

6B: TOWARDS SUSTAINABLE LAND MANAGEMENT

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A geological perspective

Australia's geological history has created a unique, very ancient, very flat continent that has accumulated enormous amounts of salts in the soils, regolith, lakes and groundwater. Most of our rivers and groundwater systems are sluggish, with only a small capacity to move salt from the continent. Thus, our farming systems must be able to work in a landscape that is old, flat and salty. Unfortunately, our current farming based around annual crops and pastures, does not work well in such a landscape. It leaks far too much water past the roots of the plants, with the consequence that much more water enters into the landscape than drains from the landscape. Groundwater then rises as the landscape fills with water, causing the abundant salt stores in the landscape to be moved to salt valley floors, rivers, wetlands. The challenge is to build an ecologically sustainable landscape consisting of a mosaic of commercial land uses that yield food and fibre, coupled with native ecosystems that provide a suite of ecosystem services which are valued and paid for by stakeholders and beneficiaries. This will require innovative and inclusive approaches that permit fair comparison of market and non-market values. The development of the concept of valuing and marketing ecosystem services as part of this process will be increasingly important.

Challenge facing rural Australia

Australian agriculture has been very successful for over 200 years, producing substantial wealth to support the nation's economic development. However, we are now producing commodities with ever-declining terms of trade and at significant cost to the environment, as evidenced by the increasing degradation of our land and water resources. Australia is geologically very old, very flat and has a dry, but highly variable climate. Any mismanagement of the land and water resources will have significant and long-lasting consequences for society. Management that resulted in permanently degraded land was once accepted by the few who knew of it. Since about 1985, however, Australian society, as reflected in the emergence of Landcare, has decided it will no longer tolerate the level of managerial inadequacy that resulted in land and water degradation. It now allocates considerable resources to fix the problem. In the past 15 years, Landcare and other institutions have produced significant changes in the attitudes and activities of land managers, industries and society as a whole. On increasing numbers of farms and small catchments where the declining condition of the land and water had been acknowledged and identified, there is emerging evidence that these activities have begun to treat the symptoms, heal the wounds and stabilise the situation. However, land managers must now shift their focus to treating the cause of the degradation. That will not be so easy, as it requires a revolution in land use.

To create and shape the future we will need to move from the familiar commodities to new products for new markets that demand products that are produced in environmentally benign ways. This will require shifting beyond 're-jigging' old farming systems and 'business as usual' to developing and designing new farming systems and other commercial land uses that are more compatible with the ecosystem and landscape processes and functions. We need commercial land use that is 'benign by design'—that does not damage land and water, while generating farm and enterprise wealth sufficient to support sustainable rural communities. In addition to commercial land use to produce food and

fibre, increasingly enterprise income will be derived from the provision and management of ecosystem services that are currently not valued, let alone paid for. The challenge then is to build a mosaic of commercial land uses that are ecologically sustainable and to spatially integrate these with land uses that provide a suite of ecosystem services that are valued and paid for by stakeholders and beneficiaries, private and public.

Discovering and building new land use practices that meet these essential criteria will require solutions to scientific and technical problems that are many, complex and difficult. At present, there are few such biophysical solutions on the horizon. Little work has been done on the use of native plants, their genes and the processes by which they capture water and nutrients. Furthermore, there are serious gaps in our ecological understanding of the rehabilitation process in Australian landscapes.

The solutions to the biophysical problems are scientifically demanding. They also require new ways of doing science within the imperatives of rural communities facing radical social and economic change. For rural communities in Australia, this is both an opportunity and a challenge. Partnerships between government, businesses, community sectors and scientists can, I believe, build a better future for regional Australia by developing a **mosaic** of farming and land use that does not harm the environment. The natural sciences have established the overall strategy to be followed. Can we marshal the investment in human and social capital to create our future?

Development of sustainable Australian agro-ecosystems

Rural production has played a key role in Australia's economic development. While there is much of a positive nature in the history of Australian agriculture, there is a growing realisation that many of the short term gains in Australia's agricultural development have been achieved at long-term cost to the environment and resource base. These costs are now becoming prohibitive (Wood 1924, Cocks *et al.* 1980, Cocks 1992, LWRRDC 1995, Hamblin and Williams 1995, Goss *et al.* 1995, Reeves *et al.* 1997, Lovering and Crabb 1997, White 1997, Williams *et al.* 1998, White 2000, NLWRA 2001a and b). Australian rural production systems have been built by drastically changing the nature and seasonal patterns in the hydrological and nutrient cycles of native ecosystems. Tropical rainforest was replaced with sugarcane monoculture, semi-arid clay plains became irrigated croplands, and heathlands on sandplains were converted to wheat and lupin fields. Consequently, the diverse production systems of Australia's rural industries all face a common core of resource and environmental problems, all related to the capture and utilisation of water, nutrient and carbon.

Most of our European style of agriculture, pastures and annual crops behave as very leaky ecosystems, particularly those that feature intensively grazed animals (Williams and Hook 1998). Water, nutrients, pesticides and carbon are lost to the landscape, where they damage groundwater, rivers and wetlands. The failure of our agro-ecological systems to capture these resources, convert them to food and fibre, and cycle them within the food web and storage reservoirs, not only perturbs the ecological and hydrological balances of our landscape; it wastes resources that could contribute to agricultural production. Our best farming practices have not been designed, at the outset, to operate in harmony with the uniquely Australian ecosystems in which they are cast. We will make progress towards ecologically sustainable development as reflected in the improved quality of natural resources when the ecosystems and landscapes created by our land use practices are as functional as those of our native ecosystems and landscapes.

It is ironic, therefore, that in Australian agriculture, where shortages of both water and nutrients greatly restrict yield, the loss of precious water and nutrients from the pasture or crops is the fundamental cause of natural resource degradation. This immediately raises the prospect that if we can develop farming systems or other land uses that do not leak and thereby make full use of available water and nutrients, they may be both more productive and ecologically sustainable. By building new farming systems that capture all the water, nutrients and carbon, we treat the environmental damage at its cause and turn the leaked material into food, fibre and ultimately, wealth. Unfortunately, at the moment, we do not have such farming systems or other land uses in large areas of regional Australia. For many current agricultural zones in Australia we do not have solutions in the form of farming or forestry practice that can treat the cause of degradation and create sufficient farm income to support viable rural communities. We need new and better solutions.

In 1994, Andrew Campbell stated: *'In short, existing systems of food and fibre production are unsustainable. The rural sector is ageing, declining, stressed and going broke, and depleting natural and human resources in the process...more sustainable systems of land use and management are unlikely to be developed or implemented by people preoccupied with short-term survival.'* This crisis has arisen, in part, because Australian agriculture has developed largely by importing plants, animals and production systems from the Northern Hemisphere. It is clear that many of these are not well suited to the unique characteristics and function of Australian ecosystems. In view of the measured depletion of many of our natural resources (NLWRA 2001a and b, White 2000 and 1997; Williams *et al.* 1998, Reeves *et al.* 1997, Commonwealth of Australia 1996), there must now be questions about the extent to which Australia can continue to be competitive in international market places by relying solely on our current production systems.

The need to harness market forces to drive new developments and a change in land use in rural Australia is critical. 'Business as usual' is not an option—what are the options for change in land use? This question was addressed by a recent CSIRO report (Stirzaker *et al.* 2000) which concluded that we need to pioneer the development of a new landscape. This landscape would comprise a mosaic of tree crops driven by large-scale industrial markets such as biomass fuels and high-value annual crops. In addition it would support mixed perennial-annual cropping systems, and areas delivering ecosystem services through the maintenance of landscape and ecosystem function associated with native biota dependent on native vegetation. In short, this requires a landscape mosaic that combines ecologically sustainable, commercial land uses with land use that provides a suite of ecosystem services (Daily 1997, Daily and Walker 2000) that are valued and paid for by stakeholders and beneficiaries.

No single land-use option will halt resource degradation such as salinity and the loss of native biodiversity in our land and rivers. We need to develop and deploy a suite of novel land uses that are matched to the diverse climate, soils, and hydrological conditions of the Australian landscape. These land uses, in combination, need to deliver nutrient and water leakage rates past the root zone that approach those of natural vegetation. This will require radical change to land use, incorporating the following features:

- Commercially driven tree production systems and/or new tree species, to be developed for large areas of the current crop and pasture zones of the Basin. These would include trees to produce fruits, nuts, oils, pharmaceuticals, bush foods and forestry products such as specialty timbers, charcoal, and biomass energy

- New farming systems made up of novel mixes of all the best current annual and perennial plants, the best agronomy, companion plantings, rotations and combinations
- New forms of cereals, pulses, oilseeds and forages selected or bred for characteristics that substantially reduce deep drainage and nitrogen leakage
- Refined land assessment tools that best locate native vegetation, tree crops, horticulture, other perennial plants, and high-value annuals to meet water quantity and quality targets, and biodiversity goals.

To realise this vision, we will need to pioneer the development of a mosaic landscape such as that described above by Stirzaker *et al.* (2000). Devising the optimal placement of the different land uses in terms of salinity control, productivity and maintenance of native biodiversity will require a robust understanding of landscape process and function, good maps of landscape properties, particularly salt storage and groundwater flow.

While a vision for sustainable landscapes is emerging, many of the components described above do not exist yet. A substantial new research and development effort is required to tackle the redesign of farming systems and their integration into the landscape as a whole. This R&D needs to combine biophysical and economic studies that deliver innovative designs well matched to soil, climate and catchment circumstances, including biodiversity, on-farm measurement and improved land assessment techniques, modern genetic improvement techniques, and a participatory process that engages all land managers. Options must recognize the geographic scale of the problem, and ensure that investigations and actions take place at the appropriate scale, typically, regional or catchment-wide.

It is essential that Australian rural industries have in place technologies that can produce uncontaminated rural products in a way that maintains the quality of land and water resources and is benign to the off-site environment. Environmental management systems that can support quality assurance systems such as ISO 14001 will become an increasing part of maintaining market access. Therefore degradation of soils, water and natural vegetation puts at risk income from rural production systems and undermines the realisation of benefits arising from rural research, such as that aimed at the genetic improvement of yield or quality potential of crops or animals. As rural production remains a mainstay of much of regional Australia, maintaining the economic competitiveness of rural industries while substantially improving their long-term ecological sustainability is a high national priority.

Natural resource degradation: extent and estimates of trends

Overall, Australia's natural endowment for agriculture is poor. Its soils are relatively infertile, easily damaged and slow to recover. Often they do not recover—a consequence of the ancient, highly weathered nature of material from which most of our soils are derived (Beckmann 1983). The same can be said for the unique ecosystems that are adapted to these soils (Hamblin and Williams 1995, Lovering and Crabb 1997). Coupled with the most variable rainfall pattern anywhere in the world, Australian farmers and scientists face a demanding task in building productive farming that does not harm the environment or damage the soil, water or vegetation resource and restrict their use or productive capacity for further generations.

Forms of degradation

The forms of land and water degradation are now well documented (Williams 1991, LWRRDC 1995, Reeves *et al.* 1997), as are the general principles and processes that determine land use action and the catchment response (Williams *et al.* 1998). The nature of natural resource degradation issues can be described in Table 1:

Table 1: Natural resource degradation issues

<ul style="list-style-type: none">• soil nutrient depletion	<ul style="list-style-type: none">• river processes and environmental flows
<ul style="list-style-type: none">• soil acidification	<ul style="list-style-type: none">• nutrient, salts and pollutants to wetlands, rivers and water bodies
<ul style="list-style-type: none">• soil structural decline	<ul style="list-style-type: none">• contamination of groundwater with nutrients, salt and pollutants
<ul style="list-style-type: none">• soil biological decline	<ul style="list-style-type: none">• riparian, remnant vegetation damage and rural tree decline
<ul style="list-style-type: none">• dryland and irrigation salinisation	<ul style="list-style-type: none">• decline in native pastures and environmental value of rangelands
<ul style="list-style-type: none">• wind and water erosion	<ul style="list-style-type: none">• loss of habitat and biodiversity
<ul style="list-style-type: none">• contamination with residues of agricultural chemicals	

The broad dimensions of land and water degradation in Australia were identified and regularly examined in terms of form and process during the 1980s, but the spatial extent, trends, and the costs in lost production and loss of environmental amenity particularly biodiversity, remain very poorly documented. Goss *et al.* (1995) state that:

These impacts are of an enduring nature, not easily reversed and are becoming increasingly expensive to correct. Such damage has:

- reduced the productive capacity of lands (although in some areas productive capacity has increased);
- long term adverse impacts on water quality and biological diversity;
- put agricultural trade at risk through contamination; and
- threatened health.

Price (1993), LWRRDC (1995) and Lovering and Crabb (1997) have estimated the cost in lost rural production as approximately \$1 billion per year. This does not include the annual estimated cost of about \$450 million resulting from degraded water quality caused by off-farm impacts on catchment and regional ecosystem function.

Salinity impacts beyond the farm gate

As the above listing indicates, the impacts and costs of natural resource degradation go well beyond the land and soil resources on the farm. This is particularly true and is becoming better documented for dryland salinity (PMSEIC 1998, NLWRA 2001).

Land

About 2.5 million ha of land is affected so far by dryland salinity, and there is potential for this to increase to more than 12 million ha. The estimated capital value of land lost to dryland salinity already exceeds \$700 million. Much of the affected land was some of the most productive agricultural land in Australia. The area damaged by salinity to date represents about 4.5 per cent of presently cultivated land. Known costs, as indicated above, include \$130 million annually in lost agricultural production, \$100 million annually in damage to infrastructure, and at least \$40 million in loss of environmental assets. Salinity affects regions in all parts of Australia. While the impacts on-farm are large, the impacts on water quality and the amenity of the environment will become increasingly important.

Water quality

Increasing salt concentrations can be observed in many streams and rivers, particularly in the southern half of the Murray-Darling Basin (Lovering and Crabb 1997, Williamson 1998). Rising groundwater in the Basin leads to saline discharges to streams and at the soil surface, where it affects runoff quality. Salinity levels in the Murrumbidgee River are increasing at between 0.8 per cent per annum and 15 per cent per annum, depending on where measurements are made. Stream salinity in the Murray now exceeds World Health Organization guidelines for about 10 per cent of the year. Recent preliminary work suggests that in the next 50 years this will rise to the extent that the water will be considered undrinkable for long periods of the year. If they develop, these changes will have significant impacts on aquatic ecosystems and all extractive users.

Remnant vegetation and wetlands

Rising water tables and increasing salinity have serious impacts on native vegetation. Remnant native vegetation is threatened, and since this is the only remaining habitat for a variety of important animal species, these are also under threat. Riparian vegetation, critical to stream bank stability, and wetland areas are already damaged and under increasing threat. In Western Australia, it was found that 80 per cent of the length of rivers and streams was degraded by salinity, and half the water bird species had disappeared from the many wetlands that were once fresh or brackish. Also in Western Australia, some 80 per cent of remnant vegetation on private land, and up to 50 per cent of conservation reserves, are threatened by salinity (PMSEIC 1998).

Road, bridges and urban infrastructure

Road and bridge damage caused by shallow saline groundwater is a major cost to local governments. The National Dryland Salinity Program has estimated that about 34 per cent of State roads, and 21 per cent of national highways in south-western NSW are affected by high water tables, and the damage costs about \$8 million per year. The impacts of salinity are diffuse, indirect, and highly pervasive. Current estimates of extent and future costs are almost certainly far too low, and reflect our limited investment in measuring salinity and its effects (PMSEIC 1998).

Soil acidification is extensive and continues

The damage to the chemical, physical and biological fertility of soils under Australian farming has been reviewed in detail by several authors (Chartres *et al.* 1992, Williams 1991, Williams and Chartres 1991, Hamblin and Williams 1995, Lovering and Crabb 1997,

Williams *et al.* 1998). However, the emphasis of these papers has been on issues and process, with very little quantitative assessment of spatial extent or temporal trend. Soil acidification is known to occur on more than 90 million hectares, of which 33 million hectares have a pH in water that has fallen below 4.8 (AACM International 1995). It is important to discriminate between accelerated acidification as a consequence of land use and naturally acidic soils. This is not always done, thus confusing analysis on the extent of soil acidification. It is important to appreciate that soil acidification is not restricted to temperate Australia; it is now a significant problem in both the humid and semi-arid tropics.

Future focus on water quality and river health

LWRRDC (1995) and Cullen and Bowmer (1995) set out the major degradation issues wherein land use, particularly agriculture, affects water resources. Agricultural land use affects water quality and the environment in the following ways (Cullen and Bowmer 1995):

- runoff from rural lands carries sediment, nutrients, organic matter and agricultural chemicals
- the extraction of water from rivers and groundwater is central to irrigated agriculture and therefore has severe impacts on aquatic ecosystems of our rivers, wetlands and estuaries; the drainage water that returns from irrigation can carry high loads of salt and agricultural chemicals
- irrigation uses rivers and wetlands as storages and conduits, resulting in distortion of the river or wetland flow regime
- land clearing and irrigation activities cause rising water tables and salinisation of rivers and wetlands.

The consequences of these impacts are seen in increases in the frequency and severity of algal blooms, loss of native fish, encouragement of introduced fish such as carp, loss of floodplain and riparian vegetation. This has impacts on habitat and ecosystem processes, and the introduction of agricultural chemicals into aquatic environments with uncertain long-term consequences.

Biodiversity loss

Biodiversity is the variety of all life forms and their patterns in space—the different plants, animals and microorganisms, the genes they contain and the ecosystems of which they form part. The term ‘biodiversity’ is poorly understood. Many people believe it means species diversity or the conservation of rare or endangered species. This interpretation leads to an extremely restricted view of biodiversity. For example, in agricultural or pastoral landscapes, it is often assumed that biodiversity is found only on conservation reserves, on uncleared agricultural land, or on remnant patches of bush on farming land that may or may not be fenced off. However, biodiversity in the agricultural and pastoral ecosystems that make up these lands is often central to the lands’ productivity. Agriculture is an ecological enterprise that depends on ecosystem processes and functions—such as soil formation, nutrient cycling, maintenance of hydrological cycles, pollination of crops—which are driven by interactions between elements of biodiversity. The narrow species-focused view of biodiversity gives rise to the notion that landscapes can be compartmentalised and that protection of remnant native vegetation is therefore the primary action required to conserve biodiversity. This attitude does not take into account

most biodiversity, and is leading to continuing loss of its essential elements. Much biodiversity is minute and exists in soil, contributing to soil fertility and agricultural productivity, but its very existence is threatened by agricultural practices.

As biodiversity is lost, ecosystems become less complex. This initiates a cascading sequence of events that can result in changes which have important and long-lasting consequences. Simplified ecosystems become less resilient, meaning that they are less able to absorb environmental shocks and disturbance while continuing to maintain their original levels of function (processes like rates of growth, transpiration, fixation and uptake of nitrogen). Reduction of biodiversity means that there are fewer components to buffer the blows inflicted by drought, fire, exotic species and climate change.

Status of biodiversity

Loss of biodiversity is Australia's most serious environmental problem. The major cause—destruction of habitat by urban development, agriculture, forestry, fishing and mining—continues at an extensive rate. Those elements of biodiversity that can be assessed all show declining trends. Five per cent of higher plants, 23 per cent of mammals, 9 per cent of birds, 7 per cent of reptiles, 16 per cent of amphibians and 9 per cent of fresh water fish are extinct, endangered or vulnerable. Australia has the world's worst record of mammal extinction. In the past 200 years, we have lost ten of 144 species of marsupials and eight of 53 species of native rodents.

The most severe losses are in Australia's agricultural zones. In many areas, less than 10 per cent of the original vegetation remains, with the cleared areas used for production. The extensive loss of native vegetation is now having major impacts on ecosystem functioning in many parts of Australia. The hydrologic balance of the agricultural zones has been radically changed. Changes in vegetation have also led to changes in surface flow of wind and water, and these have become severe degrading forces. In addition, there is now evidence that these extensive changes to the landscape may be resulting in changes in the radiation balance, leading in turn to alterations to the macro- and micro-climate. Some evidence from rainfall records over the past 80 years suggests that changes to the radiation balance are leading to reductions in rainfall in south-western Australia.

Ecosystem function and sustainable land use

Scientific solutions to degradation are many, complex and difficult

To understand how Australia's rural industries might move towards ecological sustainability, it is appropriate first to identify the scientific and technological issues that have to be solved.

A reluctance to recognise, then confront, the demanding scientific and technical challenges in finding sustainable agricultural systems for the Australian environment is a barrier to progress. The result is a failure to direct research to solve the fundamental scientific and technical issues that are the core causes of natural resource degradation. This tendency to trivialise the scientific and technical difficulties of building farming systems that do not harm the environment must be faced and addressed. So much policy has been flawed by assuming that solutions to land degradation are readily available. Consequently, Australia lacks a strategy to seek solutions to the cause of degradation.

Research and development continues to focus on improving productivity and reducing costs of current commodities such as wool, wheat and beef, with very little effort spent on finding farming solutions that do not harm the natural resource base. Further, there is a failure to recognise that the problems Australian scientists and farmers face in finding new solutions are more exacting and difficult than for most other places in the world. This is due to Australia's highly variable climate, coupled with soils that are, in general, old, highly weathered, fragile and of low fertility. The scientific problems to be solved before Australian agricultural systems approach ecological sustainability are many, complex, and difficult. The solutions to the problems confronting rural industries are not only technically demanding; they also require radical changes to the orientation of research institutions, extension and consultancy agencies, research and development corporations, as well as to the priorities of large sections of our rural community.

Urgent need to match farming and land use pattern to landscape and ecosystem function

Most of our farming operations leak water and nutrients. The very leaky nature of Australian agro-ecosystems lies at the root of nearly all land and water degradation issues. We desperately need new biophysical solutions that can plug leaky systems and capture the water and nutrient for productive purposes. As noted earlier, the irony of Australian agriculture is that while the shortage of both water and nutrients greatly restricts yield, the fundamental cause of both salinity and acidification is the loss of valuable water and nutrient beneath the crop or pasture. A key strategic focus for science and technology, therefore, is to build productive agro-ecosystems that leak much less water, nutrient and carbon to the landscape in which they are located.

To achieve this goal, the scientific effort must first recognise that the soil/plant/animal agro-ecosystems must be studied in an integrated way and examined as part of the larger-scale ecological and hydrological processes that operate over the landscape. The solution must incorporate these functions at a range of scales including paddocks, hillslope, catchment, whole landscape and the regional basin. The landscape design will need to integrate sustainable production and maintenance of biodiversity for the catchment and region. Any re-vegetation program must have multiple objectives and therefore be designed for restoring ecosystem function: hydrology, nutrient cycling, movement of biota, and maintenance of habitat. These will need to be configured with the aid of emerging knowledge of:

- salt storage, groundwater and surface water flows, river form and function
- ecosystem function and biodiversity
- bio-geo-chemical process and water quality
- carbon sequestration

While these are plausible objectives, it is most important that government planners and the community recognise that there are serious deficiencies and problems with our scientific understanding of the ecology of the rehabilitation process in Australian ecosystems and landscapes. We do not know how to reconstruct them. There is little in the way of tested theory or design rules for rehabilitation, quite apart from a process for communities to set objectives. It is all very *ad hoc* at the moment. Not much is gained if dryland salinity is

controlled by afforestation that subsequently results in serious decline in river flow. We must avoid solving one problem while creating another.

The way in which the production system interacts with the hydrological and nutrient balances and the implications of these interactions for the longer-term stability and ecological functionality have been neglected or studied in isolation from the production system. The first step in our search for an ecologically sustainable agriculture requires that we address agricultural production as an agro-ecosystem that is part of the larger-scale ecosystems and landscape processes (Williams 1991 and 1995, Williams and Hook 1992). The CSIRO is currently developing the 'Heartlands' project with a view to providing tested design principles for the implementation of regional projects that involve large-scale land use change. Knowledge of how best to revegetate land and implement land use that is ecologically sustainable and can support viable rural communities is critical to any regional development plan. At present, we risk creating new problems while solving a current one.

Focus on short-term animal or plant productivity without considering the consequences on other essential components of the agro-ecosystem and the larger-scale landscape processes can be shown to be a primary cause for degradation of the natural resource. As noted earlier, what is required is a mosaic of ecologically sustainable commercial land uses combined with land uses that provide ecosystem services (Daily 1997, Daily and Walker 2000) that are valued and paid for by stakeholders and beneficiaries. The consequence would be that a rural enterprise might derive its income stream from sources other than the traditional food and fibre production, for example, by providing services paid for by either private or public stakeholders and beneficiaries, or in some innovative mix. A possible set of income streams is set out in Table 2.

Table 2: New commodities and markets

Commodity	Share of Business %	Client
Wheat	40	World market
Wool	15	World market
Timber	10	Pulp wood, biomass energy, specialty timber
Carbon credits	7.5	Steel mill
Salinity credits	7.5	Cost sharing for catchment management
Water supply management	15	Water supply company
Biodiversity credits	5	Public/private trusts

Farming without harming: some possibilities

As discussed above, we need to develop and deploy a suite of novel land uses that are matched to the diverse climate, soils, and hydrological conditions of the Australian continent. While this is a huge undertaking, it comprises the real challenge if we seek sustainable management of rural landscapes. These land uses, in combination, need to deliver water and nutrient fluxes or leakage rates past the root zone or across the land surface that approach those under natural vegetation. This will require radical change to land use, as set out by Stirzaker *et al.* (2000), incorporating:

- The development of commercially driven tree production systems and/or novel tree species for large areas of the current crop and pasture zones of the Basin. These would include trees to produce fruits, nuts, oils, pharmaceuticals, bush foods and forestry products such as specialty timbers, charcoal, and biomass energy
- New farming systems made up of novel mixes of all the best current annual and perennial plants, the best agronomy, companion plantings, rotations and combinations
- New forms of cereals, pulses, oilseeds and forages selected or bred for characteristics that substantially reduce deep drainage and nitrogen leakage
- The refinement and building of new land assessment tools that
 - ◊ Best locate trees, other perennial plants, high-value annuals, and native vegetation to meet water quantity and quality targets, and biodiversity goals
 - ◊ Facilitate identification and re-assignment of land so that on some parts of the landscape, productivity is greatly enhanced (double yield) and other parts are removed from production to provide a range of ecosystem services.

To realise this vision, we will need to pioneer the development of a new landscape, a mosaic of tree crops driven by large-scale industrial markets such as biomass fuels. These landscapes will also yield high-value annual crops, as well as mixed perennial-annual cropping systems, and areas devoted to the maintenance of those elements of native biota dependent on native vegetation. Devising the optimal placement of these land uses in terms of salinity control, productivity and maintenance of native biodiversity will require a robust understanding of landscape process and function, good maps of landscape properties, particularly salt storage and groundwater flow.

While a vision for sustainable landscapes is emerging, many of the components described above do not yet exist. A substantial new R&D effort is needed that tackles the redesign of farming systems and their integration into the landscape as a whole. This needs to combine biophysical and economic studies that deliver novel designs well matched to soil, climate and catchment circumstances including biodiversity; on-farm measurement and improved land assessment techniques; modern genetic improvement techniques; and a participatory process that engages all land managers.

Farm forestry, new agricultural production systems and restoration of native vegetation

The cause of much of the degradation is reduced water use associated with the removal of perennial native vegetation and replacing that with annual crops and pastures. Thus farm forestry, new agricultural production systems, and restoring native vegetation present opportunities to restructure the landscape with vegetation that has a similar water use pattern to the original native vegetation, with the potential for substantial amelioration of the impending problems.

The possibility of implementing this type of solution is increasing. The expansion of forestry on cleared agricultural land is becoming more attractive in higher rainfall zones. Commercial prospects for traditional grazing are poor, while market prospects for the expansion of plantation forestry appear to be improving. Added to this is the increasing interest both in Australia and overseas in using the ability of trees to sequester carbon as a means of meeting greenhouse commitments. The opportunity to combine carbon sequestration incentives with reforestation to control dryland salinity is receiving

attention. Farm forestry and agro-forestry for the mid to lower rainfall zones appear to offer attractive options, although a great deal more work in building these new industries is essential. The Joint Venture Agroforestry Program managed by the Rural Industries Research and Development Corporation (RIRDC) is making an important contribution to building these new industries.

The use of native plants and animals may form an increasing part of rural production. Bush foods (CSIRO 1996), native wildflowers, essentials and other oils for pharmaceutical or industrial chemicals are receiving increasing attention. Indigenous people have much to contribute in the use of our native plants and animals for food and fibre. This form of diversification in farming enterprises will increase the planting of native vegetation back on to the Australian landscape and expand production on those elements of the landscape suited to high-value crops and pastures. Alley farming of native trees, shrubs and leguminous plants with cereal and oilseed production is increasingly adopted in those regions of Western Australia with light textured soils and prone to wind erosion. While many ideas are being considered, it must be emphasised that enormous work lies ahead in finding sustainable solutions.

There is an urgent need for strategic research into farming systems to find solutions to matching these sources and sinks, and then to match the residual flows to those in the ecological and landscape functions operating in the Australian environment (Williams 1999). The Redesigning Agriculture for Australian Landscapes (RAAL). Research and Development Program is a joint initiative of Land and Water Australia (formerly LWRRDC) and CSIRO. It is researching how agricultural systems in Australia can be redesigned to address a range of sustainability issues. This design approach has potential to be applied through:

- selection, plant breeding, including molecular genetics, for our commercial crops, pastures and native plants to manipulate phenology, canopy development, rooting function, distribution and temperature response
- rotating, and mixing in space and time innovative configurations of plants involving annual, perennial crops, pastures, forest and horticultural trees, native plants, bush foods etc, in alleys, blocks, windbreaks, clusters, over rotations of months or years.

Recognising the huge task ahead, the RAAL Program actively seeks opportunities to collaborate, focusing on integrating RAAL with other redesign initiatives and incorporating RAAL outputs into other research and development initiatives.

We need more information on the water using capacity of various types of vegetation and on experimentation with new farming systems that are adapted to the temporal and spatial variability of the Australian climate (Dunin *et al.* 1999). Much of this research must be at a larger geographic scale than has characterised much previous research.

Most plant breeding programs generally focus on grain yield and quality, pest control and other limitations. Few, if any, breeding efforts have focused on the role of crop and pasture species in controlling deep drainage and nitrogen leakage. In essence, crop and pasture species have not been designed with the control of natural resource degradation in mind. A study by Chu *et al.* (2000) has highlighted that the breeding, selection and bioengineering of annual crops and pastures has considerable potential to help ameliorate dryland salinity and acidification by designing crops and pastures to minimise the leakage of water and nutrients past the root zone. This contribution is likely to be over and above

current agronomic and other management improvements. Although the study identified that investments in breeding, selection and biotechnology are likely to reap short-term benefits, most of the opportunities will require a long-term (10–15 year) research and development program.

Development of new farming operations that do not harm the natural resources and environment, while generating enterprise incomes that can support sustainable communities, must be an urgent goal for rural Australia.

Sustainable rural landscapes: people and institutions

Solutions to environmental and natural resource issues require institutional, structural and social change as well as new scientific knowledge and strong economic drivers. Therefore it is a key requirement that people from all sectors of the community are involved with scientists from the earliest stages of a program involving planning, research, implementation, monitoring and evaluation. Scientific and technological innovation both on farm and in laboratory will play a fundamental and increasing role in the development of sustainable farming. However, the impact of such innovation will increase significantly if it becomes a tool for rural society and is not used to set the agenda in isolation from the rural community. This will require a paradigm shift by research institutions, rural communities, funding agencies and government. A catalyst is needed to effect the required change.

The work being done on the new Natural Resource Management Policy Statement may be a vehicle to bring realignment and focus on the development of farming systems that do not harm. Whatever the mechanism, there will need to be a policy framework for changes in farming so that our landscapes are not damaged.

The development of farming systems that do not harm the environment will require a rationalisation of resources. This will entail a refocus on farming system research within an ecological framework, coupled with the adoption of participatory methods of on farm research. It will also depend on cooperation between universities, CSIRO and State agencies in research and development that underpins the evolution of ecologically sustainable agriculture. A significant feature of the future will encompass rural communities working with biophysical scientists, sociologists and economists to build new systems. The innovative use of on-farm measurement, coupled with simulation models to design and examine alternative operations in terms of both production and impact on the natural resource, will be an increasingly important tool of discovery.

The Landcare movement: agents of change

Andrew Campbell, in his overview of the Landcare movement, was able to report in 1994 that: *'after 200 years, Europeans in Australia are starting to understand the characteristics of this ancient land, and some are starting to develop some humility in attempting to live with the land, rather than from the land'*.

The development of a strong Landcare ethic within the rural and urban community has been a major success of the past decade. It has raised the awareness and commitment of the community to natural resource management issues and it has provided a low-cost, community-based delivery mechanism for on-ground works across rural and urban communities. Those in Landcare are now seeking farming system solutions that are both profitable and benign to the resource and environment. There is an increasing awareness

now that few such solutions exist. The next stage of Landcare will be to drive the development of farming systems that do not harm and which can generate wealth in rural communities. Their innovation, coupled with appropriate strategic and well-targeted science, is a promising formula for the future.

Regional natural resource management

The devolution of increased authority to regional and catchment communities for natural resource management is well developed in some states and appears to be a useful vehicle for change. The regional level planning and implementation are most effective when generated by the regional community. Indigenous people have much to contribute to sustainable land use, and it is most important that indigenous understanding of landscape functions and their relationship to the land are a central part of regional thinking and planning. This enables regional issues to be fully taken into account in negotiating trade-offs and outcomes for the region, and in tailoring the best approach given regional circumstances. This assumes that the regional bodies have access to resources and information sufficient to their mandate.

Environmental management and quality assurance

Since the mid 1990s, rural industries have sought to use quality assurance (QA) programs such as 'CattleCare', to improve the market quality of meat and particularly, to reduce the risk of pesticide contamination. While ISO 9000 is established in Australia with a focus on service or product quality, QA with an emphasis on environmental management following the ISO 14000 standard is only now emerging as a possibility. Our forest industry is leading the way.

Global markets require quality produce and assurance that products are free of chemical residues, free of disease, and produced in a manner that is benign to the environment. Quality assurance procedures and practices have evolved at an international level and are essential to Australia's global positioning in export markets. Use of ISO 14000 standards could play a key role in providing procedures to establish Australia's credibility in global markets as a supplier of products that are 'clean and green'. If so, this would represent an economic drive for building farming that does not harm.

Conclusion

While the search for sustainable landscapes will be incremental and based on a cycle of research, innovation, monitoring, reporting and revision, it will not be well served by a failure to tackle the problem at its roots—the fundamental leakage or other dysfunctional ecological processes that drive the specific degradation process.

Developing ecologically sustainable landscapes that support robust and resilient communities is a very difficult problem, scientifically and socially. Were this not so, we would not be in our present predicament. It is most misleading to assert or assume that our current knowledge base is sufficient and that ecologically sustainable land use is possible simply by applying existing knowledge. Current information must be applied, but it must also be recognised that many current management issues are the result of failure to research and develop farming systems and their integration with other land uses so that the flows of matter and energy are compatible with the ecological, hydrological and biogeochemical processes operating in the landscape. Few commercial farming and other land use systems are able to control the cause of land degradation while generating a farm

income that can sustain rural communities. The search for farming systems and land use patterns that do not harm our environment is urgent. It must form a central plank in any strategy for regional development in Australia.

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Discussion notes

- If wheat is to continue to lead the field of income streams, (possibly with 40%, Table 2), this may require the development of perennial wheat in low rainfall areas, and alley farming or mosaics will need to be assessed by R&D, since the present dominance of broad acre wheat production often means that most of our agricultural topsoil is blown away as dust
- If the present rate of land degradation continues it may be that Australia will become a net food importer. This seems to be an ethically unsustainable position, since we belong to a world with an increasing demand for food, particularly for poorer countries. We may have international as well as national obligations to develop sustainable agricultural systems, to at least feed ourselves
- Installation of a mosaic of vegetation to correct leaky ecosystems resembles pre-industrial methods of agriculture, and trials of bush tucker cultivation would be a good example of 'working with nature' in this ancient land
- The Griffith initiative of using sewage and tiered vegetation seems to be working. This could be an increasing element in the landscape where we capture ecosystem resources by serial cycling into multi-tiered vegetation. Michael Abelman's city farm, the Dutch example of below-sea level intensive horticulture, and the trial in some Danish cities of growing vegetables from sewage and grey water in attractively designed inner-city garden centres may be setting a trend towards locally produced sustainable food supplies for an urban environment. This approach has been operating in Asia for many generations
- Permaculture and organic farming may have an important part to play in sustainable agriculture. John Pate's work on native ecosystems tells a story where these native systems work in principles consistent with polyculture and permaculture. Deep rooted perennials and nested short seasoned species work to capture and recycle resources
- The widespread adoption of sustainable agriculture and 'farming without harming' will require considerable funding, imagination and co-operation between the Federal Government and the States. At present the only dedicated organic funding stream comes from RIRDC (rural industries research and development corporation) – a welcome but mere \$275K. This contrasts with the many millions of dollars spent by the Federal Government on biotechnology R&D, which (whatever one's world view) is a technology simply not allowed under the formal regulations that govern the production of organic foods nationally and internationally

- Although one may be optimistic about organic systems offering something positive for our environment and our people, what hope is there with such contradictions in government support? For a true revolution in agricultural practice to take place there will need to be a massive education program for the farming community, consumers, and not least for the multinational chemical corporations, to persuade them that in the long run, sustainable food production methods are in the best interests of all of us.

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