Sustainable Agriculture in Australia
– Some Ways Forward

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1. THE CHALLENGE FACING AUSTRALIAN AGRICULTURE

It is a demanding journey to build an agriculture that works for the climate and soils of the great south land. Our pioneering farmers and scientists, like William Farrer, were confronted by an ancient Gondwana landscape driven by a dry, extremely variable climate very different from anything experienced in Europe or North America. Today's custodians of the land continue to seek new ways to harvest water, nutrients and carbon as food and fibre from ancient soils.

Australian agriculture has been very successful for over 200 years, producing substantial wealth to support the nation's economic development. However, it has been based on altering the hydrology of the landscape to a remarkable degree in a relatively short time. Large-scale clearing of native vegetation and its replacement with annual crops and pastures have substantially increased the amount of water leaking beneath the root zone and entering the internal drainage and groundwater systems of the landscape. This has caused water tables to rise—bringing the salt with them into the topsoil.

We are now producing commodities with ever-declining terms of trade and at significant cost to the environment, as evidenced by extensive losses of species and changes in ecosystem processes, resulting in the increasing degradation of our land and water resources. Australia is geologically very old and mismanagement of natural resources will have significant and long-lasting consequences for society. On an 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 activities have begun to treat the symptoms and heal the wounds. However, land managers must now shift their focus to treating the cause of the degradation. That will not be easy, as it requires a revolution in land use, incorporating a new vision for the role of agriculture in the landscape.

There is sufficient knowledge now to shape the re-thinking of our farming systems. Australian agriculture must build productive, sustainable farming systems that do not harm the environment in ways such as damaging soil, water and biodiversity resources. This is a tough call.

It requires agro-ecosystems that generate wealth from food and fibre products and which have within them flows of water, nutrient and carbon that are well matched to the flows that can be accommodated in hydro-geochemical cycles of the ancient continent.

For this to happen we will need to develop innovative and inclusive approaches that permit fair comparison of market and non-market values. Developing the concept of valuing and paying for ecosystem services as part of this process is will be increasingly important.

If we fail to address this urgent task in an integrated, inclusive and adaptive way, the outcome will be further losses of biodiversity, land degradation, and the cessation of agricultural production in the worst affected areas.

A key function of agriculture in the future will be to manage the landscape, its rivers, wetlands and estuaries, in ways that produce ecosystem services for our urban societies. The agricultural community can no longer be expected to produce cheap, clean food and fibre, as well as provide a free service to maintain all the ecological functions of the landscape that provide ecosystem services essential to urban societies. The services will need to be paid for and be recognised as a fundamental part of the economy. The agriculture of the future will be

paid not only for the goods it produces but will receive increasing remuneration for the services delivered through its management of healthy landscapes, rivers, wetlands and estuaries. As perceptions change, agriculture as a whole will be envisaged by the wider community as the custodian and manger of the life support systems for society.

2. THE UNIQUE AUSTRALIAN LANDSCAPE AND ITS BIOTA

If Australia's geography and climate had been similar to those of North America and Europe, our current agricultural and pastoral systems would not have caused the major problems we now face. But the geography and climate of this continent are very different to those of the Northern Hemisphere landmasses.

Australia's geological history has created an ancient, very flat continent that has accumulated enormous amounts of salts. Much of these salts are carried from the oceans in rain, deposited, trapped and accumulate in the soils, regolith, lakes and groundwater, These accumulated salts were often blown and redistributed across the landscape during the extremely dry periods of geological time and the process repeated over millennia.

Since the continent is flat, and dominated by a gentle fall towards its interior, most rivers and groundwater systems are very sluggish, with little capacity to drain the continent of its salt and water. It is much easier to add water to our groundwater systems than it is to drain water from the landscape. As a consequence, enormous stores of salt characterise the landscape.

Trees, woody shrubs and perennial grasses comprise much of Australia's native vegetation. This perennial vegetation, with its relatively deep, dense, root systems, takes full advantage of any available water, thereby minimising recharge, that is, the amount of water that leaks past the root zone to groundwater. Native plants have evolved a fragile balance to manage the low rainfall and large salt stores in subsoils, regolith and groundwater.

The evolutionary traits of our native vegetation have meant that the rate of leakage past the plant roots into the landscape's internal drainage systems is approximately equal to the drainage or discharge rates of water from the deeper soils of the landscape. Healthy native ecosystems within catchments were usually in hydraulic and salt balance.

Most of our farming operations leak water and nutrients. It is this very leaky nature of Australian agro-ecosystems that lies at the heart of almost all land and water degradation issues. This leakage results in waterlogging, mobilisation of salt and other chemicals through the landscape, leaching of nutrients to generate soil acidification, and leakage of nutrients to water bodies.

It is a great irony that in Australian agriculture, where the shortage of both water and nutrients greatly restricts yield, it is the loss of both precious water and nutrient beneath crops and pastures that is the fundamental cause of both salinity and acidification.

If we can develop systems that make full use of available water and nutrients, they may be both more productive and more ecologically sustainable. At the moment, unfortunately, we have few, if any, such solutions.

3. FARMING WITHOUT HARMING

'Business as usual' is not an option, but what are the options for change? This question was addressed in a preliminary analysis by Stirzaker *et al.*, (2000) released with the MDBC's *Draft Basin Salinity Management Strategy* in September 2000. Among other things, the CSIRO report advocated the urgent need to pioneer the development of a new rural 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, mixed perennial-annual cropping systems, and significant areas devoted to maintaining those elements of native biota that depend on native vegetation.

Such innovative solutions will need to be incorporated into the landscape not only to help deal with the growing problem of salinity but also to capture multiple benefits such as maintaining native biodiversity and community well-being. It is then that we will make progress towards ecologically sustainable development.

No single land-use option will halt the growth of 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 areas in which they are deployed. These land uses, in combination, need to deliver leakage rates past the root zone that approach those of natural vegetation.

We must address agricultural production as an agro-ecosystem that is part of the larger-scale ecosystem and landscape processes. At the moment, we run the risk of stumbling between solving one problem and creating another.

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, and good maps of landscape properties, particularly salt storage and groundwater flow.

4. SCIENCE TO CALCULATE & MEASURE FLOWS IN AGRO ECOSYSTEMS

The solutions to the biophysical problems are scientifically demanding. They require new ways of doing science within the imperatives of rural communities facing radical environmental, social and economic changes. For these communities in Australia, this is both an opportunity and a challenge.

There is an urgent need for strategic research in farming systems to find solutions to matching these sources and sinks, and then match the residual flows to those in the ecological and landscape functions operating in the Australian environment.

An important step in building sustainable agriculture has been the development of science of measurement and prediction of water, nutrient and salt flow in Australian agro-ecosystems. This work which has taken place since the 1980's, has focused on the movement of water and nutrient beyond the bottom of the root zone.

As questions of sustainability became the focus of study, (Cocks *et al*., 1980) the disciplines of soil physics (Verburg, *et al*., 1996) and hydrology paid greater attention to the measurement and predictions (Dunin, *et al*., 1999) of this small residual aspect of the water and nutrient balance of an agro-ecosystem (Probert, *et al*., 1998). The flows of water and nutrient were collated and reviewed (Smettem, 1998 and Bristow *et al*., 1998) and indicated that agricultural systems leaked much more water beneath the root zone than did the native vegetation, and that the amount leaked generally increased with rainfall.

Since this early review work there is an accumulating set of measurement and prediction (Verburg, K., and W.J. Bond, 2003) which have characterized the flow of water in Australian agro-ecosystems and indicate that annual crops and pasture plants leak some 2 to 10 times the amount of water past the root zone as does native vegetation.

Research efforts within programmes like *Redesigning Agriculture for Australian Landscapes* have compared current agricultural systems with the native plant communities that they have replaced. By doing so the research has identified novel design criteria which could be used to modify existing agricultural systems or develop new systems, which are more in tune with the Australian landscape.

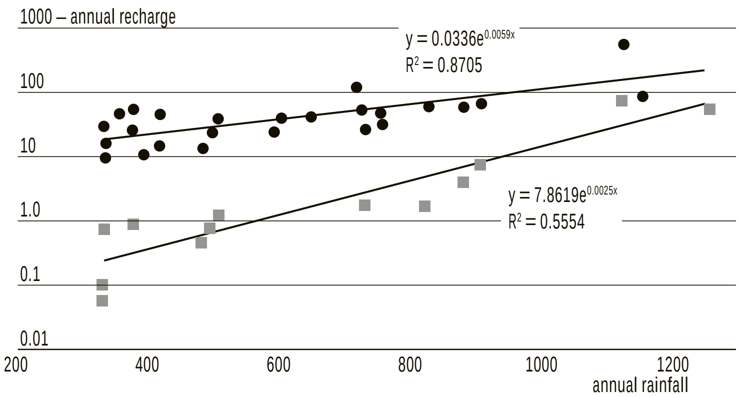


Figure 1: Summary of Western Australian measures of deep drainage in mm/year (leakage beneath the root zone) for Agricultural (top line of circles) and Native (bottom line of squares) plotted as function of rainfall in mm per year. (Source is Smettem, 1998).

5. REDESIGNING AGRO ECOSYSTEMS

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. The sacrifice of biodiversity in agricultural landscapes (Saunders , Hobbs, and Ehrlich, 1993; Saunders, 1996; Lefroy, Hobbs, and Hatton, 2000) has come at a high cost in terms of land and water degradation. Part of the solution lies in restoring crucial elements of biodiversity to the landscape and optimising the ecosystem services provided by biodiversity.

The elements in redesign towards compatibility with landscape flows of water and nutrient will engage;

- Vegetation elements, namely annuals, herbaceous perennials, woody perennials;
- Management practices (inputs, operations etc);
- Temporal and spatial organisation of vegetation within management units (paddocks) and catchments using;
- Phase farming, opportunity cropping, companion cropping, precision agriculture etc;
- Temporal and spatial organization at broader scales incorporating agro-forestry, and mosaic farming; and,
- All these elements need to be matched with soil, climate catchment characteristics.

6. PRINCIPLES OF EFFECTIVE LANDSCAPE REDESIGN

While there are considerable gaps in the scientific information available to advise on landscape design, the significance of design is being shown to be profound. The key elements of design as far as terrestrial biodiversity and ecosystem functions are concerned are size, shape, separation/connectivity, species composition, and position in the landscape.

Landscape diagnosis

Landscape diagnosis, the focus for targets, and management priorities all depend on the landscape context. The amount of native vegetation remaining determines how intact biodiversity and ecosystem functions are. A number of theoretical and empirical studies (Hobbs and Saunders, 1993; Lambeck, 1999 ; James and Saunders, 2001) have analysed the changes in the rate of loss of interconnectivity of patches, rate of species loss, and lag times associated with random and non-random clearing. These thresholds are at:

- 30 per cent cleared, with 70 per cent native cover remaining in which most of the habitat is connected. Thus, for organisms that require large areas of continuous habitat, or need to disperse through particular types of habitat, more than 70 per cent cover of suitable habitat may be necessary. As clearing or degradation reduces the cover of suitable vegetation, a threshold of connectivity is passed;

- 70 per cent cleared; and,
- More than 90 per cent cleared.

Design elements are most important for landscapes with less than 70 per cent native vegetation cover. Below 30 per cent cover, design is an essential component of revegetation to maximise results for efforts. In landscapes with 30–70 per cent native vegetation cover, design principles can help to avoid thresholds of change that cause rapid loss of species and change in ecosystem functions.

All of these factors need to be considered together.

Using vegetation cover to enhance biodiversity and reduce land and water degradation

The size of native vegetation patches (when isolated from other patches of native vegetation by large areas of agricultural land) and their arrangement on the landscape has a large influence on which species survive and consequently, which ecosystem services are maintained.

The effectiveness of conserving patches of habitat as a way of allowing species to persist in highly cleared areas is frequently debated, mostly because there are few, reliable empirical observations to guide us. A landscape strewn with small patches might be effective in maintaining some elements of biodiversity. However, the cost of maintaining small patches may be much higher than for larger patches, and those organisms with habitat requirements that are met only by large patches will become locally extinct. It would be expedient to design a landscape with an optimum number of small, medium and large patches to maintain species and minimise maintenance costs.

In landscapes where clearing has reduced native vegetation to less than 30 per cent cover, the emphasis is on revegetation, which is time consuming and expensive. We need to refine our understanding of these landscape design elements so that revegetation can be done efficiently and effectively. At present this involves planting or direct seeding, which are labour intensive and expensive.

Much research is needed in areas such as:

- Where in the landscape should vegetation be placed?
- How should the condition of current vegetation be improved?
- What sort of species and structural complexity is necessary?
- How can regeneration of remnant vegetation be used to enhance revegetation?

Scale of revegetation and its strategic location

For recharge reduction to be effective, revegetation will need to be strategically located and of sufficient scale to match the particular groundwater system that is controlling the expression of the salinisation process. The geological structures and groundwater systems of catchments determine the scale and relative importance of strategic positioning of revegetation for forestry, agroforestry and native vegetation. The scales required to meet the thresholds and targets set for biodiversity appear to be of the same order as those required for management of dryland salinity and water quality.

Studies show that in some geological settings, the specific location of planting can be critical to providing recharge reduction benefits. Increasingly, salinity management planning is applying such information to ensure plantings are carefully targeted. The greatest obstacle to controlling leakage in annual cropping systems is season-to-season variability in rainfall. Any sustainable system must have the capacity to deal with the wetter-than-average years that contribute most to drainage.

7. A SUSTAINABLE LAND USE MIX

As suggested by Williams and Saunders (2005) a sustainable mix of land uses might consist of:

- 30 per cent of the area permanently covered in native vegetation, including trees, shrubs and grasses;
- 20 per cent covered in deep-rooted trees, shrubs and grasses, planted primarily for recharge control and income from grazing and farm forestry;
- 30 per cent intensively used for annual crops; and
- 20 per cent less intensively used for mixed grazing and cropping.

The correct balance between different types of land use will vary for different catchments, size of catchments and position in the landscape. Devising the optimal placement of these land uses in terms of salinity control, productivity and maintenance of native biota will require a robust understanding of landscape processes and functions, good maps of landscape properties, particularly salt storage and groundwater flow, and an understanding of the distribution and abundance of flora and fauna. A range of options might be incorporated, such as:

- The development of commercially driven tree production systems and/or novel tree species for large areas of current crop and pasture zones. 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 comprising novel mixes of all the best current annual and perennial plants, the best agronomy, companion plantings, rotations and combinations; and,
- New forms of cereals, pulses, oilseeds and forages selected or bred for characteristics that substantially reduce deep drainage and nitrogen leakage.

Farm forestry

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 reafforestation 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 of the Rural Industries Research and Development Corporation and Land and Water Australia is making an important contribution to building these new industries.

Debates on forestry and water often become adversarial, as though there is a simple solution to these complex issues. However, interactions between forests, catchments and rivers are diverse, and usually climate-, ecosystem- and hydrogeologically specific.

Recent analysis (O'Loughlin and Nambiar, 2001; CSIRO, 2004) indicate that when pastures or crops are replaced with tree plantations or tree-dominant native vegetation, there is the reduction in the run-off and thus the flow of water in the stream (also known as the water yield). This occurs relatively quickly and is at its maximum when the canopy of the plantation or revegetation is closed. The reduction in flow is significant and increases in high rainfall zones (above 700 millimetres a year). In low to medium rainfall zones (400 – 700mm a year), the reduction is often small and difficult to predict.

In recognising that land use changes include the establishment of new plantations that reduce stream flow, the Wentworth Group of Concerned Scientists (Wentworth Group, 2003) said that 'comprehensive water accounts must accurately reflect the impacts of such changes on water availability, including different combinations of grazing, cropping, forestry enterprises and other forms of revegetation, which reduces the volume of water reaching rivers and recharging groundwater systems'.

Victorian catchments (CSIRO,2004) provides analysis that shows targeted planting to maximise stream salinity benefits can substantially improve efficiency without any marked impact on water yield loss or forestry production. This result highlights the importance of selectively targeting those areas where salinity benefits are greatest to optimise the effectiveness of new forestry or farm forestry plantations. This and other work by Forests NSW and CSIRO indicate that well-planned and strategically located reforestation and revegetation can address the hydrological imbalance that causes dryland salinity on farms and in streams, wetlands and rivers.

Research tools exist or are being developed to predict the impact of change in land use on the suite of environmental values. These tools can be used as a basis to help design landscapes. It may be possible to substantially reduce plantation impact on water yield through careful on-farm planning, location of plantations, and management through silviculture such as thinning. However, these manipulations also need to be considered in light of potential impacts on productivity and economic return. CSIRO (2004) predicted that 'the establishment of new tree plantations in agricultural landscapes will have a range of environmental outcomes. Using the right scientific and planning tools, combined with alignment with regional community objectives, forestry and revegetation can to play an important role in realising net environmental benefits, with the added advantage of providing an economic return that will help pay for the scale of revegetation needed to address some of Australia's environmental problems'.

Native flora and fauna

The use of native flora and fauna may form an increasing part of rural production. Bush foods, native wildflowers, essential and other oils for pharmaceutical or industrial chemicals are receiving increasing attention. Indigenous people have much to contribute in the use of native plants and animals for food and fibre. This form of diversification in farming enterprises will increase the planting of native vegetation onto 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.

8. THE ROLE OF ECOSYSTEM SERVICES

The phrase 'ecosystem goods and services' is appearing with increasing frequency in debates about alternative forms of land use. Daily (1997) define and ecosystem service as

'*…the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life*'.

The agricultural community continues to be caught with declining terms of trade and can no longer be expected to produce cheap, clean food and fibre, as well as provide a free service to maintain all the ecological functions of the landscape that provide ecosystem services essential to urban societies. The services will need to be paid for and be recognized as a fundamental part of the economy.

It is my view that a key function of agriculture in the future will be to manage the landscape, its rivers, wetlands and estuaries, in ways that produce ecosystem services for our urban societies.

As markets develop for ecosystem services, an increasing proportion of farmer's income will derive from the management of healthy landscapes, rivers, wetlands and estuaries. They will be seen by society as the custodian and manger of the life support systems for society as a whole.

In Blueprint for a Living Continent (Wentworth Group, 2001) suggest that we

'*Pay farmers for environmental services (clean water, fresh air, healthy soils). Where we expect farmers to maintain land in a certain way that is above their duty of care, we should pay them to provide those services on behalf of the rest of Australia.*'

The Wentworth Group maintain that such reforms will deliver large scale, long term change in the way we manage our continent. Paying farmers to restore riparian corridors along all Australia's river systems by restoring native vegetation and managing stock, is one example of significant benefits to be derived from purchasing an environmental service from farmers. If we achieved nothing else in our lifetime, this single action, because of the multiple environmental benefits is produces, would transform the health of our continent for centuries.

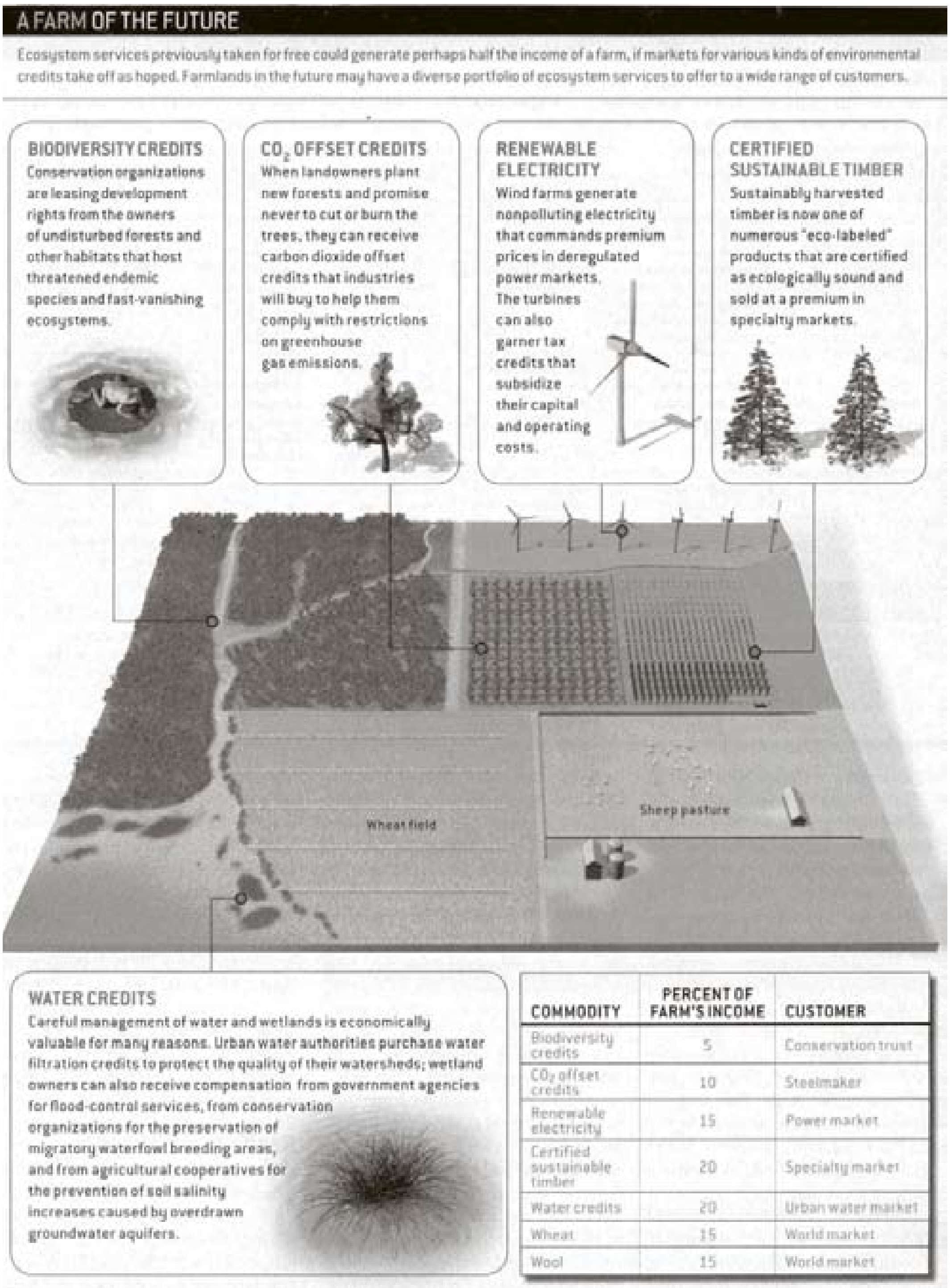
9. WHAT A FARM MIGHT LOOK LIKE IN THE FUTURE

A mosaic of ecologically sustainable, commercial land uses could be combined with land uses that provide ecosystem services that are valued and paid for by stakeholders and beneficiaries. The consequence would be that rural enterprises might derive their income from sources other than traditional food and fibre production. For example, they might provide services paid for by either private or public stakeholders and beneficiaries, or in some innovative mix. A possible set of diverse sources of income is set out in Table 1.

As fundamental reforms occur in the valuing of the ecosystems that support and drive the foundations on which productivity and the economy rest, a farm of the future might look something like that depicted in Figure 2 over the page.

COMMODITY, BUSINESS SHARE %	CLIENT
Wheat, 40	World market
Wool, 15	World market
Timber, 10	Pulp wood, biomass energy, speciality 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

Table 1: New commodities and markets. (Williams and Saunders, 2005)



A FARM OF THE FUTURE

Ecosystem services previously taken for free could generate perhaps half the income of a farm, if markets for various kinds of environmental credits take off as hoped. Farmlands in the future may have a diverse portfolio of ecosystem services to offer to a wide range of customers.

BIODIVERSITY CREDITS
Conservation organizations are leasing development rights from the owners of undisturbed forests and other habitats that host threatened endemic species and fast-vanishing ecosystems.

CO_2 OFFSET CREDITS
When landowners plant new forests and promise never to cut or burn the trees, they can receive carbon dioxide offset credits that industries will buy to help them comply with restrictions on greenhouse gas emissions.

RENEWABLE ELECTRICITY
Wind farms generate nonpolluting electricity that commands premium prices in deregulated power markets. The turbines can also garner tax credits that subsidize their capital and operating costs.

CERTIFIED SUSTAINABLE TIMBER
Sustainably harvested timber is now one of numerous "eco-labeled" products that are certified as ecologically sound and sold at a premium in specialty markets.

WATER CREDITS
Careful management of water and wetlands is economically valuable for many reasons. Urban water authorities purchase water filtration credits to protect the quality of their watersheds; wetland owners can also receive compensation from government agencies for flood-control services, from conservation organizations for the preservation of migratory waterfowl breeding areas, and from agricultural cooperatives for the prevention of soil salinity increases caused by overdrawn groundwater aquifers.

COMMODITY	PERCENT OF FARM'S INCOME	CUSTOMER
Biodiversity credits	5	Conservation trust
CO_2 offset credits	10	Steelmaker
Renewable electricity	15	Power market
Certified sustainable timber	20	Specialty market
Water credits	20	Urban water market
Wheat	15	World market
Wool	15	World market

Figure 2: A farm of the future where provision of ecosystem services are a significant part of agricultural production (Source: Wayt Gibbs, Scientific American, 2005)

10. PROGRESS IN REDESIGNING PLANT PRODUCTION SYSTEMS

The redesign of plant production systems for Australian landscapes is an imperative. Yet progress has been small and has focused on establishing a sound experimental and theoretical base for the increased leakage rates beneath agricultural systems compared to native systems preliminary. This understanding is fundamental to the design of future farming systems that do not drive salinisation or acidification processes.

Redesign of Agriculture for Australian Landscapes (RAAL) R&D Program

Phase 1 of the Redesign of Agriculture for Australian Landscapes (RAAL) R&D Program was largely completed at the end of 2001. The goal of this joint initiative of Land & Water Australia and the CSIRO is to design novel agricultural systems that ensure economic production and economic sustainability by matching these systems to the unique biophysical characteristics of the Australian environment. Phase 1 confirmed that either agricultural production systems will need to be substantially redesigned, or that land use will need substantial change, or that as a society we will need to be prepared to live with resource degradation.

The project has a range of notable features, including:

- The development of methods to calculate the proportion of a particular landscape that would need to be replanted to deep-rooted species in order to bring local water use back to something approaching that of the native plant communities prior to clearing.
- The close linking of field data with simulation modelling. This has provided a new capacity to design and evaluate novel systems using simulations.
- Through comparisons of agricultural and native plant communities, the identification of critical characteristics for the sustainability performance of the latter to include, in addition to perenniality, a mix of deep-rooted and summer-active species with shallow-rooted and winter-active species.
- Identification of a number of desirable traits in crop and pasture plants that would serve to improve their performance and water and nutrient management under Australian conditions were identified.
- Opportunities to enhance these characteristics or to incorporate them into crop and pasture plants were also identified, and provide a basis for determining priorities for further such work. Incorporating these 'sustainability characteristics' into existing and new crop and pasture plants should become a major priority for breeding, selection and bioengineering programs.

New plants for more sustainable farming systems

The search for profitable farming systems that have leakage rates similar to native vegetation is in its infancy. Brian Keating introduced a simple diagram that is helpful in understanding that moving from our relatively profitable but leaky annual crops to other farming option usually require a trade-off. Most systems that have reduced leakage are also less profitable. This is demonstrated in Figure 3. To date there are few options that sit in the win-win quarter of Figure 3. The challenge before us is to build more systems that fall in this win-win quarter.

Our current crop and forage species have been bred and/or selected for yield and desirable agronomic characters. Little or no attention has been given to their ability to use water and nitrogen and restrict dryland salinisation. Just as over a century ago William Farrer worked to develop disease resistant wheat varieties, efforts today need to focus on the role of crop and pasture species in controlling deep drainage and nitrogen leakage.

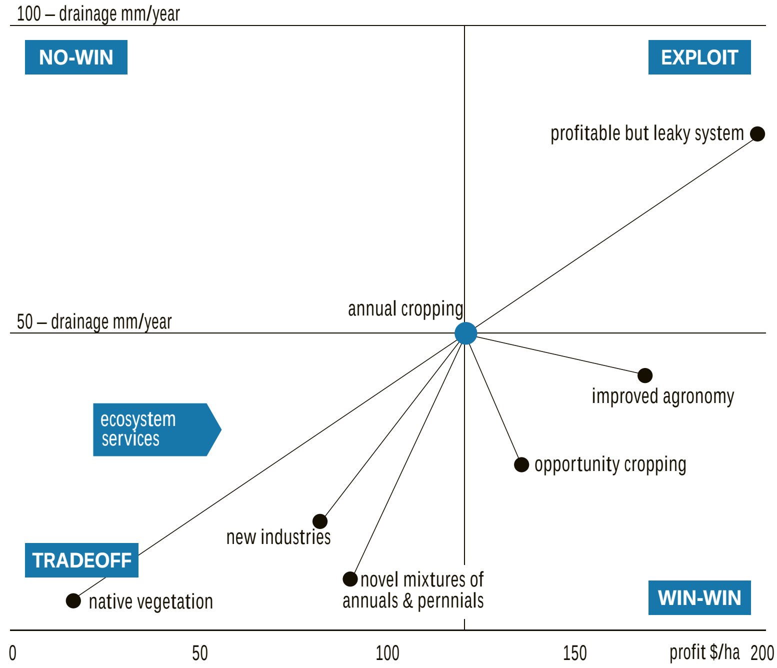


Figure 3: The profit–drainage matrix. (Figure reproduced from Williams & Gascoigne (2003) was developed by Brian Keating, CSIRO Sustainable Ecosystems, and is used with his generous permission.)

While a vision for the new industries and prospective land uses is emerging, many of essential components do not yet exist. Most of our farming system options that reduce deep drainage leakage also reduce profitability and are in the trade-off quarter. Very few farming system options reduce leakage and also increase profitability. The importance of economic benefit from sale of ecosystem services is illustrated.

A scoping study (LWRRDC/CSIRO) (2000) examined the potential for breeding and selection to build new plants for more sustainable farming systems. It highlighted that the breeding, selection and bioengineering of annual crops and pastures can contribute significantly to ameliorating dryland salinity and acidification by reducing the leakage of nutrient and water beneath the root zone. This benefit of new cultivars is likely to be over and above current agronomic and other management improvements that are currently the focus of our agronomic effort.

11. SOME WAYS FORWARD

Australia's farming systems must be able to work in a land that is old, flat and salty and which is driven by a dry, highly variable climate. To create and shape the future we will need to move from producing the familiar commodities to building a mosaic of commercial land uses that yield food and fibre and are ecologically sustainable, coupled with native ecosystems that provide a suite of ecosystem services which stakeholders and beneficiaries value and pay for.

This will require shifting beyond 'rejigging' old farming systems and 'business as usual'. Even with a revolution in land use and a mosaic of land use that significantly reduces groundwater recharge, the response in the landscape will depend on the specific characteristics of the groundwater system.

Partnerships between governments, businesses, community sectors and scientists can, I believe, build a better future for regional Australia. Increasingly, enterprise income will be derived from the provision and management of ecosystem services (such as the production of clean water, sequestration of carbon dioxide,

and production of oxygen) that are currently not valued, let alone paid for. The natural sciences have established the overall strategy to be followed, but can we marshal the investment in human and social capital to create our future?

By building new farming systems and new industries we treat the environmental damage at its cause and turn the leaked material into food and fibre and ultimately wealth. It is a real win-win situation. But can we do it? All the signs are there that we can. The movement has started, the direction is becoming clearer and we have the seeds of tomorrow. I am confident that from "*little things big things grow*".

12. ACKNOWLEDGMENTS

I am indebted to Phil Price for his vision, commitment and tenacity that lead to the establishment of the joint LWRRDC/CSIRO program on *Redesign of Agriculture for Australian Landscapes*. Without his insight, and understanding of the need for such research and access to our joint reports, this paper could not have been written. Brian Keating gave substance to this vision and I acknowledge his generous permission to use his ideas and work as reflected in figure 2 of this paper. My thinking has been enriched by the work of many CSIRO scientists including Tom Hatton, Glen Walker, Richard Stirzaker, Hamish Cresswell and Ted Lefroy. Importantly this paper draws heavily from the work of Denis Saunders and Matt Colloff particularly in the development of an unpublished paper prepared for the workshop, Murray Darling Basin 2051: Setting the vision for long-term biodiversity objectives for the Murray Darling Basin held in Canberra on 25 and 26 October 2001. I wish to acknowledge the editorial assistance of Fiona McKenzie of the Wentworth Group in bringing this paper to publication. Whilst I have benefited enormously from discussion of colleagues in CSIRO and the Wentworth Group any errors of analysis and interpretation in the text are mine.

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November 2005