Grains Research & Development Corporation

The Secretary
Senate Standing Committee on Rural and Regional Affairs and Transport
PO Box 6100
Parliament House
Canberra ACT 2600

12 September 2008

Inquiry into Natural Resource Management and Conservation Challenges

I apologise for such a late submission to the inquiry but wish to provide a copy of our recently developed "Environmental Plan for the Australian Grains Industry". A key aspect of the Plan's implementation will be through partnerships with regional NRM bodies.

The GRDC has already worked in partnership with regional NRM bodies especially through the Grain and Graze Program. This has proved to be valuable, with the broadacre industries (grains, meat and wool) working with the NRM bodies to address some of the questions relating to farm enterprise mix and environmental outcomes.

The GRDC is seeking opportunities to partner with the Caring For Our Country Program to deliver on the objectives shared between the Environmental Plan and that Program. The opportunity for industry to continue to engage with the broader community through the regional NRM bodies is significant.

Sincerely

Martin Blumenthal
Manager Agronomy Soil and Environment

Australian Government

Grains Research and
Development Corporation

GRDC
A Responsible Lead: an Environmental Plan for the Australian Grains Industry

GRDC
Grains
Research &
Development
Corporation

A RESPONSIBLE LEAD: AN ENVIRONMENTAL PLAN
FOR THE AUSTRALIAN GRAINS INDUSTRY

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EXECUTIVE SUMMARY

The Grains Research and Development Corporation (GRDC) is a statutory authority established to plan and invest in R&D for the Australian grains industry. Its primary objective is to support the effective competition by Australian grain growers in global grain markets, through enhanced profitability and sustainability.

Critical to this fundamental objective is the development of technologies that allow grain production to espouse and embody world best practice in environmental farming systems.

The considerable changes already made to farming practices – already embedded in many modern cropping operations, but often not widely appreciated outside the industry – underpin the overall resilience the industry has shown during a succession of droughts.

The GRDC, in consultation with its industry partners, has developed a comprehensive Plan. This Plan will ensure that environmental issues will be prioritised when developing research policy that impacts on the grains industry.

The implementation of the Plan will equip Australian grain growers with the knowledge needed to manage a broad range of environmental challenges – including climate change – while continuing to develop a profitable, progressive and sustainable industry.

It is a Plan that will ensure the grains industry plays a leadership role in supporting regional economies, communities and their environments.

The Plan draws on the GRDC's 2007-12 Strategic Research and Development Plan, *Prosperity through Innovation*, to enhance the management of the natural resource base within which the grains industry operates.

The Australian grains industry covers some 34 million hectares of cropland with approximately 20 million hectares of grain crops planted in any one year. Annual production varies greatly with seasonal conditions. For example, production in 2005-06 was 43 million tonnes and in 2006-07 16 million tonnes. The majority of grain produced is exported. This means the industry is under constant competitive pressure in the international marketplace.

It must increase on-farm productivity and at the same time the broader community expects an increasing level of environmental stewardship.

To demonstrate the industry's environmental credentials and research-based capabilities, and to identify particular issues to be addressed, the GRDC, in consultation with its industry partners, has developed this Plan that will establish environmental strategies as a cornerstone of grains R&D.

The Plan is based on accepted principles of ecologically sustainable development. It examines risks and opportunities from 18 environmental issues across 14 agro-ecological zones.

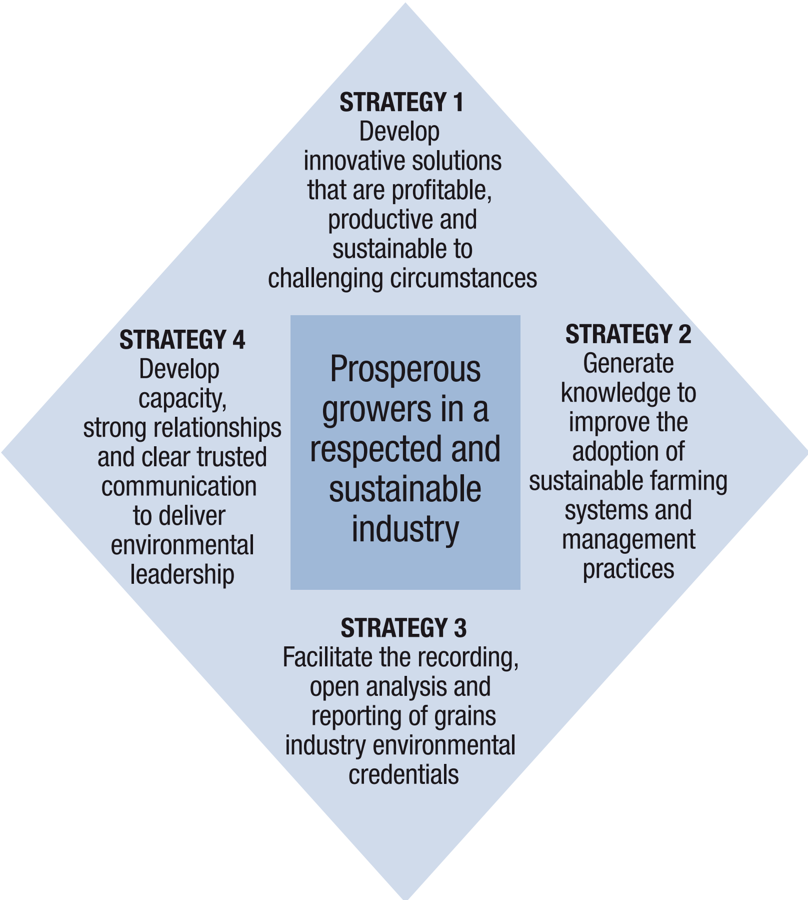
An important element of the plan is the gathering of data from grain growers about the level of environmental management practices already used on-farm. Scientific monitoring of these practices will reveal how professional grain growers are meeting the dual needs of increased productivity and environmental management.

From the outset the Plan's focus has been on-farm. Energy use and greenhouse gas emissions, pre- and post-farm, are considered, but the Plan's principal responsibility is to grain production.

The Plan complements the GRDC's 2007-12 Strategic Research and Development Plan and is consistent with the Grains Council of Australia's (GCA) Environmental Policy Principles. The Plan has been developed for industry by the GRDC through broad consultation with industry and stakeholders, including workshops in each mainland state. The Australian Government has supported the process with funding through the Sustainable Industry Initiatives of the National Landcare Program.

A key aspect of the Plan's implementation will be partnerships with regional natural resource management (NRM) bodies that are responsible for a range of resource targets. The overarching issues for grain production include climate change, soil erosion, soil nutrient loss and salinity. The implications for R&D include the identification of compensating plant traits, the breeding of cultivars and development of cropping practices that facilitate improved environmental outcomes.

FIGURE 1 THE GRAINS INDUSTRY ENVIRONMENTAL PLAN



In preparing the Plan the key soil, water, nutrient, biodiversity and atmospheric issues have been reviewed. The developed objective and strategies have been assigned performance targets.

The Plan is a tangible demonstration of how the industry is taking responsibility for managing its interface with the environment in a manner that benefits its own well-being and that of the broader community.

KEITH PERRETT
Chair

Grains Research and Development Corporation

INTRODUCTION

The GRDC's role is to drive innovation for a profitable and environmentally sustainable grains industry.

A key strategy of the GRDC's 2007-12 Strategic Research and Development Plan, *Prosperity through Innovation*, is to enhance the management of the natural resource base within which the grains industry operates.

The GRDC's Environmental Policy states:

> The GRDC is committed to investing in RD&E that addresses the environmental priorities of its stakeholders and underpins the sustainable development of an internationally competitive Australian grains industry.

Caring for the environment underpins the achievement of our vision to develop a profitable and sustainable grains industry.

Why is a Plan needed?

Australian grains production faces challenges and opportunities as the industry competes in international markets. The industry must achieve greater on-farm productivity at the same time as the broader community expects a higher level of environmental stewardship. The industry's Environmental Plan articulates clear actions to deliver improved natural resource management outcomes.

This Plan complements the GRDC's 2007-12 Strategic Research and Development Plan (adding more detail regarding environmental priorities) and is consistent with the Grains Council of Australia's (GCA) Environmental Policy Principles. The Plan has been developed for industry by the GRDC through broad consultation with industry and stakeholders, including workshops in each mainland state. The Australian Government has supported the process with funding through the Sustainable Industry Initiative of the National Landcare Program.

Working in partnership

The Grains Council of Australia is the peak body that provides overall strategic direction for the industry. The GCA's 'The Australian Grains Industry Environmental Policy Principles' highlights that good crop management leads to the more efficient conversion of inputs to grain, including efficient use of energy, with these in turn bringing environmental benefits. The principles highlight that genetic advances in crop varieties can lead to greater efficiency, reduced chemical use and increased environmental benefit. These policy principles are available on the GCA website (www.grainscouncil.com/Policy/policy.htm).

The regional Natural Resource Management model has become well established through Australian Government-funded initiatives such as the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust and continues to be important under the new Caring for Our Country Program. Fifty-six natural resource management regions have been established to determine natural resource management and sustainable agriculture priorities across the nation. Twenty-seven of these regions are in grain-growing areas. These plans are a valuable resource to inform the Environmental Plan of the Australian grains industry.

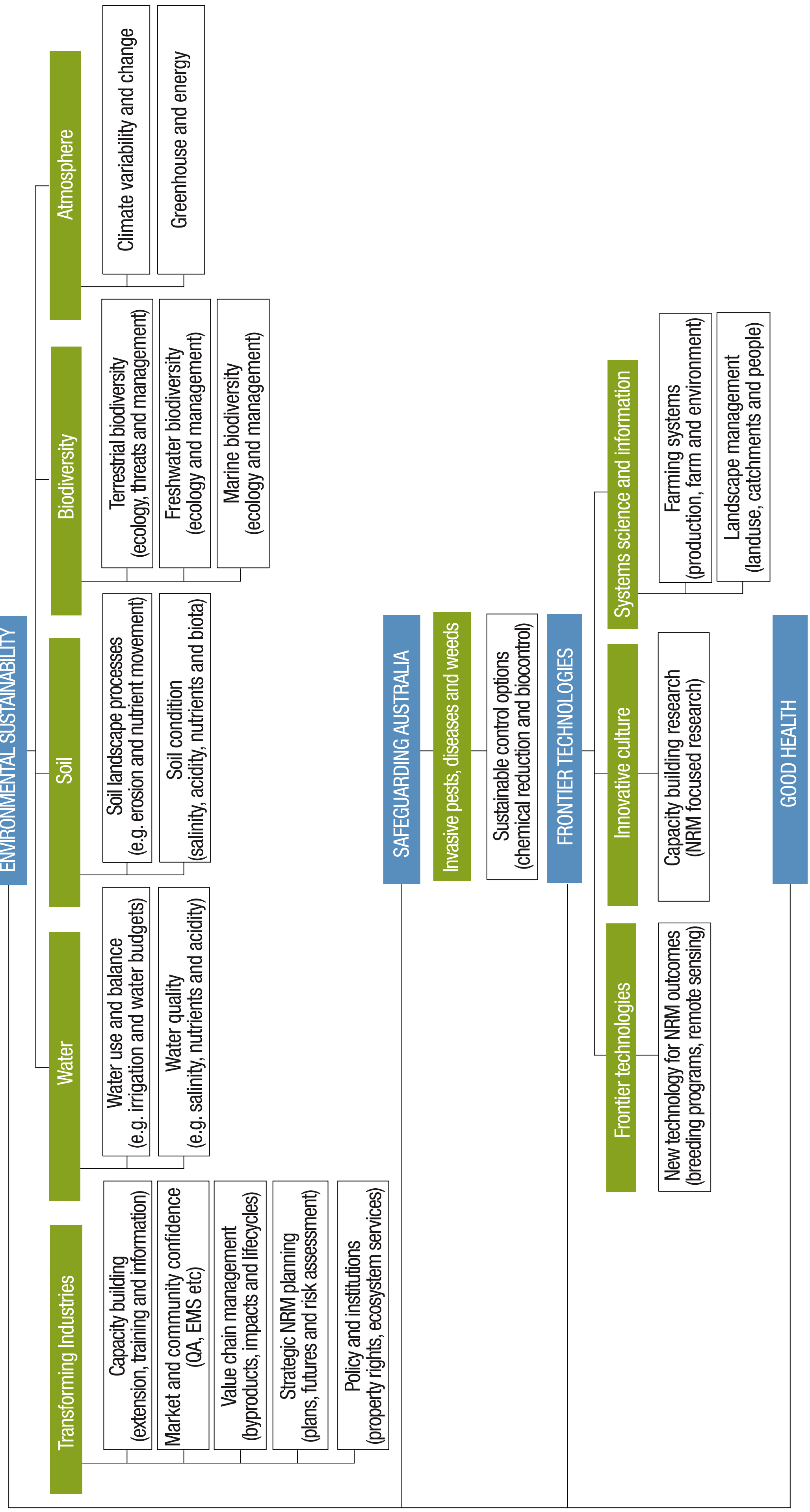
What does the Plan include and who is it for?

The Plan is for the whole grains industry across all scales: national, regional, catchment and farm. The focus of the Plan is the farm, rather than transport or storage infrastructure. The Plan is science-based and is a tool to communicate the industry's policy principles and the GRDC's environmental policy. The Plan is about setting the direction for future investment in research, development and extension (RD&E) for a sustainable grains industry.

It identifies and analyses the environmental issues of importance, reflects on current performance and past programs that have helped the industry to achieve the high standards it now enjoys and details actions to maintain and enhance the industry's momentum towards resilience and sustainability.

The Plan uses the Joint Rural Research and Development Corporations reporting framework for natural resource management to guide the categorisation of environmental issues (Figure 2, page 8). ■

FIGURE 2 JOINT RURAL RESEARCH AND DEVELOPMENT CORPORATIONS REPORTING FRAMEWORK FOR NATURAL RESOURCE MANAGEMENT



GRAINS INDUSTRY OVERVIEW

Grain production in Australia

The Australian grains industry, subject to seasonal variation, generally involves about 27,000 growers growing between 15 and 40 million tonnes of grain from 20 million hectares – valued at more than $9 billion in 2005-06. That production consisted of:

- wheat – 25 million tonnes;
- barley – 9 million tonnes;
- pulses – 2 million tonnes;
- oilseeds (canola) – 1.5 million tonnes; and
- coarse grains (sorghum, oats, triticale) – 2.5 million tonnes.

The industry employed 53,000 people in 2001 and 70 per cent of grain growers also run livestock (sheep or cattle). Figure 3 shows the distribution of the industry across the five mainland states and Tasmania.

Grain crops in Australia usually rely on rainfall (that is, they are rain-fed), with only 10 to 15 per cent of the cropping area receiving any irrigation. Soils in the grainbelt are mostly old and weathered, especially in the southern and western regions, and rainfall is often unreliable. Farming strategies have been developed to store and use the rain efficiently and there have been major changes in farming systems through the history of the industry, but especially in the past 25 or so years, as research and development outcomes have been more widely adopted.

In today's operating environment the industry has seen issues such as water, energy and nutrient use efficiency emerge. As such, most systems now in use exhibit high water use efficiency (WUE), sustainable soil management, and efficient nutrient use as well as being highly productive. WUE is a measure used to describe how efficiently grain crops use the rainfall they receive, or rainfall stored in soil prior to planting. WUE has more than doubled in the past 20 years, and there is growing use of integrated pest management (IPM) with associated reduced chemical use. Scope exists to continue to improve these efficiencies.

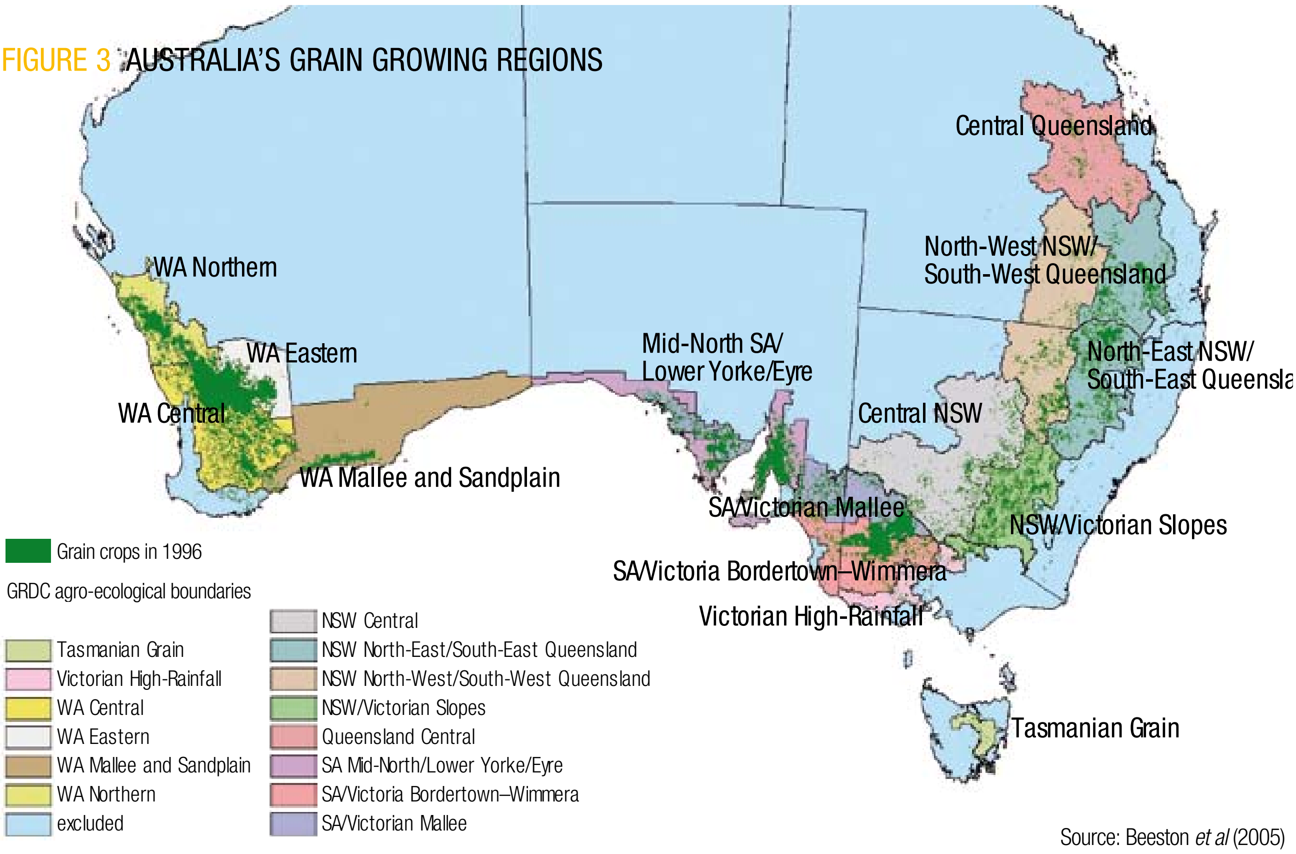
The industry

Export markets dominate with approximately 60 per cent of wheat and 22 per cent of barley exported in average years. In Western Australia approximately 95 per cent of the wheat produced is exported in most years.

Most Australian export grain is shipped to the Middle East and South-East Asian regions. Australian grain is considered high quality and finds ready use in a variety of end uses, including noodles in many Asian countries, the flat breads of the Middle East, and in other general uses. Several new high value niches are beginning to emerge, for example, the high quality of Australian durum wheat.

There is growing Australian domestic use of grain, especially of feed grains in the northern and eastern states, which has

FIGURE 3 AUSTRALIA'S GRAIN GROWING REGIONS



Source: Beeston *et al* (2005)

TABLE 1 AVERAGE CROP SIZE PER FARM (2005)

Region	Approximate area cropped each year
Nationally	700ha
Western Australia	1400ha
Queensland	1100ha
NSW, South Australia	600ha
Victoria	500ha

Source: ABS Agricultural Census 2006

been driven by increased demand from beef, poultry and dairy industries. There is increasing use of onshore processing of some grain products, for example pasta and malt, though the bulk of exported grain is in unprocessed form.

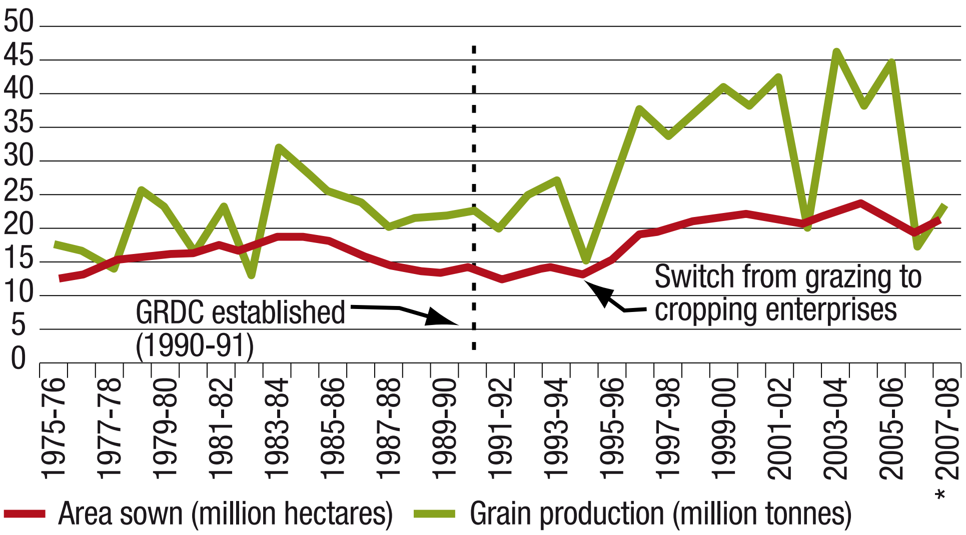
Recent decades have witnessed a more diverse array of crops being sown, with pulses (lupins, peas, beans, lentils, chickpeas in the main) and oilseeds (chiefly canola in the south, and sunflower in the north) now being included in many rotations.

The industry is characterised by highly efficient use of machinery and labour, with one family typically able to undertake several thousand hectares of crop production (Table 1).

Figure 4 shows Australian grains industry production trends over the past three decades. A switch from grazing to cropping in the mid 1990s, due to the higher relative profitability of cropping after wool prices fell, brought about a significant increase in the area being used for crop production. This has contributed to higher average grain production since the mid-1990s.

During this time, primary producers have been battling declining terms of trade, and this has been a key driver of increased productivity over this period. Importantly, new systems and practices that are integral to improved productivity have also been generating positive environmental outcomes. ■

FIGURE 4 AUSTRALIAN GRAINS INDUSTRY PRODUCTION, 1975-76 TO 2007-08



Source: ABARE Australian Commodities reports and other reports, various years

ENVIRONMENTAL ISSUES

Industry-level issues

Environmental issues often merge with, and interact with, economic and social issues, from the farm to the global scale (Table 2). It is important to assess issues in that context – interactions between issues and between scales – in order to fully appreciate the challenges and opportunities ahead.

At the global scale, climate change may result in shifts to where grain production is optimal and be a factor in changing the competitive advantage of different countries. The impacts of climate change will vary across the globe, favouring expansion of cereal production in some world regions and not in others. Attempts to reduce greenhouse gas emissions to combat climate change (and other energy-availability considerations) introduce new options for growers – including future options, such as biofuel (starch, oil or cellulose-based), in addition to staple food – which in turn may result in increased prices for grain. Fuel prices are also likely to rise and contribute to increases in the cost of fertilisers and farm chemicals.

Climate change is anticipated to result in higher temperatures and evaporation in many grain-growing regions of Australia, and greater climate variability between years, as well as increased frequency of extreme weather events (for example, storms). Management for drought will become more important, stimulating further evolution of farming systems. Future systems will also need to be compatible with policies affecting production such as carbon trading or emission accounting and reduction, payments for environmental stewardship, or the generation of wind or solar energy.

The ability to respond to such pressures and opportunities will require new skills (for example, in marketing – finding willing buyers for high-quality, high-cost grain). Regions and the industry in total will need organisations and structures to assist, skilled people able to train and develop others, and respected leadership to harness enthusiastic people and align their efforts.

These likely future changes highlight how environmental issues are interwoven with social and economic factors and how they need to be considered at a farm scale through to a global scale. The grains industry Environmental Plan must therefore address natural resource management issues within this context and benefit both the industry at large and the thousands of individuals who contribute to it.

Farm-scale issues

Grain production, by definition, uses resources for the growth of plants and the production of grain.

These resources include:

- soil (the medium and provider of nutrients, water and structural support for plants);
- water (essentially rainfall in the Australian grains industry);
- gases (carbon dioxide (CO_2) and oxygen and in the case of legumes nitrogen from the atmosphere both above and below ground); and
- sunlight, the source of energy that, via photosynthesis, drives the whole system within the plant.

Crop management practices aim to maximise the opportunities for plants to most efficiently access these resources to grow and produce grain.

Other natural resources are potentially affected by the operations or activities of grain growers in aiming for optimal conditions for grain crop growth. Farming practices aim to provide:

- freedom, or minimised impacts, from weeds, pests and diseases;
- amelioration of soil constraints, for example, subsoil structural impediments;
- additional inputs, for example fertilisers, where the naturally available nutrient levels are low and to replace elements removed in grain;
- optimal growing conditions, for example sowing depth, density and timing; and
- minimal use of harsh (high toxicity) chemicals.

The grower's role is to implement management practices that allow for optimum production, while sustaining the resources so repeated crops can be grown without depleting the resources of the farm.

TABLE 2 ISSUES AFFECTING THE AUSTRALIAN GRAINS INDUSTRY

	ENVIRONMENT	TRADE/ECONOMICS	SOCIAL
Global	■ Climate change: greenhouse, climate variability, weather extremes ■ Water availability ■ Energy: oil availability and price, biofuels ■ Biosecurity	■ Global food demand and supply: world stocks, reliable supply, ■ Changing competitive positions of countries ■ Crops for food, feed or fuel? Grain prices ■ Market access: barriers, subsidies, food miles, 'buy local', labelling, GMOs ■ Increasing cost of inputs: energy, fertilisers, chemicals ■ Carbon trade/farming ■ Climate futures/derivative trading	■ Population growth, living standards, dietary changes ■ Consumer demands: secure supply and 'quality', clean-green? ■ Eco-accounting: food miles, carbon footprints ■ Urbanisation: loss of arable land ■ Terrorism: threat of war
National / Industry	■ Water: secure supply, quality and quantity, WUE ■ Drought ■ Land degradation: erosion, salinity, acidity, biodiversity decline ■ Biosecurity: pests, weeds and diseases ■ Changing landuse (forestry) ■ Adoptable, adaptive farming systems ■ Genetically modified organisms (GMOs) ■ Greenhouse emissions; carbon sequestration, life cycle assessment/ accounting	■ Terms of trade: international competitiveness, ■ Market deregulation: market intelligence ■ Changing mix: domestic consumption, export, import ■ Marketing high cost, high quality crops ■ Water trading ■ Drought policy: preparedness, self reliance ■ Infrastructure: costs ■ Corporate farming: feedlots	■ Changing demographics: ageing, urbanisation, rural decline ■ Mining: competing for labour, land and water resources ■ Changing community values: consumer expectations, environmental regulations ■ Right to farm: social licence to farm ■ Making farming attractive to future generations: lifestyle, advocacy ■ Education: training, knowledge management ■ Environmental regulations: air, vegetation, water
State / Regional	■ Resource Condition and Management Targets: ground cover, WUE ■ Environmental flows, water quality, sediments ■ Land degradation: biodiversity, dust, erosion ■ Shifting production zones, changing farming systems, 'marginal' cropping ■ Biosecurity	■ Production targets: export targets ■ Infrastructure: transport ■ Quality assurance ■ Commodity differentiation: niche market production ■ Plant breeding: GMOs ■ Grain storage	■ Regional NRM bodies ■ Stewardship: public benefit ■ Competition for land: forestry, urban growth ■ Infrastructure: communication, education, health ■ Declining influence of agriculture: leadership
Local / Farm	■ Healthy soils: carbon, soil biota, nutrients, erosion, acidity, hydrophobic soils ■ Managing drought: variability ■ Managing pests and weeds: integrated pest management (IPM), herbicide resistance, feral animals ■ Balancing: environment/production, crop/stock ■ Local environment: off-farm impacts, lag times	■ Profitability: terms of trade, ■ Land costs: farm size, return on investment (ROI) ■ Administration costs: regulations, QA, EMS, levies, OHS, ■ Different enterprise options: different skill sets and risks ■ Marketing variable outputs ■ New business models: leasing, investors, Boards, succession planning ■ Climate futures/derivative trading	■ Rural decline: fewer service providers, high costs ■ Stress: uncertainty, apathy, mental health, succession planning, ■ Knowledge: access to brokers, skilled labour ■ Personal development: investing in people, time poor, not taking holidays ■ Leadership: attracting and retaining bright people

Source: Drawn from stakeholder consultation workshops in all mainland states

Grain growers are then able to choose the practices they see as best able to offer the balance between providing and enhancing crop access to resources, and maintaining these resources for continued crop production in the long term, while minimising impacts on the wider off-farm environment.

The farmer's greatest ability to affect the environmental aspects of the farm is by practices in soil management, tillage system, nutrient application, water management and crop protection. The use of energy (fuel, fertiliser) is also a consideration when determining the overall 'footprint' of the industry.

The environmental resources impacted by farm management decisions and practices include those directly linked to crop growth, and those associated with the optimum conditions for plant growth. They can conveniently be grouped as:

Soil factors

Soil is the fundamental natural resource with which growers work. Australia's soils are often highly weathered, shallow and can be beset with constraints in fertility, biology or structure. Exceptions to these generalisations exist, with some areas of very productive, fertile, deep soils.

Nonetheless, the importance of preserving and improving the soil resource is paramount and is well recognised by growers and the industry.

Management to improve the soil generally brings dual benefits for productivity and the environment. For these reasons the industry has seen a revolution in soil management and farming practices aimed at soil preservation and improvement.

At a fundamental level, the industry and individual grain growers want to keep the soil in place, enhance its ability to hold and provide water and nutrients to plants, and improve other soil parameters that are associated with these.

Soil considerations for this Plan include management and effects on:

- soil structure, which impacts on water, erosion and crop growth;
- soil erosion, the fundamental need to keep the soil in the paddock;
- soil organic matter, which has wide effects on many parameters, including soil biology;
- soil water relations, a complex of many factors including some listed above; and
- soil chemistry, including pH (Figure 5) and cation exchange capacity.

As will be mentioned in other areas, management of soil and the farming practices involved interact with other environmental issues, including water, nutrients, carbon, and biodiversity.

Water factors

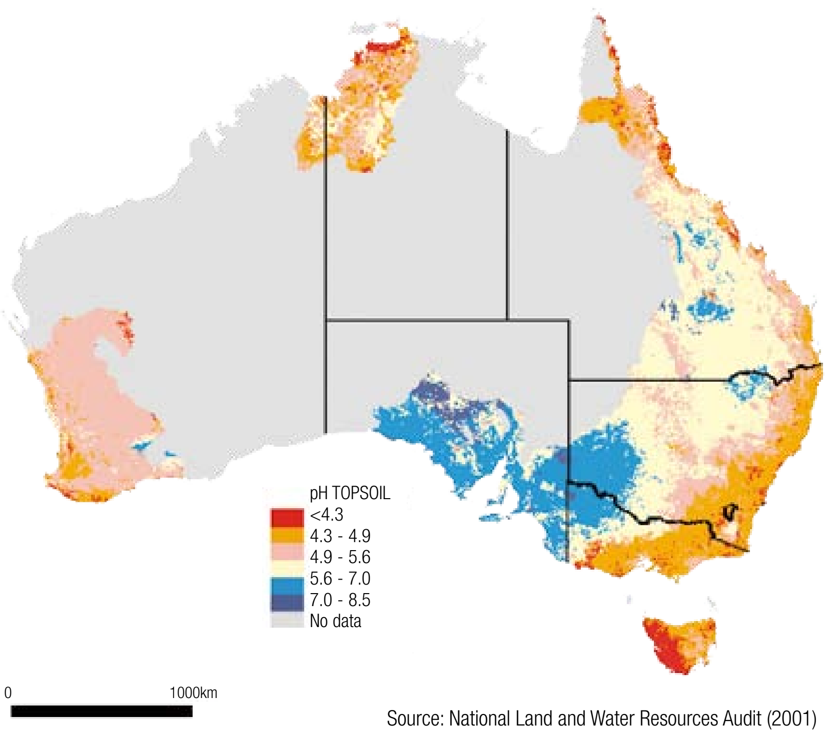
Significant interactions exist between soil management and water relations, since soil is the medium for capturing rain, holding moisture and providing water to roots. As mentioned earlier, when referring to water in the Australian grains industry, it is rainfall received either prior to planting or through the crop's life, and not irrigation water. As such, considerations around water management for the industry are often intermixed with other factors such as soil management, tillage, residue management, nutrients and chemical use.

The objective in describing the issue of water management and its effects on the grains industry is to consider the impact farming systems and crop production practices can have on water quantity and quality. Important in these are the effects of grain production on the quantity and quality of water leaving a farm.

Water issues highlighted in the Plan include:

- soil effects on water absorption, availability to the crop, runoff and drainage;
- nutrient and pesticide management and effects on leaching and runoff;
- management of crop health to allow maximum water use, and hence reduced risk of salinisation;
- management of crop residues for enhanced soil effects and their subsequent effects on water; and
- management of nitrogen and phosphorus fertilisers in combination with crop residue and tillage systems to maximise use by crops and minimise losses in water draining through the soil profile, leaving the farm as runoff or attached to soil particles in sediment loss.

FIGURE 5 SOIL ACIDITY IN AUSTRALIA



Source: National Land and Water Resources Audit (2001)

Nutrient factors

The Plan concentrates on phosphorus and nitrogen since these nutrients are the most commonly applied by growers and both have the potential to impact on environmental issues, particularly when present in runoff water or when lost through deep drainage below the root zone.

The management of nitrogen and phosphorus fertilisers in combination with crop residue and tillage system has implications for nutrient flows in water or sediments leaving the paddock and, in the case of nitrogenous fertiliser use, for greenhouse gas emissions.

Biology/biodiversity factors

Although grain crops are mostly grown as monocultures they still contribute to biodiversity (the variety of life at system, species and genetic levels):

- the impact of better soil-management techniques can increase biological diversity within soil;
- the use of precision agriculture and matching land use to capability enables some areas to be taken out of crop production and revegetated; and
- the use of integrated pest and weed management, where lower chemical use is a feature, leads to fewer non-target impacts and the retention and promotion of beneficial organisms.

In the past clearing to establish productive farmland impacted on biodiversity. Grain growers are now conscious of that impact and are interested in learning how to foster biodiversity within the commercial reality of a modern farm.

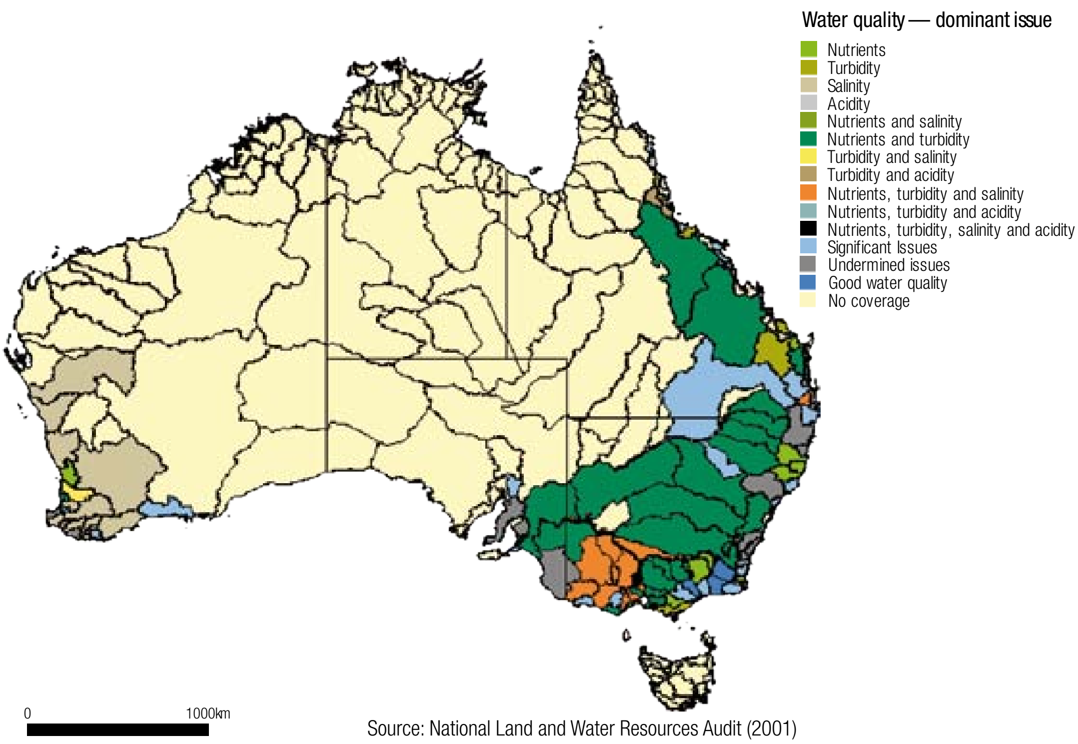
Carbon, atmosphere and energy-use factors

Crops take CO_2 from the atmosphere in the course of growth. Some of this carbon can remain in plant material (crop residues both above and below ground) and some can be ‘exported’ from the paddock as grain. However, carbon is cyclic, and moves in and out of the soil, atmosphere, and plants with time. The important considerations for the grains industry in managing carbon cycling include energy use on farms, soil carbon, fertiliser impacts and fuel use. All of these have linkages to greenhouse gas production and energy efficiency.

The area is complex and includes:

- fuel use in grain production having a direct effect on CO_2 production;
- use of nitrogen fertiliser and the potential for generation of the greenhouse gas nitrous oxide;
- nitrous oxide generated from other sources, including soil mineralisation, rotational pulse crops and pastures;
- tillage practices:
  - tillage can be a direct contributor (especially in the case of multiple till systems) to soil greenhouse gas emissions from oxidising compounds in the soil;
  - dust from tilled paddocks in dry conditions; and
- smoke from stubble burning.

FIGURE 6 WATER QUALITY ISSUES BY CATCHMENT



Source: National Land and Water Resources Audit (2001)

ASSESSING THE ON-FARM RISKS

An issue-management approach has been taken to help prioritise GRDC investments that will enhance the sustainable management of natural resources (Agtrans Research 2007). The impact of an issue is balanced against the likelihood of that issue occurring. Obvious issues for the industry are greenhouse gas emissions, climate change, salinity, soil nutrient and chemical loss, air quality impacts from wind erosion and smoke, and loss of biodiversity[1].

These issues do not occur uniformly across the whole geographic range of the industry. Different grain growing catchments are exposed to different issues. A matrix of risk by catchment helps to target future R&D and communication investments. A risk framework has been validated regionally against information contained in the NRM plans of the natural resource management regions, and against the experience of grower groups, farming systems projects and state agencies.

The key issues are best mapped against the agreed reporting framework of the Rural Research and Development Corporations' Natural Resource Management Working Group (Figure 2). The scope of the issue, current scale (ha) and impact ($), and the agro-ecological zone and NRM catchment most at risk have been identified, along with the potential and likely scale of future impact. R&D and communication activities already carried out have been examined together with good practice management options, community benefits of mitigation, opportunities for the grains sector, communication, RD&E needs and potential partners, have been assessed. Many of the environmental issues are also significant productivity constraints to the industry, for example water use and soil constraints (Beeston *et al* 2005). These 'win-wins' through multiple benefits are identified and highlighted.

The issues and impacts are summarised in the following tables.

Soil issues

Soil issues include the direct issues of erosion, salinity, acidity and sodicity, and the indirect ones of water use efficiency (WUE), soil biodiversity and effects on atmosphere and carbon.

Water issues

These include all issues that affect, and impact on, water and encompass water quantity and quality for cropping and water contamination. WUE remains a major measurement of value.

Nutrient issues

The major nutrients used in grain production - phosphorus and nitrogen - can cause environmental problems when application rates do not match crop needs. Both can have detrimental effects on waterways, and nitrogen can contribute to greenhouse gas emissions.

Biology/biodiversity issues

This includes matters of crop and farm management that have impacts on general biology and biodiversity on grain farms.

Carbon, atmosphere and energy use issues

This is a complex area and includes greenhouse gas emissions and potential sequestration on farms, use of fuel and other energy (for example, fertiliser) on farms, burning of crop residues, wind erosion and aspects of soil carbon management. ■

1. GRDC Environmental Analysis Project: RD&E Investment. Agtrans Research. Final Report 31 August 2001.

TABLE 3 SOIL ISSUES Soil issues include the direct issues of erosion, salinity, acidity and sodicity, and the indirect ones of water use efficiency, soil biodiversity and effects on atmosphere and carbon

	Scope	Scale	Impacts (current and potential)	Capacity of industry to mitigate effects
Soil erosion	Water erosion, primarily in the north. Wind erosion more relevant in southern and western regions.	Estimates of scale of erosion are difficult as few data are currently available.	Severe and largely irreversible effect on productivity. Sediment, nutrients and other contaminants can have severe environmental impacts. Wind erosion also causes sand blasting damage to young plants. Air quality also suffers. Greatly reduced soil loss from cropping lands is expected in the future with reduced impacts. The impacts will be influenced by climate change, with a higher incidence of severe rainfall events.	Maintaining stubble cover and reducing tillage operations have increased in most grain producing systems. Erosion from cultivated lands can still be high. Control of soil erosion by wind and water is still less than optimal. Opportunities include: improved soil management practices; buffer strips along waterways; and stream bank management. Transfer of knowledge is needed more than research.
Soil salinity	The onset and severity of soil salinity has environmental impacts on land and vegetation systems with additional water quality and salinity issues associated with river and stream water quality.	In 2002 the Australian Bureau of Statistics (ABS) reported that 1.97 million hectares of agricultural land in Australia show signs of salinity. 0.82 million ha of this was unsuitable for agricultural production, with Western Australia having the largest area of salinity.	Productivity losses are a major effect. Salinity and rising watertables with salt cause damage to natural and planted vegetation, riparian zones, wetlands including those of floodplains, fragmentation of wildlife corridors and general biodiversity loss. The area of saline land is expected to increase over the next 20 to 50 years. The National Dryland Salinity Program (NDSP) has reported that the five agroecological zones facing large salinity problems over the next 20 years are the WA Sandplain, SA/VIC Bordertown-Wimmera, NSW/Vic Slopes, WA Central and Vic High Rainfall. Most of these are major grain-producing regions.	Localised solutions for prevention include vegetation management, the use of perennial pasture species to control watertables, and selected drainage initiatives. Some evidence suggests that improving water use efficiency of crops can reduce water losses to groundwater. Strategies to maximise WUE may assist with managing salinity. Averting and delaying productivity loss on land that otherwise may be damaged by salinity in the future and regaining some production from land already affected by salinity are the main opportunities for the grain sector. Successful pursuit of these opportunities in some instances will decrease the impact of soil salinity on the environment. A focus of GRDCs investment in the CRC Future Farm Industries is to integrate perennial vegetation into cropping enterprises.
Soil acidity	Soil of low pH compromises yields and also other vegetation growth, and consequently can lead to salinity outbreaks.	48% (10.7 million ha) of cropped soils have surface soil acidity with a pH of less than 5.5 including 1.6 million ha with acidity of pH less than 4.8.	Yield losses on badly acidified soils are estimated to be 15 to 20% of potential yield. Environmental impacts include reduced terrestrial biodiversity (e.g. earthworms) and possibly reduced water quality (e.g. salt, sediments) and aquatic biodiversity. Subsoil acidification could increase significantly and be increasingly difficult to economically ameliorate. Acid soils can also alter the solubility of some soil nutrients, making these subject to leaching.	The simple technology of liming has been shown to provide a quite positive benefit-cost ratio for crop production systems. Treating acidification in the top layer of soil is through the application of carbonate (lime or dolomite). Adoption of liming soils has increased over the past 10 years in some areas (in particular the western region), and higher levels of adoption could be possible in both the western and southern regions, though liming is a cost on production that is often cut in drought or difficult years.
Soil sodicity	The complex interactions with soil water processes mean that sodicity needs to be viewed together with other soil issues such as plant water use and waterlogging, nutrient use and dryland salinity, all of which can result in degraded water quality in waterways.	Approximately 2.3 million ha of land used for crops has crop yield affected by sodicity. The incidence of grain farms reporting significant soil degradation in 1998-99 due to sodicity is higher in the northern regions than in the southern or western regions.	Sodicity leads to degradation of soil structure and makes soils more prone to sheet, gully and tunnel erosion processes, reduces water uptake by plants so that more water can be lost due to surface and lateral water movements, and increases water runoff taking increased amounts of clay particles, salt, nutrients and chemicals, all of which depress water quality. If soils are untreated the environmental impacts will rise as sodicity worsens. The impact of climate change and a more variable climate with its associated longer periods of drought and increased frequency of heavy rainfall events will tend to worsen the erosional processes associated with sodicity.	Application to surface soils of gypsum and other materials rich in calcium is a simple technology and can increase yields of crops. Many sodic soils in cropping areas have not been treated because of the cost of gypsum, particularly for treating subsoil sodicity. Other management practices such as retaining ground cover, minimal tillage, controlled traffic, precision agriculture, and developing buffer strips near waterways will contribute to lower environmental impacts. Other options include: use of aids for land managers to recognise waterlogged, saline and sodic soils to enable appropriate practices, inputs and land use options; increase use of management practices such as reduced tillage, maintaining ground cover, and strategic crop rotations to improve soil stability; increase soil organic matter to improve soil structure or to modify the exchangeable sodium percentage. Current investments assist growers to identify and ameliorate sodicity and other soil constraints.

TABLE 4 WATER ISSUES These include all issues that affect, and impact on, water and encompass water quantity and quality for cropping and water contamination. Water use efficiency remains a major measurement of value

	Scope	Scale	Impacts (current and potential)	Capacity of industry to mitigate effects
Water quantity – dryland water use efficiency (WUE)	WUE is defined as the ratio of actual crop yield to the potential water-limited grain yield expressed as a percentage	Low WUE can be associated with poor soil water storage, surface runoff and deep drainage with associated environmental impacts. WUE varies around Australia, but has generally doubled in the past 20 years.	Low levels of WUE can not only reduce crop yields but also increase runoff and deep drainage with increased levels of sediment, chemicals, salt and nutrients exported to waterways. Less than optimal WUE will limit yields in many cropping systems and lead to loss of water from runoff and deep drainage and so continue to have environmental impacts. These threats may be more difficult to manage with climate change.	The industry has a capacity to deal with the environmental impacts if it can store and use more water by the crop. Technologies are available to achieve this and many of these practices are currently being used. A number of opportunities are available to the industry including: improve transpiration efficiency via plant breeding; increase soil water infiltration and storage; increase water uptake in the subsoil (e.g. lucerne and other rotations); raised bed farming to prevent waterlogging and ameliorate soil constraints to facilitate water uptake. A range of GRDC projects has addressed or is addressing subsoil constraints to crop yields, impact of tillage and crop frequencies, stubble management and better decisions for managing water with implications for water runoff and drainage.
Water quantity – irrigation WUE	WUE in irrigated grain crops is important so they can compete with other irrigation water uses under an increasing water scarcity scenario.	Irrigated grain crops (excluding rice) were grown on some 347,000 hectares in 2005-06, mostly in the Murray Darling Basin in southern NSW. This was approximately 17% of total crop area.	Environmental impacts include flow reduction in waterways from irrigation extraction, water applications exacerbating natural waterlogging of soils (with or without salinity), and increased water quality degradation of waterways and groundwater The potential impact could be greater than currently if irrigated grain production increases significantly, due to the high level of chemicals and fertilisers used in irrigated cropping. Irrigated grain crops show about half the water use of other irrigated crops per ha.	The technology to increase WUE is similar to those strategies for dryland crops, however a major constraint to both profitability and environmental management is the uncertainty of availability of water. This lowers the incentive to adopt some best management practices particularly those related to rotations and optimal input mixes. Opportunities for the irrigated sector include breeding more water efficient varieties, adoption of objective irrigation scheduling methods, opportunity cropping, and risk management approaches to the quantity and timing of irrigation water applications for producing grain under variable irrigation water availabilities. The GRDC is a partner in the National Program for Sustainable Irrigation (NPSI), which aims to improve water use efficiency on irrigation properties.
Water quality – chemical loss	Water quality can be impacted by chemical runoff from grain production. This is affected by the amount of chemical used on farms and strategies used to avoid runoff or drift of chemicals.	Chemicals are used in grain producing systems. The average annual cost of chemicals for grain specialists for the three years 2004-05 to 2006-07 was $50,000 per farm.	Chemicals can have significant environmental impacts on water quality, biodiversity, non-targeted plants and human health and safety. There is limited information available on the presence of chemicals used in the grains industry in waterways. The potential impact on water quality with respect to chemicals is dependent on the future level of chemical use and the adoption of practices that reduce chemical use and limit the transport of chemicals off-farm. It is likely that much loss of chemical from farms is in association with soil loss.	There are a number of management strategies available for minimising the impacts of chemicals on water quality, though integrated pest management (IPM) strategies and practices are key. There is the opportunity for the grains industry to continue to promote the adoption of IPM and best management practices in terms of chemical application and storage. There is also the opportunity to measure and monitor the impact that chemical use on farms is having on water quality, in order to assess the size of this issue relative to other water quality issues.
Water quality – salinity	Much of the salinity in waterways emanates from both dryland and irrigated farms by surface water flows, subsurface seepage or direct groundwater flows into rivers and streams. This has implications for land, vegetation and the community.	The major water quality impacts from salinity are in the South West of Western Australia and in the lower Murray Darling Basin in NSW, Victoria, and South Australia.	Salinised rivers and streams have serious impacts on the downstream environment. Impacts include: salinisation of wetlands, loss of original vegetation and waterbird populations; saline water is unsuitable for irrigation or is used in conjunction with fresh water; and water for industrial and domestic purposes (river water and groundwater) often requires increased water treatment. Salt affected land directly drives the extent of water salinity and the area of saline land is expected to increase over the next 20 to 50 years. The influence of climate change on salinity and water quality is uncertain.	To deal with the issue of water salinity is to deal with soil salinity on an individual farm basis and on a catchment basis. Localised profitable management options are more likely to be available than widespread amelioration of salinisation processes. The principal capacity of the industry to deal with the water quality issue is through participation in catchment management authorities or NRM regional groups. Grain growers are adopting land management practices that can address the soil-salinity issue as well as reduce the amount of salt entering waterways. There are opportunities for improved planning of deep drainage at community level that takes into account environmental impacts. There are examples where community actions (e.g. groundwater pumping, surface water diversion, land management changes) directed at the protection of valuable assets such as irrigation water and town water supplies have been successful.

TABLE 5 NUTRIENT ISSUES The major nutrients used in grain production – phosphorus and nitrogen – can cause environmental problems when application rates do not match crop needs. Both can have detrimental effects on waterways, and nitrogen can contribute to greenhouse gas emissions

	Scope	Scale	Impacts (current and potential)	Capacity of industry to mitigate effects
Nutrient management	Major nutrients (nitrogen (N) and phosphorus (P)) lost from farms can end up in waterways and increase the risk of eutrophication with water quality impacts leading to biodiversity loss and increased algal blooms. Fertiliser use poorly managed to crop needs leads to excess or deficits of nutrients with potential effects on other organisms and greenhouse gas production.	Nitrogenous fertiliser use had increased 2.5 times in the 10 years to 2001, with most applied to crops. Despite farm-gate nutrient balance for major nutrients being generally neutral, there are some areas of highly negative and positive balances, resulting in nutrient run down, enrichment of waterbodies, or greenhouse gas emissions.	Nutrients were a major water quality issue for 43 of 70 river basins assessed by the Australian Water Resources Assessment (2000). Export of nutrients from grain production is only one source of increased nutrient loads in waterways. Limited data suggests there has been a slight increase in the incidence of algal blooms. Expansion and intensification of the grains industry could lead to greater fertiliser use and hence nutrient export. However, the efficiency of fertiliser use has increased and has provided higher yields, better protein levels, cost savings for fertiliser and minimised the amount of N and P available for movement to waterways. In addition, best practices are available for reducing nutrient export to waterways such as contour banks, strip farming and buffer zones. The contribution of grain farming to nutrient exports should be viewed in a whole-of-catchment context. Poorly matched nitrogen application to crop needs can result in liberation of nitrous oxide, a potent greenhouse gas.	The grains industry is only one of many sources of nutrients in waterways. The GRDC-funded Nutrient Management Initiative is designed to improve adoption by grain growers of nutrient management practices that increase crop yields and quality, while reducing potentially adverse environmental effects of fertiliser nutrients. There is the opportunity for the grains sector to continue to adopt soil management practices that minimise the export of nutrients to waterways and deficits or surpluses of nutrients over crop requirements. Attention should be given to fertiliser amounts, application practices and timing coupled with soil testing to determine requirements. Management of riparian zones on-farm provides an opportunity to reduce the export of nutrients to waterways and to assist with reducing stream bank erosion. Working with regional and catchment groups to monitor and manage nutrients in waterways on a whole of catchment basis provides another opportunity.

TABLE 6 BIOLOGY / BIODIVERSITY ISSUES This includes aspects of crop and farm management that have impacts on general biology and biodiversity on grain farms

	Scope	Scale	Impacts (current and potential)	Capacity of industry to mitigate effects
Biodiversity – terrestrial	Includes native flora and fauna, the impact of the grains industry, and activities to minimise impact.	Approximately 13% of Australia has been cleared; 3% of Australia is under grain production. All NRM areas of the grains industry have at least one terrestrial species or ecological community 'Under Threat'.	Five bioregions have < 30% native vegetation remaining, and an additional 22 bioregions have between 30% and 70% of native vegetation remaining. Habitat loss and increased fragmentation have also led to a decline in the health of associated fauna. Very little land is now cleared for cropping due to legislative and regulatory controls. However, the fractured nature of remnant native vegetation in grain-growing areas provides a challenge for maintaining biodiversity.	Can be limited due to nature of cropping. However, some increased capacity is possible with non-cropped areas on-farm and protection of remnants; landscape and catchment scales should be considered. Precision agriculture (PA) can identify the most appropriate areas for retirement from grain production. Opportunity to adopt practices including alley farming, windbreaks, agroforestry, PA, riparian zone management, and taking advantage of market-based or government incentives. Some states have introduced offset arrangements whereby development of a portion of the farm landscape can be offset by protection of other high value (biodiverse) portions of the farm landscape (e.g. biobanking). Many aspects of improved farming systems can include biodiversity conservation, including: prevention of soil erosion; greenhouse gas reduction; improved water quality; reduced salinity; improved visual amenity; integrated pest management. Better soil management and increases in organic matter can assist with below-ground biodiversity. There is an opportunity to repackage best management information specifically for grain growers.
Biodiversity – freshwater and marine	The impact of the grains industry on aquatic biodiversity is strongly related to water quantity and quality. The link between the grains industry, waterways and aquatic biodiversity is uncertain but includes: chemicals, sediment, salt, nutrients and pH.	The grains industry has an impact on water quality to varying degrees in different regions. Climate, soil type, landscapes and on-farm management practices all influence the degree of impact.	Several river basins have major and minor excesses for total nitrogen, phosphorus. salinity, turbidity and pH. The application of best management practices with respect to soil, water, fertiliser and chemical management should minimise the impact over time. Management of the riparian zone on grain farms will further reduce the impact of the industry on water quality and aquatic biodiversity.	Capacity to deal with the issue relates to the adoption of best management practices in soil management, water use efficiency and use of fertilisers and chemicals. There is capacity for riparian zone management to reduce the possibility of contaminants from grain farms reaching waterways. In many catchments the grains industry is just one of many agricultural or industrial and urban sources of water contaminants that impact on aquatic biodiversity. There is also the opportunity for the grains industry to be involved in monitoring and research initiatives undertaken by other research organisations or catchment and regional groups.
Pests, weeds, diseases	Weeds, vertebrate and invertebrate pests and diseases affect the grains industry. However, control techniques can impact on the environment and biology.	Herbicide use and herbicide resistance are increasing. Grain specialists average 12.3% of their cash costs on crop and pasture chemicals.	Total pesticide use has increased due to increases in crop area and use of minimum tillage. However, adoption of IPM is also increasing. The use of non-chemical forms of control and the possibility of GMOs may involve the use of more benign chemicals and lead to reduced impact in the future.	There is further capacity and continuing opportunity for the industry to continue to adopt IPM and non-chemical means of controlling pests, including biological control options and GMO varieties that are pest resistant, pesticide tolerant, or enable the use of more benign chemicals. Importantly, IPM has a landscape element with the functionality of desirable species transcending property boundaries. These potential benefits need to be further explored.

TABLE 7 CARBON, ATMOSPHERE AND ENERGY-USE ISSUES This is a complex area and includes greenhouse gas emissions and potential sequestration on farms, use of fuel and other energy (e.g. fertiliser) on farms, burning of crop residues, wind erosion and aspects of soil carbon management

	Scope	Scale	Impacts (current and potential)	Capacity of industry to mitigate effects
Climate change – impact on industry	Includes the potential impacts on crop productivity resulting from climate change particularly from changes in rainfall, temperature and in the carbon cycle.	Average surface warming of 1.1˚C to 6.4˚C in the 21st century. Trends in rainfall are less certain and more variable. All grain producing regions will be impacted to varying degrees.	It is likely that there have already been favourable impacts of climate change in increased yields from reduced frosts and increased carbon dioxide levels, and that these will continue. These trends may be suppressed in some regions by more severe droughts. Environmental impacts from climate change are not yet likely to be major. Yield changes are uncertain and determined by interactions of increased CO_2, rainfall and temperature changes, but an overall greater risk of yield trending gradually downwards in most areas over the coming decades. Environmental impacts include an increased erosion risk, particularly in marginal areas, increased impacts from fertiliser losses and from increased herbicide needed for some no-till systems.	The industry has capacity to manage environmental impacts resulting from climate change provided the change is gradual and provided the industry maintains economic viability. Many of the on-farm practice changes required build on well-established industry trends including no-till farming, precision agriculture, more diverse farming systems, water use efficiency gains, improved management of water and nitrogen cycles and balances, and increased use of seasonal climate forecasts. The major opportunity for the industry is to continue existing initiatives and to demonstrate that the industry is a leader in adopting more sustainable production systems within climate change challenges. The contributions being made in economic and environmental benefits can be expanded by further research and developing farming systems that are productive in a changing climate.
Climate variability	Seasonal climate risk faced by Australian grain growers	Covers the three Australian grain regions.	In drought years increased wind and water erosion are likely because ground cover levels are reduced. Wetter years are likely to have increased deep drainage and surface runoff. The potential environmental impact is greater than currently as climate change is likely to be associated with increased extreme weather conditions and higher seasonal variability.	Industry has demonstrated an increasing capacity to manage environmental impacts resulting from climate variability through surface management and sustainable farming practices. There are opportunities to identify win-win situations and strategies and to use seasonal climate forecasts to improve farm-level strategies as well as take into account broader catchment scale issues (e.g. stubble management, nitrogen management and WUE). There is still a need for improved within-season climate forecasts. The use of climate or weather derivatives to help manage the risk of uncertain climate may be an option for grain growers. The GRDC invests in the Managing Climate Variability Program to improve climate forecasting.
Greenhouse gas management	The main greenhouse gases relevant to the grains industry are nitrous oxide and carbon dioxide.	Emissions from soil, mainly nitrous oxide (N_2O), increased by 15% between 1990 and 2005. On-farm fuel use has decreased approximately 50% since 1980, though greenhouse gases are a component of fertiliser and chemical use.	Greenhouse gas emissions are contributing to global warming and climate change. Potential impact is that increased risk of climate change will result in increased cost of energy and emission taxes.	Although the nature of grain production means that emissions cannot be eliminated, they can be reduced significantly through soil and fertiliser management that better use these inputs, and reduce fuel use, plus enhanced soil management to reduce emissions from cultivation. Other options include practices that can increase carbon in the soil (no-till, retain residues) or produce renewable fuels from biomass. Information is available on farming practices and systems that reduce non-renewable energy consumption, increase organic matter in the soil and for improved nitrogen management. There is a need to develop means for predicting levels of nitrous oxide from changed practices and inputs used in grain production. There is some evidence that biochar reduces N_2O emissions while improving soil cation exchange – this warrants further investigation.
Atmosphere – smoke and particulates	Smoke from burning stubble can have harmful impacts on human health. Particulates and dust from wind erosion have undesirable impacts on community and soil health.	Contributions the grain industry makes to total emissions of smoke and dust are minor. However there are some areas where stubble is still burnt from time to time.	Atmospheric particle concentrations affect human health (e.g. asthma and other respiratory symptoms). In some areas smoke levels have been recorded that exceed guidelines (e.g. southern NSW). Factors that will alter potential impacts from smoke pollution and dust from wind erosion are a reduction in stubble burning and increased adoption of no-till.	The response by industry should be acknowledgement, and that there are now major programs to retain stubble for environmental benefits additional to improved air quality. Smoke and dust pollution is best addressed by adoption of those practices that remove the source – no-till and retention of crop stubbles.

STRATEGY 1
Develop innovative solutions that are profitable, productive and sustainable to challenging circumstances

- Periodically review the risks to industry and growers as a guide to their future needs for management information.
- Make production efficiency (and its measurement) a hallmark of Australian grain production through excellence in breeding and management.
- Develop and promote sustainable production systems (and the means to monitor them).
- Understand and communicate the interactions between farming systems, property management and the wider environment.
- Ensure business solutions are available for growers and the industry, incorporating responsiveness to changing circumstances and dealing with current and emerging risks, particularly climatic risk. ■

FARM MANAGEMENT SOLUTIONS FOR PRODUCTION AND SUSTAINABILITY

The preceding analysis highlights the role that farming practices and grain production systems can play in mitigating environmental effects while remaining productive and profitable. A strong message coming out of the stakeholder consultation workshops was that it is not just about the issues, it is about the practices grain growers are using to address the issues. A focus on the practices rather than the issues means that new solutions are sought for production and sustainability.

Throughout this Plan a recurring observation is the combination of benefits from many farming practices on both grain production and the environment. This is a feature of importance in the grains industry, and has driven the ready adoption of many farming practices and their integration into farming systems used in Australia.

Where a new technology or new practice brings increased productivity, adoption is rapid especially where cost:benefit is easily identified. However, growers also identify the environmental benefits of many of these practices, the soil benefits from adoption of no-till being a striking example. Growers value such duality of benefits since these contribute to their desire to be productive and environmentally sustainable in the longer term.

The use of ‘best’ or desirable practices in any organisation (or industry) is in keeping with International Standards, notably ISO 14001, the International Standard for Environmental Management, which encourages the implementation of the best available techniques where they are appropriate, economically viable and cost effective.

As such, a focus on encouraging the adoption of those

EXAMPLE 1: NO-TILL FARMING

A review of more than 35 years of data collected by the Queensland Department of Natural Resources and Water on the impact of cropping on water and nutrient runoff from Queensland cropping systems has confirmed that no-till farming has significant yield and environmental benefits. However, some soil types better suit no-till than others.

This data is from a 17-year catchment study conducted near Wallumbilla, completed in 2000, and from a current two-year study near Theodore, comparing hydrology and water quality when Brigalow scrub is cleared and pasture or crops sown.

There is more water runoff from land that has been cleared and cropped, compared with wooded areas. However, the adoption of no-till farming has been shown to cut nutrients and soil lost in runoff by 90 per cent compared with tilled systems. This means the quality of the water moving downstream through the catchment is significantly cleaner. In addition, there is a 10 per cent average increase in yields associated with reduced-tillage farming systems, with much greater responses in drier seasons.

These results are supported by data from 12 trials covering 150 site years. ■

farming practices that are productive and environmentally beneficial has become a preferred means for building sustainability into the grains industry.

In the future, new regulations or market forces may demand evidence of environmental performance resulting from the adoption of sustainable farming practices. Developing means to readily measure soil parameters and carbon sequestration may be as important as monitoring water use efficiency. Australia is well placed to develop such tools and establish international standards.

Soil erosion, structure, organic matter and tillage

Until the mid-1970s it was common practice to prepare cropping paddocks by aggressive cultivation. These practices were considered useful to assist rainfall infiltration and aeration, store soil water, raise nutrient levels, control weeds and diseases, and prepare the seedbed prior to sowing. In winter rainfall areas, ley pastures would typically be terminated in the late winter or spring of the year prior to cropping by use of tillage.

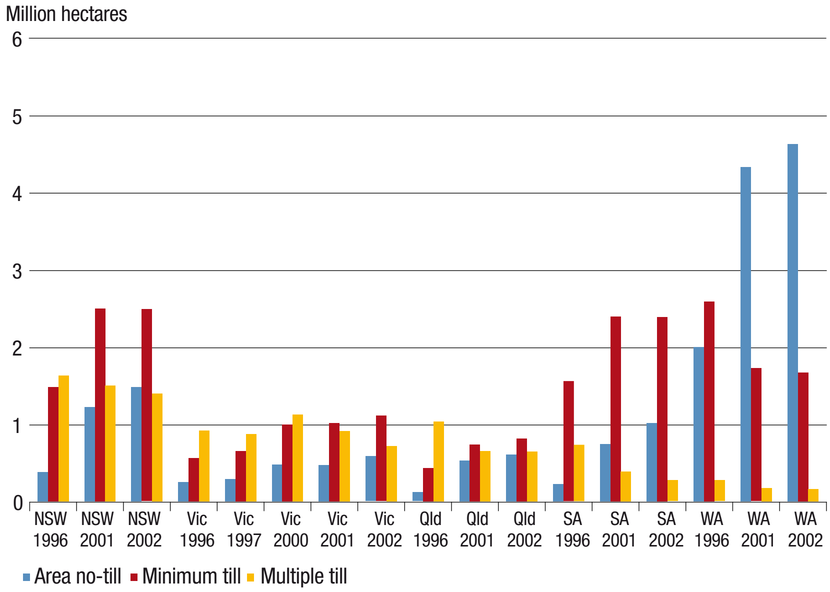
Previous crop stubble would be burnt or cultivated immediately after harvest in summer cropping areas, while in winter rainfall areas this stubble would be burnt or cultivated in the autumn, after livestock grazing through the summer.

This tillage-based, 'conventional' approach was inherently unstable because of soil structure degradation, increased soil erosion, reduced organic matter and high energy consumption. The effects of this system on soil erosion could be dramatic, with massive erosion events occurring in some areas, for example in the Mallee soils of Victoria and South Australia.

Despite the valuable efforts of state soil-conservation services, and the ability of a ley pasture to assist with providing some soil cover, soil erosion rates were considered unacceptable.

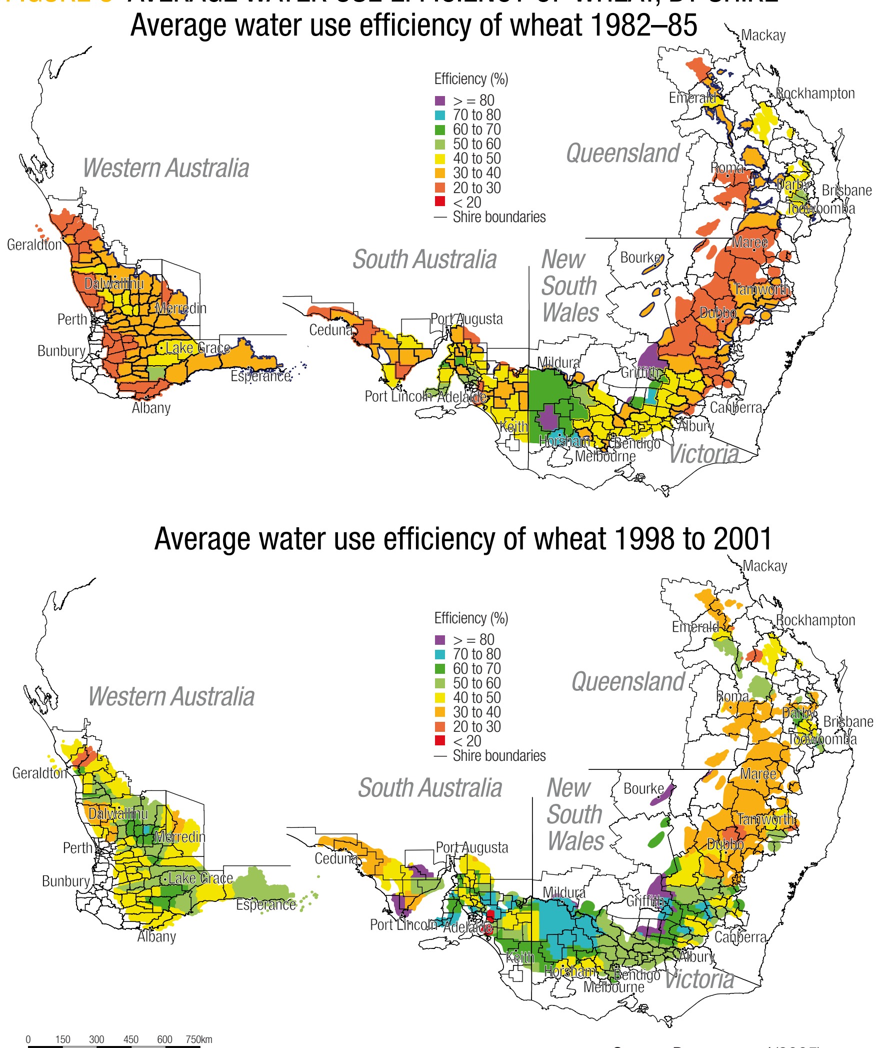
Effects from soil structural decline include surface crusting – where bare soil is exposed to rainfall following cultivation – and hard-setting and compacted layers at the depth of cultivation. These lead to reduced water infiltration and porosity, reducing the amount of soil water available, and plants' access to soil water.

FIGURE 7 ADOPTION OF NO-TILL IN AUSTRALIA – TILLAGE TRENDS 1996 TO 2002



Source: Derived from ABS data

FIGURE 8 AVERAGE WATER USE EFFICIENCY OF WHEAT, BY SHIRE



Source: Beeston *et al* (2005)

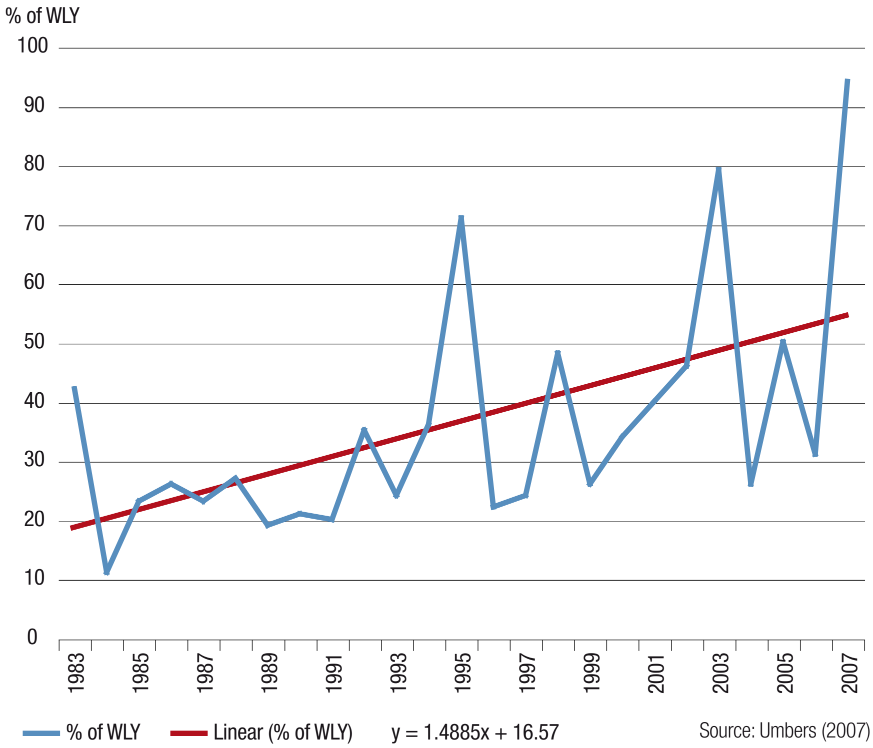
Developments in farming systems since the early 1970s have greatly reversed the trends in soil degradation. The practices of reduced and minimum-till and, increasingly, the use of no-till and crop residue retention when establishing crops have demonstrably improved soil structure, water-holding capacity, infiltration, porosity, organic matter and many other factors. The most obvious result has been a dramatic reduction in soil erosion.

Soil protection by retaining crop stubbles increases soil cover and reduces soil susceptibility to erosion by minimising exposure to wind and water. Combining the effects of no-till with the retention of crop residues dramatically reduces soil losses from erosion, while increasing production and reducing risk.

Adoption levels of no-till around Australia vary, but are as high as 85 per cent of cropped hectares in Western Australia (Figure 7).

More recent developments, where planting is carried out using disc

FIGURE 9 PERCENTAGE OF WATER-LIMITED YIELD FOR WHEAT, 1982 TO 2006



Source: Umbers (2007)

EXAMPLE 2: INTEGRATING PERENNIALS INTO CROPPING SYSTEMS

The GRDC has been a major investor in research to understand and quantify the causes of, and potential solutions to, dryland salinity. A significant component of this work has been done through a partnership with the Cooperative Research Centre for Plant-based Management of Dryland Salinity (Salinity CRC).

Lucerne is a unique perennial legume in terms of its scale of application, flexibility and pattern of regional use in farming systems. A major feature of lucerne is its capacity to contribute to the management of dryland salinity. This capacity derives from the ability of lucerne's deep roots to use a high proportion of rainfall and the ability of the plant to respond to rainfall occurring outside the winter growing period. Lucerne is currently grown across 3.2 million hectares, largely in the wheatbelt. A further 27 million hectares across the Australian landscape has potential for lucerne.

Work by the Salinity CRC (now the Future Farm Industries CRC) and others has shown that if lucerne is to be integrated successfully in cropping systems growers will need to:

- maximise the use of the lucerne pasture phase and the benefits to livestock enterprises;
- optimise the positive benefits flowing from the pasture phase to the subsequent crop;
- manage the potential costs and impacts of lucerne on following crops; and
- manage additional workload and lifestyle preferences.

By optimising the use of water to grow crops and using pastures such as lucerne to use water that moves past the root zone of crops, growers are developing integrated solutions to dryland salinity. ■

openers, the use of GPS-based guidance systems and inter-row planting, further drive the soil benefits from no-till systems.

Water, salinity and farming systems

Grain production in Australia is limited in most years by rainfall, with droughts a constant concern. Strategies to maximise the amount of (rain) water available are:

- gathering and storing more in soils – this is by the use of stubble retention, no-till and herbicide commenced and maintained fallows;
- growing crops with reduced evaporative losses from the soil surface;
- growing crops with reduced competition and water use by weeds; and
- assisting crops to access more rainwater from deeper in the soil.

The general aim is to increase water use efficiency (WUE – defined here as the ratio of actual crop yield to the potential water-limited grain yield expressed as a percentage), a measurement that can now be quantified and used to compare the management of different crops.

Cultivation-based fallowing has been replaced as a desirable practice by the use of herbicides for fallow maintenance in no-till systems, enabling moisture to be stored, while eliminating the shortfalls of cultivation, and retaining soil cover.

Better farming practices provide a high WUE, by assisting crops to access more soil water (through deeper and more vigorous roots), allowing more vigorous early growth (hence reducing evaporative losses from the soil surface), and by controlling weeds and diseases so that more of the available water is used by the crop.

Water efficient crops using more total water can lead to a reduction in deep drainage of water beyond the root zone, where it can interact with saline groundwater and re-emerge elsewhere in the landscape, thus contributing to salinisation.

Crops with shallow root systems usually cannot use all the available soil water. Shallow rooting can be due to root diseases, subsoils that are either compacted or chemically hostile, and low vigour in the plants.

Practices that manage root diseases, subsoil constraints and weeds allow crops to access more of the soil water. Other management factors contribute to higher WUE, including timeliness of planting, evenness of establishment, timing of weed control, and better matching nutrient supply with crop demand and crop rotation.

No-till systems assist water-holding capacity by improving soil structure, organic matter and lessening water runoff. They also assist root penetration by improving soil structure and facilitate soil stability by leaving old root systems in place. Establishment of new crops is thereby enhanced.

One result from the adoption of modern systems of crop production has been an increase in crops' ability to make efficient use of the water available. Figure 9 shows these data, based on wheat yield and rainfall on a national basis (derived from Australian Bureau of Agricultural and Resource Economics (ABARE), ABS and Bureau of Meteorology (BoM) data).

The data shows an increase in WUE through the period from the early 1990s as compared with the previous decade.

Soil carbon and the farming practices of today

Soil organic matter is important in maintaining soil structure, as a source of nutrients for plants and micro-organisms, and as a source or sink for atmospheric carbon.

EXAMPLE 3: BREEDING TO CONTROL CEREAL RUST

Compared with European or North American cereal prvoduction, Australian cereals are grown with fewer chemical inputs. The Australian grains industry from its earliest days has had a commitment to breeding for disease and pest tolerance rather than relying on chemical solutions for control.

For example, since 2003 stripe rust infections are estimated to have cost growers between $40 million and $90 million a year in fungicides alone. If rust-resistant varieties were not available, more fungicides would have been used by the industry where it was economic to do so.

Many fungicides do not persist in the environment and have low toxicity to mammals and birds, but their toxicity to aquatic organisms varies with the chemical and the organism.

As the use of disease-resistant cultivars removes the need to control volunteer wheat plants during summer, there is the added benefit to the environment of reduced summer cultivation, with improved soil moisture storage, reduced erosion and less export of contaminants to waterways. ■

Losses of organic matter in soils are the result of poor cropping practices through increased in situ losses and soil erosion.

Tillage mineralises organic matter, increases microbial activity by soil mixing and disturbance, and exposes organic matter otherwise protected by the soil matrix to the biosphere.

Systems of crop production that enhance soil carbon or slow the rate of decline are desirable. No-till systems can do this especially when combined with other practices, such as cover crops, minimising summer fallows and growing high-residue crops. The use of ley pastures in a mixed-farming system can also provide significant inputs of carbon to the soil.

Tillage effects on soil carbon stores are not uniform, though no-till systems either reduce losses of soil carbon, or provide increases in soil carbon. No-till alone may not be the sole influence on soil carbon in a cropping system, but can play an important role, along with other management practices.

Burning of crop residues depletes inputs of organic matter into soil. Stubble burning is now far less common or, where used at all, loss of soil organic carbon is minimised by delaying burning until late summer/early autumn and by practicing an incomplete burn.

Although the quantities of carbon involved may be unclear, under regimes of higher biomass production, in higher-rainfall environments, carbon will more likely be added to soil where no-tillage is practised and stubbles retained. Grain growers in these environments using such systems may be well placed to sequester carbon in their soils, with resulting increased soil properties, production and environmental outcomes.

Breeding for resistance: part of the system

Australia continues to breed crop plants with a strong consideration for disease resistance. Varieties with such innate resistances to fungal diseases are highly valuable to growers and the environment, since they remove the need for fungicide use for disease control.

By continuing to seek genetic means for managing diseases the industry will continue to provide environmental benefits by reducing the need for chemical fungicides for these crops.

EXAMPLE 4: MANAGING NITROGEN FERTILISERS

Nitrous oxide emissions are the major greenhouse gas emissions from the cropping industries. A major way to control these emissions is through the efficient use of fertiliser. Life cycle analysis (a means of assessing the total environmental profile of a final product, for example, the total environmental effects of producing a loaf of bread) suggests that the overall CO_2 equivalent balance for cropping systems is very dependent on efficient nitrogen use.

Delaying fertiliser application until spring when the seasonal forecast is more predictable and potential yields are more certain is one way to improve efficiency. 'Green seeker' technology can assist this by making use of leaf reflectance as an indicator of leaf nitrogen levels, enabling growers to better match nitrogen supply to demand in the crop and reduce nitrogen losses. ■

Soil nutrients and farming systems

The use of crop rotations (including pulse and oilseed crops), legume-based pastures and more careful use and budgeting of fertiliser applications have impacts on soil nutrients and their availability.

Fertilisers are expensive inputs for grain growers, so agronomic practices that can increase the efficiency of plant use of these are valuable, and enhance the profitability of fertiliser use. Nitrogen fertiliser also brings potential environmental risks, including soil acidification, groundwater accessions of nitrate, runoff in soil and potential pollution and eutrophication of water bodies. Reducing nutrient loss reduces the risks to the environment from farming.

Improved fertiliser management saves growers money on unnecessary fertiliser and minimises the amount of nitrogen (and phosphorus) available for detrimental effects in the environment, for example via leaching or movement to waterways. Recommended practices include:

- soil testing to depth;
- banding of fertiliser slightly away from seed at planting;

- budgeting of fertiliser needs;
- the application of additional fertilisers through a crop's life rather than all at planting, especially using plant or soil testing to determine level of need; and
- precision farming technology that meters fertiliser application according to yield history (yield mapping).

Precision agriculture: integration of the system for environmental benefit

Precision agriculture is a term covering a wide selection of practices using modern technology to assist with crop production. It can include:

- controlled-traffic systems;
- GPS guidance;
- autosteer (GPS system);
- inter-row or on-row planting;
- remote sensing (for example, EM38 surveys);
- yield mapping;
- variable rate fertiliser application;
- weed-sensing systems with variable rate and on/off herbicide application; and
- 'greenness' sensing to assist with nutrient application and growth regulator application.

Such systems already commonly use no-till and retention of crop stubbles, integration of comprehensive soil testing and weed mapping regimes, knowledge of subsoil constraints and other inputs.

Precision agriculture has the potential to bring substantial environmental benefits:

- if controlled traffic is used, wheel tracks are completely confined to only small areas of soil, reducing overall compaction, lowering fuel use and reducing erosion;
- no overlapping or missed strips, meaning less excess fertiliser or pesticide is applied, and nutrients are applied only as needed, in quantities required and at times of optimum efficiency, leading to less runoff or leaching;
- herbicides/pesticides are only applied to plants or areas needed, meaning less runoff, lower energy use and lower impact on biology; and
- poorer or less productive soils are not cropped, making more areas available for biodiversity plantings, trees or specialised pastures to manage water tables and deep drainage, and improving whole-farm WUE.

Overall, precision agriculture systems result in fewer, more targeted inputs, better matching of crop and soil capability and provide opportunity to reduce energy use and greenhouse gas emissions.

EXAMPLE 5: PRECISION AGRICULTURE

Over the past decade there has been a rapid expansion in technologies that give growers easier access to a wider range of spatial data on the state of their crops and soils:

- vehicle guidance has reduced overlap in spraying and the spreading of agricultural chemicals and fertilisers – growers are finding that paddocks are often effectively about 10 per cent smaller, with reduced chemical and fertiliser use and cost savings;
- accurate vehicle positioning to enable controlled traffic or tramlining, resulting in less damage to soils through compaction and improved crop growth;
- use of biomass maps, electromagnetic induction survey or other imagery to locate problem areas for further on-ground investigation; and
- variable rate technology (VRT) for application of agricultural chemicals, especially fertiliser, and 'weed seeker' technology to reduce total chemical use.

Many of these benefits are economic – but clearly less use of inputs has environmental benefits, with less potential for loss into surface and groundwater. ■

Managing biodiversity

Prosperity is a common objective of the grains industry. Prosperity is more than profit. It includes the provision of an enjoyable, productive lifestyle, effective stewardship of the farms' natural resources and establishment of an industry that fits comfortably in the landscape.

How grain growing integrates with remnant vegetation, planted native vegetation and biodiversity outcomes for individuals and communities needs to be dealt with professionally. How the industry deals with these issues will have a major impact on community perceptions of the industry.

There is a lot of information now available on how to manage remnant vegetation and revegetation for maximum biodiversity benefit.

There are opportunities to package this information in a way that is highly relevant to grain growers. Individuals in the industry can learn to value remnant and planted native vegetation more highly by developing an understanding of the economic benefits of IPM and understanding the intrinsic worth of biodiversity on an individual farm and across a landscape.

Conclusions

The Australian grains industry has a good understanding of the environmental risks to, and from, farming; and has a record of periodically reviewing them. It seeks high levels of efficiency as a means of addressing many risks and improving profit; as well as adopting strategies to manage risks and improve the condition of the natural resources that drive (and are influenced by) production.

Growers manage systems. They integrate practices into farming systems and fit their farm into the context of its surrounding landscape; dealing with off-farm and on-farm issues together. It is a complex undertaking and grain growers seek assistance in understanding interactions and working through management options to suit their circumstances.

Some efficiencies are easily measured and they, and some practices, result in observable environmental improvements. In other cases environmental gains may be very subtle and long term, or there may be long lag-times before they take effect. There is scope to improve (and become world leaders in) measures of efficiency and resource condition; while also reporting on management practices as a proxy for improvement.

Refer to page 32 Table 11: The Grains Industry Environmental Plan for the sub-strategies for this Strategy 1. ■

EXAMPLE 6: INTEGRATED PEST MANAGEMENT

While the adoption of integrated pest management (IPM) in the cotton industry has reached legendary status, adoption of IPM in the grains industry, especially in summer crops, has also led to reduced chemical use.

Insect pressure on the tropical and subtropical coast of eastern Australia is significant. Threshold models for pod-sucking bugs in mungbeans and peanuts mean that chemicals are only applied when absolutely necessary, resulting in cost savings to growers and reduced chemical use and environmental risk.

Work by the Queensland Department of Primary Industries and Fisheries (QDPI&F), for example, has seen the use of the organophosphate chemical dimethoate slashed, with half rates proving to be just as effective against mirids and much softer on beneficial insects. Reduced rates also mean reduced impacts from accidental off-target use.

An understanding of the ecology of common pests and competing beneficial insects in winter crops is likely to achieve savings in chemical application. These opportunities are currently being reviewed. The understanding of the role of remnant and native vegetation as a harbour for beneficial insects is likely to lead to a higher value being placed on them. ■

STRATEGY 2
Generate knowledge to improve the adoption of sustainable farming systems and management practices

- Develop and promote best management practices and 'management tools' for adoption on-farm.
- Develop innovation pathways to continuously improve the understanding, expertise and capacity of growers and advisers to select and adapt sustainable management practices. ■

EXCELLENCE IN PRODUCTION

Sustainable farming practices: 'win-win' solutions

The description of the various elements of farming practices (for example, precision agriculture applications) shows the range of developments that have flowed from investment in research and development, notably in the past 20 years or so, with much of this funding coming from grain growers themselves.

Many practices serve multiple objectives and are integrated by growers into their own particular farming system. Table 8 describes this effect, whereby the various elements of a farming system are shown to have both multiple and additive benefits.

These practices can also be shown to have production benefits (Table 9), with these being the key drivers for their adoption. Such production benefits are also interrelated with the environmental benefits, and together build to make a sustainable grain production system from both economic and environmental viewpoints.

Modern farming practices are the key to environmental management. Understanding the environmental effects of many farming practices allows the industry to assess its environmental performance by monitoring the levels of adoption of recommended practices.

Creating an on-farm learning environment

Australian grain growers are no different to any other people running a business. They seek to actively improve their business in a self-directed, adult-learning environment. Continuing improvement in an on-farm learning environment was a strong theme to come out of the stakeholder consultation workshops. The GRDC has invested in participatory grower-driven RD&E since 1996. The approach has followed principles of adult learning, where grower groups have driven an action-learning process on issues of local relevance. From time to time these have been issues of environmental relevance. The challenge is to work with growers on environmental issues, but ensure growers own the process. There is no doubt that the process can be facilitated by asking the right questions: What are the environmental issues? How can they be addressed? How can grain be produced with minimum harm to the environment?

The primary purpose of most farm businesses is to make a profit and to create a surplus for meeting lifestyle requirements. Many grain growers also have a strong sense of the inter-generational longevity of their business and the importance of protecting the resource for their children.

A tension exists between the need for industry leadership and self-directed experiential learning and change. A simple triple-bottom-line framework could assist growers in evaluating the economic, social and environmental outcomes of their business (Hassalls 2005). Although this plan has a focus on the environment, individuals need to balance all three elements of their business. The only way this tension can be overcome is through engagement between leaders and regional groups and individuals.

There is no doubt that grain-growing businesses will need to be flexible and adaptable in the future as they respond

TABLE 8 ENVIRONMENTAL EFFECT

Practice	Soil benefits	Water benefits	Nutrient benefits	Energy or carbon benefits	Biology/ biodiversity effect
Reduced or no-tillage	Yes	Yes	Likely	Likely	Likely
Stubble retention	Yes	Yes	Possible	Possible/ likely	Possible
Crop rotation with oilseeds and pulses	Likely	Possible, via disease management	Yes	Possible (organic nitrogen)	Possible
Integrated weed/disease management within crop rotation	n/a	Possible	Possible	Likely	Yes
Nutrient budgeting and soil testing	Likely	Possible via better WUE, reduced off-farm movement	Yes	Yes	Possible
Controlled traffic/ precision cropping	Yes	Possible	Yes	Yes	Possible

to climate change and other impacts on their farm business operating environment. Most current climate models suggest increasing aridity in much of the grain-growing regions. In the low-rainfall zone businesses may respond by growing larger and possibly more diverse crops. In the high-rainfall zone, winter waterlogging will become less of an issue and these regions are likely to become more reliable grain-growing areas. In both zones climate will have an impact on the environment: maintenance of groundcover will become even more important and an increase in cropping in the high-rainfall zone may have impacts on natural resource assets in this region, impacts that will need to be managed.

One factor that may impact on the industry in this context is the steadily declining number of grain-producing farms, their increased average size and decreased numbers of people working on these grain farms. Some data from ABS attest to these trends.

In 2000 there were 40,364 grain-producing properties in Australia, of which 31,448 were wheat growers. In 2005 these had fallen to 38,448 and 27,360 respectively.

Average grain area planted per farm conversely increased over this period as indicated in Table 10.

The increased crop area per farm is likely to have impacts on the ability (time, resources) of property managers to access training and learning of skills and adoption of sustainable practices for their farms.

TABLE 10 AVERAGE AREA OF CROP PER GRAIN FARM IN EACH AGRO-ECOLOGICAL ZONE IN 2000 AND 2005

Agro-Ecological Zone	Area of crop per grain farm 2000	Area of crop per grain farm 2005
NSW central	596	635
NSW/north-east and south-east Queensland	514	559
NSW/north-west and south-west Queensland	955	1007
NSW/Victorian slopes	339	353
Queensland Central	1069	833
SA Mid-north/Lower Yorke and Eyre	509	538
SA/Victoria Bordertown-Wimmera	343	370
SA/Victorian Mallee	767	946
Tasmanian Grain	96	116
Victorian High Rainfall	169	185
WA Central	949	935
WA Eastern	1976	2236
WA Mallee and Sandplain	1078	1341
WA Northern	1828	1878

Source: ABS Agricultural Census 2005-06

Conclusions

Requirements for ongoing change in grain production systems and farm management highlight the need for skilled growers. It is essential that the industry works with partners to ensure growers have access to a range of networks, programs and training in order to continuously improve and adapt to changing circumstances.

Growers will increasingly be challenged to find innovative solutions to complex and variable management problems and they will need to understand the links between practices and outcomes. Helping growers to continuously acquire knowledge and to be skilful in applying it to their situation will need to be a feature of the grains industry if it is to remain a positive force in years to come.

Refer to page 33 Table 11: The Grains Industry Environmental Plan for the sub-strategies for this Strategy 2. ■

TABLE 9 PRODUCTION IMPACT OR EFFECT

Practice	Yield benefits	Disease or pest management benefits	Nutrient benefits	Reduction of risk
Reduced or no-tillage	Yes	Yes	Likely	Yes
Stubble retention	Yes	Yes	Possible	Yes
Crop rotation with oilseeds and pulses	Yes	Yes	Yes	Yes
Integrated weed/disease management within crop rotation	Yes	Yes	Possible	Yes
Nutrient budgeting and soil testing	Yes	Possible	Yes	Yes
Controlled traffic/ precision cropping	Yes	Possible	Yes	Yes

STRATEGY 3
Facilitate the recording, open analysis and reporting of grains industry environmental credentials

- Facilitate the benchmarking of excellence in management among Australian grain growers, through the development and maintenance of a best practices database.
- Provide stakeholders with the information they need to remain confident in the environmental management on Australian grain farms.

INDUSTRY OBLIGATIONS AND BENEFITS

Community interest

Like all forms of economic activity, the grains industry generates benefits to the broader community and some costs. Community interests want to see that production is using natural resources efficiently and not imposing too big an impact on the environment. Unresolved concerns manifest themselves in regulations and restrictions on practice, so it is in the industry's interest to perform well and to ensure its performance is well known.

The grains industry provides broader community benefits than just producing grain. Some of these directly related to how grain growers farm and include:

- reduced tillage systems and increased groundcover that have led to reduced erosion incidence: less sediment to rivers and fewer dust storms;
- less burning of stubble, which has meant improved air quality, better visibility on roadways, and retention of carbon in the paddock;
- precision agriculture technologies that match the use of crop protection chemicals and fertilisers to the potential of the paddock, leading to greater efficiency on-farm and healthier food and catchments; and
- grain growers who manage weeds and feral animals for their own benefit and that of the whole community, thereby reducing their environmental impact.

Regional NRM bodies are setting management action and resource condition targets on the behalf of communities and government. All rural industries will need to factor these targets into future operations and performance.

Efficient, responsible resource use

The GCA's Environmental Policy Principles emphasise the important link between efficient crop production systems and environmental stewardship. More grain produced per mm of rainfall or irrigation water used and per kilojoules of energy used, through fuel and fertiliser, means greater systems efficiency. More efficient use of water and energy means less environmental impact. More efficient varieties and crop management systems mean that an increased proportion of inputs are used rather than lost.

The GRDC seeks 'win-win' opportunities that improve productivity and protect and enhance the resource base. The water and energy efficiency of the industry and specific practices and technologies will be audited to demonstrate the link between efficient production and environmental stewardship. Projects undertaking life cycle assessment of the production of grain products will underpin the energy efficiency studies. The study of Beeston *et al* (2005) examining the water use efficiency of Statistical Local Areas and agro-ecological zones will be repeated as a base measure for the new GRDC's 2007-12 Strategic Research and Development Plan, *Prosperity through Innovation*, and again in the final year of the plan.

The opportunities

Market signals

Although the signals from current Australian markets are weak, there is potential in the future that certain markets will only be accessed if the environmental credentials of the product are demonstrated. This is beginning to emerge for some food commodities, with interest in 'food miles' and 'buy local' campaigns in the UK. 'Food miles' only take into consideration the transport elements of the value chain and do not consider the efficiencies of on-farm production.

Up to four in five grain growers are mixed farmers. It is therefore important that growers incorporate good environmental practices across the whole farm business – grain, meat, wool, cotton etc – and that any 'credentials reporting' caters for mixed commodity production.

Carbon trading

The *Creating Our Future: Agriculture and Food Policy for the Next Generation* Report highlighted the potential emergence of stewardship payments and the development of markets for ecosystem services. Currently, agriculture is excluded from the National Emissions Trading Scheme planned to commence in 2010. The quantum of carbon that agriculture is able to sequester is uncertain. Agriculture's ability to account for and ensure carbon is 'locked up' for the long term is still to be determined. However, discussions are taking place on the participation of 'uncovered' industries in offset trading. Opportunities exist for the inclusion of soil carbon in any offset scheme and agriculture is likely to be eventually involved in contributing to the achievement of any emissions targets set by Australian governments.

Modelling and demonstration of practices likely to increase carbon levels are favoured by the industry, but how this rolls out will rely on good data on carbon fractions and links between practice and soil carbon levels. It is important that soil carbon is considered in the whole life cycle of grain production.

Not only does the sequestration of carbon in agriculture need to be considered, but emissions as well. For example, the use of perennial pastures increases soil carbon stores significantly, but if these pastures are grazed by livestock then methane emissions are increased.

Additionally, the use of a reduced or no-till system in higher-rainfall environments has potential to increase soil carbon, but the emissions from the use of nitrogen fertiliser and fuel have to be balanced against this.

The whole carbon balance needs to be considered, but clearly carbon trading represents an opportunity and not necessarily a threat for the industry.

Demonstrating the credentials

There is a range of environmental issues facing, and impacted by, the operations of the Australian grains industry via the farming practices and systems that growers adopt. Many practices can be demonstrated to have multiple, interacting and synergistic effects.

The industry operates across approximately 27 catchments (NRM regions) in Australia. These have all developed catchment resource condition targets that describe many environmental factors common to those outlined in this plan. Grain farms in the catchments can have direct or indirect effects on these environmental resources, and it is of major interest to these catchment bodies how the industry operates to address these issues. A natural partnership exists between grain growers and NRM bodies in wanting to assess progress and effects on catchment condition from the use of those practices able to have such effects.

The industry considers that to measure or assess its environmental effects requires a realistic, useful and scientifically valid approach. By identifying those farming practices that have positive or negative environmental impacts and measuring the adoption levels of these practices across the country, the industry can use these data as surrogates or pseudonyms for estimating environmental effects. Where feasible and available, direct impact measurement of environmental effects will also be used to validate the effects from farming practice adoption. However, impacts on resource condition play out over decades, not years.

The industry has examined several methods for measuring the adoption of those farming practices of interest, including the use of government agencies such as the Australian Bureau of Statistics (ABS) and the Australian Bureau of Agricultural and Resource Economics (ABARE), which undertake national censuses and surveys.

In addition many industry, project or region level surveys of one type or other occur around the industry in an ad hoc manner for various reasons.

Many of these activities (but not all) gather some information about what practices growers are using. The information collected may be attitudinal (about growers' intentions) or qualitative (number of farms adopting a practice). However, little quantitative data is collected on the number of hectares on which a certain practice is used.

ABS and ABARE have limited abilities to gather the detailed farming practice-based information of value for environmental effect assessment, though the data collected by them have considerable value for setting baseline levels, or for validating other surveys.

Other means of assessing the farming practices of interest include remote sensing, for example, for assessing ground cover or vegetation levels. However, these cannot, for example, measure the detail of a certain tillage practice or levels of nutrients applied, or water-use efficiency.

There is, in reality, only one valid source of data about the farming practices of interest for sustainability and environmental management – the growers themselves. Only they know the detail and can describe the scale and scope of the practices used on their properties.

For these reasons the industry sees wide value in a system of gathering data directly from growers about the farming practices in use on grain and mixed farms across Australia.

To this end, a national Farming Practices Database and reporting system has been developed allowing growers to electronically enter quantitative data about the farming practices in use on their farms. This system has many features:

- it allows rapid data gathering by using growers' email systems;
- it contains baseline and benchmark data for comparative use;
- it can regionally 'know' about the best or desirable practices in use;
- it can partner with many groups or NRM bodies to ensure relevance and reporting of value;
- it returns back to growers a report on their individual environmental effects, and shows comparisons between one farm and its peers in a region, shire or catchment;
- it is able to operate at very low cost by using electronic and automated processes;
- it gives growers productivity and environmental data and comparisons against others and against accepted benchmarks; and
- it can transform basic data about certain farming practices into environmental indicators and use 'environmental language' in reporting.

The national Farming Practices Database can be accessed at www.farmingpractices.com.au, where a PDF dataform is available, or where farm data can be directly entered.

Data is amalgamated at catchment, region, state or national scale for use in many reporting functions. Environmental assessment and progress reports are available for a small area (for example, a shire or catchment), or at national levels, and also productivity and other important industry information can be provided. Amalgamated results are calculated in real time on receipt of this data, thus allowing reporting on these impacts to be available promptly.

The database allows a range of calculations and environmental assessments, including linkages with other systems, for example calculations of a farm or regional greenhouse gas profile, water use efficiency or nutrient balances.

This provides an important farmer-based tool for the industry to measure the level of adoption of practices that are of greatest interest in environmental effect. It is a national tool available for all industry uses where data about farming practices and production is needed.

Setting some targets

With all systems aiming to provide environmental benefits, targets should be set. To achieve optimum levels of adoption of desirable farming practices, the industry can develop targets or benchmarks to enable progress to be evaluated.

ABS and ABARE data (for example from the agricultural census of 2001) are used for setting baseline levels, and the levels of adoption by the leading growers in a region form benchmarks. In so doing, continually improving ‘targets’ are present such that, as a desirable practice becomes more widely adopted, the ‘benchmark’ rises automatically.

In addition, by working in close partnership with scientists, farming systems projects and NRM bodies in the various regions of Australia, regionally specific and valid best practices can be identified, and appropriate benchmarks set for these regions.

Each farmer who enters data receives an individual report showing how their farm operation and practices compare with the appropriate benchmarks for their shire or wider region, and what progress has been achieved over successive periods of measurement.

The use of this national system will demonstrate the grains industry’s environmental credentials and its progress in achieving improved environmental management. The system can be used to reach the industry’s customers, government, the broader community and industry participants themselves.

Conclusions

Industries have obligations, as well as self-interest, to be environmentally sustainable and it is to their advantage to let consumers and communities know of their good performance. For the Australian grains industry, there is scope for increased measurement and reporting of their efficiency and resource impact (consistent with resource condition targets) but ready information can also come from monitoring and reporting the adoption of sustainable management practices (management action targets).

The industry, with support from the Australian Government, has developed a means for growers to record their management practices. This allows growers to benchmark themselves against peers and to assess their performance, as well as providing information to communities, governments and various NRM programs.

Refer to page 34 Table 11: The Grains Industry Environmental Plan for the sub-strategies for this Strategy 3. ■

STRATEGY 4
Develop capacity, strong relationships and clear trusted communication to deliver environmental leadership

Develop highly capable individuals and organisations, strong relationships with partners and promote clear, trusted communication.

- Commit to strategic action through the implementation of the grains industry Environmental Plan.
- Foster industry development through the development of industry leaders.
- Proactively develop and negotiate policies consistent with a sustainable Australian grains industry.
- Build and maintain trusted partnerships with key stakeholders, such as the new regionalNRM bodies.
- Make open and clear communication a feature of all relationships.

A PROFESSONAL, DYNAMIC INDUSTRY

Communication

The process of assessing and adapting to risks, reviewing community benefit and seeking greater production efficiencies needs to be communicated to growers, agribusiness, government and the community.

Growers can be reached through a number of industry pathways including agribusiness, grower groups, government partners and the media.

A demonstration of the industry's environmental credentials needs to reach the industry's customers, government, the broader community and industry participants themselves.

Key activities will include a special issue insert on the Environmental Plan in the GRDC newspaper *Ground Cover*, and inclusion of key environmental management projects in Crop Updates and *Ground Cover*.

The industry Farming Practices Database provides an opportunity to discuss the key environmental risks and how they can be managed and opportunities identified. Such contact will be important in the development and communication of the Environmental Plan.

Increasingly growers are gaining their agronomic and production information from agribusiness and agribusiness is becoming more interested in demonstrating its own environmental credentials. For example, Landmark is a partner in the Cooperative Research Centre for Future Farm Industries (FFI CRC). It sees advantage in integrating the use of environmental options in the advice it gives.

Partnerships with the agribusiness sector will be important in communicating the objectives of the grains Environmental Plan. Such partnerships will prove valuable in populating the Farming Practices Database. Agribusiness agronomists will be able to assist and encourage their clients to fill in the database.

Industry development and leadership

The GCA's 'The Australian Grains Industry Environmental Policy Principles' highlights that good crop management leads to the more efficient conversion of inputs to grain. Greater efficiency of energy conversion would expect to lead to a better environmental outcome. The paper highlights that genetic advances in crop varieties can lead to greater efficiency, reduced chemical use and increased environmental benefit.

The GRDC was established to help the Australian grains industry meet the aims of the *Primary Industries and Energy Research and Development Act 1989* (PIERD Act) to:

- increase the economic, environmental and social benefits to members of primary industries and the community;
- achieve sustainable use and management of natural resources;
- make more effective use of the resources and skills of the community and especially the scientific community; and
- improve accountability for expenditure on R&D activities.

Together the two organisations are well placed to take a responsible lead in environmental planning for the Australian grains industry. In particular, the Practices Line-of-Business of the GRDC has as a key strategy "enhancing sustainable management of natural resources".

The strategy states that to enhance sustainable management of natural resources, the GRDC will:

- identify and minimise the environmental impacts of the grains industry;
- provide the industry with tools to manage climate variability within the context of climate change; and
- assist the industry to demonstrate its environment credentials.

These strategies will be delivered through this Environmental Plan.

Partnership and collaboration

The GRDC does not act alone. It has a significant partnership role in dealing with environmental issues. The GRDC seeks to partner with the state agencies that have a responsibility for their natural resources, the natural resource management regions, CSIRO and other industries through their research and development corporations (RDCs). Private sector organisations working in agriculture also have a desire to demonstrate their environmental credentials.

The regional Natural Resource Management model has become well established through Australian Government funded initiatives such as the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust. Fifty-six natural resource management regions nationally have been established for the purposes of determining natural resource management and sustainable agriculture priorities. Twenty-seven of these regions are in grain-growing areas. These plans are a valuable resource to inform the Environmental Plan of the Australian grains industry.

Policy

Each of the states are developing their own environmental plans and policies. The Natural Resources Management Ministerial Council (2006) has developed a framework for future NRM programs. The Environmental Plan takes into consideration these various plans and policies and is consistent with the framework for future NRM programs. Greater engagement between the Australian Government-funded NRM program and industry needs to occur.

This Plan provides a framework for more effective engagement. An effective way of doing this is for the GRDC to engage in resource condition assessment and management. The Farming Practices Database needs to align with, and relate to, the various regional NRM evaluation frameworks.

Conclusions

This Plan sets out strategies and activities to achieve them. It supports and adds detail to other industry strategies and will be a useful communication vehicle in itself. However, it must be implemented and it must be effective. A concerted effort will be required to ensure effective communication.

Achieving that outcome will rely on the ongoing development of leadership skills within the industry, on clear, positive communication with a wide range of stakeholders (including the negotiation of appropriate policies affecting the industry), and the development of partnerships at a range of levels – from local regions up to national, and even international scenes.

Refer to page 34 Table 11: The Grains Industry Environmental Plan for the sub-strategies for this Strategy 4. ■

ENVIRONMENTAL PLAN STRATEGY AND ACTION SUMMARY

Vision: Driving innovation for a profitable and environmentally sustainable Australian grains industry (GRDC Strategic Research and Development Plan 2007-12)

Objective: Prosperous growers in a respected and sustainable industry

TABLE 11 THE GRAINS INDUSTRY ENVIRONMENTAL PLAN

STRATEGY 1 Develop innovative solutions that are profitable, productive and sustainable to challenging circumstances

Sub-strategy	Evaluation criteria	Timing of delivery and responsibility
Risk assessment and management		
■ Continue to assess risks to the industry and develop management solutions.	Periodic revision of the Agtrans Environmental Analysis.	Revise analysis by 30 June 2011. Direct negotiation with Agtrans.
■ Monitor issues (e.g. climate change, supply and demand in global markets and Australia's relative competitive position) and forecast their implications to permit the development of appropriate responses.	Undertake an annual situation analysis.	Complete by 30 June each year. Responsibility of Manager Agronomy, Soil and Environment (ASE).
■ Invest in the development of better models of Australia's climate and investigate climate derivative markets to manage climate risk.	Improved 'skill' in within-season climate forecasting; up from the 58% skill achievable from 'perfect' use of ENSO/SOI.	Through Managing Climate Variability Program by 30 June 2009.
■ Ensure all research includes an assessment of environmental risks and benefits.	Inclusion of environmental risks and benefits in the GRDC project specification form.	Completed by 30 March 2008. Responsibility of Manager Extension and Grower Programs.
Efficient production: varieties and practices		
■ Develop varieties and practices that make efficient use of inputs (e.g. water, nutrients, carbon and energy) using genetic modification when appropriate.	Trends in efficiency (Life Cycle Analysis – LCA), yield and water use efficiency (WUE) over time (repeat the Beeston 2005 study).	Repeat Beeston study by 30 June 2009. Direct negotiation with the Bureau of Rural Sciences. Complete LCA for major crops and systems in partnership with the Department of Climate Change by 30 June 2012.
■ Develop varieties that are resilient in a changing and increasingly variable climate, e.g. frost and drought tolerant.	As above	Varieties Lines of Business consistent with LOB strategy. Ongoing.
■ Develop internationally endorsed indicators of production efficiency and resource condition.	Make available indicators of production efficiency and resource condition for key catchments.	In partnership with NRM and government agencies. Direct negotiation by 30 June 2012.

TABLE 11 THE GRAINS INDUSTRY ENVIRONMENTAL PLAN

Sub-strategy	Evaluation criteria	Timing of delivery and responsibility
Sustainable production systems		
Build adaptable farming systems that manage risks and exploit opportunities.	New systems and components developed.	Through cropping in catchments investment process completed by 30 June 2012.
Assess potential new farming systems, e.g. incorporating bio-energy, carbon sequestration, and payments for environmental services or stewardship.	Systems assessed for energy, carbon and environmental benefits.	Through cropping in catchments investment process completed by 30 June 2012.
Investigate the environmental performance of complete supply chains through internationally acceptable LCA.	LCA for systems and crops.	Complete LCA for major crops and systems in partnership with DCC by 30 June 2012.
Develop benchmarks and tools to monitor sustainability, e.g. a soil health index, biodiversity index (including beneficial insects), and carbon and water use indexes.	Development of indices – integrated measures of indicators.	In partnership with CMA and government NRM agencies. Completed through direct negotiation by 30 June 2012.
Landscapes		
Investigate the landscape and catchment impacts from alternative farming systems and management practices; including their provision of services to the environment.	Information available on landscape and catchment scale impacts.	Through cropping in catchments investment process completed by 30 June 2012.
Explore the interactions between land use and farm management, with on-farm and off-farm biodiversity (e.g. integrated pest management (IPM) and farm refuges for threatened species).	IPM systems and farm refuges developed and adopted. Landscape IPM approaches investigated.	Through cropping in catchments investment process and specific IPM investments completed by 30 June 2012.
Develop information packages on best management practice for the use and protection of remnant (including offset arrangements and 'biobanking') and newly planted vegetation on grain farms to achieve high biodiversity benefits with minimum impact on total farm profitability.	Packages produced.	Through cropping in catchments investment process completed by 30 June 2012.
Business solutions		
Incorporate concepts of environmental stewardship into prosperous farm businesses.	Suitable case studies and success stories of incorporation of environmental stewardship into prosperous businesses.	Through cropping in catchments investment process completed by 30 June 2012.
Develop tools that will assist individual farm businesses to adapt to climate change and to manage within season climate variability (e.g. climate and weather derivatives).	Useful climate tools and derivatives developed.	Through Managing Climate Variability Program and adaptation to climate change investments by 30 June 2009.
Seek out and exploit new and emerging technologies with potential to assist growers.	Practical applications incorporating new technologies.	Annual audit of technologies and opportunities. Manager ASE by 30 June each year.
Explore finance and investment options to inject urban funds into rural areas.	Programs that provide for urban investment or support in agriculture.	Executive Manager Practices. Ongoing.

STRATEGY 2 Generate knowledge to improve the adoption of sustainable farming systems and management practices

Sub-strategy	Evaluation criteria	Timing of delivery and responsibility
Best management practice		
Document and periodically review and update best management practices that achieve environmental sustainability within an increasingly variable and changing climate.	Practices audit reviewed and updated.	Annual audit. Manager ASE by 30 June each year.
Set targets for the adoption of sustainable management practices as a collaboration between farmer networks and regional NRM bodies.	Joint industry/NRM management action targets set for key issues.	Through cropping in catchments investment process completed by 30 June 2012.
Develop a culture of continuous learning in all levels and components of the industry focused on building capacity to analyse and respond to emerging environmental opportunities and threats.	Number of growers involved in learning programs or training.	Annual survey.
Innovation pathways		
Support regional grower groups and work with them to emphasise the importance of balanced (triple-bottom-line) outcomes, and the learning that comes from growers working with growers and researchers.	Number of groups completing triple-bottom-line analysis of their investments.	Through cropping in catchments investment process completed by 30 June 2012.
Support participative action research to involve growers, agribusiness networks and researchers in jointly developing comprehensive solutions to farming challenges that incorporate environmental stewardship.	Number of projects and dollars invested in participatory action research.	Through cropping in catchments investment process completed by 30 June 2012.

TABLE 11 THE GRAINS INDUSTRY ENVIRONMENTAL PLAN

Sub-strategy	Evaluation criteria	Timing of delivery and responsibility
■ Work with regional NRM bodies to develop integrated extension and incentives programs to promote the adoption of sustainable management practices and the application of farm decision-making tools (e.g. regarding climate variability and change).	Number of programs, funding and growers involved in joint industry/NRM programs.	Climate Change Research Strategy for Primary Industries Strategy by 30 June 2012. Through cropping in catchments investment process completed by 30 June 2012.
■ Work with agribusiness networks to emphasise the importance of whole-farm outcomes.	Number of industry/agribusiness partnership projects.	Across all Practices LOB investments audit by 30 June each year.

STRATEGY 3 Facilitate the recording, open analysis and reporting of grains industry environmental credentials

Sub-strategy	Evaluation criteria	Timing of delivery and responsibility
Benchmarking excellence		
■ Develop and maintain a database recording the adoption rates of sustainable management practices on Australian grain-producing farms.	Number of growers using the database to enter information and benchmark against their peers.	Annual audit of growers using the Farming Practices Database by 30 June each year.
■ Work with other industries to ensure environmental impacts are considered across whole (mixed) farm businesses.	Number of cross-commodity partnerships.	Cropping in catchments investment process by 30 June 2012.
■ Encourage a culture of environmental and efficiency benchmarking amongst grain growers through promotion and ongoing enhancement of the Farming Practices Database.	Communication products distributed and number of hits to grains websites.	Annual audit of growers using the Farming Practices Database by 30 June each year.
Market promotion		
■ Periodically report on the environmental credentials of growers at a regional scale using the Farming Practices Database (either as a vehicle for a stratified survey or a generator of summary information), with emphasis on the targets of local NRM plans.	Relationship between stratified survey data (ABS and ABARE) and the grains database.	Annual state of the environment report as part of annual reporting process against environmental objectives by 30 September each year.
■ Maintain a watching brief for markets requiring environmental accreditation for grain and grain derived products.	Annual situation analysis	Complete by 30 June each year. Manager ASE.
■ Seek opportunities for the industry to obtain a market benefit from environmental stewardship.	Opportunities identified for stewardship rewards to growers.	Grains Council, GRDC Practices and New Products LOBs. Ongoing.

STRATEGY 4 Develop capacity, strong relationships and clear trusted communication to deliver environmental leadership

Sub-strategy	Evaluation criteria	Timing of delivery and responsibility
Strategic action		
■ Commit resources to the implementation of this Environmental Plan, regularly review it and promote its vision.	Human resources involved in implementing this Plan.	Executive Managers Practices and Corporate Services. Ongoing.
■ Position Australia as an advocate in international negotiations likely to affect Australian grain growers.	Environmental policy papers from industry.	Grains Council of Australia. Ongoing.
■ Actively seek to develop and involve well-skilled and enthusiastic leaders for industry programs.	Training provided that is relevant to implementation of this Plan.	Communication and Capacity Building.
■ Endeavour to gain funds for industry-based regional NRM coordinators to help implement this Plan.	Level of partnership investment and the number of industry/NRM coordinators appointed.	Use cropping in catchments investment process as an opportunity to lever co-investment by 30 June 2012.
Industry development		
■ Support individuals with scholarships and mentoring networks, to assist with succession in the industry.	Mentoring or scholarship opportunities provided, relevant to this Plan.	Communication and Capacity Building.
■ Develop means to attract, groom and retain high achievers to all aspects of the grains industry – from farm, to research, to supply chain.	Completion of a skills and capacity audit for the grains industry.	Communication and Capacity Building.
Sustainability policies		
■ Actively contribute to debate on the inclusion of agriculture in a national emissions trading scheme.	Inclusion of policy principles for agriculture into an emissions trading scheme.	Climate Change Research Strategy for Primary Industries by 30 June 2012.
■ Promote balanced, fair and effective environmental regulations.	Environmental policy papers from GCA.	Grains Council of Australia. Ongoing.
■ Promote rewards to growers for the provision of environmental services (e.g. providing habitat for endangered species) and resource stewardship.	Communicate and promote rewards to growers for the provision of environmental services.	Cropping in catchments investment process by 30 June 2012.
■ Maintain support for biosecurity protocols.	Level of development and adoption of biosecurity contingency plans.	Implementation of contingency plans.

TABLE 11 THE GRAINS INDUSTRY ENVIRONMENTAL PLAN

Sub-strategy	Evaluation criteria	Timing of delivery and responsibility
■ Developed unified industry policies e.g. grower networks, GRDC, GCA, trade, marketing and value chain operatives.	Assessment of attitudes within the industry.	Attitudinal survey procured by 30 June 2012.
Trusted partnerships		
■ Build strong relationships between farming systems groups and regional NRM bodies e.g. by collaboration in monitoring and evaluating the adoption of best practices in regard to NRM targets.	Number of industry/NRM partnership programs and joint targets.	Use cropping in catchment investment process as an opportunity to leverage co-investment by 30 June 2012.
■ Build strong partnership programs between the grains industry, the Australian Government, service providers to growers and industry, regional NRM bodies, and regional development organisations.	Number and effectiveness of multi-partner programs for growers.	Use cropping in catchment investment process as an opportunity to leverage co-investment by 30 June 2012.
■ Design partnerships at different levels and scales e.g. industry (Australian Government, regional panels), state NRM representatives, local grower groups, regional NRM bodies and service providers.	Number and effectiveness of multi-partner programs for growers.	Use cropping in catchment investment process as an opportunity to leverage co-investment by 30 June 2012.
Communication		
■ Develop an environmental communication plan to deal with all levels of interest among stakeholders.	Development of a communication plan.	Plan completed by 31 December 2008. (Manager Communication.
■ Promote a wide understanding of the grains industry; its role and contributions, its issues, its proactive approach to them and the support it requires at all stages of the value chain from neighbours, consumers and governments.	Survey of stakeholder appreciation of industry issues and performance.	Attitudinal survey completed by 30 June 2012.
■ Endeavour to bridge the city – country divide and instil confidence and pride amongst all in the Australian grains industry.	Survey of attitudes amongst growers.	Attitudinal survey completed by 30 June 2012.
■ Ensure growers understand, support and are committed to help implementation of industry plans and actions, and have opportunity to shape them and drive them.	Number of growers and grower groups involved in developing and implementing this Plan.	Participation survey completed by 30 June 2012.

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APPENDIX 1

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