to be able to track resource condition, evaluate the effectiveness of NRM programs, and determine priorities for new investment. Again, soils data and soil monitoring systems have been seriously affected by this malaise, but are far from alone.

Factors pertaining specifically to perceptions of soils, soil science and soil conservation include:

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8 This does not have to remain the case. For example, Landmark (Australia's leading rural service business with 2000 staff in 400 locations) is a participant in the Cooperative Research Centre for Future Farm Industries (CRCFFI) and is involved primarily so that its agronomists can be trained in the innovative new farming systems being developed by the CRC. http://www.futurefarmcrc.com.au/index.html

- Soils are ubiquitous, generic (to non-professionals), invariably in the background, and consequently they tend to be taken for granted. Soil degradation processes like acidification, salinity and declines in organic matter and soil structure tend to be cryptic, slow and insidious, more glowing orange lights than flashing red ones demanding immediate attention.

- Soils are not sexy or charismatic. A poor cousin among NRM issues, they enjoy the patronage of no powerful lobby groups, they rarely excite the public imagination and they do not lend themselves to media campaigns for the mass market. Koalas get more attention. The only 'squeaky wheels' clamouring for more investment in soils appears to be the soil science community.

- There is a marked lack of 'demand pull' for soils information at a high level of policy and decision-making. Even where governments have committed to enacting new soils legislation, such as in the European Union's new Thematic Strategy for Soil Protection (European Union 2006), the implementation of that legislation in member states tends to stall as soon as it is seen to be constraining development in any way (Luca Montanarella *pers comm* 2007[9]). Governments of all stripes tend to be reluctant to draw lines on maps for conservation reasons like soil protection that may constrain land use options, and do not seem to equate conservation of soils with, say, endangered species, reefs or rainforests. Of course this is not the only purpose for which one would use soils information at a national policy level, but the fact remains that Ministers and agency heads are not demanding such information, or insisting that it be up to date. When pressed, leaders of farmer organisations will agree that winding back state soil conservation services was not a good idea (Andrew Freeman *pers comm* 2007[10]), but it is not a sufficiently high priority to expend political capital lobbying about it.

- The soils community appears to have failed to join the dots — in the minds of the public and senior policy makers at least — between good soil management and broader social, environmental and economic outcomes. This problem seems to be recurring at the moment with the linkages between soil carbon and climate change.

- The integrated regional NRM framework has been evolving for nearly a decade, but there are few if any well known 'soils modules' designed to plug into the regional model, for example into regional NRM plans or regional investment strategies. A recent review of regional NRM plans (RM Consulting Group 2006) found that *"The most common areas needing more work in regional plans were soil condition and land use matched to capability (land capability)."* In several jurisdictions the information is available, but the interface mechanisms to assist regional NRM bodies to interpret it and use it have not been resourced.

- Soil conservation, at least as practised by dedicated agencies and professional bodies, for too long ignored developments in ecology at scientific, policy and management levels. Soil science remained primarily concerned with physical and chemical attributes of soil. Soil ecology and soil biodiversity remained at the fringes of soil science, when they could have been a bridge to the broader (much more powerful and influential) conservation movement. Soil conservation in Australia well into the 1990s remained mostly associated with erosion control through surface water hydrology, engineering works and bulldozer fleets rather than management of whole landscapes for multiple values. Similarly, agricultural soil efforts focussed on soil testing for fertiliser application and agronomic assessments for increased yields. Since the development of Geographic Information Systems (GIS)-based computer models and databases, many other soil applications have been developed but have yet to be widely promoted.

- Professional soil science bodies appear to be moribund and missing in action, both in public policy debates, and in building capacity within the profession. The contrast with scientists from the water and biodiversity sectors is stark. For example they have skilfully used the influence of PMSEIC[11] to reach decision makers at the highest level. Through PMSEIC, water scientists have been very influential catalysts for the National Action Plan on Salinity and Water Quality (NAP), the National Water Initiative (NWI), ecosystem services payments for biodiversity

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9 Dr Luca Montanarella, European Union Joint Research Centre, personal communication August 2007

10 Andrew Freeman, Deputy CEO, AgForce Queensland, personal communication November 2007

11 PMSEIC: the Prime Minister's Science, Engineering and Innovation Council, chaired by the Chief Scientist, the meetings of which are usually attended by the Prime Minister and consequently most of the Cabinet.

conservation, and the $480 million allocated to new hydrological standards and a comprehensive and consistent national water monitoring and accounting framework within the new $10 billion National Plan for Water Security. Admittedly water is an issue of greater public concern, especially during a severe drought, but a better organised soil science community may have had more influence in pointing out the links between soil condition and water quality, or between soil management and drought resilience.

The ideas presented in section 4 are designed in large part to counter these factors as well as responding to the drivers for change outlined in the introduction. Formal Australian policies and strategies relevant to soils are summarised in Appendix A. The remainder of this section discusses the implications of that broader policy context for soil science, policy and management in Australia, with a particular focus on opportunities.

3.2 Managing natural resources in a Federal system

Under the Australian constitution, land management and hence soil management is the clear responsibility of the States and Territories.

Until the early 1980s, the Commonwealth had very little involvement in soil conservation activities. Most States had mature soil conservation agencies, or significant soil conservation divisions of agriculture agencies, with their associated extension services, which generally enjoyed a high level of respect within the farming community. The focus was primarily on control of soil erosion and to a lesser extent soil structure decline, salinity and acidification, using various combinations of agronomy and engineering works to control surface water movement. Most jurisdictions had their own monitoring and mapping systems, in some cases linked to land capability assessment and classification programs based on modified versions of the Universal Soil Loss Equation (USLE) (Kinnell 2003). Each jurisdiction also had its own legislation dealing with soil protection and conservation, although the effectiveness of much of this legislation as implemented, was open to substantial question and critique (Bradsen 1988).

The Commonwealth initiated the National Soil Conservation Program (NSCP) in 1983 under then Minister for Primary Industries, John Kerin. The NSCP played a ‘small c’ coordination role on soil conservation activities, research in particular, and funded a range of demonstration projects from its modest budget of $1m in its first year and $20m over its first four years.

Notwithstanding the constitutional responsibility for land and water management vested in the States, the last 25 years has seen a continual increase in Commonwealth funding for and influence over natural resource management issues.

The first quantum leap was the announcement of $340m for a Decade of Landcare by then Prime Minister Bob Hawke in 1989, at the junction of the Murray and Darling Rivers, flanked by the heads of the Australian Conservation Foundation and the National Farmers Federation, with strong bipartisan support, and the involvement of both the primary industries and environment ministers and their portfolios (Campbell 1994). This increased Commonwealth funding (and ironically diluted attention on soils) by about two orders of magnitude. The second step shift was the establishment of the Natural Heritage Trust (NHT) to be funded with one billion dollars over five years from the proceeds of the sale of Telstra, announced by then Environment Minister Robert Hill in 1996, again in a partnership with the then Minister for Agriculture, John Anderson. This was extended by a further $300m in the 2003-4 budget. As the NHT programs, primarily based on small grants, began to roll out, the need for more focused and strategic investment on what were seen to be the big issues of salinity and water quality became apparent, particularly in the science community. The Australian Government responded with the announcement in 2001 by Prime Minister John Howard of a $1.4 billion National Action Plan for Salinity and Water Quality (NAP) over seven years to June 2008. Frustrations with the slow pace of water reform led Prime Minister Howard in 2003 to announce a further $2 billion for a National Water Initiative to be driven by a new National Water Commission, established within the Prime Minister’s own department and headed by a Departmental Secretary. The Intergovernmental Agreement of the National Water Initiative negotiated with the States and Territories (signed by most States in June 2004, Tasmania in June 2005 and WA in April 2006) sets out a comprehensive blueprint for the implementation of water reforms agreed by COAG

(Council of Australian Governments). As the drought intensified, the majority of the Australian population experienced tightening water restrictions and major capital cities confronted the need to find new water supply options, the then Prime Minister announced a $10 billion National Plan for Water Security on Australia Day 2007.

At face value, the National Plan for Water Security (NPWS) represents a radical departure from the way management of Australia's natural resources was envisaged in the Constitution, and from the way NRM was practised until the 1990s. It proposes *inter alia* a Commonwealth take over of the management of water resources; the abolition of the collaborative Murray Darling Basin Commission and its replacement by a Commonwealth Authority within the Department of Environment and Water; the development of new national hydrological standards and measurement protocols; and the roll-out of a nationally uniform water accounting framework to be overseen by a greatly expanded hydrology division within the Bureau of Meteorology, with $480 million of the $10B for the latter two points.

There has been a rapid and continual increase in Commonwealth NRM funding over the last 25 years, and some worthy soils-oriented projects are currently being funded through the national component of the National Landcare Program. Nevertheless, in the broader picture, Commonwealth dedication to soil conservation has been diluted considerably over this period.

3.3 Natural Resource Management

Overarching policy trends

The National Plan for Water Security is radical, but it could also be seen as merely the latest step along a consistent trend line in natural resource management over the last twenty five years:

- The perception that natural resource management (NRM) issues are of national importance and hence an identifiable and legitimate Commonwealth interest;
- Increasing Commonwealth involvement and investment in NRM issues;
- Increasing predominance of a national approach, through COAG and Ministerial Councils;
- Blurring of the boundary lines between agriculture and environment departments, with the overlap (around issues such as water, climate, forests, fisheries, nature conservation on private land, landcare, bushcare etc) often seeming larger than the 'pure' elements of each portfolio;
- Increasing interest in the use of market based instruments to influence behaviour;
- Devolution of authority (to a certain extent) and resources (to a greater extent) down to the regional level, through the Regional NRM Investment Model.

Some of these trends have been mirrored at State and Territory level. However, while the numbers are difficult to disaggregate from state agency budgets, the increase in direct Commonwealth investment has arguably not been matched by similar expenditure increases by NRM agencies at State and Territory level.

National Land & Water Resources Audit

The National Land and Water Resources Audit (the Audit) was established under the Natural Heritage Trust of Australia Act (1997), to estimate:

- the direct and indirect causes and effects of land and water degradation on the quality of the Australian environment;
- the effects of land and water degradation on Australia's economy; and
- to provide a baseline for the purposes of carrying out assessments of the effectiveness of land and water degradation policies and programs.

The Audit's first phase summary report in June 2002 (*Australia's Natural Resources 1997—2002 and beyond*) summarised the Audit's principal findings to that date, specifically the results of a range of assessments encompassing the condition of the nation's land, water and biodiversity resources. The key report relevant to the condition of Australia's soil resources was the Audit's *Australian Agriculture Assessment 2001* (NLWRA 2001a). That assessment described Australia's soils, most of which are ancient, strongly weathered and infertile by world standards, although those on floodplains are younger and more fertile. It summarised the distinctive features of Australia's soils:

- soils with surface layers containing low organic content are often poorly structured — a condition made worse by various agricultural practices;
- soils with subsurface layers that have a sharp increase in clay content are widespread, can restrict drainage and root growth and often contain bleached layers with very low nutrient levels;
- soils affected by salt either now or in geological times are found under large portions of the arable lands of the continent and have various physical and nutrient limitations;
- cracking clays that are relatively fertile cover very large areas but exhibit physical limitations;
- soils formed in Aeolian sands fringe the southern cropping lands and are more extensive in the arid zone; and
- the remaining ancient land surfaces (particularly in northern Australia) have very deep and strongly weathered soils with very low levels of nutrients.

Australia also has a high proportion of sodic soils (soils with high levels of exchangeable sodium and low levels of total salts) compared with other continents. Northcote and Skene (1972) estimated that sodic soils covered approximately 28% of the Australian continent. Australia has both a larger continental area of sodic soils (Rengasamy and Olsson, 1991; Bui et al., 1998; Levy, 2000) and a far higher ratio of sodic to saline soils than Africa, Asia, North and South America (Rengasamy and Olsson, 1991).[12]

These distinctive features, coupled with one of the most inherently variable climates in the world, mean that farming sustainably in Australia has always been extremely challenging, requiring sophisticated risk management systems and high levels of expertise, adaptability and resourcefulness.

[12] Ford et al. (1993) estimated that about 60% of Victorian soils (i.e. 13.4 Mha) were sodic. They calculated that 84% of the cropped land and 66% of that under sown pasture occurred on sodic soils. http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/40a2f70b889ac885ca256656002ed378/f12b3dcf9672895d4a25693200078fe0?OpenDocument

Box 1. The Great Barrier Reef and its catchments

The Great Barrier Reef (GBR) is the world's largest World Heritage site, fringing the north-east Australian coast for approximately 2000km with over 3200 coral reefs embedded in an ecosystem that includes mangrove forests, coastal wetlands and estuaries, seagrass meadows, deep shoals, continental shelf margin and slope. It is the key focus of a tourism industry worth around $7 billion per annum.

The development of the GBR catchments since European settlement has resulted in water quality changes into GBR waters from increasing sediment, nutrient, pesticides and other pollutants, and significant alterations to the hydrodynamic regime of the floodplain (freshwater, estuarine, and marine). The specific threats to reef ecosystems arise from exposure to turbidity-related light limitation, particulate organic matter (POM), dissolved inorganic nutrients, and sedimentation (Fabricius 2005). The evidence for the relationship between land use, water quality and declining GBR ecosystem health has led to a national policy response (the Reef Water Quality Protection Plan) which aims to halt and reverse the decline in water quality entering the Reef by 2013. Not all areas deliver significant pollutants (McKergow et al 2005) and focus on specific areas is likely to yield the best environmental, social and economic results.

This challenge is being taken up by the Reef Rescue Package, a major election commitment from the incoming Federal Government, which has a very explicit focus on soil management. The package was developed by a consortium of industry groups and regional NRM bodies in Queensland, and it aims to promote best management practices (see section 4.5) for soils, nutrients, chemicals and grazing in targeted areas of the Reef catchments. Such practices in the sugar industry for example, have led to up to tenfold reductions in on-farm chemical inputs, and consequently export off-farm into receiving waters. The consortium estimates that an investment of around $200m in well-targeted incentives and extension efforts will halve nutrient and chemical exports to the Great Barrier Reef.

Box content from Colin Creighton and Mike Grundy, photo Andrew Campbell

Soil degradation

Many hard lessons have been learned about the limitations of Australian soils in good seasons and especially in bad seasons, and significant degradation of Australian soils has occurred over the last two centuries.

Acidification

Large areas of acidic soils occur in New South Wales, Western Australia, Victoria and Tasmania. The Audit estimated that 50 million hectares of the agricultural zone are already suffering from acidification of soil surface layers and 20m ha from subsoil acidification, and that these are *"probably markedly affecting yields"* (NLWRA 2001a p viii). In the absence of remedial lime applications, it was estimated than an area of 29 to 60 million hectares would reach a soil pH of 4.8 (below which plant growth is limited) within 10 years and a further 14 to 39m ha would reach a pH of 5.5 (below which acid-sensitive plant species will not grow). The Audit noted that the amount of lime currently being applied (~2m tonnes per year) is more than an order of magnitude below the levels needed to restore soil pH levels to a satisfactory range and to keep them there (NLWRA 2001a).

Erosion

While there have been major improvements in controlling soil erosion through improved farming systems, biological control of rabbits and practices such as minimum tillage, trash retention and revegetation of gullies and sand dunes, soil erosion remains a major problem in Australia. In some areas rates of soil loss continue to exceed rates of soil development by an order of 50 times (NLWRA 2001a). *Hillslope erosion* remains high in the tropical north (with implications for the Great Barrier Reef — see Box 1 above). *Gully erosion* persists as the major erosion process affecting river condition in southern and eastern Australia, with more than 10,000 kilometres of stream length affected (with coarse sand accumulations in stream beds exacerbating flooding and smothering habitat of native fish) in the Murray Darling Basin (MDB) alone. *River bank erosion* is a major problem and around 120,000 kilometres of riparian vegetation along rivers and streams require rehabilitation (NLWRA 2001a). Sediment delivery to streams, rivers, estuaries and near shore marine zones is high in many catchments, particularly in the MDB, coastal regions of NSW, south-east Queensland (see Box 2 below) and south-west Victoria.

Dust storm approaching Silverton (near Broken Hill, NSW), 23 March 2007. Photo Stan Dineen

Box 2. South-east Queensland and Moreton Bay

The health of South-east Queensland's Moreton Bay and the region's waterways is intimately connected to the rapidly developing catchment. Protection of its health has led, in recent years to substantial reductions in point source pollution from sewage treatment plants and industry. The accent now is on reducing pollution from diffuse sources. Olley et al (2006) estimated that current erosion and sediment discharge rates are some 30 times more than that before European settlement – of the 315,000 tonnes of sediment discharged to Moreton Bay each year, 80% comes from non-urban areas, principally in the upper Brisbane and Logan Rivers catchments. Thirty-five percent of nitrogen in the waterways of SEQ also come from non-urban diffuse loads.

The current healthy waterways strategy is based on developing and meeting concepts of "sustainable loads" ie. the amounts of pollutants (e.g. nutrients and sediment) that a waterway can assimilate without becoming degraded. These will be used to guide investment and measure progress in reducing diffuse source pollution.

Central to scoping and meeting this challenge is a knowledge of the region's soils, landscapes and integrated hydrology. Poorly integrated management and understanding has created the current challenge.

Box content from Mike Grundy, photo Andrew Campbell

Nutrient loads to rivers and estuaries

Nearly 19,000 tonnes of total phosphorus and 141,000 tonnes of total nitrogen are exported to Australia's coast each year from areas of intensive agriculture, notably in north Queensland, Moreton Bay (see Box 2 above) and New South Wales. Soil management is crucial according to the Audit (NLWRA 2001a): *"Targeted erosion control and soil management provides a significant contribution to managing the supply of nutrients with much of the nutrient accompanying increased sediment loads to most rivers."*

Salinity

The definitive assessment of dryland salinity in Australia is the Audit's Australian Dryland Salinity Assessment 2000 (NLWRA 2001b). Using the best available methods at the time, a range of State and Territory agencies and research institutions concluded that around 5.7 million hectares were within regions at risk of or affected by dryland salinity and that this could increase to as much as 17 m ha by 2050. The 2050 estimates of potential salinity impacts included major off-farm assets such as 52,000 km of roads and 3,600 km of railways, 200 towns, 20,000 km of steams, and 2 million hectares of remnant native vegetation (NLWRA 2001b). The salinity costs to water, infrastructure and agricultural land within the MDB are already estimated at $305 m per year (Wilson 2004). The implications of such impacts on public infrastructure, water quality, biodiversity and agricultural production were a significant factor in the development of the National Action Plan for Salinity and Water Quality.

With improved modelling techniques and the projected impacts of climate change, the Audit's 2050 estimate of up to 17 m ha directly affected by salinity now appears to be too high. Groundwater tables have dropped in many regions, shrinking saline discharge areas and in some cases drying them up completely. It is likely that a warming, drying climate across southern Australia will reduce the symptoms of secondary salinisation and their impacts on dryland agriculture.

However the most important impacts of dryland salinity have always been off-farm. While projected decreases in rainfall and bigger declines in runoff will lead to reduced salt yields in most regions of southern Australia, they will lead to even greater reductions in streamflow. As a consequence, the concentration of salt in streams will tend to increase, even as water tables continue to drop. A detailed analysis of climate change impacts on salinity and water yields in the

Murray Darling Basin was commissioned by the AGO and undertaken by CSIRO (Austin et al 2006). That analysis predicted that under the selected climate scenarios:

- For the Murrumbidgee, water yields are estimated to drop by up to 48% by 2070, and salt yields by 30%, but end-of-valley (EOV) stream salinity concentrations are predicted to increase by 11%;
- For the Goulburn, the water yield reduction is 43% and salt yield reduction is 30%, but EOV stream salinity increases by 8%; and
- For the Border Rivers catchment, the water yield reduction is 54% and salt yield reduction is 33%, but EOV stream salinity increases by 10% by 2070.

From the depths of the current drought these projected streamflow reductions seem conservative (Campbell *in press*). While climate change in southern Australia may reduce the area of agricultural land directly affected by dryland salinity, it will not reduce the amount of salt already in the system, and water quality impacts are likely to get worse.

Other forms of land degradation

This list is by no means exhaustive. Other forms of land degradation occur, and may have significant impacts. Issues such as soil structure decline, compaction and loss of soil organic matter and soil flora and fauna all have an impact on the ability of the soil to provide the ecosystem services we expect, and to reduce the resilience of the soil to absorb these influences.

Overall, soil degradation problems have major on-site and off-site impacts that impose considerable costs on the Australian community. Soil degradation reduces food security. It pollutes water and air, affecting human health and many other species. As the soil represents 55% of Australia's continental carbon store, soil degradation generates significant greenhouse gas emissions. The soil stores enormous reservoirs of fresh water, filtering and buffering contaminants. Soil degradation reduces infiltration, increasing run-off, erosion, sedimentation and nutrient pollution of receiving waters. Conversely, practices that sequester carbon into the soil can markedly improve soil health and ecosystem function.

Soil degradation is expensive and often — in practical and economic terms — irreversible. But with good soil management, such degradation is preventable, and preventative actions represent good value investments. Good soil management requires a good knowledge base.

Soil information — key to good decision-making and reducing investment risk

A key finding of the Audit's summary report in 2002 was that there remained significant gaps in information. The baselines developed by the Audit were mostly model-based. Modelling is a necessary and reasonable approach for national assessments and for developing the resultant understanding of cause and effect, but even the most sophisticated model cannot run reliably without adequate information. An enduring system of environmental reporting based on the monitoring of key indicators requires long term consistent datasets founded on empirical data. Ground-truthing is essential to improve and to calibrate the models used to extrapolate or interpolate from empirical data and to move from process understanding to predictive capabilities.

In micro-economics it is an accepted principle that you can't manage what you can't measure. We take it for granted that Treasuries, banks, large corporations and investors of all types need sound economic data on which to base investment decisions, and that the absence of good information increases investment risk. The importance of good base data and on-going monitoring is now finally being recognised for water, with the $480 million commitment from the National Plan for Water Security to develop a nationally consistent water accounting framework. The need for such a framework is acute given the amounts of public and private investment at stake, the environmental risks, and the data required if market-based measures such as water trading are to mature.

The same factors apply well beyond water. The situation with carbon is directly analogous. The continuing decline in on-ground data collection and consequent paucity of quality national datasets for natural resources such as land, vegetation and biodiversity is becoming critical. In essence, we are losing the ability to ascertain with any confidence whether the extent and condition of our natural resource base is improving or declining, and whether or not major public investments are making a difference. The National State of Environment Report 2006 found that it was constrained in its ability to report on trends in the Australian environment by major data gaps, noting plaintively;

> *"The year 2006 must be the last state of the environment report in which the committee initiates the process of indicator and data selection. Environmental data should be continuously updated and made publicly available on the web. This will require strategic responses that are tailored to national, state and territory, and regional needs and that are sufficiently understood and accepted to be sustained…. The committee is concerned that the perpetuation of current data gaps could lead to an uncoordinated response…."*

This is not just about reporting. Large public investments are at stake. Investing on a poor, thin or patchy information base is inherently risky.

Despite the previous activity of the Audit, and progressive State of Environment reporting, there is still no definitive overview of the natural resource information that is required to be collected in the national interest, and managed as a national asset. Getting agreement on such an indicator-based reporting framework is the main task of the current phase of the Audit from 2002–2008. A high level framework (the National NRM Monitoring and Evaluation Framework) setting out Matters for Target has been agreed to by the Natural Resource Management Ministerial Council. The Audit is developing and seeking endorsement for agreed indicators under the National Monitoring and Evaluation Framework, and is identifying associated data and information needs.

The outcomes that the Natural Heritage Ministerial Board has required for the Audit are outlined in the Audit Strategic Plan. In summary:

- Develop an agreed set of resource condition and social and economic indicators that will underpin evaluation of initiatives like the NHT and NAP (using the Matters for Target and indicator headings of the National Monitoring and Evaluation Framework);
- Coordinate the development of information standards;
- Support the development of a natural resource information infrastructure to allow community access to natural resource information; and
- Undertake natural resource assessments as required.

A mid-term review of the Audit concluded that it is on track to finalise the indicator framework and identify the information needs by June 2008.

<u>National Committee on Soils and Terrain</u>

The Audit is working in partnership with all jurisdictions in seeking recommendations and endorsement of the indicator framework. One of the key mechanisms for this has been the development of national issue-based Coordination Committees, involving all jurisdictions and associated expert assistance to make recommendations on specific indicators for their area, on methods and protocols for using those indicators, and on the best ways of presenting information against the indicators (maps, graphs etc).

One of those National Coordinating Committees is the National Committee on Soils and Terrain (NCST), chaired by Noel Schoknecht from the Department of Agriculture and Food, Western Australia, and comprising representatives from all jurisdictions, the CSIRO, the Bureau of Rural Sciences and Geoscience Australia. Terms of Reference and membership of the NCST are at Appendix C. The NCST plays a key role in developing an agreed framework and national standards for soil and terrain assessment, including monitoring. It also provides national leadership on soil and terrain matters and in developing capacity within the sector. This discussion paper comprises a significant part of its policy work and has had active input from committee members.

The Australian Collaborative Land Evaluation Program (ACLEP) is a program jointly funded by the Department of Agriculture, Fisheries and Forestry and CSIRO and steered by the NCST. ACLEP has a key role in publishing and communicating standards in soil and terrain matters and providing a national portal for soils information through the Australian Soil Resource Information System (ASRIS). Further information on ACLEP and the NCST is available at www.clw.csiro.au/aclep and ASRIS is online at www.asris.csiro.au

Daly River, NT. Andrew Campbell photo.

The regional investment model for natural resource management (NRM)

A key driver for regional NRM is to develop effective responses to resource degradation issues at an appropriate scale — the catchment or landscape scale — that crosses property boundaries and even land tenures, in planning and implementing on-ground investments to put in place more sustainable management practices.

However it is not just about scale, it is also about integration. Many NRM issues are interconnected, and trying to fix one of them in isolation can have perverse impacts elsewhere. Climate change is intensifying both the impact of many of these issues and the interactions between them. It is also increasing the stakes — making it more important than ever to implement best-practice regional NRM approaches. Developing real and lasting solutions is also a matter of getting all the necessary players involved, ensuring that the right people are around the table and working together towards more sustainable approaches.

For all of the above 'bottom up' reasons, and in an attempt to rationalise service delivery across different tiers of government, the investment focus of the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust (NHT) over the last decade has seen a significant shift in public resources towards a regional investment model. This model is innovative and experimental to a degree. However it also represents a steady evolution towards more integrated, catchment-based approaches over the last 25 years, with origins as diverse as the Land Conservation District Committees in WA, the soil conservation catchment projects and land protection advisory boards in Victoria and Total Catchment Management in NSW (Campbell 1994).

Figure 4. Australia's 56 NRM Regions (from Robins and Dovers 2007)

Figure 4. Australia's 56 NRM Regions (from Robins and Dovers 2007)

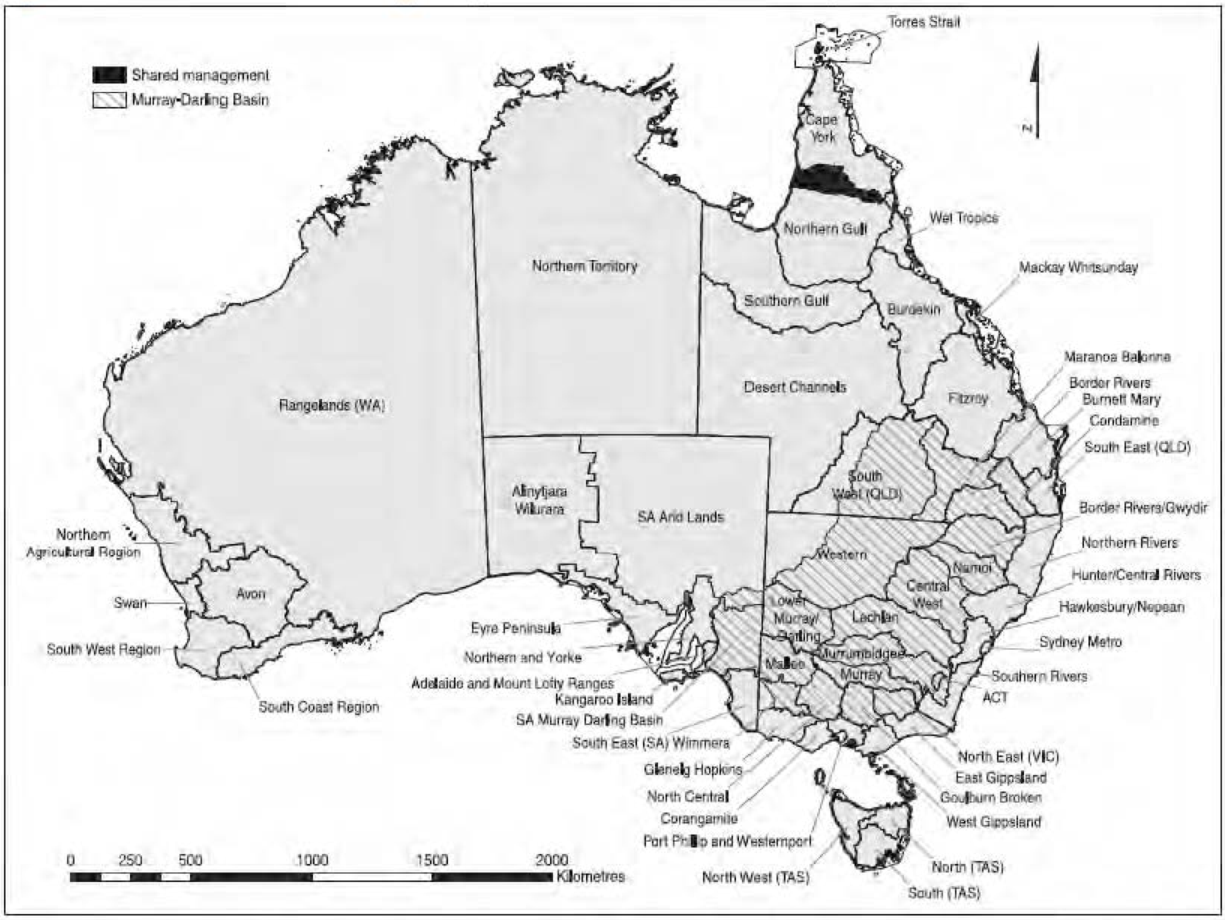


Figure 1 Australia's 56 NRM regions formalised under the NHT2. (Prepared by Karl Nissen, Centre for Resource and Environmental Studies, Australian National University, September 2006. Regional boundary and label data sourced from http://www.deh.gov.au/metadataexplorer/explorer.jsp.)

There are now 56 regional NRM bodies recognised under the NAP and NHT and complementary programs at State and Territory level, as outlined in Figure 4 above. They are set up in different ways in each jurisdiction. In Victoria, New South Wales, South Australia and Tasmania, they are statutory bodies (Catchment Management Authorities or Regional NRM Boards) established through specific NRM or catchment management legislation, and board members are Ministerial appointments. Regional NRM bodies in Queensland and Western Australia are less structured and more bottom up in nature, mostly either companies limited by guarantee or incorporated associations, with board members emerging from the community through membership voting or nominations from stakeholder and/or sub-catchment groups.

Within a few years, these new organisations have emerged at a scale between local government and state government, with a key role in NRM planning and program delivery. They manage the investment of significant public funding. To access resources from the NAP and NHT, regions must have an accredited Regional NRM Plan and Regional Investment Strategy (RIS). To June 2005, the NHT and NAP programs had allocated over $392 million to the 56 regions (NRM Ministerial Council, 2005).

The overarching framework for the regional investment model is established in Bilateral Agreements[13], between the Australian Government and each jurisdiction, and the implementation of those agreements is overseen by a Joint Steering Committee (JSC) for each jurisdiction.

As outlined above, the key 'control' over the detail of NAP investments is the Regional NRM Plan for each region, and its associated Regional Investment Strategy (RIS). These have to be accredited. The overall framework is an asset-based investment approach. Regional NRM Plans must set out the key natural resource assets to be protected, and outline Resource Condition Targets (RCTs) for each asset. They also need to outline the management actions that would need to be implemented in order to achieve the protection and/or sustainable management of the specified assets, and to set Management Action Targets (MATs). The Regional Investment Strategy should outline how its proposed investments will influence management actions to reach the MATs and consequently in due course the RCTs.

Soils and the regional model

From the diagram in Figure 1 in the introduction, and from the National Land & Water Resources Audit data mentioned above, it is obvious that Australia soils are a key natural resource asset. Soil health and soil productivity are critical short- and long-term assets for Australia in terms of the environmental, economic and social services they provide. Consequently, soils should be prominent in any asset-based NRM investment framework.

There are no specific data on how soils are being handled through the regional model, but as outlined earlier, a recent review found that regional NRM plans did not deal well with soil condition and land use matched to capability (RM Consulting Group 2006). That review recommended that:

> *"The Australian Government should consider how NRM regional bodies can be supported in better accessing current science and best practice to apply in regional planning. In particular NRM regional bodies should be supported in developing their knowledge base in the areas of soil health and land use capability."*

Critical to the objective of better supporting NRM regional bodies will be the maintenance of a coherent, useful and accessible soil information base, and the extension capacity to apply and promote the knowledge therein. This is explored in more detail in section 3.7 and section 4.

There has been a perception within DAFF and its counterpart primary industries agencies in the States and Territories, strongly shared by farmer organisations, that the regional investment model needs to do more on sustainable agriculture. Tentative steps have been made in this direction with the provision of $50 million over four years for the Environmental Stewardship Program, targeted at individual landholders. Land managers are selected for participation in the stewardship program through auction, tender and other market-based mechanisms, in which landholders can compete to provide environmental services in specific areas. These contracts are available for periods of up to 15 years, and provide incentives through payments to successful landholders to achieve long-term environmental outcomes on their properties.

The Environmental Stewardship Program is constrained in its first phase to projects targeting matters of National Environmental Significance – in the first instance the endangered Grassy White Box Woodlands vegetation community in south-eastern Australia. In principle, stewardship payments could be a highly prospective means of providing incentives for soil conservation. In practice, the implementation of such incentives is problematic. It is very difficult to structure a scheme that pays the farmer for what s/he delivers over and above what could reasonably be considered a duty of care. If the bar is set too low, that sends the wrong message (i.e. farmers don't have to look after the environment unless the taxpayer foots the bill – like people wanting to be paid not to break the speed limit). Secondly and probably more importantly in a pragmatic sense, it would open up a bottomless pit for public subsidies, and Australia would essentially be doing what we accuse Europe, Japan and the US of doing – production subsidies by another name.

[13] http://www.napswq.gov.au/publications/agreements/index.html#bilateral
http://www.nht.gov.au/publications/agreements/index.html

On the other hand if the bar is set too high, few people would take up the incentive, thus defeating the purpose.

Defining and quantifying the environmental services, and adjusting them for seasonal conditions and local variations (such as soil type) across regions and states, is very difficult. Yet such schemes need to be as administratively simple as possible in order to keep overheads down and not annoy participants, so they tend to be more blunt instruments than would be ideal from a policy perspective. That opens up the risks of payments occurring for measures that do not look like good value for the taxpayer. On the other hand, this can also be the case for projects funded by regional NRM bodies, and new soils survey techniques and improved Decision Support Systems could potentially enable environmental services payments to be targeted to soils, as is possible in the United States (see Appendix B).

Section 4.5 looks specifically at measures that could bring about a greater focus on soils within the regional NRM investment model.

3.4 Water

The key elements of the National Water Initiative and the National Plan for Water Security are outlined in Appendix A (Section 7.2).

Unfortunately there is no mention of soils or soil management in the full text of the Intergovernmental Agreement of the National Water Initiative. The National Plan for Water Security specifically mentions the need to deal with leaky irrigation systems and the need for fine-tuning irrigation scheduling to soil type. However it is still short on a deeper recognition of the connection between soil management at a paddock and property scale, and water quality and quantity at a catchment and landscape scale. Some of these missing connections are proposed in section 7.2.

From a soils perspective, the implications of what has happened in the water sector over the last decade are huge. Water is a classic example of the sort of responses — for better or worse — that can be catalysed when an issue assumes sufficient public and political importance. While at first blush it is difficult to imagine soils ever achieving comparable prominence and concern, in fact there have already been instances in Australian history when soil management has gripped the nation’s attention. The dust bowl years of the 1930s led to the formation of soil conservation agencies and the passing of soil conservation legislation in several states (Bradsen 1988). The famous photo of the dust clouds moving in over Melbourne on Ash Wednesday 1983 was also a circuit breaker. Unfortunately, climate shifts may see such images becoming more frequent unless we improve our soil management.

There is a long way to go with water, given that not all jurisdictions have yet committed to the National Plan for Water Security. It remains to be seen whether that Plan can deliver a single national system of water accounts backed up by consistent metering and monitoring systems across the country. However even at this early stage it is possible to elicit some lessons relevant to soils:

- when an issue gets to the top of the list, it is critical that the relevant science and policy community can put credible proposals on the table;
- data can attract sufficient investment when an issue assumes sufficient importance;
- for large scale public investment, there needs to be a clear narrative and logic that shows how interventions will tackle the perceived problem and what the benefits will be; and
- the key stakeholders need to be in the loop and have some ownership of the overall plan.

3.5 Climate change[14]

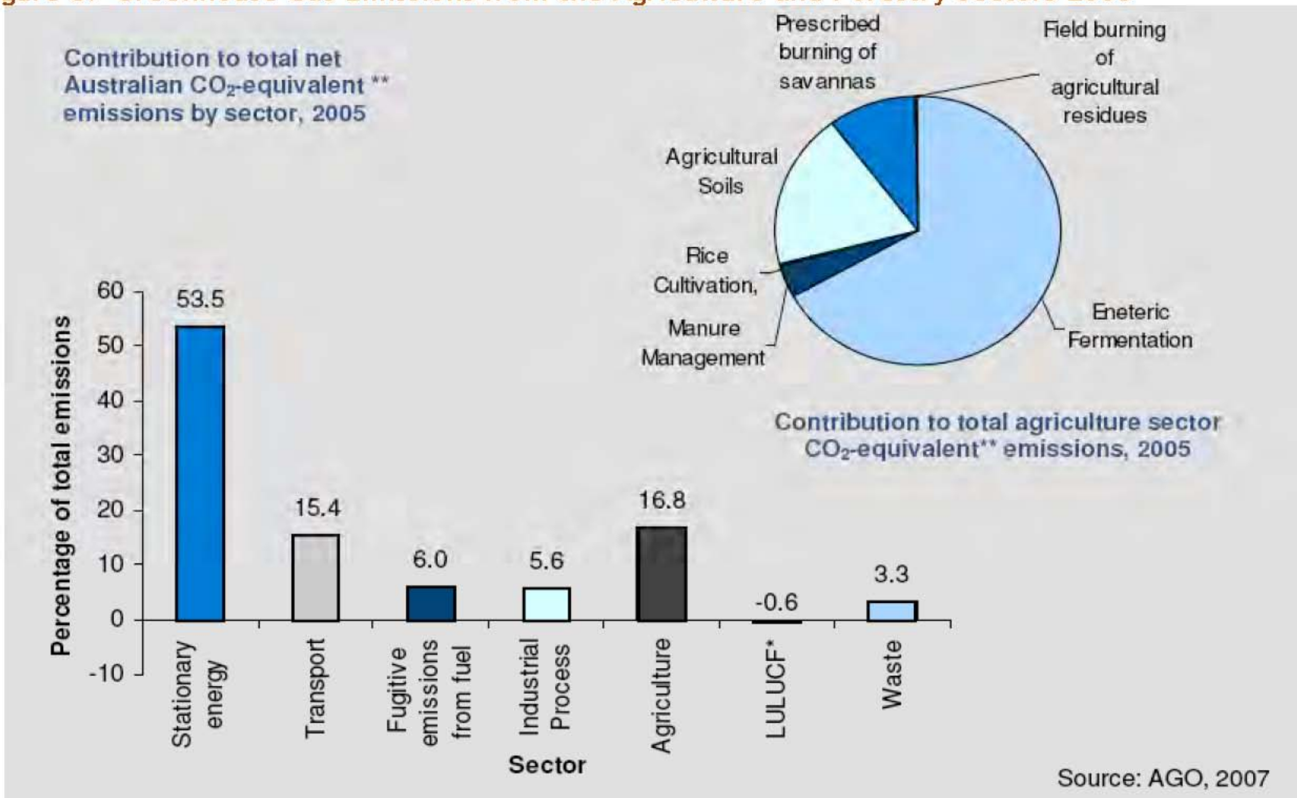
The evidence of warming of the Earth's climate system is unequivocal. It is evident from increases in global average air and ocean temperatures, melting of snow and ice, and rising sea levels. Recent trend observations of carbon emissions, temperatures and sea levels, coupled with new understanding of feedbacks, imply more severe climate change through the 21st century — and rapidly increasing risks of serious impacts, notably for water availability.

The earth is getting warmer and we are causing that to happen. Adaptation to climate change is no longer a question of "if" but rather of "how", "where" and "how fast".

For the regions of Australia in which most people live and most food and fibre is produced — i.e. the eastern seaboard and southern and south-western Australia — the greenhouse effect is leading to a hotter, drier climate on average, marked by more extreme weather events, but less rainfall and even less runoff overall. Notwithstanding the predicted decline in average annual rainfall in many areas, rainfall events are likely to be more intense, exacerbating erosion risk. Climate change is real. It won't go away for the next century at least, irrespective of current actions. It has huge implications for Australia in particular.

14 This section draws heavily on a forthcoming publication commissioned by the Australian Greenhouse Office — a Climate Change Primer targeted at Australia's 56 regional NRM bodies (Campbell, in press).

Figure 5. Greenhouse Gas Emissions from the Agriculture and Forestry Sectors 2005



The main greenhouse gases emitted from agriculture in Australia are methane and nitrous oxide. In 2005, agriculture accounted for:

- 60% of Australia's methane emissions, with over 70% of these coming from livestock through enteric fermentation and manure management; and
- 85% of Australia's nitrous oxide emissions, with major sources being release as a result of nitrogen fertiliser application and nitrogen in animal excreta (AGO, 2007).

* LULUCF: Land use, land use change and forestry

** CO_2-equivalent; this measure is used to represent emissions of all greenhouse gases listed under the Kyoto Protocol in terms of the contribution they make to global warming relative to carbon dioxide.

Figure 5. Greenhouse Gas Emissions from the Agriculture and Forestry Sectors 2005

Figure 5 above (from the Garnaut Climate Change Review 2007) sets out the contribution of agriculture to Australia's greenhouse gas emissions in 2005. Note that agriculture is the second biggest emitter (albeit well behind power stations) and that soil emissions are the second biggest component of agricultural emissions behind enteric fermentation. However soil emissions are highly variable and management-dependent. Put crudely, degrading soils emit greenhouse gases, and well-managed soils tend to accumulate soil organic carbon.

An extremely variable climate has always been a fundamental driver of ecological processes and land use systems in Australia, shaping exquisite adaptations among our unique biota, and distinctive farming systems. Australia's inherent climate variability is now being exacerbated by global warming, and underlying climatic parameters are moving. In many regions, the odds of having a good season seem to have shifted, to the point of threatening the long-term viability of some farming systems, rural businesses, natural ecosystems and individual species.

Climate change is not just another natural resource management (NRM) issue. The convergence of climate, water and energy issues in a carbon-constrained world will change the ground rules for managing natural resources in Australia. From a water perspective alone, the implications of climate change are profound. They will reach deeply into every aspect of our lives and those of our children and their descendants.

Potential implications of climate change for soil management

While perhaps not quite so immediately obvious, the implications of climate change for soil management are of the same dimensions as for water. They fall into two broad categories — the direct on-ground impacts and the policy responses, which in turn will have further on-ground impacts.

On-ground impacts

- the on-ground impacts of a drying, warming climate with more extreme weather events will generally make soil management more challenging in our main agricultural regions;
- regional shifts in climate patterns will increase demands to change farming systems or to move existing farming systems into new areas, potentially placing new pressures on soils;
- increasing energy prices, depletion of global phosphate reserves and likely pricing of carbon will lead to increasing costs of external farm inputs including diesel, fertilisers and biocides. This should intensify efforts to develop soil management systems that minimise the need for external inputs of energy and nutrients — as well as increasing the risks of soils being used unsustainably (mined);

Both the on-ground impacts of climate change on soils and the probable policy responses to climate change listed below underline the need for a strategic national approach to investment in soils. Such an approach would need to consider how policy, research, extension, education, assessment and monitoring, data management and community engagement can work together to promote and assist more sustainable soil management in Australia.

Policy responses

The soil is a huge carbon store. Of the estimated 3,060 gigatonnes of carbon in the terrestrial biosphere, 82 per cent is in soils (Lal 2004, cited in Porteous and Smith 2008). Poor soil management generates potentially large greenhouse gas emissions. There is a very strong imperative for Australia to introduce a suite of policy instruments that encourage sequestration of soil carbon and that discourage practices that lead to large emissions of soil carbon. The policy responses to climate change are likely to include:

- an urgent need to develop robust, efficient, user-friendly methods for measuring the soil carbon store and tracking changes in it;
- using these tools to develop an accounting framework for soil carbon;
- the preceding two steps are prerequisites for any moves to include soil carbon in a national emissions trading scheme;[15]
- measures to encourage abatement of greenhouse gas emissions from soils, which will inevitably lead to a greater focus on soil carbon, from a management as well as a measurement perspective;
- greater attention within planning and development approval processes on the risks associated with developments on particular types of land (not just from a soils perspective, but also flooding, storm risks, bushfires and so on) leading to demands for improvements to natural resources information systems for a wide range of users.

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15 The National Emissions Trading Task Group (2007) outlined design parameters for an Australian emissions trading scheme that included the principle of 'maximum coverage of all sources and sinks, and of all greenhouse gases'. However it expressly excluded agriculture and land use from the initial phase of the scheme until the measurement difficulties in areas such as ruminant and soil emissions can be resolved. The task force specifically said that agricultural emissions should be brought into the scheme as practical issues are resolved, and that sectors initially excluded from the scheme should be subject to other policies designed to deliver abatement.

On the latter point, soil management is just as critical as soil type, aspect, slope and so on. Better soil management leading to improved soil health makes soils less prone to erosion and waterlogging as well as being able to better utilise more variable rainfall and to cope with extreme and unseasonal rainfall events.

Some thinking has already started on how soil carbon could be recognised in a post-Kyoto policy world. In an article in the February-March 2008 edition of ECOS, James Porteous and Frank Smith discuss the Australian Soil Carbon Accreditation Scheme (ASCAS) proposed by Australian soil scientist Dr Christine Jones, under which farmers could receive incentive payments for increases in soil carbon (www.amazingcarbon.com). The ASCAS project is measuring soil carbon accumulation rates across various properties and soil types in the Northern Agricultural Region (NAR) of Western Australia (supported by Western Australia's Department of Agriculture and Food) and central Queensland (supported by Incitec Pivot Ltd).

However significant policy and practical uncertainties remain to be resolved to establish a system like this. Although the below-ground component of carbon sequestered in trees is counted in some carbon offset schemes (Campbell 2007), farmers are unlikely to be able to trade in soil carbon for at least the next five years.

3.6 Sustainable Agriculture

By now it should be obvious that soil management is fundamental to sustainable agriculture. Australia's soils and climate have always made it a tough place to farm profitably and sustainably. Peter Hayman of SARDI puts it well: *"If the world was your farm, Australia would not be one of your better paddocks…"*

It is always dangerous to lump all farmers together and assume, even implicitly, that they are an homogeneous group — far from it. There is a huge diversity of farm businesses in Australia across a wide variety of industries, and in Australia as in other developed countries, the face of agriculture is changing rapidly (Barr 2005).

The Agriculture and Food Sector Stocktake (DAFF 2005a) summarised key data across agricultural industries, and some of the key drivers of change in Australian agriculture, including:

- On-going declining terms of trade for farmers;
- The global trading environment, with a shift in emphasis from exports to Europe towards Asian markets since the early 1990s, and on-going impacts of farm subsidies and other trade barriers in Japan, Europe and the United States;
- Changing consumer preferences, an aging population, and restructuring in the retail sector, including the introduction of new supply chain initiatives;
- Increasing volumes of international trade increasing biosecurity and bioterrorism risks;
- The need for accelerated investment in upgrading transport, communication and irrigation infrastructure;
- An intensifying shortage of skilled labour in many sectors;
- Changing community perceptions of farming, in particular around animal welfare and use of GMOs;
- Sustainable natural resource management — in particular water management and conservation of biodiversity — and the need to get the right mix of incentives and regulation; and
- Climate change.

Key recommendations from the Agriculture and Food Sector Working Group under Peter Corish included continued investment in agricultural R&D and innovation, greater emphasis on improving adoption of R&D outputs and new technologies, and better application of new Information and Communication Technologies within agriculture (DAFF 2005a,b). Soil management was not mentioned specifically.

Climate change impacts on Australian agriculture have been the focus of two recent reports that have gained significant media attention. ABARE's *Australian Commodities* for the December 2007 quarter included an article by Don Gunasekera and colleagues that analysed the potential medium-long term impacts of climate change on agricultural productivity, exports and trade in Australia and internationally (Gunasekera et al 2007). Given the projected need to double world food production by 2050 discussed in the introduction to this paper, ABARE's conclusions make sobering reading:

> *» ABARE analysis indicates that future climate changes and associated declines in agricultural productivity and global economic activity may affect global production of key commodities: for example, global wheat, beef, dairy and sugar production could decline by 2–6 per cent by 2030 and by 5–11 per cent by 2050, relative to what would otherwise have been the case (the 'reference case').*
>
> *» Furthermore, Australian production of these commodities could decline by an estimated 9–10 per cent by 2030 and 13–19 per cent by 2050, relative to the reference case.*
>
> *» These changes would also have significant implications for international agricultural trade. For example, Australian agricultural exports of key commodities are projected to decline by 11–63 per cent by 2030 and by 15–79 per cent by 2050, relative to the reference case.*
>
> *» Australia is projected to be one of the most adversely affected regions from future changes in climate in terms of reductions in agricultural production and exports.*
>
> *» There is a continuing need for the agriculture sector to maintain strong productivity growth in order to cope with the potential pressures emerging from climate change. In this context, adaptation measures, including improved agricultural technologies, will be particularly important in reducing the potential impacts.*
>
> *» There is also an urgent need for policies that encourage rather than impede adjustment in vulnerable sectors in agriculture, including already marginal farming enterprises.*

Like ABARE, the Garnaut Climate Change Review (2007) concludes that Australia is one of the countries most affected by climate change, and that agriculture is among the most affected sectors of the Australian economy.

The incoming Australian Government has flagged that a cornerstone of its agricultural policies will be assisting the Australian agricultural sector to improve its capability to adapt to climate change. Numerous inquiries into drought policy over many years have recommended a shift from direct business support such as fuel, freight and fodder subsidies, towards more emphasis on building greater self-reliance, risk management and adaptive capacity within agricultural industries, while dealing with the social impacts of drought through welfare measures in the short term and structural adjustment in the longer term (Botterill and Wilhite 2005). Our track record in delivering structural adjustment measures on a widespread scale is modest and patchy at best (McColl et al 1997), but as ABARE notes in its last point above, there is an urgent imperative to do better now, particularly in the most marginal areas and enterprises.

Soil management is central to moves to build greater resilience into Australian farming systems in the face of more frequent and extreme droughts. Increasing soil carbon levels is covered further below, but it is far from the only important facet of the need to improve farming systems in the face of increasing climate variability, more frequent and intense droughts, rising energy prices and the need to reduce greenhouse gas emissions. For example, there will be an increasing need to reduce the reliance on Nitrogenous fertilisers and increase the proportion of N derived from leguminous N fixation. An excellent overview by Peoples et al (2008) explores the reliance of humans on N for our food, and summarises the balance between applied N and legume-fixed N in farming systems around the world.

Figure 6 below (Krull et al 2004) illustrates the critical role played by organic matter within soils. Improving soil carbon levels and moisture holding capacity is also a critical objective at a wider landscape level from both a greenhouse and a water management perspective. It is a key to enabling farmers to develop more flexible and opportunistic farming systems that can exploit unseasonal rainfall and survive a run of poor seasons in reasonable shape. In a context where the interactions between climate, water and energy are usually characterised by trade-offs, improving soil organic carbon levels and N-fixation by legumes in farming systems are two of the rare win-wins.

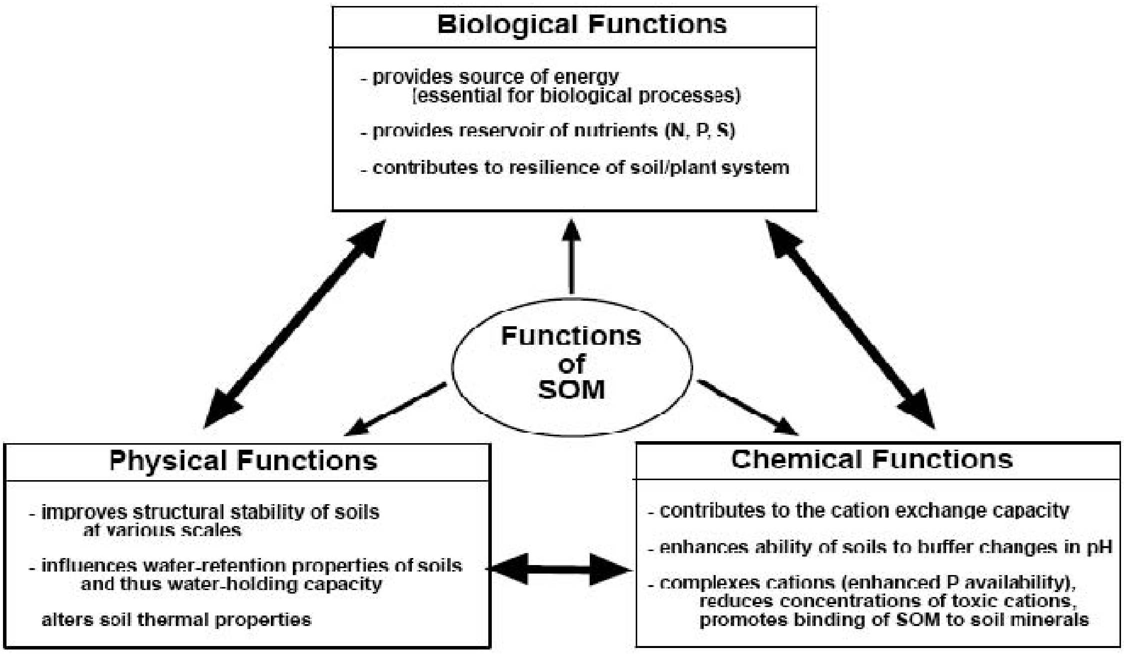

Figure 6. Principal functions of Soil Organic Matter (SOM) in soils (Krull et al 2004)

The photo at right (from Porteous and Smith 2008 and courtesy of Pat Francis, *Australian Farm Journal*) is a classic illustration of the contrast between carbon-poor farmland after rain (right of fence), showing soil compaction and surface sealing due to excessive tillage and over-grazing, leading to increased run-off and erosion; and carbon-rich soil of the adjacent stock route (left of fence). The stock route has more groundcover, better structure and greater water-holding capacity, sequestering carbon rather than emitting greenhouse gases.

Improving soil organic carbon levels could potentially deliver returns to landholders over and above productivity and resilience improvements if soil carbon ever gets recognised in emissions trading.

However both the National Emissions Trading Task Group (2006) and the Garnaut Climate Change Review (2007) make the point that the transaction costs in baseline setting, accreditation, monitoring, measurement and reporting, ensuring additionality, and preventing 'double counting' for issues such as soil carbon are likely to be high relative to the amounts of carbon involved and the consequent returns for most individual agricultural enterprises.

While that is undoubtedly true at present at the enterprise level, the equation may look rather different at the landscape scale. While the incremental increases in stored carbon per hectare may be modest, the areas involved are vast, and soil carbon sequestration can commence relatively quickly compared with, for example, forestry schemes. This underlines the central importance for Australian agriculture of having a high quality, nationally consistent soil resources information system for benchmarking and reference purposes, and robust, user-friendly tools for measuring soil carbon in the field. A conservative trading system based on best land management practices calibrated through regional soil sequestration experiments might be far cheaper than first imagined.

Of course improving soil management in Australian farming systems involves more than simply improving soil organic carbon levels. Better soil management practices vary from region to region and industry to industry. They include:

- planning farm layout according to land type and land use according to suitability, anticipating poor seasons;
- careful choice of rotations, using legume Nitrogen fixers or free-living N fixers instead of chemical N;
- tillage practices that minimise soil disturbance and compaction (supported where appropriate by precision agriculture systems);
- regular monitoring of key soil parameters and calibration of water, fertiliser and/or chemical inputs accordingly (using tools such as Yield Prophet **http://www.bcg.org.au/yield_prophet.php**) so that nutrient and chemical inputs stay on farm; and
- grazing management that maintains sufficient groundcover and optimises pasture nutrition against herd structure and seasonal conditions.

These are but a selection — there are many others — but it is interesting to note that virtually all of these practices have the net result through time of increasing soil carbon. It is important not to be too prescriptive about management practices per se, but rather to concentrate on the key parameters that indicate whether the sustainability of the system is improving. For soils these include groundcover, soil organic carbon content, nutrient status, pH and biological activity, with the latter being the hardest to get a handle on. The Farm Sustainability Dashboard (Figure 7, section 4.2) provides more detail on this point.

3.7 Roles and responsibilities

The following sections explore some of the specific measures that could be taken to bring about a more coherent and strategic approach to soils investment in Australia. Before diving into the detail however, it is important to touch on the crucial 'who?' question of the roles and responsibilities of different players.

It is arguable that in the bold innovation of the regional NRM investment model and all the work associated with its development and implementation, there has been a tendency to assume that, having built the model, the regional level will be the key delivery mechanism for natural resource management policies and programs. There are vast differences across the 56 regional NRM bodies in levels of maturity, staffing, budgets, access to resources and capacity. Lisa Robins and Steve Dovers (2007a) have analysed these differences and developed a typology that categorises the 56 regional bodies into ten 'types' that they liken to aircraft, from 'ultralight' and 'single engine' regions to 'MIG', 'Hercules' and 'Jumbo' regions. They argue that there is a case for intervention to reduce the gap between the 'haves' and 'have nots' among regional NRM bodies (Robins and Dovers 2007a). Some of the regional NRM bodies are mature, well staffed and resourced, and are actively implementing a diverse portfolio of NRM activities. Others are struggling. They feel that they have been loaded up with too much to do, too quickly, with insufficient resources or support (Walker et al 2006, Robins and Dovers 2007b).

Leaving aside the capacity differences among regional NRM bodies, it is important to first consider what sorts of NRM measures are appropriately delivered through the regional model by regional NRM bodies, as opposed to individual landholders, industry bodies, local government, state government, national approaches involving all jurisdictions, or the Commonwealth.

Achieving widespread changes in land management practices comes down to being able to translate broad policy objectives — e.g. eliminate greenhouse gas emissions and encourage net carbon sequestration and increase the soil carbon store — into practical, adoptable measures at a paddock scale, and to see widespread adoption of those measures. There are many ways of achieving this, at least in theory. Policy makers have a rich menu of instruments from which to choose, as outlined in Table 1 below.

Taking the example objective of improving soil management to increase the soil carbon store, increase water holding capacity and improve the resilience of Australian farming systems, it is instructive to scan Table 1 to look at which sorts of instruments are applicable in achieving that objective, and the most appropriate delivery mechanism for the particular instrument.

Table 1. Policy instruments for supporting change (from SELN 2006 after Dovers 1995)

1. Regulation, Enforcement and Compliance	Statutes, laws and regulations provide institutional guidelines and specify agency responsibilities for enforcing minimum standards, prohibiting certain practices and regulating resource use in policy areas such as landuse planning, vegetation management, water allocation and development control. Enforcement and compliance of regulatory frameworks facilitate changed practices. A major risk is that 'command and control' approaches limit effectiveness in achieving more than minimum standards.
2. Direct Investment	Sometimes when specific on-ground outcomes are desired, the most effective mechanism is direct investment – to contract to deliver a specified outcome.
3. Covenants and MoUs	Voluntary but official agreements and contracts for performance of a particular activity can support change processes. Examples include conservation agreements tied to property title.
4. Common Law, Duty of Care, Stewardship	Common Law refers to a system of law based on custom and general social principles that are embodied in centuries of legal case history judgments. Common Law recognises social norms, community values and rights as key enablers of effective and sustainable practice. Within Common Law there are notions of a Duty of Care that persons have to ensure that they do not create harm. Potentially this Duty of Care extends to the environment.
5. Formal Agreements	There are a variety of formal mechanisms that can be used between governments and other entities to facilitate action. Governments can commission regional NRM bodies, local government and/or NGOs to provide certain services or deliver certain outcomes.
6. Research and Development	R&D increases the stock of knowledge through basic and applied research. The implementation and adoption of research outputs contributes to practice change and the achievement of sustainable and productive outcomes.
7. Monitoring and Evaluation	Monitoring and evaluation enables progress towards policy or program goals to be measured. For many NRM issues, the baseline state of the issue at hand is not well known. Evaluation of methods used to create change is necessary to enable fine-tuning of the instruments through adaptive management.
8. Assessment Procedures	Procedures such as environmental impact assessment (EIA), social impact assessment (SIA), health impact assessment (HIA), strategic environmental assessment (SEA), lifecycle assessment (LCA), triple bottom line accounting (TBL) and sustainability assessment all have goals of improving environmental and social outcomes. By providing information about sources of harm, and opportunities for improvement, these assessment tools can facilitate change.
9. Self-Regulation	Codes of practice, codes of ethics, professional standards are approaches that encourage stakeholders to change their own practices in order to meet commonly accepted standards of practice. The process of development of these codes, and awareness of them, leads to practice change.

10. Quality Assurance processes, EMS and Ecolabling	Encouragement of the implementation of Quality Assurance processes (such as Environmental Management Systems and Farm Management Systems) creates change because it encourages continuous improvement, reflexive practice, monitoring and benchmarking against best practice. Ecolabeling is a market-based mechanism where the establishment of an ecolabel potentially provides competitive advantage to products produced under this label and compliance is created via the competitive advantage that exists. Ecolabeling is in effect a code of conduct that mandates the quality assurance of environmentally sound practices.
11. PR, Marketing and Advertising	The achievement of change can sometimes be facilitated by a public relations, advertising or marketing campaign. Awareness of an issue or of practical solutions is sometimes all that is required for change to occur.
12. Formal Education and Training	Public, targeted formal education and training programs can improve knowledge and develop skills in a specific area as a means to enabling practice change and on-ground improvements.
13. Suasion	Appeals to the right thing to do — campaigns that promote what is socially desirable.
14. Extension	Extension is the process of enabling change in individuals, communities and industries involved in the primary industry sector and with natural resource management. While extension seeks to improve communication and information flow between industry, agency and community stakeholders, it is primarily concerned with building capacity for change.
15. Participatory Approaches	Solving complex, unstructured problems requires inclusive institutions and participatory processes of mediation, negotiation, dispute resolution and other deliberative mechanisms with community and industry stakeholders. Participatory approaches may contribute to collective ownership of an issue and to a willingness to take action.
16. Market-based Mechanisms	Market-based mechanisms include a range of methods for encouraging change usually involving the assignment of property rights to goods that are not normally traded through a market, and setting up competitive processes for the provision of those goods.
17. Economic Incentives	Economic incentives refer to a range of financial inducements that attempt to change behaviour through monetary reward or penalty including: taxes on bad practices, use charges, tax deductions and/or rebates/credits, rate relief, subsidies and co-funding arrangements, direct grants, and penalties for poor practice.
18. Conditionalities or cross-compliance	Conditionalities refers to the conditions that can be imposed on a business in conjunction with the granting of for example, a licence to operate or an economic incentive. This may include stipulations on emission levels, offset compensation (such as revegetation in one area to compensate for clearing in another), and/or performance bonds.
19. Institutional Arrangements	Responsive institutional environments are necessary for enabling other instruments, policies and management. The capacity of institutions to change is essential for improving inter-organisational outcomes.
20. Change other policies	Actions to influence and/or distort policies or statutory objects can induce change processes. Examples include: ineffective subsidies; conflicting policies; misplaced statutory objects.
21. Reasoned Inaction	*Doing nothing* is valid where justified by due consideration, eg. allowing market forces to prevail.

Individual, community, industry or government

Individual landholders (farmers, indigenous communities, parks agencies, utility companies, local governments, state and Commonwealth agencies [e.g. Department of Defence]) have the primary direct responsibility for managing soil. The aggregate and cumulative impact of their countless everyday decisions and actions as they go about their business ultimately determines soil condition, vegetation cover, water use and so on. Individual behaviour of course takes place in a social, geographic, economic, institutional and political context, and is influenced — encouraged, enabled and constrained — by that context. Most of the instruments in Table 1 above seek to influence the decisions and actions (behaviour) of individual landholders, either directly by appealing to their enlightened self interest or by changing the social, economic or institutional context.

NSW Southern Tablelands, February 2007. Andrew Campbell photo.

As discussed earlier, it can be argued that landholders have a legal duty of care not to knowingly degrade soil resources, particularly to the extent that such degradation imposes harm on others or the community. It is a bigger stretch to argue that landholders have a legal duty of care to say improve soil carbon levels or maintain a given pH status. Various legislation in the States and Territories does require landholders to prevent soil erosion and establishes powers for authorities to intervene to require landholders to take remedial action. However even with soil conservation as narrowly defined, such legislation is not actively enforced and there are very few prosecutions across the whole country in any year. As yet there has been no attempt to define in legislation a broader duty of care to, for example, maintain a minimum level of soil carbon or soil biodiversity or to keep pH within a given range. This would be an heroic undertaking in legislative drafting, and in view of the sanctity of private property rights in Australia, politically courageous. Given our track record in enforcing existing environmental regulations affecting farmers (Martin et al 2007), it is also unlikely to be effective.

While it may be difficult to legislate a duty of care for soil carbon, it is possible through the systematic and sustained application of a number of the instruments above (e.g. nos 2-5, 9-15 and 17) to reinforce an ethical obligation to look after the soil and to improve soil health. A land ethic alone is insufficient to deliver sustainability, but it is a good start. Sustainability is a pipedream without a land ethic as a foundation stone (Leopold 1949, Berry 1977, Jackson 1980, Roberts 1993). Community groups such as landcare create a collective social pressure in favour of developing more sustainable farming systems, reinforcing and supporting the efforts of individual farmers already having a go, and exerting others to become more involved, or at least better informing them of the issues (Campbell 1994). Industries also have a key role here in defining acceptable standards of practice and in self-regulation to discourage individual actions that may affect the reputation, social licence to operate or access to market of an entire industry.

There is no doubt that individual landholders, community groups and industry bodies share significant responsibilities for sustainable management of soils. However the economic, political, institutional and knowledge frameworks within which they operate are overwhelmingly designed and delivered by governments.

The Parliamentary Triangle, Canberra, February 2005. Andrew Campbell photo.

Different tiers of government

Management of Australia's soil resources under the Constitution is unambiguously the responsibility of the State and Territories. However as outlined earlier, the Commonwealth has been getting increasingly involved beyond its traditional mandate in water, and is starting to do likewise with carbon (about which the Constitution is silent). A national (as opposed to unilateral Commonwealth) approach is required to the management of water, energy and greenhouse gas emissions in the light of the projected severe climate change impacts on Australia. Given the linkages between soil management and the achievement of water and greenhouse objectives, it is arguable that soils deserve comparable treatment.

The current situation is characterised by considerable flux and a lack of clarity about the respective roles and responsibilities of the Commonwealth, State and Territory Governments, regional NRM bodies (which are statutory authorities in some jurisdictions) and local government. As a basis for discussion, Table 2 below attempts to propose an indicative distribution of responsibilities across the respective tiers of government, again taking the example policy objective of increasing soil organic carbon. This list is merely illustrative, and of course there are important objectives beyond increasing soil carbon.

Table 2. Suggested distribution of responsibility for increasing soil carbon among tiers of government

Tier of Government	Responsibilities
Local	Taking soil type and condition into account in development approval processes to protect vulnerable soils. Waste management services that avoid soil contamination. Exemplary management of council lands to demonstrate practices that build soil carbon.
Regional NRM bodies[16]	Ensuring that soils are appropriately considered in regional NRM plans and in defining Resource Condition Targets and Management Action Targets. Delivering on-ground projects that protect vulnerable soils and encouraging the implementation of practices that build up soil carbon. Playing a regional leadership role across and between government agencies, industry bodies and community groups to promote measures that build up soil carbon. Working with industry bodies and farming systems research groups to develop, identify and promote on-farm practices that build soil carbon.
State/Territory	Enacting and enforcing legislation that identifies and protects vulnerable soils. Ensuring that the planning, zoning and rating systems complement this legislation. Providing a comprehensive, accessible and user-friendly soils information base, and implementing a comprehensive soils assessment, mapping and monitoring effort, according to nationally agreed data standards and protocols. Contributing data, information and research outputs into the national knowledge base according to nationally agreed data standards and protocols. Developing and maintaining specialist soils expertise and resources that underpin extension programs whether delivered by state agencies, regional NRM bodies, agribusiness or industry groups. Implementing the State/Territory component of the national soil carbon extension initiative. Exemplary management of Crown Lands to model practices that build soil carbon.
National	Designing and delivering a soil research program around nationally defined priorities — for example to develop tools for measuring and monitoring soil carbon as part of a soils assessment kit for agreed national core parameters including soil carbon, pH and soil biodiversity. Undertaking a detailed economic analysis of the costs of soil degradation and the potential return on investment from preventing such degradation and increasing the soil carbon store. Ensuring that bilateral agreements for the NAP and NHT and their successor programs deal with soil heath and soil carbon adequately. Developing a soil carbon module for incorporation in a national emissions trading scheme. Setting agreed soil condition indicators and data standards and protocols. Developing and delivering an improved Australian Soil Resources Information System (ASRIS). Developing and delivering a national soil carbon extension initiative, backed up by a suite of economic incentives and well-trained teams comprising private consultants, industry representatives, staff of state agencies and regional NRM bodies and academic institutions. Developing and funding a comprehensive soils education and training package with complementary components at tertiary, TAFE and community levels. Developing and funding a national initiative to build soils capacity. Coordinating soils research and capacity building across Australia, including a comprehensive knowledge base with leading edge knowledge management standards and tools.
Commonwealth	Participating in international collaborations to protect soil resources and increase the soil carbon store. Playing a leadership role in international climate change negotiations to ensure that measures which build soil carbon are recognised in the post-Kyoto global climate change framework. Exemplary management of Commonwealth lands to demonstrate practices that build soil carbon.

16 In some jurisdictions (notably Queensland and WA) it is not appropriate to consider regional NRM bodies as a tier of government. Chairs and CEOs of regional NRM bodies in most jurisdictions would reject the notion. However it is defensible for the sake of this discussion on respective roles and responsibilities, and where they are statutory bodies with defined NRM responsibilities under their own legislation.

4. Improving the policy and delivery framework for soil management

4.1 Options for developing a strategy

There are three broad options for developing a more strategic approach to public investment in soil science, policy and management in Australia:

1. Recognising the profound implications of climate change and recent developments such as the National Plan for Water Security that have challenged traditional State/Federal NRM relationships, and noting that most of the issues raised here with respect to soils also apply for native vegetation, weeds, feral animals and so on, it would be timely to take a fresh look in an holistic, integrated way at the institutional frameworks for managing Australia's natural resources. We need a new overarching agreement, probably through COAG, that clarifies roles and responsibilities and funding arrangements across the Federation. This would aim to deliver a much more coherent approach to generic issues such as delivery models, the knowledge base, monitoring and evaluation, resource accounting frameworks, education, training and capacity building, extension, community participation, environmental literacy, the interface with the planning system, and broader integration issues such as the linkages with energy, transport and urban development policies and associated infrastructure implications. Given the significance of soils in both the carbon and water cycles, soil management, policy and information systems would need a significant focus in such a rethink.
2. Recognising the limits to the mandate of the National Committee on Soils and Terrain, it may be more productive and quicker to develop a new dedicated, stand-alone national soils strategy, along the same lines as the National Weeds Strategy.
3. More pragmatically again, it would be constructive to identify a 'small s' strategy — a comprehensive and coherent suite of soils-focused measures that could be incorporated immediately within the existing integrated NRM delivery framework.

These options are not mutually exclusive. In reverse order, they represent a natural progression. In the author's opinion, option 1 is well overdue and should be a high priority in the new post-election spirit of cooperative federalism, but it is way beyond the scope of this document.

The remainder of this section works through possible measures that could be implemented in the short term to achieve a greater focus on soils within existing institutional arrangements. It does so with an eye on the potential for a fundamental rethink of NRM in Australia, attempting to propose measures that would be relatively robust under a wide range of institutional settings. It also tries to ensure that the factors identified in section 3.1 that may be inhibiting a greater sensibility to the needs of the soil are tackled along the way. It is possible to develop a coherent package of measures that would deliver a more strategic approach to soils investment in Australia without calling it a national soils strategy. Should a comprehensive overhaul of the whole NRM institutional framework take place, then having already thought through the soils issues and identified system-wide improvements would be a 'no regrets' measure.

The guiding philosophy behind this paper is to be clear about the overall objective — more sustainable soil management. Soil science, soil classification and monitoring systems and soil mapping resources are not ends in themselves, they are means to an end, which is more sustainable management of Australian soils. This paper tries to look at soil science, soil policy and soil information from the demand perspective — what is needed to assist in getting better management on the ground — rather than the supply perspective.

In order to get better soil management on the ground, people need to know what to do and how to do it, they need to have the commitment to do it and they need to have the capacity to put more sustainable systems and practices into effect. We need to invest in knowledge in order to make better decisions, to innovate and to learn as we go along (Campbell and Schofield 2007). Those three key ingredients — commitment, knowledge and capacity — provide the organising principle for the remainder of this section.

4.2 Rebuilding commitment

Awareness of soil-related issues and costs and long-term consequences of soil degradation to the community

As a general rule, the community **expects** food resource security. As the threats to soil productivity tend to be either slow-moving and cryptic, or associated with more newsworthy phenomena like floods or droughts, they tend not be covered well in the mass media.[17] So the wider community remains oblivious to the threats to its soils, and consequently to its long-term food and water security.

As postulated in section 3.1, a range of factors have conspired in the general drift in focus away from soils and their management in Australia over the last quarter century. Some are soil-specific and others are generic to all areas of NRM and in some cases public administration generally. Most have a bearing on commitment — the willingness to change.

The most fundamental problem appears to be a simple lack of public awareness or recognition of the linkages between soil management and other environmental issues like greenhouse pollution and water, or between soil management and food security. This is both at the level of the general public, and also at political and policy levels, where seemingly more urgent issues get most attention.

At a macro level, now is a good time to develop and promote a new narrative around the importance of better soil management in Australia, and the measures needed to achieve that. The core messages would complement the guiding principles introduced in section 2.2:

- soils are of enormous value to humans, because they are fundamental to us being able to feed, clothe and shelter ourselves over coming generations, and well-managed soils store enormous amounts of carbon and water and host extraordinary biodiversity;
- healthy soils grow healthy foods which grow healthy communities — urban and rural;
- conversely, poorly managed soils reduce food security, increase food prices, cause significant greenhouse pollution, reduce water quality and availability and increase human health risks;
- soils are effectively non-renewable[18] and soil degradation imposes enormous costs on current and future generations;
- prevention of soil degradation is much cheaper and easier than restoration and much better value for money;
- in order to develop and implement land use systems and land management practices that look after Australia's soils, we need to invest in innovative new technologies and farming practices, we need juicier carrots and smarter sticks to encourage better soil management, we need to reinvigorate extension (soils-literate) within the existing NRM framework, we need a sound information base that mirrors the knowledge initiatives for water through the National Plan for Water Security and for carbon through the National Carbon Accounting System, we need the planning system to take soils into account, and we need skilled professionals and a more coherent, cohesive national approach to deliver all of the above;

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[17] The current drought followed by floods is a classic case. During the dry, the media focus is on the battling farmer and the dying stock and crops. During the wet, the focus is on dramatic helicopter rescues and on flood damage. Media coverage of the recent central Queensland floods has been notable for lacking any sense that the floods might be a good thing, that after a long drought the country needed a drink—or that the speed and severity of the flooding may have been exacerbated by the aggregate and cumulative impact of poor soil management and lack of groundcover increasing the run-off co-efficient across vast areas. These floods, like many others, are characterised by turbid, soil-filled water. The topsoil losses and deposition of sand slugs in river beds are the real long term losses but are rarely mentioned.

[18] Topsoils can be restored but only with major additions of organic materials and intensive labour inputs. Subsoil formation is less than 1 mm per thousand years.

- a significant national investment in these areas to support better soil management would maximise the return from existing investments in water and carbon accounting, and deliver excellent benefits in terms of food, water, biodiversity, greenhouse gas abatement and carbon sequestration.

It is crucial to be able to put credible numbers on the value of well-managed soils to Australia, quantify the potential water and carbon implications, and the costs to the national economy (and specific sectors within it) of soil degradation. There are plenty of case studies of costs arising from, for example:

- inappropriate developments on coastal acid sulphate soils in northern NSW and Queensland; or
- subdivisions in steep country that give each holding some river frontage, causing stock to move up and down slopes causing gully, sheet and river bank erosion and direct pollution of streams.

It is not good enough just to highlight the problem. The key elements of a proposed response, costed and with credible claims about the benefits that would be delivered, need to be prominent.

There would of course be different versions of that story targeted to different audiences, but there is a substantial overlap between the messages for the general public and the messages for senior decision makers — both are interested in why public funds should be invested in this area compared with other environmental imperatives that are more easily understood and easier to sell.

When the key messages backed up by solid numbers have been distilled, then a reasonably conventional targeted communication effort could make a big difference:

- one or two thoughtful and well-argued feature articles in the quality mass media — e.g. *The Weekend Australian* or ABC Radio — making the links between good soil management and broader economic, environmental and social goals;
- targeted briefings for senior policy makers and decision makers — a few dozen key people capable of influencing the agendas of Ministerial Councils and COAG and then following through with detailed program design;
- getting soils on to the 'wish lists' of key stakeholders including farmer organisations, regional NRM and catchment bodies and conservation NGOs, especially those interested in climate change responses (which of course means involving them in the development of a package of measures that meets their needs, or at least complements their own agendas); and
- having credible spokespeople from the soils profession able to respond promptly to media interest.

Primary producers — farm level

At the farm level, the big picture narrative is also important. Farmers are as concerned about national priorities as other citizens, and even more so when there is a direct connection to their own situation. However in communicating with farmers about desirable directions in land management, it is critical to avoid a tenor of blame, and the tendency to use normative or prescriptive language about what farmers 'should' or 'should not' be doing in their own businesses on their own farms.

There is a wealth of extension literature about the factors influencing adoption behaviour on farms. While the environmental, social and economic context in which farming is played out may be subject to constant change, the fundamentals that influence farmer adoption have changed little over recent decades. Dave Pannell, Graham Marshall, Neil Barr, Allan Curtis, Frank Vanclay and Roger Wilkinson recently completed a comprehensive review of the literature and the issues relating to adoption of conservation technologies by rural landholders (Pannell et al 2007). Adoption is a dynamic learning process, whereby landholders learn from experience, each other and external sources in adopting new practices, preferably with some form of trialling and evaluation along the way. Adoption is an inherently subjective, contextual process — highly dependent on individual perceptions and expectations. These perceptions are influenced by three factors: the learning process, the landholder's social and economic context, and the characteristics of the technology or innovation itself.

People use information to test, adjust and reframe their understanding of the world and how best to operate in it. This costs them intellectual effort, time and money. It needs to generate benefits that exceed those costs. If the information is too far outside the receiver's frame of reference it will be rejected. Increasing doses of that information will reinforce the rejection. This is an important point for soils information.

Figure 7 below is a classic example of a farmers' frame of reference. It was developed by the Sage Group[19] of farmers convened by Land & Water Australia, comprising farmers from different sectors, each nominated by their industry as a leading producer from both a sustainability and profitability perspective (Land & Water Australia 2007). This was not intended in any way to be a representative or 'typical' group of farmers. It was explicitly about trying to bring together an elite group of producers from a wide range of commodities to tease out sustainability performance measures that are meaningful for leading producers and preferably not commodity-specific.

Notwithstanding the differences between growing cereals, apples, wine grapes, wool, beef, vegetables, cotton, dairy cows or pigs, the group found that there are common farm-level sustainability performance measures that they could all agree upon. Obviously some would be more relevant in some industries than others, and the different gauges would need to be calibrated for specific industries and regions, but the conceptual framework is robust across all those sectors.

The basic concept is like the dashboard in a car, tractor or aircraft. There are a range of dials, each of which has a safe or preferred operating range and maybe a personal, regional or industry benchmark target. There is no single 'perfect' answer — it is a question of keeping the different dials in balance through time in the prevailing climatic and economic conditions. You don't drive a car using only the fuel gauge, or the temperature gauge, or the speedometer — they each refer to only a part of the system and none of them alone can tell you if you have reached your destination safely or on time.

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[19] Named after the restaurant in which the group had its first dinner together.

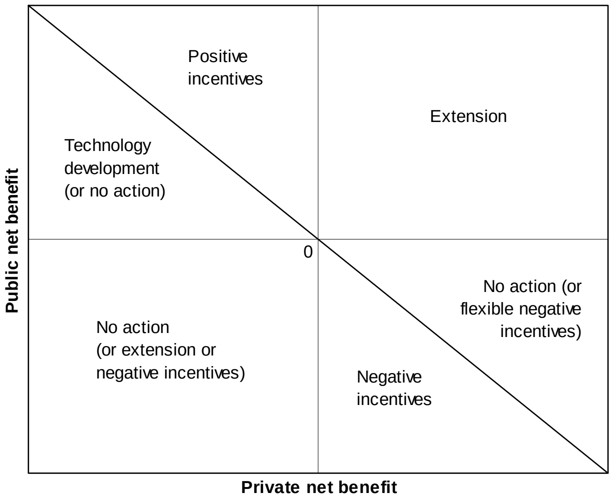
Figure 7. The SAGE Farmer Group's Farm Sustainability Dashboard (from Land & Water Australia 2007 http://www.lwa.gov.au/Programs/Other_RandD_Initiatives/The_Farm_Sustainability_Dashboard/index.aspx)

Note that out of more than twenty factors these farmers identified as their sustainability performance measures, only one dial specifically refers to soil — in this case Phosphorus status, pH and soil organic matter — although groundcover, water use efficiency and net greenhouse gas emissions also depend directly on soil management. For these farmers, anyone promoting a new soil management measure would need to be able to place the innovation within this frame of reference, preferably showing how it would move one or more of these dials in a preferred direction without causing others to reverse.

Note also the importance these leading farmers place on social factors such as the happiness of their staff and the wider community, in particular with respect to their farming system. The point behind these two dials was that top farmers are acutely aware of how their farming system is perceived, for example in animal welfare or environmental or workplace enjoyment terms. They would much prefer to be operating in a context where their own staff in particular, and the wider community in general, are comfortable with or even proud of their farming system. This has obvious relevance for soil management.

As introduced earlier, the principles of voluntary behavioural change simplify to (i) a desire to change, (ii) sufficient knowledge to support change, and (iii) the capacity to change. In the adoption literature, the perceived advantage of the new practice to the user is the most powerful predictor of adoption. The characteristics of any innovation that influence adoption include: credibility, relevance, timing, trialability, appropriateness of scale, accessibility, level of complexity, flexibility, compatibility to existing practices and values, the level of additional learning and capital outlay required, and the level of risk and uncertainty from the perspective of the landholder. Pannell and colleagues consider that these can be grouped into two categories: relative advantage, and trialability.

A combination of experience and information will promote behavioural change which in turn drives attitude change. Attempting to influence behaviour by changing attitudes is unlikely to succeed, but it can assist with motivation, or the desire to seek new options. Promoting change where the relative advantage and trialability of recommended practices is low or perceived to be low by landholders — too hard to fit within the dashboard — is unlikely to be successful, highly unlikely to be cost-effective and may be counter-productive.



Referring back to the table of potential policy instruments, Dave Pannell (in press) has since been working on a new decision support framework to assist policy makers and catchment bodies to work out what type of intervention is most likely to influence behaviour change by farmers in a given situation. The basic concept is shown in this diagram. Extension is only a valid use of public funds if both the public and private net benefit of the proposed practice change is positive. For desired practice change in situations where either the public or private net benefit is negative, then other interventions such as incentives (positive or negative) or technology development are more appropriate. Pannell believes that there is generally insufficient emphasis on technology development to develop new options that are more adoptable for farmers in their own right without incentives and with minimal extension required.

In summary, motivation for change by highlighting the advantages, favourable experience in testing change, ready access to useful information and provision of social supports are required to encourage behavioural change.

With respect to NRM practices like soil management in particular, notwithstanding the views of elite farmers like the Sage Group, the evidence suggests that most farmers are unlikely to sacrifice self-interest to manage for public good outcomes. At present, the relative advantage of many currently recommended NRM practices is perceived to be low by many landholders. Either there needs to be a closer alignment of self-interest with public interest, or practices need to be available and promoted that deliver both self-interest and public good outcomes. Conservation farming systems are an excellent example of adoptable measures that would fit into Pannell's top right hand quadrant, delivering both positive private benefits and public benefits. They increase soil organic matter and water holding capacity, reduce erosion, allow earlier and faster sowing and better weed control, cut down on diesel and tractor costs and CO_2 emissions and so on, benefiting both the landholder and the wider public.

Appeals to stewardship values and management attitudes will be effective for only a small minority of landholders in the absence of adoptable practices. Creating the environment for desired change, and supporting that change will be more effective. The ability to access information, on its own, is a poor driver of change.

Pannell et al (2007) point out that 'traditional' extension viewed the extension process as primarily a matter of communication, and consequently often focused on improving information delivery, presumably assuming that farmers lack information and are relatively passive recipients of knowledge. However, like the rest of us, farmers are besieged with information (including from banks, accountants, consultants, agribusiness, the media, other farmers and community groups) and probably receive a similar quantum of unsolicited mail.

Increased investment in improving information and knowledge management should not be undertaken lightly. If it is to be of any use in changing behaviour on the ground, the investment needs to be carefully planned, targeted and delivered. Information 'dumping' will be of little use, and may well be counter-productive. Again, this is an important message for the soils community. Reinvigorating the soils extension effort means much more than just getting better soil technical information into the hands of catchment bodies or landcare facilitators. This point is developed further at 4.4.

Better soil management practices and technologies — if they are to be adopted widely — must offer relative advantage against existing and other emerging approaches, and preferably be trialable. Participatory approaches to farm-relevant soils research should be used wherever practicable. This helps to ensure that the research is relevant to or at least cognisant of farmer goals, it increases farmer ownership of research results, and it has a better chance of incorporating local knowledge, skills and experience into the research process (Pannell et al 2007).

Finally, the soil science community needs to do better in tapping into farmers' local knowledge and their own innovation networks. Science does not have a monopoly on innovation — far from it. Leading farmers — including enthusiasts for approaches mentioned earlier like Holistic Resource Management, Natural Sequence Farming, Pasture Cropping and so on — are often trying out things that are well beyond where researchers have got to in their thinking or are tackling problems from different angles than scientists. Such innovations are often known to a few peers (rarely neighbours) and maybe a farm management consultant. In the 'old' days, agricultural extension officers would keep close tables on leading farmers and often assist in extending their ideas back into the research community as much as the other way around. But with a system relying mainly on relatively inexperienced field staff on short-term contracts, there is not often the time or the credibility necessary to form such relationships. So some of the most innovative work in soil management is essentially in the private domain — not because anyone is trying to keep it secret, but as a consequence of not having good linkages back into the more formal publicly-funded NRM knowledge system (Mike Logan *pers comm*[20]). The same is true for soil data — much collected soil information is from private sources (farmer soil tests etc) but there is a public good component if it can be added to other data in databases. This is normal in the mining industry where geological survey information is added to state geological data bases to improve strategic knowledge of the geological resource.

There are some very good models of programs that involve farmers in ways that combine research and extension for public and private benefits, such as the Land Water & Wool program (**http://www.landwaterwool.gov.au/**) of Land & Water Australia (LWA) and Australian Wool Innovation (AWI). The Evergraze project run by the CRC for Future Farm Industries and funded by AWI and Meat and Livestock Australia (MLA), that aims to increase farm profit by 50% while reducing groundwater recharge by 50% in the high rainfall zone (>600 mm) of southern Australia (**http://www.futurefarmcrc.com.au/projects.html**), is another excellent example.

Non-traditional (e.g. peri-urban)

The rapid growth rates of peri-urban regions and the rate of turnover in land ownership in such regions (Barr 2005) is such that landholders who do not rely on primary production for their main income are now significant land users. Closer subdivision can increase risks to soil and water resources, especially if the cadastral pattern is not aligned to land capability. In addition, subdivision may take highly productive land out of food and fibre production with the long-term risk of the reducing the availability of productive land to feed and clothe the nation and generate export income. The motivations of lifestyle farmers differ from those of full-time commercial farmers and they require a markedly different extension approach. For example they tend not to be around and are unable to attend field days etc during working hours, but may be more amenable to web-based services than many traditional farmers. Dave Pannell's diagram above still applies, especially as it concerns determining public benefits, but the landholder's definition of their private

[20] Mike Logan, cotton farmer Narrabri, Chairman Cotton R&D Corporation, member Sage Farmer Group, former director Land & Water Australia

benefit from soil management is likely to differ. Measures that may be unproductive for a commercial farmer could be quite attractive for a rural residential landholder, provided they do not compromise landscape or lifestyle values, especially if they are tax deductible against off-farm income.

In eastern and southern Australia in particular, it would be worthwhile to research the knowledge, capabilities and motivations of peri-urban and 'hobby' farmers in order to design a package of incentives, advisory services and web-based support that meets their particular needs.

4.3 Rebuilding the knowledge base

As introduced earlier, knowledge, along with commitment and capacity, is one of the three fundamental ingredients for more sustainable systems of land and soil management. In broad terms, we need better knowledge in order to reduce risks in decision making and to improve our understanding of biophysical processes (McKenzie, Henderson and McDonald 2002).

From the perspective of the soil science community, rebuilding and refreshing the knowledge base on Australian soils and consolidating durable institutional arrangements to secure and update that knowledge base is a no brainer — a very high priority for public investment. But that is a minority perspective. For the reasons elaborated earlier, notwithstanding significant overall increases in NRM investment, there has not been a corresponding increase in investment in the knowledge base underpinning soil management, and in several key areas the situation appears to be deteriorating.

Mapping, assessment and monitoring needs to underpin sustainable development

Resource inventory, assessment and monitoring is probably the least sexy sector of NRM, but it underpins everything else. It is usually the last thing to get properly funded and the first to get cut when budgets are tight.

The following quotes, cited by the National Land & Water Resources Audit (2002), show that this is a perennial problem. The first is from a Royal Commission into water conservation in New South Wales in 1887 (Parliament of the Colony of New South Wales 1887), lamenting the adequacy of information about water resources:

> *"On entering our duties we found ... that information available regarding our rivers was meagre and fragmentary, and that in some important points public opinion was in danger of being misled by statements and theories which there was ample evidence to refute.*
> *... we beg to recommend that the maintenance of river gauge records as extended by us should be made still more complete, and the records kept continuously and in a careful and systematic manner."*

One hundred and fourteen years after the NSW Royal Commission, the Australian Parliament's Inquiry into Catchment Management (Parliament of the Commonwealth of Australia 2001) reported:

> *"... from the evidence it has received, it is convinced that there is enough information to formulate policies and strategies. The Committee, however, is aware that the dissemination of reliable information throughout government, industry and local communities can be very poor.*
> *... It is also clear that ineffective use of data have limited the success of current catchment management programs. …the Committee concludes that while there is an expanding body of information in this area, it is often inaccessible, patchy, uncoordinated and uncollated."*

The hand-wringing from parliamentary committees is understandable but such an outcome is predictable if the activities that prevent *"often inaccessible, patchy, uncoordinated and uncollated [information]"* are under-funded. The National Land and Water Resources Audit (2002) concluded that not much had changed over the 114 years between the two quotes: data and information are often fragmented and difficult to find; some fundamental natural resource data are not being managed systematically; and coordinated programs are needed to maintain and fill gaps in time series data. This need not be so in a digitally networked age, with appropriate investment to update the system.

Governments, Ministers and Ministerial Councils and government agencies at all levels need good data and information to: assess status and trends in resource condition in order to establish baselines, set targets and priorities, formulate policies and track progress; target public investment, evaluate land use and catchment plans and investment strategies; monitor compliance with legislation; and report against national priorities and targets (Dixon and McKenzie 2007). Regional and catchment bodies need good data and information to assist in the development of their catchment and investment plans; assist their communities to get a good understanding of problems and opportunities and customise action plans to suit the soils and land conditions; and assess status and trends in resource condition in order to set priorities and track progress. Landholders and industries need good data and information to help work out their own investments, optimise the use of inputs and to track progress. Researchers need good data and information to: place experiments in the most representative locations; better understand ecosystem and landscape function; underpin the development, refinement, calibration and ground-truthing of their models; better understand and predict cause and effect relationships; and to measure status and trends in resource condition (McKenzie, Ringrose-Voase and Grundy 2008).

At the farm scale, farmers' intimate local knowledge and experience (assuming long tenure of the same land) can compensate to a degree for holes in the data sets of the formal knowledge system. But at the catchment scale, it is virtually impossible for planners, even with deep local knowledge, to compensate for a lack of base data.

McKenzie, Ringrose-Voase and Grundy (*in press*) outline major deficiencies in basic mapping of land resources in Australia:

- Maps of land resources in agricultural areas are incomplete and mostly at too coarse a scale to inform management decisions;
- Incompatible survey methods have been used by different agencies, making national and in some areas regional summaries difficult to collate;
- Many soil and land attributes that control land degradation and productivity are not consistently measured rigorously, limiting their value for planning and management;
- Statistical methods have not generally been used, and reliable estimates of current conditions may not exist;
- Because of their broad scale, mapping units often contain a wide range of soil types, and so are not effective for stratifying landscapes for planning and management.

Closer to the coalface, Greg Chapman[21] (pers comm) suggests that, notwithstanding these problems from the perspectives of soil science professionals, and the lack of people to translate data to assist decision-making, there is a lot of interest in existing soils information and there are many happy users.

If you don't have good basic datasets about the natural resources you are trying to plan for, and you don't have good data about current land uses and management practices, and you don't have the people or capacity to interpret data or do decent trend analysis, then you are starting from a fundamentally weak position in planning more sustainable NRM approaches. Moreover, if you don't have good data on who is living in the catchment, how they are making a living and their lifestyle aspirations, the planning process is unlikely to get much traction. This is particularly the case along the eastern seaboard of Australia which has seen significant demographic change over the last decade (Barr 2005, Read Sturgess et al 2003). Districts previously (and often still) thought of as 'agricultural' now need to be reconsidered, with new approaches to planning, incentives, extension and compliance.

Technical challenges to soil condition monitoring

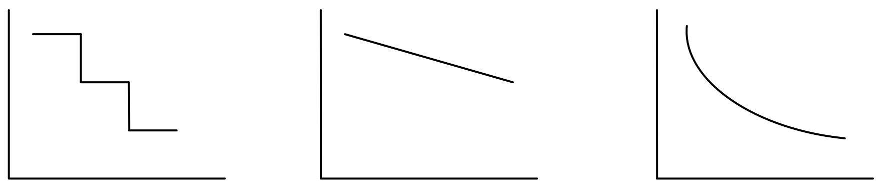
One of the aspects of most interest to land and water managers at both farm and catchment or regional levels is soil condition. However establishing a robust, technically sound framework for

[21] Greg Chapman, Theme Leader - Soil and Land Condition Monitoring, Evaluation & Reporting, Department of Environment and Climate Change, New South Wales *pers comm*, December 2007.

monitoring soil condition is difficult. A clear link must be established between the scientific goal and the decision-making process at the local, regional or national level. This section draws heavily on the work of Dixon and McKenzie (2007) who analysed challenges to soil condition monitoring in Australia, drawing on work done by expert panels convened by the National Land and Water Resources Audit (NLWRA), through its National Committee on Soil and Terrain (NCST) in 2005.

The main technical challenges are as follows (based on McKenzie 2006).

- The four processes (soil acidification, dynamics of soil organic carbon, and erosion by wind and water) can be difficult to monitor because they often occur as spatially and temporally irregular catastrophic events (sometimes described as patchiness), or decline very slowly. Improvement can be very rapid, through for example liming or filling in gullies.



wind & water erosion — soil pH change — soil carbon change

- The biophysical understanding of soil erosion, carbon dynamics and acidification is quite advanced and several robust simulation models exist for these processes. The biggest advances in tracking and forecasting changes in soil condition are likely to come from improved data to run these models. The types of data needed include soils, terrain (Digital Elevation Models [DEMs]) and various terrain variables including: slope and slope length; land use and land management practices; surface cover or its inverse, bare ground; Normalised Difference Vegetation Index (NDVI) and related indices; various climatic parameters including rainfall amount and intensity; satellite imagery and aerial photography.

  These datasets are common to several processes and it is most cost-effective to have only one or two groups nationally maintaining and providing them.

- Methods are needed to determine the location of monitoring sites and the frequency of measurement, and to extrapolate results from monitoring sites.

- Complementary computer simulation programs are required to assess whether soil changes can be detected in a reasonable time.

- Maps of soil properties are necessary to show patterns of resource condition, for designing monitoring efforts and for analysing and generalising results from a monitoring program.

- Monitoring soil condition relies on good quality measurement made at representative field sites over extended periods (i.e. decades).

- A large sampling effort is often required to distinguish the small changes over time from the large background fluctuations.

- It is essential to repeat measurements at the same site and to then analyse the differences between sites over time. (The often-suggested alternative of comparing the mean value of a soil property across all sites at time zero with the mean value for all sites at a later time is inefficient).

- Some soil properties can be readily monitored (i.e. those that are responsive to management, easy to measure and less spatially variable) while others are impractical because of the large spatial variation and cost involved.

Institutional challenges to soil condition monitoring

The current institutional framework is uncertain and unsatisfactory for long-term monitoring of soil condition within Australia.

As outlined above, a handful of regional NRM bodies may have the critical mass of technical expertise to monitor short term indicators but many lack the technical depth for or interest in, the more challenging broad scale monitoring which extends beyond their own boundaries. This is a challenge even for a well-resourced agency with good scientific services.

Restructuring of agencies and frequent changes to priorities for natural resource management is widespread and destabilising. Monitoring with its long-term benefits suffers in the competition for funds with projects that return benefits in the short term (e.g. those responding to immediate priorities or problems). Monitoring systems require several generations of staff and those responsible today may not be the beneficiaries of the effort. Individuals take on new assignments, transfer or retire, and the charters of agencies evolve. Long-term contracts are needed for both institutions and staff to ensure that the commitment is ongoing.

Data are lost over time unless the monitoring program is always active. Rapid developments in computer hardware and software can easily lead to catastrophic losses of data such as has occurred several times in recent years with land resource surveys.

Under the current institutional arrangements, the significant number of agencies involved in monitoring soil condition creates difficulties for data collection and management. These difficulties relate to agreed methods for measurement, definitions of entities, database design, continuity of data collection and uploading, and data exchange. In some instances issues relating to intellectual property must be resolved before the method in question can be recommended and further developed. A major standardisation and quality assurance effort is needed if data from disparate sources are to be combined.

The most logical repository for soil condition monitoring data is the Australian Soil Resources Information System (ASRIS – **www.asris.csiro.au**) managed by CSIRO Land and Water. Program funding as distinct from project funding is required to provide long-term security. In the immediate term, ASRIS needs a redesign to accommodate data from the soil condition monitoring systems and to improve the user interface.

The research and development costs associated with soil condition monitoring are heavy and best shared across agencies to develop a critical mass, make most efficient use of scarce resources and minimise duplication.

Improving the effectiveness of long term monitoring

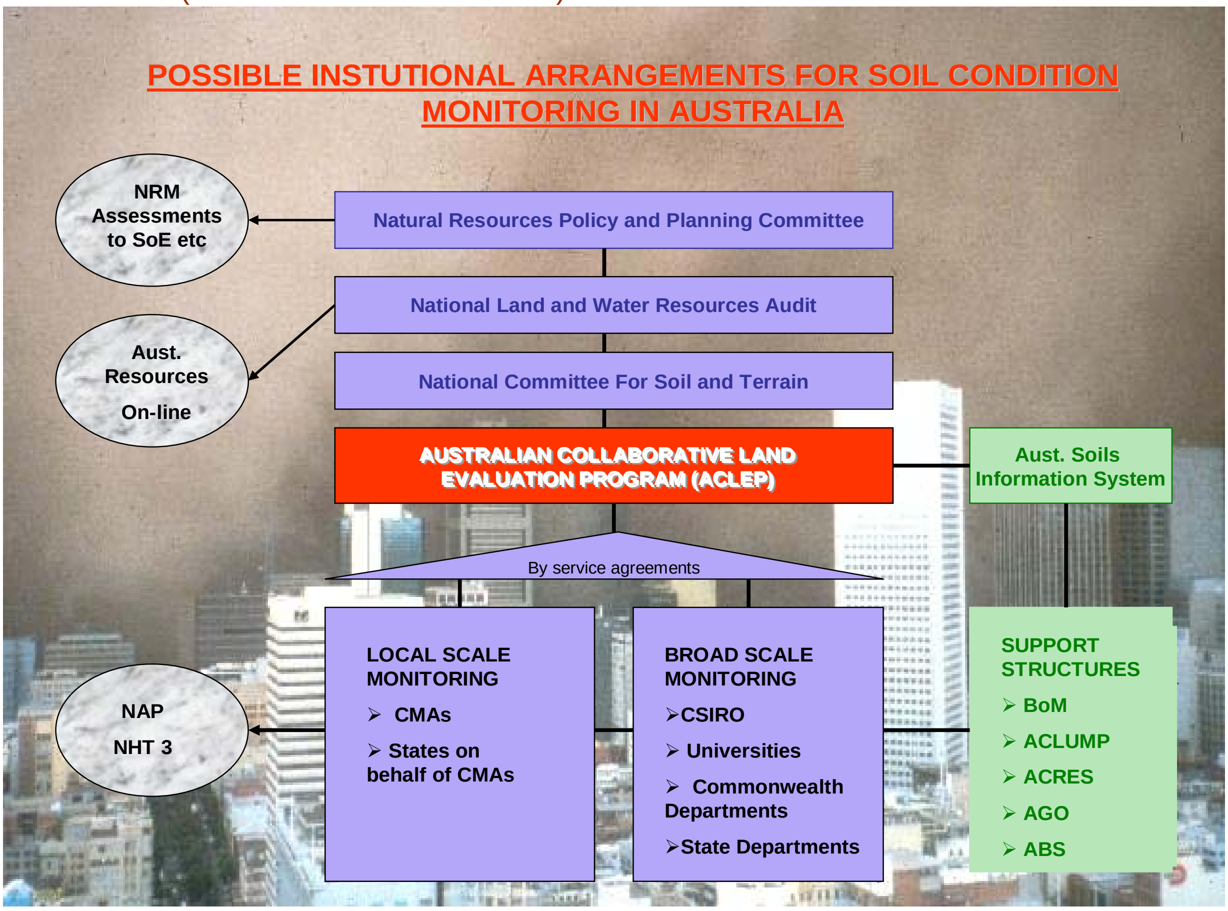
The Expert Panels convened by the NCST on behalf of the Audit presented general recommendations for the cost-effective monitoring of soil condition across Australia:

- Develop a permanent monitoring agency with links to relevant research, academic and other institutions. This agency is needed to maintain a national capability to measure and analyse changes in soil condition and to provide a basis for policy formulation.
- Formalise the Expert Panel(s) to oversee monitoring of soil acidification, soil organic carbon, and soil erosion by wind and water. Logically the Expert Panel(s) would report to the NCST.
- Enhance the Australian Soil Resource Information System (ASRIS) so it can receive and report on data from monitoring programs.
- Prepare and update contextual datasets that characterise the drivers of soil change, most notably land use, bare ground, land management practices, vegetation cover, fine-resolution terrain information and climate.
- Develop working arrangements between local scale monitoring conducted by or for regional NRM bodies, and broad scale monitoring best conducted by state or national agencies.

- Link and integrate soil condition monitoring with a program to assess land management within capability and Commonwealth monitoring of intermediate outcomes (most significant change, program logic and performance story reporting).
- Monitoring should be weighted towards regions where early change is likely (Vos et al. 2000, Tegler et al. 2001). This avoids wasting resources and ensures that monitoring provides an early warning.

During the Expert Panel discussions it became evident that if monitoring of soil condition in Australia is to be successful and lasting then an agency with a formal mandate and an institutional culture oriented to the long term such as the Bureau of Meteorology is required. One option would be for the NLWRA to assume that role, provided of course it is given long term security of tenure and budget. Security of budget is more important than size of budget and funding needs to be secured inside the program budget of the host agency rather than be project based, short term and subject to changing priorities. A possible structure diagram is provided in Figure 8 below.

Figure 8. Possible Institutional Arrangements for Soil Condition Monitoring in Australia
(from Dixon and McKenzie 2007)



Assigning long term responsibility to a specific agency would ensure:

- Development of expertise and durable capacity in the discipline of monitoring;
- Resident expertise to analyse, forecast and inform policy, use numerical prediction and reporting and reporting on natural hazards;
- Maintenance of core skills with staff development and viable career paths;
- Coordination of the ‘cells’ of expertise across the nation;
- Standardisation and quality control of the primary data collected;
- Good quality management of data over the long term and experience in managing spatial data;

- Economies of scale and avoidance of duplication;
- Adequate supporting research; and
- Efficient distribution of reports from the monitoring systems via for example report cards on the web following the "my dashboard" approach (**http://www.nrmtoolbar.net.au/**) for regional bodies.

Research and development needs and coordination of activities

Soils research in Australia has long been patchy and fragmented. CSIRO has probably the biggest single concentration of soils research capacity, with the remainder comprising small soils research groups reliant on key individuals and generally lacking critical mass. Public funding for soils research has been sporadic and on the whole, spread too thin. Peter Cullen once described water research in Australia as a cottage industry, but it is well off compared with soils research.

Some excellent soils research has been undertaken on specific issues such as acid sulphate soils, which has benefited from operating within the framework of a strategic approach in Queensland (Powell and Ahern 1999). Specific industries also fund soils research targeted to their producers' needs. For example the Grains Research and Development Corporation (GRDC) invested more than $16m in agronomy and soils research projects in 2005-6, understandably targeted to improving the sustainability and productivity of cropping systems (GRDC 2006).

The most recent national soils research initiative is the $5m Healthy Soils for Sustainable Farms program funded through the NHT and managed by Land & Water Australia. The focus of this program is on making better use of existing soils knowledge rather than novel research *per se*. As noted earlier, its initial call for proposals was over-subscribed by an order of magnitude, revealing a strong latent demand for accessing and making better use of soil knowledge among state agencies, industry groups, farmer groups and research institutions. The call for proposals under this program revealed a greater level of soils research and extension activity — albeit totally fragmented and uncoordinated — than most people realised was happening. It also showed that, while state agencies in some jurisdictions may have wound back their soils extension work, people with relevant skills and experience are still around working as consultants or on other issues. It is not too late to capture that experience and expertise for the benefit of a new generation of soils enthusiasts.

The time is ripe for a new national soils R&D program, both to target key knowledge gaps and to play a crucial national coordination role in soils research. Given that it is up and running, has involved 12,000 producers and advisers and is already a significant national collaboration, the Healthy Soils for Sustainable Farms program would be a suitable foundation for a significantly expanded national soils research and extension initiative.

There are several models for the coordination role. The Grains R&D Corporation (GRDC) has played a national leadership and coordination role in delivering a much more coherent national approach to wheat breeding, with a rationalisation of infrastructure across jurisdictions and the concentration of a critical mass of research and researchers on agreed national priorities. Land & Water Australia (LWA) has played a similar role in a number of areas including dryland salinity, riparian lands, native vegetation and tropical rivers. One lesson from all these experiences is that it is much easier for the coordinating agency to play a national leadership and coordination role if it has discretionary cash of its own to invest. In GRDC's case, it is easily the largest single cash investor in wheat breeding, and so it starts from a position of strength. In LWA's case, and as is likely to be the case with soils, with more generic issues there tends to be a diversity of funding sources of approximate parity. This means that the managing agent tends to play more of a 'small c' coordination role, with direct control over only a small proportion of the overall investment. Such a model can nevertheless be effective (Campbell and Schofield 2007).

In terms of key knowledge gaps, there are some obvious starters to enable implementation of the methods for monitoring soil condition. Two immediate priorities are calibration of mid-infrared spectroscopy for measurement of soil organic carbon pools, and remote sensing methods for estimating dry vegetation ground cover (Dixon and McKenzie 2007).

In soils, as in other areas of NRM, the research effort should be closely linked with the monitoring effort, but that is rarely the case. If both were genuinely designed at the national level, with participation and agreement from all jurisdictions, then complementarity and even synergy between monitoring and research should be feasible. Dixon and McKenzie (2007) recommended the establishment of a network of long-term ecological research (LTER) sites. They suggest a need for a small number of long-term studies of ecosystem and landscape processes in catchments that represent the main regions used for agriculture, urban development and forestry in Australia. Sites should represent well-defined landscape units and systems of land use, allowing results to be extrapolated with confidence to other locations.

Detailed research into process remains essential at a few locations to understand the relationship between land management practices and soil condition. These studies need to measure and model the dynamics of water, sediment, nutrients, contaminants, biological production and related processes and are essential for understanding the dynamics of changing land use. Excellent prototypes for such studies exist in the United States, with the 24 Long Term Ecological Research sites (LTERs) and the emergence of the National Ecological Observatory Network (Campbell 2007 *unpublished*) and in Canada, with the Ecological Monitoring and Assessment Network (Vaughan et al. 2001).

4.4 Rebuilding capacity

Knowing what to do is one thing, wanting to do it is another, being able to do it — having the resources and capacity to turn plans into action — is the final of the three key ingredients.

Education and training requirements

Some of the institutional capacity issues around soils knowledge were dealt with in the previous section. However a looming problem for soils, shared with most other aspects of agriculture and NRM, is the difficulty of attracting talented new staff into this area. Tertiary level soil science courses have declined in Australia, so the number of fresh graduates with the requisite knowledge and skills to perform many of the functions discussed above is very limited.

A multi-faceted education and training approach is required, including elements such as:

- Ensuring that there is sufficient soils science capacity at tertiary levels to give undergraduates exposure to soil science within degrees such as agriculture, forestry, geography, water management, climate science and generalist environmental science and natural resources degrees; and to provide opportunities for post-graduate training and research in soil science;
- Provision of in-service adult education courses (combining face to face and web-based teaching) in soil science and management aimed at policy staff, planners, community group leaders and interested landholders; and
- “Train the trainer” type workshops to assist the 4,000 extension staff identified by Coutts et al (2004 – see below) and people working for catchment bodies to use and extend soil assessment, mapping and monitoring tools.

Such courses would obviously need to be underpinned by updated curriculum materials that reflect the possibilities allowed by new technologies such as Geographic Information Systems (GIS) and databases, global positioning systems (GPS), airborne gamma radiometric remote sensing, digital terrain analysis, simulation modelling, statistical analyses and on-line access to data (McKenzie *et al in press*), not to mention the presentational possibilities of technologies like Google Earth.

Extension (land management advice)

Assuming that appropriately trained and expert people are available, backed up by supportive institutions, then given the public good dimensions of many aspects of soil management, it seems timely to revisit the need to re-energise soil conservation extension.

There are striking parallels between the situation in which extension finds itself today and that of soils. Extension for the purposes of this discussion is the process of engaging with individuals, groups and communities so that people are more able to deal with issues affecting them and opportunities open to them (Coutts et al 2004). Extension is a non-coercive policy instrument that aims to foster learning to improve decision making, usually towards a specific objective.

Jeff Coutts and colleagues, in a comprehensive review of extension in Australia commissioned by the cross-RDC Cooperative Venture for Capacity Building in Rural Innovation (Coutts et al 2004), developed a typology of extension models: group facilitation/empowerment; programmed learning; technology development; information access; and individual consultant/mentor (one on one).

Extension remains a valid and valuable policy instrument in NRM, in particular to assist in the development and adoption of more sustainable management practices at a landscape scale. In comparison with soils extension, production-oriented, farm scale extension activities are in better shape. Some promising industry-based models have emerged, in parallel with and perhaps accelerated by an apparent decline in state funding for generic one on one agricultural extension.

There is a continuing case for publicly-funded soil conservation extension closely linked to rigorous research and monitoring activities. As outlined earlier, many approaches to land and soil management, each with their passionate advocates, compete for attention and support in Australia. For example, one theory with active private sector proponents is the BCSR (base cation saturation ratio) as a measure of the 'ideal' soil, based primarily around the ratio of calcium (Ca) to magnesium (Mg) and potassium (K) in the soil. The BCSR is used to analyse soil test results to determine fertiliser needs, but it has been debunked in an authoritative paper by Peter Kopittke and Neal Menzies (2007) in the journal of the American Soil Science Society. They reviewed an eight year Nebraskan study that found the overall cost of fertiliser use arising from applying the BCSR was double that from applying the 'sufficient level' approach used by most universities, with no significant increase in plant production. In the absence of an extension effort that is closely connected to good science and independent of any particular commercial interests, it is easier for claims that are not well founded in science to persist, with economic and environmental consequences.

It is neither wise nor practical to expect scientists and researchers to do their own extension — even though some individuals enjoy it and are good at it. Accordingly, there is an on-going need for intermediaries between NRM science and practice who have specialist skills — skills traditionally found in the extension profession. Where the objectives are predominantly in the public interest, it is reasonable to expect such extension activities will be publicly funded. This does not necessarily mean that they should be delivered by the public sector.

Coutts et al (2004) concluded that there are more than 4,000 extension positions across Australia, measured in Full Time Equivalents, of which more than 2,700 are in the public/community sectors. Given the number of part-time extension personnel, especially in landcare/NRM roles, Coutts et al estimate that perhaps half as many people again are actually involved in extension work — so around 6,000 people in total. The proportion of part-time work is probably higher in the public/community sector, so there are likely to be at least 4,000 people working in extension roles in that sector. Most of these positions are project-based and thus on fixed term contracts, mostly of three years or less.

According to Coutts et al (2004):

> *The overall picture, then, is that there are a large number of people and programs involving extension in its many forms. State Governments have remained significant players and the Federal Government is a major funder of extension activities across Australia. There has undoubtedly been a shift in public extension from one-on-one to group approaches and from a production/economic focus to a broader platform involving environmental and social concerns. The private sector continues to expand and, as well as undertaking individual technical advice, operates in the same sphere as public extension.*

It is difficult to analyse from publicly available data whether or not the number of professionals working in extension now has declined over the last twenty years. Marsh and Pannell (2000) describe a substantial decline in public funding for 'traditional one-on-one extension' and a rise in group-based extension. Mullen et al (2000, cited by Pannell et al 2007) suggest that the rise in funding for group-based extension (landcare facilitators etc) has roughly offset the decline in traditional extension. However there is no equivalence between landcare facilitators with generalist technical knowledge and specialist training in group facilitation techniques, and traditional extension officers with a deeper technical grounding. They are complementary skill sets, not substitutable (Campbell 1994).

The following quote from a regional NRM body representative (CSIRO/BOM 2004) is a familiar lament:

> *"If the traditional extension officer system still existed we would not be in such difficulties because what is needed for catchment management is skills in group processes and in weighing up trade-offs at levels beyond the farm boundary, not the replacement of the technical skills available in extension officers."*

The regional NRM model for program is an ambitious attempt to bring about a more strategic approach, and to scale-up investment on priority targets. But it is not an appropriate scale for sorting out a long term approach to NRM extension on issues such as soils, and particularly its use in conjunction with other policy instruments such as incentives, planning, market based approaches, pricing mechanisms and regulation. Nor can one reasonably expect 56 separate catchment bodies to be focused on, for example, the development of professional expertise, the provision of career paths for staff, or the development of centres of excellence. We do not need, nor can we afford, 56 different extension systems across the country, any more than 56 different soil information systems.

While extension <u>activity</u> is being funded, investment in extension <u>infrastructure</u> is limited and has almost certainly declined. There is a predominance of project work done by people on short-term contracts. The nature of the contract is usually linked to implementation of the project, not plugging into a more durable on-going program that is grounded in and building institutional memory. It is very difficult to map out a career path in such a context, so we are losing lots of good people, often just as they have developed expertise and insight. It is very difficult to get recognition (or funding) for non-project work such as monitoring and evaluation, or professional development.[22]

It is no accident that the key principles of the Victorian LandCare program launched in 1986 were developed by soil conservation officers within the then Department of Conservation, Forests and Lands who had had the opportunity to undertake paid study leave to do post-graduate research in extension[23]. LandCare was not just a bright idea someone had in the shower. It was grounded in solid research evaluating the failures of previous approaches to soil conservation extension (Brewin 1980, Campbell 1994). In soils and in NRM generally we are still trading on the intellectual capital of senior staff, consultants and researchers trained more than fifteen years ago, under very different funding regimes.

Coutts, Douglas and Campbell (2001) proposed the development of a national extension policy framework for Australia. That challenge has since been taken up by the State Extension Leaders' Network (SELN – see **http://www.utas.edu.au/ruralcommunities/SELN/**) which has produced a discussion paper (SELN 2006). Campbell (2004) expanded on the theme, underlining drivers:

- the need to design 'meta learning' systems to analyse, extract, document and make accessible the learnings across all current projects, and from the vast repository of completed projects;

22 Greg Chapman again: *"same can be said for soil mappers employed on a series of short term contracts. It takes about 5 years on the job experience to get a soil surveyor to reasonable speed. Two contracts and they are gone. For long term regional soil survey this represents a huge loss. Replacements take a year to get up to speed with mapping the previous incumbent left as work in progress! A finished map and report might take years to be published."*

23 Bryan O'Brien, Horrie Poussard, Rob Joy and Darrell Brewin. Brewin's Masters thesis had evaluated department-led soil conservation catchment schemes and concluded that a lack of community and landholder ownership, stemming from a lack of engagement in planning and implementing on-ground works, was a key factor in the problematic durability of such schemes (Brewin 1980).

- the need to re-energise the extension profession so that we are working from an ever-greater skills base, retaining and developing good people;
- the need to build a new extension infrastructure so that issues such as training, resourcing, centres of excellence and the application of new technologies (for example in knowledge management and the internet) can be tackled systematically;
- the need to better define the extension niche and thus to inform policy instrument choice — both within extension models, and between extension and other instruments of policy; and
- the need to sort out roles and responsibilities between different levels of government, and between government, the community, industry and individual landholders.

4.5 Soils within the regional investment model

This section focuses on specific measures that could bring about a better focus on soils within the regional NRM investment model.

Soils within bilateral agreements

As most Bilateral Agreements for the next phase of NAP and NHT are almost finalised, there may be limited scope for introducing a new element at this stage.

A more prospective possibility might be at the program design level, where government can specify its priorities. In particular, the National Landcare Program (NLP), to which the previous Australian Government had allocated $151m from 2008-2012, would seem to be the program most apposite for greater attention to soil management. While the objectives of the program do not mention soils explicitly, there is plenty of scope within them to develop specific soils work, according to the program website (http://www.daff.gov.au/natural-resources/landcare/national-landcare-programme/overview08-12).

The emphases on farming practices and on the resilience of the resource base are very pertinent to soil management. There is also an explicit desire within the NLP to encourage partnerships with industry, which is another prospective opening for soils work. In terms of Australian Government funding sources for soils work targeted at the producer level, the National Landcare Program is the most prospective, however funding sources for broader non-agricultural aspects of soil conservation such as peri-urban, urban, infrastructure and the links with the planning system are far from obvious.

Regional NRM bodies

As mentioned earlier, there are major gaps in regional NRM plans when it comes to soils, soil condition targets and land capability assessment. To a large extent this is a reflection of capacity issues within the regional NRM bodies, and the lack of accessibility, user-friendliness and sheer usefulness of the information base and interpretation and decision support tools. The findings of the RM Consulting Group (2006) review do provide a hook upon which to hang proposals to develop soils information and decision support products targeted to regional NRM bodies. Such products will of course be only as good as the underlying information base, and they would be taken up far more readily if delivered in parallel with some of the education and training measures introduced earlier.

In terms of specific ideas, it would be useful to develop some generic resource condition targets (RCTs) for soils that regions could use as a template in refining their regional NRM plans. Even better if this could be done in such a way that the links to water quality and quantity and to carbon storage were made explicit. Similarly, some generic management action targets (MATs) for soils, perhaps for each agro-ecological zone, would increase the likelihood of soils being picked up explicitly in Regional Investment Strategies (RIS). Finally, some exemplar on-ground soils projects from across the regions, showing how catchment bodies and/or industry groups are working to improve soil management, would also be a useful reference point for the regions and for the 4000 extension staff identified by Coutts et al (2004).

An excellent example from such a project is shown in Figure 9 below. This is a simple classification scheme for management practices for the sugar, horticulture and grazing industries in the Queensland coastal catchments draining into the Great Barrier Reef lagoon. It was prepared by John Rolfe and colleagues (2007) for the Mackay-Whitsunday NRM Group (**www.mwnrm.org.au**). The specific excerpt in Figure 9 refers to soil management in sugar cane, but the broader classification encompasses soil management, nutrient management and chemical management modules for each of the sugar cane, horticulture and grazing industries respectively. As mentioned in Box 1, the application of 'A Class' soil management and chemical management practices in sugar cane has led to reductions in chemical inputs of the order of tenfold, with corresponding reductions in chemical export off-paddock (Colin Creighton[24] *pers comm*.) This has huge implications for improving water quality in the Great Barrier Reef lagoon.

Figure 9. Excerpt from Draft Cane, Horticulture and Grazing Management Practice Classifications

Class D Cane Soil Management	Class C Cane Soil Management
Description: 1. Cultivated bare fallow 2. Cultivated plant cane 3. Zero till ratoons 4. Records kept in head	**Description:** 1. Minimum till bare fallow or legume fallow 2. - 3. Same as Class D 4. Records kept in daily diary
Planning and record keeping: 1. None	**Planning and record keeping:** 1. Develop basic Soil Management Plan 2. Keep daily diary
Machinery: 1. Standard equipment	**Machinery:** 1. Standard equipment
Class B Cane Soil Management	**Class A Cane Soil Management**
Description: 1. Controlled traffic permanent beds 2. Zero till fallow, plant and ratoons 3. Headlands, drains and waterways managed as filter strips 4. Records kept in Paddock Journal	**Description:** 1. Controlled traffic permanent beds with **GPS guidance** of planting and harvesting operations 2. - 3. Same as Class B 4. Records kept in computer database /Paddock Journal
Planning and record keeping: 1. Identify soil types and productivity zones for each block using existing farm maps 2. Develop Soil Management Plan using soil mapping. 3. Keep records (including yield) in Paddock Journal 4. Adjust soil management for next year if required.	**Planning and record keeping:** 1. Identify soil types and productivity zones for each block using **GPS mapping** 2. Develop **GPS** based Soil Management Plan using soil mapping and remote sensing 3. Keep records in computer database/ Paddock Journal 4. Same as Class B
Machinery: 1. Standard wheel spacing on all equipment, Bed Former, Zero Till Seed Planter, Zero Till Cane Planter, Harvester and Haulouts	**Machinery:** 1. Standard wheel spacing and **GPS Guidance** on all equipment, Bed Former, Zero Till Seed Planter, Zero Till Cane Planter, Harvester and Haulouts

The Mackay Whitsunday Regional NRM Group, working with other coastal regional NRM groups (Cape York Marine Advisory Group, Terrain NRM, Burdekin Dry Tropics NRM, Fitzroy Basin Association and Burnett Mary Regional NRM Group) and with Industry Groups (Growcom, Canegrowers, AgForce Queensland, Queensland Dairyfarmers' Organisation, Cotton Australia and the Queensland Farmers' Federation), developed a *Joint Industry/Regional NRM bodies Reef Water Quality Program for Agriculture Proposal* that was instrumental in the commitment by the new Federal Government of $200 million for a Reef Rescue package. This is a great example of the potential of regional NRM bodies to take on soil management issues in a proactive way, and also to work in partnership with industry in a strategic manner to deliver catchment-scale outcomes.

[24] Colin Creighton, Executive Officer, Mackay Whitsunday Regional NRM Group, 6 February 2008

Pineapples, Nambour.
Andrew Campbell photo

Useful initiatives to assist regional NRM bodies could and should also be taken at State and national levels, such as improving and making more accessible the soils information base, increasing the availability of skilled professionals, improving the overall extension system and developing a much more cohesive and comprehensive national approach to soil monitoring and research. Such measures will make it easier for regional NRM bodies to deal with soils issues, as they will for farmers and farmer groups, local government, industry bodies and diverse state agencies.

Soils in the national NRM M&E framework

The Natural Resource Management Monitoring and Evaluation Framework recognises improved soil condition as a key outcome of regional investment. Where investments are targeted to improving soil condition investment partners expect that soil condition monitoring will have the ability to report on changes in the condition of soil as a result of the investment. This is a challenging process as the investments in changing aspects or characteristics of soils may take place over time scales beyond the investment timeframes. Whilst methods to map and describe soils have been developed and applied over many years, in Australia methods to monitor soil condition are still in their infancy.

The National Land and Water Resources Audit has been tasked with the responsibility of developing indicators and associated methods to report against soil condition outcomes. Indicators currently being addressed are soil erosion (wind and water), soil acidity and soil carbon. There are a suite of methods being recommended depending on the scale of reporting — local to national — and the timeframe of reporting.

The National Coordination Committee for Soil and Terrain is assisting the Audit to identify and test the indicator methods and its members are currently discussing the framework for a national soil monitoring program that would collect, collate information and report on soil condition nationally.

5. A way forward

5.1 Summarising the problem — what are we trying to fix?

The most fundamental problem appears to be a lack of recognition of the linkages between soil management and the big environmental issues of our time, like greenhouse pollution and water, or between soil management and food security. This is both at the level of the general public, and also at political, industry and policy levels, where seemingly more urgent issues get most attention.

This lack of recognition is both a reflection of, and a cause of, a general decline in dedicated soils efforts around the country: an incomplete and under-resourced knowledge base and monitoring effort, a loss of momentum in the soils profession and a declining number of talented new entrants into the profession.

Yet to soils professionals it is clear that Australia will not be able to meet its greenhouse objectives, manage its water supply crisis or improve the resilience of its farming systems without a renewed focus and re-energising of efforts to improve soil management. That will require reinvestment in the underlying infrastructure of data, information and professional capacity, and the rebuilding of soils literacy among NRM professionals in the field and across the regional NRM investment model.

Practical measures that would rebuild commitment, knowledge and capacity for better soil management in Australia are outlined below. Some of these are relatively quick and easy to bring about, others will take a concerted, sustained and well-organised effort. Together they comprise the bones of a more coherent strategy guiding national investment in soils — to put soils back on the NRM map in Australia.

5.2 Specific ideas

Rebuilding Commitment

The big challenge in rebuilding commitment is to make the case for a strategic national reinvestment in soils. That will require the sort of communication effort described earlier in section 4.2. That in turn will depend on having hard, credible data on the value of soils and soil information, the costs of soil degradation and the business case for reinvestment.

The value proposition has to be clear. Unless you can answer the why? question very persuasively, the what? arguments become academic.

In the first instance it would be useful to commission targeted desk-top economic analyses (updating and expanding upon NLWRA estimates) of the costs of soil degradation to the country and the potential cost-benefit of improving soil management to prevent further soil degradation.

It would also be helpful to try to quantify (preferably for each agroecological zone) and better articulate the linkages between better soil management and reducing net greenhouse gas emissions; and the linkages between better soil management and improvements in water quality and quantity.

How big is the soil carbon store? How much could greenhouse gas emissions from agricultural soils be reduced through better soil management and how much worse could it get through poor soil management? Or through not building more resilience into farming systems as regions become more marginal for cropping, or irrigation water becomes ephemeral rather than reliable?

Similarly, how does soil management affect water resources, and can we quantify the potential impact on a catchment water balance in different generic catchment types (analogous to the Groundwater Flow Systems characterisations for dryland salinity management). What gains could we expect in soil moisture holding capacity and what reductions could we expect in sedimentation, algal blooms and so on? Obviously continental scale extrapolations of some of these figures would be rubbery in the extreme, but it may be possible to use particular catchment studies as examples. Ideally, these biophysical data would be incorporated into the sort of desktop analysis mentioned above to start to develop a business case and value proposition.

Finally, it would be useful to undertake a complementary desktop economic analysis of the apparent market failure in soils data and information. If this information is so valuable, why is there no demand for it? It will be important to unpack at a finer-grained level of detail than has been possible in this paper, just why governments and businesses across Australia have so consistently and systematically under-invested in soils data. A good start has been made on this work in a study done by ACIL Tasman for the National Land & Water Resources Audit (Craemer and Barber 2007), which examined the value chain in soils information, generating some useful insights that would need to be taken into account in developing a business case for greater public investment in soils information.

Rebuilding the knowledge base

Dixon and McKenzie (2007) summarised recommendations for the cost-effective monitoring of soil condition across Australia that would go a long way towards rebuilding a coherent soils knowledge base to inform management and policy needs. They form the basis of these slightly revised suggestions:

- Complete soil survey coverage at useful management scales, to match the intensity of land use across the nation.
- Soil data and monitoring efforts, like other natural resources data, need a permanent institutional home, in an agency with a stable statutory base and a long institutional memory and culture, with durable links to relevant research, policy, academic and other institutions. This would not need to be a new agency. It would be preferable to have a revised mandate or more permanent status established for an existing institution.
- For soils data specifically, it would be sensible to formalise the Expert Panel(s) to oversee monitoring of soil acidification, soil organic carbon, and soil erosion by wind and water, reporting to the National Committee on Soil and Terrain.
- Renovate the Australian Soil Resource Information System (ASRIS), based on a comprehensive user needs analysis, so that it can receive and report on data from monitoring programs, and to make it much more accessible and user-friendly.
- Establish a set of long-term ecological research (LTER) sites, preferably as part of a new initiative like an Australian Ecosystem Observation Network.
- Prepare or update contextual datasets that characterise the drivers of soil change, most notably land use, land management practices, vegetation cover, fine-resolution terrain information and climate, and ensure they are available in a user-friendly form.
- Commission a series of R&D projects to improve methods for monitoring soil condition. Two immediate priorities are calibration of mid infrared spectroscopy for measurement of soil organic carbon pools, and remote sensing methods for estimating dry vegetation ground cover.
- Develop working arrangements between local scale monitoring for catchment management authorities, and broad scale monitoring better conducted by state or national agencies.

Rebuilding capacity

Improving the information base is an essential but not sufficient condition for getting better soil management on the ground. Without enough people with sufficient skills to interpret and apply the information, the influence of having better data will be negligible. This requires a multi-faceted education and extension effort. The situation for soils is shared across the NRM sector — there is a widespread need for a better extension system, populated by people with both solid technical training at undergraduate level, and access to excellent applied in-service training and career paths that keep them in the profession and contributing at higher levels as they gain experience.

Attracting such people will become increasingly difficult as the number of people entering the job market each year shrinks, underlining the need to take a strategic, cohesive approach across education and extension.

A key question is whether or not to try to rebuild explicitly soils-focused education and training, or whether to concentrate on having excellent soils modules to plug into more general training programs. The latter is probably the more pragmatic option. The detailed design of such a package is beyond the scope of this paper.

NSW Southern Tablelands, March 2007. Andrew Campbell photo.

This paper has identified immediate opportunities to improve the soils literacy of the regional NRM investment model. It would be useful to develop and promote:

- generic resource condition targets (RCTs) for soils that regions could use as a template in refining their regional NRM plans;
- decision support tools tailored for catchment and regional bodies that assist them to work out the main soil management issues and opportunities within their region;
- generic management action targets (MATs) for soils, perhaps for each agro-ecological zone or ASRIS major zonee.g. at level 3 or 4; and
- exemplar on-ground soils projects from across the regions, showing how catchment bodies and/or industry groups are working to improve soil management.

5.3 Conclusion

Australia will struggle to meet its greenhouse objectives, manage its water supply crisis, ensure the security of its food supply and the income it derives from food exports, or improve the resilience and profitability of its farming systems, without a renewed focus and re-energising of efforts to improve soil management.

That will require a more strategic and cohesive national approach to overall public investments in soils.

Such investment will need to include substantial renovation of the underlying infrastructure of data, information and professional capacity, based on genuinely national monitoring, research, education and extension initiatives. This will lead to the rebuilding of soils literacy among natural resource management (NRM) professionals in the field, which Australia will need if land users and the wider community are to be assisted through a very challenging period of environmental change.

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7. APPENDIX A. Summary of Australian Policies and Strategies relating to soil management

There is a wide range of national policies and agreements with potential linkages to soil management, a reasonable selection of which can be accessed via http://www.nrm.gov.au/nrm/documents.html

7.1 Soil policy and strategies in the States, Territories and Commonwealth

New South Wales

In NSW responsibility for administering the Soil Conservation Act (1938) has been recently transferred to the Department of Lands from the Department of Environment and Climate Change. The Soil Conservation Service http://www.lands.nsw.gov.au/soil_conservation within the Department of Lands operates a fleet of bulldozers which implement soil engineering works and is focussing on reestablishing many aspects of soil conservation services. It is understood a coordination group is being established. One of its first tasks will be to redevelop the current State Soil Policy as identified in the State Plan http://naturalresources.nsw.gov.au/soils/policy.shtml.

The Department of Primary Industries (DPI) http://www.dpi.nsw.gov.au/agriculture/resources/soils maintains a team of soil extension and agricultural research staff. Catchment Management Authorities (CMAs) http://www.cma.nsw.gov.au/ operating under the Catchment Management Authority Act 2003 are responsible for delivery of on ground and sustainable soil training projects and often work in concert with DECC, DPI and Lands and receive the majority of resources for natural resource management via federal and state partnership funds. The NSW Natural Resources Commission (NRC) http://www.nrc.nsw.gov.au/ has the responsibility under the Natural Resources Commission Act 2003 for setting aspirational targets and operational standards for CMAS. It also has an audit role to ensure that CMAs are operating effectively and efficiently. The two interrelated soil targets involve: improvements in soil condition; and land management being managed within its capability.

The Department of Environment and Climate Change (DECC) http://www.epa.nsw.gov.au/ has responsibility for soil mapping, research into soil and climate change and the provision of soil information. DECC is the custodian of the Soil and Land Information System, a one stop shop, single point of truth where soil information is contributed by hundreds of non government and government users http://www.naturalresources.nsw.gov.au/soils/data.shtml This is used in a similar fashion to the Queensland SALI database. It is currently establishing a program to monitor both soil condition and land management for future CMA target setting as well as monitoring resource condition changes.

Most natural resource management focus in NSW has been towards native vegetation, biodiversity and water issues and many soil projects have been undertaken to provide support to those major programs. Attention now appears to be turning towards soil management implications for carbon sequestration and the examination of soil biodiversity, land degradation and agricultural adaption interactions of climate change.

Northern Territory

Soil issues in the Northern Territory are generally governed by four Acts, the *Planning Act*, *Pastoral Land Act*, *Environmental Assessment Act* and *Soil Conservation Act*. The Department of Natural Resources, Environment and the Arts (NRETA) is the lead agency for soil information and management although the Department of Primary Industries, Fisheries and Mines (DPIFM) has a significant role to play in relation to agricultural soils and agronomy. Soil information plays a significant role in development assessment and consequent planning decisions with respect to demands for land for peri-urban and urban expansion.

The Land and Water Division of NRETA collect and manage soil data and is the custodian of this data. Soil data is stored in the corporate Soil and Land Information System (SALInfo). Major soil programs include soil mapping, soil data capture into SALInfo and development assessment. Current priorities are to capture historical soil data and begin using this data for enhanced resource assessment, landscape modelling and soil and landscape monitoring. Soil information captured in SALInfo can be viewed available online at **www.nt gov.au/nreta/nretamaps/**. Other information related to soil management is available at the NRETA website www.nt.gov.au/nreta/ <**http://www.nt.gov.au/nreta/**>

Queensland

In Queensland, the Department of Natural Resources and Water (NRW) is the lead agency for the provision of soil information for planning and soil management advice. The Department of Primary Industries and Fisheries (DPI&F) has an interest in the role of soils in contributing to agricultural productivity and the Environmental Protection Agency (EPA) has legislation that includes protection against contamination of soil and acid sulfate soil impacts (Environmental Protection Act 1994 and Coastal Protection and Planning Act 1995).

Queensland legislation and policies administered by NRW that directly address soil matters include the Soil Conservation Act 1986, the Soil Survey Act 1929, State Planning Policy 1/92: Development and Conservation of Agricultural Land, State Planning Policy 2/02: Planning and Managing Development involving Acid Sulfate Soils and the Acid Sulfate Soils Management Strategy for Queensland. Legislation and policies administered by NRW that require some soil matters to be addressed include the Land Act 1994, the Murray Darling Basin Act 1996, the Vegetation Management Act 1999, the Water Act 2000, State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide, the Blueprint for the Bush program (includes OnePlan and the State Rural Leasehold Land Strategy), the Rural Water Use Efficiency Initiative, and the Reef Water Quality Protection Plan.

NRW collects, manages and is the custodian of this soil data, which is stored in the corporate Soil and Land Information (SALI) system. Soil information plays a significant role in land degradation assessments such as for salinity, acid sulfate soils and erosion risk. This information is also used to determine land suitability for strategic planning and development assessment purposes.

Major soil programs include salinity risk assessments and acid sulfate soil mapping, provision of soil data, maps and reports, a soil analysis service, development of enhanced resource assessment techniques, landscape modelling, assessment of terrestrial carbon, soil degradation research and support of development assessment processes.

NRW officers also research and provide advice relating to soil health including compaction, acidification and fertility decline. Soil health is regulated to some extent through requirements for clearing in regional vegetation management codes. DPI&F also undertake soil health projects that aim to enhance agricultural productivity.

Information related to Queensland soil management is available at the NRW website **www.nrw.qld.gov.au/**

South Australia

There are three main acts that govern soil and land management in South Australia; the *Natural Resources Management Act 2004*, the *Pastoral Land Management and Conservation Act 1989*, and the *Development Act 1993*. Related Acts are relevant to soil and land management in specific regions of the state, including the *River Murray Act 2003*, the *South Eastern Water Conservation and Drainage Act 1992* and the *Upper South East Dryland Salinity and Flood Management Act 2002*.

The Department of Water, Land and Biodiversity Conservation administers both the *Natural Resources* Management Act *2004* and the *Pastoral Land Management and Conservation Act 1989* and is the lead agency for soil information and management, while the Department of Primary Industries and Resources SA also has a significant role. The key policy documents for soil and land management in South Australia are the South Australian Strategic Plan http://www.stateplan.sa.gov.au/ and the State Natural Resources Management Plan http://www.nrm.sa.gov.au/ReportsPlansDocuments/StateNRMPlan.aspx.

Tasmania

Soil issues in Tasmania are indirectly governed by two Acts: the *Environmental Management and Pollution Control Act (EMPCA)* and *the State Policies Act.* EMPCA includes a number of provisions covering off-site environmental impacts including soil erosion. The State Policies Act gives significant standing to State Policies such as the *State Policy for the Protection of Agricultural Land.*

The Department of Primary Industries and Water (DPIW) is the lead agency for soil information and management principally through its Land Conservation Branch. The Land Conservation Branch collects and manages soil data and is the custodian of this data. Soil data is stored in the Tasmanian Soils database. Major soil programs include establishment of benchmarks of soil condition under a range of soil type/land use combinations; land capability assessment; development of guidelines for the management of acid sulfate and dispersive soils; and soil data capture for upload into ASRIS. Soil information for Tasmania can be viewed online at http://www.asris.csiro.au/index_ie.html Other information related to soil management is available from the Land Management pages of the DPIW website http://www.dpiw.tas.gov.au/inter.nsf/ThemeNodes/LBUN-56U26G?open

Victoria

The Victorian Catchment and Land Protection (CaLP) Act 1994 (amended 1998, 2006) is the major legislation in relation to off-site effects, soil, water, weeds and pest animals. It is the main Act in Victoria that deals with soil management and it requires that landowners must take all reasonable steps to conserve soil, as well as to avoid doing anything that would cause or contribute to land degradation on someone else's land—i.e. it enshrines the concept of 'duty of care'. Government's role regarding legislation such as the CaLP Act is to act in partnership with the community to assist landholders to manage their natural resources. The lead agencies for soils are the Department of Primary Industries (DPI) for private land and the Department of Sustainability and Environment (DSE) for public land. In 2003 a Parliamentary inquiry into the distribution and management of soil acidity in Victoria prompted the Victorian DPI to develop a policy framework around soil health. Basically, it was an attempt to clarify why Government invests in research and extension around soil health and what outcomes it seeks to achieve. The DPI's Draft Soil Health Policy Framework is available at http://www.dpi.vic.gov.au/dpi/nrenfa.nsf/LinkView/41D06620E06D6480CA2572050077DE77EFA23A6BD88959974A256DEA0011DAC1 including a conceptual framework for soil health at http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soil_health_mis07898 The DSE is currently in the process of developing a Land and Biodiversity White Paper (http://www.dse.vic.gov.au/DSE/nrence.nsf/LinkView/523B19576C368289CA2572C0007B3BEA554FC9C681B6CAB6CA2572C600036DB1). A major issue is that the focus for much land resource assessment work to date has been on private lands. Little information has been collected on public lands, which has implications for current and future issues that have a major public land focus (e.g. the risk of soil loss due to bushfires).

The DPI undertakes significant research in soil chemistry, soil physics, soil biology and pedology as well as extension related to soil management and soil health. For example the DPI is working with major farming systems research groups including Southern Farming Systems, Birchip Cropping Group, Mallee Sustainable Farming Inc, Rural Solutions SA and Nutrient Management Systems on a major soil health project focused on the northwest and southwest Victorian grains industry (funded by the Victorian Government and Land & Water Australia) http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth

The Victorian Catchment Management Authorities (CMAs) are the most mature regional NRM bodies in Australia. Several, such as Corangamite (**http://www.ccma.vic.gov.au/soilhealth/**) have developed regional Soil Health Strategies. The 'Soil Knowledge Broker Service' is a pilot initiative of the Catchment Knowledge Exchange Project funded by the National Action Plan (NAP) for Salinity and Water Quality through the Victorian Catchment Management Council. The DPI administers the Victorian Soil Information System which includes the Victorian soil site and mapping database, hardcopy soil and land survey reports and the soil site sample archive. The Victorian Resources Online (VRO) website (**www.dpi.vic.gov.au/vro**) is the key means for dissemination of soils related information to the general community.

Western Australia

Soil issues in Western Australia are primarily covered by the *Soil and Land Conservation Act 1945*. Other acts that have some impact on soil management include the *Environmental Protection Act 1986* and the *Contaminated Sites Act 2003*. The Department of Agricultural and Food (DAFWA) is the lead agency on soil information and soil management, although the Department of Environment and Conservation (DEC) is the lead agency on acid sulfate soils. Soil information, especially land capability assessment, is a significant input to land planning assessments conducted by the Department of Planning and Infrastructure.

The Department of Agriculture and Food, sometimes in association with other agencies and external parties, collects and manages soil data and is the custodian of this data. Soil data is stored in corporate Soil Profile and Map Unit databases. The soil profile data is not available online, but available on request. Map unit information, including a number of interpretations, are available online via the Shared land Information Platform (**www.spatial.agric.wa.gov.au/slip/home.htm**). Soil profile and map unit information and interpretations are regularly used to assist decision making in the government, academic, community and private sectors.

The Department of Agriculture and Food also maintains a Division of NRM with roles in salinity research, NRM extension, soil assessment and surface water engineering. Agronomy and soil management in the cropping industry divisions are strongly supporting research in integrated farming systems with soil research as a primary focus, especially in maintaining the health and productive capacity of farmed soils. As the lead agency in the Soil Conservation Act, DAFWA regulates practices that cause land degradation through the Office of the Soil Commissioner. Land drainage for salinity control is the major work load, but soil erosion is equally important. Land clearing issues are now administered by DEC, more from a biodiversity point of view than land and soil degradation.

The regional NRM groups have developed regional NRM strategies, including sections on soil-related issues. The University of Western Australia, in partnership with the Department of Agriculture and Food, regional NRM groups, Land & Water Australia, Grains R&D Corporation and farmer networks is taking a lead in developing tools to understand and assess the health of soils with a land manager focus. Initially this has a Western Australian focus, but will extend nationally. More information is available at **www.soilquality.org.au/**

Australian Government

Australian Government Natural Resource Management Program

Caring for Our Country is the Government's new natural resource management program. Caring for Our Country provides $2.25 billion in funding over five years from 1 July 2008 to June 2013. It will integrate a number of existing natural resource management measures into a consolidated program, including the Natural Heritage Trust, the National Action Plan for Salinity and Water Quality, the National Landcare Program, the Environmental Stewardship Program and the Working on Country Indigenous land and environmental program. The Australian Government will release the first Caring for our Country Business Plan, covering the 2009-10 financial year, in September 2008.

The goal of Caring for our Country is to have an environment that is healthy, better-protected, well-managed, resilient, and that provides essential ecosystem services in a change environment. The program will focus on achieving strategic results and invest in six national priority areas:

- a natural reserve system
- biodiversity and natural icons
- coastal environments and critical aquatic habitats
- sustainable farm practices
- natural resource management in remote and northern Australia
- community skills, knowledge and engagement.

The delivery of natural resource management is a coordinated effort, relying on the cooperation of governments at all levels (Commonwealth, state and local), as well as that of regional bodies, which were specifically established to ensure delivery of NRM at the regional level. Local councils and organisations also play a vital role.
http://www.nrm.gov.au

A number of Australian Government initiatives and programs have been identified in section 3.2 *Managing natural resources in a Federal system*. Current programs that are being funded from the Natural Heritage Trust that relate directly to soil research and information include:

1. The Australian Collaborative Land Evaluation Program (ACLEP)
2. Protecting Australia's soil and landscape assets from acidification
3. Defining soil carbon status, carbon sequestration potential and the importance of carbon in Australian soils
4. Improving capacity to monitor wind and water erosion: a review of some approaches, technologies and jurisdictional arrangements
5. Developing a dust modelling algorithm
6. Building a foundation for soil condition assessment
7. Healthy Soils for Sustainable Farms (with partnership investment from the Grains Research and Development Corporation, and other third party participants).

ACLEP is jointly funded by the Commonwealth Scientific and Industrial Organisation (CSIRO, http://www.clw.csiro.au/aclep) Land and Water Division and entrains in-kind contributions from all State, Territory and Commonwealth agencies involved in land resource assessment. ACLEP coordinates the publication of standards on soil and land resource survey, supports the operations of the National Committee on Soil and Terrain, fosters the development of improved methods of soil and land resource survey and is developing the Australian Soil Resource Information System (ASRIS), which is the national repository and access point for soil information in Australia.

National Strategy for the Management of Acid Sulfate Soils.

The National Strategy for the Management of Coastal Acid Sulfate Soils published by NSW Agriculture (2000) was approved by the Agricultural and Resource Management Council of Australia, the Australian and New Zealand Environment and Conservation Council and the Ministerial Council for Forestry, Fisheries and Aquaculture. It provides a holistic and comprehensive approach to define the nature and extent of a major soil problem, how to prevent it from increasing and what remedial actions are needed to reduce existing acid water runoff. Its four principal objectives are:

1. Identify and define coastal acid sulfate soils (ASS) in Australia;
2. Avoid disturbance of coastal ASS;
3. Mitigate impacts when ASS disturbance is unavoidable; and
4. Rehabilitate disturbed ASS and acid drainage.

The National Committee for Acid Sulfate Soils (NatCASS) was established to facilitate and coordinate implementation of the National Strategy. It currently acts as the steering committee for the NHT-funded Acid Sulfate Soil National Knowledge project that has developed a National ASS Atlas on the ASRIS website. The project also funds a national information officer position that supports a wide range of communication activities, including a national newsletter, meetings, forums and workshops.

While primarily concerned with coastal acid sulfate soils , NatCASS has also taken on responsibility for national facilitation of inland acid sulfate soils, which have become increasingly recognised as a problem for many waterways and wetlands in inland Australia.

The National Strategy can be accessed at: **http://www.mincos.gov.au/publications**

minimal groundcover, central wheatbelt WA. Andrew Campbell photo.

7.2 Water

National Water Initiative

http://www.nwc.gov.au/NWI/index.cfm

The overall objective of the National Water Initiative (NWI) is to achieve a nationally compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes. The brown text in square brackets below indicates some of the key soil linkages that could be developed.

At the highest level, implementation of the National Water Initiative will achieve:

1. clear and nationally-compatible characteristics for secure water access entitlements;
2. transparent, statutory-based water planning [including allocations based on catchment water balances informed by soils information];
3. statutory provision for environmental and other public benefit outcomes, and improved environmental management practices [including environmental impacts of water use on soil condition- e.g.sodicity from poor quality water];
4. complete the return of all currently over-allocated or overused systems to environmentally-sustainable levels of extraction [including allocations based on catchment water balances informed by soils information and groundwater levels];
5. progressive removal of barriers to trade in water and meeting other requirements to facilitate the broadening and deepening of the water market, with an open trading market to be in place;
6. clarity around the assignment of risk arising from future changes in the availability of water for the consumptive pool;
7. water accounting which is able to meet the information needs of different water systems in respect to planning, monitoring, trading, environmental management and on-farm management;
8. policy settings which facilitate water use efficiency and innovation in urban and rural areas [e.g. avoiding stormwater pits in urban areas at risk of further salinity such as western Sydney];
9. addressing future adjustment issues that may impact on water users and communities; and
10. recognition of the connectivity between surface and groundwater resources and connected systems managed as a single resource.

The National Water Initiative agreement includes objectives, outcomes and agreed actions to be undertaken by governments across eight inter-related elements of water management, listed below. As noted in section 3.4, there is no specific mention of soils within the Intergovernmental Agreement for the NWI.

Water access entitlements and planning framework

A key aim of the Initiative is to restore surface and groundwater systems to environmentally sustainable levels. Water sharing plans will help to bring certainty for consumers, and allow them greater scope to plan agricultural and other activities.

Water markets and trading

The NWI will work towards the removal of institutional barriers to trade in water. Water trading systems will have the widest possible geographic scope, and will not be restricted to within catchment areas.

Best practice water pricing

Water pricing and institutional arrangements under the NWI will promote economically efficient and sustainable use of water resources, water infrastructure assets, and government resources; ensure sufficient revenue streams to allow efficient delivery of services; facilitate the efficient functioning of water markets; give effect to the principles of consumption-based pricing and full cost recovery; and provide appropriate mechanisms for the release of unallocated water.

Integrated management of water for environmental and other public benefit outcomes

Identify within water resource planning frameworks the environmental and other public benefit outcomes sought for water systems and to develop and implement management practices and institutional arrangements that will achieve those outcomes. [Soil survey based water application schedules, preventing irrigation and moving infrastructure away from leaky soils.]

Water resource accounting

The outcome of water resource accounting is to ensure that adequate measurement, monitoring and reporting systems are in place in all jurisdictions, to support public and investor confidence in the amount of water being traded, extracted for consumptive use, and recovered and managed for environmental and other public benefit outcomes.

Urban water reform

The NWI will ensure healthy, safe and reliable water supplies; increase water use efficiency in domestic and commercial settings; encourage the re-use and recycling of wastewater; facilitate water trading between and within the urban and rural sectors; encourage innovation in water supply sourcing, treatment, storage and discharge; and achieve improved pricing for metropolitan water.

Knowledge and capacity building

The NWI identifies areas where there is significant knowledge and capacity building needs for its ongoing implementation. Signatories to the Initiative have agreed to identify the key knowledge and capacity building priorities needed to support ongoing implementation of the Agreement, and identify and implement proposals to more effectively coordinate the national water knowledge effort.

Community partnerships and adjustment

Governments will engage water users and other stakeholders in achieving the objectives of the Initiative by improving certainty and building confidence in the reform processes; transparency in decision making; and ensuring sound information is available to all sectors at key decision points. New and improved measuring, monitoring, reporting and accounting procedures will be introduced, and improved public access to information will increase public acceptance of the Initiative.

National Plan for Water Security
http://www.environment.gov.au/water/action/npws.html#security2

The National Plan for Water Security is a $10 billion package that sets out to accelerate the implementation of the NWI, represents a radical reform of water governance arrangements in Australia and provides a $480m investment into a new nationally consistent water accounting framework, with hydrological standards to be developed and overseen by a new hydrology division within the Bureau of Meteorology. It focuses on the Murray-Darling Basin, where the bulk of Australia's agricultural water is used. Its ten key elements are:

1. a nationwide investment in Australia's irrigation infrastructure to line and pipe major delivery channels;
2. a nationwide programme to improve on-farm irrigation technology and metering;

3. the sharing or water savings on a 50:50 basis between irrigators and the Australian Government leading to greater water security and increased environmental flows;
4. addressing water over-allocation in the Murray-Darling Basin;
5. a new set of governance arrangements for the Murray-Darling Basin;
6. a sustainable cap on surface and groundwater use in the Murray-Darling Basin;
7. major engineering works at key sites in the Murray-Darling Basin such as the Barmah Choke and Menindee Lakes;
8. expanding the role of the Bureau of Meteorology to provide the water data necessary for good decision making by governments and industry;
9. a task force to explore future land and water development in northern Australia; and
10. completion of the restoration of the Great Artesian Basin.

7.3 Climate Change

http://www.greenhouse.gov.au/impacts/about.html

This is an extremely dynamic area of policy, with lots going on and frequent additions to the information base. A key initiative to watch will be the Garnaut Climate Change Review http://www.garnautreview.org.au/domino/Web_Notes/Garnaut/garnautweb.nsf in response to which the government will set new targets for reductions in Australian greenhouse gas emissions and presumably articulate how we plan to reach those targets.

A high level agricultural action plan for combating climate change is at http://www.daff.gov.au/natural-resources/climate

7.4 Weeds

The National Weeds Strategy for Australia can be found at: http://www.weeds.gov.au/publications/strategies/weed-strategy.html

7.5 Native Vegetation

The national policy framework for native vegetation can be found at: http://www.environment.gov.au/land/publications/nvf/index.html

An Australian Government policy statement is also provided at: http://www.environment.gov.au/land/publications/vegetation-policy.html

7.6 Biodiversity

The National Biodiversity Strategy is currently being revised, but the existing agreed version can be found at: http://www.environment.gov.au/biodiversity/publications/strategy/index.html

8. APPENDIX B. Some international developments in soil policy

8.1 European Union Thematic Strategy for Soil Protection

The European Union is engaged in a comprehensive and far-reaching environmental policy development process. In effect, it is a macro federation that has more parallels with Australia than we like to admit. There are lessons for Australia (positive and negative) both in the content of the new EU environmental policies and in the process of policy development.

The European Union's new Thematic Strategy for Soil Protection is arguably the most advanced policy framework for soil protection yet attempted.

European environment policy has evolved significantly since the 1970s. It has given the EU cleaner air and water and a better understanding of its dependence on a healthy environment. It is one of the policy areas most supported by EU citizens, who appear to recognise that environmental problems go beyond national and regional borders and can only be resolved through concerted action at EU and international level. From an initial focus on single pollutants and impacts, it has moved into an integration phase, with the emphasis on understanding and addressing the pressures on the environment and examining the effects of different policies and behaviour patterns.

Seven thematic strategies were proposed by the Commission during 2005 and 2006. It is interesting that, based on a comprehensive review of environmental policy, soil protection was identified as one of the seven key thematic areas, along with air quality, the marine environment, sustainable use of resources, waste prevention and recycling, pesticides and the urban environment. The Commission identified eight main threats to European soils: erosion, organic matter decline, contamination, salinisation, compaction, soil biodiversity loss, sealing (the European term for when soils become covered by houses, roads and other infrastructure), landslides and flooding.

Each thematic strategy is based on a deep review of existing policy. Each required several years of scientific and economic analysis together with extensive consultation. They are key mechanisms for delivering the objectives set out in the Sixth Environment Action Programme adopted by the Council and Parliament for the period 2002-2012. The strategies are specified in the 6th EAP and fall under its four main priorities: climate change, biodiversity, health, and resource use.

The thematic strategies provide broad analyses of issues by theme. They look at pressures and impacts on the environment, which often cut across these themes. They examine the links between environmental impacts and sectoral policies. They look at a broad range of options and a varied policy mix, including the use of market-based instruments, technology and innovation to deal with the problems identified in a strategic and effective manner. They take a longer-term perspective, setting the framework for Community and Member State action for the next two decades, i.e. they propose strategic objectives, and explore short- and medium-term measures where appropriate.

Each strategy comprises an overall approach towards the thematic issue presented in a Communication that highlights issues and proposes solutions; legislative proposals for some of the strategies; and an impact assessment. A thorough development process begins with a preliminary Communication that sets out issues and possible approaches to dealing with them. These documents are then subject to extensive consultation in expert working groups, in the impact assessment process, and on the internet. A broad range of stakeholders are consulted: Member States, academics, business and trade associations, individual companies, NGOs and other representatives of civil society.

The *Thematic Strategy on the Protection of Soil* was adopted by the European Commission on 22 September 2006. It is covered comprehensively at **http://ec.europa.eu/environment/soil/index.htm** and the background documents (if not some of the EU-specific policy detail) are very informative. The *Draft Framework Directive for Soil Protection* addresses the eight main threats and sets out a range of measures for protecting soils and securing the services they provide.

However as indicated earlier, getting agreement from Member States on the detail of measures to be enacted and implemented has proven difficult. The 20 December 2007 press release (# 16183/07) of the Council of the European Union stated:

> *In spite of the various attempts of the Presidency to present compromise proposals in order to meet delegations' concerns, it was not possible, at this stage, to attain the qualified majority needed to reach political agreement on a draft directive establishing a framework for the protection of soil.*

According to Dr Luca Montanarella of the EU Joint Research Centre (**http://eusoils.jrc.it/index.html**), who has played a leading role in the development of the Directive, the governments of Member States have been very supportive of the principle and the concept of soil protection, up to the point where there is a recognition that, especially in urbanised and urbanising (e.g. coastal) contexts, protecting the soil sometimes means constraining development. It will be interesting to see to what extent the Draft Directive will need to be watered down to *'attain the qualified majority needed to reach political agreement'* and thence become law at EU and Member State levels. Moreover, just as in Australia (Martin et al 2007), there is often a sharp contrast between legislation as enacted and as it is implemented and enforced (or not) on the ground.

8.2 United States of America

The USA was one of the first countries to establish a dedicated, professional Soil Conservation Service, (albeit well behind Iceland—see next section) in response to the dust bowls of the 1930s on the great prairies immortalised in Steinbeck's *The Grapes of Wrath*. The US Soil Conservation Service played a leading role in developing soil conservation ideas and techniques in the 20th century, and was influential in the establishment and development of soil conservation agencies in the Australian States, particularly in NSW (Breckwoldt 1988). It has now evolved into the Natural Resources Conservation Service (NRCS) of the US Department of Agriculture (USDA) **http://www.nrcs.usda.gov/**. Among its key operational roles, and probably the main instrument of promoting soil conservation in North America today, is the administration of many of the conservation measures under the enormous US Farm Bill (**http://www.nrcs.usda.gov/programs/farmbill/2002/products.html**) which provides for direct payments to landholders for eligible conservation works. These payments are subject to the sorts of problems discussed in section 3.3 on page 22, and are regarded with suspicion as thinly disguised production subsidies by Australia and its Cairns Group colleagues in international trade negotiations.

In addition to administering large chunks of the US Farm Bill, the NRCS has sophisticated soil survey and mapping capabilities, and provides a wide range of soil information products and services to landholders, town and county planners, teachers and students, and the research community (**http://soils.usda.gov/**).

The box overleaf contains a discussion draft[25] of a National Soil Resolution prepared for the US Senate by the American Society of Agronomy, Crop Science Society of America and Soil Science Society of America. Note that this has yet to be adopted and introduced by the US Senate, is more a rhetorical statement than a constructive blueprint for reform, and could be seen as a tad self-serving on the part of these learned academies. Nevertheless, the key points being made by soils science professionals in the US echo those being made by their Australian counterparts.

110th CONGRESS, 1st SESSION, S. RES. #
U.S. Soil Policy: Sustaining the National Soil Resource

IN THE SENATE OF THE UNITED STATES
______________________ submitted the following resolution; which was considered and agreed to:

[25] Dated 7 September 2007, from **http://science-policy.blogspot.com/2007/09/national-soil-resolution.html** accessed on 23 November 2007

Soil is a natural resource essential for life on earth. Soil links plants, animals, water, and air, affecting the weather, natural resources, and human health. The soil provides minerals for production; toxicity remediation potential; water purification; a growing medium for food, fiber, feed and fuel production; and ecosystems that support fish and wildlife. Soil is now used as the basis of raw inputs for industrial processes, and as a source of antibiotics.

Contemporary pressures on the soil resource elicit the need to increase the fundamental knowledge of soils and develop practical management technologies for sustainable use of this resource. Only those educated in soil science can provide such expertise. Well-trained soil professionals have experience in toxicology; nutrient management; chemical, biological and physical sciences; and natural resource and agricultural land management. Soil professionals are equipped with the information and experience needed to address the issues of today and those of tomorrow. It is now the time to invest in our natural capital, soil.

Whereas:

(1) Soil, plant, animal and human health are intricately linked. Soil degradation or improvement impacts climate, water and air quality, human health, biodiversity, food safety, and agricultural production;

(2) Soil is an essential, non-renewable resource, in that the degradation rates can be rapid and the formation and regeneration processes very slow;

(3) Soil is a dynamic system which performs many functions and services vital to human activities and ecosystems;

(4) Soil functions include biomass production; storage, filtration, and transformation of nutrients; weathering/formation of minerals (raw material); breeding ground for organisms used in medicine and bioremediation techniques; storage of carbon; and storage of the geologic and archeological heritage of the United States (U.S.);

(5) The soils in the U.S. are vulnerable to several soil degradation processes including erosion, nutrient depletion, organic matter decline, contamination, salinization, compaction, loss of soil biodiversity, urban sealing, landslides and flooding;

(6) Despite soil's importance to human health, the environment, nutrition, and food, feed, fiber and fuel production, there is little public awareness of the importance of soil protection;

(7) Protection of US soil, based on the principles of preservation of soil functions, prevention of soil degradation, mitigation of detrimental use, restoration of degraded soils and integration of these preservation principles into other policies is essential to the long-term prosperity of the United States;

(8) Spatial variability is a natural characteristic of soil; enormous differences exist in soil structural, chemical, and biological properties over the U.S. landscape;

(9) Soil diversity can be taken into account when areas of high risk are selected and appropriate measures implemented to ensure protection of the soil;

(10) Soils vary in susceptibility to degradation processes, and the risk of soil degradation can be identified;

(11) U.S. legislation in the areas of organic, industrial, chemical, biological, and medical waste pollution prevention and control should include provisions on soil protection;

(12) U.S. legislation on climate change, water quality, agricultural and rural development needs to provide a coherent and effective legislative framework for common principles and objectives that are aimed at protection and sustainable use of soil in the U.S.;

(13) Industrialization coupled with poor or inappropriate soil management practices continues to leave contaminated sites in the U.S. A common strategy to manage historic contamination of soil can prevent and control the harmful effects that soil contamination will have on human health and the environment;

(14) Soil can be used in a sustainable manner, which preserves its capacity to deliver ecological, economic, and social services, while maintaining its functions so that future generations can meet their needs.

Now therefore, be it resolved, that the U.S. Senate—

(1) recognizes it as necessary to introduce measures to improve knowledge, exchange information, and develop and implement best practices for soil management, carbon sequestration, and long-term use of the nation's soil resource;

(2) recognizes the important role of soil and the role of the Soil Science Society of American and Certified Professional Soil Scientists in managing the national soil resource;

(3) commends the members of the Soil Science Society of America for educating historic and emerging soil and environmental professionals;

(4) commends the Soil Science Society of America for continuing the legacy of education, outreach and awareness necessary for generating more public interest in and appreciation for soils for the future;

(5) acknowledges the promise of the Soil Science Society of America to continue to enrich the lives of all Americans, by improving stewardship of the soil, combating soil degradation and ensuring the future protection and sustainable use of our air, land and water resources.

8.3 Iceland

Iceland rates a mention as a country with extensive problems of land degradation and desertification, one of the longest standing and effective national soil conservation and land restoration operations in the world, and because of the author's familiarity with this fascinating country.

Iceland was first settled by humans in about 870AD. The Viking settlers brought with them sheep, cattle and horses. The birch and willow woodlands that once covered at least 25% of the country were used for fuel and building materials or burned to make space for agriculture and grazing. The impact of cloven-hoofed animals and removal of tenuous vegetation from the very fertile but highly erosive volcanic soils was staggering. About half of the original vegetative cover may have been lost, leaving behind deserts with very limited vegetation, and woodlands now cover only 1% of the country. Serious soil erosion characterises about 40% of Iceland (Arnalds et al 2001). During the 19th century, the best farmlands were progressively smothered by advancing dune systems, threatening several settlements. The landscapes from whence the fine volcanic materials were blown and washed away were left barren and unproductive, as shown below, with vegetation reduced to mosses and lichens trying to re-establish a foothold, sheep permitting.

The severity of land degradation in Iceland prompted in 1907 the establishment of Northern Europe´s only designated, and possibly the world´s oldest, Soil Conservation Service (Arnalds et al 2001), which recently celebrated its centenary. Its head office was established on a farm at the front-line of the advancing dune systems, in the most valuable farmland of the south-east of Iceland, where it remains to this day.

The first sixty years were almost entirely devoted to the urgent task of halting sand dune advance and other forms of catastrophic soil erosion in pastures and rangelands that left barren deserts behind. This work was mainly conducted by fencing and seeding the native sand stabilizer, *Leymus arenarius*. With more availability of fertilizers and better equipment around 1950, revegetation of some of the vast areas of denuded land slowly began. The picture below right shows a typical 'before and after' contrast.

Always on the lookout for new ideas, Iceland adopted significant elements of the Australian Landcare program (Arnalds 2005). This led to a much greater level of farmer participation in, and ownership of, the land reclamation schemes. While large areas of cold, wet desert remain in Iceland, the best farmland (and thus food production capacity) has been saved and the native woodlands of birch and willow are finally being re-established. Iceland is very proactive in pursuing measures to recognise carbon sequestered by soils in international greenhouse negotiations, and led the acceptance of revegetation into the Kyoto Protocol, along with Australia and the USA. Iceland´s President Grimson is an active proponent for conserving soil resources and restoring degraded land.

'Land reclamation' and 'forestry' are now words that resound in the soul of the Icelander.

8.4 International Soils law work[26]

Various international environmental strategies and instruments introduced from the 1970s to the 1990s refer to the need for humans to take better care of their soil and to control soil degradation. Despite this awareness, and the continual increase in severity of soil degradation, new strategies and global treaties during this period were concerned with a variety of environmental issues other than soil (Hannam and Boer, 2002) — notably climate change, biodiversity and desertification.

After the United Nations Conference on Environment and Development in 1992, the international soil science community began to pursue better national and international legal frameworks for soil. At the 1998 Congress of the International Union of Soil Sciences a working group was formed to investigate the possibilities for a global soil convention. Around this time the soil science community in Western Europe began to debate the benefits of a global legislative strategy for soil and the proposal for an international "Convention on the Sustainable Use of Soil" was developed — the "Tutzing Proposal" (Held *et al.*, 1998). The 2nd International Conference on Land Degradation in Thailand in January 1999 passed a resolution 'seeking the introduction of an international soil conservation instrument'. The resolution was conveyed to the IUCN Commission on Environmental Law (CEL) in 1999 and the CEL resolved to undertake an examination of the legal aspects of soil conservation.

Ian Hannam and Ben Boer (2002) analysed the international environmental law regime, including the UN Conventions for Combating Desertification, for Conservation of Biodiversity and for Climate Change. They concluded that existing international legal instruments are inadequate to cater for the principal international environmental law needs for soil, as they lack a sufficient range of legal elements needed to protect and manage soil in a sustainable way. The existing system fails to properly consider the ecological functions of soil. The IUCN's Environmental Law Program (ELP) has been investigating the advantages and disadvantages of the principal framework structures that an international environmental law instrument for soil may take (United Nations, 1999). The options presented include:

- a specific treaty for soil with all of the essential legal elements for soil;
- a Framework treaty which identifies the soil elements in existing treaties and links them through a separate binding instrument which would contain additional, specific legal rules for soil;
- a protocol to an existing treaty that creates specific rules for soil;
- an international soil charter; and
- a declaration for soil.

This debate continued at the recent Global Forum on Soils, Society and Global Change hosted by the Icelandic Soil Conservation Service and the United Nations University, held in September 2007 at Selfoss in Iceland. Representatives from all three UN Conventions attended, including the Chairman of the Intergovernmental Panel on Climate Change (IPCC). All acknowledged the centrality of soil management for each of those conventions and of the need to better recognise soil protection internationally. But there was no broad enthusiasm in favour of a new UN Convention for Soils.

The IUCN's Environmental Law Program (ELP) has also reviewed national soil legislation. It found that legislation has been used for about the past 60 years in many countries in a piecemeal fashion to control soil degradation and that most countries approach this activity in a fragmented manner. Many types of legal mechanisms are used in the legislation but would need to be applied in more inventive ways to effectively manage the soil in an ecosystem context. There are many ways available to States to approach the design of an effective legal and institutional system for soil management, including regulatory and non-regulatory approaches. Various examples of such frameworks are outlined in two key IUCN publications — Legal and Institutional Frameworks for Sustainable Soils (Hannam and Boer, 2002) and the Guide to Drafting Soil Legislation (Hannam and

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26 This section draws heavily on the work of Dr Ian Hannam (Hannam 2004, Hannam and Boer 2004) who has played a key role in the development of international legal instruments for soil protection.

Boer, 2004). The World Soils Agenda (Hurni and Meyer 2002) expressed reservations about the term ‘national soil law’ *“Soil is part of landscape ecology. To isolate it at the national level is seen as an invitation to ignore it. Integrating soil-related aspects in existing national legislation seems a better strategy.”*

9. APPENDIX C. National Committee on Soil and Terrain

9.1 Terms of Reference

Provide national leadership, coordination and direction in soil and terrain issues and information for natural resource management.

Provide broadly based advice, policy proposals and a strategic appreciation of emerging issues and priorities on soil and terrain matters for natural resource management to the Natural Resources Policies and Programs Committee (NRPPC) and the National Land and Water Resources Audit (NLWRA) as appropriate.

Provide national advocacy for all aspects of soil and terrain issues.

Act as the steering committee for the Australian Collaborative Land Evaluation Program (ACLEP).

Identify trends and technologies in soil and terrain assessment and monitoring and advise NRPPC and NLWRA of implications for natural resource management and regional development issues.

Provide the framework and national standards for soil and terrain assessment including monitoring.

Encourage capacity building in soil and terrain matters within government agencies, educational institutions and the community.

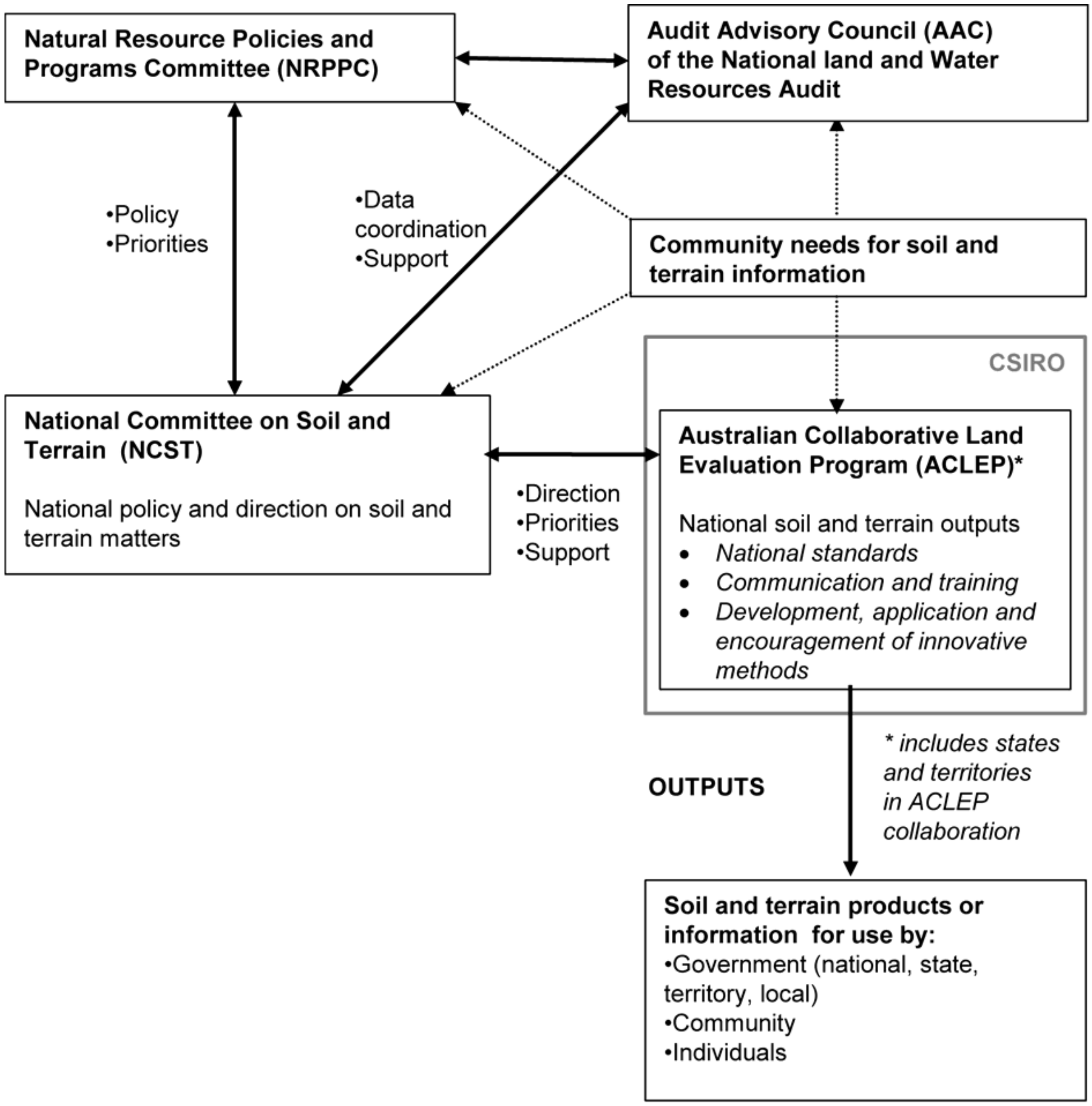
Provide a national forum to discuss and exchange views on the operation and application of soil and terrain information to natural resource management.

9.2 Membership (as at April 2008)

Mr Noel Schoknecht (Chair)	Manager, Land Resource Assessment and Monitoring, Department of Agriculture and Food, Western Australia
Mr Jason Hill	Land and Water Division, Dept. of Natural Resources, Environment and the Arts, Northern Territory
Dr Colin Pain	Geoscience Australia
Mr Mark Imhof	Project Leader, Future Farming Systems Research Division, Department of Primary Industries, Victoria
Mr Bernie Powell	Principal Scientist, Land and Environmental Assessment, Natural Resource Sciences, Dept. of Natural Resources, Mines and Water, Queensland
Mr Declan McDonald	Principal Land Management Officer, Dept of Primary Industries and Water, Tasmania
Dr Jane Stewart	Senior Scientist, Land and Forest Sciences, Bureau of Rural Sciences, Canberra
Mr David Maschmedt	Soil and Land Program, Department of Water, Land and Biodiversity Conservation, South Australia
Mr Greg Chapman	Theme Leader - Soil and Land Condition Monitoring, Evaluation & Reporting, Department of Environment and Climate Change, New South Wales
Ms Kimberly Green	Senior Policy Officer, NRM Research and Information, Department of Agriculture, Fisheries and Forestry, Canberra
Dr Mike Grundy	Theme Leader, Managing Australia's Soil and Landscape Assets, CSIRO

Although not formally on the NCST, the Chief of CSIRO Land and Water (Dr Neil McKenzie), a representative from the National Land and Water Resources Audit (NLWRA) and Natural Resources Policies and Programs Committee (NRPPC) are invited to attend all sessions.

9.3 Relationship between the NCST, ACLEP, AAC and NRPPC



10. APPENDIX D. Managing Australian Soils – a policy discussion paper.

10.1 Terms of Reference

A discussion paper that summarises, in a logical framework, the key soil resource and management issues and opportunities in Australia, with a view to developing a national soil strategy. The discussion paper will also describe the roles and responsibilities of all levels of government, and which aspects, if any, require national co-ordination.

Key components of the paper

- Rationale/philosophy for a national soil strategy
- Vision and goals
- Scope
- Guiding principles
- Overview and assessment of current and past soil policy in both Australia and overseas
- Overview of current investment in soil-related activities in Australia
- Key issues to be addressed
- Key stakeholders in the process, and their roles and responsibilities
- Synergies and opportunities for integration with other NRM issues/disciplines
- Outcomes sought
- Recommended actions, including the Terms of Reference for one or more consultancy(ies) to develop a national strategy
- Communication plan
- Executive summary

Issues to be addressed

The discussion paper is to consider, evaluate, integrate and build on previous related and relevant strategies, policies (soil conservation, primary production, natural resource management, water and native vegetation), frameworks, legislation, initiatives and programs whether at the local, regional, state, national or international level.

The following issues will be briefly explored using a logical framework (**http://en.wikipedia.org/wiki/Logical_framework_approach**) in preparation for development of the national strategy.

Protection and management of soil and land resources is a broad and complex issue. Soil is commonly a privately owned resource and the community must be well engaged in the development of a national soil strategy if it is to effectively identify key issues and appropriate responses. Specific issues to be addressed in relation to the development of a strategy for the sustainable management of Australia's soil and land resources at an individual, community, industry, academic and government levels, include the following:

1. Awareness of soil-related issues and costs and long-term consequences of soil degradation to the community
2. Public and private benefit of protecting and improving the land resource.
3. Relevance of soils to current and emerging issues, especially the impacts of climate change and opportunities for carbon sequestration.
4. Education and training requirements
5. Mapping and assessment needs to underpin sustainable development and improved decision making
6. Land use planning and management
7. Land management advice
8. Research and development needs and co-ordination of activities

9. Policy and regulation options
10. Roles and responsibilities
11. Options for participation in the development of a strategy